FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

NORTHEAST DISTRICT • LOWER ST. JOHNS BASIN

TMDL Report

Fecal Coliform TMDL for Greenfield Creek (WBID 2240)

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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

2008 305(b) Report

http://www.dep.state.fl.us/water/docs/2008_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

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

Basin Status Report : Lower St. Johns

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

Water Quality Assessment Report: Lower St. Johns

http://www.dep.state.fl.us/water/basin411/sj_lower/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 Greenfield Creek, located in the Lower St. Johns Basin. The creek was verified as impaired for fecal coliform, and therefore was included on the Verified List of impaired waters for the Lower St. Johns Basin that was adopted by Secretarial Order on May 27, 2004. The TMDL establishes the allowable fecal coliform loading to Greenfield Creek 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 Lower St. Johns Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. Greenfield Creek is WBID 2240.

Greenfield Creek is located in the east-central portion of Duval County, in northeast Florida, within the limits of the city of Jacksonville (**Figure 1.1**), south of the St. Johns River and less than a mile west of Pablo Creek (Intracoastal Waterway). The creek flows north for approximately 6 miles and gains flow from a number of smaller branches and ditches. Roughly 0.2 miles north of the WBID boundary, the creek is joined by Tiger Pond Creek before flowing into Chicopit Bay (approximately 0.6 miles north of the WBID boundary) and the St. Johns River (**Figure 1.2**). The drainage area within the Greenfield Creek WBID boundary is approximately 2.9 square miles (mi^2) and is highly urbanized. Additional information about the hydrology and geology of this area is available in the Basin Status Report for the Lower St. Johns (Department, 2002).

1.3 Background

This report was developed as part of the Department's watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related 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, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. They provide important water quality restoration goals that will guide restoration activities.

Figure 1.1. Location of the Greenfield Creek Watershed (WBID 2240) in the Lower St. Johns Basin and Major Geopolitical and Hydrologic Features in the Area

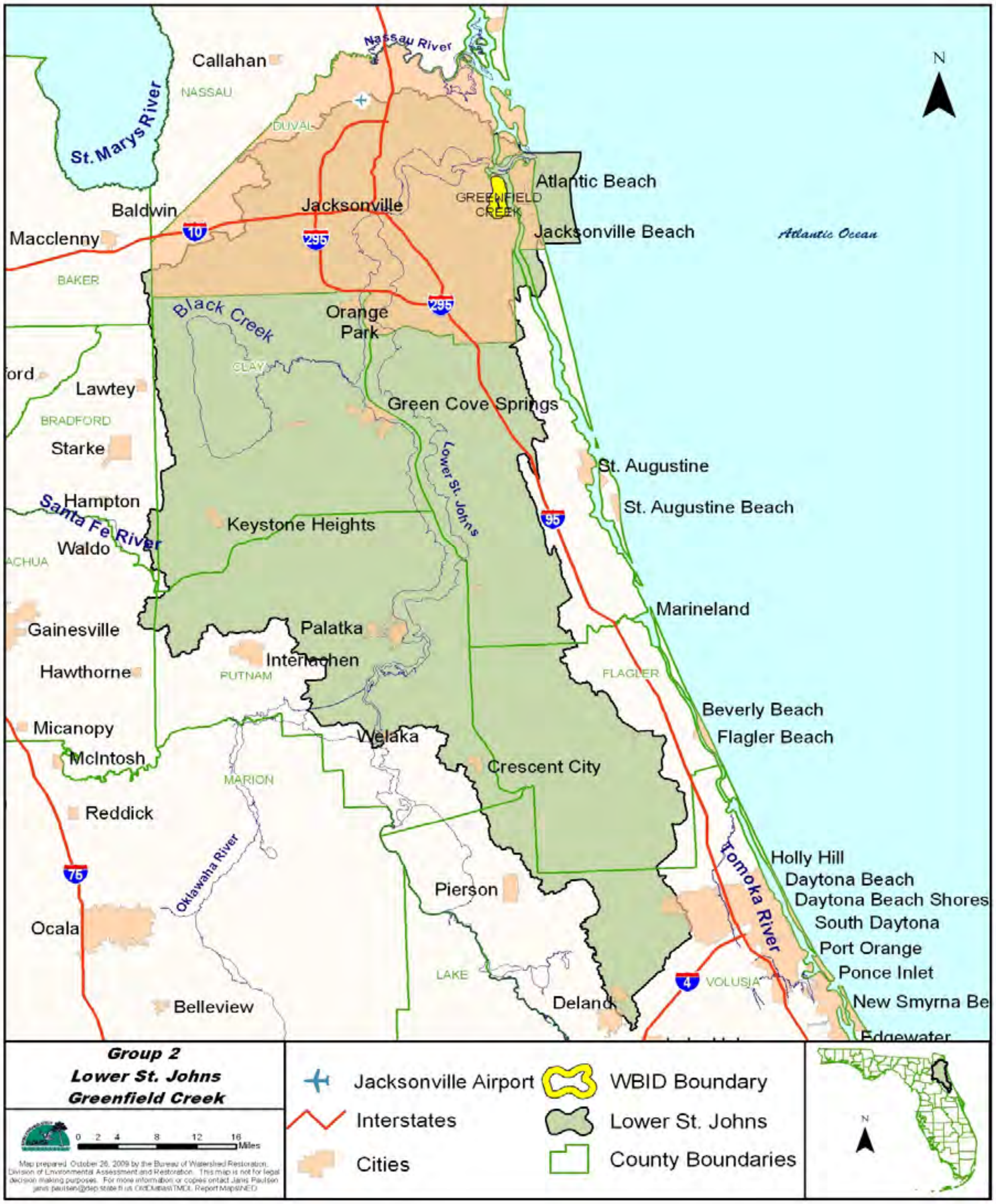
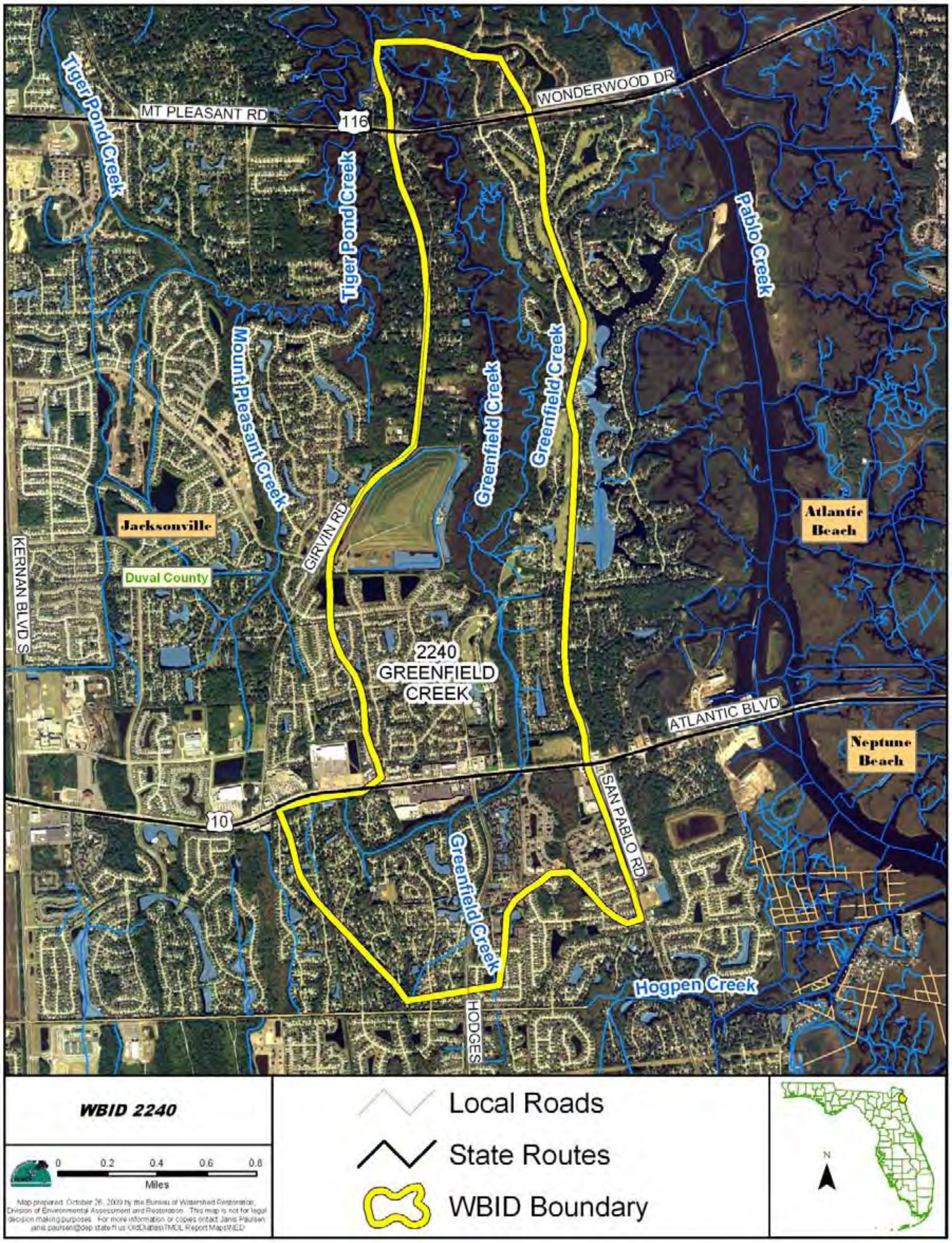


