Technical Publication SJ2006-5

# MINIMUM LEVELS DETERMINATION: ST. JOHNS RIVER AT STATE ROAD 44 NEAR DELAND, VOLUSIA COUNTY

by

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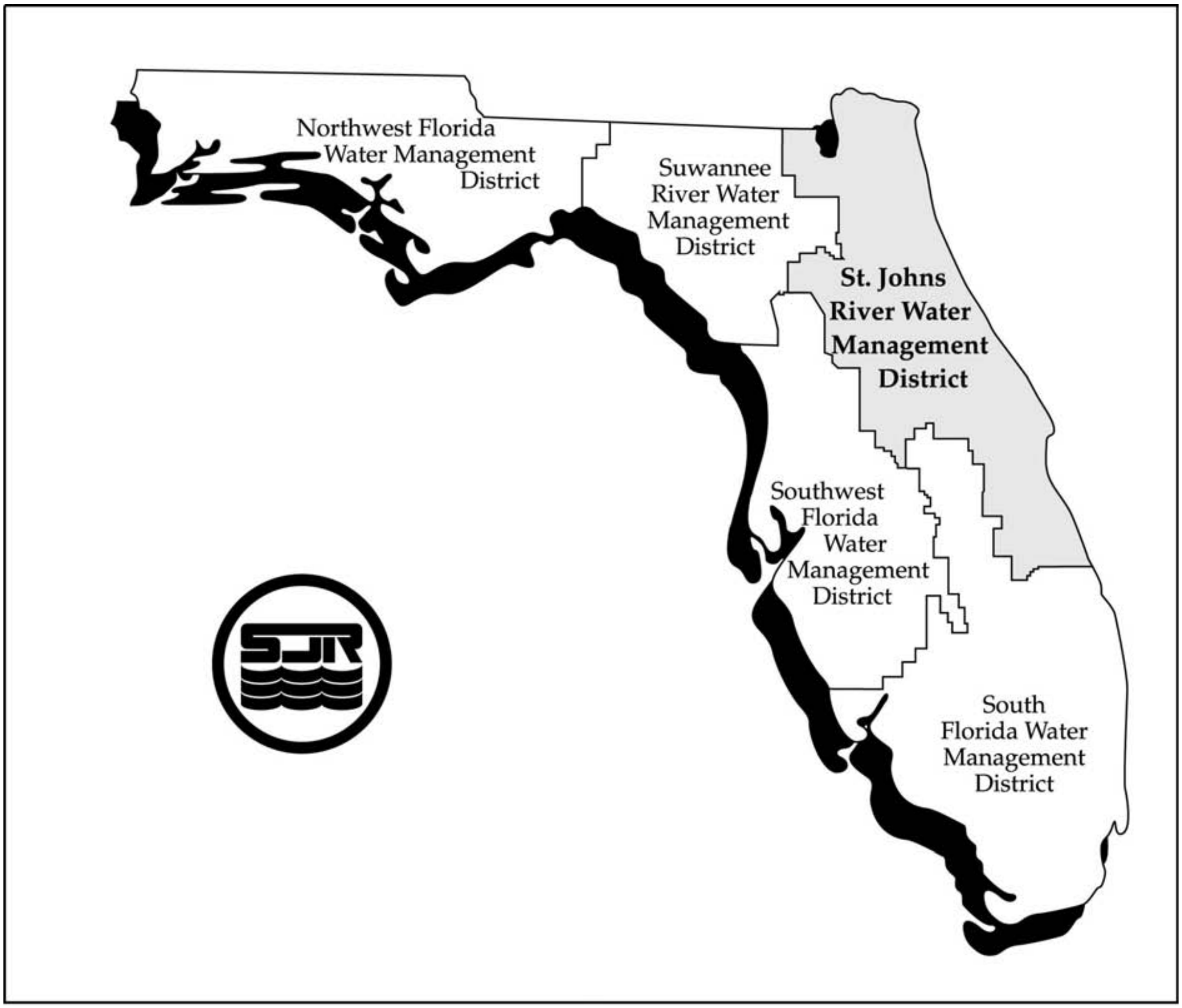
2006




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 minimum flows and levels (MFLs) for the St. Johns River at State Road (SR) 44 near DeLand, Volusia County, recommended by the St. Johns River Water Management District (SJRWMD). The St. Johns River at SR 44 near DeLand was included on the MFLs Priority Water Body List in 1999 (Florida Administrative Weekly 1999). Therefore, MFLs must be established for this river segment pursuant to Section 373.042(2), *Florida Statutes* (F.S.). The Priority Water Body List 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.

## MFLS PROGRAM DESCRIPTION

### Background

The SJRWMD MFLs program establishes MFLs for lakes, streams and rivers, wetlands, springs, and groundwater aquifers, as mandated by Section 373.042, F.S. The MFLs program gives priority to waters located within (a) an Outstanding Florida Water, (b) an aquatic preserve, (c) an area of critical state concern, or (d) an area subject to Chapter 380, Resource Management Plans (Section 62-40.473(3), *Florida Administrative Code* [*F.A.C.*]).

### Purpose

The MFLs program provides technical support to the SJRWMD regional water supply planning process (Section 373.0361, 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" (Section 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.*, MFLs should be evaluated to ensure the protection of the following natural resources and environmental values:

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

b. Fish and wildlife habitats and the passage of fish (62.40.473(1)(b), *F.A.C.*)

**c.** Estuarine resources (62.40.473(1)(c), *F.A.C.*)

d. Transfer of detrital material (62.40.473(1)(d), *F.A.C.*)

e. Maintenance of freshwater storage and supply (62.40.473(1)(e), *F.A.C.*)

f. Aesthetic and scenic attributes (62.40.473(1)(f), *F.A.C.*)

g. Filtration and absorption of nutrients and other pollutants (62.40.473(1)(g), *F.A.C.*)

h. Sediment loads (62.40.473(1)(h), *F.A.C.*)

i. Water quality (62.40.473(1)(i), *F.A.C.*)

j. Navigation (62.40.473(1)(j), *F.A.C.*)

Environmental Consulting and Technology (ECT) was contracted by SJRWMD to conduct an environmental assessment and to determine whether the MFLs recommended in this report for the St. Johns River at SR 44 near DeLand protect these 10 natural resource and environmental values. ECT (2003) determined that these MFLs for the St. Johns River at SR 44 near DeLand will protect the 10 natural resource and environmental values listed in Section 62-40.473, *F.A.C.*

**Hydrology**

The MFLs designate hydrologic conditions that prevent significant harm and identify levels and / or flows above which water is available for reasonable-beneficial use. Reasonable-beneficial use is defined as “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.). In addition, “…the Governing Board…may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety” (Section 373.223, F.S.). Hydroperiods, hydrologic constraints, and changes in hydrology are factors considered in the MFLs determination process.

MFLs apply to decisions affecting permit applications, declarations of water shortages, and assessments of water supply sources. Surface water and groundwater computer simulation models are used to evaluate existing and/or proposed consumptive uses and the likelihood they might cause significant harm. Actual or projected violations of 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.).

## MFL METHODOLOGY

SJRWMD used a multiple MFL methodology (Hall 2005) to determine the minimum river levels for the St. Johns River at SR 44 near DeLand. MFL determinations incorporate biological and topographical information collected in the field with stage data, wetland, soils, and land ownership data from geographic information system coverages, aerial photography, the scientific literature, and hydrologic and hydraulic models to generate an MFLs regime. This MFLs methodology describes a process for incorporating these factors (Hall 2005).

### Field Site Selection and Data Collection

MFL determinations for the St. Johns River at SR 44 near DeLand involved an extensive field effort to select field transect sites. Data from these sites were evaluated to ultimately determine MFLs for the location. Numerous factors were considered in the selection of the field transect sites over the large geographic area (Figure ES-1) between Lake Monroe and the St. Johns River at SR 40. Transects are fixed sample lines across a river, lake, or wetland floodplain, usually extending from open water to uplands, along which elevation, soils, and vegetation are sampled in order to characterize the influence of surface water flooding on the distribution of soils and plant communities.

Potential transect locations were initially identified from maps of wetlands, soils, topography, and land ownership. Specific transect site selection goals included locating transects in different common wetland communities, thereby ensuring sampling and consideration of different wetland ecosystems. Transect characteristics were subsequently field-verified to ensure that the particular locations contained representative wetland communities, hydric soils, and reasonable upland access while avoiding archaeological sites, alligator nests, and dredge mounds. Locating transects on public land was preferable in order to prevent future development and to

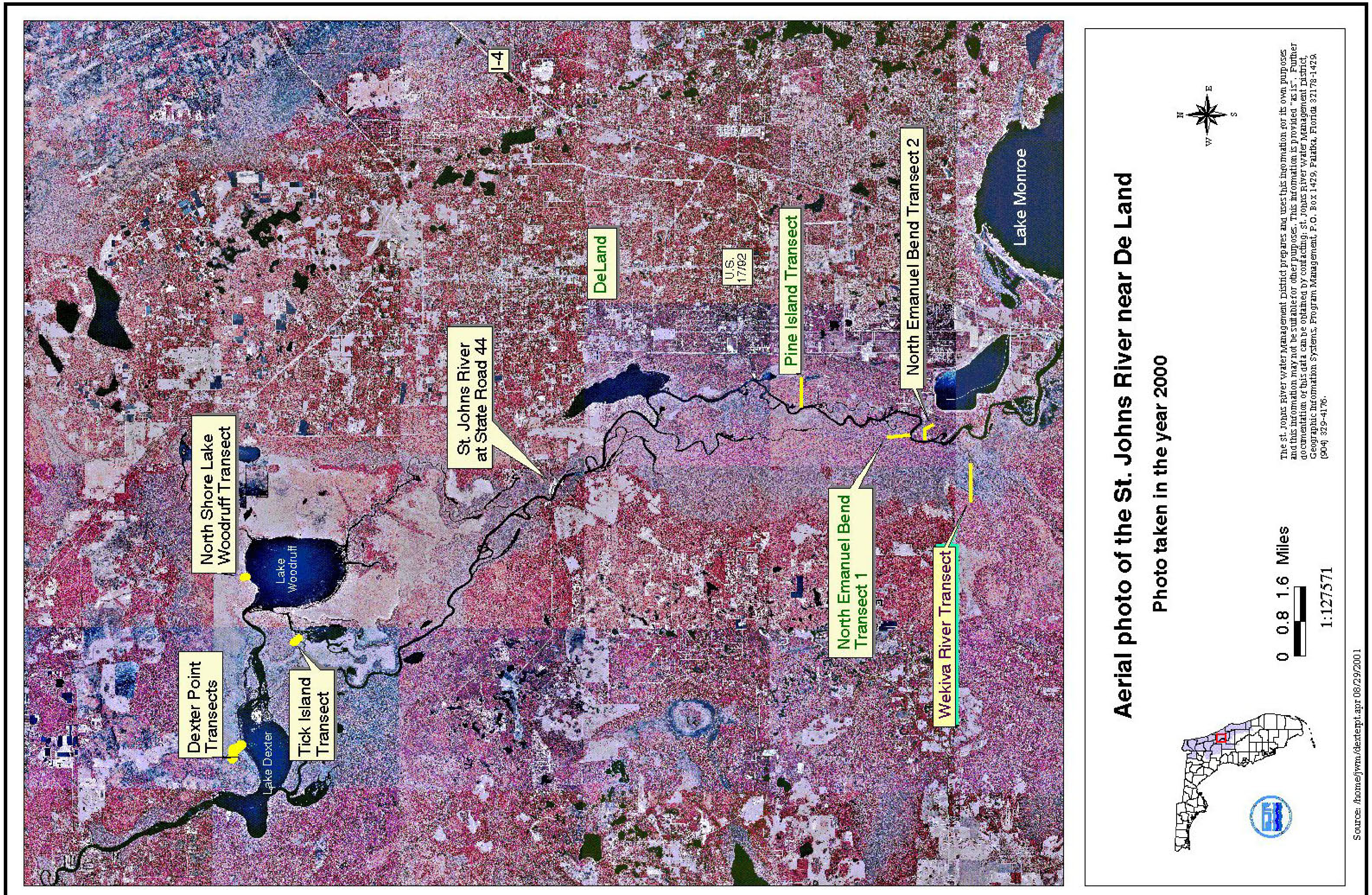


Figure ES-1. The St. Johns River at State Road 44 near DeLand, with all transects facilitate access for long-term ecological monitoring. Thirty-two sites were field-evaluated. Eight final field transect sites were selected at four locations (Table ES-1).

Table ES-1. Field transect locations

| Transect | Transect Location | Location and Date of Fieldwork |
|---|---|---|
| Pine Island | SJR at Pine Island | East bank of the SJR at Pine Island, 1.5 miles upstream from Blue Spring; April–May 2000, July 2001 |
| North Emanuel Bend transect 1 | SJR at North Emanuel Bend | West bank of the SJR at North Emanuel Bend, 1.2 miles downstream from the SJR confluence with the Wekiva River; April 2000 |
| North Emanuel Bend transect 2 | | East bank of the SJR at North Emanuel Bend, 0.7 mile downstream from the SJR confluence with the Wekiva River; April 2000, June 2001 |
| Lower Wekiva River | Lower Wekiva River | West bank of the lower Wekiva River, 0.9 mile upstream from the confluence with the SJR; September–October 2000, August 2001, August 2003 |
| Tick Island | Lake Woodruff National Wildlife Refuge | South shore of Tick Island within Lake Woodruff National Wildlife Refuge; January 2001 |
| North Shore Lake Woodruff | | North shore of Lake Woodruff; January 2001 |
| Dexter Point East transect | | East side of Dexter Point into *Spartina* and sawgrass marshes, primarily within Lake Woodruff National Wildlife Refuge; March–May 2001 |
| Dexter Point South transect | | Southerly direction from *Spartina* marsh of the Dexter Point East transect to the open water of Lake Dexter; April–May 2001 |

Note: SJR = St. Johns River

Field transects were located upstream and downstream from the SR 44 bridge over the St. Johns River in order to ensure adequate consideration of the aquatic ecosystems over a 30-mile river reach from the lower Wekiva River through Lake Woodruff National Wildlife Refuge.

SJRWMD conducted extensive soil and vegetation sampling and identification along the eight transects. Soil was classified, and plants and percent cover of plant species were estimated within the established belt width for the plant community under evaluation (quadrat). A detailed explanation of the field data collection methodology is included in Hall 2005.

# RESULTS

## MFLs for the St. Johns River at SR 44 Near DeLand

Recommended MFLs and hydroperiod categories for the St. Johns River at SR 44 near DeLand, Volusia County, are presented in Table ES-2. These were adopted by the SJRWMD Governing Board in November 2003.

Table ES-2. Recommended minimum surface water flows and levels for the St. Johns River at State Road 44 near DeLand, Volusia County

| Minimum Level* | Elevation (ft NGVD 1929 datum) | St. Johns River Flow at SR 44 (cfs) | Duration (days) | Return Interval (years) | Hydroperiod Category |
|---|---|---|---|---|---|
| Minimum frequent high level | 1.9 | 4,600 | ≥30 | ≤3 | Seasonally flooded |
| Minimum average level | 0.8 | 2,050 | ≤180 | ≥1.5 | Typically saturated |
| Minimum frequent low level | 0.3 | 1,100 | ≤120 | ≥5 | Semipermanently flooded |

Note: cfs = cubic feet per second
ft NGVD = feet National Geodetic Vertical Datum

*Levels adopted by the St. Johns River Water Management District Governing Board in November 2003.

The MFLs for the St. Johns River at SR 44 are based upon field data collected from Pine Island on the St. Johns River, North Emanuel Bend on the St. Johns River, the lower Wekiva River, and Lake Woodruff National Wildlife Refuge. Data collected from these four locations (Figure ES-1) were analyzed and resulted in minimum frequent high, minimum average, and minimum frequent low levels being determined for each of the four locations.

In order to determine minimum levels for the St. Johns River at SR 44 near DeLand, the four sets of locally determined MFLs were transferred to the SR 44 bridge over the St. Johns River at SR 44 near DeLand using hydraulic modeling techniques (Robison 2003). The four sets of transferred levels were then averaged, resulting in the recommended minimum levels for the St. Johns River at SR 44 near DeLand (Table ES–2).

The minimum levels determined at the four locations were transferred to the St. Johns River at SR 44 near DeLand for the following reasons:

- Future water level monitoring is facilitated due to an existing water level recorder at SR 44.
- Averaging the transferred levels may even out modeling and field data collection errors, while eliminating confusion by recommending one final set of levels.
- Locating field transects near SR 44 was not feasible due to land developments (marinas, campground, county park, high voltage power line right-of-way, and dwelling units) near SR 44 along the river. Additionally, the Ocala National Forest property located immediately north of SR 44 is a designated Wilderness Area, prohibiting the installation of survey benchmarks.
- SR 44 is a location included in the surface water model (Robison 2003).
- A long-term stage record exists at the SR 44 bridge.

### Minimum Flow

Each minimum level can be associated with a minimum flow for a river system. While water resource decisions can be made based on minimum levels alone, pairing each level with a corresponding minimum flow adds context to better understand the effects of proposed changes to a hydrologic system. The pairing of levels and flows of similar statistical characteristics (Robison 2003) allowed a determination of a minimum flow for each of the final three levels for the St. Johns River at SR 44 near DeLand. The flow for the minimum frequent high was set at 4,600 cubic feet per second (cfs), the flow for the minimum average was set at 2,050 cfs, and the flow for the minimum frequent low was set at 1,100 cfs (Robison 2003).

## CONCLUSION

The intent of the establishment of MFLs for the St. Johns River at SR 44 near DeLand is to identify flows and levels below which harm would occur to the aquatic ecosystems along the St. Johns River at SR 44 near DeLand and along the lower Wekiva River as a result of consumptive use of surface water and groundwater. Periodic reassessment of these MFLs is anticipated in order to ensure that these MFLs are maintained and that they do prevent significant ecological harm.

Periodic evaluation of flow, level, and ecological data will be performed to determine if established MFLs are being met and are providing adequate protection to water resources and ecology.

The MFL determinations for the St. Johns River at SR 44 near DeLand were based upon a series of assumptions. The assumptions listed below provided the theoretical, practical, and methodological background for the process used to establish biological criteria:

- The levels will provide adequate protection for the entire riverine community.
- A given wetland community type will have similar hydrologic and edaphic characteristics and occur in similar topographic positions across all transect locations.
- Transferring four sets of local levels to the St. Johns River at SR 44 results in a more robust single set of easily monitored levels.
- Infrequent high river levels (river levels above the minimum frequent high levels) are dependent upon seasonal weather events (tropical storms) when high rainfall occurs within the Middle and Upper St. Johns River basins.
- It is impractical to establish infrequent low river levels (river levels below the minimum frequent low levels) due to the low landscape elevation, approaching sea level.
- One set of levels determined for Lake Dexter and the Lake Woodruff National Wildlife Refuge will provide the required level of protection since this area has very little topographic relief.
- Histosol soil water table drawdown criteria will prevent soil subsidence.
- Mineral soil water table drawdown criteria will protect the structural integrity of the soil horizon and maintain hydric soil characteristics.
- The hydric characteristics of the clay loams sampled at higher elevations and/or further from the river channel are partially a function of soil porosity, rainfall, and upland seepage.
- Deep marsh communities occur within the river channel and/or at locations which will be inundated when river levels equal or exceed the minimum frequent low level.

- Bayhead communities are typically influenced by seepage and therefore were not sought when transect locations were designated.

The MFLs determination for the St. Johns River at SR 44 near DeLand included many information gathering tasks and subsequent analyses. Use of the best available information from the scientific literature, numerous ecological maps, personal communications with on-site public land managers, analyses of many years of river stage data, and intensive surface water modeling (Robison 2003) combined with an extensive field data collection effort resulted in a robust set of final MFLs.

To confirm that the established MFLs are avoiding significant harm to these areas, vegetation and soil water table level monitoring is being conducted.

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# PROJECT SUPPORT

Determining minimum flows and levels for the St. Johns River at SR 44 near DeLand was, in many ways, a team effort. Many people assisted and contributed in the data collection and report production. Special thanks should be given to the following:

- SJRWMD land surveyors, specifically Mark Willick, Johnny Tucker, Mike DeLoach, Tim King, Ed Sayre, and John Kuveke

- SJRWMD plant identification specialists, specifically Travis Richardson, Steve Brown, Cecil Slaughter, Chris Ware, and Sonny Hall

- Soil investigation specialists, specifically Travis Richardson and Cecil Slaughter, SJRWMD; Debra Segal and Ben Skulnick, Jones Edmunds and Associates; and Wade Hurt, USDA.

In addition, many thanks for report production assistance from Sonny Hall, Cliff Neubauer, Price Robison, and Travis Richardson of SJRWMD and Bill Dunn and Leticia Solaun with CH2M HILL.

# INTRODUCTION

This document describes the methods and data as used to establish minimum flows and levels (MFLs) for the St. Johns River at State Road (SR) 44 near DeLand, Volusia County, and presents the MFLs which were adopted by rule in November 2003. The MFLs are water levels and flows that primarily serve as hydrologic constraints for water supply development, but may also apply in environmental resource permitting.

## BACKGROUND

The St. Johns River at SR 44 near DeLand was included on the St. Johns River Water Management District (SJRWMD) MFLs Priority Water Body List, beginning in 1999 (Florida Administrative Weekly 1999). The work described in this document was performed pursuant to the requirements of Section 373.042(2), *Florida Statutes* (F.S.) and Chapter 62.40, *Florida Administrative Code (F.A.C.)*.

The St. Johns River at SR 44 near DeLand was identified on the MFLs priority list because of the projected demand for water in the region, possible water supply development projects near DeLand, the numerous environmental resources in the Lake Woodruff Planning Unit (URS 2001), and the extensive historic hydrologic records for the St. Johns River at SR 44 near DeLand (Robison 2003).

Water supply development alternatives in the *District Water Supply Plan* (Vergara 2000) included up to 221 million gallons a day (mgd) from the St. Johns River to meet projected 2020 demands. One or more surface water supply facilities may be developed on the St. Johns River near DeLand and/or upstream to Lake Washington in Brevard County. SJRWMD, in cooperation with Volusia and Seminole counties, has completed preliminary investigations of several potential withdrawal sites, two of which are along the St. Johns River between DeLand and Lake Monroe (CH2M HILL 1999).

In addition to the minimum flows and levels recommended for this site, minimum flows and/or levels are scheduled for establishment in 2005 for Lake Monroe and for the St. Johns River at SR 50. Additionally, MFLs were established for the St. Johns River downstream from Lake Washington at river mile 253.1 in 1998 (Hall and Borah 1998). Ultimately, with the establishment of MFLs on the St. Johns River downstream of Lake

Washington, at SR 50, Lake Monroe, and at SR 44 near DeLand, SJRWMD should be able to monitor and protect the St. Johns River from significant harm caused by consumptive use of water.

## MFLs Program Description

### Background

The SJRWMD MFLs program establishes MFLs for lakes, streams and rivers, wetlands, springs, and groundwater aquifers, as mandated by Section 373.042, F.S. The MFLs program gives priority to waters which are located within (a) an Outstanding Florida Water, (b) an aquatic preserve, (c) an area of critical state concern, or (d) an area subject to Chapter 380, Resource Management Plans (Section 62-40.473(3), *F.A.C.*).

### Purpose

The MFLs program provides technical support to the SJRWMD regional water supply planning process (Section 373.0361, 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" (Section 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.*, MFLs should be evaluated to ensure the protection of the following natural resources and environmental values:

a. Recreation in and on the water (62.40.473(1)(a), *F.A.C.*)
b. Fish and wildlife habitats and the passage of fish (62.40.473(1)(b), *F.A.C.*)
c. Estuarine resources (62.40.473(1)(c), *F.A.C.*)
d. Transfer of detrital material (62.40.473(1)(d), *F.A.C.*)
e. Maintenance of freshwater storage and supply (62.40.47 (1)(e), *F.A.C.*)
f. Aesthetic and scenic attributes (62.40.473(1)(f), *F.A.C.*)

g. Filtration and absorption of nutrients and other pollutants (62.40.473(1)(g), *F.A.C.*)

h. Sediment loads (62.40.473(1)(h), *F.A.C.*)

i. Water quality (62.40.473(1)(i), *F.A.C.*)

j. Navigation (62.40.473(1)(j), *F.A.C.*)

Environmental Consulting and Technology (ECT) was contracted by SJRWMD to conduct an environmental assessment and to determine whether the MFLs for the St. Johns River at SR 44 near DeLand, as presented in this document, protect these 10 natural resource and environmental values.

SJRWMD documents containing information about the hydrologic and ecological criteria used to develop the MFLs for the St. Johns River at SR 44 near DeLand were used by ECT, along with field reconnaissance and information in the scientific literature, to evaluate whether these MFLs protect water and ecological resources (ECT 2003).

ECT (2003) determined that the recommended MFLs for the St. Johns River at SR 44 near DeLand, as presented in this document, will protect the 10 natural resource and environmental values listed in Section 62-40.473, *F.A.C*. The results of the ECT assessment are summarized in Table 1.

## Hydrology

MFLs designate hydrologic conditions that prevent significant harm and identify levels and / or flows above which water is available for reasonable-beneficial use. Reasonable-beneficial use is defined as “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.). Hydroperiods, hydrologic constraints, and changes in hydrology are factors considered in the MFLs determination process.

### Hydroperiods

MFLs define the frequency and duration of high, average, 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

Table 1. Environmental assessment summary for the St. Johns River at State Road 44 near DeLand minimum flows and levels (MFLs) regime

| Resource or Value | MFL Protects the Resource From Significant Harm | | Certainty | | | Further Study/Monitoring | | |
|---|---|---|---|---|---|---|---|---|
| | Yes[1] | No[2] | High | Medium | Low | Necessary[3] | Recommended[4] | Not Needed[5] |
| a. Recreation in and on the water | X | | X | | | | | X |
| b. Fish and wildlife habitats and the passage of fish | X | | | X | | | X | |
| c. Estuarine resources | X | | | X | | | X | |
| d. Transfer of detrital material | X | | X | | | | | X |
| e. Maintenance of freshwater storage and supply | X | | X | | | | | X |
| f. Aesthetic and scenic attributes | X | | X | | | | | X |
| g. Filtration and absorption of nutrients and other pollutants | X | | X | | | | | X |
| h. Sediment loads | X | | | X | | | X | |
| i. Water quality | X | | | X | | | X | |
| j. Navigation | X | | X | | | | | X |

[1]Proposed MFLs allow for decline in water levels and flows, but the resource value should be protected.
[2]Proposed MFLs would allow water levels and flows to decline such that significant harm will occur.
[3]ECT recommends further study to support or verify.
[4]ECT recommends further study may be beneficial to ensure protection of the resource.
[5]ECT recommends no further study required.

Source: ECT 2003

frequent low, and minimum infrequent low flows and / or water levels. The MFLs represent hydrologic statistics composed of three components: a water level and / or flow, a duration, and a frequency. SJRWMD has synthesized from Cowardin et al. (1979) the continuous duration and frequency components of MFLs into seven discrete hydroperiod categories. The hydroperiod categories, related frequencies, and durations are defined in 40C-8.021, *F.A.C.*, and summarized in Table 2. The hydroperiod categories describing high-water events are intermittently flooded, temporarily flooded, and seasonally flooded. Low water events are described by the hydroperiod categories typically saturated, semipermanently flooded, intermittently exposed, and permanently flooded.

Table 2. MFLs hydroperiod categories and approximate frequency and duration

| 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 | 30 days or more |
| Typically saturated | Once every 2 years low | About 6 months |
| Semipermanently flooded | Once every 5–10 years low | Several months |
| Intermittently exposed | Once every 20 years low | Weeks to months |
| Permanently flooded | More extreme drought | Days to weeks |

### Hydrologic Constraints

The 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 presents two hypothetical exceedance curves comparing existing water level or flow duration conditions to lower hydrologic conditions defined by MFLs. The MFLs exceedance curve, defined in this case by five MFLs, is similar to the existing hydrologic regime, although typically lower. The distance between the two curves represents the water available for reasonable-beneficial uses. The area below the MFLs curve (lower curve) represents the hydrology conditions that prevent significant harm.

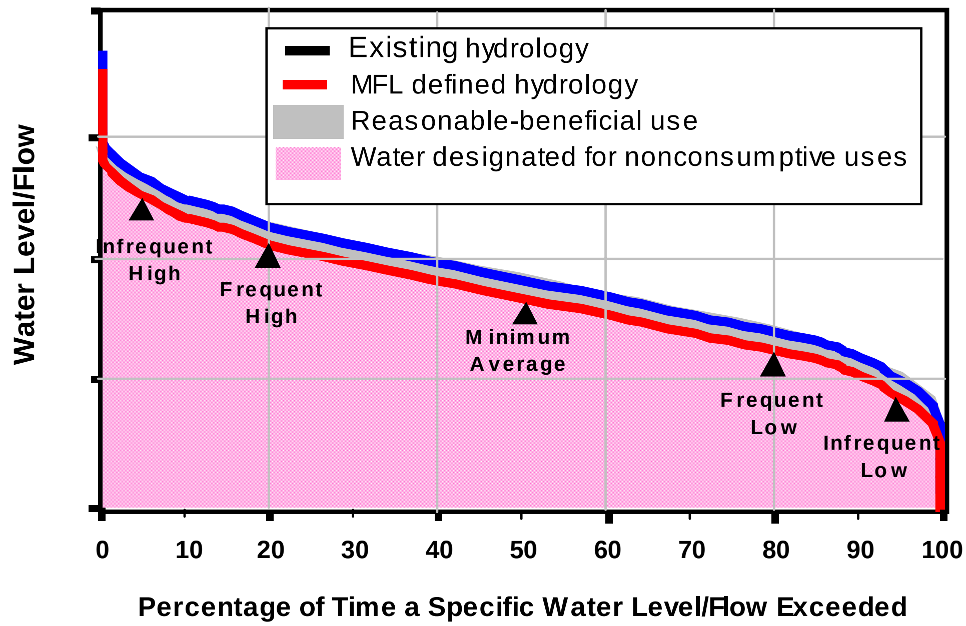



Figure 1. Hypothetical percentage exceedance curves for existing and MFL-defined hydrologic conditions

## Changes in Hydrology

MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in hydrologic conditions. 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 (lower curve, 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 impairment or destruction of ecological structures and functions.

MFLs apply to decisions affecting permit applications, declarations of water shortages, and assessments of water supply sources. Surface water and groundwater computer simulation models are used to evaluate existing and / or proposed consumptive uses and the likelihood they might cause significant harm. Actual or projected conditions where water in levels or flows is below established MFLs require that SJRWMD 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.).

## ST. JOHNS RIVER HYDROLOGY AND GENERAL INFORMATION

The St. Johns River originates in floodplains north of Lake Okeechobee and flows north over 300 miles to a point near Jacksonville where it abruptly turns eastward and flows approximately 24 miles further to the Atlantic Ocean. The St. Johns River is the longest north-flowing river in the United States and the longest river in Florida with its tributary basins lying entirely within the state boundaries (Morris 1995). The St. Johns River is divided into four major hydrologic basins: the Upper St. Johns River Basin, the Middle St. Johns River Basin, the Lake George Basin, and the Lower St. Johns River Basin (Adamus et al. 1997). The St. Johns River is normally tidal to the north end of Lake George, 110 miles upstream from the mouth, although tides have, on occasion, been reported in Lake Monroe (south of DeLand, 161 miles upstream from the mouth). The city of DeLand is located near river mile 144 within the Lake George Basin and the Lake Woodruff Planning Unit (Adamus et al. 1997), approximately 14 miles downstream from the northern boundary of the Middle St. Johns River (MSJR) Basin (Figure 2). The Middle St. Johns River final reconnaissance report (URS 2001) provides additional descriptive information regarding land use, current developments, water quality, water quantity, water supply, and ecosystems located within the Lake Woodruff Planning Unit. Additional hydrologic information and surface water modeling efforts regarding the St. Johns River at SR 44 near DeLand and the lower Wekiva River are described in Robison (2003).

The St. Johns River near DeLand is a river reach composed of multiple, extensive public land parcels with high quality, environmentally sensitive, natural ecosystems. The public land parcels include the Lower Wekiva River State Preserve, Blue Spring State Park, Hontoon Island State Park, the Ocala National Forest, Lake Woodruff National Wildlife Refuge (LWNWR), and the Dexter Point-Mary Farms Tract of the Lake George State Forest.

Proper management of these lands is important in order to provide a sanctuary for fish and wildlife communities and to ensure the continued recreation resource in central Florida.

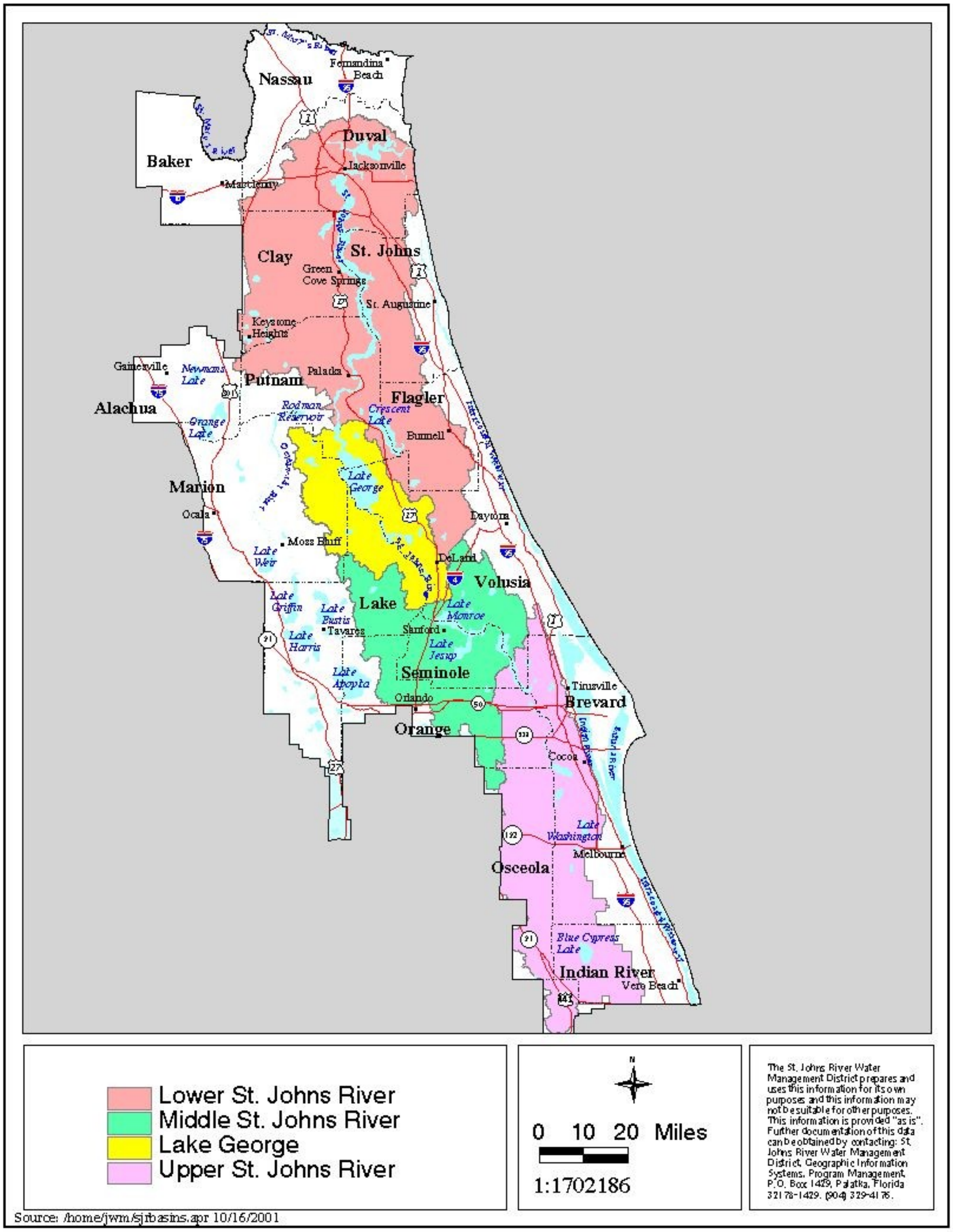



Figure 2. St. Johns River surface water basins

## ST. JOHNS RIVER WETLANDS

The SJRWMD geographic information system (GIS) wetland coverage (Figures 3 and 4) illustrates the various wetland communities delineated along the St. Johns River at SR 44 near DeLand. Table 3, generated from the SJRWMD GIS wetland coverage, lists the 10 most abundant wetland community types within a 2-mile buffer of the St. Johns River channel between Lake Monroe and Lake George. The hardwood swamp community represents the most extensive wetland type found in the area. Figure 3 illustrates the vast area of hardwood swamp along the west bank of the St. Johns River. The hydric hammock community is the second most prevalent community, commonly located on a natural levee immediately adjacent to the open water of the river and / or between the hardwood swamp and upland communities. The third most prevalent community, the shallow marsh, is uncommon south of SR 44, but very common north of SR 44, especially within LWNWR (Figures 3 and 4).

Table 3. Ten most abundant wetland types between Lake George and Lake Monroe

| Wetland Community | Acres | Ranking by Acres |
|---|---|---|
| Hardwood swamp | 20,409 | 1* |
| Hydric hammock | 6,620 | 2* |
| Shallow marsh | 6,206 | 3* |
| Shrub swamp | 2,466 | 4* |
| Wet prairie | 2,177 | 5* |
| Forested depression | 1,276 | 6* |
| Free floating | 816 | 7* |
| Bayhead | 520 | 8 |
| Cypress | 453 | 9* |
| Deep marsh | 253 | 10 |

*Indicates the community type was traversed by a minimum flows and levels field transect

Detailed wetland community descriptions are presented in the Results and Discussion section. As indicated in Table 3, eight of the 10 most abundant wetland communities were traversed by MFLs field transects.

