

Minimum and Guidance Levels for Pasco Lake in Pasco County, Florida



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Ecologic Evaluation Section
Resource Projects Department



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Brooksville, Florida 34604-6899

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Cover: Aerial photograph (looking south) of Pasco Lake in February 1998 (Southwest Florida Water Management District files).

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Minimum and Guidance Levels for Pasco Lake

State law (Section 373.042, Florida Statutes; hereafter F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. As currently defined by statute, the minimum flow for a given watercourse "shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area", and the minimum level of an aquifer or surface water body is "the level of groundwater in the aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area". Minimum flows and levels are used by the Southwest Florida Water Management District (District) for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and use of surface water management systems. Establishing a minimum flow or level does not in itself protect a water body from significant harm; however, resource protection, recovery and regulatory compliance may be ensured once the flow or level standards have been adopted.

Minimum flows and levels are 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 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 guidance and minimum lake levels is provided in Southwest Florida Water Management District (1999a, 199b) and Leeper *et al.* (2001). Bedient *et al.* (1999) and Dierberg and Wagner (2001) provide peer-review findings regarding the lake-level methods.

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

- The Ten Year Flood Guidance Level is provided as an advisory guideline for lakeshore development. It is the level of flooding expected on a frequency of not less than the ten-year recurring interval, or on a frequency of not greater than a ten percent probability of occurrence in any given year.
- The High Guidance Level is provided as an advisory guideline for construction of lakeshore development, water dependent structures, and operation of water management structures. The High Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ten percent of the time on a long-term basis.
- The High Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis.
- The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis.
- The Low Guidance Level is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis.

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

In accordance with Chapter 40D-8, F.A.C., proposed Minimum and Guidance Levels were developed for Pasco Lake, a Category 3 Lake located in Pasco County, Florida (Southwest Florida Water Management District 2006a). The levels were established

using best available information, including data that were obtained specifically for the purpose of minimum levels development. Following a public input process, the District Governing Board approved adoption of the proposed levels on November 30, 2006 and the levels (Table 1) were subsequently incorporated into Chapter 40D-8, F.A.C. The data and analyses used for development of the adopted levels are described in the remainder of this report.

Table 1. Minimum and Guidance Levels for Pasco Lake.

Minimum and Guidance Levels	Elevation (feet above NGVD)
High Guidance Level	66.1
High Minimum Lake Level	65.3
Minimum Lake Level	61.8
Low Guidance Level	59.7

Data and Analyses Supporting Development of the Minimum and Guidance Levels for Pasco Lake

Lake Setting and Description

Pasco Lake is located in north-central Pasco County, Florida (Sections 22 and 23, Township 24 South, Range 18 East) in the Coastal Rivers Basin of the Southwest Florida Water Management District (Figures 1 and 2). White (1970) classified the region of central or mid-peninsular Florida containing Pasco Lake as the Northern Gulf Coastal Lowlands. Brooks (1981) categorized the area surrounding the lake as the Land O Lakes subdivision of the Tampa Plain division of the Ocala Uplift District, and described the region as a plain with numerous small lakes imbedded in moderately thick silty sand deposits lying above the Tampa Limestone formation. As part of the Florida Department of Environmental Protection's Lake Bioassessment/ Regionalization Initiative, the area has been identified as the Tampa Plain lake region (Griffith *et al.* 1997). Lakes in the region are mostly mesotrophic, dark-water, slightly acidic systems.

Uplands in the immediate lake basin include naturally forested areas and altered areas that are currently used for livestock grazing and residential development (Figure 3). Abundant upland species include live oak (*Quercus virginiana*), pine (*Pinus* sp.), and saw palmetto (*Serenoa repens*). Inundated or wetted portions of the basin include stands of southern naiad (*Najas quadelupensis*), cattail (*Typha* sp.), torpedo grass (*Panicum repens*), maidencane (*Panicum hemitomom*), pineland heliotrope (*Heliotropium polyphyllum*), wax myrtle (*Myrica cerifera*), and several sedge species.

The lake lies within the Jumping Gully drainage basin in the Upper Coastal Areas watershed (U.S. Geological Survey Hydrologic Unit Classification System). In a review of available aerial photography of the region (e.g., see Figures 3-13), Ormiston (2000) hypothesizes that Pasco Lake historically "consisted of a small lake and associated small pond/mash areas, which received inflow by natural overland surface water flow during flood periods", but notes that at least since 1941 (the year of the earliest photograph examined), the lake has been part of a flow-through system. In an earlier study, Hutchinson (1985) noted that Pasco Lake was formed by the "dredging and damming" of Jumping Gully, a drainage feature that provides conveyance to Crews Lake.

Currently, surface water inputs to the lake include direct precipitation on the lake surface, runoff from immediately adjacent upland areas, intermittent inflow from the east through Jumping Gully and an unnamed ditch system to the north of Jumping Gully, and the introduction of pumped groundwater at the site where Jumping Gully enters the lake (Figures 2, 3 and 15). Jumping Gully and the unnamed ditch system to the north intermittently provide conveyance into the lake from several water bodies on the Cross Bar Ranch wellfield. The wellfield, a component of Tampa Bay Water's regional water supply system, has been in operation since April 1980 (Hutchinson 1985). Augmentation of Pasco Lake with pumped groundwater has been implemented by

Tampa Bay Water since 1996. In an effort to optimize augmentation practices at Pasco Lake, Tampa Bay Water has investigated subsurface conditions under the lakebed (SDII Global Corporation 2000) and evaluated lining the basin with clay to retard downward leakage (SCS Engineers, Inc. 2000, as cited in Berryman & Henigar et al. 2001b).

Pasco Lake drains to Unnamed Lake Number 22 (a.k.a. Loyce Lake) through Jumping Gully (Figures 2, 3, 14 and 15). Water levels in the lake are controlled to some extent by a fixed-crest weir located in Jumping Gully, approximately 85 feet east of U.S. Highway 41. A secondary conveyance system between the weir and Unnamed Lake Number 22 permits water from Jumping Gully to be diverted to Unnamed Lake Number 10. This conveyance system presumably also functions to drain water from Unnamed Lake Number 10 to Jumping Gully. At the outlet of Unnamed Lake Number 22, Jumping Gully provides conveyance to Crews Lake, which drains through the Pithlachascotee River to the Gulf of Mexico.

Discharge in Jumping Gully at the Pasco Lake outlet (United States Geological Survey No. 02310240, Southwest Florida Water Management District Universal Identification Number FLO 23 50) has been measured by the United States Geological Survey from the mid-1960s through January 1988, and since January 1998. In recent years, there has often been no flow in Jumping Gully. Prior to 1988, flows were typically less than 100 cubic feet per second, but reached as high as 890 cubic feet per second. There are no surface withdrawals from the lake permitted by the District. There are, however, several permitted groundwater withdrawals in the lake vicinity, including those associated with operation of the Cross Bar Ranch wellfield.

The District currently maintains a water-level gauging station in the southern portion of Pasco Lake (Figure 3). The United States Geological Survey has historically maintained a series of water level gauges at sites near the lake outlet. Because Pasco Lake is not a named lake on available United States Geological Survey topographic maps, it was not possible to determine whether the lake is included in the "Gazetteer of Florida Lakes" (Florida Board of Conservation 1969, Shafer *et al.* 1986). The 1954 (and 1988 photorevised) U.S. Geological Survey 1:24,000, Masaryktown, Fla, and Ehren, Fla. quadrangle 7.5 minute topographic maps do not include a lake surface elevation for Paso Lake (see Figure 14 for a composite of recent United States Geological Survey topographic maps of the Pasco Lake area). A topographic map of the lake basin generated in support of minimum levels development (Figure 16) indicates that the lake extends over 30 acres when it is staged at 65.7 feet above NGVD, the overflow elevation for the weir in Jumping Gully at the lake outlet.

