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MINIMUM LEVELS REEVALUATION: LAKE COLBY VOLUSIA COUNTY, FLORIDA

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by

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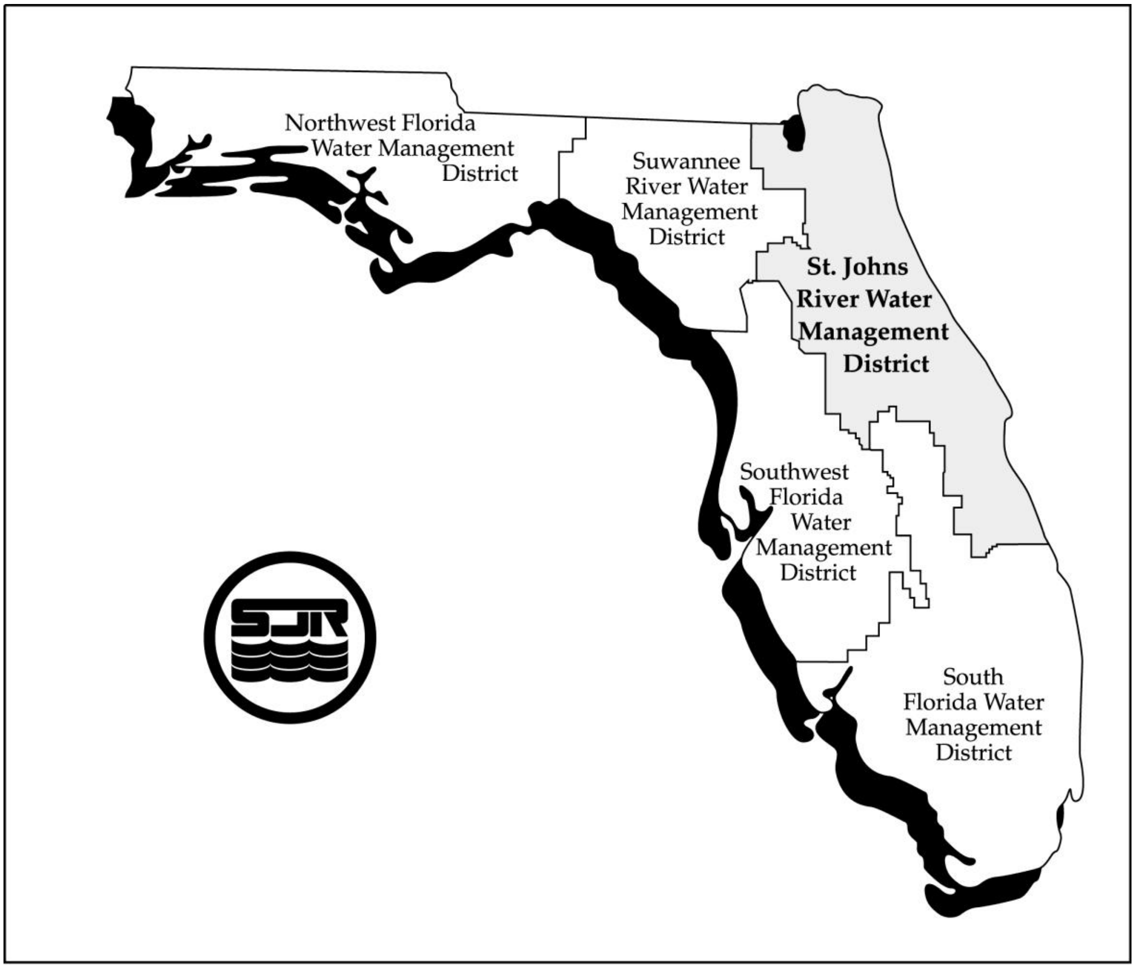

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources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

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EXECUTIVE SUMMARY

This report presents the St. Johns River Water Management District (SJRWMD) minimum flows and levels (MFLs) reevaluation for Lake Colby, Volusia County, Florida. This system is on the MFLs Priority Water Body List and Schedule (SJRWMD 2006a), which includes a schedule for the establishment and reevaluation of MFLs pursuant to Section 373.042(2), *Florida Statutes* (F.S.). MFLs for Lake Colby were determined in 1996 based upon the best information and methods available at that time (Hupalo 1996, attached Appendix A). The SJRWMD Governing Board adopted minimum levels for Lake Colby by SJRWMD rule in 1996 (Rule 40C-8.021, *Florida Administrative Code* [*F.A.C.*]). However, no hydrologic model was available at that time to assess the adequacy of the proposed MFLs. Recent development of a hydrologic model indicates that adopted minimum average and minimum frequent low levels for Lake Colby are not protected under 2003 modeled hydrologic conditions (Robison 2006). As a result, additional fieldwork was completed to reevaluate the MFLs. This reevaluation has resulted in the recommendation to modify the existing MFLs for Lake Colby (Table ES-1) based on current SJRWMD MFLs methodology.

Table ES-1. Adopted (Hupalo 1996, Appendix A) and recommended minimum surface water levels for Lake Colby, Volusia County

Minimum Levels	Adopted Elevation (ft NGVD) 1929 Datum	Adopted Hydroperiod Categories	Recommended Elevation (ft NGVD) 1929 Datum	Recommended Duration	Recommended Return Interval
Minimum frequent high level	28.3	Seasonally flooded	27.6	30 days	3 years
Minimum average level	26.6	Typically saturated	none	none	none
Minimum frequent low level	25.2	Semi-permanently flooded	22.9	120 days	3 years

ft NGVD = feet National Geodetic Vertical Datum

The recommended minimum lake levels presented here were determined with SJRWMD's multiple MFLs methodology (SJRWMD 2006b). MFLs determinations are based on evaluations of topographic, soils, and vegetation data collected within plant communities associated with the water body, together with information collected from other aquatic ecosystems and from the scientific literature.

The recommended minimum frequent high elevation component for Lake Colby, 27.6 feet (ft) National Geodetic Vertical Datum (NGVD), is 0.7 ft lower than the adopted minimum frequent high elevation component, 28.3 ft NGVD. The same criterion, mean elevation of wet prairie communities, was utilized for the determination of the adopted and recommended minimum frequent high elevation components. The difference likely arises from: (1) the determination of the average elevation for the wet prairie community from multiple transects (i.e., utilization of all data points within a community for each transect to generate an average elevation versus averaging the mean elevation of the community from each transect to generate a grand mean); (2) the use of transects in different locations; and (3) individual differences in estimating the upper and lower boundaries of a plant community. The first explanation is likely the primary cause of the difference because review of the original transects and vegetation notes reveal that Transects 1 to 4 contain a wet prairie community. Transect 3 does not traverse the wet prairie at its peak, which results in an elevation skewed toward a low value (26.9 ft NGVD); therefore, Transect 3 was excluded from the grand mean of the wet prairie community. The grand mean elevation of the wet prairie from Transects 1, 2, and 4 from the original fieldwork is 27.9 ft NGVD and gives equal weight to each transect. The mean elevation generated from all data points on Transects 1, 2, and 4 is 28.3 ft NGVD and gives more weight to transects with more data points.

Transect data from the original MFLs determination (attached Appendix A) were not included because the six transects completed during the original MFLs determination were collated into a single composite transect, thus preventing exact separation of the wet prairie communities by transect. Therefore, Transects C and D were established to collect data in similar areas as the original fieldwork. Transect C was established in the same general location as Transects 1, 5, and 6, and Transect D was established in the same general location as Transect 3 and 4.

It is recommended that the minimum frequent high elevation component, 27.6 ft NGVD, be flooded, on average, at least once every 3 years (i.e., 33 flooding events in 100 years) for a duration of at least 30 consecutive days. This flooding signature is based on current surface water inundation/dewatering signature (SWIDS) analysis and is slightly wetter than the driest flooding signature observed for wet prairies at other systems. Since the minimum frequent high level maintains a hydrologic signature within the range observed for wet prairies at other systems, this minimum level is intended to maintain the location, structure, and functions of this community. This minimum level allows for some change, which will likely be expressed in a change in species abundance, species composition, and potentially some shift in the extent of the community at its extreme (maximum/minimum) elevations. Further hydrologic shifts caused by withdrawals will likely result in significant harm via conversion of the upper portion of the wet prairie to a drier plant community and alteration of the community's structure and function at its extreme elevations.

The adopted minimum average elevation component is 26.6 ft NGVD and is equivalent to the mean elevation of the emergent marsh communities (Hupalo 1996, attached Appendix A). No minimum average level is recommended for Lake Colby. This is because Lake Colby is a sandhill lake. Based on the conceptual model of sandhill lakes developed by CH2M HILL (2005), sandhill upland lakes are astatic and lack a mean around which the system is organized. CH2M HILL (2005) also suggests that critical system behaviors of sandhill lakes may be related most strongly to high- and low water levels corresponding to drought cycles and multidecadal climate cycles and that both high- and low water levels are necessary to maintain expected ecosystem structure and functions. Therefore, only minimum frequent high and minimum frequent low levels are recommended for Lake Colby.

The recommended minimum frequent low elevation component for Lake Colby (22.9 ft NGVD) is 2.3 ft lower than the adopted minimum frequent low level (25.2 ft NGVD) because a different minimum frequent low level criterion, maximum elevation of deep marsh, was applied. The adopted minimum frequent low level for Lake Colby was equivalent to a 20-inch (in.) drawdown from the mean elevation of emergent marsh. This criterion is commonly used to determine the minimum frequent low level when seasonally flooded marshes or soils with more than 8 in. of organic matter are identified. The 20-in. factor was calculated as the mean of the range of dry-season water table depths reported by the Natural Resources Conservation Service (NRCS) for many organic soils within SJRWMD (e.g., USDA–SCS 1974 and 1980). These soils are reported to have typical dry-season low water table depths between 10 in. and 30 in. below the soil surface. In addition, Environmental Science and Engineering Inc. (ESE 1991) calculated an average minimum dry-season water table depth of 53 centimeters (cm) ± 13.5 cm (i.e., 20.9 in. ± 5.3 in.) below the soil surface, based upon field data reported from the scientific literature for 29 seasonally flooded freshwater marshes.

The elevation component of the recommended minimum frequent low level, based on the maximum elevation of deep marsh, allows a 27.6-in. drawdown from the grand mean of the shallow marsh communities observed on Transects A, B, C, and D. This shallow marsh drawdown is on the dry side but within the range observed for numerous seasonally flooded freshwater marshes (ESE 1991). Lake Colby has widely fluctuating water levels and very little accumulation of organic matter, as is common to many sandhill lakes. Thus, a drawdown of 27.6 in. from the mean shallow marsh elevation should protect the structure and functions of the shallow marsh community.

The recommended minimum frequent low level allows the maximum elevation of the deep marsh to be dewatered for 120 continuous days every 3 years, on average. This dewatering signature is wetter than the driest deep marsh, based on SWIDS analysis, but drier than approximately 75% of the 20 systems analyzed (Neubauer et al. 2006). The driest deep marsh, based on current SWIDS analysis, was not dominated by floating-leafed vegetation and would be expected to have a drier hydrologic signature than a deep marsh dominated by water lilies. Since the minimum frequent low level maintains a hydrologic signature within the range observed for deep marshes at other systems, this minimum level is intended to maintain the location, structure, and functions of this community. This minimum level allows for some change, which will likely be expressed in a change in species abundance, species composition, and potentially some shift in the extent of the community at its extreme (maximum/minimum) elevations. A further hydrologic shift caused by withdrawals that exceed MFLs will likely result in significant harm via conversion of the upper portion of the deep marsh to a drier community and alteration of the structure and function at the extreme elevations within this community.

The recommended minimum frequent high and minimum frequent low levels are protected under 2003 conditions based on long-term hydrologic model simulations. Frequency analysis of the modeled stage data shows that the minimum frequent low level is the limiting level at Lake Colby and may only allow for a small amount of additional water for consumptive use. The adopted MFLs, adopted hydroperiod categories, and the recommended MFLs and associated durations and return intervals are presented in Table ES-1. The hydroperiod categories and definitions are adapted from water regime modifiers developed by Cowardin et al. (1979). Results presented in this report are preliminary and will not become effective unless the recommended MFLs are adopted by SJRWMD Governing Board rule.

A hydrologic model for Lake Colby was calibrated for 2003 conditions (Robison 2006). These conditions included the most recent land use information and groundwater levels consistent with 2003 regional water use. Based on hydrologic model results, SJRWMD concludes that the recommended MFLs for Lake Colby are protected under 2003 conditions. To determine if changes in groundwater use allocations subsequent to 2003 would cause lake levels to fall below the recommended MFLs for Lake Colby, the existing Lake Colby hydrologic model should be run using Floridan aquifer potentiometric level declines that reflect these changes in water use allocation.

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MFLS PROGRAM OVERVIEW

The St. Johns River Water Management District (SJRWMD) minimum flows and levels (MFLs) program, based on the requirements of Section 373.042, *Florida Statutes* (F.S.), establishes MFLs for lakes, streams and rivers, wetlands, springs, and aquifers. Further, the MFLs program is subject to the provisions of Chapter 40C-8, *Florida Administrative Code* (*F.A.C.*), and provides technical support to SJRWMD's regional water supply planning process (Section 373.0361, F.S.) and the consumptive use permitting program (Chapter 40C-2, *F.A.C.*). Based on the provisions of Rule 40C-8.011(3), *F.A.C.*, "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology." Significant harm is prohibited by Section 373.042(1a) (1b), F.S. In addition, MFLs should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area (Rule 62-40.473(2), *F.A.C.*).

Factors to Be Considered When Determining MFLs

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

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

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

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

“When establishing minimum flows and levels pursuant to Section 373.042, the department or Governing Board shall consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by Section 373.042(1) caused by withdrawals.”

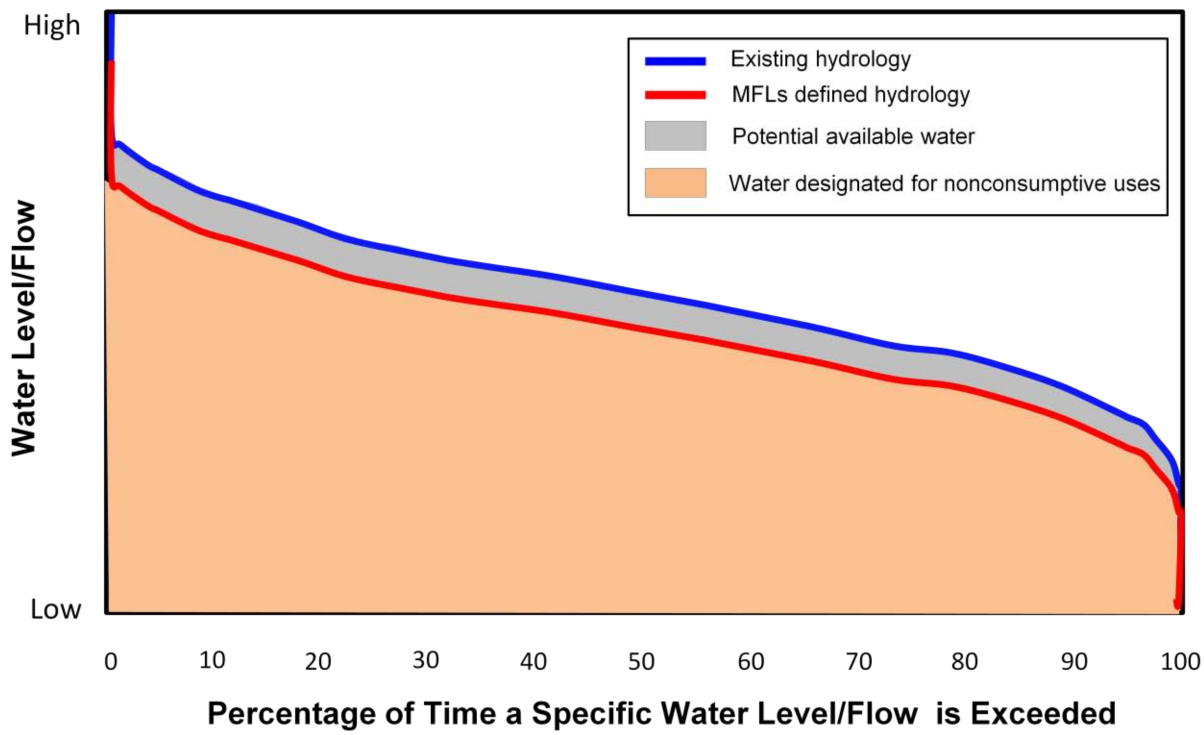
Hydrology

MFLs designate an environmentally protective hydrologic regime (i.e., hydrologic conditions that prevent significant ecological harm) and identify levels and/or flows above which water may be available for use. MFLs define the frequency and duration of high- and low water events necessary to protect relevant water resource values, criteria, and indicators that prevent significant harm to aquatic and wetland habitats. Three MFLs are usually defined for each system—minimum frequent high, minimum average, and minimum frequent low—flows and/or water levels. If deemed necessary, minimum infrequent high and/or minimum infrequent low flows and/or water levels are also defined. The MFLs represent hydrologic statistics comprised of three components: a magnitude (a water level and/or flow), duration (days), and a frequency or return interval (years). SJRWMD has synthesized the continuous duration and frequency components of the MFLs into seven discrete hydroperiod categories to facilitate MFLs determinations for lakes, rivers, and wetlands. The hydroperiod categories and the related frequencies and durations are defined in Chapter 40C-8.021, *F.A.C.*, and summarized in Table 1. However, for MFLs associated with reevaluations of established MFLs and MFLs for water bodies for which MFLs have not been previously established, these hydroperiod categories are now being replaced with specific durations and return interval values.

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 (Figure 1). However, when use of water resources shifts the hydrologic conditions below that defined by the MFLs, significant ecological harm is expected to occur (Figure 1). As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies and durations of water level and/or flow events, causing unacceptable changes to ecological structures and/or functions.

Table 1. MFLs hydroperiod categories and approximate frequencies and durations

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



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

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

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

MFLS METHODOLOGY

MFLs determinations incorporate biologic and topographic information collected in the field with stage data, wetland and soils data from geographical information system (GIS) coverages, aerial photography, the scientific literature, and hydrologic and hydraulic models, to generate an MFLs regime. MFLs methodology provides a process for incorporating these factors. This section describes the MFLs methodology and assumptions used in the MFLs determination process, including field procedures such as site selection, field data collection, and data analyses. Additional MFLs methodology descriptions are located in the (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006b).

FIELD SITE SELECTION

Many factors are considered in the selection of field transect sites. Transects are fixed sample lines across a river, lake, or wetland floodplain, that usually extend from open water to uplands, along which elevation, soils, and vegetation are sampled to characterize the influence of surface water flooding on the distribution of soils and plant communities.

Field site selection begins with the implementation of a site history survey and data search. The team collates all pertinent existing information and conducts data searches of SJRWMD library documents, project record files, the hydrologic database, and SJRWMD Division of Surveying Services files. The types of information may include:

- On-site and regional vegetation surveys and maps
- Aerial photography (existing and historical)
- Remote sensing (vegetation, land use, etc.) and topographic maps
- Soil surveys, maps and soil 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

Data sources are reviewed to familiarize the investigator with site characteristics, locate important basin features that need to be evaluated, and assess prospective sampling locations. Copies of this information are organized and placed in permanent files for future reference (SJRWMD 2006b).

Potential transect locations are identified from maps of wetlands, soils, topography, and landownership. Specific transect site selection goals include:

- Establishing transects at sites where multiple wetland communities of the most commonly occurring types are traversed.
- Selecting multiple transect locations with common wetland communities among them.
- Establishing transects that traverse unique wetland communities.
- Avoiding human altered or impacted areas.

Transect characteristics are subsequently field-verified to ensure the particular locations contain representative wetland communities, hydric soils, and reasonable upland access. These goals help to ensure ecosystem protection of commonly occurring and unique wetland ecosystems. Individual transect site selection criteria for Lake Colby are described in the Results and Discussion section of this document.

FIELD DATA COLLECTION

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

Site Survey

Upon selection of a transect site, conventional survey methods are used to establish and record elevation data at each site. The elevation data enable similar features on a single system to be quantitatively compared.

Transect site vegetation is trimmed to allow a line-of-sight along the length of the transect. A measuring tape is laid down on the ground along the length of the transect. Elevation measurements are recorded at various length intervals (i.e., 5 feet [ft], 10 ft, 20 ft, etc.) to adequately characterize the topography and transect features. Additional elevations are generally measured at obvious elevation changes, vegetation community changes, soil changes, and within river channels (where applicable).

Latitude and longitude data are also collected by using a global positioning system (GPS) along the length of each transect. These GPS data accurately locate specific features along each transect and facilitate recovery of transect locations in the future.

Soil Sampling Procedures

Detailed soil profiles are described along each transect to gain an understanding of past and present hydrologic, geologic, and anthropogenic processes that have occurred and which have resulted in the observed transect soil features. Soil profiles are described following standard Natural Resources Conservation Service (NRCS) procedures (USDA–NRCS 2002). Each soil horizon (unique layer) is generally described with respect to texture, thickness, Munsell color (Kollmorgen Corp. 1992), structure, consistency, boundary, and presence of roots.

The primary soil criteria considered in the determination of MFLs is the presence and depth of organic soils, as well as the extent of hydric soils and the location of sandhill lake soil indicators (where applicable) observed along the field transects (SJRWMD 2006b). The procedure to document hydric soils includes:

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

Additional soil sampling procedures are documented in the (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006b).

Vegetation Sampling Procedures

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

The spatial extent of plant communities or transition zones (i.e., ecotones) among plant communities was determined using reasonable scientific judgment. Reasonable scientific judgment involves the ability to collect and analyze information using technical knowledge, personal skills, and experience to serve as a basis for decision making (Gilbert et al. 1995). In this case, such judgment was based upon field observations of relative abundance of dominant plant species, occurrence and distribution of soils and hydric soil indicators, and changes in land slope or elevation along the hydrologic gradient. Plant communities and transition zones were delineated along a specialized line transect called a belt transect. A belt transect is a line 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 2). The transect belt width will vary depending upon the type of plant community to be sampled (SJRWMD 2006). For example, a belt width of 10 ft (5 ft on each side of the transect line) may suffice for sampling herbaceous plant communities of a floodplain marsh. However, a belt width of 50 ft (25 ft on each side of the line) may be required to adequately represent a forested community (e.g., hardwood swamp [Figure 2]).

Plants were identified and the percent cover of plant species was estimated if they occurred within the established belt width for the plant community under evaluation (quadrat). Percent cover is defined as the vertical projection of the crown or shoot area of a plant to the ground surface, 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 sum to more than 100% (SJRWMD 2006). Percent cover was estimated visually using cover classes (ranges of percent cover). The cover class and percent cover ranges are a variant of the Daubenmire method (Mueller-Dombois and Ellenberg 1974) and summarized in SJRWMD’s (draft) Minimum Flows and Levels Methods Manual (SJRWMD 2006). Plant species, plant communities and percent cover data were recorded on field vegetation data sheets. The data sheets are formatted to facilitate data collection in the field and, also, computer transcription.

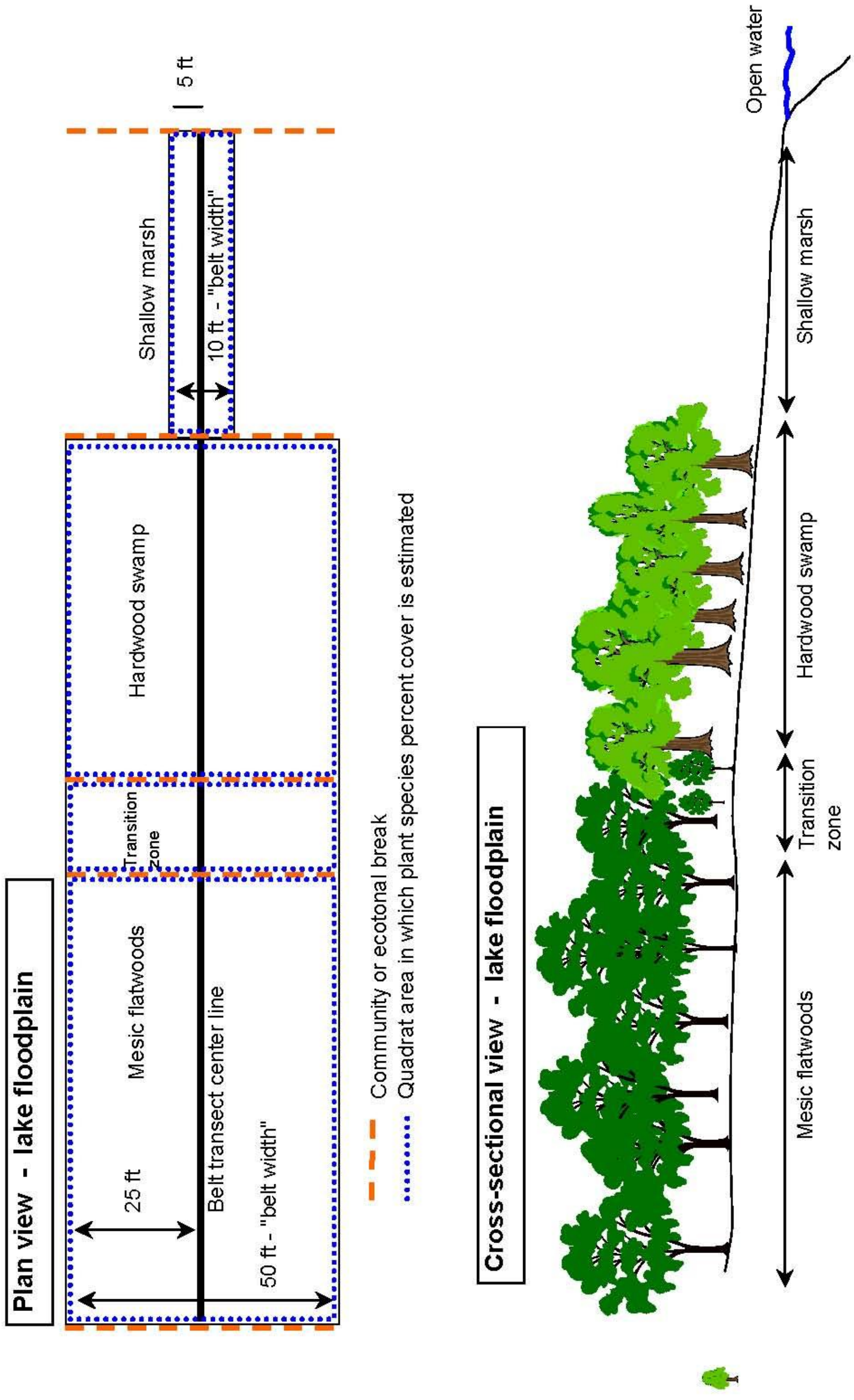


Figure 2. Example of belt transect through forested and herbaceous plant communities

DATA ANALYSIS

The primary data analysis for information collected in the MFLs determination process generally consists of performing basic statistical analyses on the surveyed elevation data, using a computer spreadsheet file. Vegetation and soils information collected along the transects are incorporated with the elevation data. Descriptive statistics are calculated for the elevations of the vegetation communities, specific hydric soil indicators, sandhill lake soil indicators (where applicable) and other relevant site characteristics.

Transect elevation data are also graphed to illustrate the elevation profile between the open water and upland community. The locations of vegetation communities along the transect, with a list of dominant species, statistical results and soils information, are typically labeled on the graph. Specific transect elevation data from Lake Colby are illustrated in the Results and Discussion section of this document.

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

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

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

1. Recreation in and on the water—The active use of water resources and associated natural systems for personal activity and enjoyment. These legal water sports and activities may include, but are not limited to, swimming, scuba diving, water skiing, boating, fishing, and hunting.
2. Fish and wildlife habitat and the passage of fish—Aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally or commercially important, or keystone species, to live, grow, and migrate. These environments include hydrologic

magnitudes, frequencies, and durations sufficient to support the life cycles of wetlands and wetland-dependent species.

3. Estuarine resources—Coastal systems and their associated natural resources that depend on the habitat where oceanic salt water meets freshwater. These highly productive aquatic systems have properties that usually fluctuate between those of marine and freshwater habitats.
4. Transfer of detrital material—The movement by surface water of loose organic material and associated biota.
5. Maintenance of freshwater storage and supply—The protection of an amount of freshwater supply for permitted users at the time of MFLs determinations.
6. Aesthetic and scenic attributes—Those features of a natural or modified waterscape usually associated with passive uses, such as bird-watching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation, that usually result in human emotional responses of well-being and contentment.
7. Filtration and absorption of nutrients and other pollutants—The reduction in concentration of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these substances move through the water column, soil or substrate, and associated organisms.
8. Sediment loads—The transport of inorganic material, suspended in water, which may settle or rise. These processes are often dependent upon the volume and velocity of surface water moving through the system.
9. Water quality—The chemical and physical properties of the aqueous phase (i.e., water) of a water body (lentic) or a watercourse (lotic) not included in definition number 7 (i.e., nutrients and other pollutants).
10. Navigation—The safe passage of watercraft (e.g., boats and ships), which is dependent upon adequate water depth and width.

CONSIDERATION OF BASIN ALTERATIONS IN ESTABLISHING MFLS

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

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

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

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

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

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

MFLs Compliance Assessment

A hydrologic model for Lake Colby was developed to provide a means of assessing whether compliance with MFLs is achieved under specific water use and land use conditions (Robison 2006). This hydrologic model was calibrated for 2003 conditions. These conditions included the most recent land use information and groundwater levels consistent with 2003 regional water use. An explanation of the use of this hydrologic model and the applicable SJRWMD regional groundwater flow model to assess whether water levels are likely to fall below MFLs under specific water use and land use conditions is presented in the attached Appendix D. This appendix also includes an introduction to the use of hydrologic statistics in the SJRWMD MFLs program.

LAKE COLBY GENERAL INFORMATION

Lake Colby is located approximately 5 miles east of Orange City and directly east of Cassadaga in Volusia County, Florida (Figure 3). The lake has an open water area of about 36 acres at a water level of 27 feet (ft) National Geodetic Vertical Datum (NGVD) (U.S. Geological Survey [USGS] Lake Helen quadrangle map, scale 1:24,000). Lake Colby and Giddings Lake are connected hydrologically via a marsh at an elevation of approximately 26.5 ft NGVD. Giddings has an open water area of about 17 acres at 27 ft NGVD (USGS Lake Helen quadrangle map, scale 1:24,000). Lake Colby is in the Crescent City–DeLand Ridge physiographic subdivision of the Central Lakes District, which consists of sand hills with summits of generally between 80 ft and 100 ft in elevation (Brooks 1982). The Central Lakes District serves as a principle recharge area for the Floridan aquifer. This region is composed of sand hills underlain by karst topography, serving as solution basins favorable for sinkhole development.

LAKE COLBY WATER QUANTITY MANAGEMENT CONCERNS

Lake Colby was selected for reevaluation because recent development of a water budget model and frequency analysis of the modeled stage data show that the hydrologic conditions defined by the adopted minimum frequent high level are being achieved, but the hydrologic conditions defined by the adopted minimum average and minimum frequent low levels are not being achieved (Figures 4, 5, 6, and 7). This reassessment is necessary to ensure that the minimum levels are based on robust criteria before any remedial action (i.e., development of a recovery strategy, permit amendment, etc.). According to hydrologic model projections for 1995–2025, using the Volusia regional groundwater flow model, the surficial aquifer may be affected by a drawdown of approximately 0.5–0.7 ft and the Floridan aquifer may be affected by a drawdown of approximately 1 ft in the direct vicinity of Lake Colby. Recorded stage data, precipitation, and nearby groundwater data, as well as other data sources, were utilized to simulate the lake stage from 2003 to 1961 (Robison 2006).

LAKE COLBY HYDROLOGY

Lake Colby intermittently receives surface water inflow from Lake Macy and discharges to Sand Lakes. Groundwater inflows originate from sand ridges surrounding the lake. Recharge to the Floridan aquifer is estimated at 0–4 in. per year, with nearby areas estimated at 4–8 in. per year and greater than 12 in. per year (Boniol et al. 1993).

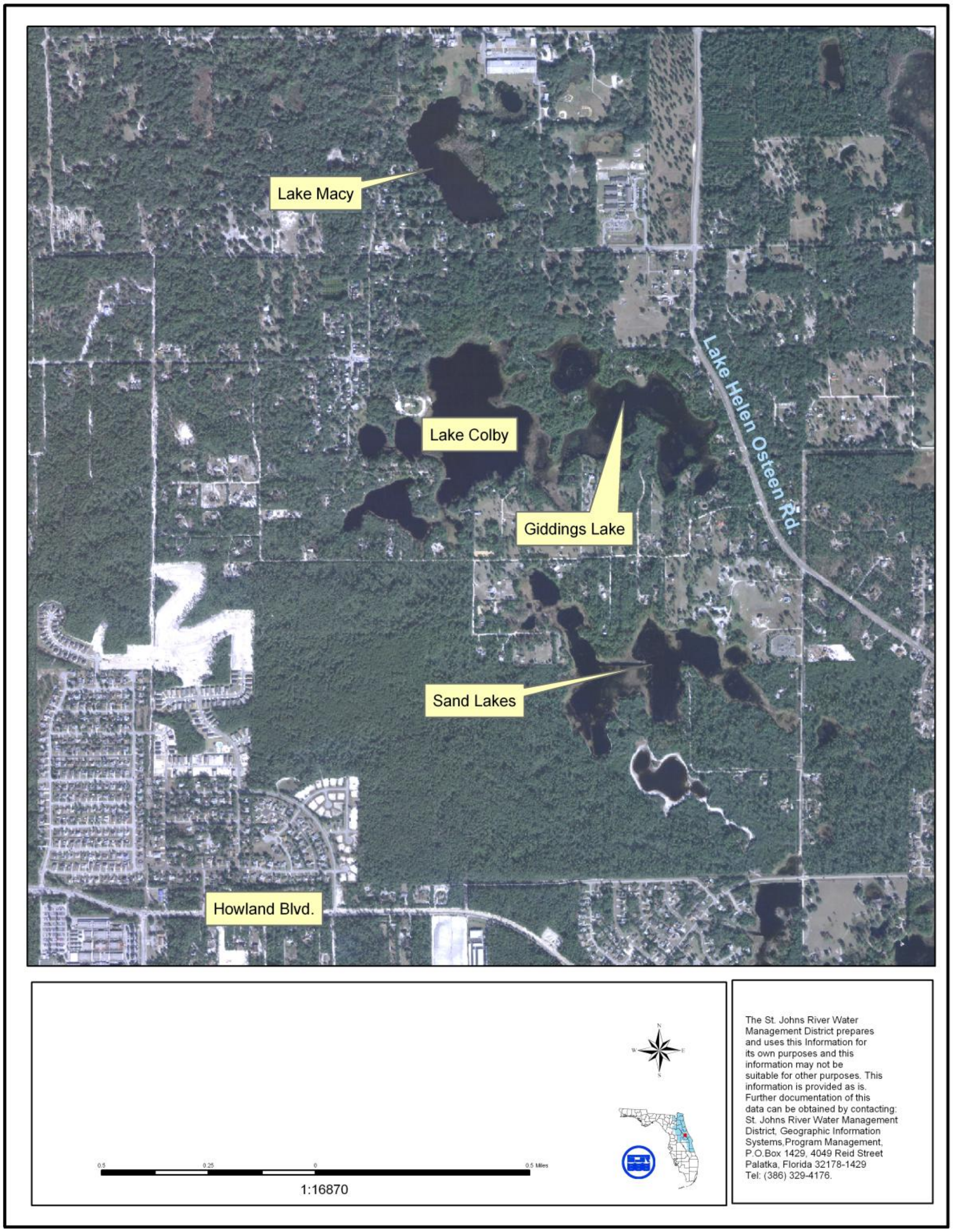


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Figure 3. General location of Lake Colby, Volusia County, and nearby water bodies

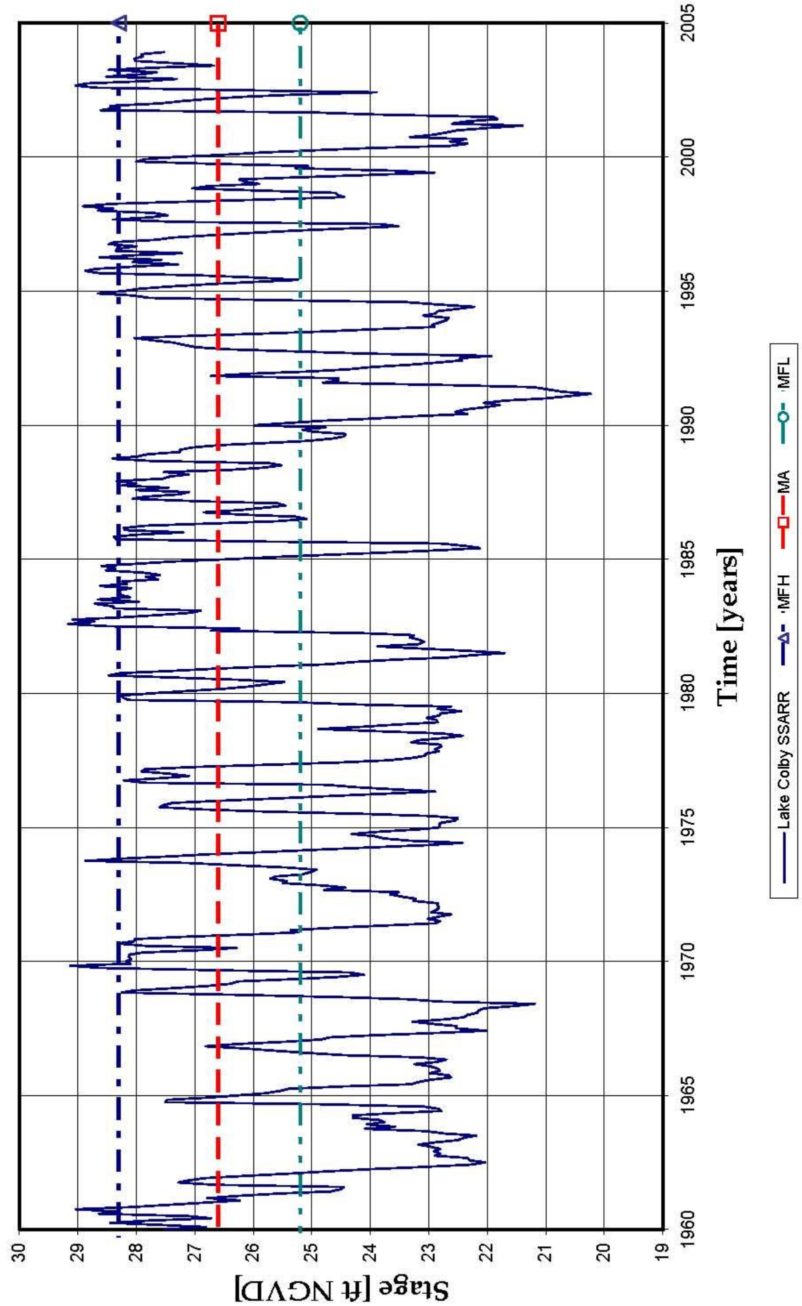

Figure 4. Hydrograph of modeled data (1961 – 2003) with adopted minimum levels, Lake Colby, Lake Colby, Volusia County

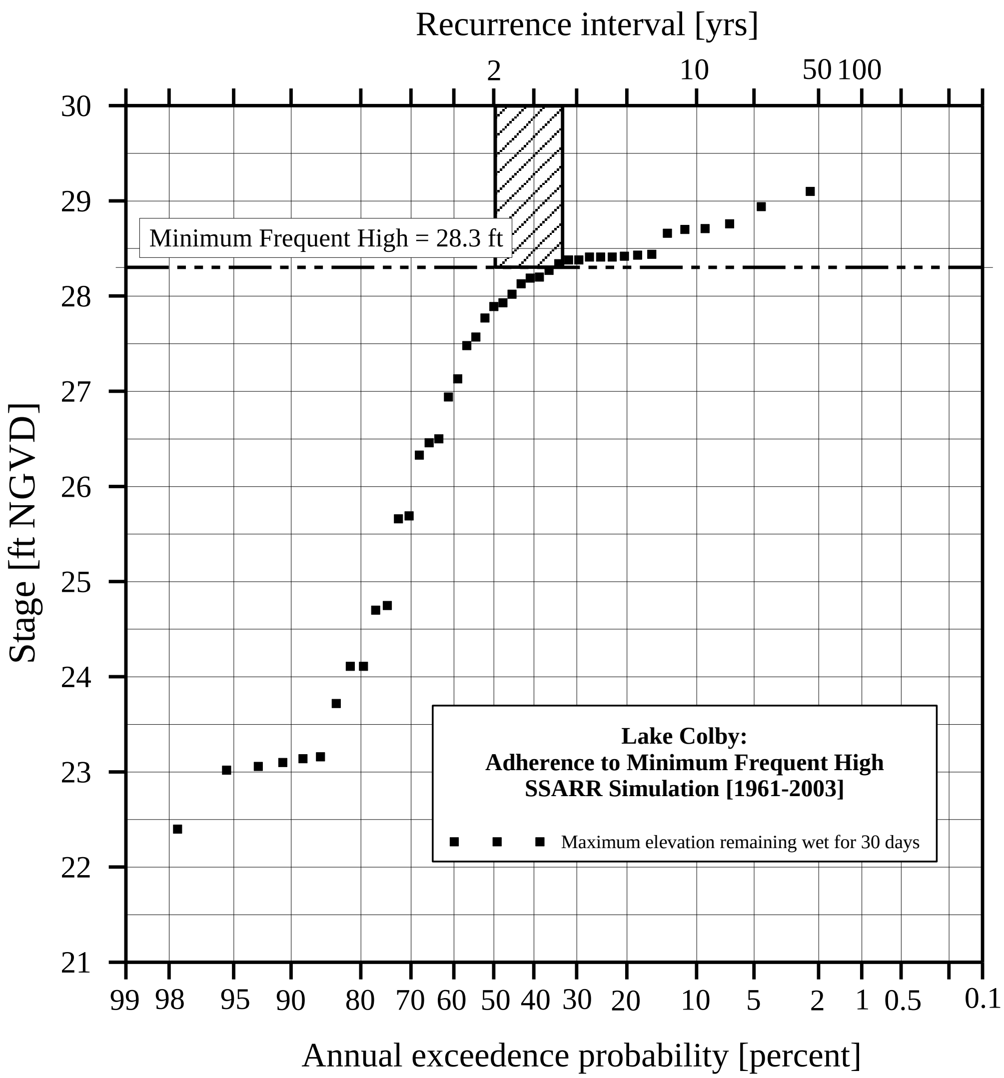

Figure 5. Frequency analysis of modeled data (1961–2003) for 30-day, continuously exceeded elevations, Lake Colby, Volusia County

*Note: The adopted minimum frequent high level just meets criteria for seasonally flooded, under 2003 modeled conditions. The adopted minimum frequent high level would be flooded for 30 continuous days approximately once every 2.9 years, under 2003 modeled conditions; whereas, the hydroperiod category seasonally flooded allows for a return interval of once every 3 years.

