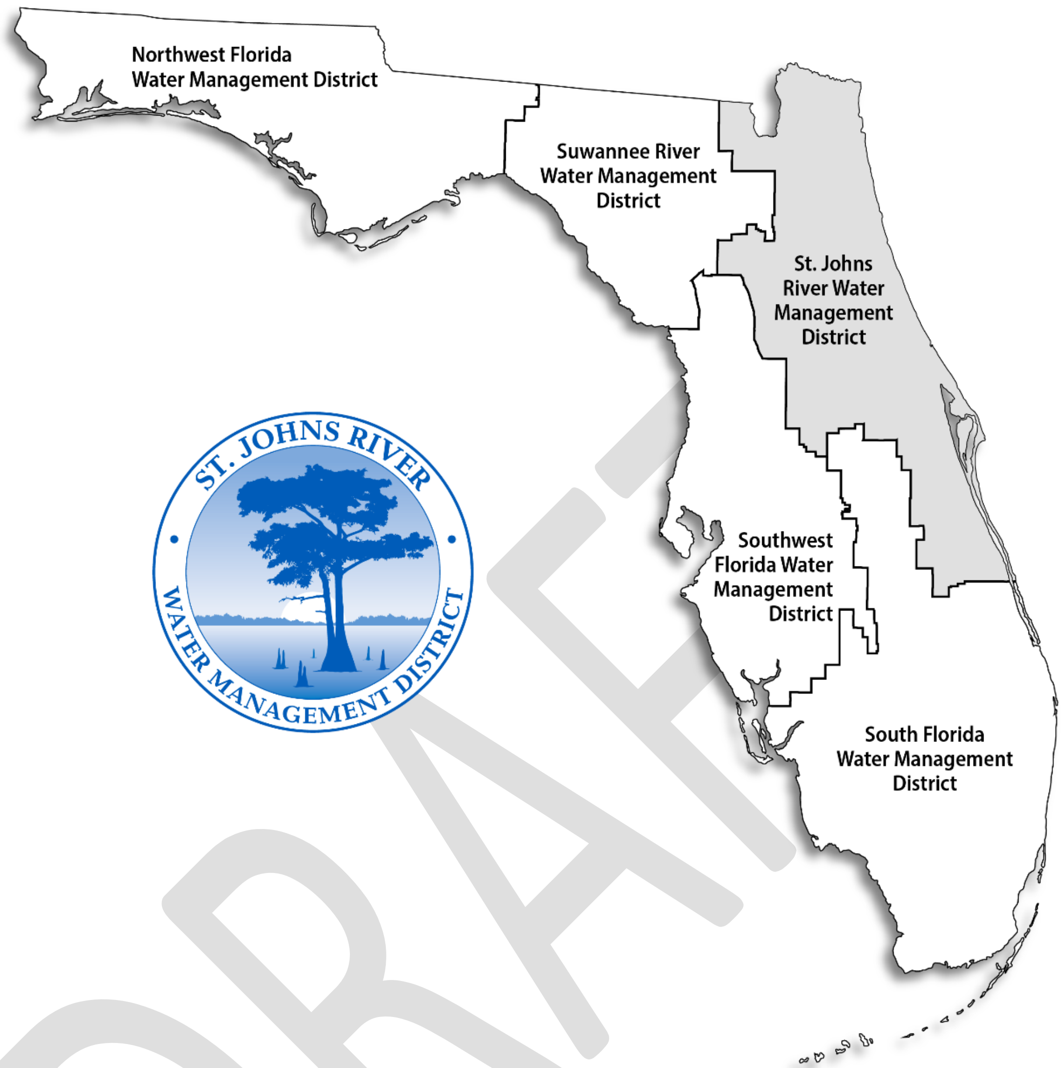
Technical Publication SJ2025-XX

MINIMUM LEVELS REEVALUATION FOR LAKE PREVATT, ORANGE COUNTY

by
Courtney R. Shadik, PhD
Erick Revuelta
Andrew B. Sutherland, PhD
Awes Karama, PhD
Holli N. Capps Herron
Sandra Fox

Bureau of Water Supply Planning
St. Johns River Water Management District
Palatka, Florida

2025



The St. Johns River Water Management District was created in 1972 by passage of the Florida Water Resources Act, which created five regional water management districts. The St. Johns District includes all or part of 18 counties in northeast and east-central Florida. Its mission is to preserve and manage the region's water resources, focusing on core missions of water supply, flood protection, water quality and natural systems protection and improvement. In its daily operations, the district conducts research, collects data, manages land, restores and protects water above and below the ground, and preserves natural areas.

This document is published to disseminate information collected by the district in pursuit of its mission. Electronic copies are available at *www.sjrwmd.com/documents/technical-reports* or by calling the district at the number below.

Scientific Reference Center
St. Johns River Water Management District
4049 Reid Street/P.O. Box 1429
Palatka, FL 32178-1429 (32177 for street deliveries)
386-329-4500

EXECUTIVE SUMMARY

To fulfill its mission and statutory responsibilities, the St. Johns River Water Management District (SJRWMD) establishes minimum flows and levels (MFLs) for priority waterbodies within its boundaries. MFLs establish a minimum hydrologic regime and define the limits at which further consumptive use withdrawals would be significantly harmful to priority water bodies. MFLs are one of many tools SJRWMD uses to assist in making sound water management decisions and preventing significant adverse impacts due to water withdrawals.

Minimum levels were adopted in 1997 for Lake Prevatt in Orange County, Florida. SJRWMD MFLs are typically reevaluated when new data become available and/or methodologies are updated. MFLs for Lake Prevatt were set over 25 years ago; therefore, this system was added to the MFLs Priority List and Schedule for reevaluation. This system is an important resource within the Central Florida Water Initiative's (CFWI) regional network of MFL water bodies that serve as critical indicators of potential impacts due to groundwater pumping.

