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 Southwest Fork Loxahatchee River WBID 3226C

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TMDL Program

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

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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 305(b) 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 Southwest Fork Loxahatchee River, a Class II waterbody[1] located in the St. Lucie and Loxahatchee Basin. The estuary was identified as impaired in the 1998 Consent Decree[2] and was verified as impaired for fecal coliform during Cycle 1 (January 1996 – June 2003), and therefore was included on the Verified List of Impaired waters for the St. Lucie and Loxahatchee Basin that was adopted by Secretarial Order in May 2004. The waterbody was re-assessed during Cycle 2 (January 2001 – June 2008) and remained impaired for fecal coliform bacteria. Waterbodies once listed as verified either are delisted or remain as verified. Verified waterbodies are adopted by Secretarial Order only once (exception: if delisted and in a subsequent cycle verified and listed). The TMDL establishes the allowable fecal coliform loading to the Southwest Fork Loxahatchee River that would restore the waterbody so that it meets its applicable water quality criteria 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 Southwest Fork Loxahatchee River is WBID 3226C.

The Southwest Fork Loxahatchee River is 1 of the 12 waterbody segments identified in the Loxahatchee Planning Unit and 1 of 69 in the St. Lucie-Loxahatchee Group 2 Basin. The watershed is located in the northeastern part of Palm Beach County (**Figure 1.1**).

The Southwest Fork Loxahatchee River originates where the C-18 canal passes through the S-46 structure on the western edge of Jupiter in northeast Palm Beach County. The southwest fork flows in a general easterly direction for approximately 1 mile until it meets with the northwest branch to form the Loxahatchee River that flows to the Atlantic Ocean, at Jupiter Inlet (**Figure 1.2**).

The area of the Southwest Fork Loxahatchee River WBID boundary is approximately 6.8 square miles (4,376 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 residential development increased during the 1970s to date, pockets of residential development, most often with associated golf courses, converted wetland and mesic areas. Residential development increased rapidly in the 1990s through middle 2000s. As development increased the needs for surface water management increased. Several water control districts exist to primarily manage

[1] 62-302.530 Bacteriological Quality (Fecal Coliform Bacteria) Most Probable Number (MPN) shall not exceed a median value of 14 with not more than 10% of the samples exceeding 43, nor exceed 800 on any one day.

[2] Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998

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 3226C 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).

National Wild and Scenic River
The Loxahatchee River is one of the “last free-flowing” rivers in southeast Florida. In 1985, portions of the Northwest Fork of the Loxahatchee River were designated as a National Wild and Scenic River, Florida’s first river to receive such designation. The Gubernatorial and Cabinet resolution included:

> *The principal goals of the plan will be to preserve and enhance the river's unique natural values, restore the river's historical hydrologic regime and reverse deleterious saltwater intrusion into the river.*

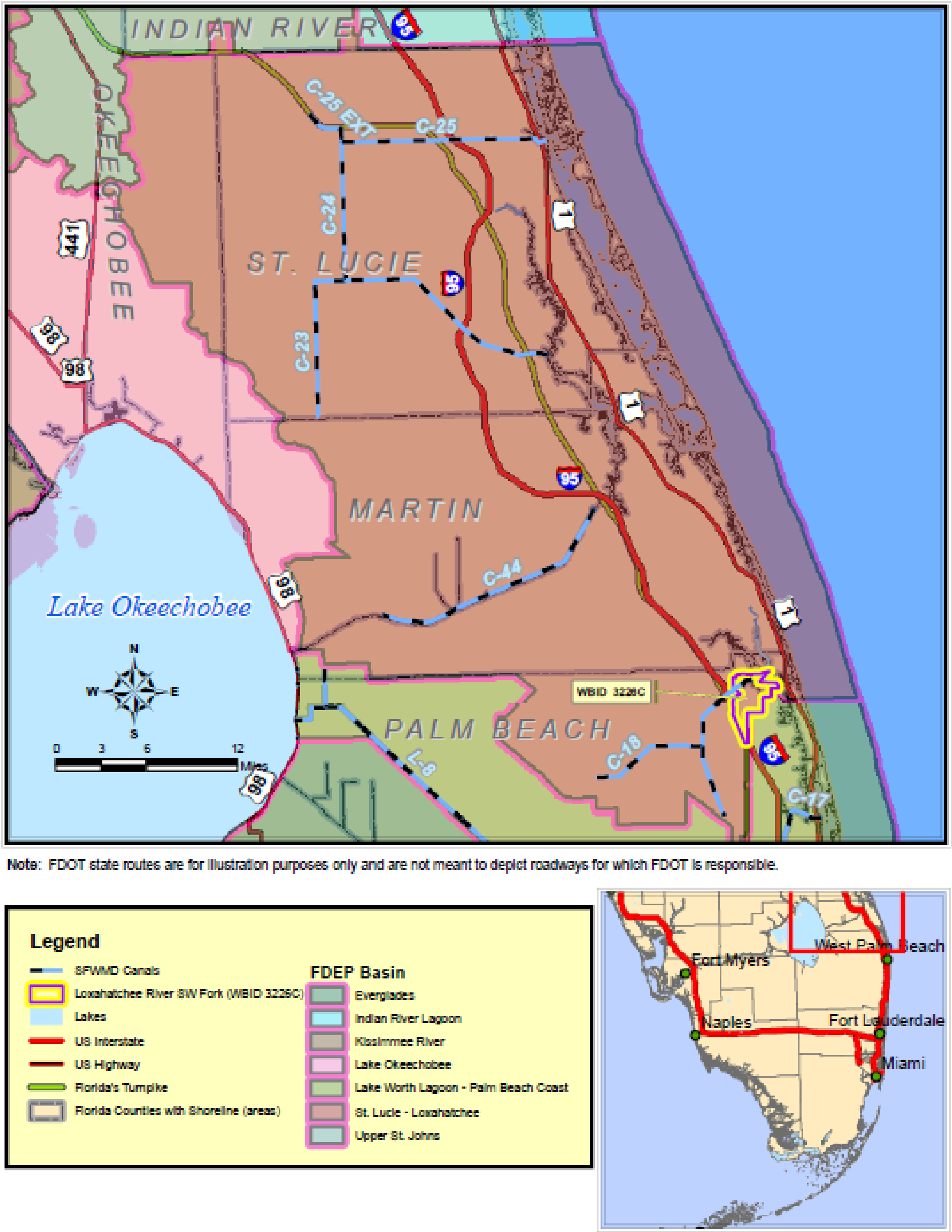
Portions of the river and estuary are also designated as Outstanding Florida Waters and an Aquatic Preserve. Outstanding Florida Waters are not a designated use classification, and while this identification does note the waters “as worthy of special protection because of their natural attributes” (FAC 62-302.200(18) Definitions). A waterbody may have special standards applied to it. For an Outstanding Florida Water, no classification action or change in designated use shall result in degradation of water quality in Outstanding Florida Waters.

Over the past one hundred years, many canals and levees have been constructed throughout the watershed. These efforts served to drain mesic and wetlands areas, as well as create flood control. This matrix of water controls altered the natural flows into the river. Construction of the C-18 canal (1958) diverted a majority of historic flows away from the Northwest Fork, and into the Southwest Fork through the S-46 structure. Channelization of the Southwest Fork nearly eradicated all of Limestone Creek. Jupiter Inlet was created (differing in size and permanence from the smaller and occasional breaks that occurred historically) in 1947. With the dredging to create and expand Jupiter Inlet, the tidal and estuarine influences increased and moved continuously further upstream of the Loxahatchee River System. As a result, portions of vegetation along the river have shifted from a freshwater marsh and swamp to mangroves. This expansion of saltwater and brackish waters has allowed the establishment of oysters. Oysters have expanded in areas that have become saltwater to brackish water dominated systems, from historic freshwater flows. The associated recreational oyster harvesting is the basis of the Southwest Fork Loxahatchee River assignment to the Class II water quality category.

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.



Note: FDOT state routes are for illustration purposes only and are not meant to depict roadways for which FDOT is responsible.

