# Minimum and Guidance Levels for Lake Crystal in Polk County, Florida

*Photographs circa 1921*

December 30, 2010

Ecologic Evaluation and Hydrologic Evaluation Sections
Resource Projects Department

Southwest Florida
Water Management District

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**Cover: View of Lake Crystal shoreline in 1921 (source: State Library and Archives of Florida – Florida Memory Project).**

# Table of Contents

# Minimum and Guidance Levels for Lake Crystal

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 (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 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 (1999), Leeper *et al.* (2001) and Leeper (2006). Peer-review findings regarding the lake level methods are available in Dierberg and Wagner (2001) and Wagner and Dierberg (2006).

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

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

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

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

- The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's

water levels are expected to equal or exceed ninety percent of the time on a long-term basis.

In accordance with Chapter 40D-8, F.A.C., proposed Minimum and Guidance Levels were developed for Lake Crystal, a Category 3 Lake located in Polk County, Florida. The levels were established using best available information, including field data that were obtained specifically for the purpose of minimum levels development. Following a public input process, the District Governing Board approved the levels (Table 1) for adoption and incorporation into Chapter 40D-8, F.A.C. on December 14, 2010. Staff prepared amendments to Rule 40D-8.624, F.A.C. that replace the original or previously adopted minimum and guidance levels established in 1991 (see Table 2) with the revised or updated minimum and guidance levels described in this report and approved by the District Governing Board. The amendments have been approved by the Governing Board for adoption into Chapter 40D-8, F.A.C. The amendments will become effective once the rulemaking process is completed which is anticipated to occur within the next few months. The data and analyses used for development of the updated adopted levels are described in the remainder of this report.

All elevation data values shown within this report on graphs, bathymetric maps, and within tables are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29). In some circumstances notations are made for data that was collected as North American Vertical Datum of 1988 (NAVD 88) and converted 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 Lake Crystal.**

| Minimum and Guidance Levels | Elevation in Feet |
|---|---|
| | NGVD 29 |
| High Guidance Level | 118.3 |
| High Minimum Lake Level | 117.5 |
| Minimum Lake Level | 114.2 |
| Low Guidance Level | 112.7 |

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

## Lake Setting and Description

Lake Crystal is located in Polk County, Florida (Section 02 Township 30 South, Range 27 East), in the Peace River Basin of the Southwest Florida Water Management District (Figure 1). The area surrounding the lake is categorized as the Iron Mountains subdivision of the Lake Wales Ridge in the Central Lake Physiographic District (Brooks 1981); a region of residual sand hills underlain by sand, gravel, and clayey sand. As part of the Florida Department of Environmental Protection's Lake Bioassessment / Regionalization Initiative, the area has been identified as the Northern Lake Wales Ridge lake region and described as an area of alkaline, low to moderate nutrient, clearwater lakes (Griffith *et al.* 1997).

The lake is located in the Lake Wales (also named Lake Wailes) drainage basin within the Peace Creek watershed. The lake has a drainage area of 114 acres (SWFWMD 2007). Surface water inflow to Lake Crystal consists of stormwater drainage from urbanized areas west, north, and south of the lake, and overland flow from the surrounding residential areas. There are no major, natural surface water systems draining into the basin, although numerous stormwater systems discharge directly into the lake. Lake Crystal discharges to the east through a shallow ditch and underground stormwater conveyance system to Lake Wales (Figure 2) (SWFWMD 2007).

A topographic map of the lake basin generated in support of Minimum Levels development (Figure 3) indicates that the lake size is approximately 12 acres at an elevation of 120 NGVD 29 and 8.6 acres at an elevation of 114 NGVD 29. Data used for production of the topographic map and bathymetric maps were obtained from field surveys collected in 2006 and from Light Detection and Ranging (LiDAR) data collected in 2005.

There are permitted ground water withdrawals within the surrounding lake area, but there are no surface water withdrawals from the lake currently permitted by the District. There is public foot access to the lake through the recreational park facility located on the east side of the lake.

The landscape of the surrounding lake area is comprised of residential and some commercial development within the western drainage areas (Figure 2). Although most of the lake watershed is dominated by urban land use, no homes are located directly on the lake (Figure 2) and the lake is surrounded by a fringe of undeveloped land. The dominant plant species observed along the shoreline is primarily torpedo grass (*Panicum repens*). A line of large live oak trees is located along the north shoreline and was referenced as a historic seasonal high water indicator (Figure 2).

