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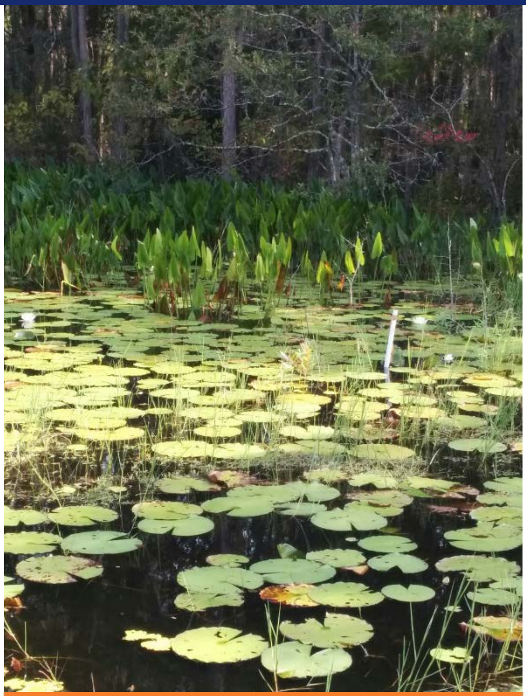

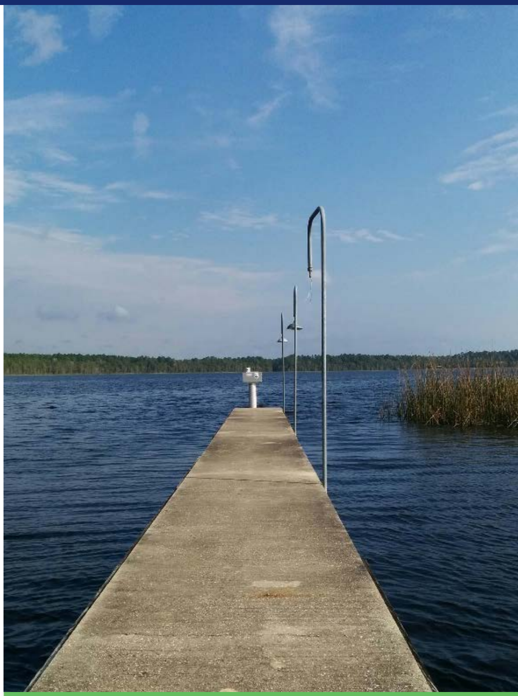

MINIMUM RECOMMENDED LAKE LEVELS: LAKE BUTLER, FLORIDA

March 2021

Prepared for:

Suwannee River Water Management District
9225 County Road 49
Live Oak, FL 32060

The Suwannee River Water Management District (SRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 15 counties in north central Florida. The mission of SRWMD 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. SRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; and land acquisition and management.

This document is published to disseminate information collected by SRWMD in pursuit of its mission. Copies of this document can be obtained from:

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Executive Summary

Under task work assignment (TWA): 19/20-061.002, Environmental Consulting and Technology, Inc. (ECT) was authorized by the Suwannee River Water Management District (SRWMD or District) to prepare a report titled Minimum Recommended Lake Levels: Lake Butler, Florida.

This report presents the SRWMD's recommended minimum flows and levels (MFLs) for Lake Butler in Union County, Florida (Summary Table). These MFLs are based on work performed by Wilson-Miller/Stantec; Dooris & Associates, LLC; ECT; and SRWMD staff using methodology developed by the St. Johns River Water Management District (SJRWMD) and supported by methods developed by the Southwest Florida Water Management District (SWFWMD).

Summary Table. Recommended minimum lake levels for Lake Butler, Union County.

Minimum Level	Recommended Elevation (ft NAVD88)	Recommended Hydroperiod Categories	Recommended Duration (days)	Recommended Return Interval (years)
Minimum frequent high level (FH)	129.55	Seasonally flooded	30	2
Minimum frequent low level (FL)	127.30	Semi-permanently flooded	120	5

ft NAVD88 = feet above North American Vertical Datum of 1988

The SJRWMD event-based MFLs methods (SJRWMD 2006; Neubauer et al. 2008) are used to determine MFLs based on the evaluation of topography, vegetation, and soils associated with a water body. Hydroperiod categories, which describe the seasonal and cyclical patterns of water in a wetland, are defined from adaptations of water regime modifiers developed by Cowardin et al. (1979). SWFWMD methods utilized in this study focus upon hydrologic indicators (Rule 40D-8.624, F.A.C.). Results presented in this report are considered recommended until the MFLs are adopted by the water management district's Governing Board as rule, in accordance with Chapter 40B-8, Florida Administrative Code (F.A.C.).

The recommended minimum frequent high (FH) level for Lake Butler is a water elevation of 129.55 feet (ft) above the North American Vertical Datum of 1988 (NAVD88) and a hydroperiod category described as "seasonally flooded" (Summary Table). The minimum frequent high stage for a seasonally flooded hydroperiod represents the average land surface elevation in the basin swamp adjacent to the lake.

The recommended minimum frequent low (FL) level for Lake Butler is a water elevation of 127.30 ft NAVD88 and a hydroperiod category described as "semi-permanently flooded" (Summary Table). This elevation represents the upper limit of the deep marsh community. This level provides sufficient water depths within the deep marsh communities to provide refuge and nesting habitat for fish and other aquatic species.

SWFWMD MFLs methods use categorical significant change standards to identify criteria sensitive to long-term changes in hydrology (Rule 40D-8.624, F.A.C.). These standards were investigated for Lake Butler MFLs development; but rather than being utilized for setting minimum lake levels, were used to support SJRWMD methodology. Two MFLs typically proposed by this methodology are the High Minimum lake Level (HML) and the Minimum Lake Level (MLL). The HML is a stage that represents the elevation of the water surface of a lake or wetland that is equaled or exceeded 10 percent of the time as determined from a long-term stage frequency analysis. The MLL is a stage that represents the elevation of the water surface of a lake or wetland that is equaled or exceeded 50 percent of the time as determined from a long-term stage frequency analysis. In this study, the HML and MLL were lower than the P10 and P50 determined from the long-term stage data (130.70 and 129.43 ft NAVD88, respectively).

Assessment of the current MFLs status for Lake Butler will be presented in a separate document.

1.0 Introduction

Under task work assignment (TWA): 19/20-061.002, Environmental Consulting and Technology, Inc. (ECT) was authorized by the Suwannee River Water Management District (SRWMD or District) to prepare a report titled Minimum Recommended Lake Levels: Lake Butler, Florida.

This report presents the SRWMD's evaluation of the minimum flows and levels (MFLs) determination for Lake Butler, Union County, Florida. These MFLs are based on work performed by Wilson-Miller/Stantec; Dooris & Associates, LLC; ECT; and SRWMD staff, using methodology developed by the St. Johns River Water Management District (SJRWMD) and the Southwest Florida Water Management District (SWFWMD).

2.0 MFLs Program Overview

2.1 Statutory Framework

The SRWMD MFLs program is based on the requirements of Sections 373.042 and 373.0421, Florida Statutes (F.S.), and is subject to the provisions of Chapter 40B-8, Florida Administrative Code (F.A.C.), The MFLs program provides technical support to the SRWMD regional water supply planning process (Section 373.0361, F.S.), consumptive use permitting (Chapter 40B-2, F.A.C.), and environmental resource permitting (Chapter 40B-4, F.A.C.) programs.

Based on the provisions of Rule 40B-8.011(3), F.A.C., "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology." Significant harm is prohibited by Section 373.042(1), F.S. Additionally, "minimum flows and levels 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.).

2.2 Water Resource Values

According to Rule 62-40.473(1), F.A.C., 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, non-consumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. These environmental values, also referred to as water resource values (WRVs) are listed below with their respective working definitions. All of these items were qualitatively reviewed, but fish and wildlife habitat and the passage of fish (Value #2) was quantitatively evaluated, because it was considered most appropriate for this lake and would maintain other relevant values. WRVs are listed as follows:

- Recreation in and on the water;
- Fish and wildlife habitats and the passage of fish;
- Estuarine resources;
- Transfer of detrital material;
- Maintenance of freshwater storage and supply;
- Aesthetic and scenic attributes;
- Filtration and absorption of nutrients and other pollutants;
- Sediment loads;
- Water quality; and
- Navigation.

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."

2.3 Hydrologic Regime

MFLs designate an environmentally protective hydrologic regime (i.e., hydrologic conditions that prevent significant harm) and identify levels and/or flows above which water may be available for reasonable–beneficial use. The SJRWMD event-based MFLs methods define the frequency and duration of high-, average-, and low water events necessary to protect relevant water resource values and prevent significant harm to aquatic and wetland habitats. Three such events may be defined for a respective system and are referred to as minimum frequent high, minimum average, and minimum frequent low flows and/or water levels (SJRWMD 2006, Neubauer et al. 2008). The MFLs represent hydrologic statistics composed of three components: a magnitude (a water level and/or flow), duration (days), and a frequency or return interval (years). Discrete hydroperiod categories to facilitate MFL determinations are listed according to specific duration and return interval values in Table 2-1 (SJRWMD 2009). "High" approximate frequencies refer to high stage/flow events that occur for a minimum approximate duration. "Low" approximate frequencies refer to low stage/flow events occurring for a maximum approximate duration (i.e., a low stage event occurring every two years and not exceeding six months).

Table 2-1. MFLs Hydroperiod categories with 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
Semi-permanently 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

SWFWMD methods use a long-term hydrologic record to determine percentile rankings of water surface elevations (Rule 40D-8.624, F.A.C.) that form the basis for minimum recommended lake levels. Such levels may include the High Minimum Lake Level (HML) and the Minimum Lake Level (MLL). The former is a lake stage elevation that must be equaled or exceeded ten percent of the time (P10) on a long-term basis; and the MLL is the elevation that must be equaled or exceeded fifty percent of the time (P50) on a long-term basis.

MFLs apply to decisions affecting permit applications, declarations of water shortages, and assessments of water supply sources. Actual or projected instances where water levels fall below established MFLs may require the SRWMD 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.).

2.4 Management Stakeholders

Lake Butler is located within the North Florida Regional Water Supply Partnership planning area (North Florida Regional Water Supply Partnership 2021). The Partnership is a collaborative effort between SRWMD, SJRWMD, the Florida Department of Environmental Protection (FDEP), local governments, concerned citizens, and other stakeholders throughout the region. The Partnership's mission is to protect the shared resources of the Floridan aquifer system through collaborative planning, scientific-tool development and other efforts.

3.0 Setting and Description

3.1 Lake and Basin Morphometry

Lake Butler is located in east central Union County near the intersection of State Roads 100 and 121 (Figure 3-1). The lake occupies approximately 420 acres at a water surface elevation of 131.12 ft NAVD88. Lake Butler is designated by FDEP as Class III waters and is not designated as impaired according to the Impaired Waters Rule (Chap. 62-303, F.A.C.). The lake is typical of most Florida lakes, formed by dissolution of underlying limestone, with regular concentric bathymetric elevation contours (FWC 2015). The depths depicted in Figure 3-2, were established based on Stantec's topographic/bathymetric survey on August 20, 2012 (Appendix A). The lake elevation was interpolated as 131.16 ft NAVD88, on this date from manual readings conducted on July 13, 2012 and August 23, 2012 (130.69 and 131.20 ft NAVD88, respectively). The lake drains through a canal on the lake's south end with an invert elevation of 129.5 ft NAVD88 (ECT 2021), allowing for a controlled depth of approximately 8.4 feet (ft).

The contributing lake watershed area is approximately 2,840 acres (Figure 3-3). The lake watershed area is generally rural with limited development (residential, transportation, etc.), most of which is located along the south lakeshore. As summarized in Table 3-1 and illustrated in Figure 3-3, the top three land uses in the lake watershed are upland forests (43.4%), wetlands (21.3%), and waters (14.9%). Detailed surveys by Stantec (Appendix A) found that inflow to the lake is directed through several storm water conveyances from the west-southwest, and to a lesser extent from the east. The inflow is dominated by surface runoff, and two of the largest sub-basins are dominated by extensive wetlands adjacent to the lake on the west and northeast (ECT 2021). The lake drains to the south through a canal to Richard Creek, which is a tributary of the New River.

