FINAL REPORT
June 2009
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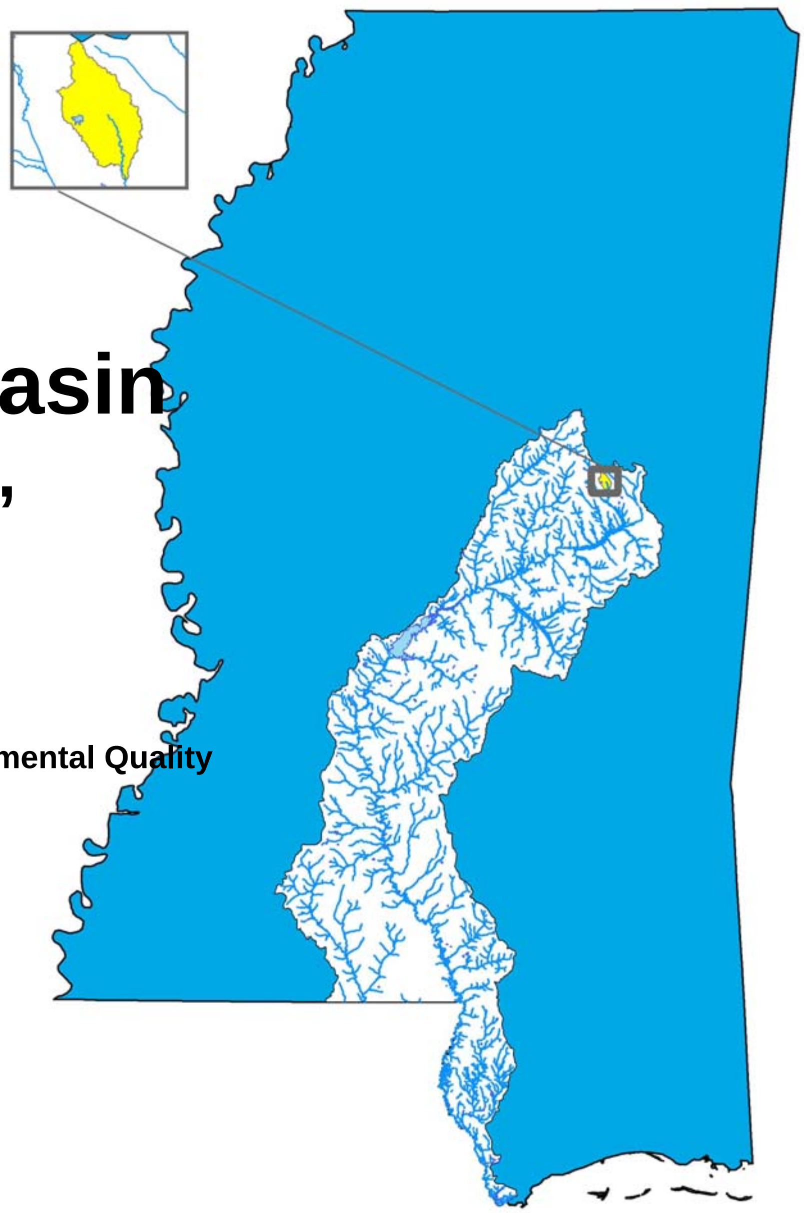
Total Maximum Daily Load

Nutrients, Ammonia Toxicity, and Organic Enrichment / Low DO For Hughes Creek



Pearl River Basin

Winston County, Mississippi

Prepared By

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FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's 1996 Section 303(d) List of Impaired Water bodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
$mile^2$	acre	640	acre	ft^2	43560
km^2	acre	247.1	days	seconds	86400
m^3	ft^3	35.3	meters	feet	3.28
ft^3	gallons	7.48	ft^3	gallons	7.48
ft^3	liters	28.3	hectares	acres	2.47
cfs	gal/min	448.8	miles	meters	1609.3
cfs	MGD	0.646	tonnes	tons	1.1
m^3	gallons	264.2	µg/l * cfs	gm/day	2.45
m^3	liters	1000	µg/l * MGD	gm/day	3.79

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	µ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

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Table 1. Listing Information

Name	ID	County	HUC	Evaluated Cause
Hughes Creek	MS122E1	Winston	03180001	Nutrients, Ammonia Toxicity, and Organic Enrichment / Low DO
At Louisville from headwaters to county road at Estes				

Table 2. Water Quality Standards

Parameter	Beneficial use	Water Quality Criteria
Nutrients	Aquatic Life Support	Waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions, in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.
Ammonia Toxicity	Aquatic Life Support	Waters shall be free from substances attributable to municipal, industrial, agricultural, or other discharges in concentrations or combinations that are toxic or harmful to humans, animals, or aquatic life. Ammonia toxicity shall be evaluated according to EPA guidelines published in 1999 Update of Ambient Water Quality Criteria for Ammonia; EPA document number EPA-822-R-99-014 or Ambient Water Quality Criteria for Ammonia (Saltwater) - 1989; EPA document number 440/5-88-004.
Dissolved Oxygen	Aquatic Life Support	DO concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. Natural conditions are defined as background water quality conditions due only to non-anthropogenic sources. The criteria herein apply specifically with regard to substances attributed to sources (discharges, nonpoint sources, or instream activities) as opposed to natural phenomena. Waters may naturally have characteristics outside the limits established by these criteria. Therefore, naturally occurring conditions that fail to meet criteria should not be interpreted as violations of these criteria.

Table 3. Total Maximum Daily Load for Hughes Creek

	WLA lbs/day	LA lbs/day	MOS	TMDL lbs/day
Total Nitrogen**	**28.14**	**25.71**	**Implicit**	**53.85**
Total Phosphorous	**6.39**	**1.30**	**Implicit**	**7.69**
TBODu	**174.75**	**46.11**	**Implicit**	**220.86***

* Based on STREAM model output
** The Ammonia Toxicity TMDL exceeds what is limited here by the TMDL for TN and is not included in this table

Table 4. Point Source Loads for Hughes Creek

Permit	Facility	Flow MGD	TN Load lbs/day	TP Load lbs/day	TBODu lbs/day
MS0002186 001	**GP Ply**	**0.08**	**1.43**	**0.88**	**49.32**
MS0002186 002	**GP Ply**	**0.01**	**1.06**	**0.00**	**7.21**
MS0002186 003	**GP Ply**	**0.10**	**1.91**	**0.00**	**19.57**
MS0002186 004	**GP Ply**	**0.03**	**1.20**	**0.51**	**8.8**
MS0020796	**Louisville**	**0.60**	**22.54**	**5.01**	**135.96**
	Total		**28.14**	**6.39**	**220.86**

EXECUTIVE SUMMARY

This TMDL has been developed for Hughes Creek which was placed on the Mississippi 2008 Section 303(d) List of Impaired Water Bodies. Hughes Creek was listed due to biological impairment. A stressor identification report indicated that organic enrichment low dissolved oxygen, nutrients, ammonia toxicity, and sediment were the primary probable stressors for the stream. Sediment will be addressed in a separate TMDL report. This TMDL will provide an estimate of the total biochemical oxygen demand (TBODu), total nitrogen (TN), total phosphorus (TP), and a concentration of ammonia toxicity (NH_3-N) allowable in this water body.

Mississippi does not have water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of criteria for nutrients. An annual concentration of 0.7 mg/l is an applicable target for TN and 0.10 mg/l for TP for water bodies located in ecoregion 65. MDEQ is presenting these preliminary target values for TMDL development which are subject to revision after the development of numeric nutrient criteria.

The Hughes Creek Watershed is located in HUC 03180001. The listed portion of Hughes Creek is at Louisville from the headwaters to the county road at Estes. The location of the watershed for the listed segment is shown in Figure 1.

The Hughes Creek Watershed evaluation indicated that the impairment is due to phosphorus, nitrogen, and ammonia from point and nonpoint sources. The limited nutrient data and estimated existing ecoregion concentrations indicate reductions of nitrogen, ammonia, and phosphorus can be accomplished with installation of best management practices. Additionally reductions are needed in the point sources in the watershed to meet the TMDLs.

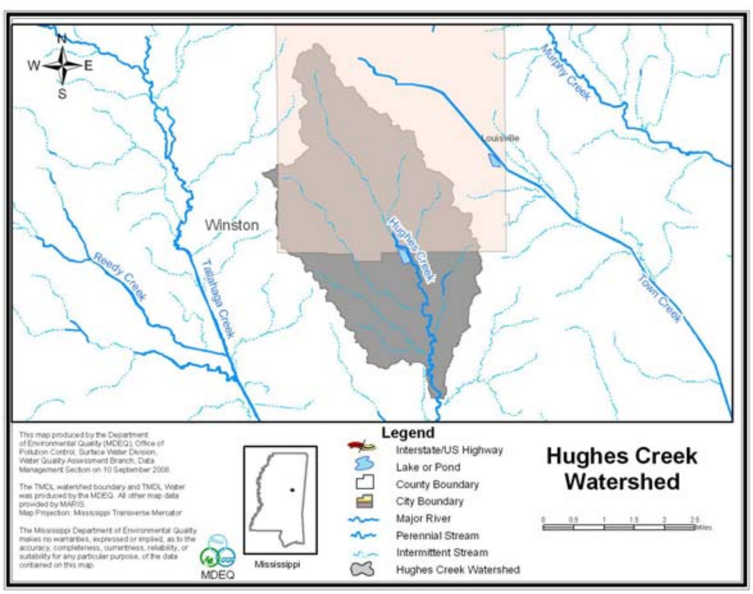


Figure 1. Hughes Creek

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. This TMDL has been developed for the 2008 §303(d) listed segment shown in Figure 2.

