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MINIMUM LEVELS DETERMINATION: LAKE MONROE IN VOLUSIA AND SEMINOLE COUNTIES, FLORIDA

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MINIMUM LEVELS DETERMINATION: LAKE MONROE IN VOLUSIA AND SEMINOLE COUNTIES, FLORIDA

by

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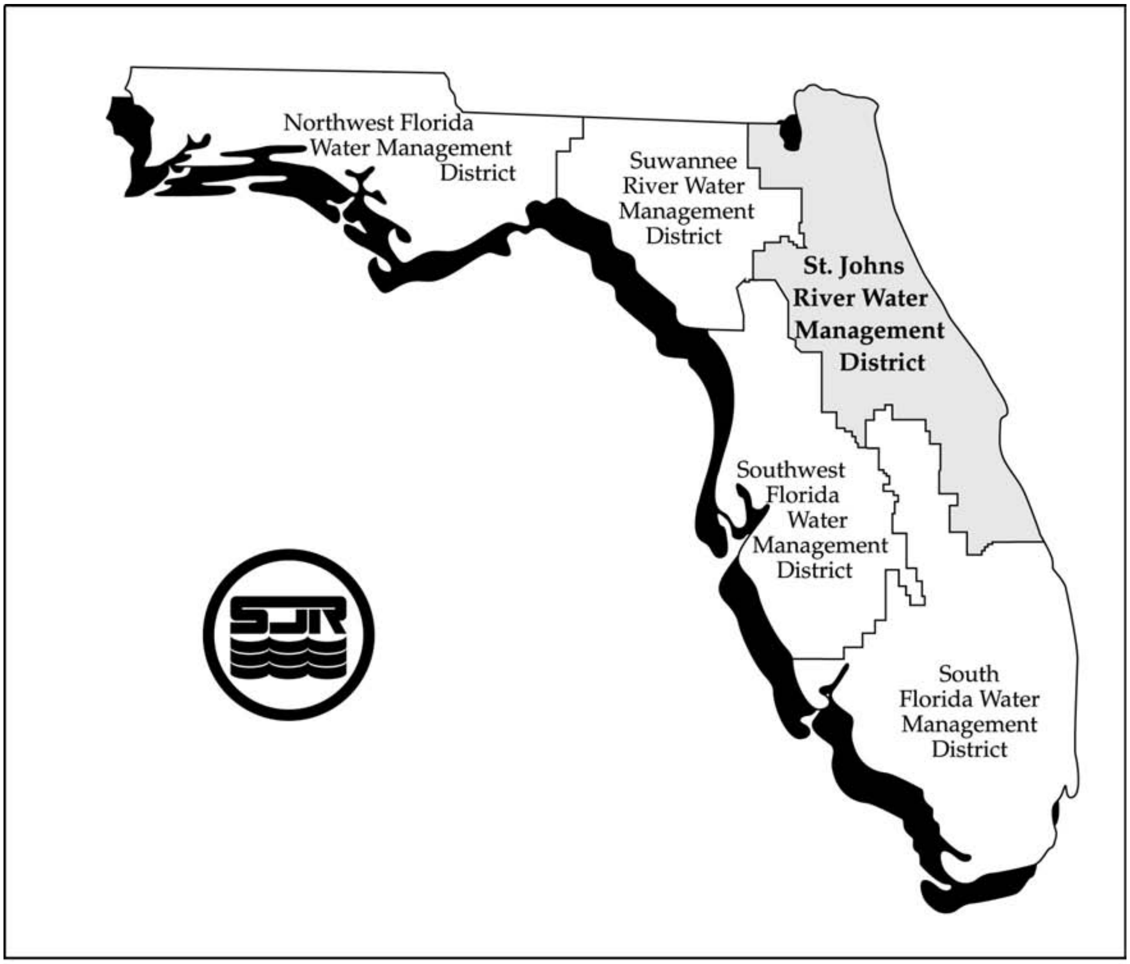

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources 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 document presents the St. Johns River Water Management District's (SJRWMD) recommended minimum levels determination for Lake Monroe in Volusia and Seminole counties, Florida, and describes work performed to support development of the recommendations. Lake Monroe is on the minimum flows and levels (MFLs) Priority Water Body List (SJRWMD 2006a) for the establishment of MFLs pursuant to Section 373.042(2), *Florida Statutes* (F.S.).

SJRWMD's MFLs program, which is implemented based on the requirements of Section 373.042, F.S., establishes MFLs for lakes, streams and rivers, wetlands, and groundwater aquifers. SJRWMD expresses MFLs in 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 as provided in Section 373.042(1), F.S.

The protection of nonconsumptive uses of water, including navigation, recreation, fish and wildlife habitat, and other natural resources, is considered when developing MFLs. 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 hydrologic change to occur relative to the existing hydrologic conditions. When use of water resources shifts the hydrologic conditions below that defined by the MFLs, significant ecological harm is expected to occur. As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies and duration of water level and / or flow events, causing impairment of ecological structures and functions.

SJRWMD used a multiple MFLs methodology (Hall et al. 2006; Neubauer et al. 2005) to develop recommended minimum levels for Lake Monroe. Minimum levels determinations incorporated biological and topographical information collected in the field with stage data, wetland, soils, and landownership data from geographic information system (GIS) coverages, aerial photography, the scientific literature, and hydrologic and hydraulic models to generate an minimum levels regime.

Field-collected soil, vegetation community and topographic data are the principle components of minimum levels determination. The elevations of the wetland communities at Lake Monroe can be associated with the long-term stage record where typical durations and frequencies of flooding and drying are known. Then the wetland community elevations can be applied toward the minimum levels determinations. Recommended minimum levels for Lake Monroe are based upon field data collected at seven transect locations in the Lake Monroe floodplain. Data collected at these seven locations (Figure ES-1) were analyzed to characterize wetland communities with existing flooding and drying regimes and to define water level elevations, durations, and frequencies that characterized those regimes. On this basis, the recommended minimum frequent-high, minimum average, and minimum frequent-low levels were determined for Lake Monroe.

CONCLUSION

The following conclusions are drawn from the work performed in association with developing recommended minimum levels for Lake Monroe.

1. Establishment and enforcement of the recommended minimum levels for Lake Monroe, as presented in this document, should adequately provide for the protection of the water resources or ecology of Lake Monroe and its floodplain from significant harm as a result of consumptive uses of water (Table ES-1).
2. Periodic reassessments of these recommended minimum levels, based on monitoring data collected in the future, would better assure that these levels are providing the expected levels of protection of the water resources and ecology of the area.

RECOMMENDATIONS

The following recommendations are offered.

1. The following recommended minimum levels for Lake Monroe should be considered for establishment and enforcement by rule (Table ES-1).
2. Existing data collection associated with the development of the recommended minimum levels for Lake Monroe should be continued at least until a comprehensive monitoring plan is developed and implemented.

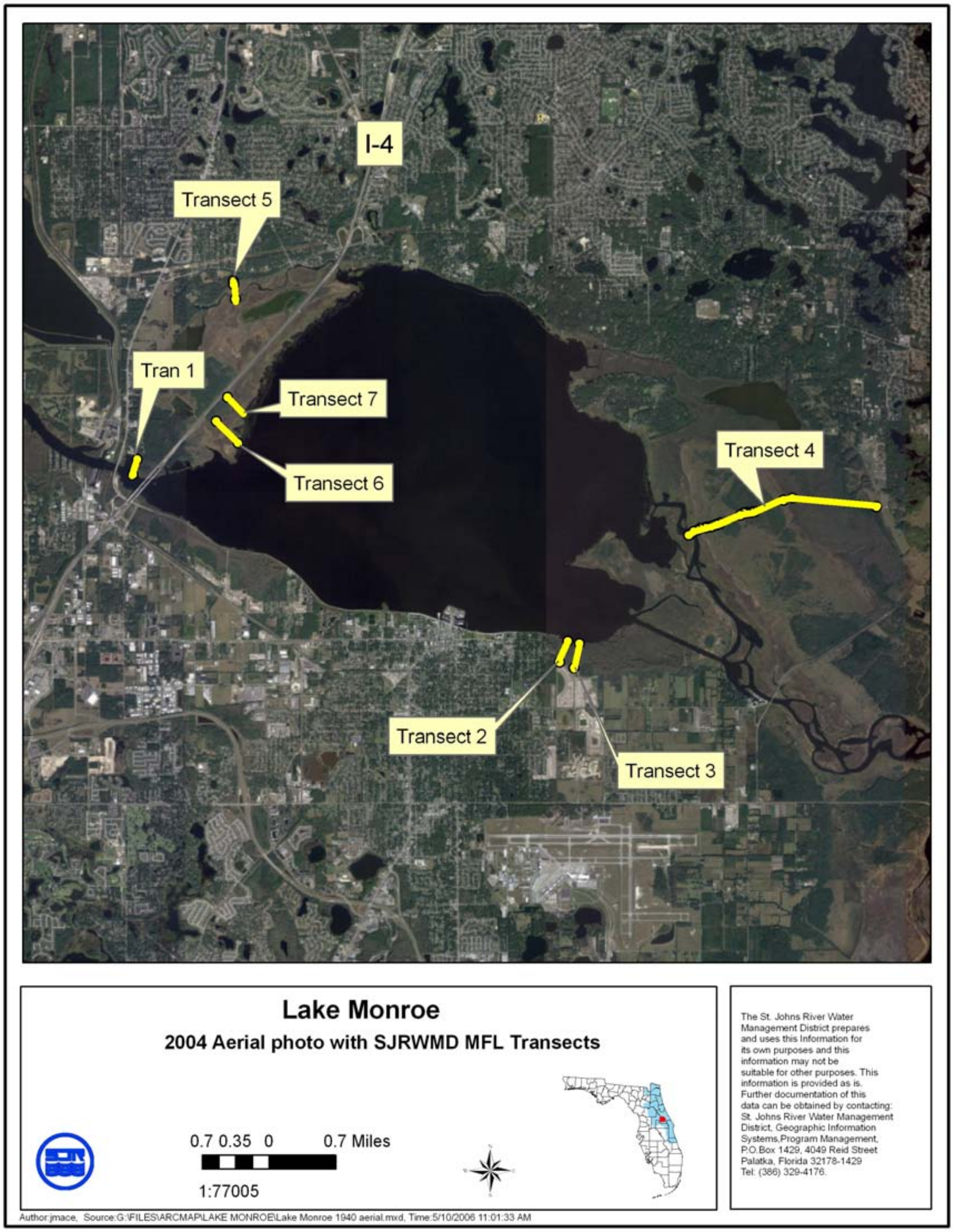

Figure ES-1. Lake Monroe 2004 aerial photograph with MFL field transect locations identified

Table ES-1. Minimum surface water levels for Lake Monroe, Volusia and Seminole counties

Minimum Levels	Elevation (ft NGVD) 1929 datum	Duration	Return Interval
Minimum frequent-high level	2.8	30 days	2 years
Minimum average level	1.2	180 days	1.5 years
Minimum frequent-low level	0.5	120 days	5 years

ft NGVD = feet National Geodetic Vertical Datum

3. A comprehensive monitoring plan should be developed within 6 months of the date of establishment of minimum levels for Lake Monroe. This plan should include an implementation schedule that assures that identified data collection and management is in place in advance of any significant withdrawals from Lake Monroe.
4. Any proposed changes in hydrologic conditions upstream of Lake Monroe should be evaluated by using modeling, as outlined in Appendix A, to determine the extent to which the proposed changes are likely to affect minimum levels.

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INTRODUCTION

This report defines the method, provides detailed information on the field transects selected, and provides results associated with the St. Johns River Water Management District's (SJRWMD) efforts to develop recommended minimum levels for Lake Monroe in Volusia and Seminole counties, Florida. The minimum levels are water levels that primarily serve as hydrologic constraints for water supply development, but may also apply in environmental resource permitting.

BACKGROUND

Lake Monroe is on the minimum flows and levels (MFLs) Priority Water Body List and Schedule (SJRWMD 2006a). As a priority listed water body, minimum levels must be established for Lake Monroe 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.

In determining the priority water body list, the following factors are considered:

- Whether the existing or projected demand for water in the area is sufficient to meaningfully affect flows and / or levels of the surface water or groundwater
- Whether any water supply development is planned in the area that may adversely affect regionally significant environmental resources
- Whether the system includes regionally significant environmental resources
- Whether historic hydrologic records (flows and / or levels) are available to allow statistical analysis and calibration of computer models when selecting particular water bodies in areas with many water bodies

Lake Monroe is consistent with these factors due to (1) the projected demand for water in the region; (2) possible water supply development projects from the St. Johns River at or near Lake Monroe; (3) the numerous environmental resources in the Lake Monroe floodplain; and (4) the extensive historic hydrologic records for Lake Monroe (Robison 2004).

Water supply development options identified in the *District Water Supply Plan 2005* (SJRWMD 2006b) include potential surface water withdrawals for public supply from the St. Johns River near Lake Monroe to meet projected 2025 demands.

In addition to the minimum levels proposed for Lake Monroe, MFLs are scheduled for establishment in February 2007 for the St. Johns River at State Road 50 (Mace 2006a). Additionally, MFLs were established for the St. Johns River downstream from Lake Washington at river mile 253.1, along with minimum levels for Lake Washington (Hall and Borah 1998) and for the St. Johns River near DeLand at river mile 144 (Mace 2006b). The establishment of minimum flows and / or levels at these different locations on the St. Johns River and at Lake Monroe will allow SJRWMD to monitor and protect Lake Monroe and the St. Johns River and from significant harm that could be caused by consumptive uses of water.

MFLs Program Description

SJRWMD's MFLs program establishes minimum flows and levels for lakes, streams and rivers, wetlands, springs, and groundwater aquifers, as mandated by state water policy (Section 373.042, F.S.).

Purpose

The MFLs program is subject to rule (Chapter 40C-8, *Florida Administrative Code* [*F.A.C.*]) and provides technical support to SJRWMD's regional water supply planning process (Section 373.036, F.S.) and the consumptive use permitting program (Chapter 40C-2, *F.A.C.*). Policy regarding MFLs states "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology" (Chapter 40C-8.011(3), *F.A.C.*). Significant harm, or the environmental effects resulting from the reduction of long-term water levels and / or flows below MFLs, is prohibited by Section 373.042(1a)(1b), F.S.

Factors Affected by MFLs

According to Section 62-40.473, *F.A.C.*, the establishment of MFLs should consider 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:

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

These 10 natural resources and environmental values are hereafter referred to as water resource values (WRVs).

Hydrology

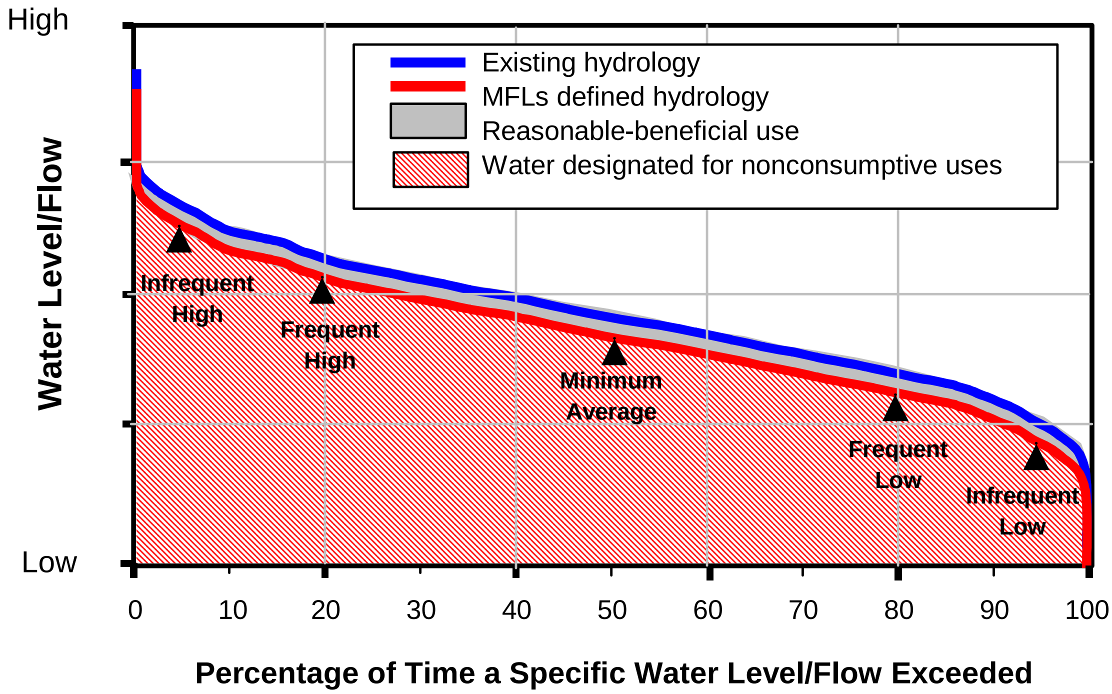
Hydroperiod, hydrologic constraints, and changes in hydrology are factors considered in the MFLs determination process. MFLs designate a hydrologic regime below which significant harm would occur and above which water is available for reasonable and beneficial use. Reasonable–beneficial use is “the use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest” (Section 373.019(13), F.S.).

Hydroperiod Categories. MFLs define the return intervals of high and low water events necessary to prevent significant harm to aquatic habitats and wetlands. Three to five MFLs are usually defined for each system—minimum infrequent-high, minimum frequent-high, minimum average, minimum frequent-low, and minimum infrequent-low flows and / or water levels. The MFLs represent hydrologic statistics comprised of three components: water level and / or flow; duration; and frequency. SJRWMD staff have synthesized from Cowardin et al. (1979) the continuous duration and frequency components of the MFLs into seven discrete hydroperiod categories. The hydroperiod categories with related frequencies and durations are defined in Chapter 40C-8.021, *F.A.C.*, and further summarized in Table 1.

Table 1. MFLs hydroperiod categories and approximate frequencies and durations

Hydroperiod Category	Approximate Frequency	Approximate Duration
Intermittently flooded	Once every 10 years high	Weeks to months
Temporarily flooded	Once every 5 years high	Weeks to months
Seasonally flooded	Once every 2 years high	Weeks to months
Typically saturated	Once every 2 years low	Months
Semipermanently flooded	Once every 5 to 10 years low	Months
Intermittently exposed	Once every 20 years low	Weeks to months
Permanently flooded	More extreme drought	Days to weeks

Changes in Hydrology. MFLs are water levels and / or flows that primarily serve as hydrologic constraints for water supply development, but may also apply in environmental resource permitting (Figure 1). 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 existing 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 (pink-diagonally lined area, Figure 1). As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies and durations of water level and / or flow events, causing unacceptable changes to ecological structures and / or functions. Significant harm can be prevented if water withdrawals do not cumulatively alter the hydrology beyond the minimum hydrologic regime defined by the MFLs.



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 reasonable–beneficial use of water (gray-shaded area).

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

MFLs apply to decisions affecting consumptive use 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 conditions where water levels would fall below established MFLs require the SJRWMD Governing Board to develop recovery or prevention strategies (Chapter 373.0421(2), F.S.). MFLs are reviewed periodically and revised as needed (Chapter 373.0421(3), F.S.).

MFLs Methodology

MFLs determinations incorporate biological and topographical information collected in the field with stage data, hydrologic and hydraulic models, and the scientific literature to generate a MFLs regime. The MFLs methodology provides a process for incorporating these factors. This section describes the MFLs methodology and assumptions used in the MFLs determination process for Lake Monroe, including field procedures, such as site selection and field data collection, data analyses, and levels determination criteria. The SJRWMD general MFLs methodology is described more completely in the *MFLs Methods Manual* (Hall et al. 2006).

Field Site Selection

Minimum levels determinations for Lake Monroe involved an extensive field effort that was concentrated along transects, which are field surveys lines that traverse the floodplain. Seven transects were located at Lake Monroe. Data collected at the seven transects were evaluated to ultimately determine minimum levels for Lake Monroe. The field investigations at Lake Monroe were initiated in January 2002. Many factors were considered in the selection of field transect sites over the large floodplain associated with Lake Monroe.

Transects, or fixed sample lines across a river, lake, or wetland floodplain, typically extend from open water to uplands, along which, elevation, soils, and vegetation are sampled to characterize the influence of surface water flooding on the distribution of soils and plant communities. Selecting transect sites involved the following steps.

Information Gathering

Field site selection began with the implementation of a site history survey and data search. The project team collected existing information and conducted data searches of the SJRWMD library documents, project record files, the hydrologic database, and Division of Surveying Services files. The following types of information were collected:

- 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

Transect Site Identification

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

Potential transect locations were initially identified from maps of wetlands, soils, topography, and landownership. Specific transect site selection goals included the following:

1. Transects established at sites where multiple wetland communities of the major types occurred
2. Locations with the common wetland types at two or more different sites, in order to ensure ecosystem protection of similar wetland types at different locations, as well as, different wetland ecosystems at Lake Monroe

The second goal had the purpose of ensuring ecosystem protection of similar wetland types, as well as different wetland ecosystems, at Lake Monroe.

Transect characteristics were subsequently field verified to ensure the particular locations contained representative wetland communities, hydric soils, and reasonable upland access, while avoiding archaeological sites and alligator nests. Locating transects on public land was preferable, to avoid future development that would affect transects and to facilitate access for long-term ecological monitoring. Numerous sites were field evaluated. Seven final transect sites were selected at Lake Monroe (Figure 2 and Table 2). Individual transect site selection criteria for the final seven transects are described in the Results and Discussion section of this document.

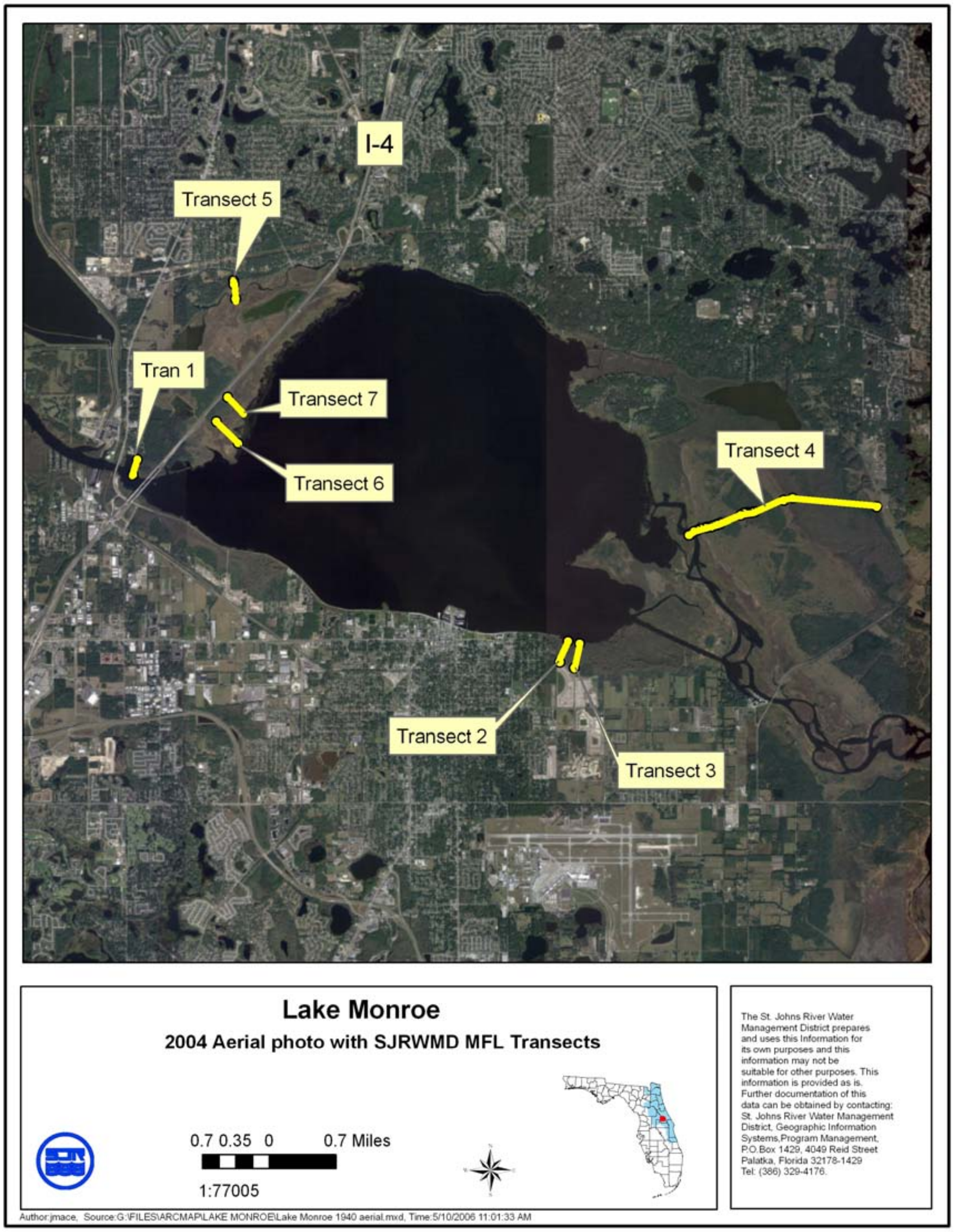


Figure 2. Aerial photo of Lake Monroe with MFL transect locations identified

Table 2. Field transect names and locations

Transect No.	Transect Location	Location and Date of Fieldwork
1	West shore	Lake Monroe Park, between Interstate 4 and U.S. 17/92; January and May, 2002
2	Southeast shore	Southeast shore of Lake Monroe, north of Celery Road; January and May, 2002
3	Southeast shore	Southeast shore of Lake Monroe, north of Celery Road; January and May, 2002
4	East shore	East shore on Lake Monroe Conservation Area; July and August 2002
5	Northwest shore	Northwest shore within Gemini Springs Park; October and November 2002
6	West shore	West shore of Lake Monroe, east of Interstate 4; March 2003
7	West shore	West shore of Lake Monroe, east of Interstate 4; March 2003

FIELD DATA COLLECTION

The field data collection procedure for determining MFLs typically involved gathering information and sampling elevation, soils, and vegetation data along fixed lines, or transects, across a hydrologic gradient. Transects were established in areas where there were changes in vegetation and soils, and the hydrologic gradient was marked (Hall et al. 2006). 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 Preparation and Survey

Once established, transect site vegetation was trimmed to allow a line of sight along the length of the transect. A measuring tape was then laid down on the ground along the length of the transect. One elevation measurement was recorded every 5–50 feet (ft) on the ground along the length of each of the seven field transects included in the minimum levels determination for Lake Monroe. Elevations were surveyed with a conventional level by professional land surveyors along each transect. The surveyors brought elevations to the individual transects from established Florida Department of Environmental Protection (FDEP) elevation benchmarks.

In general, the elevation gradient was very low and the vegetation communities were broad at the seven transects. Consequently, elevations were typically recorded at 20-foot (ft) intervals. Additional elevations were measured at obvious elevation changes, vegetation community changes, and soil changes.

Latitude and longitude data were also collected along the length of the transects, using a global positioning system (GPS) receiver with approximately a one-meter accuracy. Typically, GPS points were collected at frequent intervals (every 50–200 ft) and at directional changes along the transects. The data collection interval varied depending upon the overall length of the transect, the frequency and width of plant community changes, the number of directional changes along the transect, and the tree canopy prohibiting satellite reception at some swamp stations. These GPS data accurately located specific features along the transects, such as vegetation ecotones, and should facilitate recovering transect locations in the future. The latitude and longitude data collected with the GPS were subsequently downloaded for map production and stored in both electronic and paper files for future retrievals.

Soil Sampling Procedures

Detailed soil profiles were obtained at selected stations along the seven transects lines. Soil profiles were described by following standard Natural Resources Conservation Service (NRCS) procedures (USDA, NRCS 1998). Each soil horizon (unique layer) was 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 determination were the presence and depth of organic soils, as well as the extent of hydric soils observed along the field transects. The procedure to document hydric soils included the following:

- Removal of 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 inches (in.); and, using the completed soil description, specifying which hydric soil indicators have been matched

- Examination of the soil to a greater depth, where required, for field indicators 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 classifications.)
- 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)

Soil sampling intervals varied considerably along the seven transects. The sampling interval was dependent upon on-site soil changes. Typically, sampling occurred in a broad vegetation community at 100–300 ft intervals. However, upon recording a soil change from the previously sampled station, more sampling occurred closer to the previously sampled station, in order to identify the location of soil change.

The following soil features, if present, were identified and their locations marked along the transect lines so that soil surface elevations could be determined for these features:

- Landward extent of hydric soils
- Landward extent of surface organics
- Landward extent of histic epipedon (surface organic horizon with depths 8–16 in. thick)
- Landward extent of histosols (organic horizon with a thickness of >16 in., within 32 in. of the soil surface)
- Thickness of organic surface horizon

Vegetation Sampling Procedures

Vegetation sampling associated with the development of recommended minimum levels for Lake Monroe was completed with a specialized line transect called a belt transect. A belt transect is a line transect with width (belt width). It is essentially a widening of the line transect to form a long, thin rectangular plot, which is divided into smaller sampling areas called quadrats that correspond to the spatial extent of plant communities or transitions between plant communities (Figure 3). The belt transect width will vary depending upon the type of plant community to be sampled (Hall et al. 2006).

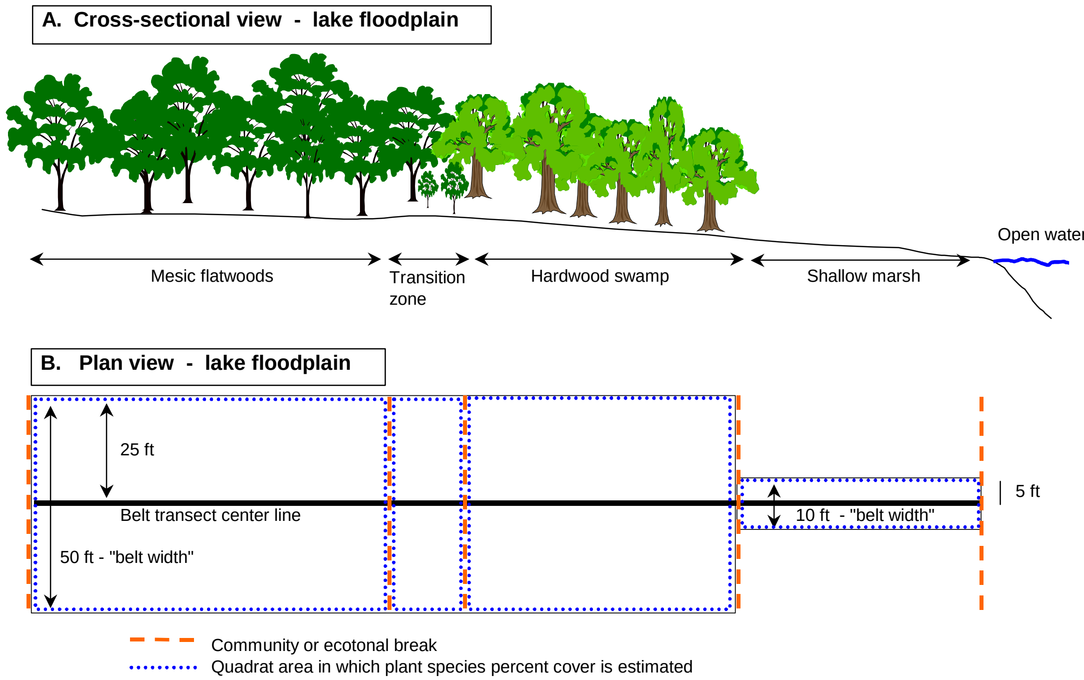


Figure 3. Example of belt transect through forested and herbaceous plant communities

For example, a 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 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 3).

Plants were identified and the percent cover of plant species was estimated for the plants within the established belt transect 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 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 does 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 add up to more than 100% (Hall et al. 2006). Multiple site visits occurred at all Lake Monroe field transects to improve the ability to characterize the vegetation composition.

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 are summarized in Table 3 (Hall et al. 2006).

Table 3. 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

Plant species, plant communities and percent cover data were recorded on field vegetation data sheets (Appendix B). The data sheets are formatted to facilitate data collection in the field and also computer transcription (Hall et al. 2006).

The *Wetlands Diagnostic Characteristics* (Kinser 1996) was used to standardize wetland plant community names recorded in the field. SJRWMD has district-wide wetland maps developed from aerial photography utilizing this classification system. Terrestrial (upland) plant community names are modified from the Florida Natural Areas Inventory classification (FNAI, FDNR 1990).

DATA ANALYSIS

The primary data analysis consisted of creating statistical summary tables on the surveyed elevation data by using a graph format in a computer spreadsheet. Vegetation and soils information collected along the transect were incorporated with the elevation data. Vegetation community average, median, minimum, and maximum elevations were calculated, along with various soil groupings. For example, the average soil surface elevation of a hardwood swamp was calculated along with the average surface elevation of histosols within the hardwood swamp, where the histosols were observed within a portion of the hardwood swamp.

Transect elevation data were also graphed to illustrate the elevation profile between the open water and upland community (Figure 3). Location of vegetation communities along the transects, with a list of dominant plant species, statistical results, and soil information, were noted on the graph, space permitting.

MINIMUM LEVELS

Standardized procedures for setting each level, using the best available information, are described in detail in the *MFLs Methods Manual* (Hall et al. 2006). Minimum levels criteria vary depending upon the level being determined (i.e., minimum frequent-high, minimum average, or minimum frequent-low) and the on-site wetland community characteristics.

For example, the primary minimum frequent-high level criterion may equal the average elevation of a wetland community that experiences flooding approximately 20% of the time, based upon the scientific literature and hydrologic data. Additional frequent-high level criteria may include the maximum elevation of a vegetation community that typically floods frequently, and/or the elevation equal to the landward extent of the hydric soils or the landward extent of a shallow (< 8 in., in depth) surface organic soil. The minimum frequent-high level should maintain the seasonal flooding regime. Seasonal high water flows or levels occur in natural systems with unaltered hydrology that provide for out-of-bank flooding of the riparian wetlands adjacent to the mainstem of a river or lake at a duration and return interval sufficient to support important ecological processes (Hill et al 1991). Levels equal to the minimum frequent-high should occur for at least 30 continuous days in the growing season at least one in three years, on average. Stream biota relies upon inundation of the floodplain for habitat and for the exchange of nutrients and organic matter (McArthur 1989). Flooding of wetlands and upland fringes redistributes and concentrates organic particulates across the floodplain (Junk 1989).