Table 3-1. Statistical summary of 2006 land use in Lake Butler watershed

FLUCCS	Description	Area (acre)	Percentage
1000	Urban & Built-up	281.4	9.9%
2000	Agriculture	288.9	10.2%
3000	Rangeland	4.4	0.2%
4000	Upland Forests	1,231.7	43.4%
5000	Waters	421.9	14.9%
6000	Wetlands	605.0	21.3%
8000	Transportation, Communication & Utilization	6.3	0.2%
	Total	2,839.6	100.0%

Figure 3-1. Lake Butler location map

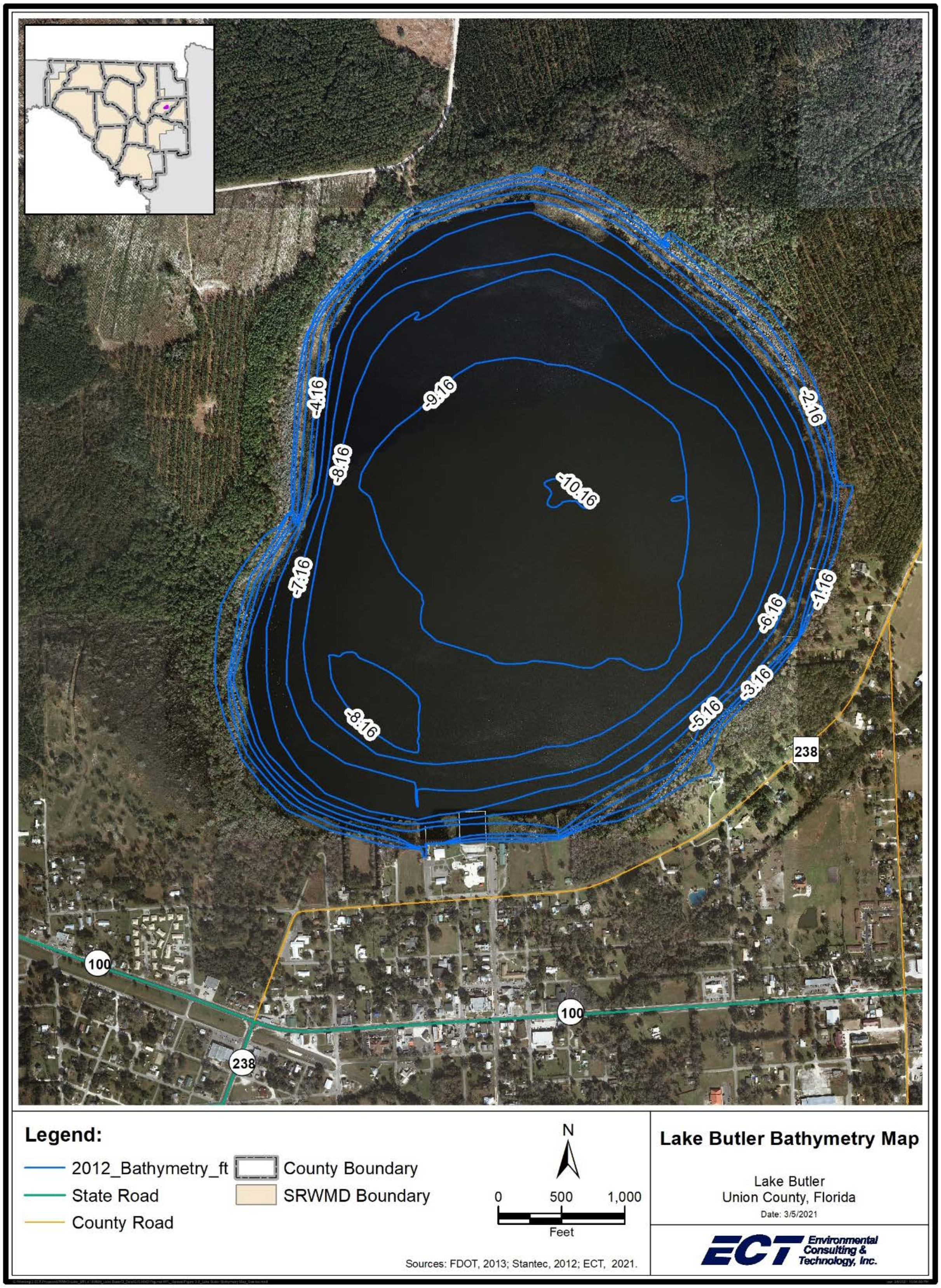

Figure 3-2. Lake Butler bathymetry, 1-foot contours

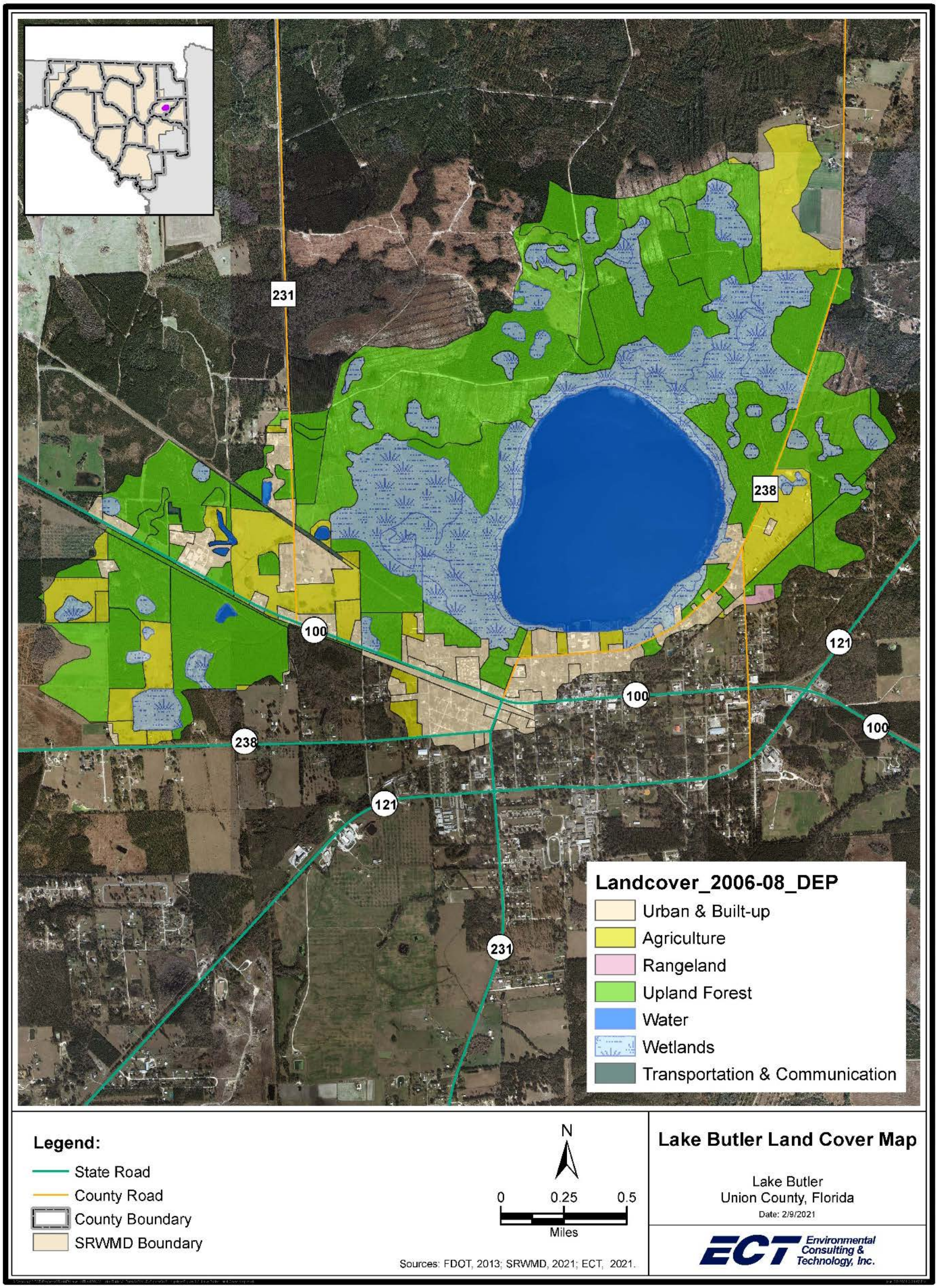

Figure 3-3. Land cover within the Lake Butler watershed (colored areas)

3.2 Hydrologic Record

The U.S. Geological Survey (USGS) has a stage gage, USGS 02321300 at Lake Butler, FL located near a concrete dock on the south lakeshore. This gage provides the long-term historical lake stage record in a variety of frequencies from 1957 to current. In order to develop appropriate stage statistics, ECT provided a temporally-interpolated lake stage dataset to establish stage frequencies for Lake Butler (ECT 2021). The resulting daily values were aggregated to monthly means for the period of record (POR). The POR of the dataset spanned from July 2, 1957 to September 30, 1967 and from November 1, 1974 to December 31, 2016 (Figure 3-4). The gage data collected after December 31, 2016 was excluded from the dataset due to missing data and/or poor data quality. The frequency percentiles provided in Table 3-2, may be used to determine minimum lake levels, per SWFWMD methods in Rule 40D-8.624, F.A.C., detailed in the results subsection in this report titled: *Lake Butler Hydrologic Indicators*.

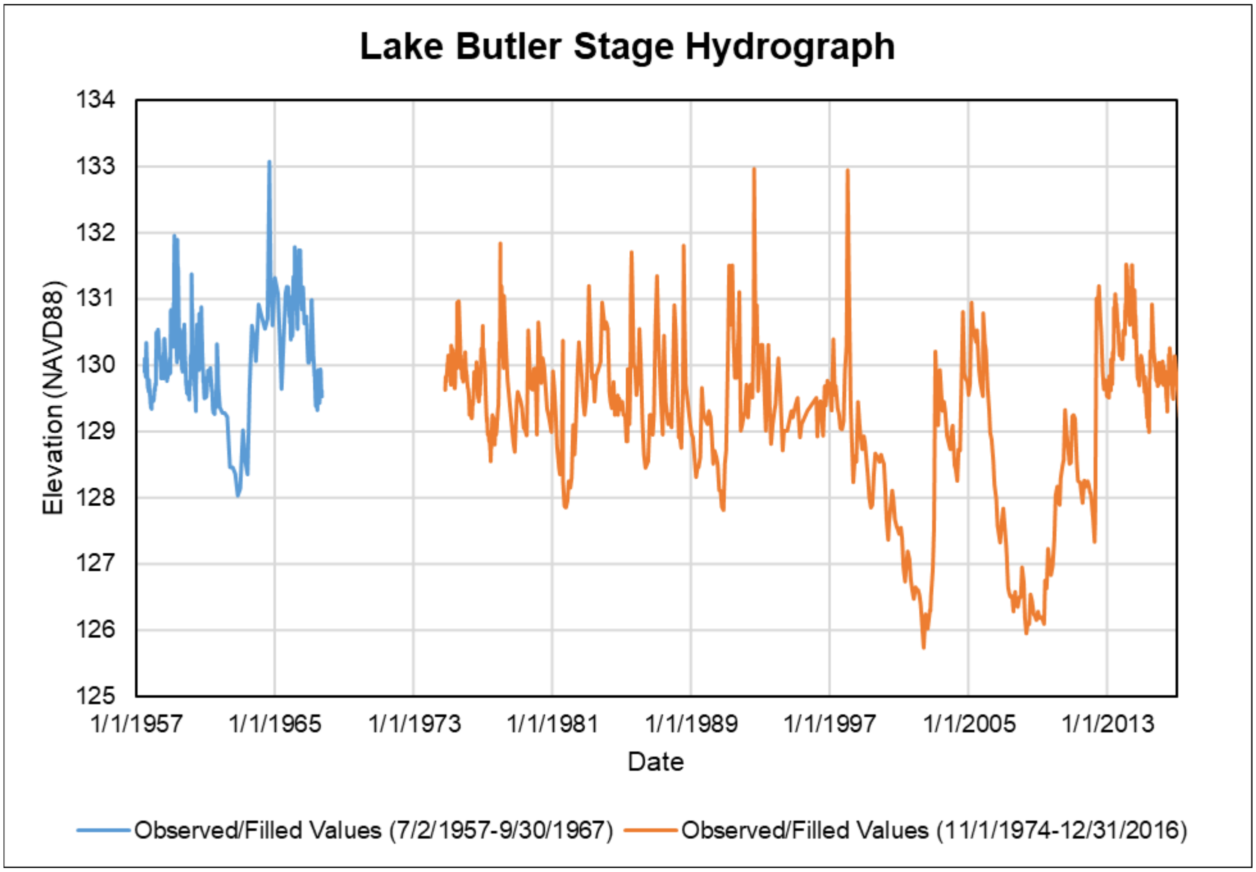

Figure 3-4. Lake Butler stage hydrograph – observed/interpolated daily stage data for the POR July 2, 1957 to September 30, 1967 and from November 1, 1974 to December 31, 2016.

Table 3-2. Monthly stage frequency percentiles for Lake Butler. These levels were determined using monthly means of the daily dataset (n=18,780).

Percentile	Monthly readings for the POR (ft NAVD88)
P10	130.70
P50	129.43
P90	127.52

Note: See definitions below

Definitions:

- "P10" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 10% of the time as determined from a long-term stage frequency analysis.
- "P50" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 50% of the time as determined from a long-term stage frequency analysis.
- "P90" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 90% of the time as determined from a long-term stage frequency analysis.

3.3 Wetlands

Wetlands contiguous to Lake Butler are shown in Figure 3-5, using data produced by the US Fish and Wildlife Service, National Wetlands Inventory (NWI). This geospatial data was developed for the purpose of mapping and tracking the status of wetlands and deep water habitats in the United States and its territories. The NWI classifies wetlands by a hierarchical structure (FGDC 2013); and in the case of Lake Butler, wetland classification is based mainly upon dominant vegetation type and hydrologic regime. It is cautionary to note that the NWI hydrologic regimes are descriptive; whereas other hydrologic regimes used in determining MFLs in Florida are defined by specific events (Neubauer et al. 2008), sometimes with identical nomenclature.

The wetlands in Figure 3-5 are classified accordingly:

- Deciduously vegetated, semi-permanently flooded (PFO6F);
- Needle-leaved evergreen, seasonally flooded (PFO4C);
- Forests of mixed sub-classes, dominated by either previously-mentioned canopy type, and subject to either seasonal flooding (i.e., PFO4/6C, PFO6/4C) or temporary flooding (PFO6/4A);
- Forests of mixed sub-classes that include broad-leaved evergreen and needle-leaved evergreen trees in a saturated water environment (PFO3/4B);
- Persistent, temporarily flooded and seasonally flooded emergent marshes (PEM1A and PEM1C, respectively); and
- Broad-leaved evergreen forested wetlands, semi-permanently flooded (PFO3F).

Emergent plant communities that are located within the lake are not included with the NWI polygons in Figure 3-5 but are described in vegetation surveys (Appendix B).

3.4 Soils

The U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) mapped most soils adjacent to the lake as a composite of both Surrency and Pantego series, frequently flooded (Dearstyne *et al*. 1991). These soils are often associated with flatwoods, and upland depressions or sluggish drains. Both are level and poorly drained, and typically exhibit a sandy to loamy upper profile with heavier textured loamy soil materials (argillic horizons) occurring deeper in the profile. Surface horizons within this map unit are typically dark, sandy, and may be mucky mineral analogues of sandy texture. In some profiles, muck may be present as a thin “Oa” horizon.

Figure 3-6 depicts the hydric soils in proximity to Lake Butler, as designated by the USDA-NRCS, Soil Survey Geographic database (Soil Survey Staff 2015). Individual mapping units are described in the legend according to texture, organic matter content, hydrologic regime, and relative elevation. Hydric soils are soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile (Rule 62-340, F.A.C.). These soils support a prevalence of vegetation typically adapted for life in saturated environments.

