FINAL

**FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION**

Division of Water Resource Management, Bureau of Watershed Management

SOUTH DISTRICT • SOUTHEAST COAST-BISCAYNE BAY BASIN

# TMDL Report

# Fecal and Total Coliform TMDL for Wagner Creek (WBID 3288A)

**David Tyler**

**June 2006**

# Acknowledgments

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**Identification of Impaired Surface Waters Rule**

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**STORET Program**

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# Chapter 1: INTRODUCTION

## 1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for Fecal and Total Coliform for Wagner Creek in the Southeast Coast – Biscayne Bay Basin. Wagner Creek was verified as impaired for total coliform, fecal coliform, and dioxin (based on a Department of Health fish consumption advisory), and was included on the Verified List of impaired waters for the Southeast Coast – Biscayne Bay Basin that was adopted by Secretarial Order in May 2006. This TMDL established the allowable loadings to Wagner Creek that would restore the waterbody so that it meets applicable water quality criterion for fecal and total colfiorm. It also addresses the results of preliminary analyses conducted to identify the potential bacteria sources.

## 1.2 Identification of Waterbody

Wagner Creek is located within the City of Miami in North Miami-Dade County, and is a tributary to the Miami River, flowing into the river from the north, just west of where NW 7th Avenue crosses the Miami River, (**Figure 1.1).**

The Wagner Creek basin comprises a drainage area of approximately 3,150 acres (ca. 5 square miles). For preliminary hydrologic/hydraulic analysis conducted by Miami-Dade County as part of the C-6 Basin Stormwater Master Plan, the drainage basin was divided into 14 sub-basins **(Figure 1.2).** The figure shows the Miami River as the basin's downstream boundary, while the upstream northern boundary parallels the Airport Expressway. The eastern boundary is irregular, but it generally extends several blocks east of Interstate 95. The western boundary is located along NW 27th Avenue. Across the Miami River to the south is the Orange Bowl, just visible in the lower portion of **Figure 1.2**.

The creek's length is approximately 1.5 miles and extends from the NW 20th Street crossing to the Miami River. The name "Wagner Creek" is sometimes used interchangeably with the name "Seybold Canal." However, Seybold Canal typically refers to the approximately 2,000-ft long portion of the creek that is a navigable waterway (other than by canoe or kayak), downstream from NW 11th Street. Upstream of this location, Wagner Creek continues north and northwest as an urban drainage feature with a vegetated shoreline up to the corner of NW 14th Street and NW 12th Avenue, at the southeast corner of the Cedars Medical Center. Further upstream, the creek's shoreline is hardened and the creek becomes a concrete-lined drainage ditch up to NW 16th Street. Wagner Creek regains its vegetated shoreline in the segment between NW 16th Street and NW 20th Street. As indicated previously, this is the creek's upstream boundary.

Upstream from NW 20th Street, the basin is drained by a system of storm sewers and French drains that connect to a double culvert box that finally discharges into the creek at the NW 20th Street. The only significant area of open water in the upper portion of the watershed is an approximately 700 foot-long drainage swale located within the Allapattah-Comstock Park.

Wagner Creek is tidally influenced throughout its length. Manatees have been observed as far upstream as NW 16th Street, which is more than a mile upstream from the Miami River (Tomasko, personal observation).

Additional information about the river's hydrology and geology are available in the Basin Status Report for the Southeast Coast – Biscayne Bay Basin (Florida Department of Environmental Protection [FDEP], 2005).

For assessment purposes, the Department has divided the Southeast Coast – Biscayne Bay Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. The Wagner Creek is totally contained within one segment, WBID 3288A (**Figure 1.1**). Wagner Creek is part of the North Dade County Planning Unit. Planning units are groups of smaller watershed (WBIDs) that are part of a larger basin, in this case Southeast Coast – Biscayne Bay Basin. The North Dade Planning Unit consists of fifteen WBIDs.

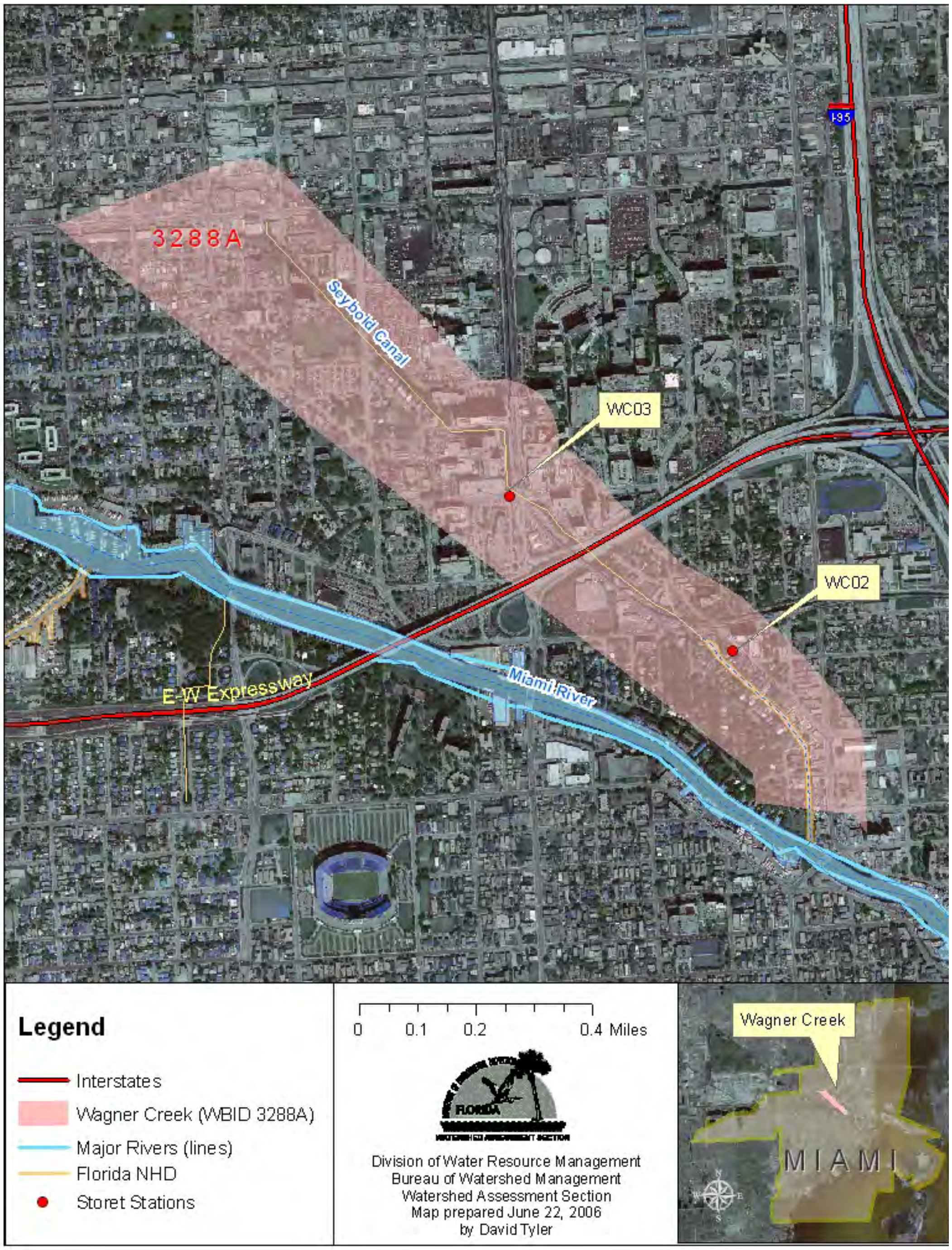



Figure 1.1. Location of Wagner Creek and Major Geopolitical Features (WBID 3288A)