The minimum average level represents the surface water level necessary over a long period to maintain the integrity of hydric soils and wetland plant communities. This level is considered the minimum that must be sustained for extended periods to maintain floodplain hydric soils and to impede the encroachment of upland plant species into the wetland plant communities. The minimum average level determination criteria typically focus on soil characteristics, when extensive histosols or a histic epipedon are sampled. An appropriate minimum average water level is necessary to conserve the floodplain organic soils. Low water levels for extended periods cause oxidation of organic soils, ultimately resulting in soil subsidence. A 0.3-ft soil water table drawdown below the average histosol or histic epipedon surface elevation has been used to protect muck soils in many MFLs determinations and was developed for Everglades peat soils (Stephens 1974). Studies of marshes in the Upper St. Johns River Basin (Brooks and Lowe 1984; Hall 1987) determined that this 0.3-ft depth corresponds to a water level exceeded approximately 60% of the time. Studies of the Wekiva River system found this hydrologic condition can also be expressed as the low stage, occurring on average every 1 to 2 years, with a duration of less than or equal to 180 days (Hupalo et. al. 1994).

Criteria for setting the minimum frequent-low level also typically focus on soil characteristics, if extensive histosols or a histic epipedon were sampled. Typically, when a widespread histic epipedon or histosol is observed, the low level is based upon a 20-in. soil water table drawdown. This 20-in. drawdown criterion was based on the best available supporting information from the literature, which described seasonally flooded marsh systems with an average minimum dry-season water table depth of 15.6 to 26.2 in. and an average hydroperiod of 255 $\pm$ 11.1 days (ESE 1991).

The minimum frequent-low level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity. The minimum frequent-low level represents a chronically low water level that generally occurs only during periods of reduced rainfall.

LAKE MONROE GENERAL INFORMATION

Lake Monroe is located in Volusia and Seminole counties, Florida, within the Middle St. Johns River Basin (Adamus et. al. 1997; Figure 4). Lake Monroe is an enlargement of the St. Johns River and covers approximately 9,406 acres when the lake stage equals 1.8 ft. National Geodetic Vertical Datum (NGVD). The St. Johns River is normally tidal to the north end of Lake George (110 miles upstream from the mouth). Tides have, on occasion, been reported in Lake Monroe (161 miles upstream from the mouth of the St. Johns River).

The city of Sanford is located on the south shore of Lake Monroe and is at the headwaters of the commercially navigable portion of the St. Johns River. With the advent of commercial steamboat service in the mid-1800s, Lake Monroe became an important distribution point for goods essential for the growth of central Florida (Belleville 2000). The Lake Monroe watershed is heavily developed and is within the highest growth-potential area of Seminole County. A large amount of acreage in the Interstate 4 / State Road (SR) 46 corridor is designated as high-intensity planned development that allows industrial, office, commercial and multifamily developments. Mixed land uses in the Sanford area lie immediately south of Lake Monroe. Extensive residential areas exist in DeBary and Deltona, northwest and northeast of Lake Monroe, respectively (SJRWMD 2001).

While the Lake Monroe watershed is very urbanized, the Lake Monroe floodplain is comprised of multiple public land parcels with relatively natural ecosystems (Figure 5). The public land parcels include the extensive Lake Monroe Conservation Area on the east shore, the Gemini Springs parcels along Interstate 4 on the west shore, the Green Springs parcel on the north shore, along with five public boat ramps. Five of the MFLs transects at Lake Monroe are located on public land (Figure 5). Additional extensive public land parcels, beginning less than one mile downstream from Lake Monroe along the St. Johns River, connect numerous public land parcels to the north including the Wekiva GeoPark, the Ocala National Forest, Blue Springs State Park, Hontoon Island State Park, and the Lake Woodruff National Wildlife Refuge. Recreational opportunities located in or adjacent to Lake Monroe include hiking, primitive camping, fishing, boating, biking, and wildlife viewing.

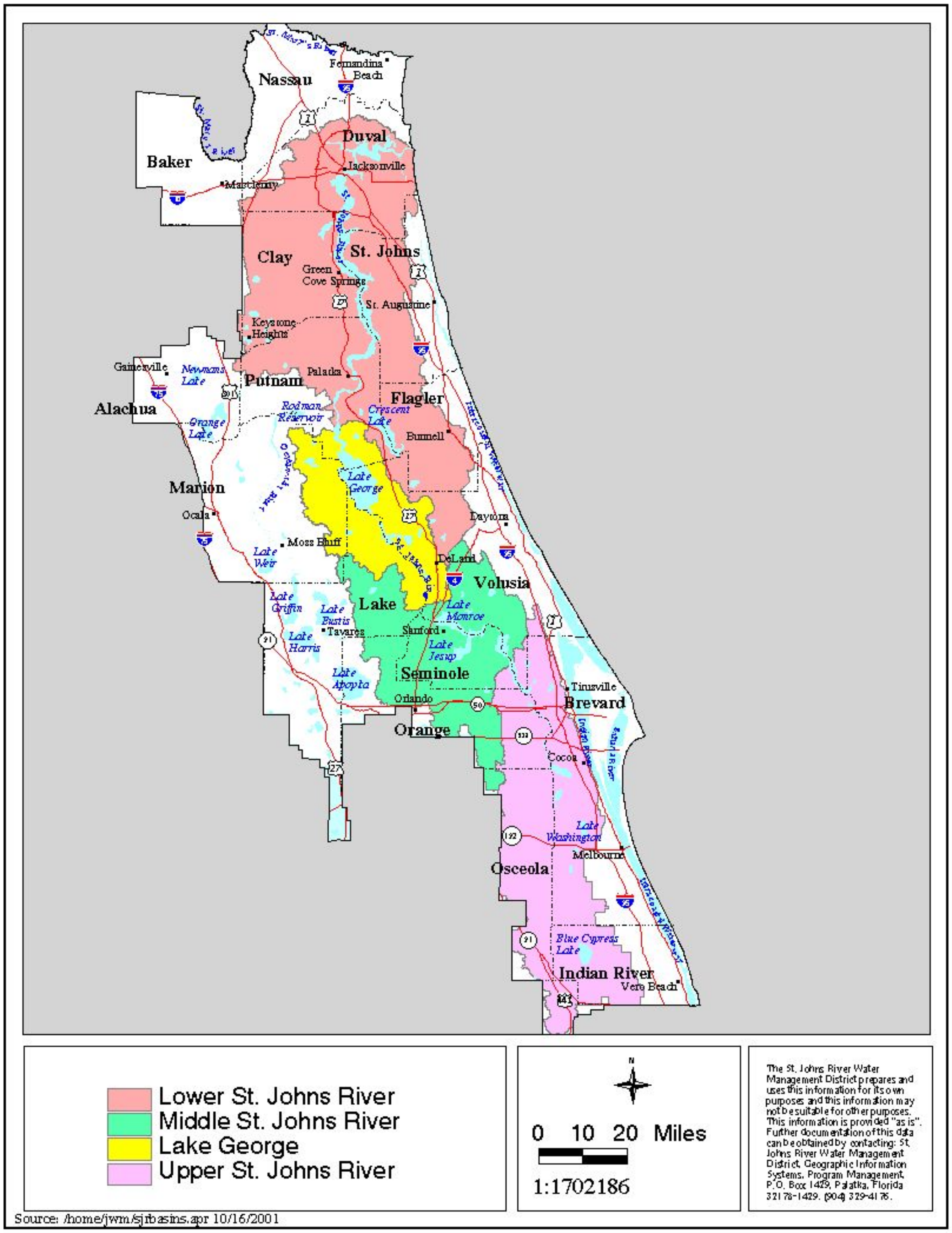


Figure 4. St. Johns River surface water basin map

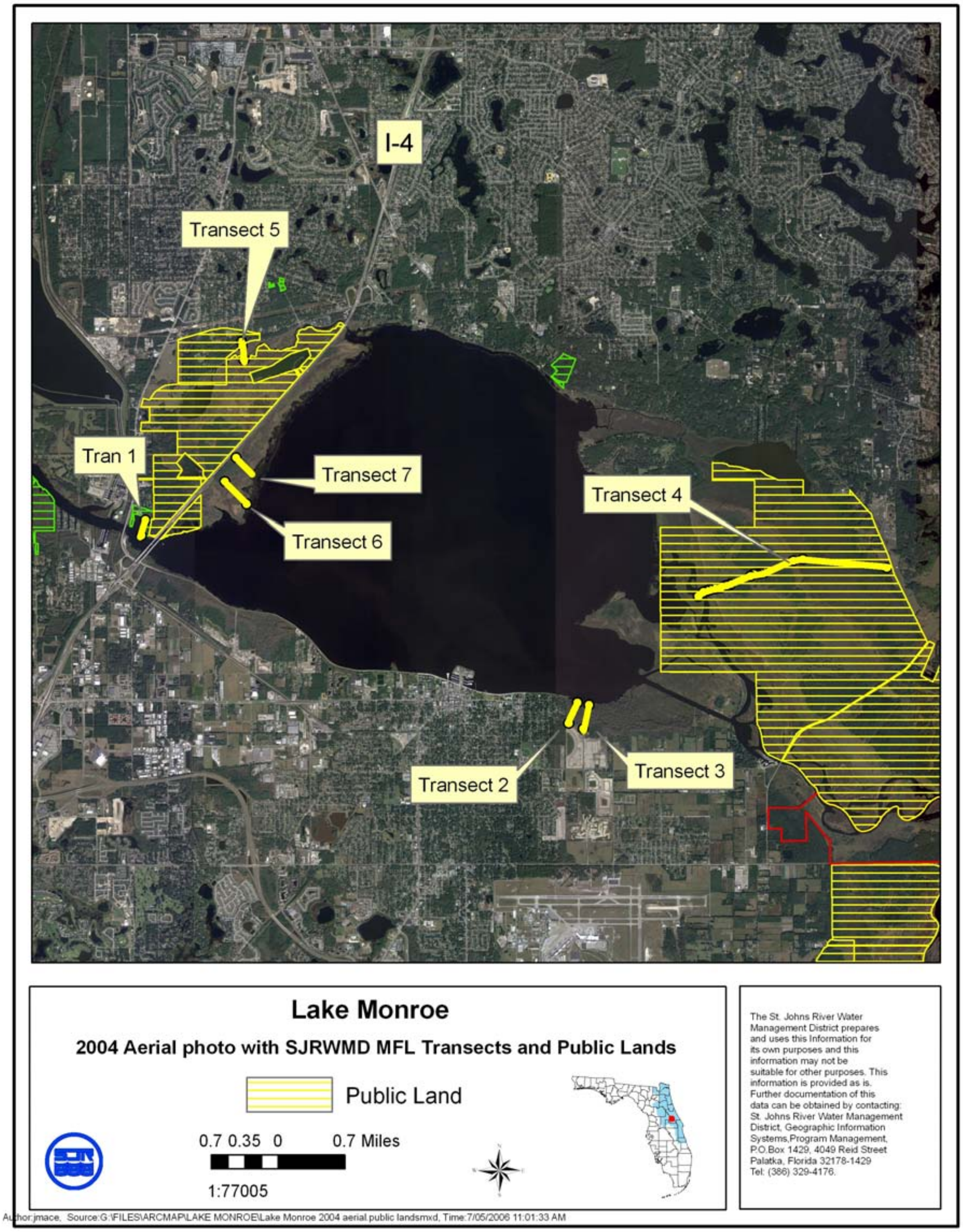


Figure 5. Lake Monroe MFL transects and public landownership

Lake Monroe and its floodplain also provide habitat for fish and wildlife, including wood storks, green-backed herons, snowy egrets, Sherman's fox squirrels, Florida scrub-jay, Florida sandhill crane, bald eagle, gopher tortoise, catfish, shiners, gar, shad, sunfish, bluegill, largemouth bass, and black crappie. Detailed vegetation and soils data collected at the seven MFL transects within the Lake Monroe floodplain are described thoroughly in the Results and Discussion section of this report.

LAKE MONROE HYDROLOGY

Surface water level data (Figure 6) for Lake Monroe has been collected from July 1920 to the present by the U.S. Geological Survey (USGS). The gauge and recorder (USGS Station 02234500) are located at the U.S. Highway 17/92 Bridge on the west lakeshore. During the period of record, the lake level has fluctuated between –0.52 and 8.5 ft NGVD (range 9.2 ft). Typical Lake Monroe stages are between 0.6 and 2.8 ft NGVD (Figure 7), with median and average levels of 1.46 and 1.85 ft NGVD, respectively.

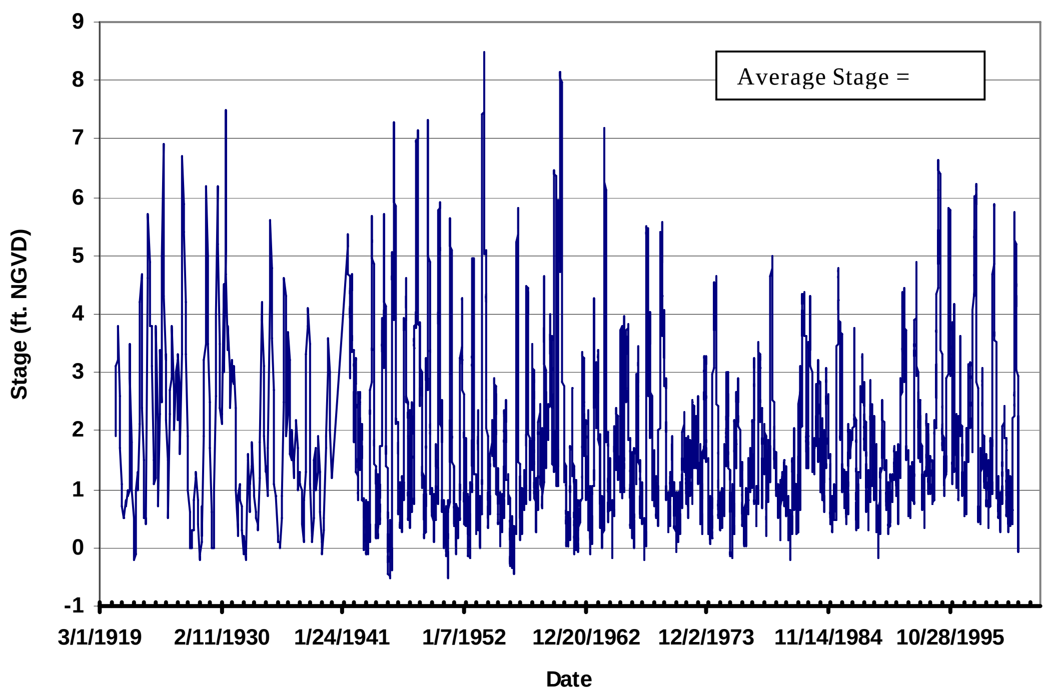


Figure 6. Lake Monroe stage, July 1920–February 2002

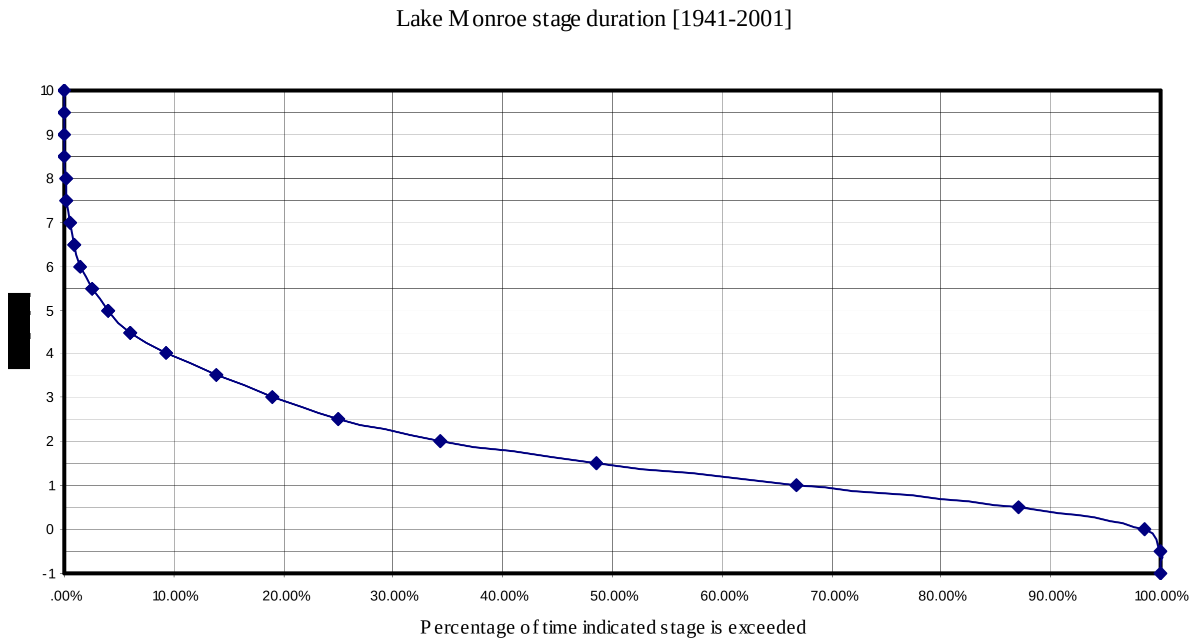


Figure 7. Stage duration curve for Lake Monroe (Robison 2004)

LAKE MONROE WETLANDS

Wetland communities surrounding Lake Monroe have been impacted by land development, highway construction, and lakeshore stabilization. The SJRWMD geographic information system (GIS) wetland coverage map (Figure 8) illustrates the existing wetland communities delineated adjacent to Lake Monroe. Wetland communities are predominately located on the east and west lakeshore. Common wetland communities delineated on Figure 8 are hardwood swamp, hydric hammock, shallow marsh, wet prairie, and forested depression. MFL transects 1–3 traversed predominately hardwood swamp and hydric hammock vegetation communities, while transects 5–7 traversed predominately shallow marsh and wet prairie vegetation communities. Transect 4 traversed an extensive hardwood swamp, multiple hydric hammocks, wet prairies and terminated in a deep marsh community. Detailed wetland community descriptions are presented in the Results and Discussion section of this document for each of the seven transects located adjacent to Lake Monroe.

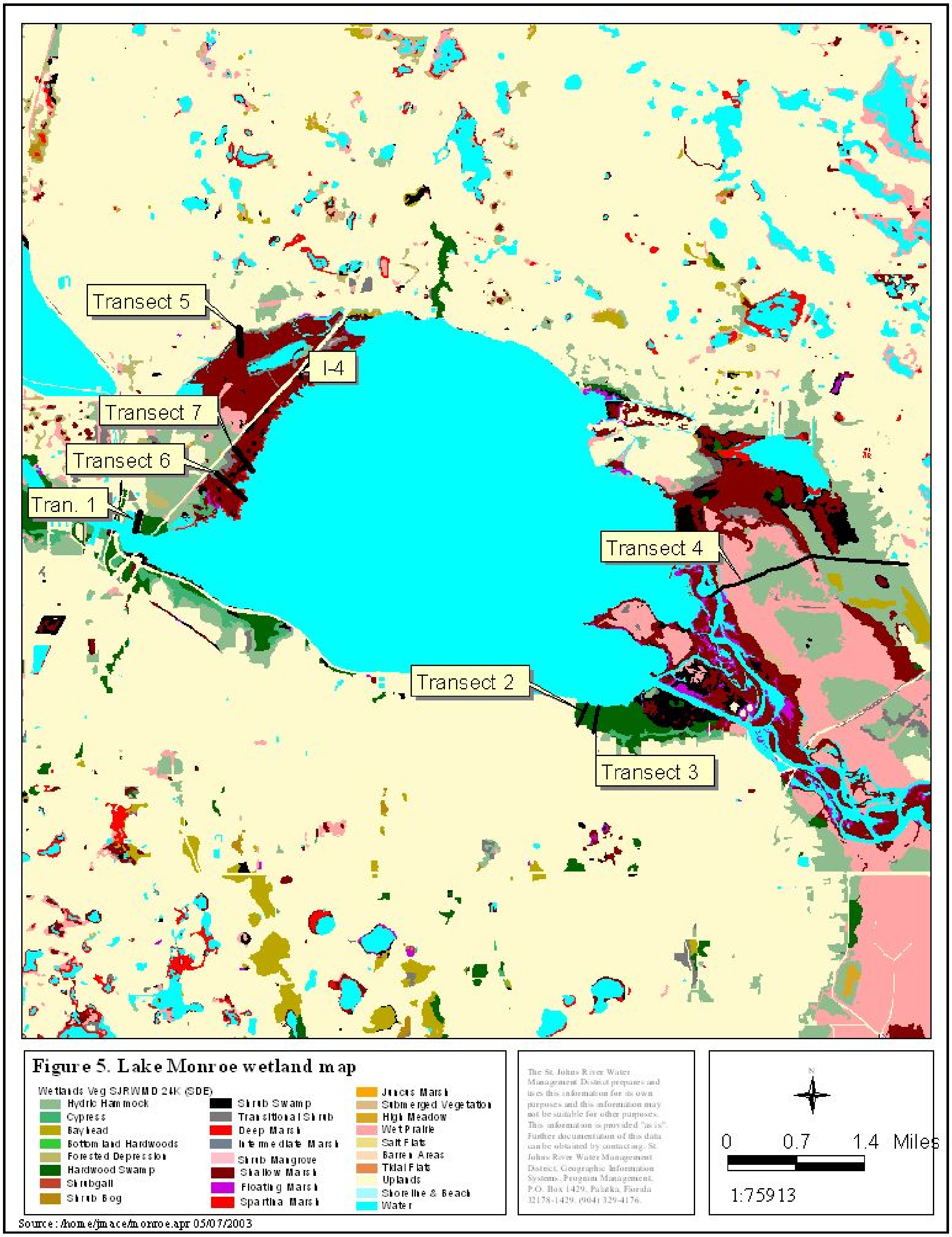


Figure 8. Lake Monroe SJRWMD wetland map

LAKE MONROE 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 their upper parts (USDA, SCS 1987). Hydric soils were mapped using the Soil Survey Geographic (SSURGO) database on the east and west shores of Lake Monroe (Figure 9). The SSURGO soil map illustrates the geographic extent of hydric soils adjacent to Lake Monroe.

Field soil sampling was performed at Lake Monroe (transects 1–3 and transects 4–7) by soil scientists with Jones, Edmunds and Associates Inc., contractor to SJRWMD. Hydric soils were identified at each transect. Differences were encountered between the specific soil series sampled along the field transects and the soil series mapped in the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS 2005) soil surveys. Regardless of the exact soil type sampled along the field transects, the hydric/nonhydric classification of soils sampled closely matched the designation of the SSURGO map (Figure 9). The field soil sampling results were relied upon for the MFLs determinations. Table 4 lists the soil series identified at the Lake Monroe transects. Transect-specific field soil sample descriptions are presented in the Results and Discussion section of this document.

MINIMUM LEVELS CONCEPTS AND CRITERIA FOR LAKE MONROE

Recommended minimum levels for Lake Monroe are based upon the concept that if the essential characteristics of the natural flooding and drying regime are maintained, then the basic structure and functions of the environmental system will be maintained. Soil and vegetation community field-collected data are the principle components of each minimum level determination. The elevations of the wetland communities in the Lake Monroe floodplain can be associated with the long-term lake stage record where typical durations and frequencies of flooding and drying are known. These wetland community elevations can be applied toward the development of recommended minimum levels. The standardized procedures for setting each level, using the best available information, as described in greater detail in the *MFLs Methods Manual* (Hall et al 2006), was followed as the basis of developing the recommended minimum levels for Lake Monroe. Minimum levels criteria

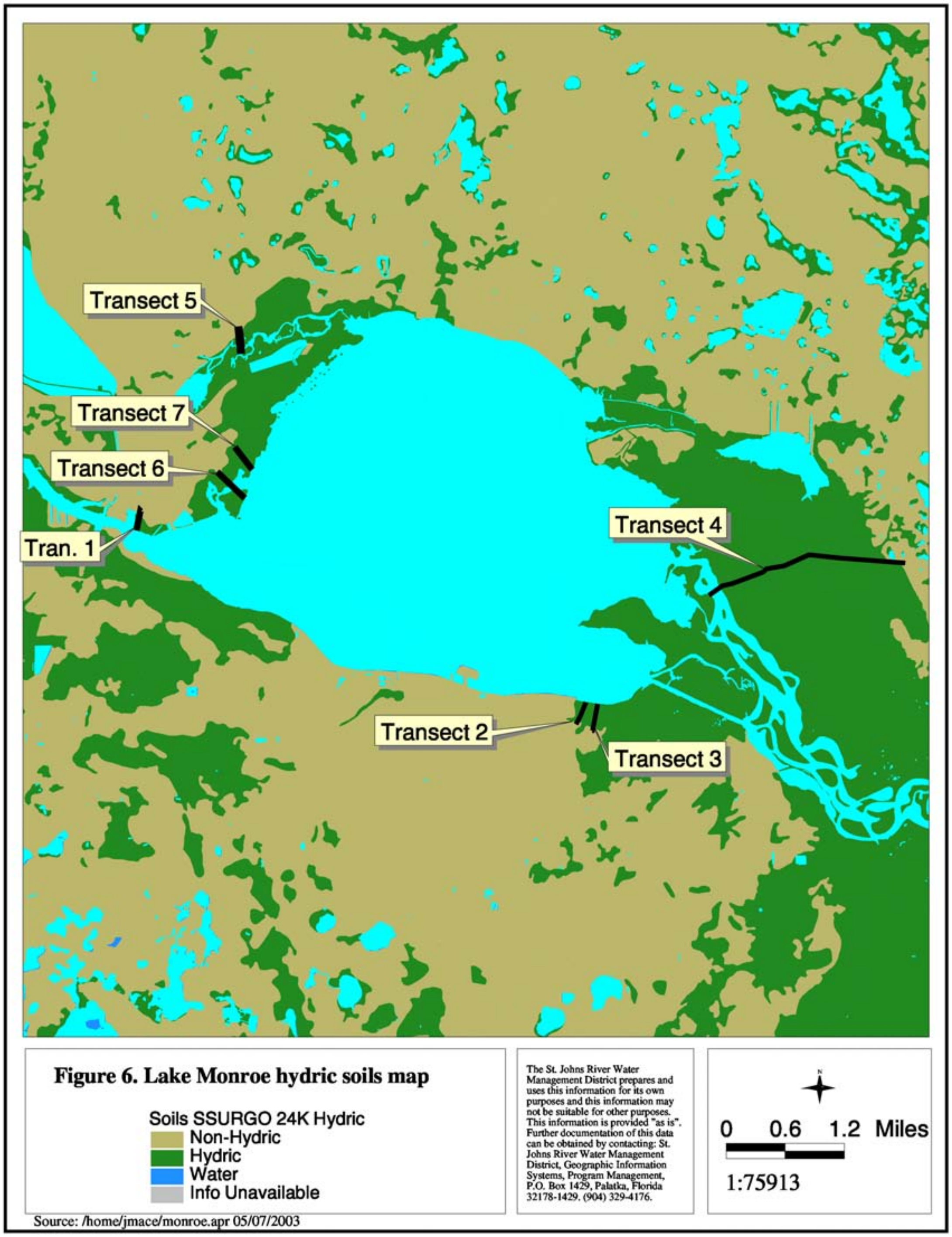


Figure 9. Lake Monroe hydric soils

Table 4. Soil water table information for soil series sampled at Lake Monroe transects

Soil Name	Water Table Above Soil Surface[2]	Typical Depth Below Soil Surface to Water Table[2]
Basinger fine sand	In depressions for 6–9 months	<12 in. for 2–6 months; 12–30 in. for >6 months
Bluff sandy clay	Frequent flooding for long duration	<10 in. for 6 or more months; seldom recedes to depths of more than 20 in.
Chobee fine sandy loam	Frequently during rainy season	<6 in. for 1–4 months; seldom >10 in. even during prolonged dry periods
Gator muck	Always except during extended droughts	At the surface except during extended droughts
Immokalee sand	Depressional areas ponded 6–9 months or more in most years	At 6–18 in. for 1–4 months; 18–36 in. for 2–10 months during most years; >60 in., in dry season
Myakka sand	Depressional areas ponded for 6–9 months	<18 in. for 1–4 months in most years; recedes to depths of 40 in.+ during very dry seasons
Ona fine sand		<10 in. for 1–2 months; depths of 10–40 in. for 4–6 months during most years
Sanibel sand	For 2–6 months during wet seasons	<10 in. for 6–12 months in most years
Scoggin series	For as much as 6 months, most years.	At the surface but may drop to 24 in.
Tequesta series	For 6–9 months in most years	At the surface or <10 in. below the surface
Terra Ceia muck	Always except during extended droughts	At the surface except during extended droughts

[1]Soil designated hydric (Carlisle 1995)
[2]From the USDA, NRCS (2003)

vary depending upon the level being determined (i.e. minimum frequent-high, minimum average, or minimum frequent-low) and the on-site wetland community characteristics.

For example, the primary high-level criterion may equal the average elevation of a wetland community that experiences flooding approximately 20% of the time, based upon the scientific literature and hydrologic data. The minimum frequent-high level should maintain the seasonal flooding regime. Seasonal high water flows or levels occur in natural systems with unaltered hydrology that provide for out-of-bank flooding of the riparian wetlands adjacent to the mainstem of a river or lake at a duration and return interval sufficient to support important ecological processes (Hill et al 1991). Levels equal to the minimum frequent-high should occur for at least 30 continuous days in the growing season at least 1 in 3 years, on average. Stream biota relies upon inundation of the floodplain for habitat and for the exchange of nutrients and organic matter (McArthur 1989). Flooding of wetlands and upland fringes redistributes and concentrates organic particulates across the floodplain (Junk 1989).

The primary minimum frequent-high level criterion at Lake Monroe was the average elevation (2.8 ft NGVD) of the hardwood swamp, surveyed at transect 4. The average elevations of the hardwood swamps surveyed at transects 1, 2, and 3 were equal or similar at 2.7, 2.8, and 2.4 ft NGVD, respectively. Major alterations have occurred within possibly all wetlands traversed at Lake Monroe. Soil sampling indicated unusual soil stratification, presumably due to dredge spoil deposited at all transects, except at transect 4. Consequently, the average elevation of the extensive hardwood swamp surveyed at transect 4 was chosen as the primary criterion for the determination of the Lake Monroe minimum frequent-high level. The hardwood swamp average ground elevation is a frequent minimum-high level criterion. It has been used repeatedly in past SJRWMD MFLs determinations and is based upon the scientific literature indicating that hardwood swamps are typically flooded seasonally (Monk 1968).

All hardwood swamps surveyed in the Lake Monroe floodplain were high-quality wetland communities, which transitioned to palm hydric hammocks at significantly higher elevations. The palm hydric hammocks experience surface water flooding infrequently (i.e., on average, once per decade) from the lake. Seasonal shallow ponding, which maintains the hydric soil characteristics within the palm hydric hammock, occurs more frequently due to local rainfall, shallow groundwater seepage, and the poorly drained soil characteristics.

The minimum average level represents the surface water level and flow necessary over a long period to maintain the integrity of hydric soils and wetland plant communities. This level and flow is considered the minimum that must be sustained for extended periods to maintain floodplain hydric soils and to impede the encroachment of upland plant species into the wetland plant communities. The minimum average level determination criteria typically focus on soil characteristics, when extensive histosols or a histic epipedon are sampled. A 0.3-ft soil water table drawdown below the average histosol or histic epipedon surface elevation has been used to protect muck soils in many MFLs determinations and was developed for Everglades peat soils (Stephens 1974). The Lake Monroe average level primary criterion was the average elevation of all points surveyed in the shallow marshes at transects 6 and 7. Due to the shallow depth (1–16 in.) and noncontinuous extent of the surface organic soil across these shallow marshes, the 0.3-ft drawdown criterion was not used for setting the minimum average level at Lake Monroe. The shallow marshes at Lake Monroe represent relatively pristine vegetation communities that rely upon inundation and / or soil saturation to maintain the marsh vegetation.

Soil saturation will impede the invasion of upland plant species into the shallow marshes while shallow inundation will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Additionally, the shallow water depths are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Dropping water levels cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Criteria for setting the minimum frequent-low level also typically focus on soil characteristics, if extensive histosols or a histic epipedon were sampled. Typically, when a widespread histic epipedon or histosol is observed, the low level is based upon a 20-in. soil water table drawdown. This 20-in. drawdown criterion was based on the best available supporting information from the literature, which describes seasonally flooded marsh systems with an average minimum dry-season water table depth of 15.6–26.2 in. and an average hydroperiod of 255 $\pm$ 11.1 days (ESE 1991).

At Lake Monroe, the organic soils surveyed extend well above the lake’s normal fluctuation range. Organic soils in the Lake Monroe floodplain must be maintained by upland seepage and surface inflows (creeks and canals). Consequently, the primary minimum frequent-low level criterion for Lake Monroe was the average elevation of the deep marshes surveyed at transects 4 and 7. The deep marsh average ground elevation is a frequent minimum-low level criterion used in past SJRWMD MFLs determinations and is based upon the scientific literature indicating that deep marshes are semipermanently flooded (Kinser 1996). Semipermanently flooded areas are typically dewatered approximately once every 5 to 10 years, for 3–4 months, during moderate droughts (Hall et al. 2006).

The following additional concepts further describe the theoretical, practical, and methodological background for the process used to establish biological criteria, and ultimately develop the recommended minimum levels for Lake Monroe.