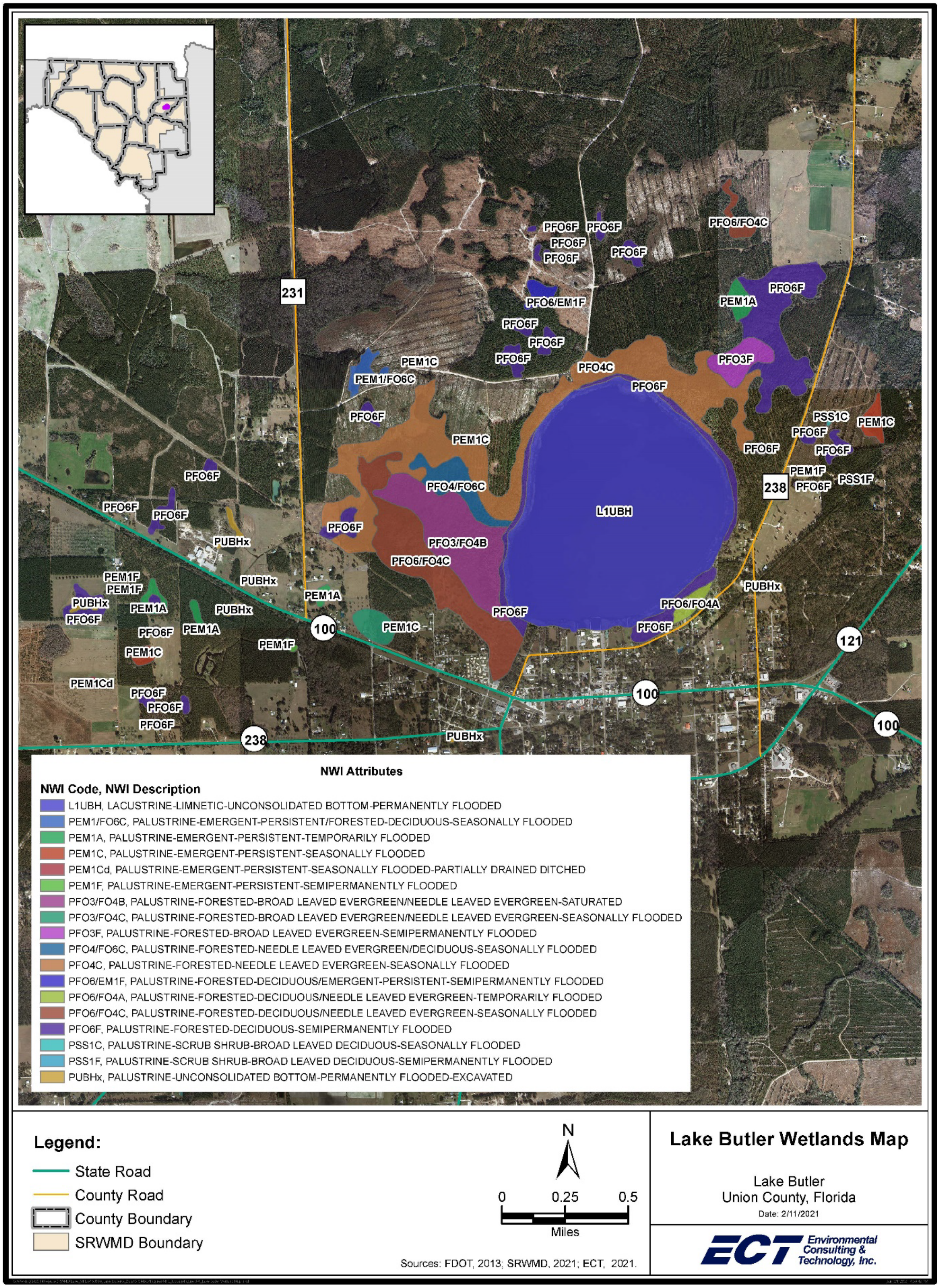

Figure 3-5. Lake Butler wetlands

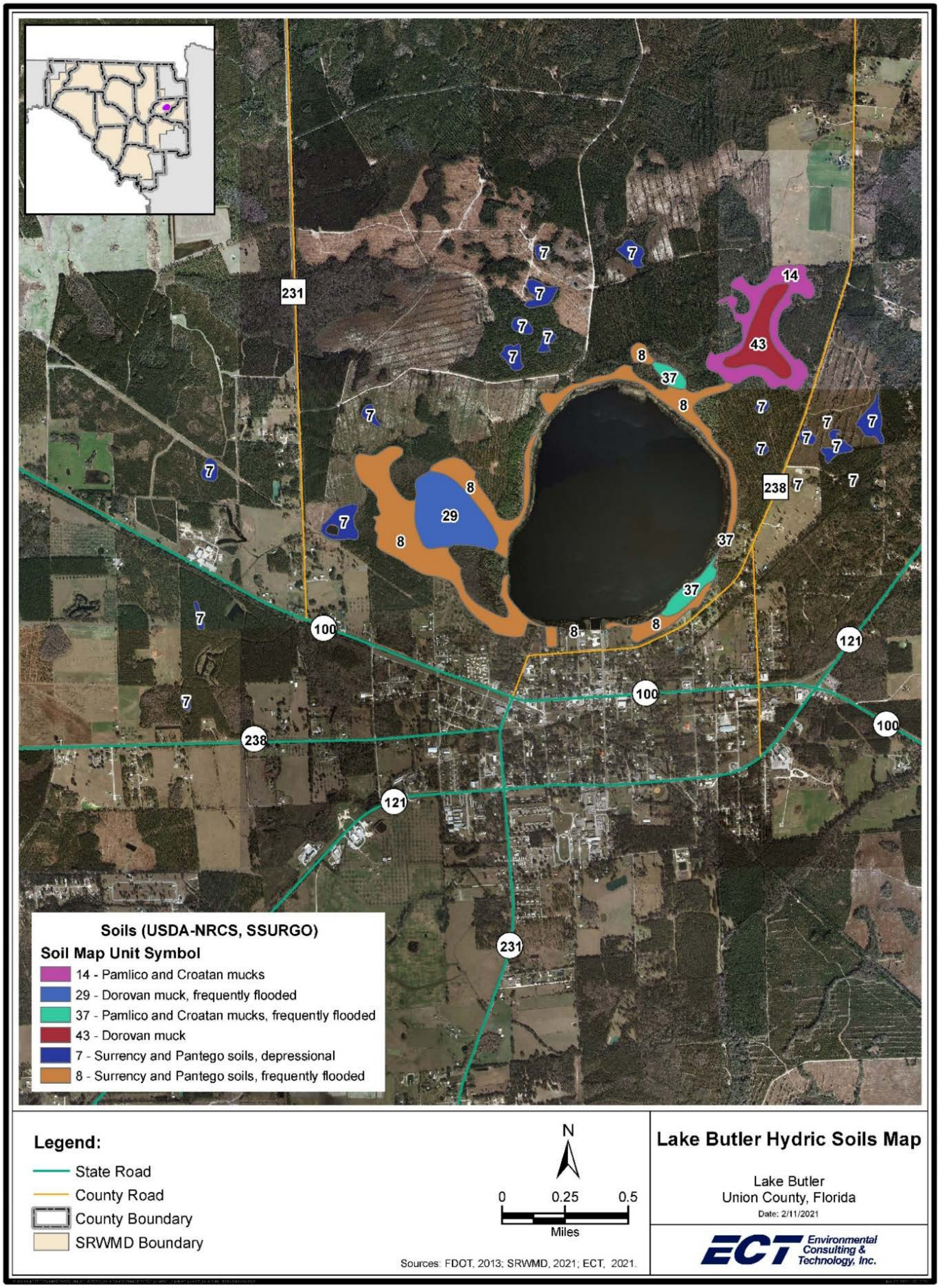

Figure 3-6. Lake Butler hydric soils

4.0 MFLs Methodology

This section summarizes the MFLs methodology and assumptions used in the minimum water levels evaluation process for Lake Butler, including field procedures such as site selection, field data collection, data analyses, and minimum levels determination criteria. Detailed methods are provided in the respective appendices of this report. The SJRWMD MFLs methodology is described more completely in their Minimum Flows and Levels Methods Manual (SJRWMD 2006, Neubauer et al. 2008). SWFWMD Lake MFLs methods are detailed in Rule 40D-8.624, F.A.C.

The field data collection procedure involves gathering detailed elevations, vegetation, soils, and hydrologic indicator data along fixed transects. In addition to sampling procedures presented for field data collection, aerial imagery, maps, and other reliable information were obtained and reviewed for evidence of alterations that may have occurred within the lake and its drainage basin. A summary of the data collection is provided below.

4.1 Site Selection

Using aerial imagery, the NWI, and soil maps as guides, five potential transects were chosen. As part of the evaluation process, the suitability of each potential transect was based on four major criteria:

- Fair representation of plant communities;
- Permission to enter the property where necessary;
- Total transect length; and
- Ease of access.

Lake Butler wetland transects extended from open water, at a depth of three feet, through the adjacent emergent marsh and seasonally flooded wetlands, and terminating in the uplands (Figure 4-1, T1 through T5). A typical transect cross-section is shown in Figure 4-2. Transect site selection was conducted between March 10 and April 6, 2012. Detailed elevation, soils, vegetation, and hydrologic indicator data were subsequently sampled along individual transects to characterize the influence of surface water flooding on the distribution of soils and plant communities.

Deep marsh transects were established along the southeastern and southwestern shoreline in the lake (Figure 4-1). These transects were established on March 24, 2016, and elevation data were collected along these transects to characterize a semi-permanently flooded community that may periodically be subject to the influence of prolonged drying within the lake proper.