**Figure 1. Regional and general location of Lake Crystal within the City of Lake Wales in Polk County, Florida.**

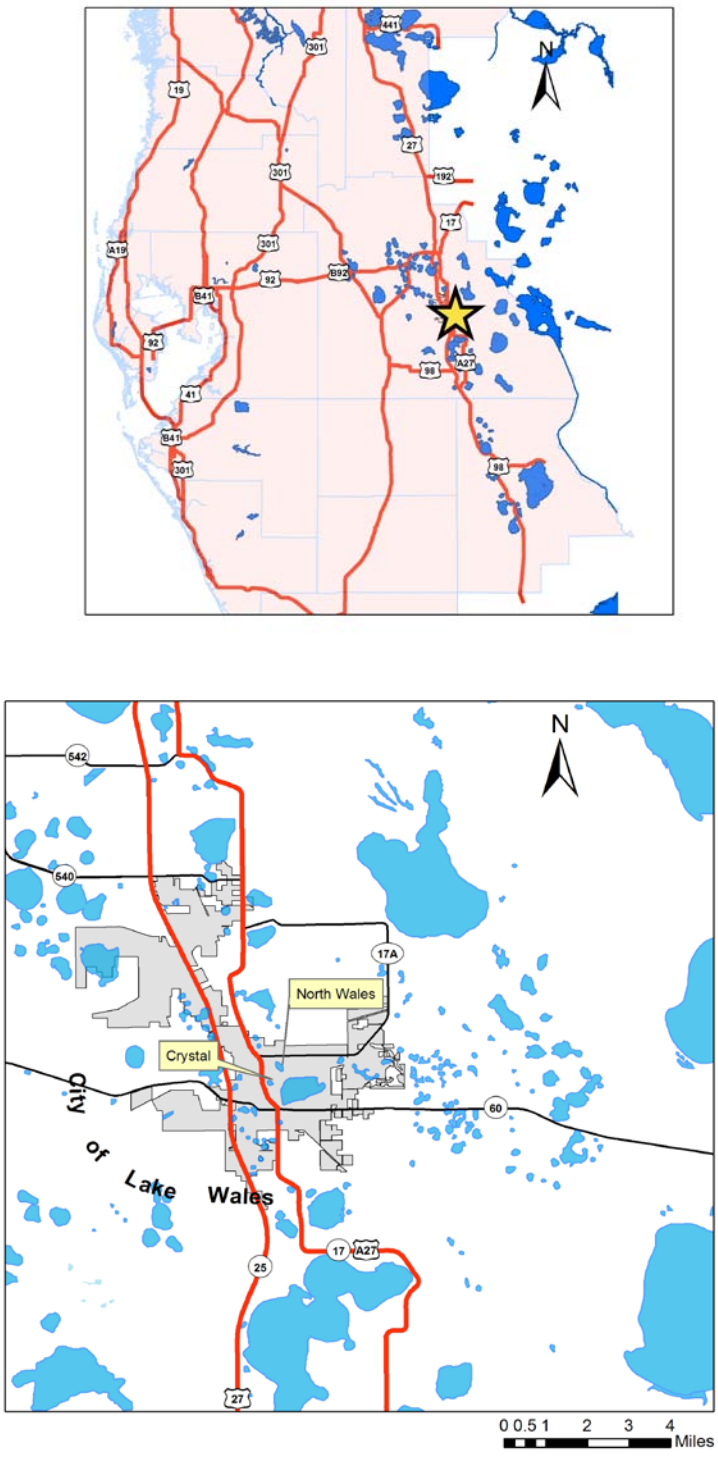
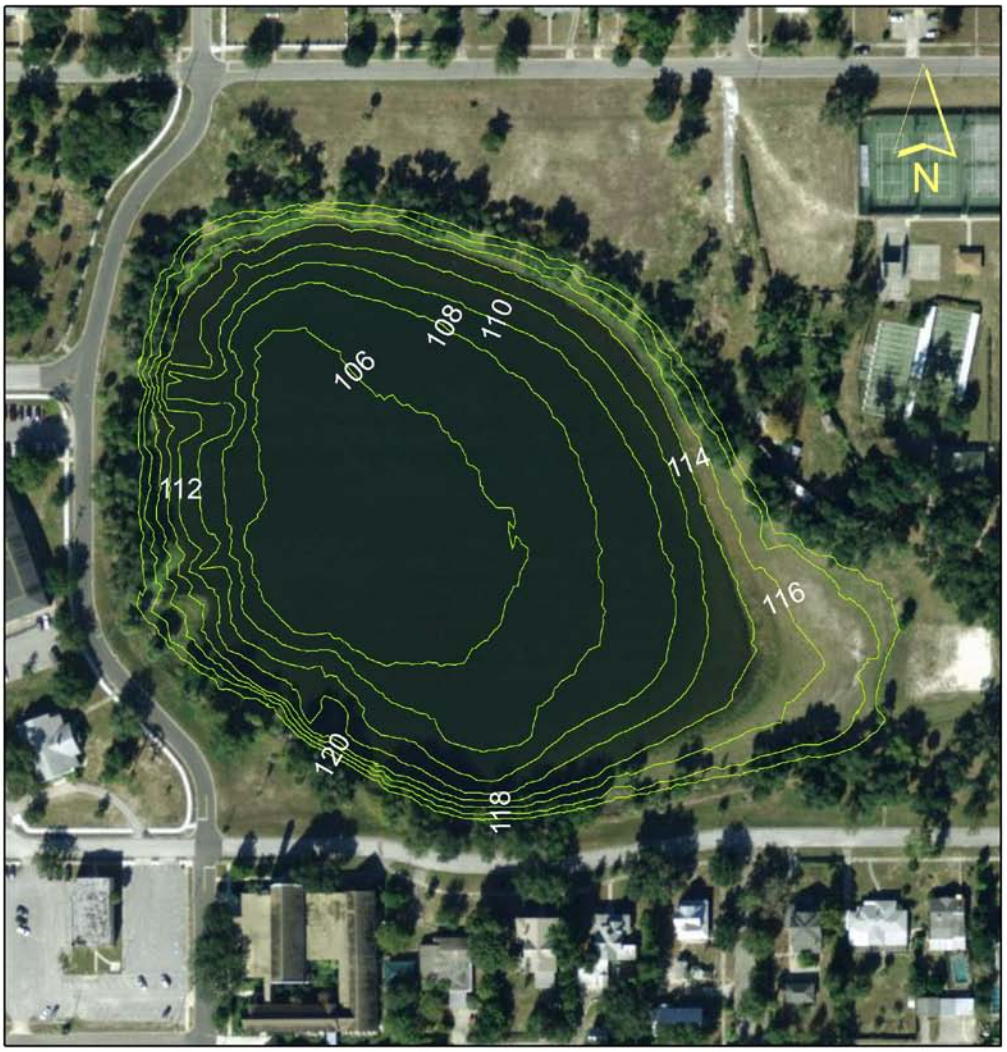


**Figure 2. Location of the lake water level gage, historic seasonal high water indicators, outlet, and control point for Lake Crystal.**

**Figure 3. Two-foot contours within the Lake Crystal basin. Values shown are elevations as NGVD 29.**




Contours were prepared using a combination of LIDAR data and spot elevation data. LIDAR was collected in 2005 by EarthData International, and spot elevation data was collected by D.C. Johnson and Associates in 2006. Background imagery is true color digital orthophotography collected in 2010.

## 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 an initiative for establishing lake management levels based on hydrologic, biological, physical and cultural aspects of lake ecosystems. By 1996, management levels for nearly 400 lakes had been established.

Based on work conducted in the 1970s (see SWFWMD 1996), the District Governing Board adopted management levels (currently referred to as Guidance Levels) for Lake Crystal in August 1991 and incorporated the levels into Chapter 40D-8, F.A.C. The Guidance Levels adopted included a High Level of 121.25 NGVD 29, a Low Level of 118.00 NGVD 29, and an Extreme Low Level of 115.0 NGVD 29 (Table 2). A Maximum Desirable Level of 121.00 NGVD 29 was also developed, but was not adopted. 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.

