Central Florida Water Initiative

WATER FOR TOMORROW

ASSESSMENT OF EFFECTS OF GROUNDWATER WITHDRAWALS ON GROUNDWATER-DOMINATED WETLANDS IN THE CENTRAL FLORIDA WATER INITIATIVE PLANNING AREA

Central Florida Water Initiative's Environmental Measures Team

August 24, 2020

FINAL REPORT

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EXECUTIVE SUMMARY

The Central Florida Water Initiative's (CFWI's) Environmental Measures Team (EMT), a sub team of the Water Resources Assessment Team (WRAT), is a technical support group consisting of scientists from three water management districts – South Florida Water Management District (SFWMD), St. Johns River Water Management District (SJRWMD), and Southwest Florida Water Management District (SWFWMD) – and public supply utility representatives. The EMT was reactivated in late 2016 to provide support for the 2020 CFWI Regional Water Supply Plan (RWSP). It was tasked with determining the status of primarily groundwater-dominated wetlands, typically without established minimum flows and levels, with respect to hydrologic stress and to develop tools to evaluate modeled future wetland conditions within the CFWI Planning Area. Groundwater-dominated wetlands are those wetlands whose water budget is largely driven by the exchange (both inflow and outflow) of groundwater due to their connectivity to an aquifer; they are mostly isolated, but also include headwater wetlands and seasonally inundated wetland strands that would be defined under regulatory rules as "connected wetlands." The results of the EMT's analyses were used to evaluate the following environmental criterion: increase in acres of stressed primarily groundwater-dominated wetlands.

Numerous tasks were conducted by the EMT in support of the determination of sustainable groundwater withdrawals in the CFWI Planning Area for the 2020 CFWI RWSP. These tasks, approved by the WRAT and Management Oversight Committee (MOC) and presented to the Steering Committee, included conducting field visits to assess the hydrologic stress status of 44 wetlands previously classified by the EMT as Class 1 wetlands and adding new wetlands to the Class 1 wetlands dataset. Class 1 wetlands are defined as wetlands or lakes with available long-term water level data of sufficient duration, known wetland edge elevations, and known hydrological stress conditions. Previous analysis by the EMT demonstrated that these wetlands were representative of primarily groundwater-dominated wetlands within the CFWI Planning Area. In addition, the same wetlands risk assessment methodology that was used by the EMT to predict probable effects of current and future groundwater withdrawals in support of the 2015 CFWI RWSP was used for the current risk assessment, with an expanded Class 1 wetlands dataset and updated groundwater model [East-Central Florida Transient X (ECFTX)]. The EMT's work products predicting the likely effects of future groundwater withdrawals on wetland resources as predicted by the ECFTX model were used by the Groundwater Availability Team (GAT) to determine the sustainable quantities of available groundwater.

Field assessments of 60 Class 1 wetlands (44 original wetlands and 16 potential new sites) were conducted during Spring and Summer 2018 using an updated methodology. The final Class 1 wetlands statistical analysis dataset used for the wetlands risk assessment included 41 of the original 44 sites and 12 of the 16 potential new sites for a total of 53 sites. An analysis of water level data from 2009 through 2017, a 9-year period of record, from these Class 1 wetlands was used to develop a statistical relationship between observed hydrologic stress and observed water level variations. This statistical relationship was used to estimate the probability (or risk) of future changes in wetland stress occurring throughout the CFWI Planning Area based on the modeled water level changes between the 2014 Reference Condition (RC) and the 2025, 2030, and 2040 Withdrawals Conditions. Primarily groundwater-dominated wetlands and lakes in Plains and Ridge physiographic regions were evaluated separately, since wetland hydrologic conditions in these systems are different as a

result of variations in underlying soils, geology, physiography, typical depths, and other factors.

There are more than one million acres of wetlands in the CFWI Planning Area, and the focus of the EMT's wetlands risk assessment was on primarily groundwater-dominated lake and wetland systems, excluding those that were determined to be too hydrologically altered for this analysis. The wetlands analyzed make up less than 20 percent of the total wetland acreage in the CFWI Planning Area. It is assumed that if these groundwater-sensitive systems are protected, less vulnerable systems will also be protected. Approximately 189,000 acres of wetlands were included in the EMT's analysis, which consisted of about 139,000 acres of wetlands located in Plains physiographic provinces and approximately 50,000 acres of wetlands located in Ridge physiographic regions.

For the Plains wetlands risk assessment, ECFTX model results for Model Layer 1 (surficial aquifer system or SAS) were used to determine the probability for stress since Plains physiographic provinces are typically characterized by having a confining layer that restricts the exchange of water between the SAS and the underlying Floridan aquifer system; the confining layer between the SAS and the Upper Floridan aquifer (UFA) is typically very restrictive but can vary throughout the Plains physiographic regions. For the Ridge wetlands risk assessment, a range of probable for stress was developed using ECFTX models results for Model Layer 1 (SAS) and Model Layer 3 (UFA), since most of the Ridge physiographic provinces are typically characterized by less or no confining conditions that vary considerably throughout the CFWI Planning Area. This range provided an estimate of low and high probability of future changes in Ridge wetlands water levels from which to estimate corresponding probabilities of changes in wetland stress conditions.

Compared to the 2014 RC, the probable net increase in stressed Plains wetland acres resulting from the 2025 Withdrawals Condition was about 800 acres and 1,000 acres for the 2030 Withdrawals Condition. The probable net increase of stressed Plains wetlands resulting from the 2040 Withdrawals Condition was just over 1,400 acres. These results represent an increase in stressed wetland acres of about 0.5, 0.7, and 1 percent, respectively, as compared to the 2014 RC.

For the 2025 Withdrawals Condition, the probable net increase in stressed Ridge wetland acres ranged from 500 to approximately 2,750 acres; this represents an increase between 1 and 5 percent in stressed wetland acres compared to the 2014 RC. For Ridge wetlands, the probable net increase in stressed acres ranged between 700 acres and about 3,600 acres for the 2030 Withdrawals Condition as compared to the 2014 RC, an increase ranging between 1.5 and 7 percent of stressed wetland acres. For the 2040 Withdrawals Condition, the probable net increase in stressed Ridge wetland acres ranged from about 1,000 to 4,700 acres; this represents an increase between 2 and 9 percent in stressed wetland acres compared to the 2014 RC.

Similar to the EMT's original analysis, understanding the limitations of the wetlands risk assessment and the appropriate use of the results is important. The focus of the EMT's work was on primarily groundwater-dominated systems since they are generally considered as being more sensitive to changes in groundwater levels than flowing (e.g., riverine) systems. Primarily groundwater-dominated wetlands represent a small percentage of the total number of wetlands in the CFWI Planning Area; therefore, extrapolating the wetland impacts resulting from the 2025, 2030, and 2040 Withdrawals Conditions to all wetlands in the planning area is not appropriate. In addition, the results of our analysis assessed the probability of wetland stress occurring at a high level and can't be applied to the local scale. The regional scale of the ECFTX model limits its accuracy precision in predicting future changes of water elevations in specific lakes and wetlands. The wetland stress response is also very sensitive to the initial hydrologic condition of each wetland, and this is not known for most of the wetlands within the CFWI Planning Area included in our analysis. It must be noted that other factors, such as land-use changes, can affect wetland quality. In addition, the results of the wetlands risk assessment are intended as a planning-level effort to determine groundwater availability, based on a specific set of Withdrawals Conditions, and are not intended to represent a site-specific impact assessment that may occur in 2025, 2030, or 2040.

As a result of the establishment of the long-term wetlands monitoring program under the Data, Monitoring and Investigations Team, which is currently in progress and is anticipated to last 20 years, the dataset of wetlands within the CFWI Planning Area with adequate data will continue to grow as well as possible refinement to the data on which future groundwater models rely on. Once the 2020 CFWI RWSP is completed, the EMT will continue to meet on a regular basis to evaluate and provide recommendations on any needed enhancements related to wetland data collection or assessment methodology.

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1.0 INTRODUCTION AND BACKGROUND

The Environmental Measures Team (EMT), a sub team of the Water Resources Assessment Team (WRAT), is a technical support group consisting of scientists from three water management districts – South Florida Water Management District (SFWMD), St. Johns River Water Management District (SJRWMD), and Southwest Florida Water Management District (SWFWMD) – and public supply utility representatives that performs environmental assessments of wetlands and surface waters and other related work in support of determining sustainable groundwater withdrawals in the Central Florida Water Initiative (CFWI) Planning Area. The EMT currently consists of the following members:

- Kym Rouse Holzwart – EMT Lead and SWFWMD representative
- David MacIntyre – EMT Co-Lead and environmental consultant (AquaSciTech Consulting) representing St. Cloud, TOHO Water Authority, Orange County, Polk County, and Reedy Creek Improvement District (STOPR)
- Kevin Rodberg – SFWMD Representative
- Lisa Prather – SFWMD Representative
- Kristian Holmberg – SJRMWD Representative
- Mark Hurst – SWFWMD Representative
- Shirley Denton – Environmental consultant (Cardno) representing Orlando Utilities Commission (OUC) (recently retired and replaced by Dan Schmutz of GPI)

1.1 Previous Efforts of the Environmental Measures Team

For the 2015 CFWI Regional Water Supply Plan (RWSP), the EMT's evaluation of wetlands and lakes within the CFWI Planning Area, most without adopted minimum flows and levels (MFLs), was an important consideration (CFWI EMT 2013). The EMT was tasked with determining the status of wetlands and lakes whose hydrology is primarily groundwater-dominated (e.g., potentially more likely to be affected by groundwater withdrawals) and to develop tools to evaluate modeled future wetland conditions within the CFWI Planning Area.

Between 2007 and 2012, over 350 primarily groundwater-dominated wetlands and lakes within and near the CFWI Planning Area were visited and assessed by consultants for the Central Florida Coordination Area (CFCA) team, the predecessor to the CFWI (CFWI EMT 2013). The CFCA team met to review the consultant's reports, evaluate aerial photographs, and categorize the wetlands as stressed or not stressed. The EMT conducted field visits to re-evaluate proposed Class 1 wetlands. The wetlands and lakes were divided into three classes based on the amount of information available as described below.

- Class 1 wetlands: These 44 wetlands and lakes were studied in detail. The location, long-term water level data, the wetland edge elevation, and the hydrologic stress condition were known (e.g., stressed/not stressed). Analyses demonstrated that these wetlands were representative of primarily groundwater-dominated wetlands within the CFWI Planning Area.
- Class 2 wetlands: This class included approximately 200 wetlands and lakes. The location and environmental condition of the wetland was known (e.g., stressed/not

stressed), but there was insufficient water level data to assess the hydrologic conditions.

- Class 3 wetlands: Thousands of groundwater-dominated wetlands and lakes within the CFWI Planning Area were included in this class. The location of these wetlands was known, but the hydrologic condition was not known.

For the 2015 CFWI RWSP, the method used to evaluate wetlands under future modeled groundwater level conditions was based on evaluations of primarily groundwater-dominated lake and wetland systems, which are generally considered to be inherently more vulnerable to impacts from lowered groundwater levels (CFWI EMT 2013). The methodology was based on a statistical assessment of the probability of future environmental stress in each wetland within and near the CFWI Planning Area based upon the relationship between observed ecologic and hydrologic conditions of the 44 Class 1 wetlands. The water level data from the Class 1 wetlands were used to compute a statistical relationship between observed stress and observed water level variations. This statistical relationship was used to estimate the probability (or risk) of future changes in wetland stress occurring, based on modeled groundwater level changes between the Reference Condition (RC) and future Withdrawals Conditions. This risk assessment was applied separately to primarily groundwater-dominated wetlands in Plains and Ridge physiographic settings because wetland hydrologic conditions and responses in these wetland types are, in general, substantially different. Statistical analyses were performed, which indicated that the characteristics of the Class 1 wetlands were adequately representative of all groundwater-dominated wetlands in the CFWI Planning Area and that the data used were appropriate for their application. The EMT's work products predicting the likely effects of future groundwater withdrawals on wetland resources as predicted by the ECFTX model were used by the Groundwater Availability Team (GAT) to determine the sustainable quantities of available groundwater.

Once the 2015 CFWI RWSP was completed, the EMT became inactive. However, it was reactivated in late 2016 to provide support for the 2020 CFWI RWSP as it relates to non-MFL groundwater-dominated wetlands and lakes. This report describes the tasks that were completed, and analyses conducted to assess the impacts of modeled future groundwater withdrawals in the CFWI Planning Area on wetlands and lakes in support of the 2020 CFWI RWSP. This information was used to evaluate the following environmental criterion: increase in acres of stressed primarily groundwater-dominated wetlands.

1.2 Spatial Distribution of Wetlands in the CFWI Planning Area

The distribution of wetlands, classified by EMT hydroclass (Attachment E in CFWI EMT 2013), is shown in **Figure 1**, and **Table 1** includes the acreages and percentages of the various wetland classifications. There are more than one million acres of wetlands within the CFWI Planning Area, and almost 70 percent of the wetlands consist of floodplains and interconnected wetlands (2D and 2F). The primarily groundwater-dominated lake and wetland systems that were the focus of the EMT's analysis include less than 30 percent of wetlands located within the CFWI Planning Area. Groundwater-dominated wetlands are those wetlands whose water budget is largely driven by the exchange (both inflow and outflow) of groundwater due to their connectivity to an aquifer. Groundwater-dominated wetlands are mostly isolated, but also include headwater wetlands and seasonally inundated wetland strands that would be defined under regulatory rules as "connected wetlands."

Table 1. Total acreages and percent coverages of EMT wetland hydroclasses (defined in Attachment E in CFWI EMT 2013) within the CFWI Planning Area.

EMT Wetland Hydroclass	Wetland Description	Wetland Acreage	Percent of Total Wetland Acres
1A + 2A-M + 1E	Groundwater-dominated and semi-groundwater-dominated mesic (Plains)	166,000	15.7
1B + 2A-X + 1F	Groundwater-dominated and semi-groundwater-dominated xeric (Ridge)	119,000	11.2
1C	Seepage slope wetlands	22,000	2.1
1D	Flats wetlands (Ridge, Plains, and floodplains)	14,000	1.3
2D	Connected (strands/sloughs, Ridge and Plains)	278,000	26.3
2F	Floodplain (lakes and wetlands)	460,000	43.4
Total		1,059,000	100

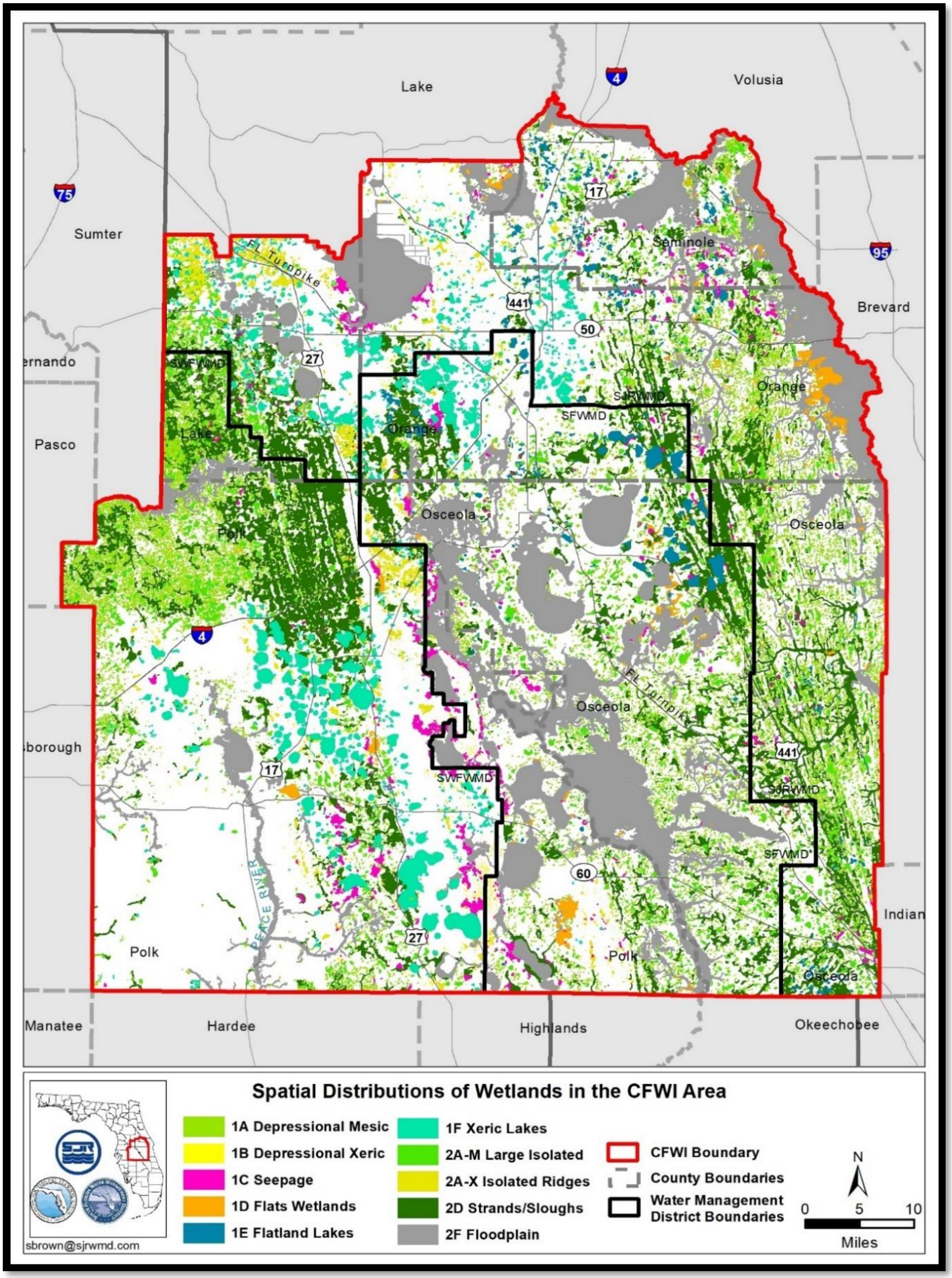

Figure 1. Spatial distribution of wetlands by EMT hydroclass classifications (defined in Attachment E in CFWI EMT 2013) within the CFWI Planning Area.

2.0 SELECTED WETLANDS ANALYSIS METHODOLOGY IN SUPPORT OF THE 2020 CFWI REGIONAL WATER SUPPLY PLAN

One option for assessing the current condition of primarily groundwater-dominated wetlands and lakes in the CFWI Planning Area was to re-evaluate a valid subset of the approximately 200 Class 2 wetlands to determine if their environmental conditions had changed since the original evaluation. Therefore, as a first step, the EMT performed a statistical power analysis to determine the number of wetlands that would need to be re-evaluated to obtain a statistically significant determination of change in the number of stressed wetlands within the CFWI Planning Area (see **Appendix D** for details). Based on the recent experience of District wetland scientists examining wetlands in the CFWI Planning Area in their routine work, EMT wetland scientists estimated that there might be a shift towards a smaller percentage of wetlands being stressed but that the change in percentage of stressed wetlands over the last 5 years was not large (probably measured in single digit percentages).

The results of the statistical power analysis indicated that a population greater than the original sample pool of Class 2 wetlands would need to be evaluated to provide a statistically significant conclusion at a 90 or 95 percent confidence level on whether a change in stress status on the order of 10 percent or more of wetlands had occurred since the last survey of Class 2 wetlands (**Appendix D**). When these results were presented to the WRAT, they requested that the EMT develop options for determining the current status of primarily groundwater-dominated wetlands and lakes with respect to hydrological stress and to evaluate modeled future groundwater withdrawals on wetlands conditions in support of the 2020 CFWI RWSP. The EMT presented various options to the WRAT. The methodology option approved by the WRAT, the Management Oversight Committee (MOC), and then subsequently presented to the Steering Committee included:

- Conducting field visits to assess the stress status of the original 44 Class 1 wetlands, as well as potential new sites, using primarily the same methodology that was used for the wetland assessments in support of the 2015 CFWI RWSP.
- Adding new wetlands to the Class 1 wetlands dataset.
- Using the same methodology to conduct the wetlands analysis that was used for the 2015 CFWI RWSP but with the expanded Class 1 wetlands dataset and the updated model [East-Central Florida Transient Expanded (ECFTX) groundwater model].

The sections that follow describe the methods and results associated with the approved methodology options listed above.

3.0 2018 ASSESSMENTS OF CLASS 1 WETLANDS

Compared to the methodology used for the original assessments that were conducted from 2007 through 2012, key changes were made to the methodology used for the 2018 Class 1 wetlands assessments, which are described in the following bullets.

- The original assessments were performed by a large number of consultants with varying skill levels. To ensure consistency and minimize variability, three wetland scientists on the EMT, one representing each water management district with significant experience assessing wetlands, conducted all the assessments. As an additional measure to ensure consistency, a field day was held in April 2018, and stress status assessments of eight Class 1 wetlands were conducted collaboratively by the water management district EMT wetland scientists.
- The stress status determinations for the original assessments were based largely on change from historical conditions based on a review of aerial photography and observations of obvious stress, such as soil subsidence. For the current assessments, historical changes that were not consistent with observed current conditions were not used as the sole determinant of current stress. In other words, even though the wetland may have been altered historically, if current conditions indicated stable hydrology, then the historical alteration was not considered in the stress status determination.
- In addition to not focusing on historical changes if the wetland had normal hydrology for the recent past (e.g., the last 10-20 years), the determination of stress was based on combinations of physical evidence of permanently reduced wetland hydrology or invasion/establishment of species from drier ecological communities and soil oxidation or loss (due to reduced water levels) observed in wetlands that had organic soils.
- The original field form required the collection of information that was not related to hydrologic stress. The field form used for the original wetland status assessments was revised, simplified, and field tested by water management district EMT wetland scientists to collect data related only to hydrologic stress (**Appendix A**).

The Class 1 wetlands for which field assessments were conducted included four original sites and three new wetlands in the SFWMD, 14 original and four new sites in the SJRWMD, and 26 original sites and 9 new wetlands in the SWFWMD (**Table 2**). The new wetlands in the SFWMD portion of the CFWI Planning Area consist of two additional wetlands at Walker Ranch and one at Split Oak. Two of the new sites in the SJRWMD were originally assessed during the EMT evaluation for the 2015 RWSP (Lake Sylvan and Prairie Lake); however, they were not included in the original Class 1 wetlands dataset. The other two new SJRWMD sites (Red Bug Lake and Chapman Marsh) are in urbanized areas. The 9 new wetlands in the SWFWMD portion of the CFWI Planning Area include two additional wetlands in the Green Swamp, one wetland in the SWFWMD's Alston Tract of the Upper Hillsborough Preserve, three wetlands in the City of Lakeland's Northeast Wellfield, one wetland in the Florida Fish and Wildlife Conservation Commission's Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract, and two wetlands that are monitored for Polk County wellfields, one in Haines City near I-4 and one on the Nature Conservancy's Saddle Blanket Scrub Preserve. A detailed description and history of each Class 1 wetland is included in **Appendix B**.

Table 2. Site descriptions of the original 44 and 16 potential new Class 1 wetlands that were assessed. Note that longitude and latitude are presented in decimal degrees.

District	EMT ID	Site Name	Physiographic Region	Wetland Hydroclass	Longitude	Latitude
SFWMD	SF-YK	Tibet Butler	Plains	1A Depressional Mesic	-81.537112	28.446165
SFWMD	SF-LA	Walker Ranch - WR11	Plains	1A Depressional Mesic	-81.404507	28.083626
SFWMD	SF-LB	Walker Ranch - WR6	Plains	1A Depressional Mesic	-81.412562	28.113903
SFWMD	SF-XZ	Walker Ranch - WR9	Plains	1A Depressional Mesic	-81.418795	28.109258
SFWMD	SF-N1[1]	Walker Ranch WR-16	Plains	1A Depressional Mesic	-81.392284	28.077793
SFWMD	SF-N2[1]	Walker Ranch WR-15	Plains	1A Depressional Mesic	-81.390062	28.082236
SFWMD	SF-WT[1]	Split Oak	Plains	1A Depressional Mesic	-81.2089024	28.358426
SJRWMD	SJ-AJ[2]	Lake Gem	Plains	1E Flatland Lakes	-81.207313	28.645854
SJRWMD	SJ-LA	Unnamed Cypress	Plains	1A Depressional Mesic	-81.119700	28.566632
SJRWMD	SJ-LB	Unnamed Wetland Nr SR 46	Ridge	1E Flatland Lakes	-81.360359	28.810519
SJRWMD	SJ-LC	Boggy Marsh	Plains	2D Strands/Sloughs (but hydrologically isolated by roads and crossings)	-81.697514	28.396950
SJRWMD	SJ-LD	Hopkins Prairie	Ridge	1F Xeric Lakes	-81.693251	29.274910
SJRWMD	SJ-LE	Lake Avalon	Ridge	1F Xeric Lakes	-81.642740	28.510180
SJRWMD	SJ-LF	Lake Apshawa	Ridge	1F Xeric Lakes	-81.773330	28.599640
SJRWMD	SJ-LH[2]	Island Lake	Plains	2A-M Large Isolated	-81.363091	28.696596
SJRWMD	SJ-LI	Lake Sylvan	Plains	1E Flatland Lakes	-81.379811	28.803797
SJRWMD	SJ-LL	City of Cocoa, Well 9T	Plains	2D Strands/Sloughs (but hydrologically isolated by roads and crossings)	-81.053314	28.394303

Table 2. Site descriptions of the original 44 and 16 potential new Class 1 wetlands that were assessed. Note that longitude and latitude are presented in decimal degrees.

District	EMT ID	Site Name	Physiographic Region	Wetland Hydroclass	Longitude	Latitude
SJRWMD	SJ-QA	Church Lake	Ridge	1F Xeric Lakes	-81.841699	28.644937
SJRWMD	SJ-QB	Johns Lake	Ridge	1F Xeric Lakes	-81.657585	28.531825
SJRWMD	SJ-QC	Trout Lake	Ridge	1F Xeric Lakes	-81.712212	28.447999
SJRWMD	SJ-QD	Long Lake	Ridge	1F Xeric Lakes	-81.469958	28.617014
SJRWMD	SJ-LJ[1]	Lake Louisa	Ridge	2G Floodplain Lakes (but regulated)	-81.74695	28.46346
SJRWMD	SJ-GA[1, 2]	Prairie Lake	Ridge	1F Xeric Lakes	-81.508483	28.595104
SJRWMD	SJ-AW[1]	Red Bug Lake	Plains	1E Flatland Lakes	-81.290839	28.648639
SJRWMD	SJ-AI[1]	Chapman Marsh	Plains	2A-M Large Isolated	-81.193906	28.641028
SWFWMD	SW-LE	Cypress Creek #199, W17 Sentry Wetland	Plains	1A Depressional Mesic	-82.394478	28.286128
SWFWMD	SW-LF[2]	Cypress Creek #190 E Marsh	Plains	2A-M Large Isolated	-82.378218	28.304856
SWFWMD	SW-LG	Cypress Creek #223 B W46	Plains	1A Depressional Mesic	-82.391208	28.290439
SWFWMD	SW-LH	Cypress Creek #211 W33	Plains	2A-M Large Isolated	-82.393056	28.276317
SWFWMD	SW-AA	Green Swamp #7	Plains	1A Depressional Mesic	-81.911111	28.312611
SWFWMD	SW-LI	Green Swamp Marsh #304	Plains	1A Depressional Mesic	-82.017890	28.354863
SWFWMD	SW-LJ	Green Swamp #6, #303	Plains	1A Depressional Mesic	-81.971260	28.394560
SWFWMD	SW-LK	Green Swamp #5, #302	Plains	1A Depressional Mesic	-82.018658	28.368859
SWFWMD	SW-LM	Green Swamp #1, #298	Plains	1A Depressional Mesic	-81.946755	28.361410
SWFWMD	SW-JJ	Lake Garfield	Ridge	1A Depressional Mesic	-81.723410	27.900860

Table 2. Site descriptions of the original 44 and 16 potential new Class 1 wetlands that were assessed. Note that longitude and latitude are presented in decimal degrees.

District	EMT ID	Site Name	Physiographic Region	Wetland Hydroclass	Longitude	Latitude
SWFWMD	SW-MM	Lake Wales	Ridge	1F Xeric Lakes	-81.578690	27.903910
SWFWMD	SW-QA	Big Gum Lake	Ridge	1F Xeric Lakes	-81.492193	27.928229
SWFWMD	SW-QB	Bonnet Lake (Highlands)	Ridge	1F Xeric Lakes	-81.438926	27.546476
SWFWMD	SW-QC	Buck Lake (Highlands)	Ridge	1F Xeric Lakes	-81.332671	27.234785
SWFWMD	SW-QD	Gator Lake	Ridge	1F Xeric Lakes	-81.686616	27.841225
SWFWMD	SW-QE	Lake Annie (Highlands)	Ridge	1F Xeric Lakes	-81.351758	27.205947
SWFWMD	SW-QF	Lake Apthorpe	Ridge	1F Xeric Lakes	-81.362716	27.344290
SWFWMD	SW-QH	Lake Leonore	Ridge	1F Xeric Lakes	-81.512255	27.793753
SWFWMD	SW-QI	Lake Placid	Ridge	1F Xeric Lakes	-81.364219	27.244505
SWFWMD	SW-QJ	Lake Streety	Ridge	1F Xeric Lakes	-81.569989	27.678406
SWFWMD	SW-QK	Lake Van	Ridge	1F Xeric Lakes	-81.768938	28.107150
SWFWMD	SW-QL	Lake Walker	Ridge	1F Xeric Lakes	-81.717885	27.853656
SWFWMD	SW-QM	Polecat Lake	Ridge	1F Xeric Lakes	-81.699882	27.843913
SWFWMD	SW-QN	Surveyors Lake	Ridge	1F Xeric Lakes	-81.691552	27.833970
SWFWMD	SW-QO	Parks Lake	Ridge	1F Xeric Lakes	-81.468410	27.915700
SWFWMD	SW-QQ	Crooked Lake	Ridge	1E Flatland Lakes	-81.553030	27.827970
SWFWMD	SW-DD[1]	Van Fleet #2	Plains	1A Depressional Mesic	-81.6634	28.2422
SWFWMD	SW-N1[1]	Green Swamp Bay	Plains	2A-M Large Isolated	-81.9537	28.4218

Table 2. Site descriptions of the original 44 and 16 potential new Class 1 wetlands that were assessed. Note that longitude and latitude are presented in decimal degrees.

District	EMT ID	Site Name	Physiographic Region	Wetland Hydroclass	Longitude	Latitude
SWFWMD	SW-N2[1]	Green Swamp #4	Plains	1A Depressional Mesic	-81.9311	28.3919
SWFWMD	SW-N3[1]	Alston Bay	Plains	2A-M Large Isolated	-82.0906	28.1804
SWFWMD	SW-N4[1,2]	NE Lakeland Wellfield G	Plains	2A-M Large Isolated	-81.902779	28.170354
SWFWMD	SW-N5[1,2]	NE Lakeland Wellfield J	Plains	2A-M Large Isolated	-81.8883	28.1652
SWFWMD	SW-N6[1,2]	NE Lakeland Wellfield K	Plains	1A Depressional Mesic	-81.8962	28.161
SWFWMD	SW-N7[1]	Saddle Blanket Scrub #2	Ridge	1B Depressional Xeric	-81.5788	27.6706
SWFWMD	SW-N8[1]	Lake Wales Ridge WEA #1	Ridge	1B Depressional Xeric	-81.595412	27.923136

[1]: Denotes new Class 1 wetland
[2]: Not included in final, expanded Class 1 wetlands dataset

Field work assessing most of the Class 1 wetlands was completed in early June 2018. **Appendix C** contains a spreadsheet of information resulting from the assessments. The EMT water management district wetland scientists met in mid-June 2018 to finalize the results of the stress status assessments by reviewing the field forms, photographs, water level data, a time series of aerial photographs, and previous assessment results. Stress status assessments were conducted at five potential new Class 1 wetlands in August and September 2018, and data for these sites were also reviewed. Additional data review continued through 2018.

3.1 Change in Stress Status of Original Class 1 Wetlands

The stress status determination for 11 of the original 44 Class 1 wetlands was different than that determined during the original evaluation, representing 25 percent of the original dataset (**Table 3** and **Figures 2** and **3**). The status of five Plains wetlands changed from stressed to not stressed, and one Plains lake changed status from unstressed to stressed. Four Ridge wetlands changed status from stressed to unstressed, while one Ridge lake changed status from not stressed to stressed. Note that these changes may not be due to a change in the condition of the site but rather to a change in how the stress status was determined.

Table 3. Site descriptions of the original Class I wetlands in which stress status changed.					
Site Name	Wetland or Lake	Plains or Ridge	Original Status	2018 Status	Comments
Tibet Butler	Wetland	Plains	Stressed	Not Stressed	Increasing water level trend, no observed field indicators of stress
Lake Gem[1]	Lake	Plains	Stressed	Not Stressed	Reduction in upper limit of water level due to existing ditch, no observed field indicators of hydrologic stress
Island Lake[1]	Wetland	Plains	Stressed	Not Stressed	Original determination based on historic imagery, no current field indicators of hydrologic stress
Lake Sylvan	Lake	Plains	Not Stressed	Stressed	Decreasing water level trend, observed field indicators of hydrologic stress
Cypress Creek #190 E Marsh[1]	Wetland	Plains	Stressed	Not Stressed	Cypress Creek Wellfield withdrawal reductions, increasing water level trend
Cypress Creek #211 W33	Wetland	Plains	Stressed	Not Stressed	Cypress Creek Wellfield withdrawal reductions, increasing water level trend
Lake Wales	Lake	Ridge	Stressed	Not Stressed	Stable water level trend, no field indicators of hydrologic stress
Big Gum Lake	Lake	Ridge	Stressed	Not Stressed	Stable water level trend, no observed field indicators of hydrologic stress
Gator Lake	Lake	Ridge	Not Stressed	Stressed	Observed field indicators of hydrologic stress
Polecat Lake	Lake	Ridge	Stressed	Not Stressed	No observed field indicators of hydrologic stress
Crooked Lake	Lake	Ridge	Stressed	Not Stressed	Increasing water level trend, removal of direct withdrawals, nearby withdrawal reductions

[1]: Not included in final, expanded Class 1 wetlands dataset

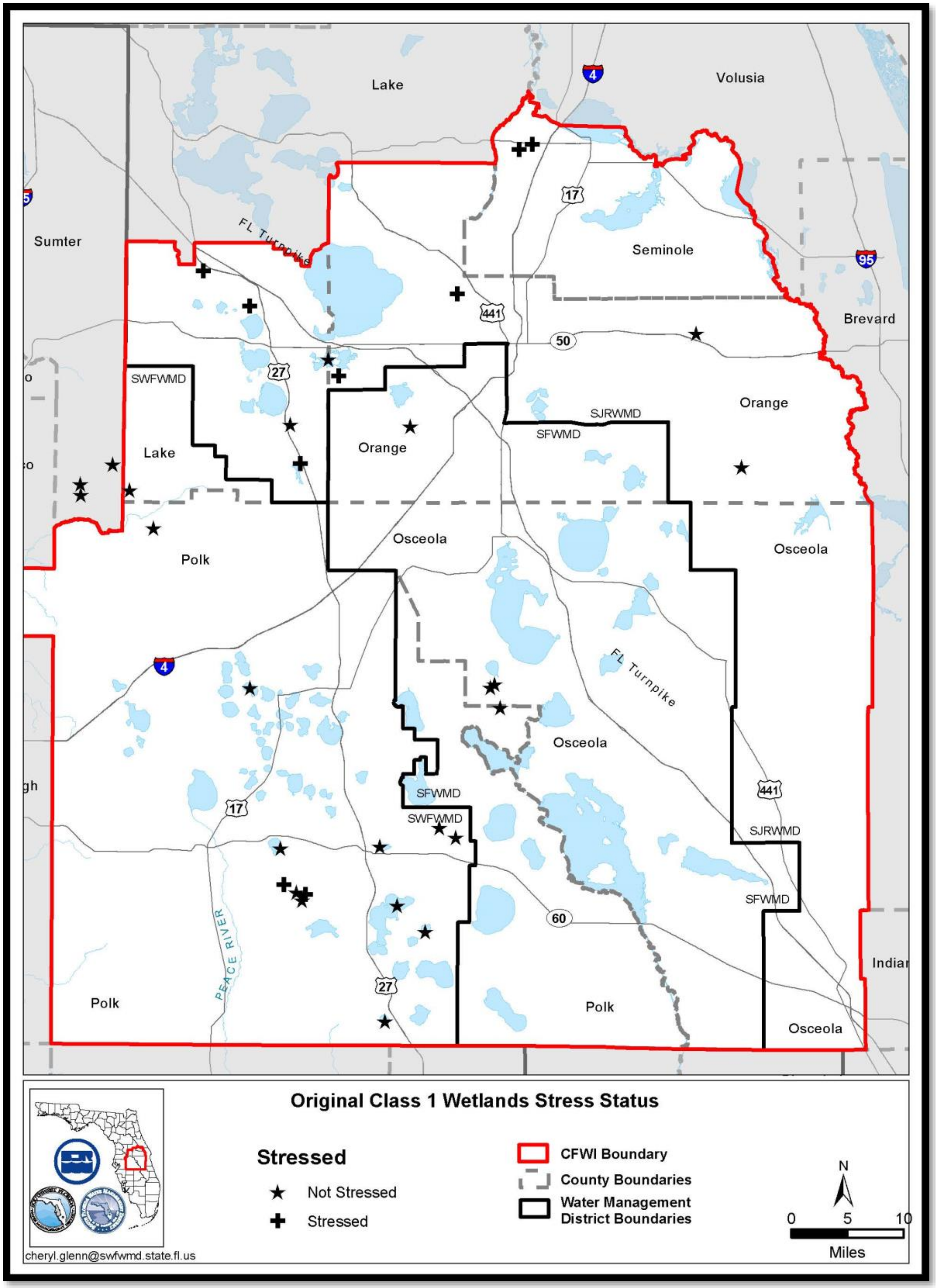

Figure 2. Location and stress status of the original 44 Class I wetlands used in the EMT analysis in support of the 2015 CFWI RWSP. Note that some of the original Class 1 wetlands located outside the CFWI Planning Area are not shown.

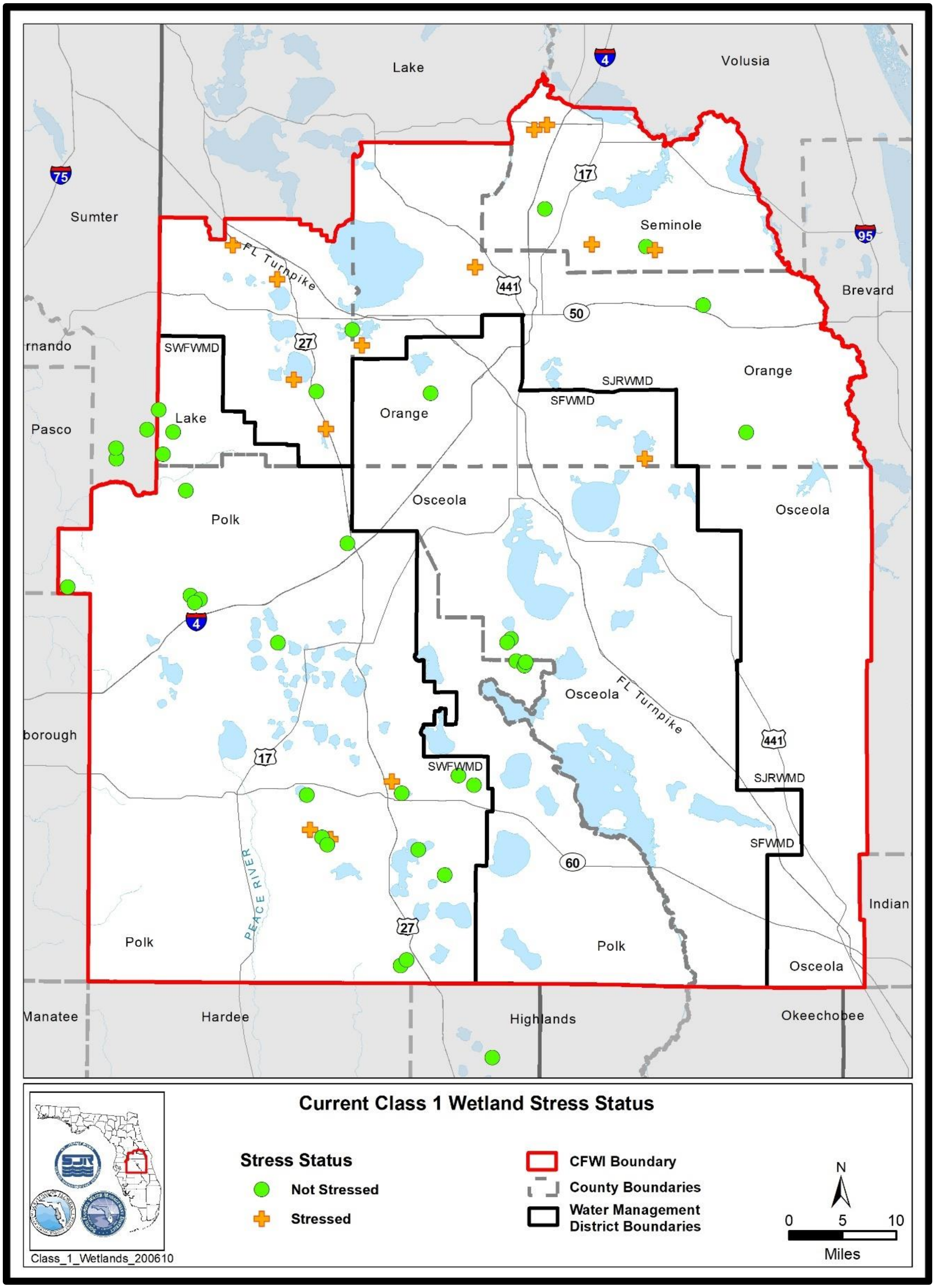

Figure 3. Location and 2018 stress status of the 53 Class 1 wetlands included in the EMT analysis in support of the 2020 CFWI RWSP. Note that some of the original Class 1 wetlands located outside the CFWI Planning Area are not shown.

In the original evaluation, there were limited instances in which the field observations did not align with review of historic aerials or institutional knowledge of the system in question. In those instances, due to the inconsistency noted in the field evaluations, the stress determination may have been made based solely on the aerial imagery review or institutional knowledge. During the 2018 re-evaluation, if the observations made in the field were in conflict with the previous status determination, additional evaluations of existing hydrology and aerial imagery were used to either support or refute the current field observations but were not used as the sole determinant of wetland stress.

The majority of Class 1 wetlands (9 of 11) that changed stress status changed from stressed to not stressed. Some of these wetlands appear to be recovering from hydrologic stress, including two wetlands within the Cypress Creek Wellfield located outside of the CFWI Planning Area, which has undergone significant reductions in groundwater withdrawals since the prior assessment. However, for some of the wetlands, the change in stress status is due to a change in how the EMT evaluated the factors in determining stress (e.g., the original assessors may have based their determination on historical aerials that were not representative of recent conditions). In addition, for some of the wetlands, it was not possible to determine the reason for the stress status determination made in the original assessment.

Two lakes changed stress status from unstressed to stressed, most likely as a result of the change in how the EMT evaluated factors in determining stress. It is not clear why Lake Sylvan was classified as not stressed during the original assessment; however, visible signs of hydrologic stress (e.g., pines encroaching well into the lake, soil subsidence) were observed during two recent, non-related evaluations and the 2018 EMT assessment. For Gator Lake, the original assessment conducted in May 2012 did not indicate observations of signs of hydrologic stress; however, the 2018 evaluation was conducted in a location where the ecotone is less disturbed, and the stress indicators may be more clearly expressed.

A detailed analysis of water level data for the period of record selected for the EMT wetlands analysis (see Section 5) for Lake Gem, Island Lake, and Cypress Creek #190 E Marsh indicated that these wetlands were not representative of primarily groundwater-dominated wetlands in the CFWI Planning Area mainly because the period-of-record water level data included both a stressed and not stressed period or the wetland was recovering. Therefore, these wetlands were not included in the final Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP. Additional details regarding the change in stress status for each of the wetlands are described in **Appendix B**.

3.2 Description of New Class 1 Wetlands Assessed

Field assessments of 16 new Class 1 wetlands within the CFWI Planning Area were conducted to determine their stress status, and analyses of the long-term water level data were conducted to determine if these sites were suitable for inclusion in the expanded Class 1 wetlands dataset for the EMT wetland analyses. Information for each of the new Class 1 wetlands can be found in **Appendix B**.

An analysis of water level data for the period of record selected for the analysis (see Section 5) for Prairie Lake, a stressed Ridge wetland, indicated that it was not representative of primarily groundwater-dominated wetlands in the CFWI Planning Area; therefore, this site was not included in the Class 1 wetlands dataset. In addition, the selected period of record of water level data for the analysis (see Section 5) for the three NE Lakeland Wellfield sites includes both a stressed and unstressed period; these sites were not included in the Class 1 wetlands dataset.

The final Class 1 wetlands dataset for the EMT wetlands analysis in support of the 2020 CFWI RWSP includes 12 new Class 1 wetlands (**Figure 4**). Nine of the new Class 1 wetlands are Plains wetlands; the assessments indicated that six are not stressed, while three are stressed. The three new Ridge Class 1 wetlands include one not stressed wetland and two sites determined to be stressed.

3.3 Final Class I Wetlands Dataset for Analysis

The final Class 1 wetlands dataset of 53 wetlands includes 41 of the original 44 sites and 12 new sites (**Figure 4**). The Class 1 wetlands dataset used for the analysis in support of the 2015 CFWI RWSP included 18 Plains wetlands and 26 Ridge wetlands. For the 2020 update to the RWSP, the Class 1 wetlands dataset includes 25 Plains wetlands and 28 Ridge wetlands (**Table 4**). While the sample size of the Class 1 wetlands dataset increased from 44 to 53 for the current analysis, the ratio of not stressed to stressed wetlands has changed, particularly for Plains wetlands. Compared to the original dataset, the number of not stressed Plains wetlands has almost doubled in the expanded Class 1 wetlands dataset, while the number of stressed Plains wetlands has decreased. The distribution of the Ridge wetlands in the current Class 1 Ridge wetlands dataset is fairly similar to the 2015 dataset (**Table 4**).

Table 4. Comparison of the not stressed/stressed Class 1 wetlands for the analyses in support of the 2015 and 2020 CFWI RWSPs.

Wetland Type	For 2015 RWSP EMT Analysis		For 2020 RWSP EMT Analysis	
	Not Stressed	Stressed	Not Stressed	Stressed
Plains	10	8	18	7
Ridge	15	11	19	9
Total	25	19	37	16

4.0 CLASS 2 AND CLASS 3 WETLANDS

The Class 2 wetlands dataset for the EMT wetlands analysis in support of the 2020 CFWI RWSP included 226 wetlands, which are described in **Table 5** and shown in **Figure 5**. Since the approved methodology did not include re-assessing the Class 2 wetlands, the EMT assumed that the stress condition determined during the original assessment had not changed. However, as part of evaluating potential new Class 1 wetlands and the wetland site selection process for the Data, Monitoring and Investigations Team (DMIT) long-term wetlands monitoring program, about 40 Class 2 wetlands were recently visited, and the stress status of Class 2 wetlands had not changed since the original assessment (**Table 5**). In addition, a thorough QA/QC review of all Class 2 wetlands was conducted by GIS analysis and review of current aerial photography.

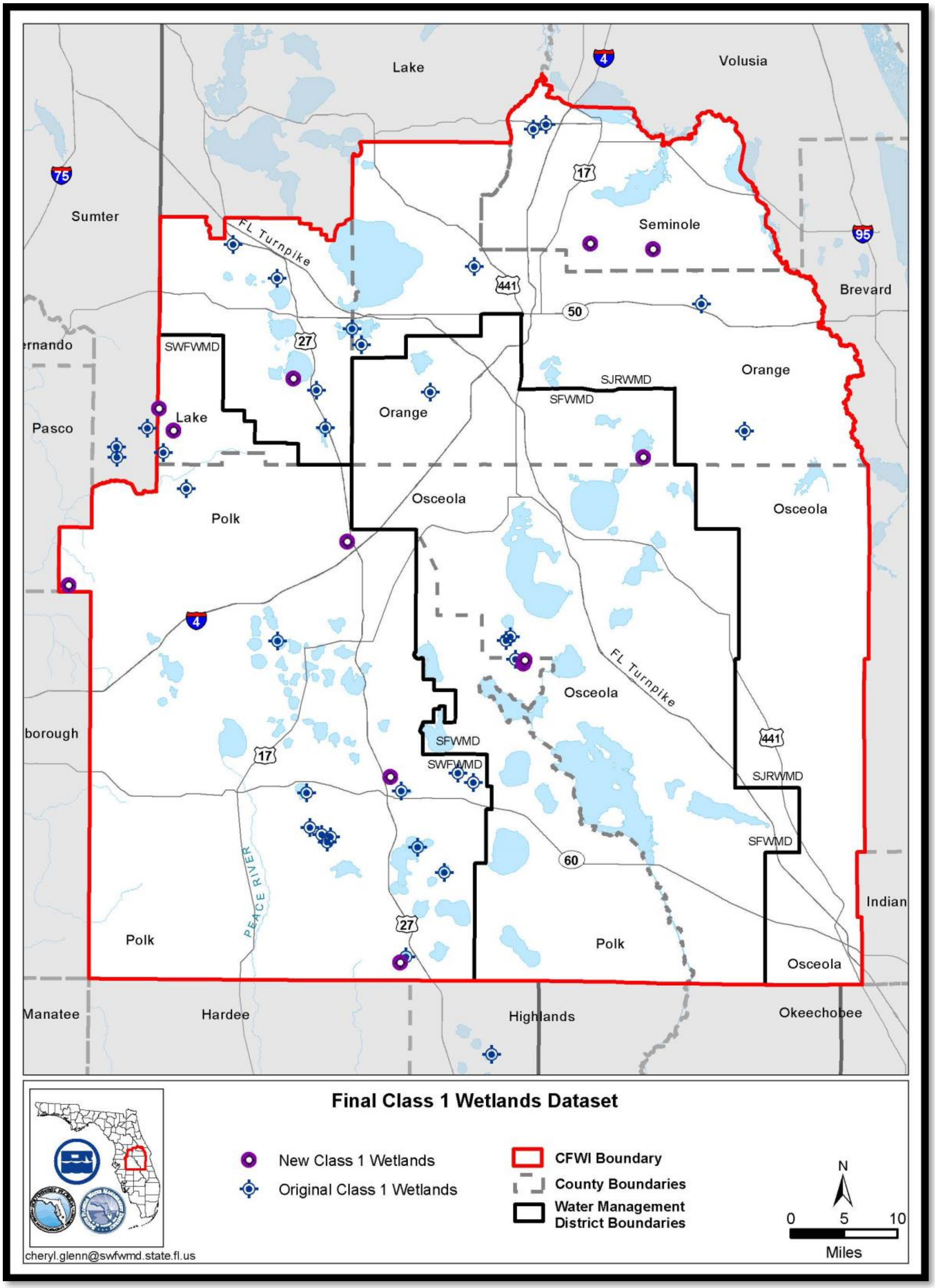

Figure 4. Location of the Class 1 wetlands included in the final dataset, which includes 41 of the original 44 wetlands and 12 new wetlands. Note that some of the original Class 1 wetlands located outside the CFWI Planning Area are not shown.

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-AC	N of Lake Weohyakapka, east of Lake Wales Ridge	Plains	Stressed	-81.424032	27.862624	
SFWMD	SF-AD	N of Lake Weohyakapka, east of Lake Wales Ridge	Plains	Stressed	-81.417806	27.862678	
SFWMD	SF-AF	Lake Ruby	Ridge	Stressed	-81.499286	28.397880	
SFWMD	SF-AG	E of RIBS at Lake Marion Circle Dr. and Hemlock	Ridge	Not Stressed	-81.489922	28.061480	
SFWMD	SF-AJ	W of San Miguel (off Marigold)	Plains	Not Stressed	-81.510353	28.172218	
SFWMD	SF-AL	Along County Rd. 535	Plains	Not Stressed	-81.463184	28.248110	
SFWMD	SF-AM	Off Fischer E of US 27	Ridge	Not Stressed	-81.641838	28.268554	
SFWMD	SF-AN	Off Mor Tay Rd.	Ridge	Not Stressed	-81.609696	28.280233	
SFWMD	SF-AS	End of Cypress Rd across golf green	Ridge	Stressed	-81.616511	28.359224	
SFWMD	SF-AT	N of Black Lake Rd.	Ridge	Stressed	-81.600443	28.344939	
SFWMD	SF-AU	Providence, SE of US 17/US 92	Ridge	Not Stressed	-81.557159	28.210364	
SFWMD	SF-BG	SE of Lake Butler	Ridge	Not Stressed	-81.545176	28.468681	
SFWMD	SF-BI	E of SR 535, S of Reaves Rd.	Ridge	Not Stressed	-81.555668	28.516614	
SFWMD	SF-BX	SW of OBT and Americana intersection	Ridge	Stressed	-81.400370	28.482169	
SFWMD	SF-BY	Lake Fran Conservation Easement off Metrowest Rd.	Ridge	Stressed	-81.451848	28.520850	
SFWMD	SF-BZ	City of Orlando, Eagle Nest Park	Plains	Stressed	-81.443911	28.509442	
SFWMD	SF-CB	N of Exit 17 of Central Florida Greenway	Plains	Stressed	-81.304030	28.373592	
SFWMD	SF-CE	South Park Circle	Plains	Stressed	-81.421644	28.445530	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-CG	Between Lake Tohopekaliga and Alligator Lake	Plains	Not Stressed	-81.269368	28.198394	
SFWMD	SF-CH	Between Lake Tohopekaliga and Alligator Lake	Plains	Stressed	-81.270235	28.188780	
SFWMD	SF-CJ	N of Clay Whaley, W of Florida Turnpike	Plains	Not Stressed	-81.328417	28.224973	
SFWMD	SF-CN	S of Sand Rd., E of SR 417	Plains	Stressed	-81.282902	28.354427	
SFWMD	SF-CP	Kissimmee, S of Mills Slough Rd and W of Florida Turnpike	Plains	Not Stressed	-81.372259	28.313671	
SFWMD	SF-CQ1	Kissimmee, E of Simpson Rd. and N of New Beginnings Rd.	Plains	Stressed	-81.345482	28.298791	
SFWMD	SF-CT	E of Wetherbee, S of Palmbay	Plains	Not Stressed	-81.373040	28.406063	
SFWMD	SF-CY	Three Lakes WMA Site III	Plains	Not Stressed	-81.072320	27.965740	
SFWMD	SF-DB	Lake Gifford	Ridge	Stressed	-81.643061	28.361329	
SFWMD	SF-DC	Lake Marion	Ridge	Not Stressed	-81.533056	28.056400	Visited in 2018, status unchanged
SFWMD	SF-DI	Along Consulate Rd. W of Florida Turnpike	Plains	Stressed	-81.413694	28.437002	
SFWMD	SF-DM	Palm Lake-lake littoral marsh	Ridge	Not Stressed	-81.496935	28.478858	
SFWMD	SF-DO	SE of US 192 near intersection with CR 545	Ridge	Stressed	-81.645315	28.343667	Visited in 2017, status unchanged, 2018 STOPR Site
SFWMD	SF-DW	W of Lake Toho between Pasture and Canter	Plains	Not Stressed	-81.453352	28.204161	
SFWMD	SF-DX	Off CR 535 S of US17/US92	Plains	Stressed	-81.465594	28.232383	
SFWMD	SF-EP	Near Sand Lake Elementary	Ridge	Not Stressed	-81.494752	28.412358	
SFWMD	SF-EQ	Hilton Resort, off Foxfire Circle	Ridge	Stressed	-81.498530	28.403293	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-EV	S off 192 just before I-4	Plains	Stressed	-81.563872	28.320465	
SFWMD	SF-EW	N off Osceola Polk Line Rd.	Ridge	Not Stressed	-81.599731	28.268461	
SFWMD	SF-EY	Avon Park Bombing Range - Wet Prairie	Plains	Not Stressed	-81.258889	27.746108	
SFWMD	SF-EZ	Avon Park Bombing Range - Freshwater Marsh	Ridge	Not Stressed	-81.302411	27.743217	
SFWMD	SF-FA	Lat Maxey	Plains	Not Stressed	-81.021278	27.661656	
SFWMD	SF-FD	W of 441 on SR 60	Plains	Not Stressed	-80.923100	27.702290	
SFWMD	SF-VC	Camp Lonesome - South of Piss Pot	Plains	Not Stressed	-81.170716	28.076513	Visited in 2018, status unchanged, selected as DMIT wetland monitoring site
SFWMD	SF-WA	NW of County Highway 580 - Snell Creek	Ridge	Not Stressed	-81.543643	28.133002	Visited in 2018, status unchanged, selected as DMIT wetland monitoring site
SFWMD	SF-WB	NW of County Highway 580	Ridge	Not Stressed	-81.545095	28.132198	Visited in 2018, status unchanged
SFWMD	SF-WC	E side of Old Lake Wilson Rd.	Ridge	Stressed	-81.588285	28.302243	
SFWMD	SF-WD	N of Sinclair just W of Old Lake Wilson Rd.	Ridge	Stressed	-81.594717	28.296793	
SFWMD	SF-WE	N of US 192 at intersection with Black Lake Rd.	Ridge	Stressed	-81.609302	28.348070	
SFWMD	SF-WF	N of US 192 curve at Black Lake Rd.	Ridge	Stressed	-81.606119	28.348862	
SFWMD	SF-WG	E of SR 545, S side of Siedel Rd.	Ridge	Not Stressed	-81.625096	28.419059	
SFWMD	SF-WH	E of SR 545 off Lake Hancock Rd.	Ridge	Not Stressed	-81.615708	28.449202	
SFWMD	SF-WI	E of SR 545, N of Porter Rd.	Ridge	Stressed	-81.638202	28.464252	
SFWMD	SF-WJ	Along Rheams Rd., S of SR 535	Ridge	Not Stressed	-81.556282	28.441113	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-WK	Along SR 535, E of Rheams Rd.	Ridge	Not Stressed	-81.554239	28.442928	
SFWMD	SF-WQ	S of Narcoossee	Plains	Not Stressed	-81.244127	28.358448	
SFWMD	SF-WR	S of Narcoossee	Plains	Stressed	-81.239446	28.354266	Visited in 2018, status unchanged
SFWMD	SF-WS	S of Narcoossee	Plains	Stressed	-81.241142	28.352585	
SFWMD	SF-WU	Split Oak Forest Mitigation Park cypress head	Plains	Not Stressed	-81.201597	28.358305	
SFWMD	SF-WV	Split Oak Forest Mitigation Park cypress head	Plains	Not Stressed	-81.205067	28.364734	
SFWMD	SF-WY	Off SR 527A	Plains	Not Stressed	-81.300185	28.230752	
SFWMD	SF-WZ	Off SR 527A	Plains	Not Stressed	-81.299677	28.225093	
SFWMD	SF-XA	Near intersection of Marigold and Bourne	Plains	Not Stressed	-81.504073	28.190088	
SFWMD	SF-XB2	W of Lake Speer at base of Lake Wales Ridge	Ridge	Not Stressed	-81.609221	28.480052	
SFWMD	SF-XC	Behind Ramada at US 192 & Poinsiana Blvd.	Plains	Not Stressed	-81.487760	28.331733	
SFWMD	SF-XD	Along International Dr. W of Gateway Point Dr.	Plains	Stressed	-81.502444	28.353689	Visited in 2015, status unchanged
SFWMD	SF-XE	E of Lake Tohopekaliga, near Hawkin Dr.	Plains	Stressed	-81.433677	28.172087	
SFWMD	SF-XF	Grass Lake	Ridge	Not Stressed	-81.647156	28.349803	
SFWMD	SF-XG	Hickorynut Lake	Ridge	Not Stressed	-81.636044	28.421085	
SFWMD	SF-XL	SE of Lake Bryan	Ridge	Not Stressed	-81.492676	28.363313	
SFWMD	SF-XN	Near Solivita Rd., S of County Highway 580	Plains	Not Stressed	-81.490194	28.133728	
SFWMD	SF-XO	Near Solivita Rd., S of County Highway 580	Plains	Not Stressed	-81.494471	28.135431	
SFWMD	SF-XP	E of Shingle Creek Floodplain	Plains	Stressed	-81.444868	28.315867	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-XR	W of CR 531	Plains	Stressed	-81.439954	28.227182	
SFWMD	SF-XU	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.394084	28.053479	
SFWMD	SF-XV	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.394025	28.050299	
SFWMD	SF-XW	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.399884	28.057562	
SFWMD	SF-XX	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.415308	28.115545	
SFWMD	SF-XY	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.416823	28.105949	
SFWMD	SF-YB	Tri County Rd.	Ridge	Stressed	-81.644910	28.274923	
SFWMD	SF-YC	Near Goodman Rd.	Ridge	Not Stressed	-81.624380	28.287969	
SFWMD	SF-YD	Apache Trail	Ridge	Not Stressed	-81.639560	28.296760	
SFWMD	SF-YF	Reedy Creek Floodplain E of Old Lake Wilson Rd.	Plains	Stressed	-81.586380	28.315144	
SFWMD	SF-YG	West of Narcoossee Rd.	Plains	Stressed	-81.247560	28.369271	
SFWMD	SF-YI	N of Dowden Rd.	Plains	Not Stressed	-81.236076	28.430206	
SFWMD	SF-YL	Lake Mable	Ridge	Stressed	-81.549443	28.423810	
SFWMD	SF-YM	SW of Turnpike at SR 435	Ridge	Not Stressed	-81.467640	28.487290	
SFWMD	SF-YN	Shadow Bay Park	Ridge	Not Stressed	-81.479676	28.492433	
SFWMD	SF-ZB1	Near Boggy Creek Rd.	Plains	Not Stressed	-81.359889	28.314260	
SFWMD	SF-ZC6	Between Kings Point Rd. and Florida Turnpike	Plains	Stressed	-81.434931	28.459519	
SFWMD	SF-ZC8	East Pine Island - STOPR Site	Plains	Not Stressed	-81.455024	28.381070	
SFWMD	SF-ZE1	Lake Britt	Ridge	Stressed	-81.618383	28.369353	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-ZE2	Lake Britt	Ridge	Stressed	-81.621607	28.363155	Visited in 2019, status unchanged but appears to be recovering
SFWMD	SF-ZE3	Western Way W off 429 through pine plantation	Ridge	Not Stressed	-81.631355	28.382660	
SFWMD	SF-ZG1	Between CR 527 and Florida Turnpike near ball fields	Plains	Not Stressed	-81.383044	28.379570	
SFWMD	SF-ZG2	Along Balcombe Rd., N of 417	Plains	Not Stressed	-81.399105	28.380938	
SFWMD	SF-ZH1	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.404763	28.067872	
SFWMD	SF-ZH2	Disney Wilderness Preserve/Walker Ranch	Plains	Not Stressed	-81.410571	28.074050	
SFWMD	SF-ZI1	Mystic Dunes Development, S of Fantasy Heights	Ridge	Stressed	-81.602339	28.314800	
SFWMD	SF-ZI2	Mystic Dunes Development, S of Fantasy Heights	Ridge	Stressed	-81.594693	28.315161	
SFWMD	SF-ZJ4	Tibet Butler	Ridge	Not Stressed	-81.539512	28.443610	Visited in 2018, status unchanged, selected as DMIT wetland monitoring site
SFWMD	SF-ZJ5	Lake Sheen	Ridge	Not Stressed	-81.525860	28.425257	
SFWMD	SF-ZJ7	E of SR 535, S of Lake Butler Rd.	Ridge	Not Stressed	-81.568709	28.492579	
SFWMD	SF-ZJ8	Tibet Butler Preserve-North	Ridge	Stressed	-81.546604	28.448967	
SFWMD	SF-ZL1	Three Lakes WMA Wet Prairie	Plains	Not Stressed	-81.069510	27.966350	
SFWMD	SF-ZL2	Three Lakes WMA Cypress Dome	Plains	Not Stressed	-81.072370	27.968550	
SFWMD	SF-ZM	Kissimmee Park Rd S of Old Canoe Creek Rd.	Plains	Not Stressed	-81.316983	28.218149	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SFWMD	SF-ZN	Adjacent to Florida Turnpike	Plains	Stressed	-81.311737	28.214526	
SFWMD	SF-ZO	S of Clay Whaley Rd.	Plains	Not Stressed	-81.319288	28.216107	
SFWMD	SF-ZP	N of Sand Rd., E of SR 417	Plains	Stressed	-81.276809	28.355675	
SFWMD	SF-ZR	S of Sand Rd., E of SR 417	Plains	Not Stressed	-81.278009	28.352465	
SFWMD	SF-ZU	S of Turnpike, E of US 441, N of Taft-Vineland Rd.	Plains	Not Stressed	-81.400647	28.422058	
SFWMD	SF-ZX	Shadow Bay	Ridge	Not Stressed	-81.481921	28.491165	
SFWMD	SF-ZY	NW of Lake Speer at base of Lake Wales Ridge	Ridge	Not Stressed	-81.604270	28.483336	
SFWMD	SF-ZZ	Lake Hartley	Ridge	Not Stressed	-81.617122	28.478422	
SJRWMD	SJ-AD	N of Snow Hill Rd.	Plains	Stressed	-81.119683	28.651250	
SJRWMD	SJ-AE	Lake Catherine	Plains	Not Stressed	-81.126883	28.640683	
SJRWMD	SJ-AJ	Lake Gem	Plains	Not Stressed	-81.207313	28.645854	Visited in 2018, status unchanged, Class 1 wetland excluded from dataset
SJRWMD	SJ-AR	Red Bug Lake Rd. near Dover Rd.	Plains	Stressed	-81.242109	28.657847	
SJRWMD	SJ-AV	Eagle Blvd. near Dodd Rd.	Plains	Stressed	-81.282406	28.657699	
SJRWMD	SJ-BT	Lake Seminary	Ridge	Not Stressed	-81.358267	28.643573	
SJRWMD	SJ-CN	South of 46 near Yankee Lake Rd.	Plains	Not Stressed	-81.393253	28.812655	
SJRWMD	SJ-CS1	N of Jamestown Blvd. across from Town Way	Plains	Stressed	-81.412987	28.682599	
SJRWMD	SJ-CX	Pearl Lake	Ridge	Not Stressed	-81.423835	28.662355	
SJRWMD	SJ-CY	Mirror Lake	Plains	Not Stressed	-81.439949	28.668807	
SJRWMD	SJ-CZ	S of Semoran at Executive Park Ct.	Plains	Not Stressed	-81.446332	28.669161	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SJRWMD	SJ-DN	Swamp NW of Lake Price	Plains	Not Stressed	-81.180056	28.600581	
SJRWMD	SJ-DO	E of Lake Claire	Plains	Not Stressed	-81.195050	28.609450	
SJRWMD	SJ-DQ	Lake Rouse	Plains	Not Stressed	-81.210670	28.574636	
SJRWMD	SJ-DR	E of Windsorgate Rd. and W of Northampton Rd.	Plains	Not Stressed	-81.183788	28.517035	
SJRWMD	SJ-DS	N of Pope Rd & SW of treatment plant	Plains	Stressed	-81.207699	28.496304	
SJRWMD	SJ-DT	S side of SR 408 between Exits 19 & 20	Plains	Not Stressed	-81.234301	28.546109	
SJRWMD	SJ-DV	Along Econlockhatche e Rd., N of powerlines	Plains	Not Stressed	-81.254217	28.503131	
SJRWMD	SJ-DX	E of SR 551, S of Quail Pond Rd.	Plains	Stressed	-81.282834	28.499261	
SJRWMD	SJ-DY	Along SR 436, SSE of Lake Barber	Ridge	Stressed	-81.323643	28.481015	
SJRWMD	SJ-DZ	E of SR 436, S of Grant Rd.	Ridge	Stressed	-81.306692	28.514006	
SJRWMD	SJ-EC	Lake Jean	Plains	Not Stressed	-81.277456	28.588340	
SJRWMD	SJ-ED	E of SR 436, W of Forsyth Rd.	Plains	Stressed	-81.300988	28.588944	
SJRWMD	SJ-EE	Lake Susannah	Ridge	Not Stressed	-81.326685	28.562677	
SJRWMD	SJ-EN	Lake Lucien	Plains	Not Stressed	-81.392999	28.628357	
SJRWMD	SJ-EO	Lake Eve	Plains	Not Stressed	-81.425048	28.628925	
SJRWMD	SJ-ER	Lake Herrick	Ridge	Stressed	-81.485970	28.546516	
SJRWMD	SJ-ET1	Lake Lucy	Ridge	Stressed	-81.496285	28.572747	
SJRWMD	SJ-EU	Crooked Lake	Ridge	Stressed	-81.479914	28.593932	
SJRWMD	SJ-EW	Altamonte Springs, between Overland and Beggs Rd.	Ridge	Not Stressed	-81.461519	28.627762	
SJRWMD	SJ-EX	Lake Pleasant	Ridge	Stressed	-81.481470	28.657798	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SJRWMD	SJ-EY	Lake Jackson	Ridge	Not Stressed	-81.464944	28.667673	
SJRWMD	SJ-EZ	Lake McCoy	Ridge	Not Stressed	-81.499793	28.687825	
SJRWMD	SJ-FL	N of Boch Rd., W of Plymouth Sorrento Rd.	Ridge	Not Stressed	-81.571647	28.782743	
SJRWMD	SJ-FM	Round Lake	Ridge	Stressed	-81.593986	28.779517	
SJRWMD	SJ-FN	SE of Sheriff Training Facility off Wadsworth	Ridge	Stressed	-81.614744	28.765387	
SJRWMD	SJ-FQ	Lake Maggiore	Ridge	Not Stressed	-81.602577	28.736233	
SJRWMD	SJ-FR	Lake Grassmere	Ridge	Not Stressed	-81.583073	28.718371	
SJRWMD	SJ-FS	Wolf Lake	Ridge	Stressed	-81.536044	28.726883	
SJRWMD	SJ-FT	Lake Wilkins	Ridge	Stressed	-81.570095	28.707100	
SJRWMD	SJ-FU	Lake Standish	Ridge	Stressed	-81.552964	28.699122	
SJRWMD	SJ-FV	Buchan Pond	Ridge	Not Stressed	-81.516053	28.694499	
SJRWMD	SJ-FW	Heinger Lake	Ridge	Not Stressed	-81.548291	28.683764	
SJRWMD	SJ-FY	Marshall Lake	Ridge	Not Stressed	-81.536550	28.676639	
SJRWMD	SJ-FZ	Lake Mitchell	Ridge	Stressed	-81.520192	28.634255	
SJRWMD	SJ-GA	Prairie Lake	Ridge	Not Stressed	-81.508483	28.595104	Visited in 2018, status unchanged, Class 1 wetland excluded from dataset
SJRWMD	SJ-GB	Spring Lake	Ridge	Not Stressed	-81.520190	28.579513	
SJRWMD	SJ-GC	Lake Lily	Ridge	Not Stressed	-81.534786	28.544522	
SJRWMD	SJ-GD	Lake Beulah	Ridge	Not Stressed	-81.563417	28.535486	
SJRWMD	SJ-GE	Lake Reaves	Ridge	Not Stressed	-81.563581	28.527316	
SJRWMD	SJ-GF	Sunset Lakes of Windermere	Ridge	Not Stressed	-81.575446	28.508779	
SJRWMD	SJ-GG	Fern Bayhead	Ridge	Stressed	-81.609169	28.513219	
SJRWMD	SJ-GI	Ridgewood Ave. near Bay Ave. (W of Lake Apopka)	Plains	Stressed	-81.668668	28.594794	
SJRWMD	SJ-GM	Doll Lake	Ridge	Not Stressed	-81.697789	28.576326	
SJRWMD	SJ-GN	Blacks Still Lake	Ridge	Not Stressed	-81.704766	28.572279	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SJRWMD	SJ-GQ	S of Florida Turnpike, N of SR 50 near Roan	Ridge	Stressed	-81.691221	28.550676	
SJRWMD	SJ-HB	Little Everglades	Ridge	Stressed	-81.774594	28.645278	
SJRWMD	SJ-HC	Little Everglades	Ridge	Stressed	-81.790450	28.627944	
SJRWMD	SJ-HD	Schoolhouse Lake, Lake Merritt	Ridge	Stressed	-81.772253	28.625534	
SJRWMD	SJ-HF	Grassy Lake	Ridge	Stressed	-81.746686	28.593224	
SJRWMD	SJ-HH	Plum Lake	Ridge	Stressed	-81.734339	28.579484	
SJRWMD	SJ-HI1	Jack's Lake	Ridge	Stressed	-81.737161	28.550569	
SJRWMD	SJ-HJ	Crystal Lake	Ridge	Not Stressed	-81.761107	28.552424	
SJRWMD	SJ-HK	Lost Lake	Ridge	Stressed	-81.718196	28.534995	
SJRWMD	SJ-HL	Lake Felter	Ridge	Not Stressed	-81.725906	28.517819	
SJRWMD	SJ-HM2	Flat Lake	Ridge	Not Stressed	-81.671258	28.491917	
SJRWMD	SJ-HR	W of US 27, S of CR 474, Trailer Park Site	Ridge	Not Stressed	-81.688860	28.367959	
SJRWMD	SJ-HX	N of CR 565 near Battleground Lake Rd.	Ridge	Stressed	-81.806031	28.571156	
SJRWMD	SJ-IB	Sunset Lake	Ridge	Stressed	-81.888733	28.576210	
SJRWMD	SJ-JA	S of Lake Howell, E of Lake Howell Lane	Plains	Not Stressed	-81.302303	28.633340	
SJRWMD	SJ-JB	Lake Louisa Isolated	Plains	Stressed	-81.738914	28.455320	
SJRWMD	SJ-JC	North of 561 near Our Rd.	Plains	Stressed	-81.819232	28.427372	
SJRWMD	SJ-JI	Bull Creek WMA	Plains	Not Stressed	-80.946744	28.013875	Visited multiple times in recent years, selected as DMIT wetland monitoring site
SJRWMD	SJ-KA	Round Lake Rd.	Ridge	Stressed	-81.594627	28.740392	
SJRWMD	SJ-KB	Round Lake Rd.	Ridge	Stressed	-81.595821	28.739527	
SJRWMD	SJ-KC	E of US 27 on Hurtwood Marsh Rd.	Ridge	Not Stressed	-81.679394	28.516815	
SJRWMD	SJ-KD	Bream Lake	Ridge	Stressed	-81.502587	28.616505	
SJRWMD	SJ-KF	Lake Emma	Plains	Stressed	-81.352599	28.760704	
SJRWMD	SJ-KH2	Lake Glen	Plains	Stressed	-81.372778	28.453176	
SJRWMD	SJ-KI	Well 5T Cocoa Well Field	Plains	Not Stressed	-81.070609	28.403397	

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SJRWMD	SJ-KK	Well 12T Cocoa Well Feld	Plains	Not Stressed	-81.025023	28.394170	
SJRWMD	SJ-KL	Well 12T Cocoa Well Field	Plains	Not Stressed	-81.022227	28.395128	
SJRWMD	SJ-KM	Well 13T Cocoa Well Field	Plains	Not Stressed	-81.015044	28.395193	
SJRWMD	SJ-LH	Island Lake	Plains	Not Stressed	-81.363091	28.696596	Visited in 2018, status unchanged, Class 1 wetland excluded from dataset
SWFWMD	SW-AB	Near Teneroc Transportation Facility	Plains	Stressed	-81.864391	28.071341	Visited in Dec. 2017, status unchanged, surrounded by stormwater ponds
SWFWMD	SW-AC	Near County Landfill	Plains	Stressed	-81.835875	28.014375	Reviewed in office in late 2017 and visited sites in general area, status appears the same, near (and affected by) Lake Hancock
SWFWMD	SW-AE	CRUSA T9	Plains	Stressed	-81.795016	27.963582	Reviewed in office in late 2017, on private property, status appears the same, likely now an ag pond
SWFWMD	SW-AF	Davenport P1	Ridge	Stressed	-81.618502	28.168362	Reviewed in office in late 2017, on private property, status appears the same, surrounded by houses
SWFWMD	SW-AI	W of Lake Weohyakapka and Tiger Creek	Ridge	Not Stressed	-81.463245	27.812075	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AK	On Lake Wales Ridge SW of Lake Pierce	Ridge	Stressed	-81.550990	27.948835	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AL	On Lake Wales Ridge SW of Lake Pierce	Ridge	Stressed	-81.540492	27.942996	Reviewed in office in late 2017, on private property, status appears the same, upland edge deforested
SWFWMD	SW-AN	N Lake Pierce	Ridge	Not Stressed	-81.518390	28.028997	Reviewed in office in late 2017, on private property, status appears the same

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SWFWMD	SW-AO	E of US 17/US 92	Ridge	Stressed	-81.598922	28.143506	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AQ	Along Loughman Rd. (CR 54)	Ridge	Not Stressed	-81.605705	28.247007	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AR	S of I-4 Loughman Rd. Interchange	Ridge	Not Stressed	-81.618437	28.248014	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AS	Along Loughman Rd.	Ridge	Stressed	-81.613216	28.251085	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-AT3	S of Loughman Rd.	Ridge	Not Stressed	-81.636164	28.255501	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-C1	Gator Creek Cypress	Plains	Stressed	-81.984671	28.177670	Visited in Dec. 2017, Sum. 2018, status unchanged, selected as DMIT wetland monitoring site
SWFWMD	SW-CC	Hilochee	Plains	Not Stressed	-81.739907	28.185078	Visited in in Winter and Summer 2018, status unchanged, selected as DMIT wetland monitoring site
SWFWMD	SW-D1	Little Lake Dinner Wetland	Plains	Stressed	-81.790673	27.998556	Visited in Dec. 2017, status unchanged, not selected as DMIT wetland monitoring site
SWFWMD	SW-EE	NERUSA - Pamplin Site	Ridge	Not Stressed	-81.633575	28.246105	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-F1	Dick's Bros. Wetland	Ridge	Stressed	-81.629312	28.062028	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-FF	NERUSA - Loma Linda Well	Ridge	Not Stressed	-81.608767	28.238525	Visited in late 2017, status unchanged, not selected as DMIT wetland monitoring site

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SWFWMD	SW-G1	Sunset Lake Wetland	Ridge	Stressed	-81.510760	27.873917	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-GG	Standard Mine	Ridge	Stressed	-81.563668	28.215180	Reviewed in office in late 2017, on private property, status appears the same
SWFWMD	SW-H1	Lake Andree Wetland	Ridge	Not Stressed	-81.478144	27.811083	Visited in Feb. 2018, status unchanged, selected as DMIT wetland monitoring site, aka Heron Pond
SWFWMD	SW-H1A	Tiger Creek Preserve-TNC	Ridge	Not Stressed	-81.483670	27.824210	Visited in 2018, status unchanged, added 2 nearby sites to DMIT monitoring program
SWFWMD	SW-LF	Cypress Creek #190 E Marsh	Plains	Not Stressed	-82.378218	28.304856	Visited in 2018, recovering, Class 1 wetland excluded from dataset
SWFWMD	SW-RR	Lake Wales Ridge State Forest	Ridge	Not Stressed	-81.470358	27.780032	Visited in July 2017, status unchanged, selected as DMIT wetland monitoring site
SWFWMD	SW-UU	Trout Lake	Plains	Stressed	-81.508392	27.653502	Visited in July 2017, status unchanged, borrow pit in wetland, not selected as DMIT wetland monitoring site
SWFWMD	SW-N4	NE Lakeland Wellfield G	Plains	Not Stressed	-81.902779	28.170354	Visited multiple times in 2017 and 2018, selected as DMIT wetland monitoring site, evaluated as potential Class 1 wetland but not included in Class 1 wetlands dataset
SWFWMD	SW-N5	NE Lakeland Wellfield J	Plains	Not Stressed	-81.8883	28.1652	Visited multiple times in 2017 and 2018, selected as DMIT wetland monitoring site, evaluated as potential Class 1 wetland but not included in Class 1 wetlands dataset

Table 5 Descriptions of the 226 Class 2 wetlands used in the EMT wetlands analysis.

District	CFCA/EMT ID	Site Name	Wetland Type	Stress Status	Longitude	Latitude	Comments
SWFWMD	SW-N6	NE Lakeland Wellfield K	Plains	Not Stressed	-81.8962	28.161	Visited multiple times in 2017 and 2018, selected as DMIT wetland monitoring site, evaluated as potential Class 1 wetland but not included in Class 1 wetlands dataset

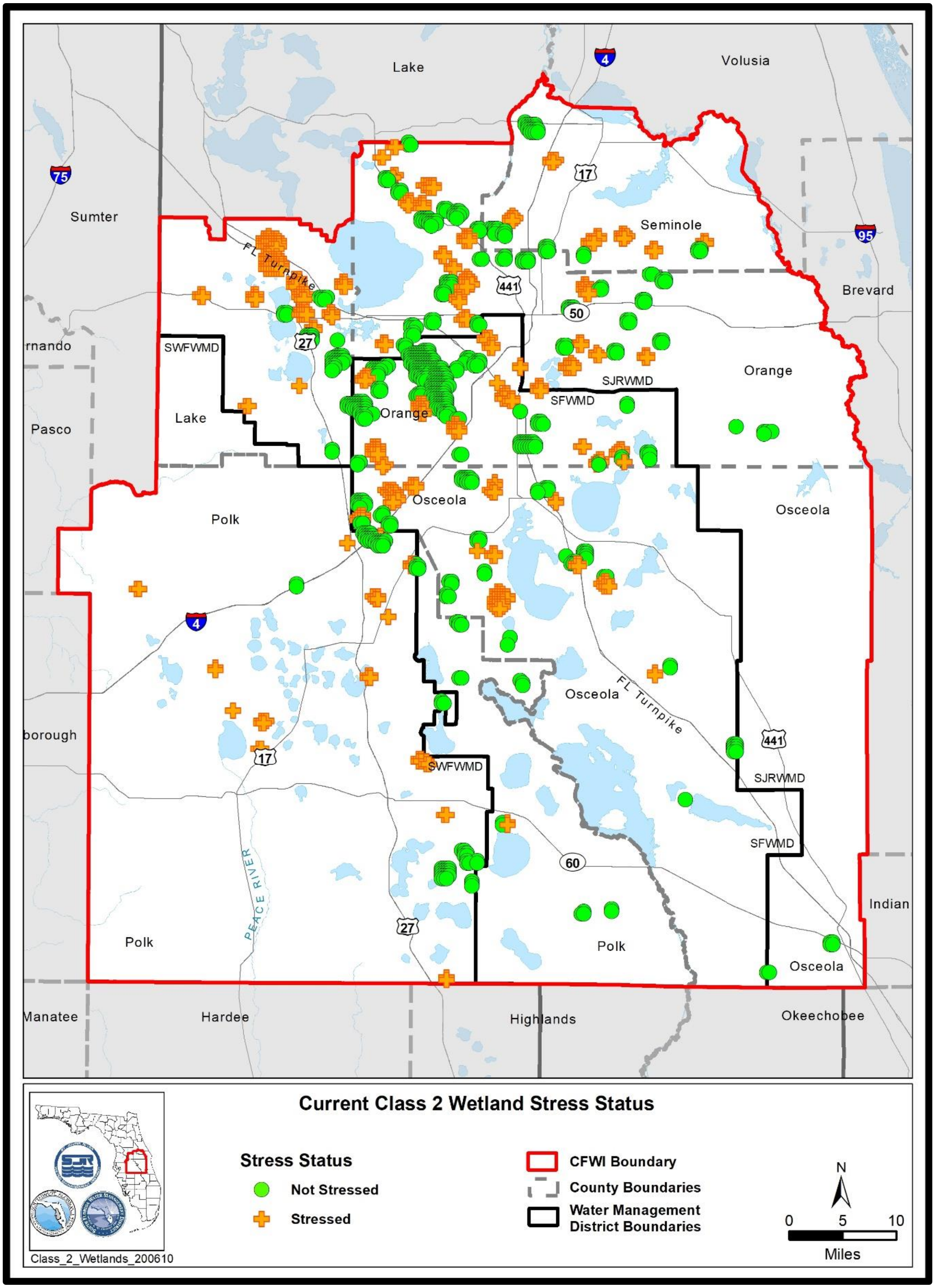

Figure 5. Location and stress status of the 226 Class 2 wetlands in the CFWI Planning Area included in the analysis for the 2020 CFWI RWSP.

During the field assessments of wetlands conducted by the EMT in support of the 2015 CFWI RWSP, wetlands were noted as substantially hydrologically altered if there were obvious physical alterations that would substantially alter the hydrology in the wetland system. It was recognized that hydrologically altered systems may be stressed by factors other than groundwater withdrawals, and these wetlands were not included in the analysis. Examples of substantially altered hydrology include:

- Ditches through the wetland that would alter water levels.
- Substantial urbanization of the contributing watershed that would substantially alter the amount of runoff being discharged to the wetland.
- A portion of the wetland was physically removed (excavated or filled).
- Isolation or re-routing of significant portions of the watershed that previously contributed water to the wetland.

For the current analysis, substantially hydrologically altered wetlands were also excluded.

The model used in the original analysis in support of the 2015 CFWI RWSP [East-Central Florida Transient (ECFT) groundwater model] did not include the entire CFWI Planning Area within its domain, but the domain for the updated model (ECFTX) includes the entire planning area. Therefore, a GIS analysis was conducted to add additional acres of Class 3 wetlands, located in the western "sliver" of the planning area, to the Class 3 wetlands dataset. The locations of the thousands of Class 3 wetlands included in the EMT wetlands analysis of primarily groundwater-dominated Plains and Ridge wetlands are shown in **Figure 6**.

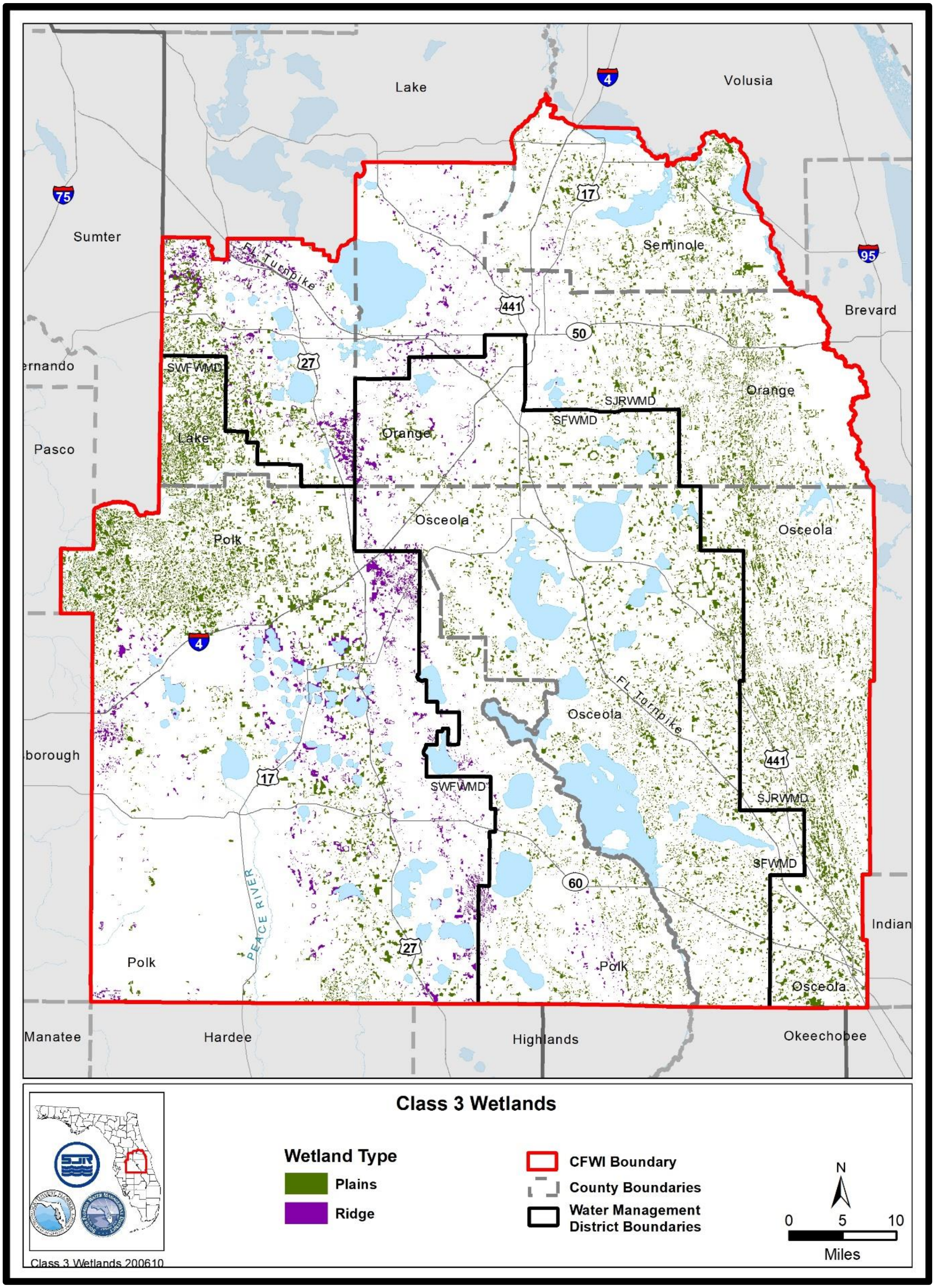

Figure 6. Location of Class 3 wetlands in the CFWI Planning Area.

5.0 DETERMINATION OF CLASS 1 WETLANDS WATER LEVEL DATA PERIOD OF RECORD AND HYDROLOGIC INDEX DEVELOPMENT FOR WETLANDS ANALYSIS

For the analysis in support of the 2015 CFWI RWSP, the EMT used Class 1 wetlands water level data from 2006 through 2011 (a 6-year period of record) to compute a statistical relationship between observed stress and observed water level variations for the wetlands analysis (CFWI EMT 2013). The EMT was interested in expanding the period of record for the analysis in support of the 2020 update to the CFWI RWSP. In this section, we briefly describe the determination of the period of record of Class 1 wetlands water level data and the development of the hydrologic index (θ) for the wetlands analysis; additional details are provided in **Appendix D**.

To determine the period of record to use for the analysis without causing the dataset to become non-representative, available water level data for each Class 1 wetland from 2006 through 2017 were organized, preprocessed, and analyzed. This involved reformatting the available data, as well as eliminating redundant or non-relevant data and creating datasets that were in a consistent form. For most wetlands included in the dataset, only one measuring device was available. However, if a site had multiple wells and staff gages, all the data were compared, and the most representative measuring device or the device with the most complete dataset was selected. If a Class 1 wetland had multiple devices and also had been selected as a DMIT monitoring site, the water level data from the upland well (which is typically located immediately adjacent to the wetland) was used to be consistent with the DMIT monitoring methodology and future analyses. **Table 7** lists the source of the water level data for each Class 1 wetland included in the dataset.

Historic water levels for each Class 1 wetland from 2006 (if available) through 2017 were summarized; **Figures 7** through **10** present the water level data from 2006 through 2017 for the stressed and unstressed Plains and Ridge Class 1 wetlands. The 80^{th} percentiles or P80s (80 percent of the water level readings exceed the P80) were calculated for several date ranges for each Class 1 wetland. A series of date ranges for P80 water levels, all starting with 2006 and ending in 2011 through 2017, were graphed as line charts and helped determine that the most current data were representative of a non-extreme condition. In other words, new years of data (2012, 2013, 2014, 2015, 2016, and 2017) were added one year at a time, and P80s were calculated for each Class 1 wetland to determine how much change occurred in the P80 as a result of adding in the additional year. An additional series of date ranges, all ending with 2017 and starting from 2006 through 2011, were graphed as line charts to help determine which period provided the longest record while not generally exhibiting a large deviation from the later years.

