Minimum and Guidance Levels for Tsala Apopka Lake in Citrus County, Florida

January 17, 2007

Ecologic Evaluation Section
Resource Conservation and Development Department

Southwest Florida
Water Management District

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On the cover: Ground-level photograph of wetland in the Floral City Pool of Tsala Apopka Lake (SWFWMD files).

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Minimum and Guidance Levels for Tsala Apopka Lake

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". Mere adoption of a minimum flow or level does not necessarily protect a water body from significant harm. Protection, recovery or regulatory compliance may, however, be gauged once the flow or level standards have been established.

Minimum flows and levels are to be established based upon the best available information and shall be developed with consideration of "…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.). Additional guidance for the establishment of minimum flows and levels is provided in the Florida Water Resources Implementation Rule (Chapter 62-40.473, Florida Administrative Code; hereafter F.A.C.), which requires 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."

To address this legislative mandate within its jurisdictional boundaries, the Southwest Florida Water Management District (District or SWFWMD) has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers and aquifers, and adopted them 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 former levels are classified as Category 2 Lakes. Lakes without 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.

Typically, two Minimum Levels and three Guidance Levels are established for lakes, and upon adoption by the District Governing Board, are 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 Ten Year Flood Guidance Level is provided as an advisory guideline for lakeshore development. It is the level of flooding expected on a frequency of not less than the ten-year recurring interval, or on a frequency of not greater than a ten percent probability of occurrence in any given year.

- 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 Tsala Apopka Lake, a Category 1 Lake system located in Citrus County, Florida, and adopted by the Governing Board on October 24, 2006. Because Tsala Apopka Lake includes three hydrologically distinct regions, known as the Floral City Pool, the Inverness Pool and the Hernando Pool, three sets of minimum and guidance levels were developed for the lake system (Tables 1-3). The levels were established using best available information, including field data that were obtained specifically for the purpose of minimum levels development. Data and analyses used for development of the levels are described in the remainder of this report.

Table 1. Minimum and Guidance Levels for the Floral City Pool of Tsala Apopka Lake in Citrus County, Florida.

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	43.4
High Guidance Level	41.8
High Minimum Lake Level	41.2
Minimum Lake Level	39.8
Low Guidance Level	39.6

Table 2. Minimum and Guidance Levels for the Inverness Pool of Tsala Apopka Lake in Citrus County, Florida.

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	41.8
High Guidance Level	40.3
High Minimum Lake Level	40.1
Minimum Lake Level	38.7
Low Guidance Level	37.8

Table 3. Minimum and Guidance Levels for the Hernando Pool of Tsala Apopka Lake in Citrus County, Florida.

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	40.5
High Guidance Level	39.0
High Minimum Lake Level	38.7
Minimum Lake Level	37.3
Low Guidance Level	35.9

Data and Analyses Supporting Development of Minimum and Guidance Levels for Tsala Apopka Lake

Lake Setting and Description

Tsala Apopka Lake is located in eastern Citrus County, Florida in the Withlacoochee River Basin of the Southwest Florida Water Management District (Figure 1). White (1970) classified the region of central or mid-peninsular Florida containing Tsala Apopka Lake as the Tsala Apopka Plain of the Western Valley. The plain, which lies between the Brooksville Ridge to the west and the Sumter and Lake Uplands to the east, is approximately 50 miles long and up to 14 miles wide. Ground surface elevations range from about 50 to 75 ft above NGVD. Brooks (1981) categorized the area surrounding the lake as the Tsala Apopka Basin of the Ocala Uplift Physiographic District, and described the basin as an erosional valley consisting of a "maze of islands, swamps, marshes and lakes". As part of the Florida Department of Environmental Protection's Lake Bioassessment/ Regionalization Initiative, the area has been identified as Tsala Apopka (Griffith *et al.* 1997), with Tsala Apopka Lake described as a series of interconnected swamps, marshes, ponds and lakes. Water bodies in the region are characterized as alkaline, eutrophic, hard-water systems. Tsala Apopka Lake is a component of the Withlacoochee River System, which is classified as an Outstanding Florida Water by the Florida Department of Environmental Protection (Chapter 62-302, F.A.C.).

Tsala Apopka Lake is thought to be a relict of a large lake system that drained southward towards Tampa Bay (White 1970, Attardi 1983). With the opening of the Dunnellon Gap and uplift of land between the Tsala Apopka Plain and Tampa Bay, the ancestral lake drained to the north, forming the northern reach of the Withlacoochee River. Fluvial activity eventually separated the river from the lake, resulting in the more recent configuration of the lake system. Until the latter part of the 1800s, surface water connections between the lake and the river during periods of average rainfall were likely restricted to forested and herbaceous wetland areas. Construction of the Orange State Canal in 1884 and in subsequent years, installation of water control structures and other canal systems significantly altered connectivity between the lake and river.

Currently, Tsala Apopka Lake is composed of numerous lakes, ponds and wetlands interspersed among upland areas. Deeper open-water systems tend to occur in the western portion of the basin; shallower ponds, swamp and herbaceous marshes extend eastward toward the Withlacoochee River. Common aquatic macrophytes include saw grass (*Cladium jamaicense*), panic grasses (*Panicum hemitomum, Panicum repens*), pickerelweed (*Pontederia cordata*), american lotus (*Nelumbo lutea*), spatterdock (*Nuphar luteum*), cattail (*Typha* sp.), Egyptian paspalidium (*Paspalidium geminatum*), southern naiad (*Najas quadalupensis*), bladderwort (*Utricularia* sp.), coontail (*Ceratophyllum demersum*), tape-grass (*Vallisneria americana),* stonewort (*Nitella* sp.), pondweed (*Potamogeton illinoensis*), and hydrilla (*Hydrilla verticillata*) (Attardi 1983,

SWFWMD 1990). Dominant woody species include water primrose (*Ludwigia* sp.), willow (*Salix* sp.), wax myrtle (*Myrica cerifera*), red maple (*Acer rubrum*), and cypress (*Taxodium* sp). Extensive canal systems have been dredged in wetlands throughout the basin, and inshore areas of many deepwater habitats have been dredged for upland fill. Uplands in the western portion of the basin are used primarily for residential development. Cleared uplands in the eastern basin are used for livestock grazing. Public access to the lake system is available at several public boat ramp facilities, parks and State-owned lands, including the District's Flying Eagle and Potts Preserve tracts (Figure 2).

For descriptive and water management purposes, open water and wetland areas of the lake system are grouped into three pools. The southernmost, the Florida City Pool, includes Floral City Lake, Hampton Lake, Tussock Lake and extensive marshes and forested wetlands lying between the lakes and the Withlacoochee River (Figure 3). Water levels in the Floral City Pool are monitored at a site along the south shore of Floral City Lake. The central pool is known as the Inverness Pool, and includes Davis Lake, Spivey Lake, Henderson Lake, Little Henderson Lake and interconnecting wetlands (Figure 4). Water levels for the Inverness Pool are monitored at a gauging station on the north shore or Lake Henderson, just east of the connection between Lakes Henderson and Little Henderson. The Hernando Pool is located to the north of the Inverness Pool, and includes Point Lonesome Lake, Van Ness Lake, Croft Lake, Hernando Lake, Todd Lake, Bellamy Lake, Dodd Lake and extensive wetland areas (Figure 5). Water levels in the Hernando Pool are monitored at a gauge site on the southwest shore of Hernando Lake.

The lake system lies within the Tsala Apopka Outlet drainage basin in the Withlacoochee River watershed (U.S. Geological Survey Hydrologic Unit Classification System). Surface water withdrawals from open water bodies in the Tsala Apopka system were likely common historically, given the prevalence of citrus production in the area (Attardi 1983, Bradner 1988). Currently, only a few surface withdrawals from the lake are permitted by the District. There are, however, a number of permitted groundwater withdrawals in the lake vicinity. Surface water inputs include direct precipitation on water bodies within the system and runoff from immediately adjacent upland areas. The main source of surface water input is, however, the Withlacoochee River (SWFWMD 1990). Inflow from the river occurs primarily in the Floral City Pool area, through the Orange State and Leslie Heifner Canals (Figure 6). Uncontrolled flow from the river also enters the lake system during periods when the river stage exceeds natural control elevations along the western bank of the river.

Control of inflow from the river to the Floral City Pool is maintained through operation of three District water control structures (Figure 6). The Floral City Water Control Structure, which is located on the Orange State Canal, has been operated by the District since 1962 to control flow into Florida City Lake and prevent backflow from the lake to the river. A smaller District structure, the Orange State Water Control Structure, has been used since 1966 to control inflows from the Orange State Canal to the marsh

area east of Florida City Lake. The Leslie Heifner Water Control Structure has been operated since 1967 to regulate flow in the Leslie Heifner Canal.

Water moves northward from the Floral City Pool to the Inverness Pool through two primary routes: the Golf Course Canal, a canal dredged through Tussock Lake to Davis Lake; and Moccasin Slough Canal, which runs through a natural wetland area known as Moccasin Slough (Figure 6). A third dredged canal, known as Shinn Ditch, also provides conveyance from the Floral City Pool, directing flow northward to the Withlacoochee River (Figure 6). Since 1965, the District has operated the Golf Course Water Control Structure, which is situated on the Golf Course Canal between Tussock and Davis Lakes, to maintain desirable water levels in the Floral City Pool and control inflow to the Inverness Pool. Until recently, flow through Moccasin Slough was uncontrolled. Operation of the Moccasin Slough Water Control Structure currently allows regulation of flow northward.

Water levels in the Inverness Pool are managed primarily through operation of the District's Bryant Slough and Brogden Bridge Water Control Structures (Figure 6). The Bryant Slough Water Control Structure is located downstream from the Moccasin Slough Structure and in varying configurations has been used since 1953 to maintain flow from the Floral City Pool to the Inverness Pool or allow diversion of water from the lake system back to the Withlacoochee River. Operation of the Brodgen Bridge Water Control Structure provides the primary means for controlling flow between the Inverness and Hernando Pools. The Brodgen Bridge Water Control Structure is located on a channel originating in a wetland area north of Henderson Lake in the Inverness Pool and terminating in wetlands east of Point Lonesome, Van Ness and Croft Lakes in the Hernando Pool. The District's Brogden Bridge Culverts, which are located near the Brodgen Bridge Water Control Structure, are used to hydrate a wetland area downstream from the Inverness Pool (Figure 6).

Outflow from the Hernando Pool is managed through maintenance and operation of the Van Ness Water Control Structure, the Tsala Apopka Outfall Canal (C-331) and the S-353 Water Control Structure (Figure 6). The Van Ness Water Control Structure has been operated by the District since 1962, and is used to divert water into Two Mile Prairie to maintain desirable water levels within the lake and provide for wetland hydration and aquifer recharge in the prairie area. The Tsala Apopka Outfall Canal is the primary controlled route for conveyance of water from the lake system back to the Withlacoochee River. Water Control Structure S-353, which is located on the canal, has been operated by the District since 1968, when it was constructed at the site of a former water control structure known as the Robinson Structure

Heath and Conover (1981) note that Tsala Apopka Lake is a meandered lake, a designation indicative of navigability, and which is often used to establish State sovereignty. The "Gazetteer of Florida Lakes" (Florida Board of Conservation 1969, Shafer *et al.* 1986) lists an area of 19,111 acres and water surface elevation of 39 feet for Tsala Apopka Lake. Portions of Tsala Apopka Lake are shown on the 1893 and 1895 United States Geological Survey 1:62,500 Florida, Panasoffkee Sheet and the

1895 Florida, Panasoffkee Sheet. Water surface elevations for the lake are not, however, provided on these maps. The 1895 United States Geological Survey 1:62,500 Florida, Tsala Apopka Sheet includes water surface elevations of 43, 39 and 38 feet above mean sea level, respectively, for Floral City Lake, Henderson Lake and Hernando Lake. The 1954 (and photorevised 1988) U.S. Geological Survey 1:24:000 Inverness, Fla. map shows the Floral City Pool at an elevation of 41 feet above mean sea level and the Inverness Pool at an elevation of 39 feet above mean sea level. The 1954 Stokes Ferry map includes an elevation of 38 feet above sea level for portions of the Inverness and Hernando Pools. Inundated areas for several open-water bodies (lakes) within the Tsala Apopka Lake system at various water surface elevations are shown in Figures 7-14.

Figure 1. Location of Tsala Apopka Lake in Citrus County, Florida. Other major water bodies and major roads are also shown.

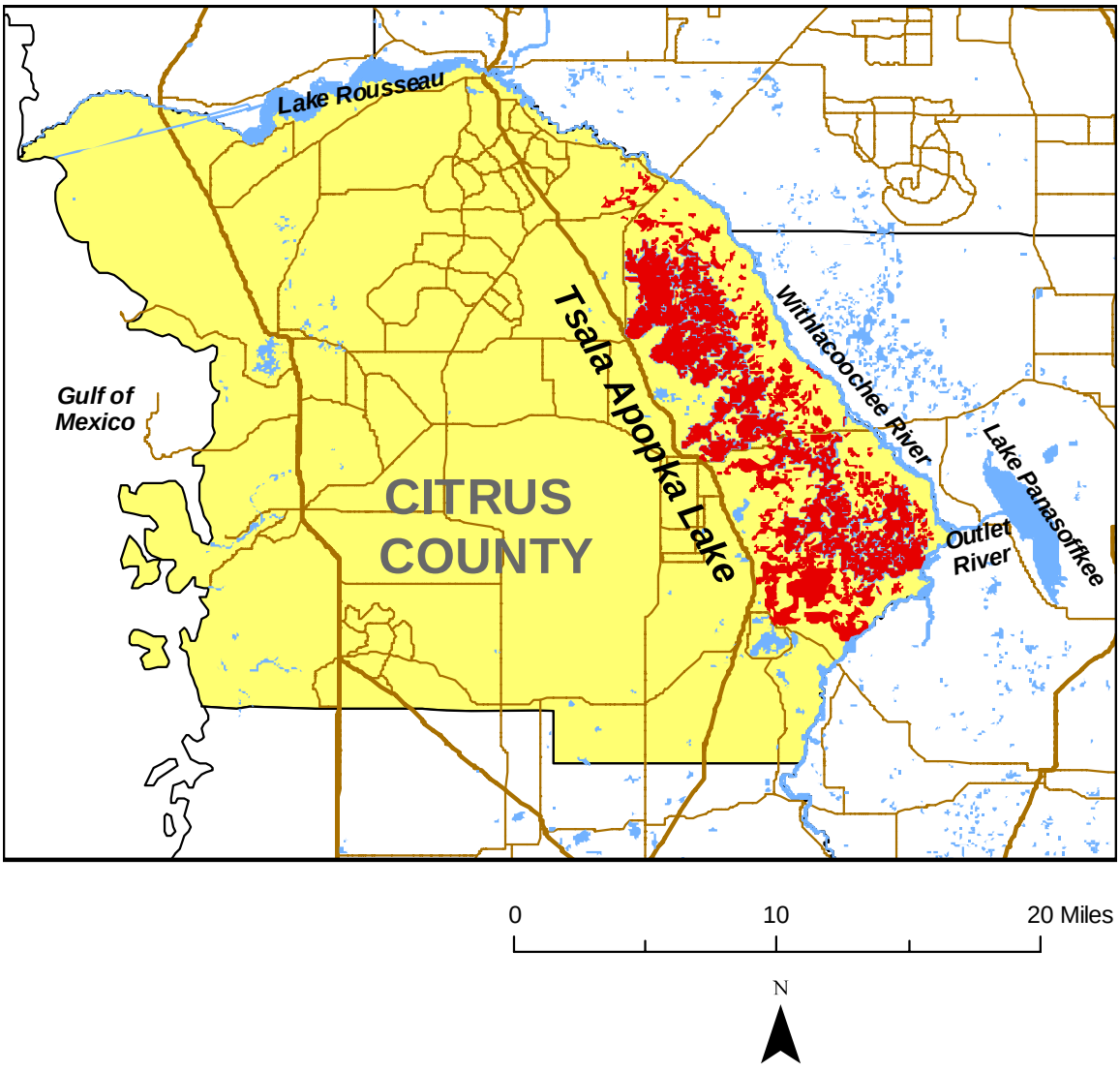


Figure 2. Location of public boat ramps and District-owned lands on Tsala Apopka Lake.

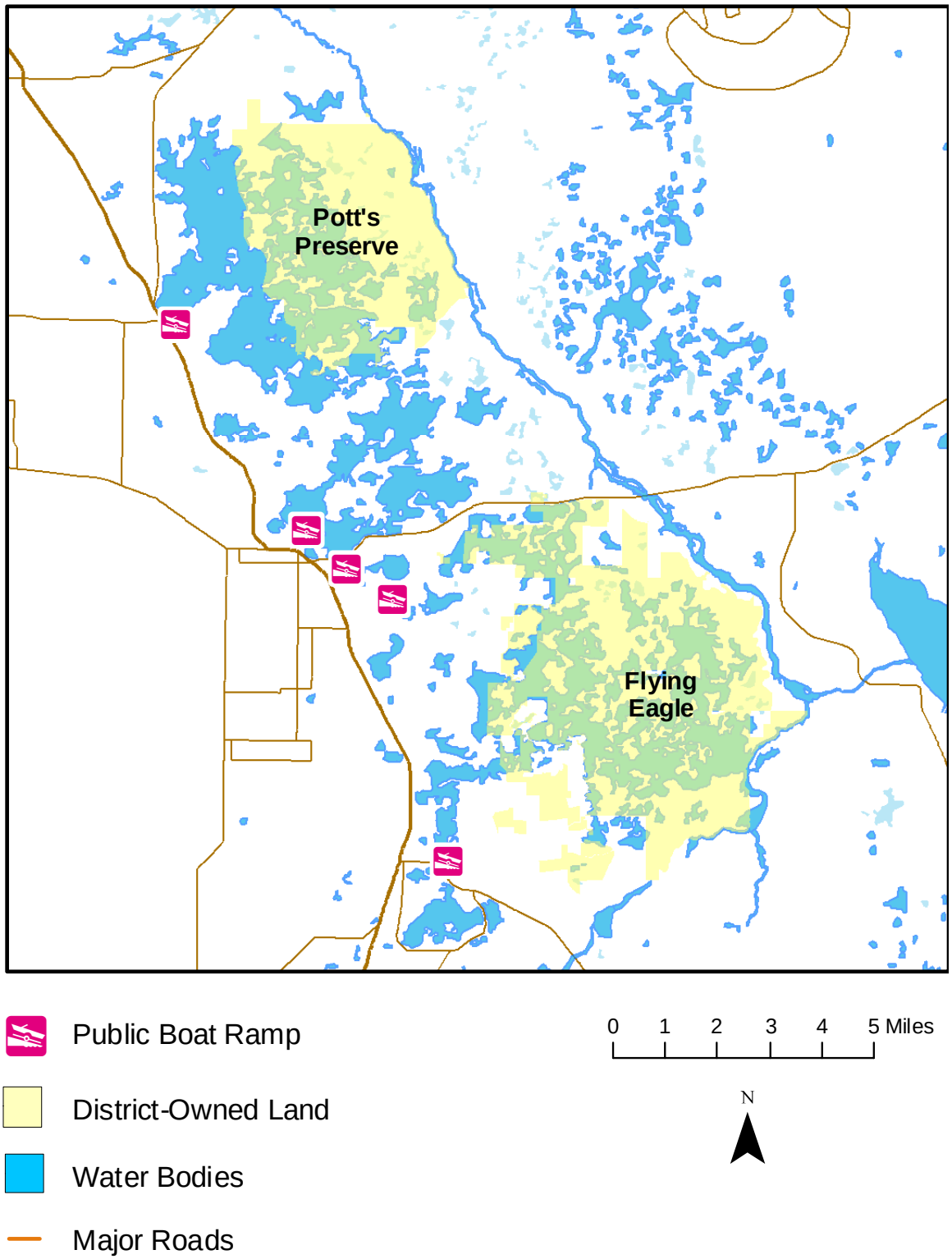
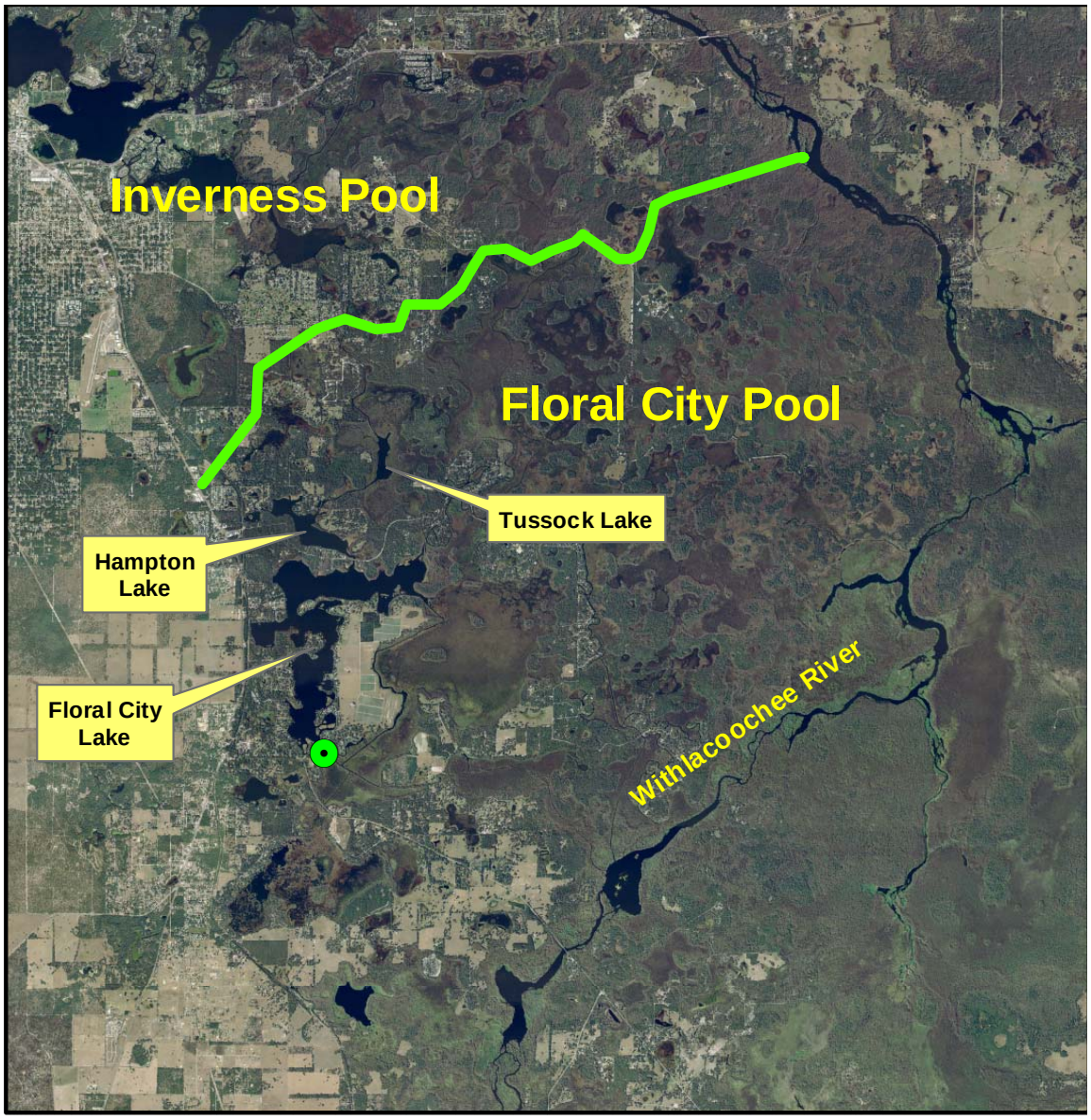
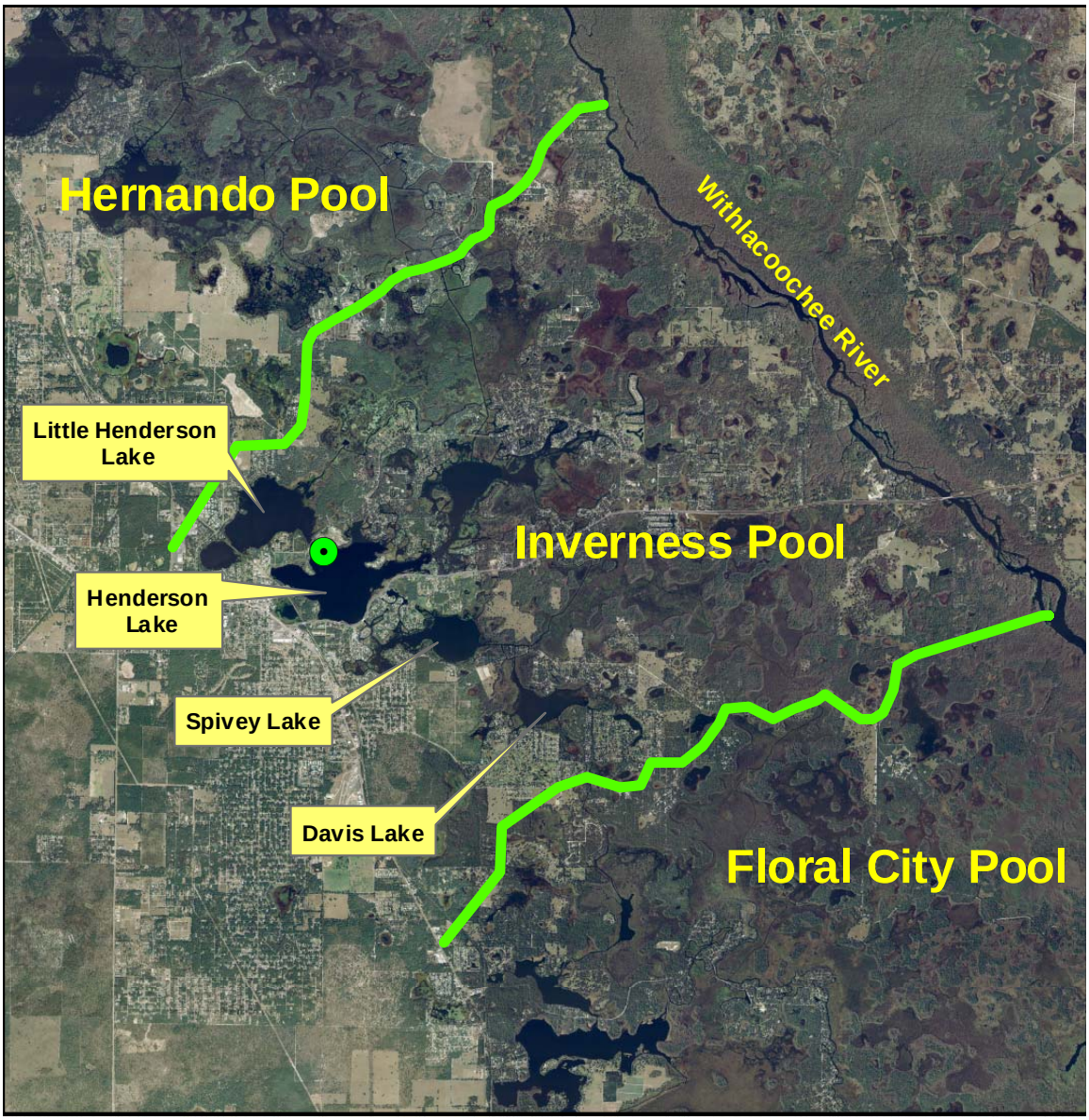


Figure 3. Generalized area map of the Floral City Pool of Tsala Apopka Lake. Major open-water bodies (lakes), the Withlacoochee River and approximate boundary between the Floral City and Inverness Pools are identified, along with the location of the District's water level gauging station for the Florida City Pool.



