FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

NORTHEAST DISTRICT • LOWER ST. JOHNS BASIN

Final TMDL Report

Dissolved Oxygen and Nutrient TMDLs for Mill Creek (WBID 2460)

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STORET Program

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

2008 305(b) Report

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

Criteria for Surface Water Quality Classifications

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

Basin Status Report for the Lower St. Johns Basin

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

Water Quality Assessment Report for the Lower St. Johns Basin

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

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Loads (TMDLs) for dissolved oxygen (DO) and nutrients for Mill Creek, in the Sixmile Creek Planning Unit of the Lower St. Johns Basin. The creek was verified as impaired for DO, and was included on the Verified List of impaired waters for the Lower St. Johns Basin that was adopted by Secretarial Order in May 2009. As the DO impairment was associated with total nitrogen (TN) and biochemical oxygen demand (BOD), Mill Creek was also verified as impaired for nutrients. These TMDLs establish the allowable loadings to Mill Creek that would restore the waterbody so that it meets its applicable water quality criteria for DO and nutrients.

1.2 Identification of Waterbody

Mill Creek is located in the northern portion of St. Johns County, just south of Jacksonville (**Figure 1.1**). The creek flows primarily southwest into Sixmile Creek and drains an area of about 11.6 square miles (**Figure 1.2**). It is approximately 4.1 miles long and is a second-order stream. Interstate 95 (I-95) crosses Mill Creek in the northeast portion of the watershed. The majority of the commercial and residential developments are along the creek. Wetlands and upland forest dominate the northern part of the watershed. This area in St. Johns County is experiencing increased development pressure.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Lower St. Johns Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. This TMDL report addresses Mill Creek, WBID 2460, for DO and nutrients.

Mill Creek is part of the Sixmile Creek Planning Unit. Planning units are groups of smaller watersheds (WBIDs) that are part of a larger basin unit, in this case the Lower St. Johns Basin. The Sixmile Creek Planning Unit consists of 11 WBIDs. **Figure 1.3** shows the locations of these WBIDs and the Mill Creek WBID in the planning unit.

1.3 Background

This report was developed as part of the Department's watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).

Figure 1.1. Location of the Mill Creek Watershed (WBID 2460) in the Lower St. Johns Basin and Major Hydrologic Features in the Area

Figure 1.2. Location of the Mill Creek Watershed (WBID 2460) in St. Johns County and Major Hydrologic Features in the Area

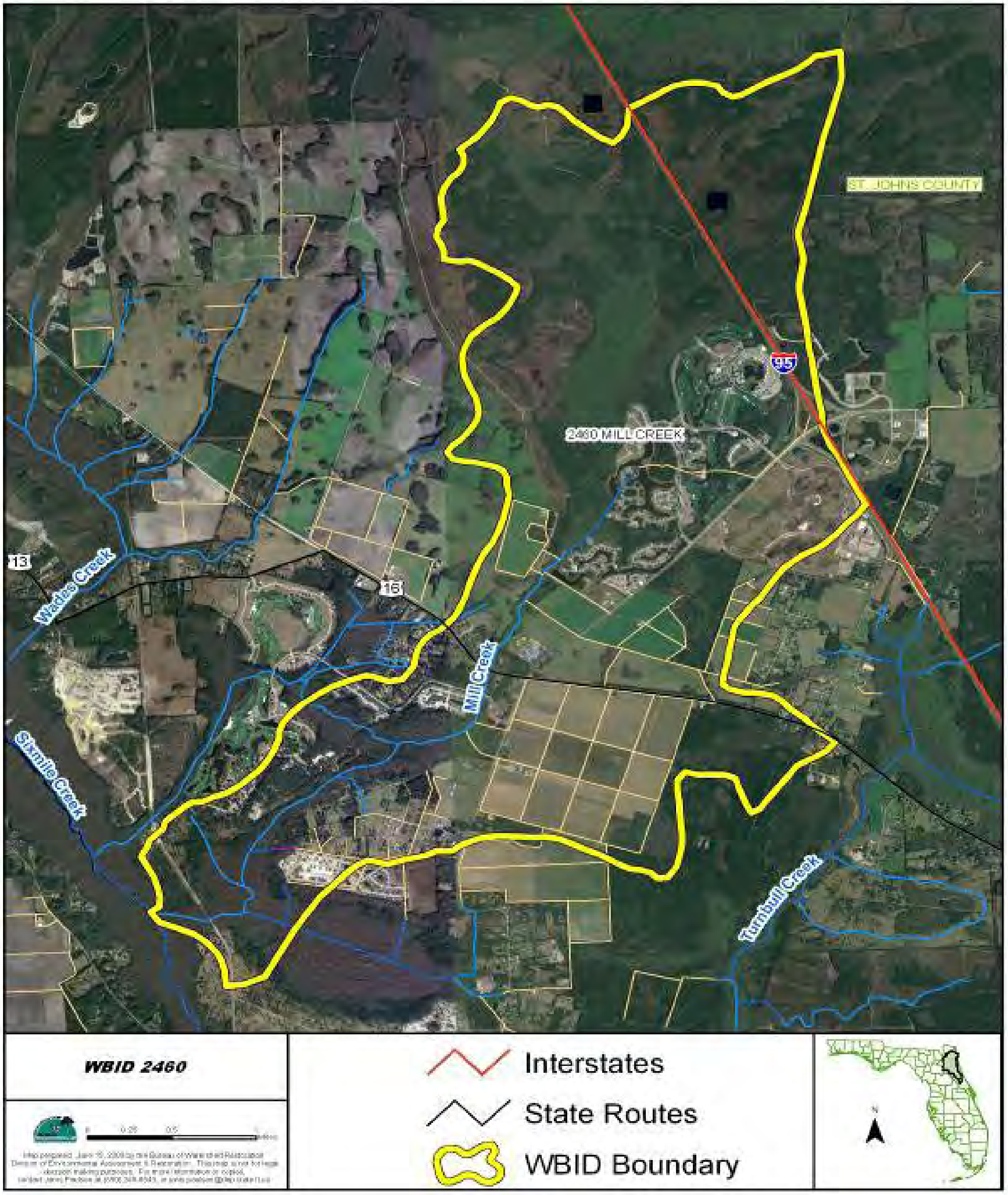
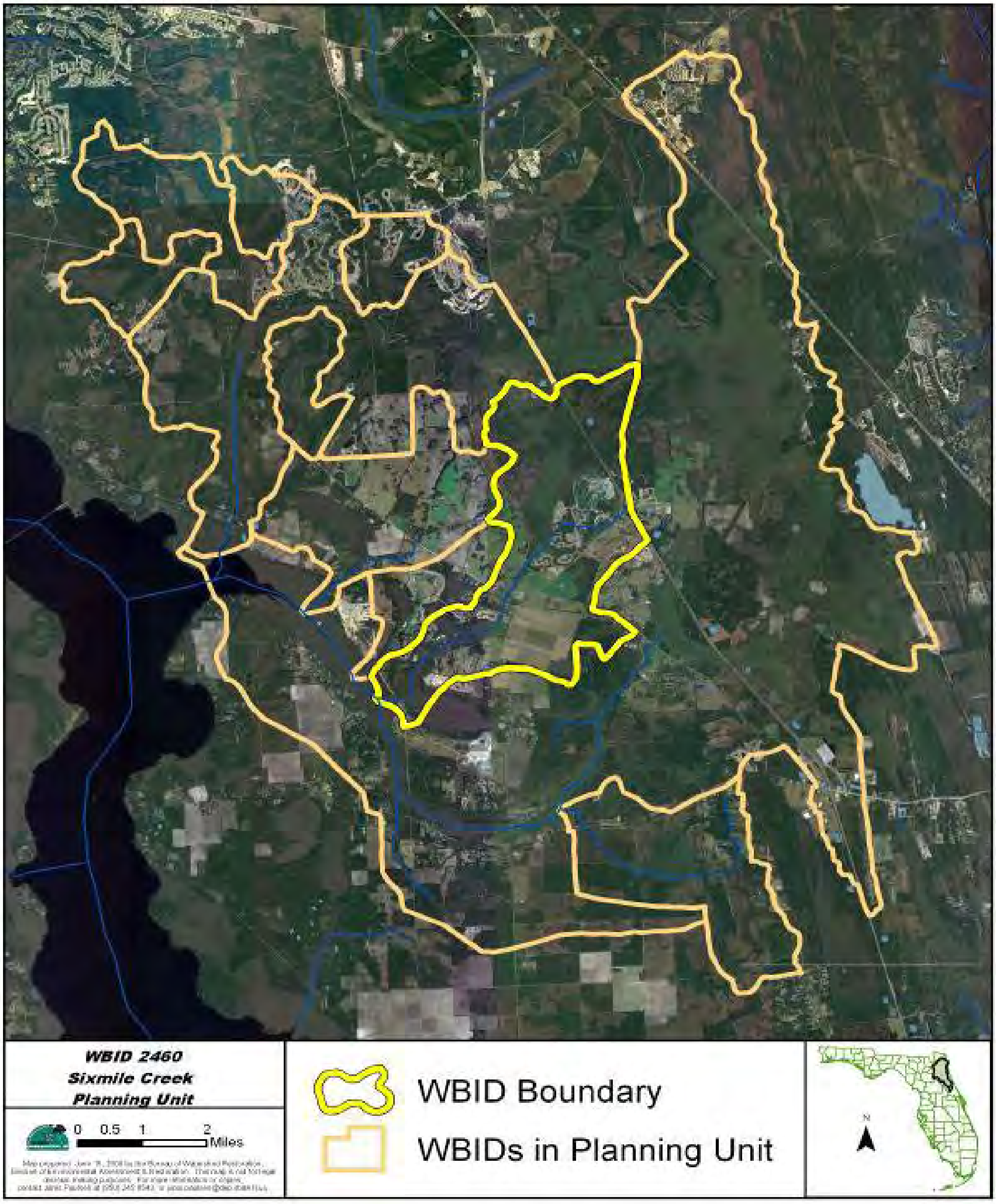


Figure 1.3. WBIDs in the Sixmile Creek Planning Unit



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.

A nutrient TMDL was adopted in April 2008 for the mainstem of the Lower St. Johns River that required a 30 percent reduction in anthropogenic loadings of nitrogen and phosphorus to the freshwater portion of the Lower St. Johns. A Basin Management Action Plan, or BMAP, was adopted in October 2008 that outlined a number of activities designed to reduce the amount of TN and total phosphorus (TP) to the freshwater portion of the Lower St. Johns River. 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 or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies, including tributaries to the Lower St. Johns such as Mill Creek.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

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

Florida's 1998 303(d) list included 55 waterbodies in the Lower St. Johns 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.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Mill Creek watershed and has verified that this waterbody segment is impaired for DO and nutrients, based on data in the Department's IWR database. **Table 2.1** summarizes the DO data for the verified period, which for Group 2 waters was January 1, 2001, through June 30, 2008. **Tables 2.2** through **2.4** provide data summaries for Mill Creek over the verified period by month, season, and year, respectively. Although chlorophyll *a* (chl*a*) levels did not exceed IWR listing thresholds, high TN concentrations in the waterbody were associated with the DO impairment, and the waterbody was found to be impaired for nutrients.

There is a 46.6 percent overall exceedance rate for DO in Mill Creek during the verified period (**Table 2.1**). Exceedances occur in all seasons and in all months except for the cold months: December, January, and February (**Tables 2.2** and **2.3**). During the verified period, samples ranged from 2.4 to 8.5 milligrams per liter (mg/L). As DO solubility is influenced by both salinity and water temperature, ranges in DO saturation (DOSAT) were also evaluated. DOSAT ranged from 31 to 81 percent, averaging 59.8 percent. Fewer than 10 percent of the DOSAT values were less than 45 percent.

When aggregating data by season, the lowest percentage of exceedances occurred in the spring and the highest in summer. Possible relationships between DO and other water quality parameters are further assessed in Chapter 5, using the complete historical dataset.

Table 2.1. Summary of DO Monitoring Data for Mill Creek (WBID 2460) During the Verified Period (January 1, 2001–June 30, 2008)

- = Empty cell

Waterbody (WBID)	Parameter	DO
Mill Creek (2460)	Total number of samples	58
Mill Creek (2460)	IWR-required number of exceedances for the Verified List	10
Mill Creek (2460)	Number of observed exceedances	27 (46.6%)
Mill Creek (2460)	Number of observed nonexceedances	31
Mill Creek (2460)	Number of seasons during which samples were collected	4
Mill Creek (2460)	Highest observation (mg/L)	8.5
Mill Creek (2460)	Lowest observation (mg/L)	2.4
Mill Creek (2460)	Median observation (mg/L)	5.1
Mill Creek (2460)	Mean observation (mg/L)	5.3
Mill Creek (2460)	Median value for 14 BOD observations (mg/L)	2.05
Mill Creek (2460)	Median value for 31 TN observations (mg/L)	1.61
Mill Creek (2460)	Median value for 31 TP observations (mg/L)	0.22
Mill Creek (2460)	Possible causative pollutant by IWR	TN and BOD
-	**FINAL ASSESSMENT:**	**Impaired**

Table 2.2. Summary of DO Data by Month for the Verified Period (January 1, 2001–June 30, 2008)

DO concentrations are mg/L.

Month	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Precipitation (inches)
January	2	7.4	7.7	7.55	7.55	0	0.00%	2.03
February	2	8.5	8.5	8.5	8.5	0	0.00%	3.32
March	2	4.4	4.5	4.45	4.45	2	100.0%	4.05
April	8	3.2	5.9	5.55	5.3	1	12.50%	1.99
May	3	4.2	5.6	5.4	5.07	1	33.33%	1.85
June	3	3.9	5.4	4.4	4.57	2	66.67%	9.08
July	6	2.4	5.0	3.95	3.95	5	83.33%	7.71
August	7	3.3	4.96	4.6	4.37	7	100.0%	5.50
September	4	4.1	6.0	5.1	5.07	2	50.00%	8.63
October	8	3.8	6.4	4.3	4.74	6	75.00%	3.55
November	8	3.8	7.6	6.4	6.18	1	12.50%	1.33
December	5	5.7	8.2	6.4	6.82	0	0.00%	3.63

Table 2.3. Summary of DO Data by Season for the Verified Period (January 1, 2001–June 30, 2008)

DO concentrations are in mg/L.

Season	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Total Precipitation (inches)
Winter	6	4.4	8.5	7.55	6.83	2	33.33%	9.40
Spring	14	3.2	5.9	5.45	5.09	4	28.57%	12.92
Summer	17	2.4	6.0	4.29	4.39	14	82.35%	21.84
Fall	21	3.8	8.2	6.00	5.78	7	33.33%	8.51

Table 2.4. Summary of DO Data by Year for the Verified Period (January 1, 2001–June 30, 2008)

DO concentrations are mg/L.

Year	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Total Precipitation (inches)
2002	21	2.4	8.2	4.9	5.32	11	52.38%	54.72
2003	1	6.4	6.4	6.4	6.40	0	0.00%	44.47
2004	9	3.8	8.5	4.9	5.94	5	55.56%	69.47
2005	1	4.96	4.96	4.96	4.96	1	100.0%	65.49
2007	17	3.3	6.4	4.4	4.80	10	58.82%	45.98
2008	9	5.2	5.9	5.6	5.58	0	0.00%	31.39

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

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

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

Mill Creek (WBID 2460) is a Class III fresh waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the impairment addressed by this TMDL is for DO.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criterion for the protection of Class III freshwater waters, as established by Rule 62-302, F.A.C., states the following:

Dissolved Oxygen Criteria:

Shall not be less than 5.0. Normal daily and seasonal fluctuations above these levels shall be maintained.

The nutrient criterion in Rule 62-302, F.A.C., is expressed as a narrative:

Nutrients:

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 or fauna [Note: For Class III waters in the Everglades Protection Area, this criterion has been numerically interpreted for phosphorus in Section 62-302.540, F.A.C.].

To assess whether this narrative criterion is being exceeded, the IWR provides thresholds for nutrient impairment in estuaries based on annual average chl*a* levels. The following language is found in Rule 62-303, F.A.C.:

62-303.351 Nutrients in Streams.
A stream or stream segment shall be included on the planning list for nutrients if the following biological imbalances are observed:

(1) Algal mats are present in sufficient quantities to pose a nuisance or hinder

> *reproduction of a threatened or endangered species, or*
>
> *(2) Annual mean chlorophyll a concentrations are greater than 20 ug/l or if data indicate annual mean chlorophyll a values have increased by more than 50% over historical values for at least two consecutive years.*

62-303.450 Interpretation of Narrative Nutrient Criteria.

> *(1) A water shall be placed on the verified list for impairment due to nutrients if there are sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll a levels or historical TSIs), to meet the data sufficiency requirements of subsection 62-303.350(2), FA.C. If there are insufficient data, additional data shall be collected as needed to meet the requirements. Once these additional data are collected, the Department shall determine if there is sufficient information to develop a site-specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water segment. If there is sufficient information, the Department shall re-evaluate the data using the site-specific thresholds. If there is insufficient information, the Department shall re-evaluate the data using the thresholds provided in Rules 62-303.351-.353, F.A.C., for streams, lakes, and estuaries, respectively. In any case, the Department shall limit its analysis to the use of data collected during the five years preceding the planning list assessment and the additional data collected in the second phase. If alternative thresholds are used for the analysis, the Department shall provide the thresholds for the record and document how the alternative threshold better represents conditions beyond which an imbalance in flora or fauna is expected to occur.*

Although the annual average chl*a* concentration did not exceed the IWR stream thresholds, nutrients were considered the cause of impairment, based on the link between DO impairment and TN.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of pollutants in the 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" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) **AND** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Nutrients in the Mill Creek Watershed

4.2.1 Point Sources

There are no NPDES wastewater facilities located in the watershed.

Municipal Separate Storm Sewer System Permittees

The Mill Creek watershed is located in St. Johns County, which has a Phase II municipal separate storm sewer system (MS4) permit (FLR04E025).

4.2.2 Land Uses and Nonpoint Sources

Nutrient loadings to Mill Creek are also generated from nonpoint sources in the watershed. These potential sources include loadings from surface runoff, ground water inflow, and septic tanks.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SJRWMD's year 2004 land use coverage (scale 1:51,000) contained in the Department's geographic information system (GIS) library. Land use categories in the watershed were aggregated using the Level 2 land use codes and tabulated in **Table 4.1**. **Figure 4.1** shows the acreage of the principal Level 1 land uses in the watershed.

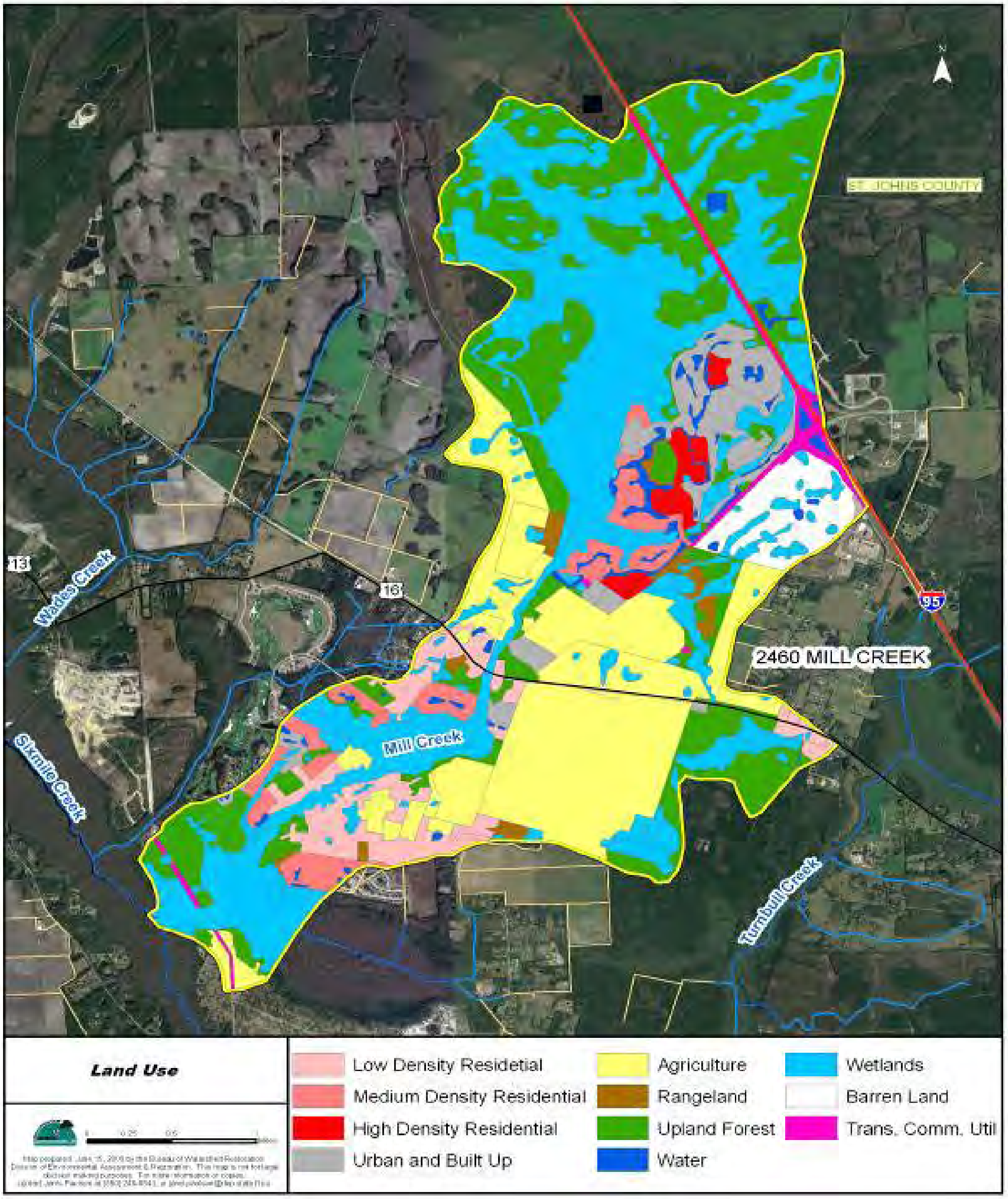
As shown in **Table 4.1**, the total area of the Mill Creek watershed is about 7,420 acres. The dominant land use category is wetland, which accounts for about 37.0 percent of the total watershed area. Urban land uses (urban and built-up; low-, medium-, and high-density residential; and transportation, communication, and utilities) occupy 13.2 percent of the total watershed area. Of the 981 acres of urban lands, residential land use occupies about 507 acres, or about 6.9 percent of the total watershed area. Natural land uses, including water/wetlands, upland forest, and barren land, occupy about 4,664 acres, accounting for about 62.8 percent of the total area.

Table 4.1. Classification of Land Use Categories in the Mill Creek Watershed (WBID 2460) in 2004

- = Empty cell

Level 2 Land Use Code	Attribute	Acres	% of Total
1100	Residential, low density – less than 2 dwelling units/acre	363.81	4.90%
1200	Residential, medium density – 2-5 dwelling units/acre	294.71	3.97%
1300	Residential, high density – 6 or more dwelling units/acre	102.1	1.37%
1400	Commercial and services	103.41	1.39%
1700	Institutional	23.38	0.31%
1800	Recreational	221.41	2.98%
1900	Open land	17.18	0.23%
2100	Cropland and pastureland	764.22	10.29%
2400	Nurseries and vineyards	632.83	8.52%
2500	Specialty farms	81.33	1.09%
3100	Herbaceous upland nonforested	19.43	0.26%
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	69.84	0.94%
4100	Upland coniferous forests	169.97	2.29%
4200	Upland hardwood forests	5.15	0.07%
4300	Upland hardwood forests cont.	270.04	3.64%
4400	Tree plantations	1280.76	17.24%
5100	Streams and waterways	0.35	0.00%
5300	Reservoirs – pits, retention ponds, dams	154.15	2.08%
6100	Wetland hardwood forests	1089.53	14.67%
6200	Wetland coniferous forests	246.09	3.31%
6300	Wetland forested mixed	883.78	11.90%
6400	Vegetated nonforested wetlands	302.94	4.08%
7400	Disturbed lands	204.25	2.75%
8100	Transportation	111.22	1.50%
8200	Communications	1.22	0.02%
8300	Utilities	14.4	0.19%
-	**SUM:**	**7,427.5**	**100.00%**

Figure 4.1. Principal Land Uses in the Mill Creek Watershed (WBID 2460) in 2004



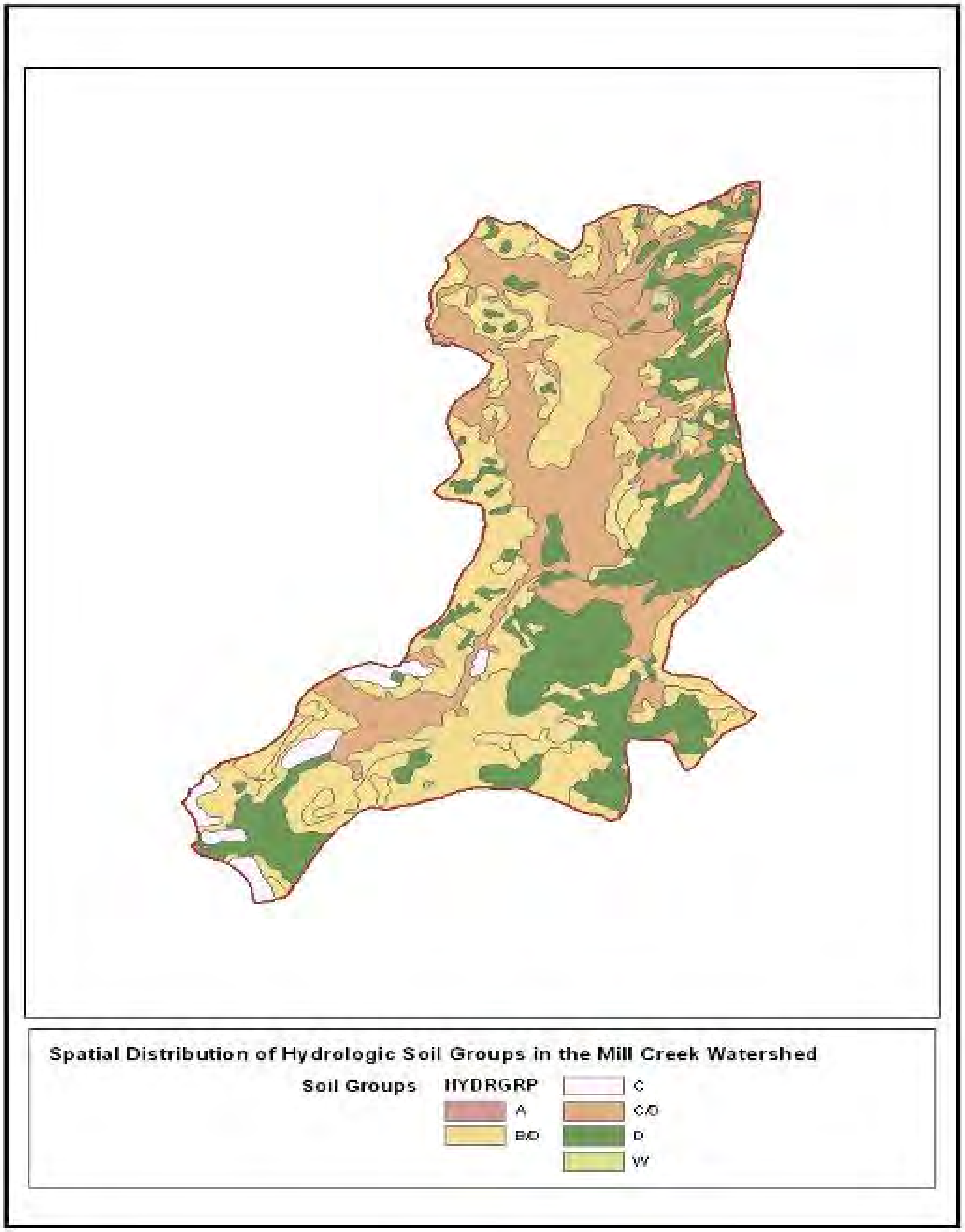
Soil Characteristics

The Soil Survey Geographic (SSURGO) Database in the Department's GIS database from the SJRWMD was accessed to provide coverage of hydrologic soil groups in the Mill Creek watershed (**Figure 4.2**). **Table 4.2** briefly describes the major hydrology soil classes. Soil groups B/D (40.6 percent) and C/D (29.6 percent) are the most common in the watershed, with type D (28.8 percent) found in the lower portion of the watershed and along its eastern boundaries.