For each of the 53 Class 1 wetlands included in the dataset, a hydrologic index (θ) was calculated by subtracting the P80 value from the wetland edge elevation (**Table 7** and **Figures 11** through **14**). Previous work by the EMT demonstrated that a probability of hydrologic stress occurring in wetlands could be related to the hydrologic index or θ (CFWI EMT 2013). The θ value distributions were reasonably approximated by the normal distribution using the Shapiro-Wilk Normality Test, as well as presented as QQ plots to help identify outliers. The Class 1 wetland θ value distributions moments (mean, standard deviation, kurtosis, skew) for each wetland group (stressed and not stressed) and each physiographic province (Plains and Ridge) were evaluated for fit to the normal distributions. As mentioned earlier, four of the original Class 1 wetlands were determined to be not representative of groundwater-dominated wetlands within the CFWI planning area and were excluded from the final dataset.

The P80 rank results for date ranges 2009-2017 and 2010-2017 were very similar; ultimately, 2009-2017, a 9-year period of record, was selected since it met the test for normality and had the longer period of record (**Table 7**). In addition, this 9-year period was chosen as the best compromise between longer periods of record for fewer sites vs. shorter periods of record for more numerous sites, while still yielding sets of hydrologic indices (θ) which approximated normal distributions.

Table 7. Hydrologic information for the 53 Class 1 wetlands included in the EMT wetlands analysis dataset.

EMT ID	Site Name	Physio-graphic Region	Water Level Data Device Type and ID	P80 (2009-2017) (ft NAVD88)	Wetland Edge Reference Elevation (ft NAVD88)	Hydrologic Index (θ) (ft)	Stressed	Hydro Altered
SF-YK	Tibet Butler	Plains	Upland Well, TB2_GW1	98.01	100.70	2.69	No	No
SF-LA	Walker Ranch - WR11	Plains	Wetland Well, WR11_GW1	64.11	66.60	2.49	No	No
SF-LB	Walker Ranch - WR6	Plains	Wetland Well, WR11_GW1	60.76	63.42	2.66	No	No
SF-XZ	Walker Ranch - WR9	Plains	Wetland Well, WR11_GW1	63.82	67.29	3.47	No	No
SF-N1	Walker Ranch WR-16	Plains	Wetland Well, WR16_GW1	61.75	63.71	1.96	No	No
SF-N2	Walker Ranch WR-15	Plains	Wetland Well, WR15_GW1	59.57	63.05	3.48	No	No
SF-WT	Split Oak	Plains	Upland Well, ENV-SITE-30-PZ-1	65.04	68.45	3.41	Yes	No
SJ-LA	Unnamed Cypress	Plains	Upland Well, #244195	68.00	69.35	1.35	No	No
SJ-LB	Unnamed Wetland Nr SR 46	Ridge	Upland Well, #409664	58.68	68.35	9.67	Yes	No
SJ-LC	Boggy Marsh	Plains	Upland Well, #3117003	115.62	117.96	2.34	Yes	No
SJ-LD	Hopkins Prairie	Ridge	Upland Well, #2401320	20.16	26.49	6.33	No	No
SJ-LE	Lake Avalon	Ridge	Upland Well, #15243091	85.46	95.80	10.34	Yes	No

Table 7. Hydrologic information for the 53 Class 1 wetlands included in the EMT wetlands analysis dataset.

EMT ID	Site Name	Physio-graphic Region	Water Level Data Device Type and ID	P80 (2009-2017) (ft NAVD88)	Wetland Edge Reference Elevation (ft NAVD88)	Hydrologic Index (θ) (ft)	Stressed	Hydro Altered
SJ-LF	Lake Apshawa	Ridge	Upland Well, #2930258	79.70	86.76	7.06	Yes	No
SJ-LI	Lake Sylvan	Plains	Upland Well, #30342852	36.02	42.01	5.99	Yes	No
SJ-LL	City of Cocoa, Well 9T	Plains	Upland Well, #243977	71.20	73.00	1.80	No	No
SJ-QA	Church Lake	Ridge	Staff Gage, #2237370	81.62	89.49	7.87	Yes	Yes
SJ-QB	Johns Lake	Ridge	Upland Well, #3840562	93.00	96.54	3.54	No	No
SJ-QC	Trout Lake	Ridge	Staff Gage, #2266239	88.57	96.74	8.17	No	No
SJ-QD	Long Lake	Ridge	Upland Well, #244198	57.89	67.88	9.99	Yes	No
SJ-LJ	Lake Louisa	Ridge	Upland Well, #3980647	91.36	96.42	5.06	Yes	No
SJ-AW	Red Bug Lake	Plains	Upland Well, #244201	65.31	68.55	3.24	Yes	No
SJ-AI	Chapman Marsh	Plains	Upland Well, #244219	63.26	65.89	2.63	Yes	No
SW-LE	Cypress Creek #199, W17 Sentry Wetland	Plains	Upland Well, #18413	59.24	64.07	4.83	Yes	No
SW-LG	Cypress Creek #223 B W46	Plains	Upland Well, #18451	62.34	68.11	5.77	Yes	No

Table 7. Hydrologic information for the 53 Class 1 wetlands included in the EMT wetlands analysis dataset.

EMT ID	Site Name	Physio-graphic Region	Water Level Data Device Type and ID	P80 (2009-2017) (ft NAVD88)	Wetland Edge Reference Elevation (ft NAVD88)	Hydrologic Index (θ) (ft)	Stressed	Hydro Altered
SW-LH	Cypress Creek #211 W33	Plains	Upland Well, #638835	65.85	69.97	4.12	No	No
SW-AA	Green Swamp #7	Plains	Wetland Well, #17707	104.38	105.95	1.57	No	No
SW-LI	Green Swamp Marsh #304	Plains	Upland Well, #17585	90.35	92.88	2.53	No	No
SW-LJ	Green Swamp #6, #303	Plains	Upland Well, #17595	94.78	97.25	2.47	No	No
SW-LK	Green Swamp #5, #302	Plains	Upland Well, #17598	95.60	97.80	2.20	No	No
SW-LM	Green Swamp #1, #298	Plains	Upland Well, #17502	97.72	99.81	2.09	No	No
SW-JJ	Lake Garfield	Ridge	Staff Gage, #24818	100.67	104.63	3.96	No	Yes
SW-MM	Lake Wales	Ridge	Staff Gage, #25351	101.71	110.38	8.67	No	No
SW-QA	Big Gum Lake	Ridge	Staff Gage, #25237	91.94	95.17	3.23	No	Yes
SW-QB	Bonnet Lake (Highlands)	Ridge	Staff Gage, #23799	88.42	90.89	2.47	No	No
SW-QC	Buck Lake (Highlands)	Ridge	Staff Gage, #25405	88.98	93.63	4.65	No	No
SW-QD	Gator Lake	Ridge	Staff Gage, #24814	130.08	131.22	1.14	Yes	No
SW-QE	Lake Annie (Highlands)	Ridge	Staff Gage, #23830	108.91	110.29	1.38	No	No

Table 7. Hydrologic information for the 53 Class 1 wetlands included in the EMT wetlands analysis dataset.

EMT ID	Site Name	Physio-graphic Region	Water Level Data Device Type and ID	P80 (2009-2017) (ft NAVD88)	Wetland Edge Reference Elevation (ft NAVD88)	Hydrologic Index (θ) (ft)	Stressed	Hydro Altered
SW-QF	Lake Apthorpe	Ridge	Staff Gage, #25460	67.94	70.10	2.16	No	Yes
SW-QH	Lake Leonore	Ridge	Staff Gage, #23850	84.25	85.17	0.92	No	No
SW-QI	Lake Placid	Ridge	Staff Gage, #25440	88.60	93.79	5.19	No	No
SW-QJ	Lake Streety	Ridge	Staff Gage, #23766	102.69	105.06	2.37	No	No
SW-QK	Lake Van	Ridge	Staff Gage, #17662	131.01	133.31	2.30	No	No
SW-QL	Lake Walker	Ridge	Staff Gage, #24816	136.87	149.17	12.30	Yes	No
SW-QM	Polecat Lake	Ridge	Staff Gage, #24812	139.93	143.52	3.59	No	No
SW-QN	Surveyors Lake	Ridge	Staff Gage, #24810	130.00	132.44	2.44	No	No
SW-QO	Parks Lake	Ridge	Staff Gage, #25233	99.24	101.86	2.62	No	No
SW-QQ	Crooked Lake	Ridge	Staff Gage, #23857	113.87	120.26	6.39	No	Yes
SW-DD	Van Fleet #2	Plains	Upland Well, #623026	124.36	125.84	1.48	No	No
SW-N1	Green Swamp Bay	Plains	Upland Well, #17505	98.49	100.83	2.34	No	No
SW-N2	Green Swamp #4	Plains	Upland Well, #17727	99.52	102.01	2.49	No	No

Table 7. Hydrologic information for the 53 Class 1 wetlands included in the EMT wetlands analysis dataset.

EMT ID	Site Name	Physio-graphic Region	Water Level Data Device Type and ID	P80 (2009-2017) (ft NAVD88)	Wetland Edge Reference Elevation (ft NAVD88)	Hydrologic Index (θ) (ft)	Stressed	Hydro Altered
SW-N3	Alston Bay	Plains	Upland Well, #18838	96.02	98.40	2.38	No	No
SW-N7	Saddle Blanket Scrub #2	Ridge	Upland Well, #702384	114.05	119.11	5.06	No	No
SW-N8	Lake Wales Ridge WEA #1	Ridge	Upland Well, #25240	121.37	129.33	7.96	Yes	No

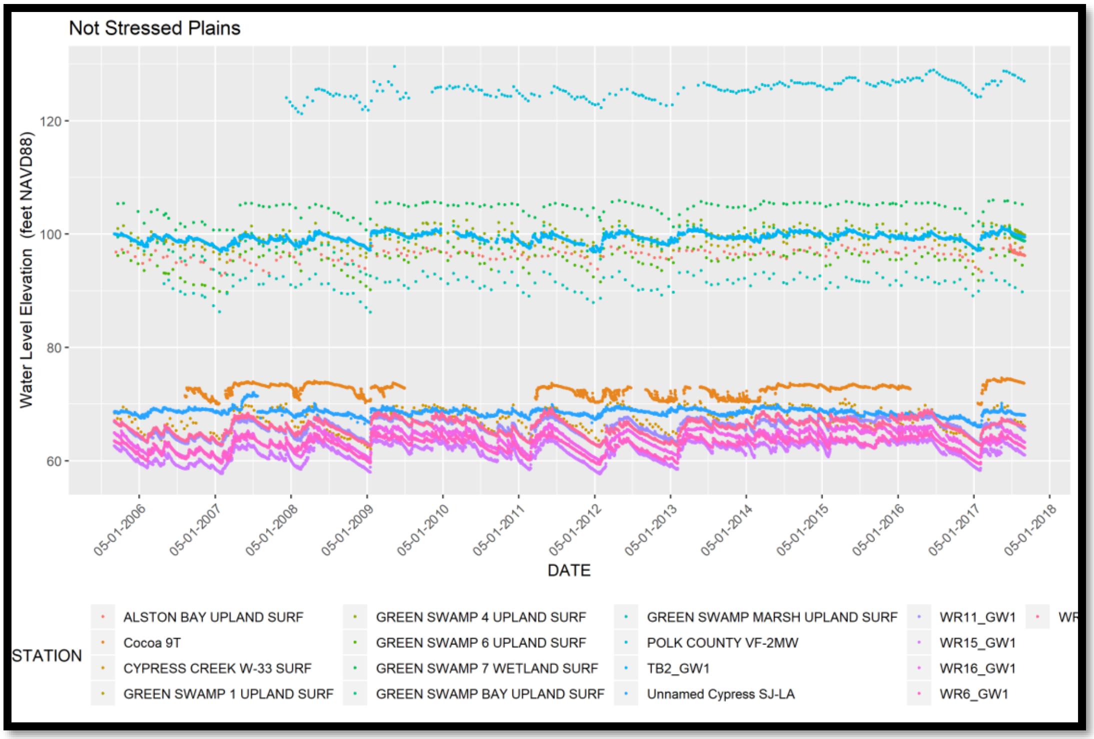

Figure 7. Water level data from 2006 through 2017 for the not stressed Plains Class 1 wetlands included in the EMT wetlands analysis dataset.

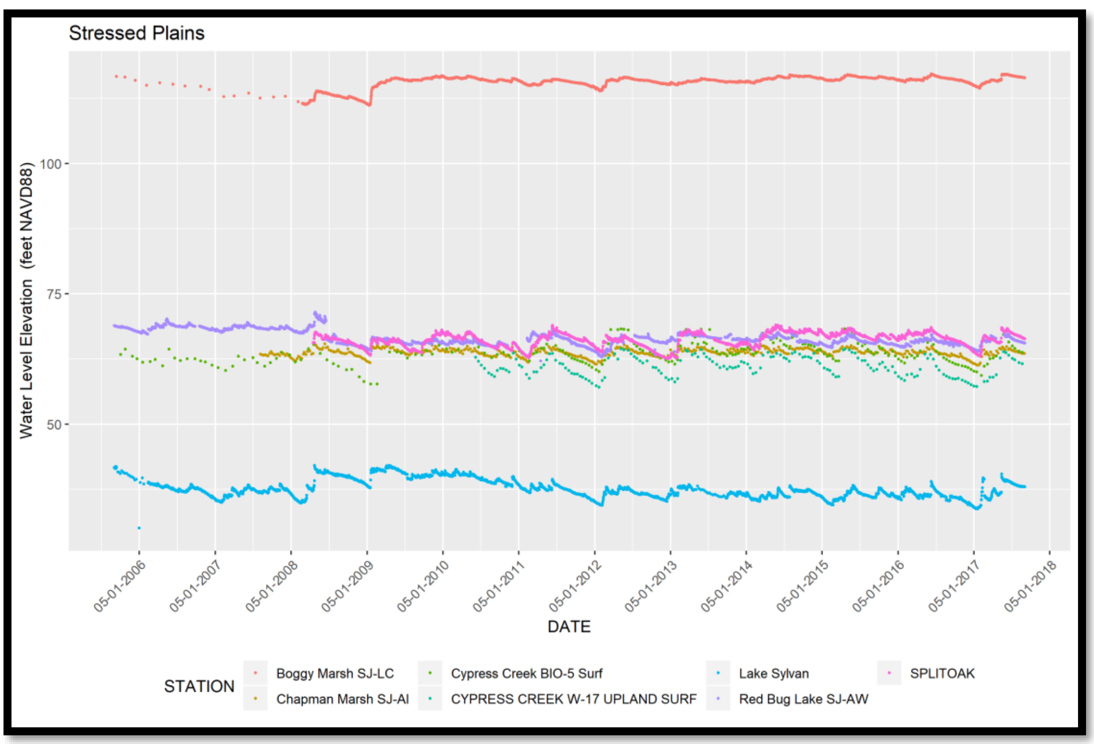

Figure 8. Water level data from 2006 through 2017 for the stressed Plains Class 1 wetlands included in the EMT wetlands analysis dataset.

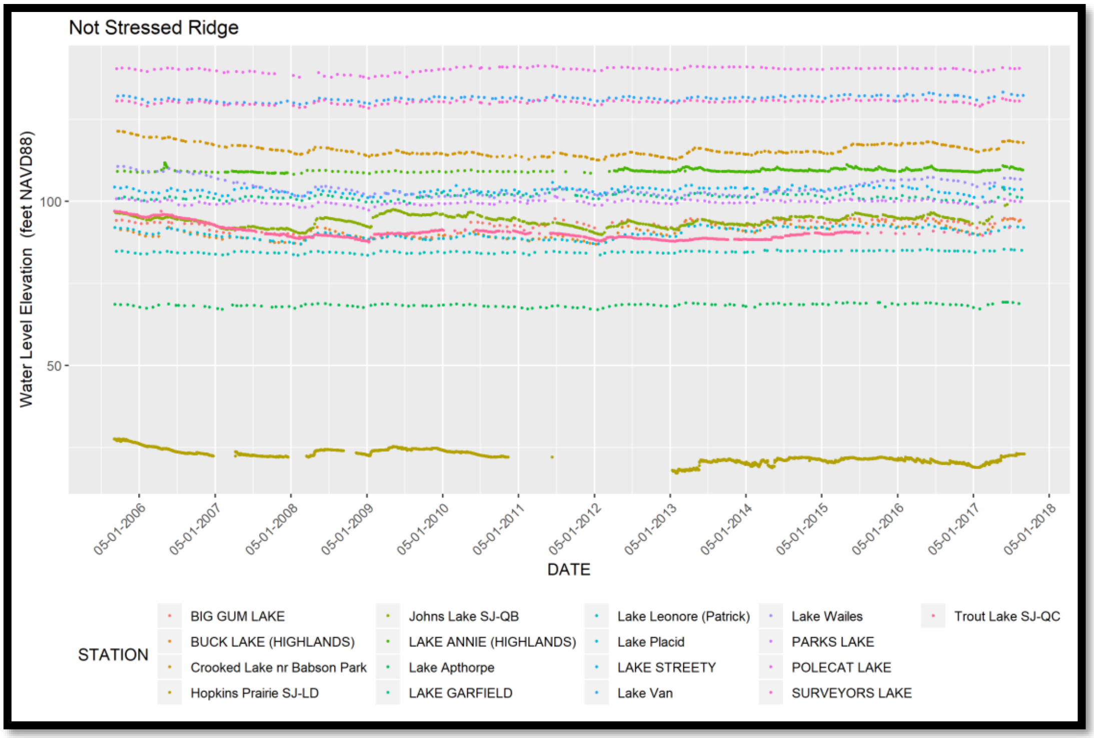

Figure 9. Water level data from 2006 through 2017 for the not stressed Ridge Class 1 wetlands included in the EMT wetlands analysis dataset.

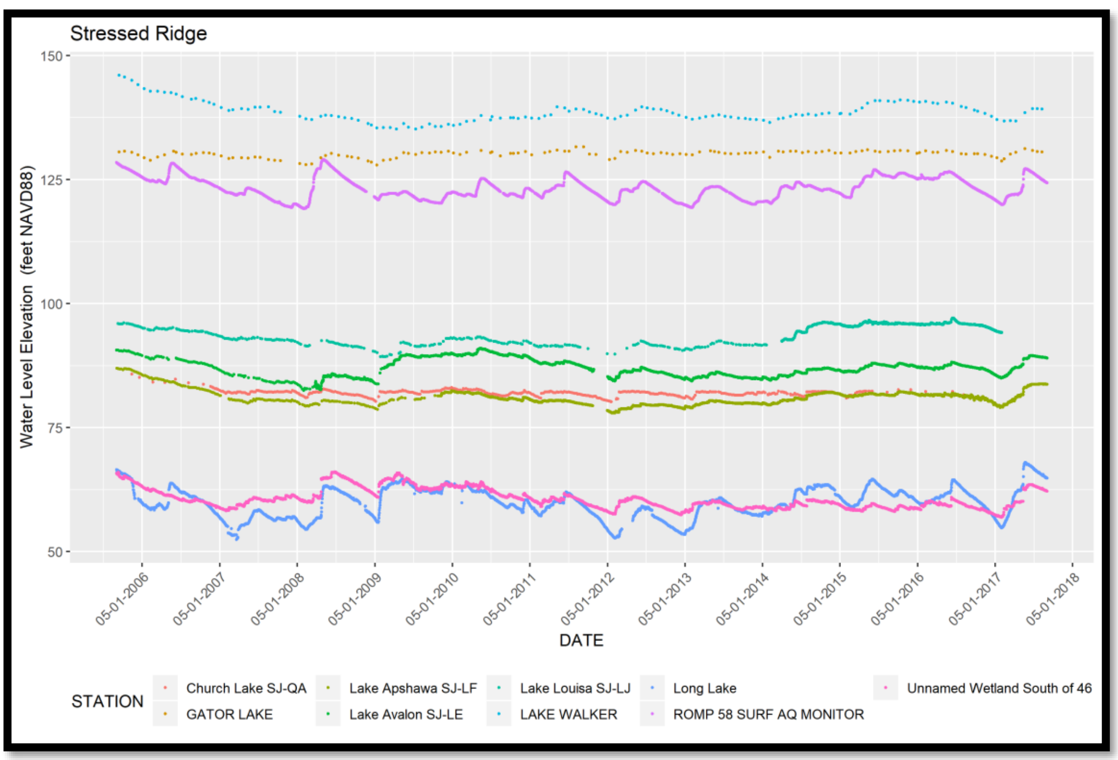

Figure 10. Water level data from 2006 through 2017 for the stressed Ridge Class 1 wetlands included in the EMT wetlands analysis dataset.

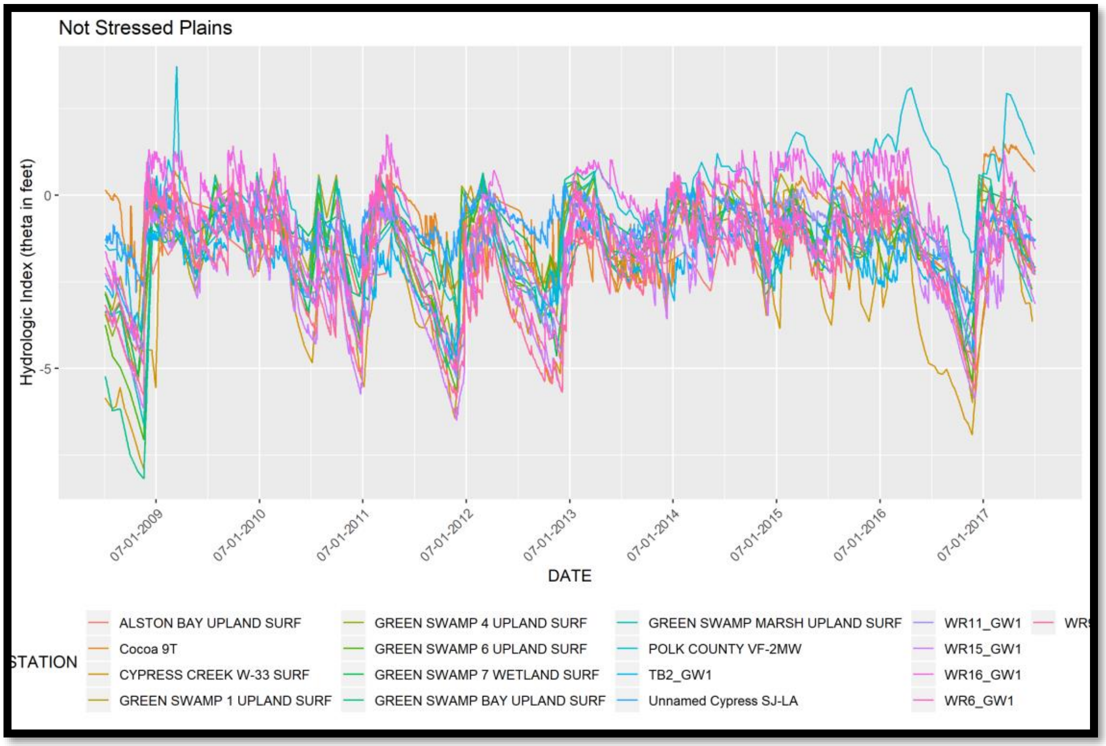

Figure 11. Hydrologic indices (θ) from 2009 through 2017 for the not stressed Plains Class 1 wetlands included in the EMT wetlands analysis dataset.

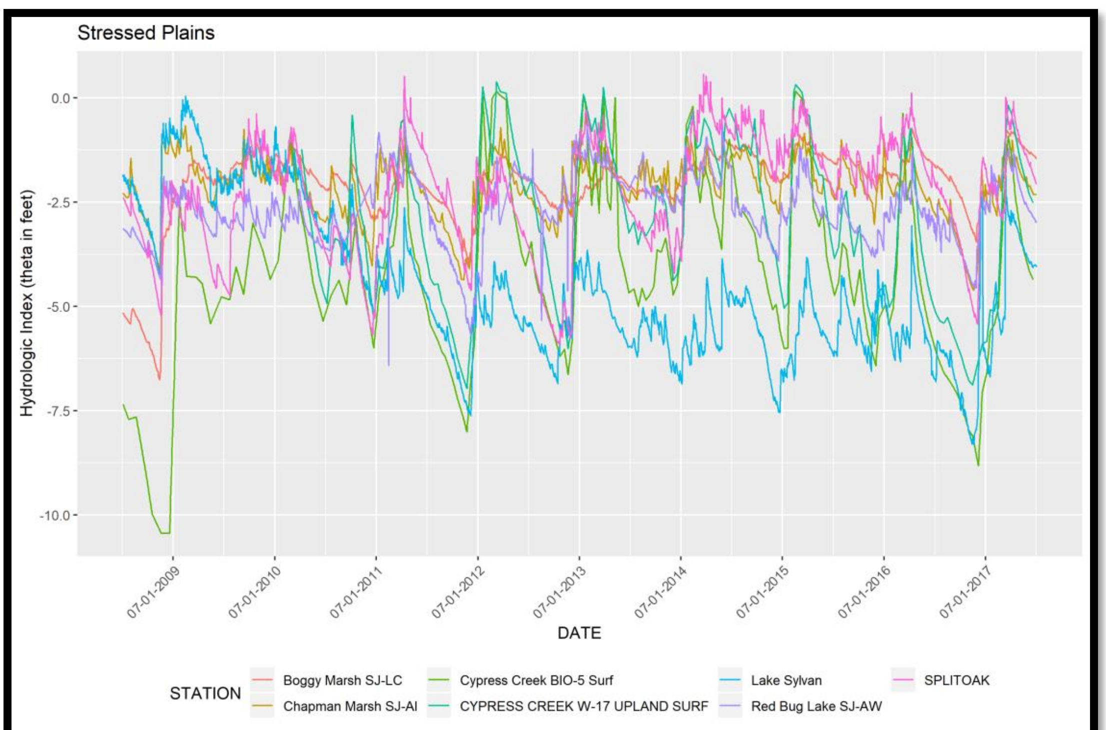

Figure 12. Hydrologic indices (θ) from 2009 through 2017 for the stressed Plains Class 1 wetlands included in the EMT wetlands analysis dataset.

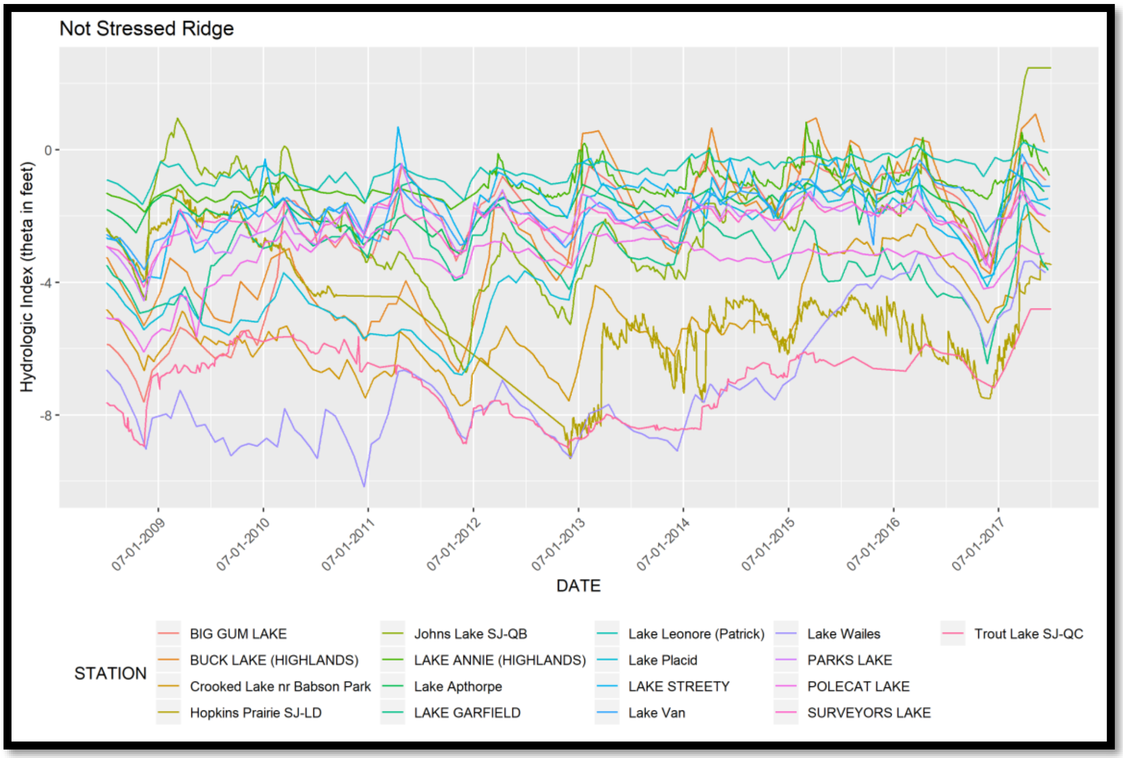

Figure 13. Hydrologic indices (θ) from 2009 through 2017 for the not stressed Ridge Class 1 wetlands included in the EMT wetlands analysis dataset.

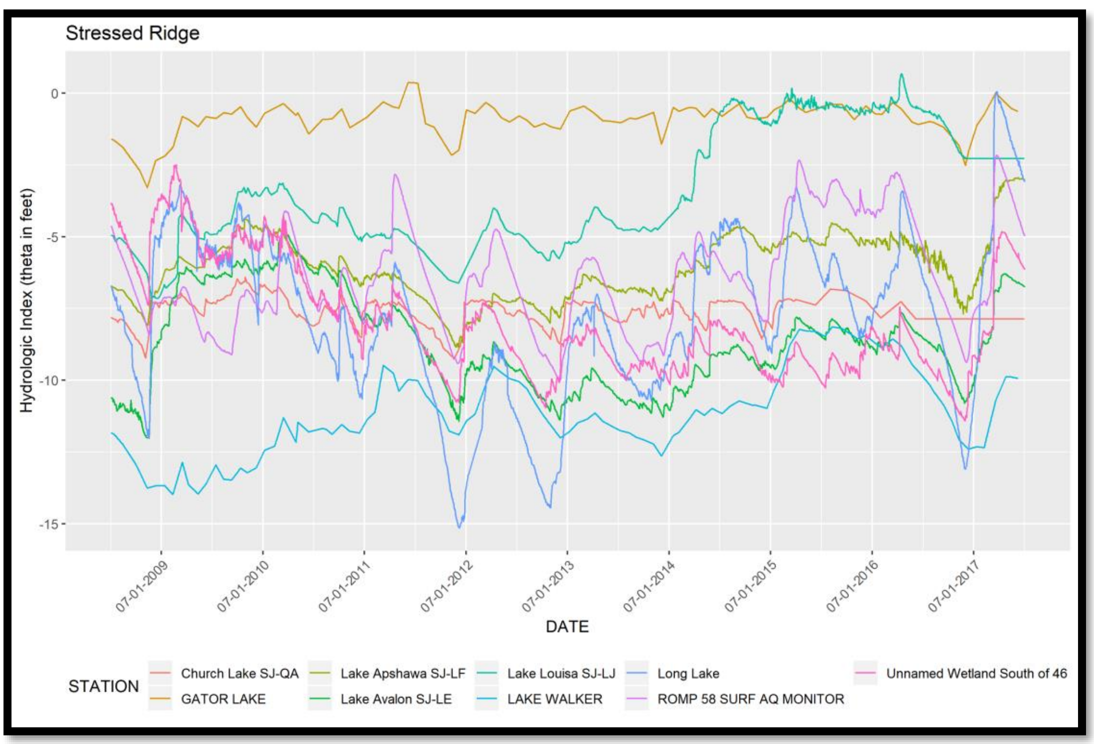

Figure 14. Hydrologic indices (θ) from 2009 through 2017 for the stressed Ridge Class 1 wetlands included in the EMT wetlands analysis dataset.

5.1 Period-of-Record (2009-2017) Rainfall in the CFWI Planning Area

For comparison to the Class 1 wetlands water level data, as well as for comparison to the ECFTX model calibration period (2003-2014), rainfall data from 2009 through 2017 were summarized from seven locations in the CFWI Planning Area (**Table 8**). Average rainfall across all sites and years was just over 51 inches. The lowest annual value recorded was about 45 inches at Orlando International Airport in 2012, while the highest rainfall recorded was almost 72 inches at Mountain Lake NWS in 2015 (**Figure 15**). The seasonal variation in monthly rainfall at each of the seven locations is shown in **Figure 16**.

Table 8. Rainfall monitoring stations examined in the CFWI Planning Area

Site ID	Site Name	Longitude	Latitude	District
15323/SHING.RG	Shingle Creek Swamp Rain Gage	-81.450344	28.377505	SFWMD
FF846/WRWX	Walker Ranch Weather Station (Disney Wilderness Preserve)	-81.399830	28.048727	SFWMD
28765084	Lake Louisa State Park at Clermont	-81.723000	28.455000	SJRWMD
7982	Sanford	-81.266700	28.800000	SJRWMD
USW00012815	Orlando International Airport	-81.325000	28.433900	SJRWMD
25147	Mountain Lake NWS	-81.599236	27.938631	SWFWMD
17350	ROMP 88 Rock Ridge	-81.906739	28.309450	SWFWMD

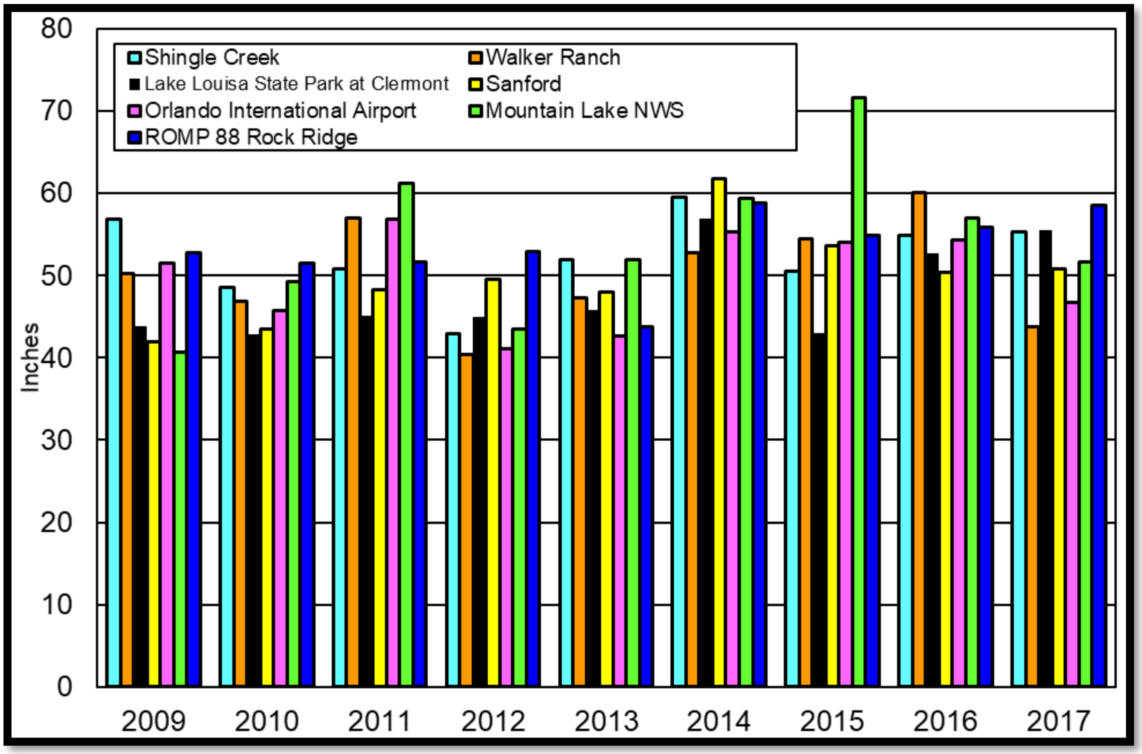

Figure 15. Yearly rainfall values from January 2009 through December 2017 from seven locations within the CFWI Planning Area.

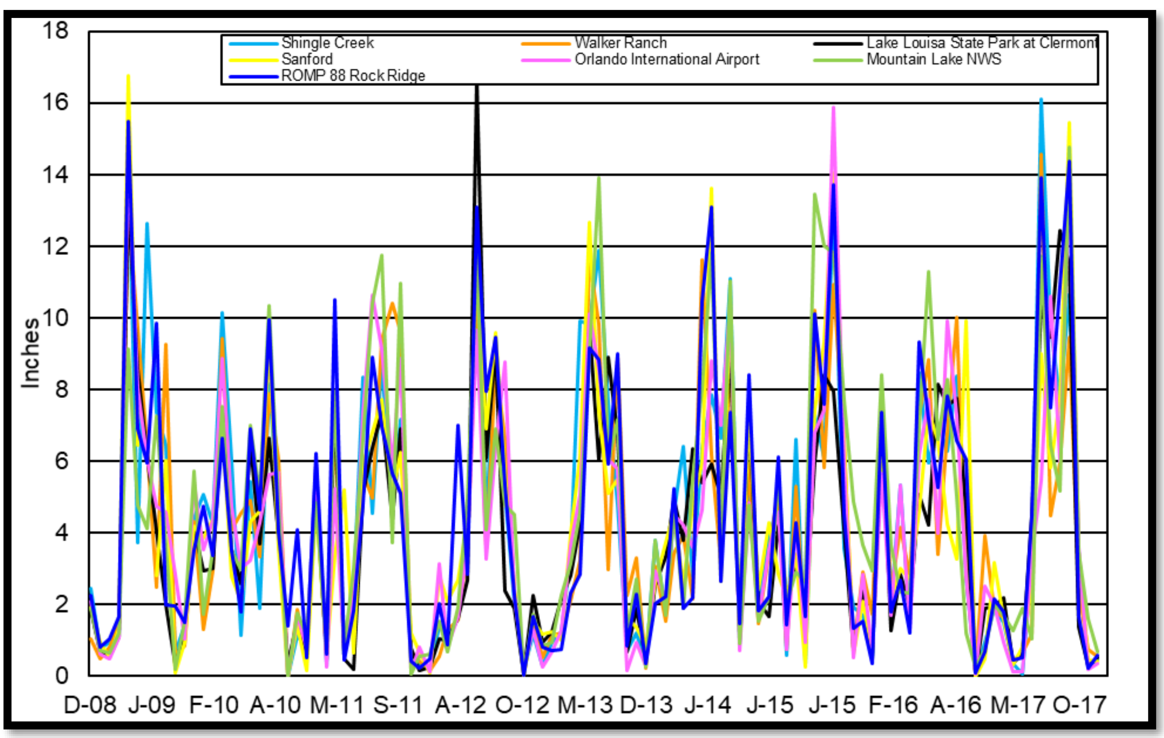

Figure 16. Monthly rainfall values (inches) from January 2009 through December 2017 from seven locations within the CFWI Planning Area.

6.0 WETLANDS RISK ASSESSMENT

Per the methodology approved by the WRAT and MOC and presented to the Steering Committee, the same wetlands risk assessment methodology that was used by the EMT in support of the 2015 CFWI RSWP (CFWI EMT 2013) was used for the current analysis. While the wetlands analysis methodology is described in detail in **Appendix D**, it is briefly described in the following paragraphs.

6.1 Wetlands Risk Assessment Methodology

Some updates to the wetlands analysis methodology that was used by the EMT for the previous analysis were necessary. They were associated with revised Class 1, 2, and 3 wetlands datasets; a different Class 1 wetlands water level period of record; and an updated model (the ECFTX model).

Using GIS, the observed ratios of stressed to unstressed Class 1 and 2 wetlands, and an urban density and physiographic region correction factor developed for the 2015 analysis, the acreages of stressed and unstressed Class 1, Class 2, and Class 3 wetlands for each ECFTX model cell were calculated for the 2014 RC. For the Class 1 wetlands, GIS processing was conducted to create a single polygon of each site by merging the polygons of different wetland types. Since Class 2 wetlands were not re-evaluated and no new Class 2 wetlands were added to the dataset, the GIS layer used for the analysis in support of the 2015 CFWI RWSP was used for the current analysis after a thorough QA/QC review. Since the stress status for each of the Class 1 and Class 2 wetlands is known, total acreages of stressed and unstressed Class 1 and 2 wetlands could be calculated utilizing the reviewed GIS layers alone. For Class 3 wetlands, stress status is not known, and initial acreages of stressed and unstressed wetlands would need to be calculated. A GIS layer was utilized to determine the total acreages of Class 3 wetlands within the planning area. Initial stress was then assigned to those acreages utilizing the ratios of stressed and unstressed Class 1 and Class 2 wetlands, along with the urban density and physiographic correction factor developed for the 2015 analysis. GIS processing was conducted to calculate the acreage of Class 3 wetlands in the western portion of the CFWI Planning Area that was not included in the previous modeling effort. Furthermore, through a GIS analysis, the open water acres of Class 1, 2, and 3 wetlands were removed so that the RC acres were not overestimated by including in the analysis non-vegetated areas in these waterbodies.

Using the statistical relationship between observed stress and observed P80 water level and hydrologic index (θ) variations for the Class 1 wetlands water level data, the probability (or risk) of future changes in wetland stress occurring, based on modeled water level changes between the 2014 RC and the 2025, 2030, and 2040 Withdrawals Conditions, was estimated. This risk assessment was applied separately to primarily groundwater-dominated wetlands (Class 1, 2, and 3) in Plains and Ridges physiographic settings because wetland hydrologic conditions in these wetlands are typically different due to underlying soils, geology, physiography, typical depths, and other factors.

Most of the Plains physiographic provinces are typically characterized by having a confining layer that restricts the exchange of water between the SAS and the underlying Floridan aquifer system. The confining layer between the SAS and the UFA is typically very restrictive but can vary throughout the Plain physiographic regions. The best predictor for probable change in the long-term water level regime of Plains wetlands due to groundwater withdrawals is the simulated change in the SAS water table at the wetland locations (CFWI EMT 2013). Therefore, ECFTX model results for Model Layer 1 (SAS) were used for the Plains wetlands risk assessment.

Most of the Ridge physiographic provinces are characterized by less or no confining conditions that vary considerably at the local scale. Because the variability occurs at a finer scale than the model grid cells and there is insufficient data available to provide calibration information on all the local variations in confinement and resulting water table elevation differences, the ECFTX model was not able to reproduce the variability in the hydrogeology of the Ridge physiographic provinces. Because of this variability, and the associated lack of data, a range of values was developed for the Ridge wetlands risk assessment. The low part of the range was based on the projected change in SAS water levels (Model Layer 1) from the ECFTX model, which may underestimate wetland water level responses to groundwater drawdown in the leakiest locations for the future groundwater withdrawal scenarios. The high part of the range was based on the projected change in UFA water levels (Model Layer 3) from the model, which may overestimate wetland water level responses to groundwater drawdown in the UFA. For Ridge wetlands, this range provides an estimate of low and high amount of future changes in Ridge wetlands water levels from which to estimate corresponding probabilities of changes in wetland stress conditions

The stress risk algorithm that was developed for post-processing of the ECFT model results for the original analysis for the 2015 CFWI RWSP was revised to incorporate the updated statistical risk equations and for compatibility with the ECFTX model output files. Post-processing of the ECFTX model runs included calculating the probable stressed and unstressed wetland acreage for each ECFTX model cell in the 2014 RC and calculating the probable change in stressed and unstressed wetland acreage for each ECFTX model cell under the 2025, 2030, and 2040 Withdrawals Conditions; calculating the probable change in total stressed wetland acreage for each Withdrawals Condition; and preparing tables, graphs, and maps showing the geographic distribution of projected stressed wetland acreage.

6.2 Wetlands Risk Assessment Results

Since primarily groundwater-dominated wetlands are potentially more likely to be affected by groundwater withdrawals, these wetlands, which make up approximately 30 percent of the wetlands in the CFWI Planning Area, were the focus of the EMT's wetlands risk assessment. The locations of the Plains and Ridge wetlands included in the wetlands risk assessment are shown in **Figure 17**. As mentioned earlier, wetlands that were determined to be substantially hydrologically altered were excluded from the analysis. Approximately 189,000 acres of primarily groundwater-dominated wetlands (combined Class 1, 2, and 3) found within the CFWI Planning Area were included in the analysis. This acreage includes about 139,000 acres of Plains wetlands and approximately 50,000 acres of Ridge wetlands (**Tables 9** and **10**).

While it is natural to compare the results of the current wetlands analysis to those of the previous analysis in support of the 2015 CFWI RWSP, there are many factors that make a direct comparison not possible or appropriate. These factors include:

- An updated and improved model, the ECFTX model, was used to calculate groundwater drawdowns for the 2025, 2030, and 2040 Withdrawals Conditions, as well as for the 2014 RC. In addition to expanding the model domain to include the entire CFWI Planning Area (which added more acres of Class 3 wetlands), many improvements were made to the model used for the original analysis, the ECFT groundwater model.

- The period of record used for the current analysis was from 2009 through 2017 (2006-2011 was the period of record used for the original analysis).
- In order not to overestimate the stressed and unstressed Plains and Ridge Class 1, 2, and 3 wetlands acreages for the 2014 RC, as well as for changes in stressed wetland acres resulting from the 2025, 2030, and 2040 Withdrawals Conditions, the open water portions of wetlands and lakes were removed from the analysis (this was not done for the original analysis).
- For the current analysis, the Class 1 wetlands dataset included 53 wetlands, while 44 wetlands were included in the Class 1 wetlands dataset for the original analysis.
- The Class 1, 2, and 3 datasets used for the current analysis underwent rigorous QA/QC review (the rigor of the QA/QC review for the original analysis is unknown).
- The results of the current analysis underwent rigorous QA/QC review (the rigor of the QA/QC review for the original analysis is unknown).

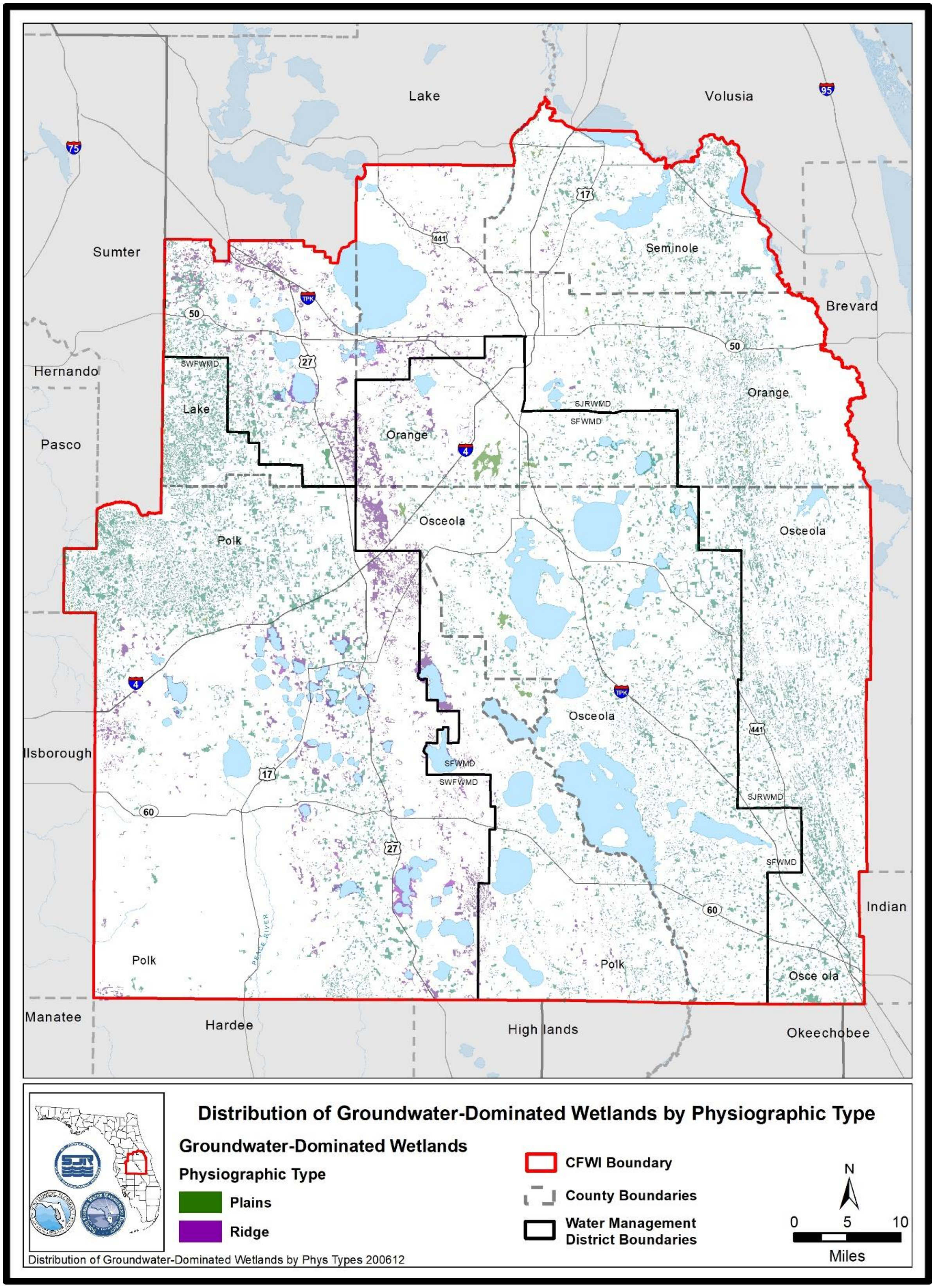

Figure 17. Distribution of Plains and Ridge wetlands within the CFWI Planning Area included in the EMT wetlands analysis.

Table 9. Summary of results (rounded to the nearest 10 acres) for the CFWI Planning Area assessment of primarily groundwater-dominated Plains wetlands, excluding wetlands with hydrologic alteration. ECFTX Model Layer 1 (Surficial Aquifer System) was used to predict the wetland water level change.

Wetland Class	Total Acres of Wetlands (Stressed and Not Stressed)	Acres of Stressed Wetlands for 2014 Reference Condition	Probable Net Change in Acres of Stressed Wetlands for 2025 Withdrawals Condition	Probable Net Change in Acres of Stressed Wetlands for 2030 Withdrawals Condition	Probable Net Change in Acres of Stressed Wetlands for 2040 Withdrawals Condition
Class 1	1,100	750	0	0	10
Class 2	5,830	1,830	0	10	10
Class 3	131,980	14,080	760	990	1,420
Total	138,910	16,660	760	1,000	1,440

Table 10. Summary of results (rounded to the nearest 10 acres) for the CFWI Planning Area assessment of primarily groundwater-dominated Ridge wetlands, excluding wetlands with hydrologic alteration.

Model Layer Used to Predict Wetland Water Level Change	Wetland Class	Total Acres of Wetlands (Stressed and Not Stressed)	Acres of Stressed Wetlands for 2014 Reference Condition	Probable Net Change in Acres of Stressed Wetlands for 2025 Withdrawals Condition	Probable Net Change in Acres of Stressed Wetlands for 2030 Withdrawals Condition	Probable Net Change in Acres of Stressed Wetlands for 2040 Withdrawals Condition
Surficial Aquifer System (Model Layer 1)	Class 1	5,530	1,400	20	20	30
	Class 2	11,340	3,200	210	320	700
	Class 3	33,610	14,080	270	360	690
	Total	50,480	18,680	500	700	1,420
Upper Floridan Aquifer (Model Layer 3)	Class 1	5,530	1,400	390	450	540
	Class 2	11,340	3,200	540	750	1,090
	Class 3	33,610	14,080	1,820	2,360	3,070
	Total	50,480	18,680	2,750	3,560	4,700

Compared to the 2014 RC, the probable net increase in stressed wetland acres for Plains and Ridge wetlands resulting from the 2025, 2030, and 2040 Withdrawals Conditions is shown in **Figure 18**. **Tables 9** and **10** also include that information by wetland class. A comparison of the probable change in the proportion of stressed and not stressed Plains and Ridge wetland acres for each of the Withdrawals Conditions is shown in **Figures 19** and **20**.

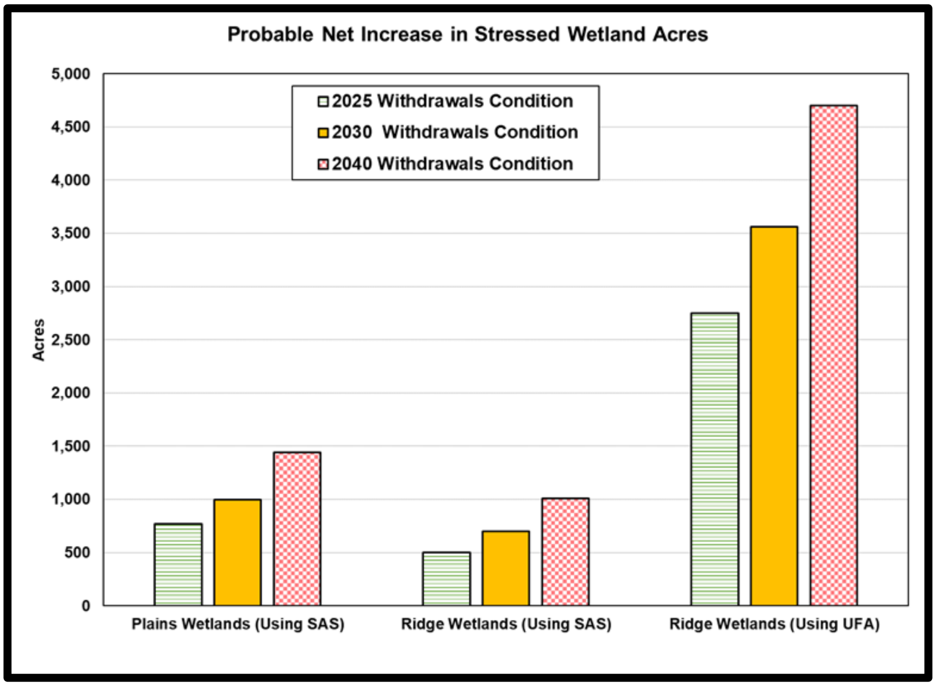

Figure 18. The probable net increase in acres of stressed Plains and Ridge wetlands for the 2025, 2030, and 2040 Withdrawals Conditions. SAS – Surficial aquifer system; UFA – Upper Floridan aquifer.

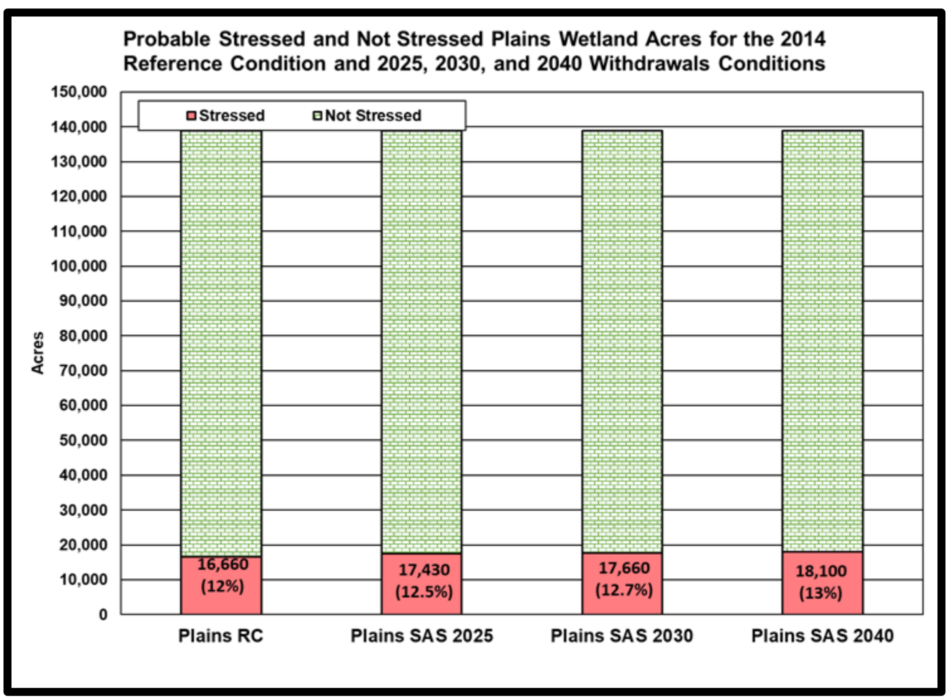

Figure 19. A comparison of probable acres of stressed and not stressed Plains wetlands for the 2025, 2030, and 2040 Withdrawals Conditions. RC – 2014 Reference Condition; SAS – Surficial aquifer system.

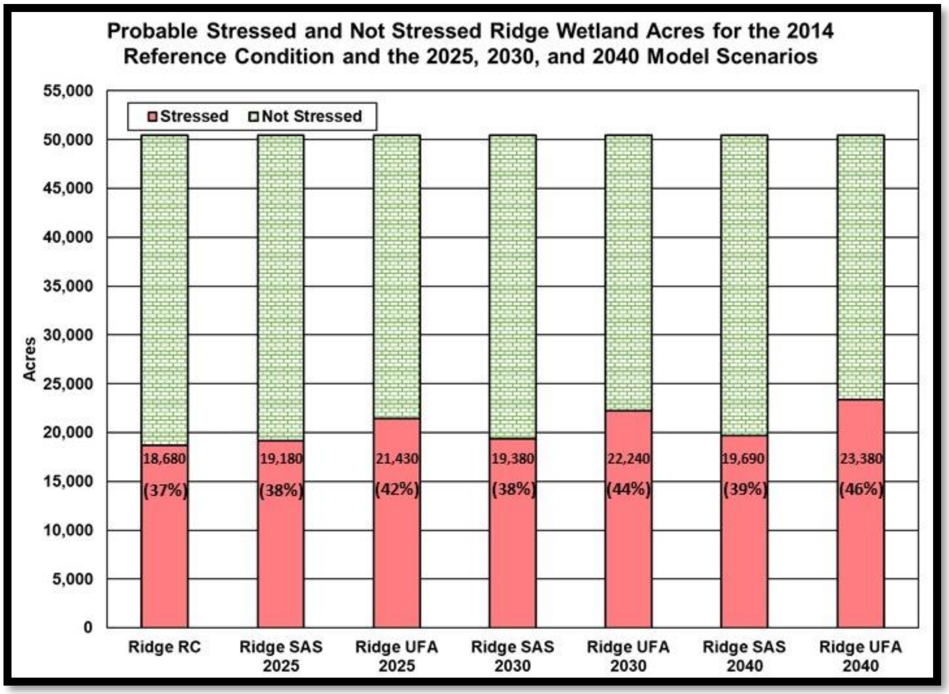

Figure 20. A comparison of probable acres of stressed and not stressed Ridge wetlands for the 2025, 2030, and 2040 Withdrawals Conditions. RC – 2014 Reference Condition; SAS – Surficial aquifer system; UFA – Upper Floridan aquifer.

Under the 2014 RC, 12 percent of the Plains wetlands are stressed (**Figure 19**). For the 2025 Withdrawals Condition the total probable acres of stressed Plains wetlands increased 0.5 percent compared to the 2014 RC. For the Plains wetlands, the total probable acres of stressed wetlands increased 0.7 percent for the 2030 Withdrawals Condition as compared to the 2014 RC (**Figure 19**). For the 2040 Withdrawals Condition, the total probable acres of stressed Plains wetlands increased 1 percent compared to the 2014 RC.

Approximately 37 percent of Ridge wetlands are stressed under the 2014 RC (**Figure 20**). For the 2025 Withdrawals Condition, the total probable acres of stressed Ridge wetlands increased between 1 and 5 percent of stressed wetland acres compared to the 2014 RC. The total probable acres of stressed Ridge wetlands increased between 1.5 and 7 percent for the 2030 Withdrawals Condition (**Figure 20**). For the 2040 Withdrawals Condition, the total probable acres of stressed Ridge wetlands increased between 2 and 9 percent compared to the 2014 RC (**Figure 20**).

For the 2025 Withdrawals Condition, regional maps of the probable acres of change in stress by model cell for Plains and Ridge wetlands are presented in **Figures 21** and **22**. Since Model Layer 1 was used to predict wetland water level changes for both Plains and Ridge wetlands in **Figure 21**, it represents the "best case," while **Figure 22** represents the "worst case" since Model Layer 3 was used to predict wetland water level changes for Ridge wetlands.

Regional maps of the probable acres of change in stress by model cell for Plains and Ridge wetlands for the 2030 Withdrawals Condition are presented in **Figures 23** and **24**. Since Model Layer 1 was used to predict wetland water level changes for both Plains and Ridge wetlands in **Figure 23**, it represents the "best case," while **Figure 24** represents the "worst case" since Model Layer 3 was used to predict wetland water level changes for Ridge wetlands.

Figures 25 and **26** include regional maps of the probable acres of change in stress by model cell for Plains and Ridge wetlands for the 2040 Withdrawals Condition. Similar to the maps for the 2030 Withdrawals Condition, **Figure 25** represents the best case and **Figure 26** represents the worst case because of the different model layers used to predict wetland water level changes for the Ridge wetlands.

Similar to the previous analysis (CFWI EMT 2013), the results of our wetland risk assessment assess the probability of wetland stress occurring at the regional scale and can't be applied to the local scale. The regional scale of the ECFTX model limits its accuracy and precision in predicting future changes of water elevations in specific lakes and wetlands. The wetland stress response is also dependent on the initial hydrologic condition of each wetland, and this is not known for most of the wetlands within the CFWI Planning Area (e.g., Class 3 wetlands). Both of these uncertainties have been minimized by averaging the effects across the entire planning area. This reduces the overall effect of random errors because randomly distributed positive and negative errors at individual locations tend to cancel each other when predicted effects at individual locations are summed to obtain a predicted net regional effect (CFWI EMT 2013).

For **Figures 21** through **26**, the negative values (green shading) represent change from stressed to unstressed, while the positive values (white, yellow, orange, and pink shading) represent change from unstressed to stressed. Also, note that white denotes areas not included in the analysis. Because these risk assessments assessed the probability of wetland stress occurring at the regional scale, these regional maps cannot be applied at the local scale. However, increased groundwater pumping can be associated with other factors, such as changes in land use and drainage that also may affect groundwater levels, but were not addressed as part of this analysis. It must be noted that our analysis is a planning-level effort to determine groundwater availability and is not intended to represent what might actually occur in 2025, 2030, or 2040. The projections of probable wetland stress are specific to the particular distribution of groundwater withdrawals and recharges.

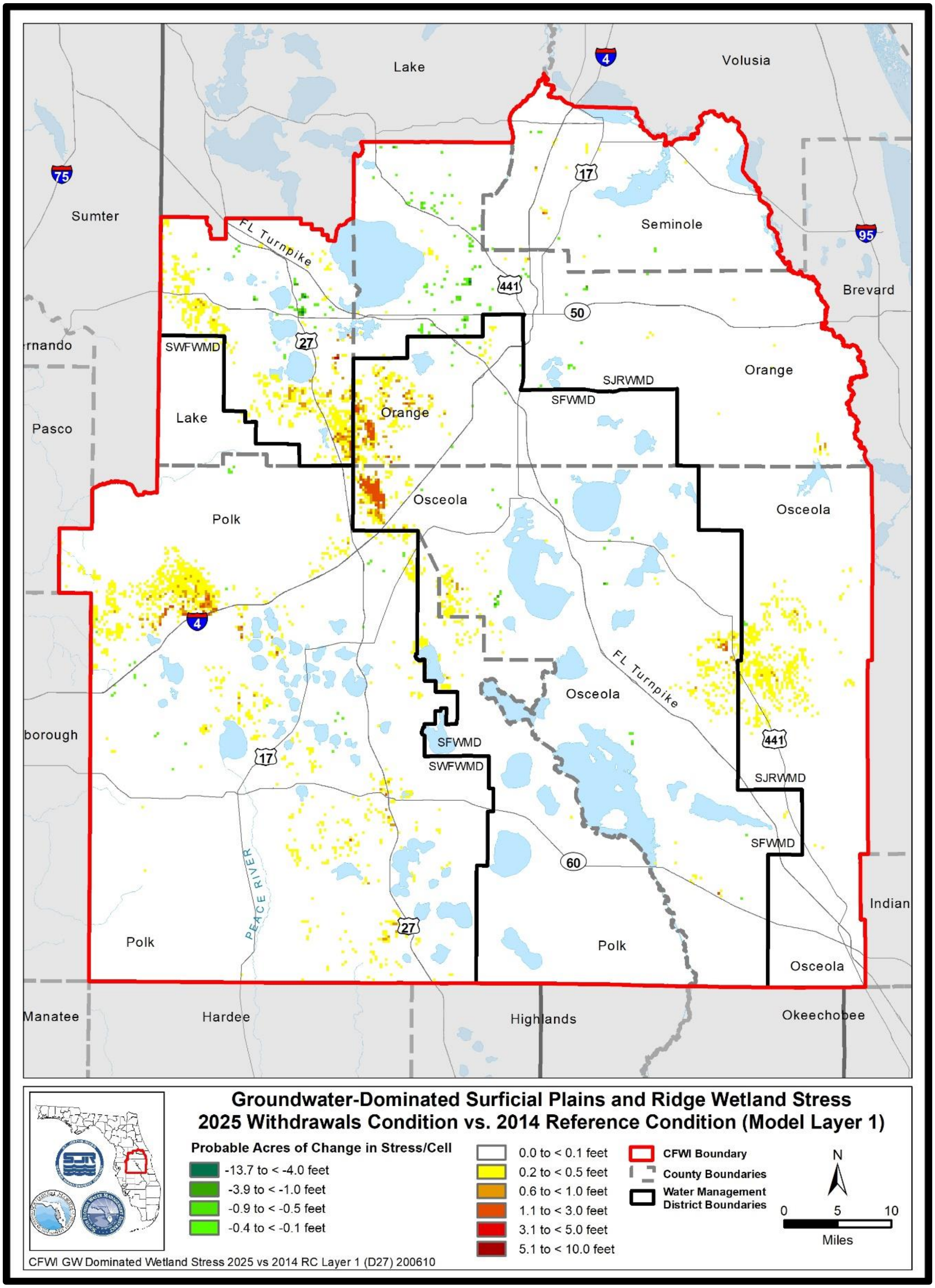

Figure 21. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains and Ridge wetlands using Model Layer 1 (Surficial aquifer system) to predict wetland water level change for the 2025 Withdrawals Condition.

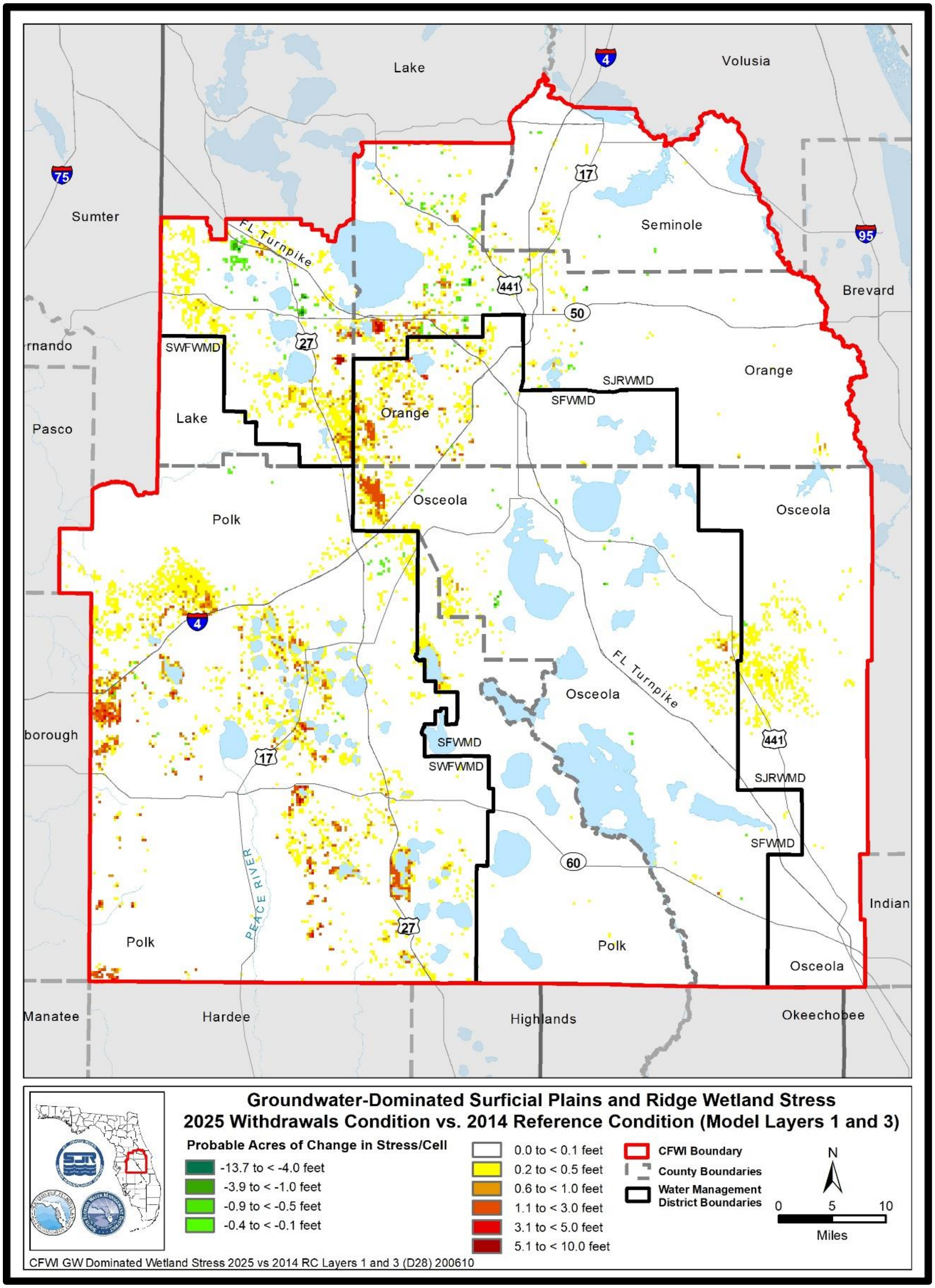

Figure 22. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains wetlands using Model Layer 1 (Surficial aquifer system) and Ridge wetlands using Model Layer 3 (Upper Floridan aquifer) to predict wetland water level change for the 2025 Withdrawals Condition.

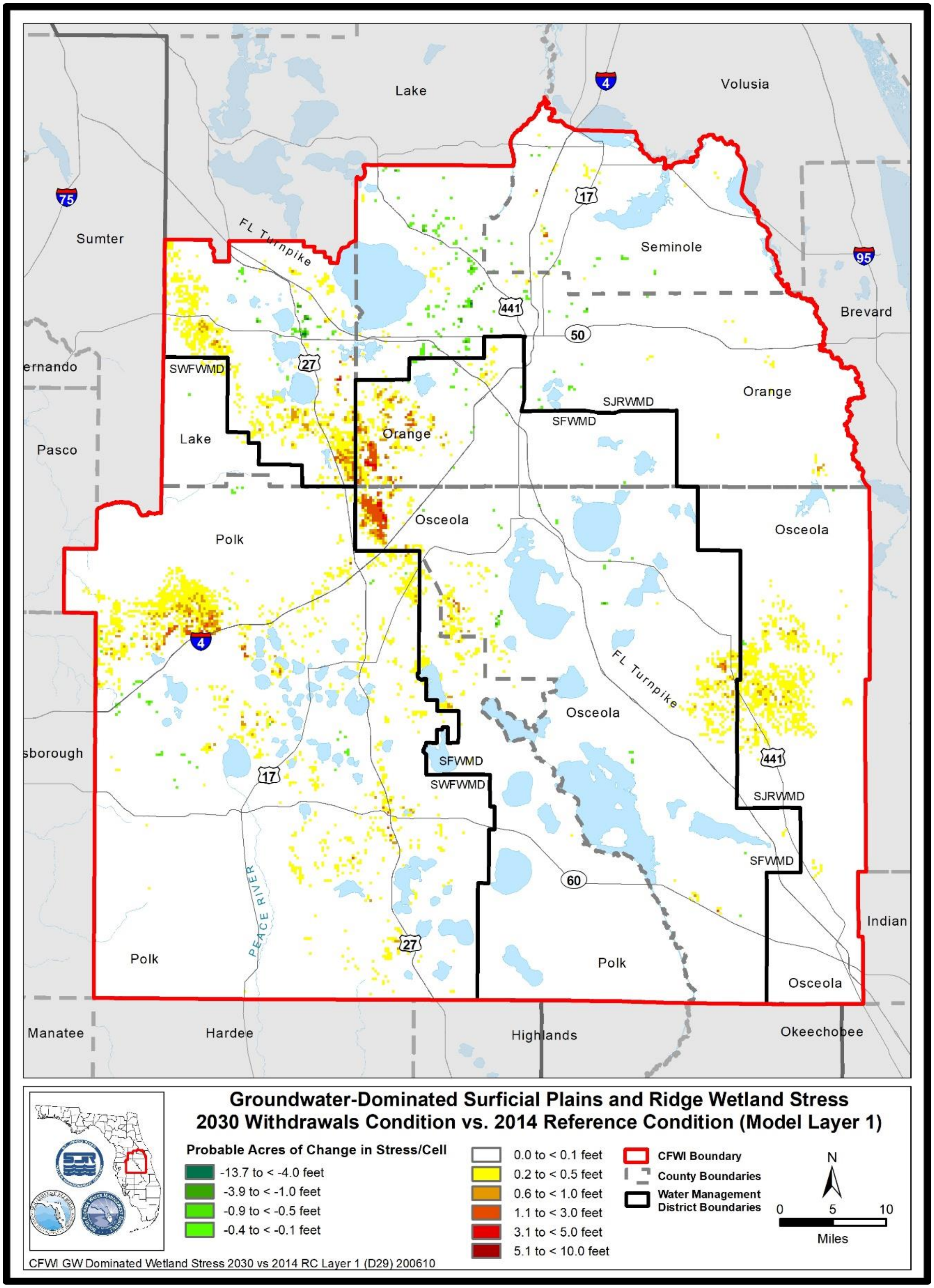

Figure 23. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains and Ridge wetlands using Model Layer 1 (Surficial aquifer system) to predict wetland water level change for the 2030 Withdrawals Condition.

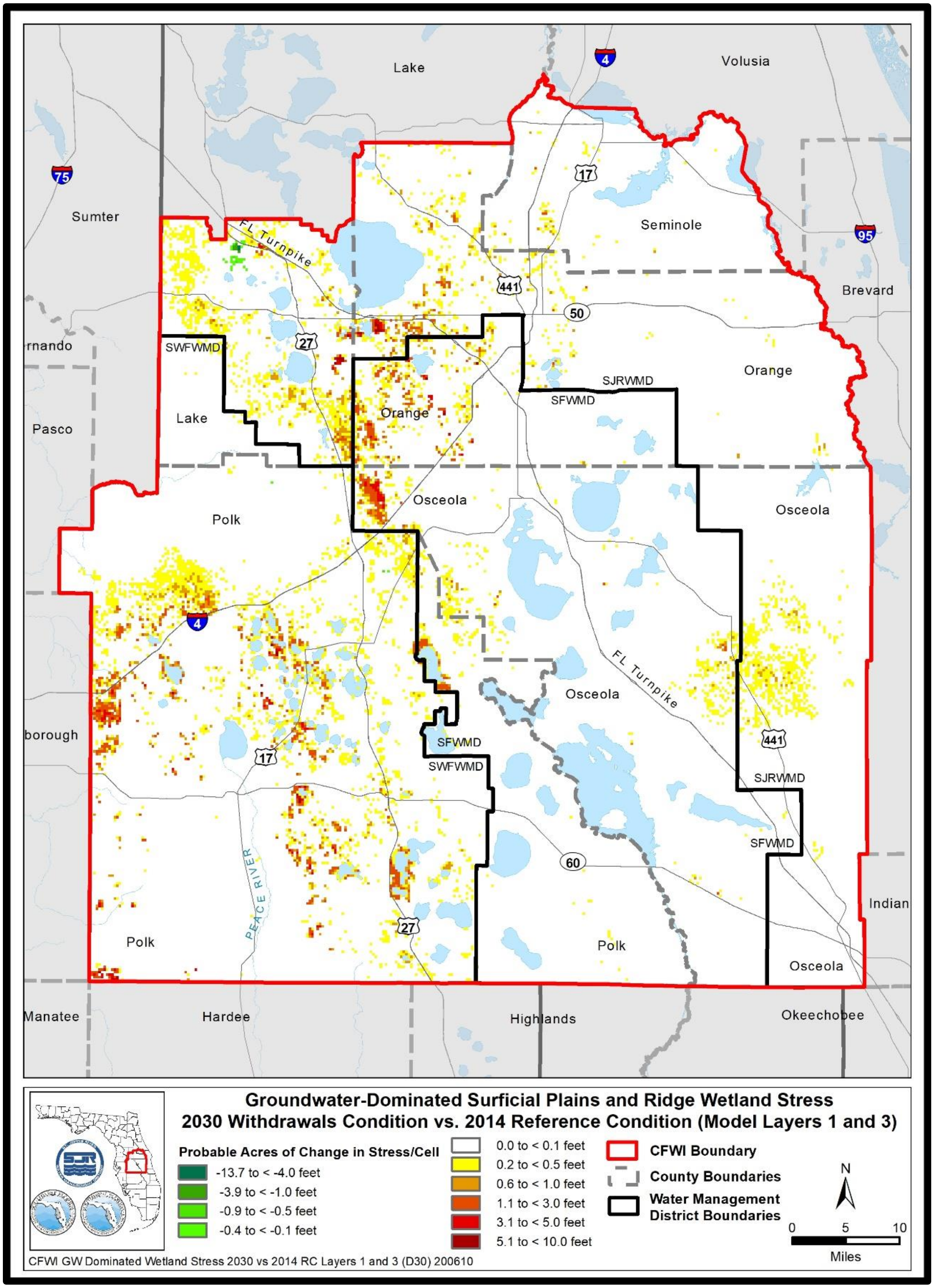

Figure 24. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains wetlands using Model Layer 1 (Surficial aquifer system) and Ridge wetlands using Model Layer 3 (Upper Floridan aquifer) to predict wetland water level change for the 2030 Withdrawals Condition.

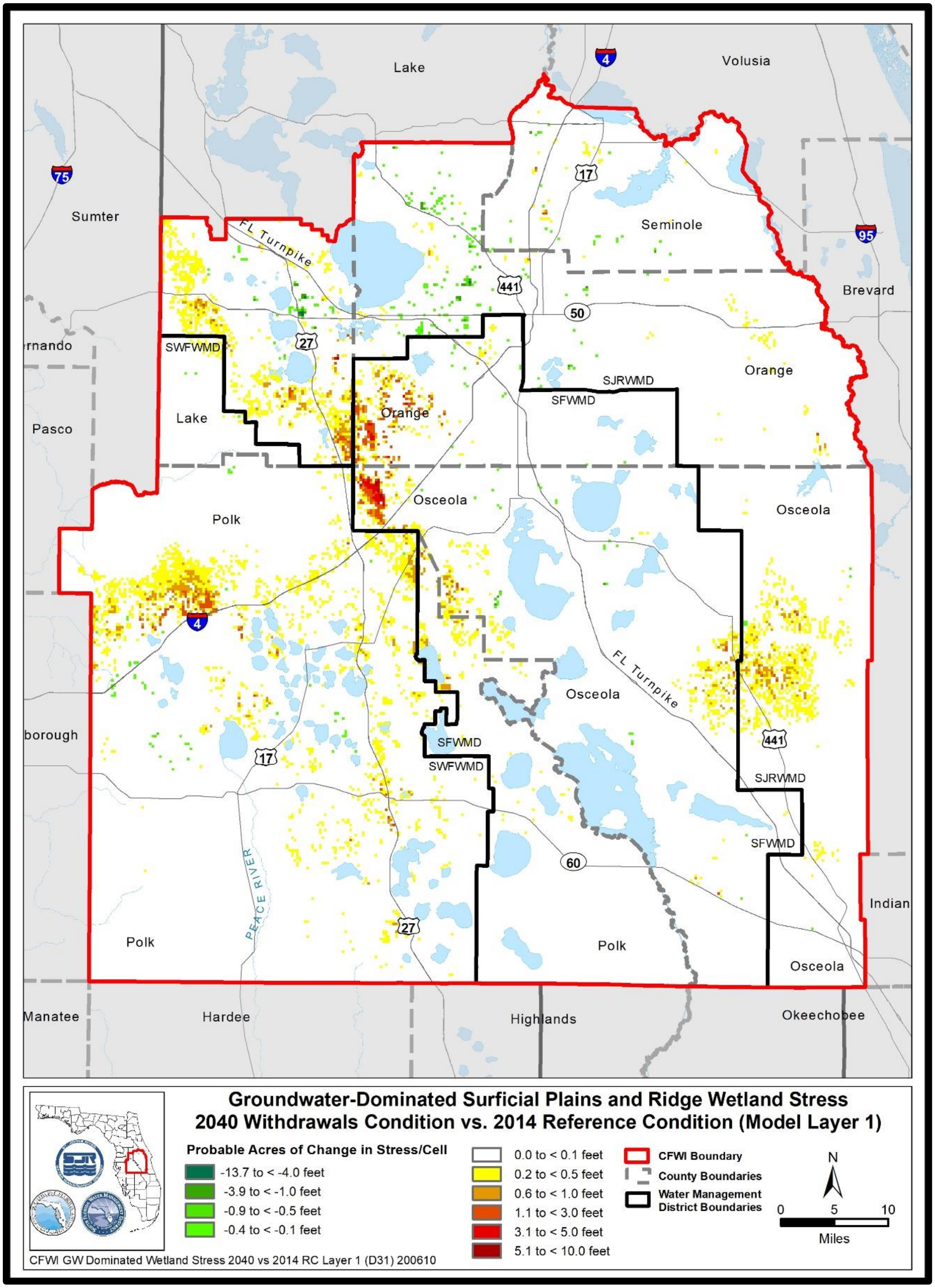

Figure 25. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains and Ridge wetlands using Model Layer 1 (Surficial aquifer system) to predict wetland water level change for the 2040 Withdrawals Condition.

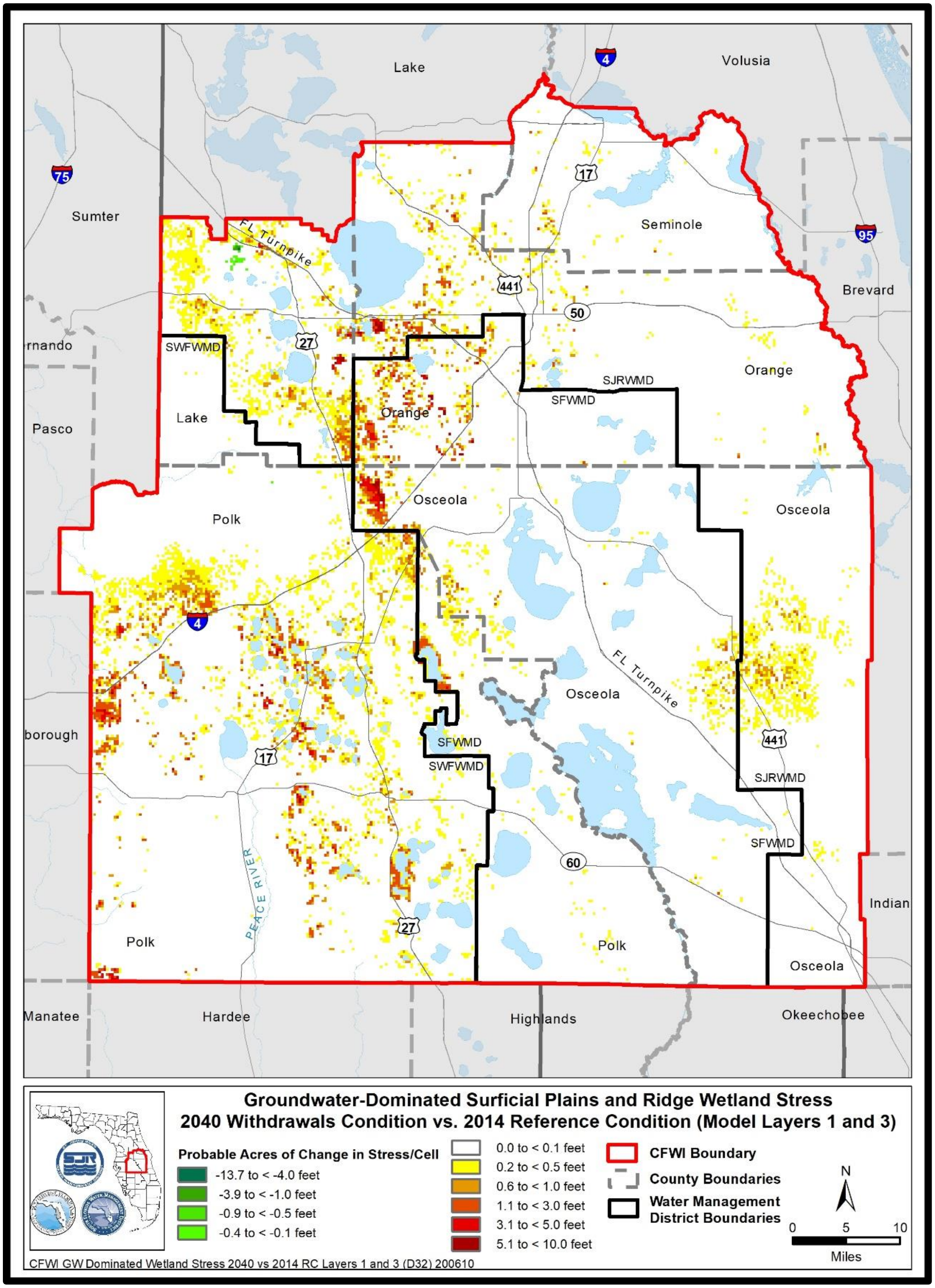

Figure 26. Compared to the 2014 Reference Condition, the probable acres of change in stress by model cell for Plains wetlands using Model Layer 1 (Surficial aquifer system) and Ridge wetlands using Model Layer 3 (Upper Floridan aquifer) to predict wetland water level change for the 2040 Withdrawals Condition.

7.0 SUMMARY

Similar to the EMT analysis conducted in support of the 2015 RWSP, results from the current analysis indicated that there are areas within the CFWI Planning Area where there are concentrations of stressed wetlands. They include Central Polk County northwest of I-4, a large portion of the Southern Water Use Caution Area (SWUCA), South Lake County, the Lake Wales Ridge along the U.S. 27 corridor, West Seminole and Orange Counties, the Wekiva River area, and East Osceola County. Scenarios for the 2025, 2030, and 2040 Withdrawals Conditions indicated that the number and extent of stressed wetlands could potentially increase in these areas and could potentially expand into additional areas where wetlands are currently not stressed. Results of the EMT analysis results were provided to the GAT to support their task of quantifying the amount of sustainable groundwater that may be currently available in the CFWI Planning Area.

It is important to understand the limitations of our analysis and results, as well as the previous analysis, and the appropriate use of these findings. Some of the limitations inherent in this our analysis are described below.

- Wetlands and lakes whose hydrology is typically groundwater-dominated only represent a small percentage of the total number of wetlands in the study area; and therefore, it would be inappropriate to extrapolate the results of probable wetland impacts to all wetlands within the CFWI Planning Area.
- The patterns of response seen in the results of these analyses generally appear to agree with the results we would expect to see in the landscape, based on experience and observations to date.
- The study did not address the degree of wetland stress, only the presence or absence of stress. This can be an important factor when considering the impact of human activities on natural systems.
- The conclusions are based on the ECFTX model output and are subject to the limitations of modeling assumptions and available input data (details included in CFWI HAT 2020).
- These analyses were conducted to support the regional water supply planning process and are at the scale and resolution appropriate for that effort. Use of these regional findings in other contexts or for other applications (e.g., to a specific wetland or lake system) would likely require additional data acquisition, analysis, and considerations.

8.0 FUTURE RECOMMENDATIONS

The EMT recognizes that future data collection efforts in the CFWI Planning Area will support the development of a more robust dataset for these types of analyses. Recommended actions for the EMT include the following:

- Improve the methods for the accurate designation of the Ridge and Plains designation of a wetland or lake, as well as the characteristics of the systems.
- Consider the collection of water level and duration data within the wetland or lake, in addition to the well data.

- Expand the Class 1 wetlands dataset using the DMIT long-term monitoring program sites and data collected under Consumptive Use and Water Use Permits where the data is compatible for analysis.
- Ensure that future monitoring sites focus on areas of high probability of stress depicted in the 2025, 2030, and 2040 Withdrawals Conditions and in areas where sufficient monitoring may currently be lacking.
- Conduct and complete a hydrologic stress assessment during annual compliance reviews of permittee sites, as well as potential permittee sites, for potential use in future EMT analyses.
- Develop a plan for the implementation of the EMT analysis that will be used for the 2025 CFWI RWSP.

9.0 REFERENCES

CFWI (Central Florida Water Initiative) Environmental Measures Team (EMT). 2013. Development of Environmental Measures for Assessing Effects of Water Level Changes on Lakes and Wetlands in the Central Florida Water Initiative Area. Central Florida Water Initiative's Environmental Measures Team, Final Report, November 2013.

CFWI Hydrologic Assessment Team (HAT). 2020. Model Documentation Report East-Central Florida Transient Expanded (ECFTX) Model. Central Florida Water Initiative's Hydrologic Assessment Team.

Appendices

Appendix A: Field Form Used for the 2018 Class 1 Wetlands Assessments

WETLAND ASSESSMENT FIELD FORM – CFWI

Revised 02-13-18

Date: ____________________ Evaluators: ____
Site Name/ID: ____
Wetland Type: Class 1 Class 2 Class 3 District: SFWMD SJRWMD SWFWMD
GPS Coordinates or Lat/Long: ____

Wetland/Lake Characteristics (Take Multiple Representative Photos)

Lacustrine or Palustrine Isolated Interconnected Seepage Slope Sandhill
Topographic Relief: Relatively Flat (0-2') Moderate (3-5') Extreme (>5')
Vegetation Zonation: Well Defined Somewhat Defined Poorly Defined
Zones Present: Transitional Zone Outer Deep Zone Deep Zone
Presence of Water in Wetland: Dry Saturated Inundated Center Throughout
If Lake, Description of Water Level: Normal Above Normal Below Normal

Habitat Characteristics (Circle Those Present and Take Representative Photos)

Shifts and Change in Plant Communities Invasion by Upland Species
Presence of Nuisance or Invasive Species Dead or Dying Vegetation/Trees
Premature Leaf Falls Discolored Foliage Leaning Trees Tree Falls
Absence of Regeneration of Wetland Species Exposed Tree Roots
Age Class Differences of Trees Evidence of Recruitment of Wetland Tree Species
Fire Scars Evidence of Logging Cattle
Overall Habitat Condition: Excellent Good Fair Poor
Justification of Condition (Based on Characteristics): ______________________________
____
____
____

Soil Characteristics at Wetland Boundary (Take Representative Photos)

Soil Type: Sand/Mineral Peat Muck Hydric Inundated Saturated Moist Dry
Soil Subsidence/Oxidation: None Yes Measured Depth: __________
Soil Fissures: None Yes Measured Depth: __________
Soil Compaction: None Yes Measured Depth: __________

Hydrologic Indicators (Circle Those Present and Take Photos of Each)

Pine Edge Saw Palmetto Edge Saw Palmetto "Horses" (Elevated Trunks)
Moss Collars Lichen Lines Stain Lines Adventitious Roots
Buttressed Tree Trunks Cypress Inflection Points Algal Mats Water Marks
Rafted Debris Crayfish Burrows Water Lines on Docks/Pilings None

Drainage Alteration in Wetland: None Yes Description: ____________________________
____
____

Drainage Alteration of Surrounding Lands: None Yes
Approx. Distance and Description: ____
____
____

Stormwater Inflows: None Yes Description: ____________________________________
____

Overall Condition of Wetland: Stressed Not Stressed

Photograph Information:

Additional Comments:

Appendix B: Class 1 Wetlands Information

Walker Ranch – WR11 (SF-LA)

Walker Ranch – WR11 is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system is a cypress dome located within the Disney Wilderness Preserve which is owned and maintained by The Nature Conservancy (TNC) (**Figures B-1, B-2, and B-3**). The TNC regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. Monitoring of this wetland system is conducted by the South Florida Water Management District (SFWMD) as part of their regional hydrologic monitoring network (**Figure B-4**). The evaluation included pedestrian transects throughout the entire system.

