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



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Ecologic Evaluation Section Resource Projects Department



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Ecologic Evaluation Section Resource Projects Department Southwest Florida Water Management District Brooksville, Florida 34604-6899

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Cover: Ground-level photograph of Lake Iola in 1988 (Southwest Florida Water Management District files).

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Minimum and Guidance Levels for Lake Iola

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 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) 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 longterm 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 Lake Iola, a Category 3 Lake located in Pasco County, Florida (Southwest Florida Water Management District 2006). 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 Lake Iola.

Minimum and Guidance Levels	Elevation (feet above NGVD)
High Guidance Level	147.3
High Minimum Lake Level	146.5
Minimum Lake Level	141.9
Low Guidance Level	138.6

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

Lake Setting and Description

Lake Iola is located in north-central Pasco County, Florida (Section 15, Township 24 South, Range 20 East) in the Hillsborough River Basin of the Southwest Florida Water Management District (Figures 1 and 2). White (1970) classified the region of central or mid-peninsular Florida containing Lake Iola as the Brooksville Ridge. Brooks (1981) categorized the area surrounding the lake as the Dade City Hills division of the Ocala Uplift District, and described the region as 'a spectacular ridge of high hills dissected from Upper Miocene sand and silty sand". He also noted that "drainage is downward to the Floridan Aquifer and [that] solution is now the dominant process influencing the landscape". As part of the Florida Department of Environmental Protection's Lake Bioassessment/ Regionalization Initiative, the area has been identified as the Southern Brooksville Ridge region (Griffith *et al.* 1997). Lakes in the region tend to be neutral to alkaline, slightly colored, mesotrophic to meso-eutrophic systems.

Wetland vegetation within the basin includes torpedo grass (*Panicum repens*), cattail (*Typha* sp.), primrose willow (*Ludwigia* sp.), wax myrtle (*Myrica cerifera*) and willow (*Salix* sp.). A few cypress (*Taxodium* sp.) trees occur along the shoreline. Uplands in the immediate lake basin include areas that are currently used for medium density residential development, citrus production and silviculture (Figure 3). Historical photographs from 1941 through 2005 (Figures 3-14) provide evidence for a long history of agriculture activity in the lake watershed. The District currently maintains a water-level gauging station along the southern shore of the lake.

The lake lies within the Crews Lake Outlet drainage basin in the Upper Coastal Areas watershed (United States Geological Survey Hydrologic Unit Classification System). Surface water inputs include direct precipitation on the lake surface, and runoff from immediately adjacent upland areas. A ditch along the northwest lakeshore could provide for conveyance to Moody Lake if the water level in Lake Iola were to exceed approximately 153.5 feet above NGVD. There are no surface withdrawals from the lake permitted by the District. There are, however, several permitted groundwater withdrawals in the lake vicinity.

The "Gazetteer of Florida Lakes" (Florida Board of Conservation 1969, Shafer *et al.* 1986) lists the size of Lake Iola as 107 acres and indicates that the lake has a watershed drainage area of 0.4 square miles. The 1954 and 1988 photorevised U.S. Geological Survey 1:24,000 Spring Lake quadrangle 7.5 minute topographic maps include a water surface elevation of 147 feet above NGVD for Lake Iola (Figure 15). A topographic map of the lake basin generated in support of minimum levels development (Figure 16) indicates that the lake extends over 108 acres when it is staged at 147 feet above NGVD.



Figure 1. Locations of Lake Iola, other regional water bodies, highways and major roads within and near Pasco County, Florida.





Figure 2. Aerial photograph of the Lake Iola area in 2005, showing major water bodies and roads. Photographic image is from United States Geological Survey digital orthophotography (United States Geological Survey 2005).





Moody Lake

0 500 1,000 Feet

Figure 3. Aerial photograph of Lake Iola in 2005, showing the location of the District water level gauge, the lake outlet, and sites where hydrologic indicators were measured. The photographic image is from United States Geological Survey digital orthophotography (United States Geological Survey 2005).





Figure 4. Aerial photograph of Lake Iola in 1999. Image is from United States Geological Survey digital orthophotography (United States Geological Survey 1999).



Figure 5. Aerial photograph of Lake Iola in 1994. Image is from United States Geological Survey digital orthophotography (United States Geological Survey 1994).

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Figure 6. Aerial photograph of Lake Iola in 1984. Image is from United States Geological Survey National High Altitude Photography (United States Geological Survey 1984).



Figure 7. Aerial photograph of Lake Iola in 1973. Image is from Woolpert (2003).



Figure 8. Aerial photograph of Lake lola and areas north of the lake in March 1957 (United States Department of Agriculture 1957b). The lake is located in the lower left portion of the photograph.



Figure 9. Aerial photograph of the western portion of Lake Iola and areas west of the lake in March 1957 (United States Department of Agriculture 1957c).



