Lake Carroll

Methods

Study Area Analysis

The watershed containing Lake Carroll was analyzed using ESRI ArcGIS 10.2. Using this software with 2014 Hillsborough County aerial, Land Use/ Land Cover (LULC), Landscape Development Intensity (LDI) Index values were calculated for the 100 meter buffer surrounding the lake following the procedures of Brown & Vivas 2003, 2005 (Brown & Vivas. 2003. A Landscape Development Intensity (LDI) Index. Center for Environmental Policy, Department of Environmental Engineering Sciences, University of Florida. Technical Report Submitted to the Florida Department of Environmental Protection) and (Brown & Vivas. 2005. Landscape development intensity index. Environmental Monitoring and Assessment 101: 289-309.) According to Brown and Vivas, "The intensity and aerial extent of human activities in a landscape may adversely affect the ecological processes of natural communities…the Landscape Development Intensity Index (LDI) functions as an objective measure of how human disturbance affects biological, chemical, and physical processes of aquatic systems. By incorporating non-renewable energy input expenditures… natural systems were assigned a non-renewable empowerment density of 0. The landscape development intensity (LDI) index is calculated as the percentage area within the catchment of a particular type of land use multiplied by the coefficient of energy use associated with that land use, summed over all land use types found in the catchment."

Lake Bathymetry and Morphological Characteristics Assessment

The **Bathymetric Map**[i] provides the lake's morphologic parameters in various units. The bottom of the lake was mapped using a Lowrance HDS 5 Gen 2 Wide Area Augmentation System (WAAS)[ii] 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 lake's area, mean and maximum depths, and volume and the creation of a bottom contour map. 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.

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[i] 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, hydraulic retention time and carrying capacity are important parts of lake management that require the use of a bathymetric map.

[ii] 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 2.

Lake Vegetation Index Assessment

Hillsborough County requested the implementation of the Florida Department of Environmental Protection methods for Lake Vegetation Index (LVI 1000) (http://www.dep.state.fl.us/water/sas/sop/sops.htm) using forms FD 9000-03 (Physical/Chemical Characterization), FD 9000-06 (Lake Habitat Assessment) FD 9000-27 (LVI Field Sheet) and FD 9000-31 (Lake Observation Field Sheet).

The Lake Vegetation Index (LVI) is a rapid assessment protocol in which selected sections of a lake are assessed for the presence or absence of vegetation through visual observation and through the use of a submerged vegetation sampling tool called a Frodus. The assessment results provide a list of species presents and the dominant and where appropriate co-dominant species that are found in each segment. These results are then entered into a scoring table and a final LVI score is determined. LVI scores provide an estimate of the vegetative health of a lake. Our assessment team was trained and qualified by FDEP to conduct these assessment as an independent team and must prequalify each year prior to conducting additional assessments. The LVI method consists of dividing the lake into twelve pie-shaped segments (see diagram below) and selecting a set of four segments from the twelve to include in the LVI. The assessment team then travels across the segment and identifies all unique species of aquatic plant present in the segment. Additionally, a Frodus is thrown at several points on a single five-meter belt transect that is established in the center of the segment from a point along the shore to a point beyond the submerged vegetation zone. For scoring, the threshold score for impairment is 37.

Four metrics are utilized in the Lake Vegetation Index Survey; Dominant Coefficient of Conservatism (CoC), Percent Florida Exotic Pest Plant Council Type 1 (% FLEPPC), Percent Native Taxa, Percent Sensitive Taxa.

The Dominant Coefficient of Conservatism (CoC) metric for the dominant or co-dominate species in each section. The CoC applies a score of 0-10 to each species based on its ecological tolerances and fidelity to pre-settlement conditions. Species with higher scores show a high fidelity to native, undisturbed habitats and are typically sensitive to alterations. Available CoC scores can be obtained from LT 7000 from the Florida Department of Environmental Protection at: http://www.dep.state.fl.us/water/sas/sop/sops.htm.

The percent FLEPPC (Florida Exotic Pest Plant Council) Category 1 invasive exotic taxa in a single sampling unit (pie slice) by dividing the number of FLEPPC Category I taxa by the total number of taxa in that sampling unit. Multiply result times 100. Refer to Appendix LVI 1000-1 to determine which plants are on the FLEPPC Category 1 list. Note that not all exotic taxa should be included in this metric, only those listed in Appendix LVI 1000-1 as Category 1 FLEPPC. If the FLEPPC updates their list of Category 1 exotics, those updates shall not be reflected in this calculation until they are included in Appendix LVI 1000-1.

