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PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Dissolved Oxygen

In

Horse Creek
(WBID 3081)

March 2013

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United States Environmental Protection Agency

Region 4 serving the southeast

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 PROBLEM DEFINITION 1
3.0 WATERSHED DESCRIPTION 2
3.1 CLIMATE 3
3.2 HYDROLOGIC CHARACTERISTICS 3
3.3 LAND USE 3
4.0 WATER QUALITY STANDARDS/TMDL TARGETS 7
4.1 NUTRIENTS CRITERIA 7
4.1.1 Narrative Nutrient Criteria 8
4.1.2 Development of Numeric Nutrient Criteria 8
4.2 DISSOLVED OXYGEN CRITERIA 9
4.3 BIOCHEMICAL OXYGEN DEMAND CRITERIA 10
4.4 NATURAL CONDITIONS 10
5.0 WATER QUALITY ASSESSMENT 10
5.1 WATER QUALITY DATA 10
5.1.1 Dissolved Oxygen 11
5.1.2 Biochemical Oxygen Demand 11
5.1.3 Nutrients 11
5.1.3.1 Total Nitrogen 11
5.1.3.2 Total Phosphorus 12
5.1.3.3 Chlorophyll-a 12
6.0 SOURCE AND LOAD ASSESSMENT 20
6.1 POINT SOURCES 20
6.1.1 Wastewater/Industrial Permitted Facilities 20
6.1.2 Stormwater Permitted Facilities/MS4s 21
6.2 NONPOINT SOURCES 22
6.2.1 Urban Areas 22
6.2.2 Pastures 24
6.2.3 Clear cut/Sparse 24
6.2.4 Forests 24
6.2.5 Water and Wetlands 24
6.2.6 Quarries/Strip mines 25
7.0 ANALYTICAL APPROACH 25
7.1 MECHANISTIC MODELS 25

US EPA ARCHIVE DOCUMENT

7.1.1 Loading Simulation Program C++ (LSPC) *25*
7.1.2 Environmental Fluids Dynamic Code (EFDC) *32*
7.1.3 Water Quality Analysis Simulation Program (WASP7) *35*
7.2 SCENARIOS 36
7.2.1 Current Condition *36*
7.2.2 Natural Condition *41*
8.0 TMDL DETERMINATION 47
8.1 CRITICAL CONDITIONS AND SEASONAL VARIATION 48
8.2 MARGIN OF SAFETY 49
8.3 WASTE LOAD ALLOCATIONS 49
8.3.1 Wastewater/Industrial Permitted Facilities *49*
8.3.2 Municipal Separate Storm Sewer System Permits *49*
8.4 LOAD ALLOCATIONS 50
9.0 RECOMMENDATIONS/IMPLEMENTATION 50
10.0 REFERENCES 51

US EPA ARCHIVE DOCUMENT

LIST OF FIGURES

Figure 2.1 Location of WBID 3081 in the Indian River Lagoon Basin. 2
Figure 3.1 Land use for WBID 3081 in the Indian River Lagoon Basin..... 4
Figure 3.2 Aerial photograph illustrating contributing subwatershed boundary and impaired WBID 6
Figure 5.1 Water quality monitoring station locations for WBID 3081, Horse Creek..... 15
Figure 5.2 Dissolved oxygen concentrations in upper Horse Creek within WBID 3081..... 15
Figure 5.3 Dissolved oxygen concentrations in lower Horse Creek within WBID 3081..... 16
Figure 5.4 Biochemical oxygen demand concentrations in upper Horse Creek within WBID 3081..... 16
Figure 5.5 Biochemical oxygen demand concentrations in lower Horse Creek within WBID 3081..... 17
Figure 5.6 Total nitrogen concentrations in upper Horse Creek within WBID 3081..... 17
Figure 5.7 Total nitrogen concentrations in lower Horse Creek within WBID 3081..... 18
Figure 5.8 Total phosphorus concentrations in upper Horse Creek within WBID 3081..... 18
Figure 5.9 Total phosphorus concentrations in lower Horse Creek within WBID 3081..... 19
Figure 5.10 Corrected chlorophyll a concentrations in upper Horse Creek within WBID 3081..... 19
Figure 5.11 Corrected chlorophyll a concentrations in lower Horse Creek within WBID 3081..... 20
Figure 7.1 Location of Horse Creek LSPC subwatersheds 27
Figure 7.2 Modeled Flow (cfs) in Horse Creek..... 29
Figure 7.3 Modeled vs. Observed Temperature (°C) at 21FLSJWMIRLHUS 30
Figure 7.4 Modeled vs. Observed DO (mg/l) at 21FLSJWMIRLHUS..... 30
Figure 7.5 Modeled BOD5 (mg/l) in Horse Creek..... 31
Figure 7.6 Modeled vs. Observed Total Nitrogen (mg/l) at 21FLSJWMIRLHUS 31
Figure 7.7 Modeled vs. Observed Total Phosphorus (mg/l) at 21FLSJWMIRLHUS..... 32
Figure 7.8 Location of Horse Creek LSPC subwatersheds and EFDC grid..... 34
Figure 7.9 Measured verse modeled salinity (ppt) in Horse Creek at station 21FLSJWIRLHUS 35
Figure 7.10 Simulated temperature verse measured temperature in the upper Horse Creek at station 21FLSJWMIRLUPHC 37
Figure 7.11 Simulated temperature verse measured temperature in the lower Horse Creek at station 21FLSJWMIRLHUS..... 37
Figure 7.12 Simulated dissolved oxygen verse measured dissolved oxygen in the upper Horse Creek at station 21FLSJWMIRLUPHC..... 38
Figure 7.13 Simulated dissolved oxygen verse measured dissolved oxygen in the lower Horse Creek at station 21FLSJWMIRLSHUS 38

US EPA ARCHIVE DOCUMENT

Figure 7.14 Simulated total nitrogen verse measured total nitrogen in the upper Horse Creek at station 21FLSJWMIRLUPHC 39
Figure 7.15 Simulated total nitrogen verse measured total nitrogen in the lower Horse Creek at station 21FLSJWMIRLSHUS 39
Figure 7.16 Simulated total phosphorus verse measured total phosphorus in the upper Horse Creek at station 21FLSJWMIRLUPHC 40
Figure 7.17 Simulated total phosphorus verse measured total phosphorus in the lower Horse Creek at station 21FLSJWMIRLSHUS 40
Figure 7.18 Natural condition temperature in the upper Horse Creek 42
Figure 7.19 Natural condition temperature in the lower Horse Creek 42
Figure 7.20 Natural condition dissolved oxygen in the upper Horse Creek 43
Figure 7.21 Natural condition dissolved oxygen in the lower Horse Creek 43
Figure 7.22 Natural condition total nitrogen in the upper Horse Creek 44
Figure 7.23 Natural condition total nitrogen in the lower Horse Creek 44
Figure 7.24 Natural condition total phosphorus in the upper Horse Creek 45
Figure 7.25 Natural condition total phosphorus in the lower Horse Creek 45
Figure 7.26 Dissolved oxygen concentration cumulative distribution function for Upper Horse Creek 46
Figure 7.27 Dissolved oxygen concentration cumulative distribution function for Lower Horse Creek 47

US EPA ARCHIVE DOCUMENT

LIST OF TABLES

Table 3.1 Land use distribution for WBID 3081 in the Indian River Lagoon Basin 4
Table 3.2 Land use distribution for the contributing subwatershed for WBID 3081 6
Table 5.1 Water quality data for the WBID 3081 in the Indian River Lagoon Basin 13
Table 5.2 Water quality data for the WBID 3081, Horse Creek 14
Table 6.1 MS4 Permits by WBID. 22
Table 6.2 County estimates of Septic Tanks and Repair Permits. 24
Table 7.1 Current condition concentrations in the impaired WBID in the Indian River Lagoon Basin..... 41
Table 7.2 Current condition loadings in the impaired WBID in the Indian River Lagoon Basin..... 41
Table 7.3 Natural condition concentrations in the impaired WBID in the Indian River Lagoon Basin..... 46
Table 7.4 Natural condition loadings in the impaired WBID in the Indian River Lagoon Basin..... 46
Table 8.1 TMDL Load Allocations for WBID 3081 in the Indian River Lagoon Basin. 48

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

SUMMARY SHEET for WBID 3081

Total Maximum Daily Load (TMDL)

2006 303(d) Listed Waterbody for TMDL addressed in this report:

WBID	Segment Name	Class and Waterbody Type	Major River Basin	HUC	County	State
3081	Horse Creek	Class III Marine	Indian River Lagoon	03080202	Brevard	Florida

TMDL Endpoint/Target:

Dissolved Oxygen

TMDL Technical Approach:

The TMDL allocations were determined by analyzing the effects of TN, TP, and BOD concentrations and loadings on DO concentrations in the waterbody. A watershed model was used to predict delivery of pollutant loads to the waterbody, and estuary models were used to evaluate the in-stream impacts of the pollutant loads.

TMDL Waste Load and Load Allocation

Constituent	Current Condition		TMDL Condition		Percent Reduction		
	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	WLA	LA	MS4
Total Nitrogen	--	4,885	--	962	--	80%	80%
Total Phosphorus	--	344	--	58	--	83%	83%
Biochemical Oxygen Demand	--	13,124	--	5,678	--	57%	57%

Endangered Species Present (Yes or Blank):

USEPA Lead TMDL (USEPA or Blank): USEPA

TMDL Considers Point Source, Non-point Source, or Both: Non-point Sources

Major NPDES Discharges to surface waters addressed in USEPA TMDL:

WBID	Segment Name	Phase	Facility Number	Affiliate	Co-Permittee
3081	Horse Creek	II	FLR04E027	Brevard County	City of Melbourne
		II	FLR04E052	Brevard County	Brevard County

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1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA 1991).

The Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The watershed management approach is the framework FDEP uses for implementing TMDLs. The state's 52 basins are divided into five groups and water quality is assessed in each group on a rotating five-year cycle. FDEP also established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. The waterbody addressed in this TMDL is located in the Indian River Lagoon and is a Group 5 waterbodies managed by the Southwest Florida Water Management District (SWFWMD).

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. These planning units contain smaller, hydrological based units called drainage basins, which are further divided by FDEP into "water segments". A water segment usually contains only one unique waterbody type (stream, lake, canal, etc.) and is about 5 square miles. Unique numbers or waterbody identification (WBIDs) numbers are assigned to each water segment. The WBID in this TMDL (WBID 3081) is located in the North Indian River Lagoon Planning Unit and is impaired for dissolved oxygen.

2.0 PROBLEM DEFINITION

To determine the status of surface water quality in Florida, three categories of data – chemistry data, biological data, and fish consumption advisories – were evaluated to determine potential impairments. The level of impairment is defined in the Identification of Impaired Waters Rule (IWR), Section 62-303 of the Florida Administrative Code (FAC). The IWR is FDEP's methodology for determining whether waters should be included on the state's planning list and verified list. Potential impairments are determined by assessing whether a waterbody meets the criteria for inclusion on the planning list. Once a waterbody is on the planning list, additional data and information will be collected and examined to determine if the water should be included on the verified list.

The TMDLs addressed in this document are being established pursuant to commitments made by the United States Environmental Protection Agency (USEPA) in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998). That Consent Decree established a schedule for TMDL development for waters listed on Florida's USEPA approved 1998 section 303(d) list. The 2006 section 303(d) list identified numerous WBIDs in the Indian River Lagoon as not meeting water quality standards. After assessing all readily available water quality data, USEPA is responsible for developing a TMDL for WBID 3081 (Figure 2.1). The parameter addressed for WBID 3081, Horse Creek, is dissolved oxygen.

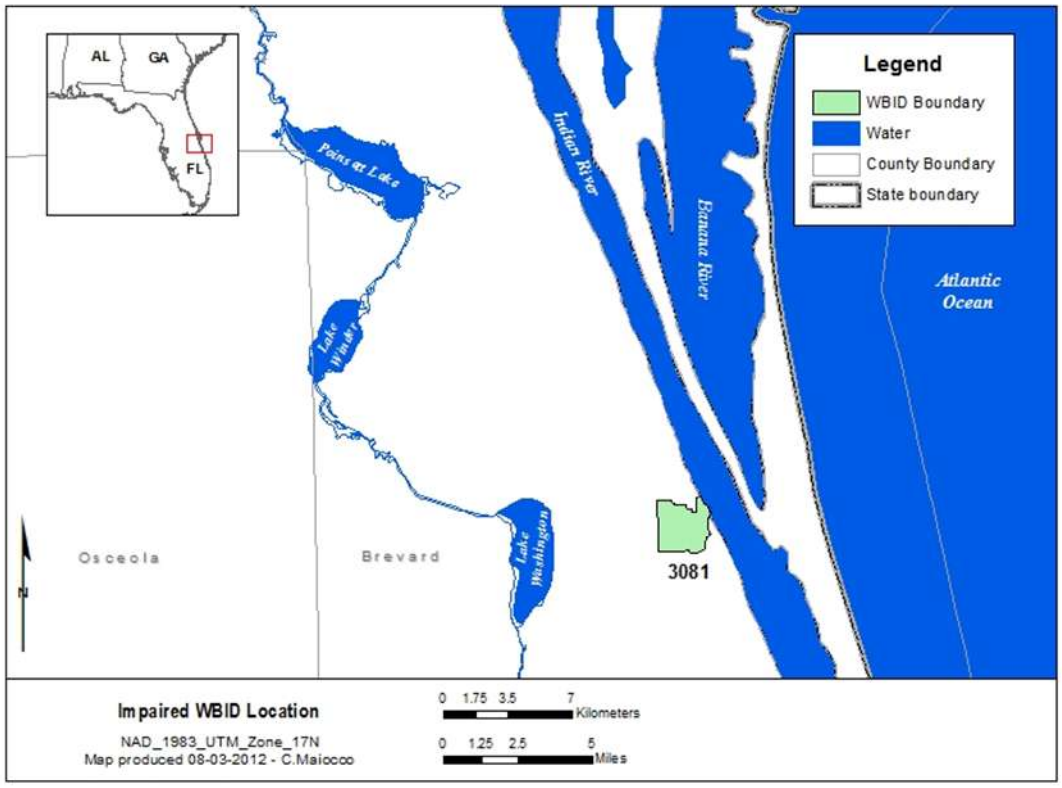

Figure 2.1 Location of WBID 3081 in the Indian River Lagoon Basin.

3.0 WATERSHED DESCRIPTION

The Indian River Lagoon (IRL) Basin is a 155 mile-long estuary situated along Florida's East Central Coast. Beginning at Ponce de Leon Inlet near New Smyrna Beach, the IRL encompasses Volusia County and stretches southward to Jupiter Inlet in Palm Beach County. The IRL Basin contains six major subbasins: Mosquito Lagoon, North IRL, Banana River Lagoon, Central IRL, South IRL, and the St. Lucie River and Estuary. Within the Florida Department of Environmental Protection's (FDEP) Total Maximum Daily Load (TMDL) Program, the IRL Basin is considered a part of the St. Johns River Water Management District (SJRWMD) covering southern Volusia County, Brevard County, and Indian River County. The South portion of the IRL and St. Lucie River and Estuary subbasins are not considered a part of the

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SJRWMD, but fall into the jurisdiction of the South Florida Water Management District (SFWMD) and are included with the Group 2 TMDL basins. (FDEP 2006)

The physiography of Indian River Lagoon varies throughout the entire basin. Horse Creek is located within the northern portion of the IRL Basin, made up of the Easter Valley and flatlands west of the Atlantic Coastal Ridge. This ridge comprises the natural western boundary of the IRL along the central portion of Brevard County. The southern end of Brevard County and other north Indian River counties are bounded by the Ten Mile Ridge, a line of sand dunes running parallel to the Indian River that now supports US Interstate 95 (Douglas Waitley 2006). A section of the Easter Valley which lies inside of the Ten Mile Ridge and Atlantic Coastal Ridge holds the Sebastian-St. Lucie Flats, which eventually drains into the Sebastian River. (Consultants 1994)

3.1 Climate

The Indian River Lagoon is located in East Central Florida and experiences a humid subtropical climate with distinct wet (May to October) and dry (November to April) seasons, high rates of evapotranspiration, and climatic extremes of floods, droughts, and hurricanes. Seasonal rainfall patterns resemble the wet and dry season patterns of humid tropics. Central Florida receives an average of 46 inches of rain every year, of which 75% falls during the wet season, which coincides with hurricane season (USACE and SFWMD 2010). Average temperatures during the wet season are in the low-80s (°F) and in the dry season are in the mid-60s (°F) (NOAA).

3.2 Hydrologic characteristics

Horse Creek is a tributary within the IRL Basin, located near the center of the basin. Approximately five miles in length, this stream travels through multiple residential areas and passes through Wickham Park, a local campground in Brevard County. Horse Creek intersects two major roads, Croton Road and Harbor City Boulevard (US-1/SR 508) before draining into Indian River Lagoon.

3.3 Land Use

Overall, the Indian River Lagoon Basin is highly developed, specifically along the coast (Figure 3.1 and Table 3.1). In the upper portion of Horse Creek, land use is consistently developed, varying only in type of development. Developed land covers approximately 1,239 acres, or 88 percent of the total land use, and is predominantly classified as medium and high intensity. A small portion of WBID 3081 is composed of forest land or golf courses. Of the entire area, 7 percent is composed of forested land. Open water and wetlands combined cover approximately 6 percent of the WBID.

The actual drainage area of Horse Creek varies from the WBID boundaries (Figure 3.2). The United States Geological Survey National Hydrography Dataset was used to delineate the drainage area. The land use composition for the drainage area of WBID 3081 is comprised of wetlands, pasture, developed and forest land uses. These contributing landuses are mainly found on the outskirts of the subwatershed (Table 3.2). While the drainage area for WBID 3081 is approximately the same size as the WBID boundary itself, the land use distribution differs

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slightly. While WBID 3081 is dominated by developed land use, its contributing land use is also dominated by forests, pasture, and wetlands.

