BAYOU SEGNETTE TMDL FOR BIOCHEMICAL OXYGEN-DEMANDING SUBSTANCES

SUBSEGMENT 020701

SURVEYED MAY 19-23, 2003

REVISED TMDL REPORT

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For:
Engineering Group 2
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Louisiana Department of Environmental Quality

REVISED
April 9, 2004

EXECUTIVE SUMMARY

This report presents the results of calibrated dissolved oxygen (DO) modeling and total maximum daily load (TMDL) calculations for subsegment 020701 (Bayou Segnette). The modeling was conducted to establish a TMDL for biochemical oxygen-demanding pollutants for the Bayou Segnette watershed. Bayou Segnette is located in southern Louisiana in the Barataria basin south of New Orleans. The size of subsegment 020701 is approximately 35 square miles. The primary land uses are marsh and wetland forest. No point source discharges were included in the model, but several small point source discharges within the subsegment were included in the TMDL.

Inputs for the calibration model were developed from data collected during the May 2003 intensive survey, data collected by the Louisiana Department of Environmental Quality (LDEQ) at one monitoring station in the watershed, the LDEQ Reference Stream Study, and NPDES permits and permit applications for each of the point source dischargers. A satisfactory calibration was achieved for the model. In those cases where the calibration was not as accurate, the difference was in the conservative direction. For the projection models, data were taken from current discharge permits, current applications, and ambient temperature records. The Louisiana TMDL Technical Procedures manual (dated 09/23/2003) has been followed in this study.

Modeling was limited to post-storm conditions for both the calibration and the projections because urban runoff pumped into the bayou during storms has a significant impact on DO and the available data was limited to post-storm conditions. The model used was LAQUAL, a modified version of QUAL-TX, which has been adapted to address specific needs of Louisiana waters.

Subsegment 020701 was listed as impaired on both the EPA 1999 Court Ordered 303(d) list for Louisiana and the LDEQ Final 2002 303(d) list. The subsegment was found to be not supporting its designated use of fish and wildlife propagation. Bayou Segnette was subsequently scheduled for TMDL development with other listed waters in the Barataria basin. According to the 1999 Court Ordered 303(d) list, the suspected causes of impairment included organic enrichment / low DO and nutrients; and the suspected sources were municipal point sources, collection system failure, inflow and infiltration, urban runoff / storm sewers, other urban runoff, and natural sources. This TMDL addresses the organic enrichment / low DO impairment and the nutrient impairment.

Based on the results of the projection modeling, meeting the water quality standard for DO of 5.0 mg/L will require man-made nonpoint sources to be reduced by 100% for summer and 71% for winter and natural background sources will have to be reduced by 31% for summer. The no load scenarios (i.e., no reduction in natural background sources) yielded minimum DO values of 4.0 mg/L for summer and 6.6 mg/L for winter. This suggests that the existing DO standard for Bayou Segnette is not appropriate for summer and needs to be reevaluated.

Nonpoint source load calculations and TMDL calculations were performed using LDEQ's standard TMDL spreadsheet. This spreadsheet calculates wasteload allocations (WLAs) for point sources, load allocations (LAs) for man-made nonpoint sources and natural nonpoint sources, and incorporates an explicit margin of safety (MOS). For this TMDL, the explicit MOS was set to 20% of the sum of the man-made nonpoint sources and the point sources. This MOS accounts for future growth as well as lack of knowledge concerning the relationship between pollutant loads and water quality. The explicit MOS is provided in addition to the implicit MOS, which is created by conservative assumptions in the modeling. A summary of the TMDL is provided in Table ES.1.

Table ES.1. TMDL for Bayou Segnette (Sum of CBODu, NBODu, and SOD).

	Summer (May-Oct)		**Winter (Nov-Apr)**	
	Reduction	**Load (kg/day)**	**Reduction**	**Load (kg/day)**
Point Source WLA	0%	1	0%	1
Point Source Reserve MOS (20%)		0		0
Natural Nonpoint Source LA	34%	9589	0%	12075
Natural Nonpoint Source MOS (0%)		0		0
Man-made Nonpoint Source LA	100%	0	71%	3091
Man-made Nonpoint Source MOS (20%)		0		773
TMDL	--	9590	--	15940

This subsegment was listed as impaired due to nutrients as well as organic enrichment / low DO. This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as stated in the declaratory ruling issued by Dale Givens 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.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement nonpoint source 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 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 has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a four year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the four-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 305(b) and 303(d) listing purposes for each biennial cycle with sampling occurring statewide each year. The four-year cycle follows an initial five-year rotation which covered all basins in the state according to the TMDL priorities. 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.

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ACKNOWLEDGMENTS

This TMDL was developed by FTN Associates, Ltd. with assistance from numerous LDEQ personnel, as well as several other people. The LDEQ project manager was Emelise Cormier and the FTN project manager was Philip Massirer. The guidance and assistance from Ms. Cormier throughout this project was extremely valuable. Other LDEQ personnel that provided valuable guidance at various times were Dick Duerr and Marian Aguillard.

Several field reconnaissance trips were made by LDEQ watershed survey personnel. A reconnaissance survey was performed by Philip Massirer of FTN, Dick Duerr of LDEQ, and several LDEQ watershed survey personnel.

The intensive survey was performed by LDEQ watershed survey personnel and the laboratory analyses of water samples were performed by LDEQ laboratory personnel. Initial compilation of some of the field data was done by LDEQ watershed survey personnel.

Operational records and other information for the pump stations were provided by Jefferson Parish Department of Engineering personnel.

The field data analysis, water quality modeling, TMDL calculations, and preparation of the report were performed by several FTN personnel including Christina Laurin, Richard Bennett, and Philip Massirer.

ABBREVIATIONS

BMP	best management practice
BOD	biochemical oxygen demand
CBODu	ultimate carbonaceous biochemical oxygen demand
CFR	Code of Federal Register
cfs	cubic feet per second
DO	dissolved oxygen
EPA	Environmental Protection Agency
FTN	FTN Associates, Ltd.
ft/sec	feet per second
$g/m^2/day$	grams per square meter per day
kg/day	kilograms per day
km	kilometer
LA	load allocation
LAC	Louisiana Administrative Code
lbs/day	pounds per day
LC	loading capacity
LDEQ	Louisiana Department of Environmental Quality
LTP	Louisiana TMDL Technical Procedures Manual
MGD	million gallons per day
NBODu	ultimate nitrogenous biochemical oxygen demand
NCM	nonconservative material
NPDES	National Pollutant Discharge Elimination System
mg/L	milligrams per liter
TMDL	total maximum daily load
USGS	United States Geological Survey
WLA	wasteload allocation

1. Introduction

This report presents a total maximum daily load (TMDL) for biochemical oxygen demanding substances for subsegment 020701 (Bayou Segnette). This subsegment was listed as impaired on both the 1999 Court Ordered 303(d) List for Louisiana (EPA 1999) and the Louisiana Department of Environmental Quality (LDEQ) Final 2002 303(d) List (LDEQ 2003a). On both of these 303(d) lists, organic enrichment/low dissolved oxygen (DO) and nutrients were cited as suspected causes of impairment. Therefore, development of a TMDL for biochemical oxygen demanding substances was required. A calibrated water quality model was developed and projections were simulated to quantify the load reductions which would be necessary in order for this subsegment to comply with established water quality standards and criteria. The TMDL in this report was developed in accordance with the LDEQ TMDL Technical Procedures Manual (known as the "LTP") (LDEQ 2003b) as well as federal requirements in Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

2. Study Area Description

2.1 General Information

Bayou Segnette is located in southern Louisiana in the Barataria Basin south of New Orleans (see Figure A1.1 in Appendix A1). Bayou Segnette begins along the south edge of Westwego and extends generally southward for approximately 12 miles to Bayou Villars. The northern and northeastern boundaries of the subsegment are formed by levees that protect Westwego and other developed areas from flooding due to backwater from the Gulf of Mexico. This subsegment is not heavily populated, but is adjacent to heavily populated areas. Subsegment 020701 includes the entire length of Bayou Segnette and covers an area of approximately 35 square miles.

The predominant land uses in the Bayou Segnette subsegment are freshwater marsh and wetland forest. Approximate percentages of each land use in the subsegment are shown in Table 2.1 and a map of land use is shown on Figure A1.2 (in Appendix A1). Most of the urban/residential land is along the outer edges of the subsegment, except for some camps concentrated along the middle portion of Bayou Segnette.

Bayou Segnette receives runoff from within subsegment 020701 as well as runoff from Westwego and other developed areas where runoff is pumped over the levees at 5 pumping stations along the north and northeast edges of the subsegment. The locations of the 5 pumping stations are shown on Figure A1.1, and information for the pumping stations is listed in Table 2.2.

