Tidal Stream Assessment Report for Double Branch Creek 03100206000259 in Hillsborough County, Florida

Date Assessed: July 18, 2012

Assessed by: David Eilers, Brett Griffiths, Jackie Boles

Reviewed by: Jim Griffin

INTRODUCTION

This assessment was conducted to update existing physical and ecological data for Double Branch Creek on the Hillsborough County & City of Tampa Water Atlas. The Lake and Stream Assessment project is a collaborative effort between the University of South Florida's Center for Community Design and Research and Hillsborough County Stormwater Management Section. The project is funded by Hillsborough County and the Southwest Florida Water Management District. The project has, as its primary goal, the rapid assessing of up to 150 lakes and stream segments in Hillsborough County during a five-year period. The product of these investigations will provide the County, property owners and the general public a better understanding of the general health of Hillsborough County lakes and streams, in terms of shoreline development, water quality, morphology (bottom contour, volume, area, etc.) and the plant biomass and species diversity. These data are intended to assist the County and its citizens to better manage lakes and streams.

Figure 1. . General photograph of the tidal portion of Double Branch Creek

BACKGROUND

This report focuses on Double Branch Creek from the mouth in Upper Tampa Bay to the bridge at Memorial Highway. This region covers the tidal region of Double Branch Creek Reach 03100206000259 which consists of two stream segments[i] (please see maps, Figures 2-6). This section of Double Branch Creek is dominated by tidal and salinity fluctuations and covers the lower reach and the estuary component above the confluence with Upper Tampa Bay.

The first section of the report provides the results of the overall morphological assessment of the stream. Primary data products include: a contour (bathymetric) map of the stream, area, volume and depth statistics, and the water level at the time of assessment. These data are useful for evaluating trends and for developing management actions such as plant management where depth and stream volume are needed.

The second section provides the results of the vegetation assessment conducted on the stream. These results can be used to better understand and manage vegetation in the stream. A list is provided with the different plant species found at various sites along the stream. Potentially invasive, exotic (non-native) species are identified in a plant list and the percent of exotics is presented in a summary table. Watershed values provide a means of reference.

The third section provides the results of the water quality sampling of the stream. Both field data and laboratory data are presented. The stream water quality is assessed based on the Water Quality Standards for Streams that were fully approved on March 15, 2013. Please see a discussion of these standards and the approach used for tidal streams in the Stream Assessment Notes at the end of this report.

The intent of this assessment is to provide a starting point from which to track changes in the stream, and where previous comprehensive assessment data is available, to track changes in the stream’s general health. These data can provide the information needed to determine changes and to monitor trends in physical condition and ecological health of the stream.

[i] A stream segment is a stream length that can be conveniently mapped and assessed during a single assessment period.

Section 1: Stream Morphology

Bathymetric Map[ii]. Table 1 provides the stream's morphologic parameters in various units. The bottom of the stream was mapped using a Lowrance LCX 28C HD or HDS 5 with Wide Area Augmentation System (WAAS)[iii] enabled Global Positioning System (GPS) with fathometer (bottom sounder) to determine the boat's position, and bottom depth in a single measurement. The result is an estimate of the stream's area, mean and maximum depths, and volume and the creation of a bottom contour map (Figure 2 through Figure 6). Besides pointing out the deeper fishing holes in the stream, the morphologic data derived from this part of the assessment can be valuable to overall management of the stream vegetation as well as providing flood storage data for flood models.

Table 1. Stream Morphologic Data (Area, Depth and Volume)

Parameter	Feet	Meters	Acres	Acre-Ft	Gallons
Surface Area (sq)	6,815,724.2	633,201.5	156.47		
Mean Depth	2.46	0.75			
Maximum Depth	12.67	3.86			
Volume (cubic)	13,958,402.2	395,257.9		320.4	104,416,823.3
Gauge (USGS 02307032)	10.39	3.17			

[ii] A bathymetric map is a map that accurately depicts all of the various depths of a water body. An accurate bathymetric map is important for effective herbicide application and can be an important tool when deciding which form of management is most appropriate for a water body. Stream volumes, hydraulic retention time and carrying capacity are important parts of stream management that require the use of a bathymetric map.

[iii] WAAS is a form of differential GPS (DGPS) where data from 25 ground reference stations located in the United States receive GPS signals form GPS satellites in view and retransmit these data to a master control site and then to geostationary satellites. For more information, see end note 3.

