LAKE ASSESSMENT REPORT FOR LAKE CARROLL IN HILLSBOROUGH COUNTY FLORIDA

Date Assessed: 6/21/06
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Reviewed by: Jim Griffin

INTRODUCTION

This assessment was conducted to update existing physical and ecological data for Lake Carroll on the Hillsborough County Watershed Atlas (http://www.hillsborough.wateratlas.usf.edu/. The 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's Northwest Hillsborough, Hillsborough River and Alafia River Basin Boards. The project has, as its primary goal, the rapid assessing of up to 150 lakes in Hillsborough County during a five year period. The product of these investigations will provide the County, lake property owners, and the general public a better understanding of the general health of Hillsborough County lakes, in terms of shoreline development, water quality, lake 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 lake centered watersheds.

Figure 1 General Photo of Lake Carroll (6/21/06).

The first section of the report provides the results of the overall morphological assessment of the lake. Primary data products include: a contour (bathymetric) map of the lake, 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 lake volume are needed.

The second section provides the results of the vegetation assessment conducted on the lake. These results can be used to better understand and manage vegetation in your lake. A list is provided with the different plant species found at various sites around the lake. 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 and are derived from the lakes assessed during the 2006 lake assessment project in that watershed.

The third section provides the results of the water quality sampling of the lake. Both field data and laboratory data are presented. The trophic state index (TSI) [i] is used to develop a general lake health statement, which is calculated for both the water column with vegetation and the water column if vegetation were removed (adjusted TSI – Adj_TSI). These data are a combination of the water chemistry and vegetative submerged biomass assessments and are useful in understanding the results of certain lake vegetation management practices.

The intent of this assessment is to provide a starting point from which to track changes in your lake, and where previous comprehensive assessment data is available, to track changes in the lake'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 lake.

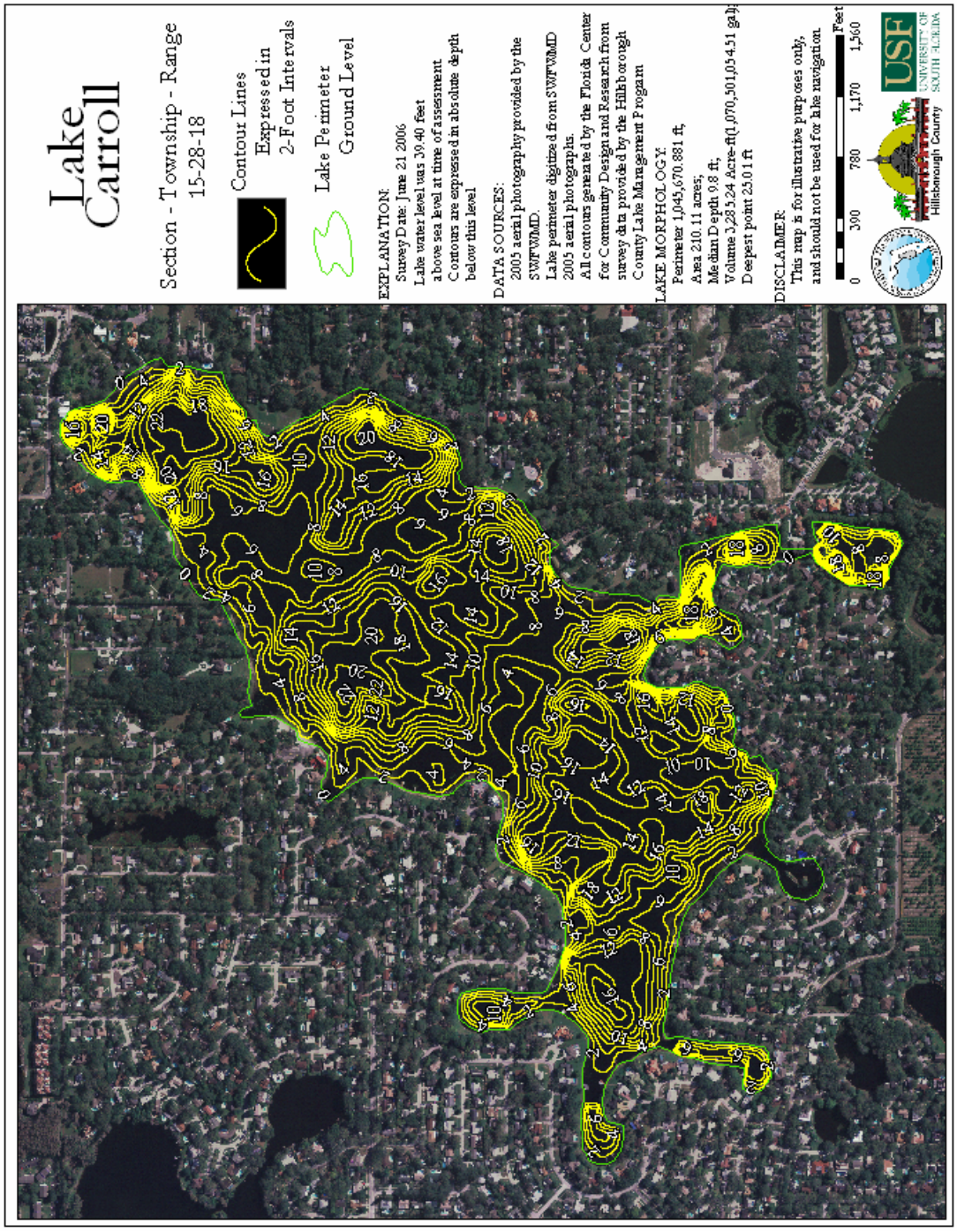
Section 1: Lake Morphology

Bathymetric Map[ii]. The bottom of the lake was mapped using a Lowrance LCX 26C HD Wide Area Augmentation System (WAAS)[iii] enabled Global Positioning System (WAAS-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 lake's area, mean and maximum depths, and volume and the creation of a bottom contour map (Figure 1). Besides pointing out the deeper fishing holes in the lake, the morphologic data derived from this part of the assessment can be valuable to overall management of the lake vegetation as well as providing flood storage data for flood models. Table 1 provides the lake's morphologic parameters in various units.

