

# Minimum and Guidance Levels for Lake Carroll in Hillsborough County, Florida



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Ecologic Evaluation and Hydrologic Evaluation Sections  
Resource Projects Department

**Southwest Florida**  
*Water Management District*



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**Cover Page: Aerial view of Lake Carroll with source imagery collected in 1957 by the United States Department of Agriculture, Soil Conservation Service (University of Florida, 2011)**

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## Minimum and Guidance Levels for Lake Carroll

State law (Section 373.042, Florida Statutes; hereafter F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. As currently defined by statute, the minimum flow for a given watercourse "shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area", and the minimum level of an aquifer or surface water body is "the level of groundwater in the aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." Minimum flows and levels are established and used by the Southwest Florida Water Management District (District) for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and use of surface water management systems.

Development of a minimum flow or level does not in itself protect a water body from significant harm; however, resource protection, recovery and regulatory compliance can be supported once the flow or level standards are established. State law governing implementation of minimum flows and levels (Chapter 373.0421, F.S.) requires development of a recovery or prevention strategy for water bodies if the "existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level". Recovery or prevention strategies are developed to: "(a) achieve recovery to the established minimum flow or level as soon as practicable; or (b) prevent the existing flow or level from falling below the established minimum flow or level." Periodic reevaluation and as necessary, revision of established minimum flows and levels are also required by state law.

Minimum flows and levels are to be established based upon the best available information with consideration given to "...changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer...", with the caveat that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421, F.S.). The Florida Water Resources Implementation Rule (Chapter 62-40.473, Florida Administrative Code; hereafter F.A.C.) provides additional guidance for the establishment of minimum flows and levels, requiring that "consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows, and environmental values associated with coastal, estuarine, aquatic and wetland ecology, including: a) recreation in and on the water; b) fish and wildlife habitats and the passage of fish; c) estuarine resources; d) transfer of detrital material; e) maintenance of freshwater storage and supply; f) aesthetic and scenic attributes; g) filtration and absorption of nutrients and other pollutants; h) sediment loads; i) water quality; and j) navigation." The Water Resource Implementation Rule also indicates that "minimum flows and levels should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond

which further withdrawals would be significantly harmful to the water resources or the ecology of the area".

The Southwest Florida Water Management District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers and aquifers, subjected the methodologies to independent, scientific peer-review, and incorporated the methods into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C). For lakes, methodologies have been developed for establishing Minimum Levels for systems with fringing cypress-dominated wetlands greater than 0.5 acre in size, and for those without fringing cypress wetlands. Lakes with fringing cypress wetlands where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands are classified as Category 1 Lakes. Lakes with fringing cypress wetlands that have been structurally altered such that lake water levels do not rise to levels expected to fully maintain the integrity of the wetlands are classified as Category 2 Lakes. Lakes without at least 0.5 acre of fringing cypress wetlands are classified as Category 3 Lakes. Chapter 40D-8, F.A.C. also provides for the establishment of Guidance Levels, which serve as advisory information for the District, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures. Information regarding the development of adopted methods for establishing Minimum and Guidance lake levels is provided in Southwest Florida Water Management District (1999a, b), Leeper *et al.* (2001) and Leeper (2006). Peer-review findings regarding the lake level methods are available in Bedient *et al.* (1999), Dierberg and Wagner (2001) and Wagner and Dierberg (2006).

Two Minimum Levels and two Guidance Levels have typically been established for lakes, and upon adoption by the District Governing Board, incorporated into Chapter 40D-8, F.A.C. The levels, which are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD), are described below.

- The **High Guidance Level** is provided as an advisory guideline for construction of lakeshore development, water dependent structures, and operation of water management structures. The High Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ten percent of the time on a long-term basis.
- The **High Minimum Lake Level** is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis.
- The **Minimum Lake Level** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis.
- The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis.

In accordance with Chapter 40D-8, F.A.C., Minimum and Guidance Levels were developed for Lake Carroll (Table 1), a Category 3 Lake located in Hillsborough County, Florida. The levels were established using best available information, including field data that were obtained specifically for the purpose of minimum levels development. The data and analyses used for development of the levels shown in Table 1 are described in the remainder of this report. All elevation data values shown within this report on graphs, bathymetric maps, and within tables are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29). In some circumstances notations are made for data that was collected as North American Vertical Datum of 1988 (NAVD 88) (also as feet) and converted to NGVD 29. All datum conversions were derived using Corpscon 6.0, a computer software program developed by the United States Army Corps of Engineers.

Following a public input process, the District Governing Board approved the minimum and guidance levels developed for Lake Carroll (Table 1) for adoption and incorporation into Chapter 40D-8, F.A.C. at their meeting held on December 20, 2011. Public input included a public workshop held on November 16, 2011 near Lake Carroll in the community of Carrollwood. Upon approval by the District Governing Board, staff prepared an amendment to Rule 40D-8.624, F.A.C. that establishes minimum and guidance levels for Lake Carroll based on current methodologies and repeals the previously adopted guidance levels established in 1980 (see Table 2). The amendment was submitted to Joint Administrative Procedures Committee and notice was provided to the Governor's Office of Fiscal Accountability and Regulatory Reform (OFARR). Approval of the amendment was received by March 15, 2012.

**Table 1. Minimum and Guidance Levels for Lake Carroll.**

Minimum and Guidance Levels	Elevation in Feet
	NGVD 29
High Guidance Level	36.8
High Minimum Lake Level	36.8
Minimum Lake Level	35.4
Low Guidance Level	33.9

# Data and Analyses Supporting Development of Minimum and Guidance Levels for Lake Carroll

## Lake Setting and Description

Lake Carroll (Figure 1) is located in Hillsborough County, Florida (Sections 10, 11, 14 and 15, Township 28 South, Range 18 East), in the Northwest Hillsborough Basin of the Southwest Florida Water Management District. Lake Carroll is located within the Land-o-Lakes lake region that was identified and mapped as part of the Florida Department of Environmental Protection's Lake Bioassessment/Regionalization Initiative (Griffith *et al.* 1997). Romie (2000) described the lake as a clear, medium hard water, oligo-mesotrophic lake, with low concentrations of total phosphorus and very low concentrations of total nitrogen. The chemical type of water or predominant ionic composition was calcium chloride.

Most of the lake shoreline has been cleared as a result of residential development (Figure 2). Approximately seventy percent of the shoreline has seawalls. Waterward of the seawalls are healthy stands of emergent or littoral vegetation. No forested wetlands or their remnants contiguous with the lake are discernable. Public access to the shoreline is not available, although the residents of Carrollwood Proper have both beach and boat access to the lake at White Sands Beach. Approximately 172 boat docks were observed on the lake during the minimum levels assessment.

The lake is located within the Sweetwater Creek drainage basin with the Tampa Bay watershed. The contributing drainage area for the lake is 1.7 square miles (SWFWMD 1996). The lake discharges through an outlet fitted with a water conservation structure located within one of canals or lobes along the southwest corner of the lake (Figure 2 and 3). The conservation structure is maintained by the District. There are no surface water withdrawals from the lake currently permitted by the District. There are ten permitted groundwater withdrawals within a one mile radius of the lake (Figure 4) and a total of 33 permitted groundwater withdrawals within a two mile radius of the lake.

The 1956 (photo-revised 1981) United States Geological Survey 1:24,000 Sulfur Springs quadrangle map indicates an elevation of 34.0 ft NGVD for Lake Carroll. The "Gazetteer of Florida Lakes" (Shafer *et al.* 1986) lists the lake area as 191 acres at this elevation. A topographic map of the basin generated in support of minimum levels development indicates that the lake extends over 203.7 acres at an elevation of 34.0 ft NGVD (Figure 5). The topographic map (Figure 5) and corresponding depth contour map (Figure 6) show that the lake basin slope is irregular with obvious dredge holes near the shoreline.