Table 4.2. Description of Hydrologic Soil Classes from the SSURGO Database

Hydrology Class	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sands and gravels.
A/D	Drained/undrained hydrology class of soils that can be drained and are classified.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils that have moderately coarse textures.
B/D	Drained/undrained hydrology class of soils that have moderately coarse textures.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.
C/D	Drained/undrained hydrology class of soils that can be drained and classified.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.

Figure 4.2. Hydrologic Soil Groups Distribution in the Mill Creek Watershed (WBID 2460)



Population

Population and housing unit information from the 2000 census at the block level was obtained from the U.S. Census Bureau. GIS was used to estimate the fraction of each block in the Mill Creek watershed and then applied to the block information to estimate the population and number of housing units. Based on **Table 4.3**, the population in the watershed is estimated at 513 people living in 184 households. Based on 2008 Florida Department of Health (FDOH) onsite sewage GIS coverage (available: http://www.doh.state.fl.us/environment/programs/EhGis/EhGisDownload.htm), about 116 housing units *(N)* were identified as being on septic tanks in the Mill Creek watershed (**Figure 4.3**).

Septic Tanks

Based on the 2000 census estimates and the FDOH onsite sewage coverage, it was assumed that all 184 residences in the Mill Creek watershed are using septic tanks. Using an estimate of 70 gallons/day/person (EPA, 1999), and drainfield TN and TP concentrations of 36 and 15 mg/L, respectively, potential annual ground water loads of TN and TP were calculated. This is a screening level calculation, and soil types, the age of the system, vegetation, proximity to a receiving water, and other factors will influence the degree of attenuation of this load (**Table 4.4**).

Table 4.3. Estimated Average Household Size in the Mill Creek Watershed (WBID 2460)

- = Empty cell
Data from U.S. Census Bureau Website, 2000, based on the St. Johns County blocks present in the Mill Creek watershed.

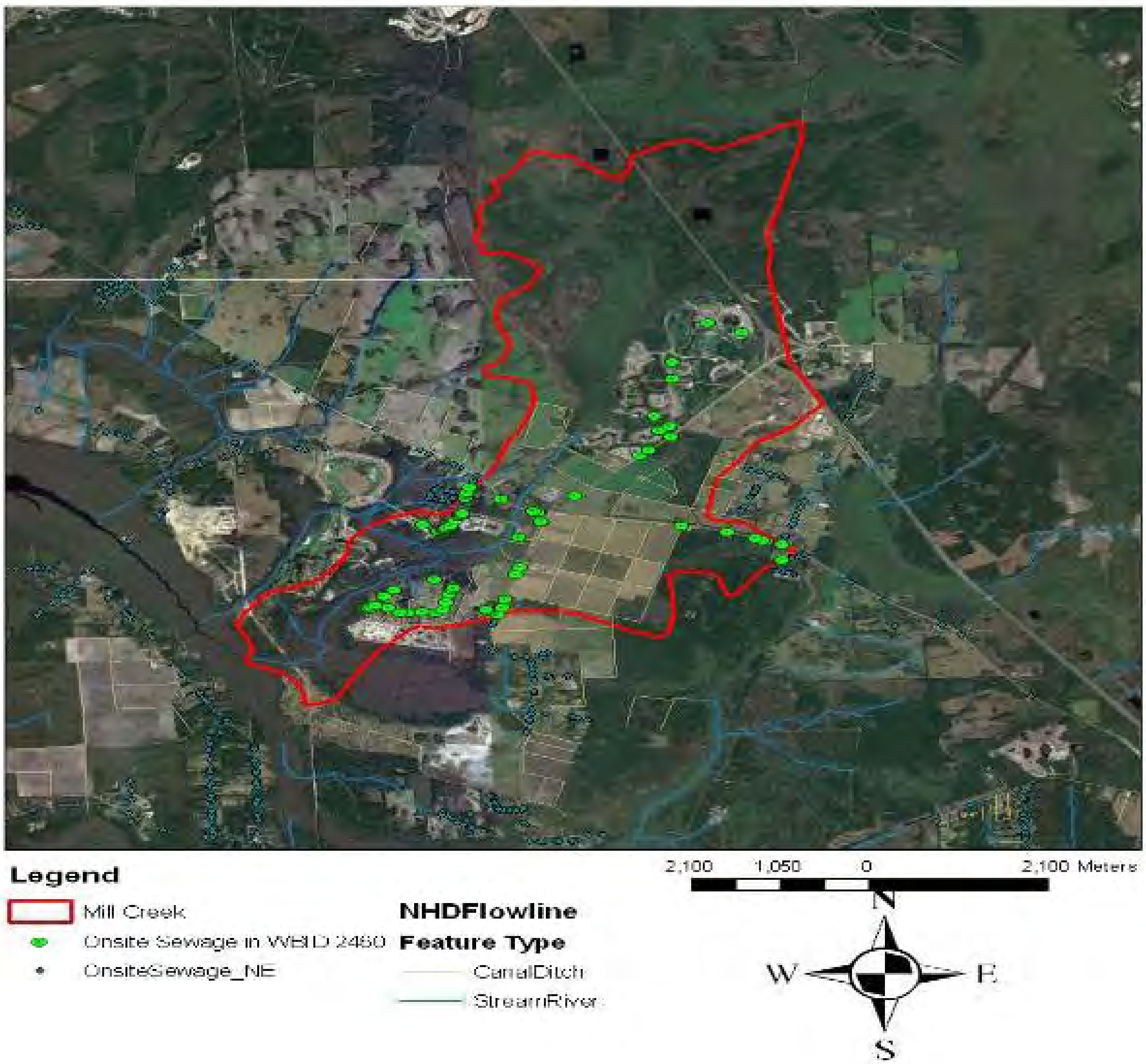
Tract	Block Group	Population	Housing Units
209	1	85	34
209	2	428	150
210.01	1	0	0
-	**Total:**	**513**	**184**
-	**-**	**AVERAGE HOUSEHOLD SIZE:**	**2.78**

Table 4.4. Estimated Nitrogen and Phosphorus Annual Loading from Septic Tanks in the Mill Creek Watershed (WBID 2460)

[1] U.S Census Bureau; see **Table 4.3** for more information on this estimate.
[2] EPA, 1999

Estimated Number of Households on Septic	Estimated Number of People per Household[1]	Gallons/ Person/ Day[2]	TN in Drainfield (mg/L)	TP in Drainfield (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
184	2.78	70	36	15	3,927	1,636

Figure 4.3. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Mill Creek Watershed (WBID 2460)



4.2.3 Summary of Nutrient Loadings to Mill Creek from Various Sources

Screening level estimates of annual nitrogen and phosphorus loadings to the watershed were developed based on 2004 land use and hydrologic soil groups. GIS shapefiles of land use and hydrologic soil groups were used to determine the acreage associated with various Level 2 land uses and soils. Estimates for annual runoff coefficients and event mean concentrations (EMCs) were based on Harper and Baker (2007) and Gao (2006). A screening level estimate of annual runoff was calculated by multiplying the long-term annual average rainfall of 52.44 inches (Jacksonville International Airport [JIA], 1955–2007) by the respective runoff coefficient and area. Estimates of annual nitrogen and phosphorus loading were obtained by multiplying the annual runoff by the corresponding EMC. A more detailed loading analysis could be performed based on the development of site-specific runoff coefficients, EMCs, and knowledge of best management practices (BMPs) that have been implemented in the watershed.

Agriculture

In the Level 3 category, eight agricultural land uses were identified in the Mill Creek watershed. Sod farm, the largest agricultural category, represented approximately 8.17 percent of the watershed area, or 606 acres. Improved pasture was the second largest, representing approximately 5.94 percent of the watershed area, or 441 acres. Unimproved and woodland pastures represented approximately 0.99 percent of the watershed area. Field and row crops totaled 3.34 percent, while ornamentals represented 0.36 percent. Finally, horse farms represented approximately 1.11 percent of the watershed, or 82 acres. Aggregating land use to Level 1 for the Mill Creek watershed yields 1,478 acres in agriculture and 89 acres in rangeland. **Table 4.5** summarizes the screening level estimates for nitrogen and phosphorus loads from agricultural sources.

Table 4.5. Estimated Annual Average TN and TP Loads from Agriculture in the Mill Creek Watershed (WBID 2460)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Cropland and pastureland	B/D	404.5	0.089	157.32	1,194.33	184.50
-	D	306.81	0.226	303.01	2,300.34	355.36
-	C/D	26.21	0.226	25.89	196.51	30.36
-	C	26.72	0.166	19.38	147.15	22.73
Cropland and pastureland	D	250.75	0.226	247.65	1,880.02	290.43
-	B/D	381.95	0.089	148.55	1,127.74	174.21
-	W	0.14	0.435	0.27	2.02	0.31
Specialty farms	B/D	80.34	0.089	31.25	237.21	36.64
-	D	0.98	0.226	0.97	7.35	1.14
-	**SUM**	**1,478.4**	**-**	**934.3**	**7,092.7**	**1,095.7**

Urban Areas

There are 1,126 acres in the Level 1 category of urban and built-up in the watershed and 127 acres in transportation, communication, and utilities. Low-density residential represents approximately a third of the total acreage in the urban and built-up category. **Table 4.6** summarizes the screening level estimates for nitrogen and phosphorus loads from urban and built-up categories in the watershed.

Forest/Wetland/Water/Open Lands

Table 4.7 summarizes estimates for nitrogen and phosphorus loadings from land uses in the forest, wetland, and water Level 2 classifications. Wetlands and upland forests represented 34 and 23 percent, respectively, of the acreage in the watershed.

Table 4.6. Estimated Urban and Built-up Annual Nitrogen and Phosphorus Loading in the Mill Creek Watershed (WBID 2460)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Residential, low density – less than 2 dwelling units/acre	C	49.1	0.166	35.62	156.04	18.51
-	B/D	267.36	0.083	96.97	424.83	50.40
-	D	21.34	0.226	21.08	92.33	10.95
-	W	1.2	0.435	2.28	9.99	1.19
-	C/D	24.81	0.226	24.50	107.34	12.73
Residential, medium density – 2-5 dwelling units/acre	B/D	150.2	0.108	70.89	399.28	63.07
-	C	28.58	0.186	23.23	130.84	20.67
-	D	19.71	0.252	21.71	122.26	19.31
-	C/D	96.23	0.226	95.04	535.30	84.56
Residential, high density – 6 or more dwelling units/acre	B/D	62.29	0.24	65.33	412.41	92.44
-	C/D	33.86	0.35	51.79	326.93	73.28
-	A	1.61	0.148	1.04	6.57	1.47
-	D	4.35	0.35	6.65	42.00	9.41
Commercial and services	B/D	50.25	0.35	76.86	374.34	54.79
-	C/D	35.65	0.435	67.77	330.07	48.31
-	D	13.28	0.435	25.24	122.96	18.00
-	W	4.24	0.435	8.06	39.26	5.75
Institutional	B/D	22.12	0.241	23.30	76.07	16.48
-	C/D	0.98	0.35	1.50	4.89	1.06
-	D	0.27	0.35	0.41	1.35	0.29
Recreational	B/D	71.1	0.089	27.65	86.53	4.14
-	D	44.26	0.226	43.71	136.78	6.54
-	C/D	105.76	0.226	104.45	326.84	15.63
-	A	0.3	0.021	0.03	0.09	0.00
Open land	B/D	7.6	0.089	2.96	9.25	0.44
-	C/D	9.17	0.226	9.06	28.34	1.36
-	D	0.41	0.226	0.40	1.27	0.06
Transportation	D	46.24	0.375	75.78	338.14	45.36
-	C/D	39.5	0.375	64.73	288.86	38.75
-	B/D	25.46	0.293	32.60	145.47	19.51
Communications	C/D	0.72	0.375	1.18	5.27	0.71
-	D	0.51	0.375	0.84	3.73	0.50
Utilities	C	8.88	0.328	12.73	56.80	7.62
-	B/D	4.09	0.278	4.97	22.17	2.97
-	D	0	0.375	0.00	0.00	0.00
-	C/D	1.43	0.375	2.34	10.46	1.40
Disturbed lands	D	197.16	0.226	194.72	847.73	105.97
-	C/D	7.08	0.226	6.99	30.44	3.81
-	**SUM**	**1,957.1**	**-**	**1,304.4**	**6,053.2**	**857.4**

Table 4.7. Estimated Forest/Wetland/Water/Open Lands Annual Nitrogen and Phosphorus Loading in the Mill Creek Watershed (WBID 2460)

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Herbaceous upland nonforested	B/D	7.84	0.089	3.05	9.54	0.46
-	C/D	6.52	0.226	6.44	20.15	0.96
-	D	5.06	0.226	5.00	15.64	0.75
Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	D	17.76	0.226	17.54	54.89	2.62
-	B/D	20.48	0.089	7.97	24.92	1.19
-	C/D	31.6	0.226	31.21	97.66	4.67
Upland coniferous forests	C	4.75	0.166	3.45	10.78	0.52
-	B/D	85.74	0.089	33.35	104.35	4.99
-	C/D	39.98	0.226	39.49	123.55	5.91
-	D	39.5	0.226	39.01	122.07	5.84
Upland hardwood forests	C	5.15	0.166	3.74	11.69	0.56
Upland hardwood forests cont.	B/D	192.36	0.089	74.81	234.11	11.20
-	C	47.66	0.166	34.57	108.19	5.17
-	C/D	24.51	0.226	24.21	75.75	3.62
-	D	5.5	0.226	5.43	17.00	0.81
Tree plantations	B/D	529.98	0.089	206.13	645.00	30.85
-	C/D	543.9	0.226	537.17	1,680.87	80.39
-	D	205.03	0.226	202.49	633.63	30.30
-	W	1.75	0.435	3.33	10.41	0.50
Streams and waterways	W	0.35	0.435	0.67	2.26	0.20
-	D	0	0.435	0.00	0.00	0.00
Reservoirs - pits, retention ponds, dams	C	2.64	0.435	5.02	17.07	1.50
-	B/D	43.36	0.435	82.43	280.35	24.67
-	D	35	0.435	66.53	226.30	19.91
-	W	14.69	0.435	27.92	94.98	8.36
-	C/D	57.93	0.435	110.12	374.55	32.96
-	A	0.56	0.435	1.06	3.62	0.32
Wetland hardwood forests	B/D	371.7	0.435	706.58	3,076.18	115.36
-	C	26.76	0.435	50.87	221.47	8.30
-	W	2.13	0.435	4.05	17.63	0.66
-	D	271.26	0.435	515.65	2,244.94	84.19
-	C/D	417.68	0.435	793.99	3,456.71	129.63
Wetland coniferous forests	B/D	35.34	0.435	67.18	292.47	10.97
-	C/D	80.1	0.435	152.27	662.91	24.86
-	D	130.6	0.435	248.26	1,080.84	40.53

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
-	W	0.04	0.435	0.08	0.33	0.01
Wetland forested mixed	B/D	174.26	0.435	331.26	1,442.17	54.08
-	C	0.07	0.435	0.13	0.58	0.02
-	D	200.84	0.435	381.79	1,662.15	62.33
-	C/D	508.52	0.435	966.67	4,208.50	157.82
Vegetated nonforested wetlands	B/D	27.95	0.435	53.13	231.31	8.67
-	D	173.73	0.435	330.25	1,437.79	53.92
-	C/D	101.25	0.435	192.47	837.94	31.42
-	**SUM**	**4,491.8**	**-**	**6,366.7**	**25,873.2**	**1,062.0**

Source Summary

Table 4.8 summarizes the various estimates from various land uses in the watershed. It is important to note that this is not a complete list and represents estimates of potential loadings. In addition, proximity to the waterbody, site-specific soil characteristics, and rainfall frequency and magnitude are just a few of the factors that could influence and determine the actual loadings from these sources that reach Mill Creek. Other factors include the location of the improved pasture and high-density residential areas relative to Mill Creek; whether there is a riparian buffer area between these land uses and the stream; the types of BMPs, both structural and nonstructural, that have been implemented for specific land uses in the watershed that reduce the actual nutrient loads delivered to Mill Creek; and, finally, the age and condition of the septic systems and drainage characteristics in the watershed compared with the county overall that could affect assumptions about the assimilation and/or retention of nutrients.

Table 4.8. Summary of Estimated Potential Annual Nitrogen and Phosphorus Loading from Various Sources in the Mill Creek Watershed (WBID 2460)

[1] Potential contribution to ground water

Source	TN (lbs/yr)	TP (lbs/yr)
Septic Tanks[1]	3,927	1,636
Urban and Built-up	6,053.2	857.4
Agriculture	7,092.7	1,095.7
Forest/Wetland/Water/ Open Lands	25,872.2	1,062.0

The screening model estimated an annual surface runoff of 8,605.4 acre-feet or 13.9 inches per year based on the watershed area. Dividing the estimated TN load by the surface runoff volume yielded an average TN concentration of 1.67 mg/L. The average and median TN concentrations from the available data were 1.58 and 1.50 mg/L, respectively. Dividing the estimated TP load by the surface runoff volume yielded an average TP concentration of 0.45 mg/L. The average and median TP concentrations from the available data were 0.242 and 0.215 mg/L, respectively. Flow and nutrient contributions from ground water inputs to Mill Creek were not included in this screening level calculation and would likely influence in-stream concentrations.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

5.1.1 Data Used in the Determination of the TMDL

Five sampling stations on Mill Creek have historical DO observations (**Figure 5.1**). **Table 5.1** contains summary information on each of the stations. **Table 5.2** provides a statistical summary of DO observations at each station, and **Appendix B** contains historical DO, corrected chl*a* (CHLAC), TN, TP, and BOD available observations from sampling sites in WBID 2460. **Figure 5.2** displays the historical observations of DO over time. DO exceedance rates by station range between 30 and 100 percent. A linear regression of DO versus sampling date in **Figure 5.2** was not significant at an alpha (α) level of 0.05 (R^2 = 0.0018). **Appendix E** contains plots of DO by season, station, and year.

Figures 5.3 through **5.6** present historical CHLAC, TN, TP, and BOD observations, respectively. Linear regressions of each parameter versus sampling date indicate that regressions for CHLAC and TN were significant at an α level of 0.05. Note that the datasets are small and sampling has not occurred uniformly over time. **Appendix E** contains additional plots by season, station, and year. **Table 5.3** presents a statistical summary of major water quality parameters from the available data.

Table 5.1. Sampling Station Summary for Mill Creek (WBID 2460)

Station	STORET ID	Station Owner	Years With Data	N
Mill Cr @ SR 16	21FLA 20030474	Department	1997–2008	37
Mill Cr 300 Yards Ab SR 16	21FLA 20030568	Department	2002–07	11
Mill Creek at SR 16	21FLSJWMLSJ108	SJRWMD	1992	3
SJ2-SS-2015 Mill Creek	21FLGW 27939	Department	2005	2
Mill Cr @ Registry Rd	21FLA 20030927	Department	2007–08	10

Table 5.2. Statistical Summary of Historical DO Data for Mill Creek (WBID 2460)

DO concentrations are mg/L.

Station	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Mill Cr @ SR 16	37	2.4	8.5	4.9	5.15	20	54.05%
Mill Cr 300 Yards Ab SR 16	11	3.8	8.5	5.7	6.01	4	36.36%
Mill Creek at SR 16	3	2.8	7.6	5.6	5.33	2	100.00%
SJ2-SS-2015 Mill Creek	2	4.93	4.99	4.96	4.96	2	100.00%
Mill Cr @ Registry Rd	10	3.3	6.0	5.55	5.13	3	30.00%

Figure 5.1. Historical Sampling Sites in Mill Creek (WBID 2460)

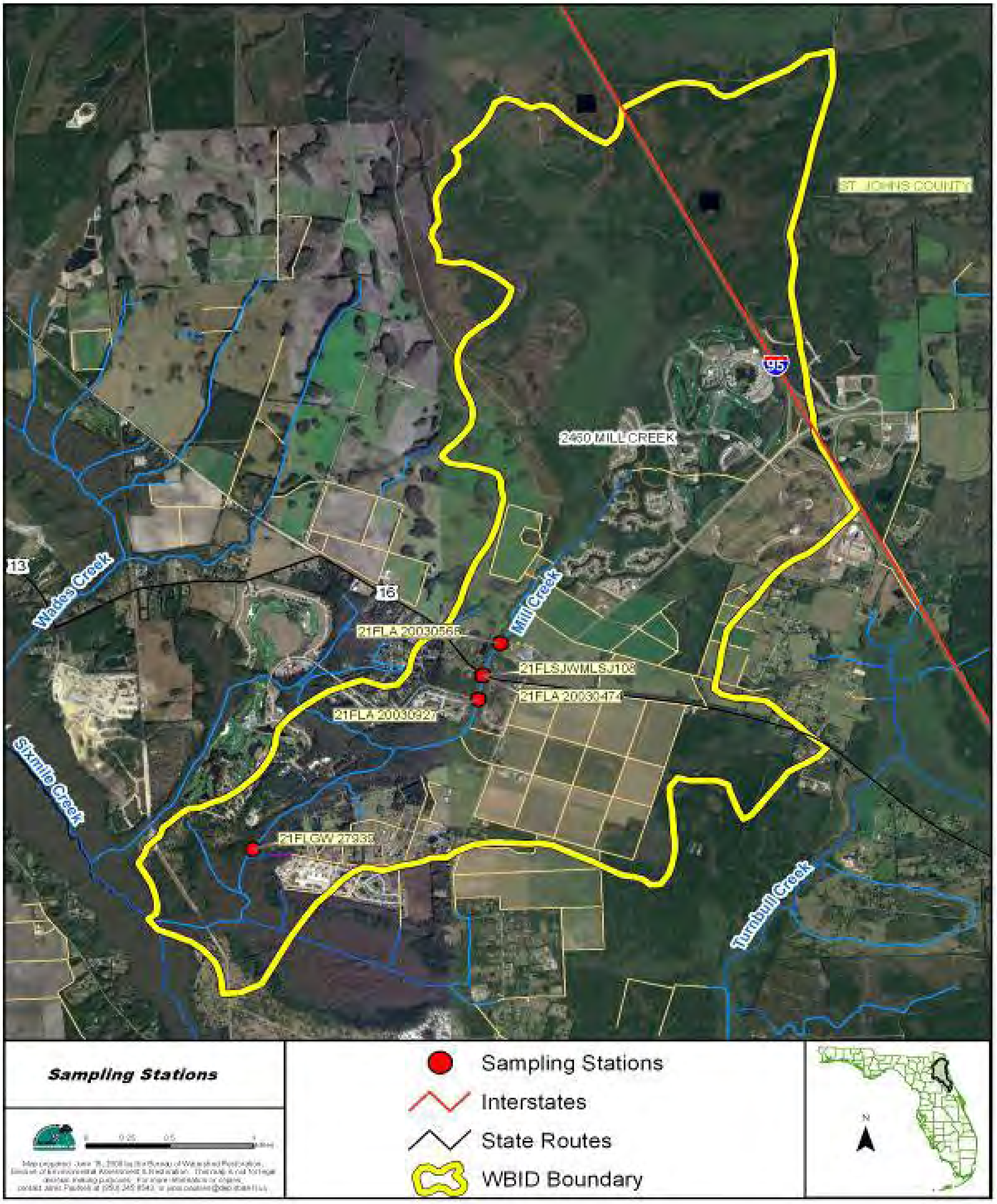


Figure 5.2. Historical DO Observations for Mill Creek (WBID 2460)

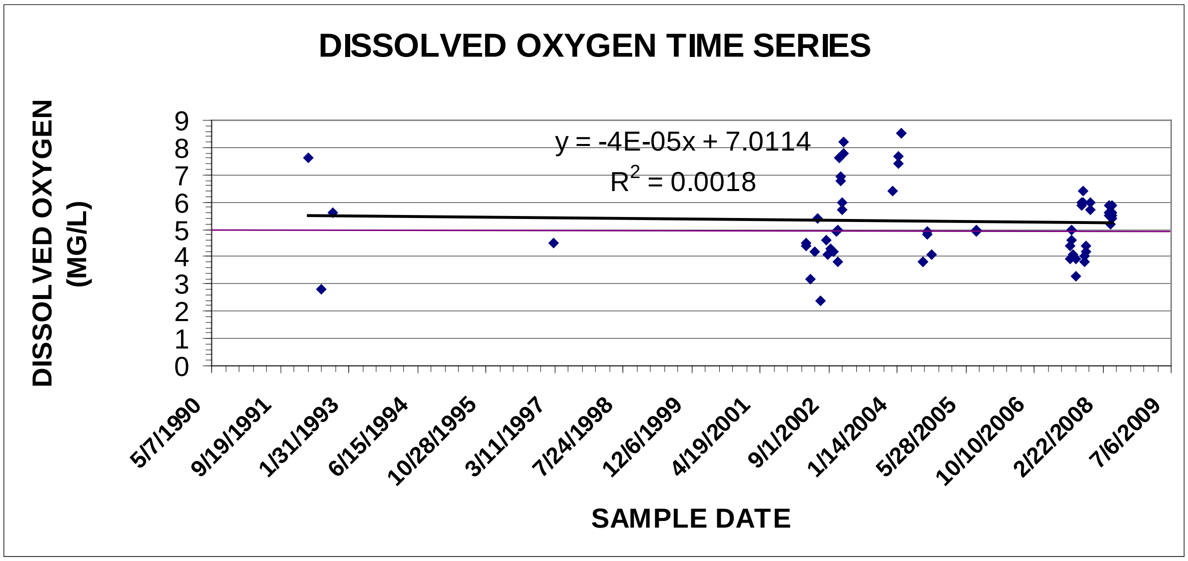


Figure 5.3. Historical CHLAC Observations for Mill Creek (WBID 2460)

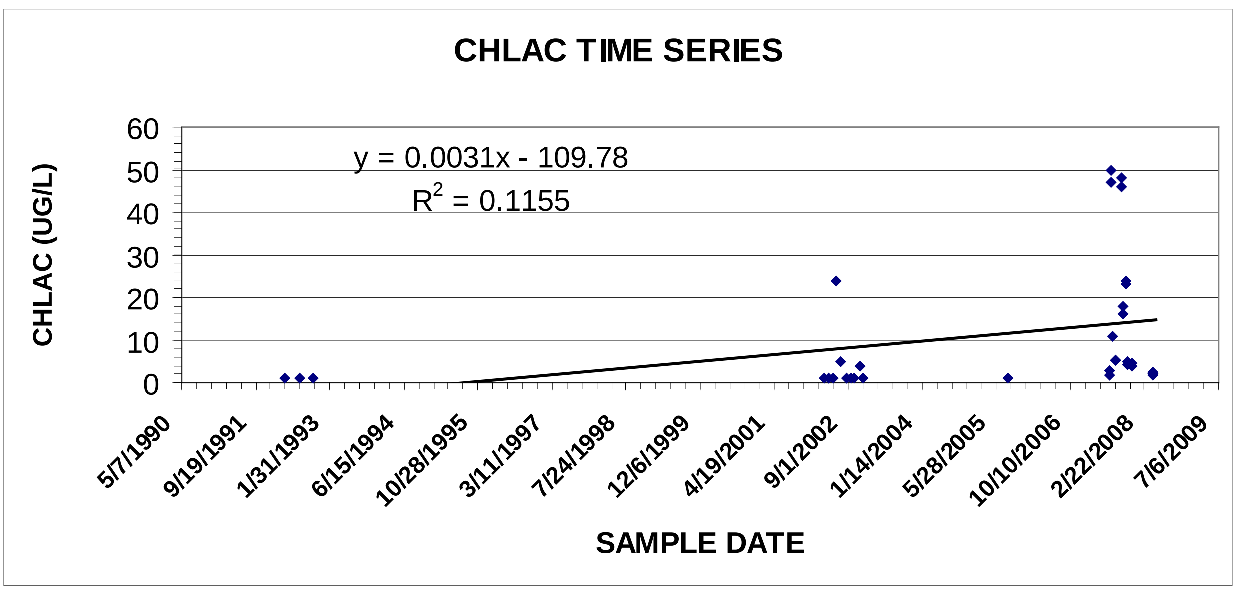


Figure 5.4. Historical TN Observations for Mill Creek (WBID 2460)

