

Minimum and Guidance Levels For Whitehurst Pond in Hernando County, Florida



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Resource Evaluation Section
Water Resources Bureau
Southwest Florida
Water Management District

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Cover Page: A comparison of 1944 and 2006 aerial photographs of Whitehurst Pond. The 1944 imagery was collected on November 12, 1944 by the United States Department of Agriculture. The 2006 imagery was collected on March 7, 2006 by the District.

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Minimum and Guidance Levels for Whitehurst Pond

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.

Development of minimum flows and levels are key components in supporting resource protection, recovery and regulatory compliance by establishing standards below which significant harm will occur in specific water bodies. Section 373.0421, 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), 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.

Section 373.0421, F.S., requires that minimum flows and levels 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. The Florida Water Resources Implementation Rule (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 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 SWFWMD 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 SWFWMD staff, 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), 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 SWFWMD 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 Whitehurst Pond (Table 1), a Category 3 lake located in Hernando 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 the levels to be adopted in Rule 40D-8.624, F.A.C. The District has not previously adopted management water levels on this lake.

All elevation values included within this report are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29). In some circumstances, data were collected as North American Vertical Datum of 1988 (NAVD 88) and a datum shift of 0.837 feet was added to the NAVD 88 elevations to convert to NGVD 29. All conversions were derived using Corpscon 6.0, a computer software program that performs vertical conversions to and from NGVD 29 and NAVD 88.

Table 1. Minimum and Guidance Levels for Whitehurst Pond.

Minimum and Guidance Levels	Elevation in Feet NGVD 29
High Guidance Level	23.0
High Minimum Lake Level	22.4
Minimum Lake Level	17.5
Low Guidance Level	14.6

Data and Analyses Supporting Development of Minimum and Guidance Levels

Lake Setting and Description

Whitehurst Pond is located in Hernando 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 west by coastal swamps and to the east the Brooksville Ridge (Figure 2). Brooks (1981) categorized the area as the Weeki Wachee Dune Field in the Ocala Uplift Physiographic District which features distinctive, low rolling limestone plains with a sand pine, longleaf pine, and turkey oak landscape. As part of the Florida Department of Environmental Protection's Lake Bioassessment Regionalization Initiative, the area has been identified as the Weeki Wachee Hills region. Griffith *et al.* 1997 describe the region as one of mostly clear water, circumneutral-pH lakes that have moderately low alkalinity and nutrients.

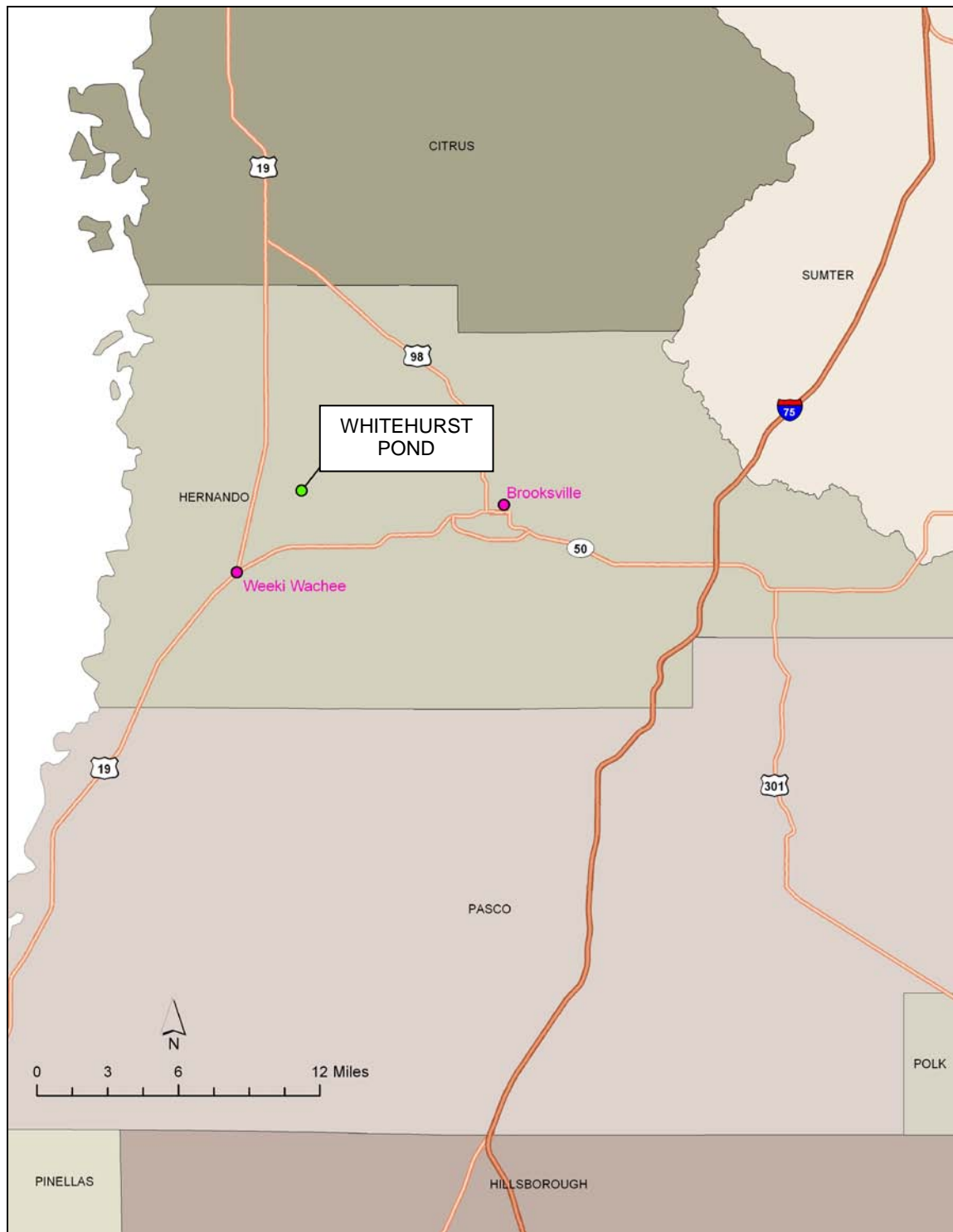


Figure 1. Location of Whitehurst Pond in Hernando County, Florida.