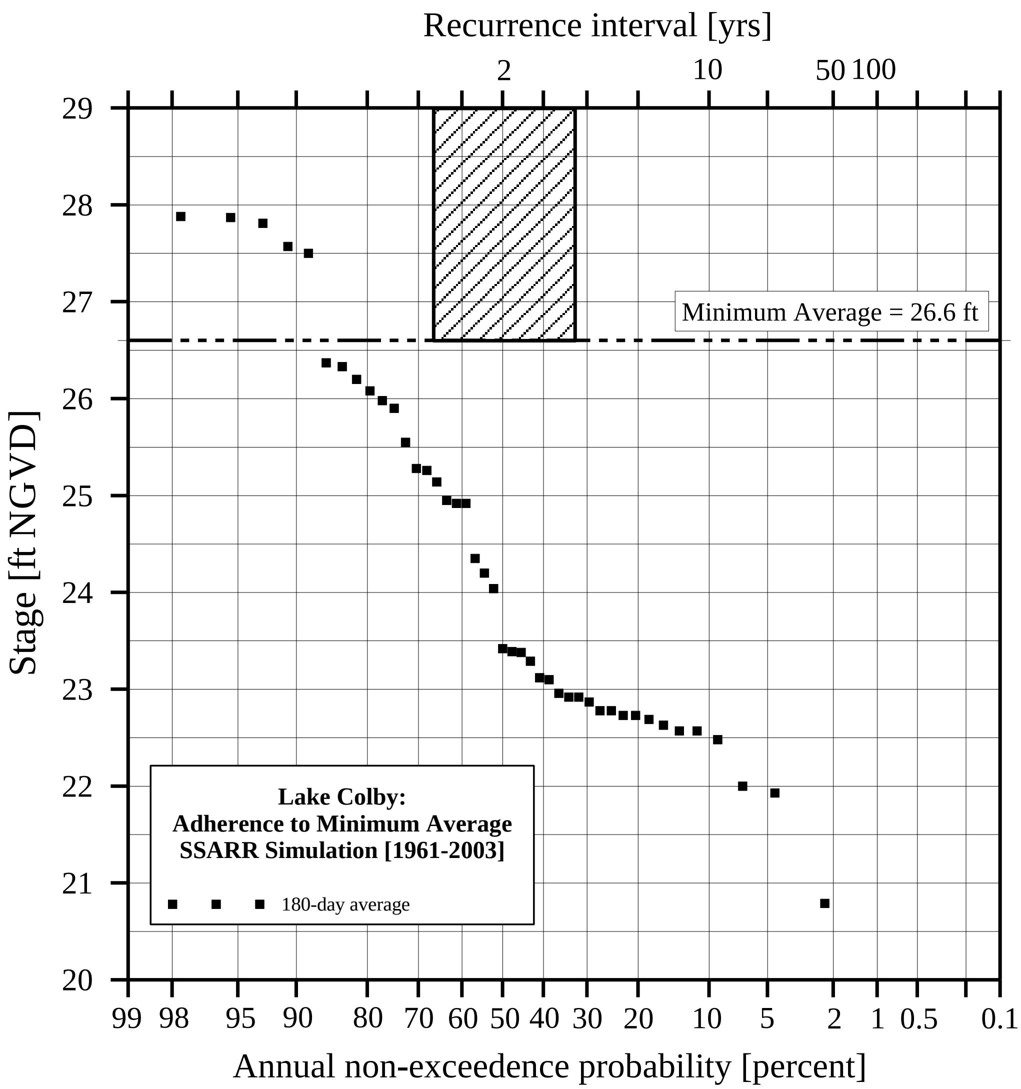

Figure 6. Frequency analysis of modeled data (1961–2003) for 180-day, average non-exceeded elevations, Lake Colby, Volusia County

*Note: The adopted minimum average level does not meet criteria for typically saturated, under 2003 modeled conditions. The adopted minimum average level would be dewatered for an average of 180 days approximately once every 1.2 years, under 2003 modeled conditions, rather than once every 1.5 years as allowed by the hydroperiod category, typically saturated.

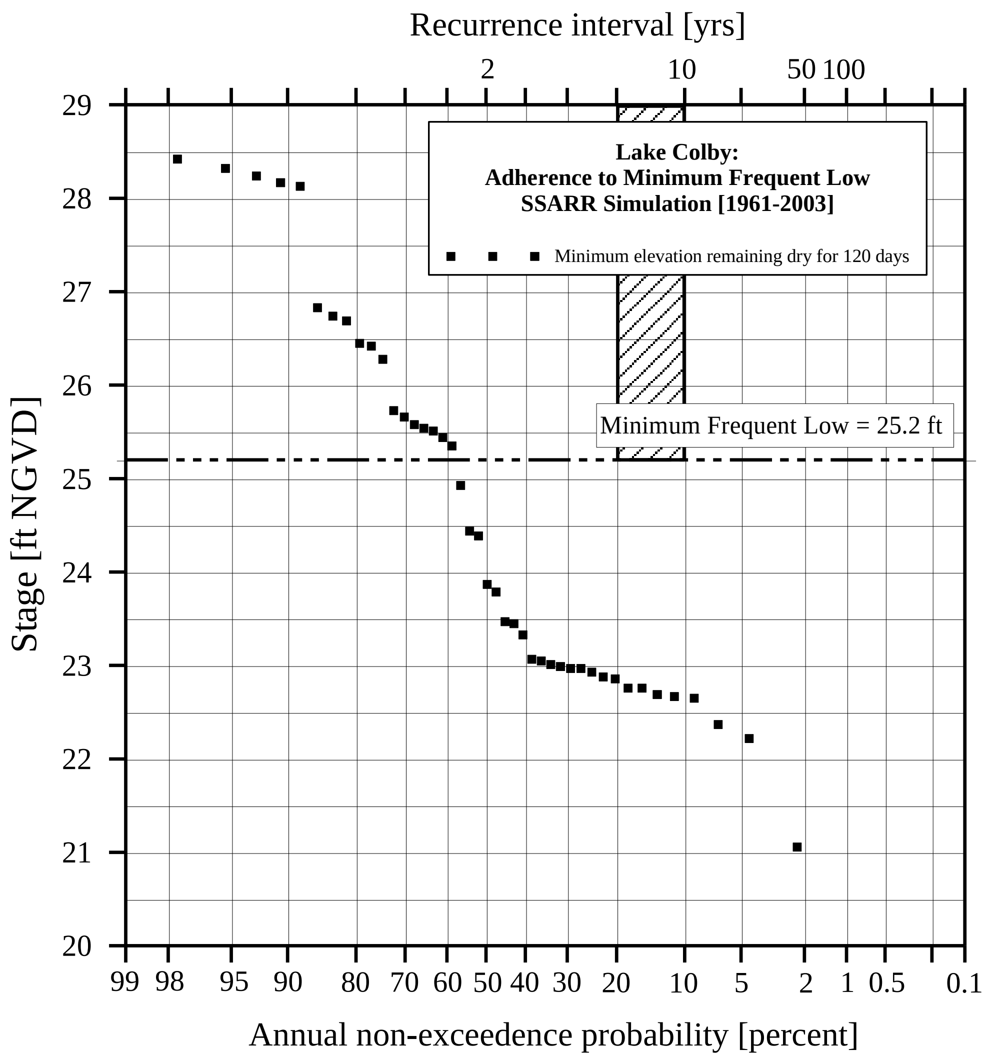

Figure 7. Frequency analysis of modeled data (1961–2003) for 120-day, continuously non-exceeded elevations, Lake Colby, Volusia County

*Note: The adopted minimum frequent low level does not meet criteria for semipermanently flooded, under 2003 modeled conditions. The adopted minimum frequent low level would be dewatered for approximately 120 continuous days once every 1.7 years, under 2003 modeled conditions, rather than once every 5 years as allowed by the hydroperiod category semipermanently flooded.

Stage data for Lake Colby exists from January 1990 to April 2005 (Figure 8). The lake stage was recorded daily until September 1996 and weekly thereafter. Several short gaps exist in the data set, but they are all less than five weeks. Weekly stage data were analyzed to give equal weight to the entire period of record. During this period, the lake fluctuated 9.5 ft, with a mean stage of 25.7 ft NGVD, as determined from 738 observations. The maximum and minimum elevations for the period of record are 29.5 ft NGVD (October 2, 2004) and 20.0 ft NGVD (July 7, 2001), respectively. A stage duration curve was generated to show the average amount of time that a given elevation was exceeded during the period of record (Figure 9).

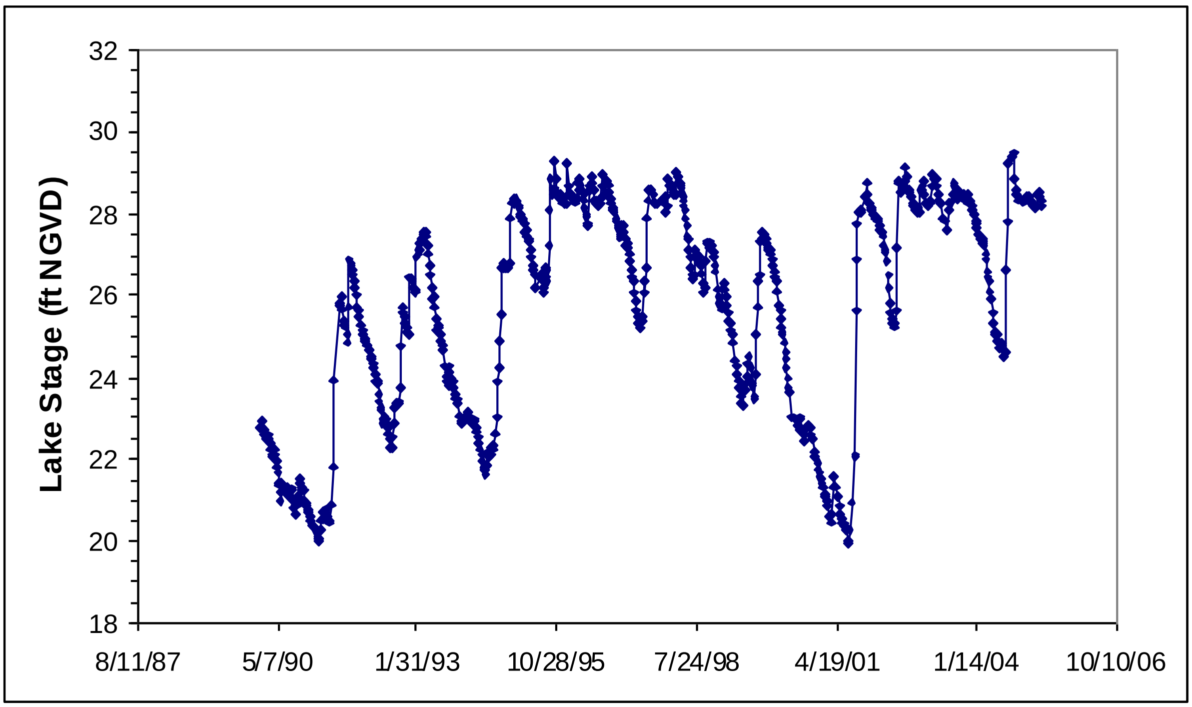

Figure 8. Lake Colby stage data January 1990–April 2005

Lake Colby Mapped Wetlands

Wetland communities mapped nearby Lake Colby consist of shallow marshes and deep marshes, as classified by the SJRWMD Wetlands Vegetation Classification System (Kinser 1996, Figure 10). Shallow marshes are herbaceous or graminoid communities that occur most often on organic soils and are subject to lengthy seasonal inundation. Deep marshes are wetlands dominated by a mixture of water lilies and deep-water emergent species and are semipermanently flooded to permanently flooded (Kinser 1996).

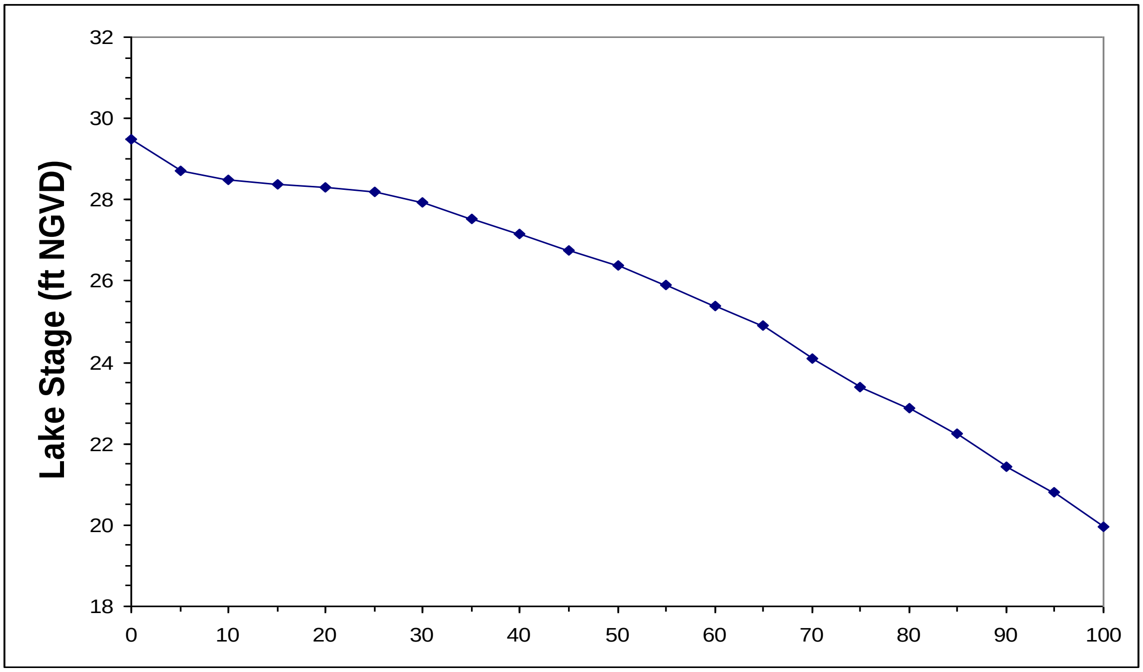

Figure 9. Stage duration curve for Lake Colby, Volusia County, Fla.

LAKE COLBY MAPPED SOILS

Soils are considered hydric or nonhydric based on the presence or absence of hydric soil indicators resulting from flooding, ponding, or saturation. Flooding is a condition in which the soil surface is covered with flowing water from any source, such as a water body overflowing its banks, runoff from surrounding slopes, inflow from high tides, or any combination of sources (FAESS 2000).

Ponding is considered the temporary accumulation of standing water in a closed depression and is removed only by percolation, evaporation, or transpiration (FAESS 2000). Saturation is characterized by zero or positive pressure in the soil water and can generally be determined by observing water in an unlined auger hole (FAESS 2000). Ponding and saturation are strongly influenced by the soil properties and the surrounding physiography.

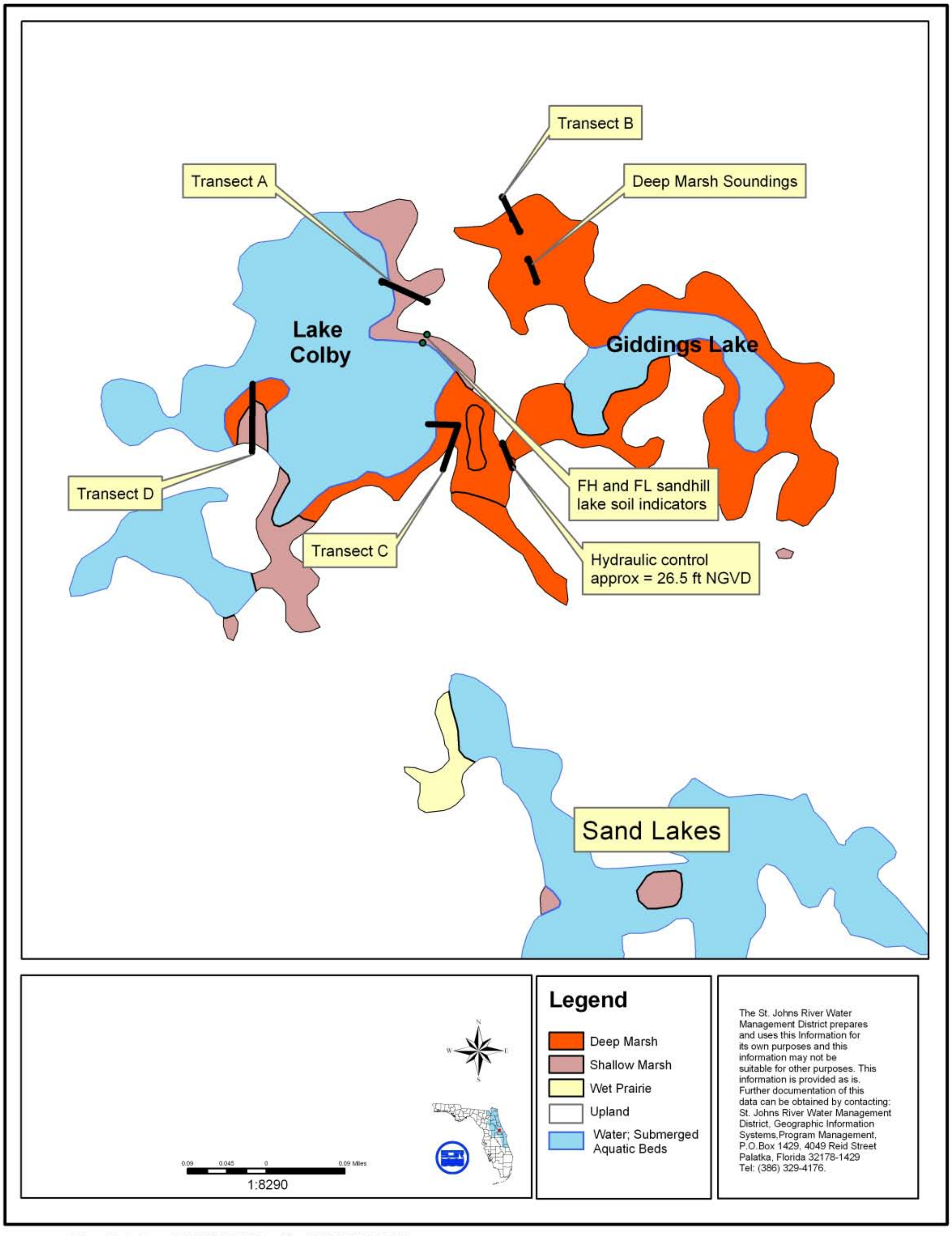

Figure 10. Mapped vegetation communities adjacent to Lake Colby, Volusia County, Fla.

Five soil series are mapped (see Figure 11) adjacent to Lake Colby:
(1) Astatula fine sand; (2) Daytona sand; (3) Myakka fine sand, depressional; (4) Paola fine sand; and (5) Tavares fine sand (USDA–SCS 1980, Figure 9). Of the mapped soil series, only Myakka find sand-depressional is considered as hydric and meets the criteria for saturation and ponding (FAESS 2000).

Myakka find sand-depressional. Myakka find sand-depressional consists of nearly level, poorly drained soil and is common in depressions within flatwoods throughout Volusia County. The permeability is rapid to moderately rapid, but is often impeded by a high water table. These areas are ponded for 6 to 9 months in most years; the water table is within 10 in. of the soil surface for 3 to 6 months in most years. During prolonged dry periods, the water table can drop to a depth of 2–3 ft (USDA–SCS 1980).

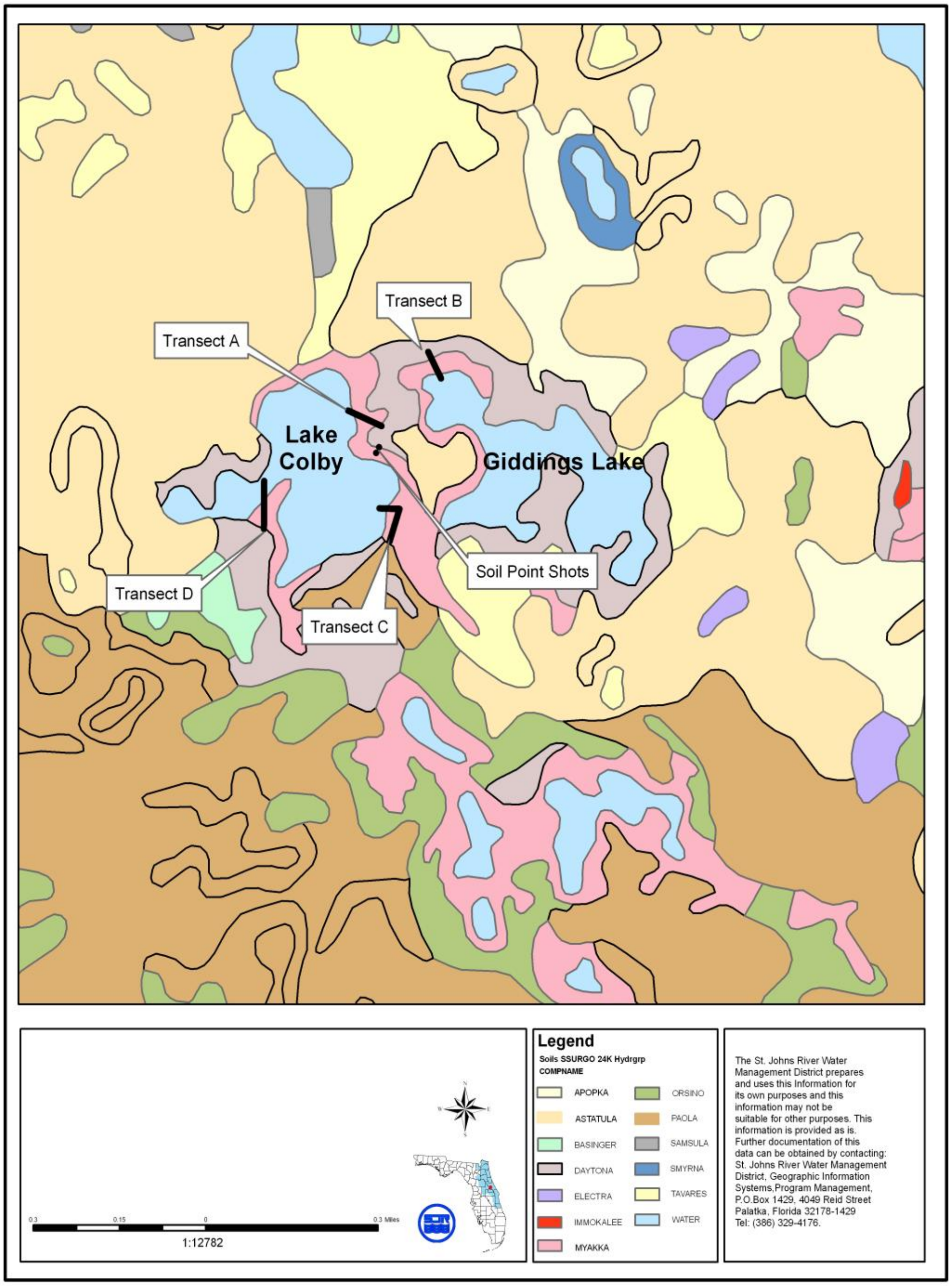

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Figure 11. Mapped soil series adjacent to Lake Colby, Volusia County, Fla.

RESULTS AND DISCUSSION

To reevaluate and determine minimum levels for Lake Colby, elevation, soils, and vegetation field data were obtained at four transect locations. This section describes the transect site selection criteria, the data collected at each transect location, the primary level determination criteria, and concludes with a description of the minimum level determinations for Lake Colby.

FIELD DATA COLLECTION

Data collection was performed on July 6, 12, 14, and 18; November 7 and 21; and December 13, 2005. The recommended minimum levels are derived from topographic data related to the occurrence of vegetation communities, hydric soils, hydric soil indicators, and sandhill lake soil indicators observed on Transects A, B, C, and D and the occurrence of sandhill lake soil indicators on the east shore of Lake Colby. Data from Transects 1, 2, 3, 4, 5, and 6 from the original minimum levels determination (attached Appendix A) were not directly utilized because these six transects were combined into a single composite transect. However, Transect C is located in the same area as original Transects 1, 5, and 6, and Transect D is located in the same area as original Transects 3 and 4, enabling similar data to be utilized.

SJRWMD's staff, BCI Engineers and Scientists' staff, and Jones, Edmunds and Associates' staff collected vegetation and soils data, and the SJRWMD Division of Surveying Services' staff collected elevation data. Elevations on Transects A, B, C, and D, point-shots, and soundings were determined via a water elevation transfer based on the staff gauge reading and datum (22.97 ft NGVD). The staff gauge datum was verified on July 14, 2005, with SJRWMD benchmark identification (ID) 02 043 0 03 (32.037 ft NGVD) and reference mark ID 02 043 1 03 (34.066 ft NGVD). The water level elevation on July 14, 2005, was 29.07 ft NGVD.

FIELD DATA—TRANSECT A

Lake Colby is dominated by shallow marshes and wet prairies and typically has a narrow transitional community between the marshes/prairies and the drier communities. Transect A was established on the east shore of Lake Colby because this location reached the upland rapidly, had a broad shallow marsh community, and traversed the dominant communities observed at the lake. Transect A extended 300 ft in a west-northwest direction (296°) from uplands to open water (Table 2 and Figures 10 and 12). Figure 12 depicts sandhill lake soil indicators, the extent of hydric soils, elevation ranges, and dominant plant species for each delineated vegetation community.

Table 2. Transect A location and fieldwork dates, Lake Colby

Latitude–Longitude (Station 0; upland)	Latitude–Longitude (Station 300; end shallow marsh)	Transect A—Location and Dates of Fieldwork
285756.02 – 811349.37	285757.19 – 811352.44	East shore of Lake Colby, July 6, 12, and 14, 2005

Vegetation at Transect A

Four vegetation communities were observed along transect A, and they were: uplands; transitional shrub; wet prairie; and shallow marsh (Table 3 and Figures 12 and 13). The plant species and cover found in each community

Table 3. Transect A vegetation community elevation statistics, Lake Colby

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Upland	0–30	-	-	30.0	-	7
Transitional shrub	30–70	29.2	29.2	28.3	30.0	9
Wet prairie	70–100	27.7	27.8	27.2	28.3	7
Shallow marsh	100–300	25.1	25.0	23.0	27.3	41

ft NGVD = feet National Geodetic Vertical Datum
N = number of elevation readings surveyed in each vegetation community

and *The Florida Wetlands Delineation Manual* (*FWDM*, Gilbert et al. 1995) wetland indicator status are listed in Table 4. The upland community was located between stations 0 ft and 30 ft (31.7 and 30.0 ft NGVD, respectively) and was dominated by saw palmetto with an overstory of sand live oak. The transitional shrub community was located between stations 30 ft and 70 ft (30.0 ft and 28.3 ft NGVD, respectively) and was dominated by saw palmetto, dahoon holly, and wax myrtle. The wet prairie was located between stations 70 ft and 100 ft (28.3 ft and 27.2 ft NGVD, respectively) and had numerous duck potato and various scattered herbaceous species. The shallow marsh community was located between stations 100 ft and 300 ft (27.2 ft and 23.0 ft NGVD, respectively) and was dominated by maidencane, buttonbush, and red ludwigia.

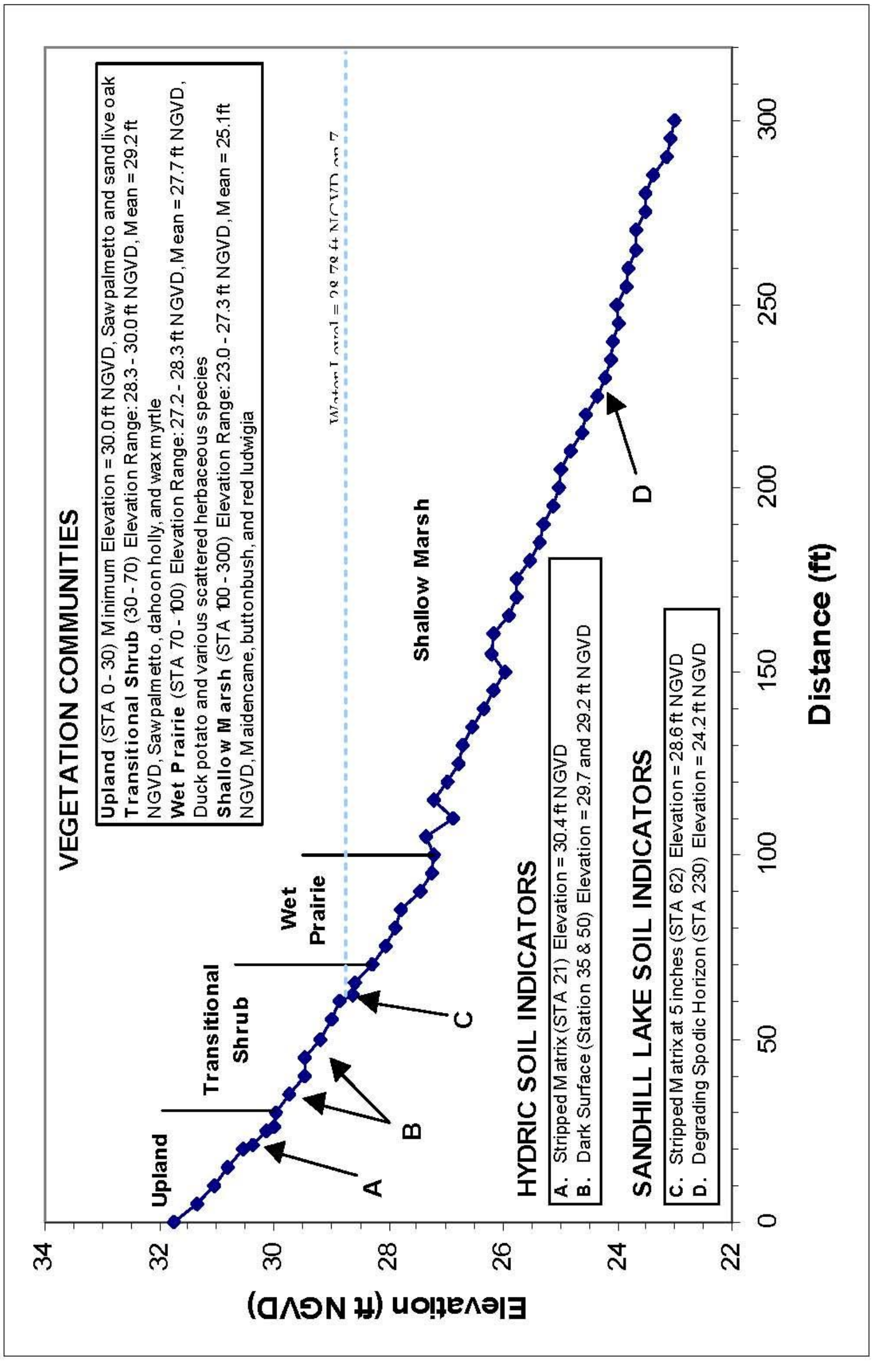

Figure 12. Transect A, Lake Colby – Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

Figure 13. Transect A photographs, Lake Colby

Wet prairie—looking downslope towards the shallow marsh

Lower end of the shallow marsh—looking toward Lake Colby

Figure 13. Transect A photographs, Lake Colby (cont.)

Table 4. Transect A vegetation species list, Lake Colby

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]			
			Upland (0–30 ft)	Transitional Shrub (30–70 ft)	Wet Prairie (70–100 ft)	Shallow Marsh (100–300 ft)
Cephalanthus occidentalis	Buttonbush	OBL			1	2
Ilex cassine	Dahoon holly	OBL		2		
Ilex glabra	Gallberry	UPL	1			
Leersia hexandra	Southern cut grass	OBL			1	1
Ludwigia repens	Red ludwigia	OBL				2
Lyonia ferruginea	Rusty lyonia	UPL	1			
Lyonia lucida	Shiny lyonia	FACW	1			
Mikania scandens	Hempweed	UPL				1
Myrica cerifera	Wax myrtle	FAC		2	1	1
Nymphaea odorata	Fragrant water lily	OBL			1	1
Panicum hemitomon	Maidencane	OBL			0	3
Panicum repens	Torpedo grass	FACW				1
Pinus elliottii	Slash pine	UPL			1	
Polygonum hirsutum	Jointweed	OBL				1
Pontederia cordata	Pickerelweed	OBL			2	1
Quercus geminata	Sand live oak	UPL	3			
Quercus myrtifolia	Myrtle oak	UPL	2			
Salvinia minima	Water spangles	OBL		0	1	1
Scirpus cubensis	Bulrush	OBL				0
Serenoa repens	Saw palmetto	UPL	3	4		
Smilax sp.	Catbrier	UPL	1			
Spartina bakeri	Sand cordgrass	FACW			1	1
Vaccinium corymbosum	Highbush blueberry	FACW	1	1		
Vaccinium elliotii	Mayberry	FAC	1			
Vitis rotundifolia	Muscadine grape	UPL		1		
Woodwardia virginica	Virginia chain fern	FACW		1	0	0

[1]Species and hydric designations are taken from Ch. 62-340.450, *F.A.C.* Species not in the rule are assumed upland (UPL) unless they are obvious aquatics; unlisted aquatic species are designated as obligates (OBL).
[2]FWDM = *The Florida Wetlands Delineation Manual* indicator status (Gilbert et al. 1995)

UPL = Upland plants that rarely occur in wetlands, but almost always occur in uplands
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands
FACW = Facultative wet plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
OBL = Obligate plants that are found or achieve their greatest abundance in an area that is subject to surface water flooding and/or soil saturation; rarely in uplands

[3]Species Occurrence: Aerial extent of vegetation species along each transect within each community where,
0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 25–50% (abundant); 4 = 51–75% (co-dominant); 5 = >75% (dominant)

Soils at Transect A

Hydric soil indicators and sandhill lake soil indicators were identified at Transect A (Table 5). In addition, soil descriptions were made to a depth sufficient to identify the soil series at stations 10 ft and 35 ft along Transect A. Soil series were not identified at further stations because the soils were too wet to enable descriptions to a sufficient depth.

Table 5. Transect A soil feature elevations (ft NGVD), Lake Colby

Location	Station	Feature	Elevation (ft NGVD)
Hydric Soil Indicators			
Transect A	Station 21 ft	Stripped matrix	30.4
Transect A	Station 35 and 50 ft	Dark surface	29.7 and 29.2
Sandhill Lake Soil Indicators			
Transect A	Station 62	Stripped matrix at 5 in.	28.6
Transect A	Station 230	Degrading spodic	24.2

ft NGVD = feet National Geodetic Vertical Datum

Myakka soils were identified at stations 10 ft and 35 ft of Transect A, in the uplands and transitional shrub, respectively (JEA 2006, attached Appendix C). Myakka soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996). This soil has an aquic moisture regime, indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Myakka soils are poorly drained to very poorly drained, with a water table at depths of less than 18 in. for a duration of 1 to 4 months during most years. The water table recedes to depths of more than 40 in. during very dry seasons. Depressional areas of Myakka soils are covered with standing water for 6 to 9 months or more in most years (USDA–NRCS 2005).

Sandhill lake soil indicators were identified at stations 62 ft and 230 ft at Transect A (JEA 2006, attached Appendix C). The sandhill lake soil indicator, stripped matrix, indicates an elevation that is exceeded by the lake stage approximately 20% of the time over the long term (Richardson et al. 2006) and was identified at station 62 ft (28.6 ft NGVD). A stripped matrix is a layer in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The stripped matrix sandhill lake soil indicator is identified at its waterward-most extent, where it begins 5 in. beneath the soil surface (Richardson et al. 2006). The sandhill lake soil indicator, less than 3 in. of sand over a degrading spodic horizon or a loamy/clayey horizon (i.e., degrading spodic), indicates an elevation that is exceeded by the lake stage approximately 80% of the time over the long term (Richardson et al. 2006) and was identified at station 230 ft (24.2 ft NGVD). This indicator was identified at the landward extent, where there was just less than 3 in. of sand over the degrading spodic layer.

Hydric soil indicators were identified at stations 21 ft and 35 ft at Transect A (JEA 2006, attached Appendix C). Station 21 ft demarcates the hydric/nonhydric soil boundary, where the hydric soil indicator stripped matrix (S6, USDA–NRCS 2002) was recorded (30.4 ft NGVD). The hydric soil indicator, stripped matrix, is a layer starting within 6 in. of the surface, in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The hydric soil indicator, stripped matrix, where it begins 6 in. beneath the soil surface (i.e., station 21 ft), is routinely used to delineate hydric soils throughout Florida (FAESS 2000) and, therefore, is generally near the wetland–upland interface. A hydric soil indicator consisting of dark surface (S7, USDA–NRCS 2002) was recorded at station 35 ft (29.7 ft NGVD). The hydric soil indicator, dark surface, is a layer 4 in. or thicker starting within the upper 6 in. of the soil surface that is predominately black. The matrix color value is 3 or less; chroma is 1 or less. At least 70% of the visible soil particles must be covered, coated, or similarly masked with organic material. The matrix color of the layer below the dark layer is chroma 2 or less (USDA–NRCS 2002). The occurrence of stripped matrix and dark surface indicate a seasonal high saturation within 6 in. of the soil surface (FAESS 2000).