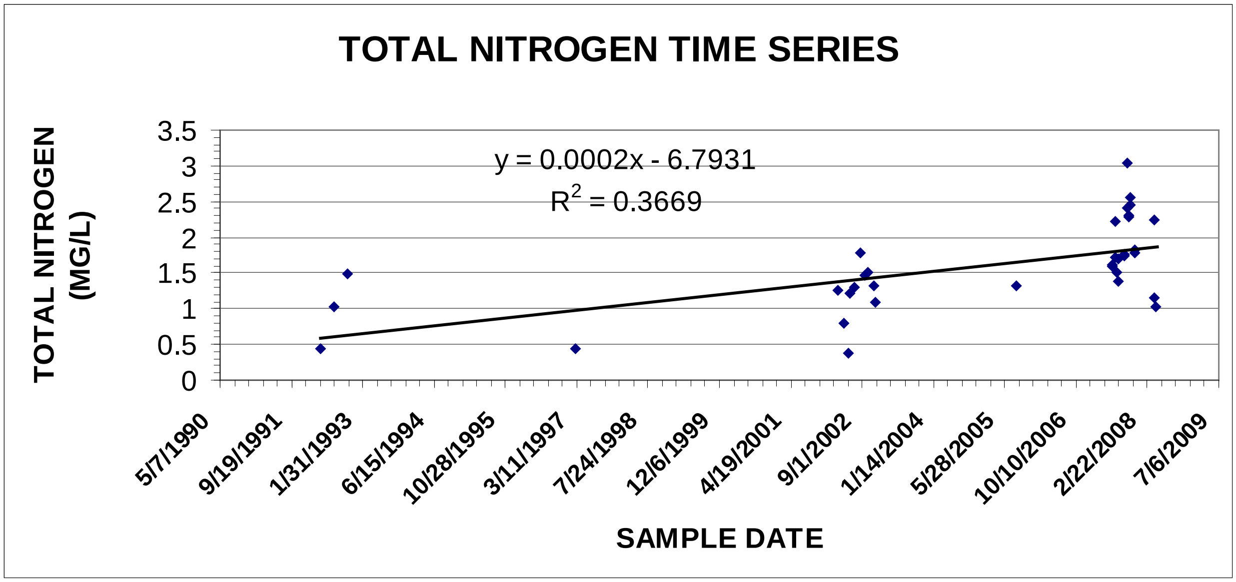


Figure 5.5. Historical TP Observations for Mill Creek (WBID 2460)

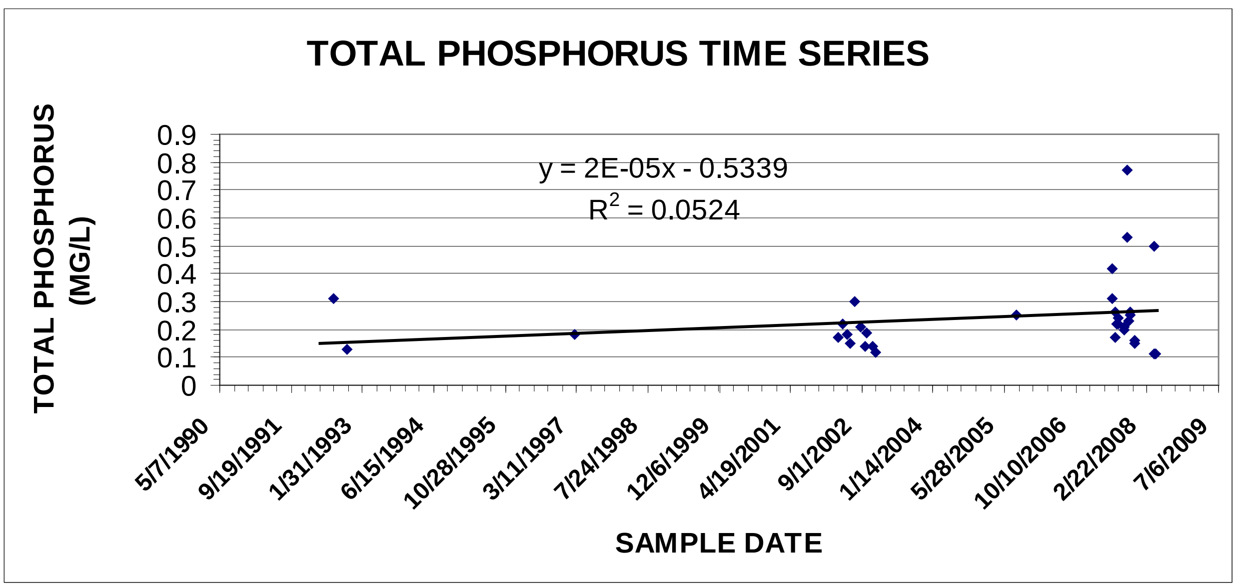


Figure 5.6. Historical BOD5 Observations for Mill Creek (WBID 2460)

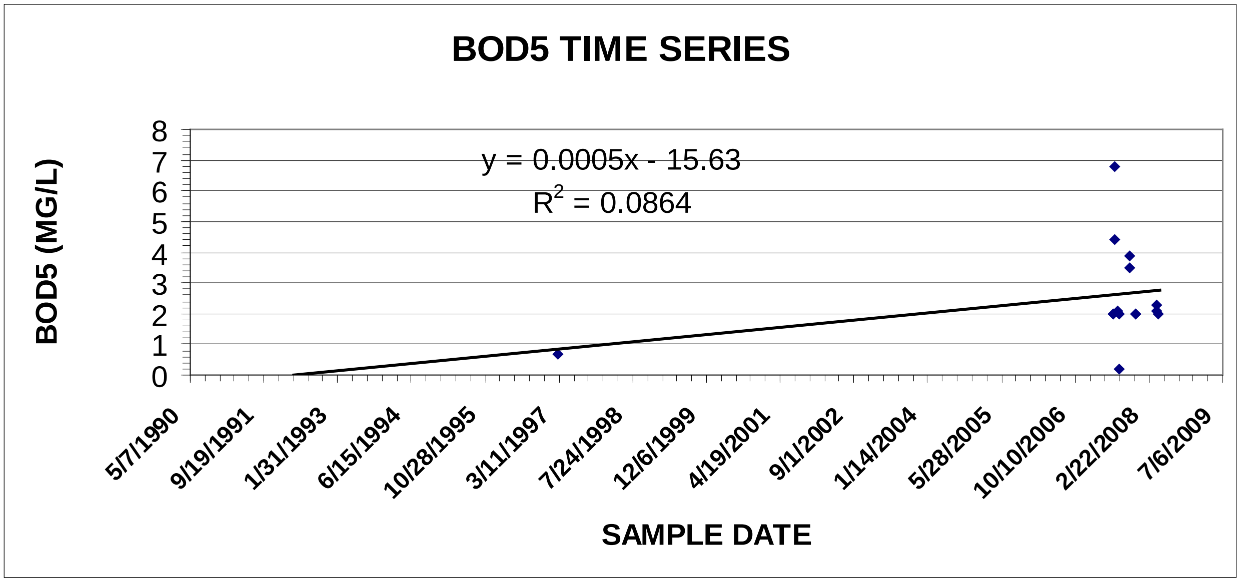


Table 5.3. Summary Statistics for Major Water Quality Parameters Measured in Mill Creek (WBID 2460)

PARM	N	MIN	25%	MEDIAN	MEAN	75%	MAX
BOD (mg/L)	15	0.2	2	2	2.5	3.2	6.8
CHLAC (ug/L)	34	1	1	3.8	10.74	16	50
CHLORIDE (mg/	24	19	30	53	46.88	61	69
COLOR (PCU)	25	15	60	100	171.80	300	600
COND (uS/cm)	63	100	308.25	426	410.27	515	750
DO (mg/L)	63	2.4	4.2	5	5.30	6	8.5
DOSAT (%)	61	31	50	60.8695	59.57	67.25	81
NH4 (mg/L)	34	0.016	0.040	0.066	0.10	0.099	0.709
NO3O2 (mg/L)	35	0.01	0.09275	0.2	0.24	0.31	0.82
PH (su)	62	5.7	6.85	7.055	7.04	7.23	7.68
SO4 (mg/L)	24	8	28.5	46.5	44.97	52.50	196.00
TEMP (C)	63	10.9	19.45	22.7	22.08	26.82	29.30
TKN (mg/L)	35	0.26	1	1.2	1.33	1.70	2.80
TN (mg/L)	35	0.38	1.22625	1.5	1.57	1.81	3.03
TOC (mg/L)	32	4	12	15	19.66	29.50	45.00
TP (mg/L)	34	0.11	0.16	0.215	0.24	0.26	0.77
TSS (mg/L)	24	2	16	16	27.08	19.50	151.00
TURB (NTU)	35	2.6	4.8	6.1	12.75	8.58	130.00

Available DO measurements were also summarized by year (**Table 5.4**) and by season (**Table 5.5**). A nonparametric test (Kruskal-Wallis) was applied to the DO, DOSAT, CHLAC, TN, TP, and BOD5 datasets to determine whether there were significant difference among seasons (**Appendix C**). At an α level of 0.05, differences were significant among seasons for DO and TN. A similar test for differences among months was significant for DO, DOSAT, and TN (**Appendix D**).

Table 5.4. Statistical Summary of Historical DO Data by Year for Mill Creek (WBID 2460)

DO concentrations are mg/L.

Year	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
1992	3	2.8	7.6	5.6	5.33	1	33.33%
1997	1	4.5	4.5	4.5	4.50	1	100.00%
2002	21	2.4	8.2	4.9	5.32	11	52.38%
2003	1	6.4	6.4	6.4	6.40	0	0.00%
2004	9	3.8	8.5	4.9	5.94	5	55.56%
2005	2	4.93	4.99	4.96	4.96	2	100.00%
2007	17	3.3	6.4	4.4	4.80	10	58.82%
2008	9	5.2	5.9	5.6	5.58	0	0.00%

Table 5.5. Statistical Summary of Historical DO Data by Season for Mill Creek (WBID 2460)

DO concentrations are mg/L.

Season	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Winter	7	4.40	8.50	7.40	6.50	3	42.86%
Spring	15	3.20	7.60	5.50	5.26	4	26.67%
Summer	19	2.40	6.00	4.29	4.33	16	84.21%
Fall	22	3.80	8.20	5.85	5.77	7	31.82%

5.1.2 TMDL Development Process

A Spearman correlation matrix was used to assess potential relationships between DO and other water quality parameters (**Appendix G**). At an alpha (α) level of 0.05, correlations between DO and sulfate (SO_4), and DO and water temperature (TEMP), were significant. A simple linear regression of DO versus TEMP explained 55 percent of the variance in DO (**Appendix H**).

In order to determine the influence of nutrients on DO without the confounding effects of water temperature on all these variables, the general linear model (GLM) was used to develop an expression that included TEMP, TN, and TP. Based on 32 cases with DO, TN, TP, and TEMP observations, the following expression was significant at an α level of 0.05 and explained 49 percent of the variance in DO:

$$DO = 8.929 - 0.093*TEMP - 10.758*TP - 0.743*TN - 0.159*TP*TEMP + 5.516*TN*TP + 0.011*TN*TEMP$$

Similarly, TEMP was a significant variable with CHLAC. A simple linear regression between CHLAC and TEMP was significant at an α level of 0.05 and explained nearly 26 percent of the variance in CHLAC (**Appendix H**). Based on 25 paired CHLAC, TN, and TEMP observations, the GLM yielded the following significant relationship and explained 57 percent of the variance in CHLAC:

CHLAC = 83.453 – 80.648*TN – 4.114*TEMP + 3.972*TEMP*TN

Since both DO and CHLAC are influenced by water temperature, and the Kruskal-Wallis test indicated significant differences among seasons for both DO and TN, the TMDL was developed using the summer average TN, TP, and TEMP values (**Tables 5.6a** through **5.6f**). Most of the observed exceedances of the DO criterion occurred during the summer, when both water temperatures and algal biomass are elevated.

Table 5.6a. Seasonal Summary Statistics for DO for Mill Creek (WBID 2460)

DO concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	7	4.40	4.40	4.50	7.40	6.50	8.30	8.50
Spring	15	3.20	3.38	4.60	5.50	5.26	5.60	7.60
Summer	19	2.40	2.58	3.83	4.29	4.33	4.92	6.00
Fall	22	3.80	3.80	4.40	5.85	5.77	6.80	8.20

Table 5.6b. Seasonal Summary Statistics for TEMP for Mill Creek (WBID 2460)

TEMP is in °C.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	7	10.9	10.9	11.6	13.5	16.3	21.9	22.9
Spring	15	12.6	13.7	19.6	20.6	21.3	24.5	28.1
Summer	19	23.8	24.2	26.9	27.5	27.4	28.3	29.3
Fall	22	13.9	14.0	16.1	20.0	19.8	22.7	26.0

Table 5.6c. Seasonal Summary Statistics for TN for Mill Creek (WBID 2460)

TN concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	2	0.44	0.44	0.44	0.85	0.85	1.26	1.26
Spring	9	0.38	0.38	0.70	1.16	1.16	1.60	2.24
Summer	12	1.02	1.05	1.35	1.60	1.57	1.75	2.22
Fall	12	1.09	1.11	1.50	2.06	2.01	2.44	3.03

Table 5.6d. Seasonal Summary Statistics for TP for Mill Creek (WBID 2460)

TP concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	2	0.170	0.170	0.170	0.175	0.175	0.180	0.180
Spring	8	0.110	0.110	0.130	0.200	0.250	0.365	0.500
Summer	12	0.140	0.143	0.205	0.220	0.228	0.255	0.310
Fall	12	0.120	0.121	0.145	0.210	0.263	0.255	0.770

Table 5.6e. Seasonal Summary Statistics for BOD5 for Mill Creek (WBID 2460)

BOD5 is in mg/L.
- = Empty cell/no data

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	1	0.7	-	-	-	0.7	-	0.7
Spring	5	2.0	2.0	2.0	2.0	2.1	2.2	2.3
Summer	5	0.2	0.2	1.6	2.1	3.1	5.0	6.8
Fall	4	2.0	2.0	2.0	2.8	2.9	3.7	3.9

Table 5.6f. Seasonal Summary Statistics for CHLAC for Mill Creek (WBID 2460)

CHLAC is in µg/L.
- = Empty cell/no data

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	1	1.0	-	-	-	1.0	-	1.0
Spring	9	1.0	1.0	1.0	1.7	4.2	2.5	24.0
Summer	12	1.0	1.0	1.0	5.4	18.5	46.5	50.0
Fall	12	1.0	1.0	2.4	4.3	8.8	17.0	24.0

Since the adopted nutrient TMDL for the Lower St. Johns River requires a 30 percent reduction in anthropogenic nitrogen and phosphorus loads to the freshwater portion of the river, and the Mill Creek watershed is a contributing watershed to the river, the GLM model for DO was used to estimate the DO concentration under the average summer water temperature following a 30 percent reduction in TN and TP. At the summer average TEMP of 27.39 ^{o}C, a reduction of TN from 1.57 to 1.10 mg/L and a reduction in TP from 0.228 to 0.160 mg/L resulted in a predicted DO concentration of 5.22 mg/L (based on 12 summer DO predictions). The historical summer average DO was 4.33 mg/L. The DO GLM predicted that with a 30 percent reduction in both nitrogen and phosphorus there would be a significant improvement in DO.

When the DO GLM was applied to the historical paired DO, TEMP, TN, and TP dataset, with a 30 percent reduction in TN and TP, the minimum DO increased from 2.4 to 4.42 mg/L.

Applying the summer TEMP and a 30 percent reduction in TN to the CHLAC GLM model resulted in a predicted CHLAC concentration of 1.7 μg/L. This represents a significant reduction from the historical summer average CHLAC of 18.5 μg/L.

The adopted Verified List for the DO impairment also identified BOD as a pollutant linked to the impairment. The median BOD concentration over the Cycle 2 verified period was 2.05 mg/L (14 values). A median BOD concentration of 2.0 mg/L for streams is considered as a threshold during the assessment to determine whether BOD is a pollutant linked to the DO impairment. Although the dataset of BOD measurements is small, there is a significant correlation between BOD and CHLAC (**Appendix H**). The simple linear regression with CHLAC explained 79 percent of the variance in BOD. Reductions in CHLAC will lower BOD levels in Mill Creek, and the median concentration should be below 2.0 mg/L.

Although the DO GLM predicted that the minimum DO would be below the Class III freshwater criterion of 5.0 mg/L at times, reductions in CHLAC and BOD will have indirect benefits to DO levels, such as reducing sediment oxygen demand. In shallow stream systems like Mill Creek, SOD can be a significant factor influencing DO. For example, in the modeling analysis for the Sixmile Creek DO TMDL (EPA, Region 4, 2010), EPA reduced SOD rates by 50 percent under a natural conditions scenario and the predicted minimum DO increased to 4.9 mg/L compared to the existing conditions minimum DO of 1.2 mg/L. In addition, over 59 percent of the watershed consists of natural land use categories (forests, water, and wetlands). The TMDLs are not expected to cause an imbalance in the natural populations of flora and fauna, or cause nuisance conditions that depress DO below natural levels.

5.1.3 Critical Conditions/Seasonality

A nonparametric test (Kruskal-Wallis) was applied to the DO, DOSAT, CHLAC, TN, and TP datasets to determine whether there were significant differences among months or seasons. At an alpha (α) level of 0.05, there were significant differences among seasons or months for both DO and TN (**Appendices C** and **D**). As seen in **Table 5.6a**, the lowest DO concentrations occurred during the summer season. The highest CHLAC levels were also observed during the summer season (**Table 5.6f**). Consequently, the TMDL analysis evaluated the DO response to TN and TP reductions under the average TEMP and nutrient concentrations reported during the summer period. Reductions in TN and TP concentrations were predicted to also improve DO concentrations throughout the rest of the year.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

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

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

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

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

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

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of 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 Mill Creek are expressed in terms of a percent reduction in TN and TP, to meet both the DO and nutrient criteria (**Table 6.1**).

Table 6.1. TMDL Components for Mill Creek (WBID 2460)

- = Empty cell/no data
NA = Not applicable
[1] As the TMDL represents a percent reduction, it also complies with EPA requirements to express the TMDL on a daily basis.

WBID	Parameter	TMDL (mg/L)	WLA for Wastewater (mg/L)	WLA for NPDES Stormwater (% Reduction)[1]	LA (% reduction)[1]	MOS
2460	TN	-	NA	30%	30%	Implicit
2460	TP	-	NA	30%	30%	Implicit

6.2 Load Allocation

TN and TP reductions of 30 percent are required from nonpoint sources. It should be noted that the load allocation includes loading from stormwater discharges that are not part of the NPDES Stormwater Program.

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are currently no permitted NPDES discharges in the Mill Creek watershed; however, the Lower St. Johns River Nutrient TMDL (Magley and Joyner, 2008) included allocations for future domestic wastewater discharges under the Apricot Act (Section 403.086(7), F.S.) and reverse osmosis (RO) discharges to the St. Johns into the freshwater portion (WBID 2213I) and marine portion (WBID 2213H). The annual freshwater discharge load was set at 9,961 kg/yr TN and 3,320 kg/yr TP. St. Johns County has applied for a NPDES permit for the Northwest Wastewater Treatment Facility (FL0670651) for the construction of a 3 MGD annual average daily flow (AADF) facility (phase 1) under the Apricot Act. The Apricot Act allows for permitting of backup discharges for reuse systems when the utility provides advanced wastewater treatment (defined in 403.086, F.S., as having annual average limits for CBOD5, total suspended solids (TSS), total nitrogen (as N), and total phosphorus of 5,5,3, and 1 mg/L, respectively) and high-level disinfection requirements. These discharges are limited to 30 percent of the permitted reuse capacity on an annual basis. Therefore, under phase 1, the discharge to Mill Creek would be permitted at 0.3 MGD AADF. In phase 2 the capacity would be increased to 6 MGD AADF and the discharge to Mill Creek would be permitted at 1.8 MGD AADF. Appendix L includes a demonstration that the proposed facility would not cause or contribute to water quality violations in Mill Creek.

The proposed discharge location is approximately 3 miles upstream of the confluence with Sixmile Creek. EPA conducted a modeling analysis as part of their development of a nutrient and dissolved oxygen TMDL for Sixmile Creek (US EPA Region 4, 2010) and concluded that the proposed discharge would not cause or contribute to water quality violations in either Mill Creek or Sixmile Creek.

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6.3.2 NPDES Stormwater Discharges

St. Johns County has a Phase II MS4 permit (FLR04E025) that may include portions of the Mill Creek watershed and would be responsible for a 30 percent reduction in current anthropogenic TN and TP loading. It should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by applying the average summer TEMP (27.39 ^{o}C.), rather than the average TEMP (22.08 ^{o}C.).

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

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

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

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

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

7.2 Other TMDL Implementation Tools

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

A multitude of assessment tools is available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River tributaries and the Hillsborough Basin, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work. In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

Earlier in the document, reference was made to the BMAP adopted in October 2008 that outlined implementation activities in the freshwater portion of the Lower St. Johns River to achieve the nutrient TMDL. Since Mill Creek represents a contributing watershed to the Lower St. Johns, applicable activities undertaken in the Mill Creek watershed as part of the Lower St. Johns River BMAP should be sufficient to address the DO and nutrient impairment in Mill Creek.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

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

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

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

Appendix B: Historical DO, CHLAC, BOD5, TN, and TP Observations in Mill Creek (WBID 2460), 1992–2008

- = Empty cell/no data

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMLSJ108	4/7/1992	7.6	1	-	0.43	
FLSJWMLSJ108	7/13/1992	2.8	1	-	1.02	0.31
FLSJWMLSJ108	10/12/1992	5.6	1	-	1.49	0.13
FLA20030474	3/3/1997	-	-	-	-	-
FLA20030474	3/3/1997	4.5	-	0.7	-	-
FLA20030474	3/3/1997	-	-	-	0.441	0.18
FLA20030474	3/20/2002	-	-	-	-	-
FLA20030474	3/20/2002	4.4	1	-	1.26	0.17
FLA20030474	3/26/2002	-	-	-	-	-
FLA20030474	3/26/2002	4.5	-	-	-	-
FLA20030474	4/23/2002	-	-	-	-	-
FLA20030474	4/23/2002	3.2	1	-	0.79	0.22
FLA20030474	5/23/2002	-	-	-	-	-
FLA20030474	5/23/2002	-	1	-	-	-
FLA20030474	5/23/2002	4.2	-	-	0.38	0.18
FLA20030474	6/11/2002	-	24	-	-	-
FLA20030474	6/11/2002	5.4	-	-	1.215	0.15
FLA20030474	7/10/2002	-	-	-	-	-
FLA20030474	7/10/2002	2.4	4.8	-	1.298	0.3
FLA20030474	8/21/2002	-	-	-	-	-
FLA20030474	8/21/2002	4.6	-	-	1.783	0.21
FLA20030474	8/21/2002	-	1	-	-	-
FLA20030474	8/28/2002	-	-	-	-	-
FLA20030474	8/28/2002	4.1	-	-	-	-
FLA20030474	9/19/2002	-	-	-	-	-
FLA20030474	9/19/2002	4.29	1	-	1.47	0.14
FLA20030474	10/9/2002	-	-	-	-	-
FLA20030474	10/9/2002	4.2	-	-	1.5	0.19
FLA20030474	10/9/2002	-	1	-	-	-
FLA20030474	10/31/2002	-	-	-	-	-
FLA20030474	10/31/2002	4.9	-	-	-	-
FLA20030474	11/12/2002	5	-	-	-	-
FLA20030568	11/12/2002	-	-	-	-	-
FLA20030568	11/12/2002	3.8	-	-	-	-
FLA20030474	11/19/2002	-	-	-	-	-
FLA20030474	11/19/2002	7.6	-	-	1.33	0.14
FLA20030474	11/19/2002	-	3.8	-	-	-
FLA20030568	11/19/2002	-	-	-	-	-
FLA20030568	11/19/2002	7.6	-	-	-	-
FLA20030474	11/26/2002	6.8	-	-	-	-
FLA20030568	11/26/2002	-	-	-	-	-

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLA20030568	11/26/2002	6.93	-	-	-	-
FLA20030474	12/5/2002	6	1	-	1.09	0.12
FLA20030568	12/5/2002	-	-	-	-	-
FLA20030568	12/5/2002	5.7	-	-	-	-
FLA20030474	12/18/2002	-	-	-	-	-
FLA20030474	12/18/2002	7.8	-	-	-	-
FLA20030568	12/18/2002	-	-	-	-	-
FLA20030568	12/18/2002	8.2	-	-	-	-
FLA20030474	12/10/2003	6.4	-	-	-	-
FLA20030474	12/10/2003	-	-	-	-	-
FLA20030474	1/22/2004	7.7	-	-	-	-
FLA20030568	1/22/2004	7.4	-	-	-	-
FLA20030474	2/19/2004	8.5	-	-	-	-
FLA20030474	2/19/2004	-	-	-	-	-
FLA20030568	2/19/2004	8.5	-	-	-	-
FLA20030568	2/19/2004	-	-	-	-	-
FLA20030474	7/21/2004	3.8	-	-	-	-
FLA20030568	7/21/2004	3.8	-	-	-	-
FLA20030474	8/19/2004	4.9	-	-	-	-
FLA20030568	8/19/2004	4.8	-	-	-	-
FLA20030474	9/21/2004	-	-	-	-	-
FLA20030474	9/21/2004	4.1	-	-	-	-
FLA20030568	9/21/2004	-	-	-	-	-
FLGW 27939	8/15/2005	4.93	1	-	1.31	0.25
FLGW 27939	8/15/2005	4.99		-	-	-
FLA20030474	6/26/2007	3.9	2.7	2	1.61	0.42
FLA20030568	6/26/2007	4.4	1.7	2	1.6	0.31
FLA20030474	7/9/2007	-	-	-	-	-
FLA20030474	7/9/2007	4.6	50	6.8	2.219	0.26
FLA20030568	7/9/2007	-	-	-	-	-
FLA20030568	7/9/2007	5	47	4.4	1.71	0.17
FLA20030474	7/23/2007	4.1	11		1.5	0.22
FLA20030474	7/23/2007	-	-	-	-	-
FLA20030474	7/23/2007	-	-	2.1	-	-
FLA20030474	8/6/2007	3.9	5.4	2	1.38	0.22
FLA20030927	8/7/2007	-	-	-	-	-
FLA20030927	8/7/2007	3.3	5.4	0.2	1.7	0.24
FLA20030474	9/18/2007	6	48	-	1.749	0.21
FLA20030927	9/18/2007	-	-	-	-	-
FLA20030927	9/18/2007	-	46	-	-	-
FLA20030927	9/18/2007	5.9	-	-	1.756	0.2
FLA20030474	10/2/2007	-	-	-	-	-
FLA20030474	10/2/2007	6.4	18	-	3.03	0.77
FLA20030927	10/2/2007	-	-	-	-	-
FLA20030927	10/2/2007	-	16	-	-	-
FLA20030927	10/2/2007	6	-	-	2.42	0.53