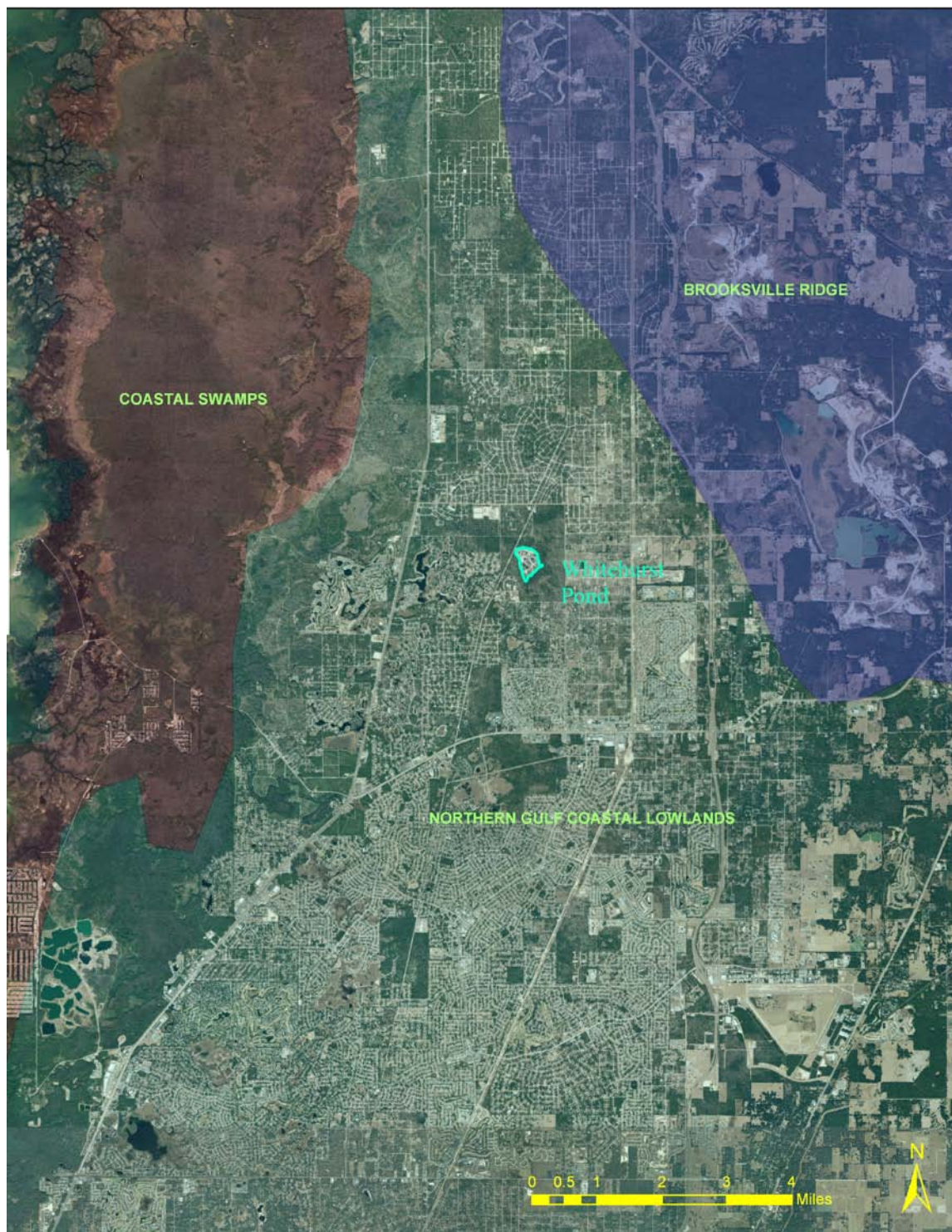


Figure 2. Physiographic regions of the Whitehurst Pond area.

The 1956 (photo-revised 1981) United States Geological Survey 1:24,000 Whitehurst Pond quadrangle map indicates elevations to be 30 ft. A topographic map of the basin generated in support of minimum levels development indicates that Whitehurst Pond lake edge is at 23 ft and extents approximately 71 acres. All the land surrounding Whitehurst Pond (Figure 3) remains as a natural sandhill community of longleaf pine-xeric oak (SWFWMD, 2009). The soils surrounding the lake are Basinger, Tavares and Candler fine sands (Hyde *et al.* 1977). There is no public access to Whitehurst Pond.

Whitehurst Pond is located in the Weeki Wachee Drainage Basin in the Upper Coastal Rivers watershed. There are no surface water withdrawals from the lake. There is one water supply well permit and many small landscape wells in the vicinity. Figure 4 shows all permitted groundwater withdrawal wells within one, two and three mile radii of the lake. Monthly average water withdrawals are generally less than 4 million gallons per day (mgd) within a three mile radius of Whitehurst Pond (Basso 2012).

Currently Adopted Minimum and Guidance Levels

The Southwest Florida Water Management District has a long history of water resource protection through the establishment of lake management levels. With the development of the Lake Levels Program in the mid-1970s, the District began an initiative for establishing lake management levels based on hydrologic, biological, physical and cultural aspects of lake ecosystems. By 1996, management levels for nearly 400 lakes had been established. Whitehurst does not currently have Adopted Minimum and Guidance Levels.

Summary Data Used for Development of Minimum and Guidance Levels

Minimum and Guidance Levels for Whitehurst Pond were developed using the methodology for Category 3 Lakes described in Rule 40D-8.624, F.A.C. Levels and additional information are listed in Table 2, 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.

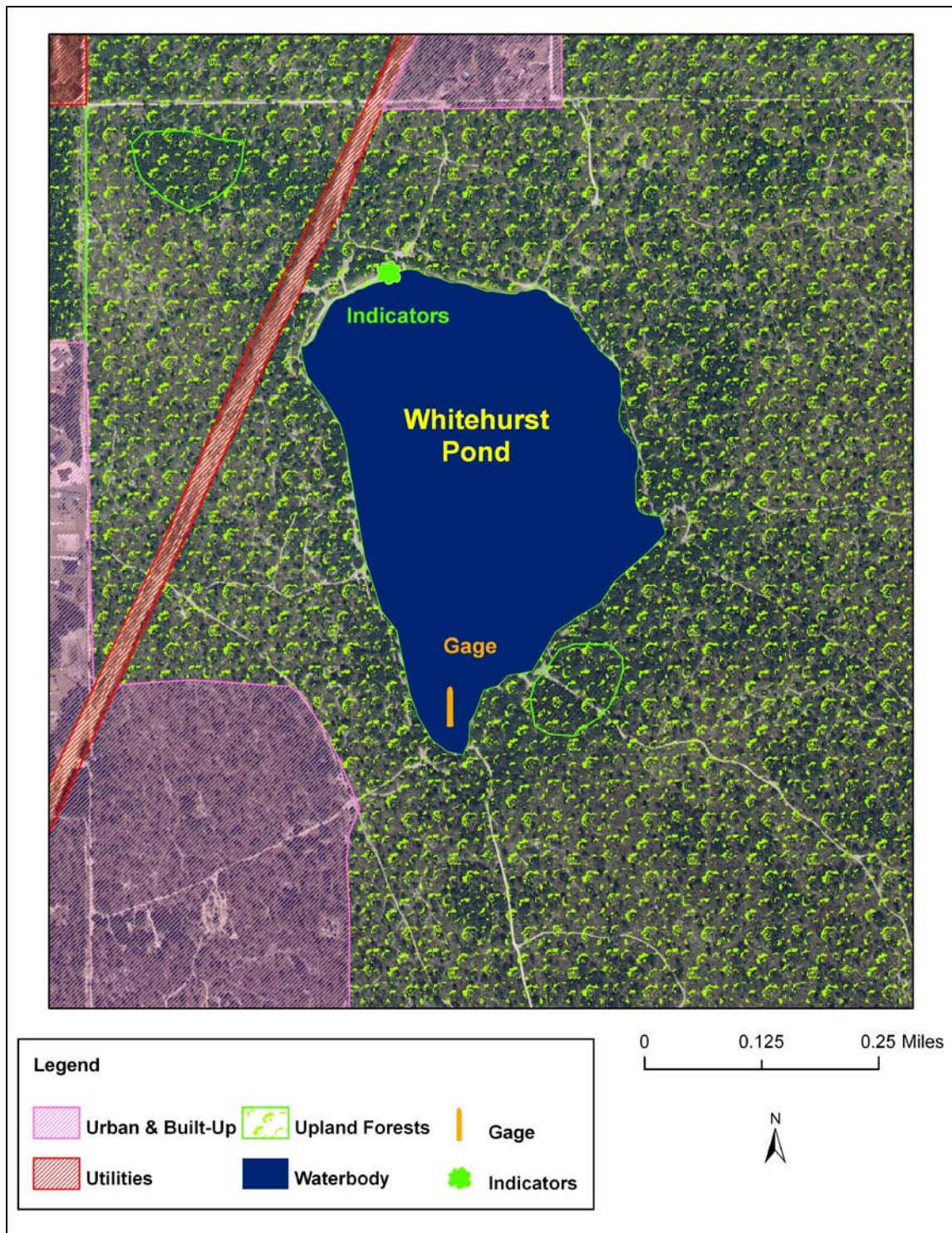


Figure 3. Location of the water level gage and hydrologic indicators at Whitehurst Pond.