The percent native taxa in a single sampling unit (pie slice) is calculated by dividing the number of native taxa by the total number of taxa in that sampling unit. Multiply result times 100. Nativity status is determined by the Plant Atlas from the Institute for Systematic Botany, and is listed in

Appendix LVI 1000-1. For informational purposes, visit the website http://www.florida.plantatlas.usf.edu/. Taxa that are native according to the Plant Atlas from the Institute for Systematic Botany but are not on the list in Appendix LVI 1000-1 may be included in this metric calculation, but inclusion of these additional taxa is not required.

The percent sensitive taxa in a single sampling unit by summing the number of taxa with a C of C (Coefficient of Conservatism) score >= 7 and then dividing by the total number of taxa in that sampling unit. Multiply result times 100. Refer to Appendix LVI 1000-1 for a list of C of C scores.

The collected bathymetric data is analyzed for submerged aquatic vegetation (SAV) calculations including the percentage of the surface area of the lake inhabited by SAV as well as an estimate of the percent volume of the lake inhabited by SAV. SAV is an important component to a lakes nutrient cycling as well as chlorophyll concentrations due to the SAV and phytoplankton competing for available nutrients in the water column. In addition SAV serves a vital role as habitat for many species of macroinvertebrates and fish as well as substrate for epiphytic algae.

Water Quality Assessment

Physical water quality samples were taken using a Eureka Manta Sub-2 multiprobe pre and post calibrated on the day of the assessment. Measurements taken with this device include: depth, conductivity, pH, Dissolved Oxygen (mg/l and % Saturation) and salinity. Chemical water parameters were collected and preserved on ice by USF Water Institute staff and analyzed at the Environmental Protection Commission of Hillsborough County Laboratory. Analysis include; Chlorophyll (a, b, c, t and corrected), Alkalinity, Color, Fecal Coliform, Enterococci, Ammonia, Nitrates/Nitrites, Total Phosphorous, Kjeldahl Nitrogen and Total Nitrogen. The results of the water quality sampling effort will be discussed in the framework of the FDEP Numeric Nutrient Criteria

Study Area

Lake Carroll is located between North Dale Mabry and interstate 275, south of West Fletcher Ave in Tampa, Florida. The Landscape Development Intensity Index of the 100 meter buffer around Lake Carroll is dominated by Residential (95.1%) land uses. The resulting LDI value for the 100 meter buffer around Lake Carroll is 7.85. The LDI value calculated for the FDEP WBID containing Lake Carroll was 6.82 with approximately 51.95% Residential, 10.8% Commercial and Services, and 8.76% Industrial land uses.