**Figure 1. General location of Lake Carroll in Hillsborough County, Florida.**

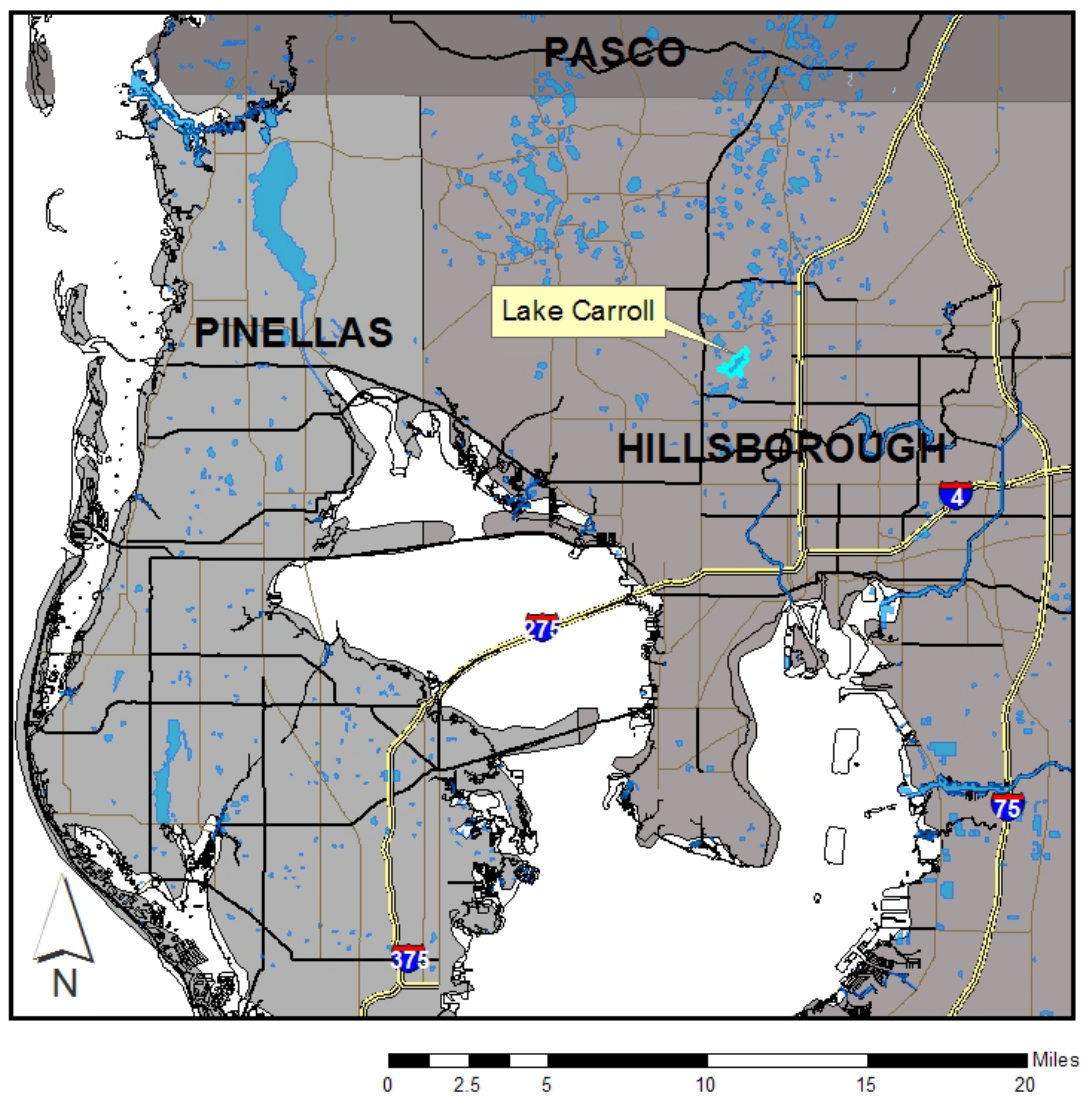
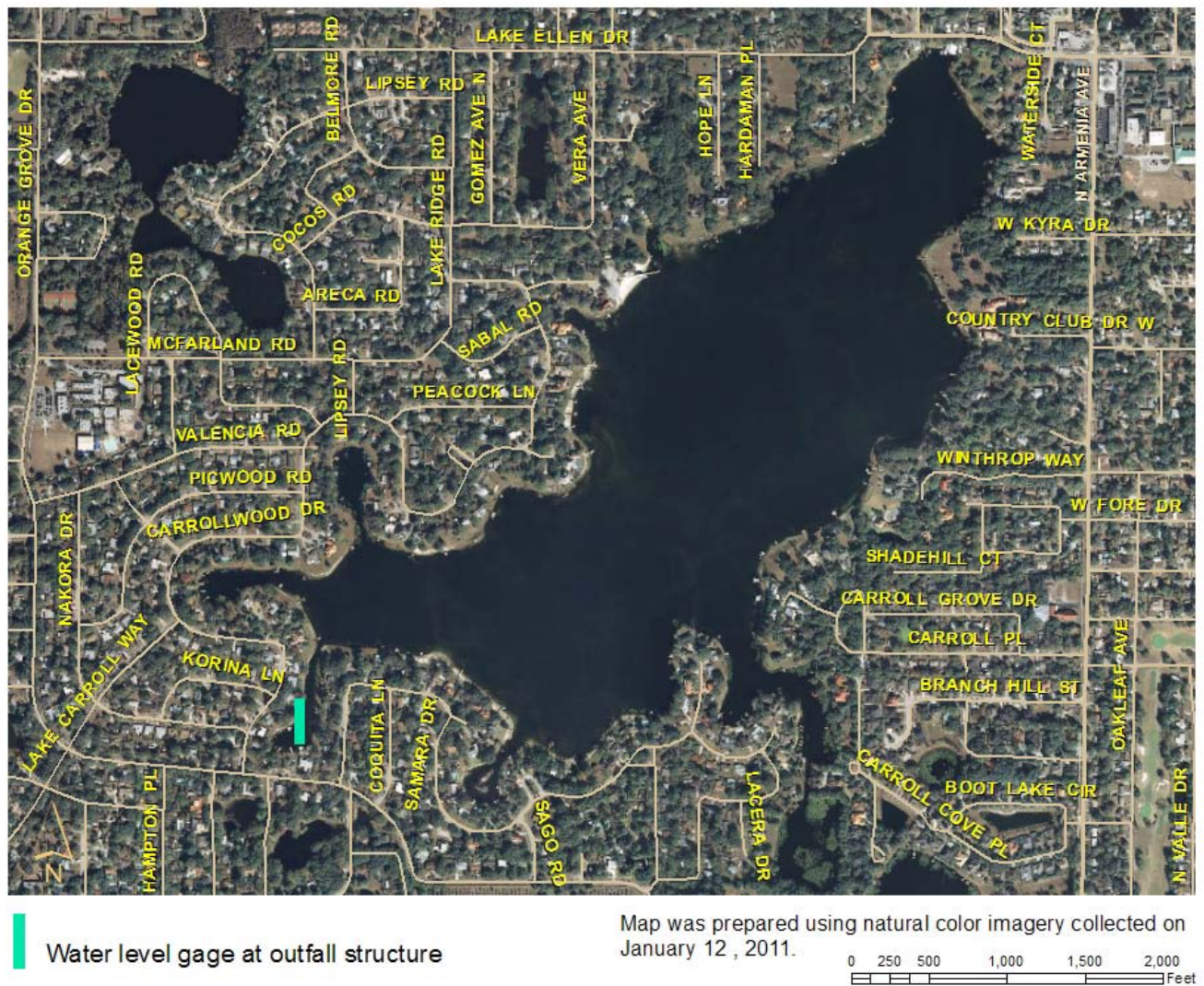
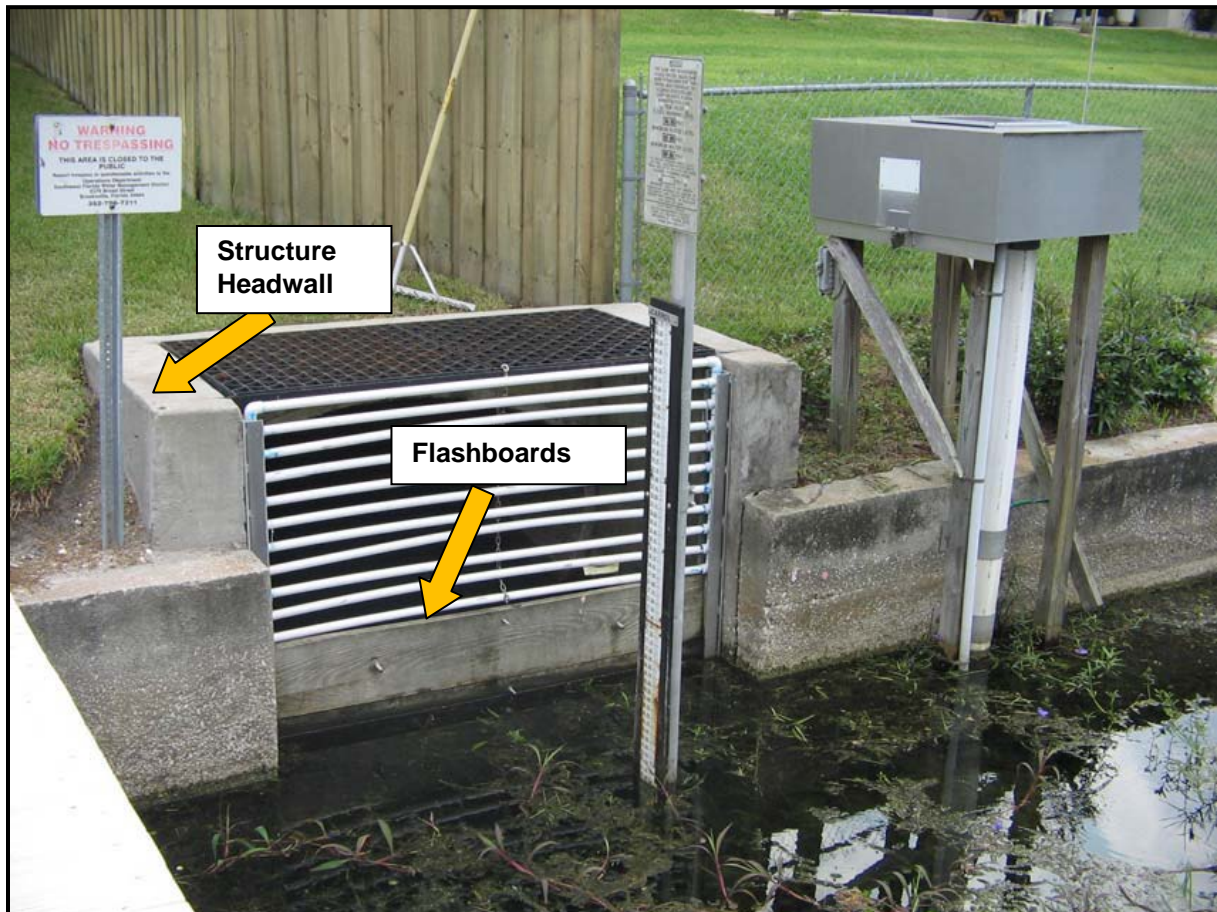




Figure 2. Location of the water level gage at Lake Carroll.



**Figure 3. Lake Carroll water conservation structure at the outlet to Lake Avis, Elaine, and WhiteTrout. Also shown are both the lake stage gage (middle of picture) and automated recording gage (right side of picture). Two elevation references are also shown in the figure with the elevation of the structure headwall at 39.39 NGVD and the elevation of the top of stop logs or flash-boards at 36.17 NGVD.**





**Figure 4. Permitted groundwater withdrawals within a one mile and two mile radius of Lake Carroll, Hillsborough County.**