Table 1. Lake Area Depth and Volume.

Parameter	Feet	Meters	Acres	Acre-Ft	Gallons
Surface Area (sq)	9,218,530.85	856,439.73	211.63		
Mean Depth	9.87	3.01			
Maximum Depth	25.01	7.62			
Volume (cubic)	143,105,176.12	4,052,286.58		3,285.24	1,070,501,054.51

Figure 2. Contour map for Lake Carroll. The lake was mapped during the 2006 lake assessment project. A differential global positioning system and fathometer combination instrument was used to obtain simultaneous horizontal and vertical measurements.



Section 2: Lake Ecology (vegetation)

The lake's apparent vegetative cover and shoreline detail are evaluated using the aerial shown in Figure 3 and by use of GPS. Submerged vegetation is determined from evenly spaced contours sampled using a Lowrance 26c HD, combined DGPS/fathometer described earlier. Twenty vegetation assessment sites were used for Lake Carroll (Figure 3) as dictated by the *Lake Assessment Protocol* (copy available on request) for a lake of this size. The site positions are set using a DGPS[iv] and then loaded into a GIS mapping program (ArcGIS) for display. Each site is field sampled in the three primary vegetative zones (emergent, submerged and floating). The latest aerials (2005, 6 inch resolution, SWFWMD aerials) 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 lake, percent area coverage (PAC) and percent volume infestation (PVI), are determined by transiting the lake 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 index is determined from the presence and absence analysis of 100 sites in the lake and the PVI index is determined by measuring the difference between hard returns (lake 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 lake (Table 2). The Watershed value in Table 2 only includes lakes sampled during the lake assessment project begun in May of 2006. These data will change as additional lakes are sampled. Tables 3 through 5 detail the results from the 2006 aquatic plant assessment for you lake. These data are determined from the 10 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 presence (1) or absence (blank) of species 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 term invasive indicates the plant is commonly considered invasive in this region of Florida and the term "Pest" indicates that the plant has a greater than 55% occurrence in your lake and is also considered a problem plant for this region of Florida, or in a non-native invasive that is or has the potential to be a problem plant in your lake and has at least 40% occurrence. These two terms are somewhat subjective; however, they are provided to give lake property owners some guidance in the management of plants on their property. Please remember that to remove or control plants in a wetland (lake shoreline) in Hillsborough County the property owner must secure an Application To Perform Miscellaneous Activities In Wetlands (http://www.epchc.org/forms_documents.htm) permit from the Environmental Protection Commission of Hillsborough and for management of in-lake vegetation outside the wetland fringe (for lakes with an area greater than 10 acres), the property owner must secure a Florida Department of Environmental Protection permit (http://www.dep.state.fl.us/lands/invaspec/).

Table 2 Total diversity, Total Non-Native, and number of EPPC pest plants.

Parameter	Lake	Watershed
Total Plant Diversity (# of Taxa)	70	98
Total Non-Native Plants	12	17
Total Pest Plant Species	2	11

Figure 3. Position of the 20 Lake Carroll vegetation assessment sites.