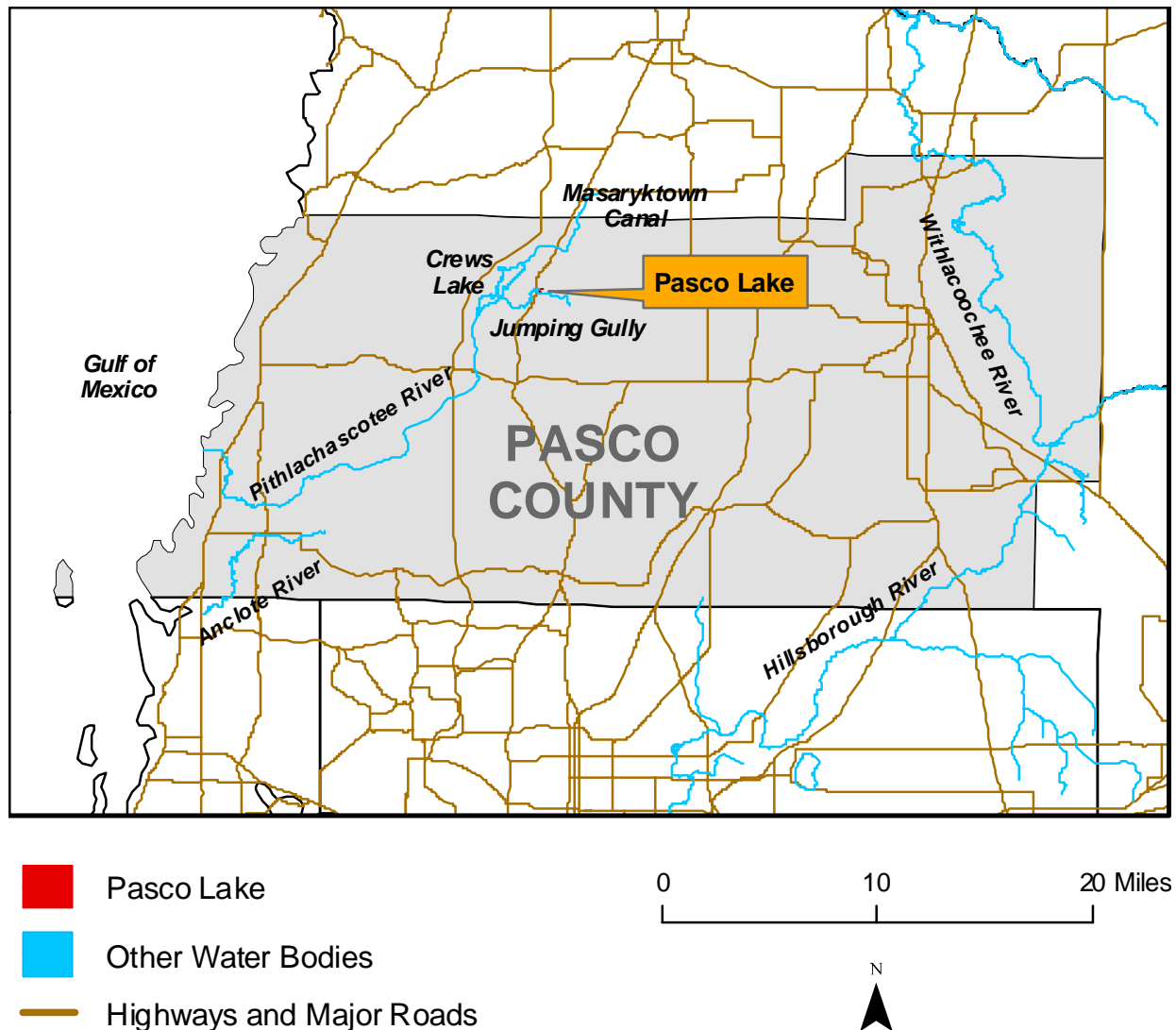


Figure 1. Location of Pasco Lake, other selected regional water bodies, highways and major roads within or near Pasco County, Florida

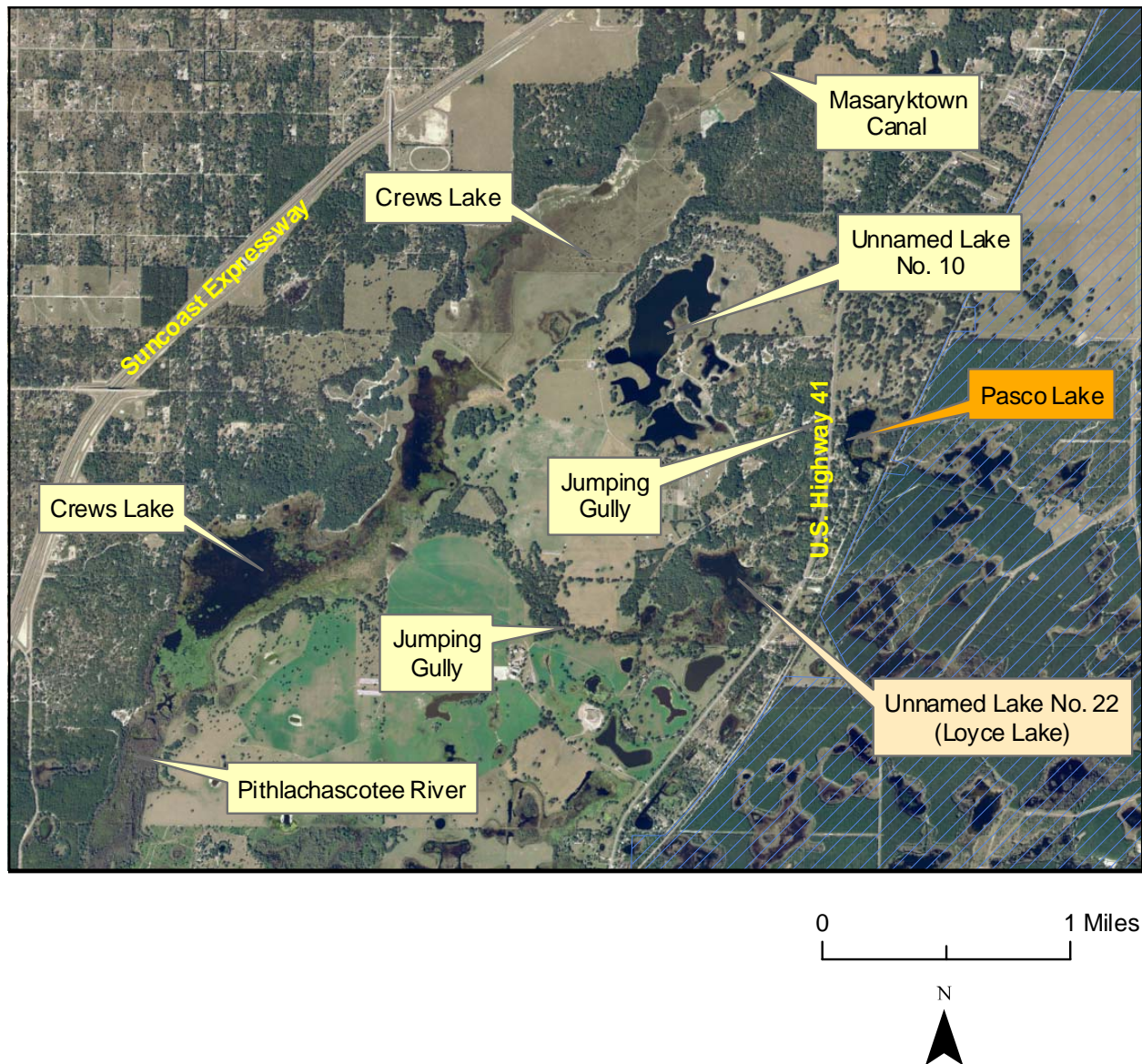


Figure 2. Aerial photograph of the Pasco Lake area in 2005 showing major water bodies, roads and the western margin of the Cross Bar Ranch Regional Wellfield (blue hatched area). The photographic image is from United States Geological Survey digital orthophotography (United States Geological Survey 2005).

