FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

SOUTHEAST DISTRICT • ST. LUCIE – LOXAHATCHEE RIVER BASINS

DRAFT TMDL Report

Fecal Coliform TMDL for North Fork St Lucie River WBID 3194

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Acknowledgments

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Florida Department of Environmental Protection, Bureau of Watershed Restoration

TMDL Program

http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

Florida STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2010 Integrated Report

http://www.dep.state.fl.us/water/docs/2010_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Report: St-Lucie-Loxahatchee

http://www.dep.state.fl.us/water/basin411/stlucie/status.htm

Water Quality Assessment Report: St-Lucie-Loxahatchee

http://www.dep.state.fl.us/water/basin411/stlucie/assessment.htm

U.S. Environmental Protection Agency

Region 4: TMDLs in Florida

http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program

http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for fecal coliform bacteria for the North Fork St. Lucie River, located in the St. Lucie and Loxahatchee Basin. The estuary was verified as impaired for fecal coliform, and Verified List of Impaired waters for the St. Lucie and Loxahatchee Basin that was adopted by Secretarial Order on May 19, 2009. The TMDL establishes the allowable fecal coliform loading to the North Fork St. Lucie River that would restore the waterbody so that it meets its applicable water quality criterion for fecal coliform.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the St. Lucie and Loxahatchee Basin into water assessment areas with a unique **W**ater**B**ody **ID**entification (WBID) number. The North Fork St. Lucie River has been identified as WBID 3194.

The North Fork St. Lucie River is 1 of the 13 waterbody segments identified in the North and South St. Lucie Planning Units and 1 of 69 located in the St. Lucie – Loxahatchee River Basin, and 1 of 87 waterbody segments in the Southeast Florida Coast basin included on the 1998 303(d) list for Florida. The watershed is located in the southeast part of St. Lucie County (**Figure 1.1**).

The North Fork St. Lucie River originates from the confluence of Tenmile Creek and Fivemile Creek, south of Ft. Pierce in eastern St. Lucie County. The North Fork flows in a general southerly direction for approximately 15 miles until it meets with the South Fork St. Lucie River to form the St. Lucie River proper and combines to flow to the Atlantic Ocean through the St. Lucie Inlet. (**Figure 1.2**).

The area of the North Fork St. Lucie River WBID boundary is approximately 57.9 square miles (37,052 acres) and is predominantly comprised of built-up urban and residential areas. Development history begins with conversions of regional wet prairies to cattle operations, harvesting within flatwoods and cypress swamps, and ditching to lower water tables. Development began near the estuary and fanned outward. As development increased the needs for surface water management increased. Several water control districts exist to primarily manage stormwater control infrastructure, such as canals, sluices, and gate systems. Additional information about the hydrology and geology of this area is available in the Basin Status Report for St. Lucie- Loxahatchee (Department, 2003).

WBID 3194 is located in the Eastern Florida Flatwoods ecoregion (USEPA, 2004), which occupies parts of central and east Florida. This ecoregion is comprised of low flat land generally containing poorly drained, sandy soils generally sloping towards the east. While the availability of water varies with the local topography and seasonal rainfall, the soil may stay wet for much of the year since the flatness of the land reduces water run-off. In low elevations the land may hold water for several months. At higher elevations, where the water table is deeper, little or no surface water may be visible.

The surficial aquifer is at or near the surface in much of the region. In this area the aquifer is unconfined, allowing water to enter, move through, and discharge from the surficial aquifer system more readily and rapidly. In these unconfined areas, the aquifer is either exposed or is covered by a thin layer of sand or by clayey, residual soil (Miller, 1990).

1.3 Background

This report is part of the Department's watershed management approach for restoring and protecting state waters under TMDL Program requirements. The watershed approach looks at waterbodies in a larger geographic context of 52 river basins. This is implemented by organizing the basins into five groups, with an individual basin group evaluated during a given single year; all basins are assessed during a 5-year cycle. The TMDL Program implements the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, specifically its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards, as set by the State of Florida. They provide important water quality restoration goals that will guide restoration activities.

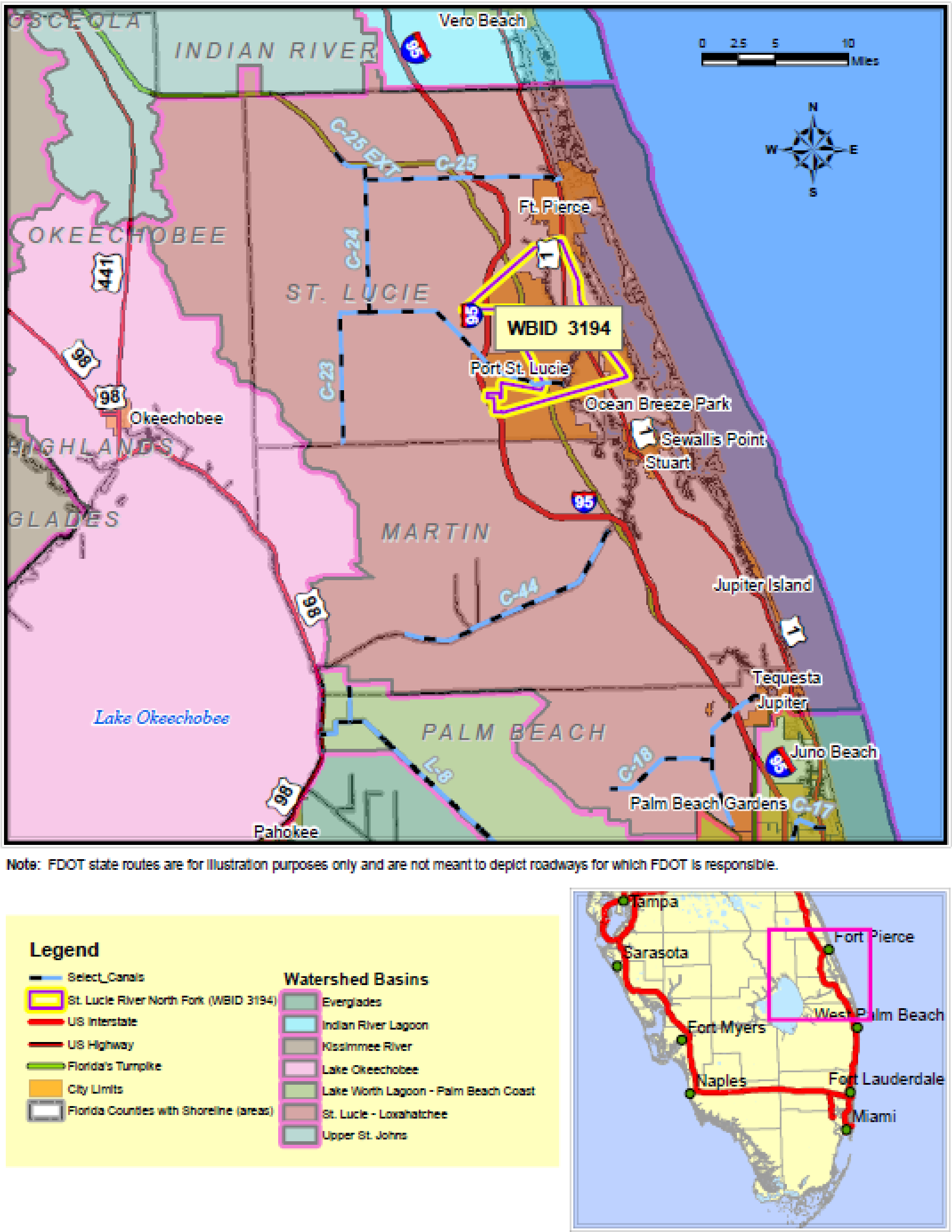

Figure 1.1. Location of the North Fork St. Lucie River Watershed (WBID 3194) in the St. Lucie-Loxahatchee River Basins and Major Geopolitical and Hydrologic Features in the Area