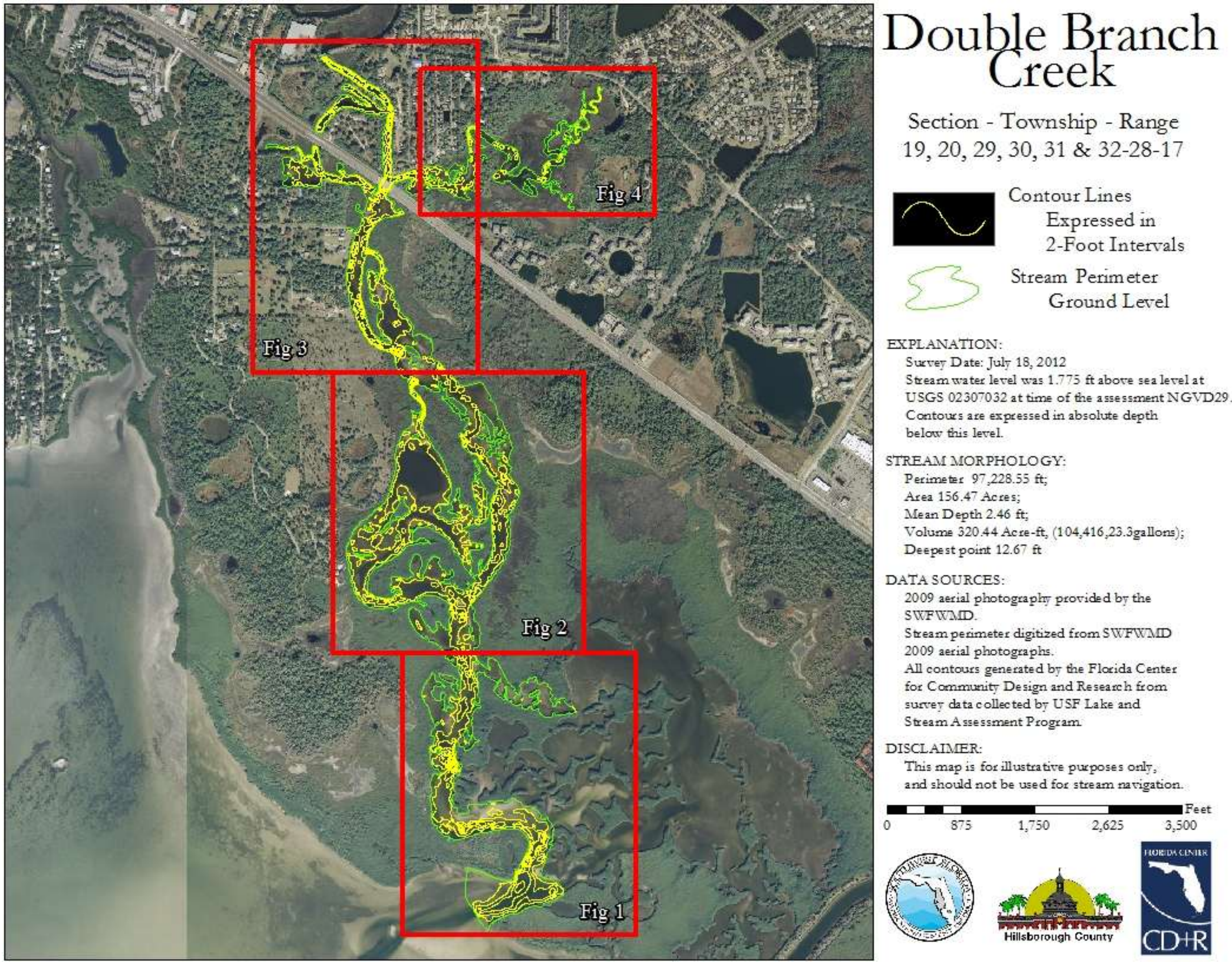

Figure 2. Double Branch Creek 2-Foot Bathymetric Contour Map Overview

Figure 3. Double Branch Creek 2-Foot Bathymetric Contour Map Inset Map 1

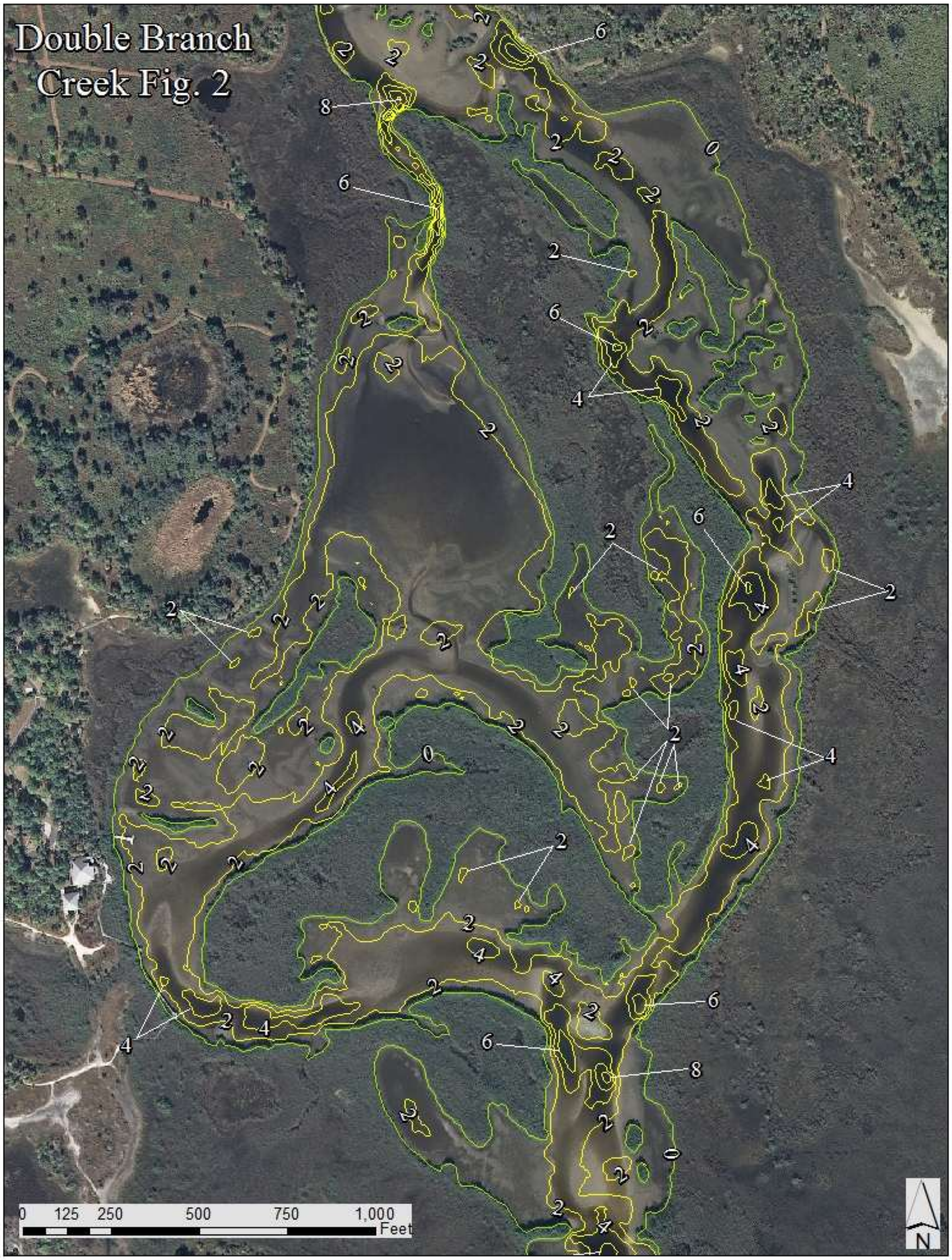

Figure 4. Double Branch Creek 2-Foot Bathymetric Map Inset Map 2

Figure 5. Double Branch Creek 2-Foot Bathymetric Contour Map Inset Map 3

Figure 6. Double Branch Creek 2-Foot Bathymetric Contour Map Inset Map 4

Section 2: Stream Ecology (Vegetation)

The stream's apparent vegetative cover and shoreline detail are evaluated using the latest stream aerial photograph as shown in and by use of WAAS-enabled GPS. Submerged vegetation is determined from the analysis of bottom returns from the Lowrance 28c HD or HDS 5 combined GPS/fathometer described earlier. As depicted in Figure 7, 32 vegetation regions have been assessed for in ~250 meter regions measured from the center of the stream. The vegetation assessment regions are set up from the downstream extent and work to the upstream extent. The region beginning and ending points are set using GPS and then loaded into a GIS mapping program (ArcGIS) for display. Each region is sampled in the three primary vegetative zones (emergent, submerged and floating)[iv]. The latest high-resolution aerial photos are used to provide shore details (docks, structures, vegetation zones) and to calculate the extent of surface vegetation coverage. The primary indices of submerged vegetation cover and biomass for the stream, percent area coverage (PAC) and percent volume inhabited (PVI), are determined by transiting the stream by boat and employing a fathometer to collect "hard and soft return" data. These data are later analyzed for presence and absence of vegetation and to determine the height of vegetation if present. The PAC is determined from the presence and absence analysis of 100 sites in the stream and the PVI is determined by measuring the difference between hard returns (stream bottom) and soft returns (top of vegetation) for sites (within the 100 analyzed sites) where plants are determined present.

The data collected during the site vegetation sampling include vegetation type, exotic vegetation, predominant plant species and submerged vegetation biomass. The total number of species from all sites is used to approximate the total diversity of aquatic plants and the percent of invasive-exotic plants on the stream (Table 2). The Watershed value in Table 2 only includes lakes and streams sampled during the stream assessment project begun in May of 2006. These data will change as additional lakes and streams are sampled.

Table 3 and 4 details the results from the 2012 aquatic plant assessment for the stream. These data are determined from the 32 sites used for intensive vegetation surveys. The tables are divided into Floating Leaf, Emergent and Submerged plants and contain the plant code, species, common name and the calculated percent occurrence (number sites species is found/number of sites) and type of plant (Native, Non-Native, Invasive, Pest). In the "Type" category, the codes N and E0 denote species native to Florida. The

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[iv] See end note 3.

code E1 denotes Category I invasive species, as defined by the Florida Exotic Pest Plant Council (FLEPPC); these are species “that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives.” The code E2 denotes Category II invasive species, as defined by FLEPPC; these species “have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species.” Use of the term invasive indicates the plant is commonly considered invasive in this region of Florida. The term “pest” indicates a plant (native or non-native) that has a greater than 55% occurrence in the stream and is also considered a problem plant for this region of Florida, or is a non-native invasive that is or has the potential to be a problem plant in the stream and has at least 40% occurrence. These two terms are somewhat subjective; however, they are provided to give stream property owners some guidance in the management of plants on their property. Please remember that to remove or control plants in a wetland (stream shoreline) in Hillsborough County the property owner must secure an Application To Perform Miscellaneous Activities In Wetlands permit from the Environmental Protection Commission of Hillsborough County and for management of in-stream vegetation outside the wetland fringe (for streams with an area greater than ten acres), the property owner must secure a Florida Department of Environmental Protection Aquatic Plant Removal Permit.

Table 2. Total Diversity, Percent Exotics, and Number of Pest Plant Species

Parameter	Lake	Watershed
Number of Vegetation Assessment Sites	32	32
Total Plant Diversity (# of Taxa)	33	33
% Non-Native Plants	18.18%	18.18%
Total Pest Plant Species	1	1