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program. As described in the District's Consumptive Use of Water Rule (Chapter 40D-2, F.A.C.), "a stressed condition for a lake is defined to be chronic fluctuation below the normal range of lake level fluctuations". For lakes with adopted Guidance Levels, chronic fluctuation below the Low Level is considered a stressed condition. For lakes without adopted levels, evaluation of stressed condition is conducted on a case-by-case basis. Lake Crystal was included on the Stressed Lakes List for 2008, 2009, and 2010 (Gant 2008, 2009, 2010).

**Table 2. Previously adopted Guidance Levels for Lake Crystal.**

| Guidance Levels | Elevation in Feet NGVD 29 |
|---|---|
| High Level (Min Flood) | 121.25 |
| Low Level | 118.00 |
| Extreme Low Level | 115.00 |

# Summary Data Used for Minimum and Guidance Levels Development

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

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

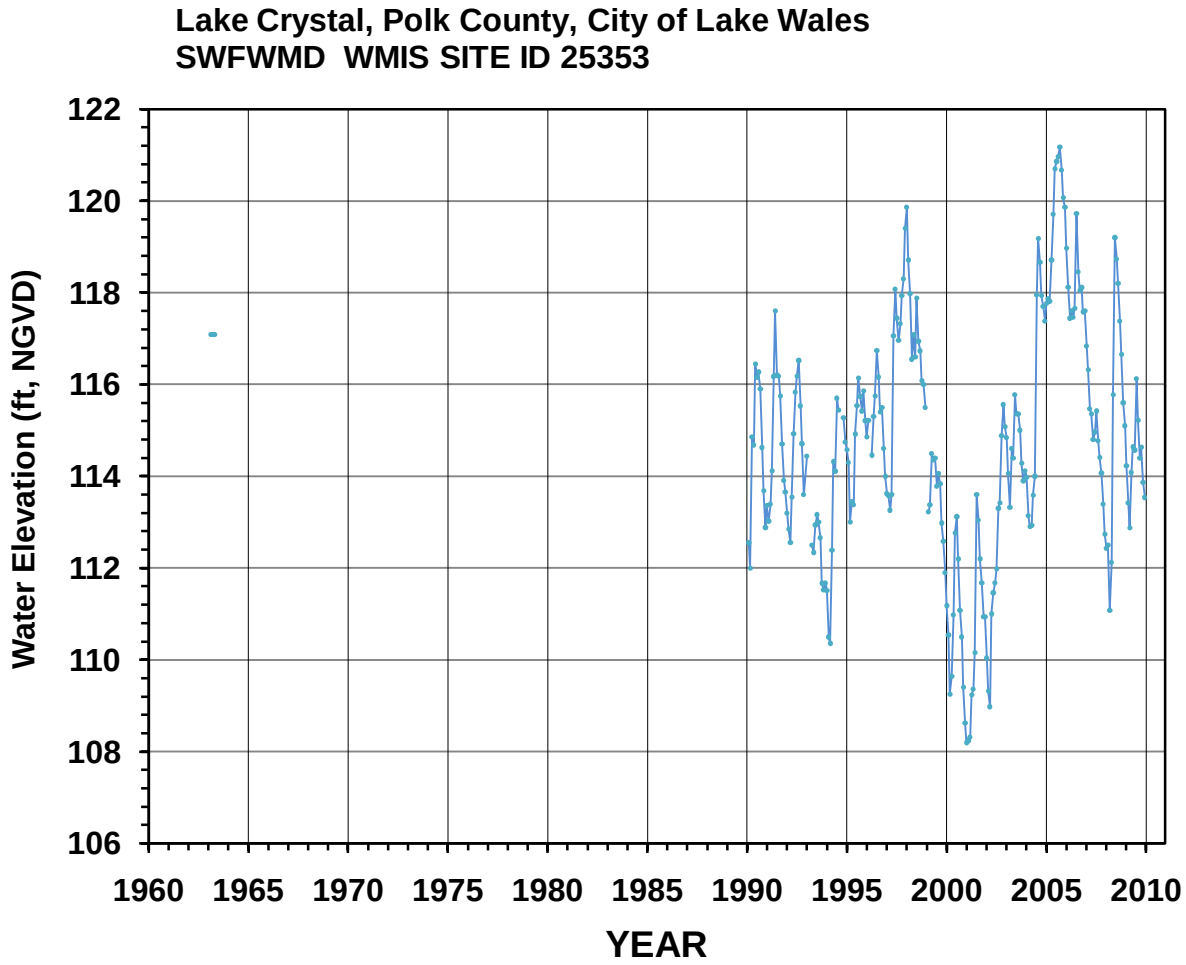
| Levels | Elevation in Feet NGVD 29 | Lake Area (acres) |
|---|---|---|
| **Lake Stage Percentiles** | | |
| Period of Record (POR) P10 | 118.1 | 10.8 |
| Period of Record (POR) P50 | 114.6 | 8.9 |
| Period of Record (POR) P90 | 111.2 | 6.8 |
| Long Term Historic P10 (composite of modeled and POR) | 118.3 | 7.8 |
| Long Term Historic P50 (composite of modeled and POR) | 115.0 | 9.1 |
| Long Term Historic P90 (composite of modeled and POR) | 112.7 | 10.9 |
| **Normal Pool and Control Point** | | |
| Normal Pool | NA | NA |
| Control Point | 120.8* | 11.6 |
| **Significant Change Standards** | | |
| Wetland Offset Elevation | 114.2 | 8.7 |
| Aesthetics Standard | 112.7 | 7.8 |
| Species Richness Standard | 112.7 | 7.8 |
| Recreation/Ski Standard | NA | NA |
| Dock-Use Standard | NA | NA |
| Basin Connectivity Standard | NA | NA |
| Lake Mixing Standard | NA | NA |
| **Minimum and Guidance Levels** | | |
| High Guidance Level | 118.3 | 11.0 |
| **High Minimum Lake Level** | **117.5** | 10.5 |
| **Minimum Lake Level** | **114.2** | 8.7 |
| Low Guidance Level | 112.7 | 7.8 |

NA = not available/not appropriate; * = control point surveyed as NAVD 88 and converted to NGVD 29

## Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.,* surface water elevations for Lake Crystal relative to NGVD 29 were obtained from the District's Water Management Information System (WMIS) data base (Site Identification Number 25350). The period of record for the data extends from April 1990 through the present date (Figure 4, see Figure 2 for current location of the SWFWMD lake water level gauge), with one data point recorded in May of 1963. The highest surface water elevation for Lake Crystal recorded in the Water Management Information System, 121.17 NGVD 29, occurred on November 08, 2005. The low of record, 108.20 NGVD 29 occurred on March 27, 2001. Based on available lake stage data, monthly mean lake surface elevations were calculated and graphed (Figure 4). The data record for Lake Crystal from 1990 to present is not continuous, *i.e.*, there are some months during the period of record when lake surface elevations were not recorded.