Figure 10. Aerial photograph of the Lake Iola area in January 1952 (United States Department of Agriculture 1952).



Figure 11. Aerial photograph of the Lake Iola area in May 1951 (United States Department of Agriculture 1951b). The lake is shown in the lower left portion of the photograph.



Figure 12. Aerial photograph of the northern portion of Lake Iola in November 1944 (United States Department of Agriculture 1944). The northern portion of the lake is located along the lower edge of the photograph.



Figure 13. Aerial photograph of Lake Iola and areas to the north of the lake in January 1941 (United States Department of Agriculture 1941b). The lake is located in the lower left portion of the photograph.



Figure 14. Aerial photograph of Lake Iola and areas to the south of the lake in January 1941 (United States Department of Agriculture 1941c).





Figure 15. Five-foot elevation (feet above NGVD) contours in the vicinity of Lake lola as shown on United States Geological Survey 7.5 minute series topographic maps (United States Geological Survey 1954, 1988). Image is from the U.S. Geological Survey 1:24,000 scale topographic map (DRG) layer available from the Mapping and GIS Section of the Southwest Florida Water Management District.



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



Figure 16. One-foot elevation (feet above NGVD) contours within the Lake Iola basin.

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) for Lake Iola were approved by the Governing Board in May 1986 and incorporated into District rules (Chapter 40D-8, F.A.C.). A Maximum Desirable Level of 147.00 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 Lake Iola 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.

Lake lola 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, Lake lola 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.

Minimum and Guidance Levels	Elevation (feet above NGVD)
Ten Year Flood Guidance Level	147.55
High Level	147.50
Low Level	145.00
Extreme Low Level	142.50

Table 2. Previously adopted guidance Levels for Lake Iola.

Summary Data Used for Minimum and Guidance Levels Development

Minimum and Guidance Levels were developed for Lake Iola 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 Lake Iola.

	Elevation	Lake Area
	(feet above NGVD)	(acres)
Lake Stage Exceedance Percentiles		
Historic P10	147.3	108
Historic P50	142.7	97
Historic P90	138.6	88
Period of Record P10	145.7	105
Period of Record P50	142.5	97
Period of Record P90	138.7	88
Normal Pool and Control Point		
Normal Pool	154.6	NA
Control Point*	~153.5	NA
Significant Change Standards		
Dock-Use Standard	149.8	115
Wetland Offset	141.9	96
Aesthetic Standard	138.6	88
Species Richness Standard	136.1	83
Basin Connectivity Standard	129.6	69
Recreation/Ski Standard	121.6	49
Lake Mixing Standard	NA	NA
Minimum and Guidance Levels		
High Guidance Level	147.3	108
High Minimum Lake Level	146.5	107
Minimum Lake Level	141.9	96
Low Guidance Level	138.6	88

NA = Not available or not applicable.

* = A Control Point elevation was not established for Lake Iola because the lake was classified as a closed basin lake. The lake may, however discharge if it's water level exceeds the listed elevation, which represents the centerline of a road lying between the lake outlet-ditch and an additional conveyance way.

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations, for Lake Iola (District Universal Identification Number STA 501 503) are available from the District Water Management Data Base from January 1965 through the present date (Figure 17, see Figure 3 for current location of the District water level gauge). The highest surface water elevation for the lake included in the database, 148.7 feet above NGVD, occurred on January 22, 1989. The low of record, 134.08 feet above NGVD, was recorded on June 22, 2002.

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 water levels and regional ground water fluctuations, all available lake-stage data for Lake Iola were classified as Historic data. Although the water level data record extends over 40 years, it was determined that Historic lake-stage exceedance percentiles would be better estimated using a longer data record. Historic lake-stage exceedance percentiles were, therefore, developed using a composite 60-year record of monthly mean lake surface elevations based on available stage records that were supplemented with modeled estimates. The 60-year period was considered sufficient for incorporating the range of lake-stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield et al. 2001, Basso and Schultz 2003, Kelly 2004).

Modeled monthly mean lake stage values for the composite data set were estimated using a linear fitting procedure known as the line or organic correlation (see Helsel and Hirsch 1992). The procedure was used to describe the relationship between available lake stage data for Lake lola 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 lake and well data collected from January 1965 through September 2002 was used to estimate water surface elevation values for Lake lola for the period from January 1946 through December 2005 (M. Hancock, Southwest Florida Water Management District unpublished data). A Historic, composite data set of monthly mean water surface elevations for Lake lola was then developed using the modeled water surface elevations and available lake stage records (Figure 18). The composite record includes periods when estimated water surface elevations were higher than the values that have been measured at the lake gauging station. The

highest value included in the composite data set, 152.47 feet above NGVD, was estimated for October 1960.