Figure 1.2. Detailed View of the Greenfield Creek Watershed (WBID 2240) in Duval County



A TMDL report is followed by the development and implementation of a restoration plan designed to reduce the amount of fecal coliform that caused the verified impairment of a waterbody. For Greenfield Creek, BMAP efforts are under way. These activities depend heavily on the active participation of local governments, businesses, citizens, and other stakeholders. The Department is currently working with these organizations and individuals to undertake or continue reductions of fecal coliform 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 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 FWRA (Subsection 403.067[4], Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

In April 2001, after a long rulemaking process, the Environmental Regulation Commission adopted a formal methodology for water quality assessment in ambient waters, as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), per the requirement in the FWRA (Section 403.067, F.S). The verified fecal coliform impairment in Greenfield Creek was based on the assessment procedures defined in this rule.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Greenfield Creek and has verified that this waterbody segment is impaired for fecal coliform bacteria. The creek was first verified for fecal coliform impairment in the Department's Cycle 1 assessment (January 1, 1996, through June 30, 2003), based on the observation that 9 out of 40 fecal coliform samples collected during the Cycle 1 verified period exceeded the assessment threshold of 400 counts per 100 milliliters (counts/100mL) (see **Section 3.2** for details). The impairment was confirmed based on the result of the Cycle 2 assessment (January 1, 2001, through June 30, 2008), when 23 out of 52 fecal coliform samples collected during the Cycle 2 verified period exceeded the assessment threshold.

Table 2.1 summarizes the fecal coliform monitoring results for the Cycle 1 and Cycle 2 verified periods for Greenfield Creek. To ensure that the fecal coliform TMDL was developed based on current conditions in the creek and that recent trends in the creek's water quality were adequately captured, monitoring data during the Cycle 2 verified period were used in the TMDL development. **Table 2.2** summarizes the fecal coliform monitoring results used to develop the TMDL.

Table 2.2 shows that on some occasions very high fecal coliform concentrations have been observed in Greenfield Creek. The mean and median concentrations indicate that, in addition to periodic extreme fecal coliform concentrations, the concentration in the creek is often above the fecal coliform water quality criterion of 400 counts/100mL.

Table 2.1. Summary of Fecal Coliform Monitoring Data for Greenfield Creek (WBID 2240) During the Cycle 1 Verified Period (January 1, 1996–June 30, 2003) and Cycle 2 Verified Period (January 1, 2001–June 30, 2008)

This is a four-column table. Column 1 lists the waterbody and WBID number, Column 2 lists the parameter, Column 3 lists the Cycle 1 results, and Column 4 lists the Cycle 2 results.

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Waterbody (WBID)	Parameter	Cycle 1 Fecal Coliform	Cycle 2 Fecal Coliform
Greenfield Creek (2240)	Total number of samples	40	52
Greenfield Creek (2240)	IWR-required number of exceedances for the Verified List	7	9
Greenfield Creek (2240)	Number of observed exceedances	9	23
Greenfield Creek (2240)	Number of observed nonexceedances	31	29
-	**FINAL ASSESSMENT**	**Impaired**	**Impaired**

Table 2.2. Summary of Fecal Coliform Monitoring Data for Greenfield Creek (WBID 2240) During the Cycle 2 Verified Period (January 1, 2001, through June 30, 2008)

This is a three-column table. Column 1 lists the waterbody and WBID number, Column 2 lists the parameter, and Column 3 lists the Cycle 2 results.

Waterbody (WBID)	Parameter	Fecal Coliform
Greenfield Creek (2240)	Total number of samples	52
Greenfield Creek (2240)	Number of observed exceedances	23
Greenfield Creek (2240)	Number of observed nonexceedances	29
Greenfield Creek (2240)	Number of seasons during which samples were collected	4
Greenfield Creek (2240)	Highest observation (counts/100mL)	10,500
Greenfield Creek (2240)	Lowest observation (counts/100mL)	14
Greenfield Creek (2240)	Median observation (counts/100mL)	305
Greenfield Creek (2240)	Mean observation (counts/100mL)	1,237

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)**

Greenfield Creek is a Class III (fresh) 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 freshwater 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. The 10 percent exceedance allowed by the water quality criterion for fecal coliform bacteria was not used directly in estimating the target load, but was included in the TMDL margin of safety (as described in subsequent chapters).

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 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 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 Greenfield Creek WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are no NPDES-permitted wastewater facilities located within or discharging within the Greenfield Creek WBID boundary.

Municipal Separate Storm Sewer System Permittees

The city of Jacksonville and the Florida Department of Transportation (FDOT) District 2 are copermittees for a Phase I NPDES municipal separate storm sewer system (MS4) permit (Permit FLS000012) that includes Greenfield Creek. FDOT and the cities of Jacksonville, Neptune Beach, and Atlantic Beach share responsibility for the permit.

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 at 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 runoff from areas with animal feeding operations or direct animal access to receiving waters.

