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MINIMUM LEVELS EVALUATION: JOHNS LAKE, LAKE AND ORANGE COUNTIES, FLORIDA

by

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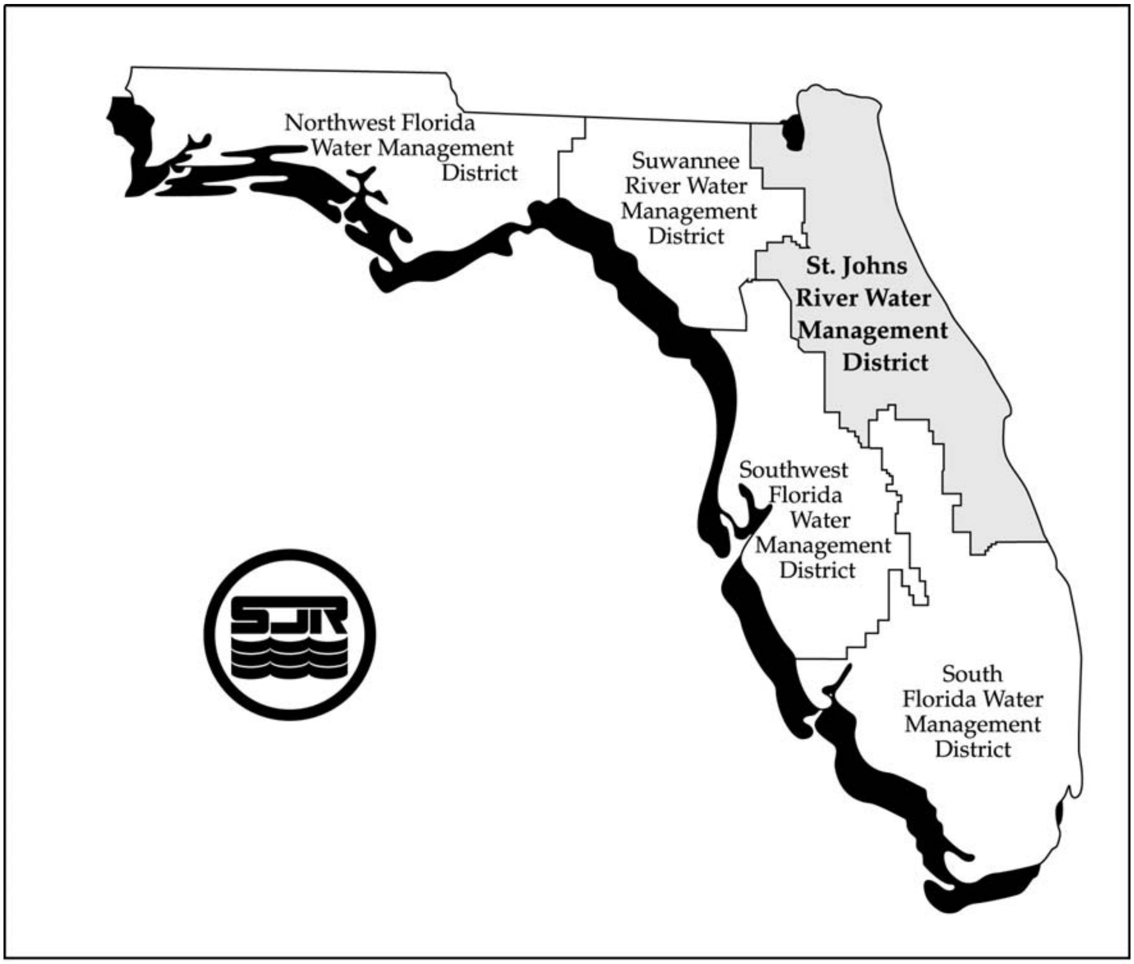

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources for the benefit of the people of the District and the state of Florida. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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EXECUTIVE SUMMARY

This report describes the St. Johns River Water Management District's (SJRWMD's) minimum flows and levels (MFLs) evaluation of Johns Lake, located in Lake and Orange counties, Florida. Johns Lake is on the *MFLs Priority Water Body List and Schedule* (SJRWMD 2006a). As a priority listed water body, minimum levels must be established for this lake pursuant to Section 373.042(2), *Florida Statutes* (F.S.). The priority water body list and schedule is based upon the importance of the water body to the region and the existence of, or potential for, significant harm to the water resources or ecology of the region.

The SJRWMD multiple MFLs method (SJRWMD 2006c, Neubauer et. al. 2007a) was used to develop the recommended MFLs presented in this document. Determination of MFLs is based on evaluations of topographic, soils, and vegetation data collected within plant communities associated with the water body. Also, best available information included the use of surface water inundation/dewatering signatures (SWIDS) developed by MFLs staff (Neubauer et. al 2004, Neubauer et al. 2007b) that quantitatively define flooding and dewatering signatures for the minimum-, mean-, and maximum elevations of selected plant communities.

Recommended MFLs with temporal components (i.e., duration and return intervals), which are based upon best available information, are presented in Table ES-1.

The hydrologic model for Johns Lake was calibrated for 2001 conditions. These conditions included the most recent land use information and groundwater levels consistent with 2001 regional water use. Based on hydrologic model results, SJRWMD concludes that the recommended MFLs for Johns Lake are protected under 2001 conditions. To determine if changes in groundwater use allocations subsequent to 2001 would cause lake levels to fall below the recommended MFLs for Johns Lake, the existing Johns Lake hydrologic model should be run using Floridan aquifer potentiometric level declines that reflect these changes in water use allocation.

Recommended MFLs presented in this report will not become effective until after they are adopted by the SJRWMD Governing Board as rule. On-site monitoring and periodic reassessment of levels should be conducted in order to determine if these levels are being achieved and if they are adequate to prevent significant ecological harm from occurring at Johns Lake. Reassessments should include analysis of period-of-record stage data and periodic monitoring of the vegetation communities and the soil water table at the Johns Lake transects.

Table ES-1. Recommended minimum surface water levels for Johns Lake, Lake and Orange counties, Fla.

Minimum Level	Recommended Elevation (ft NGVD) 1929 Datum	Recommended Duration	Recommended Return Interval
Minimum frequent high (FH) level	94.7	30 days	2 years
Minimum frequent low (FL) level	92.1	120 days	3 years

ft NGVD = feet National Geodetic Vertical Datum

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INTRODUCTION

This report describes the St. Johns River Water Management District's (SJRWMD's) minimum flows and levels (MFLs) evaluation of Johns Lake, located in Lake and Orange counties, Florida. Johns Lake is on the *MFLs Priority Water Body List and Schedule* (SJRWMD 2006a). As a priority listed water body, minimum levels must be established for this lake pursuant to Section 373.042(2), *Florida Statutes* (F.S.). The priority water body list and schedule is based upon the importance of the water body to the region and the existence of, or potential for, significant harm to the water resources or ecology of the region.

The recommended MFLs for Johns Lake are intended to protect the aquatic and wetland ecosystems from significant ecological harm caused by the consumptive use of water. In addition, MFLs provide technical support to SJRWMD's regional water supply planning process (Section 373.0361, F.S.), the consumptive use permitting program (Chapter 40C-2, *Florida Administrative Code* [*F.A.C.*]), and the environmental resource permitting program (Chapter 40C-4, *F.A.C.*).

MFLS PROGRAM OVERVIEW

The SJRWMD minimum flows and levels program develops recommended minimum flows and levels (MFLs) for lakes, streams and rivers, wetlands, springs, and groundwater aquifers. The MFLs program is subject to the provisions of Section 373.042 and Section 373.0421, F.S., and Chapter 40C-8, *F.A.C.*

Based on the provisions of Rule 40C-8.011 (3) *F.A.C.*, "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology." Significant harm is prohibited by Section 373.042(1), F.S. In addition, "MFLs should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area" (Rule 62-40.473(2), *F.A.C.*).

Factors to Be Considered When Determining MFLs

According to Rule 62-40.473(1), *F.A.C.*, in establishing MFLs pursuant to Section 373.042 and Section 373.0421, F.S., consideration shall be given to natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology, including the following:

- Recreation in and on the water (Rule 62.40.473(1)(a), *F.A.C.*)

- Fish and wildlife habitats and the passage of fish (Rule 62.40.473(1)(b), *F.A.C.*)
- Estuarine resources (Rule 62.40.473(1)(c), *F.A.C.*)
- Transfer of detrital material (Rule 62.40.473(1)(d), *F.A.C.*)
- Maintenance of freshwater storage and supply (Rule 62.40.473(1)(e), *F.A.C.*)
- Aesthetic and scenic attributes (Rule 62.40.473(1)(f), *F.A.C.*)
- Filtration and absorption of nutrients and other pollutants (Rule 62.40.473(1)(g), *F.A.C.*)
- Sediment loads (Rule 62.40.473(1)(h), *F.A.C.*)
- Water quality (Rule 62.40.473(1)(i), *F.A.C.*)
- Navigation (Rule 62.40.473(1)(j), *F.A.C.*)

In addition, based on Section 373.0421(1), F.S., the following considerations are also required:

"When establishing minimum flows and levels pursuant to Section 373.042, the department or Governing Board shall consider 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 an affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by Section 373.042(1) caused by withdrawals."

Hydrology

MFLs designate an environmentally protective hydrologic regime (i.e., the hydrologic conditions that prevent significant harm) and identify levels and/or flows above which water may be available for use. MFLs define the frequency of high-, intermediate-, and low water events necessary to protect relevant water resource values. Three MFLs are usually defined for each system—minimum frequent high, minimum average, and minimum frequent low—flows and/or water levels. If deemed necessary, the minimum infrequent high and/or minimum infrequent low flow and/or water level is also defined. MFLs represent hydrologic statistics composed of three components: a magnitude (a water level and/or flow), duration (days), and a frequency or return interval (years).

MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in the return intervals of high- and low water events. Therefore, MFLs allow for an acceptable level of change to occur relative to the historic hydrologic conditions (gray-shaded area, Figure 1). However, when use of water resources shifts the hydrologic conditions below that defined by the MFLs, significant ecological harm occurs. As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies of water level and/or flow events of defined magnitude and duration, causing impairment or loss of ecological structures and functions.

MFLs apply to decisions affecting permit applications, declarations of water shortages, and assessments of water supply sources. Surface water and groundwater computer simulation models are used to evaluate existing and/or proposed consumptive uses and the likelihood they might cause significant harm. Actual or projected instances where water levels fall below established MFLs require the SJRWMD Governing Board to develop recovery or prevention strategies (Section 373.0421(2), F.S.). MFLs are to be reviewed periodically and revised as needed (Section 373.0421(3), F.S.).

BACKGROUND INFORMATION

Johns Lake is located approximately 5 miles southeast of the City of Clermont and approximately 2 miles southwest of the City of Winter Park on the border of Lake and Orange counties, Florida (Figure 2 and Figure 3). The lake is approximately 2,417 acres in size when water levels are at approximately 94 feet (ft) National Geodetic Vertical Datum (NGVD) (U.S. Geological Survey [USGS] 1:24,000 quadrangle maps, Clermont East and Winter Garden, Fla.). Johns Lake is in a priority water resource caution area (SJRWMD 2006b).

Johns Lake is located within the Lake Wales Ridge division of the Central Lakes physiographic district (Brooks 1982). Brooks (1982) described this division as the topographic crest of central Florida. The division consists of residual sand hills, relic beach ridges, and paleo sand dune fields. Johns Lake is within an area called The Gap (Brooks 1982), which is said to be in a late stage of erosion. Much of the land surface is near 120 ft NGVD in elevation.

An active association for lakefront property owners was founded in the 1940s. This group has encouraged water quality data collection by the University of Florida Lake Watch program; hydrologic data collection by USGS and; more recently, by SJRWMD; and invasive aquatic plant control by county governments. Bass population studies by the Florida Fish and Wildlife Conservation Commission were reportedly under way in 2000 (Hickman 2000, personal communication).

Johns Lake Hydrology

The USGS quadrangle maps (1:24,000 scale, Clermont East and Winter Garden, Fla., quadrangles) show two surface water inflows. One inflow is from Black Lake and one enters the northeast lobe of Johns Lake from a wetland near the Florida Turnpike. One outflow to Lake Apopka exists in the northeast lobe of Johns Lake. The mapped surface water elevations for Johns Lake and Lake Apopka are 94 ft NGVD and 66 ft NGVD, respectively. According to USGS (1998), Johns Lake has a watershed area of 40.1 square miles. Recharge to the Floridan aquifer from Johns Lake is an estimated 0–4 in. per year (Figure 4 [Boniol and Fortich 2005]).

Semiweekly lake stage data were available for Johns Lake for the period of September 1959 through August 2007 (Figure 5). The maximum- and minimum observed water levels were 99.47 ft NGVD (April 6, 1960) and 85.52 ft NGVD (July 17, 2001), respectively. The mean- and median stage values for the period of record are 92.47 ft NGVD and 92.32 ft NGVD, respectively. A stage duration curve based upon the above-referenced data is presented in Figure 6.

A hydrologic water budget model for Johns Lake exists that was calibrated for 2001 conditions (Robison 2007). These conditions include the most recent land use information and groundwater levels consistent with 2001 regional water use.

Johns Lake Wetlands

The SJRWMD wetlands vegetation map (Figure 7) indicates that Johns Lake wetlands consist primarily of seven types: transitional shrub, hydric hammock, bottomland hardwoods, shrub swamp, wet prairie, shallow marsh, deep marsh. A description of each wetland type is provided below.

Transitional Shrub. Transitional shrub is dominated by shrubby vegetation at upland margins of wetter community types or on clear-cut hydric sites. This community also develops on wet prairie sites that have been protected from fire (Kinser 1996).

Hydric Hammock. Hydric hammock is described as forested systems dominated by a mixture of broad-leaved evergreen and deciduous tree species. Hydric hammock is seldom inundated but is with saturated soils during much of the year (Kinser 1996).

Bottomland Hardwoods. Bottomland hardwoods is described as deciduous forest communities located in the floodplains of rivers and streams that are subject to rapid rise and fall of floodwaters. At other times, these communities are relatively well-drained or, at most, saturated by lateral seepage. Associated soils are alluvial (Kinser 1996).

Shrub Swamp. Shrub swamp is dominated by willow, buttonbush, or similar appearing vegetation. The hydrology of shrub swamps is similar to cypress, hardwood swamp, or shallow marsh communities (Kinser 1996).

Wet Prairie. Wet prairie is dominated by grasses, sedges, rushes, and herbs typically dominated by sand cordgrass, or a mixture of species. This community usually is growing on mineral soils inundated for a relatively short duration each year, but with prolonged soil saturation. Wet prairies are subject to frequent fire.

Shallow Marsh. Shallow marsh is described as herbaceous or graminoid, occurring most often on organic soils that may experience lengthy seasonal inundation (Kinser 1996).

Deep Marshes. Deep marshes are described as dominated by a mixture of deep-water emergent species and water lilies and are semipermanently to permanently flooded (Kinser 1996).

The U.S. Fish and Wildlife Service, National Wetlands Inventory, identified six classes of wetlands at Johns Lake (Table 1).

Wetland vegetation communities for this MFLs determination were classified according to SJRWMD's Wetland Vegetation Classification System (Kinser 1996). Detailed wetland community descriptions are presented in the Results and Discussion section of this document for each sampling transect located at Johns Lake.

Johns Lake Hydric Soils

Lake hydrology is related to the development of hydric soils. These substrates are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA, SCS 1987). Six hydric soils were delineated adjacent to Johns Lake, three from Lake County, and three from Orange County (FAESS 1995). The U.S. Department of Agriculture, Soil Conservation Service, maps are on file and not included with the attachments of this document because of their large size—copying and reducing the maps renders the information difficult to read and interpret. The hydric soils listed from Lake County are Placid and Myakka sands, 0–2% slopes, Placid sand, slightly wet, and Myakka sand (USDA, SCS 1975).

The hydric soils listed from Orange County are Basinger fine sand, depressional, Samsula muck, and Sanibel muck (USDA, SCS 1989). Notably, these two muck soils from Orange County are not located immediately adjacent to Johns Lake (SCS 1989).

A more recent draft of the Lake County soil survey exists (USDA, SCS 1990b). However, the maps of these two soil surveys appear to be identical.

Lake County Hydric Soils

Placid and Myakka sands, 0–2% slopes:

The USDA, SCS (1975), described Placid and Myakka sands, 0 to 2% slopes as very poorly drained and poorly drained soils in low, marshy depressions. The water table in these soils is nearer the surface for longer periods than in Myakka sand, and the soil is covered with water for 4 to 6 months in most years.

Placid sand, slightly wet:

The USDA, SCS (1975), described Placid sand, slightly wet as nearly level, poorly drained soil. It is at elevations slightly higher than Placid sand. Placid sand, slightly wet occurs as low, broad areas and as narrow bands around ponds and lakes. This soil covers a transitional zone between the well-drained sandy uplands and the very poorly drained wetlands. The water table is within a depth of 10 in. for about 2 months of the year and at a depth of 10–30 in. the rest of the year.

Myakka sand:

The USDA, SCS (1975), described Myakka sand as a nearly level, poorly drained soil that has a layer stained by organic material at a depth of less than 30 in. The water table is generally at a depth of 10–40 in., but it may be less than 10 in., in the wet season, and more than 40 in. during an extended dry season.

Orange County Hydric Soils

Basinger fine sand–depressional:

The USDA, SCS (1989), described Basinger fine sand–depressional as nearly level and very poorly drained. This soil is in shallow depressions and sloughs and along the edges of freshwater marshes and swamps. Undrained areas are ponded for 6 to 9 months or more each year. In some areas, the surface layer of muck or mucky fine sand is less than 16 in. thick. Under natural conditions, the water table is above the surface for 6 to 9 months or more each year and is within 12 in. of the surface for the rest of the year.

Samsula muck:

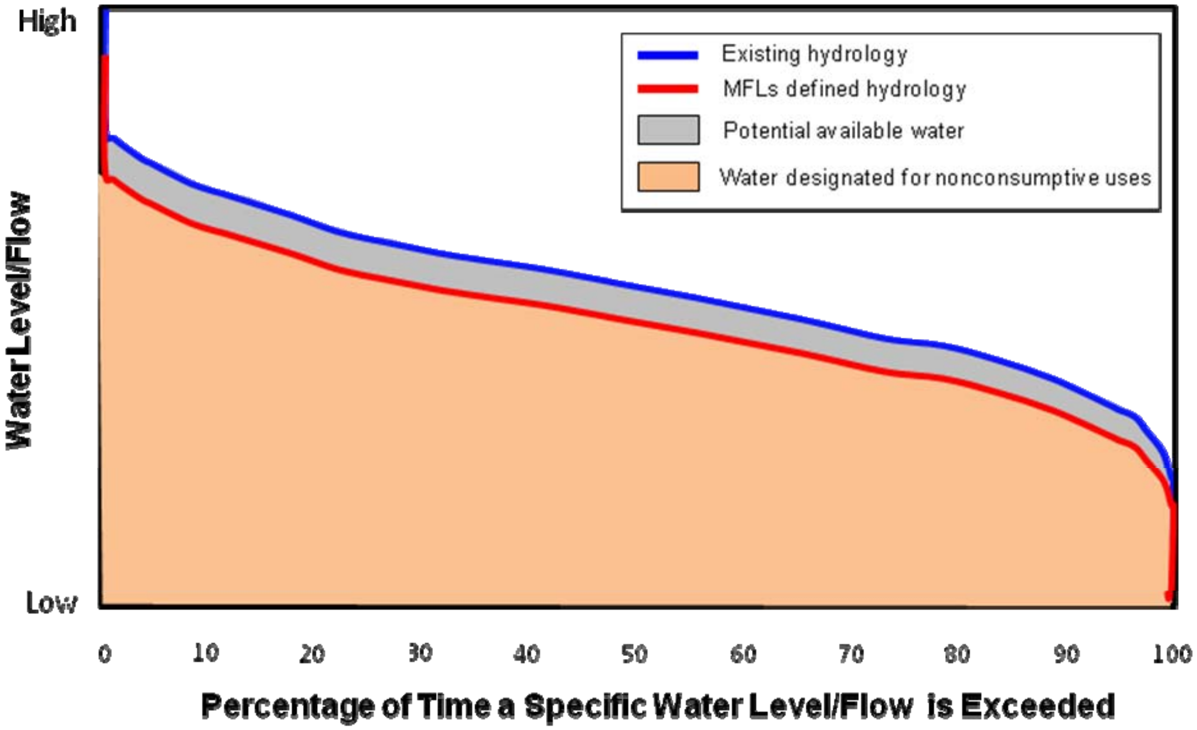
The USDA, SCS (1989), described Samsula muck as a nearly level and very poorly drained soil. This soil is in freshwater marshes and swamps. Undrained areas are ponded for 6 to 9 months or more each year except during extended dry years. A seasonal high water table fluctuates between depths of about 10 in. and the surface. This soil is subject to oxidation and subsidence if drained.