FIELD DATA—TRANSECT B

Transect B was established on the north shore of Giddings Lake because this lake is connected to Lake Colby during high water levels, and this location reached the upland rapidly, had a broad wet prairie community, and traversed the dominant communities observed at the lake. Transect B extended 235 ft in a southeast direction (156°) from upland through the shallow marsh (Table 6 and Figure 14). Figure 14 depicts the extent of hydric soils, elevation ranges, and dominant plant species for each vegetation community.

Vegetation at Transect B

Four vegetation communities were observed along Transect B: uplands; transitional shrub; wet prairie; and shallow marsh (Table 7 and Figures 14 and 15). The plant species and cover found in each community and *The Florida Wetlands Delineation Manual* (Gilbert et al. 1995) wetland indicator status are listed in Table 8. The upland community was located between stations 0 ft and 43 ft (31.5 ft and 28.9 ft NGVD, respectively) and was dominated by saw palmetto with an overstory of sand live oak. The transitional shrub community was located between stations 43 ft and 50 ft (28.9 ft and 28.5 ft NGVD, respectively) and was dominated by saw palmetto. The wet prairie was located between stations 50 ft and 125 ft (28.5 ft and 26.0 ft NGVD, respectively) and was dominated by narrow-leafed arrowhead, slash pine, St. John's wort, fringe rush, and algal bulrush. The shallow marsh community was located between stations 125 ft and 235 ft (26.0 ft and 23.9 ft NGVD, respectively) and was dominated by maidencane, torpedo grass, and algal bulrush.

Table 6. Transect B location and fieldwork dates

Latitude–Longitude (Station 0; upland)	Latitude–Longitude (Station 235; end shallow marsh)	Transect B—Location and Dates of Fieldwork
285802.28 – 811344.27	285800.24 – 811343.09	Northwest shore of Giddings Lake, July 6, 12, and 18, 2005

Table 7. Transect B vegetation community elevation statistics, Lake Colby

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Upland	0–43	-	-	28.9	-	10
Transitional shrub	43–50	28.8	28.9	28.5	29.0	4
Wet prairie	50–125	26.9	26.7	26.0	28.5	16
Shallow marsh	125–235	25.0	24.9	23.9	26.0	23

ft NGVD = feet National Geodetic Vertical Datum
N = number of elevation readings surveyed in each vegetation community

Soils at Transect B

Hydric soil indicators and sandhill lake soil indicators were identified at Transect B (Table 9). In addition, soil descriptions were made to a depth sufficient to identify the soil series at station 20 ft along Transect B. Soil series were not identified within the wet prairie or shallow marsh communities because the soils were too wet to enable descriptions to a sufficient depth.

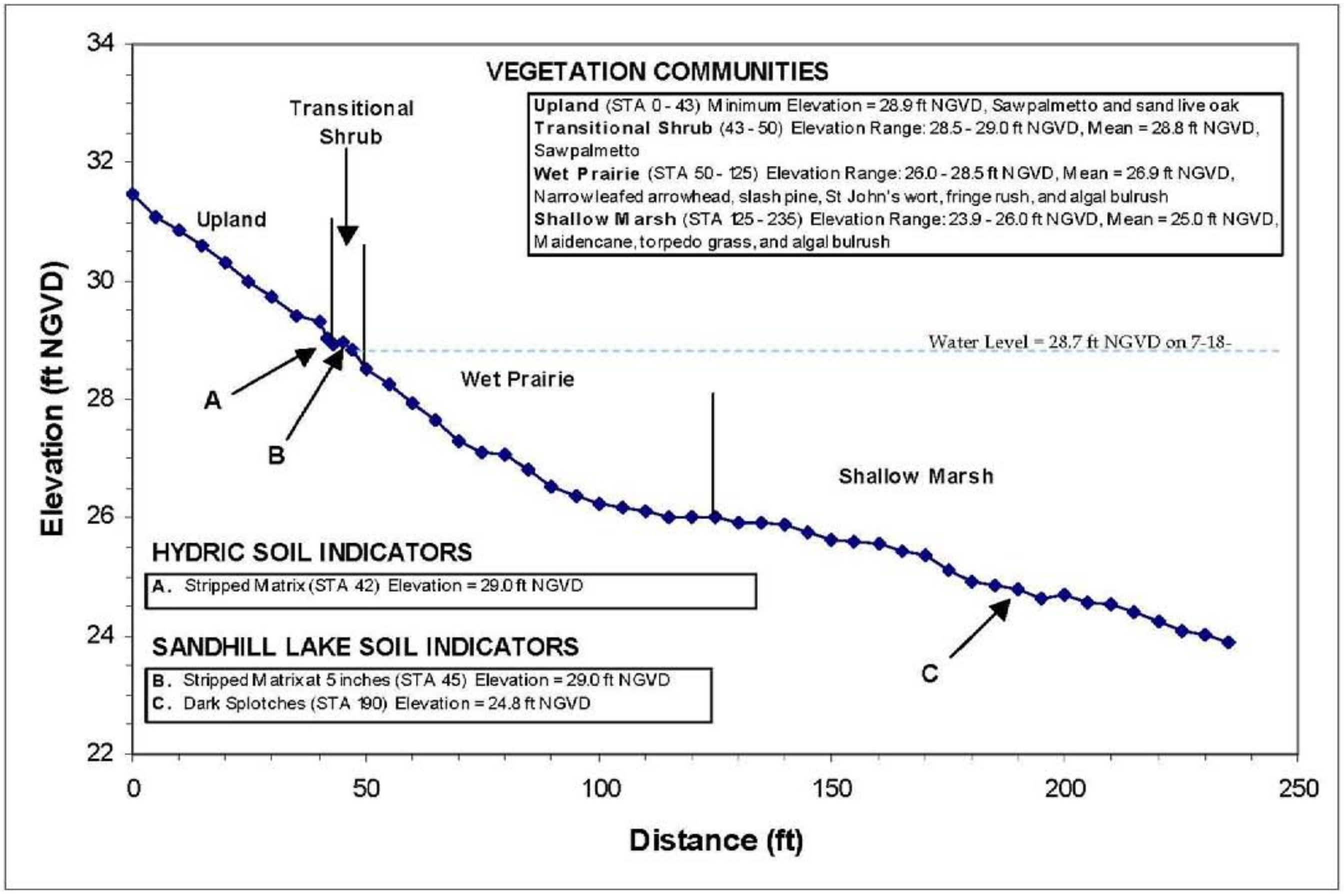

Figure 14. Transect B, Lake Colby – Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

Upland—looking upslope (NW) toward station 0 ft

Transitional shrub—looking downslope (SE) toward the wet prairie

Figure 15. Transect B photographs, Lake Colby

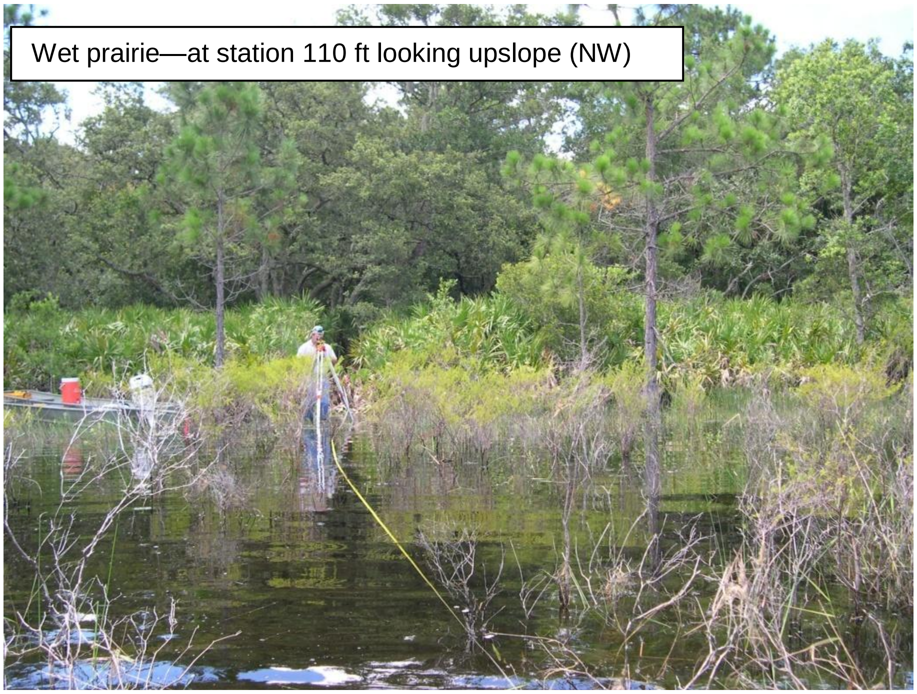

Figure 15. Transect B photographs, Lake Colby (cont.)

Table 8. Transect B vegetation species list, Lake Colby

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]			
			Upland (0–43 ft)	Transitional Shrub (43–50 ft)	Wet Prairie (50–125 ft)	Shallow Marsh (125–235 ft)
Fuirena scirpoidea	Fringe rush	OBL			2	1
Hypericum fasciculatum	St. John's wort	OBL			2	0
Ilex ambigua	Carolina holly	UPL	1			
Ilex cassine	Dahoon holly	OBL	1	1		
Ilex glabra	Gallberry	UPL	1			
Lachnanthes caroliniana	Redroot	FAC			1	
Lachnocaulon anceps	Bog buttons	FACW			1	
Lyonia lucida	Shiny lyonia	FACW	1	1		
Myrica cerifera	Wax myrtle	FAC		1	0	
Nymphaea odorata	Fragrant water lily	OBL				1
Nymphoides aquatica	Water bananas	OBL			0	1
Panicum hemitomon	Maidencane	OBL			1	2
Panicum repens	Torpedo grass	FACW			1	2
Pinus elliottii	Slash pine	UPL			2	
Pluchea rosea	Fleabane	FACW			1	0
Pteridium sp.	Bracken fern	UPL	1			
Quercus geminata	Sand live oak	UPL	3			
Quercus hemisphaerica	Laurel oak	UPL	2			
Quercus myrtifolia	Myrtle oak	UPL	1			
Rhynchospora tracyi	Striped beakrush	OBL			1	1
Sagittaria graminea	Narrow-leafed arrowhead	OBL			3	0
Serenoa repens	Saw palmetto	UPL	4	4		
Vaccinium elliotii	Mayberry	FAC	1			
Vitis rotundifolia	Muscadine grape	UPL	1			
Websteria confervoides	Algal bulrush	OBL			2	2
Xyris sp.	Yellow-eye grass	OBL			1	

[1]Species and hydric designations are taken from Ch. 62-340.450, *F.A.C.* Species not in the rule are assumed upland (UPL) unless they are obvious aquatics; unlisted aquatic species are designated as obligates (OBL).
[2]FWDM = *The Florida Wetlands Delineation Manual* indicator status (Gilbert et al. 1995)

UPL = Upland plants that rarely occur in wetlands, but almost always occur in uplands
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands
FACW = Facultative wet plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
OBL = Obligate plants that are found or achieve their greatest abundance in an area that is subject to surface water flooding and/or soil saturation; rarely in uplands

[3]Species Occurrence: Aerial extent of vegetation species along each transect within each community where,
0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 25–50% (abundant); 4 = 51–75% (co-dominant); 5 = >75% (dominant)

Table 9. Transect B soil feature elevations (ft NGVD), Lake Colby

Location	Station	Feature	Elevation (ft NGVD)
Hydric Soil Indicators			
Transect B	Station 42 ft	Stripped matrix	29.0
Sandhill Lake Soil Indicators			
Transect B	Station 45 ft	Stripped matrix at 5 in.	29.0
Transect B	Station 190 ft	Dark splotches	24.8

ft NGVD = feet National Geodetic Vertical Datum

Smyrna soil was identified in the upland community at station 20 ft on Transect B (JEA 2006, attached Appendix C). Smyrna soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996). This soil has an aquic moisture regime indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Smyrna soils are poorly drained to very poorly drained, with a water table at depths of less than 18 in. for 1 to 4 months during most years and between 12 in. and 40 in. for more than 6 months. During the rainy season, the water table may briefly rise above the soil surface. Depressional areas of Smyrna soils have a water table above the soil surface for 6 to 9 months or more in most years (USDA–NRCS 2005).

Sandhill lake soil indicators were identified at stations 45 ft and 190 ft at Transect B (JEA 2006, attached Appendix C). The sandhill lake soil indicator, stripped matrix, indicates an elevation that is exceeded by the lake stage approximately 20% of the time over the long term (Richardson et al. 2006) and was identified at station 45 ft (29.0 ft NGVD). A stripped matrix is a layer in which iron/manganese oxides and/or organic matter have been stripped from the matrix exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The stripped matrix sandhill lake soil indicator is identified at its waterward-most extent, where it begins 5 in. beneath the soil surface (Richardson et al. 2006). The sandhill lake soil indicator, dark splotches, indicates an elevation that is exceeded by the lake stage approximately 80% of the time over the long term (Richardson et al. 2006) and was identified at station 190 ft (24.8 ft NGVD). This indicator was identified at its landward extent, where there was just less than 3 in. of sand over a layer at least 3 in. thick, with 20% or more of the soil material having a Munsell soil color hue of 10YR, value 3 or less, and chroma 1 or less (see Munsell Soil Color Charts, Kollmorgen Corp. 1992).

The hydric soil indicator, stripped matrix, was identified at station 42 ft (29.0 ft NGVD) at Transect B (JEA 2006, attached Appendix C). The hydric soil indicator, stripped matrix, is a layer starting within 6 in. of the surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The hydric soil indicator stripped matrix, where it begins 6 in. beneath the soil surface (i.e., station 21 ft), is routinely used to delineate hydric soils throughout Florida (FAESS 2000) and, therefore, is generally near the wetland–upland interface. The occurrence of stripped matrix indicates a seasonal high saturation within 6 in. of the soil surface (FAESS 2000).

FIELD DATA—TRANSECT C

Transect C was established on the southeast shore of Lake Colby because this location had broad wet prairie and shallow marsh communities and was in the general location of original Transects 1, 5, and 6. Transect C extended 275 ft in a north-northeast direction (20°) and then an additional 125 ft in a westerly direction (280°) from uplands to open water (Table 10 and Figures 10 and 16). Figure 16 depicts sandhill lake soil indicators, the extent of hydric soils, elevation ranges, and dominant plant species for each vegetation community.

Table 10. Transect C location and fieldwork dates, Lake Colby

Latitude–Longitude (Station 0; upland)	Latitude–Longitude (Station 400; end shallow marsh)	Transect C—Location and Dates of Fieldwork
285746.04 – 811348.20	285748.71 – 811349.19	Southeast shore of Lake Colby, November 7 and 21, 2005

Vegetation at Transect C

Four vegetation communities were observed along Transect C: uplands; forested depression; wet prairie; and shallow marsh (Table 11 and Figures 16 and 17). The plant species and cover found in each community and *The Florida Wetlands Delineation Manual* (Gilbert et al. 1995) wetland indicator status are listed in Table 12. The upland community was located between stations 0 ft and 10 ft (31.0 ft and 30.5 ft NGVD, respectively) and contained abundant slash pine and catbrier. The forested depression community was located between stations 10 ft and 82 ft (30.5 ft and 28.7 ft NGVD, respectively) and contained abundant sweet gum, and scattered slash pine, laurel oak, wax myrtle, dahoon holly, catbrier, and highbush blueberry. The wet prairie was located between stations 82 ft and 173 ft (28.7 and 27.7 ft NGVD, respectively) and had abundant sand cordgrass and scattered water spangles. The shallow marsh community was located between stations 173 ft and 450 ft (27.7 ft and 23.0 ft NGVD, respectively) and contained co-dominant maidencane, abundant buttonbush, and scattered water spangles.

Soils at Transect C

Hydric soil indicators and sandhill lake soil indicators were identified at Transect C (Table 13). In addition, soil descriptions were made to a depth sufficient to identify the soils series at stations 5, 50, 120, and 250 ft along Transect C. Soils series were not identified beyond station 250 ft because the soils were too wet to enable descriptions to a sufficient depth.

Immokalee soil was identified in the upland and forested depression communities at stations 5 ft and 50 ft, respectively, on Transect C (JEA 2006, attached Appendix C). Immokalee soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996). This soil has an aquic moisture regime indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Immokalee soils are poorly drained to very poorly drained, with a water table at depths of 6–18 in. for 1 to 4 months during most years and between 12 in. and 40 in. for more than 6 months. Depressional areas of Immokalee soils have a water table above the soil surface for 6 to 9 months or more in most years (USDA–NRCS 2005).

Myakka soil was identified in the wet prairie at stations 120 ft on Transect C (JEA 2006, attached Appendix C). Myakka soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996).

Table 11. Transect C vegetation community elevation statistics, Lake Colby

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Upland	0–10	-	-	30.5	-	3
Forested depression	10–82	29.4	29.1	28.7	30.5	16
Wet prairie	82–173	28.3	28.5	27.5	28.8	20
Shallow marsh	173–450	25.4	25.7	23.0	27.7	57

ft NGVD = feet National Geodetic Vertical Datum
N = number of elevation readings surveyed in each vegetation community

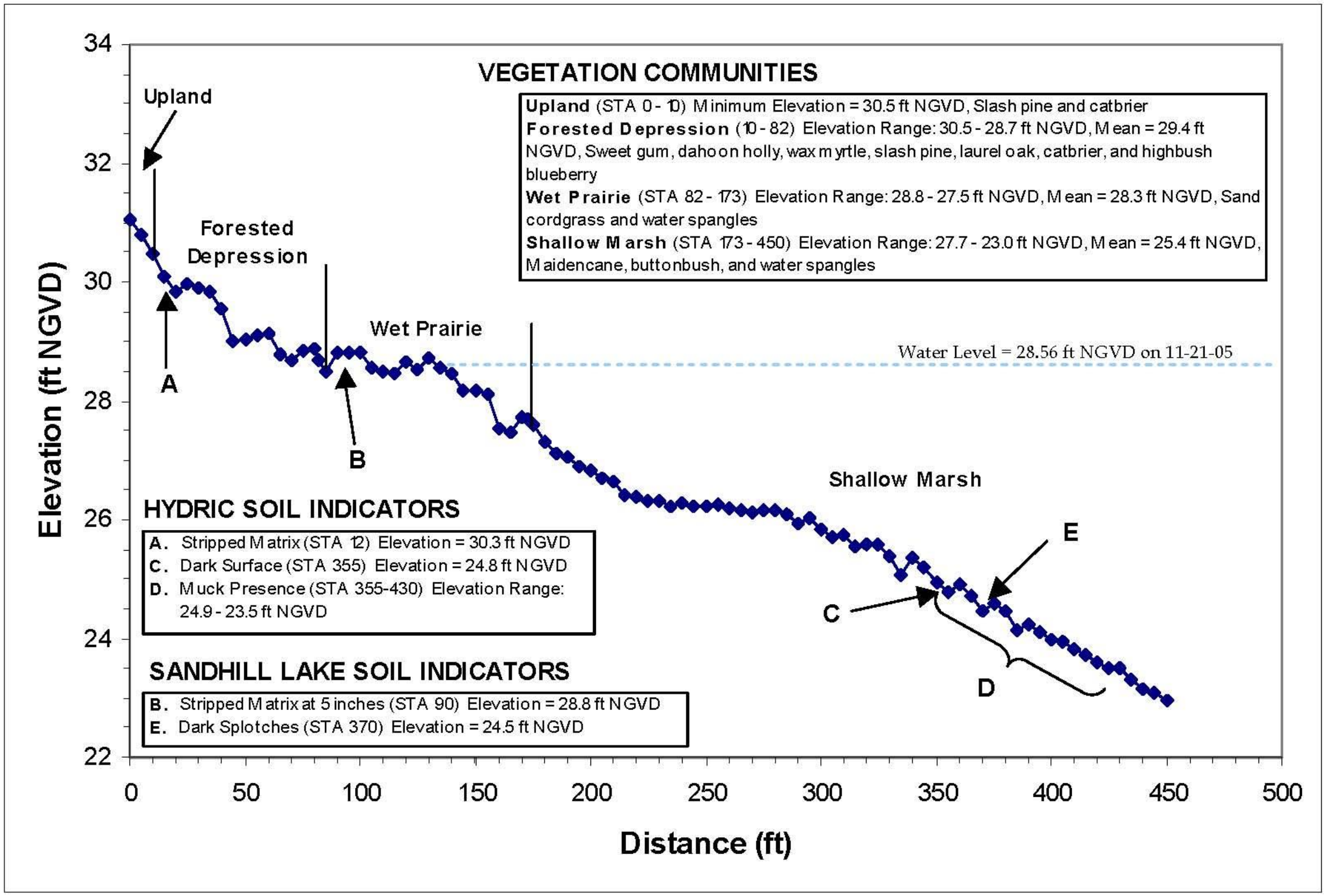

Figure 16. Transect C, Lake Colby – Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

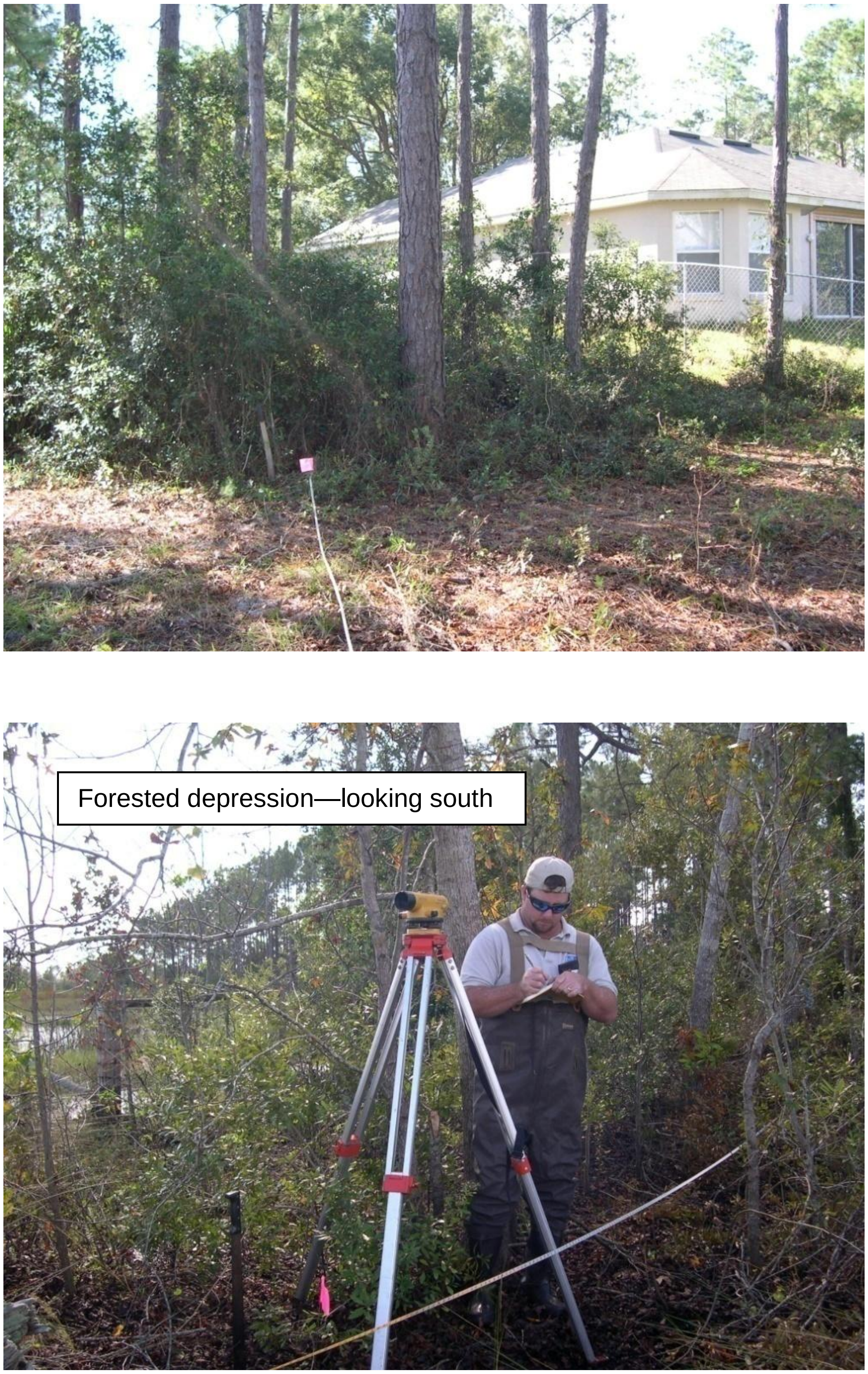

Figure 17. Transect C photographs, Lake Colby

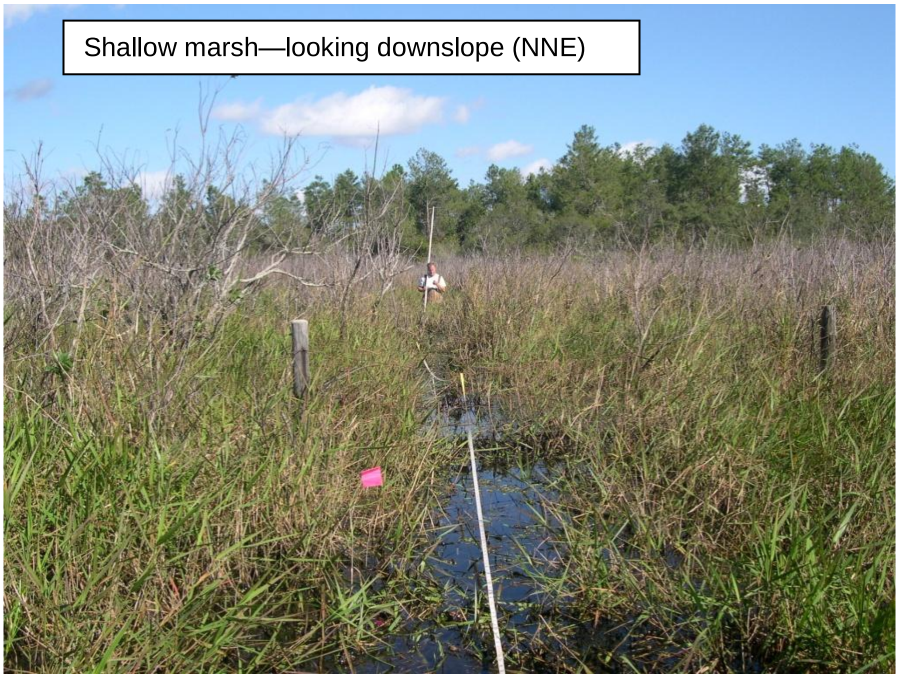

Figure 17. Transect C photographs, Lake Colby (cont.)

Table 12. Transect C vegetation species list, Lake Colby

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]			
			Upland (0–10 ft)	Forested Depression (10–82 ft)	Wet Prairie (82–173 ft)	Shallow Marsh (173–450 ft)
Amphicarpum muhlenbergianum	Blue maidencane	FACW	0	1		
Callicarpa americana	Beautyberry	UPL	0			
Cephalanthus occidentalis	Buttonbush	OBL			0	3
Cyperus haspan	Sheathed flatsedge	OBL			0	
Eupatorium capillifolium	Dog fennel	FAC	1			
Hydrocotyle umbellata	Umbrella pennywort	FACW			1	
Hypericum fasciculatum	St. John's wort	OBL			0	
Hypericum myrtifolium	St. John's wort	FACW	0	1		
Ilex cassine	Dahoon holly	OBL		2	0	
Ilex glabra	Gallberry	UPL	1			
Leersia hexandra	Southern cut grass	OBL			0	1
Lemna sp.	Duckweed	OBL			0	1
Liquidambar styraciflua	Sweet gum	FACW	1	3	1	
Ludwigia peruviana	Primrose willow	OBL			1	1
Lyonia lucida	Shiny lyonia	FACW		1	1	
Mikania scandens	Hempweed	UPL			1	1
Myrica cerifera	Wax myrtle	FAC		2	1	
Panicum ensifolium	Sword-leaf panic grass	OBL	1	0		
Panicum hemitomon	Maidencane	OBL			1	4
Paspalum notatum	Bahia grass	UPL	1	1		
Persea palustris	Swamp bay	OBL		1		
Pinus elliottii	Slash pine	UPL	3	2	0	
Pistia stratiotes	Water lettuce	OBL				0
Polygonum hirsutum	Jointweed	OBL			1	1
Pontederia cordata	Pickerelweed	OBL			0	1
Quercus geminata	Sand live oak	UPL	1			
Quercus laurifolia	Laurel oak	FACW	1	2		
Sabal minor	Dwarf palmetto	FACW			0	
Salvinia minima	Water spangles	OBL			2	2
Scirpus cubensis	Bulrush	OBL			0	1
Serenoa repens	Saw palmetto	UPL		1		
Smilax sp.	Catbrier	UPL	3	2	0	
Spartina bakeri	Sand cordgrass	FACW		0	3	0
Vaccinium corymbosum	Highbush blueberry	FACW		2		
Vaccinium myrsinites	Shiny blueberry	UPL	1	1		
Vitis rotundifolia	Muscadine grape	UPL	1	0	0	

Table 12—*continued*

[1]Species and hydric designations are taken from Ch. 62-340.450, *F.A.C.* Species not in the rule are assumed upland (UPL) unless they are obvious aquatics; unlisted aquatic species are designated as obligates (OBL).
[2]FWDM = *The Florida Wetlands Delineation Manual* indicator status (Gilbert et al. 1995)
UPL = Upland plants that rarely occur in wetlands, but almost always occur in uplands
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands
FACW = Facultative wet plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
OBL = Obligate plants that are found or achieve their greatest abundance in an area that is subject to surface water flooding and/or soil saturation; rarely in uplands
[3]Species Occurrence: Aerial extent of vegetation species along each transect within each community where,
0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 25–50% (abundant); 4 = 51–75% (co-dominant); 5 = >75% (dominant)

Table 13. Transect C soil feature elevations (ft NGVD), Lake Colby

Location	Station	Feature	Elevation (ft NGVD)
Hydric Soil Indicators			
Transect C	Station 12 ft	Stripped matrix	30.3
Transect C	Station 355 ft	Dark surface	24.8
Transect C	Stations 355–430 ft	Muck presence	24.8–23.5
Sandhill Lake Soil Indicators			
Transect C	Station 90 ft	Stripped matrix at 5 in.	28.8
Transect C	Station 370 ft	Dark splotches	24.5

ft NGVD = feet National Geodetic Vertical Datum

This (Myakka) soil has an aquic moisture regime indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Myakka soils are poorly drained to very poorly drained, with a water table at depths of less than 18 in. for 1 to 4 months during most years. The water table recedes to depths of more than 40 in. during very dry seasons. Depressional areas of Myakka soils are covered with standing water for 6 to 9 months or more in most years (USDA–NRCS 2005).

Valkaria soil was identified in the shallow marsh at station 250 ft on Transect C (JEA 2006, attached Appendix C). Valkaria soils are entisols, which have little or no evidence of soil formation. Entisols are either young soils or their parent material has not reacted to soil-forming factors (Brady and Weil 1996). This soil has an aquic moisture regime indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Valkaria soils have sandy soil material to a depth of at least 40 in. and a weakly developed spodic horizon that is neither thick enough nor dark enough to meet the criteria for a spodic horizon. Valkaria soils are poorly drained to very poorly drained, with a water table depth of 0–12 in. for 2 to 6 months during most years. During periods of extended rainfall, the water table is at the surface for a few days to 3 months. During the dry seasons, the water table may be as deep as 30 in. below the surface.

The sandhill lake soil indicator, stripped matrix, was identified at stations 90 ft, at Transect C (JEA 2006, attached Appendix C). The sandhill lake soil indicator, stripped matrix, indicates an elevation that is exceeded by the lake stage approximately 20% of the time, over the long term (Richardson et al. 2006), and was identified at station 90 ft (28.8 ft NGVD). A stripped matrix is a layer in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The stripped matrix sandhill lake soil indicator is identified at its waterward-most extent, where it begins 5 in. beneath the soil surface (Richardson et al. 2006). The sandhill lake soil indicator, dark splotches, indicates an elevation that is exceeded by the lake stage approximately 80% of the time over the long term (Richardson et al. 2006) and was identified at station 370 ft (24.5 ft NGVD). This indicator was identified at its landward extent, where there was just less than 3 in. of sand over a layer at least 3 in. thick, with 20% or more of the soil material having a Munsell soil color hue of 10YR, value 3 or less, and chroma 1 or less (see Munsell Soil Color Charts, Kollmorgen Corp. 1992).

The hydric soil indicator, stripped matrix, was identified at station 12 ft (30.3 ft NGVD) at Transect C (JEA 2006, attached Appendix C). The hydric soil indicator, stripped matrix, is a layer starting within 6 in. of the surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The hydric soil indicator, stripped matrix, where it begins 6 in. beneath the soil surface (i.e., station 12 ft), is routinely used to delineate hydric soils throughout Florida (FAESS 2000) and, therefore, is generally near the wetland-upland interface. A hydric soil indicator consisting of dark surface (USDA–NRCS 2002) was recorded at station 355 ft (24.8 ft NGVD). The hydric soil indicator, dark surface, is a layer 4 in. or thicker starting within the upper 6 in. of the soil surface that is predominately black. The matrix color value is 3 or less; chroma is 1 or less. At least 70% of the visible soil particles must be covered, coated, or similarly masked with organic material. The matrix color of the layer below the dark layer is chroma 2 or less (USDA–NRCS 2002). The occurrence of stripped matrix and dark surface indicate a seasonal high saturation within 6 in. of the soil surface (FAESS 2000). The hydric soil indicator, muck presence, was identified between stations 355–430 ft (24.9 ft and 23.5 ft NGVD, respectively) at Transect C. Muck presence is a layer of muck of any thickness that occurs within the upper 6 in. of the soil surface and contains a color value 3 or less and chroma 1 or less (USDA–NRCS

2002). The occurrence of muck presence indicates a seasonal high saturation at the surface or inundation above the soil surface (FAESS 2000).

FIELD DATA—TRANSECT D

Transect D was established on the south shore of Lake Colby, primarily because this location had wet prairie and shallow marsh communities and was in the general location of original Transects 3 and 4. Transect D extended 400 ft in a northerly direction (357°) from uplands to open water (Table 14 and Figures 10 and 18). Figure 18 depicts sandhill lake soil indicators, the extent of hydric soils, elevation ranges, and dominant plant species for each vegetation community.

Table 14. Transect D location and fieldwork dates, Lake Colby

Latitude–Longitude (Station 0; upland)	Latitude–Longitude (Station 400; end shallow marsh)	Transect D—Location and Dates of Fieldwork
285747.01 – 811401.21	285748.68 – 811347.86	South shore of Lake Colby, November 7 and 21, 2005

Vegetation at Transect D

Five vegetation communities were observed along Transect D: uplands; wet prairie 1; shallow marsh 1; wet prairie 2; and shallow marsh 2 (Table 15, Figure 18, and Figure 19). The plant species and cover found in each community and *The Florida Wetlands Delineation Manual* (Gilbert et al. 1995) wetland indicator status are listed in Table 16. The upland community was located between stations 0 ft and 15 ft (30.7 ft and 28.9 ft NGVD, respectively) and had abundant sand live oak and scattered sword-leaf panic grass. The first wet prairie community was located between stations 15 ft and 50 ft (28.9 ft and 27.2 ft NGVD, respectively) and contained scattered maidencane, pickerelweed, beakrush, bulrush, water hyacinth, and water spangles. The first shallow marsh was located between stations 50 ft and 165 ft (27.2 ft and 26.5 ft NGVD, respectively) and contained co-dominant buttonbush, abundant water lettuce and hempweed, and scattered maidencane, primrose willow, water spangles, water hyacinth, and water lettuce. The second wet prairie community was located between stations 165 ft and 225 ft (26.5 ft and 27.4 ft NGVD, respectively) and contained abundant water hyacinth and scattered sand cordgrass, and water spangles. The second shallow marsh community was located between stations 225 ft and 400 ft (27.4 ft and 23.2 ft NGVD, respectively) and contained abundant Carolina willow, hempweed, and water spangles.

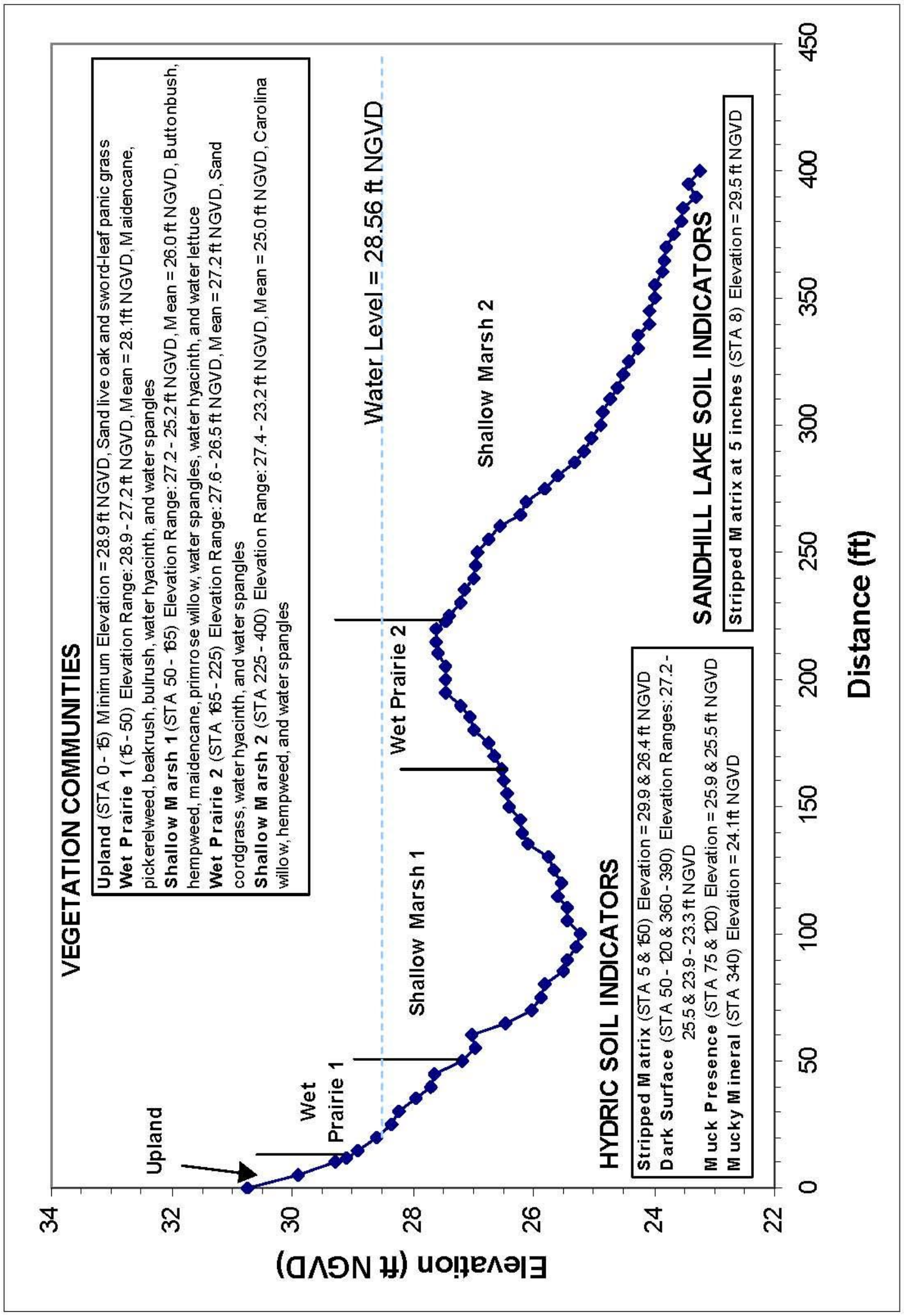

Figure 18. Transect D, Lake Colby – Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

Table 15. Transect D vegetation community elevation statistics, Lake Colby

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Upland	0–15	-	-	28.9	-	4
Wet prairie 1	15–50	28.1	28.1	27.2	28.9	8
Shallow marsh 1	50–165	26.0	26.0	25.2	27.2	24
Wet prairie 2	165–225	27.2	27.4	26.5	27.6	13
Shallow marsh 2	225–400	25.0	24.7	23.2	27.4	36
Combined wet prairie	15–50 and 165–225	27.5	27.5	26.5	28.9	21
Combined shallow marsh	50–165 and 225–400	25.4	25.5	23.2	27.4	60

ft NGVD = feet National Geodetic Vertical Datum
N = number of elevation readings surveyed in each vegetation community

Soils at Transect D

Hydric soil indicators and sandhill lake soil indicators were identified at Transect D (Table 17). In addition, soil descriptions were made to a depth sufficient to identify the soil series at stations 5 ft, 50 ft, and 190 ft along Transect D. Soil series were not identified beyond station 190 ft because the soils were too wet to enable descriptions to a sufficient depth.

