BAYOU NEZPIQUE WATERSHED TMDL
FOR DISSOLVED OXYGEN
INCLUDING WLAS FOR NINE TREATMENT FACILITIES

SUBSEGMENTS 050301, 050302, 050303, AND 050304

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EXECUTIVE SUMMARY

This report presents the results of a watershed based, calibrated modeling analysis of Bayou Nezpique. The modeling was conducted to establish a dissolved oxygen TMDL for the Bayou Nezpique watershed. The model extends from the headwaters near Oakdale, LA to the confluence of Bayou Nezpique with the Mermentau River near Jennings, La. Bayou Nezpique is located in south central Louisiana and its watershed includes the following tributaries: Beaver Creek, Boggy Bayou, East and West Forks of Bayou Nezpique, Manwell Gully, Grand Louis Bayou, Castor Creek, Bayou Blue, Roger's Gully, Bayou Duralde, Jennings STP Canal, and several unnamed tributaries. The watershed is 611.2 square miles in area. Bayou Nezpique is in the Mermentau River Basin and includes Water Quality Subsegments 050301, 050302, 050303, and 050304. The area is sparsely populated outside its small municipalities, and land use is dominated by silviculture and agriculture in the upper half of the watershed and agriculture in the lower half. A total of nine sewage treatment facilities were included in the modeling effort.

Input data for the calibration model was developed from the LDEQ Reference Stream Study; data collected during the 1985 intensive survey; data collected by LDEQ and USGS at several ambient monitoring stations in the watershed; DMRs, permits and permit applications for each of the point source dischargers; USGS drainage area and low flow publications; previous modeling studies conducted by LDEQ in the area; and data garnered from several previous LDEQ studies on non-point source loadings. A satisfactory calibration was achieved for the main stem and most of the tributaries modeled. In those cases where the calibration was not as accurate (primarily due to extremely limited data), the difference was in the conservative direction. For the projection models, data was taken from the current municipal discharge permits, current applications, and ambient temperature records. The Louisiana Total Maximum Daily Load Technical Procedures, 1999, have been followed in this study.

Modeling was limited to low flow scenarios for both the calibration and the projections since the constituent of concern was dissolved oxygen and the available data was limited to low flow conditions. The model used was QUAL-TX, a modified version of QUAL-II. QUAL-TX was selected since it offers the ability to model branched systems and has been used successfully in Louisiana in the past.

Bayou Nezpique, Subsegment 050301, was on the 1996 and 1998 303(d) list of impaired water bodies requiring the development of TMDLs. The subsegment was ranked priority one on both the 1996 and the 1998 lists. The suspected causes of impairment for the 1996 list were organic enrichment/ low DO, pathogen indicators, suspended solids and turbidity. The suspected causes of impairment for the 1998 list were organic enrichment/ low DO, pathogen indicators, copper and lead. This TMDL addresses the organic enrichment/low DO impairment. The remaining subsegments in the watershed were not on the 303(d) list, but were either modeled or addressed as point sources in the model since they contribute flow individually to the listed subsegment as shown on the Subsegment Map in Appendix H.

The results of the summer projection model show that the water quality standard for dissolved oxygen for Bayou Nezpique (WQ Subsegment 050301) of 3.0 mg/l can be maintained during the summer critical season. The water quality standard for dissolved oxygen for Beaver Creek (WQ Subsegment 050302) of 2.0 mg/l can also be maintained during the summer critical season. The Bayou Blue (WQ Subsegment 050304) system currently has a dissolved oxygen criterion of 5.0 mg/l which can not be maintained. The Castor Creek (WQ Subsegment 050303) system currently has a dissolved oxygen criterion of 5.0 mg/l which is also unlikely to be maintained based on the results of the No Load Scenario. The Bayou Blue and Castor Creek systems have been reevaluated and more appropriate DO criteria recommended. The results of the summer projection model show that a DO of 3 mg/l DO can be maintained in all four subsegments with the imposition of an 85% reduction from all manmade nonpoint sources and the imposition of 5 mg/l $CBOD_5$/2 mg/l NH_3/6 mg/l DO limits on Oberlin STP, Elton STP, Basile STP, and Jennings STP; 5 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits on Reddell STP; 10 mg/l $CBOD_5$/2 mg/l NH_3/5 mg/l DO limits for Mamou STP; 10 mg/l $CBOD_5$/10 mg/l NH_3/6 mg/l DO limits for Oakdale STP and Pine Prairie STP; and, 10 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits for Evangeline Sewer Co.'s North Mamou Subdivision WWTP. The minimum DO on the main stem is 2.92 mg/l at RK 58.152. This is well within the 10% guidance for achieving standards and reflects the conservative nature of the modeling assumptions.

The results of the winter projection model show that the water quality criteria for dissolved oxygen for Bayou Nezpique and Bayou Blue of 5.0 mg/l and for Beaver Creek of 3.0 mg/l can be maintained during the winter critical season in the entire watershed. It is also anticipated that a 5.0 mg/l DO criterion can be maintained in Castor Creek. The minimum dissolved oxygen is 4.98 mg/l and is located in the Basile POTW Tributary. This is acceptable. To achieve the criteria, the model assumed the imposition of a 90% reduction from all manmade nonpoint sources and the imposition of 10 mg/l $CBOD_5$/10 mg/l NH_3/5 mg/l DO limits on Oakdale STP, Pine Prairie STP, Oberlin STP, and Elton STP; 10 mg/l $CBOD_5$/7.5 mg/l NH_3/5 mg/l DO limits on Basile STP; 5 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits on Jennings STP; 10 mg/l $CBOD_5$/5 mg/l NH_3/5 mg/l DO limits on Reddell STP; 10 mg/l $CBOD_5$/2 mg/l NH_3/5 mg/l DO limits for Mamou STP; and, 20 mg/l $CBOD_5$/10 mg/l NH_3/5 mg/l DO limits for Evangeline Sewer Co.'s North Mamou Subdivision WWTP. The minimum DO on the main stem is **5.44** mg/l at RK 53.904.

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 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 five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-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. The sampling schedule for the first five-year cycle is shown below.

1998 - Mermentau and Vermilion-Teche River Basins
1999 - Calcasieu and Ouachita River Basins
2000 - Barataria and Terrebonne Basins
2001 - Lake Pontchartrain Basin and Pearl River Basin
2002 - Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)
Mermentau and Vermilion-Teche Basins will be sampled again in 2003.

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1. Introduction

The 1996 and 1998 303(d) lists cited Bayou Nezpique, Subsegment 050301, as being impaired due to organic enrichment/low DO and required the development of a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO). The subsegment was ranked priority one on both the 1996 and the 1998 lists. A calibrated water quality model for the entire watershed was developed and projections were modeled to quantify the point source and non-point source waste load reductions which would be necessary in order for Bayou Nezpique to comply with its established water quality standards and criteria. This report presents the results of that analysis.

2. Study Area Description

2.1 General Information

Water quality segment 0503 is part of the Mermentau River Basin. The Basin encompasses the prairie region of the state and a section of the coastal zone. The drainage area for the Basin, excluding the gulf water segment, is 3,710 square miles. The segment is located in south central Louisiana in the parishes of Evangeline, Acadia, Allen, and Jefferson Davis and has a drainage area of 611.2 square miles. The segment is long and narrow and spans the land uses characteristic of the entire basin. The northern part of the segment is a flatwoods area. The midsection is prairie, characterized by large expanses of flat grassland and scattered areas of oak trees and other mixed hardwoods, and the southern part is marshland. The flatwoods and the prairie are generally considered upland areas while the marshland is considered a coastal area. The slope of the land is generally north to south. Because of its relatively low relief, especially in the prairie and marsh areas, the region is characterized by poor drainage and annual backwater flooding of agricultural lands. The land use in the watershed is vividly depicted on the SPOT-TM map in Appendix H and summarized in Table 1.