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLA20030474	10/15/2007	4	23	3.9	2.29	0.23
FLA20030927	10/15/2007	-	-	-	-	-
FLA20030927	10/15/2007	-	24	-	-	-
FLA20030927	10/15/2007	3.8	-	3.5	2.31	0.23
FLA20030474	10/29/2007	-	-	-	-	-
FLA20030474	10/29/2007	4.4	4.9	-	-	-
FLA20030474	10/29/2007	-	-	-	2.55	0.25
FLA20030927	10/29/2007	-	-	-		
FLA20030927	10/29/2007	4.2	4.1	-	2.46	0.26
FLA20030474	11/26/2007	6	4.4	2	1.82	0.15
FLA20030927	11/26/2007	5.7	3.8	2	1.78	0.16
FLA20030474	4/7/2008	5.6	-	-	-	-
FLA20030927	4/7/2008	5.9	-	-	-	-
FLA20030474	4/14/2008	5.5	2	2.1	1.16	0.11
FLA20030927	4/14/2008	5.6	2.4	2.3	2.24	0.5
FLA20030474	4/21/2008	5.2	1.7	2	1.03	0.11
FLA20030474	4/30/2008	5.9	-	-	-	-
FLA20030927	4/30/2008	5.5	-	-	-	-
FLA20030474	5/5/2008	-	-	-	-	-
FLA20030474	5/5/2008	5.6	-	-	-	-
FLA20030927	5/5/2008	-	-	-	-	-
FLA20030927	5/5/2008	5.4	-	-	-	-

Appendix C: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Season in Mill Creek

Kruskal-Wallis One-Way Analysis of Variance for 311 cases
Dependent variable is VDO
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	10274.000
SPRING	83	13804.500
SUMMER	76	7079.500
WINTER	78	17358.000

Kruskal-Wallis Test Statistic = 83.623
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 310 cases
Dependent variable is DOSAT
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	9819.000
SPRING	83	14600.000
SUMMER	76	8203.000
WINTER	77	15583.000

Kruskal-Wallis Test Statistic = 51.556
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 103 cases
Dependent variable is VCHLAC
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	25	1343.000
SPRING	30	1263.000
SUMMER	22	1363.500
WINTER	26	1386.500

Kruskal-Wallis Test Statistic = 5.925
Probability is 0.115 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 312 cases

Dependent variable is VTN
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	9954.000
SPRING	82	9662.500
SUMMER	77	16303.000
WINTER	79	12908.500

Kruskal-Wallis Test Statistic = 48.780
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 320 cases
Dependent variable is VTP
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	76	12642.000
SPRING	85	10367.000
SUMMER	78	19013.500
WINTER	81	9337.500

Kruskal-Wallis Test Statistic = 97.574
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 116 cases
Dependent variable is VBOD
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	26	1438.500
SPRING	34	1822.500
SUMMER	27	2014.500
WINTER	29	1510.500

Kruskal-Wallis Test Statistic = 8.268
Probability is 0.041 assuming Chi-square distribution with 3 df

Appendix D: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Month in Mill Creek

Kruskal-Wallis One-Way Analysis of Variance for 311 cases
Dependent variable is VDO
Grouping variable is MONTH

Group	Count	Rank Sum
1	16	3413.500
2	38	8476.000
3	24	5468.500
4	26	5906.000
5	33	5838.000
6	24	2060.500
7	19	1574.500
8	39	4264.500
9	18	1240.500
10	22	2529.500
11	32	4646.500
12	20	3098.000

Kruskal-Wallis Test Statistic = 120.620
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 310 cases
Dependent variable is DOSAT
Grouping variable is MONTH

Group	Count	Rank Sum
1	16	2955.000
2	38	7729.000
3	23	4899.000
4	26	5935.000
5	33	6371.000
6	24	2294.000
7	19	1867.000
8	39	4953.000
9	18	1383.000
10	22	2590.000
11	32	4529.000
12	20	2700.000

Kruskal-Wallis Test Statistic = 86.953
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 103 cases
Dependent variable is VCHLAC
Grouping variable is MONTH

Group	Count	Rank Sum
1	1	10.500
2	20	1092.000
3	5	284.000
4	7	200.000
5	17	626.000
6	6	437.000
7	1	10.500
8	18	1134.000
9	3	219.000
10	7	400.500
11	14	747.000
12	4	195.500

Kruskal-Wallis Test Statistic = 20.103
Probability is 0.044 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 312 cases
Dependent variable is VTN
Grouping variable is MONTH

Group	Count	Rank Sum
1	19	3019.000
2	37	5728.000
3	23	4161.500
4	28	3963.500
5	33	2345.000
6	21	3354.000
7	18	3971.000
8	41	8840.000
9	18	3492.000
10	23	2825.000
11	31	4499.000
12	20	2630.000

Kruskal-Wallis Test Statistic = 67.149
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 320 cases
Dependent variable is VTP
Grouping variable is MONTH

Group	Count	Rank Sum
1	18	2228.000
2	39	3831.500
3	24	3278.000
4	28	2943.000
5	33	2695.500
6	24	4728.500
7	19	4401.500
8	41	10114.500
9	18	4497.500
10	23	4159.500
11	33	5650.500
12	20	2832.000

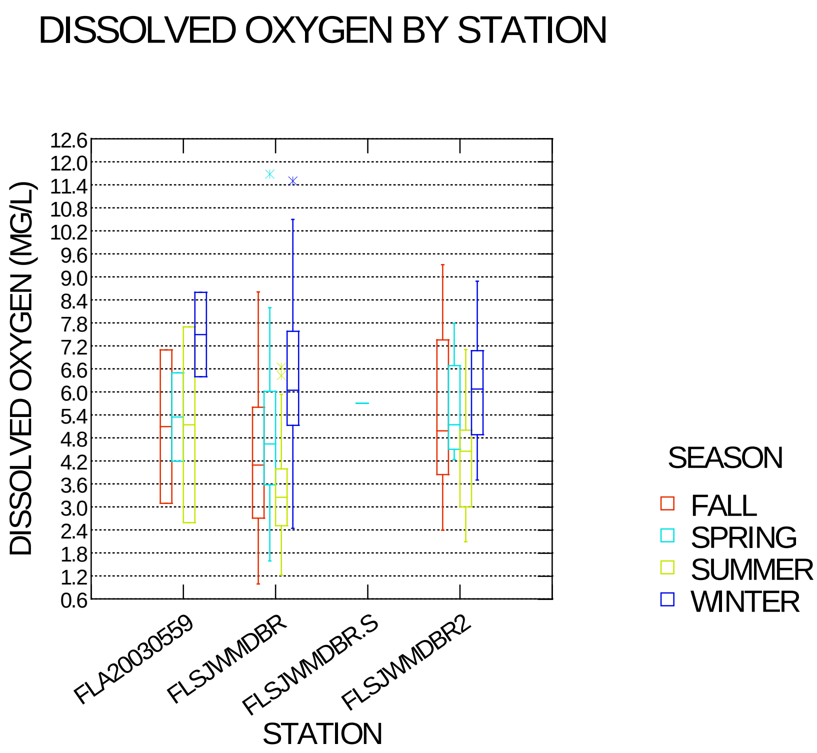
Kruskal-Wallis Test Statistic = 125.833
Probability is 0.000 assuming Chi-square distribution with 11 df

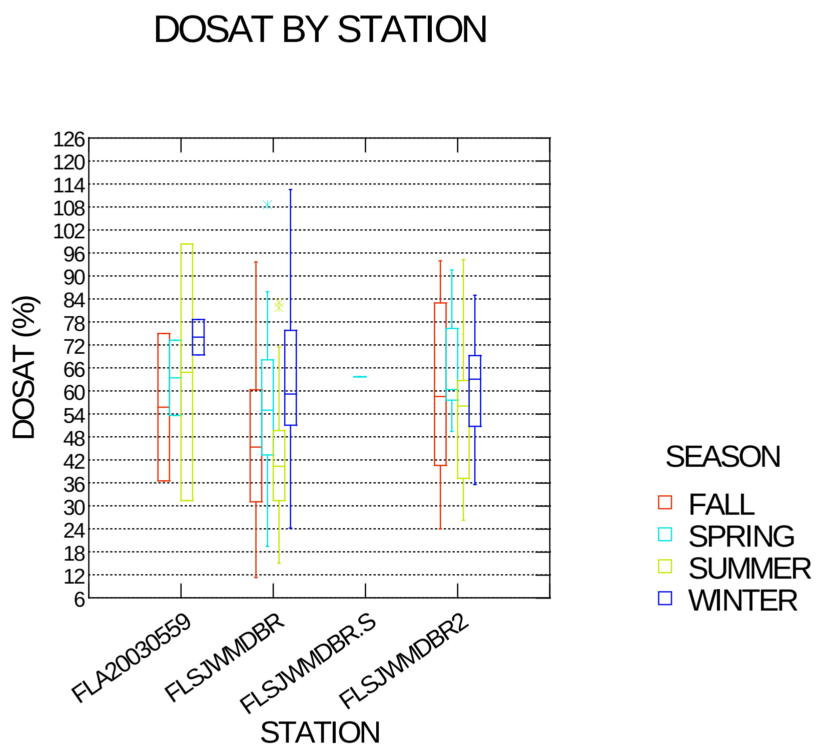
Kruskal-Wallis One-Way Analysis of Variance for 116 cases
Dependent variable is VBOD
Grouping variable is MONTH

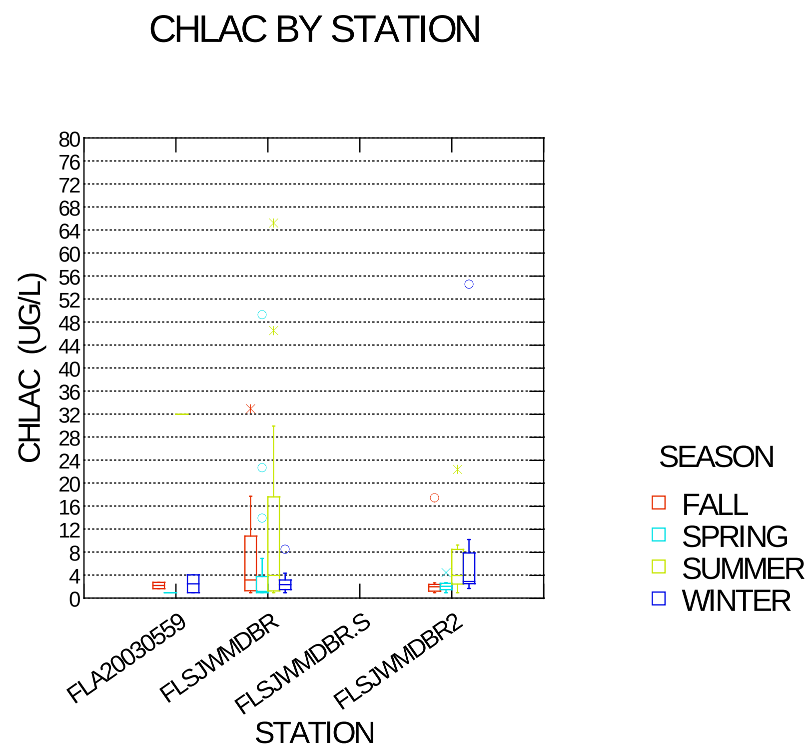
Group	Count	Rank Sum
1	7	330.500
2	11	459.000
3	11	721.000
4	14	652.000
5	9	334.000
6	11	836.500
7	7	380.500
8	12	1050.000
9	8	584.000
10	11	613.000
11	6	328.500
12	9	497.000

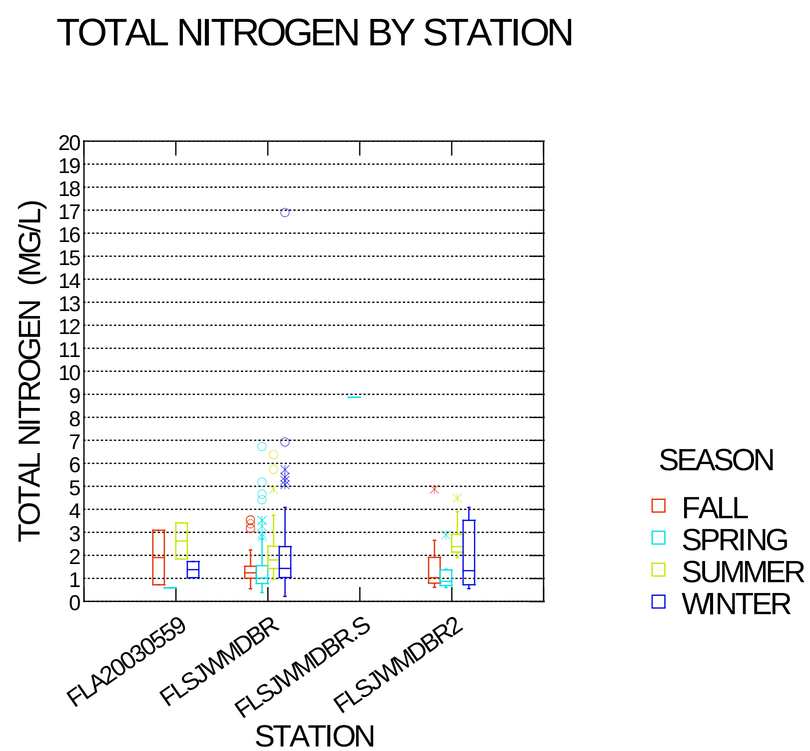
Kruskal-Wallis Test Statistic = 23.336
Probability is 0.016 assuming Chi-square distribution with 11 df

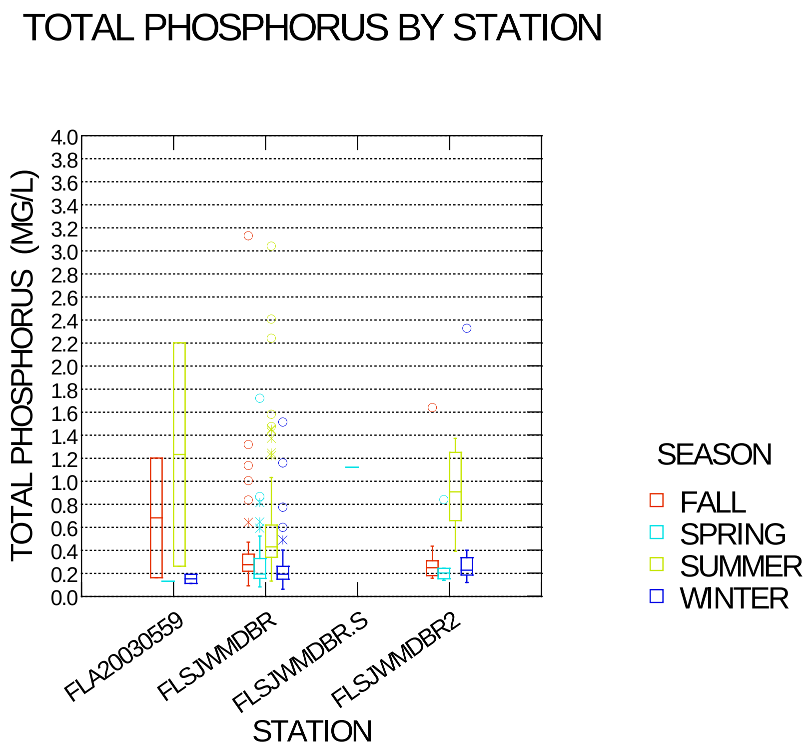
Appendix E: Chart of DO, DOSAT, CHLAC, TN, and TP Observations by Season, Station, and Year in Mill Creek (WBID 2460)

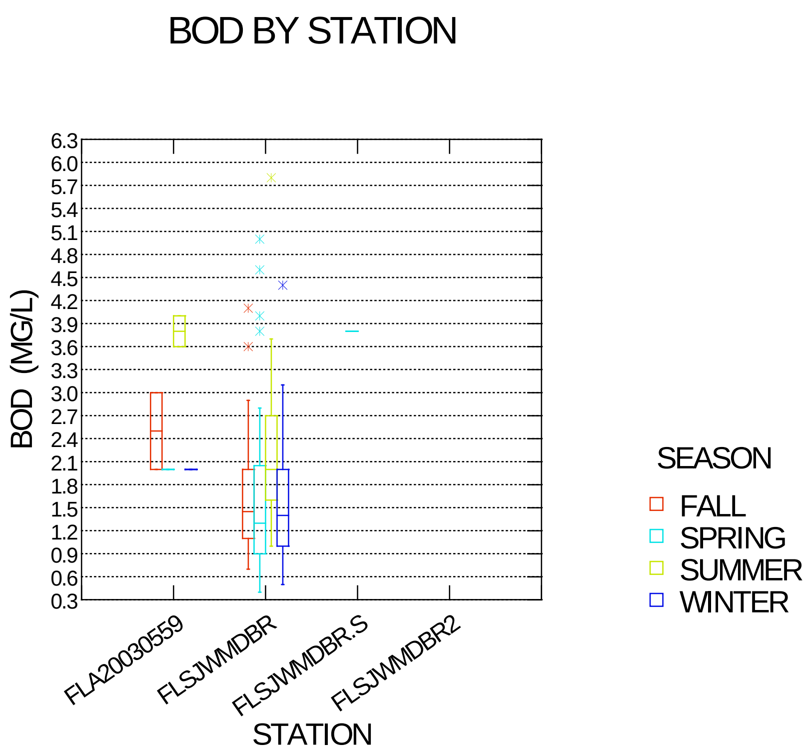


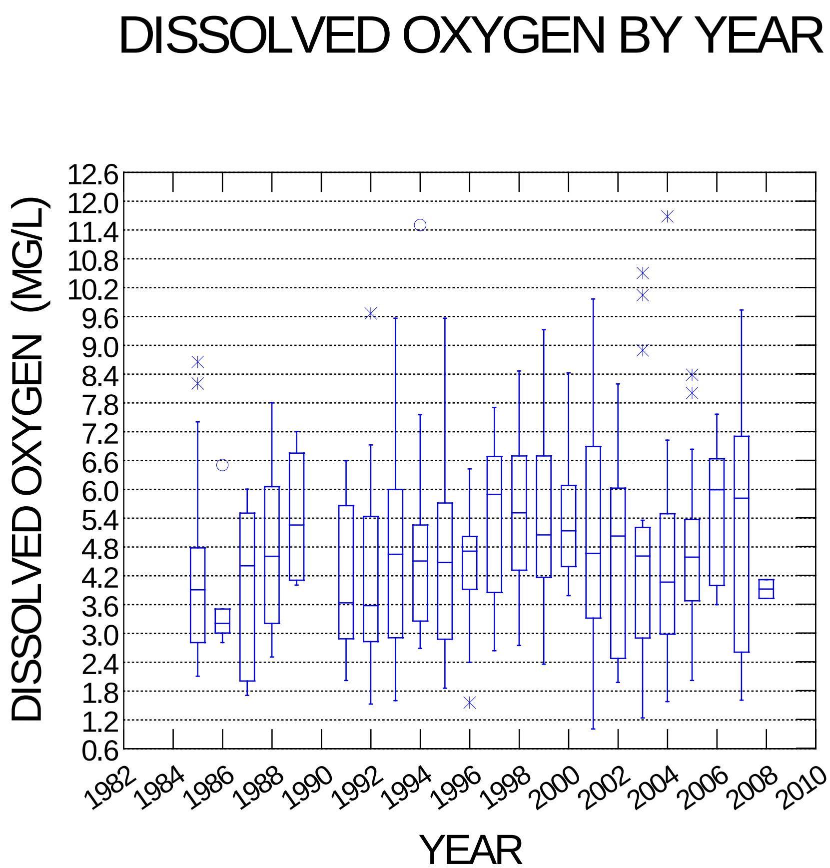

DOSAT BY STATION
DOSAT (%)
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

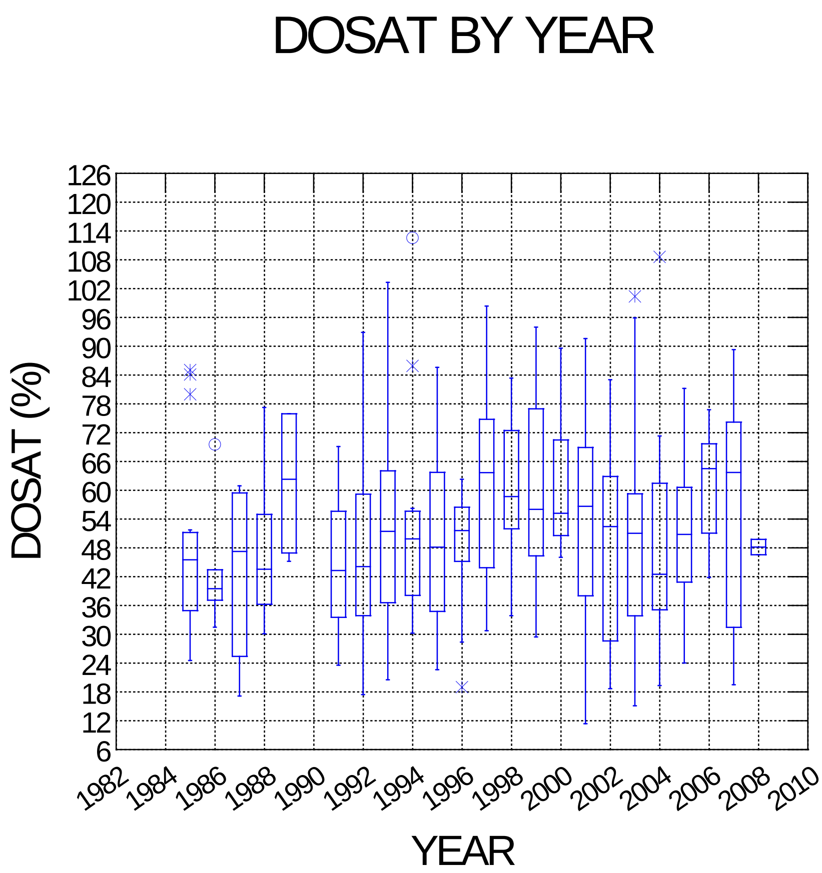

CHLAC BY STATION
CHLAC (UG/L)
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

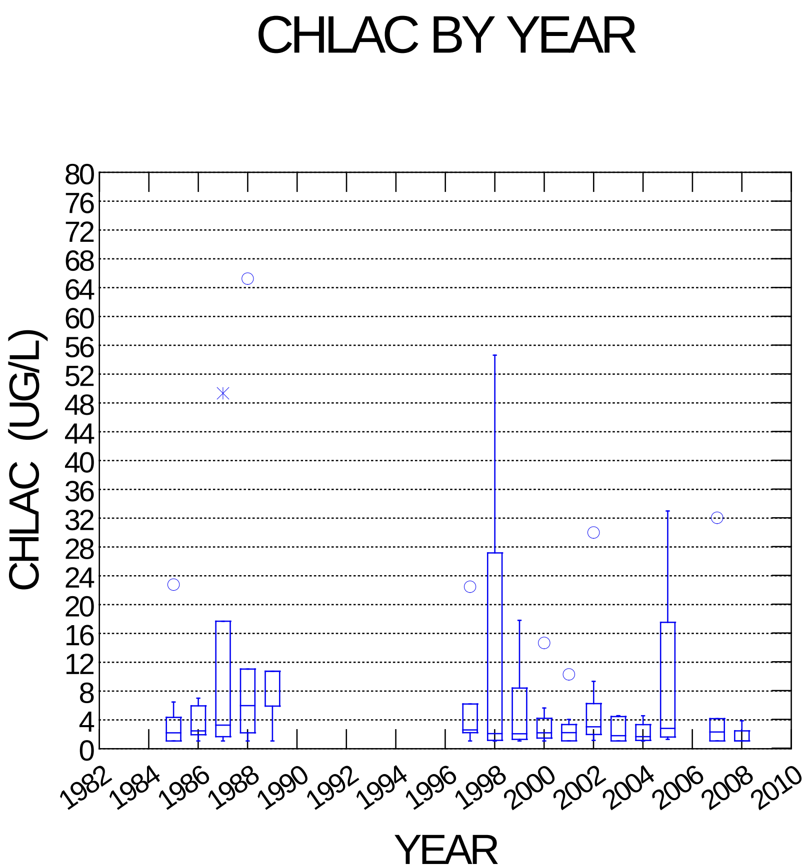

TOTAL NITROGEN BY STATION
TOTAL NITROGEN (MG/L)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

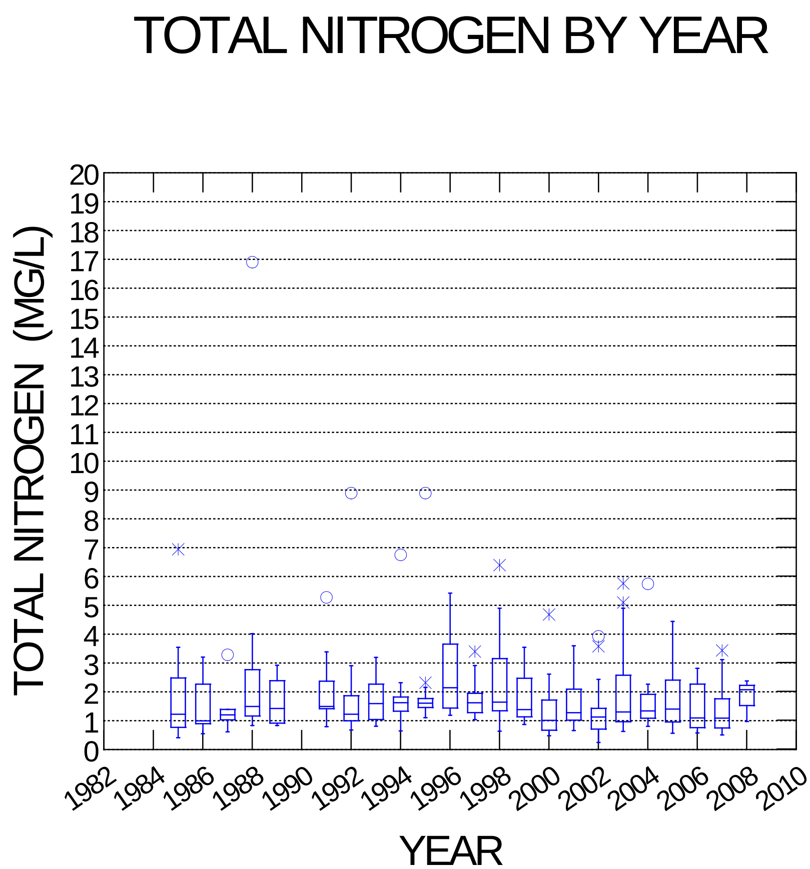

TOTAL PHOSPHORUS BY STATION
TOTAL PHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

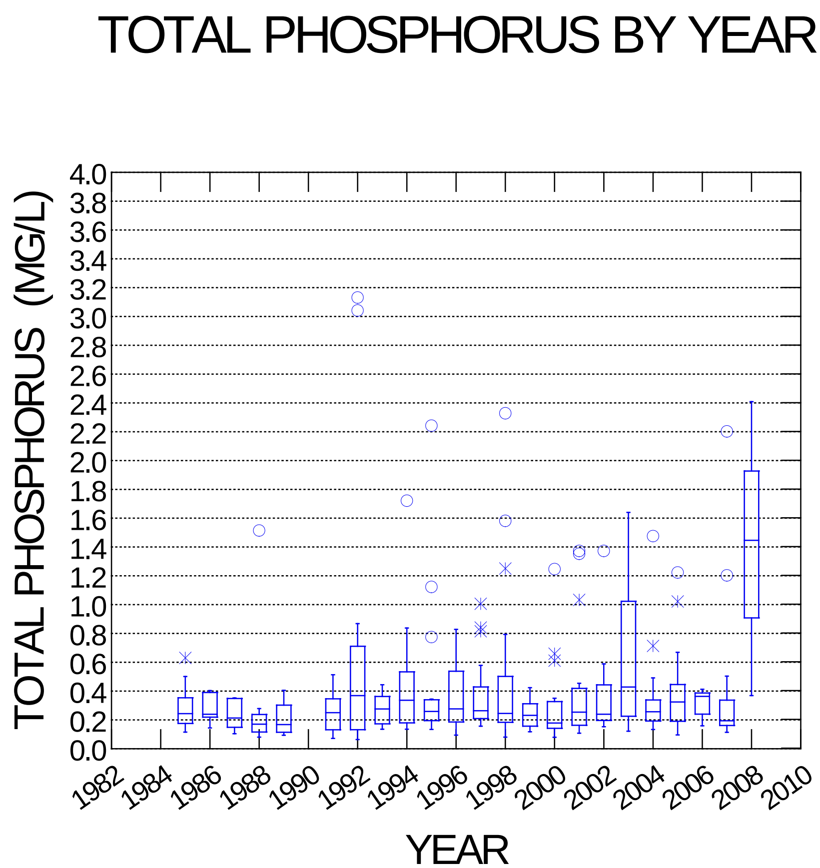

BOD BY STATION
BOD (MG/L)
6.3
6.0
5.7
5.4
5.1
4.8
4.5
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