Myakka soils were identified in the upland and wet prairie 2 communities at stations 5 ft and 190 ft, respectively, on Transect D (JEA 2006, attached Appendix C). Myakka soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996). This soil has an aquic moisture regime indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Myakka soils are poorly drained to very poorly drained, with a water table at depths of less than 18 in. for 1 to 4 months during most years.

The water table recedes to depths of more than 40 in. during very dry seasons. Depressional areas of Myakka soils are covered with standing water for 6 to 9 months or more in most years (USDA–NRCS 2005).

Immokalee soil was identified in wet prairie 1 at station 50 ft, on Transect D (JEA 2006, attached Appendix C). Immokalee soils are spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum, with or without iron oxides (Brady and Weil 1996). This soil has an aquic

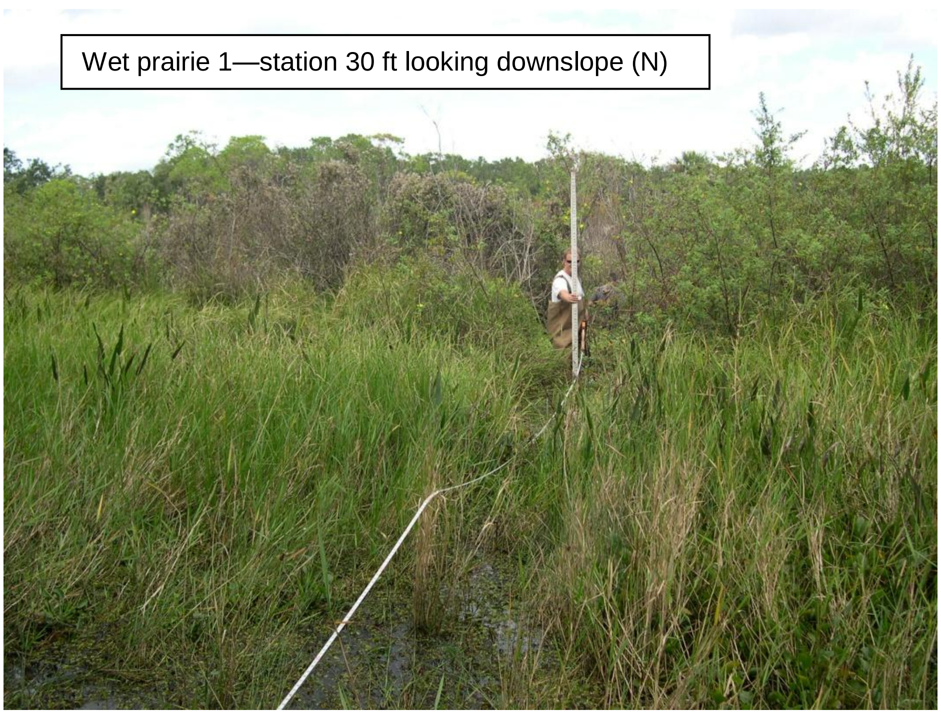

Figure 19. Transect D photographs, Lake Colby

Figure 19. Transect D photographs, Lake Colby (cont.)

Table 16. Transect D vegetation species list, Lake Colby

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]				
			Upland (0-15 ft)	Wet Prairie (15-50 ft)	Shallow Marsh (50-165 ft)	Wet Prairie (165-225 ft)	Shallow Marsh (225-400 ft)
Alternanthera philoxeroides	Alligator weed	OBL		0			
Andropogon virginicus	Broomsedge	FAC	1				
Cephalanthus occidentalis	Buttonbush	OBL			4	1	1
Eichhornia crassipes	Water hyacinth	OBL		2	2	3	0
Eriocaulon compressum	Pipewort	OBL		1			
Hydrocotyle umbellata	Umbrella pennywort	FACW	0	1			
Ludwigia peruviana	Primrose willow	OBL		0	2	1	0
Luziola fluitans	Watergrass	OBL					0
Mikania scandens	Hempweed	UPL		0	3	1	3
Panicum ensifolium	Sword-leaf Panic Grass	OBL	2				
Panicum hemitomon	Maidencane	OBL		2	2	1	1
Pistia stratiotes	Water lettuce	OBL			3	1	1
Polygonum hirsutum	Jointweed	OBL		1		1	
Pontederia cordata	Pickerelweed	OBL		2	0	1	
Quercus geminata	Sand live oak	UPL	3				
Rhynchospora microcephala	Beakrush	FACW	0	2			
Sabal palmetto	Cabbage palm	FAC				0	
Sacciolepis striata	American cupscale	OBL		1			
Sagittaria subulata	Awl-leaf arrowhead	OBL		0			
Salix caroliniana	Carolina willow	OBL			1	1	3
Salvinia minima	Water spangles	OBL		2	2	2	3
Scirpus cubensis	Bulrush	OBL		2	0		0

Table 16—*Continued*

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]				
			Upland (0-15 ft)	Wet Prairie (15-50 ft)	Shallow Marsh (50-165 ft)	Wet Prairie (165-225 ft)	Shallow Marsh (225-400 ft)
Spartina bakeri	Sand cordgrass	FACW				2	
Xyris sp.	Yelloweye-grass	OBL	0	1			

[1]Species and hydric designations are taken from Ch. 62-340.450, *F.A.C.* Species not in the rule are assumed upland (UPL) unless they are obvious aquatics; unlisted species are designated as obligates (OBL).
[2]Florida Wetlands Delineation Manual (FWDM) Wetland Indicator Status (Gilbert et al. 1995)
UPL = Upland plants that rarely occur in wetlands, but almost always occur in uplands.
FAC = Facultative plants with similar likelihood of occurring in both wetlands and uplands.
FACW = Facultative wet plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in
OBL = Obligate plants that are found or achieve their greatest abundance in an area that is subject to surface water flooding and/or soil saturation; rarely in up
[3]Species Occurrence: Aerial extent of vegetation species along each transect within each community where,
0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 25–50% (abundant); 4 = 51–75% (co-dominant);
5 = >75% (dominant).

Table 17. Transect D soil feature elevations (ft NGVD), Lake Colby

Location	Station	Feature	Elevation (ft NGVD)
Hydric Soil Indicators			
Transect D	Stations 5 and 150 ft	Stripped matrix	29.9 and 26.4
Transect D	Stations 50–120 ft Stations 360–390 ft	Dark surface	27.2–25.5 23.9–23.3
Transect D	Stations 75– ~135 ft	Muck presence	25.9–26.1
Transect D	Stations 340 ft	Mucky mineral	24.1
Sandhill Lake Soil Indicators			
Transect D	Station 8 ft	Stripped matrix at 5 in.	29.5

ft NGVD = feet National Geodetic Vertical Datum

moisture regime, indicating that the soils are saturated with water and virtually free of gaseous oxygen for sufficient periods for poor aeration to occur (Brady and Weil 1996). Immokalee soils are poorly drained to very poorly drained, with a water table at depths of 6–18 in. for 1 to 4 months during most years and between 12 in. and 40 in. for more than 6 months. Depressional areas of Immokalee soils have a water table above the soil surface for 6 to 9 months or more in most years (USDA–NRCS 2005).

The sandhill lake soil indicator, stripped matrix was identified at station 8 ft (29.5 ft NGVD) at Transect D (JEA 2006, attached Appendix C), and indicates an elevation that is exceeded by the lake stage approximately 20% of the time over the long term (Richardson et al. 2006). A stripped matrix is a layer in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The stripped matrix sandhill lake soil indicator is identified at its waterward-most extent, where it begins 5 in. beneath the soil surface (Richardson et al. 2006). No sandhill lake soil indicator of low water levels (i.e., dark splotches or less than 3 in. of sand over a degrading spodic or loamy/clayey layer) was observed along Transect D.

The hydric soil indicator, stripped matrix, was identified at stations 5 ft and 150 ft (29.9 and 26.4 ft NGVD, respectively) at Transect D (JEA 2006, attached Appendix C). The hydric soil indicator, stripped matrix, is a layer starting within 6 in. of the surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials and forming a diffuse splotchy pattern of two or more colors. The hydric soil indicator, stripped matrix, where it begins 6 in. beneath the soil surface (i.e., station 21 ft), is routinely used to delineate hydric soils throughout Florida (FAESS 2000) and, therefore, is generally near the wetland-upland interface. Stripped matrix indicates a seasonal high saturation within 6 in. of the soil surface (FAESS 2000). The hydric soil indicator, dark surface, was identified at stations 50–120 ft (elevation range: 27.2–25.5 ft NGVD) and 360–390 ft (elevation range: 23.9 ft and 23.3 ft NGVD) at Transect D. Dark surface is a layer 4 in. or thicker starting within the upper 6 in. of the soil surface that is predominately black. At least 70% of the visible soil particles must be covered, coated, or similarly masked with organic material (USDA–NRCS 2002). Dark surface indicates a seasonal high saturation within 6 in. of the soil surface (FAESS 2000). The hydric soil indicator, muck presence, was identified at stations 75 ft and 135 ft (25.9 ft and 26.1 ft NGVD, respectively) at Transect D. Muck presence is a layer of muck of any thickness that occurs within the upper 6 in. of the soil surface, with color value 3 or less and chroma 1 or less (USDA–NRCS 2002). Muck presence indicates a seasonal high saturation at the surface or inundation above the soil surface (FAESS 2000). The hydric soil indicator, mucky mineral, was identified at station 340 ft (24.1 ft NGVD) at Transect D. Mucky mineral is a surface layer at least 2 in. thick, starting within 6 in. of the soil surface (USDA–NRCS 2002). The occurrence of mucky mineral indicates a seasonal high saturation at the surface or inundation above the soil surface (FAESS 2000).

ADDITIONAL FIELD DATA

Additional field data were collected at multiple locations for the reevaluation of MFLs at Lake Colby (Table 18). Transects A, B, C, and D were located on long slopes resulting in poor resolution of sandhill lake soil indicators. In addition, indications of groundwater seepage (i.e., raised saw palmetto rhizomes and hydric soil indicators upslope of the lakes fluctuation range) were evident at Transects A, B, C, and D; therefore, sandhill lake soil indicators were identified on a steep shoreline along the east shore of Lake Colby (JEA 2006), where seepage was less pronounced (Figure 10). The sandhill lake soil indicators, stripped matrix and dark splotches (described previously), along Lake Colby’s east shore were identified at elevations of 28.0 ft and 23.6 ft NGVD, respectively. Elevation data were also collected at the waterward extent of shallow marsh vegetation at 10 locations around Lake Colby, with maximum-, mean- and minimum elevations of 23.4 ft, 23.1 ft, and 23.0 ft NGVD, respectively. Further topographic and vegetation data were collected across a deep marsh community south of Transect B on Giddings Lake, because no deep marsh communities were observed on Lake Colby (Figure 10). The deep marsh was dominated by fragrant water lily with maximum-, mean-, and minimum elevations of 22.9 ft, 22.7 ft, and 21.9 ft NGVD, respectively.

STRUCTURAL ALTERATIONS AND OTHER CHANGES

The Lake Colby drainage basin has undergone major urbanization. The lake's drainage basin area is approximately 410 acres. Based upon 2004 land use (SJRWMD 2004), the watershed contains approximately 197 acres (48%) of low- and medium-density residential development, with impervious surfaces associated with residences, driveways, roadbeds, etc. Additionally, the naturally occurring interconnections of Lake Colby with upstream and downstream lakes have been improved, although the precise timing of these improvements is unknown. The increased development and drainage improvements between the lake basins have likely caused water levels in the lake to rise more rapidly during rainfall events as compared with predevelopment conditions.

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

MINIMUM LEVELS DETERMINATION CRITERIA

Two minimum levels with associated durations and return intervals are recommended. A short description of the criteria applied to determine these minimum levels is presented. Important ecological structures and functions protected by the minimum levels are also discussed.

Soils and vegetation community field-collected data are the principle components of each MFLs determination. Standardized procedures for setting each level by using the best available information are described in the draft Minimum Flows and Levels Methods Manual (SJRWMD 2006b). Criteria vary depending upon the level being determined and the on-site wetland community characteristics. For example, the primary criterion for a level may be the average or extreme (high or low) elevation associated with a vegetation community, or soil indicator, based on the scientific literature and hydrologic data.

Vegetation data and associated elevation statistics were the primary criteria applied to determine the recommended minimum levels for Lake Colby. Vegetation communities lie along a continuum from dry (upland) to very wet (deep marsh) and were used, together with published literature concerning the hydrology and functions of individual communities, to determine the recommended minimum levels. Sandhill lake soil indicators and hydric soil indicators identified at each transect and surface water inundation/dewatering signatures (SWIDS, Neubauer et al. 2006) were used as supporting information.

Table 18. Additional field data collection locations and fieldwork dates, Lake Colby

Description	Latitude–Longitude	Location and Date
Sandhill lake soil indicator–Stripped Matrix at 5 in.	285754.05 – 811349.39	East shore of Lake Colby, July 14, 2005
Sandhill lake soil indicator–Dark Splotches	285753.55 – 811349.66	East shore of Lake Colby, July 14, 2005
Begin deep marsh–north edge of water lilies	285758.55 – 811342.51	Northwest lobe of Giddings Lake, July 18, 2005
End deep marsh–south edge of water lilies	285757.24 – 811341.94	Northwest lobe of Giddings Lake, July 18, 2005
Waterward shallow marsh–maidencane	285750.30 – 811348.42	East shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285753.56 – 811352.95	East shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285759.58 – 811358.39	Northeast shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285755.30 – 811400.49	North shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285752.25 – 811401.23	Northwest shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285751.47 – 811359.69	West shore of Lake Colby, November 21, 2005
Waterward shallow marsh–maidencane	285748.87 – 811359.81	West shore of Lake Colby, November 21, 2005
Waterward shallow marsh–American cupscale grass	285741.89 – 811359.48	Southwest shore of Lake Colby, November 21, 2005

Sandhill lake soil indicators are being developed to provide consistent hydrologic indicators to aid in the determination of MFLs at sandhill lakes. Vegetation at sandhill lakes may be an unreliable indicator of hydrology since the extent and composition of herbaceous vegetation may change in response to water level fluctuations. However, where sandhill lakes have stable vegetation communities, such as at Lake Colby, then hydrologic interpretations based on vegetation are reasonable. Soil characteristics within a lake's fluctuation range develop as a result of long-term hydrologic conditions and persist through wet and dry cycles (FAESS 2000) and can be used as reliable indicators of historic hydrology (Richardson et al. 2006).

The minimum frequent high level and minimum frequent low level, based on existing conditions at systems throughout SJRWMD, have consistently been determined at elevations with approximate stage exceedences of 20% and 80%, respectively. Unique soil morphologies were identified at sandhill lakes within SJRWMD, near the 20% and 80% stage exceedences and were termed frequent high (FH) and frequent low (FL) sandhill lake soil indicators, respectively (Richardson et al. 2006). The FH sandhill lake soil indicator, stripped matrix, beginning 5 in. beneath the soil surface, was found to be the most reliable indicator of 20% stage exceedence (Richardson et al. 2006). The FL sandhill lake soil indicator, dark splotches, was found to be the most reliable indicator of 80% stage exceedence (Richardson et al. 2006). The FL sandhill lake soil indicator, 3 in. of sand over a degrading spodic horizon or loamy/clayey horizon (i.e., degrading spodic), was found to be a good indicator of 80% stage exceedence, but needed further investigation due to the small sample size (n = 5, SJRWMD 2006b)

A stripped matrix is a soil layer in which iron/manganese oxides and/or organic matter have been stripped from the soil matrix, exposing the primary base color of the soil material (USDA–NRCS 2002). The stripped areas are generally rounded and result in splotchy coated and uncoated soil areas (USDA–NRCS 2002). Dark splotches is identified by the accumulation of organic coatings on the mineral soil particles into a darker layer within the soil matrix. The thickness, color, and depth of this dark layer are the keys to its identification. Degrading spodic is identified where there is 3 in. of sand over a degrading spodic horizon or loamy/clayey horizon. For specific details regarding identification of sandhill lake soil indicators, see Richardson et al. (2006).

The FH and FL sandhill lake soil indicators, stripped matrix, dark splotches, and the other unique soil morphologies identified by Richardson et al. (2006), represent historic hydrology and, thus, cannot directly be applied as minimum levels. MFLs must consider existing changes and structural alterations to watersheds, surface waters, and aquifers (Section 373.042(1)(a) and (b), F.S.), and nonconsumptive uses, including navigation, recreation, fish and wildlife habitat, and other natural resource values (Section 62-40.473, *F.A.C.*). Therefore, an offset is required to convert the elevations identified via sandhill lake soil indicators to minimum levels. The offsets for the sandhill lake soil indicators are currently being developed in cooperation with the University of Florida's Soil and Water Science Department, and Jones, Edmunds and Associates Inc. Sandhill lake soil indicators can only be used to support a minimum levels determination until the offsets have been developed and thoroughly reviewed.

The MFLs are also supported by current surface water inundation dewatering signatures (SWIDS) analysis. Frequency analysis of long-term stage data or modeled stage data is utilized to provide probabilities of flooding/dewatering events of a set duration (i.e., SWIDS). The probabilities are interpreted as return intervals (Gordon et al. 1992). For example, if a 30-day flooding event of an elevation of interest (e.g., maximum elevation of shallow marsh) had a probability of exceedence of 33%, then the event is interpreted as occurring approximately 33 in 100 years, or a 1:3 year return interval, on average. This approach enables like communities from systems at different elevations to be compared and results in quantitative hydrologic signatures of specific elevations (e.g., mean-, minimum-, and maximum elevation of a vegetation community, Neubauer et al. 2006). Quantitatively defining the hydrologic signatures of vegetation communities provides a hydrologic range for each vegetation community, with a transition to a drier community on one side of the range and a transition to a wetter community on the other side. These hydrologic signatures provide a target for MFLs determinations based on vegetation communities and provide an estimate of how much the return interval of a flooding or dewatering event can be shifted and still maintain a vegetation community within its observed hydrologic range.

MINIMUM LEVELS REEVALUATION FOR LAKE COLBY

Minimum Frequent High Level (27.6 ft NGVD)

The recommended minimum frequent high elevation component for Lake Colby is 27.6 ft NGVD. The minimum frequent high level is defined as "… a chronically high surface water level or flow with an associated frequency and duration that allows for inundation of the floodplain at a depth and duration sufficient to maintain wetlands functions" (Rule 40C-8.021(7), *F.A.C.*). Based on results from multiple water bodies, SJRWMD estimates that minimum frequent high level events recur, on average, at least once every 3 years for 30 or more consecutive days. Hydrologic model results (Figure 5) support the recommended minimum frequent high level with a return interval of once every 3 years, on average (i.e., 33 events in 100 years), and a duration of 30 consecutive days (Robison 2006).

The recommended minimum frequent high elevation component is equivalent to the mean elevation of the wet prairie communities on Transects A, B, C, and D (27.6 ft NGVD, Table 19). The wet prairies had similar maximum elevations (28.3 ft, 28.5 ft, 28.8 ft, and 28.9 ft NGVD, Transects A, B, C, and D, respectively), but the minimum elevations were more variable (27.2 ft, 26.0 ft, 27.5 ft, and 26.5 ft NGVD, respectively). The variability among the maximum elevations likely arises from slight differences in seepage and slope. The variability among the minimum wet prairie elevations is likely due to diverse vegetation at each transect and differences in gradient. The wet prairie located on Transect B extended lower than the surface water control elevation (~26.5 ft NGVD) between Lake Colby and Giddings Lake, but hydrology of the lakes appears to remain similar even when they do not maintain a surface connection. This assumption is supported by a comparison of the mean and minimum elevations of the shallow marsh communities among transects where seepage has less influence due to more frequent flooding (Tables 4, 8, 12, and 16). Differences among maximum and minimum elevations of similar communities typically suggest dissimilar hydrologic conditions driving the extent of the communities. With regard to the minimum wet prairie elevations, the differences are thought to represent the dynamic nature of this community type. Therefore, all four

Transects (A, B, C, and D) were utilized to calculate descriptive statistics for each community (Table 19).

Table 19. Combined transect summary statistics, Lake Colby

Transects	Feature	Mean of Means (ft NGVD)	Mean of Minimums (ft NGVD)	Mean of Maximums (ft NGVD)	N
A, B, C, and D	Upland	-	29.6	-	4
A, B, C, and D	Wet prairie	27.6	26.8	28.6	4
A, B, C, and D	Shallow marsh	25.2	23.3	27.1	4
Point-shots and A, B, C, and D	Shallow marsh	-	23.1	-	14

ft NGVD = feet National Geodetic Vertical Datum
N = number of elevation readings surveyed in each vegetation community

Transect data from the original MFLs determination (attached Appendix A) were not included because the six transects completed during the original MFLs determination were collated into a single composite transect, thus preventing exact separation of the wet prairie communities by transect. Therefore, Transects C and D were established to collect data in similar areas as the original fieldwork. Transect C was established in the same general location as Transects 1, 5, and 6, and Transect D was established in the same general location as Transect 3 and 4.

The recommended minimum frequent high elevation component is supported by the FH sandhill lake soil indicator, stripped matrix, observed on the east shore of Lake Colby (28.0 ft NGVD). Development and application of an offset will likely reduce the difference between this indicator and the minimum frequent high level. The FH sandhill lake soil indicator on Transects A, B, C, and D were not included in this calculation because each of these transects is affected by groundwater seepage, as indicated by the saw palmetto rhizomes above the ground surface and the presence of the hydric soil indicator, stripped matrix, at or above the lake’s maximum fluctuation range. In addition, Transects A, B, C, and D were on long slopes, which tend to display poor resolution of sandhill lake soil indicators, thereby reducing their accurate identification (Richardson et al. 2006).

The recommended minimum frequent high level is also supported by current SWIDS analysis of wetland vegetation communities (Neubauer et al. 2006). SWIDS analysis of 12 wet prairies shows that the median hydrologic signature for the mean elevation of wet prairies will flood for 30 continuous days, with an approximate return interval of 1:1.7 years, on average, with a range of 1:1.3 to 1:3.9 years. The return interval associated with the minimum frequent high level (1:3 years) lies within and near the dry end of the hydrologic range observed for wet prairie communities at other systems, allowing for some hydrologic shift and maintaining a natural hydrologic signature for the wet prairie community.

Frequency analysis of the modeled stage data shows that the recommended minimum frequent high level will be exceeded for 30 continuous days with an approximate return interval of 1:1.8 years, on average, under 2003 modeled hydrologic conditions (Robison 2006). The duration and return intervals show that the hydrologic requirements of the recommended minimum frequent high level are met under the 2003 hydrologic conditions and that this minimum level would allow for some additional consumptive use.

The wet prairie community on Transect A, B, C, and D had 1.1 ft, 2.5 ft, 1.3 ft, and 2.4 ft ranges in elevation (27.2–28.3 ft NGVD, 26.0–28.5 ft NGVD, 27.5–28.8 ft NGVD, and 26.5–28.9 ft NGVD, respectively). Kinser (1996) reported that wet prairies are inundated for a relatively short duration each year but are subject to prolonged soil saturation. Studies by Duever et al. (1984), ESE Inc. (1991), and Brown and Starnes (1983) have shown that wet prairies have various hydroperiods, from 32 to 200 days. These hydrologic studies of wet prairies address duration of flooding, but do not quantitatively address the magnitude or return interval of flooding. Although these studies provide an incomplete picture of the hydrology associated with wet prairie communities, they clearly show that wet prairies tolerate a wide hydroperiod. The recommended minimum frequent high elevation component of 27.6 ft NGVD allows for a varied hydroperiod across the range of this community.

Due to the short hydroperiod that wet prairies experience, this community type is the most species-rich of Florida’s marshes, containing a variety of grasses, sedges, and flowering forbs (Kushlan 1990). Wet prairie species have considerable tolerance to both flooding and drying. Many of the shallowly rooted species typical of wet prairies (i.e., St. John’s wort) are killed by drying, but reseed readily. As a result, the zone of dominance of individual species within the wet prairie migrates up- and downslope in response to fluctuating water conditions (Kushlan 1990). Higher wet prairies may, under some conditions, be invaded by saw palmetto. Environmental characteristics of wet prairies include a hydroperiod shorter than 6 months, low accumulation of organic matter (i.e., a few inches or nonexistent), and a fire frequency of more than one per decade (Kushlan 1990).

The recommended minimum frequent high level provides inundation or saturation within the wet prairie communities at Lake Colby for a frequency and duration that is intended to prevent permanent upland encroachment and sufficient to maintain the spatial extent of this community. Longer duration and more frequent inundation, as compared to the recommended minimum frequent high level, occur in the marsh communities downslope from the wet prairie communities. The longer duration and more frequent inundation in the marsh communities are sufficient to support the obligate and facultative wetland plant species within and the spatial extent and functions of the marsh communities. This level also allows sufficient water depths for fish and other aquatic organisms to feed and spawn on the lake floodplain. Bain (1990) and Poff et al. (1997) have reported that connecting the lake and floodplain are extremely important to animal productivity in the lower coastal plain. Similar benefits likely result from flooding the marsh and transitional communities at Lake Colby. As water levels rise, the amount of structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light et al. 1998). In addition to providing additional aquatic habitat, the floodplain marshes may improve water quality by functioning as filters and sinks for dissolved and suspended constituents, as found with river floodplains (Wharton et al. 1982).

The recommended minimum frequent high elevation component of 27.6 ft NGVD provides 2.4 ft of water over the combined mean elevation of the shallow marsh communities on Transects A, B, C, and D (25.2 ft NGVD, Table 19). The recommended minimum frequent high elevation component also provides approximately 1.1 ft of water over the hydraulic control between Lake Colby and Giddings Lake, 4.9 ft of water over the observed mean elevation of the deep marsh community on Giddings Lake (22.7 ft NGVD), and will inundate or saturate portions of the wet prairie communities on both lakes.

Occasional higher water levels would be necessary to establish a surface water connection with Sand Lakes downstream. The recommended minimum frequent high elevation component is 0.4 ft lower than the hydraulic control between Lake Colby and the culvert outlet. A surface connection between the lakes would allow genetic mixing between populations and reintroduction of species potentially extirpated during severe but infrequent drought conditions.

Minimum Frequent Low Level (22.9 ft NGVD)

The recommended minimum frequent low level for Lake Colby is 22.9 ft NGVD with an associated duration of 120 days and return interval of once every 3 years, on average. The minimum frequent low level is defined as "… a chronically low surface water level or flow that generally occurs only during periods of reduced rainfall. This level is intended to prevent deleterious effects to the composition and structure of the floodplain soils, the species composition and structure of floodplain and instream biotic communities, and the linkage of aquatic and floodplain food webs" (40C-8.021 (10); *F.A.C.).* Relative to the deep marsh community surveyed, the minimum frequent low level should not be dewatered for more than 120 consecutive days more often than once every 3 years, on average (i.e., 20 events in 100 years). When surface water is absent during moderate droughts, the water table is near the surface. Hydrologic model results (Figure 7) support the recommended minimum frequent low level, with a duration of 120 consecutive days and a return interval of once every 3 years, on average (Robison 2006).

The recommended minimum frequent low elevation component is equivalent to the maximum elevation of the deep marsh community observed on Transect B (22.9 ft NGVD). The deep marsh was dominated by fragrant water lilies, which require inundation to complete their life cycle (Ware 2002). It has also been observed that the bulk of water lily populations occur below an inundation frequency of 88% (Hagenbuck et al. 1974). Water lilies are intolerant of severe drought because the horizontal rhizomes quickly dry and rot (Conti and Gunther 1984), though recovery via the seedbank can occur, as the seeds can persist for more than 2.5 years if kept wet.

The recommended minimum frequent low level will likely allow some mortality of rooted, floating-leaved vegetation near the maximum elevation of the deep marsh, but these areas will recover during higher water levels. This water level limits the aquatic habitat to the main lake bodies while maintaining a diverse aquatic flora and fauna and providing foraging habitats for a variety of animals that utilize the dry portions on the lake, floodplain, or basin.

The recommended minimum frequent low elevation component is supported by water table drawdowns for vegetation communities reported in the literature, by vegetation communities and sandhill lake soil indicators observed at Lake Colby and Giddings Lake, and by current SWIDS analysis of deep marsh communities. The recommended minimum frequent low elevation component (22.9 ft NGVD) results in a 27.6-in. drawdown from the grand mean elevation of the shallow marshes observed on Transects A, B, C, and D (25.2 ft NGVD, Table 19). This drawdown is within the range reported by ESE Inc. (1991), who calculated an average minimum dry-season water table depth of 53 cm ± 13.5 cm (–20.9 in. ± 5.3 in.) based upon field data reported from the scientific literature for 29 seasonally flooded freshwater marshes. The minimum frequent low level should sufficiently protect the shallow marshes observed at Lake Colby and Giddings Lake since the drawdown within the shallow marsh, enabled by this level, is within the range observed for numerous systems.

Dewatering the shallow marsh is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils to germinate (Van der Valk 1981). Exposing the floodplain of Lake Colby for suitable durations should maintain healthy and diverse floodplain communities.

The waterward extent of emergent vegetation observed at Lake Colby (23.1 ft NGVD, Table 19) also supports the recommended minimum frequent low level. Emergent vegetation typically grades into floating-leaved species common to deep marshes, though none were present at Lake Colby. The minimum frequent low elevation component is generally near the maximum elevation range of deep marsh communities, indicating that an elevation slightly less than 23.1 ft NGVD is reasonable for the minimum frequent low elevation component.

The recommended minimum frequent low level may also be supported by the FL sandhill lake soil indicator, dark splotches, observed on the east shore of Lake Colby (23.9 ft NGVD). Development and application of an offset will likely reduce the difference between this indicator and the minimum frequent low level. The FL sandhill lake soil indicators on Transects A and B were not included in this calculation because each of these transects is affected by groundwater seepage, indicated by the saw palmetto rhizomes above the ground surface and the presence of the hydric soil indicator, stripped matrix, at or above the lake’s maximum fluctuation range. In addition, Transects A and B were on long slopes, which tend to display poor resolution of sandhill lake soil indicators, reducing their accurate identification (Richardson et al. 2006). No FL sandhill lake soil indicator was observed on Transects C or D.

The recommended minimum frequent low level is further supported by current SWIDS analysis of deep marsh communities. This level allows dewatering of the maximum elevation of the deep marsh community for 120 days every 3 years, on average, over the long term. SWIDS analysis of 20 deep marsh communities shows that the median signature for the maximum elevation of deep marsh communities is dewatered, on average, for 120 continuous days approximately 1:5.6 years, with a range of approximately 1:1.1 to less frequent than 1:100 years (Neubauer et al. 2006). The duration and return intervals associated with the recommended minimum frequent low levels are of the range observed for deep marsh communities at other systems. The recommended duration and return intervals allow for some hydrologic shift and maintain a natural hydrologic signature for the deep marsh community.

Frequency analysis of the modeled stage data shows that the recommended minimum frequent low level will be dewatered, on average, for 120 continuous days with an approximate return interval of 1:5 years under 2003 modeled hydrologic conditions (Robison 2006). The duration and return intervals show that the hydrologic requirements of the recommended minimum frequent low level are met under 2003 conditions and that a small amount of additional water may be available for consumptive use.

CONCLUSIONS AND RECOMMENDATIONS

The intent of the establishment of minimum levels for Lake Colby in Volusia County is to protect the aquatic and wetland ecosystems from significant ecological harm caused by the consumptive use of water. In addition, MFLs provide technical support to SJRWMD in the regional water supply planning process and in the consumptive use permitting program (Chapter 40C-2, *F.A.C.*). Recent completion of a hydrologic model for Lake Colby indicated that the adopted minimum average and minimum frequent low levels for Lake Colby (Hupalo 1996, attached Appendix A) were not being met under 2003 modeled hydrologic conditions (Robison 2006). Consequently, a reevaluation of the adopted levels was performed. This reevaluation has resulted in the recommendation to modify the adopted MFLs for Lake Colby (Table 20) based on current SJRWMD MFLs methodology (SJRWMD 2006b).

Table 20. Adopted (Hupalo 1996, Appendix A) and recommended minimum surface water levels for Lake Colby, Volusia County

Minimum Levels	Adopted Elevation (ft NGVD) 1929 Datum	Adopted Hydroperiod Categories	Recommended Elevation (ft NGVD) 1929 Datum	Recommended Duration	Recommended Return Interval
Minimum frequent high level	28.3	Seasonally flooded	27.6	30 days	3 years
Minimum average level	26.6	Typically saturated	none	none	None
Minimum frequent low level	25.2	Semi-permanently flooded	22.9	120 days	3 years

ft NGVD = feet National Geodetic Vertical Datum

The minimum lake levels presented within this report were determined with SJRWMD's multiple MFLs methodology (SJRWMD 2006b). MFLs determinations are based on evaluations of topographic, soils, and vegetation data collected within plant communities associated with the water body, together with information collected from other aquatic ecosystems and from the scientific literature.

The recommended minimum frequent high elevation component for Lake Colby, 27.6 ft NGVD, is 0.7 ft lower than the adopted minimum frequent high elevation component 28.3 ft NGVD. The same criterion, mean elevation of wet prairie communities, was utilized for the determination of the adopted and recommended minimum frequent high level. The difference likely arises from the determination of the average elevation for the wet prairie community from multiple transects (i.e., utilization of all data points within a community for each transect to generate an average elevation versus averaging the mean elevation of the community from each transect to generate a grand mean); the use of transects in different locations; and from individual differences in estimating the upper and lower boundaries of a plant community. The first explanation is likely the primary cause of the difference because review of the original transects and vegetation notes reveals that Transects 1 to 4 contain a wet prairie community. Transect 3 does not traverse the wet prairie at its peak, which results in an elevation skewed toward a low value (26.9 ft NGVD); therefore, Transect 3 was excluded from this explanation. The grand mean elevation of the wet prairie from Transects 1, 2, and 4 from the original fieldwork is 27.9 ft NGVD and gives equal weight to each transect. The mean elevation generated from all data points on Transects 1, 2, and 4 is 28.3 ft NGVD and gives more weight to transects with more data points.

Transect data from the original MFLs determination (attached Appendix A) were not included because the six transects completed during the original MFLs determination were collated into a single composite transect, thus preventing exact separation of the wet prairie communities by transect. Therefore, Transects C and D were established to collect data in similar areas as the original fieldwork. Transect C was established in the same general location as Transects 1, 5, and 6, and Transect D was established in the same general location as Transect 3 and 4.

It is recommended that the minimum frequent high elevation, 27.6 ft NGVD, be flooded, on average, at least once every 3 years (i.e., 33 flooding events in 100 years) for a duration of at least 30 consecutive days. This flooding signature is based on current surface water inundation/dewatering signature (SWIDS) analysis and is slightly wetter than the driest flooding signature observed for wet prairie communities at other systems. Since the minimum frequent high level maintains a hydrologic signature within the range observed for wet prairies, this minimum level is intended to maintain the location, structure, and function of this community. This minimum level allows for some change, which will likely be expressed in a change in species abundance, species composition, and potentially some shift in the extent of the wet prairie community at its extreme (maximum/minimum) elevations. A further hydrologic shift caused by withdrawals that exceed MFLs will likely result in significant harm via conversion of the upper portion of the wet prairie to a drier plant community and alteration of the community’s structure and function at its extreme elevations.

The adopted minimum average elevation component is 26.6 ft NGVD and is equivalent to the mean elevation of the emergent marsh communities (Hupalo 1996, attached Appendix A). No minimum average level is recommended for Lake Colby. This is because Lake Colby is a sandhill lake. Based on the conceptual model of sandhill lakes developed by CH2M HILL (2005), sandhill upland lakes are astatic and lack a mean around which the system is organized. CH2M HILL (2005) also suggests that critical system behaviors of sandhill lakes may be related most strongly to high- and low water levels corresponding to drought cycles and multidecadal climate cycles and that both high- and low water levels are necessary to maintain expected ecosystem structure and function. Therefore, only minimum frequent high and minimum frequent low levels are recommended for Lake Colby.

The recommended minimum frequent low elevation component for Lake Colby (22.9 ft NGVD) is 2.3 ft lower than the adopted minimum frequent low elevation component (25.2 ft NGVD), because a different minimum frequent low level criterion, maximum elevation of deep marsh, was applied. The adopted minimum frequent low elevation component for Lake Colby was equivalent to a 20-in. drawdown from the mean elevation of emergent marsh. This criterion is commonly used to determine the minimum frequent low elevation component when seasonally flooded marshes or soils with more than 8 in. of organic matter are identified. The 20-in. factor was calculated as the mean of the range of dry-season water table depths reported by the NRCS for many organic soils within the SJRWMD (e.g., USDA–SCS 1974 and 1980). These soils are reported to have typical dry-season, low water table depths of between –10 in. and –30 in. (–0.83 ft and –2.50 ft). In addition, ESE Inc. (1991) calculated an average minimum dry-season water table depth of 53 cm ± 13.5 cm (20.9 in. ± 5.3 in.) based upon field data reported from the scientific literature for 29 seasonally flooded freshwater marshes.

The recommended minimum frequent low elevation component allows a 27.6-in. drawdown from the grand mean of the shallow marsh communities observed on Transects A, B, C, and D. This shallow marsh drawdown is on the dry side, but within the range observed for numerous seasonally flooded freshwater marshes (ESE 1991). Lake Colby has widely fluctuating water levels and very little accumulation of organic matter, as is common to many sandhill lakes; thus, a drawdown of 27.6 in. from the mean shallow marsh elevation should protect the structure and functions of the shallow marsh community.

The recommended minimum frequent low level allows the maximum elevation of the deep marsh to be dewatered, on average, for 120 continuous days every 3 years. This dewatering signature is wetter than the driest deep marsh, based on current SWIDS analysis, but drier than approximately 75% of the 20 systems analyzed (Neubauer et al. 2006). The driest deep marsh, based on SWIDS analysis, was not dominated by floating-leafed vegetation and would be expected to have a drier hydrologic signature than a deep marsh dominated by water lilies. Since the minimum frequent low level maintains a hydrologic signature within the range observed for deep marshes, this minimum level is intended to maintain the location, structure, and function of this community. This minimum level allows for some change, which will likely be expressed in a change in species abundance, species composition, and potentially some shift in the extent of the community at its extreme (maximum/minimum) elevations. A further hydrologic shift caused by withdrawals that exceed MFLs will likely result in significant harm via conversion of the upper portion of the deep marsh to a drier community and alteration of the structure and function at the extreme elevations within this community.