In addition to the sources associated with anthropogenic activities, birds and other wildlife can act as fecal coliform contributors to receiving waters. While detailed source information is not always available for accurately quantifying the fecal coliform loadings from different sources, land use information can provide some hints 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 St. Johns River Water Management District's (SJRWMD) 2004 land use coverage contained in the Department's geographic information system (GIS) library. Land use categories within the Greenfield Creek WBID boundary were aggregated using the simplified Level 1 codes and tabulated in **Table 4.1**. **Figure 4.1** shows the spatial distribution of the principal land uses within the WBID boundary.

As shown in **Table 4.1**, the total area within the Greenfield Creek WBID boundary is about 1,885 acres. The dominant land use category is urban land (urban and built-up; low-, medium-, and high-density residential; and transportation, communication, and utilities), which accounts for about 68 percent of the total WBID area. Of the 1,272 acres of urban lands, residential land use occupies about 960 acres, or about 51 percent of the total WBID area. Natural land uses, which include water, wetlands, upland forest, and barren land, occupy about 601 acres, accounting for about 32 percent of the total WBID area.

Because the dominant land use in the Greenfield Creek WBID boundary is urban, the most likely sources of the fecal coliform loadings are failed septic tanks, sewer line leakage, and pet feces. A preliminary quantification of the fecal coliform loadings from these sources was conducted to demonstrate the relative contributions. **Appendix B** provides detailed load estimates and describes the methods used for the quantification. It should be noted that the information included in **Appendix B** was only used to demonstrate the possible relative contributions from different sources. The loading estimates were not used in establishing the final TMDL.

Table 4.1. Classification of Land Use Categories within the Greenfield Creek WBID Boundary in 2004

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

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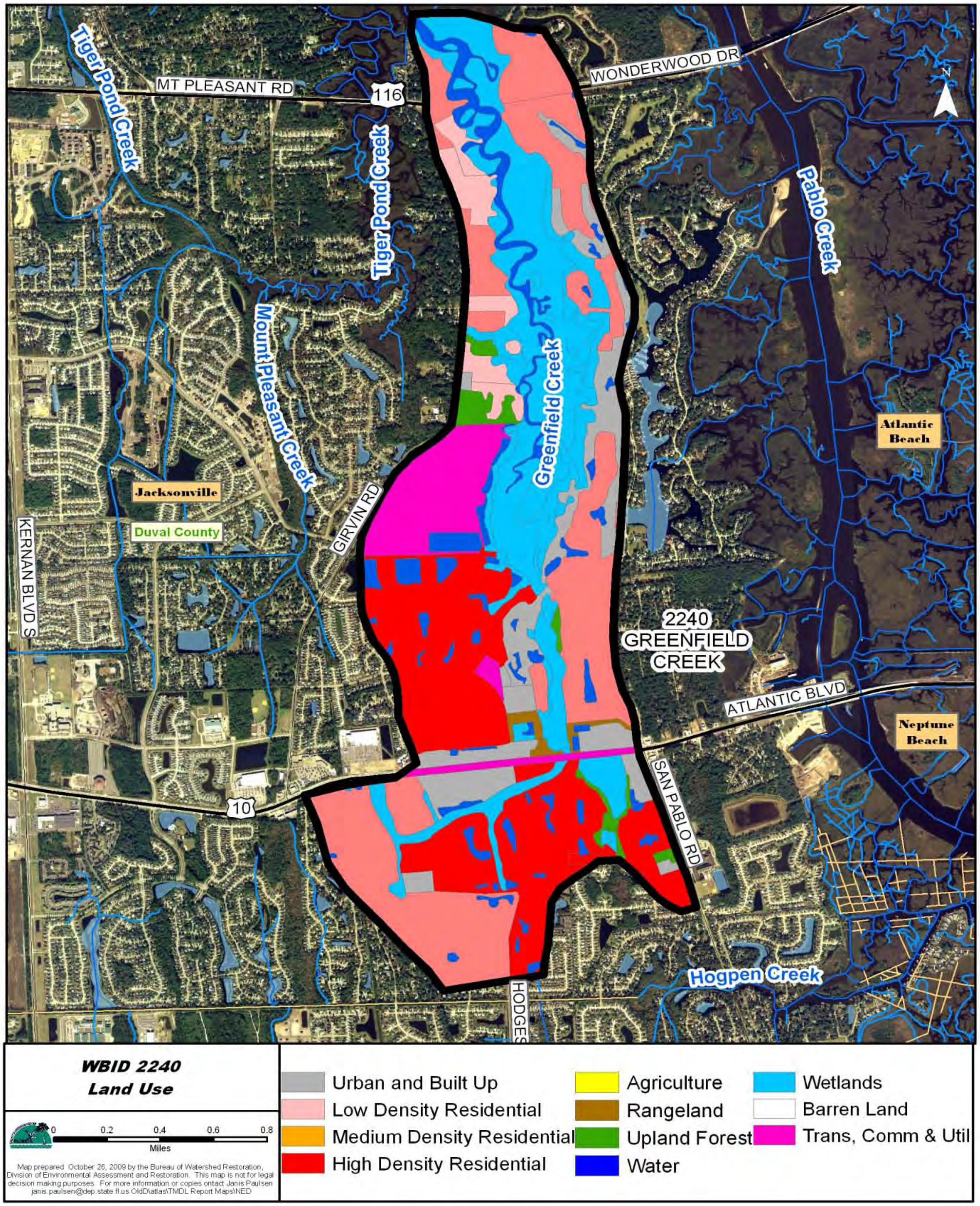
Level 1 Code	Land Use	Acreage	% Acreage
1000	Urban and built-up	183	9.7%
-	Low-density residential	64	3.4%
-	Medium-density residential	482	25.6%
-	High-density residential	414	22.0%
2000	Agriculture	0	0.0%
3000	Rangeland	12	0.6%
4000	Upland forest	34	1.8%
5000	Water	141	7.5%
6000	Wetland	426	22.6%
7000	Barren land	0	0.0%
8000	Transportation, communication, and utilities	129	6.8%
-	**TOTAL**	**1,885**	**100.0%**

Figure 4.1. Principal Land Uses within the Greenfield Creek WBID Boundary in 2004



Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

When continuous flow measurements in a watershed are available and are not tidally influenced, 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 daily bacteria load. However, flow data were not available for Greenfield Creek. The creek is also tidally influenced. For these reasons 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 for each value above the criterion, and then a median percent reduction is calculated.

5.1.1 Data Used in the Determination of the TMDL

All data used for this TMDL report were provided by the Department's Northeast District office and the city of Jacksonville. The data were included in Run_37 of the Department's IWR database. **Figure 5.1** shows the locations of the water quality sites where fecal coliform data were collected. This analysis used fecal coliform data collected during the Cycle 2 verified period (January 1, 2001, through June 30, 2008). During this period, a total of 52 fecal coliform samples were collected from 7 sampling stations in WBID 2240.

Figure 5.2 shows the fecal coliform concentrations observed in Greenfield Creek. These ranged from 14 to 10,500 counts/100mL and averaged 1,237 counts/100mL during the period of observation. High fecal coliform concentrations in 2007 were correlated with 3-day precipitation (e.g., when 3-day precipitation was 2.66 inches, the fecal coliform concentration was 10,500 counts/100mL at Station 21FLA 20030809 on October 3, 2007).