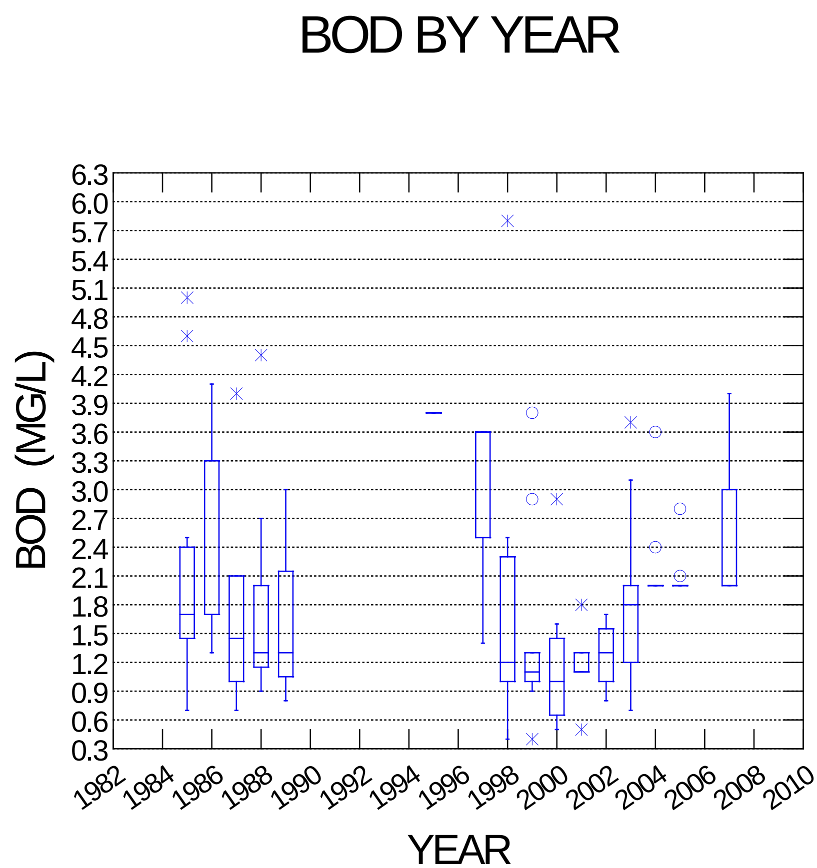

DISSOLVED OXYGEN BY YEAR
DISSOLVED OXYGEN (MG/L)
12.6
12.0
11.4
10.8
10.2
9.6
9.0
8.4
7.8
7.2
6.6
6.0
5.4
4.8
4.2
3.6
3.0
2.4
1.8
1.2
0.6
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

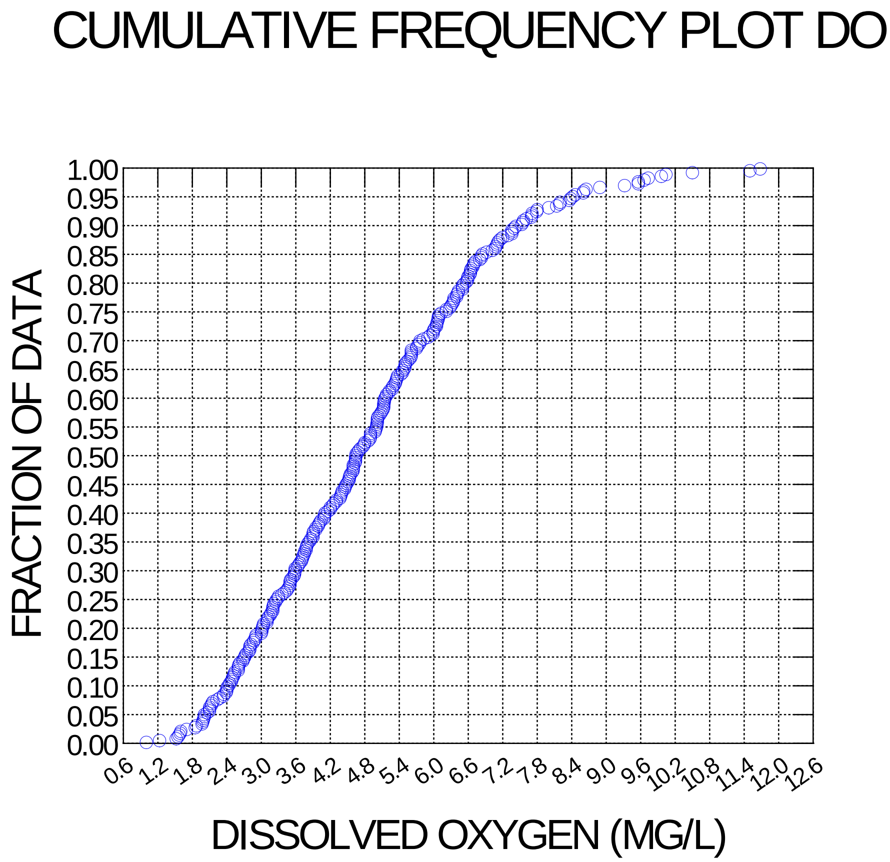

DOSAT BY YEAR
DOSAT (%)
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

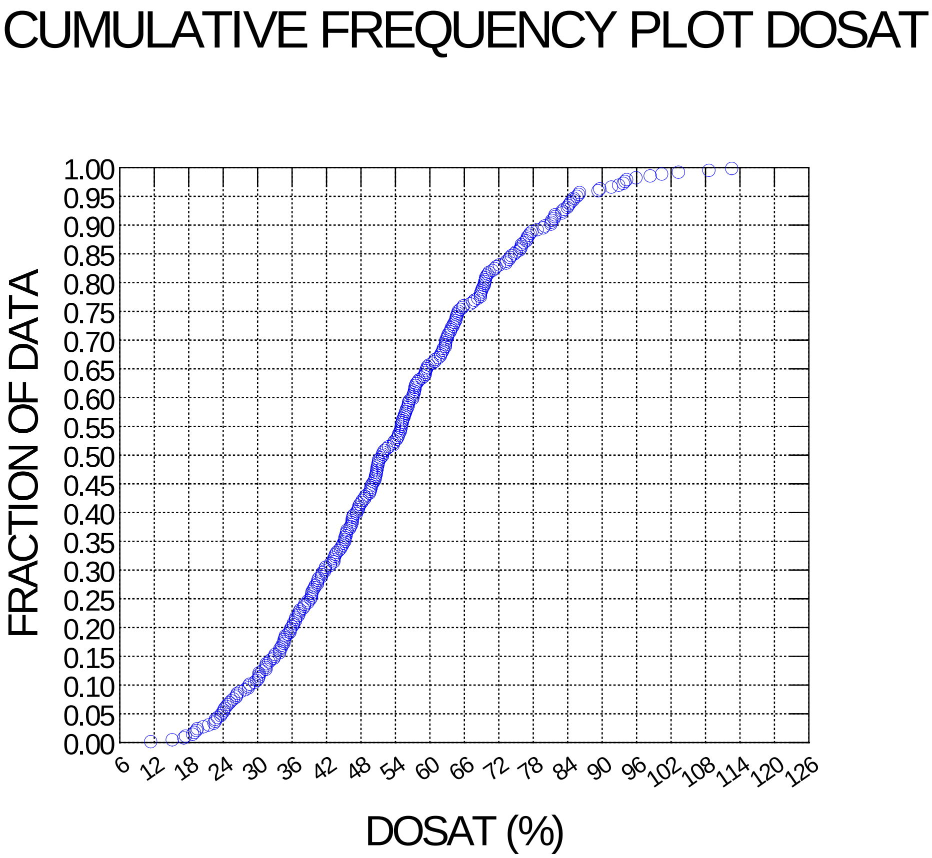

CHLAC BY YEAR
CHLAC (UG/L)
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR


TOTAL NITROGEN BY YEAR
TOTAL NITROGEN (MG/L)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

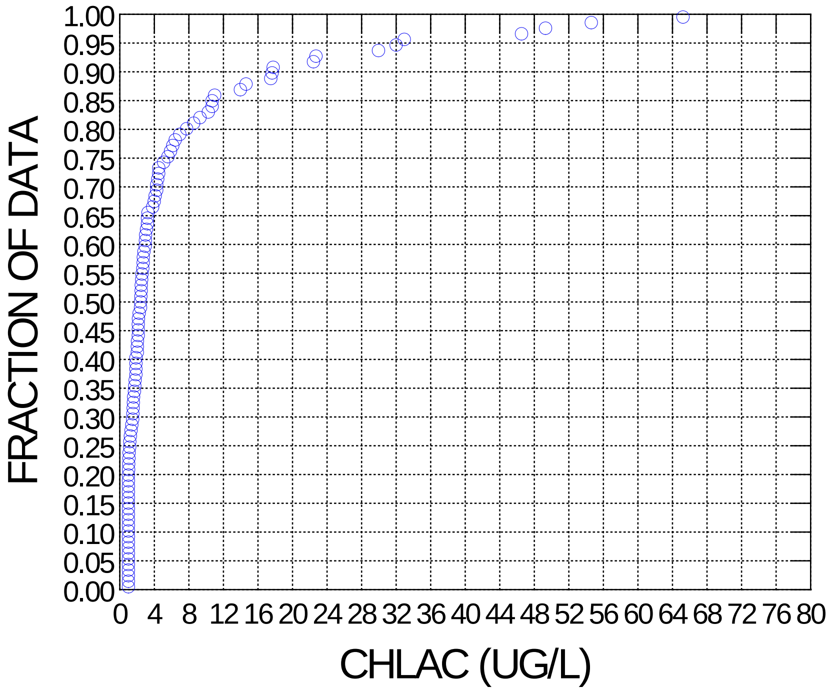

TOTAL PHOSPHORUS BY YEAR
TOTAL PHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

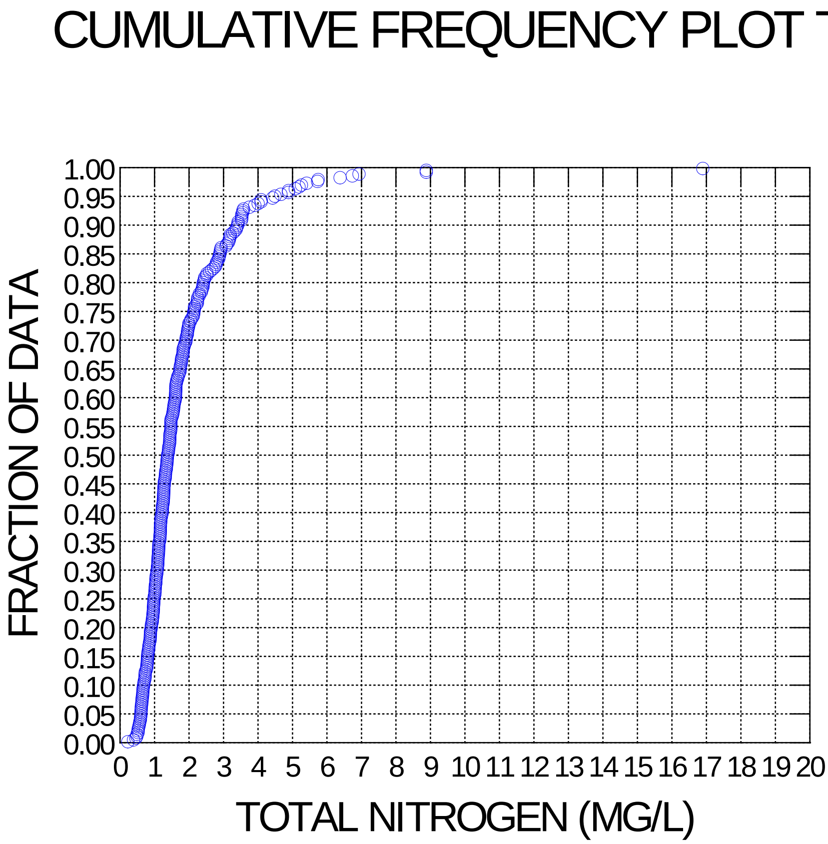

BOD BY YEAR
BOD (MG/L)
6.3
6.0
5.7
5.4
5.1
4.8
4.5
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

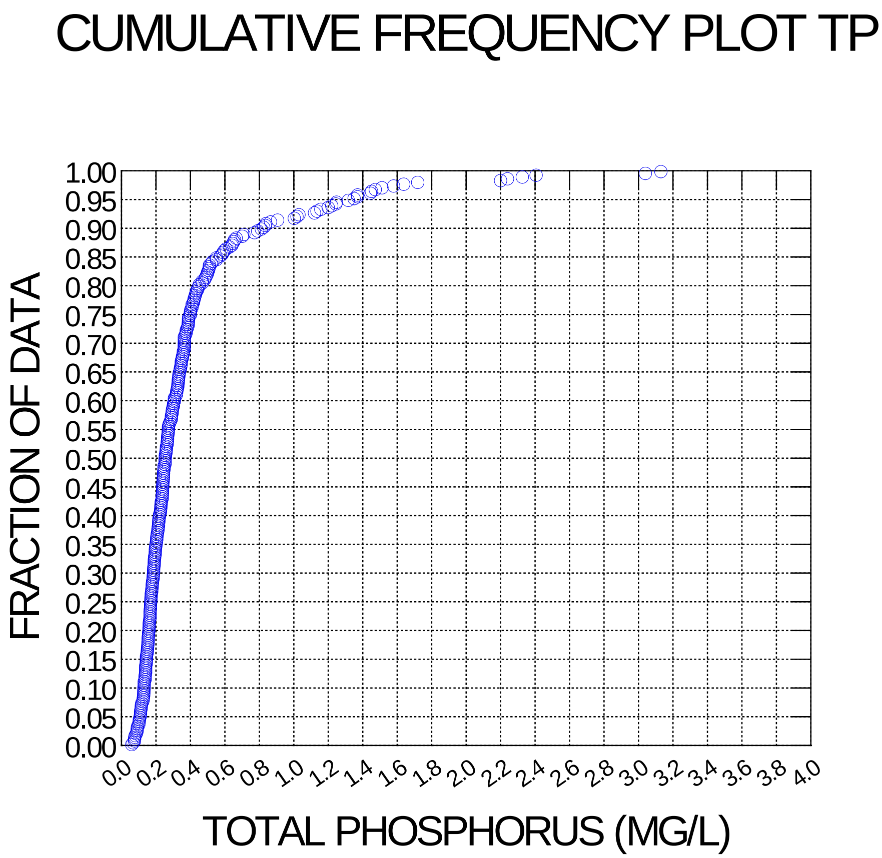

CUMULATIVE FREQUENCY PLOT DO
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
6.6
7.2
7.8
8.4
9.0
9.6
10.2
10.8
11.4
12.0
12.6
DISSOLVED OXYGEN (MG/L)

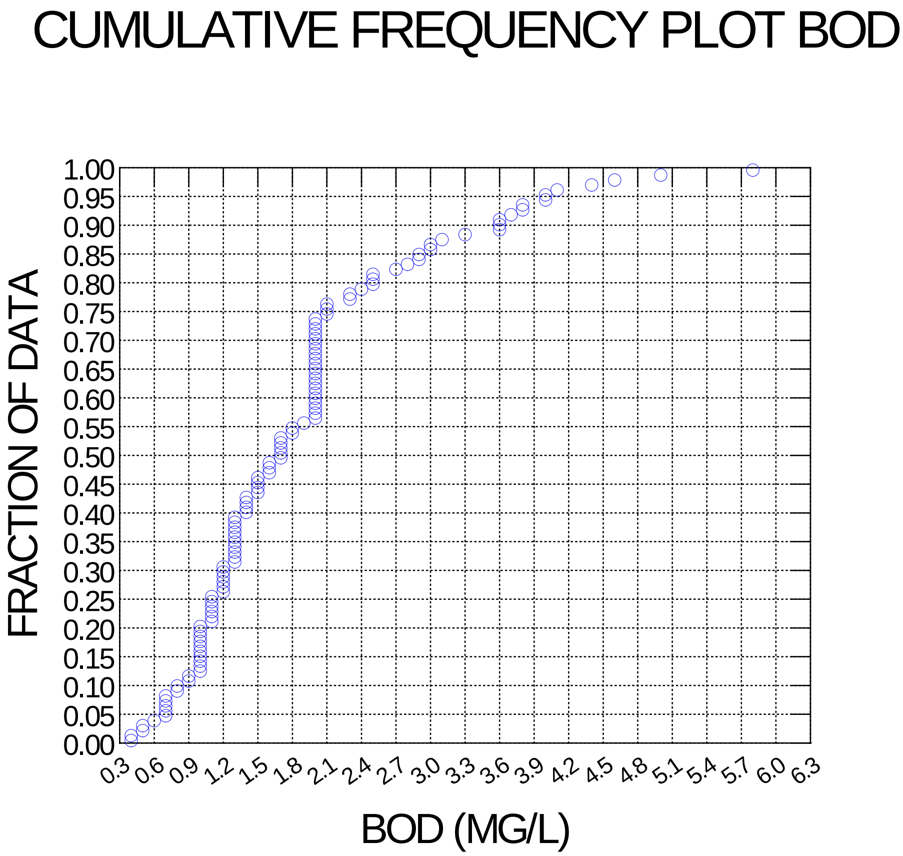

CUMULATIVE FREQUENCY PLOT DOSAT
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
114
120
126
DOSAT (%)

CUMULATIVE FREQUENCY PLOT CHLAC

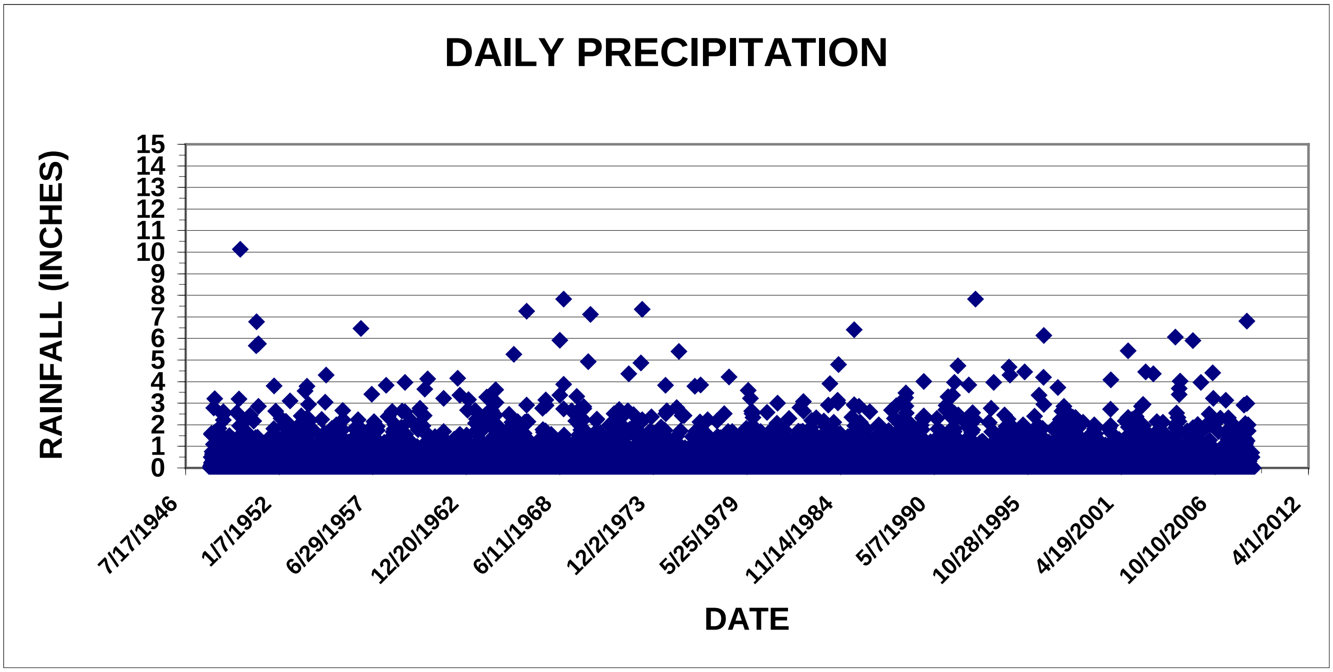



CUMULATIVE FREQUENCY PLOT TN
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TOTAL NITROGEN (MG/L)


CUMULATIVE FREQUENCY PLOT TP
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
TOTAL PHOSPHORUS (MG/L)


CUMULATIVE FREQUENCY PLOT BOD
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3 3.6 3.9 4.2 4.5 4.8 5.1 5.4 5.7 6.0 6.3
BOD (MG/L)

Appendix F: Chart of Rainfall for JIA, 1948–2008



Appendix G: Spearman Correlation Matrix Analysis for Water Quality Parameters in Mill Creek (WBID 2460)

Spearman correlation matrix

- = Empty cell/no data

-	PRECIP	PRECIP3DAY	PRECIP7DAY	PRECIP14DAY	JULIANDATE
PRECIP	1.000	-	-	-	-
PRECIP3DAY	0.640	1.000	-	-	-
PRECIP7DAY	0.306	0.621	1.000	-	-
PRECIP14DAY	-0.052	0.151	0.552	1.000	-
JULIANDATE	-0.100	0.057	0.221	0.317	1.000
VBOD	-0.297	0.080	-0.370	0.411	0.099
VCHLA	-	-0.500	0.000	-0.866	0.000
VCHLAC	0.001	0.127	0.288	0.358	0.503
VCHLOR	0.210	0.238	0.203	-0.456	0.148
VCOLOR	0.093	0.170	-0.177	0.399	0.289
VCOND	-0.077	-0.253	-0.258	-0.511	0.084
VDO	-0.079	0.042	-0.128	-0.186	0.113
VNH4	0.121	-0.082	0.096	0.304	0.174
VNO3O2	-0.021	-0.245	0.094	-0.044	0.352
VSD	-0.130	-0.201	-0.095	0.047	-0.326
VSO4	0.278	0.213	0.127	-0.309	0.045
VTKN	0.127	0.280	0.320	0.635	0.440
VTN	0.052	0.046	0.282	0.493	0.643
VTOC	-0.261	-0.087	-0.049	0.389	0.177
VTP	0.148	0.092	0.335	0.387	0.108
VTSS	0.464	0.519	0.219	-0.023	0.471
VTURB	0.062	0.203	0.258	0.146	0.441

-	VBOD	VCHLA	VCHLAC	VCHLOR	VCOLOR
VBOD	1.000	-	-	-	-
VCHLA	-	1.000	-	-	-
VCHLAC	0.444	-	1.000	-	-
VCHLOR	-0.389	0.000	0.205	1.000	-
VCOLOR	0.596	0.000	0.020	-0.602	1.000
VCOND	-0.414	0.000	0.080	0.633	-0.955
VDO	0.149	-0.866	-0.031	-0.005	0.118
VNH4	-0.090	1.000	-0.035	-0.375	0.290
VNO3O2	-0.829	0.000	-0.169	-0.053	-0.187
VSD	-0.026	-0.500	-0.240	0.285	-0.100
VSO4	-0.800	0.000	-0.101	0.772	-0.809
VTKN	0.673	0.000	0.675	-0.255	0.570
VTN	0.549	0.000	0.702	-0.308	0.564
VTOC	0.604	0.000	0.065	-0.683	0.872
VTP	0.100	1.000	0.253	-0.278	0.078
VTSS	0.566	1.000	0.585	0.189	0.365
VTURB	0.515	0.000	0.447	0.147	0.308

Spearman correlation matrix (cont.)

-	VCOND	VDO	VNH4	VNO3O2	VSD
VCOND	1.000	-	-	-	-
VDO	0.096	1.000	-	-	-
VNH4	-0.201	-0.378	1.000	-	-
VNO3O2	0.180	-0.112	0.250	1.000	-
VSD	0.014	-0.244	-0.105	-0.482	1.000
VSO4	0.783	0.174	-0.220	0.177	0.252
VTKN	-0.451	0.083	0.230	-0.250	-0.227
VTN	-0.332	0.138	0.284	0.166	-0.415
VTOC	-0.803	-0.089	0.041	-0.040	-0.319
VTP	0.012	-0.336	0.543	0.180	-0.207
VTSS	-0.261	0.358	0.096	-0.146	-0.236
VTURB	-0.320	0.139	0.062	-0.289	-0.046

-	VSO4	VTKN	VTN	VTOC	VTP
VSO4	1.000	-	-	-	-
VTKN	-0.357	1.000	-	-	-
VTN	-0.354	0.862	1.000	-	-
VTOC	-0.875	0.568	0.510	1.000	-
VTP	-0.132	0.461	0.484	0.086	1.000
VTSS	0.002	0.674	0.653	0.073	0.433
VTURB	-0.147	0.585	0.564	0.234	0.106

-	VTSS	VTURB
VTSS	1.000	-
VTURB	0.696	1.000

Pairwise frequency table

- = Empty cell/no data

-	PRECIP	PRECIP3DAY	PRECIP7DAY	PRECIP14DAY	JULIANDATE
PRECIP	109	-	-	-	-
PRECIP3DAY	109	109	-	-	-
PRECIP7DAY	109	109	109	-	-
PRECIP14DAY	109	109	109	109	-
JULIANDATE	109	109	109	109	109
VBOD	15	15	15	15	15
VCHLA	3	3	3	3	3
VCHLAC	34	34	34	34	34
VCHLOR	24	24	24	24	24
VCOLOR	25	25	25	25	25
VCOND	63	63	63	63	63
VDO	63	63	63	63	63
VNH4	34	34	34	34	34
VNO3O2	35	35	35	35	35
VSD	52	52	52	52	52
VSO4	24	24	24	24	24
VTKN	35	35	35	35	35
VTN	35	35	35	35	35
VTOC	32	32	32	32	32
VTP	34	34	34	34	34
VTSS	24	24	24	24	24
VTURB	35	35	35	35	35

-	VBOD	VCHLA	VCHLAC	VCHLOR	VCOLOR
VBOD	15	-	-	-	-
VCHLA	0	3	-	-	-
VCHLAC	12	3	34	-	-
VCHLOR	13	3	19	24	-
VCOLOR	14	3	19	22	25
VCOND	14	3	26	22	24
VDO	14	3	26	22	24
VNH4	13	2	24	23	22
VNO3O2	13	3	25	24	23
VSD	14	3	26	22	24
VSO4	13	3	19	24	22
VTKN	13	3	25	24	23
VTN	13	3	25	24	23
VTOC	13	3	23	23	22
VTP	13	2	24	23	22
VTSS	14	3	19	23	23
VTURB	14	3	20	23	25

Pairwise frequency table (cont.)