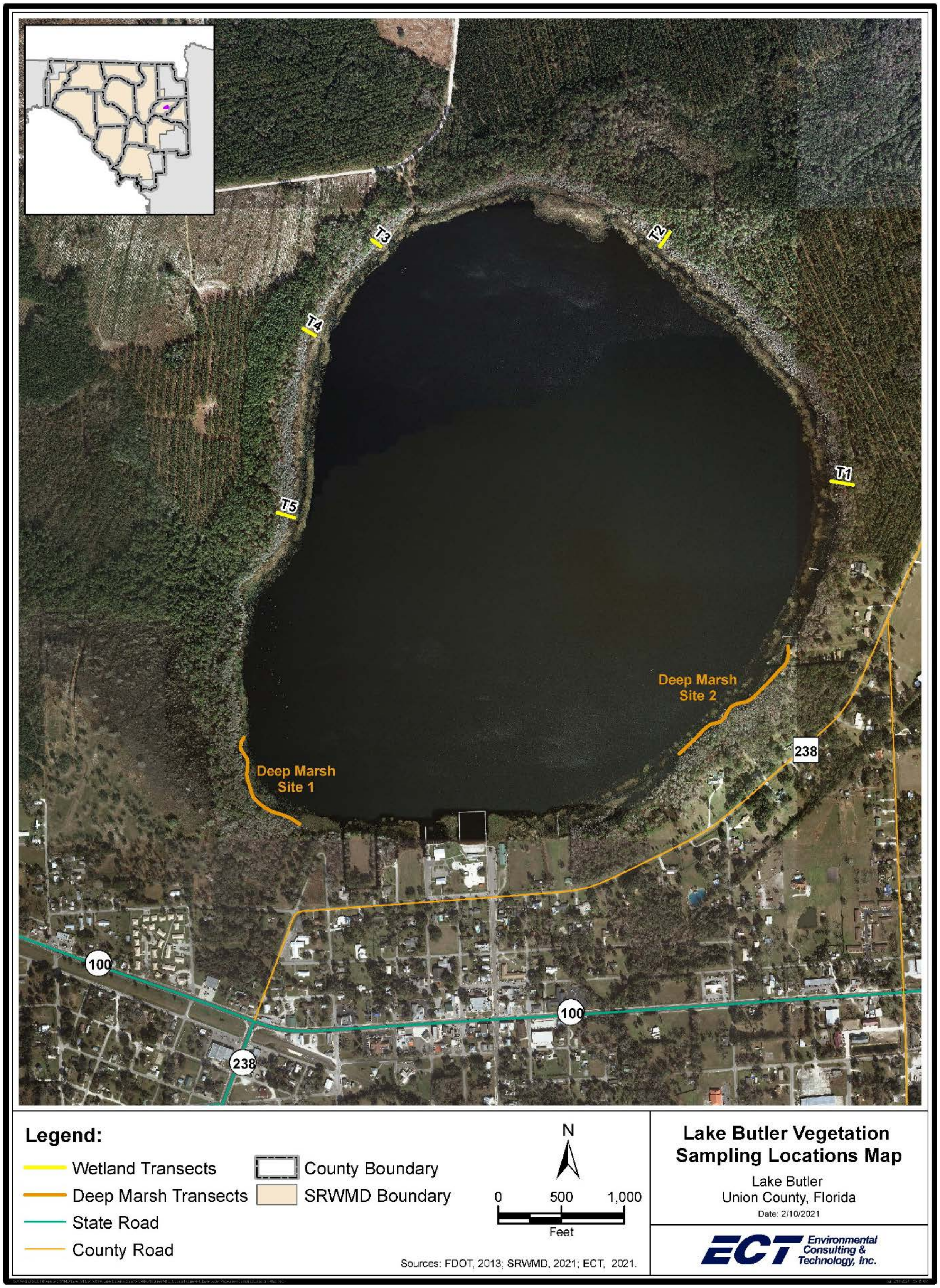

Figure 4-1. Lake Butler vegetation sampling locations

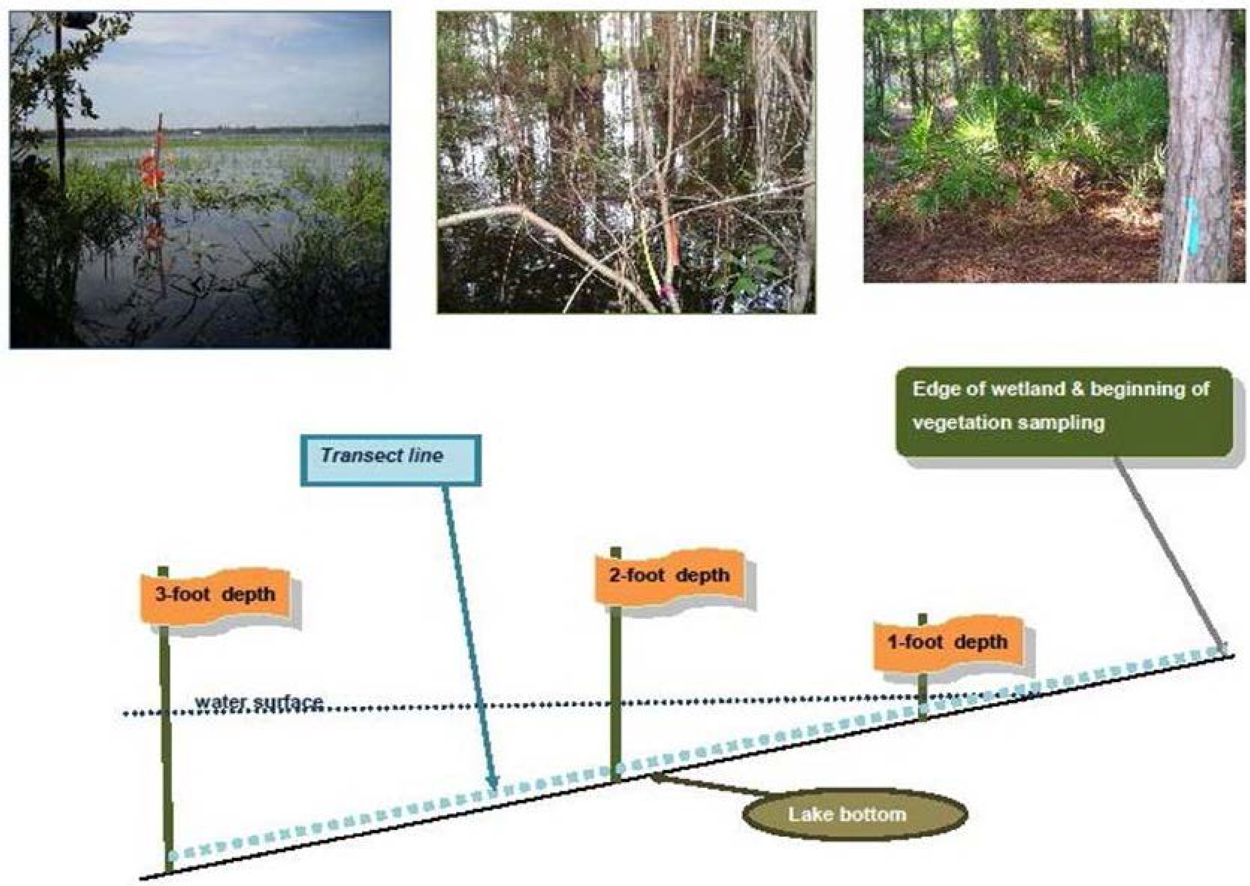

Figure 4-2. Cross-section of a typical transect with corresponding vegetation communities depicted in images at respective positions along the transect. The depths are relative to the lake level at the time of vegetation sampling.

4.2 Site Survey

A detailed elevation survey was conducted by a Florida-licensed Professional Surveyor and Mapper (PSM) between the dates of August 11 and September 7, 2012. Procedures are presented in Appendix A. Surveying tasks included:

- Establishment of a standard elevation datum;
- Preparation of sampling transects (i.e., marking boundaries);
- Gathering elevation data of vegetation communities, soil attributes, and hydrologic indicators along sampling transects;
- Gathering elevation data of natural and man-made drainage features;
- Gathering elevation data of residential and recreational infrastructure;
- Gathering bathymetric data; and
- Obtaining Light Detection and Ranging (LiDAR) data for the study area.

4.3 Vegetation Sampling Procedures

All wetland field-sampling was conducted on August 7, 14, and 16, 2012 (Figure 4-1). The main objective of this sampling effort was to qualitatively describe vegetative communities and collect data to determine an average elevation of the seasonally-flooded basin swamp community surrounding the lake, as described in the Florida Natural Areas Inventory, Guide to the Natural Communities of Florida (FNAI 2010). This was done in order to set the minimum frequent high (FH) lake level according to SJRWMD methods. Detailed vegetation sampling procedures, analyses, and results are presented in Appendix B of this report. Basin swamp vegetation sampling focused upon the following tasks:

- Field identification of plant communities along sampling transects using the FNAI, Guide to the Natural Communities of Florida (FNAI 2010).
- Field collection of quadrat data and point-intercept data along sampling transects (Oosting 1956; Krebs 1989):
  - Quadrat data was utilized in determining abundance, composition, and percent cover of the forested wetlands adjacent to the lake; and
  - Point-intercept data was used for determining species richness along sampling transects.
- Field determination of the water-ward extent of the basin swamp community along sampling transects by marking the lakeside extent of the canopy vegetation; Field determination of the landward extent of the basin swamp community along sampling transects using the Florida Wetlands Delineation Manual (Rule 62-340.300(2), F.A.C.).

Deep marsh field-sampling was conducted on March 24, 2016 (Figure 4-1). The objective of this sampling effort was to determine a benchmark elevation representing the upper limits, or landward extent, of the water lilies and deep water emergent species that experience a semi-permanently to permanently flooded hydrologic regime. This elevation would establish a minimum frequent low (FL) lake level by SJRWMD methods. Tasks included:

- Field determination of the deep marsh community by plant species composition (Kinser 1996); and
- Collecting depth soundings at the landward extents of cow-lilies (*Nuphar advena*).

4.4 Soil Sampling Procedures

The soil sampling field work was originally planned to coincide with vegetation sampling and elevation survey activities in August 2012. However, precipitation from Tropical Storm Debby resulted in excessively high water levels (up to 131.2 ft NAVD88), precluding soil sampling at that time. The water levels slowly decreased over several months, and soil sampling was eventually performed on December 18, 2012.

Where field conditions allowed, soil profiles were hand-excavated with a spade to a depth of 20 inches (50 cm); and a soil auger was used to sample deeper into the profile where water table conditions allowed. Profile descriptions followed conventions from the USDA-NRCS Field Book for Describing and Sampling Soils (Schoeneberger et al., 2002). Standard field soil morphology (e.g., horizon depths, soil texture and soil color) were recorded. Apparent water table depths on the day of soil sampling were recorded as the depth of the free water surface below the ground elevation in an unlined borehole that had equilibrated for 30 minutes. Detailed soil sampling procedures are presented in Appendix C of this report.

4.5 Hydrologic Indicator Sampling Procedures

Hydrologic indicators selected for this determination included cypress (*Taxodium* spp.) buttress inflection points from cypress trees located within the lake and its contiguous basin swamp (Figure 4-3). Inflection point identification was conducted concurrently with vegetation sampling. Critical lake levels are related to the average elevation of this indicator, per Rule 40D-8.624(7), F.A.C. Buttressing of tree bases is a morphological plant adaptation also recognized as a hydrologic indicator utilized in the delineation of the landward extent of wetlands and other surface waters (Rule 62-340.500(9), F.A.C.). Detailed sampling procedures for hydrologic indicators are presented in Appendix D of this report.

Figure 4-3. Example of marked buttress inflection point on cypress tree (Source: Dan Schmutz, Greenman Pedersen, Inc.)

5.0 Data Analyses

Microsoft Excel and R-Studio (R Core Team 2014) software were utilized for analysis of field data and illustration of respective results. Descriptive statistics were determined for the elevations of individual vegetation communities and their respective boundaries. The average elevation of the seasonally flooded basin swamp was determined to represent the FH, while the average elevation of the landward extent of the semi-permanently-flooded deep marsh was determined to represent the FL. Detailed procedures are provided in Appendices B through D, for vegetation, soils, and hydrologic indicators, respectively.

6.0 Consideration of Basin Alterations

Based on the provisions of Section 373.0421(1)(a), F.S., when establishing MFLs, SRWMD 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, SRWMD cannot allow significant harm caused by withdrawals. To accomplish this, SRWMD 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.

According to SRWMD documents related to the 2003 permit application #ERP-125-214885-1, a fixed weir existed in the outfall of Lake Butler of an unknown control elevation. The weir was partially removed in response to high lake levels resulting from Hurricane Dora and no longer functions to control the stage in the lake. The highest recorded lake level following the hurricane was 134.02 MSL on September 13, 1964, according to engineering documentation submitted with the permit application proposing reconstruction of the weir at a control elevation of 131.0 MSL. The permit application was withdrawn, the weir was not reconstructed, and the lake levels have since fluctuated naturally.

SRWMD has developed hydrologic models (ECT 2021), which addressed existing structural features, and has used 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.

SRWMD considered that the existing hydrologic condition, which was used to calibrate and verify the models, reflected 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 rapidly to changes in hydrology that are sufficiently large to cause such change. SRWMD 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.

7.0 Results and Discussion

Detailed results of analysis of vegetation, soils, and hydrologic indicator data may be found in their respective appendices (Appendices B through D).

7.1 Lake Butler Vegetation

Natural communities occurring in the Lake Butler study site were classified in accordance with descriptions developed by the FNAI (2010) and Kinser (1996). These included basin swamp, basin lake, and mesic flatwoods. We will refer to the basin lake as *the lake*.

Quantifiable attributes of the basin swamp plant community were determined from analysis of data collected along transects by both quadrat and point-intercept methods. In the canopy, a total of eight species were identified (Table 7-1), the majority (85%) being wetland indicator species designated by an indicator status as either obligate (OBL) or facultative-wet (FACW) (Rule 62-340.450, F.A.C). The most common and abundant species was swamp tupelo (*Nyssa sylvatica* var. biflora), followed in order of occurrence by red maple (*Acer rubrum*), slash pine (*Pinus elliottii*), and pond cypress (*Taxodium ascendens*). Dahoon holly (*Ilex cassine*), wax myrtle (*Morella cerifera*), laurel oak (*Quercus laurifolia*), and bald cypress (*T. distichum*) composed the remainder.

Table 7-1. Trees counted in the Lake Butler quadrats, and indicator status, per Rule 62-340.450, F.A.C.

Species (Indicator Status)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Species Count
Acer rubrum (FACW)	3	6	8	3	-	20
Ilex cassine (OBL)	-	1	1	-	1	3
Morella cerifera (FAC)	-	-	-	1	-	1
Nyssa sylvatica biflora (OBL)	6	7	4	4	8	29
Pinus elliottii	1	3	4	1	2	11
Quercus laurifolia (FACW)	-	2	-	-	-	2
Taxodium ascendens (OBL)	-	-	-	6	4	10
Taxodium distichum (OBL)	-	-	3	-	-	3
Total	10	19	20	15	15	NA
Density (trees/acre)	75	182	305	193	143	NA

Species composition of all vegetative strata in the basin swamp indicated that this wetland community has not been subject to disturbance that would result in an invasion by less flood/saturation-tolerant plant species. An abundant proportion of shrubs (92%) counted within quadrats were designated as OBL or FACW (Table 7-2). Groundcover species were more-accurately enumerated along transects by point-intercept sampling, where OBL and FACW plants included an average of 37.3% of the points sampled, while leaf litter and other detritus occurred in an average of 60.3% , Table B4, Appendix B.

Mesic flatwoods border the upland extent of the basin swamp. This community typically demonstrates a pine canopy with a layer of low shrubs including saw palmetto (*Serenoa repens*) and gallberry (*Ilex glabra*). No quantitative biological data was collected from flatwoods, but the mesic flatwoods/basin swamp boundary was determined empirically by elevation survey conducted by the PSM. This boundary is also referenced as the landward extent of the basin swamp, per State wetland delineation manual (Rule 62-340, F.A.C.).

Table 7-2. Shrubs counted in the Lake Butler quadrats and indicator status, per Rule 62-340.450, F.A.C.

Species (Indicator Status)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Species Count
Buttonbush (*Cephalanthus occidentalis*, OBL)	12	-	-	-	-	12
Virginia willow (*Itea virginica*, OBL)	-	-	-	41	5	46
Fetterbush (*Lyonia lucida*, FACW)	-	3	2	-	-	5
Sweetbay (*Magnolia virginiana*, OBL)	-	1	-	2	9	12
Wax myrtle (*Morella cerifera* , FAC)	2	1	-	1	-	4
Water oak (*Quercus nigra*, FACW)	-	-	1	-	-	1
Cabbage palm (*Sabal palmetto*, FAC)	-	-	1	1	-	2
Saw palmetto (*Serenoa repens*)	1	-	-	-	-	1
Pond cypress (*Taxodium ascendens*, OBL)	-	-	-	-	1	1
Total	15	5	4	45	15	NA
Density (shrubs/acre)	112	47	61	580	143	NA

7.1.1 Determination of the Basin Swamp Elevation

Results of field data analyses indicate median elevations for the water-ward edge and landward extent of the basin swamp to be 128.75 ft NAVD88 and 130.34 ft NAVD88, respectively. The average of these median elevations accounted for the variability between field personnel in setting benchmarks according to biological landmarks. The average elevation of the basin swamp using field data is 129.55 ft NAVD88.

7.1.2 Determination of the Deep Marsh Elevation

A mean elevation of 127.3 ft NAVD88 was determined for the shallowest extent of Lake Butler cow lily stands, thus delineating the landward extent of the deep marsh community. This elevation is recommended based upon reasonable scientific judgement using a depth sounding dataset. Although the sample size was limited due to occurrence of the target species; results from this sampling event still provided a tight range in elevation of the stands, where a 95% confidence interval represented a spread of 0.4 foot.

7.2 Lake Butler Soils

As noted in the MFLs Methodology section, soil sampling locations were constrained by transect locations, high water tables, surface water, and/or trees and tree roots. Appendix B includes summaries of soil morphology, hydric soil indicators, depth to the apparent free water table, and summarized field notes.