As part of Wekiwa Springs State Park and a water body within the Wekiva River Basin, Lake Prevatt is designated an Outstanding Florida Water. In addition to this designation, Lake Prevatt is used for recreational purposes, offers a foraging area for a diverse array of avian and other wildlife, and is connected to the Upper Floridan aquifer. The minimum levels recommended herein were developed to protect these outstanding biological, scenic, and recreational resources.

The recommended minimum levels for Lake Prevatt are based on current SJRWMD MFLs determination and assessment methodologies, including analysis of an additional 28 years of hydrologic data collected since the original MFLs were adopted and development of hydrologic regimes under current and no-pumping conditions using the most recent surface and groundwater models. Minimum levels were developed for Lake Prevatt, using a variety of metrics, to protect important ecological structures and functions including vegetation community and key environmental habitat attributes, as well as human beneficial uses (e.g., recreation and aesthetic values).

The SJRWMD MFLs approach involves two separate but interrelated processes: 1) the MFLs Determination and 2) the MFLs Assessment. The first process involves establishing the MFLs condition by determining a minimum hydrologic regime necessary to protect environmental metrics that represent a suite of relevant water resource values. The second process involves comparing the MFLs condition to a current-pumping condition to determine the current status of each environmental metric. Once all metrics are evaluated, the most limiting metric(s), in terms of available water, form(s) the basis of the overall MFL.

Numerous criteria were investigated to ensure that proposed minimum levels would protect important environmental values and beneficial uses. The MFLs condition (recommended minimum condition) and current-pumping condition were compared for each environmental criterion to determine current status. The current-pumping condition is defined as the average pumping condition between 2016 and 2020 and represents withdrawals influenced by the range of climatic conditions (e.g., rainfall) present over that period. The East Central Florida Transient Expanded version 2.0 (ECFTX v2.0) groundwater model was used for the groundwater pumping impact analysis. This impact analysis was used to develop the current-pumping condition timeseries data used in the MFLs assessment.

The status assessment indicates that all environmental criteria evaluated are met under the 2016 – 2020 average current-pumping condition. The most constraining criterion (open water area metric) has a UFA freeboard of 0.9 feet (ft) under this impacted condition. UFA drawdown of 0.2 ft is projected within the 20-year planning horizon, resulting in a remaining freeboard of 0.7 ft in 2045. Therefore, Lake Prevatt is not in prevention or recovery.

Three minimum levels, a minimum P25, P50, and P75, are recommended for Lake Prevatt (Table ES-1). These three percentiles were calculated from the MFLs condition lake level timeseries data (1953 – 2020). The MFLs condition is a long-term lake level timeseries associated with the minimum hydrological regime. Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average, and high levels for Lake Prevatt.

Table ES-1. Original (adopted) and recommended levels for Lake Prevatt.

Original (adopted)			**Recommended**	
Level	**Level (ft NAVD88)**	**Hydroperiod Category**	**Percentile**	**Recommended minimum lake level (ft NAVD88)**
Minimum Frequent High	55.0	Seasonally Flooded	25	56.0
Minimum Average	52.0	Typically Saturated	50	54.5
Minimum Frequent Low	49.9	Semipermanently Flooded	75	52.4

A suite of 10 environmental values (also called water resource values [WRVs]), listed in the Water Resource Implementation Rule (Rule 62-40.473, *Florida Administrative Code* [F.A.C.]), were considered to ensure that the MFLs condition protects all relevant WRVs. SJRWMD concludes that the recommended minimum levels for Lake Prevatt will protect relevant environmental values from significant harm due to water withdrawals. The recommended minimum levels presented in this report are preliminary and will not become effective until approved by the SJRWMD Governing Board and adopted in Rule 40C-8.031, *F.A.C.*

CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Atlantic Multidecadal Oscillation (AMO): Long-term variability of the sea surface temperature occurring in the North Atlantic Ocean, including cool and warm phases with an estimated quasi-cycle period of 60 – 80 years. These changes are natural and have been occurring for at least the last 1,000 years.

Consumptive Use Permit (CUP): A permit which allows water to be withdrawn from groundwater or surface water for reasonable-beneficial uses — such as public supply (drinking water), agricultural and landscape irrigation, commercial use and power generation — in a manner that does not interfere with other existing legal water uses and protects water resources from harm.

Current-pumping Condition Flow or Level: Long-term simulated flow or water level time series that represents what flows or water levels would be if the "current" level of groundwater pumping was present throughout the entire period of record. The estimated "current" groundwater pumping condition is based on the average amount of groundwater pumping over the latest five-year period, based on the best available data.

Deficit: The amount of water needed to recover MFLs, that is not currently being achieved. For a lake level, deficit is expressed as the amount of recovery (in ft) needed in the Upper Floridan aquifer.

El Niño Southern Oscillation (ENSO): Periodic departures from expected sea surface temperatures (SSTs) in the equatorial Pacific Ocean, ranging from about three to seven years. These warmer or cooler than normal ocean temperatures can affect weather patterns around the world by influencing high- and low-pressure systems, winds, and precipitation.

Environmental criteria: Specific ecological or human use functions or values in Rule 62-40.473(1), *F.A.C.*, that are considered when setting or assessing an MFL.

Event: A component of an MFL composed of a magnitude and duration.

Freeboard: The amount of water available for withdrawal before an MFL is not achieved. For a lake level MFL, freeboard is expressed as the allowable reduction in Upper Floridan aquifer levels in feet.

Frequency Analysis: a statistical method used to estimate the annual probability of a given hydrological (exceedance or non-exceedance) event; used to assess the current status of an event-based MFL by comparing the frequency of critical hydrological events under current-pumping conditions to the recommended minimum frequency of these events.

Hydrologic Regime: A timeseries of water levels (or flows) within a specified period of record for a specific water body. Water levels (or flows) typically vary over time, and this variation is an important component of the regime, maintaining critical environmental functions and values.

Minimum Hydrologic Regime: A hydrologic regime with an average level (or flow) that is lower than the no-pumping condition, that protects relevant environmental values from significant harm.