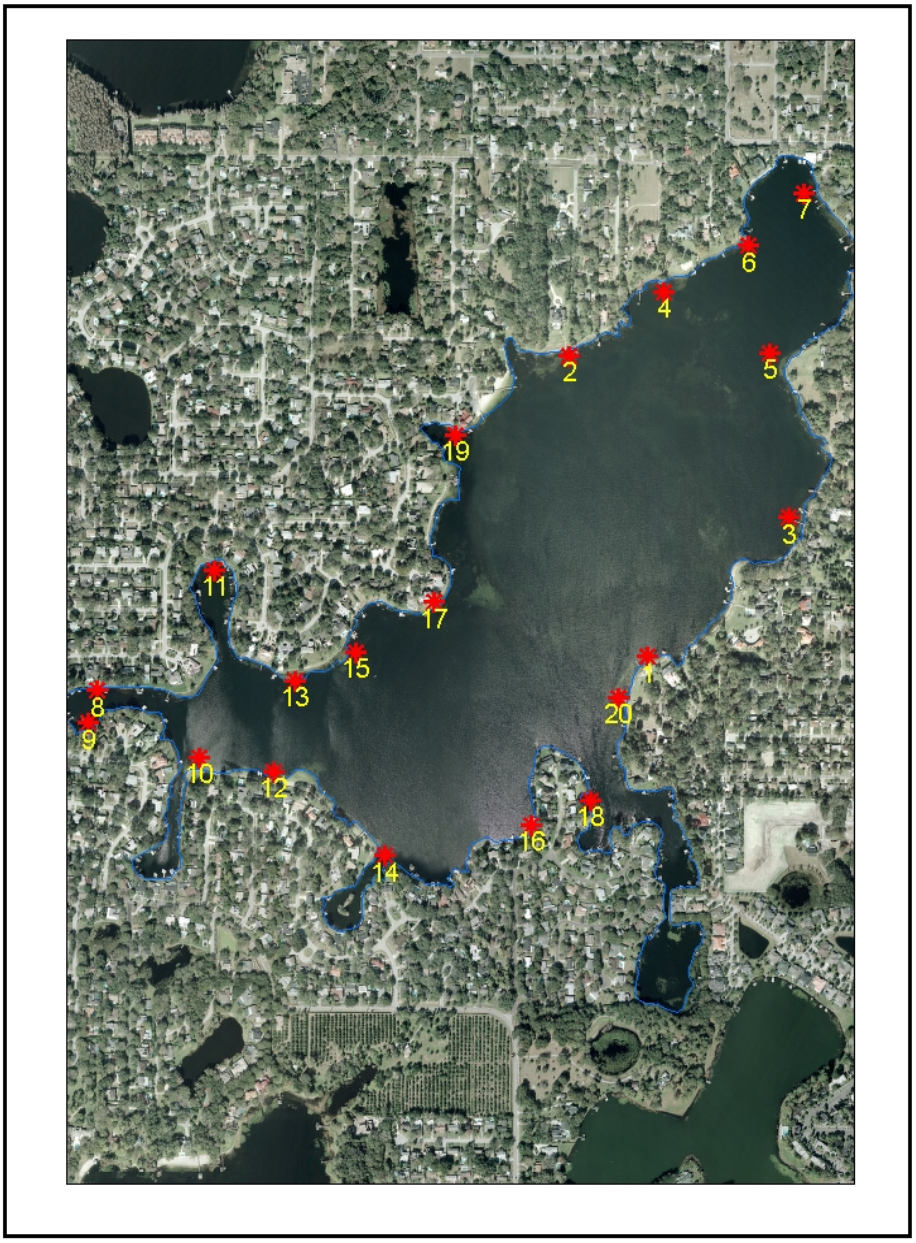


Table 3. List of Floating Leaf Zone Aquatic Plants Found in Lake Carroll.

Code	Plant Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	% Occurance
HYE	*Hydrocotyl umbellata*	Manyflower Marshpennywort, Water Pennywort	1	1	1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	85%
NOA	*Nymphaea odorata*	American White Water lily, Fragrant Water Lily	1	1	1	1	1	1		1	1	1	1							1	1	1	65%
NNA	*Nymphoides aquatica*	Banana Lily, Big Floatingheart								1	1	1	1	1	1			1	1		1	1	50%
LSA	*Limnobium spongia*	American Spongeplant, Frog's Bit											1										5%
NLM	*Nuphar lutea var. advena*	Spatterdock, Yellow Pondlily																			1		5%

Figure 4. Banana lily (Nymphoies aquatica).

Figure 5 Fragrant water lily (Nymphaea odorata).

Table 4. Part 1 of list of emergent plants. Please see glossary at the end of this document for further information.

Code	Plant Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	% Occurance
PRS	*Panicum repens*	Torpedo Grass	1	1			1	1		1	1	1	1		1		1		1	1	1	1	70%
APS	*Alternanthera philoxeroides*	Alligator Weed	1		1	1		1	1	1	1	1				1		1		1	1	1	65%
MEL	*Melaleuca quinquenervia*	Punk Tree, Melaleuca		1		1		1									1			1	1		30%
WTA	*Sphagneticola (Wedelia) trilobata*	Creeping Oxeye			1	1			1		1									1		1	30%
CLA	*Casuarina equisetifolia*	Australian Pine	1			1		1															15%
CCA	*Cinnamomum camphora*	Camphor-tree						1	1														10%
STS	*Schinus terebinthifolius*	Brazilian Pepper				1			1														10%
CSP	*Cyperus papyrus*	Papyrus			1																		5%
CEA	*Colocasia esculenta*	Wild Taro, Dasheen, Coco Yam			1																		5%
IAS	*Ipomoea spp.*	Ipomoea spp.							1														5%
SSM	*Sapium sebiferum*	Popcorn Tree, Chinese Tallow Tree				1																	5%
BCA	*Bacopa caroliniana*	Lemon Bacopa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
CAA	*Centella asiatica*	Asian Pennywort, Coinwort, Spadeleaf	1	1				1		1	1	1		1		1	1			1	1		55%
PNA	*Phyla nodiflora*	Frog-fruit, Carpetweed, Turkey Tangle Fogfruit	1			1			1	1		1			1	1	1			1	1	1	55%
COM	*Commelina spp.*	Dayflower		1	1			1	1	1	1				1		1	1		1			50%
BMI	*Bacopa monnieri*	Common Bacopa, Herb-Of-Grace							1	1	1	1		1	1		1			1		1	45%
EBI	*Eleocharis baldwinii*	Baldwin's Spikerush, Roadgrass					1		1			1	1	1	1			1			1	1	45%
ACE	*Acer rubrum var. trilobum*	Southern Red Maple		1	1	1		1	1	1				1				1					40%
EAA	*Eclipta alba (prostrata)*	False Daisy, Yerba De Tajo			1	1			1					1	1					1	1	1	40%
FSC	*Fuirena spp.*	Rush Fuirena					1			1	1			1			1			1		1	35%
POL	*Polygonum spp.*	Smartweed, Knotweed			1	1			1		1	1							1				30%
CYP	*Cyperus spp.*	Sedge			1				1					1			1		1				25%
ELE	*Eleocharis spp.*	Roadgrass, Spikerushes		1	1	1				1						1							25%
LOP	*Ludwigia spp.*	Water Primroses, Primrosewillow		1		1				1	1						1						25%
SAG	*Sagittaria ssp.*	Arrowhead						1	1					1					1		1		25%

Figure 4. Lemon Bacopa (*Bacopa caroliana*)

Table 5. . Part 2 of list of emergent plants. Please see glossary at the end of this document for further information.