The data from sampling station 21FLJXWQGC1 (**Figure 5.3**) were used to obtain long-term annual and seasonal fecal coliform averages and percent exceedances (**Tables 5.1a** and **5.1b**). No long-term temporal trends were observed. Episodic peak fecal coliform concentrations occurred throughout the period of observation, and the average concentration in the creek neither increased nor decreased over the period of observation. Seasonally, a peak in fecal coliform concentrations and exceedance rates is commonly observed during the third quarter (summer, July–September), when conditions are rainy and warm, and lower concentrations and exceedance rates are observed in the first and fourth quarters (winter, January–March; and fall, October–December), when conditions are drier and colder. However, such a relationship was not found in Greenfield Creek.

Using rainfall data collected at Jacksonville International Airport (available: http://climod.meas.ncsu.edu/), it was possible to compare annual rainfall between 2000 and 2007 with annual fecal coliform exceedance rates for the same period, and long-term (2000–07) average quarterly rainfall with long-term (2000–07) average quarterly fecal coliform exceedance rates at Station 21FLJXWQGC1 (**Figures 5.4** and **5.5**). Again, while peak fecal coliform concentrations commonly coincide with or follow periods of increased rainfall, such a relationship was not observed in Greenfield Creek.

Figure 5.1. Location of Water Quality Stations in Greenfield Creek (WBID 2240)

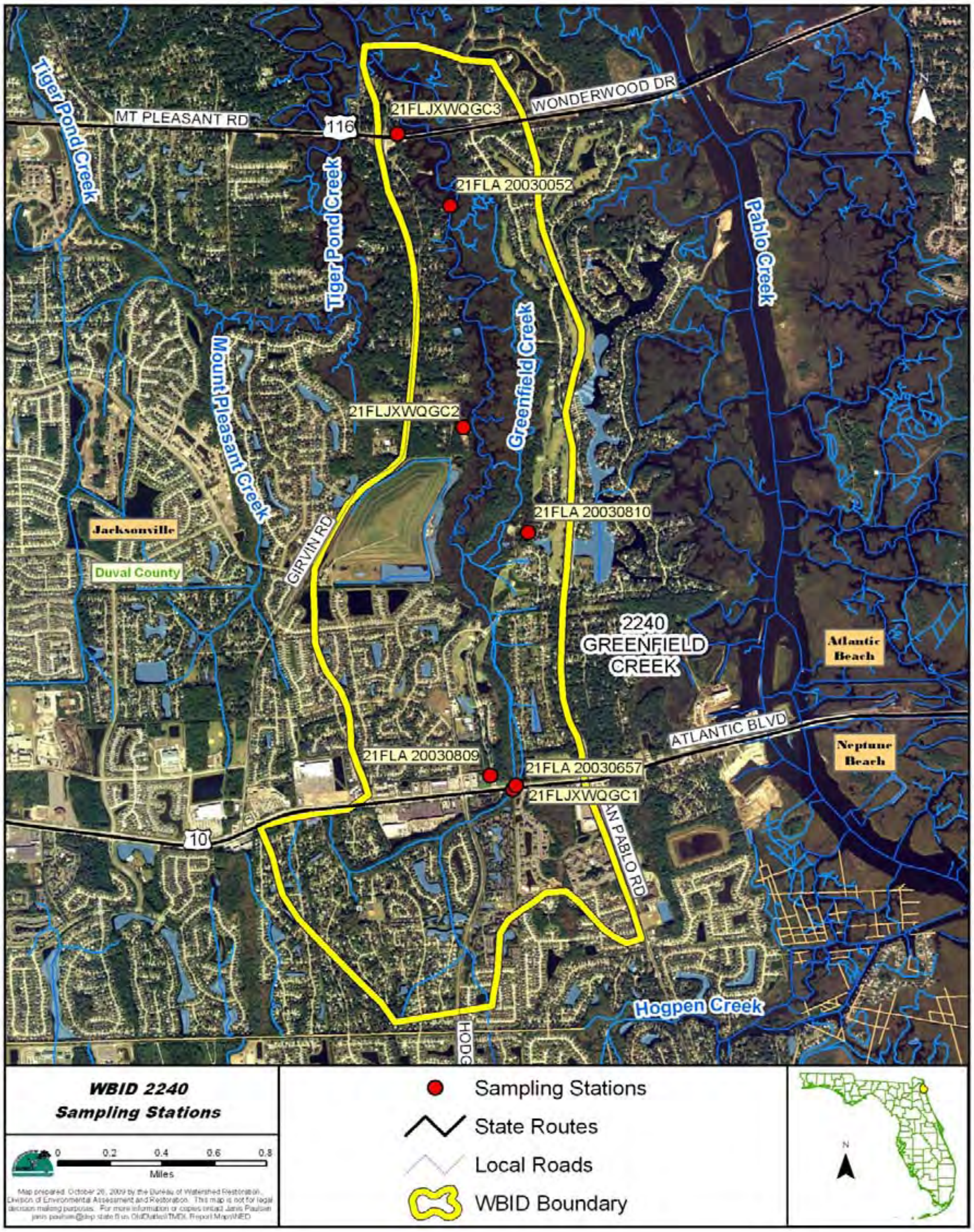
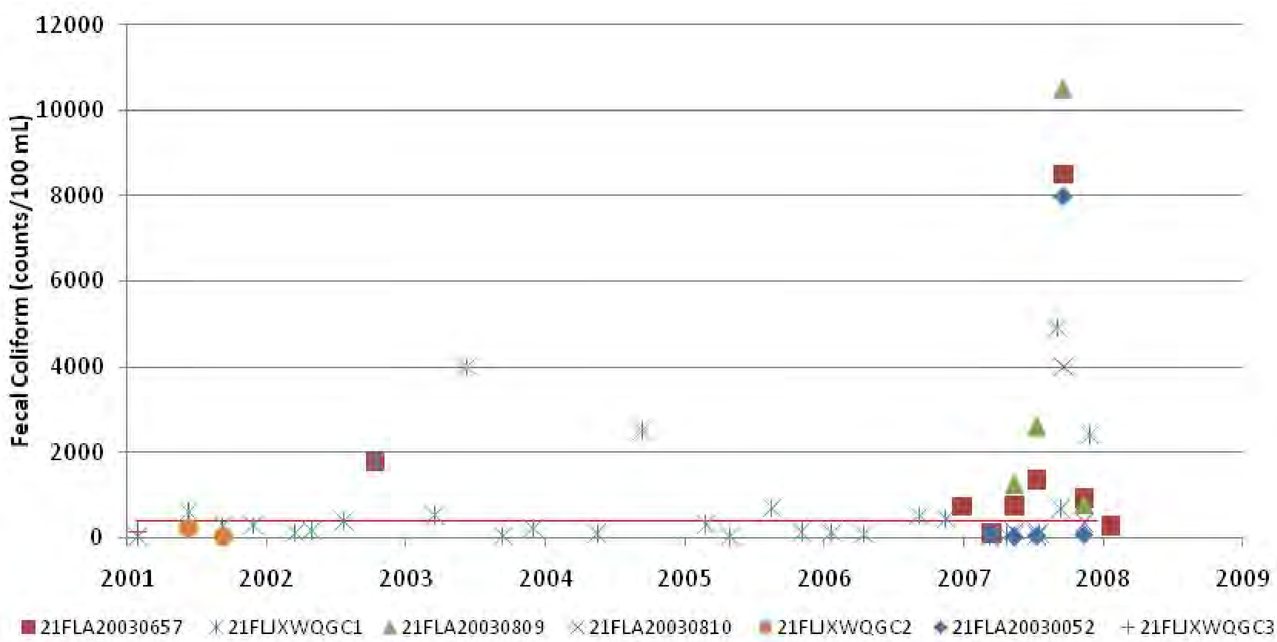


Figure 5.2. Fecal Coliform Concentration Trends in Greenfield Creek (WBID 2240) during the Cycle 2 Verified Period



Note: The red line indicates the target concentration (400 counts/100mL).