MFLs Condition: The MFLs Condition is a specific "minimum hydrologic regime" (see definition above) that is based on the most constraining MFLs metric and is necessary to protect a water body from significant harm. The MFLs condition represents an allowable change from the no-pumping condition for the entire period of record. It represents a lowering of the no-pumping condition, but only to the degree that still protects a water body from significant harm. The MFLs Condition is based upon the minimum flow or level that is most constraining to water withdrawal, for a given water body.

Minimum Flows and Levels (MFLs): Environmental flows or levels expressed as hydrological statistics, based on the most constraining environmental value, that defines the point at which additional water withdrawals will result in significant harm to the water resources or the ecology of the area (Sections 373.042 and 373.0421, F.S.).

No-pumping Condition Levels: A long-term simulated time series that represents what flows or water levels would be if there were no impact due to water withdrawal.

Pacific Decadal Oscillation (PDO): A long-lived El Niño-like pattern of Pacific climate variability with an estimated quasi-cycle period of 20-30 years.

ACRONYMS AND ABBREVIATIONS

AMO	Atlantic Multidecadal Oscillation
BMAP	Basin Management Action Plan
BOD	Biological Oxygen Demand
CFWI	Central Florida Water Initiative
CP	Current-pumping [condition]
CUP	Consumptive Use Permit
DEM	Digital Elevation Model
ECFTX	East-Central Florida Transient Expanded [groundwater model]
ENSO	El Niño Southern Oscillation
F.A.C.	*Florida Administrative Code*
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FH	Frequent High [MFL level]
FL	Frequent Low [MFL level]
FLUCCS	Florida Land Use Classification Code System
F.S.	*Florida Statutes*
GIS	Geographic Information System
GPP	Gross Primary Productivity
HAT	[CFWI] Hydrologic Analysis Team
H/HE	Histosol and Histic Epipedon
LiDAR	Light Detection and Ranging
MA	Minimum Average [MFL level]
MFLs	Minimum Flows and Levels
NAVD88	1988 North American Vertical Datum
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration

NP	No-pumping [condition]
NRCS	Natural Resources Conservation Service
OFW	Outstanding Florida Water Body
PDO	Pacific Decadal Oscillation
PET	Potential Evapotranspiration
PLRG	Pollutant Load Reduction Goal
POR	Period of Record
SJRWMD	St. Johns River Water Management District
SPI	Standardized Precipitation Index
SRWMD	Suwannee River Water Management District
SWFWMD	Southwest Florida Water Management District
SSURGO	Soil Survey Geographic database
SWIDS	Surface Water Inundation and Dewatering Signatures
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UFA	Upper Floridan aquifer
USGS	U.S. Geological Survey
USDA	U.S. Department of Agriculture
WRV	Water Resource Value

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) completed a minimum levels reevaluation for Lake Prevatt in Orange County, Florida. Pursuant to 373.042, *Florida Statutes* (F.S.), SJRWMD is charged with protecting priority waterbodies by developing minimum flows and levels (MFLs). The SJRWMD Governing Board adopted minimum levels for Lake Prevatt in 1997 (Hupalo 1997; Appendix A). Lake Prevatt was selected for reevaluation because it is an Outstanding Florida Water (OFW) and an important water resource within the Central Florida Water Initiative (CFWI) area. Lake Prevatt is connected to the Upper Floridan aquifer (UFA) and is an important part of a regional network of sentinel sites used to indicate potential impacts due to groundwater pumping. The current reevaluation was also conducted to ensure that the Lake Prevatt MFL is based on the most up-to-date methods and data.

As pressures from population growth and urbanization increase around the area of Lake Prevatt, the value of this system and other connecting water resources becomes more apparent. The recreational resource provided by the lake and its adjoining parkland within Wekiwa Springs State Park offers a year-round destination for hiking, swimming, bird watching, canoe and kayak paddling, and many other outdoor pursuits for residents of central Florida and beyond.

The MFLs determination described herein resulted in the recommendation to modify the adopted MFLs for Lake Prevatt. These recommendations are based on current SJRWMD MFLs determination and assessment methodologies and data from updated surface and groundwater models. This report describes environmental analyses used to develop protective criteria and updated minimum levels for Lake Prevatt. Hydrological analyses and current and future status assessments of recommended minimum levels are also provided.

The recommended minimum levels for Lake Prevatt are intended to support the protection of aquatic and wetland ecosystems from significant ecological harm caused by the consumptive use of water.

LEGISLATIVE OVERVIEW

SJRWMD establishes MFLs for priority water bodies within its boundaries (section 373.042, F.S.). MFLs for a given water body are the limits "at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (section 373.042, F.S.). MFLs are established using the best information available (section 373.042, F.S.), with consideration also given to "changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of the affected watershed, surface water, or aquifer...," provided that none of those changes or alterations shall allow significant harm caused by water withdrawals (section 373.0421, F.S.).

The minimum flows and levels section of the State Water Resources Implementation Rule (Rule 62-40.473, *F.A.C.*) requires that "consideration shall be given to natural seasonal fluctuations in water flows or levels, non-consumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology." The environmental values described in this Rule include:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation.

MFLs are used in SJRWMD's regional water supply planning process (section 373.709, F.S.), the consumptive use permitting program (Chapter 40C-2, *F.A.C.*), and the environmental resource permitting program (Chapter 62-330, *F.A.C.*).

SJRWMD MFLs Program Overview

The SJRWMD continues its district-wide effort to develop MFLs to protect priority surface water bodies, watercourses, associated wetlands, and springs from significant harm caused by water withdrawals. MFLs provide an effective tool for decision-making regarding the planning and permitting of surface water and groundwater withdrawals. The purpose of setting MFLs is to answer an overarching question:

"What minimum hydrologic regime is necessary to protect the critical environmental values of a priority water body from significant harm due to water withdrawals?"