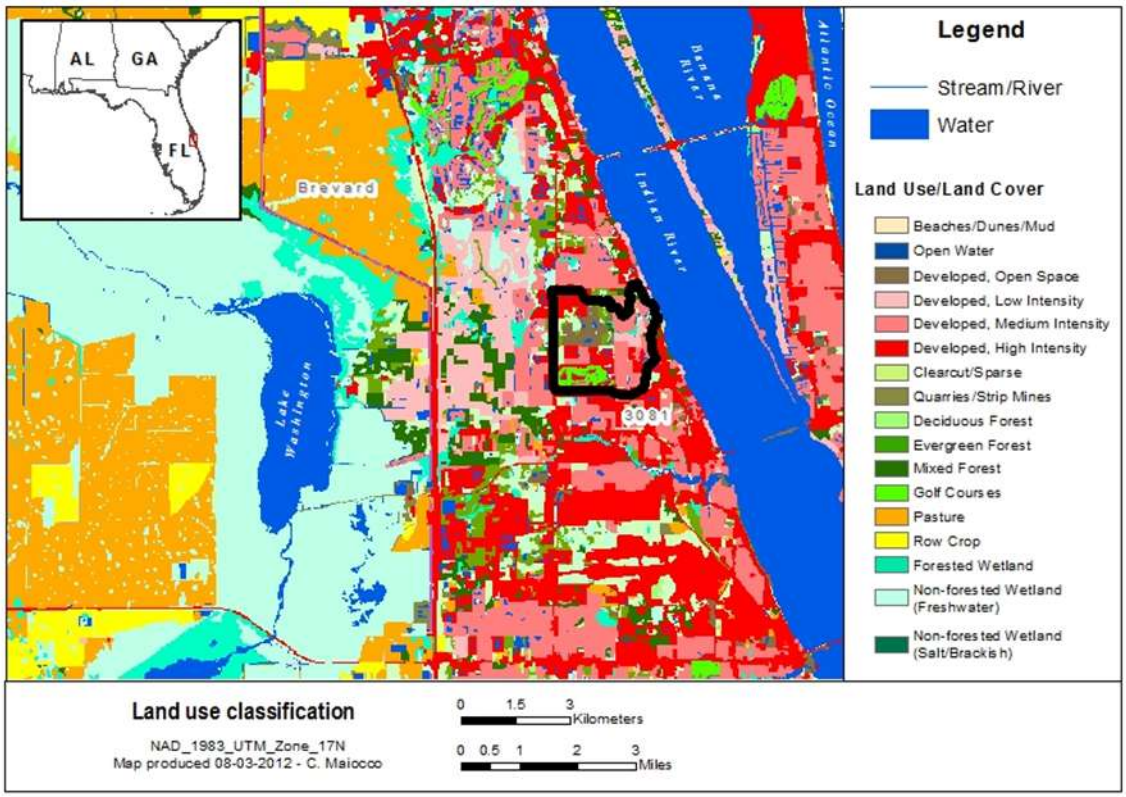

Figure 3.1 Land use for WBID 3081 in the Indian River Lagoon Basin

Table 3.1 Land use distribution for WBID 3081 in the Indian River Lagoon Basin

Land Use Classification	WBID 3081	
	Acres	%
Evergreen Forest	91	5%
Deciduous Forest	0	0%
Mixed Forest	31	2%
Forested Wetland	22	1%
Non-Forested Wetland (Freshwater)	40	2%
Open Water	46	3%
Pasture	0	0%

US EPA ARCHIVE DOCUMENT

Land Use Classification	WBID 3081	
	Acres	%
Row Crop	0	0%
Clear cut/ Sparse	132	8%
Quarries Strip mines	11	1%
Utility Swaths	0	0%
Developed, Open Space	244	14%
Developed, Low intensity	69	4%
Developed, Medium intensity	457	26%
Developed, High intensity	469	27%
Beaches/Mud/Dunes	0	0%
Golf Courses	244	8%
Totals	**1,754**	**100%**

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Figure 3.2 Aerial photograph illustrating contributing subwatershed boundary and impaired WBID

Table 3.2 Land use distribution for the contributing subwatershed for WBID 3081

Land Use Classification	Contributing subwatershed for WBID 3081	
	Acres	%
Evergreen Forest	63	4%
Mixed Forest	20	1%
Forested Wetland	23	1%
Non-Forested Wetland (Freshwater)	42	3%
Open Water	46	3%
Clear cut Sparse	95	6%
Quarries Strip mines	10	1%
Developed, Open Space	235	15%

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Land Use Classification	Contributing subwatershed for WBID 3081	
	Acres	%
Developed, Low intensity	67	4%
Developed, Medium intensity	433	27%
Developed, High intensity	456	28%
Golf Courses	110	7%
Totals	**1,600**	**100%**

4.0 WATER QUALITY STANDARDS/TMDL TARGETS

The TMDL reduction scenarios will be done to ensure that the discharge of nutrients is limited as needed to prevent violations of Florida's dissolved oxygen water quality standard of an average daily concentration of 5 mg/L and to ensure balanced flora and fauna. The EPA will establish the TMDL to be consistent with a natural condition if the dissolved oxygen standard cannot be achieved, as Florida's water quality standards provide that FDEP (see section 4.4 Natural Conditions) shall not strive to abate natural conditions.

The waterbody addressed in this report is a Class III marine water having a designated use for Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in Florida's water quality standards in Section 62-302.400, FAC. Water quality criteria for protection of all classes of waters are established in Section 62-302.530, FAC. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 FAC, which established minimum criteria that apply to all waters unless alternative criteria are specified Section 62-302.530, FAC. In addition, unless otherwise stated, all criteria express the maximum not to be exceeded at any time. The specific criteria addressed in this TMDL document are provided in the following sections.

4.1 Nutrients Criteria

In 1979, FDEP adopted a narrative criterion for nutrients which is applicable to Class I/ II/III waters. FDEP recently adopted numeric nutrient criteria (NNC) for many Class I/II/III waters in the state, including streams, which numerically interprets part of the state narrative criterion for nutrients. FDEP submitted its NNC to EPA for review pursuant to section 303(c) of the CWA. On November 30, 2012, EPA approved those criteria as consistent with the requirements of the CWA. The state criteria, however, are not yet effective for state law purposes.

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Also, in November 2010, EPA promulgated numeric nutrient criteria for Class I/II/III inland waters in Florida, including streams. On February 18, 2012, the streams criteria were remanded back to EPA by the U.S. District Court for the Northern District of Florida for further explanation. On November 30, 2012, EPA re-proposed its stream NNC for those flowing waters not covered by Florida's NNC rule.

Therefore, for streams in Florida, the applicable nutrient water quality standard for CWA purposes remains the Class I/II/III narrative criterion.

Florida's recently adopted numeric nutrient criteria interprets the narrative water quality criterion for nutrients in paragraph 62-302.530(47)(b), F.A.C. See section 62-302.531(2). The Florida rule provides that the narrative water quality criteria for nutrients in paragraph 62-302.530(47)(a), F.A.C., continues to apply to all Class I/II/III waters. See section 62-302.531(1).

Florida's recently adopted rule applies to springs, streams, lakes, and some estuary segments. Florida's rule provides that numeric nutrient criteria are expressed as a geometric mean, and concentrations are not to be exceeded more than once in any three calendar year period. Section 62-302.531 and 62-302.532, F.A.C.

Should FDEP's numeric nutrient criteria become applicable water quality standards for CWA purposes before this TMDL is established, EPA will consider the nutrient target necessary to attain section 62-302.532, F.A.C. EPA will compare that target with the target necessary to attain paragraph 62-302.530(47)(a), F.A.C., to determine which target is more stringent.

4.1.1 Narrative Nutrient Criteria

Florida's narrative nutrient criteria provide:

> The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242 F.A.C. See paragraph 62-302.530(47)(a), F.A.C.
>
> In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. See paragraph 62-302.530(47)(b), F.A.C.

Chlorophyll and DO levels are often used to indicate whether nutrients are present in excessive amounts. The target for this TMDL is based on levels of nutrients necessary to prevent violations of Florida's DO criterion pursuant to paragraph 62-302.530(47)(a), F.A.C., as set out more fully below.

4.1.2 Development of Numeric Nutrient Criteria

While not yet effective as water quality criteria, the FDEP's numeric nutrient criteria represent the state's most recent interpretation of the second part of Florida's narrative criteria, set out at

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paragraph 62-302.530(47)(b), F.A.C. See section 62-302.531(2). The first part of the narrative criteria, at paragraph 62-302.530(47)(a), F.A.C., also remains applicable to streams in Florida.

Florida's interpretation of its narrative nutrient criteria applies to streams, including (WBID3081). For streams that do not have a site specific criteria, the interpretation provides for biological information to be considered together with nutrient thresholds to determine whether a waterbody is attaining See paragraph 62-302.531(2)(c), F.A.C. The rule provides that the nutrient criteria are attained in a stream segment where information on chlorophyll a levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora and either the average score of at least two temporally independent SCIs performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or the nutrient thresholds set forth in Table 1 below are achieved. See paragraph 62-302.531(2)(c).

Florida's interpretation provides that nutrient levels should be expressed as a geometric mean, and concentrations are not to be exceeded more than once in any three calendar year period. Section 62-302.200 (25)(e), F.A.C.

Table 1 Inland numeric nutrient criteria

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold	Total Nitrogen Nutrient Threshold
Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L
Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

4.2 Dissolved Oxygen Criteria

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations.

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The water quality criterion for Class III marine waters is as follows:

Shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained. [FAC 62-302.530 (30)]

4.3 Biochemical Oxygen Demand Criteria

Biochemical Oxygen Demand (BOD) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions. [FAC 62-302.530 (11)]

4.4 Natural Conditions

In addition to the standards for nutrients, DO, and BOD described above, Florida's standards include provisions that address waterbodies which do not meet the standards due to natural background conditions.

Florida's water quality standards provide a definition of natural background:

"Natural Background" shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data. [FAC 62-302.200(19)]

Florida's water quality standards also provide that:

Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions. [FAC 62-302.300(15)]

5.0 WATER QUALITY ASSESSMENT

The WBID addressed in this report was listed as not attaining its designated use on Florida's 1998 303(d) list for DO (WBID 3081). To determine impairment, an assessment of available data was conducted. The source for current ambient monitoring data was the Impaired Waters Rule (IWR) data Run 44, using data ranging January 1, 2002 to December 31, 2009. The IWR database contains data from various sources within the state of Florida, including the WMDs and counties.

5.1 Water Quality Data

A complete list of water quality monitoring stations in WBID 3081 is listed in

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Table 5.1, and an analysis of water quality data is documented in Table 5.2. Figure 5.1 illustrates where the water quality monitoring stations are located within the WBID. Water quality data for the WBID can be found below in Figure 5.2 through Figure 5.11.

5.1.1 Dissolved Oxygen

There are several factors that affect the concentration of DO in a waterbody, and natural DO levels are a function of water temperature, water depth and velocity, salinity and relative contributions from groundwater. Oxygen can be introduced by wind, diffusion, photosynthesis, and additions of higher DO water (e.g. from tributaries). DO concentrations can be lowered by processes that use up oxygen from the water, such as respiration and decomposition, and can be lowered through additions of water with lower DO (e.g. swamp or groundwater). Decomposition of organic matter, such as dead plants and animals, also consume DO. Dissolved oxygen minimum concentrations were 3.1 mg/L for upper Horse Creek and 0.1 mg/L for lower Horse Creek. Mean DO concentrations for the upper and lower Horse Creek were 6.8 mg/L and 4.7 mg/L respectively. Also, the maximum concentrations for upper and lower Horse Creek were 11 mg/L and 14 mg/L respectively.

5.1.2 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen used by bacteria as they stabilize organic matter. The process can be accelerated when there is an overabundance of nutrients, increasing the aerobic bacterial activity in a waterbody. In turn, the levels of DO can become depleted, eliminating oxygen essential for biotic survival, and potentially causing extensive fish kills. Additionally, BOD is used as an indicator to determine the presence and magnitude of organic pollution from sources such as septic tank leakage, fertilizer runoff, and wastewater effluent. Maximum BOD measurements for upper and lower Horse Creek were 1.9 mg/L and 9.0 mg/L respectively. Mean and minimum BOD measurements for upper Horse Creek were 0.99 mg/L and 0.48 mg/L respectively while lower Horse Creek had a mean BOD measurement of 2.64 mg/L and a minimum BOD measurement of 0.7 mg/L.

5.1.3 Nutrients

Excessive nutrients in a waterbody can lead to overgrowth of algae and other aquatic plants such as phytoplankton, periphyton and macrophytes. This process can deplete oxygen in the water, adversely affecting aquatic life and potentially restricting recreational uses such as fishing and boating. For the nutrient assessment the monitoring data for total nitrogen, total phosphorus and chlorophyll a are presented. The purpose of the nutrient assessment is to present the range, variability and average conditions for the WBID.

5.1.3.1 Total Nitrogen

Total Nitrogen (TN) is comprised of nitrate (NO3), nitrite (NO2), organic nitrogen and ammonia nitrogen (NH4). Although nitrogen is a necessary nutrient required for the growth of most plants and animals, not all forms are readily used or metabolized. Increased levels of organic nitrogen can be caused from the decomposition of detritus and sewage, while increased levels in inorganic nitrogen can be cause by erosion and fertilizers. Nitrates, which natural occur in the soil, are

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components of industrial fertilizers, and are converted to nitrite by microorganisms in the environment. Surface runoff from agricultural lands can increase the natural presence of nitrates in the environment and can lead to eutrophication. Usually, the eutrophication process is observed as a change in the structure of the algal community and includes severe algal blooms that may cover large areas for extended periods. Large algal blooms are generally followed by depletion in DO concentrations as a result of algal decomposition. Total nitrogen minimum concentrations for upper and lower Horse Creek were 0.41 mg/L and 0.50 mg/L respectively, and maximum concentrations measured between 1.59 mg/L and 2.07 mg/L respectively. Total nitrogen means for upper and lower were 0.92 mg/L and 1.06 mg/L respectively.

5.1.3.2 Total Phosphorus

In natural waters, total phosphorus exists in either soluble or particulate forms. Dissolved phosphorus includes inorganic and organic forms, while particulate phosphorus is made up of living and dead plankton, and its adsorbed, amorphous, and precipitated forms. Inorganic forms of phosphorus include orthophosphate and polyphosphates, although polyphosphates are unstable and convert to orthophosphate over time. Orthophosphate is both stable and reactive, making it the form most used by plants. Excessive phosphorus can lead to overgrowth of algae and aquatic plants, the decomposition of which depletes oxygen in the water. Total phosphorus minimum concentrations were for upper and lower Horse Creek were 0.02 mg/L and 0.03 mg/L respectively. Upper and lower Horse Creek had maximum total phosphorus concentrations of 0.18 mg/L and 0.23 mg/L respectively. The mean concentrations for upper and lower Horse Creek were 0.08 mg/L and 0.09 mg/L respectively.

5.1.3.3 Chlorophyll-a

Chlorophyll is the green pigment in plants that allows them to create energy from light. In a water sample, chlorophyll is indicative of the presence of algae, and chlorophyll-*a* is a measure of the active portion of total chlorophyll. Corrected chlorophyll refers to chlorophyll-*a* measurements that are corrected for the presence of pheophytin, a natural degradation product of chlorophyll that can interfere with analysis because it has an absorption peak in the same spectral region. It is used as a proxy indicator of water quality because of its predictable response to nutrient availability. Increases in nutrients can potentially lead to blooms in phytoplankton biomass, affecting water quality and ecosystem health. Corrected chlorophyll-*a* maximum measurements for upper and lower Horse Creek were 20.6 µg/L and 89.0 µg/l respectively, with mean concentrations of 3.26 µg/L and 6.17 µg/L respectively. Minimum corrected chlorophyll-*a* concentrations for upper and lower Horse Creek were 1.00 µg/L and 0.00 µg/L respectively.

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Table 5.1 Water quality data for the WBID 3081 in the Indian River Lagoon Basin

WBID	Station Number
3081	**Upper Horse Creek Stations**
	21FLCEN 27010337
	21FLCEN 27010052
	21FLWPB 20010728
	21FLWQSPBRE706US
	21FLSJWMIRLUPHC
	Lower Horse Creek Stations
	21FLBREVMAS08
	21FLCEN 27010589
	21FLINDRHC00
	21FLINDRHC000
	21FLINDRHC010
	21FLMRC HC0000
	21FLMRC HC0100
	21FLSEAS76SEAS191
	21FLSJWMIRLHUS

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Table 5.2 Water quality data for the WBID 3081, Horse Creek

Parameter	Stats	WBID 3081	
		Upper Stations	Lower Stations
BOD, 5 Day, 20°C (mg/L)	# of obs	17	10
	min	0.48	0.70
	max	1.90	9.00
	mean	0.99	2.64
	Geomean	0.92	1.82
DO, Analysis by Probe (mg/L)	# of obs	102	460
	min	3.07	0.11
	max	10.91	13.52
	mean	6.77	4.73
	Geomean	6.59	4.32
Nitrogen, Total (mg/L as N)	# of obs	77	193
	min	0.50	0.41
	max	1.59	2.07
	mean	0.92	1.06
	Geomean	0.90	1.03
Phosphorus, Total (mg/L as P)	# of obs	83	206
	min	0.02	0.03
	max	0.18	0.23
	mean	0.08	0.09
	Geomean	0.07	0.09
Chlorophyll-A-corrected (µg/L)	# of obs	84	210
	min	1	0
	max	20.6	89.0
	mean	3.26	6.17
	Geomean	2.43	--

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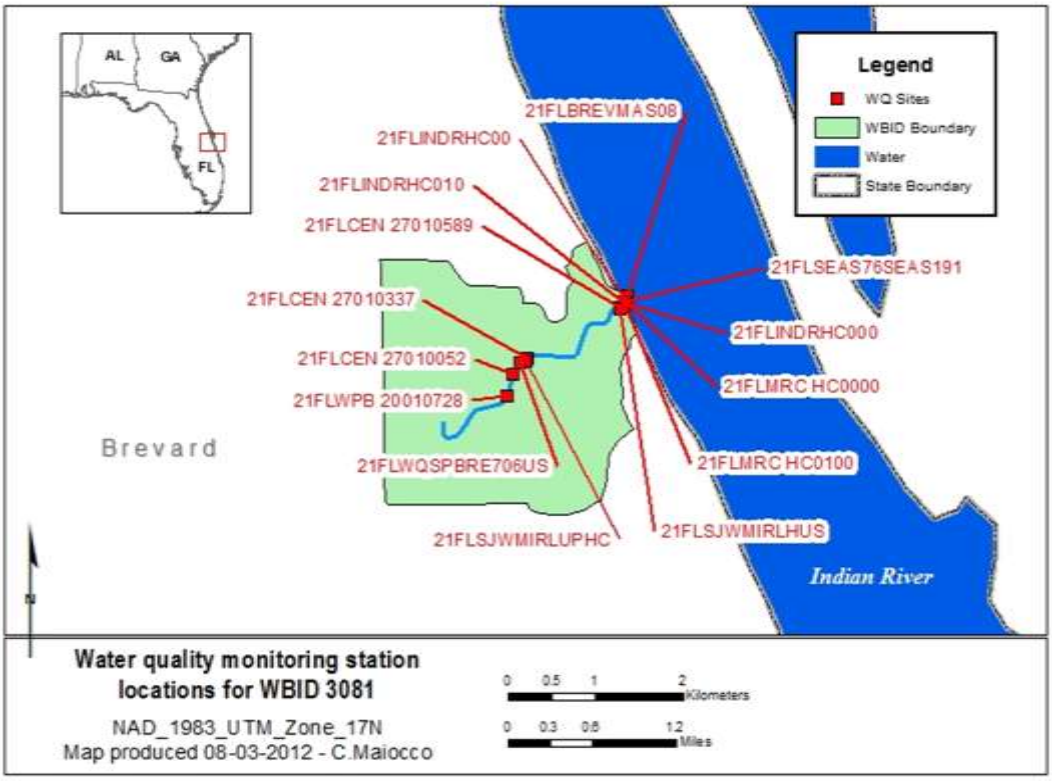

