Minimum and Guidance Levels
For Lake Kell in Hillsborough County, Florida

August 27, 2014

Resource Evaluation Section
Water Resources Bureau
Southwest Florida
Water Management District

Minimum and Guidance Levels For Lake Kell in Hillsborough County, Florida

August 27, 2014

Resource Evaluation Section
Water Resources Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604-6899

David Carr, Keith Kolasa, Don Ellison,
Ron Basso and Jason Patterson

Cover Page: A comparison of 2012 and 1938 aerial photographs of Lake Kell. The 2012 imagery was collected on August 2, 2012 by the District. The 1938 imagery was collected on November 21, 1938 by the United States Department of Agriculture, Soil Conservation Service.

Table of Contents

Minimum and Guidance Levels

Section 373.042, Florida Statutes (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. Section 373.042(1)(a), F.S., states that 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". Section 373.042(1)(b), F.S., defines the minimum level of an aquifer or surface water body as "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 (SWFWMD) 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.

Established Minimum Flows and Levels are key components in supporting resource protection, recovery and regulatory compliance, as Section 373.0421(2), F.S., requires the 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." Section 373.0421(2)(a), F.S., requires that recovery or prevention strategies be 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 required by Section 373.0421(3), F.S.

Minimum Flows and Levels are to be established based upon the best information available, and when appropriate, may be calculated to reflect seasonal variations (Section 373.042(1), F. S.). Also, establishment of Minimum Flows and Levels is to involve consideration of, and at the governing board or department's discretion, may provide for the protection of nonconsumptive uses (Section 373.042(1), F. S.). Consideration must also be 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 requirement that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421(1)(a), F. S.). Sections 373.042 and 373.0421 provide additional information regarding the prioritization and scheduling of Minimum Flows and Levels, the independent scientific review of scientific or technical data, methodologies, models and scientific and technical assumptions employed in each model used to establish a minimum flow or level, and exclusions that may be considered when setting identifying the need for establishment of Minimum Flows and Levels.

The Florida Water Resource Implementation Rule, specifically Rule 62-40.473, Florida Administrative Code (F. A. C.), provides additional guidance for the establishment of Minimum Flows and Levels, requiring that "…consideration shall be given to natural

seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic and wetlands 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."

Rule 62-40.473, F. S., 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 as provided in Section 373.042(1), F.S." It further notes that, "…a minimum flow or level need not be expressed as multiple flows or levels if other resource protection tools, such as reservations implemented to protect fish and wildlife or public health and safety, that provide equivalent or greater protection of the hydrologic regime of the water body, are developed and adopted in coordination with the minimum flow or level." The rule also includes provision addressing: protection of minimum flows and levels during the construction and operation of water resource projects; the issuance of permits pursuant to Section 373.086 and Parts II and IV of Chapter 373, F.S.; water shortage declarations; development of recovery or prevention strategies, development and updates to a minimum flow and level priority list and schedule, and peer review for Minimum Flows and Levels establishment.

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 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. Rule 40D-8.624, F.A.C., provides for the establishment of Guidance Levels, which serve as advisory information for the District, lakeshore residents and local governments, and 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 (1999), Leeper et al. (2001) and Leeper (2006). Peer-review findings regarding the lake level methods are available in Bedient et al. (1999), Dierberg and Wagner (2001) and Wagner and Dierberg (2006).

Two Minimum Levels and two Guidance Levels have typically been established for lakes, and upon adoption by the District Governing Board, incorporated into Rule 40D-8.624, F.A.C. The levels, which are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD), are described below.

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

- The **High Minimum Lake Level** is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis.

- The **Minimum Lake Level** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis.

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

In accordance with Chapter 40D-8, F.A.C., Minimum and Guidance Levels were developed for Lake Kell (Table 1), a Category 1 lake located in Hillsborough County, Florida. The levels were established using best available information, including field data that were obtained specifically for the purpose of Minimum Levels development. The data and analyses used for development of the levels are described in the remainder of this report. Following a public input process, District staff anticipates recommending that the Governing Board approve incorporation of the levels into Rule 40D-8.624, F.A.C., to replace previously adopted Guidance Levels.

All elevation data values shown within this report on graphs, bathymetric maps, and within tables are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (ft. NGVD). In some circumstances, notations are made for data that was collected as North American Vertical Datum of 1988 (NAVD 88) (also as feet) and converted to ft. NGVD. All datum conversions were derived using Corpscon 6.0, software developed by the United States Army Corps of Engineers. In this report all references to elevations will be abbreviated as ft. NGVD.

Table 1. Minimum and Guidance Levels for Lake Kell.

Minimum and Guidance Levels	Elevation in Feet NGVD 29
High Guidance Level	66.4
High Minimum Lake Level	65.6
Minimum Lake Level	64.2
Low Guidance Level	63.2

Data and Analyses Supporting Development of Minimum and Guidance Levels

Lake Setting and Description

Lake Kell is located in Hillsborough County, Florida (Section/Township/Range 13&24/22/17) (Figure 1). White (1970) classified the physiographic area as the Northern Gulf Coastal Lowlands bordered to the east by the Western Valley (Figure 2). As part of the Florida Department of Environmental Protection's Lake Bioassessment Regionalization Initiative and SWFWMD's water quality sampling program, Kell Lake is within the Southwestern Florida Flatwoods region and the Land O' Lakes region respectively (Griffith *et al.* 1997 and Romie, 2000). Each of these regions was described as having mostly low total suspended solids, clear water, circumneutral-pH lakes that have moderately low alkalinity and nutrients.

Lake Kell was estimated to be 31 acres at its top elevation of 65 ft. by Florida Board of Conservation, 1969 and 34 acres at 66 ft. by SWFWMD, 2005. The Lake Kell watershed was estimated at 1,920 acres (Johnson and Young, 1973) and is part of a larger 8,256 acre Hanna Outlet System (FDEP, 2004) (Figure 3). By the early 1980's, the land around the lake changed from entirely citrus groves to fallow groves and the first signs of residential development. The land surrounding Lake Kell is currently dominated by residential homes. Only a small portion of land around the lake has remained crop & pasture land (old groves) (SWFWMD, 2009) (Figure 4). The soils surrounding the lake are Basinger, Holopaw, and Samsula depressional soils, Myakka fine sand, and Zolfo fine sand (Hyde et al. 1977). There is no public access to Lake Kell.

Lake Kell is located in the Cypress Creek Watershed which lies within the larger Hillsborough River watershed. Water flows south out of the lake through a narrow cypress wetland into Little Lake Kell, where it discharges through a water conservation structure at the south end of Little Lake Kell (Figures 4 & 5). There are no surface water withdrawals from the lake. Figure 6 shows permitted groundwater withdrawal wells within a one, two, and three mile radii of the lake. Monthly average water use from 1992 to 2011 was generally less than 2 million gallons per day (mgd) within a three mile radius of the lake and experienced a general downtrend since 2002 averaging near 1 mgd.

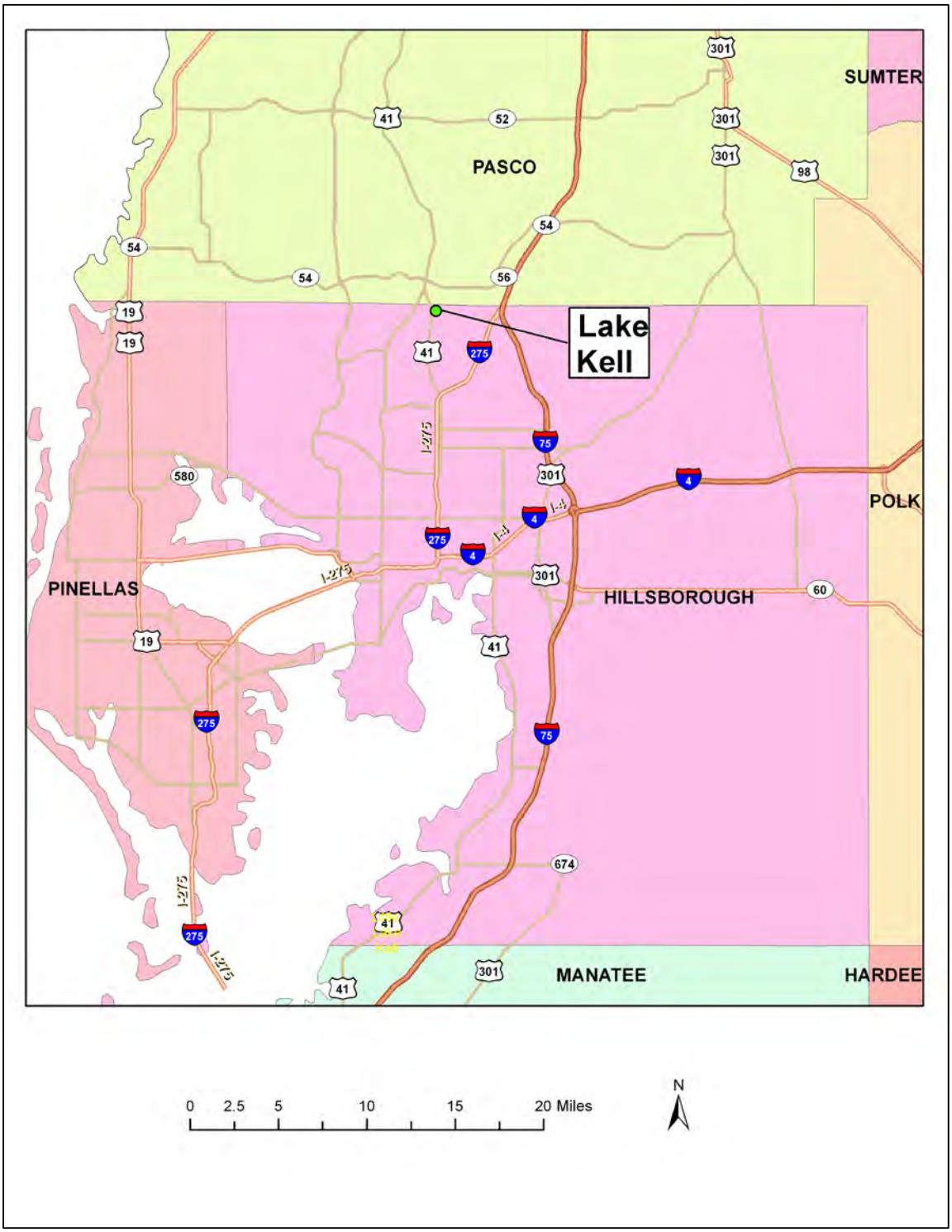

Figure 1. Location of Lake Kell in Hillsborough County, Florida.

