FINAL

**FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION**

Division of Environmental Assessment and Restoration

CENTRAL DISTRICT • MIDDLE ST. JOHNS RIVER BASIN

# TMDL Report

# Nutrient and Dissolved Oxygen TMDL for the Little Wekiva Canal, WBID 3004

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# Contents

# List of Tables

# List of Figures

# Websites

## *Florida Department of Environmental Protection, Bureau of Watershed Management*

**TMDL Program**

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

**Identification of Impaired Surface Waters Rule**

http://www.dep.state.fl.us/water/tmdl/docs/AmendedIWR.pdf

**STORET Program**

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

**2006 305(b) Report**

http://www.dep.state.fl.us/water/tmdl/docs/2006_Integrated_Report.pdf

**Criteria for Surface Water Quality Classifications**

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

**Basin Status Report for the Middle St. Johns River Basin**

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

**Water Quality Assessment Report for the Middle St. Johns River Basin**

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

## *U.S. Environmental Protection Agency, National STORET Program*

**Region 4: Total Maximum Daily Loads 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 total nitrogen (TN) and biochemical oxygen demand (BOD), which have caused nutrient and low dissolved oxygen (DO) impairments in the Little Wekiva Canal, located in the southwest section of the Middle St. Johns River Basin. The canal was verified as impaired for DO based on the results of sampling and analysis carried out between 1996 and 2002. These results revealed that 31 percent of the DO values measured during the planning period and 35 percent of the DO values measured during the verified period were below the Class III DO criterion of 5 milligrams per liter (mg/L). The Little Wekiva Canal was also verified as impaired for nutrients based on the results of chlorophyll-*a* (chl-*a*) sampling and analysis carried out between 1996 and 2002. During this period there were 84 surface water samples analyzed for TN and total phosphorus (TP) with median values of 1.16 mg/L and 0.08 mg/L, respectively.

The Little Wekiva Canal was subsequently included on the Verified List of impaired waters (impaired for nutrients [chl-*a*] and DO) that was adopted by Secretarial Order in May 2004. The TMDL for the Little Wekiva Canal establishes the allowable loadings that would restore the waterbody so that it meets its applicable water quality criteria for DO and nutrients (chl-*a*).

## 1.2 Identification of Waterbody

The Little Wekiva Canal (WBID 3004) watershed is located in central Florida, encompassing a small portion of the northwest corner of the city of Orlando (**Figure 1.1**) in north-central Orange County as well as western Seminole County. Eighty-five percent of the 21.4-square-mile ($mi^2$) drainage area (13,657 acres) of the Little Wekiva Canal is located in Orange County, and the remaining 15 percent (the northeast corner) is in Seminole County (**Figure 1.2**). The canal is in the southeastern part of the area designated by the Florida Legislature as the Wekiva Study Area and in the southwest section of the Middle St Johns River Basin. The Little Wekiva Canal is one of a total of 426 WBIDs in the Middle St. Johns River Basin; however, this TMDL only addresses WBID 3004.

The Little Wekiva Canal/River flows north and originates as a north-flowing channel outlet from 0.25-square-mile Lake Lawne (WBID 3004C) in the south-central section of WBID 3004. Lake Lawne is fed from the southwest by an east-flowing creek and on the east by a west-flowing canal. The canal is 1.9 miles long between Lake Lawne and Lake Wekiva (also known as Lake Orlando), 3.7 miles between Lake Wekiva and Lake Lotus, and 0.33 miles between Lake Lotus and Bear Lake and the outlet of WBID 3004. The Little Wekiva Canal flows from WBID 3004 into north Altamonte Springs and the Little Wekiva River. In total, including the segment in WBID 3004, the Little Wekiva Canal/River is approximately 15 miles long. It should be noted that the Little Wekiva Canal watershed has within its boundaries several lakes, two of which are impaired for nutrients (see **Table 1.1** and **Figure 1.2**).

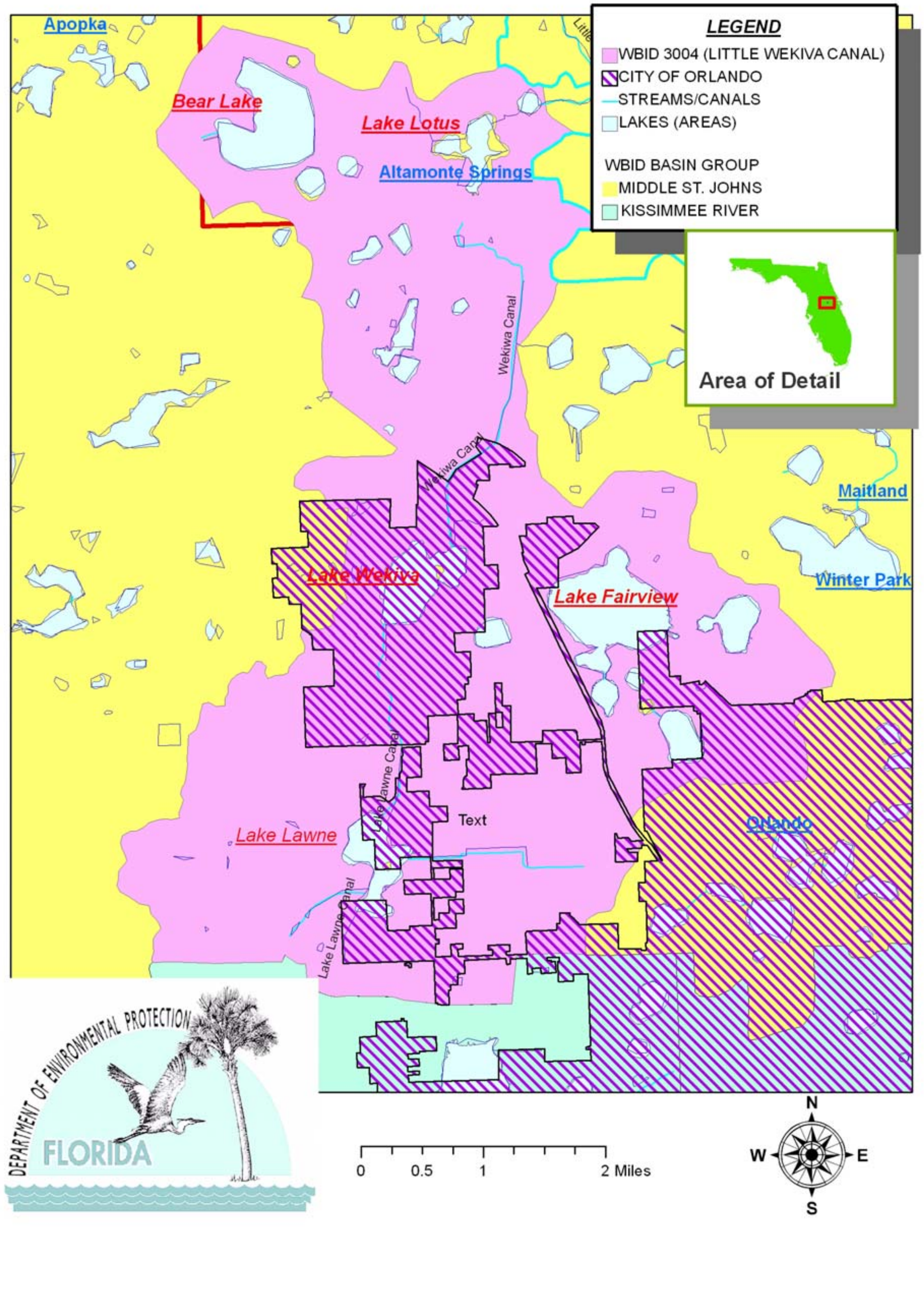



Figure 1.1. Little Wekiva Canal (WBID 3004) with Cities in Region

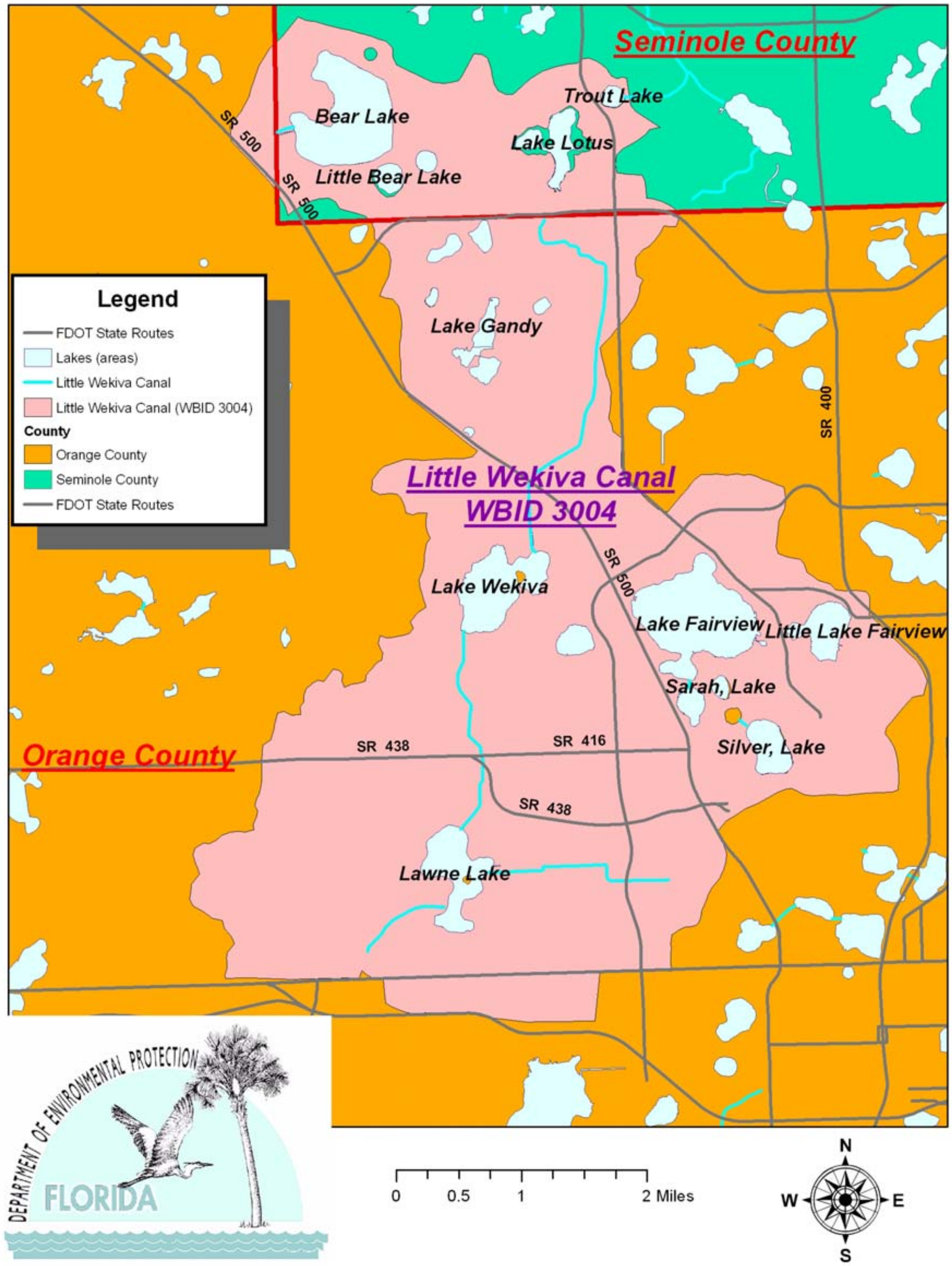



Figure 1.2. Little Wekiva Canal (WBID 3004) in Seminole and Orange County

Table 1.1. Verified Impaired Segments in the Little Wekiva Canal, WBID 3004

| WBID Number and Name | Area (acres) | Impairments |
|---|---|---|
| 3004 Little Wekiva Canal* | 13,657.2 | Nutrients, DO, Fecal Coliform, and BOD |
| 3004A Bear Lake | 309.6 | |
| 3004B Lake Fairview | 30.3 | |
| 3004C Lake Lawne | 156.7 | Nutrients |
| 3004D Silver Lake | 70.8 | Nutrients |
| 3004E Lake Daniel | 8.5 | |
| 3004F Lake Sarah | 12.6 | |
| 3004G Bay Lake | 36.5 | Nutrients |
| 3004H Little Lake Fairview | 85.0 | |
| 3004I Lake Rose | 6.2 | |
| 3004J Lake Gandy | 28.1 | |
| 3004K Lake Wekiva/Orlando | 195.3 | |
| 3004L Trout Lake | 16.6 | |
| 3004M Lake Lotus | 115.9 | |
| 3004N Lake Fairview | 364.3 | |
| 3004O Asher Lake | 5.2 | |
| 3004P Cub Lake | 14.9 | |
| 3004Q Little Bear Lake | 27.3 | |
| **TOTAL Area:** | **15,141.0** | |

* The area (13,657.2 acres) listed for WBID 3004 above excludes the areas of the lake WBIDs shown individually in **Table 1.1**.

The major population areas in the Little Wekiva Canal (WBID 3004) watershed include the Rosemont and Lockhart sections of Orlando (around Lake Wekiva), the Pine Hills section of Orlando (around Lake Lawne), and parts of Fairvilla in the southeast portion of the WBID. Besides containing portions of Orlando, WBID 3004 also includes the southwest corner of the city of Altamonte Springs, as well as highly populated areas outside the city limits of Orlando and Altamonte Springs.

## 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 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.

This TMDL report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to decrease nutrient concentrations, which should increase the amount of DO, decrease the amount of chl-*a*, and reduce any other causative pollutants responsible for the impairments of Little Wekiva Canal (WBID 3004). These activities will depend heavily on the active participation of the St. Johns River Water Management District (SJRWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake and continue reductions in the discharge of pollutants and achieve the established TMDLs for this waterbody.

### *1.3.1 Development of TMDL*

This TMDL was developed in cooperation with the SJRWMD, Orange County Public Works Department, Seminole County Public Works, and city of Orlando. There was also active coordination with a variety of local stakeholders throughout the TMDL development process. This included meetings and teleconference discussions between the Orange County Stormwater Management Division and the Department's Watershed Planning and Coordination Section. There were also regular meetings between Department officers, Seminole County officials, environmental advocacy groups, consultants, and other stakeholders who volunteered to participate, or whose participation was requested.

# 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) 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 these lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin is also required by the FWRA (Subsection 403.067[4], Florida Statutes [F.S.]), and the list is amended annually to include updates for each basin statewide.

Florida's 1998 303(d) list included 24 waterbodies in the Middle St. Johns River Basin. 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 rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007. The list of waters for which impairments have been verified using the methodology in the IWR is referred to as the Verified List.

## 2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Little Wekiva Canal (WBID 3004) and verified the impairment for low DO, with BOD as the causative pollutant, and the impairment for high nutrient concentrations (**Tables 2.1** and **2.2**). The Little Wekiva Canal was verified as impaired for DO because, based on the analysis results, there is at least 90 percent confidence that the exceedance rate is greater than or equal to 10 percent. The data are based on samples collected between 1996 and 2001. The annual chl-*a* concentrations (in micrograms per liter [μg/L]) for 1991 through 1994 were 20.5, 20.7, 13.6, and 23.2, respectively. The annual chl-*a* concentrations from 1996 through 2000 were 25.1, 13.0, 20.0, 26.6, and 10.0 μg/L, respectively. Thus, during the planning period 6 chl-*a* annual means exceeded the Class III chl-*a* assessment threshold for streams of 20 μg/L (1991, 1992, 1994, 1996, 1998, 1999) and during the verified period 3 chl-*a* annual means exceeded 20 μg/L (1996, 1998, 1999).

The BOD criterion for Class III fresh water is that BOD shall not be increased so as to cause DO to be depressed below the applicable DO criterion, and in no case shall it be great enough to cause nuisance conditions. The existence of elevated BOD (median values > 2.0 mg/L) led to the conclusion that BOD levels were affecting the DO concentrations.

## Table 2.1. Verified Impairments in the Little Wekiva Canal, WBID 3004

| WBID | Waterbody Segment | Parameters Identified Using the IWR | Concentrations Causing Impairment | Priority for TMDL Development | Projected Year for TMDL |
|---|---|---|---|---|---|
| 3004 | Little Wekiva Canal | DO and BOD | < 5.0 mg/L | Low | 2008 |
| 3004 | Little Wekiva Canal | Fecal Coliform Bacteria | > 400 per 100 mL | Low | 2008 |
| 3004 | Little Wekiva Canal | Nutrients (chl-*a*) | TN = 1.16 mg/L<br>TP = 0.08 mg/L | Low | 2008 |

Note: The parameters listed in **Table 2.1** provide a complete picture of the impairment in the Little Wekiva Canal, but this TMDL only addresses the DO, BOD, and nutrient impairment.

## Table 2.2. Summary of DO, BOD, and Chl-*a* Data from Verified Period Sampling (1996–2001) of the Little Wekiva Canal, WBID 3004

| Parameter of Concern | Number of Samples | IWR Required Exceedances (for impairment) | Actual Number of Exceedances | Summary of Analysis Concentrations (mg/L) | | | |
|---|---|---|---|---|---|---|---|
| | | | | ***Minimum*** | ***Maximum*** | ***Mean*** | ***Median*** |
| DO (IWR Run 18) | 65 | 11 | 23 | 0.5 | 12.09 | 5.92 | 6.16 |
| BOD | 62 | | | 0.2 | 9.61 | 2.4 | 2.1 |
| TP | 85 | | | 0.0024 | 0.14 | 0.054 | 0.057 |
| TN | 84 | | | 0.54 | 11.4 | 1.26 | 1.14 |

# 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)** |

### *3.1.1 Applicable Water Quality Standards and Numeric Water Quality Target*

#### Interpretation of Narrative BOD and Nutrient Criteria

The Little Wekiva Canal (WBID 3004) is considered a Class III waterbody, with a designated use of recreation, propagation, and the maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the impairment addressed by this TMDL is that DO shall not be less than 5.0 mg/L, with normal daily and seasonal fluctuations above these levels maintained. BOD shall not be increased to exceed values that would cause DO to be depressed below the established DO limit, and in no case shall it be great enough to produce nuisance conditions. The nutrient criterion is narrative and states that the discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in Rule 62-302, F.A.C. It also states that in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna (Section 62-302.530, F.A.C.).

#### Relationship between DO, Nutrients, and BOD

After verification of the low DO in the Little Wekiva Canal, the Department identified the causative pollutants by investigating those parameters typically responsible for depressed DO. These include nutrients (nitrogen and phosphorus) and BOD. To identify causative pollutants, the Department uses screening level concentrations set at the 70$^{th}$ percentile of all STORET data across the state from 1970 to 1987. The screening levels for streams are 2.0 mg/L for BOD5, 1.6 mg/L for TN, and 0.22 mg/L for TP. Although there is an expectation that one should find a relationship between the causative pollutants and DO data, it is often difficult to establish such a relationship without extensive data collection.

There is a known inverse relationship between average BOD and DO (with an elevated average BOD, one would expect to see depressed DO concentrations in a stream). However, many other factors are responsible for temporal and spatial variation in DO and BOD concentrations, including atmospheric interchange, plant respiration, sediment oxygen demand (SOD), and plant photosynthesis. This is likely the reason why there was generally no statistically significant relationship between DO and BOD when looking at a sample-by-sample analysis of the Little Wekiva Canal sample data (**Figure 3.1**). Even a sudden drop in BOD is not always matched by a corresponding increase in DO (Gray, 2004). The limited number of samples collected (and the lack of continuous sampling throughout the day) in the Little Wekiva Canal also made it more difficult to observe a correlation.

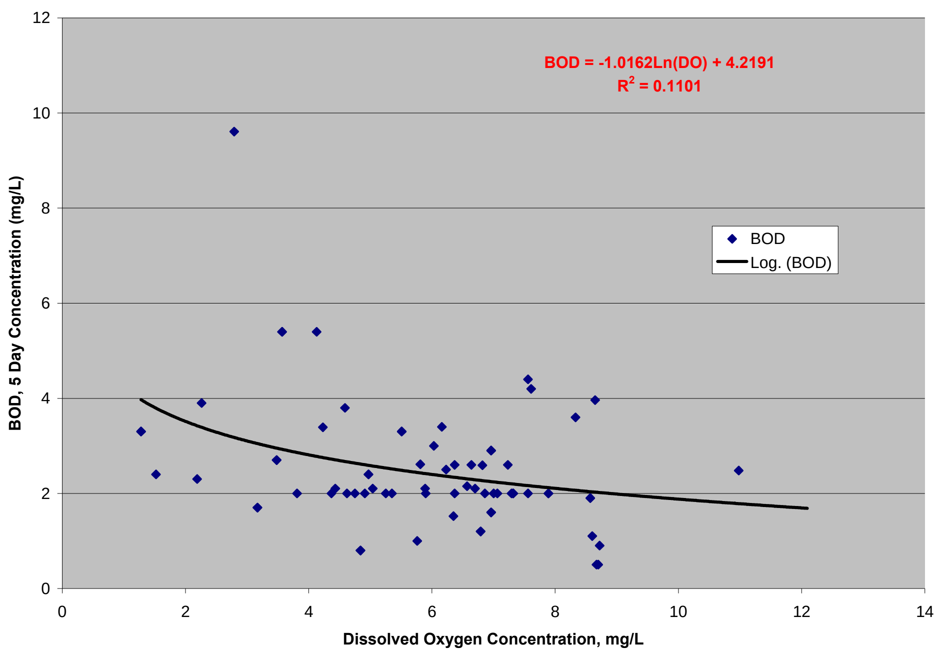



Figure 3.1. Relationship between DO and BOD in the Little Wekiva Canal on a Sample-by-Sample Basis

Even though no specific relationship between BOD and DO was observed (for the reasons outlined above), it is well established that high BOD is associated with depressed DO. Thus, the fact that the median BOD concentration of the Little Wekiva Canal exceeded the screening level of 2 mg/L (**Table 2.2**) was used as evidence that BOD was a factor in the low DO levels.