Figure 5.3. Fecal Coliform Concentrations at Station 21FLJXWQGC1 in Greenfield Creek (WBID 2240) during the Cycle 2 Verified Period

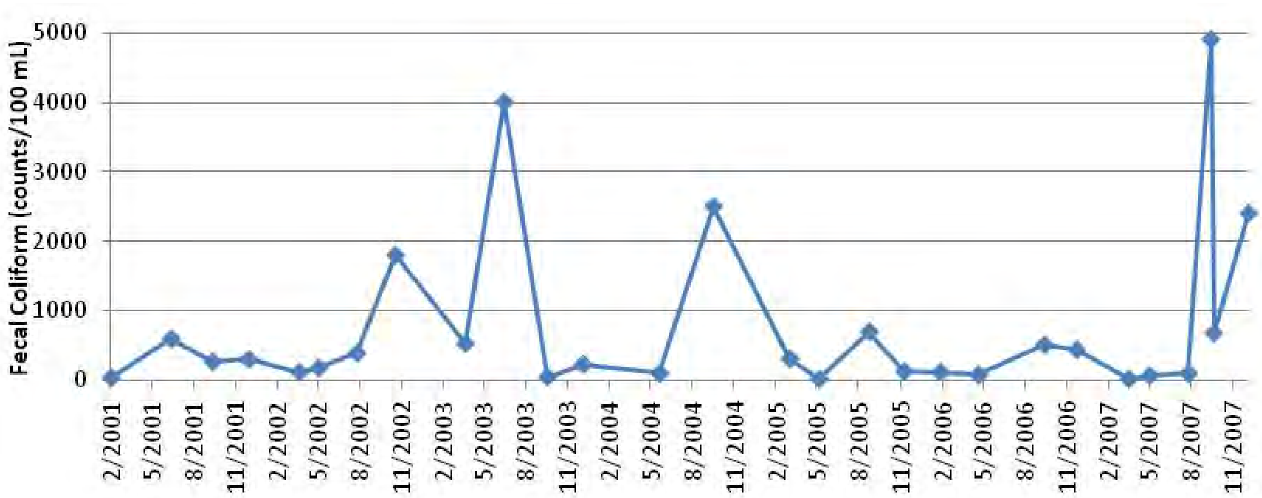


Table 5.1a. Summary Statistics of Fecal Coliform Data at Station 21FLJXWQGC1 in Greenfield Creek (WBID 2240) by Year during the Cycle2 Verified Period

This is an eight-column table. Column 1 lists the year, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

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

Year	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
2001	4	40	600	285	303	1	25%
2002	4	120	1,800	286	623	1	25%
2003	4	50	4,000	380	1,203	2	50%
2004	2	100	2,500	1,300	1,300	1	50%
2005	4	20	700	220	290	1	25%
2006	4	80	510	280	288	2	50%
2007	6	18	4,900	390	1,361	3	50%

Table 5.1b. Summary Statistics of Fecal Coliform Data at Station 21FLJXWQGC1 in Greenfield Creek (WBID 2240) by Season during the Cycle2 Verified Period

This is an eight-column table. Column 1 lists the season, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

[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	6	18	530	120	190	1	17%
Quarter 2	7	20	4,000	100	721	2	29%
Quarter 3	9	50	4,900	510	1,122	5	56%
Quarter 4	6	130	2,400	370	883	3	50%

Figure 5.4. Fecal Coliform Exceedances and Rainfall at Station 21FLJXWQGC1 in Greenfield Creek (WBID 2240) by Year during the Cycle 2 Verified Period

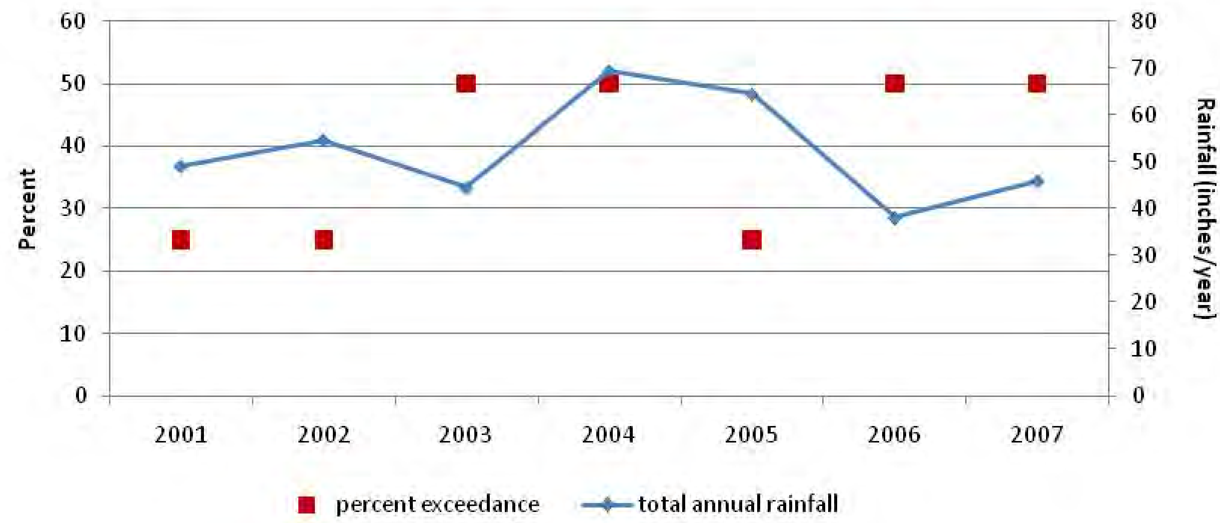
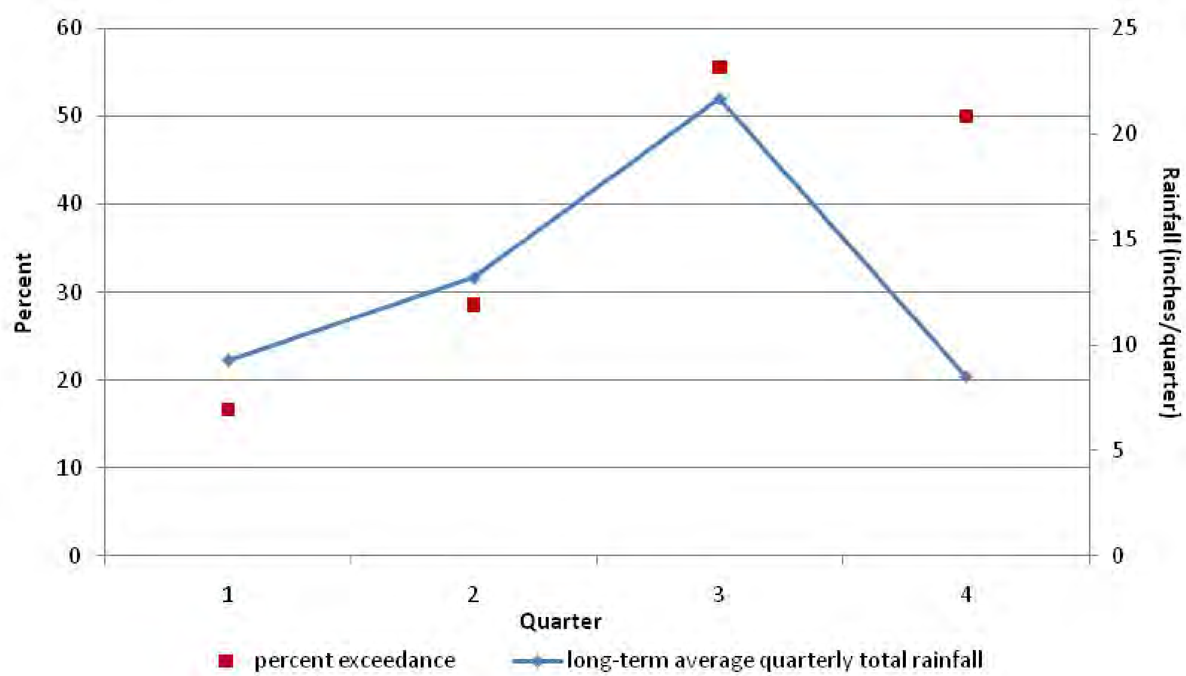