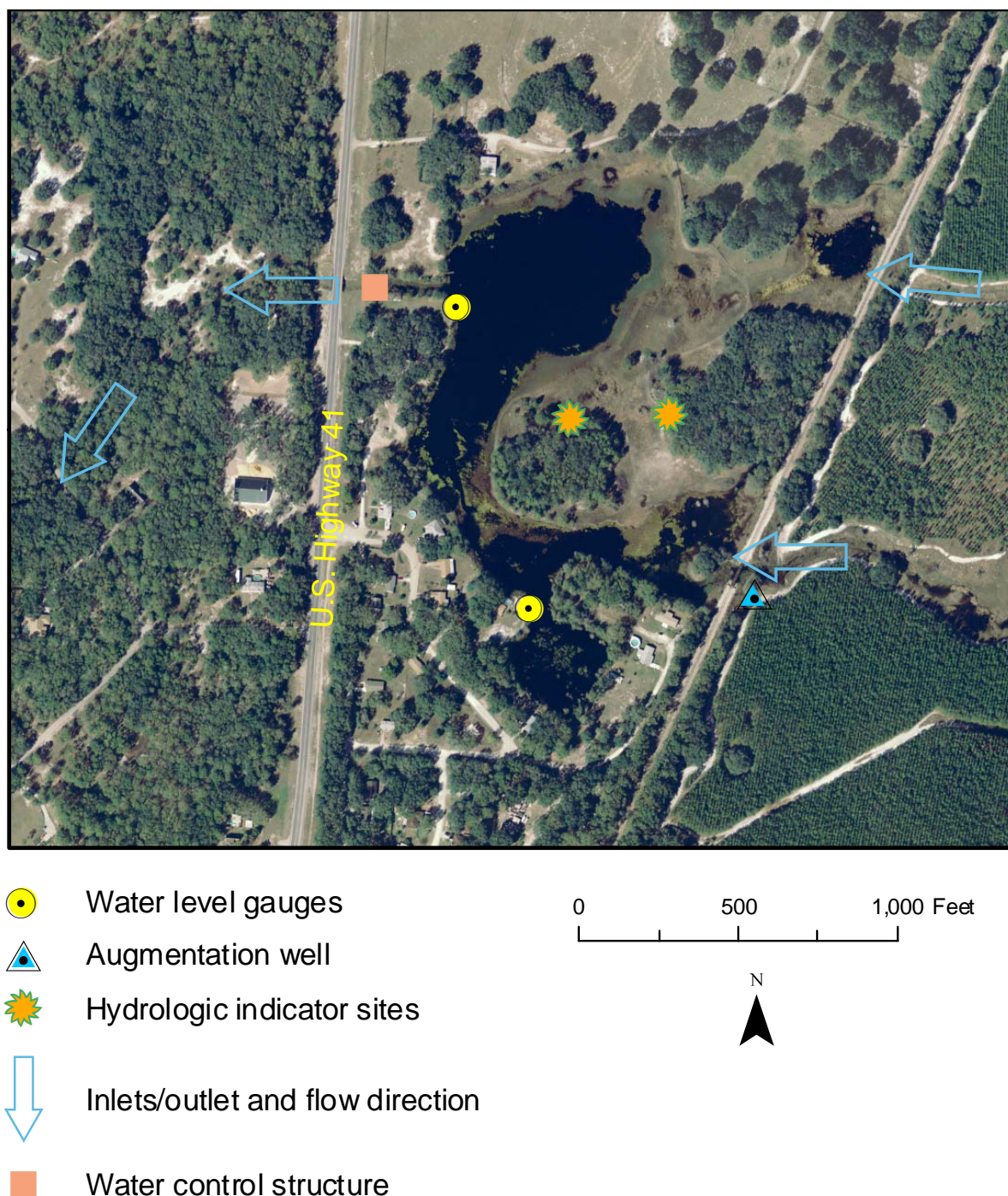


Figure 3. Aerial photograph of Pasco Lake in 2005, showing the location of: the District water level gauge in the southern portion of the basin; a set of abandoned United States Geological Survey water levels gauges in the northern portion of the basin; the well used to augment the lake; and sites where elevations of hydrologic indicators were measured. Inlets to the lake, the lake outlet and location of the outlet water control structure are also shown. The photographic image is from United States Geological Survey digital orthophotography (United States Geological Survey 2005).



0 500 1,000 Feet



Figure 4. Aerial photograph of Pasco Lake in 2004. Image is from United States Geological Survey digital orthophotography (United States Geological Survey 2004).



0 500 1,000 Feet



Figure 5. Aerial photograph of Pasco Lake in 1999. Image is from United States Geological Survey digital orthophotography (United States Geological Survey 1999).



Figure 6. Aerial photograph (looking south) of Pasco Lake in 1998 (Southwest Florida Water Management District files).



0 500 1,000 Feet



Figure 7. Aerial photograph of Pasco Lake in 1994. Image is from United States Geological Survey digital orthophotography (United States Geological Survey 1994).



0 500 1,000 Feet



Figure 8. Aerial photograph of Pasco Lake in 1984. Image is from United States Geological Survey National High Altitude Photography (United States Geological Survey 1984).



Figure 9. Aerial photograph (looking east) of Pasco Lake in 1982 (Southwest Florida Water Management District files).



0 500 1,000 Feet



Figure 10. Aerial photograph of Pasco Lake in the 1973. Image is from Woolpert (2003).



Figure 11. Aerial photograph of the Pasco Lake area in 1957 (United States Department of Agriculture 1957). The lake basin is located slightly below the center of the photograph.



Figure 12. Aerial photograph of the Pasco Lake area in 1952 (United States Department of Agriculture 1952a). The lake is located slightly below the center of the photograph.

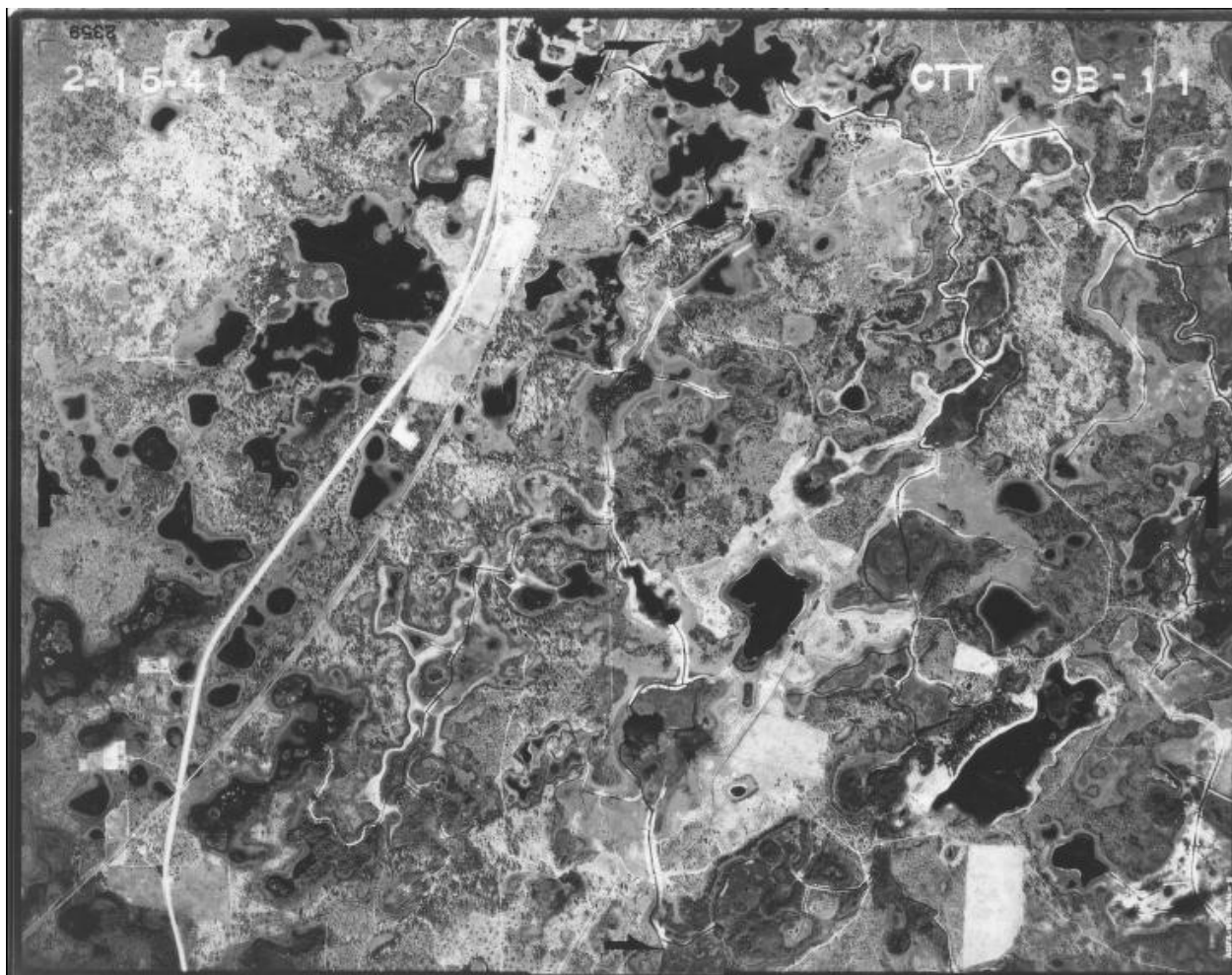


Figure 13. Aerial photograph of the Pasco Lake area in 1941 (United States Department of Agriculture 1941a). A portion of the lake is located at the top of the photograph.