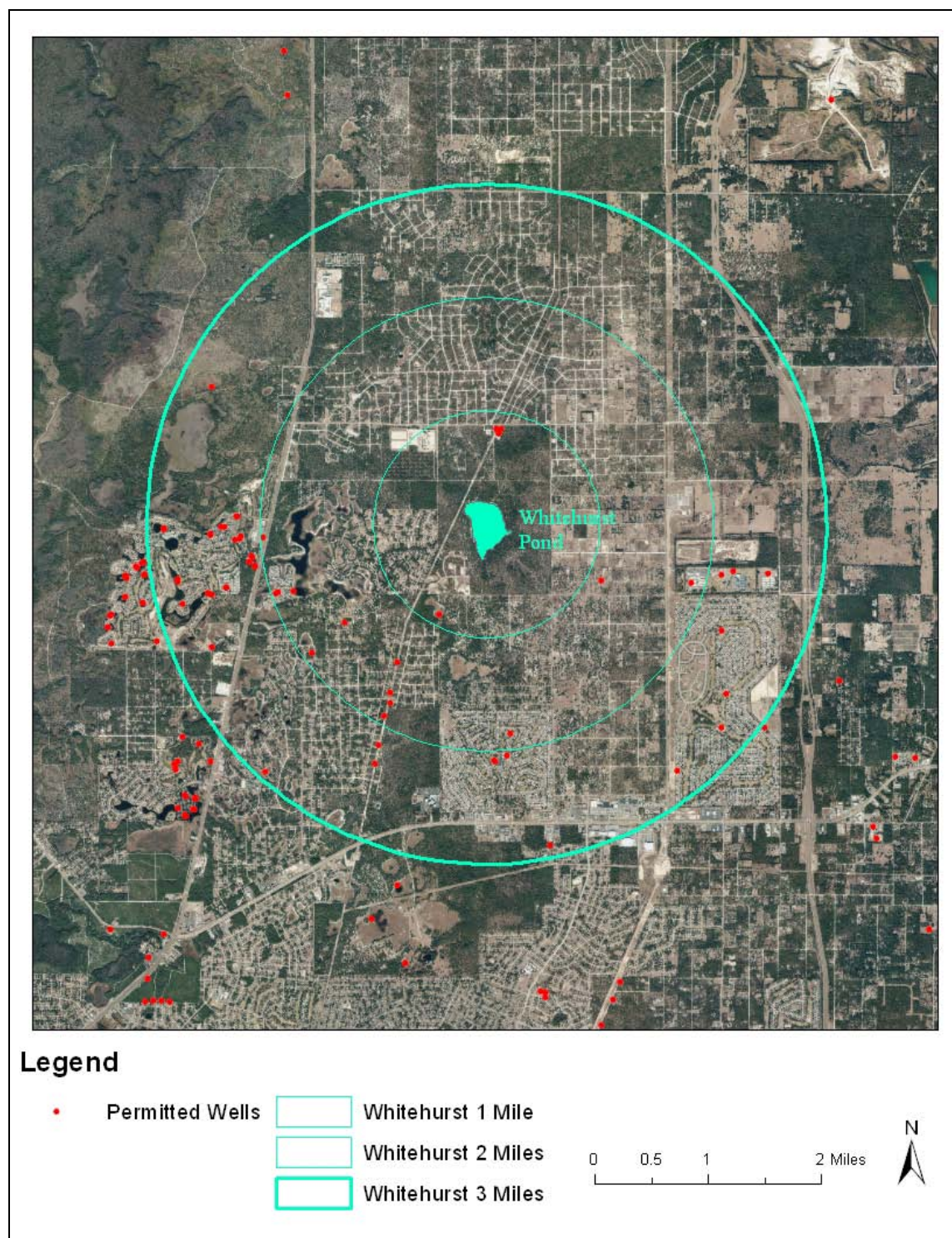


Figure 4. Permitted Groundwater withdrawals within a one mile, two mile and three mile radius of Whitehurst Pond.

Table 2. Lake Stage Percentiles, Normal Pool and Control Point Elevations, and Significant Change Standards, Minimum and Guidance Levels associated surface areas for Whitehurst Pond.

Levels	Elevation in Feet NGVD 29	Lake Area (acres)
Lake Stage Percentiles		
Period of Record (POR) P10 (1999 to 2012)	16.2	14.7
Period of Record (POR) P50 (1999 to 2012)	14.3	1.3
Period of Record (POR) P90 (1999 to 2012)	12.5	0.3
Historic P10 * (1946 to 2011)	23.0	73.4
Historic P50 * (1946 to 2011)	18.1	48.4
Historic P90 * (1946 to 2011)	14.6	1.8
Normal Pool and Control Point		
Normal Pool	23.9	76.6
Control Point	30.6	NA
Significant Change Standards		
Basin Connectivity Standard	26.0	87.8
Recreation/Ski Standard	25.7	86
Lake Mixing Standard	18.4	50.1
Species Richness Standard	17.5	42.3
Wetland Offset Elevation	17.3	39.8
Aesthetics Standard	14.6	1.8
Dock-Use Standard	NA	NA
Minimum and Guidance Levels		
High Guidance Level	23.0	73.4
High Minimum Lake Level	22.4	71.4
Minimum Lake Level	17.5	42.3
Low Guidance Level	14.6	1.8

NA - not appropriate.

* - Long term Historic percentiles based on a composite of modeled pre-POR (1946-1999) and POR (1999-2010).

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations for Whitehurst Pond relative to NGVD 29 were obtained from the District's Water Management Information System (WMIS) data base (site identification number 20591). The period of record (POR) for the data extends from February 1999 through July 2012. See figure 3 for the current location of the SWFWMD lake water level gage. Using the available lake stage data, monthly mean lake stage were calculated and graphed (Figure 6).

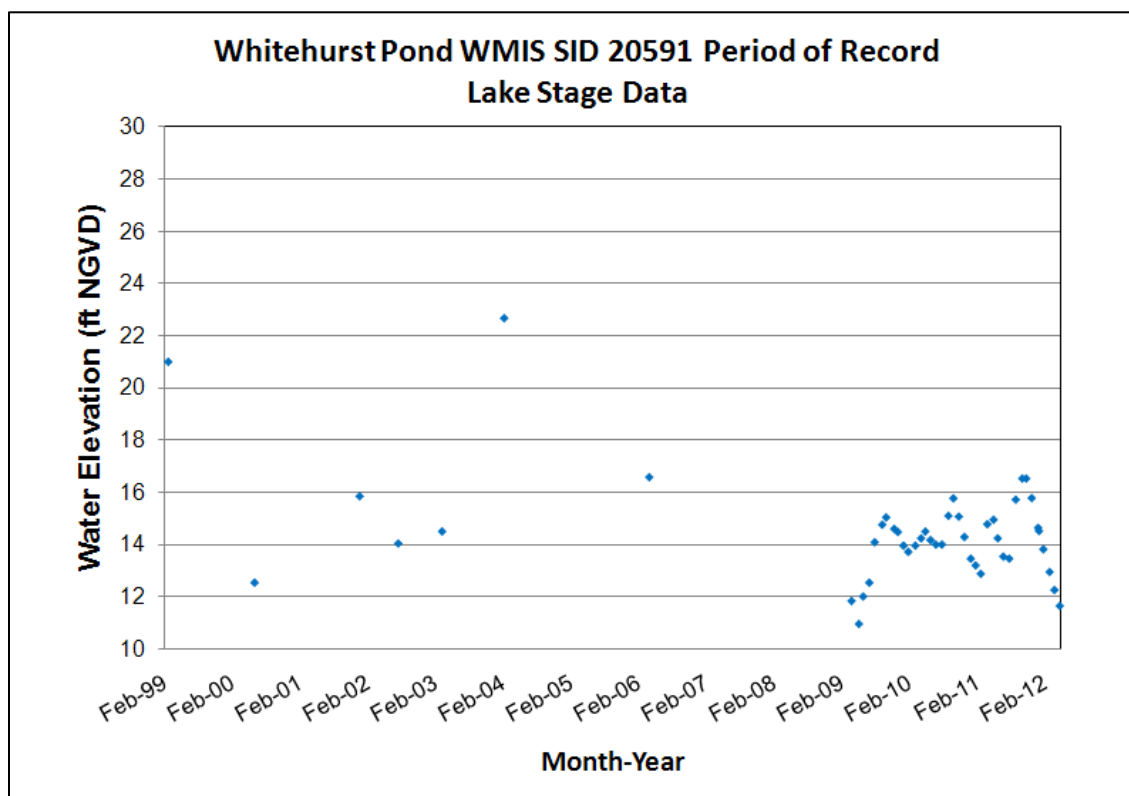


Figure 6. Whitehurst Pond (WMIS SID 20591) period of record monthly mean stage data - February 1999 through July 2012.

The highest water elevation recorded was 22.7 ft and occurred in February 9, 2004. The lowest water elevation recorded was 11.0 ft and occurred on May 11, 2009, however, this low level equates to the stage measure in the sink at the south edge of the lake where the staff gage is located. The bottom of the lake bed is at 13.3 ft. The vertical distance from the record measured high and low and the physical bottom of the lake is 9.4 ft. The horizontal distance between the recorded high water and the lake bottom is approximately 400ft – 1400 ft. This horizontal change equates to as little as a 149 ft distance to every one foot drop (149:1 ratio). This overall ratio does not take into account the disturbed topography within the lake caused by excessive off-road vehicle use. Regardless, Whitehurst Pond is typical of the many gradually sloped, shallow lakes that are common in western Hernando County, and a small vertical fluctuation in water level will result in a notable substantial change in the lake shoreline.

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 Whitehurst Pond. 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 Whitehurst Pond 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 1990.