These environmental values typically include ecological structure and function as well as human beneficial uses. Conversely, MFLs are *not* meant to represent *optimal* conditions. Rather, they are mandated by statute to set the limit to water withdrawals beyond which significant harm will occur. A fundamental assumption of SJRWMD's approach is that alternative hydrologic conditions exist that are lower than pre-withdrawal conditions but still protect the environmental functions and values of MFLs water bodies from significant harm caused by water withdrawals.

For the Lake Prevatt MFLs, significant harm is defined differently depending on the environmental metric being evaluated. There are "event-based" metrics for which significant harm is associated with a change in hydrologic event frequency. MFLs events are composed of a magnitude and duration; events are typically assessed by evaluating the effect of water withdrawal on their return interval (frequency; Neubauer et al. 2008). MFLs are developed to ensure that withdrawal-related changes in return interval of critical events are not substantial enough to cause significant harm, defined as impairment or loss of ecological structure or function. In addition to event-based metrics, there are other metrics (e.g., open water area) for which significant harm is defined as a 15% reduction relative to a pre-withdrawal condition.

The SJRWMD MFLs approach involves two separate but interrelated processes: 1) the MFLs Determination and 2) the MFLs Assessment. The first process involves establishing the MFLs condition by determining a minimum hydrologic regime necessary to protect each specific water resource value (i.e., environmental metric). The second process involves comparing this "MFLs condition" to a current-pumping condition to determine the current status of each metric. Once all metrics are evaluated, the most limiting metric(s), in terms of available water, form(s) the basis of the overall MFLs. Finally, the MFL current status is compared to future water use withdrawal projections to determine future status. The overall process involves environmental assessments, hydrologic modeling, independent scientific peer review, and rulemaking.

Many SJRWMD MFLs define a minimum hydrologic regime by establishing a protective frequency of high, intermediate, and low hydrologic events (e.g., setting multiple event-based metrics). For some priority water bodies, a protective regime is established based on a percentage of change allowable from a pre-withdrawal condition. No matter how environmental thresholds are set or how many MFLs are adopted for a given water body, the most constraining MFL (i.e., most sensitive to pumping) is always used for water supply planning and permitting.

If the status assessment indicates that an MFL is currently not being met or is projected to not be met during the 20-year planning horizon, a water management district or the Florida Department of Environmental Protection (FDEP) must adopt a recovery or prevention strategy concurrently with the adoption of the MFL. A recovery strategy is required when an MFL is not currently being met. A prevention strategy is required when an MFL is projected to not be met over the 20-year planning horizon.

SETTING AND DESCRIPTION

LOCATION AND PHYSIOGRAPHIC SETTING

Lake Prevatt is located in Orange County, Florida, approximately 2 miles north of Apopka within Wekiwa Springs State Park, 7 miles northeast of Lake Apopka (Figure 1). Most of the lake is located within Section 35, Township 20 South, Range 28 East in the U.S. Geological Survey Forest City 7.5-minute topographic quadrangle map. This area is within the Apopka Hills Physiographic subdivision of the Central Lakes District, a sandhill area modified by karst processes (Brooks 1982). Rates of groundwater recharge to the UFA directly around Lake Prevatt are medium with areas of high recharge to the west and south and areas of discharge to the northeast (Figure 2; Boniol and Mouyard 2016). Average recharge to the UFA within the Lake Prevatt watershed is 2.3 inches per year (Sarker et al. 2024). Recharge rates vary greatly depending on land use within the watershed, from 0.6 inches per year in wetland areas to 4.3 inches per year in high-density residential areas (Sarker et al. 2024).

BATHYMETRY

Lake Prevatt has a surface area of 94.5 acres at a historical median lake stage of 54.9 ft NAVD88. The body of the lake is elongated, comprised of shallow solution basins that can separate into two distinct lobes when water levels drop below 51 ft NAVD88. The deepest portion of the north lobe lies at 46.8 ft NAVD88, while the sinkholes of the south lobe reach 43.9 and 44.9 ft NAVD88 (Figure 3). Because of this separation and the deeper depths reached by the south lobe, all water level exceedances, hydrographs, and data refer to variations along the gradients observed in the south lobe. Within the south lobe of Lake Prevatt, various regions of elevation change occur. The northern portion of the south lobe resembles a broad marsh for much of the time with gradual elevation transitions from Mesic Hammock to Deep Marsh vegetation communities. The southern portion of the south lobe, where the main body of the lake is located, has much more rapid transitions between upland and open water habitats along its edges.

The relationship between water level and lake area was determined based on a digital elevation model (DEM; Appendix F) created to develop and assess fish and wildlife metrics (Figure 4; see *MFLs Determination* for details). A hydroperiod tool (see Appendix G) analysis utilizing bathymetric data and the historical period of record (POR) spanning from 1953 to 2020 determined that Lake Prevatt ranges from 0.01 acres at 44.1 ft NAVD88 to 143.9 acres at 59.4 ft NAVD88. This range is 118.8 acres at the 10^{th} exceedance percentile (P10 = 56.9 ft NAVD88) to 11.6 acres at the P90 (48.8 ft NAVD88).