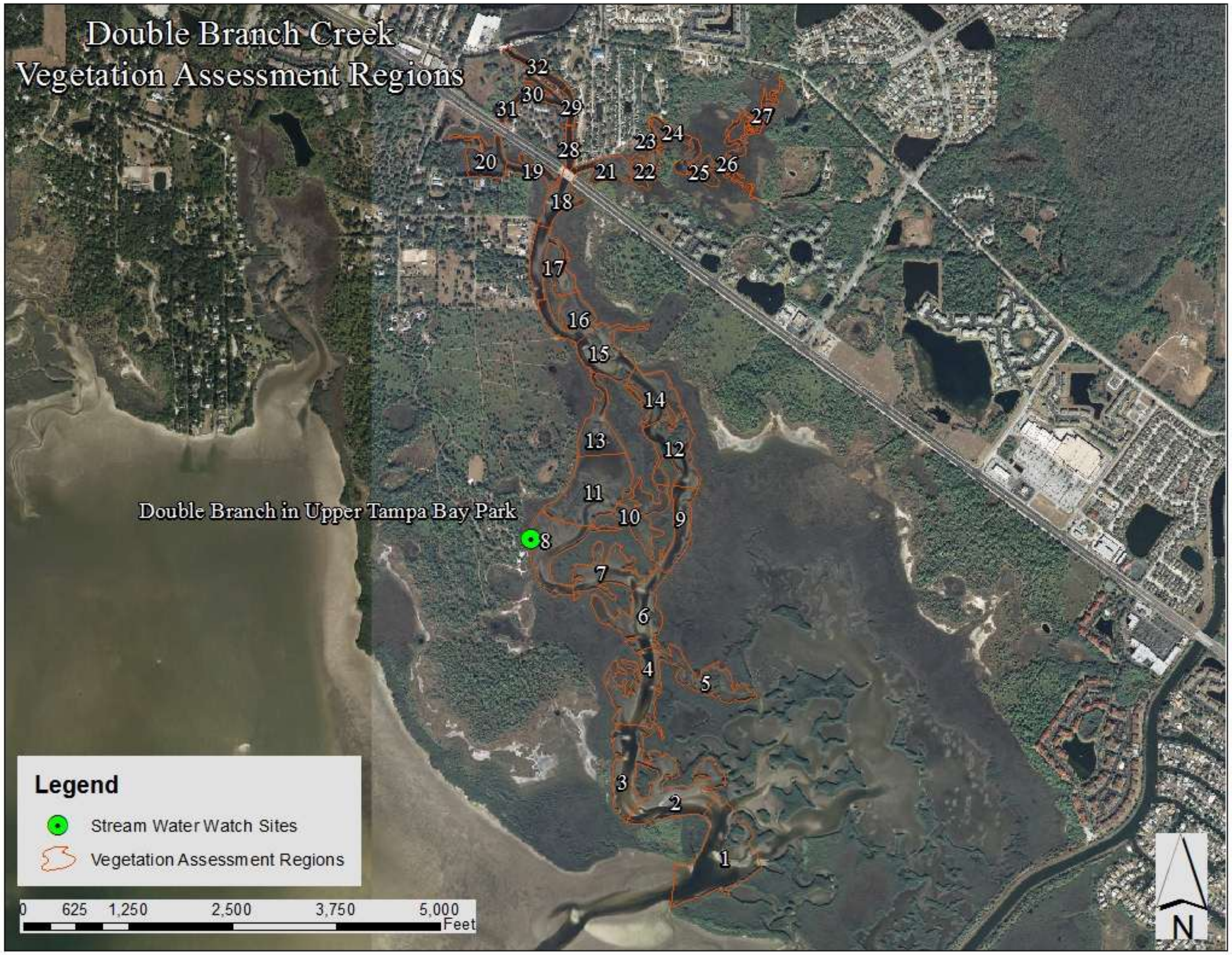


Figure 7. Double Branch Creek Vegetation Assessment Site Map

Table 3. List of Floating Leaf Zone Aquatic Plants Found

Plant Species Code	Scientific Name	Common Name	Percent Occurrence	Type
RZM	***Rhizophora mangle***	**Red Mangrove**	**100%**	**N, E0**
LAG	***Laguncularia racemosa***	**White Mangrove**	**100%**	**N, E0**
AVG	***Avicennia germinans***	**Black Mangrove**	**81%**	**N, E0**
STS	***Schinus terebinthifolius***	**Brazilian Pepper**	**65%**	**E1, P**
JRO	***Juncus roemerianus***	**Needle Rush, Black Rush**	**62%**	**N, E0**
BHA	***Baccharis halimifolia***	**Groundsel Tree; Sea Myrtle**	**56%**	**N, E0**
SAT	***Spartina alterniflora***	**Saltmarsh Cordgrass**	**53%**	**N, E0**
SPO	***Sabal palmetto***	**Sabal Palm, Cabbage Palm**	**50%**	**N, E0**
PIN	***Pinus spp.***	**Pine Tree**	**37%**	**N, E0**
IFS	***Iva frutescens***	**Bigleaf Sumpweed, Marsh Elder**	**34%**	**N, E0**
QGA	***Quercus geminata***	**Sand Live Oak**	**31%**	**N, E0**
LEL	***Leucaena leucocephala***	**White Leadtree**	**18%**	**E2**
QLA	***Quercus laurifolia***	**Laurel Oak; Diamond Oak**	**15%**	**N, E0**
COE	***Conocarpus erectus***	**Buttonwood**	**12%**	**N, E0**
TYP	***Typha spp.***	**Cattails**	**12%**	**N, E0**
SMI	***Smilax spp.***	**Catbriar, Greenbriar**	**12%**	**N, E0**
SRS	***Serenoa repens***	**Saw Palmetto**	**9%**	**N, E0**
JVA	***Juniperus virginiana***	**Red cedar**	**9%**	**N, E0**
ADM	***Acrostichum danaeifolium***	**Giant Leather Fern**	**6%**	**N, E0**
DSA	***Distichlis spicata***	**Saltgrass**	**6%**	**N, E0**
DSO	***Dalbergia sissoo***	**Indian Rosewood**	**6%**	**E2**
EUP	***Eupatorium capillifolium***	**Dog Fennel**	**6%**	**N, E0**
SPB	***Spartina bakeri***	**Sand Cordgrass**	**6%**	**N, E0**
VRA	***Vitis rotundifolia***	**Muscadine Grape**	**6%**	**N, E0**
SSM	***Sapium sebiferum***	**Chinese Tallow Tree**	**3%**	**E1**
SSS	***Solidago sempervirens***	**Seaside Goldenrod**	**3%**	**N, E0**
CRS	***Campsis radicans***	**Trumpet Vine**	**3%**	**N, E0**
DBA	***Dioscorea bulbifera***	**Air Potato**	**3%**	**E1**
CAM	***Crinum americanum***	**Swamp lily**	**3%**	**N, E0**
CFL	***Coreopsis floridana***	**Florida Tickseed**	**3%**	**N, E0**
CLA	***Casuarina equisetifolia***	**Australian Pine**	**3%**	**E1**
QNA	***Quercus nigra***	**Water Oak**	**3%**	**N, E0**
BMI	***Bacopa monnieri***	**Common Bacopa**	**3%**	**N, E0**

Figure 8. ***Juncus roemerianus,*** Needle Rush **is a common emergent vegetation found in salt marshes of Double Branch Creek**

Figure 9. ***Rhizophora mangle*****, Red Mangrove, is common along the shorelines of Double Branch Creek.**

Figure 10. *Schinus terebinthifolius*, Brazilian Pepper, was the most commonly occurring non-native invasive species on Double Branch Creek

Table 4. List of All Plants and Sample Sites

Plant Common Name	Found at Sample Sites	Percent Occurrence	Growth Type
Red Mangrove	**1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32**	**100**	**Terrestrial**
White Mangrove	**1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32**	**100**	**Terrestrial**
Black Mangrove	**1,2,3,4,5,6,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,28,29,30,32**	**81**	**Terrestrial**
Brazilian Pepper	**2,3,11,13,15,16,17,18,19,20,21,22,23,24,25,27,28,29,30,31,32**	**65**	**Emergent**
Needle Rush, Black Rush	**9,11,12,13,15,16,17,19,20,21,22,23,24,25,26,27,28,30,31,32**	**62**	**Emergent**
Groundsel Tree; Sea Myrtle	**2,11,13,14,15,17,19,20,21,22,23,24,27,28,29,30,31,32**	**56**	**Emergent**
Saltmarsh Cordgrass	**2,5,6,9,10,11,12,13,14,15,16,18,19,20,29,31,32**	**53**	**Emergent**
Sabal Palm, Cabbage Palm	**2,8,11,13,17,19,20,21,23,24,27,28,29,30,31,32**	**50**	**Terrestrial**
Pine Tree	**8,11,13,17,20,23,25,28,29,30,31,32**	**37**	**Emergent**
Bigleaf Sumpweed, Marsh Elder	**11,14,15,17,18,20,23,27,29,30,31**	**34**	**Terrestrial**
Sand Live Oak	**2,8,11,13,25,28,29,30,31,32**	**31**	**Terrestrial**
White Leadtree	**20,22,28,29,30,31**	**18**	**Terrestrial**
Laurel Oak; Diamond Oak	**20,21,24,29,32**	**15**	**Emergent**
Buttonwood	**14,17,29,32**	**12**	**Terrestrial**
Catbriar, Greenbriar	**17,29,30,32**	**12**	**Emergent**
Cattails	**24,25,26,27**	**12**	**Emergent**
Red cedar	**14,19,30**	**9**	**Terrestrial**
Saw Palmetto	**11,13,15**	**9**	**Terrestrial**
Dog Fennel	**24,29**	**6**	**Emergent**
Giant Leather Fern	**20,27**	**6**	**Emergent**
Indian Rosewood	**28,31**	**6**	**Terrestrial**
Muscadine Grape	**20,29**	**6**	**Emergent**
Saltgrass	**15,18**	**6**	**Emergent**
Sand Cordgrass	**20,26**	**6**	**Terrestrial**
Air Potato	**24**	**3**	**Emergent**
Australian Pine	**27**	**3**	**Emergent**

Plant Common Name	Found at Sample Sites	Percent Occurrence	Growth Type
Chinese Tallow Tree	**31**	**3**	**Emergent**
Common Bacopa	**27**	**3**	**Submersed**
Florida Tickseed	**20**	**3**	**Emergent**
Seaside Goldenrod	**27**	**3**	**Terrestrial**
Swamp lily	**30**	**3**	**Emergent**
Trumpet Vine	**32**	**3**	**Emergent**
Water Oak	**32**	**3**	**Emergent**

Discussion of Vegetation Assessment Results

The highest diversity of species found in the Double Branch Creek study area was in the natural region of Double Branch Creek regions 20, 29 and 32. In these regions 16 species were identified. 12.5% of these species were non-native to Florida and 1 species was considered a pest plant for these regions. In general, the lower regions 1-10 near the mouth of Double Branch creek had the lowest number of species identified ranging between 3 and 8 species but also the lowest number of non-native species with only 1 identified, *Schinus terebinthifolius* , which was only found in 2 of the lower regions. This species was more prevalent in the upper regions leading to it being considered a pest plant species for the assessment of Double Branch Creek. The highest diversity vegetation regions were in the upper regions near Memorial Highway. These regions are located in a zone of freshwater input and tidal mixing as well as human disturbance. At the mouth at Old Tampa Bay, Double Branch Creek is a predominately mangrove and salt marsh ecosystem with a braided channel.

Section 3: Long-term Ambient Water Chemistry

A critical element in any stream assessment is the long-term water chemistry data set. These data are obtained from several data sources that are available to the Water Atlas and are managed in the Water Atlas Data Download and graphically presented on the water quality page for streams in Hillsborough County. The Double Branch Creek Water Quality Page can be viewed at http://www.hillsborough.wateratlas.usf.edu/river/waterquality.asp?wbodyid=30&wbodyatlas=river).