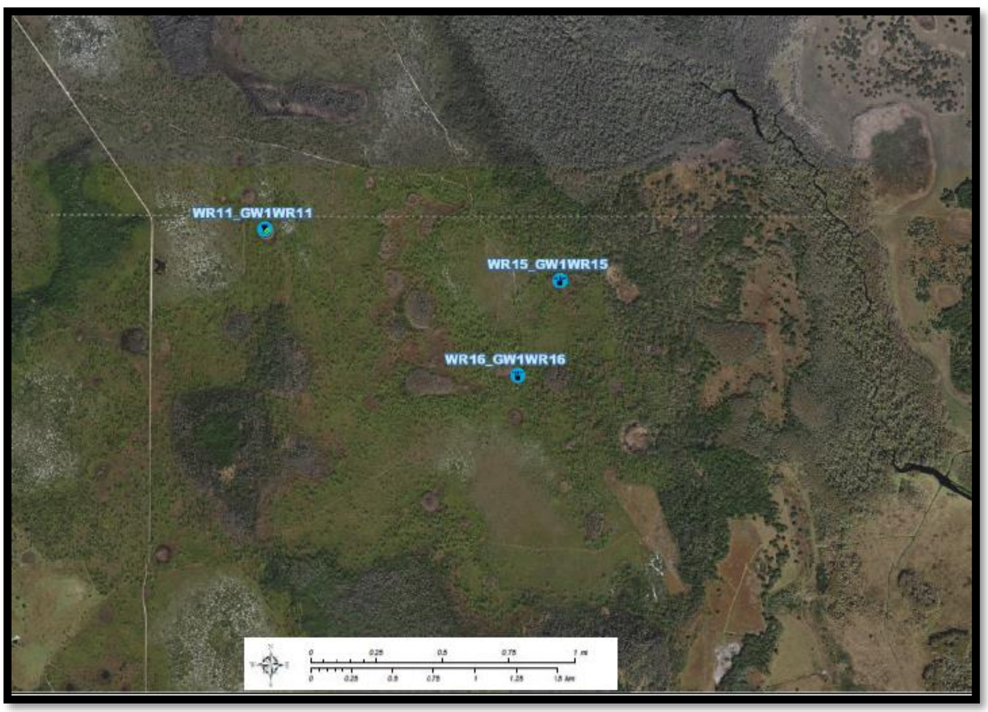

Figure B-1 Vicinity map for Walker Ranch – WR11 (SF-LA).

Figure B-2. Center of Walker Ranch – WR11 (SF-LA), May 2018.

Figure B-3. Palmetto edge of Walker Ranch – WR11 (SF-LA), May 2018.

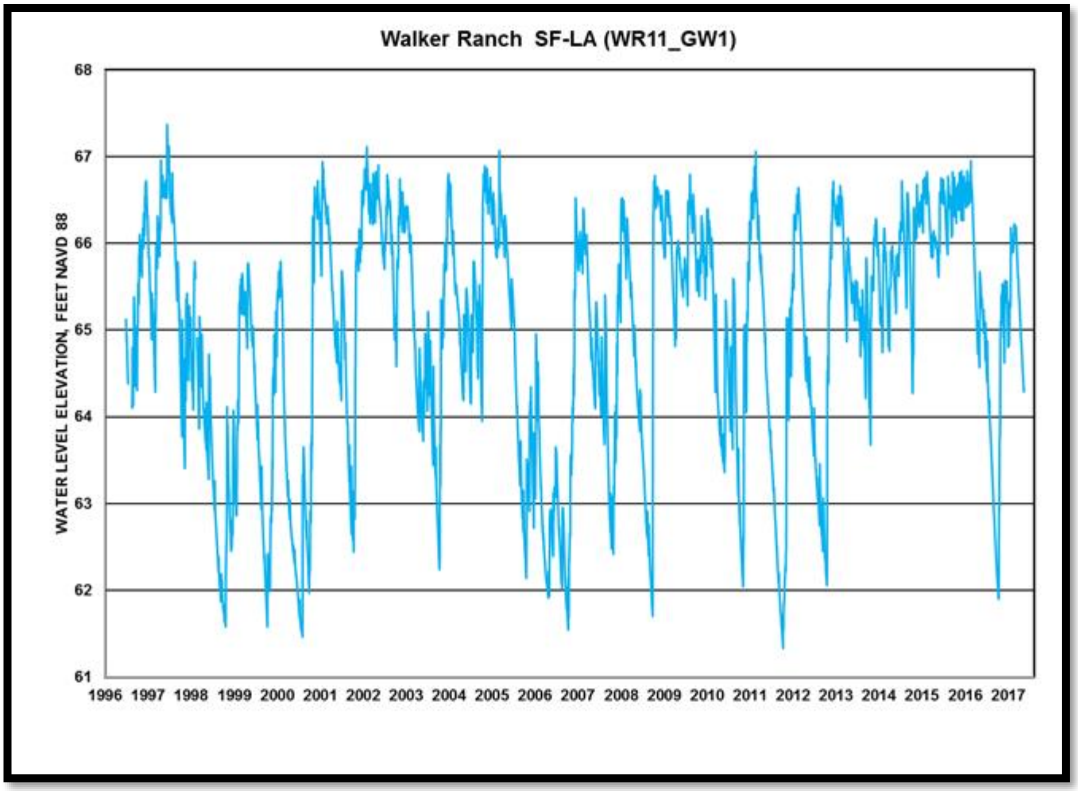

Figure B-4. Period-of-record water level data for Walker Ranch – WR11 (SF-LA).

Walker Ranch – WR6 (SF-LB)

Walker Ranch – WR6 is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system is a freshwater marsh located within the Disney Wilderness Preserve which is owned and maintained by The Nature Conservancy (TNC) (**Figures B-5, B-6, B-7, and B-8**). The TNC regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. Monitoring of this wetland system is conducted by the SFWMD as part of their regional hydrologic monitoring network (**Figure B-9**). The evaluation included pedestrian transects throughout the entire system.

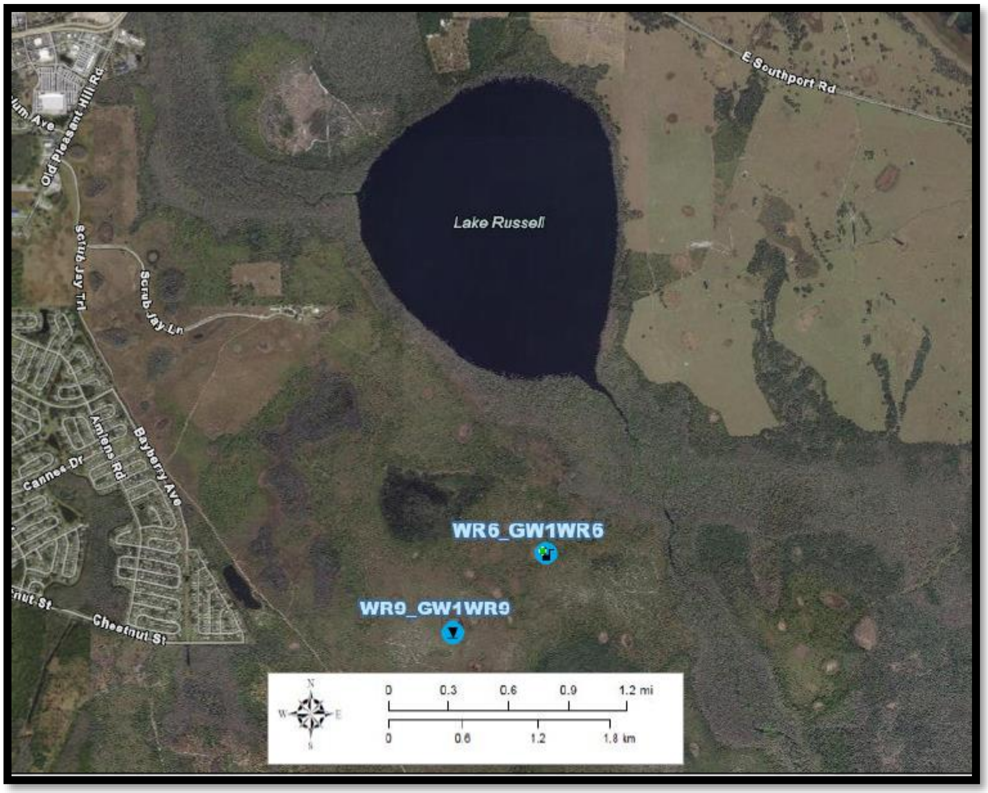

Figure B-5. Vicinity map for Walker Ranch – WR6 (SF-LB).

Figure B-6. Center of Walker Ranch – WR6 (SF-LB), May 2018.

Figure B-7. Small cypress area on east side of marsh in Walker Ranch – WR6 (SF-LB), May 2018.

Figure B-8. Palmetto edge of Walker Ranch – WR6 (SF-LB), May 2018.

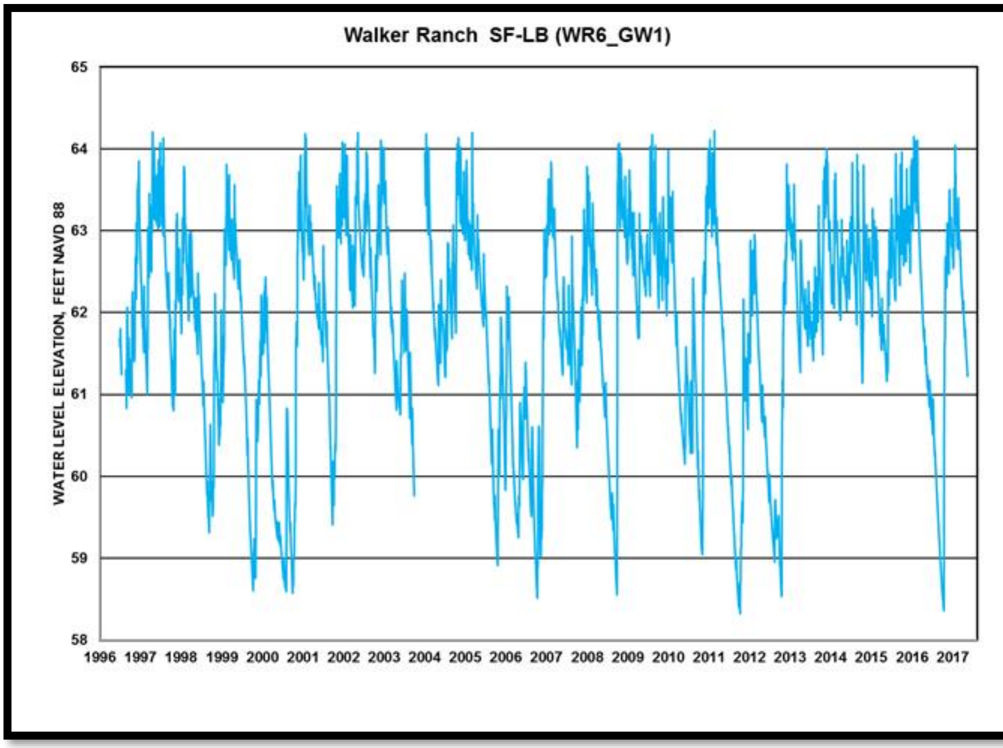

Figure B-9. Period-of-record water level data for Walker Ranch – WR6 (SF-LB).

Walker Ranch – WR9 (SF-XZ)

Walker Ranch – WR9 is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system is a freshwater marsh located within the Disney Wilderness Preserve which is owned and maintained by The Nature Conservancy (TNC) (**Figures B-10, B-11, and B-12**). The TNC regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. Monitoring of this wetland system is conducted by the SFWMD as part of their regional hydrologic monitoring network (**Figure B-13**). The evaluation included pedestrian transects throughout the entire system.

Figure B-10. View of center of Walker Ranch – WR9 (SF-XZ), May 2018.

Figure B-11. Palmetto edge of Walker Ranch – WR9 (SF-XZ), May 2018.

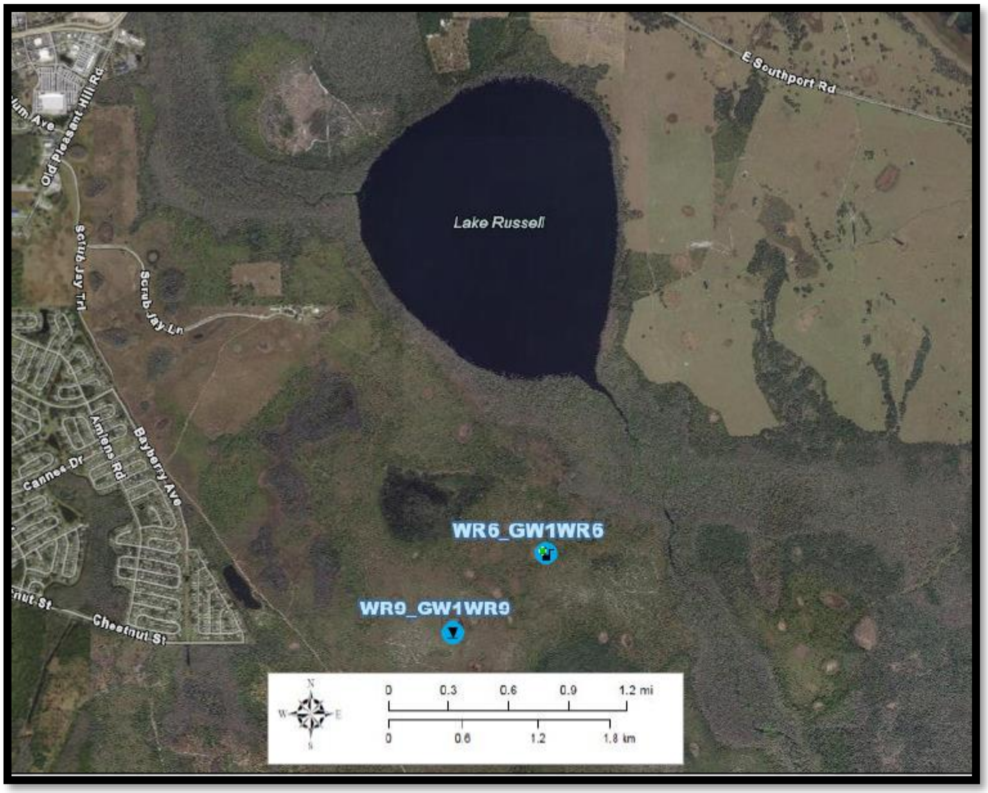

Figure B-12. Vicinity map for Walker Ranch – WR9 (SF-XZ).

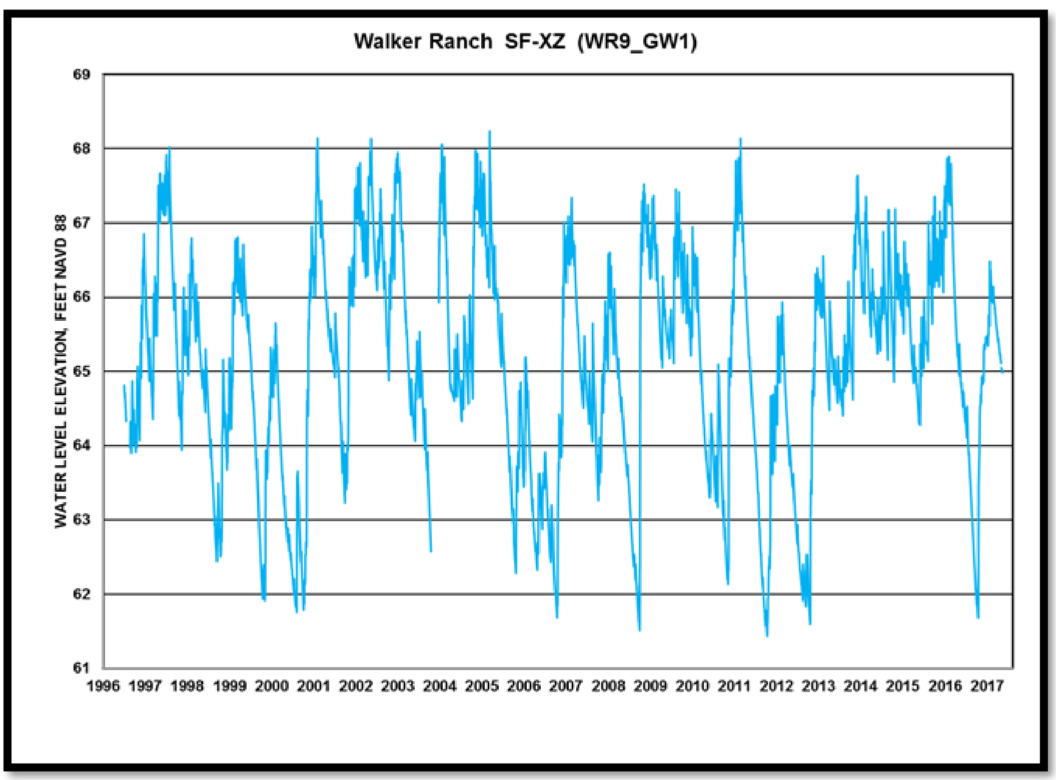

Figure B-13. Period-of-record water level data for Walker Ranch – WR9 (SF-XZ).

Walker Ranch WR-16 (SF-N1)

Walker Ranch WR-16 is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system is a cypress dome located within the Disney Wilderness Preserve which is owned and maintained by The Nature Conservancy (TNC) (**Figures B-14, B-15, B-16, and B-17**). The TNC regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. Monitoring of this wetland system is conducted by the SFWMD as part of their regional hydrologic monitoring network (**Figure B-18**). The evaluation included pedestrian transects throughout the entire system.

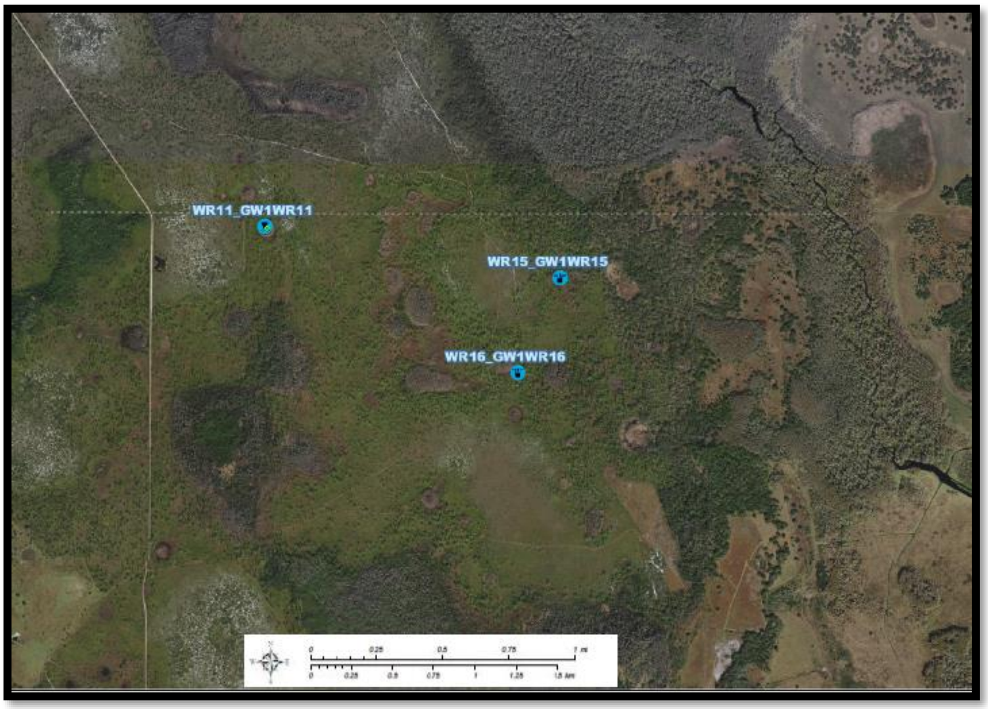

Figure B-14. Vicinity map for Walker Ranch WR-16 (SF-N1).

Figure B-15. Palmetto edge of Walker Ranch WR-16 (SF-N1), May 2018.

Figure B-16. View from edge of Walker Ranch WR-16 (SF-N1), May 2018.

Figure B-17. View from center of Walker Ranch WR-16 (SF-N1), May 2018.

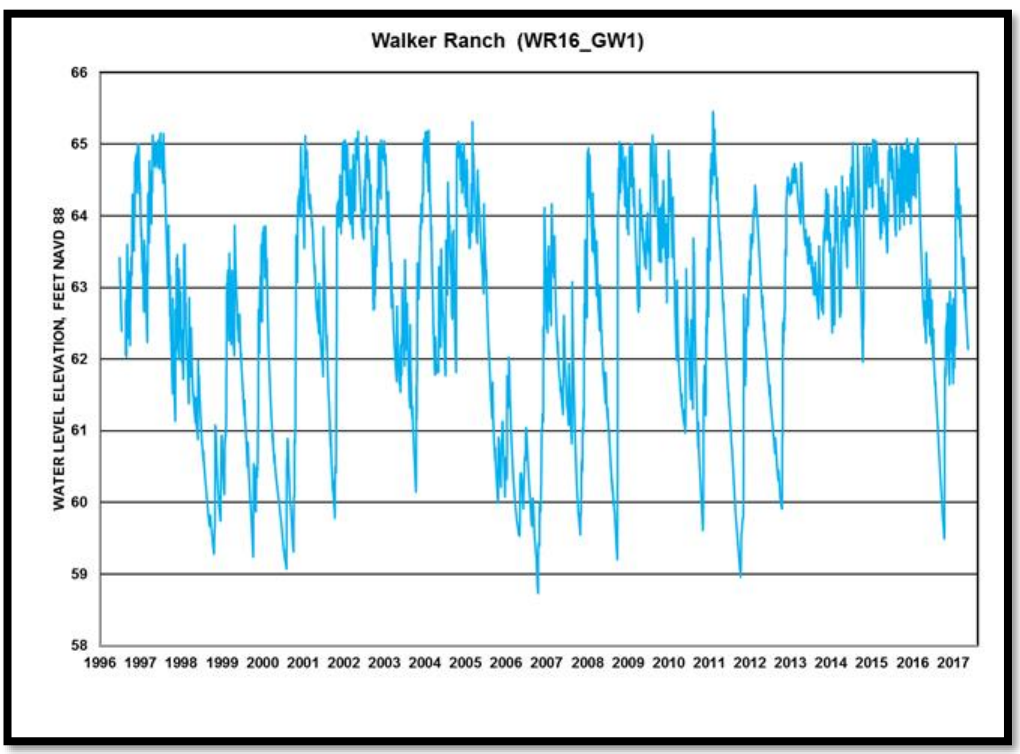

Figure B-18. Period-of-record water level data for Walker Ranch WR-16 (SF-N1).

Walker Ranch WR-15 (SF-N2)

Walker Ranch WR-15 is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system is a cypress dome located within the Disney Wilderness Preserve which is owned and maintained by The Nature Conservancy (TNC) (**Figures B-19, B-20, and B-21**). The TNC regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. Monitoring of this wetland system is conducted by the SFWMD as part of their regional hydrologic monitoring network (**Figure B-22**). The evaluation included pedestrian transects throughout the entire system.

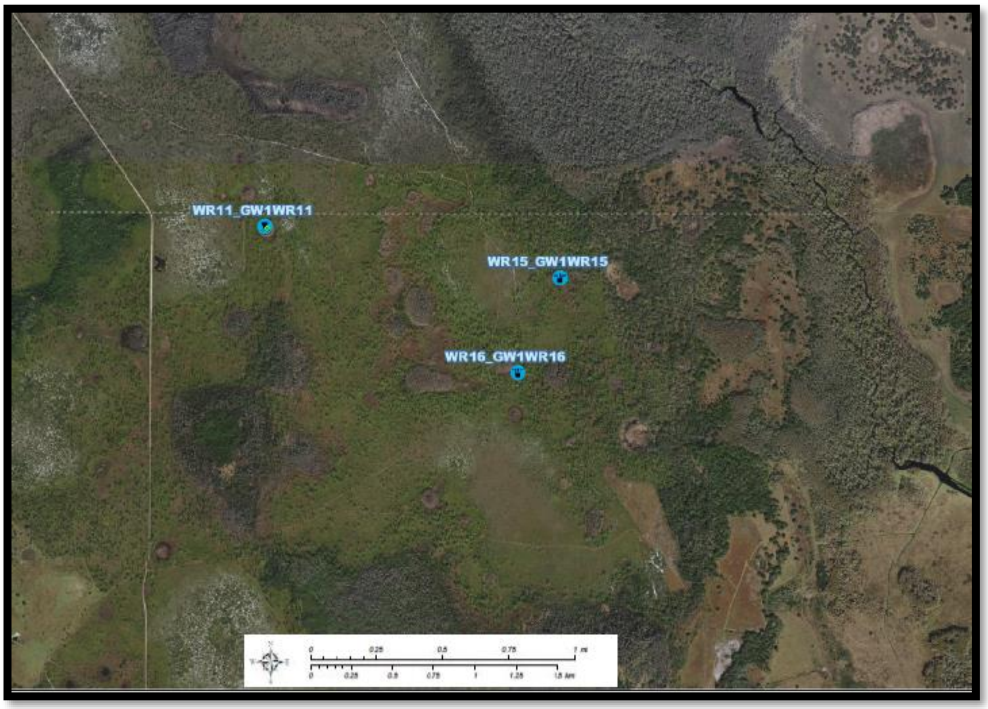

Figure B-19. Vicinity map for Walker Ranch WR-15 (SF-N2), May 2018.

Figure B-20. View from palmetto edge of Walker Ranch WR-15 (SF-N2), May 2018.

Figure B-21. View from central portion of Walker Ranch WR-15 (SF-N2), May 2018.

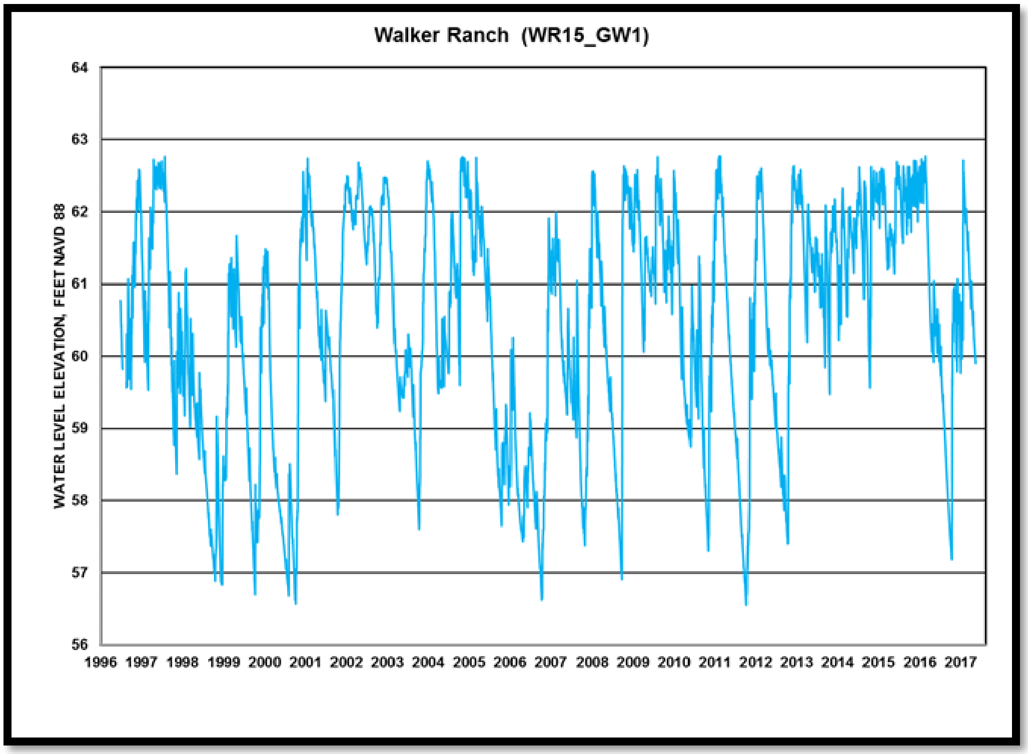

Figure B-22. Period-of-record water level data for Walker Ranch WR-15 (SF-N2).

Split Oak (SF-WT)

Split Oak is a Class 2 Plains wetland that has been added to the Class I wetlands dataset that changed stress status from not stressed to stressed. Monitoring of this wetland system is conducted by the St. Cloud, TOHO Water Authority, Orange County, Polk County, and Reedy Creek Improvement District (STOPR) as part of the wetland monitoring program established by their Water Use Permit (WUP). This system is a cypress strand located within a large area of preservation lands owned jointly between the Florida Fish and Wildlife Conservation Commission (FWC) and Osceola and Orange Counties (**Figure B-23**). The county and FWC regularly use prescribed burns on the adjacent pine flatwoods to maintain the native community. District staff conducted a stress analysis in 2008 and determined it was not stressed. An assessment of the site was conducted on May 7, 2018 during the annual compliance review for the STOPR monitoring sites. Indicators of hydrologic stress observed in the system include, leaning trees, rotting cypress knees, tree fall, the presence of soil fissures within central portion of the cypress dome, exposed tree roots, and evidence of oxidation of the muck layer of the soil (**Figures B-24, B-25, B-26, and B-27**). It should be noted that if the site is assessed during a period of inundation many of these indicators would be masked by the presence of water. The field inspection indicated that this wetland is hydrologically stressed. Access the site is off Clapp Simms Duda Road.

Figure B-23. Vicinity map for Split Oak (SF-WT).

Figure B-24. Tree fall on northern portion of Split Oak (SF-WT), May 2018.

Figure B-25 Tree fall on northern portion of Split Oak (SF-WT), May 2018.

Figure B-26. Soil subsidence within northern portion of Split Oak (SF-WT), May 2018.

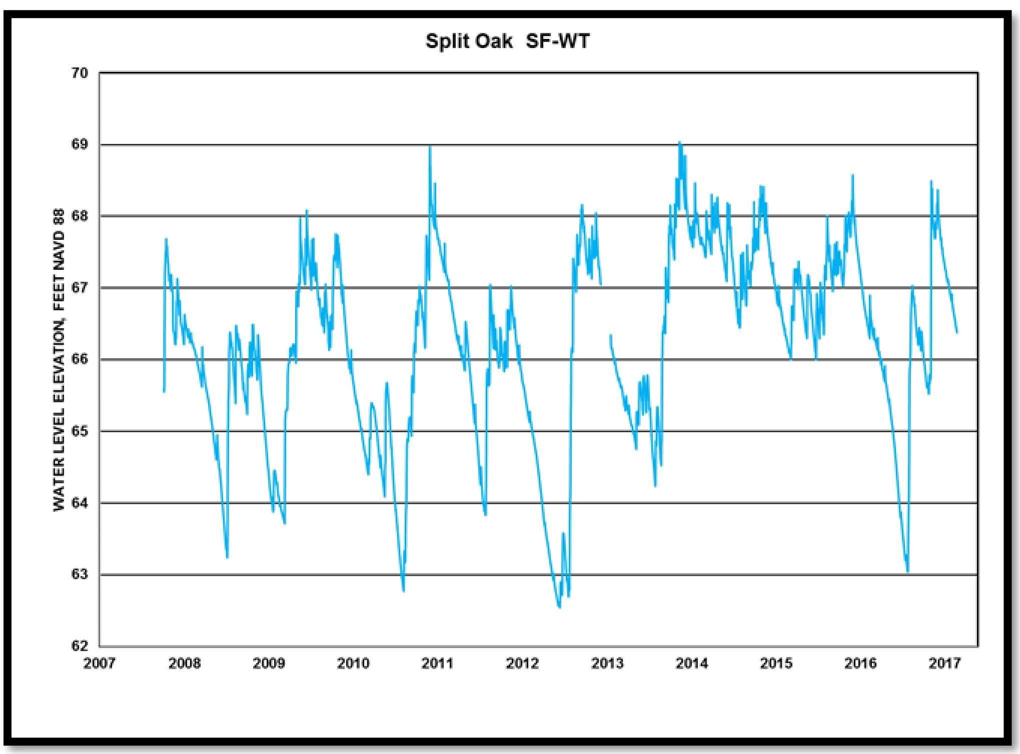

Figure B-27. Period-of-record water level data for Split Oak (SF-WT).

Tibet Butler (SF-YK)

Tibet Butler is a Plains wetland that changed stress status from stressed to not stressed. The wetland is a small cypress dome located within the Tibet-Butler Preserve (**Figures B-29 and B-30**). The 440-acre Preserve was purchased by the SFWMD through the "Save Our Rivers" Program and is managed by Orange County Parks and Recreation. The county regularly uses prescribed burns on the adjacent pine flatwoods to maintain the native community. The field inspection indicated that this wetland hydrologic condition is improving and has been determined to not be hydrologically stressed during this assessment (**Figure B-31**). The review of the period-of-record staff gage data indicates that water levels in recent years appear to be on an increasing trend (**Figure B-32**). The evaluation included pedestrian transects throughout the entire system. Access to the site is through the onsite trail system.

Figure B-29. Vicinity Map - Tibet Butler (SF-YK).

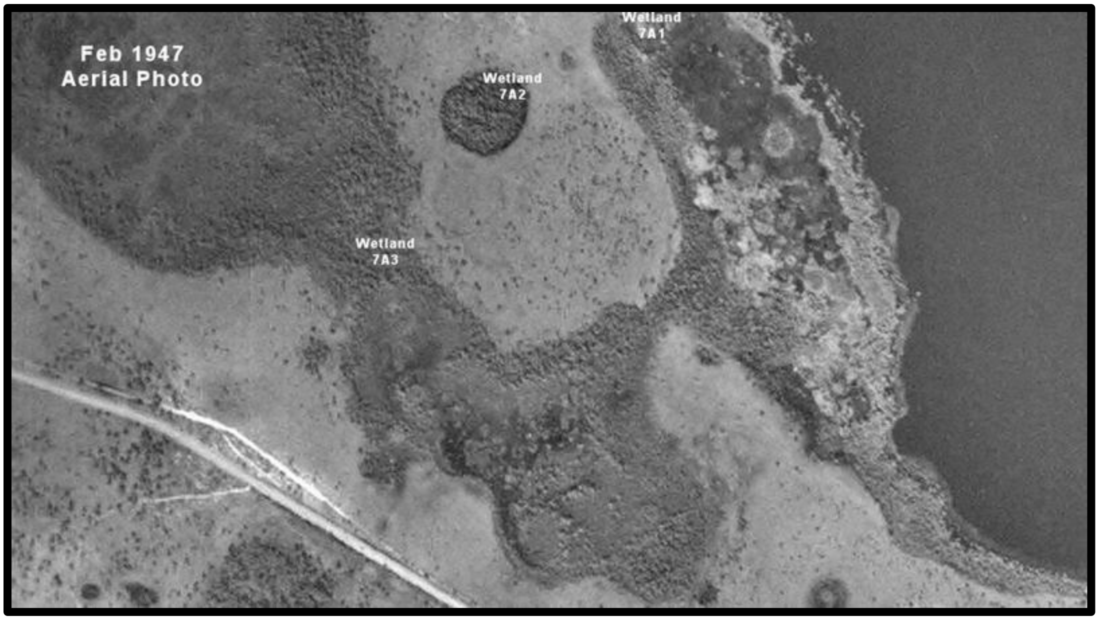

Figure B-30. Aerial photo, 1927 Tibet Butler (SF-YK).

Figure B-31. Tibet Butler (SF-YK), January 2018.

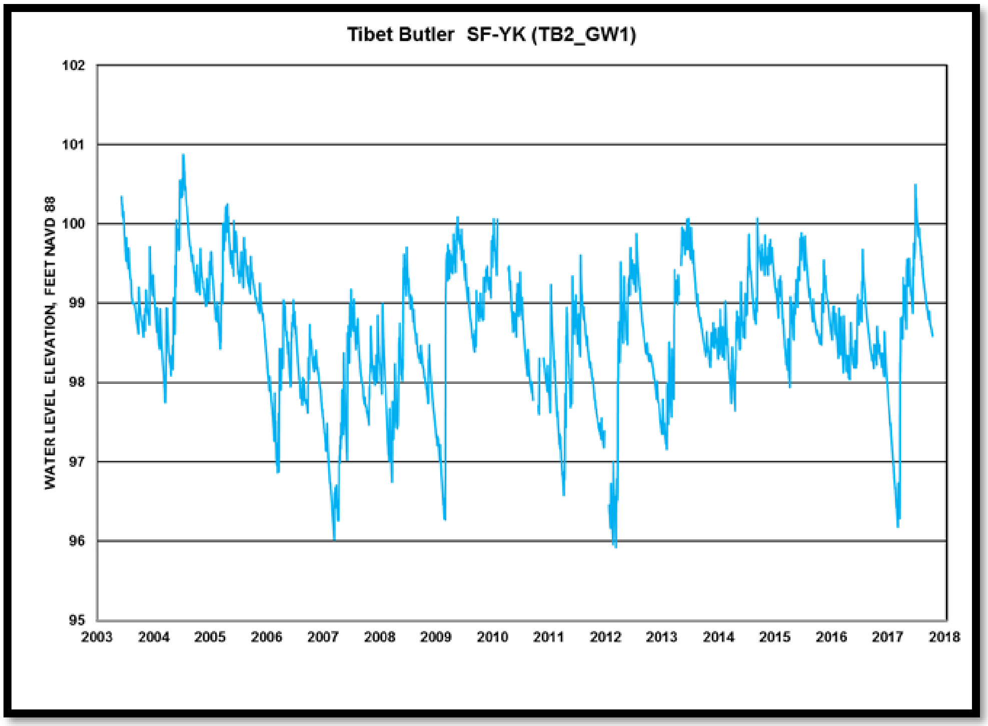

Figure B-32. Period-of-record water level data for Tibet Butler (SF-YK).

Lake Gem (SJ-AJ)

Lake Gem is a Plains lake that changed stress status from stressed to not stressed (Figures B-33 and B-34). Monitoring of this wetland system is conducted by OUC as part of the wetland monitoring program established by their CUP. Previous and current evaluations did not reveal ecological indicators of hydrologic stress. The original determination of stressed appears to be based on the presence of a ditch along the western side of the lake which discharges offsite when the lake reaches higher water levels. However, the hydrology within the lake appears to be stable and consistent with expected regional hydrologic conditions (Figure B-35). An analysis of water level data for the period of record selected for the EMT wetlands analysis for Lake Gem indicated that this site is not representative of groundwater-dominated wetlands in the CFWI Planning Area; therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP. Access to the system is through the Canterbury Retreat off of SR 434. A walking trail extends around the perimeter of the lake.

Figure B-33. Vicinity map for Lake Gem (SJ-AJ).

Figure B-34. Lake Gem, May 2018.

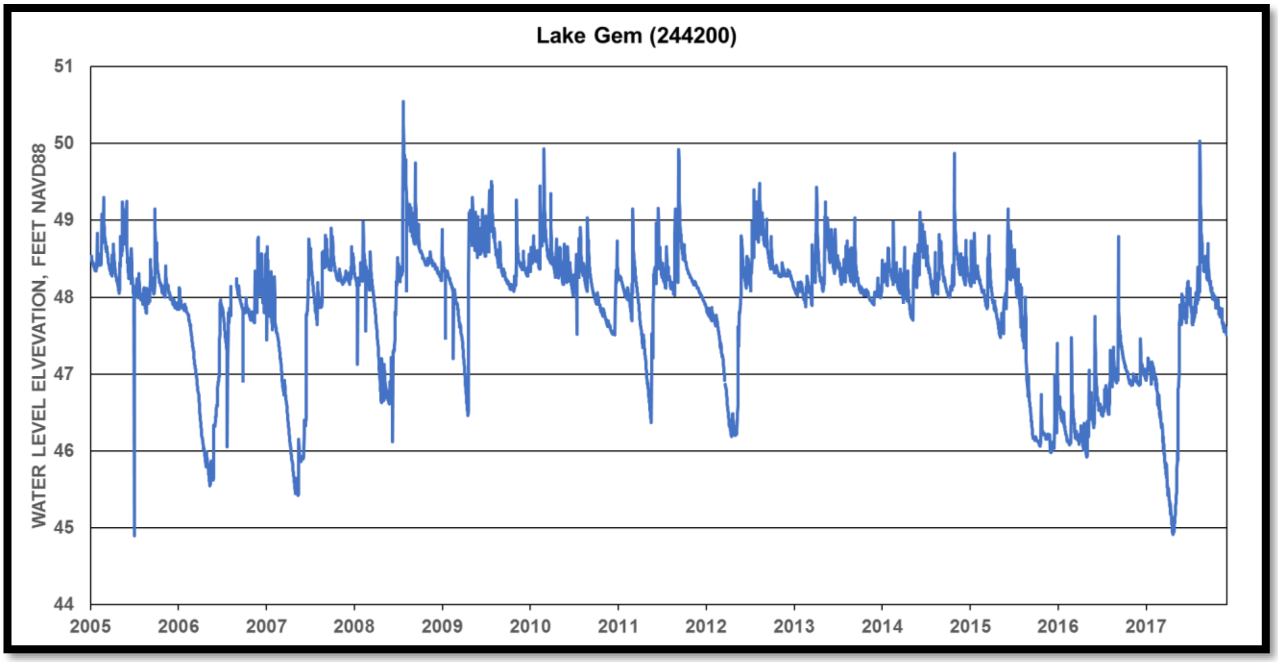

Figure B-35. Period-of-record water level data for Lake Gem (SJ-AJ).

Unnamed Cypress (SJ-LA)

Unnamed Cypress is an unstressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by the Orlando Utilities Commission (OUC) as part of the wetland monitoring program established by their CUP. This system is a cypress wetland surrounded by homes and roadways and has been incorporated into the surface water management system for the surrounding development (**Figure B-36**). The upland buffer of flatwoods vegetation surrounding the wetland has become overgrown and fire suppressed (**Figure B-37**). At higher stages, this wetland outfalls to the adjacent stormwater system (**Figure B-38**). Access to the system is off of Cypress Lake Glen Boulevard.

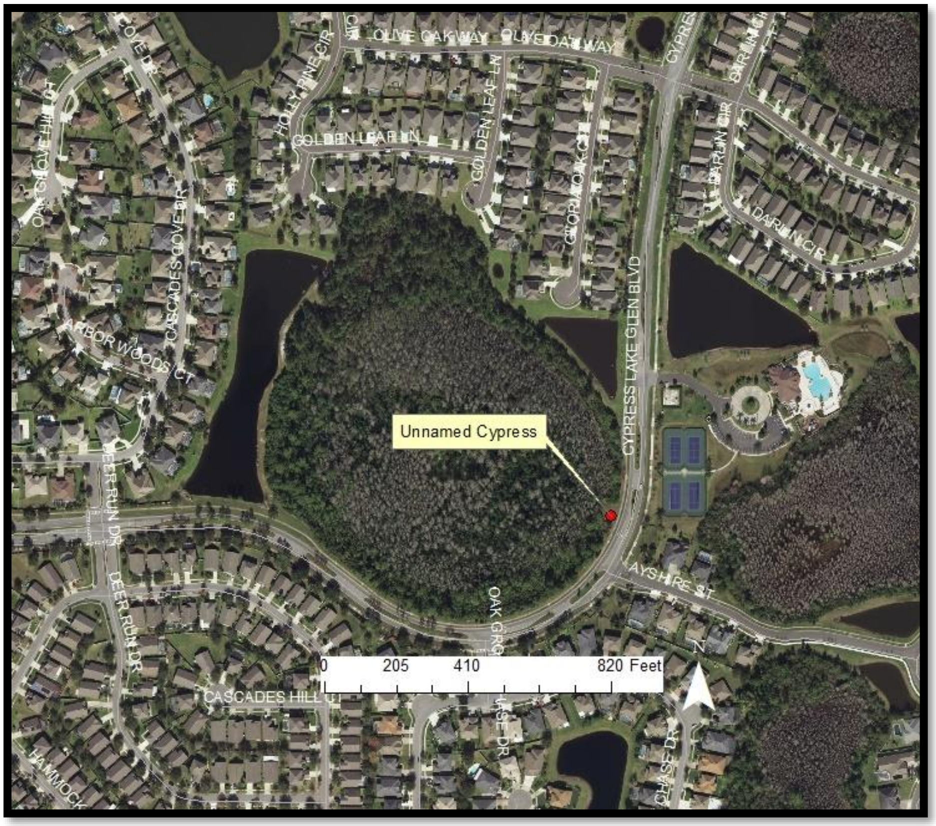

Figure B-36. Vicinity map for Unnamed Cypress (SJ-LA).

Figure B-37. Unnamed Cypress (SJ-LA), May 2018

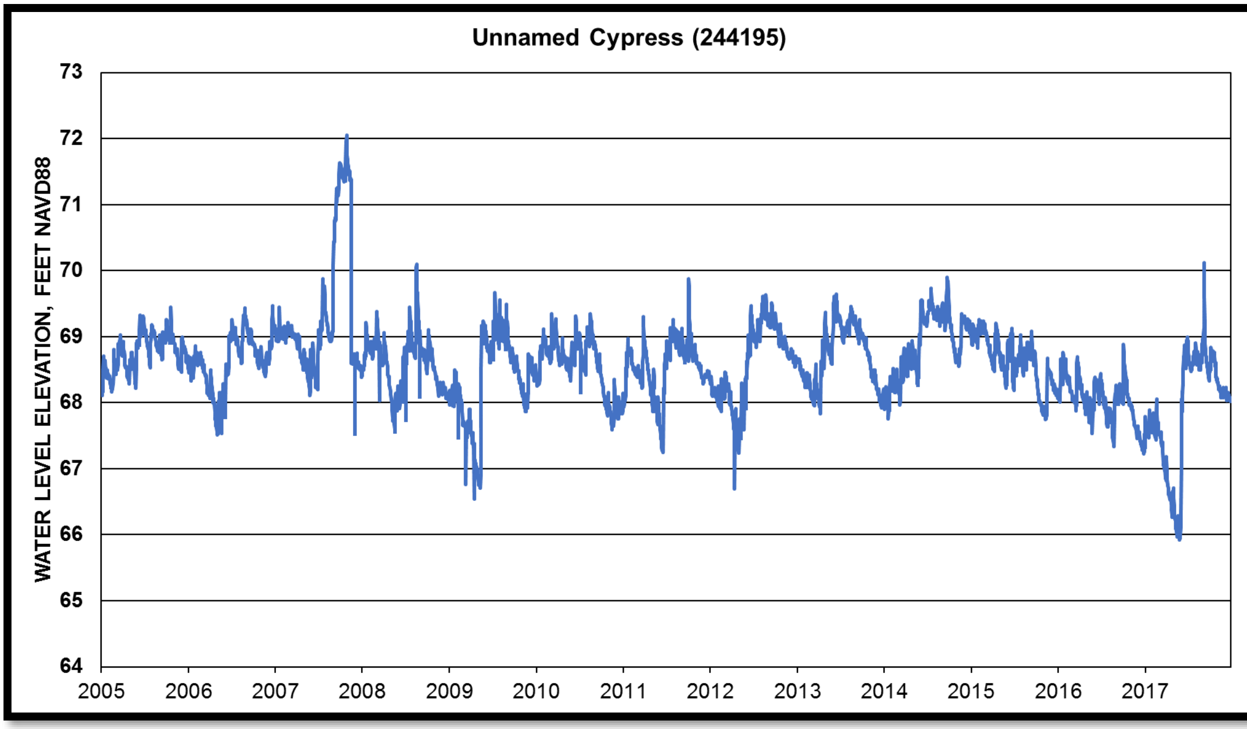

Figure B-38. Period-of-record water level data for Unnamed Cypress (SJ-LA**).**

Unnamed Wetland South of SR 46 (SJ-LB)

Unnamed Wetland is a stressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by Seminole County as part of the wetland monitoring program established by their CUP. This system consists of a small lake with a wetland edge surrounded by homes, roadways, and commercial properties (**Figure B-39**). Overall, the system is characterized by moderate relief from the adjacent uplands, through a narrow wetland edge to the open water portion of the system (**Figure B-40**). The patchy upland vegetation surrounding most of the wetland has become overgrown and is fire suppressed. Access to the system is through the commercial property in the northwest corner of the lake off of SR 46.

Figure B-39. Vicinity map for Unnamed Wetland South of SR 46 (SJ-LB).

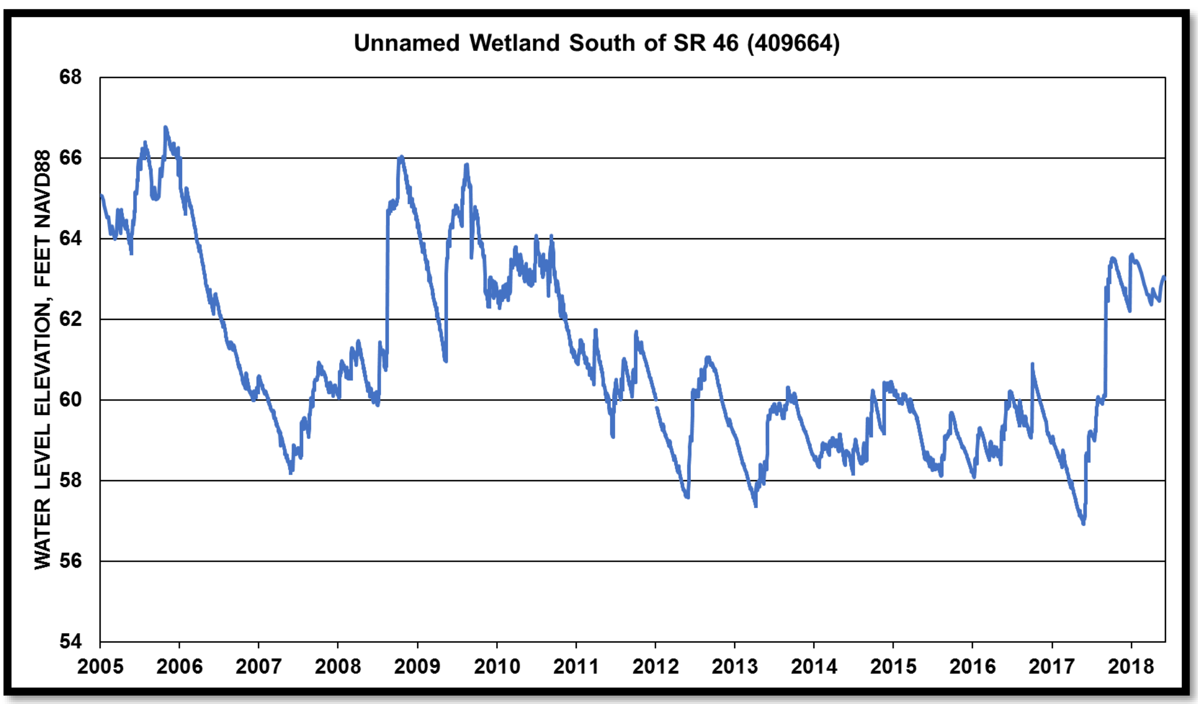

Figure B-40. Available period-of-record water level data for Unnamed Wetland South of SR 46.

Boggy Marsh (SJ-LC)

Boggy Marsh is a stressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by the St. Johns River Water Management District (SJRWMD) as part of their regional hydrologic monitoring network (**Figure B-41**). This system consists of a linear strand/slough wetland, bounded by agricultural properties to the west and residential developments on the east (**Figure B-42**). Historically, the system extended further to the north and south, and was likely connected to the larger swamp system to the west. However, this portion of the system has been isolated by roads to the north and south and the agricultural activity to the west. The system is predominantly characterized by herbaceous freshwater marsh with scattered bayhead "islands." A narrow fringe of upland vegetation persists around much of the perimeter of the wetland; however, along some segments the improved pasture may extend to or beyond the wetland edge (**Figure B-43**). Access to this wetland is along North Boggy Marsh Road.

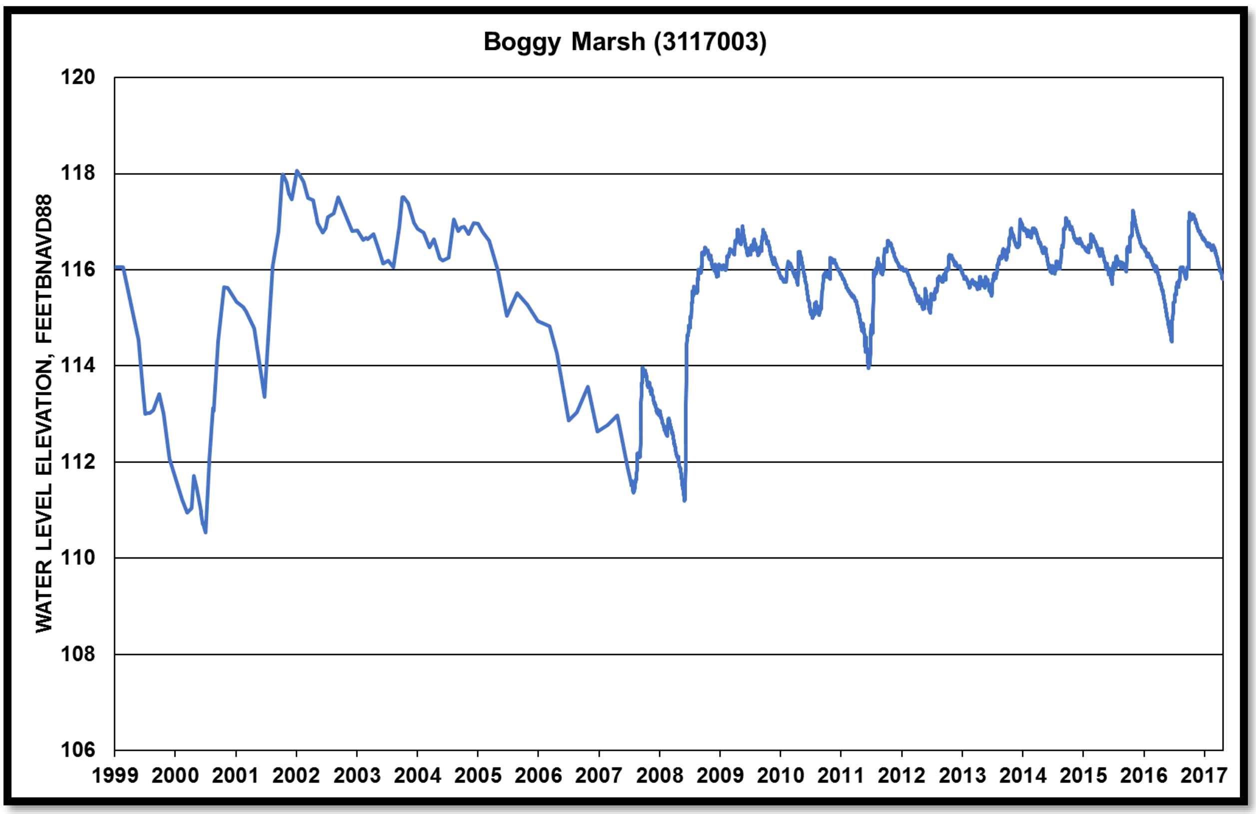

Figure B-41. Available period-of-record water level data for Boggy Marsh (SJ-LC).

Figure B-42. Vicinity map for Boggy Marsh (SJ-LC).

Figure B-43. Boggy Marsh (SJ-LC), May 2018.

Hopkins Prairie (SJ-LD)

Hopkins Prairie is one of the largest natural wetland features in the Ocala National Forest and is located outside of the CFWI Planning Area (**Figure B-44**). Hopkins Prairie is an unstressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. The wetland system consists of an elongated freshwater marsh dominated by herbaceous grasses and sedges (**Figure B-45**). At lower water levels, several pockets of open water generally persist in the eastern portion of the system. Monitoring of this wetland system is conducted by SJRWMD as part of their regional hydrologic monitoring network (**Figure B-46**). The system is accessed via FR 86 off of US 19.

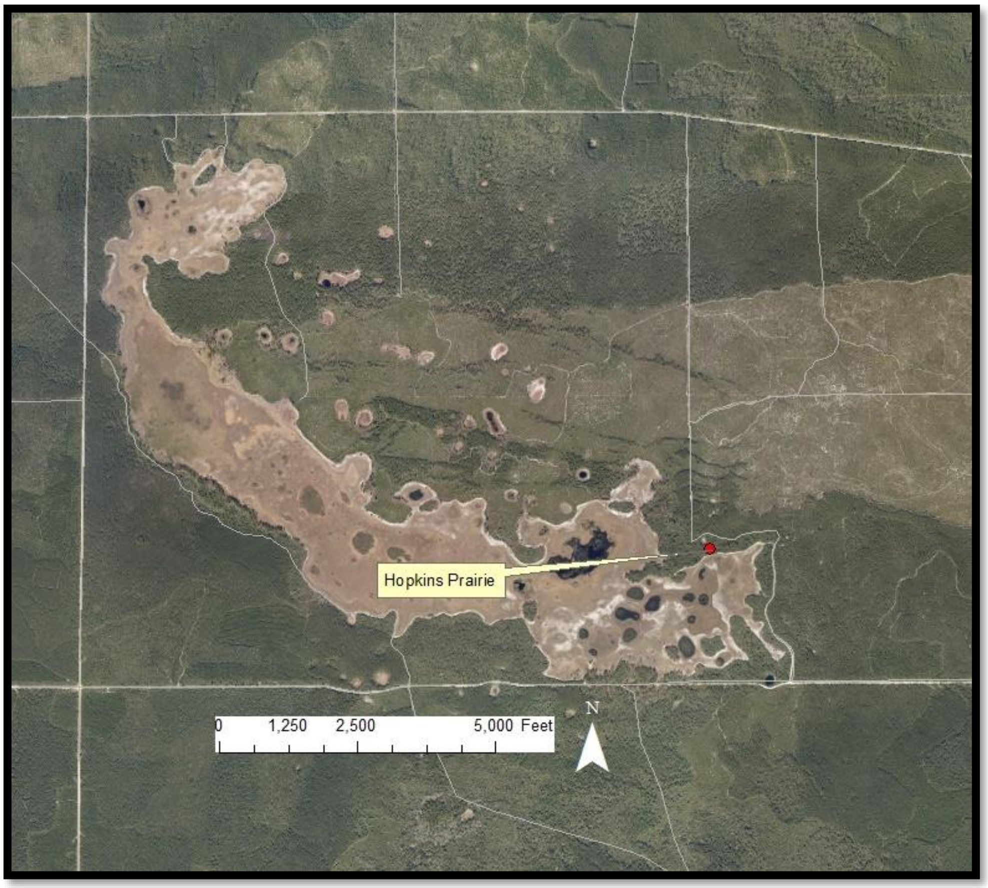

Figure B-44. Vicinity map for Hopkins Prairie (SJ-LD).

Figure B-45. Hopkins Prairie (SJ-LD), June 2018.

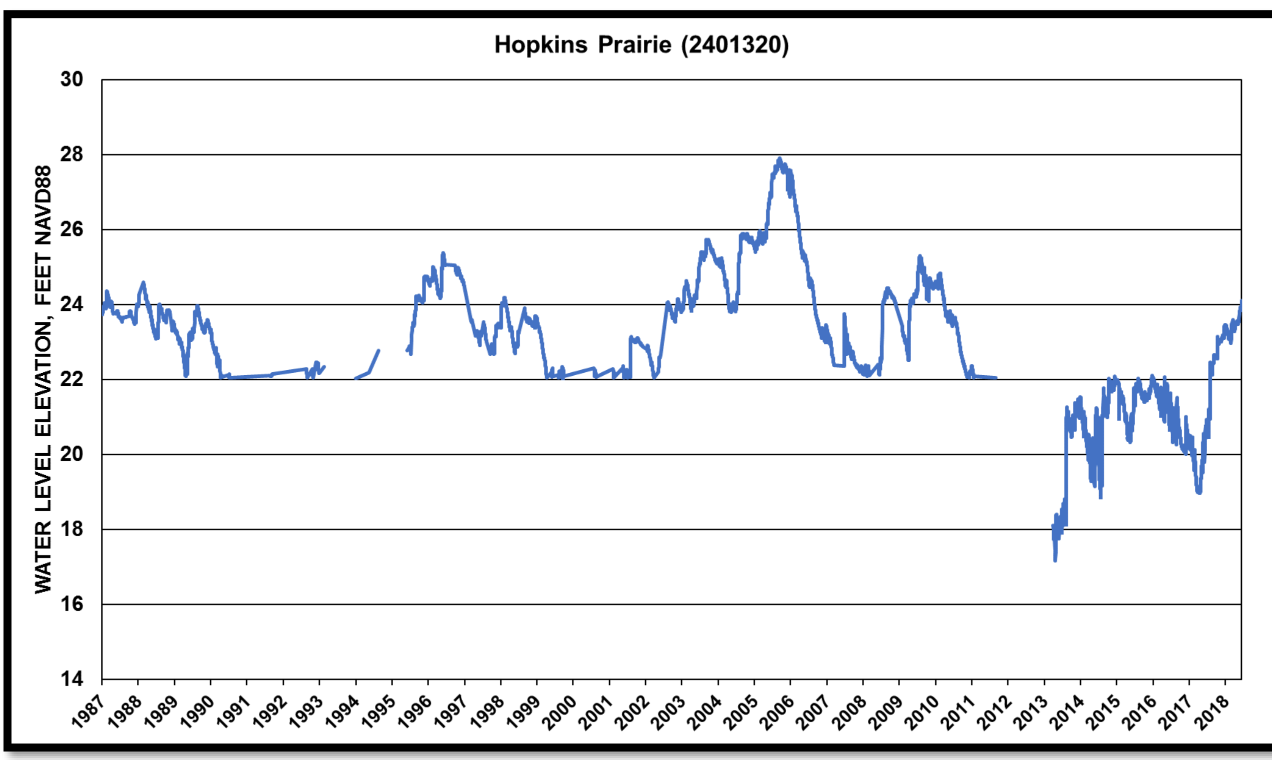

Figure B-46. Available period-of-record water level data for Hopkins Prairie (SJ-LD).

Lake Avalon (SJ-LE)

Lake Avalon is a stressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system consists of a xeric lake, bounded by agricultural properties to the south, single family residential properties in the southwest, and a new residential development on the north (**Figure B-47**). Monitoring of this wetland system is conducted by the SJRWMD as part of their regional hydrologic monitoring network (**Figure B-48**). The system is predominantly characterized by open water with a narrow littoral edge with herbaceous wetland species. The northeast portion of the system is dominated by a shallow herbaceous freshwater marsh with scattered wetland hardwoods (**Figure B-49**). Access to this wetland is along Marsh Road; however, the new development may limit historic access to the open water portion of the system.

Figure B-47. Vicinity map for Lake Avalon (SJ-LE).

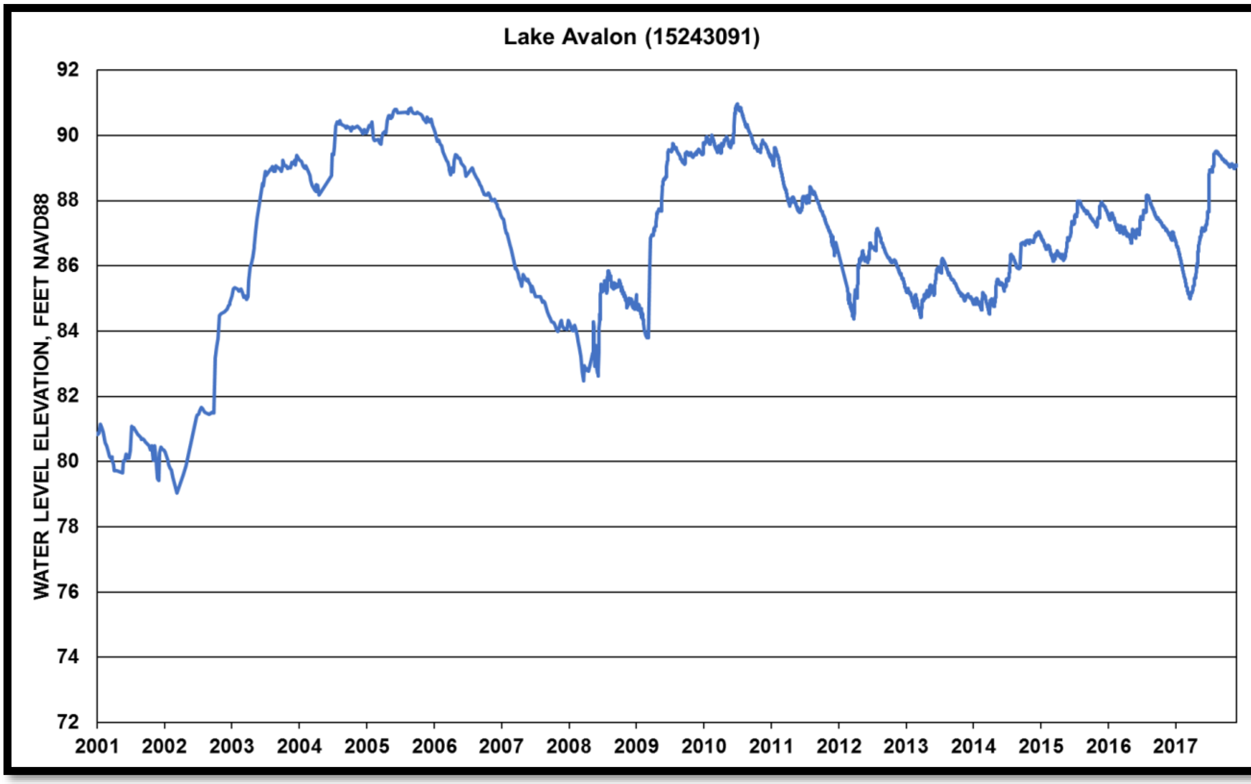

Figure B-48. Available period-of-record water level data for Lake Avalon (SJ-LE).

Figure B-49. Lake Avalon (SJ-LE), May 2018.

Lake Apshawa (SJ-LF)

Lake Apshawa is a stressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. This system consists of a xeric lake with a very steep grade from the upland community to the wetlands, bounded by single family residential properties (**Figure B-50**). Monitoring of this wetland system is conducted by the SJRWMD as part of their regional hydrologic monitoring network (**Figure B-51**). The system is predominantly characterized by open water with a narrow littoral edge with herbaceous wetland species (**Figure B-52**). The bulk of the residential parcels are maintained to the water's edge. Access to this system is through one of the residential parcels or one of the several undeveloped parcels along the lake.

Figure B-50. Vicinity map for Lake Apshawa (SJ-LF).

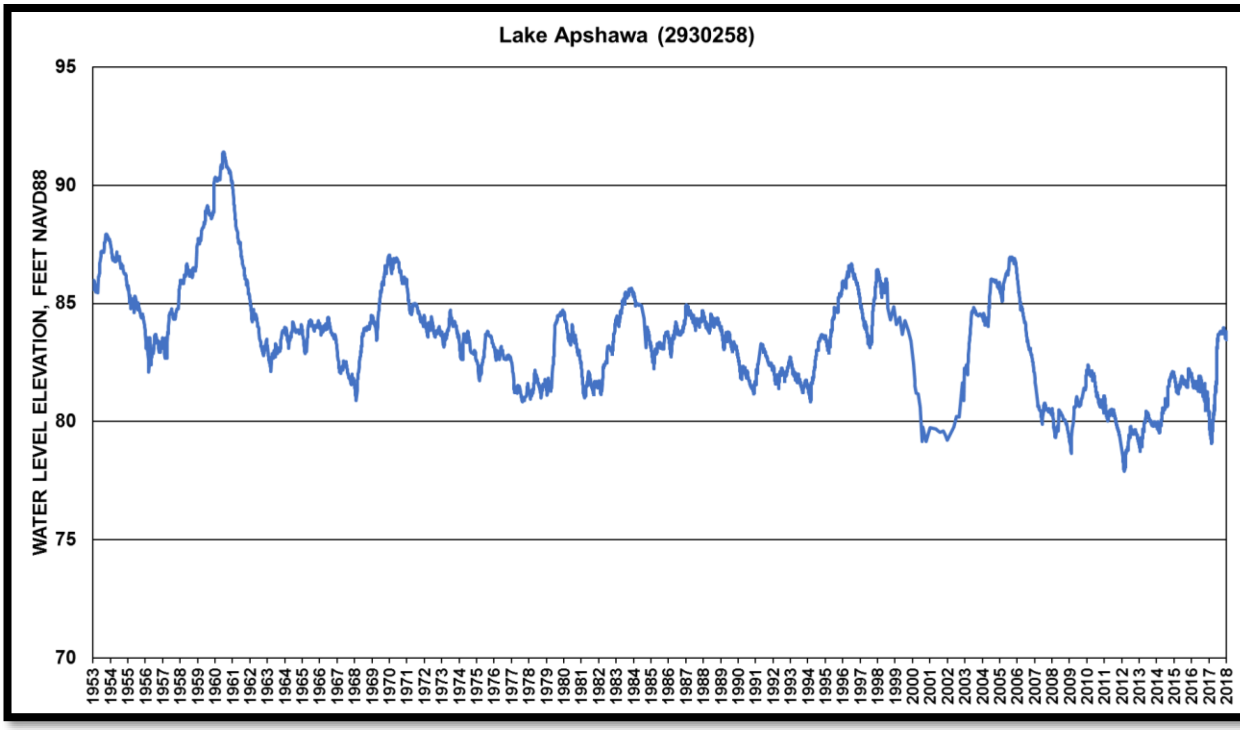

Figure B-51. Available period-of-record water level data for Lake Apshawa (SJ-LF).

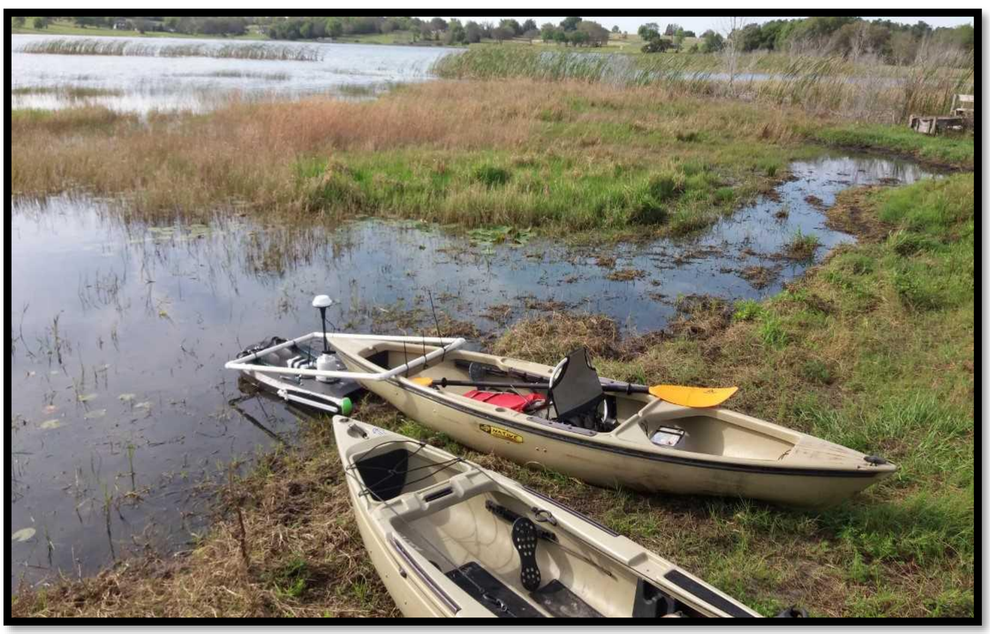

Figure B-52. Lake Apshawa (SL-LF), March 2019.

Island Lake (SJ-LH)

Island Lake is a Plains wetland that changed stress status from stressed to not stressed (Figures B-53 and B-54). Monitoring of this wetland system is conducted by the OUC as part of the wetland monitoring program established by their CUP. Previous and current evaluations did not reveal ecological indicators of hydrologic stress. The original determination of stressed was based in part on the observation that islands within the marsh system appeared to have expanded based on review of historic aerials dating back to the 1950s. Water levels within the marsh, which is surrounded by a highly-urbanized area, appear to be stable and consistent with regional climatic conditions, and as indicated by the review of water level monitoring data, surficial aquifer levels have shown an overall, gradual increase since 2005 (Figure B-55). With the exception of edge effects resulting from the adjacent developments, the marsh system is healthy (Figure B-54). An analysis of water level data for the period of record selected for the EMT wetlands analysis for Island Lake indicated that this site is not representative of groundwater-dominated wetlands in the CFWI Planning Area; therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP but was added to the Class 2 wetlands dataset. The lake can be accessed through the commercial property in the northern portion of the system off of SR 434.

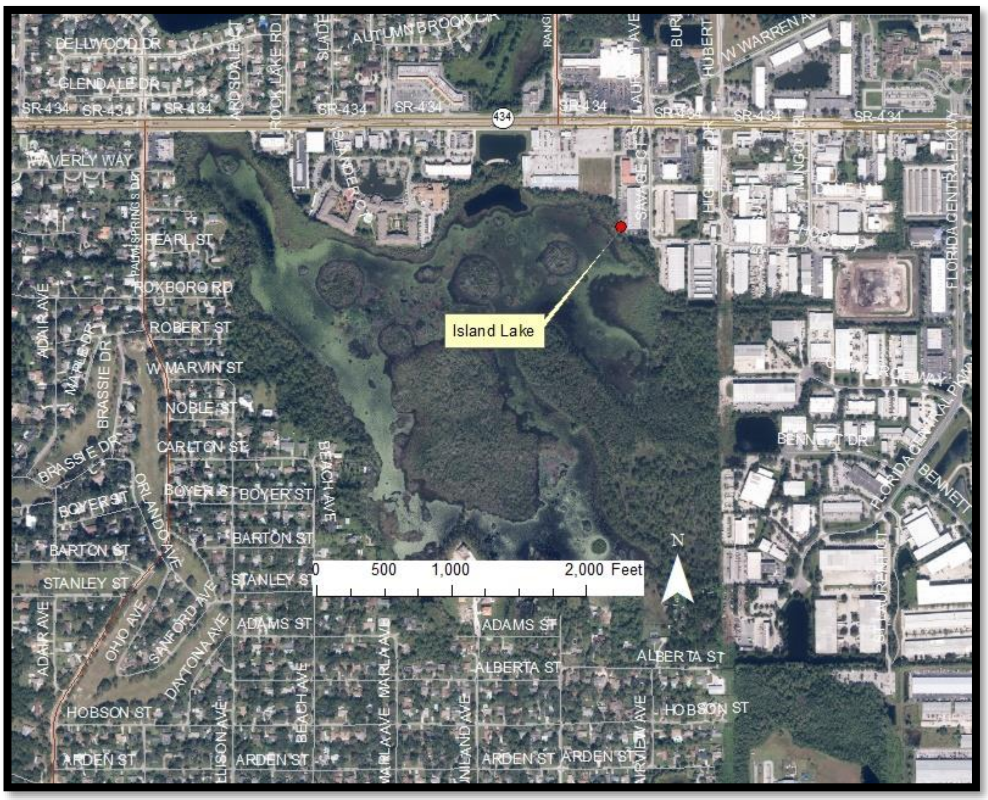

Figure B-53. Vicinity map for Island Lake (SJ-LH).

Figure B-54. Island Lake (SJ-LH), July 2018.

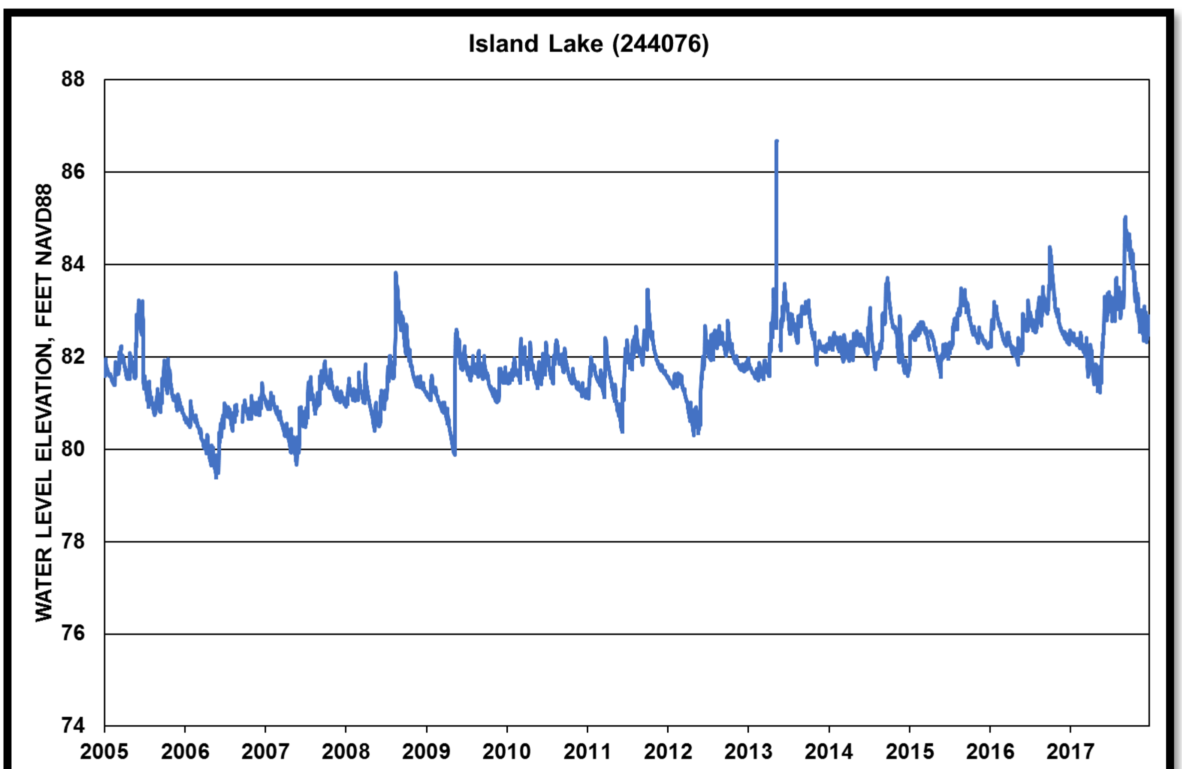

Figure B-55. Available period-of-record water level data for Island Lake (SJ-LH).

Lake Sylvan (SJ-LI)

Lake Sylvan is a Plains lake, that is accessed through Sylvan Lake Park, that changed stress status from not stressed to stressed (**Figure B-56**). Since the EMT determined the lake to be unstressed during the original evaluation, the lake has been visited multiple times. Monitoring of this wetland system is conducted by Seminole County as part of the wetland monitoring program established by their CUP. Indicators of hydrologic stress observed during low water periods within the system include the presence of soil fissures within exposed lower reaches of marsh areas, encroachment of pines and invasive species into the wetland areas, exposed tree roots, and the absence of regeneration of wetland tree species along the wetland boundaries (**Figure B-57**). In the past, Lake Sylvan has been subject to flooding during periods of excessive or extended rainfall. To address concerns of flooding from the residential neighborhoods that border the lake, a gated flood control outfall structure was constructed in 2014. During the evaluation of this system, concerns were raised regarding the outfall structure and its potential impact on the determination of stress for the lake. A review of water level data collected for the lake during the period of record indicated that the water levels within the lake did not appear to reach flood stage or necessitate opening of the structure (**Figure B-58**). Water can still outfall through the structure with the gate closed, but only when water levels reach an elevation close to that of the historic outfall that was present prior to construction of the structure. Water level data indicates that levels within the lake during the selected period of record only exceeded the historic outfall elevation during high water events in 2009 and 2010 (**Figure B-58**). Therefore, it is unlikely that the outfall structure or historic outfall to the ditch have had a significant impact on water levels within the lake during the selected period of record. A subsequent evaluation of the water level data indicates that the data for the selected period of record reflects a fairly normal distribution of frequency of water level differences from the wetland edge elevation as compared to other Plains wetlands in the dataset. The site was selected as a DMIT monitoring location, and three transects were established on the southwest and central sections of the lake.

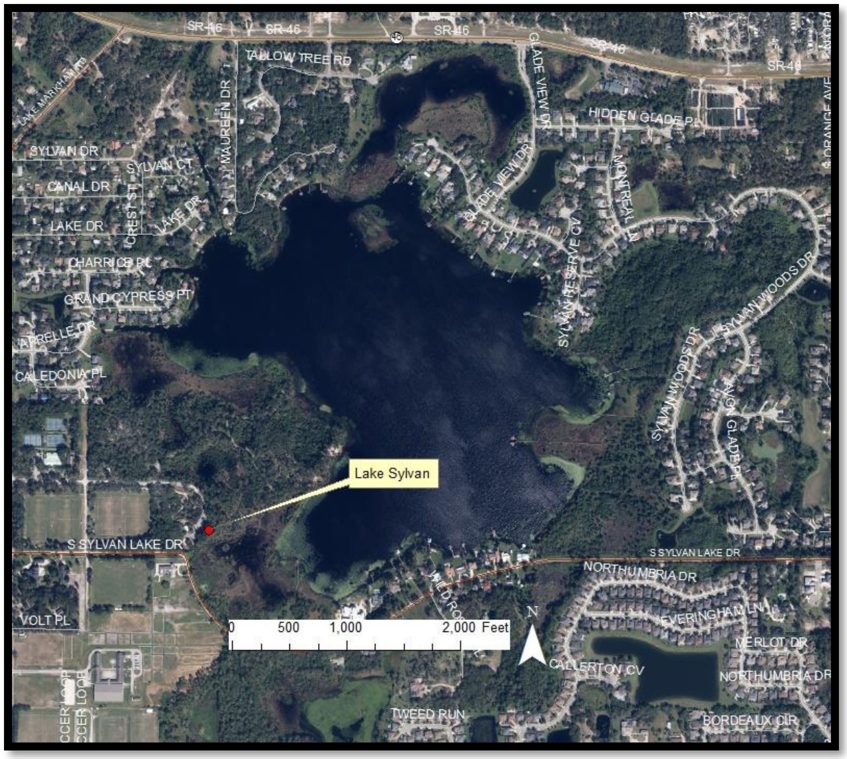

Figure B-56. Vicinity map for Lake Sylvan (SJ-LI).

Figure B-57. Lake Sylvan (SJ-LI), May 2018.

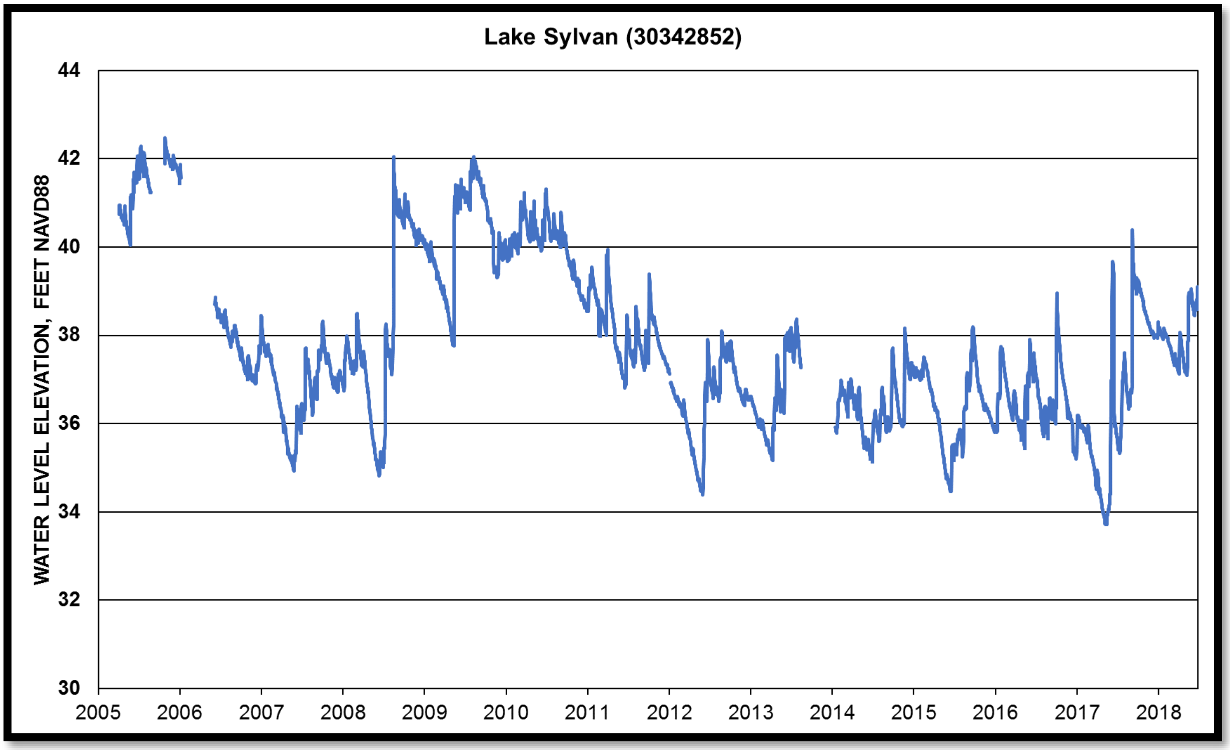

Figure B-58. Available period-of-record water level data for Lake Sylvan (SJ-LI).

City of Cocoa, Well 9T (SJ-LL)

City of Cocoa, Well 9T is a stressed Plains wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation (**Figure B-59**). Monitoring of this wetland system is conducted by the City of Cocoa as part of the wetland monitoring program established by their CUP (**Figure B-60**). This system consists of a large cypress wetland surrounded by improved pasture. Historically, the system extended further to the south, but has been bisected by Cocoa Water Plant Road. There are some small areas of intact upland vegetation around the perimeter of the system; however, along much of the wetland the improved pasture extends to or beyond the wetland edge (**Figure B-61**). Access to this wetland is through the City of Cocoa's Dyal Water Plant off of SR 520.

Figure B-59. Vicinity map for City of Cocoa 9T (SJ-LL).

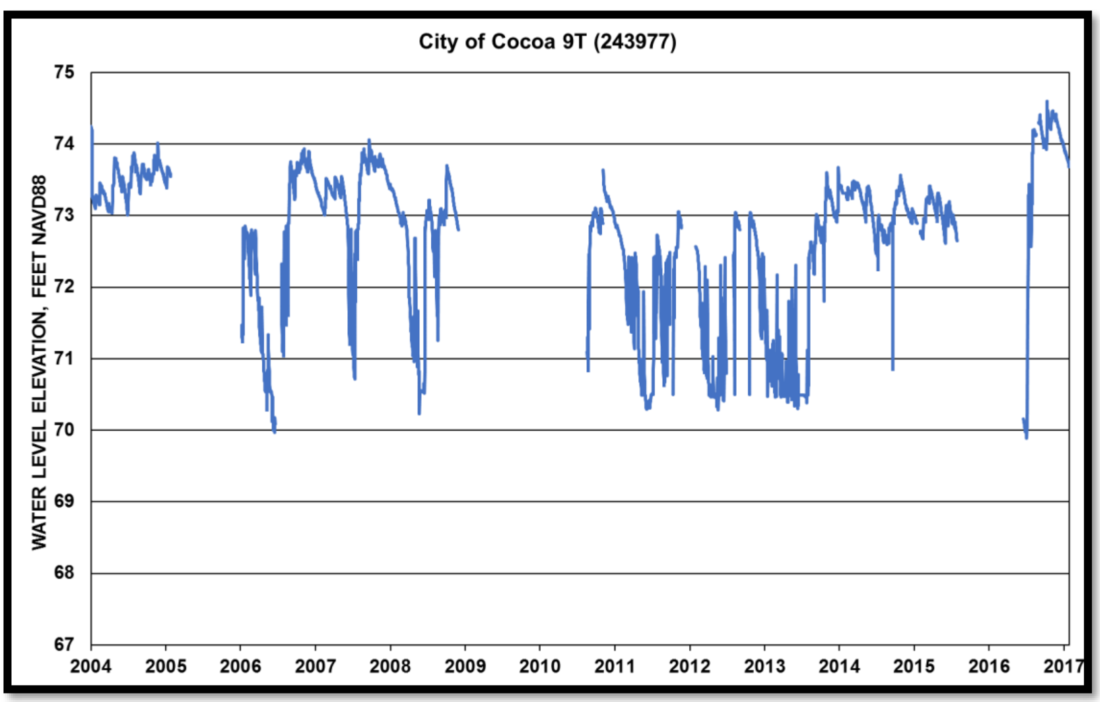

Figure B-60. Available period-of-record water level data for City of Coco 9T (SJ-LL).

Figure B-61. 9T City of Cocoa (SJ-LL), May 2018.

Church Lake (SJ-QA)

Church Lake is a stressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by the United States Geological Survey (USGS) as part of their regional hydrologic monitoring network. This system is a shallow lake surrounded by improved pasture and silviculture, SR 27 to the north, and a residential development to the east (**Figure B-62**). Water level data and visual observations indicate that this system experiences a wide fluctuation range and during periods of low water, several deeper pools persist (**Figures B-63 and B-64**). Over the last few years, the USGS has significantly reduced the frequency for data collection on this system, and it is not likely that sufficient data will be collected for future EMT evaluations. Access to the system is through The Woodlands subdivision of off US Highway 27.

Figure B-62. Vicinity map for Church Lake (SJ-QA).

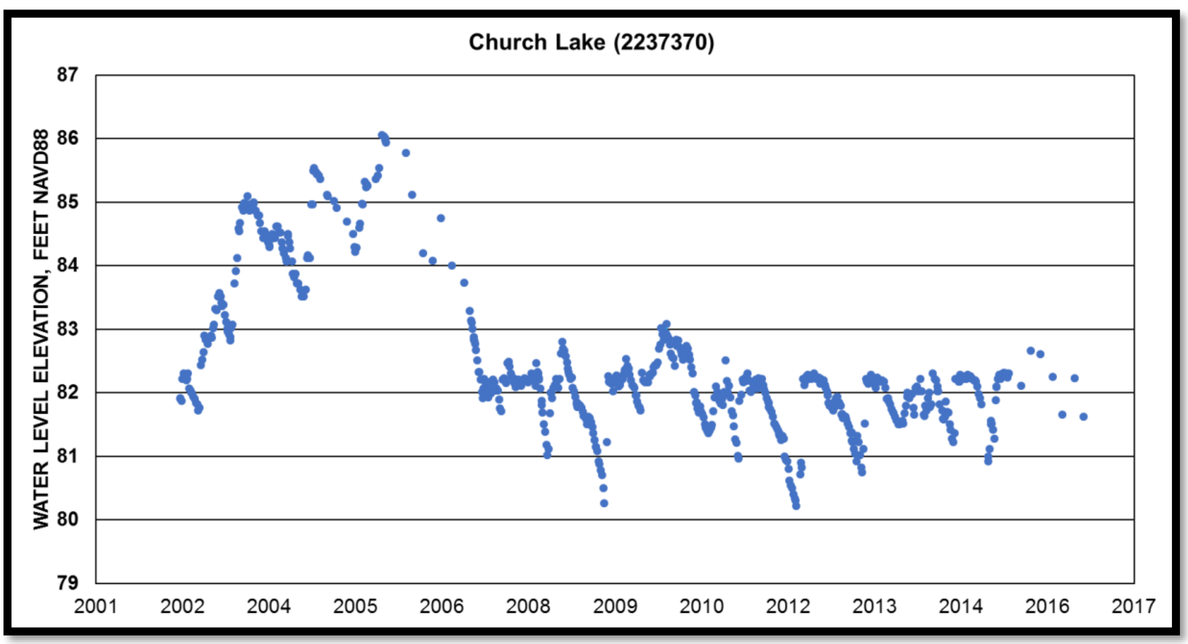

Figure B-63. Available period-of-record water level data for Church Lake (SJ-QA).