Figure 2. Physiographic regions of the Lake Kell area.

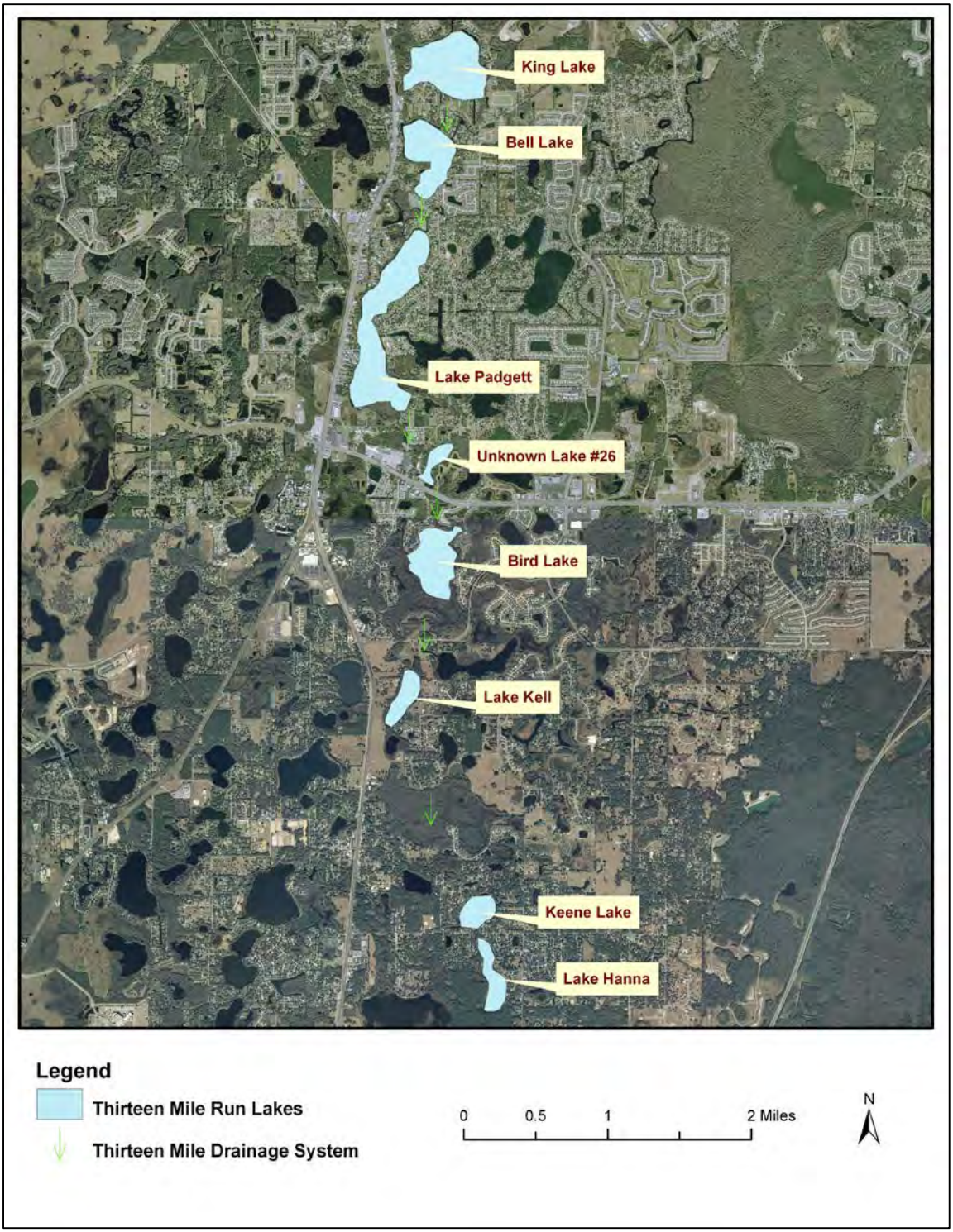

Figure 3. Thirteen Mile Run Lakes and Drainage Systems. Drainage system includes culverts, canals, swales and water control structures.

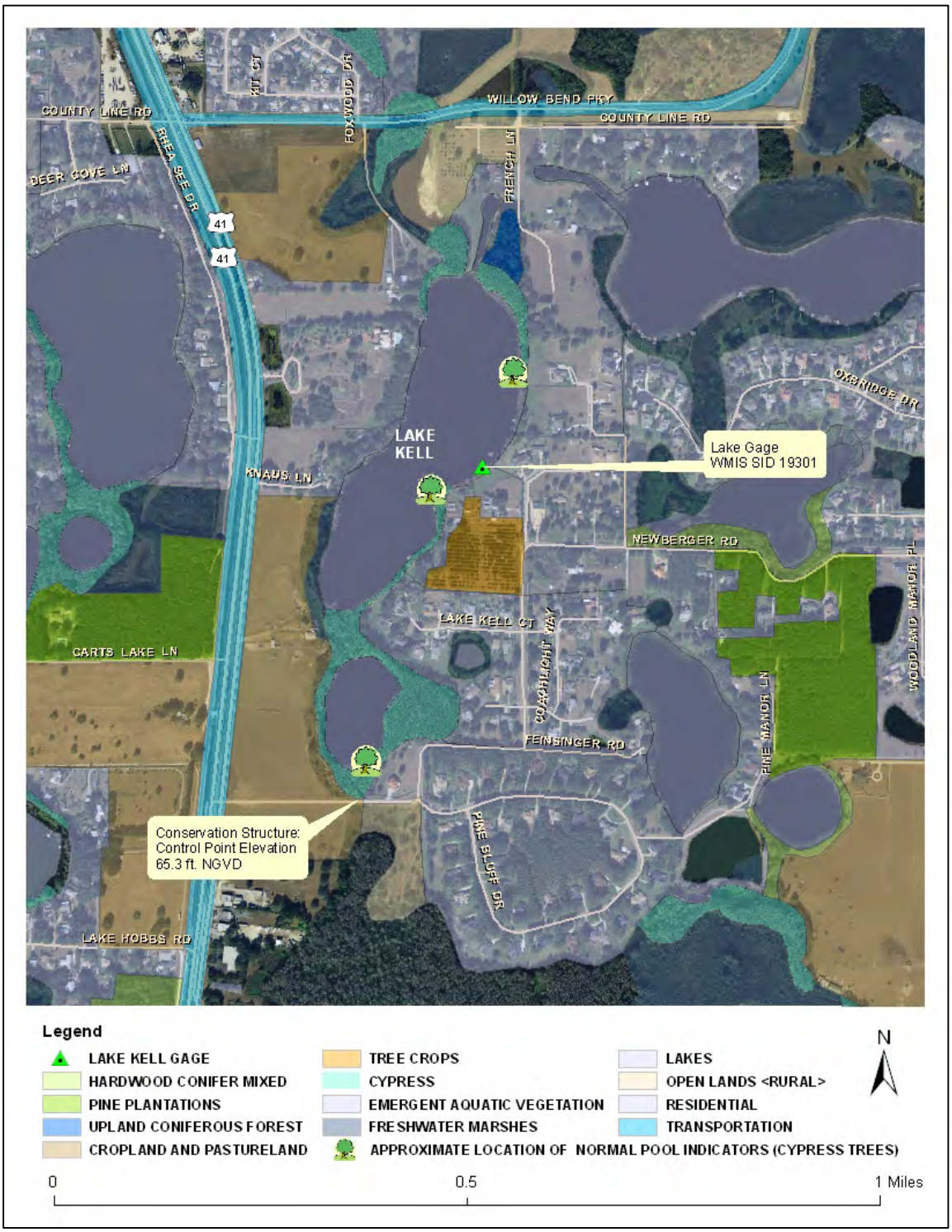

Figure 4. Florida Land Use and Cover Classification features in proximity to Lake Kell. Water level gages are located on the east side of the lake and upstream of the conservation structure at Newberger Road.

Figure 5. Conservation structure at Newberger Road.