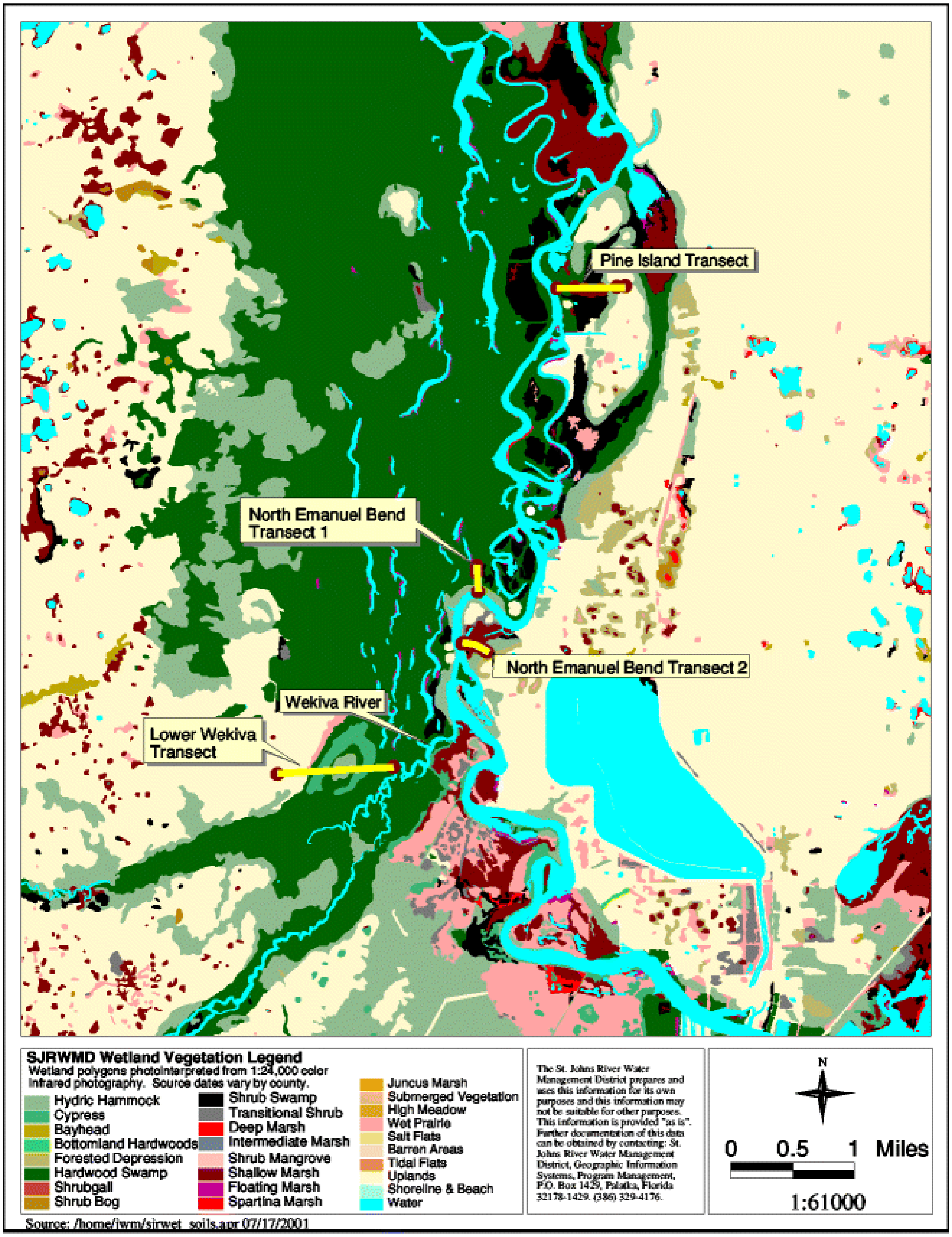



Figure 3. Middle St. Johns River wetland

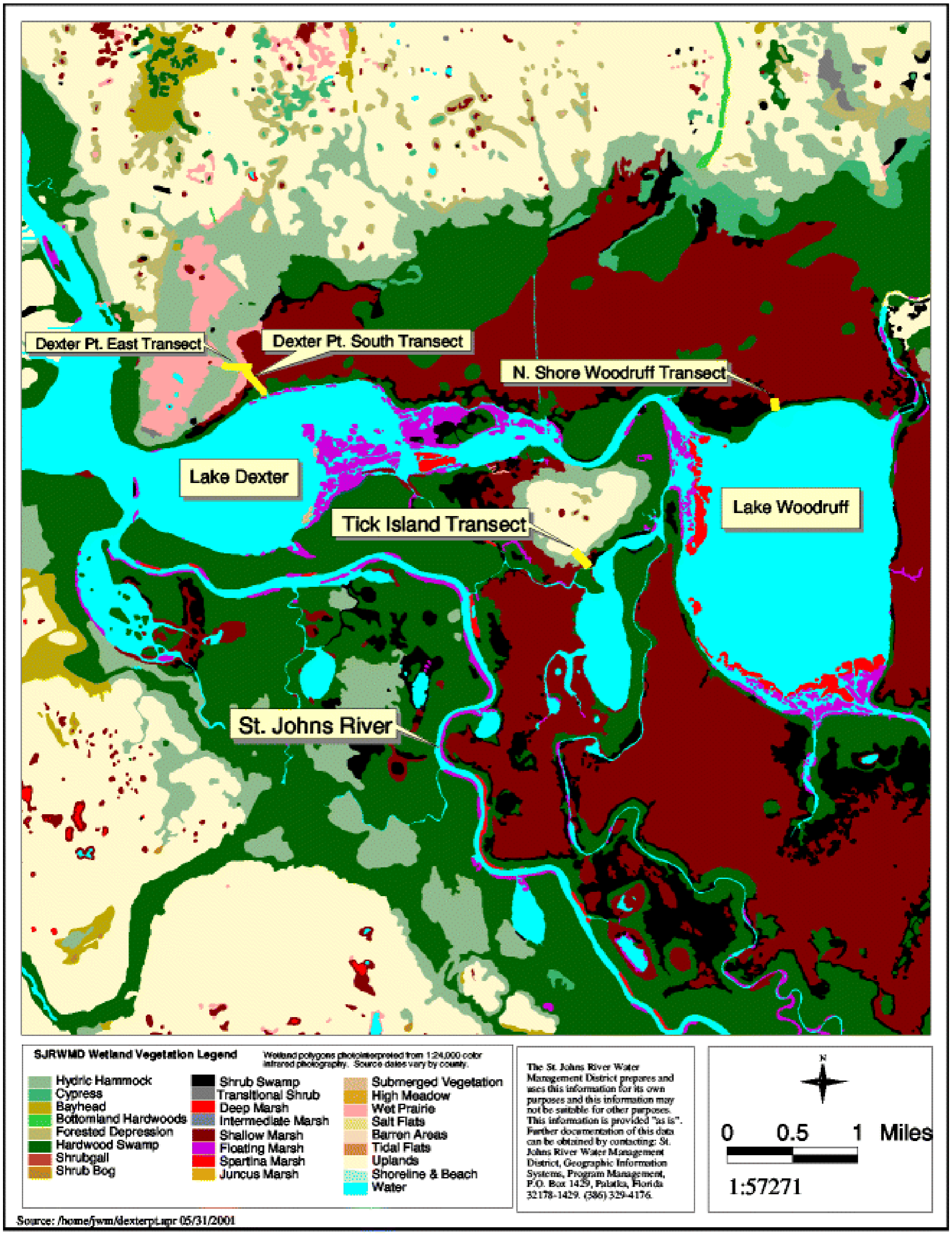



Figure 4. Lake Woodruff National Wildlife Refuge wetland

## St. Johns River Hydric Soils

Hydric soils were mapped (Figure 5; soil survey geographic [SSURGO] database) extensively along the St. Johns River at SR 44 near DeLand. Differences were encountered between the specific soil types sampled along the field transects and the soil types mapped in the Natural Resources Conservation Service (NRCS) soil surveys. Regardless of the exact soil type sampled along the field transects, the hydric / non-hydric classification of the soils sampled closely matched the designation on the SSURGO map (Figure 5).

Due to the soil type differences between the NRCS soil surveys and field soil sampling, the field soil sampling results were relied upon for the MFL determinations. Transect-specific field soil sample descriptions are presented in the Results and Discussion section of this document.

Additionally, a brief description of each soil type sampled is provided in the appendix. Table 4 summarizes pertinent soil water table information.

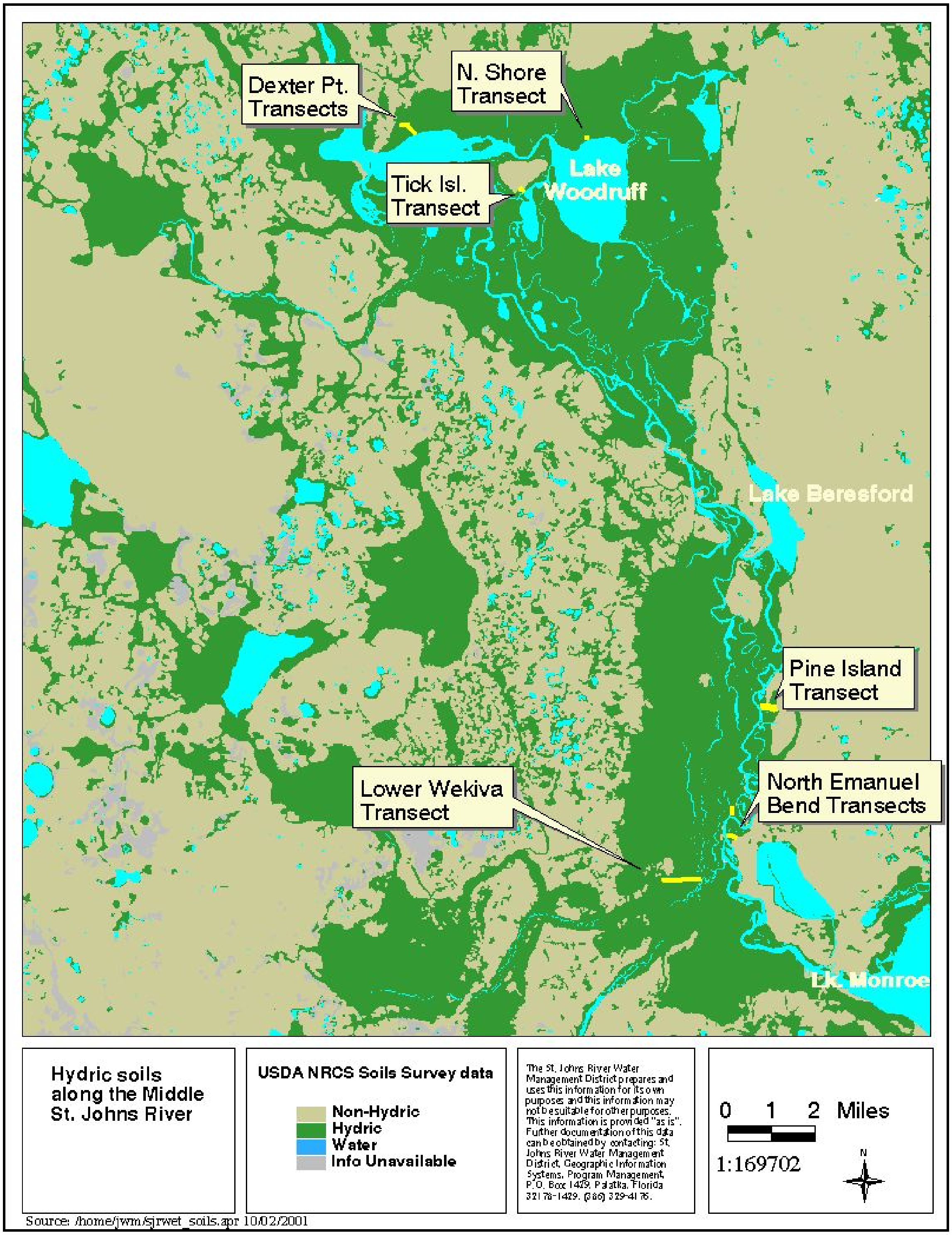



Figure 5. Hydric soils along the middle St. Johns River

Table 4. Soil water table information

| Soil Name | Water Table Above Soil Surface | Typical Depth Below Soil Surface to Water Table |
|---|---|---|
| Basinger fine sand | In depressions for 6–9 months | <12 inches for 2–6 months; 12–30 inches for >6 months |
| Chobee fine sandy loam | Frequently during rainy season | <6 inches for 1–4 months; seldom >10 inches even during prolonged dry periods |
| Delray series | For long periods after heavy rains | <12 inches for 6 months or more in most years |
| Felda series | In depressions and floodplains for >6 months | <12 inches for 2–6 months |
| Floridana series | In depressions for >6 months and floodplains for 2–3 months | Typically <10 inches |
| Gator muck | Always, except during extended droughts | At the surface, except during extended droughts |
| Holopaw sand | In depressions for >6 months | <12 inches for 2–6 months in most years |
| Immokalee sand | Depressional areas ponded 6–9 months or more in most years | At 6–18 inches for 1–4 months; 18–36 inches for 2–10 months during most years; >60 inches in dry season |
| Nittaw series | For 6–8 months in most years | |
| Paisley series | For <1 month | <10 inches for 2–6 months in most years |
| Placid sand | Depressional areas ponded >6 months | 0-6 inches for >2 months in most years |
| Pomona sand | Depressional areas ponded 6–9 months or more in most years | At 6 to 18 inches for 1–3 months and 10–40 inches for 6 months or more during most years |
| Pompano fine sand | | <10 inches for 2–6 months; <30 inches for >9 months |
| Riviera sand | Some areas flooded a few days to 3 months; depressions are ponded for 6–12 months | <10 inches for 2–4 months; 10–30 inches for the rest of the year; >40 inches for short periods in driest seasons |
| Sanibel sand | For 2–6 months during wet seasons | <10 inches for 6–12 months in most years |
| Scoggin series | For as much as 6 months in most years | At the surface, but may drop to 24 inches |
| Tequesta series | For 6–9 months in most years | At the surface or <10 inches below |
| Terra Ceia muck | Always, except during extended droughts | At the surface, except during extended droughts |

Note: Blank cells indicate no information

Source: NRCS 2001

# MFL METHODOLOGY

MFL determinations integrates biological and topographical information collected in the field with stage data; wetland, soils, and land ownership data from GIS coverages; aerial photography; the scientific literature; and hydrologic and hydraulic models to generate an MFL regime. SJRWMD's MFL methodology provides a process for incorporating these factors. This section describes the MFL methodology and assumptions used in the MFL determination process for the St. Johns River at SR 44 near DeLand, including field procedures, such as site selection and field data collection, data analyses, and levels determination criteria. Additional MFL methodology descriptions are included in Hall 2005.

## FIELD SITE SELECTION

Minimum level determination for the St. Johns River at SR 44 near DeLand involved an extensive field effort to select field sites. Data from these sites were evaluated to ultimately determine minimum levels for the St. Johns River at SR 44 near DeLand. The field investigation was initiated in January 2000. Many factors were considered in the selection of field transect sites over the large geographic area (Figure 6) between Lake Monroe and the St. Johns River at SR 40 near Astor.

Transects, or fixed sample lines across a river, lake, or wetland floodplain, usually extend from open water to uplands, along which elevation, soils, and vegetation are sampled in order to characterize the influence of surface water flooding on the distribution of soils and plant communities. Selecting transect sites was based on a significant information gathering effort.

### Information Gathering

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

- On-site and regional vegetation surveys and maps
- Aerial photography (existing and historical)

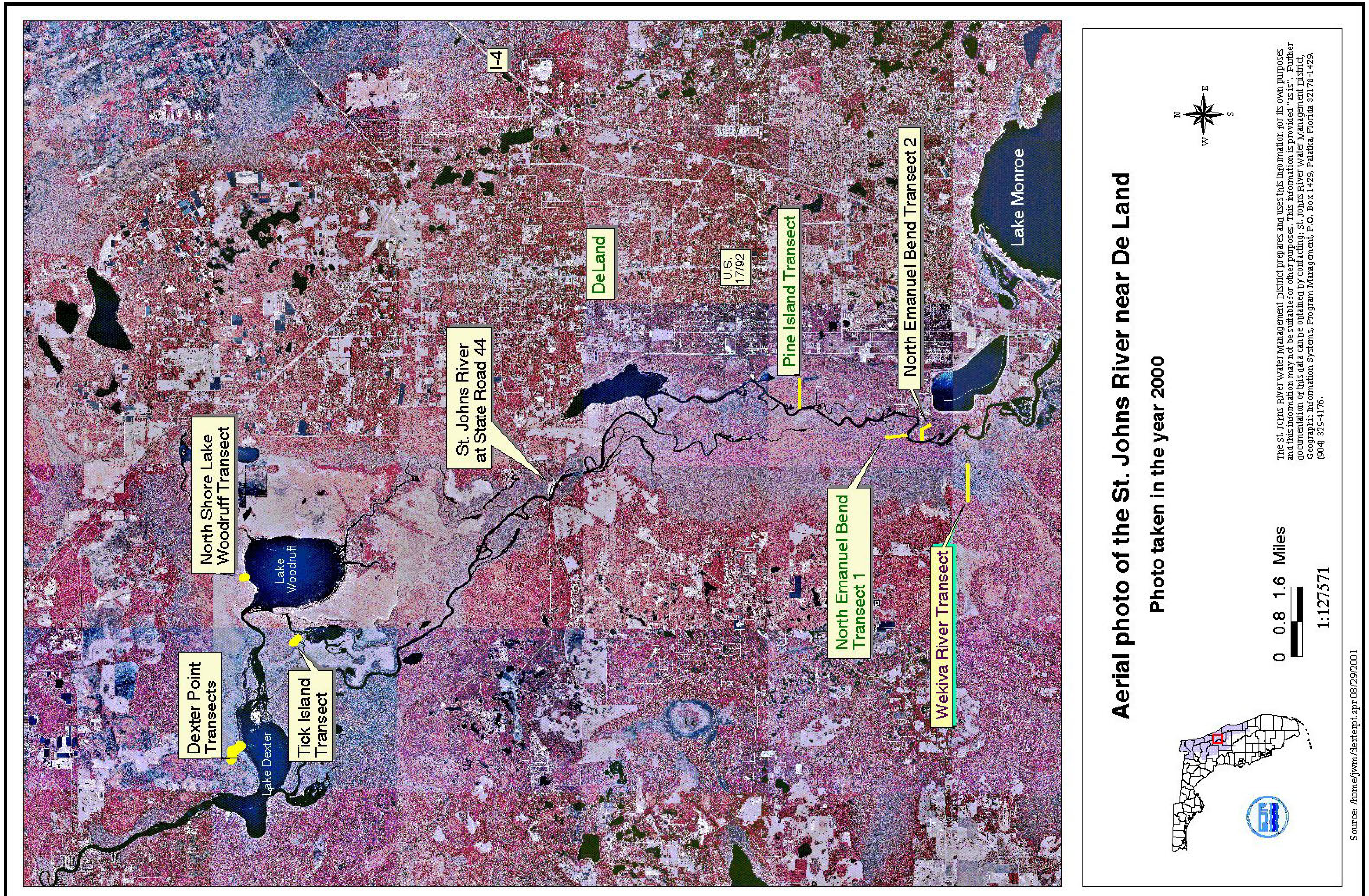



Figure 6. The St. Johns River at State Road 44 near DeLand, with all transects

- 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 and archiving (Hall 2005).

Potential transect locations were initially identified from maps of wetlands, soils, topography, and land ownership. Specific transect site selection goals included selection of (1) sites where multiple wetland communities of the major types occurred and (2) sites 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 between Lake Monroe and Astor. Eight of the 10 most common wetland communities within a 2-mile buffer of the river channel between Lakes Monroe and George were traversed by transects (Table 3). The bayhead and deep marsh wetland communities (Table 3) were not sampled because the bayhead community was not located at any of the 32 sites field evaluated during the transect site selection process and the deep marsh community was noted in locations which are inundated when the river level equals the recommended minimum frequent low level at the St. Johns River at SR 44 near DeLand.

Transect characteristics were subsequently field verified to ensure that the particular locations contained representative wetland communities, hydric soils, and reasonable upland access while avoiding archaeological sites, alligator nests, secondary river channels, and dredge mounds. Locating transects on public land was preferable in order to avoid future development that would alter transects and to facilitate access for long-term ecological monitoring. Thirty-two sites were field-evaluated. Eight final field transect sites were selected (Table 5) at four locations.

Table 5. Field transect locations

| Transect | Transect Location | Location and Date of Fieldwork |
|---|---|---|
| Pine Island | SJR at Pine Island | East bank of the SJR at Pine Island, 1.5 miles upstream from Blue Spring; April–May 2000, July 2001 |
| North Emanuel Bend transect 1 | SJR at North Emanuel Bend | West bank of the SJR at North Emanuel Bend, 1.2 miles downstream from the SJR confluence with the Wekiva River; April 2000 |
| North Emanuel Bend transect 2 | | East bank of the SJR at North Emanuel Bend, 0.7 mile downstream from the SJR confluence with the Wekiva River; April 2000, June 2001 |
| Lower Wekiva River | Lower Wekiva River | West bank of the lower Wekiva River, 0.9 mile upstream from the confluence with the SJR; Sept.–Oct. 2000, August 2001, August 2003 |
| Tick Island | Lake Woodruff National Wildlife Refuge | South shore of Tick Island within the Lake Woodruff National Wildlife Refuge; January 2001 |
| North Shore Lake Woodruff | | North shore of Lake Woodruff; January 2001 |
| Dexter Point East transect | | East side of Dexter Point into *Spartina* and sawgrass marshes, primarily within the Lake Woodruff National Wildlife Refuge; March–May 2001 |
| Dexter Point South transect | | Southerly direction from *Spartina* marsh of the Dexter Point East transect to the open water of Lake Dexter; April–May 2001 |

Note: SJR = St. Johns River

## FIELD DATA COLLECTION

The field data collection procedure for determining MFLs involved gathering information and sampling elevation, soils, and vegetation data along fixed lines, or transects, that cross a hydrologic gradient. Transects were established in areas where there were changes in vegetation and soil, and the hydrologic gradient was marked (Hall 2005). 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 transect. A measuring tape was then laid down on the ground along the length of transect. One elevation measurement was recorded every 10–20 feet (ft) on the ground along the length of each of the eight field transects included in the MFLs determination for the St. Johns River at SR 44 near DeLand.

In general, the elevation gradient was very low and the vegetation communities were very broad at the eight transects. Consequently, elevations were typically recorded at 20-ft intervals. Additional elevations were measured at obvious elevation changes, vegetation community changes, soil changes, and high-water marks and plant tussock heights.

Latitude and longitude data were also collected, using a global positioning system (GPS), along the length of the transect. These data accurately located specific features along the transect and facilitate recovering transect locations in the future.

### Soil Sampling Procedures

Detailed soil profiles were developed at selected stations along the transect line. Soil profiles were described following standard NRCS procedures (NRCS 1998). Each soil horizon (unique layer) was described with respect to texture, thickness, Munsell color (Kollmorgen Corporation 1992), structure, consistency, boundary, and presence of roots.

The primary soil criteria considered in the minimum levels 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

- Remove all loose leaf matter, needles, bark, and other easily identified plant parts to expose the soil surface.
- Dig a hole and describe the soil profile to a depth of at least 20 inches (in.).
- Using the completed soil description, specify which hydric soil indicators have been matched.

Deeper examination of soil may be required where field indicators are not easily seen within 20 in. of the surface. Soils should be excavated and described as deep as necessary to make reliable interpretations and classification (NRCS 1998).

Particular attention should be paid to changes in microtopography over short distances. Small elevation changes may result in repetitive sequences of hydric / non-hydric soils, and the delineation of individual areas of hydric and non-hydric soils may be difficult (NRCS 1998).

Soil sampling intervals varied considerably along the eight transects. The sampling interval was dependent upon on-site soil changes. Typically, sampling occurred in a broad community at 100–300-ft intervals. However, upon recording a soil change from the previously sampled location, more sampling occurred closer to the previous sample, in order to pinpoint the location of soil change. Additional soil sampling procedures are included in Hall 2005.

The following soil features, if present, were identified and their location marked along the transect line 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 8–15 in. thick)
- Landward extent of histosols (≥16-in.-thick surface organic horizon)
- Thickness of organic surface horizon

## Vegetation Sampling Procedures

Vegetation sampling associated with minimum levels determinations 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 divided into smaller sampling areas called quadrats, that correspond to the spatial extent of plant communities or transitions between plant communities (Figure 7). The transect belt width will vary, depending upon the type of plant community to

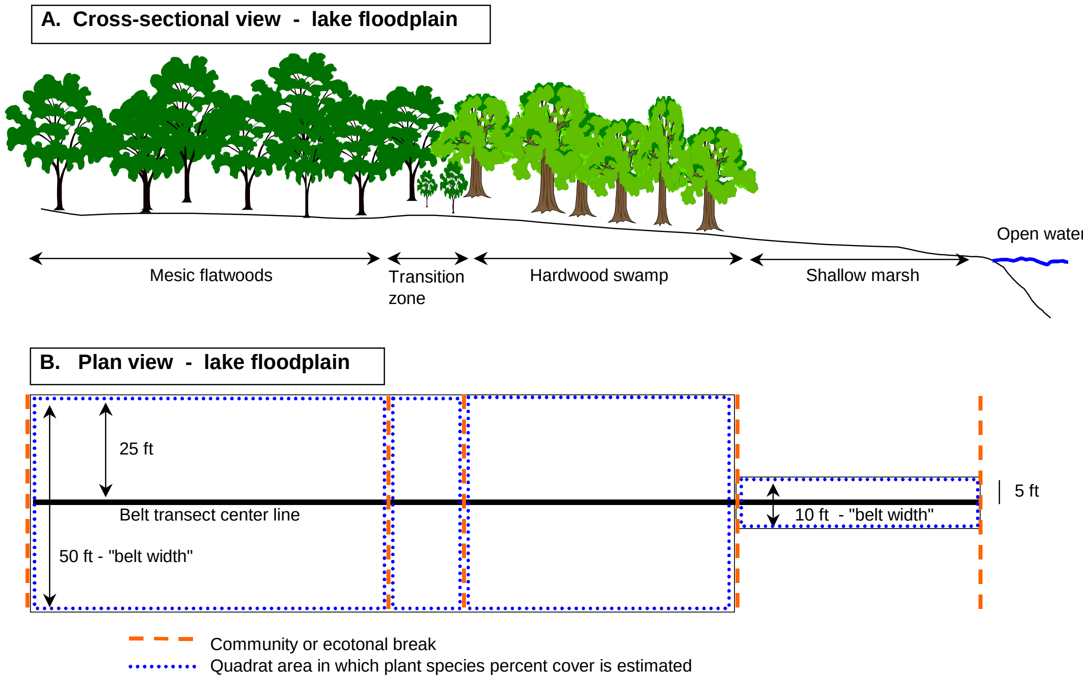



Figure 7. Belt transect through forested and herbaceous plant communities

be sampled (Hall 2005). For example, a belt width of 3–5 ft either side of the transect line may suffice for sampling herbaceous plant communities of a floodplain marsh. However, a belt width of 25–50 ft may be required to adequately represent a forested community (e.g., hardwood swamp).

Plants are identified and the percent cover of plant species is estimated if they lie within the established belt width for the plant community under evaluation (quadrat). Percent cover is defined as the vertical projection of the crown or shoot area of a plant to the ground surface 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 2005).

Percent cover is 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 6.

Table 6. 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 |

It is important that the same person or team estimate plant cover in each quadrat or community because the estimation is likely to vary from person to person or team to team.

Plant species, plant communities, and percent cover data are recorded on field vegetation data sheets (Appendix B). The data sheets are formatted to facilitate data collection in the field and also computer transcription. A detailed explanation of the field vegetation sheet is located in Hall 2005.

The document titled *Wetlands Diagnostic Characteristics* (Kinser 1996) is used to standardize wetland plant community names recorded in the field. SJRWMD has districtwide wetland maps developed from aerial photography using this classification system. Terrestrial (upland) plant community names are modified from the Florida Natural Areas Inventory classification (FNAI and FDER 1990).

## DATA ANALYSIS

The primary data analysis consisted of performing basic statistical analyses on the surveyed elevation data in a computer spreadsheet file. Vegetation and soils information collected along the transect was 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 subset of the hardwood swamp.

Transect elevation data were also graphed to illustrate the elevation profile between the open water and upland community (Figure 8). Location of vegetation communities along the transect with a list of dominant species, statistical results, and soil information were labeled on the graph.

## MINIMUM LEVELS DETERMINATION CRITERIA

Soils and vegetation community field collected data are the principle components of the minimum levels determinations. Standardized procedures for setting each level using the best available information are described in Hall 2005. Criteria vary, depending upon the level being determined (i.e., high, average, or low) and the on-site wetland community characteristics. For example, the primary high level criterion may be the average elevation of a wetland community which experiences flooding approximately 20% of the time, based upon the scientific literature and hydrologic data. Additional high level criteria may include the maximum elevation of a community which typically floods frequently, and / or the elevation equal to the landward extent of hydric soils, or the landward extent of shallow (<8 inches in depth) surface organics.

Tables 7a–d present the primary, secondary, tertiary, and other criteria used for the local minimum level determinations for the St. Johns River at SR 44 near DeLand.

Average level determination criteria typically focus on soil characteristics, when extensive histosols or a histic epipedon are sampled. An appropriate average water level is necessary to conserve the floodplain histosols. Low water levels for extended periods allow for the oxidation of organics present in histosols, ultimately resulting in soil subsidence. A –0.25-ft soil water table drawdown below the average histosol or histic epipedon surface elevation has been used to protect muck soils in this and other MFL 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)

**Figure 8. Pine Island transect topography with ecological communities**

Note: At the Pine Island transect, the minimum frequent high (MFH) equals 2.1 ft NGVD, the minimum average (MA) equals 0.9 ft NGVD, and the minimum frequent low (MFL) equals 0.4 ft NGVD.

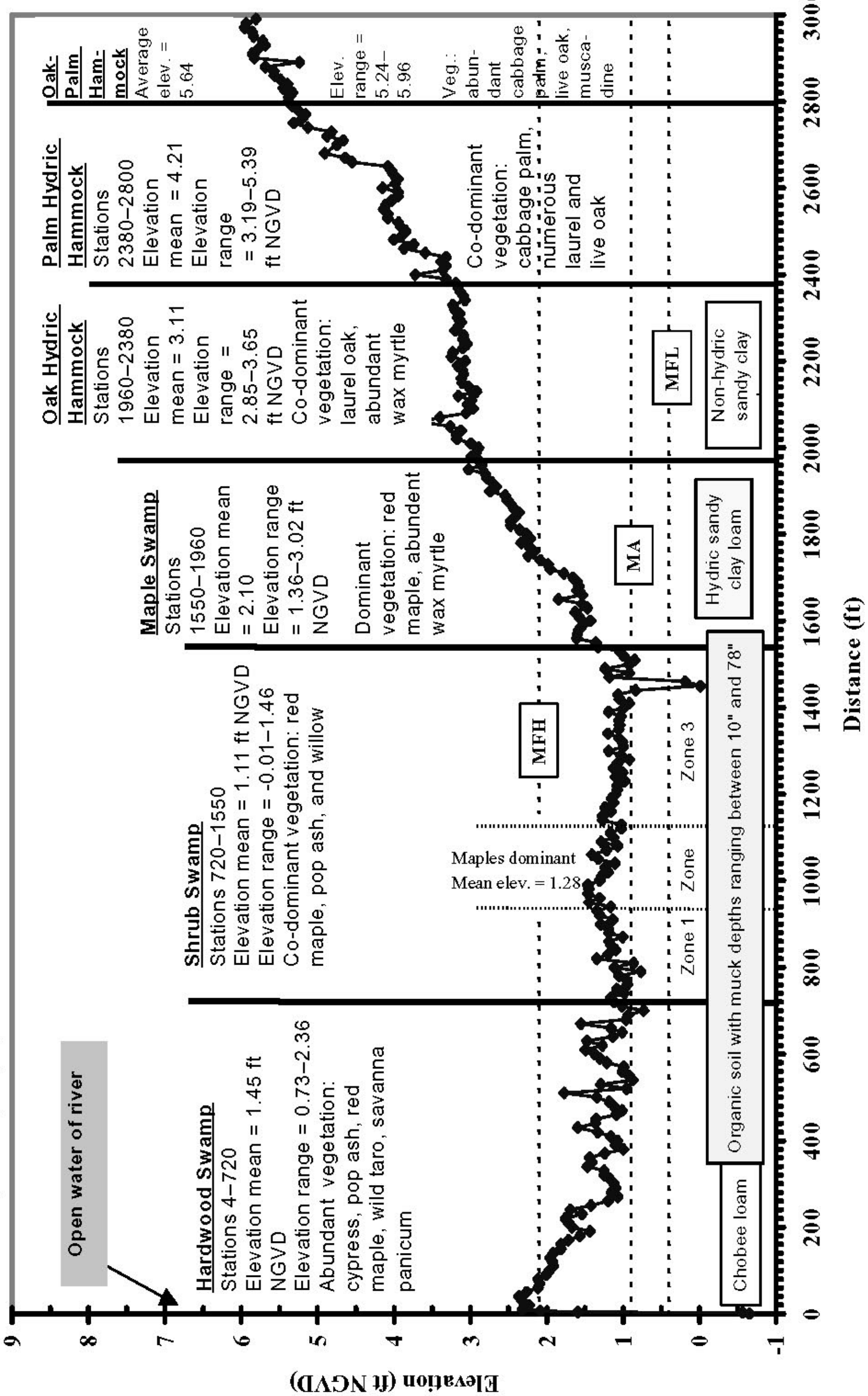


Table 7a. Minimum levels criteria summary for Pine Island

| Primary Criteria | Secondary Criteria | Tertiary Criteria | Additional Criteria |
|---|---|---|---|
| Frequent High 2.1 ft NGVD | | | |
| Average elevation of maple swamp (2.1 ft NGVD) | Maple swamps, a subcategory of mixed swamps, flooded seasonally (Monk 1968) | Similar to maximum elevation of hardwood-cypress swamp (2.4 ft NGVD; stations 4–350) at Pine Island | Hydric soil extent to ecotone maple swamp-hydric oak hammock at 2.8 ft NGVD; water depths range 0–1.4 ft in hardwood-cypress swamp equal to water depth range in hardwood swamp at North Emanuel Bend 1 at frequent high for North Emanuel Bend; water depths range 0.5–2.1 ft in shrub swamp; hydroperiod literature review; stage-duration curve, 19% exceedance |
| Minimum Average 0.9 ft NGVD | | | |
| 0.25 ft below mean surface elevation (1.15 ft NGVD) of all organic soils (stations 360–1600) | Mineral soil (Chobee) at stations 0–360 (hardwood-cypress swamp) has higher moisture content than organics (Wade Hurt, pers. com.); consequently, an anaerobic environment is maintained throughout soils of hardwood-cypress swamp at average level | Hydroperiod literature review | Stage-duration curve, 64% exceedance |
| Frequent Low 0.4 ft NGVD | | | |
| 10 inches (0.83 ft) below average surface elevation of organic soils between stations 360 and 720 (hardwood-cypress swamp; mean elevation = 1.19 ft NGVD). Specifically exclude organic soil elevations in shrub swamp and lower maple swamp because (1) shrub swamp and maple swamp are far from river, so when the St. Johns River is at low level, these communities' soil water tables are primarily a function of upland seepage and localized internal drainage, and (2) localized surface water movement likely occurs between shrub swamp and the St. Johns River downstream from the transect when the river is at a level less than the maximum elevations of hardwood-cypress swamp, thereby providing for longer inundation of shrub swamp and lower maple swamp | Organic soils reside at too low of an elevation for typical 20-inch drawdown, but 10-inch drawdown is the low end of the range cited in literature | Stage-duration curve, 89% exceedance | |

Note: ft NGVD = feet National Geodetic Vertical Datum

Table 7b. Minimum levels criteria summary for North Emanuel Bend (NEB)

| Primary Criteria | Secondary Criteria | Tertiary Criteria | Additional Criteria |
|---|---|---|---|
| Frequent High 2.5 ft NGVD | | | |
| Maximum elevation of the hardwood swamp (2.5 ft NGVD) at NEB transect 1 | Similar to average elevation of hydric hammock (2.8 ft NGVD) at NEB 1 | Inundation of hardwood swamp at NEB 1 with water depths between 0 and 1.4 ft (elevation range, 1.1–2.5 ft NGVD) | Water will inundate hardwood swamp through off-line swales; does not have to exceed maximum elevation of hydric hammock at NEB 1 before inundating hardwood swamp. Similar to average elevation of hardwood swamp (3.0 ft NGVD) at NEB 2; river will backfill marsh at NEB 2 and inundate lower elevations of hardwood swamp at NEB 2 at frequent high level. Frequent high is considerably lower than hydric hammock average elevation 4.9 ft NGVD and also considerably lower than upland communities (5.4 and 5.5 ft NGVD). Stage-duration curve exceedance, 15% |
| Minimum Average 1.1 ft NGVD | | | |
| 0.25 ft below average elevation (1.31 ft NGVD) of shallow marsh at NEB transect 2 | Localized, shallow organic surface horizons prohibit histosol designation but are important to provide saturated soil conditions to prevent organics oxidation and prohibit upland species encroachment into shallow marsh at NEB 2 | Provides ponding in slough areas of shallow marsh at NEB 2 — important for small reptiles and amphibians | Marsh hydroperiod literature review; similar to shrub swamp average elevations (1.2 ft NGVD) at NEB 1. These shrub swamps are dominated by obligate wetland plants and contain areas of deep organic soil. Shrub swamps at NEB 1 may provide important habitat and would have water depths between 0 and 0.3 ft when river equals average level. Stage-duration curve exceedance, 56% |

Table 7b—*Continued*

| Primary Criteria | Secondary Criteria | Tertiary Criteria | Additional Criteria |
|---|---|---|---|
| Frequent Low 0.6 ft NGVD | | | |
| 10 inches below average elevation of shallow marsh (1.47 ft NGVD), excluding the slough areas, at NEB 2 due to (a) soil survey "water table is seldom below 10 inches in Chobee fine sandy loam, even during prolonged dry spells." Chobee fine sandy loam extends throughout the shallow marsh at NEB 2; (b) shallow marsh is broad, flat community directly connected to the river (hydrologic control elevation, 0.72 ft NGVD); (c) elevation points in sloughs excluded from low level calculations because the sloughs represent isolated communities of deep organic soils, not Chobee. Also, average elevation of slough stations equaled 0.75 ft NGVD, indicating that these deep organic soils would be protected from oxidation at the recommended low level; (d) Chobee soils at higher elevations, above marsh, are protected/maintained by seepage | Ensures inundation of eel grass beds at NEB 2 (maximum elevation, 0.5 ft NGVD) | Stage-duration curve exceedance, 82% | |

Note: ft NGVD = feet National Geodetic Vertical Datum

Table 7c. Minimum levels criteria summary for the lower Wekiva River

| Primary Criteria | Secondary Criteria | Tertiary Criteria | Additional Criteria |
|---|---|---|---|
| Frequent High 2.8 ft NGVD | | | |
| Maximum elevation of both upper hardwood swamps on transect (2.79 and 2.81 ft NGVD) | Inundation of hardwood swamps | Water depths in upper hardwood swamp nearly equal to water depths provided by frequent high level in hardwood swamp at Pine Island and NEB (0–1.2 ft depth at Wekiva; 0–1.4 ft depth at NEB and Pine Island) | Soil characteristics indicative of prolonged flooding between stations 0 and 4000. Prominent high-water lines in upper hardwood swamp with median elevation = 5.2 ft NGVD. Stage-duration curve exceedance, 12%. Elevations considerably greater than frequent high were average elevation hydric hammock (3.2), average elevation wet prairie (3.2), palm hydric hammock (6.1), and the minimum elevation of the oak-palm hammock (8.1 ft NGVD) |
| Minimum Average 1.2 ft NGVD | | | |
| 10 inches below average surface elevation (2.08 ft NGVD) of Chobee soils from stations 100–3730 | Soil water table depth in Chobee soil of upper hardwood swamp 1 | Soil water table depth (−0.25) in the lower hardwood swamp where shallow organic surface horizon occurred | Stage-duration curve exceedance, 50%. Seepage affects Chobee soil at higher elevations |
| Frequent Low 0.6 ft NGVD | | | |
| 10 inches below average elevation (1.42 ft NGVD) of lower hardwood swamp. Soil water table in Chobee soil of lower hardwood swamp is “seldom below 10 inches form the soil surface even during prolonged dry spells” | Depressional areas such as the lower hardwood swamp are ponded for long duration in most areas | Seepage affects Chobee soil at higher elevations | Stage-duration curve exceedance 82% |

Note: ft NGVD = feet National Geodetic Vertical Datum

Table 7d. Minimum levels criteria summary for the Lake Woodruff National Wildlife Refuge (LWNWR)

| Primary Criteria | Secondary Criteria | Tertiary Criteria | Additional Criteria |
|---|---|---|---|
| Frequent High 1.7 ft NGVD | | | |
| Average elevation of transitional zone (1.7 ft NGVD) at Dexter Point East transect | Transitional zone located between *Spartina* marsh and hydric hammock | Frequent inundation to prevent upland vegetation encroachment | Prevent further encroachment of hammock species into the marsh. Inundate swamps and marshes of the LWNWR. Stage-duration curve exceedance, 13% |
| Minimum Average 0.7 ft NGVD | | | |
| 0.25 ft below average elevation (1.0 ft NGVD) of all organic soils surveyed at 116 stations within the LWNWR | Soil water table depth in Pompano sand at Dexter Point | Soil water table depth in Sanibel sand | Stage-duration curve exceedance, 54% |
| Frequent Low 0.2 ft NGVD | | | |
| 10 inches below average surface elevation of organic soils (1.0 ft NGVD) in the LWNWR | Soil water table depths in Sanibel and Pompano sands | Stage-duration curve exceedance, 89% | |

Note: ft NGVD = feet National Geodetic Vertical Datum

determined that this –0.25-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 the average every 1–2 years, with a duration of less than or equal to 180 days (Hupalo et al. 1994).

The –0.25-ft soil water table drawdown was the primary criterion used for setting the minimum average level at all the field sites on the St. Johns River at SR 44 near DeLand, except for the lower Wekiva River location. Soils surveyed on the lower Wekiva River transect were mineral, with a very shallow organic surface horizon. A 10-in. soil water table drawdown below the average Chobee mineral soil surface elevation was the primary average level determination criterion at the lower Wekiva River transect. At the recommended minimum average level on the lower Wekiva River transect, the Chobee soil water table level ranged between ponded and 25 in. below the soil surface between stations 100 and 3730. The Chobee soil water table level at the higher elevations is likely less than 25 in. from the soil surface due to seepage and rainfall. Additionally, a loamy soil such as Chobee, with an average porosity of 0.005 centimeter (cm), should have a saturated zone extending at least 12 in. above the free water surface (Mausbach 1992). The intent of the –10-in. drawdown at the average elevation of the Chobee soil between stations 100 and 3730 is to maintain the hydric characteristics of this mineral soil. Tables 7a–d list additional average level determination criteria used for the four local level determinations for the St. Johns River at SR 44 near DeLand.