Table 1. Land Uses in Segment 0503

LAND USE TYPE	NUMBER OF ACRES	% OF TOTAL AREA
Urban	9,979	1.63
Extractive	123	0.02
Agricultural	318,357	52.07
Forest Land	169,531	27.73
Water	3,312	0.54
Wetland	106,581	17.43
Barren Land	3,282	0.54
Other	224	0.04
TOTAL AREA	611,389	100

The model extends from the headwaters near Oakdale and Pine Prairie to the confluence of Bayou Nezpique with the Mermentau River near Jennings, La. The Bayou Nezpique watershed includes the following tributaries: Beaver Creek, Boggy Bayou, East and West Forks of Bayou Nezpique, Manwell Gully, Grand Louis Bayou, Castor Creek, Bayou Blue, Roger’s Gully, Bayou Duralde, Jennings STP canal and several unnamed tributaries. The watershed includes Water Quality Subsegments 050301, 050302, 050303, and 050304. The area is sparsely populated outside its small municipalities and land use is dominated by silviculture and agriculture in the upper half of the watershed and by agriculture in the lower half. A total of nine sewage treatment facilities were included in the modeling effort. Maps of the study area are presented in Appendix H.

2.2 Water Quality Standards

The Water Quality criteria and designated uses for subsegments in the Bayou Nezpique watershed are shown in Table 2.

Table 2. Water Quality Numerical Criteria and Designated Uses

Subsegment	050301	050302	050303	050304
Stream Description	Bayou Nezpique – Headwaters to Mermentau R.	Beaver Creek - Headwaters to Boggy Creek	Castor Creek - Headwaters to B. Nezpique	Bayou Blue - Headwaters to B. Nezpique
Designated Uses	A B C F	B C: NOV – APR NONE: MAY-OCT	A B C	A B C
Criteria:				
Cl	90	90	90	90
SO_4	30	30	30	30
DO	5 : DEC-FEB 3 : MAR-NOV	5 : NOV – APR 2 : MAY-OCT	5	5
pH	6.0 – 8.5	6.0 – 8.5	6.0 – 8.5	6.0 – 8.5
BAC	1	2	1	1
EC	32	32	32	32
TDS	260	260	260	260

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.

A Use Attainability Analysis (UAA) was recently completed for Mermentau River Basin supporting revision of the dissolved oxygen criterion of 5 mg/L to seasonal criteria of 5 mg/L December through February and 3 mg/L March through November. The seasonal criteria have been promulgated and apply to Bayou Nezpique and its tributaries. However, Castor Creek and Bayou Blue were not included in the UAA. An addendum to the Mermentau River Basin UAA has been prepared to support revision of the dissolved oxygen criterion for Bayou Blue and Castor Creek and two other bayous. The same seasonal criteria of 5 mg/L (winter) and 3 mg/L (summer) have been proposed for these bayous.

2.3 Wastewater Discharges

The discharger inventory for the Bayou Nezpique watershed was reviewed. There are only 25 dischargers listed in the LDEQ Permit Tracking System and the Discharger Inventory combined. Of these 25, eleven facilities were either no longer discharging to the watershed or did not discharge oxygen demanding pollutants. The remaining facilities were evaluated based on the volume of their discharge, their location with respect to the listed waterbody, any water quality data which demonstrated their impact or lack of impact, whether or not the NPS contribution included any small facilities, and best professional judgement. Only 9 facilities were considered to have any ability to impact the target reaches: the cities of Oakdale, Pine Prairie, Reddell, Mamou, Oberlin, Elton, Basile, and Jennings and the North Mamou subdivision (operated by the Evangeline Sewer Co.). The list of facilities and the modeling decision for each is shown in Appendix C4. The permits record, permits applications, and Discharger Monitoring Reports (DMR) for these facilities were examined and appropriate input information for the calibration and projection modeling runs was derived to the maximum extent possible. The input data development for the calibration model is presented in Appendix C.

2.4 Water Quality Conditions/Assessment

Subsegment 050301, Bayou Nezpique from the headwaters to the Mermentau River, is partially supporting its designated uses according to the 1998 305(b) Water Quality assessment for Louisiana. Suspected pollutants are Organic Enrichment/Low DO, Copper, Lead, and Pathogens from minor point sources, irrigated and nonirrigated crop production, forest management, and natural sources. The subsegment is on the 1998 303(d) list and is scheduled for current TMDL development. An excerpt from the 1998 303(d) list is presented in Appendix G. The subsegment was also on the 1996 303(d) list for organic enrichment/low DO, pathogen indicators, suspended solids, and turbidity.

2.5 Prior Studies

Several prior studies have been performed on portions of the Bayou Nezpique watershed. Bayou Nezpique from the headwaters to the Mermentau River was the subject of an intensive survey in 1985. The lower reach of Bayou Nezpique, the upper Mermentau River and the Jennings STP Canal were the subject of an intensive survey in 1982 and a reconnaissance survey in 1990. Modeling studies performed on these waterbodies resulted in recommendations for standards reevaluation and phased approach TMDLs. Bayou Grand Louis has also been the subject of an intensive survey and an Advanced Treatment Review modeling study. A standards reevaluation for Bayou Grand Louis was also recommended. Use Attainability Analyses have been conducted in the watershed and revised standards have been issued as shown in Table 2.

3. Documentation of Calibration Model

3.1 Model Description and Input Data Documentation

3.1.1 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 nearshore 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 QUAL-TX, "a steady-state one-dimensional water quality model that has been developed by the Water Quality Standards and Evaluation Section of the Texas Water Commission. It is a modified version of QUAL-II. The original QUAL-II model was developed by Water Resources Engineers (now Camp Dresser & McKee) for the United States Environmental Protection Agency. Since that time, many modifications have been made to QUAL-II by many people. QUAL-TX is a user oriented model incorporating many of those modifications and is intended to provide the basis for evaluating waste load allocations in the State of Texas." (QUAL-TX User's Manual, rev. 1990). QUAL-TX was selected since it offers the ability to model branched systems and it has been used successfully in Louisiana in the past.

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 judgement 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 NPS pollution is estimated from the difference between the calibration loads and the loads observed on reference or least impacted streams.

The model was hydrologically calibrated to the 1985 survey measurements of flow and chlorides. Water quality parameters and coefficients were then established based on available data and best professional judgement. The calibration model output was then compared to the 1985 survey measurements of water quality and the calibration was determined to be successful.

3.1.2 Model Schematic or Vector Diagram

A vector diagram of the modeled area is presented in Appendix H. The vector diagram shows the locations of survey stations, the reach/element design, the locations of modeled tributaries and POTWs, and the locations of tributaries contributing flow but not modeled. A digitized map of the streams showing river miles and survey sampling sites is also included in Appendix H and has been marked to depict the drainage areas associated with each reach and headwater.

3.1.3 Hydrology and Stream Geometry and Sources

The USGS maintains a daily flow gauging station on the Mermentau River near the village of Mermentau. The USGS maintained a daily flow gauging station on Bayou Nezpique near Basile through September 30, 1997. LDEQ has a monthly water quality sampling station at the Mermentau River at Mermentau station. LDEQ conducted bimonthly sampling at the Bayou Nezpique at Basile gauging station through March, 1998 , and at Bayou Nezpique near Jennings through May, 1998. Beginning in July, 1998, the LDEQ began a new ambient monitoring strategy which focuses on each Basin intensely for a limited period of time over a five year cycle. During 1998, six sites were monitored in the Bayou Nezpique watershed twice a month. These sites were at Bayou Nezpique near Jennings, Bayou Nezpique near Basile, Castor Creek east of Oberlin, Bayou Nezpique east of Jennings, Beaver Creek and Bayou Blue. The data, which was collected through September, 1998, is presented in Appendix G. LDEQ continues to perform monthly sampling at the Mermentau River near Mermentau station as part of a statewide trend program. Data from these stations was used to determine critical temperatures for each season and to evaluate critical flows.

Data collected during an intensive survey conducted from September 23 – 24, 1985, was used to establish the input for the model calibration and is presented in Appendix F. Using the survey stations where discharge measurements were made and the digitized mapping as guides, the reaches and elements were established. The survey had been performed in terms of river miles so a conversion was made to river kilometers. The reach and element design for Bayou Nezpique was made within the limitations of the model to avoid having to link multiple models. “The current version is dimensioned for a maximum of 130 reaches, 60 headwaters, 230 waste loads and 460 elements."(Qual-Tx User's Manual) The limiting factor for the Bayou Nezpique model was the number of elements. During the calibration process, several adjustments were made in order to better delineate the dissolved oxygen sag points and to accommodate changing conditions within long reaches. The resulting design incorporated 20 reaches, 9 headwaters, 15 wasteloads, and 459 elements. A simple spreadsheet was used to calculate the reach length, element length and cumulative number of elements at the bottom of each reach. The locations of each survey station, treatment plant and unmodeled tributary were fed into a related spread sheet and the element number for each of these locations was determined. These spreadsheets are presented in Appendix C1.