Bayou Segnette has numerous connections with the surrounding marshes and with other waterbodies (e.g., Lake Cataouatche, Lake Salvador, canals along the east side of Bayou Segnette, Bayou Villars on the south end). Some of the flow from the upper end of Bayou Segnette may be directed into Lake Salvador (LDEQ 1990). Bayou Segnette is influenced by tides from the Gulf of Mexico and is also influenced by wind tides. Based on hourly stage data from the Corps of Engineers gage for Bayou Segnette at Lapalco Boulevard (essentially the same location as LDEQ sampling station 0296), a typical diurnal water level fluctuation is 0.2 ft. There are no flow gages in the Bayou Segnette subsegment.

Table 2.1. Land use for subsegment 020701.

Land Use Type	**Percent of Total Area**
Fresh Marsh	43.0%
Intermediate Marsh	10.3%
Wetland Forest Deciduous	22.2%
Upland Forest Deciduous	0.4%
Upland Forest Mixed	0.7%
Wetland Scrub/Shrub Deciduous	2.0%
Wetland Scrub/Shrub Evergreen	2.0%
Upland Scrub/Shrub Mixed	1.0%
Agriculture/Cropland/Grassland	1.6%
Vegetated Urban	4.1%
Nonvegetated Urban	0.0%
Wetland Barren	0.0%
Upland Barren	0.0%
Water	12.7%
TOTAL	100.0%

Table 2.2. Information for pumping stations affecting Bayou Segnette.

Name of pumping station	Receiving water	Pumping capacity	Area draining to pump station	Other miscellaneous information
Bayou Segnette	Bayou Segnette	936 cfs	5,170 acres	Some of the runoff within this drainage area probably flows westward in Main Canal and is pumped into Lake Cataouatche.
Westwego 1	Bayou Segnette	300 cfs	1,816 acres is combined drainage area for Westwego 1 & 2 (drainage is interconnected)	Westwego 1 is a backup for Westwego 2 (it is operated only when Westwego 2 can not keep water levels low enough).
Westwego 2	Bayou Segnette	936 cfs		
Westminster	Unnamed canal draining to Bayou Segnette	1,248 cfs	4,041 acres is combined drainage area for Ames and Westminster (drainage is interconnected)	Westminster is a backup for Ames (it is operated only when Ames can not keep water levels low enough).
Ames	Millaudon Canal (drains to Bayou Segnette)	1,930 cfs		

2.2 Water Quality Standards

The designated uses and numeric water quality standards for subsegment 020701 are listed below in Table 2.3. This subsegment has a year round DO standard of 5.0 mg/L.

Table 2.3. Water quality numerical criteria and designated uses (LDEQ 2003c).

Subsegment Number	020701
Subsegment Name	Bayou Segnette – origin to Bayou Villars
Designated Uses	A, B, C
Criteria:	
DO	5.0 mg/L
Chloride	600 mg/L
Sulfate	100 mg/L
pH	6.0 – 8.5
Bacteria	see note 1 below
Temperature	32 °C
TDS	1,320 mg/L

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 / 100 mL maximum log mean and no more than 25% of samples exceeding 400 colonies / 100 mL for May through October; 1000 colonies / 100 mL maximum log mean and no more than 25% of samples exceeding 2000 colonies / 100 mL for November through April.

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. The LDEQ antidegradation policy (LAC 33: IX.1109.A) includes the following statements that are applicable to this TMDL: "No lowering of water quality will be allowed in waters where standards for the designated water uses are not currently being attained. ... The administrative authority will not approve any wastewater discharge or certify any activity for federal permit that would impair water quality or use of state waters." The TMDL in this report is consistent with the LDEQ antidegradation policy.

2.3 Point Sources

A total of five National Pollutant Discharge Elimination System (NPDES) permits were identified for point source discharges within subsegment 020701. Information for these point source discharges is shown in Table 2.4. This information was obtained by reviewing data from both the LDEQ point source database and from a point source database prepared for the Barataria and Terrebonne basins under contract to EPA Region 6. The locations of these facilities are shown on Figure A1.3 (in Appendix A1). Because none of these facilities discharges directly into Bayou Segnette, no point sources were included in the model. Prior to April 2002, the Bayou Segnette Pumping Station had a small sanitary wastewater discharge directly into Bayou Segnette, but that discharge now goes to the City of Westwego sewage treatment plant instead.

There are additional point sources whose effluent is discharged outside the subsegment but their effluent drains to the pump stations and eventually gets pumped into the Bayou Segnette subsegment. The most significant point source discharge outside the subsegment is the City of Westwego sewage treatment plant, which has a design flow of approximately 3 MGD and discharges just outside the subsegment boundary between the Westwego 1 and 2 pump stations. Municipal point sources were listed as a suspected source of pollution for the subsegment in the EPA Modified Court Ordered 303(d) List for Louisiana (EPA 2000).

Table 2.4. Information for point source discharges in subsegment 020701.

File Number	Company	Facility	Facility Type	Location	Receiving Water	Expected flow (MGD)	BOD5 (mg/L)	modeling comments
LAG530881	Master Lube of LA, Inc.		Oil Lube Cntr	Marrero, 3046 Barataria Blvd.	Estelle Canal	0.001	45	not modeled but in TMDL
LAG530921	Jefferson Parish Dept. Drainage Pump Sta.	Ames Pump Sta.	Drainage Pump Station	Marrero, 5100 Rochester Dri.	Bayou Segnette (via Millaudon Canal)	0.00008	45	not modeled but in TMDL
LAG110008	Lafarge Construction Materials	Westbank Plant	Ready Mix Concrete Plant	Marrero, 1950 Ames. Blvd.	Bayou Segnette			Assumed to have negligible oxygen demand
LA0108022	Hilcorp Energy Co.		Oil/Gas Exp. Prod. &Dev.	Bayou Segnette Field	B. Segnette, Dugas C, Outer Cataouatche			Assumed to have negligible oxygen demand
LAG530923	Jefferson Parish Dept. Drainage Pump Sta.	Westminster Lincolnshire Pump Sta.	Drainage Pump Station	Marrero, 2050 Watling Dr.	Bayou Segnette (via unnamed canal)	0.00008	45	not modeled but in TMDL

2.4 Nonpoint Sources

Suspected nonpoint sources for subsegment 020701 have been listed in the EPA Modified Court Ordered 303(d) List for Louisiana (EPA 2000). These sources included collection system failure, inflow and infiltration, urban runoff /storm sewers, other urban runoff, and natural sources. “Collection system failure” apparently refers to overflows or other failures of wastewater collection systems. “Inflow and infiltration” refers to ambient stormwater leaking into sewer pipes, which can cause the wastewater collection system to overflow, or the wastewater treatment plant to be overloaded (resulting in some wastewater bypassing the treatment facility and entering the receiving water without treatment). According to a report by LDEQ (1990), “the upper section of Bayou Segnette is impacted by sewage treatment plant bypasses during periods of heavy rain”.

One other nonpoint source that was not mentioned in the EPA 303(d) list is the domestic wastewater from approximately 150 camps and houses along the banks of Bayou Segnette. These camps and houses are all located within approximately 1.3 miles of the middle portion of Bayou Segnette (see land use map in Appendix A1). It is not known whether these camps and houses have individual wastewater treatment systems ("package plants") or whether they discharge untreated wastewater to the bayou.

2.5 Water Quality Conditions/Assessment

As mentioned in Section 1, this subsegment was listed as impaired by both EPA and LDEQ due to organic enrichment / low DO and nutrients. The suspected sources, suspected causes, and priority ranking from the EPA 303(d) list are shown in Table 2.5.

The water quality data that LDEQ used to assess this subsegment and include it on the 303(d) list were ambient monitoring data collected at LDEQ station 0296 (Bayou Segnette near Westwego). The location of this monitoring station is shown on Figure A2.1 (in Appendix A2). Data were collected at this station between 1991 and 2000. The DO data for this station are plotted in Figure A2.2; many of the values were below the water quality standard of 5.0 mg/L.

The US Geological Survey (USGS) also collected water quality data at five stations in the Bayou Segnette subsegment between 1981 and 1991. The locations of these five USGS stations are shown on Figure A2.1 and the DO data are plotted in Figures A2.3 – A2.7. It should be noted that much of this data set was collected prior to 1988, when Jefferson Parish consolidated its sewage treatment plants and rerouted the discharge to the Mississippi River. All of the USGS stations had some DO values below 5.0 mg/L, but the southern part of Bayou Segnette had fewer values below 5.0 mg/L. The station with the worst DO was on Millaudon Canal; however, the water quality in Millaudon Canal has likely improved since then because the Marrero sewage treatment plant no longer discharges to the ditches draining to the Ames pump station and into Millaudon Canal. These USGS data are presented here for information only; they were not used to develop the TMDL in this report.

Table 2.5. 303(d) listing for subsegment 020701 (EPA 2000).