Figure 1.1. Location of the Southwest Fork Loxahatchee River Watershed (WBID 3226C) in the St. Lucie-Loxahatchee River Basins and Major Geopolitical and Hydrologic Features in the Area

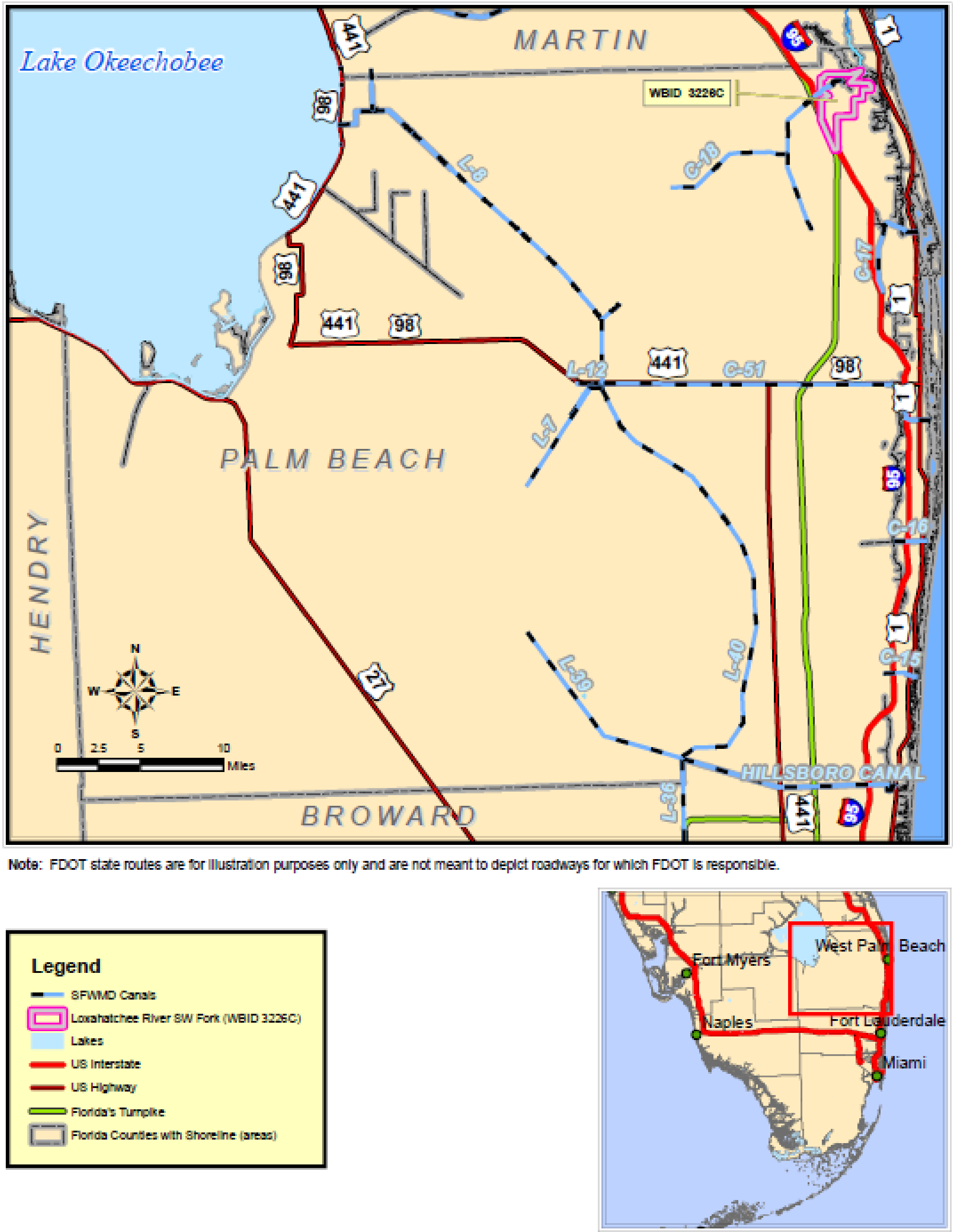


Figure 1.2. Location of the Southwest Fork Loxahatchee River Watershed (WBID 3226C) in Palm Beach County and Major Hydrologic Features in the Area

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 the Southwest Fork Loxahatchee River. These activities will solicit and include the active participation of the local citizen groups, as well as local and regional political entities such 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 the Southwest Fork Loxahatchee River and verified that this waterbody segment is impaired for fecal coliform bacteria. The verified impairment was based on data then available. This verified period data shows 59 of 73 samples exceeded Class II water quality criteria of 43 counts per 100 milliliters (counts/100mL) in more than 10% of the samples at 90% confidence level using the binomial distribution (Table 2.1). The verified list (Secretarial Order DEP 04-0623) identifies that 12 out of 73 fecal coliform samples exceeded the state water quality criteria; however, this errantly used the Class III criteria of 400 counts per 100 milliliters (counts/100mL) in more than 10% of the samples at 90% confidence level using the binomial distribution. Since the listing at the end of the Cycle 1, additional data collected during Cycle 1 has been provided to the Department and added to the IWR. This additional data further supports the assessment as impaired during Cycle 1 with 100 of 136 samples exceeding the Class II water quality criteria standards. The fecal coliform impairment verified for this waterbody during the Cycle 1 assessment was confirmed during Cycle 2 based on data collected from January 1, 2001 through June 30, 2008. [See **Section 3.2** for details]

Table 2.1 summarizes the Cycle 1 verified period data for the Southwest Fork Loxahatchee River used to verify the fecal coliform impairment and **Table 2.2** summarizes fecal coliform data from the Cycle 2 verified period (based on IWR Run 42). Data from Cycle 2 verified period represent more current conditions, so the data from the Cycle 2 verified period were used to develop the TMDL.

Table 2.1. Summary of Fecal Coliform Monitoring Data for the Southwest Fork Loxahatchee River (WBID 3226C) during the Cycle 1 Listing, Verified Period (January 1, 1996, to June 30, 2003)

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 1 numerical values for each respective parameter.

Waterbody (WBID)	Parameter	Number
Southwest Fork Loxahatchee River (WBID 3226C)	Total number of samples	73
Southwest Fork Loxahatchee River (WBID 3226C)	IWR-required number of exceedances for Impairment Verification	10
Southwest Fork Loxahatchee River (WBID 3226C)	Number of observed exceedances	59
Southwest Fork Loxahatchee River (WBID 3226C)	Number of observed nonexceedances	14
Southwest Fork Loxahatchee River (WBID 3226C)	Number of seasons during which samples were collected	4
Southwest Fork Loxahatchee River (WBID 3226C)	Highest observation (counts/100mL)	2,560
Southwest Fork Loxahatchee River (WBID 3226C)	Lowest observation (counts/100mL)	1
Southwest Fork Loxahatchee River (WBID 3226C)	Median observation (counts/100mL)	155
Southwest Fork Loxahatchee River (WBID 3226C)	Mean observation (counts/100mL)	237

Table 2.2. Summary of Fecal Coliform Monitoring Data for the Southwest Fork Loxahatchee River (WBID 3226C) during the Cycle 2 Listing, Verified Period (January 1, 2001, to June 30, 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 1 numerical values for each respective parameter.

Waterbody (WBID)	Parameter	Number
Southwest Fork Loxahatchee River (WBID 3226C)	Total number of samples	91
Southwest Fork Loxahatchee River (WBID 3226C)	IWR-required number of exceedances for Impairment Verification	12
Southwest Fork Loxahatchee River (WBID 3226C)	Number of observed exceedances	61
Southwest Fork Loxahatchee River (WBID 3226C)	Number of observed nonexceedances	30
Southwest Fork Loxahatchee River (WBID 3226C)	Number of seasons during which samples were collected	4
Southwest Fork Loxahatchee River (WBID 3226C)	Highest observation (counts/100mL)	1,200
Southwest Fork Loxahatchee River (WBID 3226C)	Lowest observation (counts/100mL)	1
Southwest Fork Loxahatchee River (WBID 3226C)	Median observation (counts/100mL)	72
Southwest Fork Loxahatchee River (WBID 3226C)	Mean observation (counts/100mL)	188

Note: Numbers are based upon applying the Water Quality Class II criteria of 43 counts / 100 mL and only using data available at Cycle 2 Verification

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 Southwest Fork Loxahatchee River is a Class II (Estuarine) waterbody, with a designated use of shellfish propagation or harvesting. The criterion applicable to this TMDL is the Class II 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 Southwest Fork is identified as a Class II waterbody:

> 62-302.400 Classification of Surface Waters, Usage, Reclassification, Classified Waters. (12) (b) 50 Palm beach County
>
> Canal C-18 - Salinity barrier to Loxahatchee River.
>
> Loxahatchee River - Upstream of Florida East Coast railroad bridge including Southwest, Northwest, and North Forks.