- A given wetland community type will have similar hydrologic and soil characteristics and occur in similar topographic positions at all transect locations.
- The shallow marsh communities surveyed at Lake Monroe were considered depressional areas with regard to the NRCS (2003) soil water table typical dry season drawdown descriptions. Soils within the shallow marshes are dewatered to limited depths for limited durations.
- Mineral soil water table drawdown criterion applied to the minimum frequent-low levels will protect the structural integrity of the soil horizons and maintain hydric soil characteristics.
- The hydric soil characteristics observed at the higher elevations in the wet prairies and palm hydric hammocks are not maintained solely by surface water inundation of Lake Monroe. The hydric soil characteristics observed at the higher elevations are largely a function of soil porosity, local rainfall, and shallow groundwater seepage, as well as infrequent surface water inundation.
- Vegetation composition and dominance in the Lake Monroe floodplain is influenced by fire. Fire may be the most influential factor maintaining the wet prairie communities. Prescribed fire on the Lake Monroe Conservation Area lands occurs approximately every 3–5 years, to eliminate woody shrubs from the wet prairies and shallow marshes (SJRWMD 2000). Wax myrtle, buttonbush, and groundsel tree quickly invade and dominate the wet prairie communities in the absence of fire. Prescribed fire results in wet prairie communities extending over a wide elevation gradient, with the lower elevations primarily maintained by the lake hydrology and the upper elevations maintained primarily by fire and groundwater seepage. Consideration for the role of fire and other disturbances (i.e., hurricane wind impacts, cattle grazing, mechanical brush removal) is necessary in interpreting relationships between vegetation communities and hydrologic conditions.

- Vegetation composition and dominance in the Lake Monroe floodplain changes dramatically throughout the year due to seasonal weather patterns, prescribed fire, and fluctuating lake levels. Consequently, on any given date field transect site vegetation monitoring may result in subtle to dramatically different vegetation composition and dominance, as compared to a previous site visit. Multiple site visits occurred at all field transects at Lake Monroe to improve the ability to characterize the vegetative communities. The basic vegetation community classification and distribution of overall community types was stable.
- The shallow marsh community, surveyed at transect 5, traverses an area that was deep slough / open water before 1960 and the construction of Interstate 4.
- It is impractical to establish an infrequent-low lake level (lake level below the minimum frequent-low level) due to the low landscape elevation, approaching sea level.
- Infrequent-high levels (lake levels above the minimum frequent-high) are dependent upon seasonal weather events (i.e. tropical storms) when high rainfall occurs within the Upper St. Johns River Basin. These infrequent lake levels should continue to occur and are important in maintaining the existing floodplain wetland communities. Minimum levels need not be set to protect these infrequent-high levels as long as infrastructure is not developed to take advantage of the infrequent high lake levels.
- Palm hydric hammocks at Lake Monroe occurred at high elevations, greater than the recommended minimum frequent-high levels, and flood infrequently (i.e., on average once per decade) from the lake. Seasonal shallow ponding, which maintains the hydric soil characteristics within the palm hydric hammocks, occurs frequently due to local rainfall, shallow groundwater seepage, and the poorly drained soil characteristics. Therefore, minimum levels were not set for this community.
- Two attributes of natural hydrology that are commonly studied with respect to wetland and aquatic communities are the seasonality or timing of flooding and drying and the rate at which water levels change. At Lake Monroe, seasonality and rate of change are controlled by natural forces (e.g., climate) and are not expected to change significantly by consumptive use. Consequently, these two aspects of natural hydrology were not considered in the setting of minimum levels (Wilson 2005).
- Rainfall patterns and subsequent lake and river levels in Florida respond to the Atlantic multidecadal oscillation (AMO) cycles. AMO denotes long-

term oscillations in the sea surface temperature of the North Atlantic Ocean and how it affects rainfall and, thus, lake levels and river flow patterns over multidecadal periods. Rivers and lakes in central and south Florida were in a multidecadal period of higher flows and levels from 1940 to 1969 and have generally exhibited lower flows and levels from 1970 to 1999 (Kelly 2004). Stage data analyses and surface water modeling performed as part of this minimum level determination for Lake Monroe incorporated stage data from both the high- and low-stage periods, thus, ensuring that the model output and stage data analyzes were not skewed towards either a low- or high-rainfall period.

- Vegetation community shifts within the Lake Monroe floodplain, due to the AMO cycles, may occur at elevations below the palm hydric hammocks. During high river flow and lake-level cycles, the wet prairie acreage may decrease as the shallow marsh shifts upslope, while during low river flow and lake-level cycles, the wet prairie acreage may increase as the shallow marsh moves downslope. The upper elevations of wet prairie are predicted to remain stable, regardless of the AMO cycle, due to the influence of fire in maintaining these vegetation communities at the higher elevations, as well as the relatively stable vegetation at the wet prairie-to-palm hydric hammock ecotone.
- To the extent that new withdrawals of water occur at or upstream from Lake Monroe, the amount, frequency, and duration of flooding and dewatering will change. Minimum levels recommended here, as well as in the water resource values assessment (ECT 2006), will ensure that the changes are small enough that the natural dynamics of the environmental system will undergo minimal-to-modest changes such that significant harm will not occur (Wilson 2005).

In summary, the foundation of the minimum levels determinations is comprised of the field-collected elevation, vegetation, and soils data to first characterize the floodplain wetland communities and then relate the wetland communities to the natural flooding and drying regime of Lake Monroe. The following Results and Discussion section describes the field collected data and the subsequent levels determinations for Lake Monroe.

RESULTS AND DISCUSSION

To develop recommended minimum levels for Lake Monroe, field data were obtained at seven transect locations (Figures 2 and 5). This section describes the transect site selection criteria, the data collected at each transect location, and concludes with a description of the minimum level determinations for Lake Monroe.

FIELD DATA TRANSECT 1

Transect 1 was located on the west shore of Lake Monroe, approximately 1,000 ft west of Interstate 4 (Table 5; Figures 2, 5 and 8) within Lake Monroe Park, managed by Volusia County. This transect site was established to characterize the hardwood swamp and hydric hammock at this location. Other areas on the west and southwest shores with hardwood swamps were highly impacted by lake-shore stabilization along either U.S. Highway 17/92 or Interstate 4.

Table 5. Lake Monroe transect 1 location and field work dates

Latitude–Longitude (Station 0; water's edge)	Latitude–Longitude (Station 1000)	Location and Date of Fieldwork
28 50 12.46–81 19 16.38	28 50 20.78–81 19 13.94	West shore of Lake Monroe, near the outlet, approximately 1,000 ft west of I-4; January 2002 and May 2002.

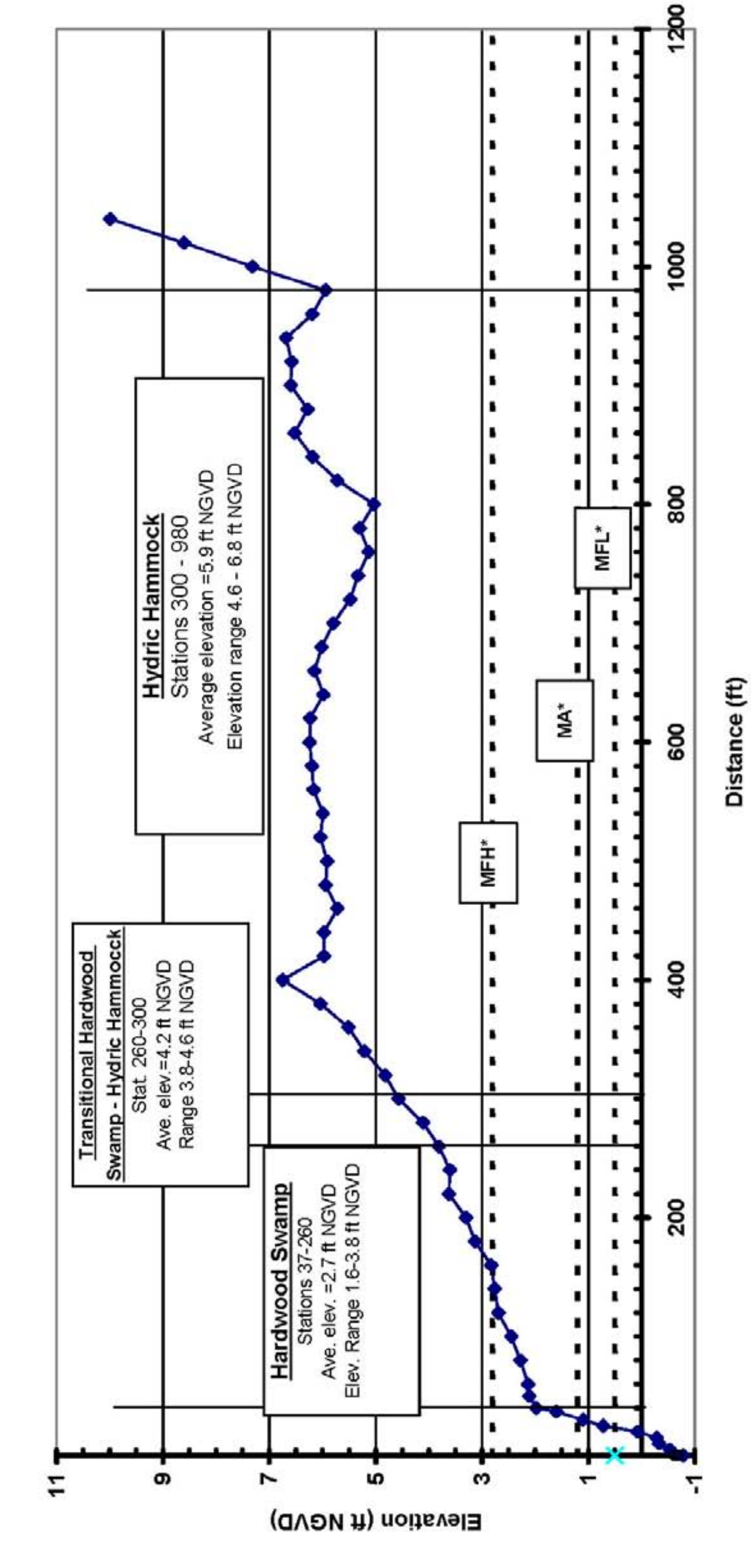
Vegetation at Transect 1

Transect 1 traversed 1,040 ft in a northerly direction from the open water of Lake Monroe through a narrow band (stations 10–37) of common reed (*Phragmites australis*), a hardwood swamp, a transitional hardwood swamp–hydric hammock community, and a hydric hammock (Figures 10 and 11, Tables 6 and 7).

The hardwood swamp (stations 37–260) overstory vegetation consisted of co-dominant bald cypress (*Taxodium distichum*) with abundant red maple (*Acer rubrum*) and numerous cabbage palm (*Sabal palmetto*). The hardwood swamp

Figure 10. Lake Monroe Transect 1 topography with ecological communities

*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD



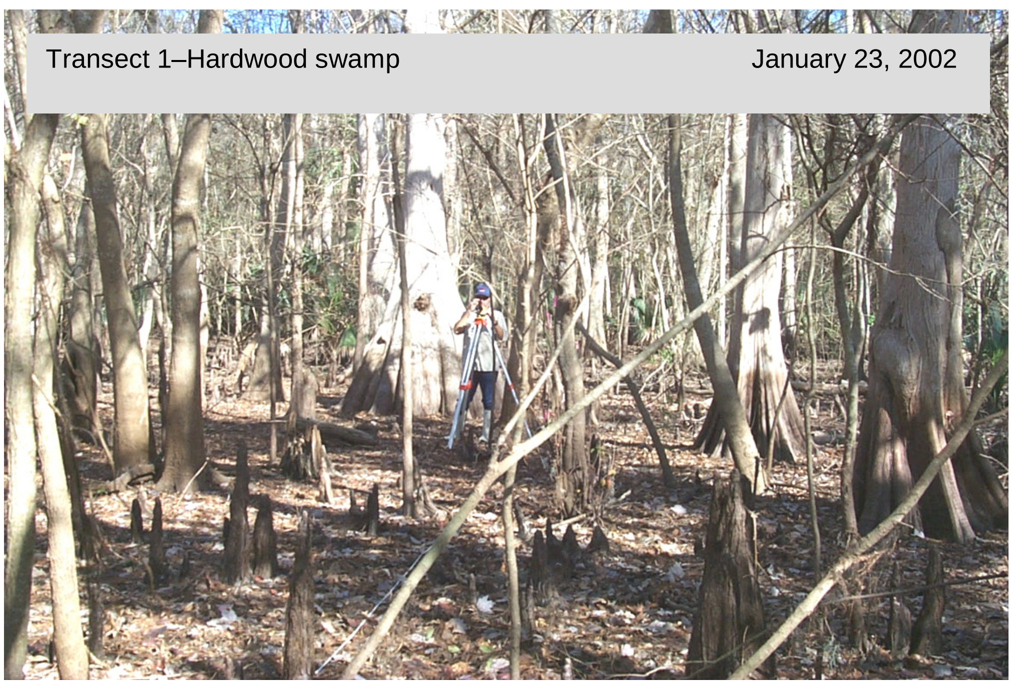


Figure 11. Transect 1 photos

Figure 11—*continued*

Table 6. Lake Monroe transect 1 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Hardwood swamp	37–260	2.7	2.7	1.6	3.8	14
Transitional hardwood swamp–hydric hammock	260–300	4.2	4.1	3.8	4.6	3
Hydric hammock	300–980	5.9	6.0	4.6	6.8	35

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

mid-canopy contained scattered American elm (*Ulmus americana*) and sugarberry (*Celtis laevigata*). The hardwood swamp understory contained abundant false nettle (*Boehmeria cylindrica*) with scattered ragweed (*Ambrosia artemisiifolia*) and squarestem (*Melanthera nivea*).

The transitional hardwood swamp–hydric hammock community (stations 260–300) overstory vegetation consisted of abundant to co-dominant cabbage palm, abundant sugarberry with numerous red maple and American elm. The transitional hardwood swamp–hydric hammock community mid-canopy vegetation consisted of numerous immature cabbage palm and sugarberry. The transitional hardwood swamp–hydric hammock understory was sparsely vegetated with scattered grape (*Vitis rotundifolia*) and catbrier (*Smilax bona-nox*).

Landward of the transitional hardwood swamp–hydric hammock community, transect 1 traversed a hydric hammock (stations 300–980). The hydric hammock overstory vegetation was dominated by cabbage palm with abundant sugarberry, numerous live oak (*Quercus geminata*), numerous American elm, and scattered to numerous bald cypress. The understory was vegetated with numerous immature cabbage palm, numerous grape and scattered shield fern (*Thelypteris sp.*). Landward of the hydric hammock, transect 1 terminated within an area containing fill dirt adjacent to a park maintenance road. Additional plant species observed along transect 1 are listed in Table 7.

Table 7. Lake Monroe transect 1 vegetation species list

Common name	Scientific name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]		
			HS	THS-HH	HH
American elm	Ulmus americana	FACW	1	2	2
Bald cypress	Taxodium distichum	OBL	4	1–3	1–2
Black gum	Nyssa aquatica	OBL	1	1	
Cabbage palm	Sabal palmetto	FAC	2	3–4	5
Cat brier	Smilax bona-nox	FAC		1	
Common reed	Phragmites australis	OBL	5[4]		
False nettle	Boehmeria cylindrica	OBL	3–4		
Laurel oak	Quercus laurifolia	FACW		1	
Muscadine grape	Vitis rotundifolia	FAC		2	2
Pop ash	Fraxinus carolinana	OBL	1		
Ragweed	Ambrosia artemisiifolia	FACU	1		
Red maple	Acer rubrum	FACW	3	2	1
Sand live oak	Quercus geminata	UPL			2–3
Southern red cedar	Juniperus silicicola	FAC		0	
Squarestem	Melanthera nivea	FACW	1		
Sugarberry	Celtis laevigata	FACW	1–2	3	3
Sweetgum	Liquidambar styraciflua	FACW		1	1
Wild taro	Colocasia esculenta	FACW	0		

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manual (Gilbert et. al. 1995);
UPL = Upland plants that occur rarely in wetlands, but occur almost always in uplands
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands
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
OBL = Obligate plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2]Plant community abbreviations:
HS = hardwood swamp (stations 37–260)
THS-HH = transitional hardwood swamp–hydric hammock (station 260–300)
HH = hydric hammock (stations 300–980)

[3]Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare);
1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); 5 = greater than 75% (dominant)

[4]Common reed was dominant between stations 10–37, waterward of the hardwood swamp.

Soils at Transect 1

Soils were mapped (SCS 1980) as Bluff sandy clay loam immediately adjacent to the open water and extending into the hydric hammock at transect 1. Landward of the Bluff soil, Riviera fine sand was mapped to the end of transect 1. Soils sampled in May 2002, in the hardwood swamp and hydric hammock at transect 1, were hydric mineral soils, but could not be classified due to dredged soil material covering the transect. The dredged soil material was likely deposited during construction of the adjacent boat basin. The dredged soil material was identified by the presence of many shell fragments and heterogeneous soil textures and colors. The C-horizon, at or near the soil surface, likely marks the top of the dredged soil material (Table 8).

The first soil sample was taken at station 100 within the hardwood swamp (stations 37–260). At station 100 soils exhibited a loamy surface, followed by a sandy C-horizon exhibiting stratified layers and underlain by a buried A horizon. An argillic horizon was detected at 24 in. below the soil surface. Soils changed noticeably between stations 106 and 110 as evidenced by a switch from a loamy surface to a sandy surface. There was no noticeable change in elevation or vegetation to signify this soil change. At station 200, an abundance of shells was detected in the C-horizon. Stratified layers were also noted between 11 and 36 in. below the soil surface at station 200.

Soils were observed at station 280 within the transition to hydric hammock vegetation community (stations 260–300). Station 280 exhibited a thick C-horizon between 5 and 28 in. below the soil surface. Shells, redoxomorphic features, and dark splotches were common in this C-horizon. A buried A-horizon was noted below the C-horizon.

Soils were characterized within the hydric hammock (stations 300–980) at stations 300, 440, 600, and 800. A thick C-horizon was present at all four stations and probably represents dredged soil material, as evidenced by many shell fragments and heterogeneous soil colors and textures. A buried A-horizon (loam), Btg (clay loam), and Oa (muck) horizons were consistently found under the thick spoil material. Due to the unusual soil stratification observed at transect 1, the soil series for these samples was not determined. Table 8 lists the soil characteristics sampled at transect 1.

Table 8. Lake Monroe transect 1 soil descriptions

Station	Vegetation Community	Soil Horizon	Horizon Description
100	Hardwood swamp	A; 0–7 in.	Loam
		C; 7–12 in.	Clay
		Ab; 12–24 in.	Loam
		Btg; 24 in.+	Clay loam
200	Hardwood swamp	A; 0–4 in.	Sand
		C1; 4–7 in.	Sand with shells
		C2; 7–11 in.	Sand with shells
		A/C; 11–36 in.	Loam and sand
		Bt; 36 in.+	Clay loam
280	Transitional to hydric hammock	A1; 0–1 in.	Sand
		A2; 1–5 in.	Sand
		C; 5–28 in.	Sand
		Btg1; 28–36 in.	Sandy loam
		Btg2; 36–40 in.	Clay loam
		Ab; 40–42 in.	Loam
		Oab; 42 in. +	Muck
300	Hydric hammock ecotone	A; 0–6 in.	Sand
		C1; 6–28 in.	Sand
		C2; 28–36 in.	Sand
		C3; 36–40 in.	Sand
		Ab; 40 in. +	Muck
440	Hydric hammock	A; 0–2 in.	Sand
		C1; 2–22 in.	Sand
		C2; 22–32 in.	Sand
		C3; 32–44 in.	Sand
		C4; 44–60 in.	Sand
		Ab; 60–63 in.	Mucky loam
		Btg; 63–68 in.	Clay loam
		Oab; 68 in. +	Muck
600	Hydric hammock	A1; 0–2 in.	Sand
		A2; 2–6 in.	Sand
		C1; 6–14 in.	Sand
		C2; 14–36 in.	Sand
		C3; 36–60 in.	Sand
		Ab; 60–62 in.	Loam
		Btg; 62–70 in.	Clay loam
		Oab; 70 in.+	Muck
800	Hydric hammock	A; 0–3 in.	Sand
		C1; 3–24 in.	Sand
		C2; 24–42 in.	Sand
		A1b; 42–44 in.	Loam
		A2b; 44–54 in.	Mucky loam
		Btg; 48–54 in.	Clay loam
		Oab; 54 in. +	Muck

FIELD DATA TRANSECT 2

Transect 2 was located on the southeast shore of Lake Monroe (Table 9; Figures 2, 5, and 8). This transect site was established in order to characterize the relatively pristine hardwood swamp and hydric hammock vegetation communities and the natural lakeshore at this location.

Table 9. Lake Monroe transect 2 location and field work dates

Latitude–Longitude (Station 1360; water's edge)	Latitude–Longitude (Station 0; upland edge)	Location and Date of Fieldwork
28 48 41.07–81 14 44.36	28 48 29.56–81 14 49.80	Southeast shore of Lake Monroe, near the inlet, north of Celery Road; January and March 2002.

Vegetation at Transect 2

Transect 2 originated within a disturbed agricultural area, immediately north of a sod farm. The sod farm has recently been developed into a single-family residential community. Transect 2 traversed 1,360 ft in a northerly direction through a hydric hammock and a hardwood swamp, terminating within the open water of Lake Monroe (Figures 12 and 13; Tables 10 and 11). Additionally, transect 2 traversed a small, intermittent creek with a poorly defined channel between stations 600 and 700 within the hardwood swamp.

The disturbed agricultural area (stations 0–180) overstory vegetation consisted of numerous ear tree (*Enterolobium cyclocarpum*), mature cabbage palm, and golden raintree (*Koelreuteria paniculata*). The disturbed agricultural area understory vegetation consisted of co-dominant blackberry (*Rubus betulifolius*), abundant grape and goldenrod (*Solidago sp.*), and numerous wax myrtle (*Myrica cerifera*).

Adjacent to the disturbed agricultural area, transect 2 traversed a hydric hammock (stations 180–380). The overstory vegetation within the hydric hammock consisted of numerous mature cabbage palm with scattered red maple, American elm, water hickory (*Carya aquatica*), and bald cypress. The hydric hammock understory vegetation consisted of co-dominant immature

Figure 12. Lake Monroe Transect 2 topography with ecological communities
*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD

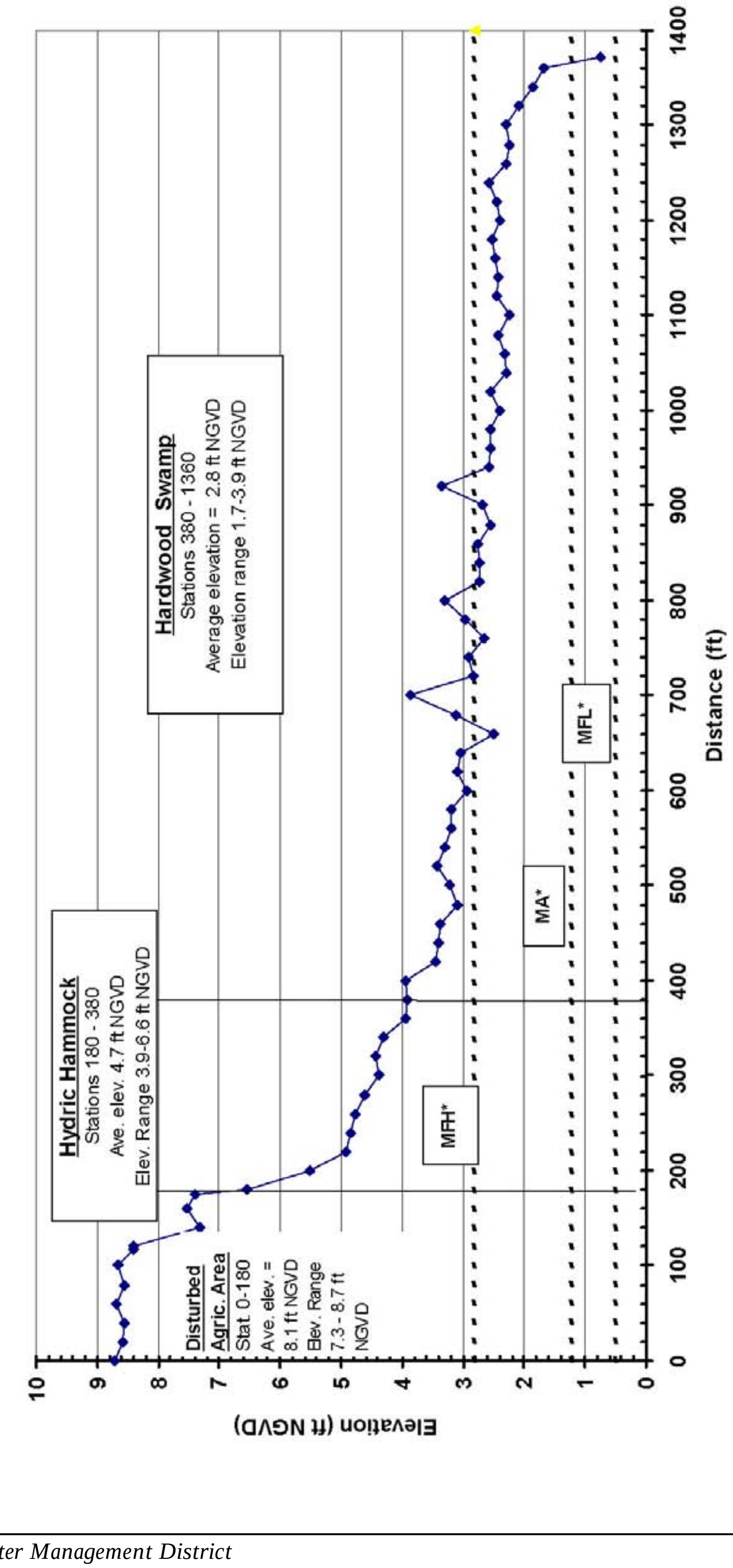


Figure 13. Transect 2 photos


Transect 2–Hardwood swamp January 29, 2002

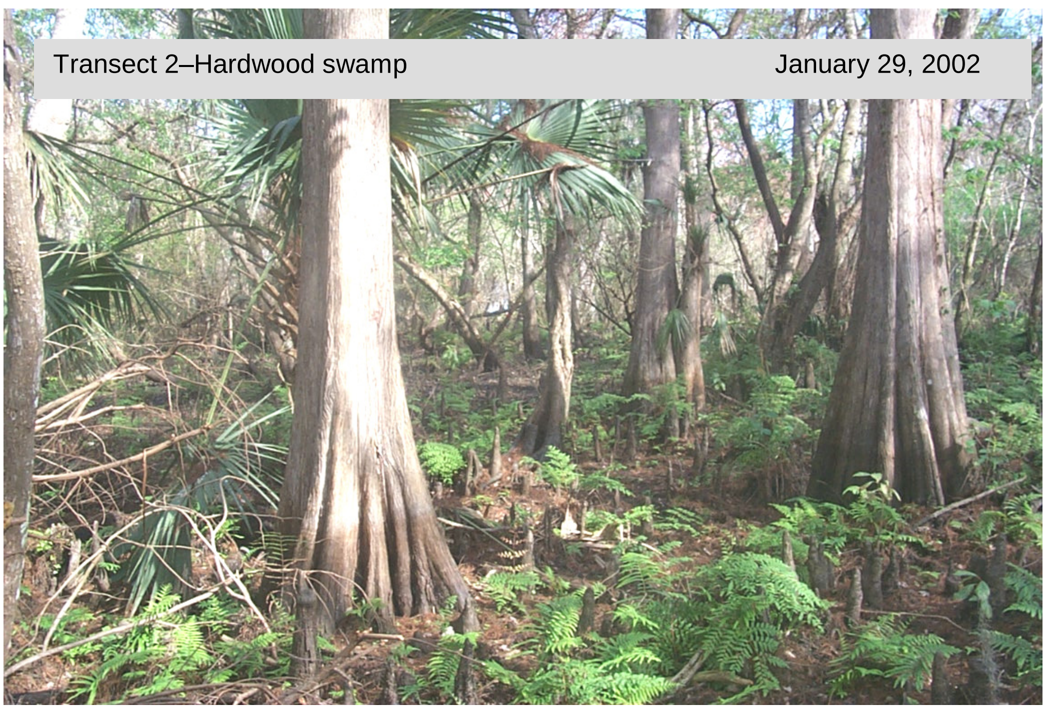

Transect 2–Hardwood swamp January 29, 2002

Figure 13—*continued*

Table 10. Lake Monroe transect 2 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Disturbed agric. area	0–180	8.1	8.5	7.3	8.7	12
Hydric hammock	180–380	4.7	4.6	3.9	6.6	11
Hardwood swamp	380–1360	2.8	2.7	1.7	3.9	51

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

cabbage palm, abundant shield fern with scattered lizard's-tail (*Saururus cernuus*), wild taro (*Colocasia esculenta*), elderberry (*Sambucus canadensis*) and royal fern (*Osmunda regalis*).

Waterward of the hydric hammock, transect 2 traversed a hardwood swamp (stations 380–1360). The overstory vegetation within the hardwood swamp consisted of co-dominant to abundant bald cypress with numerous water hickory and red maple. Scattered pop ash (*Fraxinus caroliniana*), American elm, and mature cabbage palm were also present in the hardwood swamp overstory. The hardwood swamp mid-canopy vegetation consisted of numerous to co-dominant buttonbush (*Cephalanthus occidentalis*) and scattered elderberry. The hardwood swamp understory vegetation consisted of numerous to abundant royal fern, numerous shield fern, numerous wild taro, along with scattered lizard's-tail and false nettle (*Boehmeria cylindrica*). Transect 2 terminated at the open water of Lake Monroe within a narrow band of water hyacinth (*Eichhornia crassipes*). Additional plant species observed along transect 2 are listed in Table 11.

Soils at Transect 2

Soils were mapped (SCS 1990) as Basinger fine sand immediately adjacent to the open water and extending to the disturbed agricultural area at transect 2. The Basinger series consists of very deep, poorly drained and very poorly drained soils in sloughs, depressions, low flats, and poorly defined drainage ways. They formed in sandy marine sediments (USDA, NRCS 2005). Soils sampled in March 2002, in the hardwood swamp at transect 2, were a histosol Terra Ceia muck. Landward of the hardwood swamp in the hydric hammock

Table 11. Lake Monroe transect 2 vegetation species list

Common name	Scientific name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]		
			DAA	HH	HS
American elm	Ulmus americana	FACW		1	1
Bald cypress	Taxodium distichum	OBL		1	3–4
Blackberry	Rubus betulifolius	FAC	4		
Buttonbush	Cephalanthus occidentalis	OBL			2–4
Cabbage palm-immature	Sabal palmetto	FAC		4	0
Cabbage palm-mature	Sabal palmetto	FAC	2	2	0–1
Dog fennel	Eupatorium sp.	FACW	1		
Ear tree	Enterolobium cyclocarpum	Exotic	2		
Elderberry	Sambucus canadensis	FAC	1	1	1
False nettle	Boehmeria cylindrica	OBL			1
Golden raintree	Koelreuteria paniculata	exotic	2		
Goldenrod	Solidago sp.	FACW	2		
Lizard’s tail	Saururus cernuus	OBL		1	1
Muscadine grape	Vitis rotundifolia	FAC	3		
Pop ash	Fraxinus caroliniana	OBL			1
Red maple	Acer rubrum	FACW		1	1–2
Royal fern	Osmunda regalis	OBL		1	2–3
Sand live oak	Quercus geminata	UPL	1		
Shield fern	Thelypteris sp.	FACW		3	2
Sweetgum	Liquidambar styraciflua	FACW	1		
Water hickory	Carya aquatica	OBL		1	2
Wax myrtle	Myrica cerifera	FAC	2		
Wild taro	Colocasia esculenta	OBL		1	2

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manual (Gilbert et. al. 1995);
UPL = Upland plants that occur rarely in wetlands, but occur almost always in uplands
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands
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
OBL = Obligate plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2]Plant community abbreviations:
HS = hardwood swamp (stations 37–260)
THS-HH = transitional hardwood swamp–hydric hammock (station 260–300)
HH = hydric hammock (stations 300–980)

[3]Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); 5 = greater than 75% (dominant)

[4]Common reed was dominant between stations 10–37, waterward of the hardwood swamp.

soils were sampled at stations 360 and 220. The soil at station 360 was identified as Tequesta muck, and the soil at station 220 was Chobee sand with a shallow organic surface horizon. Detailed soil sampling information is listed in Table 12.

Table 12. Lake Monroe transect 2 soil descriptions

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
220/Chobee	Hydric hammock	Oa; 0–4 in.	Muck
		Oa/A; 4–14 in.:	Muck and sand
		E; 14–17 in.	Sand
		Bh; 17–30 in.	Sand
		C'; 30 in.+	Sand
360/Tequesta	Hydric hammock	Oa; 0–10 in.	Muck
		C; 10–20 in.	Sand
		Oab; 20–32 in.	Muck
		C'; 32 in.+	Sand
380/Terra ceia	Hardwood swamp	Oa; 0–16 in.+	Muck
400/Terra ceia	Hardwood swamp	Oa; 0–36 in.	Muck
		C; 36 in.+	Sand
500/Terra ceia	Hardwood swamp	Oa; 0–48 in.	Muck
		C; 48 in.+	Sand
820/Terra ceia	Hardwood swamp	Oa; 0–36 in.+	Muck
1000 Terra ceia	Hardwood swamp	Oa; 0–60 in.+	Muck
1200/Terra ceia	Hardwood swamp	Oa; 0–60 in.+	Muck
1300/Terra ceia	Hardwood swamp	Oa; 0–60 in.+	Muck

FIELD DATA TRANSECT 3

Transect 3, located approximately 800 ft east of transect 2, was also located on the southeast shore of Lake Monroe (Table 13; Figures 2, 5, and 8). This

Table 13. Lake Monroe transect 3 location and field work dates

Latitude–Longitude (Station 20; water's edge)	Latitude–Longitude (Station 1380; upland)	Location and Date of Fieldwork
28 48 39.82–81 14 37.23	28 48 26.55–81 14 40.60	Southeast shore of Lake Monroe, near the inlet, north of Celery Road; January and March 2002.