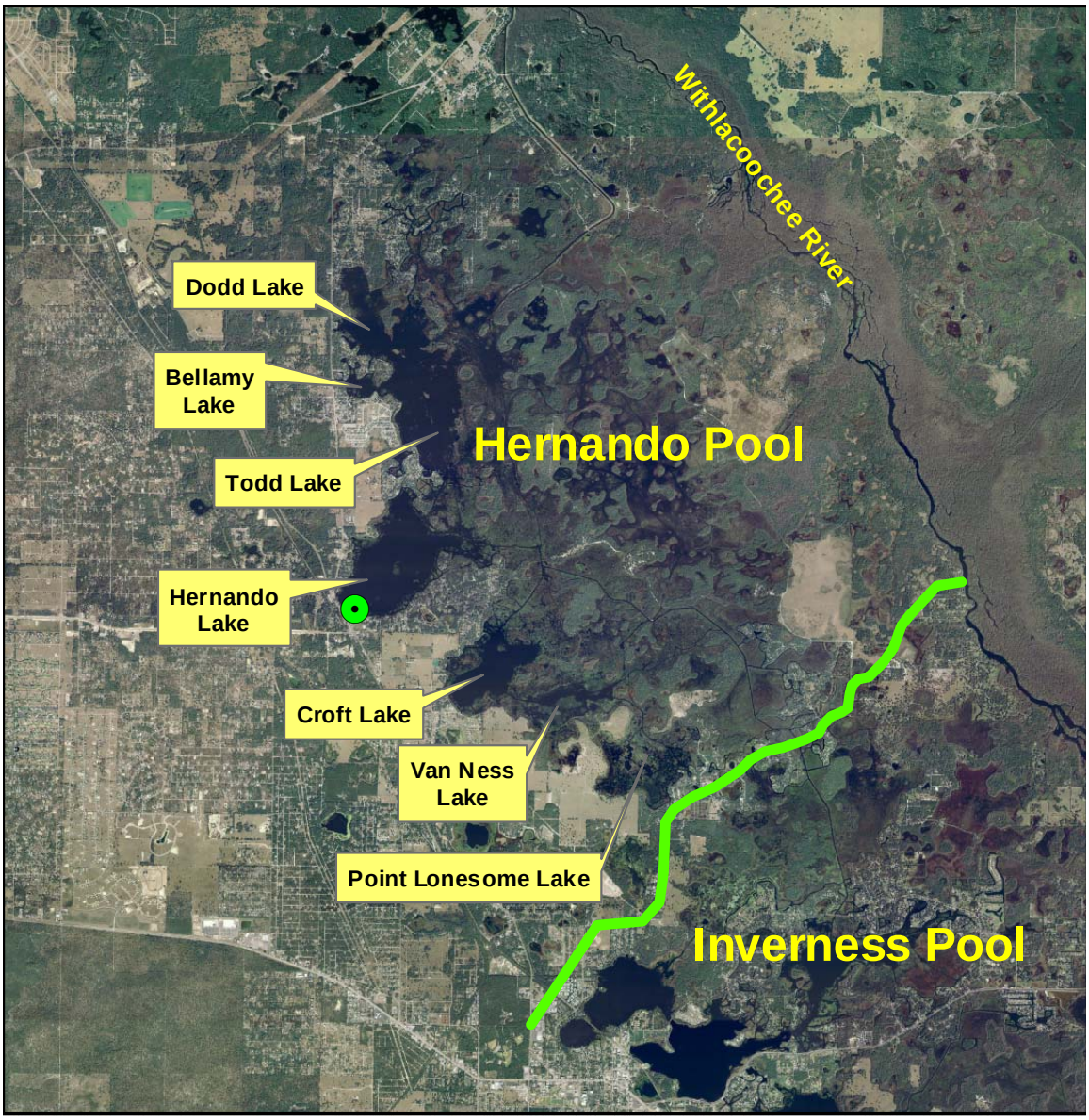
Map prepared using USGS (2005 one-foot natural color orthophotography.

Figure 4. Generalized area map of the Inverness Pool of Tsala Apopka Lake. Major open-water bodies (lakes), the Withlacoochee River and approximate boundaries between the Inverness, Floral City and Hernando Pools are identified, along with the location of the District's water level gauging station for the Inverness Pool.



Map prepared using USGS (2005) one-foot natural color digital orthophotography.

Figure 5. Generalized area map of the Hernando Pool of Tsala Apopka Lake. Major open-water bodies (lakes), the Withlacoochee River and approximate boundary between the Hernando and Inverness Pools are identified, along with the location of the District's water level gauging station for the Hernando Pool.



Map prepared using USGS (2005) one-foot natural color orthophotography.

Figure 6. District water control structures and selected canals in the vicinity of Tsala Apopka Lake.

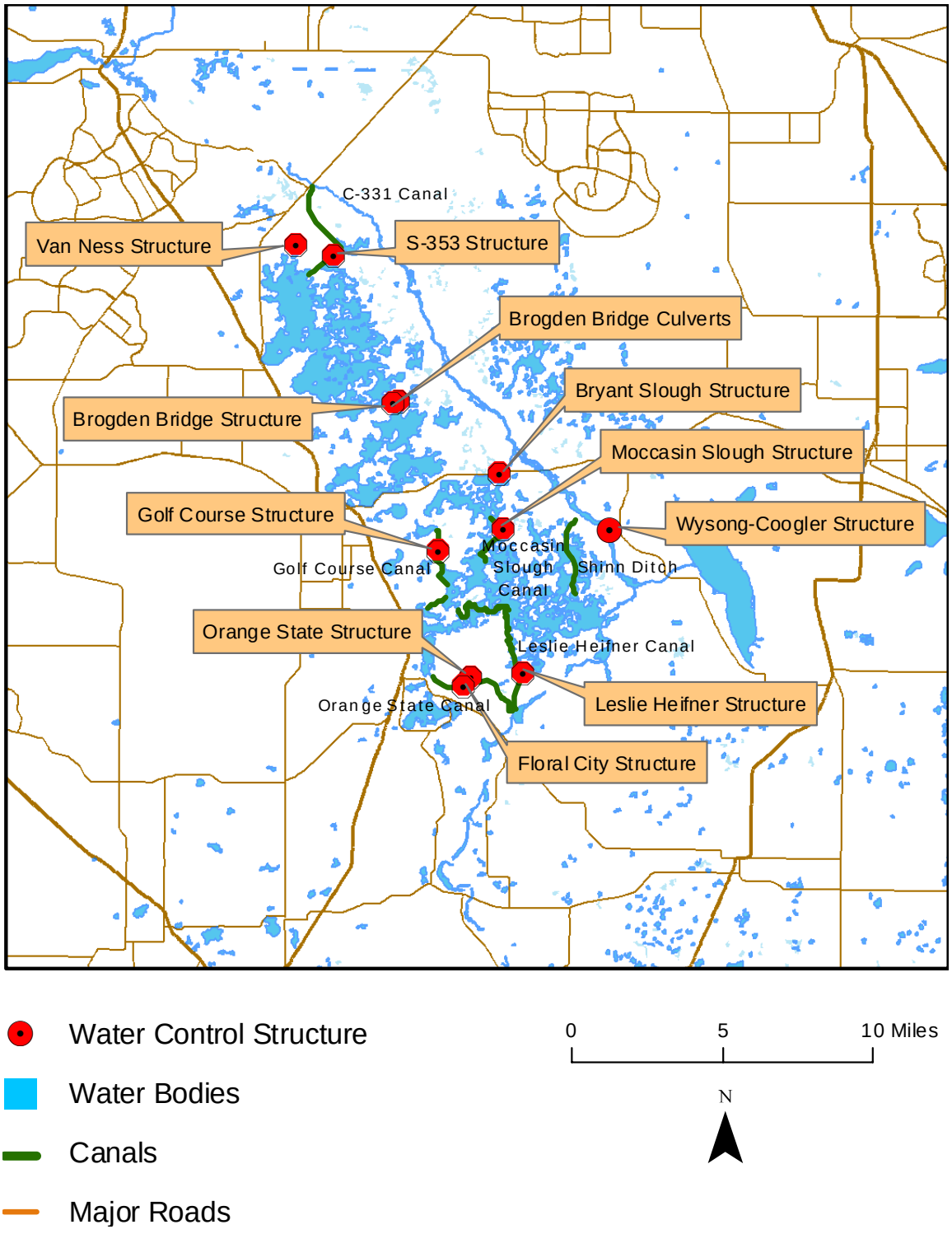
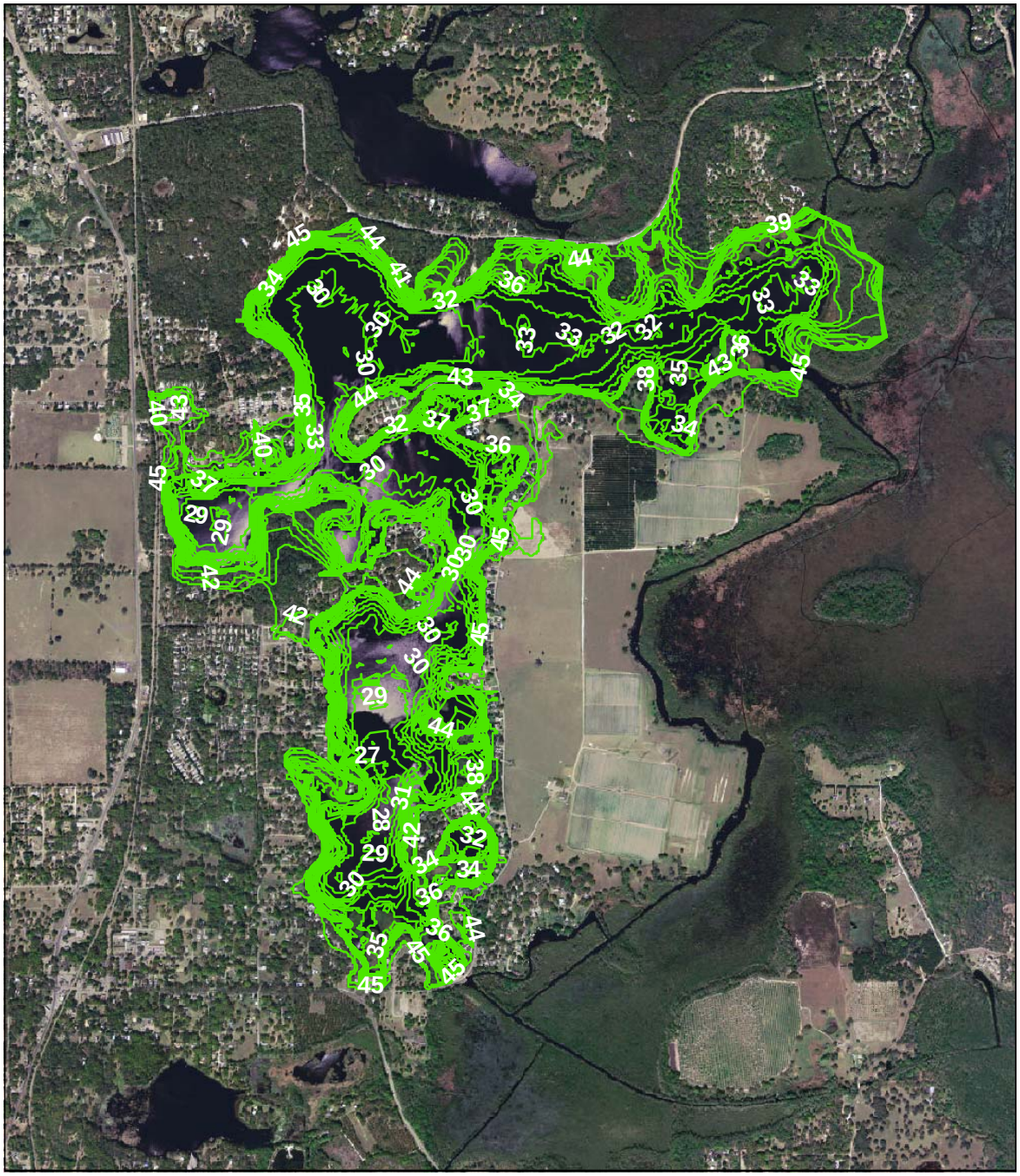


Figure 7. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Floral City Lake basin. Contours shown for the northeast portion of the basin include artifacts associated with truncation of the mapped area.

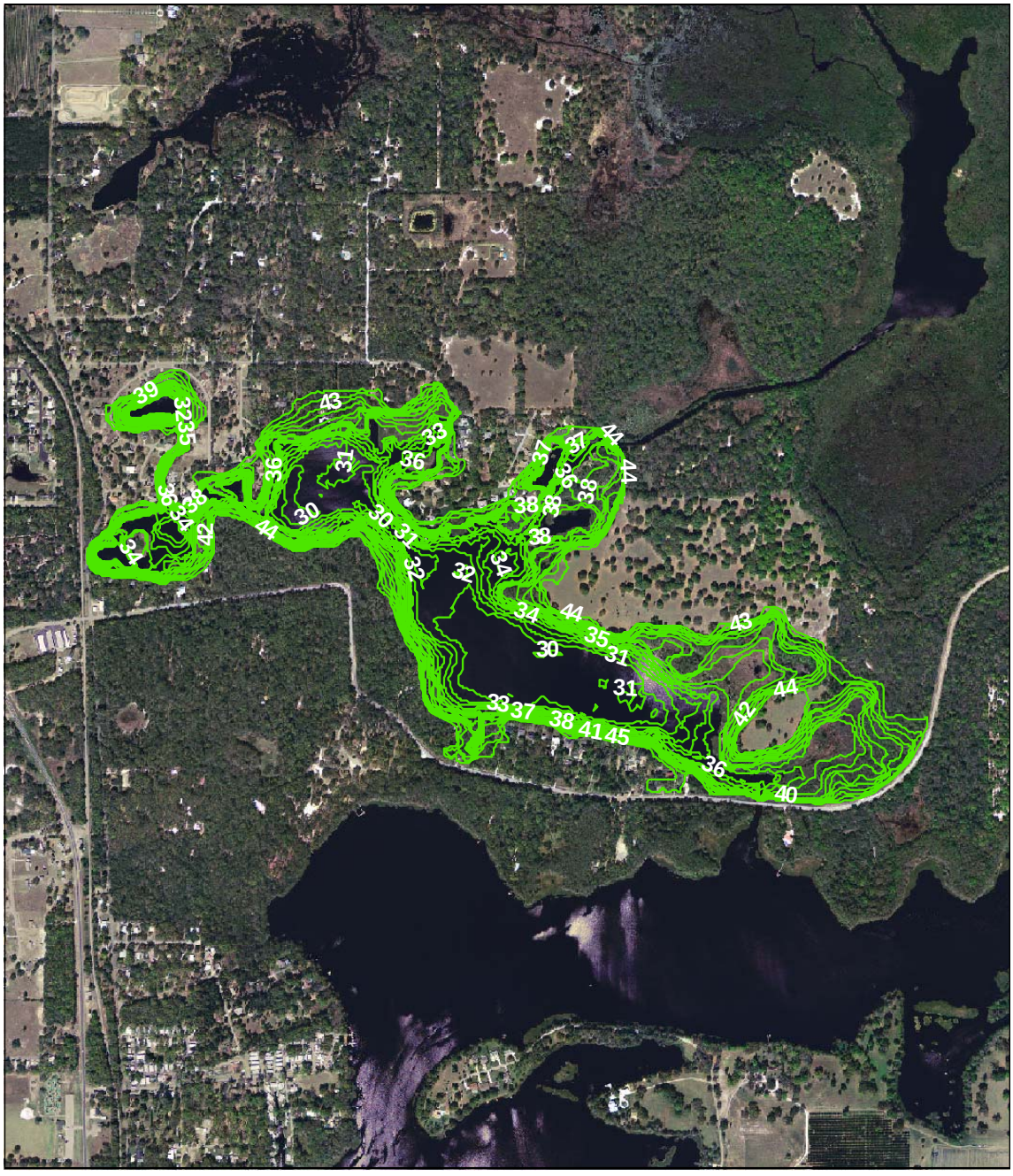


Map prepared using USGS 2004 true color digital orthophotography, elevation data from 1981 SWFWMD aerial photography with contours maps (Secs. 1, 2, 3, 10, 11, 14, and 15, Twp. 20 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

0 0.25 0.5 Miles

N

Figure 8. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Hampton Lake basin. Contours shown for the north-central portion of the basin include artifacts associated with truncation of the mapped area.

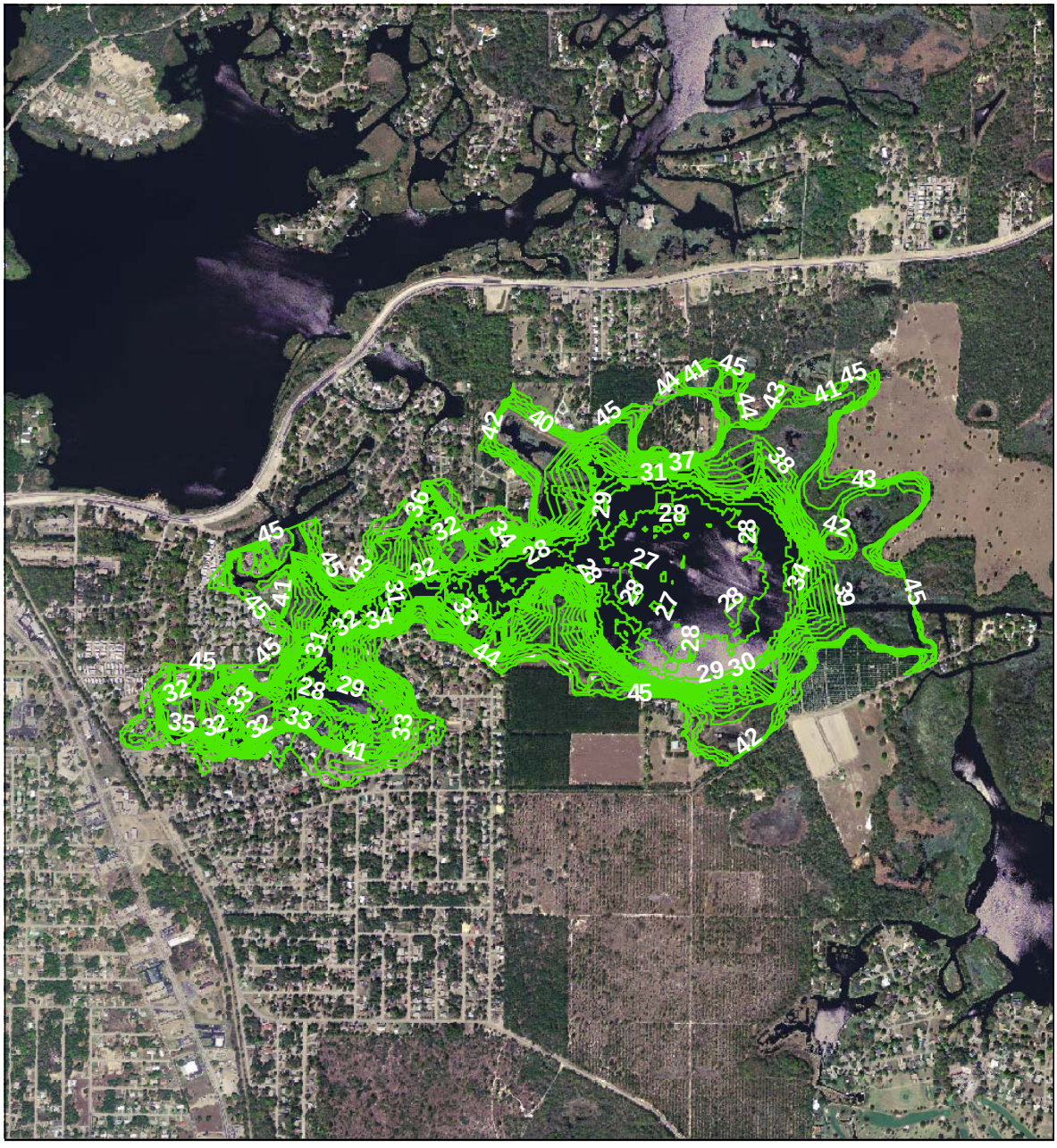


Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1981 SWFWMD aerial photography with contours maps (Secs. 34, and 35, Twp. 19 S, Rge. 20 E, and Secs. 2, and 3, Twp. 20 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

0 0.1 0.2 0.3 0.4 Miles

N

Figure 9. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Spivey Lake basin. Contours shown for the southeastern portion of the basin include artifacts associated with truncation of the mapped area.



Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1976 SWFWMD aerial photography with contours maps (Secs. 15, 16, 21, 22, Twp. 19 S, Rge. 20 E), and elevation data collected 2004 by D.C. Johnson and Associates, Inc.

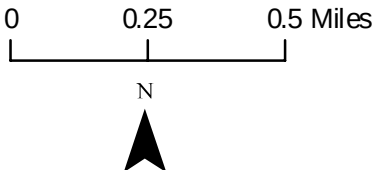
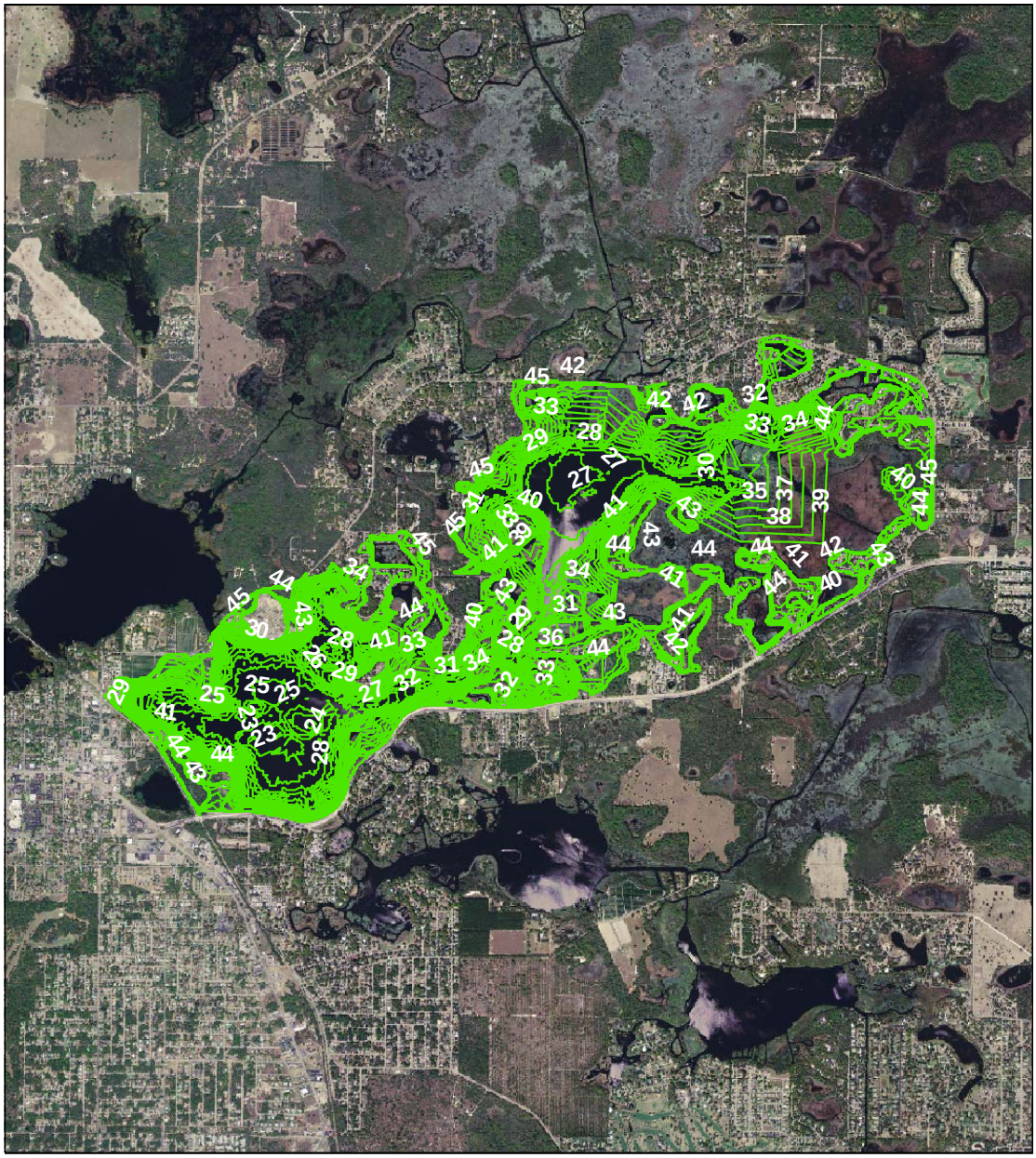


Figure 10. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Lake Henderson basin. Contours shown for the northeastern portion of the basin include artifacts associated with truncation of the mapped area.