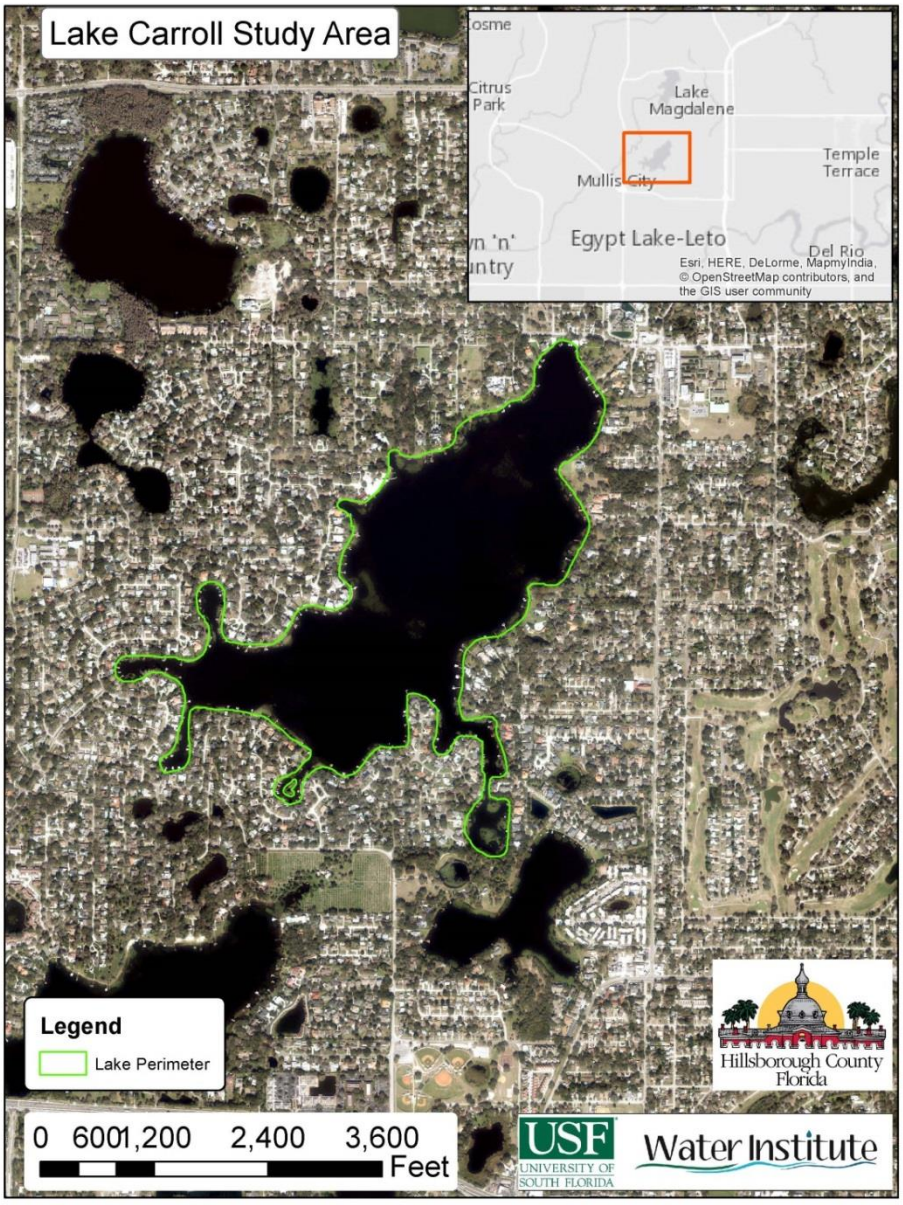

Figure 1 2016 Lake Carroll Assessment Study Area Map

Lake Bathymetry and Morphological Characterization

Lake Carroll is an urban 213 acre lake with moderate depths. Lake Carroll at the time of the assessment had a mean water depth of 9.4 feet and a maximum observed depth of 34.25 feet. The volume at this time was approximately 653,479,070 gallons. Figure 2 shows the resulting bathymetric contour map for Lake Carroll from data collected on June 23, 2016. The collected data has been overlain the 2014 Hillsborough County aerials.