Because available data for Whitehurst starts in 1999 there are no available historic lake stage data available. To recreate historic data, the model effort used two regression models. The first regression model was between a nearby Floridan well (Weeki Wachee FLDN WMIS Site ID 20584) that has a long period of data that predates 1990. The regression between the lake and the well was based on the 2006 through March 2012 time period. Results from this model that predate 1995 represent historic lake stage records for Whitehurst. The historic data from the first regression model served as the basis for the development of the final rainfall lake stage regression model. To accomplish this, a composite rainfall data set was developed for the time period of 1946 to present using data from two rainfall data collection sites. The rain gage sites included the Weeki Wachee National Weather Service (NWS), and Brooksville Chinsegut Hill NWS site (WMIS Site ID's 20915 and 20573 respectively). The rainfall regression model was based on historic data from 1975 to 1990. The resulting lake level rainfall model had a correlation coefficient of determination (r^2) equal to 0.74. The model was then applied to predict the lake stage for the long term Historic time period of the 1946 to 2011. This sixty-four-year period was considered sufficient for incorporating the range of lake stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield *et al.* 2001, Basso and Schultz 2003). These actual lake stage measurements and the final rainfall regression model representing un-impacted conditions are graphed in Figure 10a and b.

The highest historic water levels generally hovered near or above 25 ft (similar to the recorded high of 22.7 ft) and occurred four times; each time lasting several years in succession (Figure 10b). The predicted extreme high water level was 30.1 ft and occurred September-October 1960 (hurricane Donna). Historic low water levels were generally near 11 ft (similar to the record low of 11.0) and also occurred four times but generally occurred in one month intervals. The historic extreme low water level was 10.9 ft and occurred twice, once in February 1957 during the well documented droughts of the 1956-1957 and again in June of the 2001 drought. Figure 11 illustrates the

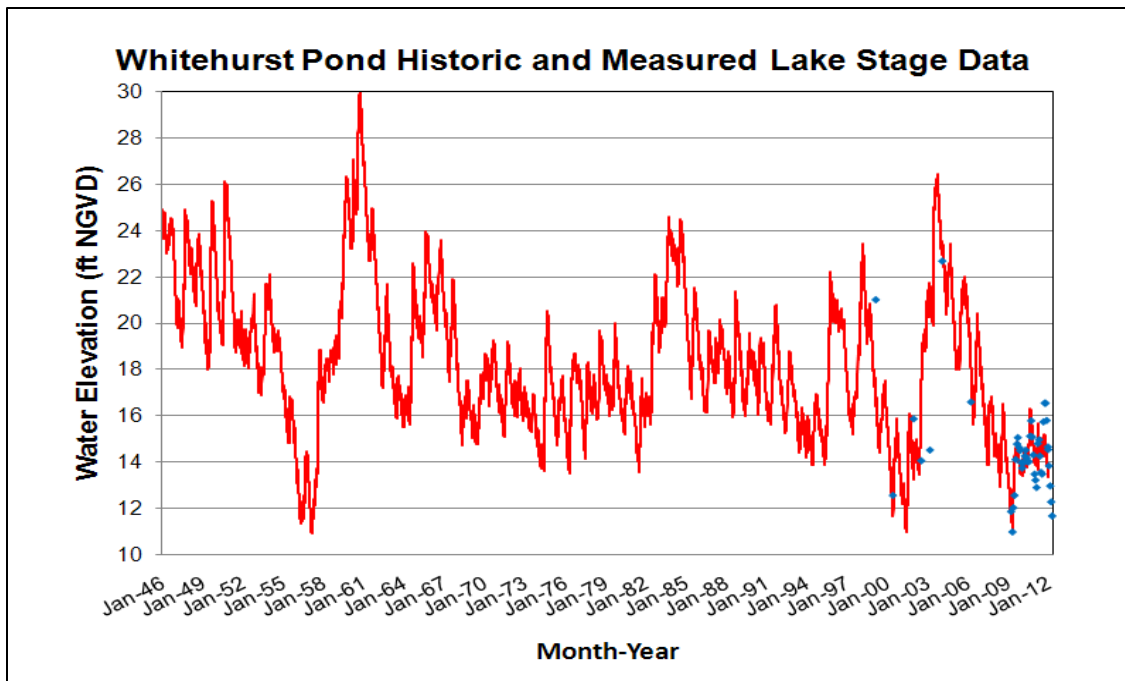


Figure 10a. January 1946 – March 2010 modeled long term historic lake stage (red line) and April 1999 – July 2012 measured lake stage (blue markers) as monthly means.

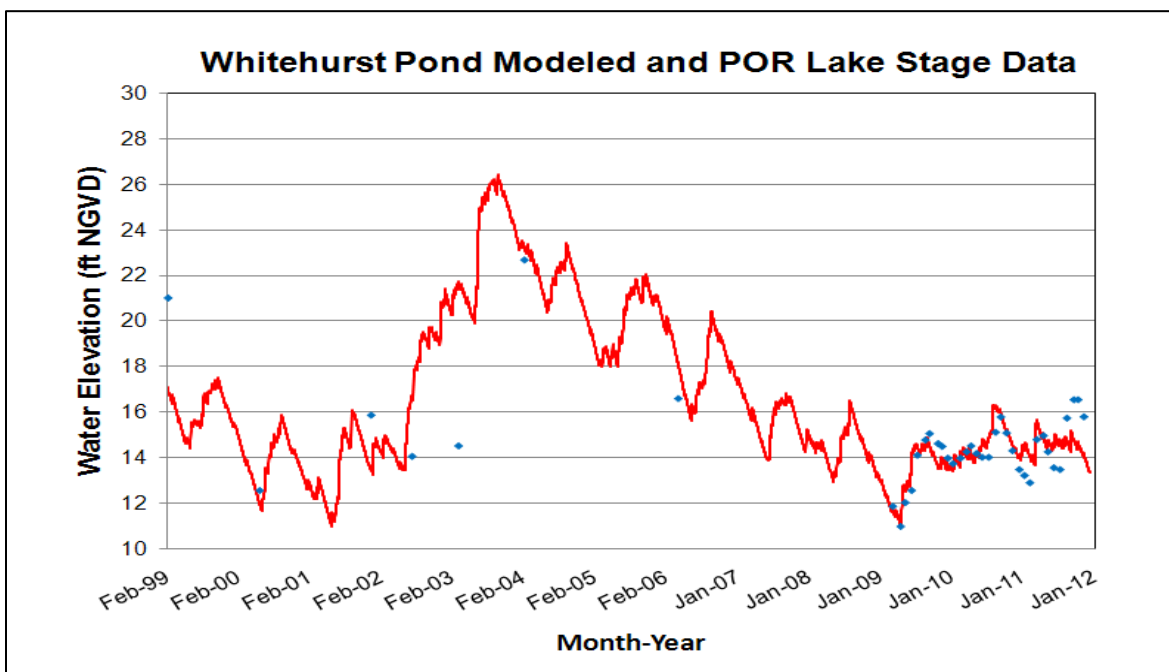


Figure 10b. February 1999 – December 2011 modeled long term historic lake stage (red line) and measured lake stage (blue line) records for Whitehurst Pond.



Figure 11. Periods of extreme historic high and low water levels for Whitehurst Pond. These levels are based on stage data since 1946 as associated with conditions observed on a December 2010 aerial imagery.

historic periods of high and low water levels since 1946 on a 2010 aerial photograph. Specific dates associated with these historic high and low water levels are given.

The final modeled historic lake stage data set comprised was used to calculate the Historic P10, P50, and P90 lake stage percentile elevations (Figure 12, Table 2). The **Historic P10** elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was **23.0 ft.** The **Historic P50** elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was **18.1 ft.** The **Historic P90** elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period, was **14.6 ft.**