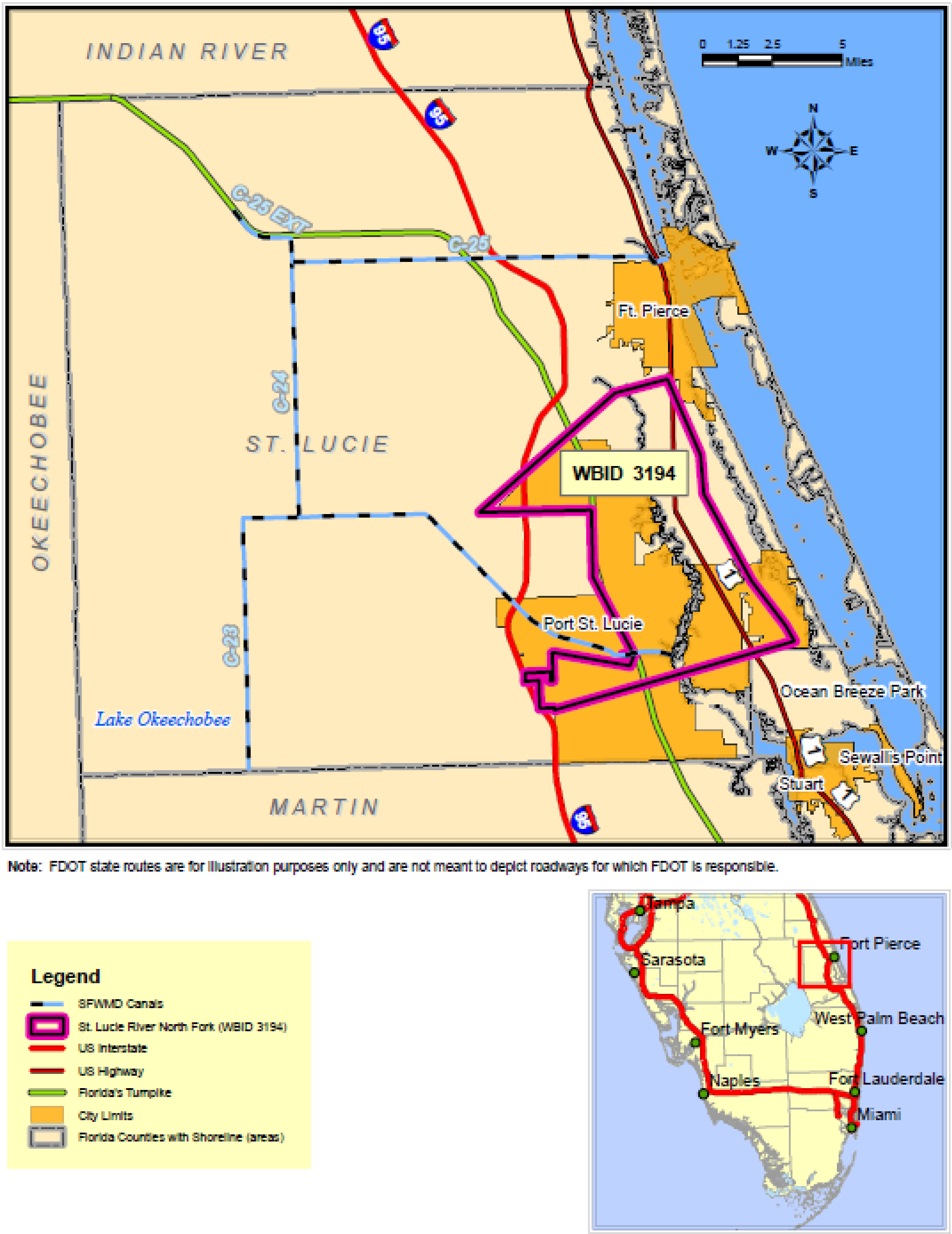

Figure 1.2. Location of the North Fork St. Lucie River Watershed (WBID 3194) in St. Lucie County and Major Hydrologic Features in the Area

This TMDL report will be followed by the development and implementation of a restoration plan designed to reduce the amount of fecal coliform below levels of impairment for North Fork St. Lucie River. These activities will depend heavily on the active participation of the local citizen groups, as well as local and regional political entities such as South Florida Water Management District (SFWMD), municipal governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable state water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the Florida Watershed Restoration Act (FWRA, Subsection 403.067[4], Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

Florida identified 87 impaired waterbodies in the Southeast Florida Coast Basin on its 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all Florida 303(d) lists created before the adoption of the FWRA were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After an extended rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in North Fork St. Lucie River and has verified that this waterbody segment is impaired for fecal coliform bacteria. The verified impairment was listed on the observation that 10 out of 55 fecal coliform samples assessed before the Cycle 2 Verified Period (January 2001 through June 2008), exceeded the assessment threshold of 400 counts per 100 milliliters (counts/100mL), an impairment criterion that more than 10% of the samples exceeded the water quality threshold (see **Section 3.2** for details).

Table 2.1 summarizes fecal coliform monitoring results for the Cycle 2 verified period for North Fork St. Lucie River used in developing the TMDL.

Table 2.1. Summary of Fecal Coliform Monitoring Data for North Fork St Lucie River (WBID 3194) During the Cycle 2 Verified Period (January 2001, through June 2008)

This is a three-column table. Column 1 lists the waterbody name and WBID number, Column 2 lists the parameter, and Column 3 lists the Cycle 2 numerical values for each respective parameter.

Waterbody (WBID)	Parameter	Number
North Fork St Lucie River (WBID 3194)	Total number of samples	55
North Fork St Lucie River (WBID 3194)	IWR-required number of exceedances for the Verified List	8
North Fork St Lucie River (WBID 3194)	Number of observed exceedances	10
North Fork St Lucie River (WBID 3194)	Number of observed nonexceedances	45
North Fork St Lucie River (WBID 3194)	Number of seasons during which samples were collected	4
North Fork St Lucie River (WBID 3194)	Highest observation (counts/100mL)	2,200
North Fork St Lucie River (WBID 3194)	Lowest observation (counts/100mL)	8
North Fork St Lucie River (WBID 3194)	Median observation (counts/100mL)	60
North Fork St Lucie River (WBID 3194)	Mean observation (counts/100mL)	275

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criterion Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

The North Fork St. Lucie River is a Class III (Estuarine) waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The criterion applicable to this TMDL is the Class III estuarine criterion for fecal coliform.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for bacterial quality are expressed in terms of fecal coliform bacteria concentration. The water quality criterion for the protection of Class III (fresh) waters, as established by Rule 62-302, F.A.C., states the following:

Fecal Coliform Bacteria:

The most probable number (MPN) or membrane filter (MF) counts per 100 mL of fecal coliform bacteria shall not exceed a monthly average of 200, nor exceed 400 in 10 percent of the samples, nor exceed 800 on any one day.

The criterion states that monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period. There were insufficient data (fewer than 10 samples in a given month) available to evaluate the geometric mean criterion for fecal coliform bacteria. Therefore, the criterion selected for the TMDL was not to exceed 400 counts/100mL in any sampling event for fecal coliform. (62-303.320: Aquatic Life-Based Water Quality Criteria) Assessment sets impairment when "the number of samples that do not meet an applicable water quality criterion due to pollutant discharges is greater than or equal to the number listed in Table 3 for the given sample size." Three additional stations were added subsequent to the assessment period. Since these additional stations do not affect the status of the impairment, they are included in this analysis. With the 3 stations added to IWR subsequent publishing of the verified list, the number of samples for the verified period was 58 with 12 samples exceeding 400 counts/100mL. As assigned by Table 3 sample sizes of 56-63 are listed if there are 10 or more exceedances. When verified the number of samples was 55 and having 10 exceedances, Table 3 identified requiring 9 or more exceedances to be verified.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of pollutants in the impaired waterbody and the amount of pollutant loadings contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA's National Pollutant Discharge Elimination System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as those from local government master drainage systems, construction sites over one acre, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term "point source" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) ***and*** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Fecal Coliform within the North Fork St. Lucie River WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are no NPDES permitted sites in the North Fork St. Lucie River watershed which are expected to contribute to the fecal coliform impairment.

Municipal Separate Storm Sewer System Permittees

There are two NPDES Phase II municipal separate storm sewer system (MS4) permits in the North Fork St. Lucie River watershed. The City of Port St. Lucie (Permit #FLR04E001) has a Phase II MS4 permit which covers approximately 24,000 acres, or 65% of the North Fork St. Lucie River WBID area. St. Lucie County (Permit #FLR04E029) has a Phase IIC MS4 permit which covers the rest of the North Fork St. Lucie River watershed.

4.2.2 Land Uses and Nonpoint Sources

Accurately quantifying the fecal coliform loadings from nonpoint sources requires identifying nonpoint source categories, locating the sources, determining the intensity and frequency with which these sources create high fecal coliform loadings, and specifying the relative contributions from these sources. Depending on the land use distribution in a given watershed, frequently cited nonpoint sources in urban areas include failed septic tanks, leaking sewer lines, and pet feces. For a watershed dominated by agricultural land uses, fecal coliform loadings can come from the runoff from areas with animal feeding operations or direct animal access to receiving waters.

In addition to the sources associated with the anthropogenic activities, birds and other wildlife can also contribute fecal coliform to receiving waters. While detailed source information is not always available to accurately quantify the fecal coliform loadings from different sources, land development information can provide some indications on the potential sources of observed fecal coliform impairment.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SFWMD's 2004-05 land use coverage contained in the Department's geographic information system (GIS) library. Land use categories within the North Fork St. Lucie River WBID boundary were aggregated by codes. These summary categories are presented in **Table 4.1**. **Figure 4.1** shows the mapped distribution of the principal land uses within the WBID boundary.

As shown in **Table 4.1**, the total area within the North Fork St. Lucie River WBID boundary is approximately 37,052 acres (57.9 sq. mi.). The dominant land use categories are urban lands (urban and built-up; low- and medium-density residential), which accounts for approximately 25,128 acres, or about 68 percent of the total WBID area, and upland forest, which accounts for approximately 4,135 acres, or about 11 percent of the total WBID area. There are 1,099 acres (or about 3 percent) of agricultural lands in the WBID area. Remnant natural land use areas, which include water, wetlands, rangeland, and barren land, occupy about 5,255 acres, accounting for about 18 percent of the total WBID area.

Table 4.1. Classification of Land Use Categories within the North Fork St. Lucie River WBID Boundary

This is a four-column table. Column 1 lists the Level 1 land use code, Column 2 lists the land use category descriptors, Column 3 lists the acreage, and Column 4 lists the percent acreage.