A primary source of stream water chemistry in Hillsborough County is the Routine Monitoring Sampling by the Hillsborough County Environmental Protection Commission. Other source data are used as available; however these data can only indicate conditions at time of sampling.

These data are displayed and analyzed on the Water Atlas as shown in Figures 11, 12, 13 and 14 for Double Branch Creek. The figures are graphs of: (1) the overall water quality index (WQI)[v], which is a method commonly used to characterize the productivity of a stream, and may be thought of as a stream's ability to support plant growth and a healthy food source for aquatic life; (2) the chlorophyll *a* concentration, which indicates the stream's algal concentration; (3) the stream's Turbidity graph which is a measure of water visibility and (4) the salinity which can be used to determine the extent of the tidal

[v] See WQI discussion in Stream Assessment Notes at end of report.

reach and measured as conductivity in micro Siemens per centimeter (μS/cm) and commonly expressed as salinity in parts per million (ppt) and chloride concentration in milligrams/liter (mg/L)[vi]. These data are used to evaluate a stream's ecological health and to provide a method of ranking streams. These and other parameters (primary nutrients) are used by the US Environmental Protection Agency (USEPA) and the Florida Department of Environmental Protection (FDEP) to determine the level of impairment of a freshwater stream and tidal stream.

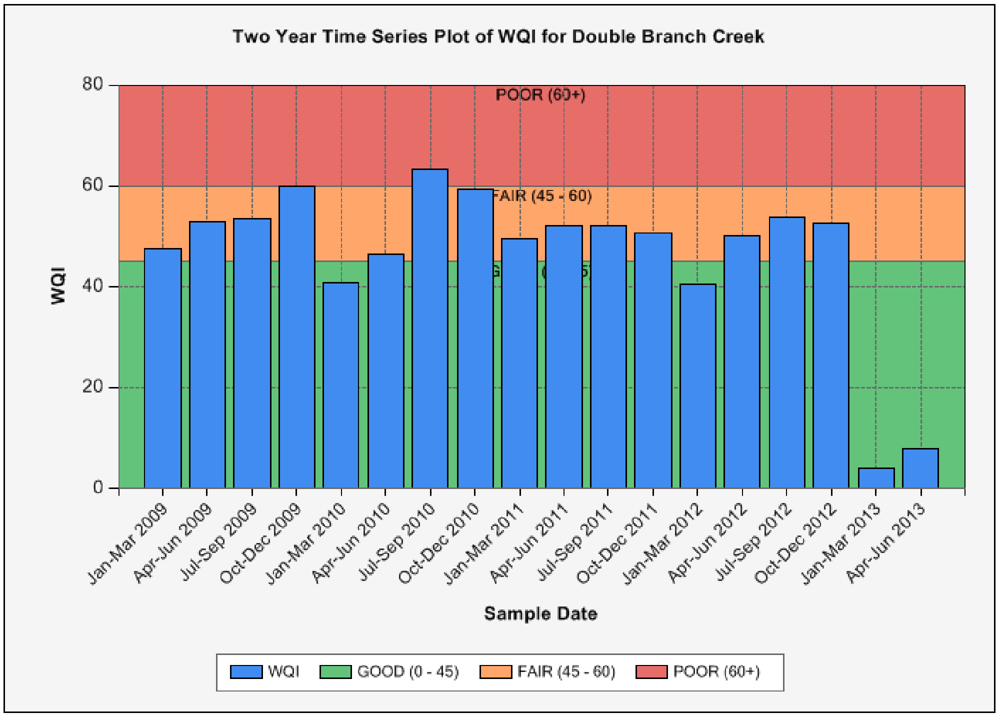


Figure 11. Recent Water Quality Index (WQI) graph for Double Branch Creek[vii]

[vi] Please see discussion of salinity in Stream Assessment notes at end of report.

[vii] Graph source: Hillsborough County Water Atlas. For an explanation of the Good, Fair and Poor benchmarks, please see the notes at the end of this report. For the latest data go to:
http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=30&data=WQI&datatype=WQ&waterbodyatlas=river&ny=10&bench=1

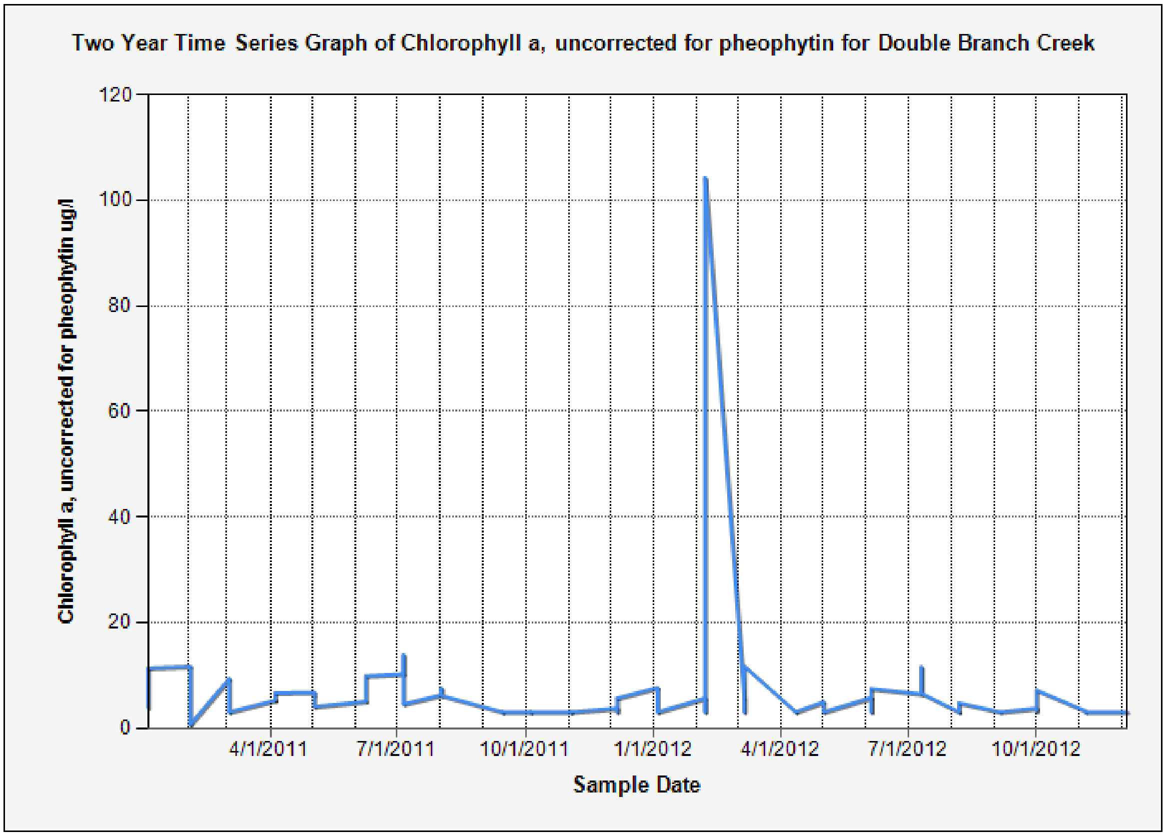


Figure 12. Recent Chlorophyll a graph for Double Branch Creek[viii]

[viii] Graph Source: Hillsborough County Water Atlas. For the latest data go to http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=30&data=Chla_ugl&datatype=WQ&waterbodyatlas=river&ny=10&bench=1