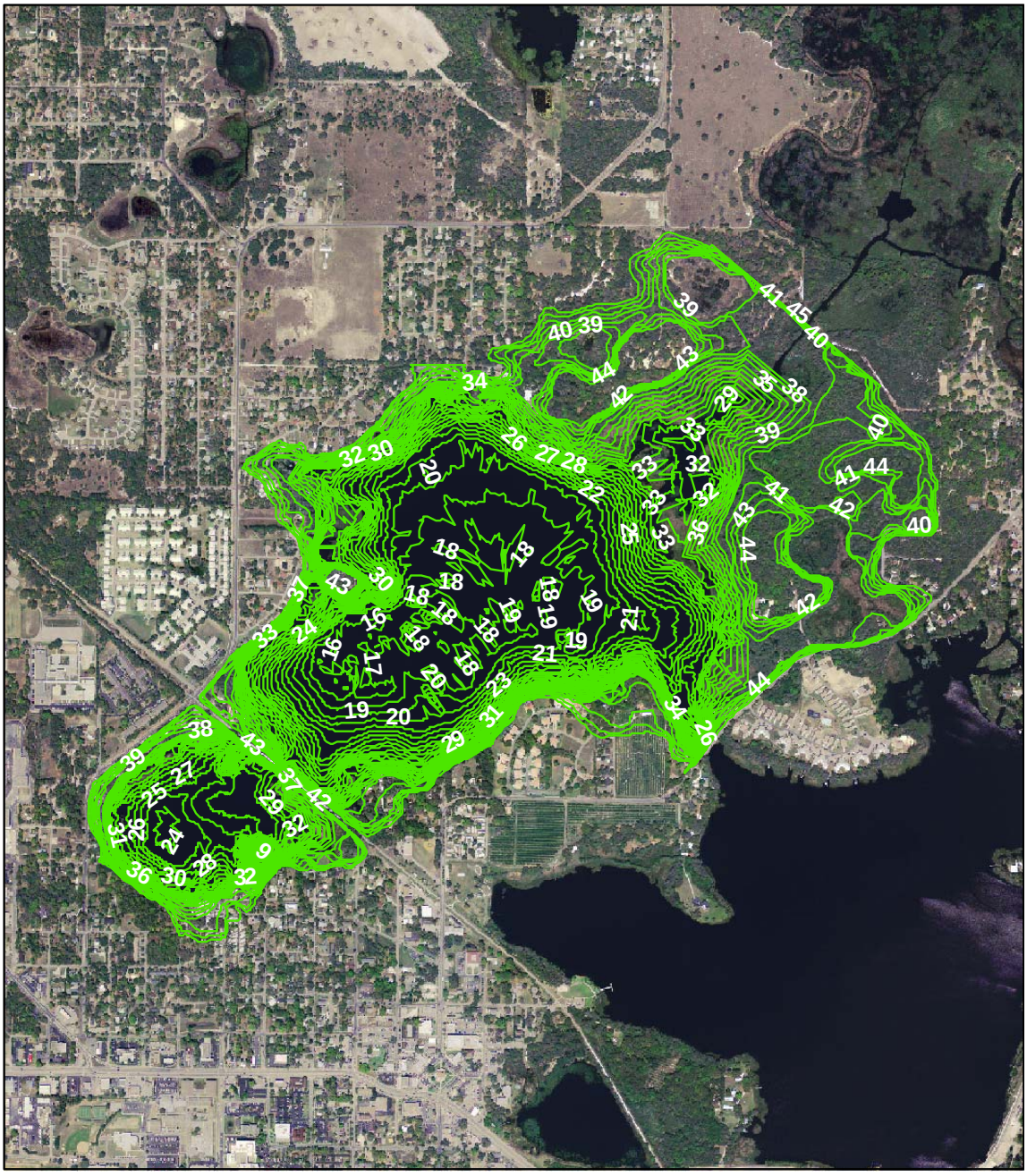


Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1976 SWFWMD aerial photography with contours maps (Secs. 2, 3, 8 - 11, 15 - 17, Twp. 19 S, Rge. 20 E), and elevation data in 2004 collected by D.C. Johnson and Associates, Inc.

0 0.5 1 Miles

N

Figure 11. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Little Lake Henderson basin. Contours shown for the northeastern portion of the basin include artifacts associated with truncation of the mapped area.

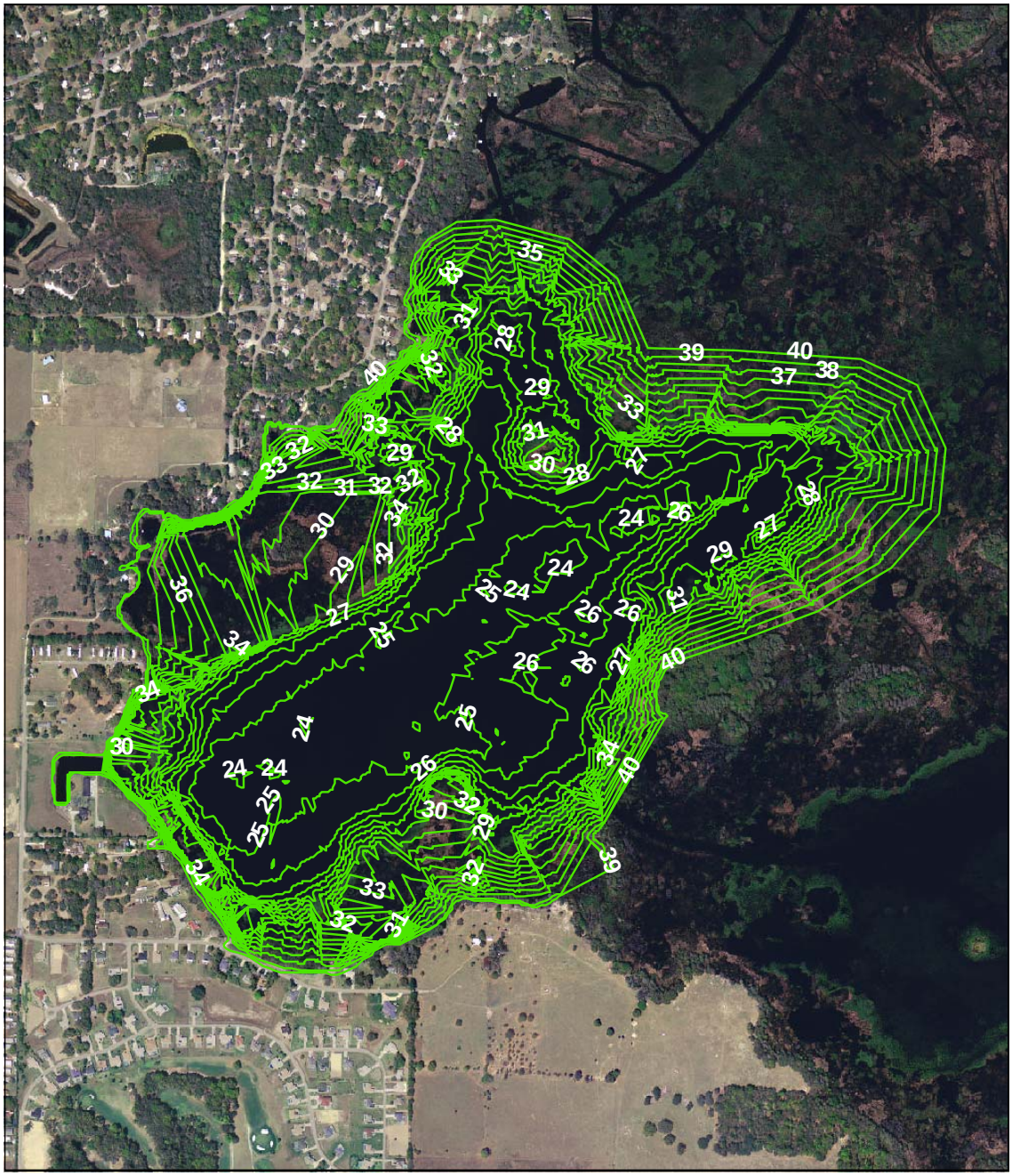


Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 and 1976 SWFWMD aerial photography with contours maps (Secs. 7 - 9, 17, and 18, Twp. 19 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

0 0.25 0.5 Miles

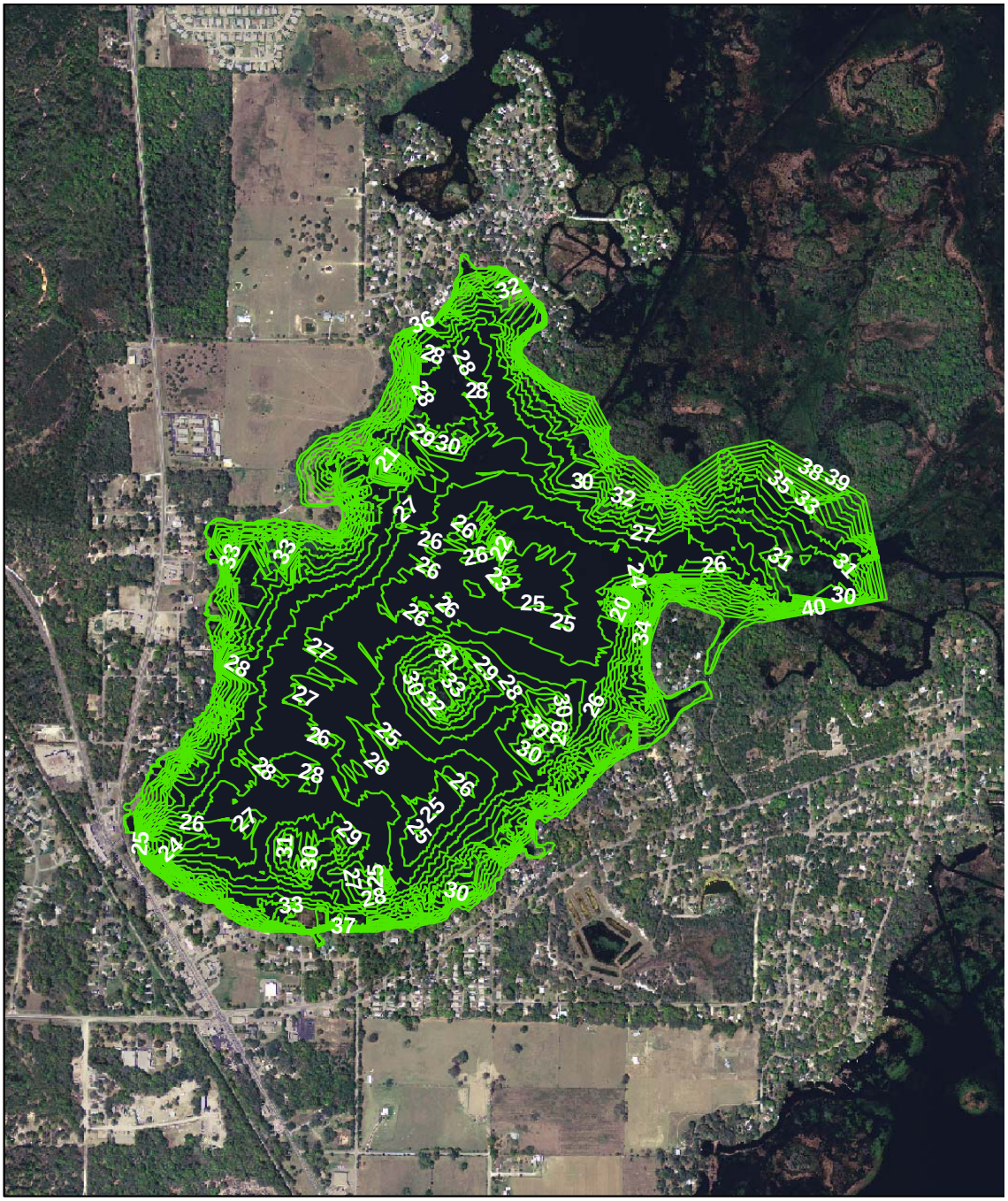
N

Figure 12. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Croft Lake basin. Contours shown for the eastern portion of the basin include artifacts associated with truncation of the mapped area.



Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 25, and 36, Twp. 18 S, Rge. 19 E, and Sec. 30, Twp. 18 S, Rge 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 13. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the Hernando Lake basin. Contours shown for the northeastern portion of the basin include artifacts associated with truncation of the mapped area.

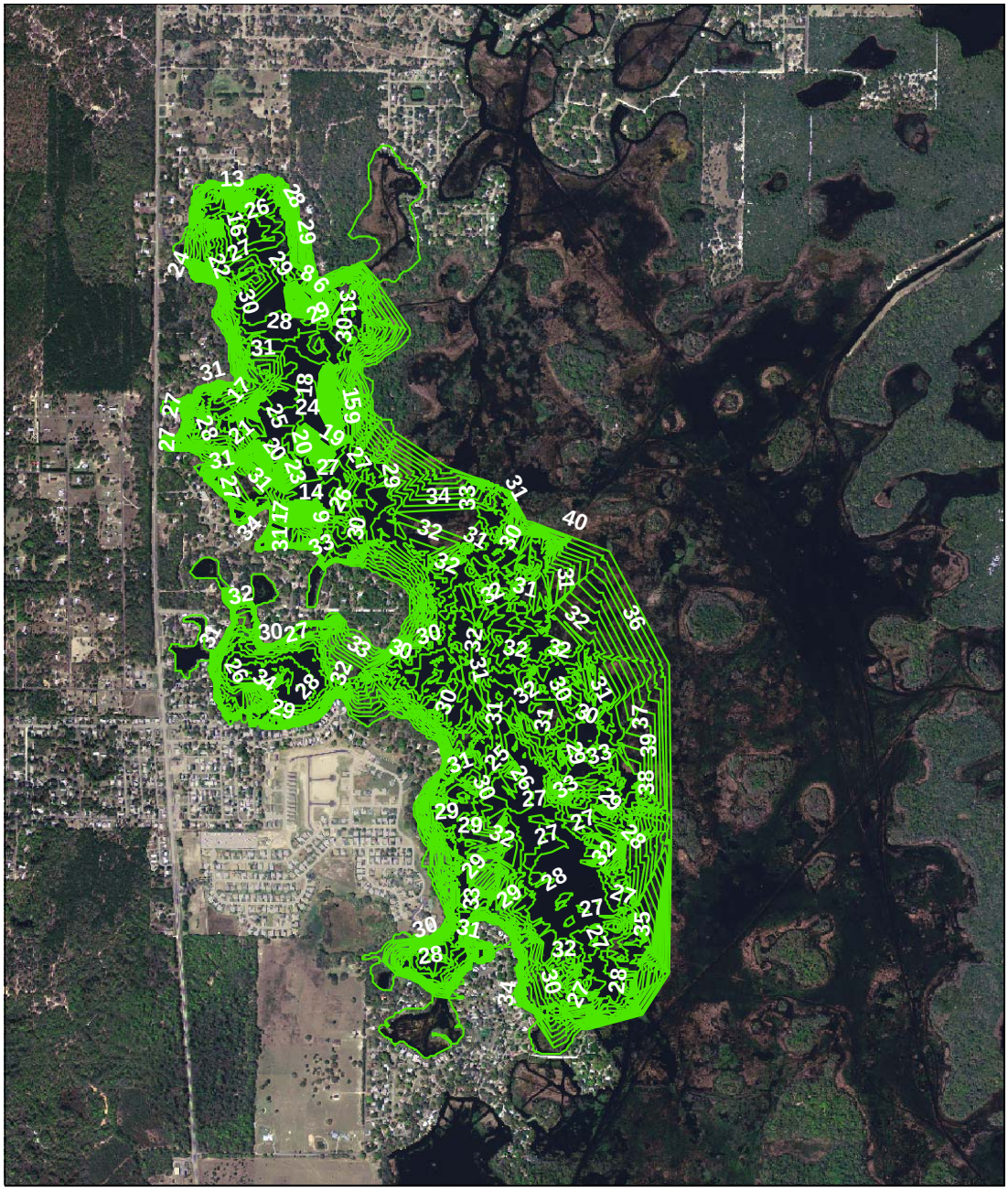


Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 13, 23 - 26, Twp. 18 S, Rge. 19 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

0 0.25 0.5 Miles

N

Figure 14. One-foot elevation (relative to the National Geodetic Vertical Datum of 1929) contours within the basins of Todd Lake, Bellamy Lake and Dodd Lake. Contours shown for the eastern portion of the basins include artifacts associated with truncation of the mapped area.



Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 1, 2, 11 - 14, Twp. 18 S, Rge. 19 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

0 0.25 0.5 Miles

N

Previously Adopted Guidance Levels and Operation Schedules

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 establishing 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 1960s, 70s and 80s (see SWFWMD 1996), the District adopted management levels (currently referred to as Guidance Levels) for the Floral City, Inverness and Hernando Pools of Tsala Apopka Lake in June 1983 and incorporated the levels into Chapter 40D-8.624, F.A.C. (Table 4). Maximum Desirable Levels of 42.25, 40.25, and 38.75 ft above NGVD were also developed for the Floral City, Inverness and Hernando Pools, respectively, but were not adopted. The previously adopted Guidance Levels and the 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 methodologies. The previously adopted levels are provided here for historical purposes; the levels are no longer included in District rules.

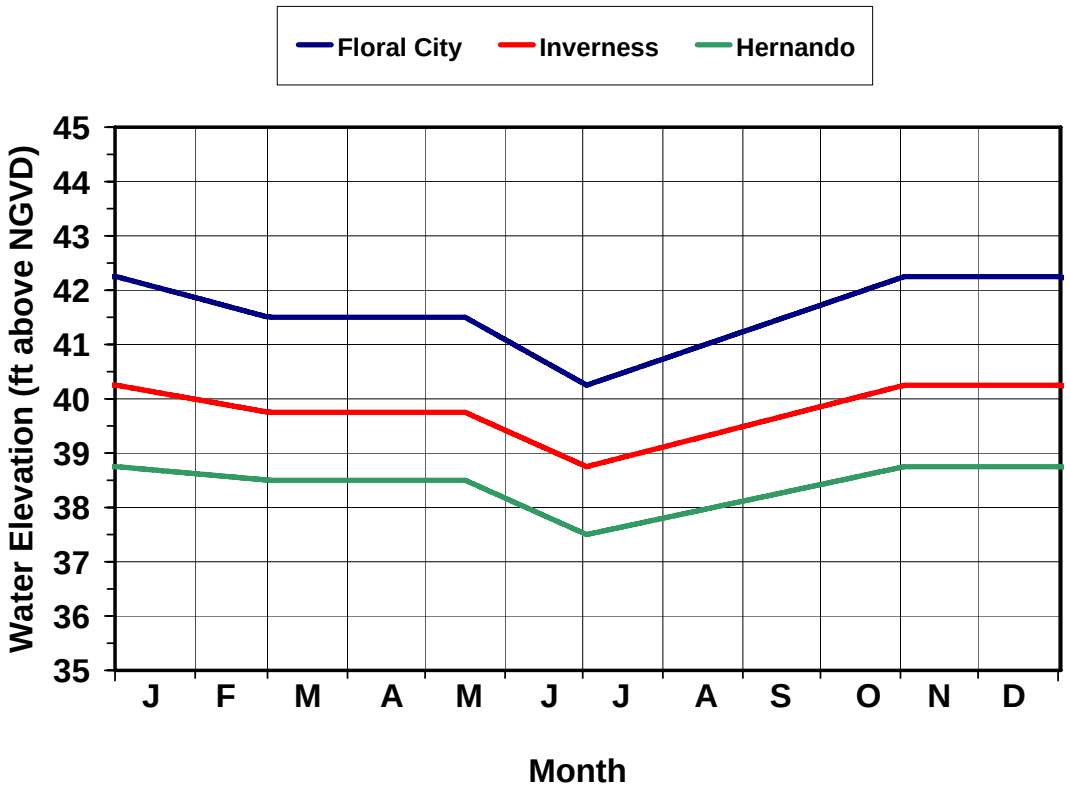
Operation of District-owned water control structures within the Tsala Apopka Lake basin is conducted in accordance with pool-specific operation schedules (Figure 15) that were developed in cooperation with the United States Army Corps of Engineers in the late 1960s. The operation schedules played a critical role in the development of the Guidance Levels that were adopted for the three lake pools in 1983. Although the previously adopted Guidance Levels have been replaced in Chapter 40D-8.624 by the currently adopted Minimum and Guidance levels, it is anticipated that the District will continue to use the existing operation schedules for the Tsala Apopka Lake water control structures, in accordance with direction provided in Chapter 40D-8.621, F.A.C. As noted in Chapter 40D-8.621, the District is required to utilize the operational capacity of its water control structures to ensure compliance with adopted Minimum Levels.

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 Guidance Levels adopted using previous Lake Level methods, chronic fluctuation below the Low Level is considered a stressed condition. For lakes without adopted levels, the evaluation of stressed condition is conducted on a case-by-case basis. None of the three main pools of Tsala Apopka Lake are included on the most recent Stressed Lakes List (Gant 2006), although the Floral City and Inverness pools have been previously classified as stressed lakes.

Table 4. Previously adopted Guidance Levels for the three pools of Tsala Apopka Lake. The levels are expressed as elevations, in feet above the National Geodetic Vertical Datum of 1929.

Pool Name	Ten Year Flood Guidance Level	High Level	Low Level	Extreme Low Level
Floral City	43.40	42.50	40.25	38.25
Inverness	41.80	40.50	38.25	36.25
Hernando	40.50	39.00	36.75	34.75

Figure 15. Schedules used for operation of District water control structures on Tsala Apopka Lake. Schedules for the three lake pools, expressed as elevations in feet above the National Geodetic Vertical Datum of 1929, are shown for one annual cycle.



Summary Data Used for Minimum and Guidance Level Development

Minimum and Guidance Levels were developed for the Floral City, Inverness and Hernando Pools of Tsala Apopka Lake using the methodology for Category 1 Lakes described in Chapter 40D-8.624, F.A.C. The levels are listed in Tables 5-7, along with additional information. Detailed descriptions of the development and use of these data are summarized in subsequent sections of this report.

Table 5. Minimum and Guidance Levels, lake stage exceedance percentiles, Normal Pool, Control Point and Historic P50 elevations, and significant change standards for the Floral City Pool of Tsala Apopka Lake.

	Elevation (feet above NGVD)
Lake Stage Exceedance Percentiles	
Historic P10	41.8
Historic P50	41.1
Historic P90	39.6
Other Levels	
Normal Pool	41.6
Control Point	37.6 – 42.0
Guidance Levels and Historic P50	
Ten Year Flood Guidance Level	43.4
High Guidance Level	41.8
Low Guidance Level	39.6
Significant Change Standards	
Cypress Standard	39.8
Dock-Use Standard*	41.4
Connectivity Standard*	NA
Mixing Standard*	40.1
Aesthetic Standard*	39.6
Species Richness Standard*	NA
Recreation/Ski Standard*	37.7
Minimum Levels	
High Minimum Lake Level	41.2
Minimum Lake Level	39.8

***** For comparative purposes only; not used for minimum levels development
NA = Not applicable or not available

Table 6. Minimum and Guidance Levels, lake stage exceeadnce percentiles, Normal Pool, Control Point and Historic P50 elevations, and significant change standards for the Inverness Pool of Tsala Apopka Lake.

	Elevation (feet above NGVD)
Lake Stage Exceedance Percentiles	
Historic P10	40.3
Historic P50	39.5
Historic P90	37.8
Other Levels	
Normal Pool	40.5
Control Point	34.25 – 40.25
Guidance Levels and Historic P50	
Ten Year Flood Guidance Level	41.8
High Guidance Level	40.3
Low Guidance Level	37.8
Significant Change Standards	
Cypress Standard	38.7
Dock-Use Standard*	40.6
Connectivity Standard*	NA
Aesthetic Standard*	37.8
Species Richness Standard*	NA
Recreation/Ski Standard*	34.0
Mixing Standard*	31.7
Minimum Levels	
High Minimum Lake Level	40.1
Minimum Lake Level	38.7

***** For comparative purposes only; not used for minimum levels development
NA = Not applicable or not available

Table 7. Minimum and Guidance Levels, lake stage exceedance percentiles, Normal Pool, Control Point and Historic P50 elevations, and significant change standards for the Hernando Pool of Tsala Apopka Lake.

	Elevation (feet above NGVD)
Lake Stage Exceedance Percentiles	
Historic P10	39.0
Historic P50	38.1
Historic P90	35.9
Other Levels	
Normal Pool	39.1
Control Point	36.5 – 40.5
Guidance Levels and Historic P50	
Ten Year Flood Guidance Level	40.5
High Guidance Level	39.0
Low Guidance Level	35.9
Significant Change Standards	
Cypress Standard	37.3
Dock-Use Standard*	40.0
Connectivity Standard*	NA
Aesthetic Standard*	35.9
Species Richness Standard*	NA
Recreation/Ski Standard*	33.2
Mixing Standard*	36.6
Minimum Levels	
High Minimum Lake Level	38.7
Minimum Lake Level	37.3

***** For comparative purposes only; not used for minimum levels development
NA = Not applicable or not available

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.,* surface water elevations, for the three main pools of Tsala Apopka Lake are available from the District's Water Management Data Base. Data are available for the Floral City Pool (District Universal Identification Number STA 52 52) from March 1957 to the present (Figure 16). The highest surface water elevation for the pool included in the database, 44.22 ft above NGVD, occurred on March 29, 1960. The low of record, 30.35 ft above NGVD, was recorded on June 18, 2001. Lake stage data for the Inverness Pool (District Universal Identification Number STA 15 15) are available from July 1957 to the present (Figure 17). The highest surface water elevation for the Inverness Pool, 42.94 ft above NGVD, occurred on April 4 and 5, 1960. The low of record, 31.56 ft above NGVD, occurred on May 31, 2001. Data are available for the Hernando Pool (District Universal Identification Number STA 488 490) from April 1936 through April 1950 and from July 1957 to the present (Figure 18). The highest surface water elevation for the pool included in the database, 41.74 feet above NGVD, occurred on April 6, 1960. The low of record, 30.92 ft above NGVD, was recorded on July 19, 1957.

For the purpose of minimum levels development, lake stage data are categorized 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 categorized as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable.

Based on water-use estimates and analysis of lake stage and regional ground water fluctuations, all available lake stage data for the Hernando Pool of Tsala Apopka Lake were classified as Historic data. Historic lake stage exceedance percentiles were calculated for the period from January 1946 through December 2005, using monthly mean values derived from the available lake stage data (Figure 19). The sixty-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 (e.g., Enfield et al. 2001, Basso and Schultz 2003, Kelly 2004). The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was 39.0 feet above NGVD. The Historic P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was 38.1 feet above NGVD. The Historic P90 elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period, was 35.9 feet above NGVD.

The period of record for the Hernando Pool lake stage data extends further back in time than the records for the Floral City and Inverness Pools. Hernando Pool data were, therefore, used to develop composite monthly mean lake surface elevations for the

Floral City and Inverness Pools. The composite data sets were composed of monthly mean values derived from available stage records for each respective pool and modeled monthly mean estimates based on relationships between lake stage in each pool and Hernando Pool water levels. Modeled monthly mean lake stage values for the composite data sets were estimated using a linear fitting procedure known as the line or organic correlation (see Helsel and Hirsch 1992). Because analysis of lake stage data for the Floral City and Inverness Pools indicated that operation of the Wysong-Coogler Water Conservation Structure on the Withlacoochee River (see Figure 6 for structure location) influenced water levels in these basins, correlations were based on data that was collected following installation of the current structure in 2002. The line of organic correlation equations developed for each comparison (i.e., Hernando Pool and Floral City Pool; Hernando Pool and Inverness Pool) were used to estimate monthly mean water surface elevations for the Floral City and Inverness Pools for the period from January 1946 through December 2001 (M. Hancock, SWFWMD unpublished data).

Historic, composite data sets of monthly mean water surface elevations for the Floral City (Figure 20) and Inverness (Figure 21) Pools were then developed using the modeled water surface elevations and lake stage records collected for each pool from January 1946 through December 2005. Based on these data sets, the Historic P10, P50 and P90 for the Floral City Pool were established at 41.8, 41.1 and 39.6 feet above NGVD, respectively. The Historic P10, P50 and P90 for the Inverness Pool were established at 40.3, 39.5 and 37.8 feet above NGVD.