- = Empty cell/no data

Level 1 Code	3226C Land Use	Acres	% Acreage
1000	Urban and Built up	3,993	10.78
-	Low Density Residential	3,722	10.05
-	Medium Density Residential	15,735	42.47
-	High Density Residential	1,678	4.53
2000	Agricultural	1,099	2.97
3000	Rangeland	534	1.44
4000	Upland Forest	4,135	11.16
5000	Water	1,624	4.38
6000	Wetlands	3,018	8.14
7000	Barren Land	79	0.21
8000	Transportation, Communication, and Utilities	1,436	3.87
	TOTAL	37,052	100.00%

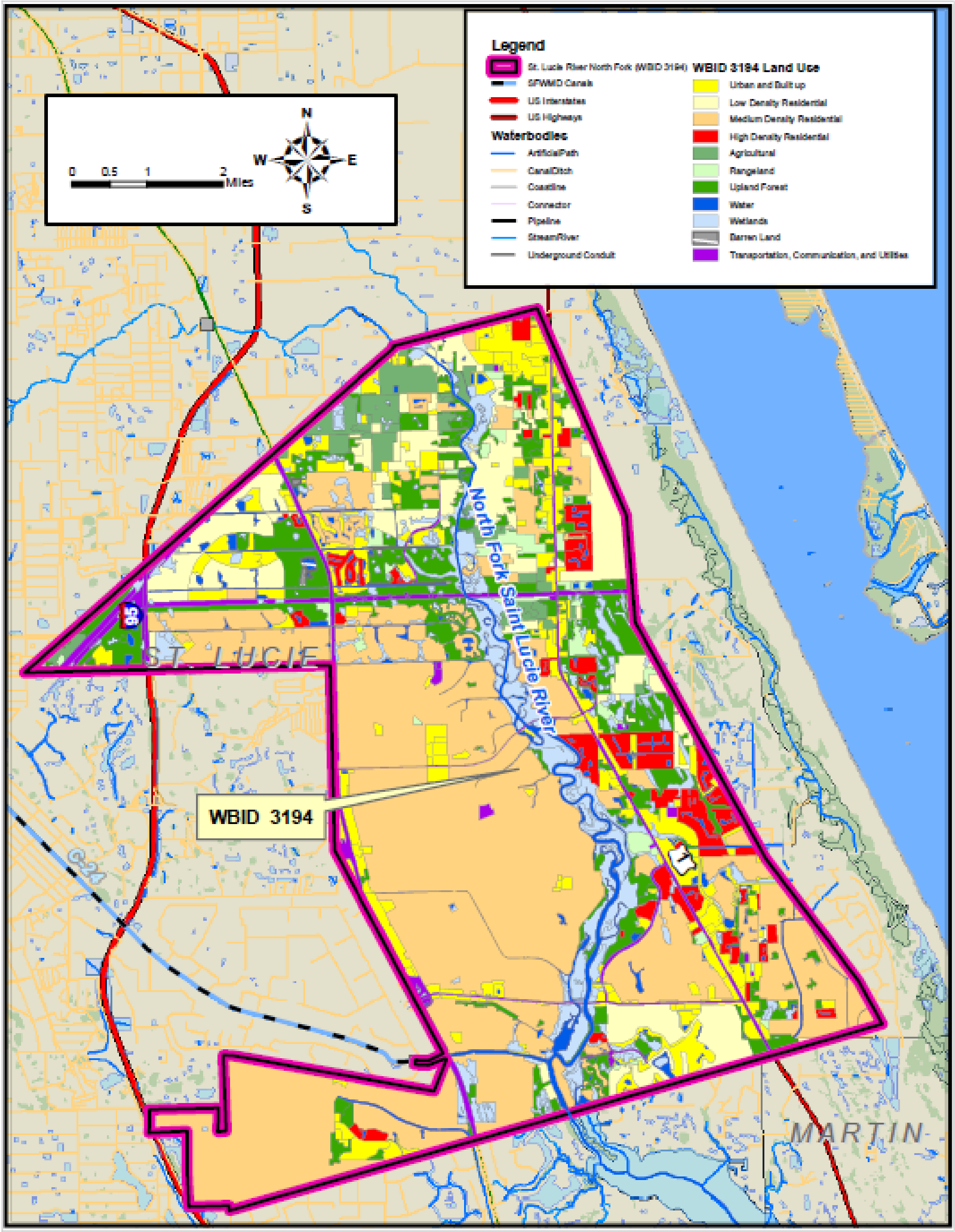

Figure 4.1. Principal Land Uses within the North Fork St Lucie River (WBID 3194) Boundary

Livestock

Agriculture is not a primary land use in the WBID. However, as livestock and other agricultural animals can be a potentially important nonpoint source of coliform a brief discussion is presented. Agricultural animal waste is associated with various pathogens in streams; these can include *E. coli, Salmonella, Giardia, Campylobacter, Shigella, and Cryptosporidium parvum* (Landry and Wolfe, 1999). Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. **Appendix B** provides detailed fecal coliform loading estimates from livestock describes the methods used for the quantification.

The human population in the North Fork St. Lucie River watershed was 102,488. This value was calculated by using the average persons per household in St. Lucie County (U.S Census) of 2.47 person/household, and then multiplying by the number of occupied residential units within the WBID boundary as determined using the 2009 Cadastral information (FDEP GIS) of 41,493 households.

Wildlife and Sediments

In addition to livestock, wildlife populations and residual bacteria populations in sediments could also contribute to fecal coliform exceedances in the watershed. Wildlife such as birds, raccoons, bobcats, rabbits, deer, and feral hogs have direct access to the stream and deposit their feces directly into the water. This wildlife deposition can be especially significant during low-flow conditions. Wildlife feces deposited on land surfaces can be transported during storm events to nearby streams. Studies have shown that fecal coliform bacteria can survive and reproduce in streambed sediments and then be resuspended into surface water when conditions are right (Jamieson et al., 2005).

Current source identification methodologies do not quantify the exact amount of fecal coliform loading from wildlife and/or sediment sources.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

When continuous flow measurements in a watershed are available, a bacteria TMDL can be developed using the load duration curve method, which was developed by the Kansas Department of Health and Environment and provides the allowable daily bacteria load. However, all necessary flow data were not available for the North Fork St. Lucie River; therefore, the fecal coliform TMDL was developed using the “percent reduction” approach. Using this method, the percent reduction needed to meet the applicable criterion is calculated based on the 90th percentile of all measured concentrations collected during the Cycle 2 verified period (January 1, 2001–June 30, 2008). Because bacteriological counts in water are not normally distributed, a nonparametric method is appropriate for the analysis of fecal coliform data (Hunter, 2002). The Hazen method, which uses a nonparametric formula, was used to determine the 90th percentile. The EPA Region 4 uses this method in developing fecal coliform TMDLs. The percent reduction of fecal coliform needed to meet the applicable criterion was calculated as described in **Section 5.1.3**.

5.1.1 Data Used in the Determination of the TMDL

Data used to develop this TMDL were provided by the Department’s Southeast District Office (Stations: 21FLWPB 28010994, 21FLWPB 28010879, 21FLWPB 28010010, 21FLWPB 28010009, 21FLWPB 28010573) and the Department’s Groundwater section (Stations: 21FLGW 18845, 21FLGW 20004, 21FLGW 20030,). The majority of data were collected at the Department’s Southeast District Office Station 21FLWPB 28010879 (n=21).

See **Figure 5.1** for the locations of the water quality stations where fecal coliform data were collected for the North Fork St. Lucie River.

At the time of the assessment, the Department verified the water quality impairment in the North Fork St. Lucie River based on the observation that 10 out of 55 fecal coliform samples collected during the Cycle 2 verified period (January 1, 2001, through June 30, 2008) exceeded the assessment threshold of 400 counts/100mL. This analysis also includes three data points (collected in 2003) incorporated into the IWR subsequent to the Cycle 2 assessment. These new data results show exceedances of fecal coliform concentrations and thus do not change the verified impairment for the waterbody.

The Cycle 2 verified period includes data collected from January 1, 2001, through June 30, 2008. During this period, a total of 58 fecal coliform samples were collected from the 8 sampling stations in WBID 3194. The fecal coliform data for the North Fork St. Lucie River collected were distributed over the Cycle 2 verified period.

Concentrations for all samples collected during the Cycle 2 verified period ranged from 2 to 3400 counts/100mL and averaged 354 counts/100mL during the period of observation. **Table 5.1** summarizes the descriptive statistics for the Cycle 2 fecal coliform results. **Figure 5.2** shows the fecal coliform concentration trends observed in the North Fork St. Lucie River.