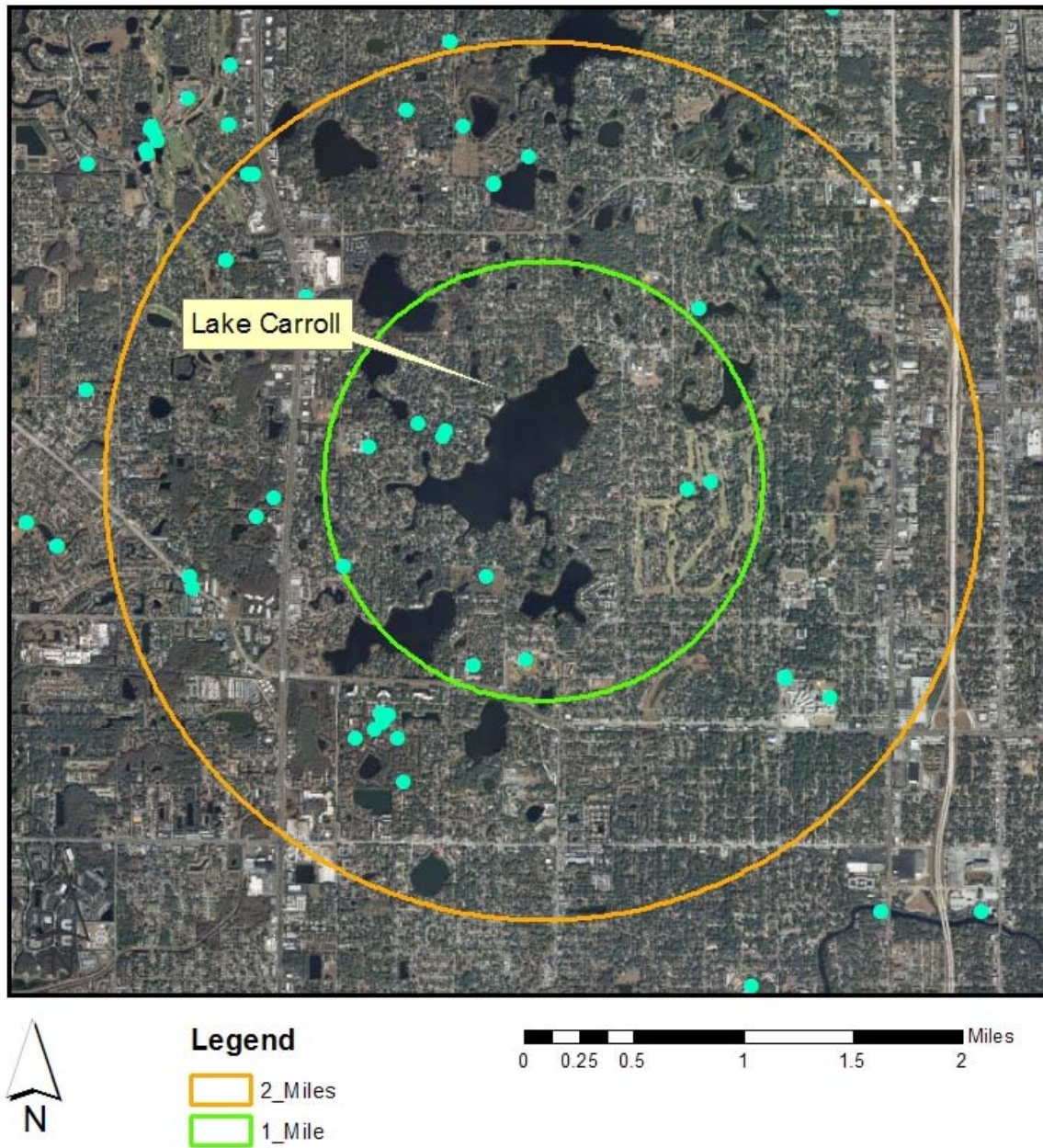
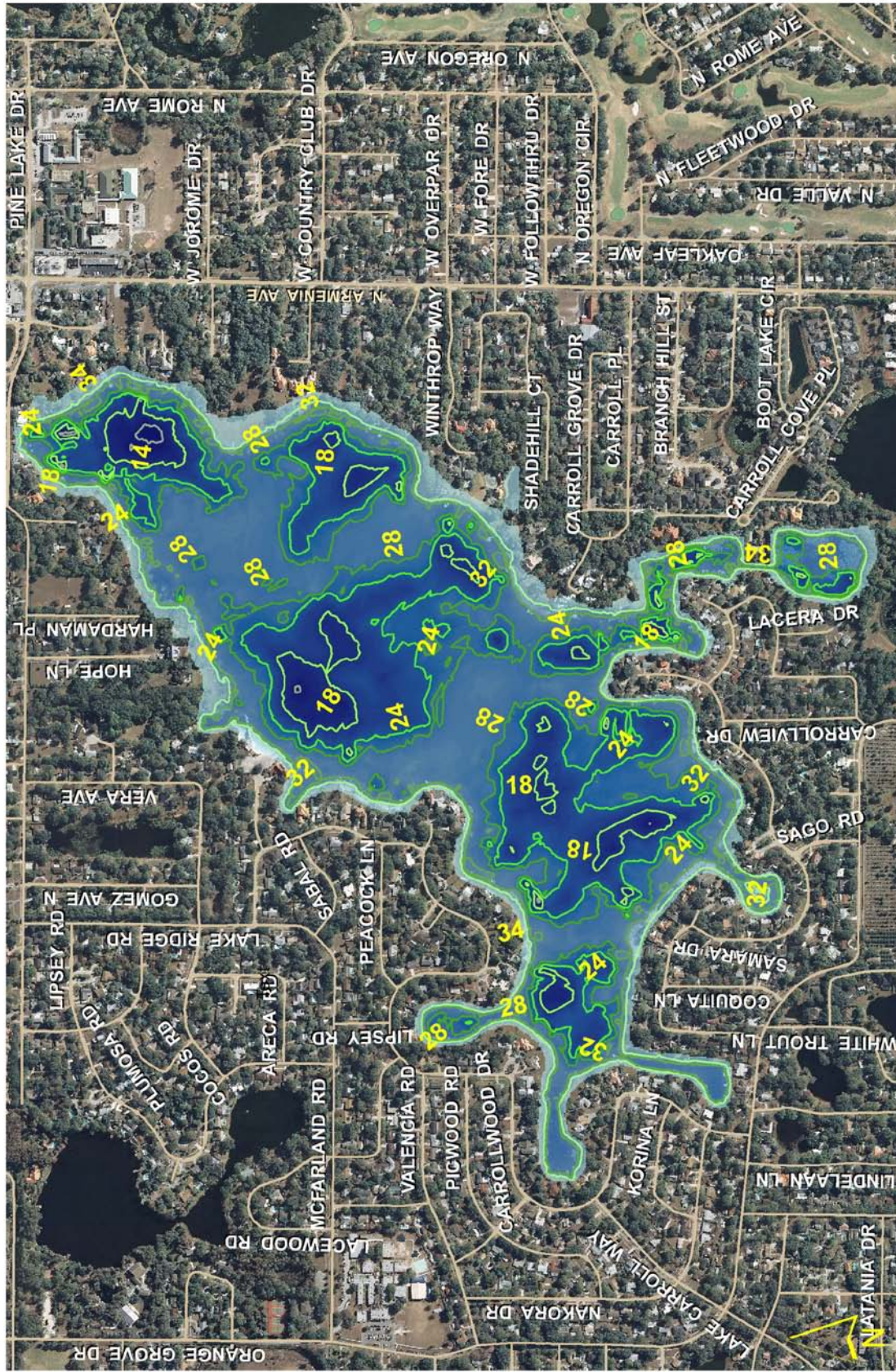




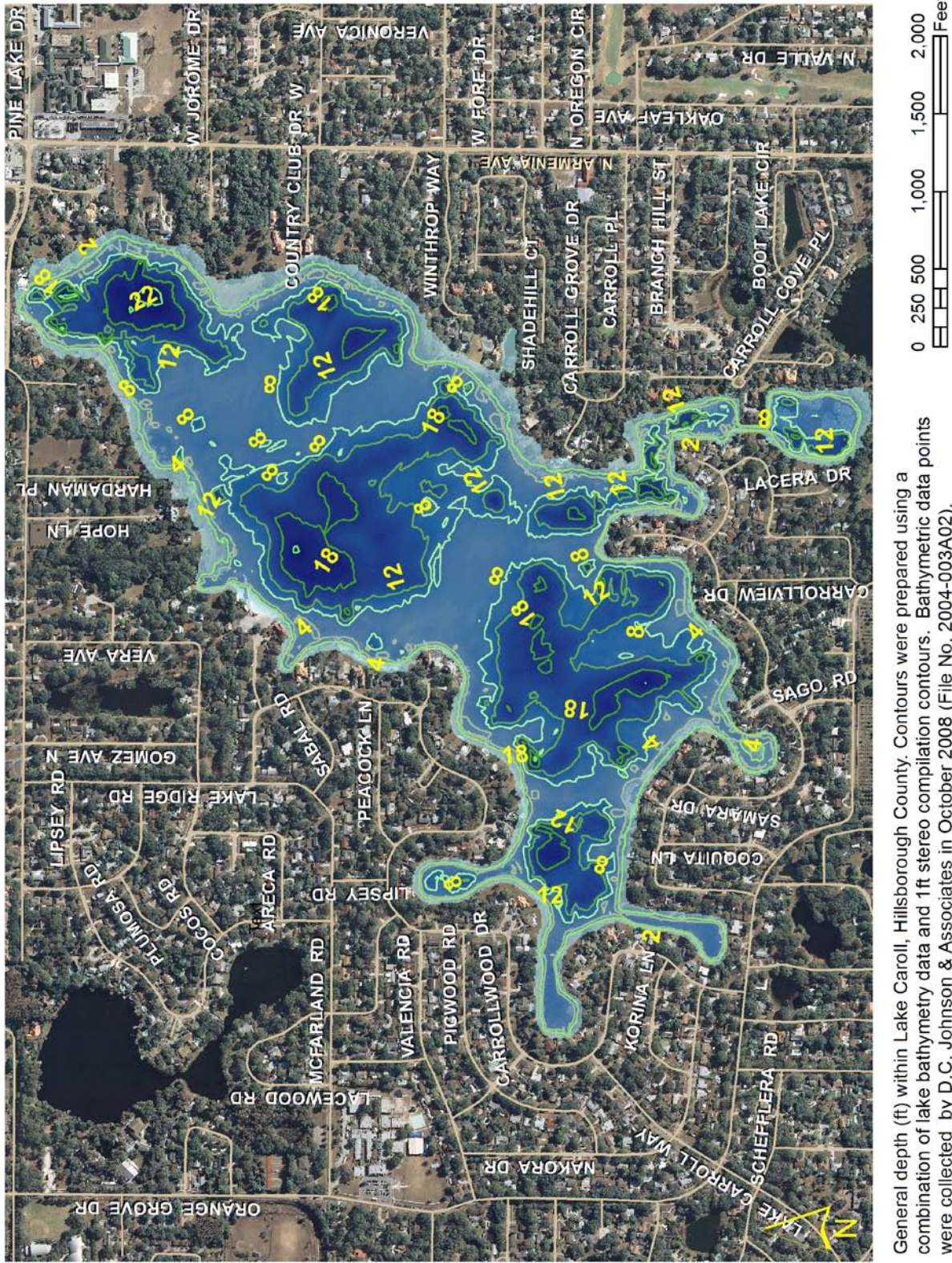
Figure 5. Approximate bottom elevations within the Lake Carroll basin. Values shown are elevations as NGVD 29.



General bottom elevation contours (as NGVD 29) for Lake Carroll, Hillsborough County. Contours were prepared using a combination of lake bathymetry data and 1 ft stereo compilation contours. Bathymetric data points were collected by D.C. Johnson & Associates in October 2008 (File No. 2004-003A02).



Figure 6. Bathymetric map of Lake Carroll showing approximate bottom depths at a lake stage of 36.0 NGVD.



## Currently Adopted Guidance Levels

The Southwest Florida Water Management District has a long history of water resource protection through the establishment of lake management levels. With the development of the Lake Levels Program in the mid-1970s, the District began an initiative for establishing lake management levels based on hydrologic, biological, physical and cultural aspects of lake ecosystems. By 1996, management levels for nearly 400 lakes had been established.

Based on work conducted in the 1970s (see SWFWMD 1996), the District Governing Board adopted management levels (currently referred to as Guidance Levels) for Lake Carroll in September 1980 (Table 2). A Maximum Desirable Level of 36.50 NGVD was also developed, but was not adopted by the Governing Board. The adopted Guidance Levels and Maximum Desirable Level were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels. The levels do not, therefore, necessarily correspond with levels developed using current methods. Minimum and Guidance Levels developed using current methods will replace existing Guidance Levels upon adoption by the District Governing Board into Chapter 40D-8, F.A.C. One of the management levels, a Ten Year Flood Guidance Level of 38.50 NGVD, was removed from Chapter 40D-8 in 2007, when the District Governing Board determined that flood-stage elevations should not be included in the District's Water Levels and Rates of Flow rules.

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program. As described in the District's Consumptive Use of Water Rule (Chapter 40D-2, F.A.C.), "a stressed condition for a lake is defined to be chronic fluctuation below the normal range of lake level fluctuations". For lakes with adopted Guidance Levels, chronic fluctuation below the Low Level is considered a stressed condition. For lakes without adopted levels, evaluation of stressed condition is conducted on a case-by-case basis. Lake Carroll was listed as stressed in 2003 and 2004 (Gant *et al.* 2003, Gant *et al.* 2004).

**Table 2. Adopted Guidance Levels for Lake Carroll as listed in Table 8-3 of subsection 40D-8.624, F.A.C.**

Guidance Levels	Elevation in Feet
	NGVD 29
Ten Year Flood Guidance Level	38.5
High Level	37.0
Low Level	34.5
Extreme Low Level	32.5



## Summary Data Used for Development of Minimum and Guidance Levels

Minimum and Guidance Levels for Lake Carroll were developed using the methodology for Category 3 Lakes described in Chapter 40D-8, F.A.C. levels and additional information are listed in Table 3, along with lake surface areas for each level or feature/standard elevation. Detailed descriptions of the development and use of these data are provided in the subsequent sections of this report.