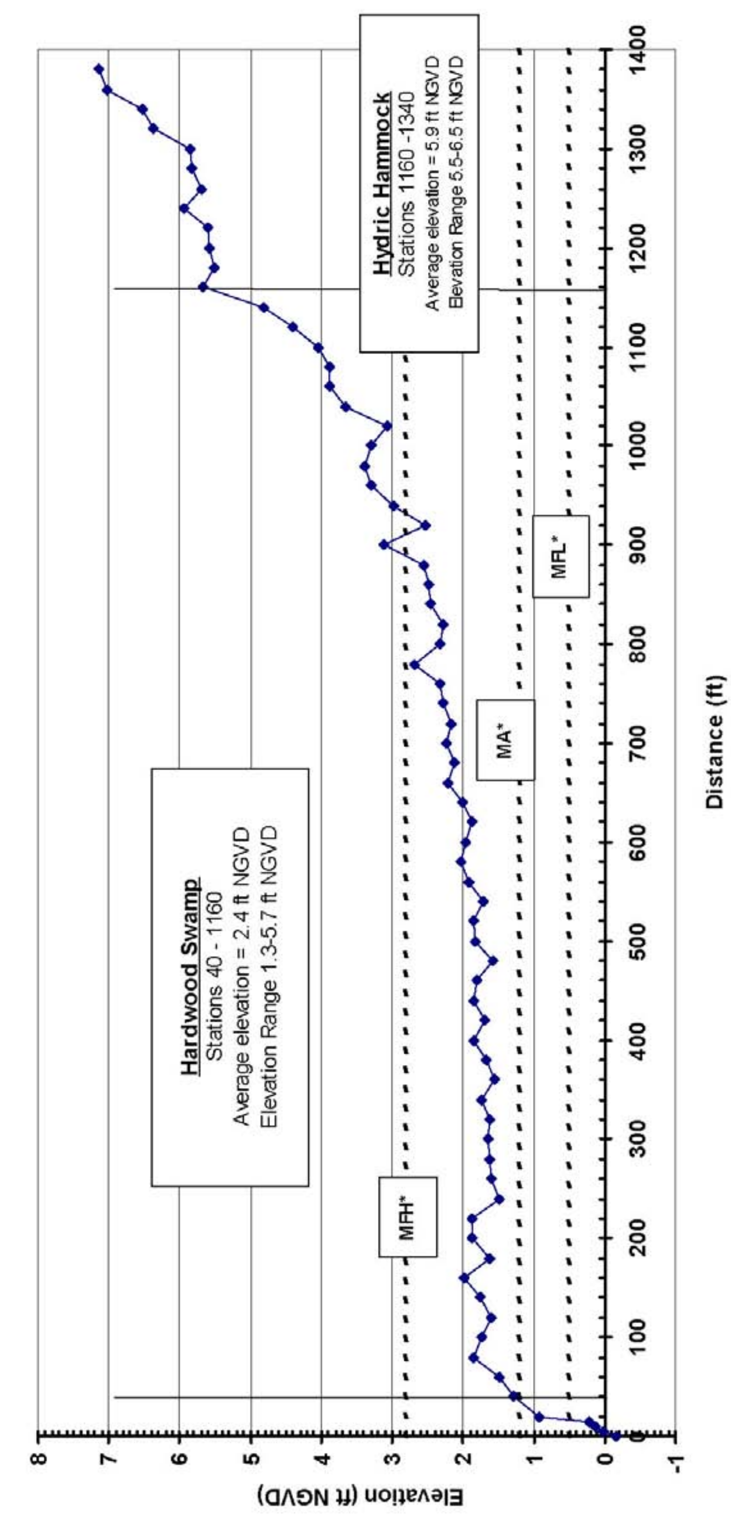
transect site was also established in order to characterize the relatively pristine hardwood swamp and hydric hammock vegetation communities along with the natural lakeshore at this location. Hydrologic differences may occur between transects 2 and 3 due to a large agricultural canal located between and parallel to the two transects. Additionally, the small, intermittent creek, which crossed transect 2 in the hardwood swamp between stations 600 and 700, likely results in different (wetter) hydrologic conditions within the hardwood swamp at transect 2. Consequently, transect 3 was established to avoid the intermittent creek and to compare its vegetation community elevations with those at transect 2. When transects 2 and 3 were elevation surveyed on January 29, 2002, the lake stage equaled 1.02 ft NGVD and transect 2 had areas of inundation / ponding between stations 600 and 1360 (lake edge) within the hardwood swamp where the ground elevation ranged between 1.7 and 3.9 ft NGVD. Meanwhile, on the same date, transect 3 had no standing water within the hardwood swamp where the ground elevation ranged between 1.3 and 5.7 ft NGVD.

Vegetation at Transect 3

The vegetation communities at transect 3 were very similar to transect 2. Transect 3 originated in the open water of Lake Monroe and traversed 1,380 ft in a southerly direction through a hardwood swamp and a hydric hammock to the edge of a sod farm (Figures 14 and 15; Tables 14 and 15). The hardwood swamp (stations 40–1160) overstory vegetation consisted of numerous to co-dominant bald cypress with numerous pop ash, red maple, and American elm. Mature cabbage palm were scattered within the hardwood swamp overstory. The hardwood swamp mid-canopy vegetation consisted of numerous buttonbush and scattered elderberry. The hardwood swamp understory vegetation consisted of numerous to dominant shield fern, abundant to co-dominant royal fern, with scattered false nettle. Fire flag (*Thalia geniculata*) was dominant in the hardwood swamp understory between stations 40 and 80.

Landward of the hardwood swamp, transect 3 traversed a hydric hammock (stations 1160–1340). The hydric hammock overstory vegetation consisted of abundant to co-dominant American elm, abundant cabbage palm, and numerous sweetgum (*Liquidambar styraciflua*), with scattered bald cypress, sugarberry, and laurel oak (*Quercus laurifolia*). The hydric hammock mid-canopy vegetation consisted of numerous to abundant elderberry and scattered buttonbush. The hydric hammock understory vegetation consisted

Figure 14. Lake Monroe Transect 3 topography with ecological communities
*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD



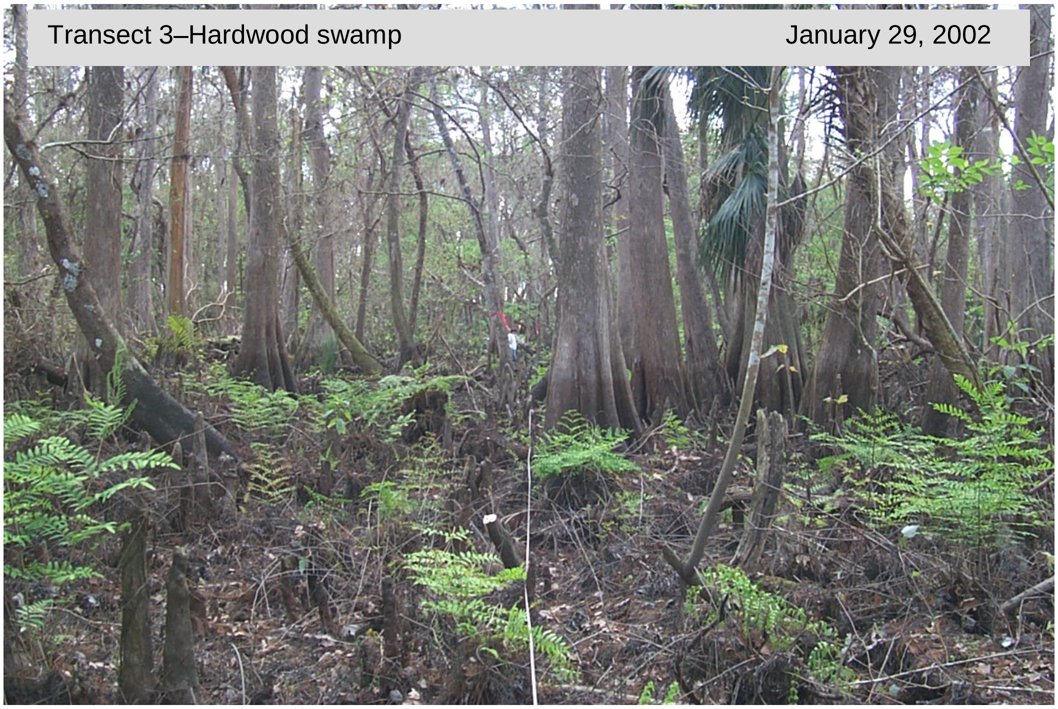


Figure 15. Transect 3 photos

Table 14. Lake Monroe transect 3 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Hardwood swamp	40–1160	2.4	2.0	1.3	5.7	57
Hydric hammock	1160–1340	5.9	5.8	5.5	6.5	10

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

of numerous shield fern with scattered false nettle and swamp fern (*Blechnum serrulatum*). Additional plant species observed along transect 3 are listed in Table 15.

Soils at Transect 3

Soils were mapped (SCS 1990) as Basinger fine sand for the entire length of transect 3. Transect 3 soils were sampled in March 2002. Soils sampled between stations 100 and 1100 within the hardwood swamp were histosols (≥16-in.-thick muck layer) even though the muck layer was often beneath a mucky loam horizon. The soil series for these hardwood swamp stations was designated either Terra Ceia or Gator, depending upon the thickness of the muck layer. A distinct sapric muck horizon was present at all stations along the 1,300-ft transect, however this muck was manifested as a surface layer and / or a buried layer. Detailed soil sampling information is listed in Table 16.

FIELD DATA TRANSECT 4

Transect 4 was located on the east shore of Lake Monroe within the Lake Monroe Conservation Area (Table 17; Figures 2, 5 and 8), approximately two miles southwest of the town of Osteen. This transect site was established in order to characterize the extensive wetland communities located on public land on the east lakeshore.

Vegetation at Transect 4

Transect 4 began at the northwest corner of the Lake Monroe Conservation Area parking lot on the west side of Reed Ellis Road and traversed 5,200 ft in a westerly direction. At station 5200, transect 4 traversed on a southwesterly

Table 15. Lake Monroe transect 3 vegetation species list

Common name	Scientific name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]	
			HS	HH
American elm	Ulmus americana	FACW	2	3–4
Bald cypress	Taxodium distichum	OBL	2–4	1
Buttonbush	Cephalanthus occidentalis	OBL	2	1
Cabbage palm	Sabal palmetto	FAC	1	3
Common reed	Phragmites australis	OBL	5[4]	
Elderberry	Sambucus canadensis	FAC	1	3
False nettle	Boehmeria cylindrica	OBL	1	1
Fire flag	Thalia geniculata	OBL	5[5]	
Laurel oak	Quercus laurifolia	FACW		1
Pop ash	Fraxinus carolinana	OBL	2–3	
Red maple	Acer rubrum	FACW	2	
Royal fern	Osmunda regalis	OBL	3–4	
Shield fern	Thelypteris sp.	FACW	2–5	2
Sugarberry	Celtis laevigata	FACW		1
Swamp fern	Blechnum serrulatum	FACW		1
Sweetgum	Liquidambar styraciflua	FACW		2
Water hyacinth	Eichhornia crassipes	OBL	3[6]	

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manuel (Gilbert et. al. 1995);

UPL = Upland plants that occur rarely in wetlands, but occur almost always in uplands

FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands

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

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

[2]Plant community abbreviations:

HS = Hardwood swamp (stations 40–1160)

HH = hydric hammock (stations 1160–1340)

[3]Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0=<1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); 5 = greater than 75% (dominant)

[4]Common reed was dominant between stations 16–60.

[5]Fire flag occurred only between stations 40–80.

[6]Water hyacinth occurred only between stations 0–60.

Table 16. Lake Monroe transect 3 soil descriptions

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
100/Terra ceia	Hardwood swamp	Oa; 0–52 in.	Muck
		A; 52 in. +	Mucky loam
400/Gator	Hardwood swamp	A; 0–12 in.	Mucky loam
		Oab; 12–52 in.	Muck
		Ab; 52 in.+	Mucky loam
600/Terra ceia	Hardwood swamp	A1; 0–6 in.	Mucky loam
		A2; 6–8 in.	Mucky loam
		Oab; 8–60 in.+	Muck
700/Terra ceia	Hardwood swamp	Oa1; 0–18 in.	Muck
		Oa2; 18–60 in.+	Muck
920/Gator	Hardwood swamp	A; 0–14 in.	Mucky loam
		Oab; 14–40 in.	Muck
		C; 40 in.+	Sand
940/Gator	Hardwood swamp	Oa; 0–2 in.	Muck
		C/Oa; 2–7 in.	Sand & muck
		Oab; 7–38 in.	Muck
		C; 38 in.+	Sand
960/Gator	Hardwood swamp	Oa; 0–1 in.	Muck
		A; 1–3 in.	Mucky sandy loam
		C; 3–7 in.	Sand
		Oab; 7–39 in.	Muck
		Ab; 39 in. +	Sand
1000/Gator	Hardwood swamp	A; 0–3 in.	Loamy sand
		Oa/C; 3–30 in.	Muck and sand
		A1b; 30 in.+	Loamy sand
1100/Gator	Hardwood swamp	Oa; 0–5 in.	Muck
		C; 5–8 in.	Sand
		Oa'; 8–13 in.	Muck
		C; 13–18 in.	Sand
		Oa''; 18–34 in.	Muck
		C;34 in.+	Sand
1160/Chobee	Hardwood swamp	A; 0–6 in.	Mucky sand
		C; 6–11 in.	Sand
		A/C; 11–17 in.	Sand
		Oab; 17–19 in.	Muck
		C/Oa; 19–27 in.	Sand and muck
		Oab'; 27–32 in.	Muck
		C; 32 in.+	Sand
1300/Chobee	Hydric hammock	A1; 0–5 in.	Sand
		A2; 5–8 in.	Sand
		C; 8–12 in.	Sand
		Oab; 12–18 in.	Muck
		C; 18–35 in.+	Sand

Table 17. Lake Monroe transect 4 location and field work dates

Latitude–Longitude (Station 0; upland)	Latitude–Longitude (Station 5250)	Latitude–Longitude (Station 10200; WP)	Location and Date of Fieldwork
28 49 55.54 81 11 31.66	28 49 59.16 81 12 30.05	28 49 43.38 81 13 22.11	East shore of Lake Monroe, near the SJR inlet, Lake Monroe Conservation Area; July, August, and November 2002

bearing to its termination 10,950 ft from its origin. This transect first traversed an upland pasture with planted longleaf pines, then an oak hammock, a palm hydric hammock (1), a hardwood swamp, a wet prairie (1), another palm hydric hammock (2), another wet prairie (2), a deep marsh, an historic channel of the St. Johns River, and terminated in a deep marsh on the shore of Lake Monroe (Figures 16 and 17; Tables 18 and 19).

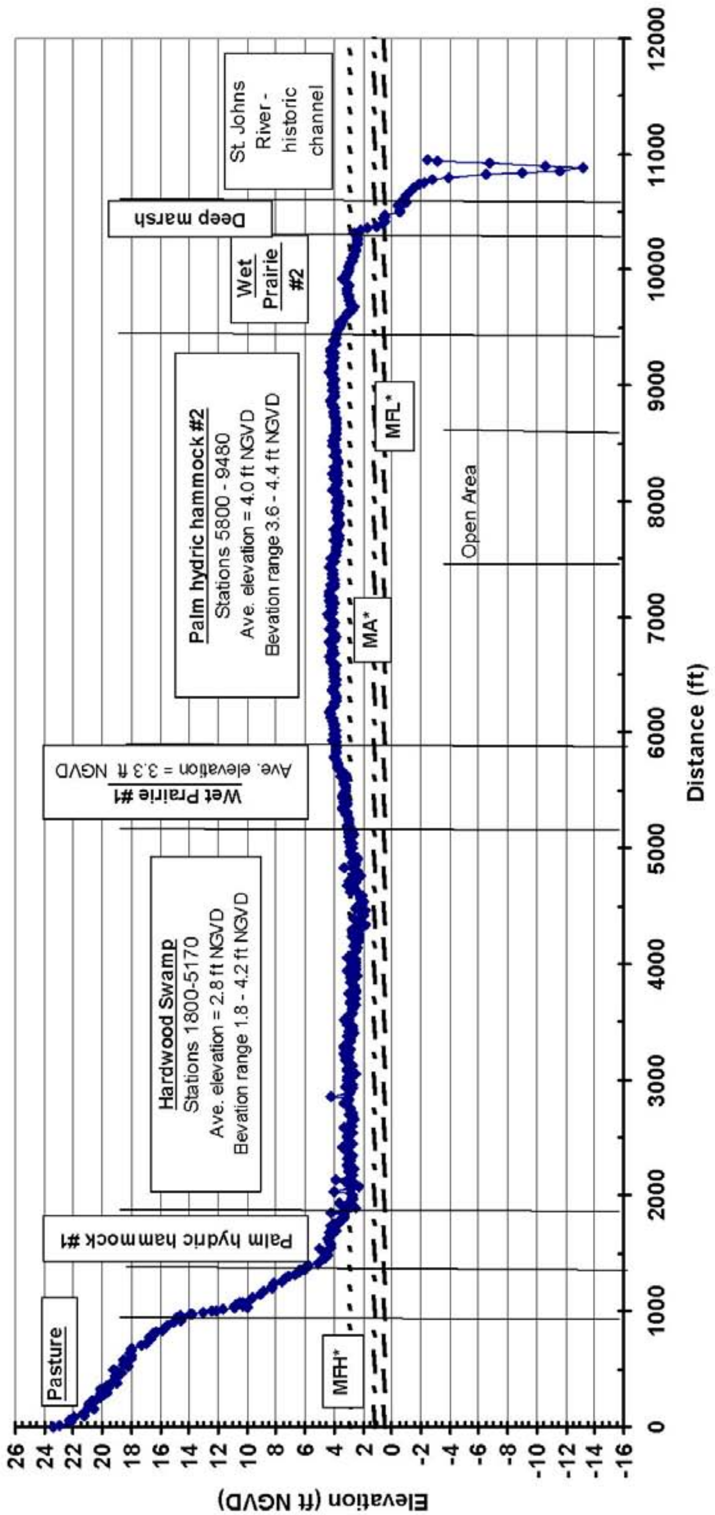
The upland pasture (stations 0–935) vegetation consisted of dominant dog fennel (*Eupatorium capillifolium*), abundant planted longleaf pine (*Pinus palustris*) saplings, numerous persimmon (*Diospyros virginiana*) saplings, and scattered wax myrtles. All vegetation within the upland pasture was less than 15 ft in height in July 2002. The understory herbaceous ground cover consisted of co-dominant St. Augustine grass (*Stenotaphrum secundatum*) with abundant bahiagrass (*Paspalum notatum*) and broomsedge (*Andropogon virginicus*), and scattered goldenrod (*Solidago sp*).

The oak hammock (stations 935–1380) overstory was dominated by sand live oak (*Quercus geminata*). Additional overstory species included scattered water oak (*Quercus nigra*) and sweetgum. The oak hammock mid-canopy and understory was dominated by saw palmetto. Many of these saw palmettos had grown to heights greater than 6 ft, with extensive exposed trunks. Cabbage palm saplings were numerous in the oak hammock mid-canopy and Virginia chain fern (*Woodwardia virginica*) was scattered in the understory.

The palm hydric hammock 1 (stations 1380–1800) was located immediately downslope from the oak hammock. Overstory vegetation consisted of co-dominant mature cabbage palm with scattered to abundant sweetgum, scattered water oak, and scattered to rare southern red cedar. The palm hydric hammock 1 understory consisted of numerous to abundant cabbage

Figure 16. Lake Monroe Transect 4 topography with ecological communities

*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD



Transect 4–Upland pasture with planted pine, station 500
July 24, 2002

Transect 4–Oak hammock, station 1300
July 24, 2002

Figure 17. Transect 4 photos

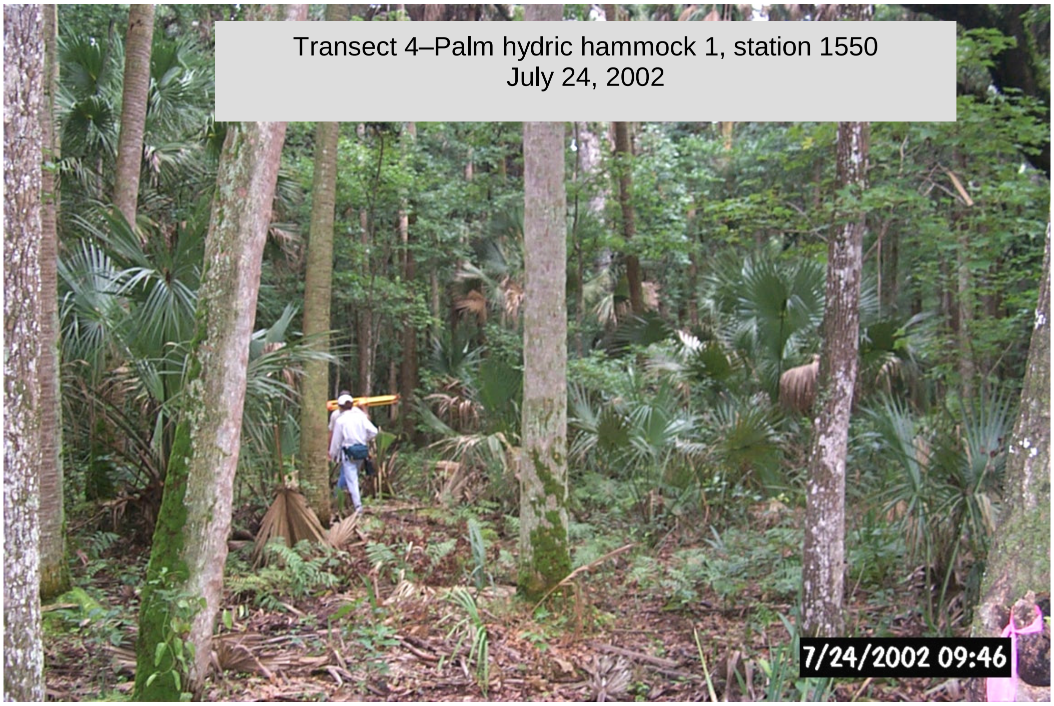


Figure 17—*continued*

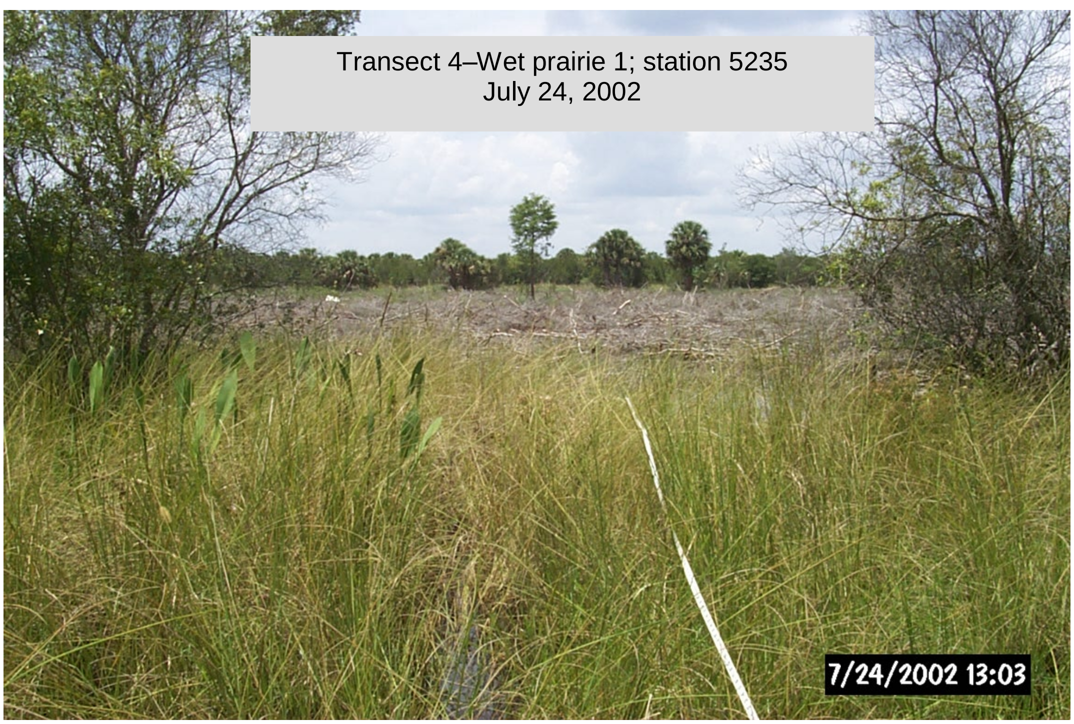


Figure 17—*continued*

Figure 17—*continued*

Figure 17—*continued*

Table 18. Lake Monroe transect 4 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Upland pasture	0–935	18.8	19.0	14.6	23.4	48
Oak hammock	935–1380	10.1	10.0	5.8	14.8	33
Palm hydric hammock 1	1380–1800	4.4	4.3	3.4	5.9	26
Hardwood swamp	1800–5170	2.8	2.8	1.8	4.2	176
Wet prairie 1	5170–5800	3.3	3.3	2.9	4.0	35
Palm hydric hammock 2	5800–9480	4.0	4.0	3.6	4.4	184
Wet prairie 2	9480–10340	2.9	2.9	2.2	3.8	44
Deep marsh	10340–10560	0.5	0.5	-0.6	2.2	12

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

Table 19. Lake Monroe transect 4 vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]							
			UP	O H	PHH #1	HS	WP #1	PHH #2	WP #2	DM
Alligator-weed	Alternanthera philoxeroides	OBL							2	3
American elm	Ulmus americana	FACW				2				
Bahiagrass	Paspalum notatum	UPL	2–4							
Bald cypress	Taxodium distichum	OBL			0	2–4	1	0–1		
Blue flag	Iris virginica	OBL				0	0			
Bristle grass	Setaria geniculata	FAC						1		
Broomsedge	Andropogon virginicus	FAC	3							
Bull arrowhead	Sagittaria lancifolia	OBL					1		1–4	
Buttonbush	Cephalanthus occidentalis	OBL				2–3	0			
Cabbage palm (mature)	Sabal palmetto	FAC	0		4	1		1–3		
Cabbage palm (immature)	Sabal palmetto	FAC		2	2–3	2–3				
Cattail	Typha sp.	OBL								3
Cinnamon fern	Osmunda cinnamomea	FACW				2				
Common reed	Phragmites australis	OBL								3
Cutgrass	Leersia sp.	OBL						1–2		

Table 19—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]							
			UP	OH	PHH #1	HS	WP #1	PHH #2	WP #2	DM
Dahoon holly	Ilex cassine	OBL				1				
Dog fennel	Eupatorium leptophyllum	FAC	5							
False–nettle	Boehmeria cylindrica	OBL			2	1–2				
Fire–flag	Thalia geniculata	OBL								1
Goldenrod	Solidago sp.	FAC	1							
Groundsel tree	Baccharis glomeruliflora	FAC	1					0	3–5	
Longleaf pine saplings	Pinus palustris	UPL	3							
Maidencane	Panicum hemitomon	OBL						2		
Persimmon	Diospyros virginiana	UPL	2							
Pickerelweed	Pontederia cordata	OBL					0–1			
Pop ash	Fraxinus caroliniana	OBL				1		1–2		
Rattle bush	Sesbania sp.	FAC							2	
Red maple	Acer rubrum	FACW				2–3				
Royal fern	Osmunda regalis	OBL			1–2	2–5				
St. Augustine grass	Stenotaphrum secundatum	FAC	4							
Sand cordgrass	Spartina bakeri	FACW					1–5	1–4		
Sand live oak	Quercus geminata	UPL		5						
Saw palmetto	Serenoa repens	UPL	0	5						
Short–bristle beakrush	Rhynchospora corniculata	OBL					1	2–3		
Soft stem bulrush	Scirpus validus	OBL							1	
Southern red cedar	Juniperus silicicola	FAC			0–1					
Smartweed	Polygonum densiflorum	OBL								3
Star rush	Dichromena colorata	OBL						1		
Swamp bay	Persea palustris	OBL				1				
Swamp dogwood	Cornus foemia	FACW				1				
Swamp fern	Blechnum serrulatum	FACW				5[4]				
Swamp gum	Nyssa aquatica	OBL				1				
Swamp rosemallow	Hibiscus grandiflorus	OBL						1	1	3
Sweetgum	Liquidambar styraciflua	FACW		1	1–3	2–3		2		
Switchgrass	Panicum virgatum	FACW						2		

Table 19—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]							
			UP	OH	PHH #1	HS	WP #1	PHH #2	WP #2	DM
Tickseed	Coreopsis sp.	FACW						1		
Virginia chain fern	Woodwardia virginica	FACW		1	2–3	2				
Water hyacinth	Eichhornia crassipes	OBL								3
Water lettuce	Pistia stratioles	OBL								1
Water oak	Quercus nigra	FACW		1	1					
Water primrose	Ludwigia sp.	OBL								3
Wax myrtle	Myrica cerifera	FAC	1			1	2–3	3–4	3	

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manual (Gilbert et. al 1995).
Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in upland
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands
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.
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 uplands

[2]Plant community abbreviations:
UP = Upland pasture (stations 0–935)
OH = oak hammock (stations 935–1380)
PHH#1 = palm hydric hammock 1 (stations 1380–1800)
HS = hardwood swamp (stations 1800–5170)
WP#1 = wet prairie (stations 5170–5800)
PHH#2 = palm hydric hammock 2 (stations 5800–9480)
WP#2 = wet prairie 2 (stations 9480–10340)
DM = deep marsh (stations 10340–10560)

[3]Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant)

[4]Swamp fern was dominant (5) only between stations 3120–3180

palm saplings, numerous to abundant Virginia chain fern, numerous false nettle, and scattered to numerous royal fern.

Downslope from palm hydric hammock 1, transect 4 traversed a broad hardwood swamp community (stations 1800–5170), which is incorrectly identified as hydric hammock on the wetlands map (Figure 8). Subtle and distinct vegetation changes occurred within this hardwood swamp community, presumably due to slight variations in elevation and sunlight penetration along with natural variations typical within such a broad community. For example, buttonbush was abundant in the hardwood swamp mid-canopy in areas, where more sunlight penetrated the overstory, and rare in the heavily shaded areas. Additionally, swamp fern was dominant in the understory between stations 3120–3180 and rare to nonexistent elsewhere along transect 4 within the hardwood swamp.

In general, the hardwood swamp overstory contained abundant to co-dominant bald cypress with numerous to abundant red maple and sweetgum. Additionally, American elm was numerous in the hardwood swamp overstory along with scattered mature cabbage palm, pop ash, and swamp gum (*Nyssa aquatica*) (Table 19). The hardwood swamp mid-canopy consisted of numerous to abundant buttonbush and immature cabbage palm with scattered swamp bay (*Persea palustris*), swamp dogwood, dahoon holly (*Ilex cassine*), and wax myrtle.

The hardwood swamp understory contained numerous to dominant royal fern, numerous Virginia chain fern, numerous cinnamon fern (Osmunda cinnamomea), scattered to numerous false-nettle, and dominant swamp fern between stations 3120 and 3180.

A distinct ecotone occurred between the hardwood swamp and wet prairie 1 at station 5170. Also, within wet prairie 1 at station 5200, the transect direction turned from west to southwest, traversing more directly to the lakeshore (Figure 8). Wet prairie 1 had been extensively drum-chopped in the spring of 2002 in order to eliminate the near monoculture of wax myrtles in this community. Wax myrtles had dominated wet prairie 1 in recent years. In July 2002, the wet prairie vegetation consisted of scattered small (<10-in. DBH) bald cypress, with numerous wax myrtles, in areas that were not drum-chopped. Additional vegetation in wet prairie 1 included scattered to dominant sand cordgrass (*Spartina bakeri*), scattered bull arrowhead (*Sagittaria lancifolia*), and scattered short-bristle beakrush (*Rhynchospora corniculata*).

Southwest of wet prairie 1, the transect traversed palm hydric hammock 2 (stations 5800–9480). Palm hydric hammock 2 was a broad community with considerable variability regarding the aerial extent of cabbage palm. The palm hydric hammock 2 overstory vegetation consisted of scattered to abundant cabbage palm, scattered to numerous pop ash, and rare-to-scattered bald cypress.

In palm hydric hammock 2, where the cabbage palm were scattered, drum chopping had also occurred in 2002. Therefore, where the cabbage palm were scattered, the vegetation was sparse with an understory of scattered to co-dominant sand cordgrass. Additional understory species in the palm hydric hammock 2 included numerous to abundant short-bristle beakrush, scattered star rush (*Dichromena colorata*), scattered bristle grass (*Setaria geniculata*), numerous maidencane (*Panicum hemitomon*), scattered to numerous cutgrass (*Leersia sp.*), numerous switchgrass (*Panicum virgatum*), and scattered tickseed (*Coreopsis sp.*). In the hydric palm hammock2, where the cabbage palms were more abundant and drum-chopping had not occurred, wax myrtle was abundant to co-dominant in the understory.

Southwest of the palm hydric hammock 2, the transect traversed wet prairie 2 (stations 9480–10340). Wet prairie 2 vegetation consisted of abundant-to-dominant groundsel tree (*Baccharis glomeruliflora*), scattered to co-dominant bull arrowhead, abundant wax myrtle, numerous alligator weed (*Altermanthera philoxeroides*), numerous rattle bush (*Sesbania sp.*), scattered swamp rose mallow (*Hibiscus grandiflorus*), and scattered soft stem bulrush (*Scirpus validus*).

Adjacent to wet prairie 2, the final vegetation community, which traversed at transect 4, was a deep marsh (stations 10340–10560). Transect 4 extended beyond station 10560 to traverse the, historic channel of the St. Johns River at stations 10580–10950. Immediately west of station 10950, an additional deep marsh community occurred. Random water depths (soundings) were recorded in this additional deep marsh area west of the secondary river channel. Vegetation data collected within both deep marsh areas were consolidated. Vegetation within the deep marsh occurred in homogenous patches/clumps. Vegetation included abundant smartweed (*Polygonum densiflorum*), swamp rosemallow, water hyacinth, water primrose (*Ludwigia sp.*), alligator weed (*Altemanthera philoxeroides*), cattail (*Typha sp.*), and common reed. Fire flag and water lettuce (*Pistia stratioles)* were scattered in the deep marsh. Additional plant species observed along transect 4 are listed in Table 19.

Soils at Transect 4

Soils were mapped (SCS 1980) from the upland to the deep marsh as Tavares, Myakka, Immokalee, St. Johns, Gator, Bluff, and Manatee series. The dominant soil series mapped were Gator muck, delineated from the palm hydric hammock 1 through the entire hardwood swamp, and Bluff sandy clay, delineated across wet prairie 1, palm hydric hammock 2, wet prairie 2, and the deep marsh located east of the historic channel of the St. Johns River. The deep marsh west of the historic river channel was mapped as Manatee loamy fine sand.