Code	Plant Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	% Occurance
AST	*Aster spp.*	Aster spp., Elliot's Aster							1							1		1				1	20%
DVA	*Diodia virginiana*	Buttonweed		1										1		1					1		20%
MSS	*Mikania scandens*	Climbing Hempvine			1	1		1												1			20%
RHY	*Rhynchospora spp.*	Beaksedge				1						1					1				1		20%
SCS	*Scirpus cubensis*	Burhead Sedge,Cuban Scirpus	1							1		1		1									20%
SCI	*Scirpus spp.*	Sedge			1			1	1											1			20%
CAN	*Canna spp.*	Canna (exotic)			1			1	1														15%
PAN	*Panicum spp.*	Panic grasses		1					1											1			15%
PSU	*Phyllanthus urinaria*	Leaf Flower				1								1									10%
BLS	*Blechnum serrulatum*	Swamp Fern		1	1																		10%
CYO	*Cyperus odoratus*	Fragrant Flatsedge				1			1														10%
PHN	*Panicum hemitomon*	Maidencane				1																1	10%
PIN	*Pinus spp.*	Pine Tree										1	1										10%
QLO	*Quercus laurifolia*	Laurel oak		1	1																		10%
SAL	*Salix spp.*	Willow				1		1															10%
TYP	*Typha spp.*	Cattails			1	1																	10%
WAX	*Myrica cerifera*	Wax Myrtle			1	1																	10%
BOC	*Boehmeria cylindrica*	Bog Hemp, False Nettle				1																	5%
CAM	*Crinum americanum*	Swamp lily															1						5%
DMI	*Desmodium incanum*	Creeping Beggarweed													1								5%
HSC	*Hibiscus coccineus*	Marsh Hibiscus			1																		5%
HTM	*Hypericum tetrapetalum*	Fourpetal St. John's-Wort								1													5%
IRI	*Iris spp.*	Flag			1																		5%
IVA	*Iris virginica*	Southern Blue Flag			1																		5%
MVA	*Magnolia virginiana*	Sweetbay Magnolia								1													5%
PCA	*Pontederia cordata*	Pickerel Weed			1																		5%
TGA	*Thalia geniculata*	Fireflag, Arrowroot			1																		5%
UNK	*UNKNOWN SPP*	Unidentified Plant Species		1																			5%

Figure 5. Australian Pine (*Casuarina equisetifolia*) is a non-native invasive species shown here on Lake Carroll.

Figure 6. Creeping Oxeye (*Sphagneticola trilobata*), foreground with yellow flowers and Brazilian Pepper (*Schinus terebinthifolius*), background, are both non-native invasive species on Lake Carroll

Table 6 List of Submerged Zone Aquatic Plants Found in Lake Carroll.

Code	Plant Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	% Occurance
HVA	*Hydrilla verticillata*	Hydrilla, water thyme											1	1	1				1				20%
VAA	*Vallisneria americana*	Tapegrass	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
EDA	*Egeria densa*	Common Waterweed	1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1	1		85%
ALG	*Algal Spp.*	Algal Mats, Floating		1	1		1		1		1	1	1		1	1		1	1	1	1	1	70%
MGM	*Micranthemum glomeratum*	Manatee Mudflower, Baby's Tears	1		1		1	1	1	1	1	1						1			1	1	55%
NGS	*Najas guadelupensis*	Southern Waternymph		1	1	1	1				1	1	1	1	1			1		1			55%
PIS	*Potamogeton illinoesis*	Pond Weed		1	1		1		1					1		1	1				1	1	45%
POT	*Potamogeton spp.*	Pond Weed					1		1														10%
CHA	*Chara spp.*	Muskgrass					1																5%
MUM	*Micranthemum umbrosum*	Shade Mudflower, Baby's Tears												1									5%
SKA	*Sagittaria kurziana*	Springtape			1																		5%

Figure 7. Hydrilla mixed with other submerged plants.

Section 3: Lake Water Chemistry

A critical element in any lake assessment is the long-term water chemistry data set. The primary source of water quality trend data for Florida Lakes is the Florida LAKEWATCH volunteer and the Florida LAKEWATCH water chemistry data. Hillsborough County is fortunate to have a large cadre of volunteers who have collected lake water samples for significant time period. These data are displayed and analyzed on the Water Atlas as shown in the following figures. Additional data, when available, is also included on the Water Atlas; however, the LAKEWATCH data remains the primary source. By the trend data shown in these figures, the lake may be considered in generally good health in terms of the trophic state index. Lake Carroll is a clear water lake and as such it must maintain a TSI of below 40 to not be considered impaired by the State of Florida guidelines. Figure 10 shows the TSI trend for Lake Carroll from 1997 through the most recent sample set in August of 2006. This same trend data for parameters of interest are shown in Figures 11, 12 and 13.

