

Minimum and Guidance Levels for King Lake (East) in Pasco County, Florida



March 19, 2008

Ecologic Evaluation Section
Resource Projects Department



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Southwest Florida Water Management District
Brooksville, Florida 34604-6899

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Cover: Ground-level photograph of King Lake (East) in 2004 (Southwest Florida Water Management District files).

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Minimum and Guidance Levels for King Lake (East)

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

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

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

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

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

- The 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 October 2007, the District Governing Board approved rule amendments pertaining to the elimination of Ten Year Flood Guidance Levels and references to the levels from Chapter 40D-8, F.A.C. Work related to the development of ten-year flood levels and other flood-recurrence levels is currently conducted through the District Watershed Management Program, and information pertaining to flood levels is included in watershed management plans that result from program activities.

In accordance with Chapter 40D-8, F.A.C., proposed Minimum and Guidance Levels were developed for King Lake (East), a Category 3 Lake located in Pasco County, Florida (Southwest Florida Water Management District 2007a). The levels were established using best available information, including data that were obtained specifically for the purpose of minimum levels development. Following a public input process, the District Governing Board approved adoption of the proposed levels on December 18, 2007 and the levels (Table 1) were subsequently incorporated into Chapter 40D-8, F.A.C. The data and analyses used for development of the adopted levels are described in the remainder of this report.

Table 1. Minimum and Guidance Levels for King Lake (East)

Minimum and Guidance Levels	Elevation (feet above NGVD)
High Guidance Level	105.7
High Minimum Lake Level	105.1
Minimum Lake Level	102.7
Low Guidance Level	101.4

Data and Analyses Supporting Minimum and Guidance Levels for King Lake (East)

Lake Setting and Description

King Lake is located in north-central Pasco County, Florida (Sections 22, 23, 26 and 27, Township 25 South, Range 20 East) in the Hillsborough River Basin of the Southwest Florida Water Management District (Figures 1 and 2). The lake is referred to by the District as King Lake (East) to distinguish it from the King Lake located near Land O' Lakes in Pasco County. White (1970) classified the region of central or mid-peninsular Florida containing King Lake as the Brooksville Ridge. Brooks (1981) categorized the area surrounding the lake as the Hillsborough Valley division of the Ocala Uplift District, and described the region as an erosional basin with numerous karst features, with considerable topographic relief in the headwaters region, which includes King Lake. As part of the Florida Department of Environmental Protection's Lake Bioassessment/Regionalization Initiative, the area has been identified as the Southern Brooksville Ridge region (Griffith *et al.* 1997). Lakes in this region tend to be neutral to alkaline, slightly colored, mesotrophic to meso-eutrophic systems.

Aquatic and wetland vegetation within the basin includes southern naiad (*Najas quadalupensis*), red ludwigia (*Ludwigia repens*), alligator-weed (*Alternanthera philoxeroides*), water pennywort (*Hydrocotyle umbellata*), fragrant water lily (*Nymphaea odorata*), spatterdock (*Nuphar luteum*), water hyacinth (*Eichhornia crassipes*), arrowhead (*Sagittaria latifolia*), cattail (*Typha* sp.), bulrush (*Scirpus* sp.), torpedograss (*Panicum repens*), primrose willow (*Ludwigia* sp.), willow (*Salix* sp.), red maple (*Acer rubrum*), and a few cypress (*Taxodium* sp.). Uplands in the immediate lake basin include cleared areas that are currently used for low-density residential development, citrus production and livestock grazing (Figure 3). Historical photographs from 1941 through 2006 (Figures 2, 3 and 6-16) provide evidence for a relatively long history of agriculture activity in the lake watershed. The District currently maintains a water-level gauging station along the northern shore of the lake (Figure 3)

The lake lies within the Bayou Branch drainage basin in the Hillsborough River watershed (United States Geological Survey Hydrologic Unit Classification System). Foote (1981) reports a drainage area of 3.37 square miles for the lake. Surface water inputs include direct precipitation on the lake surface, and runoff from immediately adjacent upland areas. A ditch along the western lakeshore provides for conveyance under a lime-rock road (Kenton Road) to wetlands that drain to Big Cypress Swamp (Creek) when the lake is staged higher than 102.0 feet above NGVD (Figures 3, 4 and 5). Documents maintained in District files (DeWitt 1984, Epperson 1984, DeWitt 1985, Richters 1986, Southwest Florida Water Management District 1996a) indicate that this lake outlet was probably modified repeatedly during the early and mid-1980s. Currently, if the lake surface were to exceed 105.4 feet, flow from the basin could also occur to the north, across another lime-rock road (Tyndall Road) and through a series of wetlands and ditched pastures to Bayou Branch and ultimately to Cypress Creek. Historically,

northward drainage from the lake probably occurred at elevations lower than 105.4 feet above NGVD. District survey work from 1986 indicates that lake could possibly have discharged to the north when the lake surface exceeded 104.79 feet above NGVD, the centerline elevation of Tyndall Road (which was known at that time as Tucker Road). Also, two currently plugged culverts with inverts of 102.8 and 102.9 feet above NGVD, likely provided conveyance northward under Tyndall Road when the lake water level rose above the high ground lying between the lake and the road. There is currently one District-permitted surface withdrawal from the lake (Water Use Permit No. 20002644.004). Eleven permitted groundwater withdrawals sites are located within one mile of the lakeshore (Figure 17). The surface water withdrawal is permitted for a total daily average withdrawal of 35,000 gallons per day; the well sites are permitted for a total of 583,000 gallons per day.

The 1954 and 1988 photorevised United States Geological Survey 1:24,000 San Antonio quadrangle 7.5 minute topographic maps include a water surface elevation of 102 feet above the National Geodetic Vertical Datum of 1929 for the lake (see Figure 18 for an excerpted image from the most recent Geologic Survey topographic map of the lake area). The "Gazetteer of Florida Lakes" (Florida Board of Conservation 1969, Shafer *et al.* 1986) includes a lake area of 263 acres associated with a water surface elevation of 102 feet above NGVD. A topographic map of the lake basin recently generated in support of minimum levels development (Figure 19) indicates that the lake extends over 368 acres when it is staged at 102 feet above NGVD.

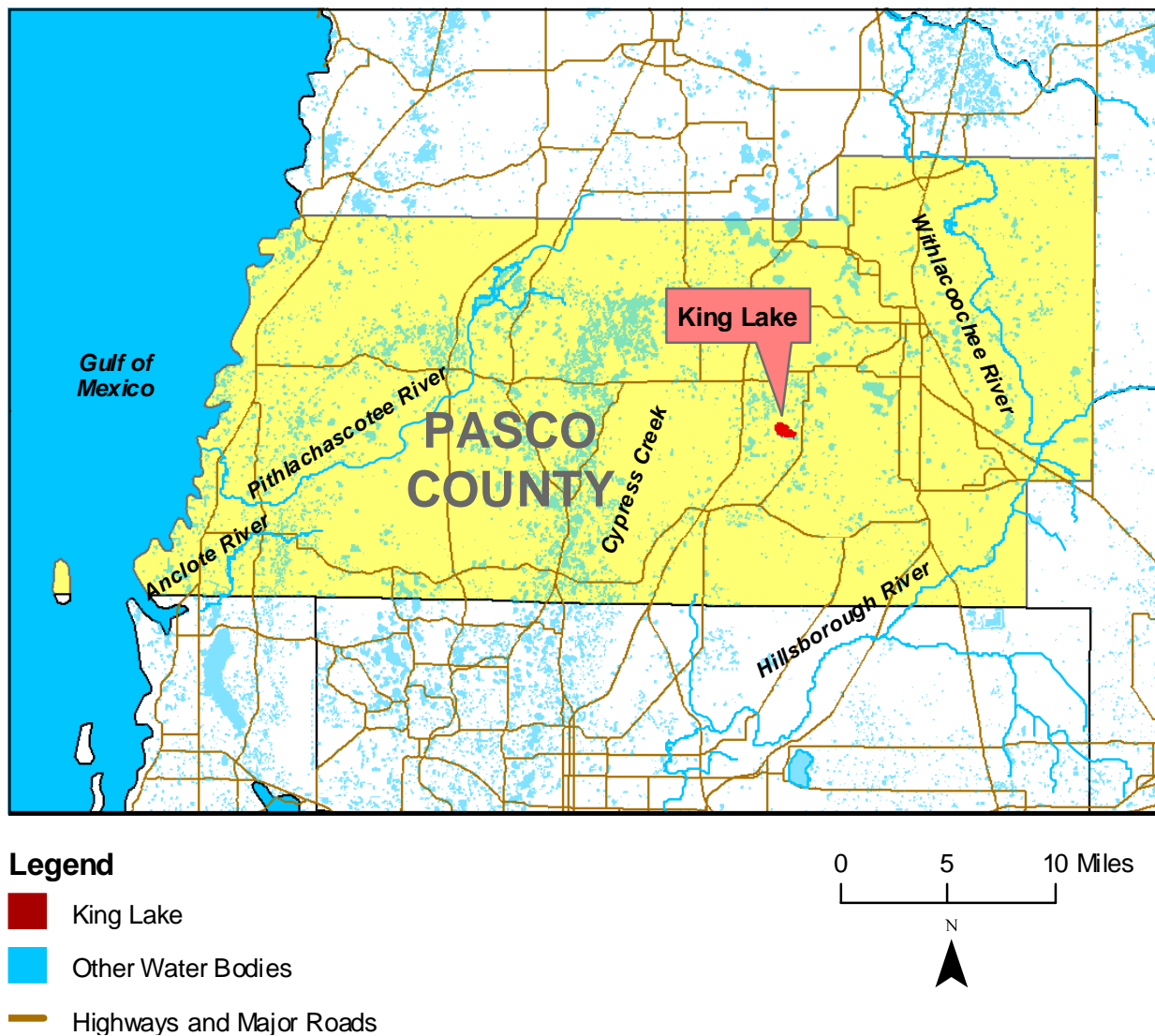


Figure 1. Location of King Lake (East), other regional water bodies, highways and major roads within and near Pasco County, Florida (image sources: Southwest Florida Water Management District 2003a,c,d and United States Geological Survey 2004b).

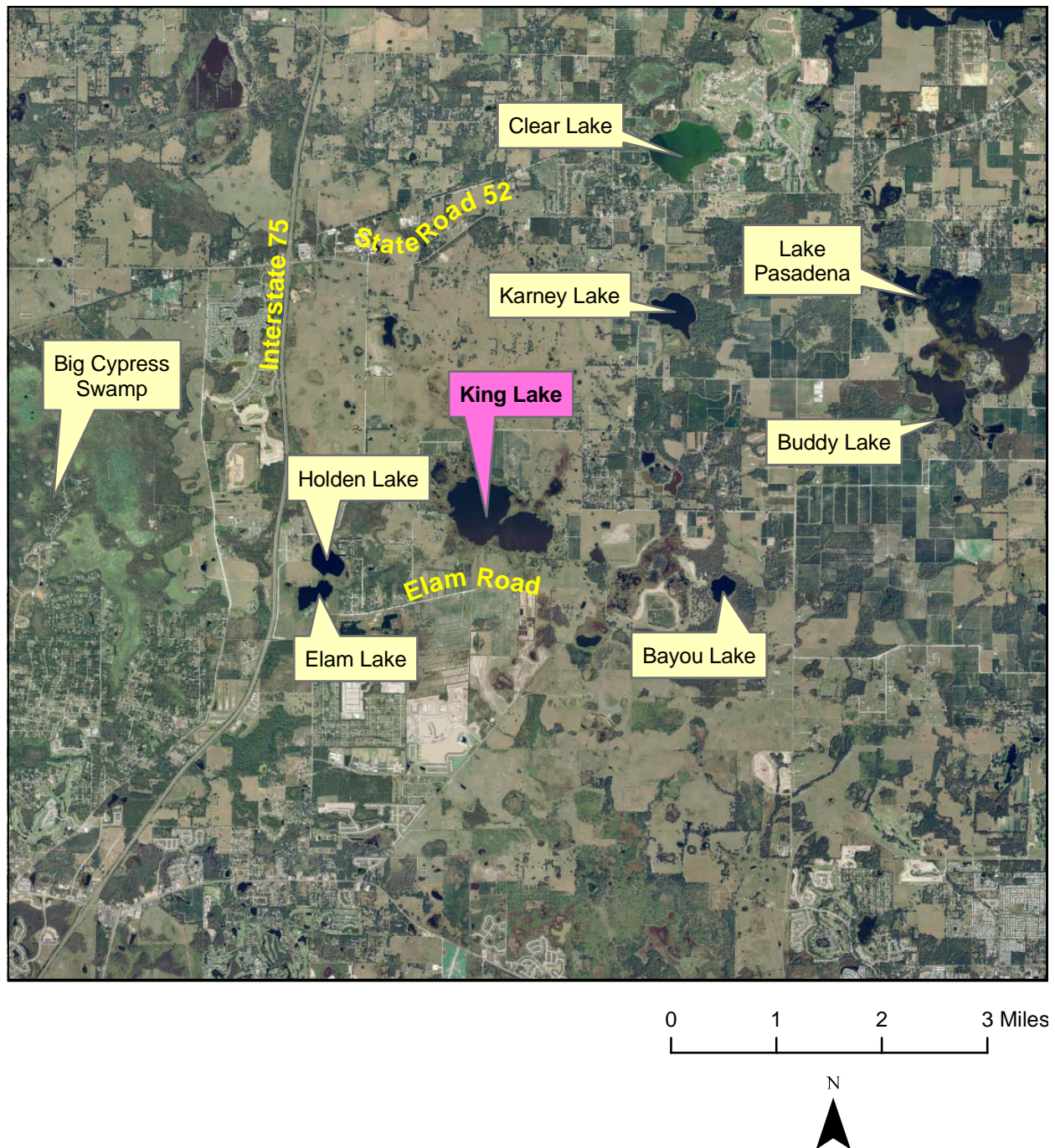
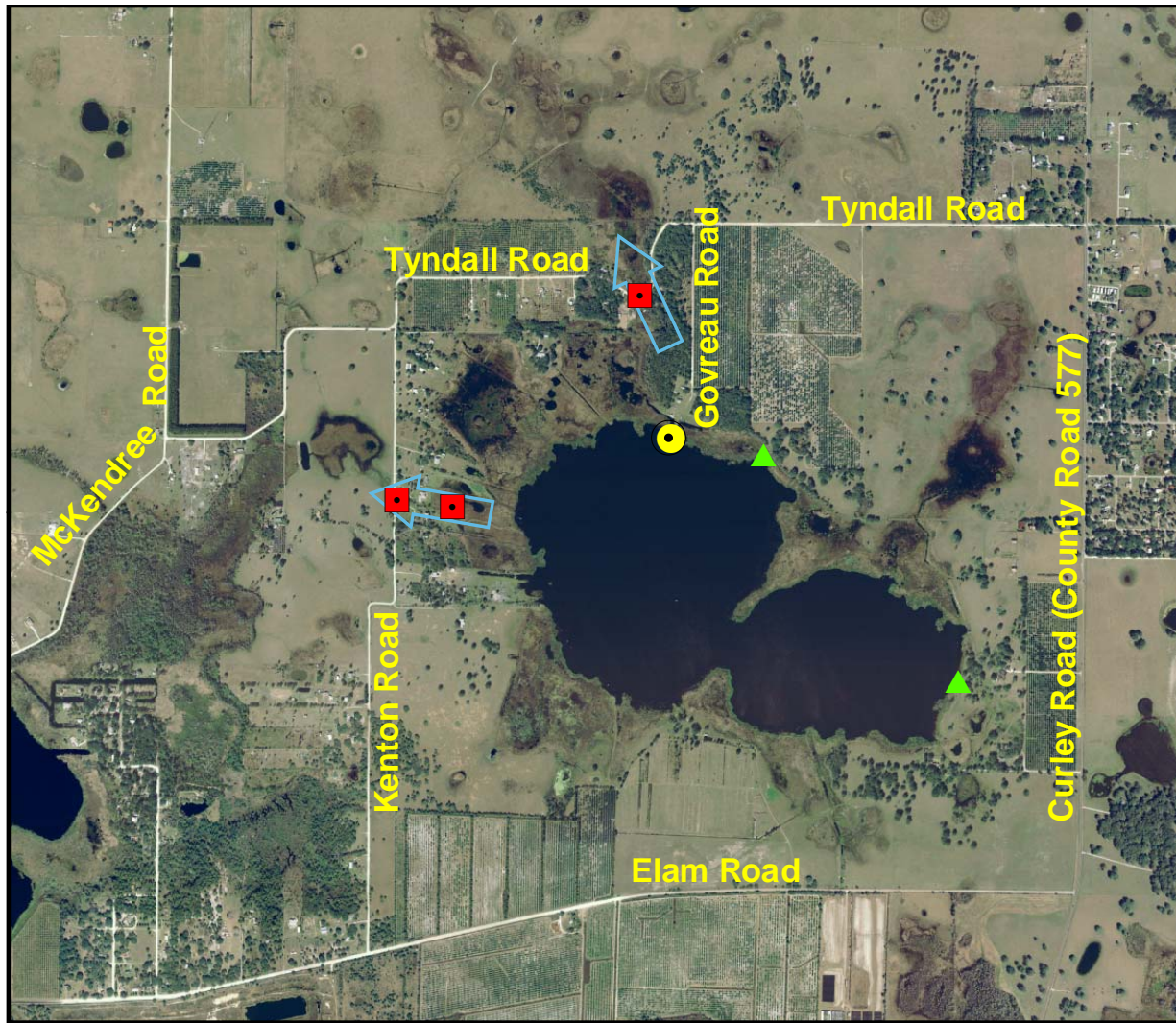