Replicated elevation control is lacking in the soil dataset, but the A9 hydric soil indicator (> 1 cm muck) was documented at a ground elevation of 130.8 ft NAVD88 for soil No.5, suggesting water levels at or near this elevation for a majority of time in most years.

7.3 Lake Butler Hydrologic Indicators

The average elevation of all cypress buttress inflection points surveyed was 130.77 ft NAVD88, which represents the lake's historic normal pool (HNP). SWFWMD MFLs methods use categorical significant change standards to identify criteria sensitive to long-term changes in hydrology (Rule 40D-8.624, F.A.C.). The *cypress standard* was used in supporting Lake Butler MFLs development. Lake Butler is classified as a Category 1 lake: This is a lake with fringing cypress swamp(s) greater than 0.5 acre in size where structural alterations have not prevented the Historic P50 from equaling or rising above an elevation that is 1.8 feet below the HNP. The two MFLs typically proposed by this methodology are the High Minimum lake Level (HML) and the Minimum Lake Level (MLL). The HML is a stage that represents the elevation of the water surface equaled or exceeded 10 percent of the time. The MLL is a stage that represents the elevation of the water surface equaled or exceeded 50 percent of the time.

By applying the cypress standard, the recommended HML for Lake Butler is a stage elevation of 130.37 ft NAVD88. This stage represents the elevation of the water surface at HNP minus 0.4 foot. Using the same application, the recommended MLL for Lake Butler is a stage elevation of 128.97 ft NAVD88. This stage represents the elevation of the water surface at HNP minus 1.8 feet. As illustrated in Figure 7-1, the HML and MLL are lower than the P10 and P50 determined from the long-term stage data collected from July 2, 1957 to September 30, 1967 and from November 1, 1974 to December 31, 2016 (130.70 and 129.43 ft NAVD88, respectively). According to the Rules 40D-8.624 (6) (a) and (7) (b), F.A.C., both HML and MLL are being met for Lake Butler, as these benchmarks are exceeded by the long-term P10 and P50, respectively, as determined from the long-term stage data.

Recommended levels determined by the SJRWMD methods are also shown in Figure 7-1 (FH and FL).

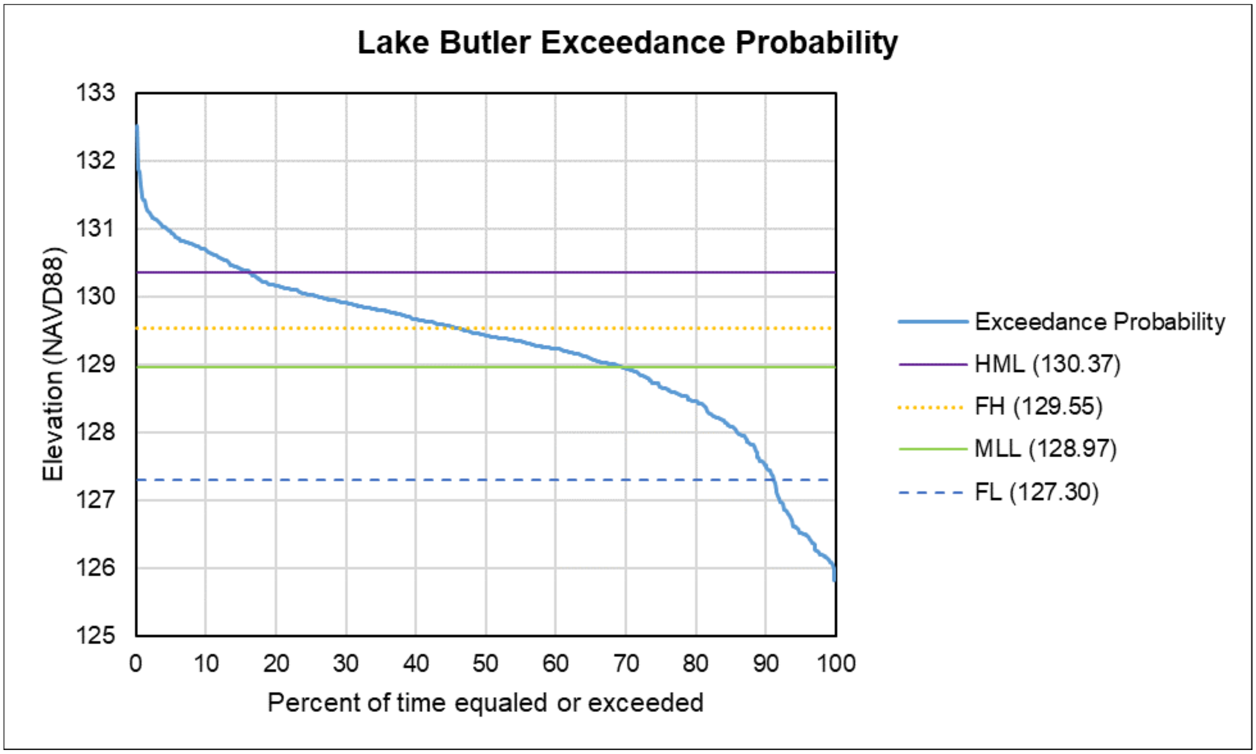

Figure 7-1. Comparison of SWFWMD and SJRWMD MFLs metrics with the stage duration curve determined from monthly mean lake stage elevations using interpolated daily stage data for the POR July 2, 1957 to September 30, 1967 and from November 1, 1974 to December 31, 2016.

8.0 Conclusions and Recommendations

The SJRWMD event-based MFLs methods (SJRWMD 2006; Neubauer et al. 2008) were utilized to determine the minimum lake levels for Lake Butler. MFLs determination was based on the evaluation of topography and vegetation data collected from plant communities associated with the water body. Soils and hydrologic indicator data were collected and analyzed in support of SJRWMD methodology. The recommended levels relate to hydroperiod categories and definitions adapted from water regime modifiers developed by Cowardin et al. (1979). The recommended MFLs for Lake Butler are summarized in Table 8-1.

Table 8-1. Minimum recommended lake levels for Lake Butler.

Designated Level	Elevation Benchmarks	Elevation (ft NAVD88)	Defining event or hydrologic criteria
Minimum Frequent High (FH)	Mean elevation of seasonally-flooded basin swamp	129.55	30-day inundation/ 2-yr return interval
Minimum Frequent Low (FL)	Mean elevation of the landward extent of the deep marsh	127.30	120-day exposure/ 5-yr return interval

Each designated level is defined by rule in Florida's Administrative Code. In the case of the minimum frequent high (FH), the definition may be found in Rule 40C-8.021(7), F.A.C. The FH elevation is set in order to provide protection of seasonally-flooded wetland communities that typically experience flooding events with a duration of 30 days, occurring every two years.

The minimum frequent low (FL), defined in Rule 40C-8.021(10), F.A.C., is intended to prevent deleterious effects to the composition and structure of floodplain soils, the species composition and structure of floodplain biotic communities, and the linkage of aquatic and floodplain food webs. The FL typically protects semi-permanently flooded communities by limiting to an approximate 5-yr return interval an event that may effectively dry the substrate for up to 120 days.

MFLs benchmarks are proposed according to SJRWMD methods, because the hydrologic conditions affecting the biological communities considered in this study represent exceedance probabilities with a broad range in lake stage. Such exceedances occur between seasonal flooding and extended drought. The methodology does not calculate MFLs based on past hydrology. Instead, *the method is primarily focused on ecological protection to ensure systems meet or exceed minimum eco-hydrologic requirements* (Neubauer et al. 2008). In the case of Lake Butler, this addresses the water resource value of fish and wildlife habitats. The vegetation data collected in this study provide sound support for the methods, as it was collected from wetland and deep marsh communities that do not exhibit evidence of long-term hydrologic alteration, such as a decrease in species richness, an increase in the numbers and dominance of invasive and exotic species, or dominance of vegetation represented by one structural type (EPA 2002). Hydrologic indicators provided further evidence that these biological communities were hydrologically intact, as specific hydrologic benchmarks can be closely approximated from the elevation of cypress buttress inflection points (historic normal pool), per SWFWMD methods.

Assessment of the current MFLs status for Lake Butler will be presented in a separate document.

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Appendix A: Site Survey

Elevation Data

The stage records in Lake Butler are reported in National Geodetic Vertical Datum (NGVD) 1929, while the survey conducted for this project was recorded in North American Vertical Datum (NAVD) 1988. In this report, NAVD88 is referenced in association with the survey data, and the vertical datum of the stage records is converted for consistency: NGVD29 stage data were converted to elevations in NAVD88 by using the following conversion for local benchmark E 82: NGVD29 elevation - 0.88 foot = NAVD88 elevation. Conversion data were obtained from the National Geodetic Survey (Datasheet 95; Version 7.89.4) and downloaded through the Florida Department of Environmental Protection's Land Boundary Information System (FDEP 2015).

Structures and Transects

All elevations intended to be surveyed including vegetation and soil sampling locations, and hydrologic indicators were clearly marked with tape, nails and tape or other highly visible method. Field marking was coordinated between the ecologists and the survey crew so that very little time separated the marking in the field from the actual survey work. Other points that were surveyed include: the overflow point on the lake outlet, the tops of docks located on city property on the south end of the lake, top of riprap on the public boat ramp, water marks on dock pilings, the lowest house on the lake, the outlet channel, the remnants of the footer on the former concrete structure in the outlet channel, and the culverts under NE 3rd St. All data were collected by a Stantec survey crew under the direct supervision of a Florida Licensed PSM and reduced using standard surveying techniques. Elevation data were provided in an EXCEL© spreadsheet for further use by SRWMD. The data were also shown on the final topographic survey. The elevation data together with the stage records were used in determining the temporal and spatial trends in water levels on the Lake.

Bathymetry

For the bathymetry survey, Stantec's survey crew, under the direct supervision of a PSM, established horizontal and vertical control for the project. Horizontal control is relative to the Florida North State Plane Coordinate System (NAD83/90) and was established from nearby control designated as Union 10 (NGS PID #AE7654) utilizing Trimble model 5800 Global Positioning System (GPS) equipment. Vertical control is relative to the NAVD88 datum. Vertical control and site benchmarks were established from nearby vertical control monument E-82 (NGS PID #BD1431) by means of differential leveling. Temporary benchmarks were established at the vicinity of the transect lines utilizing the Trimble model 5800 GPS and redundant observations. Based on the horizontal and vertical control established around Lake Butler, Stantec ran a total of 6 cross-sections, three north/south and three east/west, across the lake. Bottom truthing was performed by using a fixed rod and Trimble 5800 RTK GPS unit. Lake bottom elevations were sampled at a variety of locations and returned an accuracy of 0.2 feet as compared to the bathymetric data at each location tested. Bathymetric data were reviewed at each cross line for redundancy for an average accuracy of 0.2 feet. The cross-sections were performed utilizing an Odom Hydrotack echo sounder and 200 kHz transducer, combined with a Trimble model 5800 RTK GPS unit and Trimble HydroPro navigation software. Survey information was processed and imported into AutoCAD to prepare a final topographic survey of the lake.

The Lake Butler bathymetry map (Figure 3-2) was developed by based on the survey information and lake surface elevation estimated on August 20, 2012. The lake elevation was interpolated as 131.16 ft NAVD88, on this date from manual readings conducted on July 13, 2012 and August 23, 2012 (130.69 and 131.20 ft NAVD88, respectively).

Light Detection and Ranging (LiDAR)

In addition to survey data obtained by Stantec, a raster digital elevation model (DEM) was used for supplemental analysis of soils and vegetation communities (Figure A1). Individual pixels within this mosaic represent an area of 3.937ft x 3.937 ft., a resolution slightly greater than one meter (3.28 ft.). The DEM was created from Light Detection and Ranging (LiDAR) data acquired during the Suwannee River Expansion, 1.0 Meter LiDAR Survey, Area D project in north-central Florida, encompassing a 285 square mile area that included the Upper Santa Fe River basin.

The LiDAR point cloud was flown at a nominal post spacing of 1.0 meters for unobscured areas. The flight lines were acquired by Digital Aerial Solutions, LLC, between March 19, and March 26, 2011. The LiDAR data and derivative products were created in compliance with the U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 13-ILMF 2010; where vertical accuracy of the LiDAR data met or exceeded FEMA guidelines and specifications for flood hazard mapping (FEMA 2002). The LiDAR data and coordinate values associated with this project are referenced to the North American Datum of 1983 (HARN), State Plane Coordinate System, Zone Florida North 0903, in units of US Survey Feet. The vertical datum is NAVD88, in units of US Survey Feet.

Mapping

Project mapping utilized ESRI ArcMap 10.0 software (ESRI 2011) running on Windows-based PCs. Survey data were imported into GIS for mapping purposes by converting AutoCAD DWG format files into ArcMap shapefiles. Field data collection points, other than those set with survey data collection, (e.g., soil sampling points), were obtained using Trimble ProXT sub-meter DPGS hardware running ESRI ArcPad software. Data using ArcPad were collected as shapefiles for direct import into GIS.

Aerial photographs were obtained from the Florida Images Inventory through the Florida Land Boundary Information System (FDEP 2015). The one-foot resolution imagery was acquired January 13, 2011 from the Florida Department of Revenue (DOR 2015). The orthophotos were obtained as MrSID image files and used in their native format in GIS.

Roadway layers and other background spatial data were acquired from either the SRWMD or the Florida Geographic Data Library (SRWMD 2015, FGDL 2015). All acquired data were utilized in their native formats and converted to the map datum (NAD 83 State Plane Florida North), where necessary.