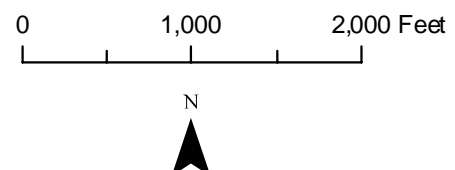
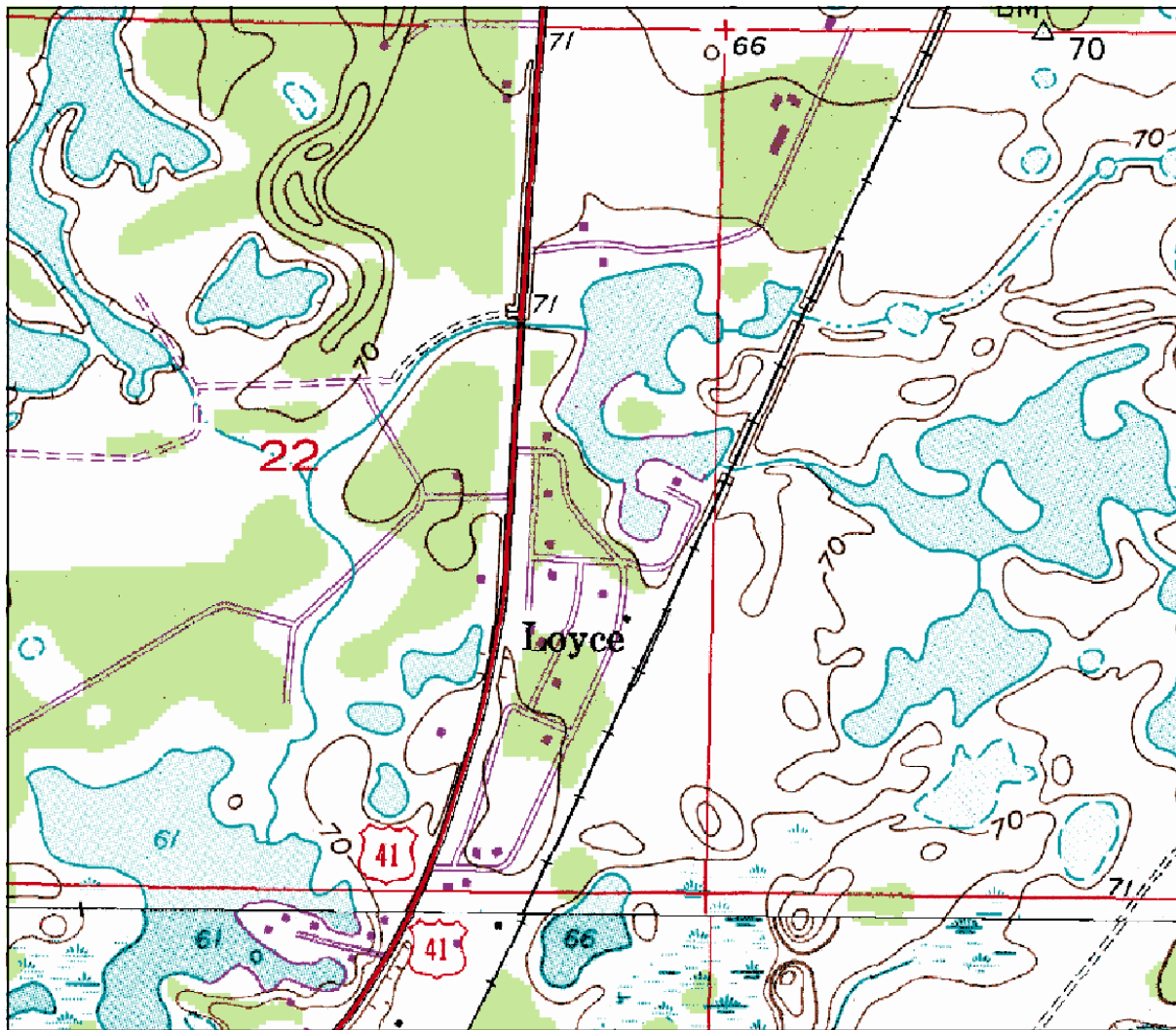
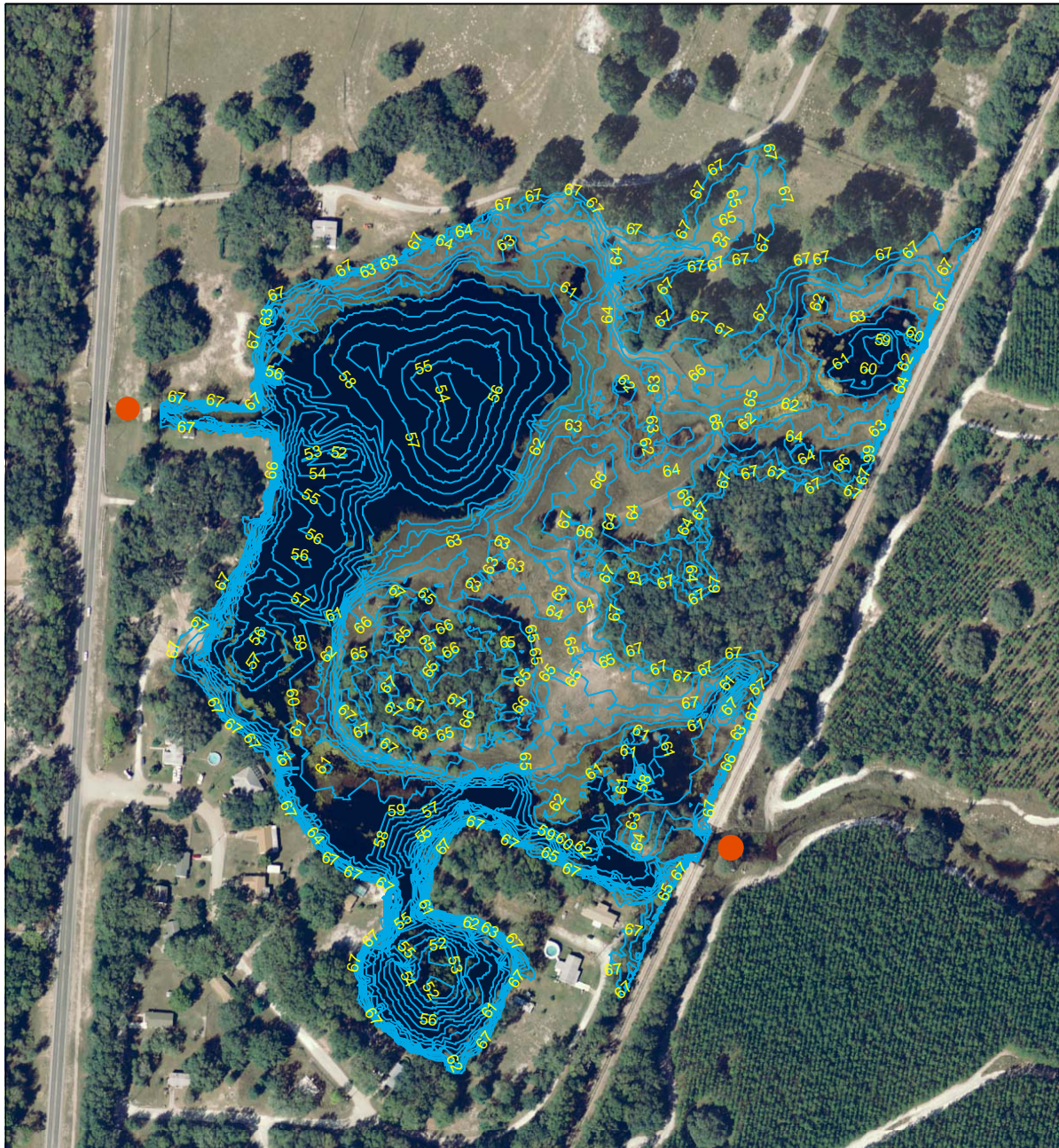


Figure 14. Five-foot elevation (in feet above NGVD) contours in the vicinity of Pasco Lake as shown on United States Geological Survey 7.5 minute series topographic maps (United States Geological Survey 1954a-d, 1988a-d). Image is from the United States Geological Survey 1:24,000 scale topographic map (DRG) layer available from the Mapping and GIS Section of the Southwest Florida Water Management District.



Figure 15. Ground-level photographs of the water control structure at the outlet of Pasco Lake in 1983 (upper panel) and 2005 (lower panel) (Southwest Florida Water Management District files).



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

0 250 500 Feet



Figure 16. One-foot elevation (feet above NGVD) contours within the Pasco Lake basin. Orange dots indicate areas where contours were truncated for mapping purposes.

Previously Adopted Guidance Levels

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

Management levels (Table 2), currently referred to as Guidance Levels, were approved for Pasco Lake by the Governing Board in November 1984 and incorporated into Chapter 40D-8, F.A.C. A Maximum Desirable Level of 66.50 feet above NGVD was also developed but was not adopted by rule. The levels were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels, and do not, therefore, necessarily correspond with levels developed using current methods. Following the November 2006 adoption of Minimum and Guidance Levels for Pasco Lake that were developed using the current methods, the previously adopted Guidance Levels were removed from Chapter 40D-8., F.A.C.