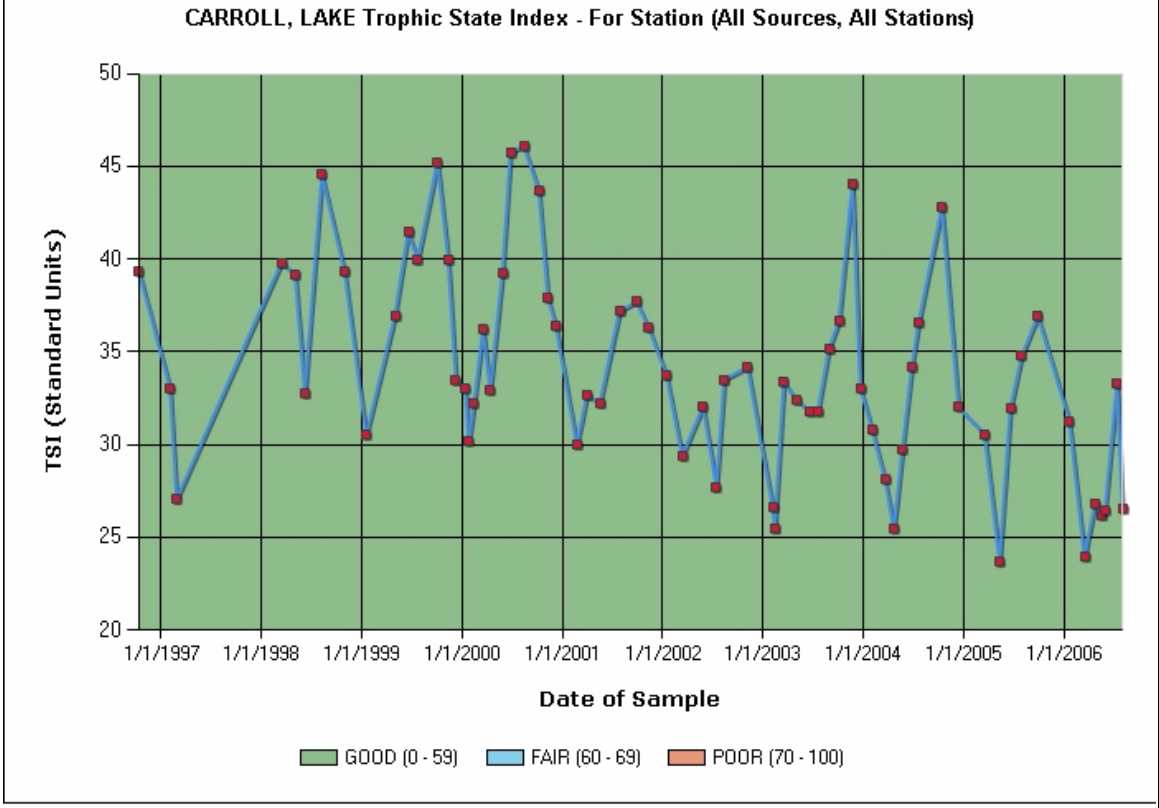


Figure 8. Trophic State Index (TSI) for Lake Carroll (*Hillsborough Watershed Atlas*)

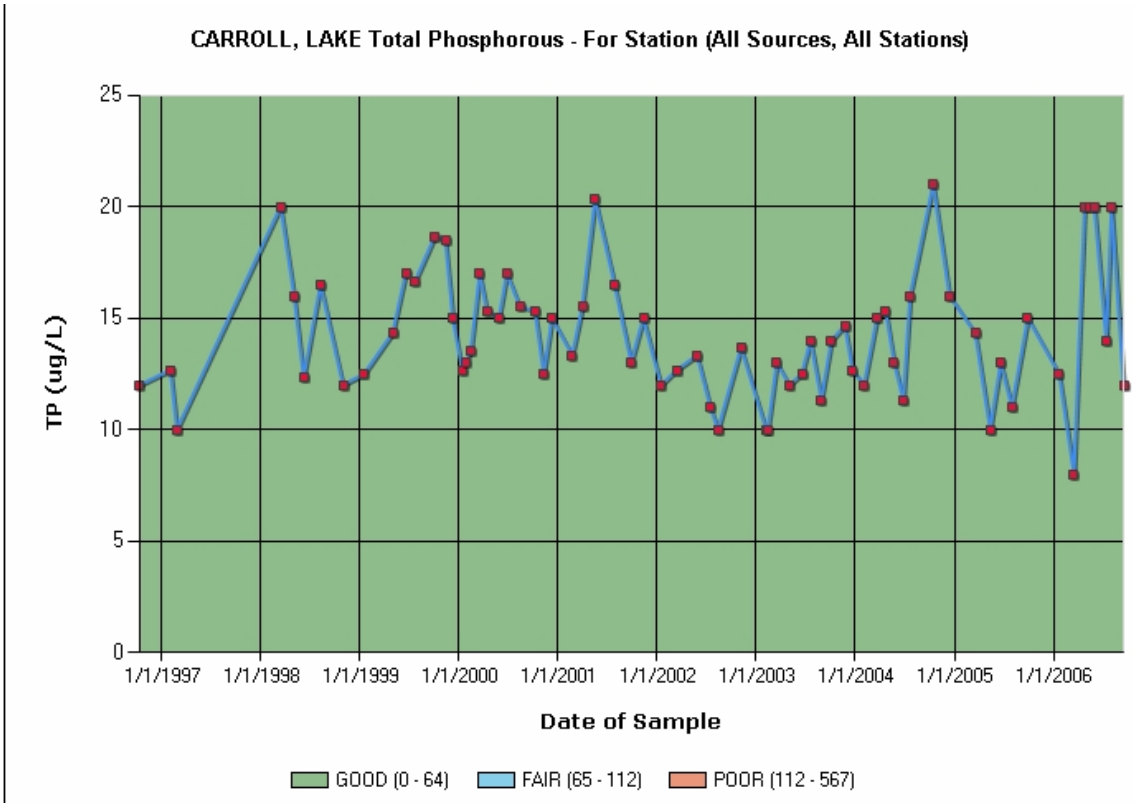


Figure 9 Total Phosphorus (TP) for Lake Carroll (*Hillsborough Watershed Atlas*)

[v]. Lake Carroll's long term water quality data contain enough violations of these criteria to be classified by Florida DEP as impaired. The more recent data indicate an improving trend. The higher TSI values correspond to sample dates that follow a 10 day and/or 20 day period of higher than average rain fall. For the period between January 1, 2005 and November 30, 2006 there is a positive relationship ($R^2 = 0.541$) between TSI and 10 day rainfall. Figure 14 shows the rainfall for the Upper Sweetwater Creek watershed.

Our assessment on June 21, 2006 followed a ten day period where rainfall was in excess of 5 inches. These data indicated a rise in TSI (35.92) from the most recent LAKEWATCH data; however, this remains below the impairment limit of 40. Phosphorus is the limiting nutrient and its control remains the most important single factor in maintaining the chlorophyll level in the lake.