Currently Adopted Minimum and Guidance Levels

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

Based on work conducted in the 1970s the District Governing Board adopted management levels (currently referred to as Guidance Levels) for Lake Kell in September 1980 (Table 2). A Maximum Desirable Level of 65.50 NGVD was also developed, but was not adopted by the Governing Board. The adopted Guidance Levels and Maximum Desirable Level were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels. The levels do not, therefore, necessarily correspond with levels developed using current methods. Minimum and Guidance Levels developed using current methods will replace existing Guidance Levels upon adoption by the District Governing Board into Chapter 40D-8, F. A. C. One of the management levels, a Ten Year Flood Guidance Level of 67.30 NGVD, was removed from Chapter 40D-8 in 2007, when the District Governing

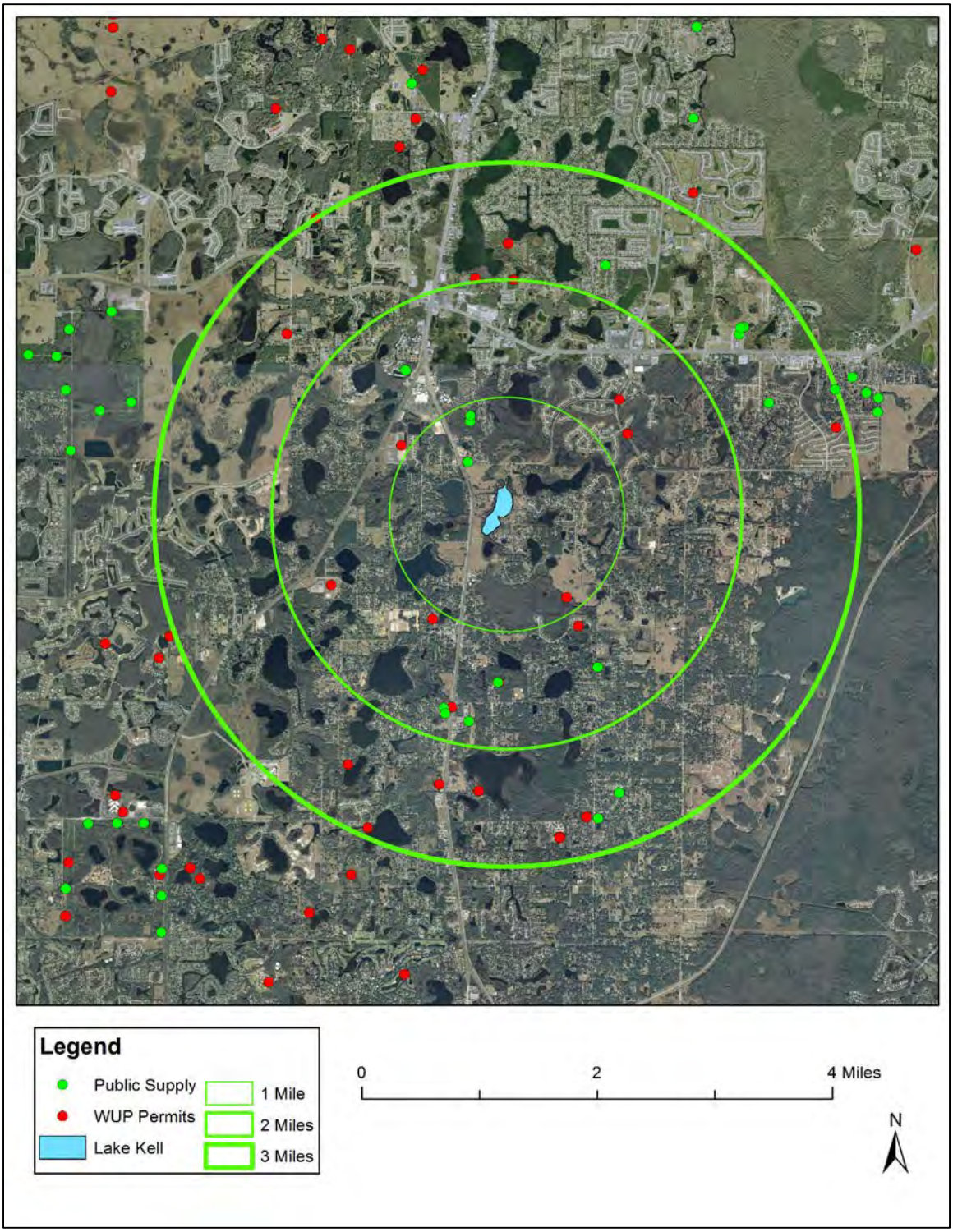

Figure 6. Public supply and water use permit withdrawal wells within a one, two, and three mile radius of Lake Kell.

Board determined that flood-stage elevations should not be included in the District's Water Levels and Rates of Flow rules.

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

Guidance Levels	Elevation in Feet NGVD 29
High Level	66.0
Low Level	63.5
Extreme Low Level	62.5

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program as referenced in the District's Water Use Permit (WUP) Handbook (Part B) dated May 19, 2014. This reference defines a stressed condition for a lake" as "chronic fluctuation below the normal range of lake level fluctuations". For lakes with District-established management levels, a stressed condition is a chronic fluctuation below the Minimum Low Management Level. A stressed condition is based on continuous monthly data for the most recent five-year period, with the latest readings being within the past 12 months, and two-thirds of the values are at or below the adopted Minimum Low Management Level. For those lakes without established management levels, stressed conditions shall be determined on a case-by-case basis through site investigation by District staff during the permit evaluation process. Lake Kell has never been on the stressed lakes list.

Summary Data Used for Development of Minimum and Guidance Levels

Minimum and Guidance Levels for Lake Kell were developed using the methodology for Category 1 Lakes described in Rule 40D-8.624, F.A.C. Additional information are listed in Table 3, along with lake surface areas for each level or feature/standard elevation. Detailed descriptions of the development and use of these data are provided in the subsequent sections of this report.

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.,* surface water elevations for Lake Kell relative to NGVD 29 were obtained from the District's Water Management Information System (WMIS) database (site identification number 19301). The period of record (POR) for this data are available from June 1971 to present. However, the Lake stage data used in this report were from June 1971 to March 2012 to reflect the data predicted by the rainfall model. See Figure 4 for the current location of the SWFWMD lake water level gage. Lake stage data for the POR were collected daily, bi-weekly, and monthly and graphed in Figure 7.

Table 3. Lake Stage Percentiles, Normal Pool and Control Point Elevations, and Significant Change Standards, Minimum and Guidance Levels associated surface areas for Lake Kell.

Levels	Elevation in Feet NGVD 29	Lake Area (acres)
Lake Stage Percentiles		
Period of Record P10 (1971 to 2012)	65.9	44.2
Period of Record P50 (1971 to 2012)	65.3	40.7
Period of Record P90 (1971 to 2012)	63.4	36.4
Historic P10 (1946 to 2012)	66.4	48.0
Historic P50 (1946 to 2012)	64.8	38.8
Historic P90 (1946 to 2012)	63.2	36.1
Normal Pool and Control Point		
Normal Pool	66.0	44.9
Control Point	65.3	40.7
Significant Change Standards		
Cypress Standard	64.2	37.6
Basin Connectivity Standard *	NA	NA
Recreation/Ski Standard*	NA	NA
Lake Mixing Standard*	NA	NA
Species Richness Standard*	60.9	33.1
Wetland Offset Elevation*	64.0	37.3
Aesthetics Standard*	63.2	36.1
Dock-Use Standard*	65.7	42.9
Minimum and Guidance Levels		
High Guidance Level	66.4	48.0
High Minimum Lake Level	65.6	42.3
Minimum Lake Level	64.2	37.6
Low Guidance Level	63.2	36.1

NA - not appropriate.
* Developed for comparative purposes only; not used to establish Lake Kell Minimum Levels

The highest water elevation recorded during this period was 67.1 ft. on September 12, 1988. Other periods of peak water levels (near 66.5 ft.) were experienced in August 1974, September 1979, February 1984, December 1997, September 2004, and July 2012. The lowest water elevation recorded was 61.9 icon ft. on June 28, 1994. Other periods of low water levels (near 61.9 ft. - 62.3 ft.) were recorded on June 1974, May 1976, May 1994, June 2001, and June 2008 (Figure 8).

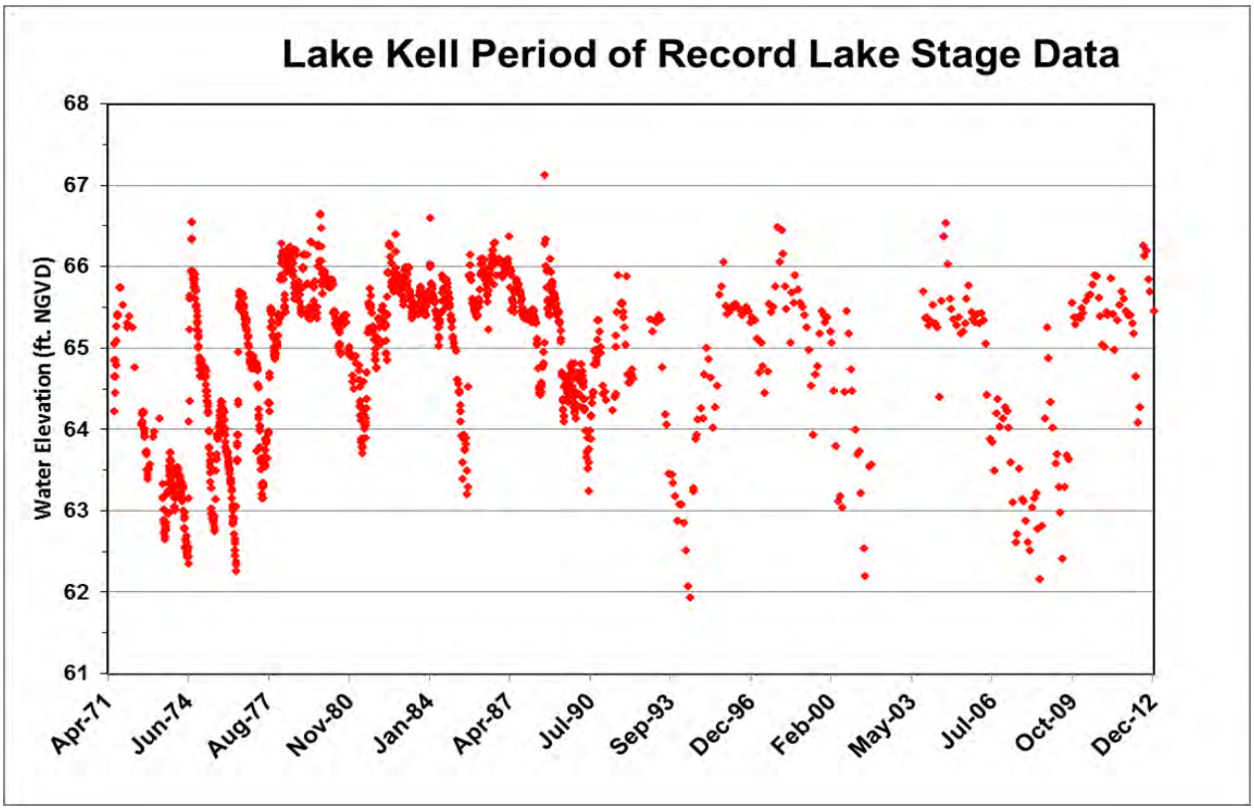

Figure 7. Lake Kell daily period of record stage data - June 1971 through December 2012.