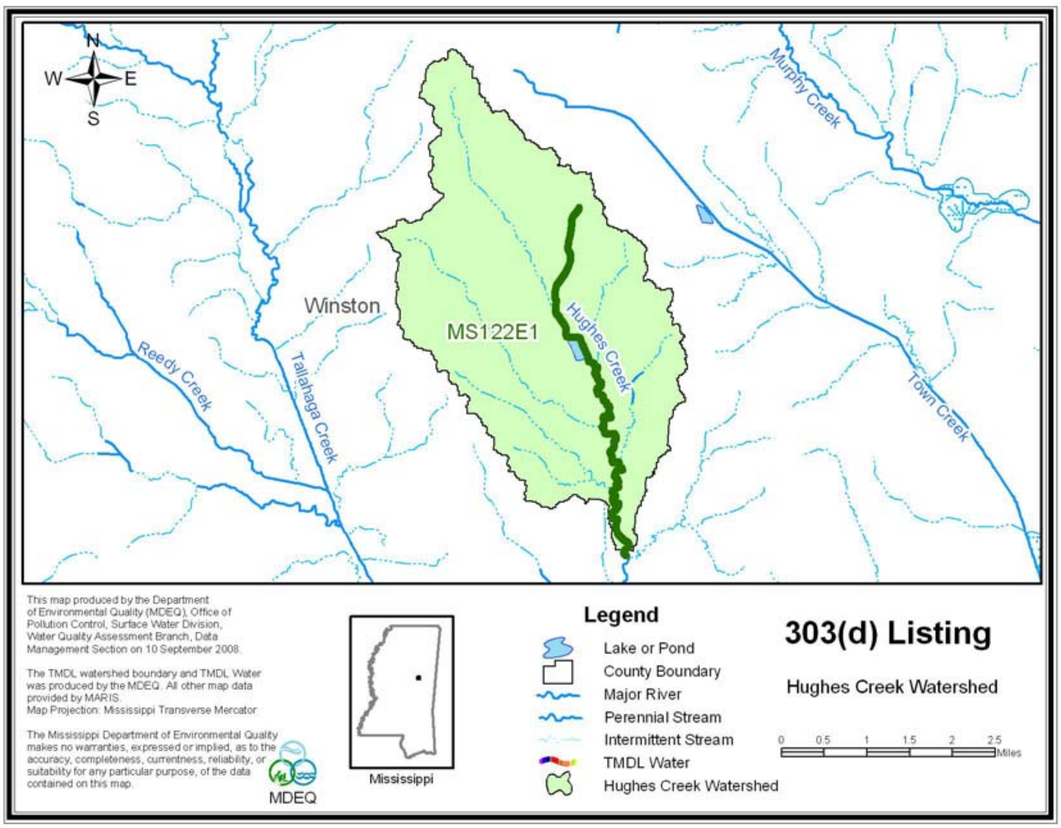


Figure 2. Hughes Creek §303(d) Listed Segment

1.2 Listing History

The impaired segment was monitored and found to be biologically impaired due to organic enrichment, ammonia toxicity, and nutrients. There are limited chemical data available in the watershed.

There are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force in coordination with EPA Region 4. MDEQ proposed a work plan for nutrient criteria development that has been mutually agreed upon with EPA Region 4 and is on schedule according to the approved timeline for development of nutrient criteria (MDEQ, 2007).

1.3 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in the document *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2007). The designated beneficial use for the listed segments is Fish and Wildlife.

1.4 Applicable Water Body Segment Standards

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2007). Mississippi's current standards contain a narrative criteria that can be applied to nutrients which states "*Waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated use* (MDEQ, 2007)."

The standard for dissolved oxygen states, "DO concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l." In addition, the State water quality standard regulations include a natural condition clause which will be used to determine the appropriate DO for Hughes Creek under critical conditions. Natural conditions are defined as background water quality conditions due only to non-anthropogenic sources. The criteria herein apply specifically with regard to substances attributed to sources (discharges, nonpoint sources, or instream activities) as opposed to natural phenomena. Waters may naturally have characteristics outside the limits established by these criteria. Therefore, naturally occurring conditions that fail to meet criteria should not be interpreted as violations of these criteria.

The standard for ammonia is "Waters shall be free from substances attributable to municipal, industrial, agricultural, or other discharges in concentrations or combinations that are toxic or harmful to humans, animals, or aquatic life." In order to implement the standard, MDEQ relies on evaluating ammonia toxicity according to EPA guidelines published in 1999 Update of Ambient Water Quality Criteria for Ammonia; EPA document number EPA-822-R-99-014 or Ambient Water Quality Criteria for Ammonia (Saltwater) - 1989; EPA document number 440/5-88-004.

1.5 Nutrient Target Development

In the 1999 Protocol for Developing Nutrient TMDLs, EPA suggests several methods for the development of numeric criteria for nutrients (USEPA, 1999). In accordance with the 1999 Protocol, "*The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or professional judgment*."

For this TMDL, MDEQ is presenting preliminary targets for TN and TP. An annual concentration 0.7 mg/l is an applicable target for TN and 0.1 mg/l for TP for water bodies located in ecoregion 65. However, MDEQ is presenting these preliminary target values for TMDL development which are subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

1.6 Ammonia-Nitrogen Toxicity

The TMDL for Ammonia-Nitrogen (NH_3-N) is based on MDEQ background water regulations at 7.0 pH and 26°C which is 2.82 mg/l NH_3-N. Ammonia is a component of the TN TMDL. Since the TMDL target for TN is 0.7 mg/l, which is smaller than the limit for ammonia toxicity at 2.86 mg/l, then the TN TMDL will be the controlling TMDL for ammonia in this watershed.

WATER BODY ASSESSMENT

2.1 Water Quality Data

The impaired segment was monitored and found to be biologically impaired due to organic enrichment, ammonia toxicity, and nutrients. There are limited chemical data available in the watershed.

2.2 Assessment of Point Sources

There are 2 NPDES point sources in the watershed included in the TMDL. GP Plywood has multiple outlets. Other NPDES permitted facilities are no longer active sources in the watershed and are not included in the model developed for this TMDL. Table 5 indicates the existing estimates of loads for these outfalls at the maximum daily load scenario (See section 3.5.2). GP requested the loads indicated for the resin plant be given to the plywood plant. The Resin plant is permanently closed.

Table 5. Loads from the Point Sources used in the STREAM model for maximum loads

Permit	Facility	Flow MGD	TN Load lbs/day	TP Load lbs/day	CBODu lbs/day	NBODu lbs/day	TBODu lbs/day
MS0028380 001	**GP Resin**	**0.06**	**0.05**	**2.55**	**3.68**	**0.22**	**3.90**
MS0028380 002	**GP Resin**	**0.05**	**9.80**	**0.00**	**8.14**	**14.65**	**22.79**
MS0002186 001	**GP Ply**	**0.08**	**0.43**	**3.26**	**40.70**	**1.95**	**42.65**
MS0002186 002	**GP Ply**	**0.01**	**0.01**	**0.00**	**0.50**	**0.04**	**0.54**
MS0002186 003	**GP Ply**	**0.10**	**0.91**	**0.00**	**8.72**	**4.18**	**12.90**
MS0002186 004	**GP Ply**	**0.03**	**0.03**	**1.39**	**2.00**	**0.12**	**2.13**
MS0020796*	**Louisville**	**0.60**	**57.61**	**26.05**	**90.17**	**45.79**	**135.96**
	Total		**68.83**	**33.24**	**153.91**	**66.94**	**220.86**

* to achieve the maximum load, the Louisville POTW load was increased from 10 $CBOD_5$ to 12 $CBOD_5$

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff, groundwater infiltration, and atmospheric deposition. The two primary nutrients of concern are nitrogen and phosphorus. Total nitrogen is a combination of many forms of nitrogen found in the environment. Inorganic nitrogen can be transported in particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen can be transported in groundwater and may enter a water body from groundwater infiltration. Finally, atmospheric gaseous nitrogen may enter a water body from atmospheric deposition.

Unlike nitrogen, phosphorus is primarily transported in surface runoff when it has been sorbed by eroding sediment. Phosphorus may also be associated with fine-grained particulate matter in the atmosphere and can enter streams as a result of dry fallout and rainfall (USEPA, 1999). However, phosphorus is typically not readily available from the atmosphere or the natural water supply (Davis and Cornwell, 1988). As a result, phosphorus is typically the limiting nutrient in most non-point source dominated rivers and streams, with the exception of watersheds which are dominated by agriculture and have high concentrations of phosphorus contained in the surface runoff due to fertilizers and animal excrement or watersheds with naturally occurring soils which are rich in phosphorus (Thomann and Mueller, 1987).

Watersheds with a large number of failing septic tanks may also deliver significant loadings of phosphorus to a water body. All domestic wastewater contains phosphorus which comes from humans and the use of phosphate containing detergents. Table 5 presents the estimated loads from various land use types in the Pearl Basin based on information from USDA ARS Sedimentation Laboratory. (Shields, et. al., 2008)

The watershed contains mainly forest land but also has different landuse types, including urban, water, and wetlands. The land use information for the watershed is based on the National Land Cover Database (NLCD). Forest is the dominant landuse within this watershed. The landuse distribution for the Hughes Creek Watershed is shown in Table 5 and Figure 3. By multiplying the landuse category size by the estimated nutrient load, the watershed specific estimate can be calculated. Table 5 presents the estimated loads, the target loads, and the reductions needed to meet the TMDLs.