Figure 5.1 Water quality monitoring station locations for WBID 3081, Horse Creek

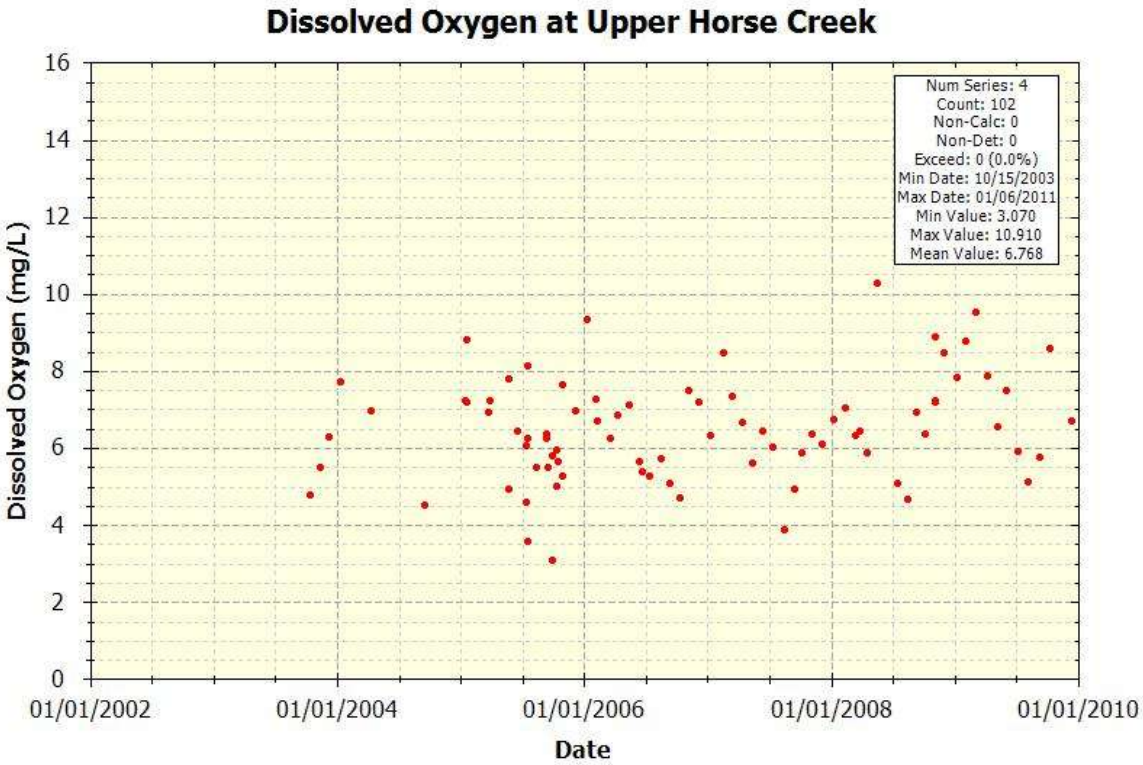

Figure 5.2 Dissolved oxygen concentrations in upper Horse Creek within WBID 3081

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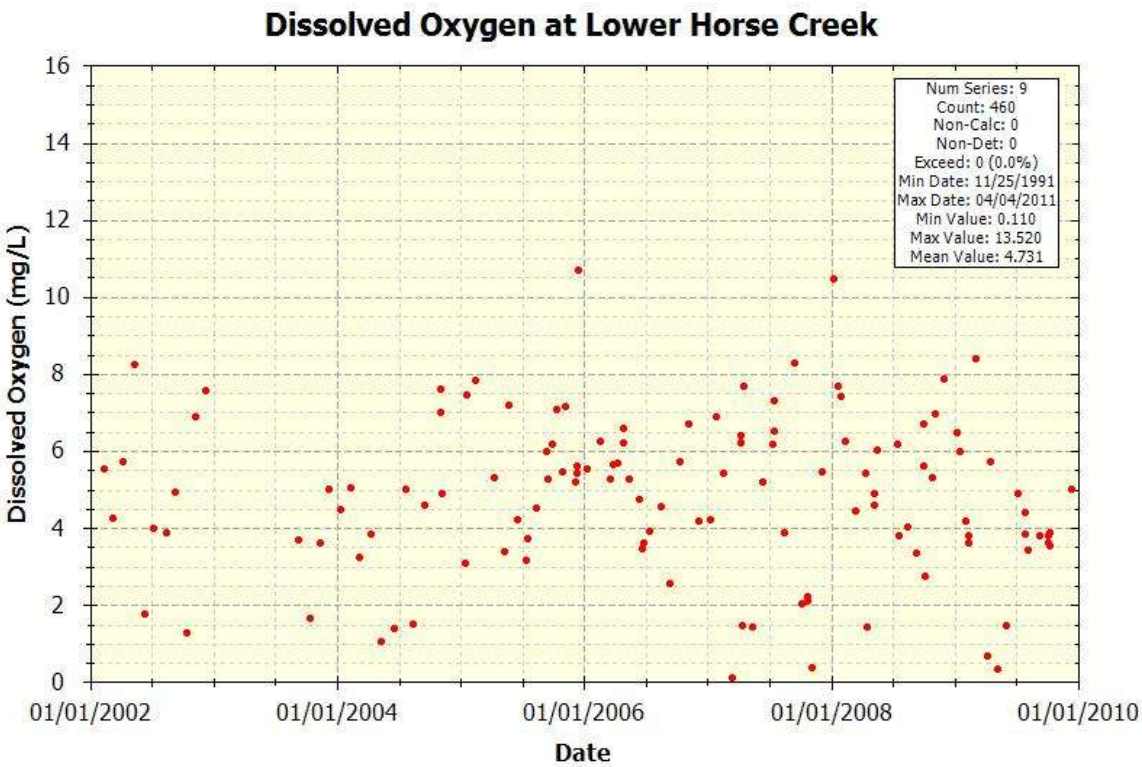

Figure 5.3 Dissolved oxygen concentrations in lower Horse Creek within WBID 3081

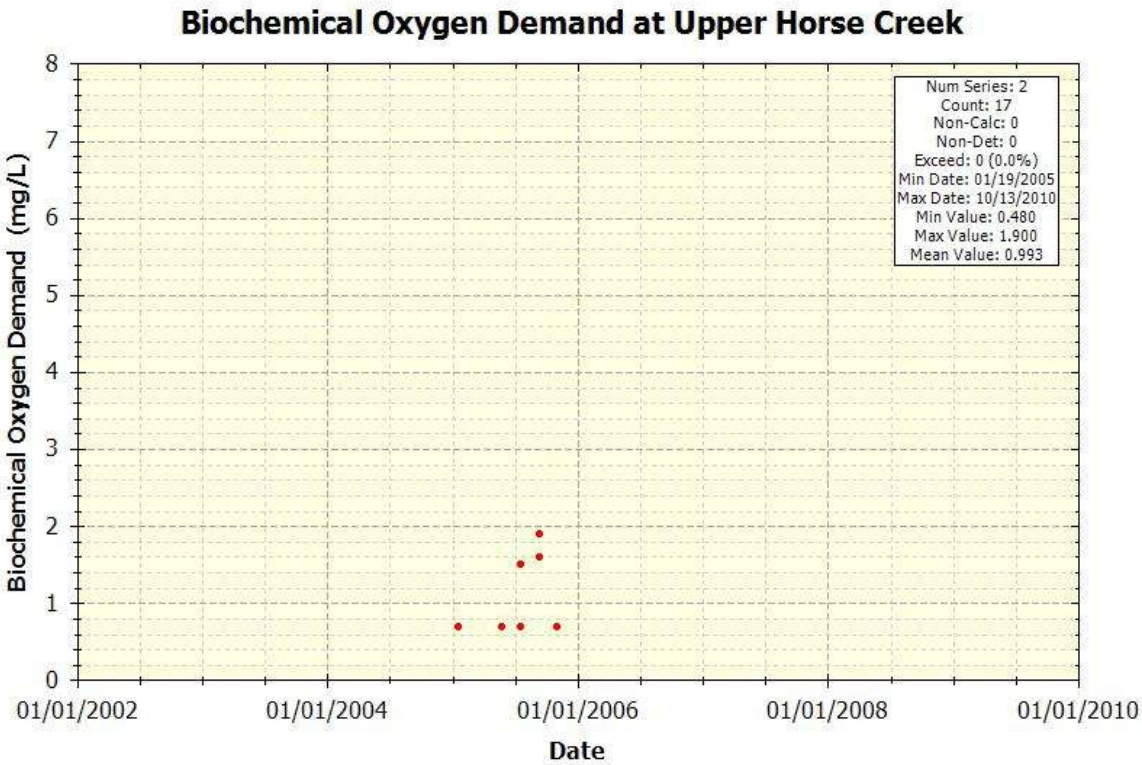

Figure 5.4 Biochemical oxygen demand concentrations in upper Horse Creek within WBID 3081

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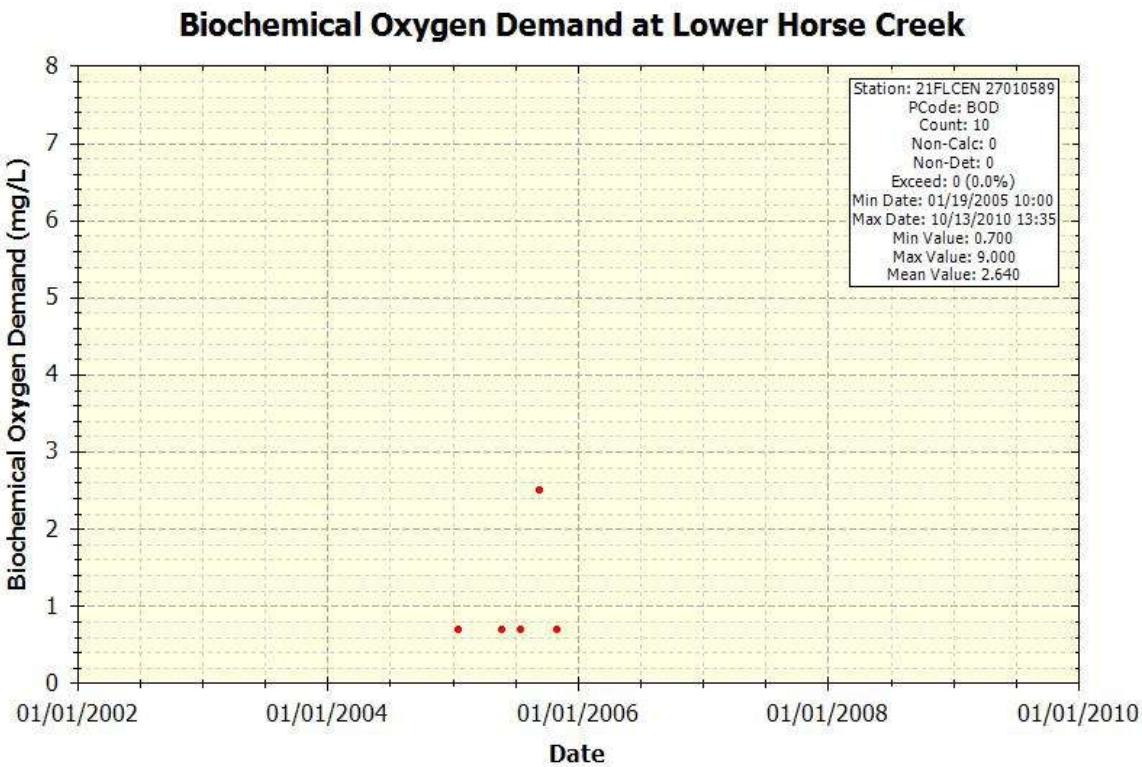

Figure 5.5 Biochemical oxygen demand concentrations in lower Horse Creek within WBID 3081

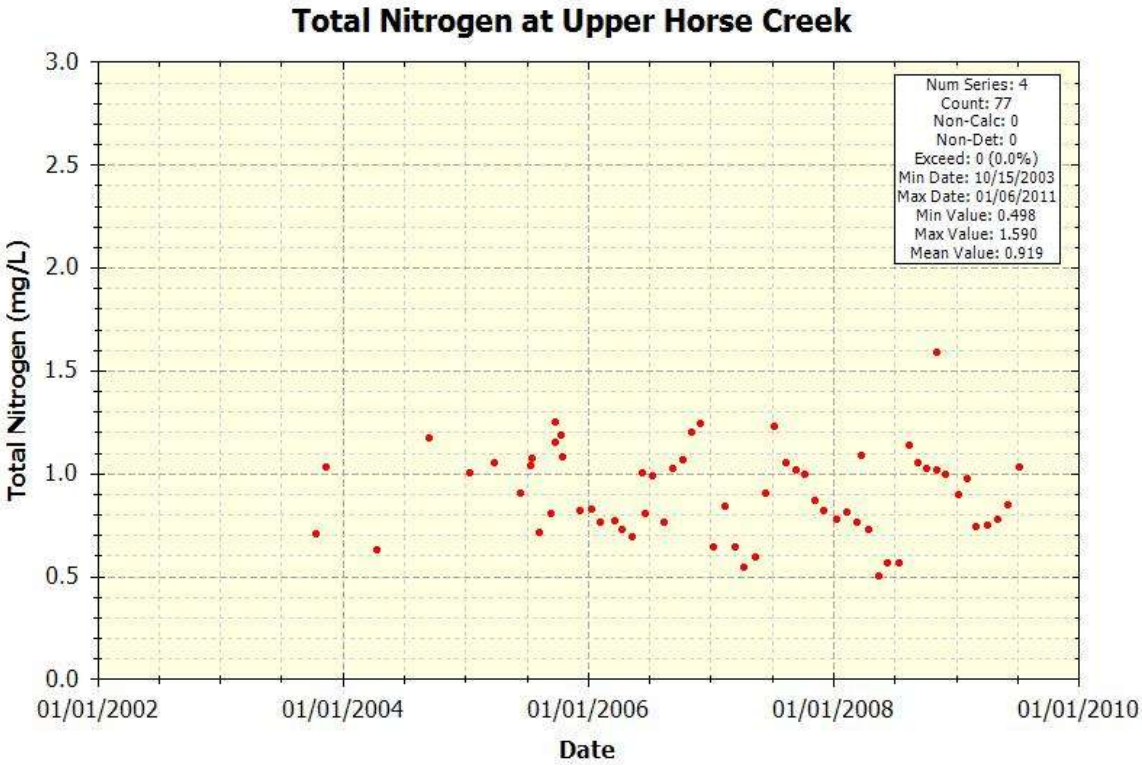

Figure 5.6 Total nitrogen concentrations in upper Horse Creek within WBID 3081

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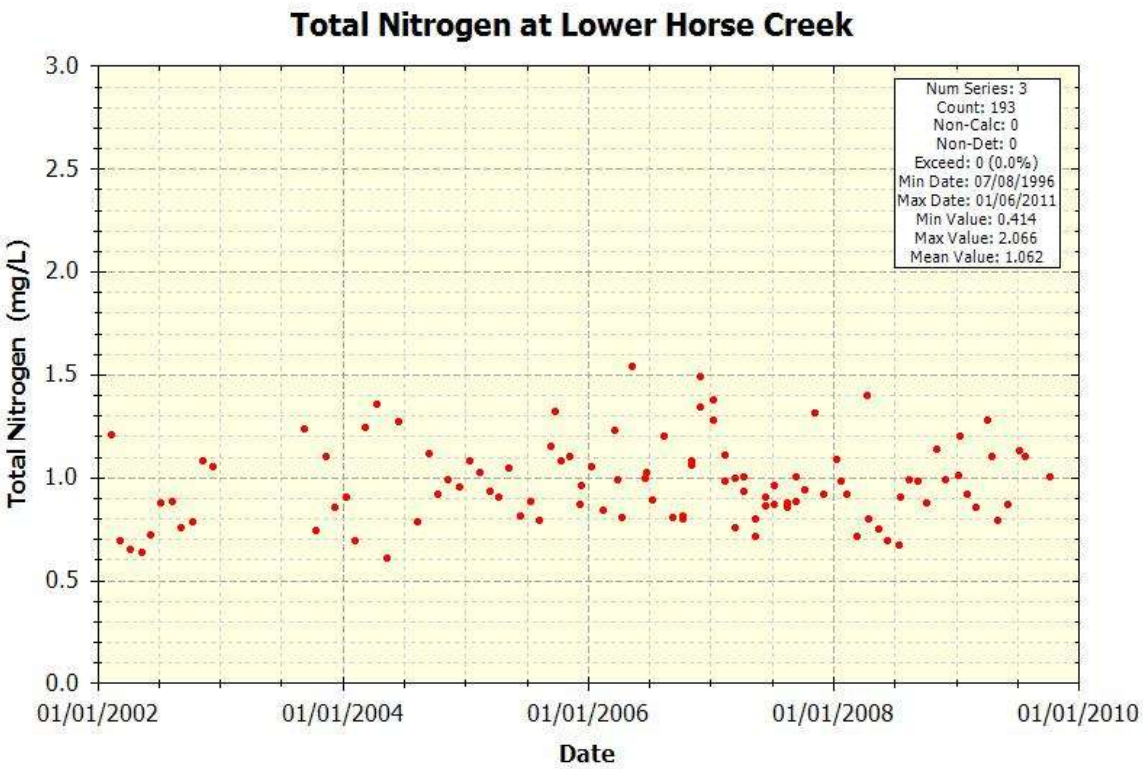

Figure 5.7 Total nitrogen concentrations in lower Horse Creek within WBID 3081

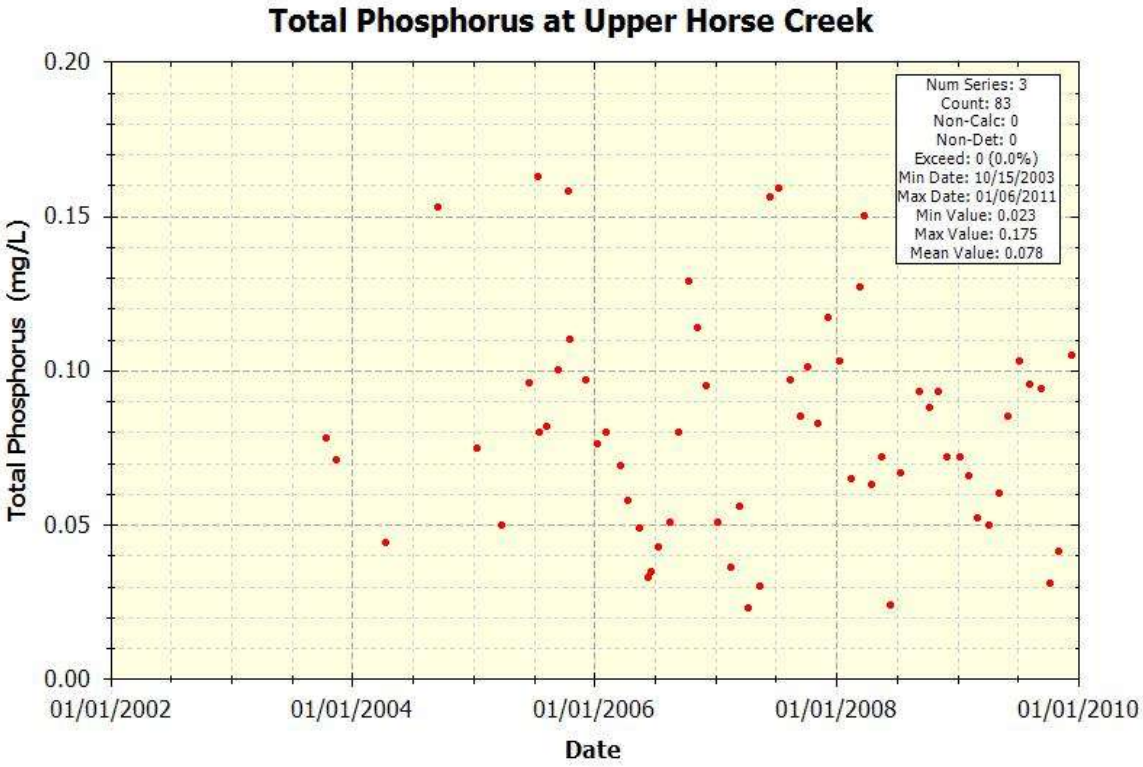

Figure 5.8 Total phosphorus concentrations in upper Horse Creek within WBID 3081

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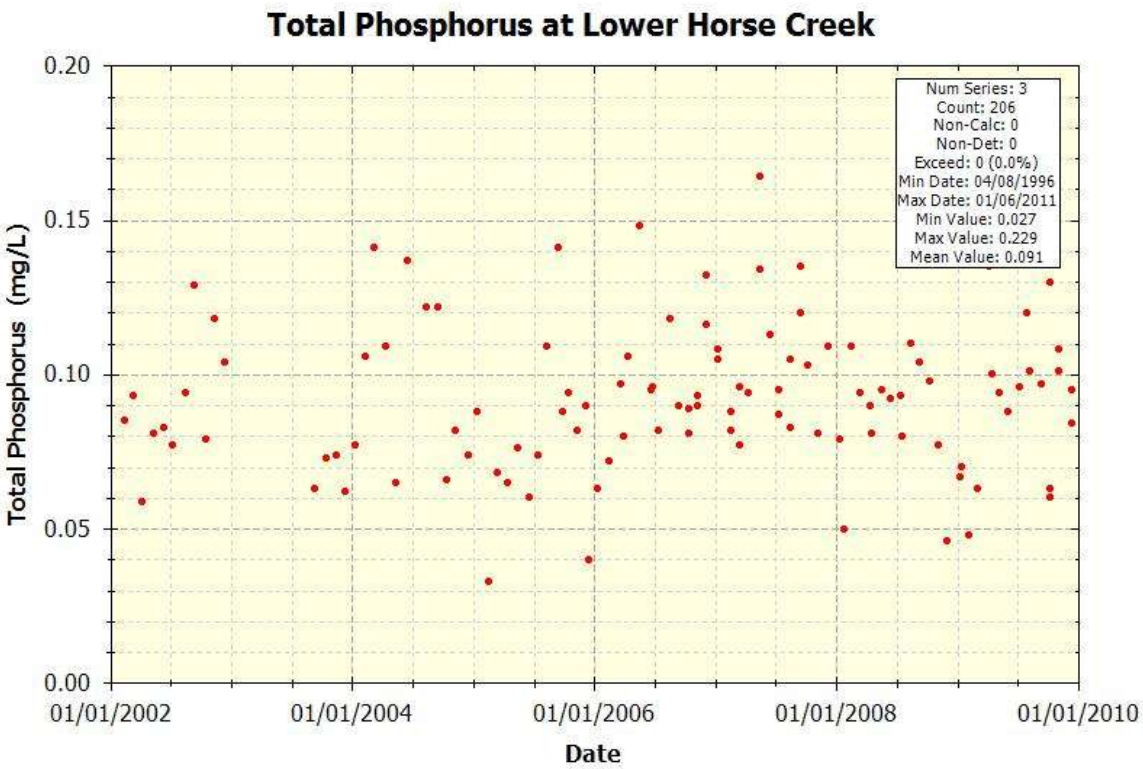