For the purpose of Minimum Levels determination, lake stage data are classified as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. In the context of Minimum Levels development, "structural alterations" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. Lake stage data are classified as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable. By these definitions, there are no structural alterations at Lake Kell. A water control structure does exist on Lake Kell; however, water level fluctuations are not affected. In that, the structure does not impede the lake from rising to levels expected to fully maintain the integrity of the wetlands on the lake. Groundwater withdrawals were quantified through simulations using the SWFWMD Northern District groundwater withdrawal model (Basso 2012). Based on the groundwater model results, groundwater withdrawal impacts to the lake are minimal, and the Historic period for Lake Kell could reasonably extend to present day. However, for the purpose of establishing the rainfall regression model in a conservative manner the historic period was defined as the period pre-dating 1963.

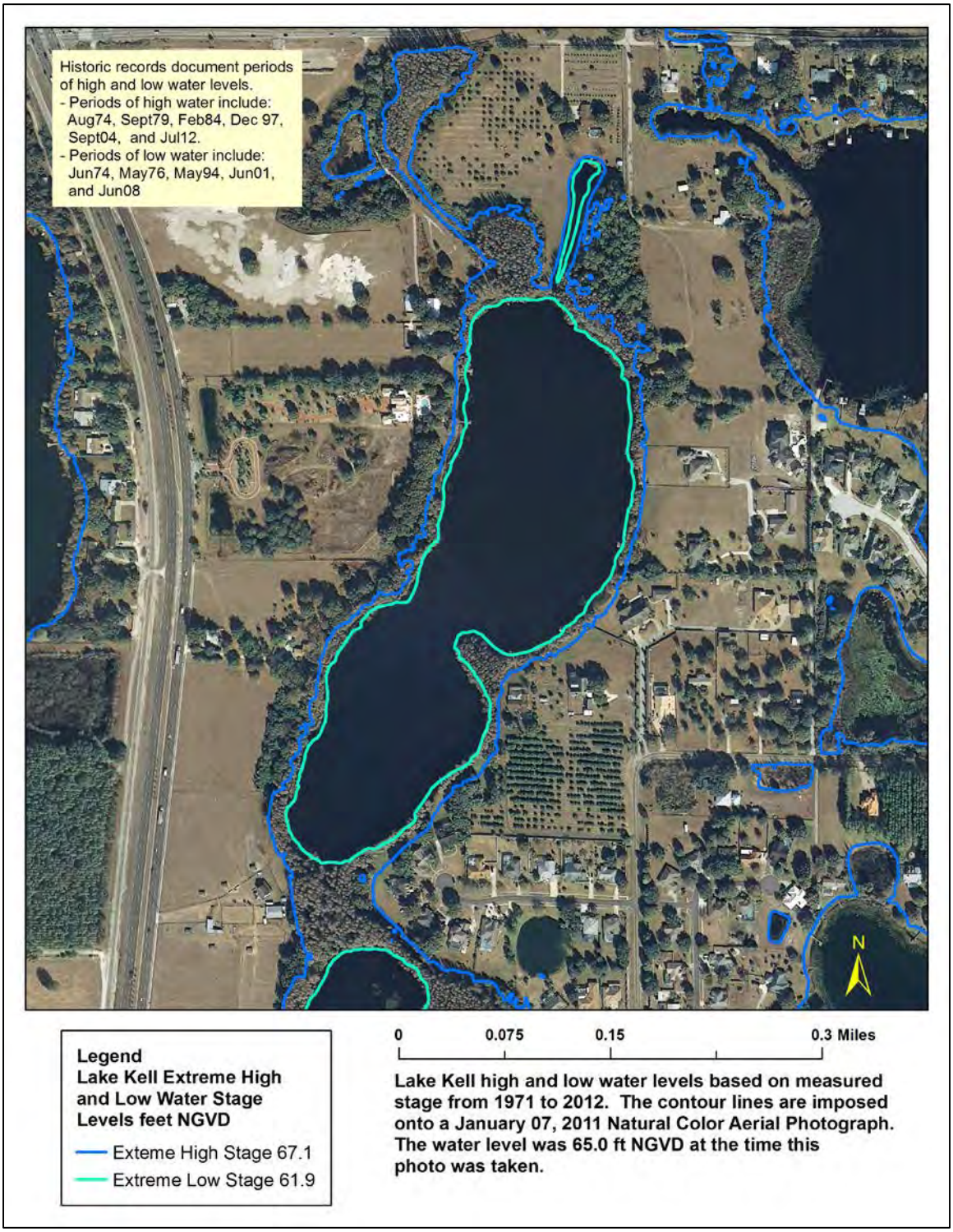

Figure 8. Periods of extreme high and low water levels during the period of recorded stage elevations on Lake Kell from 1971 to 2012.

Lake Kell rainfall regression model was calibrated to the time period of 2005 through 2012 (Ellison, 2014). Rain data consisted of National Weather Service Nexrad data for two pixels (103646 and 103172) that fall within the lake's immediate drainage basin area. The Nexrad data covered the time period from 1/1/1995 to present. From 1961 to 12/31/1994 the nearest available rain data was used and consisted of a combination of periods of multi-gage averages and periods of single gage data primarily based on the Lake Hanna rain gauge with missing values in-filled primarily from Hobbs gauge. Figure 9 includes the locations of the gages at Lakes Hanna and Hobbs, as well as gages used at Lakes Whalen, Crystal, Padgett, and Myrtle that were used for in-fill or averaging. Data prior to 1/1/1961 came from the St. Leo gage which was in-filled with data from the Hillsborough River gauge.

The resulting lake level rainfall model had a correlation coefficient of determination (r^2) equal to 0.73. The model was then applied to predict the lake stage for the long term Historic time period of the 1946 to 2012. This sixty-seven-year period was considered sufficient for incorporating the range of lake stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield *et al*. 2001, Basso and Schultz 2003). The rainfall regression model historic water levels representing un-impacted conditions are graphed in Figure 10. The lake stage record is included on the same graph to illustrate the model fit.

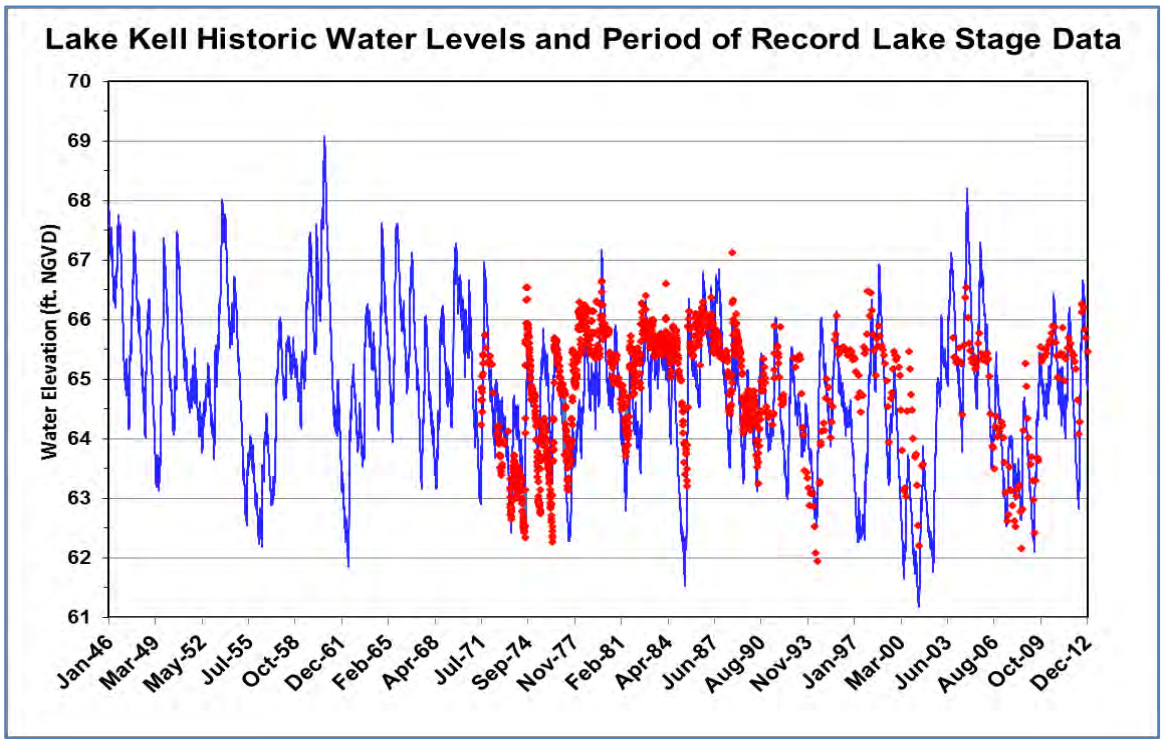

Figure 10. January 1946 – December 2012 modeled long-term historic water levels (blue line) and June 1971 – December 2012 daily lake stage data (red markers).