Figure 16. Measured surface water elevations of the Floral City Pool of Tsala Apopka Lake through December 2006.

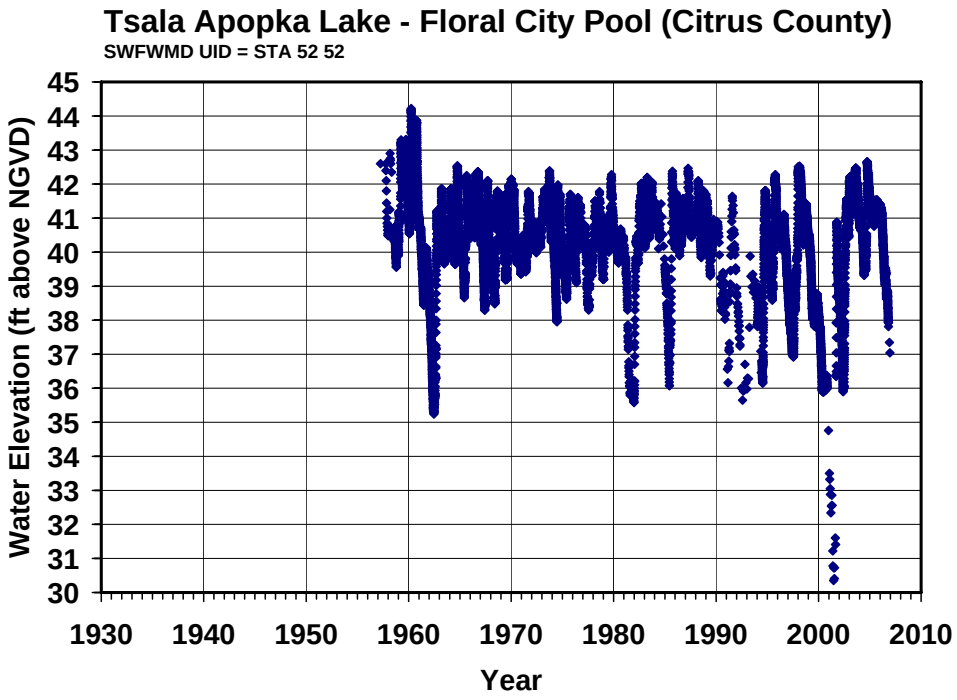


Figure 17. Measured surface water elevations of the Inverness Pool of Tsala Apopka Lake through December 2006.

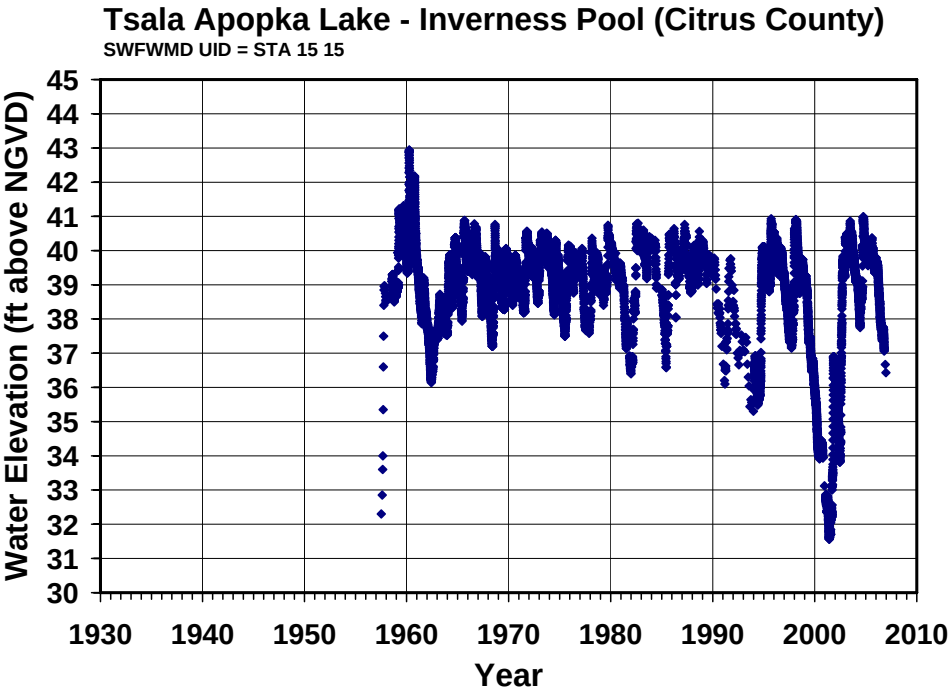


Figure 18. Measured surface water elevations of the Hernando Pool of Tsala Apopka Lake through December 2006.

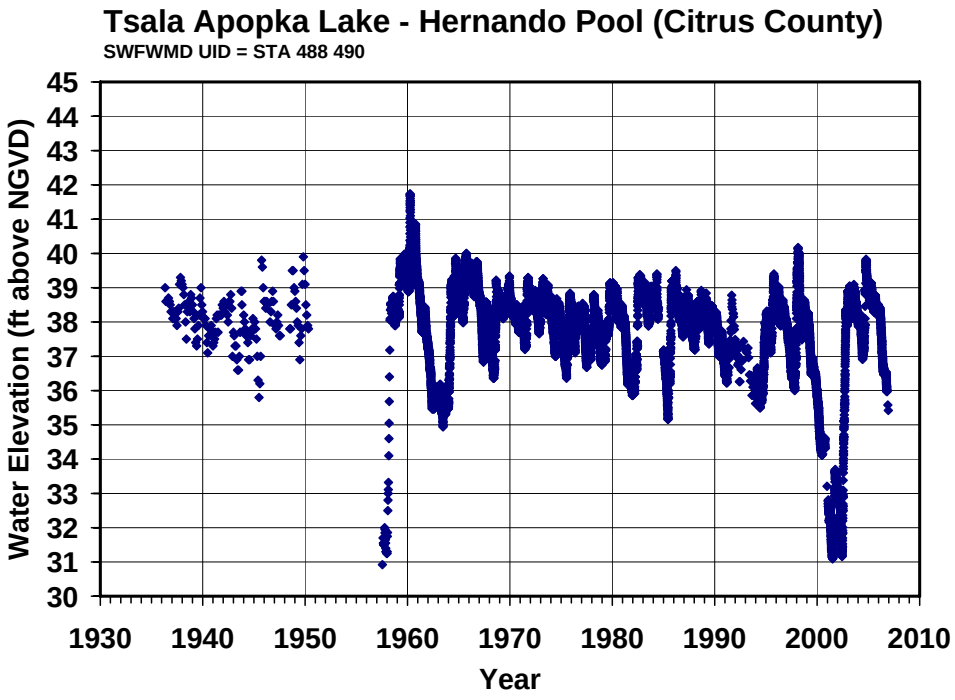


Figure 19. Monthly mean surface water elevations for the Hernando Pool of Tsala Apopka Lake for the Historic period from January 1946 through December 2005.

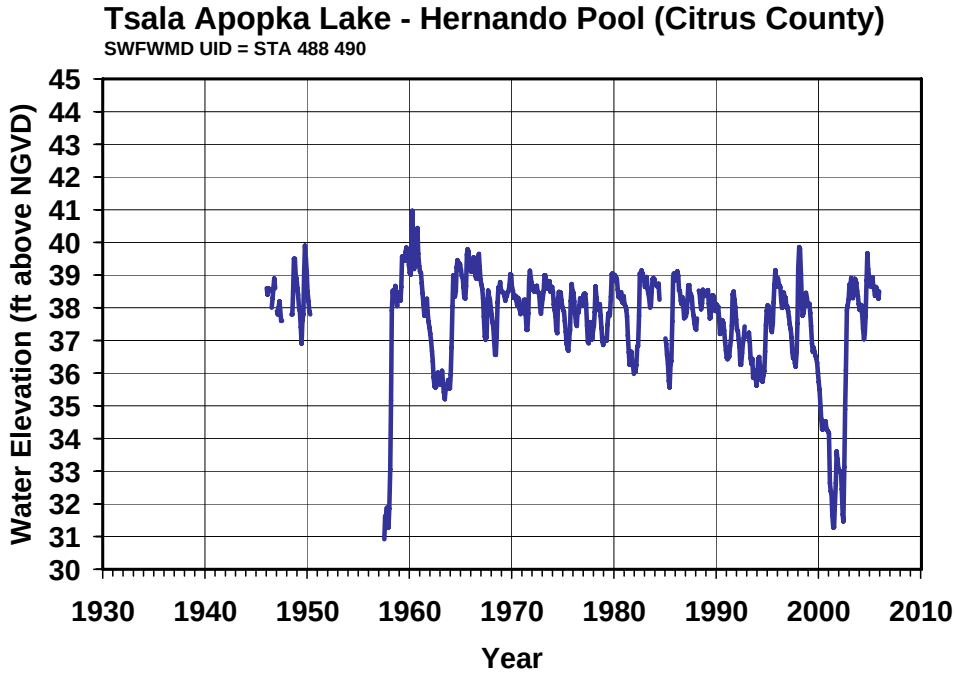


Figure 20. Composite monthly mean surface water elevations for the Floral City Pool of Tsala Apopka Lake for the Historic period from January 1946 through December 2005. Composite data include values based on measured water surface elevations (blue) and modeled values (yellow).

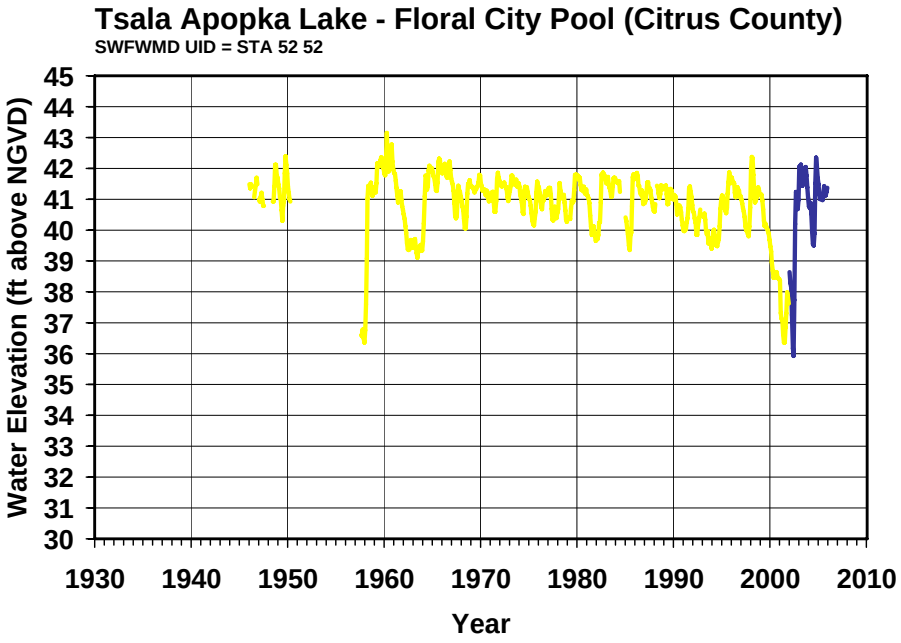
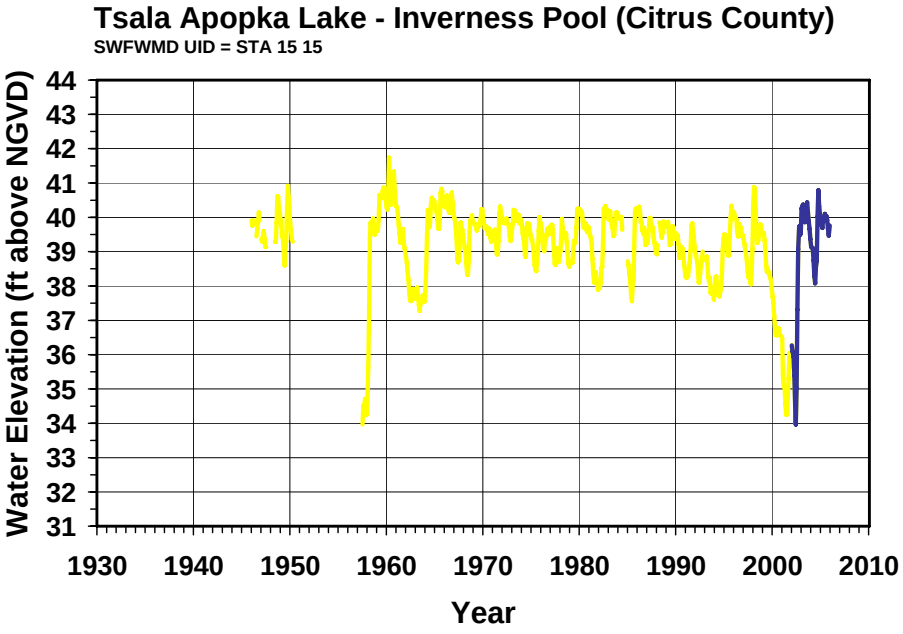


Figure 21. Composite monthly mean surface water elevations for the Inverness Pool of Tsala Apopka Lake for the Historic period from January 1946 through December 2005. Composite data include values based on measured water surface elevations (blue) and modeled values (yellow).



Normal Pools, Control Point Elevations and Determination of 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, including biological and physical features. Based on median elevations of the buttress inflection point of individual *Taxodium* sp. distributed in lake-fringing wetlands throughout the Tsala Apopka Lake basin, Normal Pool elevations were established at 41.6, 40.5 and 39.1 feet above NGVD, respectively for the Floral City, Inverness and Hernando Pools (Tables 8-10). Distribution of saw palmetto (*Serenoa repens*), which is commonly found along undisturbed lake margins in west-central Florida, indicated that the Normal Pool elevations established for the pools were appropriate. Henigar & Ray, Inc. and Sutron Coprporation (1994) report preliminary ordinary high water lines for the Inverness (39.36 feet above NGVD) and Hernando (38.48 ± 0.54 feet above NGVD) pools that are slightly lower than the respective Normal Pool elevations identified for minimum levels development. The pre-settlement (late 1840s/early 1850s) shoreline elevation of the Inverness Pool was, however, estimated at about 40-41 feet above sea level by Wharton (1984) and is consistent with the 40.5-ft Normal Pool elevation developed for the pool

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, canal or culvert) that is the principal control of water level fluctuations in the lake. Control points may be established at invert or crest elevations associated with water control structures at lake outlets. Invert elevations are the lowest point on the portion of a water control structure that provides for conveyance of water across or through the structure. Crest elevations typically refer to the top or ridge of fixed-weirs or operable gates, over which water may flow.

Controlled flow from the Floral City Pool occurs through two District water control structures. The Golf Course Water Control Structure has an invert elevation of 38.0 feet above NGVD, and includes four steel drop-gates with a crest elevation of 41.75 feet above NGVD when the gates are fully closed. The Moccasin Slough Water Control Structure has an invert elevation of 37.6 feet above NGVD and includes two weirs and drop-pocket gates with crest elevations ranging from 41.99 to 42.07 feet above NGVD when the gates are fully lifted. Based on the configuration of these two structures, the Control Point elevation for the Floral City Pool was established as a range of elevations, from 37.6 to 42.0 feet above NGVD.

Controlled flow from the Inverness Pool is managed through operation of three District water control structures. The Brogden Bridge Water Control Structure is the primary facility for control of pool water levels. The structure has a weir crest elevation of 40.25 feet above NGVD and includes two steel lift gates that may be raised to provide conveyance at an invert elevation of 34.25 feet above NGVD. A second structure on the Inverness Pool, the Bryant Slough Water Control Structure, is used to retain flow from the Floral City Pool or to divert the water back to the Withlacoochee River. The

third structure on the Inverness Pool, the Brogden Bridge Culverts Water Control Structure, is used for hydration of downstream wetlands and is not used to convey water from the Inverness Pool to the Hernando Pool. Based on the configuration of the Brodgen Bridge Water Control Structure, the Control Point elevation for the Inverness Pool was established as a range of elevations, from 34.25 to 40.25 feet above NGVD.

The primary structure used for control of water levels in the Hernando Pool is the S-353 Water Control Structure. This large concrete structure has a crest elevation of 40.5 feet above NGVD and is configured with four steel lift-gates that may be raised above a spillway with an invert of 36.5 feet above NGVD. A smaller structure on the pool, the Van Ness Water Control Structure, is used to convey water to the Two Mile Prairie area. This structure is not intended to serve as a major control facility for the Hernando Pool. Based on the configuration of the S-353 Water Control Structure, the Control Point elevation for the Hernando Pool was established as a range of elevations, from 36.5 to 40.5 feet above NGVD.

Structural alteration status is determined to support development of the High Guidance Level. Based on known modifications to conveyance ways and the distribution of water control structures throughout the basin, Tsala Apopka Lake was determined to be structurally altered. Also, based on the occurrence of the Orange State, Leslie Heifner, C-331 and inter-lake connecting canals, Tsala Apopka Lake was classified as an Open Basin Lake. Open Basin Lakes with a surface water conveyance system that connects to an ordered surface water conveyance system, *i.e.*, they discharge to other water bodies.

Table 8. Summary statistics for hydrologic indicator (cypress buttress inflection point) elevations used to establish the Normal Pool elevation for the Floral City Pool of Tsala Apopka Lake. Indicator elevations were measured in April 2005.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD)
N	25
Mean (Standard Deviation)	41.7 (0.11)
Median	41.6
Minimum	41.5
Maximum	42.0

Table 9. Summary statistics for hydrologic indicator (cypress buttress inflection point) elevations used to establish the Normal Pool elevation for the Inverness Pool of Tsala Apopka Lake. Indicator elevations were measured in July 2005.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD)
N	17
Mean (Standard Deviation)	40.4 (0.12)
Median	40.5
Minimum	40.3
Maximum	40.7

Table 10. Summary statistics for hydrologic indicator (cypress buttress inflection point) elevations used to establish the Normal Pool elevation for the Hernando Pool of Tsala Apopka Lake. Indicator elevations were measured in August 2005.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD)
N	10
Mean (Standard Deviation)	39.1 (0.07)
Median	39.1
Minimum	38.9
Maximum	39.2

Guidance Levels and the Historic P50

The Ten Year Flood Guidance Level is provided as an advisory guideline for lakeshore development and is the level of flooding expected on a frequency of not less than the ten-year recurring interval, or on a frequency of not greater than a ten percent probability of occurrence in any given year. Flood-stage frequency analysis, based on the methodology for closed basin lakes described in current District Rules (Chapter 40D-8, F.A.C) yielded ten-year flood estimates that were similar to Ten Year Flood Guidance Levels currently adopted for the Floral City, Inverness and Hernando Pools of Tsala Apopka Lake, which are 43.4, 41.8 and 40.5 feet above NGVD, respectively. Although the three pools have outlets and were classified as open basin lakes, the "closed-basin" approach was considered appropriate because peak flood elevations within the basins are influenced more by long-term rainfall and evaporation patterns than single storm events. For the analysis, the long-term gauging records were used to assess flooding potential. Flood elevation estimates were based on probability analysis of annual peak stages recorded between 1957 and 2004 for the Floral City and Inverness Pools, and between 1936 and 2004 for the Hernando Pool. Data were evaluated using various frequency distributions, including Log-Pearson Type III, Logistic and Weibull distributions, and probability plots were compared to establish the best estimate of flood frequency elevations. Based on similarities between results from these analyses and previously developed flood frequency estimates for the lake (SWFWMD 1977), continued use of the currently adopted Ten Year Flood Guidance Levels for Tsala Apopka Lake was recommended. The Ten Year Flood Guidance Levels for the three Tsala Apopka Lake pools have not been exceeded since 1960.

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 expected Historic P10 of the lake, and is established at the Historic P10, the Current P10, the Control Point or the Normal Pool elevation. Based on the availability of Historic data for Tsala Apopka Lake, the High Guidance Level was established at the Historic P10 elevation for each of the three pools, yielding elevations of 41.8, 40.3 and 39.0 feet above NGVD respectively, for the Floral City, Inverness and Hernando Pools.

The Historic P50 elevation is the elevation that the lake surface is expected to equal or exceed fifty percent of the time on a long-term basis. The level is derived to support development of minimum lake levels, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. Reference lake water regime statistics are necessary when adequate Historic or Current data are not available. Because Historic data are available for Tsala Apopka Lake, these data were used to establish the Historic P50 at 41.1, 39.5 and 38.1 feet above NGVD for the Floral City, Inverness and Hernando Pools, respectively.

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, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. Based on the availability of Historic data for Tsala Apopka Lake, the Low Guidance Level was established at the Historic P90 elevation for each of the three pools, yielding elevations of 39.6, 37.8 and 35.9 feet above NGVD, respectively, for the Floral City, Inverness and Hernando Pools.

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 the elevation 1.8 ft 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 ft 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. Based on the occurrence of lake-fringing cypress wetlands throughout the basin, and the fact that the Historic P50 elevation is less than 1.8 feet below the Normal Pool elevation for each of the three main pools, Tsala Apopka Lake was classified as a Category 1 Lake.

Significant Change Standards and Other Information for Consideration

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

For Category 1 or 2 lakes, a significant change standard is established at the elevation 1.8 feet below the Normal Pool elevation. This standard, referred to in this report as the Cypress Standard, is used to identify a desired median lake stage that may be expected to preserve the ecological integrity of lake-fringing cypress wetlands. The Cypress Standard was established at 39.8, 38.7 and 37.3 feet above NGVD for the Floral City, Inverness and Hernando Pools.

For Category 3 lakes, six significant change standards are developed, including a Dock-Use Standard, an Aesthetics Standard, a Species Richness Standard, a Basin Connectivity Standard, a Recreation/ Ski Standard, and a Lake Mixing Standard.

Potential changes in the coverage of herbaceous wetland vegetation and aquatic plants associated with use of standards for development of Minimum Levels for Category 3 lakes are also taken into consideration. Although Tsala Apopka Lake is a Category 1 Lake, Category 3 standards were developed for comparative purposes, but were not used to establish Minimum Levels.

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 two-foot water depth requirement for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Dock-Use Standard for the Floral City Pool was established at 41.4 feet above NGVD, based on the sum of the elevation of sediments at the end of 90% of 148 docks within the pool (37.9 feet above NGVD, Table 11), 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 Dock-Use Standard for the Inverness Pool was established at 40.6 feet above NGVD, based on the elevation of sediments at the end of 90% of 266 docks within the pool (36.9 feet above NGVD, Table 12), a two-foot water depth based on use of powerboats in the lake, and the 1.7 foot difference between the Historic P50 and Historic P90. The Dock-Use Standard for the Hernando Pool was established at 40.0 feet above NGVD, based on the elevation of sediments at the end of 90% of 246 docks within the pool (35.8 feet above NGVD, Table 13), a two-foot water depth based on use of powerboats in the lake, and the 2.2 foot difference between the Historic P50 and Historic P90.

The Aesthetics Standard is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to limit potential change in aesthetic values associated with the median lake stage from diminishing beyond the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetics Standard is established at the Low Guidance Level, which for the Floral City, Inverness and Hernando Pools of Tsala Apopka Lake occurs at 39.6, 37.8 and 35.9 feet above NGVD, respectively.

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 a lake, the standard is established at the lowest elevation associated with less than a 15% reduction in lake surface area relative to the lake area at the Historic P50 elevation. Because Tsala Apopka Lake is composed of numerous open-water basins and interconnecting wetland areas, development of Species Richness Standards for the three pools was not considered appropriate.

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

sub-basins, identification of water depths sufficient for movement of aquatic biota or powerboats and other watercraft across the critical high-spots, and use of Historic lake stage data or region-specific reference lake water regime statistics. Because Tsala Apopka Lake is composed of numerous open-water basins and wetland areas that are interconnected by dredged canals, development of Basin Connectivity Standards for the three pools was not considered appropriate.

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 surface water elevation (the Ski Elevation) within the basin that would 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. Bathymetric mapping of several open-water (lake) basins in the Tsala Apopka Lake system permitted development of Recreation/Ski Standard for the Floral City, Hernando and Inverness Pools. For the Floral City Pool, the standard was established at 37.7 feet above NGVD, based on values determined for Floral City Lake and Hampton Lake. For the Inverness Pool, the Recreation/Ski Standard was established at 34.0 feet above NGVD, based on values calculated for Spivey Lake, Henderson Lake and Little Lake Henderson. For the Hernando Pool, the standard was established at 33.2 feet above NGVD, based on values calculated for Croft Lake, Hernando Lake, Bellamy Lake, Dodd Lake and Todd Lake.

The Lake Mixing Standard is developed to prevent significant changes in the wind-driven mixing of the lake water column and sediment resuspension. 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. Bathymetric mapping of several open-water (lake) basins in the Tsala Apopka Lake system permitted development of Lake Mixing Standard for the Floral City, Hernando and Inverness Pools. Based on evaluation of changes in the dynamic ratio with changes in lake stage for Floral City Lake and Hampton Lake (Figures 22 and 23), the Lake Mixing Standard was established at 40.1 feet above NGVD for the Floral City Pool. Based on dynamic ratio values for Spivey Lake, Henderson Lake and Little Henderson Lake (Figures 24-26), the Lake Mixing Standard was established at 31.7 feet above NGVD for the Inverness Pool. Based on dynamic ratio values for Croft Lake, Hernando Lake, and the combined open-water areas of Bellamy Lake, Dodd Lake and Todd Lake (Figures 27-29), the Lake Mixing Standard was established at 36.6 feet above NGVD for the Hernando Pool.

Relationships between lake stage and potential herbaceous wetland area (area less than four feet in depth) or the area available for aquatic macrophyte colonization were not evaluated for development of minimum levels for Tsala Apopka Lake. The lake system includes numerous open-water lake basins and extensive forested and herbaceous wetland areas that were not mapped as part of the analyses supporting minimum levels development, and this precluded accurate assessment of potential changes in wetland and macrophyte coverage within the greater lake basin. Potential

wetland areas for the mapped areas of the Floral City and Inverness Pool lakes shown in Figures 7-11 were calculated, however, and are presented in Figures 22-29.