Subsegment number	Waterbody description	Suspected sources	Suspected causes	Priority ranking (1=highest)
020701	Bayou Segnette – origin to Bayou Villars	Municipal point sources Collection system failure Inflow and infiltration Urban runoff/storm sewers Other urban runoff Other Natural sources	Organic enrichment/low DO Pathogen indicators Oil & grease Nutrients	3

2.6 Previous Studies and Data

The historical DO data that have been collected for the Bayou Segnette subsegment were discussed in Section 2.5. Data for other parameters were also collected when the DO values were measured.

Three previous water quality studies were identified that are relevant to this TMDL for Bayou Segnette. These three studies are:

1. "Upper Barataria Estuarine Survey: A Survey of the Bacteriological Quality of Waters Entering Barataria Bay, November 1983 – October 1984" (LDEQ 1990). The focus of this study was bacteria, but the report does provide some information that is useful for this DO TMDL.

2. "Water Quality of the Barataria Unit, Jean Lafitte National Historical Park, Louisiana (April 1981 – March 1982)" (USGS 1982). This report includes monthly data for one year for the five USGS water quality stations discussed in Section 2.5.

3. Louisiana Department of Natural Resources project "BA-16 Segnette Wetlands" (LDNR 1995). This was not a water quality study, but it was a project during the 1990's that consisted of constructing a rock berm along the west side of Bayou Segnette. The purpose of the berm is to keep wave energy from Lake Salvador from eroding the thin strip of land between the bayou and the lake. This barrier protects the bayou and adjacent fresh marsh from increased salinity and erosion.

3. Field Survey

An intensive field survey was conducted by LDEQ personnel on Bayou Segnette during the week of May 19-23, 2003. The purpose of this survey was to gather information about the subsegment and collect data that would be needed to set up and calibrate a water quality model. The field data that were collected included water quality samples and in situ measurements, continuous in situ monitoring, cross sections, velocity measurements with drogues, an acoustic Doppler flow measurement, and a dye study for time of travel and dispersion.

Continuous in situ monitoring data were measured during May 15-22. At several locations, continuous monitoring data are not available because the monitors were stolen. Water quality samples and associated in situ data were collected for most of the sites on May 22. Due to rainfall in the area on May 20-21, water quality samples at some of the boundary stations were collected on both May 21 and May 22 to characterize inflows entering the bayou from the pump stations. Rainfall totals of 1.5 to 3.9 inches were reported at the pump stations during May 20-21. A map and descriptions of the field data collection sites are included in Appendix B1.

3.1 Water Quality Sampling and In Situ Data

The water quality sampling data and the in situ data collected with the water quality samples are shown in Table B2.1 (in Appendix B2). Only four out of 25 (16%) instantaneous DO readings were above the water quality standard of 5.0 mg/L. The four DO readings above the standard were taken in Bayou Bardeaux and in Bayou Villars, both of which represent surrounding water quality and are not indicative of water quality in Bayou Segnette.

Table B2.2 (also in Appendix B2) shows a comparison of data collected at BS-1 during the survey with LDEQ historical data collected during the months of May and June at station 0296 (same location as BS-1). Although DO and conductivity during the survey were slightly lower than historical median values, this comparison shows that in general, the survey data are fairly typical for Bayou Segnette.

3.2 Continuous Monitoring Data

Figures B3.1 through B3.23 (in Appendix B3) show plots of the continuous in situ data collected during the survey. Due to several monitors being stolen, continuous in situ data during the survey are only available for four stations. The diurnal fluctuations of DO were typically about 1-3 mg/L at each station. DO percent saturation levels did not exceed 100% except at BB-2. Diurnal fluctuations of pH were small at all four stations. The relatively small DO fluctuations and lack of supersaturated values indicate that algal productivity is not high. The continuous conductivity data were fairly constant at BS-1, but showed significant temporal variability at BS-4, BS-6, and BB-2. Both BS-4 and BS-6 showed large increases in conductivity on May 17, which could have been due to south winds driving higher salinity water inland from the Gulf. The continuous water level data showed diurnal variations of 0.1 m (0.3 ft) or less.

3.3 BOD Time Series Analyses

Results of 60-day BOD time series analyses are shown in Appendix B4. For each sample, values of cumulative oxygen demand and NO2+NO3 concentration were obtained at selected intervals over a period of about 60 days. These data were entered into an LDEQ spreadsheet called GSBOD, which contains algorithms for fitting first order curves to the data to calculate values of ultimate carbonaceous biochemical oxygen demand (CBODu), ultimate nitrogenous biochemical oxygen demand (NBODu), decay rates for both CBODu and NBODu, and lag times for both CBODu and NBODu. The results of these analyses are shown in Appendix B4.

The CBOD decay rates were all between 0.04/day and 0.11/day except for PS-1, PS-2, and PS-5. The NBOD decay rates were highest at PS-1, PS-3, and OCC-1. In general, the CBOD and NBOD decay rates were highest near the northern end of the subsegment where the pump stations are located. The urban runoff being pumped into the Bayou Segnette subsegment is expected to have a much different water quality than other sources of water entering the subsegment (e.g., exchange of water with Lake Salvador, Lake Cataouatche, Bayou Villars, etc.).

3.4 Cross Section Data

Cross sections were measured at a total of 21 locations along Bayou Segnette and other adjacent canals and bayous. These cross section data are shown in Appendix B5.

3.5 Velocity and Flow Measurements

Table B6.1 (in Appendix B6) shows velocity measurements made at each sampling site using drogues. The flow direction was downstream (i.e., towards the Gulf) for all drogue measurements except at BS-4 (center of channel and left side) and at BS-2 (only the right side of the channel). At BS-2, the majority of the flow was moving downstream; the upstream velocity on the side of the channel may have been a localized eddy.

Acoustic doppler flow measurements were attempted at several locations, but due to adverse wind conditions, the only consistent flow measurement was at BS-7 on May 22. A printout of information from that flow measurement is presented in Table B6.2 (in Appendix B6).

A dye study was also conducted to measure velocity and characterize dispersion in Bayou Segnette. A slug of dye was injected in Bayou Segnette near BS-5 during the morning of May 21 and three "runs" were made to locate and characterize the dye cloud at different times. Appendix B6 contains time of travel calculations (Table B6.3) and a plot of dye concentration versus distance for these three runs (Figure B6.1). The dye moved downstream (to the south) during the day on May 21, but the current reversed overnight and the dye was found upstream of the injection location the next day. This diurnal flow reversal is assumed to be typical for Bayou Segnette due to its proximity to the Gulf and its diurnal water level fluctuations.

3.6 Pump Station Operational Data

Operational records for the pumping stations prior to and during the survey were provided by Jefferson Parish personnel. As shown in Figure B6.2 (in Appendix B6), water was pumped into the Bayou Segnette subsegment almost every day during the week prior to and during the survey. Most of the pumped water was from the Ames and Westwego 2 pump stations. Figure B6.2 also shows the highly intermittent nature of the pump operations.

4. Documentation of Calibration Model

4.1 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 has the mechanisms for incorporating hydraulic characteristics of Louisiana waterbodies and was particularly suitable for use in modeling Main Canal. 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, EPA 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, LDEQ 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 LDEQ 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 impacted 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 the 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 if 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 nonpoint source pollution is estimated from the difference between the calibration loads and the loads observed on reference or least impacted streams.

4.2 Input Data Documentation

Data collected during the May 2003 intensive survey (described in Section 3) were used to establish the input for the model calibration. The survey was conducted during a period that was typical of early summer conditions.

The flows in the model were determined by using the UNET hydraulic model to dynamically simulate flows in Bayou Segnette during the survey period. The UNET model was calibrated based on velocity and flow measurements from the field survey. Flow calculations are discussed in Section 4.2.11. A simulation of conservative constituents (e.g., chloride and conductivity) was performed to confirm the flow balance and calibrate dispersion as discussed in Section 4.3.1.

Field and laboratory water quality data were entered in a spreadsheet for ease of analysis. The Louisiana GSBOD program was applied to the BOD time series data in a separate spreadsheet as described in Section 3. The survey data were the primary source for the model input data for initial conditions, decay rates, and inflow water quality.

4.2.1 Model Schematics and Maps

A vector diagram of the modeled area is presented in Appendix C and in Figure 4.1. The vector diagram shows the locations of survey stations, the reach design, and the locations of inflows and outflows. The model included a large number of inflows and outflows because Bayou Segnette is connected to numerous other waterbodies. The reach design is discussed in Section 4.2.5. Maps showing the entire subsegment are included in Appendix A1.

4.2.2 Model Options, Data Type 2

Five constituents were modeled during the calibration process. These were chlorides, conductivity, dissolved oxygen (DO), CBODu, and NBODu. The chlorides and conductivity were included in the model for the purpose of checking the flow balance and calibrating dispersion. NBODu was represented in the model as nonconservative material (NCM).