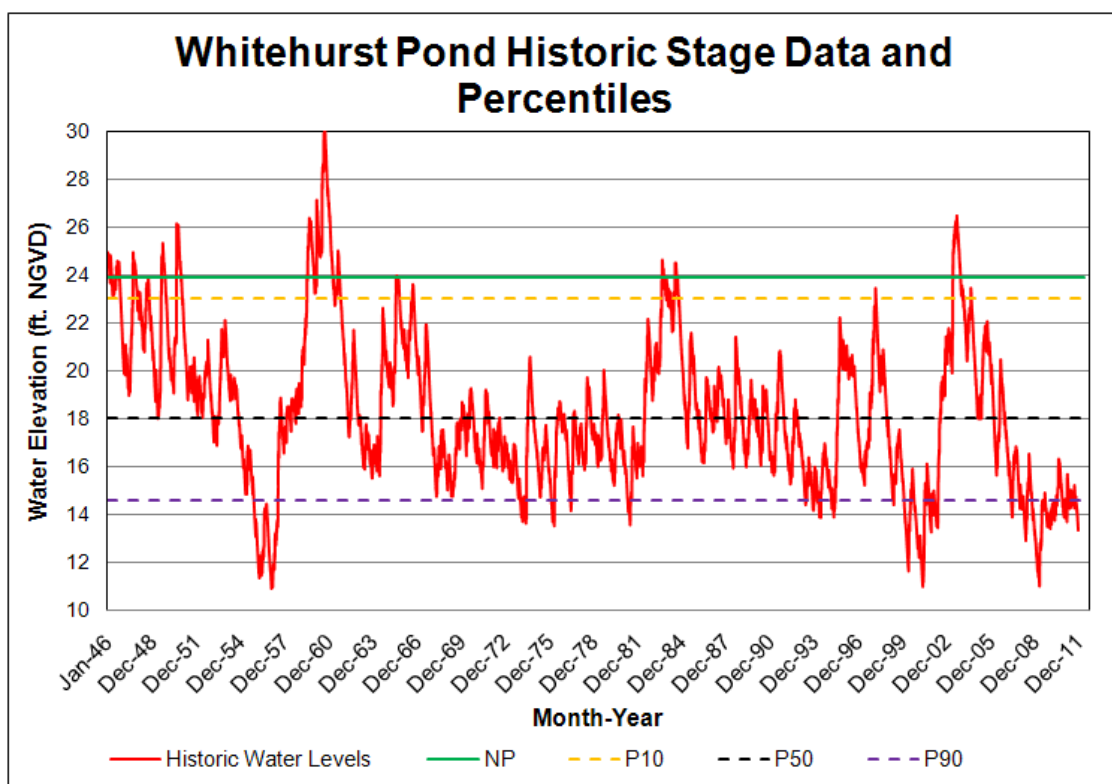


Figure 12. Whitehurst Pond Historic Lake Stage used to calculate the Historic P10, P50, and P90 Lake Stage Percentile and Normal Pool Elevations for Whitehurst Pond from January 1946 through December 2011. Historic P10, P50, and P90 are depicted as horizontal lines. Lake stage elevations are in feet above NGVD 29.

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, including biological and physical features. Based on ground

elevations measured in January 2012 at the bases of saw palmetto (*Serenoa repens*) along the north shore of the lake (Figure 3), the **Normal Pool** elevation was established at **23.9 ft**. There are no structures, buildings or paved roads adjacent to the lake. The nearest paved road is at 32.1 ft southwest of the lake but is unaffected by the lake. The land slopes upward to an elevation of 40 ft between the lake and road.

The **Control Point** 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. There is no Control Point at Whitehurst Pond. The lake is isolated and has no control point that influence water level fluctuations in the lake. However, based on review of a contour aerial map at an interval of two tenths of a foot, a narrow, naturally high “saddle” was found on the northeast shore. This potential connection across the power line corridor will likely occur at 30.6 ft. A small area of upland coniferous forest surrounded by longleaf pine xeric oak forest likely was hydrated by the lake during this period. The nearest the lake got to this height according to the predicted lake stage was in 1960 as a result of hurricane Donna. Water levels during 1958-59 were similar to those that occurred in 2003 and preceded the peak level of 27 ft estimated for 1960. During the 1960 hurricane season, 27 inches fell in a four day period (SWFWMD 2011), followed by hurricane Donna which was associated with up to 14 inches of rainfall during a three-day period in September 1960 (SWFWMD 2002). Under these conditions, Whitehurst Pond was approximately six feet above the Normal Pool and 17 ft deep near the center.

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 **23.0 ft** (Figure 13, Table 2). This elevation is very similar to the Normal Pool elevation estimated at 21.5 ft.

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 Whitehurst Pond, the **Low Guidance Level** was established at **14.6 ft** (Figure 13, Table 2).

Lake Classification

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

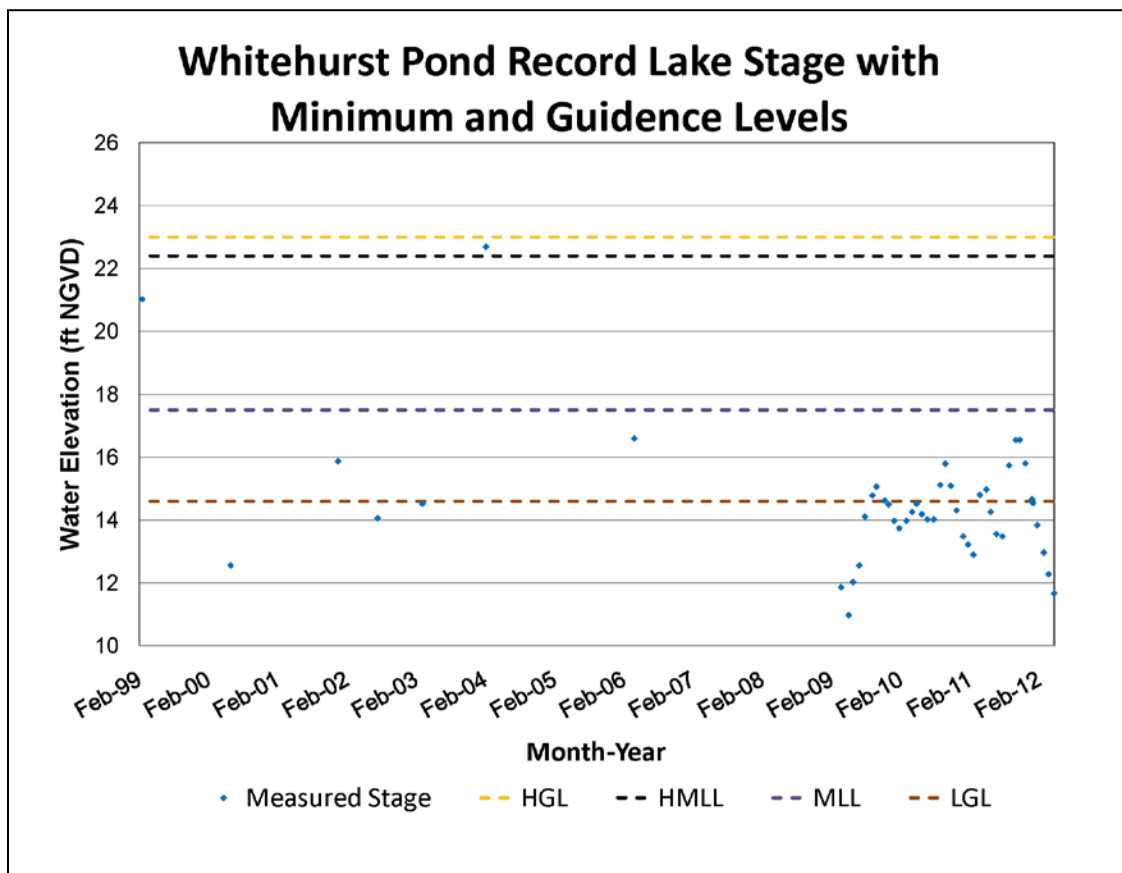


Figure 12. Mean monthly historic lake stage and Minimum and Guidance Levels for Whitehurst Pond. levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL), and the Low Guidance Level (LGL).

Significant Change Standards and Other Information for Consideration

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

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

The **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. The Whitehurst Pond basin is contiguous without lobes as many lakes in west Hernando County, however, there is a separation between the lake itself and the small sink on the southern edge. A review of the LIDAR elevation data indicated that the **Critical High Spot** connecting the sink to the lake is at **21.0 ft**. The **Basin Connectivity Standard** for Whitehurst Pond is established at **26.0 ft**, based on the sum of the elevation that ensures connectivity (21.0 ft), a two-foot clearance value for movement of biota and potential use of powerboats on the lake, and the difference between the Historic P50 and Historic P90 (3.5 ft). The Connectivity Standard corresponds to the historic P2 (HP2). Because it is considerably higher than the HP50 (Table 3), it is deemed inappropriate for development of a Minimum Lake Level for Whitehurst Pond.

The **Wetland Offset** is developed to protect herbaceous wetlands associated with a lake. The standard is based on a review (Hancock 2006) of minimum level methods used for cypress-dominated wetlands, and specifies that up to an 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. Because herbaceous wetlands could potentially be common within the Whitehurst Pond basin without the excessive off-road vehicle traffic, the Wetland Offset was determined by subtracting 0.8 ft from the Historic P50 elevation. The **Wetland Offset** for Whitehurst Pond is established at **17.3 ft** and was equaled or exceeded 57 percent of the time.

Therefore, based on the Historic water level record the Wetland Offset corresponds to the Historic P57.

The **Species Richness Standard** is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes, the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. See Figure 13 for a plot of lake surface area versus lake stage. The Species Richness Standard is established at **17.5 ft**. The Species Richness Standard was equaled or exceeded 55 percent of the time, based on the long term Historic water level record. The Species Richness standard is the closest standard below the P50, and corresponds to the Historic P55.