**Figure 4. Monthly surface water elevations (NGVD 29) through March 2010 for Lake Crystal.**



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. Lake stage data for the entire period of record (1963 to 2010) for Crystal Lake are classified as Historic. The lake was determined to have no measureable impacts associated with withdrawals as the result of its perched geomorphology. This determination was made through a water budget and leakage analysis completed by the Hydrologic Evaluation Section (Ellison and Said 2010, draft report).

Although the period of record of lake stage data for Lake Crystal are classified as Historic data, the data set is limited to records from the past two decades with only one data point from 1963 (Figure 4) and a data gap existing from 1963 to 1990. The relatively short period of continuous record from 1990 to 2010 is limited in its usefulness for its long term characterization of water level fluctuation within the basin.

A long term Historic data set of monthly mean lake surface elevations (Figures 5a) for Lake Crystal was developed using a sixty-four-year record of modeled Historic and measured lake surface elevations for the period of January 1946 through February 2010. The 64 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. The modeled Historic lake was based on rainfall measured at the Mountain Lake rain gage (WMIS Site ID 25147) from January 1946 to February 2010. The resulting lake level rainfall model had a coefficient of determination ($r^{2)}$ of 0.74, based on use of a six-year linear decay series of cumulative monthly rainfall values. The most accurate representation of long term Historic water level fluctuations was a composite data set that consisted of the modeled Historic water level (1946 to 1990) and the period of record of measured lake stage data (1990 to 2010) (Figure 5b).

The long term composite Historic data set of modeled lake stage and measured lake stage (Figure 5b) was used to calculate the **Historic P10, P50, and P90** lake stage percentile elevations (Figures 5a and 5b). The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was **118.3 NGVD 29.** The Historic P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was **115.0 NGVD 29**. The elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period or Historic P90 elevation, was **112.7 NGVD 29.**

**Figures 5a and 5b: 5a. Modeled long term Historic lake stage (as monthly means, see blue line) and measured lake stage (also as monthly means, see red dotted line). 5b. Composite of modeled long term Historic lake stage and measured lake stage (both as monthly means) used to calculate the Long Term Historic P10, P50, and P90 lake stage percentile elevations for Lake Crystal from January 1946 through February 2010. The long term Historic P10, P50, and P90 are depicted as horizontal lines. Lake stage elevations are in feet above NGVD 29.**

Figure 5a.

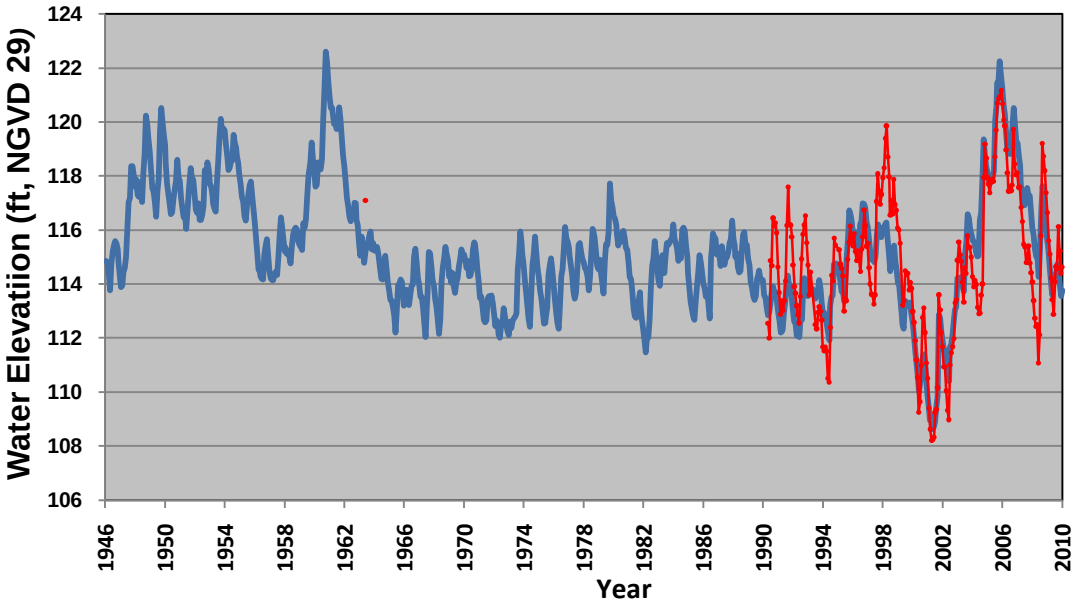
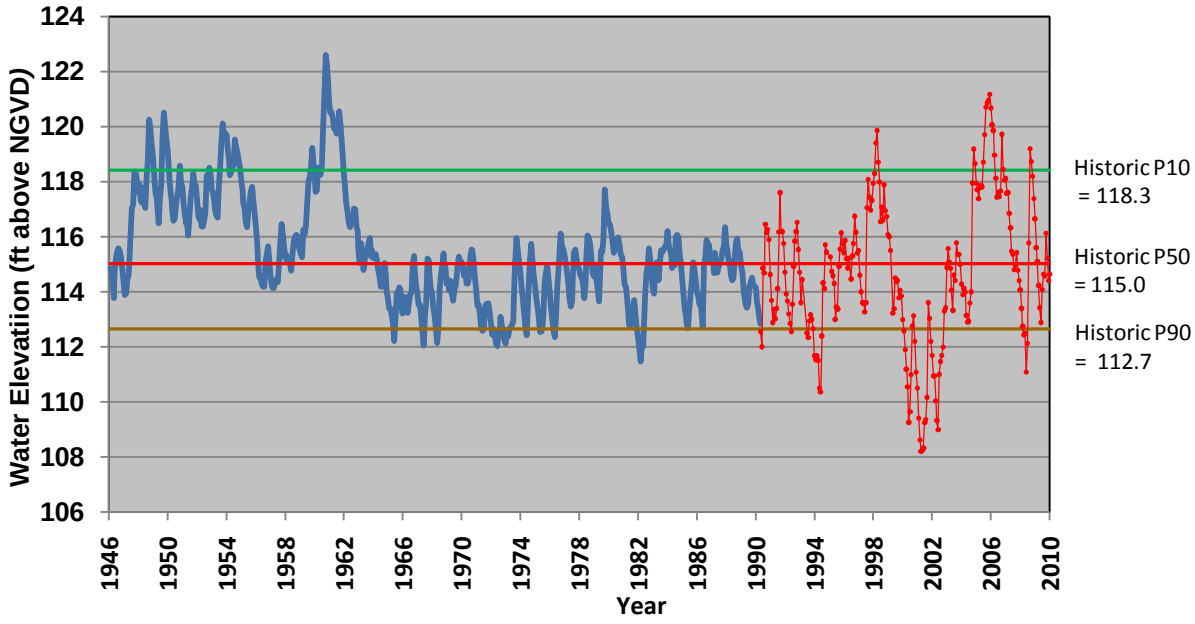



Figure 5b.