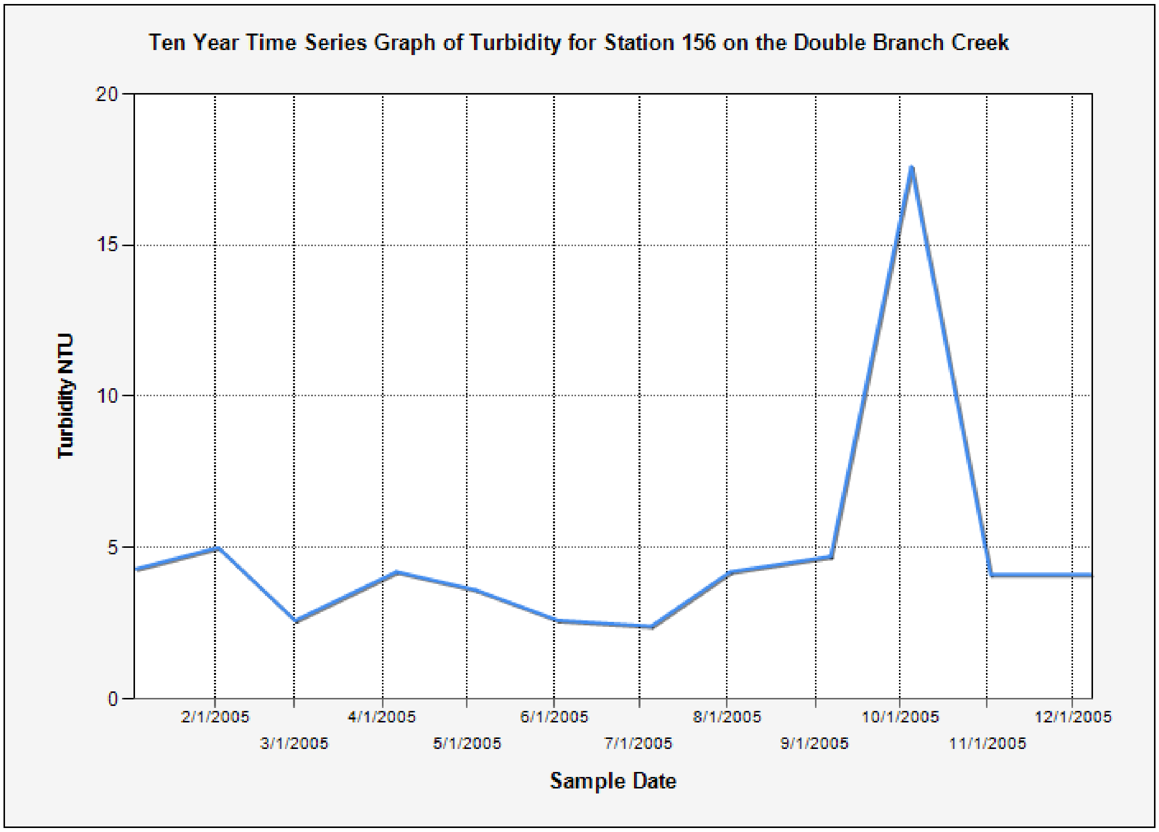


Figure 13. Recent Turbidity graph for Double Branch Creek[ix]

[ix] Graph Source: Hillsborough County Water Atlas. For the latest data go to http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=30&data=secchi_ft&datatype=WQ&waterbodyatlas=stream&ny=10&bench=1

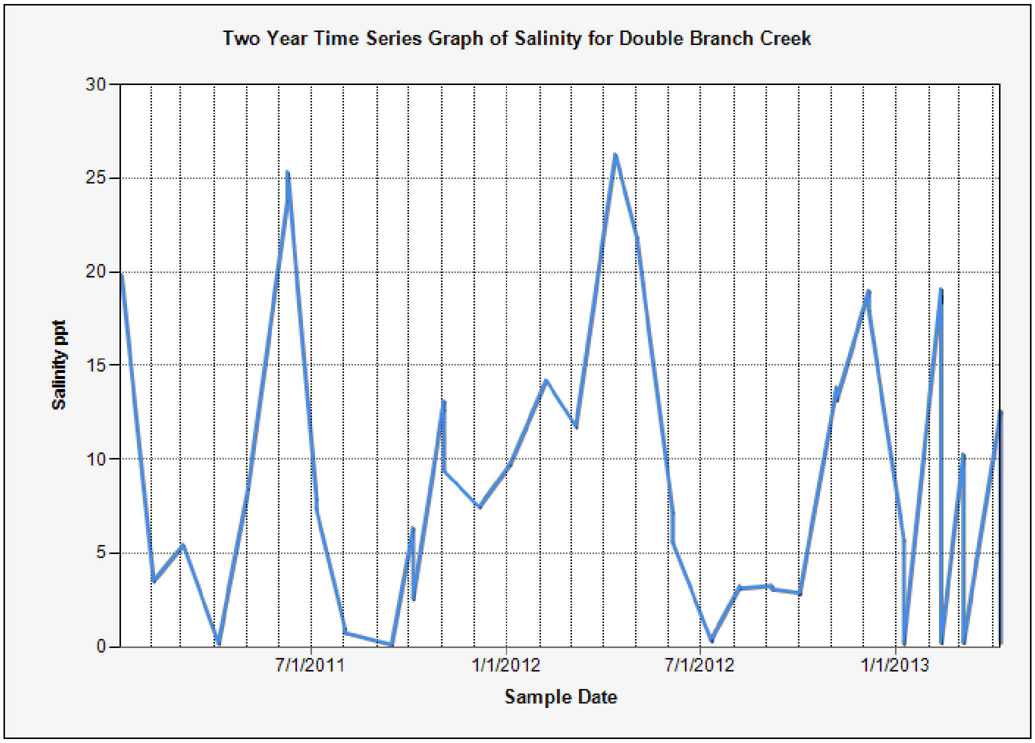


Figure 14. Graph of Salinity in Double Branch Creek

Stream Numeric Nutrient Criteria. November 30, 2012 the USEPA accepted the majority of the FDEP proposed NNCs which included an NNC for streams. In its proposed criteria, FDEP stated that tidal reaches of streams should be covered under the Florida Narrative Criteria[x]. However; tidal streams were not accepted at that time. On March 15, 2013, the USEPA also accepted the tidal creek criteria. The narrative criterion requires that the balance in natural populations of aquatic flora and fauna is maintained. For a tidal creek this can be interpreted maintaining the flora and fauna in the stream and the estuary reach to which the flows. A Tidal Creek Study will be conducted in the fall of 2013 with the goal of developing a proposed procedure for evaluating tidal creeks and for establishing numeric nutrient requirements. In the absence of an approved approach for assessing tidal creeks, the Lake and Stream Assessment program has adopted an

[x] Narrative Criteria states: 62-302-530(47)(b), Florida Administrative Code (F.A.C.), provides that "[i]n 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."

methodology that was proposed by the USEPA in their technical support document for Florida numeric nutrient criteria which includes a section for tidal creeks published November 30, 2012 (please see excerpt and reference in Stream Assessment Notes at the end of this report). The methodology proposes two approaches which consider the upstream (freshwater segment and the downstream (estuarine segment). The methodology puts forward two approaches.

- The first divides the segment by the mean chloride concentration of a segment[xi]. For segments that have a mean chloride concentration of greater than or equal to 1,500 mg/L, the estuarine criteria is used, and for those less than this value, the freshwater criteria is used.
- The second approach is a bit more complicated, it sets as the boundary conditions the approved numeric nutrient condition for the freshwater stream segment and the approved NNC for the estuarine reach and employs a relationship with salinity to calculate tidal creek NNC. The formula is then:

$$C_{TC} = C_{FW} + (S_{TC}-S_{FW}) \times (C_{Est}\text{-CFW}/S_{Est} - S_{FW}) \text{ (Equation 1)}$$

where:

C_{TC} = nutrient criterion for tidal creek segment
C_{FW} = nutrient criterion for adjoining/upstream freshwater segment
C_{Est} = nutrient criterion for adjoining estuarine segment
S_{TC} = mean salinity for tidal creek segment
S_{FW} = mean salinity for adjoining/upstream freshwater segment
S_{Est} = mean salinity for adjoining estuarine segment

The NNC for freshwater streams is provided in the Stream Assessment Notes at the end of this report, and for the Tampa Bay area (considered West Central) total phosphorous must be less than or equal to 0.49 mg/L and total nitrogen must be less than or equal to 1.65 mg/L to meet the criteria and chlorophyll a must be at or below 20 µg/L not be considered impaired. The estuarine criteria for Tampa Bay are provided in Table 5 below.

[xi] The 1,500 mg/L chloride threshold is used to define waters as *predominantly freshwater* or *predominantly marine water* [F.A.C. 62-302.200(22) and 62-302.200(23)].

Nutrient Watershed Region	Total Phosphorus (tons/million m^3)	Total Phosphorus (mg/L)	Total Nitrogen (tons/million m^3)	Total Nitrogen (mg/L)	Chlorophyll a (µg/L)
Old Tampa Bay	0.23	0.21	1.08	0.98	9.3
Hillsborough Bay	1.28	1.16	1.62	1.47	15
Middle Tampa Bay	0.24	0.218	1.24	1.13	8.5
Lower Tampa Bay	0.14	0.127	0.97	0.89	5.1

Where the conversion 1 ton / (million cubic meters) = 0.907 mg/L is used to convert to commonly used values.

Table 5. Estuary Numeric Nutrient Criteria for the Tampa Bay Region

As part of the stream assessment the physical water quality and chemical water chemistry of a stream are measured. These data only indicate a snapshot of the stream's water quality; however they are useful when compared to the trend data available from Hillsborough County Environmental Protection Commission or other sources.

Table 6 contains the summary water quality data and index values and adjusted values calculated from these data. The total phosphorus (TP), total nitrogen (TN) and chlorophyll a water chemistry sample data are the results of chemical analysis of samples taken during the assessment and analyzed by the Hillsborough County Environmental Protection Commission laboratory.

The growth of plants (planktonic algae, macrophytic algae and rooted plants) is directly dependent on the available nutrients within the water column of a stream and to some extent the nutrients which are held in the sediment and the vegetation biomass of a stream. Additionally, algae and other plant growth are limited by the nutrient in lowest concentration relative to that needed by a plant. Plant biomass contains less phosphorus by weight than nitrogen so phosphorus is many times the limiting nutrient. When both nutrients are present at a concentration in the stream so that either or both may restrict plant growth, the limiting factor is called "balanced". The ratio of total nitrogen to total phosphorous, the "N to P" ratio (N/P), is used to determine the limiting factor. If N/P is greater than or equal to 30, the stream is considered phosphorus limited, when this ratio is less than or equal to 10, the stream is considered nitrogen limited and if between 10 and 30 it is considered balanced.