Table 11. Summary statistics and elevations associated with docks in the Floral City Pool of Tsala Apopka Lake, based on data collected at Floral City Lake and Hampton Lake in February and April 2005. Percentiles (P10, P50, P90) represent elevations exceeded by 10, 50 and 90 percent of the docks.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms
N	148	132
Mean (Standard Deviation)	36.1 (1.4)	43.0 (0.6)
P10	37.9	43.7
P50 or Median	36.2	43.0
P90	34.3	42.4
Maximum	40.2	46.7
Minimum	32.1	41.4

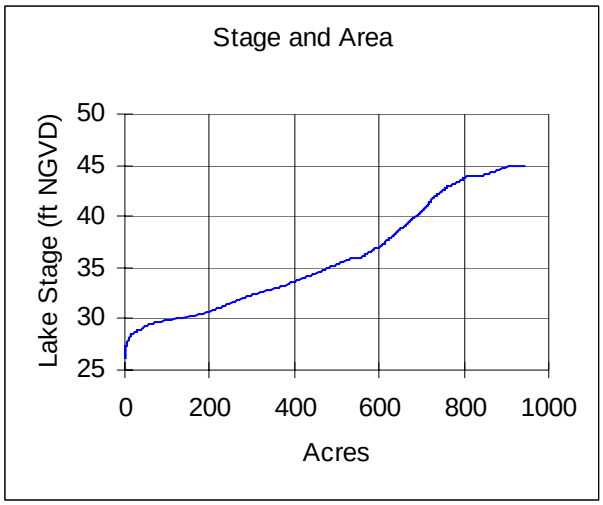
Table 12. Summary statistics for elevations associated with docks in the Inverness Pool of Tsala Apopka Lake, based on data collected at Henderson Lake, Little Henderson Lake and Spivey Lake in June and July 2005. Percentiles (P10, P50, P90) represent elevations exceeded by 10, 50 and 90 percent of the docks.

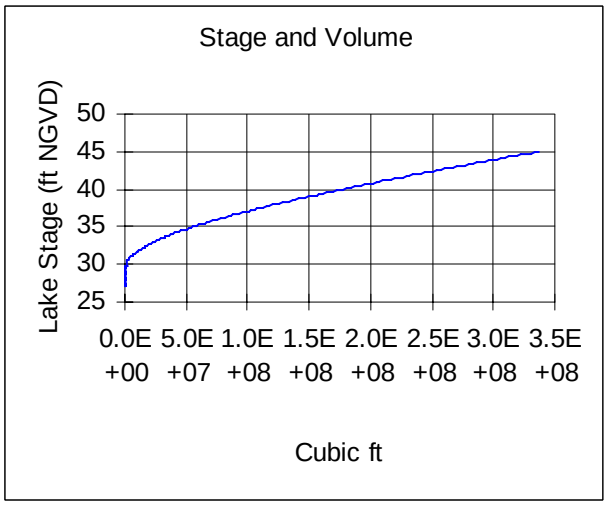
Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms
N	256	236
Mean (Standard Deviation)	34.7 (1.7)	41.5 (0.6)
P10	36.9	42.2
P50 or Median	34.9	41.5
P90	32.4	40.9
Maximum	38.2	43.8
Minimum	28.7	40.2

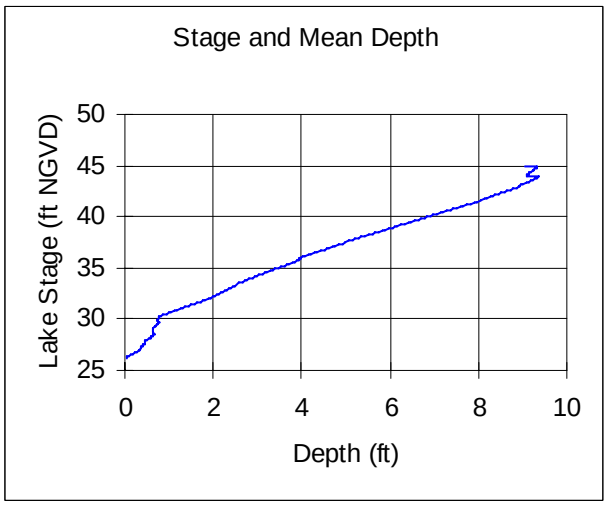
Table 13. Summary statistics for elevations associated with docks in the Hernando Pool of Tsala Apopka Lake, based on data collected at Hernando Lake, Todd Lake, Bellamy Lake, Dodd Lake, Point Lonesome Lake and Croft Lake in August 2005. Percentiles (P10, P50, P90) represent elevations exceeded by 10, 50 and 90 percent of the docks.

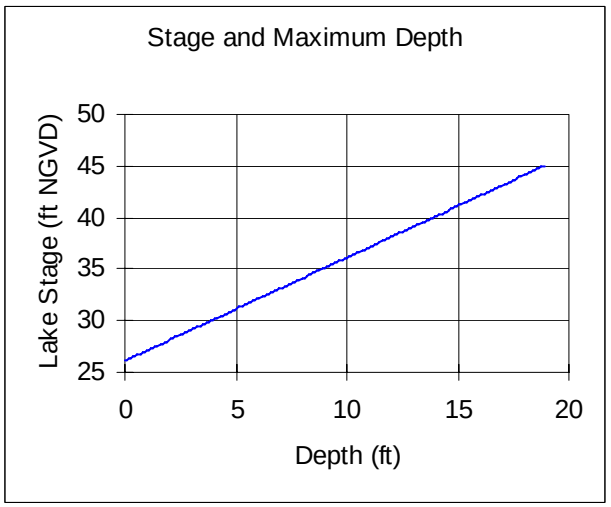
Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms
N	246	231
Mean (Standard Deviation)	34.2 (1.5)	40.2 (0.6)
P10	35.8	40.9
P50 or Median	34.4	40.1
P90	32.1	39.4
Maximum	37.2	42.0
Minimum	28.5	38.8

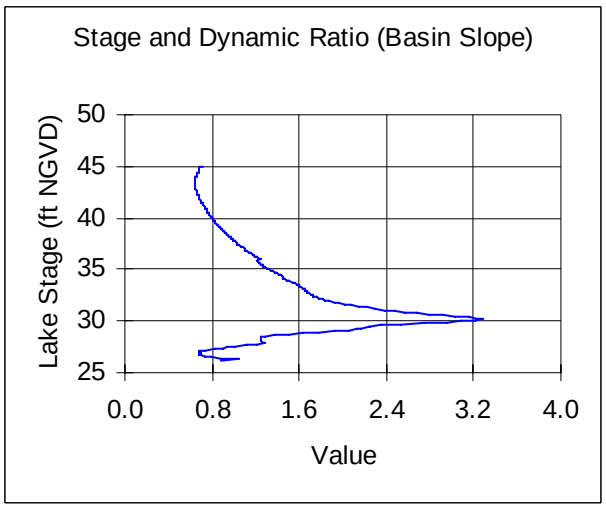
Figure 22. Floral City Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.











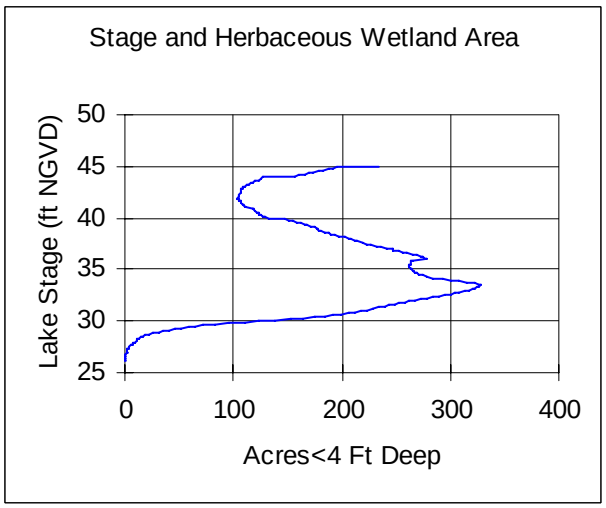
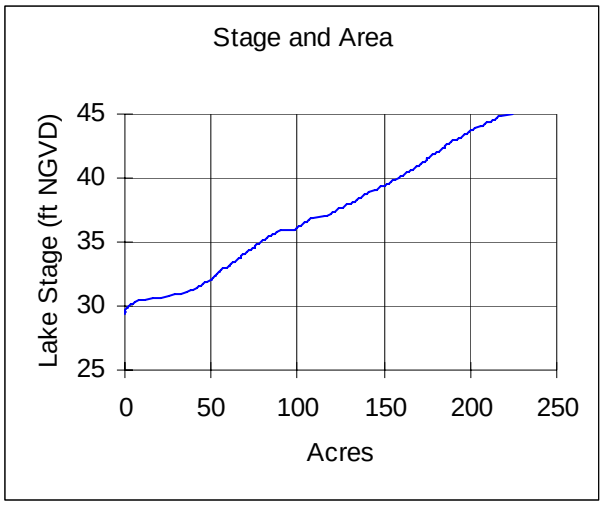
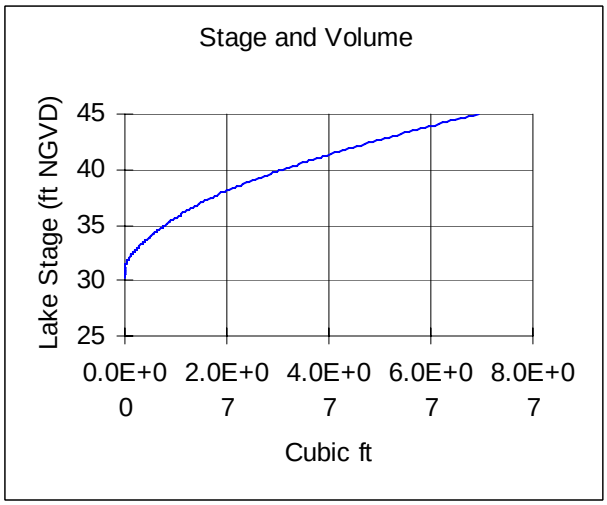
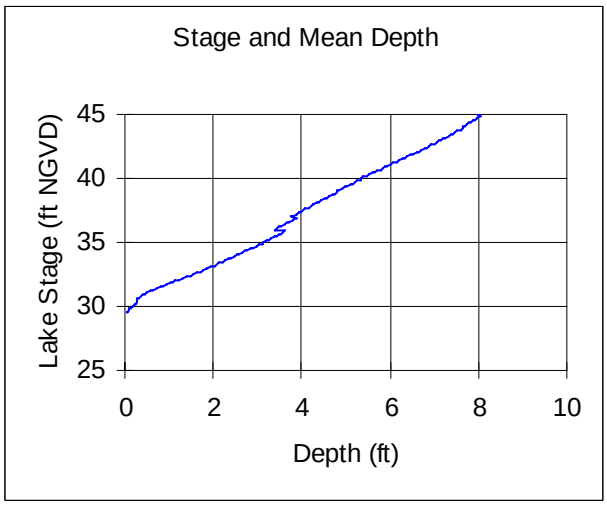
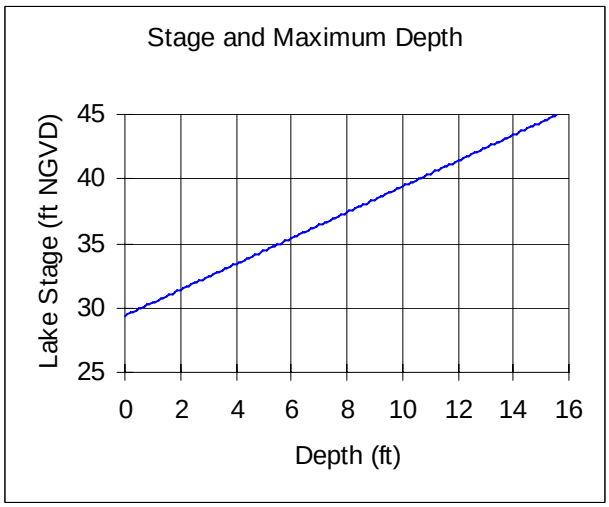


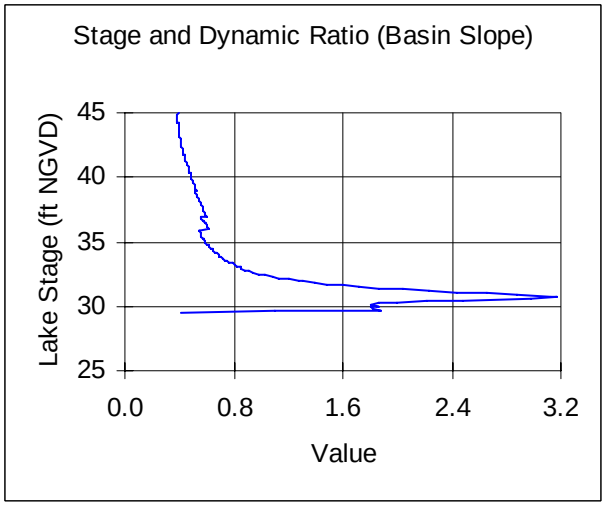
Figure 23. Hampton Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.











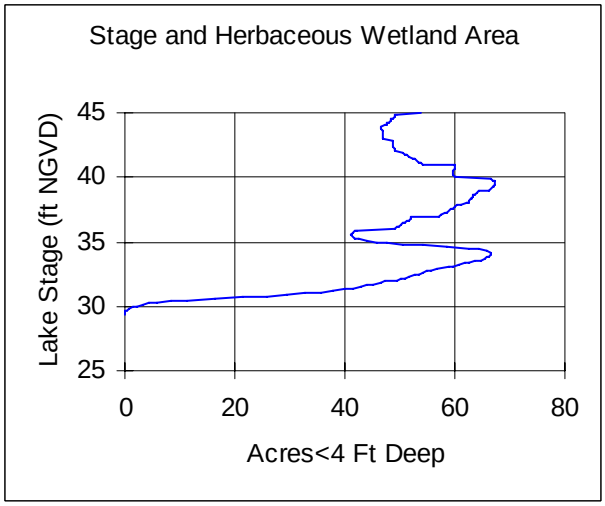
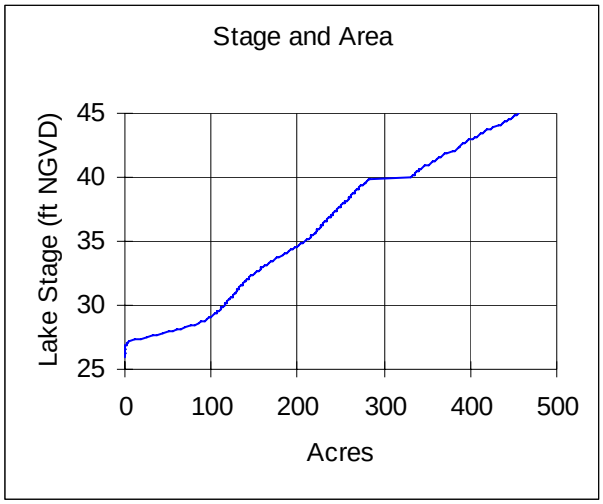
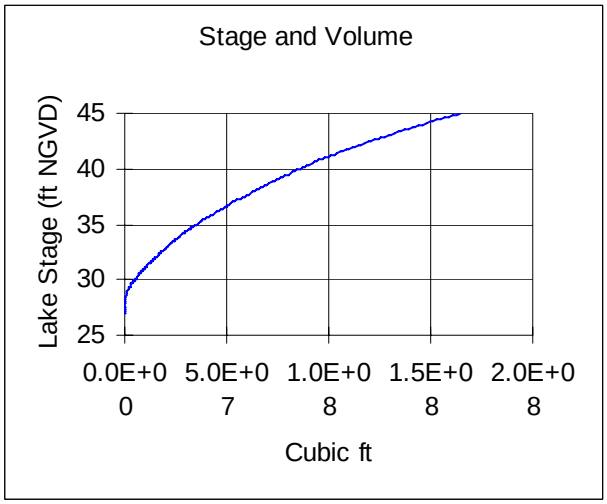
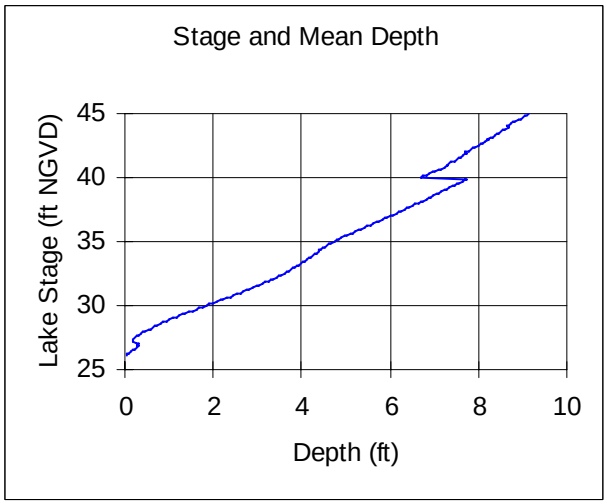
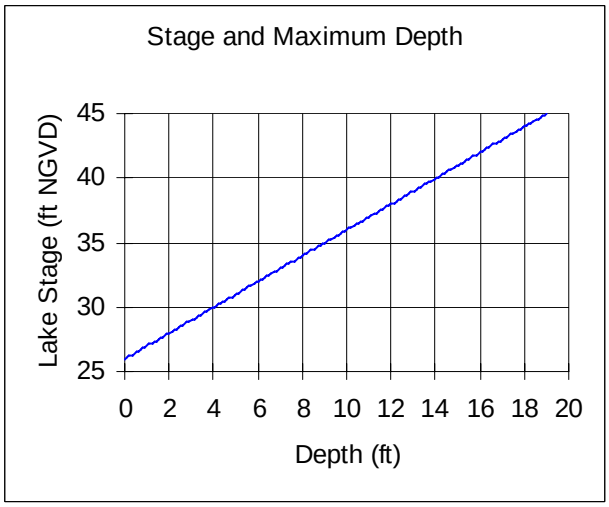


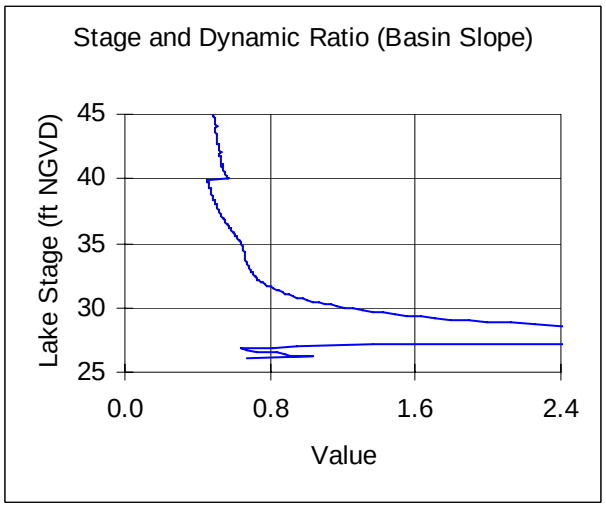
Figure 24. Spivey Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.











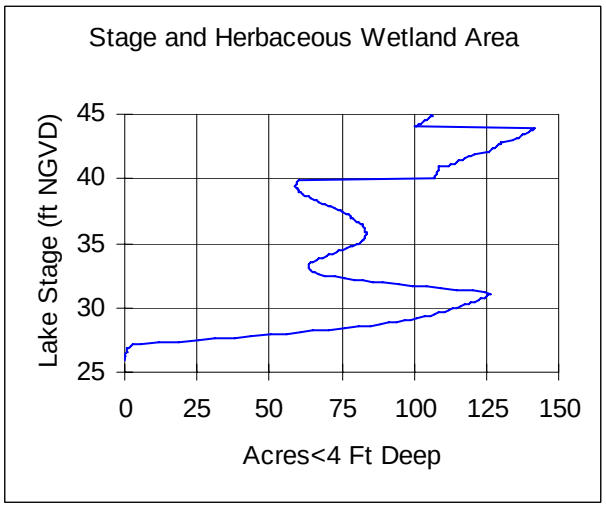
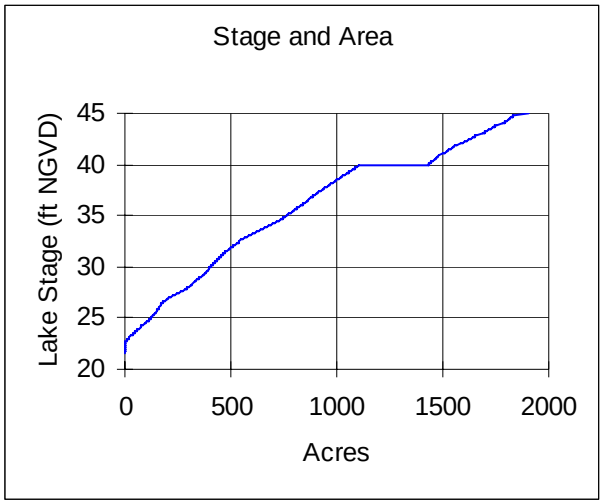
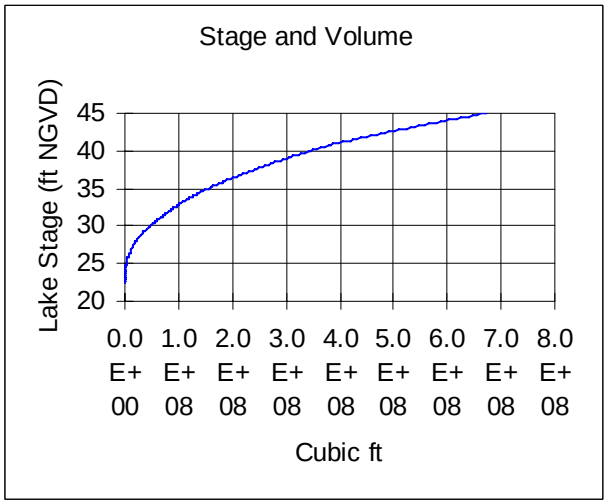
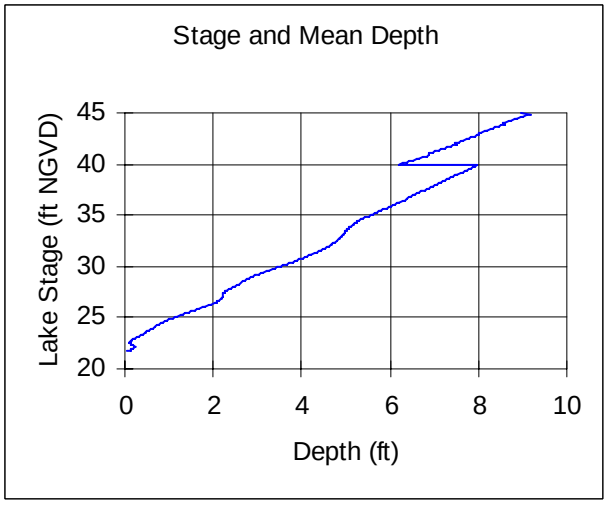
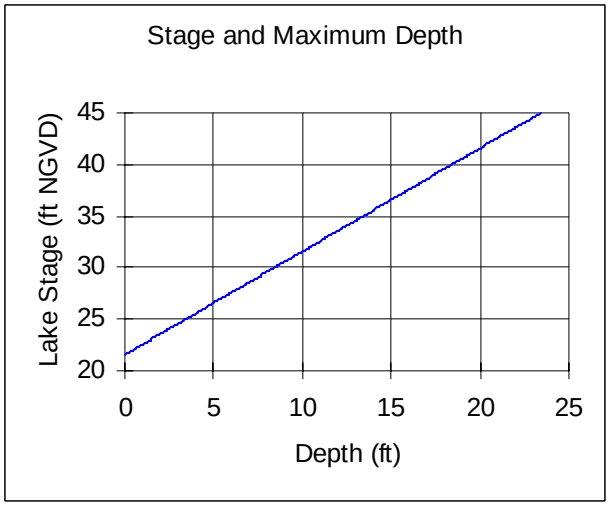


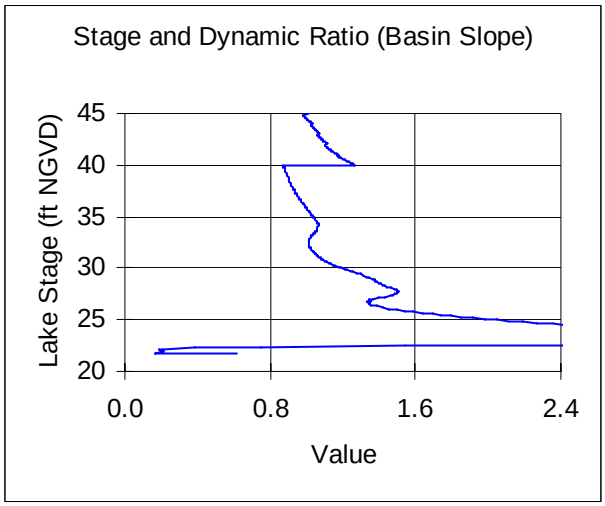
Figure 25. Henderson Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.