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

The **Normal Pool** elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the elevation of hydrologic indicators of sustained inundation. Because hydrologic indicators of Normal Pool were not observed at Lake Crystal, a Normal Pool elevation was not established for the lake. Although hydrologic indicators of Normal Pool were not found around this urban lake a line of large live oak trees was observed around the perimeter of the north side of the lake (Figures 2 and 6). Several of the oak trees had distinctive wall like buttresses located along the front of the steep bank fringing the higher portion of the lake basin. Although live oak trees are not used as indicators of Normal Pool since they do not survive frequent periods of inundation, they can be used to estimate the historic seasonal high water elevation. Based on the average relative elevation of base roots of 4 large live oak trees located along the north shore of Lake Crystal (Figures 2 and 6), the historic seasonal high water elevation was estimated at 120.3 NGVD 29.

The **Control Point** elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.,* structure, ditch, culvert, or pipe) that is the principal control of water level fluctuation in the lake. For Lake Crystal, the Control Point was established at **120.8 NGVD 29**, the high spot in the outlet swale located on the east shore of the lake (Figure 2). This elevation is similar to the highest level recorded for period of record which occurred at 121.2 NGVD on November 8, 2005. Down-gradient of the ditch high spot, one 18-inch culvert (noted as partially filled) conveys surface water runoff under Tourist Club Drive into an underground stormwater conveyance system that discharges to Lake Wales. The elevation of the culvert inverts was measured at 118.42 NGVD 29 (Figure 2). It should be noted that the control points were surveyed as NAVD 88 (using NAVD 88 Benchmarks) with NGVD 29 elevations calculated using Corpscon. Structural Alteration Status is determined to support development of Minimum and Guidance Levels. Because of known modifications to the outlet of the lake, Lake Crystal is considered to be structurally altered.

## Guidance Levels

The **High Guidance Level** is provided as an advisory guideline for construction of lake-shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic lake stage data if it is available, or is estimated using the Current P10, the control point, and the normal pool elevation. Based on the availability of the long term Historic data record for Lake Crystal, the High Guidance Level was established at **118.3 NGVD 29** (Figure 7). This elevation appears to be in agreement with the historic seasonal high water elevation estimated from the base roots of the 4 live oak trees. The historic seasonal high is expected to occur at an elevation higher than the Historic P10, and in this case was approximately 2.0 ft higher (120.3 NGVD 29) as determined from the live oak base root elevation.

**Figure 6. Line of large live oaks located along north shore of Lake Crystal in May (upper imager) and March (lower image) 2010. The average ground elevation at the base roots of four live oaks was approximately 120.3 NGVD 29.**

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. Based on the availability of the long term Historic data set for Lake Crystal, the Low Guidance Level for Lake Crystal was established at the long term Historic P90 elevation, **112.7 NGVD 29** (Figure 7 and Table 3).

## Lake Classification

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

## Significant Change Standards and Other Information for Consideration

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

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

The **Aesthetics Standard** is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic

Standard was established at the Low Guidance Level, which for Lake Crystal is **112.7 NGVD 29**. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the Historic long term period (1946 to present, Figure 5b).

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 8) for a plot of lake surface area versus lake stage. For Lake Crystal, the Species Richness Standard was established at **112.7 NGVD 29**. The Species Richness Standard was equaled or exceeded ninety percent of the time, based on the Historic, composite water level record. The standard therefore corresponds to the Historic P90. Although established by different methods the elevation established for the Aesthetics Standard and Species Richness Standard are the same.

The Recreation/Ski Standard, Dock-Use Standard, the Basin Connectivity Standard, and Lake Mixing Standard were not applicable to Lake Crystal. 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. As a result of its small surface area and morphology and the high number of stormwater discharges and associated debris observed in the lake, the Lake Crystal basin does not meet the minimum lake size or safety requirements for establishing a Recreation/Ski standard. 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. Because there are no docks on Lake Crystal a Dock-Use standard was not developed. 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 uses. Because lake-basin depth measurements indicate that Lake Crystal does not contain sub-basins, the Basin Connectivity Standard was not considered applicable for the lake. 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 <0.8. Because the dynamic ratio does not shift across the 0.8 threshold over the range of water levels that may be expected within the basin, a Lake Mixing Standard was not developed (Figure 8).

Information on herbaceous wetlands is taken into consideration when determining the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e*., basin area with a water depth of four or less feet). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values. Review of changes in potential

herbaceous wetland area or area available for aquatic plant colonization in relation to change in lake stage did not indicate that of use of any of the significant change standards would be inappropriate for establishment of the Minimum Lake Level (Figure 8).

Because herbaceous wetlands are common within the Lake Crystal basin, it was determined that an additional measure of wetland change should be considered for minimum levels development. Based on a recent review (Hancock 2007) 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 114.2 NGVD was therefore established for Lake Crystal by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded sixty-seven percent of the time, based on the Historic, composite water level record. The standard elevation therefore corresponds to the Historic P67. Review of changes in potential wetland area in relation to change in lake stage indicated there would not be a substantial increase or decrease in potential wetland area within the lake basin at the Wetland Offset Elevation (24.3% of the lake basin) relative to the potential wetland area at the Historic P50 elevation (21.4% of the lake basin).