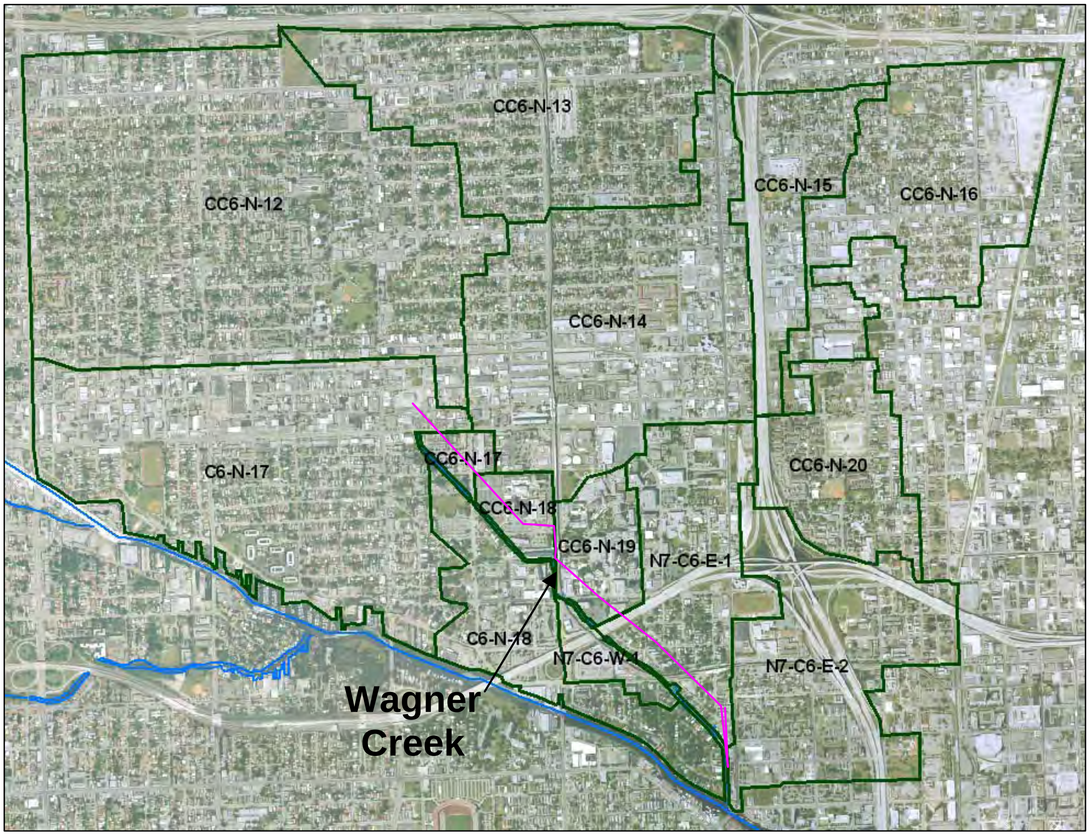



Figure 1.2. Wagner Creek and Associated Sub-basins*

* Miami Dade County Stormwater Master Plan for the C-6 Canal Basin

## 1.3 Background

This report was developed as part of the Florida Department of Environmental Protection's (Department) 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 fifty-two river basins over a five-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. TMDLs provide important water quality restoration goals that will guide restoration activities.

TMDL development is a critical step in the watershed restoration process because they provide the targets for subsequent water quality restoration efforts. A very important factor of the TMDL development effort, particularly for total and fecal coliform bacteria impairments, is the identification of sources. Per rule 62-303.460 (2), Florida Administrative Code, "If the water segment was listed on the planning list due to exceedances of water quality criteria for bacteriological quality, the Department shall, to the extent practical, evaluate the source of bacteriological contamination and shall verify that the impairment is due to chronic discharges of human-induced bacteriological pollutants before listing the water segment on the verified list."

This TMDL Report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of fecal and total coliform that caused the verified impairment of the Wagner Creek. These activities will depend heavily on the active participation of the South Florida Water Management District, local 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 EPA a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant source in each of these impaired 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.]).

Florida's 1998 303(d) list included nineteen waterbodies in the Southeast Coast – Biscayne Bay Basin, and the state's 303(d) list is amended annually to include basin updates.
However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists 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 a long rule-making process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001.

## 2.2  Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Southeast Coast – Biscayne Bay Basin.  **Table 2.1** lists all verified impairments in the Wagner Creek Basin. This TMDL addresses the fecal and total coliform impairment in Wagner Creek, WBID 3288A.

Impairments were verified for elevated levels of dioxin within the tissues of various species of fish (Checkered Puffer, Striped Mojarra and Yellowfin Mojarra) as well as impairment related to elevated concentrations of both total and fecal coliform bacteria.  Details of applicable water quality standards and water quality targets are discussed in detail in Section 3.  In summary, the threshold values that were used to assess exceedance of standards for total and fecal coliform bacteria are 2,400 and 400, respectively, colony-forming units per 100 milliliters of water (cfu / 100 m)l.  The newly identified impairment for dioxin (in fish tissue) will be addressed in a separate TMDL report that is scheduled for completion as part of the next 5-year basin rotation, due in 2011.

Table 2.1.  Verified Impaired Segments in Wagner Creek

| WBID | Waterbody Segment | Parameters of Concern | Priority for TMDL Development | Projected Year for TMDL Development |
|---|---|---|---|---|
| 3288A | Wagner Creek | Dioxin | Medium | 2011 |
| 3288A | Wagner Creek | Fecal Coliform | High | 2005 |
| 3288A | Wagner Creek | Total Coliform | High | 2005 |

This TMDL is based on data collected by the Miami-Dade County Department of Environmental Management (DERM) as part of an the extensive county-wide water quality monitoring program. A statistical analysis of this data was conducted and summary statistics of the coliform data data are presented in Tables 2.2 and 2.3 for stations 21FLDADEWC02 and 21FLDADEWC03, referred as Stations WC02 and WC03 **(Figure 1.1).** Station WC02 is located at the northernmost point of navigable waters in the creek, just south of NW 11th Street, and station WC03 is located on the south side of NW 14th Street, at the southeast corner of Cedars Medical Center. Data shown were collected between January 1997 and March 2006.

### Table 2.2. Summary of Total Coliform Bacteria Data at Stations WC02 and WC03

| Station | N | Minimum | Maximum | Mean | Median | No. of Exceedances | % Exceedance |
|---|---|---|---|---|---|---|---|
| WC02 | 133 | 10 | 3,800,000 | 99,296 | 8,000 | 111 | 83 |
| WC03 | 111 | 400 | 2,600,000 | 101,340 | 6,500 | 85 | 77 |

### Table 2.3. Summary of Fecal Coliform Bacteria Data at Stations WC02 and WC03

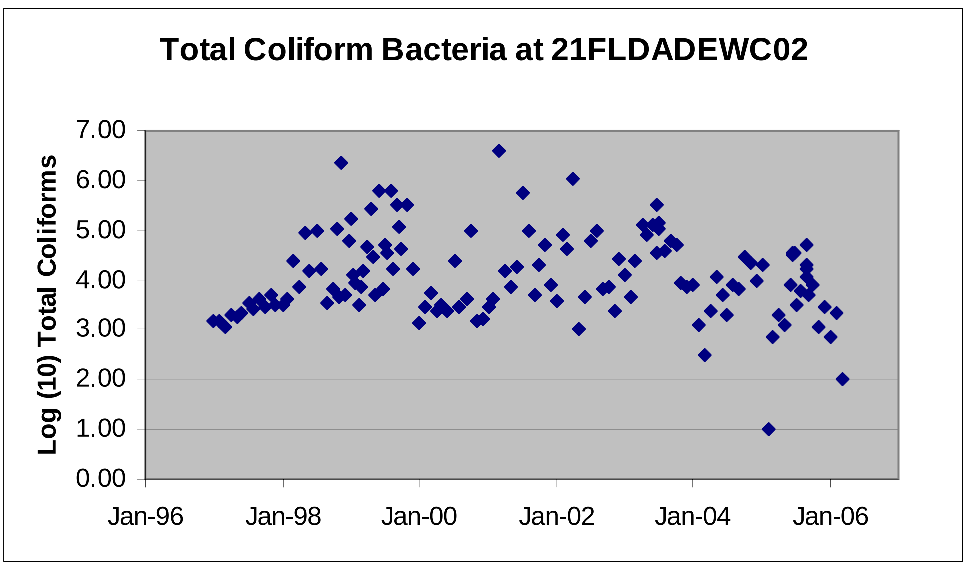
| Station | N | Minimum | Maximum | Mean | Median | No. of Exceedances | % Exceedance |
|---|---|---|---|---|---|---|---|
| WC02 | 133 | 10 | 280,000 | 15,971 | 2,100 | 119 | 89 |
| WC03 | 111 | 50 | 550,000 | 23,741 | 1,970 | 87 | 78 |

The data, in general, reflect high levels of in-stream bacteria concentrations, with median values for total and fecal coliform bacteria at stations WC02 and WC03 far in excess of the applicable water quality criteria. In fact, many of the exceedances were a 1000 times greater an order of magnitude compared to the water quality criteria. Levels of total coliform bacteria exceed the existing state standard 83 and 77 percent of the time at WC02 and WC03, respectively, whereas levels of fecal coliform bacteria exceed the existing state standard 89 percent of the time at WC02, and 78 percent of the time at WC03.

The coliform data were evaluated to determine the presence of trends over time for both total and fecal coliform bacteria at both WC02 and WC03 stations. As is commonly done with bacterial data, values were log transformed prior to assessment for trends. Log transformation allows for an easier assessment of the presence or absence of an overall trend for data that are non-normal in their distribution.

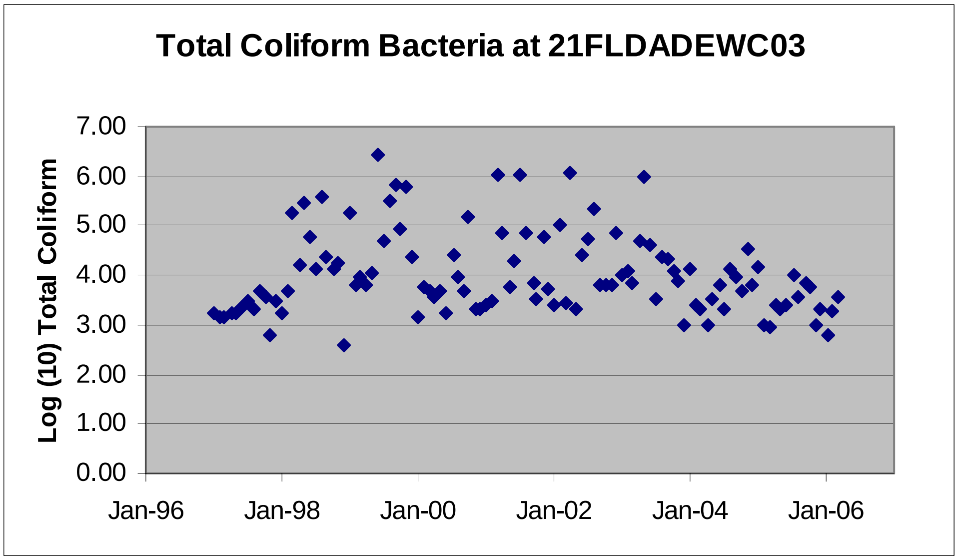
As shown in **Figure 2.1**, when tested using a linear regression of log-transformed values versus time, there was no evidence of a significant temporal trend for total coliform bacteria at water quality station WC02.