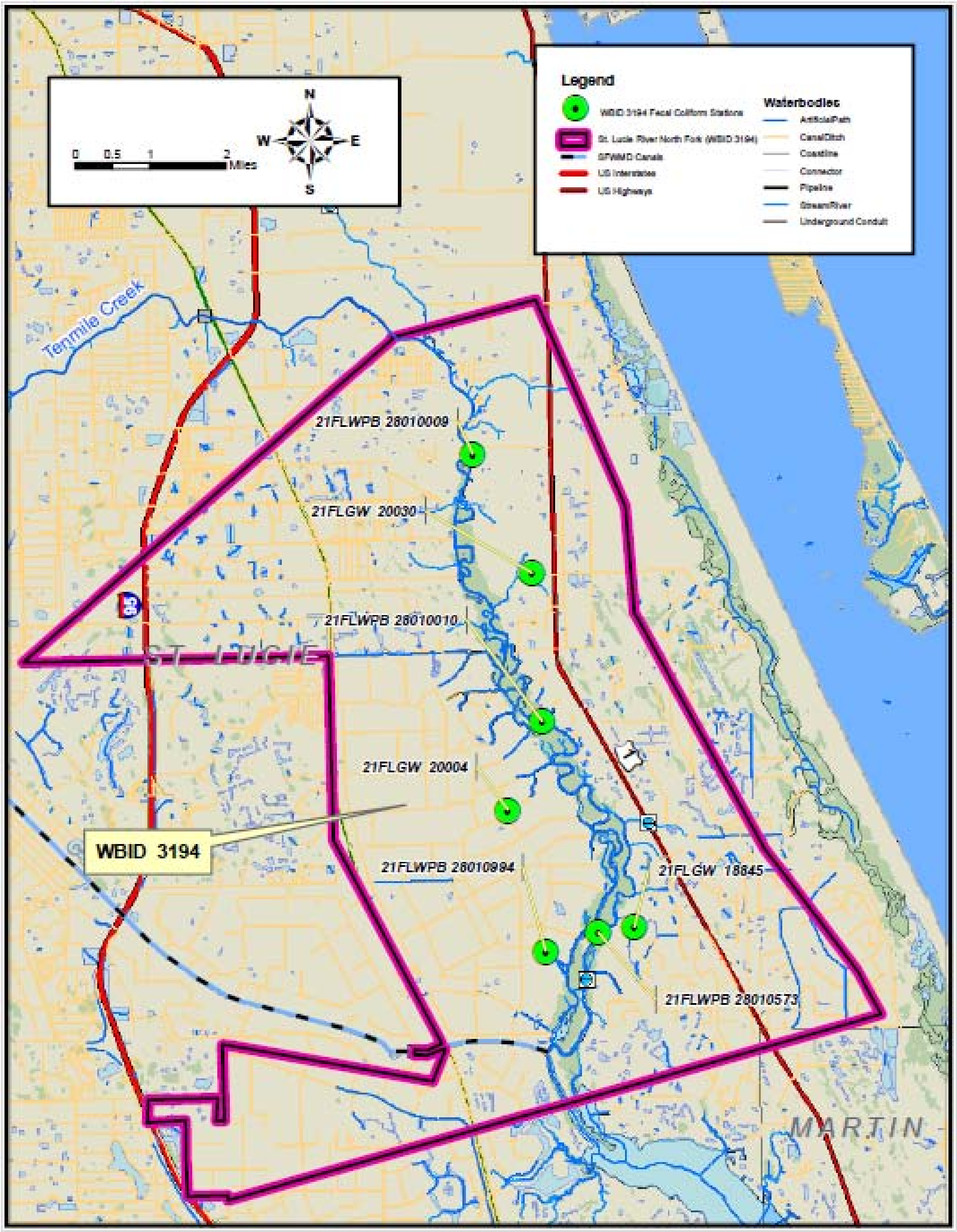

Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in North Fork St Lucie River (WBID 3194)

Table 5.1. Descriptive Statistics of Fecal Coliform Data for North Fork St Lucie River (WBID 3194) for Cycle 2 verified period

This is a two-column table. Column 1 lists the descriptive statistic, and Column 2 lists the result.

Descriptive Statistic	Result
Number of samples	58
Mean observation (counts/100mL)	354
Standard deviation	657
Median observation (counts/100mL)	64
Highest observation (counts/100mL)	3,400
Lowest observation (counts/100mL)	2
25% quartile	24
75% quartile	325

Temporal Patterns

Fecal coliform data for the Cycle 2 verified period were analyzed for annual and seasonal trends. However, episodic peak fecal coliform concentrations occurred throughout the period of observation.

Seasonally, a peak in fecal coliform concentrations and exceedance rates is common during a year's third quarter (summer, July–September), when conditions are rainy and warm. Conversely, lower concentrations and fewer exceedances are often observed in the first and fourth quarters (winter, January–March; and fall, October–December), when conditions are drier and colder. This relationship was observed in North Fork St. Lucie River, where exceedances and the highest percent exceedances were recorded in the summer months (September). Also, the winter months experienced the lowest amount of exceedances and percent exceedances. **Tables 5.2a** and **5.2b** summarizes the monthly and seasonal fecal coliform averages and percent exceedances, respectively, for data collected for the Cycle 2 verified period for this waterbody.

Table 5.2a. Summary Statistics of Fecal Coliform Data for All Stations in North Fork St Lucie River (WBID 3194) by Month during the Cycle 2 Verified Period

This is an eight-column table. Column 1 lists the month, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL observed in a given month, Column 4 lists the maximum count observed in a given month, Column 5 lists the median count, Column 6 lists the mean of all counts made in a given month, Column 7 lists the number of exceedances that occurred in the given month, and Column 8 lists the percent exceedances occurring during a given month.

- = Empty cell/no data
[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Month	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
January	-	-	-	-	-	-	-
February	4	22	155	40	64	0	0.0
March	3	46	148	80	9	0	0.0
April	7	8	757	34	167	1	14.3
May	3	20	712	99	277	1	33.3
June	6	2	490	19	147	1	16.7
July	4	20	630	210	268	1	25.0
August	11	27	3,400	60	593	3	27.3
September	6	58	2,200	288	732	2	33.3
October	6	18	109	41	50	0	0.0
November	6	9	1,182	126	432	2	33.3
December	2	220	2,000	1,110	1,110	1	50.0

Table 5.2b. Summary Statistics of Fecal Coliform Data for All Stations in North Fork St Lucie River (WBID 3194) by Season during the Cycle 2 Verified Period

This is an eight-column table. Column 1 lists the annual-quarter (Jan.-Mar. Q1, Apr.-Jun. Q2, Jul.-Sep. =Q3, Oct. -Dec. = Q4), Column 2 lists the number of samples collected during the quarters, Column 3 lists the minimum coliform count/100mL during the quarters, Column 4 lists the maximum count during the quarters, Column 5 lists the median count during the quarters, Column 6 lists the mean count during the quarters, Column 7 lists the number of exceedances that occurred during a quarter, and Column 8 lists the percent exceedances occurring during a given quarter.

- = Empty cell/no data
[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Season	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
Quarter 1	7	22	155	46	76	0	0.0
Quarter 2	16	2	757	27	180	3	18.8
Quarter 3	21	20	3,400	171	571	6	28.6
Quarter 4	14	9	2,000	63	365	3	21.4

Using rainfall data collected at the Ft. Pierce CLIMOD station in St. Lucie County (available: http://climod.meas.ncsu.edu/), it was possible to compare monthly rainfall over the years 2001-2008 with monthly fecal coliform exceedance rates for the same period, as well as average quarterly rainfall with average quarterly fecal coliform exceedance rates at all stations (**Figures 5.2** and **5.3**). Peak fecal coliform concentrations commonly coincide with, or follow, periods of increased rainfall, especially rainfalls that individually or cumulatively provide volumes that flush through surface soils and flush through stormwater ponds to surface waters. This trend was observed in North Fork St. Lucie River as 9 of the 25 exceedances in Cycle 2 Verified Period followed medium to extreme rainfall events. These fecal coliform concentrations appeared to correlate with 3-day precipitation (extreme and medium precipitation events).

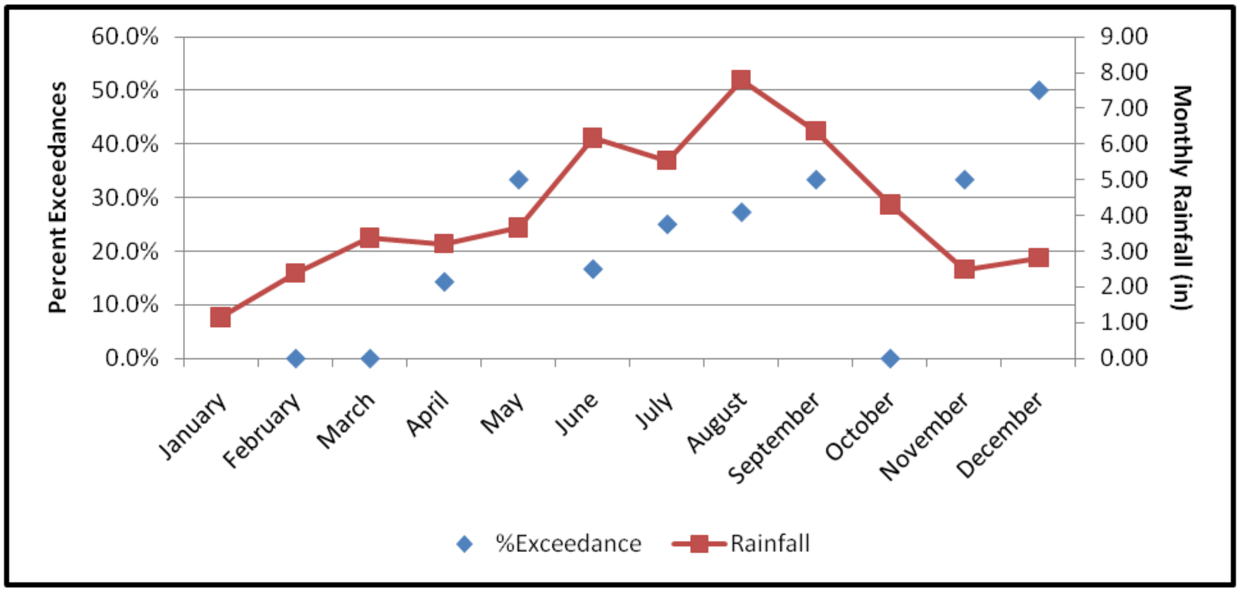

Figure 5.2. Fecal Coliform Exceedances and Rainfall at All Stations in North Fork St Lucie River (WBID 3194) by Month during the Cycle 2 Verified Period