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 (used here), or a rectangular ski area 200 ft in width and 2,000 ft in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. The **Recreation/Ski Standard** is established at **25.7 ft** for Whitehurst Pond, based on the sum of the elevation at which the lake could contain an area suitable for safe skiing (17.4 ft) and the difference between the Historic P50 and Historic P90 (3.5 ft). The Recreation/Ski Standard was equaled or exceeded 2 percent of the time, based on the long term Historic water level record. Because the standard corresponds to the Historic P2, is considerably higher than the HP50 and the lake is not considered to be structurally altered, the standard was deemed inappropriate for development of a Minimum Lake Level for Whitehurst Pond.

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 **14.6 ft** for Whitehurst Pond. 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 **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 or region-specific reference lake water regime statistics. Development of the **Dock Use Standard** was **not applicable** for Whitehurst Pond due to lack of docks on the lake.

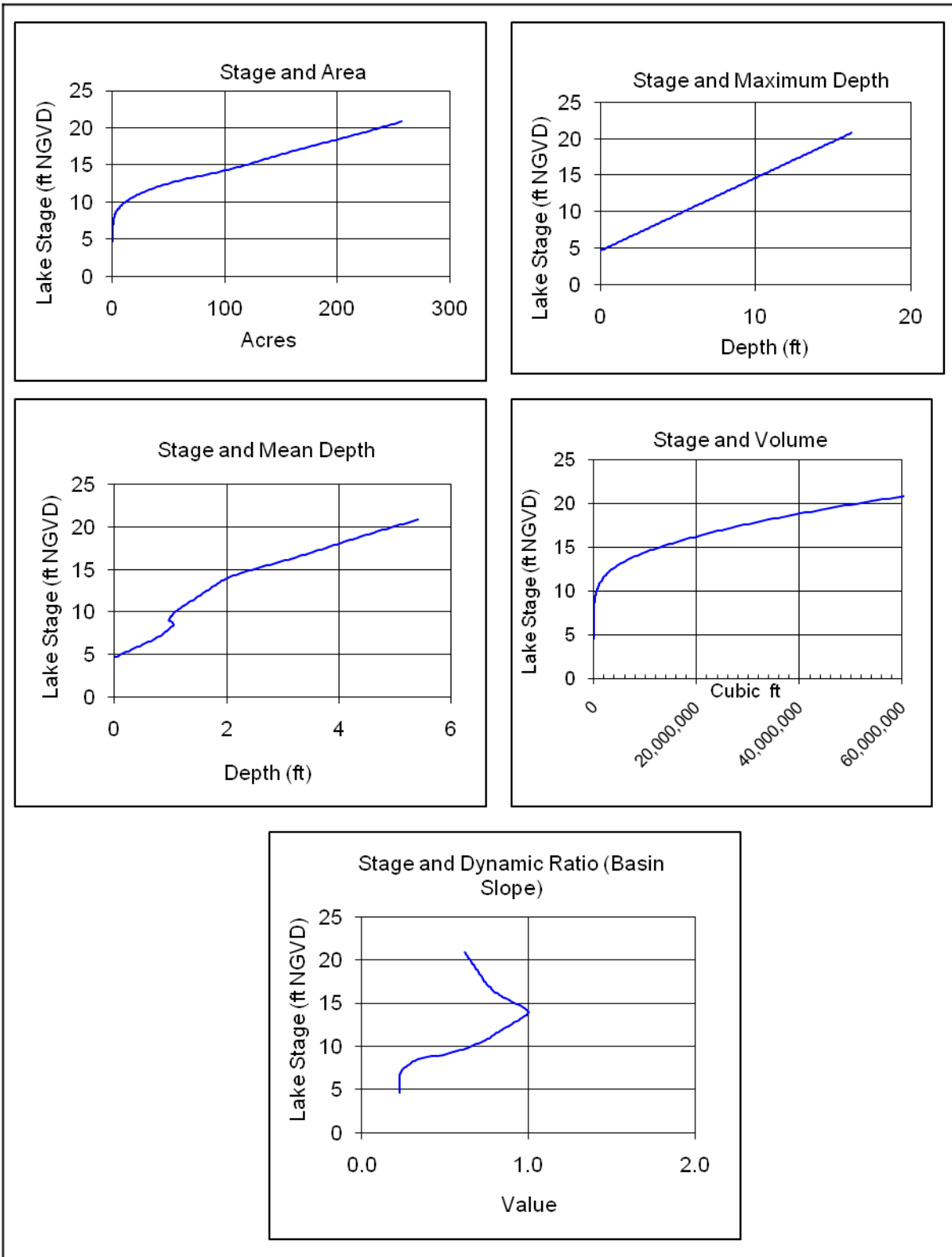


Figure 13. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope) in Whitehurst Pond as a function of lake stage (water surface elevation).

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). The **Mixing Standard** for Whitehurst Pond is established at **18.4 ft**. The Mixing Standard was equaled or exceeded 44 percent of the time, based on the long term Historic water level record. This standard elevation is above the HP50 (Table 2) and corresponds to the Historic P44.

Information on **herbaceous wetlands** is taken into consideration when developing minimum lake levels. This is accomplished by determining the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e.*, basin area with a water depth of four or less feet) (Figure 14). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values (*i.e.*, basin area with a water depth of 5.5 ft or less) (Figure 14). Review of changes in potential herbaceous wetland area or area available for submersed aquatic plant colonization in relation to change in lake stage did not indicate that use of any of the significant change standards would be inappropriate for establishment of the Minimum Lake Level for Whitehurst Pond.

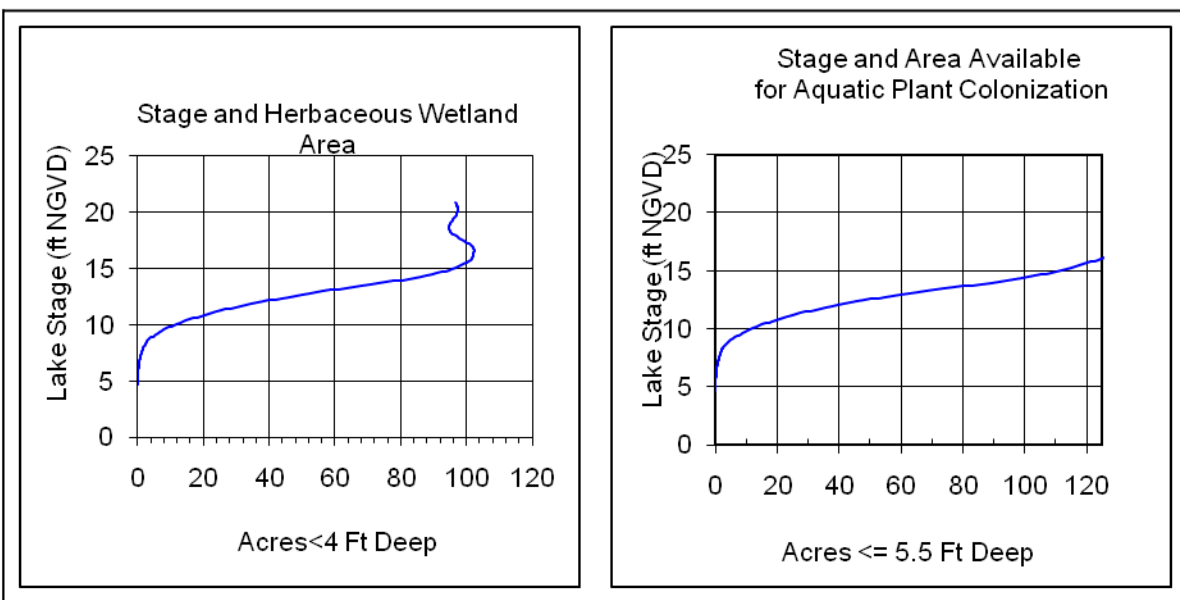


Figure 14. Potential herbaceous wetland area and area available for submersed macrophyte colonization in Whitehurst Pond as a function of lake stage (water surface elevation).

Minimum Levels

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

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 Lakes such as Whitehurst Pond, the Minimum Lake Level is typically established at the elevation corresponding to the most conservative significant change standard, *i.e.*, the standard with the highest elevation, except where that elevation is above the Historic P50 (Table 2) elevation. Based on elevations associated with appropriate standards developed for Whitehurst Pond, the **Minimum Lake Level** was established at the **Species Richness Standard (17.5 ft)**. Establishing the MLL level at the Species Richness elevation is expected to afford protection to the natural system and human-use values associated with all appropriate significant change standards identified for the lake while also providing protection for herbaceous wetlands occurring within the basin.