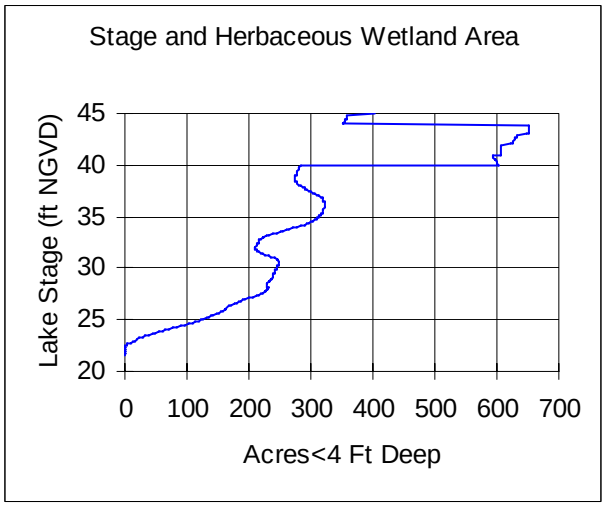
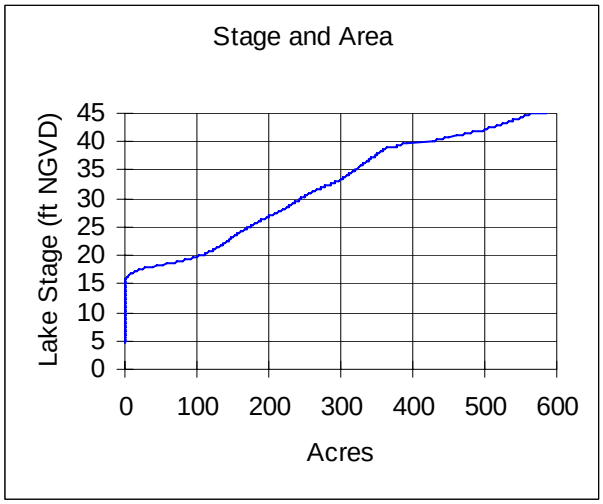
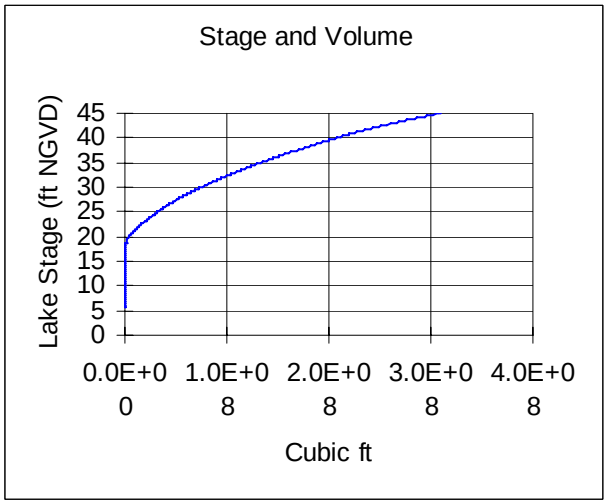
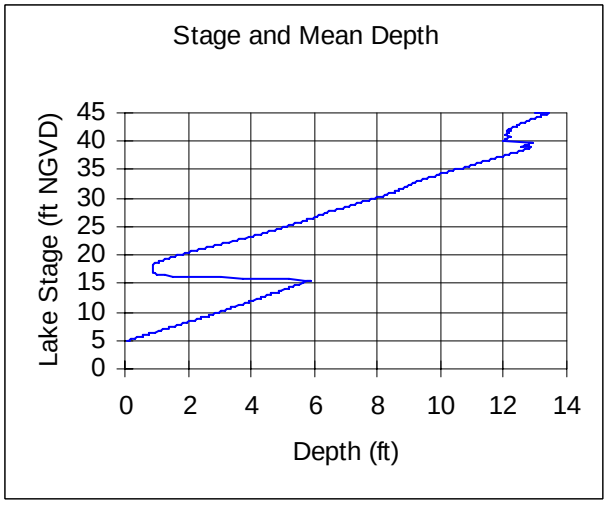
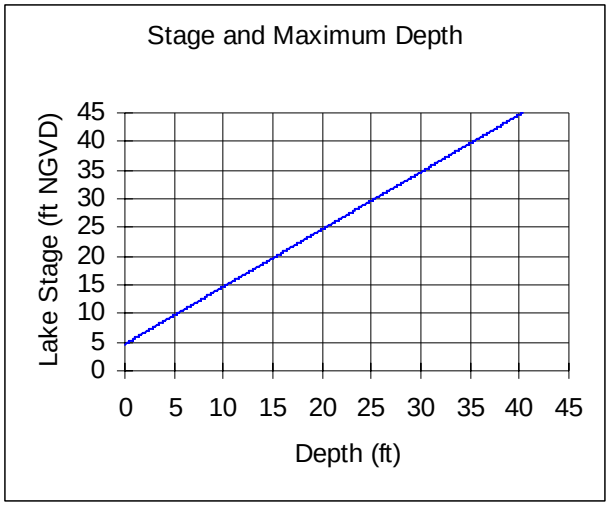


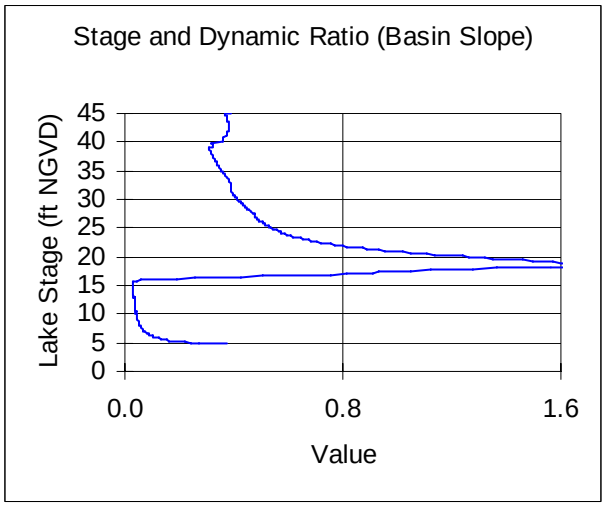
Figure 26. Little Henderson Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.











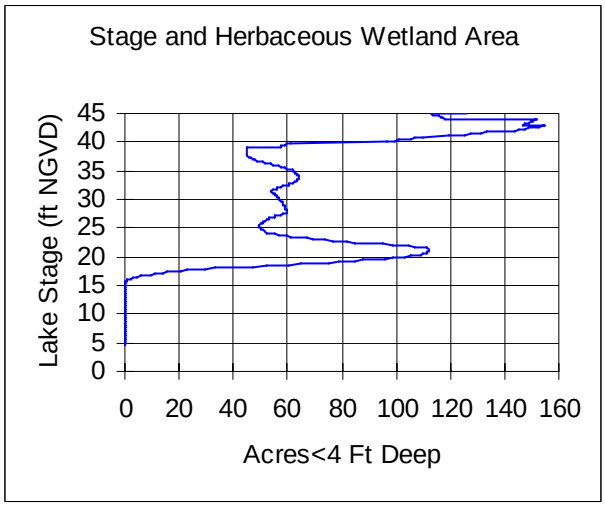
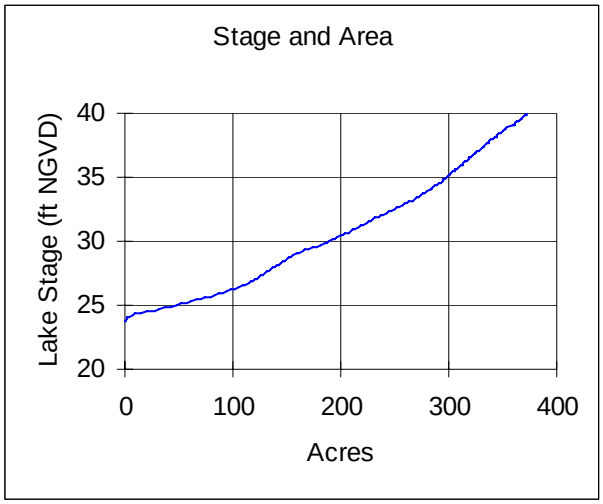
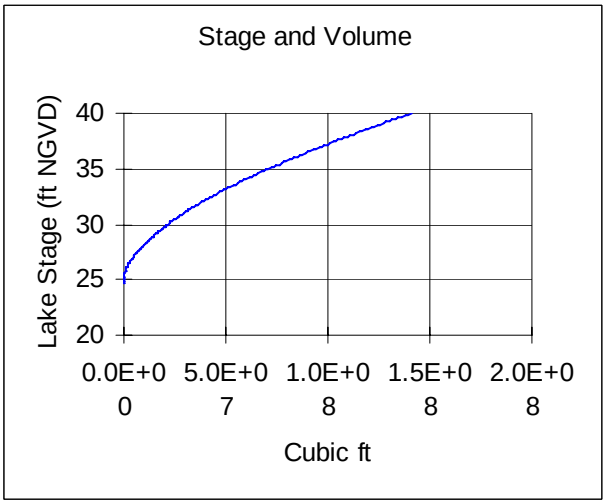
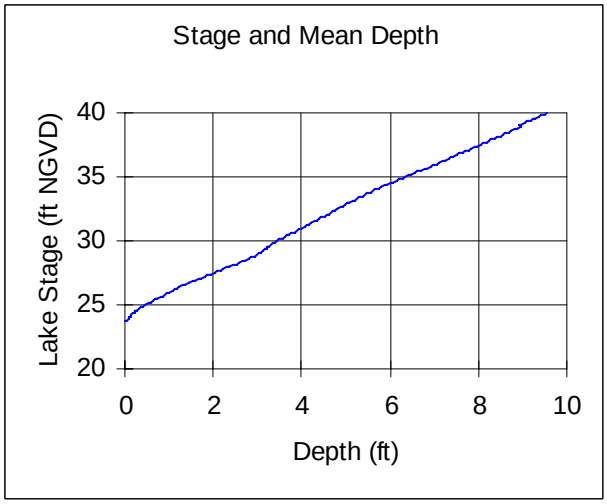
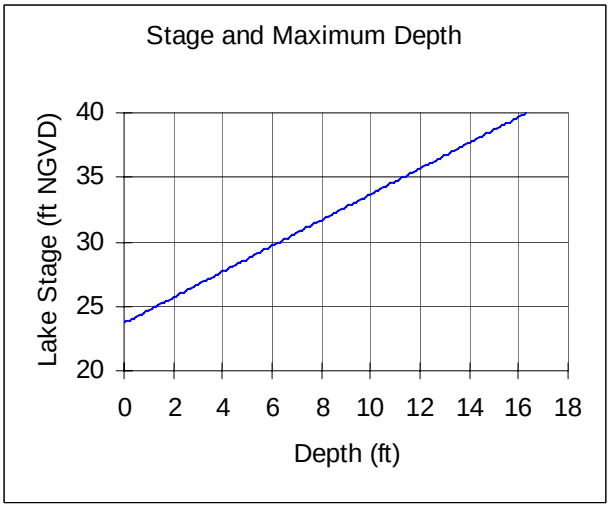


Figure 27. Croft Lake surface area, volume, mean depth, maximum depth, and dynamic ratio (basin slope) versus lake stage.









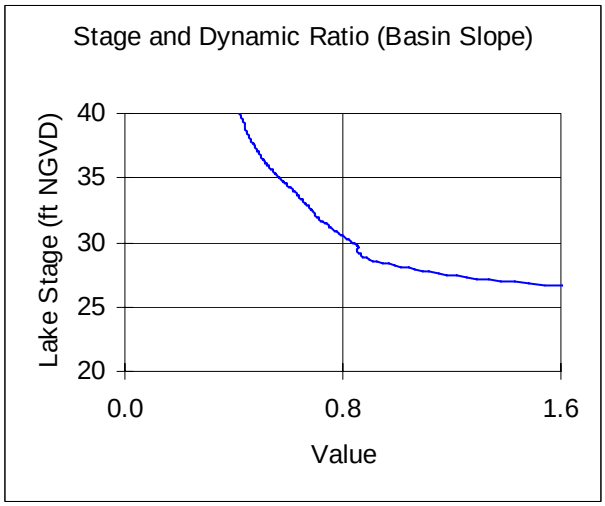
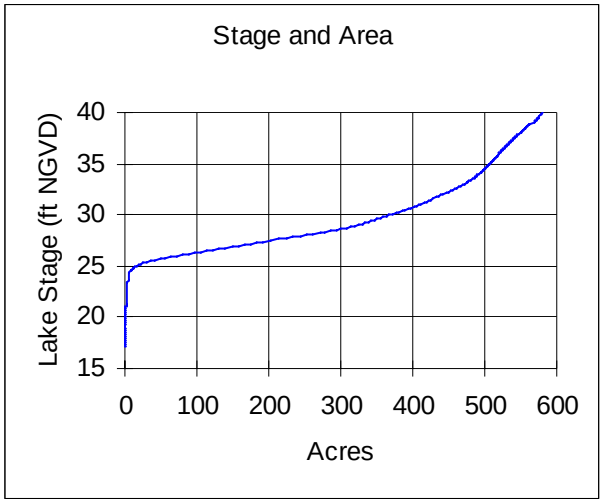
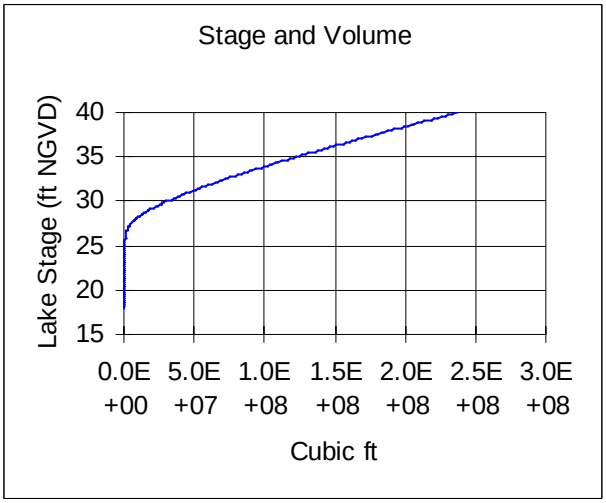
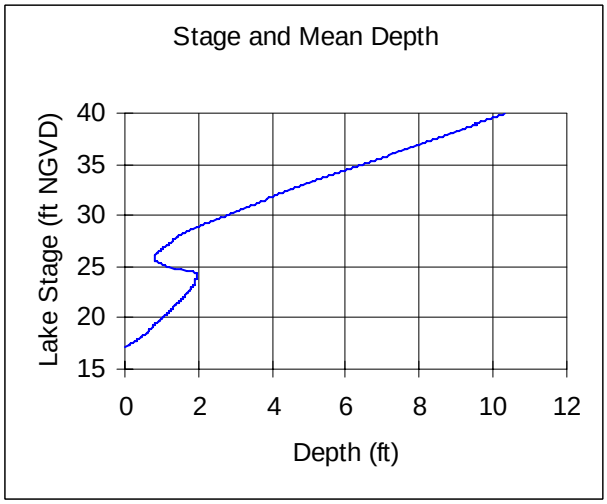
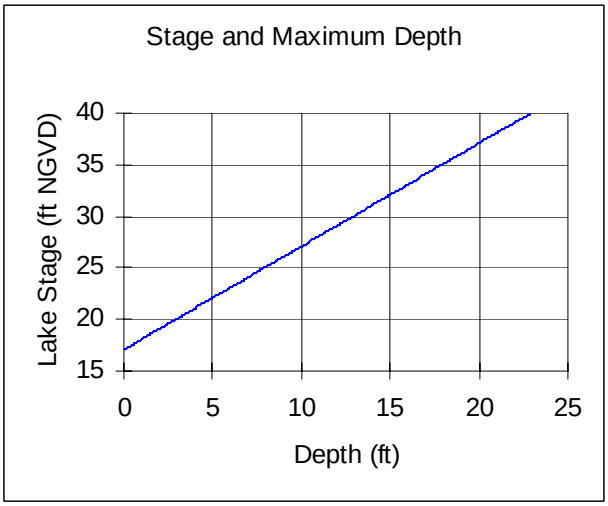


Figure 28. Hernando Lake surface area, volume, mean depth, maximum depth, and dynamic ratio (basin slope) versus lake stage.









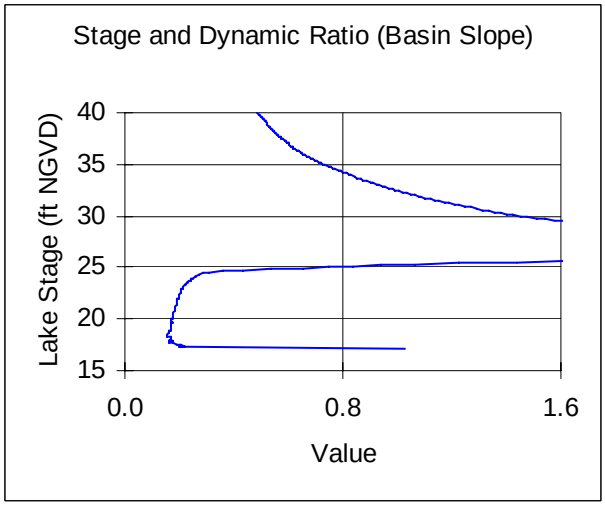
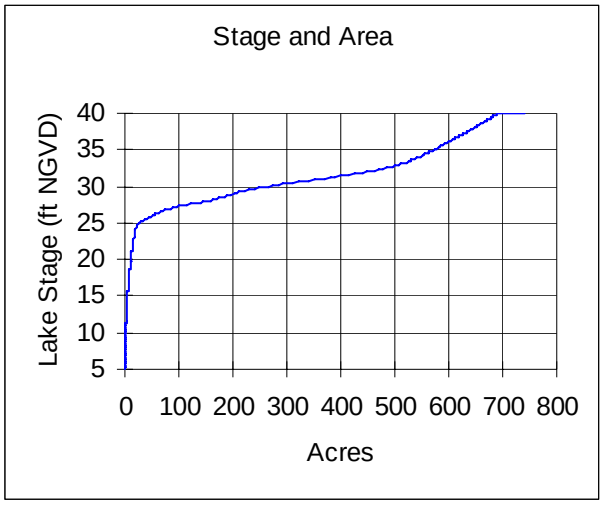
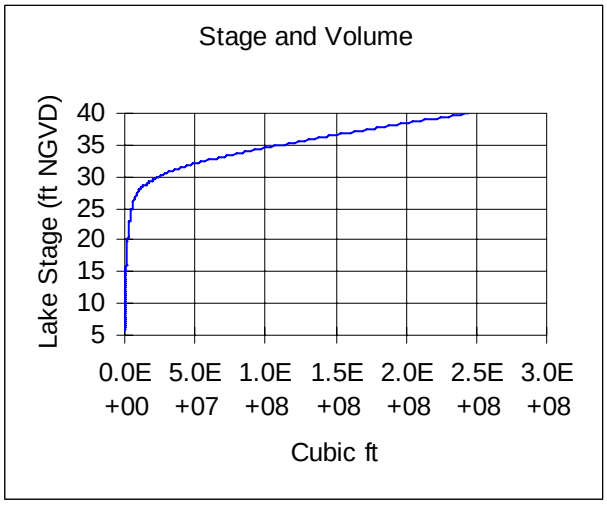
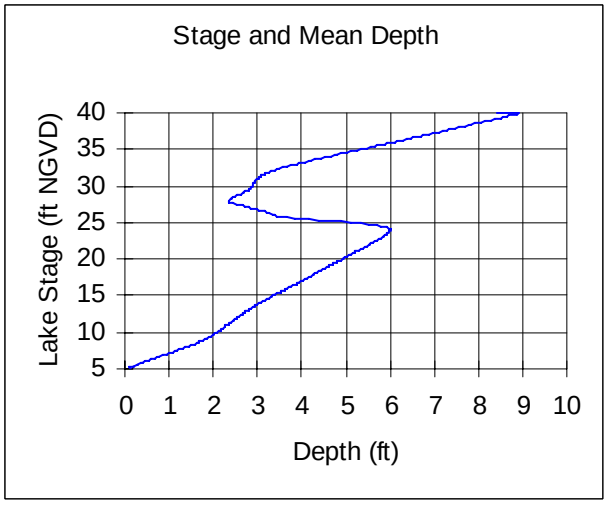
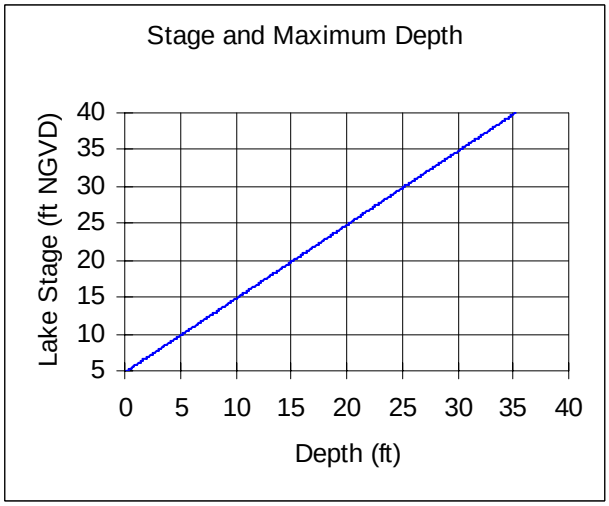


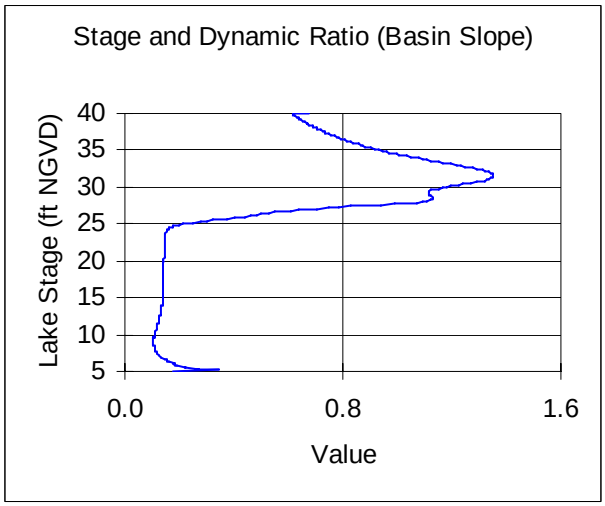
Figure 29. Combined surface area, volume, mean depth, maximum depth, and dynamic ratio (basin slope) versus lake stage for Bellamy Lake, Dodd Lake, and Todd Lake.











Minimum Levels

Minimum Lake Levels are developed using lake-specific significant change standards and other available information, including: potential 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, irrigation); surrounding land-uses; socio-economic effects; and public health, safety and welfare matters. Minimum Level 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 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 1 Lakes, the Minimum Lake Level is established at an elevation 1.8 feet below the Normal Pool elevation (referred to as the Cypress Standard in this report). Minimum Lake Levels were therefore established at 39.8, 38.7 and 37.3 feet above NGVD for the Floral City, Inverness and Hernando Pools, respectively.

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. For Category 1 Lakes, the High Minimum Lake Level is established at an elevation 0.4 feet below the Normal Pool elevation. High Minimum Lake Levels were therefore established at 41.2, 40.1 and 38.7 feet above NGVD for the Floral City, Inverness and Hernando Pools, respectively.

Water surface elevations and the minimum and guidance levels for the Floral City, Inverness and Hernando Pools of Tsala Apopka Lake are shown in Figures 30-32. During the ten-year periods ending in December 2004 and December 2005, the water surface elevations equaled or exceeded ten percent of the time (P10) and fifty percent of the time (P50) in all three pools were higher than the High Minimum and Minimum Lake Levels, respectively (Tables 14 through19). This was also the case for the Inverness and Hernando Pools, but not the Floral City Pool, for the ten-year period ending in December 2003. Figures 33-35 show ten-year P10 and P50 values for the past sixteen ten-year periods in relation to the minimum levels for each pool.

Review of available data indicated that staging of the lake at the minimum levels would not flood any man-made features within the immediate lake basins (see Figures 36-43 for the approximate lake margins when the water surface is at the minimum levels). The High Minimum Lake Level for the Floral City Pool is 2.2 feet below the lowest residential building in the Floral City Lake and Lake Hampton basins, 2.9 feet below the lowest residential building in the Tussock Lake basin, and 1.8 feet below the lowest paved road in the lake basins (Table 20). The High Minimum Lake Level for the Floral City Pool is also approximately 2 feet below the top of the public boat ramp on Floral City Lake. The High Minimum Lake Level for the Inverness Pool is 2.4 feet below the floor slab elevation of the lowest residential dwelling in the immediate pool basin, and 1.7 feet below the lowest spot on the paved roads encircling the lake-pools (Table 21).

The High Minimum Lake Level is also about 2.0 to 4.4 feet below the top of the public ramps on Little Henderson Lake, Henderson Lake and Spivey Lake. The High Minimum Lake Level for the Hernando Pool is 2.3 and 2.2 feet below the lowest residential dwelling and paved road within the basin, respectively (Table 22). The level is approximately 1.2 feet lower than the top of the public boat ramp on Hernando Lake.

Figure 30. Mean monthly surface water elevation of the Floral City Pool of Tsala Apopka Lake through December 2006, and adopted Guidance and Minimum Levels. Levels include the Ten Year Flood Guidance Level (10-YR), High Guidance Level (HGL), High Minimum Lake Level (HMLL), and Minimum Lake Level (MLL).

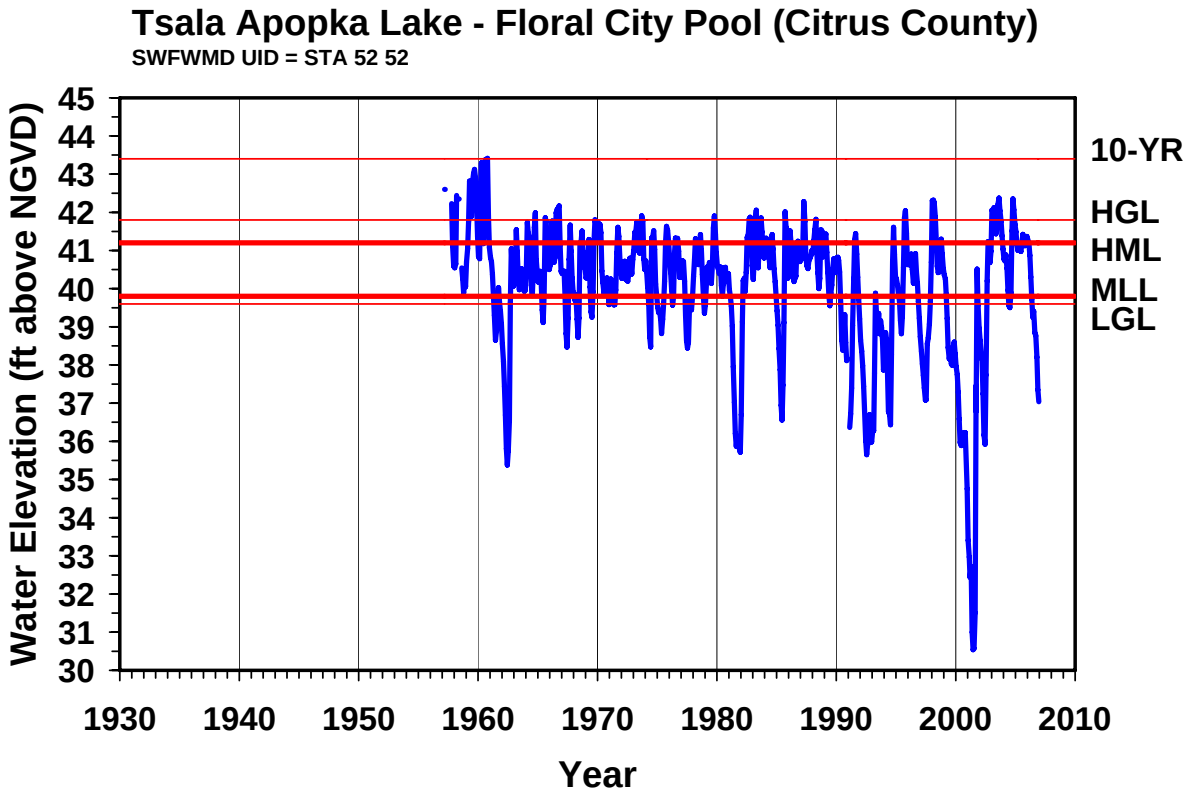


Figure 31. Mean monthly surface water elevation of the Inverness Pool of Tsala Apopka Lake through December 2006, and adopted Guidance and Minimum Levels. Levels include the Ten Year Flood Guidance Level (10-YR), High Guidance Level (HGL), High Minimum Lake Level (HMLL), and Minimum Lake Level (MLL).