Figure 2. Aerial photograph of the King Lake (East) area in 2005, showing major surface water features and roads in the lake vicinity (photographic image source: Woolpert, Inc. 2005b).



Legend

-  Water level gauge
-  Hydrologic indicators sites
-  Inlets/outlet flow direction
-  Outlet culvert

0 1,000 2,000 3,000 Feet



Figure 3. Aerial photograph of King Lake (East) in 2005, showing the District water-level gauge site, the lake outlets, and sites where hydrologic indicators were measured (photographic image source: Woolpert, Inc. (2005b)).

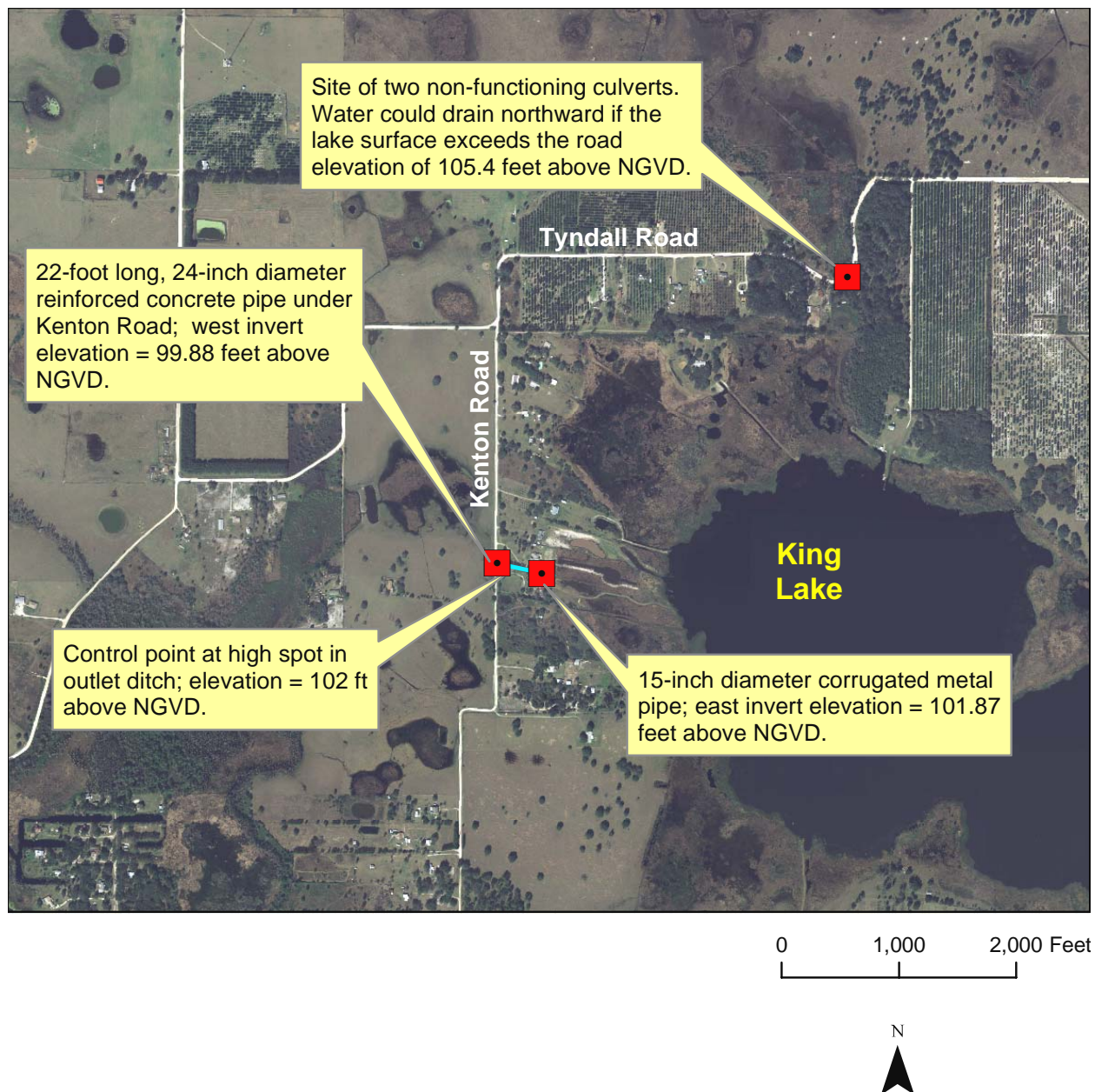


Figure 4. Outlet conveyance systems for King Lake (East) (photographic image source: 3001, Inc. 2006). Ditched flow paths are indicated by the blue line.



Figure 5. Ground-level photograph of the outlet ditch along the west shore of King Lake (East) in July 2006. The photograph was taken from Kenton Road, looking towards the lake (Southwest Florida Water Management District files).

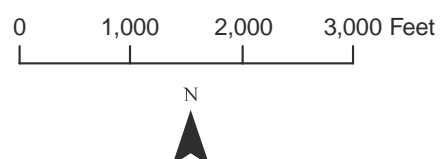


Figure 6. Aerial infrared photograph of King Lake (East) in 1999 (image source: Southwest Florida Water Management District 2002a).



0 1,000 2,000 3,000 Feet



Figure 7. Aerial infrared photograph of King Lake (East) in 1994 (image source: Southwest Florida Water Management District, date unknown).

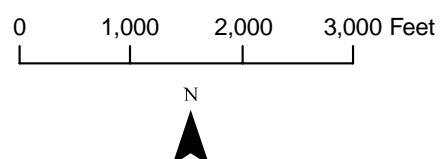
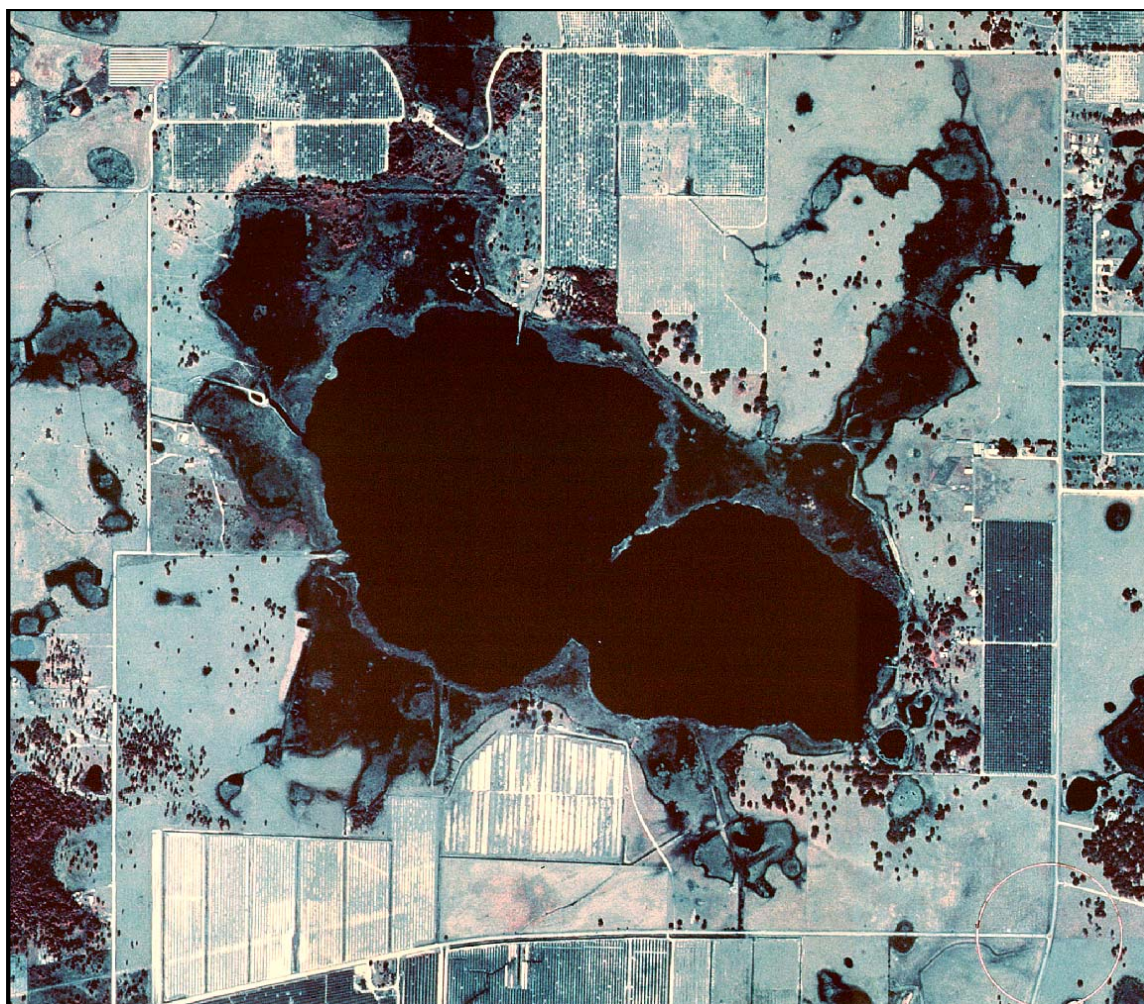
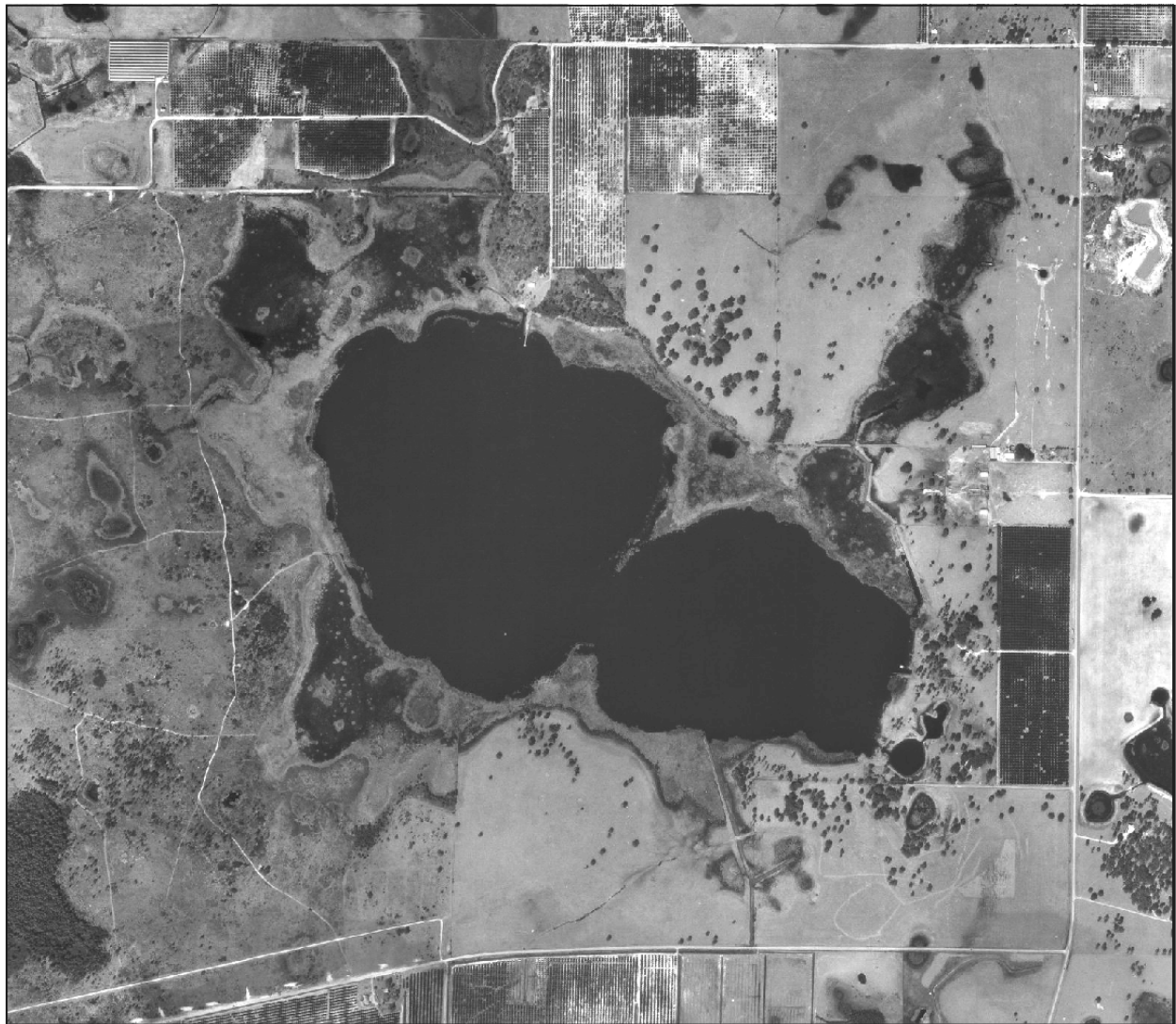


Figure 8. Aerial infrared photograph of King Lake (East) in 1984 (image source: United States Geological Survey 2004a).