The final modeled historic lake stage data set was used to calculate the Historic P10, P50, and P90 lake stage percentile elevations (Figure 11, Table 3). The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was 66.4 ft. The Historic P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was 64.8 ft. The Historic P90 elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period, was 63.2 ft.

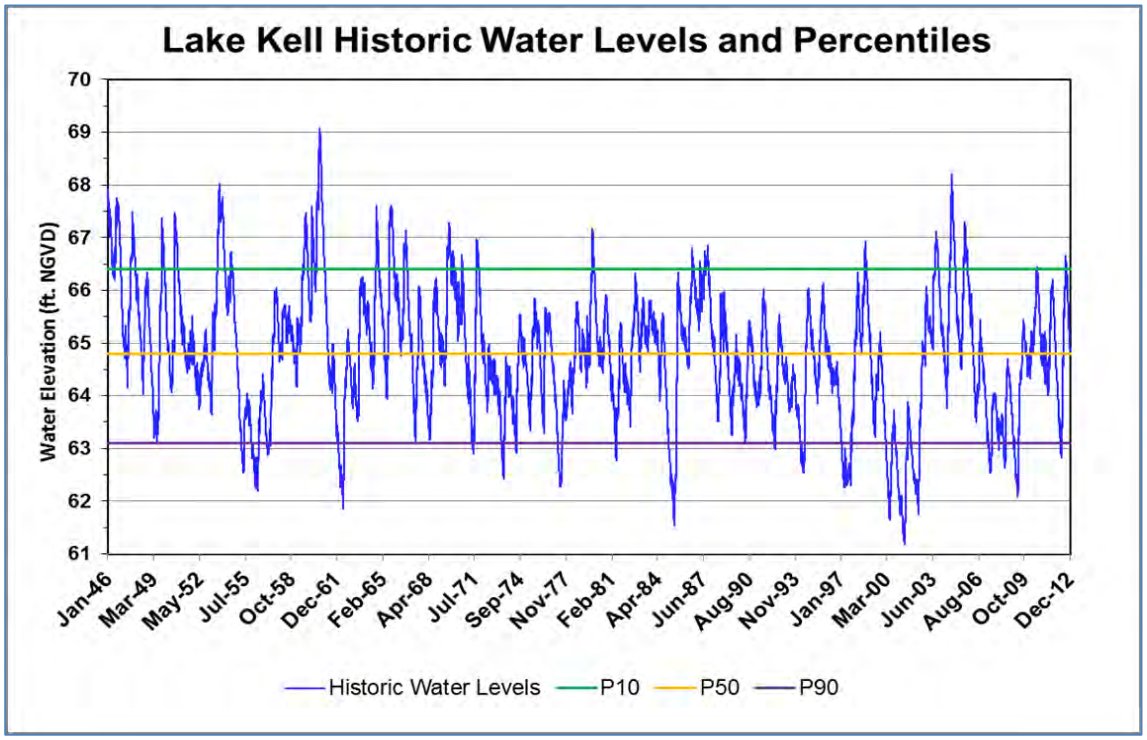

Figure 11. Historic water levels used to calculate percentile elevations for Lake Kell. Historic P10, P50, and P90 are depicted as horizontal lines.

Normal Pool Elevation, Control Point Elevation and Structural Alteration Status

The **Normal Pool** elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the elevation of hydrologic indicators of sustained inundation. The inflection points (buttress swelling) on the trunks of cypress trees have been shown to be reliable biologic indicators of hydrologic Normal Pool (Carr, et al. 2006). Eleven examples of buttress swelling on cypress trees where measured on the lake in March – April 2013 Table 4). Based on the survey of these biologic indicators, the Normal Pool elevation was established at **66.0 ft**.

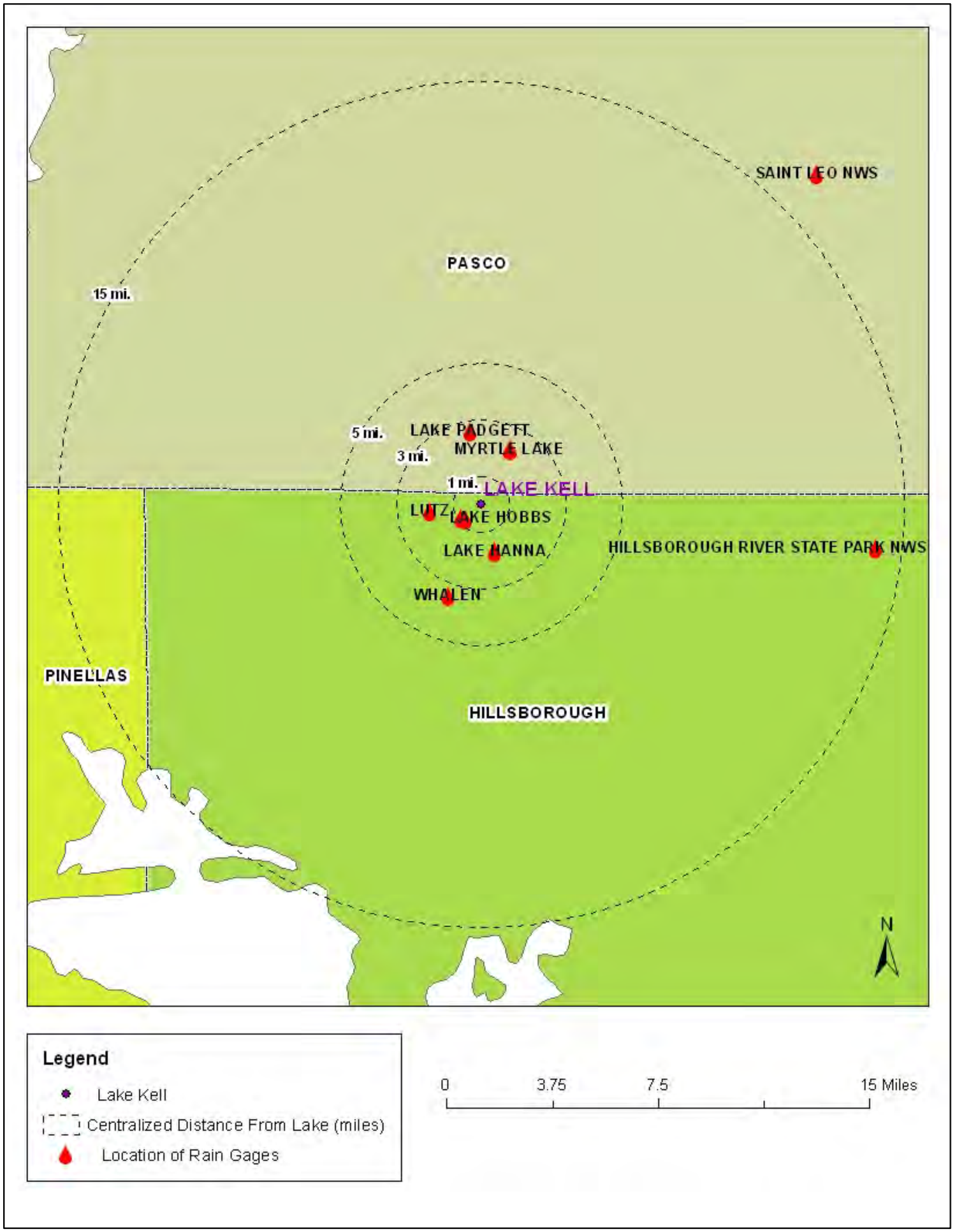

Figure 9. The locations of rain gages used in Lake Kell rainfall regression model: Lakes Whalen, Crystal, Padgett, and Myrtle, St. Leo and Hillsborough River State Park.

Table 4. Summary statistics for hydrologic indicator measurements (elevations buttress inflection points of lakeshore Taxodium sp.) used for establishing normal pool elevations for Lake Kell.

N	11
Median	66.0
Mean	65.9
Minimum	65.4
Maximum	66.3

The **Control Point** elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.,* weir, ditch, culvert, or pipe) that is the principal control of water level fluctuations in the lake. The conservation structure downstream of Little Lake Kell serves as the control point at **65.3 ft**. Two, six-inch tall flashboard risers were installed between 1973 and 1974 as part of the conservation structure to adjust water levels in the lake. These boards have rarely been used since the District took over operation from Hillsborough County in October 1977. It is possible to install one or both flashboard riser and raise the control point by 0.5 or 1.0 feet, however, the District has no plans to utilize these boards, allowing the structure to remain fully open at the control point elevation.

Structural Alteration Status is determined to support development of Minimum and Guidance Levels. Lake Kell is considered to be structurally altered because of known historic modifications to the conservation structure.

Guidance Levels

The **High Guidance Level** is provided as an advisory guideline for construction of lake-shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic lake stage data if it is available, or is estimated using the Current P10, the control point, and the normal pool elevation. Based on the availability of the long-term historic data record, the High Guidance Level was established at **66.4 ft.** (Figure 12, Table 3).

The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lake shore residents, and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time (P90) on a long-term basis. The level is established using historic or current lake stage data, and in some cases, reference lake water regime (RLWR) statistics, which are simply differences between selected lake stage percentiles for a set of reference lakes. Based on the availability of the long-term historic data set for Lake Kell, the Low Guidance Level was established at **63.2 ft.** (Figure 12, Table 3).