**Figure 2.1. Time series of log (10) – transformed total coliform bacteria abundance at station WC02 (cfu / 100ml)**




Similar to the conditions at Station WC02, when tested using a linear regression of log-transformed values versus time, there was no evidence of a significant temporal trend for total coliform bacteria at water quality station WC03 **(Figure 2.2)**.

**Figure 2.2.** **Time series of log (10) – transformed total coliform bacteria abundance at station WC03 (cfu / 100 ml)**




Data on the abundance of fecal coliform bacterial abundance were also tested for trends over time at these same two stations, as shown in Figures 2.3 and 2.4. As was seen for total coliform bacteria, there was no evidence of a significant temporal trend for fecal coliform bacteria at water quality stations WC02 and WC03.

**Figure 2.3** **Time series of log (10) – transformed fecal coliform bacteria abundance at station WC02 (cfu / 100 ml)**

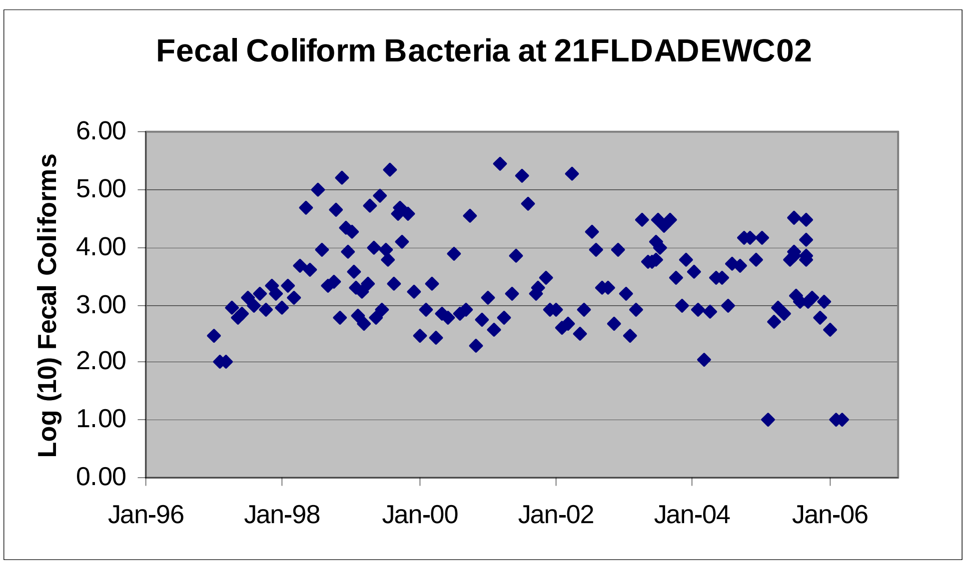
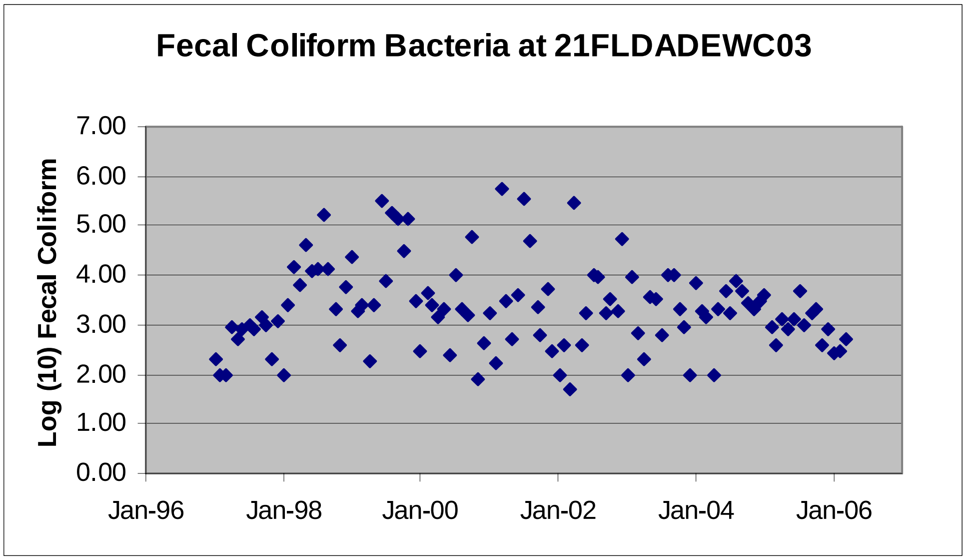


**Figure 2.4** **Time series of log (10) – transformed fecal coliform bacteria abundance at station WC03 (cfu / 100 ml)**



# Chapter 3.  DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

## 3.1  Classification of the Waterbody and Criteria 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)** |

Wagner Creek is a Class III predominately marine waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife.  The Class III water quality criteria applicable to the impairment addressed by this TMDL are total and fecal coliform bacteria.

## 3.2  Applicable Water Quality Standards and Numeric Water Quality Targets

### 3.2.1  Fecal and Total Coliform Criteria

Numeric criteria for bacterial quality are expressed in terms of fecal coliform bacteria and total coliform bacteria concentrations.  The water quality criteria for protection of Class III waters, as established by Chapter 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.*
>
> ***Total Coliform Bacteria:***
> *The MPN per 100 ml shall be less than or equal to 1,000 as a monthly average nor exceed 1,000 in more than 20 percent of the samples examined during any month; and less than or equal to 2,400 at any time.*

For both parameters, the criteria state that monthly averages shall be expressed as geometric means based on a minimum of ten samples taken over a thirty-day period.
During the development of load curves for the impaired streams (as described in subsequent sections), there were insufficient data (less than 10 samples in a given month) available to evaluate the geometric mean criterion for either fecal coliform or total coliform bacteria. Therefore, the criterion selected for the TMDLs was not to exceed 400 in 10 percent of the samples.

# 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 nutrients in the watershed and the amount of pollutant loading 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 Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including 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 Total and Fecal Coliform Bacteria in the Wagner Creek Watershed

### 4.2.1 Point Sources

There are no industrial or domestic wastewater facilities permitted to discharge to Wagner Creek. However, there is a concrete production and distribution facility Rinker Minerals – (FLG110578), that is authorized to discharge to ground water in the watershed (**Figure 4.1).** Rinker Minerals is unlikely to contribute to observed levels of either total or fecal coliform bacteria. The City of Miami does have a Municipal Separate Storm Sewer System (MS4) permit (No. FLS000002 issued February 3, 2004) that includes the Wagner Creek watershed.

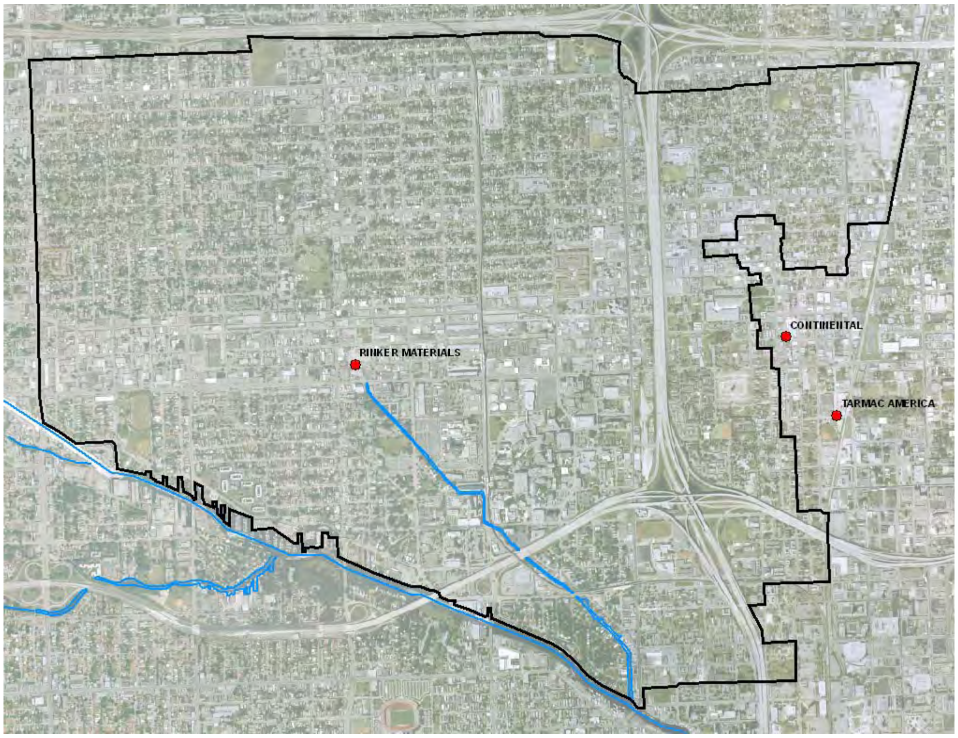



Figure 4.1.  Wastewater Facilities in the Wagner Creek Region

### 4.2.2 Illicit Point Source Discharges

Cross-contamination between storm drain and sanitary sewer systems has been known to be a problem in the Miami River watershed (Miami River Commission, 2002). Identified issues include contamination of the stormwater drainage system from improper connections to sanitary sewage pipes, leaking and broken sewage pipes, and backups and overflows of sewage conveyance systems during localized flooding (Miami River Commission, 2002).