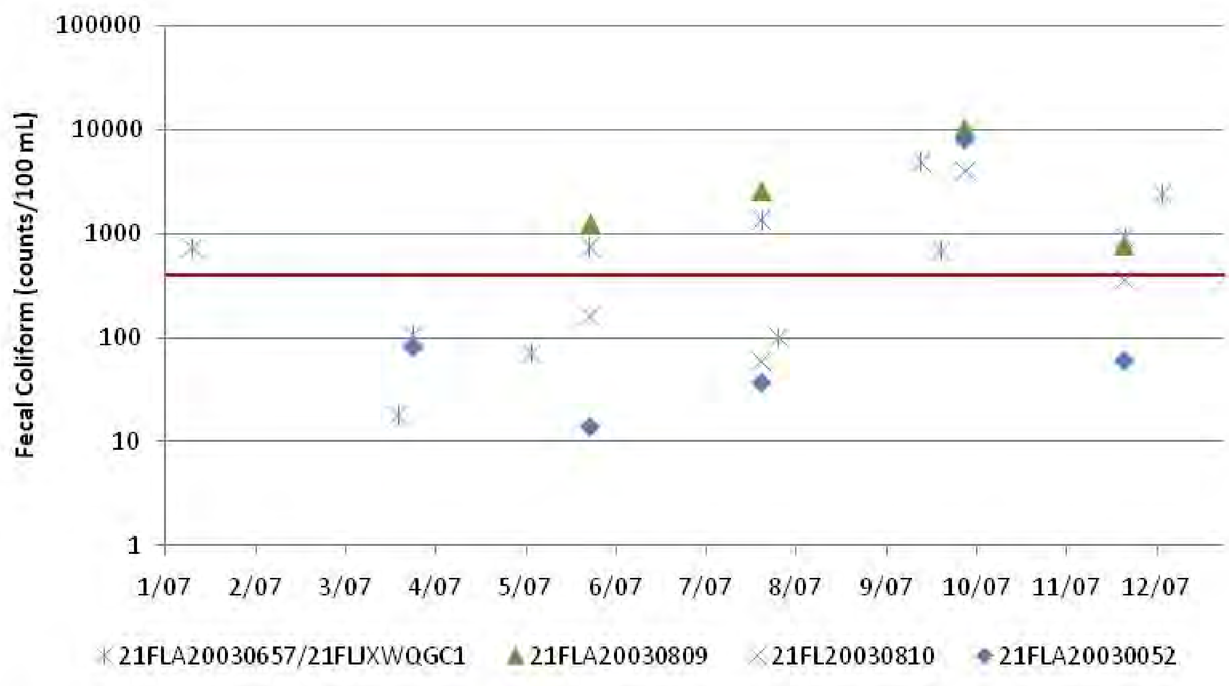
Figure 5.5. Fecal Coliform Exceedances and Rainfall at Station 21FLJXWQGC1 in Greenfield Creek (WBID 2240) by Season during the Cycle 2 Verified Period



The Greenfield Creek fecal coliform data were also analyzed to detect spatial trends. Data from 2007 at Stations 21FLJXWQGC1/21FLA20030657 (upstream), 21FLA20030809 (upstream), 21FLA20030810 (midstream), and 21FLA20030052 (downstream) were also analyzed (**Figure 5.6**). Data from upstream stations 21FLJXWQGC1 and 21FLA20030657 were combined because these stations are at the same location on Atlantic Boulevard.

While high fecal coliform concentrations were observed throughout the creek, concentrations were lower at downstream stations compared with upstream stations (**Figure 5.6** and **Table 5.2**). Lower fecal coliform concentrations in downstream portions of the creek may be due to mixing and dilution from tidal action with the St. Johns River, where fecal coliform concentrations are lower. It is also possible that the higher salinity of these mixing waters contributed to fecal coliform die-off in the more downstream portions of the creek. Additionally, lower fecal coliform concentrations in the downstream portions of the creek relative to upstream might indicate higher loadings upstream that are then subject to natural attenuation and die-off as the water flows downstream.

Figure 5.6. Spatial Fecal Coliform Concentration Trends in Greenfield Creek (WBID 2240) in 2007



Note: The red line indicates the target concentration (400 counts/100mL).

Table 5.2. Station Summary Statistics of Fecal Coliform Data for Greenfield Creek (WBID 2240) in 2007

This is an eight-column table. Column 1 lists the station, Column 2 lists the period of observation, Column 3 lists the number of samples, Column 4 lists the maximum count/100mL, Column 5 lists the mean count, Column 6 lists the median count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

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

Station	Period of Observation	Number of Samples	Maximum[1]	Mean[1]	Median[1]	Number of Exceedances[2]	% Exceedances
21FLA20030657/ 21FLJXWQGC1	2007	12	8,500	1,711	742	8	67%
21FLA20030809	2007	4	10,500	3,781	1,925	4	100%
21FL20030810	2007	4	4,000	1,145	260	1	25%
21FLA20030052	2007	5	8,000	1,638	60	1	20%

5.1.2 TMDL Development Process

Due to the lack of supporting information, mainly flow data, a simple reduction calculation was performed to determine the needed reduction. Exceedances of the state criterion were compared with that criterion. For each individual exceedance, an individual required reduction was calculated using the following:

$$\textbf{Load reduction} = \frac{\textbf{Existing loading} - \textbf{Allowable loading}}{\textbf{Existing loading}} \times \textbf{100\%}$$

After the individual results were calculated, the median of the individual values was calculated. **Table 5.3** shows the individual reduction calculations for fecal coliform. The median reduction was 70 percent.