It is also noteworthy that when observing the data on a station-by-station monthly average basis (between 1996 and 2000), a statistical analysis of the three major sampling stations provides mixed results relative to BOD concentrations (**Tables 3.1, 3.2,** and **3.3**). While the BOD medians of the upstream stations, 21FLORANLWA (referred to as LWA) and 21FLORANLWB (referred to as LWB), are well above the screening level of 2.0, the BOD median of Station 21FLORANLWD (referred to as LWD) is well below the screening level. But, at the same time, it is at Station WLD where the $R^2$ is highest. Note the $R^2$ relationship (**Figure 3.2**) when plotting monthly average DO vs. BOD (for 1996 through 2000). Thus, for WBID 3004, the best correlation between DO and BOD is seen at the station where there is a smaller range of fluctuation in BOD values and the lowest median BOD value. This is most likely because fluctuations in BOD and higher BOD values may indicate a more complex system, including time lags, of those factors that influence BOD and DO.

## Table 3.1. Station 21FLORANLWA, Little Wekiva Canal, WBID 3004

| Month | DO | Chl-*a* | TN | TKN | TP | BOD |
|---|---|---|---|---|---|---|
| January | 10.98 | 21.00 | 1.25 | 1.17 | 0.02 | 2.48 |
| February | 6.57 | 9.30 | 1.22 | 1.16 | 0.04 | 2.88 |
| March | 5.57 | 19.85 | 1.17 | 1.10 | 0.01 | 2.60 |
| April | 2.19 | 5.20 | 1.25 | 1.18 | 0.12 | 2.30 |
| May | 4.27 | 21.80 | 5.59 | 5.54 | 0.07 | 5.04 |
| June | 4.78 | 4.70 | 1.09 | 0.95 | 0.05 | 2.95 |
| July | 3.81 | 34.10 | N/A | N/A | N/A | 2.00 |
| August | 1.28 | 19.20 | 1.77 | 1.73 | 0.09 | 3.30 |
| September | 6.00 | 29.37 | 1.10 | 1.28 | 0.06 | 2.54 |
| October | 7.56 | 57.30 | 1.62 | 1.60 | 0.02 | 4.40 |
| November | 3.48 | 19.20 | 1.56 | 1.50 | 0.08 | 2.70 |
| December | 4.26 | 5.83 | 1.59 | 1.43 | 0.06 | 2.33 |
| **Average** | **5.06** | **20.57** | **1.74** | **1.69** | **0.06** | **2.96** |
| **Geometric Mean** | **4.44** | **15.87** | **1.53** | **1.47** | **0.05** | **2.86** |
| **Median** | **4.52** | **19.53** | **1.25** | **1.28** | **0.06** | **2.65** |
| **Standard Deviation** | **2.57** | **14.92** | **1.30** | **1.30** | **0.03** | **0.90** |

TKN – Total Kjeldahl nitrogen.
N/A – Not available

## Table 3.2. Station 21FLORANLWB, Little Wekiva Canal, WBID 3004

| Month | DO | Chl-*a* | TN | TKN | TP | BOD |
|---|---|---|---|---|---|---|
| January | 8.65 | 63.00 | 1.40 | 1.31 | 0.02 | 3.96 |
| February | 6.91 | 20.80 | 1.20 | 1.11 | 0.06 | 3.15 |
| March | 5.80 | 14.05 | 0.72 | 0.70 | 0.04 | 2.30 |
| April | 6.37 | 9.70 | 1.00 | 0.95 | 0.08 | 2.00 |
| May | 6.23 | 35.17 | 1.24 | 1.22 | 0.07 | 3.72 |
| June | 6.70 | 16.70 | 0.94 | 0.90 | 0.09 | 2.10 |
| July | 4.75 | 41.30 | N/A | N/A | N /A | 2.00 |
| August | 4.43 | 16.00 | 0.98 | 0.91 | 0.03 | 2.10 |
| September | 6.02 | 31.87 | 1.03 | 0.99 | 0.03 | 2.43 |
| October | 6.16 | 36.60 | 1.14 | 1.10 | 0.06 | 3.40 |
| November | 6.64 | 32.40 | 1.17 | 1.07 | 0.04 | 2.60 |
| December | 6.24 | 9.60 | 0.99 | 0.83 | 0.05 | 2.31 |
| **Average** | **6.24** | **27.27** | **1.07** | **1.01** | **0.05** | **2.67** |
| **Geometric Mean** | **6.16** | **23.26** | **1.06** | **0.99** | **0.04** | **2.60** |
| **Median** | **6.23** | **26.33** | **1.03** | **0.99** | **0.05** | **2.37** |
| **Standard Deviation** | **1.06** | **15.80** | **0.18** | **0.18** | **0.02** | **0.70** |

N/A – Not available

## Table 3.3. Station 21FLORANLWD, Little Wekiva Canal, WBID 3004

| Month | DO | Chl-*a* | TN | TKN | TP | BOD |
|---|---|---|---|---|---|---|
| January | N/A | N/A | 0.99 | 0.66 | 0.13 | N/A |
| February | 7.78 | 8.10 | 1.20 | 0.75 | 0.06 | 1.48 |
| March | 7.34 | 5.60 | 0.82 | 0.52 | 0.05 | 1.25 |
| April | 4.62 | 1.00 | 0.91 | 0.54 | 0.05 | 2.00 |
| May | 3.99 | 19.86 | 1.27 | 1.03 | 0.07 | 2.60 |
| June | 6.46 | 2.85 | 0.92 | 0.60 | 0.03 | 1.67 |
| July | 5.35 | 35.60 | 1.16 | 1.10 | 0.02 | 2.00 |
| August | 6.77 | 5.17 | 1.06 | 0.73 | 0.05 | 1.38 |
| September | 7.38 | 50.00 | 0.94 | 0.93 | 0.01 | 1.45 |
| October | 7.06 | 44.90 | 1.14 | 1.00 | 0.07 | 1.52 |
| November | 7.51 | 10.00 | 1.12 | 0.77 | 0.05 | 1.73 |
| December | 5.75 | 1.80 | 1.21 | 0.54 | 0.07 | 2.00 |
| **Average** | **6.36** | **16.81** | **1.06** | **0.76** | **0.06** | **1.73** |
| **Geometric Mean** | **6.24** | **8.60** | **1.05** | **0.74** | **0.05** | **1.70** |
| **Median** | **6.77** | **8.10** | **1.09** | **0.74** | **0.05** | **1.67** |
| **Standard Deviation** | **1.27** | **18.18** | **0.14** | **0.21** | **0.03** | **0.39** |

N/A – Not available

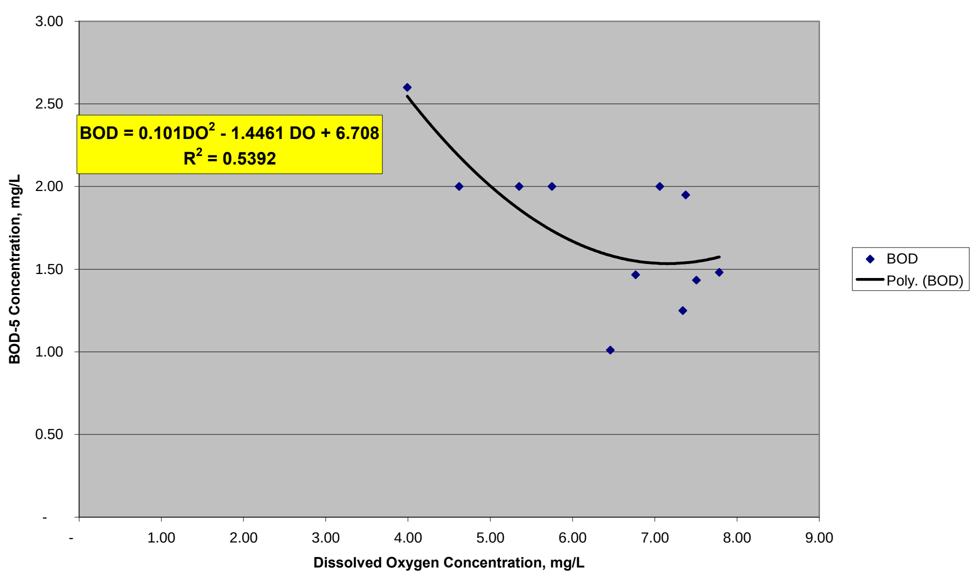



Figure 3.2. Comparison of Monthly Averages of BOD vs. DO from Samples Taken at Station LWD, 1996–2000

When observing the chl-*a* monthly averages over the same period, one again observes that Stations LWA and LWB have substantially higher levels than were found in Station LWD. When observing the individual stations, one sees that the TN of LWA is higher than LWB and LWD (whose averages are approximately the same). When graphing and looking at the relationships between nutrients and chl-*a* or DO, the picture also varies between sample stations.

For the three major sample stations in the Little Wekiva Canal (LWA, LWB, and LWD), the relationships between DO and the potential causative pollutants TN, TP and BOD, and between chl-*a* and the nutrients TP and TN were determined. **Table 3.4** lists the linear regression equations relating the four-year monthly averages (**Tables 3.1** through **3.3**) of the given parameters and their respective coefficients of determination ($R^2$). The $R^2$, which illustrates the goodness of fit of the data to the regression equation, varies between parameters and stations. The highlighted equations are those with the best correlation for given sample station.

Table 3.4. Sample Station Four–Year Monthly Averages for WBID 3004: Relationships Between Nutrients and BOD, DO, or Chl-*a*

| | Station LWA | | Station LWB | | Station LWD | |
|---|---|---|---|---|---|---|
| | ***Equation*** | ***$R^2$*** | ***Equation*** | ***$R^2$*** | ***Equation*** | ***$R^2$*** |
| DO vs. TP | TP = -.0094DO+.1045 | 0.638 | TP=.0003DO+.0472 | 0.0002 | TP=-.003DO+.066 | 0.029 |
| DO vs. BOD | BOD = .00077DO + 3.04 | 5.38 E -6 | BOD=.421DO + .091 | 0.28 | BOD = 0.101DO$^2$ - 1.4461 DO + 6.708 | 0.5392 |
| Chl-*a* vs. TN | TN = .0094Chl*a*+1.56 | 0.012 | TN=.009Chl*a*+.837 | 0.637 | TN=.0011Chl*a*+1.047 | 0.02 |
| Chl-*a* vs.TP | TP= -.00103Chl*a* +.08 | 0.241 | TP= -.0006Chl*a*+.0654 | 0.205 | TP= -.0003Chl*a*+.0554 | 0.113 |

**Tables 3.1** through **3.3** show TP annual average concentrations to be fairly constant throughout the period covered by these stations, but **Table 3.4** shows a strong correlation between TP and DO only at Station LWA. This could be due to the fact that Lake Lawne, which is immediately upstream of LWA, is a phosphorus-limited system. There is no significant coefficient of determination for TP vs. either DO or chl-*a* at the other two stations (LWB and LWD). The only station where there is any possible significant correlation between TN and chl-*a* is Station LWB, where the $R^2$ is 0.638. It is interesting that the $R^2$ appears to increase between BOD and DO as the station annual BOD average decreases. Thus, for Station LWB the $R^2$ for BOD vs. DO is 0.28, and for Station LWD the $R^2$ for these parameters is 0.539. There is a definite relationship when plotting the three stations in terms of their annual averages of DO vs. BOD (**Figure 3.4**), which supports a higher correlation between high BOD and low DO upstream than downstream.

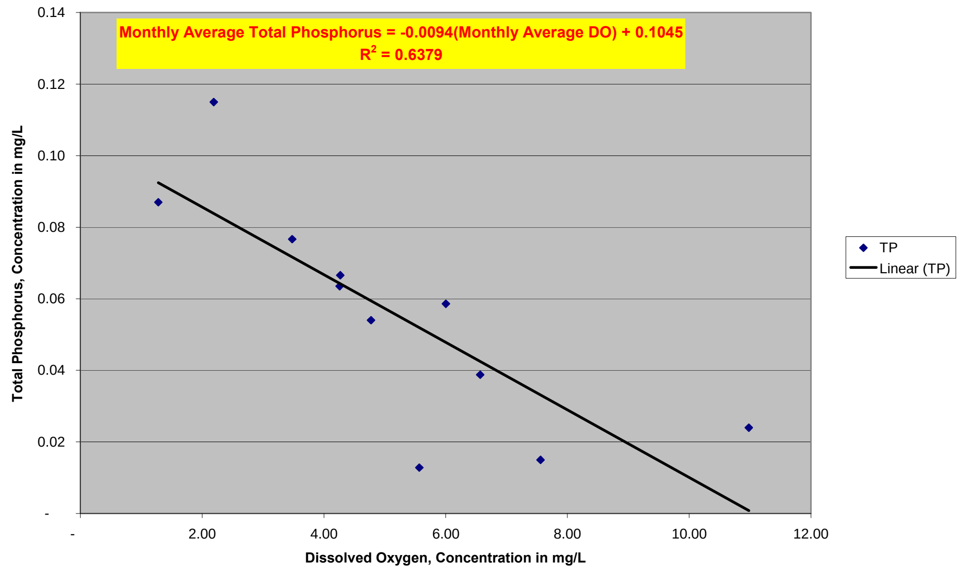



Figure 3.3. TP vs. DO at Station WLA, WBID 3004

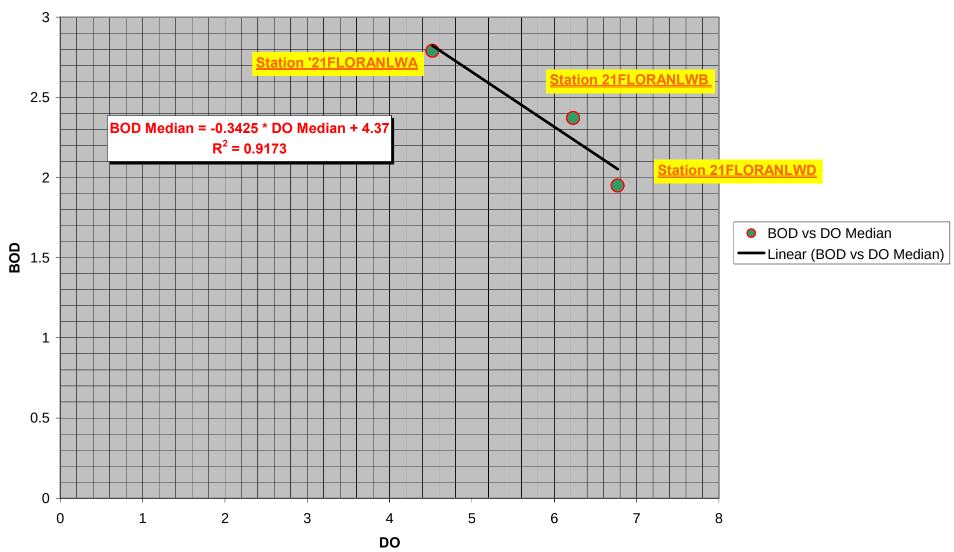



Figure 3.4. Annual Median DO and BOD at Three Stations

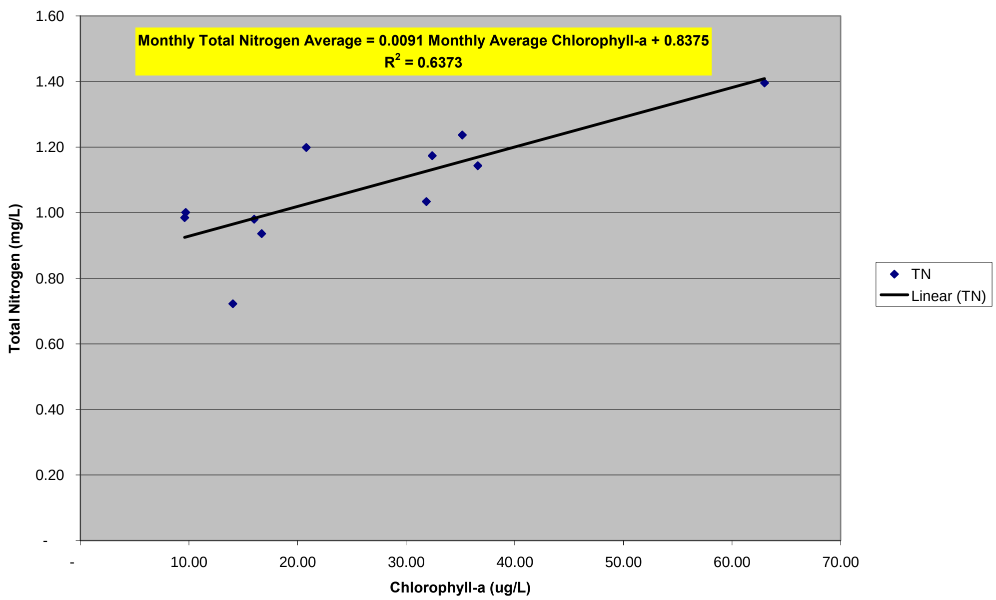



Figure 3.5. TN vs. Chl-*a* at Station LWB

The only observed relationship between DO and TP is an inverse relationship seen at Station LWA (**Figure 3.3** and **Table 3.4**). At Station LWB there is a positive relationship observed between chl-*a* and TN (**Table 3.4** and **Figure 3.5**). Although the correlation between monthly average DO and TP (Station LWA) and chl-*a* and TN (Station LWB) is much stronger than between DO and BOD at these stations, one cannot discount the impact of BOD at these stations because both BOD and DO depend on other variables to differing degrees.

The equations relating TP and BOD to DO as well as chl-*a* and TN at stations in WBID 3004 are summarized below. The regression equation relating TN to chl-*a* as shown in **Figure 3.5** is as follows:

$$TN = .0091 \text{ chl-}a + .8375 \quad R^2 = .6373$$ **(Equation 3.1)**

where:

TN = TN Concentration (mg/L), and
Chl-*a* = Chl-*a* Concentration (μg/L)

Solving the above equation at the Class III freshwater assessment threshold (chl-*a* of 20 μg/L) gives a resulting TN concentration = 1.02 mg/L. It should be noted that this target TN annual average value is below the Department's screening level for TN (1.6 mg/L). However, based on data collected in Little Wekiva Canal, a TN concentration of 1.6 mg/L would result in DO levels in the canal significantly below the DO criterion. A target of 1.02 is only slightly below the 1.06 mg/L annual average TN currently observed at downstream Station LWD. Thus, the Department set the target TN load at 1.02 mg/L.

At Station LWA, where the highest TP concentrations are found, TP is related to DO (**Figure 3.3**) by equation:

$$TP = -0.0094\ DO + .1045 \quad R^2 = .6379 \qquad \textbf{(Equation 3.2)}$$

where:

TP = TP Concentration (mg/L), and
DO = DO Concentration (mg/L)

Solving the above equation at the Class III freshwater criterion (a DO of 5 mg/L) gives a resulting TP concentration = 0.05 mg/L. The strong correlation between TP and DO is a reflection of TP being the limiting nutrient for algae in receiving waters directly downstream of Lake Lawne, which is only .01 mg/L lower than the present average TP concentration at Stations LWA and LWB (0.06 mg/L) and equal to the present average TP concentration at Station LWD. It is also far below the threshold screening level concentration of .22 mg/L. Thus, because the TP concentration is already approximately the same as the calculated target and all concentrations are also far below the TP screening level, neither a TP target nor TMDL will be pursued for the Little Wekiva Canal.

At Station LWD, where the lowest BOD, TP, and TN concentrations are found, BOD is related to DO (**Figure 3.2**) by the polynomial regression equation:

$$BOD = 0.101\ (DO)^2 - 1.4461\ DO + 6.708 \quad R^2 = 0.539 \qquad \textbf{(Equation 3.3)}$$

where:

BOD = BOD Demand – 5 Day (mg/L), and
DO = DO Concentration (mg/L)

Solving the above equation at the Class III freshwater criterion (a DO of 5 mg/L) gives a resulting BOD concentration = 2.0025 mg/L or 2.0 mg/L, which is identical to the BOD $70^{th}$ percentile screening value previously mentioned. Again, it should not be unreasonable to require a reduction to 2.0 mg/L because BOD levels within the WBID are near this concentration. Thus, the Department sets the target BOD load at 2.0 mg/L.

# 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 low DO 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 System (NPDES) Program. 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" is 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. 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 BOD and Low DO in the Little Wekiva Canal Watershed (WBID 3004)

### *4.2.1 Point Sources*

#### Estimating Point Source Loads

There are no permitted wastewater facilities located in the Little Wekiva Canal (WBID 3004), but the Altamonte Springs Regional Water Reclamation Facility, a domestic wastewater treatment facility (**Table 4.1**), is located to the northeast of WBID 3004, in WBID 2987 (Little Wekiva River). Because this facility does not discharge pollutants contributing to low DO or nutrients into WBID 3004, no pollutant loading is calculated for this facility in this report.