In response to these concerns, the Miami-Dade Water and Sewer Department has focused on identifying and responding to cross-contamination issues in the Miami River Watershed, including the Wagner Creek basin. As part of this effort, Miami-Dade identified six sanitary sewer system crossings (see Table 4.1) of Wagner Creek (Miami-Dade Water and Sewer Department, 2003).

**Table 4.1. Sanitary Sewer Crossings Underneath Wagner Creek**

| Line Segment | Sanitary Crossing Location |
|---|---|
| MH 215-202 | NW 24th Street between NW 15th Avenue and NW 17th Avenue |
| MH 220-218 | NW 23rd Street between NW 15th Avenue and NW 17th Avenue |
| MH 99-98 | NW 20th Street between NW 15th Avenue and NW 17th Avenue |
| MH 88-87 | NW 15th Avenue at NW 19th Terrace |
| MH 61-62 | NW 18th Street Road at NW 19th Street |
| MH 64-63 | NW 14th Street at NW 12th Avenue |

Miami-Dade Water and Sewer Department conducted 100 individual dye tests in the Wagner Creek basin to identify cross connections between the sanitary sewer and the storm sewer systems. Out of these 100 tests, six (6) locations showed test results that indicated cross connections (Miami-Dade Water and Sewer Department, 2003) and four additional sites were found where visual inspection suggested potential leaks into or out of the sanitary sewer lines. These locations are listed in Table 4.2.

**Table 4.2. Locations of Cross Connections or Detected Leaks in Sanitary Sewer Lines**

| Site Identifier | Address |
|---|---|
| MH 35A-800 | 1150 NW 8th Street Road |
| MH 34-33 | 1551 NW 13th Court |
| MH 844-814 | NW 7th Avenue and NW 10th Street |
| MH 821 | NW 9th Street and NW 7th Avenue |
| MH 87-63 | 1900 NW 15th Avenue |
| MH 139-140 | NW 21st Terrace and NW 15th Avenue |
| MH 136 | NW 21st Street and NW 15th Avenue |
| MH 55 | NW 12th Avenue and NW 11th Street |
| MH 96 | NW 15th Avenue and NW 20th Street |
| MH 215 | NW 17th Avenue and NW 24th Street |

In addition to these locations, a covered trench storm drain that discharges into Wagner Creek at NW 12th Avenue and NW 14th Street (at the southeast corner of the Cedars Medical Center) was found (via smoke testing) to be potentially influenced from an adjacent sanitary sewage line.

Locations where dye testing, smoke testing or other techniques indicated a cross connection between sanitary and stormwater conveyance systems were subject to appropriate restorative actions. In addition, after completing the called-for repairs to the sanitary sewer system, the Miami Dade Water and Sewer Department (2004) completed a follow-up study in which a total of 77 dye tests were conducted in the Wagner Creek basin. No further defects were identified through this second report (Miami Dade Water and Sewer Department, 2004).

As a final assessment of the role (if any) of collection system influences on bacterial abundance in Wagner Creek, a data set on recent Sanitary Sewer Overflows within the City of Miami was accessed and reviewed. This data set contains locations of reported sewer overflows, as well as information on the volume of sewage believed to have been accidentally released. Data that were analyzed covered the period February 2005 to February 2006.

While there were a total of 35 sewer overflow incidents within the City of Miami during this period, with a combined estimated volume of 287,230 gallons, only 5 incidents occurred in the Wagner Creek basin. The largest spill reported in Wagner Creek was approximately 80 gallons caused by a grease blockage of a gravity line at 816 NW 11th Street on November 3, 2005. Locations of sewage spills within the Wagner Creek basin are shown in **Figure 4.2**.

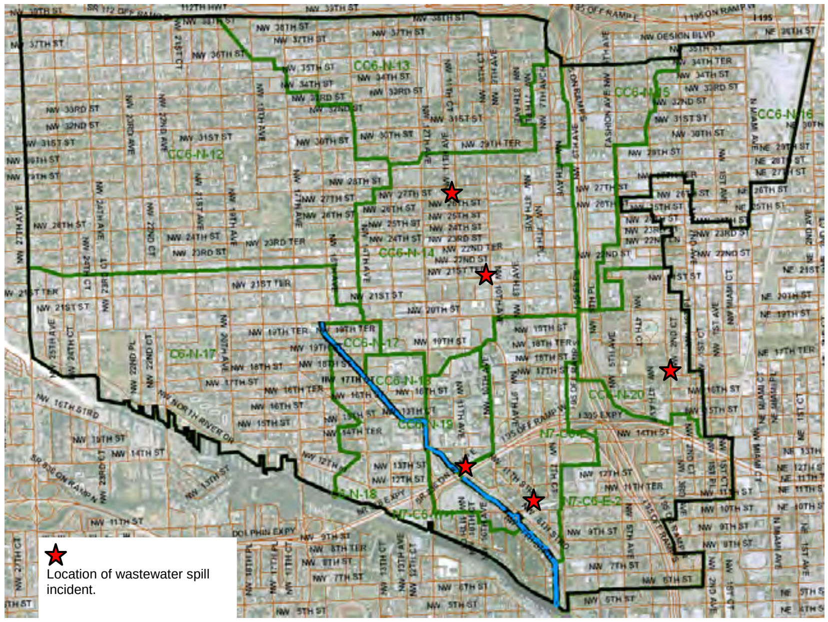



**Figure 4.2. Locations of sanitary sewer overflows in the Wagner Creek basin February 2005 and February 2006**

### 4.2.3 On-site Sewage Disposal Systems

Although on-site sewage disposal systems (i.e., septic tanks) are found in some areas within the Miami River watershed, the Miami River Commission (2002) concluded that "…none of these occurs within the Upper Wagner Creek basin…" As such, it is unlikely that septic tank systems are responsible for the elevated numbers of both total and fecal coliform bacteria within Wagner Creek.

### 4.2.4 Land Uses and Nonpoint Sources

#### Land Uses

The area just south and north of the Miami River, including most of the Wagner Creek basin, contains some of the oldest neighborhoods in the City of Miami. The spatial distribution and acreage of different land use categories in the Wagner Creek basin was identified using the City of Miami's land use coverage data from 2005. Land use distribution is tabulated in **Table 4.3**.

**Table 4.3. Classification of Land Use / Land Cover Categories in the Wagner Creek Basin**

| Land Use Description | Percent (%) |
|---|---|
| Streets and Roads | 22.30 |
| Single-Family, Med-density ( 2-5 DU/Gross Acre) | 10.22 |
| Two-Family (duplexes) | 9.42 |
| Multi-family, Low-density (Under 25 DU/Gross Acre) | 8.84 |
| Other Industrial Intensive, Non-noxious. | 7.72 |
| Sales and Services. Excludes Office Facilities. | 7.11 |
| Vacant, Non-protected, Privately Owned. | 4.07 |
| Hospitals, Nursing Homes and Adult Congregate Living Facilities | 3.85 |
| Local Parks and Playgrounds (Other than schools) | 2.90 |
| Expressways and Ramps | 2.71 |
| Governmental/Public Admin. | 2.58 |
| Public Schools, Including Playgrounds, Day care a | 2.35 |
| Single-Family, High-density (over 5 DU/Gross Acre | 2.05 |
| Railroads | 1.51 |
| Expressway Right of Way Open Areas | 1.42 |
| Townhouses | 1.34 |
| Office Building | 1.30 |
| Other Industrial Extensive, Non-noxious | 1.09 |
| Other (combined) | 7.23 |

As would be expected from such a highly urbanized landscape, the most abundant land cover in the Wagner Creek watershed is streets and roads (22%). When combined with the category of expressways and ramps, transportation accounts for a minimum of 25% of the watershed – without including parking lots and driveways. The next two most abundant land cover categories are those of medium density housing and two-family (duplex) housing, which combined account for approximately 20% of the basin.

Industrial and commercial land uses combined account for approximately 17% of the watershed land cover. The land use categories of vacant land plus parks and playgrounds account for about 7% of the land cover in the basin.