0 1,000 2,000 3,000 Feet



Figure 10. Aerial photograph of King Lake (East) in 1973 (image source: Woolpert, Inc. 2005a).

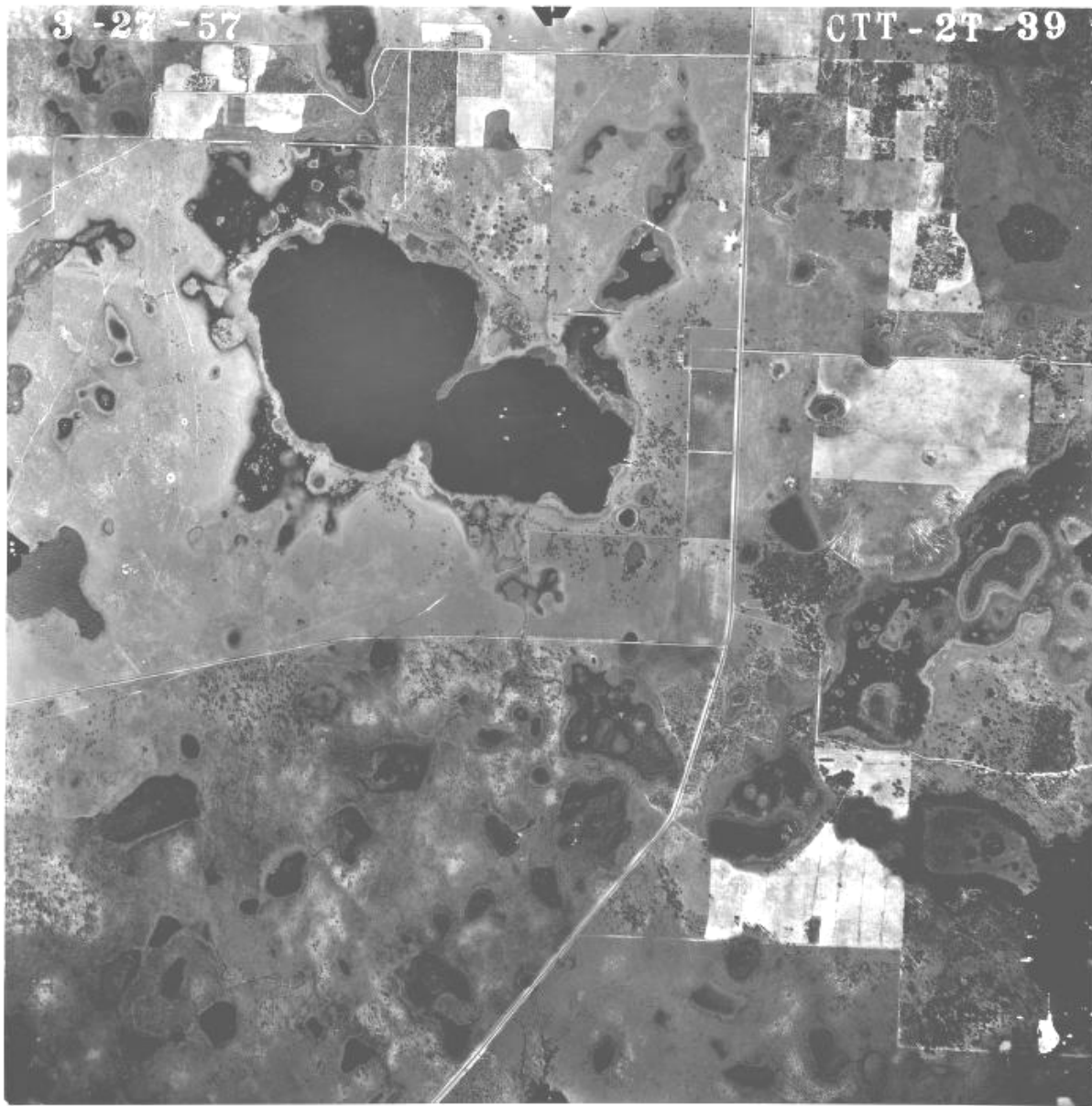


Figure 11. Aerial photograph of King Lake (East) in 1957 (United States Department of Agriculture 1957c).

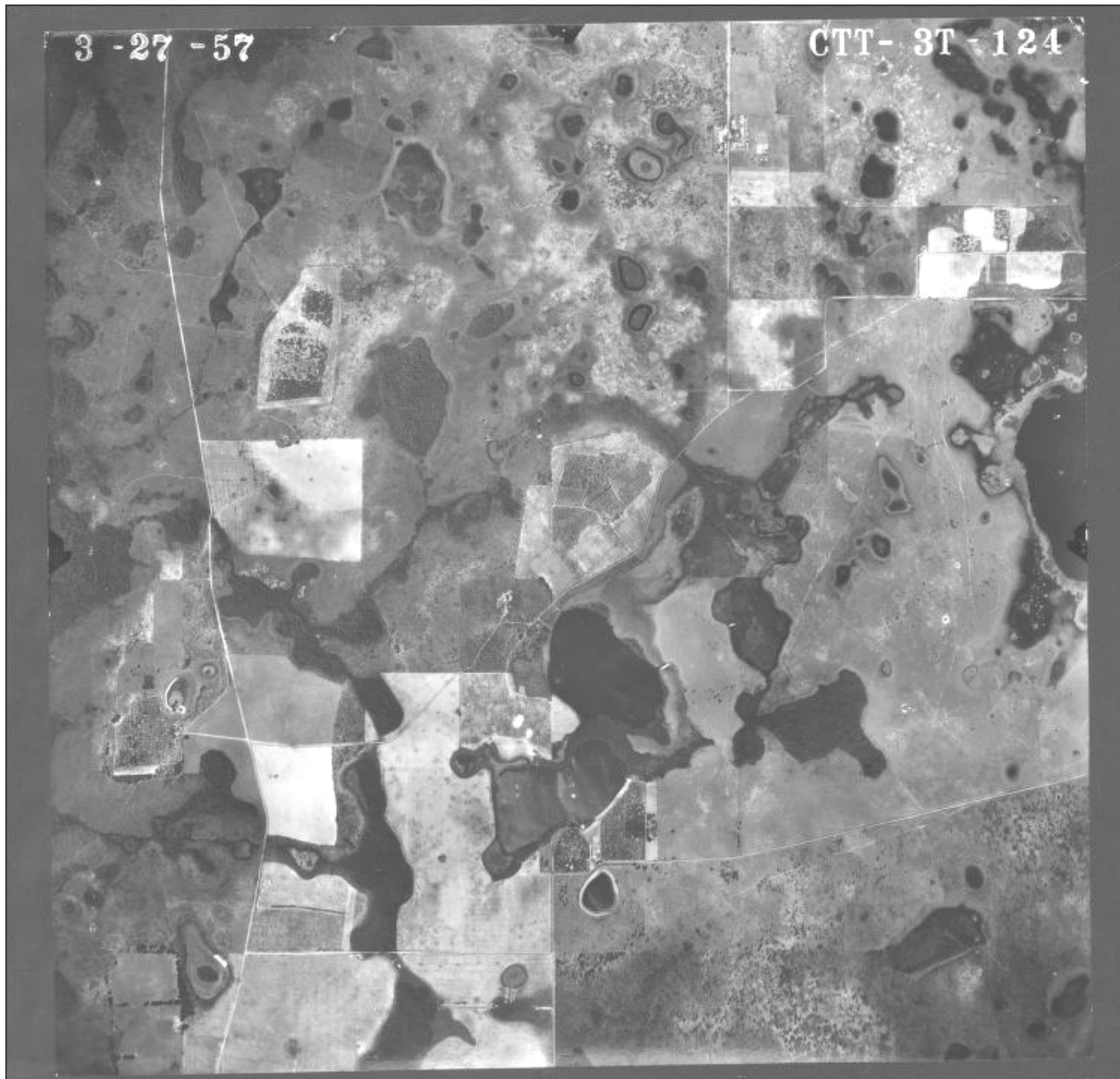


Figure 12. Aerial photograph of the western portion of King Lake (East) and areas to the west of the lake in 1957 (United States Department of Agriculture 1957d).

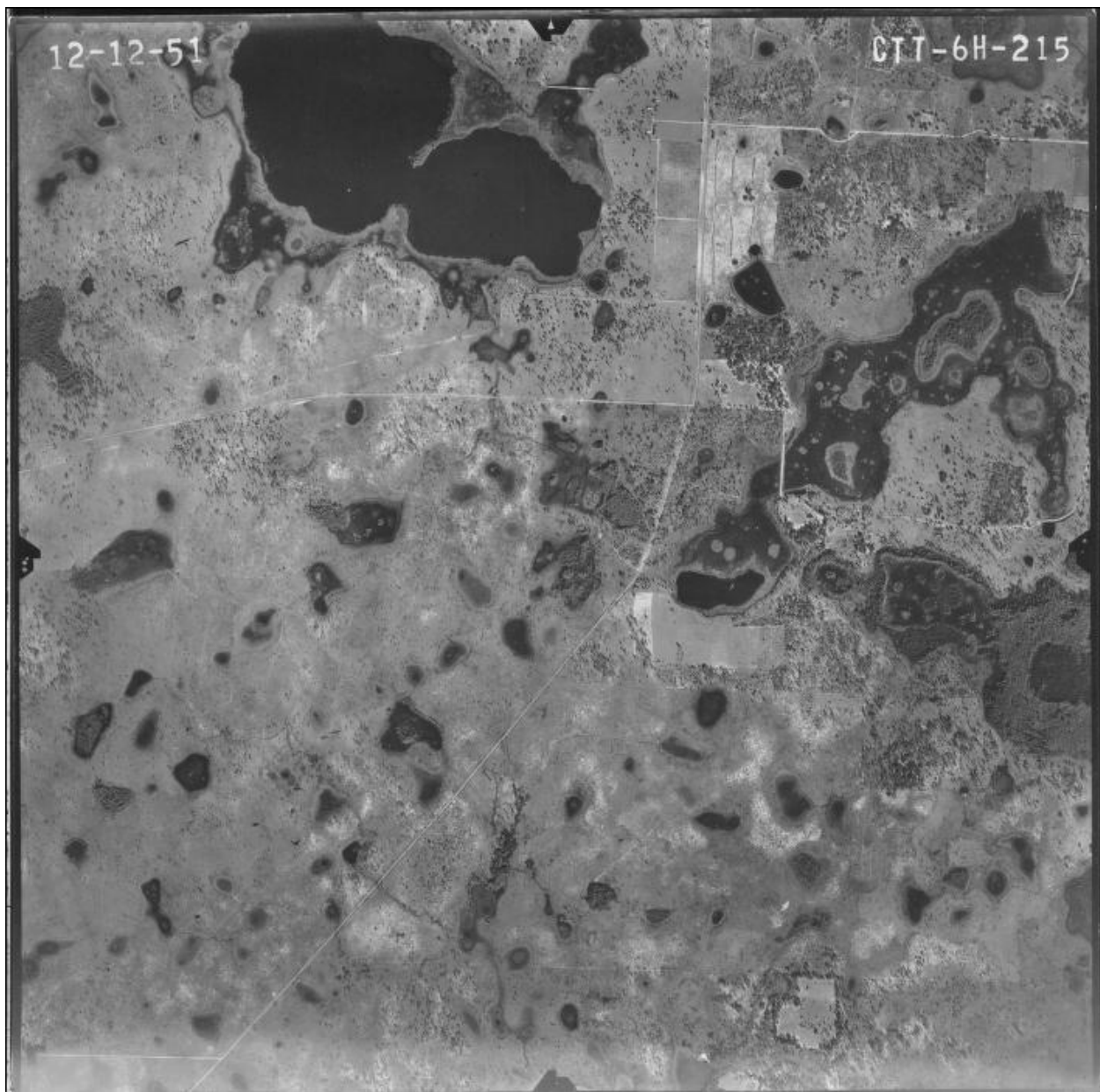


Figure 13. Aerial photograph of King Lake (East) in 1951 (United States Department of Agriculture 1951b).