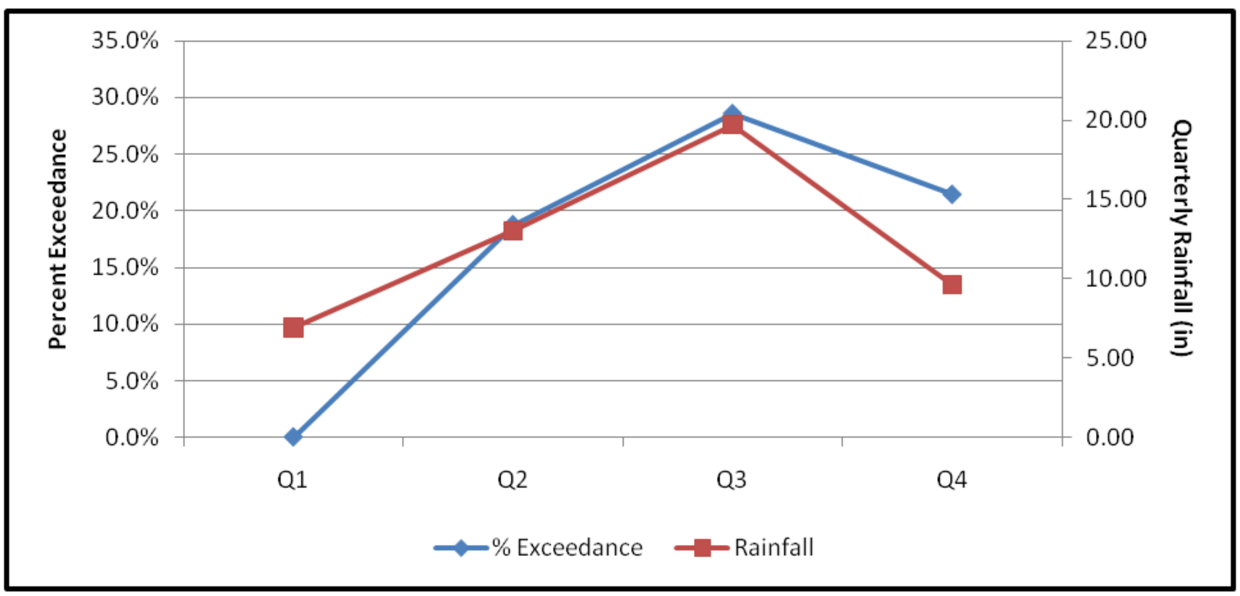

Figure 5.3. Fecal Coliform Exceedances and Rainfall at All Stations in North Fork St Lucie River (WBID 3194) by Season during the Cycle 2 Verified Period

Spatial Patterns

Fecal coliform data from the Cycle 2 verified period from the stations were analyzed to detect spatial trends in the data (see **Table 5.2**). Fecal coliform concentrations exceeding the state criterion (400 counts/100mL) were observed in 5 of the 8 stations. Although the highest exceedance rates were observed from 21FLGW 20004 and 21FLGW 20030 (both sites showed an exceedance rate of 100%), only one sample was collected from each of these stations. High percent exceedances were also recorded at Station 21FLWPB 28010009 (**Table 5.3**), located upstream of the other data points, in an area receiving industrial and agricultural stormwater runoff.

Station 21FLWPB 28010009, with maximum count of 2,200, is located upstream on the North Fork St. Lucie River and has a percent exceedance of 54%. However, the downstream stations 21FLWPB 28010879 and 21FLQPB 28010573 both have percent exceedances at or below 10%.

Table 5.3. Station Summary Statistics of Fecal Coliform Data for North Fork St. Lucie River (WBID 3194) during the Cycle 2 Verified Period

This is a nine-column table. Column 1 identifies the station, Column 2 lists the period that data were collected, Column 3 lists the number of samples collected at the station, Column 4 lists the minimum count/100mL amongst station samples, Column 5 lists the maximum count amongst station samples, Column 6 lists the median count amongst station samples, Column 7 lists the mean count amongst station samples, Column 8 lists the number of exceedances amongst station samples, and Column 9 lists the percent exceedances for the station based on the total number of exceedances in the WBID.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL

Station ID	Period of Observation	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedance	Percent Exceedance
21FLGW 18845	2003	1	2	2	2	2	0	0
21FLGW 20004	2003	1	3,400	3,400	3,400	3,400	1	100
21FLGW 20030	2003	1	2,000	2,000	2,000	2,000	1	100
21FLWPB 28010994	2005	3	280	530	370	393	1	33
21FLWPB 28010879	2005-2007	21	11	2,000	50	180	2	10
21FLWPB 28010010	2006-2007	13	9	400	80	129	0	0
21FLWPB 28010009	2006-2007	13	14	2,200	490	639	7	54
21FLWPB 28010573	2007	5	8	51	34	32	0	0.0

5.1.2 Critical Condition

The conditions that influence coliform loadings in a given watershed depend on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, a critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event of size and duration that flushes feces waste materials, mixes contaminated sediments, and flushes through soils contaminated by such as leaking septic tanks. During wet weather periods, rainfall washes off coliform bacteria that have built up on the land surface under dry conditions, resulting in the wet weather exceedances. However, significant nonpoint source contributions can also occur under dry conditions without any major surface runoff event. This can happen when nonpoint sources contaminate the surficial aquifer, and fecal coliform bacteria are brought into the receiving waters through baseflow. In addition, the fecal coliform contribution of wildlife with direct access to the receiving water can be more noticeable during dry weather due to lessened dilution.

As not all necessary flow data were available, hydrologic conditions were analyzed using rainfall. A loading curve – a type of chart that would normally be applied to flow events - was created using precipitation data from the Ft. Pierce climate station as an analog for flow data. The chart was divided in the same manner as if flow were being analyzed, where precipitation ranges were derived based on percentiles, upper percentiles are large vents low percentiles correspond to little or no rain:

- extreme precipitation events represent the upper percentiles (0–5th percentile),
- large precipitation events (5th–10th percentile),
- medium precipitation events (10th–40th percentile),
- small precipitation events (40th–60th percentile), and,
- no recordable precipitation events (60th–100th percentile).

Extreme events were determined as those with rainfall greater than 2.20 inches; large events, 1.51 to 2.20 inches; medium events, 0.16 to 1.51 inches; small events, 0.01 to 0.15 inches; and non-measurable events, less than 0.01 inch. Rain events were in fact calculated as the three-day cumulative precipitation (the day of and 2 days prior to sampling) for the analysis (**Table 5.4** and **Figure 5.4**).

Historical data show that fecal coliform exceedances occurred over extreme, medium, and not measurable precipitation events. Given that no samples were collected during large and small precipitation events, it can only be assumed, and not generalized, that fecal coliform exceedances occur over all hydrologic conditions.

The highest percentage of exceedances occurred after extreme and large precipitation events (67% & 50% exceedance, respectively), however these also account for the lowest number of samples (n=5). Exceedances were also observed during periods of medium rainfall (26% exceedance). The lowest percentage of exceedances occurred after small or no measurable precipitation events (0% & 16% exceedances, respectively). Since the greatest percentage of exceedances occur during periods of large and extreme rainfall, it is likely that nonpoint sources are probably a major contributor to the fecal coliform impairment. **Table 5.4** and **Figure 5.5** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred following all sampled categories of precipitation events—extreme, large, medium, small, and not measurable—the target fecal coliform reduction calculated in the following section and shown in **Table 5.5** is applicable under all rainfall conditions in North Fork St. Lucie River.

Table 5.4. Summary of Historical Fecal Coliform Data by Hydrologic Condition for North Fork St Lucie River (WBID 3194)

This is a seven-column table. Column 1 lists the size category of the 3-day cumulative precipitation, Column 2 lists the cumulative rainfall range (in inches) for a category, Column 3 lists the total number of samples collected, Column 4 lists the number of exceedances, Column 5 lists the percent exceedances, Column 6 lists the number of nonexceedances, and Column 7 lists the percent nonexceedances.

Precipitation Event	Event Range (inches)	Total Samples	Number of Exceedances	Percent Exceedances	Number of Nonexceedances	Percent Nonexceedances
Extreme	>2.2"	3	2	67	1	33
Large	1.51" - 2.20"	2	1	50	1	50
Medium	0.16" - 1.51"	23	6	26	17	74
Small	0.01" - 0.15"	11	0	0.0	11	100
None/Not Measurable	<0.01"	19	3	16	16	84