Criteria for setting the minimum frequent low level also focus on soil characteristics if extensive histosols or a histic epipedon were sampled. Typically, where deep ($\geq$8 in.) organic soils occur, 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 average minimum dry season water table depth of 15.6–26.2 in., with an average hydroperiod of 255 ±11.1 days (ESE 1991). The organic soils surveyed in the St. Johns River floodplain near DeLand occur at an elevation very close to sea level, preventing the typical 20-in. drawdown criterion. Also, the Volusia County soil survey (SCS 1980) described the water table in Terra Ceia muck as seldom below a depth of 10 in., except during extended dry periods. Consequently, a 10-in. soil water table drawdown criterion for the minimum frequent low level determination was applied to the mean surface elevation of histosols observed on the St. Johns River at SR 44 near DeLand transects. Additional minimum frequent low level determination criteria used for the four local level determinations for the St. Johns River at SR 44 near DeLand are summarized in Tables 7a–d. Further information regarding MFLs determination criteria are included in Hall 2005.

## MFL ASSUMPTIONS FOR THE ST. JOHNS RIVER AT SR 44 NEAR DELAND

MFL determinations for the St. Johns River at SR 44 near DeLand were based on a series of assumptions. The assumptions listed below provided the theoretical, practical, and methodological background for the process used to establish biological criteria.

- The levels will be assessed over time to ensure adequate protection for the entire riverine community.
- A given wetland community type will have similar hydrologic and edaphic characteristics and occur in similar relative topographic positions across all transect locations.
- Transferring four sets of local levels to the St. Johns River at SR 44 near DeLand results in a more robust single set of easily monitored levels. The final set of levels is more robust because it is derived from four sets of levels, based upon stand-alone work which occurred in four geographic areas encompassing a 30-mile river reach.
- Infrequent high river levels (river levels above the minimum frequent high levels) are dependent upon seasonal weather events (tropical storms) when high rainfall occurs within the Middle and Upper St. Johns River basins.
- It is impractical to establish infrequent low river levels (river levels below the minimum frequent low levels) due to the low landscape elevation, approaching sea level.
- Lake Dexter and the LWNWR are one large lake basin, with very little topographic relief. Consequently, one set of levels determined for Lake Dexter and the LWNWR will provide the required level of protection.
- Histosol soil water table drawdown criteria will prevent soil subsidence.
- Mineral soil water table drawdown criteria will protect the structural integrity of the soil horizon and maintain hydric soil characteristics.

- The hydric characteristics of the clay loams sampled at higher elevations and / or further from the river channel are partially a function of soil porosity, rainfall, and upland seepage.
- Deep marsh communities occur within the river channel and / or at locations which will be inundated when river levels equal or exceed the minimum frequent low level.

# RESULTS AND DISCUSSION

In order to determine recommended minimum levels for the St. Johns River at SR 44 near DeLand, MFLs field data were obtained at each of the eight transects. Then local minimum levels were determined for each of the four river reaches where the eight transects were located—the St. Johns River at Pine Island, the St. Johns River at North Emanuel Bend, the lower Wekiva River, and Lake Woodruff National Wildlife Refuge, including the St. Johns River at Lake Dexter. Finally, the four sets of locally determined levels were modeled using the St. Johns River at SR 44 as a convergent endpoint, and MFLs were developed for this location.

Transect site selection factors, detailed transect location information, and the three surface water level determinations (minimum frequent high, minimum average, and minimum frequent low) for each transect location are summarized in this document section (Table 8). Each set of minimum level determinations is discussed immediately following the field data descriptions for a given transect location. Additionally, the process used to transfer the minimum levels determined for each of the four river reaches to SR 44 is described.

Table 8. Field transect names, locations, local levels, and percent of time the level is exceeded (value in parentheses)

| Transect | Transect Location | Frequent High Level (ft NGVD) | Average Level (ft NGVD) | Frequent Low Level (ft NGVD) |
|---|---|---|---|---|
| Pine Island | SJR at Pine Island | 2.1 (19%) | 0.9 (64%) | 0.4 (89%) |
| North Emanuel Bend transect 1 | SJR at North Emanuel Bend | 2.5 (15%) | 1.1 (56%) | 0.6 (83%) |
| North Emanuel Bend transect 2 | | | | |
| Lower Wekiva River | Lower Wekiva River | 2.8 (14%) | 1.2 (54%) | 0.6 (84%) |
| Tick Island | Lake Woodruff National Wildlife Refuge | 1.7 (13%) | 0.7 (57%) | 0.2 (89%) |
| North Shore Lake Woodruff | | | | |
| Dexter Point East | | | | |
| Dexter Point South | | | | |

Note: ft NGVD = feet National Geodetic Vertical Datum
SJR = St. Johns River

This report section is divided into five distinct sections: four sections providing recommended results for each of the transect locations and one section providing results for the MFLs for the St. Johns River at SR 44 near DeLand. This organization provides specific types of transect information for each site which ultimately became the primary criteria applied to determined MFL recommended for the St. Johns River at SR 44 near DeLand.

## ST. JOHNS RIVER AT PINE ISLAND

### Field Data

The Pine Island transect is located on the east bank of the St. Johns River on Pine Island, approximately 8.4 miles upstream from the SR 44 bridge over the St. Johns River and 1.5 miles upstream from the confluence of Blue Spring run and the St. Johns River.

| Latitude, Longitude (station 0) | Latitude, Longitude (end station) | Location and Date of Fieldwork |
|---|---|---|
| 28 55 35.05<br>81 21 10.34 | 28 55 36.17<br>81 20 37.19 | East bank of the St. Johns River at Pine Island, 1.5 miles upstream from Blue Spring run; April–May 2000, July 2001 |

### Transect Selection Factors

The primary factors which contributed to selection of this transect location included the following:

- Extensive wetland plant communities (hardwood swamp, shrub swamp, maple swamp, oak hydric hammock, palm hydric hammock)
- Extensive area of histosols
- Transect termination in upland community
- Located within Blue Spring State Park, avoiding future development that would affect transects and facilitating access for long-term ecological monitoring
- Close proximity to staff gage at Blue Spring State Park
- Located on the reach of the St. Johns River identified for possible water withdrawal for public supply (CH2M HILL 1999)

## Vegetation at Pine Island

Dominant species within each community type traversed at Pine Island are presented in Table 9. The distribution of the vegetation communities from the river to the uplands is primarily influenced by the elevation gradient (Figure 8). The Pine Island transect originates in the open water of the St. Johns River and traverses in an easterly direction over a bank into a mature hardwood swamp, a shrub swamp, a maple swamp, an oak hydric hammock, and a palm hydric hammock, and terminates in an upland oak-palm hammock.

Table 9. Pine Island transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | HS | SS | MS | OHH | PHH | OPH |
| Alligator-weed | *Alternanthera philoxeroides* | OBL | 1 | 1 | | | | |
| American elm | *Ulmus americana* | FACW | 1–3 | 0 | 1 | 1 | | |
| American germander | *Teucrium canadense* | FACW | 1 | | | | | |
| Arrowhead | *Sagittaria lancifolia* | OBL | | 1 | | | | |
| Bald cypress | *Taxodium distichum* | OBL | 3 | | | | | |
| Bulrush | *Scirpus* sp. | OBL | | 0 | | | | |
| Buttonbush | *Cephalanthus occidentalis* | OBL | 2 | 2–4 | 1 | 0 | | |
| Cabbage palm | *Sabal palmetto* | FAC | | | | 1–2 | 3–4 | 3 |
| Carolina willow | *Salix caroliniana* | OBL[3] | | 1–4 | 1–2 | | | |
| Climbing aster | *Aster carolinianus* | OBL | 1 | 1 | 1 | | | |
| Coinwort | *Centella asiatica* | FACW | | | | 0 | | |
| Common reed | *Phragmites australis* | OBL | 5* | | | | | |
| Cutgrass | *Leersia* sp. | OBL | 3 | 2 | | | | |
| Dog fennel | *Eupatorium* sp. | FAC | 0 | | | | | |
| Dotted smartweed | *Polygonum punctatum* | FACW[3] | | 2–3 | | | | |
| False indigo | *Amorpha fruticosa* | FACW | 0–1 | | | | | |
| False-nettle | *Boehmeria cylindrica* | OBL | 1 | 1 | | | | |
| Fire-flag | *Thalia geniculata* | OBL | 1 | 1 | | | | |
| Groundsel tree | *Baccharis glomeruliflora* | FAC | | 1 | | | | |
| Horned beakrush | *Rhynchospora inundata* | OBL | | 1–2 | 0 | | | |
| Laurel oak | *Quercus laurifolia* | FACW | | | | 3–4 | 2 | 2 |
| Live oak | *Quercus virginiana* | UPL | | | | 0 | 2 | 3 |
| Marsh pennywort | *Hydrocotyle umbellata* | OBL[3] | 1 | 1–2 | 1 | 1 | | |
| Mock bishop-weed | *Ptilimnium capillaceum* | FACW | 1 | 2 | | | | |
| Morning glory | *Jacquemontia* sp. | UPL | | 1 | | | | |
| Muscadine | *Vitis rotundifolia* | FAC[3] | | | | | 2 | 3–4 |
| Parrot's feather | *Myriophyllum aquaticum* | OBL | 0 | | | | | |
| Pepper-vine | *Ampelopsis arborea* | FAC[3] | | 1–3 | 2–3 | 2–3 | | |
| Persimmon | *Diospyros virginiana* | FAC | | | | 0 | | |
| Pickerelweed | *Pontederia cordata* | OBL | 1 | | | | | |
| Poison ivy | *Toxicodendron radicans* | FAC[3] | 2 | 2 | | | | |

Table 9—*Continued*

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | HS | SS | MS | OHH | PHH | OPH |
| Pop ash | *Fraxinus caroliniana* | OBL | 3 | 1–2 | | | | |
| Red maple | *Acer rubrum* | FACW | 3 | 2–5 | 5 | 2 | | |
| Resurrection fern | *Polypodium* sp. | UPL | | | | | 2 | 2 |
| Royal fern | *Osmunda regalis* | OBL | 1 | 1 | | | | |
| Sand cordgrass | *Spartina bakeri* | FACW | | 1–4 | 1 | | | |
| Savannah panicum | *Panicum gymnocarpon* | OBL | 3–4 | | | | | |
| Saw palmetto | *Serenoa repens* | UPL | | | | 0 | 0 | 1 |
| Scarlet rosemallow | *Hibiscus coccineus* | OBL | 1 | 1 | | | | |
| Seashore mallow | *Kosteletzkya virginica* | OBL | | 2–3 | 2 | | | |
| Slash pine | *Pinus elliottii* | UPL | | | | 0 | 2–3 | 1 |
| Spider-lily | *Hymenocallis* sp. | OBL | 1–2 | | | | | |
| Swamp dock | *Rumex verticillatus* | FACW[3] | 1 | 0–1 | | | | |
| Swamp dogwood | *Cornus foemia* | FACW | | | | 0 | | |
| Swamp mallow | *Hibiscus grandiflorus* | OBL | | 1–2 | 2 | | | |
| Trumpet vine | *Campsis radicans* | FAC[3] | 1 | 1 | 2 | | | |
| Vervain | *Verbena brasiliensis* | FAC | | | 1 | | | |
| Virginia chain fern | *Woodwardia virginica* | FACW | | 0 | 3 | 2 | | |
| Waterhyacinth | *Eichhornia crassipes* | OBL | | 3[†] | | | | |
| Water oak | *Quercus nigra* | FACW | | | | 0 | 1 | 1–2 |
| Wax myrtle | *Myrica cerifera* | FAC | | 1 | 1–3 | 2–3 | | |
| Wild taro | *Colocasia esculenta* | OBL | 2–4 | | | | | |

Note: HS = hardwood swamp
SS = shrub swamp
MS = maple swamp
OHH = oak hydric hammock
PHH = palm hydric hammock
OPH = oak-palm hammock

[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

[3]Denotes indicator category from Mohlenbrock 1993

*Common reed was dominant between stations 730 and 770 only
[†]Waterhyacinth occurred only between stations 1446 and 1460

The hardwood swamp (stations 4–720) overstory vegetation consists of abundant mature red maple (*Acer rubrum*), bald cypress (*Taxodium distichum*), pop ash (*Fraxinus caroliniana*), and American elm (*Ulmus americana*). The transect passes two very large bald cypress at stations 310 and 340. These bald cypress buttress with a ground level diameter of 8–10 ft. The buttress swell extends vertically to a height of at least 6 ft. Above the buttress swell, the trunk diameter was approximately 4–6 ft. Additional very large bald cypress are growing 100–200 ft from the transect in the vicinity of stations 310–340. Buttonbush (*Cephalanthus occidentalis*) is numerous throughout the hardwood swamp mid-canopy. The hardwood swamp understory vegetation is variable, with areas where savannah panicum (*Panicum gymnocarpon*) is co-dominant, wild taro (*Colocasia esculenta*) is co-dominant, and spider lily (*Hymenocallis* sp.) is numerous.

A shrub swamp (located at stations 720–1550) is adjacent to the hardwood swamp. The shrub swamp was separated into three zones, based on the vegetation. Table 10 and Figure 8 illustrate the slight elevation differences among the three zones of the shrub swamp. In zone 1 (stations 720–920), the co-dominant overstory vegetation is red maple (<20 ft tall), Carolina willow (*Salix caroliniana*), and buttonbush. The understory in zone 1 is composed of abundant dotted smartweed (*Polygonum punctatum*) and seashore mallow (*Kosteletzkya virginica*).

Table 10. Pine Island transect soil and vegetation statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Open water of the SJR | 0–3 | -0.61 | -0.61 | -0.65 | -0.56 | 2 |
| Hardwood swamp | 4–720 | 1.45 | 1.36 | 0.73 | 2.36 | 74 |
| Shrub swamp | 720–1,550 | 1.11 | 1.12 | -0.01 | 1.46 | 83 |
| Zone 1—shrub swamp | 720–920 | 1.10 | 1.12 | 0.76 | 1.34 | 20 |
| Zone 2—shrub swamp | 920–1,110 | 1.28 | 1.29 | 1.07 | 1.46 | 19 |
| Zone 3—shrub swamp | 1,110–1,550 | 1.03 | 1.06 | -0.01 | 1.36 | 44 |
| Muck soil thickness ≥8 inches | 360–1,600 | 1.15 | 1.13 | -0.01 | 1.77 | 125 |
| Maple swamp | 1,550–1,960 | 2.10 | 2.19 | 1.36 | 3.02 | 42 |
| Oak hydric hammock | 1,960–2,380 | 3.11 | 3.11 | 2.85 | 3.65 | 43 |
| Palm hydric hammock | 2,380–2,800 | 4.21 | 4.03 | 3.19 | 5.39 | 42 |
| Oak-palm hammock | 2,800–2,990 | 5.64 | 5.69 | 5.24 | 5.96 | 20 |

Note: ft NGVD = feet National Geodetic Vertical Datum
SJR = St. Johns River

Additionally, within zone 1 between stations 720 and 770, common reed (*Phragmites australis*) is dominant. In zone 2 (stations 920–1110), the overstory is dominated by red maple (<20 ft tall), with buttonbush co-dominant. Seashore mallow, horned beakrush (*Rhynchospora inundata*), and pepper-vine (*Ampelopsis arborea*) are numerous in the understory. Additionally, within zone 2 between stations 1010 and 1110 there are many (>50) royal fern (*Osmunda regalis*) tussocks. Only a few of these royal fern tussocks are found with viable fronds. In zone 3 (stations 1110–1550), Carolina willow is co-dominant with red maple (<20 ft tall) numerous in the overstory. Sand cordgrass (*Spartina bakeri*) is numerous to co-dominant in the understory of zone 3. Other understory species numerous in zone 3 included seashore mallow, dotted smartweed, swamp mallow *(Hibiscus grandiflora*), and cutgrass (*Leersia hexandra*).

Landward of the shrub swamp, the Pine Island transect traversed a maple swamp (stations 1550–1960). The dominant maple swamp overstory vegetation is mature red maple. Wax myrtle (*Myrica cerifera*) is scattered to numerous in the mid-canopy of the maple swamp. The maple swamp understory is composed of numerous swamp mallow, seashore mallow, pepper-vine, and trumpet vine (*Campsis radicans*).

Adjacent to the maple swamp, the transect traversed an oak hydric hammock (stations 1960–2380). Laurel oak (*Quercus laurifolia*) is abundant in the overstory of the oak hydric hammock. Additional species growing in the oak hydric hammock overstory include numerous wax myrtle and red maple. Virginia chain fern (*Woodwardia virginica*) and pepper-vine are numerous in the understory of the oak hydric hammock.

Landward of the oak hydric hammock, the transect traversed a palm hydric hammock (stations 2380–2800). Cabbage palm (*Sabal palmetto*) is co-dominant in the palm hydric hammock overstory, along with numerous laurel oak, slash pine (*Pinus elliottii*), and live oak (*Quercus virginiana*). Muscadine grape (*Vitis rotundifolia*) is numerous in the understory.

The Pine Island transect terminates in an oak-palm hammock (stations 2800–2990). The vegetation composition of the oak-palm hammock (Table 9) is similar to the adjacent palm hydric hammock. The major difference is the lesser abundance of cabbage palm and a greater abundance of live oak in the oak-palm hammock. Additionally, water oak (*Quercus nigra*) is numerous in the oak-palm hammock overstory and muscadine is abundant to co-dominant in the oak-palm hammock understory.

## Soils at Pine Island

Soil observations were made intermittently along the Pine Island transect between stations 38 and 2040. The soils immediately adjacent to the river were Chobee fine sandy loam (stations 38–350) except for station 38, where Tequesta muck was identified. Black surface horizons of either shallow muck and / or mucky loam were observed in the Chobee soils near the river (stations 38–350). With the exception of the first soil sampled (station 38), these soils contained an insufficient thickness (<8 in.) of muck to be classified as a histic epipedon. Rather, the thick black surface horizons were predominantly mineral in nature, signifying a mollic epipedon. Consequently, these soils were labeled as Chobee soil due to the mollic epipedon (Debra Segal, senior scientist, Jones, Edmunds and Associates, pers. com. 2001). Soil organic matter increased substantially between stations 360 and 720 within the hardwood swamp and within the shrub swamp (stations 720–1550), with either histic epipedons or histosols present. The soils were classified as Tequesta muck, Gator muck, or Terra Ceia muck between stations 360 and 1600, with muck thickness varying from location to location (Table 11 and Figure 8).

The shrub swamp transitions into a maple swamp at station 1550. This point also marks a notable incline in surface elevation, with a steady increase in elevation throughout the maple swamp (Figure 8). Soils change substantially within the maple swamp, presumably due to changes in surface topography and associated hydrology. The low end of the maple swamp at station 1600 (elevation 1.4 feet National Geodetic Vertical Datum [ft NGVD]) exhibited a thick, 14-in. accumulation of surface muck, denoting a histic epipedon. This soil was classified as Tequesta muck. The soil at station 1680 was a sandy clay loam with no muck horizon (Felda series). The soils between stations 1800 and 2040 were classified as Paisley sand. The Paisley sand at station 1800 was marginally hydric (Debra Segal, pers. com. 2001). The first non-hydric soil was recorded at station 1970 (elevation 2.9 ft NGVD). See the appendix for soil series descriptions.

Table 11. Pine Island transect soil types and muck depths

| Station Distance (feet) | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Vegetation Community |
|---|---|---|---|---|
| 38 | 2.4 | Tequesta muck | 8 | Hardwood swamp |
| 90 | 2.0 | Chobee | 5 | Hardwood swamp |
| 130 | 2.0 | Chobee | 0 | Hardwood swamp |
| 220 | 1.8 | Chobee | 2 | Hardwood swamp |
| 280 | 1.2 | Chobee | 0 | Hardwood swamp |
| 320 | 1.2 | Chobee | 3 | Hardwood swamp |
| 340 | 1.5 | Chobee | 0 | Hardwood swamp |
| 360 | 1.4 | Gator muck | 16 | Hardwood swamp |
| 400 | 1.1 | Tequesta muck | 14 | Hardwood swamp |
| 450 | 1.4 | Gator muck | 29 | Hardwood swamp |
| 500 | 1.3 | Gator muck | 30 | Hardwood swamp |
| 600 | 1.4 | Terra Ceia muck | 40+ | Hardwood swamp |
| 900 | 1.3 | Tequesta muck | 14 | Shrub swamp |
| 1,000 | 1.3 | Terra Ceia muck | 74 | Shrub swamp |
| 1,200 | 1.1 | Terra Ceia muck | 40+ | Shrub swamp |
| 1,500 | 0.9 | Terra Ceia muck | 40+ | Shrub swamp |
| 1,560 | 1.6 | Gator muck | 26 | Maple swamp |
| 1,600 | 1.4 | Tequesta muck | 10 | Maple swamp |
| 1,680 | 1.6 | Felda series | 0 | Maple swamp |
| 1,800–1,960 | 2.6 | Paisley sand—hydric | 0 | Maple swamp |
| 1,970–2,040 | 3.0 | Paisley sand—nonhydric | 0 | Oak hydric hammock |

Note: ft NGVD = feet National Geodetic Vertical Datum

## Minimum Levels at Pine Island

The major criteria applied in the level determinations for each of the minimum levels for the St. Johns River at Pine Island are defined in Table 7a.

| Minimum Levels for Pine Island | |
|---|---|
| Minimum frequent high level | 2.1 ft NGVD |
| Minimum average level | 0.9 ft NGVD |
| Minimum frequent low level | 0.4 ft NGVD |

### Minimum Frequent High Level (2.1 ft NGVD)

The locally determined minimum frequent high level for the St. Johns River at Pine Island equals 2.1 ft NGVD, with a hydroperiod category of seasonally flooded.

Seasonally flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, river levels causing inundation are expected to occur several weeks to several months every 1–2 years (40C-8.021(15), *F.A.C.*). Modeling results (Robison 2003) support the locally determined minimum frequent high level and hydroperiod category of seasonally flooded at Pine Island, indicating that this elevation (2.1 ft NGVD) will be flooded for 60 continuous days on average once every 3 years. Additionally, the locally determined minimum frequent high level equals the 19% exceedance on the simulated stage-duration curve for the St. Johns River at Pine Island (Figure 9) (Robison 2003).

This locally determined minimum frequent high level equals the average elevation of the maple swamp traversed at Pine Island (Figure 8; stations 1550–1960). This level and hydroperiod category will ensure that the lower elevations of the maple swamp are inundated at least every 1–2 years for a period of several weeks to several months (Robison 2003). Maple swamps are considered a subcategory of mixed hardwood swamps. Monk (1968) described mixed hardwood swamps as being dominated primarily by broad-leaved deciduous species and as occurring along creeks, rivers, sloughs, and basins that are flooded seasonally. Additionally, the locally determined minimum frequent high level (2.1 ft NGVD) is similar to the maximum elevation (2.4 ft NGVD) surveyed in the hardwood swamp (stations 4–720) at Pine Island.

The locally determined minimum frequent high level and hydroperiod category will ensure inundation of the hardwood swamp (stations 4-720) adjacent to the river at Pine Island, as well as the extensive shrub swamp (stations 720–1550; Figure 8) at least every 1–2 years for a period of several weeks to several months. Water depths will range between 0 and 1.4 ft (mean water depth equals 0.7 ft) in the hardwood swamp and between 0.6 and 2.1 ft in the shrub swamp traversed at Pine Island.

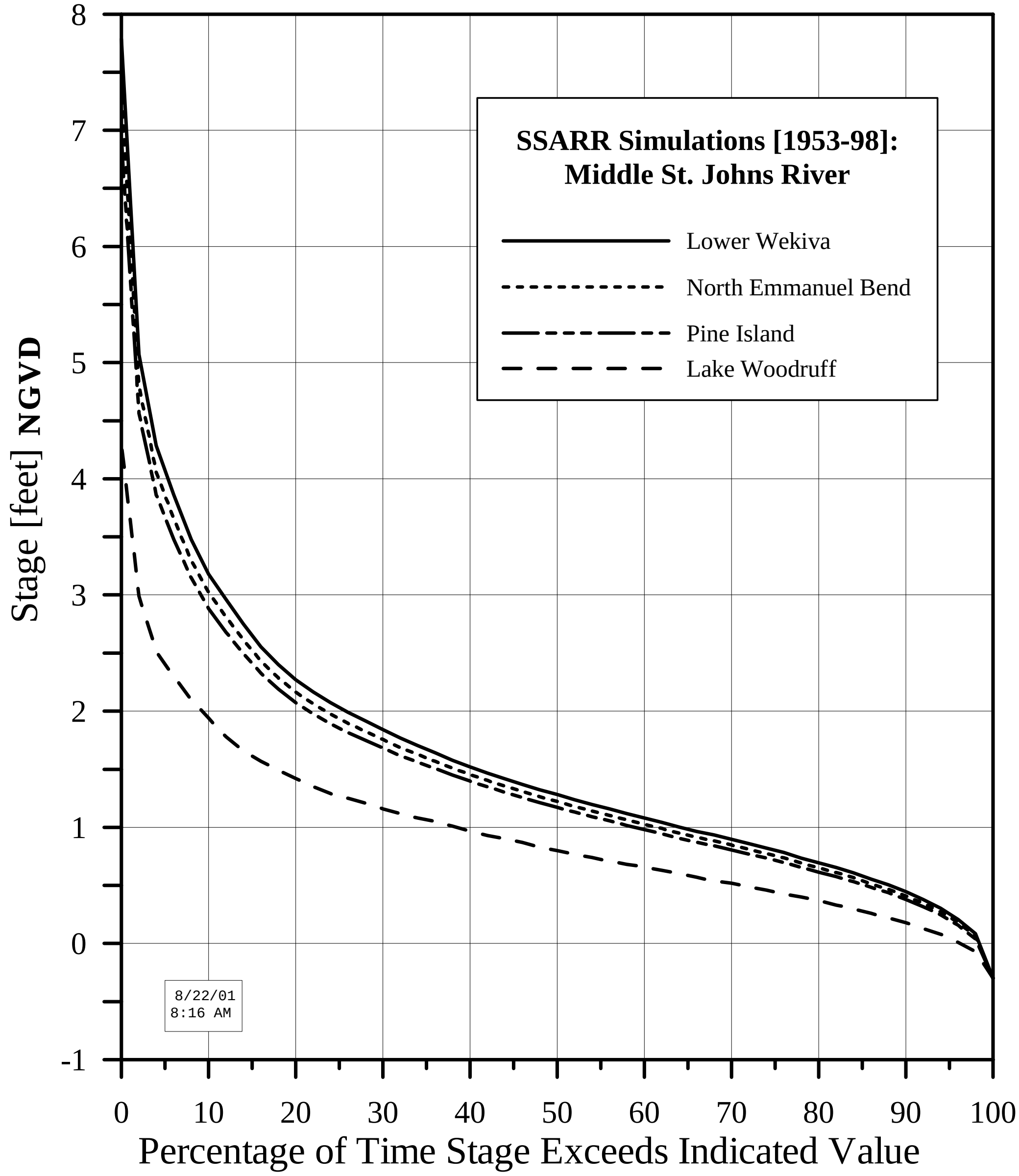



Figure 9. Stage-duration curves

The fact that the hydric soil (Paisley fine sand) extended to the ecotone of the maple swamp and oak hydric hammock (elevation 2.8 ft NGVD) was also examined in determining the minimum frequent high level at Pine Island. This hydric soil landward extent elevation indicated that the soil was inundated or saturated at 2.8 ft NGVD for extended periods. When the minimum frequent high level (2.1 ft NGVD) occurs at Pine Island, a saturated zone may occur several inches above the soil water table in the Paisley fine sand (Mausbach 1992), maintaining the hydric soil characteristics to the landward extent of the Paisley fine sand.

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive forested swamps and shrub swamps adjacent to the river channel. Valentine-Darby (1999) reviewed the literature on mixed hardwood swamps and scrub-shrub wetlands hydrology and found the following:

- CH2M HILL (1996) recommended hydroperiods for two categories of mixed swamp communities. They suggested that mixed hardwood swamps should be inundated for an average of 150 days per year (or 41%) and deep hardwood swamps should be inundated for 240 days per year (or 66%).
- Ewel (1990) reported that mixed hardwood swamps experience hydroperiods on the order of 6–9 months (i.e., 180–270 days or 50–74% of the year).
- Hupalo's 1996 hydroperiod analysis of mixed swamps at three SJRWMD lakes (Dorr, Orange, and Newnans) found that they were flooded an average of 37% of the year (or 135 days).
- Scrub-shrub wetlands are areas dominated by woody vegetation that is less than 20 ft tall. The woody vegetation includes shrubs, young trees, and trees or shrubs that are stunted due to environmental conditions. These areas are either relatively stable communities or successional stages leading to forested wetlands (Cowardin et al. 1979).
- According to Cowardin et al. (1979), the broad-leaved deciduous, scrub-shrub wetlands, such as the shrub swamp at Pine Island, are typically dominated by willow, buttonbush, alder, and young trees of species such as red maple.
- CH2M HILL (1996) recommended average hydroperiods for three types of scrub-shrub wetlands. For wax myrtle scrub-shrub communities, they recommended a hydroperiod of 90 days per year (or 24.7%), and for willow scrub-shrub communities they recommended a hydroperiod of 270 days per year (or 74%). For a third group, mixed scrub-shrub, they recommended an average flooding duration of 180 days per year (or 49.3%). The hydroperiods are based on CH2M HILL's literature review.

- Hupalo (1996) conducted hydroperiod analyses for two types of shrub-dominated communities, myrtle prairies and willow swamps. Myrtle prairies had an average hydroperiod of 19% (or 69.3 days per year). Willow swamps, in comparison, had an average hydroperiod of 77% (or 281 days per year). These analyses had sample sizes of four each, and all data points but one were from Duever et al. 1978.

Interactions with the adjacent river swamps through connection of the channel 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 main channel to the inundated areas for spawning and feeding. These migrations are more lateral, perpendicular to river flow, than upriver or downriver (Guillory 1979). As the river continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of floodplain forest are inundated (Light et al. 1998).

Additionally, river 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 (0.9 ft NGVD)

The locally determined minimum average level for the St. Johns River at Pine Island is 0.9 ft NGVD, with a hydroperiod category of typically saturated. The typically saturated hydroperiod category corresponds to a water level that may re-occur approximately every year or two for about 6 months during the dry season. The locally determined average level and hydroperiod category approximate a typical level that is slightly less than the long-term median water level while still protecting the wetland resource. Modeling results (Robison 2003) support the recommended minimum average level and hydroperiod category of typically saturated at Pine Island, indicating that a river level equal to 0.9 ft NGVD will not occur more often than once every 1.5 years for 90 days. The locally determined minimum average level (0.9 ft NGVD) equals the 64% exceedance level on the simulated stage-duration curve for the St. Johns River at Pine Island (Figure 9) (Robison 2003).

The minimum average level was calculated by subtracting 0.25 ft from the mean surface elevation of the organic soils observed at Pine Island within the hardwood swamp, shrub swamp, and lower elevations of the maple swamp (stations 360–1600; Figure 8).

An appropriate average water level is necessary to conserve the floodplain histosols (organic hydric soils). Low water levels for extended periods allow for the oxidation of organics present in histosols, ultimately resulting in soil subsidence. This criterion (0.25 ft below mean surface elevation of organic soils) has been used to protect muck soils in other minimum levels 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 –0.25-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 the average every 1–2 years with a duration of less than or equal to 180 days (Hupalo et al. 1994).

The application of the –0.25-ft average water table depth in organic soils in central and north Florida is considered reasonable and meets the legislative requirement to use best available information. For comparison, Stephens 1974 reported that a –0.8-ft average long-term water table depth prevented oxidation / subsidence for peat systems in northern Indiana, USA. Indiana wetland systems, which remain frozen during winter months, have much lower oxidation and subsidence rates than similar Florida wetlands.

The mineral soils observed within the hardwood swamp immediately adjacent to the river (stations 4–350; average surface elevation = 1.72 ft NGVD; Figure 8) were Chobee fine sandy loam. Chobee soils have a greater moisture content during dry periods than organic soils due to the extremely small particle size of Chobee soils (Wade Hurt, state soil scientist, NRCS, pers. com. July 24, 2001). The high moisture content of Chobee soils as compared to the adjacent histosols was observed during a site visit on May 24, 2001, while the region was experiencing a drought and the river level equaled approximately 0.4 ft NGVD at Pine Island. The locally determined minimum average level of 0.9 ft NGVD maintains an anaerobic soil environment within the entire hardwood swamp, the shrub swamp, and the lower elevations of the maple swamp at Pine Island, thus preventing oxidation / subsidence of organic soils and ensuring the maintenance of hydric conditions in the mineral soils.

Wetland community structure results from sequential colonization (high water) and extirpations (low water). A drying wetland, however, does not necessarily result in fish mortality. Fish that do not seek refuge in the main river channel and cannot resist direct desiccation may still survive drying wetlands by escaping to small aquatic refugia (Messina and Conner 1998). Fish may survive in puddles (depth <2.4 in.), as do some invertebrates. Crayfish burrows are abundant in bottomland hardwoods (Lambou 1990), providing refugia for many small fish. Crayfish burrows were observed along the Pine Island transect between stations 4 and 1960. Bluefin killifish, pirate perch, pygmy sunfish, tadpole madtoms, and possibly mosquitofish occupy crayfish burrows when floodplains and shallow ponds in south Georgia dry for 3–4 months (Neill 1951). The crayfish burrows lead down to the water table, sometimes opening into a complex network of horizontal passages (Creaser 1931; Neill 1951). These fish species also inhabit the St. Johns River (FWC 2001) and were recently collected from the Wekiva and Little Wekiva Rivers (Warren et al. 2000). When the St. Johns River equals the locally determined minimum average level (0.9 ft NGVD), small pools with water depths between 2 and 11 in. will persist at the lowest elevations within the hardwood swamp and the shrub swamp traversed at Pine Island.

**Minimum Frequent Low Level (0.4 ft NGVD)**

The locally determined minimum frequent low level for the St. Johns River at Pine Island is 0.4 ft NGVD, with an associated hydroperiod category of semipermanently flooded. This minimum level typically occurs every 5–10 years for several months during moderate droughts. Modeling results (Robison 2003) support the locally determined minimum frequent low level and hydroperiod category of semipermanently flooded at Pine Island, indicating that the river is at or below 0.4 ft NGVD for 60 continuous days on average once every 5 years. The locally determined minimum frequent low level at Pine Island (0.4 ft NGVD) equals the 89% exceedance from the simulated stage-duration curve for the St. Johns River at Pine Island (Figure 9) (Robison 2003).

The locally determined minimum frequent low level at Pine Island was calculated by subtracting 10 in. (0.83 ft) from the average surface elevation (1.19 ft NGVD) of the organic soils within the hardwood swamp (stations 360–720) traversed at Pine Island.

The surface elevations of the organic soils within the shrub swamp (stations 720–1550) and lower elevations of the maple swamp (stations 1550–1600) were excluded from the minimum frequent low level calculations for the following reasons:

- As traversed by the Pine Island transect, the shrub swamp and maple swamp are a great distance from the river when the river level equals the locally determined minimum frequent low level. Consequently, at the Pine Island locally determined minimum frequent low level (0.4 ft NGVD), the soil moisture and the water table level within the shrub swamp and the lower maple swamp are most likely primarily a function of upland seepage and localized internal drainage.
- Localized surface water movement between the river and the shrub swamp and lower maple swamp at the Pine Island transect likely occurs from the north when the river level is considerably lower than the maximum elevation (hydrologic control) traversed within the hardwood swamp at the Pine Island transect. Thus, the shrub swamp and lower elevations of the maple swamp are inundated for longer periods of time than would be expected if the only route for surface water to reach these communities was along the transect line. Close observation of aerial photographs (SJRWMD GIS coverage and digital orthophotos, 2000) illustrated the extension of shrub swamp north from the Pine Island transect to an open water slough connected to the St. Johns River. Likewise, field observations (July 24, 2001) indicated that deep inundation (water depth >10 in.) occurred within the shrub swamp when the river level was rising following a prolonged drought. At the same time, the soil surface of the hardwood swamp immediately adjacent to the river (stations 4–120) remained dry.

Typically, where deep ($\geq$8 in.) organic soils occur, the minimum frequent low level is based upon a soil water table drawdown of approximately 20 in. (1.7 ft). This 20-in.-drawdown criterion was based on the following literature:

- *South Florida Water Management District wetland hydroperiods study task 2 report (literature review and analysis)*, ESE, July 17, 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 ±13.5 cm (20.9 in.; 15.6–26.2 in.)."
- *Soil Survey of Volusia County, Florida*, SCS, 1980. "In Gator muck the water table is at or above the soil surface in spring, summer, and fall and is within 10 inches of the soil surface in winter. In Terra Ceia muck the water table is as much as 2 feet 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 inches except during extended dry periods."

- *Soil Survey of Brevard County, Florida*, SCS, 1974. "In Tomoka muck, the soil water table is within a depth of 10 inches for 9 to 12 months in most years, and water is frequently above the surface. In dry periods it is between 10 and 30 inches. In Montverde peat the water table is within a depth of 10 inches 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 inches. In Canova peat the soil water table in most years is within a depth of 10 inches for 9 to 12 months and many areas are continuously flooded for 3 to 6 months. In dry seasons the water table is below a depth of 10 inches for short periods."

At Pine Island, the organic soils occur too close to sea level (average elevation equaled 1.2 ft NGVD) to allow for a 20-in. drawdown. Additionally, the soil water table within the organic soils (Gator and Terra Ceia muck) observed at Pine Island is described on the NRCS (2001) Web page as saturated with water that is always at or above the soil surface except during extended droughts with no drawdown quantified. Meanwhile, the Volusia County soil survey (SCS 1980) described the soil water table in Terra Ceia muck as seldom below a depth of 10 in., except during extended dry periods. Consequently, a 10-in. soil water table drawdown criterion applied to the mean surface elevation of the organic soils in the hardwood swamp (stations 360–720) at Pine Island was deemed reasonable, based upon the best available supporting information from the literature and the extremely low surface elevation of the wetland communities traversed at Pine Island.

## ST. JOHNS RIVER AT NORTH EMANUEL BEND

There are two transects originating from the open water of the SJR at North Emanuel Bend: North Emanuel Bend transect 1 and North Emanuel Bend transect 2.

| Transect | Latitude, Longitude (station 0) | Latitude, Longitude (end station) | Location and Date of Fieldwork |
|---|---|---|---|
| North Emanuel Bend transect 1 | 28 53 25.58<br>81 21 48.02 | 28 53 36.60<br>81 21 48.71 | West bank of the SJR at North Emanuel Bend, 1.2 miles downstream from the SJR confluence with the Wekiva River; April 2000 |
| North Emanuel Bend transect 2 | 28 53 03.37<br>81 21 55.66 | 28 52 59.76<br>81 21 43.37 | East bank of the SJR at North Emanuel Bend, 0.7 mile downstream from the SJR confluence with the Wekiva River; April 2000, November 2000, June 2001 |

### Field Data for Transect 1

North Emanuel Bend transect 1 is located on the west bank of the St. Johns River at North Emanuel Bend (Figures 3 and 6). This transect is approximately 13 miles upstream from the SR 44 bridge over the St. Johns River and 1.2 miles downstream from the confluence of the Wekiva River with the St. Johns River.

### Transect Selection Factors for Transect 1

The primary factors for selecting this transect location included the following:

- An extensive region of the hardwood swamp located on the west bank of the St. Johns River at this location (Figure 3)
- Located within the Wekiva River Aquatic Preserve, avoiding future development that would affect transects and facilitating access for long-term ecological monitoring
- Within close proximity to the lower Wekiva River
- Located between two sites identified for possible water withdrawal from the St. Johns River for public supply (CH2M HILL 1999)

### Vegetation at Transect 1

North Emanuel Bend transect 1 originated in the open water of the St. Johns River. This transect maintained a northerly bearing over its entire 1,115-ft distance through a hydric hammock, a hardwood swamp, a shrub swamp, and another hardwood swamp, and terminated in another shrub swamp (Figure 10). More specifically, from stations 0–9.5, the transect was in open water. At station 10, the transect traversed a 2.1-ft-high bank. From stations 10 to 230, the transect traversed a hydric hammock. The hydric hammock overstory consisted of abundant mature water hickory (*Carya aquatica*) and pop ash with scattered mature red maple, cabbage palm, and laurel oak. The hydric hammock understory contained abundant squarestem (*Melanthera nivea*), vervain (*Verbena brasiliensis*), swamp dock (*Rumex verticillatus*), savannah panicum, and lizard's tail (*Saururus cernuus*).