Sanibel muck:

The USDA, SCS (1989), described Sanibel muck as a nearly level and very poorly drained soil. This soil is in depressions, freshwater swamps and marshes, and poorly defined drainageways. Undrained areas are ponded for 6 to 9 months or more each year except during extended dry periods. The water table fluctuates between depths of about 10 in. and the surface for 2 to 6 months. The soil is subject to oxidation and subsidence if drained. The extent of hydric soil indicators were identified at each sampling transect. Transect-specific field soil sample descriptions are presented in the Results and Discussion section of this document.

Table 1. Wetlands mapped at Johns Lake by the U.S. Fish and Wildlife Service, National Wetlands Inventory

Description
Lacustrine, limnetic, uncolidated bottom, permanently flooded
Palustrine, emergent, persistent, seasonally flooded
Palustrine, emergent, persistent, intermittently flooded
Palustrine, forested, broad-leaved deciduous, seasonally flooded
Palustrine, emergent, persistent, semipermanently flooded
Palustrine, unconsolidated bottom, permanently flooded



The existing hydrology curve represents the current river stage or flow regime.
The MFLs-defined hydrology curve represents the new river stage or flow regime, which provides for the potentially available water (gray-shaded area).

Figure 1. Hypothetical percentage exceedence curves for existing and MFLs-defined hydrologic conditions

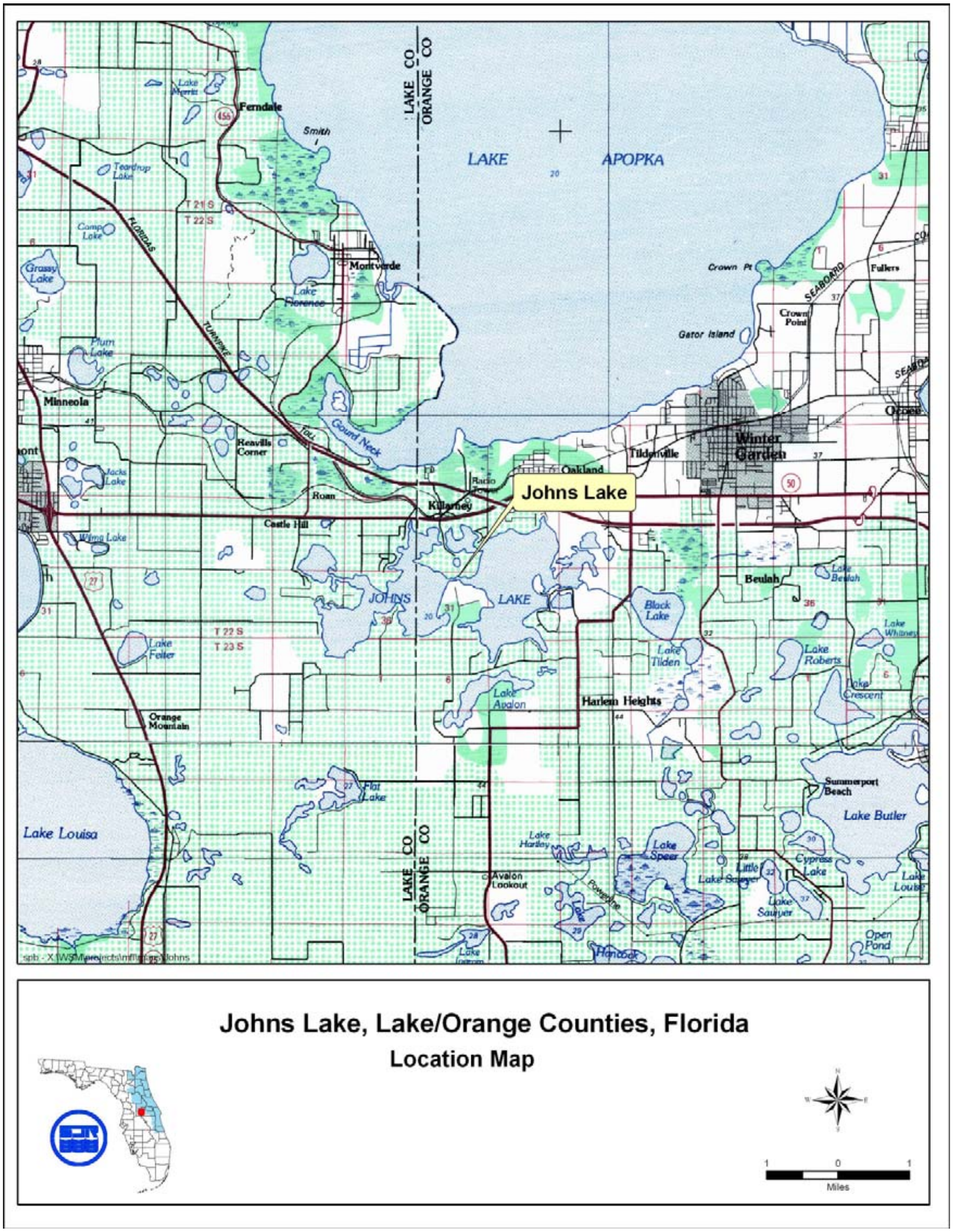


Figure 2.   Johns Lake, Lake and Orange counties, Fla., location map

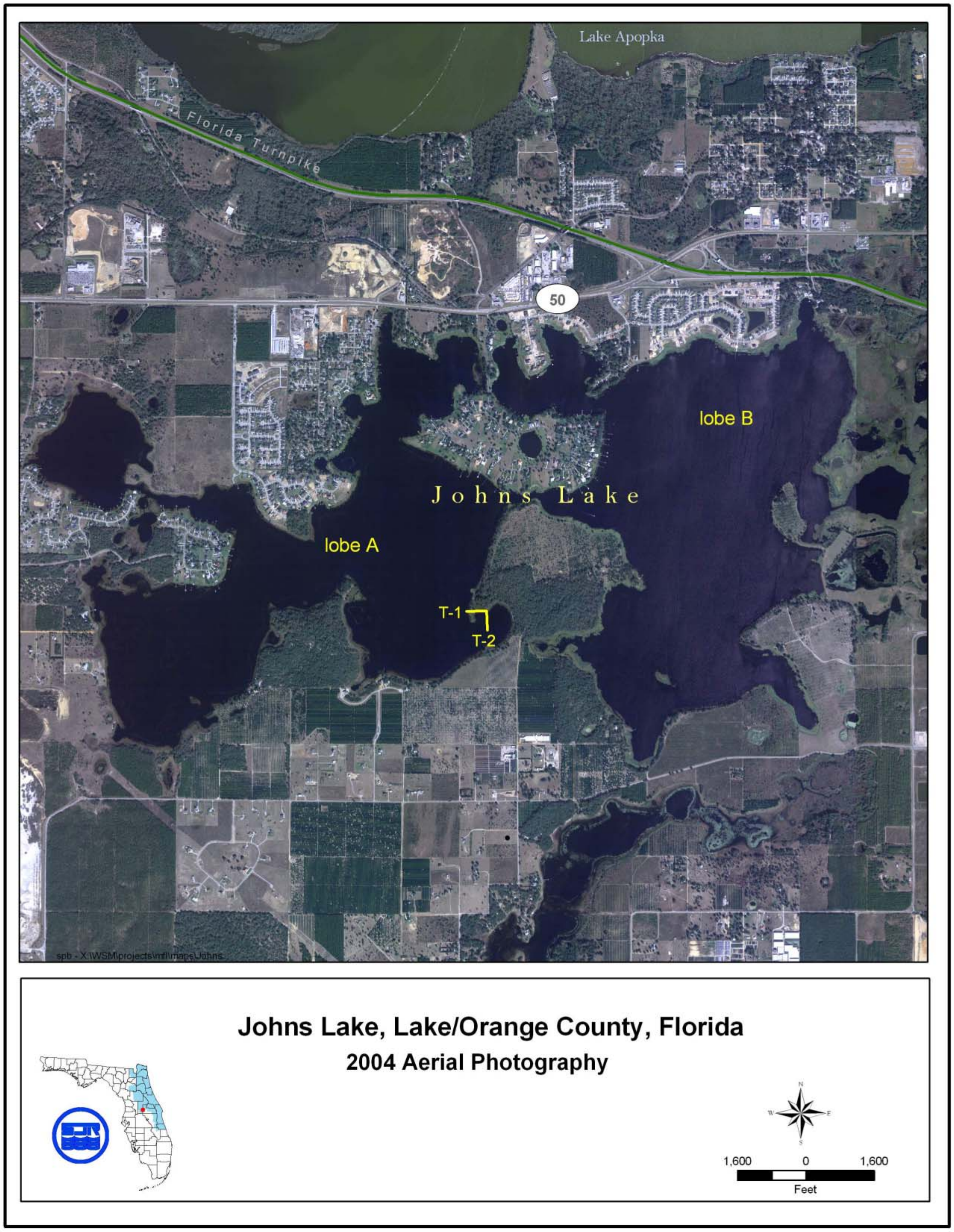


Figure 3. Johns Lake, Lake and Orange counties, Fla., digital orthoquadrangle (DOQ) map with approximate locations of transects (T1 and T2)

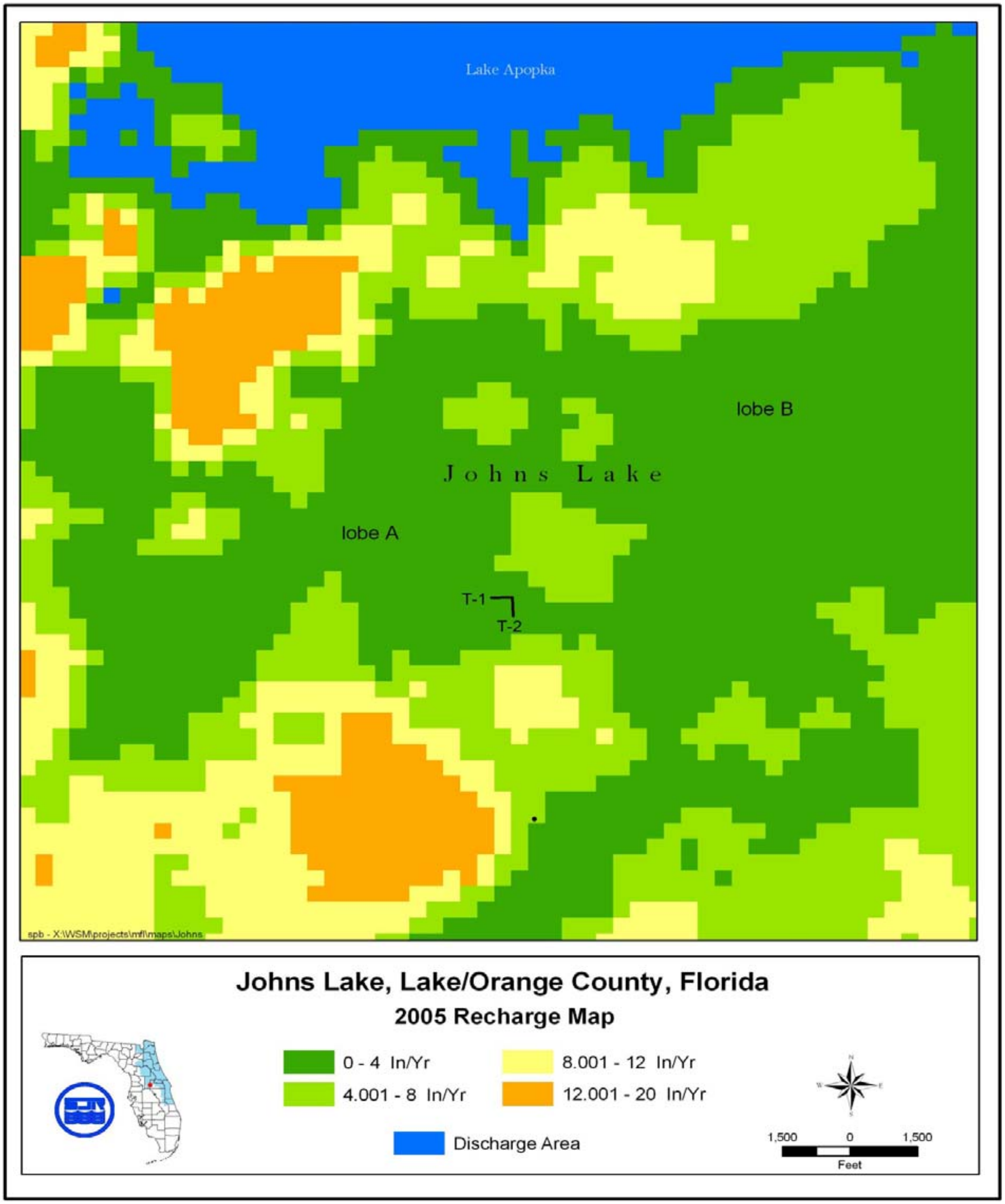


Figure 4. Potential recharge map for Johns Lake, Lake and Orange counties, Fla.

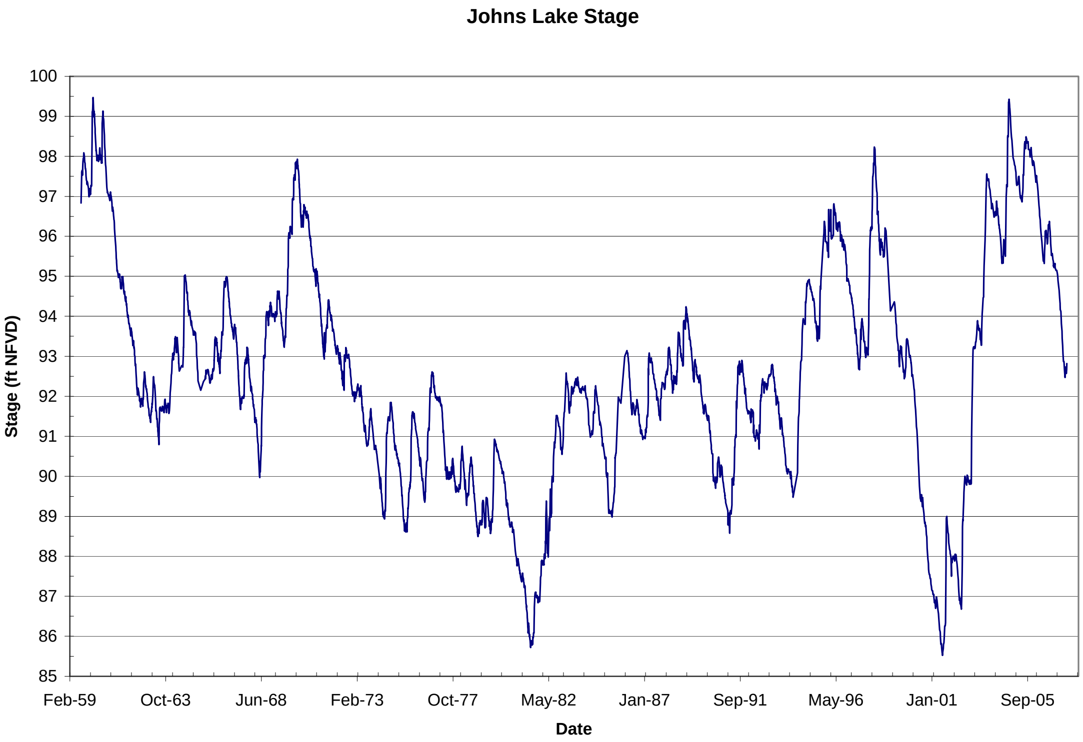


Figure 5. Hydrograph for Johns Lake, Lake and Orange counties, Fla., developed with approximately semiweekly stage data 1959–2007

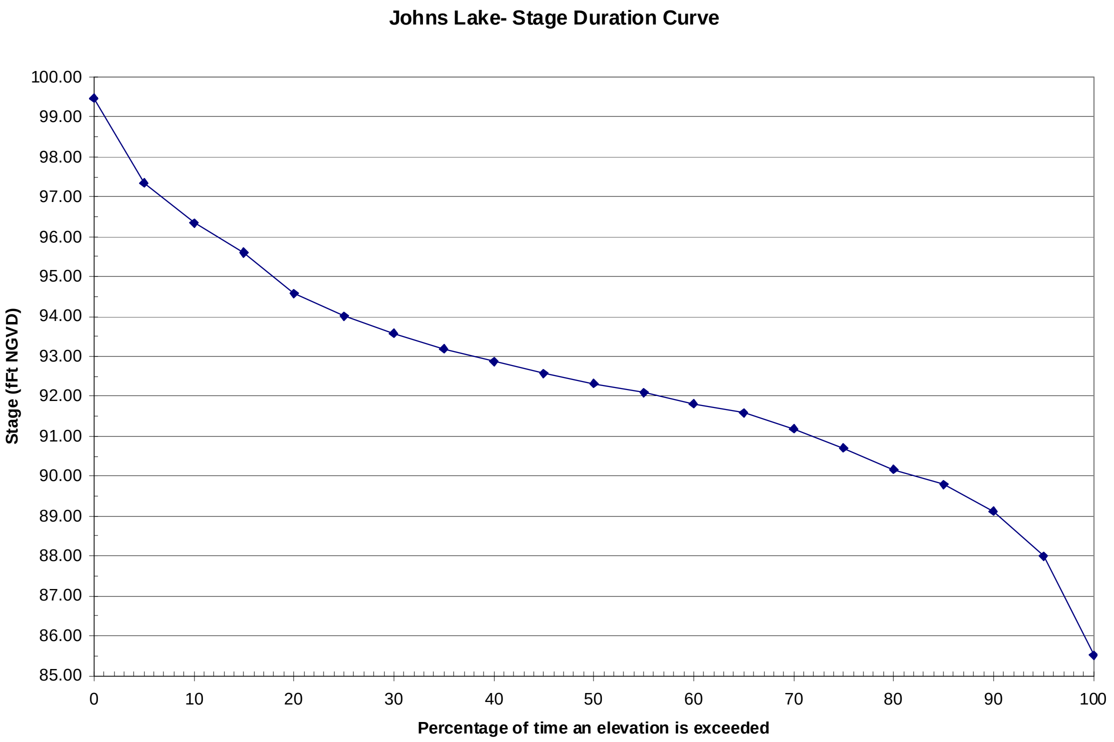


Figure 6. Johns Lake, Lake and Orange counties, Fla., stage duration curve developed from approximately semiweekly data 1959–2007

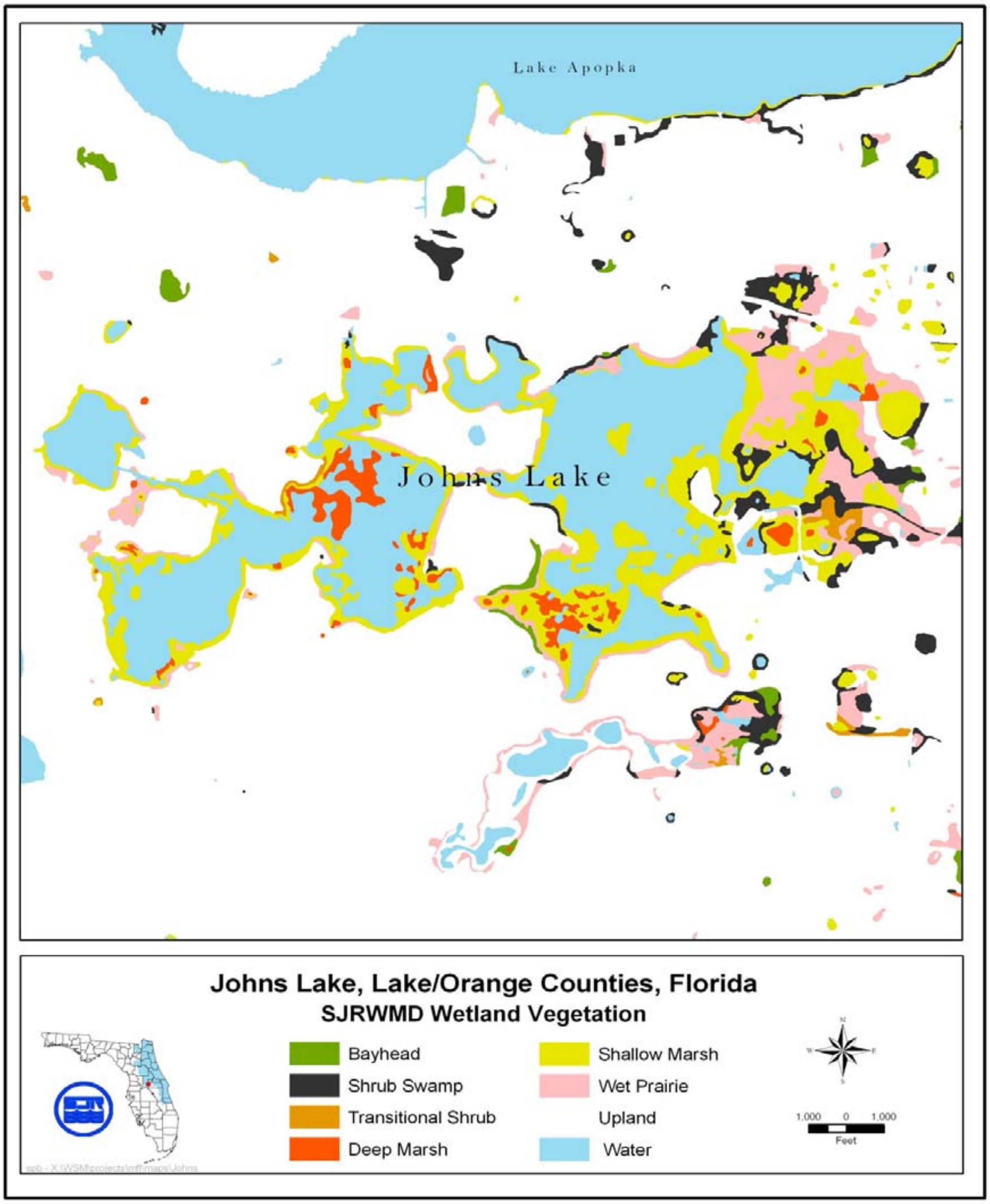


Figure 7. Mapped wetland vegetation communities at Johns Lake, Lake and Orange counties, Fla.