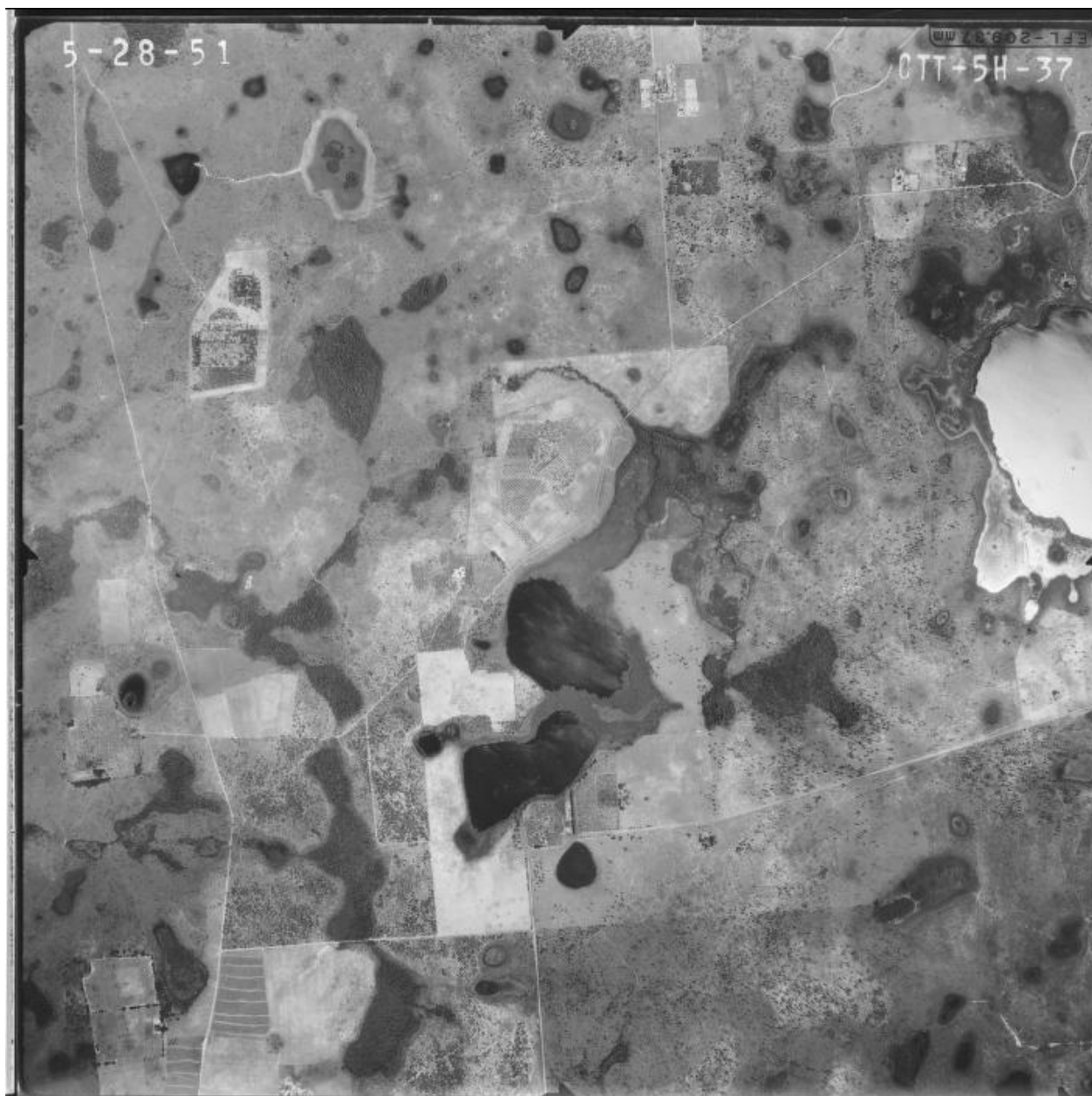


Figure 14. Aerial photograph of the western portion of King Lake (East) and areas to the west of the lake in 1951 (United States Department of Agriculture 1951a).



Figure 15. Aerial photograph of King Lake (East) in 1941 (United States Department of Agriculture 1941c).

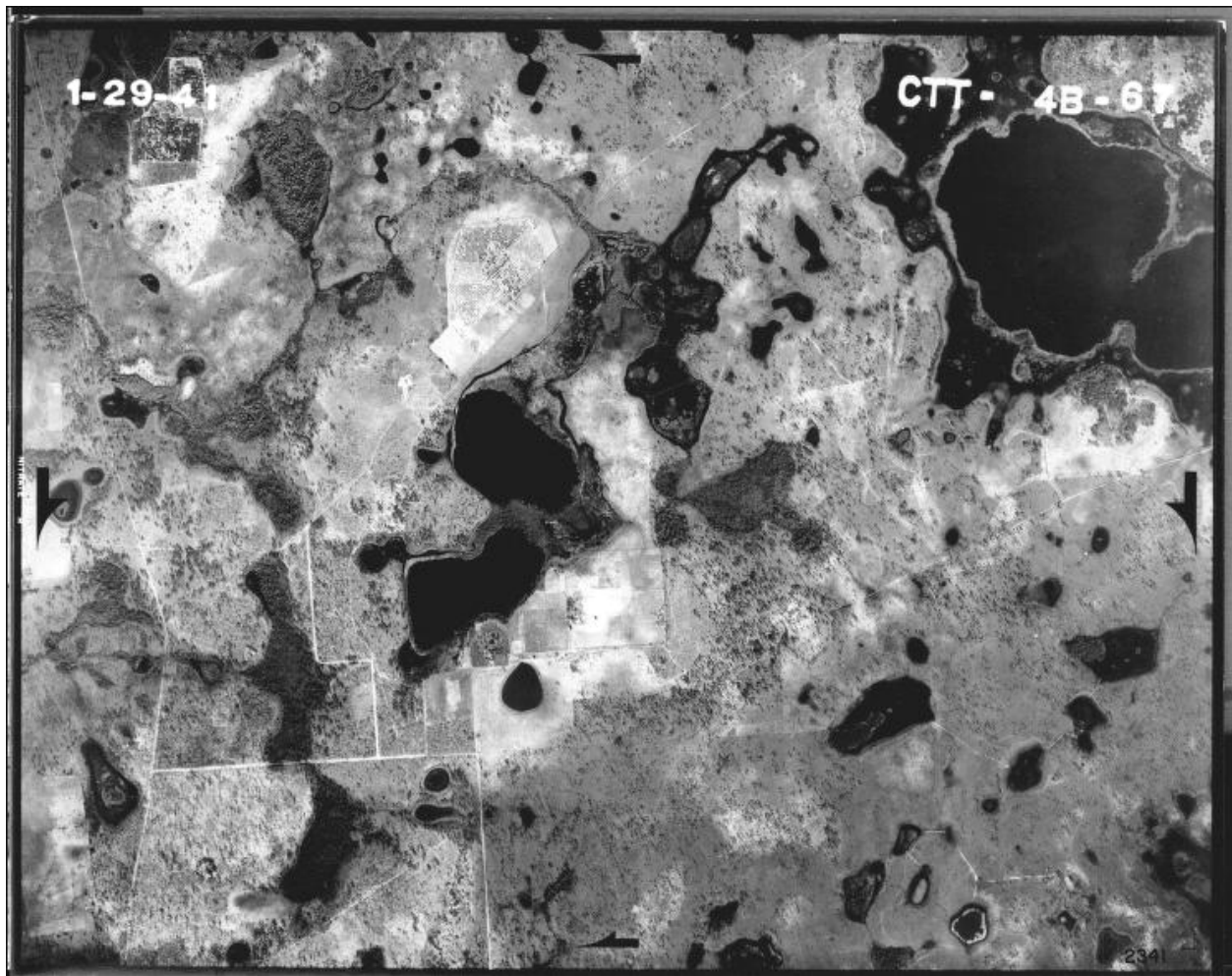
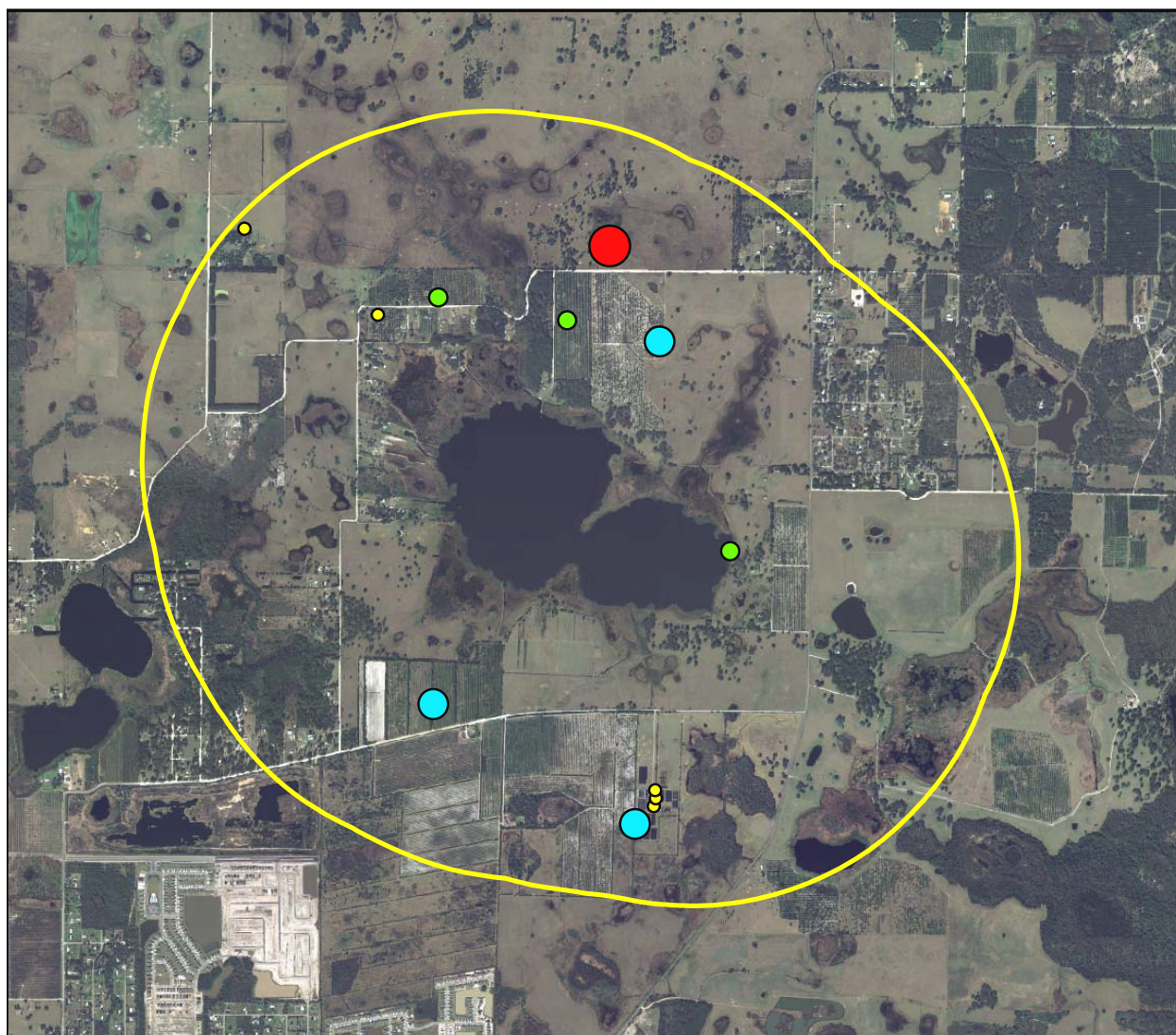


Figure 16. Aerial photograph of the western portion of King Lake (East) and areas to the west of the lake in 1941 (United States Department of Agriculture 1941a).



**Average Daily
Permitted Quantity
(Gallons per Day)**

- < 20,000
- > 20,000 to 50,000
- > 50,000 to 100,000
- > 100,000 to 200,000

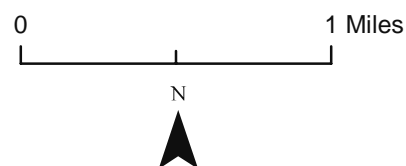


Figure 17. Permitted daily average quantities (gallons per day as of July 2007) for the surface water withdrawal from King Lake (East) and groundwater withdrawal sites within one mile of the King Lake (East) shoreline as delineated by the yellow line surrounding the lake (photographic image source: 3001, Inc. 2006; permitted quantity data source: Southwest Florida Water Management District 2007b).

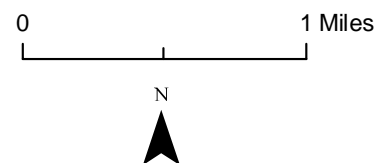
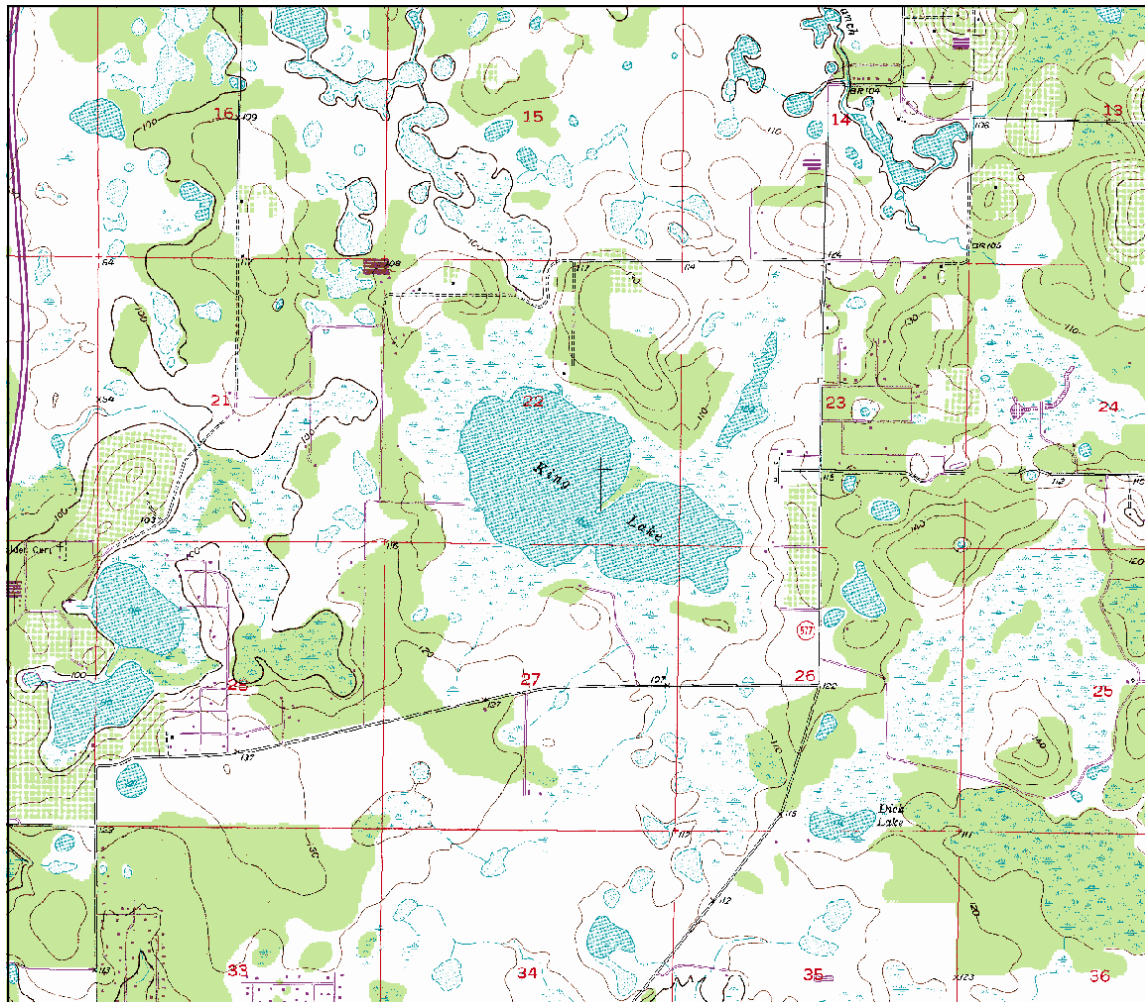
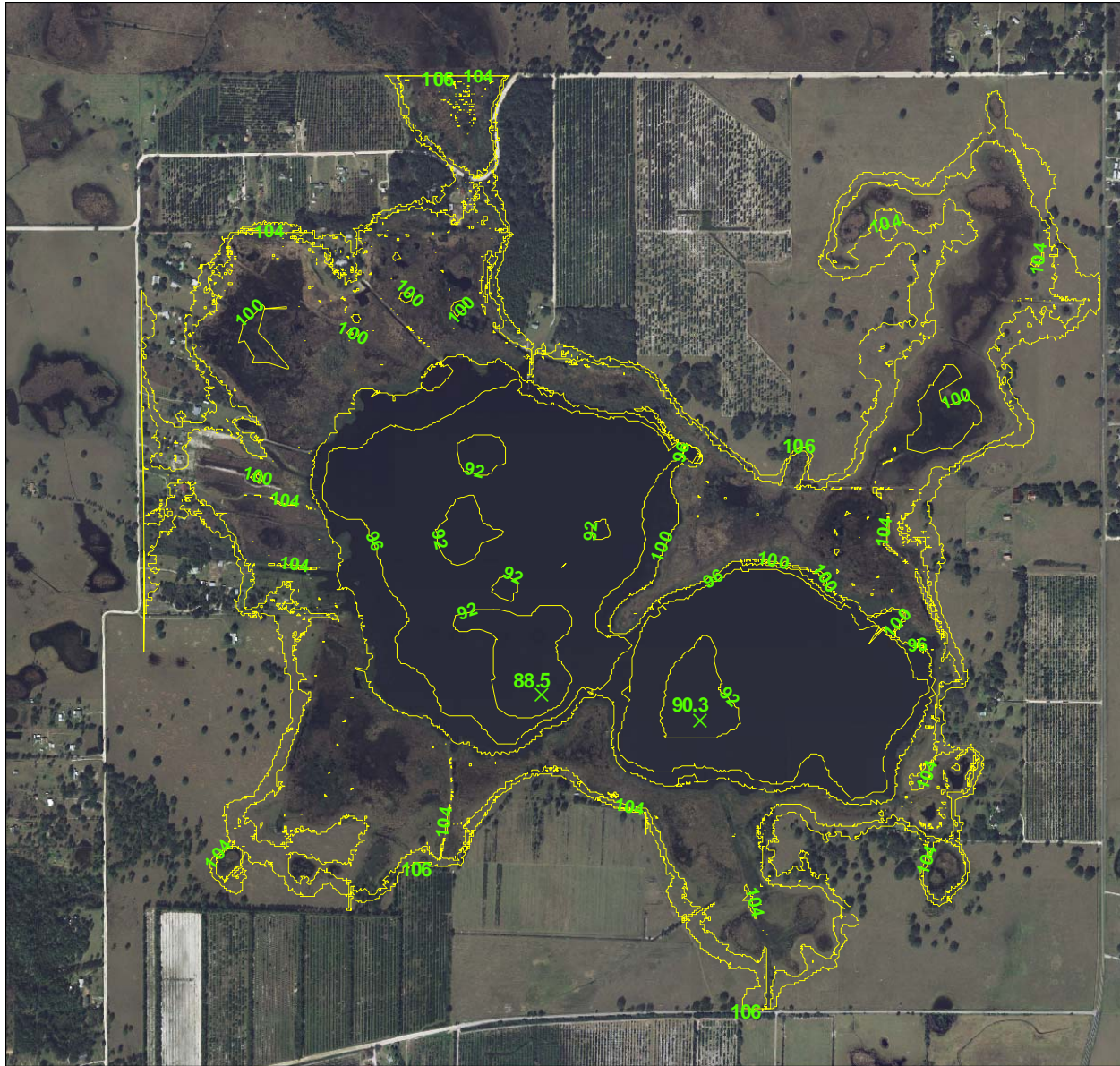