SJRWMD concludes that the recommended minimum frequent high and minimum frequent low levels should protect Lake Colby from significant ecological harm caused by the consumptive use of water. This conclusion is based upon the field-data collection effort, subsequent data analyzed, and the hydrologic modeling effort, showing that the recommended minimum frequent high and minimum frequent low levels are protected under 2003 modeled hydrologic conditions. Frequency analysis of the modeled stage data also shows that only a small amount of additional water is available for consumptive use from Lake Colby, based on the recommended minimum frequent low level.

The hydrologic model for Lake Colby was calibrated for 2003 conditions. These conditions included the most recent land use information and groundwater levels consistent with 2003 regional water use (Robison 2006). Based on hydrologic model results, SJRWMD concludes that the recommended MFLs for Lake Colby are protected under 2003 conditions. To determine if changes in groundwater use allocations subsequent to 2003 would cause lake levels to fall below the recommended MFLs for Lake Colby, the existing Lake Colby hydrologic model should be run using Floridan aquifer potentiometric level declines that reflect these changes in water use allocation.

Periodic reassessment of these levels is recommended to ensure that these levels are maintained and that they do prevent significant ecological harm from occurring at Lake Colby. Reassessments will include periodic monitoring of the vegetation communities and the soil water table at the Lake Colby transects to ensure these areas are protected. In addition, stage data from Lake Colby will be analyzed periodically to ensure that there is no, unexpected great change in the hydrologic conditions. Results presented in this report are preliminary and will not become effective unless the recommended MFLs are adopted by SJRWMD Governing Board rule.

Information included in the attached Appendix D concerning use of the hydrologic model and applicable SJRWMD regional groundwater flow model should be utilized to assess whether water levels are likely to fall below MFLs under specific water use and land use conditions.

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APPENDIX A

**Minimum Surface Water Levels
Determined for Lake Colby, Volusia County**

by

Richard Hupalo

January 5, 1996

MEMORANDUM **FOR 94-1514**

==

DATE: January 5, 1996

TO: Jeff Elledge, P.E., Director
Department of Resource Management

THROUGH: Charles A. Padera, Director
Department of Water Resources

Edgar Lowe, Ph.D, Director
Environmental Sciences Division

Greenville Hall, Ph.D, Technical Program Manager
Environmental Sciences Division

Clifford P. Neubauer, Ph.D, Supervising Environmental Specialist
Environmental Sciences Division

FROM: Ric Hupalo, Environmental Specialist IV
Environmental Sciences Division

RE: Minimum Surface Water Levels determined for Lake Colby, Volusia County
(Project # 01-43-5140-DIST-10009)

The purpose of this memorandum is to forward recommended minimum lake levels and hydroperiod categories (Table 1) determined for Lake Colby to the Department of Resource Management. Lake Colby was selected for investigation to comply with the Minimum Flows and Levels Sierra Club Defense Fund Agreement.

Table 1. Recommended minimum lake levels for Lake Colby. Terminology is defined in 40C-8.021, F.A.C.

MINIMUM LEVEL	ELEVATION (ft NGVD)	HYDROPERIOD CATEGORY
Minimum frequent high level	28.3	Seasonally flooded
Minimum average level	26.6	Typically saturated
Minimum frequent low Level	25.2	Semipermanently flooded

Lake Colby is located in the Crescent City-DeLand Ridge Physiographic Division of the Central Lakes District. This region consists of a deep layer of Plio-Pleistocene sand and shell that rests directly on the Floridan aquifer. The Central Lakes District is the region most active in collapsed sink hole development and is the principle recharge area of the Floridan aquifer (Brooks 1982). Lake Colby is located on the east side of Cassadaga, 5 miles east of Orange City (Figure 1). A city park and public boat ramp are located on the western shore of the lake.

Hydrology and Lake Morphometry
A daily record of water levels exists from January 1990 (Figure 2). The mean lake level for the period of record is 24.26 ft NGVD. A fluctuation range of 9.36 feet has occurred since 1990, the maximum recorded stage (29.32 ft NGVD) occurred in October 1995 and the recorded minimum (19.96 ft NGVD) occurred in March 1991. In a recent report on Lake Macy, Adkins (1995) plotted rainfall, observed stages, and simulated stages for several lakes, including Lake Colby (Figure 3). Adkins (1995) observed that trends in stage are in general agreement among these lakes and he concluded that low stages (at Lake Macy) were a result of low rainfall in the region. Lake Colby has recovered from recorded lows and is now near a typical seasonal high water level as judged by vegetative indicators. The water level of Lake Colby was 28.26 ft NGVD on the day that fieldwork was completed (December 12, 1995).

The lake consists of a complex of basins that connect by canals (elevations unknown) to two small adjacent water bodies (Figure 4). In addition, the lake is connected at higher lake levels (elevation unknown) by a system of aquatic beds and ponds to Giddings Lake (Figures 1 and 4). The open water area of the main lake body is 40 acres when the lake level is approximately 27 ft NGVD. A charting fathometer was used to record the bottom topography of the main lake basin on east-west and north-south bearings. The most frequently recorded depths ranged from 12–13 ft, i.e., bottom elevations of

16–15 ft NGVD. Therefore, during the height of the drought the lake was only 4–5 ft deep. Lake Colby may at times receive surface water inflow from Lake Macy via a stream channel (Figure 1). A rating curve or the elevation at which flow occurs is not reported by Adkins (1995).

Only one dock was observed to occur on the lake, having a deck elevation of 29.8 ft NGVD and extending waterward to 26.1 ft NGVD. Permitted water use (CUP 2-127-0855AUV) in land sections adjacent to Lake Colby is from the Floridan aquifer for household and utility uses and totals 16.06 mgy (personal communication, Nancy Tatum). A hydrologic model for Lake Colby is not available.

Hydric Soils

Hydric soils (33 acres) at Lake Colby occur in narrow bands along the lake shoreline and in elongated depressions between Lake Colby and adjacent water bodies (Figure 5). These areas were vegetated primarily by sand cordgrass or maidencane grass. The Volusia County Soil Survey (SCS 1980) delineated the soil at these areas as Myakka fine sand, depressional (MU-33). This is a poorly drained, fine sand soil that is located in depressions. It is commonly ponded for 6 to 9 months in most years. Transects 1, 2, 3, and 4 crossed areas mapped as MU-33 (Figure 1). Areas at Lake Colby that were delineated as MU-33 may include some mapping errors. This is likely due to the complex topography that is not perceivable from aerial photography. Much of the area mapped as MU-33 is inundated too deeply to fit the SCS hydrologic description of 2 to 6 inch ponding depths for 7 to 30 days. Secondly, the vegetation was dominated by obligate and fac-wet species and this does not fit the SCS description. The wet prairie community (described below) most closely fits the vegetative community in the SCS description.

Wetlands

Wetlands were classified by the U.S. Fish and Wildlife Service (now U.S. Biological Service, USBS) Wetland Inventory in 1987 using 1983 CIR aerial photography (Figure 6). The wetland classification type is: Lacustrine Littoral Aquatic Bed Rooted Vascular Permanently Flooded (L2AB3H). Aerial photography (Figure 4) from 1943, 1981, and 1988 indicate that these wetlands have not been permanently flooded, that semi-permanently flooded more closely describes their hydrology.

Vegetation and elevation data from six short transects were combined to represent the elevation range surveyed (Figure 7). Figure 1 shows the locations of these transects. The higher areas classified by USBS as aquatic beds were dominated by emergent marsh species such as maidencane grass or sand cordgrass. These occurred on a mucky sand substrate. Dispersed throughout the area were buttonbush, climbing hemp-weed, southern cutgrass, or pickeralweed. Waterward, in the lake littoral zone, were maidencane grass, southern cutgrass, and spatter-dock. Landward of the emergent marsh was a transitional zone of wet prairie and shrubland. Vegetation was predominantly sand cordgrass, wax myrtle and blue maidencane. Uplands at the lake shore rose steeply to live oak hammock. Summary elevation data and the dominant vegetation are listed on the composite transect in Figure 7. Scientific plant names are provided in Table 2.

The recommended minimum levels for Lake Colby are based upon consideration of elevation/vegetation transects and spot elevations conducted by ES staff and Division of Surveying Services staff (Dale Becker), information contained in the SCS soil survey and the USBS Wetland Inventory. Three levels with corresponding hydroperiod categories are recommended. A short description of the functions of each minimum level and some of the related data used in the determination follows.

MINIMUM FREQUENT HIGH LEVEL
The recommended minimum frequent high level is 28.3 ft NGVD with an associated hydroperiod category of seasonally flooded. This water level and hydroperiod category maintains the spatial extent of marshes and wet prairie. The water level 28.3 ft NGVD floods the sand cordgrass and blue maidencane dominated wet prairie, to the average elevation of this transitional zone (Table 2). The transition zone above 28.3 ft NGVD gradually changes in plant composition, from dominantly sand cordgrass and blue maidencane, to include goldenrod, dahoon holly, wax myrtle, and sweetgum. Water depths within this transitional shoreline zone are consistent with the ponding description of the MU-33 soil. Frequent, prolonged flooding to this level provides the water depths for fish and other aquatic organisms to feed or spawn on the marshes. Average water depths of approximately 1.5 feet occur in the emergent marshes and 4.6 ft in the aquatic beds, providing habitat for fish and other aquatic species. The water level is 1.5 ft below the only dock deck that was observed.

MINIMUM AVERAGE LEVEL
The recommended minimum average level is 26.6 ft NGVD with an associated hydroperiod category of typically saturated. This recommended minimum level is based on field indicators of frequent standing water. These indicators are centered around the average elevation of the emergent marsh community. The water level (26.6 ft NGVD) was calculated by subtracting 0.25 ft from the median elevation (26.86 ft NGVD) of the emergent marsh. This maintains, on average, an anaerobic, saturated soil condition on the marsh. Coincidentally, the USGS topo map (1966, photorevised 1980) shows the water surface of the lake as 27 ft NGVD.

The recommended minimum level limits the oxidation of organics and retards invasion of wetlands by upland plant species. The recommended minimum average level provides an average water depth of 3 ft in the aquatic bed wetlands. The water depth at the surveyed dock is 0.5 ft at this recommended minimum level.

MINIMUM FREQUENT LOW LEVEL
The recommended minimum frequent low level (FL) is 25.2 ft NGVD with an associated hydroperiod category of semipermanently flooded. This level recognizes that occasional drawdown conditions are necessary for marshes to stimulate decomposition and promote seed germination. This recommended level was based on the mean elevation of the emergent marsh (26.86 ft NGVD) minus 1.7 feet. We have used this formula on several other lakes where maidencane marshes occur. The aquatic beds of southern cutgrass and maidencane will on

average be flooded by 1.3 ft of water. The marshes of maidencane, buttonbush, and willow will be exposed. Declining water levels in the seasonally flooded wetlands and upper portions of the aquatic beds will provide ideal foraging habitat for wading birds. Great Egrets need water depths less than 0.8 ft and the small herons need depths less than 0.5 ft to forage efficiently when water levels are receding (Bancroft et al. 1990, p. 139). The water table of Myakka fine sand, depressional soil may drop to a depth of 2 to 3 feet in prolonged dry periods (SCS 1980). Using the average elevation of the wet prairie as a surrogate for the elevation of this soil, the recommended frequent low level is 3.1 ft below the mean elevation (28.26 ft NGVD) of the wet prairie.

Table 2. Plant species encountered at Lake Colby

SPECIES	COMMON NAME	CATG
Amphicarpum muhlenbergianum	blue-maidencane	FACW
Andropogon virginicus	broomsedge	UPL
Baccharis halimifolia	eastern baccaris	FAC
Cephalanthus occidentalis	buttonbush	OBL
Eupatorium leptophyllum	fennel	FAC+
Ilex cassine	dahoon holly	FACW
Leersia hexandra	southern cutgrass	OBL
Liquidambar styraciflua	sweetgum	FAC+
Mikania scandens	climbing hemp-weed	FACW+
Myrica cerifera	wax myrtle	FAC+
Nuphar luteum	spatter-dock	OBL
Panicum hemitomon	maidencane	OBL
Pontederia cordata	pickeralweed	OBL
Quercus virginiana	virginia live oak	UPL
Rubus betulifolius	blackberry	FAC
Sabal palmetto	cabbage palm	FAC
Sacciolepsis striata	bag-grass	OBL
Salix caroliniana	coastal plain willow	OBL
Salvini rotundifolia	common salvinia	OBL
Serenoa repens	saw palmetto	UPL
Solidago fistulosa	pinebarren goldenrod	FAC+
Spartina bakeri	sand cordgrass	FACW+
Typha latifolia	cattail	OBL

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Please call me (ext. 4338), Cliff Neubauer (4343), or Jane Mace (4389), if you wish to discuss these minimum levels or hydroperiod definitions.

RH:kkm

attachments

c:	Wayne Flowers	Tommy Walters	Hal Wilkening	Larry Battoe
	Jane Mace	Dave Clapp	Price Robison	Bob Freeman
	Larry Fayard	Chris Sweazy	Sandy McGee	MFL-REG

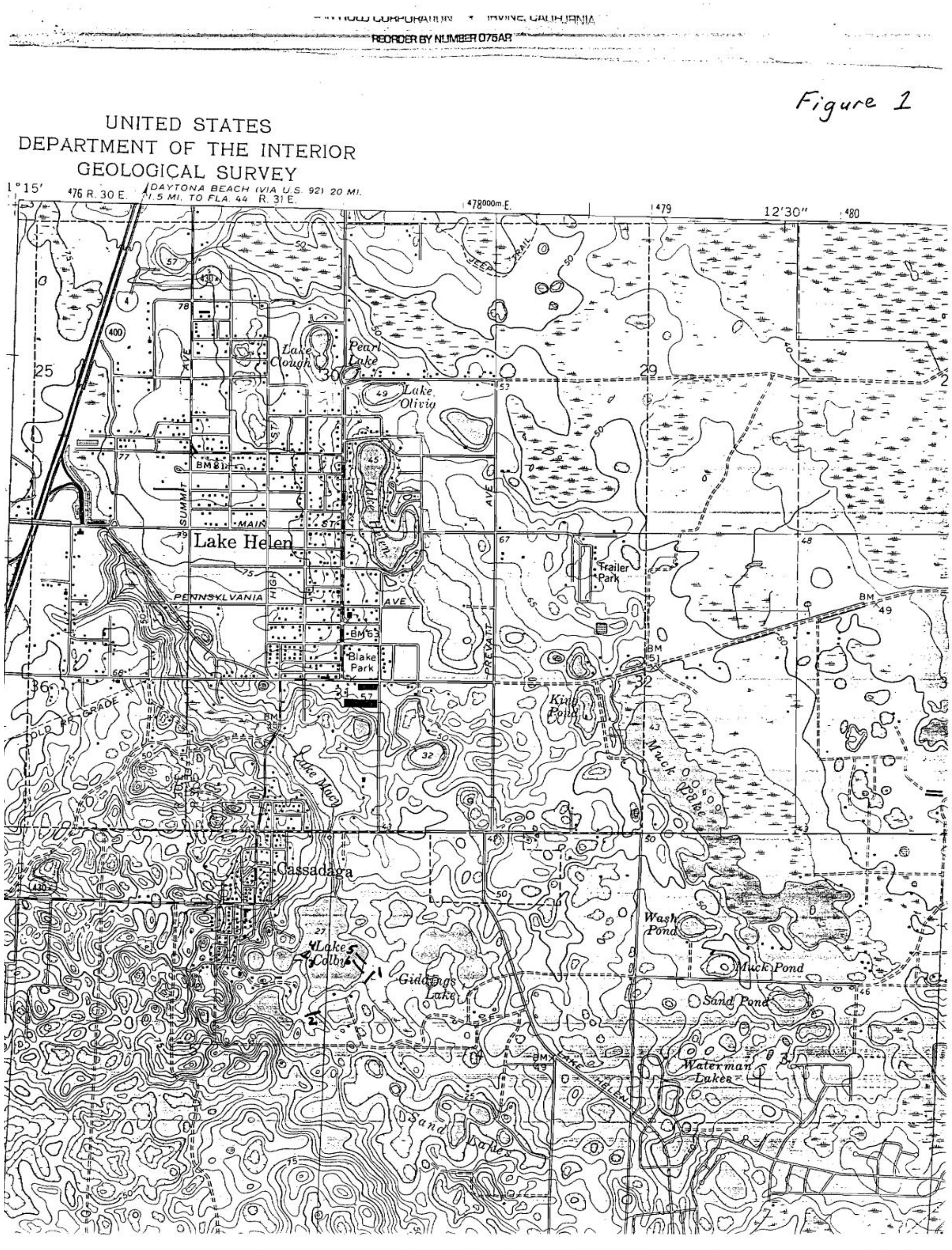

REORDER BY NUMBER 075AR
Figure 1
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
DAYTONA BEACH (VIA U.S. 92) 20 MI.
R. 30 E.
R. 31 E.
12'30"
Lake Clough
Pearl Lake
Lake Olivia
Lake Helen
Trailer Park
PENNSYLVANIA
AVE
MAIN
SUMMIT
Blake Park
King Pond
Muck Lake
Lake Macy
Cassadaga
Lake Colby
Giddings Lake
Wash Pond
Muck Pond
Sand Pond
Waterman Lakes
Sand Lakes
OLD RR GRADE

Figure 2

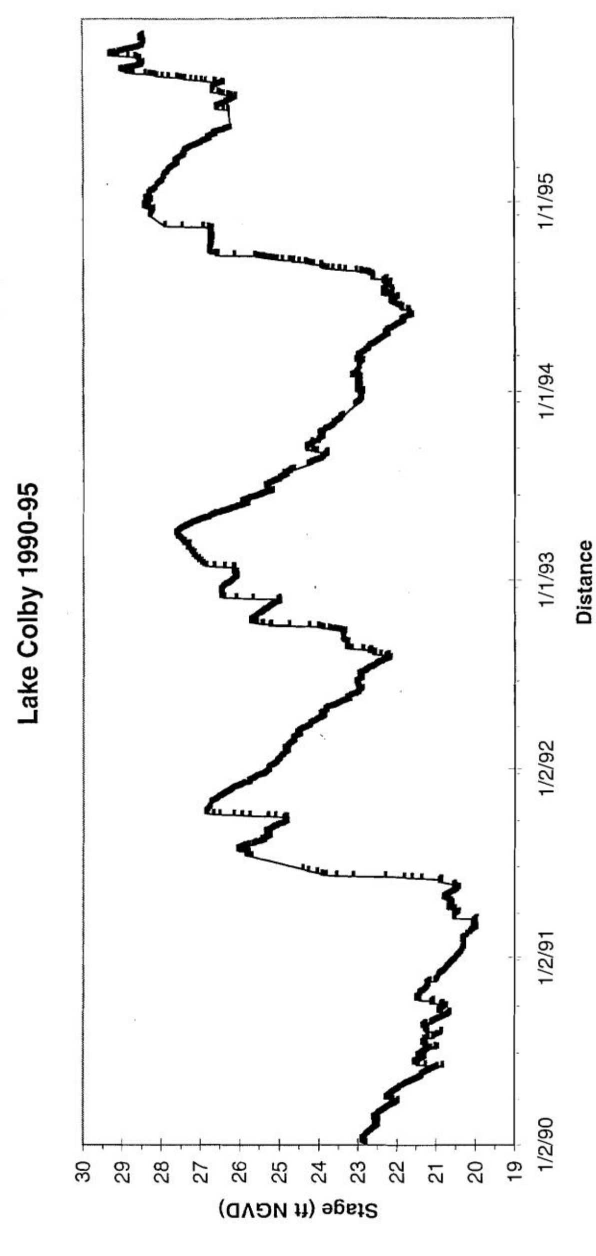

Lake Colby 1990-95
Stage (ft NGVD)
30
29
28
27
26
25
24
23
22
21
20
19
1/2/90
1/2/91
1/2/92
1/1/93
1/1/94
1/1/95
Distance

Figure 3

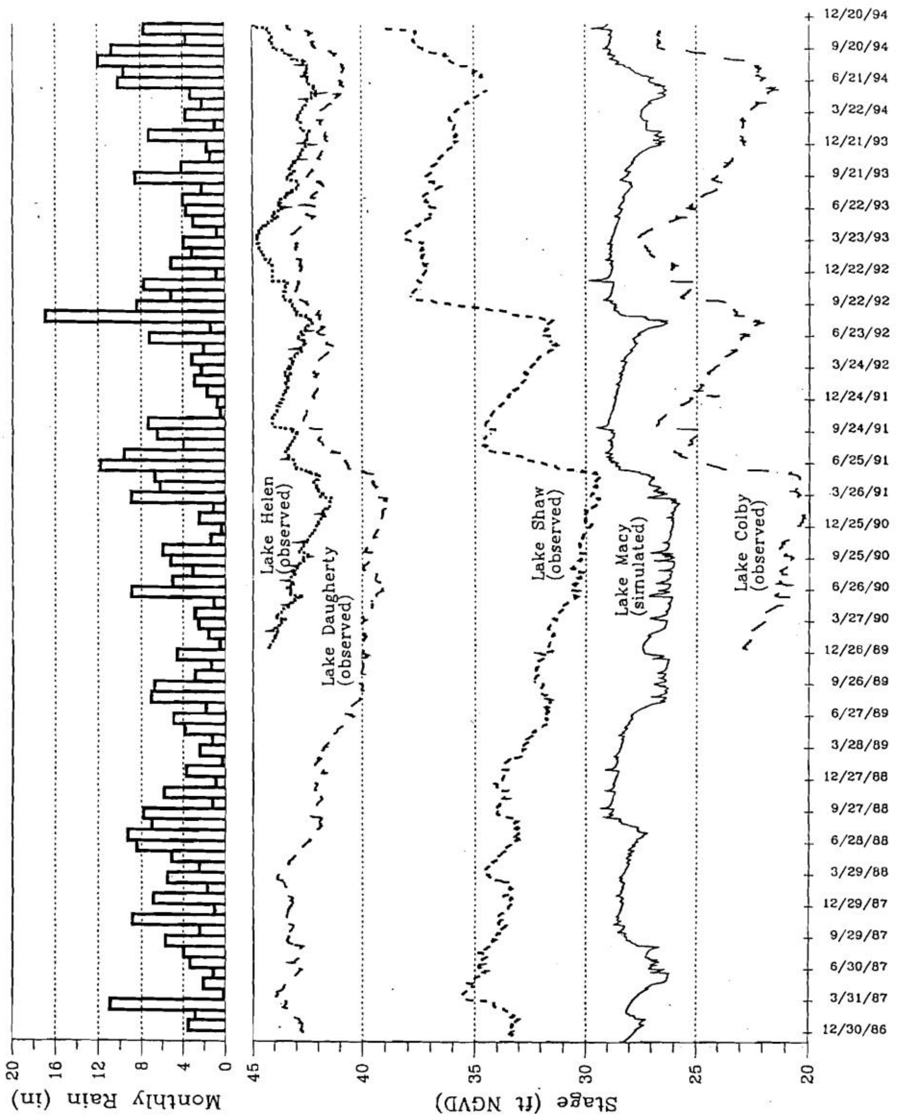
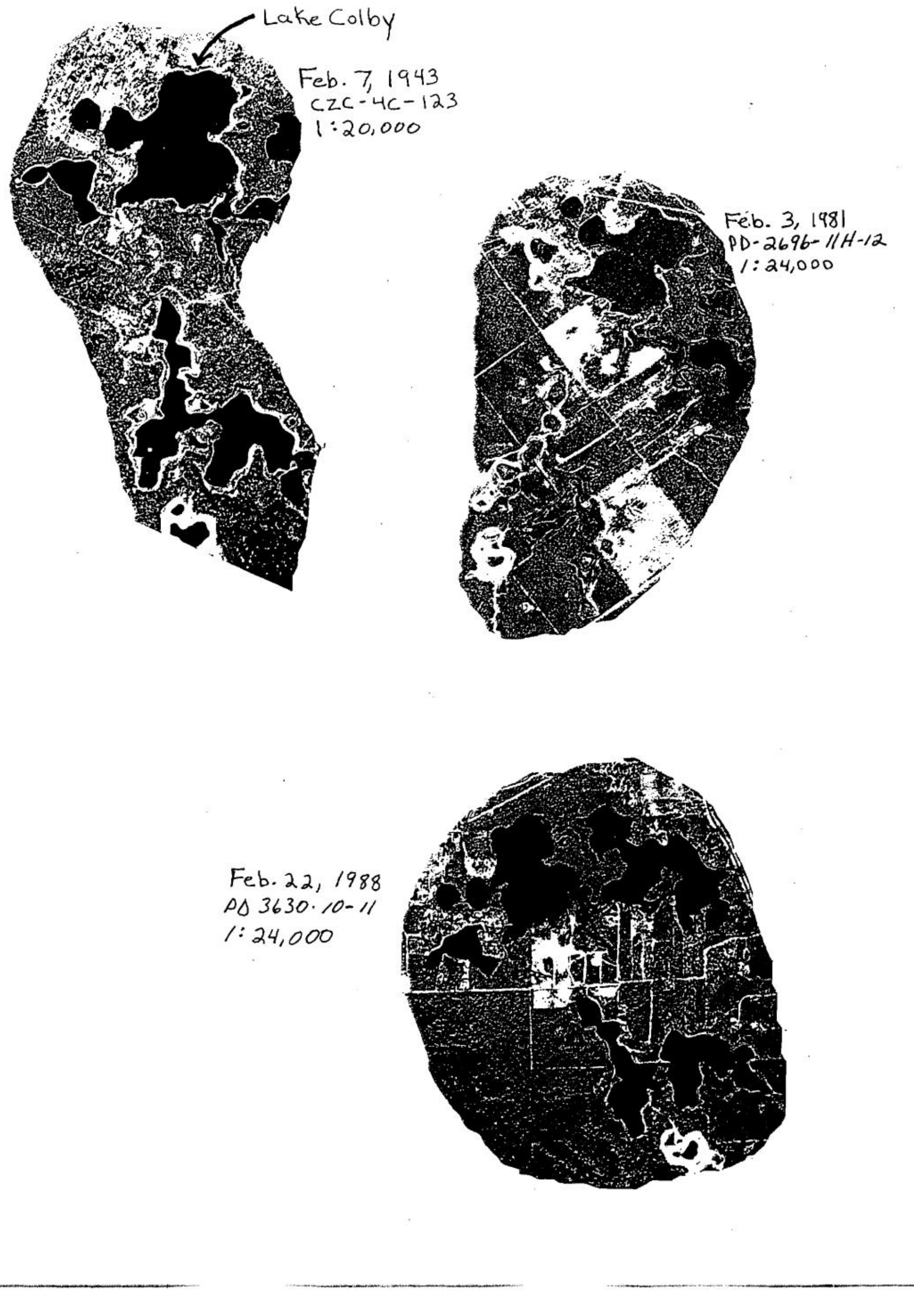


Figure 8. Comparison of Lake Stage Hydrographs
- From AdKins 1995.

17

Figure 4


Lake Colby
Feb. 7, 1943
CZC-4C-123
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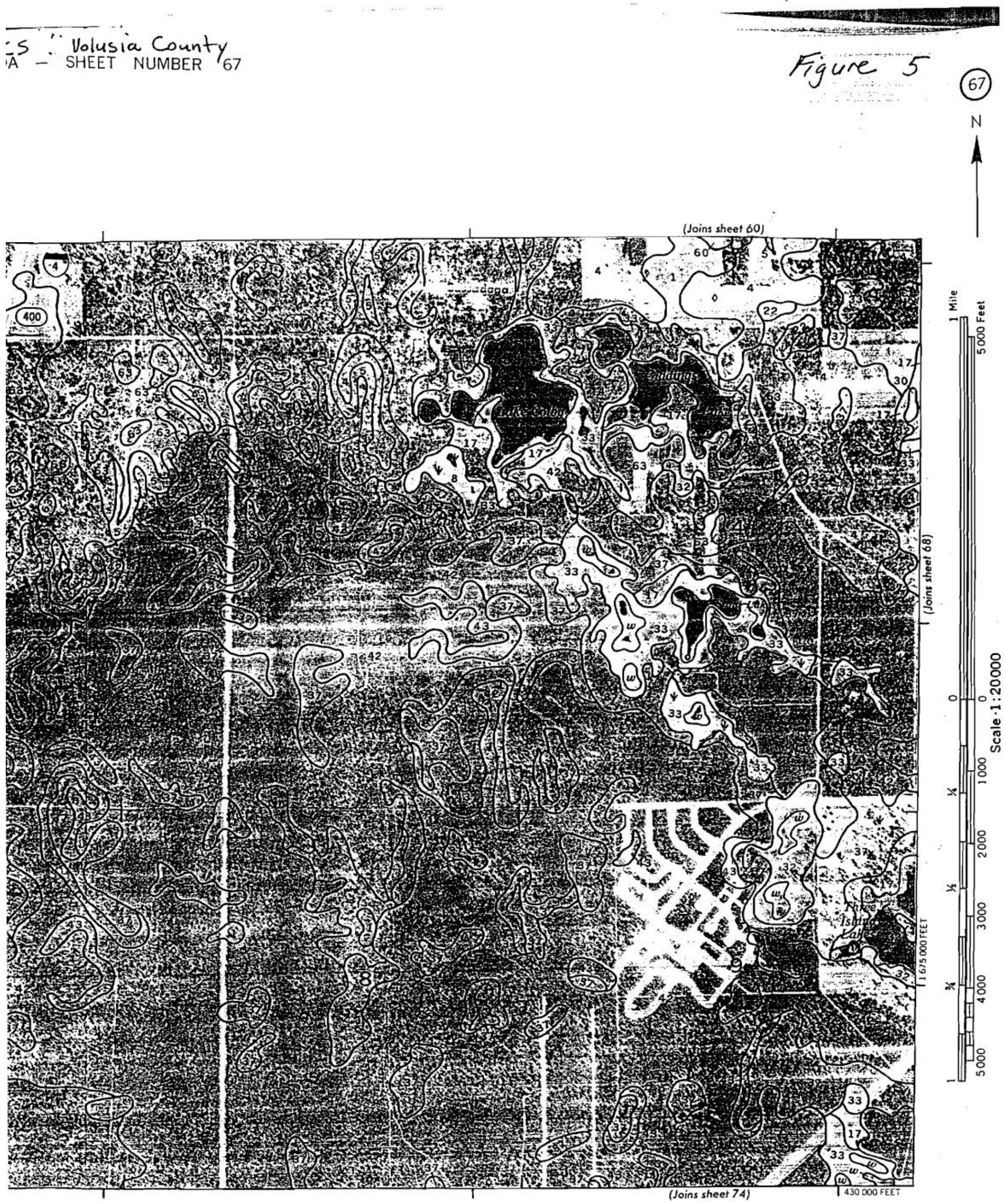
Feb. 3, 1981
PD-2696-11H-12
1:24,000
Feb. 22, 1988
PD 3630-10-11
1:24,000


Volusia County
SHEET NUMBER 67
Figure 5
67
N
(Joins sheet 60)
(Joins sheet 68)
(Joins sheet 74)
430 000 FEET
1 675 000 FEET
1 Mile
5000 Feet
Scale 1:20000
0
1000
2000
3000
4000
5000
400
Lake Colby

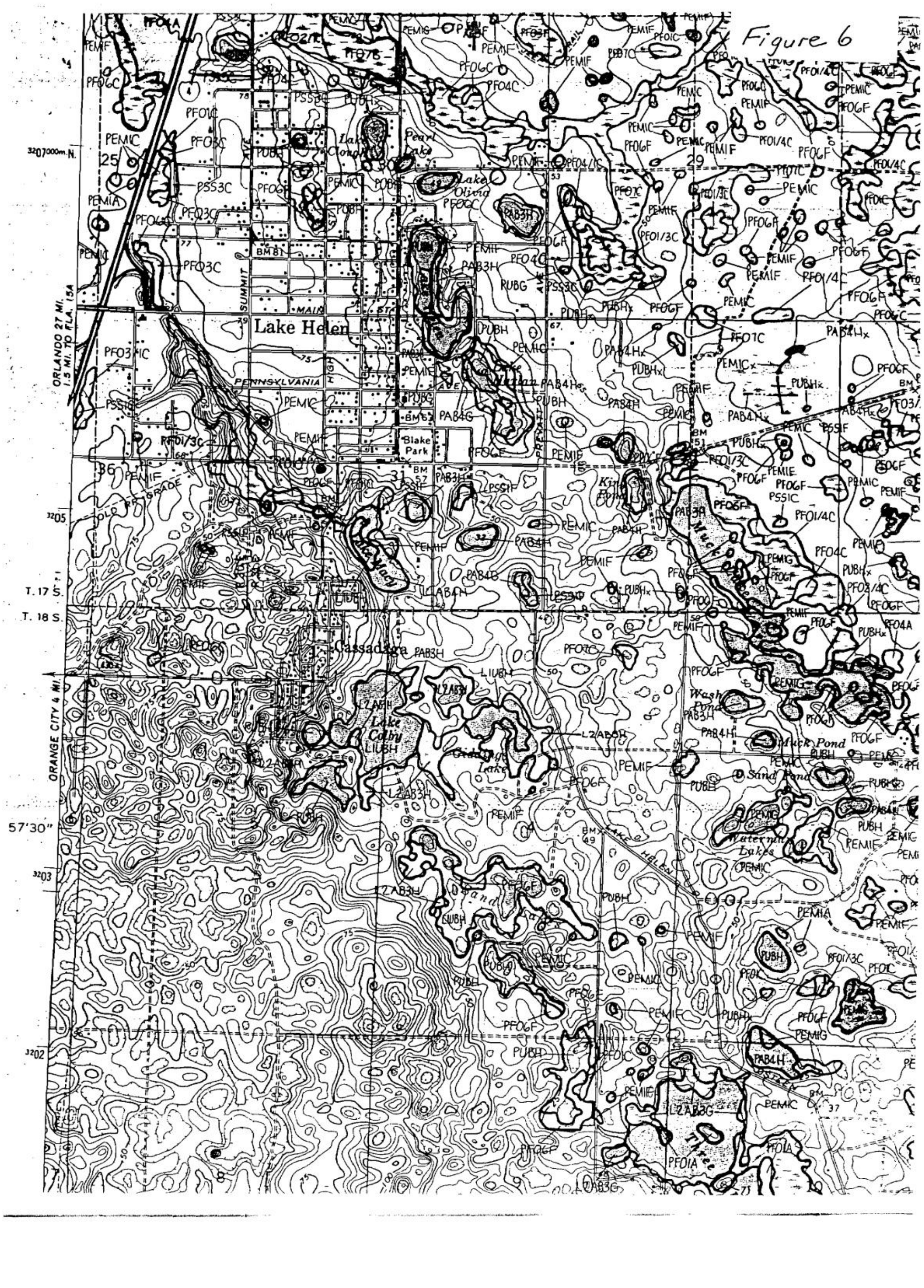
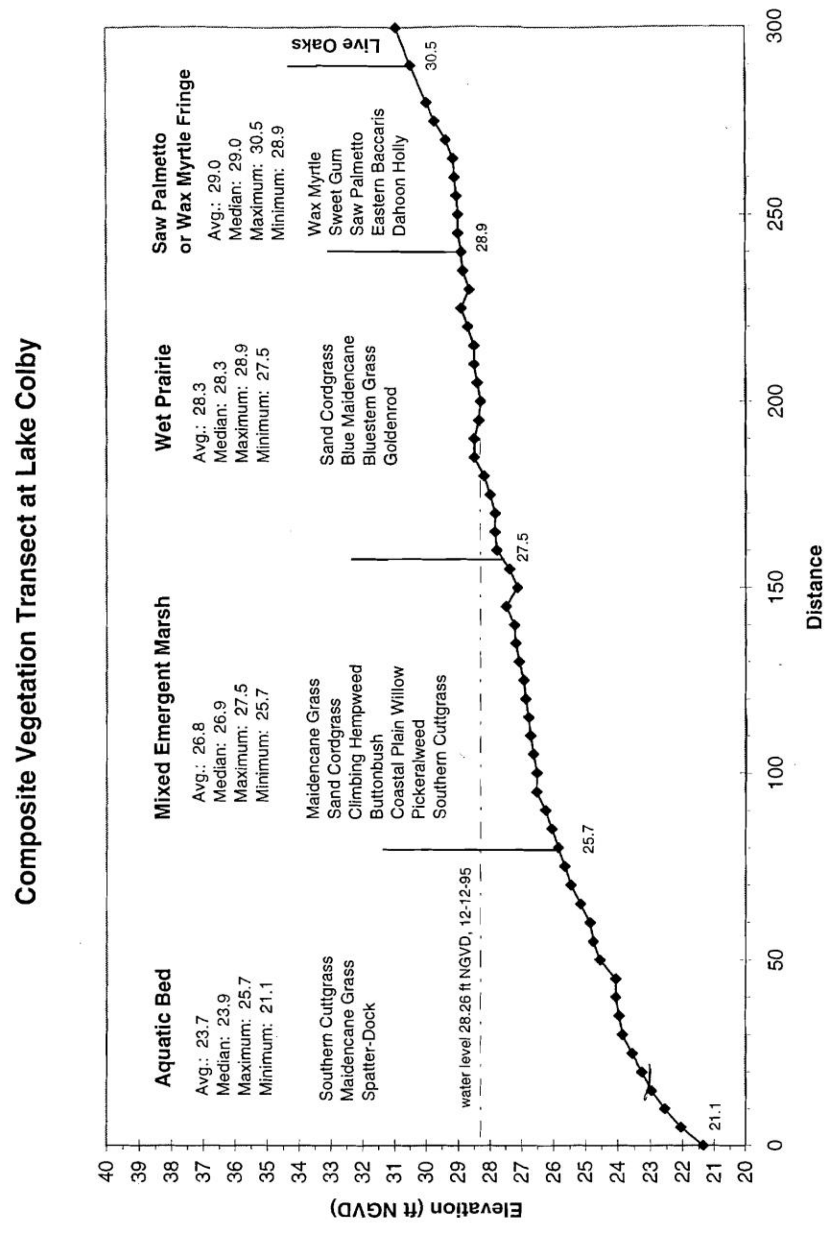


Figure 6
Lake Helen
Cassadaga
Blake Park
PENNSYLVANIA
MAIN
SUMMIT
ORLANDO 27 MI.
1.5 MI. TO FLA. 15A
ORANGE CITY 4 MI.
T. 17 S.
T. 18 S.
57'30"
Lake Colby
Lake Olivia
Wash Pond
Muck Pond
Sand Pond
Watermelon Lakes
LAKE HELEN

Figure 7


Composite Vegetation Transect at Lake Colby
Aquatic Bed
Avg.: 23.7
Median: 23.9
Maximum: 25.7
Minimum: 21.1
Southern Cuttgrass
Maidencane Grass
Spatter-Dock
Mixed Emergent Marsh
Avg.: 26.8
Median: 26.9
Maximum: 27.5
Minimum: 25.7
Maidencane Grass
Sand Cordgrass
Climbing Hempweed
Buttonbush
Coastal Plain Willow
Pickeralweed
Southern Cuttgrass
Wet Prairie
Avg.: 28.3
Median: 28.3
Maximum: 28.9
Minimum: 27.5
Sand Cordgrass
Blue Maidencane
Bluestem Grass
Goldenrod
Saw Palmetto
or Wax Myrtle Fringe
Avg.: 29.0
Median: 29.0
Maximum: 30.5
Minimum: 28.9
Wax Myrtle
Sweet Gum
Saw Palmetto
Eastern Baccaris
Dahoon Holly
Live Oaks
water level 28.26 ft NGVD, 12-12-95
21.1
25.7
27.5
28.9
30.5
Elevation (ft NGVD)
Distance
0
50
100
150
200
250
300
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

APPENDIX B

FIELD VEGETATION DATA SHEET

Vegetation Record Data Sheet

Date ______________________ **Transect No.** ______________________

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

Observers ____

Notes ____

____

____

Cover Estimates

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

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

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

APPENDIX C

SOILS INVESTIGATION AT LAKE COLBY, VOLUSIA COUNTY, IN SUPPORT OF MINIMUM FLOWS AND LEVELS

Jones Edmunds, Inc.