METHODS

MFLs determinations incorporate biologic and topographic information collected in the field with stage, wetland, and soils data from geographic information system (GIS) coverages; aerial photography; the scientific literature; and hydrologic and hydraulic models to generate an MFLs regime. This section describes the methods used in the MFLs determination process for Johns Lake, including field procedures such as site selection and field data collection, data analyses, and levels determination criteria. Additional descriptions of MFLs methods are located in SJRWMD's (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006c).

FIELD TRANSECT SITE SELECTION

Many factors are considered in the selection of field transect sites. Transects are fixed sample lines across a river, lake, or wetland floodplain. Transects usually extend from open water to uplands. Elevation, soils, and vegetation are sampled along transects to characterize the influence of surface water flooding on the distribution of soils and plant communities. Field site selection began with the implementation of a site history survey and data search. All relevant available existing information was identified and assembled through data searches of SJRWMD library documents, project record files, the hydrologic database, and the SJRWMD Division of Surveying Services files. The data collected may have included the following:

- On-site and regional vegetation surveys and maps
- Aerial photography (existing and historical)
- Remote sensing (vegetation, land use, etc.) and topographic maps
- Soil surveys, maps and descriptions
- Hydrologic data (hydrographs and stage duration curves)
- Environmental, engineering, or hydrologic reports
- Topographic survey profiles
- Occurrence records of rare and endangered flora and fauna

These data/information sources were reviewed to familiarize the investigator with site characteristics, locate important basin features that needed to be evaluated, and assess prospective sampling locations. Copies of this information were organized and placed in files for future reference and archiving.

Potential transect locations at Johns Lake were initially identified from maps of wetlands, soils, and topography. Specific transect site selection goals included:

- Establishing transects at sites where multiple wetland communities of the most commonly occurring types were traversed.
- Selecting multiple transect locations with common wetland communities among them.
- Establishing transects that traverse unique wetland communities.

Transect characteristics were subsequently field-verified to ensure that the transect locations contained representative wetland communities, hydric soils, and reasonable upland access. These goals help to ensure ecosystem protection of commonly occurring and unique wetland ecosystems at Johns Lake. The field investigation at Johns Lake occurred in May and June 2001; the previously identified types of information were considered in the selection of field transect sites at Johns Lake. Individual transect site selection criterion for the final two transects are described in the Results and Discussion section of this document.

FIELD DATA COLLECTION

The field data collection procedure for determining MFLs involved gathering information and sampling elevation, soils, and vegetation data along fixed transects, across a hydrologic gradient. Transects were established in areas where there are changes in vegetation and soil, and the hydrologic gradient was marked (SJRWMD 2006c). The main purpose in using transects in these situations, where the change in vegetation and soils is clearly directional, was to describe maximum variations over the shortest distance in the minimum time (Martin and Coker 1992).

Site Survey

Upon selection of a transect site at Johns Lake, vegetation was trimmed to allow a line-of-sight along the length of the transect. A measuring tape was then laid out along the length of the transect. Elevation measurements were recorded at various length intervals (5 ft, 10 ft, 20 ft, etc.) to adequately characterize the topography and transect features. Additional elevations were measured, including obvious elevation changes, vegetation community changes, soil changes, high water marks, and at bases of trees.

Soil Sampling Procedures

Detailed soil profiles were described along each transect to gain an understanding of past and present hydrologic, geologic, and anthropogenic processes that have occurred, resulting in the observed transect soil features. Soil profiles were described following standard Natural Resources Conservation Service (NRCS) procedures (USDA, NRCS 1998). Each soil horizon (unique layer) was generally described with respect to texture, thickness, Munsell color (Kollmorgen Corp. 1992), structure, consistency, boundary, and presence of roots. The primary soil criteria considered in the MFLs determinations are the presence and depth of organic soils, as well as the extent of hydric soils observed along the field transects (SJRWMD 2006c). The procedure to document hydric soils includes:

- Removing all loose leaf-matter, needles, bark, and other easily identified plant parts to expose the soil surface; digging a hole and describing the soil profile to a depth of at least 20 in. and, using the completed soil description, specifying hydric soil indicators that have been matched.
- Performing deeper examination of soil where field indicators are not easily seen within 20 in. of the surface. (It is always recommended that soils be excavated and described as deep as necessary to make reliable interpretations and classification.)
- Paying particular attention to changes in microtopography over short distances, since small elevation changes may result in repetitive sequences of hydric/nonhydric soils and the delineation of individual areas of hydric and nonhydric soils may be difficult (USDA NRCS 1998).

Additional soil sampling procedures are documented in SJRWMD's (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006c).

Vegetation Sampling Procedures

SJRWMD has wetland maps developed from aerial photography utilizing a unique wetland vegetation classification system. SJRWMD's Wetland Vegetation Classification System (Kinser 1996) was used to standardize the names of wetland plant communities sampled in MFLs fieldwork and in developing reports documenting the MFLs determination.

The spatial extent of plant communities or transition zones (i.e., ecotones) between plant communities was determined using reasonable scientific judgment. Reasonable scientific judgment involves the ability to collect and analyze information using technical knowledge, and personal skills and experience to serve as a basis for decision making (Gilbert et al. 1995). In this case, such judgment was based upon field observations of relative abundance of dominant plant species, occurrence and distribution of soils and hydric soil indicators, and changes in land slope or elevation along the hydrologic gradient. Plant communities and transition zones were delineated along a specialized line transect called a belt transect. A belt transect is a line to form a long, thin, rectangular plot divided into smaller sampling areas called quadrats that correspond to the spatial extent of plant communities or transitions between plant communities (Figure 8). The belt transect width will vary depending upon the type of plant community to be sampled (SJRWMD 2006). For example, a belt width of 10 ft (5 ft on each side of the transect line) may suffice for sampling herbaceous plant communities of a floodplain marsh. However, a belt width of 50 ft (25 ft on each side of the line) may be required to adequately represent a forested community (e.g., hardwood swamp, Figure 9).

Plants were identified and the percent cover of plant species was estimated if they occurred within the established belt width for the plant community under evaluation (quadrat). Percent cover is defined as the vertical projection of the crown or shoot area of a plant to the ground surface and is expressed as a percentage of the quadrat area. Percent cover as a measure of plant distribution is often considered as being of greater ecological significance than density, largely because percent cover gives a better measure of plant biomass than the number of individuals. The canopies of the plants inside the quadrat will often overlap each other, so the total percent cover of plants in a single quadrat will frequently sum to more than 100% (SJRWMD 2006c).

Percent cover was estimated visually using cover classes (ranges of percent cover). The cover class and percent cover ranges are a variant of the Daubenmire method (Mueller-Dombois and Ellenberg 1974) and summarized in SJRWMD's (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006c). Plant species, plant communities and percent cover data were recorded on field vegetation data sheets (Appendix A). The data sheets are formatted to facilitate data collection in the field and, also, computer transcription.

The calculated wetland value for each community type along each transect was computed as follows:

Compute the total wetland status value (TWSV) for each plant community type by summing the products of the cover estimate value and *The Florida Wetlands Delineation Manual* (FWDM, Gilbert et al. 1995) wetlands plant status value for each plant species occurring in the plant community. Next, compute the calculated wetland value (CWV, Wentworth et al. 1988) as the ratio of the summed TWSV and the total number of plant species within each plant community and assign the appropriate FWDM code to each community.

The FWDM code definitions and associated wetland status values and CWV ranges are presented in Table 3.

SURFACE WATER INUNDATION/DEWATERING SIGNATURES (SWIDS)

Frequency analysis of long-term stage data or modeled stage data was utilized to provide probabilities of flooding/dewatering events of a set duration (i.e., SWIDS) for wetland plant communities and organic soils. The probabilities were interpreted as return intervals (Gordon et al. 1992). For example, if a 30-day flooding event of an elevation of interest (e.g., maximum elevation of Shallow Marsh) had a probability of exceedence of 33%, then the event is interpreted as occurring approximately 33 in 100 years, or a 1:3 year return interval, on average. This approach enables like plant communities or soils indicators from systems at different elevations to be compared, resulting in quantitative hydrologic signatures of specific elevations (e.g., mean-, minimum-, and maximum elevation of a vegetation community; Neubauer et al. 2004, Neubauer et al. 2007b).

Quantitatively defining the hydrologic signatures of vegetation communities provides a hydrologic range for up to three vegetation community elevations, with drier community signatures on one side of the range and wetter community signatures on the other side. These hydrologic signatures provide a target for MFLs determinations based on vegetation communities and an estimate of how much the return interval of a flooding or dewatering event can be shifted and still maintain a vegetation community within its observed elevation range.

DATA ANALYSIS

The primary data analysis for information collected at Johns Lake consisted of using a computer spreadsheet file to perform basic statistical analyses on the surveyed elevation data. Vegetation and soils information collected along transects were incorporated with the elevation data. Descriptive statistics were calculated for the elevations of the vegetation communities and specific hydric soil indicators.

Transect elevation data were also graphed to illustrate the elevation profile between the open water and upland community. Location of vegetation communities along the transect, together with a list of dominant species, statistical results and soils information, were labeled on the graph. Specific transect elevation data from Johns Lake were illustrated and may be found in the Results and Discussion section (Table 4) of this document.

CONSIDERATION OF ENVIRONMENTAL VALUES IDENTIFIED IN RULE 62-40.473, *F.A.C.*

In establishing MFLs for water bodies pursuant to Section 373.042 and Section 373.0421, F.S., SJRWMD identifies the environmental value or values most sensitive to long-term changes in the hydrology of each water body/course. SJRWMD then typically defines the minimum number of flood events and maximum number of dewatering events that would still protect the most sensitive environmental value or values. For example, for water bodies/courses for which the most sensitive environmental values may be wetlands and organic substrates, recommended MFLs would reflect the number of flooding or dewatering events that allow for no net loss of wetlands and organic substrates. By protecting the most sensitive environmental value or values for each water body/course, the 10 environmental values identified in Rule 62-40.473, *F.A.C.*, are considered to be protected.

SJRWMD uses the following working definitions when considering these 10 environmental values:

1. Recreation in and on the water—The active use of water resources and associated natural systems for personal activity and enjoyment; these legal water sports and activities may include, but are not limited to swimming, scuba diving, water skiing, boating, fishing, and hunting.
2. Fish and wildlife habitat and the passage of fish—Aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally or commercially important, or keystone species; to live, grow, and migrate; these environments include hydrologic magnitudes, frequencies, and durations sufficient to support the life cycles of wetland and wetland-dependent species.
3. Estuarine resources—Coastal systems and their associated natural resources that depend on the habitat where oceanic salt water meets freshwater; these highly productive aquatic systems have properties that usually fluctuate between those of marine and freshwater habitats.
4. Transfer of detrital material—The movement by surface water of loose organic material and associated biota.
5. Maintenance of freshwater storage and supply—The protection of an amount of freshwater supply for permitted users at the time of MFLs determinations.
6. Aesthetic and scenic attributes—Those features of a natural or modified waterscape usually associated with passive uses, such as bird-watching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation, that usually result in human emotional responses of well-being and contentment.
7. Filtration and absorption of nutrients and other pollutants—The reduction in concentration of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these

substances move through the water column, soil or substrate, and associated organisms.

8. Sediment loads—The transport of inorganic material, suspended in water, which may settle or rise; these processes are often dependent upon the volume and velocity of surface water moving through the system.
9. Water quality—The chemical and physical properties of the aqueous phase (i.e., water) of a water body (lentic) or a watercourse (lotic) not included in definition number 7 (i.e., nutrients and other pollutants).
10. Navigation—The safe passage of watercraft (e.g., boats and ships), which is dependent upon adequate water depth and width.

CONSIDERATION OF BASIN ALTERATIONS IN ESTABLISHING MFLS

Based on the provisions of Section 373.0421(1)(a), F.S., SJRWMD, when establishing MFLs, considers changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes and alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer. However, when considering such changes and alterations, SJRWMD cannot allow harm caused by withdrawals. To accomplish this, SJRWMD reviews and evaluates available information, and makes site visits to ascertain the following information concerning the subject watershed, surface water body, or aquifer:

- The nature of changes and structural alterations that have occurred.
- The effects the identified changes and alterations have had.
- The constraints the changes and alterations have placed on the hydrology.

SJRWMD develops hydrologic models, which address existing structural features, and uses these models to consider the effects these changes have had on the long-term hydrology of water bodies for which recommended MFLs are being developed.

SJRWMD considers that the existing hydrologic condition, which is used to calibrate and verify the models, reflects the changes and structural alterations that have occurred in addition to changes that are the result of groundwater and surface water withdrawals existing at the time of model development. This consideration may also apply to vegetation and soils conditions if the changes, structural alterations, and water withdrawals have been sufficiently large to affect vegetation and soils and have been in place for a sufficiently long period to allow vegetation and soils to respond to the altered hydrology. However, the condition of vegetation and soils may not reflect the long-term existing hydrologic condition if the changes, structural alterations, and water withdrawals are relatively recent. This is because vegetation and soil conditions do not respond to all hydrologic changes nor respond instantaneously to changes in hydrology that are sufficiently large to cause such change. SJRWMD typically develops recommended MFLs based on vegetation and soils conditions that exist at the time fieldwork is being performed to support the development of these recommended MFLs.

SJRWMD also provides for the collection and evaluation of additional data subsequent to the establishment of MFLs. SJRWMD uses this data collection and evaluation as the basis of determining if the MFLs are protecting the water resources or if the MFLs are appropriately set. If SJRWMD determines, based on modeling and this data collection and evaluation process, that MFLs have not been appropriately set, SJRWMD can establish revised MFLs.

If SJRWMD determines that recommended MFLs cannot be met under post-change hydrologic conditions due to existing structural alterations, SJRWMD may consider whether feasible structural or nonstructural changes, such as changes in the operating schedules of water control structures, can be accomplished such that the recommended MFLs can be met. In such cases, SJRWMD may identify a recovery strategy that includes feasible structural or nonstructural changes.

MFLS COMPLIANCE ASSESSMENT

A hydrologic model for Johns Lake was developed to provide a means of assessing whether compliance with MFLs is achieved under specific water use and land use conditions (Robison 2007). This hydrologic model was calibrated for 2001 conditions. These conditions included the most recent land use information and groundwater levels consistent with 2001 regional water use.

An explanation of the use of this hydrologic model and the applicable SJRWMD regional groundwater flow model to assess whether water levels are likely to fall below MFLs under specific conditions for water use and land use is presented in Appendix B. This appendix also includes an introduction to the use of hydrologic statistics in the SJRWMD MFLs program.

Table 2. Summary of cover classes and percent cover ranges

Cover Class	Percentage Cover Range	Descriptor
0	< 1 %	Rare
1	1–10 %	Scattered
2	11–25 %	Numerous
3	26–50 %	Abundant
4	51–75 %	Co-dominant
5	> 75 %	Dominant

Table 3. FWDM (Gilbert et al.) code definitions and associated wetland status values and calculated wetland value ranges

FWDM Code	FWDM Code Definitions	Wetland Status Value	Calculated Wetland Value Range
UPL	**Upland**—Plants that occur rarely in wetlands, but occur almost always in uplands	4	$\geq$ 3.5
FAC	**Facultative**—plants with similar likelihood of occurring in both wetlands and nonwetlands	3	2.5–3.4
FACW	**Facultative Wet**—plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands	2	1.5–2.4
OBL	**Obligate**—plants that are not found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely in uplands	1	1–1.4

Source: *The Florida Wetlands Delineation Manual* (*FWDM*, Gilbert et al. 1995)

Figure 8. landscape

RESULTS AND DISCUSSION

Field data were collected for this assessment on July 20, 2000, by staff from SJRWMD’s Division of Water Supply Management and Division of Surveying Services. Two elevation transects were established on the southeast shore of a major lobe (A) of Johns Lake (Figure 3).

These transects characterized the following communities (or zones): mesic oak hammock (CWV = 3.6, UPL), shrub swamp (CWV = 1.9, FACW), shallow marsh (CWV = 1.7, FACW), a transitional zone (CWV = 2.1, FACW), emergent marsh, wet prairie (emergent marsh/wet prairie CWV = 1.9, FACW), aquatic bed (littoral zone), and lake bed/bottom (aquatic bed/lake bed CWV = 1.8, FACW). Soil type and depth information were collected along both transects. Important features and elevations or elevation statistics are presented in Table 4.

FIELD DATA COLLECTION—TRANSECT 1

Transect 1 was 360 ft in length and extended in an east-west direction on the east shore of Johns Lake (Figure 9). This transect began in uplands, crossed a marsh area, crossed uplands on an island and continued toward the lake until lake bed/bottom was encountered. The major plant communities that occurred were mesic oak hammock, a transitional zone, shrub swamp, shallow marsh, and emergent marsh. Lake bed elevations were characterized between stations 280–300 ft. Soils were characterized at stations 28, 50, 68, 81, 105, 116, 131, 135, 137, 189, and 250 ft.

The uplands community (stations 0–19 ft) was located at the waterward edge of a mesic oak hammock and was dominated by Virginia live oak, with caesar weed, common persimmon, panic grass, rare pokeweed, and beautyberry. A narrow band (stations 19–25 ft) of primrose willow, southern bayberry (wax myrtle), with torpedo grass and caesar weed existed between the mesic oak hammock and shrub swamp. The elevations of this transitional zone were included with the below referenced transitional zone on the island (Table 5 and Figure 9). Upland soils were identified landward of station 28 ft.

A shrub swamp (stations 25–61 ft) dominated by primrose willow, buttonweed, buttonbush, dog fennel, marsh thoroughwort, sand cordgrass, soft rush, American cupscale, and camphor weed was present upslope of the shallow marsh. Hydric soils (with the stripped matrix hydric soil indicator) were encountered at station 28 ft (approximate elevation 95.5 ft NGVD) and organic bodies hydric soil indictor was first encountered at station 50 ft (94.1 ft NGVD). Stripped matrix, organic bodies, and organic soil (muck) are described further by the USDA, Natural Resources Conservation Service (1998).

A shallow marsh (stations 61–137 ft) characterized by numerous dog fennel, marsh thoroughwort, American cupscale, and button-weed with other marsh species existed midway between the upland communities on the east shore and on the island. Organic soil bodies were present at station 68 ft (approximately 92.8 ft NGVD). Sandy muck was present at stations 81 ft (approximately 92.3 ft NGVD), 105 ft (92.2 ft NGVD), and 116 ft (approximately 92.3 ft NGVD). Organic bodies were present at stations 131 ft (approximate elevation 93.0 ft NGVD), and 135 ft (93.2 ft NGVD).

Another shrub swamp zone (stations 137–167 ft) existed on the island. This community was characterized by species similar to the landward shrub swamp. Soils with the stripped matrix hydric soil indicator were present between stations 137 (93.2 ft NGVD) and 188 ft (approximately 96.2 ft NGVD).

A transitional zone (stations 167–189 ft) characterized by Virginia live oak, caesar weed, primrose willow, dog fennel, marsh thoroughwort, buttonbush, and American cupscale was present between the shrub swamp and the mesic oak hammock.

A mesic oak hammock (stations 189–246 ft) dominated primarily by Virginia live oak and saw palmetto was present at elevations greater than 96.6 ft NGVD. A spodosol soil (a mineral soil with spodic horizon of organic matter, aluminum oxides with or without iron [Brady 1974]) was present at station 189 ft (approximately 96.6 ft NGVD).

A third shrub swamp (stations 246–263 ft) dominated by primrose willow and southern bayberry (wax myrtle) was present waterward of the mesic oak hammock. A stripped matrix with a buried spodic horizon was present at station 250 ft (96.6 ft NGVD).

A narrow emergent marsh (stations 263–280 ft) characterized by torpedo grass, marsh thoroughwort, sand cordgrass, American cupscale, and maiden-cane was present waterward of the shrub swamp.

Lake bed/bottom (stations 280–360 ft [also known as deep marsh]) was dominated by torpedo grass (280–300 ft) and spatterdock waterward of station 320 ft.

FIELD DATA COLLECTION—TRANSECT 2

Transect 2 was 400 ft long, started at station 95 ft of Transect 1, and was perpendicular (north-south direction) to Transect 1 (Figure 10). The major plant communities that occurred were shallow marsh, wet prairie, and aquatic bed (deep marsh). Hydric soils (i.e., sandy muck, organic bodies, and stripped matrix) were encountered along the entire transect (Figure 10).