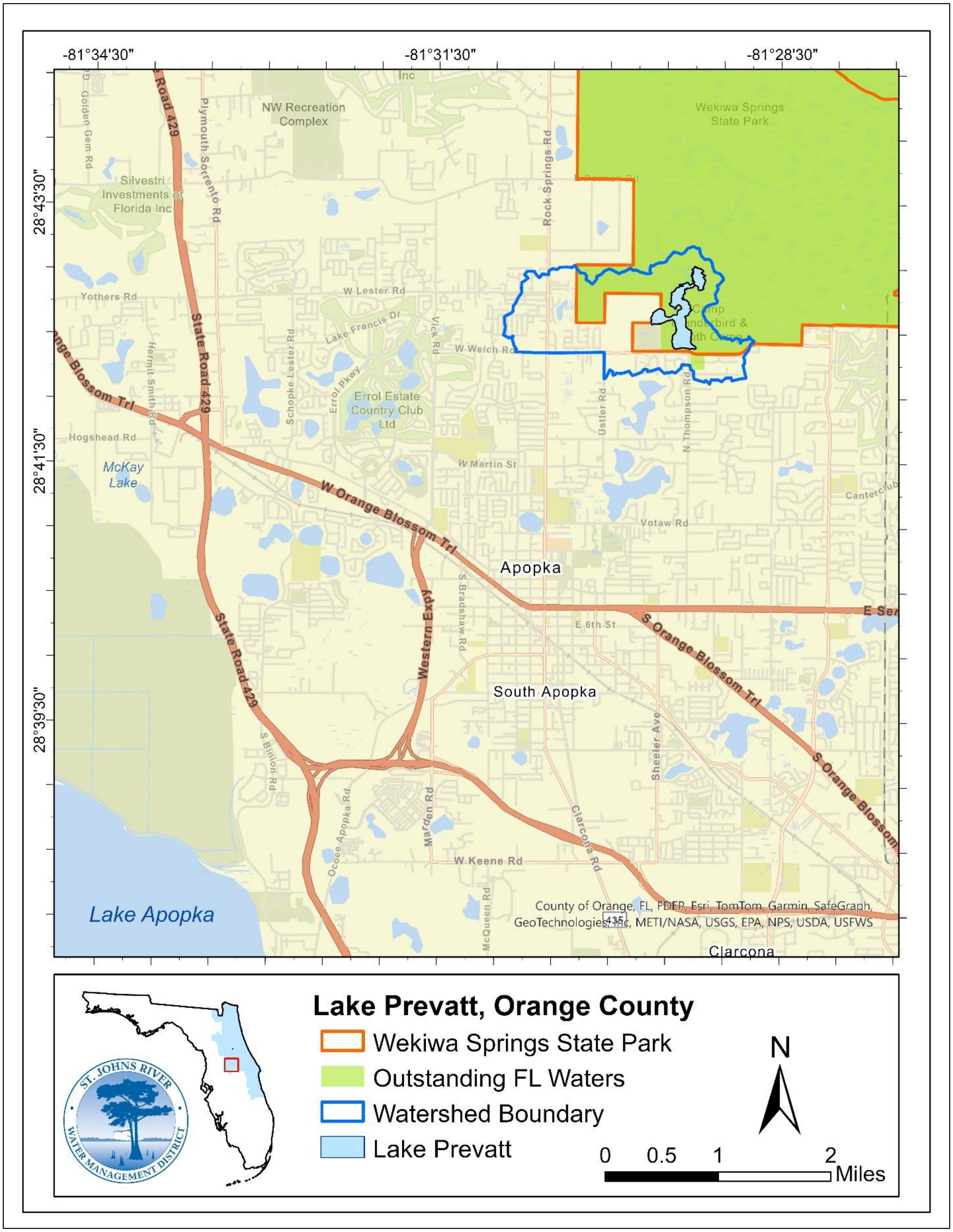


Figure 1. Location of Lake Prevatt within Wekiwa Springs State Park, north of the City of Apopka in Orange County, Florida.