**Table 3. Minimum and Guidance Levels, lake stage exceedance percentiles, and control point elevations, significant change standards, and associated surface areas for Lake Carroll.**

Levels	Elevation in Feet NGVD 29	Lake Area (acres)
<b>Lake Stage Percentiles</b>		
Period of Record (POR) P10	36.42	215
Period of Record (POR) P50	35.22	210
Period of Record (POR) P90	33.86	203
Historic P10 (1946 to 2010)	<b>36.8</b>	217
Historic P50 (1946 to 2010)	<b>35.4</b>	211
Historic P90 (1946 to 2010)	<b>33.9</b>	204
<b>Normal Pool and Control Point</b>		
Normal Pool	NA	NA
Control Point	36.17	214
<b>Significant Change Standards</b>		
Dock-Use Standard	<b>36.6</b>	216
Basin Connectivity Standard	<b>35.5</b>	211
Wetland Offset Elevation	34.6	207
Aesthetics Standard	33.9	204
Species Richness Standard	31.7, NA	182
Recreation/Ski Standard	29.5, NA	138
Lake Mixing Standard	NA	NA
<b>Minimum and Guidance Levels</b>		
High Guidance Level	<b>36.8</b>	217
<b>High Minimum Lake Level</b>	<b>36.8</b>	217
<b>Minimum Lake Level</b>	<b>35.4</b>	211
Low Guidance Level	<b>33.9</b>	204

NA = not appropriate;

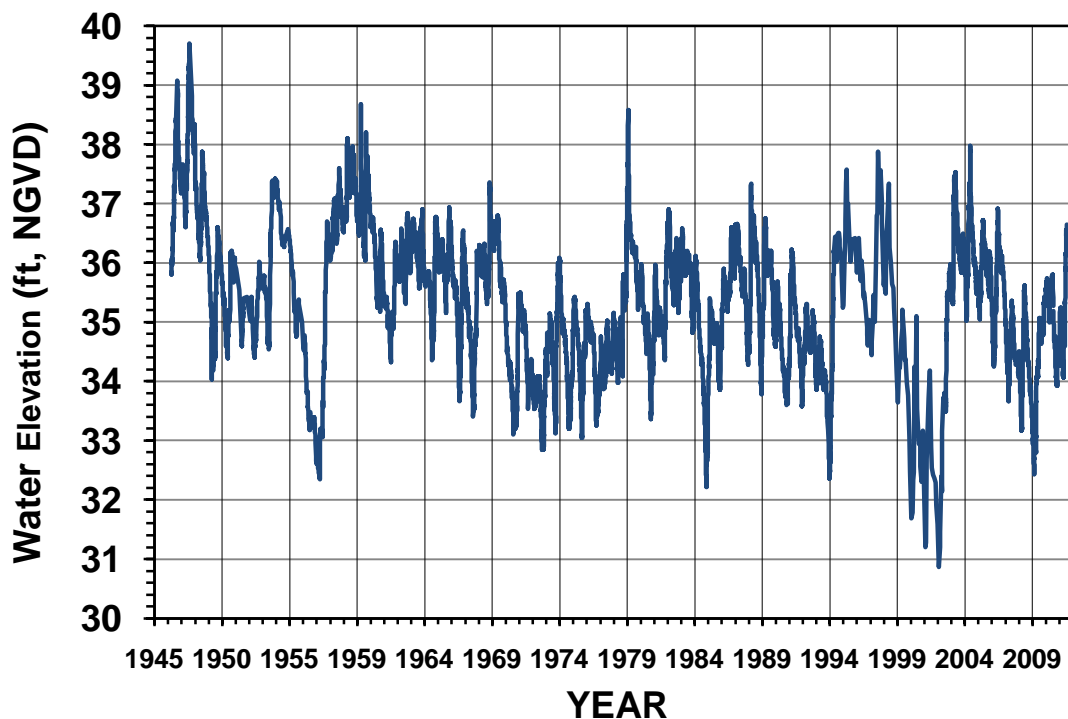
## Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations for Lake Carroll relative to NGVD 29 were obtained from the District's Water Management Information System (WMIS) data base (Site Identification Number 19740 and 670728). There is a long period of record for lake stage data on Lake Carroll, with the period of record (POR) extending from May 1946 through present day (Figure 7, see Figure 2 for current location of the SWFWMD lake water level gauge).

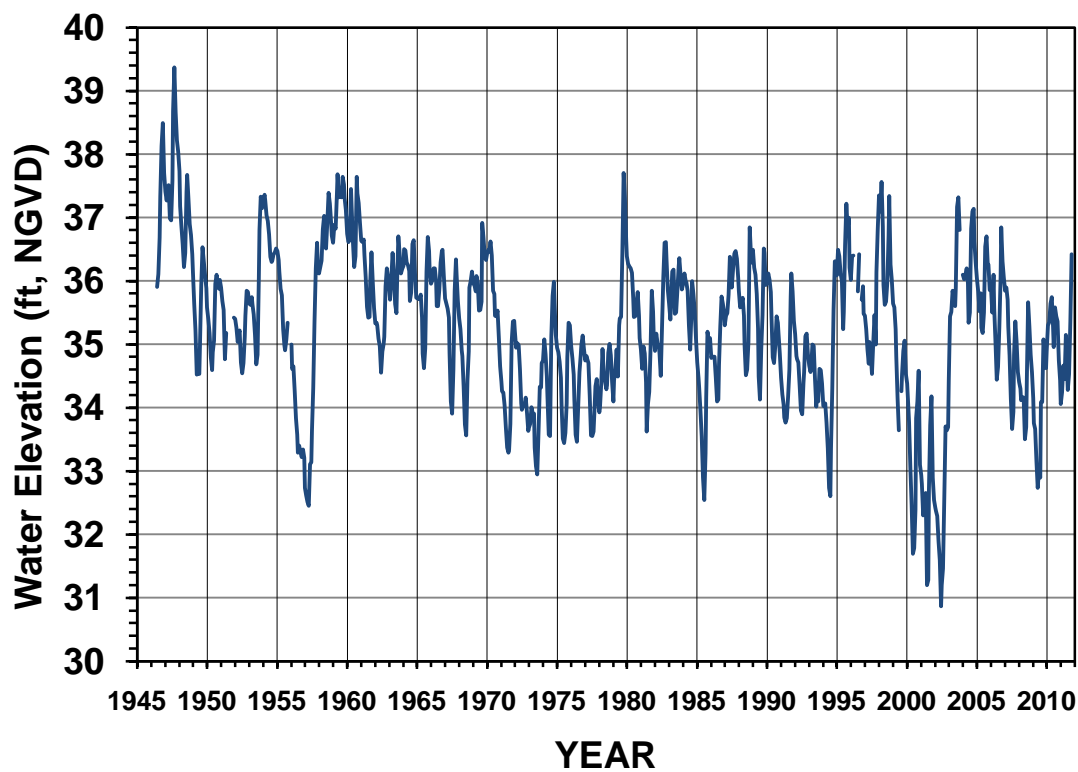
The highest surface water elevation for the lake recorded in the Water Management Information System was 39.69 NGVD 29 and occurred on September 19, 1947. The second and third highest levels occurred on September 26, 1979 (38.56 NGVD), and on December 28, 1997 (38.06) (Figure 7). Significant flooding was reported during the 1979 event. The lowest surface water elevation of 30.87 NGVD 29 occurred on May 29, 2002. The second lowest record occurred on May 31, 2002 at 31.2 NGVD 29. The vertical range between the highest and lowest recorded lake stage is 8.2 feet. Using the available daily lake stage data, monthly mean lake surface elevations were calculated and graphed (Figure 8). Although the graph of the monthly mean data does not show the full range in highs and lows, the data is useful for analyses of hydrologic relationships and comparison to other lakes in the region where only monthly data is available.



**Figure 7. Daily surface water elevations (NGVD 29) through September 2011 for Lake Carroll. SWFWMD WMIS site ID's 19740 and 670728**



**Figure 8. Monthly mean surface water elevations (NGVD 29) through September 2011 for Lake Carroll.**



For the purpose of Minimum Levels determination, lake stage data are classified as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. In the context of Minimum Levels development, "structural alterations" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. Lake stage data are classified as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable. A hydrologic analysis (SWFWMD 2010, draft report) completed for Lake Carroll indicated that the lake was determined to have no measureable impacts due to regional groundwater withdrawals. The results of the analysis indicated that lake stage data for the entire period of record (1946 to 2010) for Lake Carroll are classified as Historic (Figure 9a).

Although the period of record of lake stage data (1946 to 2010) for Lake Carroll are classified as the Historic data, a few minor data gaps occur within the record. In order to fill the data gaps a rainfall model was constructed for the lake. The completed rainfall model was used to estimate the Historic lake-stage exceedance percentiles and to develop a compliance model for the lake.

A composite rainfall data set was developed for the time period of 1946 to 2010 using data from five rainfall data collection sites. The rain gage sites included the Bay Lake National Weather Service (NWS) gage, Roy Haynes Park, Tampa International Airport NWS, Saint Leo NWS, and the Tarpon Spring Sewage Treatment Plant NWS (WMIS Site ID's 19509, 712476, 19500, 18901, and 22881 respectively). The resulting lake level rainfall model had a correlation coefficient of determination ( $r^2$ ) equal to 0.612 based on use of a two-year linear decay series of daily rainfall values. The model was then applied to predict the lake stage for the long term Historic time period of the 1946 to 2010 (Figure 9a). A composite of the modeled lake stage and observed lake stage for the sixty-four-year period was then used (Figure 9b) to determine the Historic lake stage exceedance percentiles (P10, P50, and P90). This sixty-four-year period was considered sufficient for incorporating the range of lake stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield et al. 2001, Basso and Schultz 2003).

The final composite long term Historic lake stage data set comprised of the modeled lake stage and measured lake stage (Figure 9b) was used to calculate the **Historic P10, P50, and P90** lake stage percentile elevations (Figure 9b). The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was **36.8 NGVD 29**. The Historic P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was **35.4 NGVD 29**. The Historic P90 elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period, was **33.9 NGVD 29**.

**Figures 9a. and 9b.** 9a. Modeled long term Historic lake stage (as monthly means, see blue line) and measured lake stage (also as monthly means, see red line) for Lake Carroll. 9b. Composite of modeled long term Historic lake stage and measured lake stage (both as monthly means) used to calculate the Historic P10, P50, and P90 lake stage percentile elevations for Lake Carroll from January 1946 through December 2010. The Long Term Historic P10, P50, and P90 are depicted as horizontal lines. Lake stage elevations are in feet above NGVD 29.

Figure 9a.