## Minimum Levels

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

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 Lakes, the Minimum Lake Level is typically established at the elevation corresponding to the most conservative significant change standard, *i.e*., the standard with the highest elevation, except where that elevation is above the Historic P50 elevation, in which case, the Minimum Lake Level is established at the Historic P50 elevation. Because all appropriate significant change standards were below the Historic P50 elevation, the Minimum Level for Lake Crystal could be established at **112.7 NGVD 29**, the elevation corresponding to the Aesthetics and Species Richness Standards, the two standards that were developed for the lake. The Minimum Lake Level was, however, established at the Wetland Offset elevation, 114.2 NGVD 29. This level is expected to afford protection to the natural system and human-use values associated with the identified

significant change standards and also provide protection for wetlands occurring within the basin (Figures 7 and 9).

The **High Minimum Lake Level** (HMLL) is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For Category 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. If Historic Data are available, the High Minimum Lake Level is established at an elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level is set at an elevation corresponding to the Minimum Lake Level plus the region-specific RLWR50. Based on the availability of Historic data for Lake Crystal, the High Minimum Lake Level was established at 117.9 NGVD 29 (Figures 7 and 9), by adding the difference between the Historic P50 and Historic P10 (3.7 feet) to the Minimum Lake Level.

The Minimum and Guidance levels for Lake Crystal are shown in Figure 7 along with monthly mean water surface elevations based on period of record water level measurements. Staging of the lake at Minimum levels would not be expected to flood any man-made features within the immediate lake basin (see Figures 9, 10, and 11). The High Minimum Lake Level (117.5 NGVD 29) is approximately 7.2 feet lower than the lowest floor slab within the lake basin (124.7 NGVD). The lowest floor slab was identified as an office or storage building located within the Lake Crystal park facility (124.7 NGVD 29) on the northeast side of the lake. The High Minimum Lake Level is also approximately 3.4 ft lower than the lowest spot on the paved roads (120.9 NGVD 29) encircling the lake. The lowest spot road elevation was measured within the vicinity of the lake control point (120.8 NGVD 29). Both the control point and low road elevation are located to the east of lake (Figure 2) within the lower lying region between Lake Crystal and Lake Wales. Water discharges from Lake Crystal to Lake Wales during extreme highs such as after the 2004 hurricanes when an elevation of 121.17 NGVD 29 (period of record high). This period of record high indicates that some street flooding occurred during this time period, but the lowest floor slab was approximately 3.5 ft above the period of record high.

**Table 4. Elevations of lake basin features in the immediate Lake Crystal basin (**Xynides 2010).

| **Lake Basin Features** | **Elevation in Feet NGVD 29** |
|---|---|
| Low floor slab – Public restrooms building at Crystal Lake Park | 125.66 |
| Low floor slab – Public office/shed at Crystal Lake Park | 124.69 |
| Low other – Top of concrete footbridge over lake outflow swale | 121.20 |
| Low spot on the paved roads near the lake | 120.89 |

**Figure 7. Mean monthly lake stage in feet above NGVD 29 through February 2010 and Minimum and Guidance Levels for Lake Crystal. Adopted levels include the High Guidance Level (HGL), Low Guidance Level (LGL), High Minimum Lake Level (HMLL), and Minimum Lake Level (MLL).**

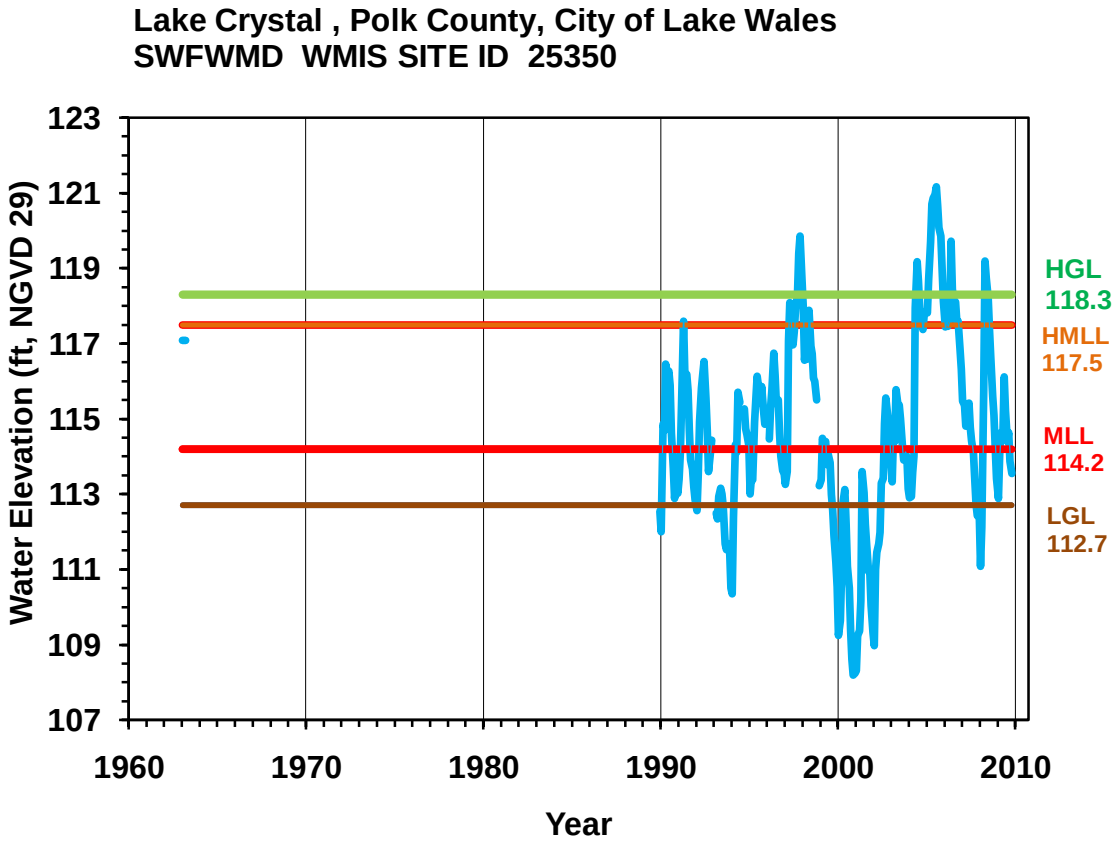


**Figure 8. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope), and potential herbaceous wetland area versus lake stage in feet above NGVD 29 for Lake Crystal.**