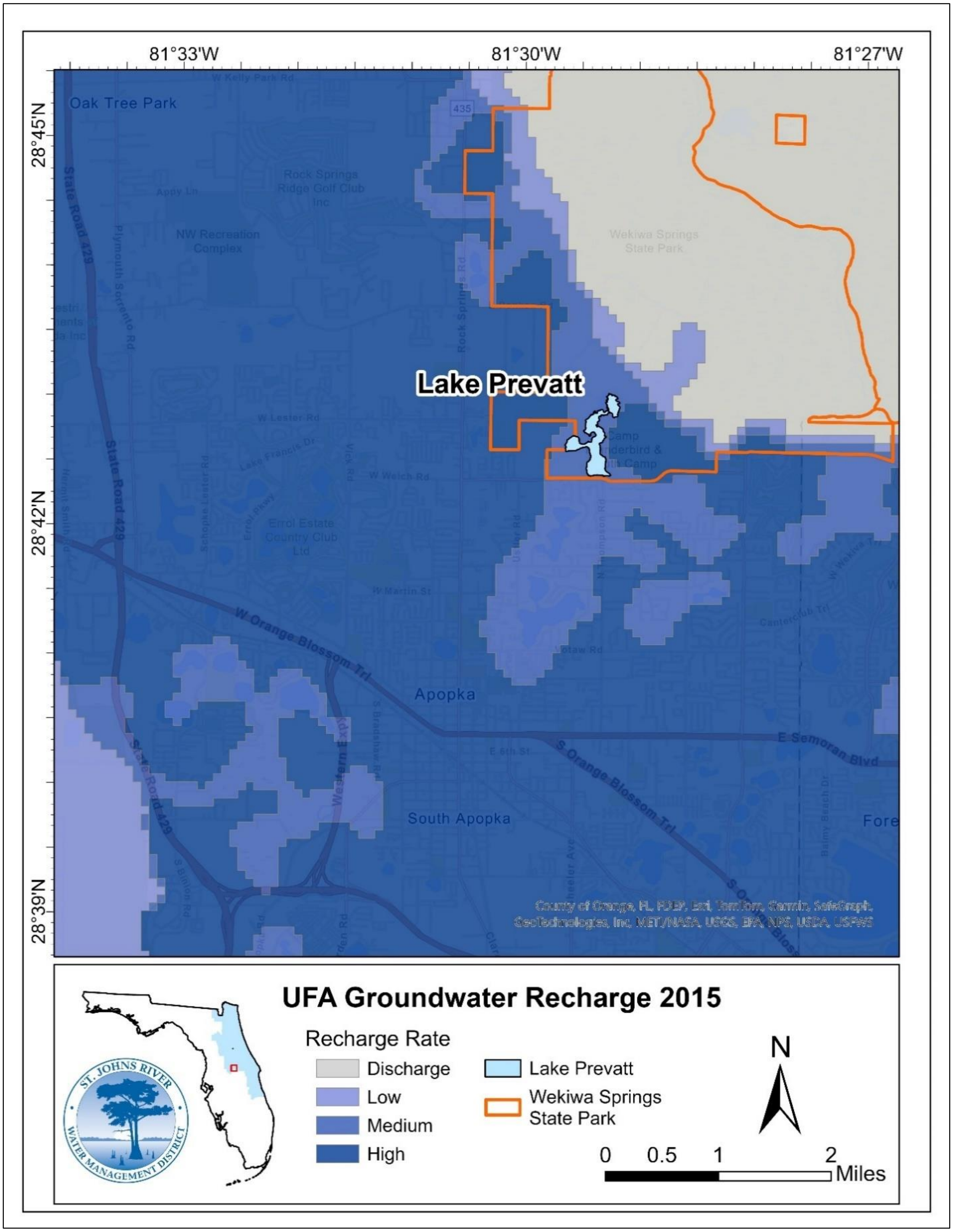


Figure 2. UFA Groundwater recharge areas (Boniol and Mouyard 2016) near Lake Prevatt, Orange County, Florida.

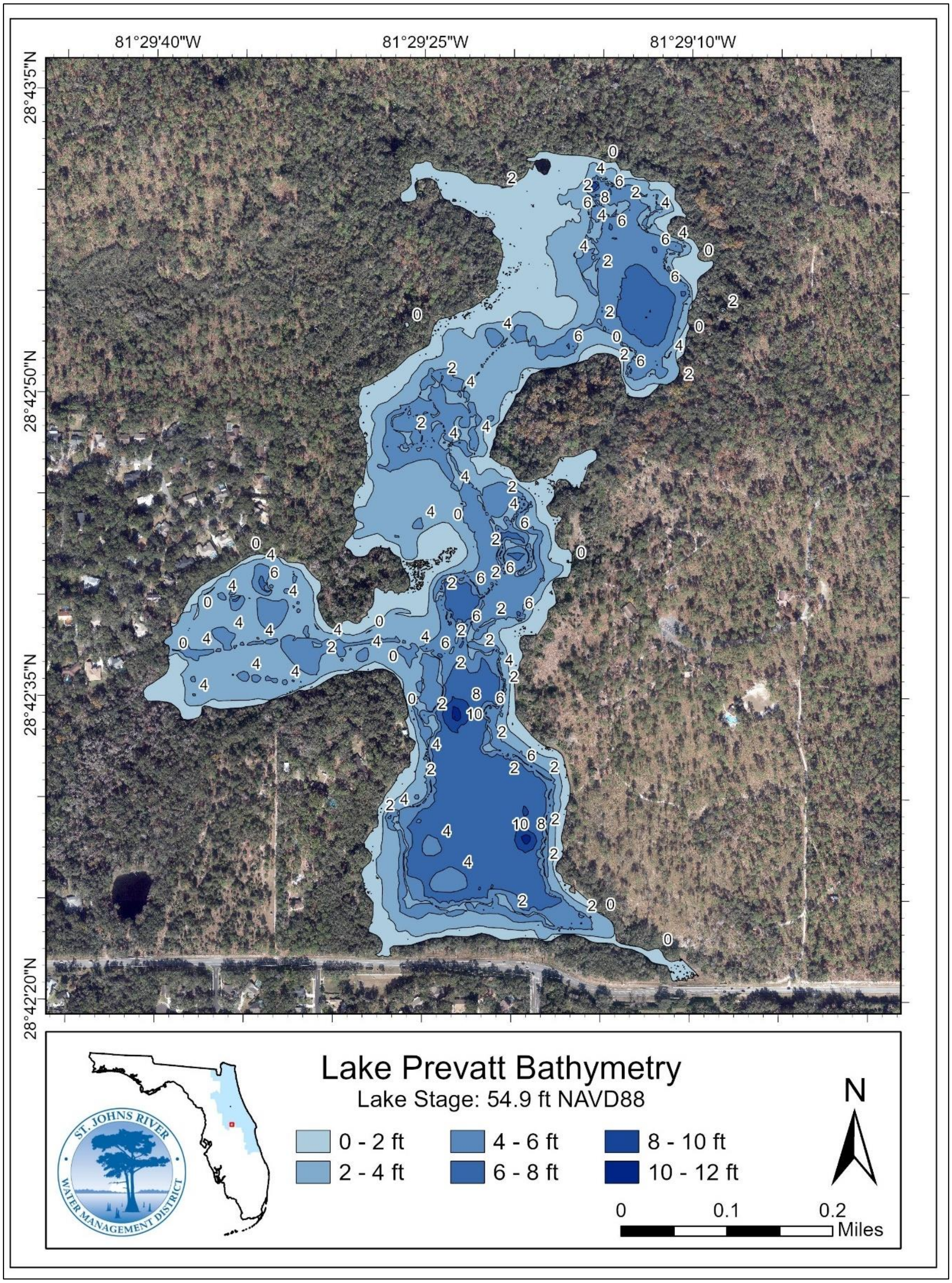


Figure 3. Lake Prevatt bathymetric contour map, based on DEM created for Lake Prevatt (Appendix F). Water depths based on a median lake stage elevation of 54.9 ft NAVD88.