The Wagner Creek basin is highly urbanized, with a high degree of impervious cover, and very little open land. This is further illustrated by the population density. According to the 2000 Census, the combined population of the census tract groups within the Wagner Creek watershed is approximately 54,296. With a watershed size of 3,157 acres, this averages out to slightly more than 17 people per acre. In contrast, Pinellas County, Florida's most densely populated county, contains approximately 921,482 people within its 179,136 acres of land for a population density of just over 5 people per acre (http://www.citydata.com/county/Pinellas_County-FL.html).

## Nonpoint Sources

The storm sewer network in the Wagner Creek basin was constructed prior to the enactment of current stormwater regulations. Therefore, much of the stormwater drainage in this area involves discharges from the highly urbanized watershed into the storm sewer network, and then directly into Wagner Creek (Miami River Commission, 2002). As a result, runoff from storm events is likely a much higher percentage of rainfall than occurs with most other landscapes in Florida.

In the absence of any identified major point sources of loadings of total and fecal coliform bacteria, non-point sources were considered the likely source of bacterial loading. This conclusion was further tested by performing a preliminary analysis of fecal coliform bacteria concentrations at long-term sites WC02 and WC03 during the both “wet” and “dry” seasons. The wet season was operationally defined as the months of June to September, and the dry season was defined as the months of October to May. In locations where point sources are likely major contributors of bacterial loading, bacterial concentrations would be expected to be higher in the dry season because bacterial abundances in wastewater (e.g., sewage discharges) would be much higher than in stormwater runoff, even from an urbanized watershed. Consequently, stormwater runoff would be expected to dilute levels that would otherwise be found in untreated sewage spills or discharges. In contrast, if stormwater runoff was the major source of bacterial loading, concentration levels in the wet season would be expected to be higher, as this would be the time period when loads would be occur.

At site WC02, mean values of fecal coliform bacteria for the wet and dry season were calculated to be 5,218 and 2,066 cfu / 100 ml, respectively. These values are highly statistically significantly different (Kruskal-Wallis; $p < 0.01$).

At site WC03, mean values of fecal coliform bacteria for wet and dry seasons were 8,031 and 1,776 cfu / 100 ml, respectively. As at WC02, these values are also highly statistically significantly different (Kruskal-Wallis; $p < 0.01$).

These statistical results support the contention that stormwater runoff is the predominant cause of bacterial loading into Wagner Creek. However, for TMDL development and subsequent BMAP development purposes, it is important to assess in more detail the potential sources of bacterial loadings, which is discussed in the following section of this report.

### Pets in Residential Areas

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 dog’s feces.

The number of pets in the Wagner Creek watershed is unknown. Therefore, APPMA statistics were used to estimate the possible fecal coliform loads contributed by pets in the watershed. According to the U. S. Census Bureau 2004, the average household size in the city of Miami is estimated at 2.49 people. There is roughly 59,296 people living in the Wagner Creek watershed, which equates to an estimated 21,806 households in the Wagner Creek watershed. Assuming that 40 percent of households have 1 dog, this translates into a total of 8,722 dogs in the watershed. According to the waste production rate for dogs and the fecal coliform counts per gram of dog wastes listed in **Table 4.4**, and assuming that 40 percent of dog owners do not pick up dog feces, the total waste produced by dogs and left on the land surface in residential areas of the watershed is 1,569,960 grams. The total fecal coliform produced by dogs is $3.45 \times 10^{12}$/day. Assuming that 10 percent of the fecal coliform are washed into receiving waters, the total load that Wagner Creek could receive is $3.45 \times 10^{11}$ fecal coliform/day. Also, note that total coliform/day counts would be roughly 10 times greater than that of fecal coliform.

### Table 4.4. Dog Population Density, Waste Load, and Fecal Coliform Density

| Type | Population density (animal/household) | Waste load (grams/animal-day) | Fecal coliform density (fecal coliform/gram) |
|---|---|---|---|
| Dogs (Weiskel et al., 1996) | 0.4* | 450 | 2,200,000 |

* Number from APPMA.

# Chapter 5:  DETERMINATION OF ASSIMILATIVE CAPACITY

## 5.1 Determination of Loading Capacity

The TMDL process aims to a) quantify the maximum amount of a pollutant that can be assimilated by a waterbody, b) identify the likely sources of the pollutant, and c) recommend regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions.  The maximum amount of total and fecal coliform bacteria concentrations allowable are based on the water quality criteria described in Section 3.

This section of the report presents estimates of the fecal and total coliform reductions needed in the Wagner Creek basin.  The method used to calculate the fecal and total coliform reductions was “Percent Reduction.”

It should be noted that a major assumption incorporated in the calculations is that bacteria loads are of anthropogenic sources.  However, this section also discusses the results of a preliminary source identification analysis.  These results should be considered during the BMAP process to determine actual reductions and associated management approaches, along with a more in-depth evaluation of the numerous factors that affect bacteria concentration other than direct discharges from nonpoint sources, such as flow and flow variations in the creek and storm sewer network, sediment accumulation and resuspension, and climatic factors affecting bacterial growth.

## 5.2 Data Used in the Determination of the TMDL

Similar to the analyses presented in the previous sections, data from the long-term water quality stations WC02 and WC03 (**Figure 1.1)** were used to develop the total and fecal coliform TMDLs for Wagners Creek.  As indicated previously, the data were collected by the Miami-Dade Department of Environmental Resources Management (DERM) as part of the County’s extensive water quality monitoring program.  Data mainly consisted of monthly water quality collection efforts between January 1997 and March 2006.  Additional data available from DERM for other stations in the basin were used to verify results.

## 5.3 Calculation of Reduction Needed to Meet the Criteria

### 5.3.1 Percent Reduction Method

For the “Percent Reduction” methodology, the State’s water quality criterion is subtracted from each total and fecal coliform bacteria concentration value that exceeded the relevant standard.  This value is then divided by the sample result and then multiplied by 100.  The results represent the percent reduction required to achieve the in-stream concentration criteria established for both total and fecal coliform bacteria for each sampling event.  The median value of the percent reduction values for each sample that exceeded the relevant criteria is then calculated and used as the overall percent reduction required to meet applicable water quality standards. A summary of the results of the calculations for the Wagner Creek basin are shown in Table 5.1.

**Table 5.1 Number of Exceedances, Percent Exceedances, and Percent Reduction Needed to Meet Total and Fecal Coliform Bacteria Concentration Standards at Water Quality Station WC02 and WC03**

| Location & Bacteria Type | Number of Exceedances | Percent Exceedances | Percent Reduction Required |
|---|---|---|---|
| **WC02 Total Coliforms** | **111** | **83** | **84** |
| **WC03 Total Coliforms** | **85** | **77** | **78** |
| **WC02 Fecal Coliforms** | **119** | **89** | **86** |
| **WC03 Fecal Coliforms** | **87** | **78** | **85** |

As shown in Table 5.1, the percent reductions for total and fecal coliform bacteria are quite similar for both WC02 and WC03. Results indicate that, to meet existing water quality criteria for total and fecal coliform bacteria, concentrations in Wagner Creek would need to be reduced by approximately 81 to 86 percent, respectively.

## 5.4 Conclusions on Required Load Reduction

Results indicate that the calculated load reductions for total and fecal coliform bacteria are in excess of 80 percent. The range of calculated load reductions for total coliform bacteria, considering both locations (WC02 and WC03) is from 78 to 84 percent, with a mean of 81 percent. While the range of calculated load reductions for fecal coliform bacteria, considering both locations (WC02 and WC03) is from 85 to 86 percent. To be conservative, we will apply a reduction target of 86 percent.

## 5.5 Critical Conditions

Critical conditions for loading of total and fecal coliform bacteria from nonpoint sources typically occur after rainfall events that follow an extended dry period. Under these conditions, bacteria that accumulate on land surfaces are washed off to the receiving water bodies. This is particularly critical in areas of warm weather such as South Florida. In addition, and particularly important for Wagner Creek, as stormwater in much of the basin's upper portion is conveyed via a storm sewer system, the accumulation of bacteria within the conveyance system itself could be significant.

## 5.6 Seasonal Variations

As discussed in Section 2, a seasonal variation analysis for the wet and dry season was conducted as part of this study. The wet season was operationally defined as the months of June to September, and the dry season was defined as the months of October to May. Results indicated that that mean values of fecal coliform bacteria for the wet season and statistically larger than those for the dry season at p values less than 0.01. This indicates that larger loads are primarily associated with the wet season.

## 5.7 Important Considerations for Bacteria TMDLs in Wagner Creek

The proposed reductions are highly conservative based on the following considerations: 1) percent reductions are calculated based only on the values that exceeded standards (i.e., calculations exclude conditions when criteria are met), and 2) the proposed reductions are predicated on an implicit assumption that bacteria that contribute to exceedances are anthropogenic in nature (whether from stormwater or wastewater).

The Department recognizes that additional information about the specific sources of bacteria is needed before the TMDLs can be fully allocated to specific sources and then implemented.

To fully understand the issue of the need for source identification efforts, the subsequent paragraphs review the history associated with the adoption of bacterial water quality standards, and the current state of knowledge regarding the specificity (or lack thereof) of these "indicator" bacteria.