The marsh community (0–187 ft) was characterized by marsh thoroughwort buttonbush, caesar weed, with American cupscale, dog fennel, yerba de Tajo, maidencane and other marsh species (Table 6).

A wet prairie community (stations 187–279 ft) characterized by marsh thoroughwort, *Coelorachis cylindrica,* with redroot, sand cordgrass, dog fennel and other herbaceous species occurred at slightly higher elevations than the above referenced marsh. A narrow band of shallow marsh (279–300 ft) characterized by a mix of species present in the shallow marsh and wet prairie communities.

A deep marsh characterized by water lily and flatsedge existed between stations 300 ft and 400 ft.

A list of plant species observed at Transects 1 and 2 with common names and *The Florida Wetlands Delineation Manual* (FWDM, Gilbert et al. 1995) wetland status is presented in Table 5. A calculated wetland value (CWV) for each community, modified from Wentworth et al (1988), is also presented. The CWV is based upon species presence data for Obligate (OBL), Facultative Wet (FACW), Facultative (FAC) and Upland (UPL) species; a weighting factor was not used in the calculation. Definitions of the CWV and wetland plant status categories occur as a footnote on Table 5.

STRUCTURAL ALTERATIONS AND OTHER CHANGES

A water control structure, with an invert elevation of 95.4 ft NGVD (USGS 1998), was constructed in 1960 on the north shore of Johns Lake. The structure drains water to Lake Apopka. In 1965, the Orange County Commission adopted the following lake levels to control water levels in the lake and the elevations of floor slabs for new construction:

- Minimum level—96.9 ft NGVD
- Maximum level—98.9 ft NGVD
- Floor level—102.9 ft NGVD

These levels allow for the following controls:

- No discharge from Johns Lake, through the water control structure, when the lake level is less than 96.9 ft NGVD.

- Discharge from Johns Lake when the lake level is greater than 98.9 ft NGVD.
- No construction of new structures with floor levels below 102.9 ft NGVD.

The original water control structure was replaced because of damage incurred in 1999. However, operation of the current structure is the same as for the original structure. These water control structures have had no noticeable effect on the condition of vegetation and soils in the basin of the lake. For example, upland edge was identified at approximately 96.3 ft, 96.6 ft, and 97.0 ft NGVD along Transect 1. These elevations are very similar to the adopted “no discharge” elevation of 96.9 ft NGVD of the outfall structures. No deep organic soils (i.e., histic epipedon or histosols) were measured at this sandhill-type lake.

The Johns Lake Improvement Association (more recently called the Johns Lake Association) reported that drainage wells located on the eastern side of the lake might have caused low water levels in 1941 (Johns Lake Association 2000). Association members were not able to locate the wells and subsequently received reports that the wells were capped. SJRWMD has been unable to substantiate the existence of drainage wells in the immediate vicinity of Johns Lake.

The drainage basin of Johns Lake has experienced significant residential development and is currently developed with about 17% impervious surfaces associated with residences, roadways, etc., based on 2004 conditions. This increased development of the basin has likely caused water levels in the lake to rise more quickly during rainfall events as compared to predevelopment conditions.

Despite the changes in the lake basin, the conditions of soils and vegetation observed at the time fieldwork, performed to support the development of recommended MFLs, did not appear to be in transition because of anthropogenic changes. Further, the model showed that MFLs were achieved under long-term existing-conditions hydrology.

MINIMUM LEVELS DETERMINATION

Two recommended MFLs (i.e., minimum frequent high level [FH] and minimum frequent low [FL]) with associated temporal components (i.e., duration and return interval) were developed for Johns Lake. A short description of the criteria and indicators used to develop these recommendations is presented below. Important ecological structures and functions protected by the minimum levels are also discussed. The recommended minimum levels were derived primarily from topographic data related to vegetation communities. Organic soils of sufficient depths (i.e., > 8 in.) were not observed at this sandhill-type lake. In addition, developing a minimum average level (MA) focused on the maximum number of dewatering events associated with the average elevation of shallow marsh was considered redundant because the FL focused on the maximum dewatering events for the entire shallow marsh community. Therefore, a recommended MA level was not developed for this system. This is consistent with the conceptual model of sandhill lakes, as described by CH2M HILL (2005), which states that "… sandhill lakes are astatic, because they appear to lack a mean around which the system is organized" and that "… critical system behaviors of sandhill lakes may be related most strongly to high and low water levels corresponding to drought cycles and multidecadal climate cycles." Because of the nature of sandhill lakes to fluctuate dramatically (CH2M HILL 2005), the lack of stable/seasonally flooded vegetation communities, and the absence of organic soils, a minimum average level is not recommended for Johns Lake.

Elevations on Transect 1 and Transect 2 were determined using a top-of-water (TOW) benchmark (TOW on July 20, 2000, was 89.31 ft NGVD) that referenced benchmark 98-093-0-03 [116.46 ft NGVD] and reference mark 98-093-1-03 [117.85 ft NGVD]).

Minimum Frequent High (FH) Level

The minimum frequent high (FH) level is defined as "… a chronically high surface water level or flow with a frequency and duration that allows for inundation of the floodplain at a depth and duration sufficient to maintain wetland functions" (Rule 40C-8.021(7), *F.A.C.*). The recommended FH level inundates/saturates the wetlands of the lake, and provides for: (1) nutrient and organic matter exchange; (2) refugia for juvenile fish; and (3) aquatic biota (i.e. fish) access to wetland resources for feeding and spawning. These flooding conditions must be of sufficient depth, duration, and frequency to prevent unacceptable changes to the structure and associated functions (i.e., prevent significant harm) of the aquatic and wetland resources. The FH level is supported by surface water inundation/dewatering signature (SWIDS) information (Figure 11).

The recommended FH level is 94.7 ft NGVD with a duration of 30 days continuously exceeded (flooded) and a return interval of 2 years (Table 6). That is, this minimum level should occur during "normal" wet seasons, about 50 years per century, on average, for 30 continuous days. This minimum-level elevation component corresponds to the mean elevation of the three, shrub swamp community zones located on Transect 1. Flooding this elevation for 30 days every 2 years, on average, should result in maintaining the locations of the shrub swamps located adjacent to Johns Lake. This minimum level maintains the seasonally flooded community (Figure 9). The return interval for this seasonally high water event was determined from the driest shrub swamp SWIDS (i.e., Lake Hires) for the mean elevations of eight systems (Figure 11). No downslope movement of this community is expected to occur if the cumulative effects of consumptive uses do not cause the return interval for this flooding event (i.e., 94.7 ft NGVD continuously flooded for at least 30 days) to occur less frequently than recommended.

The long-term 2001 conditions hydrology modeled for this system indicates that this event occurs 62 times per century (i.e., 62% annual chance of exceedence), or every 1.6 years, on average. Thus, water withdrawals could reduce the frequency of this event by approximately 12 events per century, on average (Figure 12).

The water level component of this recommended FH level is approximately 3.4 ft lower than the base of the waterward Virginia live oak (station 0 ft, 98.1 ft NGVD) and 1.6 ft lower than the upland ecotone (station 19 ft, 96.3 ft NGVD, Transect 1). This water level also allows for 2.1 ft of water over the mean elevation of the marsh communities (94.7–92.57 ft NGVD = 2.13 ft) on Transect 1 and Transect 2. This water level results in more than 4.4 ft of water over the landward edge of *Nuphar lutea* on Transect 1.

The recommended FH level allows for ≥ 7.2 ft water depth at the canal connecting lobes A and B of Johns Lake. Additionally, this minimum level corresponds to approximately the 20% exceedence value (94.58 ft NGVD) from the duration curve base upon approximately semiweekly values from August 1959 to August 2007.

Minimum Frequent Low (FL) Level

The minimum frequent low (FL) level "… means a chronically low surface water level or flow that generally occurs only during periods of reduced rainfall. This level is intended to prevent deleterious effects to the composition and structure of floodplain soils, the species composition and structure of floodplain and instream biotic communities, and the linkage of aquatic and floodplain food webs" (Rule 40C-8.021(10), *F.A.C.*).

The recommended FL level is 92.1 ft NGVD, with a duration of 120 days continuously not exceeded (dewatered) and a return interval of 3 years (Table 6). That is, this minimum level should occur during dry seasons with moderate droughts, about 33 times per century, on average, for 120 continuous (i.e., consecutive) days. This FL level elevation component corresponds to the minimum elevation of shallow marsh measured along Transect 1 and Transect 2. Dewatering this elevation for 120 days every three years, on average, should result in maintaining the location of the marsh communities located adjacent to the lake. The return interval for this low water event was determined from the driest (i.e., Halfmoon Lake) sandhill-type lake based on SWIDS signatures from 22 systems (Figure 13). No downslope movement of this community ecotone is expected to occur if the cumulative effects of consumptive uses do not cause the return interval for this event (i.e., 92.1 ft NGVD continuously not exceeded for no more than 120 days) to occur more frequently than recommended.

The 2001 hydrologic conditions modeled for this system (Robison 2007) indicate that the minimum frequent low lake stage is dewatered for 120 days, 21 times per century (i.e., 21% annual chance of non-exceedence) or approximately once every 5 years (Figure 14). Thus, water withdrawals allowable under the MFLs regime could increase the frequency of this event by approximately 12 events to 33 events per century, or approximately once every 3 years.

The water level component of the recommended FL level is approximately 1.8 ft higher than the landward elevation of spatterdock that dominated the lake bed zone near the waterward end of Transect 1. Spatterdock is a perennial water lily of deep marsh communities. The seeds and seedlings of this plant are intolerant to desiccation (Brock et al. 1987). Mature plants have floating and submerged leaves, but only submerged leaves exist during the first year of development. Growth of spatterdock seedlings to mature plants requires generally permanently flooded habitats.

This FL level results in dewatered conditions in the shallow marsh and wet prairie communities of Johns Lake. This dewatering will promote aerobic soil conditions that stimulate decomposition and promote seed germination, (required by many wetland plant species [Demaree 1932]), while inundating the aquatic bed and protecting fish habitat during low water conditions. This water level should also allow for foraging areas for wading birds during (Bancroft et al. 1990) normal dry-season low water events.

This recommended FL level results in ≥ 4.6 ft of depth in the canal connecting lobes A and B (Figure 3) of Johns Lake allowing for boat passage. This FL level is 6.53 ft higher than the recorded low lake level or 85.57 ft NGVD. In addition, this minimum level corresponds to approximately the 55% exceedence value (92.09 ft NGVD) from the duration curve based upon approximately semiweekly values from August 1959 to August 2007.

Table 4. Spot-, mean-, maximum-, and minimum elevations (ft NGVD) measured at Johns Lake

Location	Feature	Spot	Mean	Min	Max	N
Transect 1	Mesic Oak Hammock (stations 189–246 ft)		98.1	96.6	99.8	13
Transect 1	Base of waterward live oak	98.1				
Transect 1	Upland ecotone (stations 0–19 ft)	96.3				
Transect 1	Transition zones (stations19–25 ft, 167–189 ft)		95.9	95.1	96.6	9
Transect 1	Shrub Swamp (stations 25–61 ft)		94.5	93.4	95.8	9
Transect 1	Shrub Swamp (stations 246–263 ft)		96.1	95.3	97.0	5
Transect 1	Shrub Swamp (stations 137–167 ft)		94.2	93.2	95.1	8
Transect 1	Combined Shrub Swamp zones		94.7	93.2	97.0	22
Transect 2	Wet Prairie (stations 187–279 ft)		93.1	92.7	93.4	11
Transect 2	Shallow Marsh (stations 279–300 ft)		92.5	92.4	92.7	5
Transect 1	Shallow Marsh (stations 61–137 ft)		92.6	92.1	93.4	17
Transect 2	Shallow Marsh (Stations 1–187 ft)		92.6	92.2	93.1	20
Transects 1, 2	Combined Shallow Marsh zones		92.6	92.1	93.4	33
Transect 1	Emergent Marsh (stations 263–280 ft)		94.3	93.2	95.3	5
Transect 1	Lake Bottom (stations 280–360 ft)				93.2	
Transect 2	Aquatic Bed (stations 300–400 ft)				92.4	
Transect 1	Landward edge of Nuphar lutea bed	90.3				
Lake	Hydraulic control—lake lobes A and B	87.5				

ft NGVD = feet National Geodetic Vertical Datum

N = the number of elevations surveyed at each transect location

Table 5. Occurrence of plant species by community type on Transects 1 and 2, Johns Lake; shown are the calculated wetland values (CWV) for each community type based upon FWDM wetland plant status (UPL = uplands, TR = transition zone, SS = shrub swamp, SM = shallow marsh, EM-WP = emergent marsh/wet prairie, AB-LB = aquatic bed/lake bed)

Species	Common Name	Plant Community, Species Occurrence, and FWDM Factor							
		FWDM[1] Code	Wetland[2] Status	UPL	TR	SS	SM	EM-WP	AB-LB
Alternanthera philoxeroides	Alligator weed	OBL	1				1		
Amphicarpum muhlengergianu	Blue maidencane	FACW	2					2	
Baccharis halimifolia	Eastern false willow	FAC	3				3		
Bidens alba	Beggarticks	OBL	1			1			
Callicarpa americana	Beautyberry	UPL	4	4					
Cephalanthus occidentalis	Buttonbush	OBL	1		1	1	1	1	
Coelorachis cylindrica	Carolina-tail grass	FAC	3			3	3		
Cyperus esuclentus	Flatsedge	FAC	3						3
Cyperus iria	Flatsedge	FACW	2				2	2	
Cyperus retrosus	Flatsedge	FAC	3	3					
Dichanthelium commutatum	Panic grass	UPL	4	4					
Dichanthelium dichotomum	Panic grass	UPL	4	4					
Diodia virginiana	Buttonweed	FACW	2			2	2	2	
Diospyros virginiana	Common persimmon	FAC	3	3					
Echinochloa walteri	Coastal cockspur	FACW	2			2			
Eclipta alba	Yerba de Tajo	FACW	2				2		
Erichtites hieraciifolia	Fireweed	FAC	3				3		
Eupatorium capillifolium	Dog fennel	FAC	3		3	3	3	3	
Eupatorium leptophyllum	Marsh thoroughwort	OBL	1		1	1	1	1	
Fuirena scirpoidea	Umbrella-sedge	OBL	1					1	
Hypericum hyperidoides	St. Andrews cross	FAC	3	3					

Table 5—*Continued*

Species	Common Name	Plant Community, Species Occurrence, and FWDM Factor							
		FWDM[1] Code	Wetland[2] Status	UPL	TR	SS	SM	EM-WP	AB-LB
Juncus effusus	Soft rush	OBL	1			1			
Lachnanthes caroliniana	Redroot	FAC	3				3	3	
Leersia virginica	Cutgrass	OBL	1				1		
Ludwigia decurrens	Yellow loosestrife	OBL	1				1		
Ludwigia peruviana	Primrose willow	OBL	1		1	1	1	1	
Myrica cerifera	Southern bayberry	FAC	3	3		3			
Nuphar lutea	Spatterdock	OBL	1						1
Nymphaea odorata	Water lily	OBL	1				1		1
Panicum hemitomon	Maidencane	OBL	1			1	1	1	
Panicum repens	Torpedo grass	FACW	2			2		2	2
Panicum verrucosum	Warty panicum	FACW	2				2		
Phytolacca americana	Pokeweed	UPL	4	4					
Pluchea odorata	Camphor weed	FACW	2			2	2	2	
Polygonum lapathifolium	Smartweed	OBL	1				1		
Polygonum punctatum	Smartweed	OBL	1				1		
Quercus virginiana	Virginia live oak	UPL	4	4	4	4			
Rhynchospora microcephala	Southern beakrush	FACW	2					2	
Sacciolepis striata	American cupscale	OBL	1		1	1	1	1	
Serenoa repens	Saw palmetto	UPL	4	4					
Spartina bakeri	Sandcord grass	FACW	2			2	2	2	
Urena lobata	Caesar weed	UPL	4	4	4	4	4	4	
Total wetland status value by plant community type				40	15	31	39	30	7
Number of species by plant community type				11	7	16	22	16	4
Calculated wetland value by community[3] type				3.6	2.1	1.9	1.7	1.9	1.8

[1] FWDM code (Gilbert et al. 1995):
Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands
Facultative (FAC) = plants with similar likelihood of occurring in both wetlands and nonwetlands

Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and / or soil saturation, but may also occur in uplands

Table 5—*Continued*

Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and / or soil saturation; rarely in uplands

[2] Wetland status: UPL = 4; FAC = 3; FACW = 2; OBL = 1

[3] Calculated wetland value by community type = total wetland status value / number of species (UPL $\geq$ 3.5; FAC 2.5–3.4; FACW 1.5– 2.4; OBL 1–1.4)

Wetland indicator status for species not listed are italicized and assumed to be upland unless obviously aquatic.

Table 6. Recommended minimum surface water levels for Johns Lake, Lake and Orange counties

Minimum Level	Recommended Elevation (ft NGVD) 1929 Datum	Recommended Duration	Recommended Return Interval
Minimum frequent high (FH)	94.7	30 days	2 years
Minimum frequent low (FL)	92.1	120 days	3 years

ft NGVD = feet National Geodetic Vertical Datum

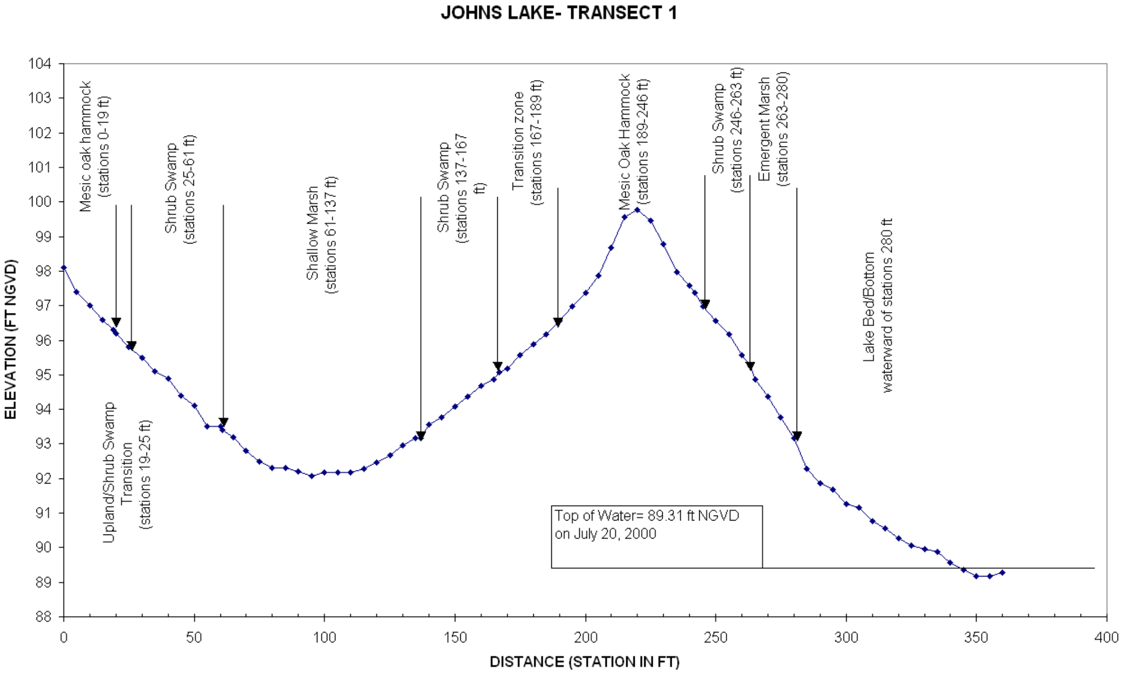


Figure 9. Johns Lake, Lake and Orange counties, Fla., elevation Transect 1, with vegetation and hydric soils information