-	VCOND	VDO	VNH4	VNO3O2	VSD
VCOND	63	-	-	-	-
VDO	63	63	-	-	-
VNH4	32	32	34	-	-
VNO3O2	33	33	34	35	-
VSD	52	52	31	32	52
VSO4	22	22	23	24	22
VTKN	33	33	34	35	32
VTN	33	33	34	35	32
VTOC	31	31	31	32	30
VTP	32	32	34	34	31
VTSS	23	23	22	23	23
VTURB	31	31	23	24	31

-	VSO4	VTKN	VTN	VTOC	VTP
VSO4	24	-	-	-	-
VTKN	24	35	-	-	-
VTN	24	35	35	-	-
VTOC	23	32	32	32	-
VTP	23	34	34	31	34
VTSS	23	23	23	23	22
VTURB	23	24	24	23	23

-	VTSS	VTURB
VTSS	24	-
VTURB	24	35

Appendix H: Linear Regression Analysis of DO and CHLAC Observations versus Nutrients and BOD in Mill Creek

Dep Var: VDO N: 14 Multiple R: 0.051 Squared multiple R: 0.003

Adjusted squared multiple R: 0.000 Standard error of estimate: 0.872

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.605	0.443	0.000	.	10.395	0.000
VBOD	0.026	0.147	0.051	1.000	0.177	0.863

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.024	1	0.024	0.031	0.863
Residual	9.125	12	0.760		

*** WARNING ***
Case 70 has large leverage (Leverage = 0.581)

Durbin-Watson D Statistic 0.872
First Order Autocorrelation 0.547

Dep Var: VDO N: 33 Multiple R: 0.063 Squared multiple R: 0.004

Adjusted squared multiple R: 0.000 Standard error of estimate: 1.245

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.657	0.641	0.000	.	7.266	0.000
VTN	0.135	0.382	0.063	1.000	0.354	0.726

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.195	1	0.195	0.125	0.726
Residual	48.069	31	1.551		

Durbin-Watson D Statistic 1.737
First Order Autocorrelation 0.043

Dep Var: VDO N: 32 Multiple R: 0.034 Squared multiple R: 0.001

Adjusted squared multiple R: 0.000 Standard error of estimate: 1.162

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.717	0.419	0.000	.	11.250	0.000
VTP	0.278	1.498	0.034	1.000	0.185	0.854

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.046	1	0.046	0.034	0.854
Residual	40.533	30	1.351		

*** WARNING ***
Case 84 has large leverage (Leverage = 0.490)

Durbin-Watson D Statistic 1.509
First Order Autocorrelation 0.193

Dep Var: VDO N: 32 Multiple R: 0.699 Squared multiple R: 0.488

Adjusted squared multiple R: 0.366 Standard error of estimate: 0.911

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	8.929	4.040	0.000		2.210	0.036
VTP	-10.758	14.814	-1.311	0.006	-0.726	0.474
VTN	-0.743	2.999	-0.355	0.010	-0.248	0.806
VTEMP	-0.093	0.196	-0.311	0.047	-0.474	0.640
VTEMP*VTP	-0.159	0.616	-0.484	0.006	-0.259	0.798
VTN*VTP	5.516	2.141	2.098	0.031	2.576	0.016
VTEMP*VTN	0.011	0.134	0.149	0.007	0.086	0.932

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	19.820	6	3.303	3.978	0.006
Residual	20.760	25	0.830		

*** WARNING ***
Case 15 has large leverage (Leverage = 0.535)
Case 84 has large leverage (Leverage = 0.896)
Case 102 has large leverage (Leverage = 0.782)

Durbin-Watson D Statistic 1.845
First Order Autocorrelation 0.067

Dep Var: VCHLAC N: 26 Multiple R: 0.507 Squared multiple R: 0.257

Adjusted squared multiple R: 0.226 Standard error of estimate: 13.403

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-37.630	16.584	0.000	.	-2.269	0.033
VTEMP	1.980	0.687	0.507	1.000	2.881	0.008

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1491.353	1	1491.353	8.302	0.008
Residual	4311.192	24	179.633		

*** WARNING ***
Case 52 has large leverage (Leverage = 0.471)
Case 53 has large leverage (Leverage = 0.478)
Case 54 has large leverage (Leverage = 0.330)
Case 56 has large leverage (Leverage = 0.319)
Case 100 has large leverage (Leverage = 0.370)

Durbin-Watson D Statistic 1.625
First Order Autocorrelation 0.184

Dep Var: VCHLAC N: 25 Multiple R: 0.755 Squared multiple R: 0.571

Adjusted squared multiple R: 0.509 Standard error of estimate: 10.870

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	83.453	40.946	0.000	.	2.038	0.054
VTEMP	-4.114	1.844	-1.051	0.092	-2.231	0.037
VTN	-80.648	27.302	-2.941	0.021	-2.954	0.008
VTEMP*VTN	3.972	1.201	3.917	0.015	3.306	0.003

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	3298.703	3	1099.568	9.306	0.000
Residual	2481.355	21	118.160		

*** WARNING ***
Case 1 has large leverage (Leverage = 0.592)
Case 79 is an outlier (Studentized Residual = 3.227)

Durbin-Watson D Statistic 2.589
First Order Autocorrelation -0.305

Dep Var: VBOD N: 12 Multiple R: 0.890 Squared multiple R: 0.792

Adjusted squared multiple R: 0.771 Standard error of estimate: 0.801

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	1.600	0.286	0.000	.	5.587	0.000
VCHLAC	0.084	0.014	0.890	1.000	6.164	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	24.390	1	24.390	37.993	0.000
Residual	6.420	10	0.642		

*** WARNING ***
Case 70 has large leverage (Leverage = 0.487)
Case 78 is an outlier (Studentized Residual = -3.613)

Durbin-Watson D Statistic 2.313
First Order Autocorrelation -0.164

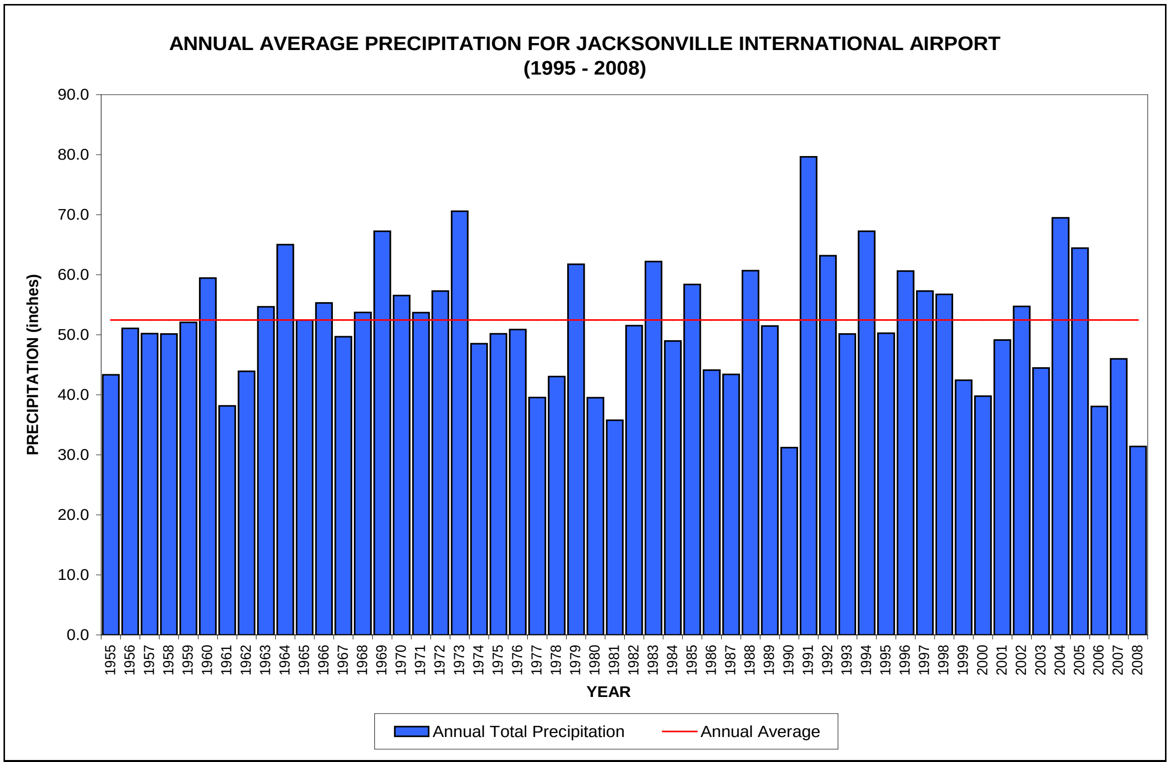
Appendix I: Monthly and Annual Precipitation at JIA, 1955–2008

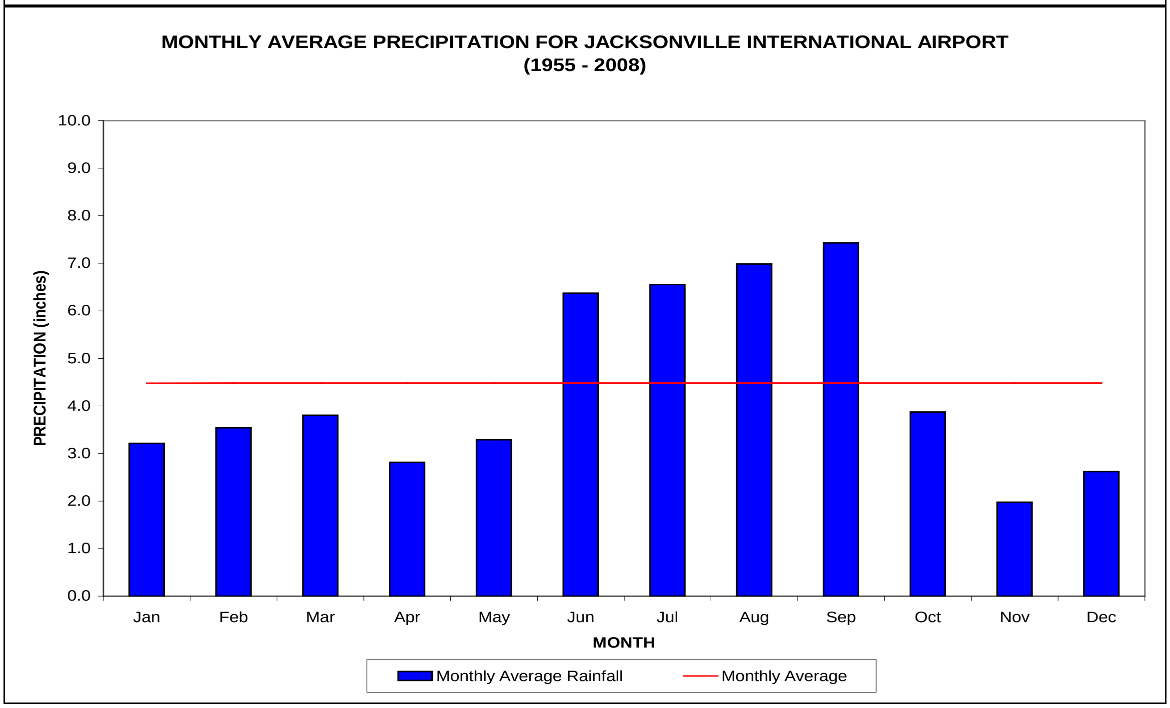
Rainfall is in inches, and represents data from JIA.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1955	3.1	2.46	1.66	1.5	4.51	2.7	5.53	3.85	10.6	5.36	1.9	0.2	**43.33**
1956	2.9	2.94	0.81	2.33	3.98	7.87	8.25	5.24	2.89	13.4	0.4	0	**51.08**
1957	0.3	1.69	3.87	1.61	5.25	7.1	12.3	3.3	8.33	3.5	1.6	1.3	**50.18**
1958	3.4	3.74	3.38	8.24	3.79	3.96	4.37	4.67	4.75	5.07	2	2.8	**50.14**
1959	3	5.22	9.75	2.65	9.2	2.94	4.51	2.86	5.67	3.12	2.2	1	**52.08**
1960	2.1	5.17	6.94	3.54	1.18	4.7	16.2	6.5	8.57	2.95	0.1	1.5	**59.45**
1961	2.9	4.85	1.17	4.16	3.06	5.27	3.48	10.6	1.02	0.27	0.9	0.5	**38.15**
1962	2.2	0.52	3.1	2.36	1.12	8.22	6.31	10.1	4.37	1.13	2.1	2.5	**43.9**
1963	5.4	6.93	2.23	1.75	1.74	12.5	6.47	4.95	4.88	1.53	2.7	3.6	**54.66**
1964	7.3	6.55	1.76	4.65	4.8	4.67	6.12	5.63	10.3	5.09	3.3	4.8	**65.03**
1965	0.7	5.5	3.91	0.95	0.94	9.79	2.71	9.58	11	1.75	1.9	3.8	**52.47**
1966	4.6	5.97	0.71	2.25	10.4	7.74	11.1	3.88	5.94	1.38	0.2	1.1	**55.3**
1967	3.1	4.35	0.81	2	1.18	12.9	5.22	12.3	1.8	1.13	0.2	4.7	**49.68**
1968	0.8	3.05	1.2	0.99	2.17	12.3	6.84	16.2	2.68	5.09	1.3	1.1	**53.72**
1969	0.8	3.39	4.23	0.34	3.78	5.12	5.89	15.1	10.3	9.81	4.6	3.9	**67.26**
1970	4.2	8.85	9.98	1.77	1.84	2.65	7.6	11	3.2	3.95	0	1.6	**56.55**
1971	2	2.55	2.41	4.07	1.9	5.52	5.07	12.8	4.17	6.46	0.8	5.9	**53.69**
1972	5.8	3.48	4.43	2.98	8.26	6.75	3.15	9.76	2.6	4.46	4.2	1.4	**57.29**
1973	4.6	5.07	10.2	11.6	5.33	4.1	5.45	7.49	7.86	4.08	0.4	4.3	**70.57**
1974	0.3	1.28	3.47	1.53	4.14	5.53	9.83	11.2	8.13	0.34	1	1.7	**48.52**
1975	3.5	2.58	2.46	5.78	7	5.21	6.36	6.23	5.24	3.63	0.4	1.8	**50.15**
1976	2.3	1.05	3.41	0.63	10	4.26	5.41	6.37	8.56	1.63	2.4	4.8	**50.87**
1977	3	3.24	1.03	1.76	3.07	2.65	1.97	7.26	7.45	1.68	3.1	3.4	**39.56**
1978	4.6	4.17	2.83	2.24	9.18	2.62	6.67	2.39	4.4	1.26	0.8	1.8	**43.04**
1979	6.3	3.75	1	4.18	7.54	5.91	4.67	4.78	17.8	0.25	3.6	2	**61.76**
1980	2.6	1.06	6.83	3.91	3.02	4.59	5.29	3.97	3.03	2.69	2.3	0.2	**39.53**
1981	0.9	4.53	5.41	0.32	1.48	3.31	2.46	6.47	1.22	1.35	4.9	3.4	**35.77**
1982	3	1.67	4.26	3.6	3.55	8.06	3.81	6.93	9.32	3.37	1.9	2	**51.52**
1983	7.2	4.27	8.46	4.65	1.38	6.86	6.11	4.63	4.61	4.29	3.3	6.4	**62.19**
1984	2.1	4.67	5.77	3.14	1.46	4.76	6.01	3.78	12.3	1.53	3.3	0.1	**48.96**
1985	1.1	1.45	1.26	2.76	2.08	3.71	6.33	8.93	16.8	8.34	2.1	3.6	**58.39**
1986	4.2	4.72	5.44	0.93	2.13	2.53	3.27	9.6	1.99	1.8	2.9	4.7	**44.1**
1987	4.1	6.47	6.27	0.14	0.75	4.18	4.4	4.48	7.13	0.3	5	0.2	**43.39**
1988	6.4	6.08	2.65	3.44	1.35	3.71	4.5	8.48	16.4	2.35	4.3	1.1	**60.68**
1989	1.7	1.77	2.14	2.79	1.55	3.66	8.98	9.16	14.4	1.39	0.5	3.4	**51.45**
1990	1.8	4.07	1.59	1.34	0.18	1.59	6.53	3.81	2.6	4.54	1.2	1.9	**31.2**
1991	10	1.52	7.33	6.31	9.35	11.7	15.9	3.48	6.2	6.36	0.7	0.6	**79.63**
1992	5.8	2.64	4.09	5.33	5.97	7.04	3.32	10.8	7.33	8.34	1.9	0.7	**63.18**
1993	3.9	2.89	5.98	0.85	1.6	2.52	7.54	2.96	7.6	8.84	3.6	1.9	**50.12**
1994	6.6	0.92	2.14	1.51	3.15	14	8.26	3.29	9.79	10.2	3.5	3.9	**67.26**
1995	1.9	2.07	3.67	1.77	1.77	5.35	9.45	9.93	5.41	3.53	3.2	2.2	**50.25**
1996	1.1	1.11	6.83	2.85	0.72	11.4	4.2	7.83	8.49	11.5	1.4	3.2	**60.63**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1997	2.9	1.28	1.84	4.56	3.43	6.33	7.69	8.24	3.97	4.84	2.4	9.8	**57.27**
1998	3.5	11.1	2.64	4.71	0.96	2.95	7.29	10.1	7.65	3.01	2.4	0.4	**56.72**
1999	4.6	1.7	0.4	1.92	1.02	7.75	3.56	3.51	13	3.24	0.8	0.9	**42.44**
2000	2.8	1.17	1.79	2.6	1.15	2.43	5.69	7.38	11.6	0.23	1.6	1.4	**39.77**
2001	0.9	0.68	5.48	0.62	2.56	5.59	8.31	3.58	16	0.81	1.4	3.1	**49.14**
2002	4.5	0.82	4.38	2.41	0.47	6.24	7.8	8.14	9.31	2.58	2.7	5.4	**54.72**
2003	0.1	4.66	10.7	2.63	2.54	6.75	7.33	1.83	3.04	2.98	0.7	1.2	**44.47**
2004	1.6	4.47	1.36	2.02	1.24	17.2	8.6	9.85	16.3	1.32	2.9	2.7	**69.47**
2005	1.9	3.56	3.67	4.53	3.51	14.8	7.37	4.43	5.76	6.49	1.1	7.4	**64.44**
2006	2.30	3.91	0.68	1.22	2.01	7.25	3.97	7.08	4.55	1.81	0.39	2.90	**38.07**
2007	2.29	2.40	2.22	1.02	1.12	6.68	9.48	3.57	5.44	8.85	0.17	2.74	**45.98**
2008	2.63	5.22	3.50	2.34	0.66	8.21	8.73	16.83	5.84	1.62	1.01	0.59	**46.01**
AVG	**3.21**	**3.54**	**3.81**	**2.82**	**3.29**	**6.37**	**6.55**	**6.99**	**7.43**	**3.87**	**1.98**	**2.62**	**52.32**

Appendix J: Annual and Monthly Average Precipitation at JIA





Appendix K: Response to Comments

August 6, 2009

H.P. Tompkins, Jr , County Engineer
St. Johns County Board of County Commissioners
Public Works I Engineering Division
2740 Industry Center Road
St. Augustine, FL 32084

RE: Draft TMDLs for Sixteen Mile Creek (WBID 2589) and Mill Creek (WBID 2460)
Released June 2009

Dear Mr. Tompkins:

Thank you for taking the time to compile your insightful comments and questions regarding the draft Total Maximum Daily Load reports we presented at the public workshop on July 9th. To aid you in reviewing our responses, we have included your comment (in blue), followed by a response to each, in the order in which they were presented.

St. Johns County appreciates the opportunity to comment on the draft TMDLs released on June 19, 2009 for the Lower St. Johns River Basin. We are providing FDEP with both general comments regarding the TMDL and BMAP processes and specific comments concerning three of the proposed TMDLs:

Dissolved oxygen TMDL for Sixteen Mile Creek, WBID 2589
Dissolved Oxygen and Nutrient TMDLs for Mill Creek, WBID 2460
Fecal Coliform TMDL for Mill Creek, WBID 2460

Based on these comments, we request that FDEP extend the adoption date of the referenced TMDLs by 90 days.

GENERAL COMMENTS:

FINANCIAL IMPLICATIONS/TIMELINE

For the TMDL and the following BMAP to be successfully implemented, it is critical that all stakeholders have the chance to make sure that the methodologies, data, and science used in support the TMDL are valid. Given the potential financial burden that the proposed TMDLs will place on the County and its citizen, 30 days is not sufficient time to allow stakeholders to conduct a thorough review of technical information used in developing the TMDLs presented on July 9, 2009.

Department Response:
We appreciate the difficulty in conducting a thorough review of the technical information used in developing the TMDLs that were presented in July within a 30-day period. The nutrient reductions proposed for Sixteen Mile Creek and Mill Creek however, are consistent with reductions required under the Lower St. Johns River nutrient TMDL that was adopted in 2008. Development of the mainstem St. Johns River involved review by an Executive Committee consisting of stakeholders representing a number of entities in the basin. The Basin Management Action Plan that was adopted to implement the

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Lower St. Johns River nutrient TMDL in the fall of 2008 was also a stakeholder-driven process that allocated reductions to both point and nonpoint sources in the watershed.

TMDL DEVELOPMENT PROCESS

The TMDL framework established in the "Impaired Waters Rule," Chapter 62-303, is meant to include all stakeholders in the regulatory process. We do not feel there has been adequate communication in the TMDL development process to allow for interested stakeholders to understand the draft TMDLs. We propose that for future TMDLs the FDEP provide more collaboration during the data analysis and model development stages of the TMDL.

Department Response:
The Department will continue to make every effort to provide more collaboration during the data analysis and TMDL development processes. As described under the Department's watershed-based approach, individual basin assessments are performed on a five-year cycle. The Lower St. Johns River Basin was first assessed and a verified list of impaired waters adopted in 2004, following a series of public meetings. Both Sixteen Mile Creek and Mill Creek were part of the 1998 list submitted to EPA which became part of a Consent Decree between EPA and Earthjustice that included a schedule for TMDL development. As part of the second cycle, public meetings on draft lists of impaired waters in the Lower St. Johns River Basin were held on November 24, 2008, and April 2, 2009. The Cycle 2 verified list of impaired water was adopted on May 19, 2009. As the DO impairments were "re-verified" in the second cycle, the Department needed to develop and adopt these TMDLs and submit them to EPA prior to September 30, 2009. Under the Consent Decree that EPA has with Earthjustice, if the state does not establish a TMDL by that time, EPA will have to propose these TMDLs no later than September 30th, 2009.

STAKEHOLDER RESP0NSIBILITY

As stated in the TMDLs, the County can only be held responsible for reducing the loads that are included within its MS4 coverage. It will be critical for FDEP to identify all parties responsible for contributing loads to the impaired water bodies.

Department Response:
As noted, our TMDL report states: "It should be noted that any MS4 permittee is only responsible for reducing the 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." The TMDL also has a load allocation (LA) component that represents nonpoint sources outside of MS4 areas. Depending upon the activities and responsible parties represented by the LA component, the County may have some obligations under the LA. All responsible parties will be identified prior to specific allocations being formally established in the BMAP.

IMPLEMENTATION SCHEDULE

The County cannot be expected to implement load-reduction projects until FDEP adopts all intermediate TMDLs between the tributaries and the main stem of the LSJR. For instance, Sixteen Mile Creek discharges to impaired waterbody Deep Creek (WBID 2549), which flows into the LSJR. The TMDL for Deep Creek has not been adopted by FDEP while the LSJR has an adopted BMAP and a draft TMDL for Sixteen Mile Creek is being proposed. Without a complete understanding of the pollutants of concern and the load reductions required in Deep Creek, it is not possible for the County to determine the optimal location or cost effectiveness of water quality improvement that could affect all three water bodies.

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Department Response:
As noted in the comment, a TMDL for Deep Creek has not been adopted by FDEP at this time for the DO (TP identified as causative pollutant) and nutrient impairments. As Sixteen Mile Creek flows into Deep Creek, water quality improvements made to Sixteen Mile Creek would benefit Deep Creek and credit for improvements in the Sixteen Mile Creek watershed may reduce the burden on what must be done to restore Deep Creek. As noted in a previous response, Deep Creek, Sixteen Mile Creek, and Mill Creek were all part of contributing watersheds to the mainstem Lower St. Johns River addressed by the nutrient TMDL and BMAP.

SPECIFIC COMMENTS

DISSOLVED OXYGEN TMDL FOR SIXTEEN MILE CREEK, WBID 2589

It is not clear how the waterbody is exceeding the nutrient criterion expressed in Rule 62-302, FAC. Only two data points are provided in the period of record that indicate chlorophyll-a concentrations greater than the average annual threshold of 20 ug/L. In addition, the seasonal means provided in Table 5.6 do not exceed 20 ug/L.

Department Response:
As noted in the document, in Cycle 1 Sixteen Mile Creek was verified impaired for nutrients based upon and annual average chlorophyll concentration above 20 υg/L. Subsequently, an error in the reported detection limits units associated with a measurement in 2002 was corrected and the recalculated annual average chlorophyll was below 20 μg/L. Although there were two observations of chlorophyll above 20 μg/L over the period of record, there were insufficient measurements during those years to calculate an annual average under the IWR methodology. Consequently, the TMDL addressed only the dissolved oxygen impairment.

The importance of dissolved oxygen's relationship with sulfate seems to be ignored in the analysis of impairment cause. If algae (chlorophyll-a) is not present above the threshold criteria as stated above, there may be another oxygen consumption mechanism driving the DO impairment. It is plausible that the impairment could be more related to sulfate loading and sediment oxygen demands instead of the traditional algal and limiting nutrient (TP and TN) causes. While the potential sources of TN, TP, and sulfates are common (fertilizers), the identification of the pollutant and the mechanism causing the impairment is critical to the TMDL and its ultimate implementation.

Department Response:
In the sulfur cycle, under anaerobic conditions, sulfate is reduced to sulfide by sulfate-reducing bacteria and in aerobic conditions sulfide is oxidized to sulfate by sulfur bacteria. Observed dissolved oxygen concentrations in Sixteen Mile Creek ranged between 0.53 and 13.81 mg/L, with less than 1 percent of the observations equaling less than 0.8 mg/L. Sulfate observations ranged between 2 and 747 mg/L (25^{th} percentile 26.8 mg/L and 75^{th} percentile 293.4 mg/L). The following graphs illustrate the time series of sulfate and the relationship between sulfate and DO. Based upon the available information, it does not appear that sulfate reduction is a significant process in Sixteen Mile Creek or that it explains the DO impairment. With respect to sediment oxygen demands (SOD), the Department is unaware of any measurements of SOD in Sixteen Mile Creek.

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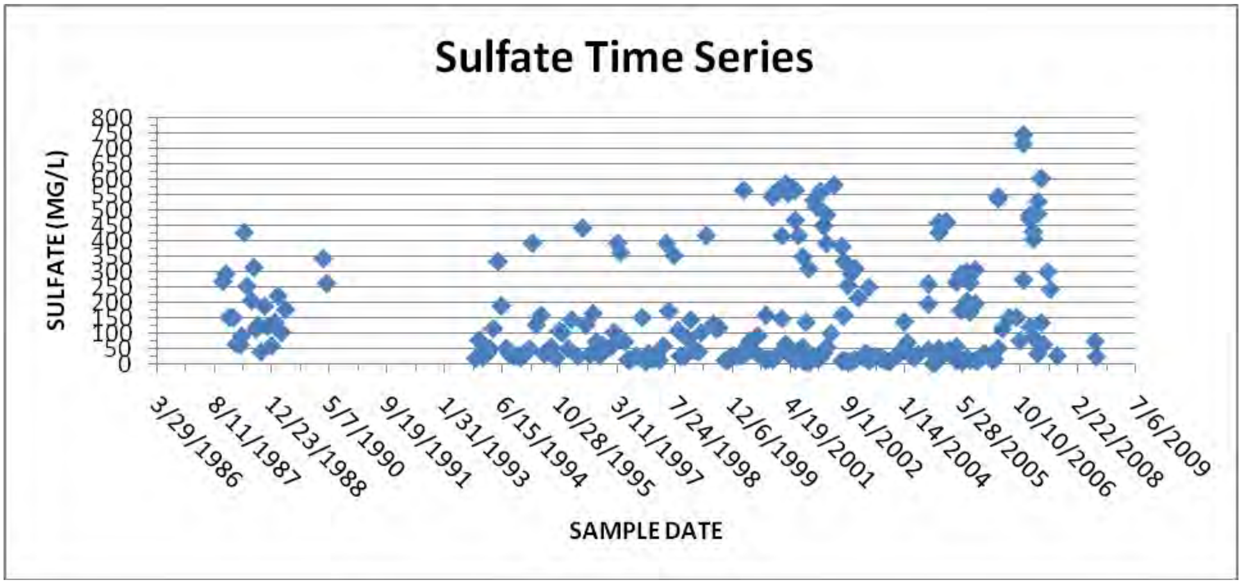

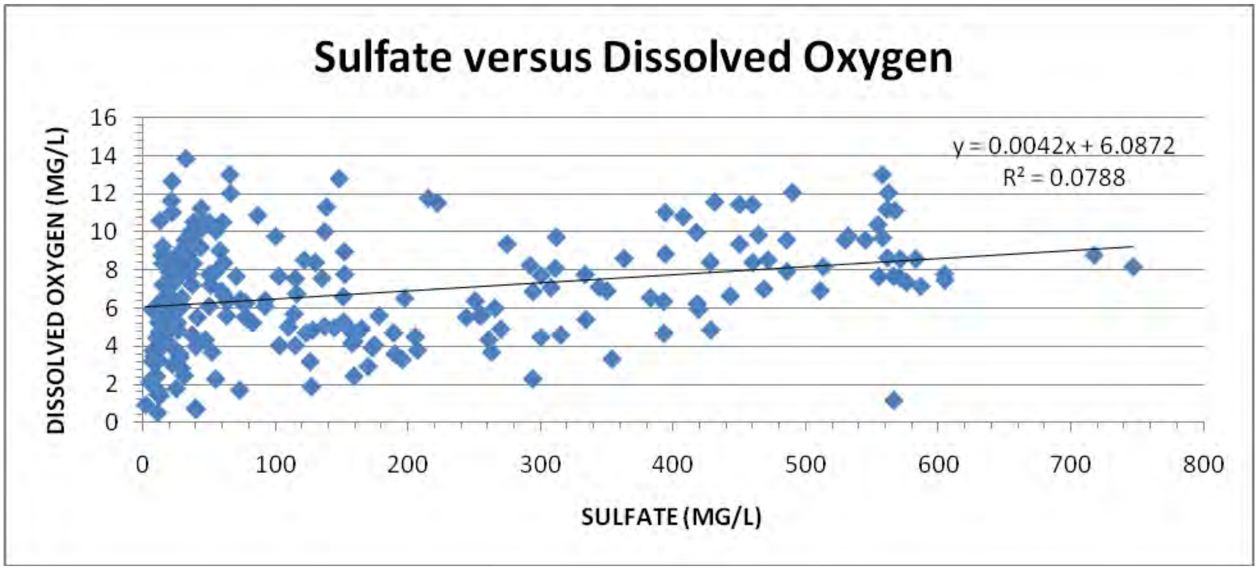

The Sixteen Mile Creek WBID covers an area of about 17,400 acres as described in the TMDL. Approximately 80% of the WBID is under the control of other entities, including Flagler County, the Flagler Estates Road and Water Control District, and the Hastings Drainage District. Both districts are Chapter 298 jurisdictions. We request that this be acknowledged in the TMDL.