Figure 18. United States Geological Survey ten-foot ground elevation contours (feet above NGVD 1929) in the vicinity of King Lake (East) (image source: Southwest Florida Water Management District 2002b).



Map created using spot elevation data collected by D.C. Johnson Associates in May 2005 and LiDAR data collected by EarthData International, Inc. in 2004.

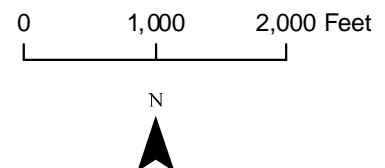


Figure 19. Four-foot ground elevation contours (feet above NGVD) and low spots within the King Lake (East) basin (photographic image source: 3001, Inc. 2006). Contours up to an elevation of 106 feet above NGVD are shown.

Previously Adopted Guidance Levels

The Southwest Florida Water Management District has a long history of water resource protection through the establishment of lake management levels. With the development of the Lake Levels Program in the mid-1970s, the District began 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.

In May 1986, the District adopted management levels (Table 2, currently referred to as Guidance Levels) for King Lake (East) and incorporated the levels into District rules (Chapter 40D-8, F.A.C.). A Maximum Desirable Level of 104.50 feet above NGVD was also developed but was not adopted by rule. The levels were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels, and do not, therefore, necessarily correspond with levels developed using current methods. Following the December 2007 adoption of Minimum and Guidance Levels for King Lake (East) that were developed using the current methods, the previously adopted Guidance Levels were removed from Chapter 40D-8., F.A.C.

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program. As described in the District's Consumptive Use of Water Rule (Chapter 40D-2, F.A.C.), "a stressed condition for a lake is defined to be chronic fluctuation below the normal range of lake level fluctuations". For lakes with adopted High, Low and Extreme Low Levels, 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.

King Lake (East) was not included on recent Stressed Lakes Lists (Gant 2005, 2006, 2007), but was previously classified as a stressed lake (Gant 1999a, 1999b, 2000, 2002, 2003, 2004). Based on adoption of Minimum Levels for the lake in December 2007, King Lake (East) will not be included in future Stressed Lakes List evaluations. Evaluation of water level fluctuations within the basin will instead be incorporated in annual determinations of compliance with adopted Minimum Levels.

Table 2. Previously adopted guidance Levels for King Lake (East).

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	105.49
High Level	105.25
Low Level	102.50
Extreme Low Level	100.00

Summary Data Used For Minimum and Guidance Levels Development

Minimum and Guidance Levels were developed for King Lake (East) using the methodology for Category 3 lakes described in Chapter 40D-8, F.A.C. The levels and additional parameters are listed in Table 3, along with surface areas for each parameter elevation. Detailed descriptions of the development and use of these data are provided in subsequent sections of this report.

Table 3. Minimum and Guidance Levels, lake stage exceedance percentiles, Normal Pool, Control Point elevation, significant change standards and associated surface areas for King Lake (East).

Levels	Elevation (feet above NGVD)	Lake Area (acres)
Lake Stage Exceedance Percentiles		
Period of Record P10 (also Current P10)	104.0	640
Period of Record P50 (also Current P50)	102.2	413
Period of Record P90 (also Current P90)	97.8	246
Historic P10	105.7	731
Historic P50	103.3	600
Historic P90	101.4	328
Normal Pool and Control Point		
Normal Pool	102.9 ^a	547
Control Point	102.0	368
Significant Change Standards		
Dock-Use Standard	103.1	583
Species Richness Standard	102.7	523
Wetland Offset Elevation	102.5	481
Lake Mixing Standard	102.2	413
Aesthetics Standard	101.4	328
Recreation/Ski Standard	100.3	279
Basin Connectivity Standard	100.1	274
Cypress Standard	NA	NA
Guidance and Minimum Levels		
High Guidance Level	105.7	731
High Minimum Lake Level	105.1	703
Minimum Lake Level	102.7	523
Low Guidance Level	101.4	328

^a = Normal Pool elevation may be an underestimate; see text for additional information.

NA = Not applicable.

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations for King Lake (East) (District Universal Identification Number STA 141 141) are available from the District Water Management Data Base from November 1977 through the present, *i.e.*, through September 2007 (Figure 20, see Figure 3 for current location of the District water level gauge). The highest surface water elevation for the lake included in the database, 104.92 feet above NGVD, occurred on September 17, 1983. The low of record, 95.08 feet above NGVD, was recorded on July 23, 2001.

For the purpose of minimum levels determination, 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 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, hydrologic data collected prior to 1976 in the vicinity of King Lake (East) may be classified as Historic data, and data collected since that period may be classified as Current data. All available measured lake stage data for King Lake (East) were therefore classified as Current data and monthly mean values based on these data were used to calculate Current P10, P50, and P90 lake-stage percentile elevations. The Current P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the Current period, was 104.0 ft above NGVD. The Current P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the Current period, was 102.2 ft above NGVD. The Current P90 elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the Current period, was 97.8 ft above NGVD.

To approximate Historic water level fluctuations for King Lake (East), a Historic composite sixty-year record of monthly mean lake surface elevations was developed and used to calculate Historic lake stage exceedance percentiles. The 60-year period was considered sufficient for incorporating the range of lake-stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield *et al.* 2001, Basso and Schultz 2003, Kelly 2004).

Modeled monthly mean lake stage values for the composite data set were developed using a linear fitting procedure known as the line of organic correlation (see Helsel and Hirsch 1992). The procedure was used initially to describe the linear relationship between available monthly mean lake stage data for King Lake (East) and water surface elevations for the Upper Floridan Aquifer system, as measured at the State Road 577 Deep well site (District Universal Identification Number WEL 361 95; United States

Geological Survey Number 281715082164401), which is located about a quarter of a mile east of King Lake (East). Monthly mean lake stage data used for the analysis were derived from water surface elevations measured at the District lake gage site. An "initial" line of organic correlation equation was developed based on lake stage and well level data collected from November 1977 through December 2005, and was used to estimate monthly water surface elevations for King Lake (East) for the period from June 1964 through December 2005. A sixty-year composite data set of monthly mean water surface elevations (unpublished District data) was then developed for King Lake (East) using modeled estimates for the period from June 1964 through October 1977 and empirically derived monthly mean lake stage values for the period from November 1977 through December 2005.

The sixty-year composite data set was considered to be representative of expected water level fluctuations in King Lake (East) with structural alteration impacts similar to those that exist currently. However, because the data set included monthly mean lake water surface elevations for the period from January 1976 to the present, when water withdrawals were assumed to have impacted lake levels, the data were not considered to be a Historic data record.

The sixty-year composite water level data set was, however, appropriate for development of a Historic composite data set for the lake. The composite data were used to develop a second line of organic correlation equation for describing the relationship between monthly water surface elevations in the data set and regional rainfall, as measured at the St. Leo rainfall station (District Universal Identification Number RNF 306 306), a long-term rainfall gauging station located in Pasco County about 3.4 miles northeast of King Lake (East). Modeled lake stage data from the sixty-year composite data set that were used for the second regression analyses were from the period from June 1964 through December 1975 and were assumed to be representative of Historic conditions, *i.e.*, reflective of a period when there were no measurable impacts due to water withdrawals and impacts due to structural alterations were similar to existing conditions. Rainfall values used for the analysis consisted of weighted twenty-four month cumulative totals for the June 1964 through December 1975 period that were derived using a linear-decay series to weight monthly rainfall values for the twenty-four month periods. The line of organic correlation equation developed for the modeled lake stage and rainfall data was used to estimate water surface elevation values for King Lake (East) for the period from January 1946 through December 2005 (unpublished District data). A Historic, composite data set of monthly mean water surface elevations for King Lake (East) was then developed using the modeled water surface elevations derived from the initial and second regression analyses. The Historic composite data set included monthly mean water surface elevation estimates from the initial regression analysis for the period from June 1964 through December 1975, and water surface elevation estimates from the second regression analysis for the periods from January 1946 through May 1964 and January 1976 through December 2005 and for a few months in the 1964 through 1975 period when estimates were not available from the initial regression analysis (Figure 21).

Based on the Historic composite data set, the Historic P10 elevation, *i.e.*, the elevation the lake water surface equaled or exceeded ten percent of the time during the Historic period, was 105.7 feet above NGVD. The Historic P50, the water surface elevation that was equaled or exceeded fifty percent of the time during the Historic period, was 103.3 feet above NGVD. The Historic P90, the lake water surface elevation equaled or exceeded ninety percent of the time during the historic period, was 101.4 feet above NGVD. The Historic P10, P50 and P90 elevations are respectively 1.7, 1.1 and 3.6 feet higher than the corresponding lake stage exceedance percentiles based on the measured water level record.

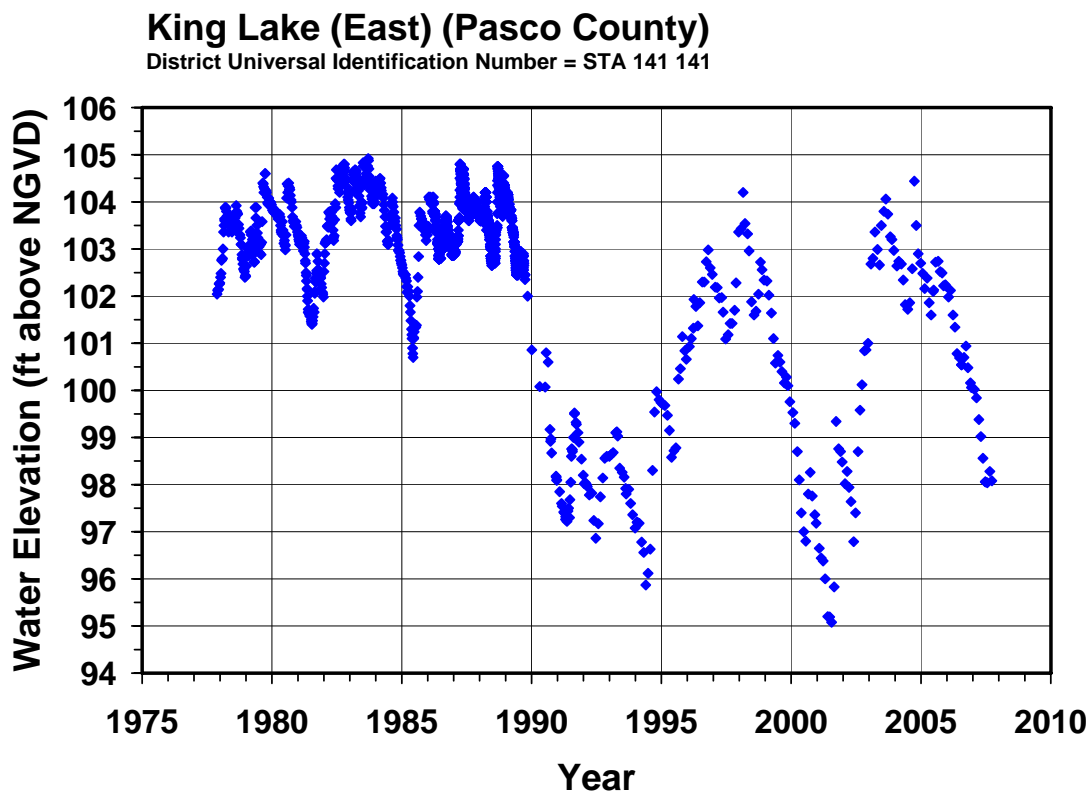


Figure 20. Measured water surface elevations in King Lake (East) through September 2007.