Figure 5.9 Total phosphorus concentrations in lower Horse Creek within WBID 3081

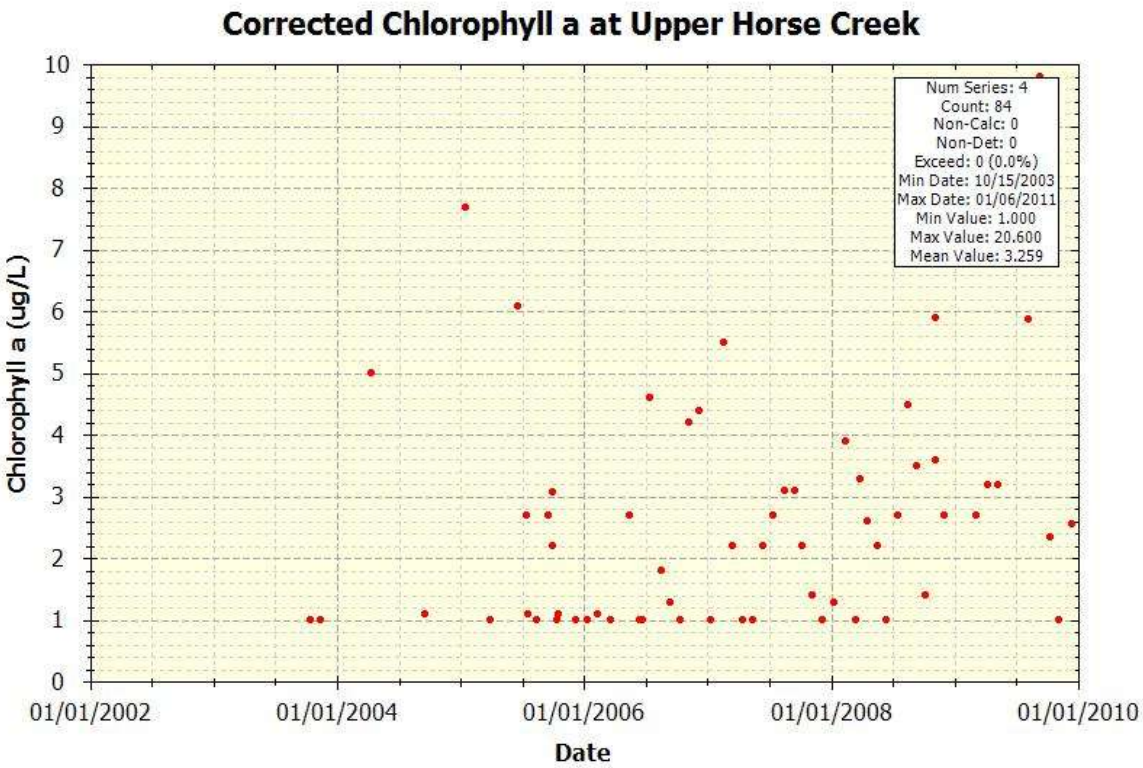

Figure 5.10 Corrected chlorophyll a concentrations in upper Horse Creek within WBID 3081

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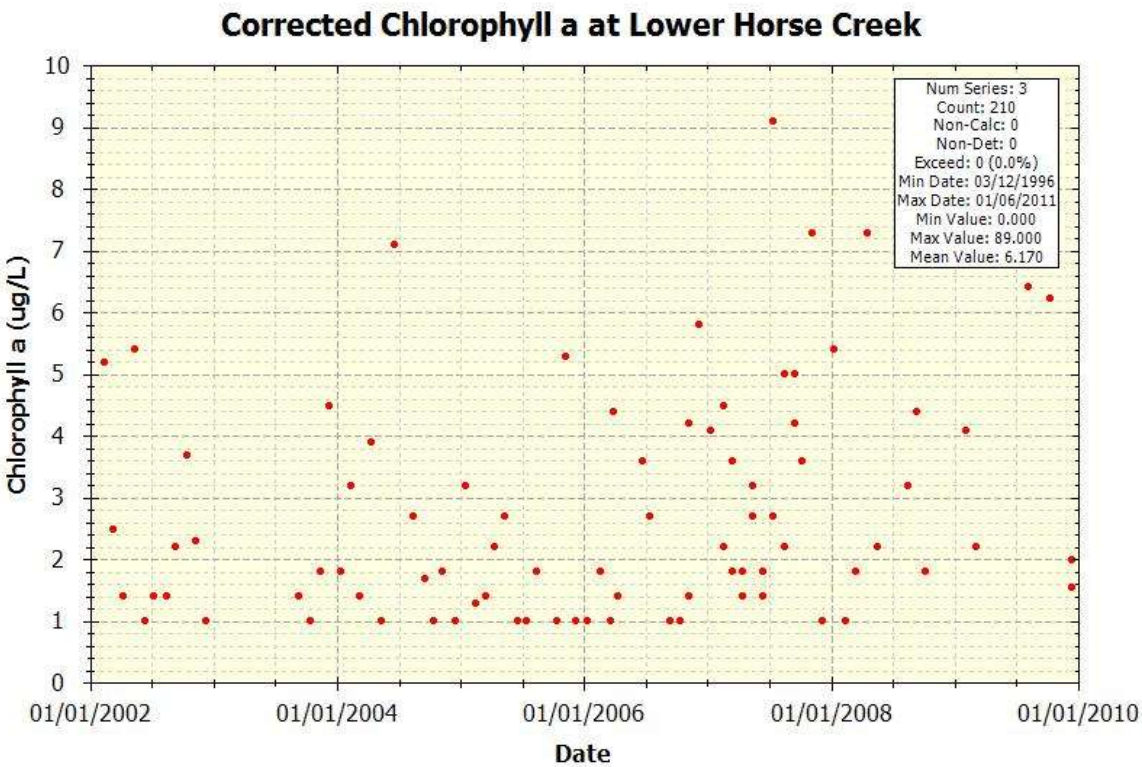

Figure 5.11 Corrected chlorophyll a concentrations in lower Horse Creek within WBID 3081

6.0 SOURCE AND LOAD ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or nonpoint sources. Nutrients can enter surface waters from both point and nonpoint sources.

6.1 Point Sources

A point source is defined as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted discharges include continuous discharges such as wastewater treatment facilities as well as some stormwater driven sources such as municipal separate stormwater sewer systems (MS4s), certain industrial facilities, and construction sites over one acre.

6.1.1 Wastewater/Industrial Permitted Facilities

A TMDL wasteload allocation (WLA) is given to wastewater and industrial NPDES permitted facilities discharging to surface waters within an impaired watershed. There are no NPDES facilities currently located within the contributing watershed of Horse Creek.

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6.1.2 Stormwater Permitted Facilities/MS4s

MS4s are point sources also regulated by the NPDES program. According to 40 CFR 122.26(b)(8), an MS4 is "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works

MS4s may discharge nutrients and other pollutants to waterbodies in response to storm events. In 1990, USEPA developed rules establishing Phase I of the NPDES stormwater program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of "medium" and "large" MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges from MS4s. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, hazardous waste treatment, etc.

Phase II of the rule extends coverage of the NPDES stormwater program to certain "small" MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES stormwater program. Only a select subset of small MS4s, referred to as "regulated small MS4s", requires an NPDES stormwater permit. Regulated small MS4s are defined as all small MS4s located in "urbanized areas" as defined by the Bureau of the Census, and those small MS4s located outside of "urbanized areas" that are designated by NPDES permitting authorities.

In October 2000, USEPA authorized FDEP to implement the NPDES stormwater program in all areas of Florida except Indian tribal lands. FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes (FS). The three major components of NPDES stormwater regulations are:

- MS4 permits that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.
- Stormwater associated with industrial activities, which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated

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industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce contamination of stormwater.

- Construction activity general permits for projects that ultimately disturb one or more acres of land and which require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction.

Stormwater discharges conveyed through the storm sewer system covered by the permit are subject to the WLA of the TMDL. Any newly designated MS4s will also be required to achieve the percent reduction allocation presented in this TMDL. Phase I and Phase II MS4 permits for WBID 3081 are listed in Table 6.1.

Table 6.1 MS4 Permits by WBID.

WBID	Segment Name	Phase	Facility Number	Affiliate	Co-Permittee
3081	Horse Creek	II	FLR04E027	Brevard County	City of Melbourne
		II	FLR04E052	Brevard County	Brevard County

6.2 Nonpoint Sources

Nonpoint sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For nutrients, these sources include runoff of agricultural fields, golf courses, and lawns, septic tanks, and residential developments outside of MS4 areas. Nonpoint source pollution generally involves a buildup of pollutants on the land surface that wash off during rain events and as such, represent contributions from diffuse sources, rather than from a defined outlet. Potential nonpoint sources are commonly identified, and their loads estimated, based on land cover data. Most methods calculate nonpoint source loadings as the product of the water quality concentration and runoff water volume associated with certain land use practices. The mean concentration of pollutants in the runoff from a storm event is known as the event mean concentration. In order to identify possible pollutant sources in the watershed, the landuse coverage was reviewed. Figure 3.2 provides a map of the land use in draining to the WBID, while Table 3.2 lists the land use distribution for the drainage area of the WBID. The following sections are organized by land use. Each section provides a description of the land use, the typical sources of nutrient loading (if applicable), and typical total nitrogen and total phosphorus event mean concentrations.

6.2.1 Urban Areas

Urban areas include land uses such as residential, industrial, extractive and commercial. Land uses in this category typically have somewhat high total nitrogen event mean concentrations and average total phosphorus event mean concentrations. Nutrient loading from MS4 and non-MS4 urban areas is attributable to multiple sources including stormwater runoff, leaks and overflows

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from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as outlined in Chapter 403 FS, was established as a technology-based program that relies upon the implementation of Best Management Practices (BMPs) that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, FAC.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water." [FAC 62-40-.432(2)(c)]

Nonstructural and structural BMPs are an integral part of the State's stormwater programs. Nonstructural BMPs, often referred to as "source controls", are those that can be used to prevent the generation of nonpoint source pollutants or to limit their transport off-site. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimization of impervious surfaces. Technology-based structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

Urban, residential, and commercial developments are likely a significant nonpoint source of nutrients and oxygen-demanding substances in the impaired WBID because a large portion of the land use is attributed to developed areas. The majority of the total developed land use in the Indian River Lagoon Basin is located close to the coast, and the majority of developed land use in WBID 3081 is located near the coast. Approximately 57 percent of the contributing land use to WBID 3081 is developed, with 53 percent of the total land use classified as high or medium intensity.

Onsite Sewage Treatment and Disposal Systems (Septic Tanks)

As stated above leaking septic tanks or onsite sewage treatment and disposal systems (OSTDs) can contribute to nutrient loading in urban areas. Water from OSTDs is typically released to the ground through on-site, subsurface drain fields or boreholes that allow the water from the tank to percolate (usually into the surficial aquifers) and either transpire to the atmosphere through surface vegetation or add to the flow of shallow ground water. When properly sited, designed, constructed, maintained, and operated, OSTDs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTD receives natural biological treatment in the soil and is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, OSTDs can be a source of nutrients, pathogens, and other pollutants to both ground water and surface water.

The State of Florida Department of Health publishes data on new septic tank installations and the number of septic tank repair permits issued for each county in Florida. Table 6.2 summarizes the cumulative number of septic systems installed in Brevard County since the 1970 census and the

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total number of repair permits issued for the eleven years between 1999-2000 and 2010-2011 (FDOH 2009). The data does not reflect septic tanks removed from service. Leaking septic systems could be a relevant source of organic and nutrient loading in the watershed.

Table 6.2 County estimates of Septic Tanks and Repair Permits.

County	Number of Septic Tanks (1970-2011)	Number of Repair Permits Issued (2000-2010)
Brevard	90,683	5,739

Note: Source: http://www.doh.state.fl.us/environment/ostds/statistics/ostdsstatistics.htm

6.2.2 Pastures

Pastures include cropland and improved and unimproved pasturelands, such as non-tilled grasses woodland pastures, feeding operations, nurseries and vineyards; as well as specialty farms. Agricultural activities, including runoff of fertilizers or animal wastes from pasture and cropland and direct animal access to streams, can generate nutrient loading to streams. The highest total nitrogen and total phosphorus event mean concentrations are associated with agricultural land uses. While 56 percent of Brevard County contains pasture land, WBID 3081 contains no pasture land or farms (USDA 2007).

6.2.3 Clear cut/Sparse

The clear cut/sparse land use classification includes recent clear cuts, areas of sparse vegetation or herbaceous dry prairie, shrub and brushland, other early successional areas, and mixed rangeland. Event mean concentrations for clear cut/sparse can be relatively low for total nitrogen and low for total phosphorus. Clear cut/sparse comprises 8 percent of the land use in the impaired WBID.

6.2.4 Forests

Upland forests include flatwoods, oak, various types of hardwoods, conifers and tree plantations. Wildlife, located within forested areas, deposit their feces onto land surfaces where it can be transported to nearby streams during storm events. Generally, the pollutant load from wildlife is assumed to represent background concentrations. Event mean concentrations for upland forests are low for both total nitrogen and total phosphorus. Forests consist of about 1 percent of the land use in the contributing watersheds in the WBID. The majority of the forested land occurs centrally in the WBID.

6.2.5 Water and Wetlands

Water and Wetlands often have very low nutrient loadings, although decaying organic matter in wetlands can contribute to high organic nutrient concentrations. Wetland land uses account for about 3 percent of the total contributing land uses to the WBID. Most of the wetland land uses

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occur along Horse Creek within the WBIDs, and are classified as forested wetlands. Only 3 percent of the land use is classified as open water.

6.2.6 Quarries/Strip mines

Land use classification includes quarries, strip mines, exposed rock and soil, fill areas, reclaimed lands, and holding ponds. These types of land cover comprise about 1 percent in WBID 3081. Event mean concentrations for some barren lands can be high in total nitrogen.

7.0 ANALYTICAL APPROACH

In the development of a TMDL there needs to be a method for relating current loadings to the observed water quality problem. This relationship could be statistical (regression for a cause and effect relationship), empirical (based on observations not necessarily from the waterbody in question) or mechanistic (physically and/or stochastically based) that inherently relate cause and effect using physical and biological relationships.

Mechanistic models were used in the development of the Horse Creek TMDL to relate the physical and biological relationships. A dynamic watershed model was used to predict the quantity of water and pollutants associated with runoff from rain events. The watershed model was linked to a hydrodynamic model that simulated tidal influences in the river. Both models were linked to a water quality simulation model that integrated the loadings and flow from the watershed model with flow from the hydrodynamic model to predict the water quality in the receiving waterbodies.

The period of simulation that was considered in the development of this TMDL is January 1, 2002 to December 31, 2009. The models were used to predict time series for BOD, TN, TP, and DO. The models were calibrated to current conditions and were then used to predict improvements in water quality as function of reductions in loadings.

7.1 Mechanistic Models

7.1.1 Loading Simulation Program C++ (LSPC)

LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality overland as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by USEPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, the USEPA Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the USEPA TMDL Modeling Toolbox. LSPC was used to simulate runoff (flow, biological oxygen demand, total nitrogen, total phosphorus and dissolved oxygen) from the land surface using a daily timestep for current and natural conditions. LSPC provided tributary flows and temperature to the EFDC estuary models and tributary water quality concentrations to WASP7 estuary models.

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An LSPC model was utilized to estimate the nutrient loads within and discharged from the Horse Creek watershed. The LSPC model utilized the data inputs, including land use and weather data, from the larger Indian River Watershed model (USEPA 2012a and USEPA 2012b).

In order to evaluate the contributing sources to a waterbody and to represent the spatial variability of these sources within the watershed model, the contributing drainage area was represented by a series of sub-watersheds for each of the models. The sub-watersheds for the Indian River Watershed model were developed using the 12-digit hydrologic unit code (HUC12) watershed data layer and the Geological Survey (USGS) National Hydrograph Dataset (NHD). The sub-watersheds were re-delineated at a smaller scale for the Horse Creek Watershed model, once again using the NHD catchments as well as the USGS National Elevation Dataset Digital Elevation Model (Figure 7.1).

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Figure 7.1 Location of Horse Creek LSPC subwatersheds

The LSPC model has a representative reach defined for each sub-watershed, and the main channel stem within each sub-watershed was used as the representative reach. The characteristics for each reach include the length and slope of the reach, the channel geometry and

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the connectivity between the sub-watersheds. Length and slope data for each reach was obtained using the USGS DEM and NHD data.

The attributes supplied for each reach were used to develop a function table (FTABLE) that describes the hydrology of the stream reach by defining the functional relationship between water depth, surface area, water volume, and outflow in the segment. The assumption of a fixed depth, area, volume, outflow relationship rules out cases where the flow reverses direction or where one reach influences another upstream of it in a time-dependent way. LSPC does not model the tidal flow in the low-lying estuaries, and therefore the main Indian River Watershed model was calibrated to non-tidally influenced USGS gages. The Horse Creek Watershed model was linked to the EFDC and WASP models to simulate the areas of the estuary that were tidally influenced.

The watershed model uses land use data as the basis for representing hydrology and nonpoint source loadings. The FDEP Level III Florida Land Use, specifically the St. Johns Water Management District (SJWMD) 2006 dataset, was used to determine the land use representation. The National Landuse Coverage Dataset (NLCD) was used to develop the impervious land use representations.

The SJWMD coverage utilized a variety of land use classes which were grouped and re-classified into 18 land use categories: beaches/dune/mud, open water, utility swaths, developed open space, developed low intensity, developed medium intensity, developed high intensity, clear-cut/sparse, quarries/strip mines, deciduous forest, evergreen forest, mixed forest, golf courses, pasture, row crop, forested wetland, non-forested wetland (salt/brackish), and non-forested wetland (freshwater). The LSPC model requires division of land uses in each sub-watershed into separate pervious and impervious land units. The NLCD 2006 percent impervious coverage was used to determine the percent impervious area associated with each land use category. Any impervious areas associated with utility swaths, developed open space, and developed low intensity, were grouped together and placed into a new land use category named *low intensity development impervious*. Impervious areas associated with medium intensity development and high intensity development were kept separate and placed into two new categories for *medium intensity development impervious* and *high intensity development impervious*, respectively. Finally, any impervious area not already accounted for in the three developed impervious categories, were grouped together into a fourth new category for all remaining impervious land use.