Field soils investigations in November 2002 found that all the soils sampled contained hydric indicators. Soil sampling began in the upland oak hammock at stations 1000 and 1200 where the soil series were Immokalee and Myakka, respectively. Soil sampling in hydric hammock 1 found soil series Sanibel (stations 1500, 1520,1600, 1700, and 1720). Terra Ceia muck was observed within hydric hammock 1 at station 1780. Soil sampling in the hardwood swamp (stations 1800-5170) found either Terra Ceia muck or Gator muck depending upon the thickness of the organic C-horizon. The remaining soils sampled within wet prairie 1, hydric hammock 2, wet prairie 2, and the deep marsh were Bluff series. Table 20 lists detailed soil sample descriptions.

Field Data Transect 5

Transect 5 was located on the northwest shore of Lake Monroe within the Gemini Springs Park property managed by Volusia County (Table 21 and Figures 2, 5 and 8). This transect site was established in order to characterize the extensive marsh community on the west lakeshore (Figure 8).

Vegetation at Transect 5

Transect 5 traversed 1,080 ft in a southerly direction. This transect originated in an upland oak hammock, then traversed a hydric hammock, a willow shrub swamp, and terminated within a shallow marsh (Figures 18 and 19; Tables 22 and 23).

The upland oak hammock (stations 0–130) overstory vegetation contained abundant laurel oak; numerous sand live oak, slash pine (*Pinus elliottii*), and cabbage palm; scattered sweetgum, camphor tree (*Cinnamomum camphora*),

Table 20. Lake Monroe transect 4 soil descriptions

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
1000/Immokalee	Oak hammock	Oa; 0–0.5 in.	Muck
		A; 0.5–6 in.:	Black sand
		E1; 6–22 in.	Grey sand
		E2; 22–32 in.	Gray sand
		Bh1; 32–47 in.	Brown sand
		Bh2; 47–52 in.	Brown sand
		Bw; 52–60+ in.	Brown sand
1200/Myakka	Oak hammock	Oa; 0–1 in.	Muck
		A1; 1–2 in.	Black muck sand
		A2; 2–5 in.	Black sand
		E; 5–25 in.	Gray sand
		Bh1; 25–35 in.	Black sand
		Bh2; 35–60+ in.	Brown sand
1500/Sanibel	Palm hydric hammock 1	Oa1; 0–4 in.	Brown muck
		Oa2; 4–7 in.	Black muck
		C; 7–54+ in.	Gray sand
1520/Sanibel	Palm hydric hammock 1	Oa1; 0–4 in.	Muck
		Oa2; 4–8 in.	Black muck
		C; 8+ in.	Gray sand
1600/Sanibel	Palm hydric hammock 1	Oa1; 0–4 in.	Muck
		Oa2; 4–12 in.	Black muck
		C; 12+ in.	Gray sand
1640/Unknown	Palm hydric hammock 1	Oa1; 0–4 in.	Muck
		Oa2; 4–12 in.	Black muck
1700/Sanibel	Palm hydric hammock 1	Oa; 0–15 in.	Black muck
1700/Sanibel	Palm hydric hammock 1	A1; 15–18 in.	Black mucky sand
		A2; 18–24 in.	Black loamy sand
		Oab; 24–33 in.	Black muck
		Ab1; 33–37 in.	Black loamy sand
		Ab2; 37–50 in.	Black sand
		C; 50–54+ in.	Gray sand
1720/Sanibel	Palm hydric hammock 1	Oa; 0–10 in.	Black muck
		C; 10–24+ in.	Gray sand
1780/Terra ceia	Palm hydric hammock 1	Oa1; 0–6 in.	Muck
		Oa2; 6–54+ in.	Black muck
2000/Terra ceia	Hardwood swamp	Oa1; 0–14 in.	Muck
		Oa2; 14–60+ in.	Black muck
2500/Terra ceia	Hardwood swamp	Oa1; 0–24 in.	Muck
		Oa2; 24–60+ in.	Black muck
3000/Terra ceia	Hardwood swamp	Oa1; 0–20 in.	Muck
		Oa2; 20–60+ in.	Black muck
3500/Terra ceia	Hardwood swamp	Oa1; 0–22 in.	Muck
		Oa2; 22–60+ in.	Black muck

Table 20—*Continued*

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
4000/Terra ceia	Hardwood swamp	Oa1; 0–14 in.	Muck
		Oa2; 14–54 in.	Black muck
		C; 54+ in.	Black loam
4300/Gator	Hardwood swamp	Oa1; 0–8 in.	Muck
		Oa2; 8–37 in.	Black muck
		C; 37+ in.	Black loam
5400/Bluff	Wet prairie 1	Oi; 0–0.5 in.	Fibric material
		Oa; 0.5–1.5 in.	Black muck
		C; 1.5–14 in.	Dark clay loam
		Cg; 14–60+ in.	Clay loam
5600/Bluff	Wet prairie 1	Oi; 0–0.5 in.	Fibric material
		Oa; 0.5–1.5 in.	Black muck
		C; 1.5–10 in.	Dark clay loam
		Cg; 10+ in.	Sandy clay loam
6300/Bluff	Palm hydric hammock 2	Oa; 0–1 in.	Black muck
		Cg1; 1–15 in.	Clay loam
		Cg2; 15–20+ in.	Sandy clay loam
7000/Bluff	Palm hydric hammock 2	Oa; 0–0.5 in.	Black muck
		Cg1; 0.5–11 in.	Clay loam
		Cg2; 11+ in.	Sandy clay loam
8000/Bluff	Palm hydric hammock 2	Oi; 0–0.5 in.	Fibric material
		Oa; 0.5–2 in.	Black muck
		C; 2–11 in.	Clay loam
		Cg; 11–23+ in.	Sandy clay loam
9000/Bluff	Palm hydric hammock 2	Oa; 0–2 in.	Black muck
		C; 2–14 in.	Clay loam
		Cg; 14–20+ in.	Sandy clay loam
9400/Bluff	Palm hydric hammock 2	Oa; 0–1.5 in.	Black muck
		C; 1.5–6 in.	Clay loam
		Cg1; 6–17 in.	Dark clay loam
		Cg2; 17–24+ in.	Sandy clay loam
9500/Bluff	Wet prairie 2	Oa; 0–1.5 in.	Black muck
		C; 1.5–16 in.	Clay loam
		Cg; 16–24+ in.	Sandy clay loam
9600/Bluff	Wet prairie 2	Oa; 0–2 in.	Black muck
		C; 2–30 in.	Clay loam
		Cg1; 30–40 in.	Dark clay loam
		Cg2; 40–60+ in.	Sandy clay loam
10000/Bluff	Wet prairie 2	Oa; 0–1.5 in.	Black muck
10000	Wet prairie 2	C; 1.5–10 in.	Clay loam
		Cg1; 10–17 in.	Dark clay loam
		Cg2; 17–24+ in.	Sandy clay loam

Table 20—*Continued*

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
10200/Bluff	Wet prairie 2	Oa; 0–2 in.	Black muck
		C; 2–18 in.	Dark clay loam
		Cg; 18–24+ in.	Sandy clay loam
10360/Bluff	Deep marsh	A; 0–6 in.	Black loamy sand
		Cg1; 6–52 in.	Clay loam
		Cg2; 52+ in.	Sandy clay loam

Table 21. Lake Monroe transect 5 location and field work dates

Latitude–Longitude (station 0; upland)	Latitude–Longitude (station 980; SM)	Location and Date of Fieldwork
28 51 58.99 81 18 14.17	28 51 49.09 81 18 12.81	Northwest shore of Lake Monroe, Gemini Springs Park, DeBary, Volusia County; October and December 2002

and water oak. The upland oak hammock understory, between stations 0 and 20, contained co-dominant bahiagrass. The remainder of the oak hammock understory contained abundant muscadine grape, numerous to abundant spikegrass (Chasmanthium sp.); numerous netted chainfern (*Woodwardia areolata*), bracken fern (*Pteridium aquilinum*), cinnamon fern; and scattered saw palmetto, beautyberry (*Callicarpa americana*), royal fern, and cat brier.

South of the oak hammock, transect 5 traversed a hydric hammock (stations 130–180). The hydric hammock overstory vegetation contained abundant laurel oak, numerous cabbage palm, and scattered bald cypress. The hydric hammock understory vegetation consisted of scattered cinnamon fern.

South of the hydric hammock, transect 5 traversed a willow shrub swamp (stations 180–220). The willow shrub swamp vegetation was co-dominant Carolina willow (*Salix caroliniana*) with scattered buttonbush.

Transect 5 terminated in a shallow marsh (stations 220–1080). The shallow marsh contained abundant to dominant sand cordgrass; numerous to abundant smartweed, swamp rosemallow, cattail; and scattered buttonbush. Additional plant species observed along transect 5 are listed in Table 23.

Figure 18. Lake Monroe Transect 5 topography with ecological communities
*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD

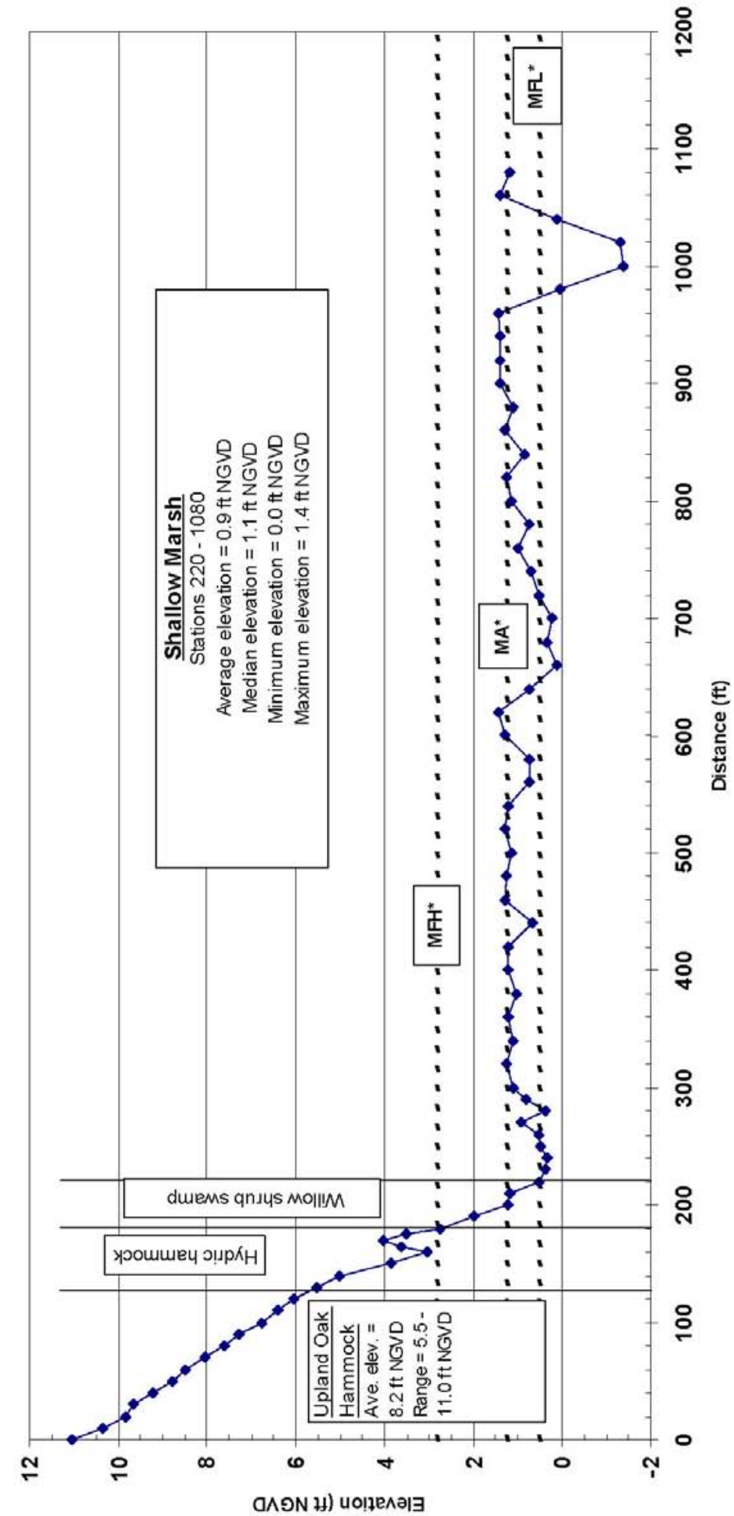


Figure 19. Transect 5 photos

Figure 19—*continued*

Table 22. Lake Monroe transect 5 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Upland oak hammock	0–130	8.2	8.3	5.5	11.0	14
Hydric hammock	130–180	3.9	3.8	2.7	5.5	8
Willow shrub swamp	180–220	1.5	1.2	0.5	2.7	5
Shallow marsh without channel	220–1080	0.9	1.1	0.0	1.4	46

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

Soils at Transect 5

Soils were mapped (SCS 1980) from the upland oak hammock to the higher elevations of the hydric hammock as EauGallie. The Gator series was mapped at the lower elevations of the hydric hammock, across the willow shrub swamp and the shallow marsh at transect 5.

Field soils investigations during December 2002 found Immokalee series at stations 70 and 110 within the upland oak hammock. The Immokalee soils sampled in the oak hammock had hydric soil indicators including organic bodies, mucky mineral, and dark surface. Soil series sampled in the hydric hammock were Ona (station 150) and Myakka (station 170). Hydric soil indicators observed in the hydric hammock included mucky mineral, stripped matrix, and dark surface. Ona soil series was also observed near the upper elevation of the willow shrub swamp at station 190 and exhibited hydric soil indicators of mucky mineral and dark surface. Downslope in the willow shrub swamp, at station 200, the soil series was not determined, but a histic epipedon was observed. A histosol was observed at station 210, within the willow shrub swamp, and the soil was identified as Gator series.

All soils sampled within the shallow marsh were histosol, and were identified as either Gator or Terra Ceia series depending upon muck depth. Table 24 lists detailed soil sampling descriptions.

Table 23. Lake Monroe transect 5 vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]			
			OH	HH	WSS	SM
Bahiagrass	Paspalum notatum	UPL	4			
Bald cypress	Taxodium distichum	OBL		1		
Beautyberry	Callicarpa americana	FACU	1			
Bluestem	Sabal minor	FACW	0	0		
Bracken fern	Pteridium aquilinum	FACU	2			
Buttonbush	Cephalanthus occidentalis	OBL			1	1
Cabbage palm (mature)	Sabal palmetto	FAC	2	2		
Camphor tree	Cinnamomum camphora	FACU	1			
Carolina willow	Salix caroliniana	OBL			4	
Cat brier	Smilax bona-nox	FAC	1	0		
Cattail	Typha sp.	OBL				2–3
Cinnamon fern	Osmunda cinnamomea	FACW	2	1		
Laurel oak	Quercus laurifolia	FACW	3	3		
Muscadine grape	Vitis rotundifolia	FAC	3			
Netted chainfern	Woodwardia areolata	OBL	2			
Royal fern	Osmunda regalis	OBL	1			
Sand cordgrass	Spartina bakeri	FACW				3–5
Sand live oak	Quercus geminata	UPL	2			
Saw palmetto	Serenoa repens	UPL	1			
Slash pine	Pinus elliottii	FACW	2			
Smartweed	Polygonum sp.	OBL				2–3
Spikegrass	Chasmanthium sp.	FACW	2–3			
Swamp rosemallow	Hibiscus grandiflorus	OBL				2–3
Sweetgum	Liquidambar styraciflua	FACW	1			
Virginia chain fern	Woodwardia virginica	FACW	0	0		
Water oak	Quercus nigra	FACW	1			

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manual (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 uplands

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

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 uplands

[2]Plant community abbreviations:

OH = oak hammock (stations 0–130)

HH = hydric hammock (stations 130–180)

WSS = willow shrub swamp (stations 180–220)

SM = hallow marsh (stations 220–1080)

[3]Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant)

Table 24. Lake Monroe transect 5 soil descriptions

Station /Soil Series	Vegetation Community	Soil Horizon	Horizon Description
70/Immokalee	Oak hammock	A; 0–12 in.	Black sand
		E; 12–39 in.	Gray sand
		Bh; 39–50 in.	Brown sand
		Bw; 50–60 in. +	Dark brown sand
110/Immokalee	Oak hammock	Oe; 0–2 in.	Hemic material
		A1; 2–6 in.	Black mucky sand
		A2; 6–12 in.	Black sand
		E; 12–42 in.	Gray sand
		Bh; 42–52 in.	Dark brown sand
		Bw; 52–60 in. +	Brown yellow sand
150/Ona	Hydric hammock	A; 0–2 in.	Black mucky sand
		E; 2–8 in.	Dark gray sand
		Bh; 8–33 in.	Dark brown sand
		Bw; 33–50 in. +	Brown sand
170/Myakka 170	Hydric hammock	A1; 0–2 in.	Black mucky sand
		A2; 2–5 in.	Black sand
	Hydric hammock	A3; 5–22 in.	Gray sand
		Bh; 22–36 in.	Brown sand
190/Ona	Willow shrub swamp	Oe; 0–0.5 in.	Hemic material
		A1; 0.5–6 in.	Black mucky sand
		A2; 6–10 in.	Black loamy sand
		Bh1; 10–13 in.	Brown sand
		Bh2; 13–20 in.	Dark brown sand
		Ab; 20–47 in. +	Gray sand
		Oa; 0–14 in.	Brown muck
		A; 14–36 in. +	Gray sand
210/Gator	Willow shrub swamp	Oi; 0–0.5 in.	Fibric material
		Oa; 0.5–24 in.	Brown muck
		E; 24–28 in.	White sand
		Ab; 28–36 in.	Gray sand
		Btg; 36–48 in. +	Sandy clay loam
290/Gator	Shallow marsh	Oa1; 0–36 in.	Brown muck
		Oa2; 36–48 in.	Black muck
300/Terra Ceia	Shallow marsh	Oa1; 0–20 in.	Brown muck
		Oa2; 20–58 in.	Black muck
		C; 58–62 in. +	Gray loam
400/Terra ceia	Shallow marsh	Oa1; 0–20 in.	Brown muck
		Oa2; 20–60 in.	Black muck
		C; 60 in. +	Gray loam
600/Gator	Shallow marsh	Oa1; 0–10 in.	Brown muck
		Oa2; 10–38 in.	Black muck
		C1; 38–44 in.	Gray loam
		C2; 44 in. +	Gray mucky sand
800/Gator	Shallow marsh	Oa1; 0–14 in.	Brown muck
		Oa2; 14–36 in.	Black muck
		C1; 36–42 in.	Gray clay loam
		C2; 42–60 in. +	Gray clay loam
940/Gator	Shallow marsh	Oa1; 0–6 in.	Brown muck
		Oa2; 6–35 in.	Black muck
		C1; 35–42 in.	Gray clay loam
		C2; 42–60 in. +	Gray clay loam

FIELD DATA TRANSECT 6

Transect 6 was located on the west shore of Lake Monroe, east of Interstate 4 (Table 25 and Figures 2, 5, and 8). This transect site was established in order to characterize the extensive wet prairie and marsh vegetation communities on the west lakeshore (Figure 8).

Table 25. Lake Monroe transect 6 location and field work dates

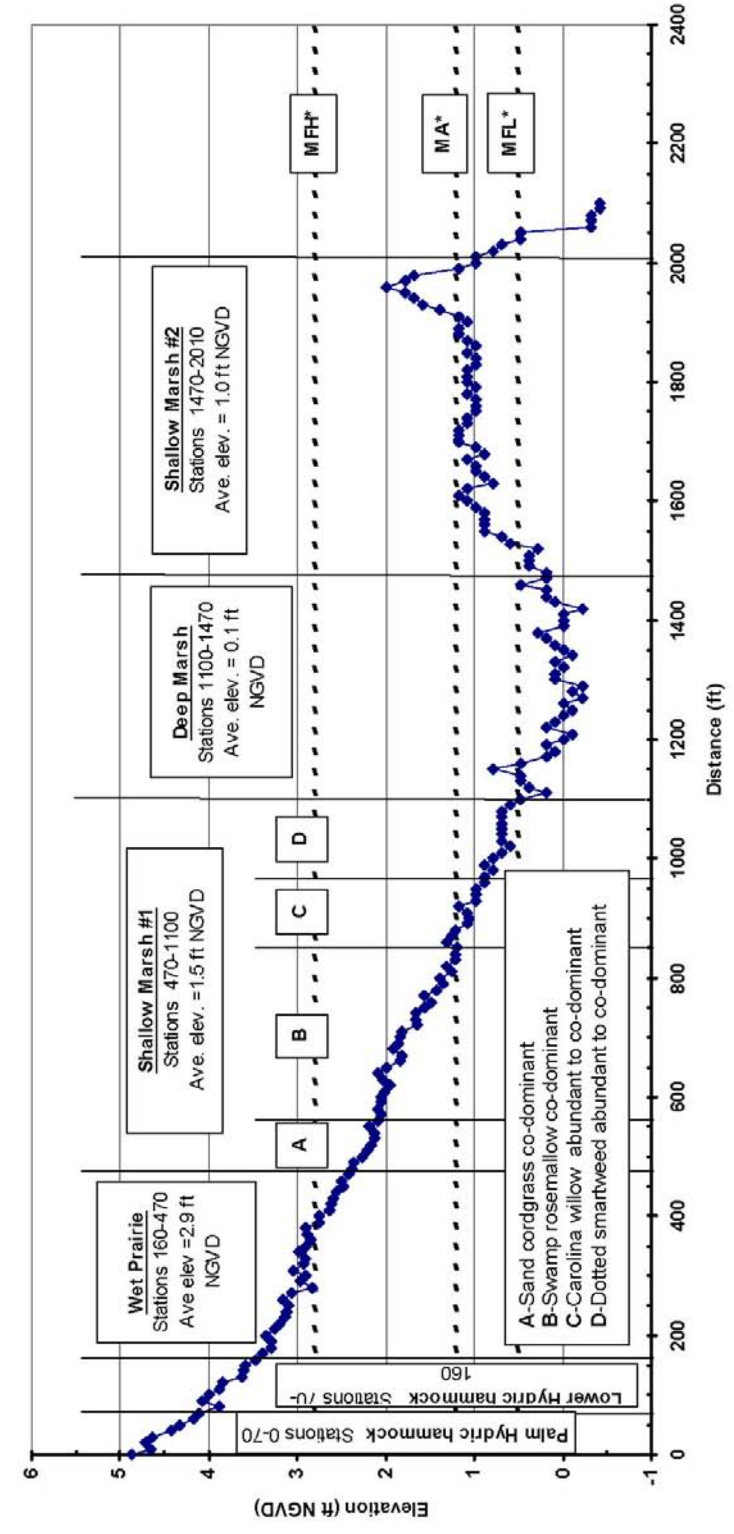
Latitude–Longitude (Station 0; hammock)	Latitude–Longitude (Station 2060; open water)	Location and Date of Fieldwork
28 50 41.969 81 18 24.483	28 50 29.805 81 18 10.799	West shore of Lake Monroe, Volusia County; March 2003

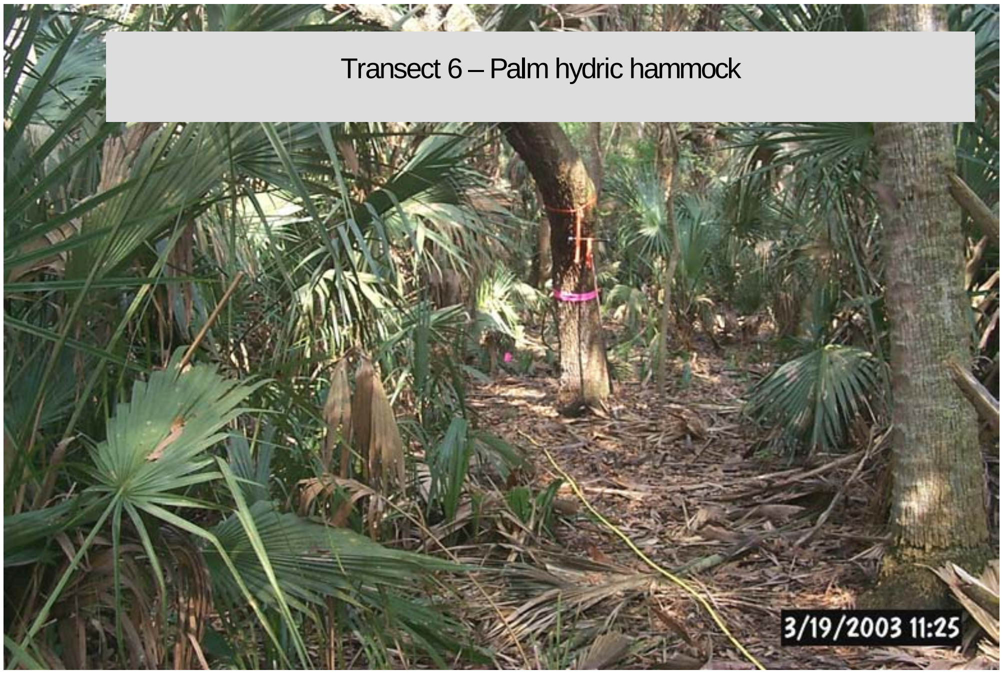
Vegetation at Transect 6

Transect 6 traversed 2,060 ft in a southeasterly direction. This transect originated in a palm hydric hammock, then traversed a lower hydric hammock, a wet prairie, a shallow marsh (1), a deep marsh, another shallow marsh (2) and terminated in the open water of Lake Monroe. (Figures 20 and 21; Tables 26 and 27). The palm hydric hammock (stations 0–70) overstory vegetation contained abundant cabbage palm and numerous sand live oak. The palm hydric hammock mid-canopy and understory contained co-dominant immature cabbage palms. Adjacent to the palm hydric hammock, the transect traversed a lower hydric hammock (stations 70–160). The lower hydric hammock overstory vegetation consisted of numerous laurel oak, scattered-to-numerous cabbage palm and American elm, and scattered swamp gum. The lower hydric hammock mid-canopy vegetation consisted of numerous wax myrtle and immature cabbage palm. The lower hydric hammock understory vegetation consisted of scattered pepper vine (*Ampelopsis arborea*), mock bishop's weed (*Ptilimnium capillaceum*), and lady's wood sorrel (*Oxalis corniculata*).

Downslope from the lower hydric hammock, the transect traversed a wet prairie (stations 160–470). The wet prairie vegetation consisted of abundant to co-dominant mock bishop's weed; abundant sedge (*Carex sp.*) and wax myrtle; numerous to abundant variable panicum (*Panicum commutatum*);

Figure 20. Lake Monroe Transect 6 topography with ecological communities
*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD





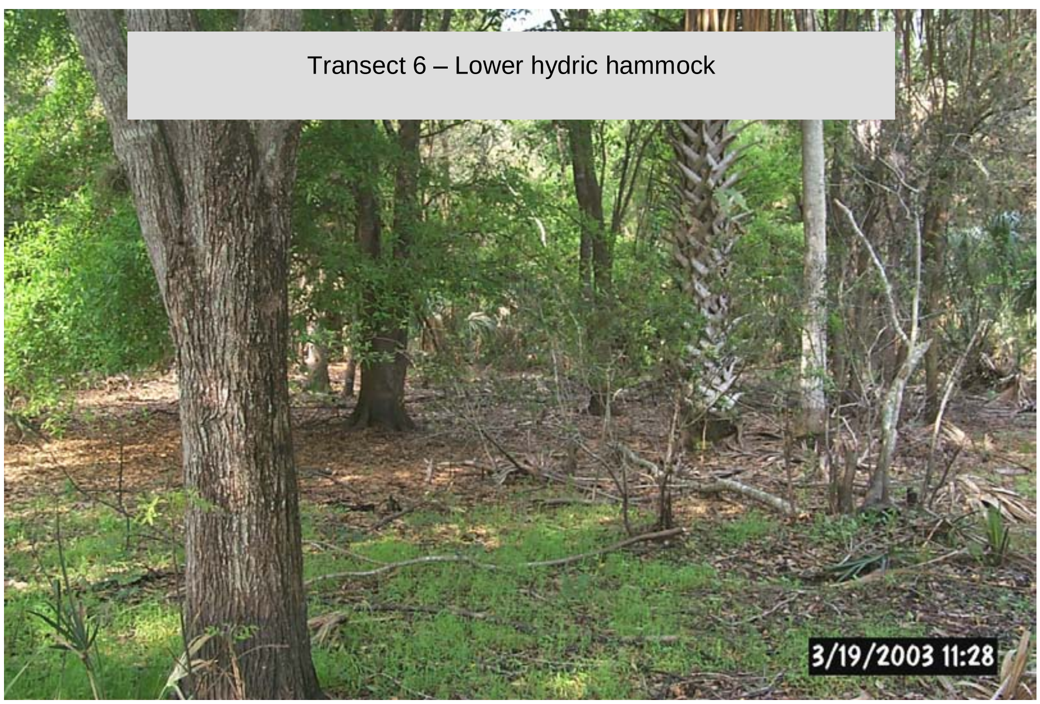


Figure 21. Transect 6 photos

Figure 21—*continued*

Figure 21—*continued*

Transect 6–Shallow marsh 2; station 1600
March 19, 2003

Transect 6–Shallow marsh 2; station 1860
March 19, 2003

Figure 21—*continued*

Table 26. Lake Monroe transect 6 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Palm hydric hammock	0–70	4.5	4.5	4.1	4.9	8
Lower hydric hammock	70–160	3.8	3.9	3.5	4.1	10
Wet prairie	160–470	2.9	2.9	2.5	3.5	32
Shallow marsh 1	470–1100	1.5	1.4	0.5	2.4	64
Deep marsh	1100–1470	0.1	0.1	-0.2	0.8	38
Shallow marsh 2	1470–2010	1.0	1.0	0.2	2.0	55

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

numerous tickseed, pepper vine, American elm saplings, swamp rosemallow, groundsel tree, and mimosa (*Mimosa sp.*). Vegetation scattered within the wet prairie included immature cabbage palm, laurel oak, swamp gum, dotted smartweed (*Polygonum punctatum*), buttonbush, saltmarsh mallow, sand cordgrass, coast cockspur-grass (*Echinochloa walteri*), soft stem bulrush, mist flower (*Conoclinium coelestinum*), butterweed (*Senecio glabellus*), plantain (*Plantago sparsiflora*), St. John's wort (*Hypericum mutilum*), Columbia waxweed (*Cuphea carthagenensis*), lady's wood sorrel, and loosestrife (*Lythrum alatum*).

Adjacent to the wet prairie, the transect traversed an extensive shallow marsh (1) (stations 470–1100). The common vegetation species were clustered within shallow marsh 1 and not necessarily found throughout the shallow marsh. For example, from stations 470–560, sand cordgrass was co-dominant. It was scattered between stations 560 and 850, rare between stations 850 and 970, and not found between stations 970 and 1100. Due to the marked clustering of the marsh vegetation, shallow marsh 1 was split into subcommunities on Figure 20 and Table 27. In general, common vegetation identified within shallow marsh 1 included swamp rosemallow (numerous to co-dominant), dotted smartweed (scattered to co-dominant), sand cordgrass (rare to co-dominant), Carolina willow (scattered to co-dominant), coast cockspur-grass (scattered to numerous), cattail (rare to numerous), numerous dead wax myrtle; and scattered buttonbush, dead dog fennel, marsh pennywort, loosestrife, and red ludwigia (*Ludwigia repens*).

Adjacent to shallow marsh 1, the transect traversed a deep marsh (stations 1100–1470). Deep marsh vegetation consisted of dominant cattail, with scattered dotted smartweed, and soft stem bulrush. The final vegetation community traversed at transect 6 was shallow marsh 2 (stations 1470-2010),

Table 27. Lake Monroe transect 6 vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]								
			PHH	LHH	WP	SM#1-A	SM#1-B	SM#1-C	SM#1-D	DM	SM#2
American cupscale	Sacciolepsis striata	OBL					0				
American elm	Ulmus americana	FACW		1–2							
American elm (saplings)	Ulmus americana	FACW			2						
Buttonbush	Cephalanthus occidentalis	OBL			1	1	1				
Butterweed	Senecio glabellus	OBL		0	1						
Cabbage palm (immature)	Sabal palmetto	FAC	4	2	1						
Cabbage palm (mature)	Sabal palmetto	FAC	3	1–2							
Carolina willow	Salix caroliniana	OBL				1	1	3–4	1	0	4
Carolina willow (dead)	Salix caroliniana	OBL				2	1–2				
Cattail	Typha sp.	OBL					1	0	2	5	2
Coast cockspur-grass	Echinochloa walteri	OBL			1		1	1–2			
Columbia waxweed	Cuphea carthagenensis	FAC			1						
Common reed	Phragmites australis	OBL									4–5
Dog fennel (dead)	Eupatorium leptophyllum	FAC					1				
Dotted smartweed	Polygonum punctatum	OBL			1		1	2	3–4	1	3–5
False-nettle	Boehmeria cylindrica	OBL			0						
Groundsel tree	Baccharis glomeruliflora	FAC			2						
Lady's wood sorrel	Oxalis corniculata	FACU		1	1						
Laurel oak	Quercus laurifolia			2	1						
Loosestrife	Lythrum alatum	OBL			1		1				
Marsh pennywort	Hydrocotyle umbellate	OBL			0–1		1				2
Mimosa sp.	Mimosa			1	2	1					
Mist flower	Conoclinium coelestinum	FAC		0	1						
Mock bishop's-weed	Ptilimnium capillaceum	OBL		1	3–4						
Morning glory	Ipomoea sp.										2–4
Pepper-vine	Ampelopsis arborea	FAC		1	2						
Plantain	Plantago sparsiflora				1						
Pop ash	Fraxinus caroliniana	OBL			0						

Table 27—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]								
			PHH	LHH	WP	SM#1-A	SM#1-B	SM#1-C	SM#1-D	DM	SM#2
Red ludwigia	Ludwigia repens	OBL					1				
Red maple (saplings)	Acer rubrum	FACW			0						
Saltmarsh mallow	Kosteletzkya virginica	OBL			1						
Sand cordgrass	Spartina bakeri	FACW			1	4	1	0			2
Sand live oak	Quercus geminata	UPL	2								
Smartweed	Polygonum densiflorum	OBL								0	2
Soft stem bulrush	Scirpus validus	OBL			1			0		1	
Spatterdock	Nuphar luteum	OBL								0	
St. John's wort	Hypericum mutilum	FACW			1						
Swamp gum	Nyssa aquatica	OBL		1	1						
Swamp rosemallow	Hibiscus grandiflorus	OBL			2	2	4		2		
Tickseed	Coreopsis gladiata	FACW			2						
Unknown sedge	Carex sp				3						
Variable panicum	Panicum commutatum	FAC		2	2–3	0					
Wax myrtle	Myrica cerifera	FAC		2	3						
Wax myrtle (dead)	Myrica cerifera	FAC				2					

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 uplands
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
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 uplands

[2] Plant Community Abbreviations:
PHH = palm hydric hammock (stations 0–70)
LHH = lower hydric hammock (stations 70–160)
WP = wet prairie (stations 160–470)
SM#1 – A = shallow marsh 1 (sand cordgrass— stations 470–560)
SM#1 – B = shallow marsh 1 (rose swamp mallow— stations 560–850)
SM#1 – C = shallow marsh 1 (willow—stations 850–970)
SM#1 – D = shallow marsh 1 (dotted smartweed—stations 970–1100)
DM = deep marsh (stations 1100–1470)
SM#2 = shallow marsh 2 (stations 1470–2010)

[3] Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0=<1% (rare); 1 = 1–10% (scattered); 2 =1 1–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant)

located between the deep marsh and the open water of Lake Monroe. Vegetation identified within shallow marsh 2 included abundant to dominant dotted smartweed, co-dominant Carolina willow, co-dominant-to-dominant common reed; numerous sand cordgrass, marsh pennywort, cattail, and smartweed. Additional plant species observed along transect 6 are listed in Table 27.