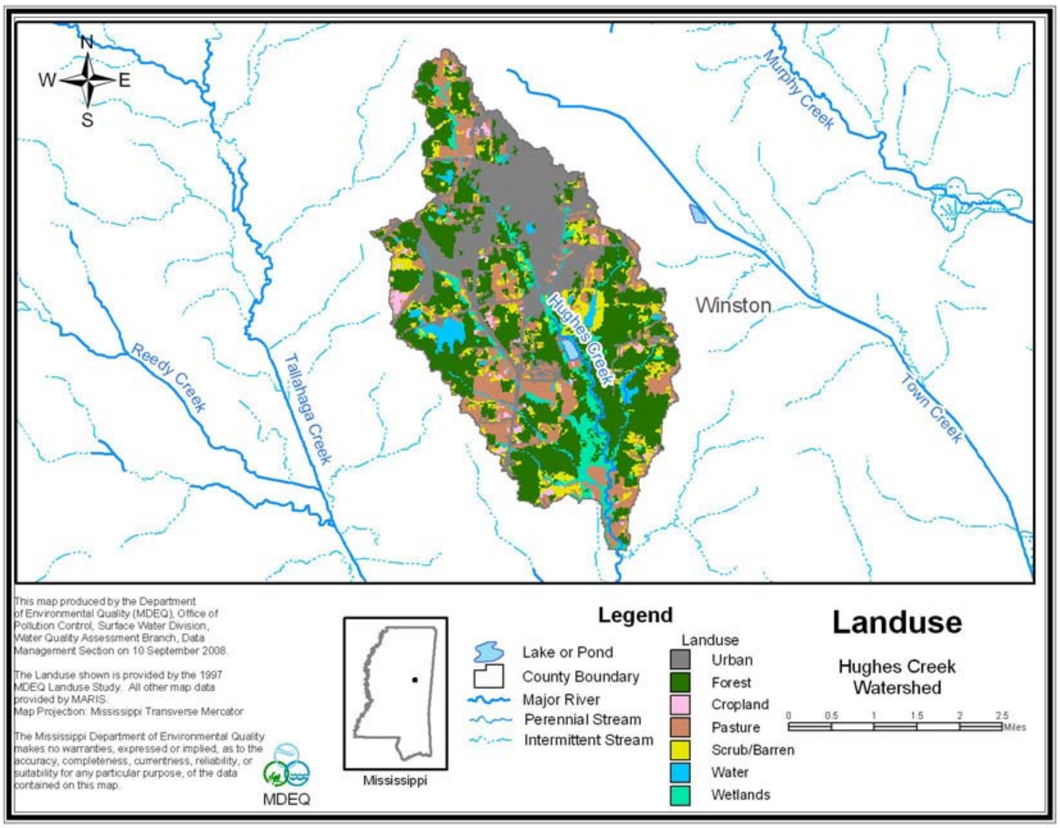


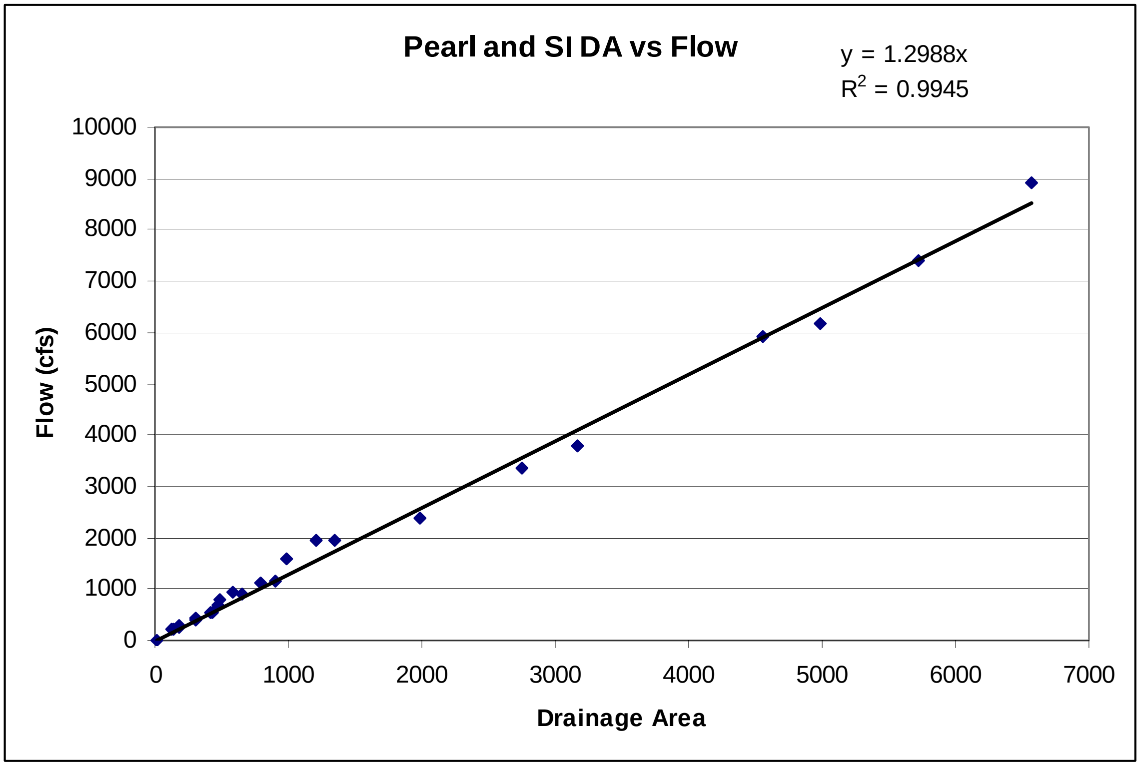
Figure 3. Hughes Creek Watershed Landuse

2.4 Estimated Existing Load for Total Nitrogen and Total Phosphorus

The average annual flow in the watershed was calculated by utilizing the flow vs. watershed area graph shown in Figure 4 below. All available gages were compared to the watershed size. A very strong correlation between flow and watershed size was developed for the Pearl and South

Independent Streams Basins. The equation for the line that best fits the data was then used to estimate the annual average flow for the Hughes Creek watershed. The TMDL target TN and TP loads were then calculated, using Equation 1 and the results are shown in Table 6.

Figure 4. Pearl and South Independent Drainage Area to Flow Comparison



Nutrient Load (lb/day) = Flow (cfs) * 5.394 (conversion factor)* Nutrient Concentration (mg/L) (Equation 1)

Table 6. TMDL Calculations and Watershed Sizes

Water body	**Hughes Creek**
Land Use	**TN kg/mile2**
Forest	111.3
Pasture	777.2
Cropland	5179.9
Urban	296.4
Water	257.4
Wetland	265.2
aquaculture	111.3
Land Use	**TP kg/mile2**
Forest	62.1
Pasture	777.2
Cropland	2589.9
Urban	3.1
Water	257.4
Wetland	265.2
aquaculture	62.1

	Water	**Urban**	**Scrub/Barren**	**Forest**	**Pasture/Grass**	**Cropland**	**Wetland**	**Total**	
Acres	183.3	1757.8	606.5	2764.2	1150.2	115.9	450.4	7028	
Percent	2.61%	25.01%	8.63%	39.33%	16.37%	1.65%	6.41%	100.00%	
Miles^2 in watershed	0.3	2.7	0.9	4.3	1.8	0.2	0.7	11.0	
Flow in cfs based on area	14.3	cfs							
TN Load kg/mi^2 annual avg	257.4	296.4	111.3	111.3	777.2	5179.9	265.2		
TP Load kg/mi^2 annual avg	257.4	3.1	62.1	62.1	777.2	2589.9	265.2		
TN Load kg/day	0.2	2.2	0.3	1.3	3.8	2.6	0.5	10.9	kg/day
TP Load kg/day	0.2	0.0	0.2	0.7	3.8	1.3	0.5	6.7	kg/day
TN target concentration	0.7	mg/l							
TP target concentration	0.1	mg/l							
TN estimated concentration	0.31	mg/l							
TP estimated concentration	0.19	mg/l							
TN target load	53.85	lbs/day							
TP target load	7.69	lbs/day							
TBODu target load	220.86	lbs/day	(based on STREAM model output)						
TN estimated load per day	24.13	lbs/day							
TP estimated load per day	14.87	lbs/day							
TN reduction needed	*NA*								
TP reduction needed	48.26%								
TBODu reduction needed	*NA*								

The land use calculations are based on 2004 data. The nutrient estimates are based on USDA ARS. The TMDL targets are based on EPA guidance for calculation of targets when considering all available data.

MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain water body responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

3.1 Modeling Framework Selection

A mathematical model, STeady Riverine Environmental Assessment Model (STREAM), for DO distribution in freshwater streams was used for developing the TMDL. STREAM is an updated version of the AWFWUL1 model, which had been used by MDEQ for many years. The use of AWFWUL1 is promulgated in the *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification* (MDEQ, 1994). This model has been approved by EPA and has been used extensively at MDEQ. A key reason for using the STREAM model in TMDL development is its ability to assess instream water quality conditions in response to point and non-point source loadings.