May 2006

SOILS INVESTIGATION AT LAKE COLBY, VOLUSIA COUNTY IN SUPPORT OF MINIMUM FLOWS AND LEVELS

Prepared for:

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Certificate of Authorization #1841

Project No. 19750-030-03

May 2006

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1.0 INTRODUCTION

The St. Johns River Water Management District (SJRWMD) recently reevaluated minimum flows and levels (MFLs) at Lake Colby, Volusia County, Florida, to verify that the adopted MFLs are preventing significant harm from occurring to the water resources. This report addresses the soils investigation that was conducted at Lake Colby to reevaluate adopted MFLs. The soils investigation included locating frequent high (minimum frequent high) and frequent low (FL) sandhill lake soil indicators, locating hydric soil indicators, and identifying soil series adjacent to the lake. Sandhill lake soil indicators were developed through cooperative efforts by the St. Johns River Water Management District (SJRWMD), Jones Edmunds and Associates Inc., and the U.S. Department of Agriculture, Natural Resouces Conservation Service (USDA-NRCS) (SJRWMD et al., 2005) to support the determination of MFLs at sandhill lakes, such as Lake Colby.

The minimum frequent high sandhill lake soil indicator provides an estimate of the ground surface elevation that is flooded approximately 20% of the time over the long term (>30 years). The FL sandhill lake soil indicator provides an estimate of the ground surface elevation that is flooded approximately 80% of the time over the long term (>30 years). minimum frequent high and FL sandhill lake soil indicators were used to identify the location of the minimum frequent high or FL hydrology, which corresponds to the 20% and 80% stage exceedence, respectively (SJRWMD et al., 2005). minimum frequent high and FL sandhill lake soil indicators are an estimate of long-term hydrology and are intended to support the determination of MFLs at sandhill lakes, such as Lake Colby.

Soils were characterized July 14 and 15, and December 13, 2005, along four transects and two point locations at Lake Colby (Figure 1) by examining and describing soil horizons, soil colors, soil textures, profile depths, hydric soil indicators and sandhill lake soil indicators. The Volusia County Soil Survey (Baldwin et al. 1980) was consulted to determine commonly mapped soil series adjacent to Lake Colby. Myakka soils were mapped in the areas of Transects A, B, C, and D. In some cases, the field-described soil series differed from those classified in the soil survey. This is likely due to the mapping scale associated with the Volusia County Soil Survey, which did not account for soil changes in the narrow transition between the upland and Lake Colby. Official soil series descriptions were found on the Soils Survey Staff website at *(http://soils.usda.gov/technical/classification/osd/).*

2.0 TRANSECT A

Transect A began in uplands (Stations 0–30) and traversed transitional shrub (Stations 30–70), wet prairie (Stations 70–100), and shallow marsh (Stations 100–300) on the eastern shore of

Lake Colby (Figure 2). At least 14 soil sites were evaluated to identify all hydric soil indicators and sandhill lake soil indicators along Transect A and the landward and waterward extent of each indicator. Six of the 14 sites met the defined parameters of either hydric soil indicators or sandhill lake soil indicators and are described in Tables 1 and 2. Two hydric soil indicators were identified along Transect A: Stripped Matrix (S6) and Dark Surface (S7) (Table 1, Table 2, and Figure 2). Special emphasis was placed on identifying the location of frequent high (minimum frequent high) and frequent low (FL) sandhill lake soil indicators (Table 1, Table 2, and Figure 2). The minimum frequent high sandhill lake soil indicator, Stripped Matrix beginning 5 in. below the soil surface (SJRWMD et al., 2005), was identified at Station 26. The FL sandhill lake soil indicator, Degrading Spodic (SJRWMD et al., 2005), was identified at Station 230, in the shallow marsh.

Two of the soil stations were characterized to a sufficient depth to determine the soil series which was Myakka. Myakka soils were identified at Stations 10 (uplands) and 35 (transitional shrub) of Transect A. Myakka soils are in the taxonomic classification subgroup Aeric Alaquods. Interpreting the subgroup name from right to left, Aeric Alaquods are Spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and oxides of aluminum and iron (Brady and Weil 1996). An aquic moisture regime indicates that soils are saturated with water and virtually free of gaseous oxygen for sufficient periods to induce anaerobic conditions (Brady and Weil 1996). Aeric Alaquods contain a light-colored albic horizon above a spodic horizon. Aeric Alaquods are alaquods that have an ochric epipedon. The ochric epipedon fails to meet the definitions for any of the other seven epipedons because it is too thin or too dry, has too high a color value or chroma, contains too little organic carbon, or is both massive and hard when dry (USDA 2003). Myakka soils are poorly to very poorly drained with a water table at depths of less than 18 in. for 1 to 4 months during most years. The water table recedes to depths of more than 40 in. during very dry seasons. Depressional areas of Myakka soils are covered with standing water for 6 to 9 months or more in most years (USDA 2005).

3.0 TRANSECT B

Transect B was on the northern shore of Giddings Lake, which is hydrologically connected to Lake Colby during high water elevations. Transect B began in uplands (Stations 0–43) and traversed transitional shrub (Stations 43-50), wet prairie (Stations 50–125), and shallow marsh communities (Stations 125–235) (Figure 3). At least four soil sites were evaluated to identify all hydric soil indicators along Transect B and the landward and waterward extent of each indicator. One soil station was characterized to a sufficient depth to determine the soil series along this transect (Smyrna). One hydric soil indicator was identified along Transect B: Stripped Matrix (S6) (Table 1, Table 2, and Figure 3). Special emphasis was placed on identifying the location of frequent high (minimum frequent high) and frequent low (minimum frequent low) sandhill lake soil indicators (Table 1, Table 2, and Figure 3). The minimum frequent high sandhill lake soil indicator, Stripped Matrix beginning 5 inches below the soil surface (SJRWMD et al., 2005), was identified at Station 45. The minimum frequent low sandhill lake soil indicator, Dark Splotches (SJRWMD et al., 2005), was identified at Station 190.

A Smyrna soil was identified at Station 20 in the upland vegetative community. Smyrna soils are in the taxonomic classification subgroup Aeric Alaquods, which is described above in the Myakka pedologic details. Smyrna soils are poorly to very poorly drained with a water table at depths of less than 18 inches for 1 to 4 months in most years and between 12 and 40 inches for more than 6 months. In the rainy season, the water table can briefly rise above the surface. Smyrna soils found in depressional areas have a water table above the surface for 6 to 9 months or more in most years (USDA 2005).

4.0 TRANSECT C

Transect C was on the southeastern shore of Lake Colby. Transect C began in uplands (Stations 0-10) and traversed a forested depression (Stations 10–82), wet prairie (Stations 82–173), and shallow marsh (Stations 173–450) (Figure 4). Thirty sites were evaluated to identify hydric soil indicators and sandhill lake soil indicators along Transect C. Landward and waterward extent of indicators were also noted. Four of the 30 soil evaluation sites were characterized to sufficient depths to determine the soil series (Immokalee, Myakka, and Valkaria). Three hydric soil indicators were identified along Transect C: Stripped Matrix (S6), Dark Surface (S7), and Muck Presence (A8) (Table 1, Table 2, and Figure 4). Special emphasis was placed on identifying the location of Frequent High (minimum frequent high) and Frequent Low (minimum frequent low) sandhill lake soil indicators (Table 1, Table 2, and Figure 4). The minimum frequent high sandhill lake soil indicator, Stripped Matrix beginning 5 inches below the soil surface (SJRWMD et al., 2005), was identified at Station 90. The minimum frequent low sandhill lake soil indicator, Dark Splotches (SJRWMD et al., 2005), was identified at Station 370.

Immokalee soils were observed at Stations 5 and 50. Immokalee soils are in the taxonomic classification subgroup Arenic Alaquods. Interpreting the subgroup name from right to left, Alaquods are Spodosols, which are characterized by a subsurface horizon with an accumulation of organic matter and of oxides of aluminum with or without iron oxides (Brady and Weil 1996). An aquic moisture regime indicates that soils are saturated with water and virtually free of gaseous oxygen for sufficient periods of time for poor aeration to occur (Brady and Weil 1996). Arenic Alaquods contain a light-colored albic horizon above a spodic horizon and have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 30–50 in. Immokalee soils are poorly to very poorly drained with water table at depths of 6–18 in. for 1 to 4 months during most years. Depressional areas of

Immokalee soil are covered with standing water for 6 to 9 months or more in most years (USDA 2005).

Myakka soil was identified at Station 120 (28.65 ft NGVD) in the wet prairie of Transect C. Myakka soils are in the taxonomic classification subgroup Aeric Alaquods, which is described in Transect A.

A Valkaria soil was identified at Station 250 (26.23 ft NGVD) and is in the taxonomic subgroup Spodic Psammaquent. Spodic Psammaquents (described from right to left) are Entisols, which are characterized as soils of recent origin. They are in the aquic moisture regime, which implies reduced soil conditions virtually free of dissolved oxygen due to soil saturation (USDA 1975). Spodic Psammaquents are sandy in texture (psamm) and contain a weak (i.e., show evidence of but do not meet the criteria) spodic horizon (spodic). These soils have an ochric epipedon. The Valkaria series contains a subsurface hardpan layer (i.e., cambic horizon or degrading spodic), which contributes to its poorly drained or very poorly drained condition. The water table in Valkaria soils is within depths of 0–12 in. for 2 to 6 months during most years. During periods of extended rainfall, the water table is at the surface for a few days to 3 months. Depressional areas of Valkaria soil are ponded for 3 months or more during most years. In dry seasons, the water table may be as deep as 30 in. below the surface. Depressional areas of Valkaria soil are ponded for about 3 months or more (USDA 2005).

5.0 TRANSECT D

Transect D was on the southwestern shore of Lake Colby. Transect D began in uplands (Stations 0–15) and traversed wet prairie 1 (Stations 15–50), shallow marsh 1 (Stations 50–165), wet prairie 2 (Stations 165–225), and shallow marsh 2 (Station 225–400) (Figure 5). Thirteen sites were evaluated to identify hydric soil indicators and sandhill lake soil indicators along Transect D and to find the upper and lower extent of each indicator. Three of the 13 sites were characterized to a sufficient depth to determine the soil series (Myakka and Immokalee). Four hydric soil indicators were identified along Transect D: Stripped Matrix (S6), Dark Surface (S7), Mucky Mineral (A7), and Muck Presence (A8) (Table 1, Table 2, and Figure 5). Special emphasis was placed on identifying the location of frequent high (minimum frequent high) and frequent low (minimum frequent low) sandhill lake soil indicators (Table 1, Table 2, and Figure 5). The minimum frequent high sandhill lake soil indicator, Stripped Matrix beginning 5 in. below the soil surface (SJRWMD et al., 2005), was identified at Station 8. No minimum frequent low sandhill lake soil indicator was identified along this transect.

Myakka soils were identified at Stations 5 and 190 in the upland and wet prairie 2 communities, respectively, of Transect D. Myakka soils are described above in the Transect A section.

An **Immokalee** soil was observed at Station 50 and is described in the Transect C section.

6.0 ADDITIONAL FIELD DATA

Transects A and B exhibited signs of seepage (e.g., raised saw palmetto rhizomes and hydric soil indicators above the lake's fluctuation range), therefore, sandhill lake soil indicators were identified at an additional location along the east shore of Lake Colby (Figure 1). The minimum frequent high sandhill lake soil indicator, Stripped Matrix (beginning 5 in. below the soil surface, SJRWMD 2005), was identified at an elevation of 28.03 ft NGVD. The minimum frequent low sandhill lake soil indicator, Dark Splotches (SJRWMD et al., 2005), was identified at an elevation of 23.63 ft NGVD. The location along the east shore of Lake Colby had a short slope between uplands and open water and appeared to have substantially less seepage.

7.0 HYDRIC SOIL INDICATORS

A hydric soil is a soil that has formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper horizons (Carlisle and Hurt 2000). Hydric soil indicators result from repeated periods of saturation and/or inundation for more than a few days. Such wetness essentially eliminates oxygen. Anaerobic microbiological activity in soils promotes the accumulation of organic matter and the reduction of iron, manganese, and sulfur which results in characteristics that persist in the soil during both wet and dry periods (Carlisle and Hurt 2000). Hydric soils can be used to estimate the seasonal high saturation, which is the highest expected annual elevation of saturation in a soil and is usually confirmed by observation of water in an unlined bore hole or the correlation of redoximorphic features with probable saturation (Carlisle and Hurt 2000). Hydric soil indicators that were identified at Lake Colby are described as follows:

- **S6. Stripped Matrix**—A layer starting within 6 in. of the surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix, exposing the primary base color of the soil materials. The stripped areas and translocated oxides and/or organic matter form a diffuse splotchy pattern of two or more colors. Stripped matrix is routinely used to delineated hydric soils throughout Florida (Carlisle and Hurt 2000). Stripped matrix has a seasonal high saturation within 6 in. of the soil surface (Carlisle and Hurt 2000).

- **S7. Dark Surface**—A layer 4 inches or thicker starting within the upper 6 in. of the soil surface that is predominately black. The matrix color value is 3 or less and chroma is 1 or less. At least 70% of the visible soil particles must be covered, coated, or similarly masked with organic material. The matrix color of the layer below the dark layer has a chroma of 2 or less (USDA 2003). Dark surface has a seasonal high saturation within 6 in. of the soil surface (Carlisle and Hurt 2000).

- **A7. Mucky Mineral**—A mucky modified mineral surface layer at least 2 inches thick starting within 6 in. of the soil surface (USDA 2003). Mucky mineral has a seasonal high saturation at the surface or inundation above the soil surface (Carlisle and Hurt 2000).

- **A8. Muck Presence**—A layer of muck of any thickness that occurs within the upper 6 in. of the soil surface and contains a color value of 3 or less and chroma 1 or less. This indicator is used in land resource regions U, V, and Z (USDA 2003). Muck presence has a seasonal high saturation at the surface or inundation above the soil surface (Carlisle and Hurt 2000). Seasonal high saturation is the highest expected annual elevation of saturation in a soil and is usually confirmed by observation of water in an unlined bore hole or the correlation of redoximorphic features with probable saturation (Carlisle and Hurt 2000).

8.0 SANDHILL LAKE SOIL INDICATORS

Sandhill lake soil indicators were developed to provide consistent hydrologic indicators to help determine MFLs at sandhill lakes (SJRWMD et al., 2005). Vegetation at sandhill lakes may be an unreliable indicator of hydrology since the extent and composition of herbaceous vegetation may change in response to widely fluctuating water levels. Soil characteristics, on the other hand, develop as a result of long-term hydrologic conditions and can be used as reliable indicators of historic hydrology (SJRWMD et al., 2005).

The minimum frequent high level and minimum frequent low level, based on existing conditions at systems throughout SJRWMD, have consistently been determined at elevations with approximate stage exceedence of 20% and 80%, respectively. Unique soil morphologies were identified at sandhill lakes within SJRWMD near the 20% (minimum frequent low) and 80% (minimum frequent high) stage exceedence (SJRWMD et al., 2005). The minimum frequent high sandhill lake soil indicator, stripped matrix beginning 5 inches beneath the soil surface, was found to be the most reliable indicator of 20% stage exceedence (SJRWMD et al., 2005). The minimum frequent low sandhill lake soil indicator, dark splotches, was found to be the most reliable indicator of 80% stage exceedence (SJRWMD et al., 2005). An additional minimum frequent low sandhill lake soil indicator was identified (degrading spodic), but it is thought to be a less reliable indicator of hydrology compared to stripped matrix or dark splotches (SJRWMD et al., 2005).

8.1 FREQUENT HIGH

- **Stripped Matrix (beginning 5 inches below the soil surface)**—A layer starting 5 in. beneath the mineral soil surface in which the stripped (uncoated) areas are 10% or more of the volume, are rounded, and are approximately 0.5- to 1-in., in diameter. The splotches of color commonly have a Munsell value of 5 or more, chroma of 1 and/or 2 (stripped), and chroma 3 and/or 4 (unstripped). The matrix may lack the 3- and/or 4-chroma material. Mobilization and translocation of oxides and /or organic matter are important processes and should result in splotch coated and uncoated areas (SJRWMD et al., 2005).

8.2 FREQUENT LOW

- **Dark Splotches**—A layer starting within 3 in. of the soil surface that is at least 3-in.-thick and has at least 20% of the soil material that is 10YR $\frac{3}{1}$ or darker and a matrix color of 10YR 4/1 or lighter. Where surface soil layer(s) are uniformly 10YR $\frac{3}{1}$ or darker (muck, mucky mineral, and/or mineral) or hemic material, the minimum frequent low occurs where the dark splotches layer starts within 3 inches of the uniformly 10YR $\frac{3}{1}$ or darker soil material or hemic material (SJRWMD et al., 2005).

- **Degrading Spodic**—This indicator requires 3 in. of sandy material with a value of 4 or less above a degrading spodic horizon. Landward there are more than 3 in. of sandy material; waterward there are 3 in. or less of sandy material above the degrading spodic horizon. A degrading spodic horizon has a hue of 10 yr or redder, value of 3 or 4, and chroma of 3 or 4 (SJRWMD et al.., 2005).

9.0 DISCUSSION

The minimum frequent high sandhill lake soil indicator, Stripped Matrix at 5 inches, occurred at similar elevations (28.6–29.0 ft) at Transects A, B and C at Lake Colby and Giddings Lake. The minimum frequent low sandhill lake soil indicators, Dark Splotches and Degrading Spodic, were also identified at similar elevations on Transects A, B, and C (24.2–24.8 ft). This close correlation suggests that these assessment areas are hydrologically similar and reflect similar historic fluctuations in lake hydrology. Soil profile characteristics and slopes along the higher elevations of these transects (4.5%, 5.2%, and 5.1%, respectively) were also similar.

Transect D had more complex topography with an area of pooling that sustained a high quality marsh and it was steeper at the higher elevation than other transects (Figure 5). The hydric soil indicator Stripped Matrix on this transect was present above the historical lake fluctuation range. This, along with the steep slope, indicates that there is likely seepage (the lateral movement of water through the soil profile) occurring on the slope. The minimum frequent high sandhill lake indicator was found at 29.5 ft, which is somewhat higher than the other transects. A longer hydroperiod, perhaps from seepage, in the high quality marsh area on Transect D has allowed muck to develop 1.03 feet higher than on Transect C. No muck was noted on Transects A or B.

There was a much greater range in elevation of hydric soil indicators among the 4 transects as compared to the sandhill lake soil indicators. These data suggest that the sandhill lake soil indicators could be correlated with more specific hydrologic conditions (i.e., 20% and 80% stage exceedence) and are repeatable for multiple points around the lake.

10.0 LITERATURE REVIEW CITED

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JONES EDMUNDS

Figure 1
Lake Colby MFL
Soil Transects
and Soil Point Shots

0 500 1,000
Feet
1:8,920
N

19750-013-01 ColbyMFL.mxd KAM 3/28/06

For Informational Purposes Only

Table 1. Locations of soil indicators observed at Lake Colby

Location	Hydric Soil Indicators				Sandhill Lake Soil Indicators	
	Stripped Matrix at 6 in (S6)	Dark Surface (S7)	Mucky Mineral (A7)	Muck Presence (A8)	Frequent high: Stripped Matrix at 5 in	Frequent low: Dark Splotches
Transect A ft. NGVD (Station #)	30.4 (Sta. 21)	29.7 (Sta. 35)	n/a	n/a	28.6 (Sta. 26)	24.2 (Sta. 230)
Transect B ft. NGVD (Station #)	29.0 (Sta. 42)	n/a	n/a	n/a	29.0 (Sta. 45)	24.8 (Sta. 190)
Transect C ft. NGVD (Station #)	~30.3 (Sta. 12)	24.8 (Sta. 355)	n/a	24.8–23.5 (Sta. 355–430)	28.8 (Sta. 90)	24.5 (Sta. 370)
Transect D ft. NGVD (Station #)	29.9 (Sta. 5)	27.2–25.9, 23.9–23.2 (Sta. 50–120, 360–390)	24.1 (Sta. 340)	25.9–26.1 (Sta. 75–~135)	~29.5 (Sta. 8)	n/a
Vertical range in ft.	1.4	6.5	n/a	2.6	0.9	0.6

Table 2 Soil Assessment at Lake Colby

Station name:	**Transect A**			
Field user:	J. Sullivan, T. Richardson, S. Hall, T. Tibbets			
Sample date:	7/14/05			
Station point	10			
Soil classification	Myakka			
Hydric soil indicator(s)	None			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Ap	0–1	10 yr 5/1–gray	Fine sand	
A	1–7	10 yr 6/1–gray	Fine sand	
Eg	7–30	10 yr 6/1–gray	Fine sand	~10% 10 yr 7/1
Bh1	30–36	10 yr 3/1–very dark gray	Fine sand	~30% 10 yr 5/1 + 10 yr 6/1
Bh2	36–45	10 yr 2/2–very dark brown	Fine sand	~30% 10 yr 2/1, free water at 25 in., 10 yr 2/1 fades w/ depth
Bh3	45–57	10yr 5/3–brown	Fine sand	
Bh4	57–68+	10yr 6/3–pale brown	Fine sand	
Station point	21			
Hydric soil indicator	S6. Stripped matrix at 6 in. below grade			
Station point	26			
Fh soil indicator	Stripped matrix at 5 in. below grade			
Station point	35			
Soil classification	Myakka			
Hydric soil indicator	S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A1	0–5	10 yr 2/1–black	Fine sand	dark surface
A2	5–8	10 yr 4/1–dark gray	Fine sand	
E	8–24	10 yr 6/2–light brownish gray	Fine sand	~10% 10 yr 7/1, free water at 13 in.
Bh1	24–29	10 yr 2/1–black	Fine sand	
Bh2	29–39	10 yr 2/2–very dark brown	Fine sand	
Bh3	39–51+	10 yr 4/2 dark grayish brown	Fine sand	

Table 2 Soil Assessment at Lake Colby

Station point	50			
Hydric soil indicator	S7. Dark surface			
Station point	230			
Fh soil indicator	Degrading spodic			
Station name:	**Transect B**			
Field user:	J. Sullivan, T. Richardson			
Sample date:	7/15/05			
Station point	20			
Soil classification	Smyrna			
Hydric soil indicator	None			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A1	0–5	10yr 3/1–very dark gray	Fine sand	Many fine fibrous roots
A2	5–9	10yr 4/1–dark gray	Fine sand	
E	9–19	10yr 4/1–dark gray	Fine sand	~20% 10 yr 4/1
Bh	19–31	10yr 3/2–very dark grayish brown	Fine sand	
E'1	31–56	10yr 5/2–grayish brown	Fine sand	
E'2	56–58+	10yr 6/2–light grayish brown	Fine sand	
Station point	42			
Hydric soil indicator	S6. Stripped matrix at 6 in. below grade			
Station point	45			
Fh soil indicator	Stripped matrix at 5 in. below grade			
Station point	190			
minimum frequent-low soil indicator	Dark splotches at 3 in.			

Table 2 Soil Assessment at Lake Colby

Station name:	**Transect C**			
Field user:	J. Sullivan, T. Richardson, T. Tibbits			
Sample date:	12/13/05			
Station point	5			
Soil classification	Immokalee			
Hydric soil indicator	None			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–7	10yr 4/1–dark gray	Fine sand	many roots
E1	7–14	10yr 6/2–light brownish gray	Fine sand	S6 at 8 in.
E2	14–19	10yr 4/2–dark grayish brown	Fine sand	with 30% 10 yr 7/1
E3	19–33	10yr 7/1–light gray	Fine sand	with 20% 6/2 and 10% 8/1
E4	33–37	10yr 6/2–light brownish gray	Fine sand	with 10% 8/1
Bh	37–62	10yr 2/1–black	Fine sand	
Station point	12			
Hydric soil indicator	S6. Stripped Matrix at 6 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A1	0–6	10 yr 5/2–grayish brown	Fine sand	S6 at 6 in., 10% 10 yr 3/2
A2	6–9	10 yr 4/2–dark grayish brown	Fine sand	10% 10 yr 7/2 w/ csg
Bh	9–16	10 yr 2/1–black	Fine sand	10% 10 yr 7/1
Eg	16–17	10 yr 7/2–light gray	Fine sand	10% 10 yr 8/1 + 5% 10 yr 5/2
Station point	14			
Hydric soil indicator	S6. Stripped matrix at 5 in.			
Station point	30			
Hydric soil indicator	S6. Stripped matrix at 5 in.			
Station point	40			
General note	1in. Mucky mineral (does not meet depth requirements for the hydric soil indicator)			
Station point	41			

Table 2 Soil Assessment at Lake Colby

Hydric soil indicator	S6. Stripped matrix at 3 in.			
Station point	45			
Hydric soil indicator	S6. Strippped matrix at 1.5 in.			
Station point	50			
Soil classification	Immokalee			
Hydric soil indicator	S6. Stripped matrix at 5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2	10 yr 3/1–very dark gray	Fine sand	
Eg1	2–5	10 yr 5/3–brown	Fine sand	10% 10 yr 7/1
Eg2	5–22	10 yr 6/2–light brownish gray	Fine sand	10% 10 yr 7/1, stripped matrix
Eg3	22–27	10 yr 7/2–light gray	Fine sand	
Bw	27–35	10 yr 2/1–black	Fine sand	
Bh	35–55	7.5 yr 3/3–dark brown	Fine sand	
Station point	70			
Hydric soil indicator	S6. Strippped matrix at 3 in.			
Station point	75			
Hydric soil indicator	S6. Strippped matrix at 3 in.			
Station point	80			
General note	1 in. Fibric organic surface horizon (did not meet color requirements for a hydric soil indicator)			
Station point	90			
Hydric soil indicator	S6. Strippped matrix at 5 in.			
Station point	95			
Hydric soil indicator	S6. Strippped matrix at 2.5 in.			
Station point	100			
Hydric soil indicator	S6. Strippped matrix at 4 in.			

Table 2 Soil Assessment at Lake Colby

Station point	105			
Hydric soil indicator	S6. Strippped matrix at 4 in,			
Station point	110			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Station point	115			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Station point	120			
Soil classification	Myakka			
Hydric soil indicator	S6. Stripped matrix at 2.5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2.5	10 yr 3/1–very dark gray	Fine sand	many roots
Eg1	2.5–7	10 yr 3/1–very dark gray	Fine sand	30% 10 yr 7/3
Eg2	7–23	10 yr 7/2–light gray	Fine sand	cumulative 15% 10 yr 8/1, 3/2
Bh1	23–30	10 yr 3/2–very dark grayish brown	Fine sand	
Bh2	30–60	7.5 yr 3/3–dark brown	Fine sand	
Station point	200			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–1	10 yr 2/1–black	Mucky sand	
Eg1	1–2	10 yr 5/1–gray	Fine sand	
Eg2	2–9	10 yr 5/2–grayish brown	Fine sand	30% 10 yr 8/1
Station point	250			
Soil classification	Valkaria			
Hydric soil indicator	S6. Strippped matrix 4.5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2	10 yr 4/1–dark gray	Fine sand	
Eg1	2–4.5	10 yr 6/2–light brownish gray	Fine sand	

Table 2 Soil Assessment at Lake Colby

Eg2	4.5–24	10 yr 8/1–white	Fine sand	
Bw1	24–27	10 yr 5/3–brown	Fine sand	
Bw2	27–30	10 yr 5/4–yellowish brown	Fine sand	
Station point	275			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–1	10 yr 2/1–black	Fine sand	
Eg1	1–2	10 yr 5/2–grayish brown	Fine sand	
Eg2	2–12	10 yr 8/1–white	Fine sand	
Station point	300			
Hydric soil indicator	S6. Strippped matrix at 3 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–1	10 yr 2/1–black	Fine sand	
Eg1	1–3	10 yr 5/2–grayish brown	Fine sand	
Eg2	3–9	10 yr 8/1–white	Fine sand	
Station point	315			
Hydric soil indicator	S6. Stripped matrix at 4.5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–1	10 yr 2/1–black	Fine sand	
Eg	1–3	10 yr 4/2–dark grayish brown	Fine sand	
B	3–4.5	10 yr 2/1–black	Fine sand	
Eg'	4.5–10	10 yr 7/2–light gray	Fine sand	
Station point	340			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2	10 yr 3/1–very dark gray	Fine sand	
Eg	2–8	10 yr 7/2–light gray	Fine sand	

Table 2 Soil Assessment at Lake Colby

Bh	8–10	10 yr 3/3–dark brown	Fine sand	
Station point	355			
Hydric soil indicators	A8. Muck presence, S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–2	10 yr 3/2–very dark grayish brown	Fibric or peat	
A1	2–4	10 yr 2/1–black	Fine sand	
A2	4–5	10 yr 2/1–black	Mucky sand	
A3	5–7	10 yr 2/1–black	Fine sand	
Eg1	7–10	10 yr 6/2–light brownish gray	Fine sand	
Eg2	10–12	10 yr 5/2–grayish brown	Fine sand	50% 10 yr 2/1
Bh	12–15	10 yr 3/1–very dark gray	Fine sand	
Station point	370			
minimum frequent-low soil indicator	A8. Muck presence			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–2	10 yr 3/2–very dark grayish brown	Fibric or peat	
A	2–4	10 yr 2/1–black	Fine sand	
A	4–6	10 yr 4/1–dark gray	Fine sand	20% 10 yr 2/1, dark splotches
Eg1	6–9	10 yr 4/1–dark gray	Fine sand	50% 10 yr 2/1, dark splotches
Eg2	9–14	10 yr 5/2–grayish brown	Fine sand	
Bh	14–16	7.5 yr 3/1–very dark gray	Fine sand	
Station point	390			
Hydric soil indicator	A8. Muck presence			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–1	10 yr 3/2–very dark grayish brown	Fibric or peat	
A1	1–2	10 yr 2/1–black	Fine sand	
A2	2–4	10 yr 4/1–dark gray	Fine sand	
Eg	4–9	10 yr 5/2–grayish brown	Fine sand	50 % 10 yr 3/1, dark splotches
Bh	9–12	7.5 yr 3/1–very dark gray	Fine sand	

Table 2 Soil Assessment at Lake Colby

Station point	410			
Hydric soil indicator	A8. Muck presence			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–1	10 yr 2/1–black	Fibric or peat	
A	1–2	10 yr 2/1–black	Fine sand	
Eg	2–7	10 yr 6/1–gray	Fine sand	
Bh	7–11	10 yr 3/2–very dark grayish brown	Fine sand	
Bw	11–13	10 yr 5/3–brown	Fine sand	
Station point	430			
Hydric soil indicator	A8. Muck presence			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–1	10 yr 3/2–very dark grayish brown	Fibric or peat	
A	1–6	10 yr 3/1–very dark gray	Fine sand	
Eg1	6–8	10 yr 6/2–light brownish gray	Fine sand	
Eg2	8–13	10 yr 5/2–grayish brown	Fine sand	10% 10 yr 2/1, 7/2
Bw	13–16	10 yr 4/3–brown	Fine sand	
Station point	450			
Hydric soil indicator	S6. Stripped matrix at 3.5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2.5	10 yr 3/1–very dark gray	Fine sand	
Eg1	2.5–3.5	10 yr 5/3–brown	Fine sand	
Eg2	3.5–8	10 yr 4/2–dark grayish brown	Fine sand	10 yr 7/1, 5/2
Bw	8–16	10 yr 4/3–brown	Fine sand	
Station name:	**Transect D**			
Field user:	J. Sullivan, T. Richardson, T. Tibbits			
Sample date:	12/13/05			

Table 2 Soil Assessment at Lake Colby

Station point	5			
Soil classification	Myakka			
Hydric Soil Indicator	S6. Stripped matrix at 6 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A1	0–4	10 yr 3/1–very dark gray	Fine sand	
A2	4–6	10 yr 4/1–dark gray	Fine sand	
Eg1	6–9	10 yr 5/1–gray	Fine sand	30% 10 yr 2/1 + 6/1
Eg2	9–25	10 yr 6/2–light brownish gray	Fine sand	5% 10 yr 2/1
Bh1	25–36	7.5 yr 3/3–dark brown	Fine sand	
Bh2	36–42	10 yr 4/4–dark yellowish brown	Fine sand	
Eg'	42–58	10 yr 5/3–brown	Fine sand	
Station point	8			
Hydric soil indicator	S6. Stripped matrix at 5 in.			
Station point	40			
Hydric soil indicator	S6. Stripped matrix at 2 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A1	0–1	10 yr 2/1–black	Mucky sand	
A2	1–2	10 yr 2/1–black	Fine sand	
E	2–10	10 yr 7/2–light gray	Fine sand	30% 10 yr 2/1 + 7/1
Station point	50			
Soil classification	Immokalee			
Hydric soil indicator	S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–9	10 yr 2/1–black	Mucky sand	
Eg1	9–16	10 yr 5/1–gray	Fine sand	
Eg2	16–34	10 yr 4/1–dark gray	Fine sand	
Bh	34–40	10 yr 3/2–very dark grayish brown	Fine sand	

Table 2 Soil Assessment at Lake Colby

Station point	75			
Hydric soil indicators	A8. Muck presence, S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oa	0–4	N 2.5/–black	Sapric or muck	
A1	4–9	10 yr 2/1–black	Fine sand	
A2	9–12	10 yr 3/1–very dark gray	Fine sand	10% 10 yr 6/1 + 7/1
Station point	120			
Hydric Soil Indicator(s)	A8. Muck presence, S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oa	0–3.5	N 2.5/–black	Sapric or muck	
A1	3.5–8.5	10yr 2/1–black	Fine sand	
A2	8.5–12	10yr 3/1–very dark gray	Fine sand	10% 10 yr 7/1
Station point	150			
Hydric Soil Indicator(s)	S6. Stripped matrix at 6"			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–3.5	10 yr 3/1–very dark gray	Fine sand	
Eg1	3.5–6	10 yr 5/1–gray	Fine sand	
Eg2	6–12	10 yr 7/2–light gray	Fine sand	10% 10 yr 7/1 + 4/4
Station point	190			
Soil classification	Myakka			
Hydric soil indicator	S6. Stripped matrix at 2"			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2	10 yr 4/1–dark gray	Fine sand	
Eg	2–23	10 yr 7/2–light gray	Fine sand	5% 10 yr 3/2
Bh	23–26	7.5 yr 3/3–dark brown	Fine sand	

Table 2 Soil Assessment at Lake Colby

Station point	230			
Hydric soil indicator	S6. Stripped Matrix at 2.5 in.			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
A	0–2.5	10 yr 2/1–black	Fine sand	
Eg	2.5–10	10 yr 7/1–light gray	Fine sand	10% 10 yr 6/1
Station point	320			
General note	Spodic horizon at 16 in.			
Station point	340			
Hydric soil indicator	A7. Mucky mineral			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–2	10 yr 2/1–black	Mucky sand	
A1	2–4	10 yr 2/1–black	Fine sand	
Eg1	4–6.5	10 yr 5/3–brown	Fine sand	
Eg2	6.5–16	10 yr 7/2–light gray	Fine sand	
Station point	360			
Hydric soil indicator	S7. Dark Surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–1	10 yr 2/1–black	Mucky sand	
A	1–5	10 yr 2/1–black	Fine sand	
Eg	5–15	10 yr 7/1–light gray	Fine sand	
Bh	15–20	7.5 yr 3/2–very dark grayish brown	Fine sand	
Station point	390			
Hydric soil indicator	S7. Dark surface			
Horizon	**Depth**	**Color**	**Soil Texture**	**Soil Description**
Oi	0–1	10 yr 2/1–black	Mucky sand	
A	1–5	10 yr 2/1–black	Fine sand	

Table 2 Soil Assessment at Lake Colby

Eg	5–15	10 yr 7/1–light gray	Fine sand	
Bh	15–20	7.5 yr 3/2–very dark grayish brown	Fine sand	