In the U.S. and elsewhere, total coliform bacteria have been used for over 100 years as indicators of fecal contamination of water supplies. In part, this is due to the inability of historical monitoring programs to detect the presence of the specific bacteria that caused outbreaks of cholera and typhoid fever – *Vibrio cholerae* and *Salmonella typhi*, respectively (National Research Council, 2004).

In the late 1800s a refined test was developed that allowed for the tracking of levels of *Escherichia coli*, a small rod-shaped bacteria that is found in very high abundances in the feces of warm-blooded animals. During World War II, the test for the abundance of *E. coli* was found to be a useful indicator of the relative abundance of *S. typhi* in raw sewage (National Research Council, 2004).

However, it was soon determined that a variety of bacteria that tested positive for "total coliform bacteria" were not fecally-derived. These findings led to the development of the test for "fecal coliform bacteria" which (tellingly) are also referred to as "thermotolerant bacteria." A major, but not the only, refinement associated with the fecal coliform bacteria assay is the use of a higher incubation temperature. Based in large part on studies conducted using water from the Ohio River basin, it was shown that approximately 18 percent of the total coliform bacteria in any given raw water sample would likely test positive using the fecal coliform bacteria test (National Research Council, 2004), which was run at a incubation temperature more similar to the human body. As the use of a total coliform bacteria standard of 1,000 cfu / 100 ml was widespread, the National Technical Advisory Committee of the U.S. Federal Water Pollution Control Administration (a precursor to the U.S. EPA) converted the existing standard of 1,000 cfu / 100 ml to a lower fecal coliform standard of 200 cfu / 100 ml (i.e., 0.18 x 1,000 = 180; 180 then rounded up to 200).

Partly in response to the issue of the non-specificity of fecal coliform bacteria as indicators of humans as a cause, preliminary source identification efforts were conducted within the Wagner Creek basin as part of this project.

## 5.8 Preliminary Source Identification Results

On two occasions (May 1, 2006 and May 19, 2006), samples were collected from six locations throughout the Wagner Creek watershed. Two of the sample sites were located at long-term stations WC02 and WC03. The other four sites were located throughout the Wagner Creek basin.

**Table 5.2 Locations of Sample Sites Preliminary Source Identification Efforts in Wagner Creek.**

| Sample Site Name | Location |
|---|---|
| SID-1 | DERM Station WC02 |
| SID-2 | DERM Station WC03 |
| SID-3 | Wagner Creek at NW 15$^{th}$ Street |
| SID-4 | Wagner Creek at NW 20$^{th}$ Street – Culvert on the West Side |
| SID-5 | Wagner Creek at NW 20$^{th}$ Street – Culvert on the East Side |
| SID-6 | NW 26$^{th}$ Street at NW 17$^{th}$ Avenue – Southeast Corner of Allapattah Comstock Park |

At each location, tests were run looking for gene sequences within both *Enterococci* sp. and *Bacteroidetes* sp. that are specific to humans. These tests can differentiate between bacteria associated with humans as a source (whether recent or in the past) versus bacteria from wildlife or other sources (e.g., decaying vegetation, native soils, etc.). Additionally, if human sewage contamination of the sediments is occurring, then these tests would be useful indicators of the amount of sediment contamination that affects the water column as well. During both sampling events, levels of fecal coliform bacteria were well in excess of the 400 cfu / 100 ml standard at all locations.

Although results are preliminary, the first sampling event found no evidence of human-specific DNA sequences at any of the sample locations. Results from the second sampling effort found traces of human-specific DNA sequences at sites SID-3, SID-2 and SID-1. However, estimates were that the amount of bacteria with the human gene DNA sequence was less than 1 (one) percent of the total bacteria enumerated. While these results do not unequivocally demonstrate that humans have no role (or a minimal role) in the bacterial contamination of Wagner Creek, they do indicate that high levels of indicator bacteria can co-occur without concurrent evidence of humans as a source.

If human fecal contamination is not the source of the high total and fecal coliform bacteria, then the question can be raised, “Where are these high values coming from?” Potential sources can include non-human fecal material, decay of vegetation (both native and non-native) and naturally occurring soil bacteria.

A potentially significant source that should be examined in greater detail is the amount of organic debris that accumulates within the storm drain system in the Wagner Creek watershed. In a study conducted in Wagner Creek by CDM (2004), it was found that 16 percent of manholes in the Upper Wagner Creek basin contained a “considerable” amount of trash (see **Figures 5.1 and 5.2**) and that approximately 10 percent of the manholes held standing water, often due to blockages associated with the high amount of trash in the stormwater system. Debris included styrofoam cups, plastic bags and utensils, food wrappers, and other debris. Additionally, the CDM report (2004) noted an abundance of “bruised fruits and vegetables” was found on the sidewalks and gutters adjacent to produce markets in the Wagner Creek basin, and that it was likely that these materials would also be transported into the storm sewer system.

**Figure 5.1 Debris within Storm Drain System in Wagner Creek (MH 276)**

**Figure 5.2 Stagnant Water With Biological Matter Accumulation in the Storm Drain System in Wagner Creek (MH 229)**

In Wagner Creek, large loads of organic material (whether anthropogenic or not) can accumulate in the storm drain system and decompose *in situ*.  Bacteria associated with decomposition activities could potentially be a source, at least partially, of the very high levels of total and fecal coliform bacteria within Wagner Creek.

Further work on the topic of source identification of bacterial contamination is warranted.

# 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 (Waste Load 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 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 total and fecal coliform bacteria TMDLs for Wagner Creek are based on “percent reduction” values calculated for long-term monitoring sites WC02 and WC03.  For total coliform bacteria, the percent reduction value calculates to an 81 percent reduction to achieve an in-stream concentration of 2,400 cfu / 100 ml.  For fecal coliform bacteria, the percent reduction value calculates to a 86 percent reduction to achieve an in-stream concentration of 400 cfu / 100 ml (Table 6.1).

## Table 6.1. TMDL Components for Wagner Creek

| WBID | Parameter | TMDL (colonies/day) | WLA | | LA (Percent Reduction)† | MOS |
|---|---|---|---|---|---|---|
| | | | Wastewater (colonies/day) | NPDES Stormwater | | |
| 3288A | Total Coliform | 2400 #/100mL | NA | 81 % | 81 % | Implicit |
| 3288A | Fecal Coliform | 400 #/100mL | NA | 86 % | 86 % | Implicit |

## 6.2 Load Allocation (LA)

Based on the average of the percent reduction and flow duration approaches, a total coliform reduction of 81 percent is needed from non-point sources to allow Wagner Creek to meet the applicable water quality criterion. For fecal coliform bacteria, a reduction of 86 percent is needed for Wagner Creek to meet the applicable water quality criterion. As there are no wastewater or industrial point sources in the basin that are likely sources of bacterial loads, load allocations will need to come from reductions in stormwater loads. It should be noted that the LA includes loading from stormwater dischargers potentially regulated by both FDEP and the South Florida Water Management District that are not part of the NPDES stormwater program.

## 6.3 Wasteload Allocation (WLA)

### *6.3.1 NPDES Wastewater Discharges*

There are no NPDES permitted facilities that discharge total or fecal coliform bacteria to surface waters in Wagner Creek. Thus, a wasteload allocation for wastewater facilities is not applicable. Future wastewater facilities (if any) would be required to meet permit limits based on the applicable total and fecal coliform bacteria criteria.

### *6.3.2 NPDES Stormwater Discharges*

The City of Miami has an individual Phase I Municipal Separate Storm Sewer System (MS4) permit (No.FLS000002 issued February 3, 2004). The permit requires the City of Miami to implement a Stormwater Management Program to reduce the discharge of pollutants to the maximum extent practical and effectively prohibit illicit discharges. It should be noted that if any future MS4 permit holders were to exist in the City of Miami, they would be responsible for reducing the loads associated with stormwater outfalls that they own or otherwise have responsible control over; they would not be responsible for reducing other non-point source loads in their jurisdiction.

## 6.4 Margin of Safety (MOS)

Consistent with the recommendations of the Allocation Technical Advisory Committee (FDEP, February 2001), an implicit MOS was used in the development of this TMDL. An implicit MOS was provided by the conservative decisions associated with the analytical assumptions and the development of assimilative capacity. In addition, FDEP used 400 cfu / 100 ml as the water quality target for fecal coliform bacteria, as opposed to setting the criterion such that no more than 10 percent of the samples could exceed the 400 standard.

# Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

## 7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, referred to as the BMAP. This document will be developed over the next year in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished. The BMAP will include the following:

- Appropriate allocations among the affected parties,
- A description of the load reduction activities to be undertaken,
- Timetables for project implementation and completion,
- Funding mechanisms that may be utilized,
- Any applicable signed agreement,
- Local ordinances defining actions to be taken or prohibited,
- Local water quality standards, permits, or load limitation agreements, and
- Monitoring and follow-up measures.

# References

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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 Chapter 62-40, F.A.C.

The rule requires the state's water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

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 stormwater permitting program to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as municipal separate storm sewer systems (MS4s). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the fifteen counties meeting the population criteria.