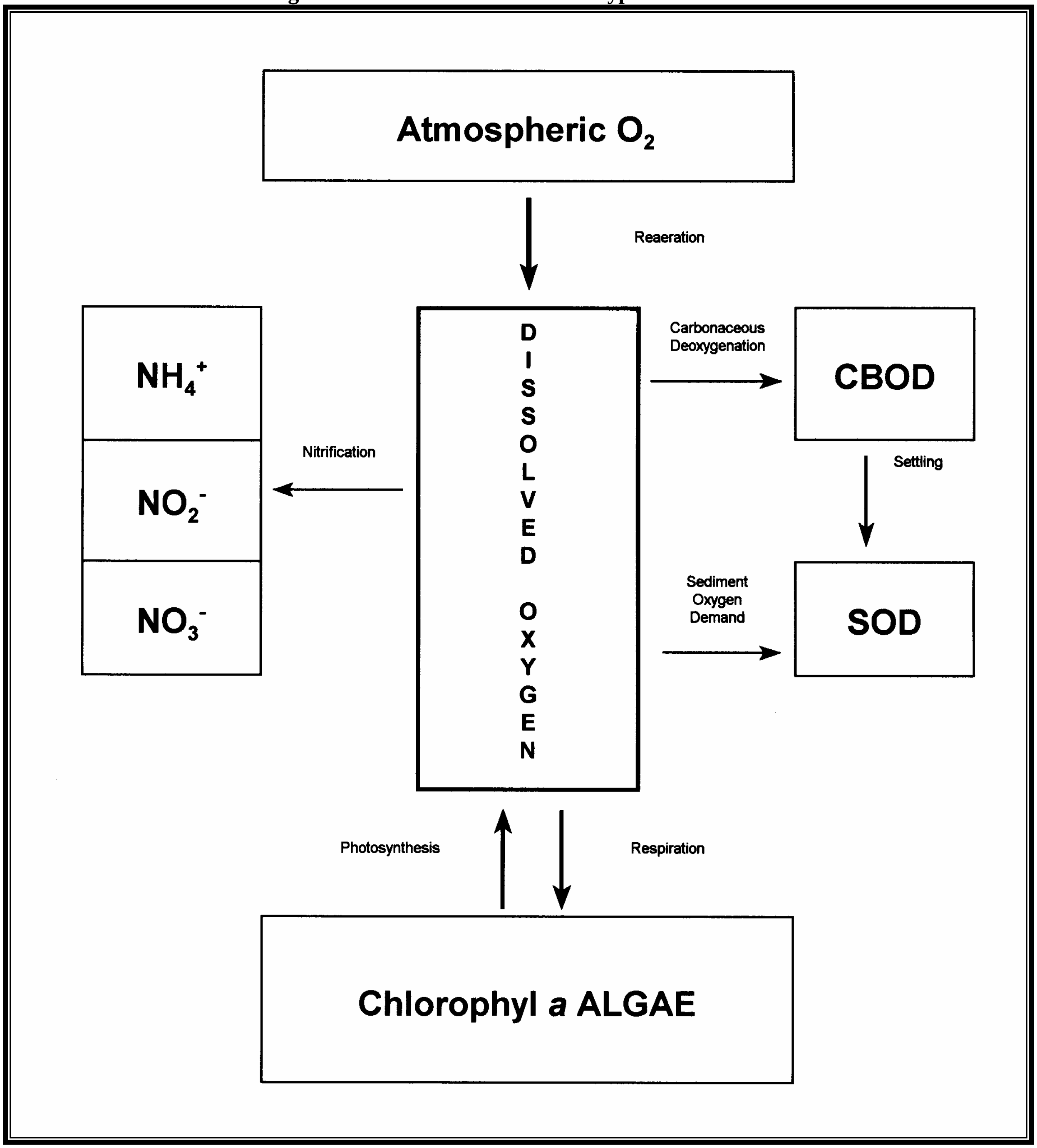
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes are related in a typical DO model. Reaction rates for the instream processes are input by the user and corrected for temperature by the model. The model output includes water quality conditions in each computational element for DO, CBODu, and NH_3-N concentrations. The hydrological processes simulated by the model include stream velocity and flow from point sources and spatially distributed inputs.

The model was set up to calculate reaeration within each reach using the Tsivoglou formulation. The Tsivoglou formulation calculates the reaeration rate, K_a (day^{-1} base e), within each reach according to Equation 2.

$$\mathbf{K_a = C*S*U} \qquad \textbf{(Eq. 2)}$$

C is the escape coefficient, U is the reach velocity in mile/day, and S is the average reach slope in ft/mile. The value of the escape coefficient is assumed to be 0.11 for streams with flows less than 10 cfs and 0.0597 for stream flows equal to or greater than 10 cfs. Reach velocities were calculated using an equation based on slope. The slope of each reach was estimated with the NHD Plus GIS coverage and input into the model in units of feet/mile.

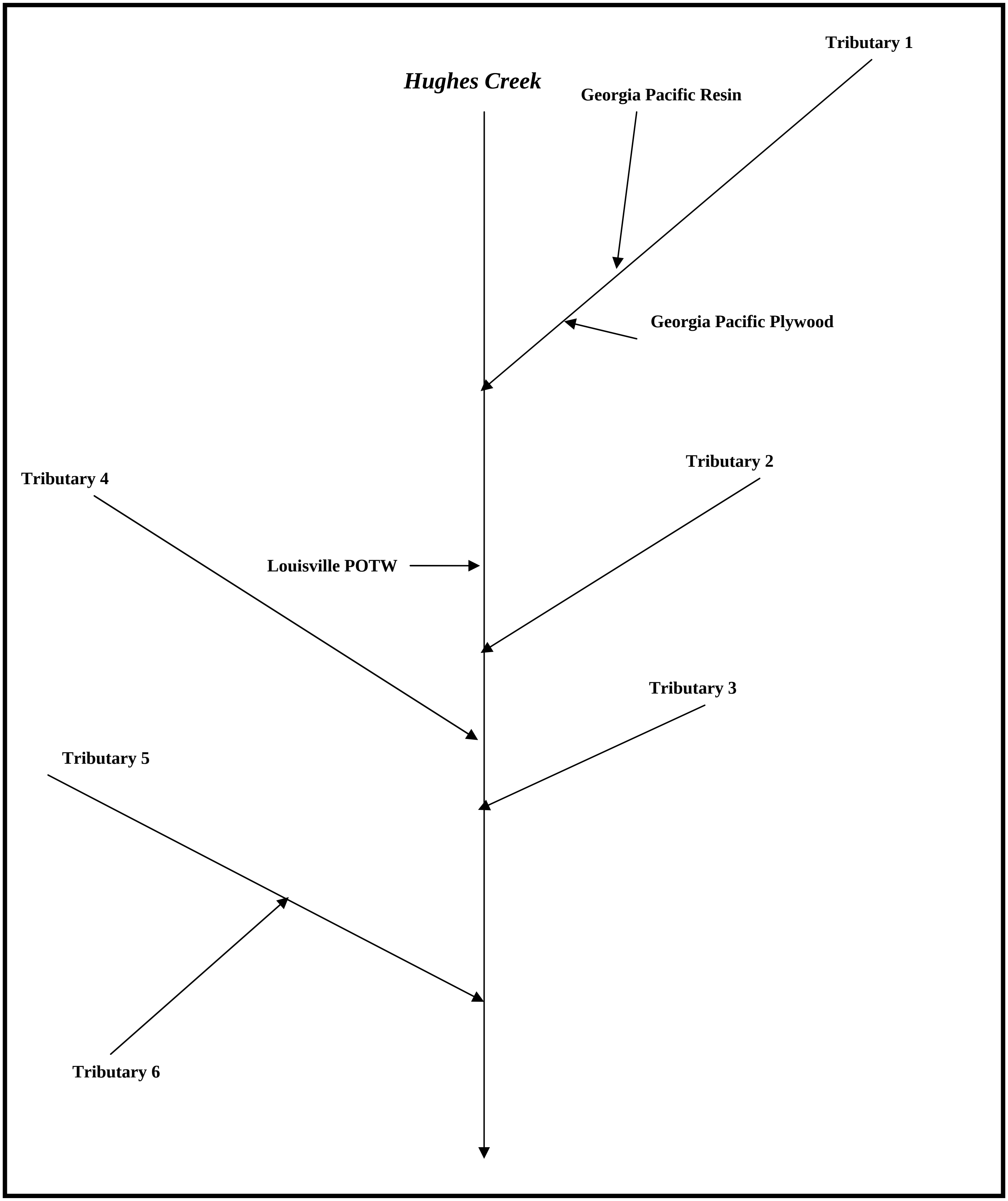
Figure 5. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for this TMDL includes the §303(d) listed segment of Hughes Creek, beginning at the headwaters. A diagram showing the model setup is shown in Figure 6.

Figure 6. Hughes Creek Model Setup (Note: Not to Scale)



The water body was divided into reaches for modeling purposes. Reach divisions were made at locations where there is a significant change in hydrological and water quality characteristics, such as the confluence of a point source or tributary. Within each reach, the modeled segments were divided into computational elements of 0.1 mile. The simulated hydrological and water quality characteristics were calculated and output by the model for each computational element.

The STREAM model was setup to simulate flow and temperature conditions, which were determined to be the critical condition for this TMDL. MDEQ Regulations state that when the flow in a water body is less than 50 cfs, the temperature used in the model is 26°C. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream CBODu decay rate at K_d at 20°C was input as 0.3 day^{-1} (base e) as specified in MDEQ regulations. The model adjusts the K_d rate based on temperature, according to Equation 3.

$$\mathbf{K_{d(T)} = K_{d(20°C)}(1.047)^{T-20}} \qquad \textbf{(Eq. 3)}$$

Where K_d is the CBODu decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and CBODu decay rate are required by the *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). Also based on MDEQ Regulations, the rates for photosynthesis, respiration, and sediment oxygen demand were set to zero because data for these model parameters are not available.

Hughes Creek currently has no USGS flow gage. The flow in Hughes Creek watershed was modeled at critical conditions based on the 7Q10 from USGS Water-Resources Investigation Report 90-4130 Low-Flow and Flow Duration Characteristics of Mississippi Streams (Telis, 1991). See Appendix 1 for the STREAM model text file.

3.3 Source Representation

Both point and non-point sources were represented in the model. The loads from the NPDES permitted point sources was added as a direct input into the appropriate reaches as a flow in MGD and concentration of $CBOD_5$ and ammonia nitrogen in mg/l. Spatially distributed loads, which represent non-point sources of flow, $CBOD_5$, and ammonia-nitrogen were distributed evenly into each computational element of the modeled water body.

Organic material discharged to a stream from an NPDES permitted point source is typically quantified as 5-day biochemical oxygen demand (BOD_5). BOD_5 is a measure of the oxidation of carbonaceous and nitrogenous material over a 5-day incubation period. However, oxidation of nitrogenous material, called nitrification, usually does not take place within the 5-day period because the bacteria that are responsible for nitrification are normally not present in large numbers and have slow reproduction rates (Metcalf and Eddy, 1991). Thus, BOD_5 is generally considered equal to $CBOD_5$. Because permits for point source facilities are written in terms of

$CBOD_5$ while TMDLs are typically developed using CBODu, a ratio between the two terms is needed, Equation 4.

$$\textbf{CBODu} = \textbf{CBOD}_5 * \textbf{Ratio} \qquad \textbf{(Eq. 4)}$$

The CBODu to $CBOD_5$ ratios are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). These values are recommended for use by MDEQ regulations when actual field data are not available. The value of the ratio depends on the wastewater treatment type.

In order to convert the ammonia nitrogen (NH_3-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen (NH_3-N) oxidized to nitrate nitrogen (NO_3-N) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification. The oxygen demand caused by nitrification of ammonia is equal to the NBODu load. The sum of CBODu and NBODu is equal to the point source load of TBODu. The permitted loads of TBODu from the existing point sources to be used in the STREAM model are given in Table 7.