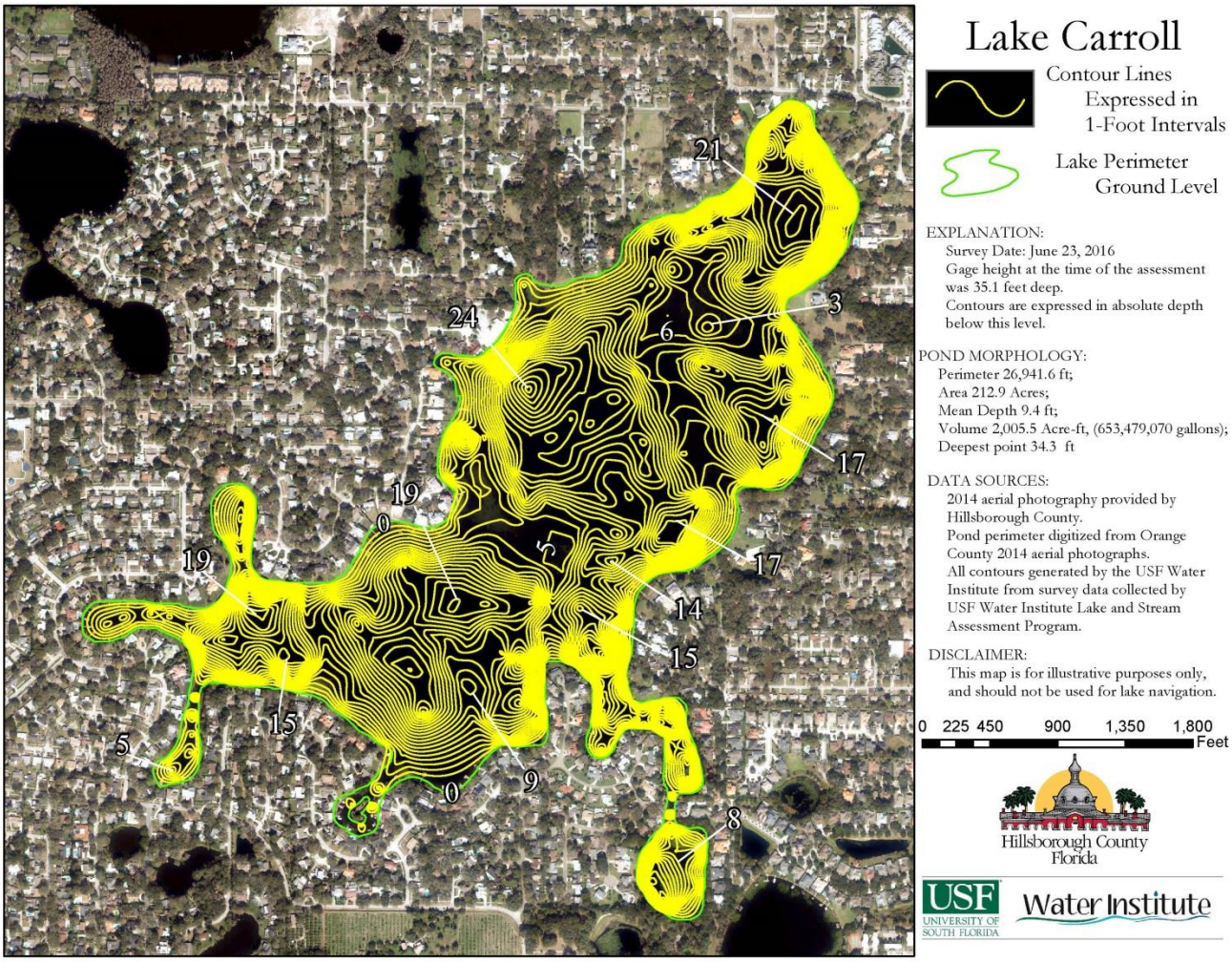

Figure 2 2016 1-Foot Bathymetric Contour Map for Lake Carroll.

Table 1 Morphological Calculations for Lake Carroll.

Parameter	Feet	Meters	Acres	Acre-Ft	Gallons
Surface Area (sq)	9,273,989	861,575	212.9	0	0
Mean Depth	9.45	2.87	0	0	0
Maximum Depth	25.16	7.67	0	0	0
Volume (cubic)	87,356,840	2,473,647	0	2,005.5	653,479,070
Gauge (relative)	35.1	10.70	0	0	0

Lake Vegetation Index Assessment

Figure 3 Overview photograph of Lake Carroll

The lake assessment for Lake Carroll was conducted on June 23, 2016. Lake Carroll received a lake habitat assessment (FEDP form FD 9000-6) score of 68 due to optimal scores for Bottom Substrate Quality and suboptimal scores for Secchi and Vegetation Quality. Marginal scores were achieved for Stormwater Inputs and Adverse Watershed Land Use. Lakeside Adverse Human Alterations and Upland Buffer Zone received poor scores.

Figure 4 Lake Carroll had a limited buffering zone of emergent vegetation surrounding the lake containing a mixture of native and invasive species.

The Lake Vegetation Index identified 49 species of wetland vegetation growing in the four selected sections along Lake Carroll. The majority of these species (39) are native species. The remaining 10 species (In bold on Table 2) are non-native and invasive to this region. The vegetation community along Lake Carroll is heavily altered by residential yards. What emergent vegetation is present is dominated by a variety of emergent species including *Typha, Taxodium* and *Panicum repens* (Figure 5). The water's surface in Lake Carroll was dominated by *Nymphaea odorata* (Figure 6). The calculated LVI score for Lake Carroll was 57, above the impairment threshold of 37. Figure 7 shows the map of Lake Dan detailing the LVI regions used for the assessment. Table 2 details the species list results of the Lake Vegetation Index. Table 3 details the scoring result for the Lake Vegetation Index. Submerged vegetation was observed during the assessment both visually and by using the frodus sampler indicating dominance by *Bacopa caroliniana* and *Vallisneria americana*. By analyzing the collected sonar chart, submerged aquatic vegetation was present in most areas to a depth of 15.2 feet. The submerged vegetation covered approximately 71% of the surface area of Lake Carroll. This submerged vegetation inhabits an estimated 19.2% of the water volume in Lake Carroll.