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

Pasco Lake has previously been classified as a stressed lake (see Gant 1999a, 1999b, 2000, 2002, 2003, 2004, 2005, 2006). Based on the adoption of Minimum Levels for the lake in November 2006, Pasco Lake was not included in the most recent stressed lakes list (Gant 2007) nor will it be included in future list evaluations. Evaluation of water level fluctuations within the basin will instead be incorporated in annual determinations of compliance with adopted Minimum Levels.

Table 2. Previously adopted guidance Levels for Pasco Lake.

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	67.50
High Level	67.00
Low Level	64.00
Extreme Low Level	62.00

Summary Data Used for Minimum and Guidance Level Development

Minimum and Guidance Levels were developed for Pasco Lake 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 elevation. Detailed descriptions of the development and use of these data are summarized in subsequent sections of this report.

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

	Elevation (feet above NGVD)	Lake Area (acres)
Lake Stage Exceedance Percentiles		
Historic P10	66.1	32
Historic P50	62.6	17
Historic P90	59.7	10
Current P10	64.8	25
Current P50	NA	NA
Current P90	NA	NA
Other Levels		
Normal Pool	67.0	35
Control Point	65.7	30
Significant Change Standards		
Basin Connectivity Standard	68.8	NA
Wetland Offset	61.8	15
Species Richness Standard	61.6	15
Aesthetic Standard	59.7	10
Recreation/Ski Standard	NA	NA
Dock-Use Standard	NA	NA
Lake Mixing Standard	NA	NA
Minimum and Guidance Levels		
High Guidance Level	66.1	32
High Minimum Lake Level	65.3	28
Minimum Lake Level	61.8	15
Low Guidance Level	59.7	10

NA = not available or not applicable

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations, for Pasco Lake are available from the District's Water Management Data Base from June 1977 through August 1989 and from October 1995 through the present (see Figure 17 for data available through October 2006). Data are currently collected at a District-maintained site (District Universal Identification Number STA 311 311) in the southern portion of the basin, and were also previously collected at sites maintained by the United States Geological Survey (District Universal Identification Number STA 311, 312, United States Geological Survey Number 02310238 - Pasco Lake near Loyce, FL), near the lake outlet (Figure 3). Differences in sub-basin depths between the District and United States Geological Survey gauge sites means that water surface elevations recorded at the two sites may have differed when the lake separated into pools under low water conditions. The highest surface water elevation for the lake included in the database, 66.92 feet above NGVD, occurred on September 12, 1988. The low of record, 49.22 feet above NGVD, was recorded on April 29, 1997. This elevation is presumed to reflect the lowest sediment elevation in the basin. Recent data collection efforts (Weidener Surveying and Mapping, P.A. 2000, D.C. Johnson 2005, Figure 3) suggest that the lake is essentially dry when the water surface elevation recedes below 50-51 feet above NGVD.

For the purpose of Minimum Levels determination, lake stage data are categorized as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. In the context of levels development, "structural alterations" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. Lake stage data are categorized as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable.

Based on water-use estimates and analysis of lake stage and regional ground water fluctuations, hydrologic data for Pasco Lake collected after December 1984 were classified as Current data, and water level records collected prior to this date were considered to be Historic data. The Current P10, *i.e.*, the water surface elevation equaled or exceeded ten percent of the time during the Current period, was 64.8 feet above NGVD. Current P50 and P90 elevations, which are water surface elevations equaled or exceeded fifty and ninety percent of the time, respectively, during the current period, were not calculated due to discrepancies in reported water surface elevation values and due to effects of lake augmentation, which was initiated during the Current period. Data discrepancies were associated with the differing sub-basin pool depths at the District and United States Geological Survey gauge sites, and were also associated with the recording of water levels as relative (*i.e.*, less than a specified elevation) rather than absolute elevations for a significant portion of the period of record. For the period from July 1988 through October 1995, for example, numerous measured water levels were recorded simply as "less than 57.9 feet above NGVD". Because the water level records for these periods were expected to be near or below the Current period of

record median elevation, use of or exclusion of these data would be expected to skew Current P50 and Current P90 estimates. Similarly, augmentation of Pasco Lake with pumped groundwater during low-water periods would be expected to skew P50 and P90 exceedance percentiles for the Current period.

Based on available Historic data, the Historic P10 was determined to be 66.1 feet above NGVD. The Historic P10 elevation was considered to likely be representative of Historic conditions, based on review of peak lake stage values occurring throughout the entire period of record (see Figure 17) and comparison of the calculated Historic P10 value with the Normal Pool and Control Point elevations (see the next section of this report). However, based on the relatively short Historic data record, available Historic data were considered insufficient for calculating Historic P50 and Historic P90 elevations.

Historic P50 and P90 elevations for Pasco Lake were, therefore, developed using reference lake water regime statistics that were based on Historic P10, P50 and P90 percentiles calculated for nearby Crews Lake. Reference lake water regime statistics represent differences between P10, P50 and P90 lake stage elevations for typical, regional lakes that exhibit little or no impacts associated with water withdrawals (*i.e.*, reference lakes). Reference lake water regime statistics are developed for use when adequate Historic or Current data are not available for calculation of Historic lake-stage exceedance percentiles. Reference lake water regime statistics include the RLWR50, RLWR90 and RLWR5090, which are, respectively, median differences between P10 and P50, P50 and P90, and P10 and P90 lake stage percentiles for a reference lake or set of reference lakes.

The lake-stage exceedance percentiles that were used to develop reference lake water regime statistics for Paso Lake were calculated using a composite 56-year record of monthly mean lake surface elevations based on available Crews Lake stage records for periods not impacted by withdrawals and modeled lake stage estimates for periods when data were not available or when withdrawals impacted lake levels. A similar composite water level record could not be constructed for Pasco Lake, due to the influence of the lake outlet structure on peak lake stages within the basin. The 56-year period of record for the Crews Lake water level data set was considered sufficient for incorporating the range of lake-stage fluctuations that would be expected for area lakes, based on long-term climatic cycles that have been shown to be associated with regional hydrologic variability (Enfield et al. 2001, Basso and Schultz 2003, Kelly 2004).

Modeled monthly mean lake stage values for the composite Crews Lake water level data set were estimated using a linear fitting procedure known as the line of organic correlation (see Helsel and Hirsch 1992). The procedure was utilized to describe the relationship between available lake stage data for Crews Lake and potentiometric surface elevations for the Upper Floridan Aquifer system, as measured at the Sharpes Ferry West Floridan well site (District Universal Identification Number WEL 2555 1834; United States Geological Survey Number 29111508592501) in Marion County. The line of organic correlation equation developed for the lake and well data collected from March 1964 through September 2002 was used to estimate water surface elevations for

Crews Lake for the period from January 1946 through September 2002 (M. Hancock, Southwest Florida Water Management District unpublished data). A Historic, composite data set of monthly mean water surface elevations for Crews Lake was then developed using the modeled water surface elevations and available lake stage records (Figure 18). Historic P10, P50 and P90 elevations of 54.9, 51.4 and 48.5 feet above NGVD, respectively, were calculated for Crews Lake using the historic, composite data set. Differences between these exceedance percentiles were then used to establish RLWR50 (3.5 feet), RLWR5090 (2.9 feet), and RLWR90 (6.4 feet) statistics to be used for determining the Historic P50 and Historic P90 for Pasco Lake.

The Historic P50 elevation for Pasco Lake, the water surface elevation equaled or exceeded fifty percent of the time during the historic period, was established at 62.6 feet above NGVD by subtracting the RLWR50 from the Historic P10 elevation, *i.e.*, from the High Guidance Level (see the Guidance Levels section of this report). The Historic P90, the elevation the lake water surface equaled or exceeded ninety percent of the time during the historic period, was established at 59.7 feet above NGVD, by subtracting the RLWR90 from the Historic P10.