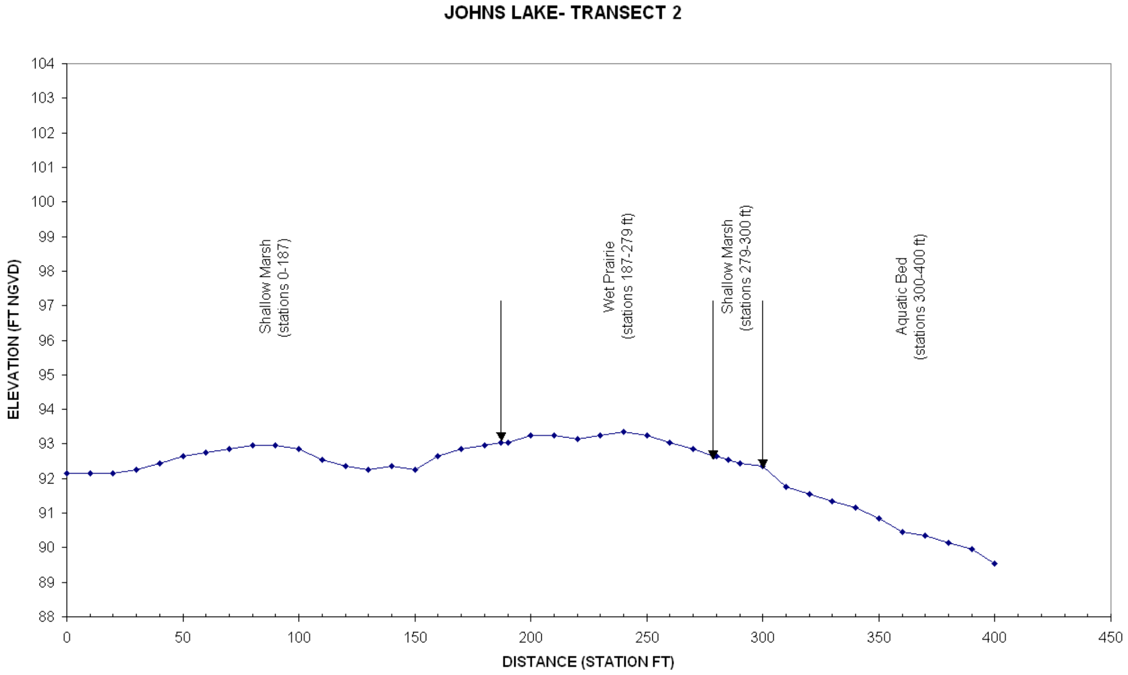


Figure 10. Johns Lake, Lake and Orange counties, Fla., elevation Transect 2, with vegetation and hydric soils information

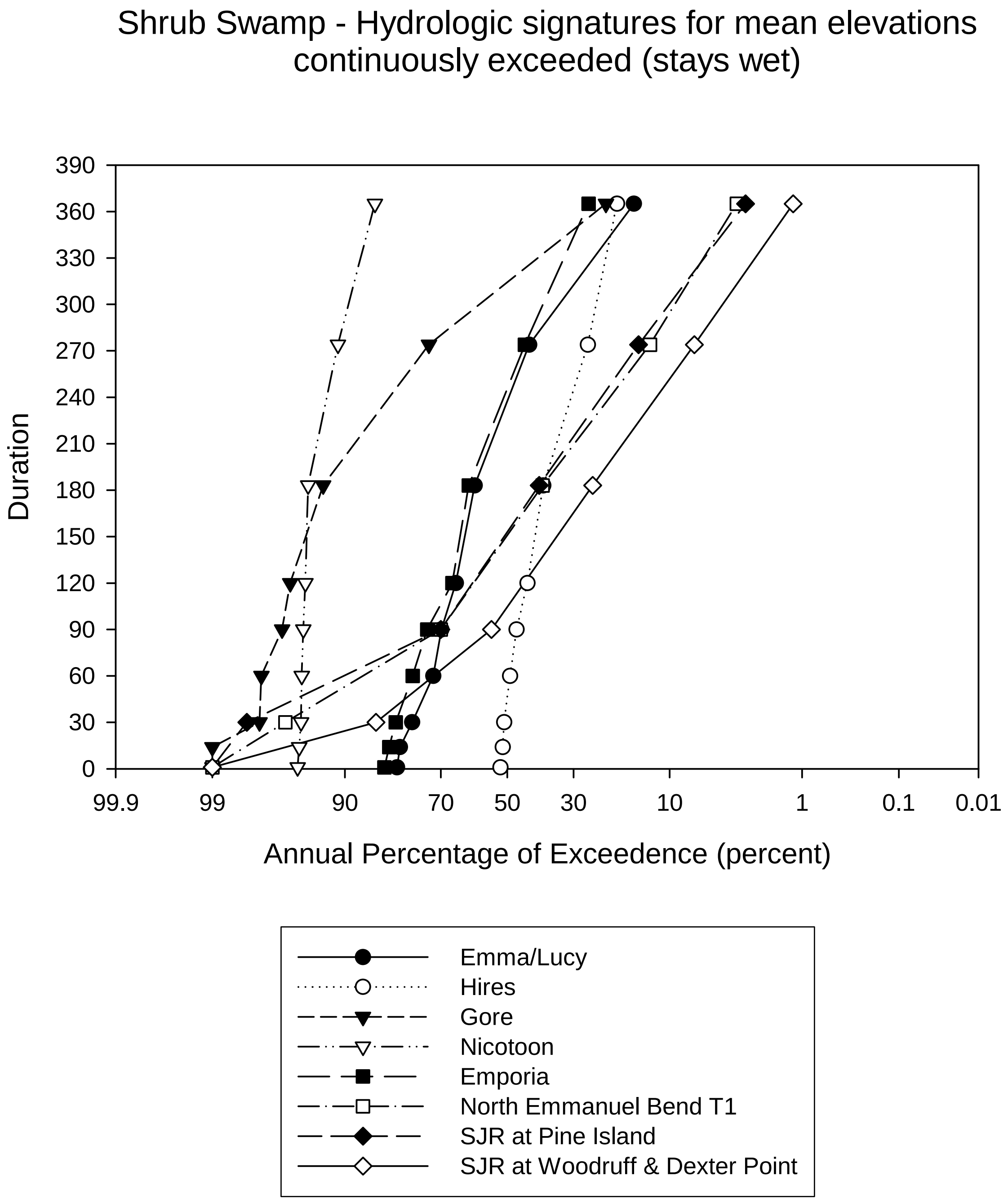


Figure 11. SWIDS for shrub swamp

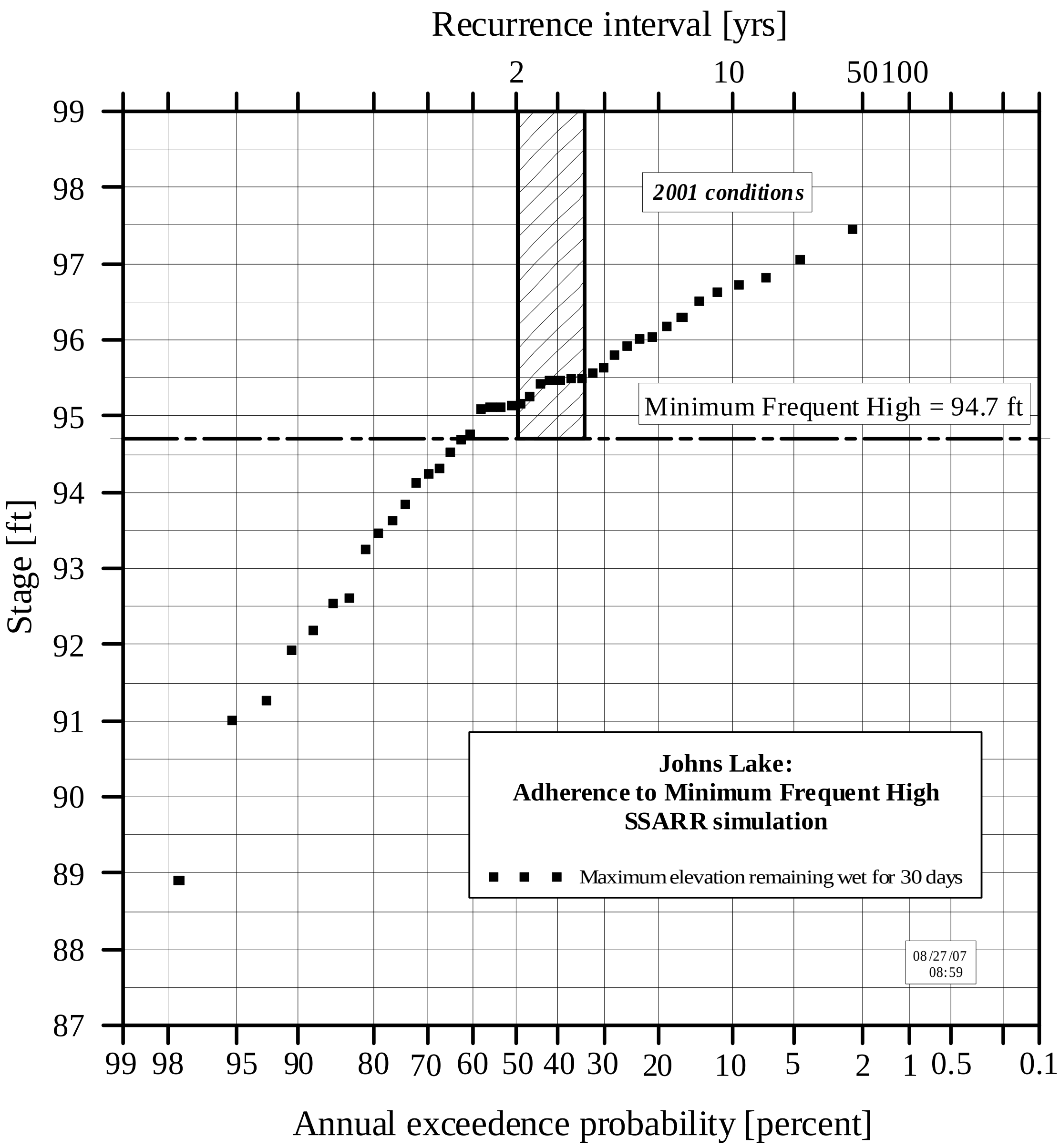


Figure 12. Johns Lake, Lake and Orange counties, Fla., stage frequency analysis results for the proposed frequent high

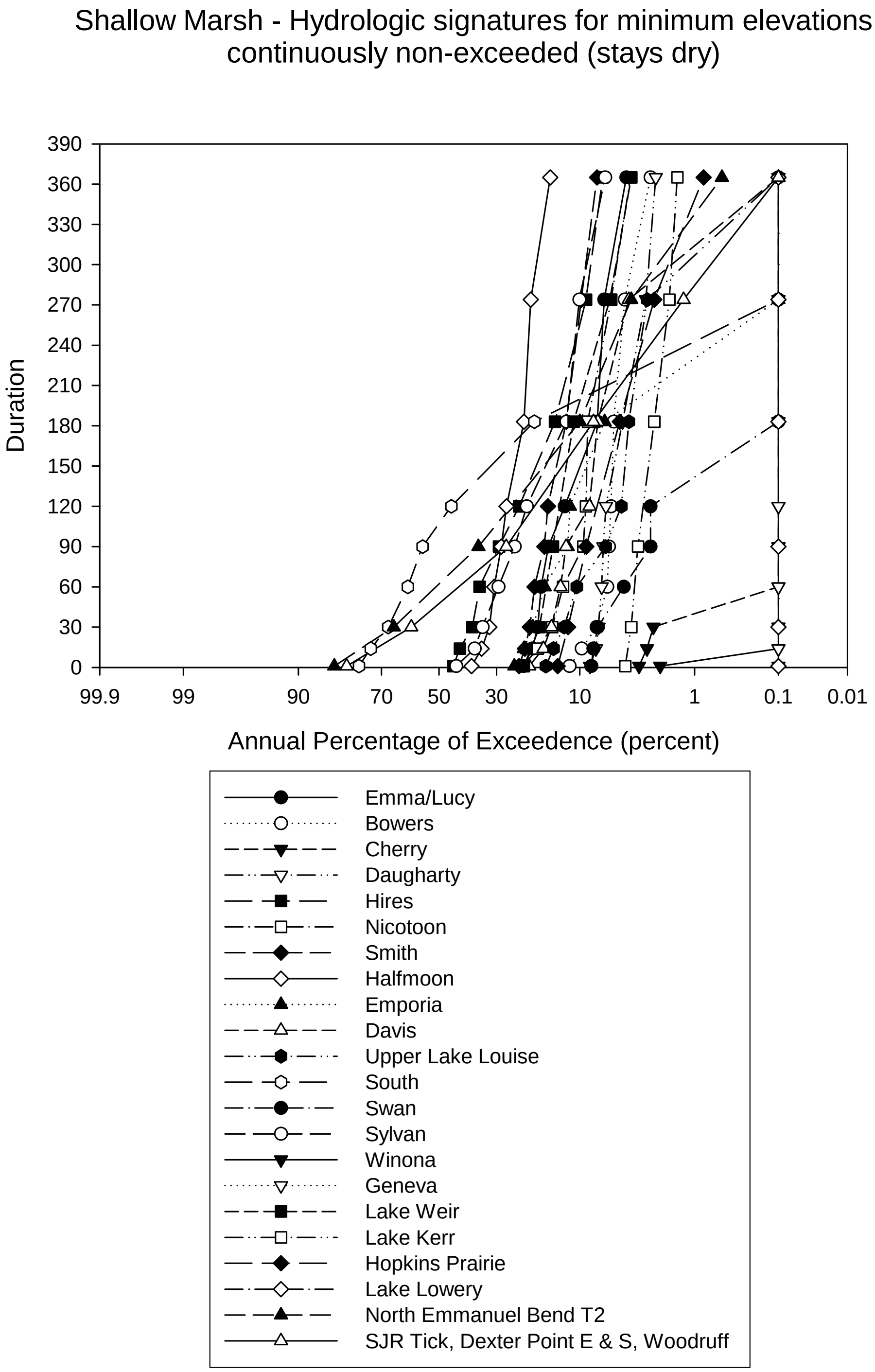

Shallow Marsh - Hydrologic signatures for minimum elevations continuously non-exceeded (stays dry)

Figure 13. SWIDS for shallow marsh

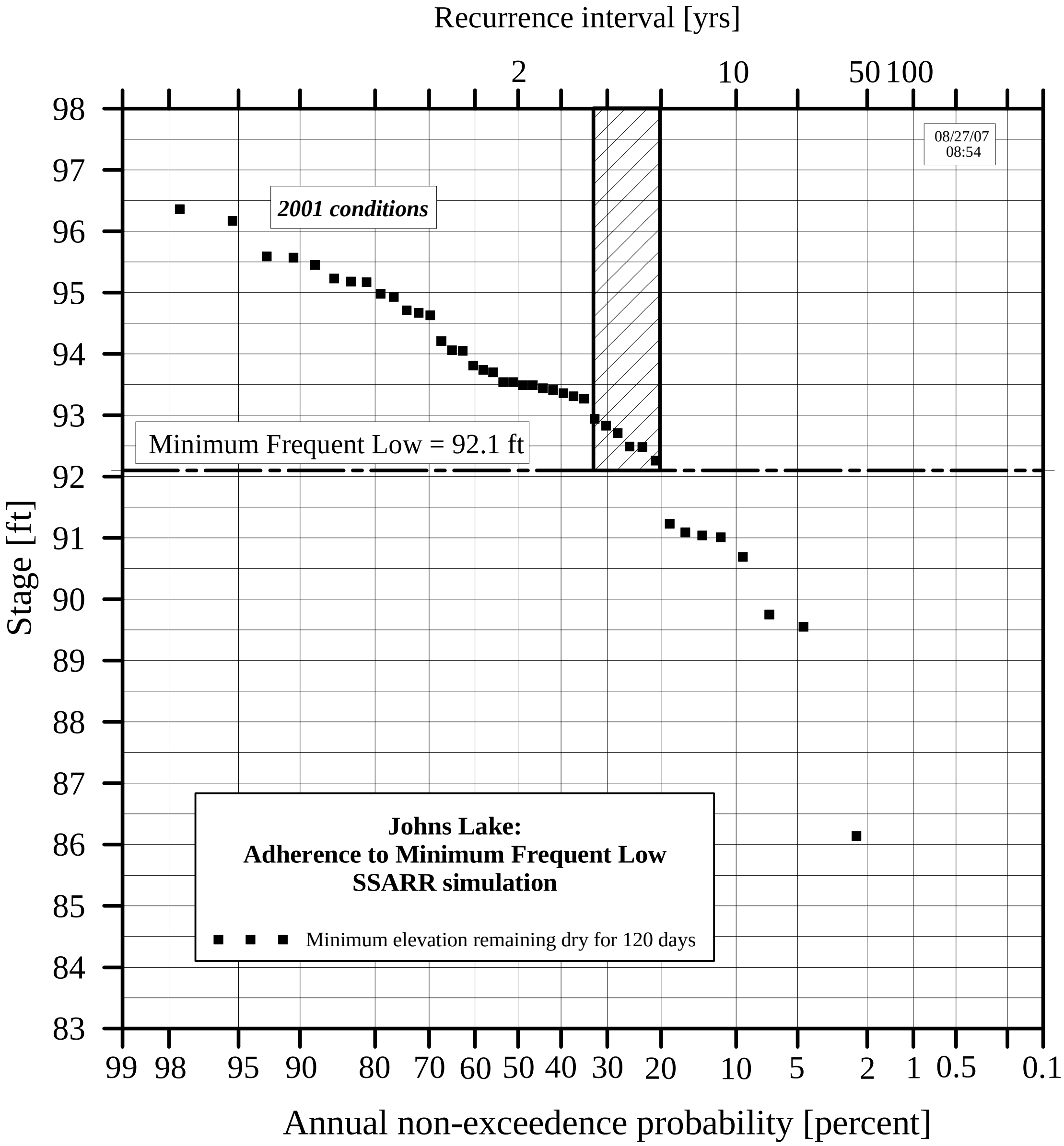


Figure 14. Johns Lake, Lake and Orange counties, Fla., stage frequency analysis results for the proposed frequent low

CONCLUSIONS AND RECOMMENDATIONS

The recommended minimum flows and levels (MFLs) for Johns Lake, located in Lake and Orange counties, Fla., are presented in Table 6. The St. Johns River Water Management District's (SJRWMD's) multiple MFLs methodology (SJRWMD 2006c, Neubauer et. al. 2007a) was used to develop the recommended MFLs for Johns Lake. Development of recommended MFLs is based on evaluations of topographic, soils, and vegetation data collected within plant communities associated with the water body. Best available information also included the use of surface water inundation/dewatering signatures (SWIDS), recently developed by MFLs staff (Neubauer et al. 2004, Neubauer et al. 2007b), to quantitatively define flooding and dewatering signatures for the minimum-, mean-, and maximum elevations of selected plant communities.

The hydrologic model for Johns Lake was calibrated for 2001 hydrologic and water use conditions. These conditions included the most recent land use information and groundwater levels consistent with 2001 regional water use. Based on hydrologic model results (Robison 2007), SJRWMD concludes that the recommended MFLs for Johns Lake are protected under 2001 conditions. To determine if changes in groundwater use allocations subsequent to 2001 would cause lake levels to fall below the recommended MFLs for Johns Lake, the existing Johns Lake hydrologic model should be run using Floridan aquifer potentiometric level declines to reflect these changes in water use allocation. Information included in Appendix B concerning use of the hydrologic model and the applicable SJRWMD regional groundwater flow model should be utilized to assess whether water levels are likely to fall below MFLs under specific water use and land use conditions.

Recommended MFLs presented in this report will not become effective until adopted by the SJRWMD Governing Board as rule, in Rule 40C-8.031, *F.A.C.*

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APPENDIX A

Vegetation Record Data Sheet

Date ____________________ **Transect No.** ____________________

Locality ____________________ **Transect Length (ft)** ______________

Observers ____

Notes ____

____

____

Cover Estimates

Class	Percent	Description
1	< 1%	Rare
2	1-10%	Sparse
3	11-25%	Uncommon
4	26-50%	Common
5	51-75%	Abundant
6	76 -95%	Dominant
7	> 95%	Monocluture

V	**Plant Species Name:**	**Plant Community Name**									
		Distance on Transect (ft)									

Note: Estimates of percent cover are made only for plants <u>rooted</u> within a particular habitat

Page ____ of _____

APPENDIX B

Implementation of MFLs for Johns Lake

Prepared by
C. Price Robison, P.E., St. Johns River Water Management District (2007)

The objective of minimum flows and levels (MFLs) is to establish limits to allowable hydrologic change in a water body or watercourse, to prevent significant harm to the water resources or ecology of an area. Hydrologic changes within a water body or watercourse may result from an increase in the consumptive use of water or the alteration of basin characteristics, such as down-cutting outlet channels or constructing outflow structures.

MFLs define a series of minimum high and low water levels and/or flows of differing frequencies and durations required to protect and maintain aquatic and wetland resources. MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in hydrologic conditions. MFLs allow for an acceptable level of change to occur relative to existing hydrologic conditions, without incurring significant ecological harm to the aquatic system.

Before MFLs can be applied, the minimum hydrologic regime must be defined or characterized statistically. Resource management decisions then can be made predicated on maintaining at least these minimum hydrologic conditions as defined by the appropriate statistics.

One way to understand how changes within a watershed alter a hydrologic regime and, therefore, how the aquatic and wetland resources might be affected, is by simulating the system with a hydrologic model. Significant harm can be avoided by regulating hydrologic changes based on the comparison of statistics of the system with and without changes.

MFLs determinations are based on a concept of maintaining the duration and return periods of selected, ecologically based stages and/or flows. Thus, a water body can fall below the selected stage and/or flow, but if it does so too often and/or for too long, then the MFLs would no longer be met.

Statistical analysis of model output provides a framework to summarize the hydrologic characteristics of a water body. The St. Johns River Water Management District (SJRWMD) MFLs program relies on a type of statistical analysis referred to as frequency analysis.

Frequency analysis

As discussed previously, aquatic resources are sustained by a certain hydrologic regime. Depending on the resource in question, a selected ground elevation, for example, might need to

- Remain wet for a certain period of time with a certain frequency
- Remain dry for a certain period of time with a certain frequency
- Be under a given minimum depth of water for a certain period of time with a certain frequency

Frequency analysis is used to estimate how often, on average, a given event will occur. If annual series data are used to generate the statistics, frequency analysis is used to estimate the probability of a given hydrologic event happening in any given year.