Table 3. Treatment Plant Flow Information

Treatment Plant	1998 Expected Flow, cfs	1998 Design Flow, cfs	1985 Design Flow, cfs	1998 Jul–Sept Average Flow, cfs	1988 Aug–Oct Average Flow, cfs
Oakdale		2.26	2.26	2.21	
Pine Prairie		0.178	0.115		
Reddell	0.105				
Evangeline Sew. Co.		0.056			
Mamou			0.930	1.32	
Oberlin		0.294	0.093	0.248	
Elton	0.201	0.299	0.299	0.110	
Basile	0.546		0.775	0.223	
Jennings		3.87	3.87	2.0	1.317

Table 4. Treatment Plant Flows for Calibration

Treatment Plant	Calibration Flow, cfs	Calibration Flow, cms	Source
Oakdale	0.35	0.011	Appendix C2, Flow Calculation Sheet #01, Item IV.
Pine Prairie	0.058	0.002	50% of 1985 Design
Reddell	0.053	0.002	50% of 1998 Expected
Evangeline Sew. Co.	0.028	0.001	50% of 1998 Design
Mamou	0.93	0.026	1985 Design
Oberlin	0.248	0.007	1998 Jul-Sept Avg
Elton	0.166	0.0047	Appendix C2, Flow Calculation Sheet #03, Item I.
Basile	0.223	0.006	1998 Jul-Sept Avg
Jennings	1.317	0.037	1988 Aug-Oct Avg

The flow in each reach, headwater, and unmodeled tributary was determined based on the survey discharge measurements, the drainage area associated with each flow, and a determination of appropriate incremental nonpoint source flowrate in terms of cms/mile. Best professional judgement was used to determine where similar streams concepts could be used. Treatment plant flows were determined based on available data from permits, applications, and DMRs. Where this type of data was lacking or inconsistent, determinations were made based on best professional judgement from available information. Flow determinations are presented in Appendix C2. The vector diagram and the digitized map showing the individual drainage areas are presented in Appendix H. Tables 3 and 4 summarize the POTW flow information and model input.

Rather than directly inputting the widths and depths of the stream, the model requires that the advective hydraulic characteristics (Leopold Coefficients and Exponents) be entered. Because of the limited amount of data, the default values for the velocity exponent (b) and the depth coefficient (d) established by Texas were used (Texas Waste Load Evaluation Methodology). The determinations of the remaining coefficients and exponents from the discharge measurements made during the survey are shown in Appendix C3.

Since the lower reaches are tidal in nature with frequent flow reverses and are very deep, wide and sluggish especially at low flow, the dispersive hydraulic coefficients were used for reaches 17 –20. The fraction of the boundary tide was decreased in the upstream direction and the exponents were assumed to be zero. The dispersion coefficient was then given values from zero to one. The use of this option was required to achieve calibration in the lower reaches.

3.1.4 Headwater and Waste Water Loads

Upstream water quality, except for dissolved oxygen, for unsampled headwaters was derived from the 1995 reference stream work performed by the LDEQ (see Smythe). Dissolved oxygen for the headwaters was determined from the average of the 4 samples taken on the East and West Forks and Castor Creek. These three streams are relatively unimpacted streams for this area. Treatment plant wasteloads were derived from permit information, permit applications, and DMRs. Some of this data was obtained directly from the LDEQ Permit Tracking System (PTS) database and the LDEQ Discharger Inventory database. Summaries and copies of selected data are presented in Appendix C4. Additional supporting documents are presented in Appendix C5.

3.1.5 Water Quality Input Data and Their Sources.

Water quality data collected on September 23-24, 1985, on Bayou Nezpique was entered in a spreadsheet for ease of analysis. The Louisiana GSBOD program was applied to the BOD data in the spreadsheet and values were computed for each sample taken of ultimate CBOD, CBOD decay rate, CBOD Lag, ultimate NBOD, NBOD decay rate, NBOD lag and ratios of ultimate to 5 day values of CBOD and NBOD. Since multiple samples were taken at each station, the average value of each parameter was computed for each station. A complete listing, as well as an abridged version of the list for convenience, are presented in Appendix F. This data was the primary source for the model input data for initial conditions; decay rates; incremental temperature, DO, and NBOD; headwater temperature and DO; and, wasteload data. Three other sources of data also figured prominently in developing the input data set: reference stream data, previous models of Bayou Nezpique, and previous determinations of nonpoint source loadings for nearby heavily impacted streams.

3.1.5.1 Temperature Correction of Kinetics, Data Type 4

The temperature correction factors specified in the LTP were entered in the model.

3.1.5.2 Initial Conditions, Data Type 11

The initial conditions are used to reduce the number of iterations required by the model. The values required for this model were temperature and DO by reach. The input values came from the survey station located closest to the reach or from an average of samples taken from adjacent streams considered similar. The input data and sources are shown in Appendix C5.

3.1.5.3 Reaeration Rates, Data Type 12

Initially in the calibration runs, the Louisiana Equation was used to determine a constant reaeration rate for those reaches with average depths less than 3.0 feet. This approach did not work well since several reaches are long and the depths vary significantly from the upper end to the bottom end. The use of a constant reach value gave stepped output and unrealistic results in long reaches. The model does not allow the input of a value for each element. In order to use the Louisiana Equation, the model would have to be revised and recompiled. The Texas Equation was therefore used in the model for streams with depths less than one meter. An analysis of the reaeration rates, presented in Appendix C6, showed that the minimum K_2 was actually used in lieu of the Texas Equation for several of these reaches. Owens & Gibbs and the minimum K_2 were used for the remaining reaches. The reaeration rate equations selected for each reach are shown in Appendix C5.

3.1.5.4 Sediment Oxygen Demand, Data Type 12

Values of SOD from the LTP were used in several preliminary calibration runs but those values had been established for wasteload allocation modeling of short stream reaches directly below treatment plant outfalls and were not suitable for a watershed level model. The SOD values were therefore achieved through calibration and are generally higher than those predicted by the LTP in the upper reaches and lower in the lower, deeper reaches. The SOD value for each reach is shown in Appendix C5. The conversion ratio of settled CBOD and settled NBOD to SOD was considered to be one for all reaches except reach 19, Jennings STP Canal where calibration could not be achieved with any conversion.

3.1.5.5 Carbonaceous BOD Decay and Settling Rates, Data Type 12

These rates are labeled Aerobic BOD Decay and BOD Settling in Qual-Tx. The decay rates used were based on the bottle rates from the survey or multiples of the bottle rates in general. The concept of similar streams was used to transfer rates between streams in the watershed. The initial settling rates were taken from the LTP and multiplied by the depths to obtain the velocity form of the settling rate required by the model. The settling rates finally used were the result of calibration. The decay and settling rates used for each reach are shown in Appendix C5.

3.1.5.6 Nitrogenous BOD Decay and Settling Rates, Data Type 15

These rates are labeled Nonconservative Material (NCM) Decay and Settling in Qual-Tx. The decision to use the nonconservative material option was based on the inadequacy of the data to model the complete nitrogen cycle. The data was originally gathered for a very different model and thus did not cover every required input parameter for a Qual-Tx model. The decay rates used were based on the bottle rates from the survey or multiples of the bottle rates in general. The concept of similar streams was used to transfer rates between streams in the watershed. A default value from the LTP was used for the Basile POTW tributary and the rates used in a previous modeling effort were the basis for those used in reaches 18 and 20. The settling rates were determined through calibration. The decay and settling rates used for each reach are shown in Appendix C5.

3.1.5.7 Incremental Conditions, Data Types 16, 17, and 18

The incremental conditions were used in the calibration to represent nonpoint source loads associated with flows. It is likely that there were overland discharges from agricultural and silvicultural areas as a result of a storm in the area just prior to the survey or that there was some input from groundwater as a result of the rain recharging the underlying water table. Since both of these sources would have been naturally filtered prior to entering the stream, reference stream data and some of the survey data from relatively unimpacted “upstream” sampling sites were used to develop the Temperature, DO, Chlorides, CBOD and NBOD. The data and its source for each reach and a summary of the reference stream findings are presented in Appendix C5.