King Lake (East) (Pasco County)

District Universal Identification Number = STA 141 141

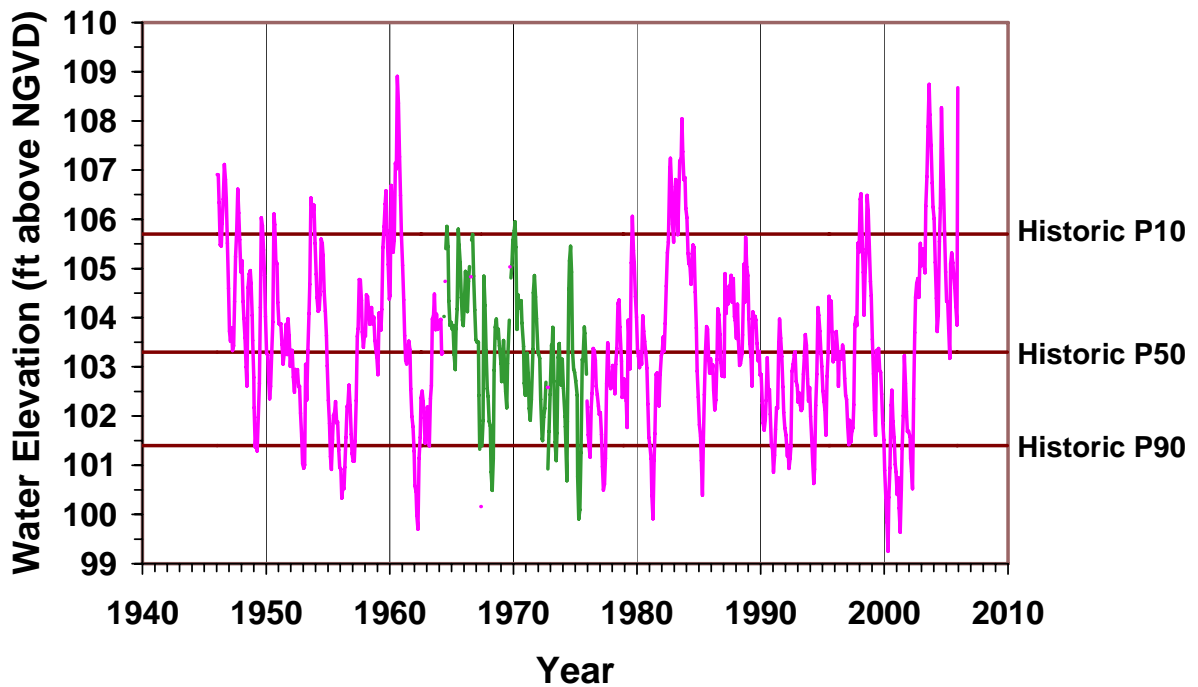


Figure 21. Historic composite monthly-mean water surface elevations for King Lake (East) from January 1946 through December 2005, and Historic lake stage exceedance percentiles. Composite data includes values based on a lake level – well level regression model (green) and a lake level – rainfall regression model (fuchsia).

Normal Pool, Control Point Elevation and Determination of Structural Alteration Status

The Normal Pool elevation, a reference elevation used for development of minimum lake and wetland levels, is established using elevations of Hydrologic Indicators of sustained inundation, including biological and physical features. For development of Minimum Lake Levels, the Normal pool elevation is considered an approximation of the Historic P10. Based on buttress inflection points measured on 8 cypress (*Taxodium* sp.) trees along the north and east shores of the lake, the Normal Pool elevation was established at 102.9 feet above NGVD (Figures 2 and 22, Table 4). It should be noted that the calculated Normal Pool elevation may not be representative of the Historic P10 elevation for the King Lake (East). Based on observed soil subsidence in the area where most of the hydrologic indicators were measured, the Normal Pool elevation may be expected to be higher than 102.9 feet above NGVD elevation.

For development of minimum and guidance levels, lakes are classified as open or closed basin lakes. Open basin lakes are systems that are connected to, or are part of an ordered surface water conveyance system, *i.e.*, they have outlets or inlets for conveyance of surface water. Closed basin lakes are those that are not part of an ordered conveyance system. Based on the existence of an outlet conveyance system that drains to the west, King Lake (East) was classified as an open basin lake.

The Control Point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.*, a weir, canal or culvert) that is the principal control of water level fluctuations in the lake. A Control Point may be established at the invert or crest elevation associated with a water control structure at a lake outlet, or at a high, stable point in a lake-outlet canal, ditch or wetland area. The invert or crest elevation is the lowest point on the portion of a water control structure that provides for conveyance of water across or through the structure. The Control Point elevation for King Lake (East) was established at 102.0 feet above NGVD, based on a recently completed survey of outlet conveyance systems located along the north and west shores of the lake (Southwest Florida Water Management District 2006). The Control Point was established at a high spot in the outlet ditch along the western lakeshore (see Figures 3 through 5).

Structural alteration status is determined to support development of the High Guidance Level. In addition to identification of outlet conveyance system modifications, comparison of the Control Point elevation with the Normal Pool is typically used to determine if a lake has been structurally altered. If the Control Point elevation is below the Normal Pool, the lake is classified as a structurally altered system. If the Control Point elevation is above the Normal Pool or the lake has no outlet, then the lake is not considered to be structurally altered. Based on the existence of the outlet ditch along the western lakeshore, and given that the Normal Pool elevation (102.9 feet above NGVD or possibly higher) is higher than the control point elevation (102.0 feet above NGVD), King Lake (East) was classified as a structurally altered lake.

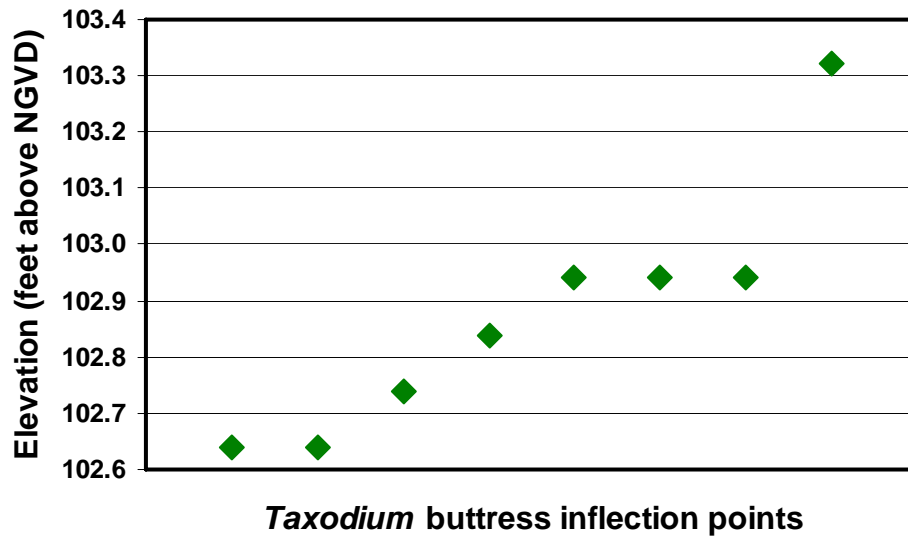


Figure 22. Elevations of cypress, *Taxodium* sp., buttress inflection points used to establish the Normal Pool elevation for King Lake (East).

Table 4. Summary statistics for hydrologic indicator measurements (elevation of the buttress inflection point of individual cypress, *Taxodium* sp., trees) used for establishing the Normal Pool Elevation for King Lake (East). Elevations were measured by District staff in July 2006.

Hydrologic Indicator	Statistic	Statistic Value (N) or Elevation (feet above NGVD)
Inflection point of cypress buttress	N	8
	Median	102.9
	Mean (SD)	102.9 (0.22)
	Minimum	102.6
	Maximum	103.3

Guidance Levels

The Ten Year Flood Guidance Level has historically been provided as advisory information for lakeshore development and is the level of flooding expected at a frequency of not less than the ten-year recurring interval, or at a frequency of not greater than a ten percent probability of occurrence in any given year. District rules (Chapter 40D-8, F.A.C.) previously included a Ten Year Flood Guidance Level of 105.49 feet above NGVD for King Lake (East) that was based on analyses conducted in the 1980s. Recent work completed in support of the District's Watershed Management Program has yielded a new, provisional ten-year recurrence flood stage for the lake. Results from the study, which involved floodplain analyses for the portion of the Cypress Creek basin in Pasco County, indicate a provisional ten-year flood level of 103.86 feet above the North American Vertical Datum of 1988 for King Lake (East) (Parsons 2007). This provisional flood level corresponds to an elevation of 104.69 feet above NGVD, based on use of a 0.83 foot datum-conversion factor. It should be noted that the Watershed Management Plan that includes the provisional flood elevation for King Lake (East) will be subjected to public review prior to finalization of the project results.

In October 2007, the District Governing Board approved rule amendments to remove all adopted Ten Year Flood Guidance Levels from Chapter 40D-8, F.A.C. The intent of this action was not to discontinue development of regional and site-specific flood stage information, but rather to promote organizational efficiency by eliminating unnecessary rules. Flood stage levels continue to be developed under the District's Watershed Management Program, but ten year flood recurrence levels are not incorporated into Chapter 40D-8, F.A.C. In accordance with this policy, Chapter 40D-8, F.A.C. does not currently include a Ten Year Flood Guidance Level for King Lake (East).

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 using Historic data if it is available, or is estimated using the Current P10, the Control Point and the Normal Pool elevation. Based on the availability of the composite Historic water level record for King Lake (East), the High Guidance Level was established at the Historic P10 elevation, 105.7 feet above NGVD.

The Low Guidance Level is provided as an advisory guideline for water dependent structures, and as 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. Reference lake water regime statistics are used when adequate historic or current data are not available. These statistics represent differences between P10, P50 and P90 lake stage elevations for typical, regional lakes that exhibit little or no impacts associated with water withdrawals (*i.e.*, reference lakes). Reference lake water regime statistics include the RLWR50, RLWR90 and RLWR5090, which are,

respectively, median differences between P10 and P50, P50 and P90, and P10 and P90 lake stage percentiles for a set of reference lakes. Based on the availability of the composite Historic water level record for King Lake (East), the Low Guidance Level was established at the Historic P90 elevation, 101.4 feet above NGVD.

Lake Classification

Lakes are classified as Category 1, 2 or 3 for the purpose of Minimum Levels development. Systems with fringing cypress wetlands greater than 0.5 acres in size where water levels regularly rise to an elevation expected to fully maintain the integrity of the wetlands (*i.e.*, the Historic P50 is not more than 1.8 feet below the Normal Pool elevation) are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 is more than 1.8 feet below the Normal Pool elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with less than 0.5 acres of fringing cypress wetlands are classified as Category 3 Lakes. Based on the limited extent of cypress-dominated wetlands within the lake-basin, King Lake (East) was classified as a Category 3 lake.

Significant Change Standards and Other Information for Consideration

Lake-specific significant change standards and other available information are developed for establishing Minimum Levels. 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, operationally referred to 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. Because King Lake (East) is a Category 3 Lake, a Cypress Standard was not developed for the basin.

For Category 3 lakes, six significant change standards, including a Dock-Use Standard, a Species Richness Standard, a Lake Mixing Standard, an Aesthetics Standard, a Recreation/Ski Standard, and a Basin Connectivity Standard are developed. These standards identify desired median lake stages that if achieved, are intended to preserve various natural system and human-use lake values.

The Dock-Use Standard is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the

elevation of lake sediments at the end of existing docks, a two-foot water depth for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Dock-Use Standard for King Lake (East) was established at 103.1 feet above NGVD, based on the elevation of sediments at the end of ninety percent of the 3 docks within the basin (99.2 feet above NGVD, Table 5), a two-foot water depth based on use of powerboats in the lake, and the 1.9 foot difference between the Historic P50 and Historic P90. Based on the Historic composite water level record, the Dock-Use Standard was equaled or exceeded fifty-eight percent of the time, *i.e.*, the standard elevation corresponds to the Historic P58.

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 fifteen percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. For King Lake (East), the Species Richness Standard was established at 102.7 feet above NGVD. Based on the Historic composite data record, the Species Richness Standard corresponds to the Historic P66, *i.e.*, was equaled or exceeded sixty-six percent of the time during the Historic period.

The Lake Mixing Standard is developed to prevent significant changes in patterns of 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 . Based on review of dynamic ratio values for lake stage elevations below the Historic P50 (Figure 23), a Lake Mixing Standard for King Lake (East) was established at 102.2 feet above NGVD. The standard was equaled or exceeded seventy-seven percent of the time during the Historic period defined by the Historic composite data record, *i.e.*, the standard corresponds to the Historic P77.

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 Aesthetic Standard is established at the Low Guidance Level, which for King Lake (East) occurs at an elevation of 101.4 feet above NGVD. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the Historic period defined by the Historic composite data set.

The Recreation/Ski Standard is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a 5-foot deep ski corridor delineated as a circular area with a radius of 418 feet, or a rectangular ski area 200 feet in width and 2,000 feet in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. For King Lake (East), the

Recreation-Ski Standard was established at 100.3 feet above NGVD, based on the sum of the Ski Elevation (98.4 feet above NGVD) and the 1.9 foot difference between the Historic P50 and Historic P90. The standard corresponds to the Historic P99, *i.e.*, it was equaled or exceeded ninety-nine percent of the time during the Historic period defined by the Historic composite data record.

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 use of the lake. 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 biota and/or watercraft across the critical high spot, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Basin Connectivity Standard for King Lake (East) was established at 100.1 feet above NGVD, based on the elevation that ensures connectivity between the two major lake sub-basins (96.2 feet above NGVD), a two-foot water depth in the area of connectivity to allow for movement of boats between the sub-basins, and the 1.9 foot difference between the Historic P50 and Historic P90 elevations. Based on the Historic composite data record, the Basin Connectivity Standard was equaled or exceeded ninety-nine percent of the time for the Historic period, *i.e.*, the standard elevation corresponds to the Historic P99.

Herbaceous Wetland Information is taken into consideration to determine the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e.*, basin area with a water depth of four or less feet). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values. Review of herbaceous wetland area in relation to change in lake stage indicated that use Lake Mixing, Aesthetics, Recreation/Ski and Basin Connectivity Standard elevations could be considered inappropriate for minimum levels development. At elevations associated with these standards, the potential wetland area within the basin would be decreased by fifty percent or more, relative to the potential wetland area available when the lake surface is at the Historic P50 elevation. Changes in the area available for aquatic plant colonization associated with changes in lake stage could not be evaluated for King Lake (East) due to the lack of available water transparency measurements.