Table 4.1. Point Sources in the Little Wekiva Canal, WBID 3004

| Facility Name | Type | Permit |
|---|---|---|
| Altamonte Springs Regional Water Reclamation Facility<br>950 Keller Road,<br>Altamonte Springs, FL 32714 | Municipal WWTF | WAFR - FL0033251 Domestic Wastewater Program |

### Municipal Separate Storm Sewer System Permittees

Within WBID 3004, Orange County has a Phase I municipal separate storm sewer system (MS4) permit (FLS000011). The Florida Department of Transportation (FDOT) District 5 and the city of Maitland are copermittees. In addition, the city of Orlando holds a separate Phase I permit (FLS000014). For the drainage areas of the other lakes, including Silver Lake, Lake Florida, Lake Orienta, and Lake Adalaide, Seminole County holds an MS4 Phase I permit (FLS000038), with FDOT District 5 and the city of Altamonte Springs being copermittees.

## *4.2.2 Land Uses and Nonpoint Sources*

Because land uses in the Little Wekiva Canal watershed are essentially urban in nature, most of the nonpoint source runoff is consistent with an urban environment. The only agriculture is in the form of 82 acres devoted to tree crops (0.6 percent of the watershed), 15 acres devoted to nurseries and vineyards (0.11 percent of the watershed), and cropland/pastureland (0.09 percent of the watershed). Thus the total contribution from agriculture is 109 acres (0.8 percent of the watershed), and there are relatively few nonpoint sources of BOD or TN from production agriculture (horticulture, food crops, or livestock) in the watershed. The main nonpoint sources include runoff and erosion from developed areas, small-scale construction, residential and commercial fertilizer use, pets, and residential septic tank failure or poor design.

### Land Uses

Land use categories in the Little Wekiva Canal watershed were aggregated using the simplified Level 1 codes (**Table 4.2**). By far the largest Level 1 land use is urban and built-up (80 percent). When looking at Level 2, which is a more detailed categorization of land use (**Table 4.3**), urban and built-up land uses comprise (in order of highest to lowest) medium-density residential (36.1 percent), high-density residential (10.7 percent), industrial (9.3 percent), commercial (9 percent), recreational (4.5 percent), institutional (3.1 percent), and low-density residential (2.8 percent). If the Level 1 Category of transportation, communication, and utilities (4.1 percent) is added to the urban and built-up category, human land uses constitute more than 80 percent of the WBID.

## Table 4.2. Level 1 Land Uses in the Little Wekiva Canal Watershed, WBID 3004

| Land Use Code and Description | Acres | % Total |
|---|---|---|
| 1000: Urban and Built-up | 10,908.3 | 79.87% |
| 6000: Wetland | 1,018.4 | 7.46% |
| 4000: Upland Forests | 632.8 | 4.63% |
| 8000: Transportation, Communication, and Utilities | 555.5 | 4.07% |
| 5000: Water | 274.9 | 2.01% |
| 2000: Agriculture | 109.8 | 0.80% |
| 3000: Rangeland | 100.4 | 0.74% |
| 7000: Barren Land | 57.0 | 0.42% |
| **Total:** | **13,657.2** | **100.00%** |

## Table 4.3. Classification of Level 2 Land Use Categories in the Little Wekiva Canal Watershed, WBID 3004

| Land Use Code and Description | Acres | % Total |
|---|---|---|
| 1200: Residential, Medium Density | 4,929.6 | 36.10% |
| 1300: Residential, High Density | 1,456.0 | 10.66% |
| 1500: Industrial | 1,271.5 | 9.31% |
| 1400: Commercial | 1,227.3 | 8.99% |
| 1800: Recreation | 612.9 | 4.49% |
| 1900: Openland | 605.8 | 4.44% |
| 4300: Upland Mixed Forest | 525.8 | 3.85% |
| 8100: Transportation | 441.6 | 3.23% |
| 1100: Residential, Low Density | 424.2 | 3.11% |
| 6300: Wetland Forest Mixed | 408.0 | 2.99% |
| 1700: Institutional | 381.0 | 2.79% |
| 6400: Vegetated Nonforested Wetlands | 377.0 | 2.76% |
| 6200: Wetland Coniferous Forests | 177.4 | 1.30% |
| 5300: Reservoirs | 161.0 | 1.18% |
| 5200: Lakes | 111.9 | 0.82% |
| 2200: Tree Crops | 82.4 | 0.60% |
| 8300: Utilities | 76.5 | 0.56% |
| 4100: Upland Coniferous | 74.7 | 0.55% |
| 7400: Disturbed Land | 57.0 | 0.42% |
| 6100: Wetland Hardwood Forests | 55.9 | 0.41% |
| 8200: Communication | 37.5 | 0.27% |
| 3200: Shrub and Brushland | 35.9 | 0.26% |
| 3300: Mixed Rangeland | 32.4 | 0.24% |
| 4200: Upland Hardwood | 32.3 | 0.24% |
| 3100: Herbaceous | 32.2 | 0.24% |
| 2400: Nurseries and Vineyards | 15.3 | 0.11% |
| 2100: Cropland and Pastureland | 12.1 | 0.09% |
| 5100: Streams and Waterways | 2.0 | 0.01% |
| **Total:** | **13,657.2** | **100.00%** |

Primarily nonhuman land use includes wetland (7.5 percent), upland forest (4.6 percent), rangeland (0.74 percent), barren land (0.42 percent) and agriculture (tree crops at 0.6 percent, nurseries and vineyards at 0.11 percent, and cropland/pastureland at 0.09 percent). Based on an analysis of land use percentages for the watershed and the corresponding Event Mean Concentrations (EMCs) (**Tables 4.4a** and **4.4b**), the three largest land use contributors of BOD, TP, and TN from stormwater runoff are medium-density residential, high-density residential, and commercial. The EMCs and directly connected impervious areas (DCIAs) shown in **Tables 4.4a** and **4.4b** were provided by CDM based on a previous study in the Little Wekiva River watershed (CDM, 2005).

Table 4.4a. Land Use Categories for Modeling and Corresponding Relative DCIA Contributions, EMC, and Pollutant Contributions

| WMM Land Use Breakdown | WBID 3004– Little Wekiva Canal Area | | DCIA for Each Land Use | Weighted Average DCIA for WBID | % of Total WBID DCIA by Land Use (% Area x DCIA) |
|---|---|---|---|---|---|
| | ***Acres*** | ***%*** | | | |
| A. Forest/Rural Open | 1,702.9 | 12.47% | 1.00% | 0.125% | 0.28% |
| B. Urban Open | 57.0 | 0.42% | 17.00% | 0.071% | 0.16% |
| C. Agriculture/Pasture | 109.8 | 0.80% | 1.00% | 0.008% | 0.02% |
| D. Low Density/Residential | 424.2 | 3.11% | 30.00% | 0.932% | 2.06% |
| E. Medium Density/Residential | 4,929.6 | 36.10% | 37.00% | 13.355% | 29.48% |
| F. High Density/Residential | 1,456.0 | 10.66% | 71.00% | 7.570% | 16.71% |
| G. Commercial | 1,608.2 | 11.78% | 85.00% | 10.009% | 22.10% |
| H. Industrial | 1,004.4 | 7.35% | 71.00% | 5.222% | 11.53% |
| I. Highways | 441.6 | 3.23% | 100.00% | 3.234% | 7.14% |
| J. Water | 274.9 | 2.01% | 28.00% | 0.564% | 1.24% |
| K. Wetland | 1,018.4 | 7.46% | 28.00% | 2.088% | 4.61% |
| L. Institutional | 381 | 2.79% | 65.00% | 1.813% | 4.00% |
| M. Golf Courses | 249 | 1.82% | 17.00% | 0.310% | 0.68% |
| **TOTAL** | **13,657.2** | **100%** | | **45%** | **100%** |

## Table 4.4b. Land Use Categories and Corresponding EMC Contributions

| Storm Water Management Model (SWMM) Land Use Breakdown | Event Mean Concentrations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Total N*** | | | ***Total P*** | | | ***Dissolved P*** | | |
| | ***EMC*** | ***EMC Weighted by Land Use % Total WBID DCIA*** | ***% Total Load Based on Weighted EMC*** | ***EMC*** | ***EMC Weighted by Land Use % Total WBID DCIA*** | ***% Total Load Based on Weighted EMC*** | ***EMC*** | ***EMC Weighted by Land Use % Total WBID DCIA*** | ***% Total Load Based on Weighted EMC*** |
| A. Forest/Rural Open | 1.41 | 1.56E-03 | 0.08% | 0.053 | 4.00E-05 | 0.01% | 0.004 | 4.34E-07 | 0.00% |
| B. Urban Open | 1.41 | 8.90E-04 | 0.04% | 0.053 | 2.28E-05 | 0.01% | 0.004 | 2.47E-07 | 0.00% |
| C. Agriculture/Pasture | 2.32 | 4.91E-04 | 0.02% | 0.34 | 8.06E-05 | 0.02% | 0.23 | 5.02E-05 | 0.02% |
| D. Low Density/ Residential | 1.97 | 4.04E-02 | 1.95% | 0.3 | 5.86E-03 | 1.59% | 0.18 | 2.86E-03 | 1.30% |
| E. Medium Density/ Residential | 2.13 | 7.13E-01 | 34.48% | 0.4 | 1.38E-01 | 37.35% | 0.24 | 8.96E-02 | 40.86% |
| F. High Density/ Residential | 2.3 | 4.96E-01 | 23.95% | 0.49 | 1.17E-01 | 31.79% | 0.26 | 8.27E-02 | 37.68% |
| G. Commercial | 1.75 | 3.30E-01 | 15.97% | 0.29 | 4.63E-02 | 12.54% | 0.14 | 1.76E-02 | 8.00% |
| H. Industrial | 2.03 | 1.80E-01 | 8.71% | 0.31 | 2.70E-02 | 7.31% | 0.17 | 1.24E-02 | 5.67% |
| I. Highways | 2.01 | 1.09E-01 | 5.27% | 0.34 | 1.79E-02 | 4.86% | 0.19 | 9.23E-03 | 4.21% |
| J. Water | 0.79 | 1.32E-03 | 0.06% | 0.11 | 7.03E-05 | 0.02% | 0.02 | 3.81E-06 | 0.00% |
| K. Wetland | 1.5 | 3.59E-02 | 1.74% | 0.19 | 3.30E-03 | 0.89% | 0.09 | 8.04E-04 | 0.37% |
| L. Institutional | 2.29 | 1.41E-01 | 6.81% | 0.15 | 1.02E-02 | 2.77% | 0.08 | 2.21E-03 | 1.01% |
| M. Golf Courses | 2.32 | 1.89E-02 | 0.91% | 0.34 | 3.11E-03 | 0.84% | 0.23 | 1.94E-03 | 0.88% |
| **TOTAL** | | **2.07E+00** | | | **3.69E-01** | | | **2.19E-01** | |

### 4.2.3 Modeling Nonpoint Source Loading

#### Estimating Flow

The determination of nonpoint source loading requires an estimation of stream flow rate as well as the concentration of pollutant. There has been nearly continuous U.S. Geological Survey (USGS) flow monitoring near the Little Wekiva Canal (WBID 3004) at USGS Site # 02234990 on State Road 434 (Wekiva Springs Road near the intersection with Kensington Park) between February 1972 and the present. Site 02234990 is approximately 3.75 canal miles north of WBID 3004. There was a 3-year interruption in monitoring between October 1, 1979, and September 30, 1982 (see **Figure 4.1**). There was also continuous flow monitoring between June 9, 1995, and March 11, 2002, at USGS Site # 02234998 on Springs Landing (see **Figure 4.2**), 5.0 miles north of WBID 3004. Finally, between 1972 and 1974 there were flow gage heights translated into flow measurements at USGS Station 02234815 at the Lake Wekiva outlet (see **Figure 4.3**).

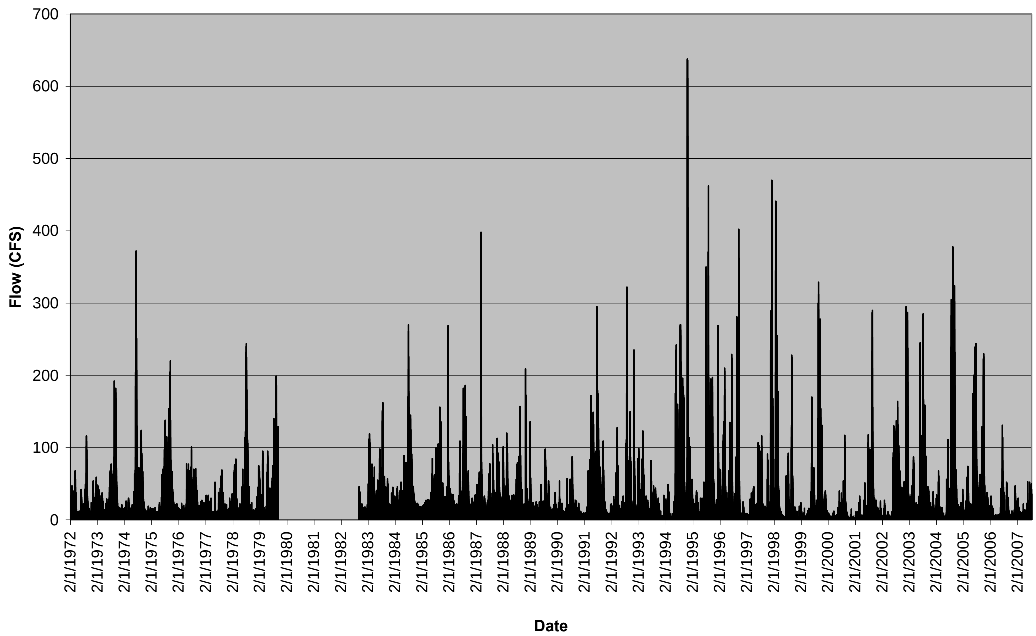



Figure 4.1. Flow at USGS Station 02234990

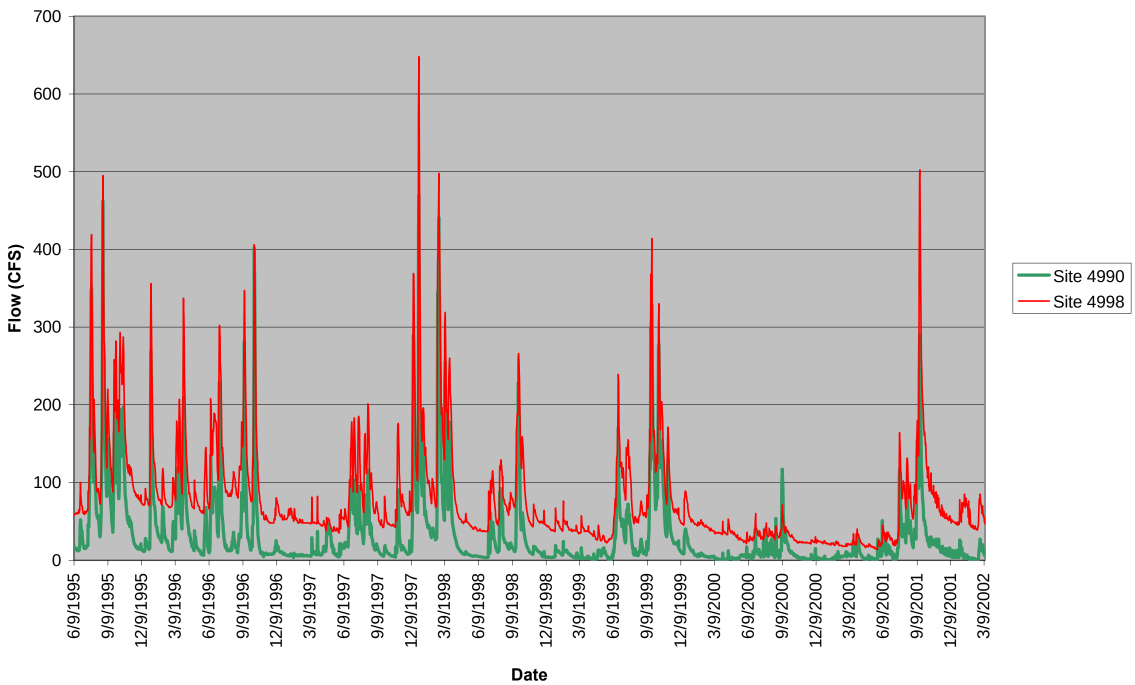



Figure 4.2. Flow at USGS Stations 02234998 and 02234990

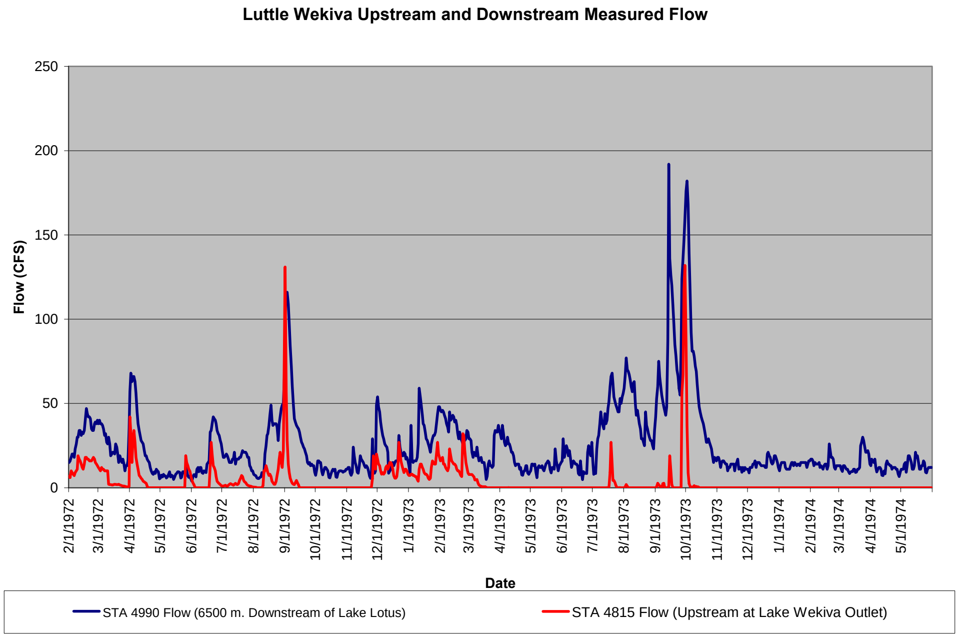



Figure 4.3. Flow at USGS Stations 02234815 and 02234990

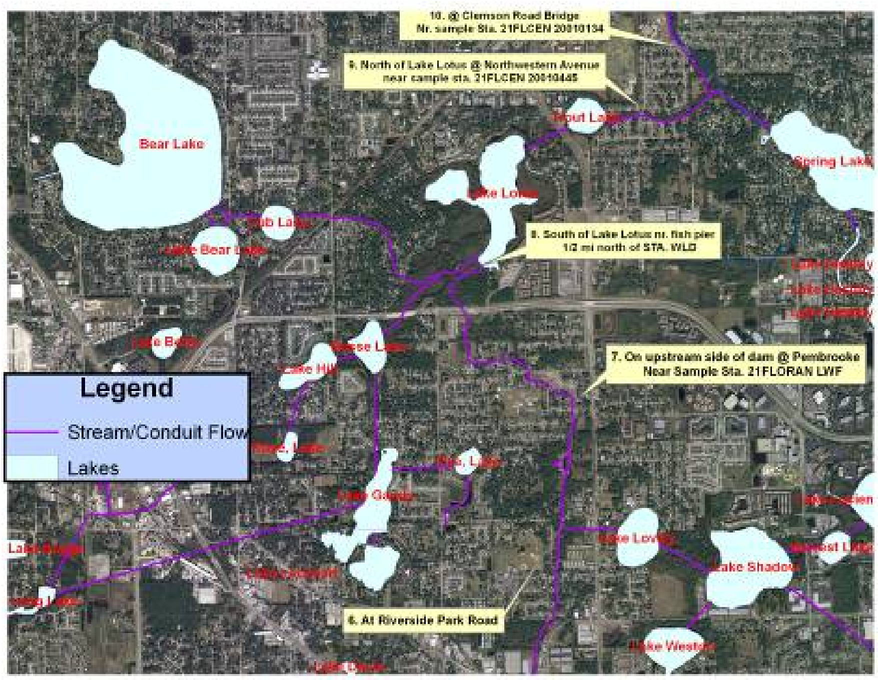
On February 22 and June 20, 2007, the USGS gaged flows at the Little Wekiva near Altamonte Springs Station (STA 2234990) were recorded as 5.8 cubic feet per second (cfs) and 4.6 cfs, respectively. On the same dates, the Department's Watershed Assessment Section crew, using a Marsh-McBirney flow meter and wading rod, recorded flows at the same site of 6.4 and 4.2 cfs, respectively. The differences are reasonable and can be attributed, at least in part, to the fact that the USGS value is a mean daily flow, and the Department's measurements represent a measurement taken across a stream during a half-hour monitoring event during those days. Both measurements were taken during a "longer than normal" dry season. There were near-drought conditions during May and June 2007, explaining the lower flow values in late June, which is typically the beginning of the wet season.