The water quality criteria for the protection of Class II waters, as established by Rule 62-302, F.A.C., states the following:

> ***Fecal Coliform Bacteria:***
>
> *The most probable number (MPN) shall not exceed a median value of 14 with not more than 10% of the samples exceeding 43, nor exceed 800 on any one day.*

The criterion selected for the TMDL was not to exceed 43 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." Using Cycle 2 data for 3226C, there are 91 total samples with 61 exceedances of the Class II criteria. A verified impairment exists when a sample size of 83-91 has 12 or more exceedances (Table 3). The TMDL assessment is made using the Cycle 2 period data as this is more current, and the impairment remains. Additionally, data dating back to the Cycle 1 was added to the IWR post verified assessment, and this data further confirmed the initial listing. The Department assessed both the median value 14 counts/100 ml as a potential TMDL target, where the median value for the existing condition is 68 counts/100 ml, which identified a percent reduction of about 79%. Additionally we applied the Hazen's 90th percentile for the existing condition, which identified percent reduction of about 91%. The 43 counts/100 ml is used as the TMDL target, because is more stringent than using the 14 counts/100 ml median value, providing a greater Margin of Safety.

62-302.700 Special Protection, Outstanding Florida Waters, Outstanding National Resource Waters

(1) It shall be the Department policy to afford the highest protection to Outstanding Florida Waters and Outstanding National Resource Waters. No degradation of water quality, other than that allowed in Rule 62-4.242(2) and (3), F.A.C., is to be permitted in Outstanding Florida Waters and Outstanding National Resource Waters, respectively, notwithstanding any other Department rules that allow water quality lowering.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant sources within 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 five acres, 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 the 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 Southwest Fork Loxahatchee River WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are 2 NPDES permitted sites in the Southwest Fork Loxahatchee River watershed. The Town of Jupiter water treatment plant (Permit # FL0042358) is located on the western edge of the Southwest Fork Loxahatchee River Watershed approximately 0.35 miles from the waterbody. This facility produces potable water from deep well sources via reverse osmosis. Reverse Osmosis Concentrate (RO) has a permitted capacity of 2.0 million gallons per day (MGD) on an annual average daily flow. Reverse Osmosis (RO) effluent is the product of well water purification, where by ions and particles are concentrated in effluent while potable water is produced. As no fecal coliform bacteria exist in the deep brine source of wells, there is no fecal coliform in the RO effluent.

The Loxahatchee Environmental Control District (Permit # FL0034649) is a domestic wastewater facility located within the Southwest Fork Loxahatchee River WBID boundary. This facility has a permitted capacity of 9.0 MGD annual average daily flow. The treated domestic wastewater effluent is released into onsite holding ponds. Effluent disposal is via deep well injection well and/or High Level Disinfected Effluent Discharge (Reclaimed Water) for irrigation, neither of which are a source of fecal coliform to surface waters.

Municipal Separate Storm Sewer System Permittees

There is one municipal separate storm sewer system (MS4) permits in the Southwest Fork Loxahatchee River watershed. Palm Beach County (Permit #FLS00018) has a Phase I MS4 permit that covers the entire Southwest Fork Loxahatchee River watershed. Town of Jupiter, the Village of Tequesta, and Florida DOT are co-permittees.

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. In watersheds with livestock agriculture, the livestock can be a source of fecal coliform bacteria; there is no livestock at scales to contribute to bacteria loads in this waterbody.

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 quantify accurately the fecal coliform loadings from different sources, land development information can provide some indications on the potential sources of observed fecal coliform impairment. Site review provides evidence of wildlife usage such as rookeries or loafing areas of birds, or rooting, wallows, rubs that indicate large populations of feral hogs, that may be coincident to or upstream from sampling locations.

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 Southwest Fork Loxahatchee River WBID boundary were aggregated using the Florida Land Use Code and Classification System (FLUCCS) expanded Level 1 codes (including low, medium, and high density residential). 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 Southwest Fork Loxahatchee River WBID boundary is approximately 4,376 acres (6.8 sq. mi.). The dominant land use categories are urban lands (urban and built-up; low- medium-, and high-density residential), which accounts for approximately 3,331 acres, or about 76 percent of the total WBID area, and water, which account for approximately 10 percent of the total WBID area. Rangeland accounts for 1.1% (48 acres) of the watershed, but there are no other agricultural lands in the WBID area. Natural land use areas, which include upland forests, water, wetlands, and rangeland, occupy about 758 acres, accounting for about 17 percent of the total WBID area.

Table 4.1. Classification of Land Use Categories within the Southwest Fork Loxahatchee 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	859	19.6
-	Low Density Residential	331	7.6
-	Medium Density Residential	1,270	29.0
-	High Density Residential	871	19.9
2000	Agricultural	-	-
3000	Rangeland	48	1.1
4000	Upland Forest	228	5.2
5000	Water	435	10.0
6000	Wetlands	47	1.1
7000	Barren Land	-	-
8000	Transportation, Communication, and Utilities	287	6.6
	TOTAL	**4,376**	**100.0%**

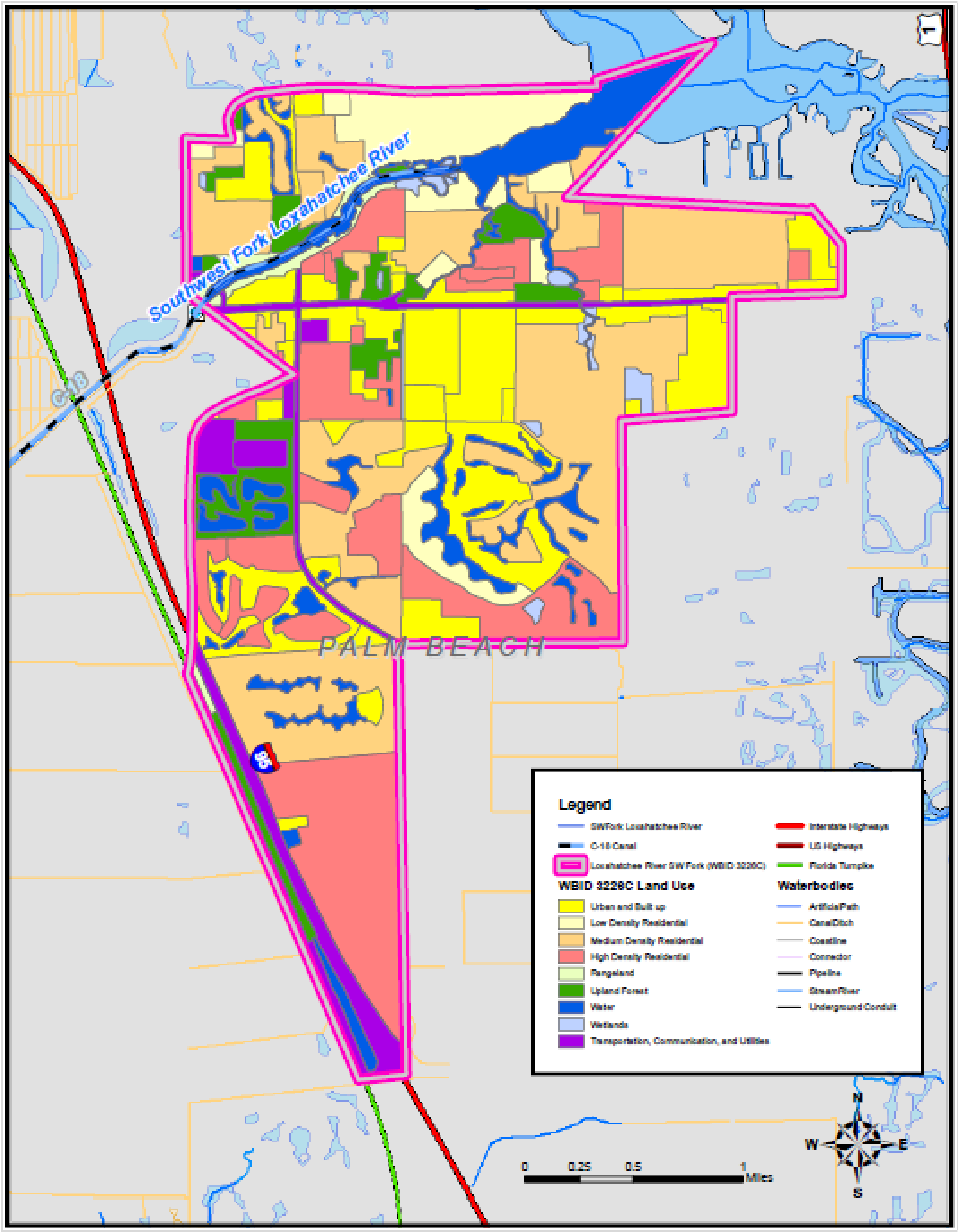


Figure 4.1. Principal Land Uses within the Southwest Fork Loxahatchee River (WBID 3226C) Boundary