Because herbaceous wetlands are common within the King Lake (East) basin, it was determined that an additional measure of wetland change should be considered for minimum levels development. Based on a recent review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was determined that up to an 0.8 foot decrease in the Historic P50 elevation would not likely be associated with significant changes in the herbaceous wetlands occurring within lake basins. A Wetland Offset elevation of 102.5 feet above NGVD was therefore established for King Lake (East) by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded seventy-one percent of the time

during the Historic period defined by the Historic composite data record, *i.e.*, the standard elevation corresponds to the Historic P71.

Table 5. Summary statistics and elevations associated with docks in King Lake (East), based on measurements made by District staff in July 2006. Percentiles (P10, P50 and 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	3	3
Mean (Standard Deviation)	98.2 (1.3)	104.0 (0.7)
P10	99.2	104.4
P50 or Median	98.0	104.3
P90	97.2	103.5
Maximum	96.9	103.2
Minimum	99.5	104.4

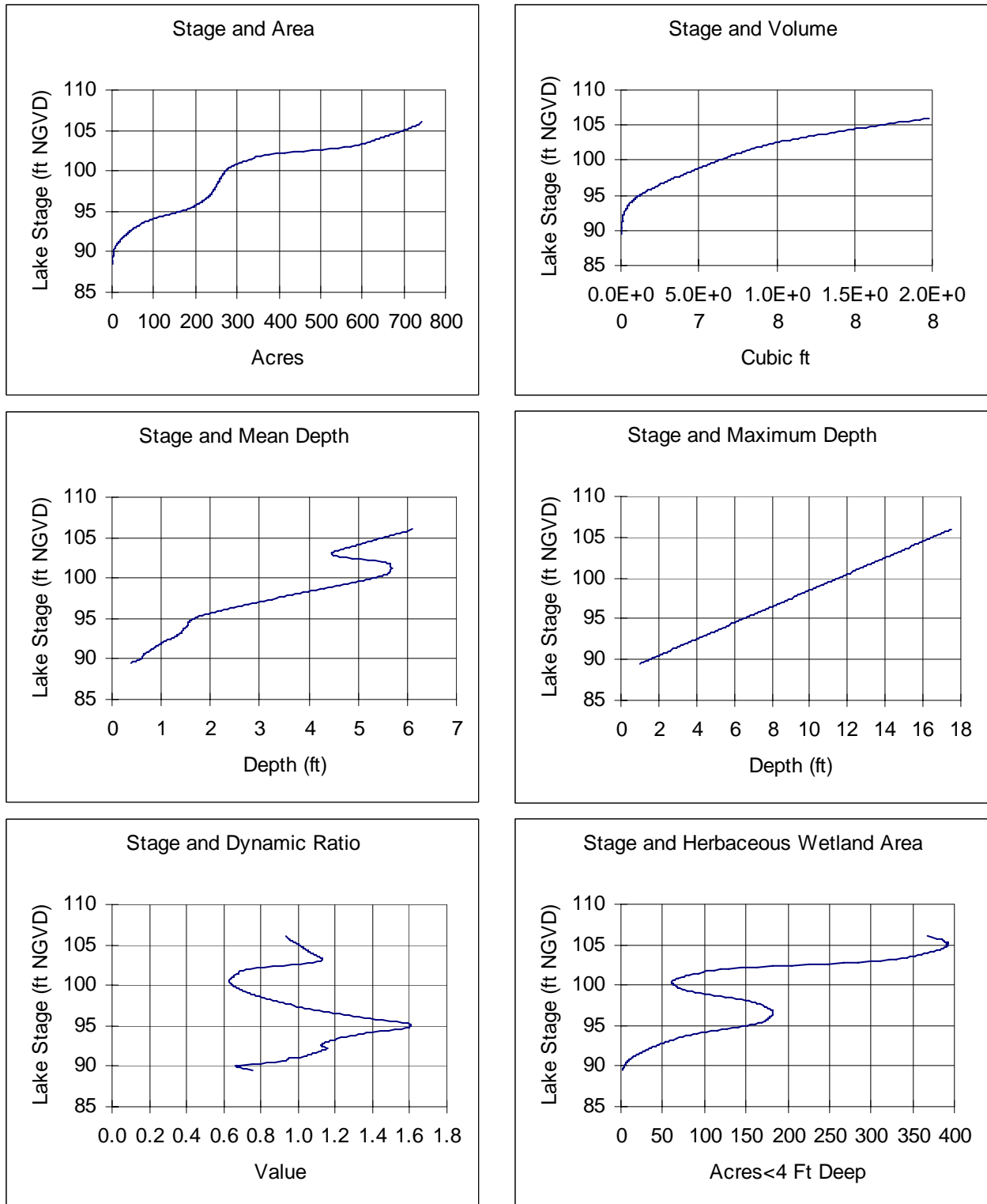


Figure 23. King Lake (East) surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.

Minimum Levels

Minimum Lake Levels, including the Minimum Lake Level and the High Minimum Lake Level, are developed using specific lake-category significant change standards and other available information or unique factors, 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 levels development is also contingent upon lake classification, *i.e.*, whether a lake is classified as a Category 1, 2 or 3 lake.

The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 lakes, the Minimum Level may be established at the elevation corresponding to the most conservative significant change standard, *i.e.*, the standard with the highest elevation, except where that elevation is above the Historic P50 elevation, in which case, the Minimum Level is established at the Historic P50 elevation. Because all of the significant change standards for King Lake (East) are lower than the Historic P50 elevation, the Minimum Level could be established at the Dock-Use Standard (103.1 feet above NGVD), the elevation of the highest significant change standard. Establishment of the Minimum Lake Level at the Dock-Use Standard was not, however, considered appropriate based on the limited number of docks ($n=3$) used to develop the standard.

The Minimum Lake Level was, instead, established at the elevation corresponding to the Species Richness Standard (102.7 feet above NGVD), the highest of the other available significant change standards. Because the Species Richness Standard is higher than the other available significant change standards and the Wetland Offset elevation, it may be expected to be protective of lake values represented by the other standards, as well as the herbaceous wetlands within the basin. The 0.6-foot decrease in the median lake stage associated with use of the Species Richness Standard for development of the Minimum Lake Level (the standard elevation is 0.6 feet lower than the Historic P50) would also not be expected to significantly impact values associated with the Dock-Use Standard. Assuming a 0.6 foot reduction in water levels over the range of lake levels in the Historic composite water level record, the amount of time that the lake surface would have equaled or exceeded the Dock-Use Standard would have been decreased to forty-two percent of the time, as compared to the fifty-eight percent of the time the standard would have been equaled or exceeded based on the unmodified Historic composite record.

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 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. If Historic Data are available, the High Minimum

Lake Level is established at an elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level is set at an elevation corresponding to the Minimum Lake Level plus the region-specific RLWR50. Based on the availability of the Historic composite water level record, the High Minimum Lake Level for King Lake (East) was established at 105.1 feet above NGVD, by adding the 2.4 foot difference between the Historic P50 and Historic P10 elevations to the Minimum Lake Level.

The Minimum and Guidance levels for King Lake (East) are shown in Figure 24 along with monthly mean water surface elevations based on period of record water level measurements. Staging of the lake at the Minimum Levels may be expected to flood some man-made features within the immediate lake basin (see Figure 25 for the approximate lake margins when the water surface is at the Minimum Levels). The High Minimum Lake Level is approximately 2.4 feet higher than a low spot on the lime-rock road located west of the lake and is also 2.4 feet higher than a private driveway in the same area (Table 6). It should also be noted that based on measured lake stage values collected since 1977, the lake has exceeded the elevation of these features forty-two percent of the time. It should also be noted that the High Minimum Lake Level is 0.6 feet lower than the Historic P10 derived for the lake based on the composite, Historic water level record. The High Minimum Lake Level is also approximately 1.6 feet lower than the lowest residential building along the lakeshore.

Table 6. Elevations of selected man-made features occurring at relatively low elevations within the immediate King Lake (East) basin, based on measurements collected by District staff in 2006 (Southwest Florida Water Management District 2006 and unpublished District data).

Lake Basin Features	Elevation (feet above NGVD)
Low floor slab – residential building	106.69
Low spot on the lime-rock road north of the lake	105.4
Top of two private concrete boat ramps	103.4 and 104.3
Top of three dock platforms	103.2 – 104.4
Low spot on the lime-rock road west of the lake	102.7
Low spot on a dirt driveway at a residence along the western lakeshore	102.7

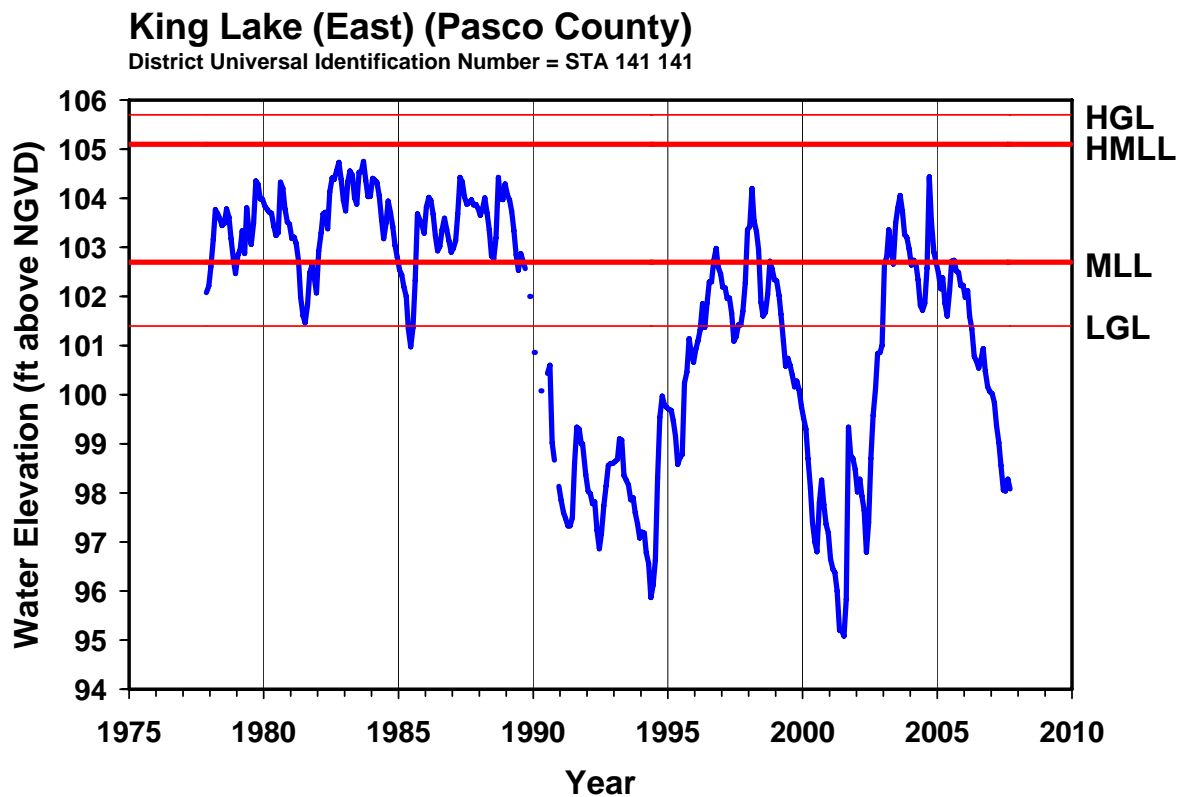
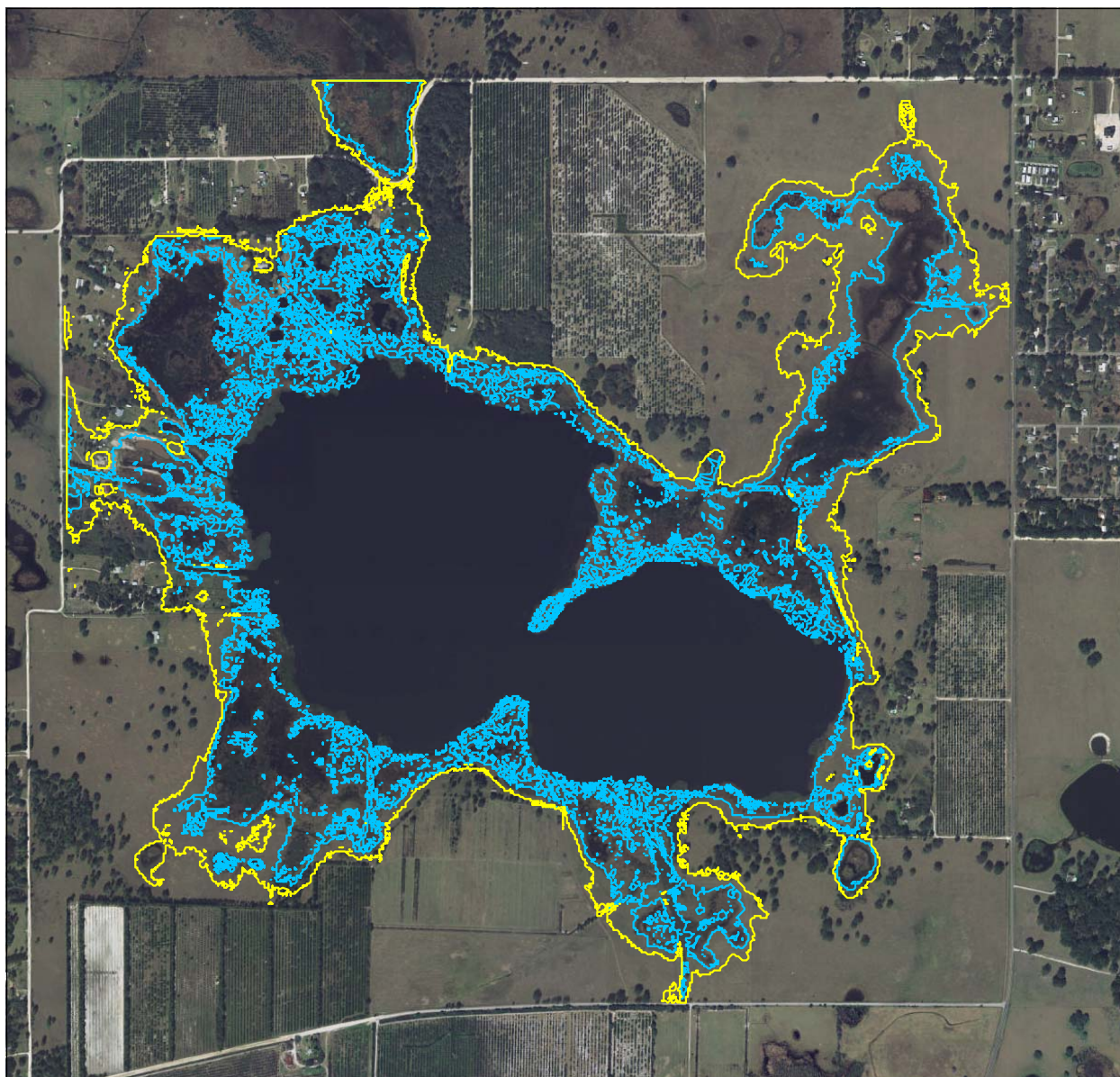
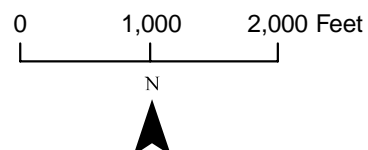


Figure 24. Mean monthly water surface elevations (blue line) in King Lake (East) through September 2007 based on measured lake stage records, and adopted Guidance and Minimum Levels (red lines). Adopted levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL) and Low Guidance Level (LGL).