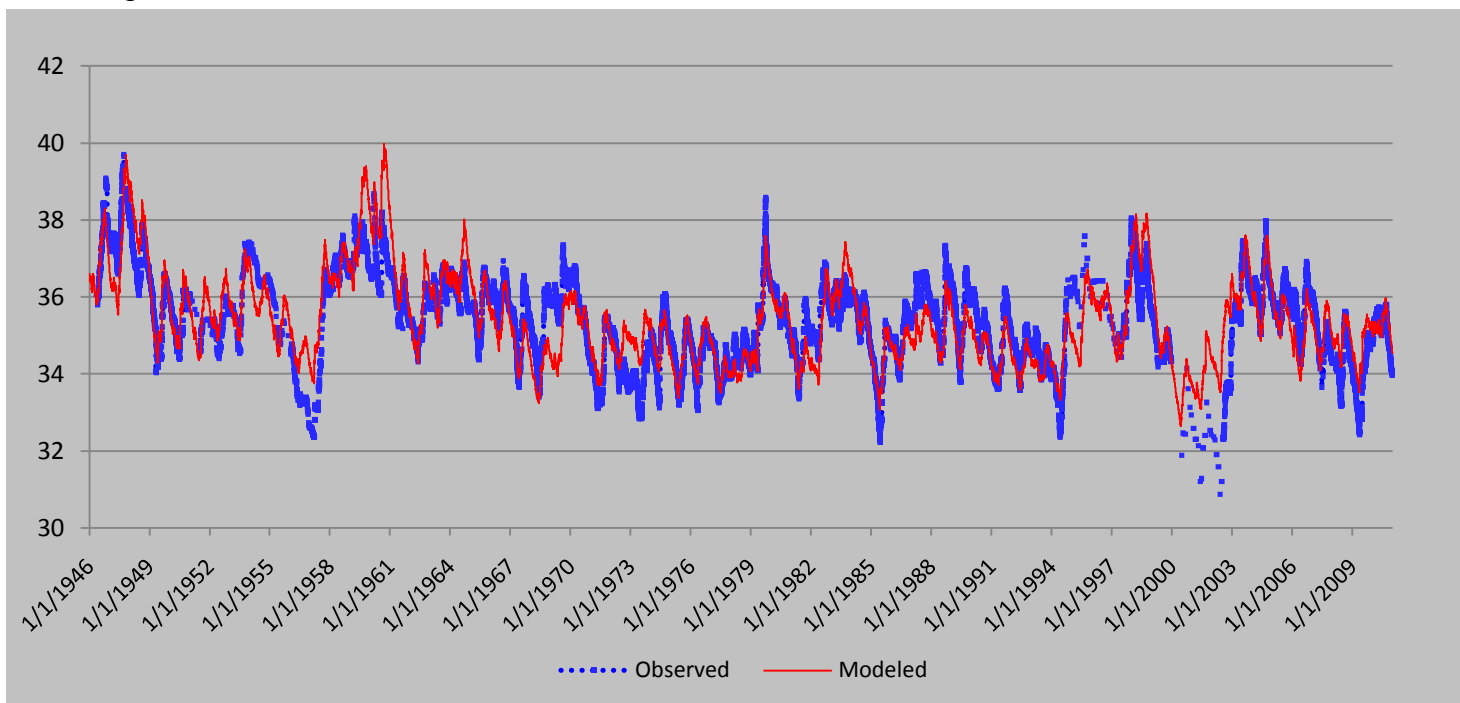
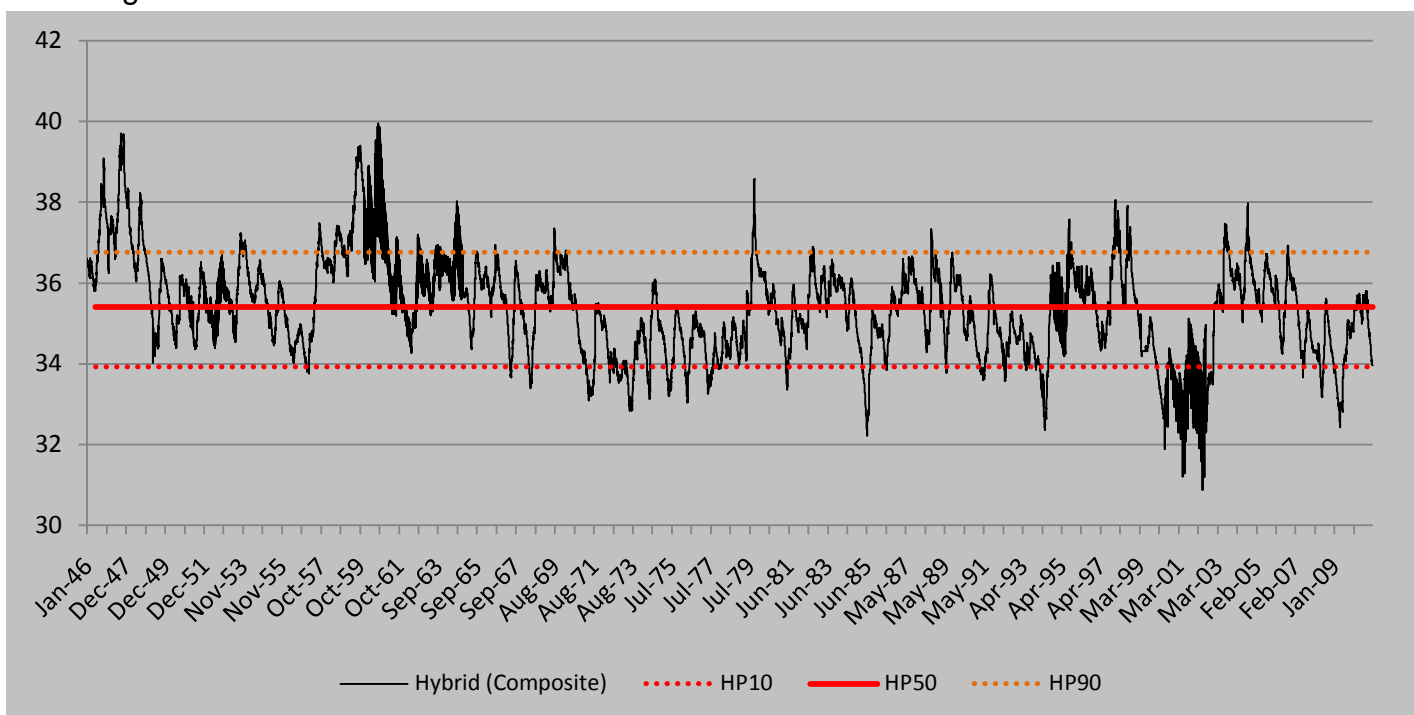


Figure 9b.



## Normal Pool Elevation, Control Point Elevation and Structural Alteration Status

The **Normal Pool** elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the elevation of Hydrologic Indicators of sustained inundation. Because Hydrologic Indicators of Normal Pool were not observed at North Lake Wales, establishment of the Normal Pool elevation was not possible.

The **Control Point** elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (e.g., weir, ditch, culvert, or pipe) that is the principal control of water level fluctuations in the lake. A small water conservation structure is located within the lake's outlet that discharges to Lakes Avis, Elaine, and White Trout (see Figure 2 and 3). The structure is maintained and operated by the District. Based on elevation data collected by professional surveyors during the topographic assessment of the watershed (Xynides 2008), the invert elevation of the structure outfall pipe was 34.18 NGVD and the elevation of the top of the flash-board riser or stop logs was 36.17 (NGVD) (see Figure 3). The elevation of the structure headwall is 39.39 NGVD and is shown in Figure 3 for visual reference of the record high lake stage that occurred in 1947 at 39.69 NGVD. The flash-board within the structure function as the control point for Lake Carroll. The control point elevation can change if the stop logs are removed, such as to alleviate flooding concerns associated with hurricanes and other unusual rain events.

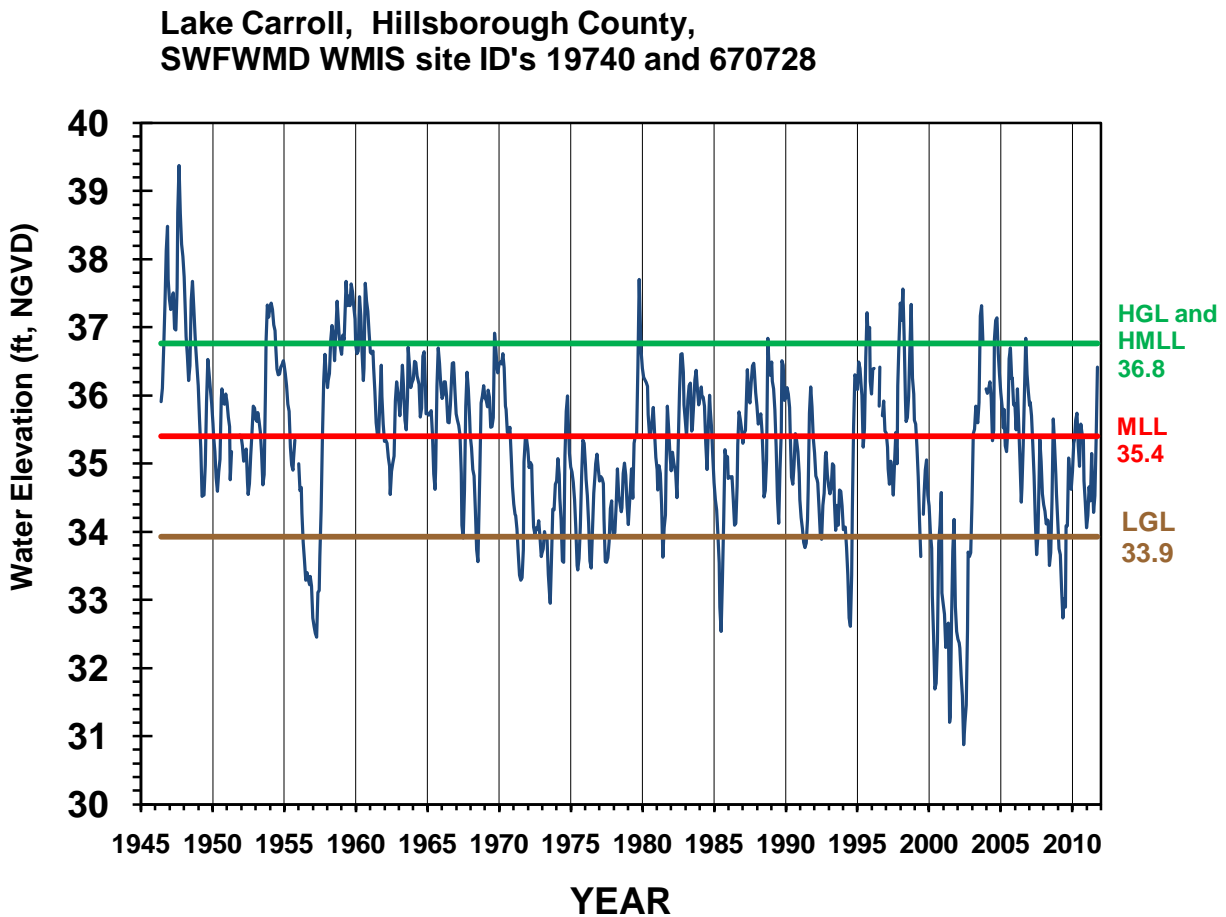
**Structural Alteration Status** is determined to support development of Minimum and Guidance Levels. Because of known modifications to the outlet of the lake, Lake Carroll is considered to be Structurally Altered.

### Guidance Levels

The **High Guidance Level** is provided as an advisory guideline for construction of lake-shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic lake stage data if it is available, or is estimated using the Current P10, the control point, and the normal pool elevation. Based on the availability of the long term Historic data record for Lake Carroll, the High Guidance Level was established at **36.8 NGVD 29** (Figure 10).