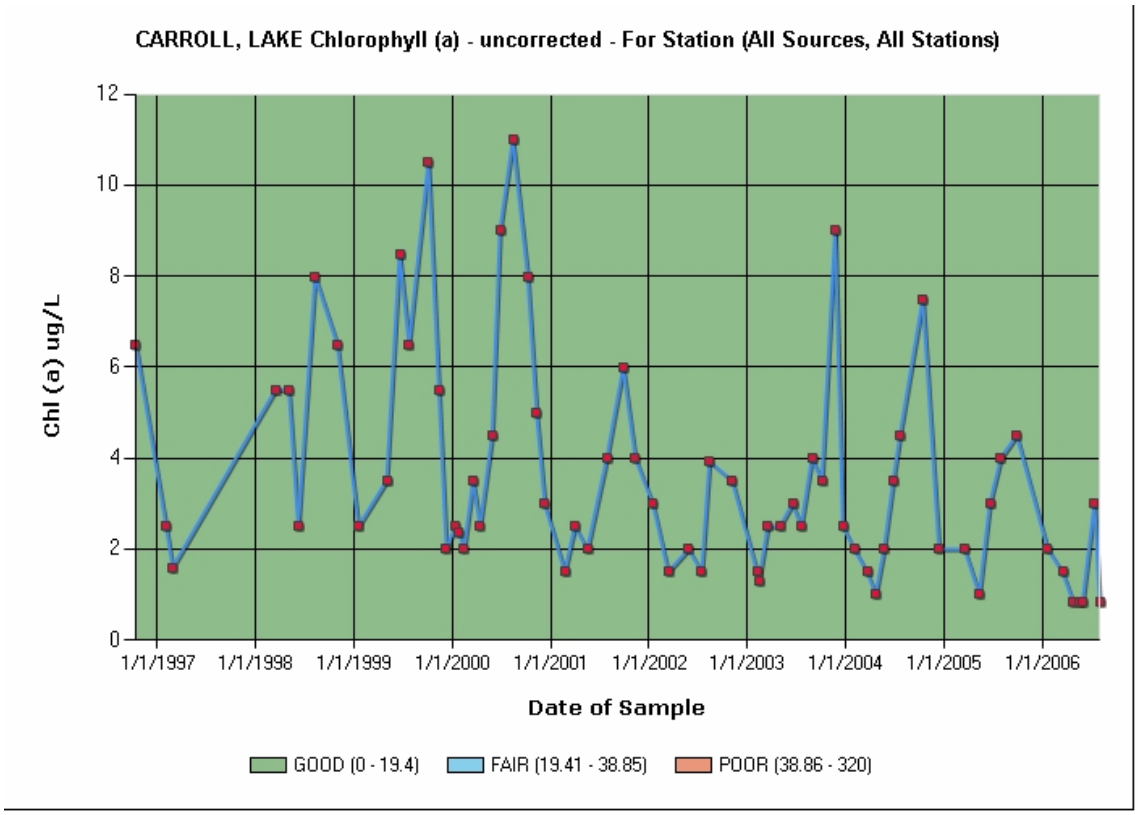


Figure 10 Chlorophyll (alpha) concentration for Lake Carroll (*Hillsborough Watershed Atlas*)

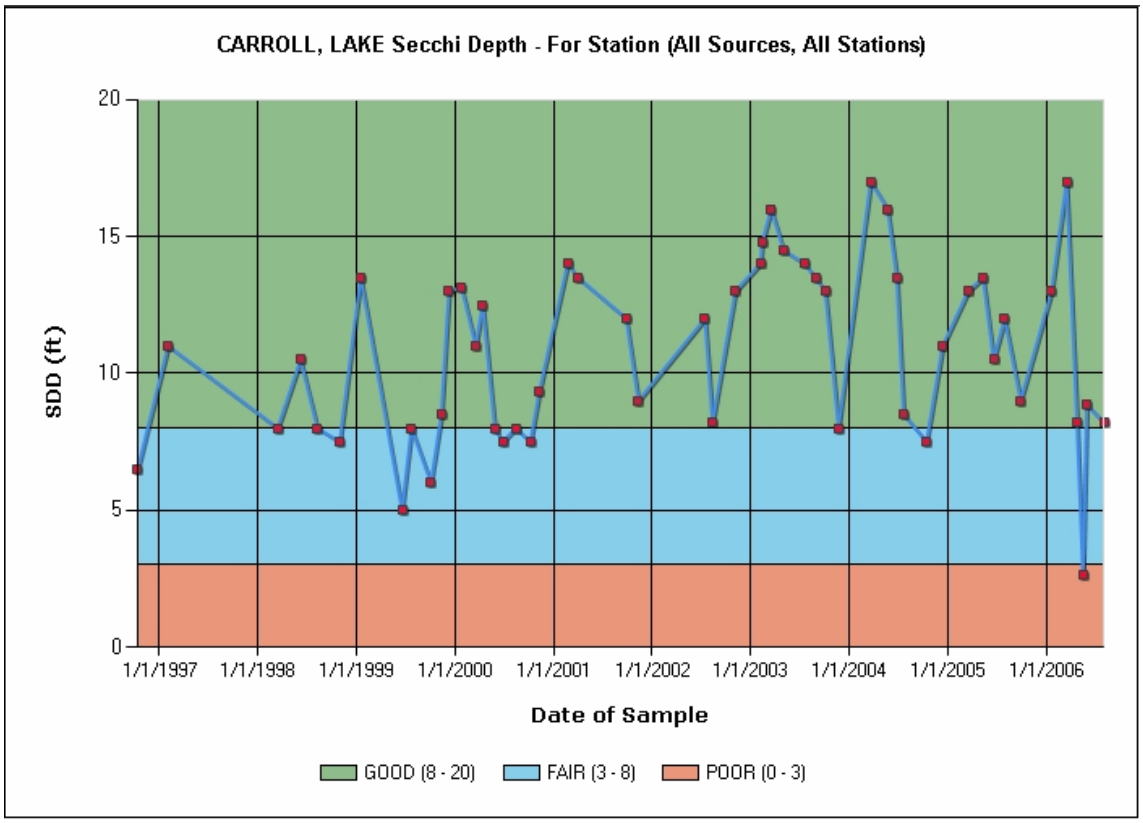


Figure 11 Secchi Disk depth for Lake Carroll (*Hillsborough Watershed Atlas*)