Table 7. Point Sources, Maximum Permitted Model Inputs

NPDES	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/l)	$CBOD_u$: $CBOD_5$ Ratio	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
MS0028380 001	0.06	5	0.1	1.5	3.68	0.22	3.90
MS0028380 002	0.05	13	10.0	1.5	8.14	11.45	19.59
MS0002186 001	0.08	13	0.68	5.0	40.70	1.95	42.65
MS0002186 002	0.01	4	0.1	1.5	0.50	0.04	0.54
MS0002186 003	0.10	7	1.1	1.5	8.72	4.18	12.90
MS0002186 004	0.03	5	0.1	1.5	2.00	0.12	2.13
MS0020796	0.60	10	2.0	1.5	75.14	17.92	93.06
					138.89	35.87	174.75

Direct measurements of background concentrations of CBODu were not available for Hughes Creek. Because there were no data available, the background concentrations of CBODu and NH_3-N were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentration used in modeling for BOD_5 is 1.33 mg/l and for NH_3-

N is 0.1 mg/l. These concentrations were also used as estimates for the CBODu and NH_3-N levels of water entering the water bodies through non-point source flow and tributaries.

Non-point source flows were included in the model to account for water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data for the 7Q10 flow condition in Hughes Creek watershed. The non-point source loads were assumed to be distributed evenly on a river mile basis throughout the modeled reaches.

3.4 Model Calibration

The model used to develop Hughes Creek TMDL was not calibrated due to lack of instream monitoring data collected during critical conditions. Future monitoring is essential to improve the accuracy of the model and the results.

3.5 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in Hughes Creek. The model was first run under regulatory load conditions. Under regulatory load conditions, the loads from the NPDES permitted point sources were based on their current location and loads shown in Table 7.

At these limits, no reduction was indicated for point sources to meet the current TMDL. That it, there is a small amount of assimilative capacity in the stream. The model was used to calculate the TMDL by increasing the load from the Louisville facility until the water quality standard was achieved in the stream. The regulatory load scenario model results are shown in Figure 7.

3.5.1 Regulatory Load Scenario

As shown in the figure, the model predicts that the DO does not go below the standard of 5.0 mg/l using the permit based allowable loads, thus reductions are not needed. Regulatory load scenario model output for ammonia nitrogen is shown in Figure 8. The modeled ammonia nitrogen is below the water quality standard of 2.82 mg/l NH_3-N, however monitored ammonia data indicate reductions are needed from stormwater runoff. As previously discussed, ammonia toxicity will also be controlled if the TMDL target for TN of 0.7 mg/l is achieved.

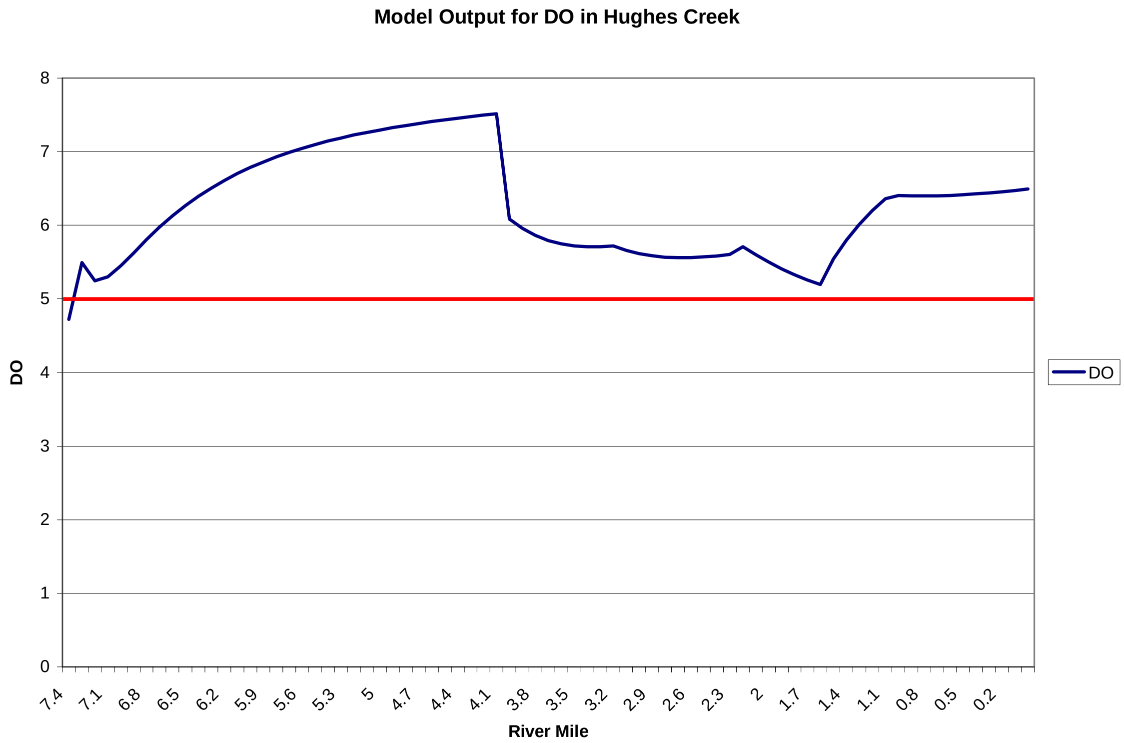


Figure 7. Model Output for DO in Hughes Creek, Regulatory Load Scenario

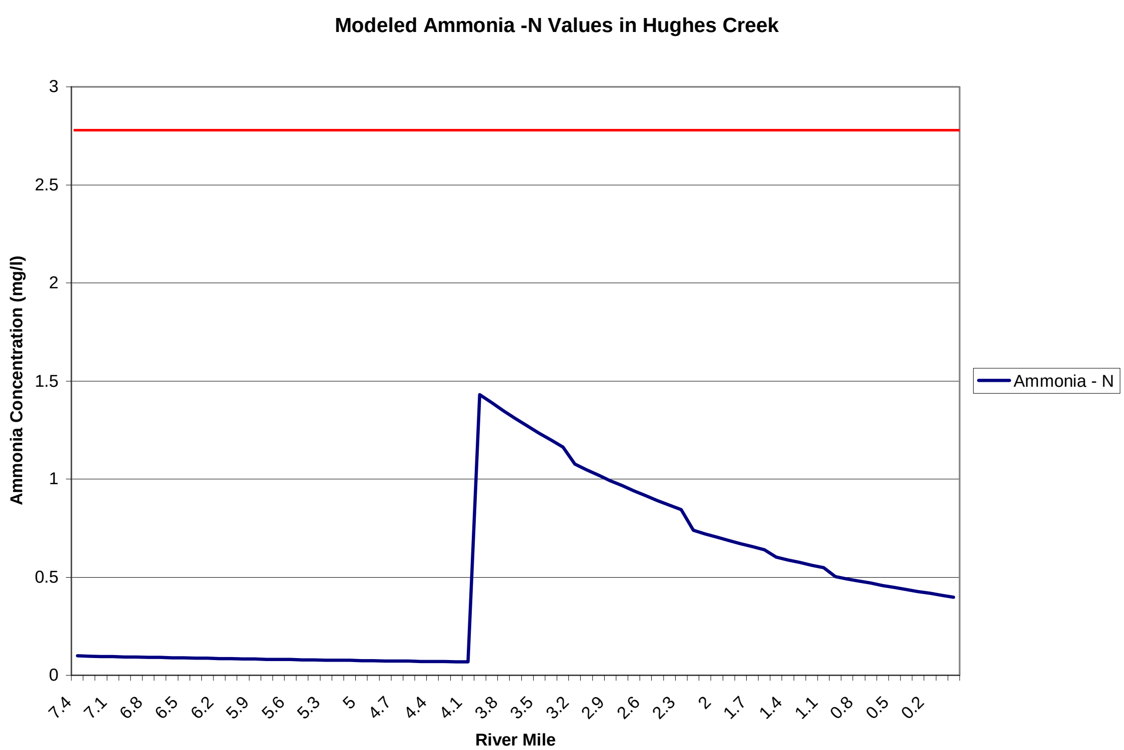


Figure 8. Model Output for Ammonia Nitrogen in Hughes Creek, Regulatory Load Scenario

3.5.2 Maximum Load Scenario

The graph of the regulatory load scenario output shows that the predicted DO does not fall below the DO standard in Hughes Creek during critical conditions. Thus, reductions of the loads of TBODu are not necessary. Calculating the maximum allowable load of TBODu involved increasing the model loads until the modeled DO was just above 5.0 mg/l. The non-point source loads in this model were already set at background conditions based on MDEQ regulations so no non point source reductions were necessary. Thus, the permitted limits were increased until the modeled DO was 5.0 mg/L. The increased loads were then used to develop the allowable maximum daily load for this report.

3.6 Evaluation of Ammonia Toxicity

Ammonia must not only be considered due to its effect on dissolved oxygen in the receiving water, but also its toxicity potential. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l. Based on the model results from the maximum load scenario, Figure 8, this standard was not exceeded in Hughes Creek. And as previously discussed, the TMDL target for TN of 0.7 mg/l will also control ammonia toxicity.

ALLOCATION

4.1 Wasteload Allocation

The organic enrichment TMDL indicates that no reduction is needed from the point sources. However, reduction is needed in the total phosphorus and total nitrogen coming from the point sources. And while the modeling indicated there is no reduction needed from point sources for ammonia toxicity, the data collected at the IBI monitoring indicated possible ammonia toxicity. Therefore, ammonia limits are also needed in this watershed. Table 8 indicates the reduction scenario selected for this TMDL.

To achieve these reductions in the model, the Georgia Pacific Resin facility had TP reduced at outfall 001 from an estimate of 5.2 mg/l to 1.0 mg/l. The TN was reduced at outfall 002 from 23.48 mg/l to 10 mg/l. The Georgia Pacific Plywood facility had TP reduced at outfall 001 and outfall 004 from an estimate of 5.2 mg/l to 1.0 mg/l. The Louisville POTW had TP reduced from an estimate of 5.2 mg/l to a cap at 1.0 mg/l. It also had TN reduced from an estimate of 11.5 mg/l to a cap at 4.5 mg/l. These reductions establish WLAs that correspond to the TMDL targets for nutrients as given in Table 6.