Baseflow can, in many cases, be correlated to the area of contributing watershed. The Little Wekiva Canal watershed is complicated by the existence of areas of springs, ground water recharge, and connecting conduits providing flow and overflow from nearby lakes and springs. Thus, on February 22 and June 20, 2007, the Department's Watershed Assessment Section crew measured flow along the length of the Little Wekiva Canal to observe the change in flow along the length of the canal. The goal was to develop a relationship between the point of continuous USGS flow measured at STA 2234990 and the various stations along the length of the Little Wekiva Canal, including the basin outlet at Station 9. The measured flows and DO at the stations are shown in **Table 4.5** and locations displayed in **Figures 4.4, 4.5, 4.6,** and **4.7**.

## Table 4.5. DO and Flow Data from February 22 and June 20, 2007

| Site No. | Site Description | DO (mg/L) | | February 22, 2007 Department | | June 20, 2007 Department | | USGS | USGS |
|---|---|---|---|---|---|---|---|---|---|
| | | *February 22, 2007* | *June 20, 2007* | *cfs* | *Gallons/ minute* | *cfs* | *Gallons/ minute* | *February 22, 2007 (cfs)* | *June 20, 2007 (cfs)* |
| 1 | Lake Lawne Inlet 1 | | 0.32 | | | | | | |
| 2 | Lake Lawne Inlet 2 | 2 | 2.6 | 0.08 | 35. | 0.1 | 50 | | |
| 3 | Lake Lawne Inlet East Side–Apartment Complex | 8.3 | 0.4 | | | | | | |
| 4 | Outlet, Lake Lawne | 13.7 | 6.21 | 0.98 | 438.7 | 1.2 | 543 | | |
| 5 | Lake Wekiva Upstream | 9.1 | 5.6 | 1.1 | 512.8 | 2.0 | 916 | | |
| 6 | Riverside Park Road | 7.8 | 8.3 | 2.9 | 1345 | | | | |
| 7 | Lake Wekiva on Upstream Side / Dam Structure | 6.5 | 4 | | | | | | |
| 8 | South of Lake Lotus | 8.9 | | 3.2 | 1416 | | | | |
| 9 | North of Lake Lotus | 5.4 | 1.6 | 6.0 | 2701 | 2.6 | 1151 | | |
| 10 | After Confluence from Lotus and Spring | 7.7 | 2.7 | 5.3 | 2386. | 2.9 | 1292 | | |
| 11 | Bridge near Hotel | | 3.9 | | | 3.5 | 1574 | | |
| 12 | Montgomery Road & Pump Station | 7.9 | 6.5 | | | 3.9 | 1750 | | |
| 13 | Rte 434 * USGS 4990 | 8.1 | 11.1 | 6.4 | 2862 | 4.2 | 1873 | 5.8 | 4.6 |
| 14 | Springs Landing Blvd | 5.2 | 4.6 | | | | | | |


## Figure 4.4. Upstream Flow Monitoring




## Figure 4.5. Downstream Flow Monitoring

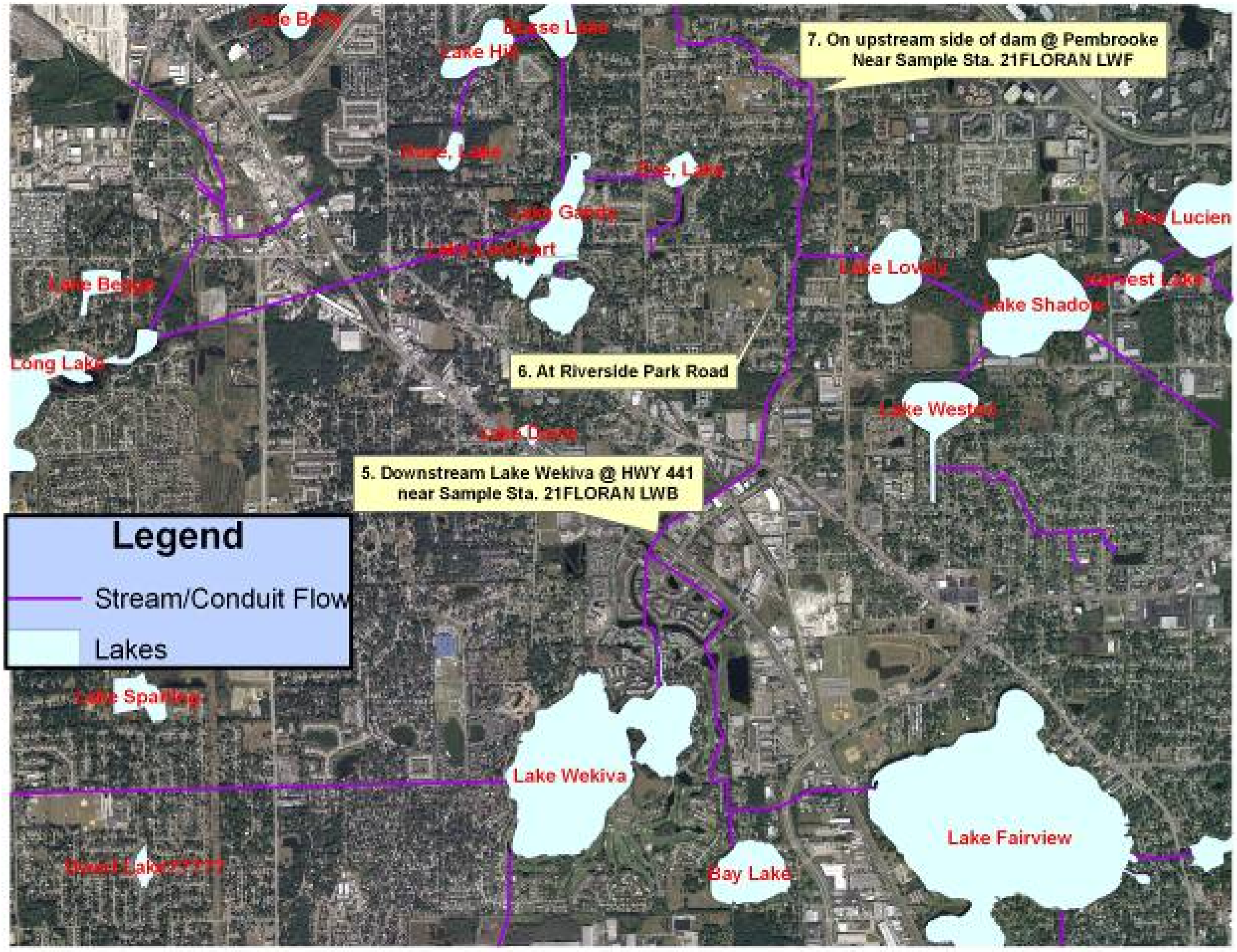



Figure 4.6. Central Flow Monitoring

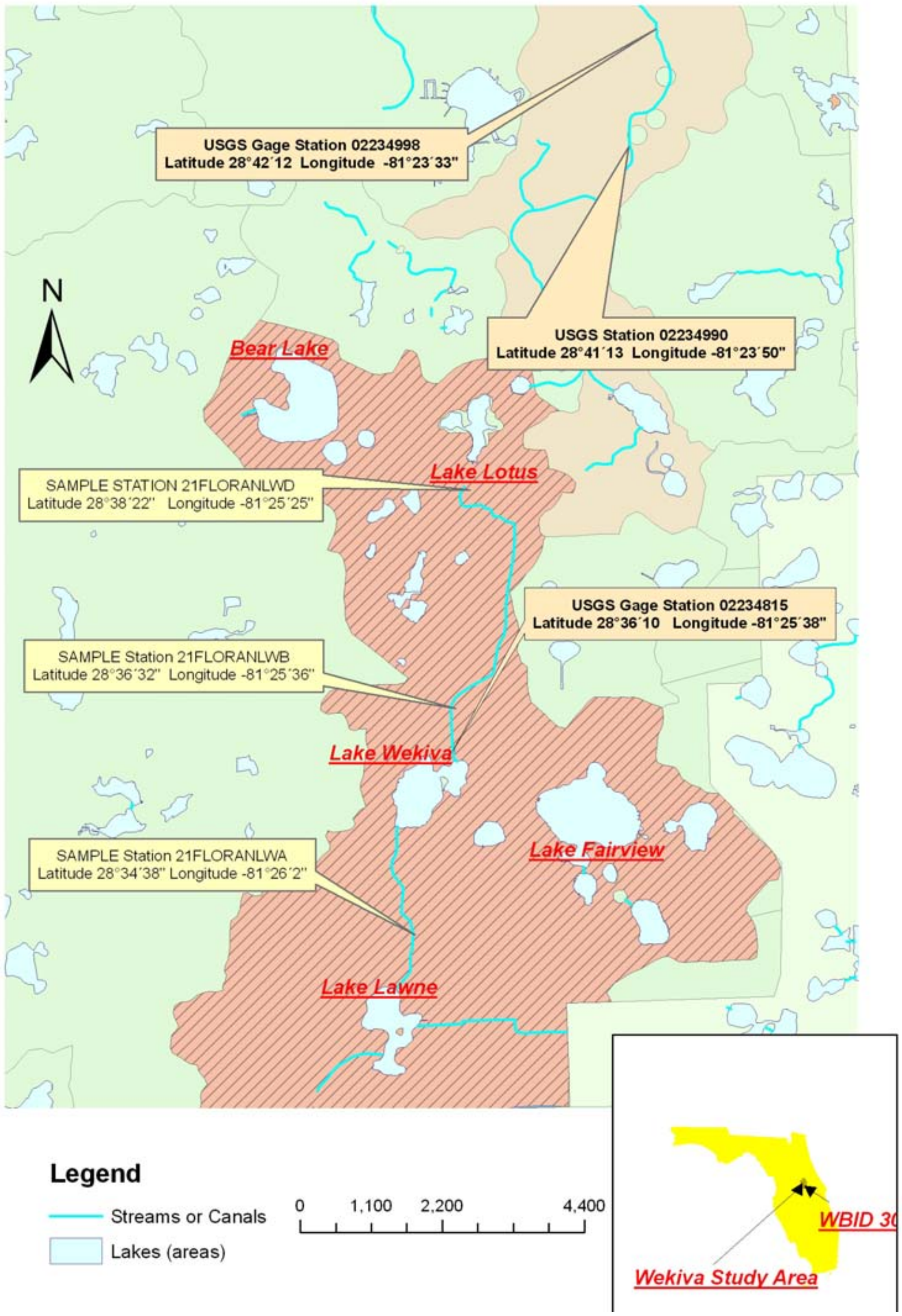


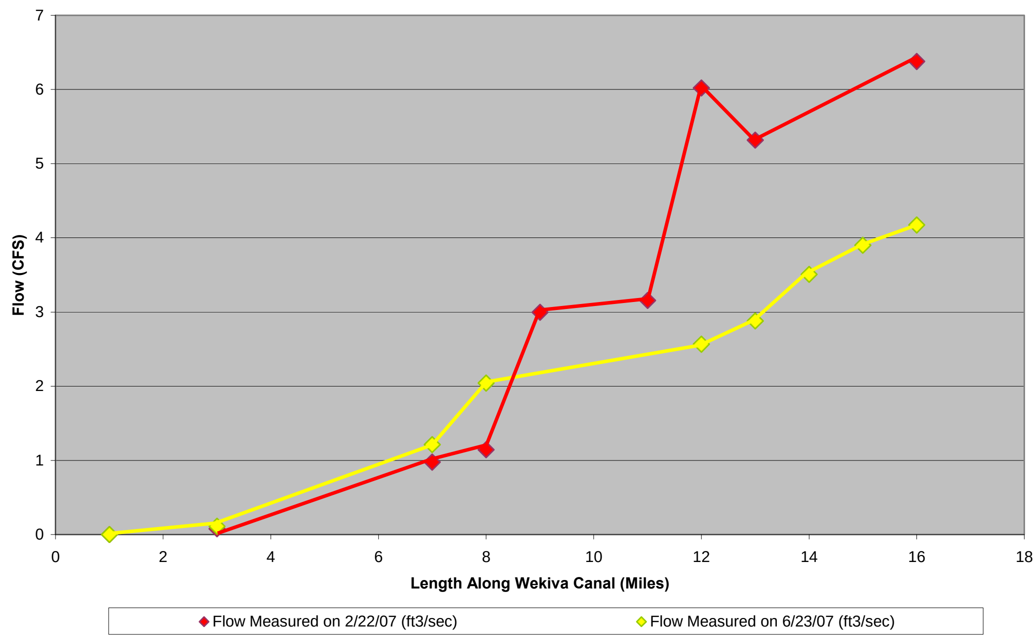

Figure 4.7. USGS Flow Monitoring Locations and Major Sampling Locations

## Baseflow Determination

To determine the baseflow for STA 2234990, the USGS flow data for this station were entered into the Soil and Water Assessment Tool (SWAT) baseflow program. Because of the proximity of STA 2234990 to the other monitored stations, the goal was to determine the relationship between these stations and STA 2234990, using the results from field flow surveys on February 22 and June 20, 2007. **Figure 4.8** shows the change in flow moving downstream in the Little Wekiva Canal. **Table 4.6** shows the station flow expressed as a percentage of the flow at Station 13, which is the same as USGS Station 2234990. The slope of the flow line in **Figure 4.8** becomes more negative between the 8- and 14-mile markers, or following Stations 9, 10, and 11. These flows were obtained during the dry season, and the percentages were assumed to be representative of the relationships between baseflows at those points along the Little Wekiva Canal.

Thus, using the average baseflow at USGS Station 2234990 over the past 10 years to develop monthly average baseflows at that point, and the average relationships between USGS Station 2234990 and the points along the Little Wekiva Canal, average monthly average baseflows were calculated at several points along the canal for use in the SWMM computer program. Thus, at Station 9, which is at the outlet of WBID 3004, the baseflow is assumed to range from 61 percent (the wet portion of the 2007 dry season) to 94 percent (the driest part of the season), for an average 78 percent of the flow (on the date of monitoring) at Station 2234990. The higher percentage at the beginning of the dry season reflected the influence of ground water recharge at points downstream of Station 9 and the contribution from nearby lakes upstream of STA 9.

The amount and location of recharge in the Little Wekiva Canal require further study, but based on the measurements taken, an observed reduction in baseflow occurs between Stations 8 and 10. This reduction during the dry season was between 0 and 11 percent of the flow measured at the preceding station. This is in the region where ground water recharge is indicated to exist in the Little Wekiva Canal.




## Figure 4.8. Little Wekiva Canal Flow, February 22 and June 20, 2007

## Table 4.6. Monthly Baseflows (in cfs) at Monitored Sites on the Little Wekiva Canal

| Month | Site Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 5 | 6 | 8 | 9 | 10 | 11 | 12 | 13 |
| January | 0.24 | 2.46 | 1.37 | 1.65 | 0.30 | 3.47 | (0.21) | 0.96 | 1.14 | 0.80 |
| February | 0.19 | 1.93 | 1.07 | 1.29 | 0.24 | 2.708 | (0.17) | 0.75 | 0.89 | 0.63 |
| March | 0.23 | 2.41 | 1.34 | 1.62 | 0.30 | 3.39 | (0.21) | 0.94 | 1.12 | 0.78 |
| April | 0.10 | 1.07 | 0.60 | 0.72 | 0.13 | 1.51 | (0.09) | 0.42 | 0.50 | 0.35 |
| May | 0.08 | 0.83 | 0.46 | 0.56 | 0.10 | 1.17 | (0.07) | 0.32 | 0.39 | 0.27 |
| June | 0.20 | 2.10 | 1.17 | 1.41 | 0.26 | 2.95 | (0.18) | 0.82 | 0.98 | 0.68 |
| July | 0.46 | 4.72 | 2.62 | 3.17 | 0.58 | 6.64 | (0.41) | 1.84 | 2.19 | 1.53 |
| August | 0.46 | 4.80 | 2.67 | 3.22 | 0.59 | 6.75 | (0.42) | 1.87 | 2.23 | 1.56 |
| September | 0.46 | 4.77 | 2.65 | 3.20 | 0.59 | 6.71 | (0.41) | 1.86 | 2.21 | 1.55 |
| October | 0.38 | 3.89 | 2.16 | 2.61 | 0.48 | 5.48 | (0.34) | 1.52 | 1.81 | 1.26 |
| November | 0.24 | 2.53 | 1.40 | 1.70 | 0.31 | 3.56 | (0.22) | 0.98 | 1.17 | 0.82 |
| December | 0.23 | 2.36 | 1.31 | 1.59 | 0.29 | 3.32 | (0.21) | 0.92 | 1.10 | 0.77 |

**Estimating Baseflow.** Baseflow was estimated for the stations in the Little Wekiva Canal by first predicting baseflow for USGS STA 2234990 with the use of the computer program Baseflow for SWAT. The SWAT Baseflow (Arnold et. al., 1995) program utilizes daily streamflow data to create baseflow. From the baseflow of STA 2234990, the relationships between flow along the length of the Little Wekiva Canal, as measured by the Department, and the continuous USGS gage-based measurements were used to develop continuous estimates for baseflow along the length of the Little Wekiva Canal (**Figures 4.9** and **4.10**). The monthly average baseflow values were derived for several points along the canal, using 10 years of USGS data for Station 2234990 (1997 through 2007).

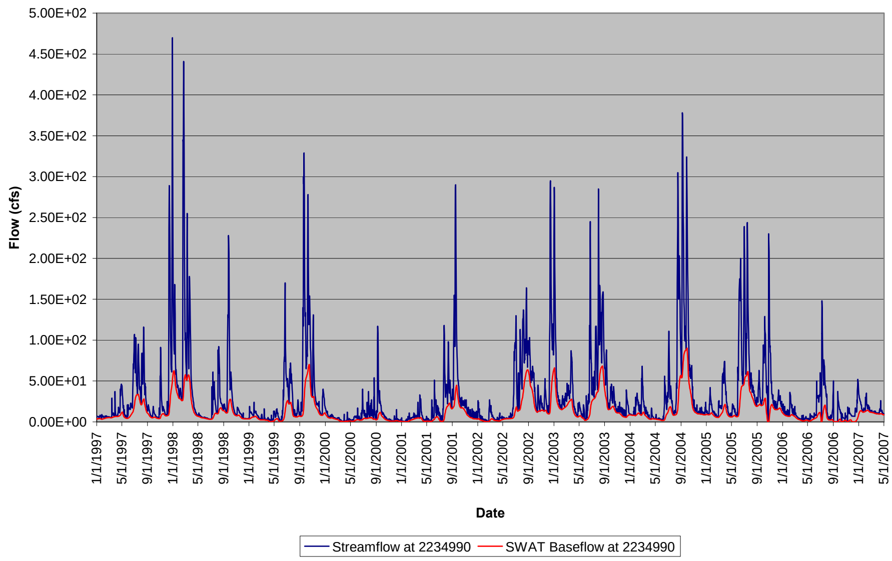



Figure 4.9. Little Wekiva Canal Flow and Baseflow, 1997–2007

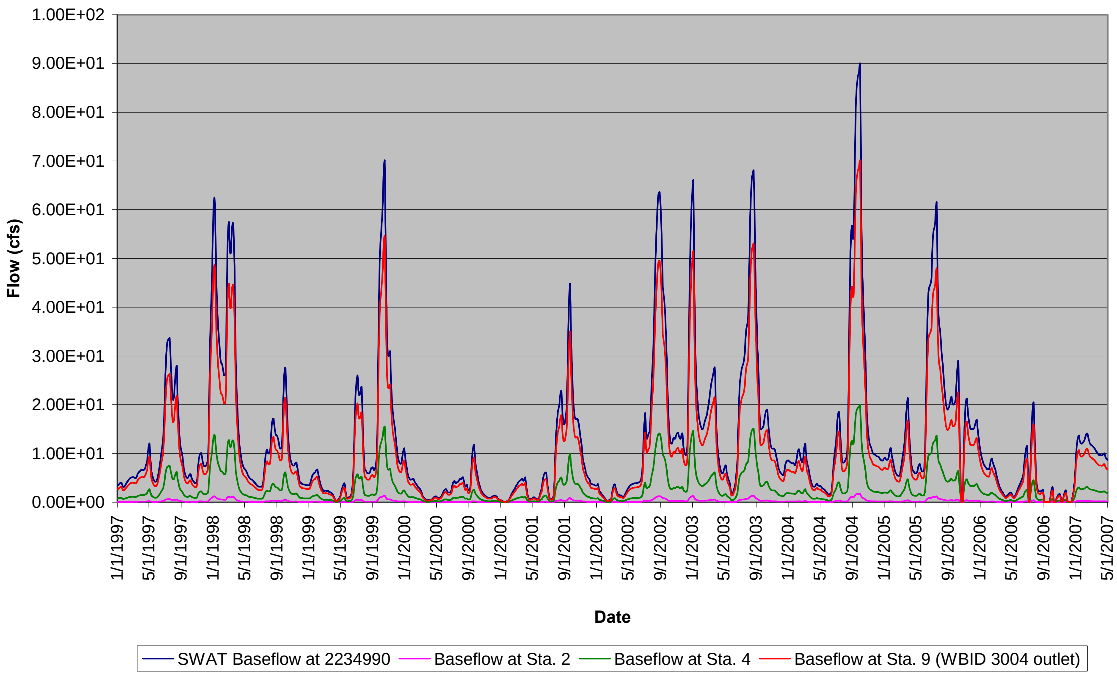



Figure 4.10. Baseflow Data Generated for Little Wekiva Canal Sample Stations Using Established Flow Relationship with USGS STA 2234990

## SWMM Model

SWMM, Version 5.0, was used to simulate the Little Wekiva Canal's water quantity and quality. The model can simulate individual storm events with a time step (time interval between computations) as low as a few seconds or minutes, or carry out a continuous simulation over an extended period (EPA, 1997). It includes the hydrologic processes of rainfall, surface and subsurface runoff, flow routing through a drainage network, storage, and treatment. SWMM is composed of three groups of elements: hydrologic, hydraulic, and quality. The hydrologic elements include rain gages, subcatchments, aquifers, and snow packs. The hydraulic elements include vehicles to move and store water and are grouped into links or nodes. Links (which handle flow mechanisms) include conduits (streams and pipes), pumps, orifices, weirs, and outlets. Nodes (which are turning points, storage points, and receiving or discharge points) include junctions, outfalls, dividers, and storage units.