4.2.3 Program Constants, Data Type 3

Three program constants were specified in the model input. First, the hydraulic calculation method was specified as 2 rather than 1. Method 2 is the preferred method and allows the user to input widths and depths rather than velocities and depths. The second program constant that was specified was the NCM oxygen uptake rate, which was set to 1.0 mg of oxygen consumed per mg of NCM decayed.

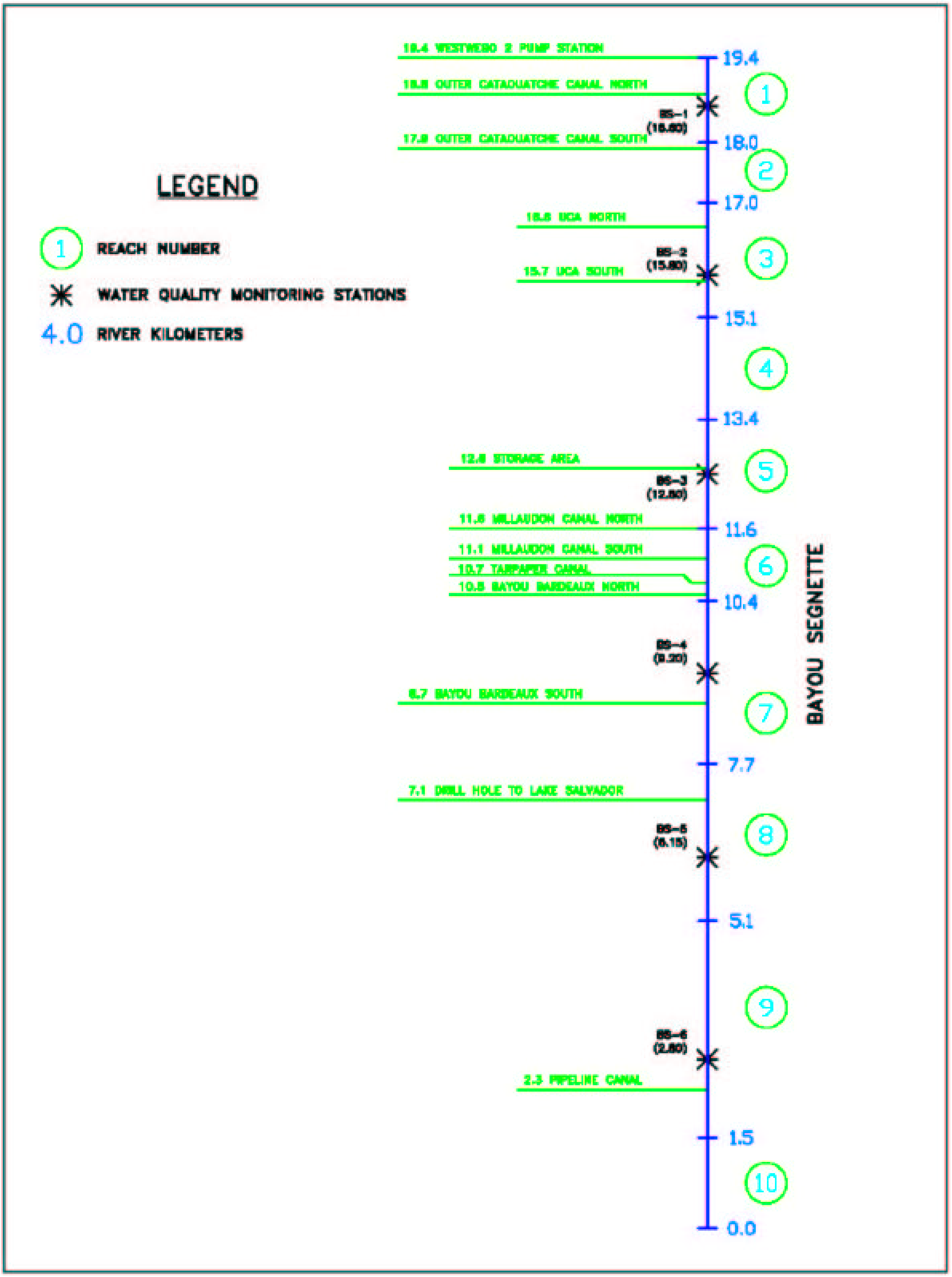

Figure 4.1. Vector diagram for Bayou Segnette LA-QUAL model.

The third program constant that was specified was a minimum surface transfer coefficient (K_L) for reaeration. Because Bayou Segnette is wide enough for wind to significantly affect reaeration, a wind-aided surface transfer coefficient was calculated using the mean daily wind speed at the New Orleans International Airport on May 22, 2003 (the day that water quality sampling occurred in the main stem of Bayou Segnette). This resulted in a value of 1.51 m/day for the minimum K_L. The calculations are shown in Table D.1 (in Appendix D).

4.2.4 Temperature Correction of Kinetics, Data Type 4

The temperature values in the model 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 the stream temperatures using the following equation:

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

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. The default theta values include 1.047 for CBOD decay, 1.070 for nonconservative material (NBOD) decay, and 1.065 for SOD. All three of these default values were consistent with the LTP (LDEQ 2003b), so no values were explicitly specified in data type 4.

4.2.5 Reach Identification Data, Data Type 8

The LA-QUAL model includes Bayou Segnette starting near its north end and extending to its south end (at Bayou Villars). No branches were modeled. A vector diagram of the model is shown in Appendix C.

The system being modeled was divided into reaches based initially on changes in width and depth. During the water quality calibration, the northern end was divided further to allow additional changes in kinetic rates. The final reach and element design included a total of 10 reaches with an element size of 0.10 km throughout the model. The widths and depths are discussed in Section 4.2.6.

4.2.6 Hydraulic Coefficients, Data Types 9 and 10

The hydraulics were specified in the model input for the LA-QUAL model using the power functions (width = a * Q^b + c and depth = d * Q^e + f). Values specified in the model for these power functions are shown in Table D.2 in Appendix D. Because water levels in Bayou Segnette are controlled primarily by backwater from the Gulf of Mexico rather than flow rate, it was assumed that changes in the stream flow rate between the calibration and projection simulations would create only negligible changes in depths and widths. Therefore, the coefficients and exponents (a, b, d, and e) were set to zero and the constants (c and f) were set based on the widths and depths from measured cross sections. Plots of modeled and observed depths and widths for Bayou Segnette are shown in Appendix E.

Because Bayou Segnette is tidally influenced and typically exhibits reversing flows (as discussed in Section 3.5), dispersion was specified in the model. The dispersion coefficients were estimated through calibration of the chloride and conductivity (as discussed in Section 4.3.1). This yielded values ranging from 8 m^2/sec at the northern end to 20 m^2/sec at the southern end. These values are shown in Table D.2.

4.2.7 Initial Conditions, Data Type 11

The initial conditions were used to specify the temperature and salinity for each reach and reduce the number of iterations required by the model for constituents being simulated. The values required for this model were temperature, salinity, and DO by reach. The input values came from the survey station(s) located closest to the reach or from an average of samples taken from stations located within the reach. The model inputs and data sources for the initial conditions are shown in Table D.3 in Appendix D.

Although chlorophyll data were available from the intensive survey, chlorophyll values were not specified in the initial conditions because the effects of algae on DO were taken into account through the determination of calibration target values for DO (discussed in Section 4.3.2).

4.2.8 Reaeration Rates, Data Type 12

For reaeration, the Louisiana equation (option 15) was used because it was developed specifically for streams in Louisiana and it has been used successfully for other TMDLs in Louisiana. Also, the velocities measured during the intensive survey were similar to the range of values for which the equation was developed (LDEQ 2003b). Based on the width and orientation of Bayou Segnette, wind-aided reaeration was simulated by specifying a minimum surface transfer coefficient in Data Type 3 (see Section 4.2.3). However, the reaeration coefficients from the Louisiana equation were slightly higher than reaeration coefficients based on wind. The model inputs for reaeration are shown in Table D.4 in Appendix D.

4.2.9 SOD, Data Type 12

The SOD values were achieved through calibration and ranged from 1.5 g/m^2/day to 4.5 g/m^2/day, except for reach 1. In reach 1, the SOD was dropped to 0.2 g/m^2/day in order to improve the DO calibration. The SOD values used in the model are shown in Table D.5 in Appendix D. Results of the water quality calibration are discussed in Section 4.3.2.

4.2.10 CBODu and NBODu Rates, Data Types 12 and 15

The CBODu and NBODu decay rates were varied along the length of the bayou based on "bottle rates" (decay rates calculated from laboratory analyses) from the samples collected during the intensive field survey. Higher decay rates were measured towards the northern end of the bayou, which is apparently due to characteristics of the urban runoff being pumped into the bayou. The decay rates for individual samples were averaged for three different parts of the bayou as shown in Appendix F. The values used in the model are also listed in Table D.4 in Appendix D.