Minimum Levels

- MLL = 102.7 ft above NGVD
- HMLL = 105.1 ft above NGVD



Map created using spot elevation data collected by D.C. Johnson Associates in May 2005 and LiDAR data collected by EarthData International, Inc. in 2004.

Figure 25. Approximate location of the Minimum Lake Level and High Minimum Lake Level for King Lake (East) (photographic image source: 3001, Inc. 2006).

Documents Cited and Reviewed for Development of Minimum and Guidance Levels for King Lake

3001, Inc. 2006. 2006 one foot natural color orthophotographs – Pasco County. Gainesville, Florida. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Bachmann, R. W., Hoyer, M. V., and Canfield, D. E., Jr. 2000. The potential for wave disturbance in shallow Florida lakes. *Lake and Reservoir Management* 16: 281-291.

Basso, R. and Schultz, R. 2003. Long-term variation in rainfall and its effect on Peace River flow in west-central Florida. Southwest Florida Water Management District. Brooksville, Florida.

Bedient, P., Brinson, M., Dierberg, F., Gorelick, S., Jenkins, K., Ross, D., Wagner, K., and Stephenson, D. 1999. Report of the Scientific Peer Review Panel on the data, theories, and methodologies supporting the Minimum Flows and Levels Rule for northern Tampa Bay Area, Florida. Prepared for the Southwest Florida Water Management District, the Environmental Confederation of Southwest Florida, Hillsborough County, and Tampa Bay Water. Published by the Southwest Florida Water Management District. Brooksville, Florida.

Berryman & Henigar, Inc., SDI Environmental Services, Inc., Ormiston, B.G., HDR Engineering, Inc., Greeley and Hansen, Inc., Legette, Brashears, & Graham, Inc., and Reynolds, Smith, & Hills, Inc. 2001. Phase I mitigation plan, Volumes 1, 2 and 3. Prepared for Tampa Bay Water. Clearwater, Florida.

Bishop, E. W. 1967. Florida lakes, part I: a study of the high water lines of some Florida lakes. Florida Board of Conservation, Division of Water Resources. Tallahassee, Florida.

Brooks, H. K. 1981. Physiographic divisions of Florida: map and guide. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Gainesville, Florida.

Comp, G.S. 1982. Technical memorandum-82-8, dated November 8, 1982, to R.G. Perry. Re: Cypress Creek Wellfield CUP #3650 lake level analysis. Southwest Florida Water Management District. Brooksville, Florida.

D.C. Johnson Associates. 2005. Surveyor's report: bathymetric survey – MFL_06-Pasco-Polk. San Antonio, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

DeWitt, O. 1984. Memorandum to William D. Courser, dated December 4, 1984, regarding: King Lake East, G.B. Epperson letter of November 23, 1984. Southwest Florida Water Management District. Brooksville, Florida.

DeWitt, O. 1985. Letter to Mr. George B. Epperson, dated January 5, 1985, regarding: King Lake @ San Antonio, Pasco County. Southwest Florida Water Management District. Brooksville, Florida.

Dierberg, F. E. and Wagner, K. J. 2001. A review of "A multiple-parameter approach for establishing minimum levels for Category 3 Lakes of the Southwest Florida Water Management District" June 2001 draft by D. Leeper, M. Kelly, A. Munson, and R. Gant. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

EarthData International, Inc. 2004a. LiDAR topographic data collected to support of Federal Emergency Management Agency Map Modernization for Pasco County, Florida. Available from the Mapping and GIS Section of the Southwest Florida Water Management District. Brooksville, Florida.

EarthData International. 2004b. 2004 digital orthophotographs natural color. Published by the United States Geological Survey. Reston, Virginia. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Enfield, D.B., Mestas-Nunez, A.M., and Trimble, P.J. 2001. The Atlantic multidecadal oscillation and its relation to rainfall and river flow in the continental U.S. *Geophysical Research Letters* 28: 2077-2080.

Epperson, G.B. 1984. Letter to the Southwest Florida Water Management District, dated November 23, 1984. Available from the Southwest Florida Water Management District Ecologic Evaluation Section. Brooksville, Florida.

Florida Board of Conservation. 1969. Florida lakes, part III: gazetteer. Division of Water Resources. Tallahassee, Florida.

Florida Lakewatch. 2004. Florida Lakewatch water chemistry summaries 2004, Volume 2. Department of Fisheries and Aquatic Sciences, Institute of Food and Agricultural Sciences, University of Florida. Gainesville, Florida.

Foose, D.W. 1981. Drainage areas of selected surface-water sites in Florida. Open-File Report 81-482. United States Department of the Interior, United States Geological Survey. Tallahassee, Florida.

Gant, R. 1999a. Memorandum to Mario Cabana, John Parker, Brian Starford and Scott Laidlow dated August 18, 1999. Subject: 1999 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 1999b. Memorandum to Mario Cabana, John Parker, Brian Starford and Scott Laidlow dated September 13, 1999. Subject: historical list of stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2000. Memorandum to Mario Cabana, John Parker, Brian Starford and Scott Laidlow dated August 18, 2000. Subject: 2000 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2002. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 18, 2002. Subject: 2002 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2003. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 30, 2003. Subject: 2003 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2004. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 29, 2004. Subject: 2004 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2005. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 31, 2005. Subject: 2005 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2006. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 27, 2006. Subject: 2006 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Gant, R. 2007. Memorandum to Ralph Kerr, John Parker, Michael Balser and Scott Laidlow dated January 23, 2007. Subject: 2007 stressed lakes. Southwest Florida Water Management District. Brooksville, Florida.

Griffith, G., Canfield, D., Jr., Horsburgh, C., Omernik, and J. Azevedo, S. 1997. Lake regions of Florida (map). United States Environmental Protection Agency, University of Florida Institute of Food and Agricultural Sciences, Florida Lakewatch, Florida Department of Environmental Protection, and the Florida Lake Management Society. Gainesville and Tallahassee, Florida.

Hancock, M. 2006. Draft memorandum to file, dated April 24, 2006. Subject: a proposed interim method for determining minimum levels in isolated wetlands. Southwest Florida Water Management District. Brooksville, Florida.

Helsel, D.R. and Hirsch, R.M. 1992. Statistical methods in water resources. Studies in Environmental Science 45. Elsevier. New York, New York.

Hogg, R. W. 2008. Letter to Dr. Martin Kelly, dated January 15, 2008. Regarding: proposed minimum level for King Lake (East). Tampa Bay Water. Clearwater, Florida.

Kelly, M. 2004. Florida river flow patterns and the Atlantic Multidecadal Oscillation. Southwest Florida Water Management District. Brooksville, Florida.

Leeper, D. 2006. Proposed methodological revisions regarding consideration of structural alterations for establishing Category 3 Lake minimum levels in the Southwest Florida Water Management District, April 21, 2006 peer-review draft. Southwest Florida Water Management District. Brooksville, Florida.

Leeper, D., Kelly, M., Munson, A. and Gant, R. 2001. A multiple-parameter approach for establishing minimum levels for Category 3 Lakes of the Southwest Florida Water Management District, June 14, 2001 draft. Southwest Florida Water Management District. Brooksville, Florida.

Malloy, R. L. 2005. E-mail dated December 27, 2005. Subject: request for info on OHWL or SUL for selected lakes. Florida Department of Environmental Protection, Bureau of Surveying and Mapping. Tallahassee, Florida.

Parsons. 2007. Cypress Creek/South Lakes Watershed (K938-13). Volume II floodplain analysis report SWFWMD Agreement No. 04CONC000154, May 2007. Tampa, Florida. Prepared for Southwest Florida Water Management District. Brooksville, Florida.

Richters, D.F. 1986. Memorandum to O. R. DeWitt, dated March 20, 1986, regarding King Lake, Section 22, Township 25, Range 20, Pasco County. Southwest Florida Water Management District. Brooksville, Florida.

Romie, K. 2000. Water chemistry of lakes in the Southwest Florida Water Management District. Brooksville, Florida.

Shafer, M. D., Dickinson, R. E., Heaney, J. P., and Huber, W. C. 1986. Gazetteer of Florida lakes. Publication No. 96, Water Resources Research Center, University of Florida. Gainesville, Florida.

Southwest Florida Water Management District. Date unknown. 1994 digital orthophotographs color infrared. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 1984a. Hillsborough River Basin, Wesley Chapel aerial photography with contours, Sheet No. 22-25-20. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation. St. Petersburg, Florida. Southwest Florida Water Management District. 1984b. Hillsborough River Basin, Wesley Chapel aerial photography with contours, Sheet No. 23-25-20. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation. St. Petersburg, Florida.

Southwest Florida Water Management District. 1984c. Hillsborough River Basin, Wesley Chapel aerial photography with contours, Sheet No. 26-25-20. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation. St. Petersburg, Florida.

Southwest Florida Water Management District. 1984d. Hillsborough River Basin, Wesley Chapel aerial photography with contours, Sheet No. 27-25-20. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation. St. Petersburg, Florida.

Southwest Florida Water Management District. 1992. Flood-stage frequency relations for selected lakes in the Southwest Florida Water Management District. September 1991, updated November 1992. Brooksville, Florida.

Southwest Florida Water Management District. 1996a. Lake Levels Program lake data sheets / 1977-1996: Hillsborough River Basin – 13. Brooksville, Florida.

Southwest Florida Water Management District. 1996b. Northern Tampa Bay Water Resource Assessment Project volume one: surface-water /ground-water interrelationships. Brooksville, Florida.

Southwest Florida Water Management District. 1999a. Establishment of minimum levels for Category 1 and Category 2 lakes, *in* Northern Tampa Bay minimum flows and levels white papers: white papers supporting the establishment of minimum flows and levels for isolated cypress wetlands, Category 1 and 2 lakes, seawater intrusion , environmental aquifer levels and Tampa Bypass canal, peer-review final draft, March 19, 1999. Brooksville, Florida.

Southwest Florida Water Management District. 1999b. Establishment of minimum levels in palustrine cypress wetlands, *in* Northern Tampa Bay minimum flows and levels white papers: white papers supporting the establishment of minimum flows and levels for isolated cypress wetlands, Category 1 and 2 lakes, seawater intrusion , environmental aquifer levels and Tampa Bypass canal, peer-review final draft, March 19, 1999. Brooksville, Florida.

Southwest Florida Water Management District. 2002a. 1999 digital orthophotographs color infrared. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2002b. United States Geological Surveys 1:24,000 scale topographic map (DRG). Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2003a. 1:24,000 detailed roads. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2003b. 2002 satellite imagery, natural color. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2003c. Florida counties. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2003d. Generalized streams and rivers. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Southwest Florida Water Management District. 2006. Surveyor's report: lake level data for establishment of minimum flows and levels – King Lake East – Pasco County, Florida. Brooksville, Florida.

Southwest Florida Water Management District. 2007a. Proposed minimum and guidance levels for King Lake (East) in Pasco County, Florida, October 19, 2007 draft. Ecologic Evaluation Section. Brooksville, Florida.

Southwest Florida Water Management District. 2007b. WUPPNT. File is updated daily and is available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

United States Department of Agriculture. 1941a. Aerial photograph number CTT-4B-67, dated January 29, 1941. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1941b. Aerial photograph number CTT-11B-4, dated May 3, 1941. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1941c. Aerial photograph number CTT-11B-19, dated May 3, 1941. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1951a. Aerial photograph number CTT-5H-37, dated May 28, 1951. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1951b. Aerial photograph number CTT-6H-215, dated December 12, 1951. Washington, D.C. Available on-line at the Aerial

Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1957a. Aerial photograph number CTT-2T-36, dated March 27, 1957. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1957b. Aerial photograph number CTT-2T-38, dated March 27, 1957. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1957c. Aerial photograph number CTT-2T-39, dated March 27, 1957. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Department of Agriculture. 1957d. Aerial photograph number CTT-3T-124, dated March 27, 1957. Washington, D.C. Available on-line at the Aerial Photography: Florida web site (www.uflib.ufl.edu/digital/collections/FLAP) maintained by the University of Florida. Gainesville, Florida.

United States Geological Survey. 1954. San Antonio quadrangle, Florida – Pasco Co., 7.5 minute series (topographic) map; San Antonio, Fla., N2815-W8215/7.5, 1954, AMS 4540 IV SE-Series V847. United States Department of the Interior Geological Survey. Washington, D.C.

United States Geological Survey. 1988. San Antonio Lake quadrangle, Florida – Pasco Co., 7.5 minute series (topographic) map; San Antonio, Fla., 28082-C3-TF-024, 1954, photorevised 1988, DMA 4540 IV SE-Series V847. United States Department of the Interior Geological Survey. Washington, D.C.

United States Geological Survey. 2004a. 1984 National high altitude photography (NHAP). Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

United States Geological Survey. 2004b. National hydrography dataset – water bodies and swamps.. United States Department of the Interior Geological Survey. Washington, D.C. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Wagner, K. and Dierberg, F. 2006. A review of "Proposed methodological revisions regarding consideration of structural alterations for establishing Category 3 Lake minimum levels in the Southwest Florida Water Management District" by D. Leeper,

2006. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

White, W. A. 1970. The geomorphology of the Florida peninsula. Geological Bulletin, No. 51. Bureau of Geology, Florida Department of Natural Resources. Tallahassee, Florida.

Wiatrowski, K. 2008. Swiftmud sets rules for lake levels. Published in the January 9, 2008 edition of the Pasco Tribune – Tampa Tribune. Tampa, Florida.

Woolpert, Inc. 2005a. 1970's black and white aerial photography. Englewood, Colorado. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.

Woolpert, Inc. 2005b. 2005 one foot natural color ortho photographs – west Pasco County. Winter Park, Florida. Available from the Southwest Florida Water Management District Mapping and GIS Section. Brooksville, Florida.