A simple example illustrates some of the concepts basic to frequency analysis. A frequently used statistic with respect to water level is the yearly peak stage of a water body. If a gauge has been monitored for 10 years, then there will be 10 yearly peaks $S_1, S_2, \cdots, S_{10}$. Once sorted and ranked, these events can be written as $\hat{S}_1, \hat{S}_2, \cdots, \hat{S}_{10}$, with $\hat{S}_1$ being the highest peak. Based on this limited sample, the estimated probability of the yearly peak being greater than or equal to $\hat{S}_1$ would be

$$P(S \geq \hat{S}_1) = \frac{1}{n} = \frac{1}{10} = 0.1; \tag{B1}$$

the probability of the 1-day peak stage in any year being greater than $\hat{S}_2$

$$P(S \geq \hat{S}_2) = \frac{2}{10} = 0.2 \; ; \tag{B2}$$

and so on. The probability the stage equaling or exceeding $\hat{S}_{10}$ would be

$$P(S \geq \hat{S}_{10}) = \frac{10}{10} = 1.0 \; . \tag{B3}$$

Because this system of analysis precludes any peak stage from being lower than $\hat{S}_{10}$, the usual convention is to divide the stage continuum into 11 parts: nine between each of the 10 peaks, one above the highest peak, and one below the lowest peak ($n - 1 + 2 = n + 1 = 11$). This suggests what is known as the Weibull plotting position formula:

$$P(S \geq \hat{S}_m) = \frac{m}{n+1} \tag{B4}$$

where,

$P(S \geq \hat{S}_m) =$ probability of S equaling or exceeding $\hat{S}_m$

$m =$ rank of the event

Thus, in the example, the probability of the peak in any year equaling or exceeding $\hat{S}_1$ would be

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{11} = 0.0909\ ; \tag{B5}$$

the probability of the 1-day peak stage in any year being greater than $\hat{S}_{10}$

$$P(S \geq \hat{S}_{10}) = \frac{10}{11} = 0.9091\ ; \tag{B6}$$

and so on. The probability the stage in any year is smaller than $\hat{S}_{10}$ would be

$$P(S < \hat{S}_{10}) = 1 - P(S \geq \hat{S}_{10}) = 1 - \frac{10}{11} = 1 - 0.9091 = 0.0909\ . \tag{B7}$$

The return period (in years) of an event, T, is defined as

$$T = \frac{1}{P} \tag{B8}$$

so the return period for $\hat{S}_1$ would be

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = \frac{1}{\frac{1}{11}} = 11\ . \tag{B9}$$

Said another way, $\hat{S}_1$ would be expected to be equaled or exceeded, on average, once every 11 years.

As the size of the sample increases, the probability of $\hat{S}_1$ being exceeded decreases. Thus, with $n = 20$,

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{21} = 0.048 \tag{B10}$$

and

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = 21 \quad . \tag{B11}$$

The stage or flow characteristics of a water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure B1 shows a flood frequency plot generated from annual peak flow data collected at the U.S. Geological Survey (USGS) gauge on the Wekiva River.

Minimum events are treated in much the same way as maximum events, except with minimums the events are ranked from smallest to largest. Thus $\hat{S}_1$ is the smallest or lowest event in a sampling. The minimum stage or flow characteristics of a gauge or water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure B2 shows a drought frequency plot generated from a hydrologic simulation of the middle St. Johns River.

One of the purposes of performing this process of sorting, ranking, and plotting events is to estimate probabilities and return periods for events larger than $\hat{S}_1$, smaller than $\hat{S}_n$, or any event between sample points. There are two methods of obtaining these probabilities and return periods. The first method is to use standard statistical methods to mathematically calculate these probabilities and return periods (Figure B3). This method is beyond the scope of this appendix; the reader is referred to a standard hydrology text (Ponce 1989, Linsley et al. 1982) or the standard flood frequency analysis text, Bulletin 17B (USGS 1982).

With the second method, interpolated or extrapolated frequencies and return periods can also be obtained by the graphical method. Once the period-of-record or period-of-simulation events have been sorted and ranked, they are plotted on probability paper. Probabilities and return periods for events outside of the sampled events can be estimated by drawing a line through the points on the graph to obtain an estimated best fit (Figure B4).

Frequency analysis is also used to characterize hydrologic events of durations longer than 1 day. Frequency analysis encompasses four types of events: (1) maximum average stages or flows; (2) minimum average stages or flows; (3) maximum stages or flows continuously exceeded; and (4) minimum stages or flows continuously not exceeded.

Maximum average stages or flows. In this case, an event is defined as the maximum value for a mean stage or flow over a given number of days. For example, if the maximum yearly values for a 30-day average are of interest, the daily-value hydrograph is analyzed by using a moving 30-day average. Therefore, a 365-day hydrograph would have 336 (365 – 30 + 1 = 336) different values for a 30-day average. These 336 values are searched and the highest is saved. After performing this analysis for each year of the period of record or period of simulation, the events are sorted and ranked. The analytical process is then the same as for the 1-day peaks.

Minimum average stages or flows. In this case, an event is defined as the minimum value for a mean stage or flow over a given number of days. For example, if the minimum yearly values for a 30-day average are of interest, the daily-value hydrograph is analyzed by using a moving 30-day average. Therefore, a 365-day hydrograph would have 336 (365 – 30 + 1 = 336) different values for a 30-day average. These 336 values are searched and the lowest is saved. After performing this analysis for each year of the period of record or period of simulation, the events are sorted and ranked. The process is then the same as for the 1-day low stages.

Maximum stage or flow continuously exceeded. In this case, an event is defined as the stage or flow that is exceeded continuously for a set number of days. For example, if the maximum yearly ground elevation that continuously remains under water for 60 days is of interest, the stage hydrograph of each year is analyzed by taking successive 60-day periods and determining the stage that is continuously exceeded for that period. This is repeated for 306 (365 – 60 + 1 = 306) periods of 60 days. The maximum stage in those 306 values is saved. Once that operation is performed for all years of record or of simulation, the results are sorted and ranked as for the 1-day peaks.

Minimum stage or flow continuously not exceeded. In this case, an event is defined as the stage or flow that is not exceeded continuously for a set number of days. For example, if the minimum yearly ground elevation that continuously remains dry for 60 days is of interest, the stage hydrograph of each year is analyzed by taking successive 60-day periods and determining the stage that is continuously not exceeded for that period. This is repeated for 306 (365 – 60 + 1 = 306) periods of 60 days. The minimum stage in those 306 values is saved. Once that operation is performed for all years of record or of simulation, the results are sorted and ranked as for the 1-day low stages.

In frequency analysis, it is important to identify the most extreme events occurring in any given series of years. Because high surface water levels (stages) in Florida generally occur in summer and early fall, maximum value analysis is based on a year that runs from June 1 to May 31. Conversely, because low stages tend to occur in late spring, the year for minimum events runs from October 1 to September 30.

Hydrologic statistics and their relationships to the Johns Lake MFLs

This section describes the process used to relate long-term hydrologic statistics to the establishment of MFLs. SJRWMD has determined two recommended MFLs for Johns Lake: (1) a minimum frequent high (FH) level and (2) a minimum frequent low (FL) level. The FH level for this lake is used here to illustrate how long-term hydrologic statistics of a lake relate to MFLs.

Each of the two MFLs is tied to characteristic stage durations and return frequencies. For example, the ground elevation represented by the FH level is expected to remain wet continuously for a period of at least 30 days. This event is expected to occur, on average, at least once every 2 years.

The standard stage frequency analysis described previously in this appendix was performed on stage data from lake model simulations of Johns Lake (SJRWMD 2003). In particular, stages continuously exceeded (ground elevations remaining wet) for 30 days were determined, sorted, ranked, and plotted (Figure B5). These stages were obtained assuming that long-term groundwater withdrawals occurred at the same level at which they occurred in 2001. Because complete land use for 2000 was not available, the model included 1995 land use (SJRWMD 1999). The ground elevation of the FH level can be superimposed on the plot (Figure B6) to demonstrate how the level is related to the pertinent hydrologic statistics. Finally, a box bounded by: (1) the FH level on the bottom; (2) a vertical line corresponding to a frequency of occurrence of once in every 3 years on the right; and (3) a vertical line corresponding to a frequency of occurrence of once in every 2 years on the left, is superimposed on the plot (Figure B7). A similar analysis was performed for the FL level (Figure B8). Both levels are being met under these conditions.

A summary of the recommended MFLs for Johns Lake is shown in Table B1. Values in this table will be used as benchmarks for modeling outputs to determine if groundwater withdrawals in the vicinity of Johns Lake will cause water levels to fall below MFLs.

Update of the Johns Lake hydrologic model

This section documents the process used by the District to update the Johns Lake hydrologic model (SJRWMD 2003). Johns Lake has a total drainage area of 6,676 acres, of which 2460 acres correspond to the lake itself. The remaining 4,216 acres make up the contributing area. Black Lake, which discharges into Johns Lake, had a total drainage area of 10,104 acres, of which 292 acres correspond to the lake itself. The remaining 9,812 acres make up the contributing area. Water levels summarized in figures B5 through B8 were generated by this model.

Johns Lake is in an area that has undergone rapid urbanization in recent years. Urbanization translates into an increase of impervious area, which, in turn, increases runoff. Impervious area is a function of land use. Therefore, the District used updated land use to update partition of the drainage area between pervious and impervious segments in the lake model. The District used the following percentages in its impervious area determinations:

• Low-density residential	10 % impervious area
• Medium-density residential	23 % impervious area
• High-density residential	65 % impervious area
• Industrial	81 % impervious area
• Commercial	81 % impervious area
• Transportation	81 % impervious area
• Institutional	65 % impervious area

For Johns Lake, using these percentages and based on 1995 land use (SJRWMD 1999), of the 4,216 acres of contributing area, 181 acres were impervious and 4,035 acres were pervious. For Black Lake, of the 9,812 acres of contributing area, 967 acres were impervious and 8,845 acres were pervious. Based on 2004 land use (SJRWMD 2004), the impervious area for Johns Lake had increased to 335 acres by 2004. This included land identified as being “under construction.” The impervious area for Black Lake had increased to 2,112 acres by 2004. This included land identified as being under construction. Therefore, the hydrologic model was updated to reflect this increase in impervious area. Permitted water withdrawals for 2001 and 2004 were assumed the same. The pertinent MFLs graphs are shown in Figure B9 and Figure B10. Both MFLs are being met under these conditions.

Evaluation of the potential impacts of proposed increased withdrawals of water from the Floridan aquifer

This section describes the process used by SJRWMD to determine if proposed or projected increased withdrawals of water from the Floridan aquifer in the vicinity of

Johns Lake would cause water levels in the lake to fall below established MFLs. SJRWMD uses two modeling tools in this process: a regional groundwater flow model and the lake model described above. The following steps are included in the process.

1. Estimation of Floridan aquifer water level drawdown (1995 through the last year of model simulation)
2. Estimation of Floridan aquifer freeboard in the year of calibration of the lake model
3. Estimation of Floridan aquifer water level decline from 1995 to the year of calibration of the lake model
4. Estimation of Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of model simulation
5. Comparison of Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of simulation (step 4) to the year of calibration freeboard (step 2)

Step 1. Estimation of Floridan aquifer water level drawdown (1995 through the last year of model simulation)

When evaluating consumptive use permit applications for increased withdrawals of groundwater from the Floridan aquifer or when performing water supply planning evaluations, SJRWMD estimates the projected drawdown in the potentiometric surface of the Floridan aquifer in the vicinity of lakes with established MFLs. The analysis includes all existing permitted uses in addition to the proposed increased withdrawals. SJRWMD uses the appropriate regional groundwater flow model to produce these estimates. In the case of Johns Lake, at the time of preparation of this document, SJRWMD was using the East-Central Florida Regional Groundwater Flow Model (McGurk and Presley 2002) for this purpose. This steady-state model is calibrated to 1995 conditions; therefore, the projected drawdown in the potentiometric surface represents the estimated drawdown that would occur from 1995 to the last year of simulation. In association with consumptive use permit evaluations, the last year of simulation represents the year through which issuance of the permit is contemplated. In SJRWMD’s water supply assessment and planning processes, the last year of simulation represents the planning horizon year and/or other intermediate years that may represent significant water use targets.

Step 2. Estimation of Floridan aquifer freeboard in year of calibration of lake model

As stated previously, the model simulation results depicted in figures B9 and B10 assume long-term Floridan aquifer withdrawals at 2001 levels. Any withdrawal increases beyond 2001 would tend to lower potentiometric levels in the area and, therefore, would tend to lower lake levels in Johns Lake. In order to determine the freeboard present at Johns Lake from the point of view of Floridan aquifer water level drawdowns, a trial-and-error process was undertaken assuming incrementally increasing drawdowns. Drawdowns are represented by subtracting a set amount from the well hydrograph used in simulation of Johns Lake. In the case of Johns Lake, for a Floridan aquifer water level drawdown of 2.8 ft, the FL level would still be met (Figure B11). However, any drawdowns greater than 2.8 ft would cause water levels to fall below the established FL level. At a drawdown of 2.8 ft, the FH level (Figure B12) would still be met. Therefore, future Floridan aquifer water level drawdowns beyond 2001 conditions will be limited to 2.8 ft in the Johns Lake area.

Step 3. Estimation of Floridan aquifer water level decline from 1995 to the year of calibration of the lake model

Because the calibration years of lake models and the applicable regional groundwater flow models do not coincide, an adjustment of projected drawdown in the potentiometric surface of the Floridan aquifer in the vicinity of the lake of interest must be made for purposes of comparison to the previously described Floridan aquifer freeboard value. The adjusted value should represent the projected drawdown from the calibration year of the lake model to the final year of simulation of the applicable regional groundwater flow model.

In order to determine this adjusted value, drawdown in the potentiometric surface of the Floridan aquifer in the vicinity of a lake of interest from 1995 through the calibration year of the lake model is estimated. This estimated value is subtracted from the projected drawdown from 1995 to the final year of simulation of the applicable regional groundwater flow model to determine the adjusted value.

Estimated drawdown in the potentiometric surface of the Floridan aquifer in the vicinity of a lake of interest from 1995 through the calibration year of the lake model is calculated using one of the following approaches.

- A water use data set for the calibration year of the lake model is prepared and used in the applicable regional groundwater flow model. The resulting drawdowns represent drawdowns from 1995 to the calibration year of the lake model.
- Estimated drawdowns in the potentiometric surface from 1995 to the calibration year of the lake model are interpolated based on estimates of drawdowns projected to occur from 1995 to some simulation year beyond the lake calibration year. This approach requires assuming a straight-line increase of the projected drawdown from 1995 to the final year of simulation and selecting the appropriate interpolated value for the period 1995 to the year of calibration for the lake model.

Step 4. Estimation of Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of model simulation

The Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of model simulation is estimated by subtracting the drawdown from 1995 through the year of calibration of the lake model (step 3) from the total drawdown (step 1).

Step 5. Comparison of Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of model simulation (step 4), to the freeboard in the year of calibration of the lake model (step 2)

If the Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of groundwater model simulation (step 4) is greater than the year of calibration of the lake model freeboard (step 2), then proposed or projected increased withdrawals through the last year of groundwater model simulation would cause water levels to fall below MFLs. If the Floridan aquifer water level drawdown from the year of calibration of the lake model through the last year of groundwater model simulation (step 4) is less than the year of calibration of the lake model freeboard (step 2), then proposed or projected increased withdrawals through the last year of groundwater model simulation would not cause water levels to fall below established MFLs.

Table B1. Summary of recommended MFLs for Johns Lake

MFLs	Level (ft NGVD)	Duration	Series	Water Year	Statistical Type	Minimum Return Period	Maximum Return Period
Minimum frequent high (FH)	94.7	30 days	Annual	June 1–May 31	Maximum, continuously exceeded	NA	2 yrs
Minimum frequent low (FL)	92.1	120 days	Annual	Oct. 1–Sept. 30	Minimum, continuously not exceeded	3 yrs	NA

ft NGVD = feet National Geodetic Vertical Datum

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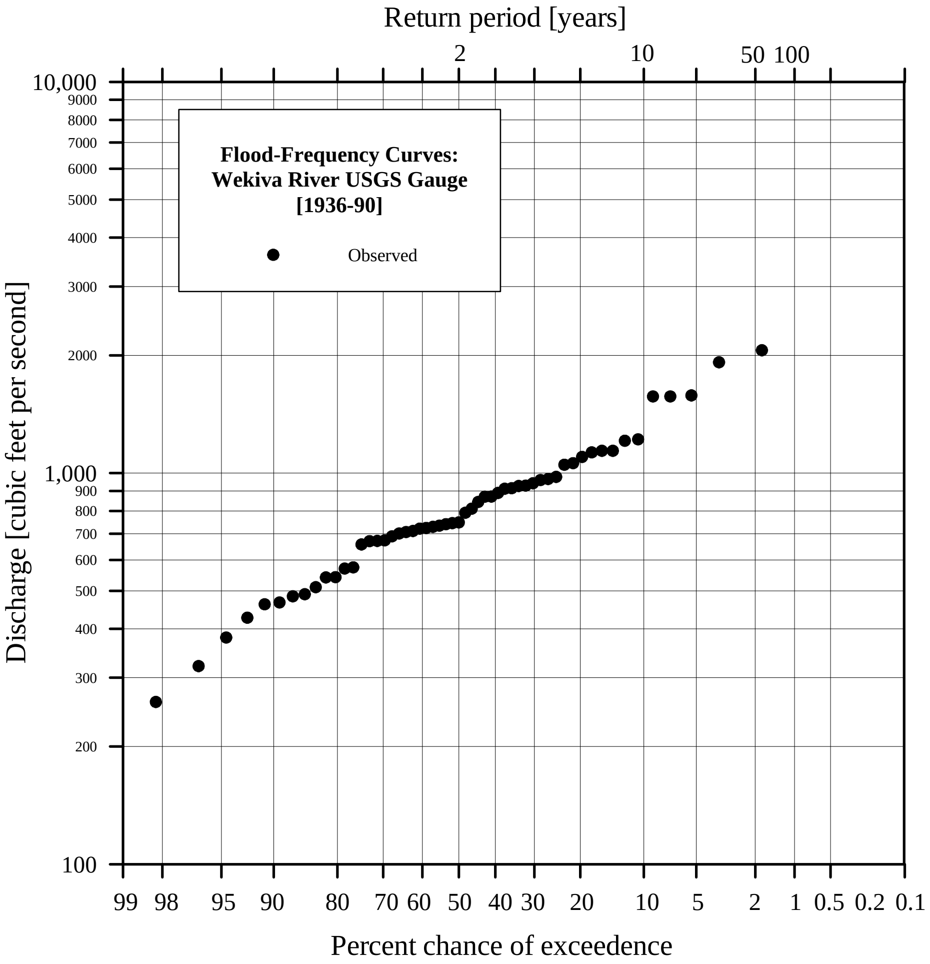


Figure B1. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida; the 1-day peak flows have been sorted, ranked, and plotted according to the Weibull plotting position formula

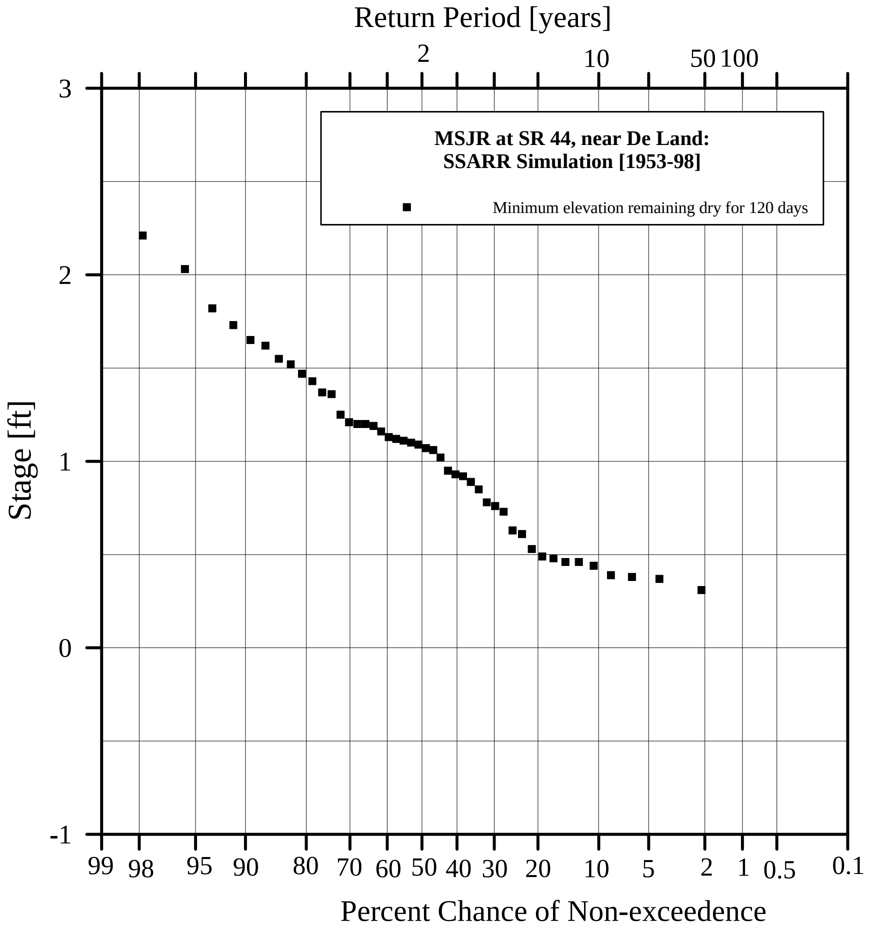


Figure B2. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand; the minimum stages continuously not exceeded for 120 days have been sorted, ranked, and plotted according to the Weibull plotting position formula