Figure B-64. Church Lake (SJ-QA), June 2018.

Johns Lake (SJ-QB)

Johns Lake is an unstressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation (**Figure B-65**). Monitoring of this wetland system is conducted by the SJRWMD as part of their regional hydrologic monitoring network (**Figure B-66**). This system consists of a lake, surrounded by xeric soils and bounded by agricultural and residential properties. The system is predominantly characterized by open water with a narrow littoral edge with herbaceous wetland species (**Figure B-67**). The site was selected as a DMIT monitoring location. and transects were established on preserve property on the southern section of the lake. Access to this wetland for EMT evaluations has been at the end of Johns Lake Road.

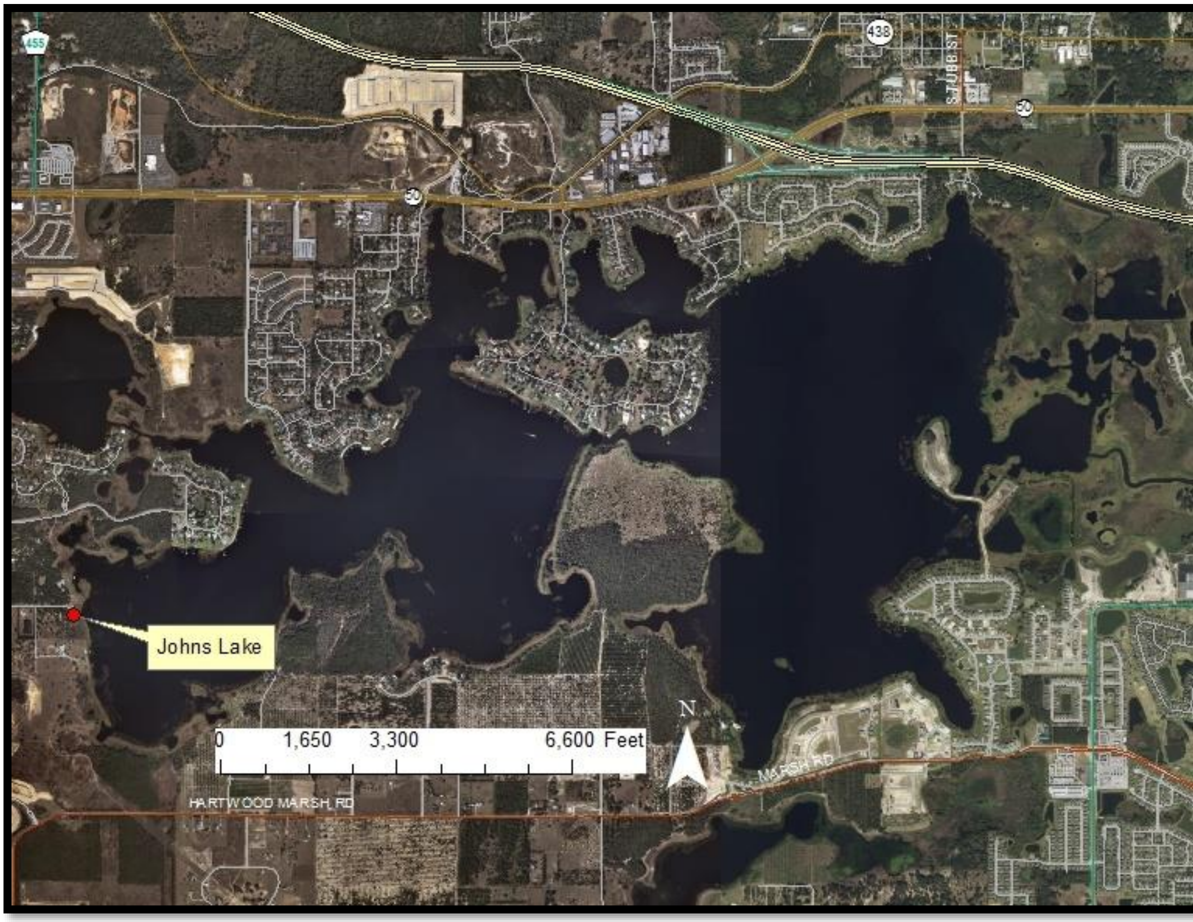

Figure B-65. Vicinity map for Johns Lake (SJ-QB).

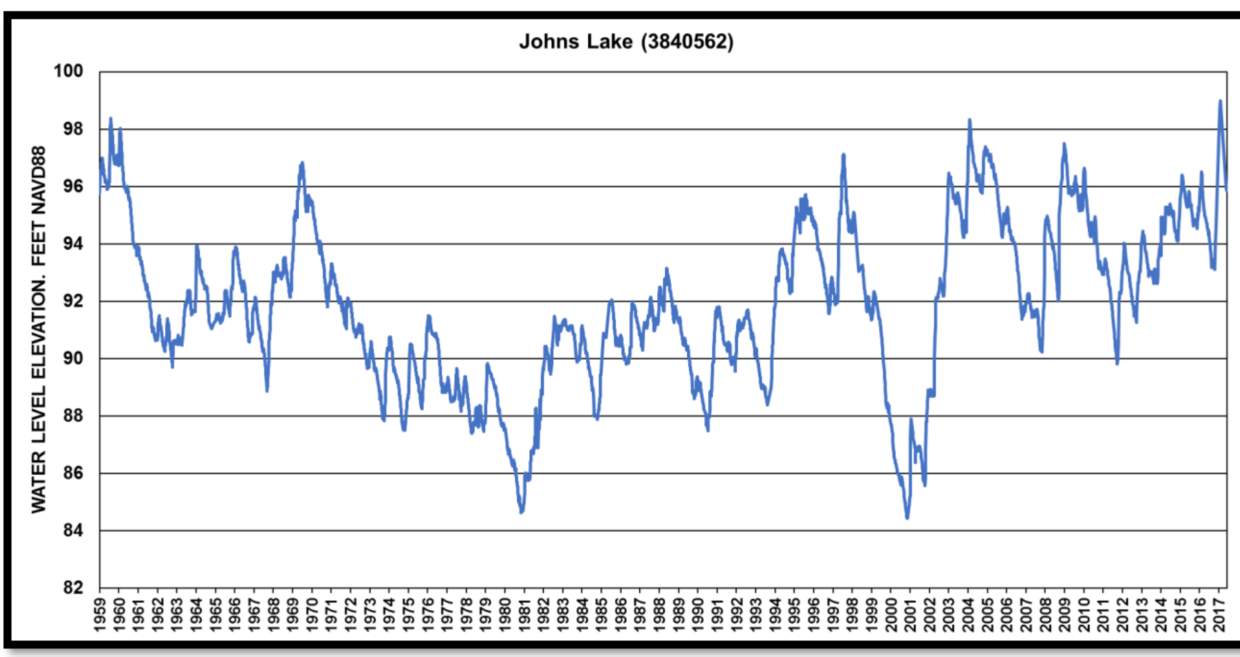

Figure B-66. Available period-of-record water level data for Johns Lake (SJ-QB).

Figure B-67. Johns Lake (SJ-QB), May 2018.

Trout Lake (SJ-QC)

Trout Lake is an unstressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation (**Figure B-68**). Monitoring of this wetland system is conducted by the USGS as part of their regional hydrologic monitoring network (**Figure B-69**). This system is a lake surrounded by improved pasture and inactive citrus, active citrus, and SR 27 to the west (**Figure B-70**). The City of Orlando and Orange County reuse project "Water Conserv II" rapid infiltration basin (RIB) Site 2 is located approximately 2.5 miles to the north. At high water levels, Trout Lake connects with Pike Lake to the southeast via a narrow ditch. Over the last several years, the USGS has significantly reduced the frequency for data collection on this system, and it is not likely that sufficient data will be collected for future EMT evaluations. Access to the lake is via Shell Pond Road off of US Highway 27.

Figure B-68. Vicinity map for Trout Lake (SJ-QC).

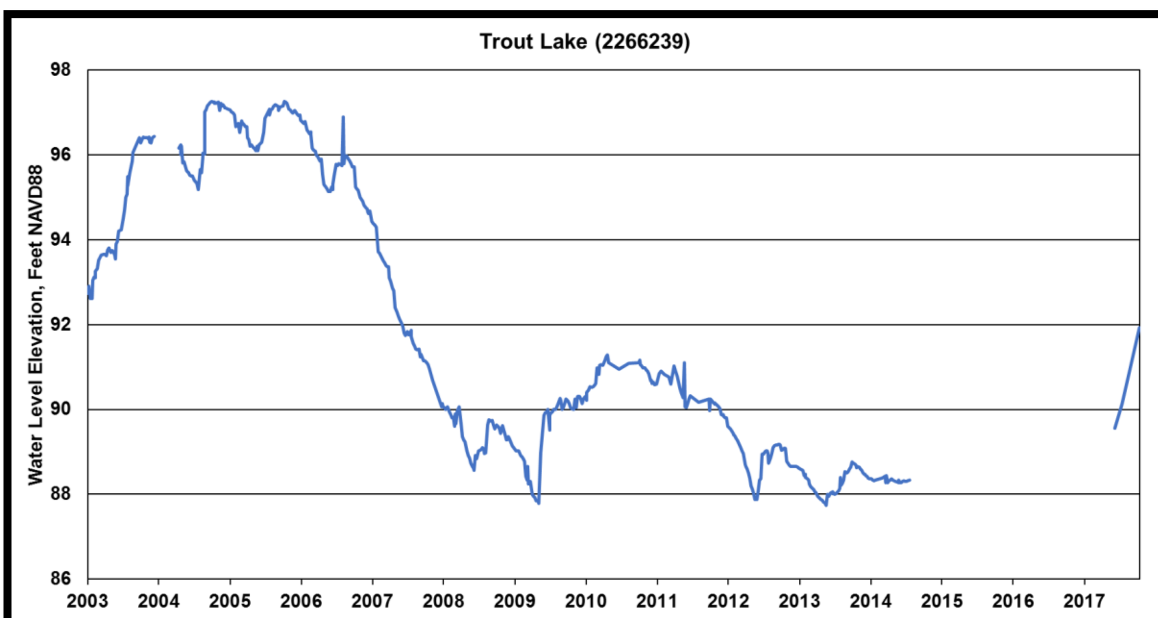

Figure B-69. Available period-of-record water level data for Trout Lake (SJ-QC).

Figure B-70. Trout Lake (SJ-QC), May 2018.

Long Lake (SJ-QD)

Long Lake is a shallow lake surrounded by steeply sloped hills and dense residential development (**Figure B-71)**. This lake is a stressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by OUC as part of the wetland monitoring program established by their CUP. Water level data and visual observations indicate that this system experiences a wide fluctuation range (**Figure B-72**). The majority of the edge of this lake is maintained/mowed by the adjacent residential properties; however, there are some undeveloped segments along the lake (**Figure B-73**). Multiple access points exist around the lake through county-maintained stormwater systems.

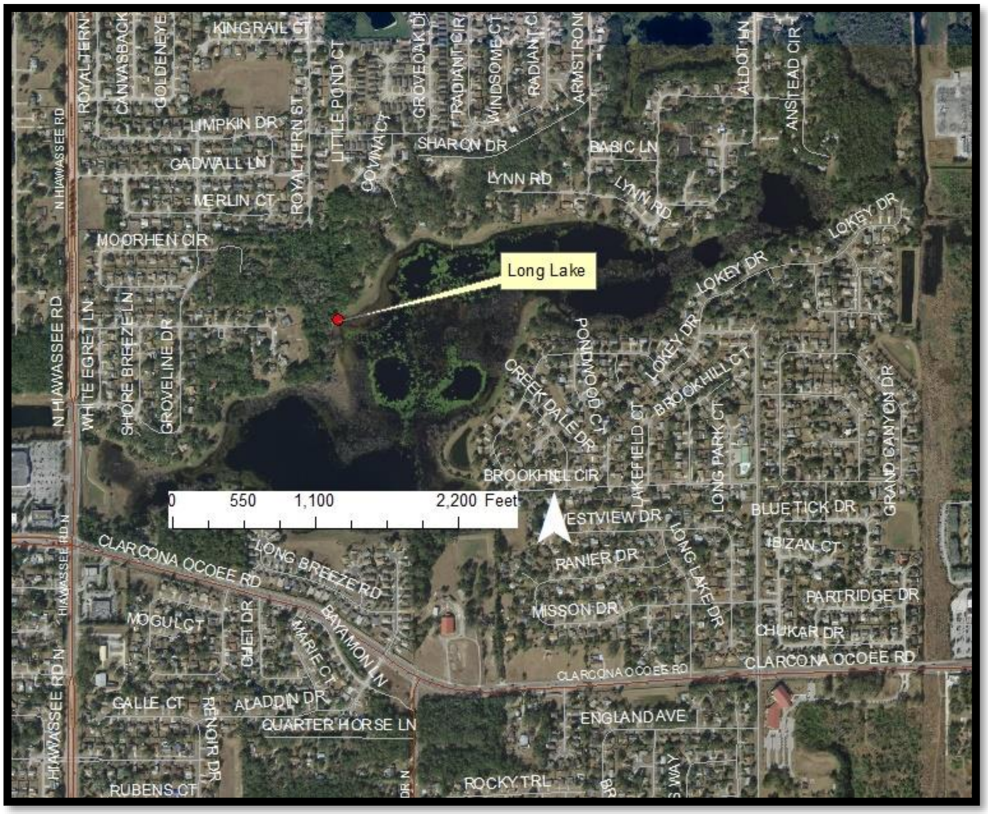

Figure B-71. Vicinity map for Long Lake (SJ-QD).

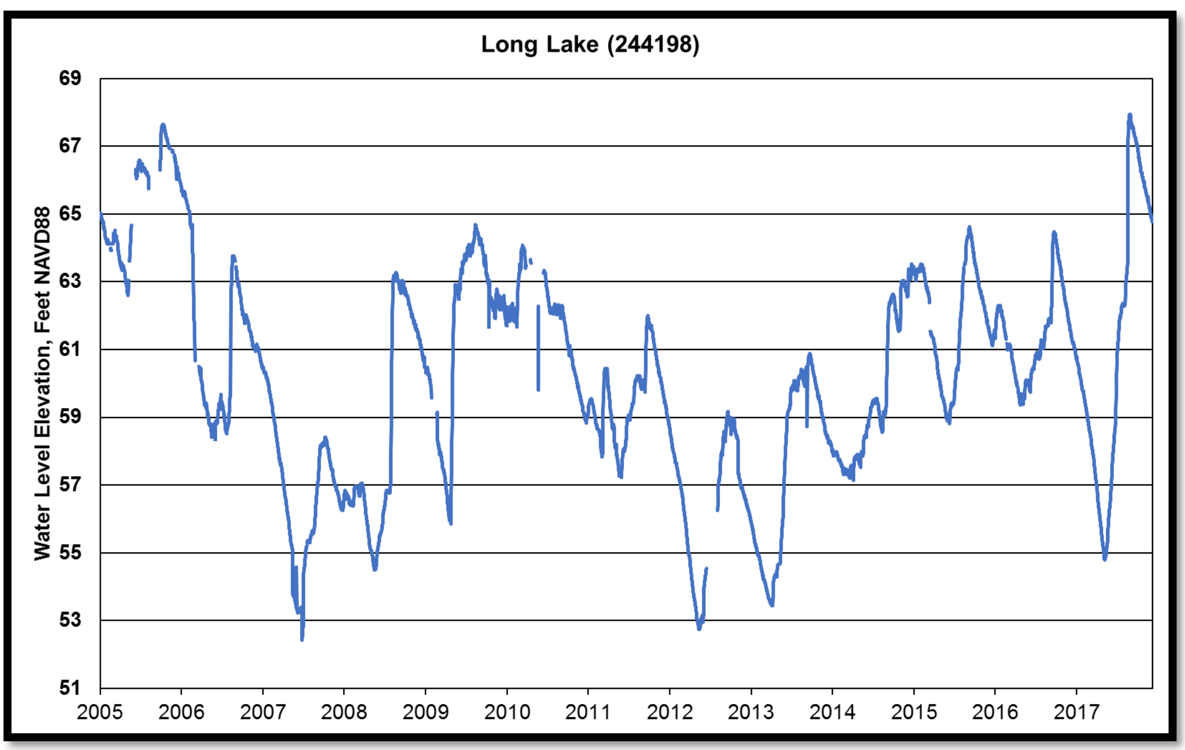

Figure B-72. Available period-of-record water level data for Long Lake (SJ-QD).

Figure B-73. Long Lake, May 4, 2018.

Lake Louisa (SJ-LJ)

Lake Louisa is a Stressed Ridge wetland used in the 2015 EMT evaluation, and observations of stress made in 2018 were consistent with those made in the prior evaluation (**Figure B-74**). Monitoring of this wetland system is conducted by the SJRWMD as part of their regional hydrologic monitoring network (**Figure B-75**). This system is a large lake surrounded by residential development along the northern half of the lake and Lake Louisa State Park along the south (**Figure B-76**). Lake Louisa is part of the Palatlakaha chain and is connected to Lake Susan to the north. Access to the lake is through the state park.

Figure B-74. Vicinity map for Lake Louisa (SJ-LJ).

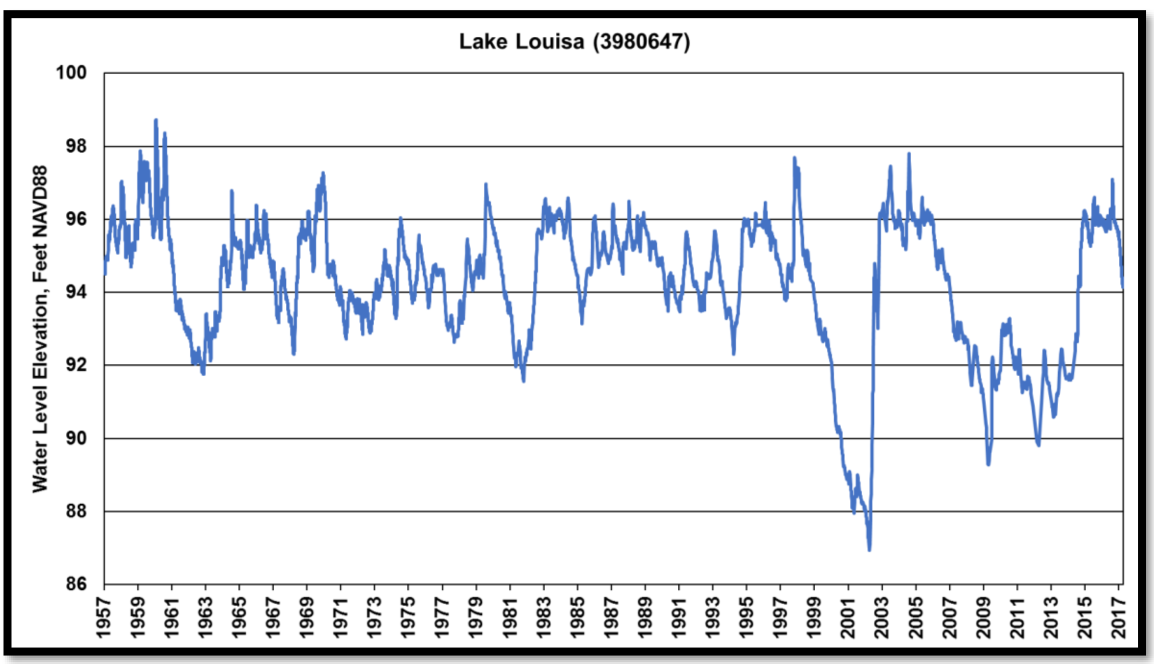

Figure B-75. Available period-of-record water level data for Lake Louisa (SJ-LJ).

Figure B-76. Lake Louisa (SJ-LJ), May 2018.

Prairie Lake (SJ-GA)

Prairie Lake is a stressed Ridge wetland evaluated for the 2015 EMT analysis, and observations of stress made in 2018 were consistent with those made in 2012. Ultimately, the site was not used in the final 2015 analysis due, in part, to problems with consistency in water level data. Monitoring of this wetland system is conducted by OUC as part of the wetland monitoring program established by their CUP, and access to the lake is through Prairie Lake Park off of Hackney Prairie Road (**Figure B-77**). Although there are still brief periodic gaps, the water level data collected for Prairie Lake from 2009-2017 provided a more consistent set of observations than the dataset that included observations from 2006-2008 used in the 2015 analysis (**Figure B-78**). However, the EMT determined that this site was not representative of groundwater-dominated wetlands within the CFWI Planning area. Therefore, it was removed from the Class 1 wetlands dataset but included in the Class 2 wetlands dataset. EMT staff agreed that ongoing monitoring of this lake will provide beneficial data and should be considered for future analyses.

The site was selected as a DMIT monitoring location and transects were established on the northwest and southern sections of the lake. Indicators of stress included encroachment of upland species into wetland areas, observed stressed condition of wetland plant species, and hydrologic indicators observed within the soil at elevations lower than anticipated (**Figure B-79**). A subsequent evaluation of the water level data revealed that the extended low water period experienced in the lake from 2011 through 2017 results in an abnormal distribution of frequency of water level differences from Wetland Edge Reference Elevation as compared to other Ridge wetlands in the dataset. Currently, water levels within Prairie Lake are extremely high, and have been so for much of the past year. High water levels at or above observed seasonal high for the lake have impacted the ability to collect water level data and have resulted in closure of the public dock for safety concerns.

Figure B-77. Vicinity map for Prairie Lake (SJ-GA).

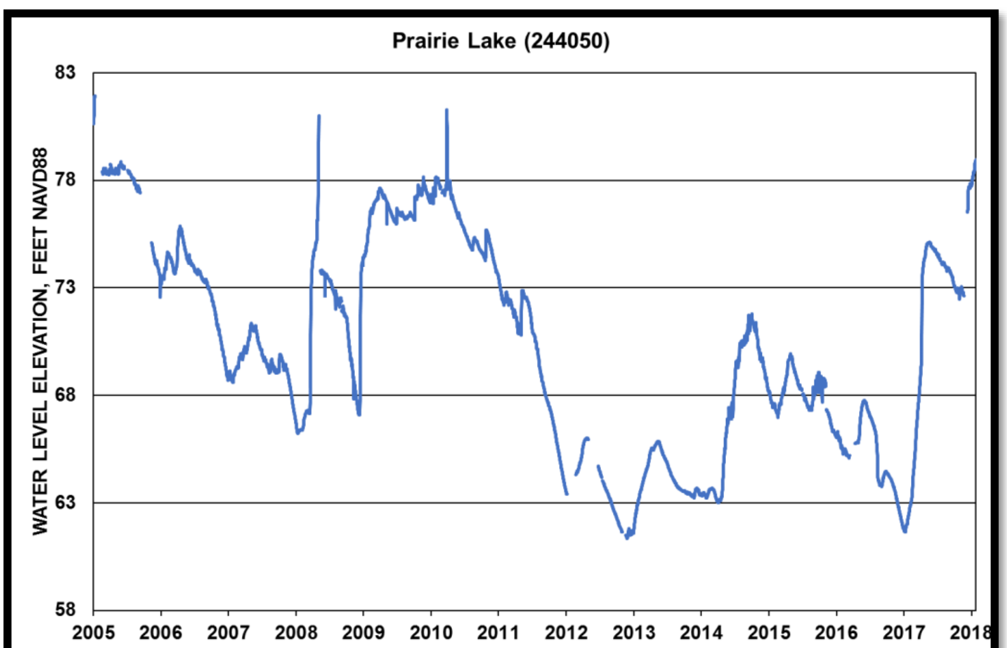

Figure B-78. Available period-of-record water level data for Prairie Lake (SJ-GA).

Figure B-79. North Shore of Prairie Lake (SJ-GA) looking south.

Red Bug Lake (SJ-AW)

Red Bug Lake was a Class 2 stressed Plains wetland used in the 2015 EMT evaluation that was added to the Class 1 wetlands dataset, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Monitoring of this wetland system is conducted by OUC as part of the wetland monitoring program established by their CUP. Based on review of aerial photographs, there appears to be a historic, significant reduction in the upper lake level, supported by site evaluations conducted by District staff (**Figure B-80**). Zonation of the marsh areas has remained consistent for the last several decades; however, periods of inundation within the marsh areas appear to be reducing in frequency and duration (**Figure B-81**). The reduced hydroperiod may be an ongoing result of the historic reduction in lake level, or a more recent change in hydrologic condition. Drier conditions within the marsh zones have led to the encroachment of woody species. Access to the lake is through Red Bug Lake Park off of Red Bug Lake Road.

Figure B-80. Vicinity map for Red Bug Lake (SJ-AW).

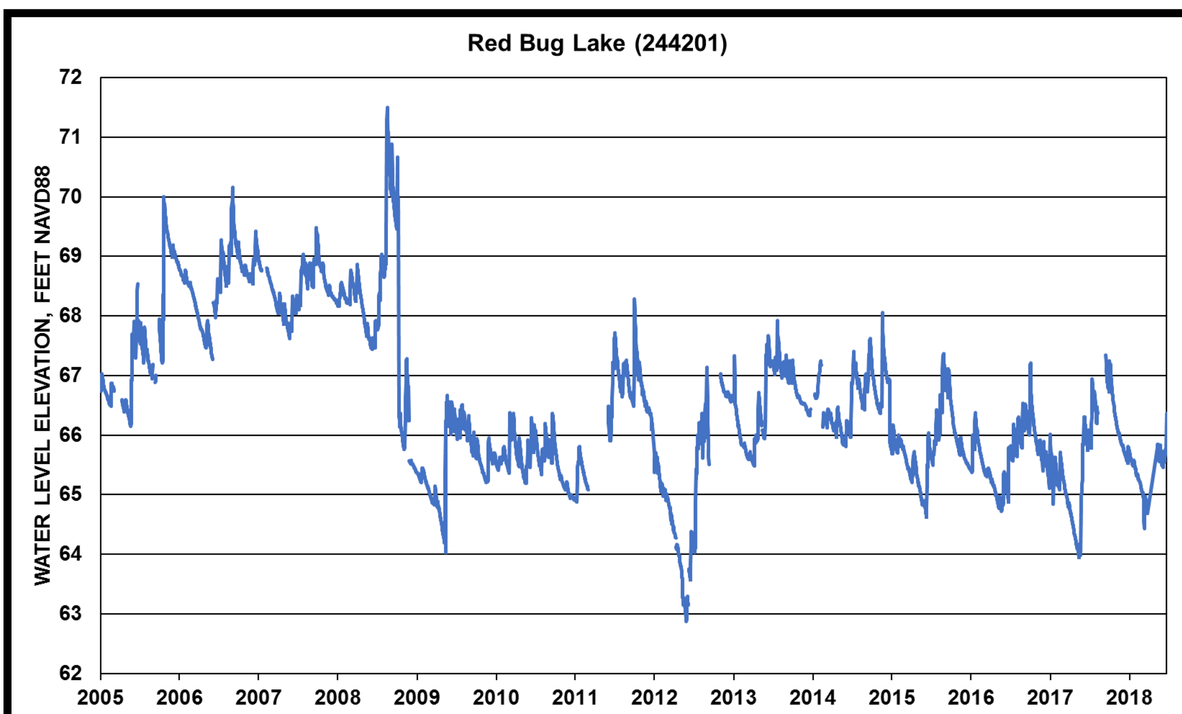

Figure B-81. Available period-of-record water level data for Red Bug Lake (SJ-AW).

Chapman Marsh (SJ-AI)

Chapman Marsh was a Class 2 stressed Plains wetland used in the 2015 EMT evaluation that was added to the Class 1 wetlands dataset, and observations of stress made in 2018 were consistent with those made in the prior evaluation. Review of aerials indicate that the wetland was historically an open water system and, since the mid-1990s, has become more of a marsh characterized with the invasion of woody species (**Figures B-82 and B-83**). The system is located within a highly urbanized setting, with a large subdivision bordering the system along the north, east, and southern boundaries, and single-family residences along the western boundary. Access to the system is at the end of E Chapman Road off of SR 434.

Figure B-82. Vicinity map for Chapman Marsh (SJ-AI).

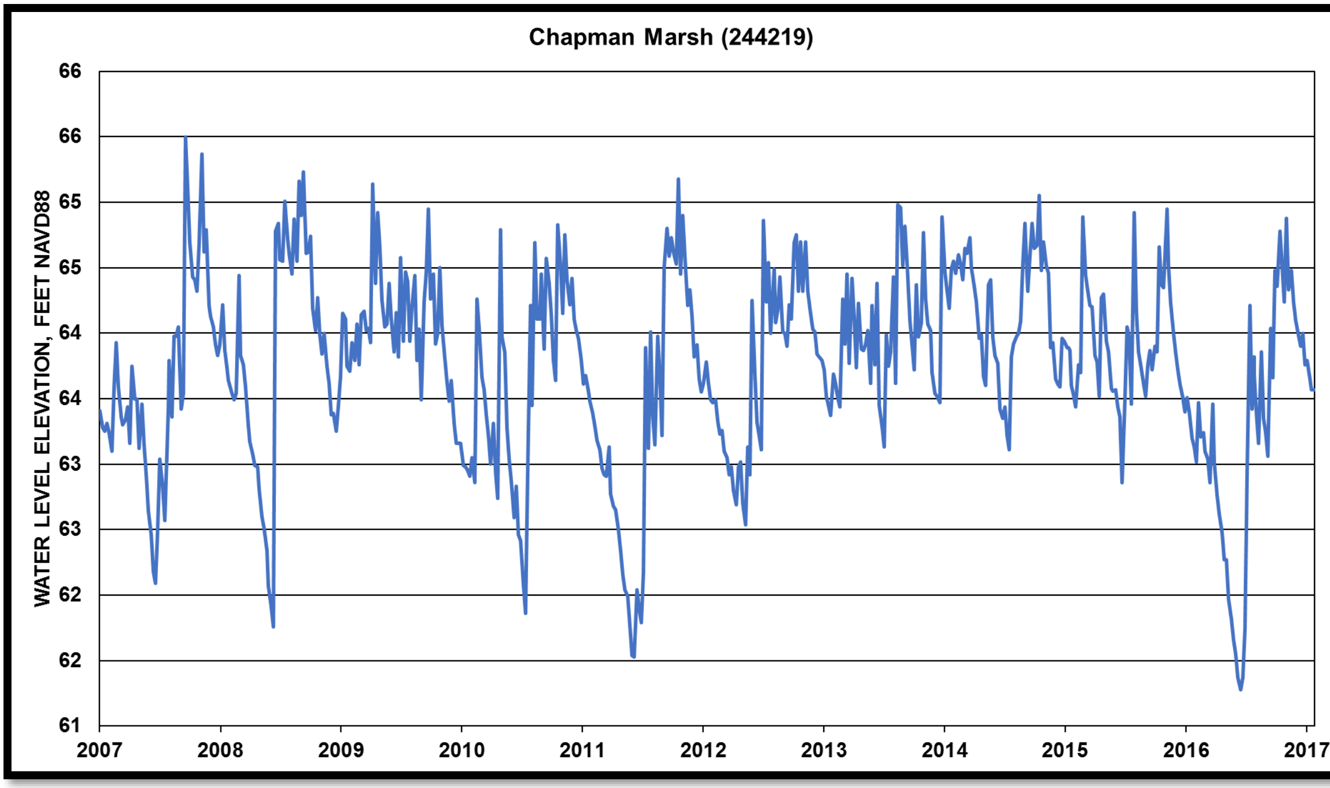

Figure B-83. Available period-of-record water level data for Chapman Marsh (SJ-AI).

Green Swamp #7 (SW-AA)

Green Swamp #7 is a small, groundwater-dominated, cypress wetland located in northwest Polk County (**Figures B-84 and B-85**). This Plains wetland is within the SWFWMD's Green Swamp Wilderness Preserve East Tract, which is managed for natural resource conservation. The wetland is accessible via the locked Smith Place Road entrance gate off of Rock Ridge Road (**Figure B-86**).

In the original assessment, as well as in 2018, the wetland was determined to be Not Stressed. Since the wetland is small in size, the entire wetland was assessed. A review of a 1970s aerial photograph (**Figure B-87**) compared with the 2017 aerial indicates that, although the wetland appears to be unchanged, the surrounding uplands were historically converted to improved pasture. Currently, the uplands are restored to pine flatwoods. There are no known hydrologic alterations to the wetland.

Since 2002, the SWFWMD has recorded surficial aquifer water levels in the wetland at least monthly, and water levels have varied as a result of climatic variations in rainfall (**Figure B-88**). The SWFWMD has also conducted annual vegetation assessments of the wetland since 2005 using the Wetland Assessment Procedure (WAP), as part of the Northern Tampa Bay Recovery Assessment. There are no known significant groundwater withdrawals in the vicinity, and the nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 10 miles away.

Figure B-84. Green Swamp #7 (SW-AA), February 2018.

Figure B-85. Interior of Green Swamp #7 (SW-AA), February 2018.

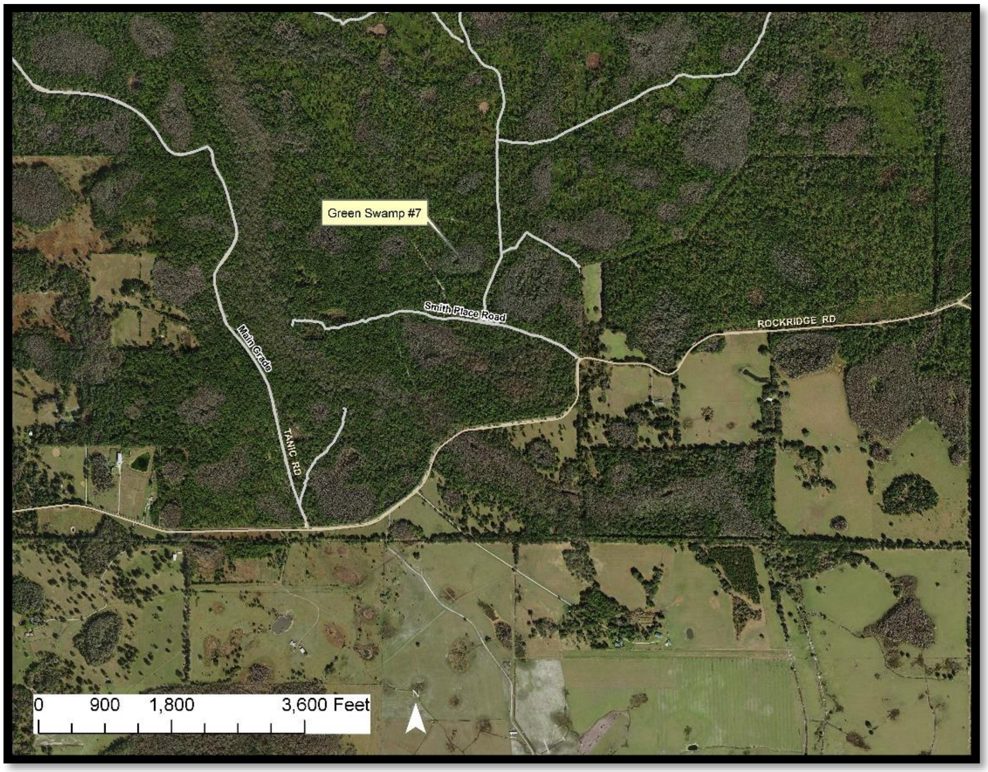

Figure B-86. Location of Green Swamp #7 (SW-AA), 2017 aerial.

Figure B-87. Green Swamp #7 (SW-AA), circa 1970 aerial photograph.

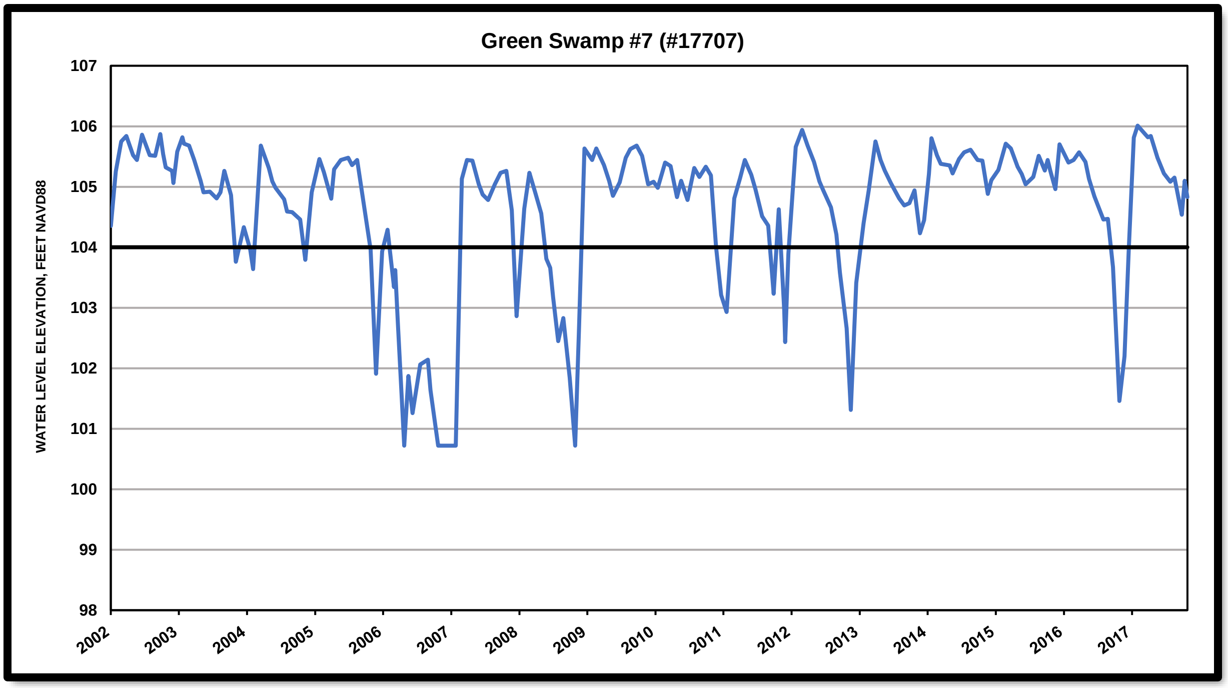

Figure B-88. Period-of-record water level data for Green Swamp #7 (SW-AA). Black line represents the land surface elevation at the monitor well (#17707).

Lake Garfield (SW-JJ)

Lake Garfield is a Ridge lake located in Central Polk County (**Figures B-89, B-90, and B-91**). The lake was originally assessed as unstressed. In 2018, it was again determined to be unstressed. The field assessment was conducted at the public boat ramp at the west end of Garfield Landing Road, south of State Road 60 (**Figure B-92**).

Historic aerial photography shows that the adjacent land use has been, and is currently, predominantly agriculture (**Figures B-92 and B-93**). The outfall for the lake is an excavated channel connecting to the Peace Creek Canal and has existed since before 1941. Based on a review of LiDAR, historic aerial photography, and on-site inspections, it appears the lake may have staged higher prior to excavation of the outfall channel.

Other than fluctuations due to rainfall, the hydrograph shows no observable lake level trends, but the period of record does not extend back prior to excavation of the lake outfall (**Figure B-94**). There are no permitted surface water withdrawals from the lake, but there are numerous permitted groundwater withdrawals in the vicinity. The SWFWMD has been recording lake level data regularly since 1982. The SWFWMD has also adopted Guidance Levels for the lake, but Minimum Levels (MFLs) have not been established. The Guidance Levels are a High Level of 104.75’ mean sea level (msl), a Low Level of 101.00’ msl, and an Extreme Low Level of 100.00’ msl. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-89. Lake Garfield (SW-JJ), April 2018.

Figure B-90. Lake Garfield (SW-JJ), April 2018.

Figure B-91. Lake Garfield (SW-JJ), April 2018.

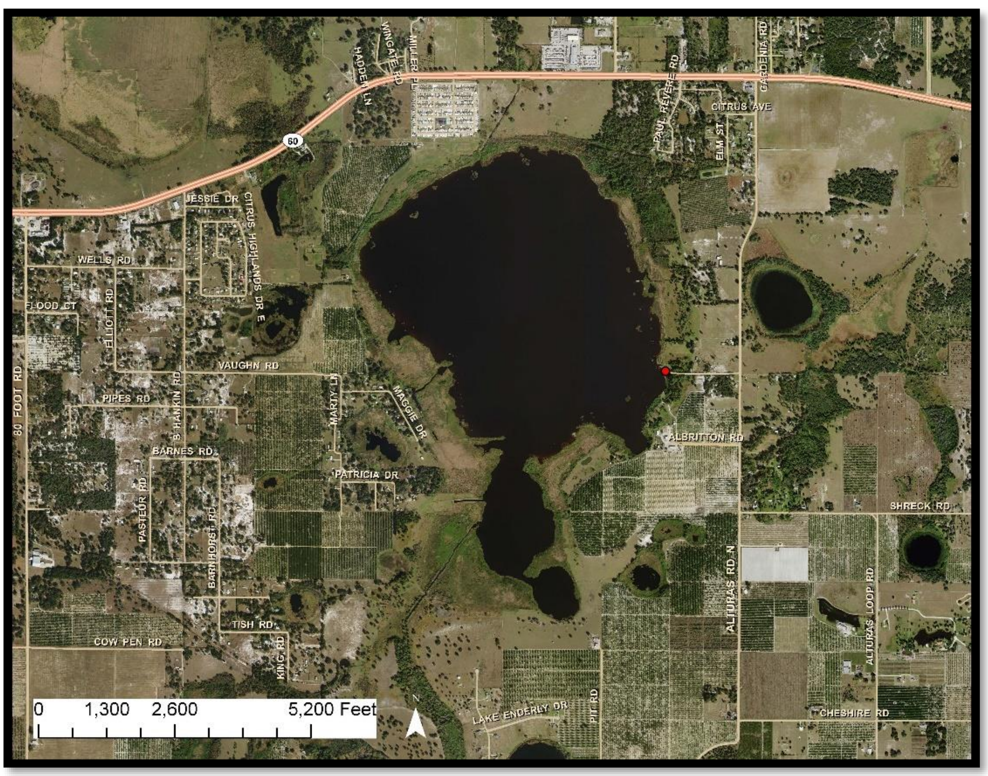

Figure B-92. Location of Lake Garfield (SW-JJ), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

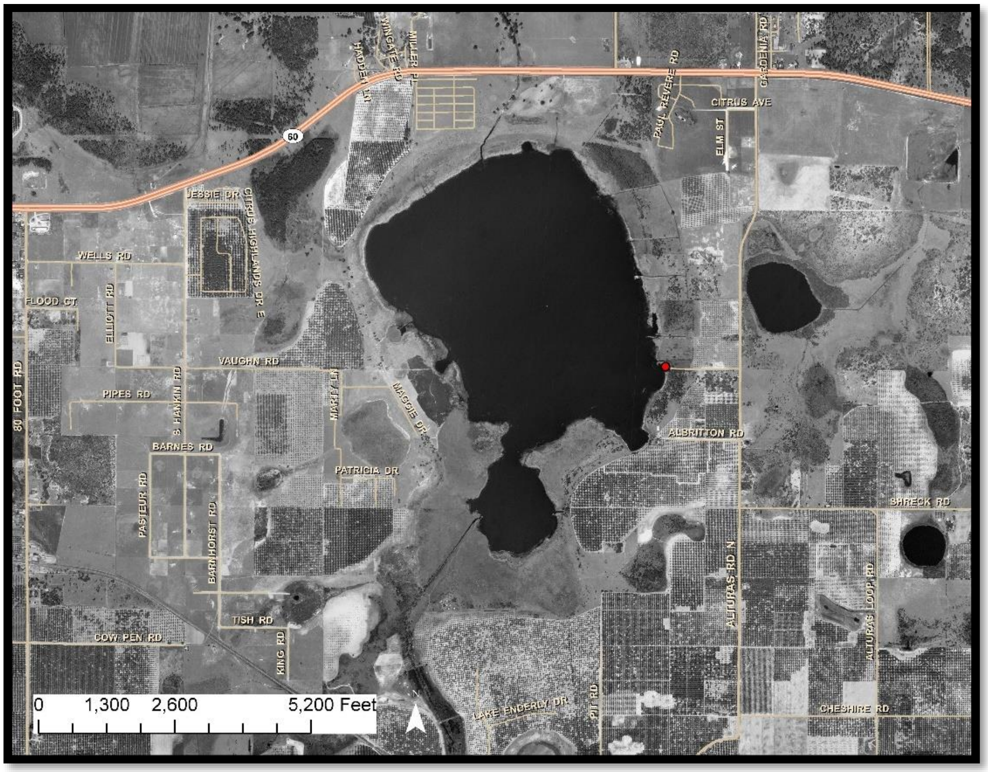

Figure B-93. Lake Garfield (SW-JJ), circa 1970 aerial photograph.

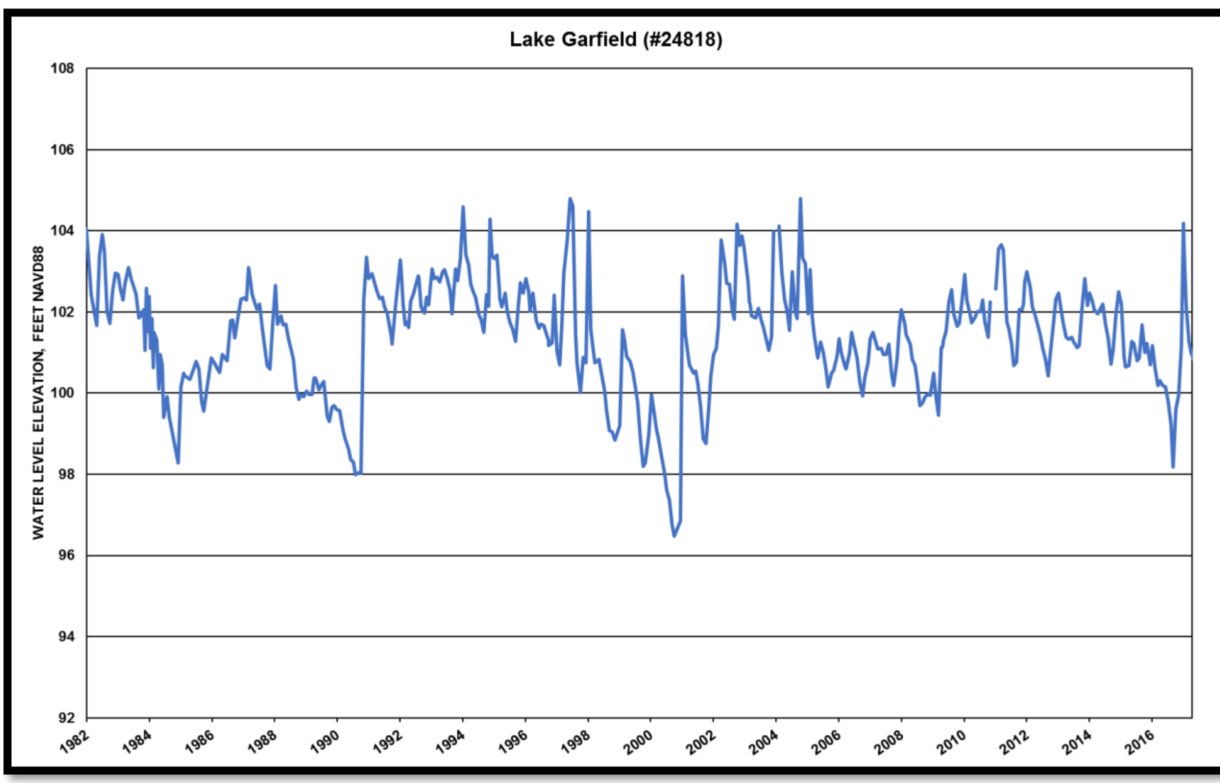

Figure B-94. Period-of-record water level data for Lake Garfield (SW-JJ).

Cypress Creek #199, W17 Sentry Wetland (SW-LE)

Cypress Creek #199, W17 Sentry Wetland is a groundwater-dominated, cypress swamp located on the SWFMWD's Cypress Creek Preserve in Central Pasco County (**Figures B-95, B-96, and B-97**). It is also within Tampa Bay Water's Cypress Creek Wellfield, which is authorized to withdraw groundwater under WUP No. 200011771.001. This Plains wetland was originally assessed as stressed, and the 2018 assessment determined that the wetland is still stressed. The 2018 stress assessment was conducted from the north side of the wetland (**Figure B-97**). The wetland is accessed from Pump Station Road and through a locked District gate leading into the wellfield.

Groundwater pumping at the wellfield began in 1976. Pumping quantities peaked in 2001, and the wetland was hydrologically impacted (e.g., reduced hydroperiod and water levels). From 2001 to 2003, groundwater withdrawals at the wellfield were substantially reduced, and reduced pumping has been maintained to date. However, the pumping rate currently averages approximately 15 million gallons per day.

The SWFWMD has recorded surficial aquifer water levels in the wetland twice each month since 2010 (**Figure B-98**). In addition, annual WAP assessments of the wetland have been conducted since 2005, as part of the Northern Tampa Bay Recovery Assessment. The SWFWMD has established a Minimum Wetland Level of 63.1' (NGVD1929) for this wetland. In 2017, this wetland was meeting its minimum level. In December 2018, Tampa Bay Water reported that this wetland is improved but not completely recovered, based on median water levels from 2008 through 2016. Water level and vegetation data collection is on-going as Tampa Bay Water is continuing to assess recovery of the wetland.

Figure B-95. Cypress Creek #199, W17 Sentry Wetland (SW-LE), June 2018.

Figure B-96. Interior of Cypress Creek #199, W17 Sentry Wetland (SW-LE), June 2018.

Figure B-97. Location of Cypress Creek #199, W17 Sentry Wetland (SW-LE), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

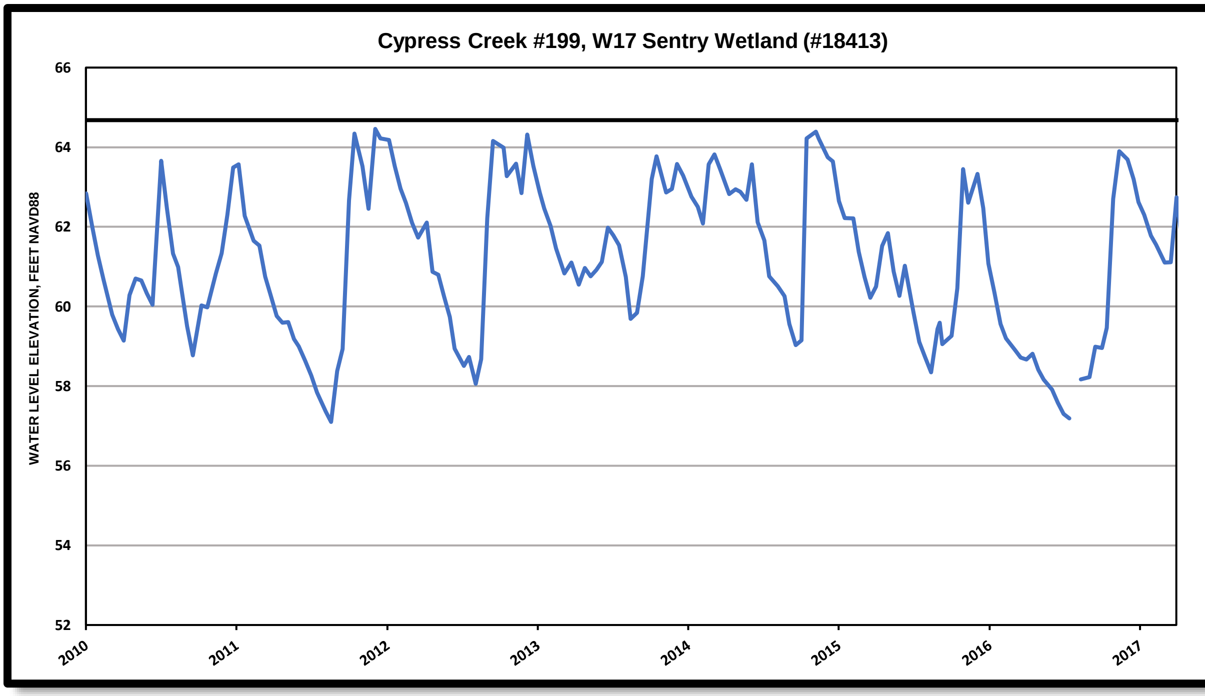

Figure B-98. Period-of-record water level data for Cypress Creek #199, W17 Sentry Wetland (SW-LE). Black line represents the land surface elevation at the monitor well.

Cypress Creek #190 East Marsh (SW-LF)

Cypress Creek #190 East Marsh, a Plains wetland, was originally assessed as stressed; however, the 2018 assessment determined that its status is currently not stressed. This wetland is located on the SWFMWD's Cypress Creek Preserve in Central Pasco County (**Figures B-99 and B-100**). The wetland is accessed from Pump Station Road and through a locked District gate leading into the wellfield (**Figure B-101**).

This groundwater-dominated marsh is also within Tampa Bay Water's Cypress Creek Wellfield, which is authorized to withdraw groundwater under WUP No. 200011771.001. Groundwater pumping at the wellfield began in 1976. Pumping quantities peaked in 2001 and this wetland was hydrologically affected; impacts included reduced hydroperiods and water levels. From 2001 through 2003, groundwater withdrawals at the wellfield were substantially reduced and reduced pumping has been maintained to date. As indicated by the review of water level monitoring data, surficial aquifer levels have increased since 2011 (**Figure B-102**). The reduced pumping rate is still approximately 15 million gallons per day average; however, pumping quantities are generally less in this area of the wellfield. The SWFWMD has conducted annual vegetation assessments of the wetland since 2005 using the WAP as part of the Northern Tampa Bay Recovery Assessment. The 2018 assessment indicated that this wetland is currently not hydrologically stressed, and while many trees have been lost, it is recovering (**Figures B-99 and B-100**). Tampa Bay Water has determined that this wetland is recovered.

An analysis of water level data for the period of record selected for the analysis for this marsh indicated that it is not representative of groundwater-dominated wetlands in the CFWI planning area, mainly because the period of record includes both a stressed and unstressed period. Therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP and was added to the Class 2 wetlands dataset.

Figure B-99. Cypress Creek #190 East Marsh (SW-LF), June 2018.

Figure B-100. Cypress Creek #190 East Marsh (SW-LF), June 2018.

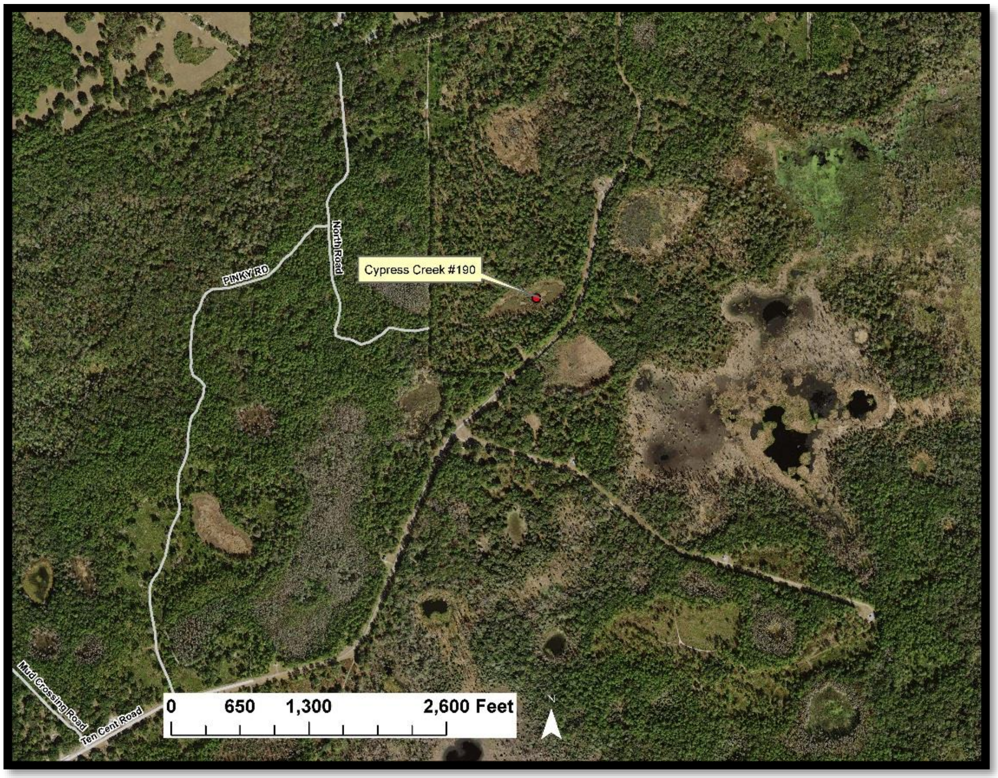

Figure B-101. Location of Cypress Creek #190 East Marsh (SW-LF), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

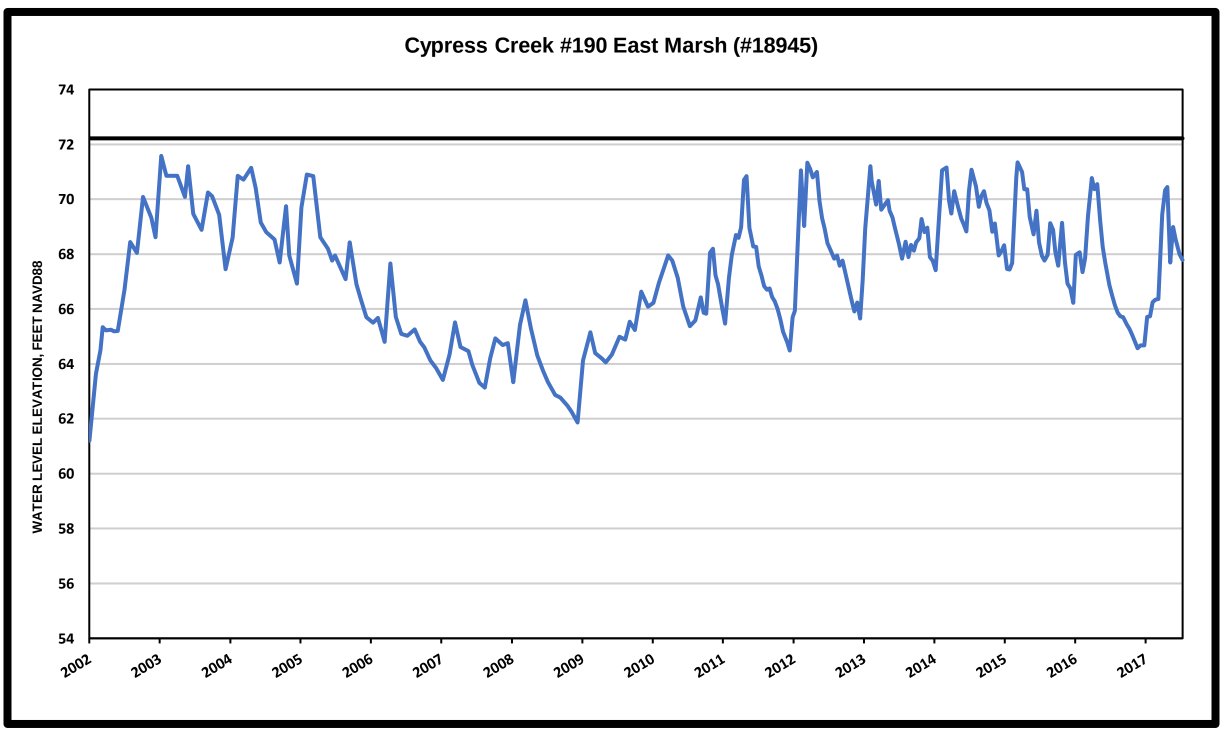

Figure B-102. Period-of-record water level data for Cypress Creek #190 East Marsh (SW-LF). Black line represents the land surface elevation at the monitor well.

Cypress Creek #223 B W46 (SW-LG)

Cypress Creek #223 B W46 is a Plains wetland and a groundwater-dominated, cypress swamp located on the SWFWMD's Cypress Creek Preserve in Central Pasco County (**Figures B-103 and B-104**). The wetland is accessed from Pump Station Road and through a locked District gate leading into the wellfield (**Figure B-105**). This wetland is also located within the Tampa Bay Water Cypress Creek Wellfield, which is authorized to withdraw groundwater under WUP No. 200011771.001.

Groundwater pumping at the wellfield began in 1976. Pumping quantities peaked in 2001, and this wetland was impacted by groundwater withdrawals. The impacts included reduced hydroperiod and water levels. From 2001 to 2003 groundwater withdrawals at the wellfield were substantially reduced, and reduced pumping has been maintained to date. However, groundwater pumping still averages approximately 15 million gallons per day.

Since 1980, the SWFWMD has recorded surficial aquifer water levels in the wetland twice each month (**Figure B-106**). Annual vegetation assessments of the wetland using the WAP as part of the Northern Tampa Bay Recovery Assessment have also been conducted since 2005. Tampa Bay Water has determined this wetland is improved but not completely recovered. Water level and vegetation data collection are on-going as Tampa Bay Water is continuing to assess recovery of the wetland. During the original assessment, as well as during the assessment conducted in 2018, this wetland was determined to be stressed. Since the wetland is small in size, the entire wetland was assessed.

Figure B-103. Cypress Creek #223 B W46 (SW-LG), June 2018.

Figure B-104. Cypress Creek #223 B W46 (SW-LG), June 2018.

Figure B-105. Location of Cypress Creek #223 B W46 (SW-LG), 2017 aerial photograph.

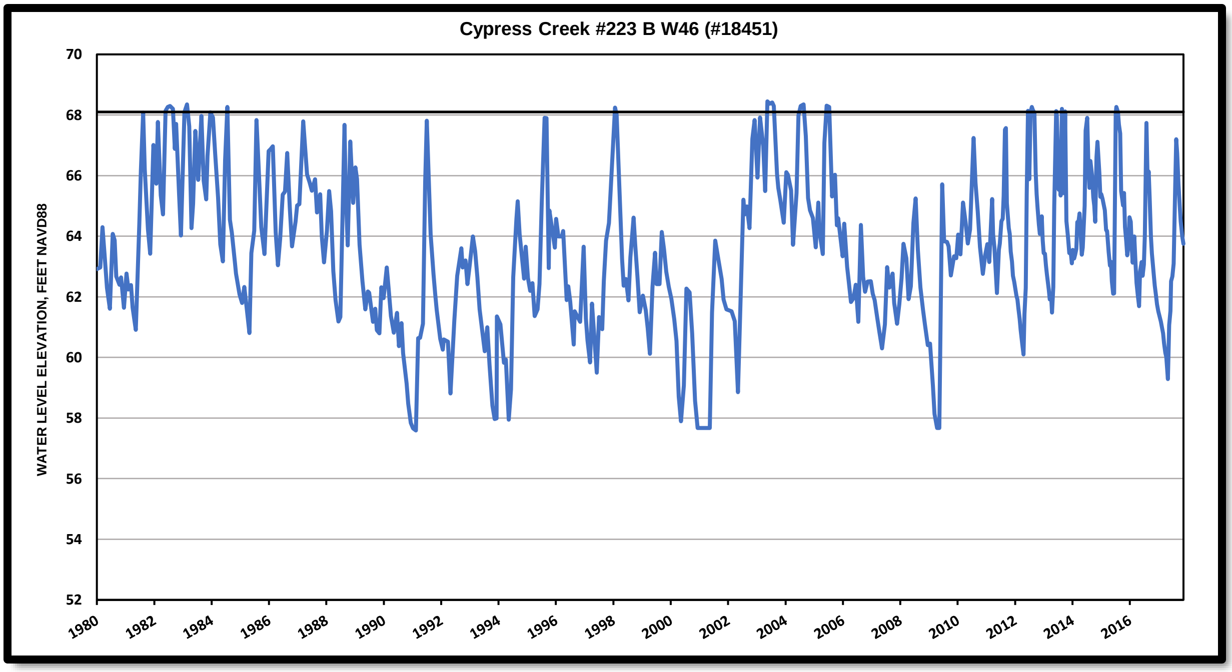

Figure B-106. Period-of-record water level data for Cypress Creek #223 B W46 (SW-LG). Black line represents the land surface elevation at the monitor well.

Cypress Creek #211 W33 (SW-LH)

Cypress Creek #211 W33 is located in Tampa Bay Water's Cypress Creek Wellfield, which is authorized to withdraw groundwater under WUP No. 200011771.001, and the SWFWMD's Cypress Creek Wellfield (**Figures B-107 and B-108**). The wetland is accessed from Pump Station Road and through a locked District gate leading into the wellfield (**Figure B-109**). This Plains wetland was originally assessed as stressed; however, the 2018 assessment determined that the wetland changed its status to unstressed.

Groundwater pumping at the wellfield, which began in 1976, has been reduced in recent years, and as indicated by the review of water level monitoring data, with the exception of the early 2017 drought, the surficial aquifer levels have increased in recent years (**Figure B-110**). The wetland was hydrologically impacted, e.g., reduced hydroperiod and water levels, as a result of pumping that peaked in 2001. From 2001 to 2003 groundwater withdrawals at the wellfield were substantially reduced, and reduced pumping has been maintained to date.

The SWFWMD has recorded surficial aquifer water levels in the wetland twice each month since 2003 (**Figure B-110**). In addition, since 2005, the District has conducted annual vegetation assessments of the wetland using the WAP as part of the Northern Tampa Bay Recovery Assessment. Tampa Bay Water has determined that this wetland is hydrologically recovered, which is consistent with the not stressed determination made during the 2018 field assessment.

Figure B-107. Cypress Creek #211 W33 (SW-LH), June 2018.

Figure B-108. Interior of Cypress Creek #211 W33 (SW-LH), June 2018.

Figure B-109. Location of Cypress Creek #211 W33 (SW-LH), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

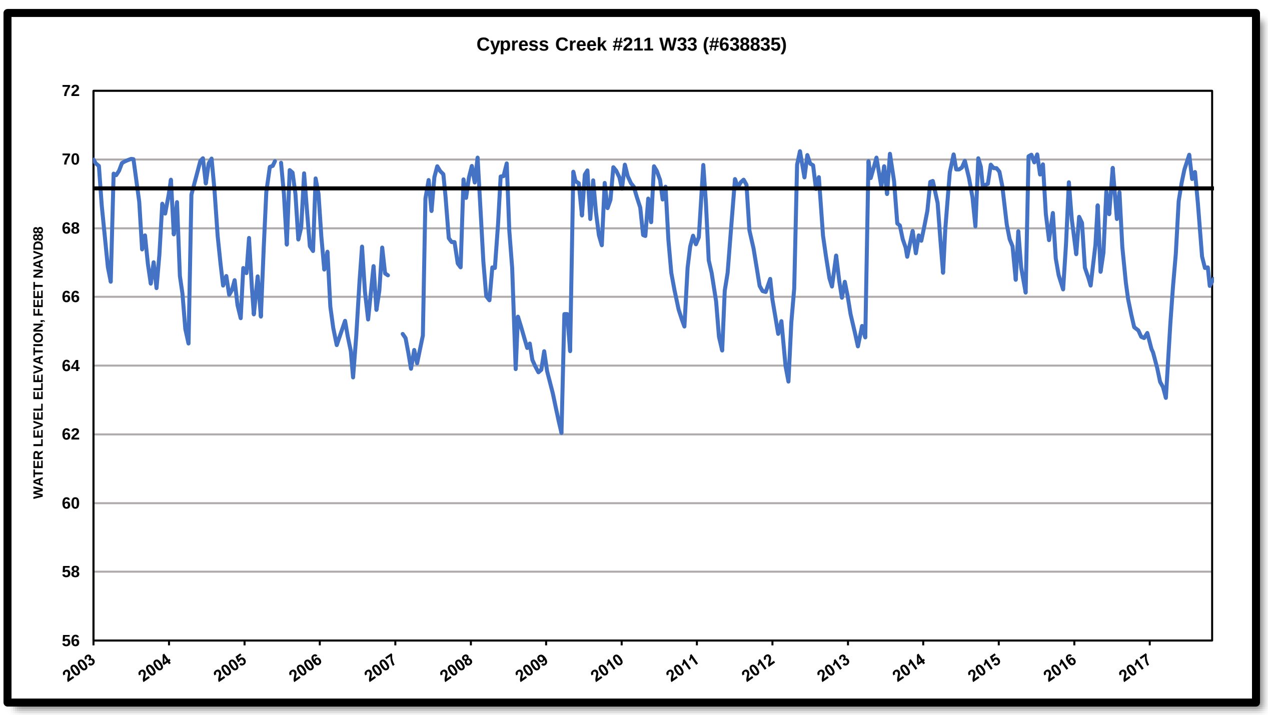

Figure B-110. Period-of-record water level data for Cypress Creek #211 W33. Black line indicates land surface elevation at the monitor well.

Green Swamp Marsh #304 (SW-LI)

Green Swamp Marsh #304 is a groundwater-dominated marsh located in South Sumter County on the SWFWMD's Green Swamp Wilderness Preserve East Tract (**Figures B-111 and B-112**). It is accessed from State Road 471 through a locked SWFWMD gate, turning east on Main Grade, an unpaved, lime rock road (**Figure B-113**). An unimproved trail, approximately 1,000 feet east of Levee Road and on the south side of Main Grade, leads to the marsh.

This Plains wetland was originally determined to be unstressed. The 2018 assessment also determined it to be unstressed. Since the wetland is an open marsh and small in size, the entire wetland was assessed. The District has recorded surficial aquifer water levels in the wetland daily since 2006, which vary depending on rainfall (**Figure B-114**). The District has also conducted annual vegetation assessments of the wetland since 2005, using the WAP as part of the Northern Tampa Bay Recovery Assessment. Sometime between 1970 and 1984, a borrow pit was excavated and a road constructed on the west side of the wetland (**Figures B-115 and B-116**). Otherwise, there do not appear to be any historic changes to the wetland or adjacent uplands. There are no known hydrologic alterations to the wetland or known significant groundwater withdrawals in the vicinity. The nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 14 miles away.

Figure B-111. Green Swamp Marsh #304 (SW-LI), June 2018.

Figure B-112. Interior of Green Swamp Marsh #304 (SW-LI), June 2018.

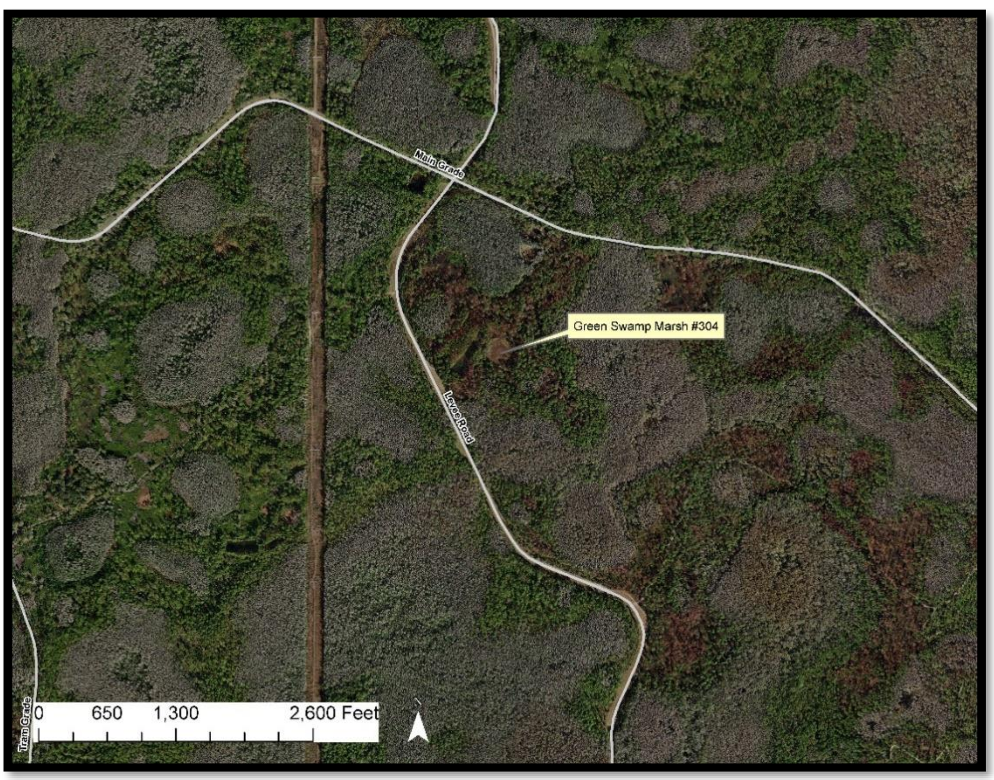

Figure B-113. Location of Green Swamp Marsh #304 (SW-LI), 2017 aerial photograph.

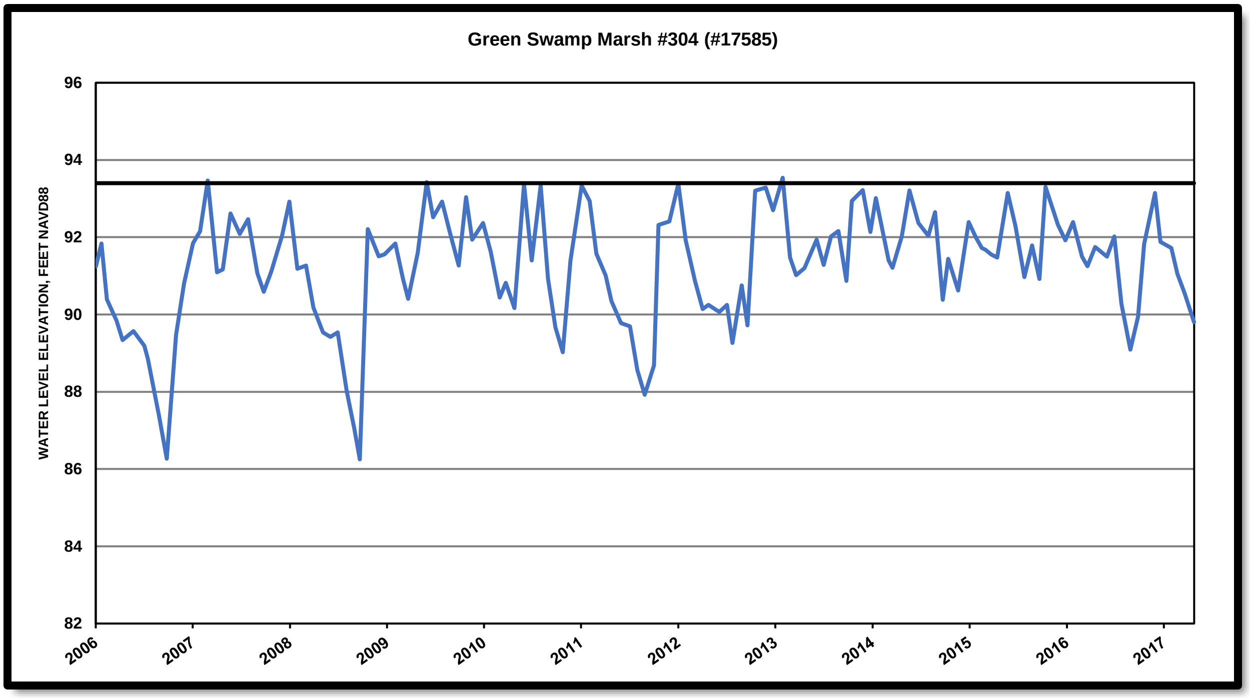

Figure B-114. Period-of-record water level data for Green Swamp Marsh #304 (SW-LI). Black line indicates land surface elevation at the monitor well.

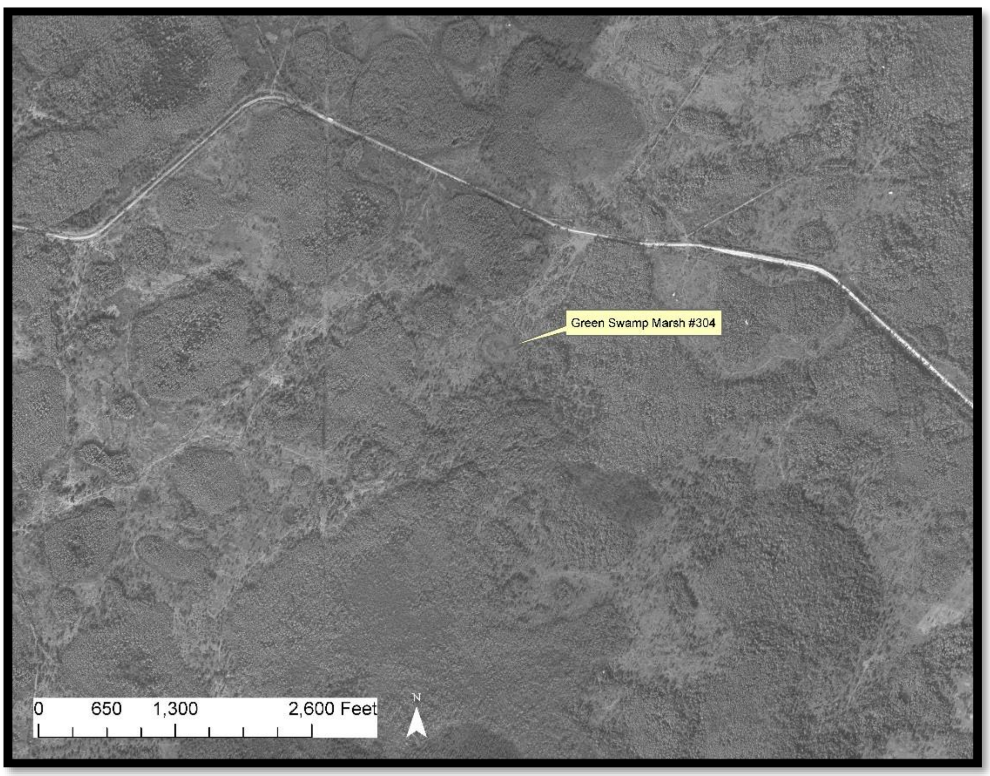

Figure B-115. Location of Green Swamp Marsh #304 (SW-LI), circa-1970 aerial photograph.

Figure B-116. Location of Green Swamp Marsh #304 (SW-LI), 1984 aerial photograph.

Green Swamp #6, #303 (SW-LJ)

Green Swamp #6, #303 is a groundwater-dominated, cypress wetland located in South Sumter County within the Green Swamp Wilderness Preserve East Tract, owned by the SWFWMD (**Figures B-117, B-118, and B-119**). This Plains wetland was originally determined to be unstressed; the 2018 assessment also indicated it to be unstressed. The wetland is accessed from State Road 471, turning east on Main Grade (unpaved) and through a locked District gate (**Figure B-120**). From Main Grade turn north on Tanic Grade and east on Three Run Grade. The 2018 Stress Assessment was conducted from the west side of the wetland (**Figure B-120**).

Since 1999, the SWFWMD has recorded surficial aquifer water levels in the wetland monthly (**Figure B-121**), and water levels have varied with rainfall. Annual vegetation assessments of the wetland have been conducted since 2005 using the WAP as part of the Northern Tampa Bay Recovery Assessment. There are no known hydrologic alterations to the wetland. There are no known groundwater withdrawals in the vicinity, and the nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 14 miles away.

Figure B-117. Green Swamp #6, #303 (SW-LJ), June 2018.

Figure B-118. Green Swamp #6, #303 (SW-LJ), June 2018.

Figure B-119. Green Swamp #6, #303 (SW-LJ), June 2018.

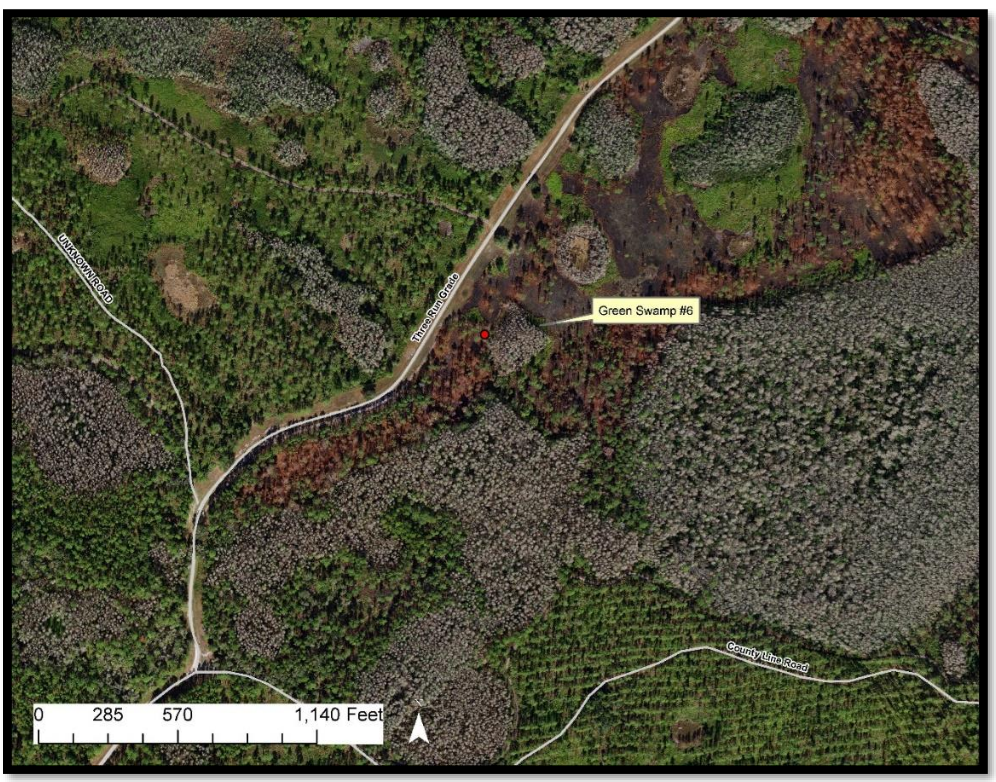

Figure B-120. Location of Green Swamp #6, #303 (SW-LJ), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

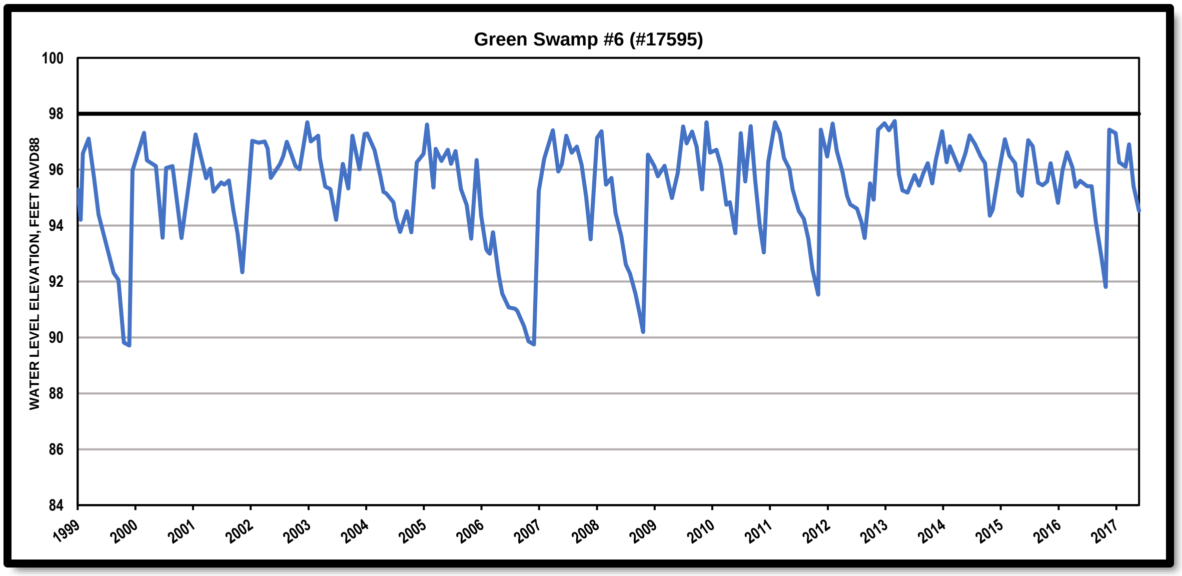

Figure B-121. Period-of-record water level data for Green Swamp #6, #303 (SW-LJ). Black line indicates land surface elevation at the monitor well.

Green Swamp #5, #302 (SW-LK)

Green Swamp #5 is located in South Sumter County and is a groundwater-dominated, cypress wetland in a Plains setting (**Figures B-122, B-123, and B-124**). It is located within the SWFWMD's Green Swamp Wildlife Preserve East Tract (**Figure B-125**). The wetland is accessed from State Road 471 through a locked District gate, turning east on Main Grade, an unpaved, lime rock road. From Main Grade, turn north on Tanic Grade, then east on Three Run Grade. An unimproved trail, located on the northwest side of Three Run Grade and approximately 0.3 mile past the intersection of Three Mile Grade and Race Track Road, leads to the wetland (**Figure B-125**).

Green Swamp #5, #302 was originally determined to be unstressed; it was also determined to be unstressed during the 2018 assessment. The SWFWMD has recorded surficial aquifer water levels in the wetland monthly since 1999 (**Figure B-126**). As part of the Northern Tampa Bay Recovery Assessment, annual vegetation assessments of the wetland have been conducted since 2005 using the WAP. There are no known hydrologic alterations to the wetland or groundwater withdrawals in the vicinity. The nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 17 miles away.

Figure B-122. Green Swamp #5, #302 (SW-LK), June 2018.

Figure B-123. Green Swamp #5, #302 (SW-LK), June 2018.

Figure B-124. Interior of Green Swamp #5, #302 (SW-LK), June 2018.

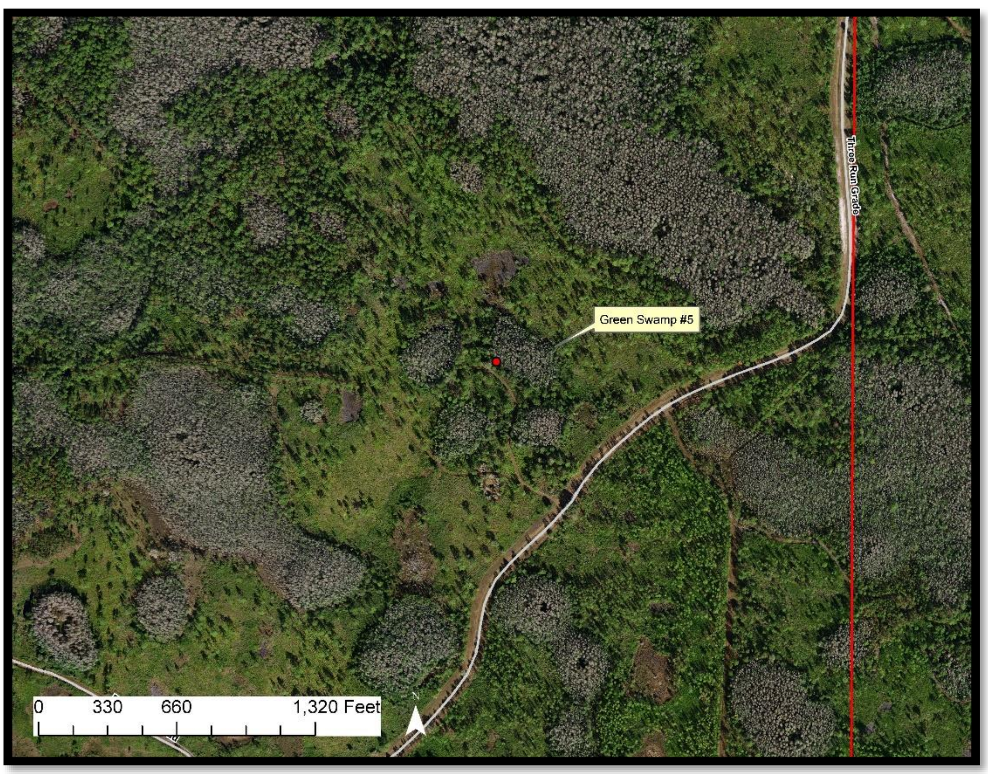

Figure B-125. Location of Green Swamp #5, #302 (SW-LK), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

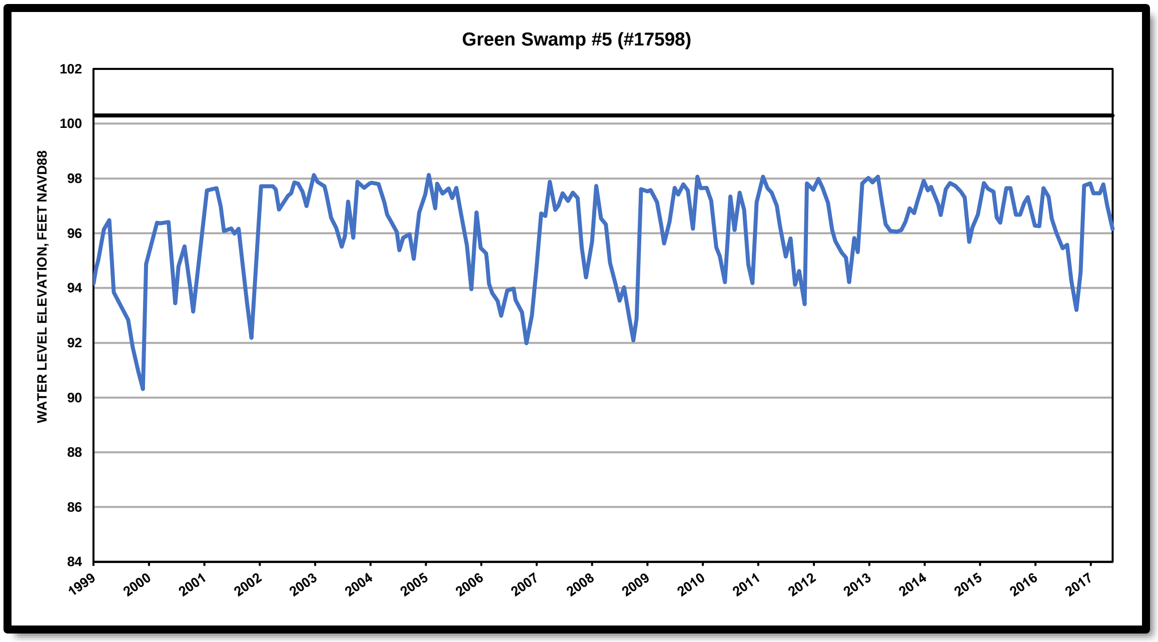

Figure B-126. Period-of-record water level data for Green Swamp #5, #302 (SW-LK). Black line indicates land surface elevation at monitor well.

Green Swamp #1, #298 (SW-LM)

Green Swamp #1, #298 is located in a Plains setting within the Green Swamp Wilderness Preserve, which is owned and managed by the SWFWMD, and in Southwest Lake County (**Figures B-127 and B-128**). This cypress wetland was determined to be Not Stressed during both the original and 2018 assessment. The wetland is accessed from Rock Ridge Road through a locked District gate on Tanic Road/Main Grade (unpaved lime rock road) (**Figure B-129**). A fire lane is on the east side of Main Grade approximately 5 miles north of Rock Ridge Road. The wetland is located on the north side of the fire lane, approximately 1000 feet east of Main Grade. The 2018 assessment was conducted from the south side of the wetland (**Figure B-129**).

The SWFWMD has recorded surficial aquifer water levels in the wetland monthly since 1999 and conducted annual vegetation assessments of the wetland since 2005 using the WAP as part of the Northern Tampa Bay Recovery Assessment. Wetland water levels have varied with rainfall (**Figure B-130**). There are no known hydrologic alterations to the wetland. There are no known groundwater withdrawals in the vicinity, and the nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 13 miles away.

Figure B-127. Green Swamp #1, #298 (SW-LM), June 2018.

Figure B-128. Green Swamp #1, #298 (SW-LM), June 2018.