Soil data for the Florida watersheds was obtained from the Soil Survey Geographic Database (SSURGO). The database was produced and distributed by the Natural Resources Conservation Service (NRCS) - National Cartography and Geospatial Center (NCGC). The SSURGO data was used to determine the total area that each hydrologic soil group covered within each sub-watershed. The sub-watersheds were represented by the hydrologic soil group that had the highest percentage of coverage within the boundaries of the sub-watershed. There were four hydrologic soil groups which varied in their infiltrations rates and water storage capacity.

In the watershed models, nonpoint source loadings and hydrological conditions are dependent on weather conditions. Hourly data from weather stations within the boundaries of, or in close proximity to, the sub-watersheds were applied to the watershed model. A weather data forcing

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file was generated in ASCII format (*.air) for each meteorological station used in the hydrological evaluations in LSPC. Each meteorological station file contained atmospheric data used in modeling the hydrological processes. These data included precipitation, air temperature, dew point temperature, wind speed, cloud cover, evaporation, and solar radiation. These data are used directly, or calculated from the observed data. The Indian River Watershed model weather stations contained data through 2009.

The hydrodynamic calibration parameters from the larger Indian River Watershed model were used to populate the Horse Creek watershed model. The Indian River Watershed model was calibrated to continuous flow USGS gages. No continuous measured flow data was located in the Horse Creek watershed, so no calibration updates were done for flow in Horse Creek and the Indian River Watershed model parameterization was used (Figure 7.2). Additionally, the water quality parameters from the larger Indian River Watershed model were used to populate the Horse Creek Watershed model. The Indian River Watershed model was calibrated to several water quality stations whose data was taken from IWR38. The Horse Creek watershed was calibrated to water quality data from IWR44, specifically to station 21FLSJWMIRLHUS, which both contained data records for the parameters of interest. LSPC water quality calibration results are presented in Figure 7.3 through Figure 7.7.

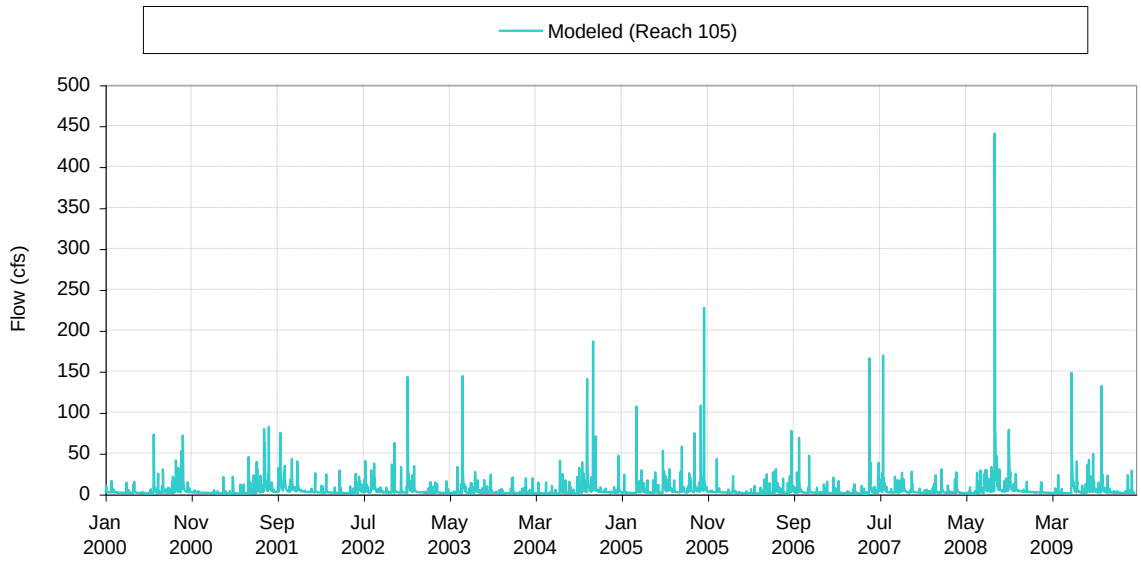

Figure 7.2 Modeled Flow (cfs) in Horse Creek

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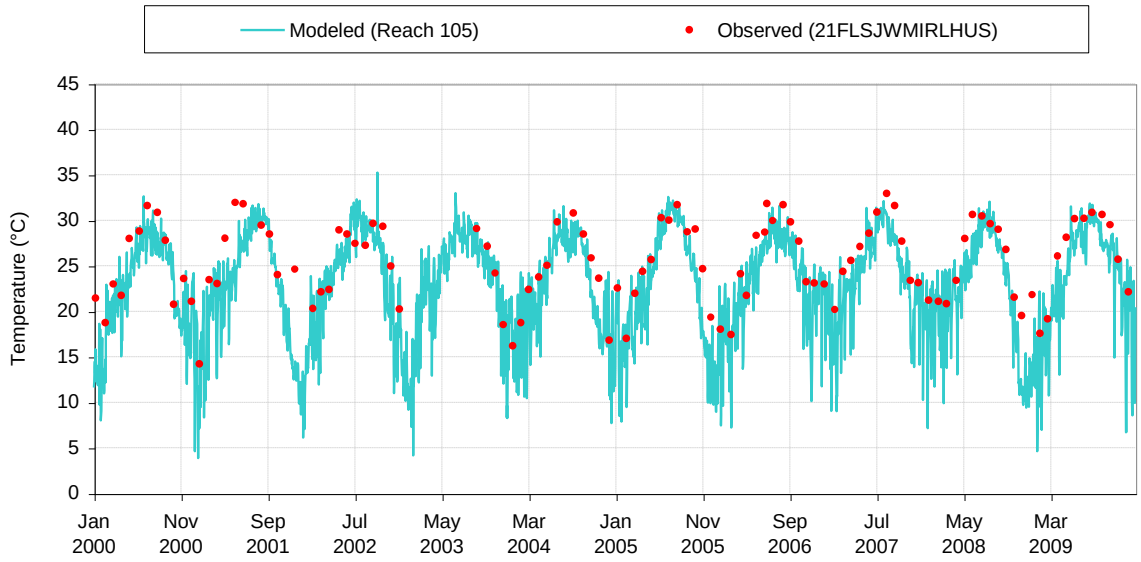

Figure 7.3 Modeled vs. Observed Temperature (°C) at 21FLSJWMIRLHUS

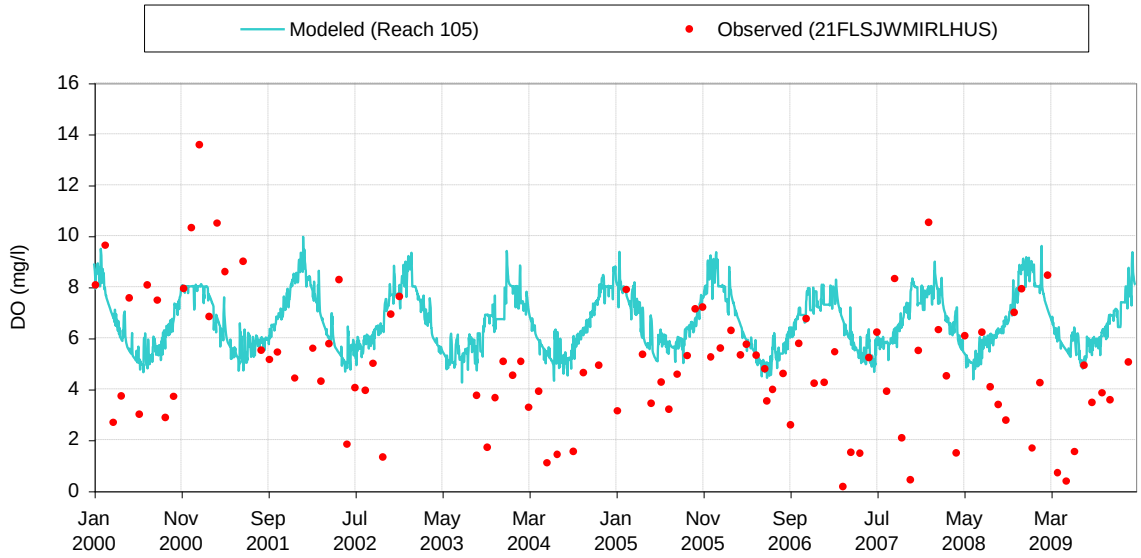

Figure 7.4 Modeled vs. Observed DO (mg/l) at 21FLSJWMIRLHUS

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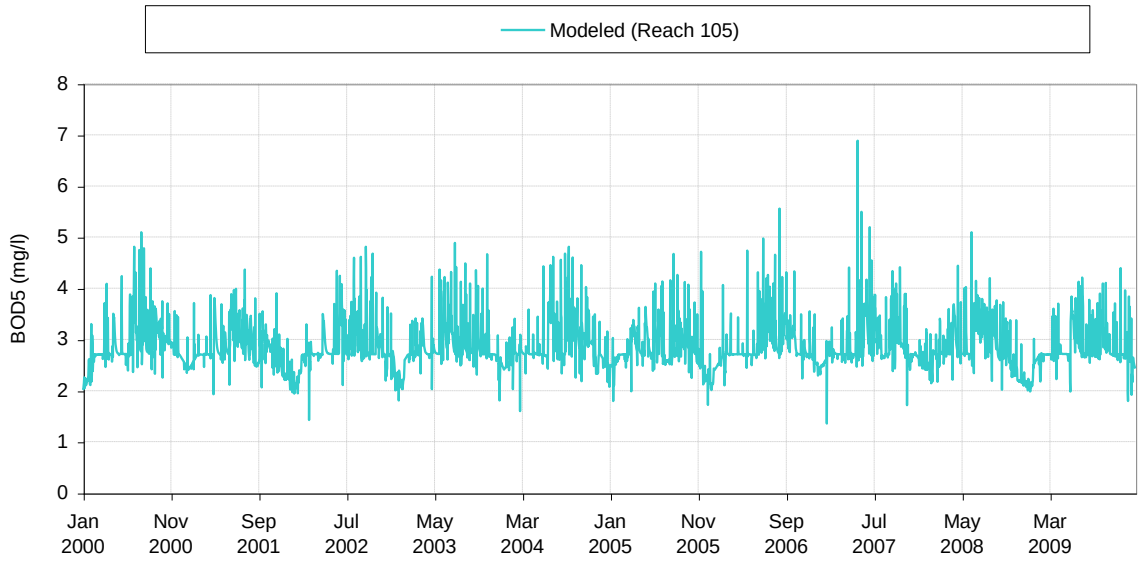

Figure 7.5 Modeled BOD5 (mg/l) in Horse Creek

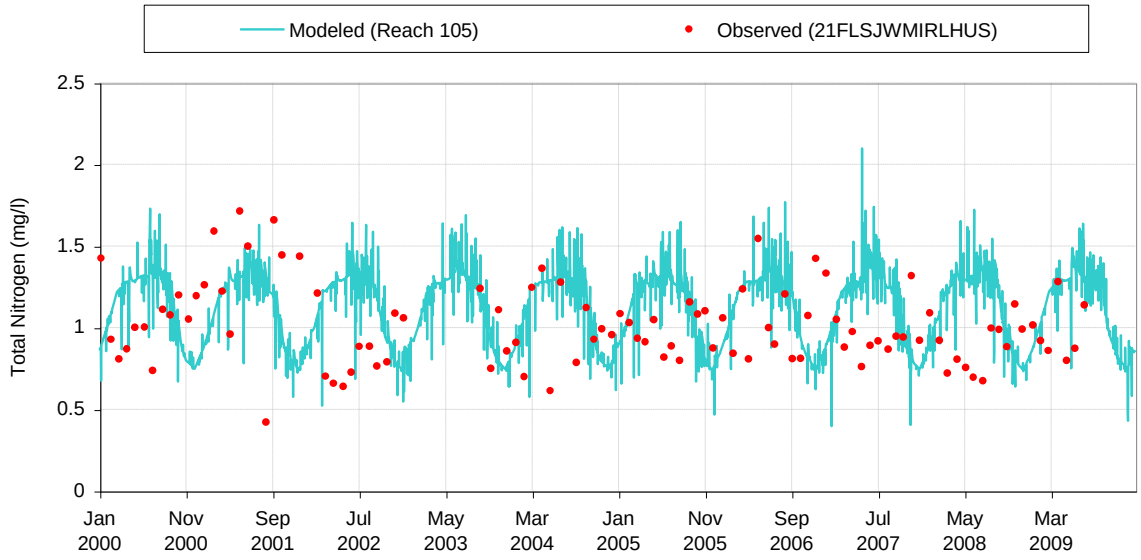

Figure 7.6 Modeled vs. Observed Total Nitrogen (mg/l) at 21FLSJWMIRLHUS

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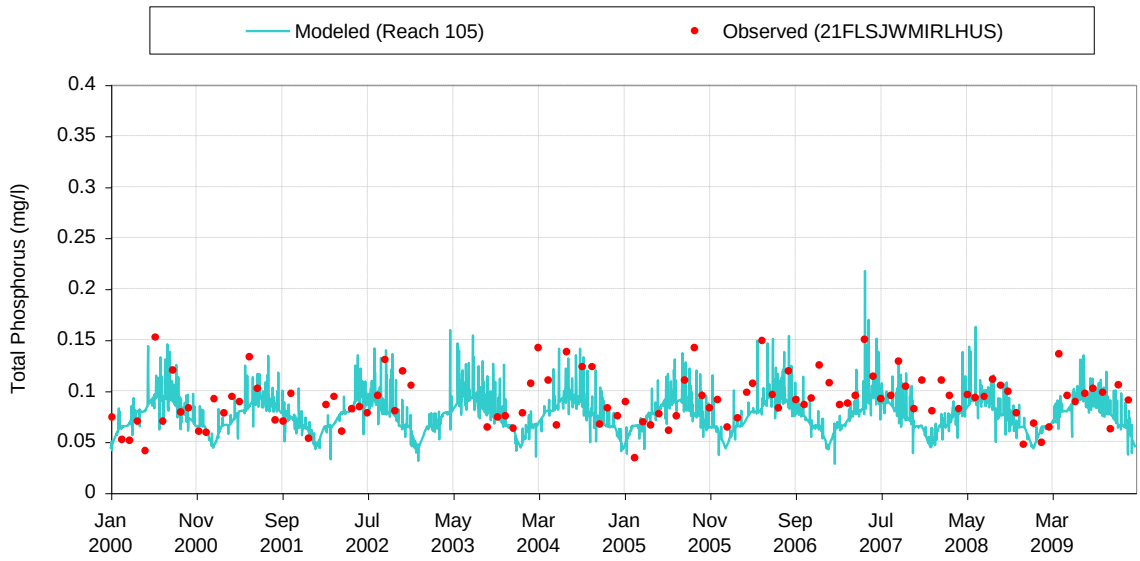

Figure 7.7 Modeled vs. Observed Total Phosphorus (mg/l) at 21FLSJWMIRLHUS

7.1.2 Environmental Fluids Dynamic Code (EFDC)

The EFDC model is a part of the USEPA TMDL Modeling Toolbox due to its application in many TMDL-type projects. As such, the code has been peer reviewed and tested and has been freely distributed and supported by Tetra Tech. EFDC was developed by Dr. John Hamrick (Hamrick 1992) and is currently supported by Tetra Tech for USEPA Office of Research and Development (ORD), USEPA Region 4, and USEPA Headquarters. The models, tools, and databases in the TMDL Modeling Toolbox are continually updated and upgraded through TMDL development in Region 4. EFDC is a multifunctional, surface-water modeling system, which includes hydrodynamic, sediment contaminant, and eutrophication components. The EFDC model is capable of 1, 2, and 3-dimensional spatial resolution. The model employs a curvilinear-orthogonal horizontal grid and a sigma or terrain following vertical grid.

The EFDC hydrodynamic model can run independently of a water quality model. The EFDC model simulates the hydrodynamic and constituent transport and then writes a hydrodynamic linkage file for a water quality model such as the Water Quality Analysis Program (WASP7) model. This model linkage, from EFDC hydrodynamics to WASP water quality, has been applied on many USEPA Region 4 projects in support of TMDLs and has been well tested (Wool et al. 2003).

The EFDC model was utilized to simulate three-dimensional circulation dynamics of hydrodynamic state variables (water surface elevation, salinity, and temperature) in the Horse Creek estuary. The EFDC model predicts water surface elevation, salinity, and temperature, in response to a set of multiple factors: wind speed and direction, freshwater discharge, tidal water level fluctuation, rainfall, surface heat flux, and temperature and salinity associated with boundary fluxes. Hourly measurements of atmospheric pressure, dry and wet bulb atmospheric

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temperatures, rainfall rate, wind speed and direction, and fractional cloud cover were obtained from data collected at one WBAN station, Miami, for 2002 through 2009. Solar short wave radiation was calculated using the CE-Qual-W2 method.

The Horse Creek Estuary model used hourly water surface elevation time series data from the National Oceanic and Atmospheric Administration (NOAA) tidal stations to simulate tides at the open boundary. Observed temperature data at water quality stations were used to simulate the temperature at the open boundaries, and average salinity in the Indian River Lagoon was used to simulate salinity. The upstream inland boundary grid cell received LSPC simulated watershed discharges.

The Horse Creek EFDC grid consisted of 58 cells, specifically 29 cells in the horizontal direction and was two layers in the vertical direction (Figure 7.8). The grid was developed using bathymetry data from NOAA. Bathymetry was unavailable for the inland, tidally influenced streams, and channel slope from the USGS digital elevation model was used to estimate slope within the channel. The Horse Creek grid extended from the Indian River Lagoon into Horse Creek.

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Figure 7.8 Location of Horse Creek LSPC subwatersheds and EFDC grid

Because there were no NOAA tidal stations located within the Horse Creek estuary, water surface elevation within the modeled cells could not be directly calibrated. Salinity measurements from IWR44 data were used to review the Horse Creek estuary EFDC calibration.

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Following model review, the salinity and temperature parameters were adjusted accordingly (Figure 7.9).

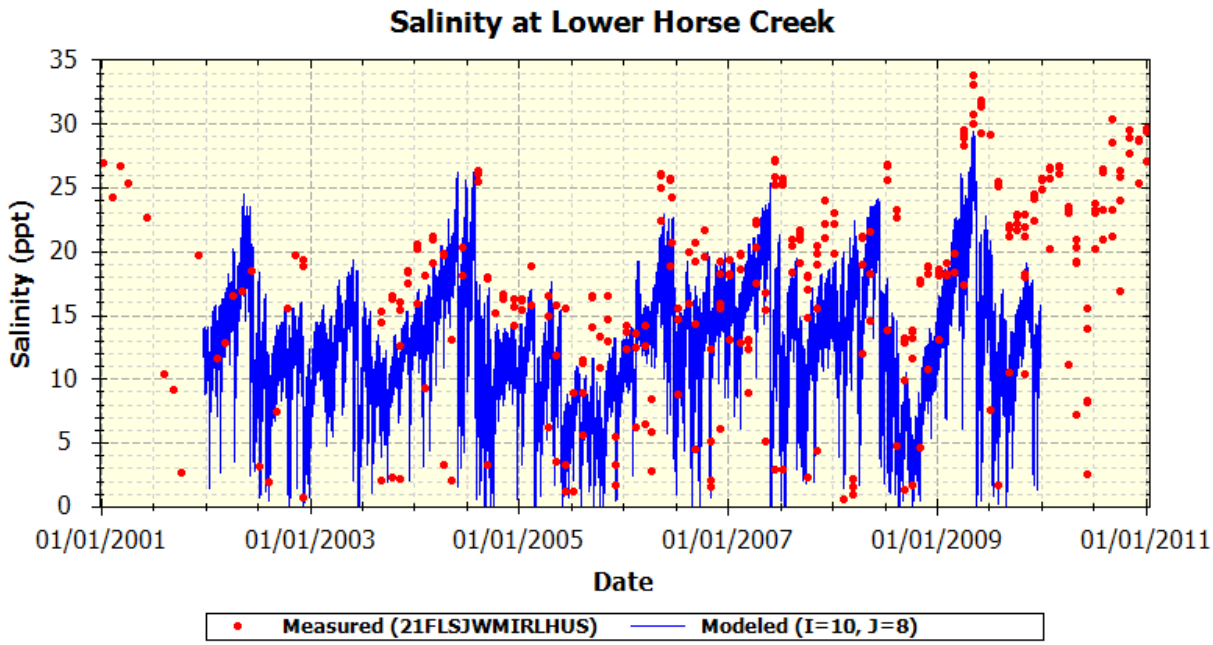

Figure 7.9 Measured verse modeled salinity (ppt) in Horse Creek at station 21FLSJWIRLHUS

7.1.3 Water Quality Analysis Simulation Program (WASP7)

The Water Quality Analysis Simulation Program Version 7.4.1 (WASP7) is an enhanced Windows version of the USEPA Water Quality Analysis Simulation Program (WASP) (Di Toro et al., 1983; Connolly and Winfield, 1984; Ambrose, R.B. et al., 1988), with upgrades to the user's interface and the model's capabilities. The major upgrades to WASP have been the addition of multiple BOD components, addition of sediment diagenesis routines, and addition of periphyton routines. The hydrodynamic file generated by EFDC is compatible with WASP7 and it transfers segment volumes, velocities, temperature and salinity, as well as flows between segments. The time step is set in WASP7 based on the hydrodynamic simulation.