Soils at Transect 6

Soils were mapped (SCS 1980) as Bluff series for the entire length of transect 6. Field soils investigations during March 2003 found Bluff series soil at the majority of the stations sampled (Table 28). Additionally, Basinger series was sampled at station 30 within the palm hydric hammock and Scoggin series was sampled at station 300 within the wet prairie. All shallow marsh 1 soils were identified as the Bluff series. Soils were not sampled within the deep marsh and shallow marsh 2 at transect 6 due to deep-water inundation within these vegetation communities at the time field soil sampling occurred. All soils sampled had the hydric soil indicator of a shallow muck surface layer and a dark surface (Table 28).

Basinger series soil is composed of poorly drained fine sands. It is typically found in sloughs and drainage ways and formed in sandy marine sediments. It has a water table at depths of less than 12 in. for 2–6 months annually and at depths of 12–30 in. for periods of more than 6 months in most years. Areas in poorly defined drainage ways and flood plains are flooded for long periods (USDA, NRCS 2005).

Scoggin series soil is composed of poorly drained sands, formed in loamy and sandy marine sediments. Scoggin sands occur in swamps and low areas bordering swamps. The water table is at or above the soil surface for as much as 6 months in most years. Standing water occurs during the summer rainy season (USDA, NRCS 2005).

Bluff series soil is composed of sandy clays and clay loams which formed in alkaline marine sediments. The water table is at depths of less than 10 in. below the soil surface for six or more months and seldom recedes to depths of more than 20 in. Bluff soil is subject to frequent flooding for long durations (USDA, NRCS 2005). According to the NRCS (2003), some pedons of Bluff soil have a muck layer on the surface up to a 5-in. thickness. In general, the muck

Table 28. Lake Monroe transect 6 soil descriptions

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
30/Basinger	Palm hydric hammock	Oa (0–0.5 in.)	Black muck; many fine roots
		A (0.5– 5 in.)	Loamy sand, many roots, stripping
		E (5–11 in.)	Dark gray sand; many roots
		Bh1 (11–21 in.)	Very dark brown sand, few roots
		Bh2Eg (21–32 in.)	Grey brown loamy sand with redoxomorphicomorphic features
		Cg1 (32–36 in.)	Light grey sandy loam with redoxomorphic depletions
		Cg2 (36–41 in.)	Light green-gray sandy loam with redoxomorphic features
		Cg3 (41+)	Light green-gray sandy clay loam with redoxomorphic features
120/Bluff	Lower hydric hammock	Oa (0–0.5 in.)	Black muck, many fine roots
		A (0.5 – 1 in.)	Sand; many fine roots
		E1 (1–10 in.)	Dark gray sand; few roots, stripping present
		E2 (10–16 in.)	Dark grayish brown sand
		Ab (16–23 in.)	Very dark gray sandy loam
		Cg1 (23–25 in.)	Light greenish gray loamy sand; redoxomorphic features
		Cg2 (25 in. +)	Light greenish gray sandy clay loam, redoxomorphic features
200/Bluff	Wet prairie	Oa (0–0.5 in.)	Black muck; many fine roots
		A1 (0.5–1 in.)	Black mucky sand; many fine roots
		A2 (1–4 in.)	Black sand; few moderate roots
		A3 (4–7 in.)	Very dark gray sand; few moderate roots
		E (7–14 in.)	Dark grayish brown and grayish brown sand
		Ab1 (14–20 in.)	Very dark gray sandy loam
		Ab2 (20–25 in.)	Very dark gray loamy sand
		Cg (25 in.+)	Light greenish gray sandy clay loam; redoxomorphic depletions
300/Scoggin	Wet prairie	A1 (0–0.5 in.)	Black mucky sand; many fine roots
		A2 (0.5–5 in.)	Very dark gray sand; few moderate roots
		E (5–10 in.)	Grayish brown and light brownish gray sand; stripping
		Ab1 (10–17 in.)	Very dark gray sandy loam
		Ab2 (17–19 in.)	Very dark gray loamy sand
		Cg (19 in.+)	Light greenish gray sandy clay loam with redoxomorphic depletions

Table 28—*Continued*

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
420/Bluff	Wet prairie	Oa (0–1 in.)	Black muck; many fine roots
		A (1–2 in.)	Black sand; few moderate roots
		E1 (2–8 in.)	Dark gray and gray sand; few moderate roots
		E2 (8–14 in.)	Grayish brown and light brownish gray sand
		Ab1 (14–19 in.)	Very dark gray sandy loam
		Ab2 (19–26 in.)	Very dark gray sand
		Cg1 (26–36 in.)	Light gray sandy loam with redoxomorphic concentrations
		Cg2 (36 in.+)	Light greenish gray sandy clay loam with redoxomorphic concent.
500/Bluff	Shallow marsh 1	Oa (0–1 in.)	Black muck; many fine roots
		A (1–5 in.)	Black sand; few moderate roots
		E (5–13 in.)	Dark grayish brown sand
		Ab (13–19 in.)	Very dark gray sandy loam
		Cg1 (19–26 in.)	Greenish gray sandy loam with redoxomorphic concentrations
		Cg2 (26 in.+)	Light greenish gray sandy clay loam with redoxomorphic concentrations
640/Bluff	Shallow marsh 1	Oa (0–4 in.)	Black muck; many fine roots
		A1 (4–6 in.)	Black sand; few moderate roots
		A2 (6–10 in.)	Very dark gray loamy sand
		A3 (10–20 in.)	Very dark gray sandy loam
		Cg1 (20–25 in.)	Light gray sandy loam with redoxomorphic concentrations
640	Shallow marsh 1	Cg2 (25 in.+)	Light greenish gray sandy clay loam with redoxomorphic concentrations
780/Bluff	Shallow marsh 1	Oa (0–4 in.)	Black muck; many fine roots
		A1 (4–10 in.)	Black sand; few moderate roots
		A2 (10–17 in.)	Very dark gray sandy loam
		Cg1 (17–23 in.)	Greenish gray sandy loam with redoxomorphic concentrations
		Cg2 (23 in.+)	Light greenish gray sandy clay loam with redoxomorphic concentrations
900/Bluff	Shallow marsh 1	Oa (0–5 in.)	Black muck; many fine roots
		A1 (5–8 in.)	Black loamy sand; few moderate roots
		A2 (8–15 in.)	Very dark gray sandy loam
		E (15–19 in.)	Grey and light gray sand
		Cg1 (19–23 in.)	Greenish gray sandy loam with redoxomorphic concentrations
		Cg2 (23 in.+)	Greenish gray sandy clay loam with redoxomorphic concentrations

Table 28—*Continued*

Station / Soil Series	Vegetation Community	Soil Horizon	Horizon Description
1000/Bluff	Shallow marsh 1	Oa (0–8 in.)	Black muck; many fine roots
		A (8–10 in.)	Very dark gray sand
		Cg1 (10–20 in.)	Greenish gray sandy loam with redoxomorphic concentrations
		Cg2(20 in.+)	Greenish gray sandy clay loam with redoxomorphic concent.

surface layer observed within the Bluff soil sampled at transect 6 increased in depth as the transect surface elevation decreased. Table 28 lists detailed soil sampling descriptions.

FIELD DATA TRANSECT 7

Transect 7 was also located on the west shore of Lake Monroe, east of Interstate 4 (Table 29 and Figures 2, 5, and 8). This transect site was established in order to characterize the extensive marsh vegetation communities on the west lakeshore and to compare the vegetation and soils data with that observed at transect 6 (Figure 8).

Table 29. Lake Monroe transect 7 location and field work dates

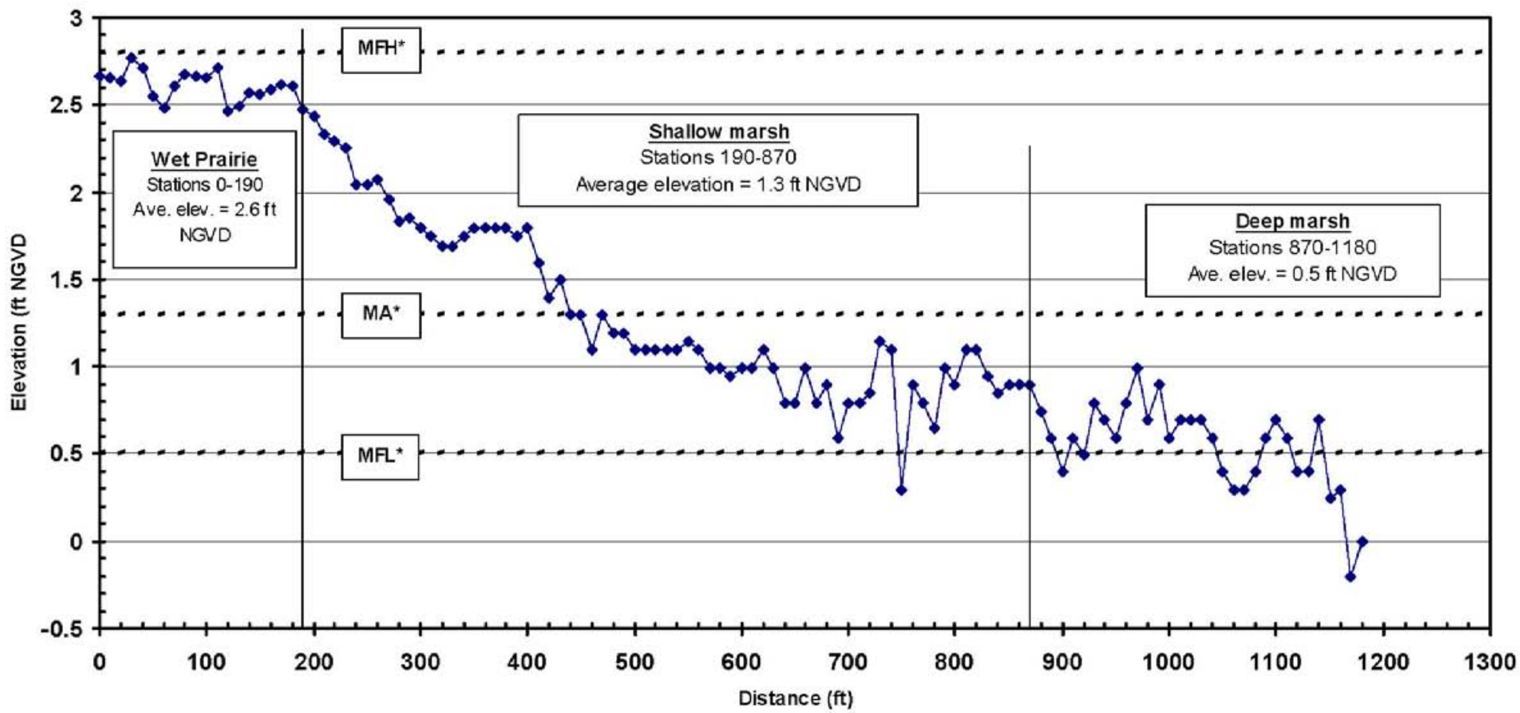
Latitude–Longitude (Station 0; hammock)	Location and Date of Fieldwork
28 50 55.135 81 18 17.407	West shore of Lake Monroe, Volusia County; March and April 2003

Vegetation at Transect 7

Transect 7 traversed 1,180 ft in a southeasterly direction. This transect originated in a wet prairie, then traversed an extensive shallow marsh and a deep marsh adjacent to the open water of Lake Monroe. (Figures 22 and 23; Tables 30 and 31).

Figure 22. Lake Monroe Transect 7 topography with ecological communities

*The Minimum Frequent High (MFH) equals 2.8 ft NGVD, the Minimum Average (MA) equals 1.2 ft NGVD, and the Minimum Frequent Low (MFL) equals 0.5 ft NGVD



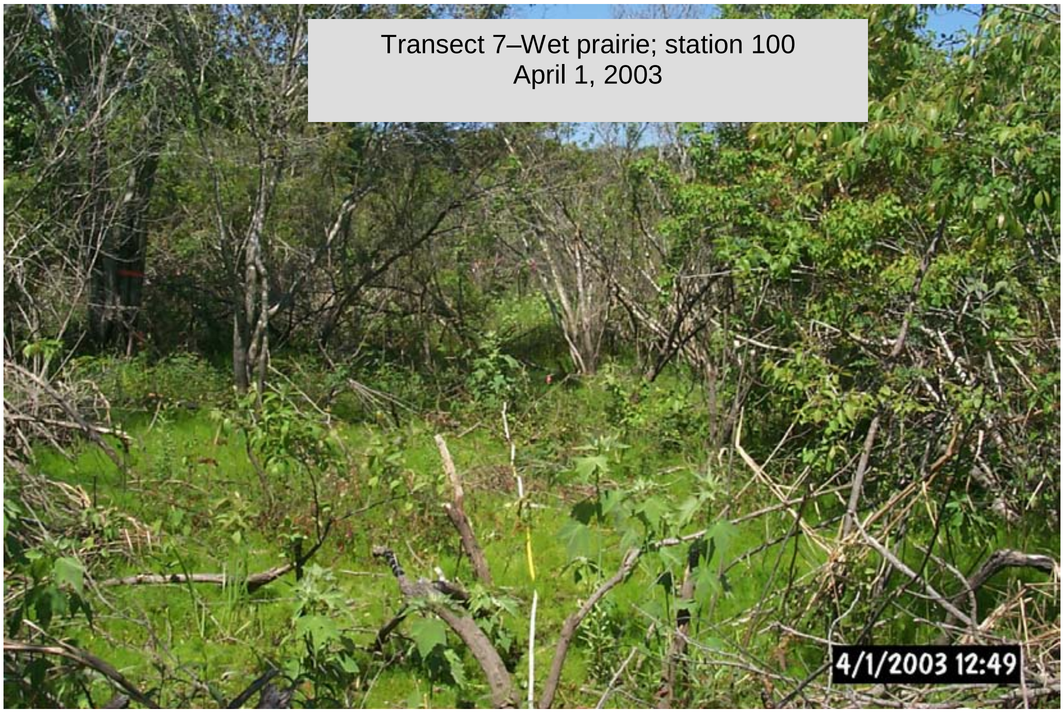


Figure 23. Transect 7 photos

Figure 23—*continued*

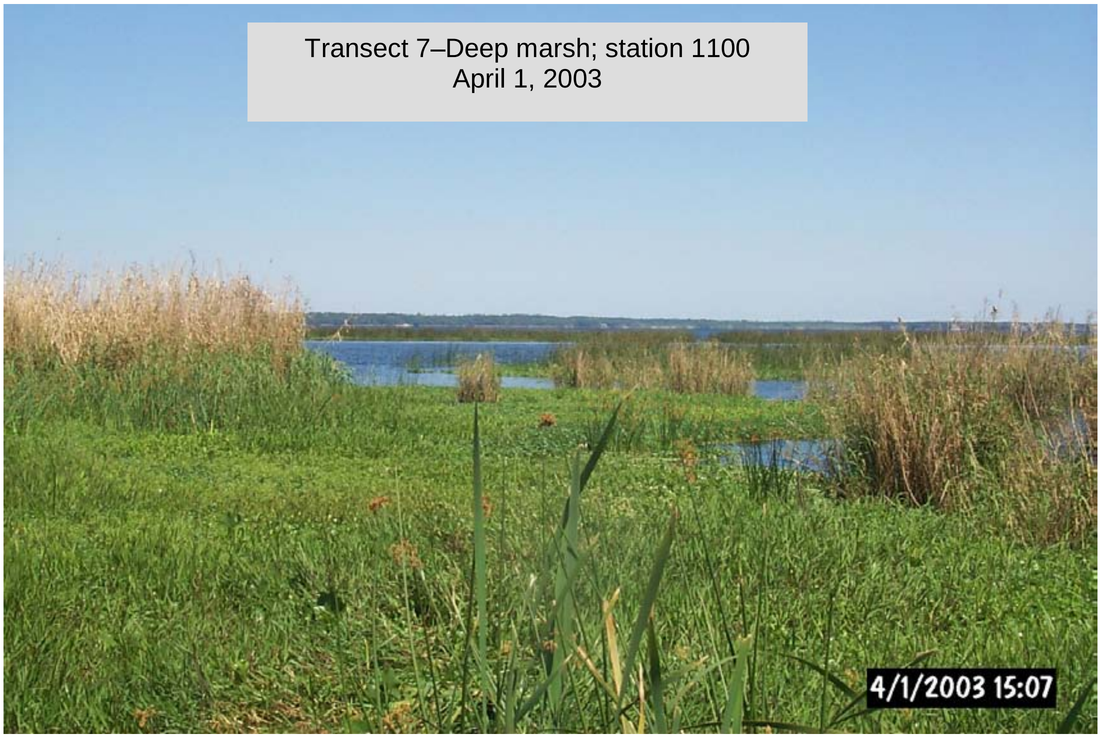


Figure 23—*continued*

Table 30. Lake Monroe transect 7 vegetation community elevation statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N*
Wet prairie	0–190	2.6	2.6	2.5	2.8	20
Shallow marsh	190–870	1.3	1.1	0.3	2.5	69
Deep marsh	870–1180	0.5	0.6	-0.2	1.0	32

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

Table 31. Lake Monroe transect 7 vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]		
			WP	SM	DM
American cupscale	Sacciolepsis striata	OBL		2	2
American elm	Ulmus americana	FACW	1		
Butterweed	Senecio glabellus	OBL		1	
Buttonbush	Cephalanthus occidentalis	OBL		2	1
Carolina willow	Salix caroliniana	OBL		2	3
Cattail	Typha sp.	OBL		1	4
Chinese tallow	Saprium sebiferum	FAC	1		
Coast cockspur-grass	Echinochloa walteri	OBL	1	1	3
Common reed	Phragmites australis	OBL			2
Dotted smartweed	Polygonum punctatum	OBL	2	1	2
Groundsel tree	Baccharis glomeruliflora	FAC	1		
Loosestrife	Lythrum alatum	OBL	1		
Marsh pennywort	Hydrocotyle umbellate	OBL		2	2
Mist flower	Conoclinium coelestinum	FAC	1		
Mock bishop's-weed	Ptilimnium capillaceum	OBL	5	2	
Pepper-vine	Ampelopsis arborea	FAC	2		
Pickerelweed	Pontederia cordata	OBL			1
Red maple (saplings)	Acer rubrum	FACW	2		
Sand cordgrass	Spartina bakeri	FACW	1	3–4	
Smartweed	Polygonum densiflorum	OBL			3
Soft stem bulrush	Scirpus validus	OBL			1
Spikerush	Eleocharis sp.	OBL	2		
Stiff marsh bedstraw	Galium tinctorium	FACW	1		
Swamp gum	Nyssa aquatica	OBL	1	2	
Swamp rosemallow	Hibiscus grandiflorus	OBL	1	4	1

Table 31—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Communities[2] With Plant Species Cover Estimates[3]		
			WP	SM	DM
Unknown sedge	Carex sp	FACW	1		
Variable panicum	Panicum commutatum	FAC	2		
Water lettuce	Pistia stratioles	OBL			1
Wax myrtle	Myrica cerifera	FAC	2		
Wax myrtle (dead)	Myrica cerifera	FAC	3		

[1]FWDM Code indicator categories established in Florida Wetlands Delineation Manual (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 uplands
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
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 uplands

[2] Plant community abbreviations:
WP = wet prairie (stations 0–190)
SM = shallow marsh (stations 190–870)
DM = deep marsh (stations 870–1180)

[3] Plant Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant)

The wet prairie (stations 0–190) overstory vegetation contained numerous wax myrtle; abundant dead wax myrtle; and scattered American elm, swamp gum, Chinese tallow (Saprium sebiferum), and groundsel tree. The wet prairie understory vegetation contained dominant mock bishop's weed; numerous variable panicum, spikerush (Eleocharis sp.), dotted smartweed, and pepper vine; and scattered swamp rosemallow, coast cockspur-grass, loosestrife, sand cordgrass, stiff-marsh bedstraw, mistflower, and an unknown sedge.

Adjacent to the wet prairie, transect 7 traversed an extensive shallow marsh (stations 190–870). The shallow marsh vegetation consisted of co-dominant swamp rosemallow; abundant to co-dominant sand cordgrass; numerous Carolina willow, American cupscale, marsh pennywort, buttonbush, swamp gum saplings, and mock bishop's weed; and scattered dotted smartweed, coast cockspur-grass, butterweed, and cattail.

Adjacent to the shallow marsh, transect 7 traversed and terminated in a deep marsh (stations 870–1180). The deep marsh vegetation consisted of co-dominant cattail; abundant Carolina willow and coastal cockspur-grass;

numerous marsh pennywort, common reed, American cupscale, smartweed, and dotted smartweed; and scattered swamp rosemallow, buttonbush, soft stem bulrush, water lettuce, and pickerelweed. Additional plant species observed along transect 7 are listed in Table 31.

Soils at Transect 7

Bluff series soil was mapped (SCS 1980) for the entire length of transect 7. Field soils investigations during March 2003 found Bluff series soil at stations 0–550 (Table 32). All soils sampled had the hydric soil indicators of a muck surface layer and a dark surface. Bluff series soil is comprised of sandy clays and clay loams which formed in alkaline marine sediments. The water table is at depths of less than 10 in. below the soil surface for 6 or more months and seldom recedes to depths of more than 20 in. below the soil surface. These soils are subject to frequent flooding for long durations (USDA, NRCS 2005). According to the NRCS (2003), some pedons of Bluff soil have a muck layer on the surface up to a 5-in. thickness.

Table 32. Lake Monroe transect 7 soil descriptions

Station / Soil series	Vegetation Community	Soil Horizon	Horizon Description
0/Bluff	Wet prairie	Oa (0–1 in.)	Black muck; many fine roots
		A1 (1–1.5 in.)	Black mucky sand, many fine roots
		A2 (1.5–7 in.)	Black loamy sand, few moderate roots
		A3 (7–14 in.)	Black sandy loam
		Cg (14–60 in. +)	Greenish gray sandy loam, redoxomorphic concentrations
100/Bluff	Wet prairie	Oa (0–1 in.)	Black muck; many fine roots
		A1 (1–1.5 in.)	Black mucky sand, many fine roots
		A2 (1.5–7 in.)	Black loamy sand, few moderate roots
		A3 (7–18 in.)	Black sandy loam
		Cg1 (18–23 in.)	Greenish gray coarse sandy loam with redoxomorphic concentrations
		Cg2 (23–33 in. +)	Greenish gray fine sandy loam with redoxomorphic concentrations
200/Bluff	Shallow marsh	Oa (0–1 in.)	Black muck; many fine roots
		A1 (1–1.5 in.)	Black mucky sand, many fine roots
		A2 (1.5–17 in.)	Very dark gray sandy loam with redoxomorphic concentrations
		Cg1 (17–48 in.)	Greenish gray coarse sandy loam with redoxomorphic concentrations
		Cg2 (48 in. +)	Greenish gray sandy clay loam with redoxomorphic concentrations

Table 32—*Continued*

Station / Soil series	Vegetation Community	Soil Horizon	Horizon Description
300/Bluff	Shallow marsh	Oa (0–1.5 in.)	Black muck; many fine roots
		A1 (1.5–3 in.)	Black mucky sand, many fine roots
		A2 (3–17 in.)	Black sandy loam
		Cg (17–58 in.+)	Greenish gray fine sandy loam with redoxomorphic. concentrations
400/Bluff	Shallow marsh	Oa (0–1 in.)	Black muck; many fine roots
		A1 (1–1.5 in.)	Black mucky sand, many fine roots
		A2 (1.5–17 in.)	Very dark gray sandy loam
		Cg1 (17–28 in.)	Greenish gray coarse sandy loam with redoxomorphic concentrations
		Cg2 (28–36 in. +)	Greenish gray fine sandy loam with redoxomorphic concentrations
550/Bluff	Shallow marsh	Oa (0–2 in.)	Black muck; many fine roots
		A1 (2–2.5 in.)	Black mucky sand, many fine roots
550	Shallow marsh	A2 (2.5–26 in.)	Very dark gray sandy loam
		Cg (26–31 in.+)	Greenish gray sandy clay loam with redoxomorphic concentrations
600/ Unknown	Shallow marsh	Oa (0– 8 in.)	Black muck
700/ Unknown	Shallow marsh	Oa (0–11 in.)	Black muck
800/Unknown	Shallow marsh	Oa (0–16 in.)	Black muck
900/Unknown	Deep marsh	Oa (0–12 in.)	Black muck
1000/Unknown	Deep marsh	Oa (0–25 in.)	Black muck
1100/Unknown	Deep marsh	Oa (0–18 in.)	Black muck

Detailed soil sampling between station 550 and 1180 (transect end) was not possible due to deep-water inundation. Soil probing occurred between stations 550 and 1100 to determine the surface organic soil depths. A general increase in organic depth was reported as the transect elevation decreased. Table 32 lists additional soil sampling descriptions.

MINIMUM LEVELS FOR LAKE MONROE

Minimum Frequent-High Level (2.8 ft NGVD)

The recommended minimum frequent-high level determined for Lake Monroe equals 2.8 ft NGVD. This level corresponds to a typical seasonally flooded lake stage. The minimum frequent-high level is associated with duration and a return interval such that during extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur, on average, for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15) *F.A.C.*). Model results based upon gauge data for the period from 1953 through 1998 (Robison 2004) indicate that a lake level equal or greater than 2.8 ft NGVD occurs under existing conditions for approximately 30 continuous days, on average, 6 out of every 10 years (return interval of 1.7 years). The recommended minimum frequent-high level for Lake Monroe results in a change in the return interval of this flooding event from an event which historically occurred, on average, every 1.7 years to a flooding event which would occur, on average, every 2.0 years, while maintaining a 30-continuous-day duration at a stage of 2.8 ft NGVD (Table 33).

Table 33. Minimum surface water levels for Lake Monroe, Volusia and Seminole counties

Minimum Levels	Elevation (ft NGVD) 1929 datum	Duration	Return Interval
Minimum frequent-high level	2.8	30 days	2 years
Minimum average level	1.2	180 days	1.5 years
Minimum frequent-low level	0.5	120 days	5 years

ft NGVD = feet National Geodetic Vertical Datum

The recommended minimum frequent-high level of 2.8 ft NGVD equals the average elevation of the hardwood swamp surveyed at transect 4 (Tables 18 and 33; Figure 16). The average elevations of the other hardwood swamps surveyed at transects 1, 2, and 3 were equal or similar at 2.7, 2.8, and 2.3 ft NGVD, respectively. Major alterations have occurred within possibly all wetlands surveyed at Lake Monroe. Soil sampling indicated unusual soil stratification presumably due to dredge spoil deposited at all transects except for transect 4. Consequently, the average elevation of the extensive hardwood swamp surveyed at transect 4 was chosen as the primary criterion for the determination of the minimum frequent-high level.

The recommended minimum frequent-high level of 2.8 ft NGVD for Lake Monroe will ensure inundation and / or soil saturation within the hardwood swamps at least every one to two years for a period of several weeks to several months. Water depths will range between 0 and 1.5 ft in the hardwood swamps when the lake level equals the recommended minimum frequent-high level of 2.8 ft NGVD. Monk (1968) described hardwood swamps as being dominated primarily by broad-leaved deciduous species and as occurring along creeks, rivers, sloughs, and basins that are flooded seasonally. According to Ewel (1990), hardwood swamps have a hydroperiod of approximately 6–9 months, a fire frequency of one per century, an organic matter accumulation of deeper than 40 in., and a water source of shallow groundwater. Dominant species typically include swamp blackgum, red maple, pop ash, water elm, cypress, and willows (Kinser 1996).

Additionally, the recommended minimum frequent-high level of 2.8 ft NGVD is very similar to the average elevations of three wet prairie communities surveyed at Lake Monroe (transects 4, 6 and 7; 2.9, 2.9, and 2.6 ft NGVD, respectively) (Table 34). A fourth wet prairie at Lake Monroe had an average elevation of 3.3 ft NGVD and the average elevation of all the Lake Monroe wet prairie points surveyed equaled 3.0 ft NGVD. The average elevation of a wet prairie is a criterion frequently applied when determining the minimum frequent-high level of a lake or river system. Wet prairies experience short hydroperiods (50–150 days per year) (Kushlan 1990). Wet prairies occur on relatively flat, low, poorly drained land (FNAI, FDNR 1990). Soils usually consist of sands, which may contain a clay or organic matter component. When organic matter is present, accumulations are generally only up to a few inches deep (Kushlan 1990). Wet prairie soils sampled at Lake Monroe were mineral with a shallow (0.5–2.0 in.) surface organic horizon. Defining the wet prairie ecotones between the adjacent shallow marsh communities and/or hydric hammocks at Lake Monroe was difficult due to very gradual and broad transition zones. Consequently, the average elevation of the wet prairies was not chosen as the primary minimum frequent-high level criterion for Lake Monroe.

The recommended minimum frequent-high level of 2.8 ft NGVD also equals the average surface elevation of the deep organic soils (histosols) surveyed in the hardwood swamps at transects 2, 3, and 4 and palm hydric hammock 1 at transect 4. This organic soil average elevation was calculated from 230 elevation points. The majority (n = 227) of these points were observed within the various hardwood swamps with the remaining three points located

Table 34. Lake Monroe vegetation transect summary statistics

Vegetation Community	**Stations** Distance (ft)	**Mean** (ft NGVD)	**Median** (ft NGVD)	**Min** (ft NGVD)	**Max** (ft NGVD)	**N***
Upland pasture (TR. 4)	0–935	18.8	19.0	14.6	23.4	48
Oak hammock (TR. 4)	935–1380	10.1	10.0	5.8	14.8	33
Upland oak hammock (TR. 5)	0–130	8.2	8.3	5.5	11.0	14
Disturbed agricultural(TR. 2)	0–180	8.1	8.5	7.3	8.7	12
Hydric hammock (TR. 3)	1160–1340	5.9	5.8	5.5	6.5	10
Hydric Hammock (TR. 1)	300–980	5.9	6.0	4.6	6.8	35
Hydric hammock (TR. 2)	180–380	4.7	4.6	3.9	6.6	11
Palm hydric hammock (TR. 6)	0–70	4.5	4.5	4.1	4.9	8
Palm hydric hammock 1 (TR. 4)	1380–1800	4.4	4.3	3.4	5.9	26
Trans. hardwood swamp–hydric hammock (TR. 1)	260–300	4.2	4.1	3.8	4.6	3
Palm hydric hammock 2 (TR. 4)	5800–9480	4.0	4.0	3.6	4.4	184
Hydric hammock (TR. 5)	130–180	3.9	3.8	2.7	5.5	8
Lower hydric hammock (TR. 6)	70–160	3.8	3.9	3.5	4.1	10
Wet prairie 1(TR. 4)	5170–5800	3.3	3.3	2.9	4.0	35
Wet prairie points (TR 4, 6 and 7)		3.0	3.0	2.2	4.0	131
Wet Prairie 2 (TR. 4)	9480–10340	2.9	2.9	2.2	3.8	44
Wet prairie (TR. 6)	160–470	2.9	2.9	2.4	3.5	32
Wet prairie (TR. 7)	0–190	2.6	2.6	2.5	2.8	20
Hardwood swamp (TR. 4)	1800–5170	2.8	2.8	1.8	4.2	176
Hardwood swamp (TR. 2)	380–1360	2.8	2.7	1.7	3.9	51
Hardwood swamp (TR. 1)	37–260	2.7	2.7	1.6	3.8	14
Hardwood swamp (TR. 3)	40–1160	2.4	2.0	1.3	5.7	57
Willow shrub swamp (TR. 5)	180–220	1.5	1.2	0.5	2.7	5
Shallow marsh 1 (TR. 6)	470–1100	1.5	1.4	0.5	2.4	64
Shallow marsh (TR. 7)	190–870	1.3	1.1	0.3	2.5	69
Shallow marshes TR. 5, 6, and 7		1.2	1.1	0.0	2.5	234
Shallow marsh 2 (TR. 6)	1470–2010	1.0	1.0	0.2	2.0	55
Shallow marsh without channel (TR. 5)	220–1080	0.9	1.1	0.0	1.4	46
Deep marsh (TR. 7)	870–1180	0.5	0.6	–0.2	1.0	32
Deep marsh (TR. 4)	10340–10560	0.5	0.5	–0.6	2.2	12
Deep marsh (TR. 6)	1100–1470	0.1	0.1	–0.2	0.8	38
Bulrush–waterward extent along west shore near TR. 6 and 7	random	–1.5	–1.5	–1.7	–1. 2	27

N* equals the number of ground elevation points surveyed in each vegetation community
ft NGVD = feet National Geodetic Vertical Datum

within palm hydric hammock 1 adjacent to the hardwood swamp at transect 4. Deep organic soils are indicative of long-term soil saturation and/or surface water inundation. Long-term soil saturation at surface elevations greater than 2.8 ft NGVD within the hardwood swamps is likely maintained by seepage from the adjacent hydric hammocks and localized ponding within these extensive swamps.