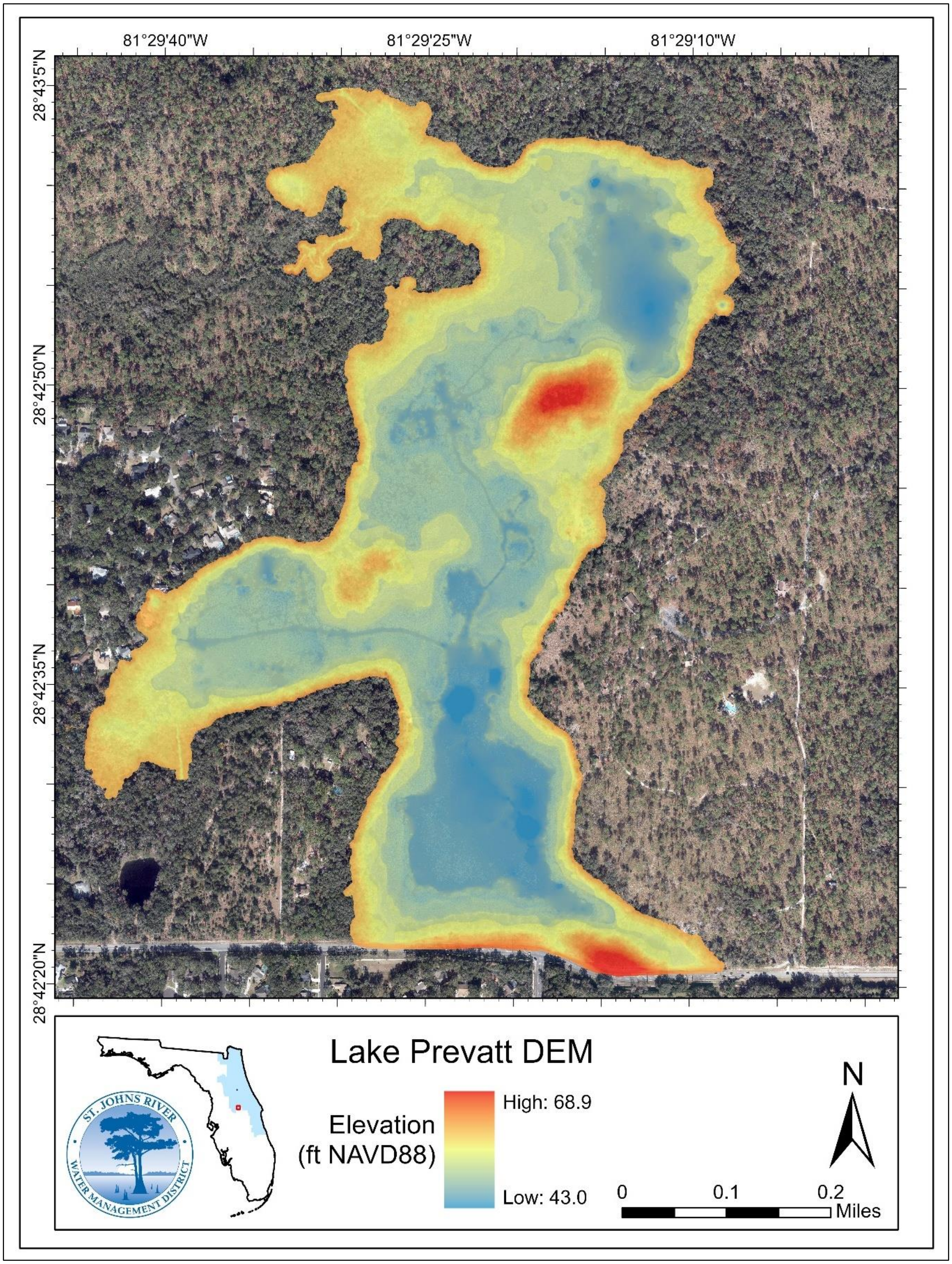


Figure 4. Lake Prevatt digital elevation model (DEM; Appendix F).

HYDROLOGY

Lake Prevatt is classified as having high water level fluctuation range and average water level symmetry (Epting et al. 2008). This classification includes isolated to intermittent ridge lakes with moderate leakage to the UFA and low surface water outflow. The lake is considered the most downstream in a series of lakes and ponds that drain an area known as the Lakes McCoy, Coroni, and Prevatt drainage basin; however, recent surface water models (Appendix B; Sarker et al. 2024) suggest that water flow from this path into Lake Prevatt occurs only under extreme rainfall or flooding conditions and therefore does not contribute a significant volume of water under normal conditions.

Water enters the system primarily through a channel on the western side of the north lobe, just south of the outfall canal of the lake. This inflow stream transports water from the main portion of the 1,039-acre watershed to the west of Lake Prevatt, through a wetland system in the western extent of Wekiwa Springs State Park, before flowing into Lake Prevatt. The amount of water that enters the lake via this inflow is driven by rainfall in the western portion of the Lake Prevatt watershed (Sarker et al. 2024). The main outflow from the lake is through Carpenter Branch, also in the lake's north lobe, to Mill Creek before draining to the Rock Springs Run – Wekiva River floodplain. The outfall elevation from Lake Prevatt is approximately 55.6 NAVD88 (PEC 1997).

Water Level Data

Lake Prevatt water level data are collected by SJRWMD, currently on a daily basis and less frequently in the past. Two gauges exist on the lake; one in the north lobe (gauge 15470818) and one in the south lobe (gauge 15472917). The north lobe gauge has the longest period of record (POR) with 1 – 4 readings per year from 1/1/1960 – 2/25/1981, approximately monthly readings from 6/24/1982 – 3/1/2004, and daily readings from 4/13/2004 – 1/11/2024. The south lobe had 11 random readings taken between 3/1/2010 and 1/12/2015 before a permanent gauge was installed in 2022. Daily measurements are available from the south lobe between 5/19/2022 – present. Mean and median water levels from observed records are approximately equal in each lobe, with the mean being around 54.0 ft NAVD88 for the South Lobe and 53.8 ft NAVD88 for the North Lobe and median being 53.8 ft NAVD88 for the South Lobe and 53.7 ft NAVD88 for the North Lobe (Table 1; Figure 5). The south lobe has a smaller range in observed water level values (9.3 ft) than the north lobe (12.3 ft) likely due to the difference in available POR data.

Table 1. Water level (WL) summary statistics for Lake Prevatt north (POR: 1/1/1960-1/11/2024) and south (POR: 3/1/2010-1/12/2015, 5/19/2022 – 5/28/2024) lobes. Summary statistics are for all available water level observations.