Figure 5 emergent vegetation zone on Lake Carroll

Figure 6 *Nymphaea odorata* on Lake Carroll

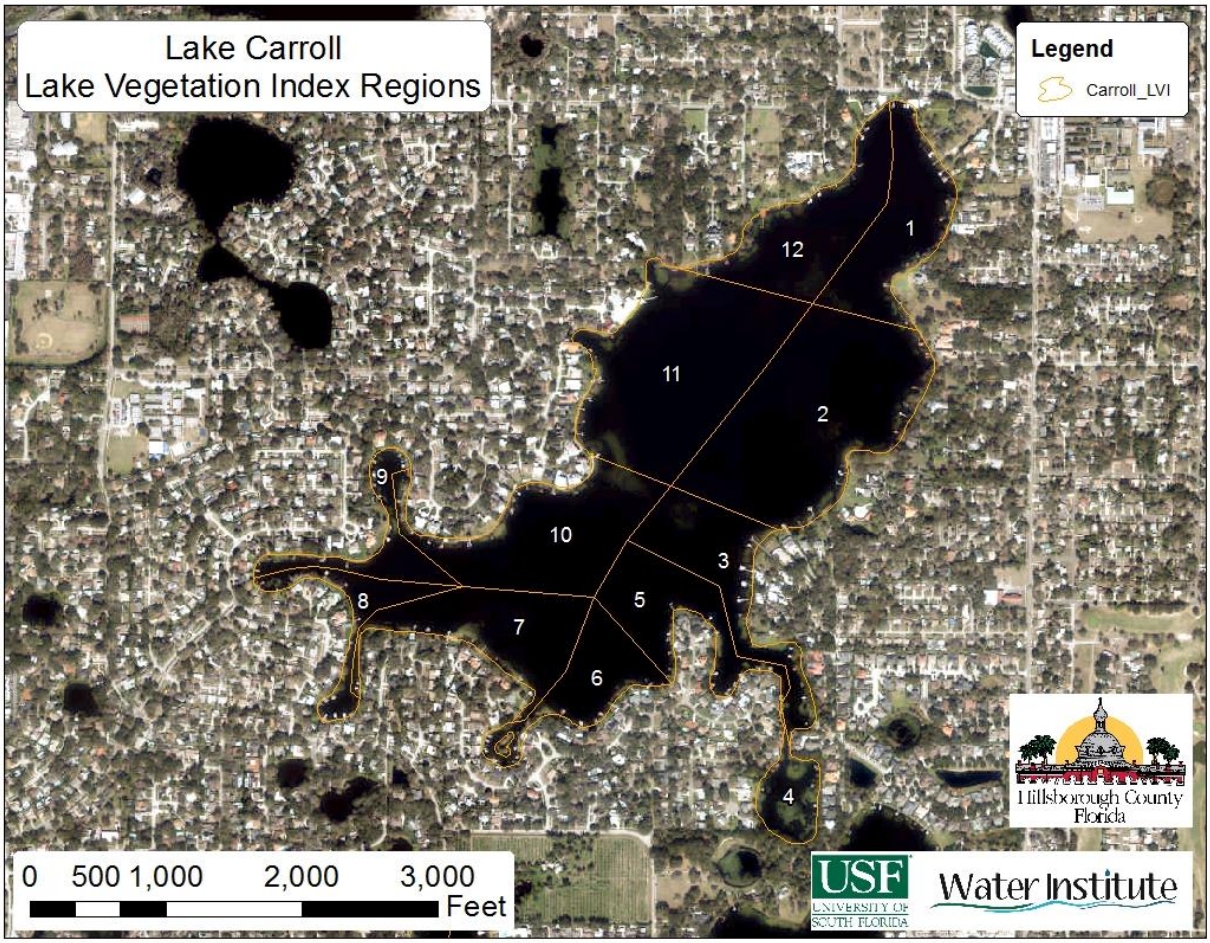

Figure 7 Lake Vegetation Index region map for Lake Carroll.