WASP7 helps users interpret and predict water quality responses to natural phenomena and man-made pollution for various pollution management decisions. WASP7 is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the basic program. The purpose of the WASP7 water quality modeling was to reproduce the three-dimensional transport and chemical and biological interactions of major components of water quality in the Horse Creek estuary. WASP7 modeled total nitrogen (TN) and its speciation, total phosphorus (TP) and its speciation, chlorophyll-a, dissolved oxygen, and carbonaceous biochemical oxygen demand (CBOD). The model predicts these parameters in response to a set of hydrological, meteorological, atmospheric, and chemical and biological factors: loads from point and nonpoint sources, benthic ammonia and phosphate

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fluxes, sediment oxygen demand (SOD), solar radiation, air temperature, reaeration, offshore and inland boundary conditions.

The Horse Creek WASP7 model utilized the same grid cells that were developed for the Horse Creek EFDC model. The hydrodynamic simulation from the Horse Creek EFDC model was input into the WASP7 model. Open boundary water quality conditions used measured water quality data from Indian River Lagoon. Water quality loading from the LSPC model was used to simulate loads coming from rivers and streams into the estuary.

Because the LPSC model simulated TN, TP, and BOD and the WASP model simulated TN and its speciation, TP and its speciation, and CBOD, the water quality concentrations from LSPC were adjusted for WASP simulation prior to being input into the WASP model. TN was speciated into nitrate-nitrite (NOX), ammonia (NH4), and organic nitrogen (ON), and TP was speciated into orthophosphate (PO4) and organic phosphorus (OP). Water quality data in the Horse Creek watershed was reviewed to determine the ratio of NOX, NH4, and ON in TN, and the ration of PO4 and OP in TP. The in-stream BOD loads from LSPC were converted to ultimate CBOD using an f-ratio of 1.5.

Water quality parameters from the Pellicer Creek TMDL model were used for initial parameter population for the Horse Creek WASP7 model. The Horse Creek estuary model calibration was reviewed against water quality data located in IWR44. Following review, the calibration was adjusted accordingly to provide the best existing scenario model calibration for the water quality parameters of concern. Results at select water quality stations are presented in the Current Condition scenario, Section 7.2.1.

7.2 Scenarios

Two modeling scenarios were developed and evaluated in this TMDL determination: a current condition and a natural condition scenario. Concentrations and loadings were evaluated to determine if DO concentrations in the natural condition scenario could meet the DO standard, and the impact of nutrients on the DO concentrations. The results from the scenarios were used to develop the TMDL.

7.2.1 Current Condition

The current condition scenario evaluated current hydrologic and water quality conditions in the watershed, specifically water quality concentration and loadings at the outlet of WBID 3081. The current condition annual average concentrations for the Indian River Lagoon Basin WBID are presented in Table 7.1 The current condition simulation was used to determine the base loadings for the WBID. The base loading (Table 7.2), when compared with the TMDL scenarios, were used to determine the percent reduction in nutrient loads that will be needed to achieve water quality standards. Figure 7.10 through Figure 7.17 provide calibrated current condition modeled parameters for the Horse Creek basin.

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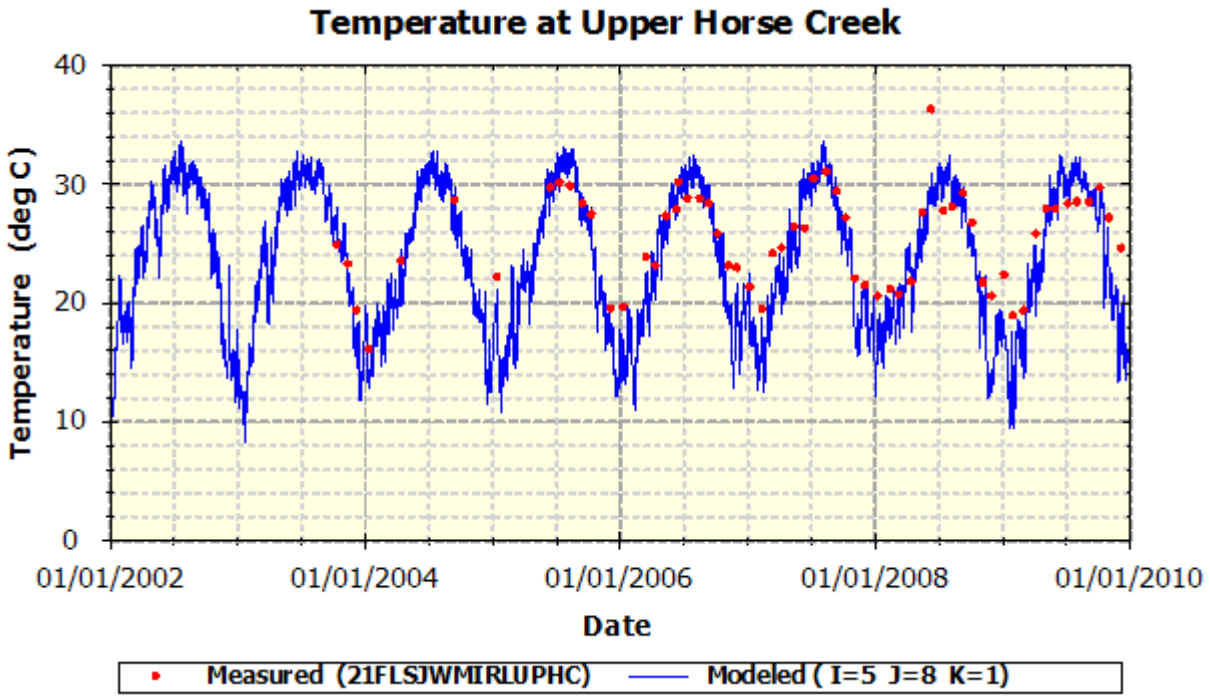

Figure 7.10 Simulated temperature verse measured temperature in the upper Horse Creek at station 21FLSJWMIRLUPHC

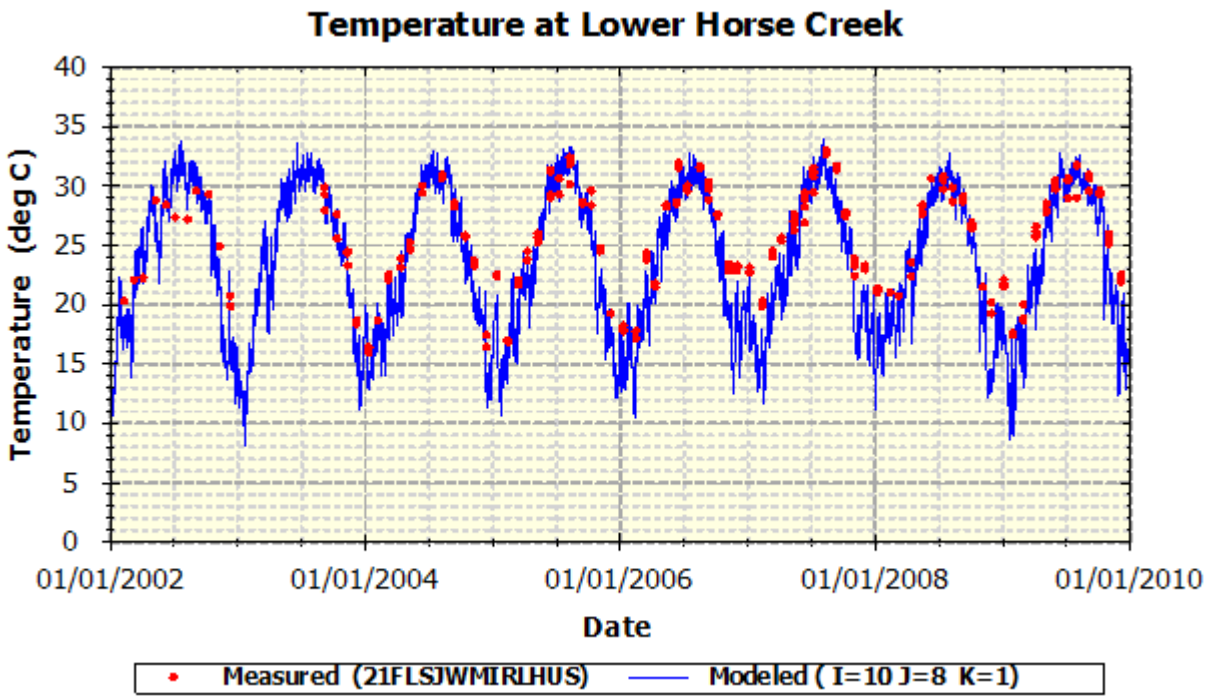

Figure 7.11 Simulated temperature verse measured temperature in the lower Horse Creek at station 21FLSJWMIRLHUS

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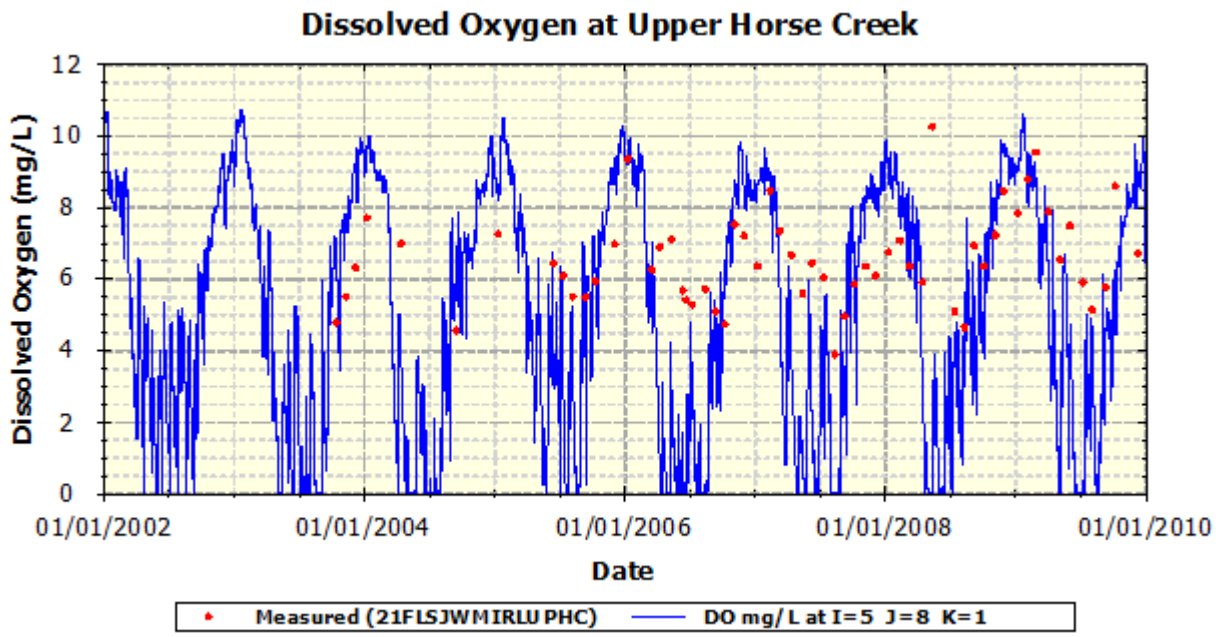

Figure 7.12 Simulated dissolved oxygen verse measured dissolved oxygen in the upper Horse Creek at station 21FLSJWMIRLUPHC

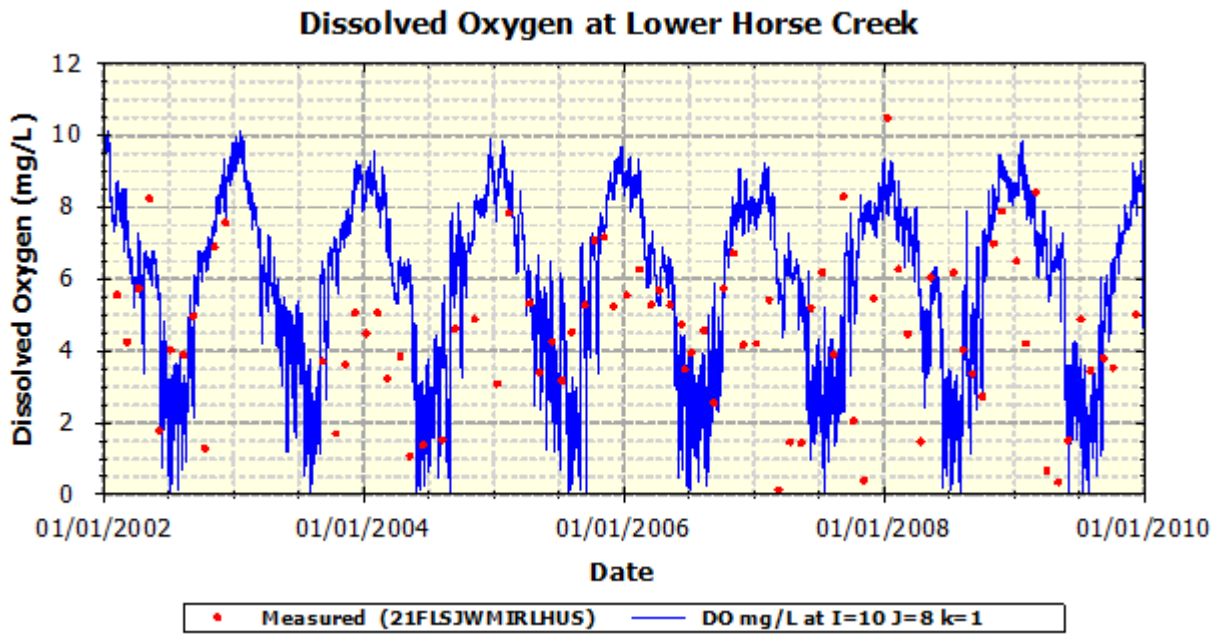

Figure 7.13 Simulated dissolved oxygen verse measured dissolved oxygen in the lower Horse Creek at station 21FLSJWMIRLSHUS

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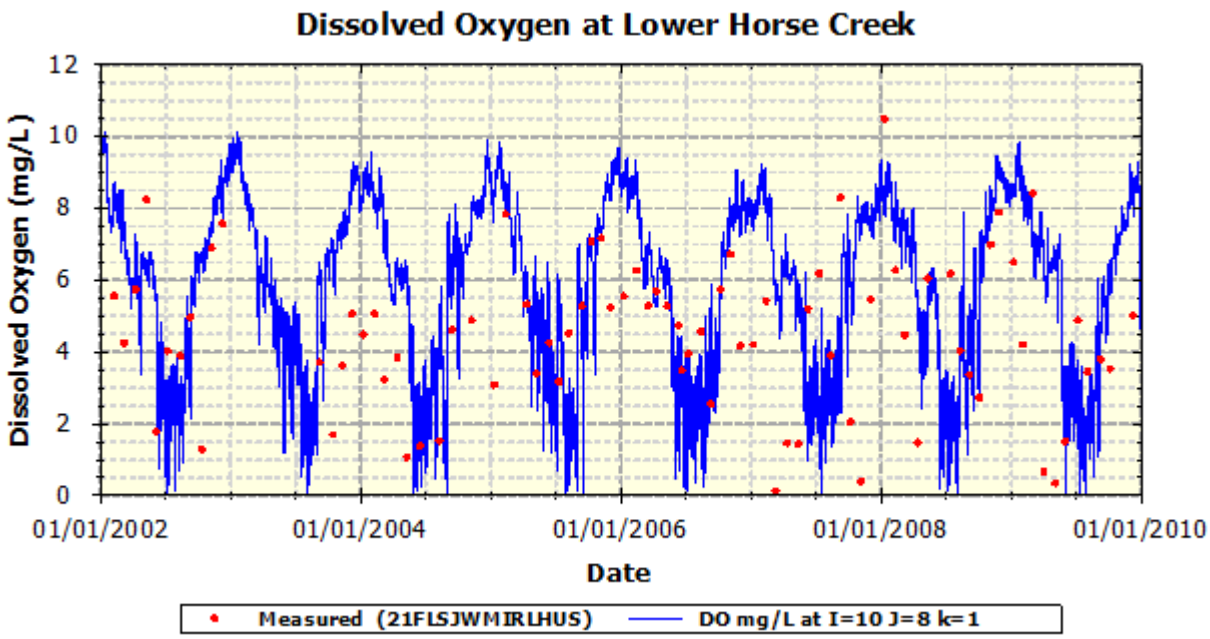

Figure 7.14 Simulated total nitrogen verse measured total nitrogen in the upper Horse Creek at station 21FLSJWMIRLUPHC

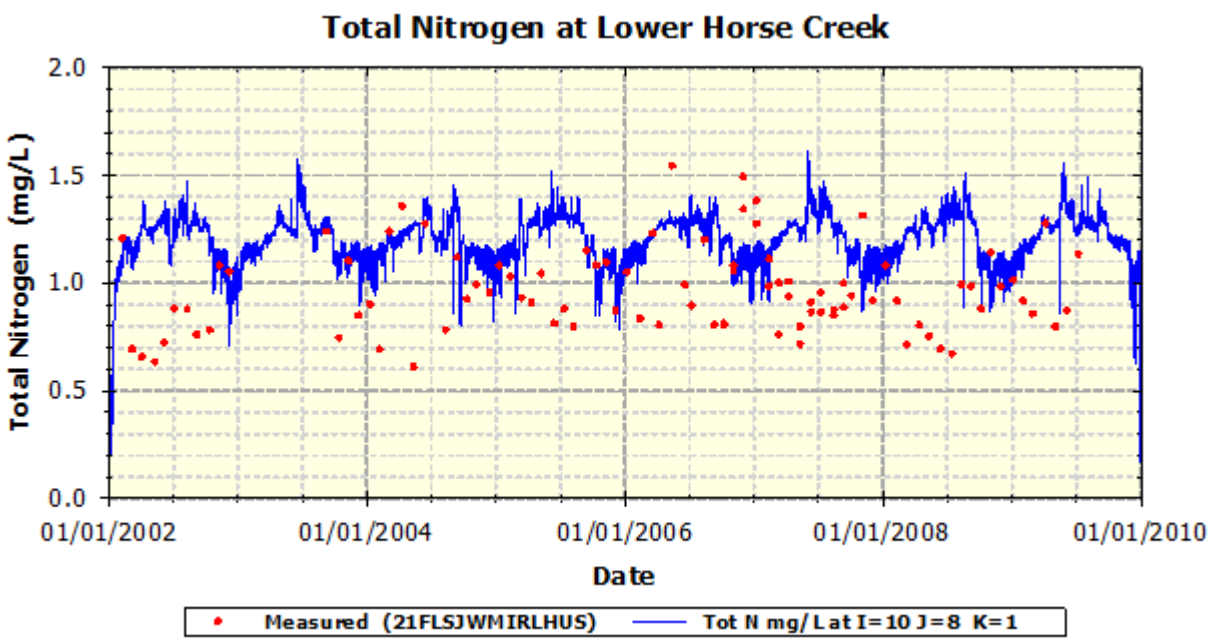

Figure 7.15 Simulated total nitrogen verse measured total nitrogen in the lower Horse Creek at station 21FLSJWMIRLSHUS