The **High Minimum Lake Level (HMLL)** is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For Category 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. If Historic Data are available, the High Minimum Lake Level is established at an elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level is set at an elevation corresponding to the Minimum Lake Level plus the region-specific RLWR50, which is the difference between the Historic P10 and P50 for a set of reference lakes. Based on the availability of long term Historic data for Whitehurst Pond, the **HMLL** is established at **22.4 ft**, by adding the difference between the Historic P50 and Historic P10 (4.9 ft) to the Minimum Lake Level.

The Minimum and Guidance levels for Whitehurst Pond are shown in Figure 12 along with surface water elevations based on historic water levels. The levels are also shown as contour lines on historic aerial photographs (Figures 15 – 18). The most recent (2010) and oldest (1944) aerial photographs available are represented in Figures 15 and 18 (respectively). Figure 16 presents a 2007 aerial which illustrates water levels near the historic extreme low. Figure 17 presents a 1984 aerial which illustrates water levels near the extreme high. Unfortunately, aerial photography is not available that would show the extreme water levels in 1960.

Compliance Evaluation

Compliance with the Minimum Lake Level and High Minimum Lake Level was evaluated using the rainfall model that was used to develop the long term Historic lake stage exceedance percentiles (Ellison 2012). The model was used to evaluate whether measured lake stage value fall within prediction intervals established for the calibration window or time period used for model development. Water levels in Whitehurst Pond were determined to be in compliance with both the Minimum Lake Low Level and High Minimum Level based on rainfall data available through December 2011.

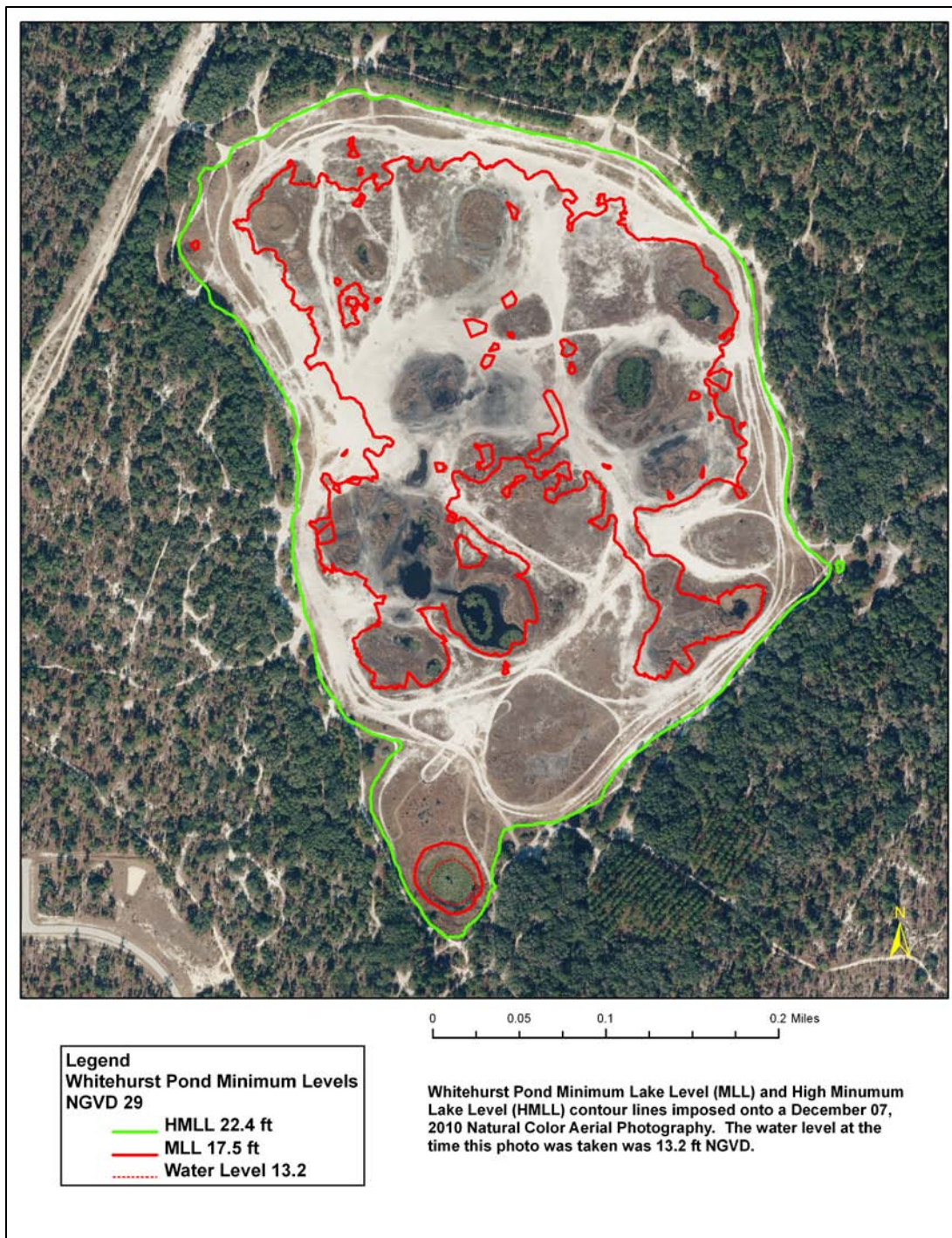


Figure 15. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Whitehurst Pond relative to conditions on December 07, 2010. Based on gage readings, the estimated lake stage was 13.2 ft on the date of the imagery.

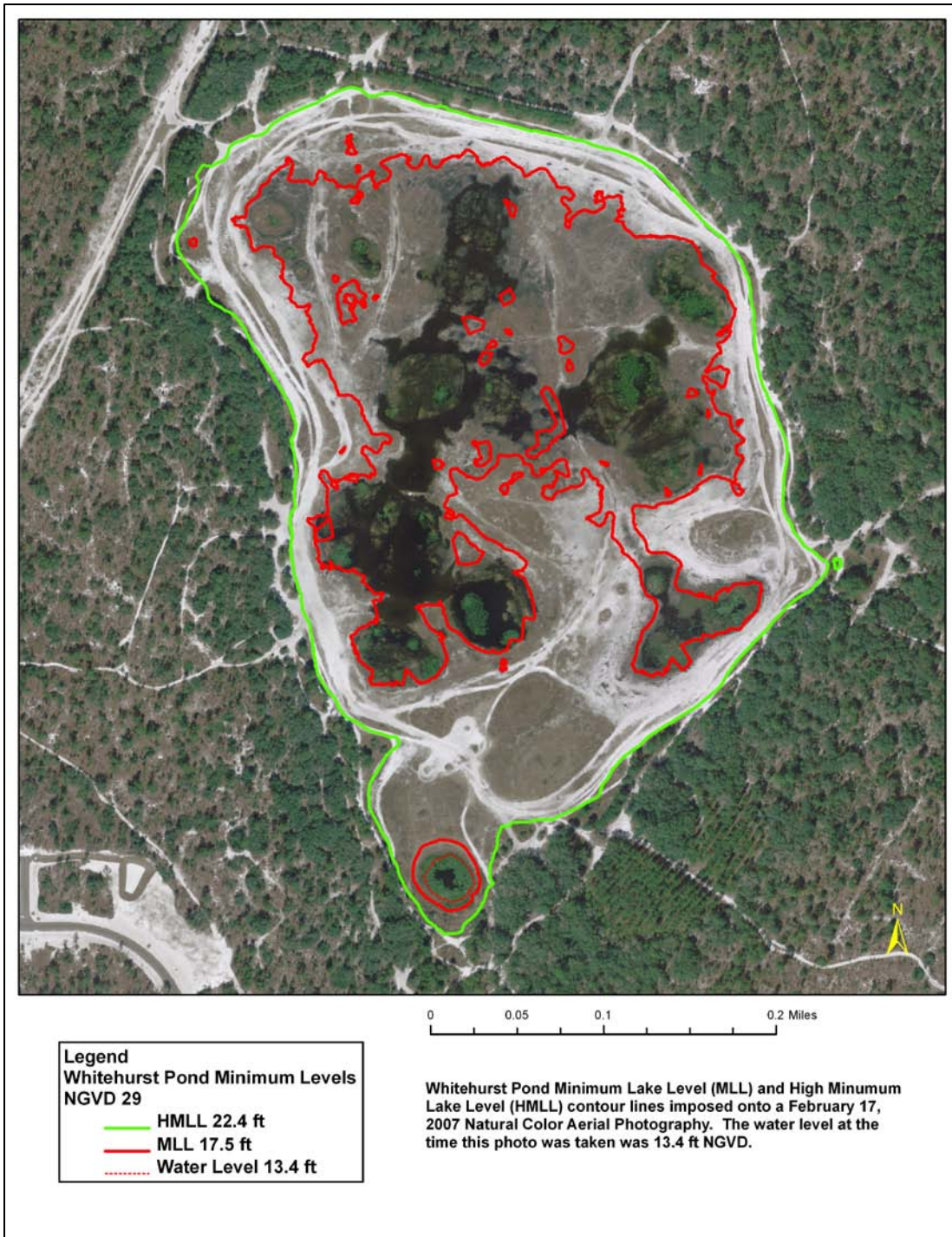


Figure 16. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Whitehurst Pond relative to conditions on February 17, 2007. Based on gage readings the estimated lake stage was 13.4 ft.