Table 6. Water Quality Parameters (Laboratory) for Double Branch Creek

Parameter	East Branch below Memorial HWY	West Branch below Memorial HWY	Bellow Hillsborough Ave.	Mouth at Old Tampa Bay
Ammonia (mg/L)	0.109	0.100	0.093	0.154
Chlorophyll-a (µg/L)	3.1	3.1	3.5	5.1
Color (PCU)	121.0	205.3	199.1	107.0
Enterococci (#/100mL)	240	140	120	40
Fecal Coliform (#/100mL)	60	140	40	60
Kjeldahl Nitrogen (mg/L)	1.009	1.021	1.029	0.751
Total Nitrogen (mg/L)	1.086	1.043	1.053	0.774
Total Phosphorous (mg/L)	0.129	0.140	0.138	0.138

The color of a stream is also important to the growth of algae. Dark, tannic streams tend to suppress algal growth and can tolerate a higher amount of nutrient in their water column; while clear streams tend to support higher algal growth with the same amount of nutrients. The color of a stream, which is measured in a unit called the "cobalt platinum unit (PCU)" because of the standard used to determine color, is important because it is used by the State of Florida to determine stream impairment as explained earlier. Rivers, streams or other "flow through" systems tend to support lower algal growth for the same amount of nutrient concentration. All these factors are important to the understanding of your stream's overall condition. Table 6 includes many of the factors that are typically used to determine the actual state of plant growth in your stream. These data should be understood and reviewed when establishing a management plan for a stream; however, as stated above other factors must be considered when developing such a plan. Please contact the Water Atlas Program if you have questions about this part or any other part of this report.

The water quality of the tidal region of Double Branch Creek varies seasonally based on rainfall and discharge from the freshwater portions of the stream. Dissolved oxygen concentrations were low throughout the study area.

7 contains the field data taken in the upstream and downstream extents of the stream using a multi-probe (we use either a YSI 6000 or a Eureka Manta) which has the ability to directly measure the temperature, pH, dissolved oxygen (DO), percent DO (calculated from DO, temperature and conductivity). These data are listed for three levels in the stream and twice for the surface measurement. These three locations cover the predom-

inantly freshwater portion upstream, the mixing zone and the confluence with the receiving estuary.

Table 7 Water Chemistry Data Based on Manta Water Chemistry Probe for Double Branch Creek

Sample Location	Sample Depth (m)	Time	Temp (deg C)	Conductivity (mS/cm3)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH
Bottom- east branch below memorial	0.85	7/25/2012 11:00:00 AM	26.95	0.381	45.11	3.66	6.68
Mean Value- east branch below memorial	0.74	7/25/2012 11:00:00 AM	27.02	0.379	45.18	3.66	6.68
Middle- east branch below memorial	0.76	7/25/2012 11:00:00 AM	26.97	0.379	45.03	3.66	6.68
Surface- east branch below memorial	0.52	7/25/2012 11:00:00 AM	27.22	0.374	45.44	3.68	6.68
Surface- west branch below memorial	0.68	7/25/2012 11:45:00 AM	27.14	0.213	47.04	3.81	6.40
Middle- west branch below memorial	1.51	7/25/2012 11:45:00 AM	27.09	0.209	46.98	3.81	6.40
Mean Value- west branch below memorial	1.67	7/25/2012 11:45:00 AM	27.10	0.210	47.05	3.81	6.41
bottom- west branch below memorial	2.35	7/25/2012 11:45:00 AM	27.09	0.210	47.13	3.82	6.42
Mean Value - below Hillsborough	0.86	7/25/2012 12:00:00 PM	27.38	0.295	47.23	3.81	6.44
Middle - below Hillsborough	0.94	7/25/2012 12:00:00 PM	27.37	0.294	47.75	3.85	6.44
Surface - Below Hillsborough	0.58	7/25/2012 12:00:00 PM	27.40	0.301	46.72	3.76	6.44
Bottom - below Hillsborough	1.13	7/25/2012 12:00:00 PM	27.36	0.291	47.27	3.81	6.44
Bottom - mouth	2.24	7/25/2012 12:30:00 PM	29.68	1.169	55.54	4.16	6.88
Surface - mouth	0.66	7/25/2012 12:30:00 PM	29.55	10.592	54.65	4.11	6.87
Middle - mouth	1.31	7/25/2012 12:30:00 PM	29.69	11.165	55.39	4.15	6.87
Mean Value - mouth	1.47	7/25/2012 12:30:00 PM	29.64	10.977	55.21	4.14	6.87

To better understand many of the terms used in this report, we recommend that the reader visit the Hillsborough County & City of Tampa Water Atlas and explore the "Learn More" areas which are found on the resource pages. Additional information can also be found using the Digital Library on the Water Atlas website.

Section 4: Conclusion

Double Branch Creek is a large area (156-acre) stream that would be considered in the healthy category of streams based on water chemistry. It has a plant diversity of 33 species relative to the total watershed plant diversity of 33 species with about < 1 percent of the open water areas containing submerged aquatic vegetation. Vegetation helps to maintain the nutrient balance in the stream as well as provide good fish habitat. The stream has many open water areas to support various types of recreation and has a fair diversity of plant species. The primary pest plants in the stream include *schinus terebinthifolius*.

This assessment was accomplished to assist stream property owners to better understand and manage their streams. Hillsborough County supports this effort as part of their Stream Waterwatch Program (SWW) and has developed guidelines for stream property owner groups to join the SWW and receive specific assistance from the County in the management of their stream. For additional information and recent updates please visit the Hillsborough County & City of Tampa Water Atlas website.

Stream Assessment Notes

NOTE 1: The Water Quality Index (WQI) is used for streams, black waters (natural tea and coffee-colored waters), and springs, while the Trophic State Index (TSI) is used for lakes and estuaries. The WQI is calculated by averaging the values of most or all of the parameters within five water quality parameter categories: 1) water clarity (measured as turbidity and/or Secchi disk depth), 2) dissolved oxygen, 3) oxygen demanding substances (measured as biochemical oxygen, chemical oxygen demand and/or total organic carbon), 4) nutrients (measured as total nitrogen, nitrite plus nitrate, and/or total phosphorus), and 5) bacteria (total coliform and-or fecal coliform).

Water Atlas presents WQIs over the last four seasons (three month intervals). The WQI "value" for a waterbody is determined by averaging the values (data) of the aforementioned parameters for each "season" (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec). These seasonal averages are then averaged to provide an overall "rating" or WQI. The term "confidence" expresses the degree of completeness of the index; in other words, "confidence" states how many parameter categories were used to calculate the Overall Water Quality Index.

Ranges of WQI values have been established to provide a general ranking of the waterbody (Figure 1.) WQI values may also include the 'Confidence' (Figure 2), which provides you with some relative idea as to how much information was used to calculate the WQI for that waterbody.

Note: The acronym WQI also stands for "Water Quality Inspection" in much of the DEP literature.

WQI	Rating
0-45	Good
45-60	Fair
>60	Poor

Figure 1. Water Quality Index (WQI) ranges and their designations.

WQI	Rating	Confidence	Season
30	Good	5/5	Winter (2000)
40	Good	3/5	Fall (2000)
30	Good	2/5	Summer (2000)

50	Fair	3/5	Summer (2000)

Figure 2. WQI rankings are provided with examples of Confidence values.

NOTE 2: Definition of a "Stream" from 62-302.531 Florida Administrative Code (FAC): "Stream" shall mean, for purposes of interpreting the narrative nutrient criterion in paragraph 62-302.530(47)(b), F.A.C., under paragraph 62-302.531(2)(c), F.A.C., a predominantly fresh surface waterbody with perennial flow in a defined channel with banks during typical climatic and hydrologic conditions for its region within the state. During periods of drought, portions of a stream channel may exhibit a dry bed, but wetted pools are typically still present during these conditions. Streams do not include:

> non-perennial water segments where fluctuating hydrologic conditions, including periods of desiccation, typically result in the dominance of wetland and/or terrestrial taxa (and corresponding reduction in obligate fluvial or lotic taxa), wetlands, or portions of streams that exhibit lake characteristics (e.g., long water residence time, increased width, or predominance of biological taxa typically found in non-flowing conditions) or tidally influenced segments that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions; or
>
> ditches, canals and other conveyances, or segments of conveyances, that are man-made, or predominantly channelized or predominantly physically altered and;

are primarily used for water management purposes, such as flood protection, stormwater management, irrigation, or water supply; and

have marginal or poor stream habitat or habitat components, such as a lack of habitat or substrate that is biologically limited, because the conveyance has cross sections that are predominantly trapezoidal, has armored banks, or is maintained primarily for water conveyance.

NOTE 3: The "Stream Condition Index (SCI)" shall mean a Biological Health Assessment that measures stream biological health in predominantly freshwaters using benthic macroinvertebrates, performed and calculated using the Standard Operating Procedures for the SCI in the document titled SCI 1000: *Stream Condition Index Methods* (DEP-SOP-003/11 SCI 1000) and the methodology in *Sampling and Use of the Stream Condition Index (SCI) for Assessing Flowing Waters: A Primer* (DEP-SAS-001/11), both dated 10-24-11, which are incorporated by reference herein. Copies of the documents may be obtained from the Department's website at http://www.dep.state.fl.us/water/wqssp/swq-docs.htm or by writing to the Florida Department of Environmental Protection, Standards and Assessment Section, 2600 Blair Stone Road, MS 6511, Tallahassee, FL 32399-2400. For water quality standards purposes, the Stream Condition Index shall not apply in the South Florida Nutrient Watershed Region.