Landward of the hydric hammock was a hardwood swamp (stations 230–630). The hardwood swamp overstory contained dominant mature pop ash. Other species in the overstory included scattered red maple, bald cypress, and water hickory. The hardwood swamp understory contained co-dominant squarestem, vervain, and abundant American germander (*Teucrium canadense*), and cutgrass. Adjacent to the hardwood swamp was a shrub swamp (stations 630–880). The shrub swamp vegetation species included buttonbush, Carolina willow, climbing aster, and fire-flag (*Thalia geniculata*). From stations 880 to 1080, the transect traversed another hardwood swamp (hardwood swamp 2). Hardwood swamp 1 and hardwood swamp 2 had similar vegetation, except that hardwood swamp 2 had numerous mature bald cypress compared to scattered mature bald cypress at hardwood swamp 1, and the pop ash were abundant, not dominant, in hardwood swamp 2. The median elevation of the two hardwood swamps is very similar. Hereafter, hardwood swamps 1 and 2 are referred to as the hardwood swamp at North Emanuel Bend transect 1.

The transect terminated in another shrub swamp (shrub swamp 2; stations 1080–1115) with nearly identical plant species composition (Table 12), elevations (Table 13), and soils (Table 14) to shrub swamp 1. Table 13 and Figure 10 illustrate elevation statistics for all plant communities at North Emanuel Bend transect 1.

### Soils at Transect 1

Soils along the entire transect were classified as Nittaw series (Cecil Slaughter, soil scientist, SJRWMD, pers. com. 2000). The Nittaw series includes Nittaw mucky fine sand, depressional; Nittaw muck; and Nittaw, Okeelanta, and Basinger soils, frequently flooded (SCS 1990). The distinguishing characteristics among the Nittaw series soil types are the presence and the depth of muck. Some soil profiles do not have a muck

**Figure 10. North Emanuel Bend transect 1 topography with ecological communities**

Note: At North Emanuel Bend, the minimum frequent high (MFH) equals 2.5 ft NGVD, the minimum average (MA) equals 1.1 ft NGVD, and the minimum frequent low (MFL) equals 0.6 ft NGVD.

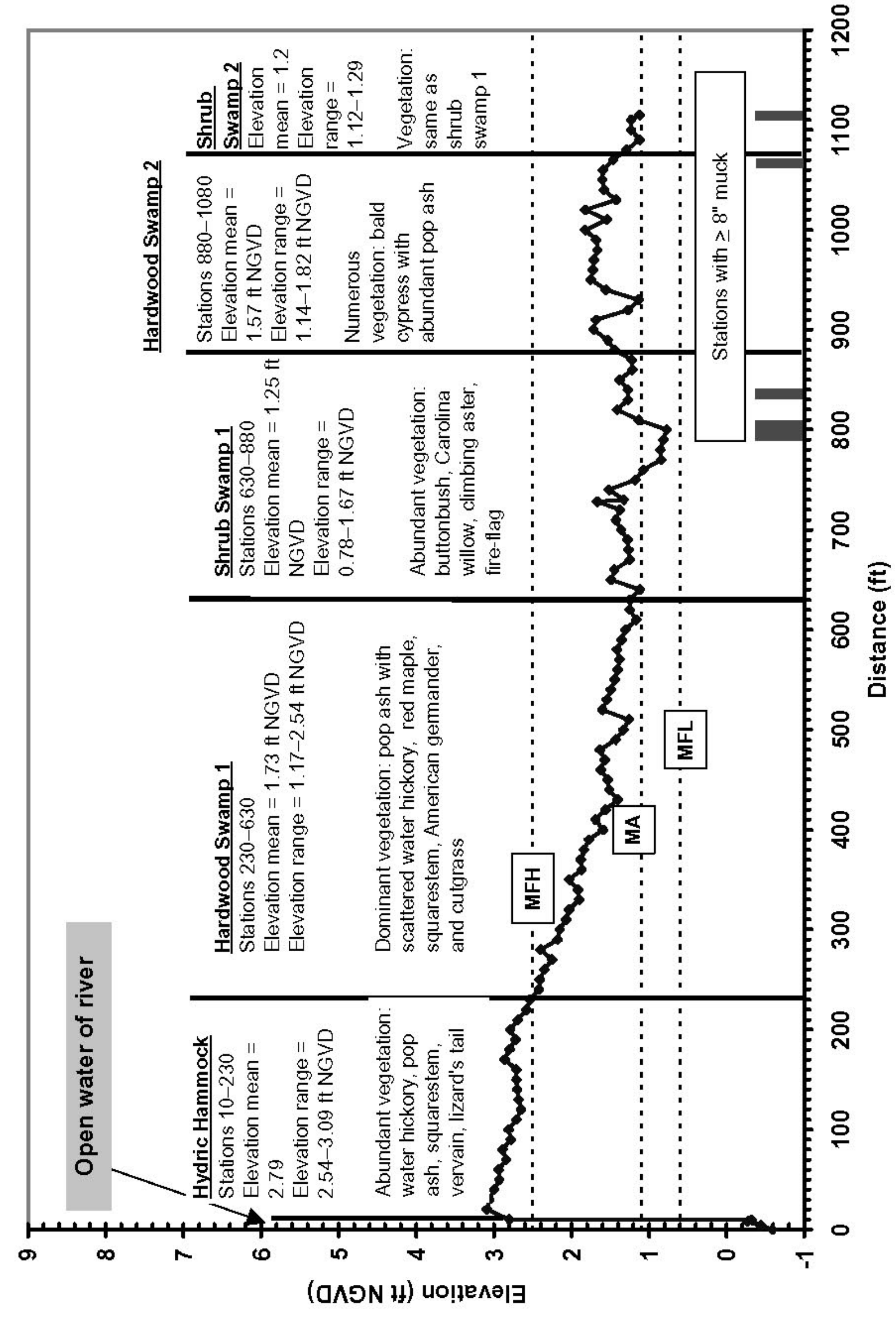


Table 12. North Emanuel Bend transect 1 vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | |
|---|---|---|---|---|---|---|---|
| | | | HH | HS 1 | SS 1 | HS 2 | SS 2 |
| Alligator-weed | *Alternanthera philoxeroides* | OBL | 1–2 | 2 | | | |
| American elm | *Ulmus americana* | FACW | 1–2 | 0–1 | 1 | 3 | |
| American germander | *Teucrium canadense* | FACW | 2 | 2–3 | | | |
| Bald cypress | *Taxodium distichum* | OBL | 1 | 1 | | 2 | |
| Bamboo | *Arundinaria tecta* | UPL | | | 1 | | |
| Blue flag | *Iris virginica* | OBL[3] | 2 | 1–2 | | | |
| Box elder | *Acer drummondii* | FACW | 0 | | | | |
| Buttonbush | *Cephalanthus occidentalis* | OBL | | 1 | 3–4 | 1–2 | 3–4 |
| Cabbage palm | *Sabal palmetto* | FAC | 1 | | | | |
| Carolina willow | *Salix caroliniana* | OBL[3] | | | 2–3 | | 1 |
| Climbing aster | *Aster carolinianus* | OBL | | | 2–3 | | |
| Cutgrass | *Leersia* sp. | OBL | | 2–3 | | | |
| Dotted smartweed | *Polygonum punctatum* | FACW[3] | | | 2 | 1 | |
| False indigo | *Amorpha fruticosa* | FACW | 1 | | | | |
| False-nettle | *Boehmeria cylindrica* | OBL | | | | 1 | |
| Fire-flag | *Thalia geniculata* | OBL | | 1–2 | 2–4 | 2 | 3–4 |
| Flatsedge | *Cyperus pseudovegetus* | FACW[3] | 1 | | | | |
| Hop sedge | *Carex lupulina* | OBL | 1 | 1–2 | 1 | 3 | |
| Laurel oak | *Quercus laurifolia* | FACW | 2 | 0 | | | |
| Lizard’s tail | *Saururus cernuus* | OBL | 2–3 | | | | |
| Marsh pennywort | *Hydrocotyle umbellata* | OBL[3] | 1 | 2 | | | |
| Mikania | *Mikania scandens* | FACW[3] | | | | | 1 |
| Mock bishop-weed | *Ptilimnium capillaceum* | FACW | 2 | 2 | | | |
| Pepper vine | *Ampelopsis arboreum* | FAC | | | 1 | | |
| Pickerelweed | *Pontederia cordata* | OBL | | 1–2 | 1 | | |
| Pine barrens triden | *Tridens ambiguus* | FACW | 2 | | | | |
| Poison ivy | *Toxicodendron radicans* | FAC | 1 | 1 | 1 | 1 | 2 |
| Pop ash | *Fraxinus caroliniana* | OBL | 3 | 5 | 1–2 | 3–4 | 3 |
| Ragweed | *Ambrosia artemisiifolia* | FAC[3] | 1 | | | | |
| Red maple | *Acer rubrum* | FACW | 1 | 1 | 1 | 3 | 3 |
| Savannah panicum | *Panicum gymnocarpon* | OBL | 2–3 | 3 | | | |
| Scarlet rosemallow | *Hibiscus coccineus* | OBL | | 1 | 1–2 | 1–2 | |
| Spider-lily | *Hymenocallis* sp. | OBL | | | 1 | | |
| Squarestem | *Melanthera nivea* | FACW | 1–5 | 2 | | | |
| Swamp dock | *Rumex verticillatus* | FACW[3] | 2-3 | 2 | | | |
| Trumpet vine | *Campsis radicans* | FAC | 1 | 1 | 1 | | |
| Variable panicum | *Dichanthelium commutatum* | FAC | 2 | | | | |
| Vervain | *Verbena brasiliensis* | FAC | 3–4 | 4 | | | |

Table 12—*Continued*

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | |
|---|---|---|---|---|---|---|---|
| | | | HH | HS 1 | SS 1 | HS 2 | SS 2 |
| Water hickory | *Carya aquatica* | OBL | 3 | 1 | | | |
| Water-locust | *Gleditsia aquatica* | OBL | | 0–1 | | | |
| Wild taro | *Colocasia esculenta* | OBL | 1–2 | 2 | | | |

Note: HH = hydric hammock
HS 1 = hardwood swamp 1
SS 1 = shrub swamp 1
HS 2 = hardwood swamp 2
SS 2 = shrub swamp 2

[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

[3]Denotes indicator category from Mohlenbrock 1993

Table 13. North Emanuel Bend transect 1 soil and vegetation statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Open water of the SJR | 0–9.5 | -0.40 | -0.38 | -0.59 | -0.27 | 4 |
| Hydric hammock | 10–230 | 2.79 | 2.79 | 2.54 | 3.09 | 23 |
| Hardwood swamp 1 | 230–630 | 1.73 | 1.60 | 1.17 | 2.54 | 41 |
| Hardwood swamp 2 | 880–1,080 | 1.57 | 1.59 | 1.14 | 1.82 | 21 |
| Hardwood swamp combined | 230–630<br>880–1,080 | 1.67 | 1.60 | 1.14 | 2.54 | 62 |
| Shrub swamp 1 | 630–880 | 1.25 | 1.28 | 0.78 | 1.67 | 27 |
| Shrub swamp 2 | 1,080–1,115 | 1.20 | 1.23 | 1.12 | 1.29 | 5 |
| Shrub swamp combined | 630–880<br>1,080–1,115 | 1.24 | 1.26 | 0.78 | 1.67 | 32 |
| Stations with any muck | See Table 16 | 1.26 | 1.27 | 0.82 | 1.68 | 14 |
| Stations with ≥8 inches of muck | See Table 16 | 1.13 | 1.13 | 0.82 | 1.29 | 6 |

Note: ft NGVD = feet National Geodetic Vertical Datum
SJR = St. Johns River

Table 14. North Emanuel Bend transect 1 soil type and muck depths

| Station Distance (feet) | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Vegetation Community |
|---|---|---|---|---|
| 680 | 1.3 | Nittaw | 3 | Shrub swamp 1 |
| 740 | 1.5 | Nittaw | 4 | Shrub swamp 1 |
| 780 | 0.9 | Nittaw | 6 | Shrub swamp 1 |
| 790 | 0.8 | Nittaw | 16 | Shrub swamp 1 |
| 810 | 1.1 | Nittaw | 12 | Shrub swamp 1 |
| 820 | 1.4 | Nittaw | 6 | Shrub swamp 1 |
| 830 | 1.3 | Nittaw | 6 | Shrub swamp 1 |
| 840 | 1.3 | Nittaw | 12 | Shrub swamp 1 |
| 990 | 1.9 | Nittaw | 4 | Hardwood swamp 2 |
| 1,040 | 1.6 | Nittaw | 6 | Hardwood swamp 2 |
| 1,080 | 1.3 | Nittaw | 8 | Hardwood swamp 2 |
| 1,090 | 1.1 | Nittaw | 8 | Shrub swamp 2 |
| 1,100 | 1.2 | Nittaw | 6 | Shrub swamp 2 |
| 1,115 | 1.1 | Nittaw | 8 | Shrub swamp 2 |

Note: ft NGVD = feet National Geodetic Vertical Datum

horizon. The thickness of the muck or Oa horizon may range from 0 to 14 inches in Nittaw series soil types. Table 14 presents the stations where muck was observed and the muck thickness along the transect. Figure 10 illustrates where the histic epipedon (≥8-in. muck) was observed. Soil series descriptions are located in the appendix.

### Field Data for Transect 2

North Emanuel Bend transect 2 is located on the east bank of the St. Johns River at North Emanuel Bend (Figures 3 and 6). This transect is 0.5 mile upstream from North Emanuel Bend transect 1 and 0.7 mile downstream from the confluence of the Wekiva River with the St. Johns River.

### Transect Selection Factors for Transect 2

This transect location was selected based on the following factors:

- Extensive wetland plant communities (shallow marsh, shrub swamp, hardwood swamp, hydric hammock)

- One of the few areas of extensive shallow marsh, relatively close to uplands, between SR 44 and Lake Monroe
- Transect termination within an upland community
- Close proximity to the lower Wekiva River
- Located between two sites identified for possible water withdrawal from the St. Johns River for public supply (CH2M HILL 1999)

**Vegetation at Transect 2**

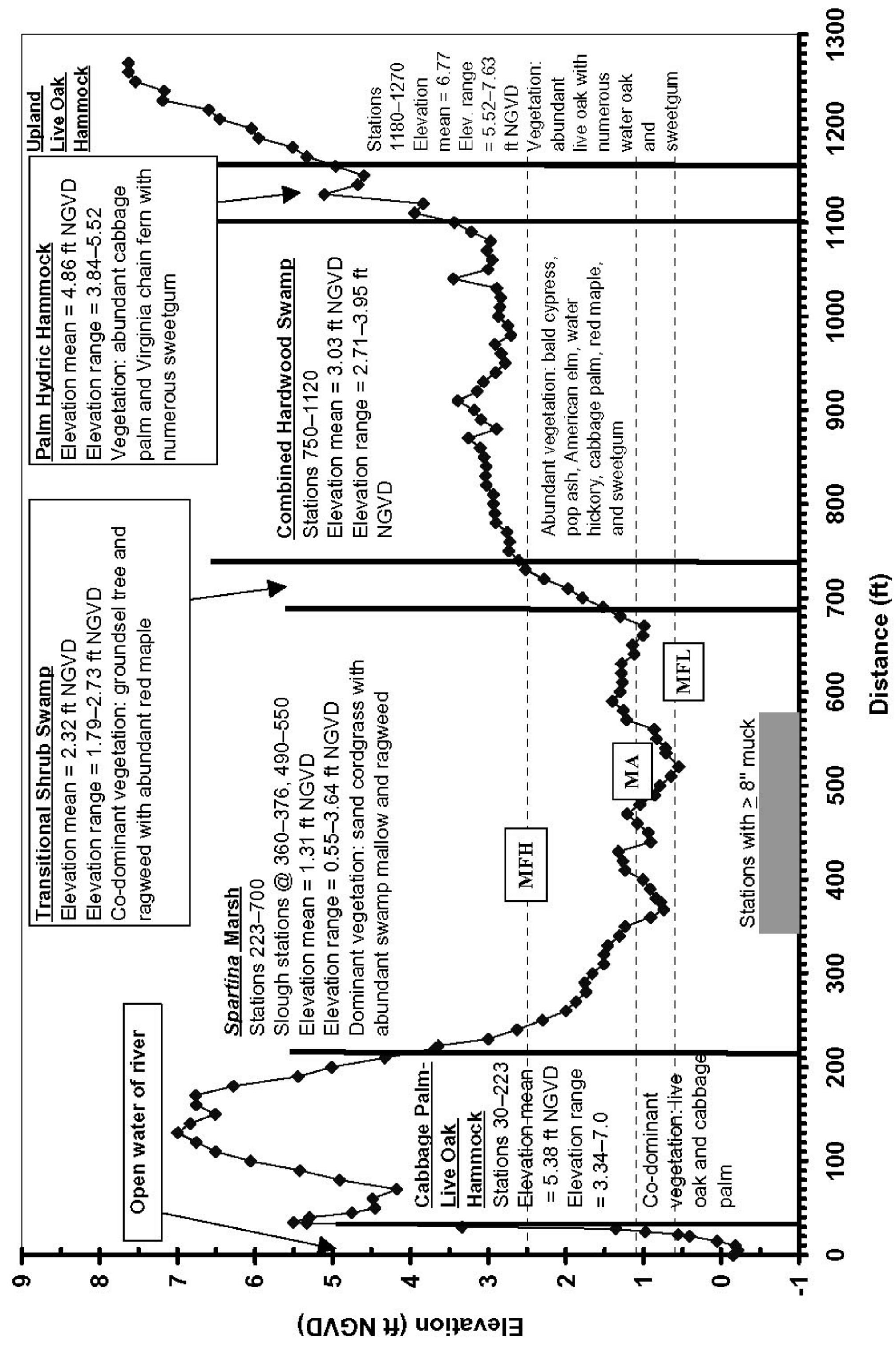
North Emanuel Bend transect 2 originates in the open water of the St. Johns River. This transect maintained an easterly bearing from the river for approximately 530 ft. At station 530, this transect took a southeasterly bearing to its termination point approximately 1,270 ft from the river.

Open water of the St. Johns River occurred between stations 0 and 30. Stations 0–22 traversed eelgrass (*Vallisneria americana*) beds. Between Stations 22 and 28, the transect traversed a shoreline littoral zone where bald cypress and pop ash were abundant. The shoreline was heavily shaded by large live oak trees rooted at higher elevations. Between stations 28 and 34, the transect traversed a steep bank, approximately 4 ft high. A cabbage palm-live oak hammock occurred at the top of the bank and extended for approximately 190 ft (stations 30–223; Figure 11). The cabbage palm-live oak hammock overstory vegetation consisted of co-dominant live oak and cabbage palm. The cabbage palm-live oak hammock understory vegetation consisted of abundant catbrier (*Smilax* sp.), muscadine grape, small cabbage palm, and trumpet vine.

Landward of the cabbage palm-live oak hammock was a *Spartina* marsh (stations 223–700). The dominant plant species in the *Spartina* marsh was sand cordgrass (*Spartina bakeri*). Swamp rosemallow and ragweed (*Ambrosia artemisiifolia*) were abundant in the *Spartina* marsh. Within the *Spartina* marsh, the transect traversed two sloughs. The first slough (stations 360–376) was not vegetated. The second slough (stations 490–550) had large clumps of sesbania (*Sesbania macrocarpa*) growing within it to the north of the transect. Landward of the *Spartina* marsh, the transect traversed a transitional shrub swamp (stations 700–750). Groundsel tree (*Baccharis glomeruliflora*) was co-dominant, and red maple was abundant in the transitional shrub swamp overstory. Ragweed was co-dominant in the transitional shrub swamp understory.

**Figure 11. North Emanuel Bend transect 2 topography with ecological communities**

Note: At North Emanuel Bend, the minimum frequent high (MFH) equals 2.5 ft NGVD, the minimum average (MA) equals 1.1 ft NGVD, and the minimum frequent low (MFL) equals 0.6 ft NGVD.



Adjacent to the transitional shrub swamp was a hardwood swamp (stations 750–1120). The hardwood swamp at stations 750–900 had a slightly different appearance than at stations 900–1120. The tree species composition (Table 15) was very similar within the entire hardwood swamp, but the tree size was noticeably different with much smaller, immature trees between stations 750 and 900. The elevation statistics (Table 16) were similar for the two zones of hardwood swamp. Therefore, it is reasonable to characterize the hardwood swamp as one community. The hardwood swamp overstory vegetation included abundant bald cypress, pop ash, American elm, water hickory, cabbage palm, red maple, and sweetgum (*Liquidambar styraciflua*). The hardwood swamp mid-canopy vegetation consisted of numerous large buttonbush and scattered swamp dogwood (*Cornus foemia*). The hardwood swamp understory was sparsely vegetated, presumably due to the heavy shade provided by the overstory.

Landward of the hardwood swamp, the transect traversed a palm hydric hammock (stations 1120–1180). Cabbage palms were abundant in the overstory, along with numerous sweetgum and scattered laurel oak. The palm hydric hammock understory had abundant Virginia chain fern with scattered muscadine grape and catbrier.

The transect terminated in an upland live oak hammock (stations 1180–1270). Mature live oak trees were abundant in the overstory, along with numerous water oak and sweetgum. Cabbage palms were also numerous in the overstory of the upland live oak hammock between stations 1180 and 1210. Between stations 1180 and 1220, the understory vegetation consisted of abundant muscadine grape. Saw palmetto (*Serenoa repens*) was dominant in the understory of the upland live oak hammock from station 1220 to station 1270.

## Soils at Transect 2

Soils observations were taken along the entire transect. The majority of the soils were classified as Chobee fine sandy loam, with Basinger fine sand and Pompano fine sand at the higher elevations near the end of the transect (Cecil Slaughter, soil scientist, SJRWMD, pers. com. 2000). The Chobee fine sandy loam was observed from station 70, adjacent to the St. Johns River, to approximately station 1200. The Chobee fine sandy loam was determined to be hydric at each location sampled along transect 2. Where transect 2 traversed the cabbage palm-live oak hammock between stations 34 and 223,

Table 15. North Emanuel Bend transect 2 vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | PO | SM | TSS | HS | PHH | LOH |
| American elm | *Ulmus americana* | FACW | | 0 | 2 | 2–4 | | |
| American germander | *Teucrium canadense* | FACW | 1 | 1 | | | | |
| Bald cypress | *Taxodium distichum* | OBL | 2 | | | 0–3 | 1 | |
| Beautyberry | *Callicarpa americana* | FACU[3] | 0 | | | | | |
| Buttonbush | *Cephalanthus occidentalis* | OBL | | 0 | | 1–2 | | |
| Cabbage palm | *Sabal palmetto* | FAC | 3–4 | | | 2–3 | 2–3 | 2 |
| Caesar-weed | *Urena lobata* | UPL | 0 | | | | | |
| Catbriar | *Smilax bona-nox* | FAC[3] | 3 | | | 1 | 1 | |
| Cattail | *Typha* sp. | OBL | | 0 | | | | |
| Climbing aster | *Aster carolinianus* | OBL | 1 | | | | | |
| Dwarf haw | *Crataegus uniflora* | UPL | | | | 0 | | |
| Elephant's foot | *Elephantopus* sp. | FAC | 1 | | | | | |
| False Indigo | *Amorpha fruticosa* | FACW | 0 | | | | | |
| Gallberry | *Ilex glabra* | FACW | | | | | 1 | |
| Ground cherry | *Physalis walteri* | UPL | | | | 1 | | |
| Groundsel tree | *Baccharis glomeruliflora* | OBL | 1 | | 4 | | | |
| Laurel cherry | *Prunus caroliniana* | UPL | 1–2 | | | | | |
| Laurel oak | *Quercus laurifolia* | FACW | | 0 | 1–2 | 1 | | |
| Live oak | *Quercus virginiana* | UPL | 3–4 | | | | | 3 |
| Mock bishop-weed | *Ptilimnium capillaceum* | FACW | | | 0 | 1 | | |
| Muhlenbergia | *Muhlenbergia* sp. | FACW | | | | 1 | | |
| Muscadine | *Vitus rotundifolia* | FAC[3] | 2 | | | 1 | 1 | |
| Panic grass | *Dichanthelium commutatum* | FAC | 1 | | | | | |
| Pepper-vine | *Ampelopsis arborea* | FAC[3] | 1 | | 1 | 1 | | |
| Persimmon | *Diospyros virginiana* | FAC | | | 1 | 1 | | |
| Poison ivy | *Toxicodendron radicans* | FAC[3] | | | | 1–2 | | |
| Pop ash | *Fraxinus caroliniana* | OBL | 1 | | | 1–2 | | |
| Ragweed | *Ambrosia artemisiifolia* | FAC[3] | 1 | 3 | 3–4 | | | |
| Red maple | *Acer rubrum* | FACW | | | 3 | 2–4 | | |
| Resurrection fern | *Polypodium* sp. | UPL | 1 | | | | | |
| Rush | *Juncus effusus* | OBL | | 1 | | | | |
| Sand cordgrass | *Spartina bakeri* | FACW | | 5 | 1 | | | |
| Sandweed | *Hypericum* sp. | FACW | 0 | | | | | |
| Saw palmetto | *Serenoa repens* | UPL | | | | | | 4–5 |
| Sesbania | *Sesbania macrocarpa* | FACW | | 3 | | | | |
| Southern magnolia | *Magnolia grandiflora* | FAC | | | | | 0 | |
| Sugar-berry | *Celtis laevigata* | FACW | | | | 1 | | |
| Swamp bay | *Persea palustris* | OBL | | | | | 0 | |
| Swamp dogwood | *Cornus foemia* | FACW | | | | 0 | | |
| Swamp privet | *Forestiera acuminata* | FACW | 0 | | | | | |
| Swamp rosemallow | *Hibiscus grandiflorus* | OBL | | 3–4 | 1 | | | |
| Sweetgum | *Liquidambar styraciflua* | FACW | | | | 1–3 | 2 | 2 |
| Trumpet vine | *Campsis radicans* | FAC | 3–4 | | | 1–3 | | |
| Virginia chainfern | *Woodwardia virginica* | FACW | | | | | 2–3 | 1 |

Table 15—*Continued*

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | PO | SM | TSS | HS | PHH | LOH |
| Water hickory | *Carya aquatica* | OBL | | | | 1–2 | | |
| Water oak | *Quercus nigra* | FACW | | | | | 1 | 1 |
| Wood grass | *Oplismenus setarius* | UPL[3] | 1 | | | | | |

Note: PO = palm-oak hammock
SM = *Spartina* marsh
TSS = transitional shrub swamp
HS = hardwood swamp
PHH = palm hydric hammock
LOH = live oak hammock

**[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

[3]Denotes indicator category from Mohlenbrock 1993

Table 16. North Emanuel Bend transect 2 vegetation community statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Open water of the SJR with eelgrass | 0–22 | 0.78 | -0.05 | -0.24 | 0.56 | 6 |
| Shoreline littoral zone | 22–30 | 1.56 | 1.17 | 0.56 | 3.34 | 4 |
| River bank | 30–34 | 4.34 | 4.34 | 3.34 | 5.34 | 2 |
| Cabbage palm-live oak hammock | 30–223 | 5.38 | 5.38 | 3.34 | 7.00 | 24 |
| *Spartina* marsh with slough elevations | 223–700 | 1.31 | 1.24 | 0.55 | 3.64 | 50 |
| *Spartina* marsh with slough elevations excluded | 223–700 | 1.47 | 1.28 | 0.86 | 3.64 | 40 |
| Sloughs | 360–376<br>490–550 | 0.75 | 0.76 | 0.55 | 0.91 | 10 |
| *Spartina* marsh with ≥4 inches muck | 240–700 | 1.23 | 1.23 | 0.55 | 2.63 | 47 |
| *Spartina* marsh with ≥8 inches muck | 350–590 | 0.98 | 0.91 | 0.55 | 1.40 | 26 |
| Transitional shrub swamp | 700–750 | 2.32 | 2.40 | 1.79 | 2.73 | 6 |
| Immature hardwood swamp | 750–900 | 2.97 | 2.98 | 2.72 | 3.25 | 17 |
| Mature hardwood swamp | 900–1,120 | 3.08 | 2.97 | 2.71 | 3.95 | 23 |
| Combined hardwood swamp | 750–1,120 | 3.03 | 2.96 | 2.71 | 3.95 | 38 |
| Palm hydric hammock | 1,120–1,180 | 4.86 | 4.97 | 3.84 | 5.52 | 7 |
| Upland live oak hammock | 1,180–1,270 | 6.77 | 6.88 | 5.52 | 7.63 | 10 |

Note: ft NGVD = feet National Geodetic Vertical Datum
SJR = St. Johns River

the Chobee soil was overlain by alluvial material on the surface, a hydric soil indicator (Cecil Slaughter, pers. com. 2000). At the saw palmetto line (station 1220), the soil was Basinger fine sand. In the saw palmetto, the soil was Pompano fine sand. Table 17 presents a brief summary of the soil sampled along transect 2. Figure 11 illustrates where the deep (≥8 in.) muck was observed (stations 350–590). Soil series descriptions are located in the appendix.

Table 17. North Emanuel Bend transect 2 soil descriptions

| Station Distance (feet) | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Vegetation Community |
|---|---|---|---|---|
| 70 | 4.2 | Chobee | 0 | Cabbage palm-live oak hammock |
| 130 | 7.0 | Chobee | 0 | Cabbage palm-live oak hammock |
| 200 | 5.0 | Chobee | 0 | Cabbage palm-live oak hammock |
| 220 | 3.7 | Chobee | 0 | Cabbage palm-live oak hammock |
| 230 | 3.0 | Chobee | 1-inch mucky sand | *Spartina* marsh |
| 240 | 2.6 | Chobee | 4 | *Spartina* marsh |
| 350 | 1.2 | Chobee | 12 | *Spartina* marsh |
| 450 | 0.9 | Chobee | 12 | *Spartina* marsh |
| 490 | 0.9 | Chobee | 12 | *Spartina* marsh |
| 590 | 1.4 | Chobee | 12 | *Spartina* marsh |
| 700 | 1.8 | Chobee | 6 | *Spartina* marsh |
| 720 | 2.3 | Chobee | 0 | Transitional shrub swamp |
| 750 | 2.7 | Chobee | 0 | Transitional shrub swamp |
| 800 | 2.9 | Chobee | 0 | Immature hardwood swamp |
| 1,200 | 6.0 | Chobee | 0 | Upland live oak hammock |
| 1,220 | 6.6 | Basinger fine sand | 0 | Upland live oak hammock |
| 1,240 | 7.2 | Pompano fine sand | 0 | Upland live oak hammock |

Note: ft NGVD = feet National Geodetic Vertical Datum

## Minimum Levels at North Emanuel Bend

Refer to Table 7b for the major criteria applied in the minimum level determinations for the St. Johns River at North Emanuel Bend.

| Minimum Levels for North Emanuel Bend | |
|---|---|
| Minimum frequent high level | 2.5 ft NGVD |
| Minimum average level | 1.1 ft NGVD |
| Minimum frequent low level | 0.6 ft NGVD |

### Minimum Frequent High Level (2.5 ft NGVD)

The locally determined minimum frequent high level for the St. Johns River at North Emanuel Bend is 2.5 ft NGVD, with the assigned hydroperiod category of seasonally flooded. Seasonally flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, river levels causing inundation are expected to occur several weeks to several months every 1–2 years (Chapter 40C-8.021(15), *F.A.C.*). Modeling results (Robison 2003) support the locally determined minimum frequent high level and hydroperiod category of seasonally flooded at North Emanuel Bend, indicating that this elevation (2.5 ft NGVD) will be flooded for 45 continuous days on average once every 3 years. The locally determined minimum frequent high level (2.5 ft NGVD) equals the 15% exceedance on the simulated stage-duration curve for the St. Johns River at North Emanuel Bend (Figure 9) (Robison 2003).

The locally determined minimum frequent high level (2.5 ft NGVD) equals the maximum elevation of the hardwood swamp at North Emanuel Bend transect 1. This minimum frequent high level also corresponds closely to the average elevation (2.8 ft NGVD) of the hydric hammock (stations 10–230) at North Emanuel Bend transect 1 (Figure 10) and the average elevation (2.3 ft NGVD) of the transitional shrub swamp (stations 700–750) at North Emanuel Bend transect 2. At the locally determined minimum frequent high level, significant portions of the floodplain at North Emanuel Bend are flooded and directly connected to the St. Johns River.

The locally determined minimum frequent high level provides for inundation of the hardwood swamp at transect 1 with water depths from 0 to 1.4 ft. The river level at North Emanuel Bend does not have to exceed the maximum elevation of the hydric hammock at transect 1 (3.1 ft NGVD; Figure 10) in order for the hardwood swamp at transect 1 to become inundated. Several areas were noted near transect 1 where the river bank was less steep, at a lower elevation, or non-existent, allowing river water access to the hardwood swamp landward of the hydric hammock when the river level is considerably lower than 3.1 ft NGVD.

As mentioned previously, interactions with the adjacent river swamps through connection of the channel to the floodplain are extremely important to animal productivity in lower Coastal Plain rivers (Bain 1990; Poff et al. 1997). The aquatic fauna habitat is greatly expanded when the St. Johns River inundates the extensive marshes and forested swamps adjacent to the river channel at North Emanuel Bend.

When the St. Johns River recedes below the locally determined minimum frequent high level, the water within the hardwood swamp at transect 1 may become isolated from the river. The river floodplain at North Emanuel Bend is structurally complex, with multiple factors influencing inundation durations within the hardwood swamp at transect 1. The inundation duration within the hardwood swamp at transect 1 is difficult to predict because the floodplain slopes away from the river and the properties of the Nittaw soils in this river reach (very poorly drained, slowly permeable, subject to flooding and water standing above the soil surface for 6–9 months in most years [NRCS 2001]). Additionally, field observations via motorboat of the river bank height indicated there were areas at North Emanuel Bend near transect 1 where the bank is lower, allowing for river water to inundate and remain connected to the hardwood swamp at transect 1 when the river recedes below the locally determined minimum frequent high level. Conversely, these low areas may allow the hardwood swamp to drain more rapidly and, therefore, reduce the period of inundation.

The locally determined minimum frequent high level at North Emanuel Bend also corresponds closely to the average elevation (3.0 ft NGVD) of the hardwood swamp at transect 2 (Figure 11; stations 750–1120). Somewhat similarly to transect 1, river water levels may inundate the hardwood swamp at transect 2 without inundating the high bank (oak-palm hammock; stations 30–223) located near the beginning of transect 2. The *Spartina* marsh traversed at transect 2 extends north of transect 2 to the St. Johns River downstream of

North Emanuel Bend (Figure 3). Soundings (water depths) taken from the St. Johns River downstream of North Emanuel Bend and extending south into the *Spartina* marsh to transect 2 indicate that the hydraulic control elevation at which river water backflows into the *Spartina* marsh was approximately 0.7 ft NGVD. Consequently, when the river level equals the minimum frequent high level, water will backflow into this *Spartina* marsh and inundate the lower elevations of the hardwood swamp at North Emanuel Bend transect 2.

The hardwood swamps at North Emanuel Bend transects 1 and 2 have average elevations that differ by 1.3 ft (Tables 12 and 15). This elevation difference will result in different inundation durations for the two hardwood swamps and is reflected in the plant species composition (Tables 13 and 16). Specifically, the vegetation composition within the hardwood swamp at transect 1 consisted of abundant to dominant pop ash (an obligate wetland plant) in the overstory with predominantly obligate herbaceous species in the understory. At transect 2, the hardwood swamp overstory contained a more diverse array of tree species, including American elm, bald cypress, cabbage palm, pop ash, red maple, sweetgum, and water hickory. These tree species, ranging in wetland status from obligate to facultative, were scattered throughout the hardwood swamp at transect 2 with no dominant species. Also, the topography at the individual transects is notably different. At transect 1 (Figure 10), the elevation within hardwood swamp 1 is nearly level but decreasing as the transect extends further from the river, while at transect 2 (Figure 11), the elevation within the hardwood swamp is gradually increasing as the transect extends from the *Spartina* marsh. Although the hardwood swamps at the two transects are different, they both represent ecologically diverse communities which require periodic inundation in order to maintain their structure and functions.

Also noteworthy are the different hydric hammock average elevations recorded at North Emanuel Bend. The hydric hammock at North Emanuel Bend transect 2 had an average elevation equal to 4.9 ft NGVD, 2.1 ft higher than the average elevation of the hydric hammock at North Emanuel Bend transect 1. These two hydric hammocks differ in both vegetation species composition and topography. The hydric hammock at transect 1 is immediately adjacent to the St. Johns River. The terrain at transect 1 (Figure 10) is nearly flat, excluding the immediate river bank. The hydric hammock vegetation at transect 1 is diverse with many wetland and transitional species (Table 12). The hydric hammock at transect 2 (Figure 11) is located on a seepage slope immediately adjacent to an upland community. Additionally, the vegetation at transect 2 is noticeably less diverse, consisting almost exclusively of cabbage palm and live oak, facultative and upland species, respectively (Table 15).

Vince et al. (1989) suggest that complex interacting factors influence the species composition of hydric hammocks and distinguish it from other communities. They propose that the geographical location, the hydrological regime, edaphic conditions, and fire frequency and intensity are the major determinants of the structure of hydric hammocks. Additionally, Vince et al. suggest that hydric hammocks low in species diversity and 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 (e.g., hurricane-induced flooding). The hydric hammock at North Emanuel Bend transect 2 (stations 1120–1180; Figure 11), and the palm hydric hammock at Pine Island (stations 2380–2800; Figure 8) are low in plant species diversity and infrequently inundated. According to simulation models, water levels have exceeded the North Emanuel Bend transect 2 hydric hammock average elevation 2% of the time. Likewise, simulated water levels have exceeded the average elevation of the Pine Island palm hydric hammock 3% of the time (Figure 9) (Robison 2003).

### Minimum Average Level (1.1 ft NGVD)

The locally determined minimum average level for the St. Johns River at North Emanuel Bend is 1.1 ft NGVD with a hydroperiod category of typically saturated. This minimum average level corresponds to a water level that may reoccur approximately every year or two for about 6 months during the dry season. The locally determined average level and hydroperiod category approximate a typical level that is slightly less than the long-term median water level while still protecting the wetland resource. Modeling results (Robison 2003) support the locally determined minimum average level and hydroperiod category of typically saturated at North Emanuel Bend, indicating that a river level equal to 1.1 ft NGVD will not occur more often than once every 1.5 years for 150 days. The locally determined minimum average level (1.1 ft NGVD) equals the 56% exceedance on the simulated stage-duration curve for the St. Johns River at North Emanuel Bend (Figure 9) (Robison 2003).

The locally determined minimum average level was calculated by subtracting 0.25 ft from the mean elevation of the *Spartina* marsh (stations 223–700) at transect 2, North Emanuel Bend. An organic surface horizon was observed in the *Spartina* marsh soils at North Emanuel Bend transect 2. However, these soils were not classified as histosols due to the predominantly shallow muck depths (<16 in.). A shallow organic surface horizon was also observed at several locations at North Emanuel Bend transect 1. However, due to the non-continuous nature of the shallow organic horizons at North Emanuel Bend transect 1 (Figure 10), the North Emanuel Bend transect 1 organic horizon surface elevations were omitted from the minimum average level determination.

This locally determined minimum average level, which will result in saturated soil conditions within the *Spartina* marsh at North Emanuel Bend, is necessary in order to prevent organic soil oxidation and subsidence and prevent long-term encroachment of upland plant species into wetland communities. Additionally, at the locally determined average, level water depths will range between 2.4 and 7.2 inches in the slough areas of the *Spartina* marsh traversed at North Emanuel Bend transect 2. Shallow ponding within these sloughs will provide aquatic refugia for numerous small fish, amphibians, and small reptiles.

Also, the water depths (2.4–7.2 in.) within the *Spartina* marsh sloughs 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 marsh. Birds effectively exploit these concentrations (Bancroft et al. 1990).

The second slough traversed (stations 490–550) within the *Spartina* marsh at North Emanuel Bend transect 2 will remain connected to the St. Johns River at the minimum average level (1.1 ft NGVD). The *Spartina* marsh traversed at transect 2 extends north of transect 2 to the St. Johns River downstream of North Emanuel Bend (Figure 3). Based upon soundings (water depths) taken from an airboat, the hydraulic control elevation at which river water backflows into the *Spartina* marsh was approximately 0.7 ft NGVD. Consequently, when the river level equals the minimum average level, water will backflow into this *Spartina* marsh and inundate the *Spartina* marsh slough lower elevations at North Emanuel Bend transect 2.

Aquatic habitats that are connected to the main channel, such as the lower elevations within the *Spartina* marsh traversed at North Emanuel Bend transect 2, are of crucial importance to fishes and invertebrates of the floodplain. Connected aquatic habitats provide shallow, quiet waters in floodplain streams as refugia from the deep, swiftly flowing waters of the main channel (Light et al. 1998).