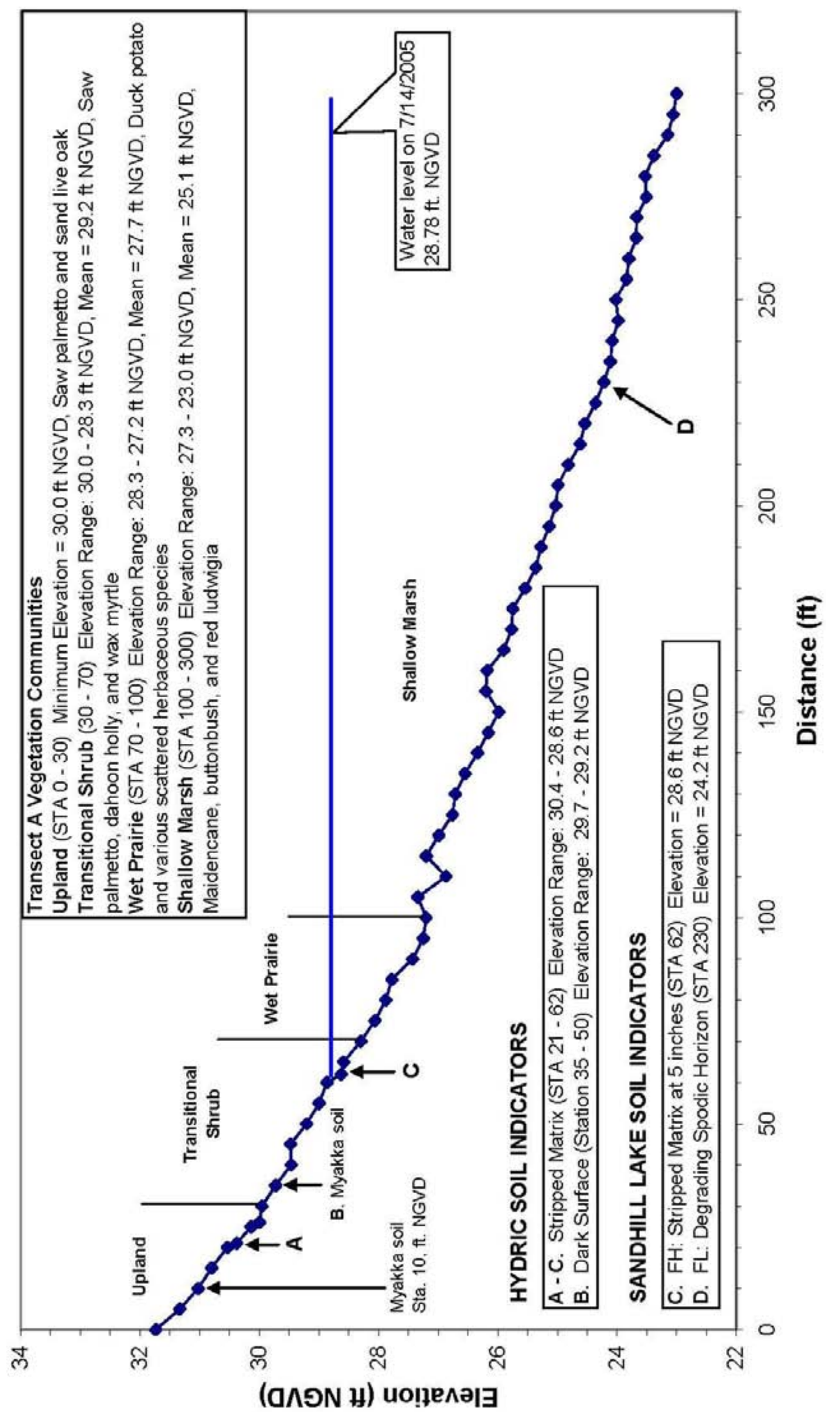

Figure 2. Transect A—Relating soils, vegetation, and topography at Lake Colby

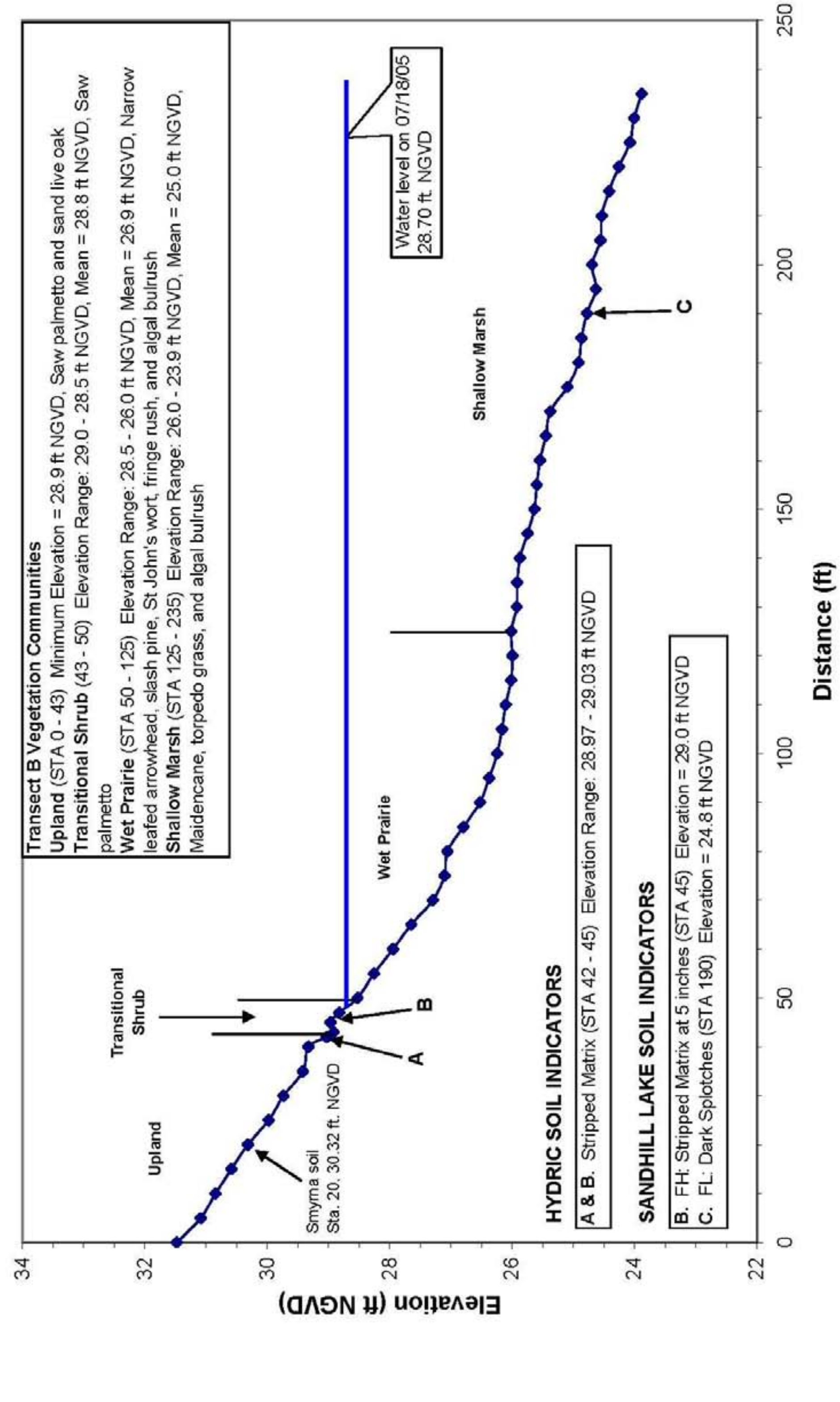

Figure 3. Transect B—Relating soils, vegetation and topography at Lake Colby

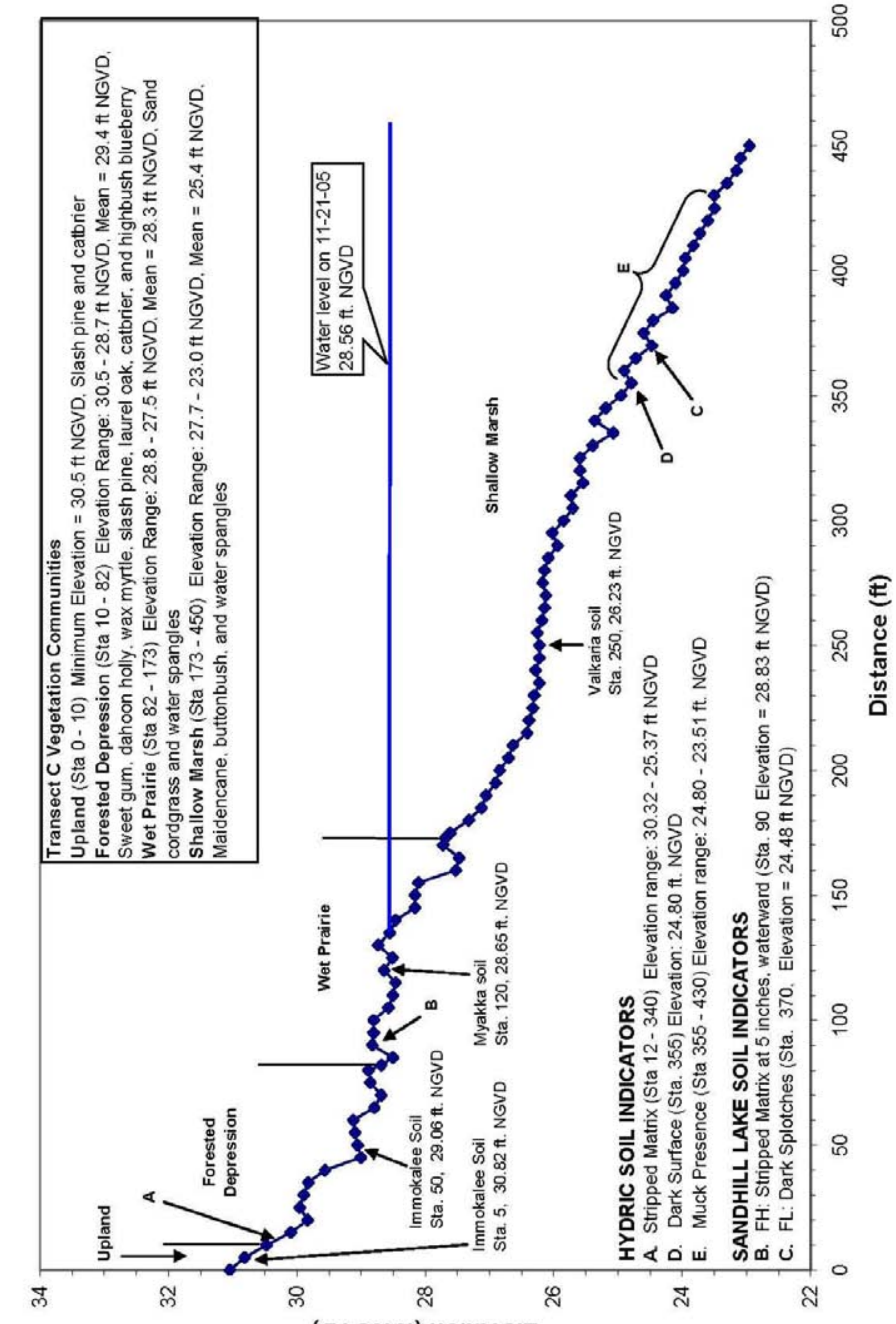

Figure 4. Transect C—Relating soils, vegetation, and topography at Lake Colby

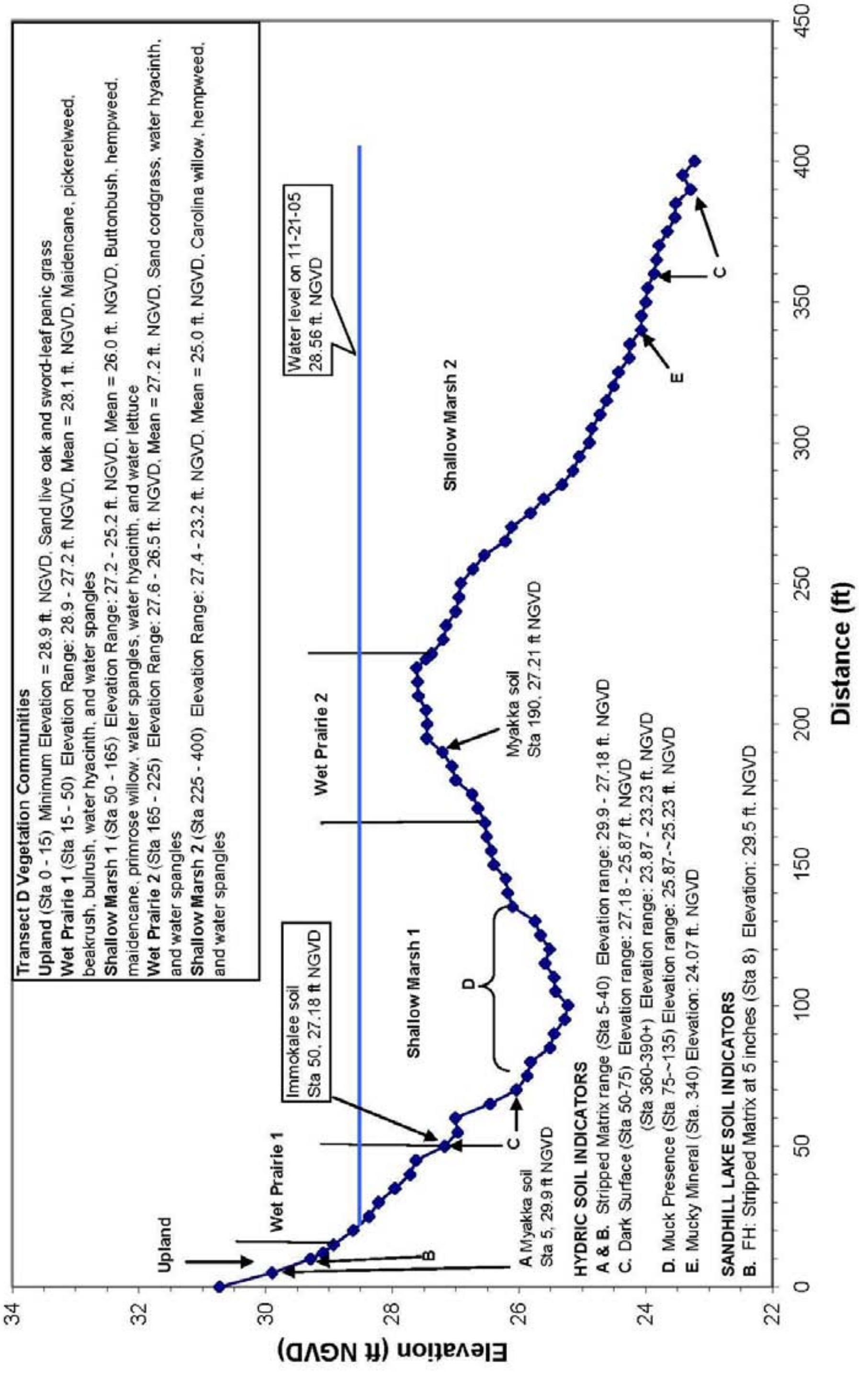

Figure 5. Transect D—Relating soils, vegetation, and topography at Lake Colby

APPENDIX D

IMPLEMENTATION OF MFLS FOR LAKE COLBY

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

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

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

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

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

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

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

Frequency analysis

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

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

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

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

$$P(S \geq \hat{S}_1) = \frac{1}{n} = \frac{1}{10} = 0.1 \quad ; \qquad \textbf{(D1)}$$

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

$$P(S \geq \hat{S}_2) = \frac{2}{10} = 0.2 \quad ; \qquad \textbf{(D2)}$$

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

$$P(S \geq \hat{S}_{10}) = \frac{10}{10} = 1.0 \quad . \qquad \textbf{(D3)}$$

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

$$P(S \geq \hat{S}_m) = \frac{m}{n+1} \quad \textbf{(D4)}$$

where,

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

$m =$ rank of the event.

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

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{11} = 0.0909 ; \quad \textbf{(D5)}$$

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

$$P(S \geq \hat{S}_{10}) = \frac{10}{11} = 0.9091 ; \quad \textbf{(D6)}$$

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

$$P(S < \hat{S}_{10}) = 1 - P(S \geq \hat{S}_{10}) = 1 - \frac{10}{11} = 1 - 0.9091 = 0.0909 \quad \textbf{(D7)}$$

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

$$T = \frac{1}{P} \quad \textbf{(D8)}$$

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

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = \frac{1}{\frac{1}{11}} = 11 . \quad \textbf{(D9)}$$

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

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

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{21} = 0.048 \qquad \textbf{(D10)}$$

and

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = 21 \qquad \textbf{(D11)}$$

The stage or flow characteristics of a water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure D1 shows a flood frequency plot generated from annual peak flow data collected at the U.S. Geological Survey (USGS) gauge on the Wekiva River.

Minimum events are treated in much the same way as maximum events, except that with minimums the events are ranked from smallest to largest. Thus $\hat{S}_1$ is the smallest or lowest event in a sampling. The minimum stage or flow characteristics of a gauge or water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure D2 shows a drought frequency plot generated from a hydrologic simulation of the middle St. Johns River.

One of the purposes of performing this process of sorting, ranking, and plotting events is to estimate probabilities and return periods for events larger than $\hat{S}_1$, smaller than $\hat{S}_n$, or any event between sample points. There are two methods of obtaining these probabilities and return periods. The first method is to use standard statistical methods to mathematically calculate these probabilities and return periods (Figure D3). This method is beyond the scope of this appendix; the reader is referred to a standard hydrology text (Ponce 1989, Linsley et al. 1982) or the standard flood frequency analysis text, Bulletin 17B (USGS 1982).

With the second method, interpolated or extrapolated frequencies and return periods can also be obtained by the graphical method. Once the period-of-record or period-of-simulation events have been sorted and ranked, they are plotted on probability paper. Probabilities and return periods for events outside of the sampled events can be estimated by drawing a line through the points on the graph to obtain an estimated best fit (Figure D4).

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

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

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

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

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

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

Hydrologic statistics and their relationships to the Lake Colby MFLs

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

Each of the two MFLs is tied to characteristic stage durations and return frequencies. For example, the ground elevation represented by the FH level is expected to remain wet continuously for a period of at least 30 days. This event is expected to occur, on average, at least once every 3 years.

The standard stage frequency analysis described previously in this appendix was performed on stage data from lake model simulations of Lake Colby (Robison 2007). In particular, stages continuously exceeded (ground elevations remaining wet) for 30 days were determined, sorted, ranked, and plotted (Figure D5). These stages were obtained assuming that long-term groundwater withdrawals occurred at the same level at which they occurred in 2003. The ground elevation of the FH level can be superimposed on the plot (Figure D6) to demonstrate how the level is related to the pertinent hydrologic statistics. Finally, a box bounded by (1) the FH level on the bottom; (2) a vertical line corresponding to a frequency of occurrence of once in every 3 years on the right; and (3) a vertical line corresponding to a frequency of occurrence of once in every 2 years on the left, is superimposed on the plot (Figure D7). Similar analyses were performed for the FL level (Figure D8). Both levels are being met under these conditions.

A summary of the recommended MFLs for Lake Colby is shown in Table D1. Values in this table will be used as benchmarks for modeling outputs to determine if groundwater withdrawals in the vicinity of Lake Colby will cause water levels to fall below MFLs.

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

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

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

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

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

When evaluating consumptive use permit applications for increased withdrawals of groundwater from the Floridan aquifer or when performing water supply planning evaluations, SJRWMD estimates the projected drawdown in the potentiometric surface of the Floridan aquifer in the vicinity of lakes with established MFLs. The analysis includes all existing permitted uses in addition to the proposed increased withdrawals. SJRWMD uses the appropriate regional groundwater flow model to produce these estimates. In the case of Lake Colby, at the time of preparation of this document, SJRWMD was using the Volusia Regional Groundwater Flow Model (Williams 2006) for this purpose. This steady-state model is calibrated to 1995 conditions; therefore, the projected drawdown in the potentiometric surface represents the estimated drawdown that would occur from 1995 to the last year of simulation. In association with consumptive use permit evaluations, the last year of simulation represents the year through which issuance of the permit is contemplated. In SJRWMD's water supply assessment and planning processes, the last year of simulation represents the planning horizon year and/or other intermediate years that may represent significant water use targets.

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

As stated previously, the model simulation results depicted in Figures D7 and D8 assume long-term Floridan aquifer withdrawals at 2003 levels. Any withdrawal increases beyond 2003 would tend to lower potentiometric levels in the area and, therefore, would tend to lower lake levels in Lake Colby. In order to determine the freeboard present at Lake Colby from the point of view of Floridan aquifer water level drawdowns, a trial-and-error process was undertaken assuming incrementally increasing drawdowns. Drawdowns are represented by subtracting a set amount from the well hydrograph used in simulation of Lake Colby. In the case of Lake Colby, for a Floridan aquifer water level drawdown of 0.9 ft, the FL level would still be met (Figure D9). However, any drawdowns greater than 0.9 ft would cause water levels to fall below the established FL level. At a drawdown of 0.9 ft, the FH level would still be met (Figure D10). Therefore, future Floridan aquifer water level drawdowns beyond 2003 conditions will be limited to 0.9 ft in the Lake Colby area.

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

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

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

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

- A water use data set for the calibration year of the lake model is prepared and used in the applicable regional groundwater flow model. The resulting drawdowns represent drawdowns from 1995 to the calibration year of the lake model. Based on drawdowns projected for 2003 conditions by the Volusia

Regional Groundwater Flow Model, drawdown in the vicinity of Lake Colby between 1995 and 2003 was approximately 0.2 ft.

- Estimated drawdowns in the potentiometric surface from 1995 to the calibration year of the lake model are interpolated based on estimates of drawdowns projected to occur from 1995 to some simulation year beyond the lake calibration year. This approach requires assuming a straight-line increase of the projected drawdown from 1995 to the final year of simulation and selecting the appropriate interpolated value for the period 1995 to the year of calibration for the lake model.

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

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

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

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

Because the estimated 2003 freeboard for Lake Colby is 0.9 ft and the drawdown in the vicinity of Lake Colby between 1995 and 2003 was approximately 0.2 ft, then the allowable drawdown from 1995 to some future year would be limited to 1.1 ft.

Table D1. Summary of recommended MFLs for Lake Colby

MFLs	Level (ft NGVD)	Duration	Series	Water Year	Statistical Type	Minimum Return Period	Maximum Return Period
Minimum frequent high	27.6	30 days	Annual	June 1– May 31	Maximum, continuously exceeded	NA	3 yrs
Minimum frequent low	22.9	120 days	Annual	Oct. 1– Sept. 30	Minimum, continuously not exceeded	3 yrs	NA

ft NGVD = feet National Geodetic Vertical Datum

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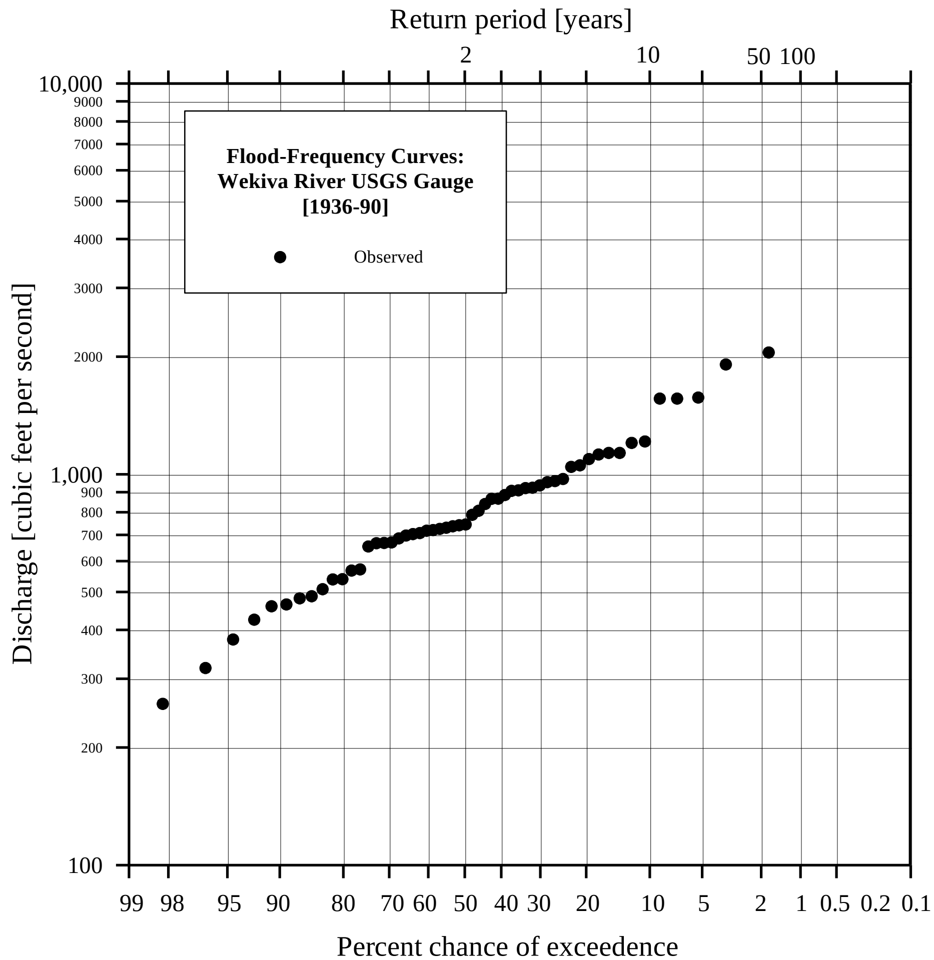


Figure D1. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Fla.; the 1-day peak flows have been sorted, ranked, and plotted according to the Weibull plotting position formula

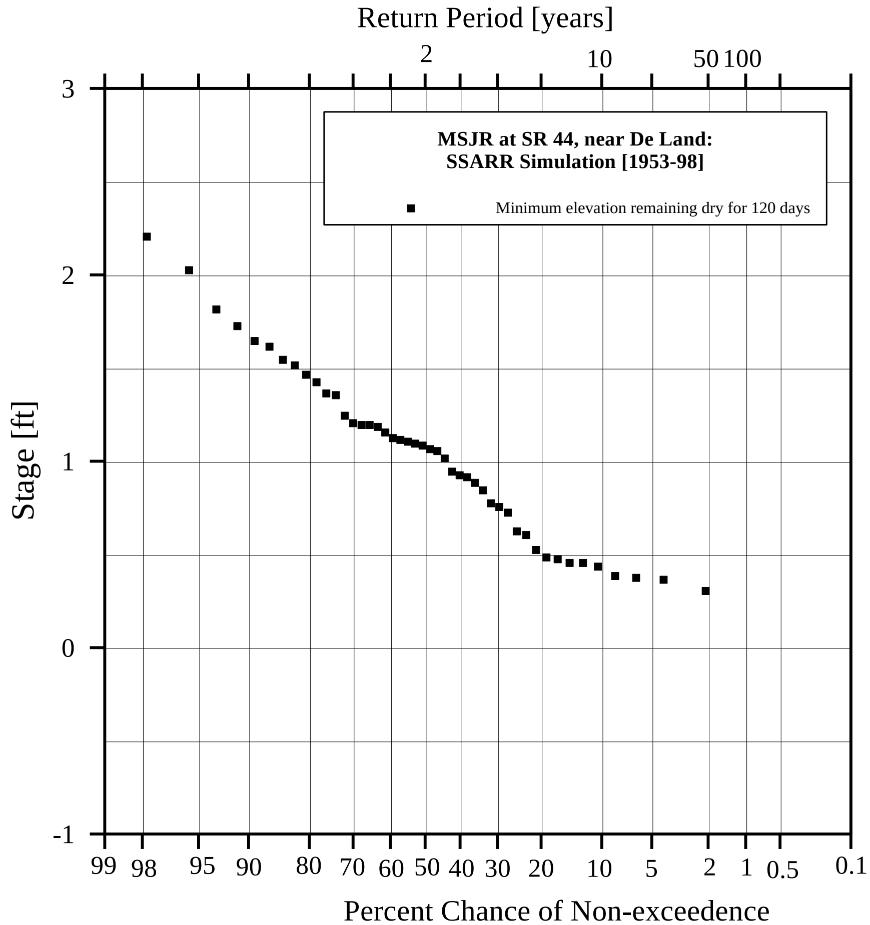


Figure D2. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand; the minimum stages continuously not exceeded for 120 days have been sorted, ranked, and plotted according to the Weibull plotting position formula

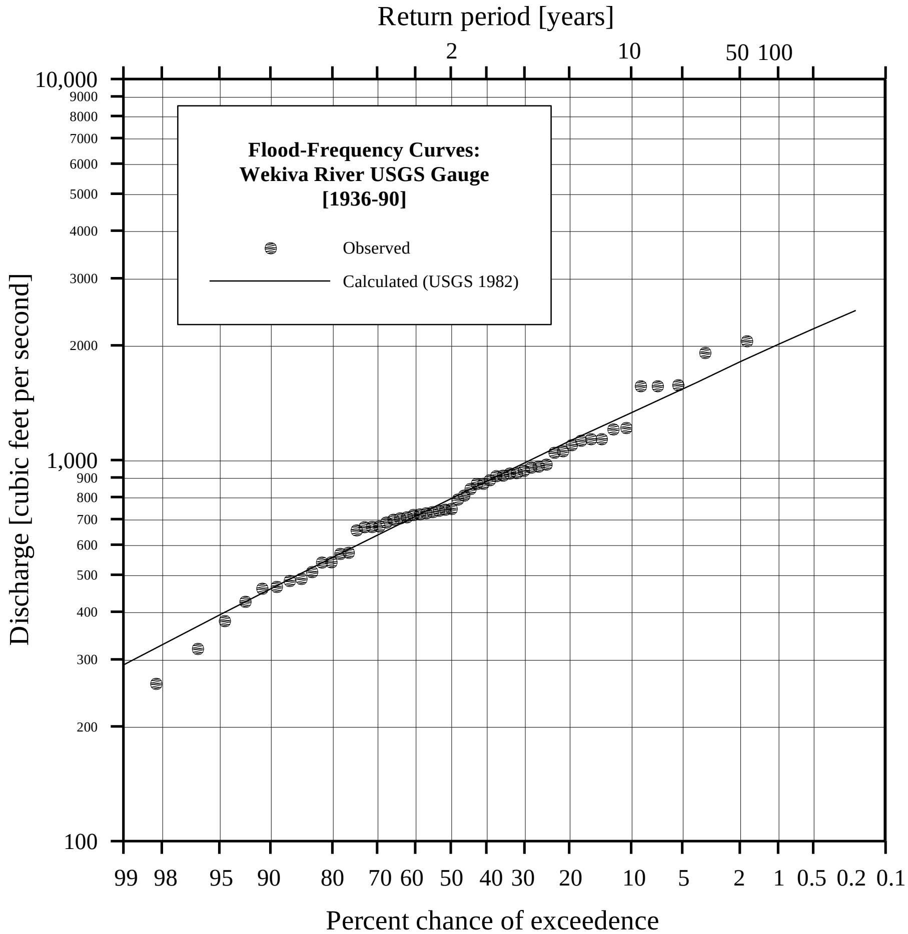


Figure D3. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Fla., fitted by standard mathematical procedure

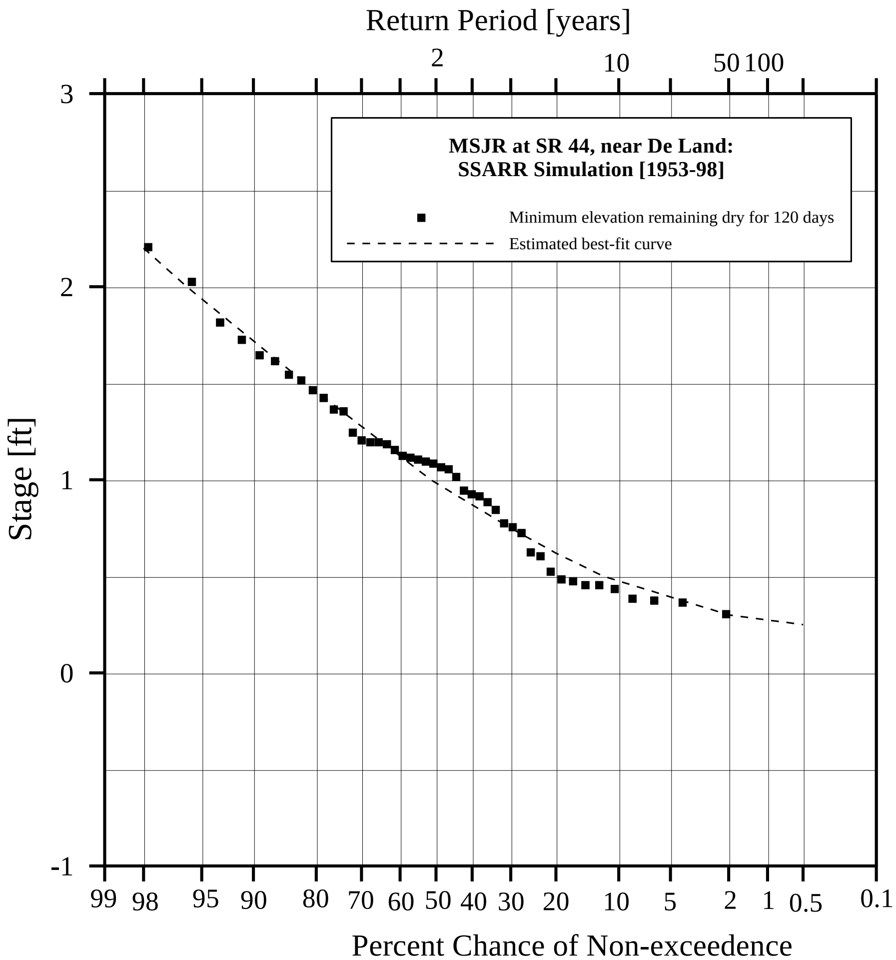


Figure D4. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand, fitted by the graphical method

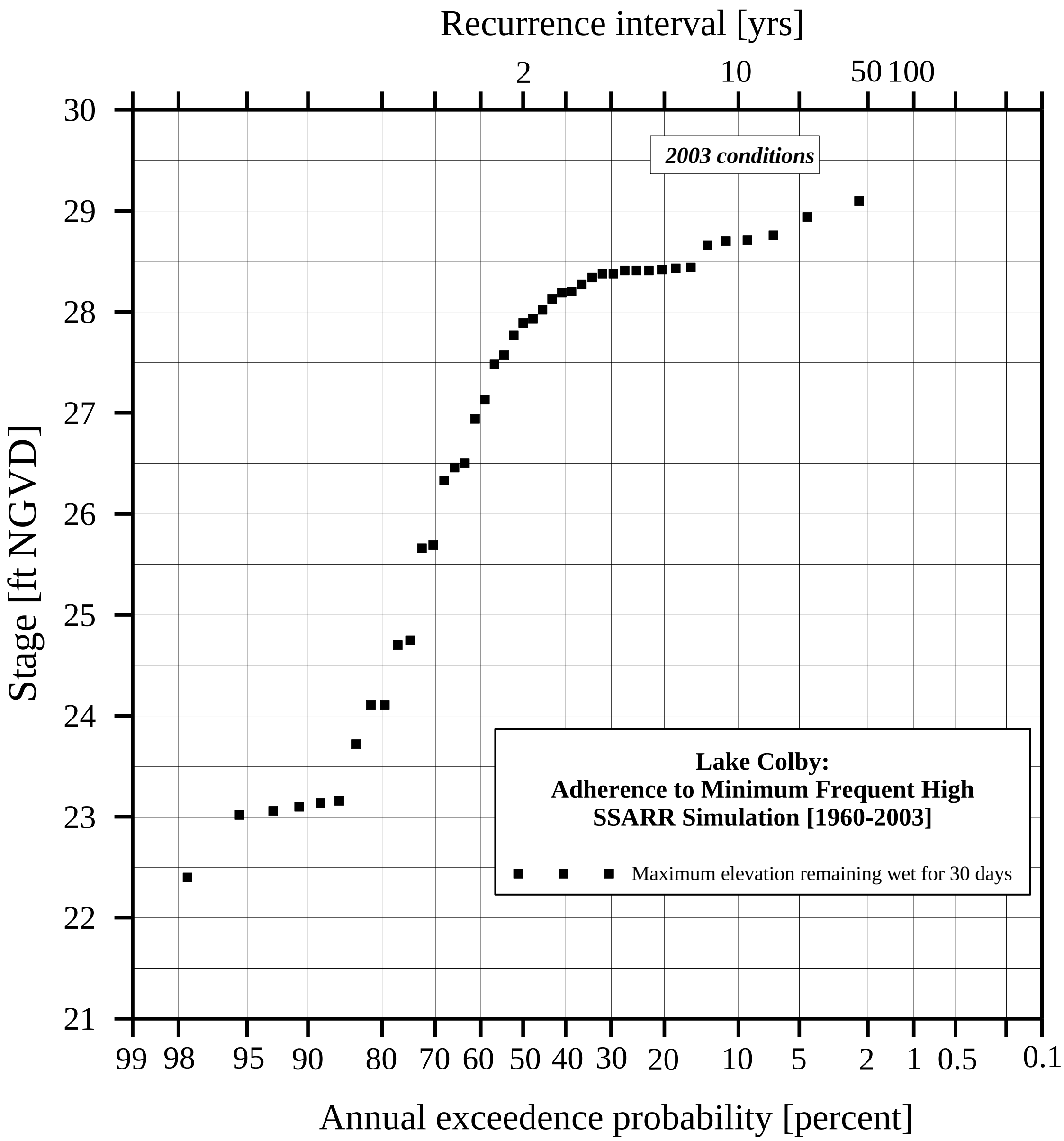


Figure D5. Flood frequencies computed using daily stages from model simulations of Lake Colby, for elevations continuously wet for 30 days and 2003 conditions

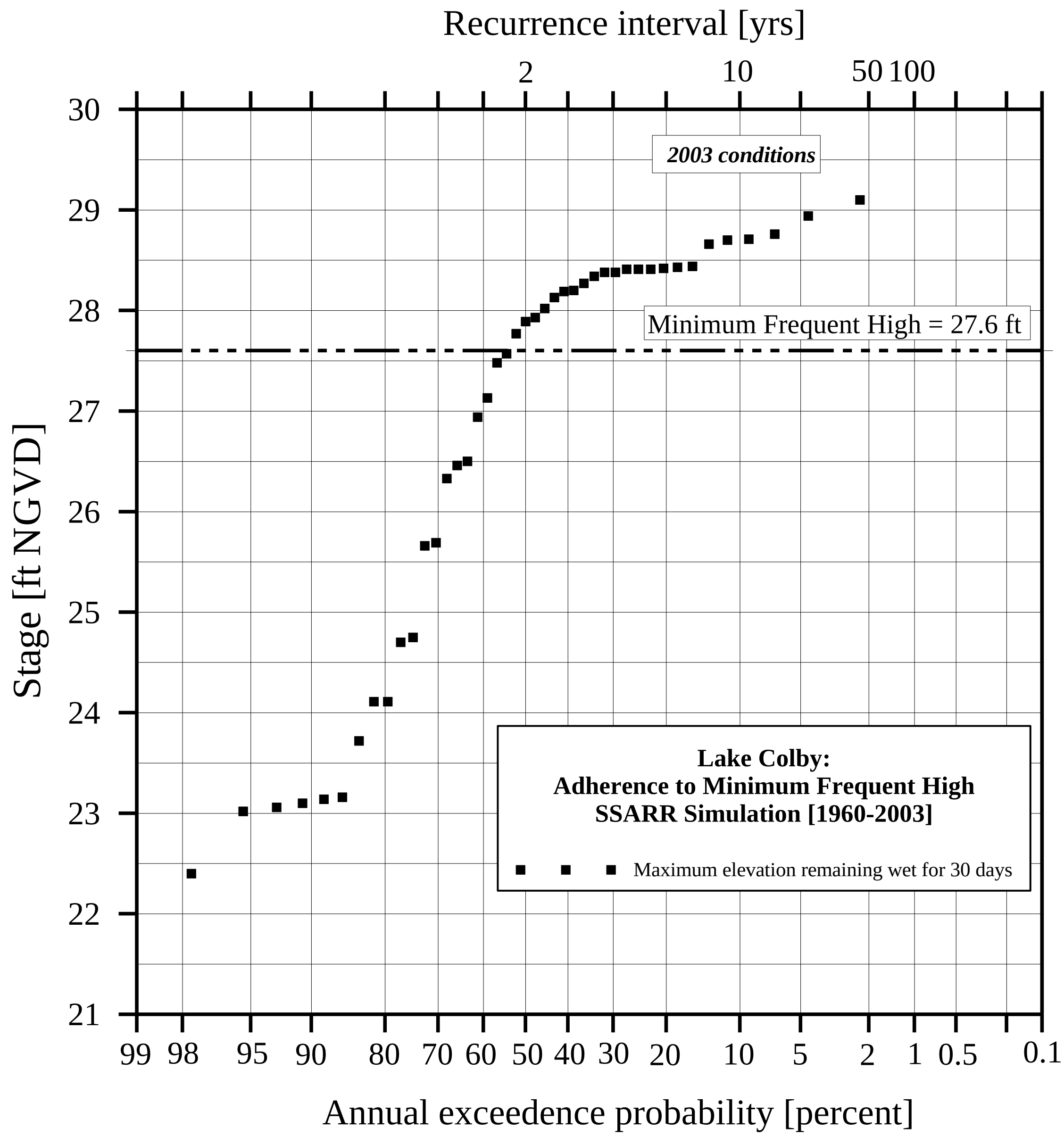


Figure D6. Flood frequencies computed using daily stages from model simulations of Lake Colby, for elevations continuously wet for 30 days and 2003 conditions with the minimum frequent high of 27.6 ft NGVD superimposed