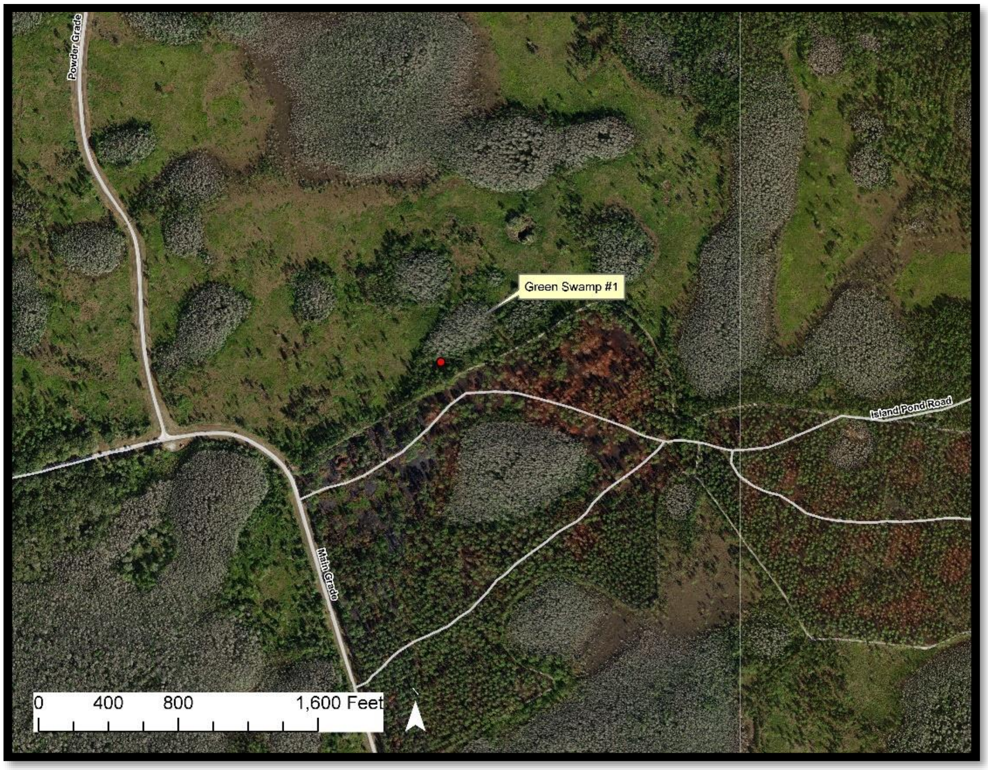

Figure B-129. Location of Green Swamp #1, #298 (SW-LM), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

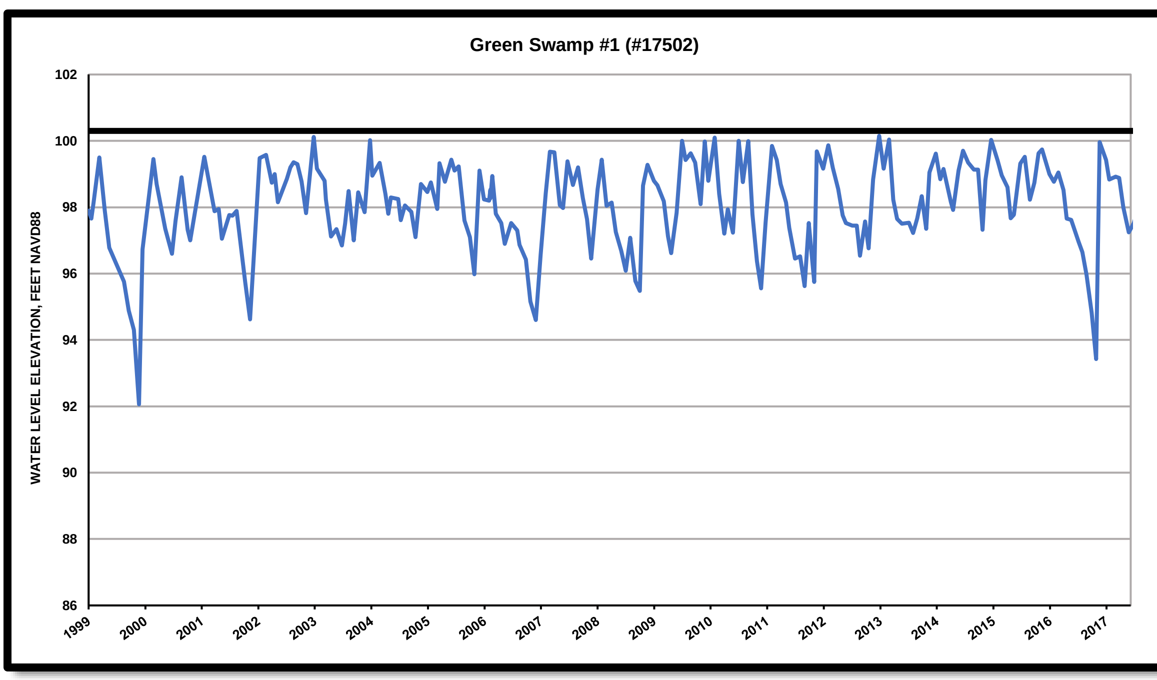

Figure B-130. Period-of-record water level data for Green Swamp #1, #298 (SW-LM). Black line indicates land surface elevation at monitor well.

Lake Wales (SW-MM)

Lake Wales (also known as Lake Wailes) is a 300-acre Ridge lake located in the heart of the City of Lake Wales, with a mean depth of 10' (Figures B-131, B-132, and B-133). The lake's shoreline is completely developed, and it is surrounded by a multi-use paved trail and part of Lake Wailes Park (Figure B-134). The 2018 assessment was conducted along the northwest portion of the lake on and around the park's gazebo and dock (Figure B-134).

During the original assessment, the lake was determined to be stressed; however, it was determined to be unstressed during the 2018 assessment. The review of the period-of-record staff gage data indicates that lake levels have been stable since 2002, with levels after 2002 typically higher than before 2002 (Figure B-135). Water levels in the lake have been trending higher for the last 5 years (Figure B-135). In addition to the stable water levels for many years, a review of historical aerials and the field inspection indicated that the lake is not hydrologically stressed.

The SWFWMD initially established Minimum and Guidance Levels for Lake Wales in 2007. The lake was re-evaluated 10 years later and revised MFLs were adopted in 2017. The revised MFLs are a Minimum Lake Level of 103.8 ft. NAVD88 and a High Minimum Lake Level of 106.7 ft. NAVD88. As of the 2017, the most recent assessment year, Lake Wales was meeting its Minimum Level, but was not meeting its High Minimum Level by 1.4 feet. The Minimum Level is the median water level, i.e., the level the lake should reach or exceed at least 50 percent of the time. The High Minimum Level is the level the lake should reach or exceed ten percent of the time.

Figure B-131. Lake Wales (SW-MM), April 2018.

Figure B-132. Lake Wales (SW-MM), April 2018.

Figure B-133. Lake Wales (SW-MM), April 2018.

Figure B-134. Location of Lake Wales (SW-MM), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

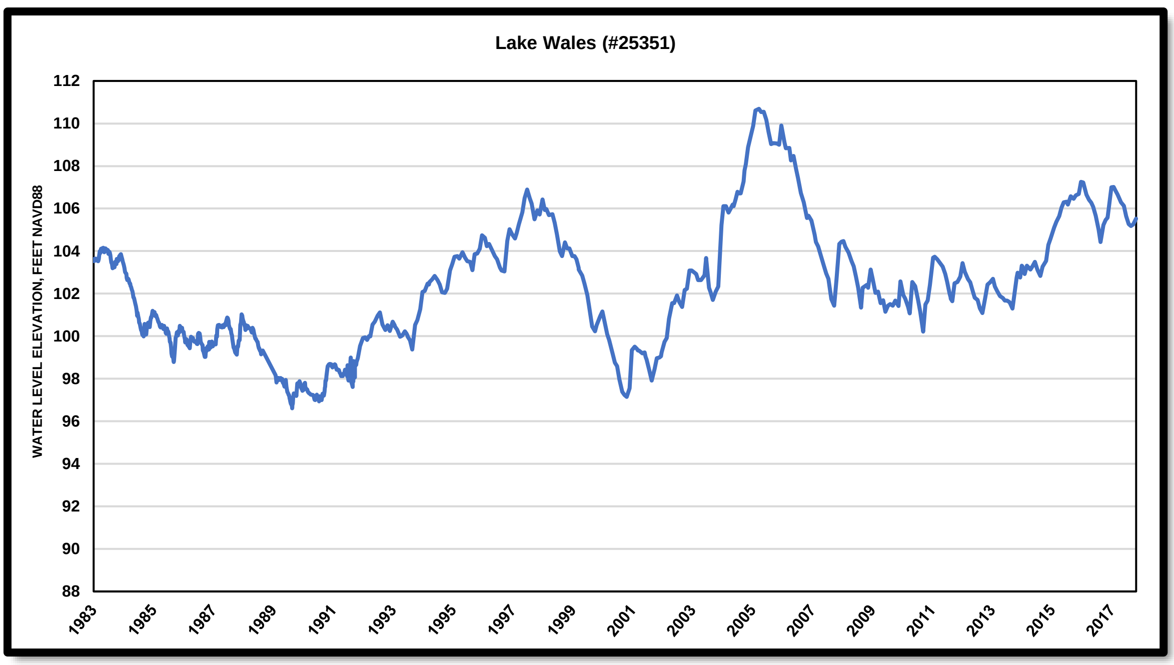

Figure B-135. Period-of-record water level data for Lake Wales (SW-MM).

Big Gum Lake (SW-QA)

Big Gum Lake is an approximately 200-acre Ridge lake located in Polk County. It was determined to be stressed during the original assessment. However, the stress status of the lake resulting from the 2018 assessment changed to unstressed. Much of the shoreline of the lake is natural with some residential development and citrus groves (**Figures B-136, B-137, B-138, and B-139**). The lake was accessed at the location of the SWFWMD staff gage, a private residence off Mammoth Grove Road (**Figure B-140**).

Staff gage data has been collected from the lake since 1981, and the data for this lake indicate stable water levels since about 2010 (**Figure B-141**). As shown on historical aerial photographs, a large ditch was constructed in the northern portion of the lake during the 1940s; however, since the 1970s, lake levels have been relatively stable. Combined with the period-of-record water level data and the review of historical aerials, the field inspection indicated that the lake is not hydrologically stressed.

The SWFWMD has adopted Guidance Levels for the lake, but Minimum Levels have not been established. Guidance Levels are lake water levels adopted to provide advisory information for the SWFWMD, lake shore residents and local governments, or to aid in the management or control of adjustable structures. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-136. Big Gum Lake (SW-QA), April 2018.

Figure B-137. Big Gum Lake (SW-QA), April 2018.

Figure B-138. Big Gum Lake (SW-QA), April 2018.

Figure B-139. Big Gum Lake (SW-QA), April 2018.

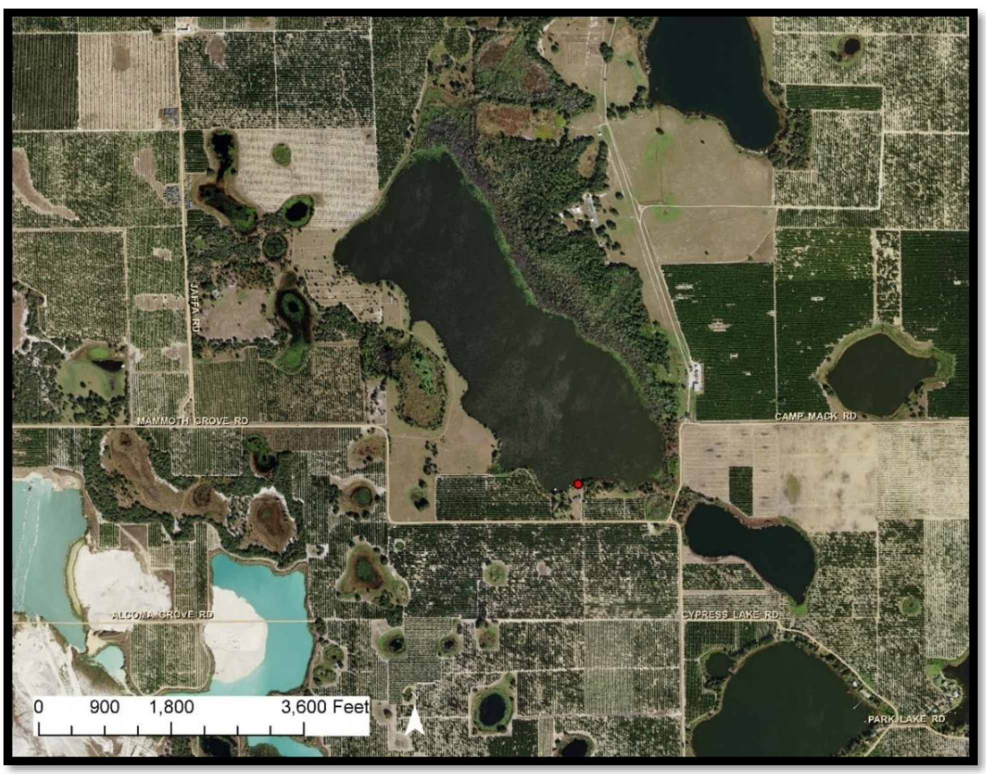

Figure B-140. Location of Big Gum Lake (SW-QA), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

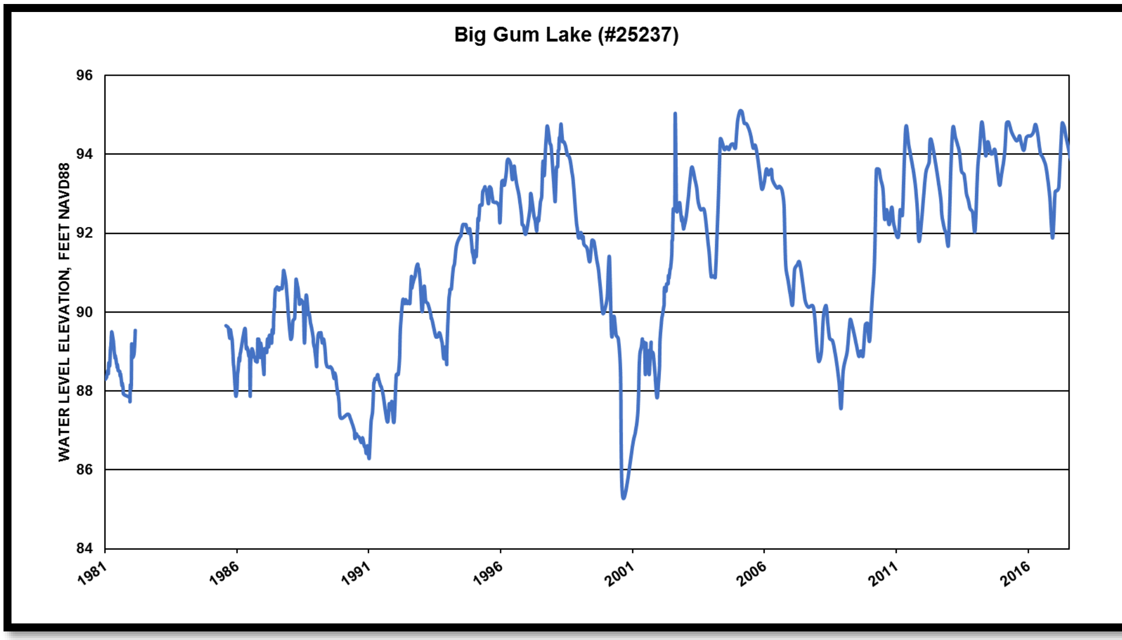

Figure B-141. Period-of-record water level data for Big Gum Lake (SW-QA).

Bonnet Lake (SW-QB)

Bonnet Lake is a 268-acre Ridge lake in Highlands County; it has a maximum depth of about 10' (Figures B-142, B-143, and B-144). Much of the surrounding land has been developed into mobile home and RV parks, and residential development. The lake was accessed from Lake Bonnet Village on the north side of the lake (Figure B-145).

During both the original and 2018 assessment, Bonnet Lake was determined to be not stressed. Water levels have been measured in the lake since 2004; and levels have been in an upward trend since about 2013 (Figure B-146).

The SWFWMD has adopted Guidance Levels for the lake but Minimum Levels have not been established. Guidance Levels are lake water levels adopted to provide advisory information for the SWFWMD, lake shore residents and local governments, or to aid in the management or control of adjustable structures. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-142. Bonnet Lake (SW-QB), October 2018.

Figure B-143. Bonnet Lake (SW-QB), October 2018.

Figure B-144. Bonnet Lake (SW-QB), October 2018.

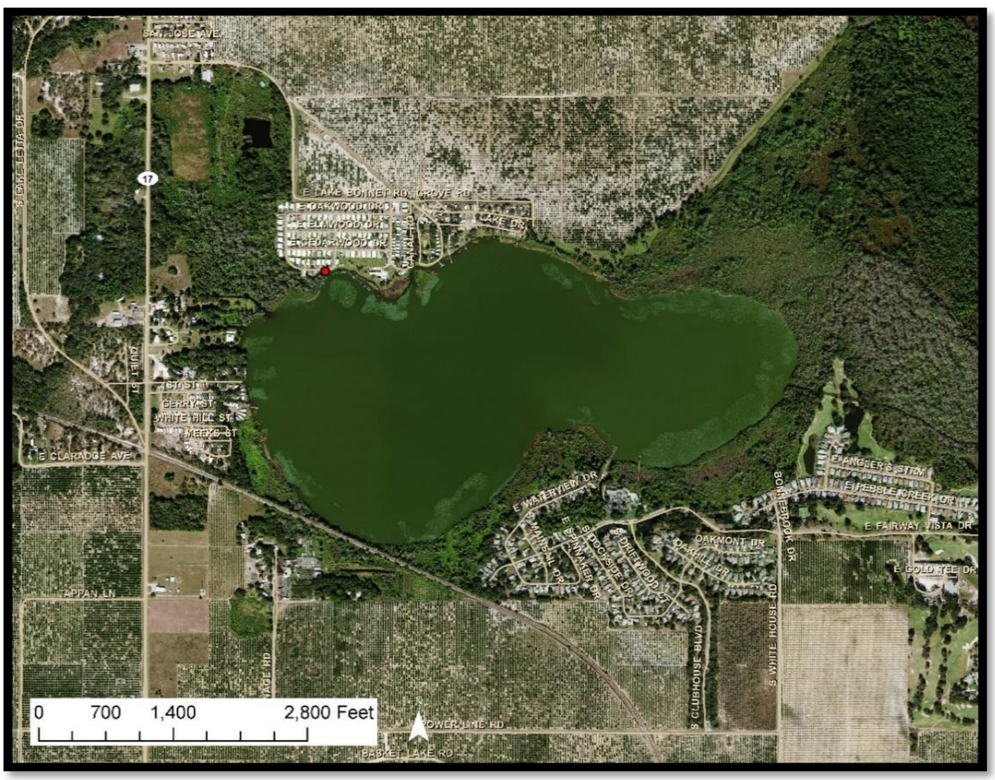

Figure B-145. Location of Bonnet Lake (SW-QB), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

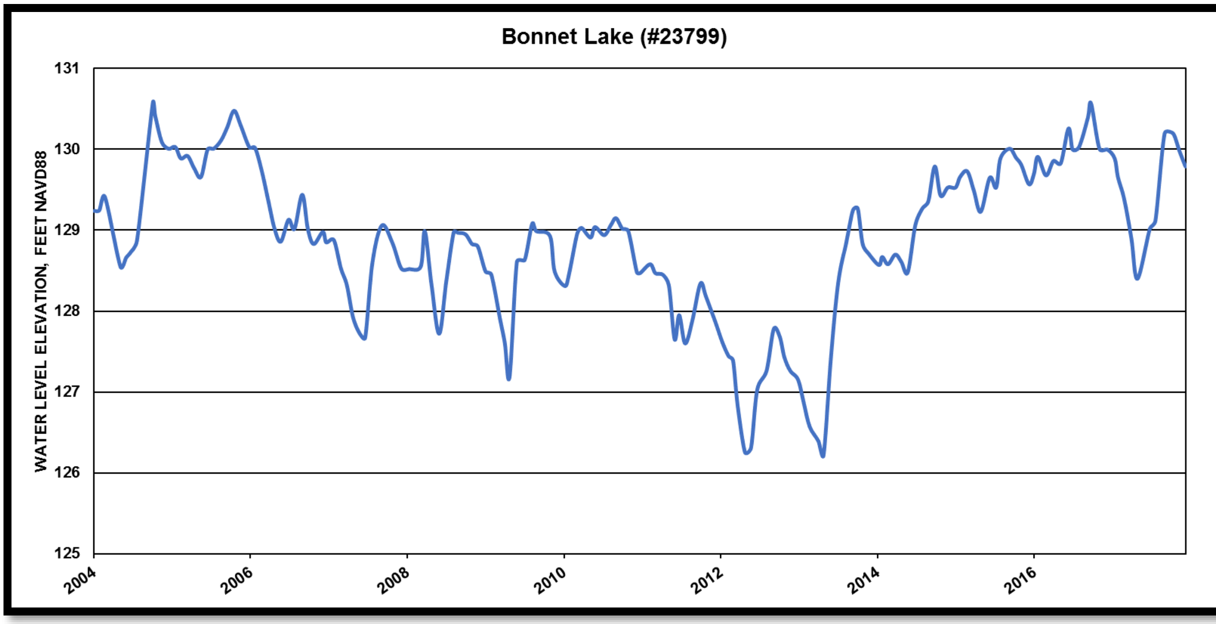

Figure B-146. Period-of-record water level data for Bonnet Lake (SW-QB).

Buck Lake (SW-QC)

Buck Lake is a 10-acre Ridge lake in Highlands County, located about 4 miles south of Lake Placid on U.S. Highway 27 (Figures B-147, B-148, and B-149). The east side of the lake has a few commercial properties; the land around the rest of the lake consists of citrus groves. The lake was accessed from commercial properties adjacent to the highway, and the assessment was conducted on the east side of the lake (Figure B-150). Buck Lake was determined to be unstressed during both the original and 2018 assessment.

Water levels in Buck Lake have been monitored since 1986 (Figure B-151). A review of the period-of-record water level indicates that water levels have been on an increasing trend since 2012.

The SWFWMD has adopted Guidance Levels for the lake but Minimum Levels have not been established. Guidance Levels are lake water levels adopted to provide advisory information for the SWFWMD, lake shore residents and local governments, or to aid in the management or control of adjustable structures. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-147. Buck Lake (SW-QC), April 2018.

Figure B-148. Buck Lake (SW-QC), April 2018.

Figure B-149. Buck Lake (SW-QC), April 2018.

Figure B-150. Location of Buck Lake (SW-QC), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

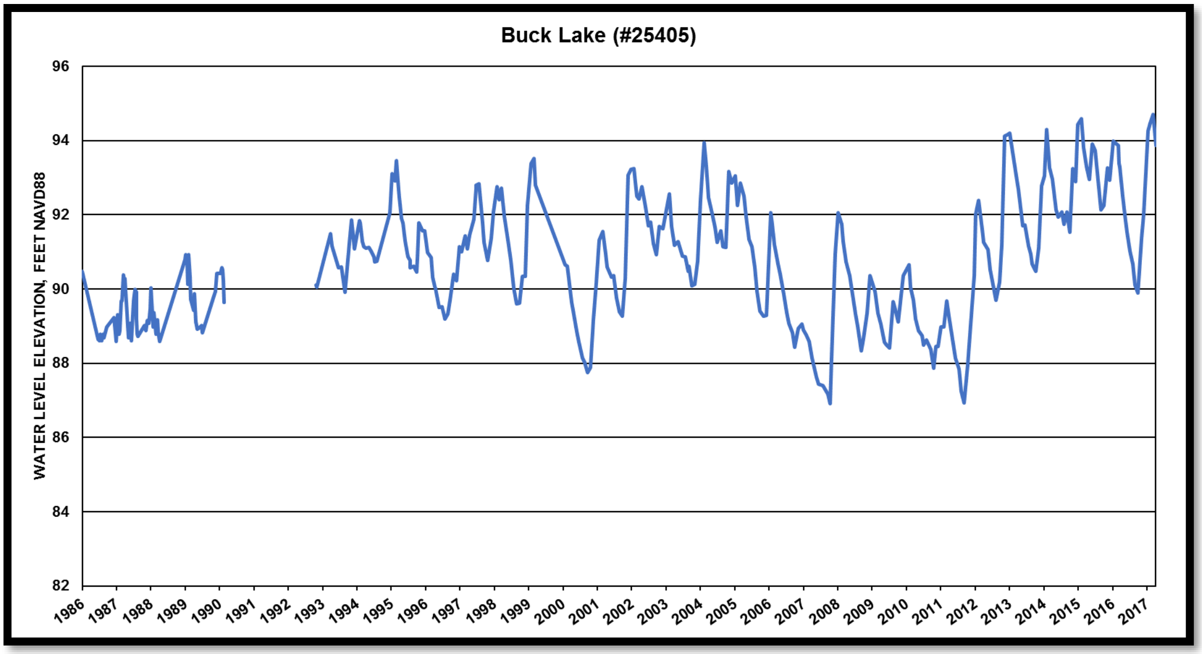

Figure B-151. Period-of-record water level data for Buck Lake (SW-QC).

Gator Lake (SW-QD)

Gator Lake is a 116-acre Ridge lake located in Polk County (Figures B-152, B-153, B-154, B155, and B-156). This lake is connected to other lakes via a large wetland system adjacent to the northeast portion of the lake; it is connected to Surveyors Lake via a ditch to the southwest. Agricultural development occurs along the western and southern shorelines. For the 2018 assessment, the lake was accessed through private property at the location of the SWFWMD staff gage (Figure B-157).

While the lake was determined to be unstressed during the original assessment; the 2018 assessment indicated that Gator Lake was stressed. A review of the historical aerials from the 1940s through the present indicated no change in the lake level. The staff gage data from 1997 through the present indicated more fluctuation in lake levels prior to 2010 as compared to after 2010; the lowest lake levels were recorded before 2010, and levels since 2010 have been more stable (Figure B-158). However, hydrologic stress, in the form of a shift in plant communities (e.g., upland plants invading wetlands) and slight soil subsidence and oxidation, was observed in the wetlands along the lake shore on the site where the staff gage is accessed during the April 2018 field visit (Figures B-155 and B-156).

The SWFWMD has adopted Guidance Levels for the lake but Minimum Levels have not been established. Guidance Levels are lake water levels adopted to provide advisory information for the SWFWMD, lake shore residents and local governments, or to aid in the management or control of adjustable structures. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-152. Gator Lake (SW-QD), April 2018.

Figure B-153. Gator Lake (SW-QD), April 2018.

Figure B-154. Gator Lake (SW-QD), April 2018.

Figure B-155. Shoreline Wetlands Along Gator Lake (SW-QD), April 2018.

Figure B-156. Shoreline Wetlands Along Gator Lake (SW-QD), April 2018.

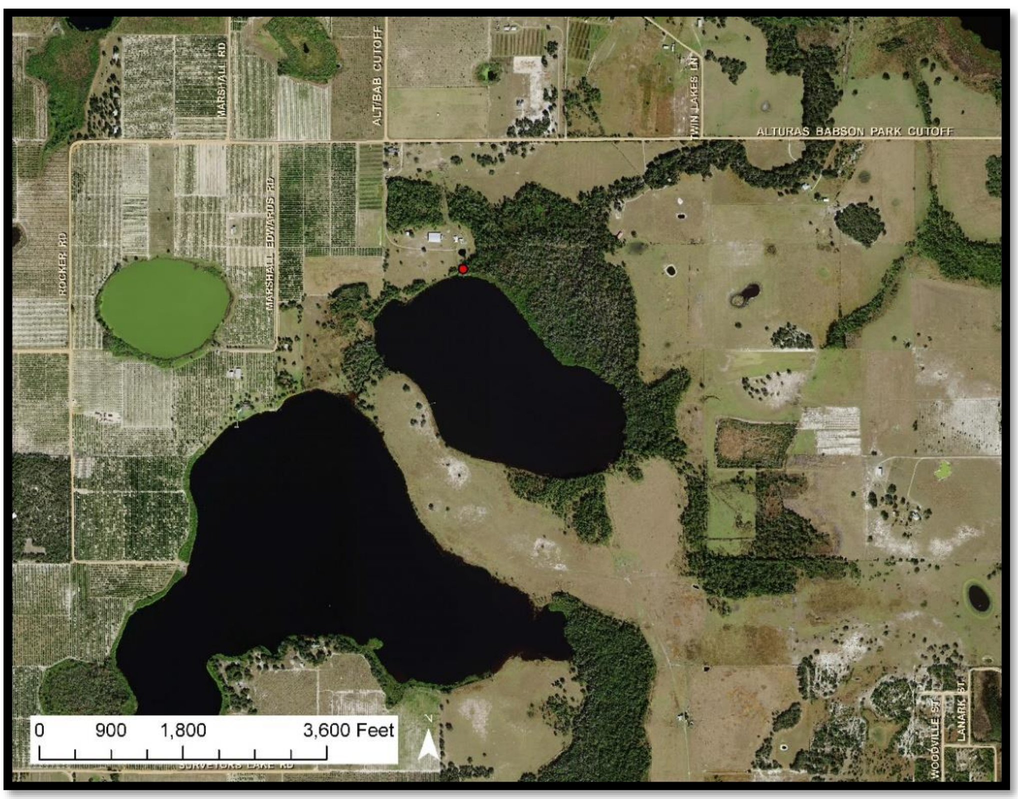

Figure B-157. Location of Gator Lake (SW-QD), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

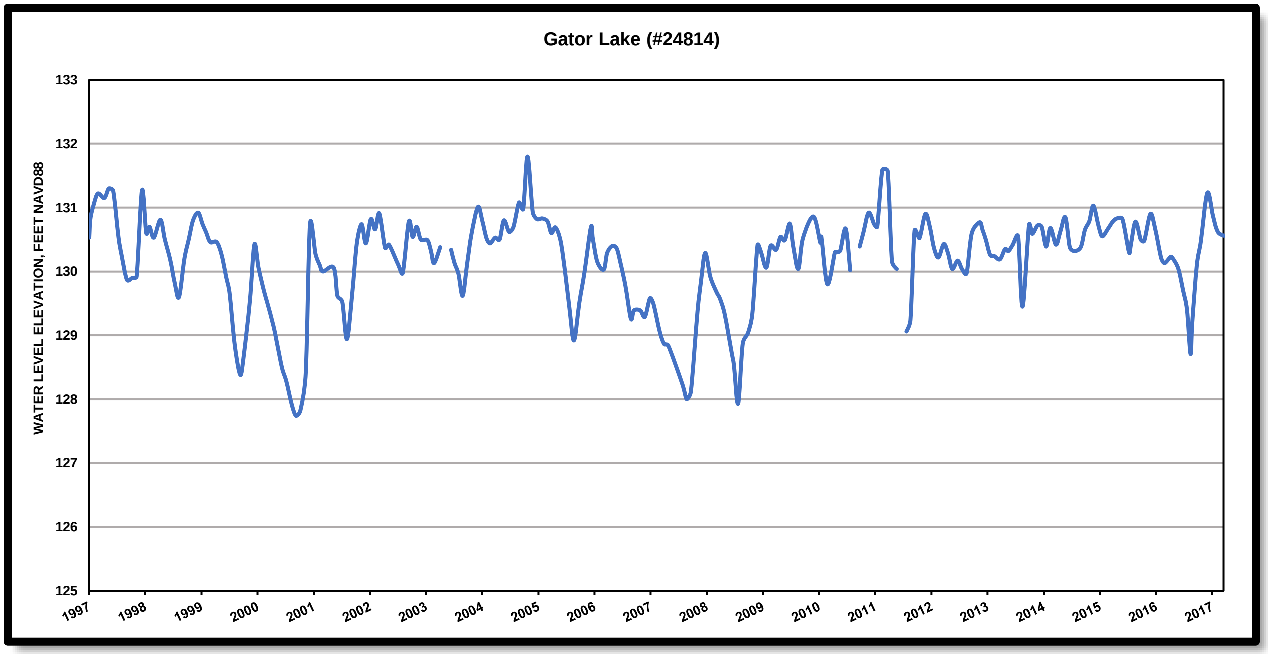

Figure B-158. Period-of-record water level data for Gator Lake (SW-QD).

Lake Annie (SW-QE)

Lake Annie is a pristine, 90-acre sinkhole lake located in a Ridge setting at the northern end of Archbold Biological Station in Highlands County (Figures B-159, B-160, B-161, and B-162). While the lake is located in a Ridge physiographic province, it lies in a valley within the Lake Wales Ridge and is surrounded by flatwoods. The 2018 assessment was conducted at the dock located at the northern end of the lake via a dirt path from SR 70 (Figure B-163). Lake Annie was determined to be unstressed during both the original and 2018 assessment.

Lake Annie, which is 68 feet deep, is the uppermost water body in a chain of connected lakes and streams and is the southernmost of a series of sinkhole lakes extending 200 miles north along and beyond the Lake Wales Ridge. The lake is fed by rainfall and groundwater and has not been affected by human influence because of its position at the head of the drainage system, a small drainage basin with little surface inflow, and absence of development around the lake. The watershed of Lake Annie lies largely within the protected lands of Archbold Biological Station; surface inflow occurs only after high rainfall via two ditches on the south and east shores.

Water level data has been collected from Lake Annie since the 1930s, but because of data gaps, water level data beginning in 1995 is shown in the figure (Figure B-164). With the exception of a couple of high rainfall events, water levels in the lake typically vary only about 2 feet.

Figure B-159. Lake Annie (SW-QE), April 2018.

Figure B-160. Lake Annie (SW-QE), April 2018.

Figure B-161. Lake Annie (SW-QE), April 2018.

Figure B-162. Lake Annie (SW-QE), April 2018.

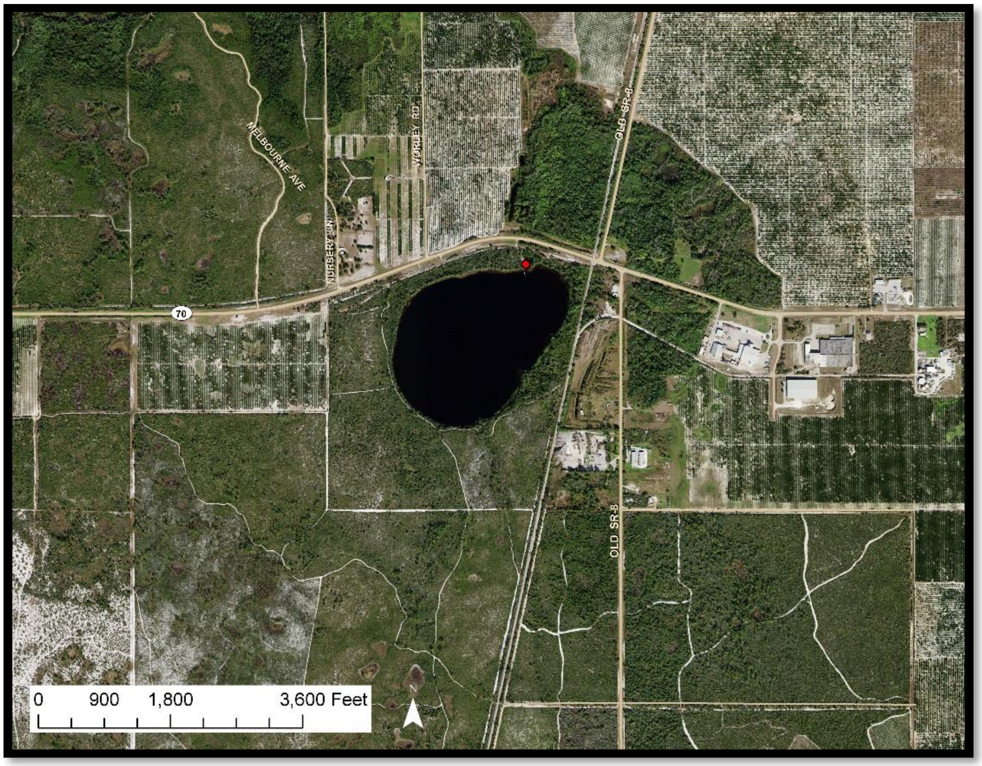

Figure B-163. Location of Lake Annie (SW-QE), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

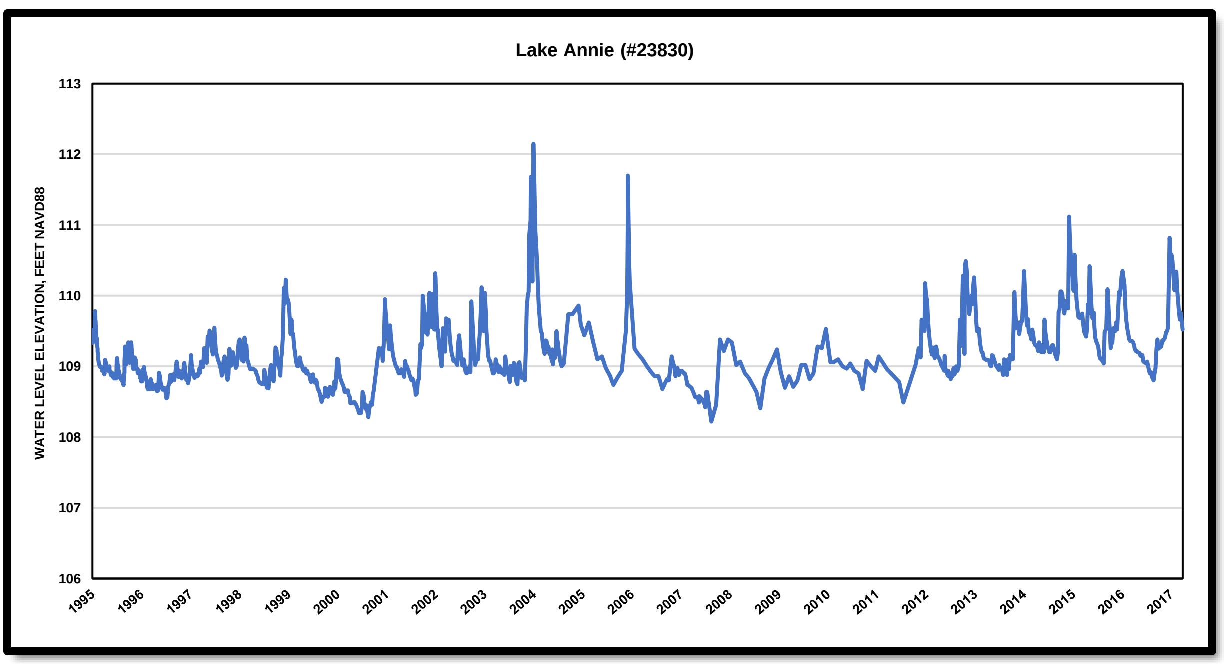

Figure B-164. Period-of-record water level data for Lake Annie (SW-QE). Note that water level data from 1931 through 1941, which ranged from 108.5 to 110.6 NGVD88, is not shown.

Lake Apthorpe (SW-QF)

Lake Apthorpe is Ridge lake located in Highlands County (**Figures B-165, B-166, and B-167**). The 2018 assessment was conducted at the public boat ramp and dock on the south side of the lake, which is accessed from U.S. Highway 27 and St. John Street (**Figure B-168**). While most of the lands to the north, northeast, east, and southeast are undeveloped, lands to the south, west, and northwest consist of citrus groves. During both the original and 2018 assessment, Lake Apthorpe was determined to be unstressed. Water levels have been measured in the lake since 2003 (**Figure B-169**); lake levels are stable and only vary about 2 feet.

Figure B-165. Lake Apthorpe (SW-QF), April 2018.

Figure B-166. Lake Apthorpe (SW-QF), April 2018.

Figure B-167. Lake Apthorpe (SW-QF), April 2018.

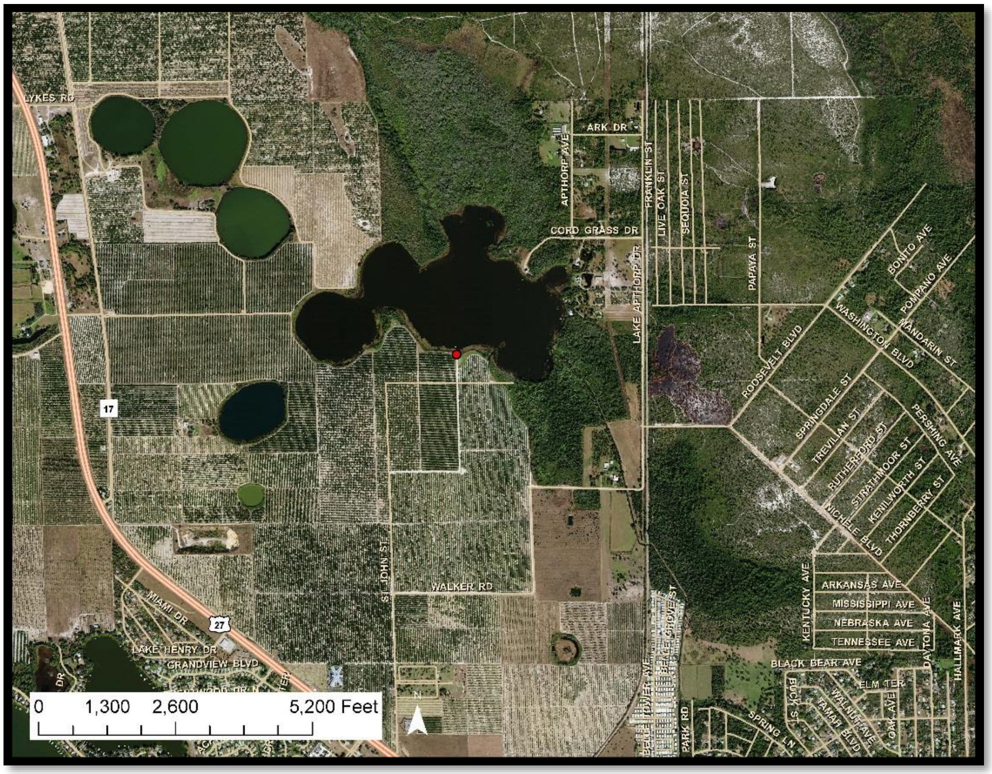

Figure B-168. Location of Lake Apthorpe (SW-QF), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

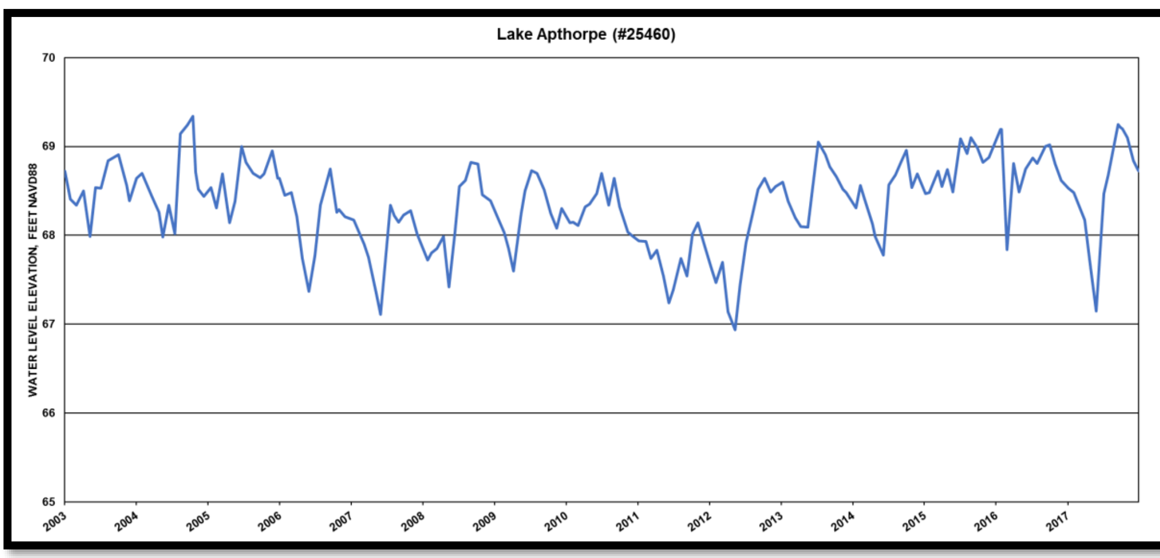

Figure B-169. Period-of-record water level data for Lake Apthorpe (SW-QF).

Lake Leonore (SW-QH)

Lake Leonore is 393-acre Ridge lake located near Babson Park in Polk County (**Figures B-170, B-171, and B-172**). The 2018 assessment was conducted at the northeast corner of the lake accessible via a dirt road off Murray Road (**Figure B-173**). There is a large swamp contiguous to the lake to the north, and the land surrounding the rest of the lake is in citrus.

At the assessment site, there is a large pump and piping indicating that water is withdrawn from the lake for agricultural purposes (**Figure B-172**). Lake Leonore was determined to be unstressed during both the original and 2018 assessment. Water levels have been measured in the lake since 2004, and water levels have shown an increasing trend since 2013 (**Figure B-174**).

The SWFWMD has adopted Guidance Levels for the lake but Minimum Levels have not been established. Guidance Levels are lake water levels adopted to provide advisory information for the SWFWMD, lake shore residents and local governments, or to aid in the management or control of adjustable structures. For 2019, the most recent determination, the lake is not stressed relative to the adopted Guidance Levels.

Figure B-170. Lake Leonore (SW-QH), February 2018.

Figure B-171. Lake Leonore (SW-QH), February 2018.

Figure B-172. Lake Leonore (SW-QH), February 2018.

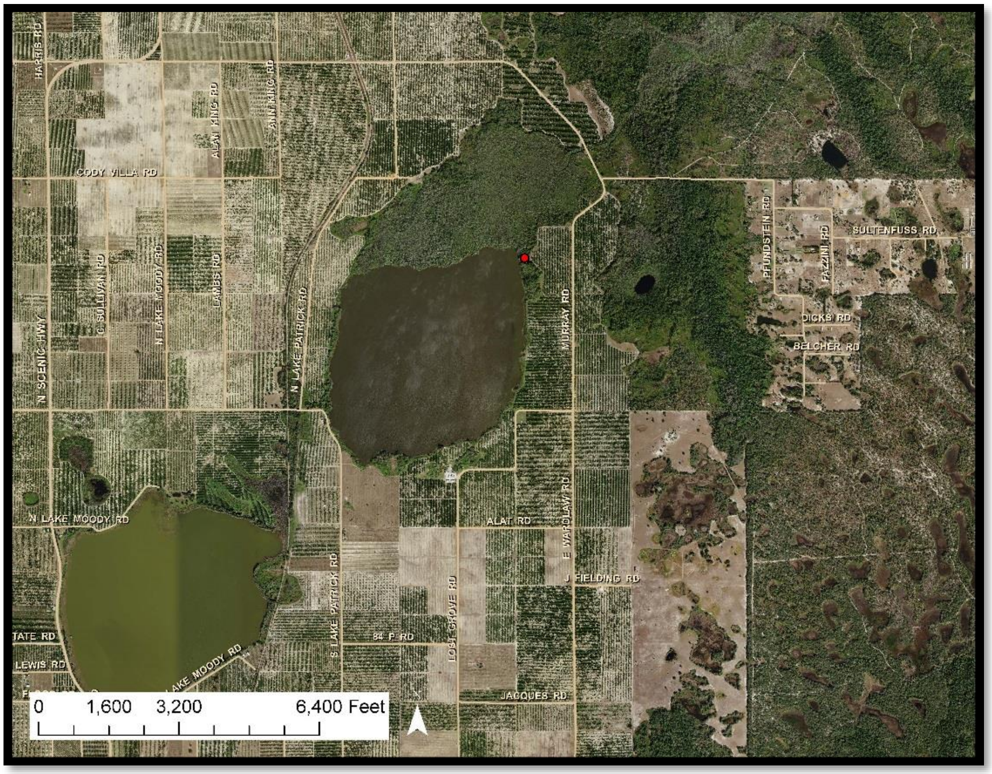

Figure B-173. Location of Lake Leonore (SW-QH), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

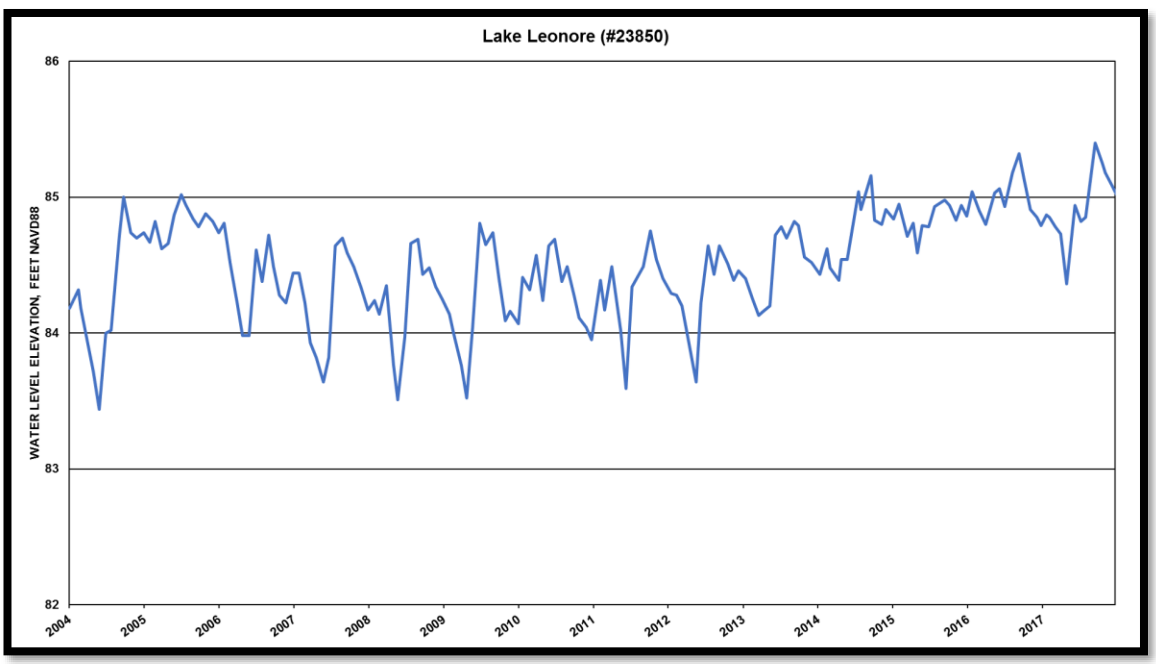

Figure B-174. Period-of-record water level data for Lake Leonore (SW-QH).

Lake Placid (SW-QI)

Lake Placid is an approximately 3,400-acre Ridge lake, with a maximum depth of 57', located to the south of the city of Lake Placid in Highlands County (Figures B-175, B-176, and B-177). The 2008 assessment was conducted at the public boat ramp located on the west side of the lake on Placid View Drive (Figure B-178). The lake is surrounded by agricultural and residential development.

During both the original and 2018 assessment, Lake Placid was determined to be Not Stressed. Water levels have been measured in the lake since 2003 (Figure B-179). Water levels began to decrease in 2006 but have been on an increasing trend since 2013 and have returned to levels observed in the early 2000s (Figure B-179).

The SWFMWD has adopted Minimum Levels for the lake, consisting of a High Minimum Level and a Minimum Level. The Minimum Level is the median water level, i.e., the level the lake should reach at least 50 percent of the time. For Lake Placid that elevation is 91.4 ft. NAVD88. The High Minimum Level is the level the lake should reach or exceed ten percent of the time. That elevation for Lake Placid is 92.6 ft. NAVD88. As of the 2017, the most recent assessment year, Lake Placid is meeting its Minimum Levels.

Figure B-175. Lake Placid (SW-QI), April 2018.

Figure B-176. Lake Placid (SW-QI), April 2018.

Figure B-177. Lake Placid (SW-QI), April 2018.

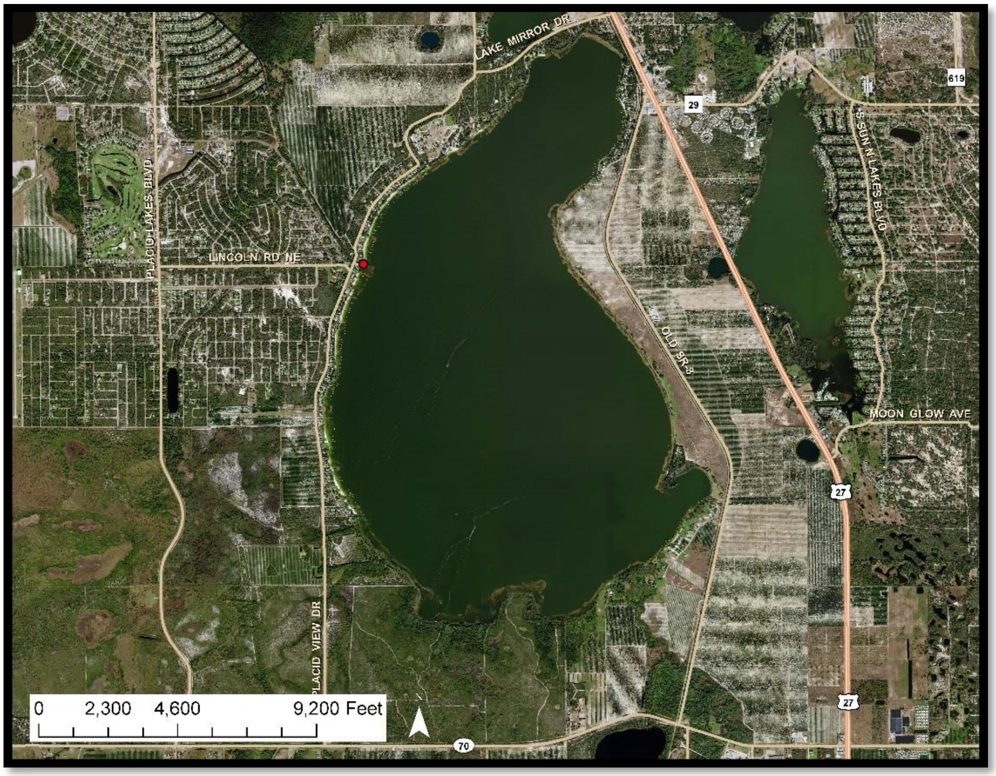

Figure B-178. Location of Lake Placid (SW-QI), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

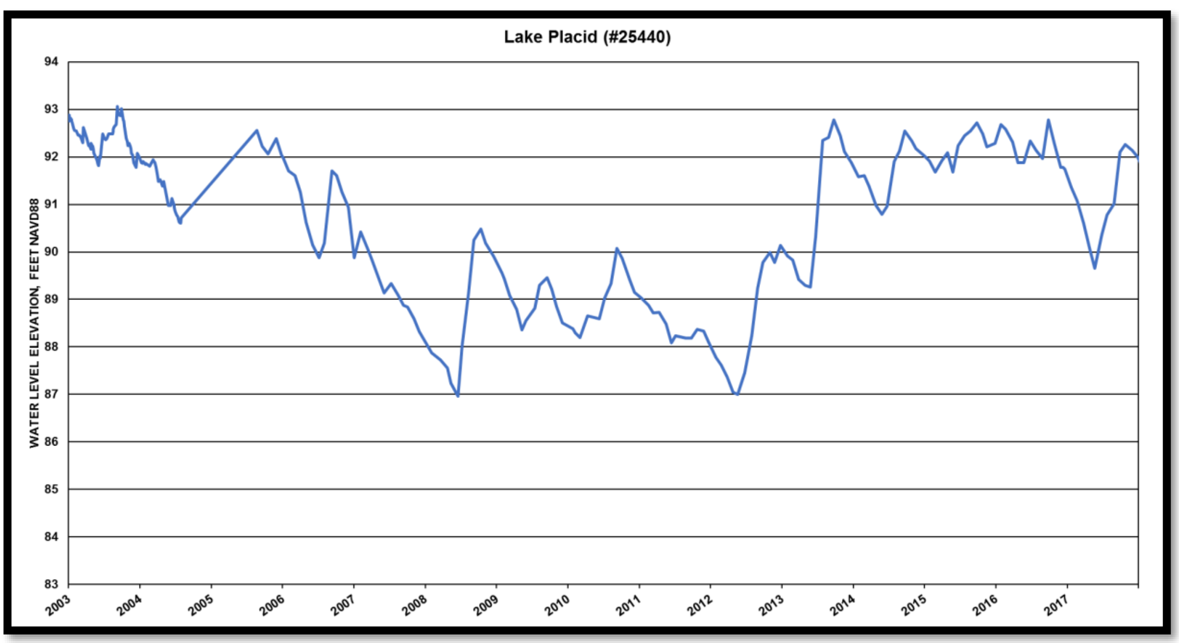

Figure B-179. Period-of-record water level data for Lake Placid (SW-QI).

Lake Streety (SW-QJ)

Lake Streety is 324 acres in size and is a Ridge lake located in Polk County (**Figures B-180, B-181, and B-182**). The 2018 assessment was conducted on the northern shoreline where Lake Streety Road runs along the shoreline; Lake Streety Road is accessible via US 27 (**Figure B-183**). The tannic lake, surrounded by cypress wetlands, is just north of Avon Park Cutoff Road in a rural area with relatively undisturbed shoreline and is surrounded by agricultural lands, most planted in citrus.

Lake Streety was determined to be unstressed during both the original and 2018 assessments. Lake Streety's water levels have been measured regularly since the early 1980s, and water levels have relatively stable (**Figure B-184**).

Figure B-180. Lake Streety (SW-QJ), April 2018.

Figure B-181. Lake Streety (SW-QJ), April 2018.

Figure B-182. Lake Streety (SW-QJ), April 2018.

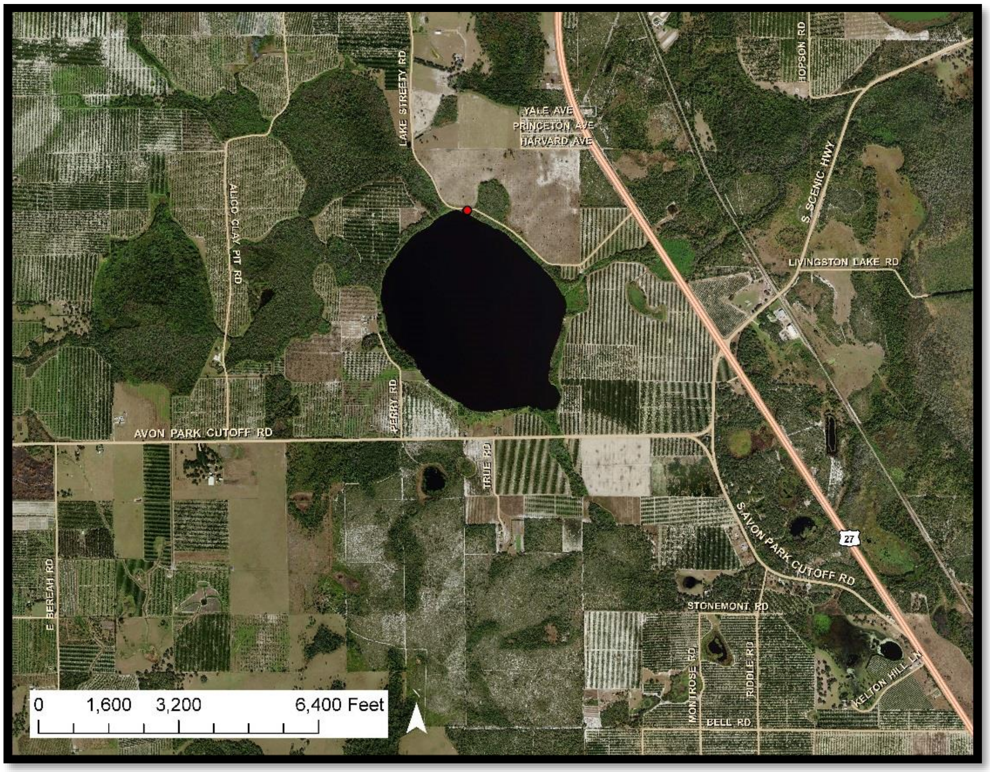

Figure B-183. Location of Lake Streety (SW-QJ), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

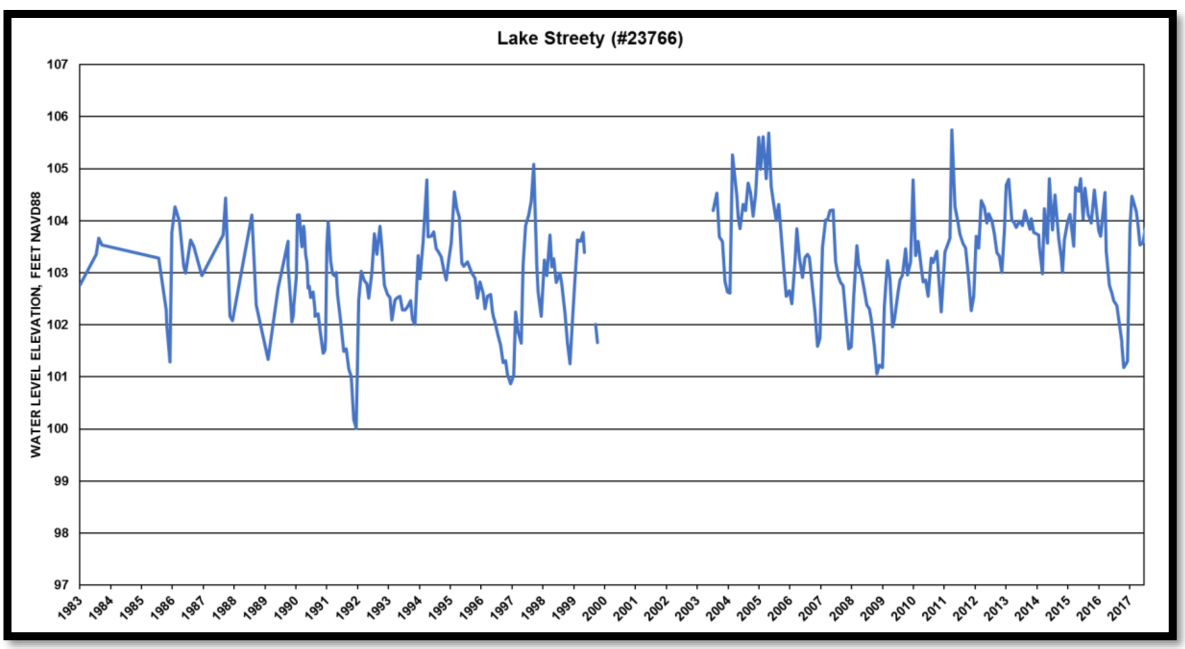

Figure B-184. Period-of-record water level data for Lake Streety (SW-QJ).

Lake Van (SW-QK)

Lake Van is a Ridge lake located in Polk County that is 595 acres in size (**Figures B-185, B-186, and B-187**). The 2018 assessment was conducted on the eastern shoreline via a fairly new residential subdivision located on Adams Barn Road in the City of Auburndale (**Figure B-188**). The surrounding agricultural lands are being converted into residential development.

Water levels in Lake Van have been measured since 2003 (**Figure B-189**). They have been on an increasing trend since about 2009). Lake Van was determined to be unstressed during both the original and 2018 assessments.

Figure B-185. Lake Van (SW-QK), April 2018.

Figure B-186. Lake Van (SW-QK), April 2018.

Figure B-187. Lake Van (SW-QK), April 2018

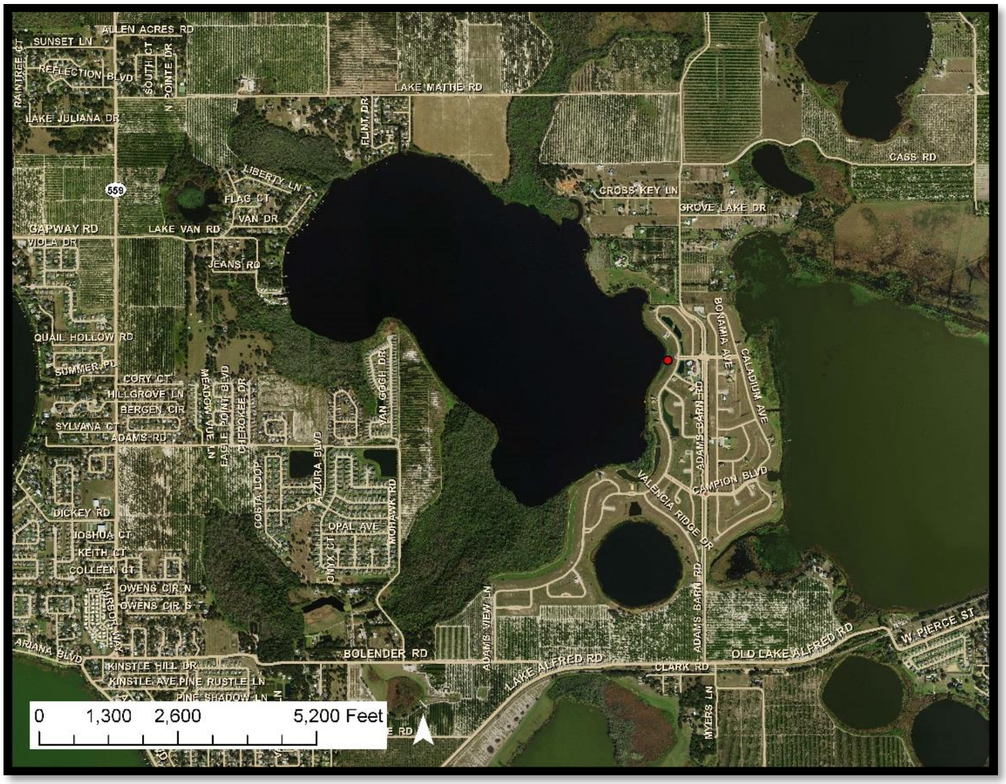

Figure B-188. Location of Lake Van (SW-QK), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

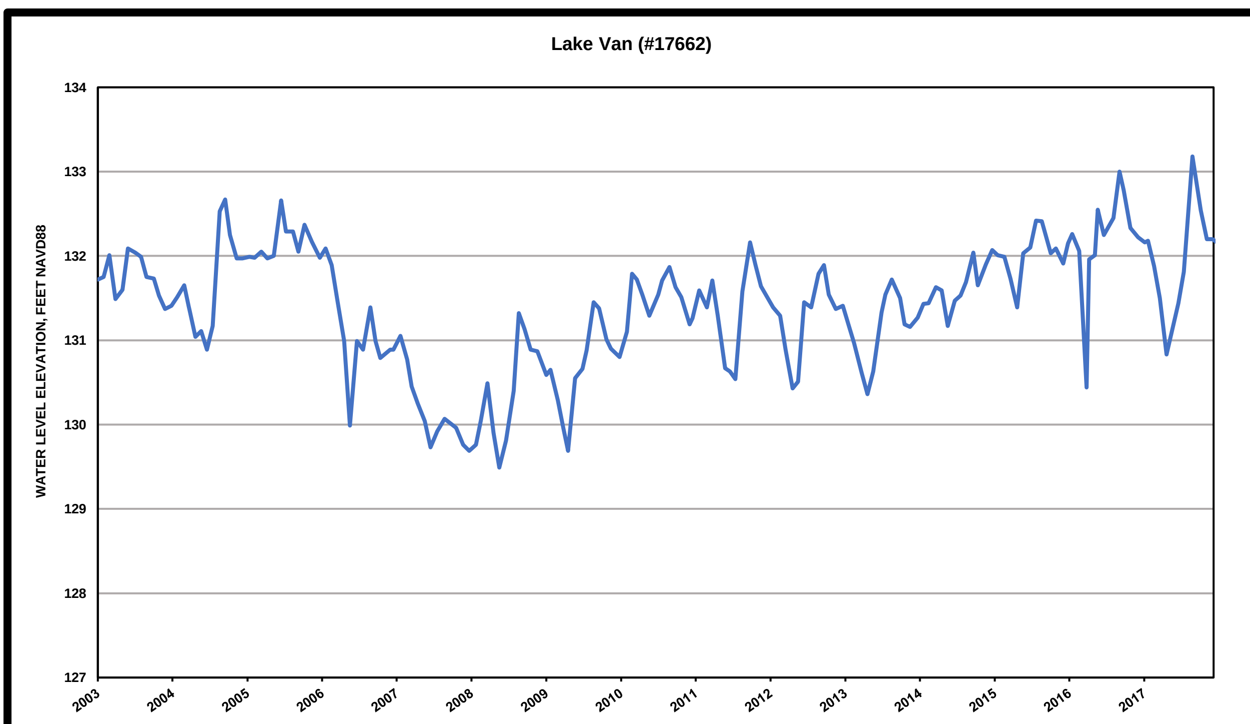

Figure B-189. Period-of-record water level data for Lake Van (SW-QK).

Lake Walker (SW-QL)

Lake Walker is a Ridge lake in Polk County that is about 43 acres in size (**Figures B-190, B-191, and B-192**). The 2018 assessment was conducted along the western shoreline adjacent to Walker Lake Road **(Figure B-193**). While most of the surrounding lands are agricultural, there are residences along the northern, eastern, and southern shorelines. Lake Walker was determined to be stressed during both the original and 2018 assessments. During the 2018 assessment, compacted soils and a shift in the plant community (e.g., upland plants invading the wetlands) was observed along the shoreline of the lake. While staff gage data for the lake, which has been collected since the late 1970s, indicate a slight increasing trend in water levels (**Figure B-194**), the many exposed docks around the lake indicate that water levels were higher in the past as compared to current conditions.

Figure B-190. Lake Walker (SW-QL), April 2018**.**

Figure B-191. Lake Walker (SW-QL), April 2018.

Figure B-192. Lake Walker (SW-QL), April 2018.

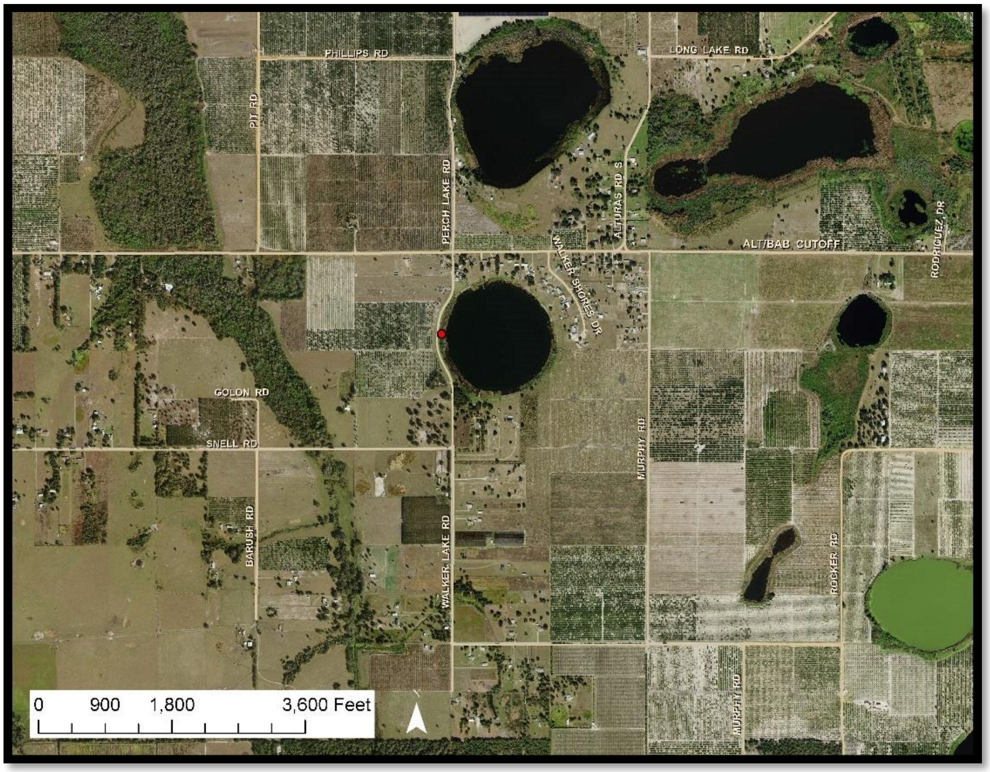

Figure B-193. Location of Lake Walker (SW-QL), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

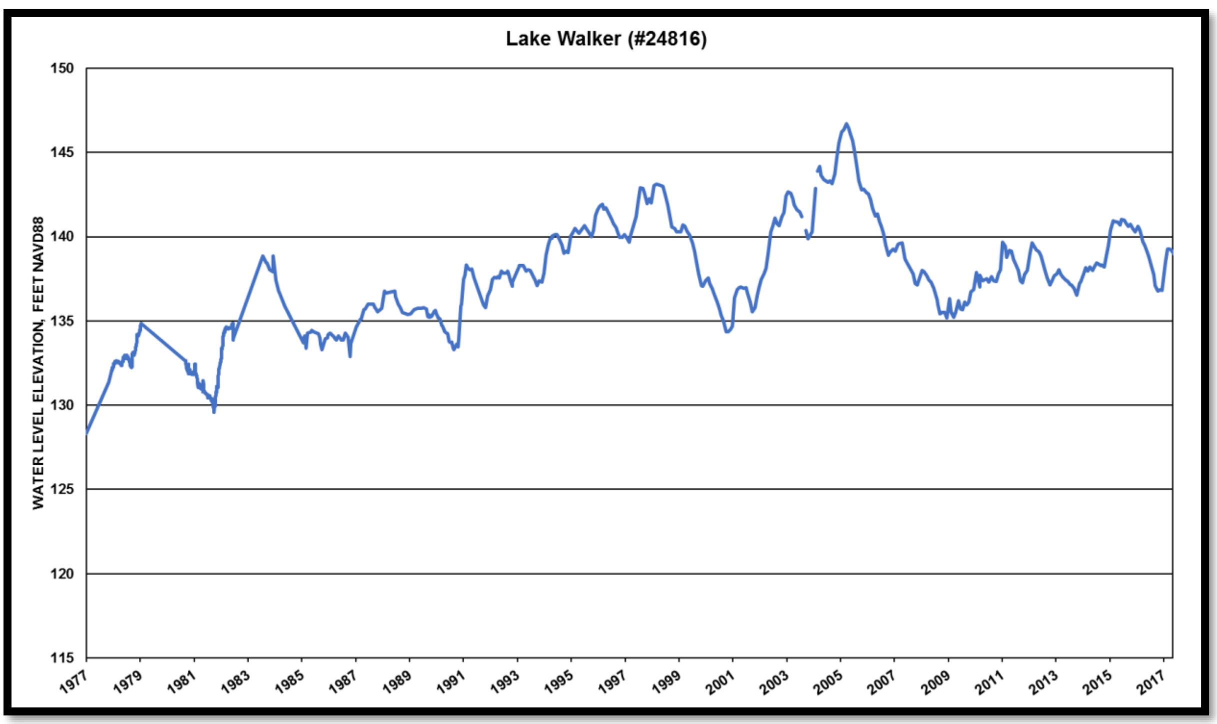

Figure B-194. Period-of-record water level data for Lake Walker (SW-QL).

Polecat Lake (SW-QM)

Polecat Lake is an approximately 39-acre Ridge lake located in Polk County (Figures B-195 and B-196). The lake was accessed on the west side at the staff gage location down a dirt path via Rocker Road for the 2018 assessment (Figure B-197). The lake, which is completely surrounded by citrus groves, was determined to be stressed in the original assessment and unstressed during the 2018 assessment. The field inspection indicated that the lake had water quality issues but was not hydrologically stressed. Unlike other nearby lakes, the color of the water of Polecat Lake is pea green (Figures B-195 and B-196).

Polecat Lake water levels have been measured since the mid-1980s (Figure B-198). The lowest water levels were recorded during the 1980s. After a period of low water levels around 2007-2009, water levels increased in 2010 and have remained stable (Figure B-198).

Figure B-195. Polecat Lake (SW-QM), April 2018.

Figure B-196. Polecat Lake (SW-QM), April 2018.

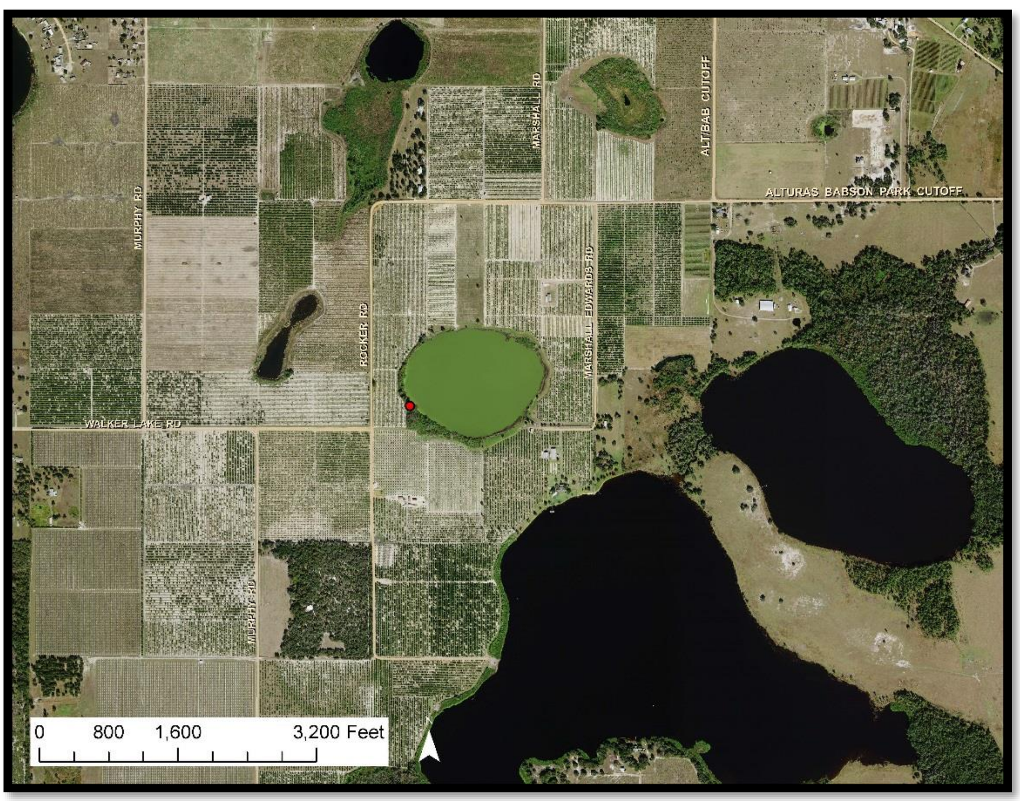

Figure B-197. Location of Polecat Lake (SW-QM), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

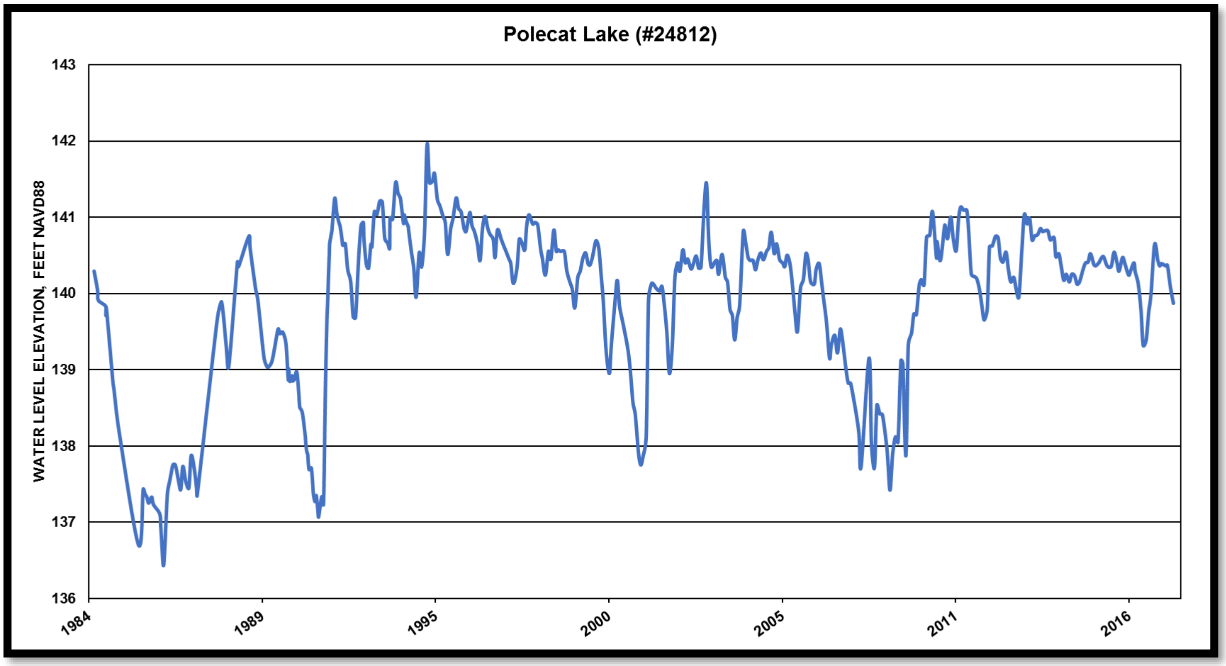

Figure B-198. Period-of-record water level data for Polecat Lake (SW-QM).

Surveyors Lake (SW-QN)

Surveyors Lake is a 284-acre Ridge lake in Polk County (**Figures B-199, B-200, and B-201**); its mean depth is 9', with a maximum depth of 14'. The 2018 assessment was conducted along the western shoreline at the public boat ramp at the end of Rocker Road (**Figure B-202**). This lake is in a rural area and completely surrounded by agricultural lands. It is connected to Gator Lake via a ditch to the northeast. During both the original and 2018 assessments, Surveyors Lake was determined to be unstressed.

Water level data have been collected from Surveyors Lake since 1984 (**Figure B-203**). Lowest levels were recorded around 1991, and water levels have been stable since about 2001, fluctuating about 2'.

Figure B-199. Surveyors Lake (SW-QN), April 2018.

Figure B-200. Surveyors Lake (SW-QN), April 2018.

Figure B-201. Surveyors Lake (SW-QN), April 2018.

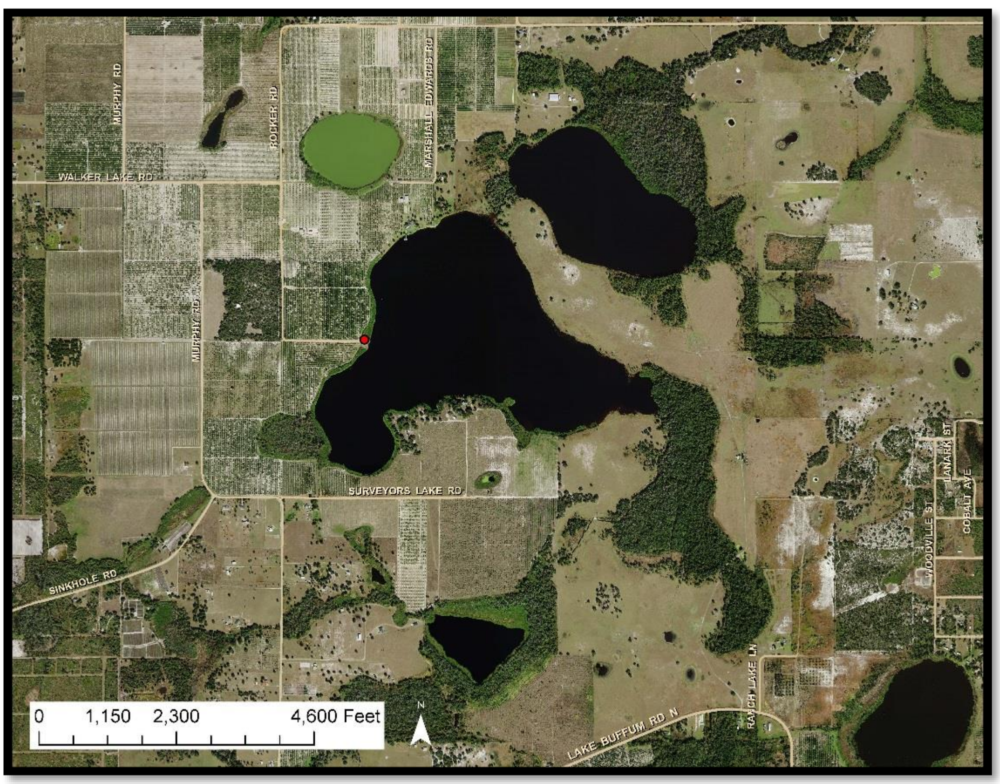

Figure B-202. Location of Surveyors Lake (SW-QN), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

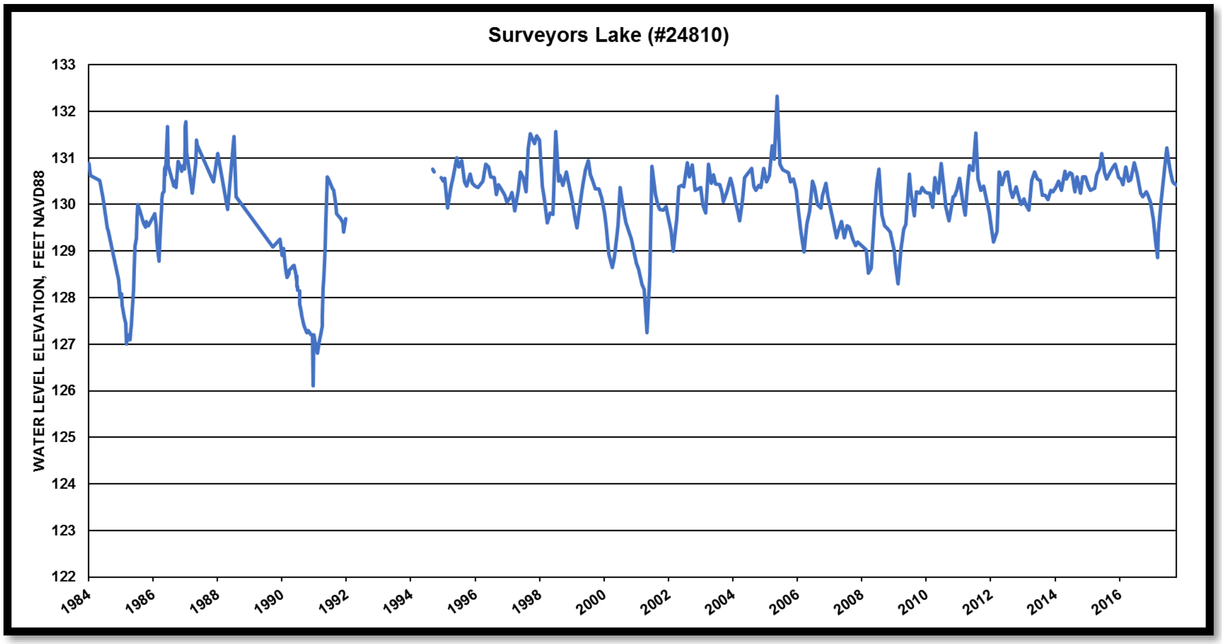

Figure B-203. Period-of-record water level data for Surveyors Lake (SW-QN).

Parks Lake (SW-QO)

Parks Lake is a Ridge lake in Polk County that is 102 acres in size (**Figures B-204, B-205, and B-206**). The 2018 assessment was conducted along the southwestern shoreline at the staff gage located on a dirt road off Lake Park Road (**Figure B-207**). The lake is located in a rural area; the majority of the lake is surrounded by citrus groves. Parks Lake was determined to be unstressed during the original and 2018 assessments.

Water level data for Parks Lake have been collected regularly since 1986 (**Figure B-208**). While water levels have been stable since about 2006, they are lower than levels measured during the late 1990s and early 2000s.

Figure B-204. Parks Lake (SW-QO), April 2018.

Figure B-205. Parks Lake (SW-QO), April 2018.

Figure B-206. Parks Lake (SW-QO), April 2018.

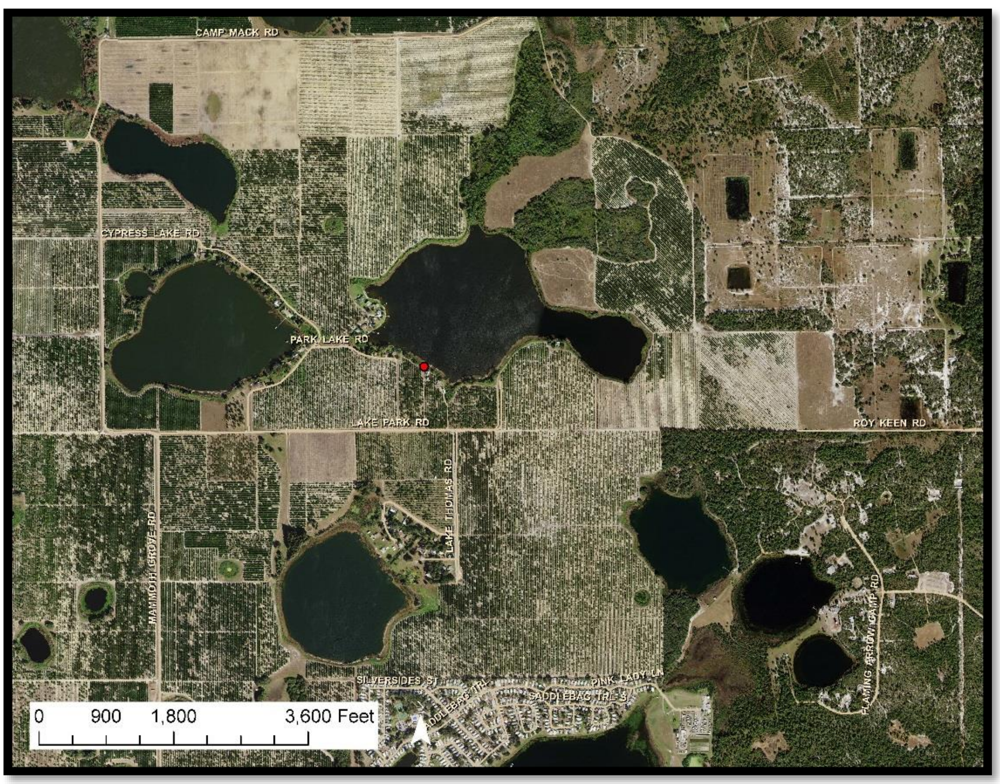

Figure B-207. Location of Parks Lake (SW-QO), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

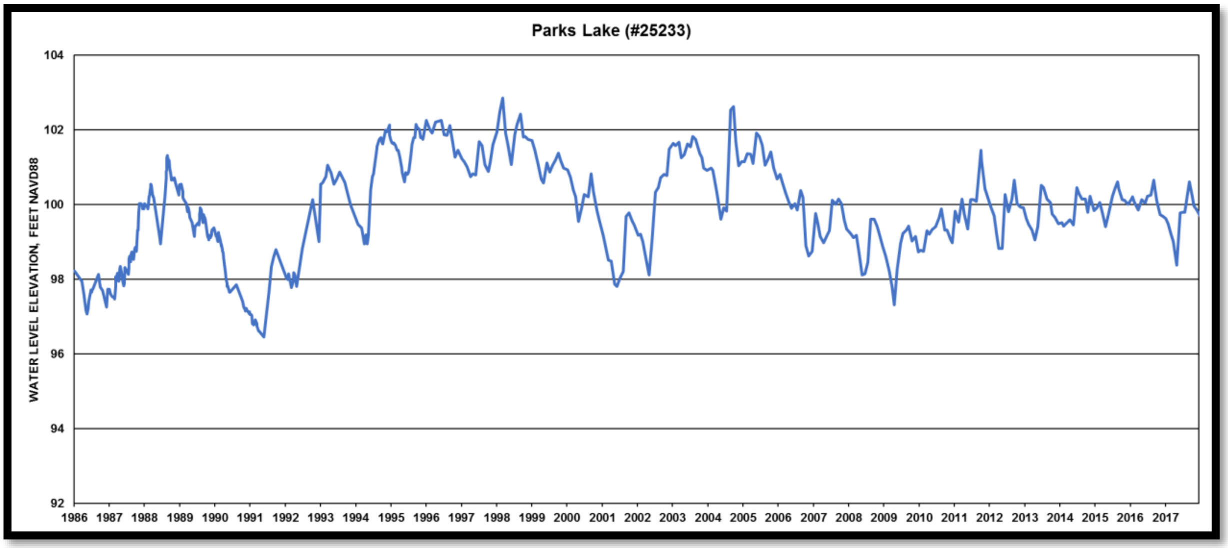

Figure B-208. Period-of-record water level data for Parks Lake (SW-QO).