NOTE 4: Definition of a Tidal Stream: Tidally influenced segments that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions (excerpt from above FAC definitions).

For streams (other than exceptions listed above), if a site specific interpretation pursuant to paragraph 62-302.531(2)(a) or (2)(b), FAC, has not been established (see at: http://www.hillsborough.wateratlas.usf.edu/upload/documents/62-302.pdf), biological information shall be used to interpret the narrative nutrient criterion in combination with Nutrient Thresholds. The narrative nutrient criterion in paragraph 62-302.530(47)(b), FAC., shall be interpreted as being achieved in a stream segment where information on chlorophyll a levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora or fauna, and either:

the average score of at least two temporally independent SCIs performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or

the nutrient thresholds set forth in the table below are achieved.

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold[1]	Total Nitrogen Nutrient Threshold[1]
Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L
Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

[1]These values are annual geometric mean concentrations not to be exceeded more than once in any three calendar year period.

NOTE 5: Tidal Creeks On March 15, 2013 the USEPA and the FDEP agreed that the FDEP proposed standards (62-302.532 FAC, Estuary-Specific Numeric Interpretations of the Surface Water Quality Standards; see at: http://www.hillsborough.wateratlas.usf.edu/upload/documents/62-302.pdf) would be used to determine impairment in all streams. As above, this criterion allows the use of narrative standards for tidal streams but adopts those above for the majority of freshwater streams in Florida. Narrative Criteria, 62-302-530(47)(b), FAC, provides that “[i]n 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.”

Since no actual standard exists for tidal creeks we elected to use the USEPA approach that is outlined below.

Tidal Creek Overview From the (Technical Support Document for U.S. EPA’s Proposed Rule for Numeric Nutrient Criteria, Volume 1 Estuaries, November 30, 2012):

“Tidal creeks and associated marshes and mangroves are refuges for small forage fish and for juveniles of larger fish to which they are considered an important spawning and nursery habitat. For example, juveniles of common snook (*Centropomus undecimalis*) depend on tidal creeks for shelter from larger predators (Adams 2005). Dominant aquatic animals in tidal creeks include mummichogs (Fundulidae) and grass shrimp (Palaeomonidae), but many other estuarine species also thrive in these habitats (Greenwood et al. 2009; Krebs et al. 2009; Janicki Environmental 2011). In general, undisturbed tidal creeks in Florida have higher fish densities than adjacent open waters. Tidal creeks can be degraded by suburban and urban development in their watersheds. Stressors from watershed development include hydrologic modification because of increased flashiness from impervious surfaces; channelization for marinas and docks; and nutrient pollution from lawn fertilizers, urban and agricultural runoff, and septic systems. As a result, tidal creeks draining developed areas have higher nutrient, chlorophyll, and fecal coliform bacteria concentrations compared to streams draining undeveloped watersheds (Holland et al. 2004; Mallin et al. 2004). Furthermore, hypoxic episodes are more extreme (prolonged and with lower dissolved oxygen) in developed watersheds than in undeveloped watersheds (Holland et al. 2004). In addition to increased nutrient concentrations, watershed development results in increased variability and volume of runoff during and after rainfall. The runoff surges cause more rapid and more extreme salinity changes as well as increased scour and changes in channel morphology. Tidal creeks with watersheds that have high impervious surface area have been observed to support degraded fish and invertebrate communities in South Carolina. Although commercially important spot and shrimp populations were reduced in affected creeks, mummichog and grass shrimp remained (Holland et al. 2004; Lerberg et al. 2000; Mallin et al. 2004). Other studies have shown that low-salinity waters of tidal creeks in developed areas can develop nuisance algal bloom conditions (Mallin et al. 2004; MacPherson et al. 2007), with the bloom waters moving back and forth with the tides. Such bloom conditions can also contribute to more severe hypoxic episodes.

Derivation of Numeric Nutrient Criteria for Tidal Creeks*:* Tidal creeks were classified separately from estuaries because tidal creeks are expected to have higher nutrient and chlorophyll concentrations than adjacent, open waters. The classification and segmentation approach used for estuaries was not considered practical because of the large number and variety of small systems. A definitional approach was chosen, applicable to all tidal creeks, to be implemented on a case-by-case basis as data allow. Several options were considered for deriving numeric nutrient criteria for tidal creeks, including applying inland freshwater criteria derived for upstream waters or applying estuarine criteria derived for downstream waters. Neither of those two approaches alone would be applicable to the full range and variability of tidal creeks. Ultimately, EPA selected two approaches for deriving numeric TN and TP criteria that account for the inherent variability of tidal creeks.

The first approach is to apply separately derived inland TN and TP criteria for adjacent freshwaters if the mean chloride of the tidal creek is less than 1,500 mg/L, or apply estuarine TN and TP criteria for adjacent downstream waters if the mean chloride of the tidal creek is greater than or equal to 1,500 mg/L.

The second approach uses linear interpolation to derive criteria for TN and TP for tidal creeks using criteria that were derived separately for adjacent inland freshwater and estuary areas on the basis of mean salinity. Criteria would be derived by that method only where there are sufficient salinity data to allow for interpolation. The calculation uses the following formula:

$$C_{TC} = C_{FW} + (S_{TC} - S_{FW}) \times \left(\frac{C_{Est} - C_{FW}}{S_{Est} - S_{FW}}\right)$$

where

C_{TC} = nutrient criterion for tidal creek segment

C_{FW} = nutrient criterion for adjoining/upstream freshwater segment

C_{Est} = nutrient criterion for adjoining estuarine segment

S_{TC} = mean salinity for tidal creek segment

S_{FW} = mean salinity for adjoining/upstream freshwater segment

S_{Est} = mean salinity for adjoining estuarine segment

Example:

Segment	Mean Salinity (ppt)	Criterion Concentration
Freshwater segment	0.5	2.5
Tidal creek segment	20	C_{TC}
Estuarine segment	30	0.8

$$C_{TC} = 2.5 + (20 - 0.5) \times \left(\frac{0.8 - 2.5}{30 - 0.5}\right) = 1.376$$

Tampa Bay Tidal Creeks (From Letter Memorandum, Titled *Tampa Bay Numeric Nutrient Criteria: Tidal Creeks*, prepared by Janicki Envirionmental, Inc. for Tampa Bay Estuary Program. 16 February 2011):

“There are approximately sixty tidal creeks that are terminal tributaries to Tampa Bay or to smaller embayments within the bay (Figure 3). Tampa Bay tidal creeks differ substantially in scale from the larger tidal rivers and these differences in relative channel geomorphology result in disparate hydrological and physicochemical characteristics from Tampa Bay’s tidal rivers. Some of the larger tidal creeks extend far enough into the watershed that they have lower order, freshwater tributaries that feed into them (e.g., Bullfrog Creek, Double Branch Creek, Frog Creek). Tidal creeks also differ from freshwater tributaries of the same size primarily due to their connection to the estuary. Small freshwater tributaries do not experience the semidiurnal tides which cause the daily and even hourly fluctuations in water level, flow direction, salinity, water temperature and dissolved oxygen (DO) often recorded in tidal creeks (Buzzelli et al., 2007). Delineation of estuarine and freshwater tributaries to Tampa Bay is provided in Figure 3 below. Unmodified tidal creeks are characterized by sinuous, meandering channels with average water depths <1.0 m, while those creeks modified for drainage, mosquito control, or navigation often have straightened channels with steeper, more uniform banks than unmodified creeks. Tidal creeks altered for navigation are typically deeper than other creeks (>2.0 m in depth) and often have hardened shorelines that have been cleared of vegetation. Most tidal creeks in Tampa Bay are relatively narrow, spanning only 25-50 m from bank to bank, in contrast to the tidal rivers which are 100-300 m wide on average, although some of the larger tidal creeks reach 100 m or more in width near the mouth. The bathymetry of tidal creeks consists of alternating areas of deep, erosional and shallow, depositional bottom, unless the creek has been channelized, in which case, it is often uniformly deep."

Figure 3. Named Tidal Creeks in Tampa Bay Region. From Letter Memorandum, Titled Tampa Bay Numeric Nutrient Criteria: Tidal Creeks, prepared by Janicki Envirionmental, Inc. for Tampa Bay Estuary Program. 16 February 2011.

Tidal Creeks of interest for our reports include those that flow to Old Tampa Bay, Hillsborough Bay and Middle Tampa Bay. In our assessment we will then use the freshwater stream criteria for tidal creeks segments it a chloride concentration less than or equal to

1,500 mg/L and estuary criteria (see below) for segments with a chloride concentration of greater than 1,500 mg/L.

(1) Estuary-specific numeric interpretations of the narrative nutrient criterion in paragraph 62-302.530(47)(b), FAC, are in the table below. The concentration-based estuary interpretations are open water, area-wide averages. The interpretations expressed as load per million cubic meters of freshwater inflow are the total load of that nutrient to the estuary divided by the total volume of freshwater inflow to that estuary.