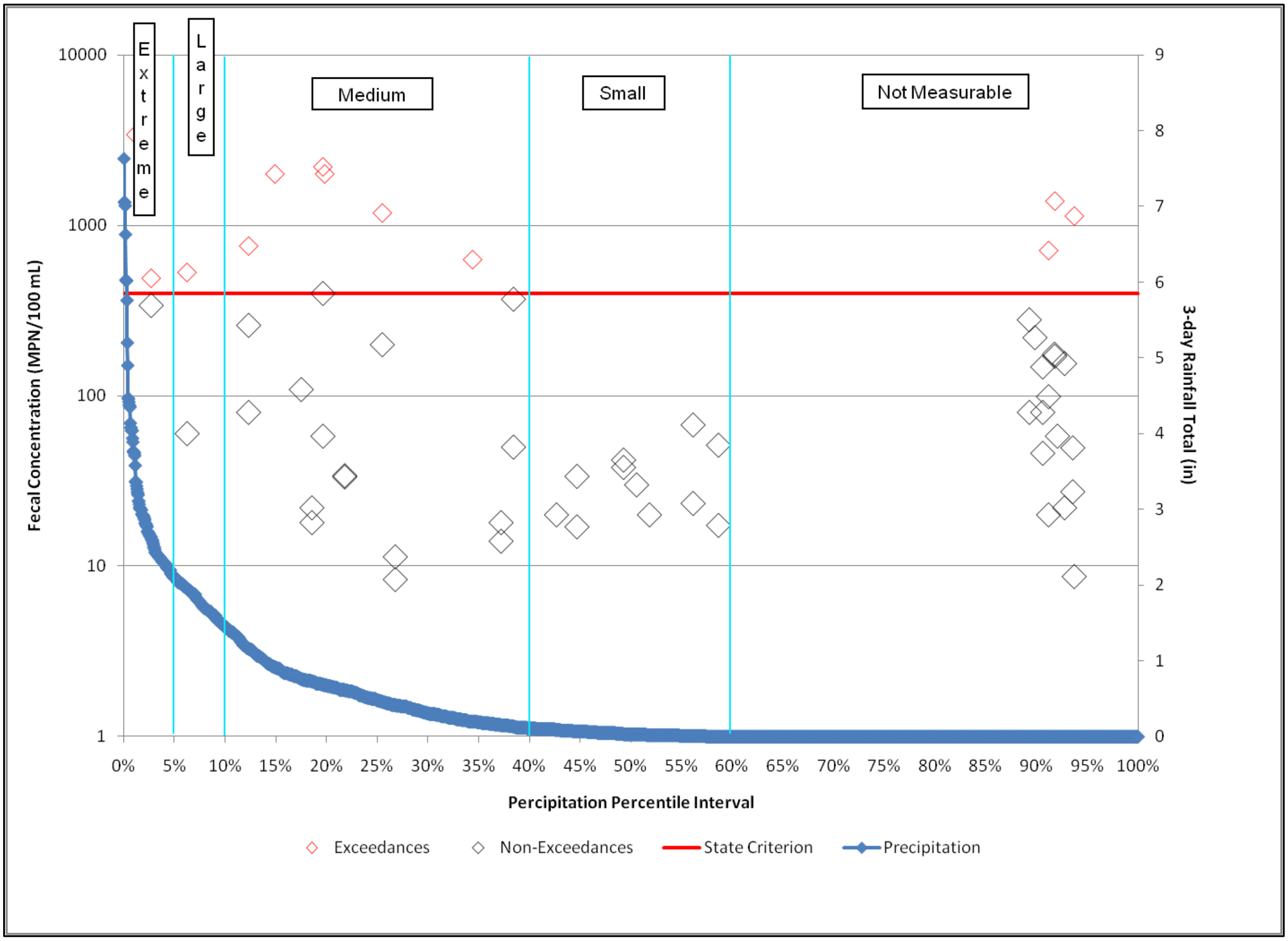

Figure 5.4. Historical Fecal Coliform Data by Hydrologic Condition for North Fork St Lucie River (WBID 3194)

Table 5.5. Calculation of Fecal Coliform Reductions for the North Fork St Lucie River (WBID 3194) TMDL Based on the Hazen Method

This is a five-column table. Column 1 identifies the station, Column 2 gives the sampling date, Column 3 lists the fecal coliform concentration (MPN/100mL), Column 4 shows the ordinal rank of the concentration in Column 3, and Column 5 lists the percentile by the Hazen method (Formula 2).

- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (MPN/100 mL)	Rank	Percentile by Hazen Method
21FLGW 18845	6/30/2003	2	1	0.86%
21FLWPB 28010573	4/16/2007	8.33	2	2.59%
21FLWPB 28010010	11/6/2007	8.67	3	4.31%
21FLWPB 28010879	4/16/2007	11.33	4	6.03%
21FLWPB 28010009	6/14/2007	14	5	7.76%
21FLWPB 28010009	4/23/2007	17	6	9.48%
21FLWPB 28010879	11/19/2007	17.33	7	11.21%
21FLWPB 28010010	6/14/2007	18	8	12.93%
21FLWPB 28010879	10/8/2007	18	9	14.66%
21FLWPB 28010879	7/28/2005	20	10	16.38%
21FLWPB 28010879	5/22/2006	20	11	18.10%
21FLWPB 28010879	6/21/2006	20	12	19.83%
21FLWPB 28010010	2/26/2007	22	13	21.55%
21FLWPB 28010573	10/8/2007	22	14	23.28%
21FLWPB 28010010	10/15/2007	23.33	15	25.00%
21FLWPB 28010010	8/16/2007	27.33	16	26.72%
21FLWPB 28010879	8/30/2005	30	17	28.45%
21FLWPB 28010879	8/6/2007	33.33	18	30.17%
21FLWPB 28010010	4/23/2007	33.67	19	31.90%
21FLWPB 28010573	8/6/2007	34	20	33.62%
21FLWPB 28010879	2/20/2007	38	21	35.34%
21FLWPB 28010573	2/20/2007	42	22	37.07%
21FLWPB 28010879	3/14/2006	46	23	38.79%
21FLWPB 28010009	8/16/2007	49.5	24	40.52%
21FLWPB 28010879	7/19/2005	50	25	42.24%
21FLWPB 28010573	11/19/2007	51.33	26	43.97%
21FLWPB 28010879	9/6/2006	58	27	45.69%
21FLWPB 28010879	10/31/2006	58	28	47.41%
21FLWPB 28010879	8/2/2005	60	29	49.14%
21FLWPB 28010009	10/15/2007	67.5	30	50.86%
21FLWPB 28010879	8/17/2005	80	31	52.59%
21FLWPB 28010010	3/14/2006	80	32	54.31%
21FLWPB 28010879	4/12/2006	80	33	56.03%
21FLWPB 28010010	5/22/2006	99	34	57.76%

Station	Date	Fecal Coliform Concentration (MPN/100 mL)	Rank	Percentile by Hazen Method
21FLWPB 28010879	10/5/2005	109	35	59.48%
21FLWPB 28010009	3/14/2006	148	36	61.21%
21FLWPB 28010009	2/26/2007	155	37	62.93%
21FLWPB 28010010	9/27/2006	171	38	64.66%
21FLWPB 28010879	9/13/2006	176	39	66.38%
21FLWPB 28010010	11/1/2006	200	40	68.10%
21FLWPB 28010879	12/14/2005	220	41	69.83%
21FLWPB 28010010	4/12/2006	260	42	71.55%
21FLWPB 28010994	8/16/2005	280	43	73.28%
21FLWPB 28010010	6/27/2006	340	44	75.00%
21FLWPB 28010994	7/19/2005	370	45	76.72%
21FLWPB 28010010	9/6/2006	400	46	78.45%
21FLWPB 28010009	6/27/2006	490	47	80.17%
21FLWPB 28010994	8/1/2005	530	48	81.90%
21FLWPB 28010879	7/13/2005	630	49	83.62%
21FLWPB 28010009	5/22/2006	712	50	85.34%
21FLWPB 28010009	4/12/2006	757	51	87.07%
21FLWPB 28010009	11/6/2007	1,134	52	88.79%
21FLWPB 28010009	11/1/2006	1,182	53	90.52%
21FLWPB 28010009	9/27/2006	1,387	54	92.24%
21FLGW 20030	8/19/2003	2,000	55	93.97%
21FLWPB 28010879	12/8/2005	2,000	56	95.69%
21FLWPB 28010009	9/6/2006	2,200	57	97.41%
21FLGW 20004	8/11/2003	3,400	58	99.14%
		Existing condition concentration– 90th percentile interpolated (counts/100mL)		1168
		Criterion concentration (counts/100mL)		400
		Final % reduction {(1,168-400)/1,168}		66%

5.1.3 TMDL Development Process

Due to the limited supporting information a simple reduction calculation was performed to determine the reduction in fecal coliform concentration necessary to achieve the concentration target (400 counts/100mL). The percent reduction needed to reduce pollutant load was calculated by comparing the existing concentrations and target concentration using **Formula 1**:

$$\text{Needed \% Reduction} = \frac{\text{Existing 90}^{\text{th}}\text{ Percentile Concentration} - \text{Allowable Concentration}}{\text{Existing 90}^{\text{th}}\text{ Percentile Concentration}} \times 100$$

Formula 1

Using the Hazen method for estimating percentiles, as described in Hunter (2002), the existing condition concentration was defined as the 90th percentile of all the fecal coliform data collected during the Cycle 2 verified period (January 2001–June 2008). The 90th percentile is also called the 10 percent exceedance event, i.e., that threshold above which only 10% of exceedances occur. This will result in a target condition that is consistent with the state bacteriological water quality assessment threshold for Class III waters.

In applying this method, all of the available data are ranked (ordered) from the lowest to the highest (**Table 5.5**), and the Hazen Method (**Formula 2)** is used to determine the percentile value of each data point.

$$\text{Percentile} = \frac{\text{Rank} - 0.5}{\text{Total Number of Samples Collected}}$$ **Formula 2**

If none of the ranked values calculates to be exactly the 90th percentile value, then the 90th percentile number (used to represent the existing condition concentration) is calculated by interpolating between the two data points that bound (above and below) the 90th percentile rank using **Formula 3,** as described below.

$$90^{\text{th}} \text{ Percentile Concentration} = C_{\text{lower}} + (P_{90\text{th}} * R)$$ **Formula 3**

Where:

> *C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90th percentile, in this case, 1134 counts/100mL.*
>
> *P_{90th} is the percentile difference between the 90th percentile and the percentile number immediately lower than the 90th percentile (in this case, ~88%), which is 90% – 88.79% = 1.21%*
>
> *R is a ratio defined as R= (fecal coliform concentration$_{upper}$ – fecal coliform concentration $_{lower}$)/(percentile$_{upper}$ – percentile$_{lower}$)*

To calculate *R*, the percentile values below and above the 90th percentile were identified, in this case, 88 and 92 percent, respectively (**Table 5.5**). Next, the fecal coliform concentrations corresponding to the lower and upper percentile values were identified (1134 and 1182 counts/100mL, respectively) (**Table 5.5**). The fecal coliform concentration difference between the lower and higher percentiles was then calculated and divided by the unit percentile. The unit percentile difference is the difference between the lower and upper percentiles (e.g., 90.52% – 88.79% = 1.7 percentile unit difference). R was then calculated as R = (1182 – 1134)/(90.52% – 88.79%) = 2774.

The *C_{lower}, P_{90th}*, and *R* were substituted into **Formula 3** to calculate the 90th percentile fecal coliform concentration (i.e., 90th Percentile Concentration = 1134+ (0.0121*2774) = 1167.5 counts/100mL).

Using **Formula 1**, the percent reduction for the period of observation (January 2001–June 2008) was calculated as 66 percent for North Fork St. Lucie River (i.e., % reduction needed = [(1168–400)/1168]*100 = 66%).

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (b) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of best management practices (BMPs).