Crooked Lake (SW-QQ)

Crooked Lake is a Ridge lake located in Polk County that is approximately 4,300 acres in size. Its maximum depth is 45’, with a mean depth of 13’. Residential development is located on the north and northeastern shorelines, while the eastern, southern, and western shorelines are mostly conservation lands (Figures B-209, B-210, and B-211). Agricultural lands, primarily citrus groves, make up much of the lake basin. The previous assessment determined the lake to be stressed, but it was unstressed during the 2018 assessment. The 2018 assessment was conducted along the eastern shoreline from Polk County’s Crooked Lake Prairie (Figure B-212).

An outlet ditch connecting from Little Crooked Lake (the southernmost basin of Crooked Lake) to Lake Clinch was reported to have been constructed in the 1880s and modified in the 1940s and 1950s. The review of the historical aerials and the period-of-record staff gage data indicated a pattern of decreasing water levels from the 1940s through about 1991; since that time, water levels have been on an increasing trend, with increased lake levels in recent years (Figure B-213).

Land and water use in the Crooked Lake watershed has changed over the years, although agriculture has been the dominant use. Much of the agricultural land use is, and has historically been, for citrus. In general, irrigation of citrus groves became more prevalent in the 1960s. There is historical evidence, e.g., consumptive use permits, that water was pumped directly from the lake for irrigation; removal of this stressor may have contributed to the recent increased lake levels. In addition, historical lake levels were most likely affected by agricultural pumping from the Upper Floridan aquifer, and this pumping was greatly reduced after freezes during the 1980s. The lake was not hydrologically stressed during the 2018 field inspection (Figures B-209, B-210, and B-2116).

The SWFWMD initially established Minimum Levels for Crooked Lake in 2007. The lake was reevaluated and revised MFLs, approximately 1.2 feet lower than the previous MFLs, were established in 2017. The revised levels are a Minimum Lake Level of 116.72 ft. NAVD88 and a High Minimum Lake Level of 119.72 ft. NAVD88. The 2017 assessment indicated that Crooked Lake is meeting its minimum levels.

Figure B-209. Crooked Lake (SW-QQ), February 2018.

Figure B-210. Crooked Lake (SW-QQ), February 2018.

Figure B-211. Crooked Lake (SW-QQ), February 2018.

Figure B-212. Location of Crooked Lake (SW-QQ), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

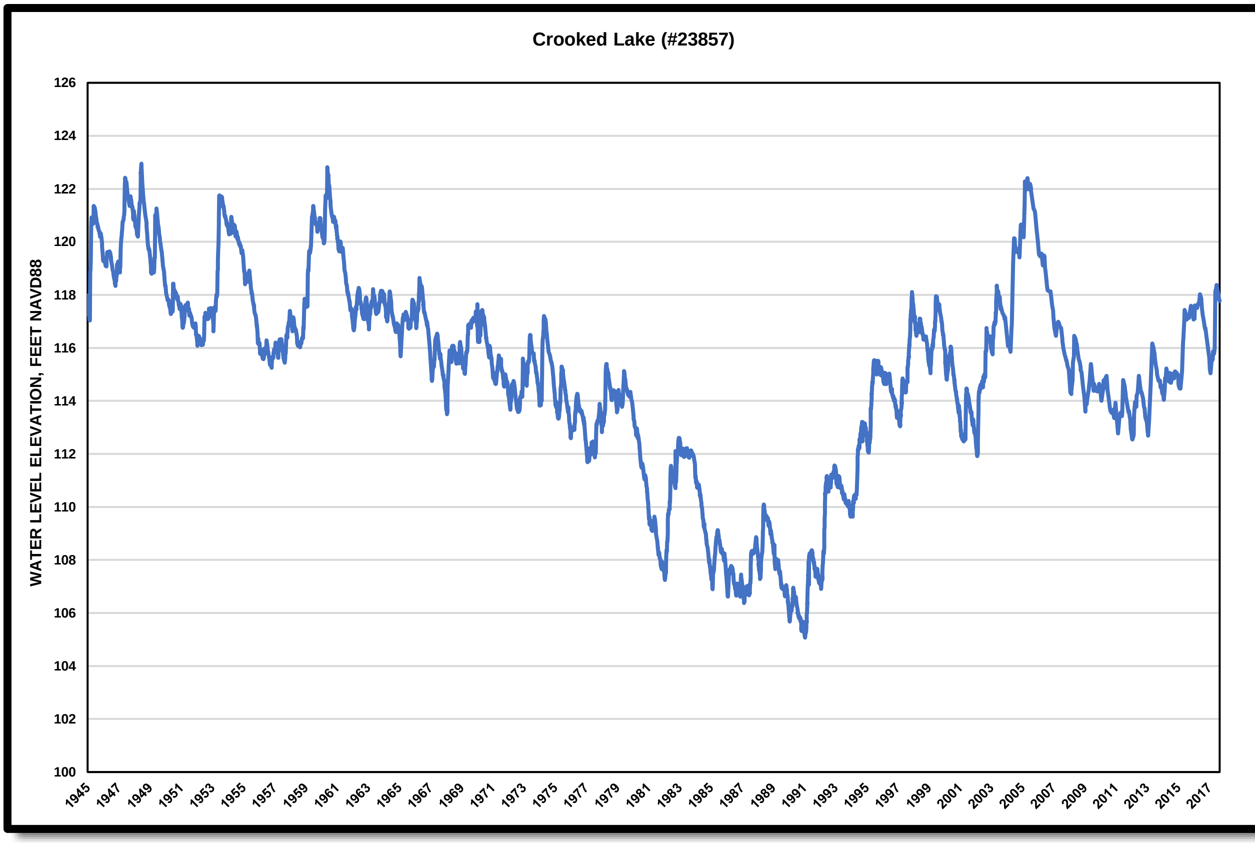

Figure B-213. Period-of-record water level data for Crooked Lake (SW-QQ).

Van Fleet #2 (SW-DD)

Van Fleet #2 is cypress swamp located in a Plains setting on property owned by Polk County and is within the County's Northeast Regional Utility Service Area (NERUSA) wellfield (**Figures B-214, B-215, and B-216**). The wetland is accessed from Waverly Barn Road, west of U.S. Highway 27 (**Figure B-217**). This groundwater-dominated wetland was assessed as unstressed in 2018.

The SWFWMD issued WUP No. 6509.003 to Polk County in 1994. Beginning in 1995 and continuing to 2003, groundwater pumping by Polk County facilities exceeded permitted quantities. In 2002, the SWFWMD documented impacts to Van Fleet #2 that were attributed to over pumping the adjacent county well. Due to permit enforcement action by the SWFWMD beginning in 2003, the county reduced pumping at the well adjacent to Van Fleet #2. Since 2003, groundwater and surface water levels in Van Fleet #2 have rebounded, and the county has implemented an Environmental Monitoring Plan. The county is continuing to monitor groundwater and surface water levels in the wetland (**Figure B-218**).

Van Fleet #2 meets the requirement of being a Class 1 wetland, so it was added to the dataset for the current EMT analysis. It is also one of the wetlands included in the DMIT long-term wetlands monitoring program.

Figure B-214. Van Fleet #2 (SW-DD), September 2018.

Figure B-215. Van Fleet #2 (SW-DD), September 2018.

Figure B-216. Van Fleet #2 (SW-DD), September 2018.

Figure B-217. Location of Van Fleet #2 (SW-DD), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

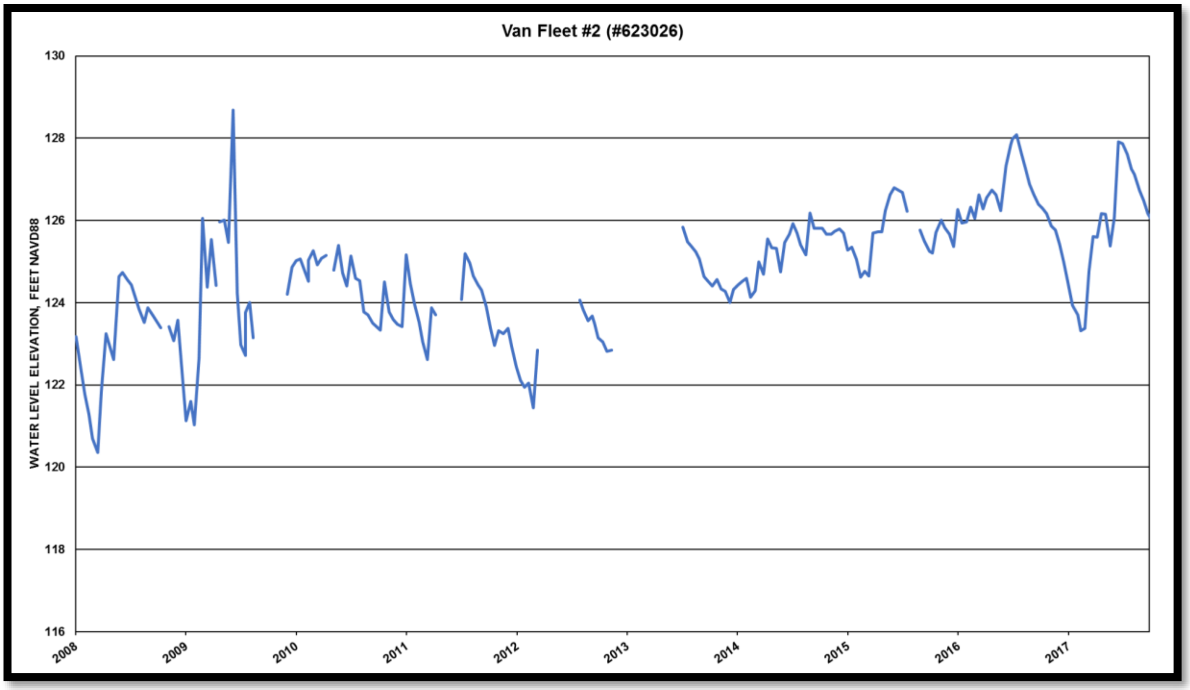

Figure B-218. Period-of-record water level data for Van Fleet #2 (SW-DD).

Green Swamp Bay (SW-N1)

Green Swamp Bay is a bayhead wetland located in a Plains setting in Southwest Lake County on the SWFWMD's Green Swamp Wilderness Preserve East Tract (**Figures B-219, B-220, and B-221**). The wetland is accessed from State Road 471, turning east on Main Grade (unpaved) and through a locked District gate (**Figure B-222**). From Main Grade turn north on Tanic Grade then east on Three Run Grade. The wetland is on the east side of Three Run Grade approximately 3 miles from Tanic Grade.

The wetland was determined to be unstressed during the 2018 assessment, which was conducted on the west side of the wetland (**Figure B-222**). Green Swamp Bay meets the requirement of being a Class 1 wetland, so it was added to the dataset for the current EMT analysis. It is also one of the wetlands included in the DMIT long-term wetlands monitoring program.

The SWFWMD has recorded surficial aquifer water levels in the wetland monthly since 2000 (**Figure B-223**), and water levels have varied with rainfall. The SWFWMD has also conducted annual vegetation assessments of the wetland since 2005 using the WAP as part of the Northern Tampa Bay Recovery Assessment. There are no known hydrologic alterations to the wetland. There are no known groundwater withdrawals in the vicinity, and the nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 17 miles away.

Figure B-219. Green Swamp Bay (SW-N1), June 2018.

Figure B-220. Green Swamp Bay (SW-N1), June 2018.

Figure B-221. Green Swamp Bay (SW-N1), June 2018.

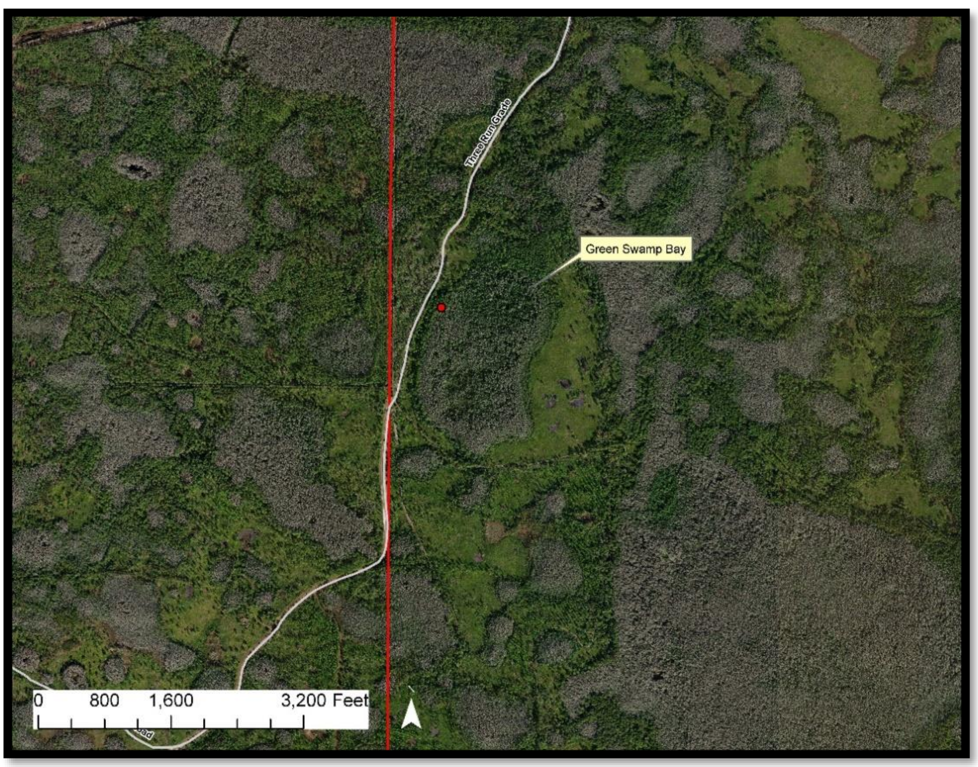

Figure B-222. Location of Green Swamp Bay (SW-N1), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment, and the red line is the CFWI Planning Area boundary.

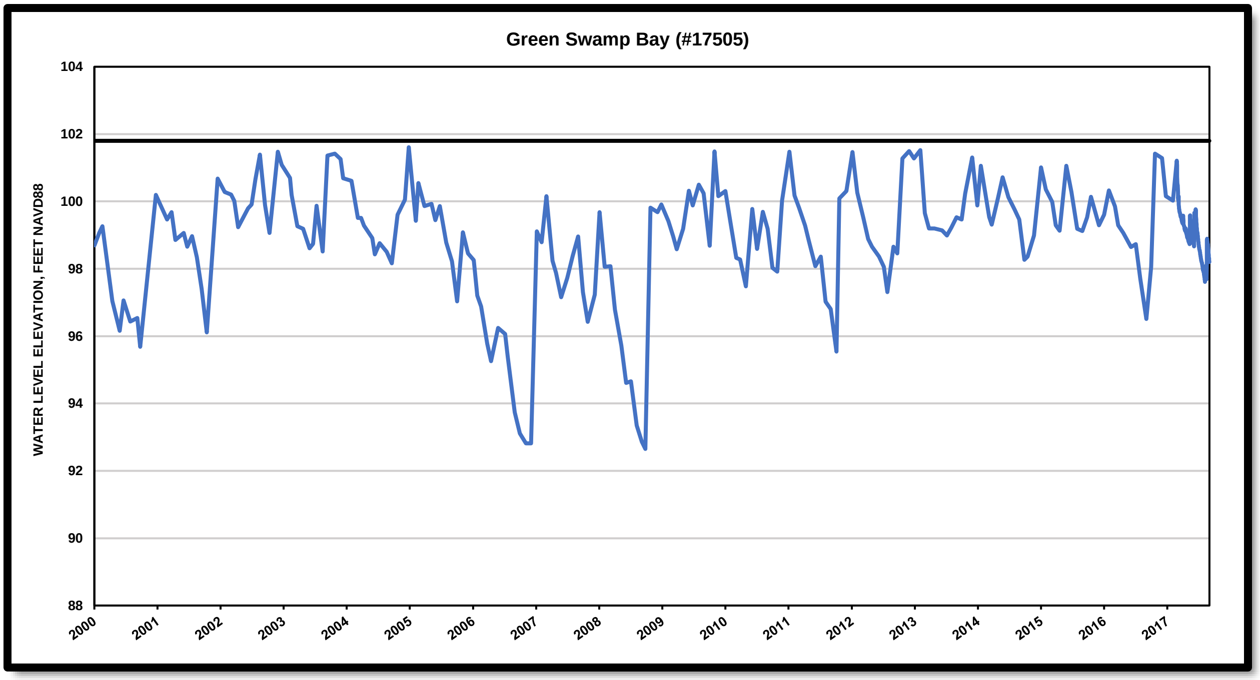

Figure B-223. Period-of-record water level data for Green Swamp Bay (SW-N1). Black line represents the land surface elevation at the monitor well (#17505).

Green Swamp #4 (SW-N2)

Green Swamp #4 is a groundwater-dominated cypress Plains wetland located on the SWFWMD's Green Swamp Wilderness Preserve East Tract (**Figure B-224, B-225, and B-226**). The wetland is accessed from State Road 471, turning east on Main Grade (unpaved) and through a locked District gate (**Figure B-227**). From Main Grade turn north (left) on Powder Grade then right on Island Pond Road.

During the 2018 assessment, which was conducted on the southwest side of the wetland (**Figure B-227**), Green Swamp #4 was determined to be unstressed. Since this wetland meets the Class 1 wetland requirements, it was added to the dataset for the current EMT analysis. In addition, Green Swamp #4 is included in the DMIT long-term wetlands monitoring program.

Since 1999, the SWFWMD has recorded surficial aquifer water levels in the wetland monthly (**Figure B-228**), and water levels have varied with rainfall. Since 2005, as part of the Northern Tampa Bay Recovery Assessment, the SWFWMD has conducted annual vegetation assessments of the wetland using the WAP. There are no known hydrologic alterations to the wetland or any groundwater withdrawals in the vicinity of the wetland. The nearest public supply wellfield (City of Lakeland Northeast Wellfield) is approximately 17 miles away.

Figure B-224. Green Swamp #4 (SW-N2), June 2018.

Figure B-225. Green Swamp #4 (SW-N2), June 2018.

Figure B-226. Green Swamp #4 (SW-N2), June 2018.

Figure B-227. Location of Green Swamp #4 (SW-N2), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

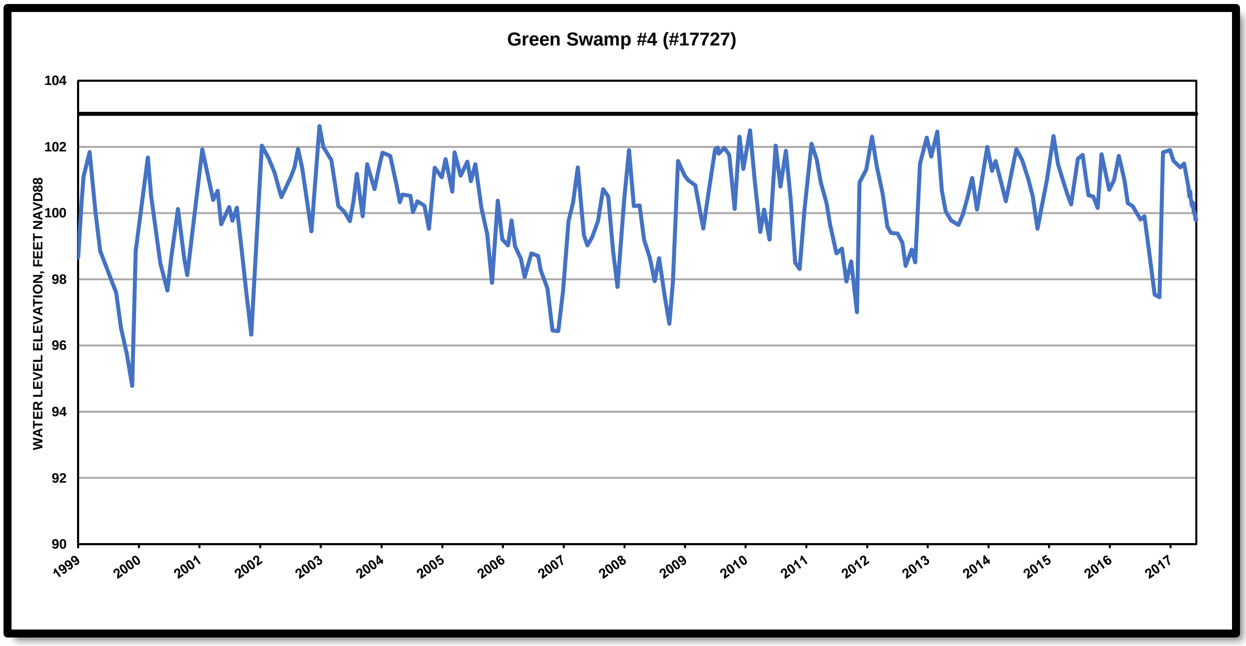

Figure B-228. Period-of-record water level data for Green Swamp #4 (SW-N2). Black line represents the land surface elevation at the monitor well (#17727).

Alston Bay (SW-N3)

This Plains wetland is a groundwater-dominated bay swamp located on the Alston Tract within the District's Upper Hillsborough Preserve (**Figures B-229, B-230, and B-231**). The wetland is accessed from Deems Road and through a locked District gate (**Figure B-232**). The 2018 assessment, which was conducted from the east side of the wetland, determined that the wetland was not stressed. Since this wetland meets the Class 1 wetland requirements, it was added to the dataset for the current EMT analysis. In addition, Alston Bay is included in the DMIT long-term wetlands monitoring program.

The SWFWMD has monitored Surficial Aquifer levels adjacent to the wetland since 2000 (**Figure B-233**). The District has also monitored the general condition of the wetland using the Wetland Assessment Procedure since 2005. There are no known hydrologic alterations to the wetland or any groundwater withdrawals in the vicinity of the wetland.

Figure B-229. Alston Bay (SW-N3), June 2018.

Figure B-230. Alston Bay (SW-N3), June 2018.

Figure B-231. Alston Bay (SW-N3), June 2018.

Figure B-232. Location of Alston Bay (SW-N3), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

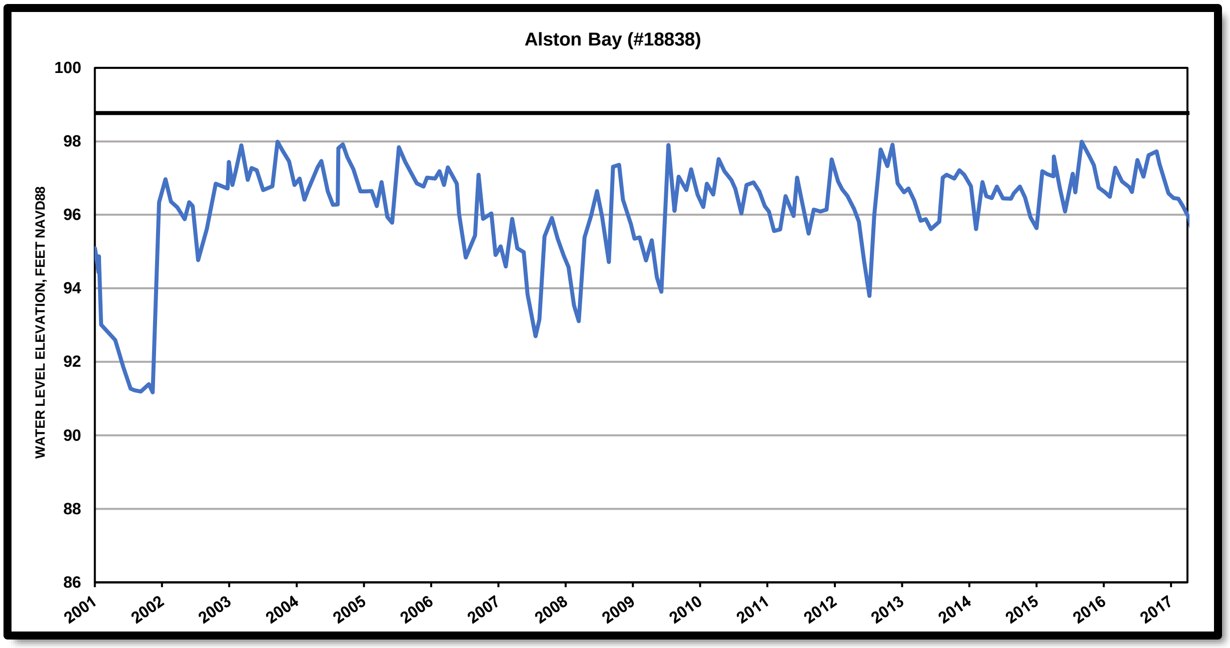

Figure B-233 Period-of-record water level data for Alston Bay (SW-N3). Black line represents the land surface elevation at the monitor well.

NE Lakeland Wellfield G (SW-N4)

NE Lakeland Wellfield G is a Plains wetland and groundwater-dominated, cypress wetland located on the City of Lakeland's Northeast Wellfield (**Figures B-234, B-235, and B-236**). The wetland is located on property owned by the City of Lakeland and is accessed from Old Polk City Road through a locked gate (**Figure B-237**).

During the 2018 assessment, which was conducted on the west side of the wetland (**Figure B-237**), this wetland was determined to be not stressed. Since this wetland meets the Class 1 wetland requirements, it was a potential addition to the dataset for the current EMT analysis. In addition, Wetland G is included in the DMIT long-term wetlands monitoring program. An analysis of water level data for the period of record selected for the analysis in support of the 2020 CFWI RWSP indicated that this site is not representative of groundwater-dominated wetlands in the CFWI planning area, mainly because the period of record includes both a stressed and unstressed period (**Figure B-238**). Therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis but was included in the Class 2 wetlands dataset.

Figure B-234. NE Lakeland Wellfield G (SW-N4), June 2018.

Figure B-235. NE Lakeland Wellfield G (SW-N4), June 2018.

Figure B-236. NE Lakeland Wellfield G (SW-N4), June 2018.

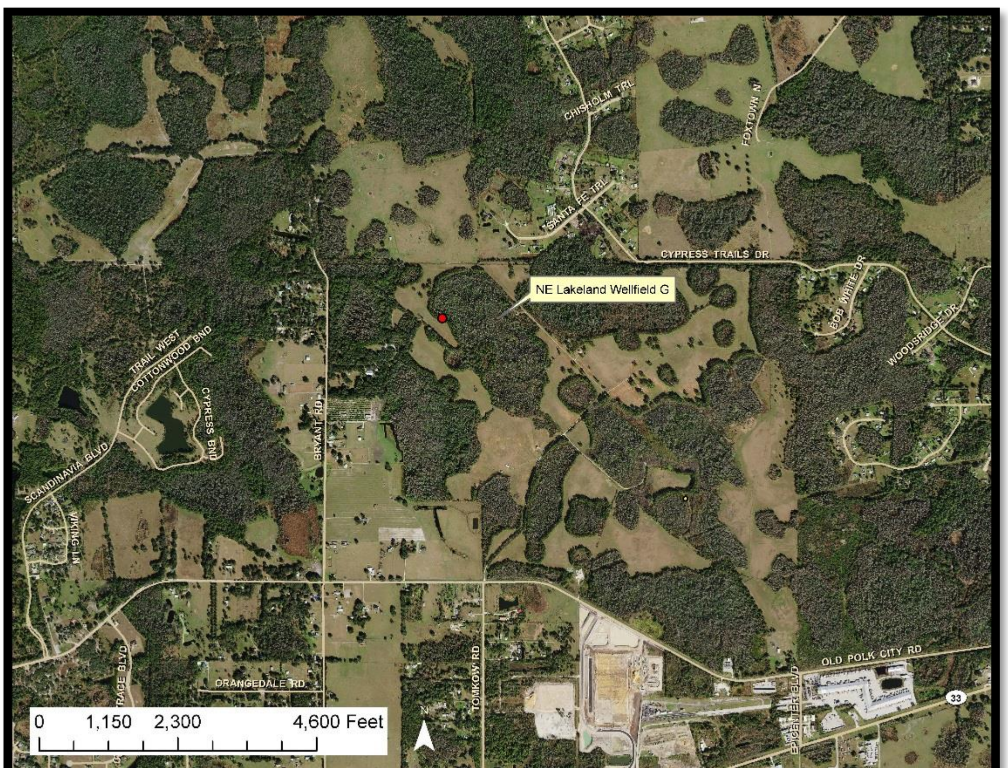

Figure B-237. Location of NE Lakeland Wellfield G (SW-N4), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

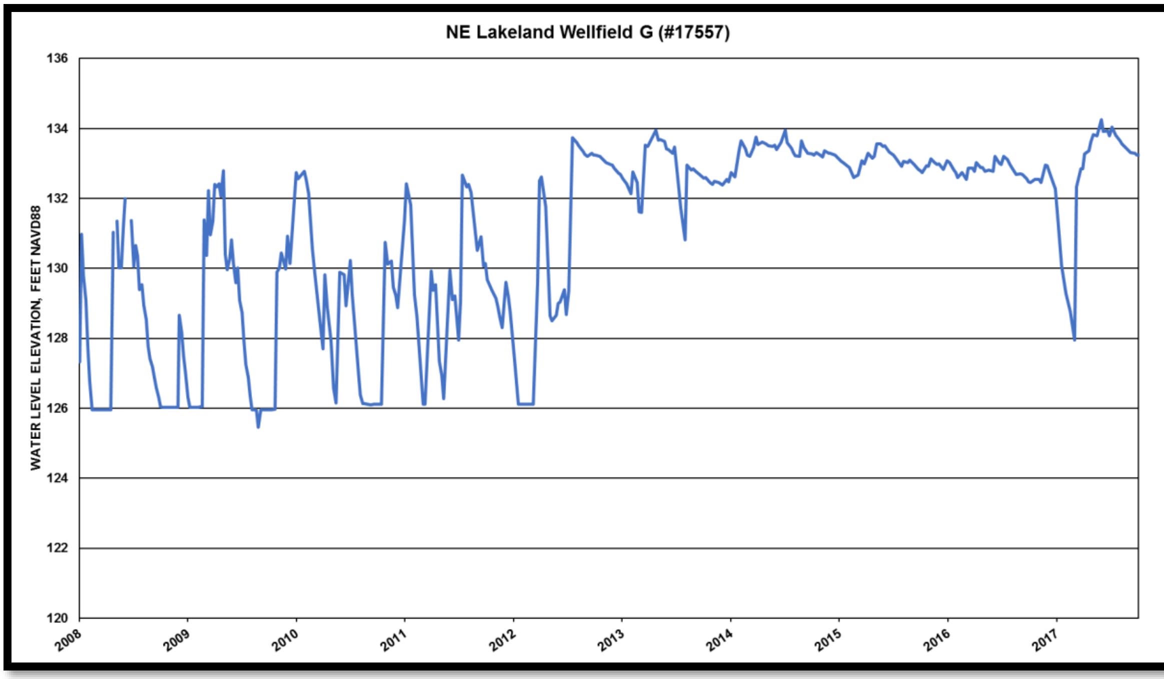

Figure B-238. Period-of-record water level data for NE Lakeland Wellfield G (SW-N4). Ground elevation at the monitor well is unknown at this time.

Groundwater pumping at the Northeast Lakeland Wellfield was permitted by the SWFWMD in 1987 under WUP No. 4912.002. Subsequently, the SWFWMD identified Upper Floridan aquifer and wetland impacts associated with wellfield pumping. In 1993, the District issued WUP 4912.003, which required monitoring and measures to address any wetland impacts. In 2008, the District issued WUP No. 4912.008, which required a Wetland Improvement Plan to address wetland impacts. In response to the impacts, the city implemented mitigation measures, including constructing ditch blocks and removing drainage pipes within several old agricultural drainage ditches on site, grading to restore surface water sheet flow to the wetlands, and harvesting the extensive stands of planted pines on the property. The Wetland Improvement Plan activities were completed in November 2011. The city has also implemented Surficial Aquifer monitoring and WAP monitoring of many wetlands within the wellfield, including Wetland G. The monitoring has documented increased water levels in the Surficial Aquifer, and hydrologic and vegetative improvements in the wetlands since completion of the Wetland Improvement Plan (**Figure B-238**).

NE Lakeland Wellfield J (SW-N5)

NE Lakeland Wellfield J is a groundwater-dominated, cypress wetland in a Plains setting located on the City of Lakeland's Northeast Wellfield (**Figures B-239, B-240, and B-241**). The wetland is located on property owned by the City of Lakeland and is accessed from Old Polk City Road through a locked gate (**Figure B-242**).

During the 2018 assessment, which was conducted on the north side of the wetland (**Figure B-242**), this wetland was determined to be not stressed. Since this wetland meets the Class 1 wetland requirements, it was a potential new Class 1 wetland that could be added to the dataset for the current EMT analysis. In addition, Wetland J is included in the DMIT long-term wetlands monitoring program. An analysis of water level data for the period of record selected for the analysis indicated that it is not representative of groundwater-dominated wetlands in the CFWI planning area, mainly because the period of record includes both a stressed and unstressed period (**Figure B-243**). Therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP but was included in the Class 2 wetlands dataset.

Groundwater pumping at the Northeast Lakeland Wellfield was permitted by the District in 1987 under WUP No. 4912.002. Subsequently, the District identified aquifer and wetland impacts associated with wellfield pumping. In 1993 the District issued WUP 4912.003, which required monitoring and measures to address any wetland impacts. In 2008 the District issued WUP No. 4912.008, which required a Wetland Improvement Plan to address wetland impacts. In response to the impacts the city implemented mitigation measures, including constructing ditch blocks and removing drainage pipes within several old agricultural drainage ditches on site, grading to restore surface water sheet flow to the wetlands, and harvesting the extensive stands of planted pines on the property. The Wetland Improvement Plan activities were completed November 2011. The city has also implemented Surficial Aquifer monitoring and WAP monitoring of several wetlands within the wellfield, including Wetland J. The monitoring has documented increased water levels in the Surficial Aquifer, and hydrologic and vegetative improvements in the wetlands since completion of the Wetland Improvement Plan (**Figure B-243**).

An analysis of water level data for the period of record selected for the analysis for this marsh indicated that it is not representative of groundwater-dominated wetlands in the CFWI planning area, mainly because the period of record includes both a stressed and unstressed period. Therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis and was added to the Class 2 wetlands dataset.

Figure B-239. NE Lakeland Wellfield J (SW-N5), June 2018.

Figure B-240. NE Lakeland Wellfield J (SW-N5), June 2018.

Figure B-241. NE Lakeland Wellfield J (SW-N5), June 2018.

Figure B-242. Location of NE Lakeland Wellfield J (SW-N5), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

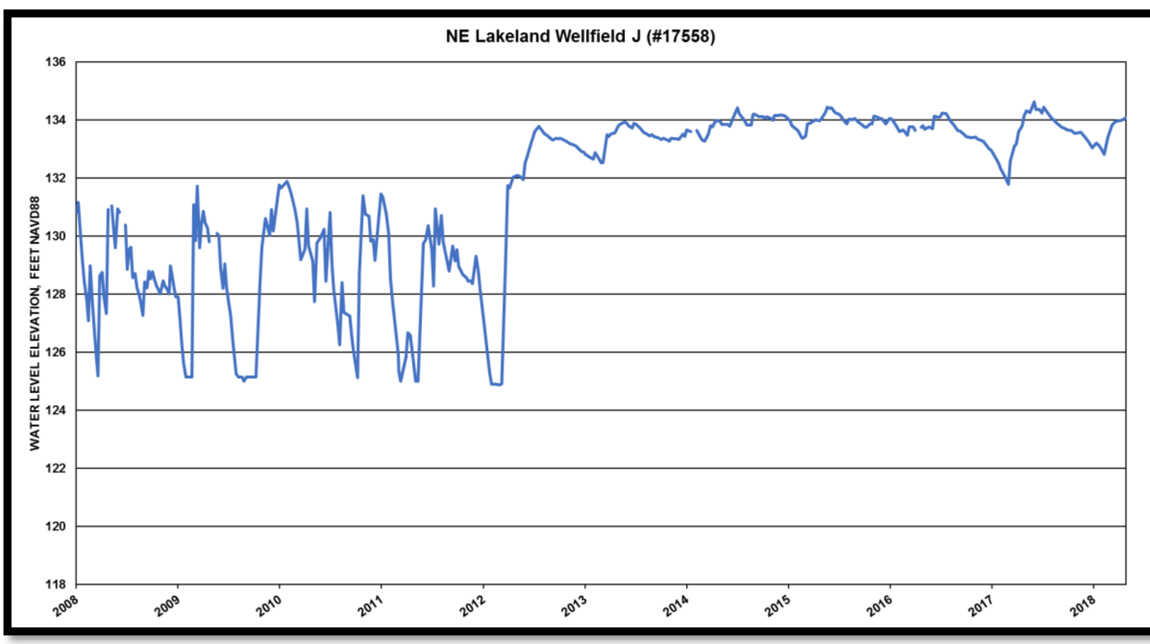

Figure B-243. Period-of-record water level data for NE Lakeland Wellfield J (SW-N5). Ground elevation at the monitor well is unknown at this time.

NE Lakeland Wellfield K (SW-N6)

NE Lakeland Wellfield K is a groundwater-dominated, cypress wetland located in a Plains setting on the City of Lakeland's Northeast Wellfield (**Figures B-244, B-245, and B-246**). The property is owned by the City of Lakeland and the wetland is accessed from Old Polk City Road through a locked gate (**Figure B-247**).

During the 2018 assessment, which was conducted on the north side of the wetland (**Figure B-247**), the wetland was determined to be not stressed. No stress determination was made prior to 2018. Since this wetland meets the Class 1 wetland requirements, it was a potential new Class 1 wetland. In addition, Wetland K is included in the DMIT long-term wetlands monitoring program. However, the analysis of water level data for the period of record selected for the analysis indicated that it is not representative of groundwater-dominated wetlands in the CFWI planning area, mainly because the period of record includes both a stressed and unstressed period (**Figure B-248**). Therefore, this site was not included in the final, expanded Class 1 wetlands dataset for the analysis in support of the 2020 CFWI RWSP but was included in the Class 2 wetlands dataset.

Groundwater pumping at the Northeast Lakeland Wellfield was permitted by the District in 1987 under WUP No. 4912.002. Subsequently, the District identified aquifer and wetland impacts associated with wellfield pumping. In 1993 the District issued WUP 4912.003, which required monitoring and measures to address any wetland impacts. In 2008 the District issued WUP No.4912.008, which required a Wetland Improvement Plan to address wetland impacts. In response to the impacts the City implemented mitigation measures, including constructing ditch blocks and removing drainage pipes within several old agricultural drainage ditches on site, grading to restore surface water sheet flow to the wetlands, and harvesting the extensive stands of planted pines on the property. The Wetland Improvement Plan activities were completed November 2011. The City has also implemented Surficial Aquifer monitoring and WAP monitoring of several wetlands within the wellfield, including wetland K. The monitoring has documented increased water levels in the Surficial Aquifer, and hydrologic and vegetative improvements in the wetlands since completion of the Wetland Improvement Plan (**Figure B-248**).

Figure B-244. NE Lakeland Wellfield K (SW-N6), June 2018.

Figure B-245. NE Lakeland Wellfield K (SW-N6), June 2018.

Figure B-246. NE Lakeland Wellfield K (SW-N6), June 2018.

Figure B-247. Location of NE Lakeland Wellfield K (SW-N6), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

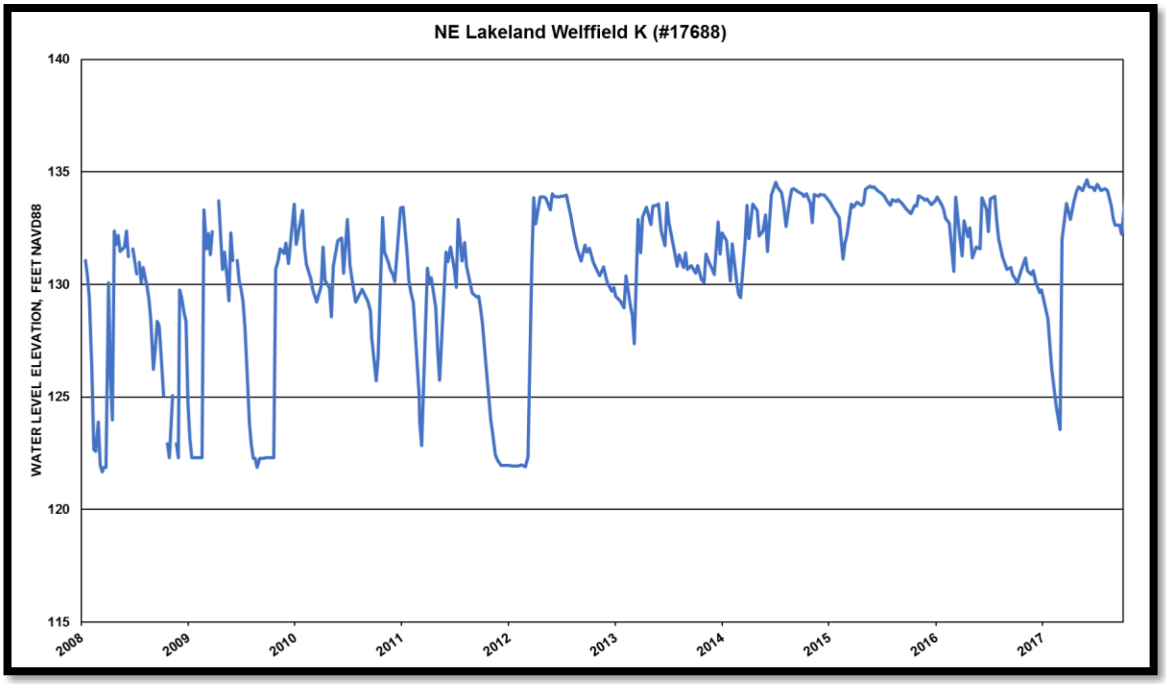

Figure B-248. Period-of-record water level data for NE Lakeland Wellfield K (SW-N6). Ground elevation at the monitor well is unknown at this time.

Saddle Blanket Scrub #2 (SW-N7)

This groundwater-dominated, seepage bayhead wetland is located in a Ridge setting on the Lake Wales Ridge on The Nature Conservancy's Saddle Blanket Scrub Preserve (**Figures B-249, B-250, B-251, and B-252**). Because this is a seepage wetland with a steep elevation change, the wetland edge is maintained by water levels in the saturated soils. This wetland was evaluated in September 2018; it was determined to be unstressed, and the quality of habitat was excellent. Since this wetland meets the Class 1 wetland requirements, it was added to the dataset for the current EMT analysis; in addition, this site is included in the DMIT long-term wetlands monitoring program.

This wetland has been monitored under Polk County's Southeast Regional Utilities Service Area WUP No. 20006508.010 (renewed on April 10, 2012) since 2010 as a reference wetland (R3). Surface and ground water levels have been measured every two weeks via two monitoring wells and a staff gage (**Figure B-253**). Vegetation surveys have been conducted each year during the spring at the end of the dry season since 2012 using the WAP, and soils have also been surveyed.

For the Class 1 wetlands analysis, water levels measured from the well in the uplands on the southeast side of the wetland were used (**Figure B-253**). The staff gage and second monitoring well are located in the center of the wetland. Water level data from the interior monitoring well was historically collected using a Solinst Levelogger; however, water level discrepancies were identified between July 2011 and July 2013; therefore, the use of the Levelogger was discontinued.

Figure B-249. Saddle Blanket Scrub #2 (SW-N7), September 2018.

Figure B-250. Saddle Blanket Scrub #2 (SW-N7), September 2018.

Figure B-251. Interior of Saddle Blanket Scrub #2 (SW-N7), September 2018.

Figure B-252. Location of Saddle Blanket Scrub #2 (SW-N7), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

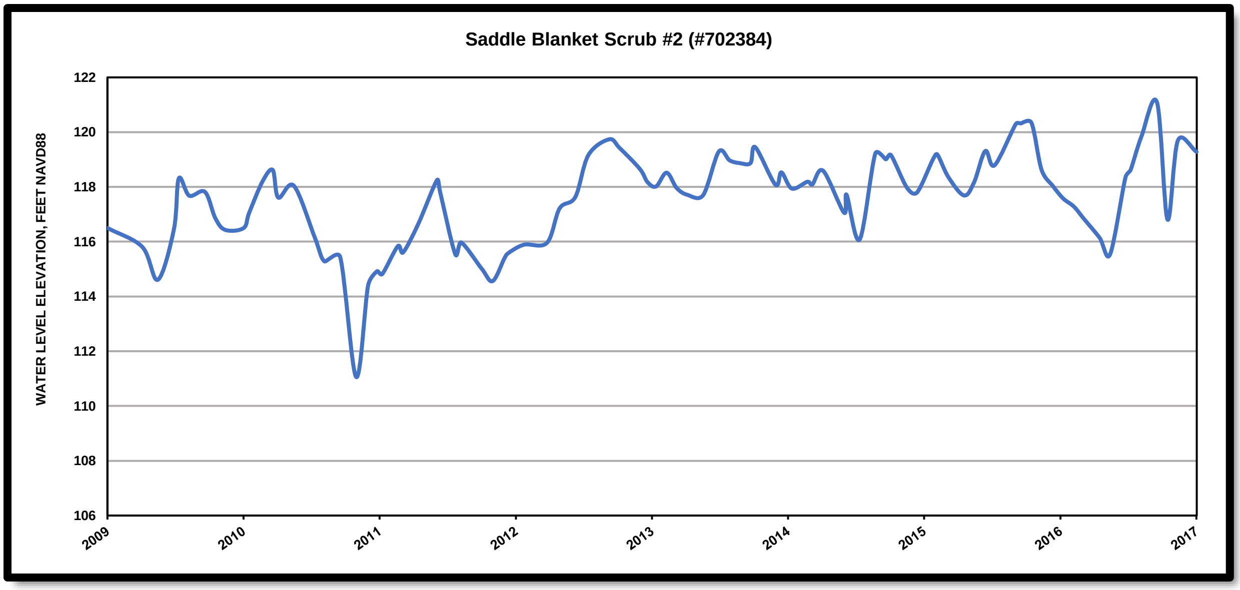

Figure B-253. Period-of-record water level data for Saddle Blanket Scrub #2 (SW-N7). Ground elevation at the monitor well is unknown at this time.

Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1 (SW-N8)

This wetland is a Ridge wetland and a groundwater-dominated marsh located in the Lake Wales Ridge Wildlife and Environmental Area, which is owned and managed by the Florida Fish and Wildlife Conservation Commission (FWC) (**Figure B-254, B-255, and B-256**). The wetland is located within the city limits of the City of Lake Wales, and is accessed from Florida Avenue, west of North Scenic Highway and through a locked gate (**Figure B-257**). Although this wetland is contiguous with the remaining FWC property to the north, it is surrounded by City of Lake Wales facilities (a school and a park) on the east and west sides, and a residential subdivision on the south side, and is bisected by a Duke Energy powerline and easement (**Figure B-257**).

Since this wetland meets the Class 1 wetland requirements, it was added to the dataset for the current EMT analysis. In addition, this site is included in the DMIT long-term wetlands monitoring program. During the 2018 assessment, which was conducted on the east side of the wetland (**Figure B-257**), this wetland was determined to be stressed. Surficial aquifer water levels for this wetland are monitored at a District ROMP well located east of the wetland (Figure B-258).

Figure B-254. Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1 (SW-N8), April 2018

Figure B-255. Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1 (SW-N8), April 2018

Figure B-256. Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1 (SW-N8), April 2018

Figure B-257. Location of Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1 (SW-N8), 2017 aerial photograph. Red marker indicates the location of the 2018 stress assessment.

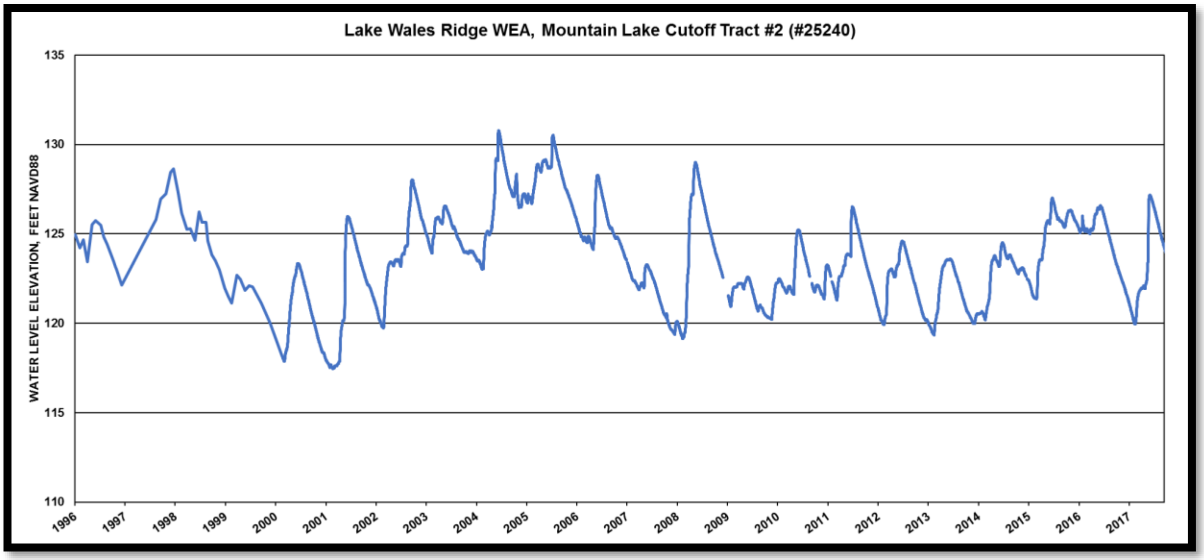

Figure B-258. Period-of-record water level data for Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #2 (SW-N8).

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Appendix C: Class 1 Wetlands Assessment Results

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SF-LA	Walker Ranch - WR11	5/18/2018	W	Flat	Well Defined	Transitional, Outer Deep	Saturated, Throughout	NA	Leaning Trees, Tree Falls, Age Class Differences of Trees, Evidence of Recruitment of Wetland Tree Species	Excellent
SF-LB	Walker Ranch - WR6	5/18/2018	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Saturated, Throughout	NA	Fire Scars	Excellent
SF-XZ	Walker Ranch - WR9	5/18/2018	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Saturated, Throughout	NA	Fire Scars	Excellent
SF-N1	Walker Ranch WR-16	5/18/2018	W	Flat	Well Defined	Transitional, Outer Deep	Saturated, Throughout	NA	Age Class Difference of Tree, Evidence of Recruitment of Wetland Tree Species, Fire Scars	Excellent
SF-N2	Walker Ranch WR-15	5/18/2018	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Saturated, Throughout	NA	Dead/Dying Trees, Leaning Trees, Tree Falls, Age Class Difference of Tree, Fire Scars	Good
SF-WT	Split Oak	5/6/2018 and 8/21/2018	W	Moderate	Well Defined	Transitional, Outer Deep, Deep	Dry	NA	Dead/Dying Trees, Leaning Trees, Tree Falls, Exposed Tree Roots, Age Class Difference of Trees, Evidence of Recruitment of Trees, Fire Scars	Excellent
SF-YK	Tibet Butler	1/30/2018	W	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Center	NA	Leaning Trees, Absence of Regeneration, Evidence of Logging, Fire Scars	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SJ-AJ*	Lake Gem	4/20/2018	L	Moderate	Somewhat defined	Transitional	Dry	Normal	Presence of Nuisance or Invasive Species	Good
SJ-LA	Unnamed Cypress	5/29/2018	W	Flat	Somewhat defined	Transitional	Throughout	Above Normal	Presence of Nuisance or Invasive Species, Dead or Dying Vegetation, Exposed Tree Roots, Evidence of Recruitment of Wetland Tree Species	Good
SJ-LB	Unnamed Wetland Nr SR 46	5/31/2018	L	Moderate	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	Shifts and Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance or Invasive Species, Dead or Dying Vegetation/Trees	Fair
SJ-LC	Boggy Marsh	5/31/2018	W	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	Invasion by Upland Species, Presence of Nuisance or Invasive Species, Absence of Regeneration of Wetland Species	Good
SJ-LD	Hopkins Prairie	6/6/2018	W	Flat	Well	Transitional, Outer Deep, Deep	Throughout	Normal	Invasive Species	Excellent
SJ-LE	Lake Avalon	5/4/2018	L	Moderate	Well	Transitional, Outer Deep, Deep	Throughout	Normal	Invasion by Upland Species, Presence of Nuisance or Invasive Species	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SJ-LF	Lake Apshawa	6/1/2018	L	Moderate	Poor	Transitional, Outer Deep, Deep	Center	Above Normal	Presence of Nuisance or Invasive species, Absence of regeneration of wetland species	Fair
SJ-LH*	Island Lake	4/20/2018	W	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Dry	Normal	Presence of Nuisance or Invasive Species	Good
SJ-LI	Lake Sylvan	5/29/2018	L	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Center	Below Normal	Shifts and Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance or Invasive Species, Dead or Dying Vegetation/Trees, Discolored Foliage, Absence of Regeneration of Wetland Species, Exposed Tree Roots	Fair
SJ-LL	City of Cocoa, Well 9T	5/29/2018	W	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	Shifts and Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance or Invasive Species, Age Class Difference of Trees, Evidence of Recruitment of Wetland Tree Species, Evidence of Logging, Cattle	Excellent

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SJ-QA	Church Lake	6/1/2018	L	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	Shifts and Change in Plant communities, Invasion by Upland Species, Dead or Dying vegetation/trees	Good
SJ-QB	Johns Lake	5/4/2018	L	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Normal	Presence of Nuisance or Invasive Species, Dead or Dying Vegetation	Good
SJ-QC	Trout Lake	5/31/2018	L	Moderate	Somewhat defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	None	Good
SJ-QD	Long Lake	5/4/2018	L	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Center	Below Normal	Invasion by Upland Species, Presence of Nuisance or Invasive Species, Evidence of Recruitment of Wetland Tree Species	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SJ-LJ	Lake Louisa	5/31/2018	L	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Center	Normal	Shifts and Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance or Invasive Species, Leaning Trees, Tree Falls, Absence of regeneration of Wetland Species, Age class difference of trees, Evidence of recruitment of wetland tree species	Good
SJ-GA*	Prairie Lake	5/4/2018	L	Moderate	Somewhat Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Invasion by Upland Species, Presence of Nuisance or Invasive Species	Fair
SJ-AW	Red Bug Lake	9/6/2018	L	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Throughout	Above Normal	Shifts and Change in Plant Communities, Leaning Trees, Exposed Tree Roots	Good
SJ-AI	Chapman Marsh	9/6/2018	W	Flat	Poorly Defined	Transitional	Center	NA	Shifts and Change in Plant Communities, Invasion by Upland Species, Exposed Tree Roots	Fair
SW-AA	Green Swamp #7	02/09/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Fire Scars	Excellent

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SW-JJ	Lake Garfield	04/24/18	L	Flat	Well Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Shifts/Changes in Plant Communities, Invasion by Upland Species, Presence of Nuisance/Invasive Species	Fair
SW-LE	Cypress Creek #199, W17 Sentry Wetland	06/01/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Invasion by Upland Species, Leaning Trees, Tree Falls, Absence of Regeneration of Wetland Species, Exposed Tree Roots	Fair
SW-LF*	Cypress Creek #190 E Marsh	06/01/18	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Shifts/Changes in Plant Communities, Invasion by Upland Species	Good
SW-LG	Cypress Creek #223 B W46	06/01/18	W	Flat	Poorly Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Shifts/Changes in Plant Communities, Invasion by Upland Species, Dead/Dying Vegetation/Trees, Tree Falls, Absence of Regeneration of Wetland Species	Poor
SW-LH	Cypress Creek #211 W33	6/1/2018 and 8/1/2028	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Age Class Differences of Trees, Evidence of Recruitment of Wetland Tree Species	Excellent

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SW-LI	Green Swamp Marsh #304	06/04/18	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Evidence of Recruitment of Wetland Tree Species, Fire Scars	Excellent
SW-LJ	Green Swamp #6, #303	2/16/18 and 6/4/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Age Class Differences of Trees	Excellent
SW-LK	Green Swamp #5, #302	2/16/18 and 6/4/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Center	NA	None	Excellent
SW-LM	Green Swamp #1, #298	2/16/18 and 6/4/18	W	Flat	Poorly Defined	Outer Deep, Deep	Dry	NA	Evidence of Recruitment of Wetland Tree Species	Good
SW-MM	Lake Wales	04/19/18	L	Moderate	Poorly Defined	Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Poor
SW-QA	Big Gum Lake	04/19/18	L	Moderate	Somewhat Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species, Dead or Dying Vegetation/Trees	Fair
SW-QB	Bonnet Lake	10/03/18	L	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Fair
SW-QC	Buck Lake	04/24/18	L	Moderate	Poorly Defined	Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Fair
SW-QD	Gator Lake	04/19/18	L	Flat	Well Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Shifts/Change in Plant Communities	Fair
SW-QE	Lake Annie	04/24/18	L	Flat	Somewhat Defined	Outer Deep, Deep	Throughout	Above Normal	Presence of Nuisance/Invasive Species	Good
SW-QF	Lake Apthorpe	04/24/18	L	Moderate	Somewhat Defined	Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SW-QH	Lake Leonore	02/27/18	L	Extreme	Somewhat Defined	Outer Deep, Deep	Throughout	Normal	None	Good
SW-QI	Lake Placid	04/24/18	L	Moderate	Somewhat Defined	Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Fair
SW-QJ	Lake Streety	04/24/18	L	Moderate	Somewhat Defined	Deep Zone	Throughout	Normal	Presence of Nuisance/Invasive Species	Good
SW-QK	Lake Van	04/24/18	L	Moderate	Somewhat Defined	Outer Deep, Deep	Throughout	Normal	Presence of Nuisance/Invasive Species	Fair
SW-QL	Lake Walker	04/19/18	L	Extreme	Somewhat Defined	Transitional, Outer Deep, Deep	Throughout	Below Normal	Shifts/Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance/Invasive Species	Poor
SW-QM	Polecat Lake	04/19/18	L	Moderate	Poorly Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Invasion by Upland Species, Presence of Nuisance/Invasive Species	Poor
SW-QN	Surveyors Lake	04/19/18	L	Moderate	Poorly Defined	Transitional	Throughout	Normal	Presence of Nuisance/Invasive Species	Poor
SW-QO	Parks Lake	04/19/18	L	Moderate	Well Defined	Transitional, Outer Deep, Deep	Throughout	Normal	Shifts/Change in Plant Communities, Presence of Nuisance/Invasive Species	Fair
SW-QQ	Crooked Lake	02/27/18	L	Flat	Well Defined	Transitional, Outer Deep, Deep	Throughout	Normal	None	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SW-DD	Van Fleet #2	09/11/18	W	Flat	Somewhat defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Invasion by Upland Species, Leaning Trees, Tree Falls, Absence of Regeneration of Wetland Species, Age Class Differences of Trees, Evidence of Recruitment of Wetland Tree Species	Fair
SW-N1	Green Swamp Bay	2/16/18 and 6/4/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Center	NA	Age Class Differences of Trees	Excellent
SW-N2	Green Swamp #4	06/04/18	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Inundated, Center	NA	Evidence of Recruitment of Wetland Tree Species	Excellent
SW-N3	Alston Bay	06/04/18	W	Flat	Poorly Defined	Outer Deep, Deep	Inundated, Center	NA	Fire Scars	Good
SW-N4*	NE Lakeland Wellfield G	06/01/18	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Dead/Dying Vegetation/Trees, Evidence of Recruitment of Wetland Tree Species	Good
SW-N5*	NE Lakeland Wellfield J	06/01/18	W	Flat	Well Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Dead/Dying Vegetation/Trees, Age Class Difference of Trees, Evidence of Recruitment of Wetland Tree Species	Good
SW-N6*	NE Lakeland Wellfield K	06/01/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Inundated, Throughout	NA	Dead/Dying Vegetation/Trees	Good

Table C-1a. Class 1 wetlands information (sites not Included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Assessment Date	Lake or Wetland	Topographic Relief	Vegetation Zonation	Zones Present	Presence of Water in Wetland	If Lake, Description of Water Level	List of Habitat Characteristics	Overall Habitat Condition
SW-N7	Saddle Blanket Scrub #2	09/11/18	W	Extreme	Well Defined	Transitional, Outer Deep, Deep	Inundated, Center	NA	Age Class Differences of Trees, Evidence of Recruitment of Wetland Tree Species	Excellent
SW-N8	Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1	04/19/18	W	Flat	Somewhat Defined	Transitional, Outer Deep, Deep	Saturated, Center	NA	Shifts/Change in Plant Communities, Invasion by Upland Species, Presence of Nuisance/Invasive Species, Exposed Tree Roots	Poor

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SF-LA	Walker Ranch - WR11	Muck	None	None	None	Pine Edge, Saw Palmetto Edge, Adventitious Roots, Moss Collars, Lichen Lines, Stain Lines, Buttressed Tree Trunks, Cypress Inflection Points, Algal Mats, Water Marks, Water Lines on Docks/Pilings	None	None	None
SF-LB	Walker Ranch - WR6	Sand/Mineral	None	None	None	Pine Edge, Saw Palmetto Edge, Adventitious Roots, Lichen Lines, Stain Lines, Buttressed Tree Trunks, Cypress Inflection Points, Algal Mats, Water Marks, Water Lines on Docks/Pilings	None	None	None
SF-XZ	Walker Ranch - WR9	Sand/Mineral	None	None	None	Saw Palmetto Edge, Stain Lines, Water Lines on Pilings	None	None	None
SF-N1	Walker Ranch WR-16	Sand/Mineral	None	None	None	Saw Palmetto Edge, Stain Lines, Water Lines on Pilings, Pine Edge, Lichen Lines, Moss Collars, Adventitious Roots, Cypress Inflection Points, Water Marks	None	None	None
SF-N2	Walker Ranch WR-15	Sand/Mineral	None	None	None	Saw Palmetto Edge, Stain Lines, Water Lines on Pilings, Pine Edge, Lichen Lines, Moss Collars, Adventitious Roots, Cypress Inflection Points, Water Marks	None	None	None
SF-WT	Split Oak	Sand/Mineral	Yes	Yes	None	Pine Edge, Saw Palmetto Edge, Adventitious Roots, Moss Collars, Lichen Lines, Stain Lines, Buttressed Tree Trunks, Cypress Inflection Points, Algal Mats, Water Marks	None	None	None

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SF-YK	Tibet Butler	Sand/Mineral	None	None	None	Moss Collars, Elevated Lichen Lines, Adventitious Roots, Buttressed Tree Trunks, Water Marks, Rafted Debris, Cypress Inflection Points	None	None	None
SJ-AJ*	Lake Gem	Sand/Mineral	None	None	None	Lichen Lines, Stain Lines, Buttressed Tree Trunks	Yes	Yes	Yes
SJ-LA	Unnamed Cypress	Sand/Mineral	Yes	None	None	Saw Palmetto "Horses", Moss Collars, Lichen Lines, Buttressed Tree Trunks, Cypress Inflection Points, Water Marks	Yes	Yes	Yes
SJ-LB	Unnamed Wetland Nr SR 46	Sand/Mineral	None	None	None	Lichen lines, Adventitious roots	Yes	Yes	Yes
SJ-LC	Boggy Marsh	Sand/Mineral	None	None	None	Lichen lines, Adventitious roots	None	Yes	Yes
SJ-LD	Hopkins Prairie	Sand/Mineral	None	None	None	Pine Edge, Saw Palmetto Edge, Adventitious Roots	None	None	None
SJ-LE	Lake Avalon	Sand/Mineral	None	None	None	Stain Lines, Adventitious Roots, Algal Mats, Rafted Debris	None	Yes	Yes
SJ-LF	Lake Apshawa	Sand/Mineral	None	None	None	None	None	None	None
SJ-LH*	Island Lake	Sand/Mineral	None	None	None	Lichen Lines, Buttressed Tree Trunks	None	Yes	Yes
SJ-LI	Lake Sylvan	Sand/Mineral	Yes	None	None	Lichen Lines, Stain Lines, Adventitious Roots	Yes	Yes	Yes
SJ-LL	City of Cocoa, Well 9T	Sand/Mineral	None	None	None	Saw Palmetto "Horses", Lichen Lines, Buttressed Tree Trunks, Cypress Inflection Points	None	None	None
SJ-QA	Church Lake	Sand/Mineral	None	None	None	Pine Edge, Stain Lines, Adventitious roots	None	Yes	Yes

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SJ-QB	Johns Lake	Sand/Mineral	None	None	None	Lichen Lines, Stain Lines, Adventitious Roots, Rafted Debris, Water Lines on Docks/Pilings	None	Yes	None
SJ-QC	Trout Lake	Sand/Mineral	None	None	None	None	Yes	Yes	Yes
SJ-QD	Long Lake	Sand/Mineral	None	None	None	Adventitious Roots, Buttressed Tree Trunks, Cypress Inflection Points, Rafted Debris	None	Yes	Yes
SJ-LJ	Lake Louisa	Sand/Mineral, Dry	Yes	None	None	Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Cypress Inflection Points, Rafted Debris, Water Lines on Docks and Pilings	Yes	Yes	Yes
SJ-GA*	Prairie Lake	Sand/Mineral	None	None	None	Stain Lines, Water Marks, Rafted Debris, Water Lines on Docks/Pilings	None	Yes	Yes
SJ-AW	Red Bug Lake	Sand/Mineral, Hydric, Moist	Yes	None	None	Buttressed Tree Trunks, Cypress Inflection Points, Water Lines on Docks/Pilings	None	Yes	Yes
SJ-AI	Chapman Marsh	Sand/Mineral, Muck, Hydric, Moist	Yes	None	None	Saw Palmetto Edge, Saw Palmetto "Horses" (Elevated Trunks), Adventitious Roots	None	Yes	Yes
SW-AA	Green Swamp #7	Sand/Mineral, Hydric, Moist	None	None	None	Moss Collars, Lichen Lines, Stain Lines, Pine Edge, Adventitious Roots, Buttressed Tree Trunks, Cypress Infection Points, Saw Palmetto Horses	None	None	None
SW-JJ	Lake Garfield	Sand/Mineral, Hydric, Dry	Yes	None	None	Pine Edge, Adventitious Roots, Rafted Debris	Yes	None	Yes
SW-LE	Cypress Creek #199, W17 Sentry Wetland	Sand/Mineral, Hydric, Saturated	Yes	None	None	Pine Edge, Saw Palmetto Edge, Moss Collars, Lichen Lines, Stain Lines, Cypress Inflection Points	None	None	None

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SW-LF*	Cypress Creek #190 E Marsh	Sand/Mineral, Hydric, Saturated	None	None	None	Pine Edge, Lichen Lines, Stain Lines, Buttressed Tree Trunks, Water Marks	None	None	None
SW-LG	Cypress Creek #223 B W46	Sand/Mineral, Hydric, Moist	None	None	None	Saw Palmetto Edge, Buttressed Tree Trunks, Algal Mats, Hummocks, No Distinct Indicators	None	None	None
SW-LH	Cypress Creek #211 W33	Sand/Mineral, Hydric, Inundated	None	None	None	Saw Palmetto Edge, Moss Collars, Lichen Lines	None	None	None
SW-LI	Green Swamp Marsh #304	Sand/Mineral, Hydric, Inundated	None	None	None	Pine Edge, Saw Palmetto Edge, Adventitious Roots, Buttressed Tree Trunks	None	None	None
SW-LJ	Green Swamp #6, #303	Sand/Mineral, Hydric, Moist	None	None	None	Saw Palmetto Edge, Moss Collards, Lichen Lines, Buttressed Tree Trunks, Cypress Inflection Points	None	None	None
SW-LK	Green Swamp #5, #302	Sand/Mineral, Moist	None	None	None	Saw Palmetto Edge, Moss Collars, Adventitious Roots, Cypress Inflection Points	None	None	None
SW-LM	Green Swamp #1, #298	Muck, Hydric, Moist	None	None	None	Moss Collars, Adventitious Roots, Buttressed Tree Trunks, Cypress Infection Points	None	None	None
SW-MM	Lake Wales	Sand/Mineral, Hydric, Dry	None	None	None	Water Lines on Docks/Pilings	Yes	Yes	Yes
SW-QA	Big Gum Lake	Sand/Mineral, Hydric, Dry	None	None	None	Stain Lines, Adventitious Roots, Water Lines on Docks/Pilings	None	None	Yes
SW-QB	Bonnet Lake	Sand/Mineral, Hydric, Moist	None	None	None	Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Water Lines on Docks/Pilings	Yes	None	None
SW-QC	Buck Lake	Sand/Mineral, Hydric, Moist	None	None	None	Water Lines on Docks/Pilings	None	None	Yes

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SW-QD	Gator Lake	Muck, Hydric, Moist	None	None	None	Lichen Lines, Water Marks, Buttressed Tree Trunks, Water Marks, Rafted Debris, Hummocks	None	None	Yes
SW-QE	Lake Annie	Sand/Mineral, Hydric, Moist	None	None	None	Pine Edge, Saw Palmetto Edge, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Water Marks, Water Lines on Docks/Pilings, Hummocks	None	None	None
SW-QF	Lake Apthorpe	Muck, Hydric, Moist	None	None	None	Water Lines on Docks/Pilings	None	None	None
SW-QH	Lake Leonore	Peat, Hydric, Inundated	None	None	None	Stain Lines	None	None	None
SW-QI	Lake Placid	Sand/Mineral, Hydric, Moist	None	None	None	Adventitious Roots, Water Lines on Docks/Pilings	None	None	None
SW-QJ	Lake Streety	Sand/Mineral, Muck, Hydric, Moist	None	None	None	Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Cypress Inflection Points, Algal Mats	None	None	None
SW-QK	Lake Van	Sand/Mineral, Hydric, Moist	None	None	None	Water Lines on Docks/Pilings	None	Yes	Yes
SW-QL	Lake Walker	Sand/Mineral, Hydric, Dry	None	None	Yes	Adventitious Roots, Algal Mats	None	None	Yes
SW-QM	Polecat Lake	Muck, Hydric, Moist	None	None	None	None	None	None	Yes
SW-QN	Surveyors Lake	Muck, Hydric, Moist	None	None	None	Adventitious Roots, Rafted Debris	None	None	None
SW-QO	Parks Lake	Sand/Mineral, Hydric, Dry	None	None	None	Stain Lines, Water Lines on Docks/Pilings	None	None	Yes
SW-QQ	Crooked Lake	Muck, Hydric, Dry	None	None	None	Adventitious Roots, Algal Mats, Rafted Debris	None	None	Yes

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SW-DD	Van Fleet #2	Sand/Mineral, Hydric, Inundated	None	None	None	Saw Palmetto Edge, Lichen Lines, Stain Lines, Buttressed Tree Trunks, Cypress Inflection Points, Water Marks	None	Yes	None
SW-N1	Green Swamp Bay	Muck, Hydric, Moist	None	None	None	Pine Edge, Saw Palmetto Edge, Moss Collars, Lichen Lines, Buttressed Tree Trunks, Cypress Infection Points, Hummocks	None	None	None
SW-N2	Green Swamp #4	Sand/Mineral, Muck, Hydric, Moist	None	None	None	Pine Edge, Saw Palmetto Edge, Moss Collars, Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Cypress Infection Points, Water Marks	None	None	None
SW-N3	Alston Bay	Sand/Mineral, Muck, Hydric, Moist	None	None	None	Moss Collars, Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Cypress Infection Points	None	None	None
SW-N4	NE Lakeland Wellfield G	Sand/Mineral, Hydric, Moist	None	None	None	Pine Edge, Saw Palmetto Edge, Moss Collars, Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks	Yes	None	None
SW-N5	NE Lakeland Wellfield J	Sand/Mineral, Hydric, Inundated	None	None	None	Pine Edge, Moss Collars, Buttressed Tree Trunks	Yes	None	None
SW-N6	NE Lakeland Wellfield K	Sand/Mineral, Hydric, Inundated	None	None	None	Pine Edge, Stain Lines, Buttressed Tree Trunks, Hummocks, Indicators Weak	Yes	None	None

Table C-1b. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Soil Type at Wetland Boundary	Soil Subsidence/ Oxidation	Soil Fissure	Soil Compaction	List of Hydrologic Indicators	Drainage Alteration in Wetland/ Lake	Drainage Alteration of Surrounding Lands	Stormwater Inflows
SW-N7	Saddle Blanket Scrub #2	Muck, Hydric, Saturated	None	None	None	Saw Palmetto Edge, Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Water Marks	None	None	None
SW-N8	Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1	Sand/Mineral, Hydric, Dry	Yes	None	None	Lichen Lines, Stain Lines, Adventitious Roots, Buttressed Tree Trunks, Water Marks	None	Yes	Yes

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SF-LA	Walker Ranch - WR11	Not Stressed	Not Stressed	NA	Plains	No	-81.404507	28.083626	1A Depressional Mesic
SF-LB	Walker Ranch - WR6	Not Stressed	Not Stressed	NA	Plains	No	-81.412562	28.113903	1A Depressional Mesic
SF-XZ	Walker Ranch - WR9	Not Stressed	Not Stressed	NA	Plains	No	-81.418795	28.109258	1A Depressional Mesic
SF-N1	Walker Ranch WR-16	Not Stressed	NA	NA	Plains	No	-81.392284	28.077793	1A Depressional Mesic
SF-N2	Walker Ranch WR-15	Not Stressed	NA	NA	Plains	No	-81.390062	28.082236	1A Depressional Mesic
SF-WT	Split Oak	Stressed	NA	NA	Plains	No	-81.20890235	28.3584259	1A Depressional Mesic
SF-YK	Tibet Butler	Not Stressed	Stressed	Review of the period of record staff gage data, historical aerials, and the field inspection indicated system in recovery from a period of stress.	Plains	No	-81.537112	28.446165	1A Depressional Mesic
SJ-AJ*	Lake Gem	Not Stressed	Stressed	Previous and current field evaluations did not reveal stress indicators. "Stressed" determination was based on history from District staff.	Plains	No	-81.207313	28.645854	1E Flatland Lakes
SJ-LA	Unnamed Cypress	Not Stressed	Not Stressed	NA	Plains	No	-81.119700	28.566632	1A Depressional Mesic
SJ-LB	Unnamed Wetland Nr SR 46	Stressed	Stressed	NA	Ridge	Yes	-81.360359	28.810519	1E Flatland Lakes
SJ-LC	Boggy Marsh	Stressed	Stressed	NA	Plains	No	-81.697514	28.396950	2D Strands/Sloughs (but hydrologically isolated by roads and crossings)
SJ-LD	Hopkins Prairie	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.693251	29.274910	1F Xeric Lakes

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SJ-LE	Lake Avalon	Stressed	Stressed	NA	Ridge	Yes	-81.642740	28.510180	1F Xeric Lakes
SJ-LF	Lake Apshawa	Stressed	Stressed	NA	Ridge	Yes	-81.773330	28.599640	1F Xeric Lakes
SJ-LH*	Island Lake	Not Stressed	Stressed	Previous and current field evaluations did not reveal stress indicators. "Stressed" determination was based on aerial history and possible increase in size of "islands" within the marsh.	Plains	No	-81.363091	28.696596	2A-M Large Isolated
SJ-LI	Lake Sylvan	Stressed	Not Stressed	Encroachment of pines well into wetland, visible signs of soil subsidence	Plains	No	-81.379811	28.803797	1E Flatland Lakes
SJ-LL	City of Cocoa, Well 9T	Not Stressed	Not Stressed	NA	Plains	No	-81.053314	28.394303	2D Strands/Sloughs (but hydrologically isolated by roads and crossings)
SJ-QA	Church Lake	Stressed	Stressed	NA	Ridge	Yes	-81.841699	28.644937	1F Xeric Lakes
SJ-QB	Johns Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.657585	28.531825	1F Xeric Lakes
SJ-QC	Trout Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.712212	28.447999	1F Xeric Lakes
SJ-QD	Long Lake	Stressed	Stressed	NA	Ridge	Yes	-81.469958	28.617014	1F Xeric Lakes
SJ-LJ	Lake Louisa	Stressed	Stressed	NA	Ridge	Yes	-81.74695	28.46346	2G Floodplain Lakes (but regulated)
SJ-GA*	Prairie Lake	Stressed	Stressed	NA	Ridge	Yes	-81.5113	28.59775	1F Xeric Lakes
SJ-AW	Red Bug Lake	Stressed	Stressed	NA	Plains	No	-81.290839	28.648639	1E Flatland Lakes
SJ-AI	Chapman Marsh	Stressed	Stressed	NA	Plains	No	-81.193906	28.641028	2A-M Large Isolated
SW-AA	Green Swamp #7	Not Stressed	Not Stressed	NA	Plains	No	-81.911111	28.312611	1A Depressional Mesic
SW-JJ	Lake Garfield	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.723410	27.900860	1A Depressional Mesic
SW-LE	Cypress Creek #199, W17 Sentry Wetland	Stressed	Stressed	NA	Plains	No	-82.394478	28.286128	1A Depressional Mesic

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SW-LF*	Cypress Creek #190 E Marsh	Not Stressed	Stressed	Due to reduced pumping at the wellfield, SA water levels have improved; the field inspection indicated that the wetland was not hydrologically stressed and is in recovery	Plains	No	-82.378218	28.304856	2A-M Large Isolated
SW-LG	Cypress Creek #223 B W46	Stressed	Stressed	NA	Plains	No	-82.391208	28.290439	1A Depressional Mesic
SW-LH	Cypress Creek #211 W33	Not Stressed	Stressed	Due to reduced pumping at the wellfield, SA water levels have improved; the field inspection indicated that the wetland was not hydrologically stressed and is in recovery	Plains	No	-82.393056	28.276317	2A-M Large Isolated
SW-LI	Green Swamp Marsh #304	Not Stressed	Not Stressed	NA	Plains	No	-82.017890	28.354863	1A Depressional Mesic
SW-LJ	Green Swamp #6, #303	Not Stressed	Not Stressed	NA	Plains	No	-81.971260	28.394560	1A Depressional Mesic
SW-LK	Green Swamp #5, #302	Not Stressed	Not Stressed	NA	Plains	No	-82.018658	28.368859	1A Depressional Mesic
SW-LM	Green Swamp #1, #298	Not Stressed	Not Stressed	NA	Plains	No	-81.946755	28.361410	1A Depressional Mesic
SW-MM	Lake Wales	Not Stressed	Stressed	Review of the period of record staff gage data, historical aerials, and the field inspection indicated that the lake is not hydrologically stressed.	Ridge	Yes	-81.578690	27.903910	1F Xeric Lakes

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SW-QA	Big Gum Lake	Not Stressed	Stressed	Review of the period of record staff gage data, historical aerials, and the field inspection indicated that the lake is not hydrologically stressed.	Ridge	Yes	-81.492193	27.928229	1F Xeric Lakes
SW-QB	Bonnet Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.438926	27.546476	1F Xeric Lakes
SW-QC	Buck Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.332671	27.234785	1F Xeric Lakes
SW-QD	Gator Lake	Stressed	Not Stressed	Review of the historical aerials indicates no change in the lake level; review of the period of record staff gage data indicates less variability in the water level fluctuation in recent years (highs not as high and lows not as low); field inspection indicated hydrologic stress in the wetlands along the lake shore on the site where the staff gage is accessed.	Ridge	Yes	-81.686616	27.841225	1F Xeric Lakes
SW-QE	Lake Annie	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.351758	27.205947	1F Xeric Lakes
SW-QF	Lake Apthorpe	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.362716	27.344290	1F Xeric Lakes
SW-QH	Lake Leonore	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.512255	27.793753	1F Xeric Lakes
SW-QI	Lake Placid	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.364219	27.244505	1F Xeric Lakes
SW-QJ	Lake Streety	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.569989	27.678406	1F Xeric Lakes
SW-QK	Lake Van	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.768938	28.107150	1F Xeric Lakes
SW-QL	Lake Walker	Stressed	Stressed	NA	Ridge	Yes	-81.717885	27.853656	1F Xeric Lakes

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SW-QM	Polecat Lake	Not Stressed	Stressed	Review of historical aerials and period of record staff gage data indicates stable water levels, field inspection indicated a poor-quality lake but not due to hydrologic stress.	Ridge	Yes	-81.699882	27.843913	1F Xeric Lakes
SW-QN	Surveyors Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.691552	27.833970	1F Xeric Lakes
SW-QO	Parks Lake	Not Stressed	Not Stressed	NA	Ridge	Yes	-81.468410	27.915700	1F Xeric Lakes
SW-QQ	Crooked Lake	Not Stressed	Stressed	Review of historical aerials and period of record staff gage data indicates increased water levels in recent years, the lake was not hydrologically stressed during the field inspection, lake meeting its high minimum level and 0.1' from meeting its low minimum level in 2016.	Ridge	Yes	-81.553030	27.827970	1E Flatland Lakes
SW-DD	Van Fleet #2	Not Stressed	NA	NA	Plains	No	-81.6634	28.2422	1A Depressional Mesic
SW-N1	Green Swamp Bay	Not Stressed	NA	NA	Plains	No	-81.9537	28.4218	2A-M Large Isolated
SW-N2	Green Swamp #4	Not Stressed	NA	NA	Plains	No	-81.9311	28.3919	1A Depressional Mesic
SW-N3	Alston Bay	Not Stressed	NA	NA	Plains	No	-82.0906	28.1804	2A-M Large Isolated
SW-N4*	NE Lakeland Wellfield G	Not Stressed	NA	NA	Plains	No	-81.9027796	28.17035396	2A-M Large Isolated
SW-N5*	NE Lakeland Wellfield J	Not Stressed	NA	NA	Plains	No	-81.8883	28.1652	2A-M Large Isolated

Table C-1c. Class 1 wetlands information (sites not included in EMT wetlands analysis denoted by *).

CFCA/EMT ID	Site Name	Status in 2018	Status During Previous Assessment	Reason for Change in Stress Status	Physiographic Region	Ridge	Longitude	Latitude	Hydroclass
SW-N6*	NE Lakeland Wellfield K	Not Stressed	NA	NA	Plains	No	-81.8962	28.161	1A Depressional Mesic
SW-N7	Saddle Blanket Scrub #2	Not Stressed	NA	NA	Ridge	Yes	-81.5788	27.6706	1B Depressional Xeric
SW-N8	Lake Wales Ridge Wildlife and Environmental Area, Mountain Lake Cutoff Tract #1	Stressed	NA	NA	Ridge	Yes	-81.595412	27.923136	1B Depressional Xeric
SW-QK	Lake Van	Not Stressed	Not Stressed	NA	Plains	No	-81.404507	28.083626	1A Depressional Mesic
SW-QL	Lake Walker	Not Stressed	Not Stressed	NA	Plains	No	-81.412562	28.113903	1A Depressional Mesic

Appendix D: Wetlands Risk Assessment Methodology

1.0 INTRODUCTION

The EMT was reactivated in late 2016 to provide support for the 2020 update to the CFWI RWSP as it relates to non-MFL, primarily groundwater-dominated wetlands and lakes. It was tasked with determining the current status of wetlands and lakes with respect to hydrologic stress and to develop tools to evaluate modeled future wetland conditions within the CFWI Planning Area.

This Appendix describes the methods used to determine the probability that groundwater-dominated wetlands in Ridge or Plains settings within the CFWI Planning Area might change stress status as a result of changes in future hydrologic conditions as predicted by ECFTX model. As defined in the report, groundwater-dominated wetlands are those wetlands whose water budget is largely driven the exchange (both inflow and outflow) of groundwater due to their connectivity to an aquifer. Groundwater-dominated wetlands are mostly isolated, but also include headwater wetlands and seasonally inundated wetland strands that would be defined under regulatory rules as "connected wetlands." The changes in hydrologic conditions represent changes in groundwater levels as a result of future changes in groundwater withdrawals. A change of wetland stress status can result from changing hydrologic conditions that allow a Stressed wetland to become Not Stressed, or (more commonly) changing hydrologic conditions that cause a Not Stressed wetland to become Stressed.

2.0 CLASS 2 WETLANDS POWER ANALYSIS

In WRAT discussions regarding changing wetland conditions, there was a consensus among EMT wetland scientists that, during recent years, field staff had observed a small shift towards a slightly lower incidence of observed stress in groundwater-dominated wetlands compared to observations made for EMT wetlands analysis in support of the 2015 CFWI RWSP. This led to consideration of whether it would be appropriate to reassess the current typical rates of stress occurrence in the different classes of groundwater-dominated wetlands.

Due to limitations on the time and resources available, it would only have been possible to reassess a limited subset of the original Class 2 wetlands, and to use that subset to draw an inference about a possible change in the prevalence of stressed wetland conditions in the larger population of groundwater-dominated wetlands. Therefore, the key consideration was the number of wetlands that would have to be included in a subset of wetlands to be reassessed in order to conclude with reasonable reliability whether the overall prevalence of stress in groundwater-dominated wetlands had changed since the EMT wetlands analysis in support of the 2015 CFWI RWSP (CFWI EMT 2013). In statistics, this question is addressed using a procedure known as a Power Analysis.

In general terms, a Power Analysis is an assessment of the probability of detecting an actual effect of a given sample size with a given level of confidence. In this case, the effect that was sought was a change in the frequency of occurrence of stressed wetlands in the total populations of Ridge and Plains groundwater-dominated wetlands. The effect was expressed as a difference in the frequency of occurrence of stress in a random sample drawn from the parent population of wetlands. In statistical terms, the default hypothesis (e.g., no effect or difference between groups) is referred to as the Null Hypothesis and is represented by the symbol H_0. When a statistician rejects the Null Hypothesis, they are indicating there appears to be a meaningful "statistically significant" outcome. For the EMT analysis, this would be represented by a statistically significant difference in the frequency of occurrence of stress between an original sample of the wetlands and a more recent sample. The Power Analysis is constructed to assess the probability that if the Null Hypothesis is false, it will be correctly identified as false. Under certain conditions such as a low sample size, statistical analyses may fail to properly reject a Null Hypothesis (see Type II Error description below). As shown in Table D-1, there are two distinct potential errors when deciding whether to accept or reject the Null Hypothesis:

- A Type 1 Error occurs when the Null Hypothesis is <u>true</u>, but the Null Hypothesis is <u>rejected</u> as a result of the statistical test.

    - The probability of committing a Type I Error is known as the Significant Criterion and is denoted by the symbol α. A Type I Error is also known as a False Positive test result.
    - The significance criterion can be thought of as the probability that a true Null Hypothesis will be rejected just because the random variation of a given sample will give an incorrect impression that the Null Hypothesis is false because it varies significantly from the statistical characteristics of the parent population.
    - The larger the sample size, the more closely its statistical characteristics will approximate those of the parent population, and the lower the probability of falsely rejecting a Null Hypothesis about the parent population because of a mismatch between the statistical characteristics of the random sample and those of the parent population from which it was drawn.

- A Type II Error occurs when the Null Hypothesis is <u>false</u>, but the Null Hypothesis is <u>not rejected</u> as a result of the statistical test.

    - The probability of committing a Type II Error is denoted by the symbol β, and the quantity $(1-\beta)$ is known as the Statistical Power of the test, which is sometimes denoted by the symbol π. A Type II Error is also known as a False Negative test results.
    - The Statistical Power of the test can be thought of as the probability that it will correctly reject a false Null Hypothesis about the statistical attributes of the parent population.
    - A test with a Statistical Power, $\pi = 0.80$ (80 percent) has a $\beta = 0.20$ (20 percent) probability of allowing a False Negative test result due to random variation of the sampling process. That is, a 20 percent chance of failing to reject the hypothesis that the two samples are drawn from the same parent distribution,

when there is a (real) statistically significant difference between the former distribution of stress in wetlands and the new distribution of stress in wetlands.

- The larger the sample size, the more closely its statistical characteristics will approximate those of the whole population, and the lower the probability, β, that the test will fail to reject a false Null Hypothesis because of a mismatch between the statistical characteristics of the random sample and those of the parent population from which it was drawn.

For the occurrence of stressed wetlands, it is possible to structure the Power Analysis to assess the probability of failing to reject a Null Hypothesis, H_0, that the frequency of occurrence of stressed wetlands has not changed, when the true condition is that frequency of stress has changed by a specified percentage from the frequency that was observed in the analysis of Class 2 wetlands performed for the 2015 CFWI RWSP. The Power Analysis can then be used to calculate the minimum sample size that would be required to detect the specified percentage change in stress occurrence while achieving specified significance criterion, α, and Statistical Power, π, targets. This approach allowed the EMT to assess how many Class 2 wetlands would have to be reassessed in order to draw a statistically valid conclusion whether the occurrence of stress in wetlands had changed by a specified percentage from the values seen in the 2015 CFWI RWSP analysis.

Table D-1. Summary of possible Power Analysis hypothesis and test result combinations.

		Null Hypothesis (H_0) is Actually	
		True	**False**
Statistical Decision on Validity of the Null Hypothesis (H_0)	Reject	Type I Error (False Positive) Probability = α	Correct Inference (True Positive) Probability = 1 - β
	Do Not Reject	Correct Inference (True Negative) Probability = 1 - α	Type II Error (False Negative) Probability = β

The EMT decided that recent field observations might indicate an overall reduction of about 10 percent in the occurrence of stressed wetlands. It was decided that the minimum targets for False Positive and False Negative test conclusions were:

- Significance Criterion, α = 0.1 (10 percent) = probability of a False Positive test conclusion, and
- Statistical Power, π = 0.8 (80 percent); therefore β = 0.2 (20 percent) = the probability of a False Negative test conclusion.

The Power Analysis showed that Ridge wetlands would require the largest sample size for evaluation in order to detect a 10 percent change in the average incidence of stress. It would require the evaluation of over 580 Ridge wetlands in order to detect a 10 percent change in the average incidence of stress at the specified Significance Criterion and Statistical Power values. In other words, the sample of Ridge wetlands would have to be revised far beyond the original 2015 CFWI RWSP sample size in order to draw reliable conclusions about a change of stress occurrence at this level. Wetland surveys of this type would have required more resources and time than was available once the EMT was reconvened as a working sub team. It was also decided to not just resurvey the Class 2 wetlands analyzed previously because the results of any such resampling of a smaller data set within the bounds of the time and resources available would not have allowed a reliable conclusion to be drawn as to whether the average occurrence of stress in wetlands had really changed since the surveys in support of the EMT wetlands analysis for the 2015 CFWI RWSP were performed.

3.0 HYDROLOGIC INDEX DEVELOPMENT FOR PREDICTION OF WETLAND STRESS

In the original analysis in support of the 2015 CFWI RWSP (CFWI EMT 2013), the EMT demonstrated that the probability of hydrologic stress occurring in wetlands could be related to a hydrologic index, θ, which is defined as:

$$\theta = ERE - P80 \qquad \text{.................................(1)}$$

Where:

ERE = Wetland Edge Reference Elevation (ft NAVD 88); and

P80 = The water elevation that is exceeded 80 percent of the time (ft NAVD 88).

As described in Section 1.1. of the report, primarily groundwater-dominated wetlands were classified into three classes, based on the types of information available at each site, as shown in **Table D-2**.

Table D-2. Summary of wetland classifications.