The North Emanuel Bend minimum average level (1.1 ft NGVD) is similar to the combined shrub swamp average elevation (1.2 ft NGVD) at North Emanuel Bend transect 1. The shrub swamps at transect 1 are dominated by obligate wetland plant species (Table 12) and contain areas of deep muck (Figure 10). The shrub swamps traversed at transect 1 are embedded in vast areas of hardwood swamp on the west floodplain of the St. Johns River. These shrub swamps may provide important habitat for various wetland fauna during the dry season. Water depths in shallow pools within the shrub swamps traversed at North Emanuel Bend transect 1 would range between 0 and 4 in. at the minimum average level.

As mentioned previously, wetland community structure results from sequential colonization (high water) and extirpations (low water). A drying wetland, however, does not necessarily result in fish mortality. Fish that do not seek refuge in the main river channel and cannot resist direct desiccation may still survive drying wetlands by escaping to small aquatic refugia (Messina and Conner 1998). Fish may survive in puddles (depth <2.4 in.), as do some invertebrates. Crayfish burrows are abundant in bottomland hardwoods (Lambou 1990), providing refugia for many small fish. Crayfish burrows were observed along transect 1 between stations 230 and 1115 and along transect 2 between stations 223 and 1120 at North Emanuel Bend. Bluefin killifish, pirate perch, pygmy sunfish, tadpole madtoms, and possibly mosquitofish occupy crayfish burrows when floodplains and shallow ponds in south Georgia dry for 3–4 months (Neill 1951). The crayfish burrows lead down to the water table, sometimes opening into a complex network of horizontal passages (Creaser 1931; Neill 1951). These fish species also inhabit the St. Johns River (FWC 2001) and were recently collected from the Wekiva and Little Wekiva Rivers (Warren et al. 2000).

**Minimum Frequent Low Level (0.6 ft NGVD)**

The locally determined minimum frequent low level for the St. Johns River at North Emanuel Bend is 0.6 ft NGVD, with an associated hydroperiod category of semipermanently flooded. This minimum level typically occurs every 5–10 years for several months during moderate droughts. Modeling results (Robison 2003) support the locally determined minimum frequent low level and hydroperiod category of semipermanently flooded at North Emanuel Bend, indicating that the river is at or below 0.6 ft NGVD for 90 continuous days on average once every 5 years. The North Emanuel Bend minimum frequent low level (0.6 ft NGVD) equals the 83% exceedance on the simulated stage-duration curve for the St. Johns River at North Emanuel Bend (Figure 9) (Robison 2003).

The North Emanuel Bend locally determined minimum frequent low level is 10 in. below the average elevation of the *Spartina* marsh, excluding the slough areas, at North Emanuel Bend transect 2 (1.47 ft – 0.83 ft = 0.64 ft NGVD). The following factors affected the decision to implement the 10-in. soil water table drawdown within the *Spartina* marsh as the primary criterion for determining the minimum frequent low level at North Emanuel Bend:

1. According to the Soil Survey of Volusia County (1980), the water table in Chobee fine sandy loam is seldom below 10 in. from the soil surface even during prolonged dry spells. Chobee fine sandy loam extends throughout the *Spartina* marsh at North Emanuel Bend transect 2.
2. The *Spartina* marsh at North Emanuel Bend transect 2 is a broad, flat community directly connected to the river (hydraulic control elevation equal to 0.7 ft NGVD).
3. The elevation points (n=10) collected within the *Spartina* marsh sloughs were excluded from the minimum frequent low level calculations because the slough communities represent isolated areas of deep organic soils. These deep organic soils are not Chobee fine sandy loam identified within the typical marsh community elevations. Also, the mean elevation of the slough stations was 0.75 ft NGVD, indicating that these deep organic soils would be protected from oxidation and subsidence at the recommended minimum frequent low level of 0.6 ft NGVD.
4. While the Chobee fine sandy loam extended to 6.0 ft NGVD throughout the hardwood swamp and hydric hammock at transect 2, seepage presumably affects the water table within these higher communities due to the sloping topography. Additionally, ponding may occur in Chobee fine sandy loam at higher elevations primarily due to rainfall and the soil characteristics (very poorly drained).

Additional criteria for determining the North Emanuel Bend minimum frequent low level included ensuring eel grass bed inundation (elevation ≤0.5 ft NGVD) at North Emanuel Bend transect 2. All other vegetation communities traversed by transects 1 and 2 at North Emanuel Bend would be exposed at the minimum frequent low level (Figures 10 and 11).

# LOWER WEKIVA RIVER

## Field Data

The lower Wekiva River transect is located on the west bank of the lower Wekiva River, approximately 0.9 mile upstream from the confluence of the Wekiva and St. Johns Rivers and 0.8 mile downstream from the confluence of Blackwater Creek and the Wekiva River (Figures 3 and 6). Additionally, this transect is located approximately 15.1 miles upstream from the SR 44 bridge over the St. Johns River.

| Latitude, Longitude (station 0) | Latitude, Longitude (end station) | Location and Date of Fieldwork |
|---|---|---|
| 28 52 10.43<br>81 22 28.56 | 28 52 07.53<br>81 23 24.76 | West bank of the lower Wekiva River, 0.9 mile upstream from the confluence with the SJR; September–October 2000, August 2001 |

## Transect Selection Factors

The lower Wekiva River transect was selected based on the following factors:

- Extensive wetland plant communities (hardwood swamps, hydric hammock, wet prairie, palm hydric hammock) from the Wekiva River to an oak-palm upland
- Located within the Lower Wekiva River State Preserve with upland access in the Seminole State Forest, avoiding future development that would affect transects and promoting long-term ecological monitoring
- Wetlands hydrologically influenced by the St. Johns River
- Close proximity to the Seminole County property identified for possible water withdrawal from the St. Johns River for public supply (CH2M HILL 1999)

## Vegetation at Lower Wekiva River

The lower Wekiva River transect traversed from the open water of the lower Wekiva River due west through a lower hardwood swamp, an upper hardwood swamp, a hydric hammock, a palm hydric hammock, and a wet prairie, and terminated in an oak-palm upland (Tables 18 and 19, Figures 3 and 12). Dominant species within each community type are listed in Table 18.

Figure 12 illustrates the elevation gradient along the lower Wekiva River transect.

The lower hardwood swamp (stations 20–1280) overstory vegetation consisted of co-dominant pop ash with abundant bald cypress. Additionally, red maples were numerous in the lower hardwood swamp overstory while buttonbush was numerous in the mid-canopy. The lower hardwood swamp understory had abundant pickerelweed (*Pontederia cordata*) and savannah panicum. Additional lower hardwood swamp understory species included numerous dotted smartweed, short-bristle beakrush (*Rhynchospora corniculata*), water paspalum (*Paspalum repens*), waterhyacinth (*Eichhornia crassipes*), and false-nettle (*Boehmeria cylindrica*)

Adjacent to the lower hardwood swamp, the transect traversed an upper hardwood swamp 1—referred to as upper hardwood swamp 1 (stations 1280–1780). The upper hardwood swamp 1 vegetation composition differed from the lower hardwood swamp in that the upper hardwood swamp 1 overstory contained numerous water hickory and sweetgum, as well as the vegetation species found in the lower hardwood swamp overstory. Likewise, the understory of the upper hardwood swamp 1 contained many of the same plant species as the lower hardwood swamp, such as numerous pickerelweed, false-nettle, and dotted smartweed. Additional species observed in the understory of the upper hardwood swamp 1 included abundant coinwort (*Centella asiatica*), buttonweed (*Diodia virginiana*), musky mint (*Hyptis alata*), dog fennel (*Eupatorium* sp.), and Brown's savory (*Micromeria brownei*).

Landward of the upper hardwood swamp 1, the transect traversed a hydric hammock (stations 1780–2660). The hydric hammock overstory included co-dominant water hickory with abundant sweetgum and cabbage palm. Additional species numerous in the overstory included bald cypress, swamp gum, and American elm. Wax myrtle was abundant in the mid-canopy.

**Figure 12. Lower Wekiva River transect topography with ecological communities**

Note: At the Wekiva River transect, 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 0.6 ft NGVD.

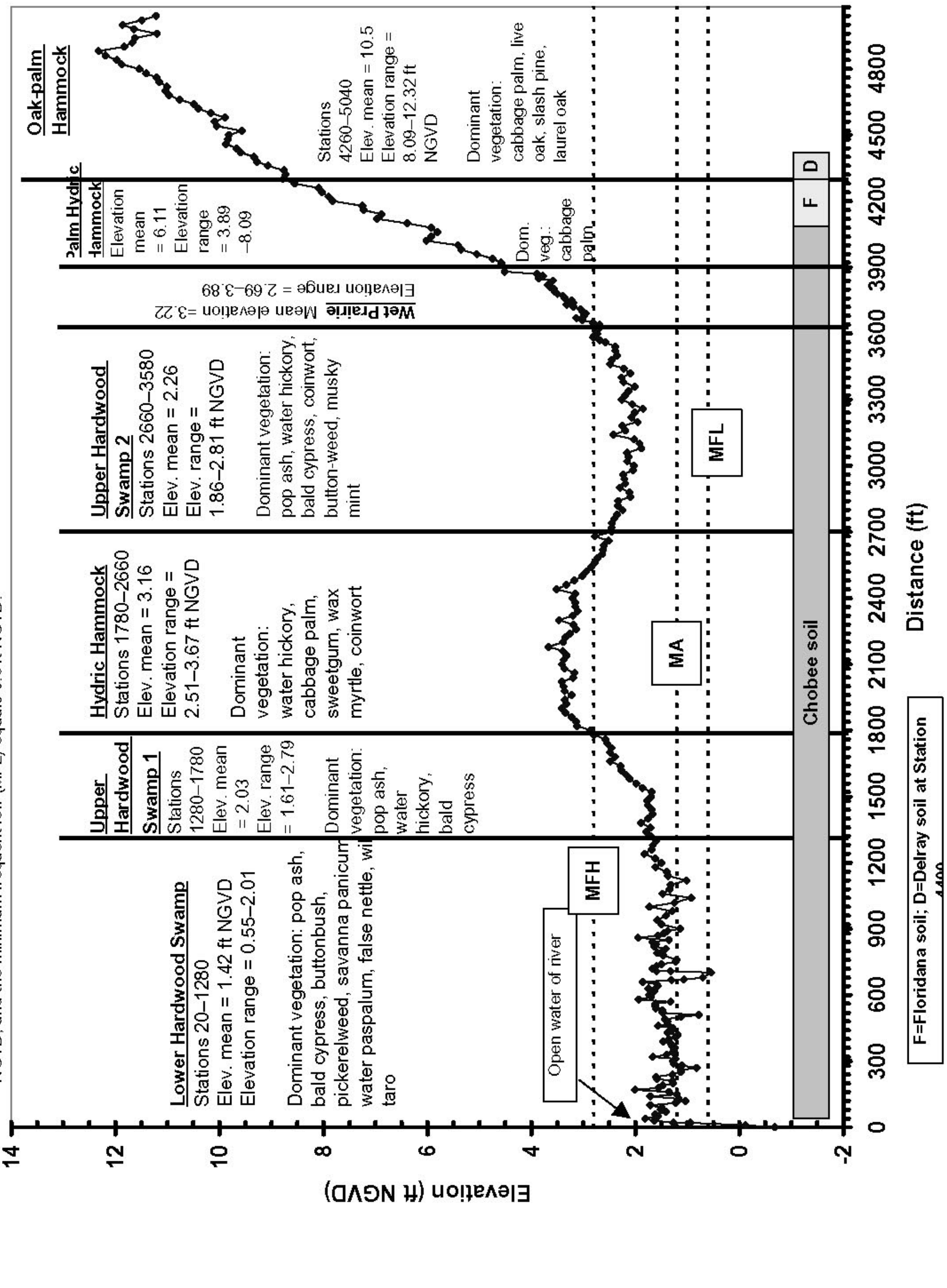


Table 18. Lower Wekiva River transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | LHS | UHS 1 | HH | UHS 2 | WP | PHH | OPH |
| Alligator-weed | *Alternanthera philoxeroides* | OBL | 1 | | | | | | |
| American elm | *Ulmus americana* | FACW | | | 1–2 | | | 1 | |
| American germander | *Teucrium canadense* | FACW | | 1 | | 2 | 1 | | |
| Antler fern | *Ceratopteris pteriodoides* | OBL | 1 | | | | | | |
| Bald cypress | *Taxodium distichum* | OBL | 3 | 1–2 | 1–2 | 1–2 | 1 | | |
| Barnyard grass | *Echinochloa muricata* | FACW | 0 | 1 | | 1 | | | |
| Beaked panicum | *Panicum anceps* | FAC | 1 | 1 | 1 | | 1 | | |
| Blue flag | *Iris virginica* | OBL | | | | 1 | | | |
| Bluestem | *Sabal minor* | FACW | | | | | | 1–2 | |
| Brown's savory | *Micromeria brownei* | OBL | | 1–3 | | | | | |
| Buttonbush | *Cephalanthus occidentalis* | OBL | 2–3 | | | | | | |
| Button-weed | *Diodia virginiana* | FACW | | 3–4 | | 3 | 1 | | |
| Cabbage palm | *Sabal palmetto* | FAC | 0 | 1 | 3 | 0–1 | 2 | 4–5 | 4 |
| Carolina jessamine | *Gelsemium sempervirens* | UPL | | | | | | | 1 |
| Carpet grass | *Axonopus furcatus* | OBL | | 1 | | | | | |
| Climbing aster | *Aster carolinianus* | OBL | 1 | | | | | | |
| Coinwort | *Centella asiatica* | FACW | | 3–4 | 2–4 | 4 | 3–4 | | |
| Cutgrass | *Leersia* sp. | OBL | | 1 | 1 | 1 | | | |
| Dog fennel | *Eupatorium leptophyllum* | FAC | | 1 | | | 1–4 | | |
| Dotted smartweed | *Polygonum punctatum* | FACW[3] | 1–2 | 2–3 | | | | | |
| Dwarf palmetto | *Sabal minor* | FACW | | | | | | 1–2 | |
| Dwarf haw | *Crataegus uniflora* | UPL | | | 0 | | | 1 | |
| Early paspalum | *Paspalum praecox* | OBL | | 1 | | | 1 | | |
| False-nettle | *Boehmeria cylindrica* | OBL | 1–2 | 2–3 | | | | | |
| Fire-flag | *Thalia geniculata* | OBL | 1 | | | | | | |
| Gum bumelia | *Bumelia lanuginosa* | FAC | | 1 | | | 0 | | |
| Ironwood | *Carpinus caroliniana* | FACW | | | | | | 1 | |
| Laurel oak | *Quercus laurifolia* | FACW | | | | | | 1 | |
| Live oak | *Quercus virginiana* | FACU | | | | | | | 1 |
| Lizard's tail | *Saururus cernuus* | OBL | | 0–1 | | | | | |
| Loblolly pine | *Pinus taeda* | FAC | | | | | | | 1–2 |
| Longleaf cupgrass | *Eriochloa michauxii* | FACW | | | | | 1–2 | | |
| Marsh fleabane | *Pluchea longifolia* | OBL | 1 | 1 | | | | | |
| Milk pea | *Galactia elliotti* | UPL | | | | | | | 1 |
| Mistflower | *Eupatorium coelestinum* | FAC | | 3 | | 1 | 1 | | |
| Moonflowers | *Ipomoea alba* | FAC | 1 | | | | | | |
| Muscadine | *Vitus rotundifolia* | FAC | | | | | | | 0–1 |
| Musky mint | *Hyptis alata* | FACW | | 1–3 | | 1–2 | 2 | | |
| Panic grass | *Dichanthelium commutatum* | FAC | | 1 | 1 | | | | |
| Panicum | *Panicum* sp. | OBL | | | | 1 | 2 | | |
| Pepper-vine | *Ampelopsis arborea* | FAC | 1 | | | | | | |
| Pickerelweed | *Pontederia cordata* | OBL | 2–3 | 2 | | 1 | | | |

Table 18—*Continued*

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | LHS | UHS 1 | HH | UHS 2 | WP | PHH | OPH |
| Poison ivy | *Toxicodendron radicans* | FAC | 2 | 2 | | | | | |
| Pop ash | *Fraxinus caroliniana* | OBL | 4 | 1–2 | 1 | 3–4 | | | |
| Red maple | *Acer rubrum* | FACW | 2 | | | | | | |
| Sand live oak | *Quercus geminata* | UPL | | | | | | | 3 |
| Savannah panicum | *Panicum gymnocarpon* | OBL | 1–3 | 3 | | | | | |
| Saw palmetto | *Serenoa repens* | UPL | | | | | | | 2 |
| Seashore mallow | *Kosteletzkya virginica* | OBL | 1 | 1 | | 1 | 1 | | |
| Sesbania | *Sesbania punicea* | FAC | | | | | 2–3 | | |
| Shiny blueberry | *Vaccinium myrsinites* | UPL | | | | | | | 1 |
| Short-bristle beakrush | *Rhynchospora corniculata* | OBL | 1–2 | 1 | 1–2 | 1 | 1 | | |
| Slash pine | *Pinus elliottii* | UPL | | | | | | 1–2 | 2 |
| Staggerbush | *Lyonia ferruginea* | FAC | | | | | | | 1 |
| Swamp dogwood | *Cornus foemia* | FACW | 1 | | | | | | |
| Swamp gum | *Nyssa aquatica* | OBL | | 1–2 | 1–2 | | | | |
| Sweetgum | *Liquidambar styraciflua* | FACW | | | 2–3 | | | 1–2 | |
| Thistle | *Cirsium altissina* | FAC | | 0–1 | | | | | |
| Water hickory | *Carya aquatica* | OBL | | 2–3 | 3–4 | 2 | 1–2 | 1 | |
| Waterhyacinth | *Eichhornia crassipes* | OBL | 1–2 | | | | | | |
| Water oak | *Quercus nigra* | FACW | | | | | | | 1 |
| Water paspalum | *Paspalum repens* | OBL | 0–2 | | | | | | |
| Wax myrtle | *Myrica cerifera* | FAC | | | 2–3 | 1 | 2 | | |
| Wild taro | *Colocasia esculenta* | OBL | 2 | | | | | | |
| Woods grass | *Oplismenus hirtellus* | FAC | | | | | | 1 | |

Note: LHS = lower hardwood swamp
UHS 1 = upper hardwood swamp
HH = hydric hammock
UHS 2 = upper hardwood swamp 2
WP = wet prairie
PHH = palm hydric hammock
OPH = oak-palm hammock

[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

[3]Denotes indicator category from Mohlenbrock 1993

Table 19. Lower Wekiva River transect vegetation community statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Lower hardwood swamp | 20–1,280 | 1.42 | 1.42 | 0.55 | 2.01 | 109 |
| Upper hardwood swamp 1 | 1,280–1,780 | 2.03 | 1.88 | 1.61 | 2.79 | 26 |
| Hydric hammock | 1,780–2,660 | 3.16 | 3.20 | 2.51 | 3.67 | 45 |
| Upper hardwood swamp 2 | 2,660–3,580 | 2.26 | 2.23 | 1.86 | 2.81 | 48 |
| Combined upper hardwood swamps | 1,280–1,780, 2,660–3,580 | 2.21 | 2.20 | 1.61 | 3.14 | 74 |
| Wet prairie | 3,580–3,870 | 3.22 | 3.19 | 2.69 | 3.89 | 30 |
| Palm hydric hammock | 3,870–4,260 | 6.11 | 5.92 | 3.89 | 8.09 | 21 |
| Oak-palm hammock | 4,260–5,040 | 10.50 | 10.62 | 8.09 | 12.32 | 40 |

Note: ft NGVD = feet National Geodetic Vertical Datum

The hydric hammock understory was sparsely vegetated except for three areas where coinwort was co-dominant.

The wetland map (Figure 3) illustrates how the hydric hammock traversed by the lower Wekiva River transect is a circular area embedded within a vast hardwood swamp. Consequently, landward of the hydric hammock, the transect traversed more upper hardwood swamp (stations 2660–3580). This second area is referred to as the upper hardwood swamp 2. The vegetation composition of the two upper hardwood swamps is very similar, with one distinct difference. The overstory of the upper hardwood swamp 2 (stations 2660–3580) is more dominated by pop ash than the upper hardwood swamp 1 (stations 1280–1780).

Landward of the upper hardwood swamp 2, the transect traversed a wet prairie (stations 3580–3870). The wet prairie overstory consisted of scattered water hickory and cabbage palm, with scattered bald cypress saplings. The overstory vegetation species composition of the wet prairie was atypical. Figure 3 illustrates the spatial shape of the wet prairie community. The transect bisected the wet prairie at its narrow southern tip, where water hickory and cabbage palms were infringing upon the wet prairie from the adjacent communities. The mid-canopy and understory species composition are more typical of a wet prairie. Wax myrtle was numerous in the wet prairie mid-canopy. The wet prairie understory included areas where coinwort and dog fennel were co-dominant. Sesbania (*Sesbania punicea*) was numerous in the wet prairie understory. Additional plants located in the wet prairie understory included numerous musky mint, *Panicum* sp., and longleaf cupgrass (*Eriochloa michauxii*).

Landward of the wet prairie, the transect traversed a palm hydric hammock (stations 3870–4260). The palm hydric hammock overstory, mid-canopy, and understory were dominated by cabbage palm. Additional plant species within the overstory of the palm hydric hammock included scattered slash pine, laurel oak, sweetgum, and water hickory. Additional plant species within the palm hydric hammock mid-canopy included scattered American elm, ironwood (*Carpinus caroliniana*), and dwarf haw (*Crataegus uniflora*). Additional plant species within the palm hydric hammock understory included scattered bluestem (*Sabal minor*) and woods grass (*Oplismenus hirtellus*).

Adjacent to the palm hydric hammock, the transect terminated in an upland oak-palm hammock (stations 4260–5040). Cabbage palm was co-dominant in the oak-palm hammock overstory, with abundant sand live oak (*Quercus geminata*) and numerous slash pine and loblolly pine (*Pinus taeda*). The oak-palm hammock understory included numerous saw palmetto and scattered milk pea (*Galactia elliottii*) and yellow jessamine (*Gelsemium sempervirens*).

### Soils at Lower Wekiva River

The soils were sampled between stations 100 and 4400 (Table 20) along the lower Wekiva River transect. Soils were similar throughout the majority of the lower Wekiva River transect (stations 100–4000) and consisted of a shallow surface organic sapric (Oa) horizon, underlain by a mucky loam A horizon, and then underlain by a black Bt horizon of clay loam, sandy loam, loam, or sandy clay loam. In some cases, a hemic (Oe) surface horizon occurred over the sapric horizon (Table 20). Due to a thick black epipedon, the soils between stations 100 and 4000 exhibit a mollic epipedon, are classified as a Mollisol, and are designated as Chobee soils. The Oa, A, and B horizons were black in color and contained relatively high amounts of organic matter, attesting to long periods of anaerobic conditions (Debra Segal, pers. com. 2001).

From approximately the midpoint of the palm hydric hammock (station 4100) to the upper elevation of the palm hydric hammock (station 4200), a Floridana soil was observed. The Floridana soil lacked a surface muck (Oa) horizon,

Table 20. Lower Wekiva River transect soil summary

| Station Distance (feet) | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Vegetation Community |
|---|---|---|---|---|
| 100 | 1.7 | Chobee | 7 | Lower hardwood swamp |
| 200 | 1.3 | Chobee | 7 | Lower hardwood swamp |
| 310 | 1.2 | Chobee | 4 | Lower hardwood swamp |
| 600 | 1.7 | Chobee | 3 | Lower hardwood swamp |
| 900 | 1.1 | Chobee | 3 | Lower hardwood swamp |
| 1,100 | 1.3 | Chobee | 4 | Lower hardwood swamp |
| 1,200 | 1.5 | Chobee | 3 | Lower hardwood swamp |
| 1,500 | 1.7 | Chobee | 4 | Upper hardwood swamp 1 |
| 1,587 | 2.1 | Chobee | 3 | Upper hardwood swamp 1 |
| 1,800 | 2.9 | Chobee | 4 | Hydric hammock |
| 2,100 | 3.4 | Chobee | 5 | Hydric hammock |
| 2,400 | 3.2 | Chobee | 3 | Hydric hammock |
| 2,700 | 2.5 | Chobee | 3 | Hydric hammock |
| 3,000 | 2.0 | Chobee | 3 | Upper hardwood swamp 2 |
| 3,300 | 2.3 | Chobee | 7 | Upper hardwood swamp 2 |
| 3,700 | 3.0 | Chobee | 4 | Wet prairie |
| 3,800 | 3.6 | Chobee | 1 | Wet prairie |
| 3,850 | 3.9 | Chobee | 1 | Wet prairie |
| 3,920 | 4.6 | Chobee | 1 | Palm hydric hammock |
| 4,000 | 5.4 | Chobee | 0.5 | Palm hydric hammock |
| 4,100 | 6.4 | Floridana | 0 | Palm hydric hammock |
| 4,200 | 7.8 | Floridana | 0 | Palm hydric hammock |
| 4,400 | 9.3 | Delray | 0 | Oak-palm hammock |

Note: ft NGVD = feet National Geodetic Vertical Datum

being replaced by a shallow mucky sand horizon, underlain by a sandy (E) horizon, and finally a dark sandy loam, loamy sand, or sandy clay loam. The Btg horizon became lower in the soil profile, making the soil series Floridana.

The final soil sample (station 4400; Table 20) was the Delray series. The Delray soil had a Btg horizon at a depth of greater than 40 in. The Delray soil contained a stripped matrix approximately 0.5–1.0 in. below the soil surface, making it a hydric soil, but lacking sufficient surface organic matter for a muck or mucky mineral hydric soil indicator.

A thin, spotty black muck surface was present between stations 4100 and 4400, evidently formed from washed-up rainwater, not from in situ processes (Ben Skulnick, soil scientist, Jones Edmunds and Associates, pers. com. 2002).

Soil series descriptions are located in the appendix.

## Minimum Levels at Lower Wekiva River

The major criteria applied in the minimum level determinations for the lower Wekiva River are presented in Table 7c.

| Minimum Levels for the Lower Wekiva River | |
|---|---|
| Minimum frequent high level | 2.8 ft NGVD |
| Minimum average level | 1.2 ft NGVD |
| Minimum frequent low level | 0.6 ft NGVD |

### Minimum Frequent High Level (2.8 ft NGVD)

The locally determined minimum frequent high level for the lower Wekiva River is 2.8 ft NGVD with a hydroperiod category of seasonally flooded. Seasonally flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, river levels causing inundation are expected to occur several weeks to several months every 1–2 years (40C-8.021(15), *F.A.C.*). Modeling results (Robison 2003) support the locally determined minimum frequent high level and hydroperiod category of seasonally flooded at the lower Wekiva River transect, indicating that this elevation (2.8 ft NGVD) will be flooded for 45 continuous days on average once every 3 years. The locally determined minimum frequent high level (2.8 ft NGVD) is exceeded approximately 14% of the time at the lower Wekiva River transect (Figure 9) (Robison 2003).

The locally determined minimum frequent high level equals the maximum elevation of both upper hardwood swamps (stations 1280–1780 and 2660–3580) traversed on the lower Wekiva River transect (Figure 12 and Table 21).

Table 21. Swamp inundation depths at transect locations on the St. Johns River and the lower Wekiva River provided by minimum frequent high level

| Vegetation Community | Location and Minimum Frequent High Level (ft NGVD) | Water Depths Provided by Minimum Frequent High Level (feet) |
|---|---|---|
| Hardwood swamp | SJR at Pine Island, 2.1 | 0–1.4 |
| Hardwood swamp combined | SJR at North Emanuel Bend transect 1, 2.5 | 0–1.4 |
| Combined upper hardwood swamp | Lower Wekiva River, 2.8 | 0–1.2 |
| Lower hardwood swamp | Lower Wekiva River, 2.8 | 0.8–2.2 |

Note: ft NGVD = feet National Geodetic Vertical Datum
SJR = St. Johns River

Surface water at the locally determined minimum frequent high level (2.8 ft NGVD) will encircle the hydric hammock traversed between stations 1780–2660 and completely inundate the vast upper hardwood swamp. The wetland map (Figure 3) illustrates that the hydric hammock traversed at stations 1780–2660 is a relatively small circular area embedded within a vast hardwood swamp. This vast hardwood swamp was delineated in the field as upper hardwood swamp 1 (stations 1280–1780) and upper hardwood swamp 2 (stations 2660–3580), with the upper hardwood swamp 2 landward (west) of the hydric hammock. Thus, at the locally determined minimum frequent high level, the floodplain forest will be inundated and directly connected to the lower Wekiva River and the St. Johns River. This connection contributes greatly to the secondary productivity of the riverine system.

As mentioned previously, interactions with the adjacent river swamps by connecting the channel to the floodplain are extremely important to animal productivity in lower Coastal Plain rivers (Bain 1990; Poff et al. 1997). The aquatic fauna habitat is greatly expanded when the lower Wekiva River inundates the extensive forested swamps adjacent to the river channel. The locally determined minimum frequent high level (2.8 ft NGVD) will provide inundation of the lower and upper hardwood swamps traversed on the lower Wekiva River transect (water depths 0.8–2.2 ft and 0–1.2 ft, respectively). For comparison, the inundation depths provided by the locally determined minimum frequent high level within the hardwood swamp at Pine Island and the locally determined minimum frequent high level within the hardwood swamp at North Emanuel Bend transect 1 along the St. Johns River are illustrated in Table 21.

The greater inundation depth within the lower hardwood swamp at the lower Wekiva River transect is due to the topography at this transect location. Unlike the locations along the St. Johns River where hardwood swamps were traversed (Figures 8 and 10), at the lower Wekiva River transect, the lower hardwood swamp is directly connected to the open water river channel with minimal bank / high ground immediately adjacent to the river (Figure 12). Consequently, the lower hardwood swamp resides at a lower elevation within the landscape, resulting in a deeper inundation when the lower Wekiva River equals the locally determined minimum frequent high level.

Additional factors supporting the locally determined minimum frequent high level (2.8 ft NGVD) include Chobee soil characteristics indicative of prolonged flooding and / or saturation between stations 100 and 4000. Specifically, the Chobee soil sampled contained a relatively high amount of organic matter, indicative of anaerobic conditions (Debra Segal, pers. com. 2001). The soil surface elevation ranged between 0.55 and 5.4 ft NGVD within the Chobee soil sampled along the lower Wekiva River transect. Depressional areas with Chobee soil are typically flooded for long duration (June–November) in most years. In non-depressional areas, the Chobee soil water table is within 6 in. of the soil surface for 1–4 months in most years (NRCS 2001).

At the locally determined minimum frequent high level (2.8 ft NGVD), the Chobee soil water level would be above the soil surface in the hardwood swamps and 5 in. below the average soil surface elevation within the hydric hammock and the wet prairie. Additionally, as the lower Wekiva River transect extends from the river and the land-surface elevation increases within the wet prairie and palm hydric hammock communities (Figure 12), the Chobee soil water table level is likely related more to recent rainfall and seepage than the river water level. Recent field observations in the rainy season (July 2003) indicated $\geq$6 in. of standing water within the upper hardwood swamp 2, where the average ground elevation equaled 2.3 ft NGVD. Simultaneously, the Wekiva River level equaled 1.7 ft NGVD at station 0.

Also noteworthy were the prominent high-water lines seen throughout the lower and upper hardwood swamps along the lower Wekiva River transect. The median elevation of the high-water lines equaled 5.2 ft NGVD (n=6; surveyed October 24, 2000, within the upper hardwood swamp 2). These water lines likely result from an extreme high-water event during October and November 1999 when the St. Johns River at the U.S. Highway 17 gage exceeded 5.0 ft NGVD for 6 weeks. The lower Wekiva River level equal to 5.2 ft NGVD is exceeded approximately 2% of the time (Figure 9) (Robison 2003).

Additional elevations traversed at the lower Wekiva River transect (Figure 12) greater than the locally determined minimum frequent high level include the average elevations of the hydric hammock (stations 1780–2660) equal to 3.2 ft NGVD, the wet prairie (stations 3580–3870) equal to 3.2 ft NGVD, the palm hydric hammock (stations 3870–4260) equal to 6.1 ft NGVD, and the minimum elevation of the oak-palm hammock equal to 8.1 ft NGVD.

**Minimum Average Level (1.2 ft NGVD)**

The locally determined minimum average level for the lower Wekiva River is 1.2 ft NGVD with a hydroperiod category of typically saturated. The recommended hydroperiod category corresponds to a water level that may re-occur approximately every year or two for about 6 months during the dry season. The locally determined minimum average level and hydroperiod category approximate a typical level that is slightly less than the long-term median water level while still protecting the wetland resource. Modeling results (Robison 2003) support the locally determined minimum average level and hydroperiod category of typically saturated at the lower Wekiva River transect, indicating that a river level equal to 1.2 ft NGVD will not occur more often than once every 1.6 years for 180 days. The locally determined minimum average level is exceeded approximately 54% of the time at the lower Wekiva River transect (Figure 9) (Robison 2003).

The locally determined minimum average level results in an average Chobee soil water table drawdown equal to 10 in. below the soil surface between stations 100–3730 (average surface elevation = 2.08 ft NGVD) at the lower Wekiva River transect. According to the Soil Survey of Volusia County (SCS 1980), the Chobee soil water table is seldom below 10 in. from the soil surface. The Chobee soil water table level would range between ponded and 25 in. below the soil surface at station 3730 at the locally determined minimum average level of 1.2 ft NGVD. Station 3730 is the midpoint of the wet prairie community along the transect. The entire wet prairie is on a seepage slope (Figure 12). As mentioned previously, the Chobee soil water table level at the higher elevations on the lower Wekiva River transect is likely higher (<25 in. from the soil surface) due to seepage and rainfall. Also, a loamy soil, such as Chobee, with an average porosity of 0.005 cm should have a saturated zone extending at least 12 in. above the free water surface (Mausbach 1992).

Additionally, the locally determined minimum average level (1.2 ft NGVD) is 0.25 ft below the average elevation of the lower hardwood swamp (stations 20–1280; Figure 12) where the organic soil surface horizon ranged in depth from 3 to 7 in. This level should result in saturated soil conditions within the entire lower hardwood swamp. Extended periods of anaerobic soil conditions are necessary to prevent long-term encroachment of upland plant species into wetland communities, thereby conserving the hydric nature and ecological functions of the floodplain communities.

At the locally determined minimum average level, shallow pools (water depth <6 in.) will exist within the lower hardwood swamp, providing aquatic fauna habitat for numerous small fish, amphibians, and small reptiles. These shallow pools may provide important habitat for various wetland fauna during the dry season.

As mentioned previously, wetland community structure results from sequential colonization (high water) and extirpations (low water). A drying wetland, however, does not necessarily result in fish mortality. Fish that do not seek refuge in the main river channel and cannot resist direct desiccation may still survive drying wetlands by escaping to small aquatic refugia (Messina and Conner 1998). Fish may survive in puddles (depth <2.4 in.), as do some invertebrates. Crayfish burrows are abundant in bottomland hardwoods (Lambou 1990), providing refugia for many small fish. Crayfish burrows were observed along the Wekiva River transect between stations 20 and 5040. Bluefin killifish, pirate perch, pygmy sunfish, tadpole madtoms, and possibly mosquitofish occupy crayfish burrows when floodplains and shallow ponds in south Georgia dry for 3–4 months (Neill 1951). The crayfish burrows lead down to the water table, sometimes opening into a complex network of horizontal passages (Creaser 1931; Neill 1951). These fish species were recently collected from the Wekiva and Little Wekiva rivers (Warren et al. 2000).

## Minimum Frequent Low Level (0.6 ft NGVD)

The recommended minimum frequent low level for the lower Wekiva River is 0.6 ft NGVD with an associated hydroperiod category of semipermanently flooded. This minimum level typically occurs every 5–10 years for several months during moderate droughts. Modeling results (Robison 2003) support the recommended minimum frequent low level and hydroperiod category of semipermanently flooded at the lower Wekiva River transect, indicating that the river is at or below 0.6 ft NGVD for 90 continuous days on average once every 5 years. The recommended minimum frequent low level is exceeded approximately 84% of the time at the lower Wekiva River transect (Figure 9) (Robison 2003).

The lower Wekiva River minimum frequent low level is 10 in. below the average elevation of the lower hardwood swamp (1.42 ft – 0.83 ft = 0.59 ft NGVD). The following factors affected the decision to implement the 10-in. soil water table drawdown within the lower hardwood swamp as the primary criterion for determining the minimum frequent low level for the lower Wekiva River:

- The lower hardwood swamp traversed at the lower Wekiva River transect is a broad depressional community directly connected to the river. According to NRCS (2001), depressional areas with Chobee soil are ponded for long duration in most areas. Consequently, for this low depressional community, a 10-in. soil water table drawdown would be characteristic of a moderate drought occurring every 5–10 years.
- According to the Soil Survey of Volusia County (SCS 1980), the water table in Chobee fine sandy loam is seldom below 10 in. from the soil surface, even during prolonged dry spells.
- While the Chobee soil extended into the palm hydric hammock (Figure 12), seepage likely affects the water table within these higher communities due to the sloping topography. Additionally, ponding may occur in Chobee soil at higher elevations primarily due to rainfall and the very poorly drained soil characteristics.

## LAKE WOODRUFF NATIONAL WILDLIFE REFUGE

There are four transect sites within Lake Woodruff National Wildlife Refuge: Tick Island, North Shore of Lake Woodruff, Dexter Point East, and Dexter Point South.

| Transect | Latitude, Longitude (station 0) | Latitude, Longitude (end station) | Location and Date of Fieldwork |
|---|---|---|---|
| Tick Island | 29 05 45.45<br>81 26 32.14 | 29 05 51.43<br>81 26 38.40 | South shore of Tick Island; January 2001 |
| North Shore Lake Woodruff | 29 06 48.23<br>81 25 07.21 | 29 06 53.04<br>81 25 08.04 | North shore of Lake Woodruff; January 2001 |
| Dexter Point East transect | 29 07 05.70<br>81 29 19.61 | 29 07 04.83<br>81 29 06.55 | East side of Dexter Point into *Spartina* and sawgrass marshes, primarily within the LWNWR; March–April 2001 |
| Dexter Point South transect | 29 07 04.84<br>81 29 10.58 | 29 06 53.94<br>81 29 00.55 | Southerly direction from *Spartina* marsh of Dexter Point East transect to the open water of Lake Dexter; April–May 2001 |

## Field Data for Tick Island Transect

Figures 4 and 6 illustrate the extensive wetlands within the LWNWR affecting transect site selections. An additional factor instrumental to the selection of field transects within the LWNWR was to ensure ecosystem protection and hydrologic monitoring in regard to migratory wading bird habitat. The LWNWR was designated in 1970 as a migratory wading bird refuge, with the primary management goal oriented at preserving wading bird habitat.

## Site Selection Factors for Tick Island Transect

The Tick Island transect is located on the south shore of Tick Island (Figures 4 and 6). Three different surface water routes connect Tick Island Mud Lake (the water body at the transect origin) with the St. Johns River and Lake Dexter. Figure 6 illustrates a small channel flowing west of the Tick Island transect origin, approximately 1.5 miles, to the St. Johns River upstream of Lake Dexter. Additionally, another small channel splits north from the west channel and connects directly with Lake Dexter. And, finally, a wide surface water connection occurs between Tick Island Mud Lake and the northwest shore of Lake Woodruff, adjacent to a channel connecting Lake Woodruff with Lake Dexter (Figure 4).

## Transect Selection Factors for Tick Island Transect

The transect site selection factors included

- No perimeter canal at transect site

- Pristine *Spartina* marsh to edge of open water
- Hydric palm hammock
- Traverse from open water to uplands
- Extensive histosols within the *Spartina* marsh
- Public land, avoiding future development that would affect transects and facilitating access for future ecological monitoring

**Vegetation at Tick Island Transect**

Dominant species within each community type are listed in Table 22. Figure 13 illustrates the elevation gradient along the Tick Island transect. This transect originated on the shore of Tick Island Mud Lake, a water body closely associated with the west shore of Lake Woodruff (Figure 4). The transect traversed northwest for 850 ft into the burnt pine flatwoods of Tick Island. The transect originated in a *Spartina* marsh (stations 0–320). Sand cordgrass (*Spartina bakeri*) was dominant, and seashore mallow was abundant within the marsh. Landward of the *Spartina* marsh, the transect traversed a palm hydric hammock (stations 320–620). Cabbage palm was dominant in the palm hydric hammock overstory. The palm hydric hammock understory was sparsely vegetated except for areas where swamp fern (*Blechnum serrulatum*) and dog fennel were abundant.

A recent (1998) wildfire burned on Tick Island (Henry Sansing, LWNWR refuge manager, pers. com. 2001). The fire charred but did not kill most of the palm trees within the palm hydric hammock. However, landward of the palm hydric hammock, the transitional zone (stations 620–740) vegetation was heavily impacted by the fire. The transitional zone overstory had abundant burnt cabbage palm and scattered burnt oaks. The transitional zone mid-canopy was composed of numerous wax myrtle and sweetgum saplings. The transitional zone understory consisted of abundant dog fennel and bracken fern (*Pteridium aquilinum*). Swamp fern and saw palmetto were numerous in the transitional zone understory.