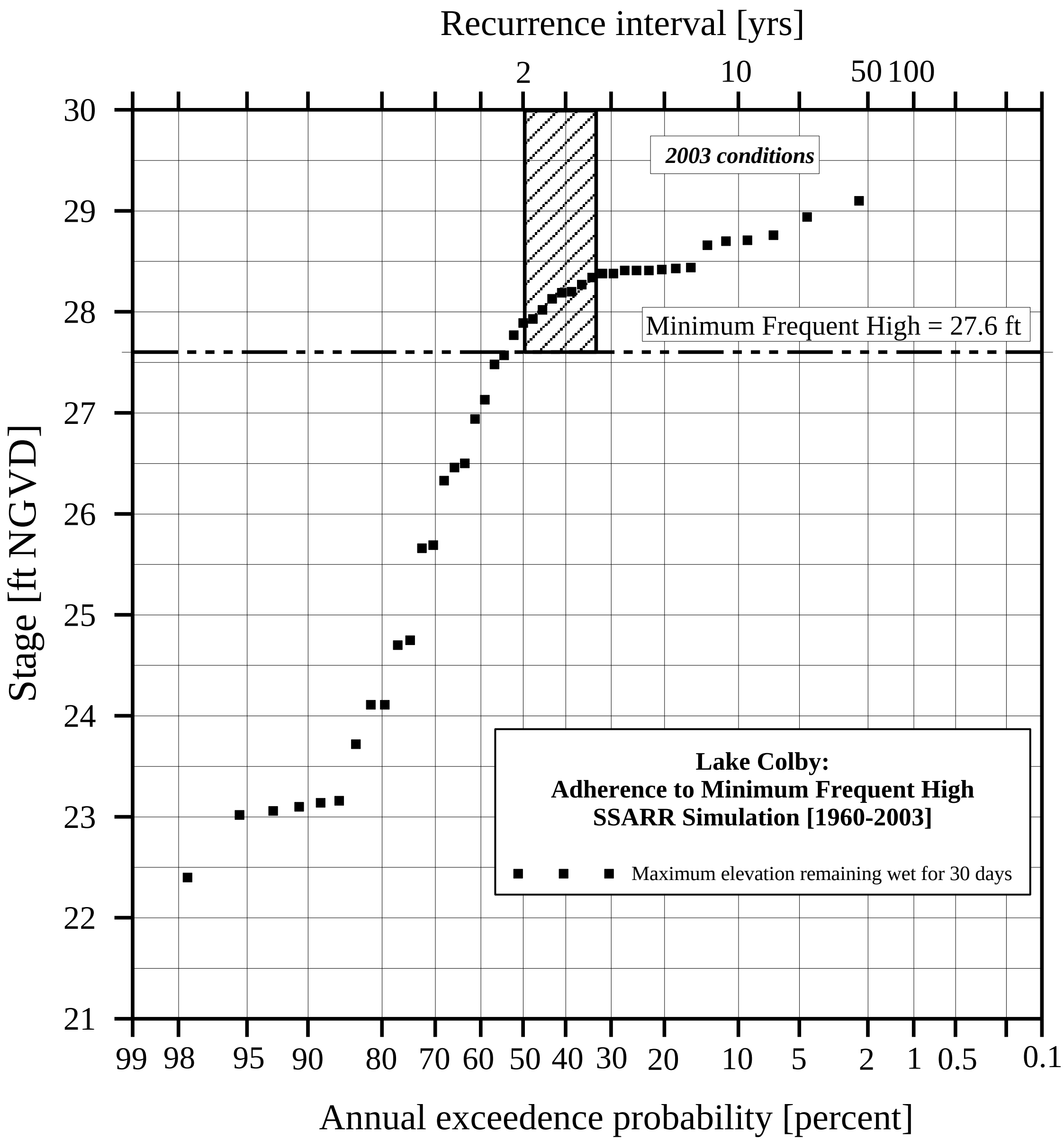


Figure D7. Flood frequencies computed using daily stages from model simulations of Lake Colby, for elevations continuously wet for 30 days and 2003 conditions with a superimposed box bounded by (1) the minimum frequent high; (2) a vertical line corresponding to a return period of 2 years; and (3) a vertical line corresponding to a return period of 3 years

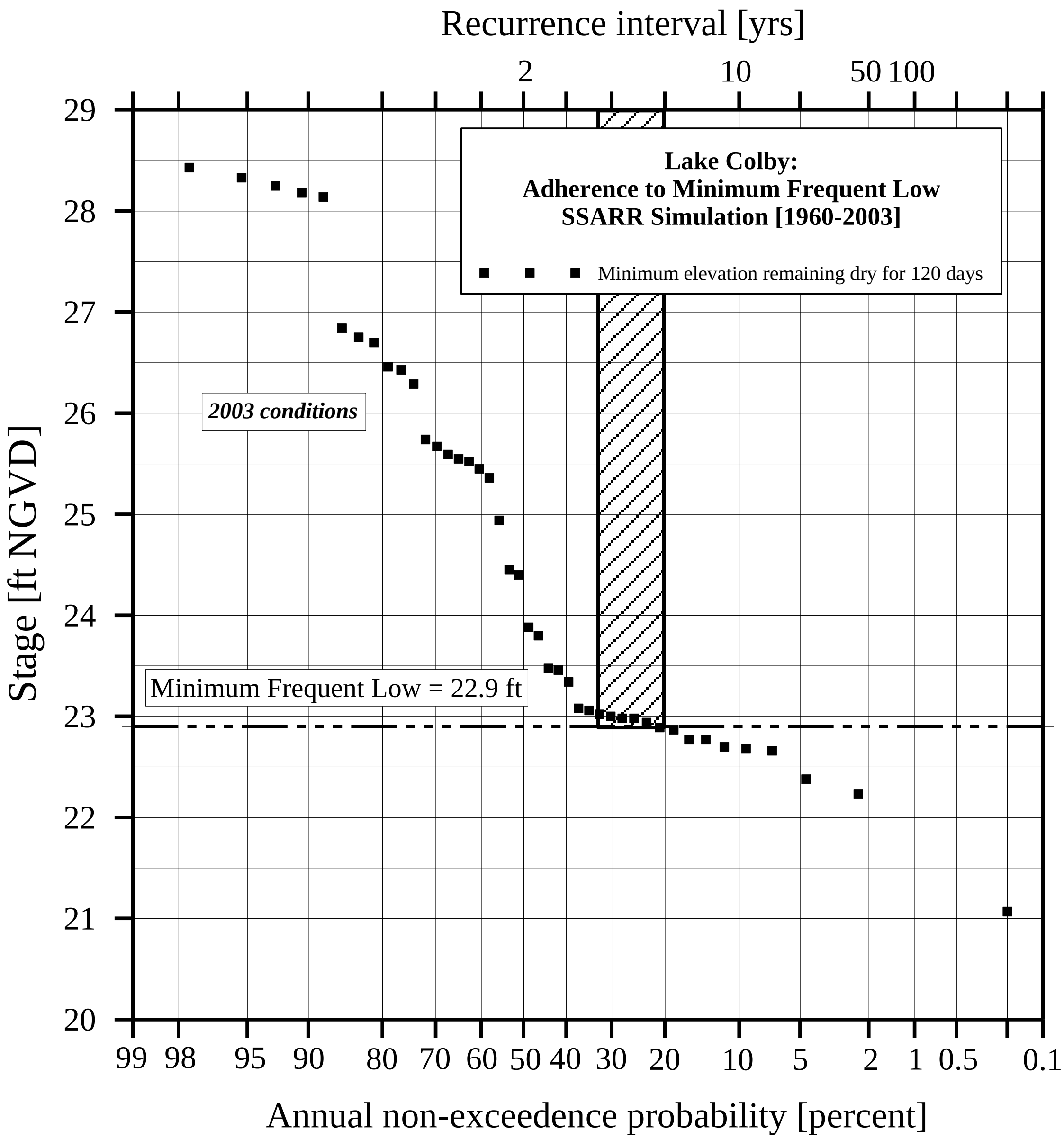


Figure D8. Drought frequencies computed using daily stages from model simulations of Lake Colby, for the minimum frequent low level and 2003 conditions

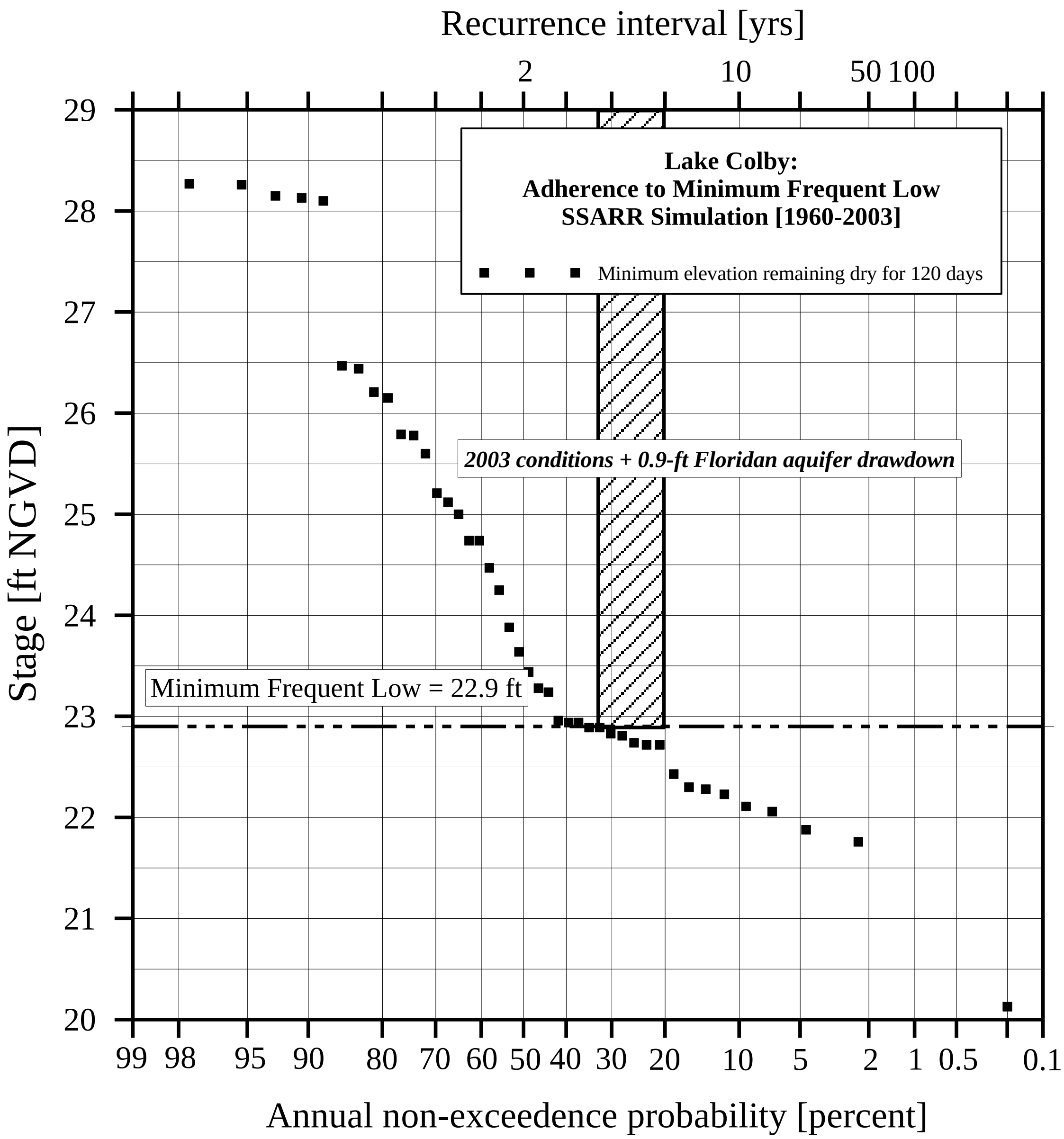


Figure D9. Drought frequencies computed using daily stages from model simulations of Lake Colby, for the minimum frequent low level and 2003 conditions plus a 0.9-ft Floridan aquifer drawdown

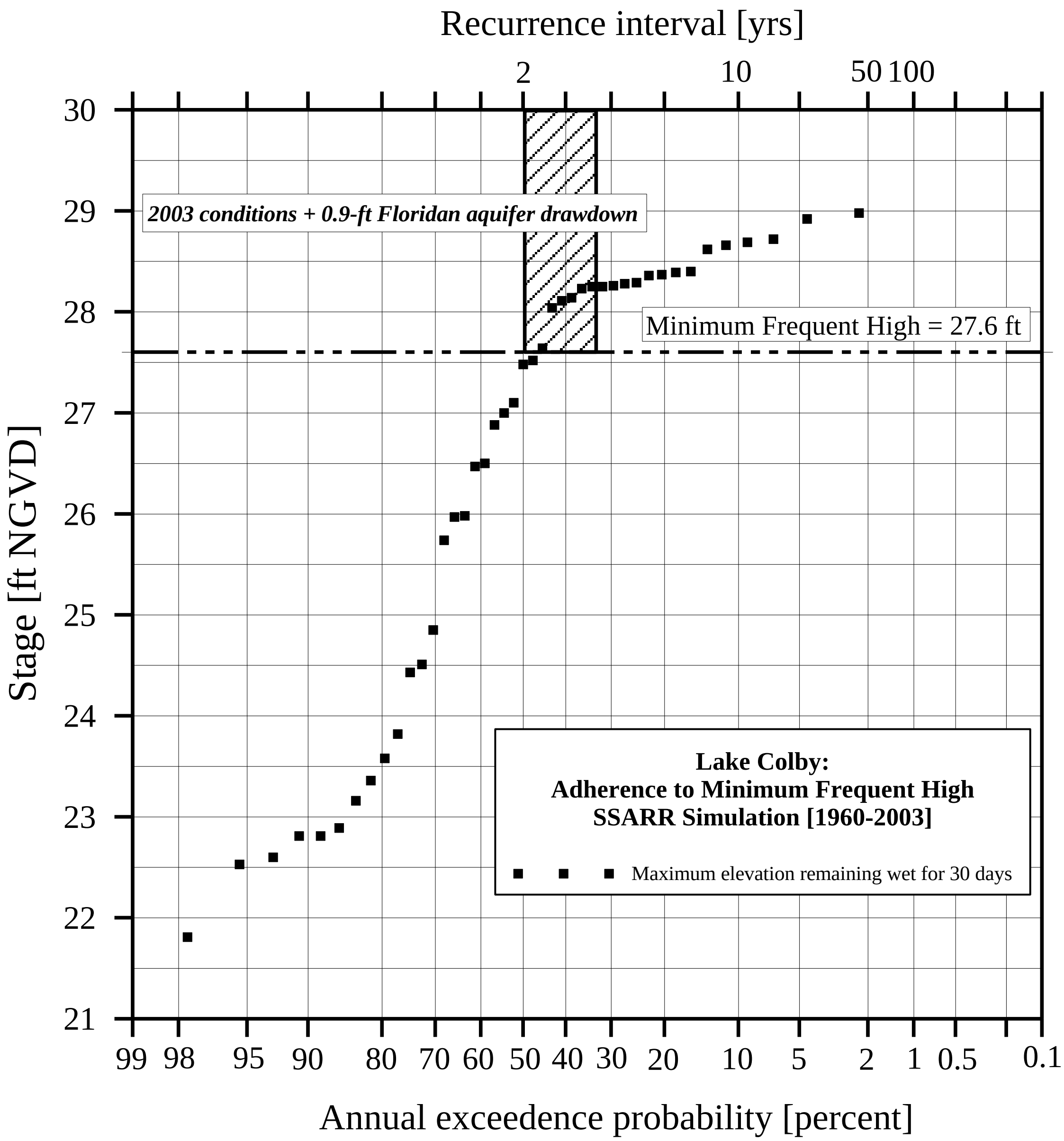


Figure D10. Flood frequencies computed using daily stages from model simulations of Lake Colby, for the minimum frequent high level and 2003 conditions plus a 0.9-ft Floridan aquifer drawdown

Table 16. Transect D vegetation species list, Lake Colby

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]				
			Upland (0-15 ft)	Wet Prairie (15-50 ft)	Shallow Marsh (50-165 ft)	Wet Prairie (165-225 ft)	Shallow Marsh (225-400 ft)
Alternanthera philoxeroides	Alligator weed	OBL		0			
Andropogon virginicus	Broomsedge	FAC	1				
Cephalanthus occidentalis	Buttonbush	OBL			4	1	1
Eichhornia crassipes	Water hyacinth	OBL		2	2	3	0
Eriocaulon compressum	Pipewort	OBL		1			
Hydrocotyle umbellata	Umbrella pennywort	FACW	0	1			
Ludwigia peruviana	Primrose willow	OBL		0	2	1	0
Luziola fluitans	Watergrass	OBL					0
Mikania scandens	Hempweed	UPL		0	3	1	3
Panicum ensifolium	Sword-leaf Panic Grass	OBL	2				
Panicum hemitomon	Maidencane	OBL		2	2	1	1
Pistia stratiotes	Water lettuce	OBL			3	1	1
Polygonum hirsutum	Jointweed	OBL		1		1	
Pontederia cordata	Pickerelweed	OBL		2	0	1	
Quercus geminata	Sand live oak	UPL	3				
Rhynchospora microcephala	Beakrush	FACW	0	2			
Sabal palmetto	Cabbage palm	FAC				0	
Sacciolepis striata	American cupscale	OBL		1			
Sagittaria subulata	Awl-leaf arrowhead	OBL		0			
Salix caroliniana	Carolina willow	OBL			1	1	3
Salvinia minima	Water spangles	OBL		2	2	2	3
Scirpus cubensis	Bulrush	OBL		2	0		0

Table 16—*Continued*

Species	Common Name	FWDM Code[1,2]	Plant Communities With Plant Species Cover Estimates[3]				
			Upland (0-15 ft)	Wet Prairie (15-50 ft)	Shallow Marsh (50-165 ft)	Wet Prairie (165-225 ft)	Shallow Marsh (225-400 ft)
Spartina bakeri	Sand cordgrass	FACW				2	
Xyris sp.	Yelloweye-grass	OBL	0	1			

[1]Species and hydric designations are taken from Ch. 62-340.450, *F.A.C.* Species not in the rule are assumed upland (UPL) unless they are obvious aquatics; unlisted aquatic species are designated as obligates (OBL).

[2]Florida Wetlands Delineation Manual (FWDM) Wetland Indicator Status (Gilbert et al. 1995)

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

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

FACW = Facultative wet plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands.

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

[3]Species Occurrence: Aerial extent of vegetation species along each transect within each community where,

0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 25–50% (abundant); 4 = 51–75% (co-dominant);
5 = >75% (dominant).

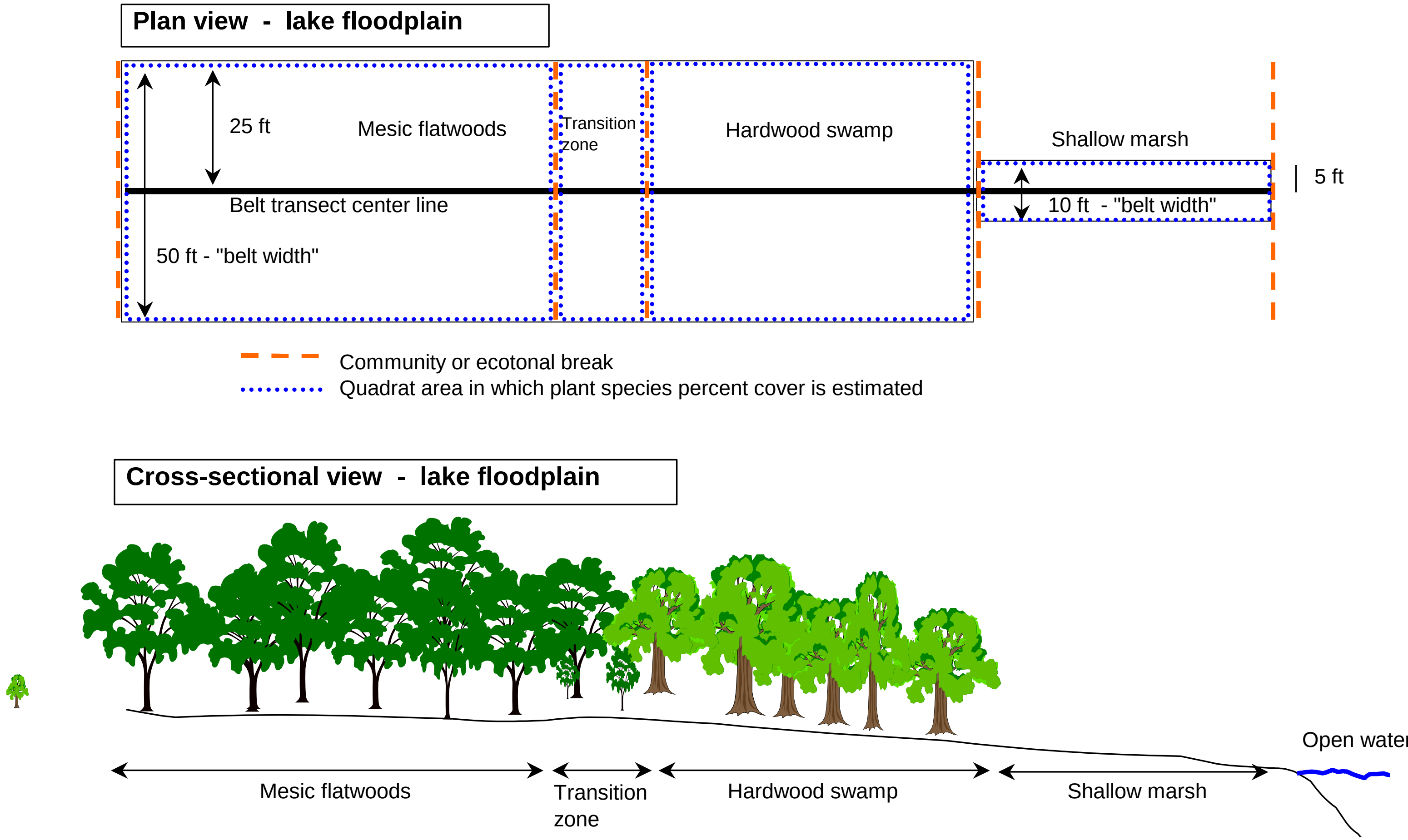
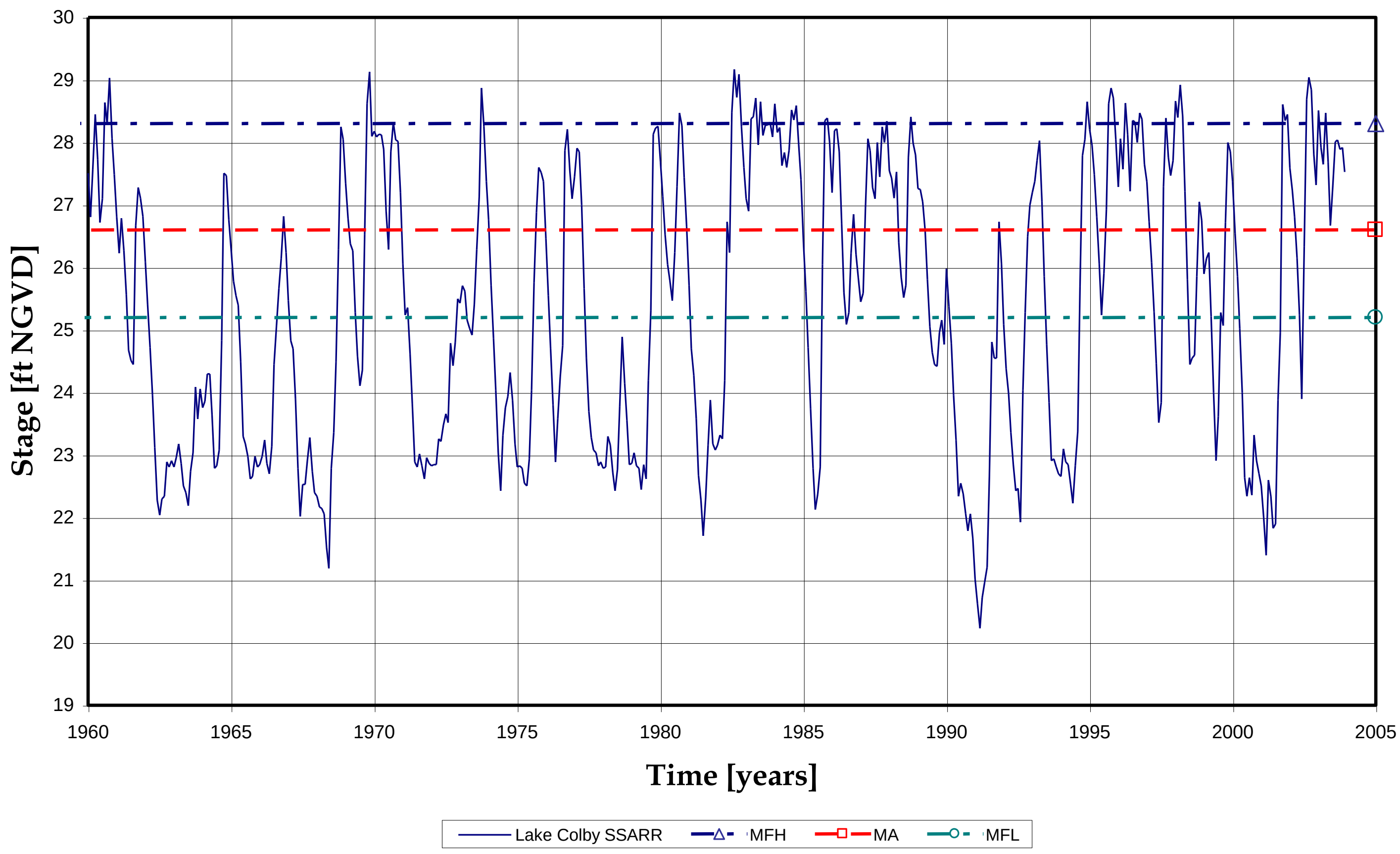


Figure 2. Example of belt transect through forested and herbaceous plant communities



Stage [ft NGVD]
30
29
28
27
26
25
24
23
22
21
20
19
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Time [years]
Lake Colby SSARR
MFH
MA
MFL

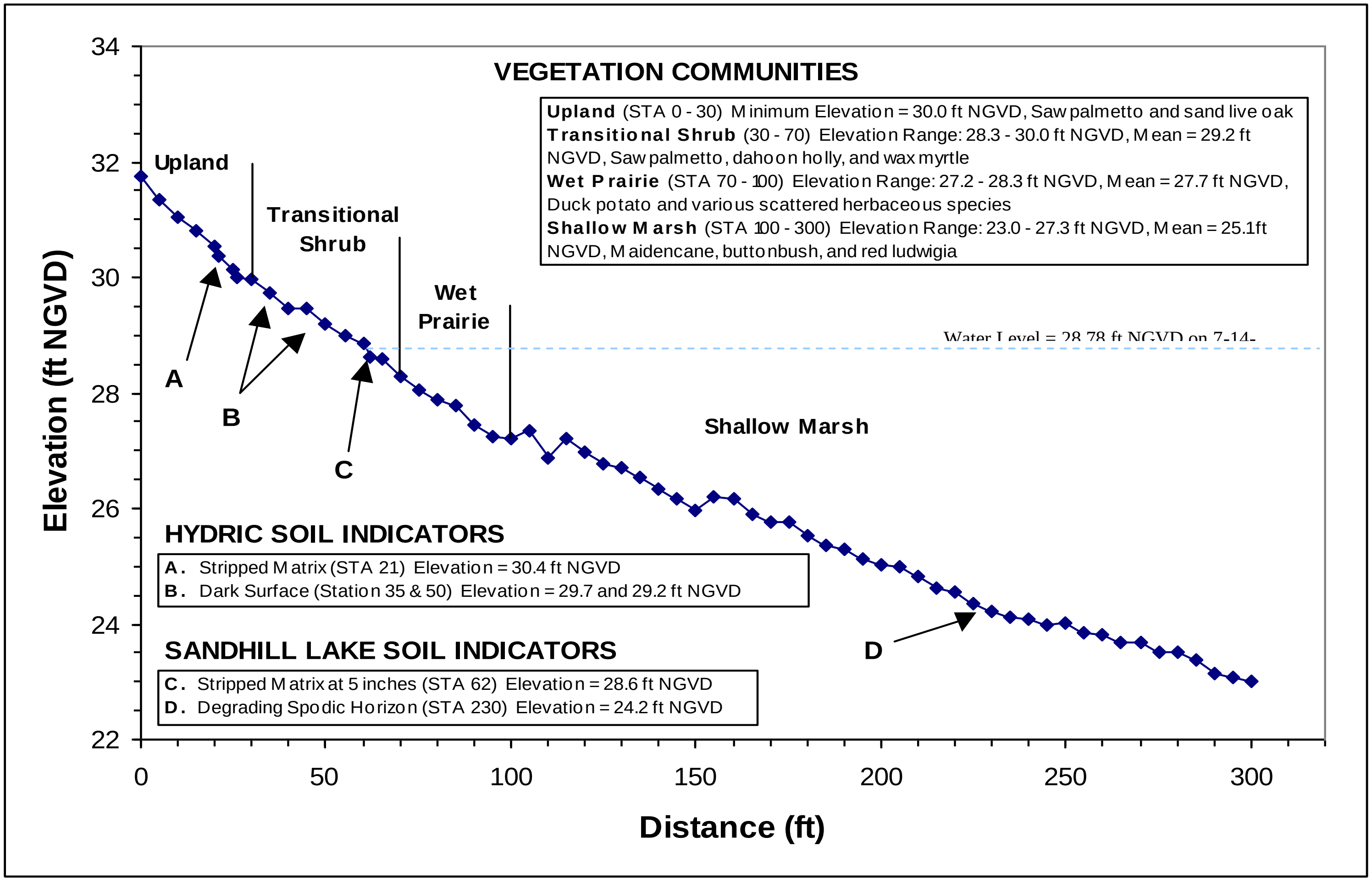


Figure 4. Hydrograph of modeled data (1961–2003) with adopted minimum levels, Lake Colby, Volusia County, Fla.

Figure 12. Transect A, Lake Colby—Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

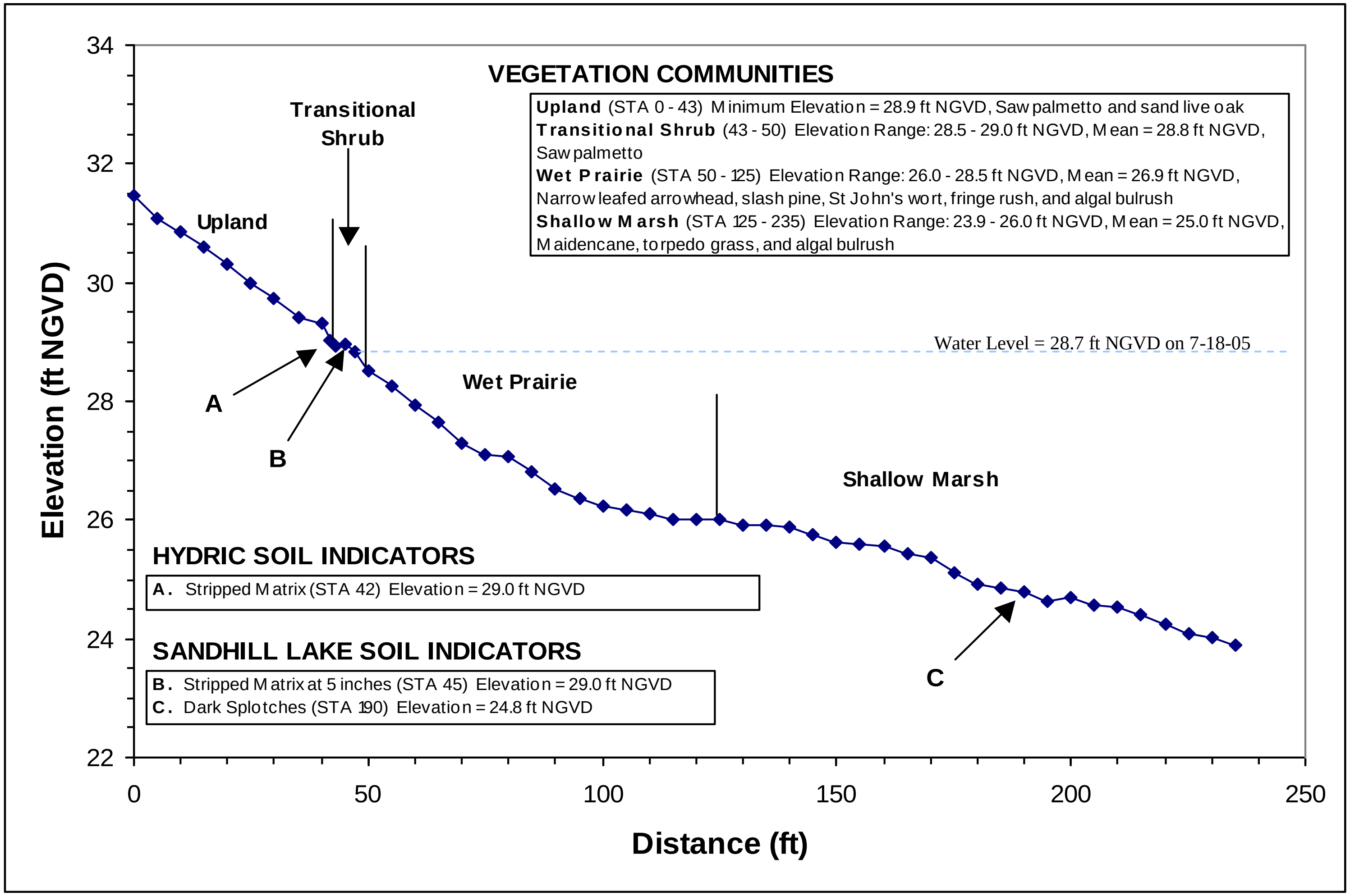


Figure 14. Transect B, Lake Colby—Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

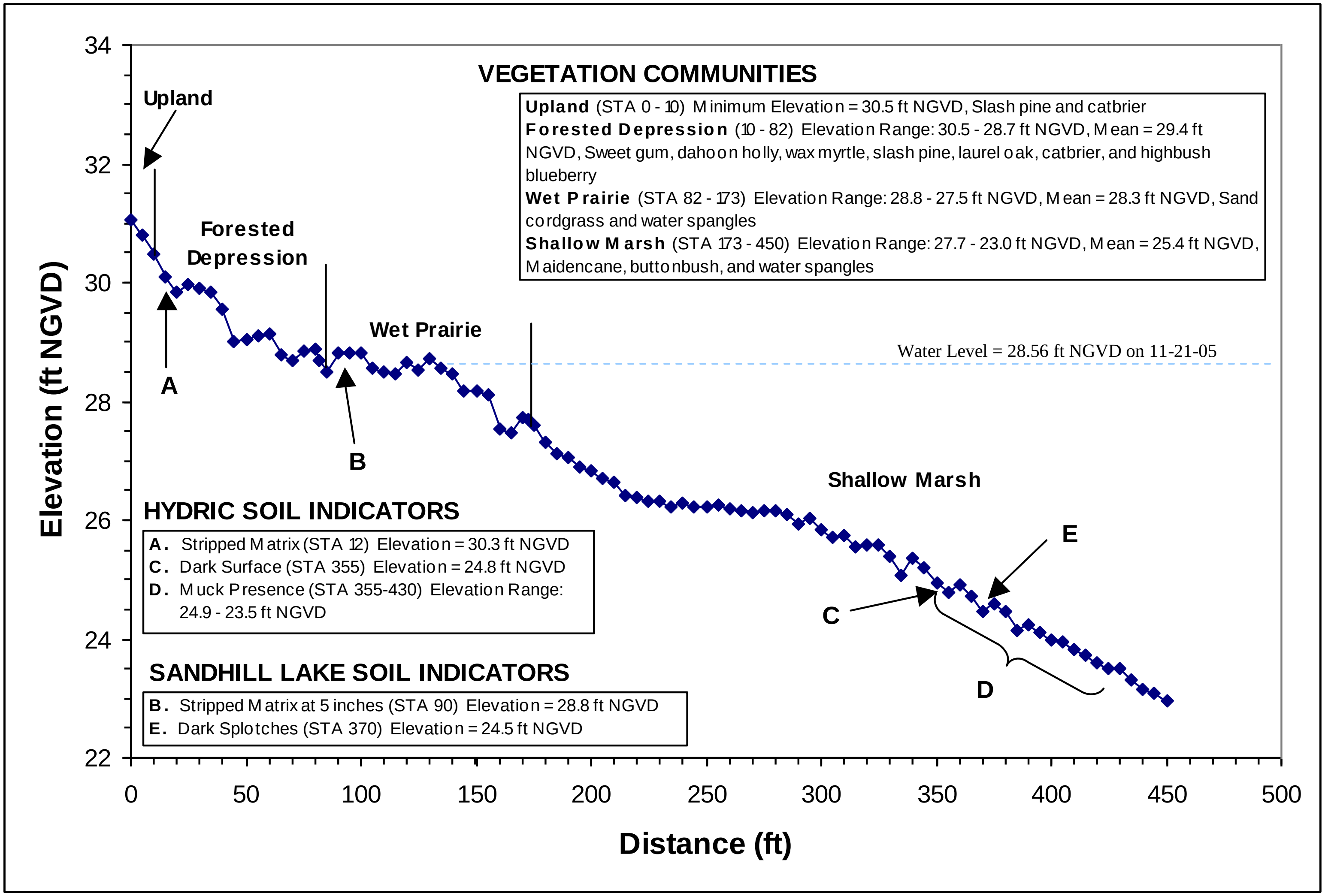


Figure 16. Transect C, Lake Colby—Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators

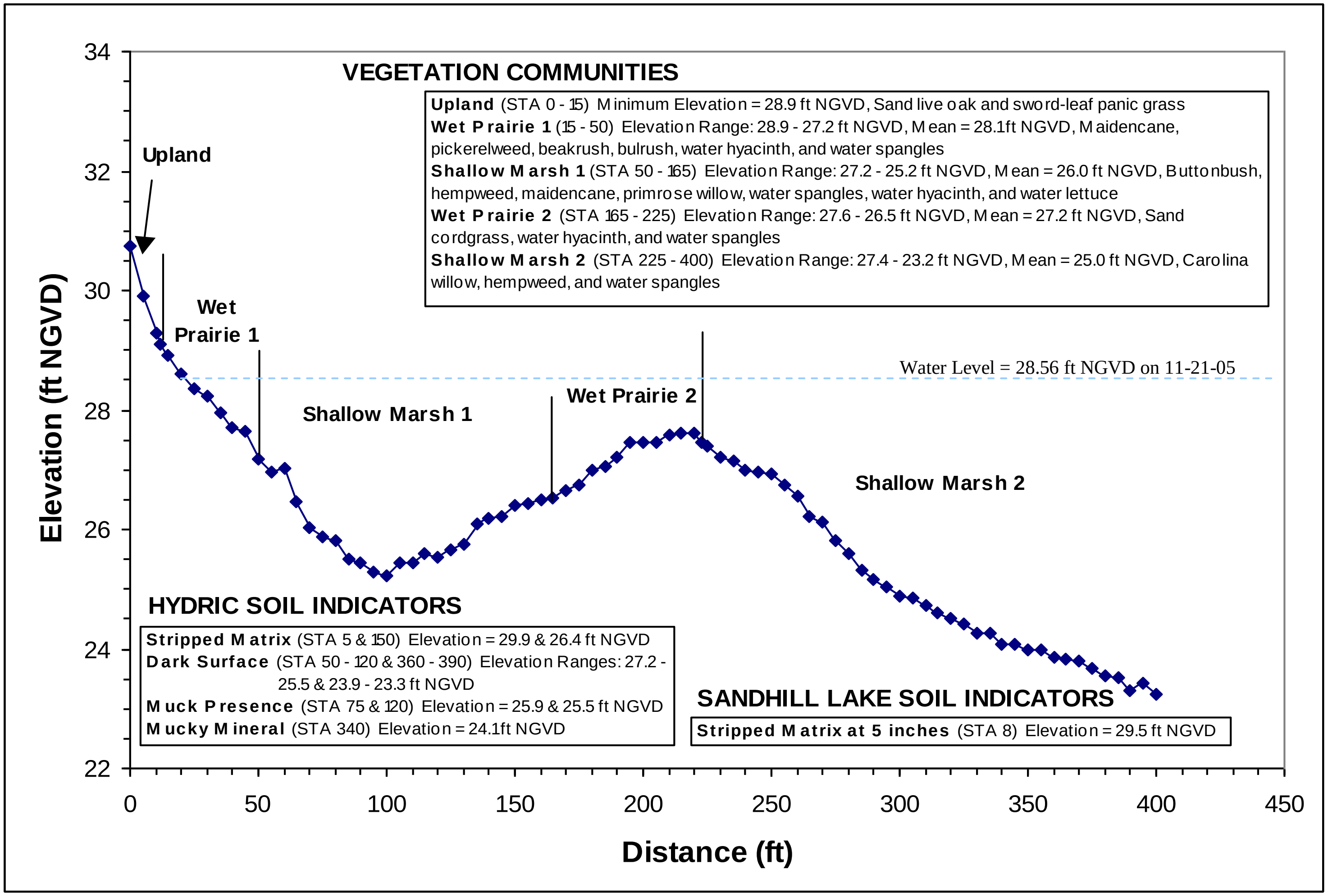


Figure 18. Transect D, Lake Colby—Topography, vegetation communities, hydric soil indicators, and sandhill lake soil indicators