The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was 147.3 feet above NGVD. The Historic P50, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was 142.7 feet above NGVD. The Historic P90, the lake water surface elevation equaled or exceeded ninety percent of the time during the historic period, was 138.6 feet above NGVD. The Historic P50 and P90 elevations are within a few tenths of a foot of the P50 and P90 values (142.5 and 138.7 feet, respectively) derived from the empirical data collected during the past 40 years. The Historic P50 is, however, 1.6 feet higher than the P50 (145.7 feet above NGVD) based on the period of record data.



Figure 17. Measured surface water elevations for Lake Iola through October 2006. Data were obtained from the District Water Management Database.



Figure 18. Composite monthly-mean surface water elevations and Historic lakestage exceedance percentiles for Lake Iola, from January 1946 through December 2005. 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).

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 of long-term water levels. Based on ground elevations measured in August 2006 at the base of saw palmetto *(Serenoa repens)* shrubs located along the north shore of the lake, the Normal Pool elevation was established at 154.6 feet above NGVD (Table 4, Figures 3 and 19). This elevation is substantially higher than the safe upland line (146.0 feet above NGVD) that has been identified for the lake by the Florida Department of Environmental Protection (Malloy 2005), and is also about 2.7 feet higher than the median elevation at

the base of large live oak (*Quercus virginiana*) trees along the north lakeshore (Table 5).

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. Historical aerial photography indicates that the ditch along the northeast shore of Lake Iola that could provide conveyance from the basin towards Moody Lake has been in existence since at least 1941. However, because the lake surface would have to exceed approximately 153.5 feet above NGVD to top the road that lies between the outlet ditch and a ravine that drop to a wetland area south of Moody Lake, Lake Iola was classified as a closed 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. Because Lake lola is classified as a closed basin lake, a Control Point elevation was not established. As noted above, however, the lake would be expected to discharge to the northwest if the lake level were to exceed approximately 153.5 feet above NGVD.

Structural alteration status is determined to support development of the High Guidance Level. In addition to identification of outlet conveyance system modifications, comparison of the Control point elevation with the Normal Pool is typically used to determine if a lake has been structurally altered. If the Control Point elevation is below the Normal Pool, the lake is classified as a structurally altered system. If the Control Point elevation is above the Normal Pool or the lake has no outlet, then the lake is not considered to be structurally altered. Based on the existence of the ditch along the northeast lakeshore, and given that the Normal Pool elevation (154.6 feet above NGVD) is higher than the elevation (~153.5 feet above NGVD) that the lake would need to reach to begin flowing towards Moody Lake, Lake Iola was classified as a structurally altered lake.

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

Statistic	Statistic Value (N) or Elevation (feet above NGVD)	
Ν	8	
Median	154.6	
Mean (SD)	154.7 (0.4)	
Minimum	154.1	
Maximum	155.3	



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

Table 5. Summary statistics for additional hydrologic indicator measurements (elevation at the base of large live oak, *Quercus virginiana, trees*) for Lake Iola. Data were collected in August 2006 by District staff.

Statistic	Statistic Value (N) or Elevation (feet above NGVD)	
Ν	7	
Median	151.9	
Mean (SD)	151.9 (0.5)	
Minimum	151.2	
Maximum	152.7	

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 147.55 feet above NGVD for Lake Iola (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 probability analysis of a long-term simulated water level record for Lake Iola, Ardaman and Associates, Inc. (2007) identified a ten year flood recurrence level at 147.9 feet above NGVD. It should be noted that the Watershed Management Plan that includes the provisional flood elevation for Lake Iola 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 Lake Iola.

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 Historic data for Lake Iola, the High Guidance Level was established at the Historic P10 elevation, 147.3 feet above NGVD.

The Low Guidance Level is provided as an advisory guideline for water dependent structures, and as information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. Reference lake water regime statistics are used when adequate historic or current data are not available. These statistics represent differences between P10, P50 and P90 lake stage elevations for typical, regional lakes that exhibit little or no impacts associated with water withdrawals (*i.e.*, reference lakes). Reference lake water regime statistics include the RLWR50, RLWR90 and RLWR5090, which are, respectively, median differences between P10 and P50, P50 and P90, and P10 and P90 lake stage percentiles for a set of reference lakes. Based on the availability of Historic data for Lake lola, the Low Guidance Level was established at the Historic P90 elevation, 138.6 feet above NGVD.