Pets

Pets whose waste is deposited outdoors can be a significant source of coliform pollution through surface runoff in the Southwest Fork Loxahatchee River watershed. Studies report that up to 95 percent of the fecal coliform found in urban stormwater can have non-human origins (Alderiso et al., 1996; Trial et al., 1993). Appendix B provides calculations for potential loading from pets.

Wildlife and Sediments

In addition to livestock and wildlife populations, residual bacteria populations in sediments could 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 re-suspended into surface water when conditions are right (Jamieson et al., 2005).

Current source identification methodologies do not quantify the 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 Southwest Fork Loxahatchee 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 90^{th} 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 nonparametric Hazen Method was used to determine the 90^{th} percentile of fecal coliform counts. The percent reduction of fecal coliform needed to meet the applicable criterion was calculated by determining the recent reduction necessary to go from the 90^{th} percentile to the existing water quality standard (described in **Section 5.1.3)**.

5.1.1 Data Used in the Determination of the TMDL

Data used to develop this TMDL (Cycle 2) were collected by the Department's Southeast District Office (Stations: 21FLWPB 28010274, 21FLWPB 28010615, and 21FLWPB 28010283) and the Loxahatchee River District (Station: 21FLLOX 71, 21FLLOX 72, and 21FLLOX 73). The majority of data were collected at the Loxahatchee River District data collection stations 21FLLOX 71 (n=27), 21FLLOX 72 (n=27), and 21FLLOX 73 (n=27) while the other are from Station 21FLWPB28010274 (n=6) and 21FLWPB 28010615 (n=5), and 21FLWPB 28010283 (n=5). The total number of samples, N=97, is for all data available in the IWR (Run 43) from the Cycle 2 verified period (January 2001 – June 2008), which includes 6 data points collected during the verified period but only supplied to the Department after Cycle 2. See **Figure 5.1** for the locations of the water quality stations where fecal coliform data were collected for the Southwest Fork Loxahatchee River.

At the time of the assessment, the Department verified the water quality impairment in the Southwest Fork Loxahatchee River on the observation that 12 out of 73 fecal coliform samples collected during the Cycle 1 verified period (January 1996, through June 2003) exceeded the Class III assessment threshold of 400 counts/100mL. This was an error, as the waterbody is designated as Class II waters. Applying the Class II water quality criteria of 43 counts/100mL, 59 out of 73 fecal coliform samples exceeded the water quality threshold. Thus, the waterbody was impaired during Cycle 1.

The Cycle 2 verified period includes data collected from January 2001, through June 2008. During this period, a total of 97 fecal coliform samples were collected from the 6 sampling stations in WBID 3226C. The fecal coliform data for the Southwest Fork Loxahatchee River collected were distributed over the Cycle 2 verified period, during all four seasons.

Fecal coliform counts for all samples collected during the Cycle 2 verified period ranged from 1 to 1,200 counts/100mL and averaged 179 counts/100mL during the period of observation. **Table 5.1** summarizes the descriptive statistics for the Cycle-2 period fecal coliform results. **Figure 5.2** shows the fecal coliform concentration trends observed in the Southwest Fork Loxahatchee River.

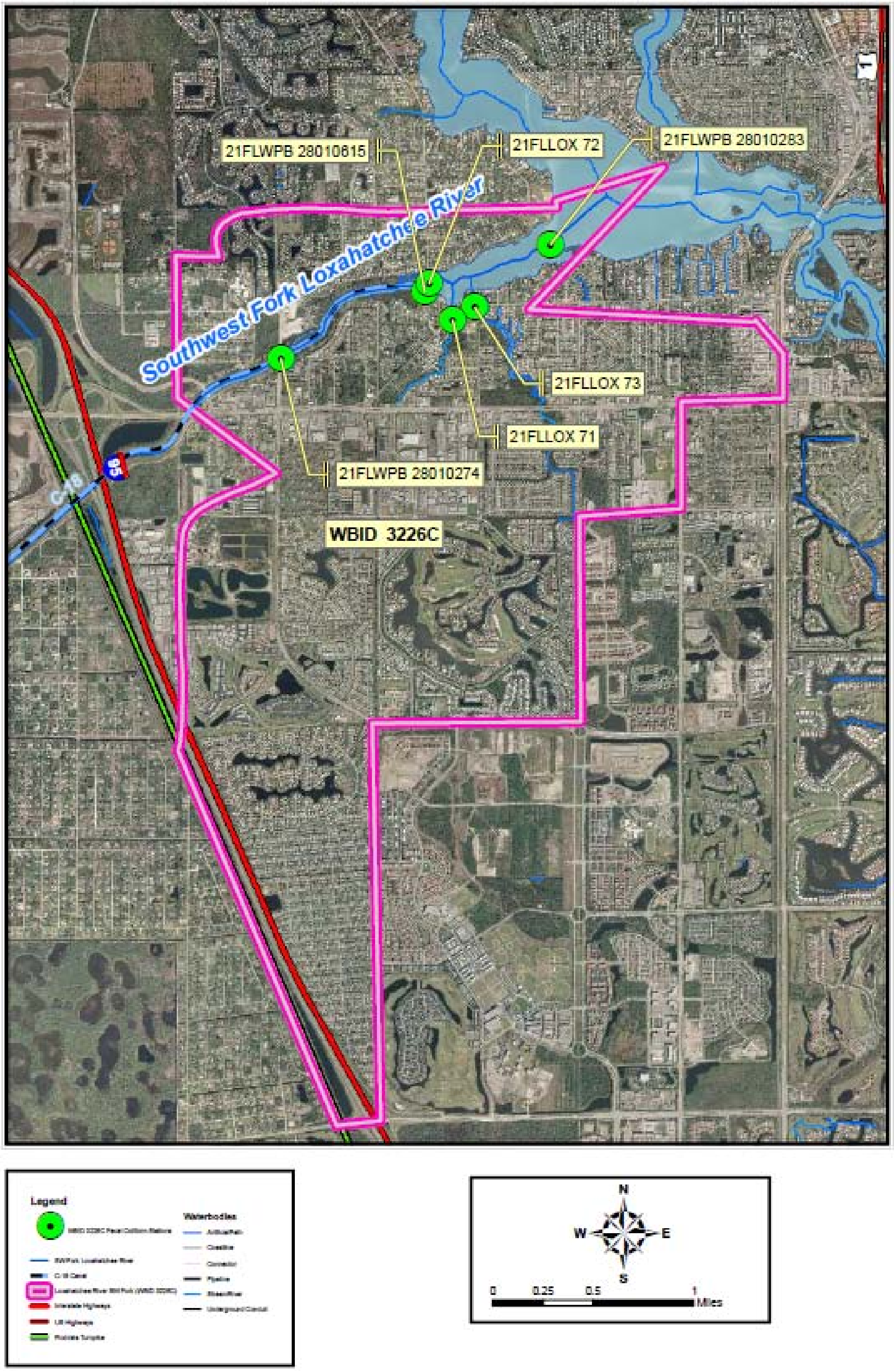


Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in the Southwest Fork Loxahatchee River (WBID 3226C)

Table 5.1. Descriptive Statistics of Fecal Coliform Data for the Southwest Fork Loxahatchee River (WBID 3226C) 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	97
Mean observation (counts/100mL)	179
Standard deviation	258
Median observation (counts/100mL)	68
Highest observation (counts/100mL)	1,200
Lowest observation (counts/100mL)	1
25% quartile	32
75% quartile	200

Temporal Patterns

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

Seasonally, a peak in fecal coliform concentrations and exceedance rates is expected during a year's third quarter (summer, July–September), when conditions are rainy and warm (Florida's rainy season). 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 cooler. This seasonal pattern was reflected in data on the Southwest Fork Loxahatchee River had fecal coliform concentrations that exceed the State criteria in all four seasons with the highest monthly percent exceedances recorded in September. Contrary to the expected seasonal pattern, one of the highest fecal coliform concentrations and one of the highest monthly percent exceedances were observed during November. **Tables 5.2a** and **5.2b** summarizes the monthly and seasonal fecal coliform averages and percent exceedances, respectively, using all IWR data collected during the Cycle 2 verified period for this waterbody.