The aquatic fauna habitat is greatly expanded when Lake Monroe inundates the forested swamps traversed at transects 1, 2, 3, and 4. Additionally, at the recommended minimum frequent-high level (2.8 ft NGVD), soil saturation and/or inundation will occur in the wet prairie communities at transects 4, 6, and 7 (elevation ranges between 2.2 and 4.0 ft NGVD). Interactions with the adjacent swamps and wet prairies by connecting the river/lake to the floodplain are extremely important to animal productivity in lower coastal plain rivers (Bain 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the river channel/lake to the inundated areas for spawning and feeding. As water levels continue to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of floodplain forests are inundated (Light, et al. 1998).

The palm hydric hammocks, hydric hammocks, and the transitional hardwood swamp–hydric hammock communities traversed at Lake Monroe will experience surface water inundation when the lake rises to an infrequent high level (>3.5 ft NGVD). However, more frequent surface water ponding will occur during the rainy season within these hammocks due to local rainfall and the poorly drained soil characteristics. Vince et al. (1989) suggest that hydric hammocks dominated by cabbage palm and live oak exist where long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated less often, perhaps only once per decade due to tropical systems impacting the Upper St. Johns River Basin.

Additionally, river and lake water quality may improve significantly as water flows through the floodplain. The floodplain with its vast back swamp, functions as an important filter and sink for dissolved and suspended constituents (Wharton et al. 1982).

Minimum Average Level (1.2 ft NGVD)

The recommended minimum average level determined for Lake Monroe is 1.2 ft NGVD. The minimum average level approximates a typical lake stage that is slightly less than the long-term median water level while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The recommended minimum average level corresponds to a water level that is expected to occur, on average, every year or 2 for about 6 months during the dry season. Model results based upon gauge data for the period from 1953 through 1998 (Robison 2004) indicate that under existing conditions the Lake Monroe stage occurs at or below 1.2 ft NGVD for duration of 180 days approximately every 1.7 years. The recommended minimum average level results in a change in the return interval of this dry season event from an event which historically occurred, on average, every 1.7 years to an event which would occur, on average, every 1.5 years, while maintaining a 180-day duration at a stage of 1.2 ft NGVD.

The minimum average level of 1.2 ft NGVD equals the average elevation of all the shallow marsh points surveyed at Lake Monroe (transects 5, 6, and 7; Table 34). Saturated or inundated soil conditions in the shallow marshes, as provided by the recommended minimum average level at Lake Monroe, will maintain the wetland vegetation while preventing long-term encroachment of upland plant species into the shallow marshes.

Bluff soils, which experience frequent flooding for long durations (USDA, NRCS 2005), were identified over a broad extent in the shallow marshes at transects 6 and 7 at an average elevation of 1.6 ft NGVD. Additionally, according to the NRCS (2003), the Bluff series soil water table occurs at depths of less than 10 in. from the soil surface for 6 months or more in most years. At the recommended minimum average level of 1.2 ft NGVD the maximum Bluff soil water table drawdown in the shallow marshes at transect 6 and 7 would equal 14 in. and 16 in., respectively. A 14-in. and 16-in. soil water table drawdown at the upper elevations of the shallow marshes, with soil saturation at the average elevation of the shallow marshes and shallow ponding at the lower elevations within the shallow marshes at transect 6 and 7 typify annual dry season conditions for Bluff soil in these shallow marsh communities.

Additionally, soil saturation and inundation will prevent organic soil oxidation in the shallow marshes traversed at transects 5, 6, and 7. Deep (>34 in.) organic soils were observed throughout the shallow marsh at transect 5 (Table 24). The shallow marsh traversed at transect 5 had an average elevation equal to 0.9 ft NGVD with an elevation ranging between 0 and 1.4 ft NGVD. A shallow (1 in. to >16 in.) organic surface horizon was observed within the marshes traversed at transects 6 and 7. A histic epipedon

(8–16 in.-thick organic horizon) was observed at one location (Table 28) in shallow marsh 1 at transect 6 where the elevation equaled 0.8 ft NGVD. A histic epipedon or histosol ($\geq$16-in.-thick organic horizon) was observed at the lower elevations within the shallow marsh at transect 7 (Table 32). The area of shallow marsh at transect 7 where a histic epipedon or histosol was observed had an average surface elevation equal to 0.9 ft NGVD with an elevation ranging between 0.3 and 1.1 ft NGVD. Consequently, the organic soils in the shallow marshes at transects 5, 6, and 7 would be protected by saturation or surface water inundation at the recommended minimum average level of 1.2 ft NGVD.

Typically, where organic soils (histosol or histic epipedon) are observed, a 0.3-ft organic soil drawdown criterion is employed when determining the minimum average level. This criterion (0.3 ft below mean surface elevation of organic soils) has been used to protect muck soils in other MFLs determinations and was developed for Everglades peat soils (Stephens 1974). Studies of marshes in the Upper St. Johns River Basin (Brooks and Lowe 1984; Hall 1987) determined that this 0.3 ft-depth corresponds to a water level exceeded approximately 60% of the time. Studies of the Wekiva River system found this hydrologic condition can also be expressed as the low stage occurring, on average, every 1 to 2 years with a duration of less than or equal to 180 days (Hupalo et al. 1994).

The 0.3-ft organic soil drawdown criterion was not the primary minimum average level criterion for Lake Monroe for the following reasons:

- Mineral soils (Bluff series) were observed exclusively in shallow marsh 1 at transect 6
- Bluff series soil was also observed exclusively at the higher elevations (stations 200–550) within the shallow marsh at transect 7
- Portions of the shallow marsh at transect 5 were floating. Consequently, the transect 5 shallow marsh average elevation may not represent a typical shallow marsh community elevation at Lake Monroe.
- Based upon the *1914 Florida Atlas* (Moore 1987), transect 5 traversed what appears to be a relic open-water slough of Lake Monroe. The hydrology along the northwest shore, including the slough / shallow marsh at transect 5, was permanently altered by the completion of Interstate 4 in 1961. Interstate 4 separates a large marsh and open water area from direct connectivity to the lake, except for a narrow, at times water hyacinth

clogged, passage via the Gemini Springs run at the northwest corner of Lake Monroe. Additionally, the transect 5 marsh is hydrologically influenced by Gemini Springs run.

- If the 0.3-ft organic soil drawdown minimum average level criterion is used, thereby subtracting 0.3 ft from the average organic soil surface elevation in the shallow marshes at transect 5 and 7 (average surface elevation = 0.9 ft NGVD), the resulting Lake Monroe minimum average level would equal 0.6 ft NGVD. A lake stage equal to 0.6 ft NGVD is exceeded approximately 80% of the time (Figure 7). As found with the minimum levels determination for the St. Johns River near DeLand (Mace 2006b), the St. Johns River stage at Lake Monroe exists near sea level for long durations and the use of the minimum average level organic soil drawdown criterion results in an unrealistically low lake stage.

In addition, at the recommended minimum average level of 1.2 ft NGVD, the water depths (range 0–1.2 ft) in the shallow marshes traversed at transects 5, 6, and 7 are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Dropping water levels cause fish to be concentrated in isolated pools throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Minimum Frequent-Low Level (0.5 ft NGVD)

The recommended minimum frequent-low level for Lake Monroe is 0.5 ft NGVD. This level represents a low lake stage that generally occurs only during moderate drought. The minimum frequent-low level is predicted to occur on average, approximately once every 5–10 years for duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity. Model results based upon gauge data for the period from 1953 through 1998 (Robison 2004) indicate that under existing conditions the recommended minimum frequent-low level for Lake Monroe occurs for duration of 120 continuous days approximately once every 10 years. The recommended minimum frequent-low level results in a change in the return interval of this drought event from an event which historically occurred, on average, every 10 years to an event which would occur, on average, every 5 years, while maintaining a 120-day duration at a stage of 0.5 ft NGVD.

The recommended minimum frequent-low level of 0.5 ft NGVD for Lake Monroe equals the average elevation of the deep marshes surveyed at transects 4 and 7 (Table 34). According to Kinser (1996), deep marshes are semi-permanently to permanently flooded. In the deep marshes at transects 4 and 7 the water depths will range between 0 in. and 13 in. with a soil water table drawdown ranging from inundated to 20 in. below the soil surface. A deep marsh was also traversed at transect 6 (Figure 20). The transect 6 deep marsh had a lower average elevation (0.1 ft NGVD) and will be hydrologically protected at the recommended minimum frequent-low level.

When Lake Monroe equals the recommended minimum frequent-low level the Bluff soil water table drawdown in the shallow marshes at transects 6 and 7 will range between inundated to 24 in. below the soil surface. According to the NRCS (2003), the water table in Bluff soils seldom recedes to a depth of more than 20 in. below the soil surface. Bluff soils were also observed in the wet prairies, palm hydric hammock 2, and the deep marsh at transect 4. Within these communities, the water table drawdown will range between inundated at the lower elevations of the deep marsh to an average 42-in. soil water table drawdown within palm hydric hammock 2. However, shallow groundwater seepage likely occurs at the higher elevations limiting a soil water table drawdown to an average depth of 42 in., in palm hydric hammock 2.

At the recommended minimum frequent-low level of 0.5 ft the organic soil water table drawdowns within the hardwood swamps traversed at transects 1, 2, 3, and 4 would average 26, 28, 23, and 28 in. respectively. Typically, where extensive organic soils occur, the minimum frequent-low level is based upon an average organic soil water table drawdown of 20 in. However, due to the unusual soil stratification observed in the organic soils in the hardwood swamps at transects 1–3, with the high elevation extent of organic soils into palm hydric hammock 1 at transect 4, and the low elevation extent of organic soils in the shallow marshes at transects 5 and 7, the 20-in. organic soil water table drawdown criterion was not used for determining the minimum frequent-low level at Lake Monroe. The 20-in. average soil water table drawdown criterion was based upon the following literature:

Hydroperiods and Water Level Depths of Freshwater Wetlands in South Florida: A Review of the Scientific Literature, ESE 1991—"Seasonally flooded marsh systems had an average hydroperiod of 255 +/– 11.1 days (n = 29), with an average minimum dry season depth of –53 cm +/– 13.5 cm (20.9 in. +/– 5.3 in.)."

Soil Survey of Volusia County, Florida, USDA, SCS 1980—"In Gator muck the water table is at or above the soil surface in spring, summer, and fall and is within 10 in. of the soil surface in winter. In Terra Ceia muck the water table is as much as 2 ft above the soil surface during the rainy season. It is at or above the surface for 6 to 9 months in most years and is seldom below a depth of 10 in. except during extended dry periods."

Soil Survey of Brevard County, Florida, USDA, SCS 1974—"In Tomoka muck, the soil water table is within a depth of 10 in. for 9 to 12 months in most years, and water is frequently above the surface. In dry periods, it is between 10 and 30 in. In Monteverde peat, the water table is within a depth of 10 in. below the soil surface for 9 to 12 months in most years, and water stands on the surface each year for more than 6 months. In dry seasons the water table is lower, but seldom falls below a depth of 30 in."

The average organic soil water table drawdowns in the hardwood swamps listed above for transects 1–4 at Lake Monroe, at the recommended minimum frequent-low level of 0.5 ft NGVD, are within the organic soils drawdown ranges cited in *Soil Survey of Brevard County* (USDA, SCS 1974) and in *Hydroperiods and Water Level Depths of Freshwater Wetlands in South Florida: A Review of the Scientific Literature* (ESE 1991). Additionally, unique topographic and hydrologic features at transects 1–4 likely provide wetter soil water table conditions than expected by the minimum frequent-low lake surface water level. For example, at transects 2 and 4, creeks bisect the hardwood swamps, providing additional moisture to these hardwood swamps. Additionally, all four hardwood swamps likely receive groundwater seepage from the hydric hammocks immediately upslope.

At the recommended minimum frequent-low level of 0.5 ft NGVD, shallow ponding would occur at the lower elevations of the shallow marshes, where the deep marshes and the bulrush beds traversed at transects 5, 6, and 7 at Lake Monroe (Table 35). Shallow ponding in the marshes and aquatic beds provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Aquatic habitats, such as the marshes and aquatic beds, connected to

Table 35. Water depths in Lake Monroe marshes at the minimum frequent-low level (0.5 ft NGVD)

Vegetation Community	Stations Distance (ft)	Water Depth (in.)
Shallow marsh 1 (TR. 6)	470–1100	saturated
Shallow marsh (TR. 7)	190–870	0–2.4
Shallow marsh 2 (TR. 6)	1470–2010	0–3.6
Shallow marsh without channel (TR. 5)	220–1080	0–6
Deep marsh (TR. 7)	870–1180	0–8.4
Deep marsh (TR. 4)	10340–10560	0–13.2
Deep marsh (TR. 6)	1100–1470	0–8.4
Bulrush-waterward extent along west shore near TR. 6 and 7	random	20.4–26.4

the open water of Lake Monroe, are of crucial importance to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters, serving as refugia from the deep, flowing rough waters of the main channel and lake (Light, et al. 1998).

Additionally, at the recommended minimum frequent-low level, the shallow water depths in the marshes traversed at Lake Monroe, serving as ideal habitat for wading bird foraging. As mentioned previously, wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in., and the small herons need depths of 6 in. or less. Dropping water levels cause fish to be concentrated in isolated pools throughout the marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

VALIDITY OF RECOMMENDED MINIMUM LEVELS FOR LAKE MONROE

The process of developing recommended minimum levels for Lake Monroe included a multitude of information-gathering tasks and subsequent analyses. The foundation of this effort was comprised of the field collected elevation, vegetation, and soils data. The field data were used to characterize the floodplain wetland communities. Multiple site visits occurred at all field transects at Lake Monroe to improve the ability to characterize the wetland communities. The basic wetland community classifications and distribution of overall community types were stable between 2002 and 2006. The wetland communities were then related to the natural flooding and drying regime of Lake Monroe. Use of the best available information from the scientific literature, ecological maps, personal communications with on–site public land managers, analyses of many years of lake/river stage data, and intensive surface water modeling (Robison 2004) combined with the extensive field data collection effort, resulted in the recommended minimum levels.

The establishment of minimum levels should consider natural seasonal fluctuations in water levels, nonconsumptive uses, and the 10 water resource values (WRVs) associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology (Section 62–40.473, *F.A.C)*. Environmental Consulting and Technology Inc. (ECT 2006), contracted by SJRWMD, conducted an environmental assessment to determine whether the minimum levels recommended within this report for Lake Monroe protect the 10 WRVs. ECT Inc. conducted this assessment by examining differences between two water level regimes for Lake Monroe: (1) existing conditions and (2) a constant surface water withdrawal from Lake Monroe of 180 cfs. The 180-cfs withdrawal regime was determined, through modeling, to represent the withdrawal limits beyond which minimum levels would no longer be met at Lake Monroe. ECT Inc. concluded (ECT 2006) that the minimum levels recommended for Lake Monroe will protect all 10 WRVs listed in Section 62-40.473, *F.A.C.* Additionally, ECT Inc. recommended that the marinas be dredged periodically to allow safe mooring and boat passage, and that detailed bathymetry surveys be conducted within the marinas and in the navigational channels to verify the threshold stage for safe boat passage. ECT Inc. also recommended continued water quality monitoring in and near Lake Monroe to establish a sediment budget for the lake and to provide information for future water quality assessments.

One example in illustrating the strength of the minimum levels field data collected at Lake Monroe included a comparison of the wetland community elevation data surveyed at the seven transects. The similarity of the average elevations of a given wetland community surveyed at different locations in the Lake Monroe floodplain illustrate the strength of the fieldwork methodology. For example, hardwood swamps were surveyed at four locations and had mean elevations equal to 2.8, 2.8, 2.7, and 2.4 ft NGVD. Additionally, wet prairie mean elevations surveyed at five locations equaled 3.3, 3.0, 2.9, 2.9, and 2.6 ft NGVD; and shallow marsh mean elevations surveyed at four locations equaled 1.5, 1.3, 1.0, and 0.9 ft NGVD (Table 34).

Additional analyses, which was performed to illustrate the strength of the methodology and particularly the field data used in the process of developing recommended minimum levels for Lake Monroe, included the development of land surface elevation-duration curves. Land surface elevation-duration curves were created for the hardwood swamp (Figure 24), shallow marsh (Figure 25), and deep marsh (Figure 26) vegetation communities to facilitate visually comparing these vegetation communities surveyed at Lake Monroe. In particular, this comparison focuses on whether or not the field methodology resulted in identical types of vegetation communities being delineated similarly. Similarly delineated vegetation communities should experience similar surface water hydrology at the different transects. The hardwood swamp, shallow marsh, and deep marsh communities were chosen for this analysis because the average elevations of these communities were the primary criteria used in determining the minimum levels for Lake Monroe.

The average ground surface elevation of the hardwood swamp, surveyed at transect 4, was the primary minimum frequent-high level criterion. An analysis of hardwood swamp elevation-duration data (Figure 24) indicates the close and parallel shape of the four hardwood swamp lines. This confirms that the vegetation communities at the different locations were delineated similarly in the field and will experience similar lake hydrology. Typically, in the field the maximum hardwood swamp elevation transition to the upslope hydric hammock was gradual, making the vegetation community delineation difficult. Three of the four hardwood swamps had maximum elevations within 0.4 ft of each other.

Hardwood swamp 3 (Figure 24) is noticeably different with a maximum elevation more than 1 ft greater than the other hardwood swamps maximum elevations. Additionally, the majority of the elevation points surveyed at hardwood swamp 3 were lower than the other hardwood swamps (Figure 24). A possible explanation for the greater maximum elevation at hardwood swamp 3 was spoil deposited at the landward edge of this hardwood swamp community when a nearby agricultural canal was constructed. Because of the markedly greater maximum elevation surveyed at the hardwood swamp–hydric hammock ecotone at transect 3, this hardwood swamp was revisited and the hardwood swamp maximum elevation ecotone location was field verified by additional wetland ecologists.

The minimum hardwood swamp elevations were all within 0.5 ft of each other (Figure 24). Typically, the minimum hardwood swamp elevation occurred at the edge of the open water of Lake Monroe, except for at transect 4.

Figure 24. Lake Monroe hardwood swamp elevation durations

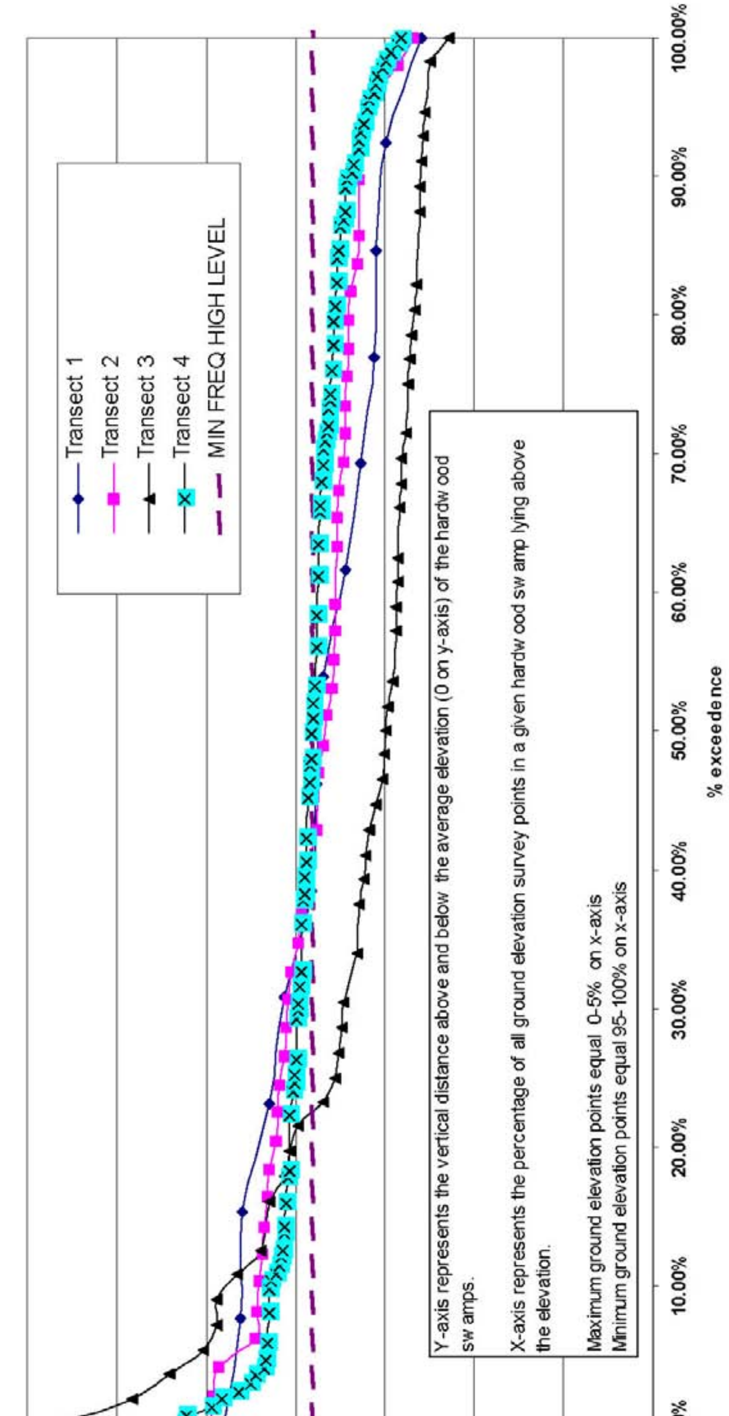


Figure 25. Lake Monroe shallow marsh elevation durations

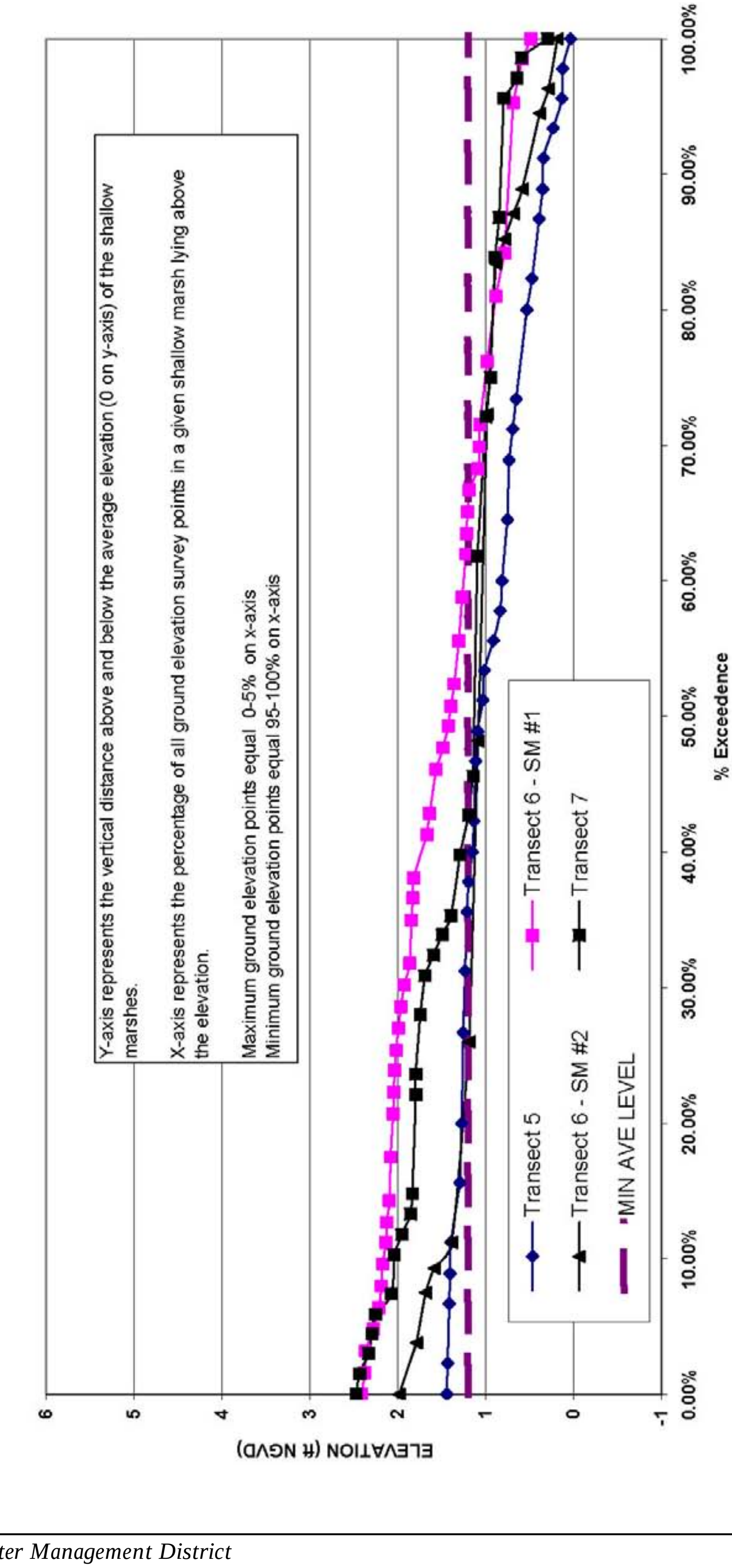
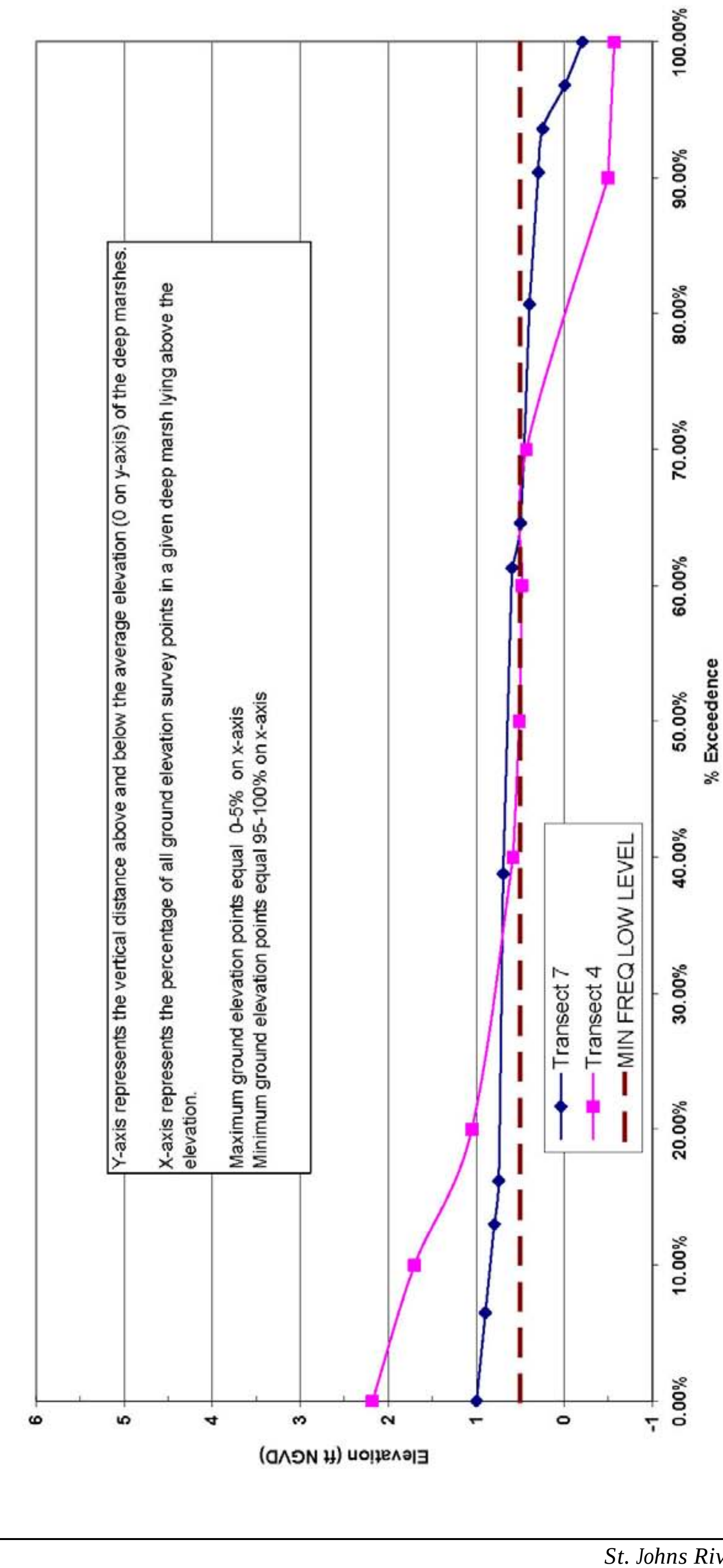


Figure 26. Lake Monroe deep marshes elevation durations



The average ground surface elevation of the shallow marsh community was the primary minimum average level criterion for Lake Monroe. Based on an analysis of shallow marsh elevation-duration data (Figure 25), the parallel shape of the four shallow marshes confirms that this community type was delineated similarly and will experience similar lake hydrology at the different locations. Based on this analysis, the maximum shallow marsh elevations were within 1.0 ft of each other, while the minimum shallow marsh elevations were within 0.4 ft of each other. The closeness of the maximum and minimum elevations confirms that the field methodology was consistent. In fact, shallow marsh 1 at transect 6 and the shallow marsh at transect 7 (Figure 25) are nearly identical. These two shallow marshes were both located between a wet prairie and deep marsh community where vegetation community delineations should be similar. More noteworthy is that field delineations for all four of the shallow marshes (Figure 25) resulted in similar elevations. Shallow marsh 2 at transect 6 is uniquely located on a lakeshore berm between the open water of Lake Monroe and a deep marsh (Figure 20). Meanwhile, the transect 5 shallow marsh, with consistently lower elevations, had a minimum elevation nearly identical to the other shallow marshes. The transect 5 shallow marsh was located on the northwest shore, west of Interstate 4, where the landscape has been altered by the highway construction.

The average ground surface elevation of the deep marsh communities surveyed at transects 4 and 7 were the primary minimum frequent-low level criterion for Lake Monroe. Based on an analysis of deep marsh elevation-duration data (Figure 26), the parallel shape of the two deep marshes confirms that this vegetation community type was delineated similarly and will experience similar lake hydrology at the different locations. Based on this analysis, the maximum deep marsh elevations were within 1.2 ft of each other, while the minimum deep marsh elevations were within 0.4 ft of each other. Although the deep marshes surveyed at transects 4 and 7 are located miles apart on opposite lakeshores, the closeness of the maximum and minimum elevations confirms that the field methodology was consistent.

In summary, the ground elevation-duration curves (Figures 24–26) graphically show the wetland vegetation community data obtained at different locations in the Lake Monroe floodplain and indicate that like-vegetation community types were delineated similarly, thus, adding credibility to the field data collection and ultimately the recommended minimum levels for Lake Monroe.

IMPLEMENTATION OF MINIMUM LEVELS

As changes in hydrologic conditions at or upstream from Lake Monroe are considered, SJRWMD plans to perform modeling evaluations, as outlined in Appendix A, to determine the extent to which the proposed changes are likely to affect minimum levels.

CONCLUSION

The following conclusions are drawn from the information presented in this document.

1. Establishment and enforcement of the recommended minimum levels for Lake Monroe, as presented in this document, should adequately provide for the protection of the water resources or ecology of the area, which includes Lake Monroe and its associated flood plain, from significant harm as a result of consumptive uses of water (Table 36).
2. Periodic reassessments of these recommended minimum levels, based on monitoring data collected in the future, would better assure that these levels are providing the expected levels of protection of the water resources and ecology of the area.

Table 36. Minimum surface water levels for Lake Monroe, Volusia and Seminole counties

Minimum Levels	Elevation (ft NGVD) 1929 datum	Duration	Return Interval
Minimum frequent-high level	2.8	30 days	2 years
Minimum average level	1.2	180 days	1.5 years
Minimum frequent-low level	0.5	120 days	5 years

ft NGVD = feet National Geodetic Vertical Datum

RECOMMENDATION

The following recommendations are offered concerning the information presented in this document.

1. The following recommended minimum levels for Lake Monroe should be considered for establishment and enforcement by rule (Table 37).
2. Existing data collection associated with the development of the recommended minimum levels for Lake Monroe should be continued at least until a comprehensive monitoring plan is developed and implemented.
3. A comprehensive monitoring plan should be developed within 6 months of the date of establishment of minimum levels for Lake Monroe. This plan should include an implementation schedule that assures that identified data collection and management is in place in advance of any significant withdrawals from Lake Monroe.
4. Any proposed changes in hydrologic conditions in Lake Monroe should be evaluated using modeling, as outlined in Appendix A, to determine the extent to which the proposed changes are likely to affect the minimum levels.

Table 37. Minimum surface water levels for Lake Monroe, Volusia and Seminole counties

Minimum Levels	Elevation (ft NGVD) 1929 datum	Duration	Return Interval
Minimum frequent-high level	2.8	30 days	2 years
Minimum average level	1.2	180 days	1.5 years
Minimum frequent-low level	0.5	120 days	5 years

ft NGVD = feet National Geodetic Vertical Datum

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APPENDIX A—IMPLEMENTATION OF MFLS FOR LAKE MONROE

Prepared by
C. Price Robison, P.E., St. Johns River Water Management District (2006)

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 can then 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 philosophy of maintaining the duration and return periods of selected stages and / or flows. Thus, a water body can fall below a minimum level, but if it does so too often and / or for too long, then that minimum level 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 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 estimates how often, on average, a given event will occur. If annual series data are used to generate the statistics, frequency analysis estimates 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 statistics 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

$$P(S \geq \hat{S}_1) = \frac{1}{n} = \frac{1}{10} = 0.1; \qquad \textbf{(A1)}$$

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

$$P(S \geq \hat{S}_2) = \frac{2}{10} = 0.2; \qquad \textbf{(A2)}$$

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

$$P(S \geq \hat{S}_{10}) = \frac{10}{10} = 1.0. \qquad \textbf{(A3)}$$

Since 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:

$$P(S \geq \hat{S}_m) = \frac{m}{n+1} \qquad \textbf{(A4)}$$

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

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{11} = 0.0909; \qquad \text{(A5)}$$

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

$$P(S \geq \hat{S}_{10}) = \frac{10}{11} = 0.9091; \qquad \textbf{(A6)}$$

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

$$P(S < \hat{S}_{10}) = 1 - P(S \geq \hat{S}_{10}) = 1 - \frac{10}{11} = 1 - 0.9091 = 0.0909 \qquad \textbf{(A7)}$$

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

$$T = \frac{1}{P} \qquad \textbf{(A8)}$$

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

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = \frac{1}{\frac{1}{11}} = 11 \qquad \textbf{(A9)}$$

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,

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{21} = 0.048 \tag{A10}$$

and

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = 21 \tag{A11}$$

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 A1 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 A2 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 A3). 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 A4).