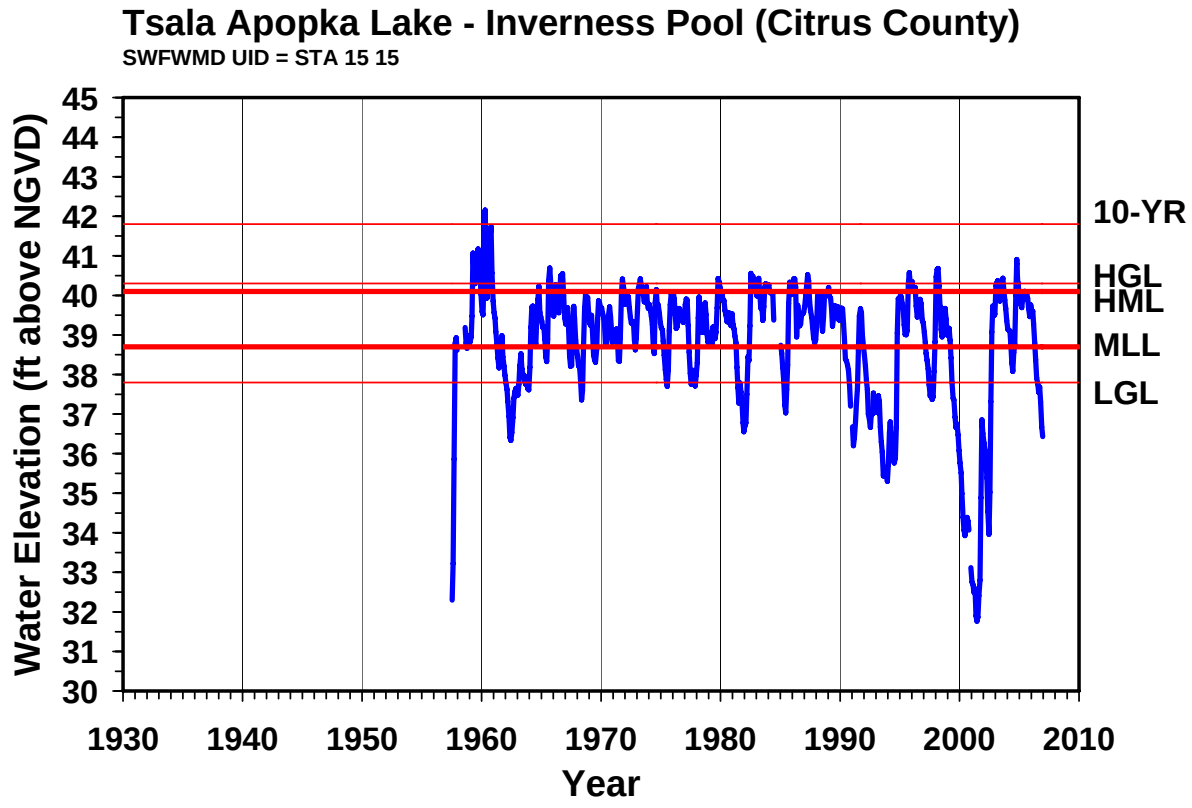


Figure 32. Mean monthly surface water elevation of the Hernando Pool of Tsala Apopka Lake through December 2006, and adopted Guidance and Minimum Levels. Levels include the Ten Year Flood Guidance Level (10-YR), High Guidance Level (HGL), High Minimum Lake Level (HMLL), and Minimum Lake Level (MLL).

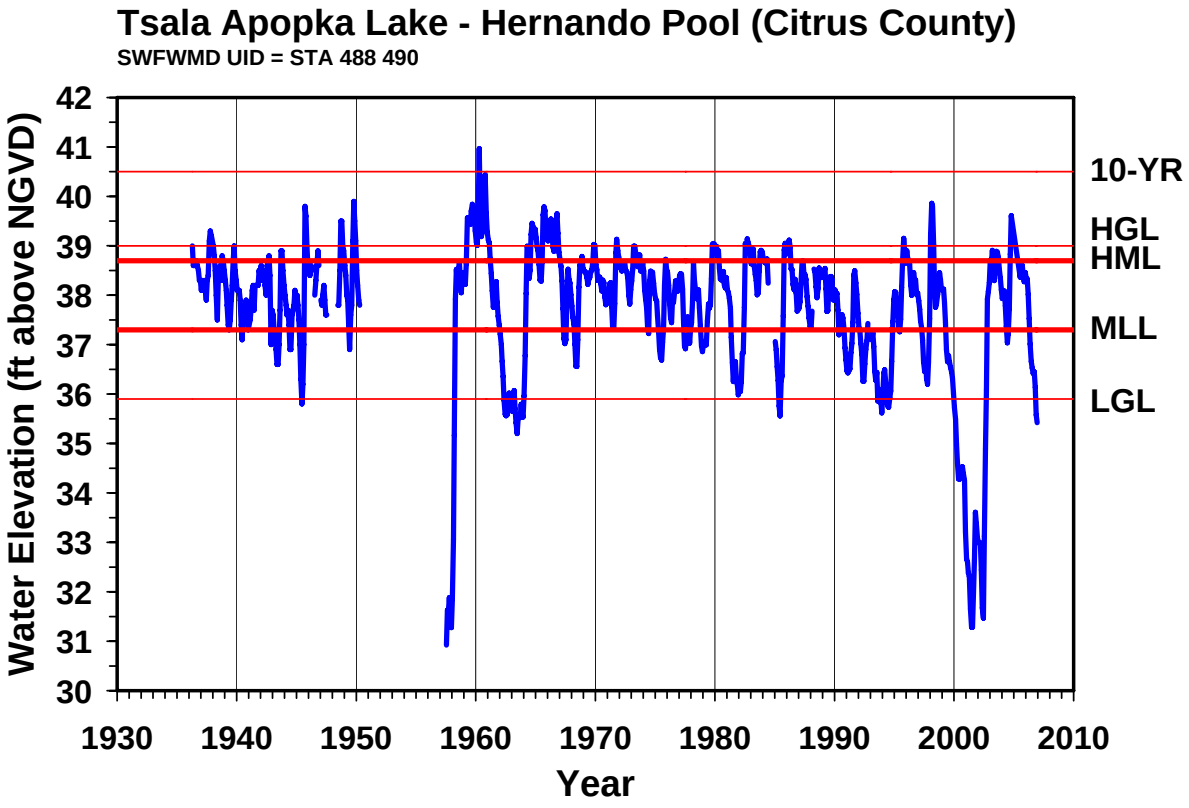


Table 14. Comparisons between the water surface elevations equaled or exceeded ten percent of the time (P10) over the last six 10-year periods and the High Minimum Lake Level (HMLL) for the Floral City Pool of Tsala Apopka Lake.

10-year Period			HMLL Equaled or Exceeded?	Difference between P10 and HMLL
January 1996	through	December 2005	Yes	0.7 ft above
January 1995	through	December 2004	Yes	0.8 ft above
January 1994	through	December 2003	Yes	0.7 ft above
January 1993	through	December 2002	No	0.2 ft below
January 1992	through	December 2001	No	0.3 ft below
January 1991	through	December 2000	No	0.2 ft below
January 1990	through	December 1999	No	0.2 ft below

Table 15. Comparisons between the water surface elevations equaled or exceeded fifty percent of the time (P50) over the last six 10-year periods and the Minimum Lake Level (MLL) for the Floral City Pool of Tsala Apopka Lake.

10-year Period			MLL Equaled or Exceeded?	Difference between P50 and MLL
January 1996	through	December 2005	Yes	0.5 ft above
January 1995	through	December 2004	Yes	0.1 ft above
January 1994	through	December 2003	No	0.2 ft below
January 1993	through	December 2002	No	0.8 ft below
January 1992	through	December 2001	No	1.1 ft below
January 1991	through	December 2000	No	0.8 ft below
January 1990	through	December 1999	No	0.6 ft below

Table 16. Comparisons between the water surface elevations equaled or exceeded ten percent of the time (P10) over the last six 10-year periods and the High Minimum Lake Level (HMLL) for the Inverness Pool of Tsala Apopka Lake.

10-year Period			HMLL Equaled or Exceeded?	Difference between P10 and HMLL
January 1996	through	December 2005	Yes	0.1 ft above
January 1995	through	December 2004	Yes	0.2 ft above
January 1994	through	December 2003	Yes	0.2 ft above
January 1993	through	December 2002	No	0.1 ft below
January 1992	through	December 2001	No	0.1 ft below
January 1991	through	December 2000	No	0.1 ft below
January 1990	through	December 1999	No	0.1 ft below

Table 17. Comparisons between the water surface elevations equaled or exceeded fifty percent of the time (P50) over the last six 10-year periods and the Minimum Lake Level (MLL) for the Inverness Pool of Tsala Apopka Lake.

10-year Period			MLL Equaled or Exceeded?	Difference between P50 and MLL
January 1996	through	December 2005	Yes	0.3 ft above
January 1995	through	December 2004	Yes	0.3 ft above
January 1994	through	December 2003	Yes	0.1 ft above
January 1993	through	December 2002	No	1.3 ft below
January 1992	through	December 2001	No	1.2 ft below
January 1991	through	December 2000	No	0.9 ft below
January 1990	through	December 1999	No	0.3 ft below

Table 18. Comparisons between the water surface elevations equaled or exceeded ten percent of the time (P10) over the last six 10-year periods and the High Minimum Lake Level (HMLL) for the Hernando Pool of Tsala Apopka Lake.

10-year Period			HMLL Equaled or Exceeded?	Difference between P10 and HMLL
January 1996	through	December 2005	Yes	0.2 ft above
January 1995	through	December 2004	Yes	0.2 ft above
January 1994	through	December 2003	Yes	0.01 ft above
January 1993	through	December 2002	No	0.2 ft below
January 1992	through	December 2001	No	0.2 ft below
January 1991	through	December 2000	No	0.2 ft below
January 1990	through	December 1999	No	0.2 ft below

Table 19. Comparisons between the water surface elevations equaled or exceeded fifty percent of the time (P50) over the last six 10-year periods and the Minimum Lake Level (MLL) for the Hernando Pool of Tsala Apopka Lake.

10-year Period			MLL Equaled or Exceeded?	Difference between P50 and MLL
January 1996	through	December 2005	Yes	0.5 ft above
January 1995	through	December 2004	Yes	0.4 ft above
January 1994	through	December 2003	Yes	0.1 ft above
January 1993	through	December 2002	No	0.6 ft below
January 1992	through	December 2001	No	0.5 ft below
January 1991	through	December 2000	No	0.2 ft below
January 1990	through	December 1999	Yes	0.1 ft above

Figure 33. P10 and P50 values for the past sixteen ten-year periods in relation to the High Minimum Lake Level (HMLL) and Minimum Lake Level (MLL) for the Floral City Pool.

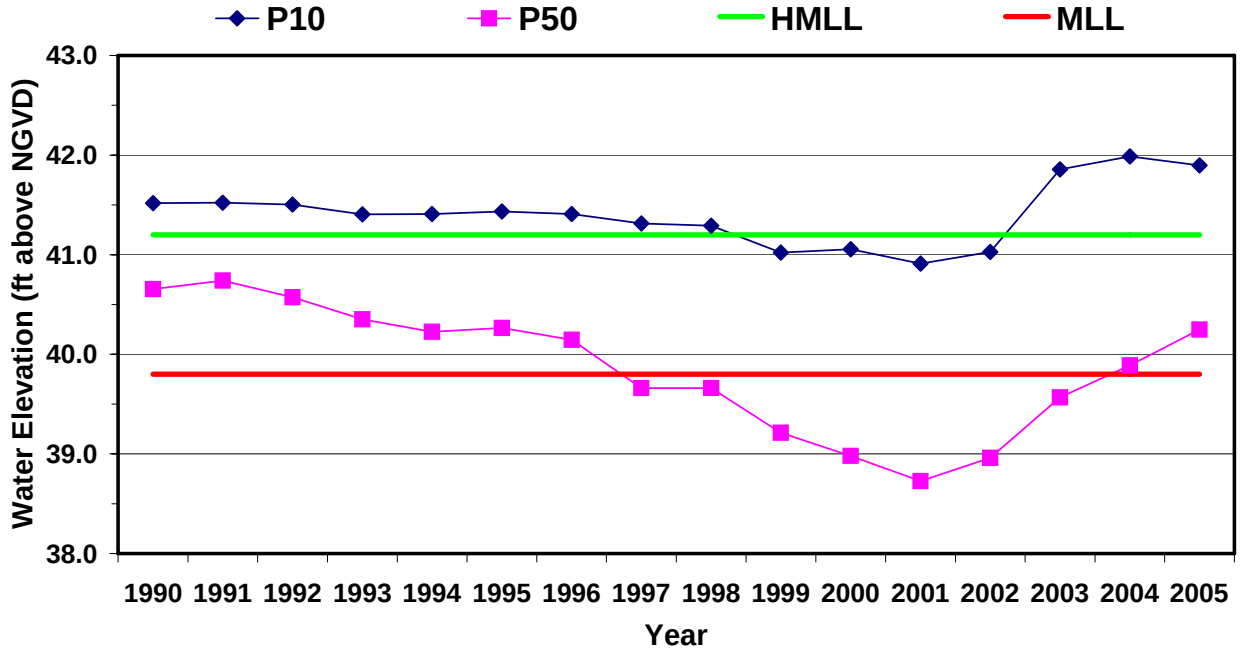


Figure 34. P10 and P50 values for the past sixteen ten-year periods in relation to the High Minimum Lake Level (HMLL) and Minimum Lake Level (MLL) for the Inverness Pool.

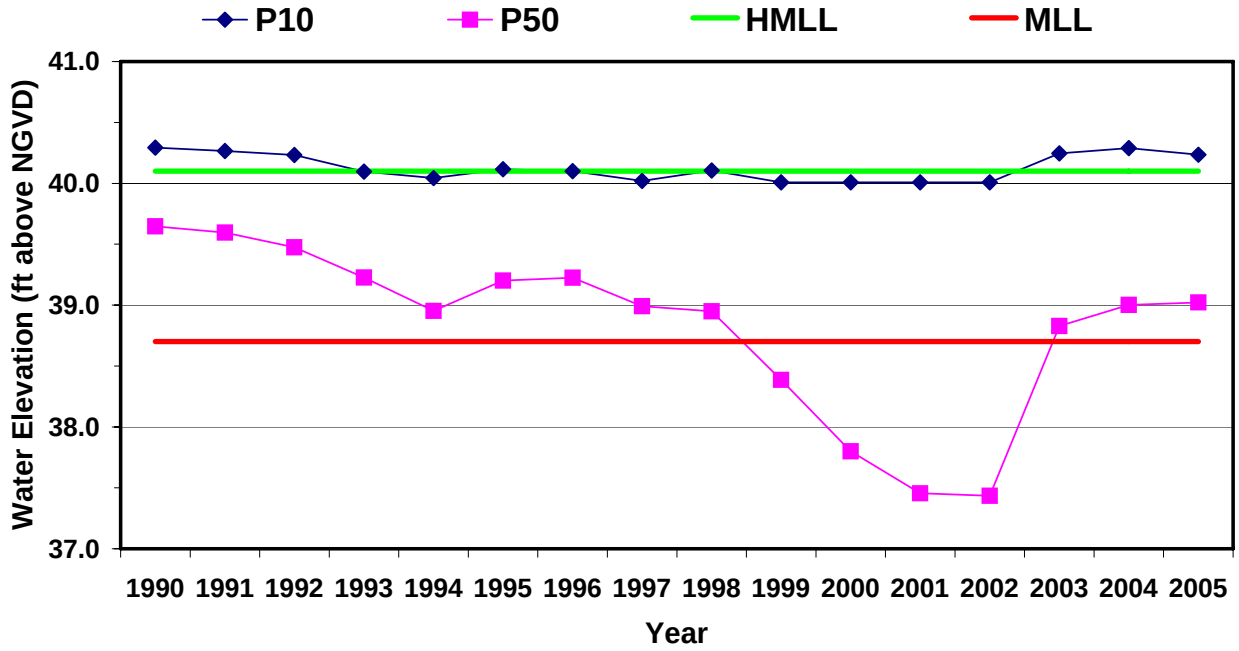


Figure 35. P10 and P50 values for the past sixteen ten-year periods in relation to the High Minimum Lake Level (HMLL) and Minimum Lake Level (MLL) for the Hernando Pool.

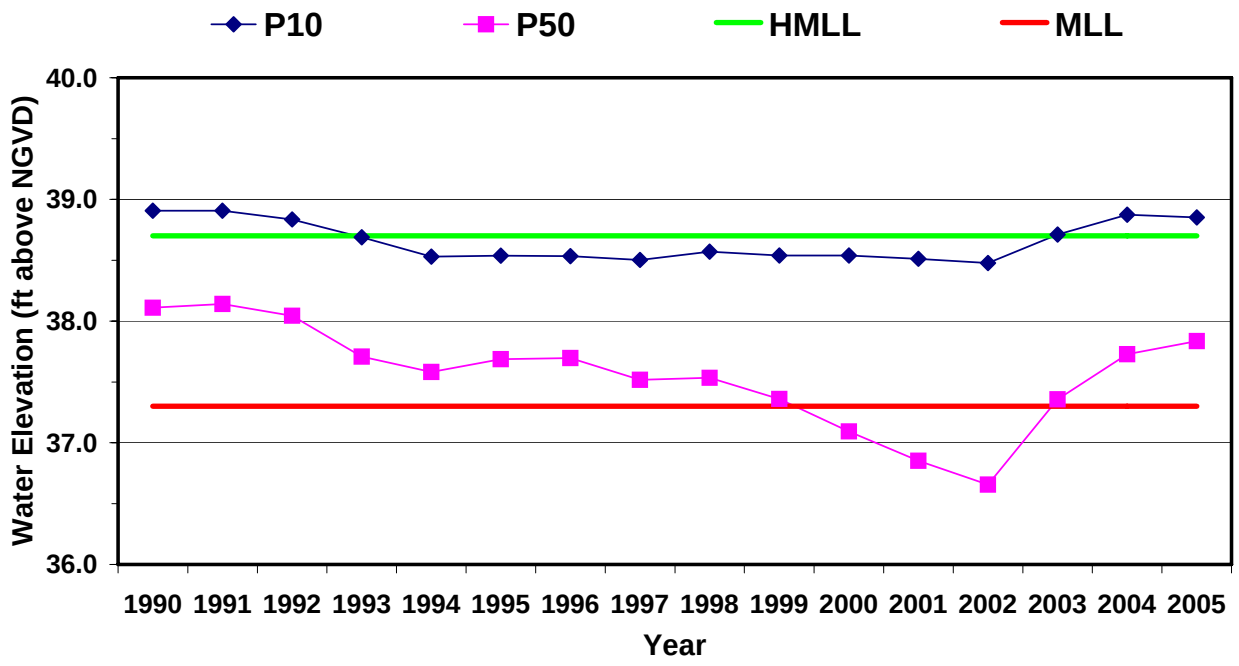
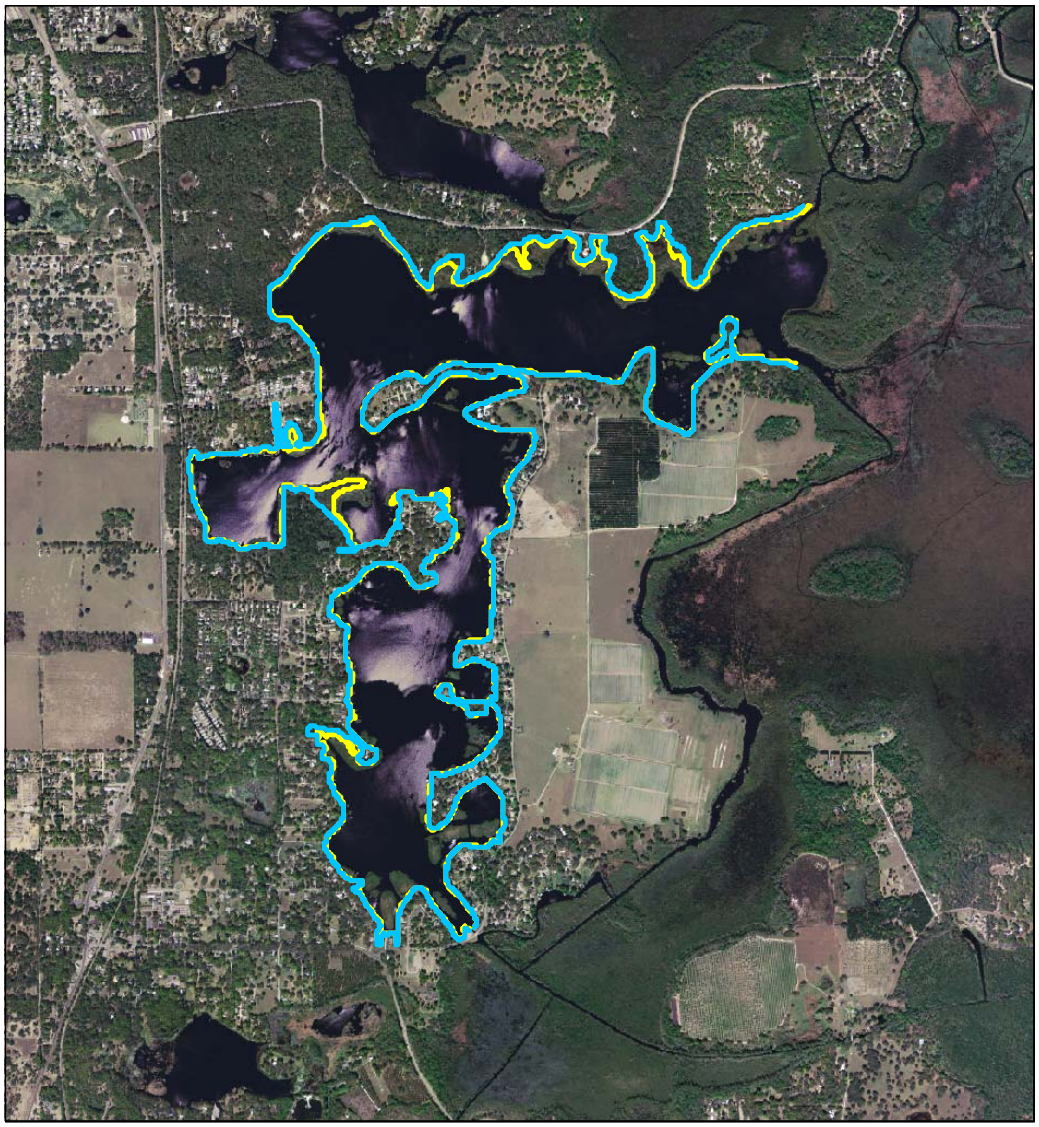


Figure 36. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Floral City Pool in the Floral City Lake basin.



Minimum Levels

MLL = 39.8 ft above NGVD

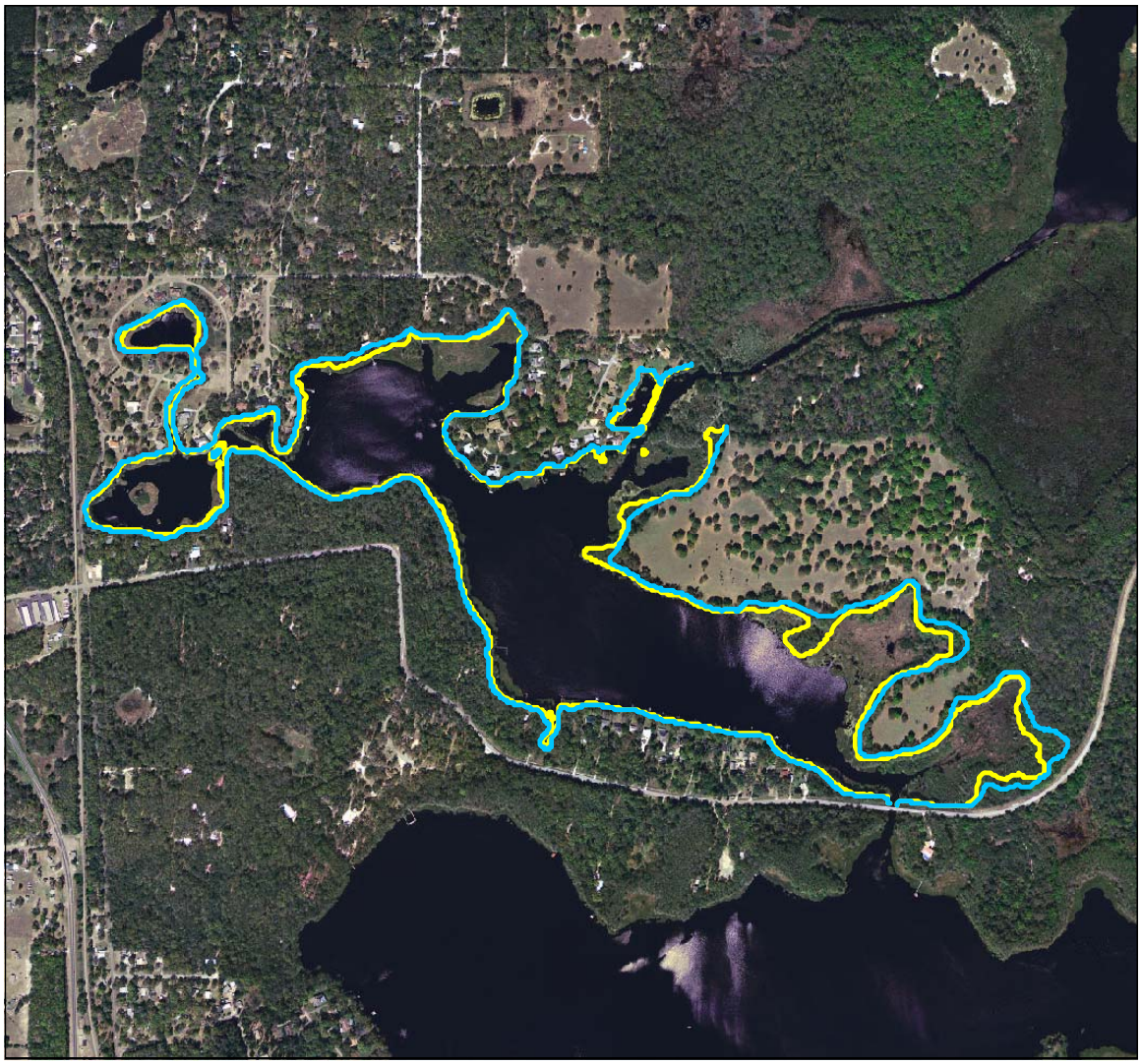
HMLL = 41.2 ft above NGVD

0 0.2 0.4 0.6 Miles

N

Map prepared using USGS 2004 true color digital orthophotography, elevation data from 1981 SWFWMD aerial photography with contours maps (Secs. 1, 2, 3, 10, 11, 14, and 15, Twp. 20 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 37. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Floral City Pool in the Hampton Lake basin.