CBODu and NBODu settling rates were not used in the model because there was no information suggesting that simulating CBODu or NBODu settling was necessary. The effects of settled CBODu and NBODu on DO are already implicitly included in the SOD.

4.2.11 Flow Calculations

Average flows for Bayou Segnette during the intensive field survey were estimated using a dynamic hydraulic model (UNET) to simulate inflows and outflows to the bayou. The UNET model was configured to simulate inflows and outflows to Bayou Segnette at approximately 16 boundary locations. The geometry input for the UNET model was based on cross section data from the LDEQ intensive survey. Boundary conditions for the model were based on stages (water levels) measured by the Corps of Engineers and operational records for the pump stations. The model was calibrated to measured velocities from drogue measurements and the dye study. The flows predicted by the UNET model at each boundary were averaged over two tidal cycles (52 hours) and then input to the LA-QUAL model. Averaging the flows over one or more tidal cycles is appropriate for input to a steady state water quality model, especially since the residence time of the modeled waterbody is much longer than a tidal cycle. Additional documentation for the hydraulic modeling is included in Appendix G.

4.2.12 Incremental Inflow, Data Types 16, 17, and 18

Based on the results of the UNET hydraulic modeling, no incremental inflow was needed to balance the flows. Therefore, incremental inflow was not specified in the model.

4.2.13 Nonpoint Source Loads, Data Type 19

Nonpoint source loads which are not associated with a flow are input into this part of the model. These loads can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, CBODu, and NBODu loads. These loads were used as calibration parameters and adjusted to get the model to match observed data. The values used for model input data for nonpoint source loads are shown in Table D.5 in Appendix D. No NBODu loads were needed in the model due to the large loading of NBODu from the water pumped into the bayou by the Westwego 2 pump station.

4.2.14 Headwaters, Data Types 20, 21, and 22

The upstream (northern) end of Bayou Segnette forms a “dead end” with no drainage area due to the levees along the northern boundary of the subsegment. There is no measurable runoff into the very northern end of the bayou. Therefore, the headwater inflow was specified as zero in the model (the pumped inflow was specified as a wasteload).

4.2.15 Wasteloads, Data Types 24, 25, and 26

Thirteen tributaries/distributaries were specified in the model as wasteloads. Model input values for these wasteloads are summarized in Table D.6 in Appendix D.
The flow rates for the 13 tributaries/distributaries were set to averages of the predicted flows from the UNET model (discussed in Section 4.2.11). Three of these wasteloads were outflows and the other 10 were inflows. Concentrations of CBODu and NBODu for the wasteloads were based on observed data collected on both May 21 and May 22 during the intensive survey.

The DO values for the ambient inflows were based on estimated daily average DO values for each sampling station. Because continuous monitoring data were not available for most of the boundary stations, the daily average DO at each station was estimated using continuous monitoring data from a nearby mainstem station. The ratio of the instantaneous DO to daily average DO at each continuous monitoring station was calculated for 15 minute intervals throughout the day. Then each instantaneous DO at a boundary station was divided by the ratio corresponding to the measurement time at the boundary station (see calculations in Appendix H).

4.2.16 Lower Boundary Conditions, Data Type 27

Because Bayou Segnette is tidally influenced and dispersion was explicitly simulated in the LA-QUAL model, lower boundary conditions were specified in the model. These values were based on observed data collected at station BV-1 on both May 21 and May 22 during the intensive survey. The DO value for the lower boundary was based on estimates of daily average DO that were calculated in the same manner as described above for the tributaries. The model inputs for the lower boundary conditions are summarized in Table D.7 in Appendix D.

4.3 Model Discussion and Results

4.3.1 Simulation of Chloride and Conductivity

Before calibrating the water quality, the model predictions for chloride and conductivity were examined to evaluate the flow balance and calibrate dispersion. Plots of predicted and observed chloride and conductivity for Bayou Segnette are shown in Appendix I.

The predicted chloride and conductivity values were close to the observed values except at BS-5, where both the chloride and conductivity were significantly underpredicted. The only ways to get the model to match the chloride and conductivity at BS-5 would be to add a source of chloride and conductivity in the model near that location or set the dispersion coefficient to an unreasonably high value. Neither of these actions would have been appropriate. The dispersion coefficients were set so that they were lowest at the northern end of the bayou (which forms a “dead end”) and highest at the southern end of the bayou (closest to the Gulf of Mexico).

4.3.2 Water Quality Calibration Results

Plots of predicted and observed values of CBODu, NBODu, and DO for Bayou Segnette are shown in Appendix J. A plot of predicted and observed DO is also shown in Figure 4.2.

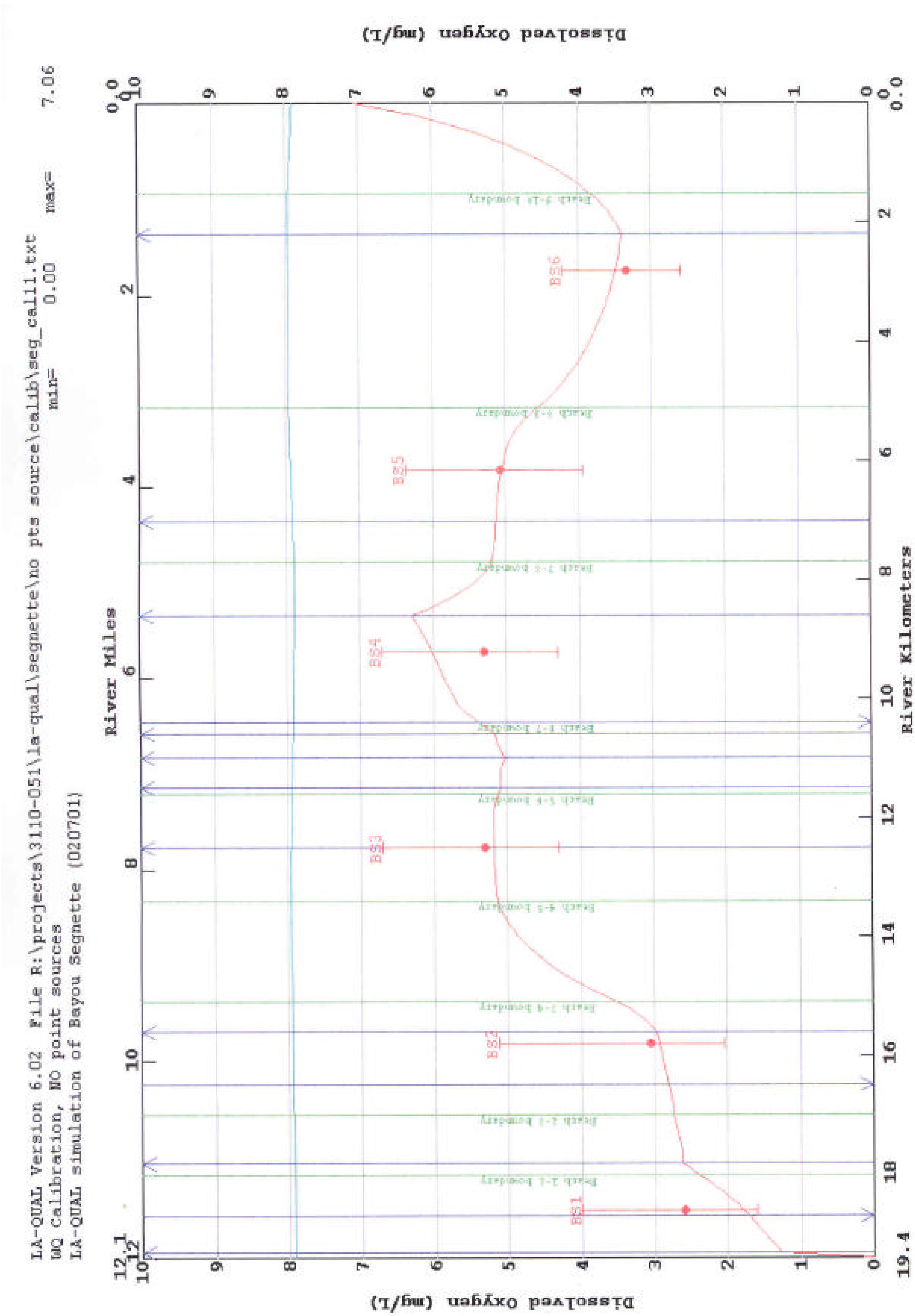

Figure 4.2. Predicted and observed DO for Bayou Segnette calibration model.

A printout of the tabular model output is included in Appendix K. The predicted values of CBODu and NBODu were close to the observed values except for slight overpredictions of CBODu at BS-5 and NBODu at BS-2. Predicted concentrations of both CBODu and NBODu were highest at the upstream end due to loadings from the Westwego 2 pump station. The overprediction of NBODu at BS-2 may be caused by the fact that the model simulates a continuous loading over an indefinite time period from the pump station, whereas in reality, the pump station operated for only a short time period.