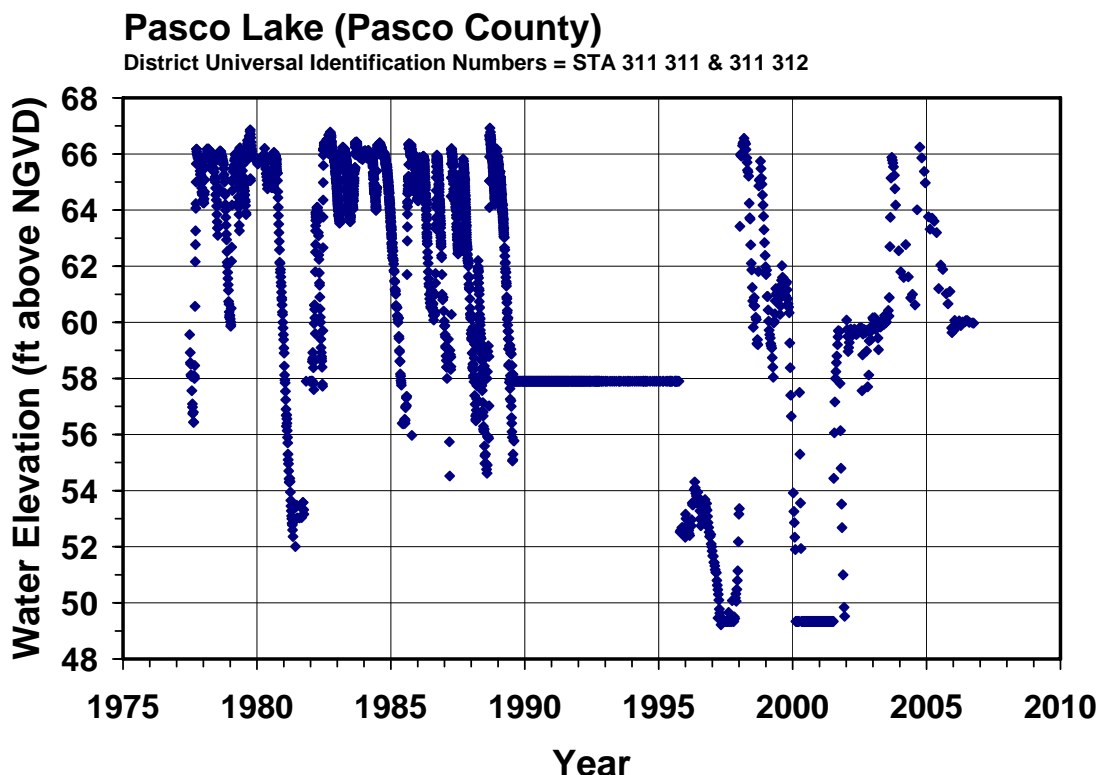


Figure 17. Surface water elevation values for Pasco Lake through October 2006. Data were obtained from the District Water Management Database. Note that for the period from July 1989 through October 1995, most measured water levels were recorded as "<57.9 feet above NGVD", so it may be assumed that the lake surface was lower than 57.9 feet for this period.

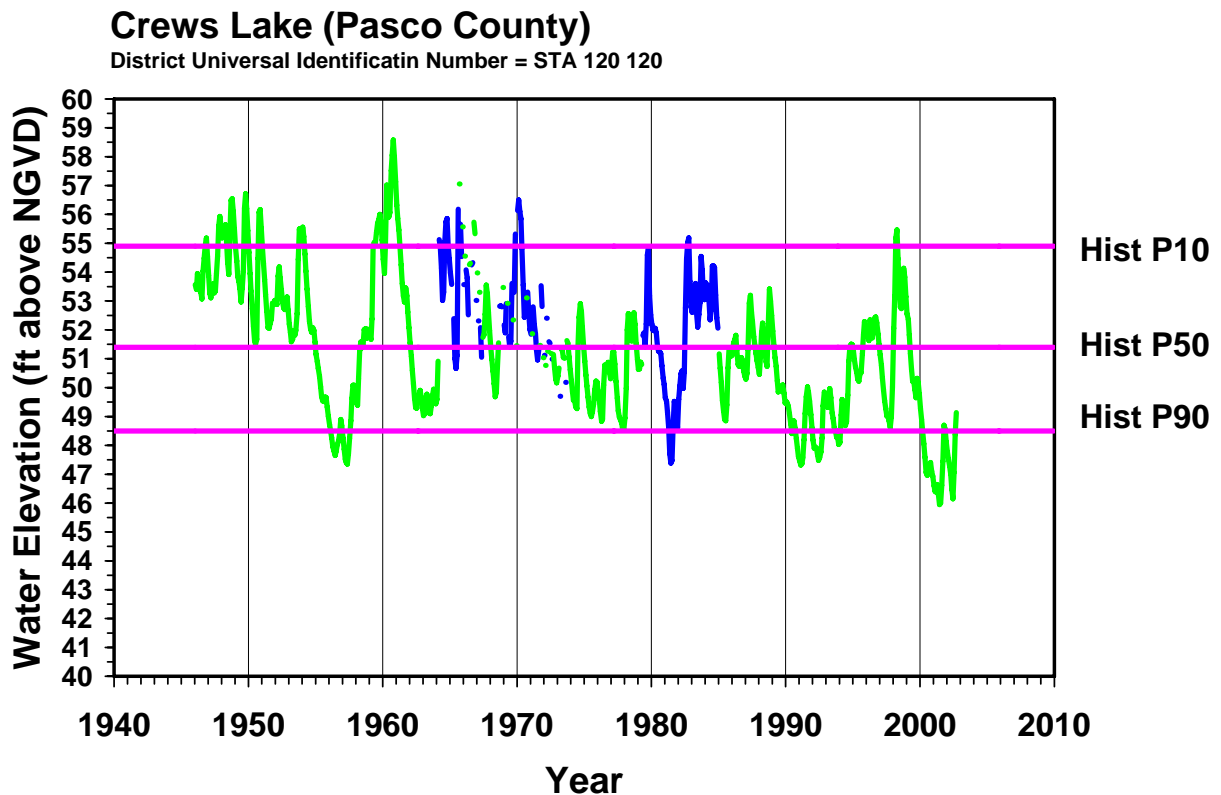


Figure 18. Composite monthly-mean surface water elevations and Historic lake-stage exceedance percentiles for Crews Lake, from January 1946 through September 2002. Composite data include values based on measured water surface elevations (blue) and modeled values (green). Historic exceedance percentiles include the Historic P10 (Hist P10), Historic P50 (Hist P50) and Historic P90 (Hist P90). Differences between the Historic exceedance percentiles were used to establish reference lake water regime statistics for Pasco Lake.

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

The Normal Pool elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the distribution of Hydrologic Indicators of sustained inundation. Hydrologic indicators of Normal Pool include biological and physical features that become established as a result of recent or long-term water levels. Based on ground elevations at the base of saw palmetto (*Serenoa repens*) shrubs located along the lake margin, the Normal Pool elevation was established at 67.0 feet above NGVD (Table 4, Figures 3 and 19).

For development of Minimum and Guidance Levels, lakes are classified as open or closed basin lakes. Open basin lakes are systems that are connected to, or are part of an ordered surface water conveyance system, *i.e.*, they have outlets or inlets for

conveyance of surface water. Closed basin lakes are those that are not part of an ordered conveyance system. Because Pasco Lake discharges through Jumping Gully to Unnamed Lake Number 22, it was classified as an open basin lake.

The Control Point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (e.g., weir, canal or culvert) that is the principal control of water level fluctuations in the lake. A control point may be established at the invert or crest elevation associated with a water control structure at a lake outlet, or at a high, stable point in a lake-outlet canal, ditch or wetland area. The invert elevation is the lowest point on the portion of a water control structure that provides for conveyance of water across or through the structure. A crest elevation typically refers to the top or ridge of fixed-weirs or operable gates, over which water may flow. The control point elevation for Pasco Lake was established at 65.7 feet above NGVD, the surveyed crest elevation (SWFMWD 2006b) for the weir at the lake outlet in Jumping Gully.

Structural alteration status is determined to support development of the High Guidance Level. In addition to identification of outlet conveyance system modifications, comparison of the control point elevation with the normal pool elevation is typically used to determine if a lake has been structurally altered. If the control point elevation is below the normal pool, the lake is classified as a structurally altered system. If the control point elevation is above the normal pool or the lake has no outlet, then the lake is not considered to be structurally altered. Based on identified modifications to the lake outlet conveyance system and because the Control Point is lower than the Normal Pool elevation, Pasco Lake was classified as structurally altered.

Table 4. Summary statistics for hydrologic indicator measurements (elevation at the base of *Serenoa repens* shrubs) used for establishing the Normal Pool Elevation for Pasco Lake. Data were collected in August 2006 by District staff.

Statistic	Statistic Value (N) or Elevation (feet above NGVD)
N	35
Median	67.0
Mean (SD)	67.0 (0.3)
Minimum	66.5
Maximum	67.7



Figure 19. Ground elevations at the base of *Serenoa repens* shrubs used to establish the Normal Pool elevation for Pasco Lake.

Guidance Levels

The Ten Year Flood Guidance Level has historically been provided as advisory information for lakeshore development and is the level of flooding expected on a frequency of not less than the ten-year recurring interval, or on a frequency of not greater than a ten percent probability of occurrence in any given year. District rules (Chapter 40D-8, F.A.C.) previously included a Ten Year Flood Guidance Level of 67.50 feet above NGVD for Pasco Lake (see Southwest Florida Water Management District 1991, 1996a). Recent work completed in support of the District's Watershed Management Program has, however, yielded a new, provisional ten-year recurrence flood stage for the lake. Based on a storm-event modeling approach, Ardaman and Associates, Inc. (2007) identified a ten year flood recurrence level for Pasco Lake at 68.5 feet above NGVD. It should be noted that the Watershed Management Plan that includes the provisional flood elevation for the Lake will be subjected to public review prior to finalization of project results.