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 Lake Monroe MFLs

This section will illustrate the process used to relate long-term hydrologic statistics to the establishment of MFLs. As discussed in the main body of this report, SJRWMD has determined three MFLs on Lake Monroe (1) a minimum frequent high (MFH); (2) a minimum average (MA); and (3) a minimum frequent low (MFL). The MFH for this location will be used to illustrate how long-term hydrologic statistics of a river system relate to MFLs.

Each of the three MFLs is tied to characteristic stage durations and return frequencies. For example, the ground elevation represented by the MFH 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 model simulations of Lake Monroe (Robison 2004). In particular, stages continuously exceeded (ground elevations remaining wet) for 30 days were determined, sorted, ranked, and plotted (Figure A5). The ground elevation of the MFH can be superimposed on the plot (Figure A6) to demonstrate how the level is related to the pertinent hydrologic statistics. Finally, a box bounded by (1) the MFH on the bottom, (2) a vertical line corresponding to a frequency of occurrence of once in every 2 years on the right, and (3) a vertical line corresponding to a frequency of occurrence of once in every 1.5 years on the left, is superimposed on the plot (Figure A7).

As, for example, surface water withdrawals are imposed on Lake Monroe or on the St. Johns River system upstream of Lake Monroe, the pertinent 30-day events will tend to occur less often. Therefore, the plotted events of Figure A7 will tend to shift to the right as conditions become drier. Given large enough withdrawals, eventually all 30-day values will shift outside of the box. In this case, based on modeling results, the MFH will no longer be met. Similar analyses are done for the MA (Figure A8) and the MFL (Figure A9).

Summary of MFLs for Lake Monroe

A summary of the MFLs for Lake Monroe is shown in Table A1. Values in this table will be used as benchmarks for modeling outputs to determine if water withdrawals at or upstream of Lake Monroe will meet MFLs.

Table A1. Summary of MFLs for Lake Monroe

MFLs	Level (ft NGVD)	Duration	Series	Water Year	Statistical Type	Minimum Return period	Maximum Return period
Minimum frequent-high	2.8	30 days	Annual	June 1–May 31	Maximum, continuously exceeded	NA	2 yrs
Minimum average	1.2	180 days	Annual	Oct. 1–Sept. 30	Minimum, mean not exceeded	1.5 yrs	NA
Minimum frequent-low	0.5	120 days	Annual	Oct. 1–Sept. 30	Minimum, continuously not exceeded	5 yrs	NA

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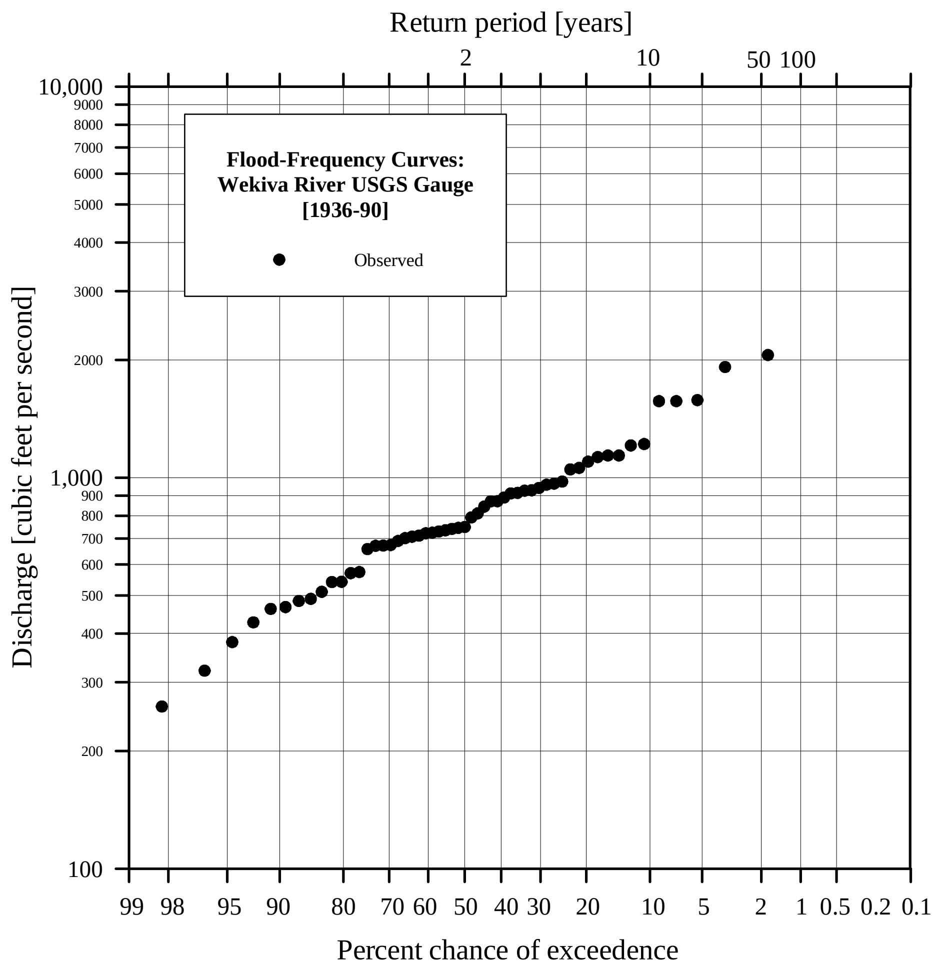

Figure A1. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida. The 1–day peak flows have been sorted, ranked, and plotted according to the Weibull plotting position formula.

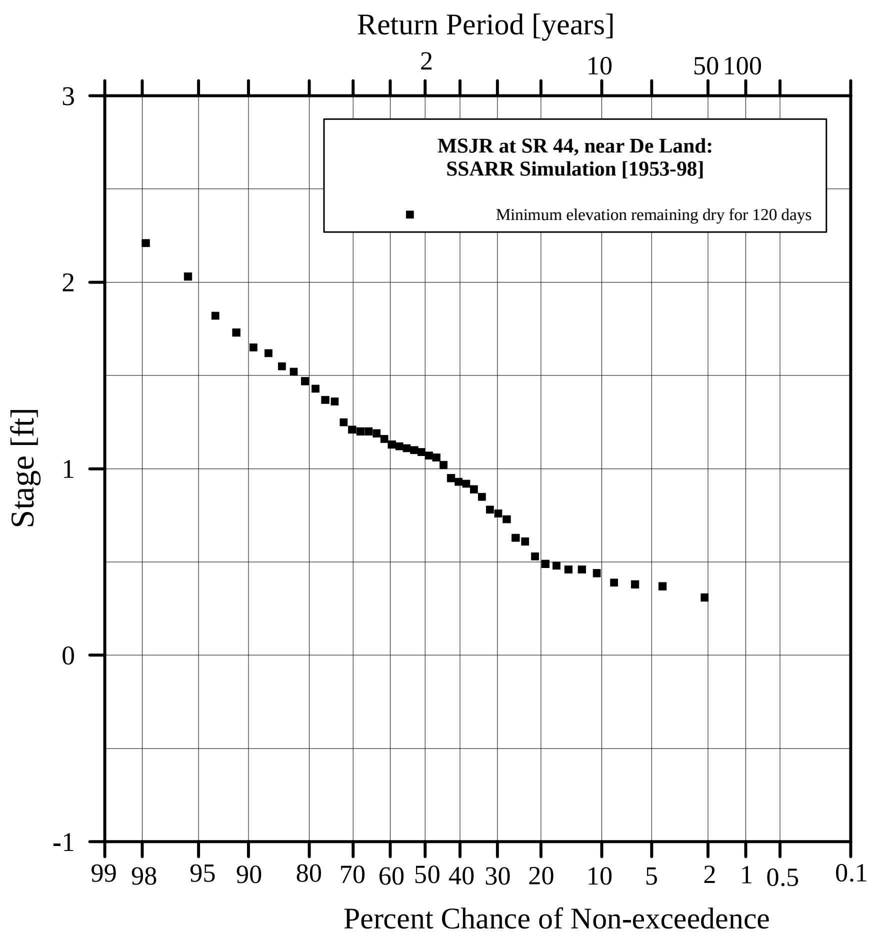

Figure A2. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand. The minimum stages continuously not exceeded for 120 days have been sorted, ranked, and plotted according to the Weibull plotting position formula.

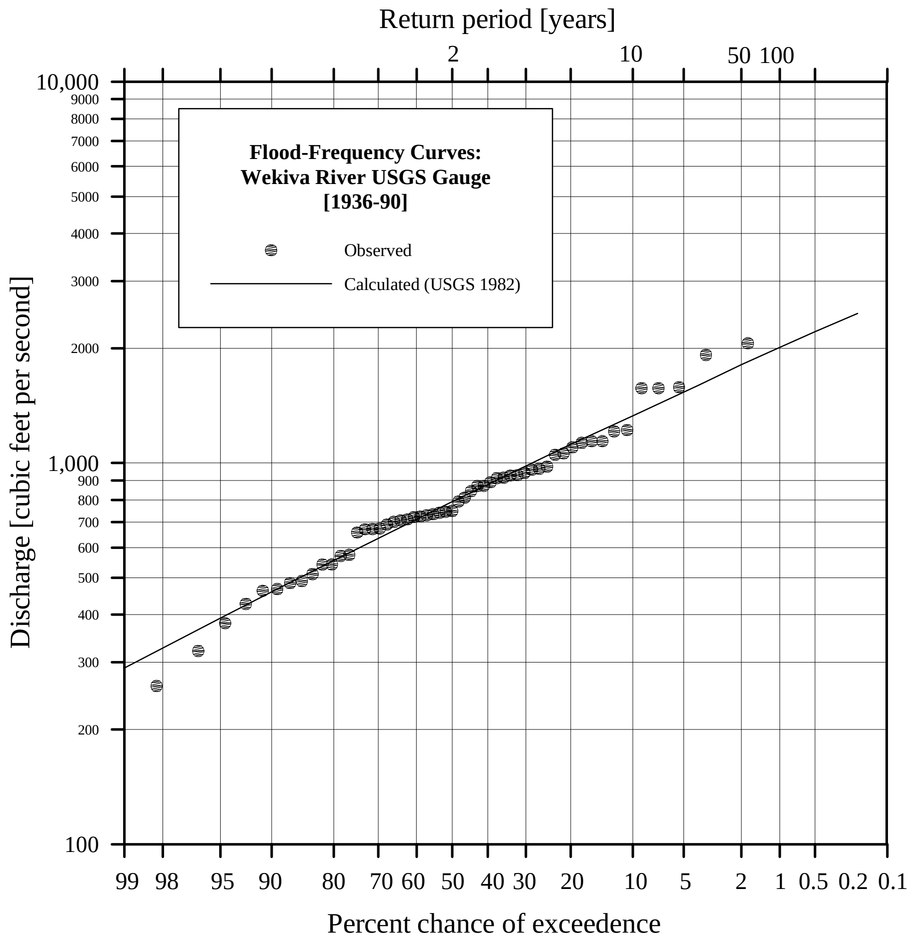

Figure A3. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida, fitted by standard mathematical procedure

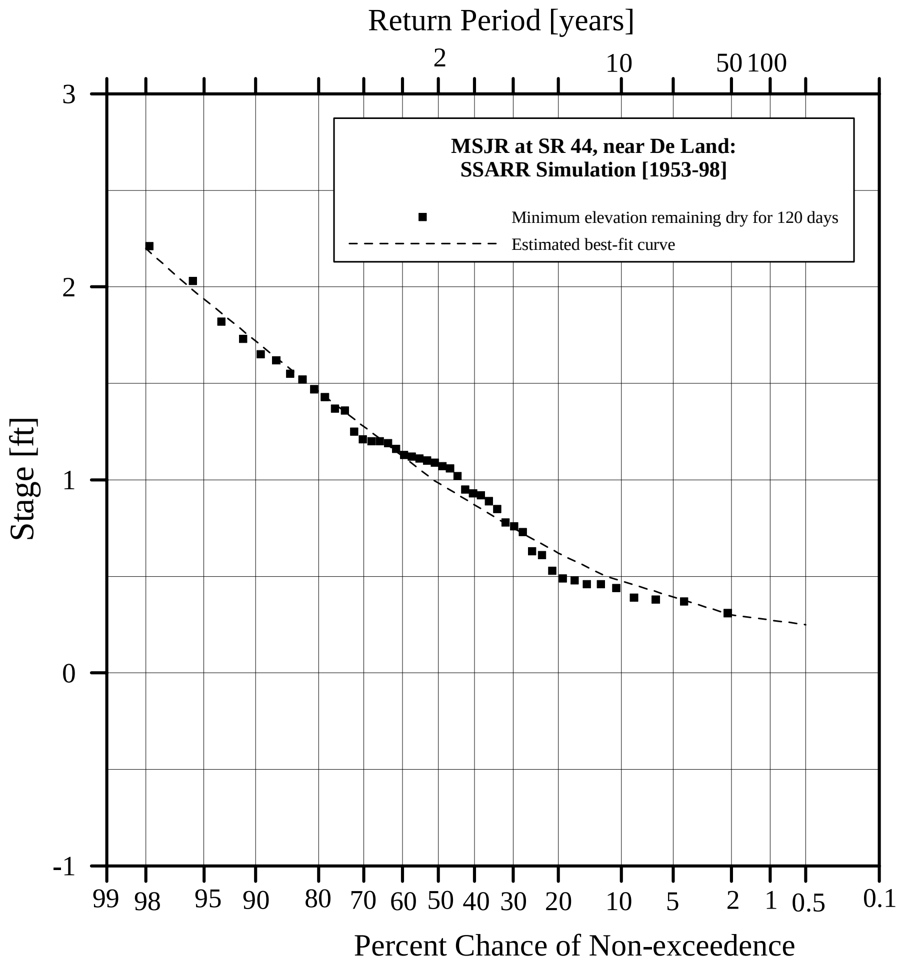

Figure A4. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand, fitted by the graphical method

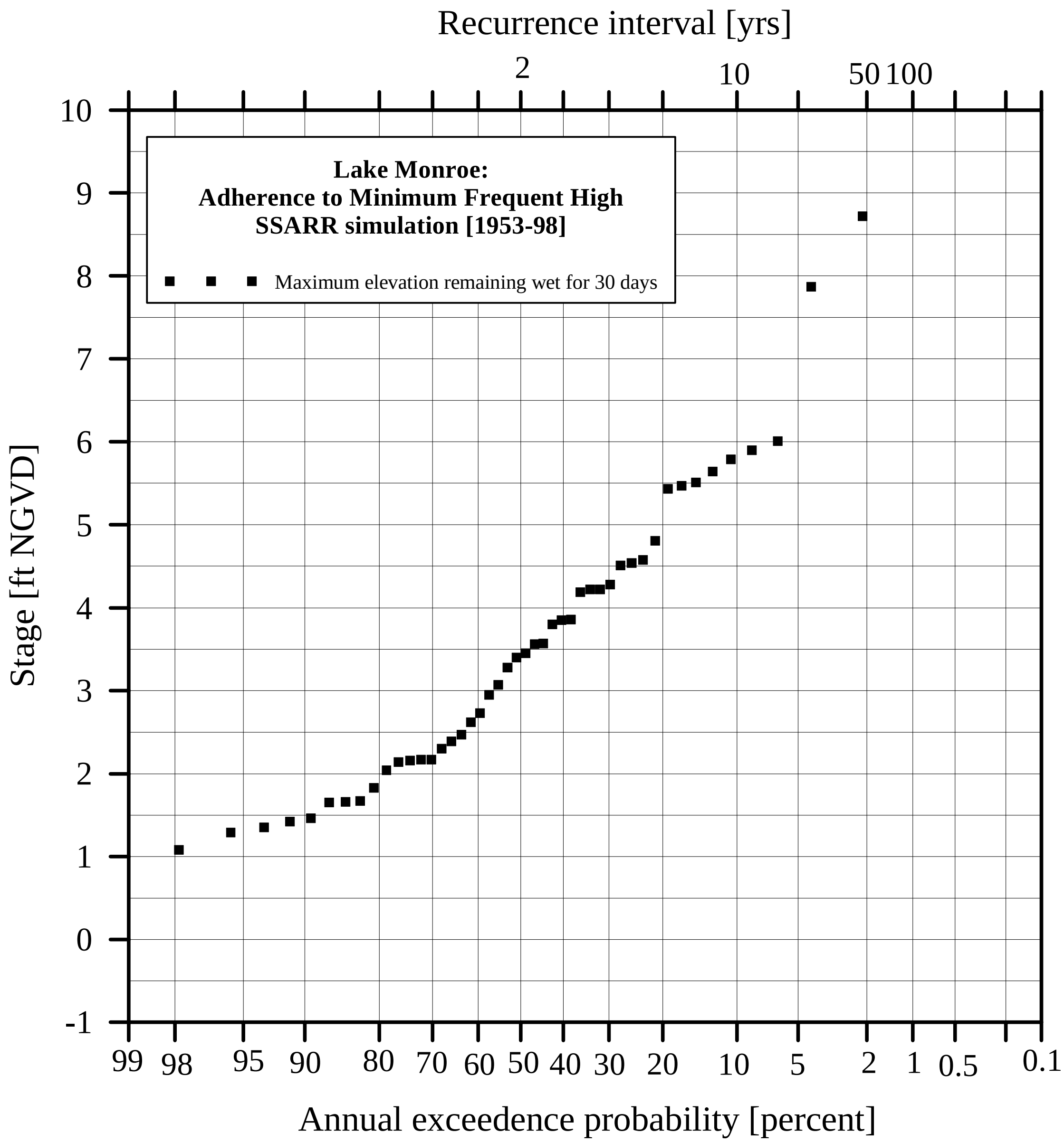

Figure A5. Flood frequencies computed using daily stages from model simulations of Lake Monroe, for elevations continuously wet for 30 days

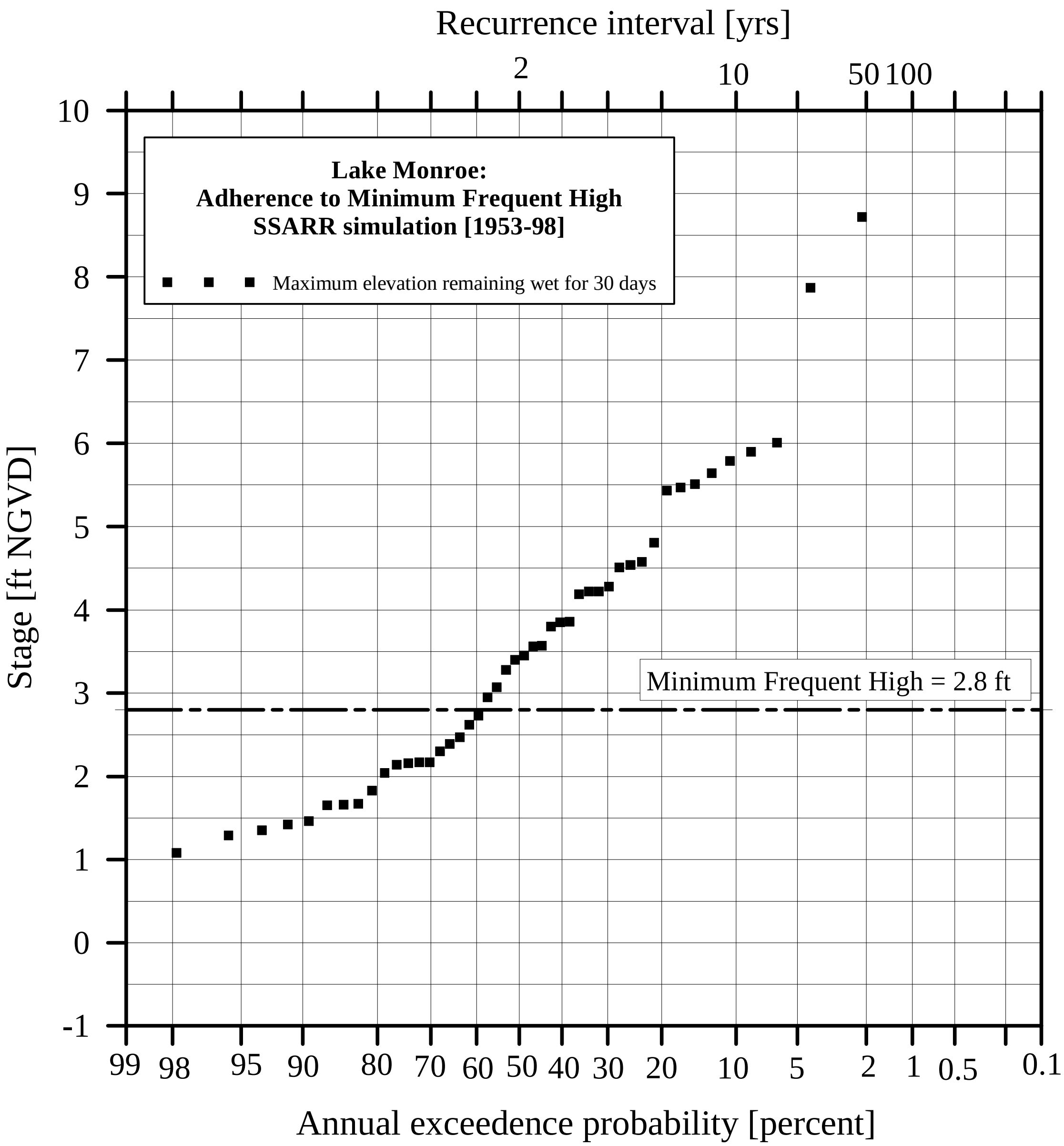

Figure A6. Flood frequencies computed using daily stages from model simulations of Lake Monroe, for elevations continuously wet for 30 days with the MFH of 2.8 ft NGVD superimposed

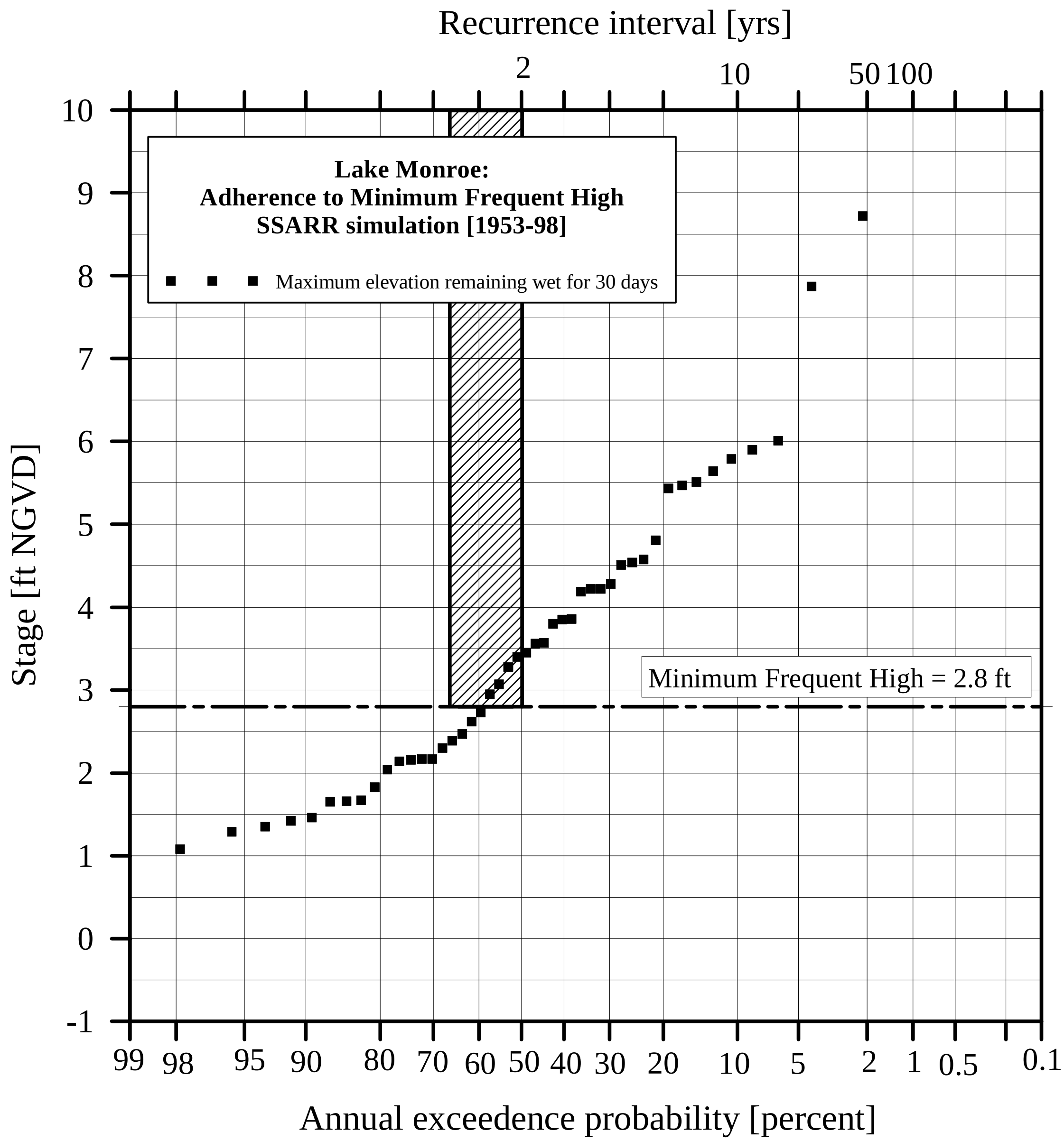

Figure A7. Flood frequencies computed using daily stages from model simulations of Lake Monroe, for elevations continuously wet for 30 days with a superimposed box bounded by (1) the MFH, (2) a vertical line corresponding to a return period of 1.5 years, and (3) a vertical line corresponding to a return period of 2 years

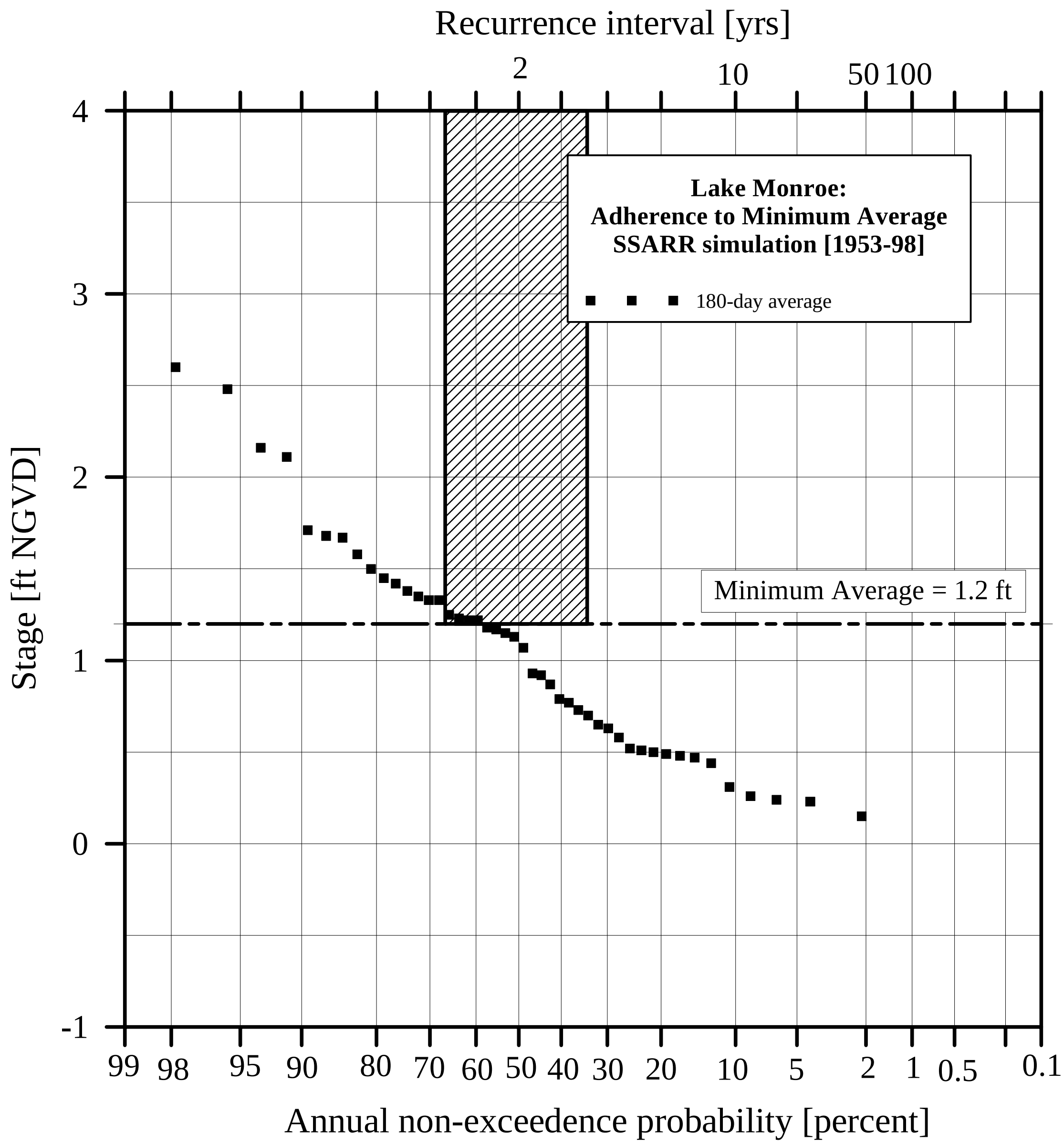

Figure A8. Drought frequencies computed using daily stages from model simulations of Lake Monroe, for the MA level

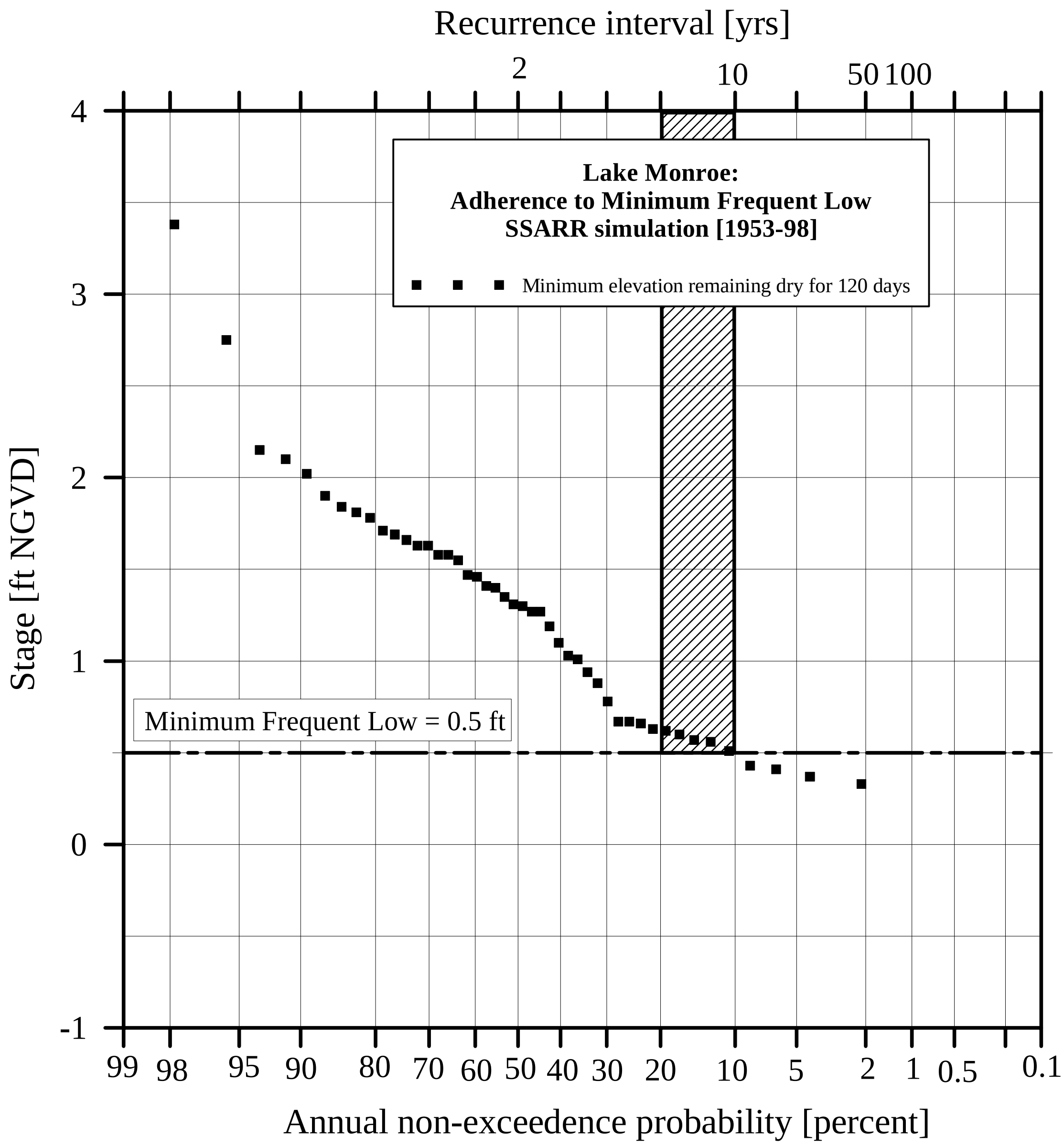

Figure A9. Drought frequencies computed using daily stages from model simulations of Lake Monroe, for the MFL level

APPENDIX B. VEGETATION DATA SHEET

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 rooted within a particular habitat

Page ____ of _____