3.1.5.8 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 as SOD, CBOD and NBOD loads. Over the years LDEQ has collected data on heavily impacted streams in Louisiana. These data were reviewed and summarized by Smythe and Waldon and have been used to develop part of the input data for Bayou Nezpique. A copy of the summary table is presented in Appendix G. LDEQ also determined these types of loadings as part of the 1995 Reference Stream work and these loads have also been used to determine some of the input data. It is important to note that the reference stream data available at this time is for non-flowing streams. The nonpoint source loading for a non-flowing stream is expected to be significantly greater than that for a flowing stream but this has not been verified to date. The Bayou Nezpique system is not a non-flowing stream, but neither is it a free-flowing stream. It was therefore decided to use the non-flowing reference stream data mean values for this model. In some cases a percentage of the reference stream loading has been adequate to achieve calibration. Some of the nonpoint source loads in kg/km/day which were based on reference stream data appear to be very small loads, but they do not address stream width. An analysis was made of the calibration NPS and SOD loads in terms of gm-O_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). The analysis is presented in Appendix C5. In general the total NPS load exceeds the reference stream load. 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. Only two streams do not show an exceedance of the reference stream loads, Bayou Grand Louis and Jennings STP Canal. It appears from the survey data, particularly the chloride samples, that these streams are primarily effluent conveyances and do not actually receive significant NPS contributions during low flow conditions. The data and sources are presented in Appendix C5. A description of the methodology used to evaluate the various NPS loads is in Appendix E8.

3.1.5.9 Headwaters, Data Types 20, 21, and 22

The reference stream data was assumed to be representative of the chlorides, UCBOD and UNBOD of the headwaters. Since the reference streams were studied at significantly lower temperatures than the Bayou Nezpique survey, the average values of temperature and DO for the 4 least impacted streams surveyed and sampled during the 1985 survey were used as headwater conditions. The data and sources are presented in Appendix C5.

3.1.5.10 Wasteloads, Data Types 24, 25, and 26

The wasteloads entered in the model were of two different types: treatment plant effluent and unmodeled tributaries. There are no known point source dischargers to the unmodeled tributaries. Several of the unmodeled tributaries were sampled during the survey and the results of these samples were the basis for the input data. Where the unmodeled tributary had not been sampled, then either reference stream, least impacted area streams, or similar streams concepts were used to develop the input data. The wasteloads from the treatment plants were determined from permits, applications and DMRs which have been included or summarized in Appendix C4. The temperature of treated effluent has been assumed to be 30º C. The data and sources are presented in Appendix C5.

3.1.5.11 Boundary Conditions, Data Type 27

The lower boundary conditions were assumed to be equivalent to the measurements taken at survey station 05-BN-16.

3.2 Model Discussion and Results

The calibration model input and output is presented in Appendix B. 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 1.

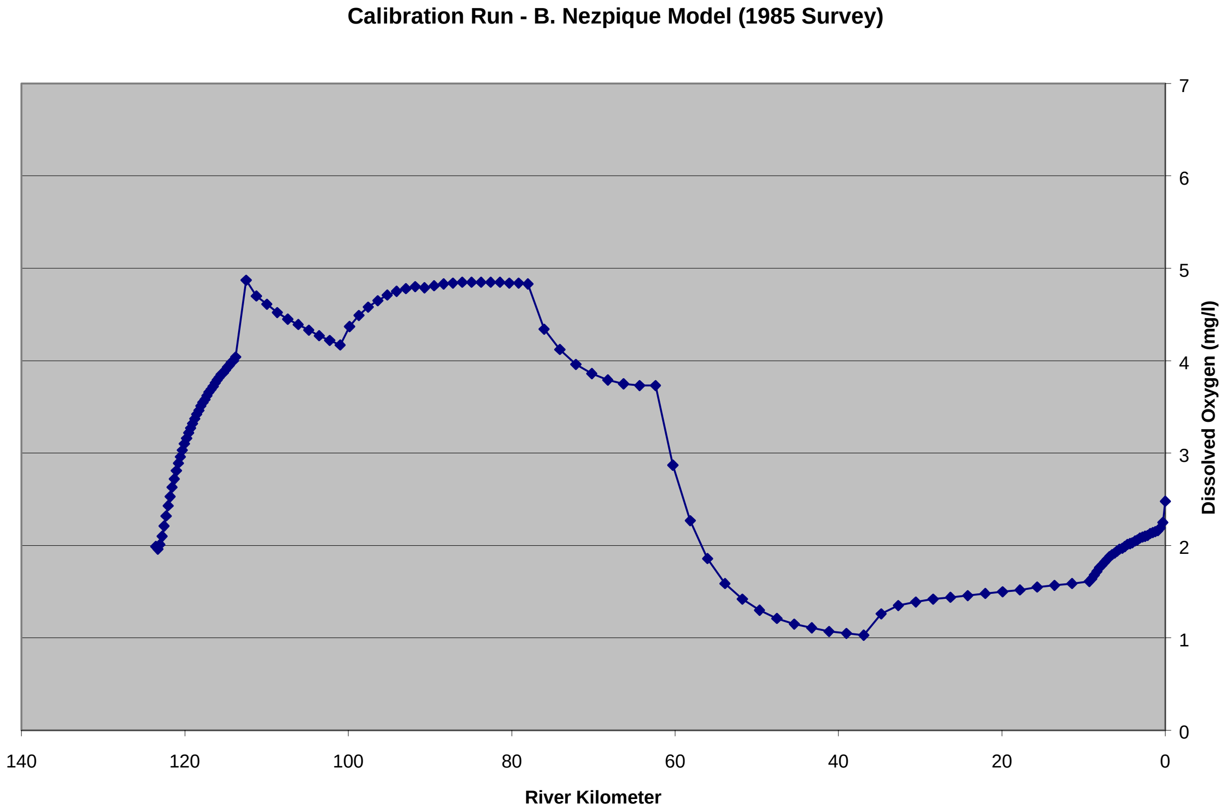
Bayou Nezpique main stem extends from Manwell Gully to the Mermentau River and is represented by Reaches 6, 10, 15, 17, 18, and 20. None of the treatment plants discharge directly into the main stem. Very good calibration was achieved for DO, CBOD, Chlorides and NBOD on the main stem. The calibration model shows that in the summer of 1985, the DO standard of 3 mg/l was not being met in Bayou Nezpique downstream of RK 60.287, the beginning of Reach 17 at the junction with the Basile POTW tributary. The use of the model’s dispersion capability was required in Reaches 18, 19, and 20 to achieve calibration. These waters are known to be affected by tides, wind tides, and irrigation water withdrawals causing reverse flows. The previous model of Lower Bayou Nezpique/Mermentau River also made use of dispersion in these reaches. The minimum DO on the main stem was 1.03 mg/l at RK 36.9.

Beaver Creek/Boggy Bayou/East Fork Bayou Nezpique is a system of tributaries to the main stem of Bayou Nezpique. The system extends from Oakdale to Manwell Gully and is represented by Reaches 2, 3, 4, and 5. Two dischargers are located on these tributaries, Oakdale and Pine Prairie. Pine Prairie discharges into an unnamed tributary, Reach 4, and is discussed below. Oakdale POTW actually discharges upstream from the beginning of Reach 2 and achieves some load reduction before reaching the model beginning point. In order to achieve calibration, a 30% reduction of the treated effluent above Reach 2 was required. The capability to do this is built into Qual-Tx. Very good calibration was achieved for DO and NBOD. The calibrations for CBOD and Chlorides were acceptable and were the best that could be achieved with the limited data. All calibrations were very good in the lower reach which empties into the main stem of Bayou Nezpique at RK 113.8. The calibration shows that the DO criteria of 2 mg/l in Beaver Creek (Reaches 2 and part of 3, Subsegment 050302), and 3 mg/l (Headwaters of Bayou Nezpique) in the remaining reaches (part of 3 and 5) were being met. The minimum DO in reaches 2, 3, and 5 was 3.22 mg/l at RK 36.5.