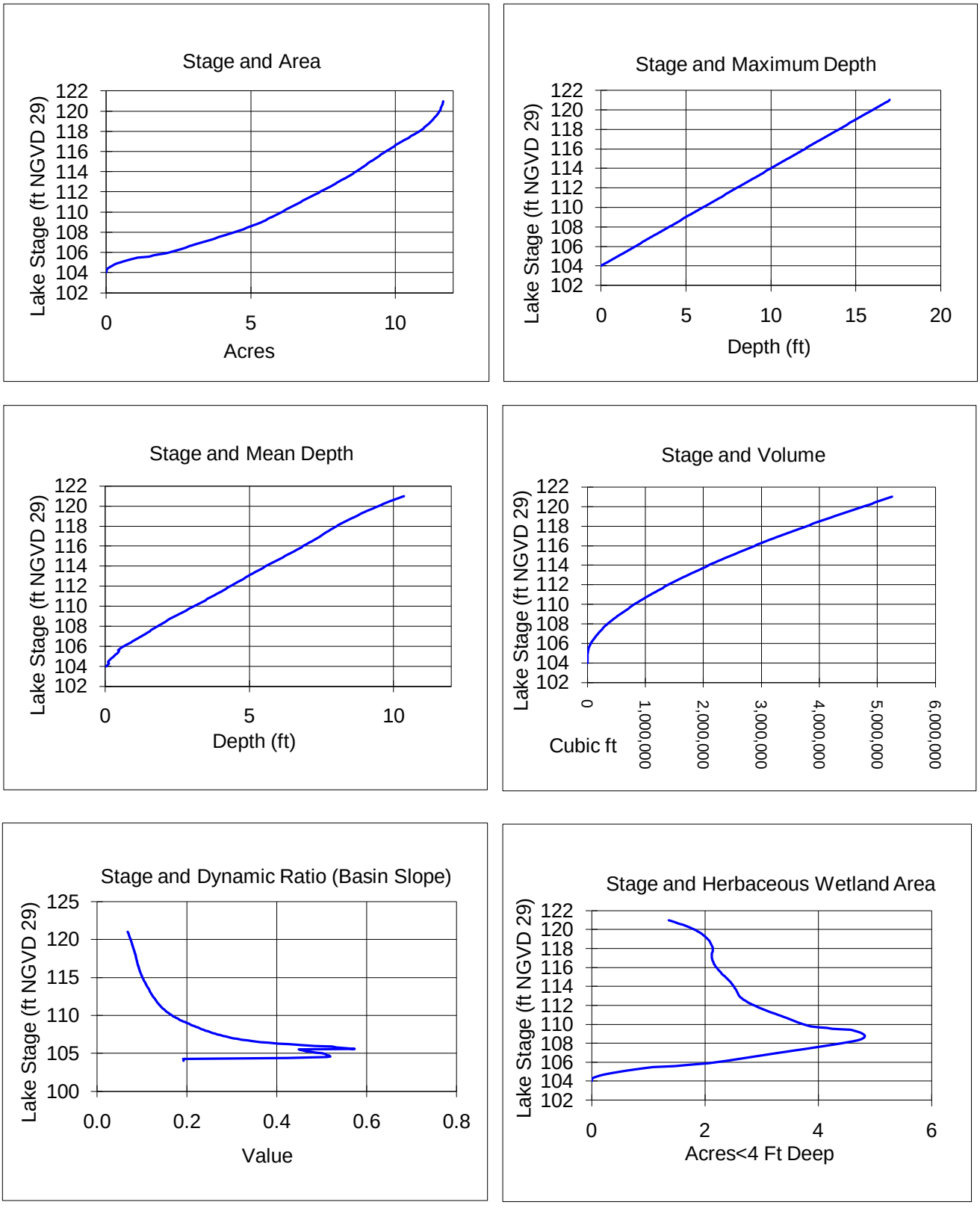


**Figure 9. Approximate location of the adopted Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Crystal in Lake Wales, Polk County, during recent conditions documented in the 2010 aerial imagery. The estimated lake stage was 114.0 NGVD 29 on the date of the imagery.**

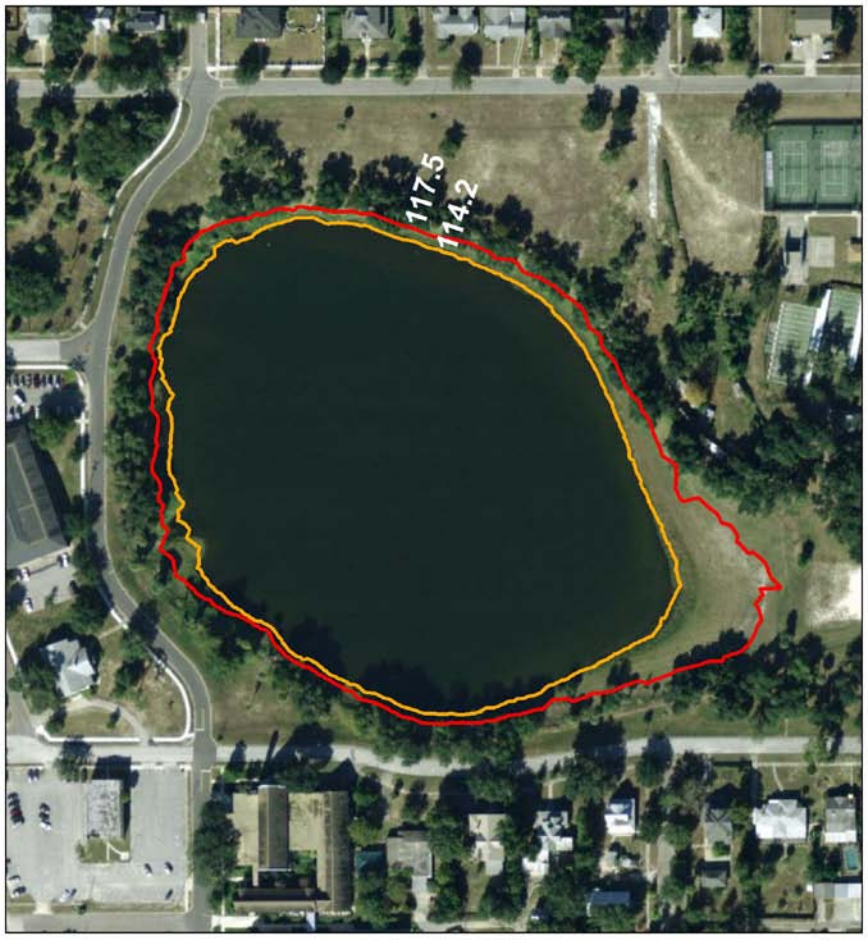
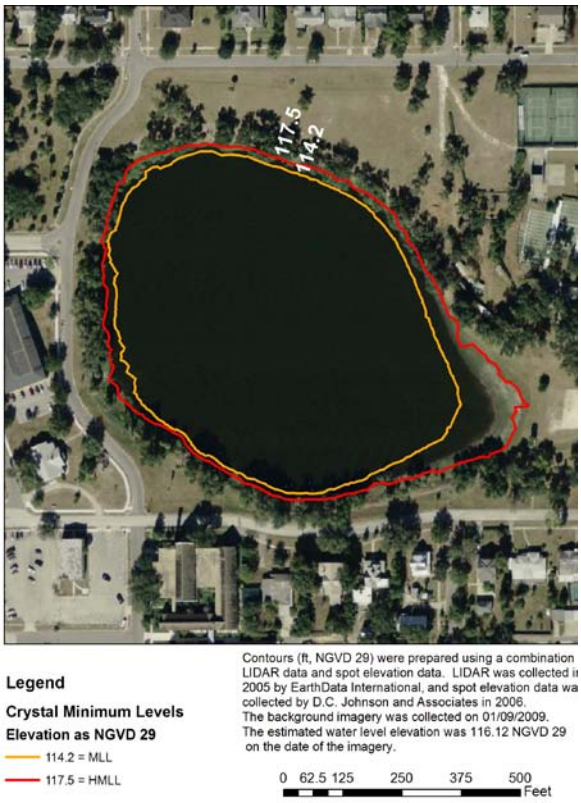