The transect terminated in a burnt pine flatwoods (stations 740–850). The burnt pine flatwoods overstory was composed of numerous burnt pines, burnt oaks, and scattered burnt cabbage palm. Saw palmetto was dominant in

Table 22. Tick Island transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | |
|---|---|---|---|---|---|---|
| | | | SM | PHH | TZ | BPF |
| American elm | *Ulmus americana* | FACW | | | 1 | |
| Bracken fern | *Pteridium aquilinum* | UPL | | | 3 | 3 |
| Broomsedge | *Andropogon virginicus* | FAC | | | | 1 |
| Cabbage palm | *Sabal palmetto* | FAC | | 4–5 | 3–4 | 1–2 |
| Carolina willow | *Salix caroliniana* | OBL | 1 | | | |
| Dog fennel | *Eupatorium capillifolium* | FAC | | 2–3 | 3 | 2 |
| Groundsel tree | *Baccharis halimifolia* | FAC | | 1 | 1–2 | 1 |
| Long-leaf chasmanthium | *Chasmanthium sessiliflorum* | FAC | | 1–2 | | |
| Sand cordgrass | *Spartina bakeri* | FACW | 5 | | | |
| Sand live oak | *Quercus geminata* (burnt) | UPL | | 1 | 1–2 | 2 |
| Saw palmetto | *Serenoa repens* | UPL | | | 2 | 4 |
| Sawgrass | *Cladium jamaicense* | OBL | 1 | | | |
| Seashore mallow | *Kosteletzkya virginica* | OBL | 3 | | | |
| Slash pine | *Pinus elliottii* (burnt) | UPL | | | 1 | 1–2 |
| St. John's wort | *Hypericum fasciculatum* | OBL | | 1 | | |
| Swamp fern | *Blechnum serrulatum* | FACW | | 2–4 | 2 | |
| Sweetgum | *Liquidambar styraciflua* | FACW | | 0–2 | 2 | 1 |
| Wax myrtle | *Myrica cerifera* | FAC | | 1 | 2–3 | 2–3 |

Note: SM = *Spartina* marsh
PHH = palm hydric hammock
TZ = transitional zone
BPF = burnt pine flatwoods

[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

[3]Denotes indicator category from Mohlenbrock 1993

the burnt pine flatwoods understory. Bracken fern and wax myrtle were abundant in the burnt pine flatwoods understory. Soil and vegetation statistics are presented in Table 23.

### Soils at Tick Island Transect

Organic histosols (Table 24) were observed throughout the *Spartina* marsh and in the lower elevations of the palm hydric hammock at the Tick Island transect. Landward of the histosols, mineral soils were observed (Figure 13 and Table 24). All soils observed along the transect were hydric (Carlisle 1995). Soil series descriptions are located in the appendix.

### Field Data for North Shore Lake Woodruff Transect

The North Shore Lake Woodruff transect traverses the north shore of Lake Woodruff (Figures 4 and 6). This transect is approximately 2.5 miles from the eastern shore of Lake Dexter and 6.0 miles from the St. Johns River inflow to Lake Dexter. Figures 4 and 6 illustrate the extensive wetlands surrounding Lake Woodruff. A perimeter canal along the east, south, and west shores of Lake Woodruff affected the transect site selection.

### Transect Selection Factors for North Shore Lake Woodruff Transect

Specific site selection factors for the North Shore Lake Woodruff transect are listed below.

No perimeter canal along the north shore of Lake Woodruff

- Extensive wetlands (maple swamp, shrub swamp, shallow marsh)
- Relatively close to elevation benchmark and water level recorder
- Extensive histosols along entire transect
- Public land, avoiding future development that would affect transects and facilitating access for future ecological monitoring

Table 23. Tick Island transect soil and vegetation statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| *Spartina* marsh | 0–320 | 1.22 | 1.23 | 0.85 | 1.45 | 18 |
| Histosols (Terra Ceia and Gator muck) | 0–360 | 1.32 | 1.25 | 0.85 | 1.97 | 21 |
| Palm hydric hammock | 320–620 | 2.47 | 2.34 | 1.45 | 3.73 | 17 |
| Transitional zone | 620–740 | 4.39 | 4.36 | 3.73 | 4.91 | 7 |
| Burnt pine flatwoods | 740–850 | 5.19 | 5.17 | 4.83 | 5.56 | 7 |

Note: ft NGVD = feet National Geodetic Vertical Datum

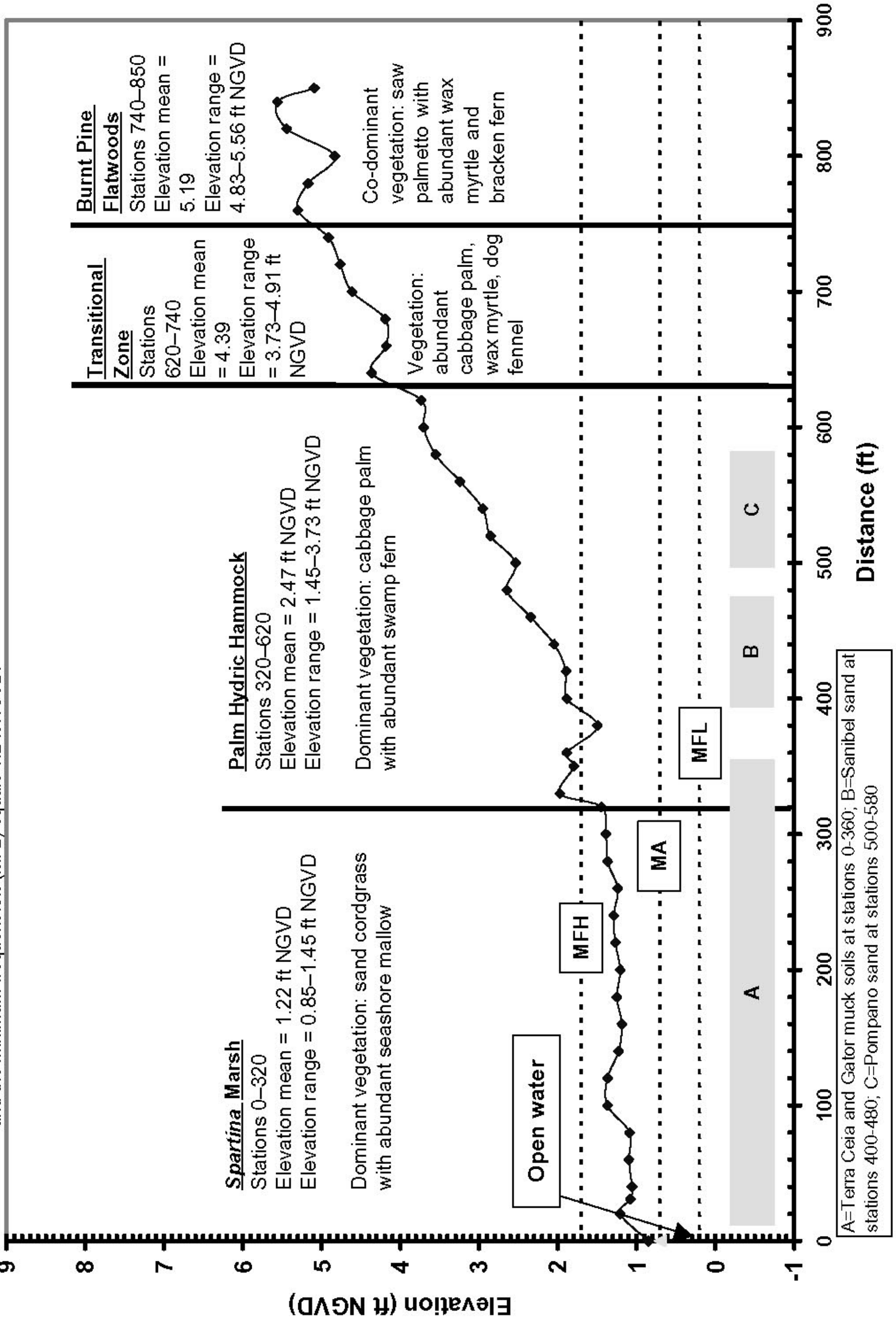
Table 24. Tick Island transect soil summary

| Station | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Plant Community |
|---|---|---|---|---|
| 30 | 1.1 | Terra Ceia muck | 84 | *Spartina* marsh |
| 60 | 1.1 | Terra Ceia muck | 84 | *Spartina* marsh |
| 120 | 1.4 | Terra Ceia muck | 84 | *Spartina* marsh |
| 240 | 1.3 | Terra Ceia muck | 84 | *Spartina* marsh |
| 260 | 1.2 | Gator muck | 45 | *Spartina* marsh |
| 280 | 1.4 | Gator muck | 39 | *Spartina* marsh |
| 320 | 1.4 | Gator muck | 18 | *Spartina* marsh |
| 330 | 2.0 | Gator muck | 18 | Palm hydric hammock |
| 360 | 1.9 | Gator muck | 25 | Palm hydric hammock |
| 400 | 1.9 | Sanibel sand | 6 | Palm hydric hammock |
| 440 | 2.0 | Sanibel sand | 4 | Palm hydric hammock |
| 480 | 2.6 | Sanibel sand | 4 | Palm hydric hammock |
| 500 | 2.5 | Pompano fine sand | 0 | Palm hydric hammock |
| 540 | 3.0 | Pompano fine sand | 0 | Palm hydric hammock |
| 560 | 3.2 | Pompano fine sand | 0 | Palm hydric hammock |
| 580 | 3.6 | Pompano fine sand | 0 | Palm hydric hammock |
| 600 | 3.7 | Holopaw sand | 0 | Palm hydric hammock |
| 660 | 4.2 | Paisley loamy fine sand | 0 | Transitional zone |
| 740 | 4.9 | Holopaw sand | 0 | Burnt pine flatwoods |

Note: ft NGVD = feet National Geodetic Vertical Datum

**Figure 13. Tick Island transect topography with ecological communities**

Note: At Tick Island, the minimum frequent high (MFH) equals 1.7 ft NGVD, the minimum average (MA) equals 0.7 ft NGVD, and the minimum frequent low (MFL) equals 0.2 ft NGVD.



## Vegetation at North Shore Lake Woodruff Transect

Dominant species within each community type are listed in Table 25. The North Shore transect (Figure 14) originated on the shore of Lake Woodruff, immediately adjacent to the open water. The first vegetation community traversed was a maple swamp (stations 0–90). Red maple was dominant in the overstory of the maple swamp, with numerous Carolina willow and buttonbush in the mid-canopy. The maple swamp understory was sparsely vegetated with scattered horned rush (*Rhynchospora corniculata*). Adjacent to the maple swamp, the transect traversed a willow-maple shrub swamp (stations 90–220). Red maple, Carolina willow, and wax myrtle were abundant in the willow-maple shrub swamp overstory. The overstory canopy height was noticeably less in the willow-maple shrub swamp than the maple swamp overstory. Presumably, the willow-maple shrub swamp vegetation is less mature than the maple swamp rather than stunted due to different hydrology. The mean elevation of these two communities is essentially equal, resulting in identical hydrology.

Table 25. North Shore Lake Woodruff transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | |
|---|---|---|---|---|---|
| | | | Maple Swamp | Willow-Maple Shrub Swamp | Sawgrass-Willow Marsh |
| Buttonbush | *Cephalanthus occidentalis* | OBL | 2 | 2 | 1 |
| Carolina willow | *Salix caroliniana* | OBL | 2 | 3 | 2–4 |
| Horned rush | *Rhynchospora corniculata* | OBL | 1 | | |
| Red maple | *Acer rubrum* | FACW | 5 | 2–3 | 1 |
| Royal fern | *Osmunda regalis* | OBL | | 2–3 | 0–2 |
| Sawgrass | *Cladium jamaicense* | OBL | | 2 | 3–5 |
| Wax myrtle | *Myrica cerifera* | FAC | 1 | 2–3 | 2–3 |

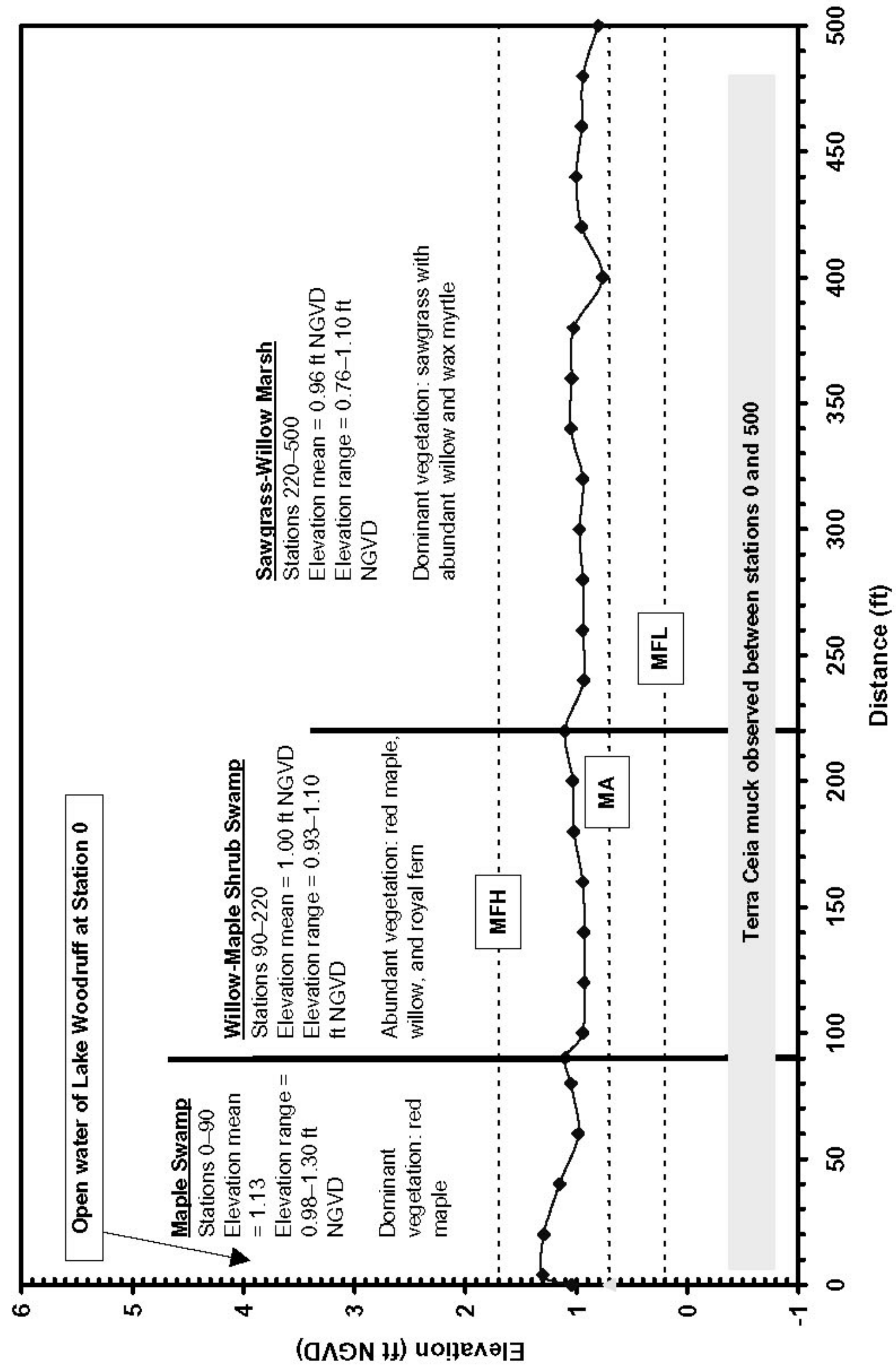
[1]FWDM code indicator categories established in *Florida Wetlands Delineation Manual* (Gilbert et al. 1995)

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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

**Figure 14. Lake Woodruff North Shore transect topography with ecological communities**

Note: At Lake Woodruff, the minimum frequent high (MFH) equals 1.7 ft NGVD, the minimum average (MA) equals 0.7 ft NGVD, and the minimum frequent low (MFL) equals 0.2 ft NGVD.



The willow-maple shrub swamp understory included numerous royal fern and sawgrass (*Cladium jamaicense*). Landward of the willow-maple shrub swamp, the transect terminated within a sawgrass-willow marsh (stations 220–500). Sawgrass was the dominant vegetation throughout the sawgrass-willow marsh. Additionally, Carolina willow was numerous to co-dominant, wax myrtle was numerous, and royal fern was rare to numerous within the sawgrass-willow marsh. Soil and vegetation statistics are presented in Table 26.

Table 26. North Shore Lake Woodruff transect soil and vegetation statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Maple swamp | 0–90 | 1.13 | 1.10 | 0.98 | 1.30 | 7 |
| Willow-maple shrub swamp | 90–220 | 1.00 | 0.98 | 0.93 | 1.10 | 7 |
| Sawgrass-willow marsh | 220–500 | 0.96 | 0.95 | 0.76 | 1.10 | 14 |
| Terra Ceia muck | 0–500 | 1.00 | 0.98 | 0.76 | 1.30 | 28 |

Note: ft NGVD = feet National Geodetic Vertical Datum

## Soils at North Shore Lake Woodruff Transect

The soils sampled along the entire North Shore transect were Terra Ceia muck. Samples were taken at 100-ft intervals (n=5), beginning at station 4. The sampled Terra Ceia muck depths ranged between 74 and 90 in. (Table 27). The Terra Ceia series description is located in the appendix.

Table 27. North Shore Lake Woodruff transect soil summary

| Station Distance (feet) | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Plant Community |
|---|---|---|---|---|
| 4 | 1.3 | Terra Ceia muck | 74 | Maple swamp |
| 100 | 0.9 | Terra Ceia muck | 79 | Willow-maple shrub swamp |
| 200 | 1.0 | Terra Ceia muck | 74 | Willow-maple shrub swamp |
| 300 | 1.0 | Terra Ceia muck | 90 | Sawgrass-willow marsh |
| 400 | 0.8 | Terra Ceia muck | 70 | Sawgrass-willow marsh |

Note: ft NGVD = feet National Geodetic Vertical Datum

## DEXTER POINT TRANSECTS (LAKE WOODRUFF NATIONAL WILDLIFE REFUGE)

### Site Selection Factors

Two transects (Dexter Point East and Dexter Point South; Figures 4 and 6) were established at Dexter Point. The Dexter Point East transect originated within the Mary Farms Tract of the Lake George State Forest, managed by the Florida Division of Forestry, and terminated within the LWNWR. The Dexter Point South transect was entirely contained within the LWNWR. Two transects were located at Dexter Point in order to traverse from an upland community perpendicular to the land gradient, extending into the *Spartina* and sawgrass marshes at Dexter Point (Dexter Point East transect) and then to traverse through the marsh communities, willow swamp, and maple swamp to the open water of Lake Dexter (Dexter Point South transect).

### Transect Selection Factors

Specific site selection factors for both Dexter Point transects are listed below.

- Extensive *Spartina* marsh to compare with the Tick Island transect
- Extensive sawgrass marsh
- Extensive palm hydric hammock to compare with the Tick Island transect
- Traverse from open water of Lake Dexter to uplands
- Extensive histosols within the marshes
- Public land, avoiding future development that would affect transects and facilitating access for future ecological monitoring

### Vegetation at Dexter Point East Transect

Dominant species within each community type are listed in Table 28. Figure 15 illustrates the elevation gradient along the Dexter Point East transect. This transect originated at the edge of a burnt pine flatwoods located within the Florida Division of Forestry (DOF) property known as the Dexter Point-Mary Farms tract. The transect traversed 1,260 ft in an easterly direction from the burnt pine flatwoods through a flatwoods-hydric hammock transitional zone, an upper palm hydric hammock, a lower palm hydric hammock, a shrub transitional zone at the edge of the marsh, and a *Spartina* marsh, and terminated within a sawgrass marsh. A property boundary occurs

Table 28. Dexter Point East transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | FHHTZ | UPHH | LPHH | STZ | SM | SGM |
| Bluestem | *Sabal minor* | FACW | | | 1 | | | |
| Bracken fern | *Pteridium aquilinum* | UPL | 2 | | | | | |
| Broomsedge | *Andropogon virginicus* | FAC | 1 | 1 | | 1 | | |
| Bull arrowhead | *Sagittaria lancifolia* | OBL | | | | | 1 | |
| Cabbage palm | *Sabal palmetto* | FAC | 4 | 4 | 4–5 | 1 | | |
| Carolina willow | *Salix caroliniana* | OBL | | | | | | 1 |
| Cattail | *Typha* sp. | OBL | | | | | 1 | 0 |
| Climbing aster | *Aster caroliniana* | OBL | | | | 1 | | |
| Coin wort | *Centella asiatica* | FACW | | 1–3 | 1 | 1 | | |
| Dog fennel | *Eupatorium capillifolium* | FAC | 1 | 2–3 | 1 | | | |
| Fall panicum | *Panicum dichotomiflorum* | FACW | | 1 | | | | |
| Fireweed | *Erechtites hieracifolia* | FAC | | 2 | | | | |
| Groundsel tree | *Baccharis glomeruliflora* | FACW | | 1 | 1 | | | |
| Horned rush | *Rhynchospora corniculata* | OBL | | 1–2 | | | | |
| Live oak | *Quercus virginiana* (burnt) | UPL | 1 | 1–2 | 2 | | | |
| Maidencane | *Panicum hemitomon* | OBL | | 1 | | | | |
| Marsh pennywort | *Hydrocotyle umbellata* | OBL | | 1 | 1 | | | |
| Panic grass | *Dichanthelium laxiflorum* | FAC | | 1 | 1 | | | |
| Pond pine | *Pinus serotina* | FACW | | | | 0 | | |
| Red maple | *Acer rubrum* | FAC | | | | 1 | | |
| Sand cordgrass | *Spartina bakeri* | FACW | | | | 3 | 5 | |
| Saw palmetto | *Serenoa repens* | UPL | 1–2 | 0 | 0 | | | |
| Sawgrass | *Cladium jamaicense* | OBL | | | | | | 5 |
| Sedge | *Carex albolutescens* | FAC | | 3 | | | | |
| Slash pine | *Pinus elliottii* (burnt) | UPL | 3 | 3 | | | | |
| Southern red cedar | *Juniperus silicicola* | FAC | | 1 | 1 | | | |
| Swamp hibiscus | *Hibiscus grandiflorus* | OBL | | | | | 1 | |
| Sweetgum | *Liquidambar styraciflua* | FACW | 1 | 1 | 1 | | | |
| Virginia chain fern | *Woodwardia virginiana* | OBL | | 1 | | | | |
| Water oak | *Quercus nigra* | FAC | | | 1 | | | |
| Wax myrtle | *Myrica cerifera* | FAC | 3 | 3 | | 2–3 | | |
| Yellow canna lily | *Canna flaccida* | OBL | | 1–4 | | | | |

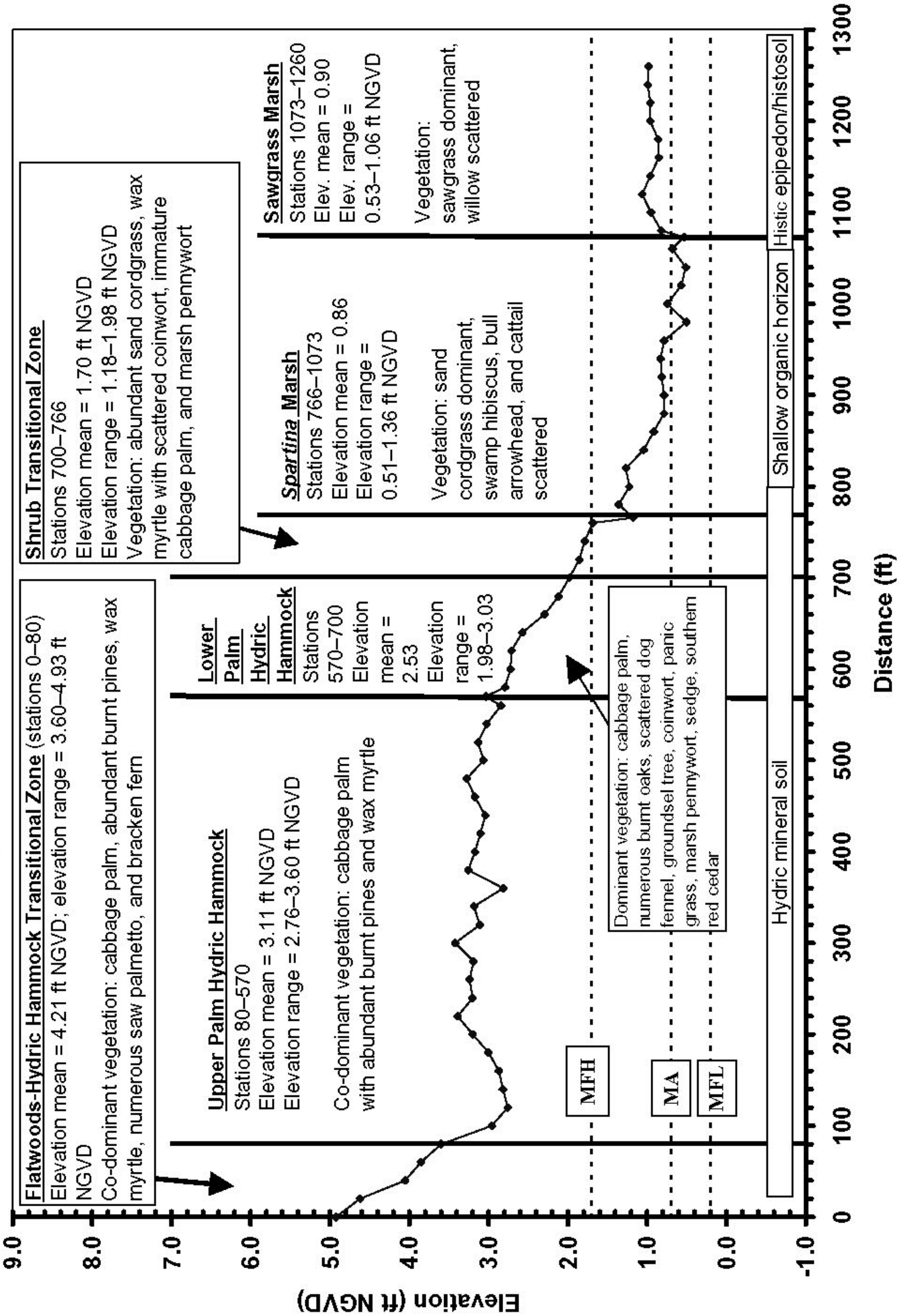
Note: FHHTZ = flatwoods-hydric hammock transitional zone
LPHH = lower palm hydric hammock
SGM = sawgrass marsh
SM = *Spartina* marsh
STZ = shrub transitional zone
UPHH = upper palm hydric hammock

[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 species cover estimates: Aerial extent of vegetation species along transect within a 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=>75% (dominant)

**Figure 15. Dexter Point East transect topography with ecological communities**

Note: At Dexter Point, the minimum frequent high (MFH) equals 1.7 ft NGVD, the minimum average (MA) equals 0.7 ft NGVD, and the minimum frequent low (MFL) equals 0.2 ft NGVD.



at the landward edge of the *Spartina* marsh, with the *Spartina* and sawgrass marshes located within the LWNWR. Table 29 summarizes the elevation statistics for each vegetation community traversed along the Dexter Point East transect.

Table 29. Dexter Point East transect vegetation community statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| Flatwoods-hydric hammock transitional zone | 0–80 | 4.21 | 4.05 | 3.60 | 4.93 | 5 |
| Upper palm hydric hammock | 80–570 | 3.11 | 3.12 | 2.76 | 3.60 | 26 |
| Lower palm hydric hammock | 570–700 | 2.53 | 2.64 | 1.98 | 3.03 | 8 |
| Shrub transitional zone | 700–766 | 1.70 | 1.79 | 1.18 | 1.98 | 5 |
| *Spartina* marsh | 766–1,073 | 0.86 | 0.79 | 0.51 | 1.36 | 17 |
| Sawgrass marsh | 1,073–1,260 | 0.90 | 0.96 | 0.53 | 1.06 | 11 |

Note: ft NGVD = feet National Geodetic Vertical Datum

The flatwoods-hydric hammock transitional zone (stations 0–80) overstory vegetation consisted of co-dominant cabbage palm, abundant burnt pines, and scattered burnt oaks. A wildfire in July 1998 (Crista Furtsch, forester, DOF, pers. com. 2001) killed all the pines and oaks and approximately 50% of the cabbage palms within the flatwoods-hydric hammock transitional zone. The flatwoods-hydric hammock transitional zone understory consisted of abundant wax myrtle, numerous saw palmetto, numerous bracken fern, scattered sweetgum saplings, scattered dog fennel, and scattered broomsedge (*Andropogon virginicus*).

The upper palm hydric hammock (stations 80–570) overstory was dominated by cabbage palm. Additional overstory vegetation species included abundant pines and scattered to numerous oaks. Approximately 50% of the oaks and pines survived the 1998 wildfire within the upper palm hydric hammock. The upper palm hydric hammock understory consisted of scattered to co-dominant yellow canna lily (*Canna flaccida*), abundant wax myrtle, abundant dog fennel, abundant sedge (*Carex albolutescens*), abundant coinwort, scattered to numerous horned rush, numerous fireweed (*Erechtites hieracifolia*), numerous maidencane, scattered sweetgum saplings, and scattered southern red cedar (*Juniperus silicicola*) saplings.

The lower palm hydric hammock (stations 570–700) overstory was also dominated by cabbage palm, with numerous burnt oaks but no pines. The lower palm hydric hammock understory was sparsely vegetated with scattered sweetgum saplings, dog fennel, groundsel tree, coinwort, panic grass (*Dichanthelium laxiflorum*), sedge, marsh pennywort (*Hydrocotyle umbellata*), bluestem, water oak saplings, and southern red cedar saplings.

Adjacent to the lower palm hydric hammock, the Dexter Point East transect traversed a shrub transitional zone (stations 700–766). The shrub transitional zone was sparsely vegetated, with an open canopy. Plant species in the shrub transitional zone included numerous to abundant wax myrtles, abundant sand cordgrass, scattered immature cabbage palm, scattered red maple, scattered coinwort, scattered marsh pennywort, and scattered climbing aster.

The *Spartina* marsh (stations 766–1073) was dominated by sand cordgrass. Additional plant species in the *Spartina* marsh were scattered cattail (*Typha* sp.), bull arrowhead (*Sagittaria lancifolia*), and swamp hibiscus. The Dexter Point East transect terminated within a sawgrass marsh (stations 1073–1260). Sawgrass was the dominant plant species located within the sawgrass marsh. Carolina willow saplings were scattered and cattail was scattered within the sawgrass marsh.

### Soils at Dexter Point East Transect

The soils sampled at the Dexter Point East transect are summarized in Table 30. Hydric mineral soils were observed from the transect origin in the flatwoods-hydric hammock transitional zone into the higher elevations of the *Spartina* marsh (Figure 15). These soils are poorly drained or very poorly drained and exhibit various hydric soil indicators such as organic bodies, black surface layer, mucky sand surface layers, a stripped matrix within the upper 6 in. of the soil, and gleyed and depleted matrices. Gleyed coloration and depleted matrices develop in soils that have maintained saturation for extended periods.

Soils transitioned sharply from a mineral surface to an organic surface within the *Spartina* marsh. A thin (5-in.) organic horizon first appeared within the *Spartina* marsh at station 850. Organic horizon depths typically increased (Table 30) within the *Spartina* marsh with increased transect distance.

Table 30. Dexter Point East transect soil summary

| Station | Elevation (ft NGVD) | Soil Name | Muck Thickness (inches) | Plant Community |
|---|---|---|---|---|
| 25 | 4.6 | Immokalee | 0 | Flatwoods transitional zone |
| 80 | 3.6 | Pomona | 0 | Upper palm hammock |
| 120 | 2.8 | Chobee | 0 | Upper palm hammock |
| 200 | 3.2 | Riviera | 0 | Upper palm hammock |
| 500 | 3.1 | Scoggin | 0 | Upper palm hammock |
| 600 | 2.7 | Scoggin | 0 | Lower palm hammock |
| 740 | 1.8 | Scoggin | 0 | Shrub transitional zone |
| 760 | 1.7 | Insufficient data | 0 | Shrub transitional zone |
| 770 | 1.2 | Insufficient data | 0 | *Spartina* marsh |
| 780 | 1.4 | Insufficient data | 0 | *Spartina* marsh |
| 790 | 1.3 | Insufficient data | 0 | *Spartina* marsh |
| 800 | 1.2 | Insufficient data | 0 | *Spartina* marsh |
| 850 | 0.9 | Riviera | 5 | *Spartina* marsh |
| 950 | 0.8 | Tequesta muck | 6 | *Spartina* marsh |
| 1000 | 0.7 | Tequesta muck | 8 | *Spartina* marsh |
| 1060 | 0.7 | Tequesta muck | 12 | *Spartina* muck |
| 1080 | 0.8 | Tequesta muck | 9 | *Spartina* marsh |
| 1100 | 1.0 | Tequesta muck | 16 | Sawgrass marsh |
| 1200 | 1.0 | Terra Ceia muck[1] | >24 | Sawgrass marsh |

Note: ft NGVD = feet National Geodetic Vertical Datum

[1]Terra Ceia muck, if organic matter extends greater than or equal to 52 inches below soil surface

The deepest organic horizons occurred within the sawgrass marsh at the transect end.

## Vegetation at Dexter Point South Transect

Dominant species within each community type are listed in Table 31. Figure 16 illustrates the elevation gradient along the Dexter Point South transect. The Dexter Point South transect originated within the LWNWR at station 845 of the Dexter Point East transect. The Dexter Point South transect traversed 1,440 ft in a southerly direction through a *Spartina* marsh, a *Sagittaria* slough, a sawgrass marsh, a sawgrass-willow marsh, and a willow swamp, and terminated at the shore of Lake Dexter within a maple swamp.

Table 31. Dexter Point South transect vegetation species list

| Common Name | Scientific Name | FWDM Code[1] | Plant Community Species Cover Estimates[2] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | SM | SS | SGM | SGWM | WS | MS |
| Bull arrowhead | *Sagittaria lancifolia* | OBL | 0–1 | 5 | | | | |
| Buttonbush | *Cephalanthus occidentalis* | OBL | | | | | 1 | 4 |
| Cabbage palm | *Sabal palmetto* | FAC | | | | | | 1 |
| Carolina willow | *Salix caroliniana* | OBL | | | 1–2 | 3–4 | 4 | 2 |
| Cattail | *Typha* sp. | OBL | 1 | 1 | 1 | | | |
| Horned rush | *Rhynchospora corniculata* | OBL | | | | | | 2 |
| Maidencane | *Panicum hemitomon* | OBL | | | | | | 1 |
| Pickerelweed | *Pontederia cordata* | OBL | | | | | | 1–2 |
| Red maple | *Acer rubrum* | FAC | | | | 1 | 2 | 3–4 |
| Royal fern | *Osmunda regalis* | OBL | | | | 0 | | |
| Saltmarsh mallow | *Kosteletzkya virginica* | OBL | 1 | 1 | 1 | 1 | 1 | |
| Sand cordgrass | *Spartina bakeri* | FACW | 5 | | | | | |
| Sawgrass | *Cladium jamaicense* | OBL | | | 5 | 4 | 2 | |
| Soft-stem bulrush | *Scirpus validus* | OBL | | 3 | | | | |
| Southern shield fern | *Dryopteris ludoviciana* | FACW | | | | | 2 | 1 |
| Swamp dogwood | *Cornus foemina* | FACW | | | | | | 1 |
| Swamp hibiscus | *Hibiscus grandiflorus* | OBL | 1 | 1 | 2–3 | 2–3 | 2 | |
| Virginia chain fern | *Woodwardia virginiana* | OBL | | | | 1 | 2 | 1 |
| Wax myrtle | *Myrica cerifera* | FAC | | | | 1 | 1 | 1 |

Note: SM = *Spartina* marsh
SS = *Sagittaria* slough
SGM = sawgrass marsh
SGWM = sawgrass-willow marsh
WS = willow swamp
MS = maple swamp

[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 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)

**Figure 16. Dexter Point South transect topography with ecological communities**

Note: At Dexter Point, the minimum frequent high (MFH) equals 1.7 ft NGVD, the minimum average (MA) equals 0.7 ft NGVD, and the minimum frequent low (MFL) equals 0.2 ft NGVD.

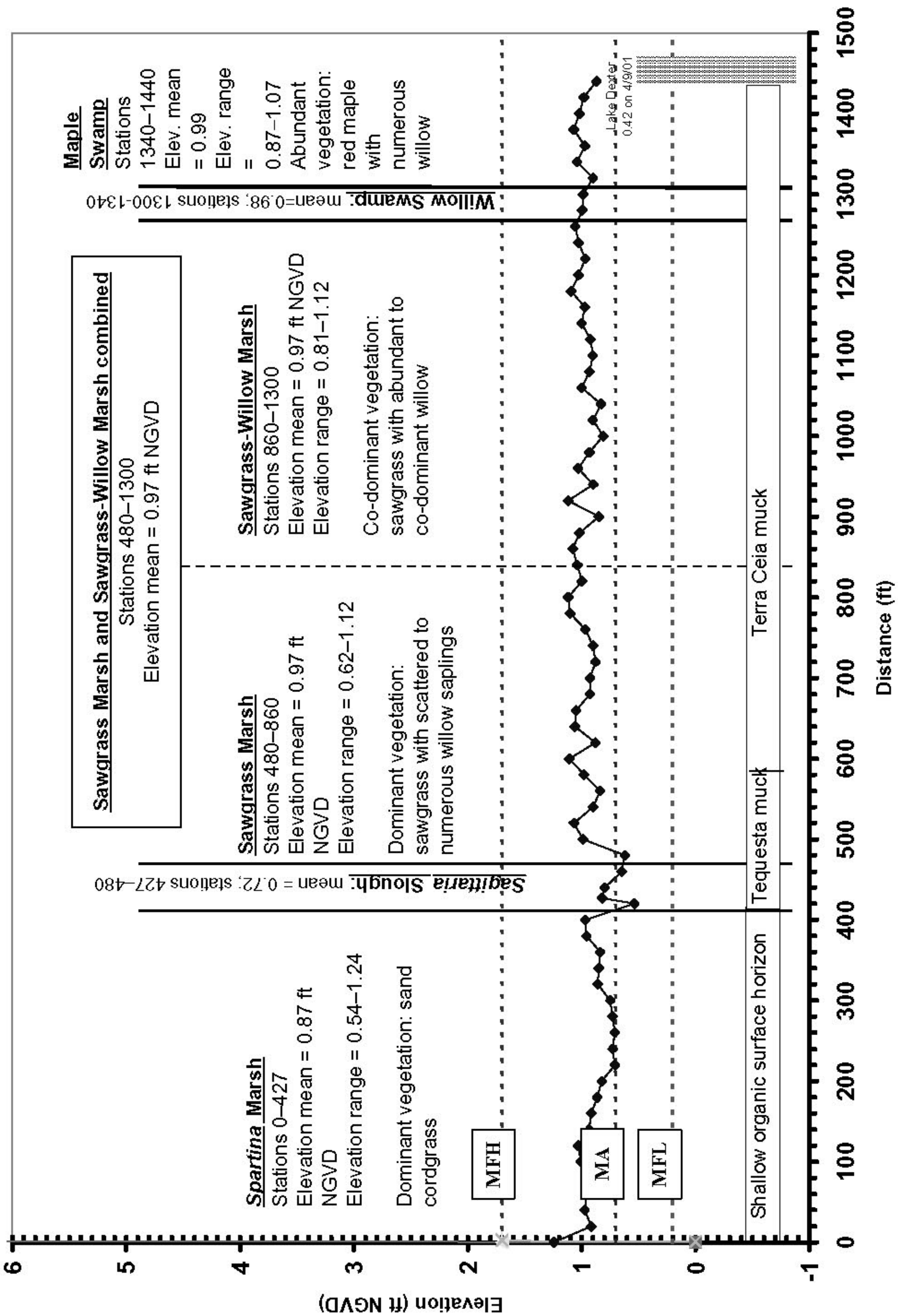


Table 32 summarizes the elevation statistics for each vegetation community traversed along the Dexter Point South transect.