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDL for North Fork St. Lucie River is expressed in terms of counts/day and percent reduction, and represents the maximum daily fecal coliform load the stream can assimilate without exceeding the fecal coliform criterion (**Table 6.1**).

Table 6.1. TMDL Components for Fecal Coliform in North Fork St Lucie River (WBID 3194)

This is a six-column table. Column 1 lists the parameter, Column 2 lists the TMDL (counts/100mL), Column 3 lists the WLA for wastewater (counts/100mL), Column 4 lists the WLA for NPDES stormwater (percent reduction), Column 5 lists the LA (percent reduction), and Column 6 lists the MOS.

N/A = Not applicable

Parameter	TMDL (counts/100mL)	WLA for Wastewater (counts/100mL)	WLA for NPDES Stormwater (% reduction)	LA (% reduction)	MOS
Fecal coliform	400	N/A	66%	66%	Implicit

6.2 Load Allocation

Based on a percent reduction approach, the LA is a 66 percent reduction in fecal coliform from nonpoint sources. It should be noted that the LA includes loading from stormwater discharges regulated by the Department and the water management districts that are not part of the NPDES Stormwater Program (see **Appendix A**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are no NPDES permitted sites in the North Fork St. Lucie River watershed which would contribute to the fecal coliform impairment.

It should be noted that the state requires all NPDES-permitted wastewater point source dischargers to meet bacteria criteria at the end of the pipe. It is the Department's current practice not to allow mixing zones for bacteria. Any point sources that may discharge in the WBID in the future will also be required to meet end-of-pipe standards for coliform bacteria.

6.3.2 NPDES Stormwater Discharges

There are two NPDES Phase II municipal separate storm sewer system (MS4) permits in the North Fork St. Lucie River watershed. The City of Port St. Lucie (Permit #FLR04E001) has a Phase II MS4 permit which covers approximately 24,000 acres, or 65% of the North Fork St. Lucie River WBID area. St. Lucie County (Permit #FLR04E029) has a Phase IIC MS4 permit which covers the rest of the North Fork St. Lucie River watershed.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by not subtracting contributions from natural sources and sediments when the percent reduction was calculated. This makes the estimation of human contribution more stringent and therefore adds to the MOS.

Chapter 7: TMDL IMPLEMENTATION

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.). A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines that a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent, stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;*
- *A description of further research, data collection, or source identification needed in order to achieve the TMDL;*
- *Timetables for implementation;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information in managing water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

7.2 Other TMDL Implementation Tools

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. This is because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old-fashioned detective work that is best done by those in the area.

Many assessment tools are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River Tributaries and Hillsborough Basins, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work.

In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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 authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES Stormwater Program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and the master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES Stormwater Program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's program focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Estimates of Fecal Coliform Loadings from Potential Sources

The Department provides these estimates for informational purposes only and did not use them to calculate the TMDL. They are intended to give the public a general idea of the relative importance of each source in the waterbody. The estimates were based on the best information available to the Department when the calculation was made. The numbers provided do not represent actual loadings from the sources.

Pets

Pets (especially dogs) could be a significant source of coliform pollution through surface runoff within the North Fork St. Lucie River WBID boundary. Studies report that up to 95 percent of the fecal coliform found in urban stormwater can have nonhuman origins (Alderiso et al., 1996; Trial et al., 1993).

The most important nonhuman fecal coliform contributors appear to be dogs and cats. In a highly urbanized Baltimore catchment, Lim and Olivieri (1982) found that dog feces were the single greatest source of fecal coliform and fecal strep bacteria. Trial et al. (1993) also reported that cats and dogs were the primary source of fecal coliform in urban subwatersheds. Using bacteria source tracking techniques, it was found in Stevenson Creek in Clearwater, Florida, that the amount of fecal coliform bacteria contributed by dogs was as important as that from septic tanks (Watson, 2002).

According to the American Pet Products Manufacturers Association (APPMA), about 4 out of 10 U.S. households include at least 1 dog. A single gram of dog feces contains about 2.2 million fecal coliform bacteria (van der Wel, 1995). Unfortunately, statistics show that about 40 percent of American dog owners do not pick up their dogs' feces. The number of dogs within the North Fork St. Lucie River WBID boundary is unknown. Therefore, the statistics produced by APPMA were used in this analysis to estimate the possible fecal coliform loads contributed by dogs.

Using information from the Florida Department of Revenue's (DOR) 2009 Cadastral tax parcel and ownership coverage contained in the Department's geographic information system (GIS) library, residential parcels were identified using DOR's land use codes. The number of households within the North Fork St. Lucie River WBID boundary was estimated to be approximately 41,493. Assuming that 40 percent of the households in this area have 1 dog, there are about 16,597 dogs within the WBID.

Assuming that 40 percent of dog owners do not pick up their dogs' feces, the total waste produced by dogs and left on the land surface in residential areas in the WBID is approximately 2,987 kilograms/day. The total load produced by dogs is about 6.57×10^{12} counts/day of fecal coliform.

It should be noted that this load only represents the fecal coliform load created in the WBID and is not intended to be used to represent a part of the existing load that reaches the receiving waterbody. The fecal coliform load that eventually reaches the receiving waterbody could be significantly less than this value due to attenuation in overland transport. **Table B.1** shows the waste production rate for a dog (450 grams/animal/day) and the fecal coliform counts per gram of dog waste (2,200,000 counts/gram).

Table B.1. Dog Population Density, Wasteload and Fecal Coliform Density Based on the Literature (Weiskel et al., 1996)

This is a four-column table. Column 1 lists the animal type (dog), Column 2 lists the population density, Column 3 lists the wasteload, and Column 4 lists the fecal coliform density.

- = Empty cell/no data
* Number from APPMA

Animal Type	Population Density (animals/household)	Wasteload (grams/ animal-day)	Fecal Coliform Density (counts/gram)
Dog	0.4*	450	2,200,000

The human population in the North Fork St. Lucie River watershed, calculated based on the average persons per household was 102,488. This value was calculated by using the average persons per household in St. Lucie County (U.S Census) of 2.47 person/household, and then multiplying by the number of occupied residential units within the WBID boundary as determined using the 2009 Cadastral information (FDEP GIS) of 41,493 households.

Septic Tanks

Septic tanks are another potentially important source of coliform pollution in urban watersheds. When properly installed, most of the coliform from septic tanks should be removed within 50 meters of the drainage field (Minnesota Pollution Control Agency, 1999). However, the physical properties of an aquifer, such as thickness, sediment type (sand, silt, and clay), and location play a large part in determining whether contaminants from the land surface will reach the groundwater (USGS, 2010). The risk of contamination is greater for unconfined (water-table) aquifers than for confined aquifers because they usually are nearer to land surface and lack an overlying confining layer to impede the movement of contaminants (USGS, 2010).

Sediment type (sand, silt, and clay) also determines the risk of contamination in a particular watershed. “Porosity, which is the proportion of a volume of rock or soil that consists of open spaces, tells us how much water rock or soil can retain. Permeability is a measure of how easily water can travel through porous soil or bedrock. Soil and loose sediments, such as sand and gravel, are porous and permeable. They can hold a lot of water, and it flows easily through them. Although clay and shale are porous and can hold a lot of water, the pores in these fine-grained materials are so small that water flows very slowly through them. Clay has a low permeability (USGS, 2010).”

Also, the risk of contamination is increased for areas with a relatively high ground water table. The drain field can be flooded during the rainy season, resulting in ponding and coliform bacteria can pollute the surface water through stormwater runoff. Additionally, in these circumstances, a high water table can result in coliform bacteria pollution reaching the receiving waters through baseflow.

In addition, watersheds located in karst regions are extremely vulnerable to contamination. Karst terrain is characterized by springs, caves, sinkholes, and a unique hydrogeology that results in aquifers that are highly productive (USGS, 2010). In comparison to non-karst areas, the springs, caves, sinkholes, etc act as direct pathways for pollutants to enter waterbodies.

Septic tanks may also cause coliform pollution when they are built too close to irrigation wells. Any well that is installed in the surficial aquifer system will cause a drawdown. If the septic tank system is built too close to the well (e.g., less than 75 feet), the septic tank discharge will be within the cone of influence of the well. As a result, septic tank effluent may enter the well, and once the polluted water is used to irrigate lawns, coliform bacteria may reach the land surface and wash into surface waters through stormwater runoff.

A rough estimate of fecal coliform loads from failed septic tanks within the North Fork St. Lucie River WBID boundary can be made using **Equation B.1**:

L = 37.85* N * Q * C * F **Equation B.1**

Where:

L is the fecal coliform daily load (counts/day);
N is the number of households using septic tanks in the WBID;
Q is the discharge rate for each septic tank (gallons/day);
C is the fecal coliform concentration for the septic tank discharge (counts/100mL);
F is the septic tank failure rate; and
37.85 is a conversion factor (100 mL/gallon).

Based on data obtained from FDOH, which is currently undertaking a project to inventory the use of onsite treatment and disposal systems (i.e., septic tanks) by determining the methods of wastewater disposal for developed property sites statewide, 41,493 housing units *(N)* within the North Fork St. Lucie River WBID boundary are known or thought to be using septic tanks to treat their domestic wastewater (**Figure B.1**). FDOH's parcel data were obtained from the Florida Department of Revenue 2008 tax roll. FDOH's wastewater disposal data were obtained from county Environmental Health Departments, wastewater treatment facilities, Department domestic wastewater treatment permits, existing county and city inventories, and other available information. If there was not enough information to determine with certainty whether a property used a septic system, FDOH employed a probability model to analyze the characteristics of the property and estimate the probability that the property was served by a septic tank.