An important difference between the federal and state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES Program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. 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 similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

## Appendix B: Summary of Monitoring Results for Fecal and Total Coliform in Wagner Creek (WBID 3288A)

| Station | Date | Time | Fecal Coliform (cfu/100mL) | Total Coliform (cfu/100mL) |
|---|---|---|---|---|
| 21FLDADEWC02 | 1/7/1997 | 1034 | 300 | 1500 |
| 21FLDADEWC02 | 2/4/1997 | 1036 | 100 | 1700 |
| 21FLDADEWC02 | 3/4/1997 | 1102 | 100 | 1100 |
| 21FLDADEWC02 | 4/8/1997 | 1020 | 900 | 1900 |
| 21FLDADEWC02 | 5/6/1997 | 1037 | 600 | 1800 |
| 21FLDADEWC02 | 6/3/1997 | 1050 | 700 | 2200 |
| 21FLDADEWC02 | 7/8/1997 | 1116 | 1300 | 3500 |
| 21FLDADEWC02 | 8/5/1997 | 1050 | 1000 | 2600 |
| 21FLDADEWC02 | 9/9/1997 | 1120 | 1700 | 4000 |
| 21FLDADEWC02 | 10/7/1997 | 1040 | 800 | 2900 |
| 21FLDADEWC02 | 11/4/1997 | 1057 | 2200 | 4800 |
| 21FLDADEWC02 | 12/2/1997 | 1043 | 1500 | 3200 |
| 21FLDADEWC02 | 1/6/1998 | 1128 | 900 | 3200 |
| 21FLDADEWC02 | 2/3/1998 | 1101 | 2200 | 4300 |
| 21FLDADEWC02 | 3/3/1998 | 1125 | 1300 | 25000 |
| 21FLDADEWC02 | 4/7/1998 | 1108 | 4600 | 7000 |
| 21FLDADEWC02 | 5/5/1998 | 1047 | 50000 | 90000 |
| 21FLDADEWC02 | 6/2/1998 | 1139 | 4000 | 15000 |
| 21FLDADEWC02 | 7/7/1998 | 1037 | 99000 | 102000 |
| 21FLDADEWC02 | 8/4/1998 | 1041 | 8800 | 16600 |
| 21FLDADEWC02 | 9/1/1998 | 1035 | 2100 | 3600 |
| 21FLDADEWC02 | 10/6/1998 | 1020 | 2600 | 6900 |
| 21FLDADEWC02 | 10/20/1998 | 1215 | 43000 | 110000 |
| 21FLDADEWC02 | 11/3/1998 | 1043 | 600 | 4550 |
| 21FLDADEWC02 | 11/17/1998 | 1320 | 160000 | 2300000 |
| 21FLDADEWC02 | 12/8/1998 | 1019 | 22000 | 4900 |
| 21FLDADEWC02 | 12/22/1998 | 942 | 8000 | 61000 |
| 21FLDADEWC02 | 1/5/1999 | 1200 | 17800 | 169000 |
| 21FLDADEWC02 | 1/19/1999 | 1105 | 3600 | 12600 |
| 21FLDADEWC02 | 2/2/1999 | 1043 | 1920 | 9000 |
| 21FLDADEWC02 | 2/16/1999 | 1100 | 640 | 3300 |
| 21FLDADEWC02 | 3/2/1999 | 830 | 1690 | 7200 |
| 21FLDADEWC02 | 3/16/1999 | 1155 | 480 | 14600 |
| 21FLDADEWC02 | 4/6/1999 | 1043 | 2300 | 47000 |
| 21FLDADEWC02 | 4/20/1999 | 1140 | 53000 | 270000 |
| 21FLDADEWC02 | 5/4/1999 | 1052 | 7100 | 25000 |
| 21FLDADEWC02 | 5/18/1999 | 1220 | 600 | 4900 |
| 21FLDADEWC02 | 6/8/1999 | 1116 | 80000 | 620000 |
| 21FLDADEWC02 | 6/22/1999 | 1150 | 800 | 6800 |
| 21FLDADEWC02 | 7/6/1999 | 1104 | 9000 | 49000 |
| 21FLDADEWC02 | 7/20/1999 | 1120 | 6100 | 34000 |

| Station | Date | Time | Fecal Coliform (cfu/100mL) | Total Coliform (cfu/100mL) |
|---|---|---|---|---|
| 21FLDADEWC02 | 8/3/1999 | 1020 | 220000 | 610000 |
| 21FLDADEWC02 | 8/17/1999 | 1125 | 2370 | 17000 |
| 21FLDADEWC02 | 9/7/1999 | 1146 | 39000 | 340000 |
| 21FLDADEWC02 | 9/21/1999 | 1500 | 49000 | 120000 |
| 21FLDADEWC02 | 10/5/1999 | 1021 | 12000 | 42000 |
| 21FLDADEWC02 | 11/2/1999 | 1106 | 34000 | 230000 |
| 21FLDADEWC02 | 12/7/1999 | 1050 | 1300 | 7700 |
| 21FLDADEWC02 | 1/4/2000 | 1120 | 300 | 1400 |
| 21FLDADEWC02 | 2/8/2000 | 1035 | 800 | 2800 |
| 21FLDADEWC02 | 3/7/2000 | 1120 | 2400 | 5600 |
| 21FLDADEWC02 | 4/4/2000 | 1132 | 1300 | 2600 |
| 21FLDADEWC02 | 6/6/2000 | 1115 | 600 | 2400 |
| 21FLDADEWC02 | 7/11/2000 | 1135 | 7500 | 25000 |
| 21FLDADEWC02 | 8/8/2000 | 1148 | 700 | 3000 |
| 21FLDADEWC02 | 8/8/2000 | 1152 | 600 | 3000 |
| 21FLDADEWC02 | 9/12/2000 | 1130 | 800 | 4000 |
| 21FLDADEWC02 | 9/12/2000 | 1135 | 900 | 4000 |
| 21FLDADEWC02 | 10/3/2000 | 1300 | 35000 | 100000 |
| 21FLDADEWC02 | 11/7/2000 | 1050 | 200 | 1500 |
| 21FLDADEWC02 | 11/7/2000 | 1055 | 190 | 1400 |
| 21FLDADEWC02 | 12/5/2000 | 1032 | 550 | 1600 |
| 21FLDADEWC02 | 1/9/2001 | 1138 | 1300 | 2800 |
| 21FLDADEWC02 | 2/6/2001 | 1050 | 360 | 4000 |
| 21FLDADEWC02 | 3/6/2001 | 1108 | 280000 | 3800000 |
| 21FLDADEWC02 | 4/3/2001 | 1108 | 600 | 15000 |
| 21FLDADEWC02 | 5/8/2001 | 1103 | 1600 | 7300 |
| 21FLDADEWC02 | 5/8/2001 | 1108 | 700 | 7900 |
| 21FLDADEWC02 | 6/5/2001 | 1129 | 7300 | 19000 |
| 21FLDADEWC02 | 7/10/2001 | 1146 | 170000 | 550000 |
| 21FLDADEWC02 | 8/7/2001 | 1108 | 57000 | 100000 |
| 21FLDADEWC02 | 9/18/2001 | 1033 | 1500 | 5200 |
| 21FLDADEWC02 | 10/2/2001 | 1108 | 2000 | 21000 |
| 21FLDADEWC02 | 11/6/2001 | 1141 | 2900 | 52000 |
| 21FLDADEWC02 | 12/4/2001 | 1124 | 800 | 7900 |
| 21FLDADEWC02 | 1/8/2002 | 1117 | 800 | 3900 |
| 21FLDADEWC02 | 2/5/2002 | 1058 | 410 | 81000 |
| 21FLDADEWC02 | 3/5/2002 | 1117 | 470 | 44000 |
| 21FLDADEWC02 | 4/2/2002 | 1110 | 180000 | 1070000 |
| 21FLDADEWC02 | 5/7/2002 | 1057 | 310 | 1000 |
| 21FLDADEWC02 | 6/4/2002 | 1100 | 800 | 4700 |
| 21FLDADEWC02 | 7/9/2002 | 1120 | 19000 | 63000 |
| 21FLDADEWC02 | 8/6/2002 | 1130 | 9100 | 100000 |
| 21FLDADEWC02 | 9/10/2002 | 1100 | 1900 | 6800 |
| 21FLDADEWC02 | 10/8/2002 | 1107 | 2000 | 7500 |