Department Response:
The document will be revised to acknowledge the two 298 districts. We have asked Mr. Mike Kelter, representing the Flagler Estates Road and Water Control District, for a figure that illustrates the jurisdictional boundaries of the 298 districts. If the county can provide additional information regarding jurisdictional boundaries of the county and the 298 districts in this area we would appreciate it.

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The runoff coefficients and EMCs used to the calculate the loads for Sixteen Mile Creek were based on Gao (2006) and Harper and Baker (2007), which vary significantly from those used in the Pollution Load Screening Model applied to calculate loads for the LSJR. Consistency between the main stem and its tributaries would seem preferable to achieve fair allocations.

Department Response:
The load/concentration estimates described in Chapter 4 were provided to indicate the relative importance of various sources of nutrients in the watershed and represented potential loads. Estimates were based on a long-term average rainfall, EMCs based on land use activities, and runoff coefficients based upon soil types and land use activity. The TMDL reductions were not based on model estimated loads and/or concentrations. As discussed in Chapter 5, the assimilative capacity was based upon relationships developed between water quality measurements taken in the Sixteen Mile Creek WBID. In the mainstem nutrient TMDL, the Pollution Load Screening Model was used to provide daily watershed loads to the St. Johns River. Seasonal coefficients were used for various land use and soil type combinations and water quality coefficients were derived from a multiple regression analysis of monitored watersheds. As pointed out in Appendix M of the Lower St. Johns Nutrient TMDL document, in-stream processes such as sedimentation, denitrification, and assimilation reduce nutrient loads from the watershed, which are then delivered to the St. Johns River.

DISSOLVED OXYGEN AND NUTRIENT TMDLS FOR MILL CREEK, WBID 2460

It is not clear how the waterbody is exceeding the nutrient criterion expressed in Rule 62-302, FAC. The seasonal means for chlorophyll-a provided in Table 5.6 do not exceed the annual average threshold of 20 ug/L.

Department Response:
In Cycle 1, Mill Creek was verified for a nutrient impairment based on an annual average chlorophyll concentration greater than 20 υg/L in 2002 and nitrogen was identified as the limiting nutrient. Subsequently, an error in the MDL units for a reported observation was identified which resulted in a recalculated annual average below 20 μg/L. Dissolved oxygen (DO) was also verified impaired based upon the number of exceedances of the Class III criterion. In cycle 2, DO was still impaired based on the number of exceedances and TN was identified as the causative pollutant. Since elevated TN was associated with the DO impairment, nutrients were still considered impaired.

As with the Sixteen Mile Creek Draft TMDL, the importance of dissolved oxygen's relationship with sulfate seems to be ignored in the analysis of impairment cause. Is it assumed that the sulfate reduction that could be occurring within these streams is included in the BOD component of the TMDL?

Department Response:
As noted in the response to a similar question raised in the Sixteen Mile Creek TMDL, under anaerobic conditions, sulfate is reduced to sulfide by sulfate-reducing bacteria and in aerobic conditions sulfide is oxidized to sulfate by sulfur bacteria. Observed dissolved oxygen concentration in Mill Creek ranged between 2.40 and 8.50 mg/L. Sulfate observations ranged between 8 and 196 mg/L (25^{th} percentile 28.5 mg/L and 75^{th} percentile 57.5 mg/L). The following graphs illustrate the time series of sulfate, the relationship between sulfate and DO, and the relationship between sulfate and BOD. Based upon the available information, it does not appear that sulfate reduction is a significant process in Sixteen Mile Creek or that it explains the DO impairment.

H.P. Tompkins, Jr , County Engineer
St. Johns County Board of County Commissioners
August 6, 2009
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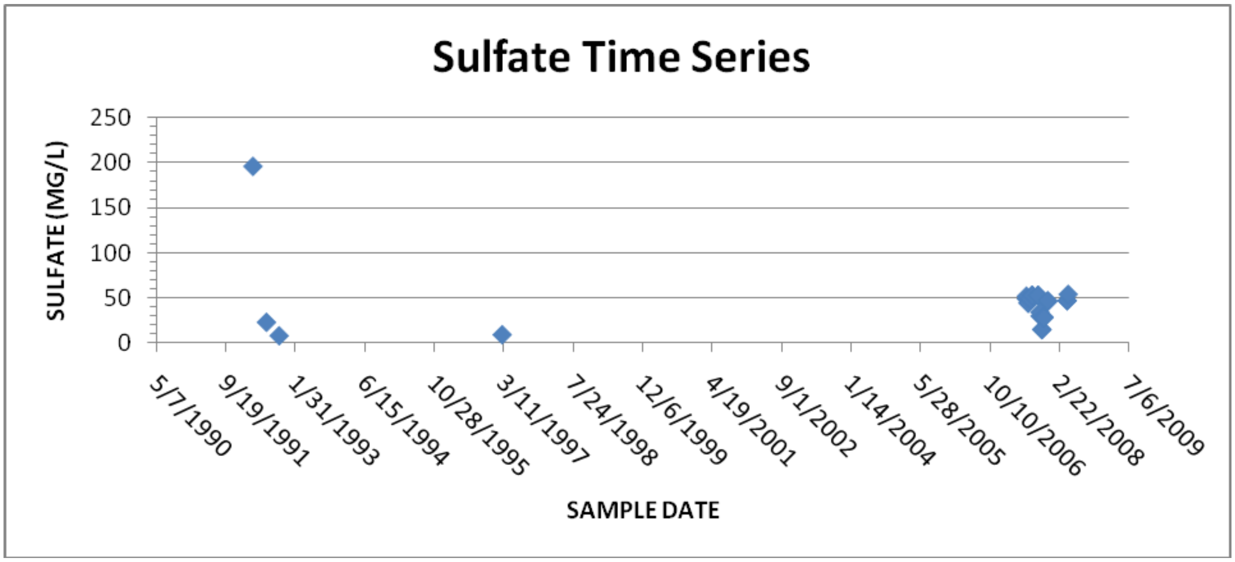

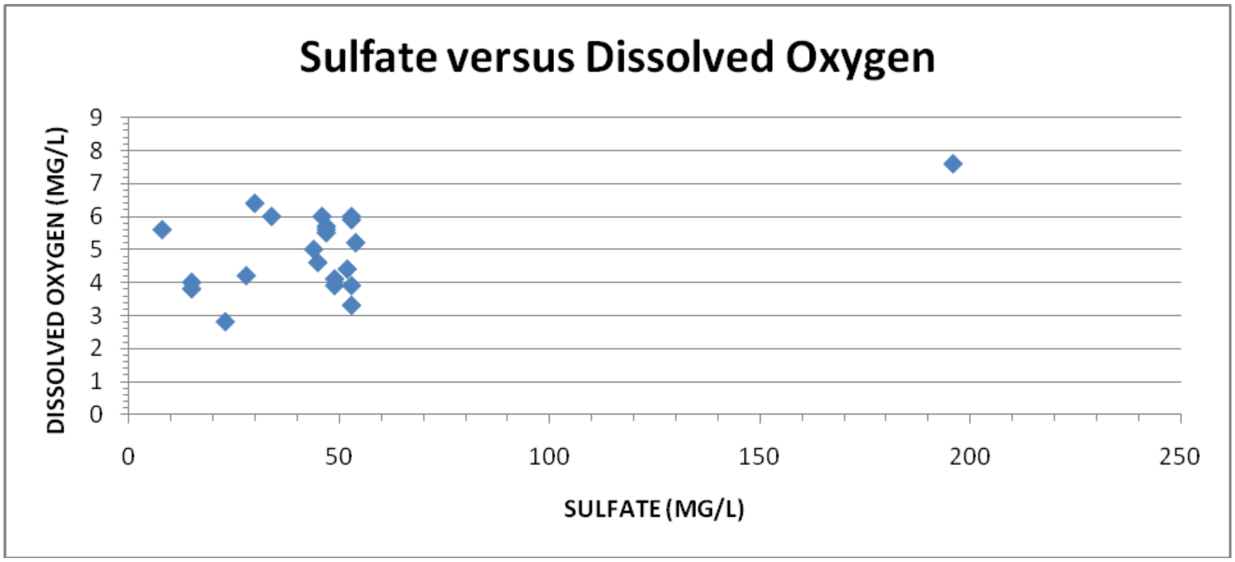

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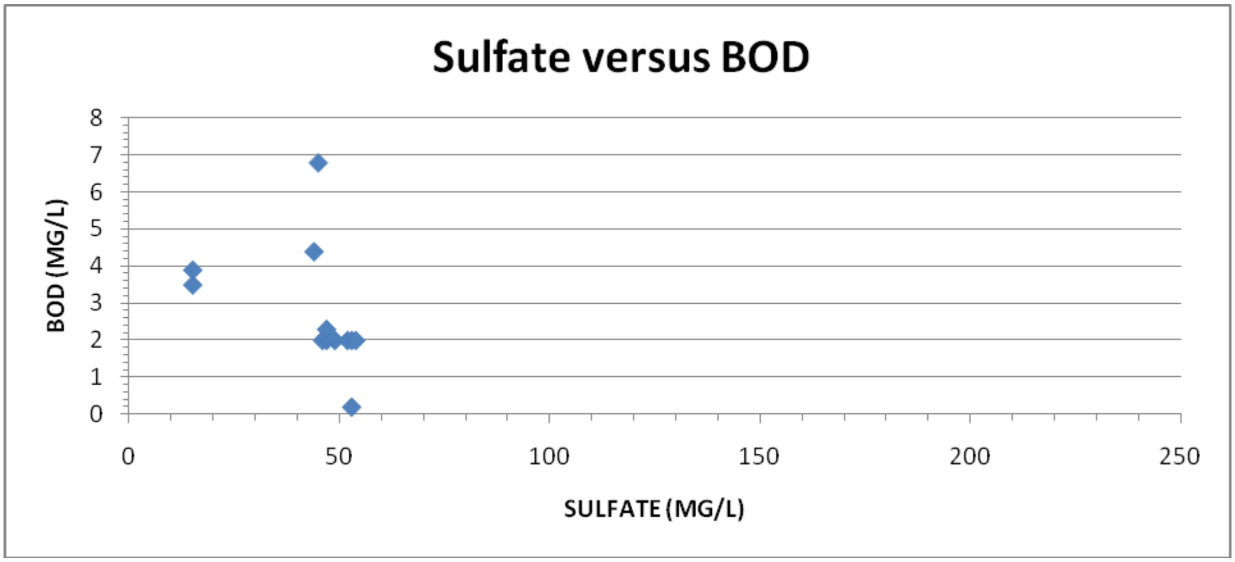

The 2004 SJRWMD land use data used to calculate the potential nitrogen and phosphorus loadings requires updates in several areas based on 2008 aerial photography. Most notably, there is an approximately 600-acre area south of SR 16 which is predominantly residential, but which is classified as agriculture in Figure 4.1 of the draft TMDL.

Department Response:
The Department will contact the SJRWMD regarding updates to the 2004 land use data. It would also be informative if the County had any information regarding this residential area and whether this area should have been classified as residential prior to 2004 or has been a conversion from agricultural since 2004.

As with the Sixteen Mile Creek Draft TMDL, the runoff coefficients and EMCs used to calculate the loads for Mill Creek were based on Gao (2006) and Harper and Baker (2007), which vary significantly from those used in the Pollution Load Screening Model applied to calculate loads for the LSJR. Consistency between the main stem and its tributaries would seem preferable to achieve fair allocation.

Department Response:
The load/concentration estimates described in Chapter 4 were provided to indicate the relative importance of various sources of nutrients in the watershed and represented potential loads. Estimates were based on a long-term average rainfall, EMCs based on land use activities, and runoff coefficients based upon soil types and land use activity. The TMDL reductions were not based on model-estimated loads and/or concentrations. As discussed in Chapter 5, the assimilative capacity was based upon relationships developed between water quality measurements taken in the Mill Creek WBID. In the mainstem nutrient TMDL, the Pollution Load Screening Model was used to provide daily watershed loads to the St. Johns River. Seasonal coefficients were used for various land use and soil type combinations and water quality coefficients were derived from a multiple regression analysis of monitored watersheds. As pointed out in Appendix M of the Lower St. Johns Nutrient TMDL document, in-stream processes such as sedimentation, denitrification, and assimilation reduce nutrient loads from the watershed that are delivered to the St. Johns River.

H.P. Tompkins, Jr , County Engineer
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FECAL COLIFORM TMDL FOR MILL CREEK, WBID 2460

The TMDL discusses the potential sources of fecal coliform. Another recognized source of fecal coliform in Florida is the re-production of fecal coliform in the environment. In these cases, fecal coliform released from its host organism finds conducive environmental conditions (cool temperatures, food sources, and shelter from predation) to reproduce outside a host organism. We request that this potential source be added to the discussion in Section 4 of the draft TMDL.

Department Response:
Based on your suggestion, we added text in Chapter 4, as shown below:
In addition, some studies show that fecal coliform can reproduce in the sediments and be re-suspended to surface water when conditions are right. Current methodology cannot quantify fecal coliform coming from each source. Therefore, we were unable to estimate fecal coliform loading from the sediments in this chapter.

It is not clear how the percent reductions were calculated in Table 5.1. The column labeled "fecal coliform exceedances" appears to represent daily values. In this case the water quality criterion for the daily maximum limit of 800 counts per 100 m1 is more appropriate. If the criterion for no more than 400 counts per 100 ml in ten percent of the samples is applicable, then the values in the "fecal coliform exceedances" should be represented by a statistical value rather than a daily result?

Department Response:
The state's water quality criterion for fecal coliform has three components. As described in Chapter 2 of the draft report, we determined that the language allowing a 10 percent exceedance rate over 400 counts/100mL is more consistent with the assessments being made using the Impaired Waters Rule methodology (Chapter 62-303, Florida Administrative Code). Please note, if we used 800 counts/100mL for the TMDL calculation instead of 400 counts/100mL, then the TMDL would be a 64 percent reduction instead of a 72 percent reduction. When we evaluate fecal coliform impairment we use the criterion "no more than 400 counts per 100 ml in ten percent of the samples," but when we calculate the TMDL, we use any exceedances without consideration of 10 percent, which gives a margin of safety. The reductions are based on using the median of all the exceedances, which allows for a long-term smoothing of the data. However, based on recent litigation results from the federal courts, in addition to the expression of the TMDL in any other meaningful way (e.g., not to exceed 400 counts/100mL by more than10 percent for all the data), all TMDLs must also be expressed as being "daily."

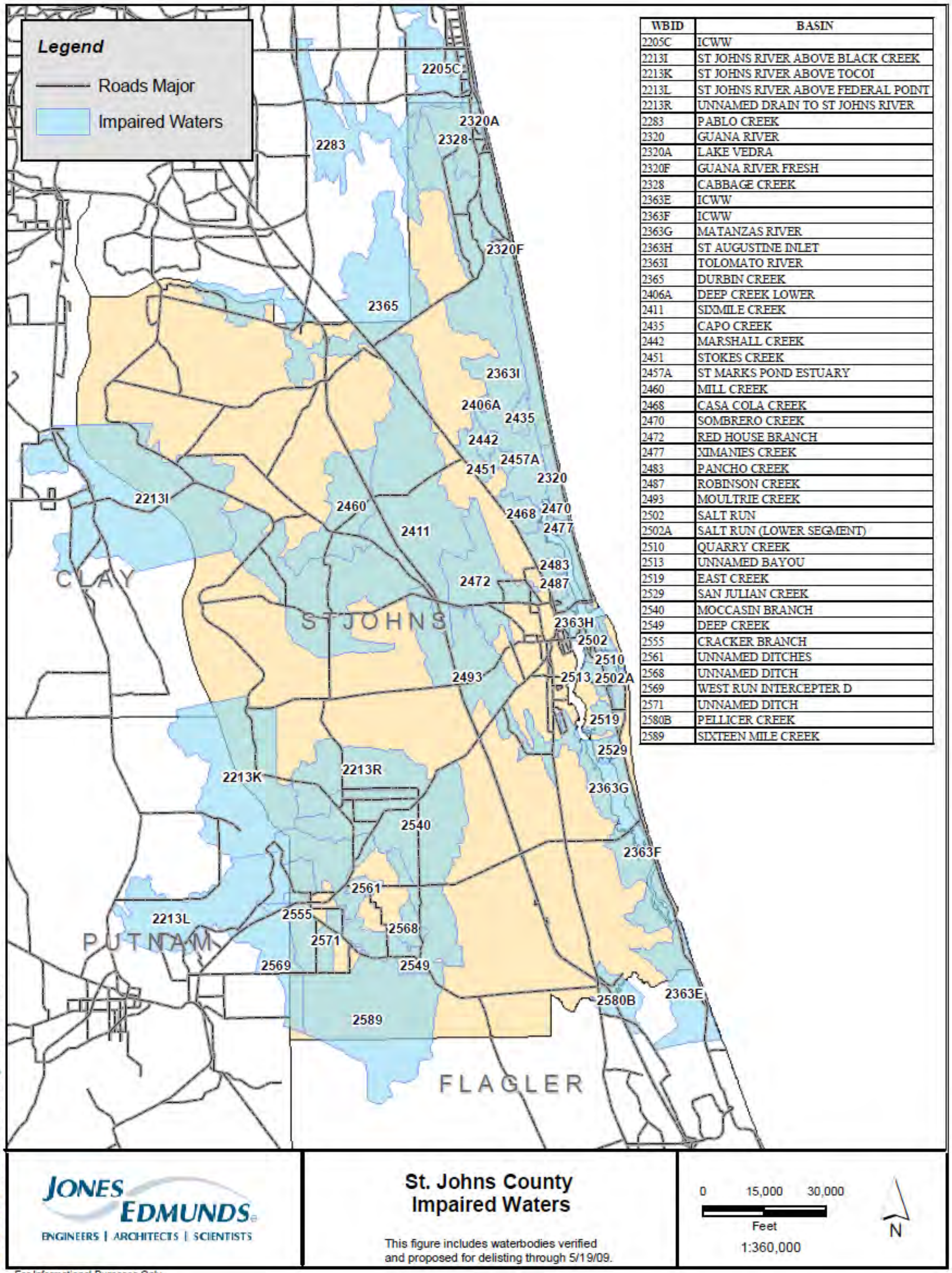
If you have any questions regarding these comments, please contact Dr. Wayne Magley (850/245-8463) for dissolved oxygen and nutrient issues, or Dr. Kyeongsik Rhew at (850/245-8461) for questions relating to fecal coliform.

Finally, as discussed previously, we do not have the discretion to extend the period for proposing these TMDL rules due to the time constraints imposed by the court-ordered Consent Decree.

Sincerely,

Jan Mandrup-Poulsen, Administrator
Watershed Evaluation and TMDL Section

ec: Jeff Martin



WBID	BASIN
2205C	ICWW
2213I	ST JOHNS RIVER ABOVE BLACK CREEK
2213K	ST JOHNS RIVER ABOVE TOCOI
2213L	ST JOHNS RIVER ABOVE FEDERAL POINT
2213R	UNNAMED DRAIN TO ST JOHNS RIVER
2283	PABLO CREEK
2320	GUANA RIVER
2320A	LAKE VEDRA
2320F	GUANA RIVER FRESH
2328	CABBAGE CREEK
2363E	ICWW
2363F	ICWW
2363G	MATANZAS RIVER
2363H	ST AUGUSTINE INLET
2363I	TOLOMATO RIVER
2365	DURBIN CREEK
2406A	DEEP CREEK LOWER
2411	SIXMILE CREEK
2435	CAPO CREEK
2442	MARSHALL CREEK
2451	STOKES CREEK
2457A	ST MARKS POND ESTUARY
2460	MILL CREEK
2468	CASA COLA CREEK
2470	SOMBRERO CREEK
2472	RED HOUSE BRANCH
2477	XIMANIES CREEK
2483	PANCHO CREEK
2487	ROBINSON CREEK
2493	MOULTRIE CREEK
2502	SALT RUN
2502A	SALT RUN (LOWER SEGMENT)
2510	QUARRY CREEK
2513	UNNAMED BAYOU
2519	EAST CREEK
2529	SAN JULIAN CREEK
2540	MOCCASIN BRANCH
2549	DEEP CREEK
2555	CRACKER BRANCH
2561	UNNAMED DITCHES
2568	UNNAMED DITCH
2569	WEST RUN INTERCEPTER D
2571	UNNAMED DITCH
2580B	PELLICER CREEK
2589	SIXTEEN MILE CREEK

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For Informational Purposes Only

August 10, 2009

Mr. Joshua Boan
Environmental Process/Natural Sciences Manager
Environmental Research Administrator
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Email: joshua.boan@dot.state.fl.us

Re: FDOT Comments on Newly Released Draft TMDLs

Dear Mr. Boan,

The Department appreciates the time and effort you and your staff put into reviewing these draft TMDLs. We have made necessary edits to some draft TMDL reports as a result of your comments. Because of your efforts, the final TMDL will be improved. To aid you in reviewing our responses, we have included your comments, followed by a response to each (in blue), in the order in which they were presented. Please contact me at Jan.Mandrup-Poulsen@dep.state.fl.us. if you have any further questions.

Sincerely

Jan Mandrup-Poulsen, Administrator
Watershed Evaluation and TMDL Section
Florida Department of Environmental Protection

DISTRICT 2 COMMENTS

GENERAL COMMENTS

The following comments relate to multiple TMDLs where specific comments are provided below for each of the TMDL documents.

1. It appears that the nutrient load assessments for the transportation category (Chapter 4) are based upon values presented in Harper (2007) (i.e., 1.64 mg/l TN and 0.22 mg/l TP). Harper's numbers are determined by averaging the average results from eleven different datasets from studies conducted between 1975 and 2005. Each study was given equal weight in the averaging procedure regardless of the number of events sampled and the methodologies used. Between December 2004 and October 2007 roadway runoff water quality data were collected by Johnson Engineering for FDOT District 1 at four locations within District 1. Ten events were sampled for each of the four locations, with samples collected at both the inflows and outflows of existing stormwater treatment ponds. All collection, transfer, and handling procedures were conducted in accordance with FDEP Standard Operating Procedures, and samples were analyzed by certified labs. Average values for TN and TP ***at the pond inflows*** were determined to be 1.17 mg/l and 0.158 mg/l, respectively. [It is perhaps noteworthy to observe that the highest average TN and TP values were measured at the first site sampled (i.e., samples collected between December 2004 and November 2005) which is also the site with the lowest percentage of impervious area.] Given the changes to roadway management practices that FDOT has undertaken over the past several years and the rigorous quality control used in these studies compared with the older studies, we believe that the numbers presented by Johnson Engineering are more representative than Harper's numbers of present day TN and TP loading conditions. [This comment applies to all nutrient and DO TMDL documents reviewed. This included WBIDs 2410, 2389, 2203, 2213P,2265A, 2460, 2589, 2578.]

   Department Response: A copy of the Johnson Engineering Study report was not included with the comments we received. If FDOT could provide the report to Mr. Eric Livingston (Bureau Chief for the Bureau of Watershed Restoration) it will be reviewed for incorporation into the stormwater database and use in estimation of transportation event mean concentrations (EMCs).

1. The load reductions determined for the non-point sources, which include the WLA for the stormwater (under the MS4 permit) and the LA, have not been allocated but simply applied evenly between the WLA for Stormwater and the LA. Sufficient studies have not been completed to determine if an even distribution of the load reductions is justified, therefore some language acknowledging this (within the TMDL and ultimately within the Rule) should be put into both the TMDL documents and ultimately the rules to allow the ability to finalize (and therefore change the assigned reductions) under the BMAP. [This comment applies to all TMDLs reviewed in which there was an WLA-MS4 allocation specified.]

   Department Response: In 2001, the Department submitted to the Governor and Legislature a document outlining the intended process for the allocation of loads under the TMDL Program. One key provision of the proposal was to level the "playing field," such that once stakeholders had the opportunity to meet and discuss what steps needed to be taken and to get appropriate credit for those initiatives already completed, the specific allocations will be set by the agreements reached under the Basin Management Action Plan (BMAP). This process has been successfully used in several adopted BMAPs and has demonstrated the flexibility that remains after setting the initial reductions for stormwater-related allocations (LA and WLA_{sw}) at identical levels.

The laws of Florida form the underlying basis for the initial equal allocations. In particular, Section 403.067(6)(b) of Florida Statutes, states in part that:

"Allocations may also be made to individual basins and sources or as a whole to all basins and sources or categories of sources of inflow to the water body or water body segments. An initial allocation of allowable pollutant loads among point and nonpoint sources may be developed as part of the total maximum daily load. However, in such cases, the detailed allocation to specific point sources and specific categories of nonpoint sources shall be established in the basin management action plan…"

Additionally, each of the draft TMDL reports contains language in the NPDES Stormwater Discharges section in chapter 6 of the reports (repeated below) to address the issue of allocation between the WLA for stormwater and the LA portions of the TMDL.

"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."

Appendix L: Evaluation of NW WWTF Apricot Discharge in Mill Creek

October 19, 2010

Mr. Wayne Magley, Ph.D., P.E.
Florida Department of Environmental Protection
Environmental Manager, Watershed Assessment Section
2600 Blair Stone Road
Room 238, MS #3555
Tallahassee, FL 32399-2400

Subject: St. Johns County Utility Department
Northwest Wastewater Treatment Plant Backup Discharge in Mill Creek

Dear Dr. Magley:

Introduction and Background

The St. Johns County (County) Northwest (NW) service area is projected to experience growth over the next several years. The St. Johns County Utility Department (SJCUD) plans to construct a new regional wastewater treatment plant to provide for the wastewater treatment needs of this service area. The new wastewater treatment plant, referred to as the Northwest Wastewater Treatment Plant (NW WWTP), will be located off the proposed County Road CR 2209 just north of International Golf Parkway. **Figure 1** shows the project location.

The NW WWTP will provide advanced wastewater treatment (AWT, TSS: 5 mg/L, $CBOD_5$: 5 mg/L, TN: 3 mg/L, and TP: 1 mg/L annual average) and will provide reclaimed water to multiple reuse customers in the area. The proposed NW WWTP will be permitted as a water reclamation facility under the Florida Department of Environmental Protection's (FDEP) F.A.C. Chapter 62:610 Part III – Slow-rate Land Application Systems; Public Access Areas, Residential Irrigation, and Edible Crops. SJCUD has currently identified 4.72 million gallons per day (mgd) of committed reuse customer demand.