Table 32. Dexter Point South transect vegetation community statistics

| Vegetation Community | Station Distance (feet) | Mean (ft NGVD) | Median (ft NGVD) | Minimum (ft NGVD) | Maximum (ft NGVD) | N |
|---|---|---|---|---|---|---|
| *Spartina* marsh | 0–427 | 0.87 | 0.86 | 0.54 | 1.24 | 23 |
| *Sagittaria* slough | 427–480 | 0.72 | 0.72 | 0.62 | 0.82 | 4 |
| Sawgrass marsh | 480–860 | 0.97 | 0.98 | 0.62 | 1.12 | 20 |
| Sawgrass-willow marsh | 860–1,300 | 0.97 | 0.99 | 0.81 | 1.12 | 23 |
| Sawgrass marsh and sawgrass-willow marsh combined | 480–1,300 | 0.97 | 0.98 | 0.62 | 1.12 | 43 |
| Willow swamp | 1,300–1,340 | 0.98 | 0.98 | 0.90 | 1.04 | 3 |
| Maple swamp | 1,340–1,440 | 0.99 | 1.00 | 0.87 | 1.07 | 6 |

Note: ft NGVD = feet National Geodetic Vertical Datum

The *Spartina* marsh (stations 0–427) was dominated by sand cordgrass, with scattered cattail, bull arrowhead, and swamp hibiscus. Waterward of the *Spartina* marsh lies a narrow *Sagittaria* slough (stations 427–480). *Sagittaria lancifolia* (bull arrowhead) was dominant in the slough. Additional species in the *Sagittaria* slough included abundant soft-stem bulrush (*Scirpus validus*), scattered cattail, and scattered swamp hibiscus.

Waterward of the *Sagittaria* slough, the transect traversed a sawgrass marsh (stations 480–860). Sawgrass was the dominant species. Additional species within the sawgrass marsh included scattered to numerous Carolina willow saplings, numerous to abundant swamp hibiscus, and scattered cattail. Adjacent to the sawgrass marsh, the transect traversed a sawgrass-willow marsh (stations 860–1300). Vegetation within the sawgrass-willow marsh included co-dominant sawgrass and abundant to co-dominant Carolina willow saplings, with numerous to abundant swamp hibiscus, scattered red maple saplings, wax myrtle, and Virginia chain fern.

Waterward of the sawgrass-willow marsh, the Dexter Point South transect traversed a narrow willow swamp (stations 1300–1340). Mature Carolina willows were co-dominant, and mature red maples were numerous in the willow swamp overstory. The willow swamp mid-canopy vegetation consisted of scattered buttonbush and wax myrtle. The understory within the willow swamp contained numerous Virginia chain fern and southern shield fern (*Dryopteris ludoviciana*).

The Dexter Point South transect terminated at the shore of Lake Dexter within a maple swamp (stations 1340–1440). The maple swamp overstory vegetation consisted of abundant to co-dominant mature red maple, with numerous Carolina willow. The maple swamp mid-canopy vegetation consisted of co-dominant buttonbush with scattered wax myrtle and swamp dogwood. The maple swamp understory vegetation consisted of numerous horned rush, scattered to numerous pickerelweed, scattered maidencane, immature cabbage palm, Virginia chain fern, and southern shield fern.

### Soils at Dexter Point South Transect

Except for the Riviera soil sampled at the beginning of the Dexter Point South transect, organic soils were observed along the entire Dexter Point South transect. Organic soil horizon depths generally increased as the transect extended from the *Spartina* marsh, through the *Sagittaria* slough, and into the sawgrass marsh, willow swamp, and maple swamp to the shore of Lake Dexter (Table 33). The soils with a shallow organic horizon were classified as Tequesta muck, and the deeper organic horizon soils were designated as Terra Ceia muck.

## Minimum Levels at the Lake Woodruff National Wildlife Refuge

The major criteria applied in the level determinations for the St. Johns River at Lake Dexter and the LWNWR are presented in Table 7d.

| Minimum Levels for the Lake Woodruff National Wildlife Refuge | |
|---|---|
| Minimum frequent high level | 1.7 ft NGVD |
| Minimum average level | 0.7 ft NGVD |
| Minimum frequent low level | 0.2 ft NGVD |

Table 33. Dexter Point South transect soil summary

| Station | Elevation (ft NGVD) | Soil Name* | Muck Thickness (inches) | Plant Community |
|---|---|---|---|---|
| 0 | 1.2 | Riviera sand | 5 | *Spartina* marsh |
| 200 | 0.8 | Tequesta muck | 8 | *Spartina* marsh |
| 300 | 0.7 | Tequesta muck | 6 | *Spartina* marsh |
| 340 | 0.8 | Tequesta muck | 7 | *Spartina* marsh |
| 400 | 1.0 | Tequesta muck | 8 | *Spartina* marsh |
| 430 | 0.8 | Tequesta muck | 12 | *Sagittaria* slough |
| 440 | 0.8 | Tequesta muck | 11 | *Sagittaria* slough |
| 600 | 1.1 | Terra Ceia muck | >16 | Sawgrass marsh |
| 800 | 1.1 | Terra Ceia muck | >20 | Sawgrass marsh |
| 1000 | 0.8 | Terra Ceia muck | >24 | Sawgrass marsh |
| 1200 | 1.0 | Terra Ceia muck | >20 | Sawgrass marsh |
| 1320 | 0.9 | Terra Ceia muck | >24 | Willow swamp |
| 1360 | 1.0 | Terra Ceia muck | >36 | Maple swamp |
| 1400 | 1.0 | Terra Ceia muck | >36 | Maple swamp |
| 1430 | 0.9 | Terra Ceia muck | >48 | Maple swamp |

Note: ft NGVD = feet National Geodetic Vertical Datum

*Terra Ceia muck if organic matter extends greater than or equal to 52 inches below soil surface

## Minimum Frequent High Level at the Lake Woodruff National Wildlife Refuge (1.7 ft NGVD)

The locally determined minimum frequent high level for the St. Johns River at the LWNWR is 1.7 ft NGVD, with the assigned hydroperiod category of seasonally flooded. Seasonally flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water is typically present for extended periods during the growing season (30 days or more), resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, river levels causing inundation are expected to occur several weeks to several months every 1–2 years (40C-8.021(15), *F.A.C.*). Modeling results (Robison 2003) support the locally determined minimum frequent high level and hydroperiod category of seasonally flooded at the LWNWR, indicating that this elevation (1.7 ft NGVD) will be flooded for 45 continuous days on average once every 3 years. The locally determined minimum frequent high level equals the 13% exceedance value from the stage-duration curve simulated for the LWNWR (Figure 9) (Robison 2003).

The locally determined minimum frequent high level (1.7 ft NGVD) corresponds to the average elevation of the transitional zone (stations 700–766; Figure 15) between the lower palm hydric hammock and the *Spartina* marsh traversed at the Dexter Point East transect. The transitional zone between the lower palm hydric hammock and the *Spartina* marsh at the Dexter Point East transect contains both marsh and hydric hammock vegetation and hydric mineral soil characteristics indicative of long-term saturation and/or inundation. The common plant species (Table 31) within this zone include abundant sand cordgrass and wax myrtle, facultative wet and facultative species, respectively. Figure 17 illustrates the marsh, shrub, and hydric hammock vegetative characteristics of this transitional zone. Frequent inundation, as specified by the hydroperiod category of seasonally flooded, within the lower elevations of this transitional zone will prevent upland vegetation encroachment into this area, as well as a further shift of transitional vegetation into the *Spartina* marsh. Observations of aerial photographs taken in 1942 indicated that the transitional zone community was *Spartina* marsh at that time.

The aquatic fauna habitat is greatly expanded when the water levels inundate the extensive marshes and swamps within the LWNWR, directly connecting the wetland communities with the river channel. As mentioned previously, interactions with the adjacent river and lake swamps through connection of the channel 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 fishes migrate from the main channel to the inundated areas for spawning and feeding. These migrations are more lateral, perpendicular to river flow, than upriver or downriver (Guillory 1979). As the river continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of floodplain forest are inundated (Light et al. 1998).

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


Figure 17. Transitional zone (stations 700–766) at Dexter Point East transect

The locally determined minimum frequent high level results in inundation of all marsh communities traversed by the four LWNWR transects with water depths between 0.3 and 1.2 ft. Additionally, water depths within the maple and willow swamps traversed at the Dexter Point South transect and the North Shore of Lake Woodruff transect would range between 0.4 and 0.8 ft at the locally determined minimum frequent high level.

The locally determined minimum frequent high level (1.7 ft NGVD) is below the elevations traversed within the palm hydric hammocks at Dexter Point and Tick Island. The Dexter Point East transect lower palm hydric hammock community (mean elevation 2.53 ft NGVD) and the Tick Island transect palm hydric hammock community (mean elevation 2.47 ft NGVD) have low species diversity, reside on seepage slopes, and resemble the hydric hammocks described by Vince et al. (1989) with long dry periods interrupted by occasional episodes of flooding, perhaps only once per decade (e.g., hurricane-induced flooding). As mentioned previously, Vince et al. (1989) suggest that complex interacting factors influence the species composition of hydric hammocks and distinguish this type from other communities. They propose that the geographical location, the hydrological regime, edaphic conditions, and fire frequency and intensity are the major determinants of the structure of hydric hammocks. According to model simulations, surface water levels have exceeded the Dexter Point East transect lower palm hydric hammock and the Tick Island palm hydric hammock average elevations approximately 4% of the time (Figure 9) (Robison 2003).

### Minimum Average Level at the Lake Woodruff National Wildlife Refuge (0.7 ft NGVD)

The locally determined minimum average level for the St. Johns River at the LWNWR is 0.7 ft NGVD, with a hydroperiod category of typically saturated. The typically saturated hydroperiod category corresponds to a water level that may re-occur approximately every year or two for about 6 months during the dry season. The minimum average level and hydroperiod category approximates a typical level that is slightly less than the long-term median water level while still protecting the wetland resource. Modeling results (Robison 2003) support the locally determined minimum average level and hydroperiod category of typically saturated at the LWNWR, indicating that a river level equal to 0.7 ft NGVD will not occur more often than once every 1.5 years for 120 days. The locally determined minimum average level equals the 57% exceedance value from the stage-duration curve simulated for the LWNWR (Figure 9) (Robison 2003). The locally determined minimum average level was calculated by subtracting 0.25 ft from the average surface elevation of all locations sampled within the LWNWR where a histic epipedon (organic surface layer $\geq$8 inches in depth) was observed (n=116) (Table 34).

An appropriate average water level is necessary to conserve the hydric nature and ecological functions of the floodplain histosols (organic hydric soils). Low water levels for extended periods result in the oxidation of organic soils, ultimately resulting in soil subsidence. This criterion (0.25 ft below average surface elevation of organic soils) has been used to protect muck soils in other MFL determinations and was developed from data collected from Everglades peat soils (Stephens 1974). Studies of marshes in the Upper St. Johns River Basin (Brooks and Lowe 1984; Hall 1987) determined that this –0.25-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 the average every 1–2 years with a duration of less than or equal to 180 days (Hupalo et al. 1994).

Table 34. Locations within Lake Woodruff National Wildlife Refuge with a histic epipedon or histosol

| Transect | Stations | Average Surface Elevation of Organic Soil (ft NGVD) | Vegetation Community |
|---|---|---|---|
| Tick Island | 0–360 | 1.28 | *Spartina* marsh and lower elevations of palm hydric hammock (Figure 13) |
| North Shore Lake Woodruff | 0–500 | 1.00 | Maple swamp, shrub swamp, sawgrass-willow marsh (Figure 14) |
| Dexter Point East | 1000–1260 | 0.83 | *Spartina* marsh, sawgrass marsh (Figure 15) |
| Dexter Point South | 400–1440 | 0.95 | *Spartina* marsh, *Sagittaria* slough, sawgrass marsh, willow swamp, maple swamp (Figure 16) |

Note: ft NGVD = feet National Geodetic Vertical Datum

Additional criteria examined when determining the LWNWR minimum average level included the mineral soil water table levels provided by the minimum average level within the Scoggin sand observed at the Dexter Point East transect and the Sanibel and Pompano sands observed at the Tick Island transect. The locally determined minimum average level will maintain hydric conditions for these mineral soils. Table 35 summarizes the resulting mineral soil water table information and illustrates that the locally determined minimum average level for the LWNWR will result in a mineral soil water table level similar to NRCS (2001) typical, dry season water table levels. Additional mineral soils sampled at these transects were excluded due to the narrow extent of occurrence.

Table 35. Lake Woodruff National Wildlife Refuge mineral soil water table depths at minimum average level

| Soil Name | Water Table Depth at Minimum Average Level | NRCS Typical Dry Season Water Table Depth | Vegetation Community Location |
|---|---|---|---|
| Pompano sand | 27 inches | Within 30 inches for >9 months of the year | Hydric palm hammock at Tick Island transect |
| Sanibel sand | 17 inches | <10 inches for 6–12 months in most years | Hydric palm hammock at Tick Island transect |
| Scoggin sand | 22 inches | May drop to >24 inches in the winter | Upper and lower hydric palm hammock and shrub transitional zone at Dexter Point East transect |

Note: NRCS = Natural Resources Conservation Service

As mentioned previously, wetland community structure results from sequential colonization (high water) and extirpations (low water). A drying wetland, however, does not necessarily result in fish mortality. Fish that do not seek refuge in the main river channel and cannot resist direct desiccation may still survive drying wetlands by escaping to small aquatic refugia (Messina and Conner 1998). Fish may survive in puddles (depth <2.4 in.), as do some invertebrates. Crayfish burrows are abundant in bottomland hardwoods (Lambou 1990), providing refugia for many small fish. Crayfish burrows were observed in the LWNWR within the maple swamp traversed at the Lake Woodruff North Shore transect (stations 0–90), within the palm hydric hammocks (stations 80–700) traversed at the Dexter Point East transect, and within the *Sagittaria* slough (stations 427–480) traversed at the Dexter Point South transect. Bluefin killifish, pirate perch, pygmy sunfish, tadpole madtoms, and possibly mosquitofish occupy crayfish burrows when floodplains and shallow ponds in south Georgia dry for 3–4 months (Neill 1951). The crayfish burrows lead down to the water table, sometimes opening into a complex network of horizontal passages (Creaser 1931; Neill 1951). These fish species also inhabit the St. Johns River (FWC 2001).

At the locally determined minimum average level, shallow pools (water depth <2.3 in.) will exist within the *Spartina* and sawgrass marshes and *Sagittaria* slough traversed at Dexter Point, providing aquatic habitat refugia for numerous small fish, amphibians, and small reptiles. These pools will also concentrate the wading bird prey. Birds effectively exploit these concentrations. 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 less than 6 in. (Bancroft et al. 1990).

### Minimum Frequent Low Level at the Lake Woodruff National Wildlife Refuge (0.2 ft NGVD)

The locally determined minimum frequent low level for the St. Johns River at the LWNWR is 0.2 ft NGVD, with an associated hydroperiod category of semipermanently flooded. This minimum low level typically occurs every 5–10 years for several months during moderate droughts. Modeling results (Robison 2003) support the locally determined minimum frequent low level and hydroperiod category of semipermanently flooded at the LWNWR, indicating that the river is at or below 0.2 ft NGVD for 30 continuous days on average once every 5 years. The locally determined minimum frequent low level equals the 89% exceedance value from the simulated stage-duration curve for the LWNWR (Figure 9) (Robison 2003).

The locally determined minimum frequent low level was calculated by subtracting 10 in. (0.83 ft) from the average surface elevation (1.00 ft NGVD) of all locations sampled within the LWNWR where a histic epipedon (organic surface layer ≥8 inches in depth) was observed (n=116) (Table 34). Typically, where organic soils occur, the minimum frequent low level is based upon a soil water table drawdown of approximately 20 in. (1.7 ft). This 20-in. soil water table drawdown criterion was based upon the following literature:

- *South Florida Water Management District wetland hydroperiods study task 2 report (literature review and analysis)*, ESE, July 17, 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 ±13.5 cm (20.9 in.; 15.6–26.2 in.)
- *Soil Survey of Volusia County, Florida*, SCS, 1980. "In Gator muck the water table is at or above the soil surface in spring, summer, and fall and is within 10 inches of the soil surface in winter. In Terra Ceia muck the water table is as much as 2 feet 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 inches except during extended dry periods."
- *Soil Survey of Brevard County, Florida*, SCS, 1974. "In Tomoka muck, the soil water table is within a depth of 10 inches for 9 to 12 months in most years, and water is frequently above the surface. In dry periods it is between 10 and 30 inches. In Montverde peat the water table is within a depth of 10 inches 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 inches. In Canova peat the soil water table in most years is within a depth of 10 inches for 9 to 12 months and many areas are continuously flooded for 3 to 6 months. In dry seasons the water table is below a depth of 10 inches for short periods."

Similar to the Pine Island transect, the organic soils surveyed within the LWNWR occur too close to sea level (average surface elevation equaled 1.0 ft NGVD) to allow for a 20-in. drawdown. Additionally, the soil water table within the organic soils (Gator and Terra Ceia muck) observed in the LWNWR is described in NRCS 2001 as saturated with water that is always at or above the soil surface except during extended droughts, with no drawdown quantified. Consequently, a 10-in. soil water table drawdown criterion applied to the mean surface elevation of all the organic soils sampled in the LWNWR was deemed reasonable, based upon the best available supporting information from the literature and the extremely low surface elevation of these wetland communities.

Additional criteria examined when determining the LWNWR minimum frequent low level included the resulting mineral soil water table drawdown of 24 in. at the average elevation of the Sanibel sand and a 33-in. soil water table drawdown at the average elevation of the Pompano fine sand surveyed at the Tick Island transect. Typically, the dry season soil water table drawdown for Sanibel sand is less than 10 in. for 6–12 months during most years. Pompano fine sand soil water table is within depths of 30 in. for more than 9 months during the drier months each year (NRCS 2001). At the locally determined minimum frequent low level, the Scoggin soil average water table drawdown would equal 28 in. at the Dexter Point East transect. According to the Volusia County Soil Survey (SCS 1980), in the winter dry season, the Scoggin soil water table may drop to 24 in. or more. The mineral soil water table drawdowns resulting from the locally determined minimum frequent low level are slightly greater than the dry season water table levels cited by NRCS (2001) and SCS (1980). However, these soil water table drawdown levels are considered reasonable for a 1-in-5-year drought event.

## MFLs for the St. Johns River at SR 44 Near DeLand

### MFLs Analysis Summary

The minimum levels recommended for the St. Johns River at SR 44 near DeLand are based upon a significant field effort (14,465 ft of transects) in pristine wetland communities, combined with an intensive surface water modeling effort (Robison 2003). Eight field transects were located in four unique localities upstream and downstream from the SR 44 bridge over the St. Johns River, in order to ensure the protection of the aquatic ecosystems over a 30-mile river reach from the lower Wekiva River through the LWNWR.

After deriving the four sets of local levels, each set of levels was transferred to the SR 44 bridge over the St. Johns River near DeLand using hydraulic modeling techniques (Robison 2003). The four sets of minimum levels that were transferred to SR 44 were then averaged, resulting in the final set of minimum levels for the St. Johns River at SR 44 near DeLand (Table 36).

Table 36. Minimum levels transferred to the St. Johns River at the State Road 44 bridge near DeLand

| Location | Locally Determined Levels (ft NGVD) | | | Locally Determined Levels Transferred to SR 44 (ft NGVD) | | |
|---|---|---|---|---|---|---|
| | FH | MA | FL | FH at SR 44 | MA at SR 44 | FL at SR 44 |
| Lower Wekiva River | 2.8 | 1.2 | 0.6 | 2.0 | 0.9 | 0.4 |
| North Emanuel Bend | 2.5 | 1.1 | 0.6 | 1.9 | 0.8 | 0.4 |
| Pine Island | 2.1 | 0.9 | 0.4 | 1.7 | 0.7 | 0.3 |
| Lake Woodruff National Wildlife Refuge | 1.7 | 0.7 | 0.2 | 2.0 | 0.8 | 0.3 |
| SJR near DeLand (mean of levels transferred to SR 44) | | | | 1.9 | 0.8 | 0.3 |

Note: FH = frequent high
FL = frequent low
ft NGVD = feet National Geodetic Vertical Datum
MA = minimum average
SJR = St. Johns River
SR = state road

## Minimum Levels at SR 44

Table 37 lists the recommended minimum levels for the St. Johns River at SR 44 near DeLand along with an associated flow, duration, return interval, and hydroperiod category for each level.

Table 37. Recommended minimum surface water flows and levels for the St. Johns River at State Road 44 near DeLand, Volusia County

| Minimum Level* | Elevation (ft NGVD 1929 datum) | St. Johns River Flow at SR 44 (cfs) | Duration (days) | Return Interval (years) | Hydroperiod Category |
|---|---|---|---|---|---|
| Minimum frequent high level | 1.9 | 4,600 | ≥30 | ≤3 | Seasonally flooded |
| Minimum average level | 0.8 | 2,050 | ≤180 | ≥1.5 | Typically saturated |
| Minimum frequent low level | 0.3 | 1,100 | ≤120 | ≥5 | Semipermanently flooded |

Note: cfs = cubic feet per second
ft NGVD = feet National Geodetic Vertical Datum
SR = state road

*Levels adopted by the St. Johns River Water Management District Governing Board in November 2003.

The minimum levels determined at the four locations were transferred to the St. Johns River at SR 44 near DeLand for the following reasons:

- Future water level monitoring is facilitated due to an existing water level recorder.
- Averaging the transferred levels may even out modeling and field data collection errors, while eliminating confusion by recommending one final set of levels.
- Locating field transects near SR 44 was not feasible due to land developments (marinas, campground, county park, high voltage power line right-of-way, and dwelling units) near SR 44 along the river. Additionally, the Ocala National Forest property located immediately north of SR 44 is a designated Wilderness Area, prohibiting the installation of survey benchmarks.
- SR 44 is a location included in the surface water model (Robison 2003).
- A long-term stage record exists at the SR 44 bridge.

The locally determined levels were transferred to SR 44 based on results from the backwater model (HEC-RAS) (Robison 2003). River stages were transferred to upstream and downstream locations using a straight-line interpolation between the stage at the outlet of Lake Monroe and the stage at DeLand. The same water surface slope was used to extrapolate stages downstream to Lake Dexter and the LWNWR (Figure H. III-3, Robison 2003). Further details regarding how stages/levels were transferred to SR 44 can be found in Robison (2003; in particular, the chapter “Hydraulic model of the middle St. Johns River (HEC-RAS)”).

## Minimum Flows at SR 44

In many rivers, a given flow is paired for practical purposes with a unique stage. However, the St. Johns River flows near DeLand are dependent on both stage and water surface slope (Robison 2003). A given water level for the St. Johns River at SR 44 near DeLand does not correspond to a unique flow. Figures 18 and 19 illustrate this point. A stage of 3.0 ft NGVD for the St. Johns River at Lake Monroe might correspond to a discharge of anywhere between 500 and 4,000 cubic feet per second (cfs) (Figure 18). A stage of 2.0 ft NGVD for the St. Johns River at SR 44 might correspond to a discharge of anywhere between 2,000 and 5,000 cfs (Figure 19).

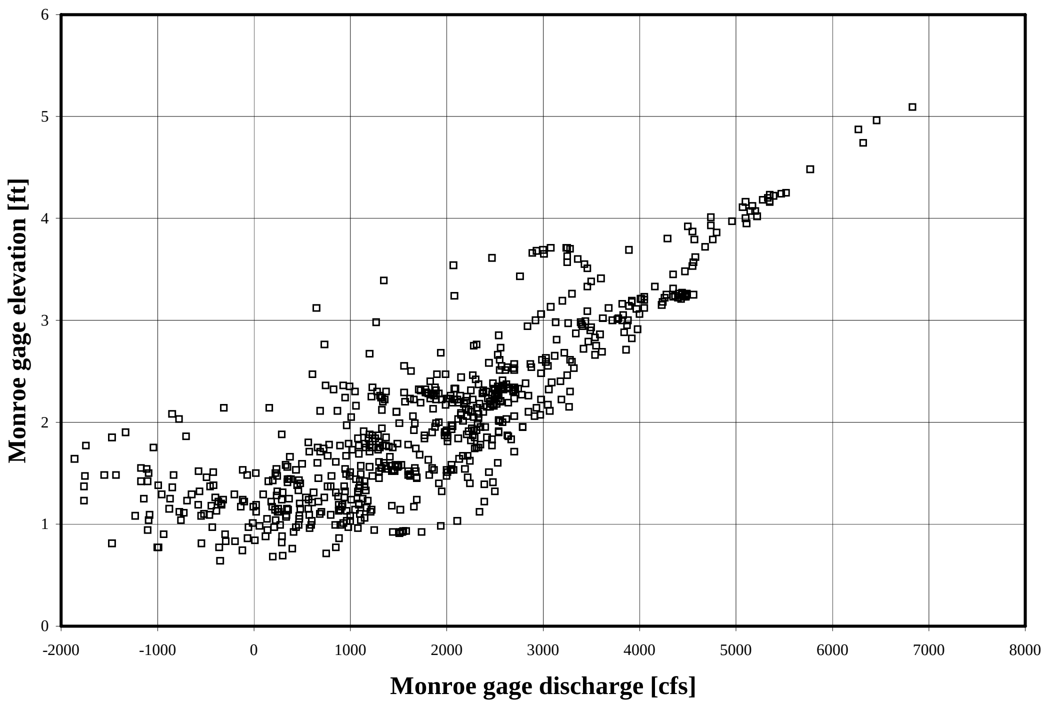



Figure 18. St. Johns River at Lake Monroe stage-discharge curve

However, flows are subject to the same statistical analyses as levels. Thus, each of the minimum levels is associated with a duration, a return period, and whether that particular level corresponds to an average condition or whether a given ground elevation should remain continuously wet or continuously dry. If flows of similar statistical characteristics can be assumed to be associated with each of the levels, then minimum flows can be determined.

Pairing of levels and flows of similar statistical characteristics (Robison 2003) determined a minimum flow for each of the final three levels for the St. Johns River at SR 44 near DeLand. The flow for the minimum frequent high was set at 4,600 cfs, the flow for the minimum average was set at 2,050 cfs, and the flow for the minimum frequent low was set at 1,100 cfs (Robison 2003).

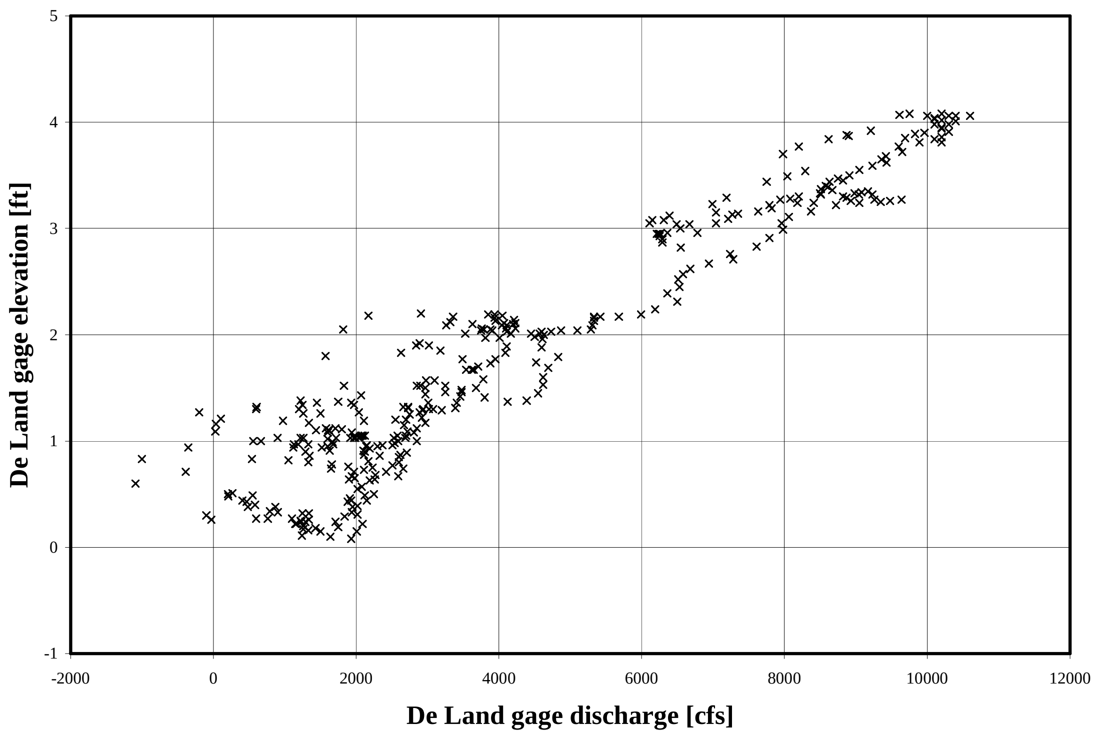



Figure 19. St. Johns River at State Road 44 stage-discharge curve

## Durations, Return Intervals, and Hydroperiod Categories at SR 44

| Minimum Frequent High MFLs at SR 44 Durations and Return Intervals | |
|---|---|
| Duration | Return Interval |
| 21 days | 1:2 years |
| 30 days | 1:2.13 years |
| 50 days | 1:3 years |

Each of the recommended minimum flows and levels is associated with a duration, a return interval, and a hydroperiod category (Table 37). Modeling results indicate that the recommended minimum frequent high flow and level for the St. Johns River at SR 44 near DeLand will occur for a duration of 21 continuous days (several weeks) with a return interval of once in every 2 years. The recommended minimum frequent high flow and level hydroperiod category is “seasonally flooded.” Seasonally flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, river levels causing inundation are expected to occur several weeks to several months every 1–2 years.

Due to inconsistent language within the Chapter 40C-8, *F.A.C.*, definition of seasonally flooded regarding the duration (stated as “30 days or more” and also as “several weeks to several months”), additional modeling results are presented here. These results indicate that the minimum frequent high level at SR 44 will occur for a duration of 30 continuous days every 1 in 2.13 years, and a duration of 50 continuous days is expected to occur once in every 3 years.

Modeling results indicate that the recommended minimum average flow and level for the St. Johns River at SR 44 near DeLand will occur for a duration no longer than 180 continuous days with a return interval no more frequent than once every 1.5 years (Table 37). The recommended minimum average flow and level hydroperiod category is “typically saturated.” Typically saturated is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where, for extended periods of the year, the water level should saturate or inundate. This results in saturated substrates for periods of one-half year or more during non-flooding periods of typical years. This recommended minimum average flow and level is expected to have a recurrence interval on the average of 1–2 years over a long-term period of record. Obligate wetland plant species are expected to predominate near this water level.

Modeling results indicate that the recommended minimum frequent low flow and level for the St. Johns River at SR 44 near DeLand will occur for a duration no longer than 120 continuous days with a return interval no more frequent than once every 5 years (Table 37). The recommended minimum frequent low flow and level hydroperiod category is “semipermanently flooded.” Semipermanently flooded is defined in Chapter 40C-8, *F.A.C.*, as a hydroperiod category where surface water inundation persists in most years. When surface water is absent, the water table is usually near the land surface. Exposure of these ground elevations is expected to re-occur, on average, about every 5–10 years for extended periods (several or more months) during moderate droughts.

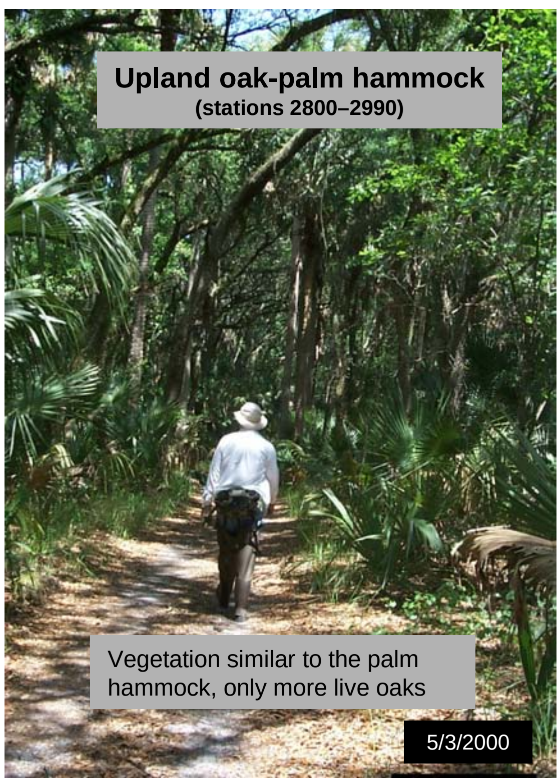

**Hydric hammock**
**(stations 10–230)**


Dominant overstory vegetation: water hickory and pop ash
Dominant understory vegetation: vervain, swamp dock, lizard’s tail, savannah panicum


Hardwood swamp
(stations 4–720)
Dominant vegetation:
bald cypress, pop ash,
red maple, wild taro,
savannah panicum
5/3/2000
5/3/2000 11:50
Shrub swamp
(stations 720–1550)
Dominant vegetation: red maple,
willow, pop ash, sand cordgrass
5/3/2000 11:41
Maple swamp
(stations 1550–1960)
Dominant vegetation: red
maple with scattered wax
myrtle
5/3/2000 11:39


Oak hydric hammock
(stations 1960–2380)
Dominant vegetation: laurel oak and wax myrtle
5/3/2000 11:35


Palm hydric hammock
(stations 2380–2800)
Dominant vegetation: cabbage palm with numerous laurel oak and live oak
5/3/2000 11:33

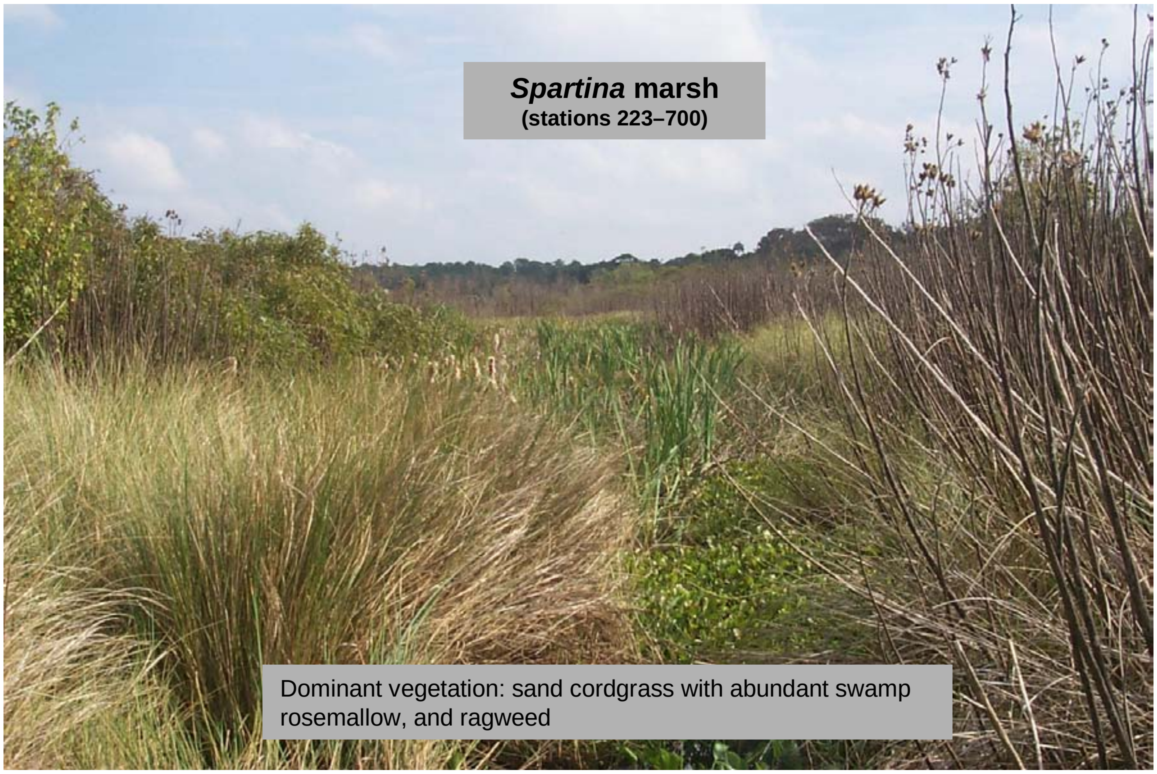

Upland oak-palm hammock
(stations 2800–2990)
Vegetation similar to the palm hammock, only more live oaks
5/3/2000


**Hardwood swamp 1** **(stations 230–630)**


Dominant overstory vegetation: pop ash
Dominant understory vegetation: vervain, wood sage, southern cutgrass

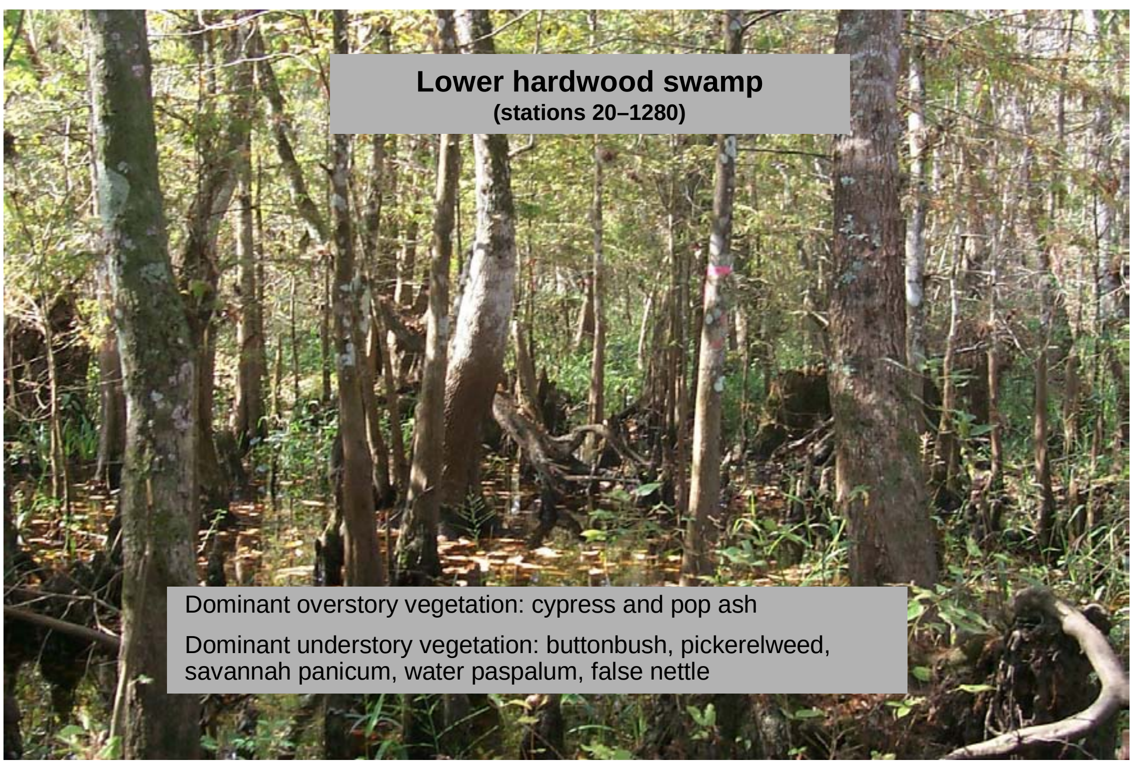

Shrub swamp 1
(stations 630–880)
Dominant vegetation: buttonbush, climbing aster, willow, *Thalia*
6/27/2000


Hardwood swamp 2
(stations 880–1080)
Dominant overstory vegetation: pop ash and bald cypress
Dominant understory vegetation: vervain, wood sage, southern cutgrass
6/27/2000


*Spartina* marsh
(stations 223–700)
Dominant vegetation: sand cordgrass with abundant swamp rosemallow, and ragweed


Hardwood swamp
(stations 750–1120)
Dominant vegetation: cypress, pop ash, American elm, cabbage palm, and red maple
8/23/2000