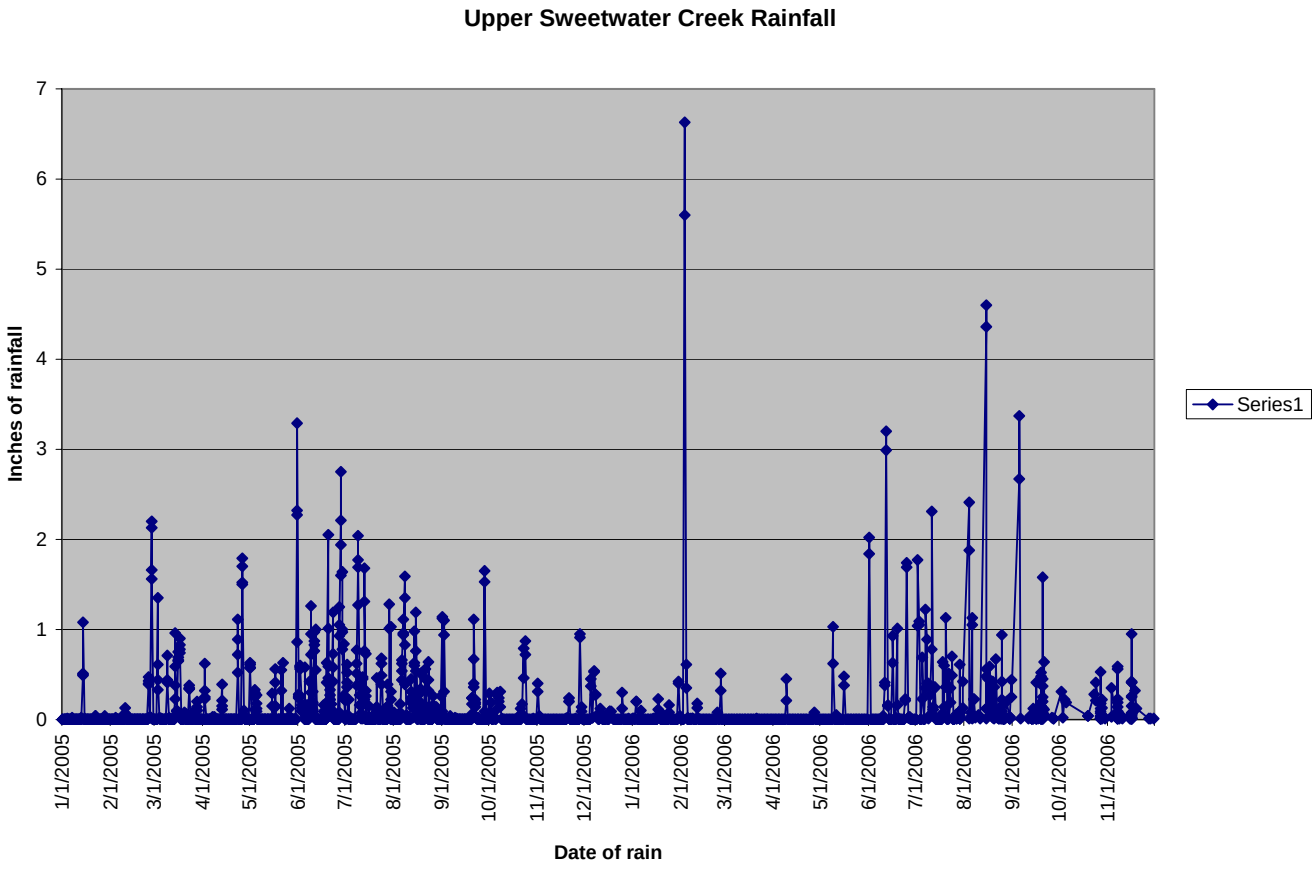


Figure 12. Sweetwater Creek Rainfall for 2005 – November 2006.

As part of the lake assessment, the physical water quality and water chemistry of a lake are measured. These data only indicate a snap shot of the lakes water quality; however they are useful to comparing to the trend data. Table 7 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. These data compare reasonably well with the LAKEWATCH data especially when rainfall is considered. The trophic state index (TSI) calculated from the sample data (35.92) is well within the values shown in Figure 10.

Table 8 contains the field data taken in the center of the lake using a YSI Corporation – 6000 multi-probe which has the ability to directly measure the temperature, pH, dissolve oxygen (DO), percent DO (calculated from DO, temperature and conductivity) and Turbidity. These data are listed for three levels in the lake and twice for the surface

measurement. The duplicate surface measurement was taken as a quality assurance check on measured data. The bottom overall dissolved oxygen in high in Lake Carroll and the bottom reading is higher than the other levels. While this is an unusual measurement and should be checked, it may indicate a high level of productivity for submerged vegetation. The pH also shows the same trend and pH is also elevated by the productivity (high photosynthetic activity). Surface ORP (measure of reductively) may indicate an error for initial surface reading).

Table 7 Water Quality Parameters (laboratory) Note, although the ratio of total nitrogen to total phosphorus for this sample set would indicate a balanced system the we use the long term trend data to determine N:P. These data indicate a phosphorus limited system with a slight trend towards becoming balanced.

Summary Table for Water Quality		
Parameter	Value	Comment
TP ug/L	23.00	
TN mg/L	0.45	
Chla ug/L	1.40	
Chla TSI	21.65	
TP TSI	50.20	
TN TSI	42.24	
Secchi Disk (SD)	14.74	
TSI	35.92	P limited*
PAC	85%	
PVI	35%	
Adj TP	4.53	P from Veg Added
Adj TSI	38.04	With additional P

Table 8 Field Observed Values (YSI). The Secchi Disc measurement was 14.2 feet.