The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lake shore residents, and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time (P90) on a long-term basis. The level is established using Historic or Current lake stage data, and in some cases, the Reference Lake Water Regime (RLWR) statistics. Based on the availability of the long term Historic data set for Lake Carroll, the Low Guidance Level was established at **33.9 NGVD 29** (Figure 10, Table 3).

**Figure 10. Mean monthly lake stage for the period of record and Minimum and Guidance Levels for Lake Carroll, in feet above NGVD 29. Levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL), and the Low Guidance Level (LGL).**



## Lake Classification

Lakes are classified as Category 1, 2, or 3 for the purpose of Minimum Levels development. Those with fringing cypress wetlands greater than 0.5 acres in size where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands (*i.e.*, the Historic P50 is equal to or higher than an elevation 1.8 feet below the Normal Pool elevation) are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 elevation is more than 1.8 feet below the Normal Pool elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with cypress wetlands less than 0.5 acres in size are classified as Category 3 Lakes. Because Lake Carroll does not have fringing cypress wetlands, it is classified as a **Category 3 Lake**.

## Significant Change Standards and Other Information for Consideration

Lake-specific significant change standards and other available information are developed for establishing minimum levels for Category 3 Lakes. The standards are used to identify thresholds for preventing significant harm to cultural and natural system values associated with lakes in accordance with guidance provided in the Florida Water Resources Implementation Rule (Chapter 62-40.473, F.A.C.). Other information taken into consideration includes potential changes in the coverage of herbaceous wetland vegetation and aquatic plants.

Six significant change standards are developed for Category 3 Lakes, including an Aesthetics Standard, a Species Richness Standard, a Recreation/Ski Standard, a Dock-Use Standard, a Basin Connectivity Standard, and a Lake Mixing Standard. A Wetland Offset Elevation is also developed and used along with the significant change standards to identify desired median lake stage elevations that if achieved, are intended to preserve various natural system and human-use lake values.

The **Dock-Use Standard** is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a clearance value for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Dock-Use Standard for Lake Carroll was established at 36.6 feet above NGVD, based on the elevation of sediments at the end of ninety percent of the 172 docks within the lake (33.1 feet above NGVD, Table 4), a two-foot water depth based on use of powerboats in the lake, and the 1.5 foot difference between the Historic P50 and Historic P90. The sediment elevations were measured in February of 2011 with a corresponding water level of 34.70 NGVD. The median water depth at the end of the 172 docks measured was 3.4 feet (Table 5). Based on the Historic composite water level record, the Dock-Use Standard was equaled or exceeded thirty percent of the time, *i.e.*, the standard elevation corresponds to the Historic P13.

The **Basin Connectivity Standard** is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational lake-use. The standard is based on the elevation of lake sediments at a critical high-spot between lake basins or lake, in this case the east and west pools, clearance values for movement of aquatic biota or powerboats and other watercraft, and use of Historic lake stage data or region-specific reference lake water regime statistics. The morphology of Lake Carroll is rather irregular with modern day aerials showing five small lobes or basins. A review of historical aerial imagery (1938, 1957, and 1968 see Figures 17, 18, and 19) indicate that these features were dredged sometime between 1957 and 1968. The bottom depth of each lobe was evaluated to determine which lobe contained the shallowest water or critical high spot. A review of the 1 ft stereo compilation contours, spot elevation data, and bathymetric contours indicated that the critical high spot occurred within the canals of two of the lobes. These two basins are located along the southeast side of the lake as shown in Figure 11.

The critical high within the connections to these basins was approximately 32.0 NGVD. The Basin Connectivity Standard was established at 35.5 NGVD, based on the sum of the elevation that ensures connectivity (32.0 NGVD as critical high spot), a two foot clearance value for movement of biota and use of powerboats on the lake, and the difference between the Historic P50 and Historic P90 (1.5 ft). It should be noted that the Connectivity Standard determined for Lake Carroll is very similar to the Historic P50 elevation of 35.4 NGVD. Based on the Historic composite water level record, the Connectivity Standard was equaled or exceeded forty seven percent of the time, *i.e.*, the standard elevation corresponds to the Historic P47.

Based on a review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was determined that up to an 0.8 foot decrease (or Wetland Offset) in the Historic P50 elevation would not likely be associated with significant changes in the herbaceous wetlands occurring within lake basins. Because herbaceous wetlands are common within the Lake Carroll basin, the **Wetland Offset** was determined by subtracting 0.8 feet from the Historic P50 elevation. A Wetland Offset elevation of 34.6 NGVD was therefore established for Lake Carroll and was equaled or exceeded 74.5 percent of the time, based on the Historic, composite water level record. The standard elevation therefore corresponds to the Historic P74.5.

The **Aesthetics Standard** is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard was established at the Low Guidance Level, which for Lake Carroll is 33.9 NGVD 29. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the composite Historic long term period (1946 to present, Figure 9b).

The **Species Richness Standard** is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes, the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area relative to the lake area at the Historic P50 elevation (see Figure 12) for a plot of lake surface area versus lake stage). For Lake Carroll, the Species Richness Standard was established at 31.7 NGVD 29. The Species Richness Standard was equaled or exceeded 100 percent of the time, based on the long term composite Historic water level record. The standard is therefore not appropriate in this case.

The **Recreation/Ski Standard** is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a five-foot deep ski corridor delineated as a circular area with a radius of 418 ft, or a rectangular ski area 200 ft in width and 2,000 ft in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Recreation/Ski Standard was established at 29.5 ft NGVD, based on the sum of the elevation at which the lake could contain an area suitable for safe skiing (28.0 NGVD) and the difference between the Historic P50 and Historic P90 (1.5 ft). Based on a review of the long term composite Historic water level record for Lake Carroll, the lake stage has not dropped below 30.87 NGVD during this time period. The Recreation/Ski Standard is not appropriate in this case.

The Lake Mixing Standard is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann *et al.* 2000) shifts from a value of  $<0.8$  to a value  $>0.8$ , or from a value  $>0.8$  to a value of  $<0.8$ . Because the dynamic ratio does not shift across the 0.8 threshold as the lake level changes (Figure 12), a Mixing Standard was not developed for the lake.

Information on herbaceous wetlands is taken into consideration when determining the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e.*, basin area with a water depth of four or less feet). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values (*i.e.*, basin area with a water depth of 13.5 feet or less feet). Review of changes in potential herbaceous wetland area or area available for submersed aquatic plant colonization in relation to change in lake stage did not indicate that use of any of the significant change standards would be inappropriate for establishment of the Minimum Lake Level (Figure 13). However, a substantial increase in the area of herbaceous wetland would likely occur at both the Species Richness Standard (31.7 NGVD) and the Recreation/Ski Standard (29.5 NGVD) (see Figure 13, bottom). This increase would likely occur as the result of the increase in area of the lake that contains water 4 feet or less in depth. A substantial



increase in emergent vegetation would conflict with the high recreational use of this lake and would impede navigation.

**Figure 11. Location of critical high spot(s) used to develop the Connectivity Standard for Lake Carroll, Hillsborough County.**



**Table 4. Summary statistics for bottom elevations associated with docks in Lake Carroll as based on measurements made by District staff in February 2011. Percentiles (10th, 50th and 90th) represent elevations met or exceeded by 10, 50 and 90 percent of the docks.**

<b>Summary Statistics</b>	<b>Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks</b>	<b>Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms</b>
N (number of docks)	172	172
Median	31.4	41.6
10 <sup>th</sup> Percentile	27.5	39.6
50 <sup>th</sup> Percentile	31.4	41.6
90 <sup>th</sup> Percentile	33.1	45.1
Maximum	34.2	51.9
Minimum	20.9	38.2

**Table 5. Summary statistics for depth associated with the waterward end of docks in Lake Carroll as based on measurements made by District staff in February 2011.**

<b>Summary Statistics</b>	<b>Statistic Value (N) or and approximate Depth (ft) at Waterward End of Docks</b>
N (number of docks)	172
Median	3.4
10 <sup>th</sup> Percentile	7.2
50 <sup>th</sup> Percentile	3.4
90 <sup>th</sup> Percentile	1.6
Maximum	13.8
Minimum	0.5

## Minimum Levels

Minimum Lake Levels are developed using specific lake-category significant change standards and other available information or unique factors, including: substantial changes in the coverage of herbaceous wetland vegetation and aquatic macrophytes; elevations associated with residential dwellings, roads or other structures; frequent submergence of dock platforms; faunal surveys; aerial photographs; typical uses of lakes (e.g., recreation, aesthetics, navigation, and irrigation); surrounding land-uses; socio-economic effects; and public health, safety and welfare matters. Minimum Levels development is also contingent upon lake classification, *i.e.*, whether a lake is classified as a Category 1, 2 or 3 lake.

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 Lakes, the Minimum Lake Level is typically established at the elevation corresponding to the most conservative significant change standard, *i.e.*, the standard with the highest elevation, except where that elevation is above the Historic P50 elevation, in which case, the Minimum Lake Level is established at the Historic P50 elevation. Because both the Dock-Use Standard and Basin Connectivity Standard for Lake Carroll were higher than the Historic P50 elevation, the Minimum Level was established at the Historic P50 elevation, 35.4 NGVD (Figures 10, 14, 15, and 16). This level is expected to afford protection to the natural system and human-use values associated with the identified significant change standards and also provide protection for wetlands occurring within the basin.

The **High Minimum Lake Level (HMLL)** is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For Category 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. If Historic Data are available, the High Minimum Lake Level is established at an elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level is set at an elevation corresponding to the Minimum Lake Level plus the region-specific RLWR50. Based on the availability of long term composite Historic data for Lake Carroll, the High Minimum Lake Level was established at 36.8 NGVD 29 (Figures 10, 14, 15, and 16), by adding the difference between the Historic P50 and Historic P10 (1.4 feet) to the Minimum Lake Level. Since the Minimum Lake Level was established at the Historic P50, the High Minimum Lake Level is equivalent to the Historic P10.