During the public notice review of this TMDL, GP indicated that the resin facility closed permanently and requested the nutrient and organic load assigned to the resin facility be transferred to the plywood facility. This request was granted.

Future permits will be considered in accordance with Mississippi's *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification*(1994).

Table 8. TMDL Loads for TN, TP, and TBODu

Permit	Facility	Flow MGD	TN Load lbs/day	TP Load lbs/day	CBODu lbs/day	NBODu lbs/day	TBODu lbs/day
MS0028380 001	**GP Resin**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
MS0028380 002	**GP Resin**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
MS0002186 001	**GP Ply**	**0.08**	**1.43**	**0.88**	**47.37**	**1.95**	**49.32**
MS0002186 002	**GP Ply**	**0.01**	**1.06**	**0.00**	**7.17**	**0.04**	**7.21**
MS0002186 003	**GP Ply**	**0.10**	**1.91**	**0.00**	**15.39**	**4.18**	**19.57**
MS0002186 004	**GP Ply**	**0.03**	**1.20**	**0.51**	**8.68**	**0.12**	**8.8**
MS0020796	**Louisville**	**0.60**	**22.54**	**5.01**	**75.14**	**17.92**	**93.06**
	Total		**28.14**	**6.39**	**138.89**	**35.87**	**174.75**

4.2 Load Allocation

Best management practices (BMPs) should be encouraged in the watersheds to reduce potential TBODu, TN, and TP loads from non-point sources. The LA for TBODu, TN, and TP was calculated by subtracting the WLA from the TMDL. For land disturbing activities related to silviculture, construction, and agriculture, it is recommended that practices, as outlined in "Mississippi's BMPs: Best Management Practices for Forestry in Mississippi" (MFC, 2000), "Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater" (MDEQ, et. al, 1994), and "Field Office Technical Guide" (NRCS, 2000), be followed, respectively.

4.3 Incorporation of a Margin of Safety

The margin of safety is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water body. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit.

4.4 Calculation of the TMDL

Equation 1 was used to calculate the TMDL for TP and TN (see Table 6). The target concentration was used with the average flow for the watershed to determine the nutrient TMDLs. The allocations in the TMDL are established to attain the applicable water quality standards.

Table 9. TMDL Loads

	WLA lbs/day	LA lbs/day	MOS	TMDL lbs/day
Total Nitrogen	**28.14**	**25.71**	**Implicit**	**53.85**
Total Phosphorous	**6.39**	**1.30**	**Implicit**	**7.69**
TBODu	**174.75**	**46.11**	**Implicit**	**220.86**

The nutrient TMDL loads were then compared to the estimated existing loads previously calculated. A 48.26% reduction in TP loading is recommended based on the Land Use Land Cover estimate provided in Table 6. A TN reduction is not indicated by the estimates in Table 6, however, the data indicate a TN reduction is needed.

The TN TMDL calculations indicate a WLA of 68.83 lbs. in Table 5 and a LA of 24.13 lbs. in Table 6. This sums to a load of 92.96 lbs./day. The TN TMDL target load is 53.85 which is a reduction of 39.11 lbs. or 42%. The WLA needs to reduce from 68.83 lbs. to 28.14 lbs.

The TP TMDL calculations indicate a WLA of 32.34 lbs. in Table 5 and a LA of 14.87 lbs. in Table 6. This sums to a load of 47.11 lbs./day. The TP TMDL target load is 7.69 lbs. which is a reduction of 39.42 lbs. or 83.6%. The WLA needs to reduce from 32.24 lbs. to 6.39 lbs. The LA needs to reduce from 14.87 lbs. to 1.30 lbs.

For the LA, the same Best Management Practices (BMPs) will control both nutrients. Best management practices are encouraged in this watershed to reduce the nonpoint nutrient loads.

3.5 Seasonality and Critical Condition

This TMDL accounts for seasonal variability by requiring allocations that ensure year-round protection of water quality standards, including during critical conditions.

CONCLUSION

Nutrients were addressed through an estimate of a preliminary total phosphorous concentration target and a preliminary total nitrogen concentration target. Based on the estimated existing and target total phosphorous concentrations, this TMDL recommends a reduction of the point and nonpoint phosphorous and nitrogen loads entering these water bodies to meet the preliminary target of TP at 0.10 mg/l and TN at 0.7 mg/l. The implementation of BMP activities should reduce the nutrient load entering the creeks. The current TBODu loads are below the model TMDL limits, therefore no reduction is needed at this time for TBODu. These limits will provide improved water quality for organic enrichment and the support of aquatic life in the water bodies, and will result in the attainment of the applicable water quality standards.

4.1 Next Steps

MDEQ's Basin Management Approach and Nonpoint Source Program emphasize restoration of impaired waters with developed TMDLs. During the watershed prioritization process to be conducted by the Pearl River Basin Team, this TMDL will be considered as a basis for implementing possible restoration projects. The basin team is made up of state and federal resource agencies and stakeholder organizations and provides the opportunity for these entities to work with local stakeholders to achieve quantifiable improvements in water quality. Together, basin team members work to understand water quality conditions, determine causes and sources of problems, prioritize watersheds for potential water quality restoration and protection activities, and identify collaboration and leveraging opportunities. The Basin Management Approach and the Nonpoint Source Program work together to facilitate and support these activities.

The Nonpoint Source Program provides financial incentives to eligible parties to implement appropriate restoration and protection projects through the Clean Water Act's Section 319 Nonpoint Source (NPS) Grant Program. This program makes available around $1.6M each grant year for restoration and protections efforts by providing a 60% cost share for eligible projects.

Mississippi Soil and Water Conservation Commission (MSWCC) is the lead agency responsible for abatement of agricultural NPS pollution through training, promotion, and installation of BMPs on agricultural lands. USDA Natural Resource Conservation Service (NRCS) provides technical assistance to MSWCC through its conservation districts located in each county. NRCS assists animal producers in developing nutrient management plans and grazing management plans. MDEQ, MSWCC, NRCS, and other governmental and nongovernmental organizations work closely together to reduce agricultural runoff through the Section 319 NPS Program.

Mississippi Forestry Commission (MFC), in cooperation with the Mississippi Forestry Association (MFA) and Mississippi State University (MSU), have taken a leadership role in the development and promotion of the forestry industry Best Management Practices (BMPs) in Mississippi. MDEQ is designated as the lead agency for implementing an urban polluted runoff control program through its Stormwater Program. Through this program, MDEQ regulates most construction activities. Mississippi Department of Transportation (MDOT) is responsible for implementation of erosion and sediment control practices on highway construction.

Due to this TMDL, projects within this watershed will receive a higher score and ranking for funding through the basin team process and Nonpoint Source Program described above.

4.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDLs and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. Anyone wishing to become a member of the TMDL mailing list should contact Kay Whittington at Kay_Whittington@deq.state.ms.us.

All comments should be directed to Kay_Whittington@deq.state.ms.us or Kay Whittington, MDEQ, PO Box 10385, Jackson, MS 39289. All comments received during the public notice period and at any public hearings become a part of the record of this TMDL and will be considered in the submission of this TMDL to EPA Region 4 for final approval.

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Appendix 1 – STREAM Model INPUT Text

```
1            BEGINNING AT RIVER MILE     1.3

                                  *** LOADS ***

                            DISSOLVED  CARBONACEOUS
                  FLOW     OXYGEN          BOD           TKN
                  (CFS)    (MG/L)      (LBS/DAY)     (LBS/DAY)
HEADWATER          .010     7.000          .11            .00
DIST. INPUT        .059     2.000          .64            .03

                                *** PARAMETERS ***

CS= 8.22 MG/L       PA=  .00 MG/L       RA=  .00 MG/L       S=  .00 MG/L

KR=  .15 /DAY       KD=  .15 /DAY       KN=  .30 /DAY       KA= 4.59 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU  SLOPE= 22.1 FT/MILE  ESCAPE COEF=  .11 /DAY

                             *** STREAM CONDITION ***

   RIVER    FLOW    DO   DEFICIT   CBOD      TKN    VEL
   MILE     CFS    MG/L    MG/L    MG/L     MG/L    FPS
   1.300    .017   4.878   3.343   1.998    .096    .100
   1.200    .017   5.665   2.556   1.975    .094    .100
   1.100    .025   5.435   2.786   1.959    .094    .100
   1.000    .032   5.490   2.730   1.945    .093    .100
    .900    .040   5.636   2.585   1.932    .092    .100
    .800    .047   5.806   2.414   1.920    .091    .100
    .700    .054   5.977   2.244   1.908    .090    .100
    .600    .062   6.137   2.083   1.896    .090    .100


1            BEGINNING AT RIVER MILE      .6

                                  *** LOADS ***

                            DISSOLVED  CARBONACEOUS
                  FLOW     OXYGEN          BOD           TKN
                  (CFS)    (MG/L)      (LBS/DAY)     (LBS/DAY)
UPSTREAM           .062     6.137          .63            .03
WASTE SOURCE       .091     6.000         1.47            .05    Resin 001
WASTE SOURCE       .077     6.000        13.00           3.19    Resin 002

                                *** PARAMETERS ***

CS= 8.22 MG/L       PA=  .00 MG/L       RA=  .00 MG/L       S=  .00 MG/L

KR=  .30 /DAY       KD=  .30 /DAY       KN=  .30 /DAY       KA= 4.59 /DAY
```

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 22.1 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
.600	.230	6.037	2.184	12.179	2.634	.100
.500	.230	6.087	2.134	11.901	2.574	.100
.400	.230	6.136	2.085	11.628	2.515	.100
.400	.230	6.136	2.085	11.628	2.515	.100

1 BEGINNING AT RIVER MILE .4

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)	
UPSTREAM	.230	6.136	14.42	3.12	
WASTE SOURCE	.153	6.000	8.66	.91	Plywood 003
WASTE SOURCE	.116	6.000	40.64	.43	Plywood 001
WASTE SOURCE	.015	6.000	.49	.01	Plywood 002
WASTE SOURCE	.050	6.000	2.02	.03	Plywood 004