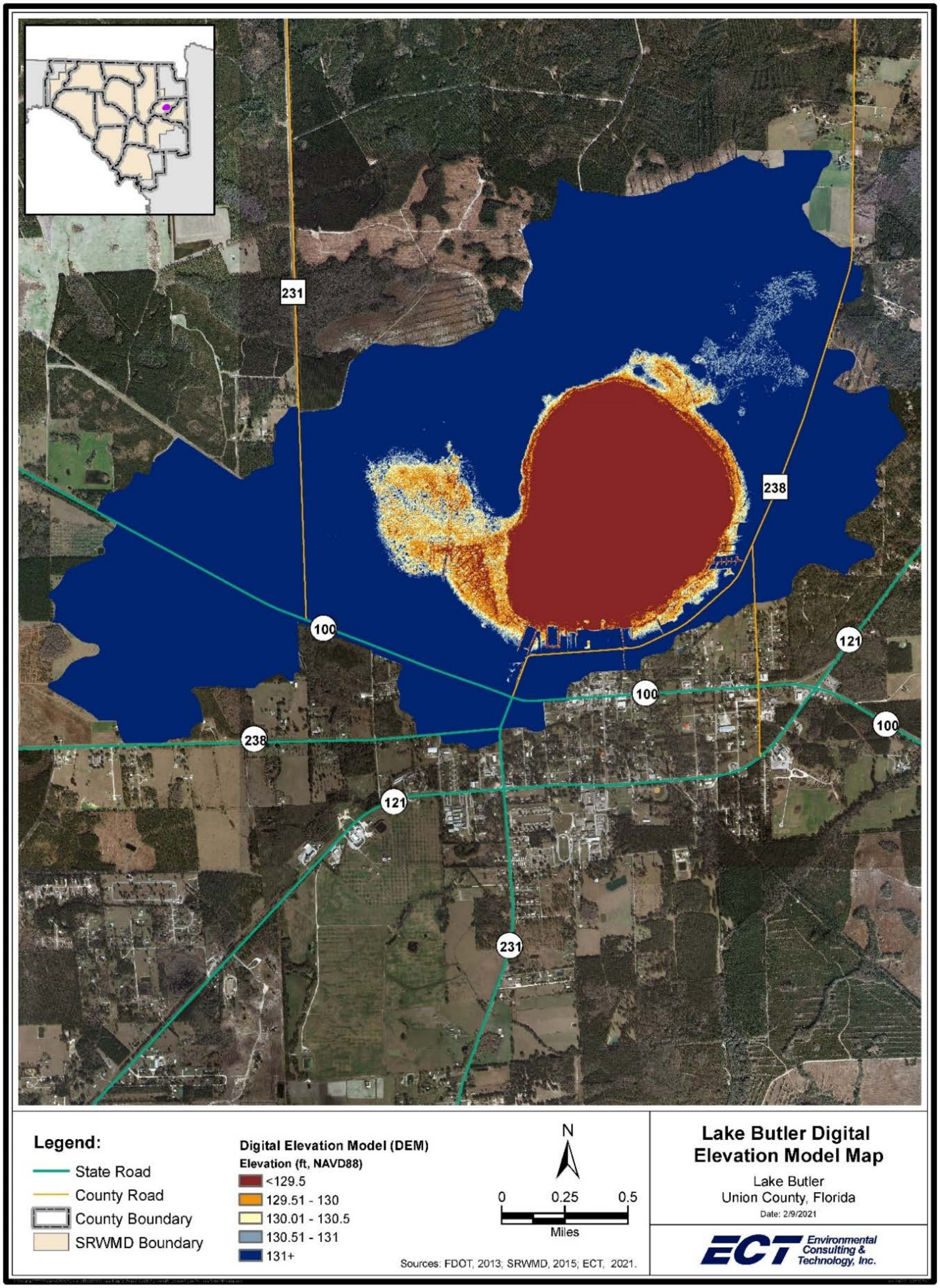

Figure A1. Digital Elevation Model (DEM) classified in ArcGIS to illustrate the ranges of elevations between the lake and surrounding uplands.

Appendix B: Vegetation Sampling Methods, Analyses, and Results

Vegetation Sampling Methods

Wetland Community Determination

All vegetation sampling was conducted on August 7, 14, and 16, 2012. A visual inspection was conducted along each transect to determine vegetative community composition. Two communities were identified in accordance with descriptions developed by the Florida Natural Areas Inventory (FNAI 2010). These were the basin swamp and the swamp lake. The basin swamp is described as a typically large basin wetland with peat substrate; seasonally inundated; still water or with water output; Panhandle to central peninsula; occasional or rare fire; forest of cypress/tupelo/mixed hardwoods; pond cypress (*Taxodium ascendens*), swamp tupelo (*Nyssa sylvatica* var. biflora). The swamp lake is described as a generally shallow, open water area within basin swamps; still water or flow-through; peat, sand or clay substrate; statewide except Keys; variable water chemistry, but characteristically highly colored, acidic, soft water with moderate mineral content (sodium, chloride, sulfate); oligo-mesotrophic to eutrophic. mesic flatwoods occur landward of the basin swamp and are described as flatland with sand substrate; mesic; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years); open pine canopy with a layer of low shrubs and herbs; longleaf pine (*Pinus palustris*) and/or slash pine (P. *elliottii*), saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), dwarf live oak (*Quercus minima*), wiregrass (*Aristida stricta*). Although marshes are described as exclusive communities by FNAI, the emergent vegetation occurring in the littoral zone of the lake is consistent in species composition with that described for the Basin Marsh, including maidencane (*Panicum hemitomon*), arrowhead (*Sagittaria* spp.), pickerelweed (*Pontederia cordata*) , fragrant water lily (*Nymphaea odorata*), and coastal plain willow (*Salix caroliniana*).

Standard ecological parameters were determined from the data collected on the woody and herbaceous plants to characterize the vegetation communities within the lake and adjacent swamps. These parameters include plant species identification; relative density, diversity, and abundance (Adamus 1990, Krebs 1989, Krebs 1994, Oosting 1956, and Pielou 1977).

Point Intercept Sampling

The point intercept method was used to sample species occurring along each transect (Oosting, 1956; Krebs, 1989). In this procedure, a tape measure is laid longitudinally along the transect centerline. If any part of a living plant touches the sampling tape at a point assigned a specified interval, then the respective plant species is recorded for that point. A point is assigned to litter/detritus when no part of a living plant touches the tape at the sampling interval. There was no bare ground (sand) along any of the transects. Sampling was performed at 0.5-foot intervals along each transect commencing at the edge-of-wetland (EOW) marker and proceeding to the 3-foot depth marker (Figure 4-2).

The five transect lines were not identical in their physical features. They varied in length between the EOW marker and the 3-foot depth marker from 87 feet to 177.5 feet, and the elevation differences between the two markers ranged from 1.63 feet to 3.02 feet. Elevation gradients ranged from 0.012

vertical foot/ horizontal foot to 0.029 foot/foot. Further discussion of the characteristics of the five transects is provided below.

Quadrat Sampling

The quadrat method was used to provide further data on trees and shrubs (Oosting 1956; Krebs 1989).

Quadrats were centered on the transect line and extended the entire length of the line. The width of each quadrat was consistent at five meters (16.405 ft.) on each side of the transect. Because the lengths of the five transects varied, the area sampled in the quadrat also varied. Quadrat areas ranged from 265 m^2 to 541 m^2.

Abundance, composition, and percent cover were estimated for all tree and shrub species within each quadrat. Trees were defined as woody plants with a diameter at breast height (dbh) of greater than or equal to 2.54 cm (1 in.), while shrubs are defined as woody plants greater than or equal to 50 cm (19.69 in.) in height with a dbh less than 2.54 cm (1 in.).

The areal extent of the submerged plant community was determined by visual means and by sampling the lake bottom with a grappling hook waterward of the emergent zone and in the open lake basin.

A log of all markers was maintained by Dooris and Associates personnel for each transect showing each marker number for all of the sampling points and their locations together with their relative distances from other markers on the same transect. When the ecological sampling was completed on each transect, all logs were provided to the Stantec surveyors and project manager. The surveyors subsequently visited each transect and obtained the latitude, longitude and elevations of the community, vegetation, soils, and hydrologic markers.

As markers were established and the ecological/soils sampling completed, digital photographs were taken from the on-the-ground perspective from several points along each transect. All photographs were labeled, catalogued and provided electronically to the Stantec Project Manager.

All data were recorded on field sheets and checked prior to departing each transect line. The transect markers and hydrologic indicator markers were left in place for later determination of elevation and location (latitude/longitude) by surveyors.

Field Determination of Elevation at the Water-ward Edge of Basin Swamp (SRWMD)

District staff conducted a site visit on September 6, 2013, in order to obtain location, and associated elevation data, of the water ward edge of the basin swamp community at all vegetation transects. This data was not collected during either point-intercept or quadrat sampling and is necessary for an empirically-derived estimate of mean basin swamp elevation. The lake stage was adequate for navigation by boat with a small outboard motor to each transect. All community edges were submersed, and depth measurements were conducted for each vegetation break, consistently defined by the basin swamp canopy/ swamp lake emergent vegetation interface.

During the site visit, the lake elevation was recorded from the SRWMD-maintained staff gage at the public dock and swimming area on the south side of the lake. The lake stage was 130.83 ft NAVD88. Depth of substrate at the vegetation break of each transect was subtracted from the lake stage to determine their respective elevations. It was noted that the lake was draining through the outfall below NE 3rd Street at this time.

Determination of the Elevation at the Landward Extent of the Deep Marsh Community

SRWMD staff conducted depth-soundings on March 24, 2016, to determine the landward elevation of the deep marsh community. Multiple soundings (n=28) were conducted along two segments of shoreline within stands of floating-leaved cow lily (*Nuphar advena*, Figure B1)

Figure B1. Cow lily stand, nearshore Lake Butler.

Since shallow emergent vegetation was not continuous throughout the site where cow lily occurred on Lake Butler, depths were recorded from the landward extents of individual cow lily stands to represent the upper boundary of the deep marsh community. These locations were typically located adjacent flooded cypress on the sampling date.

Results and Discussion

Wetland Plant Communities of Lake Butler

As described in the Methods section of this report, the FNAI plant community system was used as a guide in classifying the assemblages of plant species observed in the lake and along transects. Using this system, the vegetation was grouped into swamp lake and basin swamp communities. Community delineations used in this project were based on visual inspections and were consistent with the species composition descriptions developed by FNAI. A complete list of the common and scientific names of all plant species encountered in the sampling for the project is provided in Table .

That table also includes the FDEP wetland status of all plant species observed (Rule 62-340.450, F.A.C.).

Table B1. Names and classifications of plant species observed in Lake Butler transects and quadrats.

Species	FDEP Classification	Common Name
Baccharis halimifolia	FAC	Eastern false willow
Cabomba caroliniana	Submersed aquatic	Carolina fanwort
Cephalanthus occidentalis	OBL	buttonbush
Eichhornia crassipes	Floating aquatic	Water hyacinth
Hydrilla verticillata	Submersed aquatic	Hydrilla
Hypericum fasciculatum	OBL	St John's Wort
Ilex cassine	OBL	Dahoon holly
Itea virginica	OBL	Virginia willow
Juncus effusus	OBL	Soft rush
Lachnanthes caroliniana	FAC	Red root
Ludwigia octovalvis	OBL	Mexican primrose willow
Ludwigia repens	OBL	Creeping primrose willow
Lyonia lucida	FACW	Fetterbush
Magnolia virginiana	OBL	Sweetbay
Morella cerifera	FAC	Southern bayberry
Nymphaea odorata	OBL	Fragrant water lily
Nymphoides aquatica	OBL	Floating hearts
Nyssa sylvatica var. *biflora*	OBL	Swamp tupelo
Panicum hemitomon	OBL	Maidencane
Paspalum distichum	OBL	Knotgrass
Panicum repens	FACW	Torpedo grass
Salvinia minima	Floating aquatic	Water spangles
Pinus elliottii	UPL	Slash pine
Pontederia cordata	OBL	Pickerelweed
Quercus laurifolia	FACW	Laurel oak/swamp laurel oak

Community-Level Characteristics: Quadrat & Point-Intercept Results

Plant communities in the lake included emergent, submergent and floating-leaved communities. The well-developed emergent zone occurs around the entire lake perimeter and is heavily dominated by maidencane. Knotgrass and torpedo grass were also prevalent. Other species included fetterbush, pickerelweed, beakrush, Mexican primrose willow, soft rush and Virginia willow.

Submersed species included hydrilla, Carolina fanwort, and bladderwort. Bladderwort was dense in some areas and observed in the lake bottom near the waterward termini of transects 3, 4, and 5. Hydrilla and fanwort were most prevalent in the U-shaped canal on the lake's southwest shore.

The floating-leaved community occurred in very low numbers throughout the littoral zone, except in the U-shaped canal where dense rafts of water hyacinth were common and water spangles were thick to the point of being almost stacked in layers. Other plant species in this community included fragrant water lily and floating hearts. Of the species identified in the swamp lake community, hydrilla and water hyacinth are invasive exotics.

The basin swamp community surrounds the basin of Lake Butler except along approximately 2,100 feet of the south shore which is developed (Figures 3-1 and 3-3). The following discussion utilizes the quantitative vegetation data collected along the transect lines using both the quadrat method and the point-intercept method.

A total of eight species represented by 79 trees were identified in the tree quadrats of the five transect lines (Table). Transects 2, 3 and 4 each had five species, while Transects 1 and 5 had three and four species, respectively. The most common and abundant species was swamp tupelo which appeared in all of the five quadrats and represented almost 37% of all of the trees identified. Red maple was the second most abundant species at 25% followed in order of occurrence by slash pine (14%) and pond cypress (13%). Collectively, dahoon holly, wax myrtle, laurel oak and bald cypress composed the remainder of the trees identified. Two species, swamp tupelo and slash pine, occurred in all quadrats, while three species (wax myrtle, laurel oak and bald cypress) appeared in only one quadrat each.

Table B2. Trees counted in the Lake Butler quadrats.

Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Species Count
Acer rubrum	3	6	8	3	-	20
Ilex cassine	-	1	1	-	1	3
Morella cerifera	-	-	-	1	-	1
Nyssa sylvatica biflora	6	7	4	4	8	29
Pinus elliottii	1	3	4	1	2	11
Quercus laurifolia	-	2	-	-	-	2
Taxodium ascendens	-	-	-	6	4	10
Taxodium distichum	-	-	3	-	-	3
Total	10	19	20	15	15	NA
Density (trees/acre)	75	182	305	193	143	NA

The density of trees within the quadrats ranged from extrapolated values of 75 to 305 trees per acre with the highest density occurring on Transect 3 and the lowest density occurring on Transect 1. As the most common and abundant species in the quadrats, swamp tupelo may provide an indication of the history of the basin swamp community on Lake Butler. The density of this species within the five quadrats ranged from extrapolated densities of 45 trees/acre on Transect 1, to 76 trees/acre on Transect 5. Higher densities generally are typical of timber-harvested swamp communities, while lower densities are expected in old growth swamps. Swamp tupelo densities indicated that parts of the basin swamp surrounding the lake may have been logged in the past and the current community represents a combination of old growth and harvested swamp (Conner and Buford 1998).

With one exception, wax myrtle, all trees identified in the quadrats are classified by FDEP (Chapter 62-340.450, F.A.C.) and/or NWI (NWI 1997) as either OBL or FACW, i.e., they are species tolerant of wet conditions. The wax myrtle is classified as FAC by FDEP and as upland (UPL) by NWI.

A total of nine species represented by 84 individual shrubs were identified in the shrub quadrats of the five transect lines (Table). Transects 2 and 4 each had four species, while Transects 1, 3 and 5 had three species. The most abundant species was Virginia willow which composed 56% of the total shrubs counted in the five quadrats. The second most abundant species were buttonbush and sweetbay, each composing 14% of the total count. The most common species were sweetbay and wax myrtle which appeared in three of the five quadrats. No species appeared in all five quadrats. Collectively, cabbage palm, fetterbush, pond cypress, saw palmetto, water oak and wax myrtle composed the remainder of the species. Four species (pond cypress, buttonbush, saw palmetto and water oak) appeared in only one quadrat each.

Table B3. Shrubs counted in the Lake Butler quadrats.

Species (Indicator Status)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Species Count
Buttonbush (*Cephalanthus occidentalis*, OBL)	12	-	-	-	-	12
Virginia willow (*Itea virginica*, OBL)	-	-	-	41	5	46
Fetterbush (*Lyonia lucida*, FACW)	-	3	2	-	-	5
Sweetbay (*Magnolia virginiana*, OBL)	-	1	-	2	9	12
Wax myrtle (*Morella cerifera* , FAC)	2	1	-	1	-	4
Water oak (*Quercus nigra*, FACW)	-	-	1	-	-	1
Cabbage palm (*Sabal palmetto*, FAC)	-	-	1	1	-	2
Saw palmetto (*Serenoa repens*)	1	-	-	-	-	1
Pond cypress (*Taxodium ascendens*, OBL)	-	-	-	-	1	1
Total	15	5	4	45	15	NA
Density (shrubs/acre)	112	47	61	580	143	NA

The density of shrubs within the quadrats varied from 47 to 580 shrubs per acre with the highest density occurring on Transect 4 and the lowest occurring on Transect 2. All shrubs identified in the quadrats are classified by FDEP and/or NWI as either OBL or FACW, except three species: cabbage palm, saw palmetto and wax myrtle. FDEP classifies cabbage palm and wax myrtle as FAC, while saw palmetto is not classified. NWI classifies cabbage palmetto as FAC and saw palmetto as FACU; and wax myrtle is listed as UPL. The four wax myrtles occurred in the quadrats of Transects 1, 2 and 4, while the two cabbage palms were found in Transect 3 and 4. The single saw palmetto was found in Transect 1.

The point-intercept procedure identified linear patterns in species distribution in the basin swamp. The percentage occurrence of species generated from this data is shown in

Table . The data indicated that leaf litter/detritus occupied the majority of the points along each transect. Transect 1 had the highest percentage of litter and Transect 4 had the lowest. The average percentage of litter on all five transects was 60%. Only one species, Virginia chain fern, occurred on all five transects and was most abundant on Transects 2 and 4 where it occupied greater than 6% of each of those transects. Eight species occurred on only one transect. Those species included: St. John's wort, creeping primrose willow and blackberry on Transect 1; sweetbay, floating hearts, laurel oak and water oak on Transect 2; and Mexican primrose willow on Transect 5. There were no species exclusive to Transects 3 and 4.

Table B4. Percent occurrence of plants identified in the Lake Butler point intercept sampling.

Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Acer rubrum	0.85	-	0.58	-	-
Baccharis halimifolia	0.28	-	-	-	-
Cephalanthus occidentalis	0.56	-	-	2.36	-
Hypericum fasciculatum	0.28	-	-	-	-
Itea virginica	-	2.52	-	12.26	2.52
Lachnanthes caroliniana	-	5.40	0.58	2.83	0.72
Ludwigia octovalvis	-	-	-	-	0.36
Ludwigia repens	13.28	-	-	-	-
Magnolia virginiana	-	1.08	-	-	-
Morella cerifera	-	0.36	-	0.94	-
Nymphaea odorata	5.65	-	-	-	0.72
Nymphoides aquatica	-	0.36	-	-	-
Nyssa sylvatica biflora	0.28	1.08	-	-	1.08
Panicum hemitomon	-	16.55	29.48	35.85	32.73
Pontederia cordata	3.11	-	-	0.47	1.80
Quercus laurifolia	-	0.36	-	-	-
Quercus nigra	-	0.36	-	-	-
Rhynchospora inundata	0.85	-	-	-	1.80
Rubus argutus	0.28	-	-	-	-
Taxodium ascendens	-	-	0.58	-	1.08
Toxicodendron radicans	0.28	0.36	-	-	-
Woodwardia virginica	0.56	6.47	1.16	6.60	0.72
Leaf litter & other detritus (%)	73.73	65.11	67.63	38.68	56.47
Species richness	12	11	5	7	10
Number of sampling points on transect	354	277	173	212	278

In Transect 1, litter was the most commonly encountered item, particularly in the initial 138 feet. Within this length, litter was sporadically interrupted by one or more of the 12 species that occurred on the transect line. Between 138 feet and the end of the transect (177.5 feet), the species included: pickerelweed, creeping primrose willow, and fragrant water lily. Two tree species were observed on Transect 1: red maple, which occurred at three consecutive points (118, 118.5, and 119 feet; and swamp tupelo, represented by a single individual located at 65.5 feet. Other species on this transect included: blackberry, buttonbush, Eastern false willow, beakrush, poison ivy, St. John's wort and Virginia chain fern. Of the 12 species observed on Transect 1, creeping primrose willow was by far the most abundant, occupying over 13% of the total points on the transect. The second and third most abundant species were pickerelweed and fragrant water lily which occupied 3% and almost 6% of the total number of points, respectively.

In Transect 2, litter was most commonly encountered, mostly within the initial 119 feet but sporadically interrupted by one or more of the 11 other species occurring on the transect. Four tree species were observed on Transect 2: water oak near the beginning of the transect, swamp tupelo

(127.0, 127.5 and 132 feet), laurel oak (31.5 feet), and sweetbay (96.5 feet). Other species observed along the transect included: floating hearts, maidencane, poison ivy, red root, Virginia chain fern, Virginia willow and wax myrtle. Of the 11 species observed on Transect 2, maidencane was the most abundant, occupying almost 17% of the total points. The second and third most abundant species were red root and Virginia chain fern which occupied 5.4% and 6.5% of the total points, respectively. Of particular interest is the extensive zone of maidencane (approximately 32 feet long) which, with the exception of five points, occupied all points from 106.5 to the end of the transect (138.5 feet).

In Transect 3, litter was the most commonly encountered item, particularly in the initial 52 feet of the transect. Within this length, litter was sporadically interrupted by one or more of the five species that occurred on the transect line. Between 52 feet and the end of the transect (87 feet), the remaining species included: maidencane, pond cypress and red root. Two tree species were observed on Transect 3: red maple, which occurred at one point (20.0 feet), placing the species in less than one foot of water; and pond cypress which was represented by a single individual located at 61.0 ft. from the start of the transect. Aside from the four species already mentioned, the only other species observed along the transect was Virginia chain fern. Of the 5 species observed on Transect 3, maidencane was the most abundant, occupying 29.5% of the total points.

In Transect 4, litter was the most abundant item; however, unlike Transects 1, 2 and 3, litter did not form a long, unbroken zone of coverage. Rather, litter was interrupted by one or more of the seven species that occurred on the transect line. No tree species were observed on Transect 4. Of the seven species observed on Transect 4, maidencane was the most abundant, occupying almost 36% of the total points. Two other species were also abundant: Virginia willow covering 12%, and Virginia chain fern which occupied almost 7%. Other species on the transect line included buttonbush, pickerelweed and red root. As described above for Transects 2 and 3, it is of particular interest that, except for litter, maidencane occupied most of the transect.

In Transect 5, litter was the most commonly encountered item, particularly in the initial 86 feet. Within this length, litter was sporadically interrupted by one or more of the 10 species intercepted. Between 86 feet and the end of the transect (139.5 feet), the species included fragrant water lily, maidencane, pickerelweed, red root, and Virginia willow. Of the 10 species, maidencane was the most abundant, occupying almost 33% of the total points on the transect. Aside from maidencane, no species achieved a per cent coverage greater than 3% with most occurring at less than 2% of the points. Two tree species were observed on Transect 5, swamp tupelo and pond cypress, each of which occupied only 1.08% of the sampling points. Other species included Mexican primrose willow, beakrush and Virginia chain fern. As described for Transects 2 through 4; other than litter, maidencane occupied most of the transect, covering an almost unbroken zone at the end of the transect. The composite species richness for the aggregated transects, derived by combining the species observed in both quadrat and point-intercept procedures, varied from 8 to14 (Table B5). Transect 1 had the highest species richness, while Transect 3 had the lowest. The species identified in the basin swamp using the two sampling methods were typical of this community, and no exotic, invasive species were encountered.

Table B5. Composite species richness for each Lake Butler MFLs transect.

Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Acer rubrum	X	-	X	-	-
Baccharis halimifolia	X	-	-	-	-
Cephalanthus occidentalis	X	-	-	X	-
Hypericum fasciculatum	X	-	-	-	-
Itea virginica	-	X	-	X	X
Lachnanthes caroliniana	-	X	X	X	X
Ludwigia octovalvis	-	-	-	-	X
Ludwigia repens	X	-	-	-	-
Lyonia lucida	-	X	X	-	-
Magnolia virginiana	-	X	-	X	X
Morella cerifera	X	X	-	X	-
Nymphaea odorata	X	-	-	-	X
Nymphoides aquatica	-	X	-	-	-
Nyssa sylvatica biflora	X	X	-	-	X
Panicum hemitomon	-	X	X	X	X
Pontederia cordata	X	-	-	X	X
Quercus laurifolia	-	X	-	-	-
Quercus nigra	-	X	X	-	-
Rhynchospora inundata	X	-	-	-	X
Rubus argutus	X	-	-	-	-
Sabal palmetto	-	-	X	X	-
Serenoa repens	X	-	-	-	-
Taxodium ascendens	-	-	X	-	X
Toxicodendron radicans	X	X	-	-	-
Woodwardia virginica	X	X	X	X	X
Composite species richness	14	12	8	9	11

Determination of the Average Basin Swamp Elevation

Determination of Water-ward Elevation of the Basin Swamp Wetland Community

The elevation corresponding to the water-ward edge of the basin swamp community at each transect is listed in Table B6, as determined from Stantec's elevation surveys. This elevation defines the ecotone between basin swamp and swamp lake communities. The median of these elevations is 128.75 ft NAVD88.

Table B6. Elevations (ft NAVD88) of the water-ward edge of the basin swamp from Stantec's surveys.

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Average Elevation	Median Elevation
128.77	128.23	128.91	128.65	128.75	128.66	128.75

Determination of Landward Extent of the Basin Swamp Wetland Community

The elevations corresponding to the landward extents of the basin swamp are given in Table 7, as determined from Stantec's elevation surveys.

Table B7. Elevations (ft NAVD88) of the landward edge of the basin swamp (EOW) from Stantec's surveys.

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Average EOW	Median EOW
130.3	129.2	129.93	130.8	130.3	130.13	130.34

The median landward edge of the basin swamp is 130.34 ft NAVD88. Therefore, the empirically derived mean elevation of the basin swamp community is 129.55 ft NAVD88, which is a robust average derived from the median water-ward edge and the median landward edge of wetland. This accounts for any variability among reviewers in field-determination of the two community boundaries.

Determination of the Elevation at the Landward Extent of the Deep Marsh Community

A mean elevation of 127.3 ft NAVD88 was determined for the shallowest extent of Lake Butler cow lily stands (n=28, Figure B2), thus delineating the landward extent of the deep marsh community. The 95% confidence interval (95%CI), also shown in the figure, is located between 126.4 and 128.2 NAVD88.

The four greatest outliers shown in Figure , contribute to the 1.8-foot spread between the top and bottom of the 95%CI, as does their influence in the departure from a normal distribution in the data (Figure). The departure from normality was confirmed by the Shapiro-Wilk normality test (p=0.007).

Removing the four greatest outliers in the dataset resulted in a mean elevation of 127.2 ft NAVD88, and the spread in the 95%CI was reduced to 0.9 feet (between 126.8 and 127.7 ft NAVD88). Although the distribution of data about the mean was tighter, the elimination of these outliers did not result in a normally-distributed dataset at α=0.05, albeit very close (p=0.03).

Since the opportunity to conduct depth soundings necessary to map the deep marsh boundary was limited by the availability of cow lily stands, the data may be improved if the species proliferates in the future. Additional species may also be utilized to determine the same benchmark but would need to be evaluated for justification, as has been done for cow lily (Neubauer et al. 2008; SJRWMD 2006). Accordingly, the more conservative mean value of 127.3 ft NAVD88 (n=28) will be recommended for FL, as determined from this sampling effort and data analysis.