SWMM requires the subcatchment properties of percent imperviousness, infiltration rate, depression storage, and surface roughness (EPA, 1988). It also requires other inputs such as stream or conduit geometry (shape, width, depth, side slopes), land uses, baseflow, baseflow concentrations, and EMCs by land use. These basic components were used to represent the Little Wekiva Canal and are shown (**Figure 4.11**) as they appear in the Windows-based SWMM (Rossman, 2004; EPA, 2005), with a backdrop transferred from GIS Arcmap.

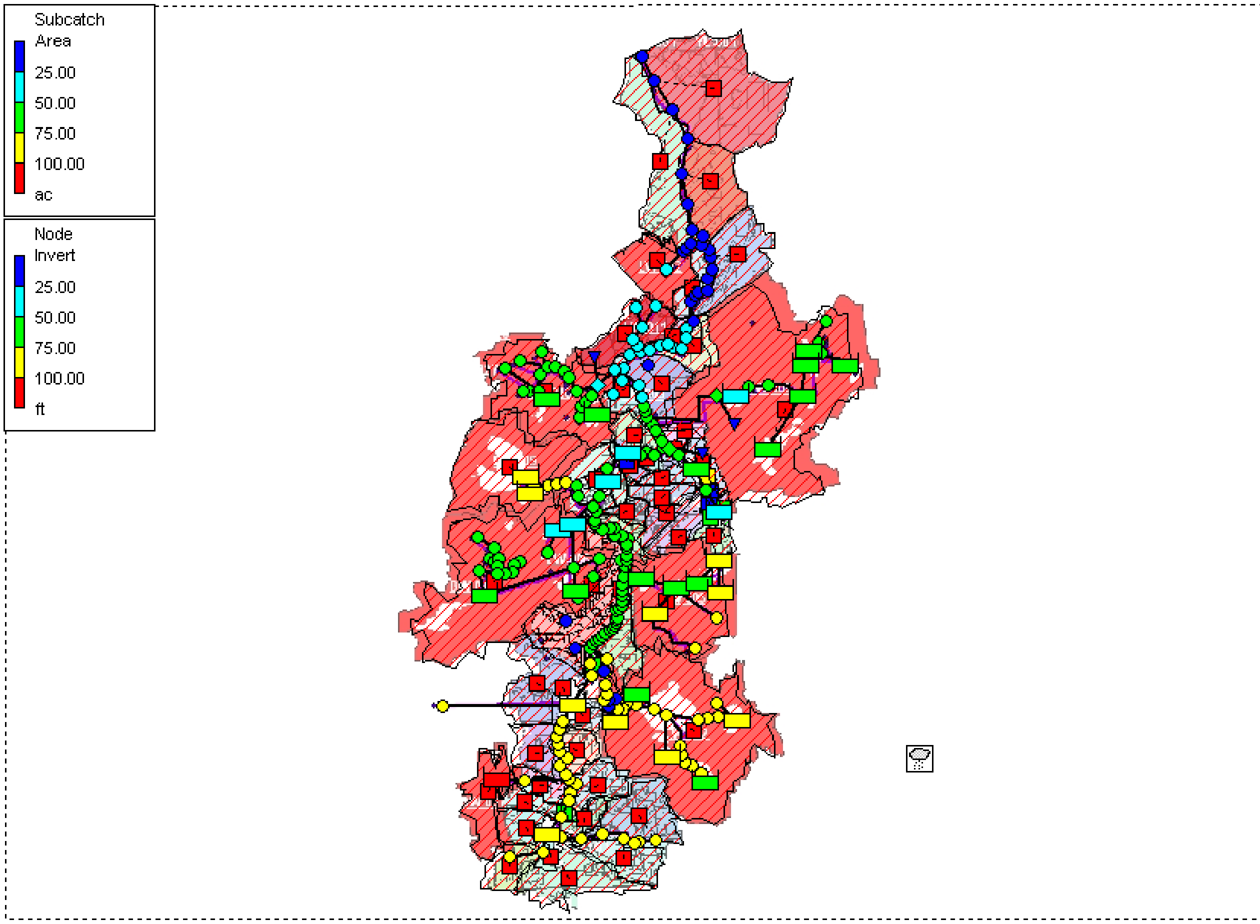



Figure 4.11. Basic Components of SWMM applied to the Little Wekiva Canal

The Little Wekiva watershed and surrounding area were divided into 57 subcatchments for the following reasons:

- *A greater number of subcatchments provides more opportunities to use internal mechanisms to create storage and delay flow in the modeled basin. This more accurately simulates long-term storm effects and gives width to the flow hydrograph.*
- *Instead of lumping and averaging all properties within larger subcatchments, for each smaller subcatchment one can specify such parameters as area, infiltration rate, percent impervious area, slope, point of entry into conduit (stream), ground water characteristics, and land uses.*

Given that SWMM lumps the properties of each subcatchment, the best way to model an individual subcatchment with different characteristics is to create a new subcatchment. Of course, there is a balance between making subcatchment divisions and the time required to define each subcatchment. The benefits are also proportional to the degree of detail that one can describe for the different parameters related to each subcatchment. Other data inputs include stream widths and depths (from information obtained during stream flow measurements), surface slopes, areas, soils, land use (information obtained from GIS shape files and maps), and rainfall data. **Table 4.4a** displays the imperviousness factors associated with each land use.

**Data Required for Estimating BOD and TN Loadings.** To estimate TN and BOD loadings from the Little Wekiva Canal watershed using SWMM, the following data were collected:

A. ***Rain precipitation data*** *were obtained from the weather station located in Orange County, Orlando WSO Airport (086638).*

B. ***Areas of different land use categories*** *in the Little Wekiva Canal watershed (WBID 3004) were obtained by aggregating GIS land use coverage based on the simplified Level 1 codes, as well as Level 2 codes. These were applied to the subcatchments within SWMM. These areas are listed in* ***Tables 4.2*** *and* ***4.3*** *(for the entire watershed) and* ***Table 4.10*** *These subcatchments are sub-areas that drain to a single outlet contributing to the WBID flow. These tables show the percent distributions of each land use category in the watershed.*

C. ***Percent impervious area of each land use category*** *is a very important parameter in estimating surface runoff using SWMM. Nonpoint pollution monitoring studies throughout the United States over the past 15 years have shown that annual per-acre discharges of urban stormwater pollution are positively related to the amount of imperviousness in land use (User's Manual: Watershed Management Model, 1998). Ideally, the impervious area is the area that does not retain water and, therefore, 100 percent of the precipitation falling on the impervious area should become surface runoff. In practice, however, the runoff coefficient for impervious area typically ranges between 95 and 100 percent. Impervious runoff coefficients lower than this range were observed in the literature, but usually the number should not be lower than 80 percent. For pervious area, the runoff coefficient usually ranges between 10 and 20 percent, although values lower than this range were also observed (User's Manual: Watershed Management Model, 1998). In this analysis, the imperviousness was obtained by integrating information from* ***Tables 4.4a, 4.4b,*** *and* ***4.7*** *to develop a weighted average impervious figure, based on the relative land uses for the given WBID division.*

It should be noted that the impervious area percentages do not necessarily represent DCIA. Using a single-family residence as an example, rain falls on rooftops, sidewalks, and driveways. The sum of these areas may represent 30 percent of the total area of the residential lot. However, much of the rain that falls on the roof drains to the grass and infiltrates to the ground or runs off the property, and thus does not run directly to the street. For SWMM, DCIA was used to characterize imperviousness according to land use (see **Table 4.7** for references).

To simulate infiltration, SWMM provides the user with the option of using either the Horton Equation or the Green-Ampt Equation. The Green-Ampt equation was selected because the parameters required were more accessible. The parameters required by the Green-Ampt equation are the soil saturated hydraulic conductivity, the initial deficit (difference between initial moisture and soil porosity), and the soil suction head (average values of soil capillary suction along wetting front). The GIS soils shape file (from the SJRWMD's Soil Survey Geographic

[SSURGO] Database) was used to determine the percentage of the watershed soils in each of the area divisions. The required soil properties were calculated using information from the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) Soils Manuals for Orange and Seminole Counties, as well as the GIS data files. The saturated hydraulic conductivity or permeability values were typically given in the form of a range, with final values estimated based on information about soil hydrologic group and drainage class. Based on the percentage of each soil in the watershed's section, the weighted averages of these soil properties were calculated and these values were entered into the respective subcatchment data file (**Table 4.8**). **Figure 4.12** shows the 10-year stream flow obtained through the use of the SWMM program.

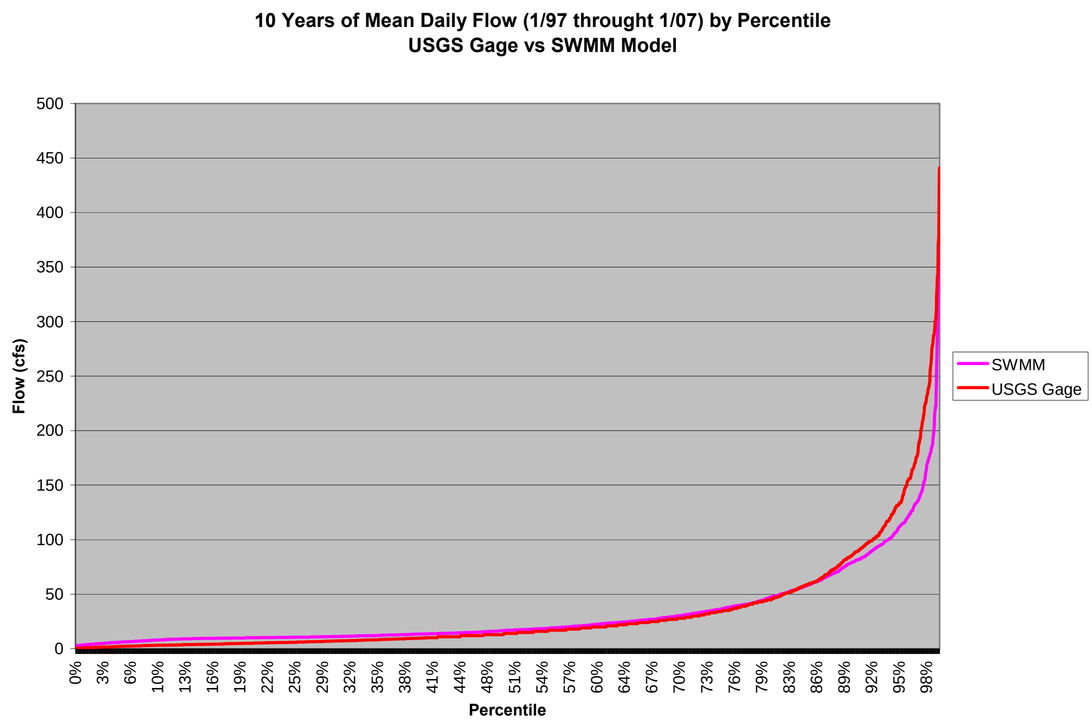
## Table 4.7. Illustrating DCIA Calculations for the Little Wekiva Canal Drainage Area Sections (Used in SWMM)

| Land Uses | % Directly Connected Impervious Areas (DCIA) For Given Land Uses Source: CDM | Weighted DCIA Components of Below Land Sections producing total DCIA Weighted = DCIA for land use x % of that land use in given land section | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | SWMM Model Subcatchments for Little Wekiva, Areas, & % landuses | | | | | | |
| | | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| | | 280.4 ac. | 132.3 ac. | 243.7 ac. | 704.5 ac. | 1025 ac. | 788.4 ac. | 1,999 ac. |
| Forest/Rural Open | 1.0% | 0.3% | 0.0% | 0.1% | 0.1% | 0.0% | 0.0% | 0.1% |
| Urban Open | 17.0% | 0.0% | 0.1% | 0.0% | 2.3% | 0.1% | 0.0% | 0.2% |
| Agriculture/Pasture | 1.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Low Density Residential | 30.0% | 0.0% | 0.0% | 0.7% | 2.3% | 0.0% | 9.2% | 2.2% |
| Medium Density Residential | 37.0% | 18.9% | 24.9% | 13.4% | 13.5% | 5.1% | 17.1% | 19.3% |
| High Density Residential | 71.0% | 1.8% | 17.3% | 31.0% | 2.9% | 0.0% | 0.0% | 0.0% |
| Commercial | 85.0% | 8.4% | 4.1% | 0.0% | 7.9% | 0.0% | 0.0% | 0.0% |
| Industrial | 71.0% | 0.0% | 0.0% | 0.0% | 0.8% | 0.0% | 0.7% | 0.0% |
| Highways | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Water/Wetland | 28.0% | 2.0% | 0.8% | 2.8% | 4.7% | 23.3% | 6.1% | 8.4% |
| Total Weighted Average DCIA for Subcatchment | | 31.4% | 47.2% | 48.0% | 34.5% | 28.6% | 33.1% | 30.2% |

| Sample Calculation: Based on Land Use for Section 47, the DCIA for section 20 is calculated below. | |
|---|---|
| DCIA = (.1% x 1.0%) + (0.2% x 17%) + (2.2% x 30%) + (19.3% x 37%) + (8.4% x 28.0%) | |
| DCIA = | 28.7% |

## Table 4.8. Saturated Hydraulic Conductivities and Suction Heads used for Green-Ampt Infiltration Equation in SWMM

| Division | HYDCON | SUCT | Division | HYDCON | SUCT | Division | HYDCON | SUCT |
|---|---|---|---|---|---|---|---|---|
| 1 | 6.64 | 2.64 | 9 | 0.63 | 4.41 | 17 | 3.87 | 3.36 |
| 2 | 0.71 | 4.28 | 10 | 3.19 | 2.74 | 18 | 7.79 | 2.31 |
| 3 | 3.42 | 2.79 | 11 | 1.45 | 3.94 | 19 | 6.43 | 2.35 |
| 4 | 3.07 | 3.09 | 12 | 4.58 | 2.77 | 20 | 5.31 | 2.45 |
| 5 | 4.79 | 2.61 | 13 | 1.20 | 3.99 | 21 | 3.84 | 2.78 |
| 6 | 10.39 | 1.89 | 14 | 1.83 | 3.95 | 22 | 5.29 | 2.73 |
| 7 | 14.29 | 1.77 | 15 | 4.59 | 2.52 | 23 | 5.16 | 2.64 |
| 8 | 6.65 | 2.44 | 16 | 7.32 | 2.30 | | | |




## Figure 4.12. Little Wekiva Canal Flow and SWMM Flow

## Table 4.9. Error Associated with Extended Period Flow Prediction Using SWMM

| Total 10-Year Measured Flow (Million Gallons) at STA 2234990 (based on average daily cfs) | Total 10-Year SWMM Simulated Flow in Million Gallons | Error as % of Total USGS Gage Flow | Error as % of Median USGS Flow |
|---|---|---|---|
| 76,645 | 79,718 | 4% | 16% |

The EMCs used in the model (**Table 4.4b**) were entered into the "land use" section. The baseflow concentrations for BOD and TN were determined by averaging the respective concentrations from the samples collected during the three "lowest flow" conditions (**Table 4.10**). The values also were in the range of literature (**Table 4.11**).

## Table 4.10. Dry Season, Low-Flow Concentrations

| Sample Date | Sample Station | DO (mg/L) | BOD (mg/L) | TKN (mg/L) | NO2 (mg/L) | NO3 (mg/L) | TN (Calc) (mg/L) |
|---|---|---|---|---|---|---|---|
| 3/8/2000 | 21FLORANLWA | 4.59 | 3.8 | 1.5 | 0.02 | 0.16 | 1.68 |
| 4/28/2005 | 21FLORANLWA | | | 1.15 | 0.004 | 0.046 | 1.2 |
| 1/19/2006 | 21FLORANLWA | 6.2 | | 0.99 | | 0.154 | 1.15 |
| 4/20/2006 | 21FLORANLWA | 2 | 4 | 1.41 | | 0.114 | 1.54 |
| 1/18/2007 | 21FLORANLWA | 5.8 | | | | | |
| 3/8/2000 | 21FLORANLWB | 7.23 | 2.6 | 0.59 | 0.005 | 0.02 | 0.615 |
| 4/28/2005 | 21FLORANLWB | | | 0.99 | 0.002 | 0.078 | 1.07 |
| 1/19/2006 | 21FLORANLWB | 6.8 | | 0.65 | | 0.285 | 0.94 |
| 4/20/2006 | 21FLORANLWB | 7.3 | 3 | 0.9 | | 0.008 | 0.91 |
| 1/18/2007 | 21FLORANLWB | 4.9 | | | | | |
| 3/16/2000 | 21FLORANLWD | 6.03 | | 0.67 | 0.009 | 0.68 | 1.359 |
| 2/21/2001 | 21FLORANLWD | 12.09 | 2 - U | 0.32 | 0.006 | 0.63 | 0.96 |
| 4/28/2005 | 21FLORANLWD | | | 0.58 | 0.004 | 0.326 | 0.91 |
| 1/19/2006 | 21FLORANLWD | 10 | | 0.52 | 0.02 | 0.554 | 1.08 |
| 4/7/2006 | 21FLORANLWD | 4.52 | 1 - U | 0.43 | 0.004 | 0.447 | 0.9 |
| 4/20/2006 | 21FLORANLWD | 4 | 1 - U | 0.49 | 0.004 | 0.216 | 0.75 |
| 1/18/2007 | 21FLORANLWD | 6 | | | | | |
| **21FLORANLWA AVERAGE** | | **4.648** | **3.900** | **1.263** | **0.012** | **0.119** | **1.393** |
| **21FLORANLWB AVERAGE** | | **6.558** | **2.800** | **0.783** | **0.004** | **0.098** | **0.884** |
| **21FLORANLWD AVERAGE** | | **7.107** | **0.667** | **0.502** | **0.008** | **0.476** | **0.993** |
| **Overall Average (3 Station)** | | **6.104** | **2.456** | **0.849** | **0.008** | **0.231** | **1.090** |

## Table 4.11. Ranges of Baseflow Concentrations, Literature Summary

| Range of Baseflow Concentrations (mg/L) (from Chapter 3 Chart, "Urban Wastewater Pollutant Concentrations" [Duncan, 1995]) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***BOD*** | | | | ***TN*** | | | |
| | ***Sample Size*** | ***Min*** | ***Mean*** | ***Max*** | ***Sample Size*** | ***Min*** | ***Mean*** | ***Max*** |
| Urban | 15 | 2 | 5 | 12 | 13 | 0.90 | 2.10 | 4.50 |
| Rural | 8 | 1.1 | 2.1 | 3.8 | 13 | 0.45 | 0.95 | 2.10 |

Model output was transferred to an Excel spreadsheet and summarized in **Tables 4.14a** and **4.14b**. Detailed output is shown in **Appendices B** and **C**. The results of the "water quantity" section of the model showed a good mass balance (a 5 percent difference in total flow between SWMM-simulated stream flow and stream flow from the gage-based flow) (**Table 4.13)**. The cumulative flow matched well through the first months of simulation and began to deviate during the later months (**Figure 4.13**). The flow hydrograph comparison (**Figure 4.14**) illustrates that there are multiple storm events where SWMM simulated higher flow than the gage, and there are a few gage-based storm flows that are much higher than the SWMM simulation.

SWMM was calibrated by changing the percent impervious areas input (a range of values is available for impervious areas for various land uses); the initial selected values that were on the high end of that range were replaced with lower ones to bring the peak flows from the SWMM simulation down. This is one of two parameters suggested by model developers for calibration to reduce peaks and volume of flow. Another parameter suggested for calibration is the width of overland flow path (reducing the width should increase the time span of the storm hydrograph). A factor that limits the impact of these calibration tools is the time step used in this application. Calibration has a greater impact where the time of concentration is larger than the modeled time step. For this modeling effort, the time step was fixed by the fact that daily rainfall data are used, rather than a smaller interval.