Beaver Creek/Boggy Bayou/East Fork Bayou Nezpique is a system of tributaries to the main stem of Bayou Nezpique. The system extends from Oakdale to Manwell Gully and is represented by Reaches 2, 3, 4, and 5. Two dischargers are located on these tributaries, Oakdale and Pine Prairie. Pine Prairie discharges into an unnamed tributary, Reach 4, and is discussed below. Oakdale POTW actually discharges upstream from the beginning of Reach 2 and achieves some load reduction before reaching the model beginning point. In order to achieve calibration, a 30% reduction of the treated effluent above Reach 2 was required. The capability to do this is built into Qual-Tx. Very good calibration was achieved for DO and NBOD. The calibrations for CBOD and Chlorides were acceptable and were the best that could be achieved with the limited data. All calibrations were very good in the lower reach which empties into the main stem of Bayou Nezpique at RK 113.8. The calibration shows that the DO criteria of 2 mg/l in Beaver Creek (Reaches 2 and part of 3, Subsegment 050302), and 3 mg/l (Headwaters of Bayou Nezpique) in the remaining reaches (part of 3 and 5) were being met. The minimum DO in reaches 2, 3, and 5 was 3.22 mg/l at RK 36.5.

Bayou Grand Louis system includes two dischargers, Evangeline Sewer Co. and Mamou and is represented by Reaches 7, 8, and 9. Evangeline Sewer Co. discharges into an unnamed tributary, Reach 8, and is discussed below. Mamou POTW actually discharges upstream from the beginning of Reach 7 and achieves some load depletion before reaching the model beginning point. A 25 % reduction of the treated effluent above Reach 7 was needed to achieve calibration. Bayou Grand Louis enters the main stem of Bayou Nezpique at RK 101.0. A good calibration was achieved for CBOD and NBOD. Dissolved oxygen was underestimated in the upper part of the system but was very well calibrated in the lower part of the system. Chlorides are calibrated in the upper part of the system but underestimated in the lower part of the system It is apparent from the data that Bayou Grand Louis functions primarily as a treated effluent conveyance. The calibration shows that the DO criterion of 3.0 mg/l (Headwater of Bayou Nezpique) was not being met in the summer of 1985. The minimum DO in reaches 7 and 9 was 1.01 mg/l at RK 13.6.

Figure 1. Calibration Model Dissolved Oxygen versus River Kilometer



The Bayou Blue system (Subsegment 050304) extends from Oberlin to the main stem of Bayou Nezpique at RK 78.0 and is represented by Reaches 11-14. Two dischargers are located in this system, Oberlin and Elton. Elton POTW discharges into an unnamed tributary, Reach 13, and is discussed below. A good calibration was achieved for DO, CBOD, Chlorides and NBOD. The calibration shows that the DO criterion of 5.0 mg/l was not being met in the summer of 1985 anywhere in the system. The minimum DO in reaches 11, 12, and 14 was 0.0 mg/l from RK 48.308 to RK 45.956.

Basile POTW Canal (Reach 16) receives the Basile effluent and enters the main stem at RK 62.4. With only one point to calibrate to, the calibration results are reasonably good. Dissolved oxygen is slightly underestimated, CBOD is very well calibrated, Chlorides are slightly underestimated, and NBOD is somewhat overestimated. The calibration shows that the DO criterion of 3.0 mg/l (Headwater of Bayou Nezpique) was being met in the summer of 1985. The headwater value for DO of 2.8 mg/l may account for the underestimated DO. The minimum DO in reach 16 downstream of the headwater was 3.17 mg/l at RK 0.0.

Since no data were collected on Manwell Gully (Reach 1) during the survey, a calibration was not possible. The minimum DO value produced by the model was 1.96 mg/l at RK 123.3. This does not meet the DO criterion of 3.0 mg/l.

Since no data were collected on Unnamed Tributary to Pine Prairie POTW (Reach 4) during the survey, a calibration was not possible. The minimum DO value produced by the model was 2.71 mg/l at RK 10.0. This does not meet the DO criterion of 3.0 mg/l.

Since no data were collected on Unnamed Tributary to Evangeline Sewer Co. (Reach 8) during the survey, a calibration was not possible. The minimum DO value produced by the model was 1.6 mg/l at RK 5.76. This does not meet the DO criterion of 3.0 mg/l.

The Unnamed Tributary to Elton POTW (Reach 13) receives the Elton effluent and enters the Bayou Blue system at RK 21.6. With only one point to calibrate to, the calibration results are very good. The calibration shows that the DO criterion of 5.0 mg/l was not being met in the summer of 1985. The minimum DO in reach 13 was 0.8 mg/l at RK 0.76.

Jennings STP Canal (Reach 19) receives the Jennings effluent and enters the main stem at RK 9.3. With only one point to calibrate to, the calibration results are very good. The calibration could not be made without the use of the dispersion feature. The calibration shows that the DO criterion of 3.0 mg/l (Headwater of Bayou Nezpique) was not being met in the summer of 1985. The minimum DO in reach 19 was 0.82 mg/l at RK 0.3.

4. Water Quality Projections

Since the calibrated model indicated that the DO criterion was not being met in the lower reaches of Bayou Nezpique and many of its tributaries, three summer loading scenarios were performed in addition to the traditional summer and winter projections. These additional scenarios were:

a. No Load Scenario - No point source loads and no nonpoint source loads above reference stream background
b. No Discharge Scenario – No point source loads with the calibrated nonpoint source loads
c. No NPS Scenario – Current permitted dischargers with no NPS loads above reference stream background

4.1 Critical Conditions

4.1.1 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 Nezpique TMDL, LDEQ has employed an analysis of its long-term ambient data to determine critical seasonal conditions and used a combination of implied and explicit margins of safety.

Critical conditions for dissolved oxygen were determined for the Mermentau Basin using long term water quality data from six stations on the LDEQ Ambient Monitoring Network and the Louisiana Office of State Climatology water budget. Graphical and regression techniques were used to evaluate the temperature and dissolved oxygen data from the Ambient Monitoring Network and the run-off determined from the water budget. Since nonpoint loading is conveyed by run-off, this seemed 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 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.

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

LDEQ simulated critical summer conditions in the Bayou Nezpique dissolved oxygen TMDL projection modeling by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. LDEQ simulated critical winter conditions by using the lowest of the monthly 7Q10 flow published for the winter months or 1 cfs, whichever was higher, for all headwaters, and 90th percentile temperature for the season. Again, incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. In addition, LDEQ assumes that all point sources are discharging at maximum capacity.

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 combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implied margin of safety which is estimated to be in excess of 10%. Over and above this implied margin of safety, LDEQ used an explicit MOS of 20% for both point and nonpoint loads. The total MOS is estimated to exceed 30% for the Bayou Nezpique TMDL.

4.1.2 Hydrology and Stream Geometry and Sources

The only tributary considered to have the potential for a non-zero 7Q10 was the East Fork of Bayou Nezpique upstream from the confluence with Boggy Bayou. This stream is fed from Miller's Lake and accounted for a significant proportion of the flow during calibration (survey site 05-BN-02). A 7Q10 determination was made for the sampling site 05-BN-10 located at river mile 34.1. Documentation for this determination is presented in Appendix E6. The 7Q10 value of 1.92 cfs at river mile 34.1 was then proportioned based on the measured discharges at 05-BN-

10 and 05-BN-02 to determine the 7Q10 flow in the East Fork. A winter critical flow was developed from the average of the monthly 7Q10s at the Basile gauging station. A proportion was again assigned to East Fork Bayou Nezpique for the winter projection.

Critical temperatures for each season were determined from the temperature data collected by LDEQ as part of its historical and current ambient monitoring strategy. The 90th percentile temperature for each season was computed for Bayou Nezpique near Jennings from 1991 to the present and for Bayou Nezpique near Basile for the last ten years. A limited amount of data, primarily from 1998, was available on some of the tributaries to Bayou Nezpique. These data were combined and the 90th percentile season temperature was computed for use on the tributaries. The temperature spreadsheets are shown in Appendix E6.