| Station | Date | Time | Fecal Coliform (cfu/100mL) | Total Coliform (cfu/100mL) |
|---|---|---|---|---|
| 21FLDADEWC02 | 11/13/2002 | 1140 | 450 | 2300 |
| 21FLDADEWC02 | 12/3/2002 | 1145 | 8800 | 27000 |
| 21FLDADEWC02 | 7/8/2003 | 1205 | 10000 | 140000 |
| 21FLDADEWC02 | 8/5/2003 | 1210 | 23000 | 40000 |
| 21FLDADEWC02 | 9/9/2003 | 1235 | 30000 | 61000 |
| 21FLDADEWC02 | 10/7/2003 | 850 | 3000 | 50000 |
| 21FLDADEWC02 | 11/4/2003 | 1145 | 1000 | 9000 |
| 21FLDADEWC02 | 12/3/2003 | 1210 | 5800 | 7200 |
| 21FLDADEWC02 | 1/6/2004 | 1130 | 3600 | 7800 |
| 21FLDADEWC02 | 2/3/2004 | 1145 | 800 | 1200 |
| 21FLDADEWC02 | 4/6/2004 | 1140 | 730 | 2400 |
| 21FLDADEWC02 | 5/4/2004 | 1130 | 3000 | 11200 |
| 21FLDADEWC02 | 6/8/2004 | 1340 | 3000 | 5000 |
| 21FLDADEWC02 | 7/6/2004 | 1325 | 1000 | 1900 |
| 21FLDADEWC02 | 7/6/2004 | 1328 | 1000 | 2500 |
| 21FLDADEWC02 | 8/3/2004 | 1130 | 5100 | 8000 |
| 21FLDADEWC02 | 9/7/2004 | 1205 | 4800 | 6900 |
| 21FLDADEWC03 | 1/7/1997 | 910 | 200 | 1800 |
| 21FLDADEWC03 | 2/4/1997 | 905 | 100 | 1500 |
| 21FLDADEWC03 | 3/4/1997 | 845 | 100 | 1500 |
| 21FLDADEWC03 | 4/8/1997 | 857 | 900 | 1700 |
| 21FLDADEWC03 | 5/6/1997 | 845 | 500 | 1700 |
| 21FLDADEWC03 | 6/3/1997 | 735 | 800 | 2200 |
| 21FLDADEWC03 | 7/8/1997 | 815 | 1000 | 3000 |
| 21FLDADEWC03 | 8/5/1997 | 855 | 700 | 2000 |
| 21FLDADEWC03 | 9/9/1997 | 810 | 1500 | 5000 |
| 21FLDADEWC03 | 10/7/1997 | 900 | 1000 | 3600 |
| 21FLDADEWC03 | 11/4/1997 | 835 | 200 | 600 |
| 21FLDADEWC03 | 12/2/1997 | 825 | 1200 | 3100 |
| 21FLDADEWC03 | 1/6/1998 | 825 | 100 | 1700 |
| 21FLDADEWC03 | 2/3/1998 | 842 | 2600 | 5000 |
| 21FLDADEWC03 | 3/3/1998 | 800 | 15000 | 181000 |
| 21FLDADEWC03 | 4/7/1998 | 910 | 6500 | 16000 |
| 21FLDADEWC03 | 5/5/1998 | 1108 | 40000 | 300000 |
| 21FLDADEWC03 | 6/2/1998 | 820 | 12200 | 60000 |
| 21FLDADEWC03 | 7/7/1998 | 900 | 13000 | 14000 |
| 21FLDADEWC03 | 8/4/1998 | 955 | 160000 | 390000 |
| 21FLDADEWC03 | 9/1/1998 | 920 | 13000 | 24000 |
| 21FLDADEWC03 | 10/6/1998 | 839 | 5000 | 12000 |
| 21FLDADEWC03 | 10/6/1998 | 916 | 2000 | 14000 |
| 21FLDADEWC03 | 11/3/1998 | 855 | 400 | 16000 |
| 21FLDADEWC03 | 12/8/1998 | 840 | 5800 | 400 |
| 21FLDADEWC03 | 2/2/1999 | 830 | 1970 | 6650 |
| 21FLDADEWC03 | 3/2/1999 | 912 | 2600 | 9400 |

| Station | Date | Time | Fecal Coliform (cfu/100mL) | Total Coliform (cfu/100mL) |
|---|---|---|---|---|
| 21FLDADEWC03 | 4/6/1999 | 902 | 180 | 6200 |
| 21FLDADEWC03 | 5/4/1999 | 922 | 2500 | 11000 |
| 21FLDADEWC03 | 6/8/1999 | 840 | 310000 | 2600000 |
| 21FLDADEWC03 | 7/6/1999 | 1005 | 8000 | 48000 |
| 21FLDADEWC03 | 8/3/1999 | 930 | 250000 | 680000 |
| 21FLDADEWC03 | 9/7/1999 | 925 | 140000 | 670000 |
| 21FLDADEWC03 | 10/5/1999 | 949 | 31000 | 90000 |
| 21FLDADEWC03 | 11/2/1999 | 830 | 140000 | 630000 |
| 21FLDADEWC03 | 12/7/1999 | 830 | 3100 | 23000 |
| 21FLDADEWC03 | 1/4/2000 | 830 | 300 | 1500 |
| 21FLDADEWC03 | 2/8/2000 | 840 | 4500 | 6000 |
| 21FLDADEWC03 | 3/7/2000 | 840 | 2500 | 5000 |
| 21FLDADEWC03 | 4/4/2000 | 830 | 1500 | 3700 |
| 21FLDADEWC03 | 6/6/2000 | 830 | 250 | 1800 |
| 21FLDADEWC03 | 7/11/2000 | 800 | 10400 | 26000 |
| 21FLDADEWC03 | 7/11/2000 | 806 | 12000 | 30000 |
| 21FLDADEWC03 | 8/8/2000 | 850 | 2000 | 9000 |
| 21FLDADEWC03 | 9/12/2000 | 820 | 1600 | 5000 |
| 21FLDADEWC03 | 10/3/2000 | 910 | 60000 | 150000 |
| 21FLDADEWC03 | 11/7/2000 | 830 | 80 | 2000 |
| 21FLDADEWC03 | 12/5/2000 | 840 | 420 | 2000 |
| 21FLDADEWC03 | 1/9/2001 | 846 | 1800 | 2600 |
| 21FLDADEWC03 | 2/6/2001 | 815 | 170 | 3000 |
| 21FLDADEWC03 | 3/6/2001 | 802 | 550000 | 1100000 |
| 21FLDADEWC03 | 4/3/2001 | 830 | 3000 | 69000 |
| 21FLDADEWC03 | 5/8/2001 | 830 | 500 | 6000 |
| 21FLDADEWC03 | 6/5/2001 | 815 | 3900 | 19000 |
| 21FLDADEWC03 | 7/10/2001 | 800 | 350000 | 1050000 |
| 21FLDADEWC03 | 8/7/2001 | 830 | 49000 | 70000 |
| 21FLDADEWC03 | 8/7/2001 | 835 | 60000 | 90000 |
| 21FLDADEWC03 | 9/18/2001 | 940 | 2300 | 6900 |
| 21FLDADEWC03 | 10/2/2001 | 830 | 600 | 3200 |
| 21FLDADEWC03 | 11/6/2001 | 920 | 5300 | 60000 |
| 21FLDADEWC03 | 12/4/2001 | 800 | 300 | 5200 |
| 21FLDADEWC03 | 1/8/2002 | 855 | 100 | 2600 |
| 21FLDADEWC03 | 2/5/2002 | 855 | 390 | 100000 |
| 21FLDADEWC03 | 3/5/2002 | 830 | 50 | 2700 |
| 21FLDADEWC03 | 4/2/2002 | 835 | 280000 | 1160000 |
| 21FLDADEWC03 | 5/7/2002 | 855 | 390 | 2100 |
| 21FLDADEWC03 | 6/4/2002 | 825 | 1700 | 26000 |
| 21FLDADEWC03 | 7/9/2002 | 1010 | 10000 | 52000 |
| 21FLDADEWC03 | 7/9/2002 | 1011 | 10000 | 38000 |
| 21FLDADEWC03 | 8/6/2002 | 830 | 9200 | 210000 |
| 21FLDADEWC03 | 9/10/2002 | 915 | 1800 | 6300 |

| Station | Date | Time | Fecal Coliform (cfu/100mL) | Total Coliform (cfu/100mL) |
|---|---|---|---|---|
| 21FLDADEWC03 | 10/8/2002 | 830 | 3200 | 6500 |
| 21FLDADEWC03 | 11/13/2002 | 815 | 1900 | 6300 |
| 21FLDADEWC03 | 12/3/2002 | 835 | 52000 | 71000 |
| 21FLDADEWC03 | 7/8/2003 | 845 | 600 | 3300 |
| 21FLDADEWC03 | 8/5/2003 | 850 | 10000 | 24000 |
| 21FLDADEWC03 | 9/9/2003 | 840 | 10000 | 22000 |
| 21FLDADEWC03 | 10/7/2003 | 850 | 2000 | 12000 |
| 21FLDADEWC03 | 11/4/2003 | 855 | 900 | 8000 |
| 21FLDADEWC03 | 12/2/2003 | 827 | 100 | 1000 |
| 21FLDADEWC03 | 1/6/2004 | 845 | 6800 | 13000 |
| 21FLDADEWC03 | 1/6/2004 | 855 | 6700 | 13000 |
| 21FLDADEWC03 | 2/3/2004 | 845 | 1900 | 2400 |
| 21FLDADEWC03 | 4/6/2004 | 840 | 100 | 1000 |
| 21FLDADEWC03 | 5/4/2004 | 830 | 2100 | 3200 |
| 21FLDADEWC03 | 6/8/2004 | 830 | 4800 | 6500 |
| 21FLDADEWC03 | 7/6/2004 | 850 | 1700 | 2000 |
| 21FLDADEWC03 | 8/3/2004 | 900 | 8000 | 14000 |
| 21FLDADEWC03 | 9/7/2004 | 900 | 5000 | 9000 |
| 21FLDADEWC03 | 9/7/2004 | 950 | 4900 | 8800 |

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