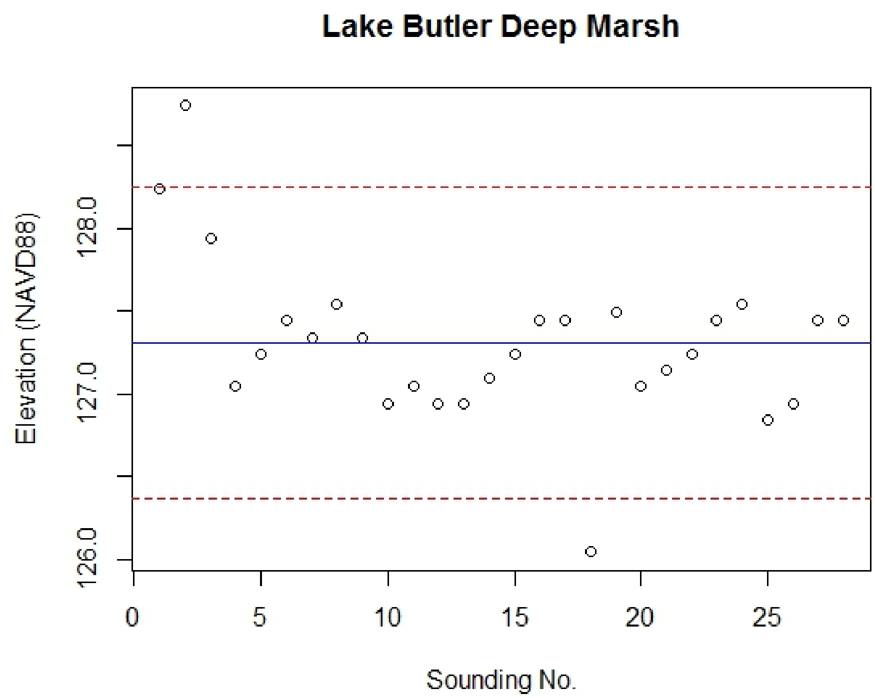

Figure B2. Elevations of the landward extent of the deep marsh community determined from soundings from cow lily stands. Blue line = mean, and red dotted lines=95%CI.

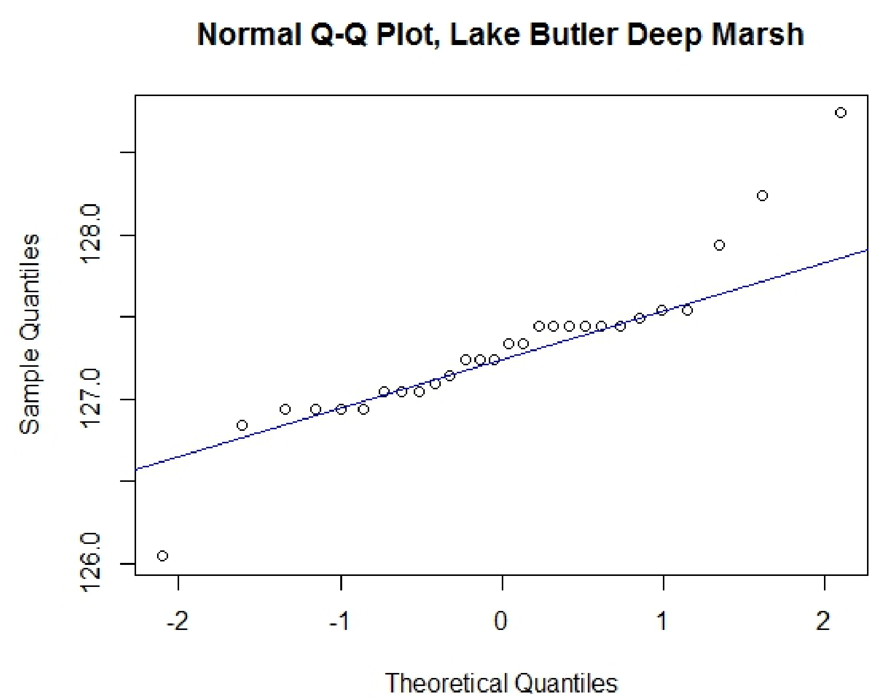

Figure B3. Normal Q-Q plot of elevation data determined for the deep marsh community.

Appendix C: Soil Sampling Methods, Analyses, and Results

Elevation Data

The survey conducted for this project was recorded in NGVD29. In this report, the vertical datum was converted for consistency: NGVD29 stage data were converted to elevations in NAVD88 by using the following conversion for local benchmark E 82: NGVD29 elevation - 0.88 foot = NAVD88 elevation (Appendix A).

Soils Assessment

All of the transects were located generally along the northern shore of Lake Butler. The USDA- NRCS soil survey (Figure 3-6) mapped most of these areas along the northern lake margin as Surrency and Pantego soils, frequently flooded (Dearstyne et al., 1991). This soil map unit is normally associated with creek and river floodplains, or other areas with frequent inundation. The primary soil map unit components, Surrency and Pantego soils, are level, very poorly drained soils that occur low in the landscape. The soils typically exhibit a sandy to loamy upper profile with heavier textured loamy soil materials (argillic horizons) occurring deeper in the profile. Surface horizons within this map unit are typically dark, sandy, and may be mucky mineral analogues of sandy soil textures. In some profiles, muck may be present as a thin “Oa” horizon.

Field classification of the transect soil profiles were consistent with the Surrency series and related soils, with loamy argillic horizons occurring below a depth of 20 inches. Three of the profiles exhibited umbric epipedons that were consistent with a Surrency soil series classification. The three other soils possessed ochric epipedons that fit morphologically with the Pelham or Plummer soil series, although those series are poorly drained versus very poorly drained. No Pantego soils (argillic horizon above the 20-inch depth) were observed along the transects. Not all soil profiles could be reliably field classified, due to collapse of auger holes under high water table conditions.

Soil sampling locations were constrained by transect locations, high water tables, surface water, and/or trees and tree roots. Basic soil morphology descriptions, identity of hydric soil indicators, depth to the apparent free water table, and miscellaneous site notes for each of the transect soil locations were documented during the soil sampling events and are summarized in narrative fashion below for each soil sampling location.

Soil 1 (landward of Transect 1): Mucky fine sand from 0-3” depth; hydric soil indicator A7 (5cm Mucky Mineral) present. Apparent free water table occurred at 18” depth. No elevation data available.

Soil 2 (15 feet landward of Transect 1): Muck from 0-2” depth; mucky loam from 2-14” depth; hydric soil indicators A7 (5cm Mucky Mineral), A9 (1cm Muck), and A12 (Thick Dark Surface). Apparent free water table occurred at 2” depth. No elevation data available.

Soil 3 (Transect 2): Muck from 0-2” depth; mucky loam from 2-11” depth; hydric soil indicators A7 (5cm Mucky Mineral) and A9 (1cm Muck). Surface water was 5” deep above soil surface. No elevation data available.

Soil 4 (Transect 3): Mucky loam from 0-9” depth; hydric soil indicator A7 (5cm Mucky Mineral); muck presence on soil surface (not a hydric soil indicator in LRR “T”). Free water table depth was not available (due to collapsed hole) but was within a few (0-4) inches of ground surface. Ground surface elevation: 129.92 ft NAVD88.

Soil 5 (Transect 4): Muck from 0-1” depth; mucky loam from 1-7” depth; hydric soil indicators A7 (5cm Mucky Mineral) and A9 (1cm Muck). Apparent free water table occurred at 15” depth. Ground surface elevation: 130.82 ft NAVD88.

Soil 6 (Transect 5): Muck from 0-1” depth; mucky loam from 1-5” depth; hydric soil indicators A7 (5cm Mucky Mineral) and A9 (1cm Muck). Heavy clay argillic horizon occurred just below 20” depth, with redox concentrations in fine root channels. Water table occurred at 16” depth but may represent a perched or semi-restricted water table. No elevation data available.

Due to the after-effects of Tropical Storm Debby and the necessity of performing soil sampling several months after transect establishment, reliable ground elevations were confirmed for only two of six soil sampling locations (Soils No.4 and No.5). The established vegetation transects all terminated near the landward limit of cypress communities along the interface with pine plantation vegetation; therefore, all of the soil sampling locations reflect a consistently wet hydrology associated with periodic inundation.

As noted above, all of the soil sampling locations possessed mucky mineral surface soil textures, indicative of prolonged saturation or near-saturated soil moisture conditions in most years. The mucky mineral hydric soil indicator has been shown to display good statistical coherence with cypress community hydrologic conditions (Epting 2007).

Four soil profiles (No.2, No.3, No.5, and No.6) possessed more than one centimeter of muck, qualifying for the A9 hydric soil indicator. Another soil (No.4) had a thin (<1cm) muck presence that did not qualify for the A9 indicator. Muck is formed and persists in soils that are saturated and anaerobic for prolonged periods. When natural or manmade changes in hydrology decrease water levels and/or the duration of high water tables, muck materials can eventually oxidize until the muck content is diminished or no longer present in surface soils.

Although replicated elevation control is lacking in the soil dataset, the A9 hydric soil indicator (>1cm muck) was documented at a ground elevation of 130.82 ft NAVD88 for soil No.5, which suggests that water levels are likely at or near this elevation for a majority of time in most years. A thinner muck presence was documented at a lower elevation of 129.92 ft NAVD88 for soil No.4. Both soils occur on relatively flat land, and care was taken to avoid biased sampling in micro- depressions or other topographic anomalies. The difference in muck thickness is unknown but is likely due to some interplay of leaf litter accumulation, upslope hydrology, disturbance, or other site variables.

Only one soil profile (soil No.2) met the criteria for the Thick Dark Surface (A12) hydric soil indicator. The other soils with deeper “A” horizons failed to meet criteria due to the subsoil matrix colors and the lack of redox concentrations. In fact, none of the examined soil profiles displayed redox concentrations, despite evidence of iron (redox concentrations, high-chroma subsoil colors) further upslope of all transects. The lack of redox concentrations may be due to consistently high water tables in the transect areas, and/or a thorough reduction of soil iron from prolonged soil inundation in the months following Tropical Storm Debby.

Appendix D: Hydrologic Indicator Sampling, Analyses, and Results

Hydrologic Indicators

Two ecological hydrologic indicators were used in this project. The primary indicator used was the inflection point on both species of cypress buttresses which provides guidance as to the lake's historic normal pool (HNP). The waterward limit of the saw palmetto or EOW was also marked and the elevations were obtained.

Normal pool elevations are determined by using reasonable scientific judgment when evaluating hydrologic indicators that demonstrate sustained inundation. Adventitious roots and inflection points on cypress buttresses are examples of hydrologic indicators that can be used to establish normal pool elevations. The normal pool elevation in Lake Butler was established at 130.77 ft NAVD88 based on the average elevation of the inflection points on the buttressing of cypress identified within the quadrats on all of the transects (Table D1).

The median elevation of the EOW for the five transects is lower than that of the cypress buttress by -0.43 foot (Table D2). This is consistent with findings of Carr et al. (2006) in a study of cypress domes, where *Lyonia lucida*, moss collars, and buttress swellings were inundated 2–3% of the time, and other indicators including ground elevations at the lowest *Serenoa repens* (EOW) were inundated 13–29% of the time, An explanation for this observation is that the cypress buttress inflection points are better indicators of historic water levels while the plants used to determine the EOW are better indicators of more recent water elevations, e.g., in the last 15 years. The lake's stages have declined over time (Figure 3-4), and the edge-of-wetland indicators appear to have responded to lower water levels. The control point elevation was determined to be the downstream culvert in the Outlet Canal under NE 2nd St, the elevation of which was 131.33 ft NAVD88 from Stantec's surveys. The normal pool elevation was lower than the control point elevation, so the lake is not considered to be structurally altered.

Table D1. Elevations (ft NAVD88) of cypress buttress inflection points along Lake Butler transects

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
131.60	129.20	130.91	130.90	130.90
131.50	130.60	130.60	130.90	130.70
130.80	130.60	130.40	130.90	130.80
130.80	-	-	-	-
131.00	-	-	-	-

Table D2. Elevations (ft NAVD88) of the edge-of-wetland (EOW) indicators on Lake Butler transects

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Average EOW	Median EOW
130.34	129.24	129.93	130.78	130.34	130.13	130.34

The elevations of structures and facilities around a lake also are indicators of water level patterns. This information can assist in the development of recommended minimum levels on a lake and in avoiding flooding of homes and inundating public facilities. It is helpful to know the elevation(s) of the lowest floor of homes around a lake when recommending minimum elevations, and in the case of Lake Butler there are two homes that sit at relatively low elevations of 132.59 and 133.70 ft NAVD88, respectively. Both homes are on the south side of the lake north of NW 3rd St.; one is located on the east side and one is located on the west side of the Outlet Canal. The floor elevations of these homes are 1.26 feet and 2.37 feet higher than the control point elevation of 131.33 ft NAVD88.

The elevations of the public docks and the boat ramp facilities are provided in Table D3. The median elevation of the tops of the wooden docks (131.14 ft NAVD88) is lower than the control point of the lake by 0.19 foot, but the average elevation of the docks (131.48 ft NAVD88) is 0.15 foot higher than the control point elevation. The median and the average elevations of the top of the riprap at the boat ramp (129.46 ft NAVD88) are identical and are lower than the control point of the lake by 1.87 feet. The median and average elevations of the concrete dock at the boat ramp and the concrete headwall at the dock area are all higher than the lake control point by 0.69 to 0.91 foot.

Table D3. Elevations (ft NAVD88) of public docks and boat ramp facilities on Lake Butler

	Wooden docks	Riprap at boat ramp	Concrete dock	Concrete headwall
	132.16	130.66	131.85	132.35
	132.20	130.58	132.07	132.24
	132.20	130.38	132.07	132.24
	132.27	130.21	132.08	132.35
	132.17	129.89	132.01	132.25
	132.25	129.88	-	132.16
	132.27	129.44	-	132.17
	131.07	129.99	-	132.18
	130.95	130.04	-	-
	131.16	129.77	-	-
	131.15	129.72	-	-
	131.09	129.05	-	-
	131.11	129.18	-	-
	131.04	129.13	-	-
	131.14	129.21	-	-
	131.07	129.36	-	-
	130.92	129.46	-	-
	131.10	129.46	-	-
	130.76	129.03	-	-
	-	128.61	-	-
	-	127.93	-	-
	-	127.22	-	-
Average	131.48	129.46	132.02	132.24
Median	131.14	129.46	132.07	132.24