Minimum Levels

MLL = 39.8 ft above NGVD

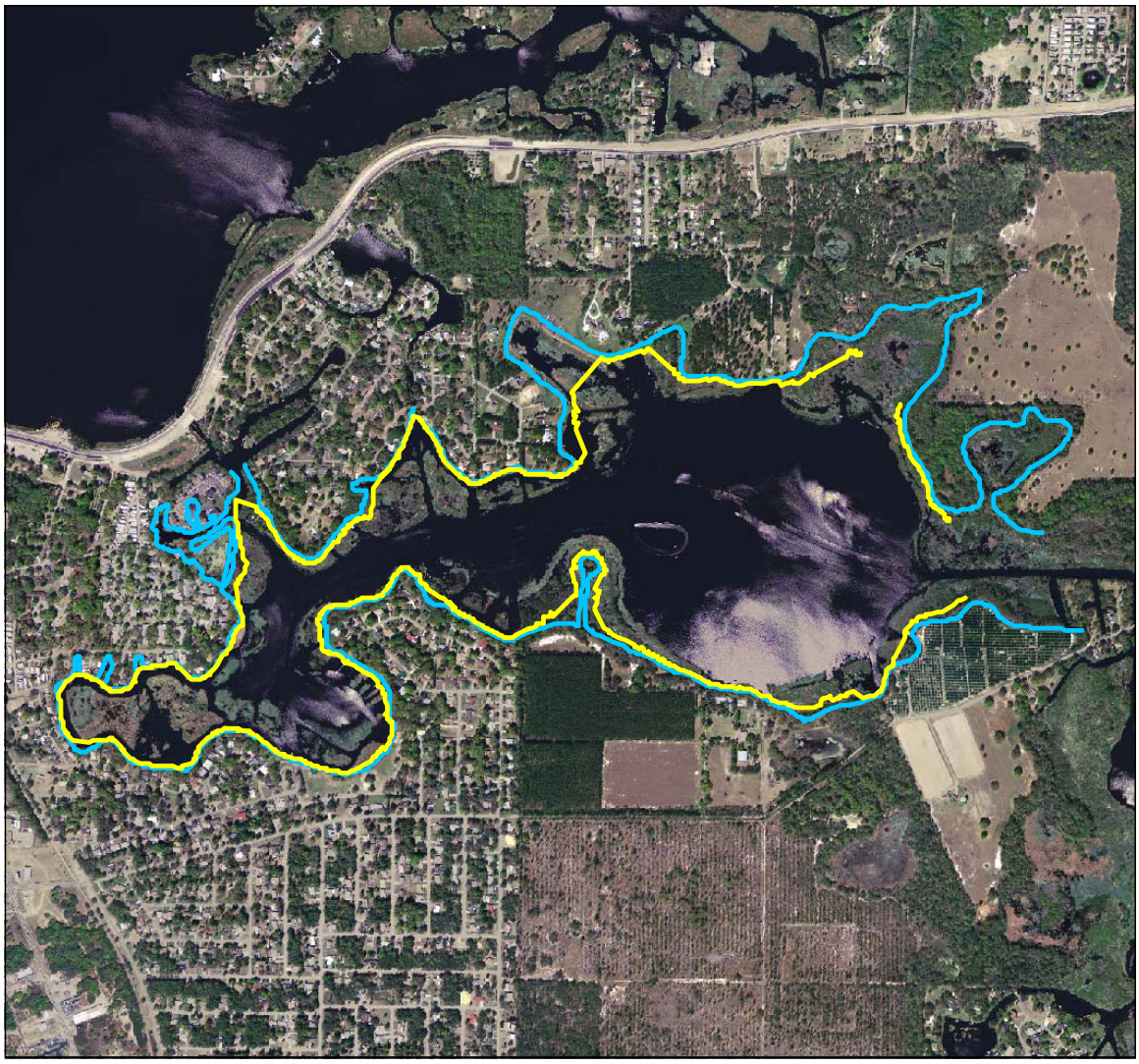
HMLL = 41.2 ft above NGVD

0 0.1 0.2 0.3 0.4 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1981 SWFWMD aerial photography with contours maps (Secs. 34, and 35, Twp. 19 S, Rge. 20 E, and Secs. 2, and 3, Twp. 20 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 38. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Inverness Pool in the Spivey Lake basin.



Minimum Levels

MLL = 38.7 ft above NGVD

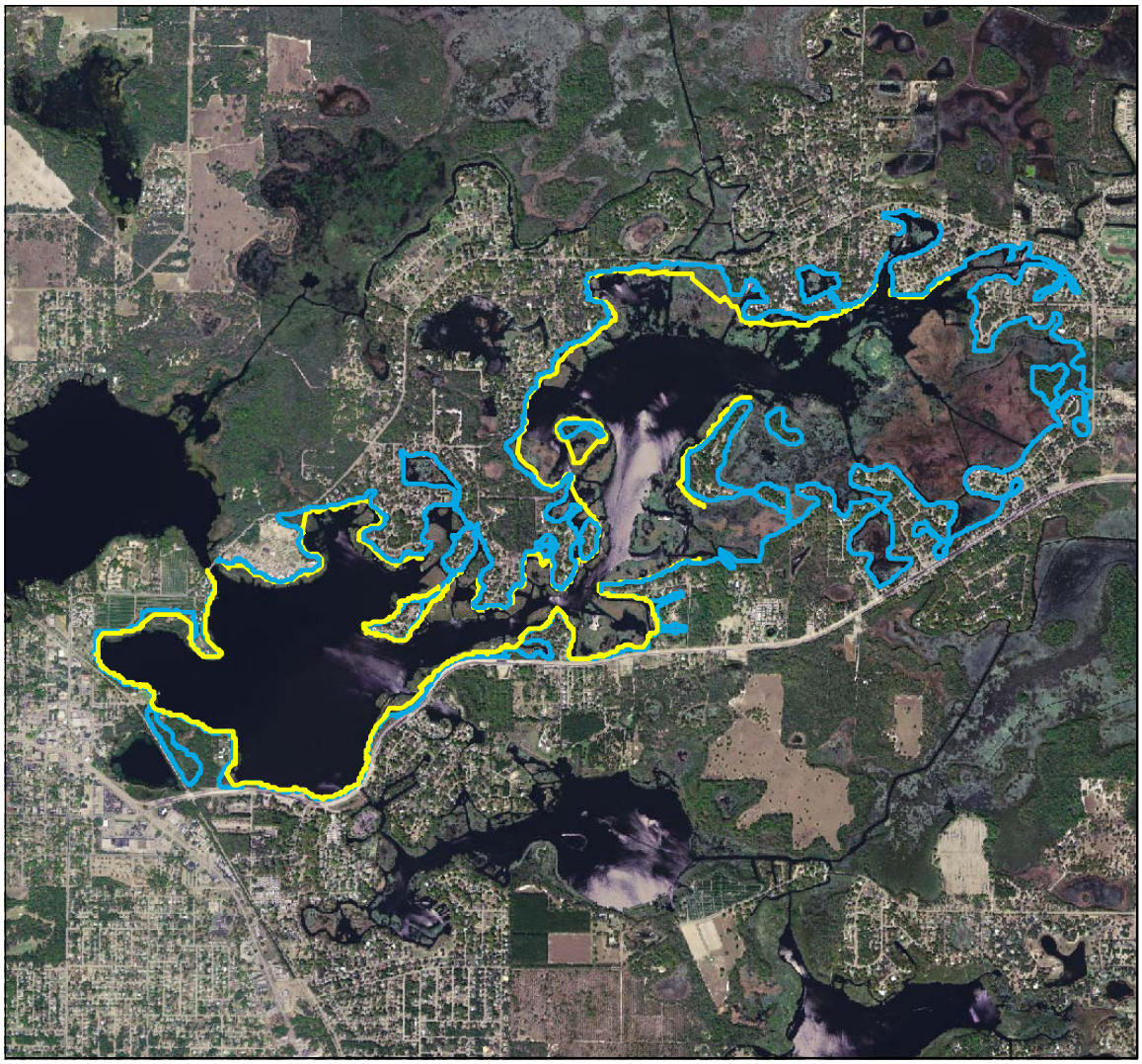
HMLL = 40.1 ft above NGVD

0 0.1 0.2 0.3 0.4 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1976 SWFWMD aerial photography with contours maps (Secs. 15, 16, 21, 22, Twp. 19 S, Rge 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 39. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Inverness Pool in the Henderson Lake basin.



Minimum Levels

MLL = 38.7 ft above NGVD

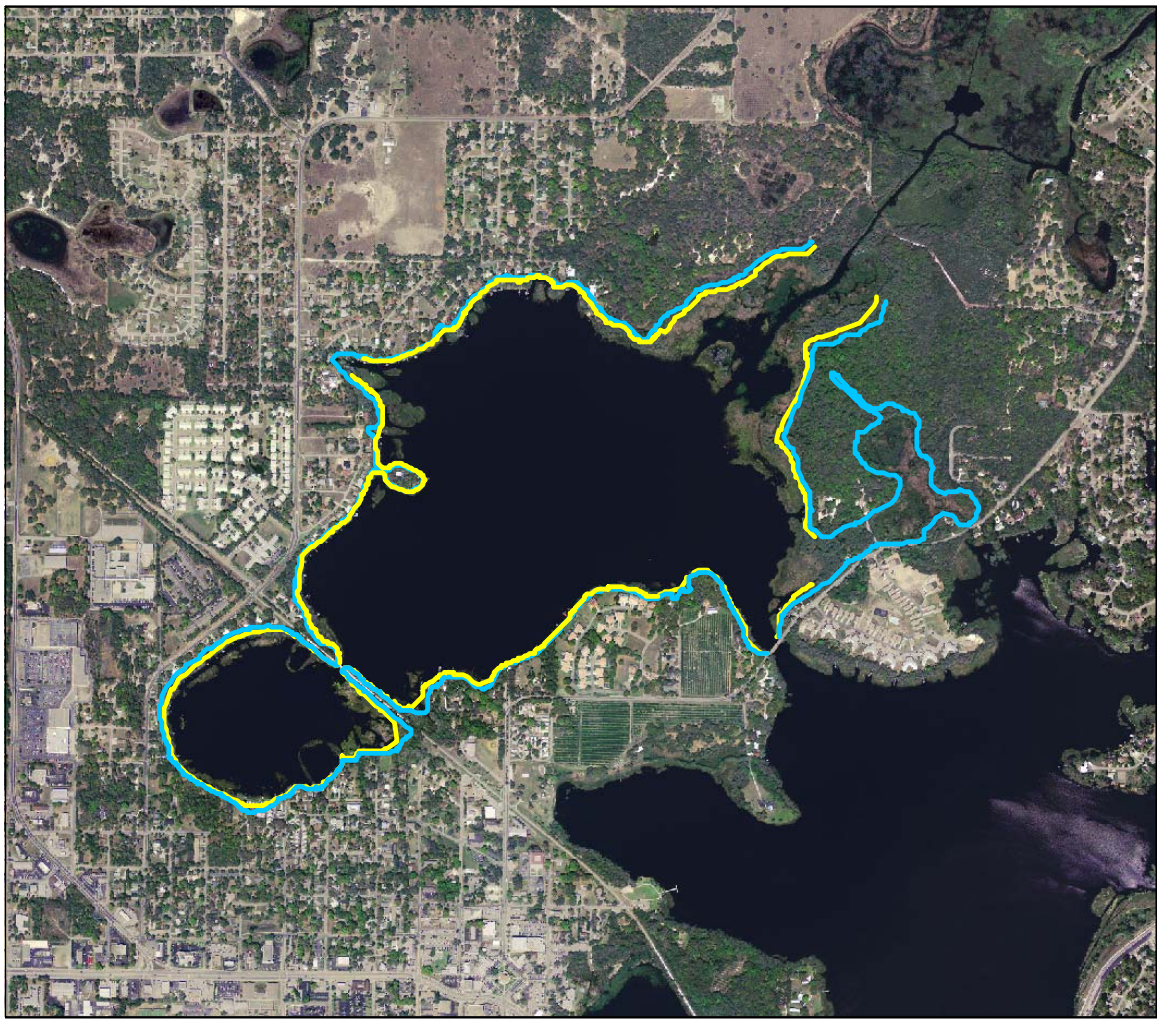
HMLL = 40.1 ft above NGVD

0 0.5 1 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1976 SWFWMD aerial photography with contours maps (Secs. 2, 3, 8 - 11, 15 - 17, Twp. 19 S, Rge. 20 E), and elevation data in 2004 collected by D.C. Johnson and Associates, Inc.

Figure 40. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Inverness Pool in the Little Henderson Lake basin.



Minimum Levels

MLL = 38.7 ft above NGVD

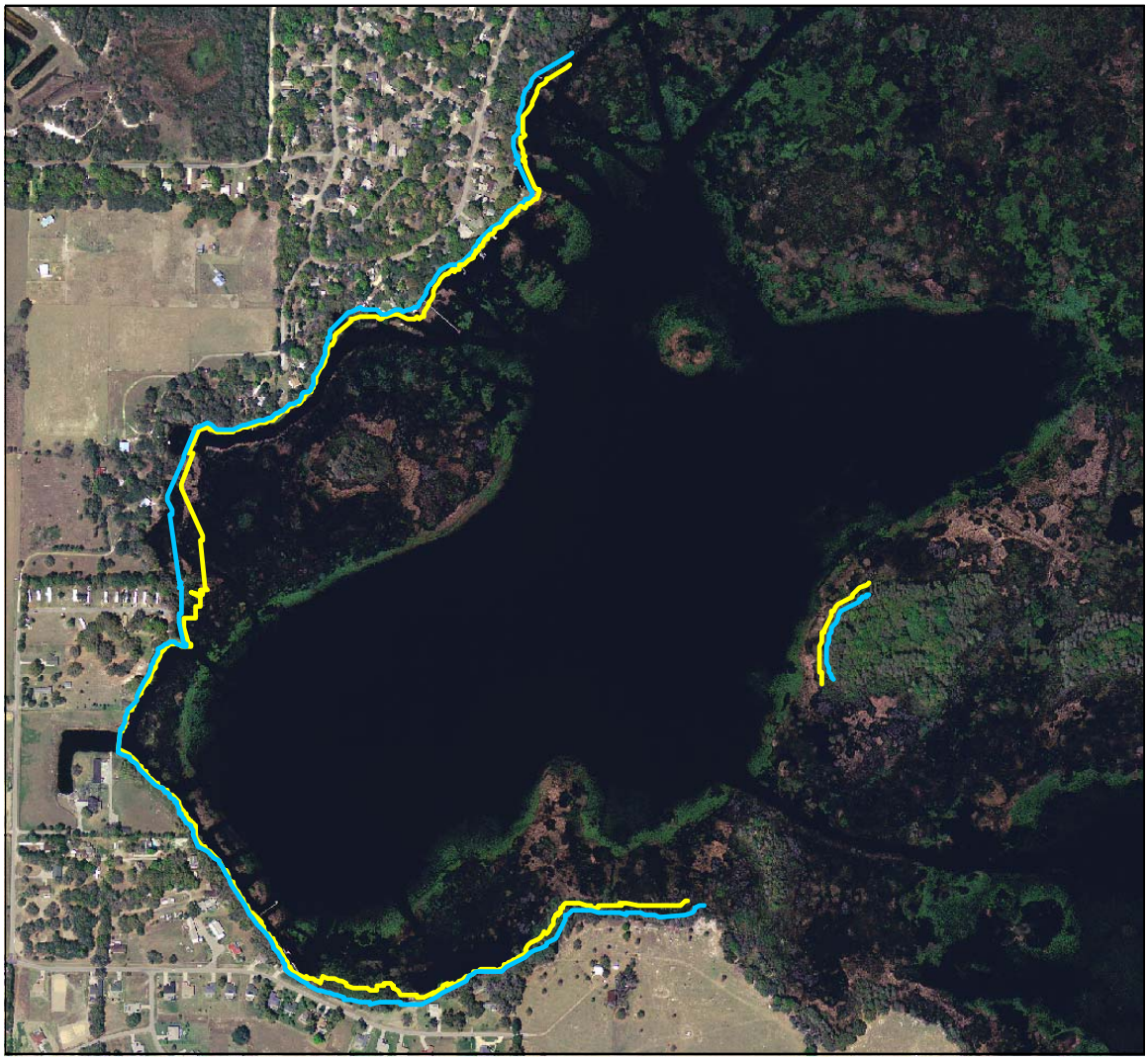
HMLL = 40.1 ft above NGVD

0 0.25 0.5 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 and 1976 SWFWMD aerial photography with contours maps (Secs. 7 - 9, 17, and 18, Twp. 19 S, Rge. 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 41. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Hernando Pool in the Croft Lake basin.



Minimum Levels

MLL = 37.3 ft above NGVD

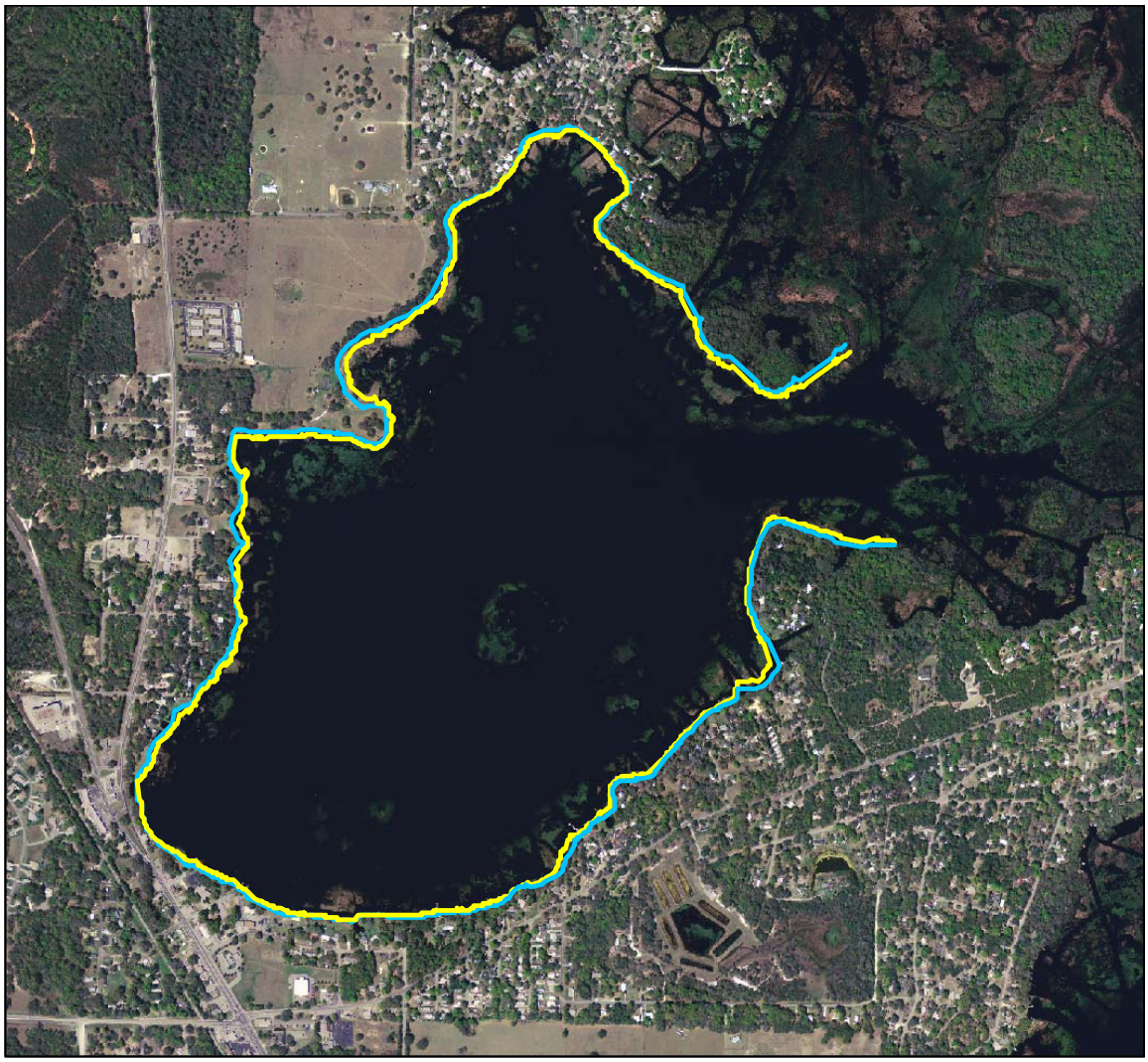
HMLL = 38.7 ft above NGVD

0 0.1 0.2 0.3 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 25, and 36, Twp. 18 S, Rge. 19 E, and Sec. 30, Twp. 18 S, Rge 20 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 42. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Hernando Pool in the Hernando Lake basin.



Minimum Levels

MLL = 37.3 ft above NGVD

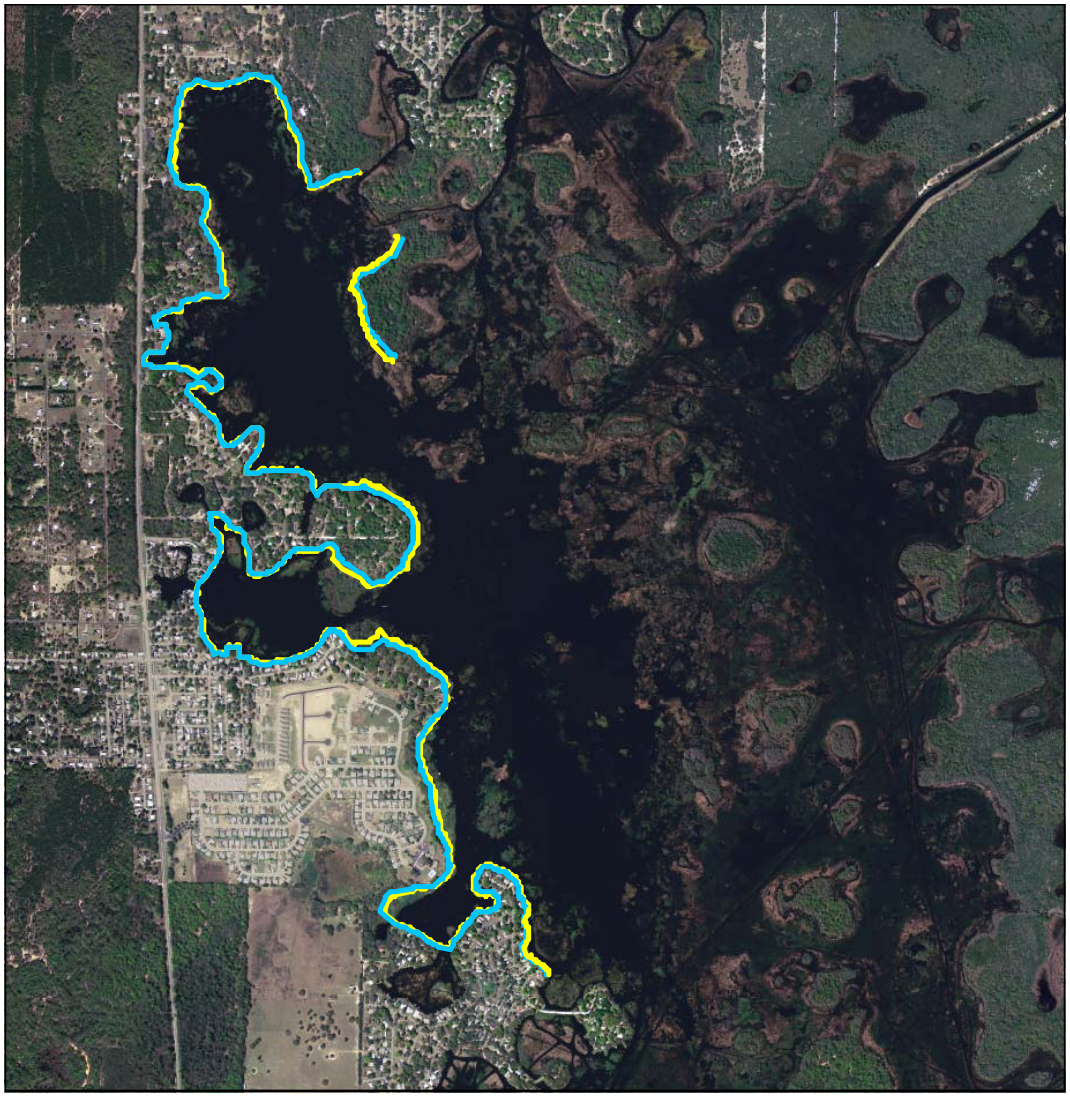
HMLL = 38.7 ft above NGVD

0 0.25 0.5 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 13, 23 - 26, Twp. 18 S, Rge. 19 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Figure 43. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for the Hernando Pool in the combined Bellamy Lake, Dodd Lake and Todd Lake basin.



Minimum Levels

MLL = 37.3 ft above NGVD

HMLL = 38.7 ft above NGVD

0 0.25 0.5 Miles

N

Map prepared using 2004 USGS true color digital orthophotography, elevation data from 1973 SWFWMD aerial photography with contours maps (Secs. 1, 2, 11 - 14, Twp. 18 S, Rge. 19 E), and elevation data collected in 2004 by D.C. Johnson and Associates, Inc.

Table 20. Elevations of selected lake basin features in the Floral City Pool of Tsala Apopka Lake

Feature and Lake	Elevation (feet above NGVD)
Low floor slab – Floral City Lake	43.41
Low floor slab – Hampton Lake	43.95
Low floor slab – Tussock Lake	44.11
Low road – Floral City Lake	42.99
Low road – Hampton Lake	43.46
Low road – Tussock Lake	43.98
Low other (shed floor) –Hampton Lake	43.60
Low other (pole barn slab)	43.76
Top / bottom of public boat ramp – Floral City Lake	43.2 / not measured*

* Lake bottom (sediment elevations) in basin near boat ramp range from ~35 to ~37 feet above NGVD

Table 21. Elevations of selected lake basin features in the Inverness Pool of Tsala Apopka Lake.

Feature and Lake	Elevation (feet above NGVD)
Low floor slab – Davis Lake	43.66
Low floor slab – Spivey Lake	44.73
Low floor slab – Henderson Lake	42.52
Low floor slab – Little Henderson Lake	43.66
Low road – Davis Lake	43.67
Low road – Spivey Lake	43.32
Low road – Henderson Lake	41.84
Low road – Little Henderson Lake	42.34
Top / bottom of public boat ramp – Spivey Lake	44.5 / not measured
Top / bottom of public boat ramp – Henderson Lake	44.0 / 33.6
Top / bottom of public boat ramp – Little Henderson Lake	42.1 / 33.0
Low other (shed floor) – Spivey Lake	42.0

Table 22. Elevations of selected lake basin features in the Hernando Pool of Tsala Apopka Lake.

Feature and Lake	Elevation (feet above NGVD)
Low floor slab – Dodd Lake	41.02
Low floor slab – Bellamy Lake	41.13
Low floor – Hernando Lake	41.45
Low floor slab – Todd Lake	41.75
Low floor slab – Croft Lake	42.17
Low floor slab – Point Lonesome	41.14
Low road – Dodd Lake	42.29
Low road – Bellamy Lake	40.92
Low road – Hernando Lake	41.51
Low road – Todd Lake	41.50
Low road – Croft Lake	43.80
Low road – Point Lonesome	41.61
Top / bottom of public boat ramps – Hernando Lake	39.9 / ~32.2 and 32.4
Low other (shed) – Bellamy Lake	41.01
Low other (shed) – Hernando Lake	41.20
Low other (pool deck) – Hernando Lake	41.8
Low other (shed) – Point Lonesome	40.85

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