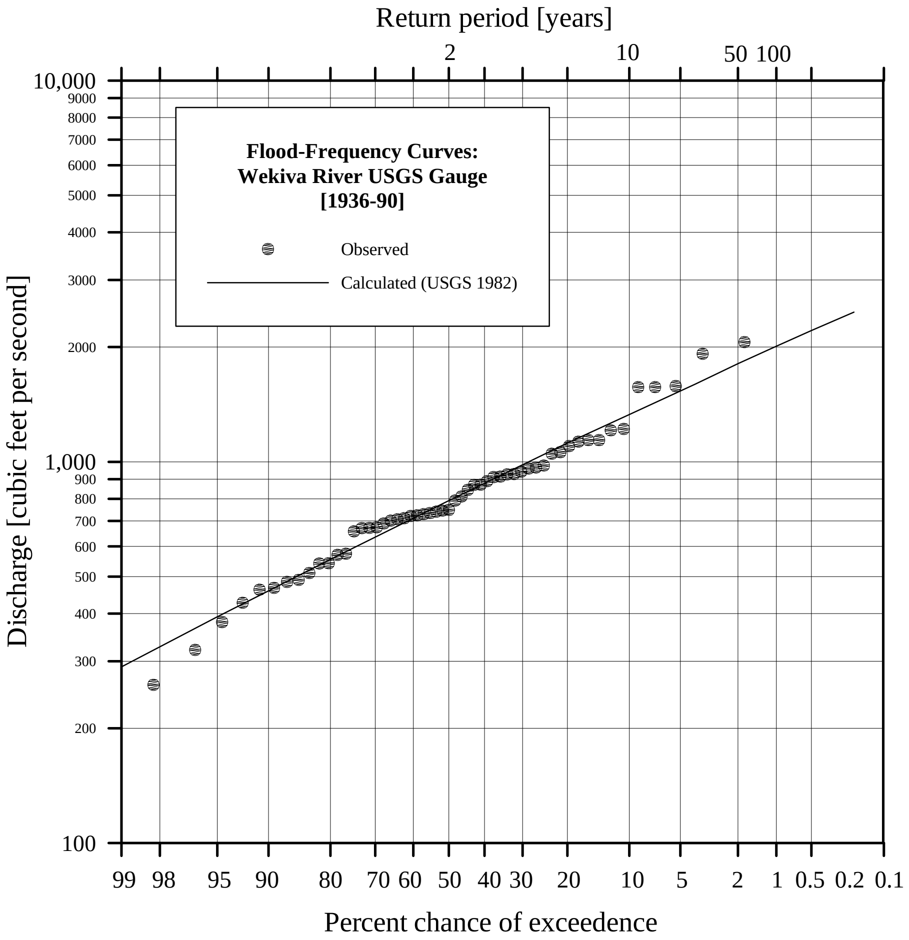


Figure B3. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida, fitted by standard mathematical procedure

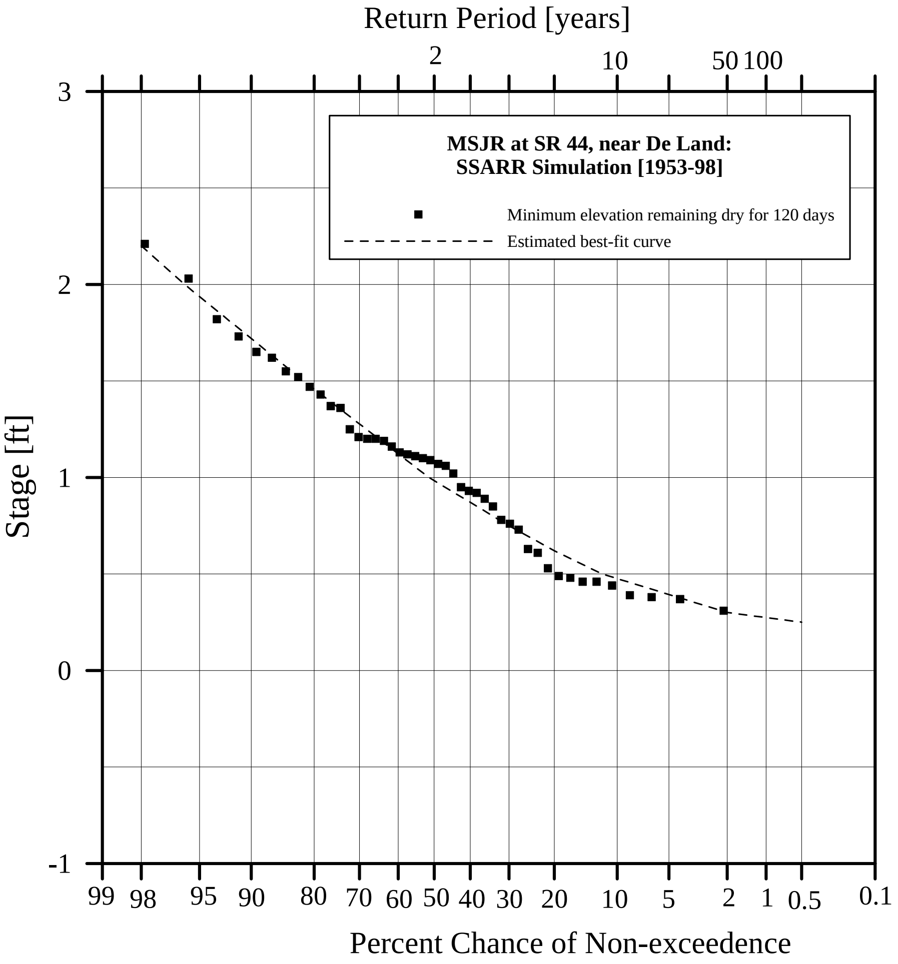


Figure B4. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand, fitted by the graphical method

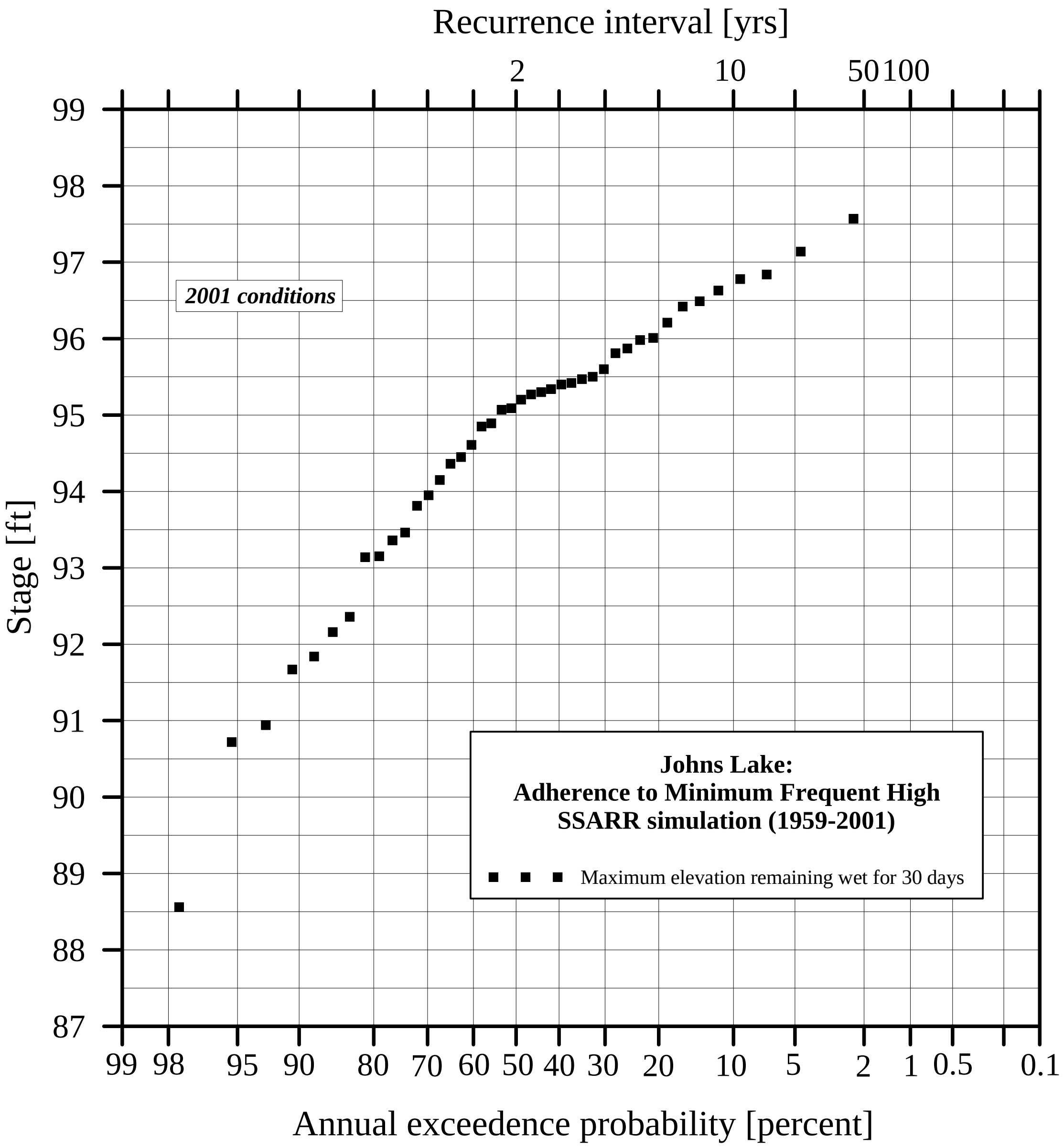


Figure B5. Flood frequencies computed using daily stages from model simulations of Johns Lake, for elevations continuously wet for 30 days and 2001 conditions; the model assumed 2001 water use and 1995 land use

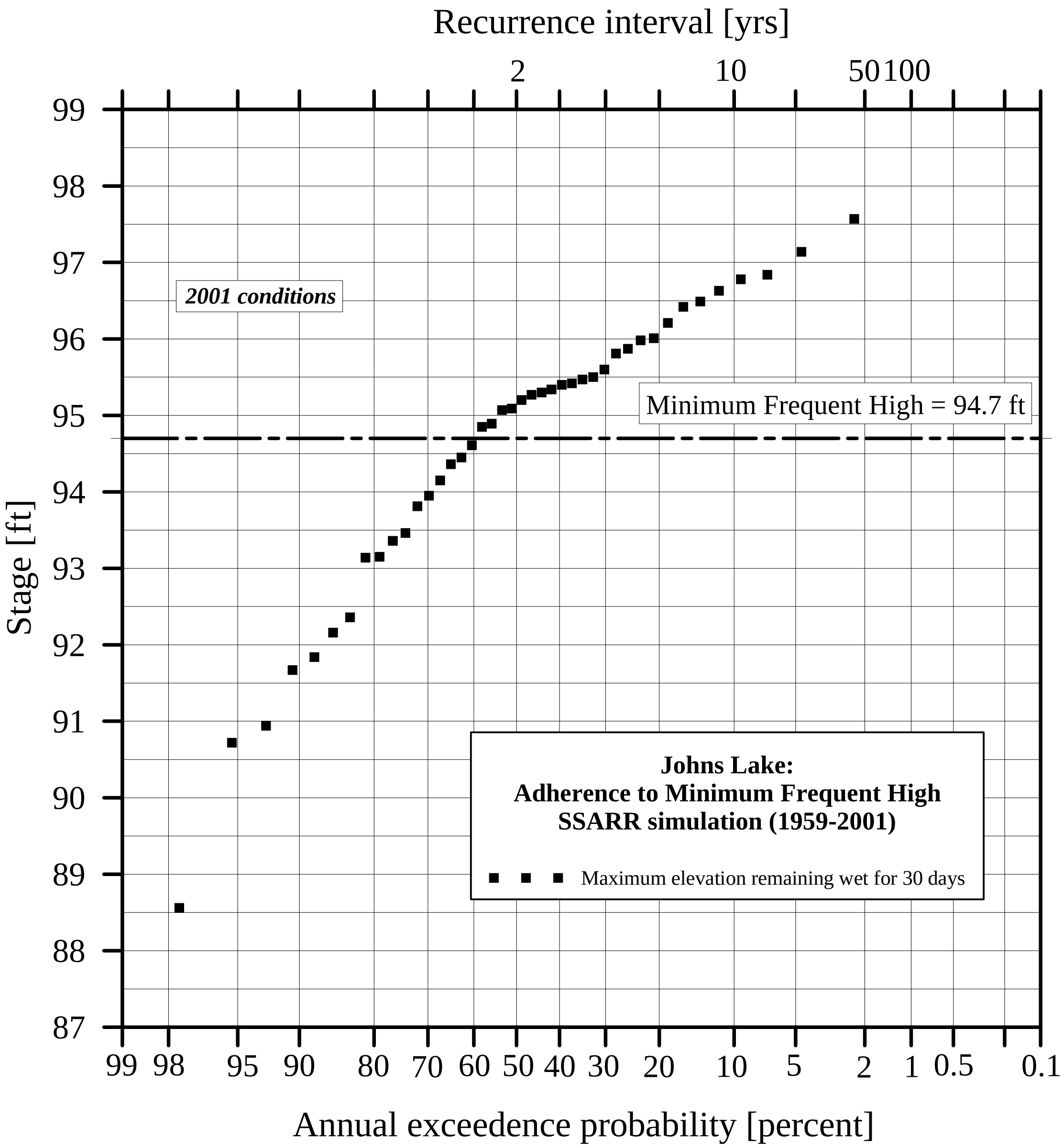


Figure B6. Flood frequencies computed using daily stages from model simulations of Johns Lake, for elevations continuously wet for 30 days and 2001 conditions with the FH of 94.7 ft NGVD superimposed; the model assumed 2001 water use and 1995 land use

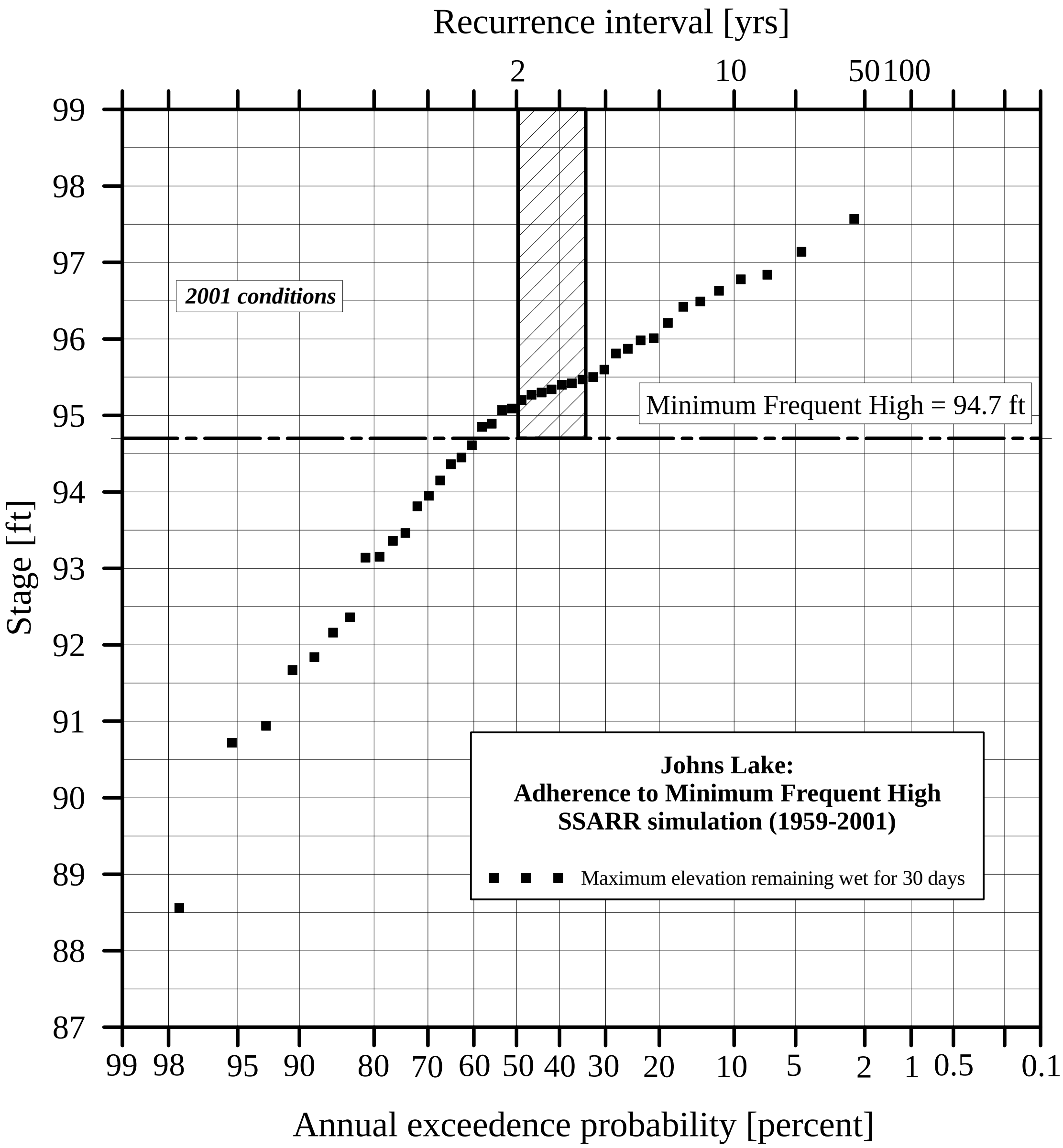


Figure B7. Flood frequencies computed using daily stages from model simulations of Johns Lake, for elevations continuously wet for 30 days and 2001 conditions with a superimposed box bounded by (1) the FH; (2) a vertical line corresponding to a return period of 2 years; and (3) a vertical line corresponding to a return period of 3 years (the model assumed 2001 water use and 1995 land use)

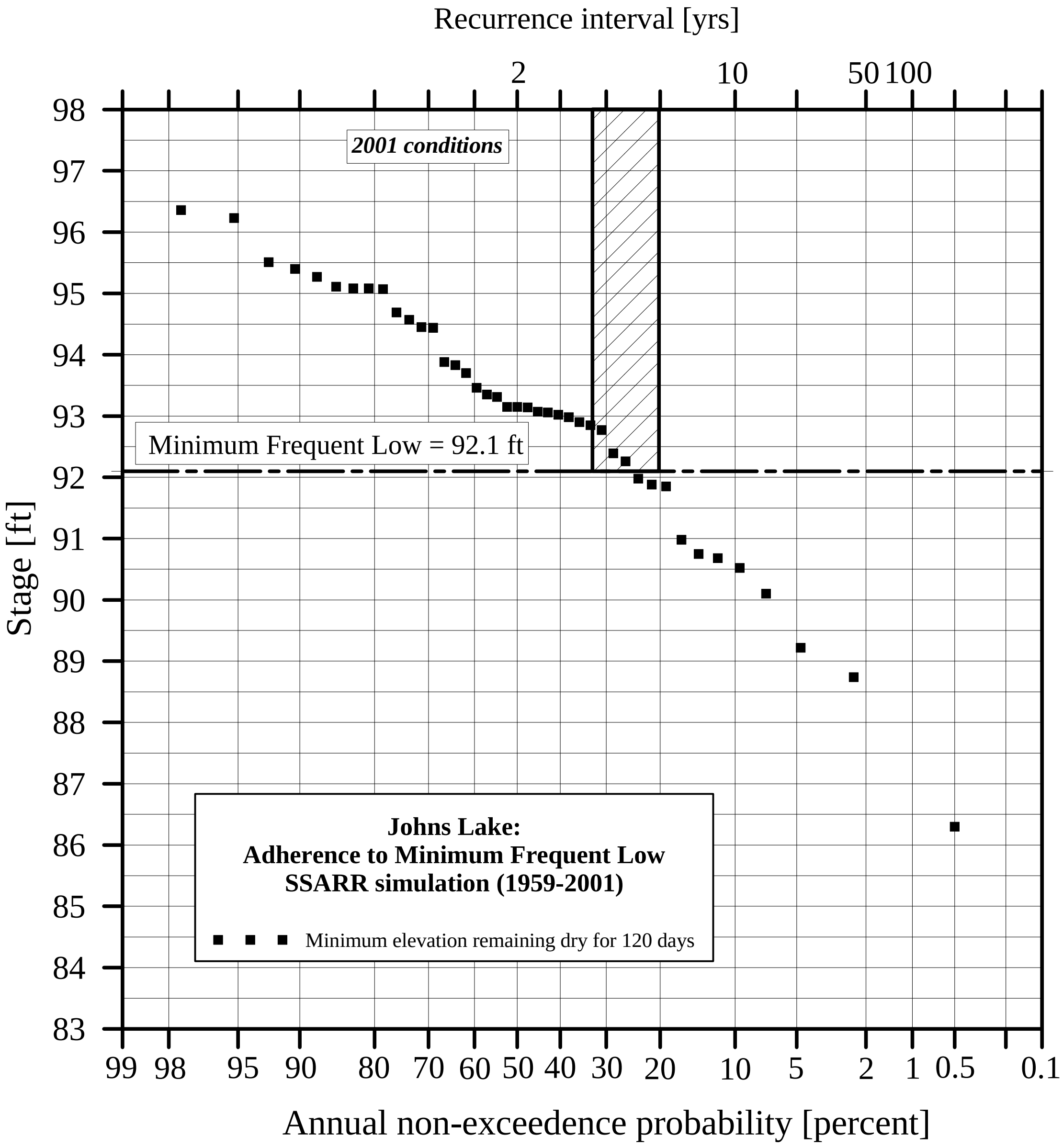


Figure B8. Drought frequencies computed using daily stages from model simulations of Johns Lake, for the FL level and 2001 conditions; the model assumed 2001 water use and 1995 land use