Table 5.2a. Summary Statistics of Fecal Coliform Data for All Stations in the Southwest Fork Loxahatchee River (WBID 3226C) 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 43 counts/100mL

Month	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
January	16	12	640	35	111	6	38
February	0						
March	18	1	1,080	42	141	8	44
April	0						
May	15	17	460	64	126	13	87
June	3	2	7	2	4	0	0
July	15	10	1,180	140	285	11	73
August	0						
September	15	10	795	90	191	12	80
October	3	23	44	42	36	1	33
November	12	34	1,200	210	321	11	92
December	0						

Table 5.2b. Summary Statistics of Fecal Coliform Data for All Stations in the Southwest Fork Loxahatchee River (WBID 3226C) 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 43 counts/100mL

Season	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2] (43 counts/100mL)	% Exceedances
Quarter 1	34	1	1,080	39	127	14	41
Quarter 2	18	2	460	63	105	13	72
Quarter 3	30	10	1,180	104	238	23	77
Quarter 4	15	23	1,200	200	264	12	80

Using rainfall data collected at the Stuart CLIMOD station in Martin County (available: http://climod.meas.ncsu.edu/), it was possible to compare monthly rainfall with monthly fecal coliform exceedance rates over the years 2001-2008, 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 not observed in the Southwest Fork Loxahatchee River, as only 14 of the 46 exceedances in Cycle 2 Verified Period followed medium to extreme rainfall events (see Table 5.4). These fecal coliform concentrations show a correlation to the cumulative 3-day precipitation (extreme and medium precipitation events).

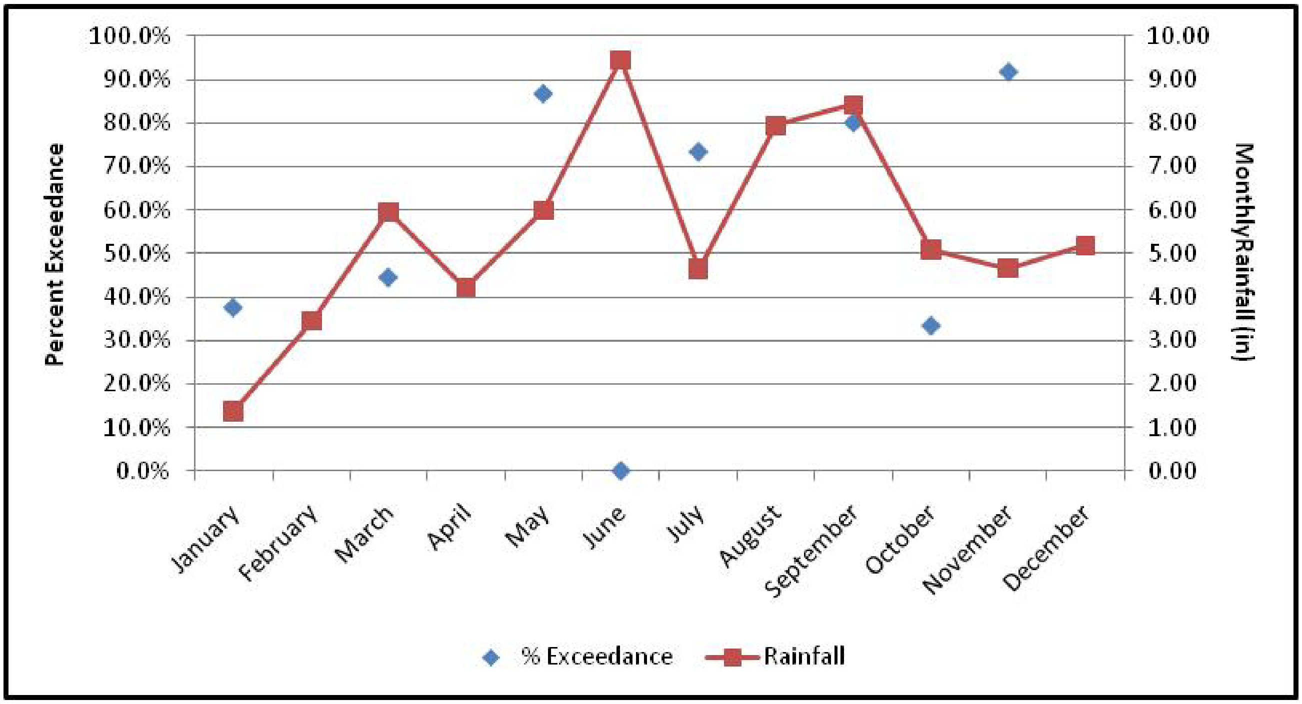


Figure 5.2. Fecal Coliform Exceedances and Rainfall at All Stations in the Southwest Fork Loxahatchee River (WBID 3226C) by Month during the Cycle 2 Verified Period

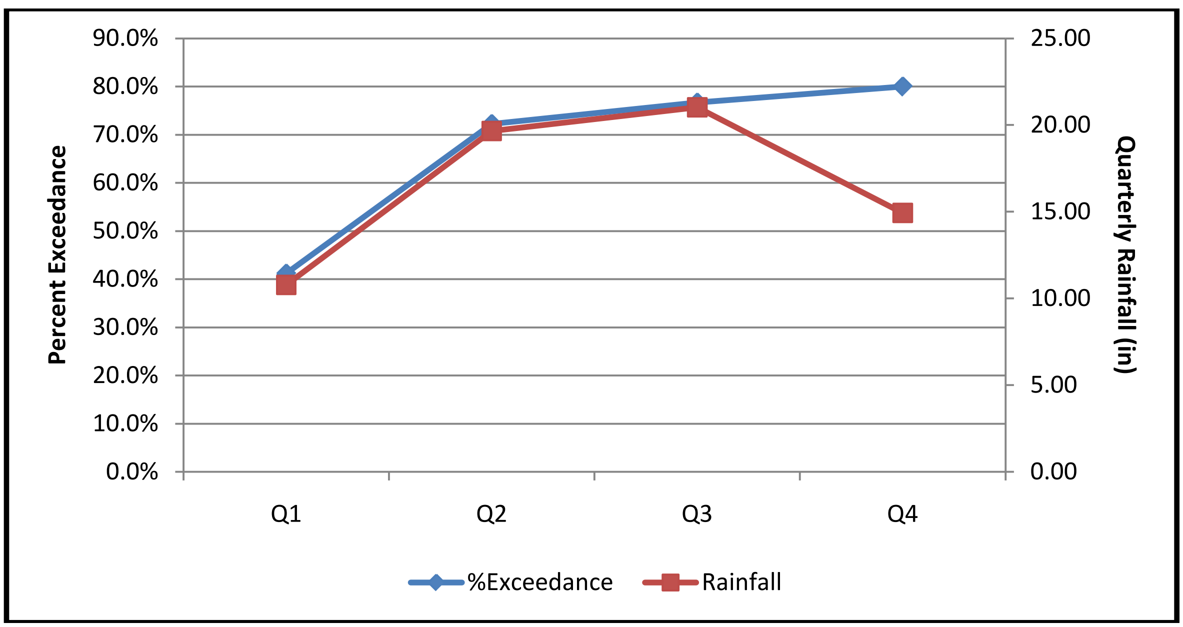


Figure 5.3. Fecal Coliform Exceedances and Rainfall at All Stations in the Southwest Fork Loxahatchee River (WBID 3226C) by Season during the Cycle 2 Verified Period

Spatial Patterns

Fecal coliform data from Cycle 2 verified period from the stations were analyzed to detect spatial trends in the data (see **Table 5.3**). Fecal coliform concentrations exceeding the state criterion (43 counts/100mL) were observed at 5 of the 6 stations. The highest concentrations were recorded at Station 21FLLOX 73 (**Table 5.3**), located in the middle reach of the Southwest Fork of Loxahatchee River, an area receiving residential stormwater runoff. Station 21FLWPB 28010274 with maximum concentration of 122 (counts/100mL), is located upstream and is dominated by flows from the C-18 canal. This indicates that fecal coliform loads are not coming from the C-18, and that influences are from the micro-basins within the waterbody.