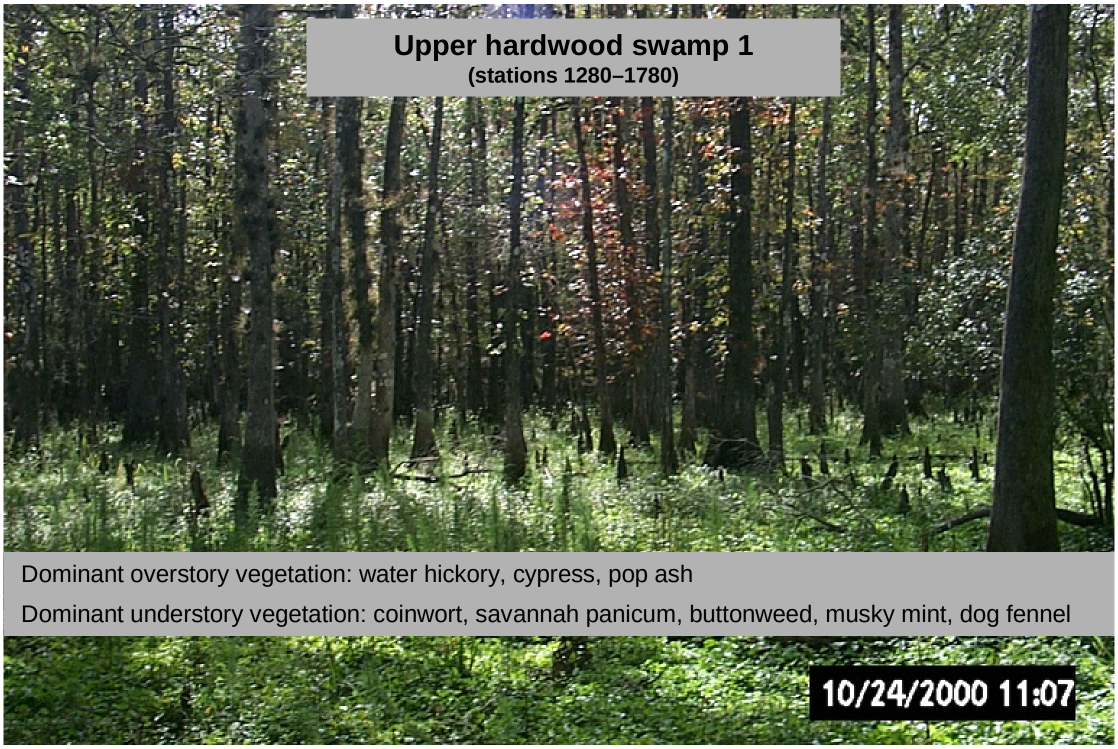
**Lower Wekiva River near the start of transect**



**Lower hardwood swamp**
**(stations 20–1280)**

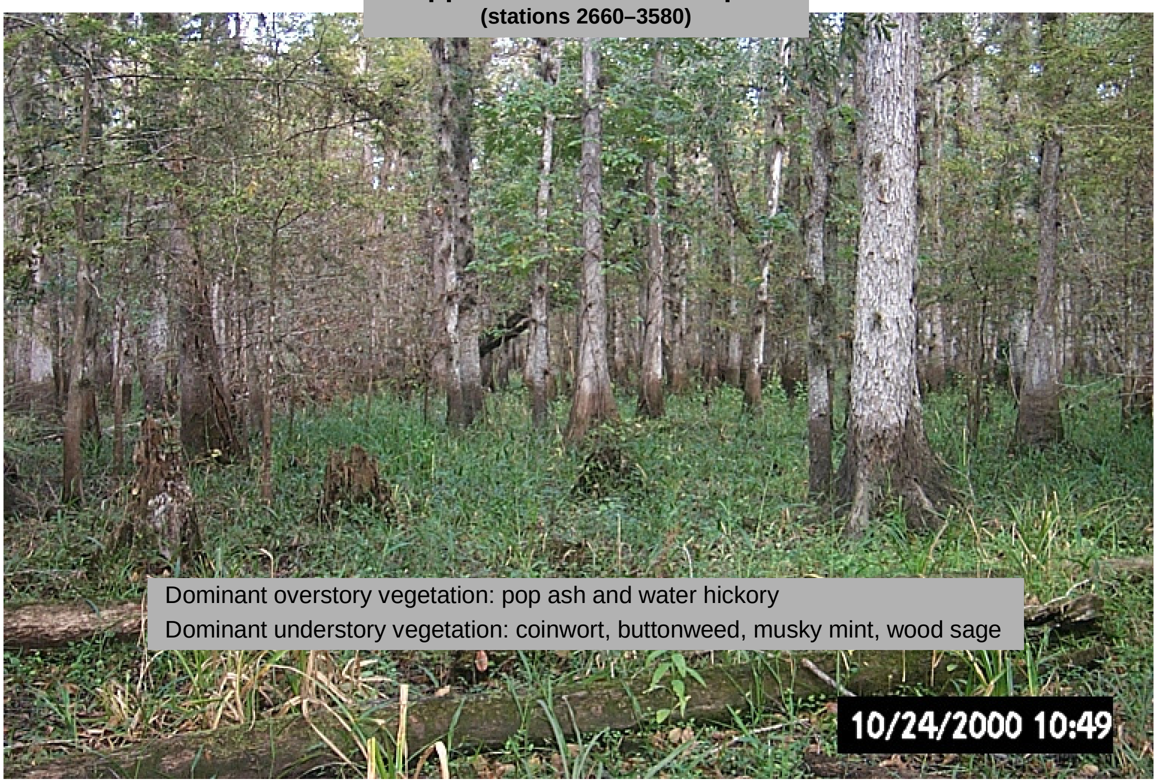
Dominant overstory vegetation: cypress and pop ash

Dominant understory vegetation: buttonbush, pickerelweed, savannah panicum, water paspalum, false nettle

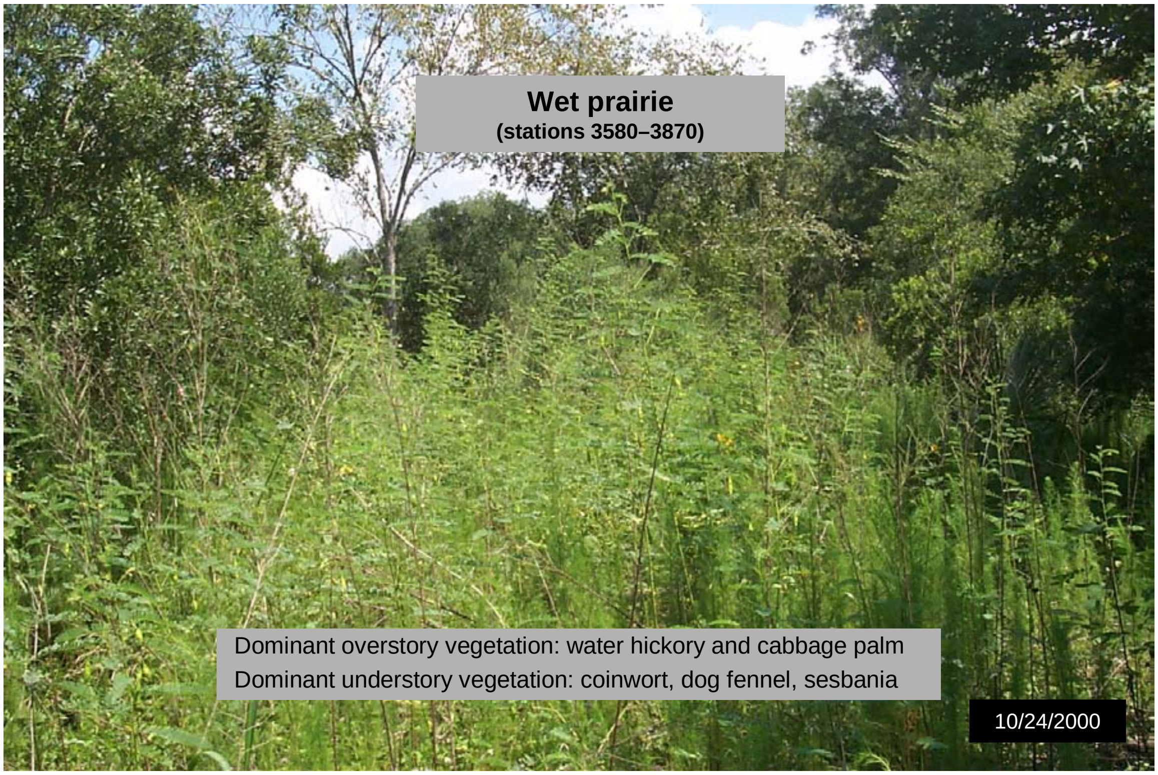

Upper hardwood swamp 1
(stations 1280–1780)
Dominant overstory vegetation: water hickory, cypress, pop ash
Dominant understory vegetation: coinwort, savannah panicum, buttonweed, musky mint, dog fennel
10/24/2000 11:07


Hydric hammock
(stations 1780–2660)
Dominant overstory vegetation: water hickory, cabbage palm, sweetgum
Dominant understory vegetation: wax myrtle, cabbage palm, coinwort
10/24/2000 11:01


**Upper hardwood swamp 2**
**(stations 2660–3580)**




Dominant overstory vegetation: pop ash and water hickory
Dominant understory vegetation: coinwort, buttonweed, musky mint, wood sage


Wet prairie
(stations 3580–3870)
Dominant overstory vegetation: water hickory and cabbage palm
Dominant understory vegetation: coinwort, dog fennel, sesbania
10/24/2000


Palm hydric hammock
(stations 3870–4260)
Dominant vegetation: cabbage palm with scattered slash pine
10/24/2000 10:30


Oak-palm hammock
(stations 4260–5040)
Dominant overstory vegetation: cabbage palm with sand live oak and scattered slash pine
Dominant understory vegetation: cabbage palm and saw palmetto
10/24/2000

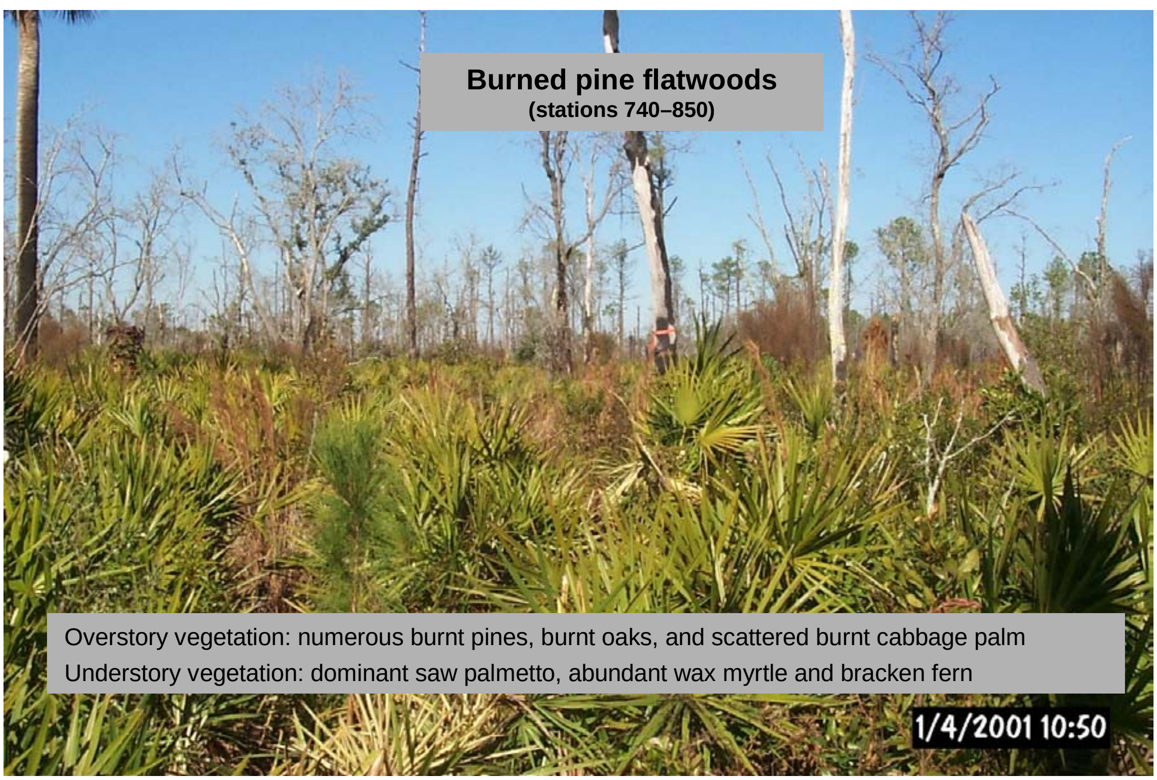

***Spartina*** **marsh at Tick Island transect**
**(stations 0–320)**

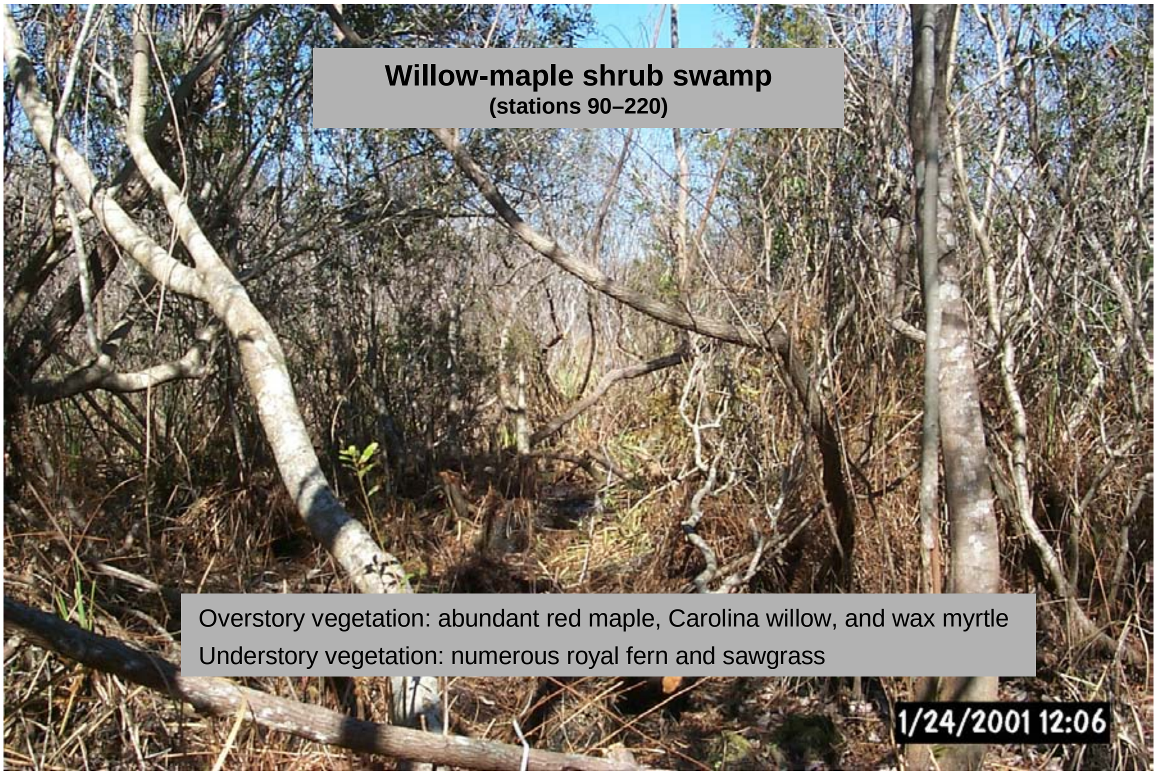

Dominant vegetation: sand cordgrass and abundant seashore mallow


**Palm hydric hammock**
**(stations 320–620)**


Dominant overstory vegetation: cabbage palm
Dominant understory vegetation: swamp fern


Transitional zone
(stations 620–740)
Overstory vegetation: abundant burnt cabbage palm, scattered burnt oaks
Understory vegetation: abundant dog fennel and bracken fern
1/4/2001 10:48


Burned pine flatwoods
(stations 740–850)
Overstory vegetation: numerous burnt pines, burnt oaks, and scattered burnt cabbage palm
Understory vegetation: dominant saw palmetto, abundant wax myrtle and bracken fern
1/4/2001 10:50


Willow-maple shrub swamp
(stations 90–220)
Overstory vegetation: abundant red maple, Carolina willow, and wax myrtle
Understory vegetation: numerous royal fern and sawgrass
1/24/2001 12:06


Sawgrass-willow marsh
(stations 220–500)
Dominant vegetation: sawgrass, with numerous to co-dominant Carolina willow and numerous wax myrtle
1/24/2001 12:10

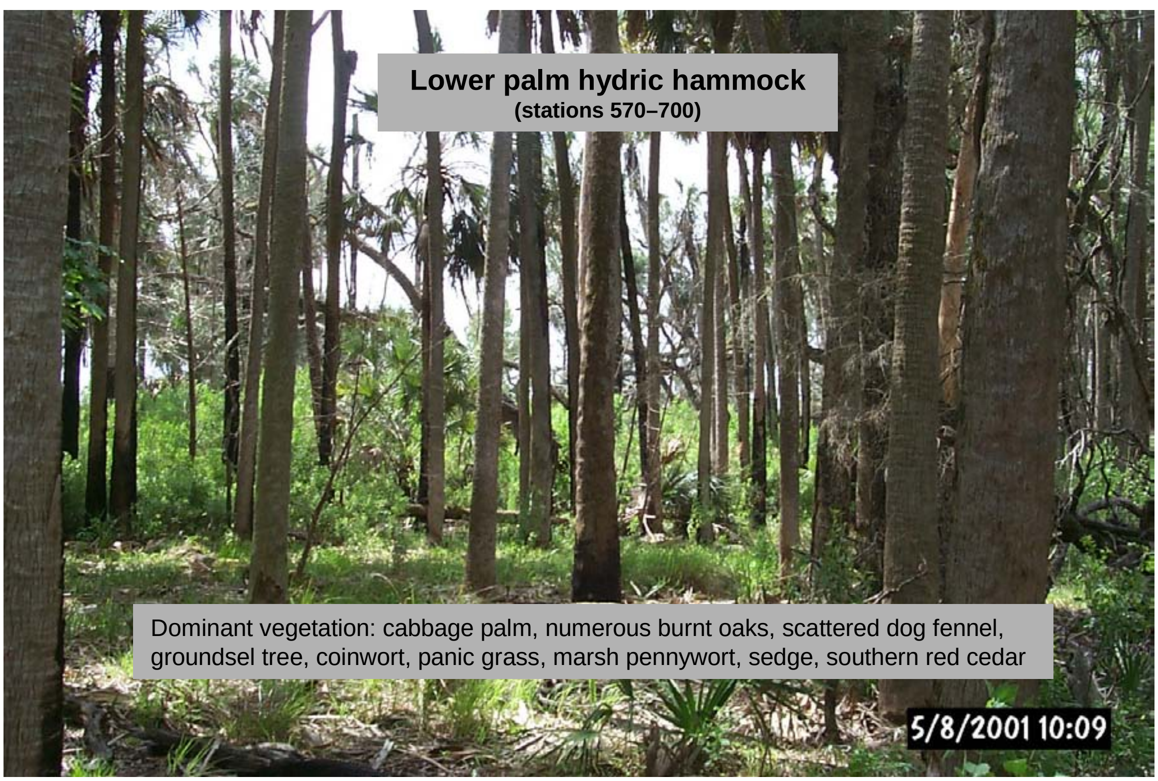

**Flatwoods-hydric hammock transitional zone**
**(stations 0–80)**

Co-dominant vegetation: cabbage palm, abundant burnt pines, wax myrtle, numerous saw palmetto, and bracken fern


**Upper palm hydric hammock**
**(stations 80–570)**

Co-dominant vegetation: cabbage palm with abundant burnt pines and wax myrtle


Upper palm hydric hammock
(stations 80–570)
Yellow canna lily
5/8/2001 09:37


Lower palm hydric hammock
(stations 570–700)
Dominant vegetation: cabbage palm, numerous burnt oaks, scattered dog fennel, groundsel tree, coinwort, panic grass, marsh pennywort, sedge, southern red cedar
5/8/2001 10:09


Shrub transitional zone
(stations 700–766)
Vegetation: abundant sand cordgrass, wax myrtle with scattered coinwort, immature cabbage palm, and marsh pennywort
5/8/2001 10:44


*Spartina* marsh
(stations 766–1073)
Vegetation: sand cordgrass dominant with scattered swamp hibiscus, bull arrowhead, Carolina willow, and cattail
5/8/2001 11:47


Sawgrass marsh
(stations 1073–1260)
Vegetation: sawgrass dominant, willow scattered
5/8/2001 12:29


Sawgrass marsh
(stations 480–860)
Dominant vegetation: sawgrass with scattered to numerous willow saplings
5/8/2001 13:52


Sawgrass-willow marsh
(stations 860–1300)
Co-dominant vegetation: sawgrass with abundant to co-dominant willow
5/8/2001 14:08


Willow swamp
(stations 1300–1340)
Co-dominant vegetation: Carolina willow with numerous red maple
5/8/2001 14:10


Maple swamp
(stations 1340–1440)
Abundant vegetation: red maple with numerous Carolina willow
5/8/2001 14:11


Transect end—Lake Dexter
(station 1440)
5/8/2001 14:13

# SUMMARY AND RECOMMENDATIONS

## SUMMARY

The MFLs recommended for the St. Johns River at SR 44 near DeLand were derived through a multitude of information gathering tasks and subsequent analyses. Use of the best available information from the scientific literature, numerous ecological maps, personal communications with on-site public land managers, analyses of many years of river stage data, and intensive surface water modeling (Robison 2003), combined with an extensive field data collection effort, resulted in the final recommended MFLs.

One factor illustrating the strength of the minimum levels field data collected near DeLand and the surface water modeling results includes a comparison of the stage exceedance values predicted to occur within similar vegetation communities at different transect localities. For example, the St. Johns River stage is predicted to exceed the average elevation of the shrub swamp communities at Pine Island and North Emanuel Bend approximately 52% and 50% of the time, respectively. Water levels are predicted to exceed the average elevation of the hardwood swamp at Pine Island, North Emanuel Bend transect 1, and the lower hardwood swamp on the lower Wekiva River transect approximately 38%, 33%, and 40% of the time, respectively. The strong similarities of the stage exceedance values for a given vegetative community at different locations illustrates the accuracy of field sampling at different locations and lends credence to the surface water modeling results. Table 38 lists additional stage exceedance values comparisons.

Additionally, Table 36 illustrates the strong similarities among the sets of transferred levels. For example, the four minimum average levels transferred to the St. Johns River at SR 44 equaled 0.9 (lower Wekiva River), 0.8 (North Emanuel Bend), 0.8 (the LWNWR), and 0.7 (Pine Island) ft NGVD. The similarity among these transferred minimum average levels is expected when similar criteria are used to determine the local minimum average level, and the surface water modeling is realistic. Identical criteria were used to determine the minimum average level at Pine Island and at the LWNWR with very similar criteria used at North Emanuel Bend. The primary minimum average level criteria used for the lower Wekiva River was different due to the lack of a shallow marsh community and the lack of deep organic soils at the lower Wekiva River transect. The criteria used to determine each local level are summarized in Table 7.

Table 38. Stage exceedance at vegetation communities, based on average elevation

| Vegetation Community Location | Stage Exceedance at Community Average Elevation (% of time) |
|---|---|
| Shrub swamp—Pine Island | 52 |
| Shrub swamp—North Emanuel Bend 1 | 50 |
| Hardwood swamp—Pine Island | 38 |
| Hardwood swamp—North Emanuel Bend 1 | 33 |
| Lower hardwood swamp—Lower Wekiva River | 40 |
| Hydric hammock—Lower Wekiva River | 10 |
| Hydric hammock—North Emanuel Bend 1 | 12 |
| Sawgrass-willow—North shore Lake Woodruff | 41 |
| Sawgrass-willow—Dexter Point South | 40 |
| Maple swamp—North Shore Lake Woodruff | 32 |
| Maple swamp—Dexter Point South | 39 |
| Transitional shrub—North Emanuel Bend 2 | 17 |
| Transitional shrub—Dexter Point East | 13 |
| Palm hydric hammock—Lower Wekiva River | 1 |
| Palm hydric hammock—North Emanuel Bend 2 | 2 |
| Palm hydric hammock—Pine Island | 1 |
| Palm hydric hammock—Dexter Point East | 4 |
| Palm hydric hammock—Tick Island | 5 |
| Sawgrass marsh—Dexter Point East | 44 |
| Sawgrass marsh—Dexter Point South | 40 |
| *Spartina* marsh—Dexter Point East | 46 |
| *Spartina* marsh—Dexter Point South | 46 |

The intent of the establishment of MFLs for the St. Johns River at SR 44 near DeLand is to protect the aquatic ecosystems along the St. Johns River near DeLand and along the lower Wekiva River from significant ecological harm caused by consumptive uses of water. These MFLs provide SJRWMD with a monitoring tool. Periodic reassessment of these MFLs is anticipated in order to ensure that these recommended MFLs are maintained and that they do prevent significant ecological harm. This section concludes with a discussion of the ecological protection provided by the minimum levels for the St. Johns River at SR 44 near DeLand and the proposed future ecological monitoring at the individual field transects.

## ECOLOGICAL PROTECTION FROM MINIMUM FLOWS AND LEVELS AT SR 44 NEAR DELAND

According to Section 62-40.473, *F.A.C.*, MFLs should be evaluated to ensure the protection of the following natural resources and environmental values:

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

Environmental Consulting and Technology (ECT) was contracted by SJRWMD to conduct an environmental assessment and to determine whether the recommended MFLs for the St. Johns River at SR 44 near DeLand protect these 10 natural resource and environmental values.

SJRWMD documents containing information about the hydrologic and ecological criteria used to develop the MFLs for the St. Johns River at SR 44 near DeLand were used by ECT, along with field reconnaissance and information in the scientific literature to evaluate whether these MFLs protect water and ecological resources (ECT 2003).

ECT (2003) determined that the MFLs for the St. Johns River at SR 44 near DeLand will protect the 10 natural resource and environmental values listed in Section 62-40.473, *F.A.C.* The results of this assessment are summarized in Table 39.

Table 39. Environmental assessment summary for the St. Johns River at State Road 44 near DeLand minimum flows and levels (MFLs) regime

| Resource or Value | MFL Protects the Resource From Significant Harm | | Certainty | | | Further Study/Monitoring | | |
|---|---|---|---|---|---|---|---|---|
| | Yes[1] | No[2] | High | Medium | Low | Necessary[3] | Recommended[4] | Not Needed[5] |
| a. Recreation in and on the water | X | | X | | | | | X |
| b. Fish and wildlife habitats and the passage of fish | X | | | X | | | X | |
| c. Estuarine resources | X | | | X | | | X | |
| d. Transfer of detrital material | X | | X | | | | | X |
| e. Maintenance of freshwater storage and supply | X | | X | | | | | X |
| f. Aesthetic and scenic attributes | X | | X | | | | | X |
| g. Filtration and absorption of nutrients and other pollutants | X | | X | | | | | X |
| h. Sediment loads | X | | | X | | | X | |
| i. Water quality | X | | | X | | | X | |
| j. Navigation | X | | X | | | | | X |

[1]Proposed MFLs allow for decline in water levels and flows, but the resource value should be protected.
[2]Proposed MFLs would allow water levels and flows to decline such that significant harm will occur.
[3]ECT recommends further study to support or verify.
[4]ECT recommends further study may be beneficial to ensure protection of the resource.
[5]ECT recommends no further study required.

Source: ECT 2003

Additionally, to ensure that the final three recommended levels for the St. Johns River at SR 44 near DeLand will provide appropriate water levels at the local field sites, the final three SR 44 levels (1.9, 0.8, and 0.3 ft NGVD) were transferred back to the local areas (Table 40). Because the four sets of local minimum levels were very similar when transferred to SR 44, it is not surprising that when the four values for a given level at SR 44 were averaged and the averaged value transferred back to the local area, the level transferred from SR 44 would be nearly equal to the originally determined local level. Table 40 illustrates the similarities among the original locally determined levels and the levels transferred from SR 44 to the local sites.

Table 40. Recommended minimum levels at State Road (SR) 44 and levels transferred back to local areas

| Location | SR 44 Levels Transferred Back to Local Areas (ft NGVD) | | | Original Locally Determined Levels (ft NGVD) | | |
|---|---|---|---|---|---|---|
| | FH | MA | FL | FH | MA | FL |
| Lower Wekiva River | 2.6 | 1.1 | 0.5 | 2.8 | 1.2 | 0.6 |
| North Emanuel Bend | 2.5 | 1.1 | 0.5 | 2.5 | 1.1 | 0.6 |
| Pine Island | 2.4 | 1.0 | 0.5 | 2.1 | 0.9 | 0.4 |
| Lake Woodruff National Wildlife Refuge | 1.6 | 0.7 | 0.2 | 1.7 | 0.7 | 0.2 |

Note: FH = frequent high
FL = frequent low
ft NGVD = feet National Geodetic Vertical Datum
MA = minimum average

## RECOMMENDATIONS

The intent of the recommended MFLs and hydroperiod categories for the St. Johns River at SR 44 near DeLand (Table 37) is to identify flows and levels necessary to prevent significant harm from occurring to the aquatic ecosystems along the St. Johns River near DeLand. Periodic reassessment of these MFLs, including ecological monitoring at the local transects, is planned in order to ensure that these MFLs are maintained and that they do prevent significant ecological harm.

## Future Ecological Monitoring

The St. Johns River at SR 44 near DeLand is a relatively pristine natural area of regional importance. Future ecological monitoring is planned at the local field transects established as part of the minimum levels determinations for the St. Johns River at SR 44 near DeLand. Shallow monitoring wells to record above and below groundwater levels were installed in 2003–2004 at two locations at the lower Wekiva River transect, two locations at the Pine Island transect, two locations at the Dexter Point South transect, and one location at the Tick Island transect. The shallow monitoring well data will enable SJRWMD to quantify the relationship between river water level and soil water table level at sites of varying distance from the river with both organic and mineral soils. Additionally, water quality data are being collected at two of these wells. These data (water temperature, conductivity, oxidation and reduction potential, dissolved oxygen, and pH) will be used to document the aquatic faunal habitat conditions in the floodplain backwater areas.

Surface water level recorders were installed in 2002 on the St. Johns River at High Banks (approximately 0.5 mile downstream from North Emanuel Bend) and on the lower Wekiva River at the transect site. Surface water level recorders with varying periods of record are located in Lake Woodruff National Wildlife Refuge and on the St. Johns River at SR 40, the St. Johns River at SR 44, the St. Johns River at Blue Spring (1.5 miles downstream from the Pine Island transect), and the St. Johns River at the U.S. Highway 17/92 bridge at Lake Monroe. Stage and flow data from these gages will be analyzed periodically to ensure that there is no unexpectedly great change in the hydrologic conditions.

Contractual studies examining the importance of river levels to the local fisheries in the St. Johns and Ocklawaha rivers are under way (Dale Jones, fisheries biologist, FWC, pers. com. 2002). Knowledge of riverine fish ecology in Florida is primarily based on fish sampling in permanent stream channels. Needed scientific study of floodplains as fisheries habitat is hampered by their hydrologic complexity and by practical and logistical problems in using conventional fish sampling techniques in seasonally inundated forests (Leitman et al. 1991).

The preceding field data collection, combined with the surface water modeling effort (Robison 2003), will provide the tools to evaluate whether the recommended MFLs for the St. Johns River at SR 44 near DeLand protect this aquatic ecosystem from significant harm due to consumptive use of water.

Additionally, the MFLs established for the St. Johns River at river mile 253.1 downstream of Lake Washington, and the anticipated establishment of MFLs for the St. Johns River at SR 50 and for Lake Monroe, will provide additional information to assist in the protection of the St. Johns River at SR 44 near DeLand.

MFLs for the St. Johns River at SR 44 near DeLand were adopted by the SJRWMD Governing Board in 2003 and listed in Chapter 40C-8.031, *F.A.C*, on November 10, 2003.

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# APPENDIX—SOIL DESCRIPTIONS

From: *Official Soil Series Descriptions* (NRCS Soil Survey Division, 2003, http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi)

## SOILS TYPES SURVEYED ALONG ALL TRANSECTS

| Soil Name | Transect |
|---|---|
| Basinger fine sand | North Emanuel Bend transect 2 |
| Chobee fine sandy loam | Pine Island, North Emanuel Bend transect 2, Lower Wekiva River |
| Delray series | Lower Wekiva River |
| Felda series | Pine Island |
| Floridana series | Lower Wekiva River |
| Gator muck | Pine Island, Tick Island |
| Holopaw sand | Tick Island |
| Immokalee sand | Dexter Point East |
| Nittaw series | North Emanuel Bend transect 1 |
| Paisley series | Pine Island, Tick Island |
| Placid sand | Lower Wekiva River |
| Pomona series | Dexter Point East |
| Pompano fine sand (non-hydric) | North Emanuel Bend transect 2, Tick Island |
| Riviera series | Dexter Point East, Dexter Point South |
| Sanibel sand | Tick Island |
| Scoggin series | Dexter Point East transect |
| Tequesta muck | Pine Island, Dexter Point East, Dexter Point South |
| Terra Ceia muck | Pine Island, Tick Island, North Shore Lake Woodruff, Dexter Point East and South |

**Basinger fine sand.** Basinger fine sand is poorly drained. It is typically found in sloughs and drainage ways. Basinger fine sand formed in sandy marine sediments. It has a water table at depths of less than 12 inches for 2 to 6 months annually and at depths of 12 to 30 inches for periods of more than 6 months in most years. Depressions are covered with standing water for periods of 6 to 9 months or more in most years. Areas in poorly defined drainage ways and floodplains are flooded for long periods.

**Chobee fine sandy loam**. Chobee fine sandy loam is a very poorly drained soil found in low places in coastal hammocks, in drainage ways, and on floodplains. This soil is covered with standing water for extended periods during the rainy season from June to November and after prolonged heavy rain in winter. The water table is within 6 inches of the soil surface for 1 to 4 months during most years and is seldom below 10 inches even during prolonged dry spells. Chobee fine sandy loam typically has a black mat 1 inch thick of decomposing plant parts and roots on the surface. The surface layer is black fine sandy loam about 6 inches thick. The subsoil is between depths of 6 and 54 inches.

**Delray series.** The Delray series consists of soils that are very poorly drained. These soils form in sandy and loamy marine sediment. These soils are in sloughs and on broad, low plains on the flatwoods. In most years, Delray soils have a seasonal high water table within 12 inches of the surface for 6 months or more. The surface layer of Delray soil remains wet for long periods after heavy rains.

**Felda series.** The Felda series consists of very deep, poorly drained and very poorly drained, moderately permeable soils in drainage ways, sloughs and depressions, and on floodplains and low flat areas. These soils formed in stratified, unconsolidated marine sands and clays. The water table is within 12 inches of the surface for 2 to 6 months each year. Depressions are ponded for more than 6 months each year. Areas on floodplains are flooded for brief–to-long duration.

**Floridana series.** The Floridana series consists of very deep, very poorly drained, slowly to very slowly permeable soils on low broad flats, floodplains, and in depressional areas. These soils formed in thick beds of sandy and loamy marine sediments. The water table within Floridana soil is typically at depths of less than 10 inches below the surface, and depressional areas are ponded for more than 6 months during most years. Floodplains are flooded for 2 to 3 months during most years.

**Gator muck.** The Gator series consists of very poorly drained organic soils that formed in moderately thick beds of hydrophytic plant remains overlying beds of loamy and sandy marine sediments. These soils are located in depressions and on floodplains. The thickness of the organic material ranges from 16 to 50 inches. Gator soils are saturated with water that is always at or above the soil surface except during extended droughts. Floodplains are flooded for a very long duration.

**Holopaw sand.** Holopaw sand consists of deep and very deep, poorly and very poorly drained soils formed in sandy marine sediments. These soils are on low-lying flats, in poorly defined drainages or depressional areas. The water table is within 12 inches of the soil surface for 2 to 6 months during most years. Depressional areas are ponded for more than 6 months during most years.

**Immokalee sand.** Immokalee sand consists of deep and very deep, poorly drained and very poorly drained soils that formed in sandy marine sediments. These soils occur in flatwoods and in depressions of peninsular Florida. The water table is at depths of 6 to 18 inches for 1 to 4 months during most years. It is between depths of 18 to 36 inches for 2 to 10 months during most years. It is below 60 inches during the dry periods of most years. Depressional areas are covered with standing water for periods of 6 to 9 months or more in most years.

**Nittaw series.** The Nittaw series consists of very poorly drained, slowly permeable soils that formed in thick deposits of clayey sediments of marine origin. These soils are in well defined drainage ways, broad, nearly level swamps, and marshes of central and southern peninsular Florida. They are subject to flooding and water standing above the soil surface for 6 to 8 months in most years during late spring, summer, and fall. The duration and extent of flooding are variable and are directly related to the frequency and intensity of rainfall. The Nittaw series includes Nittaw mucky fine sand, depressional; Nittaw muck; and Nittaw, Okeelanta, and Basinger soils, frequently flooded (SCS 1990b). The distinguishing characteristics between the Nittaw series soil types are the presence and depth of muck. Some pedons do not have a muck horizon.

**Paisley series.** The Paisley series consists of deep, poorly drained, slowly permeable soils that formed in clayey marine sediments influenced by underlying calcareous materials. The water table is at a depth of 10 inches or less for 2 to 6 months during most years. Water is on the surface of the soil for less than 1 month.

**Placid sand**. Placid sand consists of very deep, very poorly drained, rapidly permeable soils formed in sandy marine sediments on low flats, in depressions, and in poorly defined drainages on uplands, and on floodplains on the Lower Coastal Plain. The soil has formed under conditions of fluctuating but very shallow groundwater table in thick beds of marine sand. Internal drainage is impeded by a very shallow water table. Depth to the groundwater table is 0 to 6 inches for more than 2 months in most years. In depressional areas, the water table is above the soil surface for more than 6 months annually.

**Pomona sand.** Pomona sand consists of very deep, poorly and very poorly drained soils that formed in sandy and loamy marine sediments. Pomona soils are on low, broad, nearly level ridges within the flatwoods areas of the Lower Coastal Plain. Under natural conditions, the water table is within a depth of 6 to 18 inches for 1 to 3 months and is at a depth of 10 to 40 inches for 6 months or more during most years. Depressional areas are ponded for 6 to 9 months or more in most years.

**Pompano fine sand.** Pompano fine sand is a non-hydric, poorly drained sandy soil that formed in thick beds of marine sands. This soil occurs in depressions and drainage ways and broad low flat areas in the flatwoods. Typically, the surface layer is dark gray fine sand about 7 inches thick. The underlying material is fine sand to a depth of 80 inches or more. The water table is at depths of less than 10 inches from the soil surface for 2 to 6 months each year. Even during the drier months, the water table is within 30 inches from the soil surface for more than 9 months each year.

**Riviera sand.** Riviera sand consists of deep, poorly and very poorly drained, slowly to very slowly permeable soils that formed in stratified marine sandy and loamy sediments. Riviera sands are located on broad low flats and in depressions on the Lower Coastal Plain. The water table is within 10 inches of the surface for 2 to 4 months in most years and 10 to 30 inches deep most of the rest of the year. It is below 40 inches for short periods in driest seasons. Some areas are flooded for periods ranging from a few days to about 3 months. Depressions are ponded for periods ranging from 6 to 12 months.

**Sanibel sand.** Sanibel sands are very poorly drained sandy soils with organic surfaces. They formed in rapidly permeable marine sediments. The soils occur on nearly level to depressional areas with slopes less than 2%. The water table in Sanibel sand is at depths of less than 10 inches for 6 to 12 months during most years. Water is above the surface for periods of 2 to 6 months during wet seasons.

**Scoggin series.** Scoggin soils are very poorly drained, formed in loamy and sandy marine sediments in central peninsular Florida. They occur in swamps and low areas bordering swamps. The water table is at or above the surface for as much as 6 months in most years. Standing water occurs during the summer rainy season.

**Tequesta muck.** The Tequesta series consists of very poorly drained, moderately slowly permeable soils that formed in stratified marine sandy and loamy sediments on the Lower Coastal Plain. A typical pedon has a surface 12-inch-thick organic horizon underlain by sands. Tequesta soils are in depressional areas, freshwater swamps and marshes, and broad low flats adjacent to organic soils. The water table is at the surface or within 10 inches of the surface for 6 to 12 months during most years. In its natural state, water is above the surface for 6 to 9 months during most years.

**Terra Ceia muck.** The Terra Ceia series consists of very deep, very poorly drained organic soils that formed from non-woody fibrous hydrophytic plant remains. These soils occur mostly in nearly level freshwater marshes and occasionally on river floodplains. The thickness of the organic horizon typically equals 51 to 65 inches. The water table in Terra Ceia muck is at or above the soil surface except during extended dry periods. Areas on floodplains are flooded for long durations.

# APPENDIX B—VEGETATION DATA SHEET

## Vegetation Record Data Sheet

Date ______________________ Transect No. ______________________

Locality ______________________ Transect Length (ft) ______________

Observers ______________________________________________

Notes ______________________________________________

| Cover Estimates | | |
|---|---|---|
| Class | Percent | Description |
| 0 | < 1% | Rare |
| 1 | 1-10% | Scattered |
| 2 | 11-25% | Numerous |
| 3 | 26-50% | Abundant |
| 4 | 51-75% | Co-dominant |
| 5 | >75% | Dominant |

| | | Plant Community | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | Distance on Transect (ft) | | | | | | | | | |
| V | Plant Species | | | | | | | | | | |
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Note: Estimates of percent cover are made only for plants rooted within a particular habitat     Page ____ of _____