Wetland Class	Data Class Characteristics		
	Wetland Type	Current Stress Condition	Water Levels
Class 1	Known	Known	Known
Class 2	Known	Known	Unknown
Class 3	Known	Unknown	Unknown

As described in Section 3 of the report, the EMT evaluated 60 potential Class 1 wetlands (the original 44 Class 1 wetlands plus potential new additions) for inclusion in the analysis dataset. The final dataset included 53 wetlands with 2018 stress status evaluations and fairly complete records of water level data to calculate the P80 water elevation based on water level monitoring data for the period 2009 through 2017. This 9-year period was chosen as the best compromise between longer periods of record available from fewer sites vs. shorter periods of record available from more numerous sites, while still yielding sets of hydrologic indices (θ values) which represent the overall distribution of wetland hydrologic conditions. Primarily groundwater-dominated wetlands and lakes in Plains and Ridge physiographic regions were evaluated separately, since wetland hydrologic conditions in these systems are typically different as a result of differences in underlying soils, geology, physiography, typical depths, and other factors. The methods used to determine the wetland reference edge elevations (ERE) for the original 44 Class 1 wetlands are presented in Attachment D of the previous EMT report (CFWI EMT 2013), while the elevations for the new Class 1 wetlands were established by EMT staff during field inspections.

The total fraction of Not Stressed and Stressed wetland θ values is calculated similarly.

$$F_u = \left(\frac{N_u}{N_u + N_s}\right) \times 100\% \qquad \text{.................................(2)}$$

$$F_s = \left(\frac{N_s}{N_u+N_s}\right) \times 100\% \quad \text{.................................(3)}$$

Where:

N_u	=	Number of Not Stressed wetland values of θ
N_s	=	Number of Stressed Wetland values of θ
F_u	=	The total fraction of Not Stressed wetland θ values
F_s	=	The total fraction of Stressed wetland θ values

It was shown that the θ value distributions met the assumption of normal distribution using the Shapiro-Wilk Normality Test (**Table D-3**). The Shapiro Wilk Normality Test tests the hypothesis that the data are normally distributed. The null-hypothesis is that the data are normally distributed, and the hypothesis is rejected at a chosen confidence level, $1 - \alpha$, if the p-value returned by the test is less than α. All candidate periods of record were unable to reject the null hypothesis at a 90 percent confidence level (p-value < 0.1 for 7 < n < 5000) for the Stressed and Not Stressed Plains and Ridge wetlands, except for the Not Stressed Ridge wetlands with a period of record start year of 2010.

Table D-3. Summary of Shapiro-Wilk Normality Test for the Class 1 wetlands dataset.

p-Values	Plains Wetlands		Ridge Wetlands	
Start Year	**Not Stressed**	**Stressed**	**Not Stressed**	**Stressed**
n=	18	7	19	9
2007	0.644	0.129	0.434	0.571
2008	0.247	0.097	0.361	0.550
2009	0.236	0.289	0.136	0.530
2010	0.215	0.413	0.086	0.370

The time series data were checked to assess how long a time period could be used without showing a significant time series trend and limiting the number of extreme rainfall years in relatively short records, because both factors tend to skew the calculated P80 water levels in wetlands. In general, longer time series will yield more reliable P80 water level statistics, but our ability to use long records was limited to two factors:

- The longer the record, the more likely that it will show a trend in water levels due to various man-made influences on the surface water and groundwater systems.
- For longer desired record lengths, there are fewer wetland sites that have water level data with a long enough record (e.g., more than 10 years), which reduces the number of wetlands available to provide P80 water level values to be used for fitting a distribution to the resulting hydrologic index, θ, values. This is problematic because fitted distributions based on fewer observations are inherently subject to greater error in fitting the distribution.

After assessing all these factors, a period of 2009 through 2017 was selected as the best timeframe for use in calculating hydrologic index values for use in this analysis. As shown in

Table D-3, the four classes of wetlands all pass the Shapiro-Wilk Normality Test for this period of record. Therefore, it is possible to fit normal distributions to the hydrologic index, θ, values for each wetland class, and to use the resulting fitted normal distributions in developing assessments of wetland stress risk for altered water levels caused by groundwater pumping.

For each wetland type, the statistical distribution of the hydrologic index, θ, was assessed separately for Stressed and Not Stressed wetlands. The number of wetlands in each subclass and the calculated mean and standard deviation of the θ values in each subclass are summarized in **Table D-4**.

Table D-4. Summary of Class 1 Wetlands Hydrologic Index statistics.

Wetland Type	Not Stressed Symbol	Stressed Symbol	Statistical Attribute	Not Stressed Value	Stressed Value
Plains Wetlands	N_u	N_s	Number of wetlands	18	7
	$\bar{\theta}_u$	$\bar{\theta}_s$	Mean value of θ	2.42 ft.	4.03 ft.
	${s_\theta}^2_u$	${s_\theta}^2_s$	Standard deviation of θ	.717 ft.	1.49 ft.
Ridge Wetlands	N_u	N_s	Number of wetlands	19	9
	$\bar{\theta}_u$	$\bar{\theta}_s$	Mean value of θ	3.97 ft.	7.93 ft.
	${s_\theta}^2_u$	${s_\theta}^2_s$	Standard deviation of θ	2.19 ft.	3.30 ft.

The probability density values for Not Stressed and Stressed wetlands at different values of θ were calculated as follows:

$$p_u(\theta) = N(\bar{\theta}_u, {s_\theta}^2{}_u, \theta_u) \quad \text{.......} (4)$$

$$p_s(\theta) = N(\bar{\theta}_s, {s_\theta}^2{}_s, \theta_s) \quad \text{.......} (5)$$

Where:

$p_u(\theta)$	=	The probability density of Not Stressed wetlands at a wetland hydrologic index value of θ (ft.)
$p_s(\theta)$	=	The probability density of Stressed wetlands at a value of θ
$N(\bar{\theta}, {s_\theta}^2, \theta)$	=	The normal distribution probability density function based on the distribution parameters listed below
$\bar{\theta}$	=	The average of the observed θ values for the selected wetland sub-sample (i.e., either the Not Stressed or the Stressed sub-sample, as appropriate) (ft.)
${s_\theta}^2$	=	The variance of the observed θ values for the selected wetland sub-sample
θ	=	The value of the wetland hydrologic index value at which the probability density is to be calculated (ft.)

Data from the 226 Class 2 wetlands (described in Section 4 of the report) were used as a random sample of the relative frequency of occurrence of Not Stressed and Stressed wetland sites. In the field assessment of wetlands for the original analysis (CFWI EMT 2013), wetlands were noted as "significantly hydrologically altered" (SHA) if there were obvious alterations that would significantly alter the hydrology that originally gave rise to the wetland system. It was observed that the designation of SHA appeared to have little impact on occurrence of stress in the groundwater-dominated Ridge wetlands and that the hydroperiods of these systems were generally thought to be more susceptible to groundwater alterations than to the observed surface water alterations. Therefore, similar to the original analysis, the SHA Ridge wetlands were analyzed in the same manner as non-SHA Ridge wetlands in this analysis.

For the Plains wetland systems, in the original analysis it was observed that the designation of SHA was strongly correlated with stress in wetlands (94 percent of SHA Plains wetlands were Stressed, compared to 18 percent of non-SHA Plains wetlands). Assessment of the hydrology of these systems also suggested that their water levels are dominated by surface water effects, and that it is difficult to accurately assess the effects of moderate changes in groundwater elevations on surface water levels in the SHA wetland systems. Therefore, similar to the original analysis, SHA Plains wetland systems were excluded from this analysis. After removal of the SHA Plains wetlands, the relative occurrence of Stressed and Not Stressed wetlands in the Class 2 data for the CFWI area is summarized in **Table D-5**.

Table D-5. Summary of Stressed and Not Stressed frequency of wetlands in Class 2 wetlands dataset.

	Not Stressed		Stressed	
Wetland Type	**Count**	F_u	**Count**	F_s
Plains (non-SHA)	65	61.9%	40	38.1%
Ridge (All)	68	55.7%	54	44.3%

4.0 DEVELOPMENT OF STRESS PROBABILITY FUNCTIONS FOR WETLANDS WITH KNOWN INITIAL CONDITIONS

A program developed in the R programming language: ZetaCalcIntegrals.R, was used to implement the following equations and methods. References to equation numbers are include in the comments of this program's source code located towards the end of this document. Additional scripts used to preprocess data for the program may be found in SharePoint via https://swfwmd.sharepoint.com/sites/cfwiemto365.

The probability density functions for the Not Stressed and Stressed wetlands (Figures D-1 and D-2) each represent a fraction (F_u and F_s, respectively), of the total probability density function for all wetlands. The contribution of each sub-set of wetlands (Not Stressed and Stressed) to the total probability density function for all wetlands can be calculated as:

$$p'_u(\theta) = F_u \times p_u(\theta) \quad \text{.................................(6)}$$

$$p'_s(\theta) = F_s \times p_s(\theta) \quad \text{.................................(7)}$$

Where:

$p'_u(\theta)$	=	The population-weighted contribution of Not Stressed wetlands to the total population probability density of all wetlands at a wetland hydrologic index value of θ (ft.)
$p'_s(\theta)$	=	The population-weighted contribution of Stressed wetlands to the total population probability density of all wetlands at a wetland hydrologic index value of θ (ft.)
Other terms	=	As previously defined

The total population probability density function of all wetlands in the sample can be calculated from **Equations 6 and 7** as:

$$p'_{all}(\theta) = p'_u(\theta) + p'_s(\theta) \quad \text{..............................} (8)$$

Where:

$p'_{all}(\theta)$	=	The total population probability density of all wetlands in the sample evaluated at a wetland hydrologic index value of θ (ft.)
Other terms	=	As previously defined

For any randomly selected wetland at a given value of θ, the probability that the wetland will have a hydrologic index value of θ, and the probability that the wetland will be stressed is the ratio of the population density of Stressed wetlands to the population density of all wetlands. Similarly, the probability that any randomly selected wetland will be Not Stressed at a given value of θ is the ratio of the population density of Not Stressed wetlands to the population density of all wetlands.

$$\Psi_u(\theta) = \frac{p'_u(\theta)}{p'_{all}(\theta)} = \frac{p'_u(\theta)}{\{p'_u(\theta) + p'_s(\theta)\}} \quad \text{..............................} (9)$$

$$\Psi_s(\theta) = \frac{p'_s(\theta)}{p'_{all}(\theta)} = \frac{p'_s(\theta)}{\{p'_u(\theta) + p'_s(\theta)\}} \quad \text{............................} (10)$$

$$\Psi_u(\theta) = 1 - \Psi_s(\theta) \quad \text{............................} (11)$$

Where:

$\Psi_u(\theta)$	=	The probability that any randomly selected wetland will be Not Stressed at a given value of θ (dimensionless)
$\Psi_s(\theta)$	=	The probability that any randomly selected wetland will be Stressed at a given value of θ (dimensionless)
Other terms	=	As previously defined

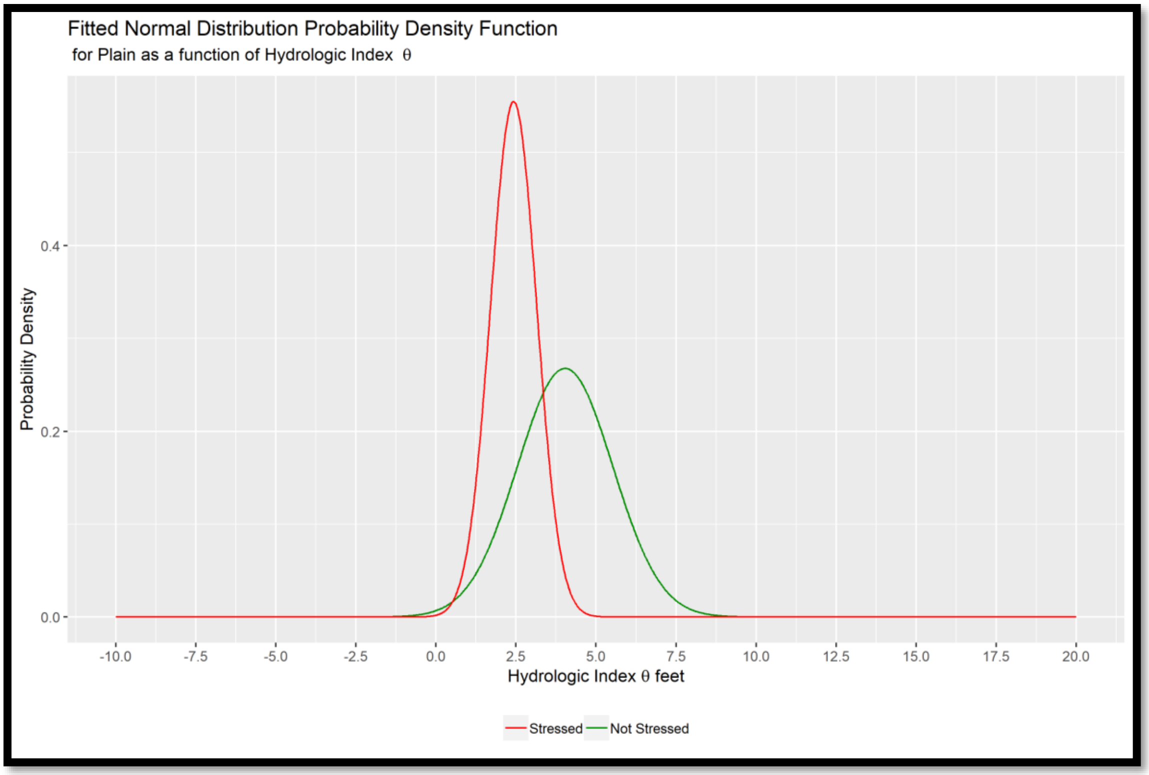

Figure D-1. Plains wetlands probability density functions.

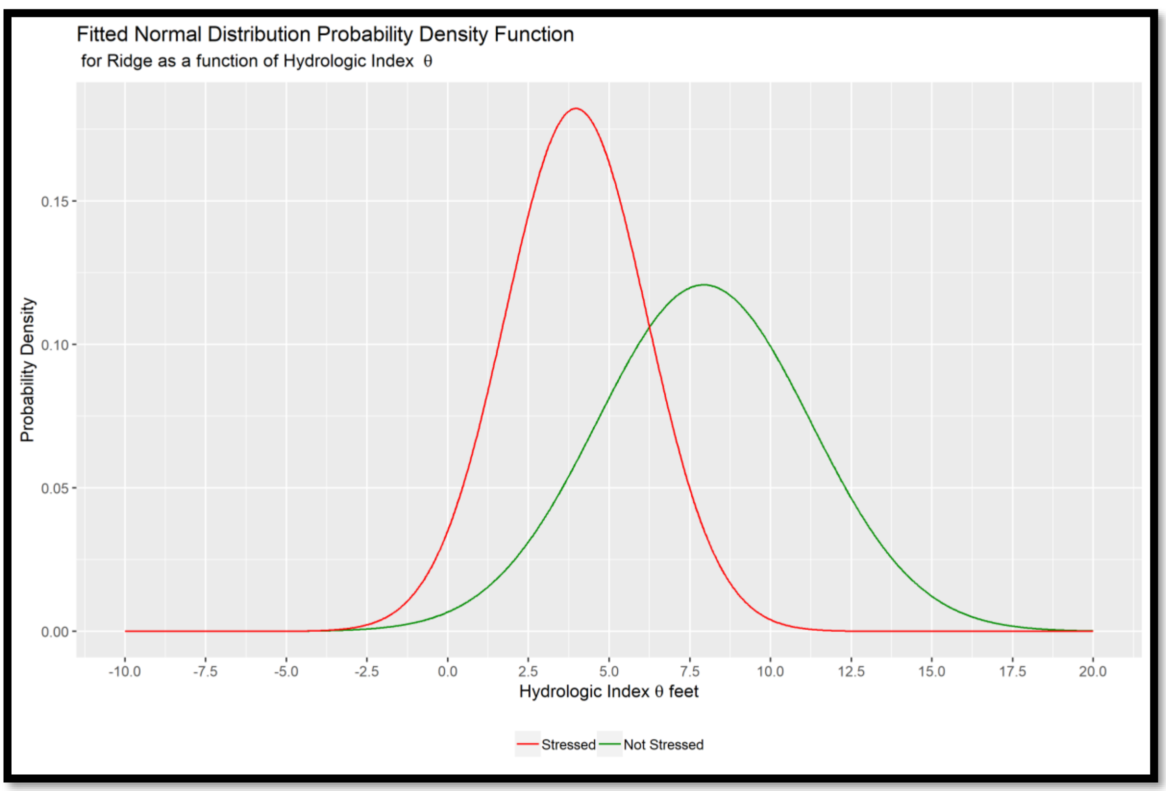

Figure D-2. Ridge wetlands probability density functions.

The resulting stress probability functions (Ψ functions) for Plains are shown in **Figure D3**, and the Ψ functions for Ridge wetlands are shown in **Figure D-4**. Note that the Ψ functions are not probability density functions and $\int_{-\infty}^{\infty} \psi(\theta)\, d\theta \neq 1$. Unlike probability density functions, the area under the probability curve is not equal to one ($\int_{-\infty}^{\infty} \Psi(\theta)\, d\theta \; \neq 1$).

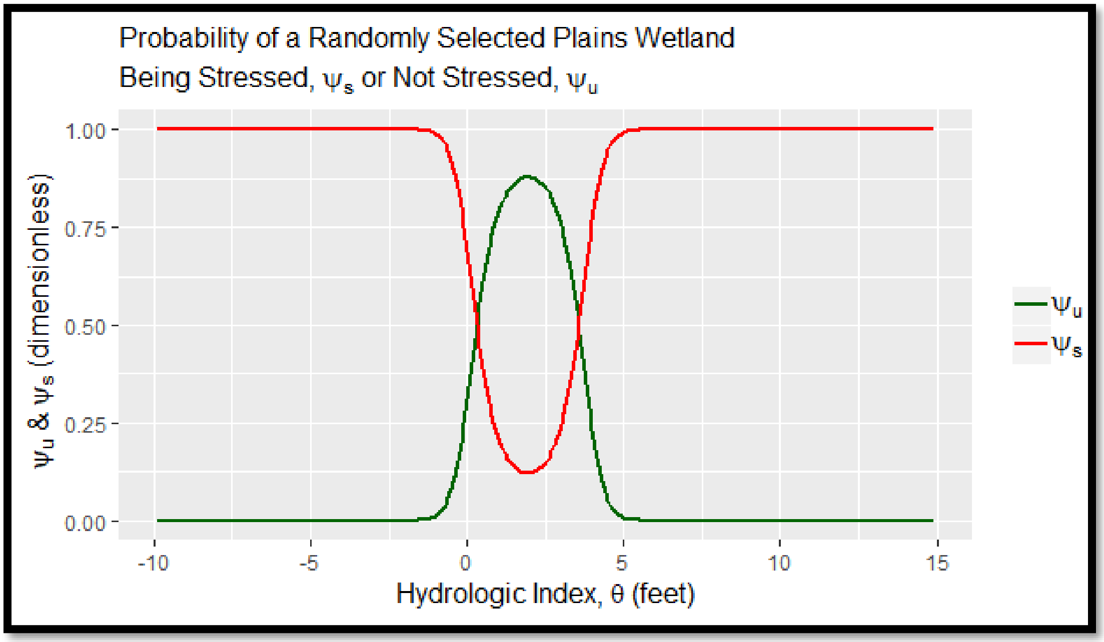

Figure D-3 Probability of a randomly-selected Plains wetland being Stressed (ψ_s) or Not Stressed (ψ_u) as a function of observed Hydrologic Index (θ) value.

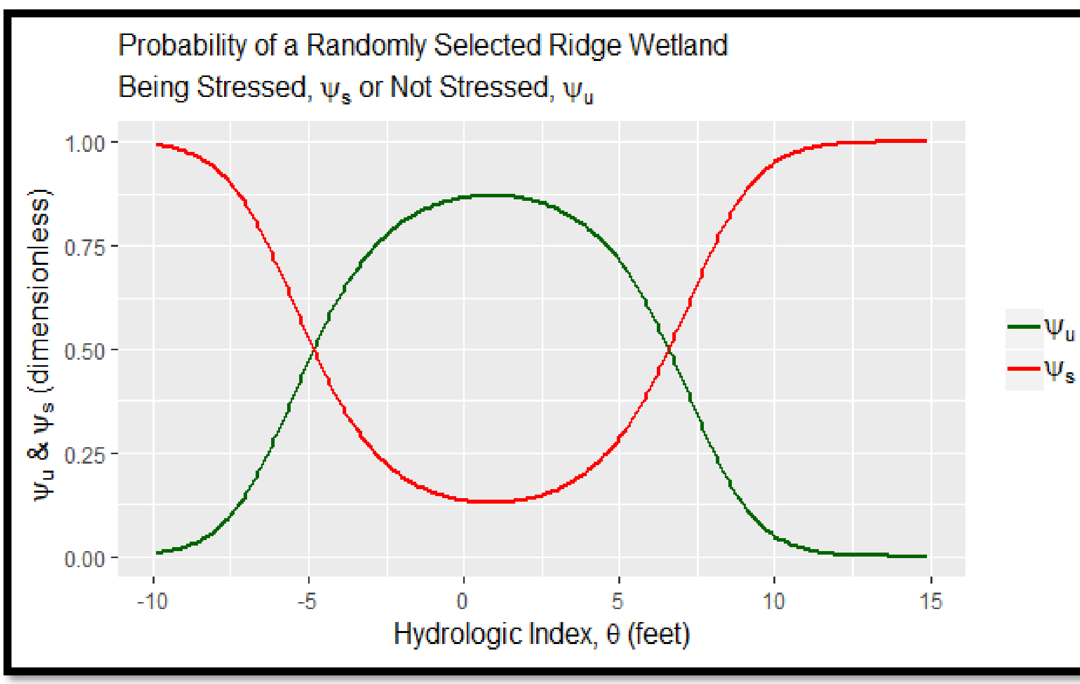

Figure D-4. Probability of a randomly-selected Ridge wetland Being Stressed ($\boldsymbol{\Psi_s}$) or Not Stressed ($\boldsymbol{\Psi_u}$) as a function of observed Hydrologic Index ($\boldsymbol{\theta}$) value.

The Ψ_u and Ψ_s functions represent the probabilities of a randomly selected wetland being found to be Not Stressed or Stressed, respectively, at a specified value of the wetland Hydrologic Index, θ. It can be seen that the range of hydrologic index values at which a Ridge wetland is more likely to be Not Stressed than Stressed is much broader than the corresponding range for Plains wetlands. This is thought to be a product of the hydrology of these two physiographic regions; water levels typically vary much more in Ridge settings than in the Plains settings, and the native wetland systems are adapted to these conditions. While the Ψ_u and Ψ_s probability functions provide useful information, we are frequently more interested in a different probability – the probability that a wetland of known initial stress condition and known initial wetland hydrologic index value, θ, will change its stress status when the wetland hydrologic index is altered to some different value of θ.

Using the data from **Tables D-4 and D-5**, a series of curves was developed showing the probability of Not Stressed Plains wetlands becoming Stressed due to a change in the hydrologic index, θ. The probability of stress is shown as a function of the initial value of θ and of Δθ, the amount of future change in the value of θ. The function for probability of inducing stress in an initially Not Stressed wetland is represented as $\zeta_{u\rightarrow s}$ shown in **Figures D-5 thru D-8** Similarly, a probability function represented as $\zeta_{s\rightarrow u}$ produces the curves in **Figures D-9 through D-12** showing the probability of (eventually) inducing recovery of an initially hydrologically Stressed wetland to a Not Stressed condition, for negative and positive values of Δθ, respectively.

The probabilities of a change in the wetland stress condition as a result of a change of wetland hydrologic index from an initial value of θ_1 to a final value of θ_2 is represented by the functions $\zeta_{u\rightarrow s}\ (\theta_1, \theta_2)$ for adverse change from an Not Stressed to a Stressed condition, and $\zeta_{s\rightarrow u}(\theta_1, \theta_2)$ for a beneficial change from a Stressed condition to a Not Stressed condition. Changes in $\zeta_{u\rightarrow s}\ (\theta_1, \theta_2)$ and $\zeta_{s\rightarrow u}(\theta_1, \theta_2)$ are caused by an imposed change in water levels that cause a change of the hydrologic index value from θ_1 to θ_2.

A corresponding change of stress probability from:

$$\Psi_u(\theta_1)\ to\ \Psi_u(\theta_2) \qquad \text{..............................} (12)$$

and from:

$$\Psi_s(\theta_1)\ to\ \Psi_s(\theta_2) \qquad \text{..............................} (13)$$

The $\zeta_{u\rightarrow s}\ (\theta_1, \theta_2)$ and $\zeta_{s\rightarrow u}(\theta_1, \theta_2)$ functions are discontinuous. As discussed further below, this means that the appropriate equations to use for calculation of the $\zeta_{u\rightarrow s}\ (\theta_1, \theta_2)$ function varies depending on the initial and final values of $\Psi_u(\theta_1)$ and $\Psi_u(\theta_2)$. Similarly, the appropriate equations to use for calculation of the $\zeta_{s\rightarrow u}(\theta_1, \theta_2)$ function varies depending on the initial and final values of $\Psi_s(\theta_1)$ and $\Psi_s(\theta_2)$.

Consider the case of a Not Stressed wetland that is subjected to a change in the wetland hydrologic index, from an initial value of θ_1 to a final value of θ_2. The corresponding probabilities of a wetland being Not Stressed under these conditions are $\Psi_u(\theta_1)$ and $\Psi_u(\theta_2)$, respectively.

If $\Psi_u(\theta_1) > \Psi_u(\theta_2)$, the wetland has been moved to a condition that is less favorable for occurrence of Not Stressed wetlands, and we would, therefore, expect some risk of the wetland experiencing an adverse change of stress status. However, if $\Psi_u(\theta_1) \leq \Psi_u(\theta_2)$, the wetland has been moved to a condition that is more favorable for occurrence of Not Stressed wetlands; since the wetland was already Not Stressed there is no reason to expect a change in stress status when it is subjected to more favorable conditions. Therefore, if $\Psi_u(\theta_1) \leq \Psi_u(\theta_2)$, the probability of an adverse change of stress condition is zero.

However, if $\Psi_u(\theta_1) > \Psi_u(\theta_2)$, conditions have become less favorable for Not Stressed wetlands, and the probability of an adverse change from a Not Stressed condition to a Stressed condition is greater than zero. Also consider a case where a large population of N wetlands are found at an initial hydrologic index value of θ_1, and are subjected to a change that induces a final hydrologic index value of θ_2, such that $\Psi_u(\theta_1) > \Psi_u(\theta_2)$ so that a decrease in the fraction of Not Stressed wetlands is expected. The expected initial number of Not Stressed wetlands would be $N \times \Psi_u(\theta_1)$, and the expected final number of Not Stressed wetlands would be $N \times \Psi_u(\theta_2)$. Therefore, the number of Not Stressed wetlands that changed status to a Stressed condition would be:

$$\{[N \times \Psi_u(\theta_1)] - [N \times \Psi_u(\theta_2)]\} \qquad \text{..............................(14)}$$

or

$$N \times [\Psi_u(\theta_1) - \Psi_u(\theta_2)] \qquad \text{..............................(15)}$$

Therefore, the probability of any randomly selected Not Stressed wetland in this population becoming Stressed would be the number that changed from Not Stressed to Stressed condition divided by the initial number of Not Stressed wetlands in the population:

$$\{N \times [\Psi_u(\theta_1) - \Psi_u(\theta_2)]\} \,/\, N \times \Psi_u(\theta_1) \qquad \text{............................ (16)}$$

which simplifies to:

$$\left[1 - \frac{\Psi_u(\theta_2)}{\Psi_u(\theta_1)}\right]$$

..............................(17)

Therefore, the risk of an adverse change in wetland stress status from a Not Stressed condition to a Stressed condition can be calculated as:

If $[\Psi_u(\theta_1) \leq \Psi_u(\theta_2)]$;

$$\zeta_{u \to s}(\theta_1, \theta_2) = 0 \qquad \text{..............................(18)}$$

If $[\Psi_u(\theta_1) \geq \Psi_u(\theta_2)]$;

$$\zeta_{u \to s}(\theta_1, \theta_2) = \left[1 - \frac{\Psi_u(\theta_2)}{\Psi_u(\theta_1)}\right] \qquad \text{..............................(19)}$$

Conversely, the probability of a beneficial change (improvement) from a Stressed condition to a Not Stressed condition can be calculated as:

If $[\Psi_s(\theta_1) \leq \Psi_s(\theta_2)]$;

$$\zeta_{s \to u}(\theta_1, \theta_2) = 0 \qquad \text{..............................(20)}$$

If $[\Psi_s(\theta_1) \geq \Psi_s(\theta_2)]$;

$$\zeta_{s\to u}(\theta_1,\theta_2) = \left[1 - \frac{\Psi_s(\theta_2)}{\Psi_s(\theta_1)}\right] \quad \text{..............................(21)}$$

Where:

$\zeta_{u\to s}(\theta_1,\theta_2)$	=	The probability of an adverse change in wetland status from a Not Stressed to a Stressed condition, as a result of a change in the wetland hydrologic index from an initial value of θ_1 to a final value of θ_2 (dimensionless)
$\zeta_{s\to u}(\theta_1,\theta_2)$	=	The probability of a beneficial change in wetland status from a Stressed to a Not Stressed condition, as a result of a change in the wetland hydrologic index from an initial value of θ_1 to a final value of θ_2 (dimensionless)
Other terms	=	As previously defined

The application ranges of the discontinuous probability functions for the probability of inducing a change in the stress status of wetlands by changing the wetland hydrologic index value are summarized in **Table D-6**.

Table D-6 Application ranges of discontinuous functions for calculation of the probability of inducing a change in the stress status of wetlands by changing the wetland Hydrologic Index value.

	Initial vs. Final Values of $\Psi_u(\theta)$ & $\Psi_s(\theta)$	
	$\Psi_u(\theta_1) \geq \Psi_u(\theta_2)$ $\Psi_s(\theta_1) \leq \Psi_s(\theta_2)$	$\Psi_u(\theta_1) \leq \Psi_u(\theta_2)$ $\Psi_s(\theta_1) \geq \Psi_s(\theta_2)$
Probability of **Adverse** Stress Change in Initially Not Stressed Wetlands	$\zeta_{u\to s}(\theta_1,\theta_2) = \left[1 - \frac{\Psi_u(\theta_2)}{\Psi_u(\theta_1)}\right]$	$\zeta_{u\to s}(\theta_1,\theta_2) = 0$
Probability of **Beneficial** Stress Change (Recovery) in Initially Stressed Wetlands	$\zeta_{s\to u}(\theta_1,\theta_2) = 0$	$\zeta_{s\to u}(\theta_1,\theta_2) = \left[1 - \frac{\Psi_s(\theta_2)}{\Psi_s(\theta_1)}\right]$

Figure D-5 thru **D-12** descriptions as they relate to **Table D-6**:

Figures D-5 and **D-6**: Probability of Adverse Stress Change in Initially Not Stressed Wetlands $\zeta_{u\to s}(\theta_1,\theta_2)$ with future water levels higher than current levels (negative values of Δθ, where $\Delta\theta = (\theta_2 - \theta_1)$);
Figures D-7 and **D-8**: Probability of Adverse Stress Change in Initially Not Stressed Wetlands $\zeta_{u\to s}(\theta_1,\theta_2)$ with future water levels lower than current levels (positive values of Δθ, where $\Delta\theta = (\theta_2 - \theta_1)$);
Figures D-9 and **D-10**: Probability of Beneficial Stress Change (Recovery) in Initially Stressed Wetlands $\zeta_{s\to u}(\theta_1,\theta_2)$ with future water levels higher than current levels (negative values of Δθ, where $\Delta\theta = (\theta_2 - \theta_1)$);
Figures D-11 and **D-12**. Probability of Beneficial Stress Change (Recovery) in Initially Stressed Wetlands $\zeta_{s\to u}(\theta_1,\theta_2)$ with future water levels lower than current levels (positive values of Δθ, where $\Delta\theta = (\theta_2 - \theta_1)$);
Where new conditions show probable beneficial conditions $\Psi_u(\theta_1) \leq \Psi_u(\theta_2)$: No Probability of Adverse Stress Change in Initially Not Stressed Wetlands ; and
Where new conditions show probable adverse conditions $\Psi_s(\theta_1) \leq \Psi_s(\theta_2)$: No Probability of Beneficial Stress Change in Initially Stressed Wetlands.

Examples of the resulting probability functions for probability of an adverse and beneficial change in wetland status from a Not Stressed to a Stressed condition and Stressed to Not Stressed condition for multiple positive values of $\Delta\theta$, and for multiple negative values of $\Delta\theta$, where $\Delta\theta = (\theta_2 - \theta_1)$, are shown in **Figures D-5 through D-12**.

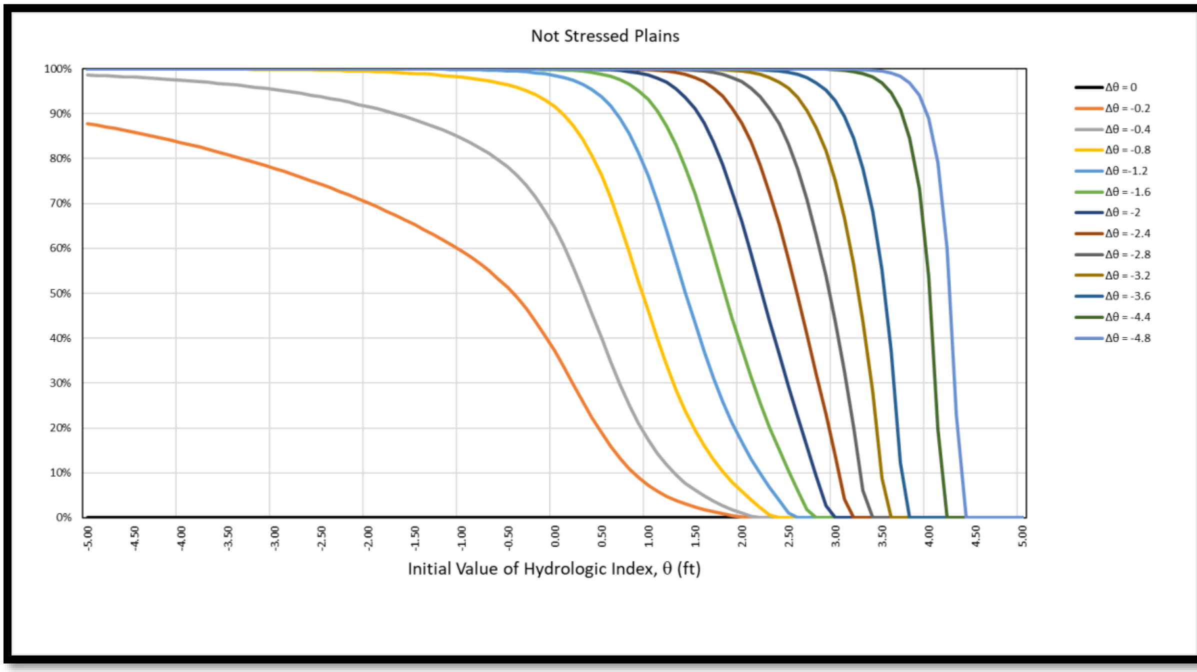

Figure D-5. Not Stressed Plains wetlands probability of becoming Stressed for multiple negative values of $\Delta\theta$.

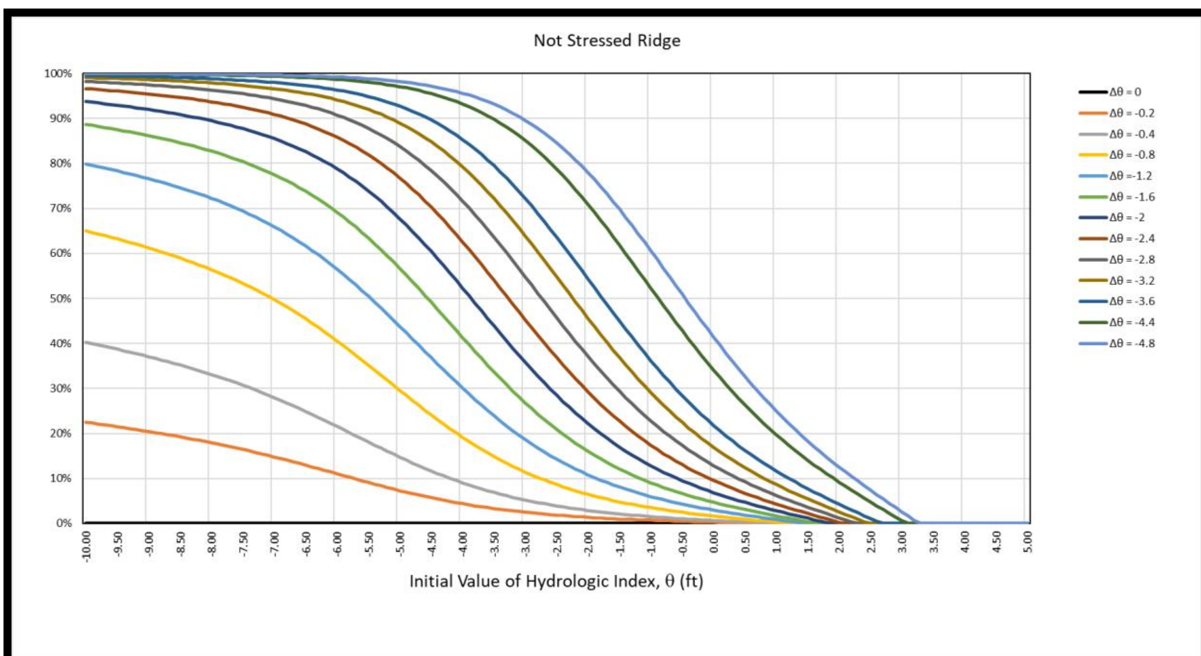

Figure D-6. Not Stressed Ridge wetlands probability of becoming Stressed for multiple negative values of $\Delta\theta$.

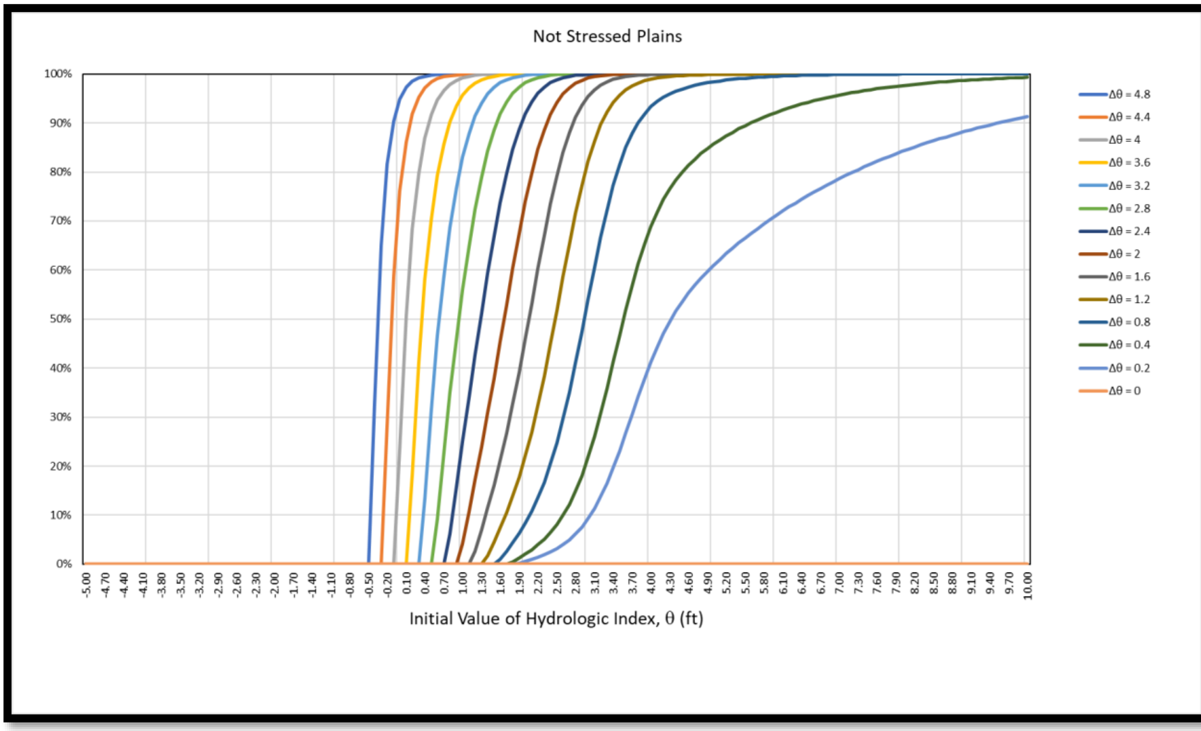

Figure D-7. Not Stressed Plains wetlands probability of becoming Stressed for multiple positive values of $\Delta\theta$.

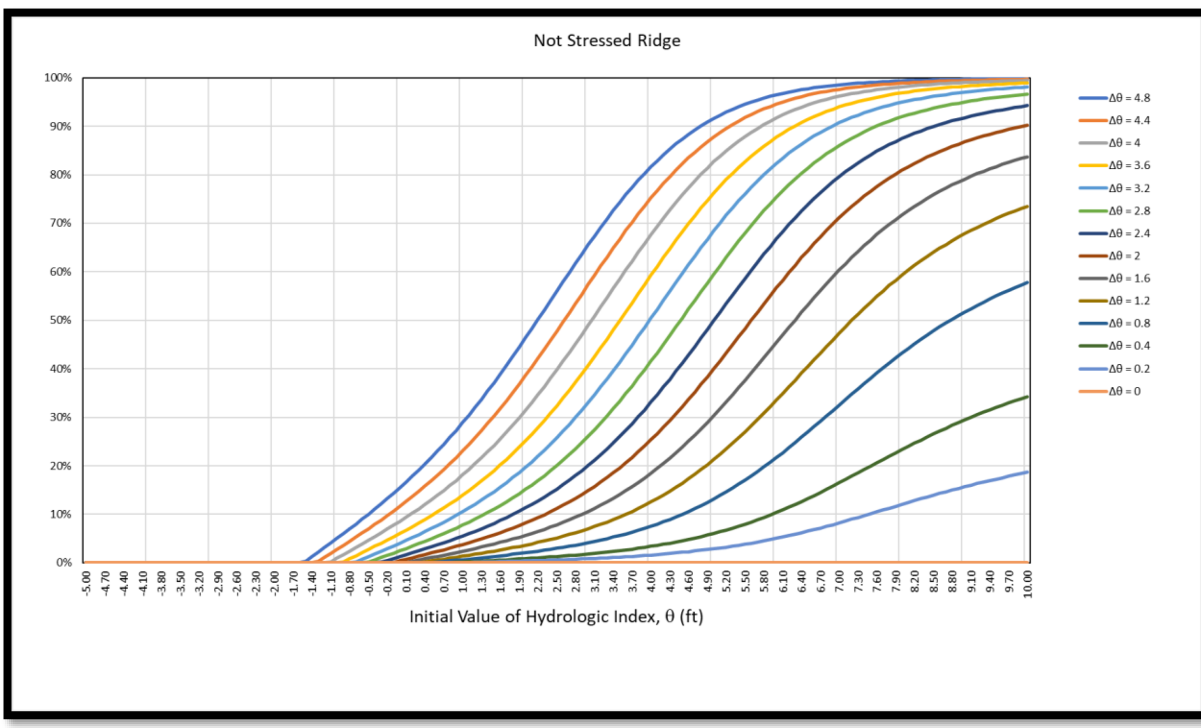

Figure D-8. Not Stressed Ridge wetlands probability of becoming Stressed for multiple positive values of $\Delta\theta$.

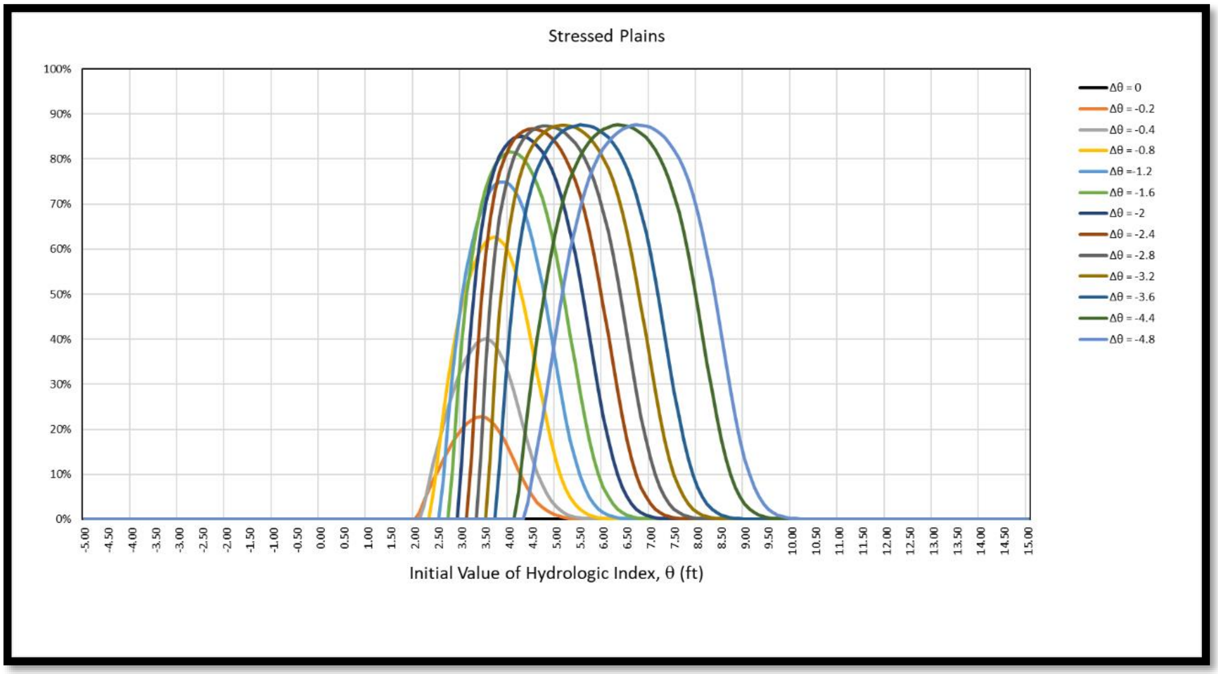

Figure D-9. Stressed Plains wetlands probability of becoming Not Stressed for multiple negative values of $\Delta\theta$.

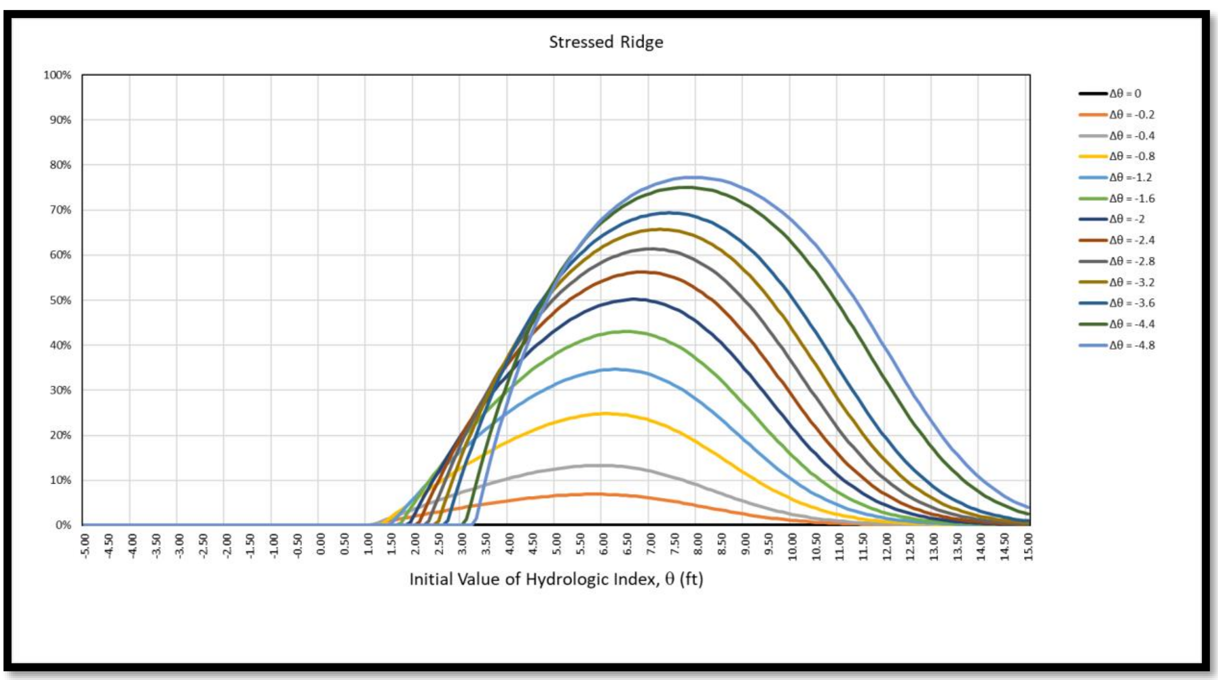

Figure D-10. Stressed Ridge wetlands probability of becoming Not Stressed for multiple negative values of $\Delta\theta$.

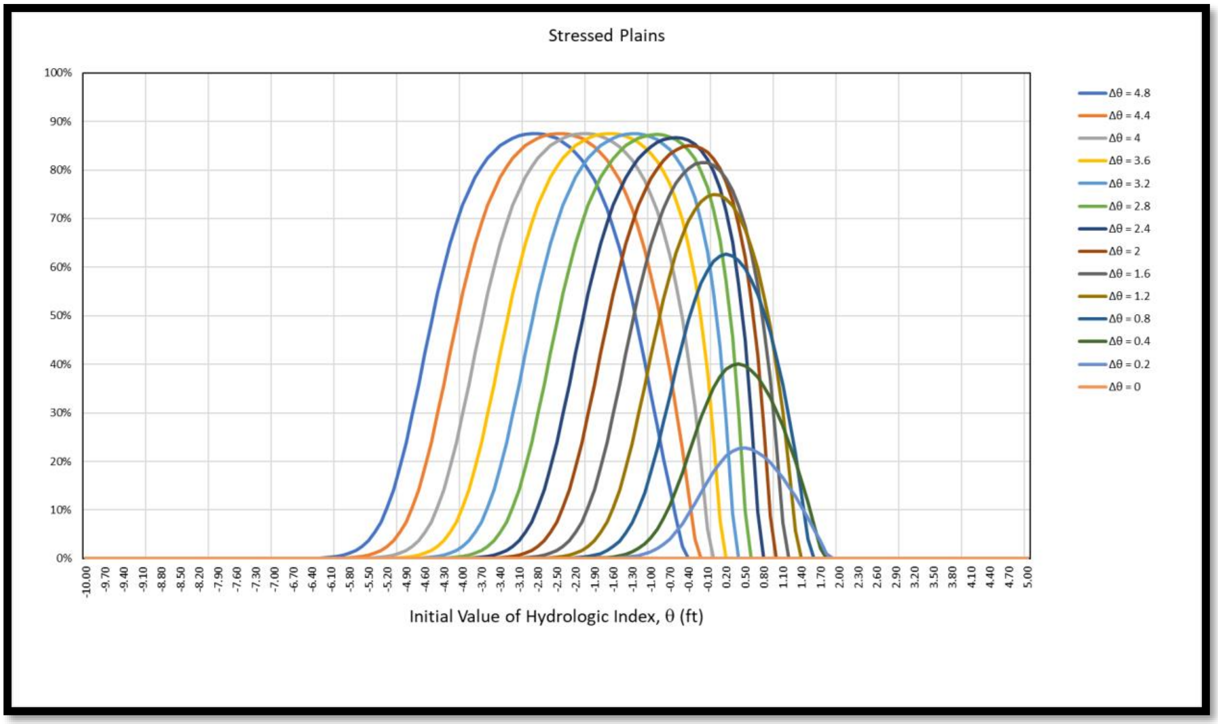

Figure D-11. Stressed Plains wetlands probability of becoming Not Stressed for multiple positive values of $\Delta\theta$.

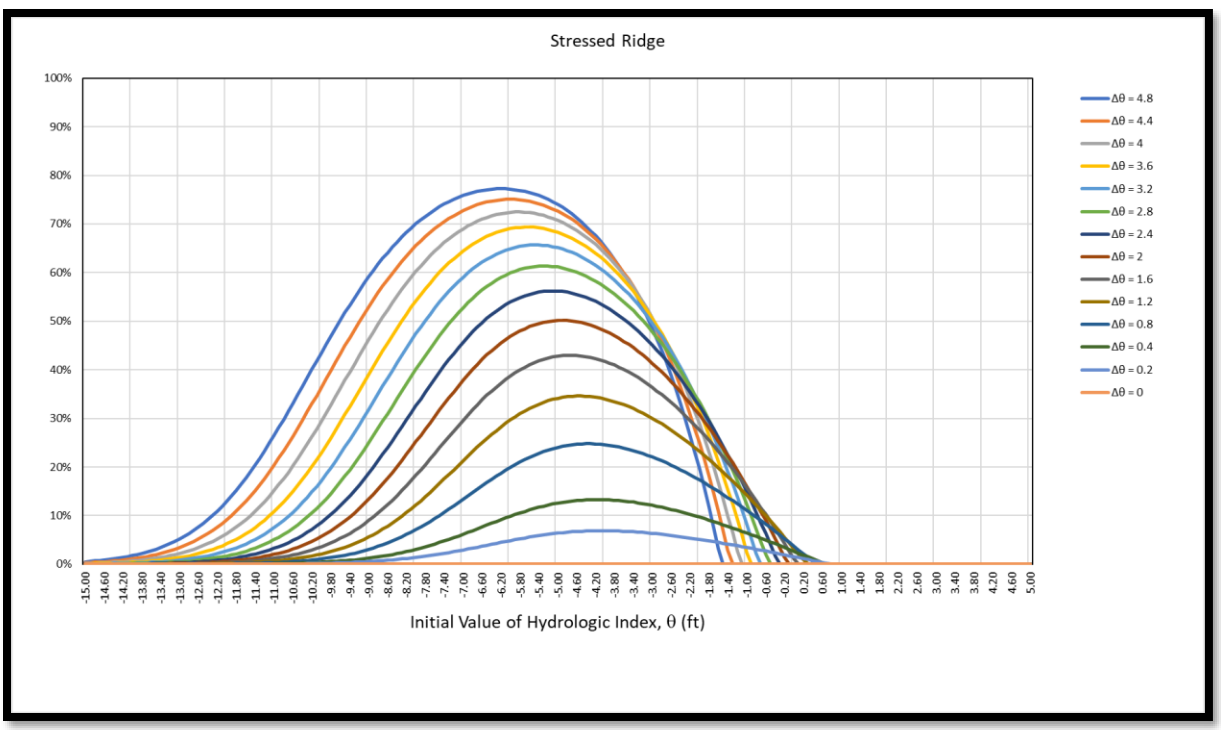

Figure D-12. Stressed Ridge wetlands probability of becoming Not Stressed for multiple positive values of $\Delta\theta$.

Note that significant probabilities of inducing a beneficial change are obtained by changing an initial θ value in a Stressed wetland from a relatively extreme high or low value towards the mean θ value that is characteristic of Not Stressed wetlands. Therefore, these benefit functions have their highest values within the range of θ values that are observed in our data set and become numerically insignificant as we extrapolate to final condition θ values ($\theta_2 = \theta_1 + \Delta\theta$) that lie outside the observed dataset.

5.0 DEVELOPMENT OF STRESS PROBABILITY FUNCTIONS FOR WETLANDS WITH UNKNOWN INITIAL CONDITIONS

As shown in the Figures D-5 through D-12, the probability of inducing a stress change is strongly dependent on the initial stress status and the initial hydrologic condition (i.e., the initial θ value) of the wetland; this applies to both Plains and Ridge wetlands, and the creation of both stress and beneficial change. This dependency is problematic because we don't know these two initial condition values for most of the wetlands.

This problem can be treated statistically by calculating the population-weighted average values of $\zeta_{u\to s}$ and $\zeta_{s\to u}$, and we can estimate the density of initially Stressed and Not Stressed wetlands from our survey sample of wetlands (the Class 2 wetlands). The population-weighted average values of $\zeta_{u\to s}$ and $\zeta_{s\to u}$ are denoted as $\bar{Z}_{u\to s}$ and $\bar{Z}_{s\to u}$, respectively, and are calculated as:

$$\bar{Z}_{u\to s}(\Delta\theta) = \int_{-\infty}^{\infty} p_{u\theta}(\theta)\zeta_{u\to s}(\theta, \theta + \Delta\theta)d\theta \quad \text{........................} \quad (22)$$

$$\bar{Z}_{s\to u}(\Delta\theta) = \int_{-\infty}^{\infty} p_{s\theta}(\theta)\zeta_{s\to u}(\theta, \theta + \Delta\theta)d\theta \quad \text{........................} \quad (23)$$

These two functions allow us to calculate the average probability of inducing a stress change (creating stress or benefit) for any given value of $\Delta\theta$. The resulting values of $\bar{Z}_{u\to s}$ and $\bar{Z}_{s\to u}$ for Plains and Ridge wetlands are shown as functions of $\Delta\theta$ in **Figure D-13**. The following two figures were created by using ZetaCalcIntegrals to produce 4 series of Zetas in file called polynomData.csv and importing this data into Excel to create "xy" charts.

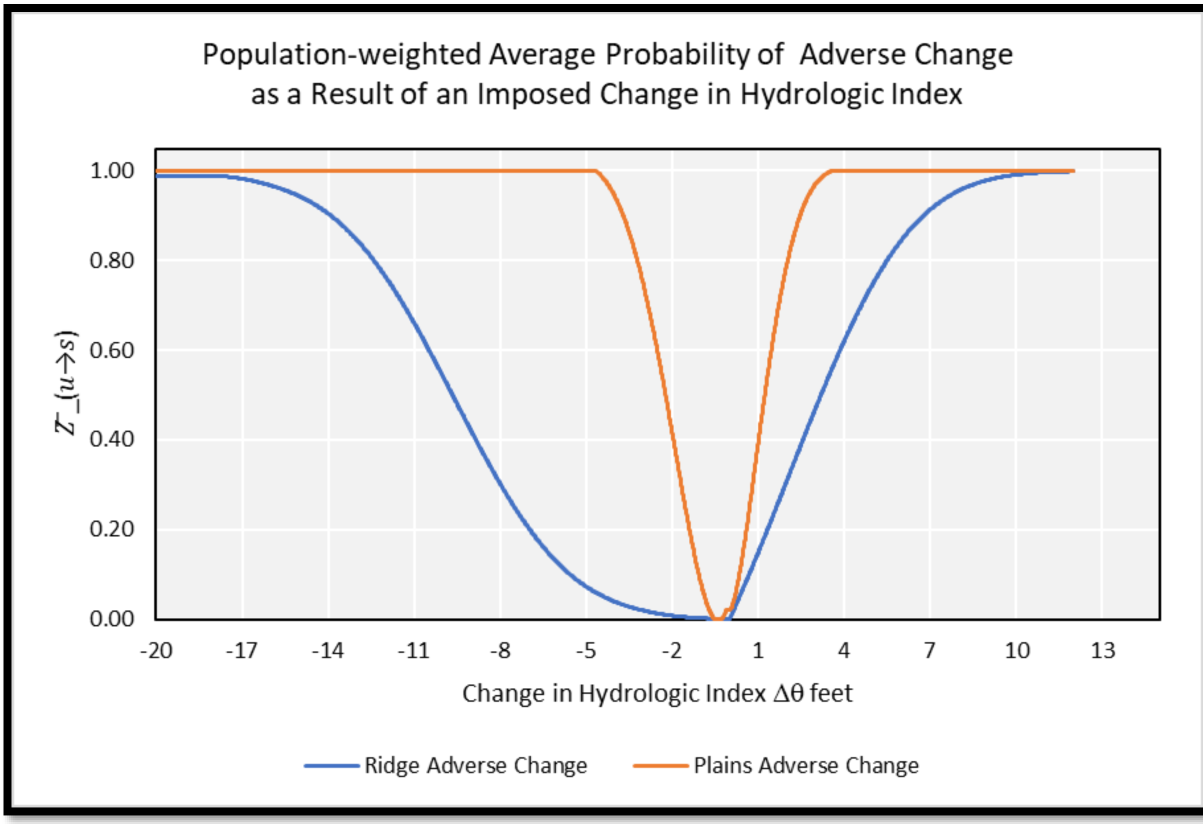

Figure D-13. Population-averaged probabilities of Not Stressed Plains and Ridge wetlands becoming Stressed, for use with wetlands where the initial condition is unknown.

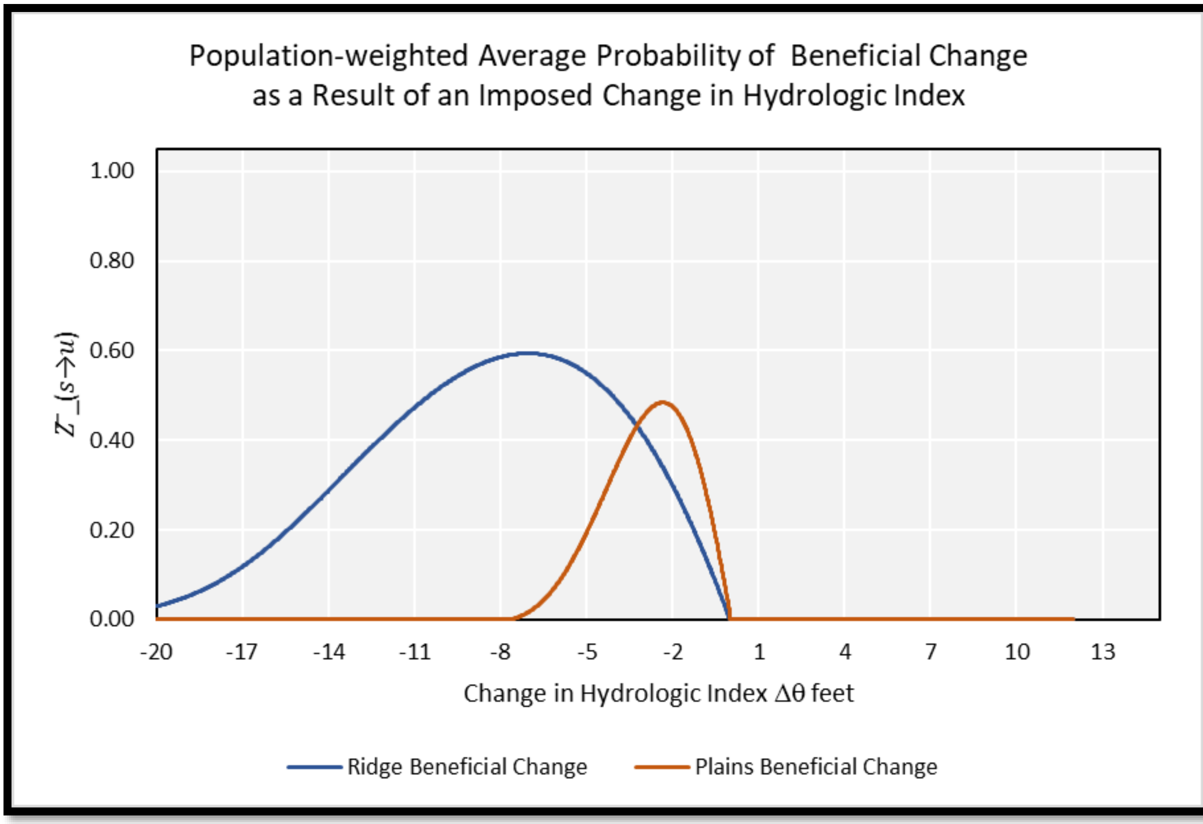

Figure D-14. Population-averaged probabilities of Stressed Plains and Ridge wetlands becoming Not Stressed, for use with wetlands where the initial condition is unknown.

6.0 PREDICTED AREAS OF WETLANDS SUBJECT TO CHANGE IN STRESS STATUS

From the of $\bar{Z}_{u\rightarrow s}$ and $\bar{Z}_{s\rightarrow u}$ functions, we can calculate a population-weighted average probability of stress change at each wetland location in each cell of the ECFTX model, based on the value of $\Delta\theta$ for that cell. The resulting predicted probability of stress status change is extremely unreliable at any individual wetland location or group of wetland locations because the actual local probabilities of stress status change are strongly dependent on the unknown initial conditions of the wetland or group of wetlands. The usefulness of this calculation is that the estimated **total** areas of wetlands that will undergo a stress status change can be calculated as:

$$A_{u\rightarrow s} = \sum_{i=1}^{n}[(\bar{Z}_{u\rightarrow s})_i \cdot (a_i)] \qquad \text{........................ (24)}$$

$$A_{s\rightarrow u} = \sum_{i=1}^{n}[(\bar{Z}_{s\rightarrow u})_i \cdot (a_i)] \qquad \text{........................ (25)}$$

Where:

$A_{u\rightarrow s}$ The total area of wetlands predicted to change status from Not Stressed to Stressed;

$A_{s\rightarrow u}$ The total area of wetlands predicted to change status from Stressed to Not Stressed

i Index value for wetland segments in individual ECFTX model cells.

n Total number if wetland segments in all ECFTX model cells.

$(\bar{Z}_{u\rightarrow s})_i$ The population-weighted value of the probability of inducing stress, calculated for wetland segment number "i" based on the predicted value of $\Delta\theta$ for that type of wetland (Plains/Ridge) in that ECFTX model cell.

$(\bar{Z}_{s\rightarrow u})_i$ The population-weighted value of the probability of inducing recovery from stress, calculated for wetland segment "i" based on the predicted value of $\Delta\theta$ for that type of wetland (Plains/Ridge) in that ECFTX model cell.

a_i The area of wetland of specified type (Plains/Ridge) for wetland segment number "i"

Area calculations can be performed by post-processing MODFLOW model results using P80headDiffProbabilites.R to estimate total area of groundwater-dominated wetlands that will undergo a change in stress, as well as provide some mapping products presenting areas of change in stress. Also, note that the value of each increment of wetland area subject to a predicted change in stress will likely bear only a weak statistical correlation to the actual area of wetland in that location for which stress will occur. However, so long as the errors in the incremental values of wetland area subjected to a predicted change in stress are randomly and independently distributed with a mean value of zero, the cumulative total area subject to a predicted change in stress, ($A_{u\rightarrow s}$ or $A_{s\rightarrow u}$) should have relatively small cumulative total error because all the random local increments of error will tend to cancel each other out when summed for large values of "n". This was tested using a synthetic wetland data set which matched the theoretical hydrologic index distributions, in which all the initial and final wetland hydrologic index values and stress conditions were known. The wetlands were then treated as Class 3 wetlands (i.e., as if the initial wetland hydrologic index values and stress conditions were not known). The results for the Class 3 wetlands cumulative area calculation were compared to calculation of the true cumulative area of changed wetland stress in the synthetic data set. It was found that error in the cumulative area of changed stress became small (typically less than 2 percent) once the number of model cells containing wetlands that were included in the summation exceeded 500. The ability of the method to estimate the total acreage of changed stress conditions in groundwater-dominated wetlands with reasonable accuracy depends on including a relatively large number of model cells containing wetlands in the summation. Therefore, it is not appropriate to apply the method to predict the amount of change that will occur across relatively localized areas containing Class 3 wetlands.

7.0 ECFTX MODEL WATER LEVEL PREDICTOR VARIABLES FOR ΔΘ IN WETLANDS

The value of $\Delta\theta$ for a wetland is the change of θ from some initial condition 1 to some other future condition 2. Since θ = ERE – P80, and ERE is a constant value that remains the same for any given wetland, it follows that $\Delta\theta$ = ΔP80. In order to predict a $\Delta\theta$ value, we need to be able to predict a ΔP80 water level value for the specified wetland.

7.1 Plains Wetlands

We have previously discussed that for primarily groundwater-dominated Plains wetlands, independent review of hydrologic conditions and review of the ECFTX model results both lead us to a conclusion that water levels in the SAS are generally dominated more by local surface hydrology than by the influence of changes in the underlying UFA potentiometric elevation. The best predictor of long-term, groundwater-induced changes in Plains wetland water levels is the predicted change in SAS water tables at the location of the wetland. Consequently, our best current predictor for $\Delta\theta$ in wetlands resulting from groundwater alterations is the ΔP80 water level from reference condition to future condition calculated for the SAS water table in ECFTX model cells that contain Plains wetland segments.

7.2 Ridge Wetlands

It has been previously described that for primarily groundwater-dominated Ridge wetland systems, the localized leakance heterogeneity in the ridge areas might make the potentiometric surface of the UFA a better predictor of long-term changes in Ridge wetland water levels than the SAS water table. However, not all Ridge wetland systems can be characterized this way as there exists a SAS layer in the physiographic region. For that reason, results for Ridge wetlands are best represented in the form of two alternative assessments of the future predicted areas of Stressed Ridge wetlands:

- An extreme worst case based on the assumption that all Ridge wetlands are so leaky that their P80 water levels will move on a 1:1 basis with P80 potentiometric levels in the underlying UFA; and
- A possibly under-conservative case based on the assumption that all Ridge wetland P80 water levels will move on a 1:1 basis with P80 water table levels in the underlying SAS.

Initially, it was anticipated that the first option listed above, incorporating some average scaling factor, C, would be the best option: where: $\Delta\theta = \Delta P80_{[\text{Ridge wetland}]} = C \bullet \Delta P80_{[\text{UFA}]}$ and $C < 1$.

On further consideration, it was noted that the SAS water levels used for calibration of the ECFTX model in Ridge areas tend to be dominated by known lake levels and observations from wells and piezometers that tend to be close to wetlands or water bodies (i.e., in locations where data is most available) (CFWI HAT 2020). Because of this distribution of calibration targets, the likely calibrated leakance values in the Ridge may be dominated by water levels that are more characteristic of the areas close to lakes and wetlands, and less characteristic of the zones furthest from these features. If so, response of the SAS water levels in the ridge areas of the ECFTX model may be a better fit to the leakier depressional areas than was originally anticipated. On this basis, we suspect that overall, the predicted future areas of Stressed wetlands in the Ridge areas, based on changes in the SAS water levels, are probably closer to reality than those based on UFA potentiometric elevations. The assumption of a universal 1:1 correspondence between wetland Δθ values and ΔP80 potentiometric elevations in the UFA (no scaling factor) seems likely to yield overly conservative estimates.

R CODE FOR WETLANDS RISK ASSESSMENT

WetlandStressSFWMDsYr.R

```
#-------------------------------------------------------------------------------
# Developed by: Kevin A. Rodberg, Science Supervisor
# Resource Evaluation Section, Water Supply Bureau, SFWMD
# (561) 682-6702
#
# January 2019
#
# Script is provided to import spreadsheet data and calculate percentile rankings and
plot figures
##------------------------------------------------------------------------------
# package management: provide automated means for first time use of script to
automatically install any new packages required for this code, with library calls
wrapped in a for loop.
#--
list.of.pkgs <- c("readr","dplyr","zoo","ggplot2", "reshape2", "data.table",
 "future","listenv","readxl","purrr")

new.pkgs <- list.of.pkgs[!(list.of.pkgs %in% installed.packages()[, "Package"])]

if (length(new.pkgs)){ install.packages(new.pkgs) }
for (pkg in list.of.pkgs){ library(pkg,character.only = TRUE) }

workdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SFWMD/"
workOutdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SFWMD/StartYr
/"

Station.Coordinates <- utils::read.csv(paste0(workdir,"StationCoordinates.csv"))
Station.DatumAdj <- readr::read_csv(paste0(workdir,"StationDatumAdj.csv"), skip = 6)
Station.DatumAdj <- as.data.frame(Station.DatumAdj[,names(Station.DatumAdj)[c(1,4)]])
stations.SFWMD <- base::merge(Station.Coordinates,Station.DatumAdj, by.x="DBKEY",
by.y="Point" )
stations.SFWMD$Point <- NULL
#---
# Read and merge 3 csv files for wetland waterlevels
#---
TibetButler <- read_csv(paste0(workdir,"TibetButler.csv"),
 col_types = cols(`Daily Date` = col_date(format = "%d-%b-%y"),
 `Revision Date` = col_skip()))
Wetlands.SFWMD <-
as.data.frame(TibetButler[!is.na(TibetButler[,"DBKEY"]),c(1,2,3,4,5)])

WalkerRanch <- readr::read_csv(paste0(workdir,"WalkerRanch.csv"),
 col_types = cols(`Daily Date` = col_date(format = "%d-%b-%y"),
 `Revision Date` = col_skip()))
Wetlands.SFWMD <- base::rbind(Wetlands.SFWMD,
 as.data.frame(WalkerRanch[!is.na(WalkerRanch[,"DBKEY"]),
 c(1,2,3,4,5)]))

SplitOak <- readr::read_csv(paste0(workdir,"SplitOak.csv"),
```

```
 col_types = cols(`Daily Date` = col_date(format = "%d-%b-%Y"),
 `Revision Date` = col_skip()))
Wetlands.SFWMD <- base::rbind(Wetlands.SFWMD,
 as.data.frame(SplitOak[!is.na(SplitOak[,"DBKEY"]),c(1,2,3,4,5)]))

names(Wetlands.SFWMD) <- c("Station","DBKEY","DATE","Value","Qualifer" )

# Assign NA to records with certain qualifiers
skipQualifiers = c('M', 'N', 'PT', '?', 'U')
Wetlands.SFWMD[Wetlands.SFWMD$Qualifer %in% skipQualifiers, ]$`Data Value` = NA
unique.dbkeys <- unique(Wetlands.SFWMD$DBKEY)
AllStations_SF <- data.frame()

cat (paste0('Interpolating and imputing missing data','\n'))

drange = as.data.frame(seq.Date(as.Date('2006/1/1'),as.Date('2017/12/31'),by=1))
names(drange)= 'DATE'

for (dbk in unique.dbkeys){
 cat(paste(dbk,'\n'))
 OneStation <- Wetlands.SFWMD[Wetlands.SFWMD$DBKEY ==dbk,c(3,4)]
 OneStation.Alldates<-merge(drange,OneStation, all.x=TRUE) %>%
 mutate(approx = na.approx(Value,rule=1,na.rm=FALSE))
 OneStation.Alldates <- cbind(dbk,OneStation.Alldates)
 AllStations_SF <- rbind(AllStations_SF,OneStation.Alldates)
}

# -- Next 2 assignments statements for NGVD to NAVD adjustment specific to SFWMD

AllStations_SF <- merge(stations.SFWMD[,c("STATION","DBKEY","Height")],
 AllStations_SF[AllStations_SF$DATE >= '2006-01-01'
 & AllStations_SF$DATE < '2018-01-01', ],
 by ="DBKEY",by.y="dbk")
AllStations_SF$approx <- AllStations_SF$approx + AllStations_SF$Height
AllStations_SF$Height <- NULL

# Full Date range handled in previous steps
# start = 2006
# end = 2017

# for (drange in seq(start,end)){
# ich = paste0('2006-',drange)
# AllStations_SF[format.Date(AllStations_SF$DATE, "%Y") <= as.character(drange),ich]
<-as.double(drange)
# }

cat (paste0('Calculating Percentile Ranks','\n'))
start = 2006
end = 2011

PivotPranks <- NULL
for (yr in seq(start,end)){
 ich = paste0(yr,'-2017')
 qStations <- AllStations_SF[!is.na(AllStations_SF$approx) &
 AllStations_SF$DATE >= as.Date(paste0(yr,'-01-01')),]
```

```
 # Default R formulation of plotting position
 # QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5))),
by=STATION]

 # weibull formulation of plotting position
 QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5),type=6)),
by=STATION]

 names(QByYr)= c("STATION","P80","P50")
 QByYr$drange <- ich
 PivotPranks<-rbind(PivotPranks,QByYr)
}

cat (paste0('Exporting data from calculations','\n'))

Pranks <- melt(as.data.frame(PivotPranks))
names(Pranks)=c("STATION","DateRange","prank","value")
PrankFile = paste0(workOutdir,'../SFWMD_Pranks.csv')
csvStatus %<-% write.csv(Pranks,PrankFile, row.names=FALSE)

DataTable = paste0(workOutdir,'../SFWMD_DataTable.csv')
AllStations_SF <- AllStations_SF[order(AllStations_SF$STATION,AllStations_SF$DATE),]
csvStatus %<-% write.csv(AllStations_SF[,-c(1)],DataTable, row.names=FALSE)

p80<-dcast(Pranks[Pranks$prank=='P80',],STATION~DateRange+prank,mean )
PrankFile = paste0(workOutdir,'../SFWMD_P80.csv')
csvStatus %<-% write.csv(p80,PrankFile, row.names=FALSE)

cat (paste0('Exporting charts','\n'))
#---
# Define plotting functions
#---
plotLines <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DateRange,value,group=prank),label=value) +
 geom_line(aes(color=prank),size=1) +
 geom_point(aes(color=prank),size=2) +
 geom_text(aes(label=value), hjust=-.2, vjust=0) +
 theme(legend.position="bottom") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHisto <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(bins=20,color="black", fill="lightblue") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHistoDens <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(aes(y=..density..),bins=30,color="black", fill="white") +
```

```
 geom_density(alpha=.2,fill="#FF6666") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotTS <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DATE,approx)) +
 geom_line( ) +
 stat_smooth(aes(x = DATE),
 se = F, method = "lm", formula = y ~ poly(x, 10)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)") +
 scale_x_date(date_breaks = "12 month", date_labels = "%m-%d-%Y") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1))
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
#--
# Set environment for mutliprocessing
#--
plan(multisession, gc = TRUE)
results <- listenv()

unique.stations <- unique(Pranks$STATION)
Pranks$value <- round(Pranks$value,2)

#---
# Create plots for each station using multiprocessing "future" function
#---
x = 0
for (stn in unique.stations){
 x= x + 1
 cat(paste0(stn,'\n'))
 filename =paste0(workOutdir,'figures/',stn,'_ranks.png')
 OneStation <- Pranks[Pranks$STATION ==stn,]
 results[[x]] <- future({plotLines(filename,OneStation)})

 filename =paste0(workOutdir,'figures/',stn,'_histo.png')
 OneStation <- AllStations_SF[AllStations_SF$STATION ==stn,]
 results[[x]] <- future({plotHisto(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_histoDensity.png')
 results[[x]] <- future({plotHistoDens(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_hydrog.png')
 results[[x]] <- future({plotTS(filename,OneStation)})
}
plan(sequential)
```

WetlandStressSJRWMDsYr.R

```
#------------------------------------------------------------------------------
# Developed by: Kevin A. Rodberg, Science Supervisor
# Resource Evaluation Section, Water Supply Bureau, SFWMD
# (561) 682-6702
#
# January 2019
#
# Script is provided to import spreadsheet data and calculate percentile rankings and
plot figures
#------------------------------------------------------------------------------
#--
# package management: provide automated means for first time use of script to
automatically install any new packages required for this code, with library calls
wrapped in a for loop.
#--
list.of.pkgs <- c("readr","dplyr","zoo","ggplot2", "reshape2", "data.table",
 "future","listenv","readxl","purrr")

new.pkgs <- list.of.pkgs[!(list.of.pkgs %in% installed.packages()[, "Package"])]

if (length(new.pkgs)){ install.pkgs(new.pkgs) }
for (pkg in list.of.pkgs){ library(pkg,character.only = TRUE) }

workdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SJRWMD/"
workOutdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SJRWMD/StartY
r/"

#Station.Coordinates <- utils::read.csv(paste0(workdir,"StationCoordinates.csv"))
#Station.DatumAdj <- readr::read_csv(paste0(workdir,"StationDatumAdj.csv"), skip = 6)
#Station.DatumAdj <-
as.data.frame(Station.DatumAdj[,names(Station.DatumAdj)[c(1,4)]])
#stations.SFWMD <- base::merge(Station.Coordinates,Station.DatumAdj, by.x="DBKEY",
by.y="Point" )
#stations.SFWMD$Point <- NULL

df <-NULL
file <- paste0(workdir ,'Class 1 Wetlands NAVD 88.xlsx')
sheets <- excel_sheets(file)
df <- map_df(sheets, ~ read_excel(file, sheet = .x, skip = 0))
names (df)
df$DATE <- as.Date(df$DATE)
drange = as.data.frame(seq.Date(as.Date('2006/1/1'),as.Date('2017/12/31'),by=1))
names(drange)= 'DATE'
dfPOR<-merge(drange,df[df$DATE>= as.Date('2006/01/01'),], by='DATE')
SJR_unpivot <- melt(dfPOR,id='DATE')
names(SJR_unpivot)<-c('DATE','STATION','value')
Wetlands.SJR<- SJR_unpivot[order(SJR_unpivot$STATION,SJR_unpivot$DATE),]
Wetlands.SJR<- Wetlands.SJR[,c('STATION','DATE','value')]

# SJR_Pivot = dcast(Wetlands.SJR,DATE ~ STATION,mean)

names(Wetlands.SJR) <- c("STATION","DATE","Value")
```

```
unique.stations <- unique(Wetlands.SJR$STATION)
AllStations_SJ <- data.frame()

cat (paste0('Interpolating and imputing missing data','\n'))

for (dbk in unique.stations[unique.stations != 'Date']){
 cat(paste(dbk,'\n'))
 OneStation <- Wetlands.SJR[Wetlands.SJR$STATION ==dbk,c(2,3)] %>%
 mutate(approx = na.approx(Value,rule=2))
 OneStation <- cbind(dbk,OneStation)
 AllStations_SJ <- rbind(AllStations_SJ,OneStation)
}
names(AllStations_SJ)[names(AllStations_SJ) == 'dbk'] <- 'STATION'

# Full Date range handled in previous steps
# start = 2006
# end = 2017

# for (drange in seq(start,end)){
# ich = paste0('2006-',drange)
# AllStations_SF[format.Date(AllStations_SF$DATE, "%Y") <= as.character(drange),ich]
<-as.double(drange)
# }

cat (paste0('Calculating Percentile Ranks','\n'))
start = 2006
end = 2011

PivotPranks <- NULL
for (yr in seq(start,end)){
 ich = paste0(yr,'-2017')
 qStations <- AllStations_SJ[!is.na(AllStations_SJ$approx) &
 AllStations_SJ$DATE >= as.Date(paste0(yr,'-01-01')),]

 # Default R formulation of plotting position
 # QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5))),
by=STATION]

 # weibull formulation of plotting position
 QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5),type=6)),
by=STATION]

 names(QByYr)= c("STATION","P80","P50")
 QByYr$drange <- ich
 PivotPranks<-rbind(PivotPranks,QByYr)
}
cat (paste0('Exporting data from calculations','\n'))

unique.stations <-unique(PivotPranks$STATION)
Pranks <- melt(PivotPranks)
names(Pranks)=c("STATION","DateRange","prank","value")

PrankFile = paste0(workOutdir,'../SJRWMD_Pranks.csv')
csvStatus %<-% write.csv(Pranks,PrankFile, row.names=FALSE)
```

```
DataTable = paste0(workOutdir,'../SJRWMD_DataTable.csv')
csvStatus %<-% write.csv(AllStations_SJ[,1:4],DataTable, row.names=FALSE)

p80<-dcast(Pranks[Pranks$prank=='P80',],STATION~DateRange+prank,mean )
PrankFile = paste0(workOutdir,'../SJRWMD_P80.csv')
csvStatus %<-% write.csv(p80,PrankFile, row.names=FALSE)

cat (paste0('Exporting charts','\n'))
#---
# Define plotting functions
#---
plotLines <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DateRange,value,group=prank),label=value) +
 geom_line(aes(color=prank),size=1) +
 geom_point(aes(color=prank),size=2) +
 geom_text(aes(label=value), hjust=-.2, vjust=0) +
 theme(legend.position="bottom") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHisto <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(bins=20,color="black", fill="lightblue") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHistoDens <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(aes(y=..density..),bins=30,color="black", fill="white") +
 geom_density(alpha=.2,fill="#FF6666") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotTS <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DATE,approx)) +
 geom_line( ) +
 stat_smooth(aes(x = DATE),
 se = F, method = "lm", formula = y ~ poly(x, 10)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)") +
 scale_x_date(date_breaks = "12 month", date_labels = "%m-%d-%Y") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1))
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
#--
# Set environment for mutliprocessing
#--
plan(multisession, gc = TRUE)
results <- listenv()

unique.stations <- unique(Pranks$STATION)
```

```
Pranks$value <- round(Pranks$value,2)
#---
# Create plots for each station using multiprocessing "future" function
#---
x = 0
for (stn in unique.stations){
 x= x + 1
 cat(paste0(stn,'\n'))
 filename =paste0(workOutdir,'figures/',stn,'_ranks.png')
 OneStation <- Pranks[Pranks$STATION ==stn,]
 results[[x]] <- future({plotLines(filename,OneStation)})

 filename =paste0(workOutdir,'figures/',stn,'_histo.png')
 OneStation <- AllStations_SJ[AllStations_SJ$STATION ==stn,]
 results[[x]] <- future({plotHisto(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_histoDensity.png')
 results[[x]] <- future({plotHistoDens(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_hydrog.png')
 results[[x]] <- future({plotTS(filename,OneStation)})
}
plan(sequential)
```

WetlandStressSWFWMDsYr.R

```
#--------------------------------------------------------------------------------
# Developed by: Kevin A. Rodberg, Science Supervisor
# Resource Evaluation Section, Water Supply Bureau, SFWMD
# (561) 682-6702
#
# January 2019
#
# Script is provided to import spreadsheet data and calculate percentile rankings and
plot figures
#--------------------------------------------------------------------------------
#--
# package management: provide automated means for first time use of script to
automatically install any new packages required for this code, with library calls
wrapped in a for loop.
#--
list.of.pkgs <- c("readr","dplyr","zoo","ggplot2", "reshape2", "data.table",
 "future","listenv","readxl","purrr")

new.pkgs <- list.of.pkgs[!(list.of.pkgs %in% installed.packages()[, "Package"])]

if (length(new.pkgs)){ install.packages(new.pkgs) }
for (pkg in list.of.pkgs){ library(pkg,character.only = TRUE) }

workdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SWFWMD/"
workOutdir =
"//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018/SWFWMD/StartY
r/"

drange = as.data.frame(seq.Date(as.Date('2006/1/1'),as.Date('2017/12/31'),by=1))
names(drange)= 'DATE'
dfPOR <- drange
setwd(workdir)
xlFiles <-list.files(pattern = "*.xlsx")
SWF_unpivot<- NULL
file = xlFiles[34]
#for (file in xlFiles[30:35]){
for (file in xlFiles){

 sheets <- excel_sheets(file)
 for (sht in sheets) {
 cat(paste0(file,'::',sht,'\n'))
 }

 df <- map_df(sheets, ~ read_excel(file, sheet = .x, skip = 0))
 names(df) <- c("Site ID","STATION","Parameter","DATE","value",
 "Units","No of Records","Data Source","Status","Quality Description")
 df$DATE <- as.Date(df$DATE)
 if (nrow(df[is.na(df$STATION),])) {cat(paste0(file,':[',sheets,']'))}
 df.Wide <- dcast(df,DATE~STATION,mean)
# df.Wide <- dcast(df,DATE~STATION+`Site ID`,mean)
 df.AllDates<-merge(drange,df.Wide[df.Wide$DATE>= as.Date('2006/01/01'),],
all.x=TRUE)
 df.unpivot <- melt(df.AllDates,id='DATE')
```

```
 SWF_unpivot <-rbind(SWF_unpivot,df.unpivot)
}
# quickList<- as.data.frame(unique(SWF_unpivot$variable))
# write.csv(quickList,'h:/quiclist.csv')
names(SWF_unpivot)<-c('DATE','STATION','value')
result <- tryCatch({SWF_unpivot[is.nan(SWF_unpivot$value),]$value=NA},
 warning = function(war) { print(paste("MY_WARNING: ",war))},
 error = function(err) {print("No NA's found") })
Wetlands.SWF<- SWF_unpivot[order(SWF_unpivot$STATION,SWF_unpivot$DATE),]
Wetlands.SWF<- Wetlands.SWF[,c('STATION','DATE','value')]

# SWF_Pivot = dcast(Wetlands.SWF,DATE ~ STATION,mean)
names(Wetlands.SWF) <- c("STATION","DATE","Value")

unique.stations <- unique(Wetlands.SWF$STATION)
AllStations_SW <- data.frame()

cat (paste0('Interpolating and imputing missing data','\n'))

drange = as.data.frame(seq.Date(as.Date('2006/1/1'),as.Date('2017/12/31'),by=1))
names(drange)= 'DATE'

for (dbk in unique.stations){
 cat(paste(dbk,'\n'))
 OneStation <- Wetlands.SWF[Wetlands.SWF$STATION ==dbk,c(2,3)]
 OneStation.Alldates<-merge(drange,OneStation, all.x=TRUE) %>%
 mutate(approx = na.approx(Value,rule=1,na.rm=FALSE))
 OneStation.Alldates <- cbind(dbk,OneStation.Alldates)
 AllStations_SW <- rbind(AllStations_SW,OneStation.Alldates)
}
AllStations_SW <-AllStations_SW[AllStations_SW$DATE >= '2006-01-01'
 & AllStations_SW$DATE < '2018-01-01', ]

names(AllStations_SW)[names(AllStations_SW) == 'dbk'] <- 'STATION'

# Full Date range handled in previous steps
# start = 2006
# end = 2017

# for (drange in seq(start,end)){
# ich = paste0('2006-',drange)
# AllStations_SF[format.Date(AllStations_SF$DATE, "%Y") <= as.character(drange),ich]
<-as.double(drange)
# }

cat (paste0('Calculating Percentile Ranks','\n'))
start = 2006
end = 2011

PivotPranks <- NULL
for (yr in seq(start,end)){
 ich = paste0(yr,'-2017')
 qStations <- AllStations_SW[!is.na(AllStations_SW$approx) &
 AllStations_SW$DATE >= as.Date(paste0(yr,'-01-01')),]
```

```
 # Default R formulation of plotting position
 # QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5))),
by=STATION]

 # weibull formulation of plotting position
 QByYr<-as.data.table(qStations)[,as.list(quantile(approx,probs=c(.2, .5),type=6)),
by=STATION]
 names(QByYr)= c("STATION","P80","P50")
 QByYr$drange <- ich
 PivotPranks<-rbind(PivotPranks,QByYr)
}
cat (paste0('Exporting data from calculations','\n'))

unique.stations <-unique(PivotPranks$STATION)
Pranks <- melt(PivotPranks)
names(Pranks)=c("STATION","DateRange","prank","value")

PrankFile = paste0(workOutdir,'../SWFWMD_Pranks.csv')
csvStatus %<-% write.csv(Pranks,PrankFile, row.names=FALSE)
DataTable = paste0(workOutdir,'../SWFWMD_DataTable.csv')
csvStatus %<-% write.csv(AllStations_SW[,1:4],DataTable, row.names=FALSE)

p80<-dcast(Pranks[Pranks$prank=='P80',],STATION~DateRange+prank,mean )
PrankFile = paste0(workOutdir,'../SWFWMD_P80.csv')
csvStatus %<-% write.csv(p80,PrankFile, row.names=FALSE)

cat (paste0('Exporting charts','\n'))
#---
# Define plotting functions
#---
plotLines <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DateRange,value,group=prank),label=value) +
 geom_line(aes(color=prank),size=1) +
 geom_point(aes(color=prank),size=2) +
 geom_text(aes(label=value), hjust=-.2, vjust=0) +
 theme(legend.position="bottom") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHisto <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(bins=20,color="black", fill="lightblue") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
plotHistoDens <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation[!is.na(OneStation$approx),], aes(approx)) +
 geom_histogram(aes(y=..density..),bins=30,color="black", fill="white") +
 geom_density(alpha=.2,fill="#FF6666") +
 labs(title=stn,x = "Water Level (Feet NAVD88)")
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
```

```
}
plotTS <- function(fileName,OneStation){
 graphics.off()
 p <- ggplot(OneStation, aes(DATE,approx)) +
 geom_line( ) +
 stat_smooth(aes(x = DATE),
 se = F, method = "lm", formula = y ~ poly(x, 10)) +
 labs(title=stn,y = "Water Level (Feet NAVD88)") +
 scale_x_date(date_breaks = "12 month", date_labels = "%m-%d-%Y") +
 theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1))
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)
}
#--
# Set environment for mutliprocessing
#--
plan(multisession, gc = TRUE)
results <- listenv()

unique.stations <- unique(Pranks$STATION)
Pranks$value <- round(Pranks$value,2)
#---
# Create plots for each station using multiprocessing "future" function
#---
x = 0
for (stn in unique.stations){
 x= x + 1
 cat(paste0(stn,'\n'))
 filename =paste0(workOutdir,'figures/',stn,'_ranks.png')
 OneStation <- Pranks[Pranks$STATION ==stn,]
 results[[x]] <- future({plotLines(filename,OneStation)})

 filename =paste0(workOutdir,'figures/',stn,'_histo.png')
 OneStation <- AllStations_SW[AllStations_SW$STATION ==stn,]
 results[[x]] <- future({plotHisto(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_histoDensity.png')
 results[[x]] <- future({plotHistoDens(filename,OneStation)})

 x= x + 1
 filename =paste0(workOutdir,'figures/',stn,'_hydrog.png')
 results[[x]] <- future({plotTS(filename,OneStation)})
}
plan(sequential)
```