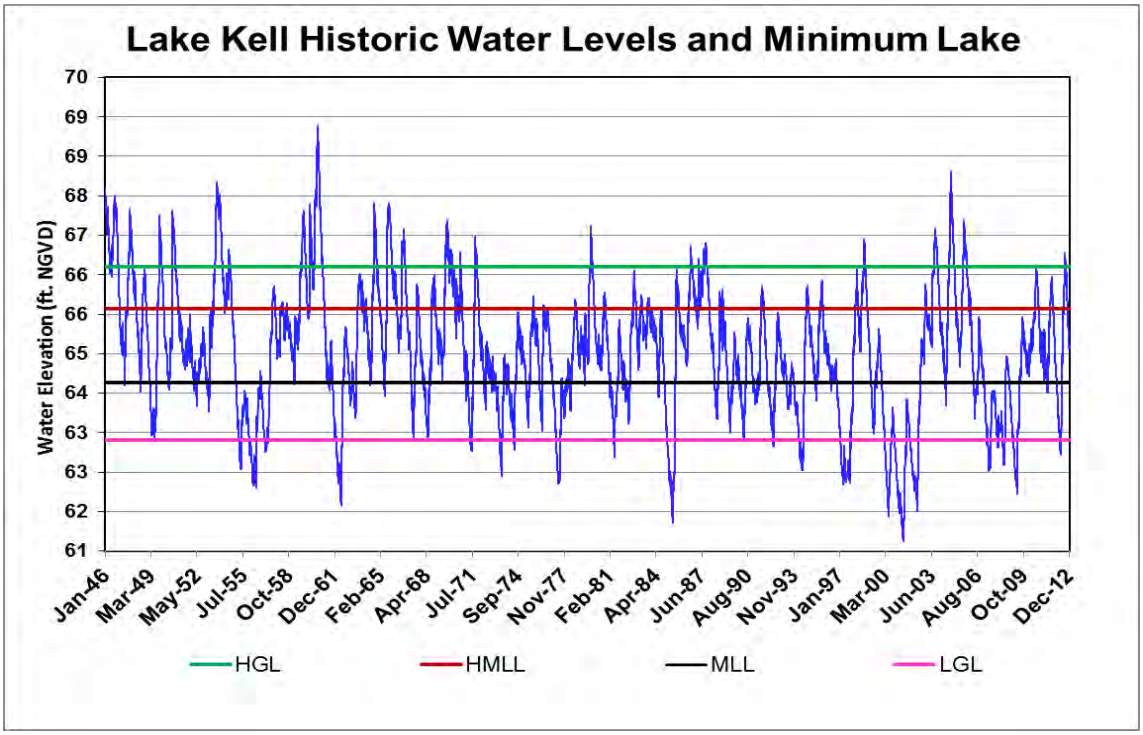

Figure 12. Historic water levels and Minimum and Guidance Levels for Lake Kell. Levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL), and the Low Guidance Level (LGL).

Lake Classification

Lakes are classified as Category 1, 2, or 3 for the purpose of Minimum Levels development. Systems with fringing cypress wetlands greater than 0.5 acres in size where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands (*i.e.,* the Historic P50 is equal to or higher than an elevation 1.8 feet below the Normal Pool elevation) are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 elevation is less 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 presence of lake-fringing cypress wetlands of 0.5 acre or more in size within the lake basin, and the Historic P50 (64.8 ft.) is higher than 1.8 feet below the Normal Pool elevation (64.2 ft.), Lake Kell was classified as a Category 1 lake.

Significant Change Standards and Other Considerations

The standards are used to identify thresholds for preventing significant harm to cultural and natural system values associated with lakes in accordance with guidance provided in the Florida Water Resources Implementation Rule (Chapter 62-40.473, F. A. C.). The method of establishing. Minimum Lake Levels depends on the category within which the subject lake falls (40D-24).

For 2 lakes, the High Minimum Lake Level is established at the High Guidance Level and the Minimum Lake Level is established at the historic P50 elevation. The High Minimum Lake Level for Category 1 lakes like Lake Kell is established 0.4 feet below the normal pool elevation. The Minimum Lake Level is established at 1.8 feet below the normal pool elevation. Although not identified by name in the District's Minimum Flows and Levels rule, the elevation 1.8 feet below normal pool is typically referred to as the Cypress Standard in District documents pertaining to Minimum Levels development. Based on the historic composite water level record, the **Cypress Standard** for Lake Kell (**64.2 ft.**) was equaled or exceeded sixty-nine percent of the time, *i.e*., the standard elevation corresponds to the Historic P69.

For Category 3 lakes, six significant change standards, including a Dock-Use Standard, a Basin Connectivity Standard, an Aesthetics Standard, a Recreation/Ski Standard, a Species Richness Standard, and a Lake Mixing 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. Although Lake Kell is a Category 1 Lake, Category 3 Lake standards were developed for comparative purposes. These standards were not, however, used to establish the Minimum Levels.

The **Aesthetics Standard** is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard is established at the Low Guidance Level, which is **63.2 ft.** for Lake Kell. 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 long-term period.

The **Species Richness Standard** is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes, the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. The Species Richness Standard established for Lake Kell is established at **60.9 ft.** (see Figure 13 for a plot of lake surface area versus lake stage).

The **Recreation/Ski Standard** is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a five-foot deep ski corridor delineated as a circular area with a radius of 418 ft., or as used in this case, a rectangular ski area 200 ft. in width and 2,000 ft. in length, and use of historic lake stage data. The Recreation/Ski Standard is established at 69.0 ft. for Lake Kell, based on the sum of the elevation at which the lake could contain an area suitable for safe skiing (67.4 ft.) and the difference between the Historic P50 and Historic P90 (1.6 ft.). The Recreation/Ski Standard exceeds even the most extreme high periods of water

levels based on the long-term historic water level record, therefore, the standard was deemed inappropriate for development of a Minimum Lake Level for Lake Kell.

The **Dock-Use** Standard is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a clearance water depth value for boat mooring, and use of historic lake stage data. The Dock-Use Standard for Lake Kell was established at **65.7 ft.**, based on the elevation of sediments at the end of ninety percent of the 13 docks within the lake (62.1 ft., Table 5), a two-foot water depth based on use of powerboats in the lake, and the 1.6 ft. difference between the Historic P50 and Historic P90. The sediment elevations were measured in April of 2012 with a corresponding water level of 64.7 NGVD.

Table 5. Summary statistics and elevations associated with docks in Lake Kell as based on measurements made by District staff in April 2012. Percentiles (10th, 50th and 90th) represent the percentage of docks at or below the corresponding elevation.

Summery Statistics	Statistics Value (N) or Elevation (feet) of Sediments at Waterward End of Docks	Statistics Value (N) or Elevation (feet) of Dock Platforms
N (number of docks)	13	13
Median	60.06	67.26
10th Percentile (P90)	55.76	66.48
50th Percentile	60.06	67.26
90th Percentile (P10)	62.06	68.1
Maximum	62.76	74.76
Minimum	54.66	62.46

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 sub-basins (lobes), clearance water depths for movement of aquatic biota or powerboats and other watercraft, and use of historic lake stage data or region-specific reference lake water regime statistics. Lake Kell is contiguous, without lake sub-basins (lobes), therefore establishing a conductivity standard is not appropriate.

The **Lake Mixing Standard** is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann *et al.* 2000) shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value of <0.8 (Figure 13). A shift in the dynamic ratio indicates at

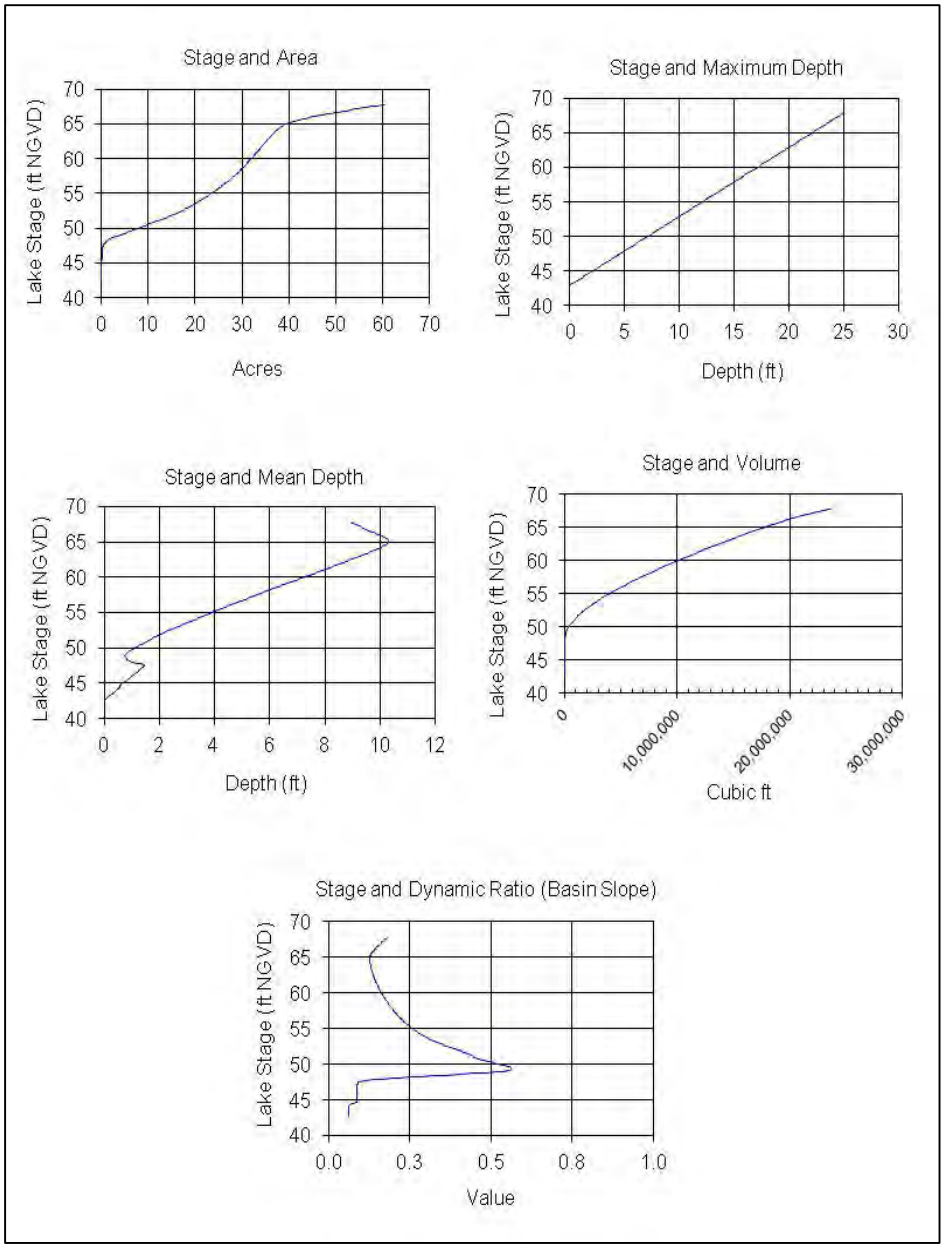

Figure 13. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope) in feet for Lake Kell.