According to recent LDEQ policy, the DO calibration target at each station was set as shown below based on the diurnal DO fluctuations from the continuous monitoring data:

Diurnal DO fluctuation < 2 mg/L:	daily average DO
Diurnal DO fluctuation 2-9 mg/L:	1 mg/L above daily minimum DO

The diurnal DO fluctuations were determined from continuous monitoring data collected on the day of the water quality sampling in the main stem of Bayou Segnette (May 22). The diurnal fluctuations on May 22 were slightly greater than 2 mg/L at BS-1 and BS-4, but slightly less than 2 mg/L at BS-6. Therefore, DO calibration targets were set to 1 mg/L above the daily minimum at BS-1 and BS-4 and the daily average at BS-6. Because continuous monitoring data were not available for other stations on the main stem, daily minimum and daily average DO values were estimated using the same methodology as described for the wasteloads (see Section 4.2.15 and Appendix H).

The DO calibration for was good except for underpredicting the DO at BS-1 and overpredicting the DO at BS-4. The low DO concentrations predicted at the upstream end of the model were caused by the low DO of water from the Westwego 2 pump station (0.24 mg/L) and high CBODu and NBODu concentrations. The underprediction of DO at BS-1 may be linked to the overprediction of NBODu at the upstream end (i.e., steady state simulation of a dynamic, short duration event). The overprediction of DO at BS-4 is due to the large inflow (6.54 m^3/sec) from the southern end of Bayou Bardeaux, which comes in to Bayou Segnette at river km 8.7 with a relatively high DO (6.58 mg/L).

5. Water Quality Projections

Since the calibrated model indicated that the DO criterion was not being met in Bayou Segnette, no-load scenarios were performed in addition to the traditional summer and winter projections.

5.1 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 Bayou Segnette, critical conditions for DO were based on analyses of long term temperature and DO data from the LDEQ Ambient Monitoring Network and local precipitation data. As in most other DO TMDLs, critical conditions were defined here in terms of water temperature and hydrologic conditions.

Critical temperatures for DO were determined by calculating 90th percentile values for each season using long term temperature data for Bayou Segnette near Westwego (LDEQ station 0296). These calculations are shown in Appendix L. The 90th percentile temperatures were used based on guidance in the LTP. Higher temperatures are more critical for DO because increasing temperature causes DO saturation values to decrease and rates of oxygen demand (SOD, CBOD decay, and NBOD decay) to increase. The correlation between higher temperature and lower DO in Bayou Segnette is clearly shown in Figure L.1 (located in Appendix L).

For most streams in upland areas, critical conditions for DO are characterized by low flow because reaeration is lower when velocities (and turbulence) are lower. However, because Bayou Segnette is a low gradient waterbody, its velocities are low enough under most flow conditions that reaeration is controlled by the surface transfer coefficient (K_L) rather than by velocity. Therefore, velocity and reaeration were not considered in the determination of the critical hydrologic conditions for Bayou Segnette.

Because Bayou Segnette has no continuous point source loading, Bayou Segnette experiences the highest loading of pollutants during storm conditions due to urban runoff pumped from outside the subsegment and nonpoint source runoff from within the subsegment. The model calibration, the LDEQ and USGS historical water quality data (Section 2.5), and the intensive survey sampling results (Section 3.1) all show that the urban runoff from the pumping stations has a significant impact on DO in parts of Bayou Segnette. In the Bayou Segnette calibration, the minimum DO occurred at the upstream end of the model near the location where the Westwego Pump Station 2 was pumping poor quality urban runoff into the bayou. At this location, there is virtually no upstream or immediately adjacent watershed to provide better quality runoff to dilute the pumped water. Therefore, larger volumes of pumped water (i.e., larger storms) would be expected to result in higher BOD concentrations and possibly lower DO concentrations at the upper end of Bayou Segnette.

In order to identify any existing correlation between DO in the bayou and volume of urban runoff being pumped, the LDEQ historical DO data were plotted against 3-day antecedent rainfall at the New Orleans Audubon station (located just across the Mississippi River from Westwego). As shown in Figure L.2 (located in Appendix L), low DO values have occurred under a wide range of hydrologic conditions. This plot does not show a strong and consistent correlation between rainfall (which should be somewhat proportional to volume of water pumped) and DO in the bayou. Based on these data, critical conditions for DO could be represented by a wide range of hydrologic conditions.

The intensive survey from May 2003 was conducted shortly after a storm event for which rainfall totals reported at the pump stations ranged from 1.5 to 3.9 inches. Based on the analysis of DO and rainfall and the water quality characteristics of the upper end of Bayou Segnette as discussed above, the hydrologic conditions from the intensive survey were considered to be acceptable for critical conditions for this DO TMDL.

Using the intensive survey conditions to represent critical hydrologic conditions was also supported by the fact that the morning DO values from the continuous monitoring at station BS-1 during May 21-22 (about 2 mg/L) were similar to the lowest DO values that have been observed historically at LDEQ station 0296 (1-2 mg/L).

The modeling incorporates various conservative assumptions that establish an implicit MOS. Additionally, an explicit MOS of 20% was used for all man-made loads to account for future growth, safety, model uncertainty, and data inadequacies.

5.2 Input Data Documentation

The values and sources of the input data used for the summer projection, summer no-load, winter projection, and winter no-load scenarios are shown in Appendix M. Except as mentioned below, the projection inputs were unchanged from the calibration.

5.2.1 Program Constants, Data Type 3

For the projections, the minimum surface transfer coefficient for reaeration (K_L) was calculated based on long term average wind speeds rather than the wind speed during the intensive survey. Long term average wind speeds for each month of the year for New Orleans were examined and the lowest values within each season (summer and winter) were used to calculate the minimum K_L values. These calculations are shown in Appendix N.

5.2.2 Initial Conditions, Data Type 11

The initial temperatures were set to the 90th percentile temperature for each season in accordance with the LTP. The initial DO and salinity values were unchanged from the calibration.

5.2.3 SOD and Nonpoint Sources, Data Types 12 and 19

The nonpoint source values were calculated for each projection scenario using a load equivalent spreadsheet. An analysis was made of the calibration nonpoint source and SOD loads in terms of total loading in units of gO_2/m^2/day and compared to the reference stream loads in the same terms (which accounted for the width differences between the reference and the modeled streams). Calibration values were used where they were smaller than reference stream values. The same spreadsheet also calculated load reductions for the tributary inflows.

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 runoff loads which are flushed into the stream during runoff events, and subsequently settle to the bottom in the slow moving streams. These benthic loads decay and breakdown during the year, becoming easily resuspended into the water column during the high temperature season. This season has historically been identified as the critical dissolved oxygen season.

LDEQ simulates part of the nonpoint source oxygen demand loading as resuspended benthic load and SOD. The calibrated nonpoint loads (CBODu, NBODu, 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. Recently the suppressant started failing around day seven and the manufacturer of the suppressant will only guarantee its potency for a five day period. LDEQ felt a five day test would not adequately depict the water quality of streams and began a search for a new test method. The research found a new proposed method for testing long term BODs in Standard Methods.

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 readings 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 method. However, the sum of CBOD and NBOD should be about the same for both new and old test methods. For this reason, background values in this model are based on the sum of reference stream benthic loads.

LDEQ's reference stream data were examined to identify reference streams that might be applicable for estimating background loads for Bayou Segnette. Although none of the reference streams is located in or near the Barataria basin, four reference streams were identified as having some characteristics (i.e., sediment type and velocity) similar to Bayou Segnette. The nonpoint source loads estimated by LDEQ for these four reference streams are shown in Table 5.1 below. All of the reference streams were shallower than Bayou Segnette, but the four shown in Table 5.1 are the deepest LDEQ reference streams. Based on previous experience with DO TMDLs in Louisiana, the total nonpoint source loads for Saline Bayou and Beaucoup Bayou (3.9 to 4.0 g/m^2/day) seemed unreasonably high as estimates of background loading for Bayou Segnette. Therefore, the background load for Bayou Segnette was set to 2.0 g/m^2/day based on the estimated loads for Big Roaring Bayou and Indian Bayou.

Table 5.1. Data from selected LDEQ reference streams (Smythe 1999).