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= 4.59 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 22.1 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
.400	.564	6.055	2.165	21.759	1.474	.100
.300	.564	6.015	2.205	21.261	1.440	.100
.200	.564	5.998	2.222	20.775	1.407	.100
.100	.564	5.998	2.222	20.299	1.375	.100
.000	.564	6.010	2.210	19.835	1.343	.100
.000	.564	6.010	2.210	19.835	1.343	.100

2 BEGINNING AT RIVER MILE 1.7

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.096	2.000	1.03	.05

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 6.09 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 29.4 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
1.700	.015	5.261	2.960	1.999	.095	.100
1.600	.015	6.152	2.069	1.976	.093	.100
1.500	.021	6.027	2.193	1.958	.093	.100
1.400	.026	6.111	2.110	1.944	.092	.100
1.300	.031	6.256	1.965	1.930	.091	.100
1.200	.037	6.412	1.809	1.917	.091	.100
1.100	.042	6.560	1.661	1.905	.090	.100
1.000	.047	6.694	1.526	1.894	.089	.100
.900	.053	6.814	1.407	1.882	.088	.100
.800	.058	6.919	1.302	1.871	.087	.100
.700	.063	7.011	1.209	1.860	.086	.100
.600	.069	7.092	1.128	1.849	.085	.100
.500	.074	7.164	1.057	1.838	.084	.100
.400	.079	7.227	.993	1.827	.083	.100
.300	.085	7.283	.937	1.817	.083	.100
.200	.090	7.333	.887	1.807	.082	.100
.100	.095	7.378	.843	1.796	.081	.100
.000	.101	7.418	.802	1.786	.080	.100
.000	.106	7.146	1.075	1.797	.081	.100

3 BEGINNING AT RIVER MILE .9

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.092	2.000	.99	.05

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 4.31 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 20.8 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
.900	.019	4.604	3.616	1.998	.096	.100
.800	.019	5.411	2.809	1.975	.094	.100
.700	.028	5.183	3.038	1.960	.094	.100
.600	.038	5.258	2.963	1.946	.094	.100
.500	.047	5.422	2.798	1.933	.093	.100
.400	.056	5.609	2.612	1.922	.092	.100
.300	.065	5.793	2.427	1.910	.091	.100
.200	.074	5.966	2.254	1.899	.090	.100
.100	.084	6.124	2.096	1.887	.089	.100
.000	.093	6.267	1.953	1.876	.088	.100

4 BEGINNING AT RIVER MILE 3.5

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.255	2.000	2.75	.14

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 4.67 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 22.5 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
3.500	.017	4.927	3.294	1.998	.095	.100
3.400	.017	5.714	2.506	1.975	.093	.100
3.300	.024	5.488	2.732	1.959	.093	.100
3.200	.031	5.542	2.678	1.945	.092	.100
3.100	.038	5.686	2.535	1.932	.091	.100

3.000	.045	5.854	2.367	1.919	.091	.100
2.900	.052	6.021	2.199	1.908	.090	.100
2.800	.060	6.179	2.041	1.896	.089	.100
2.700	.067	6.324	1.897	1.885	.088	.100
2.600	.074	6.455	1.766	1.874	.087	.100
2.500	.081	6.572	1.649	1.863	.086	.100
2.400	.088	6.677	1.544	1.852	.085	.100
2.300	.095	6.770	1.450	1.841	.084	.100
2.200	.102	6.855	1.366	1.831	.083	.100
2.100	.109	6.930	1.291	1.820	.082	.100
2.000	.116	6.998	1.223	1.810	.082	.100
1.900	.123	7.059	1.161	1.800	.081	.100
1.800	.130	7.115	1.106	1.790	.080	.100
1.700	.137	7.165	1.055	1.780	.079	.100
1.600	.145	7.211	1.009	1.770	.078	.100
1.500	.152	7.253	.967	1.760	.077	.100
1.400	.159	7.292	.929	1.750	.077	.100
1.300	.166	7.327	.893	1.740	.076	.100
1.200	.173	7.360	.861	1.730	.075	.100
1.100	.180	7.390	.830	1.721	.074	.100
1.000	.187	7.418	.802	1.711	.073	.100
.900	.194	7.444	.776	1.702	.073	.100
.800	.201	7.469	.752	1.693	.072	.100
.700	.208	7.492	.729	1.683	.071	.100
.600	.215	7.513	.708	1.674	.071	.100
.500	.222	7.533	.688	1.665	.070	.100
.400	.230	7.552	.669	1.656	.069	.100
.300	.237	7.569	.651	1.647	.068	.100
.200	.244	7.586	.634	1.638	.068	.100
.100	.251	7.602	.619	1.629	.067	.100
.000	.258	7.617	.604	1.620	.066	.100

6 BEGINNING AT RIVER MILE 1.2

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.042	2.000	.45	.02

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 7.37 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 35.5 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
1.200	.013	5.779	2.441	1.999	.095	.100
1.100	.013	6.637	1.584	1.976	.093	.100
1.000	.016	6.603	1.617	1.958	.092	.100
.900	.020	6.681	1.540	1.942	.092	.100
.800	.023	6.792	1.429	1.927	.091	.100
.700	.026	6.906	1.315	1.913	.090	.100
.600	.029	7.012	1.208	1.901	.089	.100
.500	.033	7.108	1.113	1.888	.088	.100
.400	.036	7.192	1.029	1.876	.087	.100
.300	.039	7.265	.955	1.864	.087	.100
.200	.042	7.330	.891	1.853	.086	.100
.100	.046	7.387	.834	1.842	.085	.100
.000	.049	7.437	.784	1.831	.084	.100
.000	.052	7.099	1.122	1.841	.085	.100

5 BEGINNING AT RIVER MILE 2.8

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.067	2.000	.72	.04

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 6.09 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 29.4 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
2.800	.013	5.872	2.349	1.999	.094	.100
2.700	.013	6.573	1.647	1.976	.092	.100
2.600	.016	6.477	1.744	1.957	.091	.100
2.500	.019	6.511	1.709	1.940	.090	.100
2.400	.022	6.596	1.624	1.925	.090	.100
2.300	.025	6.698	1.523	1.911	.089	.100
2.200	.027	6.801	1.420	1.898	.088	.100
2.100	.030	6.898	1.323	1.886	.087	.100
2.000	.033	6.987	1.233	1.873	.086	.100

1.900	.036	7.068	1.153	1.862	.085	.100
1.800	.039	7.140	1.081	1.850	.084	.100
1.700	.042	7.204	1.016	1.839	.083	.100
1.600	.045	7.262	.959	1.828	.082	.100
1.500	.048	7.314	.907	1.817	.082	.100
1.400	.051	7.360	.860	1.806	.081	.100
1.300	.054	7.402	.818	1.795	.080	.100
1.200	.057	7.440	.781	1.785	.079	.100
1.100	.060	7.474	.746	1.774	.078	.100
1.000	.062	7.506	.715	1.764	.077	.100
.900	.065	7.534	.686	1.754	.077	.100
.800	.068	7.561	.660	1.744	.076	.100
.700	.071	7.585	.636	1.734	.075	.100
.600	.074	7.607	.613	1.724	.074	.100

5 BEGINNING AT RIVER MILE .6

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
UPSTREAM	.074	7.607	.69	.03
DIST. INPUT	.058	2.000	.63	.03
6	.052	7.099	.52	.02

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 4.05 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 19.5 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
.600	.134	7.065	1.156	1.786	.080	.100
.500	.134	7.292	.928	1.766	.078	.100
.400	.143	7.230	.991	1.759	.077	.100
.300	.151	7.197	1.024	1.751	.077	.100
.200	.159	7.184	1.036	1.744	.076	.100
.100	.168	7.186	1.035	1.736	.076	.100
.000	.176	7.196	1.024	1.728	.075	.100
.000	.184	6.962	1.258	1.740	.076	.100

HUGHES BEGINNING AT RIVER MILE 7.4

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
HEADWATER	.010	7.000	.11	.00
DIST. INPUT	.276	2.000	2.98	.15

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .15 /DAY KD= .15 /DAY KN= .30 /DAY KA= 4.26 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 20.5 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
7.400	.018	4.760	3.461	1.998	.096	.100
7.300	.018	5.523	2.698	1.975	.094	.100
7.200	.026	5.271	2.949	1.959	.093	.100
7.100	.034	5.322	2.899	1.945	.093	.100
7.000	.042	5.467	2.753	1.932	.092	.100
6.900	.051	5.640	2.580	1.920	.091	.100
6.800	.059	5.815	2.406	1.908	.090	.100
6.700	.067	5.980	2.240	1.897	.089	.100
6.600	.075	6.133	2.087	1.886	.088	.100
6.500	.083	6.272	1.948	1.875	.088	.100
6.400	.091	6.398	1.823	1.864	.087	.100
6.300	.099	6.511	1.710	1.853	.086	.100
6.200	.107	6.612	1.608	1.842	.085	.100
6.100	.116	6.704	1.517	1.832	.084	.100
6.000	.124	6.787	1.434	1.822	.083	.100
5.900	.132	6.861	1.359	1.811	.082	.100
5.800	.140	6.929	1.292	1.801	.081	.100
5.700	.148	6.990	1.230	1.791	.080	.100
5.600	.156	7.046	1.175	1.781	.080	.100
5.500	.164	7.097	1.124	1.771	.079	.100
5.400	.172	7.144	1.077	1.761	.078	.100
5.300	.180	7.187	1.034	1.751	.077	.100
5.200	.189	7.226	.994	1.741	.076	.100
5.100	.197	7.263	.958	1.732	.075	.100
5.000	.205	7.296	.924	1.722	.075	.100
4.900	.213	7.328	.893	1.713	.074	.100
4.800	.221	7.357	.864	1.703	.073	.100
4.700	.229	7.384	.836	1.694	.072	.100