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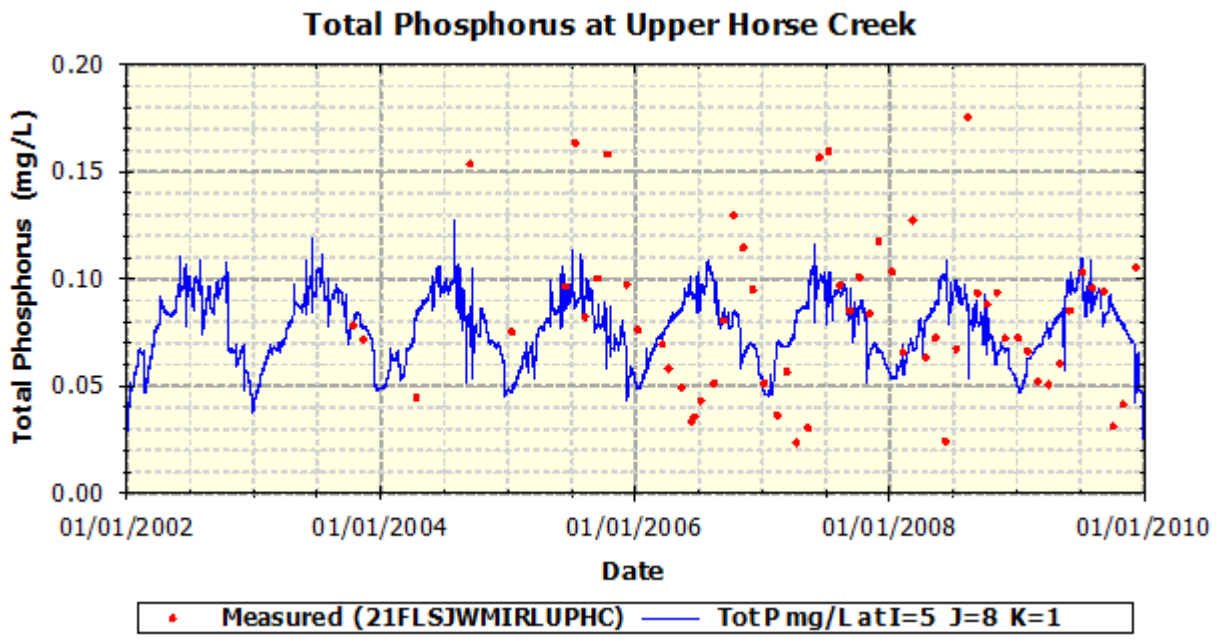

Figure 7.16 Simulated total phosphorus verse measured total phosphorus in the upper Horse Creek at station 21FLSJWMIRLUPHC

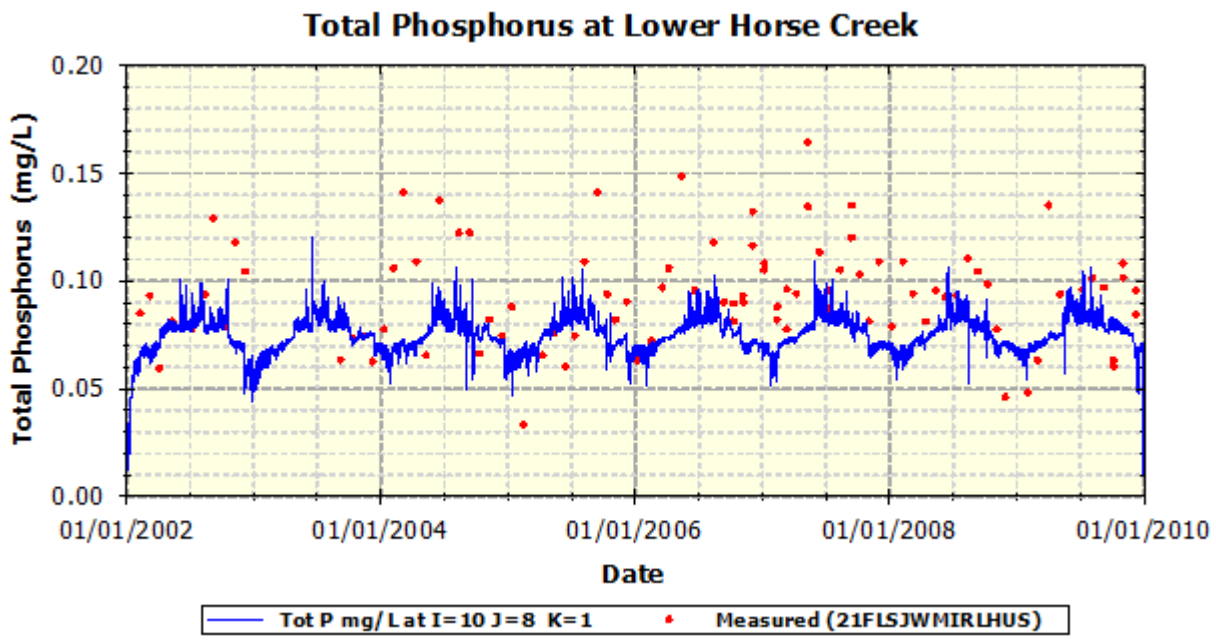

Figure 7.17 Simulated total phosphorus verse measured total phosphorus in the lower Horse Creek at station 21FLSJWMIRLSHUS

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Table 7.1 Current condition concentrations in the impaired WBID in the Indian River Lagoon Basin.

Parameter	WBID 3081
Total nitrogen (mg/L)	1.19
Total phosphorus (mg/L)	0.74
BOD (mg/L)	1.00
Dissolved oxygen (mg/L)	6.0

Table 7.2 Current condition loadings in the impaired WBID in the Indian River Lagoon Basin.

Parameter	WBID 3081	
	WLA (kg/yr)	LA (kg/yr)
Total nitrogen (mg/L)	--	4,885
Total phosphorus (mg/L)	--	344
BOD (mg/L)	--	13,124

7.2.2 Natural Condition

The natural condition scenario was developed to estimate water quality conditions if there was no impact no impact from anthropogenic sources. The point sources located in the model were removed for the the natural condition analysis. Land uses that were associated with anthropogenic activities (urban, (urban, agriculture, transportation, barren lands and rangeland) were converted to upland forests or or forested wetlands based on the current ration of forest and wetland land uses in the model. The The natural condition water quality predictions are presented in

Table 7.3 and Table 7.4.

The purpose of the natural conditions scenario was to determine whether water quality standards could be achieved without abating the naturally occurring loads from the watershed. The natural condition modeling scenario indicated that the DO standard is not achievable under natural conditions, indicating that low DO is a naturally occurring phenomenon in WBID 3081. Figure 7.18 through Figure 7.25 provide the natural condition scenario output parameters for the Indian River Lagoon Basin model. Additionally, Figure 7.26 and Figure 7.27**Error! Reference source not found.**Figure 7.26 provide the cumulative distribution function of DO concentrations for both the modeled existing condition and natural condition results. The cumulative distribution curve shows there is an increase in DO concentrations in the natural condition scenario, although DO is still below 5 mg/L approximately 25% to 35% of the time in both the lower and upper portions of Horse Creek.

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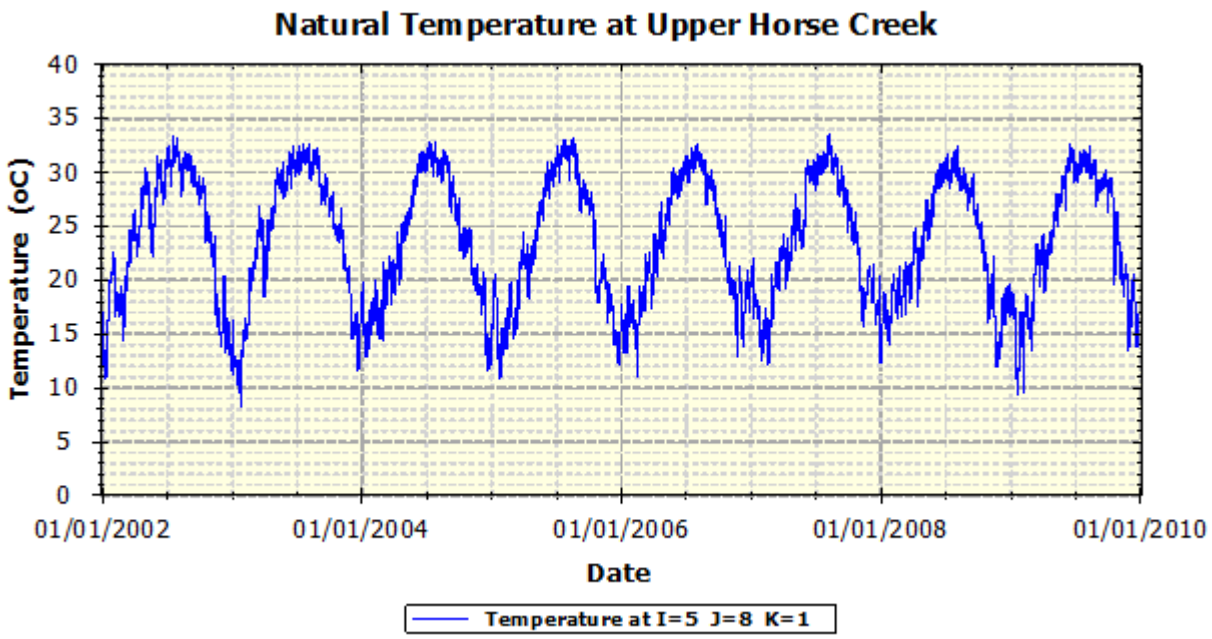

Figure 7.18 Natural condition temperature in the upper Horse Creek

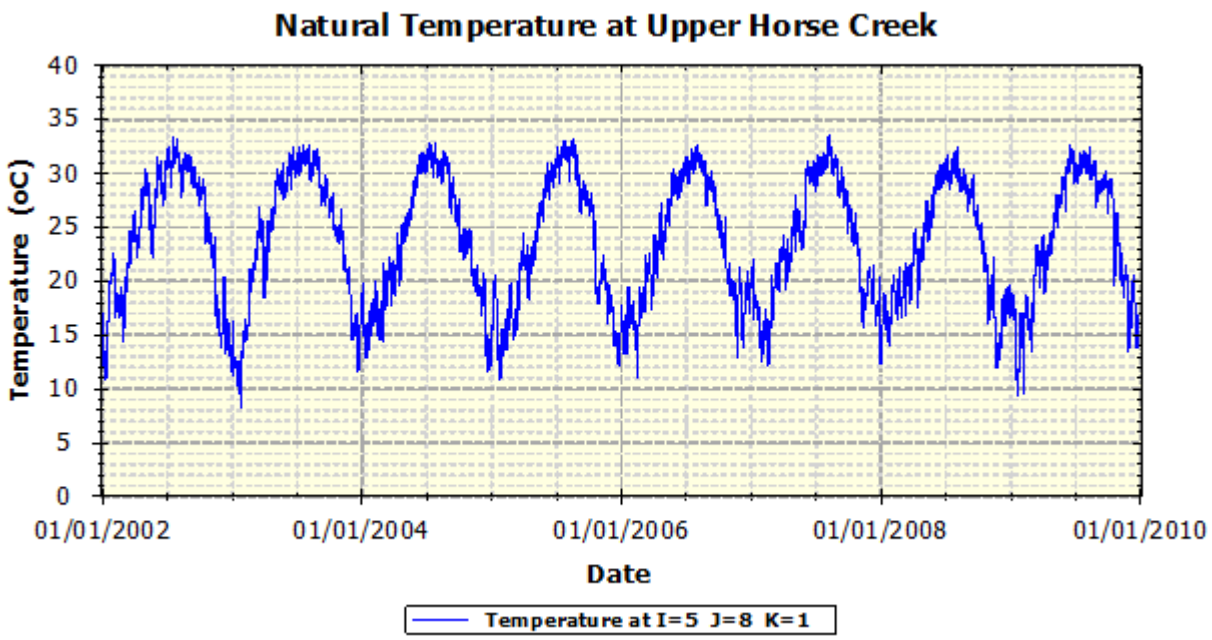

Figure 7.19 Natural condition temperature in the lower Horse Creek

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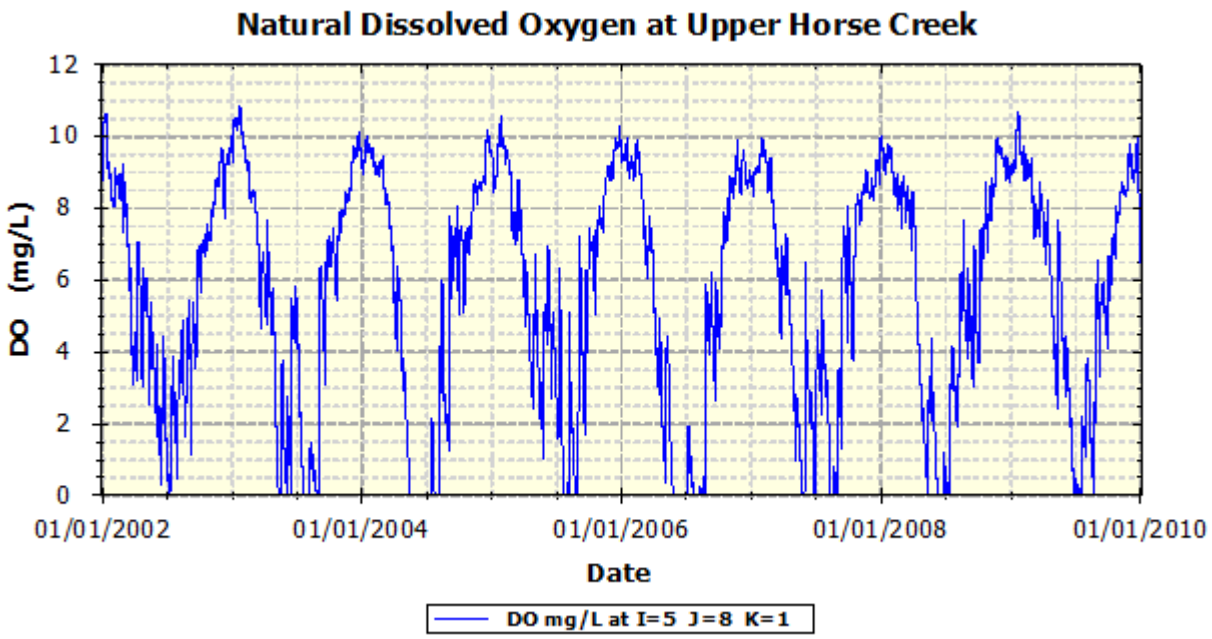

Figure 7.20 Natural condition dissolved oxygen in the upper Horse Creek

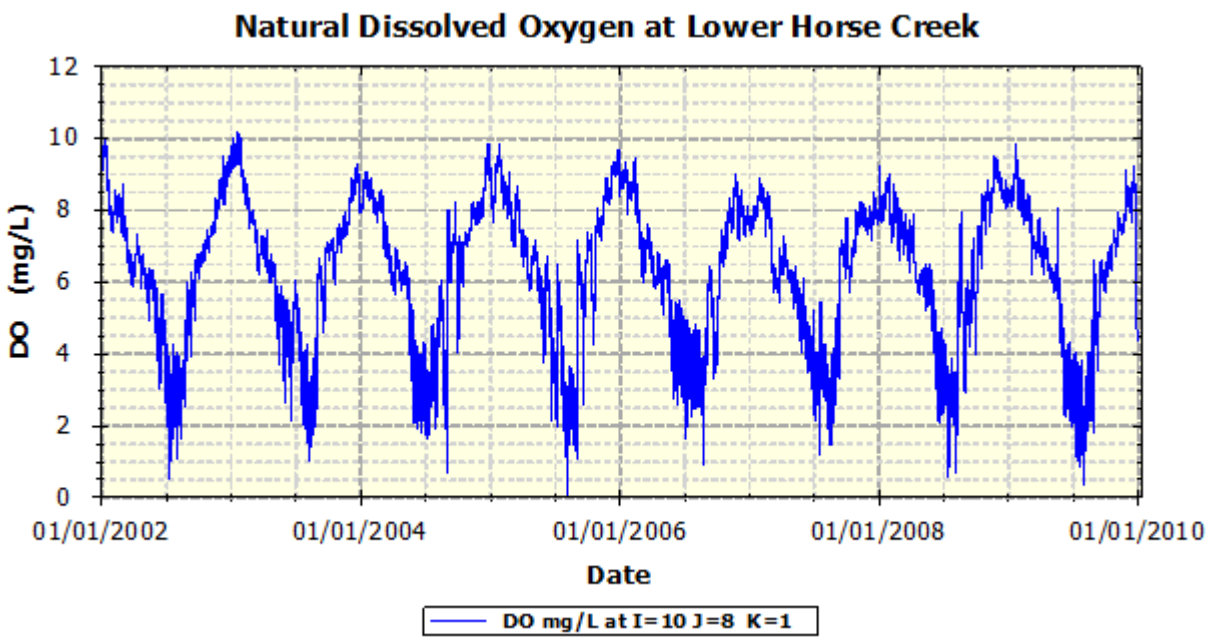

Figure 7.21 Natural condition dissolved oxygen in the lower Horse Creek

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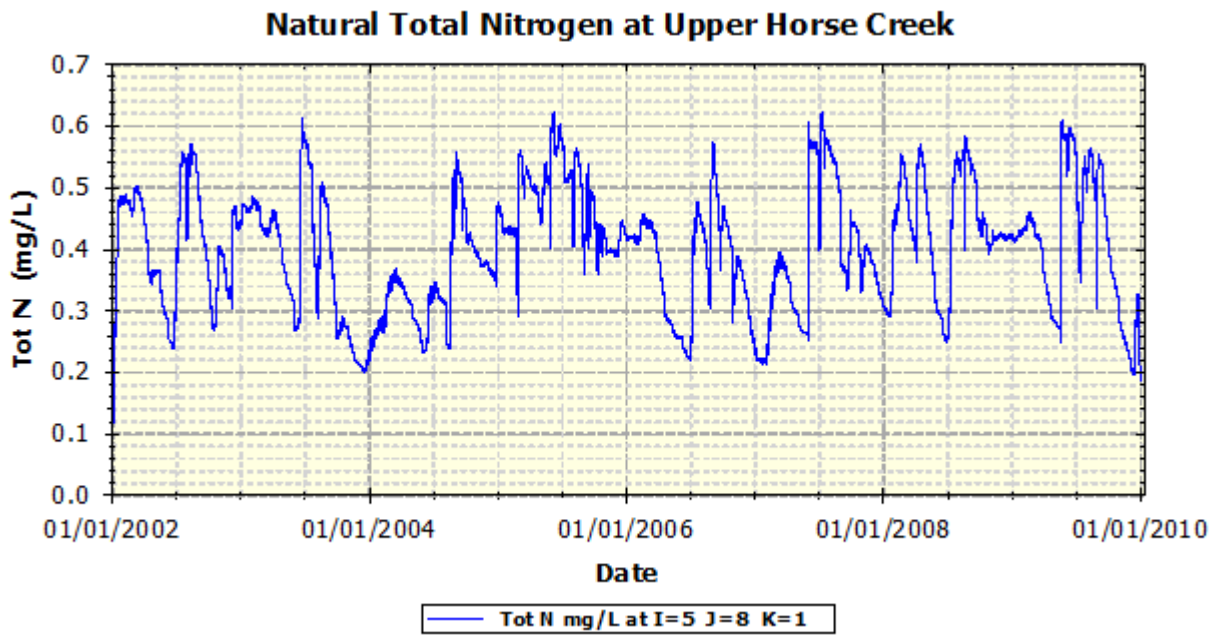