The stream cross-section was automatically adjusted for the projection flows by the model through the use of the Leopold coefficients and exponents. For reaches 1-14 and 16, the Leopold coefficients and exponents used for calibration were not changed for the projection runs. For the lower reaches however, the widths produced by the projection model using the calibration values of the Leopold coefficients and exponents were much too narrow and would in turn have produced very unrealistic modeling results in these reaches. For this reason, an adjustment was made in the velocity coefficient and exponent which would produce widths in the lower reaches based on the side slopes at the gauging station at Basile. By doing this, the coefficients and exponents no longer followed the “rules of one” which usually govern the Leopold Equations. The model output was examined and it was determined that even though the “rules of one” were violated, the model produced consistent flows, widths, depths and velocities. It is probable that the addition of the default depth at zero flow (input “e” in data type 9), renders the “rules of one” moot. The projections and scenarios were then made using the new coefficients in the lower reaches. It was decided that it would not change the calibration results if the new coefficients were used since the results of the calibration model were used to determine the new coefficients. The determinations of the new coefficients and exponents for reaches 15, 17, 18, 19, and 20 are shown in Appendix E6.

The flow in each headwater and unmodeled tributary except for East Fork Bayou Nezpique was set at 0.1 cfs = 0.00283 cms for summer critical conditions in accordance with the LTP. The flow in each headwater and unmodeled tributary except for East Fork Bayou Nezpique was set at 1.0 cfs = 0.0283 cms for winter critical conditions in accordance with the LTP.

Treatment plant flows were determined based on available data from current permits and applications and then increased by 25% in order to explicitly incorporate a 20% margin of safety in the effluent loads. Treatment plant projected flows are summarized in Table 5.

4.1.3 Water Quality Input Data and Their Sources.

The initial conditions were set to the 90th percentile critical season temperature in accordance with the LTP. The dissolved oxygen values for the initial conditions were set at the stream criteria.

Table 5. Projected Treatment Plant Flow Information

Treatment Plant	Current or Expected Flow, MGD	Modeled Flow, MGD	Modeled Flow, cms
Oakdale	1.46	1.825	2.824
Pine Prairie	0.100	0.125	0.193
Reddell	0.068	0.085	0.132
Evangeline Sew. Co.	0.0364	0.0455	0.070
Mamou	0.6	0.75	1.16
Oberlin	0.363	0.454	0.702
Elton	0.193	0.241	0.373
Basile	0.5	0.625	0.967
Jennings	2.5	3.125	4.835

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.

The incremental conditions were used in the calibration to represent nonpoint source loads associated with flows. For the projection and scenario runs, the incremental flows were set to zero to emulate the critical conditions for dissolved oxygen.

The reference stream data was assumed to be representative of the chlorides, UCBOD and UNBOD of the headwaters. The 90th percentile critical season temperature and 90% of the saturation value for dissolved oxygen at that temperature were used for the headwaters in accordance with the LTP. Calculations of the DO for these conditions are in Appendix E8.

The lower boundary conditions were set at the 90th percentile critical season temperature, the dissolved oxygen criteria, and the reference stream CBOD and NBOD loads for all projections and scenarios.

4.1.3.1 Sediment Oxygen Demand, Data Type 12

Except for the “No Discharge Scenario” (No point source loads with the calibrated nonpoint source loads), the SOD values were set at the reference stream values. For both the summer and winter projection runs, the values had to remain at the reference stream values in order to meet the DO criteria. The value and sources for SOD for each projection run are presented in Appendices E1-E7.

4.1.3.2 Nonpoint Sources, Data Type 19

Except for the “No Discharge Scenario” (No point source loads with the calibrated nonpoint source loads), the NPS values were based on the reference stream values except where the calibration value was smaller than the reference stream value. In some cases a percentage of the reference stream loading has been used. Some of the nonpoint source loads in kg/km/day which were based on reference stream data appear to be very small loads, but only because they do not address stream width. An analysis was made of the projected NPS and SOD loads in terms of gm-O_2/m^2/day and compared to the reference stream loads in the same terms. The values and sources of the nonpoint input and the load analyses are presented in Appendices E1 through E7 for each of the projection runs. A brief summary of the methodology used is presented in Appendix E8.

4.1.3.3 Wasteloads, Data Types 24, 25, and 26

Except for the "No Discharge Scenario" (no point source loads with the calibrated nonpoint source loads) and the "No Load Scenario" (no point source loads and no nonpoint source loads above reference stream background), the wasteloads entered in the projection models for the treatment plants were taken from the current permit or application or determined by the projection. The unmodeled tributary wasteloads were set at reference stream values for the "No NPS Scenario" and the "No Load Scenario". For the "No Discharge Scenario", the wasteloads entered for the unmodeled tributaries were set at the calibration values. For the summer and winter projection runs, the wasteloads entered for the unmodeled tributaries were set at 50% of the calibration values. The values and sources of the data are presented in Appendices E1-E5.

4.2 Model Discussion and Results

The projection model input and output data sets are presented in Appendix D. The summer and winter projections are presented as complete printouts. The three scenarios are presented as the input data set and the dissolved oxygen graphs only.

4.2.1 No Load Scenario

Under this Scenario, the treatment plant discharges were eliminated and the SOD was reduced to reference stream values except where the calibration value was less than the reference stream value. The NPS load was also reduced to reference stream values except where the calibration value was smaller. As shown in the output graphs, the main stem and all tributaries except the Bayou Blue system meet the existing dissolved oxygen criteria. It is obvious from this plot that the current DO criterion of 5 mg/l DO for Bayou Blue should be reevaluated. By analogy, the adjacent Castor Creek system should also be evaluated for a DO criterion change.

4.2.2 No Discharge Scenario

Under this Scenario, the treatment plant discharges were eliminated and the SOD value was set at the calibration value. The NPS load used was also set at the calibration value. As shown in the output graphs, the main stem and tributaries except Manwell Gully, Beaver Creek, Evangeline Sewer Co. Tributary, and Bayou Grand Louis do not meet the existing dissolved oxygen criteria. These plots clearly show that the main stem is overwhelmed by the NPS loads.

4.2.3 No NPS Scenario

Under this Scenario, the treatment plant discharges were set at current permit values and the SOD was reduced to reference stream values except where the calibration value was less than the reference stream value. The NPS load was also reduced to reference stream values except where the calibration value was smaller. As shown in the output graphs, Beaver Creek/Boggy Bayou/East Fork system, Pine Prairie POTW Tributary, and Bayou Grand Louis meet the existing dissolved oxygen criteria. The main stem, Basile Tributary and Bayou Blue do not meet the criteria. The plots show that the impact of the treatment plants on the main stem is much less than the impact of the nonpoint sources. This is reasonable since the treatment plants do not directly discharge into the main stem. The impact in some tributaries is greater from the treatment plants than from the NPS loads. These tributaries however, are primarily effluent conveyances and do not receive significant NPS loads.

4.2.4 Summer Projection

Bayou Nezpique main stem was modeled from the headwaters of Manwell Gully to the Mermentau River. The results of the model show that the water quality standard for dissolved oxygen for Bayou Nezpique of 3.0 mg/l can be maintained during the summer critical season in the Bayou Nezpique watershed. The Bayou Blue system currently has a dissolved oxygen criteria of 5.0 mg/l which can not be maintained. The Bayou Blue and the adjacent Castor Creek systems have been reevaluated and more appropriate DO criteria recommended. To meet a DO criterion of 3.0 mg/l throughout the entire watershed requires the imposition of an 85% reduction from all manmade nonpoint sources and the imposition of 5 mg/l $CBOD_5$/2 mg/l NH_3/6 mg/l DO limits on Oberlin, Elton, Basile, and Jennings; 5 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits on Reddell; 10 mg/l $CBOD_5$/2 mg/l NH_3/5 mg/l DO limits for Mamou; 10 mg/l $CBOD_5$/10 mg/l NH_3/6 mg/l DO limits for Oakdale and Pine Prairie; and, 10 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits for Evangeline Sewer CO. The minimum DO on the main stem is 2.92 mg/l at RK 58.152. This is well within the 10% guidance for achieving standards and reflects the conservative nature of the modeling assumptions. The minimum DO and its location for each reach is shown in the following Table 6. A graph of the dissolved oxygen concentration versus river kilometer for the summer projection is presented in Figure 2.