Table 2 Lake Vegetation Index results for Lake Carroll 6/23/2016

SPECIES	Region				
	CofC	2	5	8	11
Alternanthera philoxeroides	0.00	**1**	**1**	**1**	**1**
Hydrocotyle	2.00	**1**	**1**	**1**	**1**
Ludwigia arcuata	3.50	**1**	**1**	**1**	**1**
Nymphaea odorata	5.00	**1**	**1**	**1**	**1**
Panicum repens	0.00	**1**	**1**	**1**	**1**
Sphagneticola trilobata	0.00	**1**	**1**	**1**	**1**
Bacopa caroliniana	4.50	**c**	**c**	**c**	**c**
Vallisneria americana	7.00	**c**	**c**	**c**	**c**
Bacopa monnieri	3.50	**1**	**1**		**1**
Cyperus odoratus	3.00	**1**		**1**	**1**
Eclipta prostrata	2.00		**1**	**1**	**1**
Nuphar	3.50	**1**		**1**	**1**
Nymphoides aquatica	6.09	**1**		**1**	**1**
Utricularia gibba	6.37	**1**	**1**		**1**
Taxodium	7.00	**1**	**1**	**1**	
Eleocharis baldwinii	2.82			**1**	**1**
Cyperus alternifolius	0.00	**1**	**1**		
Eupatorium capillifolium	0.83	**1**		**1**	
Fuirena scirpoidea	5.50	**1**	**1**		
Ludwigia leptocarpa	3.00	**1**		**1**	
Ludwigia peruviana	0.00		**1**	**1**	
Pontederia cordata	5.38	**1**	**1**		
Quercus laurifolia	4.00	**1**		**1**	
Centella asiatica	1.92				**1**
Diodia virginiana	3.00				**1**
Eleocharis interstincta	7.80				**1**
Micranthemum glomeratum	5.85				**1**
Mikania scandens	1.95				**1**
Nitella	6.00				**1**
Acer rubrum	4.65	**1**			
Blechnum serrulatum	5.50	**1**			
Casuarina equisetifolia	0.00	**1**			
Colocasia esculenta	0.00	**1**			
Commelina diffusa	2.02		**1**		
Cyperus surinamensis	2.03			**1**	
Erechtites hieracifolia	1.00		**1**		
Hibiscus coccineus	5.45	**1**			
Hygrophila polysperma	0.00			**1**	
Ilex cassine	6.00	**1**			
Iris virginica	5.50	**1**			
Juncus megacephalus	3.50	**1**			
Lemna	1.00			**1**	
Melaleuca quinquenervia	0.00	**1**			
Mimosa pigra	0.00			**1**	
Panicum hemitomon	5.82			**1**	
Polygonum glabrum	4.50	**1**			
Polygonum hydropiperoides	2.50	**1**			
Sagittaria lancifolia	3.00		**1**		
Salix caroliniana	2.95	**1**			

Table 3 Scoring Summary for the Lake Vegetation Index

LVI Score Summary	Region			
	2	5	8	11
Total # of taxa in sampling unit	32	19	23	21
% Native taxa in sampling unit	78.125	68.42105	73.91304	85.71429
% FLEPPC CAT 1 taxa in sampling unit	12.5	10.52632	17.3913	4.761905
% Sensitive taxa in sample unit	6.25	10.52632	8.695652	9.52381
Dominant CoC in sample unit	5.75	5.75	5.75	5.75

Native Score ((x-62.5)/37.5) or ((x-66.67)/25.89)=	0.442449	0.067634	0.279762	0.735585
Invasive FLEPPC 1 Score (1 - (x/30))=	0.583333	0.649123	0.42029	0.84127
Sensitive Score (x/(27.78 or 20)) =	0.3125	0.526316	0.434783	0.47619
Dominant CoC Score (x/(7.91 or 7)) =	0.821429	0.821429	0.821429	0.821429
Raw Score Total = N+I+S+D =	2.159711	2.064501	1.956263	2.874474
Division Factor = (3 D=0 or 4) =	4	4	4	4
Average LVI dividend = Raw /DF	0.539928	0.516125	0.489066	0.718618
South				
LVI Score for sampling unit =	53.99277	51.61254	48.90658	71.86184
Total LVI SCORE =	57			

Water Quality Assessment

Long-term water quality data is partially available, however the temporal coverage is insufficient for Lake Carroll for the calculation of the FDEP Numeric Nutrient Criteria. The available data was collected as part of this lake assessment. Table 4 provides a summary of the Physical/Chemical conditions recorded at the middle of Lake Carroll.