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

The High Guidance Level is provided as an advisory guideline for construction of lakeshore development, water dependent structures, and operation of water

management structures. The High Guidance Level is the expected Historic P10 of the lake, and is established using historic data if it is available, or is estimated using the Current P10, the control point and the normal pool elevation. Based on the availability of a representative Historic P10 elevation, the High Guidance Level for Pasco Lake was established at 66.1 feet above NGVD,

The Low Guidance Level is provided as an advisory guideline for water dependent structures, and as information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. The Low Guidance Level for Pasco Lake was established at 59.7 feet above NGVD, by subtracting the RLWR90 derived from the composite, historic Crews Lake data record from the High Guidance Level for Pasco Lake.

Lake Classification

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

Significant Change Standards and Other Information for Consideration

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

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

The Basin Connectivity Standard is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational use of the lake. The standard is based on the elevation of lake sediments at a critical high spot between lake basins or lake sub-basins, identification of water depths sufficient for movement of biota and/or watercraft across the critical high spot, and use of Historic lake stage data or region-specific reference lake water regime statistics. For Pasco Lake, the Basin Connectivity Standard was established at 68.8 feet above NGVD, based on the elevation that ensures connectivity between the lake sub-basins (64.9 feet above NGVD), a one-foot water depth in the area of connectivity to allow for movement of biota between the sub-basins, and the appropriate RLWR5090 (2.9 feet). If powerboats were used at the lake, the Basin Connectivity Standard would be established at 69.8 feet above NGVD, based on a requirement for a water depth of two feet at the critical high spot of connectivity.

The Species Richness Standard is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at a lake, the standard is established at the lowest elevation associated with less than a fifteen percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. For Pasco Lake, the Species Richness Standard was established at 61.6 feet above NGVD.

The Aesthetics Standard is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to limit potential change in aesthetic values associated with the median lake stage from diminishing beyond the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard is established at the Low Guidance Level, which for Pasco Lake occurs at an elevation of 59.7 feet above NGVD.

The Dock-Use Standard is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a two-foot water depth for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics. Based on the lack of existing, functional docks in the basin, a Dock-Use Standard was not developed for Pasco Lake.

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 a rectangular ski area 200 feet in width and 2,000 feet in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. Based on field observations indicating that the lake is not used for recreational skiing, and also based on basin morphology, which would not allow for the occurrence of a suitable ski area, a Recreation/Ski Standard was not developed for Pasco 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 of <0.8 . Because the dynamic ratio does not shift across the 0.8 threshold as the stage of Pasco Lake ranges from dry conditions up to 67 feet above NGVD (Figure 20), a Mixing Standard was not developed.

Herbaceous Wetland Information is taken into consideration to determine the elevation at which change in lake stage would result in substantial change in potential wetland area within the lake basin (*i.e.*, basin area with a water depth of four or less feet). Review of changes in potential herbaceous wetland area in relation to change in lake stage did not indicate that use of the applicable significant change standards would be inappropriate for establishment of the Minimum Lake Level (Figure 20). However, because herbaceous wetlands are common within the lake basin, it was determined that an additional measure of potential wetland change should be considered for minimum levels development. Based on a recent review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was determined that up to an 0.8 foot decrease in the Historic P50 elevation would likely not lead to significant change in the herbaceous wetlands occurring within lake basins. A Wetland Offset elevation of 61.8 feet above NGVD was therefore established for Pasco Lake by subtracting 0.8 feet from the Historic P50 elevation.

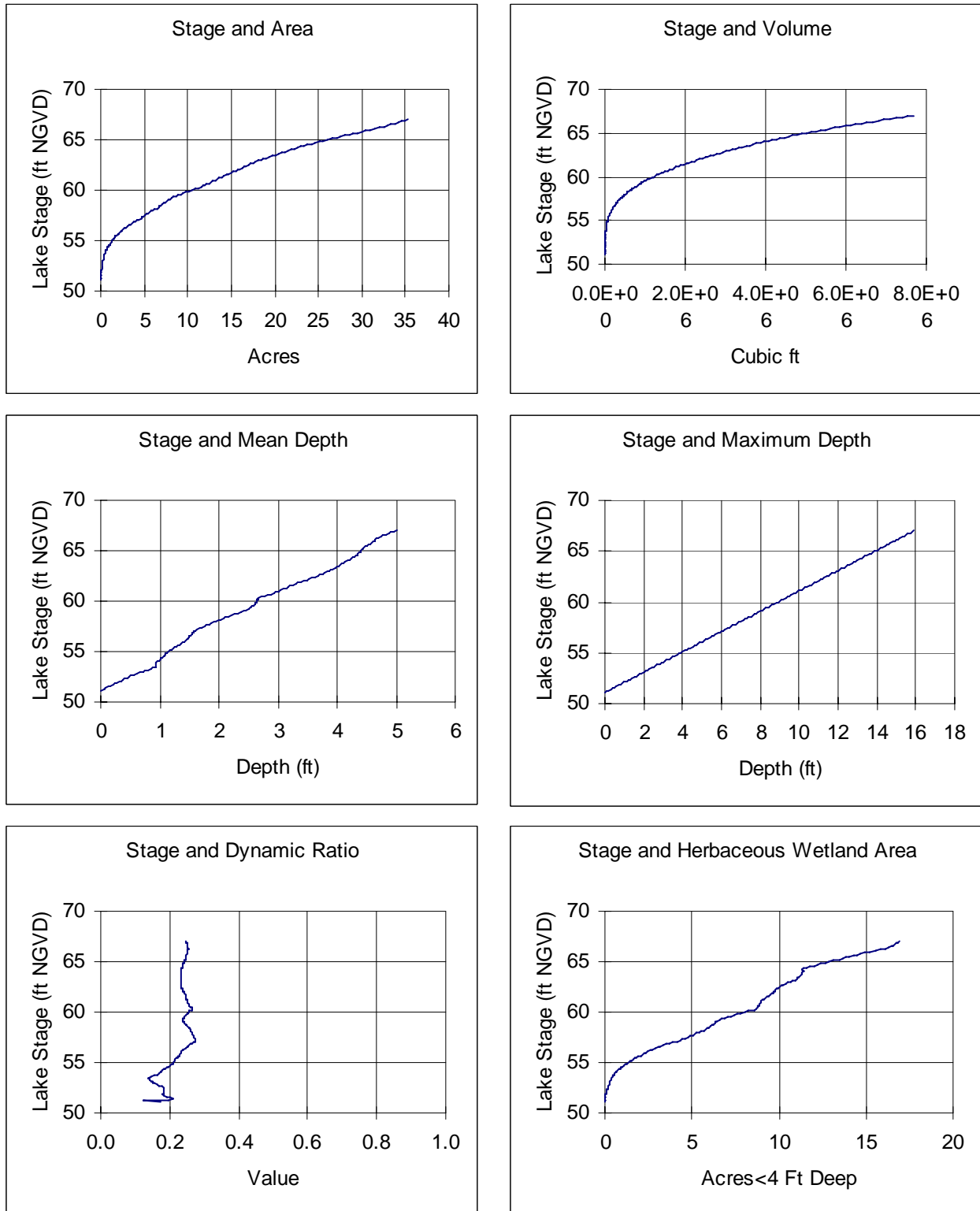


Figure 20. Pasco Lake surface area, volume, mean depth, maximum depth, dynamic ratio (basin slope) and potential herbaceous wetland area versus lake stage.

Minimum Levels

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

The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 lakes, the Minimum 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 Level is established at the Historic P50 elevation. Because the Basin Connectivity Standard for Pasco Lake is higher than the Historic P50 elevation, the Minimum Level could be established at the Historic P50 elevation, 62.6 feet above NGVD. However, because the Basin Connectivity Standard is also higher than the Historic P10, and because establishment of the Minimum Lake Level at the Historic P50 elevation would mean that any withdrawal impact, no matter how small, would not be permitted, it was determined that it would not be appropriate to use the Basin Connectivity Standard for establishing the Minimum Lake Level. The Minimum Lake Level could, instead, be established at 61.6 feet above NGVD, the elevation corresponding to the Species Richness Standard, the highest standard below the Historic P50. However, because the Wetland Offset elevation is higher than the Species Richness Standard, the Minimum Lake Level was established at the Wetland Offset elevation, 61.8 feet above NGVD.

The High Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For Category 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. If Historic Data are available, the High Minimum Lake Level is established at an elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level is set at an elevation corresponding to the Minimum Lake Level plus the region-specific RLWR50. Because Historic data are not available for Pasco Lake, the High Minimum Lake Level was established at 65.3 feet above NGVD, by adding the RLWR50 (3.5 feet) to the Minimum Lake Level.