The facility will also require a backup discharge point for periods of reduced reclaimed water demand. The backup discharge will be issued under the Florida APRICOT Act, contained in Section 403.086(7), F.S. The proposed discharge location is proposed to be to the St. Johns River via the Mill Creek Subbasin (tributary of the Six Mile Creek Basin), which in turn is tributary to the St. Johns River.

Figure 1
Northwest WWTP
Site Location Map

The purpose of this letter is to demonstrate that the proposed discharge from the NW WWTP under the APRICOT Act requirements does not cause or contribute to dissolved oxygen (DO) concentration below the DO violations in the Mill Creek subbasin. This memorandum includes the following information:

- Project background including NW WWTP flows and effluent wastewater quality
- Available water quality data in Mill Creek
- Expected flows in Mill Creek
- Demonstration that the discharge would not cause or contribute to Mill Creek DO violations
- Review of nutrient travel time

Project Background

NW WWTP Design Flows and Effluent Water Quality

The NW WWTP will provide advanced wastewater treatment (AWT) with high level disinfection and produce the following annual average wastewater quality TSS:BOD_5:TN:TP of 5:5:3:1 mg/L, respectively. The NW WWTP will be designed to ensure that the effluent discharged to the surface waters contains a minimum DO concentration of 5.0 mg/L. **Table 1** presents the expected NW WWTP effluent water quality. The NW WWTP will have an off-spec pond to retain effluent that does not meet the targeted wastewater quality for re-treatment at the plant.

Table 1 Summary of Anticipated NW WWTP Effluent Water Quality

Parameter	Unit	Value
BOD_5	mg/L	5
DO	mg/L	5
TSS	mg/L	5
TN	mg/L	3
TP	mg/L	1
Temp	°C	18-25

To meet the expected growth projections for the NW service area, the first phase of the proposed plant will have a design capacity of 3-mgd annual average day flow (AADF). Prior to reaching the full capacity of Phase 1, an additional 3 mgd of capacity will be added under Phase 2, bringing the total plant capacity to 6 mgd, AADF. Backup discharge for the final built-out capacity for the NW WWTP will be 12 mgd. This memorandum only evaluates Phase 1 and Phase 2. Final built-out capacity will be evaluated at a future date when the expansion is required. The NW WWTP design flows in mgd and cubic feet per second (cfs) are summarized in **Table 2**.

Table 2 Design Flows from NW WWTP (AADF)

Phase	Flow (mgd)	Flow (cfs)
Initial	1.0	1.5
Phase 1	3.0	4.6
Phase 2	6.0	9.3
Built Out	12.0	18.6

Existing TMDLs Allocations for the NW WWTP in Downstream Basins

The proposed discharge location for the NW WWTP will be to Mill Creek, a tributary of Six Mile Creek and the Lower St. Johns River. Both the Six Mile Creek and the Lower St. Johns River have implemented a total maximum daily load (TMDL) with an allocation for the NW WWTP discharge.

The Lower St. Johns River basin has implemented TMDLs for nutrients. In the development of the "Basin Management Action Plan for the Implementation of Total Daily Maximum Loads for Nutrients Adopted by the Florida Department of Environmental Protection for the Lower St. Johns River Basin Main Stem," nitrogen and phosphorus loads were allocated for the new or expanding domestic advanced wastewater treatment plants that would discharge to a surface water under the provision of the APRICOT Act. The NW WWTP was included in this allocation.

The TMDL allocation for the NW WWTP discharge under the APRICOT Act is presented in **Table 3**. The BMAP is regularly revised to re-allocate loads to address changing service needs.

Table 3 NW WWTP TMDL Load Allocation for Lower St. Johns River

Constituent	TMDL Load Allocated in BMAP for Lower St. Johns River Basin, October 2008 (lb/yr)
Total Phosphorus	3,799
Total Nitrogen	12,943

The Six Mile Creek basin has implemented a TMDL for DO. In the development of the TMDL document by the United State Environmental Protection Agency (EPA) titled "Proposed Total Maximum Daily Loads for the Six Mile Creek WBID 2411 Dissolved Oxygen August 2010," nitrogen, phosphorus, and BOD concentrations were allocated for the NW WWTP wastewater treatment plants to discharge up to an average annual daily flow of 6 mgd under the provision of the APRICOT Act. The TMDL allocation for the NW WWTP discharge under the APRICOT Act is presented in **Table 4**.

Table 4 NW WWTP TMDL Load Allocation for Six Mile Creek

Constituent	TMDL Allocated for Six Mile Creek August 2010 (mg/L) (6 mgd Discharge)
Total Phosphorus	1
Total Nitrogen	3
BOD	10

Mill Creek Water Quality Background Data

FDEP has proposed a TMDL for DO for the Mill Creek basin. The water quality parameters of concern that need to be evaluated to determine the effects of the NW WWTP APRICOT discharge on Mill Creek are BOD_5 and DO.

Water quality and other available data were downloaded from the EPA STORET database. The modern STORET database contains the surface water quality information collected from 2000 to present by the following regulatory agencies: Division of Environmental Health, Bureau of Water Programs, FDEP, FFWC, and Florida Lakewatch. Three stations (2132, 2041, and 21430) were located near the crossing of Mill Creek and State Road 16 (approximately 4,000 ft downstream of proposed outfall location). The data points from these three stations range from March 20, 2002 to May 5, 2008 with no data points between the time period from October 2004 to May 2007. The summary of water quality data from these three sample points is provided in **Table 5.**

Table 5 Mill Creek Background Water Quality Data from STORET

Parameter	Units	Minimum	Maximum	Average	No. of Data Points
BOD_5	mg/L	0.7	6.8	2.6	16
DO	mg/L	2.4	8.5	5.2	36
TSS	mg/L	5	151	28	20
TN	mg/L	0.4	3.0	1.5	31

Table 5 Mill Creek Background Water Quality Data from STORET

Parameter	Units	Minimum	Maximum	Average	No. of Data Points
pH	-	6.6	7.6	7.0	36
Temp	°C	11	29	23	36

Data in the table were used to characterize the background water quality in Mill Creek at the location of the proposed discharge. In spreadsheet modeling of DO and BOD_5 downstream of the proposed discharge, these values were used for both low flow and average flow conditions. Review of the data, presented graphically in **Figures 2 and 3**, did not show a significant difference in average DO or BOD concentrations based strictly on water depth (which was used as a surrogate for flow, as flow data were not available). Most of the flow alternatives evaluated had a water depth of 0.5 to 1.0 feet.

Expected Flows in Mill Creek

This section provides background information for the Mill Creek Subbasin, as well as explains the methodology to establish Mill Creek flows. These flows were used to analyze the effect of the NW WWTP outfall on stream water quality.

Description of Basin, Subbasin, and Proposed Outfall Location

The Mill Creek Subbasin (WBID 2460) lies entirely in St. Johns County, Florida. The subbasin encompasses 7,424 acres and is composed largely of naturally vegetated areas, as well as agricultural, residential, and commercial land uses. The subbasin is a tributary to the Six Mile Creek (WBID 2411), the primary stream in the Six Mile Creek Basin (HUC 03080103). The Six Mile Creek Basin discharges into the Lower St. Johns River. The confluence of the Mill Creek Subbasin with Six Mile Creek Basin occurs to the southwest of the intersection of International Golf Parkway and State Road 16, and the confluence of the Six Mile Creek with the St. Johns River occurs southwest of the intersection of State Road 16 with State Road 13.

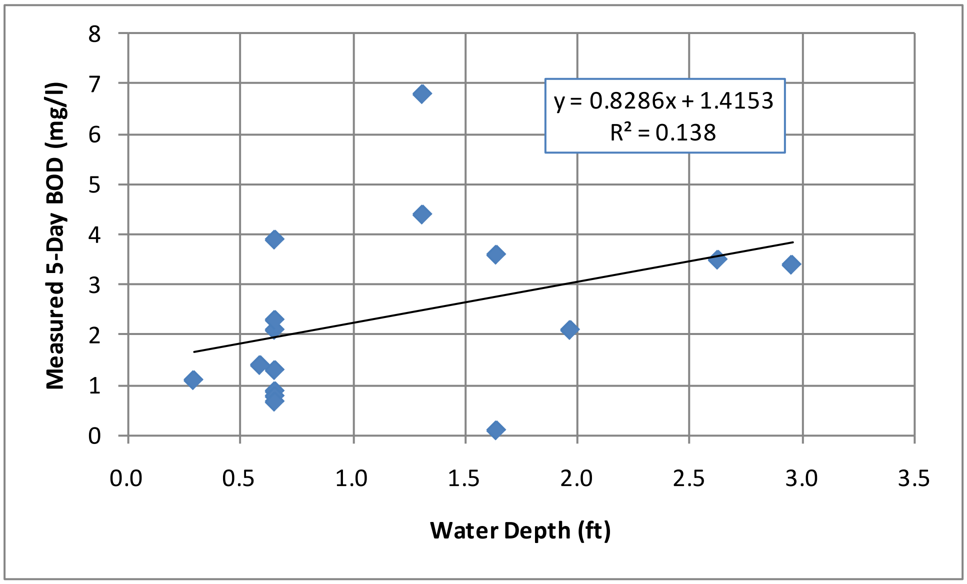

Figure 2 Relationship between Water Depth and BOD_5 Concentration in Mill Creek

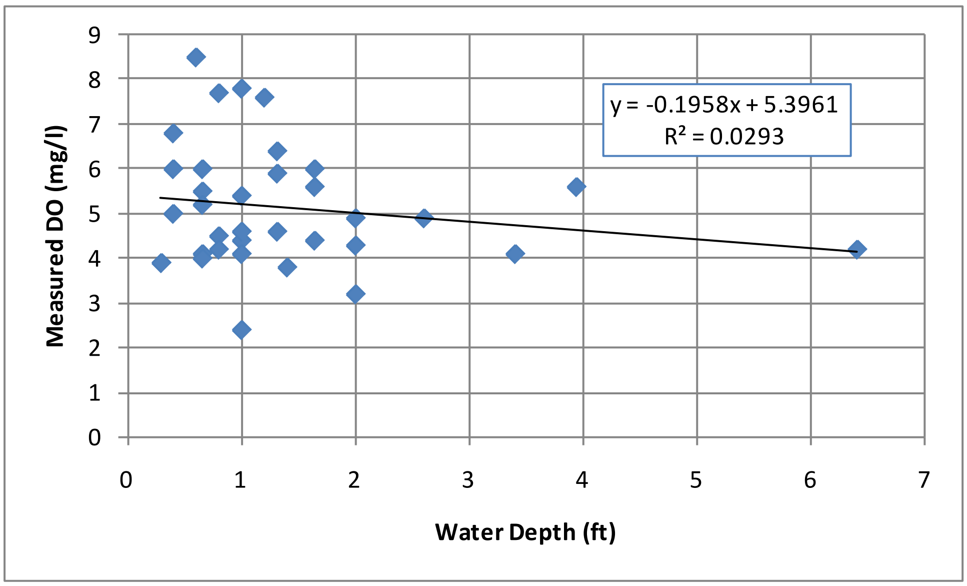

Figure 3 Relationship between Water Depth and DO Concentration in Mill Creek

The proposed outfall is located at the intersection of the future CR 2209 and Mill Creek, approximately 3 miles upstream of the confluence with Six Mile Creek. The estimated portion of Mill Creek upstream of proposed outfall location 2 is 4,222 acres, representing 57 percent of the subbasin. This information was used to pro-rate the Mill Creek flow at the proposed outfall location and is summarized in **Table 6**.

Table 6 Subbasins Pro-Rated to Proposed Outfall Location

	Total Area (acres)	% of Mill Creek Subbasin
Entire Six Mile Creek Subbasin	7,424	-
Proposed Outfall Location	4,222	57%

Methodology to Establish Mill Creek Flows

Due to limited existing data, modeled data represented the most feasible option for establishing flow conditions for Mill Creek. The Hydrological Simulation Program – FORTRAN (HSPF) for the Six Mile Creek Basin was provided by the St. Johns River Water Management District (SJRWMD) to Camp Dresser & McKee Inc. (CDM) for a study for the Tri-County Agricultural Area (TCAA). The model represents the entire Six Mile Creek Basin, but this analysis for the NW WWTP used the sub-model for the Mill Creek Subbasin.

Rain data were acquired from the Jacksonville International Airport, the St. Augustine Lighthouse, and the St. Augustine Airport. The rain gages located in St. Augustine are located in closer proximity to the NW WWTP and associated proposed outfall locations; however, consistent hourly data were not available for these two locations. The rainfall data available for the Jacksonville International Airport represent a 50-year period of hourly rainfall data, ranging from 1955 through 2004. A comparison was made between the annual average rainfall for the two St. Augustine locations to verify similar hydrology between the Jacksonville International Airport and the rainfall data in St. Augustine.

The St. Augustine Airport data were available for the time period between 1980 through 2004 with data missing for the years of 1994, 1995, 1996, and 2000. Additionally, the accuracy of the data was questionable, with the years between 1994 and 2004 indicating between 100 to 4000 inches per year of precipitation. Therefore, the annual rainfalls were compared for the time period between 1980 and 1993 to the Jacksonville International Airport rainfall data. The maximum and minimum range of annual rainfall was within a 1-3 percent difference between the 2 locations and the average annual rainfall for the periods reviewed was within a 10 percent difference.

The St. Augustine Lighthouse data were available for the time period between 1974 through 2004 with data missing for the years of 1976, 1978, 1986, 1987, and 1991. The available data were compared to the Jacksonville International Airport rainfall data. The maximum and minimum range of annual rainfall was within a 1 percent difference between the two locations and the average annual rainfall for the periods reviewed was within a 3 percent difference.

The Jacksonville International Airport data were continuously available with hourly data for a longer duration of time to provide better use in the hydrological simulation program. Neither of the closer locations had continuous data that were useful for the model and none of the locations with rainfall data were located in the basin of Mill Creek. Therefore, the Jacksonville International Airport rainfall data were used for this study.

Verification of Model

Daily flows from the Mill Creek Subbasin were generated by the HSPF model for the 50 years of rain data from the Jacksonville International Airport rain gage. The model output was reviewed to determine the maximum daily flow for each year in the 50-year simulation. These peak flow values were then analyzed using the Log Pearson Type III method to evaluate 10-year, 50-year, and 100-year return period flood flow conditions for the Mill Creek Subbasin, physically represented at the confluence of Mill Creek with Six Mile Creek. The values for these flood events from the HSPF model were compared to flood flow conditions for the Mill Creek Subbasin provided in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for St. Johns County, Florida (revised September 2, 2004). The FEMA FIS model was used as a basis for culvert improvements along Mill Creek, including the proposed culvert improvements at SR 16 (Bridge Hydraulic Report: State Road 16 at Mill Creek, St. Johns County, Florida; prepared for the Florida Department of Transportation by Kimley-Horn and Associates; April 2008). **Table 7** presents a comparison of the two models for the return-event flows at the confluence of Six Mile Creek and Mill Creek. The low percent differences verify the SJRWMD HSPF model and validate its use to estimate Mill Creek flows for this study.

Table 7 Comparison of Modeled Flood Events for Verification of HSPF Model

	10-year (cfs)	50-year (cfs)	100-year (cfs)
FIS FEMA	1,462	2,102	2,362
SJRWMD HSPF	1,666	2,282	2,515
Percent Difference	12%	8%	6%

Modeled Historic Mill Creek Flows

The historical Mill Creek flows, as modeled by the SJRWMD HSPF, were analyzed to establish an average flow for the entire 50-year data set, regardless of precipitation levels. In accordance with the flow conditions established above, low flow, average flow, and flood flow (10-, 50-, and 100-year) conditions for the entire Mill Creek Subbasin are presented in **Table 8**. The flows for the total Mill Creek Subbasin at the confluence with Six Mile Creek are pro-rated appropriately to the proposed outfall location.

Table 8 Modeled Historic Conditions for Mill Creek Flow

	Low (cfs)	Average (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)
At confluence with Six Mile Creek	4.0	20.8	1,666	2,282	2,515
At NW WWTP Outfall	2.3	11.8	950	1,301	1,434

It should be noted that the combination of the low flow condition in Mill Creek and the reduction in reclaimed water demand resulting in a discharge to Mill Creek from NW WWTP represents a rare scenario. The low flow condition represents the 10^{th} percentile value for flows on days with a threshold rainfall of 0.05 inch or greater.

Evaluation of NW WWTP Discharge Impacts on Mill Creek Water Quality

To demonstrate "no cause or contribute" relationship between the DO in Mill Creek and the NW WWTP APRICOT discharge, the water quality parameters of concern identified previously were evaluated to compare the effect of the NW WWTP effluent on the water quality of the receiving water bodies. The demonstration included BOD sag calculations and dilution calculations of the Mill Creek water quality to the NW WWTP effluent water quality at the flow combinations discharging to Mill Creek. The dilution calculations will be shown for the initial flow of 1.0 mgd, Phase 1 flow of 3.0 mgd, and Phase 2 flow of 6.0 mgd. For all levels of NW WWTP flow, the dilution calculation will be conducted for the average flow, 10-year, 50-year, and 100-year stream flows at the NW WWTP outfall location. The in-stream changes and travel time in Mill Creek for total nitrogen (TN) and total phosphorus (TP) was also reviewed.

Biological Oxygen Demand and Dissolved Oxygen

The Mill Creek average background level for Biochemical Oxygen Demand (BOD_5) is generally lower than the permitted NW WWTP effluent limit for BOD_5. The average BOD_5 anticipated to be discharged in the wastewater effluent stream is 5 mg/L. The sample values obtained from the available data in Mill Creek indicate a background level of BOD_5 at 0.7 mg/L, an average of 2.6 mg/L with a minimum of 0.7 mg/L and a maximum of 6.8 mg/L. The expected resulting ambient water concentration of BOD_5 at the immediate mixing point assuming no reaction time for the anticipated flow combinations are presented in **Table 9**.

Table 9 Proposed Outfall Location BOD Dilution Results at Average, 10-Year, 50-Year, and 100-Year Stream Flows

BOD_5 Combined Stream Concentration				Mill Creek Modeled Historical Flows for Proposed Outfall (BOD_5=2.6 mg/L)*			
				Average	10-Year	50-Year	100-Year
(cfs)		(cfs)	(mgd)	12	950	1,301	1,434
(mgd)				8	614	841	927
WWTP Flow (BOD_5=5 mg/L)	Initial	1.5	1.0	2.9	2.6	2.6	2.6
	Phase 1	4.6	3.0	3.3	2.6	2.6	2.6
	Phase 2	9.3	6.0	3.7	2.6	2.6	2.6

**Mill Creek BOD_5 WQ Data Range: Min=0.7 mg/L, Avg = 2.6 mg/L, Max=6.8 mg/L*

The Mill Creek average background level for DO is generally slightly higher than the permitted NW WWTP effluent DO concentration. The minimum DO concentration discharged in the wastewater effluent stream will be designed to be 5 mg/L. The sample values obtained from the available data in Mill Creek indicate a background level of DO, an average of 5.2 mg/L with a minimum of 2.4 mg/L and a maximum of 8.5 mg/L. The expected resulting concentration of DO at the immediate mixing point for the anticipated flow combinations are presented in **Table 10**.

Table 10 Proposed Outfall Location DO Dilution Results at Low, Average, 10-Year, 50-Year, and 100-Year Stream Flows

DO Combined Stream Concentration					Mill Creek Modeled Historical Flows for Proposed Outfall (DO=5.2 mg/L)*			
				Low	Average	10-Year (10%)	50-Year (2%)	100-Year (1%)
(cfs)		(cfs)	(mgd)	2	12	950	1,301	1,434
(mgd)				1	8	614	841	927
WWTP Flow (DO=5 mg/L)	Initial	1.5	1.0	5.1	5.2	5.2	5.2	5.2
	Phase 1	4.6	3.0	5.1	5.2	5.2	5.2	5.2
	Phase 2	9.3	6.0	5.1	5.2	5.2	5.2	5.2

**Mill Creek DOWQ Data Range Min=2.4 mg/L, Avg=5.2 mg/L, Max=8.5 mg/L*

The result of the combined concentration of DO shows no negative effect on DO concentration in Mill Creek under all flow conditions at the proposed outfall location as a result of adding the NW WWTP effluent flow.

The effect of the BOD discharge on Mill Creek DO was assessed using spreadsheet calculations of processes including first order BOD decay, sediment oxygen demand (SOD) and stream reaeration. The calculations were set up to evaluate an upstream reach of approximately 1 mile and a downstream reach of approximately 3 miles (to the confluence with Six Mile Creek).

The upstream reach represents the Mill Creek transport system above the proposed outfall location. Values for the processes listed above were assigned such that the calculated DO at the outfall location was equivalent to the average measured DO for Mill Creek (5.2 mg/L, as shown in Table 1). These included the following:

- First order CBOD decay rate of 0.1/day
- First order nitrification rate of 0.1/day
- Sediment oxygen demand (SOD) of 0.5 $g/m^2/d$
- Tsivoglou escape coefficient of 0.0052/ft

The first three values were set based on values considered typical of natural streams with relatively low BOD and ammonia levels. The escape coefficient was calibrated so that the calculated first order reaeration rate resulted in a DO of 5.2 mg/L in the upstream reach, under average flow conditions with average inflow concentrations of 5.2 mg/L DO, 2.6 mg/L BOD_5 and 0.12 mg/L for ammonia N. Values of flow depth and velocity were calculated using Manning's equation with channel cross-section geometry, roughness and slope based on hydraulic data presented in the SR 16 bridge hydraulic report referenced earlier.

The downstream reach was assigned similar values for SOD and first order BOD decay and nitrification rate, but the calculated reaeration rate was higher based on the increased flow and velocity downstream of the discharge location.

The evaluation under average flow conditions (10 cfs at the discharge location) suggests that the discharge will only result in DO concentrations of less than 5.0 mg/L in Mill Creek if the discharge is significantly lower than the ambient average DO concentration of 5.2 mg/L. The spreadsheet calculations were done assuming a NW WWTP discharge DO concentration of 5.0 mg/L. The calculation results for both the 3 mgd and 6 mgd discharge values, the DO concentration at initial dilution mixing is 5.1 mg/L. Further downstream, the DO concentration actually increases, to a value of 5.2 mg/L at the confluence with Six Mile Creek.

The evaluation under low flow conditions (11.8 cfs at the discharge location) again suggests that the discharge may actually increase DO concentrations in Mill Creek. In the upstream reach, the calculations showed that the DO concentration in the creek above the discharge location would likely be lower than the average value of 5.2 mg/L. In the one-mile upstream reach, the DO drops from 5.2 mg/L to 4.8 mg/L. Again assuming a discharge DO concentration of 5 mg/L, the DO concentration after initial dilution actually increases from 4.8 mg/L to 4.9 mg/L. For the 3 mgd case, the DO then drops somewhat as the discharge moves downstream, with a minimum DO of 4.7 mg/L at the confluence with Six Mile Creek. When the discharge is 6 mgd, the minimum DO in Mill Creek is 5.0 mg/L, again at the downstream end of Mill Creek at the confluence with Six Mile Creek. A summary of these calculations is presented in **Table 11**.

Table 11 DO Sag Calculations in Mill Creek with 3.0 mgd NW WWTP Discharge

Location	DO Calculation Results (mg/L)		
	Average Flow (11.8 cfs) w/ Discharge	Low Flow (2.3 cfs) w/o Discharge	Low Flow (2.3 cfs) w/ Discharge
Upstream of Discharge	5.2	4.8	4.8
Discharge Location	5.1	4.8	4.9
Confluence with Six Mile Creek	5.2	3.8	4.7[1]

[1] Without discharge from NW WWTP, DO concentration would be 3.8 mg/L. Discharge from the NW WWTP is showing improvement to the existing condition DO concentration.

These calculations show that the additional stream reaeration caused by the additional flow in the creek, and the DO concentration of the discharge, can be expected to cancel out any adverse impacts of the additional BOD discharge to the creek. It should be noted that the method of analysis did not include additional dilution from natural inflows downstream of the discharge location in Mill Creek, and therefore is a "worst case" calculation when considering the discharge impacts.

Total Nitrogen and Total Phosphorus

The background levels for TN are generally lower than the maximum permitted NW WWTP effluent limit for TN. The maximum TN anticipated to be seen in the wastewater effluent stream is 3 mg/L. The water quality samples obtained from the available data in Mill Creek show a minimum background level of TN at 0.4 mg/L, an average of 1.5 mg/L, and a maximum of 3 mg/L. The resulting combined stream concentration for the Mill Creek and NW WWTP effluent flows at the anticipated flow combinations for the proposed outfall location is presented in **Table 12**.

The background levels for TP are generally lower than the maximum permitted NW WWTP effluent limit for TP. The maximum TP anticipated to be seen in the wastewater effluent stream is 1 mg/L. The water quality samples obtained from the available data in Mill Creek show a minimum background level of TN at 0.1 mg/L, an average of 0.2 mg/L, and a maximum of 0.8 mg/L. The resulting combined stream concentration for the Mill Creek and NW WWTP effluent flows at the anticipated flow combinations for the proposed outfall location is presented in **Table 13**.

Table 12 Proposed Outfall Location TN Dilution Results at Average, 10-Year, 50-Year, and 100-Year Stream Flows

TN Combined Stream Concentration				Mill Creek Modeled Historical Flows for Proposed Outfall Location 2 (TN=1.5 mg/L)*			
				Average	**10-Year**	**50-Year**	**100-Year**
(cfs)		**(cfs)**	**(mgd)**	12	950	1,301	1,434
(mgd)				8	614	841	927
WWTP Flow (TN=3 mg/L)	Initial	1.5	1.0	1.7	1.5	1.5	1.5
	Phase 1	4.6	3.0	1.9	1.5	1.5	1.5
	Phase 2	9.3	6.0	2.2	1.5	1.5	1.5

**Mill Creek TN WQ Data Range Min=0.4 mg/L, Avg = 1.5mg/L, Max=3 mg/L*

Table 13 Proposed Outfall Location TP Dilution Results at Average, 10-Year, 50-Year, and 100-Year Stream Flows

TP Combined Stream Concentration				Mill Creek Modeled Historical Flows for Proposed Outfall Location (TP=0.2 mg/L)*			
				Average	**10-Year**	**50-Year**	**100-Year**
(cfs)		**(cfs)**	**(mgd)**	12	950	1,301	1,434
(mgd)				8	614	841	927

WWTP Flow (TP=1 mg/L)	Initial	1.5	1.0	0.3	0.2	0.2	0.2
	Phase 1	4.6	3.0	0.4	0.2	0.2	0.2
	Phase 2	9.3	6.0	0.6	0.2	0.2	0.2

**Mill Creek TN WQ Data Range Min=0.1 mg/L, Avg = 0.2 mg/L, Max=0.8 mg/L*

The spreadsheet calculations show that the travel time from the proposed discharge point to the confluence with Six Mile Creek is 3.2 hours for average flow conditions and 6.0 hours for low flow conditions without the proposed discharge. When a 3 mgd discharge is added, the travel times range from 2.8 hours (average flow) to 3.8 hours (low flow). The travel times range from 2.6 to 3.1 hours when a 6 mgd discharge is added. Given the limited travel time in Mill Creek, it is unlikely that the discharge would result in additional algal biomass growth in the creek.

Conclusion

The spreadsheet calculations show that the additional stream reaeration caused by the additional flow in the creek, and the DO concentration of the discharge, can be expected to cancel out any adverse impacts of the additional BOD discharge to the creek. Thus, the NW WWTP discharge as shown in Table 14 does not "cause or contribute to" lower DO concentrations and indeed it improves the ambient DO. Additionally, the travel time in Mill Creek is limited and it is unlikely that the discharge will result in additional algal biomass growth in the creek.

Table 14 NW WWTP Discharge to Mill Creek

Constituent	NW WWTP Discharge to Mill Creek, (mg/L) (6 mgd Discharge)
Total Phosphorus	1
Total Nitrogen	3
BOD	5

Very truly yours,

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