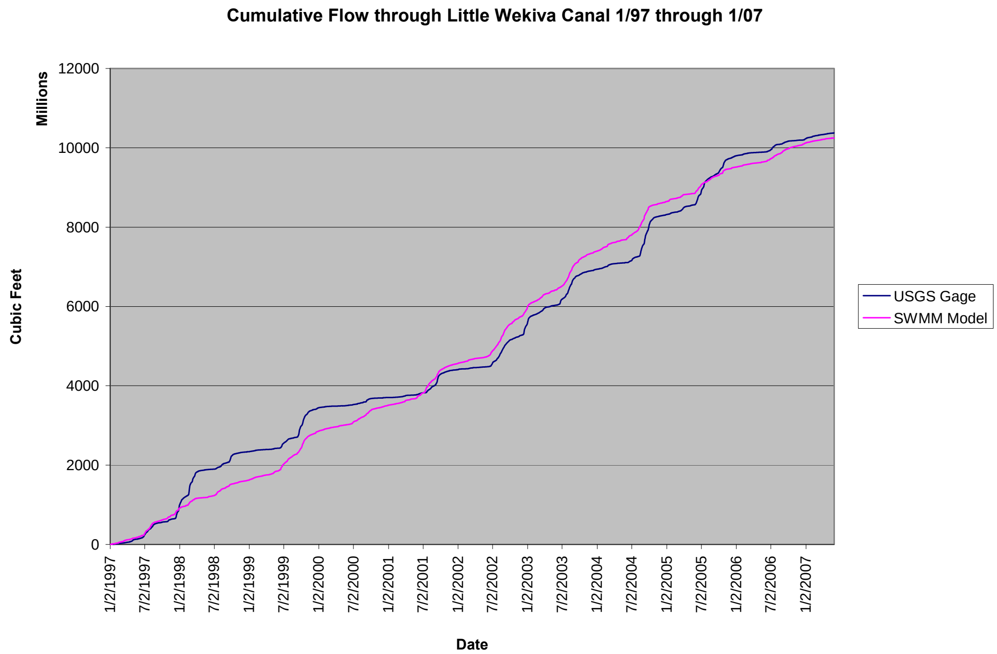



Figure 4.13. Modeling Cumulative Flow from the Little Wekiva Canal, 1997–2007

## Table 4.12.SWMM Output Comparison Table

| Date | A | B | C | E | F | G | I |
|---|---|---|---|---|---|---|---|
| | *SWMM Simulated Flow (cfs)* | *BOD Concen-tration (mg/L)* | *Total Nitrogen (mg/L)* | *Flow Based on Station 2234990 Gage* | *BOD Load (lbs/day) A x B x 5.395* | *TN load (lbs/day) A x C x 5.395* | *BOD load limit A x 2.0 mg/L x 5.395* |
| 1/2/97 | 6.15 | 1.4 | 0.99 | 6.80 | 46.45 | 32.85 | 66.36 |
| 1/3/97 | 6.54 | 1.35 | 0.97 | 6.60 | 47.63 | 34.22 | 70.57 |
| 1/4/97 | 7.54 | 1.17 | 0.84 | 6.50 | 47.59 | 34.17 | 81.36 |
| 1/5/97 | 8.18 | 1.07 | 0.75 | 6.40 | 47.22 | 33.10 | 88.26 |
| 1/6/97 | 8.57 | 1.02 | 0.71 | 6.10 | 47.16 | 32.83 | 92.47 |
| 1/7/97 | 8.83 | 0.99 | 0.69 | 6.20 | 47.16 | 32.87 | 95.28 |
| 1/8/97 | 9.04 | 0.97 | 0.67 | 5.50 | 47.31 | 32.68 | 97.54 |
| 1/9/97 | 18.58 | 4.38 | 1.4 | 5.70 | 439.05 | 140.33 | 200.48 |
| 1/10/97 | 10.45 | 0.8 | 0.53 | 6.30 | 45.10 | 29.88 | 112.76 |
| 1/11/97 | 10.15 | 0.83 | 0.55 | 6.60 | 45.45 | 30.12 | 109.52 |
| 1/12/97 | 10.26 | 0.83 | 0.56 | 6.50 | 45.94 | 31.00 | 110.71 |
| 1/13/97 | 10.37 | 0.83 | 0.57 | 5.30 | 46.44 | 31.89 | 111.89 |
| 1/14/97 | 11.79 | 0.72 | 0.48 | 6.00 | 45.80 | 30.53 | 127.21 |
| 1/15/97 | 14.14 | 3.14 | 1.1 | 7.40 | 239.54 | 83.91 | 152.57 |
| 1/16/97 | 9.71 | 0.84 | 0.54 | 8.10 | 44.00 | 28.29 | 104.77 |
| 1/17/97 | 9.85 | 0.84 | 0.55 | 8.20 | 44.64 | 29.23 | 106.28 |
| 1/18/97 | 9.97 | 0.83 | 0.56 | 7.50 | 44.64 | 30.12 | 107.58 |
| 1/19/97 | 10.07 | 0.83 | 0.56 | 6.80 | 45.09 | 30.42 | 108.66 |
| 1/20/97 | 10.13 | 0.83 | 0.57 | 5.80 | 45.36 | 31.15 | 109.30 |
| 1/21/97 | 10.17 | 0.83 | 0.57 | 5.70 | 45.54 | 31.27 | 109.73 |
| 1/22/97 | 10.2 | 0.83 | 0.58 | 4.40 | 45.67 | 31.92 | 110.06 |
| 1/23/97 | 10.21 | 0.83 | 0.58 | 3.10 | 45.72 | 31.95 | 110.17 |

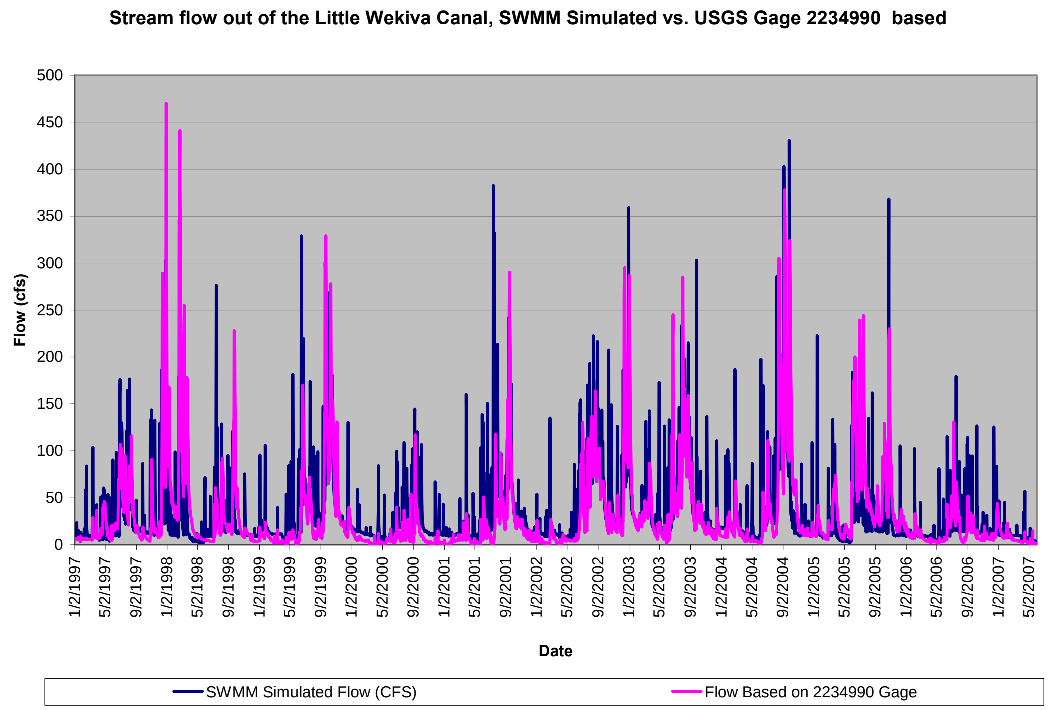



Figure 4.14. Stream Flow From the Little Wekiva Canal (WBID 3004), Comparison Between SWMM Simulation and Calculated Flow Based on USGS Gage STA 2234990

Table 4.13. Simulation Summary of the Little Wekiva Canal

| LITTLE WEKIVA CANAL FLOW BETWEEN 1/2/1997 AND 12/31/2006 | | | | | |
|---|---|---|---|---|---|
| METHOD OF DETERMINATION | TOTAL 10-YR VOLUME (MILLION GALLONS) | FLOW (CUBIC FEET PER SECOND) | | | |
| | | Average | Median | Maximum | Minimum |
| *SWMM SIMULATION* | 79,718 | 33.8 | 16.2 | 494.8 | 2.7 |
| *USGS GAGE BASED CALCULATION* | 76,645 | 32.5 | 14.0 | 470.0 | 0.1 |

| LITTLE WEKIVA CANAL LOADS, 1/2/1997 THROUGH 12/31/2006 | | | |
|---|---|---|---|
| SIMULATION SCENARIO | Load | Reduction Relative to | |
| BOD | (LBS/YR) | Pounds | Percent |
| *SWMM SIMULATION OF EXISTING CONDITIONS* | 86,051 | N/A | N/A |
| *SWMM SIMULATION OF BOD LOAD AT 2.0 mg/L (SCREEN LEVEL)* | 133,066 | (47,015) | -54.6% |
| *SWMM SIMULATION OF NATURAL CONDITIONS* | 20,041 | 66,010 | 76.7% |
| *AVERAGE OF SCREENING LEVEL & BACKGROUND* | 76,554 | 9,497 | 11.0% |
| TOTAL NITROGEN | | | |
| *SWMM SIMULATION OF EXISTING CONDITIONS* | 77,725 | N/A | N/A |
| *SWMM SIMULATION OF TN LOAD AT 1.02 MG/L* | 67,864 | 9,862 | 12.7% |
| *SWMM SIMULATION OF NATURAL CONDITIONS* | 17,389 | 60,337 | 77.6% |
| *AVERAGE OF 1.02 MG/L LOAD AND NATURAL CONDITIONS* | 42,626 | 35,099 | 45.2% |

Table 4.14a.SWMM Simulation Summary of Downstream Sample Site WLD

| LITTLE WEKIVA CANAL POLLUTANT CONCENTRATION (mg/L) AT STA LWD (DATA vs. SWMM). | | | |
|---|---|---|---|
| **BOD** | **Average** | **Maximum** | **Minimum** |
| *SWMM SIMULATION OF EXISTING CONDITIONS, 97 - '05* | 1.17 | 5.72 | - |
| *FIELD SAMPLE ANALYSIS (62 GRAB SAMPLES, '97 - '05)* | 1.73 | 2.60 | 1.25 |
| *SWMM SIMULATION OF NATURAL CONDITIONS, '97 - '05* | 0.35 | 0.62 | 0.06 |
| **TOTAL NITROGEN** | | | |
| *SWMM SIMULATION OF EXISTING CONDITIONS, '97 - '05* | 1.45 | 1.96 | 0.34 |
| *FIELD SAMPLE ANALYSIS (30 GRAB SAMPLES, '97 - '05)* | 1.06 | 1.27 | 0.82 |
| *SWMM SIMULATION OF NATURAL CONDITIONS, '97 - '05* | 0.66 | 1.04 | 0.12 |

Table 4.14b.SWMM Simulation Summary of Upstream Sample Site WLA

| AT THE UPSTREAM STATION LWA (DATA vs. SWMM). | | | |
|---|---|---|---|
| **BOD** | **Average** | **Maximum** | **Minimum** |
| *SWMM SIMULATION OF EXISTING CONDITIONS, 97 - '05* | 2.66 | 5.29 | 0.39 |
| *FIELD SAMPLE ANALYSIS (62 GRAB SAMPLES, '97 - '01)* | 2.96 | 9.61 | 1.00 |
| **TOTAL NITROGEN** | | | |
| *SWMM SIMULATION OF EXISTING CONDITIONS, '97 - '05* | 1.56 | 1.96 | 0.57 |
| *FIELD SAMPLE ANALYSIS (30 GRAB SAMPLES, '97 - '05)* | 1.74 | 2.75 | 0.42 |

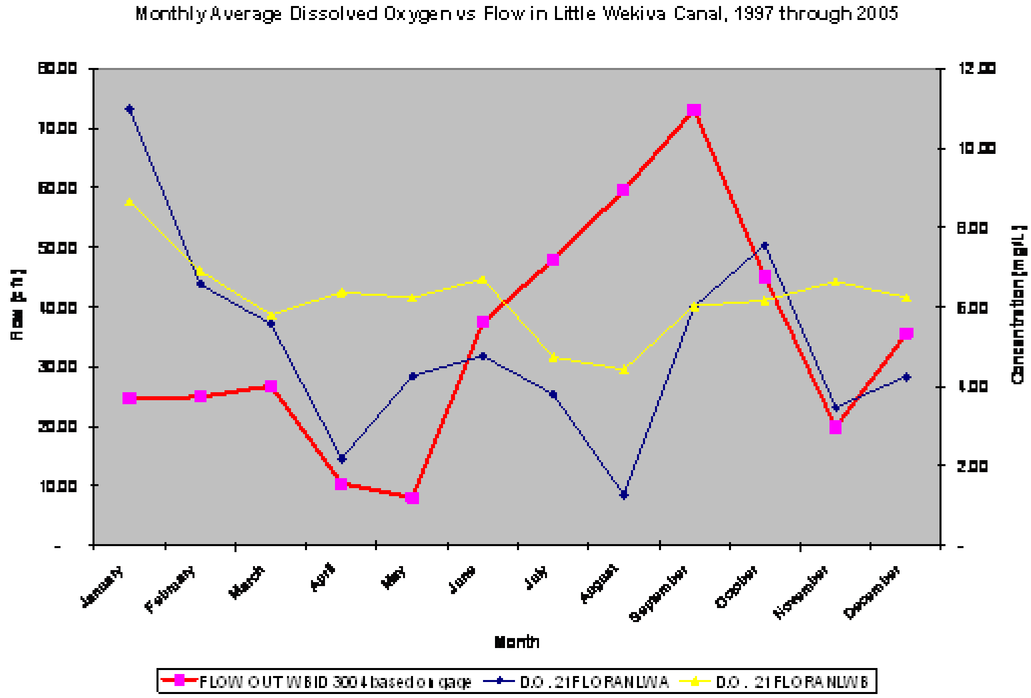
# Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

## 5.1 Overall Approach

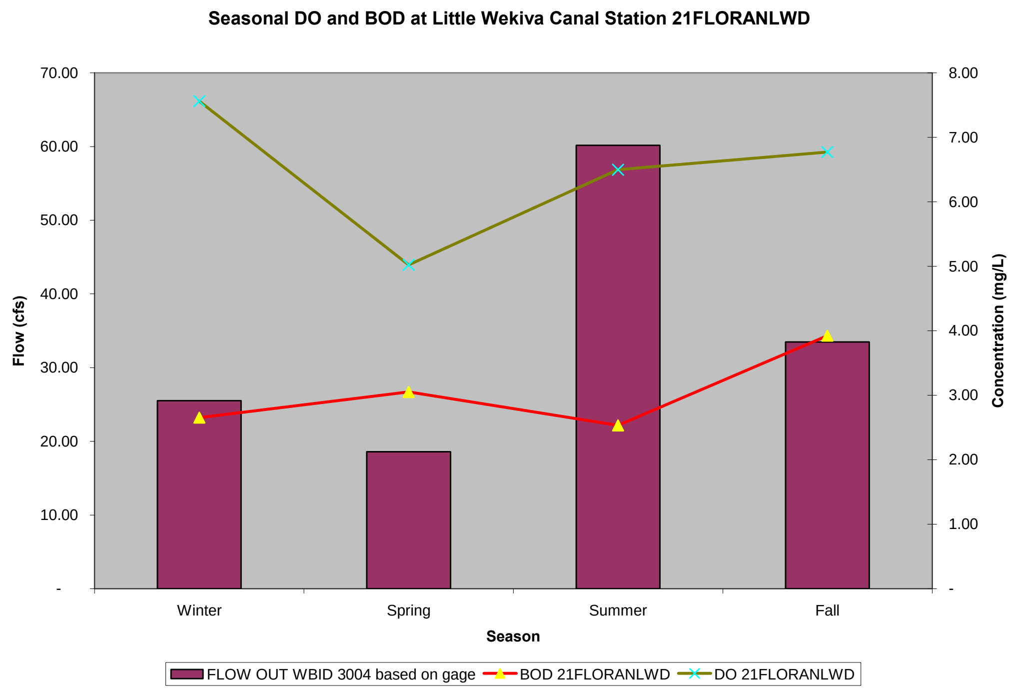
The overall approach is to model the existing BOD, TP, and TN loads using SWMM, and then reduce loads of BOD, TP, and TN loads until the target DO is expected to be met based on the target BOD and target TN. For BOD, TP, and TN, the load will be set through consideration of the observed relationships with DO (BOD and TP) and chl-*a* (for TN), as well as the simulated natural predevelopment conditions.

## 5.2 Relationship Between Measured Flow and Nutrients, BOD, and DO

Attempts were also made to relate DO to stream flow. As has been found in other studies, low DO concentrations were consistent with low-flow conditions. Using all of the individual data, there was no correlation between DO and the flow rate of the Little Wekiva Canal (**Figure 5.1**). However, there were some relationships between quarterly flow and DO values. For 2002 (which was chosen because it has the most complete set of data for DO and flow), DO was at its lowest average and median values during the third quarter, or the rainy season, when the flow is at its highest average and median values (**Figure 5.2**). Unfortunately, there were not enough BOD data to evaluate quarterly averages during 2002. There were adequate TN data to evaluate quarterly averages, and the TN median and average quarterly concentrations were highest during the third quarter as well (**Figure 5.3** and **5.4**).




## Figure 5.1. Relationship Between DO and Flow Rate




## Figure 5.2. Relationship Between Quarterly Median DO and Flow Rate

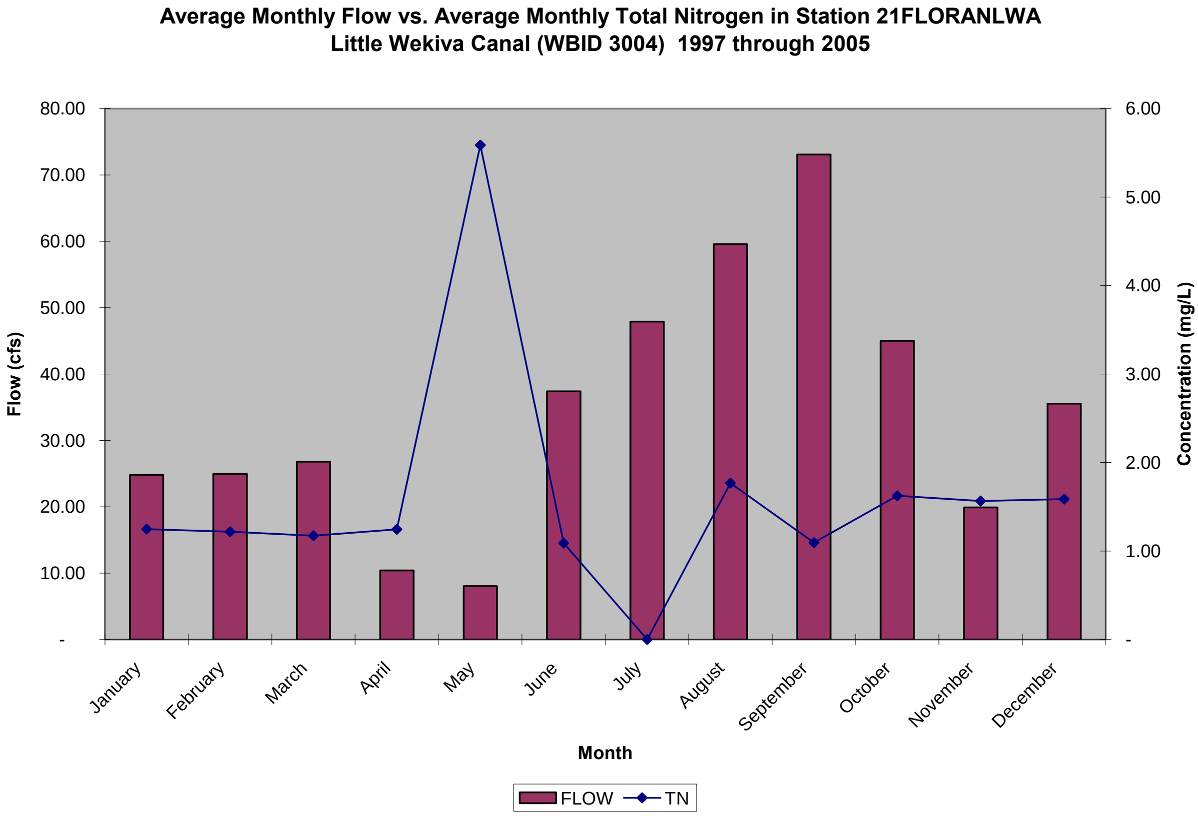



Figure 5.3. Relationship Between Quarterly Average TN and Flow Rate

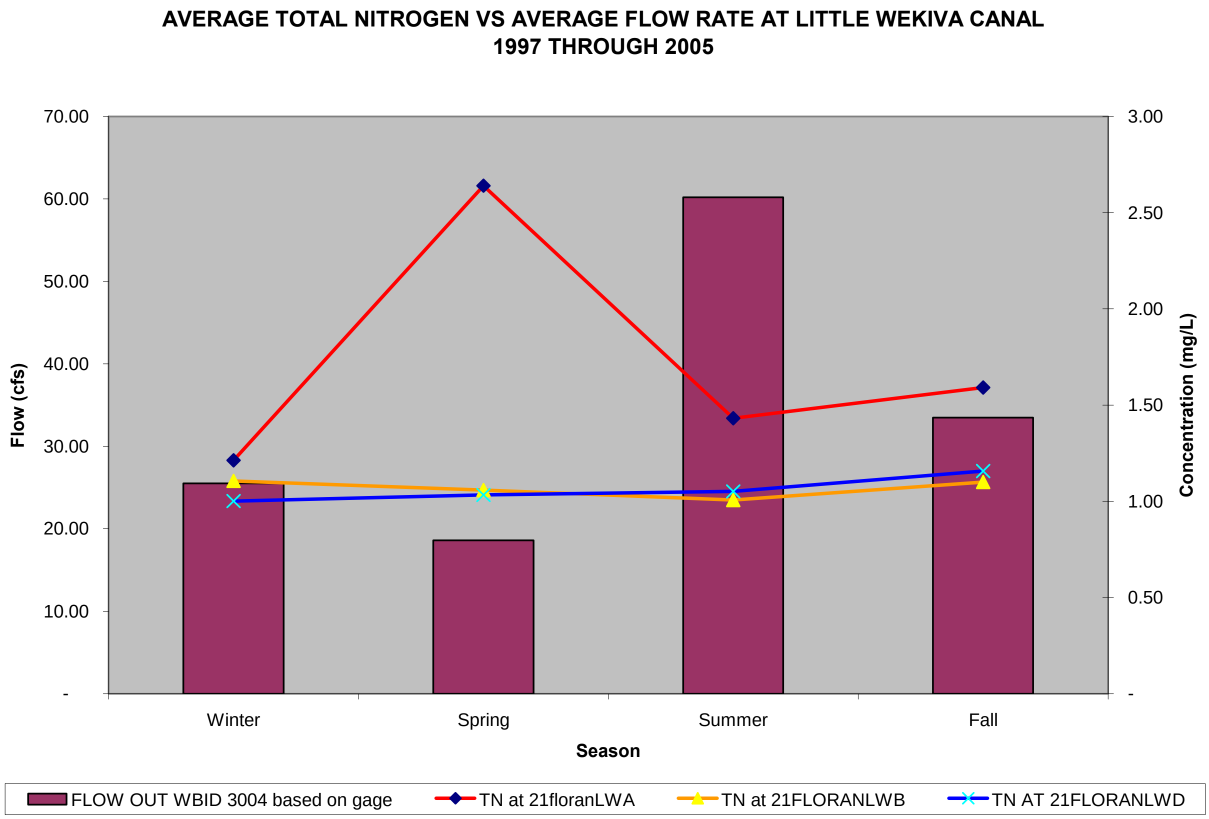



Figure 5.4. Relationship Between Quarterly Average TN and Flow Rate

## 5.3 Critical Conditions

The Little Wekiva Canal TMDL was determined through the simulation of flow and pollutant loads during the entire year, rather than focusing on a critical "low-flow" season or condition. Depressed DO levels have been observed in all flow conditions, with higher averages observed during high-flow periods, and thus has not been solely related to seasonal or flow condition. There may be other as yet undetermined critical conditions related to low DO or elevated BOD, but based on current knowledge it was determined that it was best to simulate the annual flows and concentrations and relate them to the target maximum loads.