Table 5.3. Calculation of Fecal Coliform Reductions for the Greenfield Creek (WBID 2240) TMDL

This is a five-column table. Column 1 lists the date, Column 2 lists the sampling station, Column 3 lists the fecal coliform exceedance concentration (counts/100mL), Column 4 lists the target concentration (counts/100mL), and Column 5 lists the percent reduction.

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Date	Sampling Station	Fecal Coliform Exceedance Concentration (counts/100mL)	Fecal Coliform Target (counts/100mL)	% Reduction
6/18/2001	21FLJXWQGC1	600	400	33.33%
10/23/2002	21FLA 20030657	1,800	400	77.78%
10/23/2002	21FLJXWQGC1	1,800	400	77.78%
3/26/2003	21FLJXWQGC1	530	400	24.53%
6/19/2003	21FLJXWQGC1	4,000	400	90.00%
9/21/2004	21FLJXWQGC1	2,500	400	84.00%
8/29/2005	21FLJXWQGC1	700	400	42.86%
9/18/2006	21FLJXWQGC1	510	400	21.57%
11/28/2006	21FLJXWQGC1	440	400	9.09%
1/10/2007	21FLA 20030657	733	400	45.43%
5/27/2007	21FLA 20030657	750	400	46.67%
5/27/2007	21FLA 20030809	1,250	400	68.00%
7/25/2007	21FLA 20030657	1,354	400	70.46%
7/25/2007	21FLA 20030809	2,600	400	84.62%
9/18/2007	21FLJXWQGC1	4,900	400	91.84%
9/25/2007	21FLJXWQGC1	680	400	41.18%
10/3/2007	21FLA 20030810	4,000	400	90.00%
10/3/2007	21FLA 20030052	8,000	400	95.00%
10/3/2007	21FLA 20030657	8,500	400	95.29%
10/3/2007	21FLA 20030809	10,500	400	96.19%
11/27/2007	21FLA 20030809	775	400	48.39%
11/27/2007	21FLA 20030657	925	400	56.76%
12/10/2007	21FLJXWQGC1	2,400	400	83.33%
-	-	-	**Median % Reduction**	**70.46**%

5.1.3 Critical Condition

The critical condition for coliform loadings in a given watershed depends on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, the critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event. During the wet weather period, 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 appear under dry conditions without any major surface runoff event. This usually happens 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, by contributing to exceedances.

The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

As no current flow data were available, hydrologic conditions were analyzed using rainfall. A loading curve–type chart, that would normally be applied to flow events, was created using precipitation data from Jacksonville International Airport instead. The chart was divided in the same manner as if flow were being analyzed, where extreme precipitation events represent the upper percentiles (0–5th percentile), followed by 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). Three-day (the day of and 2 days prior to sampling) precipitation accumulations were used in the analysis (**Table 5.4** and **Figure 5.7**).

Historical data show that fecal coliform exceedances occurred under all hydrologic conditions, except for large precipitation events (1.33 to 2.1 inches), for which no samples were collected. The highest percentage of exceedances (78 percent) occurred after extreme precipitation events, but these periods also had the fewest samples (n=9). The lowest percentage of exceedances occurred after periods of no measurable precipitation (26 percent). The fact that higher exceedance rates occurred after extreme precipitation events than after periods of little or no rainfall indicates that nonpoint sources are probably a major contributing factor. However, while the lowest percentage of exceedances occurred after periods of no or little rainfall, the exceedance rate is not insignificant. It could indicate point sources of fecal coliform pollution to Greenfield Creek, but also nonpoint sources. That there are no point sources located in or discharging to Greenfield Creek, other than permitted stormwater point sources (i.e., MS4 systems), indicates that nonpoint sources such as baseflow, which contributes to the creek's flow during dry conditions, have been impacted by failed septic tanks or leaking sewer infrastructure. The high exceedance rates and episodic extreme fecal coliform concentrations that occurred after all categories of sampled precipitation events indicate that various nonpoint sources likely contribute fecal coliform pollution to Greenfield Creek. **Table 5.4** and **Figure 5.7** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred following all sampled categories of precipitation events—extreme, medium, small, and not measurable—the target fecal coliform reduction calculated in the previous section and shown in **Table 5.3** is applicable under all rainfall conditions in Greenfield Creek.

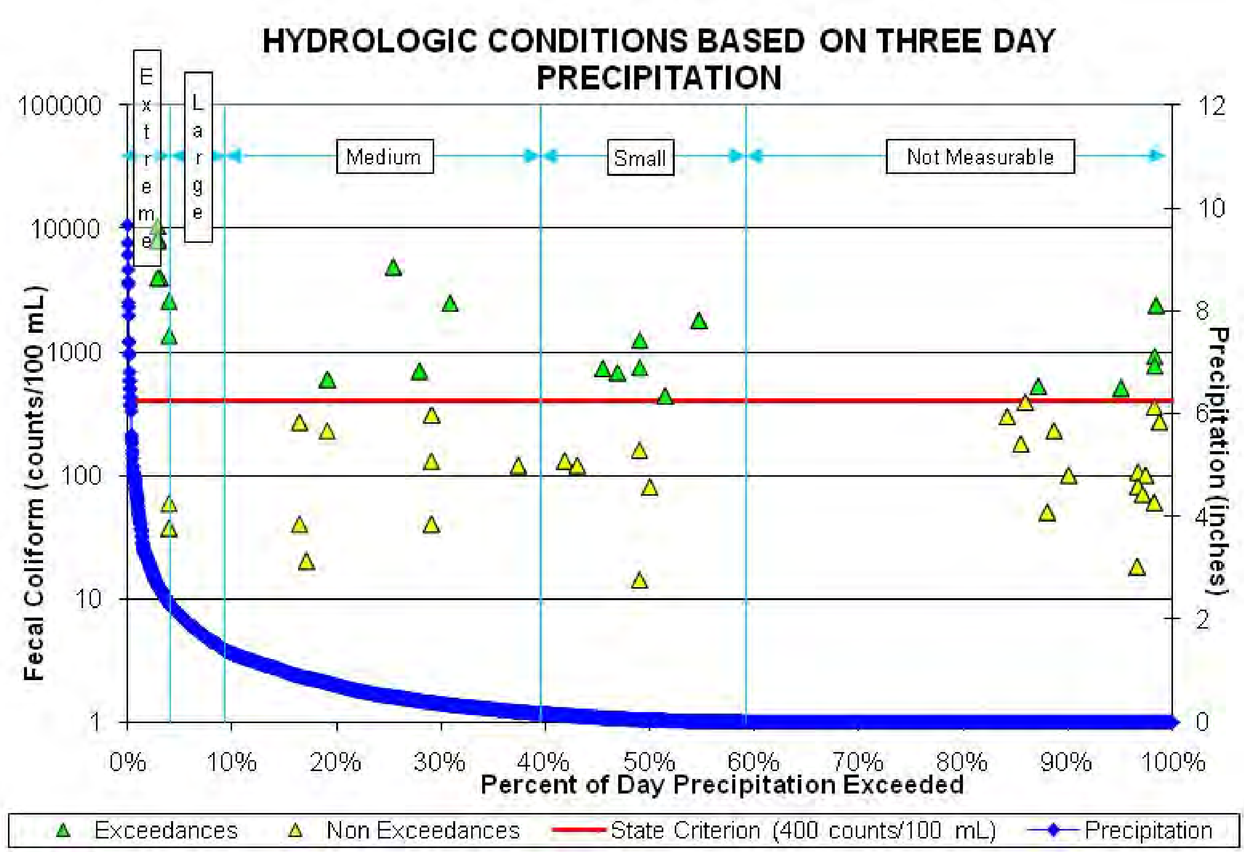
Table 5.4. Summary of Historical Fecal Coliform Data by Hydrologic Condition

This is a seven-column table. Column 1 lists the type of precipitation event, Column 2 lists the event range (in inches), Colum 3 lists the total number of samples, 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.