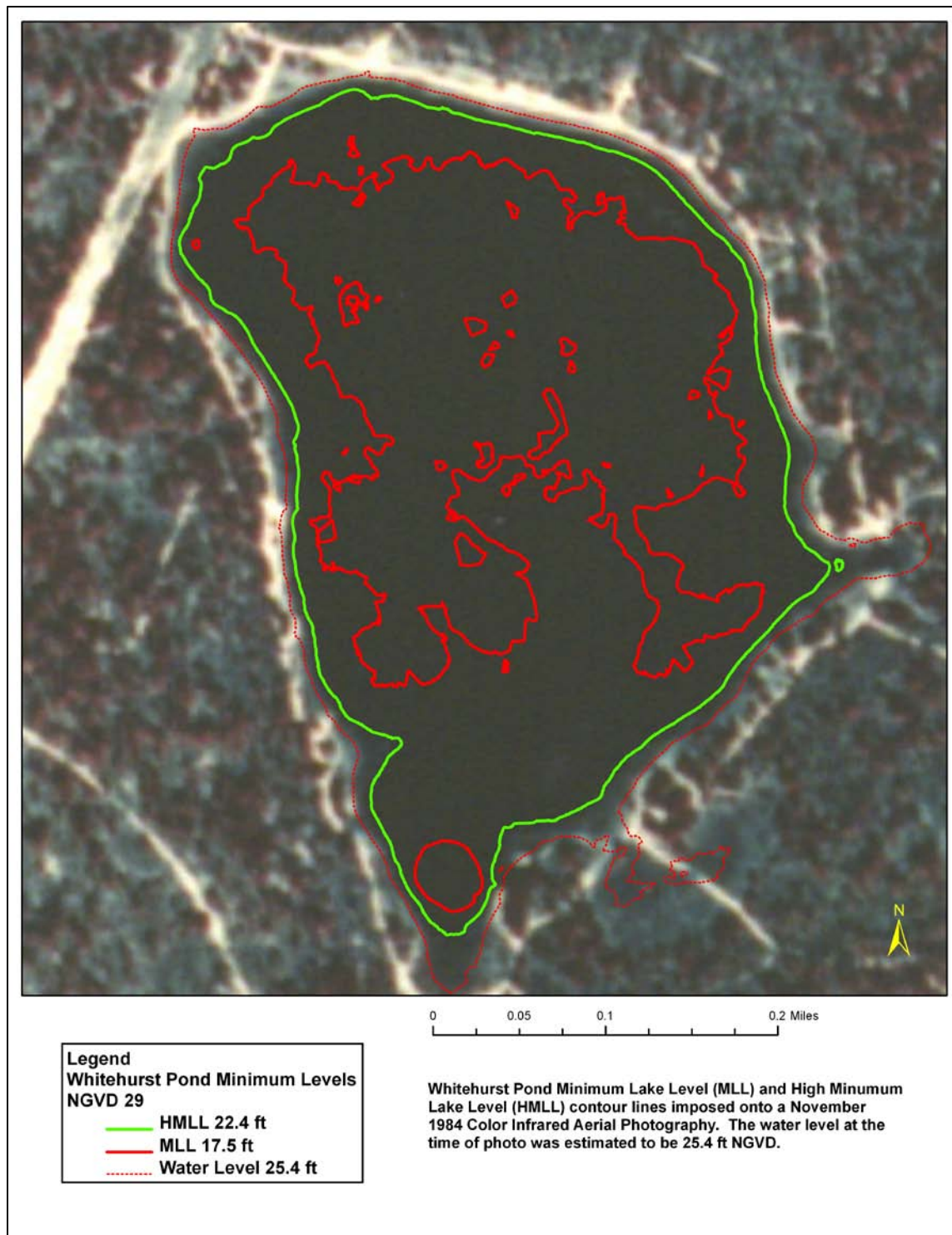


Figure 17. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Whitehurst Pond relative to conditions on November 1984. Based on interpretation of contour lines at the lake edge at the time of this imagery, the lake stage was estimated at 25.4 ft.

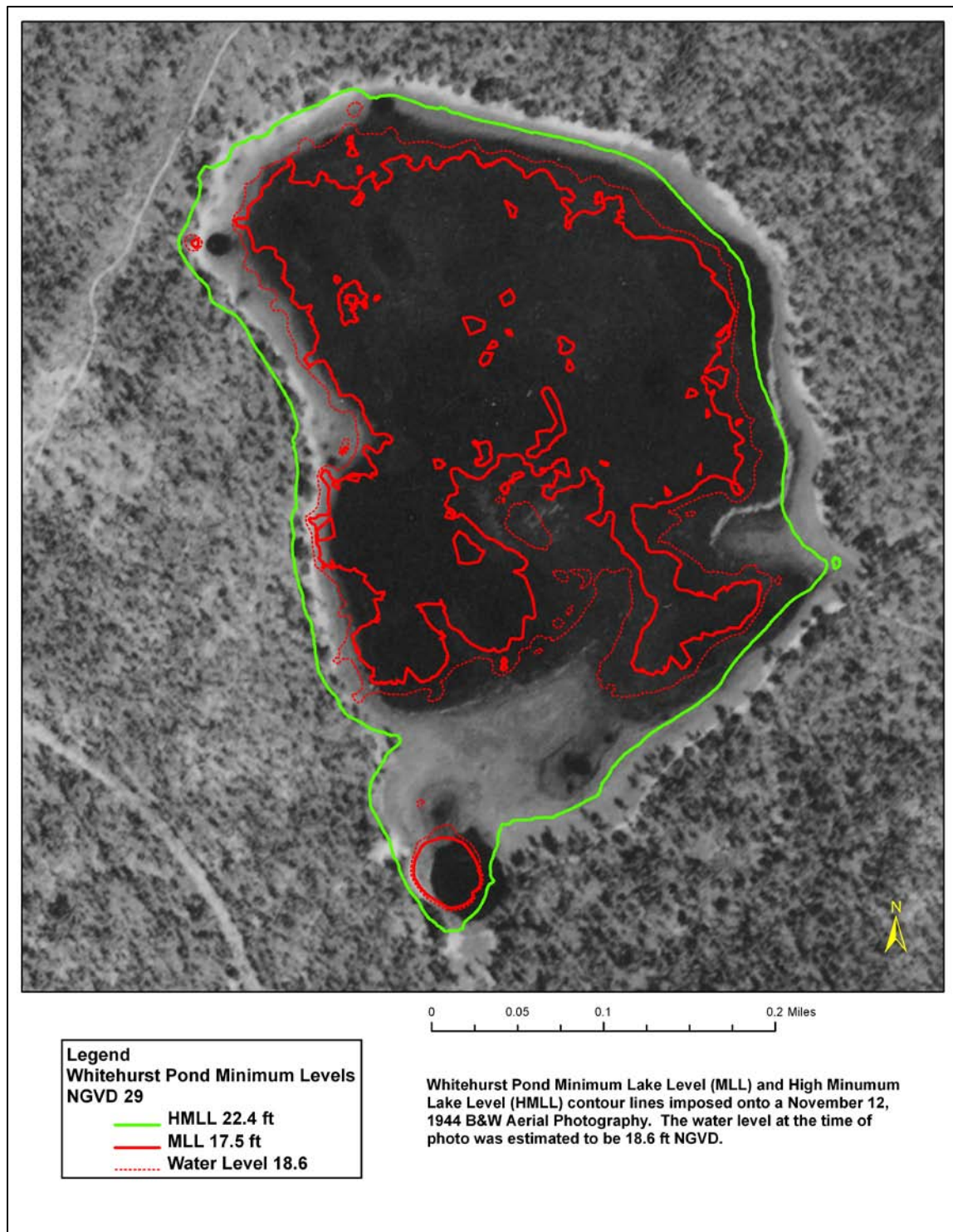


Figure 18. Approximate location of water level (i.e., shoreline) associated with the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Whitehurst Pond relative to conditions on November 12, 1944. Based on interpretation of contour lines at the lake edge at the time of this imagery, the lake stage was estimated at 18.6 ft.

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