Table 5.3. Station Summary Statistics of Fecal Coliform Data for the Southwest Fork Loxahatchee River (WBID 3226C) during the Cycle 2 Verified Period

This is an 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 each 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 waterbody.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 43 counts/100mL

Station ID	Period of Observation	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedance	Percent Exceedance
21FLLOX 71	2001-2007	27	2	600	82	132	22	81
21FLLOX 72	2001-2007	27	8	1,180	40	120	12	44
21FLLOX 73	2001-2007	27	10	1,200	260	375	25	93
21FLWPB 28010274	2007	6	2	122	14	30	1	17
21FLWPB 28010615	2007	5	4	51	25	26	2	40
21FLWPB 28010283	2007	5	1	42	10	16	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 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 Stuart 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 events and 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 a 3 day total rainfall greater than 2.22 inches/3 days; large events, 1.45 to 2.22 inches/3 days; medium events, 0.40 to 1.45 inches/3 days; small events, 0.01 to 0.40 inch/3 days; and non-measurable events, i.e., less than 0.01 inch/3 days. For the analysis, rain events were calculated as the three-day cumulative precipitation (the day of and 2 days prior to sampling) (**Table 5.4** and **Figure 5.5**).

Data show that fecal coliform exceedances occurred over large, medium, small, and not measurable precipitation events. Exceedances occurred over all hydrologic conditions.

The highest percentage of exceedances (82 percent) occurred after medium precipitation events. Exceedances were also observed in samples collected after large precipitation events (67 percent exceedances). The lowest percentage of exceedances occurred after periods of no measurable precipitation (45 percent). The fact that the highest exceedance rates occurred after medium and large precipitation events, rather than after periods of little or no rainfall, indicates that nonpoint sources are may be a major contributing factor. **Table 5.4** and **Figure 5.5** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred in the majority of the precipitation intervals —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 the Southwest Fork Loxahatchee River.

Table 5.4. Summary of Historical Fecal Coliform Data by Hydrologic Condition for the Southwest Fork Loxahatchee River (WBID 3226C)

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 for total samples in the rainfall interval, Column 6 lists the number of nonexceedances, and Column 7 lists the percent nonexceedances for total samples in the rainfall interval.

Precipitation Event	Event Range (inches)	Total Samples During Event	Number of Exceedances	% Exceedances	Number of Non-exceedances	% Non-exceedances
Extreme	>2.22"	0	0	N/A	0	N/A
Large	1.45" - 2.22"	3	2	67%	1	33%
Medium	0.40" - 1.45"	39	32	82%	7	18%
Small	0.01" - 0.40"	17	11	65%	6	35%
None/Not Measurable	<0.01"	38	17	45%	21	55.3%

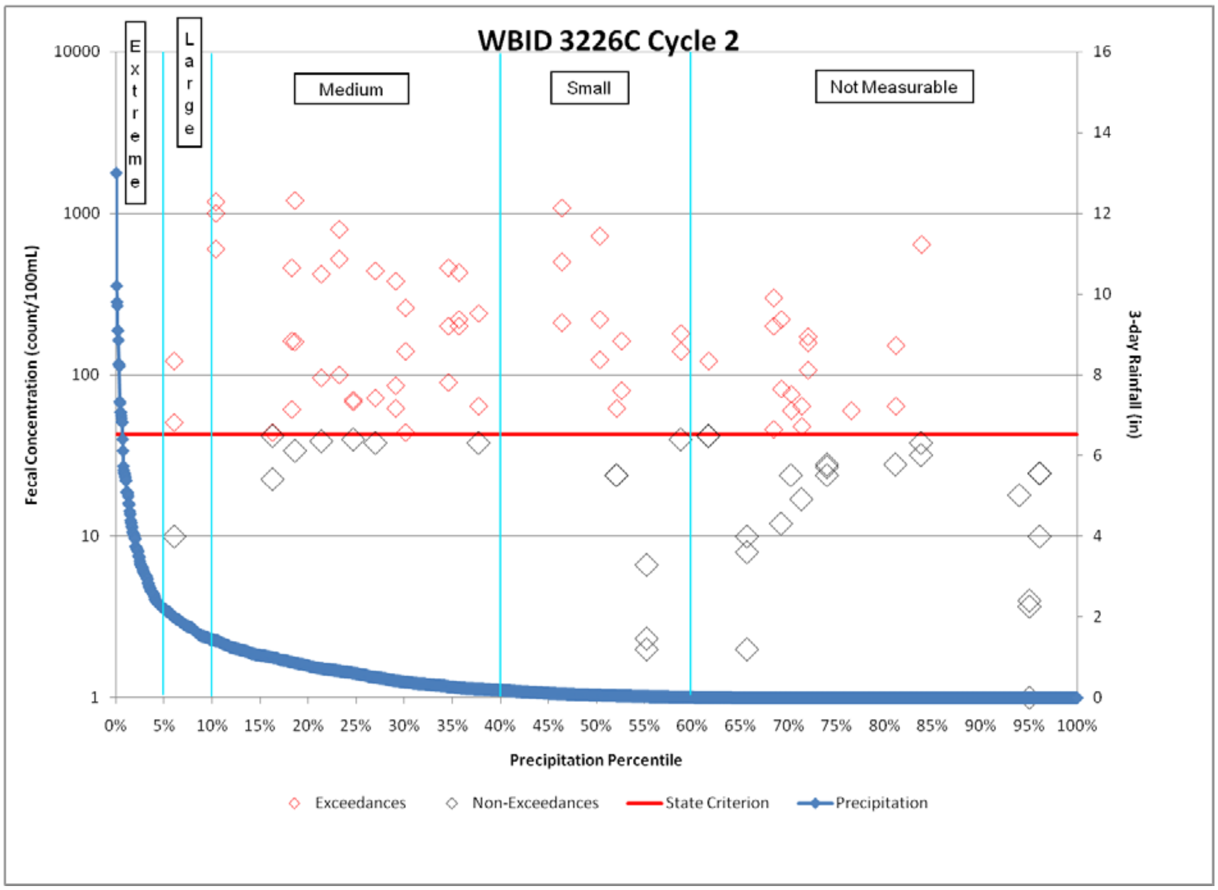


Figure 5.4. Historical Fecal Coliform Data by Hydrologic Condition for the Southwest Fork Loxahatchee River (WBID 3226C)

Table 5.5. Calculation of Fecal Coliform Reductions for the Southwest Fork Loxahatchee River (WBID 3226C) 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 (count/100mL), Column 4 shows the ordinal rank of the concentration in Column 3, and Column 5 lists the percentile by the Hazen method.

- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (count/100 mL)	Rank	Percentile by Hazen Method
21FLWPB 28010283	3/20/2007	1	1	0.52%
21FLLOX 71	3/14/2001	2	2	1.55%
21FLWPB 28010274	6/21/2007	2	3	2.58%
21FLWPB 28010283	6/21/2007	2.3	4	3.61%
21FLWPB 28010615	3/20/2007	3.6	5	4.64%
21FLWPB 28010274	3/20/2007	4	6	5.67%
21FLWPB 28010615	6/21/2007	6.6	7	6.70%
21FLLOX 72	3/14/2001	8	8	7.73%
21FLLOX 73	3/14/2001	10	9	8.76%
21FLWPB 28010274	7/11/2007	10	10	9.79%
21FLWPB 28010283	9/18/2007	10	11	10.82%
21FLLOX 72	1/10/2002	12	12	11.86%
21FLLOX 72	5/8/2002	17	13	12.89%
21FLWPB 28010274	1/30/2007	18	14	13.92%
21FLWPB 28010274	10/30/2007	22.6	15	14.95%
21FLLOX 71	1/10/2001	24	16	15.98%
21FLLOX 72	1/10/2001	24	17	17.01%
21FLLOX 72	3/21/2002	24	18	18.04%
21FLLOX 73	1/8/2003	24	19	19.07%
21FLWPB 28010283	7/11/2007	24.6	20	20.10%
21FLWPB 28010615	7/11/2007	24.6	21	21.13%
21FLLOX 71	1/8/2003	27	22	22.16%
21FLLOX 72	1/8/2003	28	23	23.20%
21FLLOX 72	5/10/2004	28	24	24.23%
21FLLOX 71	1/26/2005	32	25	25.26%
21FLLOX 72	11/13/2002	34	26	26.29%
21FLLOX 72	9/18/2002	38	27	27.32%
21FLLOX 72	1/20/2004	38	28	28.35%
21FLLOX 72	1/26/2005	38	29	29.38%
21FLLOX 72	7/28/2004	39	30	30.41%
21FLLOX 72	9/6/2001	40	31	31.44%
21FLLOX 72	3/4/2004	40	32	32.47%

Station	Date	Fecal Coliform Concentration (count/100 mL)	Rank	Percentile by Hazen Method
21FLLOX 71	3/12/2003	42	33	33.51%
21FLLOX 72	3/12/2003	42	34	34.54%
21FLWPB 28010283	10/30/2007	42	35	35.57%
21FLLOX 71	7/7/2003	44	36	36.60%
21FLWPB 28010615	10/30/2007	44	37	37.63%
21FLLOX 72	11/8/2001	46	38	38.66%
21FLLOX 71	5/8/2002	48	39	39.69%
21FLWPB 28010615	9/18/2007	50.6	40	40.72%
21FLLOX 71	3/21/2002	60	41	41.75%
21FLLOX 71	5/14/2003	60	42	42.78%
21FLLOX 72	5/23/2005	61	43	43.81%
21FLLOX 73	1/10/2001	62	44	44.85%
21FLLOX 72	5/3/2001	62	45	45.88%
21FLLOX 73	5/8/2002	64	46	46.91%
21FLLOX 71	9/18/2002	64	47	47.94%
21FLLOX 71	5/10/2004	64	48	48.97%
21FLLOX 73	9/6/2001	68	49	50.00%
21FLLOX 71	9/6/2001	70	50	51.03%
21FLLOX 71	1/20/2004	72	51	52.06%
21FLLOX 73	3/21/2002	76	52	53.09%
21FLLOX 72	5/21/2003	80	53	54.12%
21FLLOX 71	1/10/2002	82	54	55.15%
21FLLOX 71	5/3/2001	86	55	56.19%
21FLLOX 72	9/18/2003	90	56	57.22%
21FLLOX 71	7/28/2004	96	57	58.25%
21FLLOX 72	9/23/2004	100	58	59.28%
21FLLOX 72	7/25/2002	107	59	60.31%
21FLLOX 73	3/12/2003	122	60	61.34%
21FLWPB 28010274	9/18/2007	122	61	62.37%
21FLLOX 71	11/18/2004	124	62	63.40%
21FLLOX 72	7/7/2003	140	63	64.43%
21FLLOX 71	3/4/2004	140	64	65.46%
21FLLOX 73	5/10/2004	152	65	66.49%
21FLLOX 71	7/25/2002	158	66	67.53%
21FLLOX 71	11/13/2002	160	67	68.56%
21FLLOX 73	5/21/2003	162	68	69.59%
21FLLOX 71	5/23/2005	162	69	70.62%
21FLLOX 73	7/25/2002	172	70	71.65%
21FLLOX 73	3/4/2004	180	71	72.68%

Station	Date	Fecal Coliform Concentration (count/100 mL)	Rank	Percentile by Hazen Method
21FLLOX 71	11/8/2001	200	72	73.71%
21FLLOX 71	9/18/2003	200	73	74.74%
21FLLOX 72	11/19/2003	200	74	75.77%
21FLLOX 71	3/24/2005	210	75	76.80%
21FLLOX 73	1/10/2002	220	76	77.84%
21FLLOX 71	11/19/2003	220	77	78.87%
21FLLOX 72	11/18/2004	220	78	79.90%
21FLLOX 73	9/18/2002	240	79	80.93%
21FLLOX 73	7/7/2003	260	80	81.96%
21FLLOX 73	11/8/2001	300	81	82.99%
21FLLOX 73	5/3/2001	380	82	84.02%
21FLLOX 73	7/28/2004	420	83	85.05%
21FLLOX 73	11/19/2003	430	84	86.08%
21FLLOX 73	1/20/2004	440	85	87.11%
21FLLOX 73	9/18/2003	460	86	88.14%
21FLLOX 73	5/23/2005	460	87	89.18%
21FLLOX 72	3/24/2005	500	88	90.21%
21FLLOX 71	9/23/2004	520	89	91.24%
21FLLOX 71	7/19/2001	600	90	92.27%
21FLLOX 73	1/26/2005	640	91	93.30%
21FLLOX 73	11/18/2004	720	92	94.33%
21FLLOX 73	9/23/2004	795	93	95.36%
21FLLOX 73	7/19/2001	1,000	94	96.39%
21FLLOX 73	3/24/2005	1,080	95	97.42%
21FLLOX 72	7/19/2001	1,180	96	98.45%
21FLLOX 73	11/13/2002	1,200	97	99.48%
		Existing condition concentration– 90th percentile interpolated (counts/100mL)		492
		Criterion concentration (counts/100mL)		43
		Final % reduction {(492-43)/492 * 100}		91.3%

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 (43 counts/100mL). The percent reduction needed to reduce pollutant load was calculated by comparing the existing concentrations and target concentration using **Formula 1**:

Formula 1:

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

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 II 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.

Formula 2:

$$\text{Percentile} = \frac{\text{Rank} - 0.5}{\text{Total Number of Samples Collected}} \; x \; 100$$

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.

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

Where:

C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90th percentile, in this case, 460 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% – 89.18% = 0.82%

R is a ratio defined as R= (fecal coliform concentration$_{upper}$ – fecal coliform concentration $_{lower}$)/(percentile$_{upper}$ – percentile$_{lower}$)

The 90th Percentile is 492 counts / 100mL

Using **Formula 1**, the percent reduction for the period of observation (January 1, 2001–June 30, 2008) was calculated as 91 percent for the Southwest Fork Loxahatchee River (i.e., % reduction needed = [(492–43)/ 492]*100 = 91.3%).

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:

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

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

$$\mathbf{TMDL \cong \sum WLAs_{wastewater} + \sum WLAs_{NPDES\ Stormwater} + \sum LAs + MOS}$$

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 the Southwest Fork Loxahatchee 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 the Southwest Fork Loxahatchee River (WBID 3226C)

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	43	Must meet Permit limits	91%	91%	Implicit

6.2 Load Allocation

Based on a percent reduction approach, the LA is a 91 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 two NPDES permitted sites in the Southwest Fork Loxahatchee River watershed. The Town of Jupiter water treatment plant (Permit # FL0042358) is located on the western edge of the Southwest Fork Loxahatchee River Watershed, approximately 0.35 miles from the waterbody. This facility produces potable water from deep well sources via reverse osmosis. The Reverse Osmosis (RO) facility has a permitted capacity of 2.0 million gallons per day (MGD), annual average daily flow. Reverse Osmosis (RO) effluent is the product of well water purification, where by ions and particles are concentrated in effluent while potable water is produced. As no fecal coliform bacteria exist in the deep brine source of wells, there is no fecal coliform in the RO effluent.