The assimilative capacity for BOD must be sufficient to achieve the loads consistent with the screening level of 2.0 mg/L. However, it should be noted that natural background BOD levels in some regions of Florida have been shown to be approximately 2.0 mg/L (Duncan, 1995). At one location on the Little Wekiva Canal WBID, BOD during low-flow seasons has been observed to average below method detection limits. In recognition of these two factors, the approach taken here is to simulate and determine the natural background BOD load for the Little Wekiva Canal, and set the BOD target to be midway between the load consistent with a 2.0 mg/L and the load associated with undeveloped land uses.

Based on the results of the SWMM simulation for 2002 through 2004 (**Table 4.13**), the average BOD load in the Little Wekiva Canal was 86,051 lbs/year. The SWMM simulation results also indicate that the BOD load at the screening level of 2.0 mg/L would have been 133,066 lbs/year (55 percent below the simulated existing load), and the BOD load associated with natural undeveloped conditions is 20,041 lbs/year (76.7 percent below the simulated existing load). The assimilative capacity for BOD is thus 76,554 lbs/year (the average of these two loads).

Similarly, the assimilative capacity for TN is the average of the load associated with the critical concentration related to chl-*a* (1.02 mg/L based on regression relationship) and the load associated with undeveloped land use conditions. The SWMM simulation results (**Table 4.13**) for 1997 through 2005 estimated the average TN load at 77,725 lbs/yr. At a load consistent with the concentration of 1.02 mg/L, the total load would have been 67,864 lbs/year. Based on the SWMM results, the TN load associated with natural undeveloped conditions is 17,389 lbs/year. The assimilative capacity is thus 42,626 lbs/year (the average of these two loads).

In modeling the natural undeveloped conditions, the baseflow concentrations were left the same as the present conditions. In simulating natural conditions, all land uses for the watershed were changed to upland forest, except the channelized wetland, which was converted to wetland. The TN and BOD reduced loads were thus associated with the reduced EMCs associated with the undeveloped land uses.

# 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:

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

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

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

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

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

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. The TMDLs for the Little Wekiva Canal (WBID 3004) are expressed in terms of pounds per year and percent reduction, and represent the amount of BOD and TN loading that will bring the current DO levels to the standard of 5 mg/L (**Table 6.1**).

Table 6.1. TMDL Components and Current Loadings for the Little Wekiva Canal, WBID 3004

| Parameter | WLA | | LA (lbs/year) | MOS | % Reduction |
|---|---|---|---|---|---|
| | *Wastewater (lbs/year)* | *NPDES Stormwater (% Reduction)* | | | |
| BOD | N/A | 11.0% | 76,554 | Implicit | 11.0% |
| TN | N/A | 45.2% | 42,624 | Implicit | 45.2% |

N/A – Not available

## 6.2 Wasteload Allocation

### *6.2.1 NPDES Wastewater Discharges*

There are currently no wastewater facilities in the Little Wekiva Canal watershed.

### *6.2.2 NPDES Stormwater Discharges*

The WLAs for stormwater discharges with an MS4 permit (Orange and Seminole Counties and the city of Winter Park) are an 11 percent reduction in BOD load and a 45.2 percent reduction in TN load. 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.

## 6.3 Load Allocation

The LA is the nonpoint source component of the load, which, combined with WLA stormwater discharges, is responsible for 100 percent of the current load as well as the percentage load reduction. The TMDL is 76,554 lbs/yr of BOD and 42,626 lbs/yr of TN, all of which is allocated to the categories of LA and WLA stormwater. Based on the SWMM simulation, this represents a BOD and TN load reduction of 11 percent and 45.2 percent, respectively.

## 6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee iDepartment, February 1, 2001), an implicit MOS was used in the development of this TMDL. An implicit MOS was provided by the conservative decisions associated with a number of modeling assumptions, the development of site-specific alternative water quality targets, and the development of assimilative capacity. This includes the establishment of the TMDL at a load that is expected to maintain the annual average BOD concentration below the screening threshold of 2 mg/L and TN below the critical concentration of 1.02 mg/L (**Tables 4.13**, **4.14a, and 4.14b**). In establishing these loads, error margins were included by setting the assimilative capacities midway between simulated natural background conditions and the screening load (BOD) or critical load (TN).

# 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, who will attempt to reach consensus on detailed allocations and on how load reductions will be accomplished. The BMAP will include, among other things:

- *Appropriate load reduction allocations among the affected parties,*
- *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 to achieve the TMDL,*
- *Timetables for implementation,*
- *Confirmed and potential funding mechanisms,*
- *Any applicable signed agreement(s),*
- *Local ordinances defining actions to be taken or prohibited,*
- *Any applicable local water quality standards, permits, or load limitation agreements,*
- *Milestones for implementation and water quality improvement, and*
- *Implementation tracking, water quality monitoring, and follow-up measures.*

An assessment of progress toward the BMAP milestones will be conducted every five years, and revisions to the plan will be made as appropriate, in cooperation with basin stakeholders.

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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.

The rule 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, 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 had been developed for Newnans Lake at the time this analysis 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 5 or more acres of land, and 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 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 FDOT throughout the 15 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 1 and 5 acres, and to local governments with as few as 10,000 people. The 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, as are 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 reopener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

# Appendix B: SWMM Output Used To Calculate Pollutant Loads

## Table B.1. Little Wekiva Canal Natural Background Condition Daily Simulation Summary

**BACKGROUND**

*SWMM Simulation, utilizing Weather Data from Orlando WSO Airport Weather Station*

***Outflow from Little Wekiva Canal (WBID 3004)***

| Date | A SWMM Simulated Flow (CFS) | B BOD Concentration (mg/L) | C Total Nitrogen (mg/L) | D Total Phosphorus (mg/L) | E Flow Based on 2234990 Gage | F BOD Load (LBS/DAY) A x B x 5.395 | G TN load (LBS/DAY) A x C x 5.395 | H TP load (LBS/DAY) A x D x 5.395 | I BOD load limit A x 2.0 mg/L x 5.395 | J BOD load limit A x .05 mg/L x 5.396 | J TN load limit A x 1.02 mg/L x 5.396 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/2/1997 | 10.09 | 0.54 | 0.84 | 0.05 | 6.80 | 17.92 | 45.73 | 2.72 | 108.87 | 2.72 | 55.52 |
| 1/3/1997 | 10.08 | 0.51 | 0.81 | 0.05 | 6.60 | 17.99 | 44.05 | 2.72 | 108.76 | 2.72 | 55.47 |
| 1/4/1997 | 9.18 | 0.51 | 0.82 | 0.05 | 6.50 | 20.75 | 40.61 | 2.48 | 99.05 | 2.48 | 50.52 |
| 1/5/1997 | 10.08 | 0.54 | 0.85 | 0.05 | 6.40 | 23.83 | 46.22 | 2.72 | 108.76 | 2.72 | 55.47 |
| 1/6/1997 | 9.5 | 0.52 | 0.85 | 0.05 | 6.10 | 24.04 | 43.56 | 2.56 | 102.51 | 2.56 | 52.28 |
| 1/7/1997 | 9.38 | 0.53 | 0.85 | 0.05 | 6.20 | 25.25 | 43.01 | 2.53 | 101.21 | 2.53 | 51.62 |
| 1/8/1997 | 7.91 | 0.52 | 0.84 | 0.05 | 5.50 | 25.36 | 35.85 | 2.13 | 85.35 | 2.13 | 43.53 |
| 1/9/1997 | 10.41 | 0.49 | 0.8 | 0.05 | 5.70 | 49.12 | 44.93 | 2.81 | 112.32 | 2.81 | 57.29 |
| 1/10/1997 | 9.88 | 0.51 | 0.83 | 0.05 | 6.30 | 28.75 | 44.24 | 2.67 | 106.61 | 2.67 | 54.37 |
| 1/11/1997 | 9.76 | 0.51 | 0.83 | 0.05 | 6.60 | 27.93 | 43.70 | 2.63 | 105.31 | 2.63 | 53.71 |
| 1/12/1997 | 10 | 0.51 | 0.83 | 0.05 | 6.50 | 28.23 | 44.78 | 2.70 | 107.90 | 2.70 | 55.03 |
| 1/13/1997 | 10.06 | 0.5 | 0.82 | 0.05 | 5.30 | 27.97 | 44.50 | 2.71 | 108.55 | 2.71 | 55.36 |
| 1/14/1997 | 10.09 | 0.5 | 0.81 | 0.05 | 6.00 | 31.80 | 44.09 | 2.72 | 108.87 | 2.72 | 55.52 |
| 1/15/1997 | 9.66 | 0.49 | 0.79 | 0.05 | 7.40 | 37.38 | 41.17 | 2.61 | 104.23 | 2.61 | 53.16 |
| 1/16/1997 | 10.1 | 0.49 | 0.8 | 0.05 | 8.10 | 25.67 | 43.59 | 2.72 | 108.98 | 2.72 | 55.58 |
| 1/17/1997 | 8.39 | 0.5 | 0.8 | 0.05 | 8.20 | 26.57 | 36.21 | 2.26 | 90.53 | 2.26 | 46.17 |
| 1/18/1997 | 9.64 | 0.49 | 0.79 | 0.05 | 7.50 | 26.36 | 41.09 | 2.60 | 104.02 | 2.60 | 53.05 |
| 1/19/1997 | 9.25 | 0.5 | 0.81 | 0.05 | 6.80 | 27.16 | 40.42 | 2.50 | 99.81 | 2.50 | 50.90 |
| 1/20/1997 | 9.79 | 0.5 | 0.8 | 0.05 | 5.80 | 27.33 | 42.25 | 2.64 | 105.63 | 2.64 | 53.87 |
| 1/21/1997 | 9.95 | 0.49 | 0.79 | 0.05 | 5.70 | 26.88 | 42.41 | 2.68 | 107.36 | 2.68 | 54.75 |
| 1/22/1997 | 9.62 | 0.48 | 0.78 | 0.05 | 4.40 | 26.41 | 40.48 | 2.59 | 103.80 | 2.59 | 52.94 |
| 1/23/1997 | 9.28 | 0.48 | 0.78 | 0.05 | 3.10 | 26.44 | 39.05 | 2.50 | 100.13 | 2.50 | 51.07 |
| 1/24/1997 | 9.09 | 0.48 | 0.78 | 0.05 | 4.70 | 26.47 | 38.25 | 2.45 | 98.08 | 2.45 | 50.02 |
| 1/25/1997 | 10.01 | 0.47 | 0.77 | 0.05 | 9.00 | 32.68 | 41.58 | 2.70 | 108.01 | 2.70 | 55.08 |
| 1/26/1997 | 9.95 | 0.47 | 0.77 | 0.05 | 7.70 | 25.20 | 41.33 | 2.68 | 107.36 | 2.68 | 54.75 |
| 1/27/1997 | 9.96 | 0.48 | 0.77 | 0.05 | 6.60 | 30.14 | 41.38 | 2.69 | 107.47 | 2.69 | 54.81 |
| 1/28/1997 | 9.94 | 0.48 | 0.78 | 0.05 | 6.50 | 25.69 | 41.83 | 2.68 | 107.25 | 2.68 | 54.70 |
| 1/29/1997 | 9.95 | 0.48 | 0.78 | 0.05 | 6.20 | 25.87 | 41.87 | 2.68 | 107.36 | 2.68 | 54.75 |
| 1/30/1997 | 9.96 | 0.47 | 0.77 | 0.05 | 6.00 | 28.22 | 41.38 | 2.69 | 107.47 | 2.69 | 54.81 |
| 1/31/1997 | 9.75 | 0.47 | 0.77 | 0.05 | 7.10 | 24.87 | 40.50 | 2.63 | 105.20 | 2.63 | 53.65 |
| 2/1/1997 | 9.24 | 0.45 | 0.76 | 0.05 | 5.80 | 24.01 | 37.89 | 2.49 | 99.70 | 2.49 | 50.85 |
| 2/2/1997 | 9.22 | 0.44 | 0.74 | 0.05 | 6.30 | 23.50 | 36.81 | 2.49 | 99.48 | 2.49 | 50.74 |
| 2/3/1997 | 9.2 | 0.44 | 0.75 | 0.05 | 5.60 | 22.91 | 37.23 | 2.48 | 99.27 | 2.48 | 50.63 |
| 2/4/1997 | 9.18 | 0.44 | 0.75 | 0.05 | 5.50 | 22.46 | 37.14 | 2.48 | 99.05 | 2.48 | 50.52 |
| 2/5/1997 | 9.17 | 0.44 | 0.75 | 0.05 | 5.50 | 22.10 | 37.10 | 2.47 | 98.94 | 2.47 | 50.46 |
| 2/6/1997 | 9.15 | 0.44 | 0.76 | 0.05 | 5.50 | 21.82 | 37.52 | 2.47 | 98.73 | 2.47 | 50.35 |
| 2/7/1997 | 9.27 | 0.44 | 0.75 | 0.05 | 5.50 | 31.26 | 37.51 | 2.50 | 100.02 | 2.50 | 51.01 |
| 2/8/1997 | 9.33 | 0.43 | 0.74 | 0.05 | 6.10 | 34.03 | 37.25 | 2.52 | 100.67 | 2.52 | 51.34 |
| 2/9/1997 | 9.1 | 0.45 | 0.76 | 0.05 | 7.00 | 23.31 | 37.31 | 2.45 | 98.19 | 2.45 | 50.08 |
| 2/10/1997 | 9.01 | 0.45 | 0.77 | 0.05 | 7.30 | 23.94 | 37.43 | 2.43 | 97.22 | 2.43 | 49.58 |
| 2/11/1997 | 8.65 | 0.45 | 0.77 | 0.05 | 6.40 | 24.13 | 35.93 | 2.33 | 93.33 | 2.33 | 47.60 |
| 2/12/1997 | 6.9 | 0.47 | 0.78 | 0.05 | 5.90 | 24.52 | 29.04 | 1.86 | 74.45 | 1.86 | 37.97 |
| 2/13/1997 | 9.44 | 0.45 | 0.77 | 0.05 | 5.90 | 23.02 | 39.22 | 2.55 | 101.86 | 2.55 | 51.95 |
| 2/14/1997 | 9.31 | 0.41 | 0.69 | 0.04 | 5.90 | 76.89 | 34.66 | 2.01 | 100.45 | 2.51 | 51.23 |
| 2/15/1997 | 9.36 | 0.43 | 0.73 | 0.05 | 6.60 | 64.58 | 36.86 | 2.52 | 100.99 | 2.52 | 51.51 |
| 2/16/1997 | 10.33 | 0.39 | 0.66 | 0.04 | 7.30 | 166.09 | 36.78 | 2.23 | 111.46 | 2.79 | 56.84 |
| 2/17/1997 | 9.06 | 0.44 | 0.75 | 0.05 | 6.70 | 67.63 | 36.66 | 2.44 | 97.76 | 2.44 | 49.86 |
| 2/18/1997 | 9.08 | 0.45 | 0.77 | 0.05 | 5.90 | 53.05 | 37.72 | 2.45 | 97.97 | 2.45 | 49.97 |
| 2/19/1997 | 9 | 0.46 | 0.78 | 0.05 | 6.10 | 37.15 | 37.87 | 2.43 | 97.11 | 2.43 | 49.53 |
| 2/20/1997 | 7.65 | 0.47 | 0.79 | 0.05 | 5.80 | 30.58 | 32.60 | 2.06 | 82.54 | 2.06 | 42.10 |
| 2/21/1997 | 8.71 | 0.46 | 0.78 | 0.05 | 5.50 | 29.48 | 36.65 | 2.35 | 93.98 | 2.35 | 47.93 |
| 2/22/1997 | 9.06 | 0.46 | 0.79 | 0.05 | 5.80 | 24.40 | 38.61 | 2.44 | 97.76 | 2.44 | 49.86 |
| 2/23/1997 | 9.01 | 0.46 | 0.78 | 0.05 | 6.10 | 22.58 | 37.91 | 2.43 | 97.22 | 2.43 | 49.58 |
| 2/24/1997 | 9.01 | 0.47 | 0.79 | 0.05 | 6.00 | 23.07 | 38.40 | 2.43 | 97.22 | 2.43 | 49.58 |
| 2/25/1997 | 7.99 | 0.49 | 0.81 | 0.05 | 6.00 | 24.06 | 34.92 | 2.16 | 86.21 | 2.16 | 43.97 |
| 2/26/1997 | 8.97 | 0.46 | 0.79 | 0.05 | 6.10 | 22.58 | 38.23 | 2.42 | 96.79 | 2.42 | 49.36 |
| 2/27/1997 | 6.51 | 0.47 | 0.8 | 0.05 | 6.10 | 23.38 | 28.10 | 1.76 | 70.24 | 1.76 | 35.82 |
| 2/28/1997 | 6.76 | 0.47 | 0.8 | 0.05 | 6.30 | 24.22 | 29.18 | 1.82 | 72.94 | 1.82 | 37.20 |
| 3/1/1997 | 8.88 | 0.5 | 0.82 | 0.05 | 5.90 | 26.11 | 39.28 | 2.40 | 95.82 | 2.40 | 48.87 |
| 3/2/1997 | 8.94 | 0.5 | 0.83 | 0.05 | 5.70 | 26.25 | 40.03 | 2.41 | 96.46 | 2.41 | 49.20 |
| 3/3/1997 | 8.99 | 0.5 | 0.82 | 0.05 | 5.60 | 26.38 | 39.77 | 2.43 | 97.00 | 2.43 | 49.47 |
| 3/4/1997 | 9.05 | 0.5 | 0.82 | 0.05 | 5.40 | 26.54 | 40.04 | 2.44 | 97.65 | 2.44 | 49.80 |
| 3/5/1997 | 9.09 | 0.5 | 0.82 | 0.05 | 5.50 | 26.73 | 40.21 | 2.45 | 98.08 | 2.45 | 50.02 |
| 3/6/1997 | 9.13 | 0.5 | 0.82 | 0.05 | 5.50 | 26.92 | 40.39 | 2.46 | 98.51 | 2.46 | 50.24 |
| 3/7/1997 | 9.17 | 0.5 | 0.82 | 0.05 | 5.60 | 27.08 | 40.57 | 2.47 | 98.94 | 2.47 | 50.46 |
| 3/8/1997 | 8.82 | 0.49 | 0.82 | 0.05 | 5.30 | 26.70 | 39.02 | 2.38 | 95.17 | 2.38 | 48.54 |
| 3/9/1997 | 9.93 | 0.5 | 0.82 | 0.05 | 5.00 | 27.41 | 43.93 | 2.68 | 107.14 | 2.68 | 54.64 |
| 3/10/1997 | 9.79 | 0.48 | 0.81 | 0.05 | 5.10 | 26.47 | 42.78 | 2.64 | 105.63 | 2.64 | 53.87 |