ZetaCalcIntegrals.R

```
#===============================================================================
==============
# ZetaCalcIntegrals.R
#
# Y:\proj\CFWI_WetlandStress\Update2018\ZetaCalcIntegrals.R
#
or\\ad.sfwmd.gov\dfsroot\data\wsd\SUP\proj\CFWI_WetlandStress\Update2018\ZetaCalcInte
grals.R
#===============================================================================
==============
# Evaluate Wetland Stress criteria to compute Zetas
#using Integral functions for Probable Change in Stressed Acres
#
# Created by Kevin A. Rodberg - February 2019
#
#zetaModels generated by ZetaCalcIntegrals.R (this script) are used by
P80headDiffProbabilities.R to create cell by cell probability matrix of change in
wetland stress and calculates the probable change in acres by wetland type (Ridge or
Plains) from stressed to unstressed and from unstressed to stressed.
#===============================================================================
==============
#--
# package management: provide automated means for first time use of script to
automatically install any new packages required for this code, with library calls
wrapped in a for loop.
#--
pkgChecker <- function(x){
 for( i in x ){
 if( ! require( i , character.only = TRUE ) ){
 install.packages( i , dependencies = TRUE )
 require( i , character.only = TRUE )
 }
 }
}
list.of.pkgs <- c("readr","dplyr","zoo","ggplot2", "reshape2", "data.table",
 "future","listenv","readxl","purrr","e1071" ,"rcompanion","tictoc")

suppressMessages(pkgChecker(list.of.pkgs))
#===============================================================================
==============
# Read preprocessed P80 data sets
#===============================================================================
==============
workdir= "Y:/proj/CFWI_WetlandStress/Update2018"
setwd(workdir)

SFWMD_P80b <- read_csv("./SFWMD/SFWMD_P80.csv")
SWFWMD_P80b <- read_csv("./SWFWMD/SWFWMD_P80.csv")
SJRWMD_P80b <- read_csv("./SJRWMD/SJRWMD_P80.csv")
AllP80 <-bind_rows(SFWMD_P80b,SWFWMD_P80b,SJRWMD_P80b)

EMT_ID <- read_csv("EMT_ID.csv")
AllP80 <-merge(EMT_ID,AllP80)
write.csv(AllP80,file='AllP80.csv',row.names=FALSE)
```

```
Class1Wetlands <- read_excel("Class 1 Wetland Info for Analysis ALLv1.xlsx", na =
"NA")
Class1P80 <-merge(Class1Wetlands,AllP80, by.x='CFCA/EMT ID', by.y='EMT_ID')
# Remove redundant 2006-2017_P80
Class1P80$`2006-2017_P80.y`<-NULL
names(Class1P80)[names(Class1P80)=='2006-2017_P80.x']<-"2006-2017_P80"
names(Class1P80)

makeQQplots <- function(oneTest, ranks, stress, phys) {
 filename = paste0('./QQplots/QQplot',stress,phys,ranks, '.png')
 png(filename)
 qqnorm(oneTest[,2],
 main= paste("Class 1 ",phys, " Wetlands",stress,'\n', ranks, '\n',
 format(Sys.time(), "%a %b %d %X %Y")))
 qqline(oneTest[,2],col=2,qtype=2)
 dev.off()
}
#=====================================================================================
==============
# Calculate Shapiro Wilkes
#=====================================================================================
==============
thetas = data.frame()
strStr <- "Stress Status in 2018"
physStr <- "Physiographic Region"

physVec <-c("Plain","Ridge")
stressVec <- c("Stressed","Not Stressed")
#ranks = "2007-2017_P80"
# ranks = "2008-2017_P80"
ranks = "2009-2017_P80"
# ranks = "2010-2017_P80"
rankVec <- c( "2006-2017_P80","2007-2017_P80","2008-2017_P80","2009-2017_P80","2010-
2017_P80" )
for (ranks in rankVec) {
 theta = Class1P80$"Edge Reference Elevation (ft NAVD 88)" - Class1P80[,ranks]
 thetas = rbind(thetas,cbind.data.frame(EMT_ID=Class1P80$`CFCA/EMT ID`,
 rank=ranks,theta=as.numeric(theta)))
}
thetas <- merge(thetas,Class1P80[,c(1,3,6,7)], by.x='EMT_ID', by.y = "CFCA/EMT ID")

names(thetas)[names(thetas) == "Stress Status in 2018"] <-"Stress"
names(thetas)[names(thetas) == "Physiographic Region"] <-"phys"
wideTheta <- dcast(thetas,EMT_ID~rank,value.var='theta',mean)
thetaEval <- merge(wideTheta,Class1P80[,c(1,3,6,7,12)], by.x='EMT_ID', by.y =
"CFCA/EMT ID")

for (ranks in rankVec) {
 for (phys in physVec) {
 for (stress in stressVec) {
 oneTest <- thetaEval[thetaEval$'Stress Status in 2018' == stress &
 thetaEval$'Physiographic Region' == phys ,
 c('EMT_ID',ranks,'Stress Status in 2018','Physiographic Region')]
 names(oneTest)[names(oneTest) == ranks] <- "theta"
```

```
 names(oneTest)[names(oneTest) == 'Stress Status in 2018'] <-"stress"
 names(oneTest)[names(oneTest) == "Physiographic Region"] <-"phys"
 makeQQplots(oneTest, ranks, stress, phys)
 swTest <- shapiro.test(oneTest$theta)
 cat (paste0('"shapiro.test for ","',stress,'","',phys,'", "',ranks,'",'))
 cat(paste0(swTest$statistic, ' ', swTest$p.value, '\n'))
 }
 }
}
#=====================================================================================
==============
# Calculate thetas
#=====================================================================================
==============
#rankVec <- c( "2007-2017_P80" )
# rankVec <- c( "2008-2017_P80" )
rankVec <- c( "2009-2017_P80" )
# rankVec <- c( "2010-2017_P80" )
thetas = data.frame()

for (ranks in rankVec) {
 theta = Class1P80$"Edge Reference Elevation (ft NAVD 88)" - Class1P80[,ranks]
 thetas = rbind(thetas,cbind.data.frame(EMT_ID=Class1P80$'CFCA/EMT ID',
rank=ranks,theta=as.numeric(theta)))
}
thetas <- merge(thetas,Class1P80[,c(1,3,6,7)], by.x='EMT_ID', by.y = "CFCA/EMT ID")

names(thetas)[names(thetas) == strStr] <-"Stress"
names(thetas)[names(thetas) == physStr] <-"phys"
#=====================================================================================
==============
# Fs and Fu are fraction of stressed wetlands and unstressed wetlands
      Equations: 10 & 11
#=====================================================================================
==============
thetas$Fu = NA
thetas$Fs = NA
thetas$mean = NA
thetas$sd = NA

for (phys in physVec) {

#=====================================================================================
==============
 # identify number of stressed vs unstressed and total for each physiographic type

#=====================================================================================
==============
 stressKnt <- nrow(thetas[thetas$phys== phys
 & thetas$Stress == "Stressed",])
 UstressKnt <- nrow(thetas[thetas$phys== phys
 & thetas$Stress == "Not Stressed",])
 allKnt <- nrow(thetas[thetas$phys== phys ,])
```

```
#================================================================================
==============
 # Fs and Fu are fraction of stressed wetlands and unstressed wetlands
      Equations: 2 & 3

#================================================================================
==============
 thetas[thetas$phys==phys,]$Fs <- stressKnt/allKnt
 thetas[thetas$phys==phys,]$Fu <- UstressKnt/allKnt
}
# Fractions (Fu and Fs) from Class 2 are used as documented
thetas[thetas$phys=='Plain',]$Fs <- 39/101
thetas[thetas$phys=='Plain',]$Fu <- 62/101
thetas[thetas$phys=='Ridge',]$Fs <- 54/121
thetas[thetas$phys=='Ridge',]$Fu <- 67/121
#================================================================================
==============
# phys Urban DisSim SHA sf_us sf_su SFus SFsu
# ------ ---------- ------ ----- ----- ----- ----- -----
# class 1 1.000 1.000
# class 2 1.000 1.000
# Class 3 Plain low 0.694 0.82 0.824 0.176 0.469 0.100
# Class 3 Plain Mod & High 0.616 0.581 0.824 0.176 0.295 0.063
# Class 3 Ridge All 0.671 1 0.581 0.419 0.390 0.281
#================================================================================
==============
# transform data by subsets using: phys- Physiographic Region (Ridge or Plain)
stress- Wetland Stress Status in 2018,
#================================================================================
==============
rankVec <- c( "2006-2017_P80","2007-2017_P80","2008-2017_P80","2009-2017_P80","2010-
2017_P80" )
for (phys in physVec) {
 for (stress in stressVec) {
 #-------------------------------------------------------------------------------
-----
 # mean and sd are calculated for use with a probability density function for the
selected physiographic region type and initial Stress Status in 2018
 #-------------------------------------------------------------------------------
-----
 thetas[thetas$Stress == stress & thetas$phys == phys, ]$mean <-
 mean(thetas[thetas$Stress == stress & thetas$phys == phys, ]$theta)
 thetas[thetas$Stress == stress & thetas$phys == phys, ]$sd <-
 sd(thetas[thetas$Stress == stress & thetas$phys == phys, ]$theta)
 }
}
thetaInterval = .1
# thetaSeq<-seq(-20,25,thetaInterval)
# deltas <- seq(-15, 15,thetaInterval)
thetaSeq<-seq(-25,25,thetaInterval)
deltas <- seq(-20, 15,thetaInterval)

Plain<- as.data.frame(thetaSeq)
names(Plain) <-c('theta')
```

```
newColumns <-c('phys','Ppu','Ps','Pu','Pps','PpAll','PsiU','PsiS')
Plain[newColumns]<-0.0
Plain$phys <- "Plain"

Ridge<- as.data.frame(thetaSeq)
names(Ridge) <-c('theta')
Ridge[newColumns]<-0.0
Ridge$phys <- "Ridge"

plotPDF <- function (filename,wetLData, Mean,SD , phys, stress) {
 graphics.off()
 subtitleString <-paste0("for ",stress,' ',phys," as a function of Hydrologic Index
")
 ggplot(data=wetLData, aes(x=theta)) +
 xlab(expression(paste("Hydrologic Index ", theta, " feet"))) +
 ylab("Probability Density") +
 stat_function(fun=dnorm, args = list(mean=Mean, sd=SD))+
 theme(legend.position="bottom") +
 # xlim(-10, 20) +
 scale_x_continuous(breaks = c(seq(-10,20,2.5)), limits = c(-10,20)) +
 # labs(title =expression(atop("Fitted Normal Distribution Probability Density
Function" ,
 # bquote(.(subtitleString)~ {Delta*theta},")"))))
 labs(title ="Fitted Normal Distribution Probability Density Function",
 subtitle= bquote(~ .(subtitleString) ~ theta))
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)

}
plotComboPDF <- function (filename,wetLData, Mean,SD , Mean2, SD2 , phys) {
 graphics.off()
 subtitleString <-paste0("for ",phys," as a function of Hydrologic Index ")
 ggplot(data=wetLData, aes(x=theta,colour=stress)) +
 xlab(expression(paste("Hydrologic Index ", theta, " feet"))) +
 ylab("Probability Density") +
 stat_function(fun=dnorm, args = list(mean=Mean, sd=SD),aes(colour='red'))+
 stat_function(fun=dnorm, args = list(mean=Mean2, sd=SD2),aes(colour='green4'))+
 scale_colour_manual(values = c("red", "green4"), labels = c("Stressed", "Not
Stressed")) +
 theme(legend.position="bottom",legend.title=element_blank()) +
 # xlim(-10, 20) +
 scale_x_continuous(breaks = c(seq(-10,20,2.5)), limits = c(-10,20)) +
 # labs(title =expression(atop("Fitted Normal Distribution Probability Density
Function" ,
 # bquote(.(subtitleString)~ {Delta*theta},")"))))
 labs(title ="Fitted Normal Distribution Probability Density Function",
 subtitle= bquote(~ .(subtitleString) ~ theta))
 ggsave(filename=fileName,width=10,height=6.66,units="in",dpi=300)

}
Wetlands <-rbind(Plain,Ridge)
#=====================================================================================
==============
# dnorm function returns probability from density function at each theta value
Equations: 4 & 5
```

```
#===================================================================================
==============
for (phys in physVec) {
 if (phys == 'Plain') {
 Mean_S <- max(thetas[thetas$Stress =="Stressed" & thetas$phys==phys,]$mean)
 SD_S <- max(thetas[thetas$Stress =="Stressed" & thetas$phys==phys,]$sd)
 # 2014 values: Mean <- 5.18 SD <- 1.75 vs 2019 values:
 cat(paste("Stressed",phys,'Mean=',round(Mean_S,2),'StdDev=',round(SD_S,4)),'\n')
 Wetlands[Wetlands$phys == phys,]$Ps <- dnorm(Wetlands[Wetlands$phys == phys,]$theta,
Mean_S, SD_S)

 fileName = paste0('C:\\Users\\krodberg\\Desktop\\Stressed_',phys,'_pdf.png')
 plotPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_S, SD_S, phys, "Stressed")

 Mean_N <- max(thetas[thetas$Stress =="Not Stressed" & thetas$phys==phys,]$mean)
 SD_N <- max(thetas[thetas$Stress =="Not Stressed" & thetas$phys==phys,]$sd)
 # 2014 values: Mean <- 2.73 SD <- 0.95 vs 2019 values:
 cat(paste("Not Stressed",phys,'Mean=',round(Mean_N,2),'StdDev=',round(SD_N,4)),'\n')
 Wetlands[Wetlands$phys == phys,]$Pu <- dnorm((Wetlands[Wetlands$phys ==
phys,]$theta), Mean_N, SD_N)
 fileName = paste0('C:\\Users\\krodberg\\Desktop\\NotStressed_',phys,'_pdf.png')
 plotPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_N, SD_N, phys, "Not
Stressed")

 fileName = paste0('C:\\Users\\krodberg\\Desktop\\',phys,'_pdf.png')
 plotComboPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_S, SD_S,Mean_N, SD_N,
phys)

 }
 else if (phys == 'Ridge')
 {
 Mean_S <- max(thetas[thetas$Stress =="Stressed" & thetas$phys==phys,]$mean)
 SD_S <- max(thetas[thetas$Stress =="Stressed" & thetas$phys==phys,]$sd)
 # 2014 values: Mean <- 7.86 SD <- 2.55 vs 2019 values:
 cat(paste("Stressed",phys,'Mean=',round(Mean_S,2),'StdDev=',round(SD_S,4)),'\n')
 Wetlands[Wetlands$phys == phys,]$Ps <- dnorm(Wetlands[Wetlands$phys ==
phys,]$theta,Mean_S, SD_S)

 fileName = paste0('C:\\Users\\krodberg\\Desktop\\Stressed_',phys,'_pdf.png')
 plotPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_S, SD_S, phys, "Stressed")

 Mean_N <- max(thetas[thetas$Stress =="Not Stressed" & thetas$phys==phys,]$mean)
 SD_N <- max(thetas[thetas$Stress =="Not Stressed" & thetas$phys==phys,]$sd)
 # 2014 values: Mean <- 3.42 SD <- 1.57 vs 2019 values:
 cat(paste("Not Stressed",phys,'Mean=',round(Mean_N,2),'StdDev=',round(SD_N,4)),'\n')
 Wetlands[Wetlands$phys == phys,]$Pu <- dnorm(Wetlands[Wetlands$phys ==
phys,]$theta,Mean_N, SD_N)
 fileName = paste0('C:\\Users\\krodberg\\Desktop\\NotStressed_',phys,'_pdf.png')
 plotPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_N, SD_N, phys, "Not
Stressed")

 fileName = paste0('C:\\Users\\krodberg\\Desktop\\',phys,'_pdf.png')
 plotComboPDF(fileName,Wetlands[Wetlands$phys == phys,], Mean_S, SD_S,Mean_N, SD_N,
phys)
```

```
 }

#===================================================================================
============
 # Pps and Ppu are Population-weighted contributions of stress and unstress wetlands
to the total population probability density of all wetlands at each wetland
hydrologic index (theta) Equations: 6,7 & 8

#===================================================================================
============
 Wetlands[Wetlands$phys == phys,]$Ppu <-
 Wetlands[Wetlands$phys == phys,]$Pu*max(thetas[thetas$phys==phys,]$Fu)
 Wetlands[Wetlands$phys == phys,]$Pps <-
 Wetlands[Wetlands$phys == phys,]$Ps*max(thetas[thetas$phys==phys,]$Fs)

 Wetlands[Wetlands$phys == phys,]$PpAll <-
 Wetlands[Wetlands$phys == phys,]$Ppu + Wetlands[Wetlands$phys == phys,]$Pps

#===================================================================================
============
 # PsiU and PsiS Population-weighted Cumulative Probability Equation 9 & 10

#===================================================================================
============
 Wetlands[Wetlands$phys == phys,]$PsiU <-
 Wetlands[Wetlands$phys == phys,]$Ppu /Wetlands[Wetlands$phys == phys,]$PpAll
 Wetlands[Wetlands$phys == phys,]$PsiS <-
 Wetlands[Wetlands$phys == phys,]$Pps /Wetlands[Wetlands$phys == phys,]$PpAll

}
write.csv(file='h:/Wetlands.csv',Wetlands)
#===================================================================================
==============
# Returns stress appropriate PsiValue lookup from Wetlands Table using theta and
final theta (or theta+delta) type is not key, but used to subset data enable better
performance with multiple processors
#===================================================================================
==============
PsiVals <- function(type, status, hydIndex) {
 val <- round(hydIndex,2)
 if (status == 'Not Stressed' & !is.na(val)) {
 retVal<-(Wetlands[Wetlands$phys == type &
 val == round(Wetlands[Wetlands$phys == type,]$theta, 2), ]$PsiU)
 } else if (status == 'Stressed' & !is.na(val)) {
 retVal<-(Wetlands[Wetlands$phys == type &
 val == round(Wetlands[Wetlands$phys == type,]$theta, 2),]$PsiS)
 } else {
 retVal<-NA
 }
}
#---------------------------------------------------------------------------
# Vectorize function to work with dataframes input
#---------------------------------------------------------------------------
vPsiVals <- Vectorize(PsiVals)
#---------------------------------------------------------------------------
```

```
## Function used to calculate zetas Equation 12, 13, 14, & 15
# Function used to calculate zetas Equation 18, 19, 20, & 21
#-----------------------------------------------------------------------------
makeZetas <- function(phys,stress,deltas,thetaSeq) {
 z = matrix(NA,length(thetaSeq),1+length(deltas))
 z[,1] <- vdf[,1]
 for (i in seq(2,1+length(deltas))){
 psiTheta2 <-unname(unlist(vPsiVals(phys,stress,vdf[,i])))
 psiTheta1 <-unname(vPsiVals(phys,stress,vdf[,1]))
 z[,i] = 1 - ( psiTheta2/psiTheta1)
 z[is.nan(z[,i]) ,i] <- NA
 z[z[,i]<0,i] <- 0
 z[z[,i]>1,i] <- NA
 }
 StressZetas<- as.data.frame(cbind(phys,stress,z,
 Wetlands[Wetlands$phys==phys,]$Ps,
 Wetlands[Wetlands$phys==phys,]$Pu))
 names(StressZetas) <- c("phys","stress","theta",deltas,"Ps","Pu")
 cat(paste('Zetas Calculated for',stress, phys,'\n'))
 return(StressZetas)
}
#---
# Define matrix/dataframe for intial and possible thetas
#---
vdf = c()
for (x in thetaSeq) {
 possibleThetas<- deltas+x
 vdf<-c(vdf,possibleThetas)
}
dim(vdf)<-c(length(deltas),length(thetaSeq))
vdf <- t(vdf)
vdf[vdf< min(thetaSeq)]<-NA
vdf[vdf> max(thetaSeq)]<-NA

# Add theta column to beginning
vdf <-cbind(Wetlands[1:length(thetaSeq),]$theta,vdf)

physVec = c('Ridge','Plain')
stressVec = c('Not Stressed','Stressed')
ix = 0
#-----------------------------------------------------------------------------
# Plot stress probability curves for positive and negative theta (Psi u and Psi s)
#-----------------------------------------------------------------------------
psiStress <-unname(unlist(vPsiVals("Plain","Stressed",vdf[,1])))
psiNotStress <-1-psiStress
PsiVals4Plot<-
as.data.frame(rbind(cbind(vdf[,1],"PsiS",psiStress),cbind(vdf[,1],"PsiN",psiNotStress
)))
names(PsiVals4Plot)<- c('theta','variable','psiVal')
PsiVals4Plot$theta<- as.numeric(as.character(PsiVals4Plot$theta))
PsiVals4Plot$psiVal<- as.numeric(as.character(PsiVals4Plot$psiVal))
my.labs <- list(bquote(psi[u]),bquote(psi[s]))
ggplot(data=PsiVals4Plot[PsiVals4Plot$theta > -10 & PsiVals4Plot$theta < 10,],
 aes(x=theta, y=psiVal,color=variable)) +
 theme(plot.title = element_text(size = 20, face = "bold"),
```

```
 axis.title = element_text(size=16),
 legend.title=element_text(size=16),
 legend.text=element_text(size=16)) +
 geom_line(size=2) +
 xlab(expression(paste("Hydrologic Index, ", theta, " (feet)"))) +
 ylab(expression(paste(psi[u]," & ",psi[s], " (dimensionless)"))) +
 scale_color_manual(labels=my.labs, values = c("darkgreen", "red")) +
 theme(legend.title = element_blank()) +
 ggtitle (expression(paste("Probability of a Randomly Selected Wetland Being
Stressed, ",psi[s]," or Not Stressed, ",psi[u] )))

plan(multiprocess)
data <- listenv()
#-------------------------------------------------------------------------------
# Create zetas using multiprocessing functions
#-------------------------------------------------------------------------------
tic("Calculate Zetas")
for (phys in physVec){
 for (stress in stressVec){
 cat(paste(phys, stress, '\n'))
 ix = ix + 1
 data[[ix]] %<-% makeZetas(phys,stress,deltas,thetaSeq)
 }
}
xdata <- as.list(data)
zetas<- do.call(rbind,xdata)
zetaMelt <- melt(zetas,id=c("phys","stress","theta","Ps","Pu"),na.rm=T)
zetaMelt <-transform(zetaMelt, theta = as.numeric(as.character(theta)))
zetaMelt <-transform(zetaMelt, delta = as.numeric(as.character(variable)))
zetaMelt <-transform(zetaMelt, value = as.numeric(value))
zetaMelt <-transform(zetaMelt, Ps = as.numeric(as.character(Ps)))
zetaMelt <-transform(zetaMelt, Pu = as.numeric(as.character(Pu)))
#-------------------------------------------------------------------------------
# calculate series of ittle zetas values for Big Zetas
## for population-weighted average probability of change in stress Equation 16 & 17
# for population-weighted average probability of change in stress Equation 22 & 23
#-------------------------------------------------------------------------------
zetaMelt$ZetaSU <- NA
zetaMelt[zetaMelt$stress == 'Stressed',]$ZetaSU<- thetaInterval*
 zetaMelt[zetaMelt$stress == 'Stressed',]$value *
 zetaMelt[zetaMelt$stress == 'Stressed',]$Ps

zetaMelt$ZetaUS <- NA
zetaMelt[zetaMelt$stress == 'Not Stressed',]$ZetaUS<- thetaInterval*
 zetaMelt[zetaMelt$stress == 'Not Stressed',]$value *
 zetaMelt[zetaMelt$stress == 'Not Stressed',]$Pu
toc()
#-------------------------------------------------------------------------------
# Calculate Probability of Change as a function of delta theta
# Big Z for Not Stressed Ridge and Plain
#-------------------------------------------------------------------------------
BigZ<-aggregate(zetaMelt[zetaMelt$stress=='Not Stressed',]$ZetaUS,
 list(delta=zetaMelt[zetaMelt$stress=='Not Stressed',]$delta,
 phys = zetaMelt[zetaMelt$stress=='Not Stressed',]$phys,
 stress = zetaMelt[zetaMelt$stress=='Not Stressed',]$stress
```

```
 ),sum, na.rm=T)

ZRPu_sNeg <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Ridge' & BigZ$delta <= 0,])
ZRPu_sPos <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Ridge' & BigZ$delta >= 0,])
ZPPu_sNeg <- lm(x ~ poly(delta,10),data=BigZ[BigZ$phys=='Plain' & BigZ$delta <= 0,])
# ZPPu_sNeg <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Plain' & BigZ$delta <= 0,])
ZPPu_sPos <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Plain' & BigZ$delta >= 0,])

polynomData <-NULL
#-----------------------------------------------------------------------------
# Calculate probability change curves for positive and negative delta theta for
initially unstressed Plains wetlands
#-----------------------------------------------------------------------------
x <-data.frame(delta=(seq(min(BigZ$delta),0, .01)))
x$pred1 <- predict(ZRPu_sNeg,x)
newdata <-data.frame(delta=(seq(0,max(BigZ$delta), .01)))
newdata$pred1 <- predict(ZRPu_sPos,newdata)
newdata <-rbind(x,newdata)
polynomData <-newdata
setnames(polynomData, "pred1", "ZRPu")
#-----------------------------------------------------------------------------
# ...And for initially unstressed Ridge wetlands
#-----------------------------------------------------------------------------
x <-data.frame(delta=(seq(min(BigZ$delta),0, .01)))
x$pred1 <- predict(ZPPu_sNeg,x)
newdata <-data.frame(delta=(seq(0,max(BigZ$delta), .01)))
newdata$pred1 <- predict(ZPPu_sPos,newdata)
newdata <-rbind(x,newdata)
polynomData<- merge(polynomData,newdata)
setnames(polynomData, "pred1", "ZPPu")
#-----------------------------------------------------------------------------
# Calculate Probability of Change as a function of delta theta Big Z for Stressed
Ridge and Plain
#-----------------------------------------------------------------------------
BigZ<-aggregate(zetaMelt[zetaMelt$stress=='Stressed',]$ZetaSU,
 list(delta=zetaMelt[zetaMelt$stress=='Stressed',]$delta,
 phys = zetaMelt[zetaMelt$stress=='Stressed',]$phys,
 stress = zetaMelt[zetaMelt$stress=='Stressed',]$stress
 ),sum, na.rm=T)
ZRPs_uNeg <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Ridge' & BigZ$delta <= 0,])
ZRPs_uPos <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Ridge' & BigZ$delta >= 0,])
ZPPs_uNeg <- lm(x ~ poly(delta,10),data=BigZ[BigZ$phys=='Plain' & BigZ$delta <= 0,])
# ZPPs_uNeg <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Plain' & BigZ$delta <= 0,])
ZPPs_uPos <- lm(x ~ poly(delta,9),data=BigZ[BigZ$phys=='Plain' & BigZ$delta >= 0,])
#-----------------------------------------------------------------------------
# Calculate probability change curves for positive and negative delta theta for
initially stressed Plains wetlands
#-----------------------------------------------------------------------------
x <-data.frame(delta=(seq(min(BigZ$delta),0, .01)))
x$pred1 <- predict(ZRPs_uNeg,x)
newdata <-data.frame(delta=(seq(0,max(BigZ$delta), .01)))
newdata$pred1 <- predict(ZRPs_uPos,newdata)
newdata <-rbind(x,newdata)
polynomData<- merge(polynomData,newdata)
setnames(polynomData, "pred1", "ZRPs")
```

```
#---------------------------------------------------------------------------
# ...And for initially unstressed Ridge wetlands
#---------------------------------------------------------------------------
x <-data.frame(delta=(seq(min(BigZ$delta),0, .01)))
x$pred1 <- predict(ZPPs_uNeg,x)
newdata <-data.frame(delta=(seq(0,max(BigZ$delta), .01)))
newdata$pred1 <- predict(ZPPs_uPos,newdata)
newdata <-rbind(x,newdata)
polynomData<- merge(polynomData,newdata)
setnames(polynomData, "pred1", "ZPPs")
#---------------------------------------------------------------------------
# Plot probability change curves for positive and negative delta theta
#---------------------------------------------------------------------------
polynomData$delta = as.character(polynomData$delta)
longPolynom <- melt(polynomData)
longPolynom$delta <- as.numeric(longPolynom$delta)

names(longPolynom) <- c('delta','Category','Zeta')
levels(longPolynom$Category)[match("ZRPu",levels(longPolynom$Category))] <- "Ridge
Adverse Chg"
levels(longPolynom$Category)[match("ZRPs",levels(longPolynom$Category))] <- "Ridge
Beneficial Chg"
levels(longPolynom$Category)[match("ZPPu",levels(longPolynom$Category))] <- "Plain
Adverse Chg"
levels(longPolynom$Category)[match("ZPPs",levels(longPolynom$Category))] <- "Plain
Beneficial Chg"
theta = expression(theta)
text4Title<-paste0("Population-weighted Average Probability of Change\n",
 "as a Result of an Imposed Change in Hydrologic Index(",expression(theta),")")

for (cat in levels(longPolynom$Category)){
 if (length(which(longPolynom[longPolynom$Category == cat &
 longPolynom$delta <= 0.00 ,]$Zeta> .999))>0) {
 cat(paste(cat, 'Zeta > .9999 \n'))
 longPolynom[longPolynom$Category == cat &
 longPolynom$delta <0.0 &
 longPolynom$delta <=
 max(longPolynom[longPolynom$Category == cat &
 longPolynom$Zeta > .999 &
 longPolynom$delta <0,]$delta,na.rm = T) ,]$Zeta <- .99999999999999
 }
 if (length(which(longPolynom[longPolynom$Category == cat &
 longPolynom$delta <= 0.00 ,]$Zeta < .00000001 ))>0) {
 cat(paste(cat, 'Zeta < .00000001 \n'))
 longPolynom[longPolynom$Category == cat &
 longPolynom$Zeta < .00000001 &
 longPolynom$delta <=0.0 &
 longPolynom$delta >=
 min(longPolynom[longPolynom$Category ==
 cat & longPolynom$Zeta < .00000001 &
 longPolynom$delta <=0.0,]$delta,na.rm = T) ,]$Zeta <- .00000001
 }
 if (length(which(longPolynom[longPolynom$Category == cat &
 longPolynom$delta >= 0.00 ,]$Zeta> .999))>0) {
 cat(paste(cat, 'Zeta > .9999 \n'))
```

```
 longPolynom[longPolynom$Category == cat &
 longPolynom$Zeta > .999 &
 longPolynom$delta >= 0.0 &
 longPolynom$delta >
 min(longPolynom[longPolynom$Category ==
 cat & longPolynom$Zeta > .999 &
 longPolynom$delta >0,]$delta,na.rm = T) ,]$Zeta <- .99999999999999
 }
 if (length(which(longPolynom[longPolynom$Category == cat &
 longPolynom$delta >= 0.00 ,]$Zeta < .00000001 ))>0) {
 cat(paste(cat, 'Zeta < .00000001 \n'))
 longPolynom[longPolynom$Category == cat &
 longPolynom$Zeta < .00000001 &
 longPolynom$delta >=0.0 &
 longPolynom$delta <=
 min(longPolynom[longPolynom$Category ==
 cat & longPolynom$Zeta < .00000001 &
 longPolynom$delta >=0.0,]$delta,na.rm = T) ,]$Zeta <- .00000001
 }
}
longPolynom[longPolynom$Zeta <0,]$Zeta<- 0.000000001

ggplot(data=longPolynom, aes(x=delta, y=Zeta, color=Category)) +
 theme(plot.title = element_text(size = 14, face = "bold"),
 axis.title = element_text(size=12),
 legend.title=element_text(size=12),
 legend.text=element_text(size=12)) +
 geom_line(size=2) +
 xlab(expression(paste("Change in Hydrologic Index ", Delta, theta, " feet"))) +
 theme(legend.position="bottom") +
 scale_x_continuous(breaks = c(seq(-21,15,3))) +
 labs(title =expression(atop("Population-weighted Average Probability of Change" ,
 paste("as a Result of an Imposed Change in Hydrologic Index (",{Delta*theta},")"))))

zetaModels=list(ZRPu_sNeg=ZRPu_sNeg,ZRPu_sPos=ZRPu_sPos,
 ZPPu_sNeg=ZPPu_sNeg,ZPPu_sPos=ZPPu_sPos,
 ZRPs_uNeg=ZRPs_uNeg,ZRPs_uPos=ZRPs_uPos,
 ZPPs_uNeg=ZPPs_uNeg,ZPPs_uPos=ZPPs_uPos)

workdir= "Y:/proj/CFWI_WetlandStress/Update2018"
saveRDS(zetaModels, paste0(workdir,"/zetaModels.RDS"))

write.csv(file=paste0(workdir,'/polynomData.csv'),polynomData,row.names=FALSE)

write.csv(file=paste0(workdir,'/Zetas.csv'),zetas,row.names=FALSE)
write.csv(file=paste0(workdir,'/ZetasMelt.csv'),zetaMelt)
write.csv(file=paste0(workdir,'/Wetlands.csv'),Wetlands)

wideTheta <- dcast(thetas,EMT_ID~rank,value.var='theta',mean)
thetaEval <- merge(wideTheta,Class1P80[,c(1,3,4,5,11)], by.x='EMT_ID', by.y =
"CFCA/EMT ID")
write.csv(file=paste0(workdir,'/thetas4Eval.csv'),thetaEval)tclFuncs.R

library(tcltk2)
#================================================
```

```
# define ok and Cancel functions for tcl buttons and stadardize some tcl vars
#==============================================
done <- tclVar(0)
fnOK <- function() { tclvalue(done) <- 1}
fnCncl <- function() { tclvalue(done) <- 2}
fontHeading <- tkfont.create(family = "Arial",size = 24,weight = "bold",slant =
"italic")
#==============================================
# Function to exit a little more nicely
#==============================================
exit <- function(msg)
{
 cat(paste0("*** ERROR ***: ", msg))
 closeAllConnections()
 .Internal(.invokeRestart(list(NULL, NULL), NULL))
 options(warn=0)

}
promptUser4Text <- function(msg) {
 winc <- tktoplevel()
 lbl.msg <- tk2label(winc, text = msg, font = fontHeading)
 tkgrid(lbl.msg, padx = 30)
 tkraise(winc)
 entryInit=""
 btn.OK <- tk2button(winc,text = "OK",width = -6,command = fnOK)
 btn.Cncl <- tk2button(winc,text = "Cancel",width = -6,command = fnCncl)
 responseVarTcl <- tclVar(paste(entryInit))
 textEntryWidget <- tk2entry(winc, width = 35, textvariable = responseVarTcl)
 tkgrid(tklabel(winc, text = "Range of values",font = fontHeading),
 textEntryWidget, btn.OK,btn.Cncl,padx = 10, pady = 5)
 tkraise(winc)
 tkwait.variable(done)
 tkdestroy(winc)
 if (tclvalue(done) != 1) {
 exit("User canceled Data Entry")
 }
 promptResponse <-tclvalue(responseVarTcl)

 return(promptResponse)
}
#==============================================
# Function to Prompt for user to enter an integer
#==============================================
readinteger <- function() {
 n <- readline(prompt = "Enter an integer: ")
 return(as.integer(n))
}
#==============================================
# Function opens window to Accept a string defining range of integers vals which are
reformed as a unique sequence
#==============================================
readRange <- function() {
 winB <- tktoplevel()
 msg = paste("Total Number Stress Periods Available=", TtlStrPd,
 "\n\nChoose Range or Periods of interest \n i.e.: 1:3,5,7:100,200 \n")
```

```
 lbl.msg <- tk2label(winB, text = msg, font = fontHeading)
 tkgrid(lbl.msg, padx = 30)
 tkraise(winB)
 entryInit=""
 btn.OK <- tk2button(winB,text = "OK",width = -6,command = fnOK)
 btn.Cncl <- tk2button(winB,text = "Cancel",width = -6,command = fnCncl)
 rangeVarTcl <- tclVar(paste(entryInit))
 textEntryWidget <- tk2entry(winB, width = 35, textvariable = rangeVarTcl)
 tkgrid(tklabel(winB, text = "Range of values",font = fontHeading),
 textEntryWidget, btn.OK,btn.Cncl,padx = 10, pady = 5)
 tkbind(winB, "<Return>", fnOK)
 tkraise(winB)
 tkwait.variable(done)
 tkdestroy(winB)
 if (tclvalue(done) != 1) {
 exit("User canceled Model Selection")
 }
 # Convert string of numeric vals to a range
 rngStr <-tclvalue(rangeVarTcl)
 rngStr <- gsub(" ", ",", rngStr)
 rngStr <- gsub(",,", ",", rngStr)

 df <- as.vector(rngStr)
 rng <-
 sapply(df, function(x)
 dget(textConnection(paste('c(', x, ')'))))
 rng <- unique(sort(rng))
 return(rng)
}
```

P8Oheads.R

```
list.of.packages <-c( "data.table","tcltk2","rModflow","future.apply","tictoc")

new.packages <- list.of.packages[!(list.of.packages %in%
installed.packages()[,"Package"])]
if (!'githubinstall' %in% installed.packages()[,"Package"]){
 install.packages('githubinstall')
}
library(devtools)
if(length(new.packages)) install.packages(new.packages)
if ("rModflow" %in% new.packages) devtools::install_github("KevinRodberg/rModflow")

library (data.table)
library(tcltk2)
library(rModflow)
library(future.apply)
library(rasterVis)
library(RColorBrewer)
library(tictoc)
#=================================================================
# R:\ModflowBinary\P80heads.R
#=================================================================
# Beginning of P80 Modflow Heads
#
# Created by Kevin A. Rodberg - October 2018
#
# Purpose: Create matrix of Layer 1 heads for all simulation

# stress periods from Modflow Binary data
# and calculate P80
#=================================================================
# Choose Modflow Binary Heads file
#=================================================================
source
("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ReusableFunctions/tclFuncs.R")

readHeadsbinByLay <- function(filPtr, selectLayer,maxSP) {
 bigVector <- vector('numeric')
 HeaderRead <- readHeadsHeader(filPtr)
 kntFloats <- HeaderRead$K * HeaderRead$NR * HeaderRead$NC
 Lay1floats <- HeaderRead$NR * HeaderRead$NC
 HeadBlock <- readBin(filPtr, double(), n = Lay1floats, size = 4)
 bigVector <- c(bigVector, HeadBlock[1:Lay1floats])
 i <- 1
 cat(paste("0%.."))
 SP_rng <- maxSP-1
 repeat {
 HeaderRead <- readHeadsHeader(filPtr)
 # Don't read past EOF
 if (length(HeaderRead) > 0) {
 if (HeaderRead$K == selectLayer) {
 i <- i + 1
 HeadBlock <-
 readBin(filPtr, double(), n = Lay1floats, size = 4)
 bigVector <- c(bigVector, HeadBlock[1:Lay1floats])
```

```
 } else {
 seek(filPtr, (Lay1floats * 4), origin = 'current')
 }
 }
 # don't read everything unless necessary
 if (length(HeaderRead) == 0) {
 cat('\n')
 break
 }

 if (HeaderRead$KPER > max(SP_rng)) {
 cat('\n')
 break
 }
 # Display % complete
 cat(paste('\r',format(as.numeric(HeaderRead$KPER) / max(SP_rng) * 100,digits =
2,nsmall = 2),"%"))
 }

 return(bigVector)
}

MFmodel.Params <- defineMFmodel()
model <- chooseModel()
M <- as.data.frame(MFmodel.Params[model,])

winA <- tktoplevel()
msg = paste('Identify Binary Heads file for :', model)
lbl.message <- tk2label(winA, text = msg, font = fontHeading)
tkgrid(lbl.message, padx = 30)
tkraise(winA)

mpath <- toString(MFmodel.Params[model,]$mpath)
headsFile<-choose.files(default=mpath)

tkdestroy(winA)

if (length(headsFile) == 0) {
 exit("User cancelled HeadsFile choice")
}
to.read = file(headsFile, "rb")
#================================================
# Estimate number of stress periods in Heads file
#================================================
fileSz <- file.info(headsFile)$size
TtlStrPd = fileSz / ( M$nlays * ((M$ncols * M$nrows * 4) + 44))
#================================================
# Define range of Stress Periods to read
#================================================
SP_rng <- readRange()
if (max(SP_rng) > TtlStrPd || min(SP_rng) < 1) {
 exit('Out of Range')
}
#================================================
# Retrieve Heads by Layer
```

```
#================================================
to.read <- file(headsFile, "rb")
selectLayer = 1
maxSP <- as.integer(TtlStrPd)
Layer1 <- readHeadsbinByLay(to.read, selectLayer, maxSP)
close(to.read)

yourTheme = rasterTheme(region = brewer.pal('BrBG', n = 9))
# Reformat Layer1 as 3D array using col, row, StressPeriod dimensions
# create dataframe of Head values for this Layer (layer 1)
HeadsMatrix<- array(Layer1,c(M$ncols,M$nrows,maxSP))
plan(multiprocess)
#system.time(x<-apply(HeadsMatrix,c(1,2),quantile,probs=c(.5),na.rm=T))
tic()
xf <-future_apply
(HeadsMatrix,MARGIN=c(1,2),FUN=stats::quantile,probs=c(.2),na.rm=T,type=6)
toc()
my.at = seq(-1,150,15)
levelplot(raster(t(xf[,])),par.settings = yourTheme,at=my.at)
```

P8OheadDifference.R

```
#===============================================================================
==============
# R:\ModflowBinary\P80headDifference.R
#===============================================================================
==============
#===============================================================================
==============
# Beginning of P80 Modflow Heads
#
# Created by Kevin A. Rodberg - February 2019
#
# Purpose: Create difference matrix of p80 Reference Condition Heads minus another
P80 Simulation Heads from Layer 1 and the specified stress periods (POR) from Modflow
runs using makes use of by R tools for Modflow: rModflow::readHeadsbinByLay from
install_github("KevinRodberg/rModflow")
#===============================================================================
==============
# source:
# //ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ModflowBinary/P80heads.R
#===============================================================================
==============
#--
# package management: provide automated means for first time use of script to
automatically install any new packages required for this code, with library calls
wrapped in a for loop.
#--
pkgChecker <- function(x){
 for( i in x ){
 if( ! require( i , character.only = TRUE ) ){
 install.packages( i , dependencies = TRUE )
 require( i , character.only = TRUE )
 }
 }
}
list.of.packages <-c( "data.table","devtools","utils","githubinstall",
 "tcltk2","rModflow","future.apply","future","listenv",
 "rasterVis","sp","maptools","rgeos","raster",
 "ggplot2","RColorBrewer","tictoc","polynom")

suppressWarnings(pkgChecker(list.of.packages))
new.packages <- list.of.packages[!(list.of.packages %in%
installed.packages()[,"Package"])]

if ("rModflow" %in% new.packages) devtools::install_github("KevinRodberg/rModflow")
lapply(list.of.packages,require, character.only=TRUE)

source
("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ReusableFunctions/tclFuncs.R")
message <- "Do you want to use the same binary heads selections?\n"
skip <- FALSE
if(exists('RCheadsFile') & exists('SIMheadsFile') ){
 if(file.exists(RCheadsFile) & file.exists(SIMheadsFile) ){
 if (utils::askYesNo(paste(message,RCheadsFile,'\n',SIMheadsFile,'\n'),
 prompts = getOption("askYesNo", gettext(c("Yes", "No", "Cancel"))))){
```

```
 cat('Bypassing data selections \n')
 skip <- TRUE
 }
 }
}
if (!skip){
 #=================================================================
 # Choose Modflow Model to be processed via GUI such as ECFTX, NPALM, LWCSIM, etc
 #=================================================================
 MFmodel.Params <- defineMFmodel()
 model <- chooseModel()
 M <- as.data.frame(MFmodel.Params[model,])
 #=================================================================
 # Select first Modflow Binary Heads file to process
 #=================================================================
 winA <- tktoplevel()
 msg = paste('Identify Binary Heads file for :', model)
 lbl.message <- tk2label(winA, text = msg, font = fontHeading)
 tkgrid(lbl.message, padx = 30)
 tkraise(winA)
 MFmodel.Params[model,]$mpath <-

'\\\\ad.sfwmd.gov\\dfsroot\\data\\wsd\\SUP\\proj\\CFWI_WetlandStress\\Update2018\\Mod
elRuns\\*.*'
 mpath <- toString(MFmodel.Params[model,]$mpath)
 RCheadsFile<-choose.files(default=mpath)
 tkdestroy(winA)

 if (length(RCheadsFile) == 0) {
 exit("User cancelled HeadsFile choice")
 }
 #=================================================================
 # Select second Modflow Binary Heads file to process
 #=================================================================
 winA <- tktoplevel()
 msg = paste('Identify Binary Heads file for :', model)
 lbl.message <- tk2label(winA, text = msg, font = fontHeading)
 tkgrid(lbl.message, padx = 30)
 tkraise(winA)
 MFmodel.Params[model,]$mpath <-

'\\\\ad.sfwmd.gov\\dfsroot\\data\\wsd\\SUP\\proj\\CFWI_WetlandStress\\Update2018\\Mod
elRuns\\*.*'
 mpath <- toString(MFmodel.Params[model,]$mpath)
 SIMheadsFile<-choose.files(default=mpath)
 tkdestroy(winA)

 if (length(RCheadsFile) == 0 || length(SIMheadsFile) ==0) {
 exit("User cancelled HeadsFile choices")
 }
 #=================================================================
 # Estimate number of stress periods in Heads file
 #=================================================================
 fileSz1 <- file.info(RCheadsFile)$size
 fileSz2 <- file.info(SIMheadsFile)$size
```

```
 fileSz <- min(fileSz1,fileSz2)
 TtlStrPd = fileSz / ( M$nlays * ((M$ncols * M$nrows * 4) + 44))
 #=================================================================
 # Define range of Stress Periods to read
 #=================================================================
 SP_rng <- readRange()
 if (max(SP_rng) > TtlStrPd || min(SP_rng) < 1) {
 exit('Out of Range')
 }
}
#=================================================================
# Retrieve Heads for Layer1 from Reference Condition (RC) and Simulation (SIM) Runs 2
files are read in asyncronously using the future package
#=================================================================
if (is.null(MFLay) ){
 MFLay <-1
}
maxSP <- as.integer(TtlStrPd)
plan(multiprocess)
processed= listenv(NULL)
#====================================================================
# tic() Initiates stacked timers and and toc() echos elapsed time
#====================================================================
tic("Modflow Binary Heads Data Processing")
tic("Heads Retrieval")
cat(paste("Initiating call to readHeadsbinByLay for Layer ",
 MFLay, " as Reference ",
 "Condition [+]\nwith input from ", RCheadsFile, '\n'))
processed[[1]] <- future({readHeadsbinByLay(RCheadsFile,
 MFLay, maxSP)})

cat(paste("Initiating call to readHeadsbinByLay for Layer ",
 MFLay, " as Model Simulation ",
 "of Interest [:]\nwith input from ", SIMheadsFile, '\n'))
processed[[2]] <- future({readHeadsbinByLay(SIMheadsFile,
 MFLay, maxSP)})
#====================================================================
# Wait for values from future with progress indicators
#====================================================================
cat(paste('Waiting for background processing to complete','\n'))

while (!resolved(processed[[1]])){
 if (!resolved(processed[[2]])){
 cat("+")
 }
 cat(":")
}
cat("\n")
#====================================================================
# Reformat Layer1 as 3D array using col, row, StressPeriod dimensions
#====================================================================
Layer1RC2d <- array(future::value(processed[[1]]),c(M$ncols,M$nrows,maxSP))
Layer1SIM2d<- array(future::value(processed[[2]]),c(M$ncols,M$nrows,maxSP))
toc()
#====================================================================
```

```
# Process P80 calculations for each model cell in parallel
#====================================================================
tic("P80 Calculations")
cat(paste('Initiating Percentile rank calculations','\n'))

qRC <- future_apply (Layer1RC2d,MARGIN=c(1,2),
 FUN=stats::quantile,probs=c(.2),na.rm=T,type=6)
qSIM <- future_apply (Layer1SIM2d,MARGIN=c(1,2),
 FUN=stats::quantile,probs=c(.2),na.rm=T,type=6)
toc()
toc()
```

P80headDiffProbabilities.R

```
#===============================================================================
==============
# R:/ModflowBinary/P80headDiffProbabilities.R
#===============================================================================
==============
#===============================================================================
==============
# Beginning of P80 Head Difference evaluation for Probable Change in Stressed Acres
#
# Created by Kevin A. Rodberg - February 2019
#
# Purpose: Uses 2 matrices returned by P80headDifference.R, inports csvfiles of
wetland point locations, and probability calculation data [zetaModels generated by
ZetaCalcIntegrals.R]. Creates cell by cell probability matrix of change in wetland
stress and calculates the probable change in acres by wetland type (ridge or plain)
from stressed to unstressed and from unstressed to stressed.
#===============================================================================
==============
#--
# package management:
# provide automated means for first time use of script to automatically install any
new packages required for this code, with library calls wrapped in a for loop.
#--
pkgChecker <- function(x){
 for( i in x ){
 if( ! require( i , character.only = TRUE ) ){
 install.packages( i , dependencies = TRUE )
 require( i , character.only = TRUE )
 }
 }
}
list.of.packages <-c( "data.table","devtools","utils","githubinstall",
 "tcltk2","rModflow","future.apply","future","listenv",
 "rasterVis","sp","maptools","rgeos","raster",
 "ggplot2","RColorBrewer","tictoc","dplyr","polynom")

suppressWarnings(pkgChecker(list.of.packages))

new.packages <- list.of.packages[!(list.of.packages %in%
installed.packages()[,"Package"])]

if ("rModflow" %in% new.packages) devtools::install_github("KevinRodberg/rModflow")
lapply(list.of.packages,require, character.only=TRUE)

options(warn=-1)
#-------------------------------------------------------------------------------
--------------
# Provides GUI to choose model - may not be needed any long in this code since its
used in P80headDifference.R
#-------------------------------------------------------------------------------
--------------
source
("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ReusableFunctions/tclFuncs.R")
#source ("./ECFTX/tclFuncs.R")
```

```
plan(multiprocess)
ip=0
lowQuantile = 999
hiQuantile = -999
pltGrphs <- listenv(NULL)
probReturn <- listenv(NULL)
#=====================================================================================
==============
tic('Process one layer')
#=====================================================================================
==============
#-------------------------------------------------------------------------------------
--------------
# Code provides option to not reread very large files
# MFLay <- NULL is an easy way to force P80headDifference to start
#-------------------------------------------------------------------------------------
--------------
if (!exists('Layer1SIM2d') | !exists('MFLay')) {
 MFLay <- 1
 source
("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ModflowBinary/P80headDifference.
R")
} else {
 if(!(utils::askYesNo(paste("Do you want to use layer ",MFLay,
 " from the previous binary heads data?"),
 prompts = getOption("askYesNo",
 gettext(c("Yes", "No", "Cancel")))))){
 if (MFLay == 1){ MFLay <- 3 } else { MFLay <-1 }
 source
("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/devel/source/R/ModflowBinary/P80headDifference.
R")
}
}
#=====================================================================================
==============
tic('Create Differences from P80 Heads Layers')
#=====================================================================================
==============
dataPath <- '//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018'
DiffLay %<-% (qRC - qSIM)

#Hint: If I subtract from this diffrence I get Stressed Wetlands Recovering
#DiffLay <- (qSIM - qRC) -1.5
#-------------------------------------------------------------------------------------
--------------
# Calculate mean water level layers simultaneously
#-------------------------------------------------------------------------------------
--------------
avgRC %<-% future_apply (Layer1RC2d,MARGIN=c(1,2),FUN=mean,na.rm=T)
avgSIM %<-%future_apply (Layer1SIM2d,MARGIN=c(1,2),FUN=mean,na.rm=T)
#-------------------------------------------------------------------------------------
--------------
# Calculate a mean difference water level layer
```

```
#-------------------------------------------------------------------------------------
--------------
HdDif <- avgRC-avgSIM
#=====================================================================================
==============
# Fisnished Creating Differences from P80 Heads Layers
#=====================================================================================
==============
toc()
#=====================================================================================
==============
tic('GIS overhead')
#=====================================================================================
==============
cat('Developing GIS data sets for raster plots \n')
#-------------------------------------------------------------------------------------
--------------
# NAD83 HARN StatePlane Florida East FIPS 0901 Feet
#-------------------------------------------------------------------------------------
--------------
HARNSP17ft = CRS("+init=epsg:2881")
HARNUTM17Nm = CRS("+init=epsg:3747")
latlongs = CRS("+proj=longlat +datum=WGS84")
#-------------------------------------------------------------------------------------
--------------
# Set up county boundry shapefile for overlay on raster maps
#-------------------------------------------------------------------------------------
--------------
gClip <- function(shp, bb) {
 if (class(bb == "matrix")
 b_poly <- as(extent(as.vector(t(bb))), "SpatialPolygons")
 else
 b_poly <- as(extent(bb), "SpatialPolygons")
 rgeos::gIntersection(shp, b_poly, byid = T)
}
WMDbnd.Path <- "//whqhpc01p/hpcc_shared/krodberg/NexRadTS"
WMDbnd.Shape <- "CntyBnds"

CFWIbnd.Path <-
"//ad.sfwmd.gov/dfsroot/data/wsd/GIS/GISP_2012/DistrictAreaProj/CFWI/Data"
CFWIbnd.Shape <- "CFWI_Boundary"

physio.Path <-paste0("//ad.sfwmd.gov/dfsroot/data/wsd/GIS/GISP_2012/",
 "References/FDEP/Richardson_Sept2012/PhysiograhicProvinces")
physio.shape <- "PHYSIOGRAPHIC_PROVINCES"

SomeLakes.Path <-
paste0("//ad.sfwmd.gov/dfsroot/data/wsd/GIS/GISP_2012/DistrictAreaProj/",
 "ECFT/Data/Waterbodies")
SomeLakes.shape <- "Lakecells_Dissolve"

WMDbnd %<-% rgdal::readOGR(dsn=WMDbnd.Path,layer=WMDbnd.Shape,verbose=FALSE)
CFWIbnd %<-% rgdal::readOGR(dsn=CFWIbnd.Path,layer=CFWIbnd.Shape,verbose=FALSE)
physiobnd %<-% rgdal::readOGR(dsn=physio.Path,layer=physio.shape,verbose=FALSE)
SomeLakes %<-% rgdal::readOGR(dsn=SomeLakes.Path,layer=SomeLakes.shape,verbose=FALSE)
```

```
WMDbnd <- sp::spTransform(WMDbnd,CRS=HARNSP17ft)
CFWIbnd <- sp::spTransform(CFWIbnd,CRS=HARNSP17ft)
physiobnd <- sp::spTransform(physiobnd,CRS=HARNSP17ft)
SomeLakes <- sp::spTransform(SomeLakes,CRS=HARNSP17ft)
#====================================================================================
==============
# Finished GIS overhead
#====================================================================================
==============
toc()
#====================================================================================
==============
tic('Develop rasters')
#====================================================================================
==============
#------------------------------------------------------------------------------------
--------------
# calculate number of rows and columns
#------------------------------------------------------------------------------------
--------------
res=MFmodel.Params[model,]$res
xmin=MFmodel.Params[model,]$xmin
ymin=MFmodel.Params[model,]$ymin
rasRows=MFmodel.Params[model,]$nrows
rasCols=MFmodel.Params[model,]$ncols
xmax=xmin+(res*rasCols)
ymax=ymin+(res*rasRows)

cellsize=c(res,res)
ras <- raster::raster(res=cellsize,
xmn=xmin,xmx=xmax,ymn=ymin,ymx=ymax,crs=HARNSP17ft)
#------------------------------------------------------------------------------------
--------------
# define raster and map extents using MFmodel data extents
#------------------------------------------------------------------------------------
--------------
rasExt <- raster::extent(ras)
clpBnds2 <- gClip(WMDbnd, ras)
#------------------------------------------------------------------------------------
--------------
# Create raster plot of the DiffMatrix
# note: t() is used to transpose the array axis for plotting
#------------------------------------------------------------------------------------
--------------
diffRas<-raster::raster(t(DiffLay[,]),rasExt[1:4], crs=HARNSP17ft)

diffRas <- raster::crop(diffRas, extent(buffer(CFWIbnd,width=10000)))
diffRas %<-% raster::mask(diffRas, CFWIbnd)

title = paste("Change in Head Layer ",MFLay,": \n",
 RCheadsFile, '\nminus\n',SIMheadsFile)

basePath <- paste0("//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/",
 "CFWI_WetlandStress/Update2018/Figures4StressAcres/")
```

```
filename = paste0('p80headDiffLay',MFLay,'.tif')
ip=ip+1
pltGrphs[[ip]] <- future({
 raster::writeRaster(diffRas, filename, format="GTiff", overwrite=TRUE)
})
lowQuantile = min(lowQuantile,quantile(DiffLay,probs=c(.03),na.rm=T),na.rm=T)
hiQuantile = max(hiQuantile,quantile(DiffLay,probs=c(.97),na.rm=T),na.rm=T)
my.at = c(quantile(DiffLay,probs=c(.00001),na.rm=T),
 -2.5,-2.0,-1.5,-1.25,-1.0,-.75,-.5,-.25,-.2,-.15,-.1,-.05,0.0,
 .05,.1,.15,.2,0.25,0.50,0.75,1.0,1.25,1.5,2.0,2.5,
 quantile(DiffLay,probs=c(.99999),na.rm=T))

Class1.Wetland.Info <-
 read.csv(paste0(dataPath,"/Class 1 Wetland Info for Analysis ALLv1.csv"))
c1Wtl.pnts <-
 sp::SpatialPointsDataFrame(Class1.Wetland.Info[,11:12],Class1.Wetland.Info,
 proj4string=latlongs)
c1Wtl.pnts <- sp::spTransform(c1Wtl.pnts,HARNSP17ft)

filename=paste0(basePath,"Lay",MFLay,"_P80HeadDifference.png")
WLTheme = rasterTheme(region = brewer.pal('BrBG', n = 9))
options(scipen=7)
myplot= (levelplot(diffRas,par.settings = WLTheme,at=my.at,main=title)+
 latticeExtra::layer(sp.points(c1Wtl.pnts, pch = 20,col = "black")) +
 latticeExtra::layer(sp.text(coordinates(c1Wtl.pnts),
 txt=c1Wtl.pnts$CFCA.EMT.ID,pos=1,cex=.5 )) +
 latticeExtra::layer(sp.polygons(clpBnds2, col='darkgray'))+
 latticeExtra::layer(sp.polygons(physiobnd, col='brown'))+
 latticeExtra::layer(sp.polygons(SomeLakes, col='gray'))+
 latticeExtra::layer(sp.polygons(CFWIbnd, col='red'))
)
trellis.device(device="png", filename=filename, width=4500,height=4500,
 units="px",res=300)
print(myplot)
dev.off()
#---
# Convert array layers to rasters
#---
qRCras %<-% raster::raster(t(qRC[,]),rasExt[1:4], crs=HARNSP17ft)
qSIMras %<-% raster::raster(t(qSIM[,]),rasExt[1:4], crs=HARNSP17ft)
RCras %<-% raster::raster(t(avgRC[,]),rasExt[1:4], crs=HARNSP17ft)
SIMras %<-% raster::raster(t(avgSIM[,]),rasExt[1:4], crs=HARNSP17ft)
HdDifras %<-% raster::raster(t(HdDif[,]),rasExt[1:4], crs=HARNSP17ft)

qRCras[qRCras > 900]<-NA
RCras[RCras > 900]<-NA
qSIMras[qSIMras> 900 ]<-NA
SIMras[SIMras> 900 ]<-NA
#---
# Function to create maps as png and tif from rasters
#---
plotTiffAndPng <- function(ras2Plot,rasName){
 ras2Plot[ras2Plot > 900] <- NA
 Rng = max(abs(quantile(ras2Plot,probs=c(.00001),na.rm=T)),
```

```
 abs(quantile(ras2Plot,probs=c(.99999),na.rm=T)))
 interval = Rng/10
 my.at = c(seq(-Rng,Rng,interval))
 filename = paste0(rasName,MFLay,'.tif')
 writeRaster(ras2Plot, paste0(basePath,filename), format="GTiff", overwrite=TRUE)
 filename = paste0(basePath,rasName,MFLay,'.png')
 title =paste0(rasName,MFLay)
 myplot= (levelplot(ras2Plot,par.settings = WLTheme,at=my.at, main = title)+
 latticeExtra::layer(sp.polygons(clpBnds2, col='darkgray'))+
 latticeExtra::layer(sp.polygons(physiobnd, col='brown'))+
 latticeExtra::layer(sp.polygons(SomeLakes, col='blue'))+
 latticeExtra::layer(sp.polygons(CFWIbnd, col='red')))
 trellis.device(device="png", filename=filename,
width=3000,height=4500,units="px",res=300)
 print(myplot)
 dev.off()
}
ip=ip+1
pltGrphs[[ip]] <- future({plotTiffAndPng(HdDifras,'meanHeadDiffLay')})
ip=ip+1
pltGrphs[[ip]] <- future({plotTiffAndPng(SIMras,'meanSIMLay')})
ip=ip+1
pltGrphs[[ip]] <- future({plotTiffAndPng(RCras,'meanRCLay')})
ip=ip+1
pltGrphs[[ip]] <- future({plotTiffAndPng(qSIMras,'p80SIMLay')})
ip=ip+1
pltGrphs[[ip]] <- future({plotTiffAndPng(qRCras,'p80RCLay')})
#===============================================================================
==============
# Fisnished Developing rasters for GIS and map pngs
#===============================================================================
==============
toc()
#===============================================================================
==============
tic("Read Wetland datasets")
#===============================================================================
==============
# Read Polynomial Coefficiencts for Zeta Calculations and wetlands points by class
from GIS exports and eliminate unnecessary columns, rename fields for consistency, as
well as fix Stressed column indicator to be consistent for
# Class 1 and 2
#===============================================================
# polys<-read.csv(paste0(dataPath,"/PolyCoeff2019.csv"))
SFact<-read.csv(paste0(dataPath,"/StressFactor.csv"))

class1 %<-% read.csv(paste0(dataPath,"/WetlandsClass1_2019.csv"))
class2 %<-% read.csv(paste0(dataPath,"/WetlandsClass2_2019v2.csv"))
class3 %<-% read.csv(paste0(dataPath,"/WetlandsClass3_2019v2.csv"))

class1<- merge(x=class1,
 y=Class1.Wetland.Info[,c('CFCA.EMT.ID','Stress.Status.in.2018')],
 by.x = "CFCA_EMT_I", by.y = 'CFCA.EMT.ID')

class1Scale <- class1 %>%
```

```
 group_by(CFCA_EMT_I) %>%
 summarize(sum(ACRES_COMB))
class1Scale<-merge(class1Scale,Class1.Wetland.Info, by.x='CFCA_EMT_I'
,by.y='CFCA.EMT.ID')
write.csv(class1Scale,paste0(dataPath,'/class1FromR.csv'))

class2Scale <- class2 %>%
 group_by(CFCA_ID) %>%
 summarize(sum(ACRES_COMB))
temp <-unique(class2[,c(2,5,14,15,17,18)])
class2Scale<-merge(class2Scale,temp, by.x='CFCA_ID' ,by.y='CFCA_ID')
write.csv(class2Scale,paste0(dataPath,'/class2FromR.csv'))

#NotNeeded <- c("OBJECTID","CFCA_EMT_1","PERCENT_AC","Shape_Length","Shape_Area")
NotNeeded <- c("OBJECTID")
class1[NotNeeded]<-NULL
setnames(class1, "CFCA_EMT_I", "CFCA_EMT_ID")
setnames(class1, "Wetland_Ty", "Wetland_Type")
setnames(class1, "Physiograp", "Phys")
setnames(class1, "Stress.Status.in.2018", "Stressed")
setnames(class1, "ACRES_COMB", "Acres")

levels(class1$Stressed)[which(levels(class1$Stressed)=="Not Stressed")] <- "NO"
levels(class1$Stressed)[which(levels(class1$Stressed)=="Stressed")] <- "YES"

Needed <- c("CFCA_ID","ACRES_COMB","Ridge_or_Plains","SEQNUM","XCOORD_UTM"
,"YCOORD_UTM" ,"Stressed")

class2 <- class2[,Needed]
setnames(class2, "CFCA_ID", "CFCA_EMT_ID")
setnames(class2, "ACRES_COMB", "Acres")
setnames(class2, "Ridge_or_Plains", "Phys")

levels(class2$Phys)[which(levels(class2$Phys)=="Plains")] <- "Plain"

Needed<-c("SEQNUM","Hydroclass","EcoHydro_T","Wetland_Ty","Urban_Dens","SusceptGW",
 "Class","XCOORD_UTM","YCOORD_UTM","ACRES_COMB")

class3 <- class3[,Needed]
setnames(class3, "ACRES_COMB", "Acres")
setnames(class3, "Wetland_Ty", "Phys")
setnames(class3, "Urban_Dens", "Urban_Density")

vars4AreaZ <- c("Zus","Zsu")
class1[vars4AreaZ]<- NA
class2[vars4AreaZ]<- NA
class3[vars4AreaZ]<- NA

vars4SF <- c("SFsu","SFus")
class1[vars4SF]<-1.0
class2[vars4SF]<-1.0
class3[vars4SF]<-NA
#-------------------------------------------------------------------------------
# Wetland Weighting Factors:
```

```
# The reason for the weighting factors is that the Class 1 & Class 2 wetlands have
been physically inspected.
#
# 1. Wetlands that are of the wrong hydrobiologic type have been excluded
# 2. "Significantly Hydrologically Altered" (SHA) Wetlands have been excluded
# 3. Wetland condition is known to be either stressed or unstressed.
#
# Without physical inspections of the Class 3 wetlands to supply that information,
the total GIS wetland area is assigned a probability factor to represent the
likelihood of the wetland being one for which either the Zu->s or Zs->u equation is
appropriate.
#
# These probability factors were derived by comparing the Class 2 wetlands to the
corresponding total wetland coverages.
#
# First multiply by the Dissimilarity Factor and the SHA Factor - this reduces the
total acreage by an amount that corrects for the likelihood of GIS wetland area that
is the "wrong" type of wetland, or that is SHA.
#
# Second Multiply that product again - once by the fraction of the surviving wetlands
that are initially unstressed to produce the SFu->s total correction factor, and once
by the fraction of the surviving wetlands that are initially stressed to produce the
SFs->u total correction factor.
#
# TotCorrFact_us = DisFac*SHA_Fact*SFus
# TotCorrFact_su = DisFac*SHA_Fact*SFsu
#---------------------------------------------------------------------------------
 #---------------------------------------------------------------------------------
 #  Wetland  Urban  Dissimilar   SHA      Stress   Stress  Correction  Correction
 #  Type     Density   Factor    Factor   Factor   Factor    Factor       Factor
 #                                        (u->s)   (s->u)    (u->s)       (s->u)
 #---------------------------------------------------------------------------------
 #  Plain      low      0.694     0.820     0.824    0.176    0.469        0.100
 #  Plain  Mod & High  0.616     0.581     0.824    0.176    0.295        0.063
 #  Ridge      All      0.671     1.000     0.581    0.419    0.390        0.281
#---------------------------------------------------------------------------------
class3[class3$Phys=='Plain',]$SFus = SFact[SFact$Wetland.Type=='Plain' &
 SFact$Urban.Density == 'low',]$Sfus

class3[class3$Phys=='Plain',]$SFsu = SFact[SFact$Wetland.Type=='Plain' &
 SFact$Urban.Density == 'low',]$Sfsu

class3[class3$Phys=='Plain' & (class3$Urban_Density=='Moderate' |
 class3$Urban_Density=='High') ,]$SFus =
 SFact[SFact$Wetland.Type=='Plain' & SFact$Urban.Density == 'Mod & High',]$Sfus

class3[class3$Phys=='Plain' & (class3$Urban_Density=='Moderate' |
 class3$Urban_Density=='High') ,]$SFsu =
 SFact[SFact$Wetland.Type=='Plain' & SFact$Urban.Density == 'Mod & High',]$Sfsu

class3[class3$Phys=='Ridge',]$SFus = SFact[SFact$Wetland.Type=='Ridge',]$Sfus
class3[class3$Phys=='Ridge',]$SFsu = SFact[SFact$Wetland.Type=='Ridge',]$Sfsu
#=====================================================================================
==============
# Finished Reading Wetland datasets
```

```
#================================================================================
==============
toc()
#================================================================================
==============
tic('Calculate probable stress for wetlands')
#================================================================================
==============
#--------------------------------------------------------------------------------
--------------
# Create template dataframe for Stats
#--------------------------------------------------------------------------------
--------------
if (!exists('Stats')){
 Layer <- c(rep(1,12),rep(3,12))
 Class<- rep(c(1,1,2,2,3,3,1,1,2,2,3,3),2)
 Stress<-rep(c(rep('Stressed',6),rep('Unstressed',6)),2)
 Phys<-rep(c('Ridge','Plain'),12)
 Stats<-data.frame(Layer,Class,Stress,Phys,stringsAsFactors=FALSE)
 statColumns<-c('Total','Initial','Delta','Relative','Aquifer','exclude')
 Stats[statColumns]<-NA
}

WetType = c("Plain" ,"Ridge")

WetCond<-c('YES', 'NO')
ZetaCond<-c('Stressed', 'Unstressed')
#--------------------------------------------------------------------------------
--------------
# Read zeta Models created by ZetaCalcIntegrals.R rather than polyCoeff.csv
#--------------------------------------------------------------------------------
--------------
#workdir= "Y:/proj/CFWI_WetlandStress/Update2018"
workdir= "//ad.sfwmd.gov/dfsroot/data/wsd/SUP/proj/CFWI_WetlandStress/Update2018"
zetaModels=readRDS( paste0(workdir,"zetaModels.RDS"))
#--------------------------------------------------------------------------------
--------------
# Function to create probLay matrix of probabilities
#--------------------------------------------------------------------------------
--------------
getProbLay<- function(DiffLay,NegModel,PosModel){
 probLay<-DiffLay
 newdata <- data.frame (delta = as.vector(DiffLay[DiffLay<0]))
 probtemp<- predict(NegModel,newdata=newdata)
 probLay[DiffLay<0]<-probtemp
 newdata <- data.frame (delta = as.vector(probLay[DiffLay>=0]))
 probtemp<- predict(PosModel,newdata=newdata)
 probLay[DiffLay>=0]<-probtemp
 return(probLay)
}
ip=0
ipl=0
for (c in ZetaCond){
 p<- NULL
 probLay<- (DiffLay*0)
```

```
 for (t in WetType) {
 cc = 'NO'
 zetaName = 'us'
 probTitle <- 'Unstressed to Stressed'
 if(c == 'Stressed'){
 cc = 'YES'
 zetaName = 'su'
 probTitle <- 'Stressed to Unstressed'
 }
 ipl=ipl+1
 if (t == 'Ridge' & c == 'Unstressed'){
 probLay<-getProbLay(DiffLay,zetaModels$ZRPu_sNeg,zetaModels$ZRPu_sPos)
 } else if (t == 'Ridge' & c == 'Stressed'){
 probLay<-getProbLay(DiffLay,zetaModels$ZRPs_uNeg,zetaModels$ZRPs_uPos)
 } else if (t == 'Plain' & c == 'Unstressed'){
 probLay<-getProbLay(DiffLay,zetaModels$ZPPu_sNeg,zetaModels$ZPPu_sPos)
 }else if (t == 'Plain' & c == 'Stressed'){
 probLay<-getProbLay(DiffLay,zetaModels$ZPPs_uNeg,zetaModels$ZPPs_uPos)
 } else {
 cat('Something goofed up!\n')
 cat(paste(c, t))
 }
 probLay[probLay<0] <- 0
 probLay[probLay>1] <- 1
 #---------------------------------------------------------------------------
 # probLay matrix of probabilities is intersected w/wetlands pnts by SEQNUM
 #---------------------------------------------------------------------------
 zetaCol <-match(paste0('Z',zetaName),names(class1))
 class1[class1$Phys == t & class1$Stressed ==cc,zetaCol] <-
 round(probLay[class1[class1$Phys == t & class1$Stressed ==cc,]$SEQNUM],8)

 zetaCol <-match(paste0('Z',zetaName),names(class2))
 class2[class2$Phys == t & class2$Stressed ==cc,zetaCol] <-
 round(probLay[class2[class2$Phys == t & class2$Stressed ==cc,]$SEQNUM],8)

 # Initial stress condition is not know for class 3
 zetaCol <-match(paste0('Z',zetaName),names(class3))
 class3[class3$Phys == t,zetaCol] <-
 round(probLay[class3[class3$Phys == t,]$SEQNUM],8)
 #---------------------------------------------------------------------------
 # Crop raster data by extent of CFWI bndry
 #---------------------------------------------------------------------------
 probRas<-raster::raster(t(probLay[,]),rasExt[1:4], crs=HARNSP17ft)
 yourTheme = rasterTheme(region = brewer.pal('YlOrRd', n = 9))
 CFWIprobs <- raster::crop(probRas, extent(buffer(CFWIbnd,width=10000)))
 CFWIprobs <- raster::mask(CFWIprobs, CFWIbnd)
 ip=ip+1
 pltGrphs[[ip]] <- future({
 plotTiffAndPng(CFWIprobs,paste('CFWIprob',t,probTitle))
 })
 }
}
#---------------------------------------------------------------------------
# Class 1, 2, & 3 wetland probable change in area is calculated as Stressed becoming
unstressed: AreaXZsu = Acres * SFsu * probs
```

```
#
# Unstressed becoming stressed: AreaXZus = Acres * SFus * probs
#-----------------------------------------------------------------------
class1 <- class1 %>% mutate(AreaXZsu = Acres*SFsu*Zsu)
class1 <- class1 %>% mutate(AreaXZus = Acres*SFus*Zus)

class2 <- class2 %>% mutate(AreaXZsu = Acres*SFsu*Zsu)
class2 <- class2 %>% mutate(AreaXZus = Acres*SFus*Zus)

class3 <- class3 %>% mutate(AreaXZsu = Acres*SFsu*Zsu)
class3 <- class3 %>% mutate(AreaXZus = Acres*SFus*Zus)
#=============================================================================
==============
# Fisnised Calculating probable stress for wetlands
#=============================================================================
==============
toc()
#=============================================================================
==============
tic("Creating maps")
#=============================================================================
==============
class1.pnts <- sp::SpatialPointsDataFrame(coords = class1[, c("XCOORD_UTM",
"YCOORD_UTM")],
 data = class1,proj4string = HARNUTM17Nm)
c1.pnts<-sp::spTransform(class1.pnts,HARNSP17ft)

class2.pnts <- sp::SpatialPointsDataFrame(coords = class2[, c("XCOORD_UTM",
"YCOORD_UTM")],
 data = class2,proj4string = HARNUTM17Nm)
c2.pnts<-sp::spTransform(class2.pnts,HARNSP17ft)

class3.pnts <-sp::SpatialPointsDataFrame(coords = class3[, c("XCOORD_UTM",
"YCOORD_UTM")],
 data = class3,proj4string = HARNUTM17Nm)
c3.pnts<-sp::spTransform(class3.pnts,HARNSP17ft)

probRas<-raster::raster(t(probLay[,]),rasExt[1:4], crs=HARNSP17ft)
yourTheme = rasterTheme(region = brewer.pal('YlOrRd', n = 9))
#-----------------------------------------------------------------------
# Crop raster data by extent of CFWI bndry
#-----------------------------------------------------------------------
CFWIprobs <- raster::crop(probRas, extent(buffer(CFWIbnd,width=10000)))
CFWIprobs <- raster::mask(CFWIprobs, CFWIbnd)

updateStatsDelta<- function(Stats,MFLay,t,c,class,source) {
 # cat(paste(Stats[Stats$Layer == MFLay &
 # Stats$Phys ==t &
 # Stats$Stress ==c &
 # Stats$Class==class,]$Delta,
 # MFLay,t,c,class,sum(source,na.rm=T),'\n'))
 Stats[Stats$Layer == MFLay &
 Stats$Phys ==t &
 Stats$Stress ==c &
 Stats$Class==class,]$Delta <- round(sum(source,na.rm=T),2)
```

```
 return(Stats)
}
updateStatsInitial<- function(Stats,MFLay,t,c,class,Acres) {
 # cat(paste(Stats[Stats$Layer == MFLay &
 # Stats$Phys ==t &
 # Stats$Stress ==c &
 # Stats$Class==class,]$Initial,
 # MFLay,t,c,class,sum(Acres,na.rm=T),'\n'))
 Stats[Stats$Layer == MFLay &
 Stats$Phys ==t &
 Stats$Stress ==c &
 Stats$Class==class,]$Initial <- round(sum(Acres,na.rm=T),2)
 return(Stats)
}
ip=0
deltas = stack()
if (MFLay == 1){
 deltasByPhys = stack()
}
for (t in WetType) {
 ttlWetAcres = 0
 for (c in ZetaCond){
 if (c == 'Stressed') {
 cc <-'YES'
 c1sub <-c1.pnts[c1.pnts$Phys==t & c1.pnts$Stressed==cc,c('Phys','AreaXZsu')]
 c2sub <-c2.pnts[c2.pnts$Phys==t & c2.pnts$Stressed==cc,c('Phys','AreaXZsu')]
 c3sub <-c3.pnts[c3.pnts$Phys==t ,c('Phys','AreaXZsu')]
 c123sub<-rbind(c1sub,c2sub)
 c123sub<-rbind(c123sub,c3sub)
 Stats<-updateStatsDelta(Stats,MFLay,t,c,1,c1sub$AreaXZsu)
 Stats<-updateStatsDelta(Stats,MFLay,t,c,2,c2sub$AreaXZsu)
 Stats<-updateStatsDelta(Stats,MFLay,t,c,3,c3sub$AreaXZsu)

 Acres = c1.pnts[c1.pnts$Phys ==t & c1.pnts$Stressed ==cc ,]$Acres
 Stats<-updateStatsInitial(Stats,MFLay,t,c,1,Acres)
 Acres = c2.pnts[c2.pnts$Phys ==t & c2.pnts$Stressed ==cc ,]$Acres
 Stats<-updateStatsInitial(Stats,MFLay,t,c,2,Acres)
 Acres = c3.pnts[c3.pnts$Phys ==t,]$Acres * c3.pnts[c3.pnts$Phys ==t,]$SFsu
 Stats<-updateStatsInitial(Stats,MFLay,t,c,3,Acres)
 } else {
 cc<-'NO'
 c1sub <-c1.pnts[c1.pnts$Phys==t & c1.pnts$Stressed==cc,c('Phys','AreaXZus')]
 c2sub <-c2.pnts[c2.pnts$Phys==t & c2.pnts$Stressed==cc,c('Phys','AreaXZus')]
 c3sub <-c3.pnts[c3.pnts$Phys==t,c('Phys','AreaXZus')]

 c123sub<-rbind(c1sub,c2sub)
 c123sub<-rbind(c123sub,c3sub)

 Stats<-updateStatsDelta(Stats,MFLay,t,c,1,c1sub$AreaXZus)
 Stats<-updateStatsDelta(Stats,MFLay,t,c,2,c2sub$AreaXZus)
 Stats<-updateStatsDelta(Stats,MFLay,t,c,3,c3sub$AreaXZus)

 Acres = c1.pnts[c1.pnts$Phys ==t & c1.pnts$Stressed ==cc ,]$Acres
 Stats<-updateStatsInitial(Stats,MFLay,t,c,1,Acres)
 Acres = c2.pnts[c2.pnts$Phys ==t & c2.pnts$Stressed ==cc ,]$Acres
```

```
 Stats<-updateStatsInitial(Stats,MFLay,t,c,2,Acres)
 Acres = c3.pnts[c3.pnts$Phys ==t,]$Acres * c3.pnts[c3.pnts$Phys ==t,]$SFus
 Stats<-updateStatsInitial(Stats,MFLay,t,c,3,Acres)
 }
 if (MFLay == 3){
 Stats[Stats$Layer == 3 & Stats$Phys =='Plain' ,]$Delta<- 0
 Stats[Stats$Layer == 3 & Stats$Phys =='Plain' ,]$Initial<- 0
 }
 #
 # Calc total inital acres of each type and class
 #
 c1.delta<-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==1,]$Delta
 c2.delta<-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==2,]$Delta
 c3.delta<-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==3,]$Delta

 c1.initial <-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==1,]$Initial
 c2.initial <-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==2,]$Initial
 c3.initial <-Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Stress ==c &
Stats$Class==3,]$Initial

 tabStats =
paste('c1=',round(c1.delta,2),'c2=',round(c2.delta,2),'c3=',round(c3.delta,2),'\n',
 round(sum(c1.delta,c2.delta,c3.delta),2),'/',
 round(sum(c1.initial,c2.initial,c3.initial),2),'=',
 round(100*sum(c1.delta,c2.delta,c3.delta)/
 sum(c1.initial,c2.initial,c3.initial),2),'% of',t,'Wetlands')
 if (c == ZetaCond[2]){
 title = paste0('Layer ',MFLay,' ',c,' ',t,' to ', ZetaCond[1], '\n',tabStats)
 filename=paste(basePath,paste0('Lay',MFLay,t,'-
',c,'_to_',ZetaCond[1]),".png",sep="")
 acre.At = c(0,.5,1,2.5,5,7.5,10,max(c123sub$AreaXZus))
 deltaArea<- rasterize(c123sub,CFWIprobs,c123sub$AreaXZus)
 cat(paste("Max acres for ", c, t, max(deltaArea@data@values,na.rm=T),'\n'))
 tiffilename=paste(basePath,paste0('Lay',MFLay,t,'-
',c,'_to_',ZetaCond[1]),".tif",sep="")
 }else {
 title = paste0('Layer ',MFLay,' ',c,' ',t,' to ', ZetaCond[2], '\n',tabStats)
 filename=paste(basePath,paste0('Lay',MFLay,t,'-
',c,'_to_',ZetaCond[2]),".png",sep="")
 acre.At = c(0,.5,1,2.5,5,7.5,10,max(c123sub$AreaXZsu,na.rm=TRUE))
 deltaArea<- rasterize(c123sub,CFWIprobs,c123sub$AreaXZsu)
 cat(paste("Max acres for ", c, t, max(deltaArea@data@values,na.rm=T),'\n'))
 tiffilename=paste(basePath,paste0('Lay',MFLay,t,'-
',c,'_to_',ZetaCond[2]),".tif",sep="")
 }
 if (MFLay == 1 & t == "Plain" ){
 cat(paste('Adding Lay ',MFLay,' ',t,' to deltasByPhys stack \n'))
 deltasByPhys <- stack(deltasByPhys,deltaArea)
 cat(paste('Plains Lay1 step for deltasByPhys names After:', paste(
unlist(names(deltasByPhys)), collapse=' ') ,'\n'))
```

```
 }
 if (MFLay == 3 & t == "Ridge" ){
 cat(paste('Adding Lay ',MFLay,' ',t,' to deltasByPhys stack \n'))
 deltasByPhys <- stack(deltasByPhys,deltaArea)
 cat(paste('Ridge Lay3 step for deltasByPhys names After:', paste(
unlist(names(deltasByPhys)), collapse=' ') ,'\n'))
 }
 deltaArea[deltaArea==0]<-NA
 if(!(MFLay ==3 & t == 'Plain')){
 if (cc=='NO'){
 yourTheme = rasterTheme(region = brewer.pal('YlOrRd', n = 9))
 } else {
 yourTheme = rasterTheme(region = brewer.pal('YlGn', n = 9))

 }

 ip=ip+1
 cat(paste('Adding Lay ',MFLay,' ',t,' to deltas stack \n'))
 deltas <- stack(deltas,deltaArea)
 pltGrphs[[ip]] <- future({
 myplot= (levelplot(deltaArea,par.settings = yourTheme,at=acre.At, main = title)+
 latticeExtra::layer(sp.polygons(clpBnds2, col='darkgray'))+
 latticeExtra::layer(sp.polygons(physiobnd, col='brown'))+
 latticeExtra::layer(sp.polygons(SomeLakes, col='blue'))+
 latticeExtra::layer(sp.polygons(CFWIbnd, col='red')))
 trellis.device(device="png", filename=filename,
width=3000,height=4500,units="px",res=300)
 print(myplot)
 dev.off()
 })
 ip=ip+1
 pltGrphs[[ip]] <- future({
 raster::writeRaster(deltaArea, tiffilename, format="GTiff", overwrite=TRUE)
 })
 }
 Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==1,]$Total<-
 sum(Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==1,]$Initial,na.rm=T)
 Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==2,]$Total<-
 sum(Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==2,]$Initial,na.rm=T)
 Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==3,]$Total<-
 sum(Stats[Stats$Layer == MFLay & Stats$Phys ==t & Stats$Class==3,]$Initial,na.rm=T)
 }
}
if (MFLay == 1){
 names(deltas)<- c('Plain_StoU','Plain_UtoS','Ridge_StoU','Ridge_UtoS')
 cat(paste('Before:', paste( unlist(names(deltasByPhys)), collapse=' ') ,'\n'))
 names(deltasByPhys)<- c('Plain_StoU','Plain_UtoS')
 cat(paste('After:', paste( unlist(names(deltasByPhys)), collapse=' ') ,'\n'))
 cat(paste('Switching sign on Stressed to Unstressed Plain','\n'))
 deltas$Plain_StoU <- deltas$Plain_StoU*(-1.0)
 deltasByPhys$Plain_StoU <- deltasByPhys$Plain_StoU*(-1.0)
} else {
 names(deltas)<- c('Ridge_StoU','Ridge_UtoS')

 cat(paste(deltas@layers[[1]]@data@max, deltas@layers[[2]]@data@max,'\n'))
```

```
 cat(paste(deltasByPhys@layers[[1]]@data@max,
deltasByPhys@layers[[2]]@data@max,'\n'))
 cat(paste('Before Stack:', paste( unlist(names(deltasByPhys)), collapse=' ') ,'\n'))

 # deltasByPhys<-stack(deltasByPhys,deltas)
 cat(paste(deltasByPhys@layers[[1]]@data@max, deltasByPhys@layers[[2]]@data@max,
 deltasByPhys@layers[[3]]@data@max, deltasByPhys@layers[[4]]@data@max,'\n'))

 cat(paste('deltasByPhys names Before:', paste( unlist(names(deltasByPhys)),
collapse=' ') ,'\n'))
 names(deltasByPhys)<- c('Plain_StoU','Plain_UtoS','Ridge_StoU','Ridge_UtoS')
 cat(paste('deltasByPhys names After:', paste( unlist(names(deltasByPhys)),
collapse=' ') ,'\n'))
 }
cat(paste('Switching sign on Stressed to Unstressed Ridge','\n'))
deltas$Ridge_StoU <- deltas$Ridge_StoU*(-1.0)

# Layer 1 ridges aren't saved to this dataframe for final tiff
if (MFLay == 3){
 deltasByPhys$Ridge_StoU <- deltasByPhys$Ridge_StoU*(-1.0)
}
index<-names(deltas)
FinalNetStress <- raster::stackApply(deltas,1,fun=base::sum,na.rm=TRUE)
tiffilename=paste0(basePath,paste0('Lay',MFLay,"_NetStress.tif",sep=""))

# export tiff with Layer 1 Plain and layer 3 Ridge stress Acres
FinalNetStress2 <- raster::stackApply(deltasByPhys,1,fun=base::sum,na.rm=TRUE)
tiffilename2=paste0(basePath,paste0('Lay',MFLay,"_NetStress2.tif",sep=""))

ip=ip+1

# extreme = max(abs(maxValue(FinalNetStress)), abs(minValue(FinalNetStress)))
filename=paste0(basePath,paste0('Lay',MFLay,"_NetStress.png",sep=""))
title = paste0('Lay',MFLay,'_NetStress')
if (lowQuantile <0){
 ramp<-c(seq(lowQuantile, -.01, length=5), seq(0.01, hiQuantile, length=5))
 yourTheme = rasterTheme(region = c(colorRampPalette(c("seagreen", "white"))(5),
 colorRampPalette(c("white", "firebrick"))(5)))
}else {
 ramp<-seq(-1, hiQuantile, length=10)
 yourTheme = rasterTheme(region =colorRampPalette(c("white", "firebrick"))(11))
}
pltGrphs[[ip]] <- future({
 myplot= (levelplot(FinalNetStress,par.settings = yourTheme,at=ramp, main = title)+
 latticeExtra::layer(sp.polygons(clpBnds2, col='darkgray'))+
 latticeExtra::layer(sp.polygons(SomeLakes, col='blue'))+
 latticeExtra::layer(sp.polygons(CFWIbnd, col='red')))
 trellis.device(device="png", filename=filename,
width=3000,height=4500,units="px",res=300)
 print(myplot)
 dev.off()
})
pltGrphs[[ip]] <- future({
 raster::writeRaster(FinalNetStress, tiffilename, format="GTiff", overwrite=TRUE)
})
```

```
pltGrphs[[ip]] <- future({
 raster::writeRaster(FinalNetStress2, tiffilename2, format="GTiff", overwrite=TRUE)
})
toc()
#=====================================================================================
==============
# Finished Creating maps
#=====================================================================================
==============
Stats[Stats$Layer==1,]$Aquifer <- 'Surficial'
Stats[Stats$Layer==3,]$Aquifer <- 'Upper Floridan'
Stats[Stats$Stress=="Stressed",]$Relative <-
Stats[Stats$Stress=="Stressed",]$Delta*(-1.0)
Stats[Stats$Stress=="Unstressed",]$Relative <-
Stats[Stats$Stress=="Unstressed",]$Delta
Stats$exclude = FALSE
# Stats[Stats$Layer==1 & Stats$Phys =="Ridge",]$exclude = TRUE
Stats[Stats$Layer==3 & Stats$Phys =="Plain",]$exclude = TRUE
write.csv(Stats,paste0(basePath,'WetlandStressStats.csv'))
#=====================================================================================
==============
# Create Bar Charts from Wetland Stats
#=====================================================================================
==============
colours <- c("red", "orange", "blue", "yellow", "green")
longStats<-melt(Stats,id.vars=1:4)
longStats<-within(longStats, Class <- factor(Class))

pieces<-unlist(strsplit(RCheadsFile,"[\\\\]|[^[:print:]]"))
RCtitle <- pieces[length(pieces)-1]
pieces<-unlist(strsplit(SIMheadsFile,"[\\\\]|[^[:print:]]"))
SIMtitle <- pieces[length(pieces)-1]
L = MFLay

ggplot(longStats[longStats$variable=='Delta' & longStats$Layer == L,],
 aes(x = paste(Stress,Phys), y = value,
 fill = Class)) +
 geom_bar(stat = 'identity') +
 xlab("Initial Condition") +
 ylab("Acres of Change") +
 ggtitle(paste0("Layer",L,'\n',RCtitle,' minus ',SIMtitle))
plotfile =paste0(basePath,'Lay',L,'Barchart.png')
ggsave(plotfile,width = 10,height = 7.5,units = "in",dpi = 300,device = "png")
#=====================================================================================
==============
toc()
```