what elevation the lake depth and bottom slope becomes susceptible to bottom sediment re-suspension. Review of the dynamic ratio for lake stages between the High and Low Guidance Levels did not indicate that potential changes in basin susceptibility to such sediment re-suspension would be of concern for Minimum Levels development. Because the dynamic ratio does not shift across the 0.8 threshold as the lake level changes, a Mixing Standard was not developed for the lake.

The **Wetland Offset** is developed to protect lake associated herbaceous wetlands. The standard is based on a review (Hancock 2006) of Minimum Level methods used for cypress-dominated wetlands, and specifies that up to a 0.8 foot decrease in the Historic

P50 elevation (*i.e*., the Wetland Offset) would not likely be associated with significant changes in herbaceous wetlands occurring within lake basins. The Wetland Offset was determined by subtracting 0.8 ft. from the Historic P50 elevation. The Wetland Offset for Lake Kell is established at **64.0 ft**. The wetland offset elevation is only 0.2 ft. below the Minimum Lake Level (Table 3).

Minimum Levels

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

A Category 1 Lake has lake-fringing cypress swamps greater than 0.5 acres in size where structural alterations have not prevented the Historic P50 from equaling or rising above an elevation that is 1.8 ft. below the normal pool of cypress swamps. In the case of Lake Kell, Normal Pool was derived from the median of eleven inflection point elevations on the trunks of cypress trees along the lake edge. In accordance to Chapter 40D-8, F. A. C., Lake Kell is deemed a Category 1 Lake.

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. The Minimum Lake Level is established at the elevation of 1.8 ft. below the Normal Pool elevation (66 ft.) in the cypress swamps contiguous with the lake as indicated above. The Minimum Lake Level for Lake Kell is **64.2 ft**.

The **High Minimum Lake Level (HMLL)** for Category 1 lakes is established 0.4 ft. below the Normal Pool elevation in the cypress swamps contiguous with the lake. The HMLL for Lake Kell is **65.6 ft**.

For comparison purposes, the Minimum and Guidance Levels are presented in the North American Vertical Datum of 1988 (NAVD88) (Table 5). Many federal, state, and local agencies, such as the US Army Corps of Engineers, the Federal Emergency Management Agency, United States Geological Survey, and the District are in the process of migrating from NGVD29 to the NAVD88 standard because the NGVD29 datum will no longer be supported in the future.

Table 5. Minimum and Guidance Levels for Lake Kell in NAVD88.

Minimum and Guidance Levels	Elevation in Feet NAVD88
High Guidance Level	65.6
High Minimum Lake Level	64.8
Minimum Lake Level	63.4
Low Guidance Level	62.4

The Minimum and Guidance Levels for Lake Kell are shown in Figure 12 along with surface water elevations based on historic water levels. The MLL and HMLL levels are also shown as contour lines on historic aerial photographs (Figures 14 – 16). Figure 14 presents a 2010 aerial which illustrates water levels near the HMLL. Figure 15 and 16 present a 2007 and 1973 aerial respectively, which illustrates water levels near the MLL.

Assessment of the Lake Kell Minimum Level Condition

The Minimum Level developed for Lake Kell was assessed to determine if lake levels are fluctuating relative to the Minimum Level in an appropriate manner. The methods used included using the prediction interval of the rainfall regression model developed to model the historic data; and evaluating the cumulative median relative to the Minimum Level (Ellison 2014). Both methods indicated that the lake is at or above the Minimum Lake Level of 64.2 NGVD 29.

The Minimum Lake Level and High Minimum Lake Level were evaluated for compliance using same predictive model that was used to develop the long term Historic Exceedance percentiles (Ellison 2014). The model was used to evaluate whether the predicted lake stage and observed lake stage fits within the prediction intervals established with the model's calibration window or time period. Lake Kell was determined to be in compliance for both the Minimum Low Level and High Minimum Level based on rainfall data through May 2014.

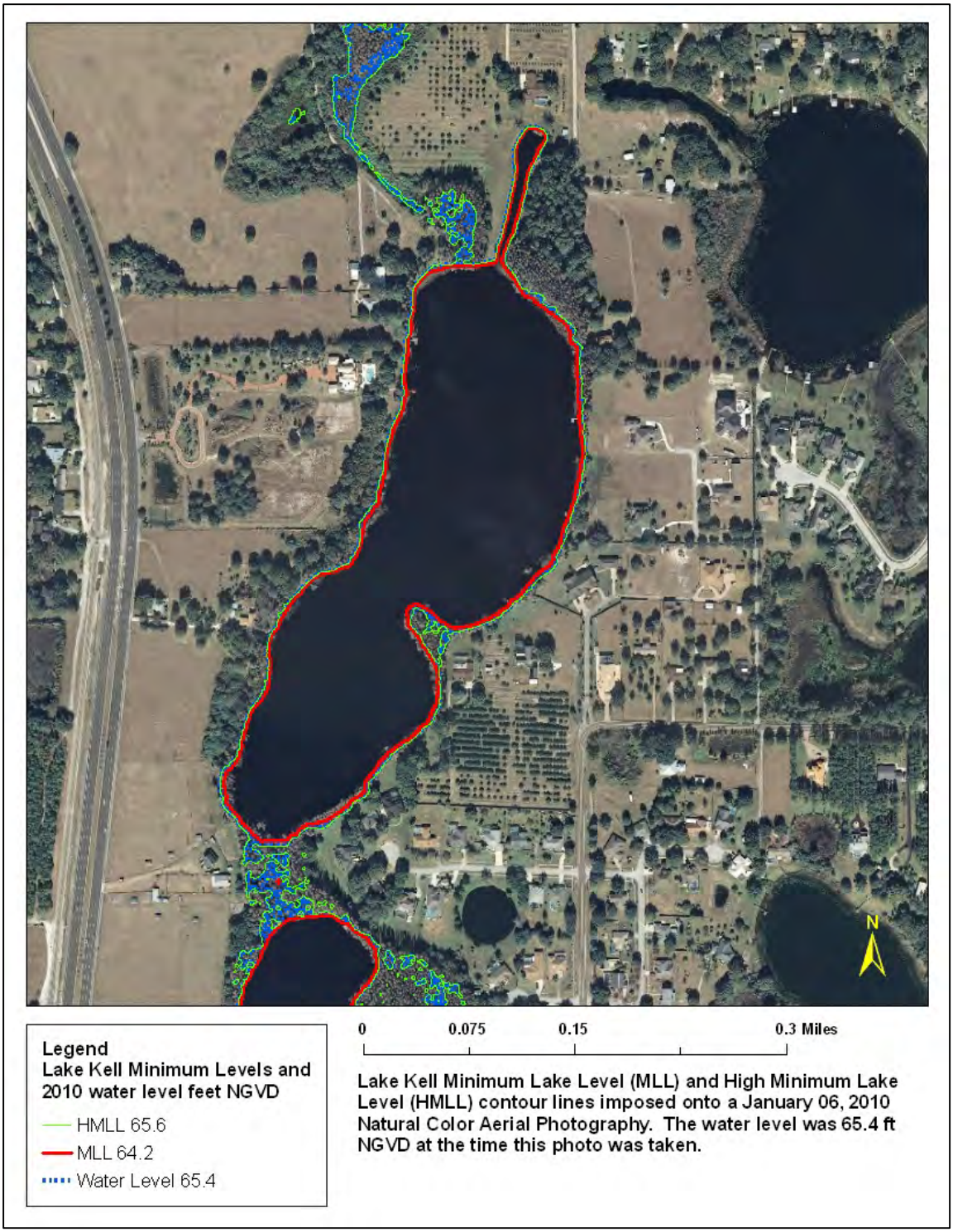

Figure 14. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Kell relative to conditions on January 6, 2010. Based on gage readings, the estimated lake stage was 65.4 ft. on the date of the imagery.