Figure 7.22 Natural condition total nitrogen in the upper Horse Creek

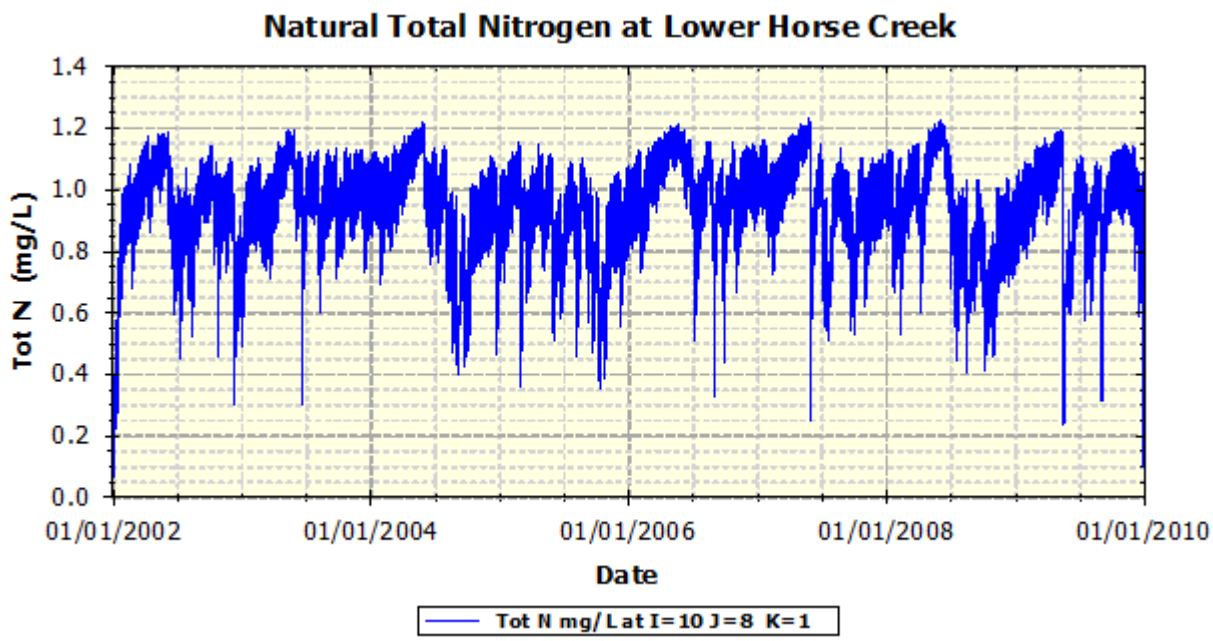

Figure 7.23 Natural condition total nitrogen in the lower Horse Creek

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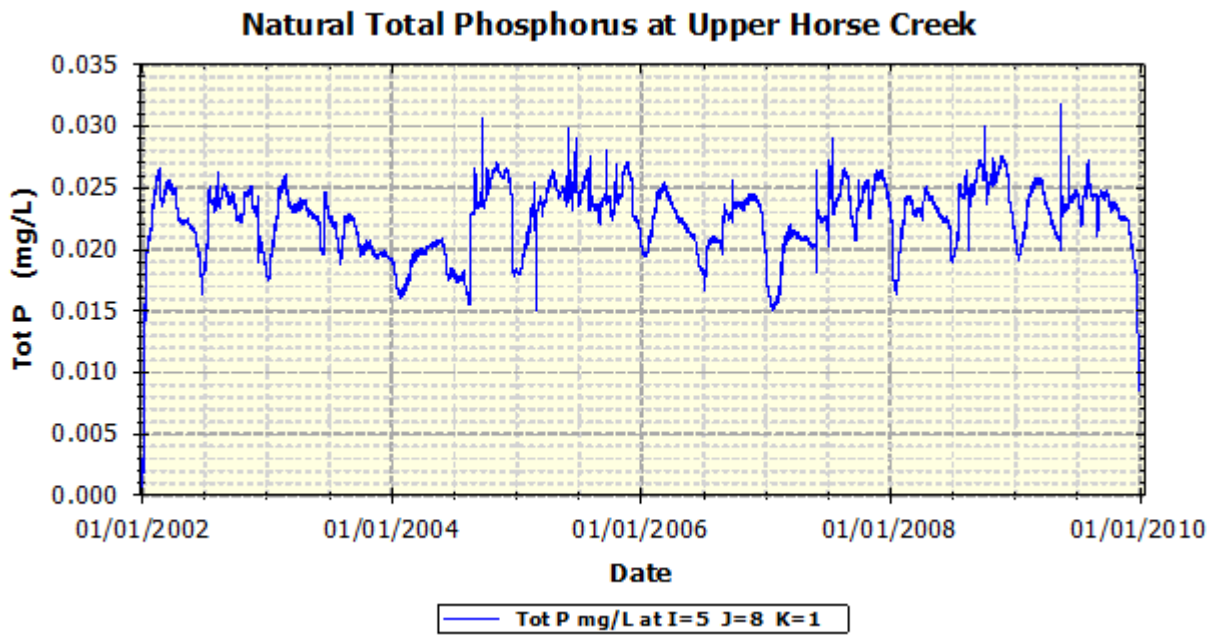

Figure 7.24 Natural condition total phosphorus in the upper Horse Creek

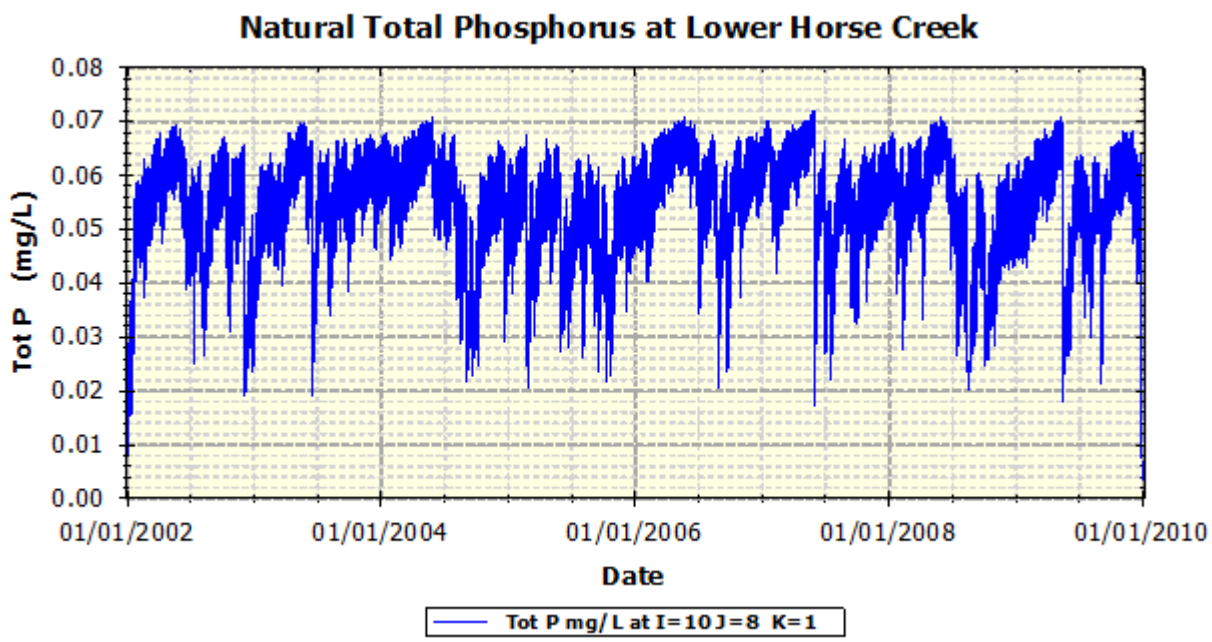

Figure 7.25 Natural condition total phosphorus in the lower Horse Creek

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Table 7.3 Natural condition concentrations in the impaired WBID in the Indian River Lagoon Basin.

Parameter	WBID 3081
Total nitrogen (mg/L)	0.93
Total phosphorus (mg/L)	0.05
BOD (mg/L)	0.73
Dissolved oxygen (mg/L)	6.2

Table 7.4 Natural condition loadings in the impaired WBID in the Indian River Lagoon Basin.

Parameter	WBID 3081	
	WLA (kg/yr)	LA (kg/yr)
Total nitrogen (mg/L)	--	962
Total phosphorus (mg/L)	--	58
BOD (mg/L)	--	5,678

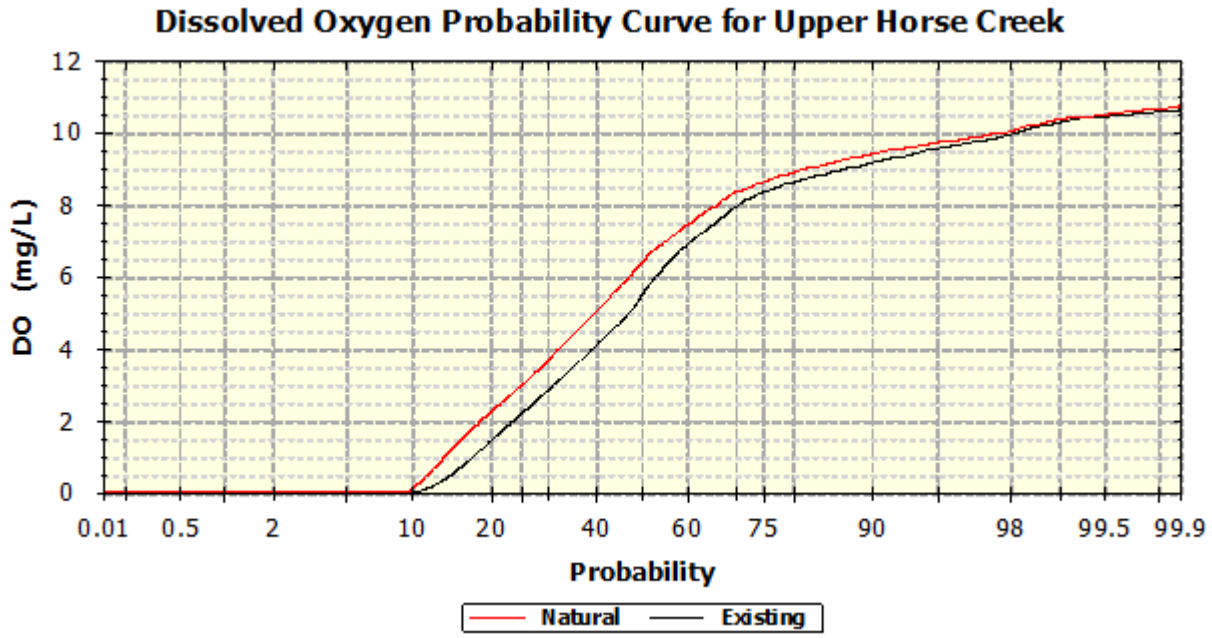

Figure 7.26 Dissolved oxygen concentration cumulative distribution function for Upper Horse Creek

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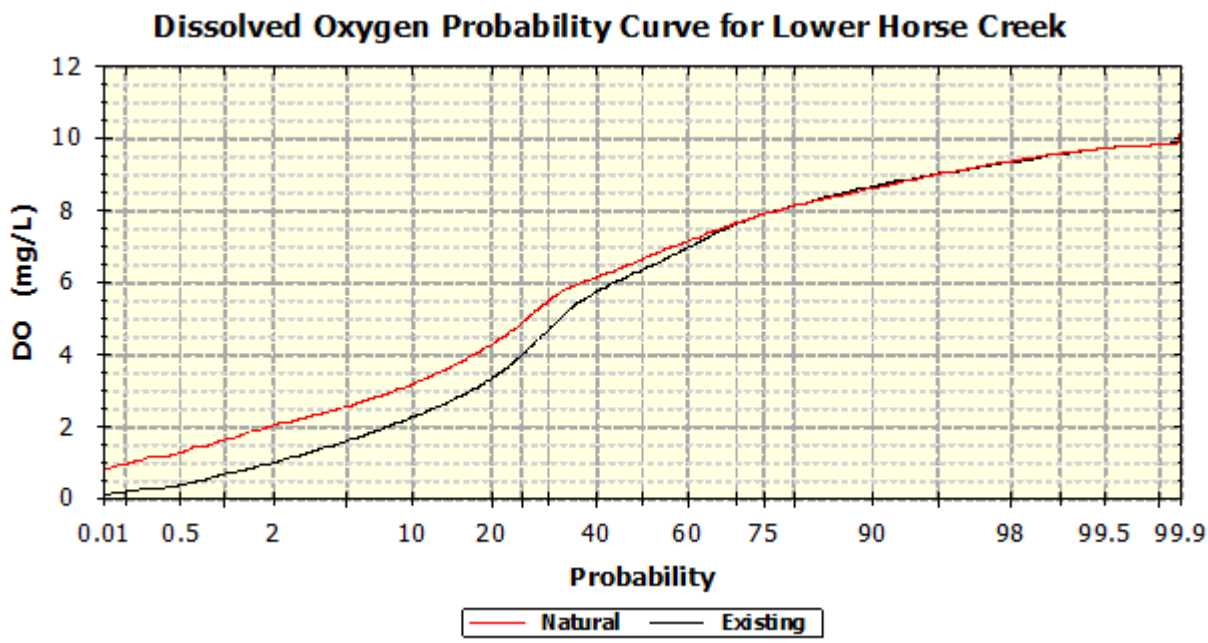

Figure 7.27 Dissolved oxygen concentration cumulative distribution function for Lower Horse Creek

8.0 TMDL DETERMINATION

The TMDL for a given pollutant and waterbody is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody and still achieve water quality standards and the waterbody's designated use. In this TMDL development, allowable concentrations from all pollutant sources that cumulatively amount to no more than the TMDL must be set and thereby provide the basis to establish water quality-based controls. These TMDLs are expressed as annual geometric mean concentrations, since the approach used to determine the TMDL targets relied on geometric means. The TMDLs targets were determined to be the conditions needed to restore and maintain a balanced aquatic system. Furthermore, it is important to consider nutrient loading over time, since nutrients can accumulate in waterbodies.

The TMDL was determined for the concentrations and loadings at the outlet of WBID 3081, and included all loadings from upstream sources and streams. During the development of this TMDL, it was determined that the natural condition scenario (removal of all anthropogenic sources and land uses) did not meet the Florida standards for DO. The DO was greater during

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the natural condition run, and nutrient loadings from the natural condition scenario were therefore used to determine the TMDL in accordance with the Natural Conditions narrative rule. By using the natural conditions nutrient loadings for the TMDL, the nutrient reductions also ensure protection of the downstream estuaries. EPA believes that setting the TMDL condition to a natural condition protects both 47(a) and 47(b) of the Florida narrative nutrient standard. It assures that no man induced activities would have caused an imbalance of flora and fauna. Natural background levels are presumed to protect aquatic life. Florida's water quality standards do not allow the abatement of natural conditions, this TMDL represents the lowest level of nutrients that could be established. The allocations for WBID 3081 for total nitrogen, total phosphorus, and biochemical oxygen demand are presented in Table 8.1.

Table 8.1 TMDL Load Allocations for WBID 3081 in the Indian River Lagoon Basin.

Constituent	Current Condition		TMDL Condition		Percent Reduction		
	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	WLA	LA	MS4
Total Nitrogen	--	4,885	--	962	--	80%	80%
Total Phosphorus	--	344	--	58	--	83%	83%
Biochemical Oxygen Demand	--	13,124	--	5,678	--	57%	57%

8.1 Critical Conditions and Seasonal Variation

EPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition is the combination of environmental factors creating the "worst case" scenario of water quality conditions in the waterbody. By achieving the water quality standards at critical conditions, it is expected that water quality standards should be achieved during all other times. Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year, and that the TMDLs account for any seasonal change in flow or pollutant discharges, and any applicable water quality criteria or designated uses (such as swimming) that are expressed on a seasonal basis.

The critical condition for nonpoint source concentration and wet weather point source concentrations is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, nutrients build up on the land surface, and are washed off by rainfall. The critical condition for continuous point source concentrations typically occurs during periods of low stream flow when dilution is minimized. Although loading of nonpoint source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that

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nutrient impairment is more likely to occur during warmer months, and at times when the waterbody is poorly flushed.

8.2 Margin of Safety

The Margin of Safety accounts for uncertainty in the relationship between a pollutant load and the resultant condition of the waterbody. There are two methods for incorporating an MOS into TMDLs (USEPA 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for Allocations

This TMDL uses an implicit MOS since the TMDL targets for nutrients were set to natural background conditions.

8.3 Waste Load Allocations

Only MS4s and NPDES facilities discharging directly into lake segments (or upstream tributaries of those segments) are assigned a WLA. The WLAs, if applicable, are expressed separately for continuous discharge facilities (e.g., WWTPs) and MS4 areas, as the former discharges during all weather conditions whereas the later discharges in response to storm events.

8.3.1 Wastewater/Industrial Permitted Facilities

A TMDL wasteload allocation (WLA) is given to wastewater and industrial NPDES-permitted facilities discharging to surface waters within an impaired watershed. There are no NPDES-permitted facilities within WBID 3081 at this time.

8.3.2 Municipal Separate Storm Sewer System Permits

The WLA for MS4s, which are listed in Table 6.1, are expressed in terms of percent reductions equivalent to the reductions required for nonpoint sources. Given the available data, it is not possible to estimate concentrations coming exclusively from the MS4 areas. Although the aggregate concentration allocations for stormwater discharges are expressed in numeric form, i.e., percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual stormwater outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by this TMDL often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of stormwater discharge to receiving water flow.

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This TMDL assumes for the reasons stated above that it is infeasible to calculate numeric water quality-based effluent limitations for stormwater discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water quality-based effluent limitations for stormwater sources of nutrients derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that: (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these stormwater discharges; and (2) the state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

All Phase 1 MS4 permits issued in Florida include a re-opener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule. Florida may designate an area as a regulated Phase II MS4 in accordance with Rule 62-620.800, FAC. Florida's Phase II MS4 Generic Permit has a "self-implementing" provision that requires MS4 permittees to update their stormwater management program as needed to meet their TMDL allocations once those TMDLs are adopted. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within its jurisdiction. All future MS4s permitted in the area are automatically prescribed a WLA equivalent to the percent reduction assigned to the LA. The MS4 service areas described in Section 6.1.2 of this report are required to meet the percent reduction prescribed in Table 8.1 through the implementation of BMPs.

8.4 Load Allocations

The load allocation for nonpoint sources was assigned a percent reduction in nutrient concentrations from the current concentrations coming into each of the WBIDs addressed in the TMDL report.

9.0 RECOMMENDATIONS/IMPLEMENTATION

The initial step in implementing a TMDL is to more specifically locate pollutant source(s) in the watershed. FDEP employs the Basin Management Action Plan (B-MAP) as the mechanism for developing strategies to accomplish the specified load reductions. Components of a B-MAP are:

- Allocations among stakeholders
- Listing of specific activities to achieve reductions
- Project initiation and completion timeliness
- Identification of funding opportunities
- Agreements
- Local ordinances
- Local water quality standards and permits
- Follow-up monitoring

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10.0 REFERENCES

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