N/A = Not applicable

Precipitation Event	Event Range (inches)	Total Samples	Number of Exceedances	% Exceedances	Number of Non-exceedances	% Non-exceedances
Extreme	>2.1"	9	7	77.78%	2	22.22%
Large	1.33" - 2.1"	0	N/A	N/A	N/A	N/A
Medium	0.18" - 1.33"	12	4	33.33%	8	66.67%
Small	0.01" - 0.18"	12	7	58.33%	5	41.67%
None/ Not Measurable	<0.01"	19	5	26.32%	14	73.68%

Figure 5.7. Historical Fecal Coliform Data by Hydrologic Condition



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 Greenfield Creek is expressed in terms of counts/100mL 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 Greenfield Creek (WBID 2240)

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	70%	70%	Implicit

6.2 Load Allocation

Based on a percent reduction approach, the LA is a 70 percent reduction in fecal coliform from nonpoint sources. It should be noted that it 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

No NPDES-permitted wastewater facilities were identified within the Greenfield Creek WBID boundary. The state already requires all NPDES 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

The WLA for stormwater discharges with an MS4 permit is a 70 percent reduction in current fecal coliform loading for WBID 2240. It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

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 allowing any exceedances of the state criterion, even though intermittent natural exceedances of the criterion would be expected and would be taken into account when determining impairment. Additionally, the TMDL calculated for fecal coliform was based on meeting the water quality criterion of 400 counts/100mL without any exceedances, while the actual criterion allows for 10 percent exceedances over the fecal coliform criterion.

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.

A multitude of assessment tools is 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 the Hillsborough Basin, 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 FDOT 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 has provided these estimations 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.

Additional information about the potential fecal coliform sources in this area is available in the technical report for the Greenfield Creek watershed (PBS&J, 2008).

Pets

Pets (especially dogs) could be a significant source of coliform pollution through surface runoff within the Greenfield Creek 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 was 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 23 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 Greenfield Creek WBID boundary is not known. Therefore, the statistics produced by APPMA were used in this analysis to estimate the possible fecal coliform loads contributed by dogs.

Using information obtained from the Duval County Property Appraiser's Office website (available: http://www.coj.net/Departments/Property+Appraiser/default.htm) and data obtained from the Florida Department of Health (FDOH) to calculate the number of properties in residential land use areas within the Greenfield Creek WBID boundary, the number of households within the WBID boundary was estimated to be 3,786. The next section describes the data provided by FDOH. Property data from the Duval County Property Appraiser's Office were used to determine the number of units in large apartment complexes within the WBID boundary. Assuming that 40 percent of the households in this area have 1 dog, the total number of dogs within the WBID is about 1,514.

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). 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 is approximately 272,700 grams/day. The total fecal coliform produced by dogs is about 6.0×10^{11} counts/day. 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. Dog Population Density, Wasteload, and Fecal Coliform Density (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.

* Number from APPMA.

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

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, in 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.

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 Greenfield Creek 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 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 (100mL/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, 109 housing units *(N)* within the Greenfield Creek 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. Within the Greenfield Creek WBID boundary, 35 properties are known to use septic tanks and 74 are estimated to use septic systems. Because the probability that these 74 properties are in fact served by septic tanks ranges from 77 to 99 percent, all 109 properties were assumed to be served by septic tanks for the purposes of this report. 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 Duval County is about 2.51 people/household. The same population densities were assumed within the Greenfield Creek 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 Duval County based on FDOH's septic tank inventory and the number of septic tank repair permits issued in Duval County as published by FDOH (available: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm). The cumulative number of septic tanks in Duval 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 based on FDOH's 2008/2009 inventory, assuming that none of the installed septic tanks will be removed after being installed (**Table B.2**). 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 listed in **Table B.2**.

Based on **Table B.2**, the average annual septic tank failure discovery rate is about 0.47 percent for Duval County. 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 2.4 percent. Based on **Equation B.1**, the estimated fecal coliform loading from failed septic tanks within the Greenfield Creek WBID boundary is about 1.7×10^{10} counts/day.

Figure B.1. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Residential Land Use Areas within the Greenfield Creek WBID Boundary

Table B.2. Estimated Number of Septic Tanks and Septic Tank Failure Rates for Duval County, 2001–08

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

- = Empty cell/no data
* The failure rate is 5 times the failure discovery rate.

Descriptive Statistic	2001	2002	2003	2004	2005	2006	2007	2008	Average
Number of new septic tank installations	381	359	459	373	487	598	576	-	462
Cumulative total number of septic tanks	64,885	65,266	65,625	66,084	66,457	66,944	67,542	68,118	-
Number of septic tank repair permits issued	344	369	369	324	226	249	269	-	307
Failure discovery rates (%)	0.53%	0.57%	0.56%	0.49%	0.34%	0.37%	0.40%	-	0.47%
Failure rates (%)*	2.7%	2.9%	2.8%	2.5%	1.7%	1.9%	2.0%	-	2.4%

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.

The number of properties connected to the sewer system was also based on data obtained from FDOH's ongoing inventory of wastewater treatment and disposal methods for developed properties. As for septic tanks, if there was not enough information to determine with certainty whether a property was sewered, the probability that the property was served by a septic tank was determined. If that probability was low (less than 50 percent), the property was estimated to be served by a sewer system. Within the Greenfield Creek WBID boundary, 1,230 properties are known to be served by sewer systems, and another 820 are estimated to be served by septic tanks. Because the probability that these 820 properties are in fact served by septic tanks is low—25 percent or less for each of these properties—all 2,050 properties were assumed to be served by sewer systems for the purposes of this report.

Information from the Duval County Property Appraiser's Office was used to determine that several properties tied to the sewer system within the Greenfield Creek WBID boundary were apartment complexes with multiple units and thus contained multiple households. Information obtained from the Property Appraiser's website indicated that 5 of the sewered residential properties contained a total of 1,632 units. Thus the number of households connected to the sewer system within the WBID boundary was estimated to be 3,677 (2,050 – 5 +1632).

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 Greenfield Creek WBID boundary can be made using **Equation B.2**.

$$L = 37.85 * N * Q * C * F \qquad \textbf{Equation B.2}$$

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 Greenfield Creek WBID boundary served by sewer systems is 3,677. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size (2.51) by the per capita wastewater production rate per day (70 gallons/day/person). The commonly cited concentration (*C*) for domestic wastewater is 1×10^6 counts/100mL 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.2**, the estimated fecal coliform loading from sewer line leakage in the WBID is about 1.2×10^{11} counts/day.

Wildlife

Wildlife is another possible source of fecal coliform bacteria within the Greenfield Creek WBID boundary. As shown in **Figure 4.1**, wetland areas border Greenfield Creek 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 likely serve as habitat for wildlife that has the potential to contribute fecal coliform to the creek.

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