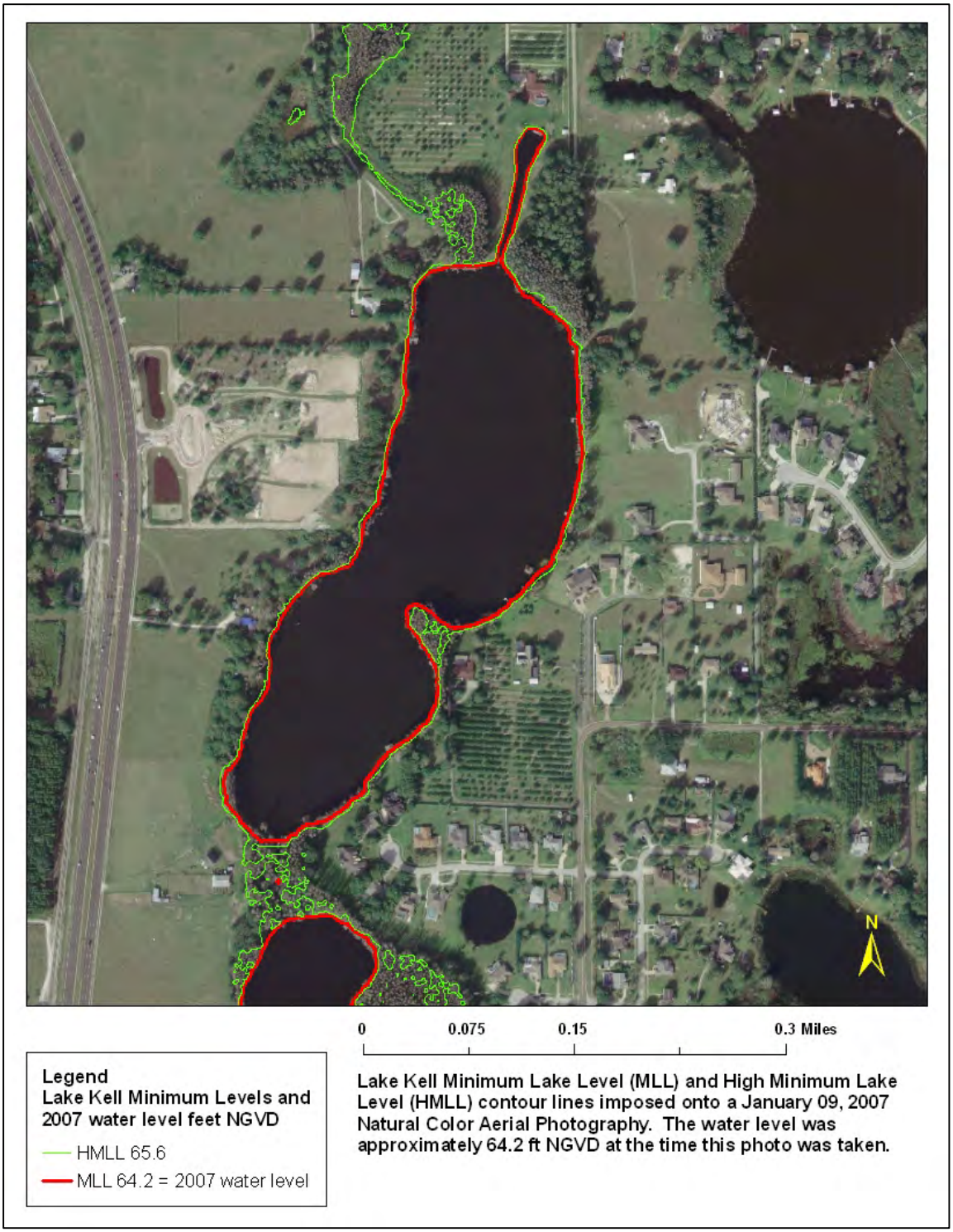

Figure 15. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Kell relative to conditions on January 9, 2007. Based on gage readings the estimated lake stage was 64.2 ft., equal to the MLL.

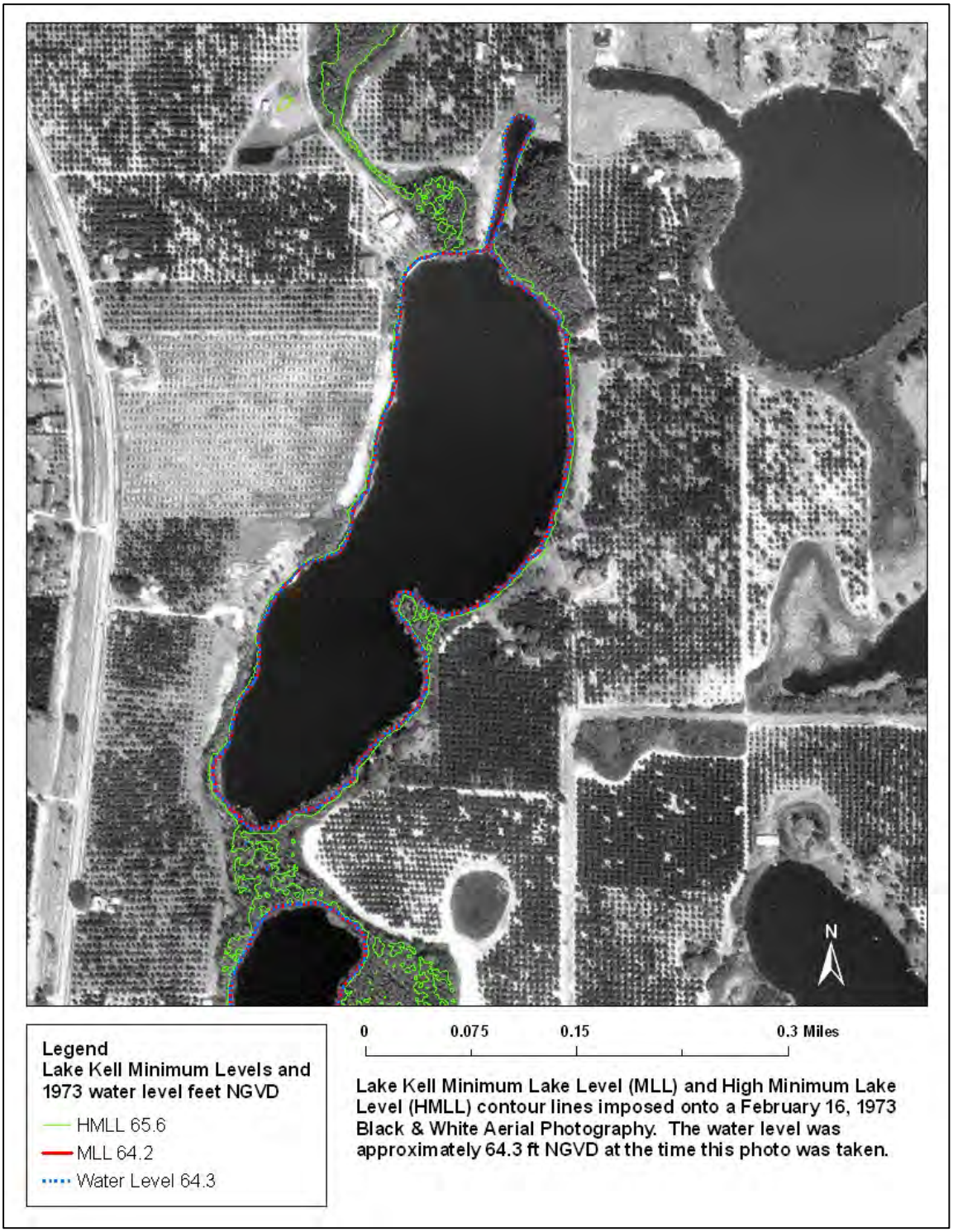

Figure 16. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Kell relative to conditions on February 16, 1973. Based on interpretation of contour lines at the lake edge at the time of this imagery, the lake stage was estimated at 64.3 ft.

References

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 2012. Technical Memorandum to Lake Kell Minimum Lake Levels File dated November 8, 2012 regarding groundwater withdrawal impacts to Lakes Kell, Hanna, and Keene, Southwest Florida Water Management District, Brooksville, Florida.

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. Southwest Florida Water Management District. Brooksville, Florida.

Carr, D. W., Leeper, D. A., and Rochow, T. F. 2006. Comparison of Six Biologic Indicators of Hydrology and the Landward Extent of Hydric Soils in West-central Florida, USA Cypress Domes. Wetlands 26:4 1012–1019 pp.

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.

Ellison, D. 2014. Technical Memorandum dated June 13, 2014 regarding Lakes Hanna, Keene and Kell Hydrogeology, Rainfall Correlation Models, Historic Percentile Estimations, and Assessment of Minimum Lake Level Status.

Enfield, D.B., Mestas-Nuez, A., and Trimble, P.J. 2001. The Atlantic Mulitdecadal Oscillation and Its Relation to Rainfall and River Flows in the Continental U.S. Geophysical Research Letters, 28:10 2077-2080 pp.

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

Florida Department of Environmental Protection. 2004. Drainage Basins. FDEP, Tallahassee, Florida.

Griffith, G. E., Canfield, D. E., Jr., Horsburgh, C. A., Omernik, J. M., and Azevedo, S. H. 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.

Hyde, A. G., Law, L., Weatherspoon R. L., Cheyney, M. D., and Eckenrod, J. J. 1977. Soil Survey of Hillsborough County, Florida. USDA Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department. USDA Soil Conservation Service, Washington, D.C.

Johnson, M., and Michael Young. 1973. Regulation Schedule for Lakes Kell, Keene, Hanna, and Stemper. 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, June14, 2001 draft. 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.

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

Southwest Florida Water Management District. 1999. 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. 2005. One-Foot Contours for Hillsborough County 2001. Southwest Florida Water Management District, Brooksville, Florida.

Southwest Florida Water Management District. 2009. Southwest Florida Water Management District Water Maters Magazine, October 2009. Southwest Florida Water Management District, Brooksville, Florida.

Wagner, K. J. and Dierberg, F. E. 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. Florida Geological Survey Bulletin 51. Bureau of Geology, Division of Interior Resources, Florida Department of Natural Resources, Tallahassee, FL.