## Table B.2. Little Wekiva Canal Natural Daily BOD Simulation Summary

| Date | STREAM FLOW | | BOD | | | | |
|---|---|---|---|---|---|---|---|
| | SWMM Simulated Flow (CFS) | Area:Ratio Relationship Utilizing 2234990 Gage | Existing Conditions | | Natural Background | | Load at FLDEP Screening Level (BOD=2.0 mg/L) |
| | | | SWMM Simulated Concentration (mg/L) | SWMM Based Load (LBS/DAY) | SWMM Simulated Concentration (mg/L) | SWMM Based Load (LBS/DAY) | SWMM Simulated Screening Level Load (LBS/DAY) |
| 1/2/1997 | 10.09 | 6.80 | 1.4 | 46.45 | 0.54 | 17.92 | 66.36 |
| 1/3/1997 | 10.08 | 6.60 | 1.35 | 47.63 | 0.51 | 17.99 | 70.57 |
| 1/4/1997 | 9.18 | 6.50 | 1.17 | 47.59 | 0.51 | 20.75 | 81.36 |
| 1/5/1997 | 10.08 | 6.40 | 1.07 | 47.22 | 0.54 | 23.83 | 88.26 |
| 1/6/1997 | 9.5 | 6.10 | 1.02 | 47.16 | 0.52 | 24.04 | 92.47 |
| 1/7/1997 | 9.38 | 6.20 | 0.99 | 47.16 | 0.53 | 25.25 | 95.28 |
| 1/8/1997 | 7.91 | 5.50 | 0.97 | 47.31 | 0.52 | 25.36 | 97.54 |
| 1/9/1997 | 10.41 | 5.70 | 4.38 | 439.05 | 0.49 | 49.12 | 200.48 |
| 1/10/1997 | 9.88 | 6.30 | 0.8 | 45.10 | 0.51 | 28.75 | 112.76 |
| 1/11/1997 | 9.76 | 6.60 | 0.83 | 45.45 | 0.51 | 27.93 | 109.52 |
| 1/12/1997 | 10 | 6.50 | 0.83 | 45.94 | 0.51 | 28.23 | 110.71 |
| 1/13/1997 | 10.06 | 5.30 | 0.83 | 46.44 | 0.50 | 27.97 | 111.89 |
| 1/14/1997 | 10.09 | 6.00 | 0.72 | 45.80 | 0.50 | 31.80 | 127.21 |
| 1/15/1997 | 9.66 | 7.40 | 3.14 | 239.54 | 0.49 | 37.38 | 152.57 |
| 1/16/1997 | 10.1 | 8.10 | 0.84 | 44.00 | 0.49 | 25.67 | 104.77 |
| 1/17/1997 | 8.39 | 8.20 | 0.84 | 44.64 | 0.50 | 26.57 | 106.28 |
| 1/18/1997 | 9.64 | 7.50 | 0.83 | 44.64 | 0.49 | 26.36 | 107.58 |
| 1/19/1997 | 9.25 | 6.80 | 0.83 | 45.09 | 0.50 | 27.16 | 108.66 |
| 1/20/1997 | 9.79 | 5.80 | 0.83 | 45.36 | 0.50 | 27.33 | 109.30 |
| 1/21/1997 | 9.95 | 5.70 | 0.83 | 45.54 | 0.49 | 26.88 | 109.73 |
| 1/22/1997 | 9.62 | 4.40 | 0.83 | 45.67 | 0.48 | 26.41 | 110.06 |
| 1/23/1997 | 9.28 | 3.10 | 0.83 | 45.72 | 0.48 | 26.44 | 110.17 |
| 1/24/1997 | 9.09 | 4.70 | 0.83 | 45.76 | 0.48 | 26.47 | 110.27 |
| 1/25/1997 | 10.01 | 9.00 | 2.67 | 185.68 | 0.47 | 32.68 | 139.08 |
| 1/26/1997 | 9.95 | 7.70 | 0.84 | 45.05 | 0.47 | 25.20 | 107.25 |
| 1/27/1997 | 9.96 | 6.60 | 0.81 | 50.87 | 0.48 | 30.14 | 125.60 |
| 1/28/1997 | 9.94 | 6.50 | 0.83 | 44.42 | 0.48 | 25.69 | 107.04 |
| 1/29/1997 | 9.95 | 6.20 | 0.83 | 44.73 | 0.48 | 25.87 | 107.79 |
| 1/30/1997 | 9.96 | 6.00 | 0.74 | 44.43 | 0.47 | 28.22 | 120.09 |
| 1/31/1997 | 9.75 | 7.10 | 0.81 | 42.87 | 0.47 | 24.87 | 105.85 |
| 2/1/1997 | 9.24 | 5.80 | 0.68 | 36.28 | 0.45 | 24.01 | 106.71 |
| 2/2/1997 | 9.22 | 6.30 | 0.69 | 36.85 | 0.44 | 23.50 | 106.82 |
| 2/3/1997 | 9.2 | 5.60 | 0.71 | 36.96 | 0.44 | 22.91 | 104.12 |
| 2/4/1997 | 9.18 | 5.50 | 0.72 | 36.75 | 0.44 | 22.46 | 102.07 |
| 2/5/1997 | 9.17 | 5.50 | 0.73 | 36.67 | 0.44 | 22.10 | 100.45 |
| 2/6/1997 | 9.15 | 5.50 | 0.74 | 36.69 | 0.44 | 21.82 | 99.16 |
| 2/7/1997 | 9.27 | 5.50 | 2.76 | 196.10 | 0.44 | 31.26 | 142.10 |
| 2/8/1997 | 9.33 | 6.10 | 3.32 | 262.76 | 0.43 | 34.03 | 158.29 |
| 2/9/1997 | 9.1 | 7.00 | 0.69 | 35.74 | 0.45 | 23.31 | 103.58 |
| 2/10/1997 | 9.01 | 7.30 | 0.68 | 36.17 | 0.45 | 23.94 | 106.39 |
| 2/11/1997 | 8.65 | 6.40 | 0.69 | 37.00 | 0.45 | 24.13 | 107.25 |
| 2/12/1997 | 6.9 | 5.90 | 0.7 | 36.52 | 0.47 | 24.52 | 104.34 |
| 2/13/1997 | 9.44 | 5.90 | 0.72 | 36.82 | 0.45 | 23.02 | 102.29 |
| 2/14/1997 | 9.31 | 5.90 | 4.61 | 864.51 | 0.41 | 76.89 | 375.06 |
| 2/15/1997 | 9.36 | 6.60 | 2.2 | 330.43 | 0.43 | 64.58 | 300.39 |
| 2/16/1997 | 10.33 | 7.30 | 3 | 1277.64 | 0.39 | 166.09 | 851.76 |

## Table B.3. Little Wekiva Canal Daily TN Simulation Summary

| Date | STREAM FLOW | | TOTAL NITROGEN | | | | |
|---|---|---|---|---|---|---|---|
| | SWMM Simulated Flow (CFS) | Area:Ratio Relationship Utilizing 2234990 Gage | Existing Conditions: SWMM Simulated Concentration (mg/L) | Existing Conditions: SWMM Based Load (LBS/DAY) | Natural Background: SWMM Simulated Concentration (mg/L) | Natural Background: SWMM Based Load (LBS/DAY) | Critical TN Concentration Based on Regression Equation (TN=1.02 mg/L): SWMM Simulated Load (LBS/DAY) at Critical Total Nitrogen Concentration |
| 1/2/1997 | 10.09 | 6.80 | 0.99 | 32.85 | 0.84 | 45.73 | 33.84 |
| 1/3/1997 | 10.08 | 6.60 | 0.97 | 34.22 | 0.81 | 44.05 | 35.99 |
| 1/4/1997 | 9.18 | 6.50 | 0.84 | 34.17 | 0.82 | 40.61 | 41.49 |
| 1/5/1997 | 10.08 | 6.40 | 0.75 | 33.10 | 0.85 | 46.22 | 45.01 |
| 1/6/1997 | 9.5 | 6.10 | 0.71 | 32.83 | 0.85 | 43.56 | 47.16 |
| 1/7/1997 | 9.38 | 6.20 | 0.69 | 32.87 | 0.85 | 43.01 | 48.59 |
| 1/8/1997 | 7.91 | 5.50 | 0.67 | 32.68 | 0.84 | 35.85 | 49.75 |
| 1/9/1997 | 10.41 | 5.70 | 1.4 | 140.33 | 0.80 | 44.93 | 102.24 |
| 1/10/1997 | 9.88 | 6.30 | 0.53 | 29.88 | 0.83 | 44.24 | 57.51 |
| 1/11/1997 | 9.76 | 6.60 | 0.55 | 30.12 | 0.83 | 43.70 | 55.85 |
| 1/12/1997 | 10 | 6.50 | 0.56 | 31.00 | 0.83 | 44.78 | 56.46 |
| 1/13/1997 | 10.06 | 5.30 | 0.57 | 31.89 | 0.82 | 44.50 | 57.07 |
| 1/14/1997 | 10.09 | 6.00 | 0.48 | 30.53 | 0.81 | 44.09 | 64.88 |
| 1/15/1997 | 9.66 | 7.40 | 1.1 | 83.91 | 0.79 | 41.17 | 77.81 |
| 1/16/1997 | 10.1 | 8.10 | 0.54 | 28.29 | 0.80 | 43.59 | 53.43 |
| 1/17/1997 | 8.39 | 8.20 | 0.55 | 29.23 | 0.80 | 36.21 | 54.20 |
| 1/18/1997 | 9.64 | 7.50 | 0.56 | 30.12 | 0.79 | 41.09 | 54.86 |
| 1/19/1997 | 9.25 | 6.80 | 0.56 | 30.42 | 0.81 | 40.42 | 55.41 |
| 1/20/1997 | 9.79 | 5.80 | 0.57 | 31.15 | 0.80 | 42.25 | 55.74 |
| 1/21/1997 | 9.95 | 5.70 | 0.57 | 31.27 | 0.79 | 42.41 | 55.96 |
| 1/22/1997 | 9.62 | 4.40 | 0.58 | 31.92 | 0.78 | 40.48 | 56.13 |
| 1/23/1997 | 9.28 | 3.10 | 0.58 | 31.95 | 0.78 | 39.05 | 56.18 |
| 1/24/1997 | 9.09 | 4.70 | 0.58 | 31.98 | 0.78 | 38.25 | 56.24 |
| 1/25/1997 | 10.01 | 9.00 | 1 | 69.54 | 0.77 | 41.58 | 70.93 |
| 1/26/1997 | 9.95 | 7.70 | 0.58 | 31.10 | 0.77 | 41.33 | 54.70 |
| 1/27/1997 | 9.96 | 6.60 | 0.5 | 31.40 | 0.77 | 41.38 | 64.05 |
| 1/28/1997 | 9.94 | 6.50 | 0.58 | 31.04 | 0.78 | 41.83 | 54.59 |
| 1/29/1997 | 9.95 | 6.20 | 0.58 | 31.26 | 0.78 | 41.87 | 54.97 |
| 1/30/1997 | 9.96 | 6.00 | 0.51 | 30.62 | 0.77 | 41.38 | 61.25 |
| 1/31/1997 | 9.75 | 7.10 | 0.58 | 30.70 | 0.77 | 40.50 | 53.98 |
| 2/1/1997 | 9.24 | 5.80 | 0.53 | 28.28 | 0.76 | 37.89 | 54.42 |
| 2/2/1997 | 9.22 | 6.30 | 0.54 | 28.84 | 0.74 | 36.81 | 54.48 |
| 2/3/1997 | 9.2 | 5.60 | 0.55 | 28.63 | 0.75 | 37.23 | 53.10 |
| 2/4/1997 | 9.18 | 5.50 | 0.56 | 28.58 | 0.75 | 37.14 | 52.06 |
| 2/5/1997 | 9.17 | 5.50 | 0.57 | 28.63 | 0.75 | 37.10 | 51.23 |
| 2/6/1997 | 9.15 | 5.50 | 0.58 | 28.76 | 0.76 | 37.52 | 50.57 |
| 2/7/1997 | 9.27 | 5.50 | 1.04 | 73.89 | 0.75 | 37.51 | 72.47 |
| 2/8/1997 | 9.33 | 6.10 | 1.14 | 90.22 | 0.74 | 37.25 | 80.73 |
| 2/9/1997 | 9.1 | 7.00 | 0.54 | 27.97 | 0.76 | 37.31 | 52.83 |
| 2/10/1997 | 9.01 | 7.30 | 0.55 | 29.26 | 0.77 | 37.43 | 54.26 |
| 2/11/1997 | 8.65 | 6.40 | 0.56 | 30.03 | 0.77 | 35.93 | 54.70 |
| 2/12/1997 | 6.9 | 5.90 | 0.58 | 30.26 | 0.78 | 29.04 | 53.21 |
| 2/13/1997 | 9.44 | 5.90 | 0.59 | 30.18 | 0.77 | 39.22 | 52.17 |
| 2/14/1997 | 9.31 | 5.90 | 1.38 | 258.79 | 0.69 | 34.66 | 191.28 |
| 2/15/1997 | 9.36 | 6.60 | 0.77 | 115.65 | 0.73 | 36.86 | 153.20 |
| 2/16/1997 | 10.33 | 7.30 | 0.95 | 404.59 | 0.66 | 36.78 | 434.40 |
| 2/17/1997 | 9.06 | 6.70 | 0.31 | 47.65 | 0.75 | 36.66 | 156.78 |
| 2/18/1997 | 9.08 | 5.90 | 0.35 | 41.26 | 0.77 | 37.72 | 120.24 |

## Table B.4. Little Wekiva Canal Daily TP Simulation Summary

| Date | STREAM FLOW | | TOTAL PHOSPHORUS | | | | |
|---|---|---|---|---|---|---|---|
| | SWMM Simulated Flow (CFS) | Area:Ratio Relationship Utilizing 2234990 Gage | Existing Conditions | | Natural Background | | Critical TP Concentration Based on Regression Equation (TN=0.05 mg/L) |
| | | | SWMM Simulated Concentration (mg/L) | SWMM Based Load (LBS/DAY) | SWMM Simulated Concentration (mg/L) | SWMM Based Load (LBS/DAY) | SWMM Simulated Load (LBS/DAY) at Critical Total Phosphorus Concentration |
| 1/2/1997 | 10.09 | 6.80 | 0.06 | 1.99 | 0.05 | 2.72 | 1.66 |
| 1/3/1997 | 10.08 | 6.60 | 0.05 | 1.76 | 0.05 | 2.72 | 1.76 |
| 1/4/1997 | 9.18 | 6.50 | 0.05 | 2.03 | 0.05 | 2.48 | 2.03 |
| 1/5/1997 | 10.08 | 6.40 | 0.04 | 1.77 | 0.05 | 2.72 | 2.21 |
| 1/6/1997 | 9.5 | 6.10 | 0.04 | 1.85 | 0.05 | 2.56 | 2.31 |
| 1/7/1997 | 9.38 | 6.20 | 0.04 | 1.91 | 0.05 | 2.53 | 2.38 |
| 1/8/1997 | 7.91 | 5.50 | 0.04 | 1.95 | 0.05 | 2.13 | 2.44 |
| 1/9/1997 | 10.41 | 5.70 | 0.22 | 22.05 | 0.05 | 2.81 | 5.01 |
| 1/10/1997 | 9.88 | 6.30 | 0.03 | 1.69 | 0.05 | 2.67 | 2.82 |
| 1/11/1997 | 9.76 | 6.60 | 0.03 | 1.64 | 0.05 | 2.63 | 2.74 |
| 1/12/1997 | 10 | 6.50 | 0.03 | 1.66 | 0.05 | 2.70 | 2.77 |
| 1/13/1997 | 10.06 | 5.30 | 0.03 | 1.68 | 0.05 | 2.71 | 2.80 |
| 1/14/1997 | 10.09 | 6.00 | 0.03 | 1.91 | 0.05 | 2.72 | 3.18 |
| 1/15/1997 | 9.66 | 7.40 | 0.15 | 11.44 | 0.05 | 2.61 | 3.81 |
| 1/16/1997 | 10.1 | 8.10 | 0.03 | 1.57 | 0.05 | 2.72 | 2.62 |
| 1/17/1997 | 8.39 | 8.20 | 0.03 | 1.59 | 0.05 | 2.26 | 2.66 |
| 1/18/1997 | 9.64 | 7.50 | 0.03 | 1.61 | 0.05 | 2.60 | 2.69 |
| 1/19/1997 | 9.25 | 6.80 | 0.03 | 1.63 | 0.05 | 2.50 | 2.72 |
| 1/20/1997 | 9.79 | 5.80 | 0.03 | 1.64 | 0.05 | 2.64 | 2.73 |
| 1/21/1997 | 9.95 | 5.70 | 0.03 | 1.65 | 0.05 | 2.68 | 2.74 |
| 1/22/1997 | 9.62 | 4.40 | 0.03 | 1.65 | 0.05 | 2.59 | 2.75 |
| 1/23/1997 | 9.28 | 3.10 | 0.03 | 1.65 | 0.05 | 2.50 | 2.75 |
| 1/24/1997 | 9.09 | 4.70 | 0.03 | 1.65 | 0.05 | 2.45 | 2.76 |
| 1/25/1997 | 10.01 | 9.00 | 0.13 | 9.04 | 0.05 | 2.70 | 3.48 |
| 1/26/1997 | 9.95 | 7.70 | 0.03 | 1.61 | 0.05 | 2.68 | 2.68 |
| 1/27/1997 | 9.96 | 6.60 | 0.03 | 1.88 | 0.05 | 2.69 | 3.14 |
| 1/28/1997 | 9.94 | 6.50 | 0.03 | 1.61 | 0.05 | 2.68 | 2.68 |
| 1/29/1997 | 9.95 | 6.20 | 0.03 | 1.62 | 0.05 | 2.68 | 2.70 |
| 1/30/1997 | 9.96 | 6.00 | 0.03 | 1.80 | 0.05 | 2.69 | 3.00 |
| 1/31/1997 | 9.75 | 7.10 | 0.03 | 1.59 | 0.05 | 2.63 | 2.65 |
| 2/1/1997 | 9.24 | 5.80 | 0.03 | 1.60 | 0.05 | 2.49 | 2.67 |
| 2/2/1997 | 9.22 | 6.30 | 0.03 | 1.60 | 0.05 | 2.49 | 2.67 |
| 2/3/1997 | 9.2 | 5.60 | 0.03 | 1.56 | 0.05 | 2.48 | 2.60 |
| 2/4/1997 | 9.18 | 5.50 | 0.03 | 1.53 | 0.05 | 2.48 | 2.55 |
| 2/5/1997 | 9.17 | 5.50 | 0.03 | 1.51 | 0.05 | 2.47 | 2.51 |
| 2/6/1997 | 9.15 | 5.50 | 0.03 | 1.49 | 0.05 | 2.47 | 2.48 |
| 2/7/1997 | 9.27 | 5.50 | 0.14 | 9.95 | 0.05 | 2.50 | 3.55 |
| 2/8/1997 | 9.33 | 6.10 | 0.16 | 12.66 | 0.05 | 2.52 | 3.96 |
| 2/9/1997 | 9.1 | 7.00 | 0.03 | 1.55 | 0.05 | 2.45 | 2.59 |
| 2/10/1997 | 9.01 | 7.30 | 0.03 | 1.60 | 0.05 | 2.43 | 2.66 |
| 2/11/1997 | 8.65 | 6.40 | 0.03 | 1.61 | 0.05 | 2.33 | 2.68 |
| 2/12/1997 | 6.9 | 5.90 | 0.03 | 1.57 | 0.05 | 1.86 | 2.61 |
| 2/13/1997 | 9.44 | 5.90 | 0.03 | 1.53 | 0.05 | 2.55 | 2.56 |
| 2/14/1997 | 9.31 | 5.90 | 0.23 | 43.13 | 0.04 | 2.01 | 9.38 |
| 2/15/1997 | 9.36 | 6.60 | 0.11 | 16.52 | 0.05 | 2.52 | 7.51 |
| 2/16/1997 | 10.33 | 7.30 | 0.15 | 63.88 | 0.04 | 2.23 | 21.30 |
| 2/17/1997 | 9.06 | 6.70 | 0.01 | 1.54 | 0.05 | 2.44 | 7.69 |
| 2/18/1997 | 9.08 | 5.90 | 0.02 | 2.36 | 0.05 | 2.45 | 5.90 |

## Appendix C: General SWMM Little Wekiva Canal Simulation Model Component Summary

| | |
|---|---|
| Raingages | 1 |
| Subcatchments | 57 |
| Aquifers | 4 |
| Snowpacks | 0 |
| RDII Hydrographs | 0 |
| Infiltration | GREEN_AMPT |
| --------------------- | |
| Junction Nodes | 200 |
| Outfall Nodes | 3 |
| Flow Divider Nodes | 3 |
| Storage Unit Nodes | 32 |
| --------------------- | |
| Conduit Links | 226 |
| Pump Links | 0 |
| Orifice Links | 0 |
| Weir Links | 0 |
| Outlet Links | 0 |
| --------------------- | |
| Flow Units | CFS |

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