Table 4 Lake Carroll Water Quality (Field)

Depth (m)	Temp (°C)	pH	DO (mg/L)	DO (% Sat)	Cond (umho/cm)	Salinity (ppt)	Secchi (m)
0.28	32.13	8.87	8.48	113.8	214	0.1	3
0.49	32.11	7.49	7.7	102.57	214	0.1	
2.86	31.64	7.51	7.41	97.92	214	0.1	
4.92	31.35	7.78	7.69	101.17	214	0.1	

The chemical water quality analysis for Lake Carroll is shown in Table 5 for the sample taken on June 28, 2016. Table 6 includes this data in the numeric nutrient criteria framework using the data from this assessment since geometric mean values for the past three years for available parameters are not available. Table 7 contains a calculated NNC using the available data. Total Phosphorous values were below the nutrient threshold for clear alkaline lakes with insufficient data developed by FDEP of 0.03 mg/l with a value of 0.016 mg/l. Total Nitrogen values were below the nutrient threshold for clear alkaline lakes with insufficient data developed by FDEP of 1.05 mg/l with a value of 0.511 mg/l. Chlorophyll-a values are below the nutrient threshold for clear alkaline lakes developed by FDEP of 20.0 µg/l with a value of 3.9 µg/l.

Bacteria testing showed elevated levels of Fecal Coliform (200 colonies/100ml) equal to the threshold set forth in FDEP 62-302.530 as well as elevated Enterococci bacteria (240 colonies/100ml) (https://www.flrules.org/gateway/RuleNo.asp?title=SURFACE%20WATER%20QUALITY%20STANDARDS&ID=62-302.500) "Most Probable Number (MPN) or Membrane Filter (MF) counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period."

Table 5 Lake Carroll Water Quality Results from 6/28/2016 (Laboratory)

Parameter	Value	Units
Alkalinity	30.0	mg/LCaCO3
Nitrates/Nitrites	0.003	mg/L
Fecal Coliform	200	#/100 ml
Enterococci	240	#/100 ml
Chlorophyll a	3.9	ug/L
Chlorophyll b	2.6	ug/L
Chlorophyll c	0.8	ug/L
Chlorophyll t	5.2	ug/L
Chlorophylla Corr	3.9	ug/L
Chlorophyll-pheo	6.6	ug/L
Ammonia	0.007	mg/L
Kjeldahl Nitrogen	0.508	mg/L
Total Nitrogen	0.511	mg/L
Total Phosphorus	0.016	mg/L
Color(345)F.45	24.8	Pt/Co

Table 6 Numeric Nutrient Criteria Framework

Parameter	Value
Geometric Mean (Geomean) Color (pcu)	24.8
Number of Samples	1
Geometric Mean Alkalinity (mg/L CACO3)	30
Number of Samples	1
Lake Type	Clear Alkaline
Chlorophyll a Criteria (ug/L)	20
Insufficient for Geomean Criteria then P mg/L	0.03
Insuffcient for Geomean Criteria then N mg/L	1.05
Geomean Chla ug/L	3.9
Geomean TP mg/L	0.016
Geomean TN mg/L	0.511
Number of Samples	1
Potential Impaired Chlorophyll a	Not Impaired
Potential Impaired TP	Not Impaired
Potential Impaired TN	Not Impaired

Table 7 NNC calculation for Lake Carroll

Yearly Geomeans	Chlorophyll a (ug/L)	Total Phosphorous (mg/L)	Total Nitrogen (mg/L)	Number of Samples
2014	2.97	0.011	0.441	5
2015	1.85	0.12	0.437	3
2016	2.98	0.017	0.523	2
3-Year Geomean	2.54	0.013	0.465	

Conclusion

The results of the assessment of Lake Carroll does not show impairment based on Total Nitrogen, Total Phosphorous and Chlorophyll concentrations according to the FDEP numeric nutrient criteria using the single sample taken during this assessment. Although some data is available for the previous 3 year period, the data is temporally insufficient. Long term sampling would be necessary to determine actual NNC values. The system also does not show impairment in the vegetation communities according to the Lake Vegetation Index with high overall species, low occurrences of non-native, invasive species and a multiple sensitive plant species with an overall LVI score of 57. Bacteria sampling revealed an elevated biomass of Fecal Coliform and Enterococci bacteria present at the time of the assessment.