	Big Roaring Bayou	Indian Bayou	Beaucoup Bayou	Saline Bayou Site 2-3
Sediment type	silt	silt	silt	silt
Velocity during survey (m/sec)	0.00	0.00	0.00	0.23
Depth during survey (m)	1.08	0.64	0.67	0.93
NPS CBODu load (g/m^2/day)	0.688	0.218	0.169	0.531
NPS NBODu load (g/m^2/day)	0.095	0.090	0.498	1.637
SOD at 20°C (g/m^2/day)	1.45	1.52	4.20	2.25
Temperature during survey (°C)	20.15	20.82	16.45	16.11
SOD at stream temp. (g/m^2/day)	1.46	1.60	3.36	1.76
Total NPS load (g/m^2/day)	2.24	1.91	4.03	3.93
CBODu concentration (mg/L)	3.48	2.94	2.72	1.60
NBODu concentration (mg/L)	5.41	7.26	5.80	3.70

Background concentrations of CBODu and NBODu for the tributaries (including the inflow from the Westwego 2 pump station, Lake Salvador inflow, etc.) were also estimated based on LDEQ's reference stream data. Concentrations of CBODu and NBODu in these four reference streams are shown in Table 5.1. The concentrations for Saline Bayou appeared to be inconsistent with the values for the other three streams. Therefore, the background concentrations for tributary inflows to Bayou Segnette were based on values for Big Roaring Bayou, Indian Bayou, and Beaucoup Bayou. Based on data for these three streams, a concentration of 9 mg/L of total BODu (i.e., sum of CBODu and NBODu) was selected as the background value. However, the LDEQ TMDL spreadsheet requires individual concentrations of CBODu and NBODu. Therefore, the background concentration of total BODu was divided between CBODu and NBODu based on the ratio of CBODu to NBODu for each inflow in the calibration.

For the Bayou Segnette projections, it was assumed that reductions of CBODu and NBODu in tributary inflows would also result in improvements in the DO concentrations of the tributary inflows. Therefore, the DO concentrations for tributary inflows were set assuming that measured values from the survey (adjusted to daily averages) represented no reduction of nonpoint sources, 90% saturation represented complete reduction of man-made nonpoint sources, and 100% saturation represented complete reduction of man-made and natural nonpoint sources.

5.2.4 Wasteloads, Data Types 24, 25, and 26

As discussed in Section 5.1, the tributary flow rates for the projections were the same as in the calibration. Tributary concentrations of CBODu, NBODu, and DO were set based on background concentrations and percent reduction calculations in the spreadsheets as discussed in Section 5.2.3.

5.2.5 Lower Boundary Conditions, Data Type 27

For the projections, the temperature for the lower boundary was set to the 90th percentile temperature and the DO was set to 90% saturation (slightly lower than in the calibration). Values for other parameters were unchanged from the calibration.

5.3 Model Discussion and Results

5.3.1 No-Load Scenarios

The summer and winter no-load scenarios were run to predict DO concentrations with no man-made sources under critical conditions. Printouts of the spreadsheets with nonpoint source load calculations for these scenarios are presented in Appendix O. Graphs of the predicted DO and printouts of the tabular output are presented in Appendix P.

The minimum predicted DO values from the no-load scenarios were 4.0 mg/L for summer and 6.6 mg/L for winter. In other words, these simulations showed that complete elimination of man-made sources would result in DO values below the current standard during summer and above the standard during winter. Based on these results, the current DO standard should be reevaluated for summer.

5.3.2 Summer and Winter Projections

The summer and winter projection simulations were run to determine the allowable loadings and percent reductions for Bayou Segnette that would result in the existing DO standard being maintained. Printouts of the spreadsheets with nonpoint source load calculations for these scenarios are presented in Appendix Q. Graphs of the predicted DO and printouts of the tabular output for these scenarios are presented in Appendix R. Graphs of predicted DO are also shown in Figures 5.1 and 5.2.

As shown in Table 5.2, the load reductions that were required for the model to show the DO standard being met included both a complete elimination of man-made nonpoint sources plus

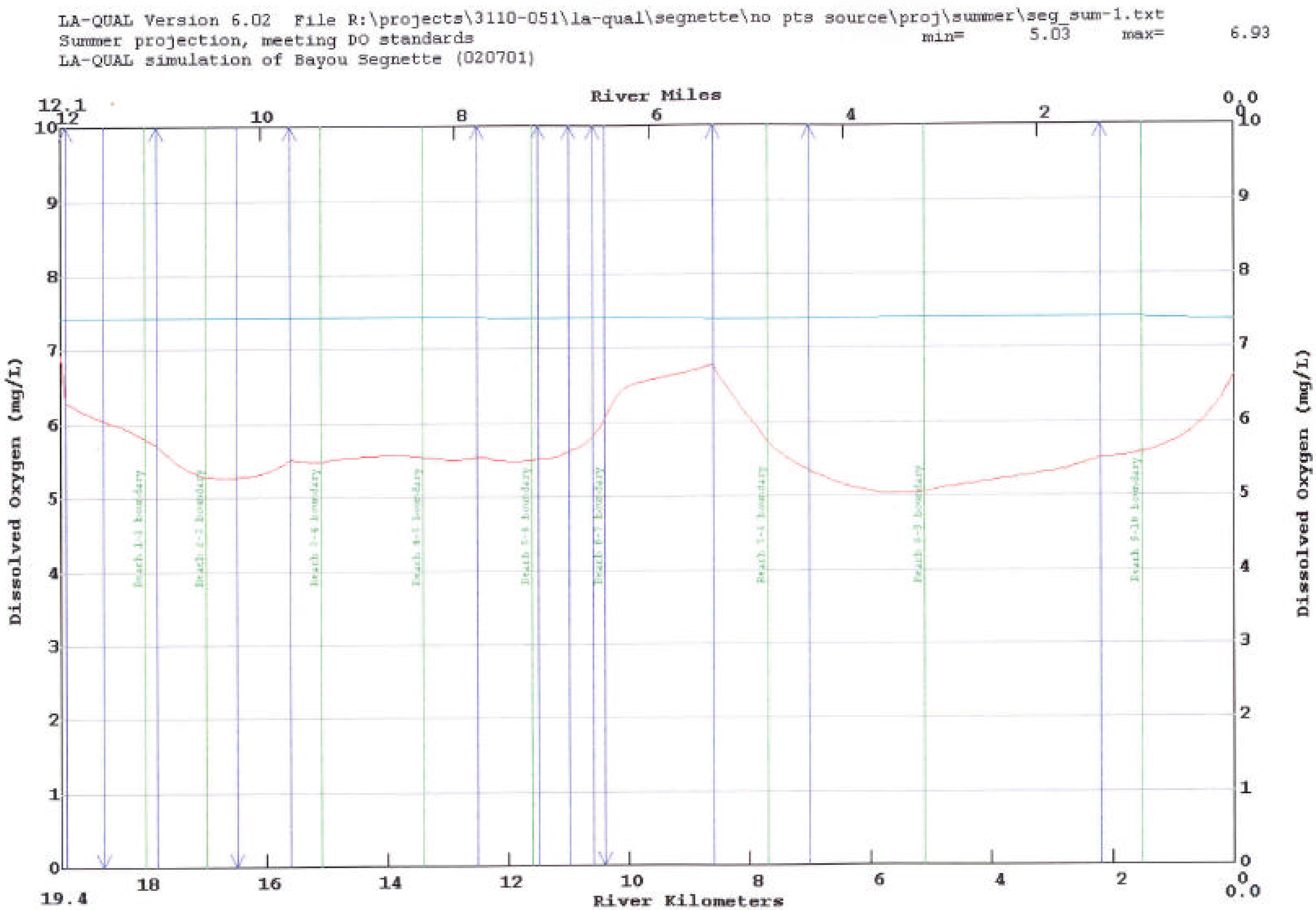

Figure 5.1. Predicted DO for Bayou Segnette summer projection.