4.2.5 Winter Projection

The results of the model show that the water quality criterion for dissolved oxygen for Bayou Nezpique of 5.0 mg/l can be maintained during the winter critical season in the entire watershed. The minimum dissolved oxygen is 4.98 mg/l and located in the Basile POTW Tributary. This is acceptable. To achieve the criterion, the model assumed the imposition of a 90% reduction from all manmade nonpoint sources and the imposition of 10 mg/l $CBOD_5$/10 mg/l NH_3/5 mg/l DO limits on Oakdale, Pine Prairie, Oberlin, and Elton; 10 mg/l $CBOD_5$/7.5 mg/l NH_3/5 mg/l DO limits on Basile; 5 mg/l $CBOD_5$/5 mg/l NH_3/6 mg/l DO limits on Jennings; 10 mg/l $CBOD_5$/5 mg/l NH_3/5 mg/l DO limits on Reddell; 10 mg/l $CBOD_5$/2 mg/l NH_3/5 mg/l DO limits for Mamou; and, 20 mg/l $CBOD_5$/10 mg/l NH_3/5 mg/l DO limits for Evangeline Sewer CO. The minimum DO on the main stem is 5.44 mg/l at RK 53.904. The minimum DO and its location for each reach is shown in the following Table 7. A graph of the dissolved oxygen concentration versus river kilometer for the winter projection is presented in Figure 3.

Table 6. Summer Projections Minimum Dissolved Oxygen for Each Reach.

Reach Number	DO Criteria @ Minimum DO Location, mg/l	Minimum DO in Reach, mg/l	Location of Minimum DO, River Kilometers
1	3	3.11	121.55-121.3
2	2	3.9	31.9-29.7
3	2	2.99	23.78-23.040
4	3	3.66	8.0-6.25
5	3	3.72	13.41
6	3	3.61	101.0
7	3	3.91	13.6
8	3	3.69	4.32-4.08
9	3	4.05	13.328
10	3	3.79	96.4
11	5	3.58	45.956
12	5	3.87	38.035
13	5	3.74	0.0
14	5	3.78	18.72
15	3	3.21	70.2
16	3	2.99	0.0
17	3	2.92	58.152
18	3	5.01	34.788
19	3	3.68	0.2
20	3	3.61	0.0

Figure 2. Summer Projection Model Dissolved Oxygen versus River Kilometer

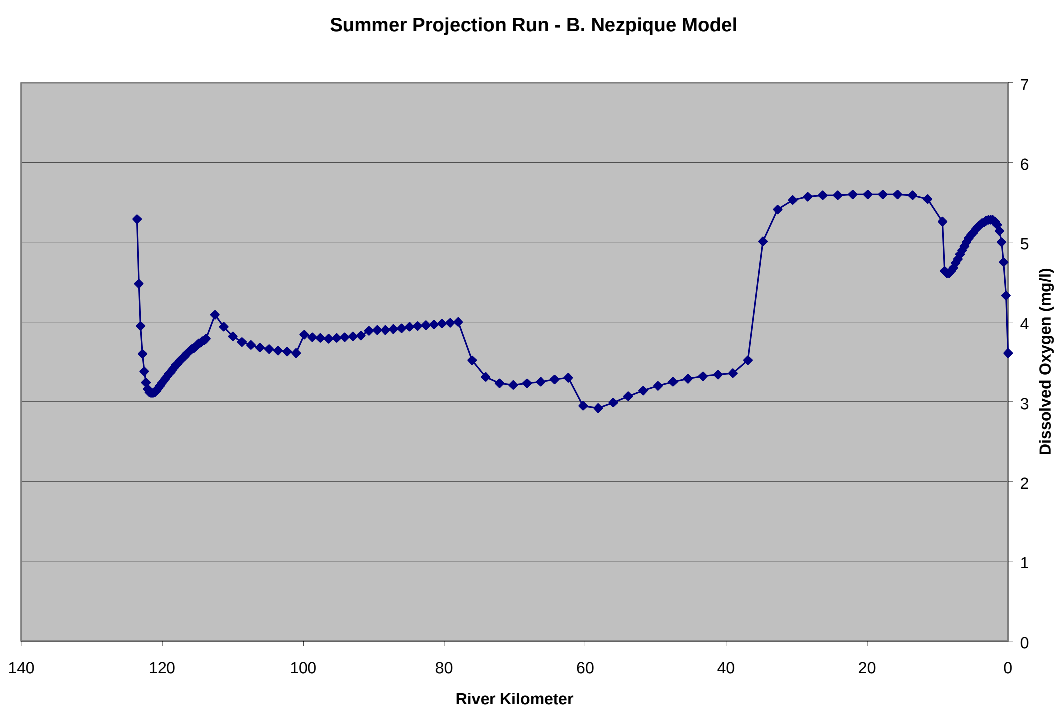
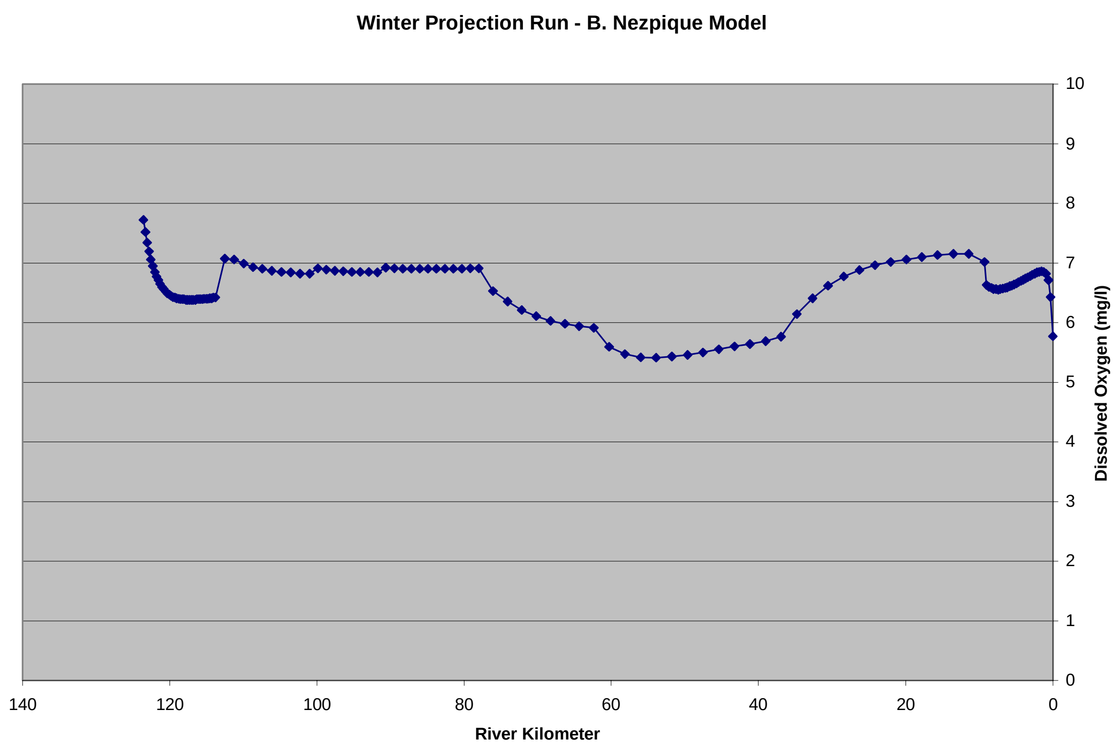


Table 7. Winter Projections Minimum Dissolved Oxygen for Each Reach.

Reach Number	DO Criteria @ Minimum DO Location, mg/l	Minimum DO in Reach, mg/l	Location of Minimum DO, River Kilometers
1	5	6.38	117.8-116.55
2	3	5.91	39.5
3	5	5.98	22.3-19.34
4	5	6.79	2.75-0.00
5	5	6.6	13.41
6	5	6.82	102.28-101.00
7	5	6.39	13.6
8	5	6.7	1.2-0.00
9	5	6.56	13.328
10	5	6.84	91.8
11	5	5.66	45.956
12	5	6.31	38.035
13	5	6.36	0.00
14	5	5.96	15.84
15	5	5.91	62.4
16	5	4.98	0.2
17	5	5.44	53.904
18	5	6.16	34.788
19	5	5.24	0.30
20	5	5.77	0.00

Figure 3. Winter Projection Model Dissolved Oxygen versus River Kilometer 4.3



4.3 Calculated TMDL, WLAs and LAs

TMDLs for the oxygen demanding constituents (CBOD, NH3N, and SOD), have been calculated for the summer and winter projection runs. They are presented in Appendix A by point source and reach. The summer TMDL is in this case greater than the winter TMDL because the SOD constitutes a much greater share of the NPS loading in the winter and is temperature corrected. A summary of the loads is presented in Table 9.