The Loxahatchee Environmental Control District (Permit # FL0034649) is a domestic wastewater facility located within the Southwest Fork Loxahatchee River WBID boundary. This facility has a permitted capacity of 9.0 MGD annual average daily flow. The treated domestic wastewater effluent is released into on-site holding ponds. Surface water discharges are only under extreme wet weather conditions. Irrigation quality water, free of fecal coliform, is supplied to approved Public Access Land application projects.

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, i.e., to meet all permit requirements.

6.3.2 NPDES Stormwater Discharges

There is one NPDES Phase I municipal separate storm sewer system (MS4) permits in the Southwest Fork Loxahatchee River watershed. Palm Beach County (Permit #FLS00018) has a Phase I MS4 permit that covers the entire Southwest Fork Loxahatchee River watershed. The Town of Jupiter and the Village of Tequesta are Co-Permittees on this permit.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit Margin of Safety (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.

Livestock

There is no livestock of consequence within WBID 3226C

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 Southwest Fork Loxahatchee River WBID boundary can be made using **Equation B.1**:

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

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, 148 housing units *(N)* within the Southwest Fork Loxahatchee 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.

Based on the information published by the Census Bureau, the average household size for Palm Beach County is about 2.49 people/household. The same population densities were assumed within the Southwest Fork Loxahatchee 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 1×10^6 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 Palm Beach 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 Palm Beach 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 Palm Beach County is approximately 0.83 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 4.14 percent for Palm Beach County. Based on **Equation B.1**, the estimated fecal coliform loading from failed septic tanks within the Southwest Fork Loxahatchee River WBID boundary is approximately 4.04 x 10^{10} counts/day.

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 8,750 housing units within the Southwest Fork Loxahatchee 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 Southwest Fork Loxahatchee 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 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 Southwest Fork Loxahatchee River WBID boundary served by sewer systems is estimated to be 8,750. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size for the Palm Beach County (2.49 persons/ 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 2.89 x 10^{11} counts/day.

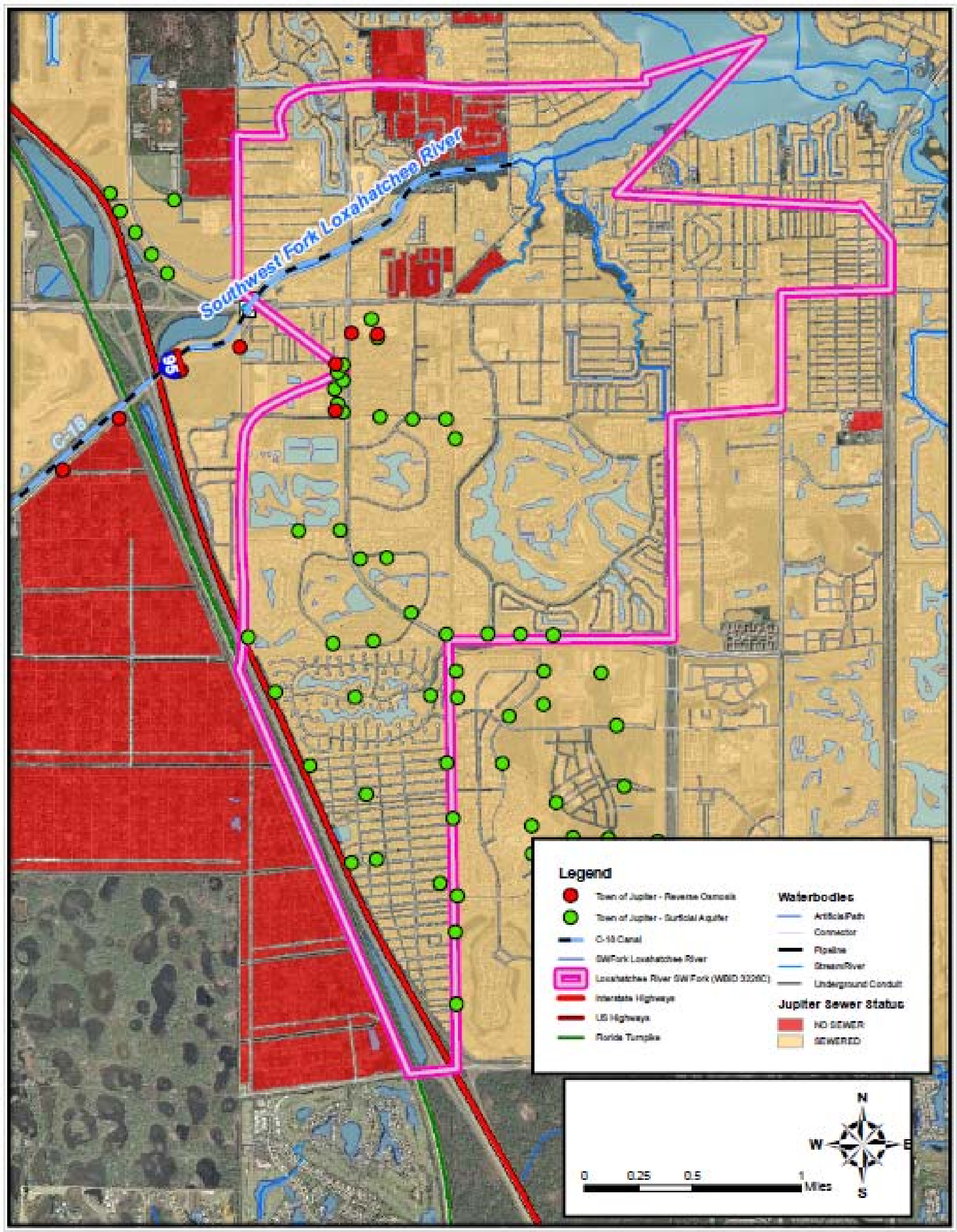

Figure B.1. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Residential Land Use Areas within the Southwest Fork Loxahatchee River WBID Boundary

Table B.1. Estimated Number of Septic Tanks and Septic Tank Failure Rates for Palm Beach County (2004–09)

This is an eight-column table. Column 1 lists the type of statistic, Columns 2 through 7 list the estimate for each year from 2004 to 2009, respectively, and Column 8 lists the average.

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

Descriptive Statistic	2004	2005	2006	2007	2008	2009	2004
New installations (septic tanks)	788	691	776	314	245	114	733
Accumulated installations (septic tanks)	77,391	78,179	78,870	79,646	79,960	80,205	76,300
Repair permits (septic tanks)	682	407	531	520	402	434	627
Failure discovery rate (%)	0.88%	0.52%	0.67%	0.65%	0.50%	0.54%	0.83%
Failure rate (%)[1]	4.41%	2.60%	3.37%	3.26%	2.51%	2.71%	4.14%

Wildlife

Wildlife is another possible source of fecal coliform bacteria within the Southwest Fork Loxahatchee River WBID boundary. As shown in **Figure 4.1**, wetland areas border the Southwest Fork Loxahatchee River and several of its contributing streams within the WBID boundary. Additionally, grassland and upland forested areas are close to the creek. These areas 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. Further the scale and composition of open space would not suggest significant loading from wildlife.

Pets

Pets whose waste is deposited outdoors can be a significant source of coliform pollution through surface runoff in the Southwest Fork Loxahatchee River watershed. 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 Liveri (1982) found that dog feces were the single greatest source for 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 watersheds. 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 significant as those 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 one dog. A single gram of dog feces contains about 23 million fecal coliform bacteria (van der Waal, 1995). Further implicating this potential source is that statistics show that about 40 percent of American dog owners do not pick up their dog's feces.

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 Southwest Fork Loxahatchee River WBID boundary was estimated to be approximately 8,898. Assuming that 40 percent of the households in this area have 1 dog, there are about 3,559 dogs within the waterbody.

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 641 kilograms/day. The total load produced by dogs is about 1.41 x 10^{12} counts/day of fecal coliform.

Table B.2. Estimated Number of Fecal coliform resulting from Dog Feces

This is a two-column table. Column 1 lists the type of data, Columns 2 lists the value of data.

Est. FC produced by Dogs	**3226C**
FC Load by dogs (counts/day)	1.41E+12
# dogs WBID	3,559
waste produced by dog (grams/day)	450
Percentage of owners don't pick up after dog	40%
Waste not picked up (grams/day)	640,656
FC density (counts/gram)	2,200,000
FC counts/100mL/day from Dogs	1.40944E+12

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).

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