**Figure 10: Approximate location of the adopted Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Crystal as associated with conditions observed on 01/09/2009 (top) and on 01/07/2006 (bottom). The estimated lake stage was 116.12 NGVD29 on 01/09/2009 and was 120.3 NGVD 29 on 01/07/2006.**



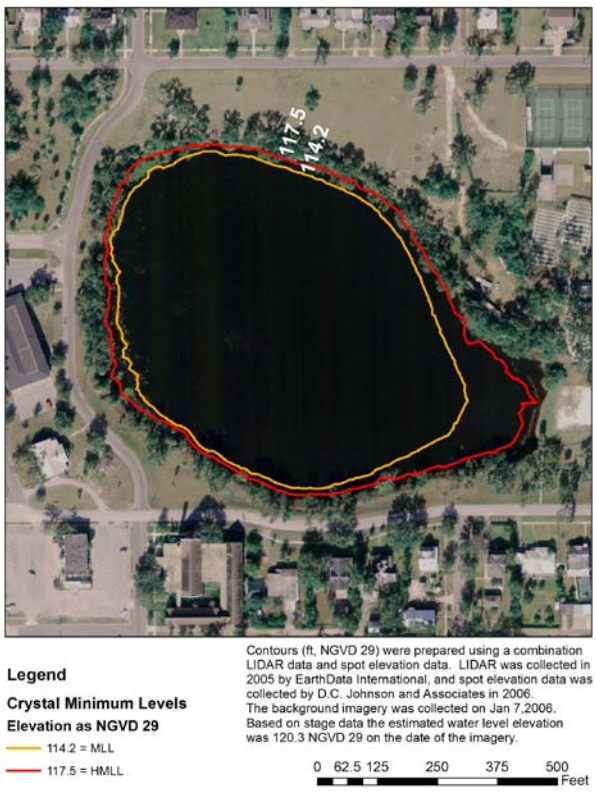
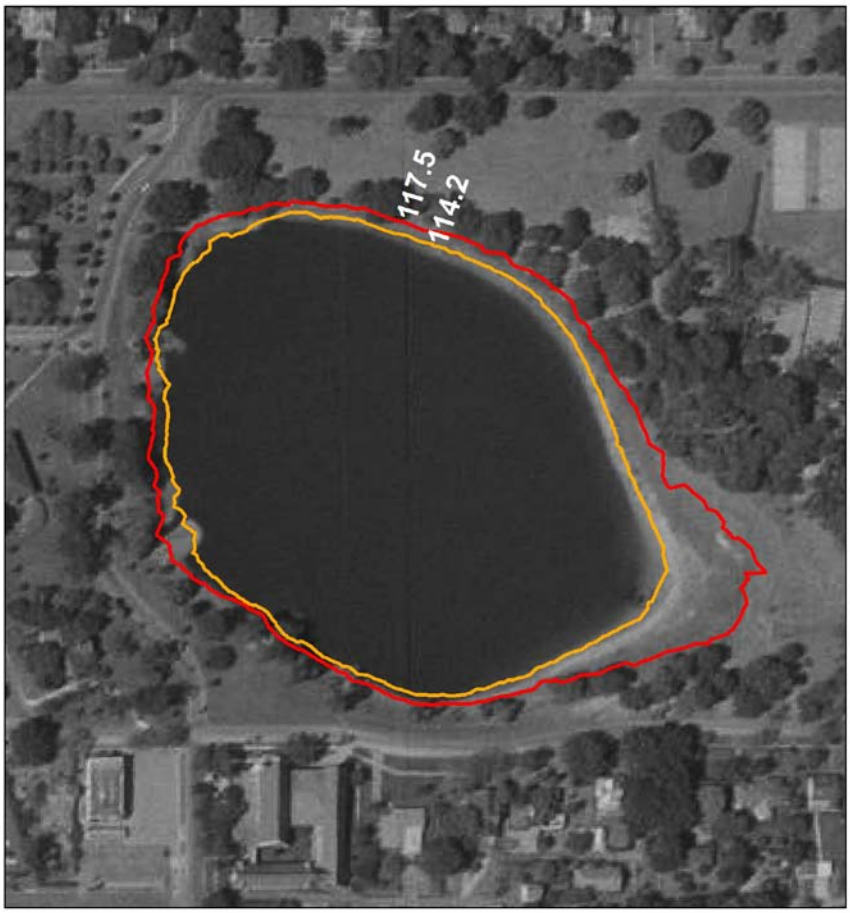



**Figure 11. Approximate location of the adopted Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for North Lake Wales as associated with conditions observed in March 1970. Lake stage records are not available during this period; however, the estimated elevation was 113.0 NGVD 29 based on lake basin contours.**



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