Table 8. Total Maximum Daily Load (Sum of CBOD, NH3N, and SOD)

ALLOCATION	SUMMER (MAR-NOV) (lbs/day)	WINTER (DEC-FEB) (lbs/day)
Point Source WLA	1,646.13	2294.95
Point Source Reserve MOS	411.53	573.75
Natural Nonpoint Source LA	12,394.65	9,446.57
Natural Nonpoint Source Reserve MOS	3,098.66	2,361.64
Manmade Nonpoint Source LA	959.80	1,011.28
Manmade Nonpoint Source Reserve MOS	239.95	252.82
TMDL	18,750.73	15,940.97

5. Sensitivity Analyses

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 QUAL-TX 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. A sensitivity analysis was performed on the summer projection. 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 reported in Appendix I are sorted by percentage variation of minimum DO in the main stem Bayou Nezpique from largest percentage variation to the smallest. As shown in the summary table in Appendix I, reaeration is the parameter to which DO is most sensitive (38%-69%). The other parameters creating major variations in the minimum DO values are Benthal SOD (38%-41%) and Temperature (17%-21%). Depth, velocity and wasteload flows are slightly sensitive with variations ranging from 3% to 10%. The model is not sensitive to CBOD decay, NBOD decay, tidal range and headwater flow.

6. Conclusions

The TMDL requires a watershed wide 85% - 90% decrease in manmade nonpoint source loads. The main stem of Bayou Nezpique also continues to require no direct point source discharges as previously determined by Bostock in *Bayou Nezpique Wasteload Allocation*. Effluent treatment

Table 9. Minimum Dissolved Oxygen for Bayou Nezpique Main Stem for Projections.

PERMIT NO.	FACILITY	CURRENT FLOW, MGD	CURRENT LIMITS, mg/l	MODELED FLOW, MGD	SUMMER PROJECTION LIMITS, mg/l	WINTER PROJECTION LIMITS, mg/l
LA0033430	OAKDALE, CITY OF (WWTP)	1.46	10BOD5/15TSS	1.83	10BOD5/10NH3/6DO	10BOD5/10NH3/5DO
LA0079057	PINE PRAIRIE, VILLAGE OF (STP)	0.1	10BOD5/15TSS	0.13	10BOD5/10NH3/6DO	10BOD5/10NH3/5DO
LA0109452	REDDELL STP	0.068	10BOD5/15TSS/5NH3/5DO-SUMMER 20BOD5/15TSS/10NH3/5DO -WINTER	0.084	5BOD5/5NH3/6DO	10BOD5/5NH3/5DO
LAG560049	EVANGELINE SEWER CO INC	0.0364	20BOD5/20TSS	0.05	10BOD5/5NH3/6DO	20BOD5/10NH3/5DO
LA0020125	MAMOU, TOWN OF (WWTP)	0.6	10BOD5/15TSS/2NH3/5DO	0.75	10BOD5/2NH3/5DO	10BOD5/2NH3/5DO
LA0020087	OBERLIN, TOWN OF (STP)	0.363	10BOD5/15TSS	0.45	5BOD5/2NH3/6DO	10BOD5/10NH3/5DO
LA0061719	ELTON, TOWN OF (WWTP)	0.193	10BOD5/15TSS	0.24	5BOD5/2NH3/6DO	10BOD5/10NH3/5DO
LA0044865	BASILE WWTP	0.5	10BOD5/15TSS	0.63	5BOD5/2NH3/6DO	10BOD5/7.5NH3/5DO
LA0041769	JENNINGS, CITY OF (STP)	2.5	10BOD5/15TSS	3.13	5BOD5/2NH3/6DO	5BOD5/5NH3/6DO
	MINIMUM DO IN BAYOU NEZPIQUE MAIN STEM				2.92	5.41

levels are required to be upgraded to advanced levels or better with effluent reaeration by all dischargers.

In the event that Bayou Blue continues to have a DO criterion of 5 mg/l year round, no discharge from all sources would be required during the summer months. Although Castor Creek was not directly modeled and has no point source discharges, it is unlikely that a 5.0 mg/l DO standard can be achieved in Castor Creek if it cannot be achieved in Bayou Blue in a "no load" condition. Also, as in Bayou Blue, the 85%-90% reduction in manmade nonpoint source loads is unlikely to allow the stream to meet a DO criterion of 5 mg/l. Dissolved Oxygen criteria revisions are recommended for both Bayou Blue and Castor Creek based on the results of the “No Load Scenario”.

The modeling which has been conducted for this TMDL is very conservative and based on limited, somewhat dated information. Also, the data gathering design for the 1985 survey was based on the use of a non-branched steady state model which required different types of input data from that required by Qual-Tx. A larger than normal number of assumptions were required to conduct the current modeling effort. The inherently conservative nature of the model has been increased due to these assumptions.

Many of the treatment plants have been at advanced levels of treatment for many years and many BMPs have been implemented in the Mermentau Basin. It is possible that the watershed has not yet begun to exhibit the improvements in water quality which can be expected from these control measures. Future studies may show that this TMDL is smaller than that which can actually be accommodated by the watershed.

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 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 five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-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. The sampling schedule for the first five-year cycle is shown below.

1998 - Mermentau and Vermilion-Teche River Basins
1999 - Calcasieu and Ouachita River Basins
2000 - Barataria and Terrebonne Basins
2001 - Lake Pontchartrain Basin and Pearl River Basin
2002 - Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)
Mermentau and Vermilion-Teche Basins will be sampled again in 2003.

7. References

Bostock, Helen. *Bayou Nezpique Wasteload Allocation*. Louisiana Department of Environmental Quality Report Number WLA 90.29. Baton Rouge, LA: December, 1990.

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.

Forbes, Max J., Jr. *Low-Flow Characteristics of Louisiana Streams.* USGS Water Resources Technical Report No. 22. Baton Rouge, LA: Louisiana Department of Transportation and Development, Office of Public Works, 1980.

Hebel, Max. *Survey Report for the Bayou Nezpique Intensive Survey*. Louisiana Department of Environmental Quality. University of Southwestern Louisiana, Center for Louisiana Inland Water Studies, Report Number SUR 90.27. Baton Rouge, LA: December, 1990.

Louisiana Department of Environmental Quality. *Dissolved Oxygen Use Attainability Analysis, Mermentau River Basin*. Baton Rouge, LA: May, 1998.

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

Rogers, Madeline. *Town of Mamou Advanced Treatment Facility Water Quality Review*. Louisiana Department of Environmental Quality Report Number ATR 89.18. Baton Rouge, LA: December, 1989.

Rogers, Madeline. *Proposed Phased Approach TMDL for the Jennings STP Canal*. Louisiana Department of Environmental Quality. University of Southwestern Louisiana, Center for Louisiana Inland Water Studies Report Number CLIWS-WLA 92.06. Baton Rouge, LA: March, 1993.

Shoemaker, L., et. al. *Compendium of Tools for Watershed Assessment and TMDL Development*. Office of Wetland, Oceans, and Watersheds, USEPA, EPA841-B-97-006. Washington, DC: May, 1997.

Smythe, E. deEtte and M. G. Waldon. *Bayou Queue de Tortue Steady-State Calibrated Water Quality Model: Limnoss*. Louisiana Department of Environmental Quality. University of Southwestern Louisiana, Center for Louisiana Inland Water Studies Report Number CLIWS-WQR 93.03. Baton Rouge, LA: February 16, 1995.

Smythe, E. deEtte. *Overview of the 1995 Reference Streams*. Louisiana Department of Environmental Quality. Baton Rouge, LA: August 15, 1997.

Texas Water Commission. *Qual-Tx User's Manual* (Version 3.3). Water Quality Division, Water Quality Standards and Evaluation Section, Water Quality Evaluation Unit. Austin, TX: December 3, 1990.

Texas Water Commission. *Waste Load Evaluation Methodology*. Water Quality Division, Water Quality Evaluation Unit. Austin, TX: November, 1990.

Waldon, M. G. *Mermentau River – Lower Bayou Nezpique Calibrated Water Quality Model*. Louisiana Department of Environmental Quality. University of Southwestern Louisiana, Center for Louisiana Inland Water Studies Report Number WQR 92.04. Baton Rouge, LA: January, 1993.

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: April, 1998.

8.0 Appendices

See Attached Appendices A-I.