4.600	.237	7.410	.811	1.685	.072	.100
4.500	.245	7.433	.787	1.675	.071	.100
4.400	.254	7.456	.765	1.666	.070	.100
4.300	.262	7.477	.744	1.657	.070	.100
4.200	.270	7.497	.724	1.648	.069	.100
4.100	.278	7.515	.705	1.639	.068	.100
4.100	.286	7.359	.862	1.649	.069	.100

HUGHES BEGINNING AT RIVER MILE 4.1

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)	
UPSTREAM	.286	7.359	2.55	.11	
WASTE SOURCE	.928	6.000	75.03	10.00	Louisville 10-2-6
DIST. INPUT	.100	2.000	1.08	.05	
1	.564	6.010	60.37	4.09	

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= 2.70 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 13.0 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
4.100	1.789	6.196	2.025	14.294	1.471	.100
4.000	1.789	6.060	2.161	13.967	1.437	.100
3.900	1.800	5.936	2.285	13.575	1.396	.100
3.800	1.811	5.843	2.377	13.195	1.356	.100
3.700	1.822	5.777	2.443	12.826	1.318	.100
3.600	1.833	5.733	2.487	12.469	1.280	.100
3.500	1.844	5.707	2.513	12.122	1.244	.100
3.400	1.855	5.696	2.524	11.785	1.209	.100
3.300	1.867	5.698	2.523	11.458	1.175	.100

HUGHES BEGINNING AT RIVER MILE 3.3

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
UPSTREAM	1.867	5.698	115.49	11.84
DIST. INPUT	.089	2.000	.96	.05
2	.106	7.146	1.03	.05

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= 2.00 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 9.6 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
3.300	1.981	5.760	2.461	10.903	1.112	.100
3.200	1.981	5.698	2.523	10.653	1.087	.100
3.100	1.989	5.639	2.582	10.375	1.058	.100
3.000	1.997	5.595	2.625	10.105	1.030	.100
2.900	2.005	5.566	2.655	9.841	1.003	.100
2.800	2.013	5.548	2.673	9.585	.976	.100
2.700	2.021	5.541	2.680	9.336	.950	.100
2.600	2.029	5.542	2.679	9.094	.925	.100
2.500	2.037	5.551	2.670	8.859	.901	.100
2.400	2.045	5.566	2.655	8.629	.877	.100
2.300	2.053	5.587	2.634	8.406	.854	.100
2.300	2.062	5.573	2.648	8.381	.851	.100

HUGHES BEGINNING AT RIVER MILE 2.3

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
UPSTREAM	2.062	5.573	93.30	9.48
DIST. INPUT	.010	2.000	.11	.00
4	.258	7.617	2.26	.09

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= .87 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 4.2 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
2.300	2.321	5.798	2.423	7.626	.764	.100
2.200	2.321	5.676	2.545	7.452	.746	.100
2.100	2.322	5.564	2.656	7.279	.729	.100
2.000	2.323	5.464	2.757	7.109	.712	.100
1.900	2.324	5.374	2.846	6.944	.695	.100
1.800	2.326	5.295	2.926	6.782	.679	.100
1.700	2.327	5.225	2.996	6.625	.663	.100
1.600	2.328	5.163	3.057	6.471	.647	.100

HUGHES BEGINNING AT RIVER MILE 1.6

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
UPSTREAM	2.328	5.163	81.35	8.14
DIST. INPUT	.010	2.000	.11	.00
3	.093	6.267	.94	.04

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= 2.96 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 14.3 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
1.600	2.423	5.204	3.017	6.292	.626	.100

1.500	2.423	5.510	2.710	6.148	.611	.100
1.400	2.424	5.769	2.452	6.004	.597	.100
1.300	2.426	5.989	2.231	5.864	.583	.100
1.200	2.428	6.177	2.044	5.727	.569	.100
1.100	2.429	6.338	1.883	5.594	.556	.100

HUGHES BEGINNING AT RIVER MILE 1.1

*** LOADS ***

	FLOW (CFS)	DISSOLVED OXYGEN (MG/L)	CARBONACEOUS BOD (LBS/DAY)	TKN (LBS/DAY)
UPSTREAM	2.429	6.338	73.38	7.29
DIST. INPUT	.010	2.000	.11	.00
5	.184	6.962	1.73	.08

*** PARAMETERS ***

CS= 8.22 MG/L PA= .00 MG/L RA= .00 MG/L S= .00 MG/L

KR= .30 /DAY KD= .30 /DAY KN= .30 /DAY KA= 1.49 /DAY

TEMP=26.00 C

REAERATION BY TSIVOGLOU SLOPE= 7.2 FT/MILE ESCAPE COEF= .11 /DAY

*** STREAM CONDITION ***

RIVER MILE	FLOW CFS	DO MG/L	DEFICIT MG/L	CBOD MG/L	TKN MG/L	VEL FPS
1.100	2.614	6.381	1.840	5.321	.522	.100
1.000	2.614	6.372	1.848	5.200	.510	.100
.900	2.615	6.367	1.853	5.080	.498	.100
.800	2.616	6.367	1.854	4.962	.487	.100
.700	2.617	6.370	1.851	4.848	.476	.100
.600	2.618	6.376	1.845	4.736	.465	.100
.500	2.618	6.385	1.835	4.627	.454	.100
.400	2.619	6.397	1.823	4.520	.443	.100
.300	2.620	6.412	1.809	4.416	.433	.100
.200	2.621	6.428	1.792	4.314	.423	.100
.100	2.622	6.446	1.774	4.215	.413	.100
.000	2.623	6.466	1.755	4.118	.404	.100
.000	2.623	6.465	1.756	4.117	.404	.100

HEADWATER

RIVER	MILE	Q	DO	CBOD	TKN	TYPE	DESCRIPTION

HUGHES	7.40	.01	7.00	.1	.0
1	1.30	.01	7.00	.1	.0
2	1.70	.01	7.00	.1	.0
3	.90	.01	7.00	.1	.0
4	3.50	.01	7.00	.1	.0
5	2.80	.01	7.00	.1	.0
6	1.20	.01	7.00	.1	.0

WASTE SOURCE

RIVER	MILE	Q	DO	CBOD	TKN	TYPE	DESCRIPTION
HUGHES	4.10	.93	6.00	75.0	10.0	.00	Louisville 10-2-
1	.60	.09	6.00	1.5	.0	.00	Resin 001
1	.60	.08	6.00	13.0	3.2	.00	Resin 002
1	.40	.15	6.00	8.7	.9	.00	Plywood 003
1	.40	.12	6.00	40.6	.4	.00	Plywood 001
1	.40	.01	6.00	.5	.0	.00	Plywood 002
1	.40	.05	6.00	2.0	.0	.00	Plywood 004

SPECIFIC INPUT

RIVER	MILE	Q	DO	CBOD	TKN	TYPE	DESCRIPTION
HUGHES	7.40	.28	2.00	3.0	.1	1.00	
HUGHES	4.10	.10	2.00	1.1	.1	1.00	
4	3.50	.25	2.00	2.7	.1	1.00	
HUGHES	3.30	.09	2.00	1.0	.0	1.00	
5	2.80	.07	2.00	.7	.0	1.00	
HUGHES	2.30	.01	2.00	.1	.0	1.00	
2	1.70	.10	2.00	1.0	.1	1.00	
HUGHES	1.60	.01	2.00	.1	.0	1.00	
1	1.30	.06	2.00	.6	.0	1.00	
6	1.20	.04	2.00	.5	.0	1.00	
HUGHES	1.10	.01	2.00	.1	.0	1.00	
3	.90	.09	2.00	1.0	.1	1.00	
5	.60	.06	2.00	.6	.0	1.00	

REACH PARAMETER

RIVER	MILE	CD	ND	CV	NV	DEPTH	VEL	S	C	KA
1	1.30						.10	.11	22.12	
1	.60						.10	.11	22.12	
1	.40						.10	.11	22.12	
2	1.70						.10	.11	29.36	
3	.90						.10	.11	20.79	
4	3.50						.10	.11	22.51	
6	1.20						.10	.11	35.53	
5	2.80						.10	.11	29.37	
5	.60						.10	.11	19.52	
HUGHES	7.40						.10	.11	20.55	

HUGHES	4.10	.10	.11	13.01
HUGHES	3.30	.10	.11	9.63
HUGHES	2.30	.10	.11	4.21
HUGHES	1.60	.10	.11	14.27
HUGHES	1.10	.10	.11	7.20

REACH RATE

RIVER	MILE	TEMP	KR	KD	KN	PA	RA	S
1	1.30	26.00	.15	.15	.30	.00	.00	.00
1	.60	26.00	.30	.30	.30	.00	.00	.00
1	.40	26.00	.30	.30	.30	.00	.00	.00
2	1.70	26.00	.15	.15	.30	.00	.00	.00
3	.90	26.00	.15	.15	.30	.00	.00	.00
4	3.50	26.00	.15	.15	.30	.00	.00	.00
6	1.20	26.00	.15	.15	.30	.00	.00	.00
5	2.80	26.00	.15	.15	.30	.00	.00	.00
5	.60	26.00	.15	.15	.30	.00	.00	.00
HUGHES	7.40	26.00	.15	.15	.30	.00	.00	.00
HUGHES	4.10	26.00	.30	.30	.30	.00	.00	.00
HUGHES	3.30	26.00	.30	.30	.30	.00	.00	.00
HUGHES	2.30	26.00	.30	.30	.30	.00	.00	.00
HUGHES	1.60	26.00	.30	.30	.30	.00	.00	.00
HUGHES	1.10	26.00	.30	.30	.30	.00	.00	.00

SEQUENCE TABLE

RIVER	TRIBUTARY	TRIBUTARY	ORGIN	TERMINUS
1			1.30	.60
1			.60	.40
1			.40	.00
2			1.70	.00
3			.90	.00
4			3.50	.00
6			1.20	.00
5			2.80	.60
5	6		.60	.00
HUGHES			7.40	4.10
HUGHES	1		4.10	3.30
HUGHES	2		3.30	2.30
HUGHES	4		2.30	1.60
HUGHES	3		1.60	1.10
HUGHES	5		1.10	.00

DELTA= .10

Stop - Program terminated.