Sample Location	Time	Temp (oC)	Conductivity (mS/cm3)	Dissolved Oxygen (%)	DO (mg/L)	PH (PH)	ORP (ORP)	Tubidity (NTU)
surface	15:04	31.07	0.217	115.9	8.6	8.64	251.8	0
mid	15:04	31.06	0.218	114.4	8.47	8.68	116	0.1
bottom	15:04	30.7	0.218	123.3	9.25	9.07	120.2	0.5
surface	15:04	31.16	0.218	115.3	8.54	8.78	127.9	0.1
Mean		30.9975	0.21775	117.225	8.715	8.7925	153.975	0.175

Table 7 also provides data derived from the vegetation assessment which is used to determine an adjusted TSI (Adj TSI) based on adjusted phosphorus (Adj. TP). This is accomplished by calculating the amount of phosphorus that could be released by existing

submerged vegetation if this vegetation were treated with an herbicide or managed by the addition of Triploid Grass Carp (*Ctenopharyngodon idella*). Carp are used in Lake Carroll to manage vegetation and all indications from this and previous lake assessment indicate that the carp have acted as a good biological solution to the control of invasive species like Hydrilla. Approximately 85% of the lake has submerged vegetation present and this vegetation represents about 35% of the available lake volume. The vegetation holds enough phosphorus to add about 4.53 µg/L of the nutrient to the water column. Because the growth of algae in the water is regulated by the availability of phosphorus (the lake is phosphorus limited), the release of this phosphorus would stimulate algal growth. These changes in the water chemistry and biology would be indicated by an increased TSI. If all the submerged vegetation were removed the TSI would increase by 4.53 units and the new TSI would be 38.04. The lake water clarity which is indicated by the Secchi Disk (SD) depth (a measure of visibility) would be reduced under these conditions.

Section 4: Conclusion

Lake Carroll is a medium to large sized (211 acres) lake that would be considered in the mesotrophic (good) category of lakes based on water chemistry. About 85% of the open water areas contain submerged vegetation and this vegetation helps to maintain the nutrient balance in the lake as well as provide good fish habitat. The lake has many open water areas that support various types of recreation and has a good diversity of plant species. The primary nuances plants in the lake include Punk tree (Melaleuca), Aligator weed (*Alternanthera philoxeroides*), Hydrilla (*Hydrilla verticillata*), and Pond Weed (Potamogeton illinoesis). For more information and recent updates please see the Hillsborough Watershed Atlas (water atlas) website at:
http://www.hillsborough.wateratlas.usf.edu/lake/waterquality.asp?wbodyid=5168&wbodyatlas=lake

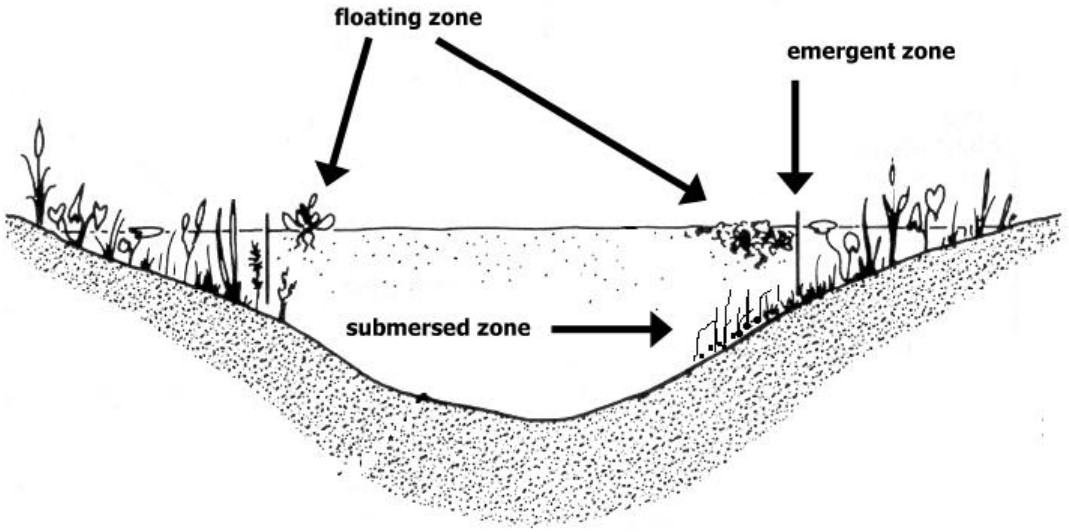
i"Trophic" means "relating to nutrition." The Trophic State Index (TSI) takes into account chlorophyll, nitrogen, and phosphorus, which are nutrients required by plant life. For more information please see *learn more* at: http://www.hillsborough.wateratlas.usf.edu/lake/default.asp?wbodyid=5168&wbodyatlas=lake

[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. Lake volumes, hydrolic retention time and carrying capacity are important parts of lake 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. 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.

[iv] Differential global positions systems use a reference signal to improve the accuracy of measurements.

[v] The three primary aquatic vegetation zones are shown below:



[v] A lake is impaired if " (2) For lakes with a mean color less than or equal to 40 platinum cobalt units, the annual mean TSI for the lake exceeds 40, unless paleolimnological information indicates the lake was naturally greater than 40, or
For any lake, data indicate that annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the means plotted versus time, or the annual mean TSI has increased by more than10 units over historical values. When evaluating the slope of mean TSIs over time, the Department shall use a Mann's one-sided, upper-tail test for trend, as described in Nonparametric Statistical Methods by M. Hollander and D. Wolfe (1999 ed.), pages 376 and 724 (which are incorporated by reference), with a 95% confidence
level."
Excerpt from Impaired Water Rule (IWR). Please see:
http://www.dep.state.fl.us/water/tmdl/docs/AmendedIWR.pdf