Lake Classification

Lakes are classified as Category 1, 2 or 3 for the purpose of Minimum Levels development. Systems with fringing cypress wetlands greater than 0.5 acres in size where water levels regularly rise to an elevation expected to fully maintain the integrity of the wetlands (*i.e.*, the Historic P50 is not more than 1.8 feet below the Normal Pool elevation) are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 is more than 1.8 feet below the Normal Pool elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with less than 0.5 acres of fringing cypress wetlands are classified as Category 3 Lakes. Based on the lack of lake-fringing cypress wetlands within the lake-basin, Lake Iola 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. The Basin Connectivity Standard was established at 129.6 feet above NGVD, based on the elevation that ensures connectivity between the major and minor sub-basins of the lake (123.5 feet above NGVD), a two-foot water depth in the area of connectivity to allow for movement of boats between the sub-basins, and the difference between the Historic P50 and Historic P90 elevations (4.1 feet). The standard elevation was equaled or exceeded one hundred percent of time during the Historic period.

The Species Richness Standard is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at 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 Lake Iola, the Species Richness Standard was established at 136.1 feet above NGVD. The Species Richness Standard was equaled or exceeded ninety-nine percent of the time during the Historic period; *i.e.*, the standard elevation corresponds to the Historic P99.

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 Lake lola occurs at an elevation of 138.6 feet above NGVD. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the Historic period.

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 bottomdwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a two-foot water depth for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics. The Dock-Use Standard for Lake lola was established at 149.8 feet above NGVD, based on the elevation of sediments at the end of ninety percent of the 6 docks within the basin (143.7 feet above NGVD, Table 6), a two-foot water depth based on use of powerboats in the lake, and the 4.1-foot difference between the Historic P50 and Historic P90. Because the standard was based on only a few docks, and because the standard elevation is higher than the Historic P10 elevation and the recently identified ten year flood recurrence level, the Dock-Use Standard was not considered appropriate for development of minimum levels for Lake Iola.

The Recreation/Ski Standard is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a 5-foot deep ski corridor delineated as a circular area with a radius of 418 feet, or a rectangular ski area 200 feet in width and 2,000 feet in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. For Lake Iola, the Recreation-Ski Standard was established at 121.6 feet above NGVD, based on the sum of the Ski Elevation (117.5 ft above NGVD) and the 4.1-foot difference between the Historic P50 and Historic P90. The standard elevation was equaled or exceeded one hundred percent of the time during the Historic period.

The Lake Mixing Standard is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann *et al.* 2000) shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value of <0.8. Because the dynamic ration does not shift across the 0.8 threshold at any water surface elevation up to 151 feet above NGVD, a Lake Mixing Standard was not established for Lake Iola.

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 of 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 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 141.9 feet above NGVD was therefore established for Lake Iola by subtracting 0.8 feet from the Historic P50 elevation. Table 6. Summary statistics and elevations associated with docks in Lake Iola, based on measurements made by District staff in July 2006. Percentiles (P10, P50, P90) represent elevations exceeded by 10, 50 and 90 percent of the docks.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms
Ν	6	3
Mean (Standard Deviation)	138.5 (4.6)	149.1 (0.5)
P10	143.7	149.4
P50 or Median	137.5	149.2
P90	134.3	148.7
Maximum	144.9	149.4
Minimum	132.0	148.6



Figure 20. Lake lola 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 all appropriate significant change standards were below the Historic P50 elevation, the Minimum Level for Lake lola could be established at 138.6 feet above NGVD, the elevation corresponding to the highest of the standards, the Aesthetics Standard. The Minimum Lake Level was, however, established at the Wetland Offset elevation, 141.9 feet above NGVD. 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.

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 plus the difference between the Historic P10 and Historic P50. If Historic data are not available, the High Minimum Lake Level plus the tevel is set at an elevation corresponding to the Minimum Lake Level plus 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 available for Lake Iola, the High Minimum Lake Level was established at 146.5 feet above NGVD, by adding the difference between the Historic P50 and Historic P10 (4.6 feet) to the Minimum Lake Level.

The minimum and guidance levels for Lake Iola are shown in Figure 21 along with monthly mean water surface elevations based on recorded water level measurements. 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 (D.C. Johnson Associates 2006), the High Minimum Lake Level is 5.4 feet below the lowest spot on the paved roads in the lake vicinity, and 8 feet below the floor elevation of the lowest occupied, residential home within the immediate

lake basin (Table 7). The floor elevation for an abandoned building in the basin is about 3.8 feet above the High Minimum Lake Level and 1.6 feet above the finished floor of a lakeside cabana located behind a lakeside resident's home.



Figure 21. Minimum and Guidance Levels and mean monthly surface water elevations for Lake Iola 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).

 Table 7. Elevations of lake basin features in the immediate Lake lola basin.

Lake Basin Features	Elevation (feet above NGVD)
Low Floor Slab – residential building	154.5
Low Floor Slab – abandoned residential building	150.3
Low Other – floor slab of finished lakeside cabana	148.1
Low Spot on the Paved Roads Near the Lake	151.9



Minimum Level Contours	0	500	1,000 Feet
MLL = 141.9 ft above NGVD	L		
HMLL = 146.5 ft above NGVD		N	

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

Figure 22. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Iola.

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