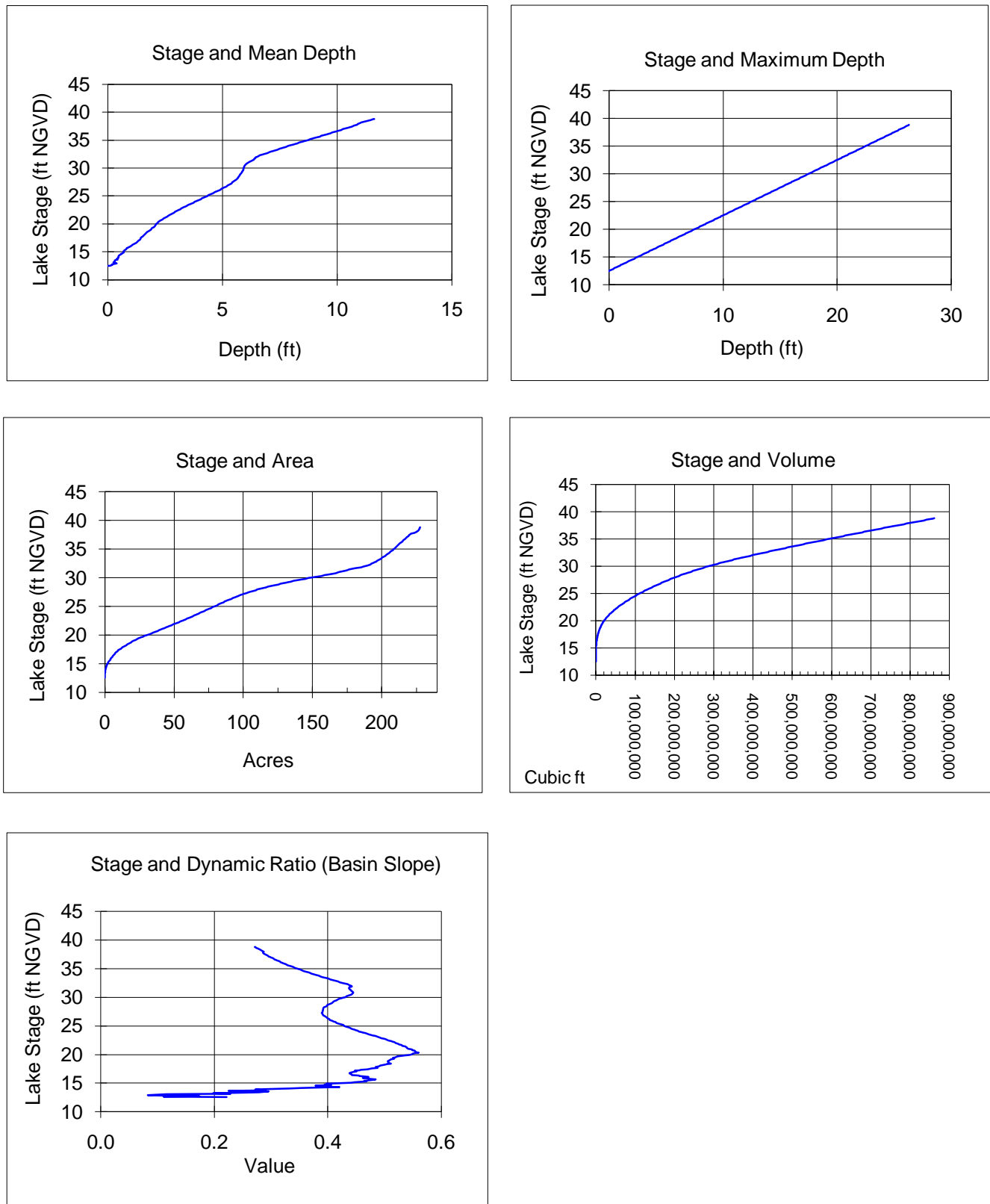
The Minimum and Guidance levels for Lake Carroll are shown in Figure 10 along with monthly mean water surface elevations based on period of record water level measurements. Staging of the lake at Minimum levels (Figures 14, 16, and 17) would not be expected to flood any man-made features within the immediate lake basin. The High Minimum Lake Level (36.8 NGVD 29) is approximately 3.26 feet lower than the lowest residential floor slab (40.06 NGVD 29) within the lake basin (Table 6). The High Minimum Lake Level is also approximately 2.17 ft lower than the lowest spot on the

paved roads (38.97 NGVD 29) encircling the lake. The High Minimum Lake Level is only 0.31 feet lower than the slab of a boat house located within the northwest region of the lake. The boat house is considered a historical landmark on the lake and appears to have been constructed during the 1930's or earlier. A period of record high of 39.69 NGVD was measured on September 19, 1947. This period of record high was 2.89 feet higher than the High Minimum Lake Level.

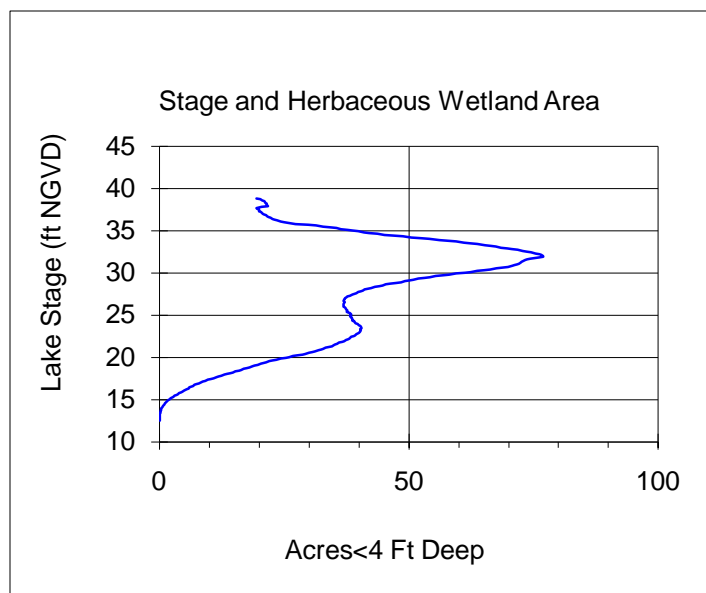
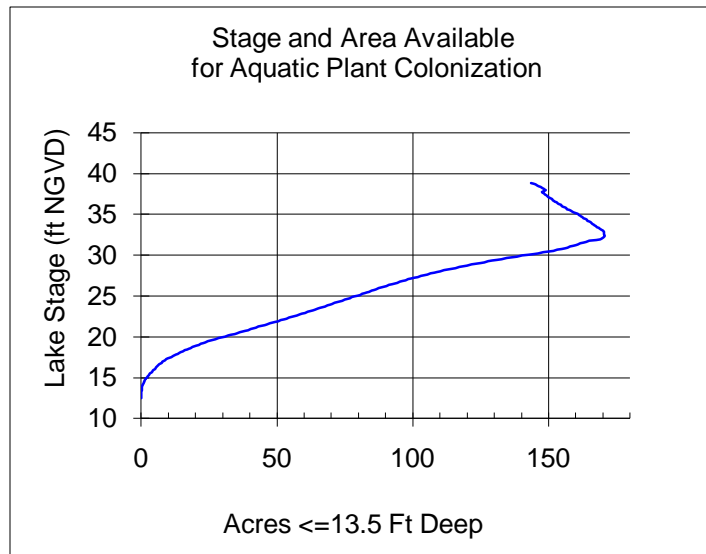
**Table 6. Elevations of lake basin features in the immediate Lake Carroll basin**  
(Xynides 2008).

<b>Lake Basin Features</b>	<b>Elevation in Feet NGVD 29</b>
Low elevation of lake side building, boat house	<b>37.11</b>
Low spot on the paved public roads near the lake	<b>38.97</b>
Low floor slab – residential	<b>40.06</b>
Stormwater conveyance pipe inlet	<b>39.29</b>

**Figure 12. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope) in feet above NGVD 29 for Lake Carroll.**

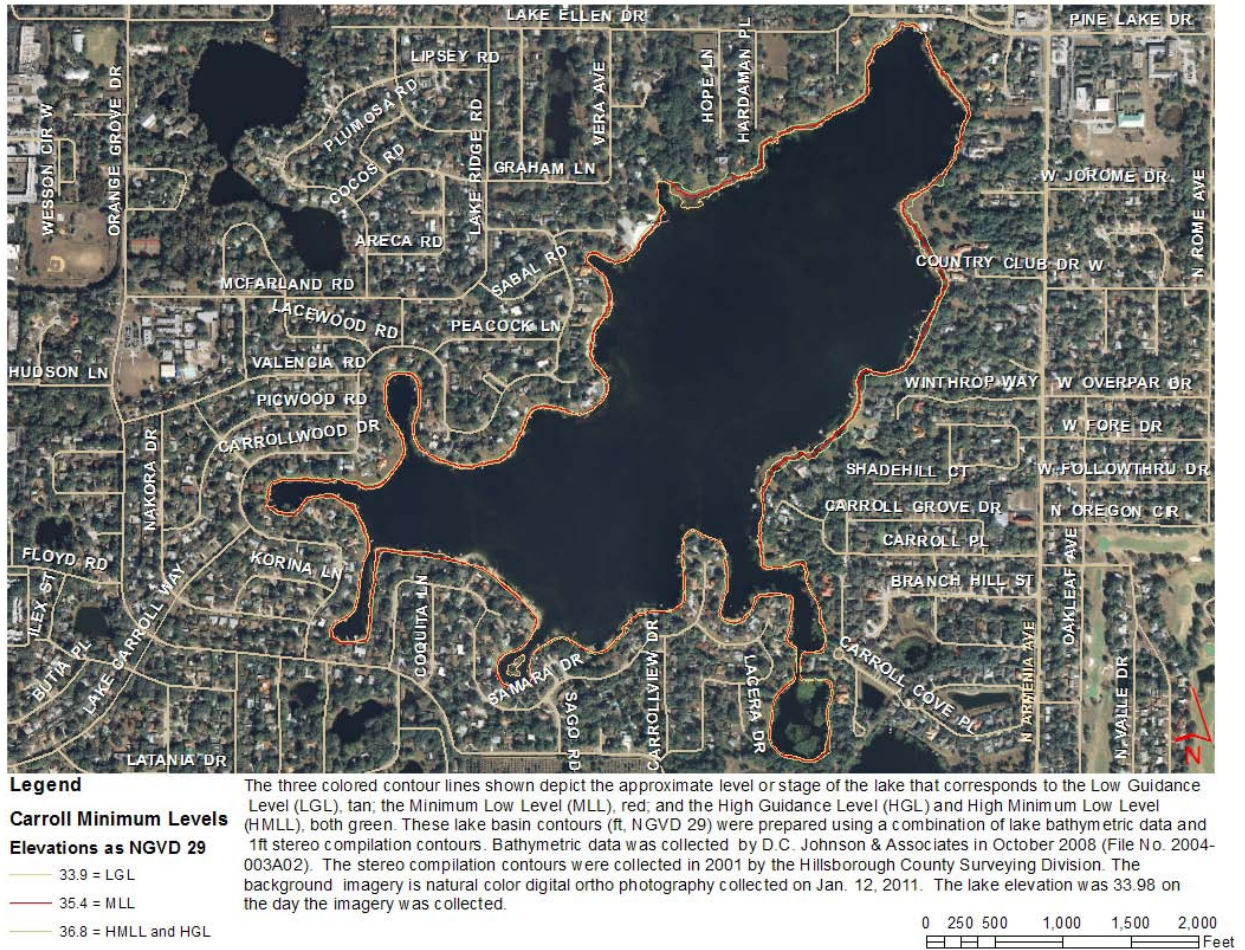


**Figure 13. Potential herbaceous wetland area and area available for submersed macrophyte colonization in Lake Carroll as a function of lake stage (water surface elevation).**