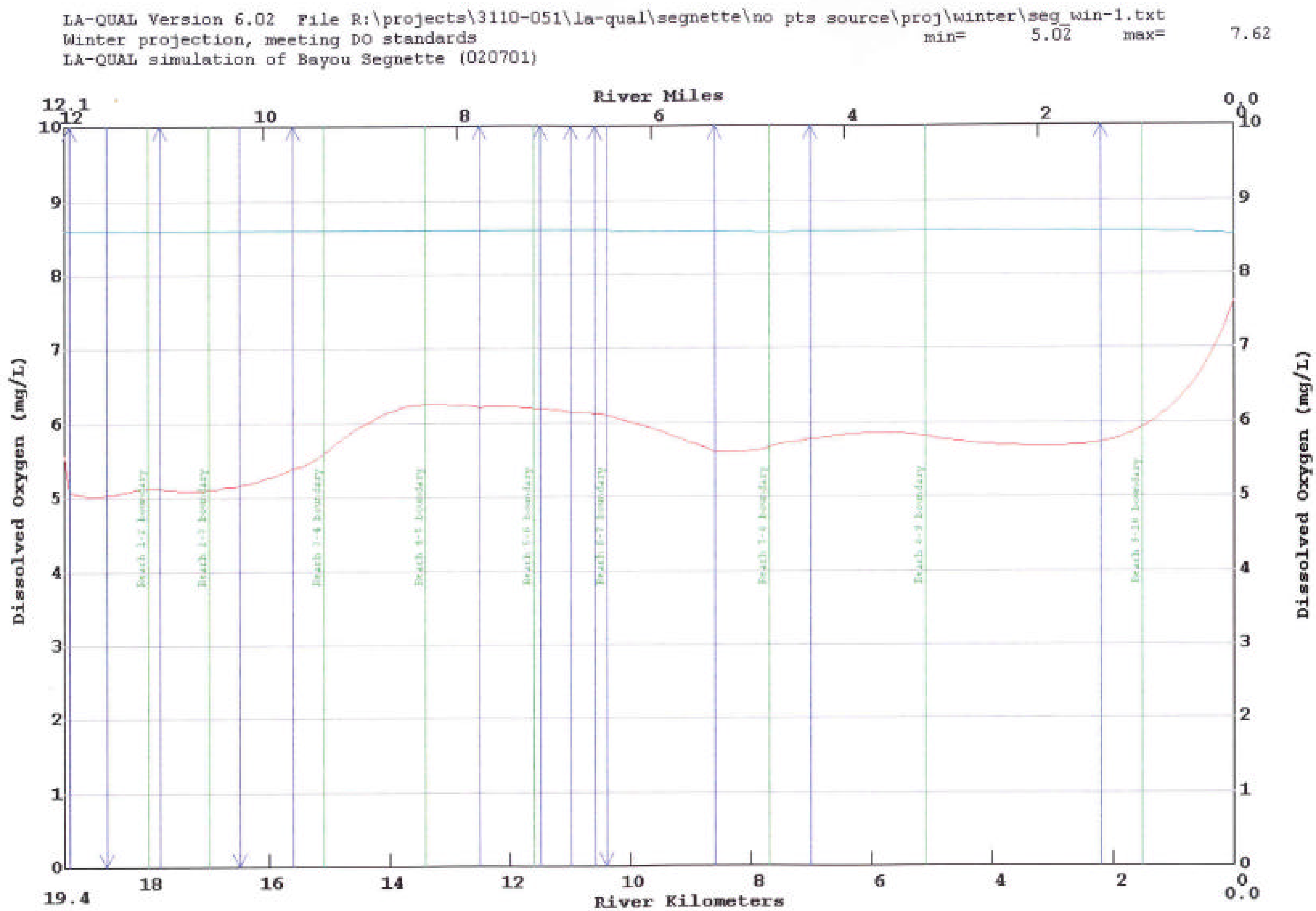

Figure 5.2. Predicted DO for Bayou Segnette winter projection.

some reduction of background nonpoint sources during summer. For each scenario, a uniform percent reduction was applied to all reaches in the model.

Table 5.2. Summary of nonpoint source load reductions required to meet the DO standard.

	Man-made nonpoint sources	Background nonpoint sources
Summer (May – October)	100%	34%
Winter (November – April)	71%	0%

5.4 Calculated TMDL, WLAs, and LAs

5.4.1 Outline of TMDL Calculations

An outline of the TMDL calculations is provided below to assist in understanding the TMDL calculations, which are shown in Appendix Q. Slight variances may occur based on individual cases. All of the TMDL calculations were done using the LDEQ TMDL spreadsheet.

A) The natural background benthic loading was estimated from reference stream resuspension (nonpoint CBOD and NBODu) and SOD load data.

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

- Calibration resuspension and SOD loads were summed for each reach as g/m^2/day of oxygen demand 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.

C) Projection benthic loads are determined by trial and error during the modeling process using a uniform percent reduction for resuspension and SOD. Point source design flows are increased to obtain an explicit MOS of 20%. Headwater and tributary concentrations of CBODu, NBODu, and DO range from reference stream levels to calibration levels based on the percent reductions. 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^{o}C is calculated as the sum of the projection resuspension and SOD components expressed as g/m^2/day of oxygen demand.
- 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 nonpoint load and the man-made nonpoint load found during calibration.
- The projection loads are also computed in units of lbs/day and kg/day for each reach

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

- Headwater and tributary CBODu and NBODu loading in lbs/day and kg/day.

- 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 lbs/day and kg/day.

- Point source CBODu and NBODu loading in lbs/day and kg/day.

- The margin of safety in lbs/day and kg/day.

5.4.2 Results of TMDL Calculations

The TMDL for the biochemical oxygen demanding constituents (CBODu, NBODu, and SOD) was calculated for the summer and winter critical seasons. Printouts of the TMDL spreadsheets are presented in Appendix Q. A summary of the loads is presented in Table 5.3.

The nonconservative behavior of dissolved oxygen allows many small or remote point source dischargers to be assimilated by their receiving waterbodies before they reach the modeled waterbody. These dischargers are said to have very little to no impact on the modeled waterbody and therefore, they are not included in the model and are not subject to any reductions based on this TMDL. These facilities are permitted in accordance with state regulation and policies that provide adequate protective controls. New similarly insignificant point sources will continue to be issued permits in this manner. Significant existing point source dischargers are either included in the model or are determined to be insignificant by other modeling. New significant point source dischargers would have to be evaluated individually to determine what impact they have on the impaired waterbody and the appropriate controls.

The point source wasteload allocation (WLA) includes loads from all permitted point sources within the subsegment that are known to discharge oxygen demanding effluent. For this subsegment, no point sources were included in the model because they were small and far away from the modeled waterbody. Their loads were accounted for in the model by calibration as part of the boundary conditions or nonpoint source loading.

The LDEQ TMDL spreadsheet applies a user-specified explicit MOS to the point source loads and to the man-made nonpoint source loads (i.e., all man-made sources). The explicit MOS that was specified in the spreadsheet was 20%. This TMDL required a complete elimination of the man-made nonpoint source loads, thereby eliminating the need for an explicit MOS for that portion of the load.

It should be noted that the 20% explicit MOS used for the point sources accounts for future growth as well as uncertainties associated with the modeling process. The TMDL also includes an implicit MOS created by conservative assumptions in the modeling (see Section 5.1).

Table 5.3. TMDL for subsegment 020701 (sum of CBODu, NBODu, and SOD).

	Load (kg/day) for:	
	Summer (May-Oct)	**Winter (Nov-Apr)**
Point Source WLA	1	1
Point Source Reserve MOS	0	0
Natural Nonpoint Source LA	9589	12075
Man-made Nonpoint Source LA	0	3091
Man-made Nonpoint Source MOS	0	773
TMDL	9590	15940

6. 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 LA-QUAL 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 value. Thus the sensitivity of each parameter is reviewed separately. A sensitivity analysis was performed on the calibration scenario. Parameters were varied by +/- 30%, except temperature, which was adjusted +/- 2 degrees Centigrade. The results of the sensitivity analysis are summarized in Table 6.1.

The model was most sensitive to stream reaeration, stream depth, wasteload NBODu, and NBODu decay rate. Because the minimum DO occurred at the upstream end of the model, the model output was least sensitive to dispersion and to SOD (which was very low at the upstream end of the model).

Table 6.1. Summary of calibration model sensitivity analysis.

Parameter	Negative Parameter Changes			Positive Parameter Changes		
	Parameter Change	**Minimum DO (mg/L)**	**Percentage Difference in DO**	**Parameter Change**	**Minimum DO (mg/L)**	**Percentage Difference in DO**
Stream reaeration	+30	1.08	21%	-30	0.69	-22%
Stream depth	+30	0.75	-16%	-30	1.09	22%
Wasteload NBODu	+30	0.75	-16%	-30	1.09	22%
NBODu Decay	+30	0.76	-15%	-30	1.07	20%
Stream temperature	+30	0.81	-9%	-30	0.97	9%
Wasteload DO	+30	0.94	6%	-30	0.83	-7%
Wasteload CBODU	+30	0.85	-4%	-30	0.92	3%
CBODU decay rate	+30	0.85	-4%	-30	0.92	3%
Stream velocity	+30	0.86	-3%	-30	0.93	4%
Wasteload Flow	+30	0.86	-3%	-30	0.93	4%
Benthal demand (SOD)	+30	0.88	-1%	-30	0.89	0%
Dispersion	+30	0.89	0%	-30	0.89	0%

7. Conclusions

The percent reductions of man-made nonpoint sources that are required by this TMDL are 100% for summer and 71% for winter. Additionally, background loads would need to be reduced by 34% in the summer to maintain a minimum DO of 5.0 mg/L under critical conditions.

This subsegment was listed as impaired due to nutrients as well as organic enrichment / low DO. This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as stated in the declaratory ruling issued by Dale Givens 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.

This TMDL has been developed 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 nonpoint source 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 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 has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a four year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the four-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 305(b) and 303(d) listing purposes for each biennial cycle with sampling occurring statewide each year. The four-year cycle follows an initial five-year rotation which covered all basins in the state according to the TMDL priorities. 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.

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