The discharge rate from each septic tank (*Q*) was calculated by multiplying the average household size by the per capita wastewater production rate per day. Based on the information published by the Census Bureau, the average household size for St. Lucie County is about 2.47 people/household. The same population densities were assumed within the North Fork St. Lucie River WBID boundary. A commonly cited value for per capita wastewater production rate is 70 gallons/day/person (EPA, 2001). The commonly cited concentration (*C*) for septic tank discharge is $1x10^6$ counts/100mL for fecal coliform (EPA, 2001).

No measured septic tank failure rate data were available for the WBID when this TMDL was developed. Therefore, the failure rate was derived from the number of septic tanks in St. Lucie County based on FDOH's septic tank inventory and septic tank repair permits issued in both counties as published by FDOH (available: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm).

Based on FDOH's 2008–09 inventory, the cumulative number of septic tanks in St. Lucie County on an annual basis was calculated by subtracting the number of issued septic tank installation permits for each year from the current number of septic tanks in the county, assuming that none of the installed septic tanks will be removed after being installed (**Table B.3**). The reported number of septic tank repair permits was also obtained from the FDOH website.

Based on this information, the annual discovery rates of failed septic tanks were calculated and are presented in **Table B.3**. The average annual septic tank failure discovery rate for St. Lucie County is approximately 0.50 percent. Assuming that failed septic tanks are not discovered for about 5 years, the estimated annual septic tank failure rate is about 5 times the discovery rate, or 2.50 percent for St. Lucie County. Based on **Equation B.1**, the estimated fecal coliform loading from failed septic tanks within the North Fork St. Lucie River WBID boundary is approximately 3.36×10^{11} counts/day.

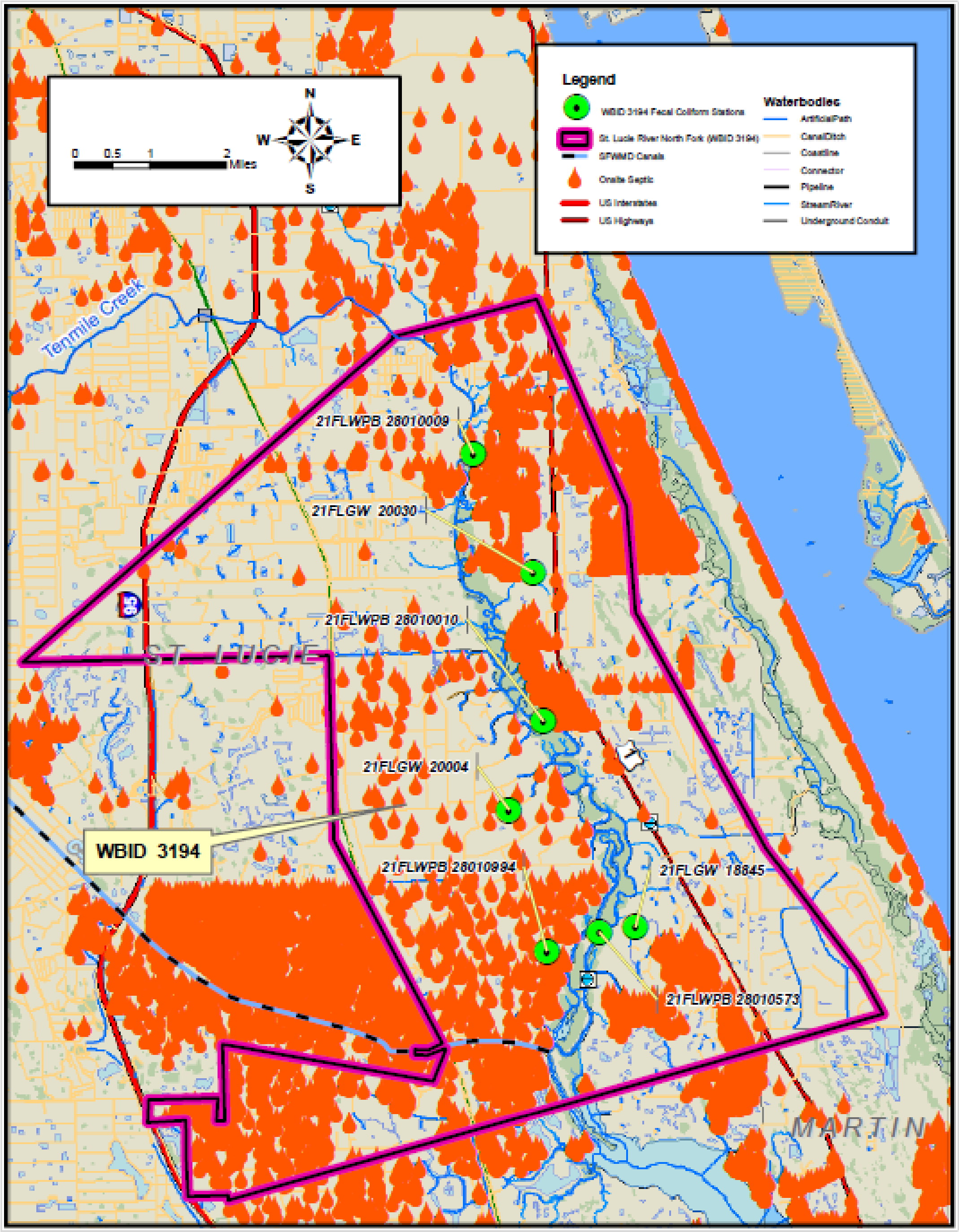

Figure B.1. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Residential Land Use Areas within the North Fork St. Lucie River WBID Boundary

Table B.3. Estimated Number of Septic Tanks and Septic Tank Failure Rates for St. Lucie County (2002–07)

This is a ten-column table. Column 1 lists the type of statistic, Columns 2 through 9 lists the estimate for each year from 2001 to 2008, respectively, and Column 10 lists the average.

[1] The failure rate is 5 times the failure discovery rate.

Descriptive Statistic	2001	2002	2003	2004	2005	2006	2007	2008	Average
New installations (septic tanks)	431	544	813	679	478	297	89	47	401
Accumulated installations (septic tanks)	40,555	40,986	41,530	42,343	43,022	43,500	43,797	43,886	41,854
Repair permits (septic tanks)	302	243	231	201	207	152	116	95	206
Failure discovery rate (%)	0.74%	0.59%	0.56%	0.47%	0.48%	0.35%	0.26%	0.22%	0.00
Failure rate (%)[1]	3.72%	2.96%	2.78%	2.37%	2.41%	1.75%	1.32%	1.08%	2.50%

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) can also be a potential source of fecal bacteria pollution. Human sewage can be introduced into surface waters even when storm and sanitary sewers are separated. Leaks and overflows are common in many older sanitary sewers where capacity is exceeded, high rates of infiltration and inflow occur (i.e., outside water gets into pipes, reducing capacity), frequent blockages occur, or sewers are simply falling apart due to poor joints or pipe materials. Power failures at pumping stations are also a common cause of SSOs. The greatest risk of an SSO occurs during storm events; however, few comprehensive data are available to quantify SSO frequency and bacteria loads in most watersheds. Therefore, in this report, the possible fecal coliform load contributed by sewer line leakage was estimated based on an empirical leakage rate of 0.5 percent of the total raw sewage (Culver et al., 2002) created within the WBID by the households connected to the sewer system.

The number of properties connected to the sewer system was based on data obtained from the Florida Department of Health's (FDOH) ongoing inventory of wastewater treatment and disposal method for developed properties. Using information from the DOR's 2009 Cadastral tax parcel and ownership coverage, residential parcels were identified using DOR's land use codes. The final number of households within the WBID boundary was calculated by adding the number residential units on the parcels for all improved residential land use codes. As a result, it was estimated that 41,493 housing units within the North Fork St. Lucie River WBID boundary are served by sewer systems (**Figure B.1**).

Fecal coliform loading from sewer line leakage can be calculated based on the number of people in the watershed, typical per household generation rates, and typical fecal coliform concentrations in domestic sewage, assuming a leakage rate of 0.5 percent (Culver et al., 2002). Based on this assumption, a rough estimate of fecal coliform loads from leaks and SSOs within the North Fork St. Lucie River WBID boundary can be made using **Equation B.1.**

$$L = 37.85 * N * Q * C * F \qquad \textbf{Equation B.1}$$

Where:

- L is the fecal coliform daily load (counts/day);
- N is the number of households using sanitary sewer in the WBID;
- Q is the discharge rate for each household (gallons/day);
- C is the fecal coliform concentration for domestic wastewater (counts/100mL);
- F is the sewer line leakage rate; and

37.85 is a conversion factor (100mL/gallon).

The number of households *(N)* within the North Fork St. Lucie River WBID boundary served by sewer systems is estimated to be 39,437. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size for the St. Lucie County (2.47persons/household) (US Census Bureau, 2000) by the per capita wastewater production rate per day (70 gallons/day/person). The commonly cited concentration (*C*) for domestic wastewater is $1x10^6$ counts/100 mL for fecal coliform (EPA, 2001). The contribution of fecal coliform through sewer line leakage was assumed to be 0.5 percent of the total sewage loading created from the population not on septic tanks (Culver et al., 2002). Based on **Equation B.1**, the fecal coliform loading from sewer line leakage in the WBID is approximately 1.29×10^{12} counts/day.

Wildlife

Wildlife is another possible source of fecal coliform bacteria within the North Fork St. Lucie River WBID boundary. As shown in **Figure 4.1**, wetland areas border the North Fork St. Lucie River and several of its contributing branches within the WBID boundary. Additionally, rangeland (dry prairie, shrub, and brushland) and upland forested areas are close to the creek. These areas likely serve as habitat for wildlife that has the potential to contribute fecal coliform to the creek. However, as these represent natural inputs, this TMDL does not assign any reductions to these sources.

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