Estuary	Total Phosphorus	Total Nitrogen	Chlorophyll *a*
(a) Clearwater Harbor/St. Joseph Sound	Annual geometric mean values not to be exceeded more than once in a three year period. Nutrient and nutrient response values do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.		
1. St.Joseph Sound	0.05 mg/L	0.66 mg/L	3.1 µg/L
2. Clearwater North	0.05 mg/L	0.61 mg/L	5.4 µg/L
3. Clearwater South	0.06 mg/L	0.58 mg/L	7.6 µg/L
(b) Tampa Bay	Annual totals for nutrients and annual arithmetic means for chlorophyll a, not to be exceeded more than once in a three year period. Nutrient and nutrient response values do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.		
1. Old Tampa Bay	0.23 tons/million cubic meters of water	1.08 tons/million cubic meters of water	9.3 µg/L
2. Hillsborough Bay	1.28 tons/million cubic meters of water	1.62 tons/million cubic meters of water	15.0 µg/L
3. Middle Tampa Bay	0.24 tons/million cubic meters of water	1.24 tons/million cubic meters of water	8.5 µg/L
4. Lower Tampa Bay	0.14 tons/million cubic meters of	0.97 tons/million cubic meters of	5.1 µg/L

Note: 1 ton / (million cubic meter) = 0.907 mg/L

NOTE 6: Salinity Salinity is a way of expressing the “saltiness” or dissolved salt content (primarily sodium chloride, magnesium and calcium sulfates and bicarbonates) of natural waters and is normally only used for saltwater systems. The unit of salinity commonly used is a part per thousand (ppt). Natural water salinity regimes commonly discussed in the literature include freshwater (< 0.05 ppt), Oligohaline (0.05-0.5 ppt), mesohaline (0.5-5 ppt), polyhaline (5-18 ppt), mixoeuhaline (18-30) ppt) and metahaline (30-40) ppt. Seawater in the open ocean is normally in the metahaline regime.

The salinity of a natural water is an important factor to measure and to understand. Salinity can be used to trace the movement of estuarine waters within a tidal stream which is a factor of tide and wind velocity. It is also important in understanding the types of organisms that might be expected to exist in a specific segment of a tidal stream. Additionally, salinity influences the kinds of plants that will grow either in a in the stream or along the wetland margin of a stream. A plant adapted to saline conditions is called a halophyte. Organisms (mostly bacteria) that can live in very salty conditions are classified as extremophiles,or halophiles specifically. An organism that can withstand a wide range of salinities is euryhaline.

One of the criteria that has been proposed by the USEPA in their technical volume on estuary and tidal creek numeric nutrient criteria is based on the chloride concentration for a stream. They propose a chloride concentration of 1,500 mg/L as the point where a stream should be classified as tidal. That is a stream segment with a chloride concentration greater that this value is a tidal segment. Looking at the table below which gives a relationship between salinity, conductivity and chloride concentration, this value converts to a salinity of 2.47 ppt.

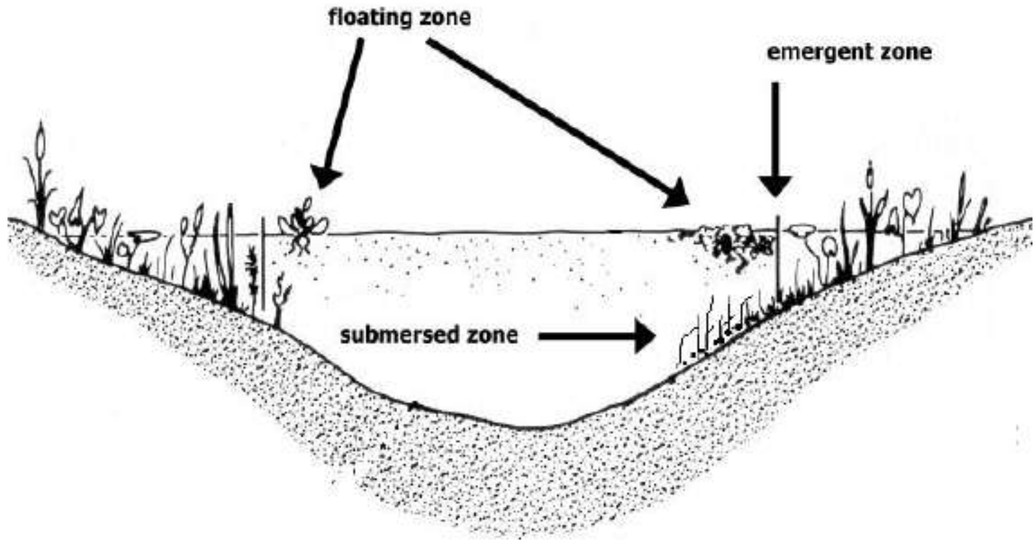
Relationship between Electrical Conductivity (EC - µS/cm), salinity concentration, chloride concentration and Practical Salinity Units

EC @25°C	Salinity ppt or g/l	Salinity ppm or mg/l	Cl ppm or mg/l	PSU
100	0.05	51	31	0.07
200	0.10	97	59	0.12
300	0.14	144	88	0.17
400	0.19	193	117	0.22
500	0.24	241	147	0.27
600	0.29	291	177	0.32
700	0.34	341	207	0.37
800	0.39	391	237	0.42
900	0.44	442	268	0.47
1000	0.49	493	299	0.52
1200	0.60	596	362	0.61
1400	0.70	699	425	0.71
1600	0.80	804	488	0.81
1800	0.91	910	552	0.90
2000	1.02	1016	617	1.00
2200	1.12	1123	682	1.10
2400	1.23	1231	747	1.19
2600	1.34	1339	813	1.29
2800	1.45	1448	879	1.38
3000	1.56	1558	946	1.48
3200	1.67	1668	1012	1.57
3400	1.78	1778	1080	1.67
3600	1.89	1889	1147	1.76
3800	2.00	2001	1215	1.85
4000	2.11	2113	1283	1.95
4200	2.23	2225	1351	2.04
4400	2.34	2338	1419	2.13
4600	2.45	2451	1488	2.23
4800	2.56	2565	1557	2.32
5000	2.68	2678	1626	2.41
6000	3.25	3253	1975	2.88
7000	3.84	3836	2328	3.33
8000	4.43	4426	2687	3.79
9000	5.02	5022	3049	4.24
10000	5.62	5625	3414	4.69
12000	6.85	6846	4155	5.57
14000	8.09	8087	4909	6.44
16000	9.35	9345	5673	7.31
18000	10.62	10621	6447	8.15
20000	11.91	11911	7230	8.99
22000	13.22	13215	8022	9.82
24000	14.53	14534	8822	10.64
26000	15.86	15865	9630	11.45
28000	17.21	17208	10446	12.25
30000	18.56	18564	11268	13.04
32000	19.93	19931	12098	13.82
34000	21.31	21309	12935	14.60
36000	22.70	22699	13778	15.37
38000	24.10	24099	14629	16.13
40000	25.51	25510	15485	16.88
42000	26.93	26932	16348	17.63
44000	28.36	28364	17217	18.37
46000	29.81	29806	18093	19.10
48000	31.26	31259	18975	19.83
50000	32.72	32722	19863	20.56
52000	34.19	34195	20757	21.27
54000	35.68	35678	21657	21.99

NB There is no direct conversion between many of these units.

The above information is a guide only and where relationships between values have been established, they are specific to Hickling Broad water quality data only

Vegetation Zones: The three primary aquatic vegetation zones are shown below:



An **adjusted chlorophyll a value** (µg/L) was calculated by modifying the methods of Canfield et al (1983). The total wet weight of plants in the stream (kg) was calculated by multiplying stream surface area (m^2) by PAC (percent area coverage of macrophytes) and multiplying the product by the biomass of submersed plants (kg wet weight m^2) and then by 0.25, the conversion for the 1/4 meter sample cube. The dry weight (kg) of plant material was calculated by multiplying the wet weight of plant material (kg) by 0.08, a factor that represents the average percent dry weight of submersed plants (Canfield and Hoyer, 1992) and then converting to grams. The potential phosphorus concentration (mg/m^3) was calculated by multiplying dry weight (g) by 1.41 mg TP g-1 dry weight, a number that represents the mean phosphorus (mg) content of dried plant material measured in 750 samples from 60 Florida lakes (University of Florida, unpublished data), and then dividing by stream segment volume (m^3) and then converting to µg/L (1000/1000). From the potential phosphorus concentration, a predicted chlorophyll a concentration was determined from the total phosphorus and chlorophyll a relationship reported by Brown (1997) for 209 Florida lakes. Adjusted chlorophyll a concentrations were then calculated by adding each lake's measured chlorophyll a concentration to the predicted chlorophyll a concentration.

Wide Area Augmentation System (WAAS) is a form of differential GPS (DGPS) where data from 25 ground reference stations located in the United States receive GPS signals form GPS satellites in view and retransmit these data to a master control site and then to geostationary satellites. The geostationary satellites broadcast the information to all WAAS-capable GPS receivers. The receiver decodes the signal to provide real time correction of raw GPS satellite signals also received by the unit. WAAS-enabled GPS is not as accurate as standard DGPS which employs close by ground stations for correction, however; it was shown to be a good substitute when used for this type of mapping application. Data comparisons were conducted with both types of DGPS employed simultaneously and the positional difference was determined to be well within the tolerance established for the project.