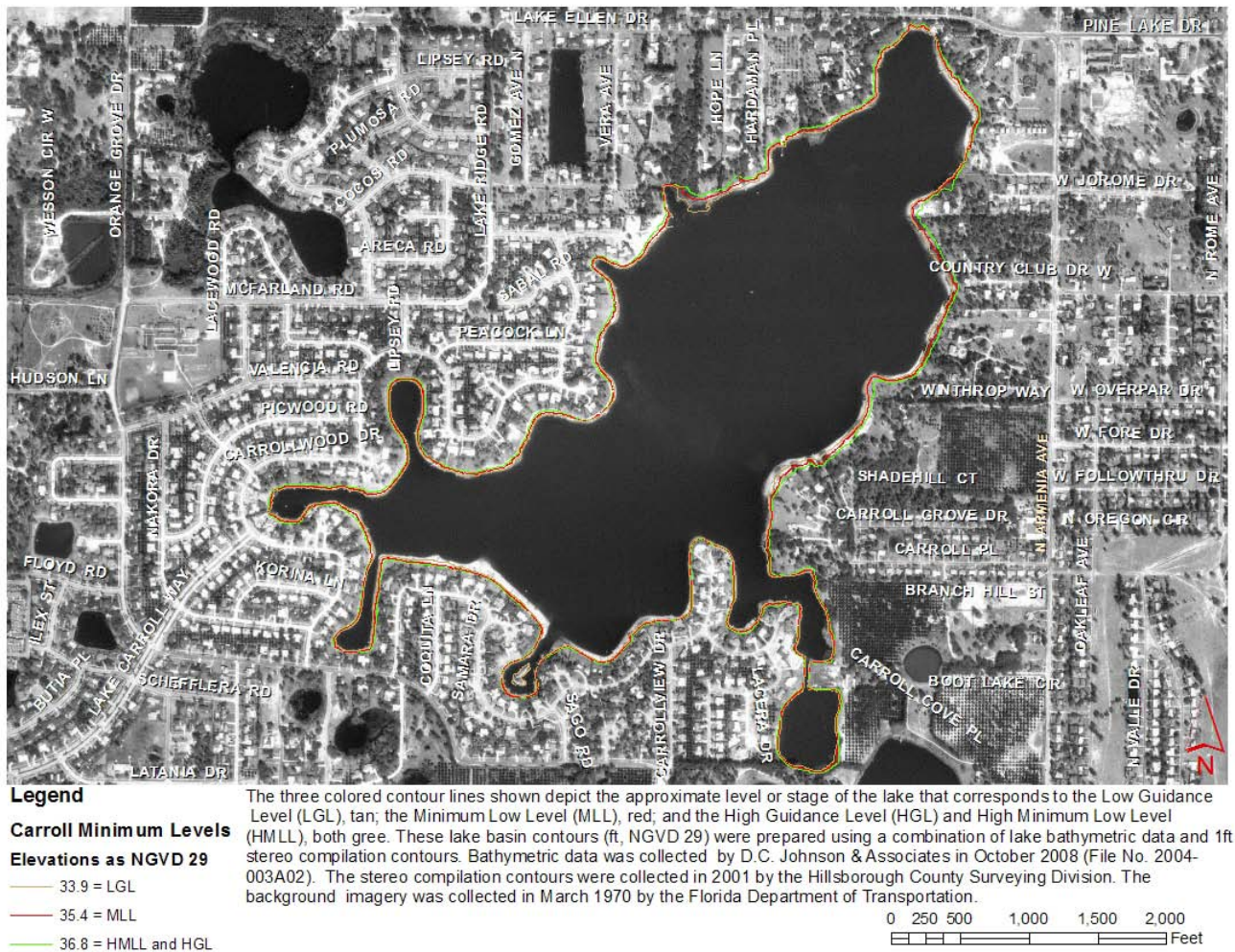


**Figure 14. Approximate location of the Minimum Lake Level (MLL), Low Guidance Level (LGL), High Minimum Lake Level (HMLL), and High Guidance Level (HGL) for Lake Carroll in Hillsborough County, during recent conditions shown within the 2011 aerial imagery. Based on gage readings the estimated lake stage was 33.96 NGVD 29 on the date of the imagery.**





**Figure 15. Approximate location of the Minimum Lake Level (MLL), Low Guidance Level (LGL), High Minimum Lake Level (HMLL), and High Guidance Level (HGL) for Lake Carroll as associated with conditions observed in March 1970.**

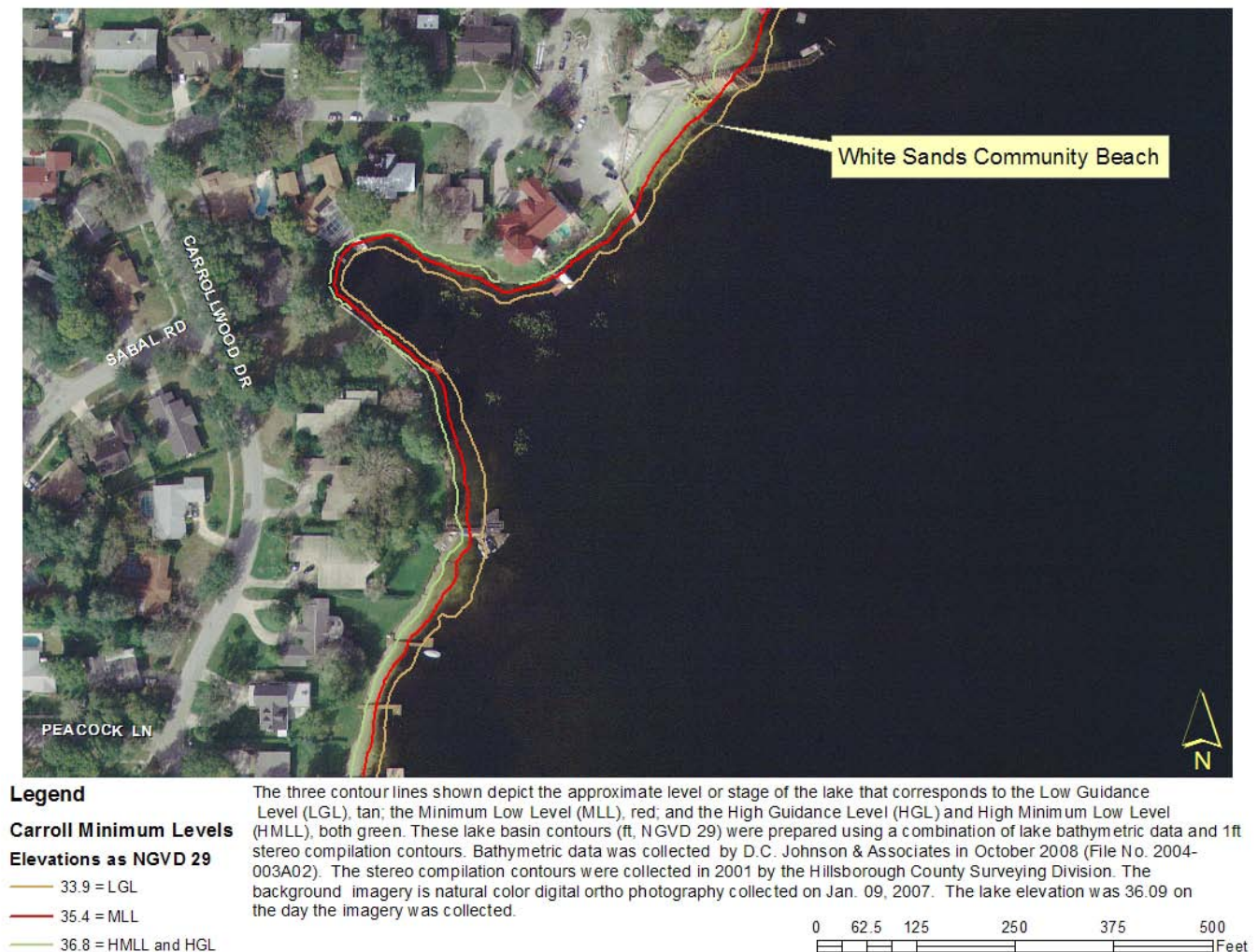




**Figure 16. Approximate location of the Minimum Lake Level (MLL), Low Guidance Level (LGL), High Minimum Lake Level (HMLL), and High Guidance Level (HGL) for Lake Carroll as associated with conditions observed on 01/12/2011 at the White Sands beach located along the western shoreline. Based on gage readings the estimated lake stage was 33.96 NGVD 29.**

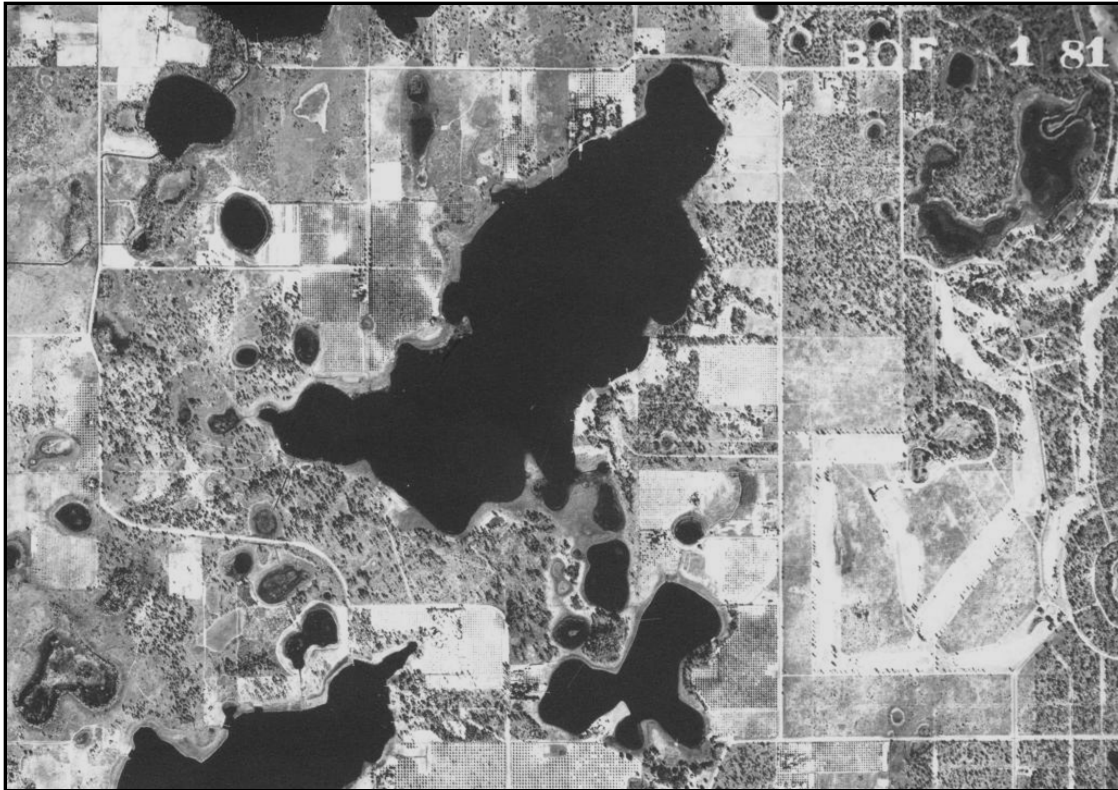


**Figure 17. Approximate location of the Minimum Lake Level (MLL), Low Guidance Level (LGL), High Minimum Lake Level (HMLL), and High Guidance Level (HGL) for Lake Carroll as associated with conditions observed on 01/09/2007 at the White Sands beach located along the western shoreline. Based on gage readings the estimated lake stage was 36.09 NGVD 29.**





**Figure 17. Historical aerial imagery collected by the U.S. Department of Agriculture, Soil Conservation Service. The top image was photographed in 1938 and the bottom image was photographed in 1957 (University of Florida, 2011).**



**Figure 18. Historical aerial imagery collected by the U.S. Department of Agriculture, Soil Conservation Service in 1968 (University of Florida, 2011).**



**Figure 19. Historical aerial photographs taken in 1967, source unknown.**



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