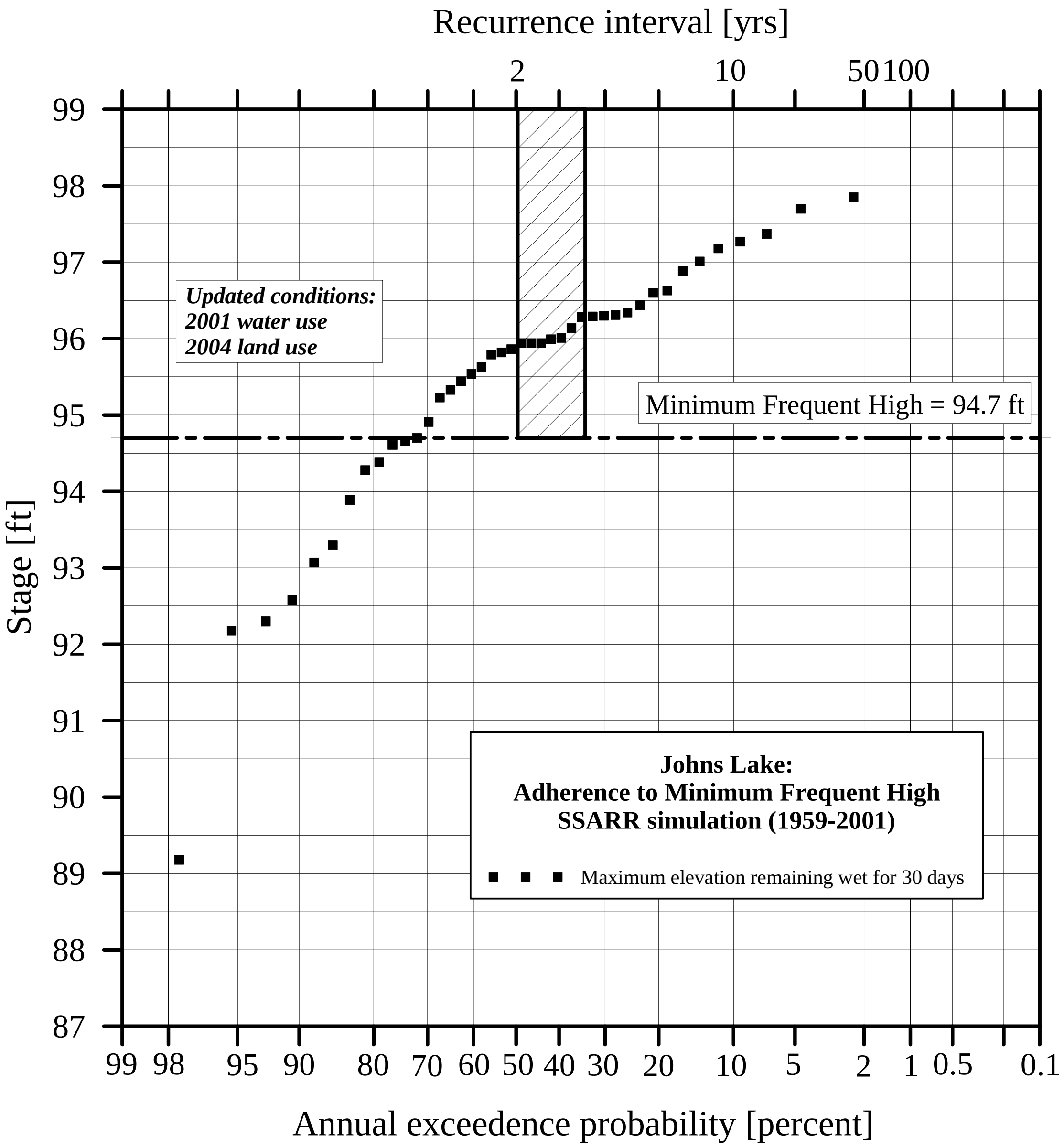


Figure B9. Flood frequencies computed using daily stages from model simulations of Johns Lake, for the FH level and updated conditions; the model assumed 2001 water use and 2004 land use

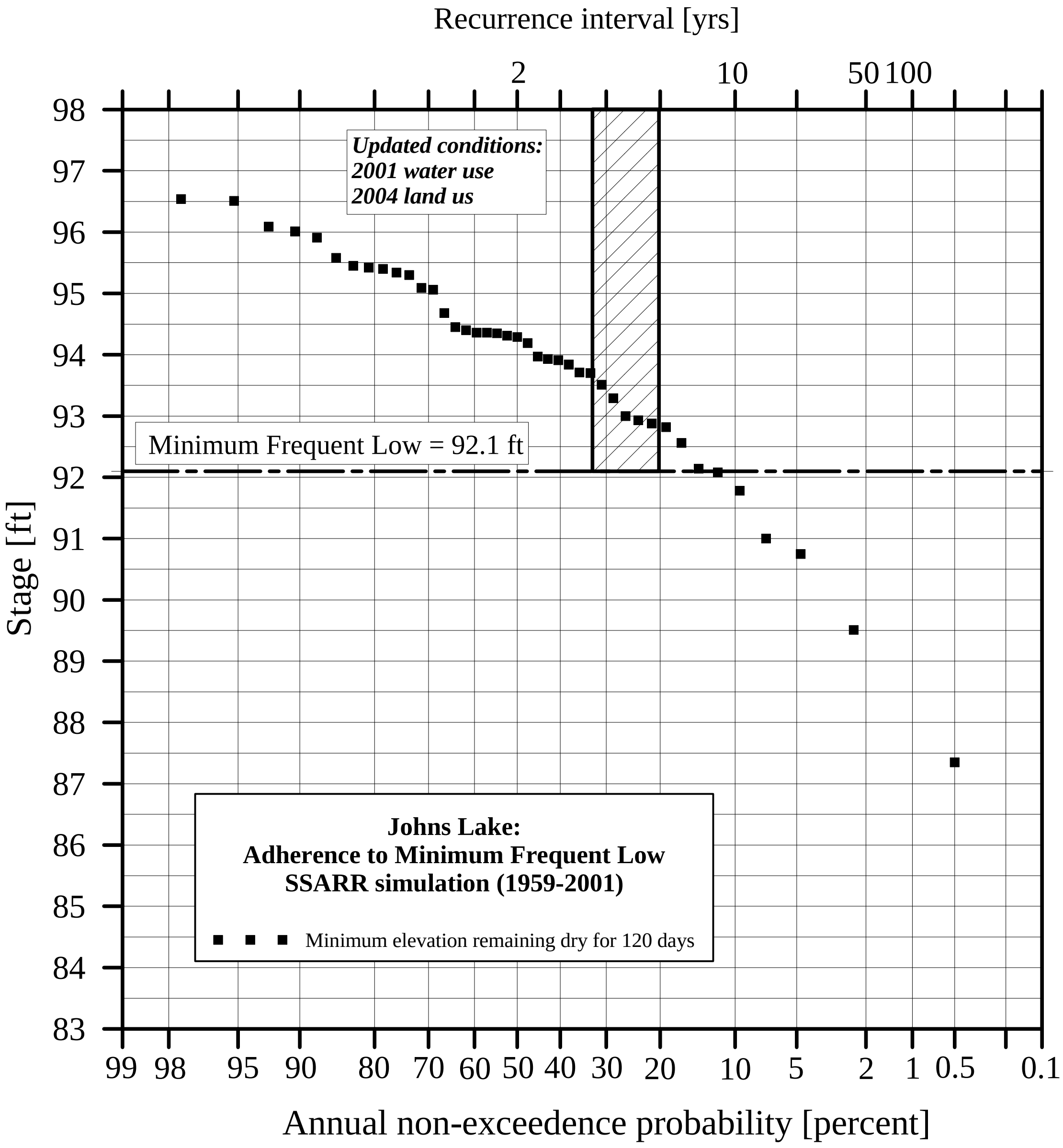


Figure B10. Drought frequencies computed using daily stages from model simulations of Johns Lake, for the FL level and updated conditions; the model assumed 2001 water use and 2004 land use

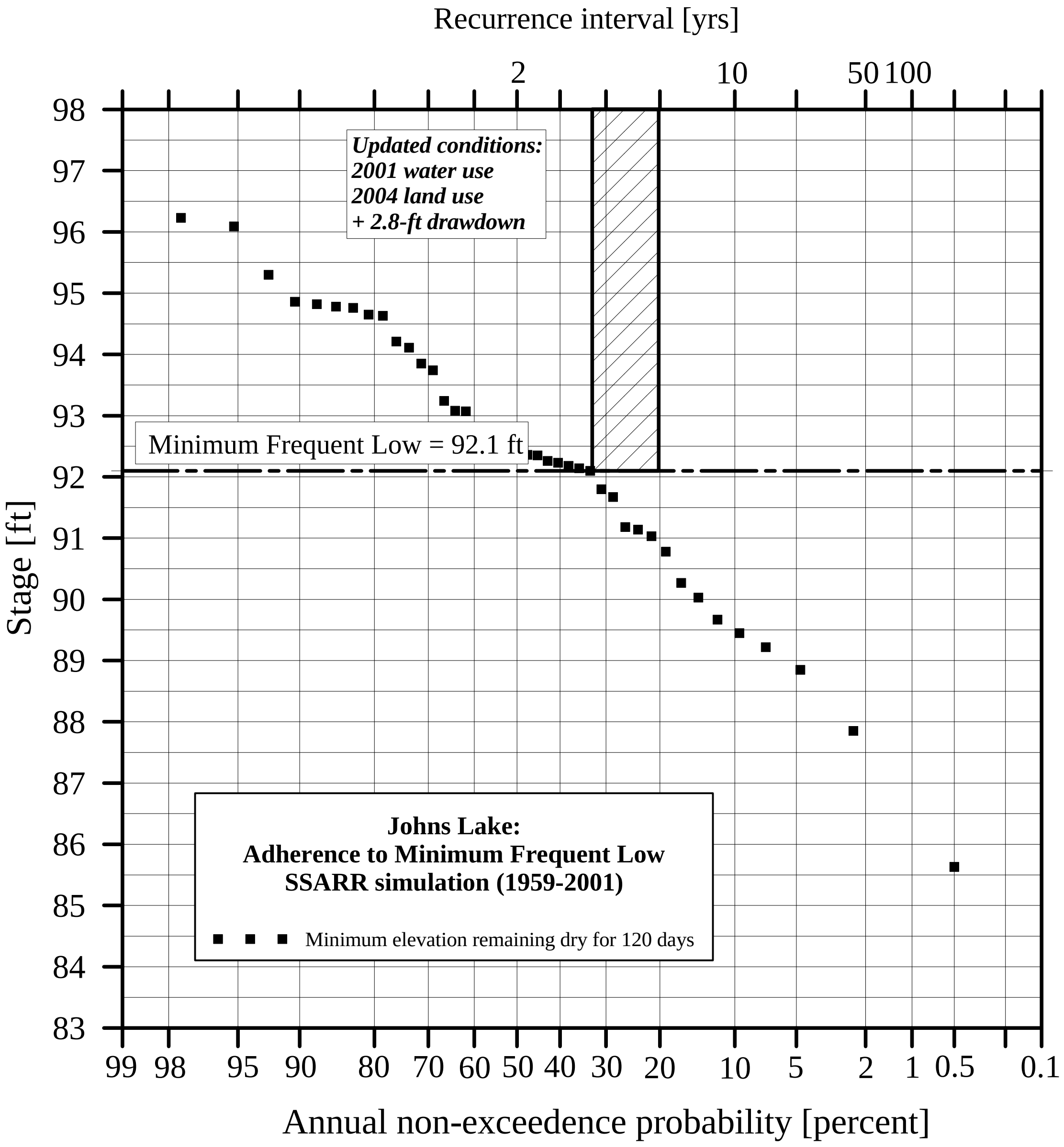


Figure B11. Drought frequencies computed using daily stages from model simulations of Johns Lake, for the FL level and updated conditions plus a 2.8-ft Floridan aquifer drawdown; the model assumed 2001 water use and 2004 land use

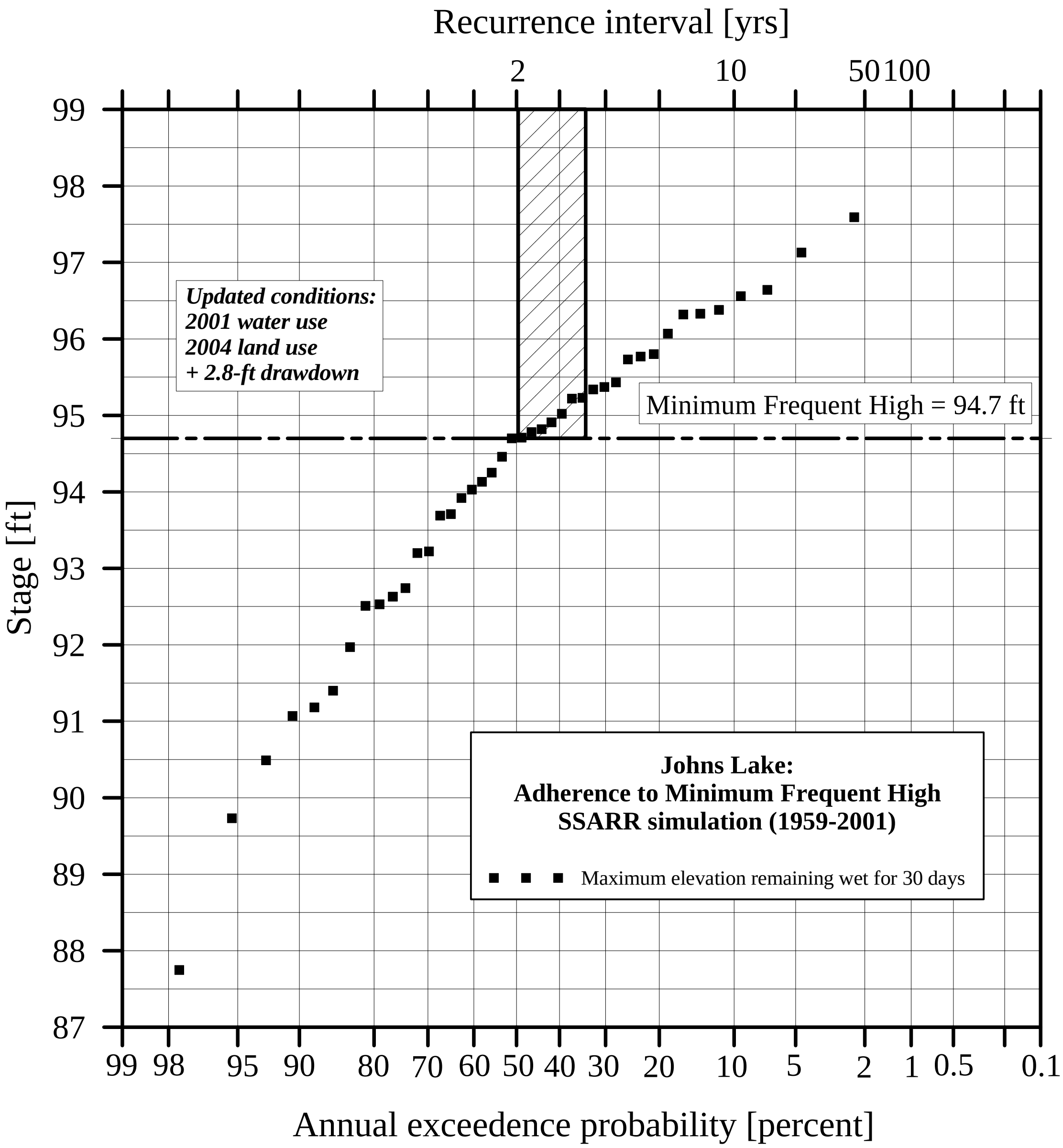
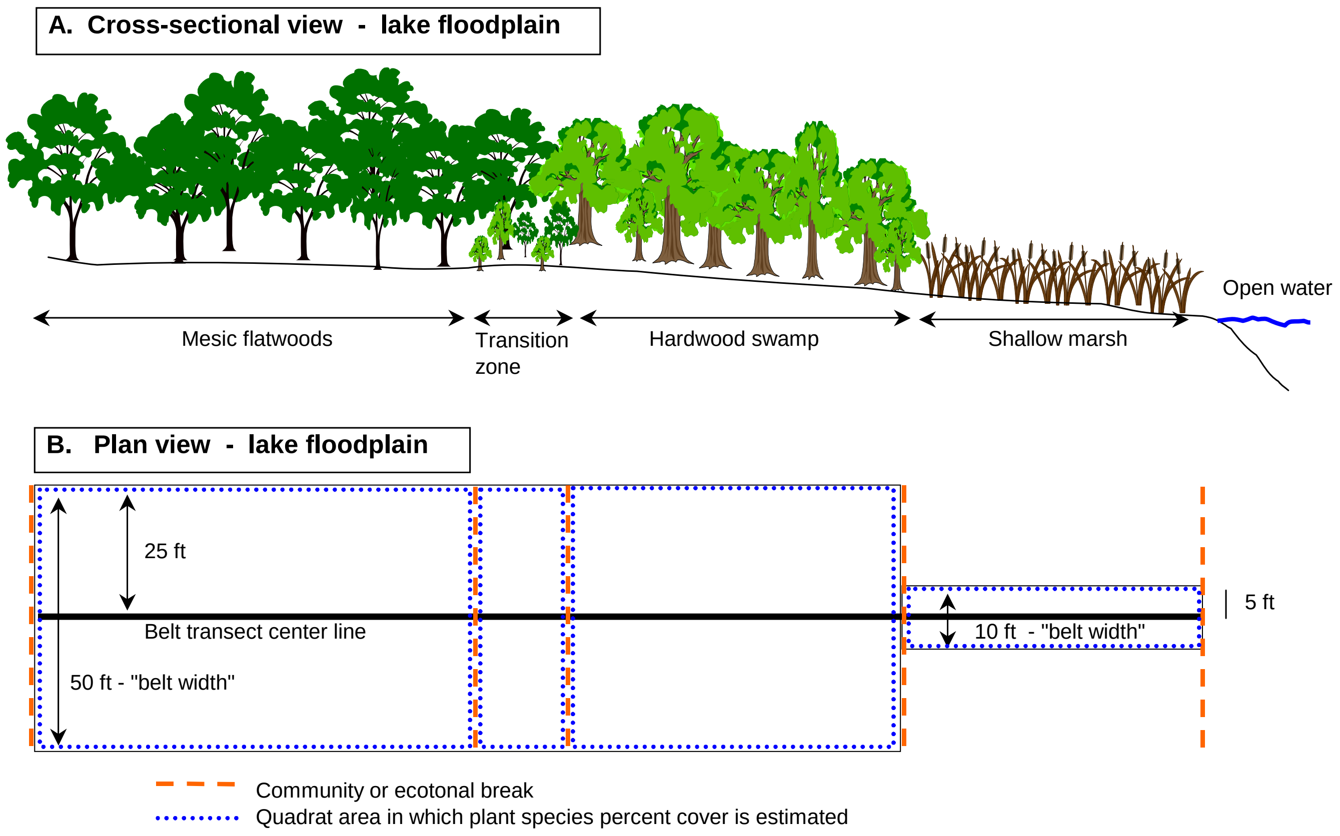


Figure B12. Flood frequencies computed using daily stages from model simulations of Johns Lake, for the FH level and updated conditions plus a 2.8-ft Floridan aquifer drawdown; the model assumed 2001 water use and 2004 land use


A. Cross-sectional view - lake floodplain

B. Plan view - lake floodplain

Figure 8. Example of belt transect through forested and herbaceous plant communities