Adopted minimum and guidance levels for Pasco Lake are shown in Figure 21 along with recorded, monthly mean water surface elevations. Review of available data indicated that staging of the lake at the minimum levels would not flood any man-made features within the immediate lake basin (see Figure 22 for the approximate lake

margins when the water surface is at the minimum levels). Based on recent field survey data (Southwest Florida Water Management District 2006), the High Minimum Lake Level is 2.3 feet below the lowest spot on the public roads in the lake vicinity, and 3.3 feet below the floor elevation of the lowest residential home within the immediate lake basin (Table 5). The floor elevation for a shed/outbuilding located in a residential yard along the lake is about 2.7 feet above the High Minimum Lake Level.

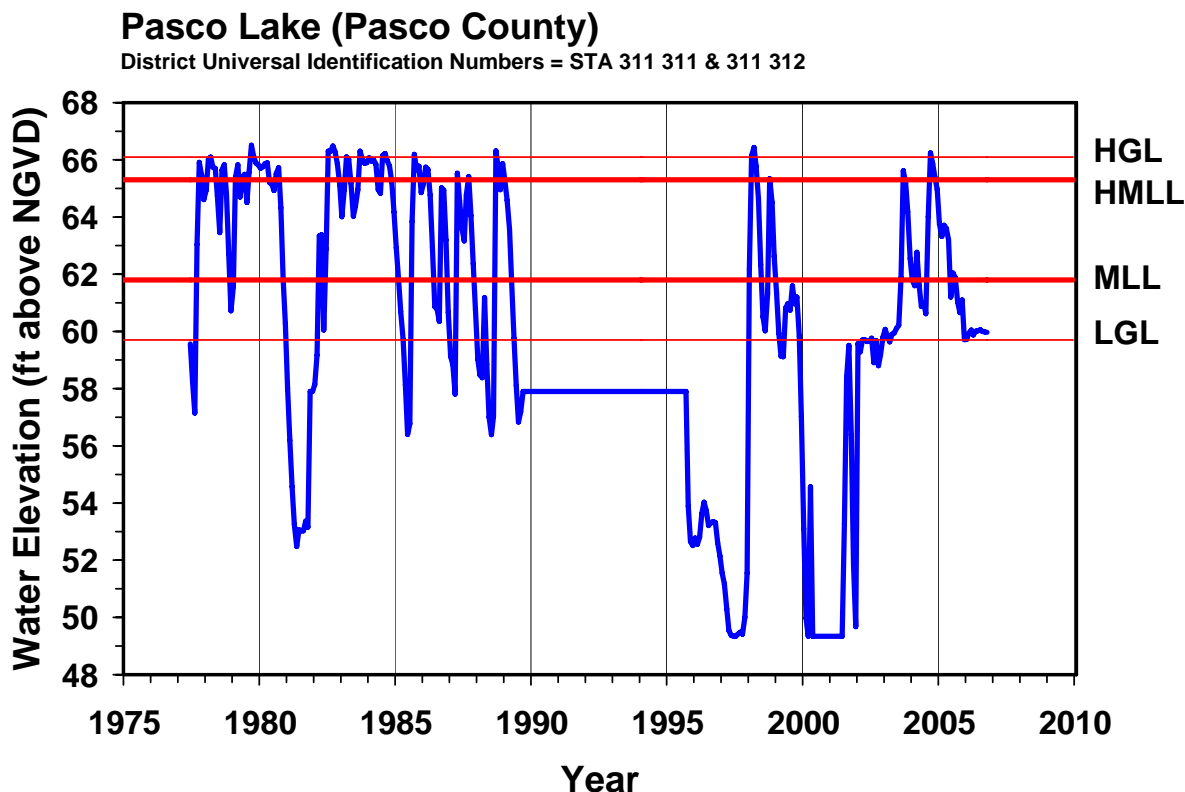
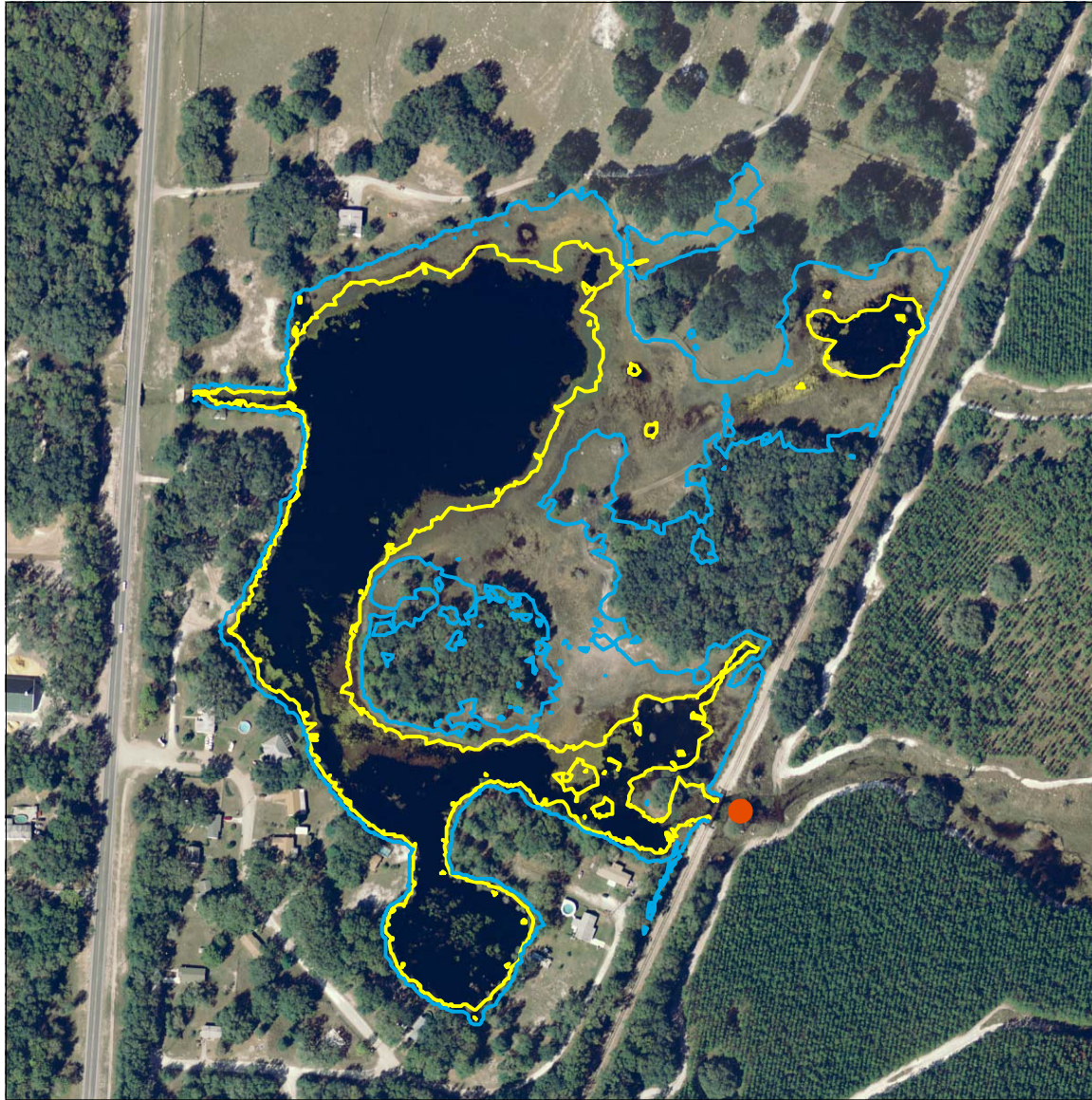


Figure 21. Guidance and Minimum Levels and mean monthly surface water elevations for Pasco Lake through October 2006. Adopted levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL) and Low Guidance Level (LGL). Note that for the period from July 1989 through October 1995, most measured water levels used to estimate monthly mean values were recorded as "<57.9 feet above NGVD", so it may be assumed that the lake surface was below this elevation for this period.

Table 5. Elevations of lake basin features in the immediate Pasco Lake basin.

Lake Basin Features	Elevation (feet above NGVD)
Lowest Floor Slab – Residential Dwelling	68.6
Second Lowest Floor Slab – Residential Dwelling	69.2
Concrete Slab for Carport	68.8
Concrete Slab for an Outbuilding (Shed)	68.0
Low Road – Limerock Road	67.6



Minimum Level Contours

- MLL = 61.8 ft above NGVD
- HMLL = 65.3 ft above NGVD

0 250 500 Feet



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

Figure 22. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Pasco Lake The orange dot indicates an area where contours were truncated for mapping purposes.

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