	North Lobe Lake Prevatt WL (ft NAVD88)	South Lobe Lake Prevatt WL (ft NAVD88)
Average	53.8	54.0
1 Standard Deviation	1.8	1.7
Minimum	45.8	48.5
Median	53.7	53.8
Maximum	58.2	57.8
Range	12.3	9.3

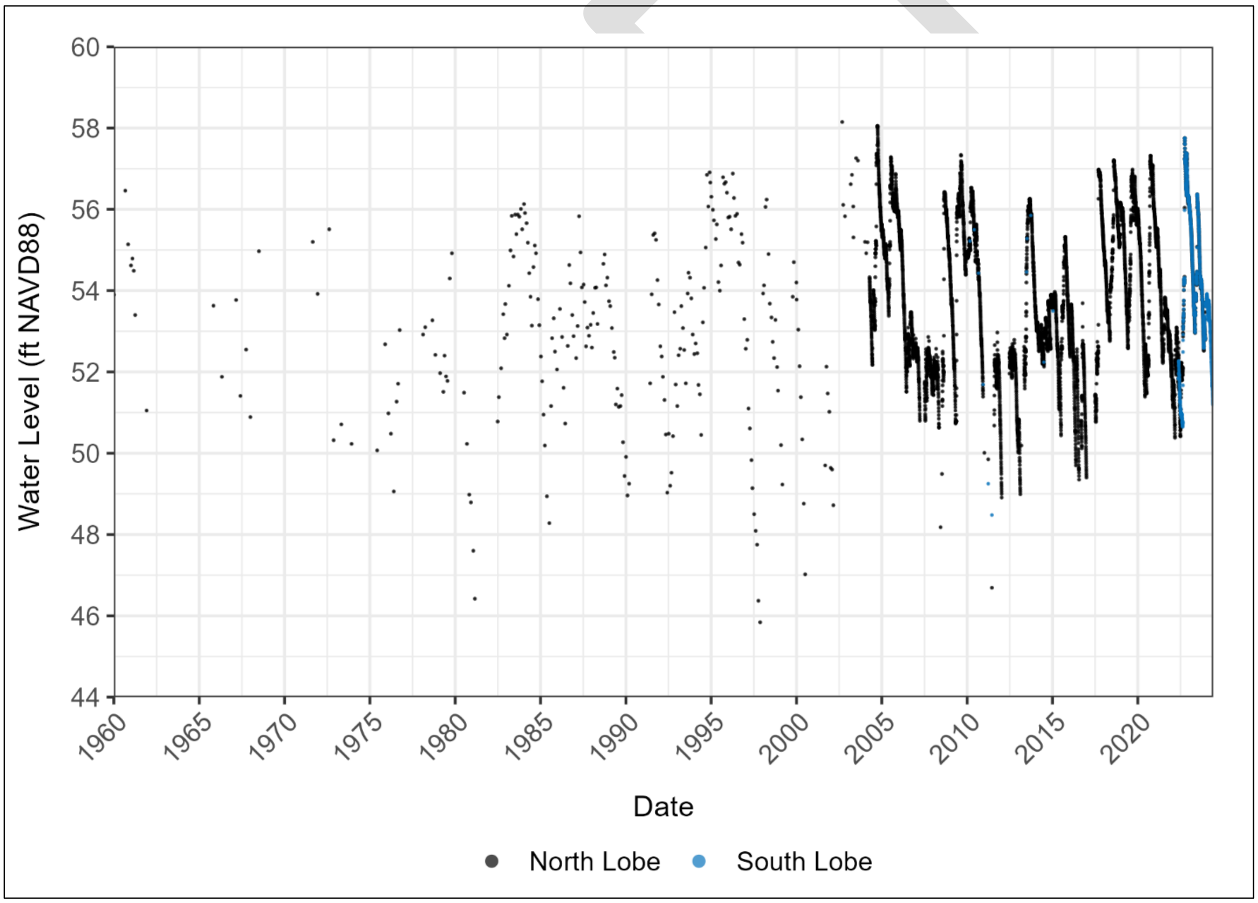


Figure 5. Observed water levels from the north lobe (black) and south lobe (blue) of Lake Prevatt from 1/1/1960 – present.

Summary statistics for historical water levels for both the north and south lobes, as recreated by the Lake Prevatt Hydrological Simulation Program – Fortran (HSPF) model (Appendix B), are presented in Table 2. Mean and median levels for the north and south lobes of Lake Prevatt were comparable throughout the historical period of record from 1/1/1953 – 12/31/2020. Historical mean water levels were 54.3 and 54.0 ft NAVD88 for the north and south lobes, respectively; historical median water levels were 54.9 ft for both lobes. The two lake lobes have the same POR at elevations greater than 51 ft NAVD88; at elevations below 51 ft NAVD88, the lake lobes disconnect allowing water levels to fluctuate independently of one another (Figure *6.* Historical water levels as reconstructed by the Lake Prevatt HSPF model for the North (blue) and South (black) lobes.Figure 6). The south lobe of Lake Prevatt fluctuates an additional 3 ft more than the north lobe (north: 12.1 ft of fluctuation; south: 15.2 ft of fluctuation; Table 2). The greater fluctuation range is made possible by the lower elevations present in the south lobe than in the north lobe. The south lobe fluctuation encompasses the extreme high stage elevations that occur after storm events and extreme low stage elevations that occur when the lake almost completely dries out during drought events.

Table 2. Water level (WL) summary statistics for Lake Prevatt lobes (POR: 1/1/1953 – 12/31/2020). Summary statistics are based on daily historical water level reconstruction.

	North Lobe Lake Prevatt WL	**South Lobe Lake Prevatt WL**
Mean	54.3	54.0
1 Standard Deviation	2.3	2.9
Minimum	46.8	44.1
Median	54.9	54.9
Maximum	58.9	59.4
Range	12.1	15.2

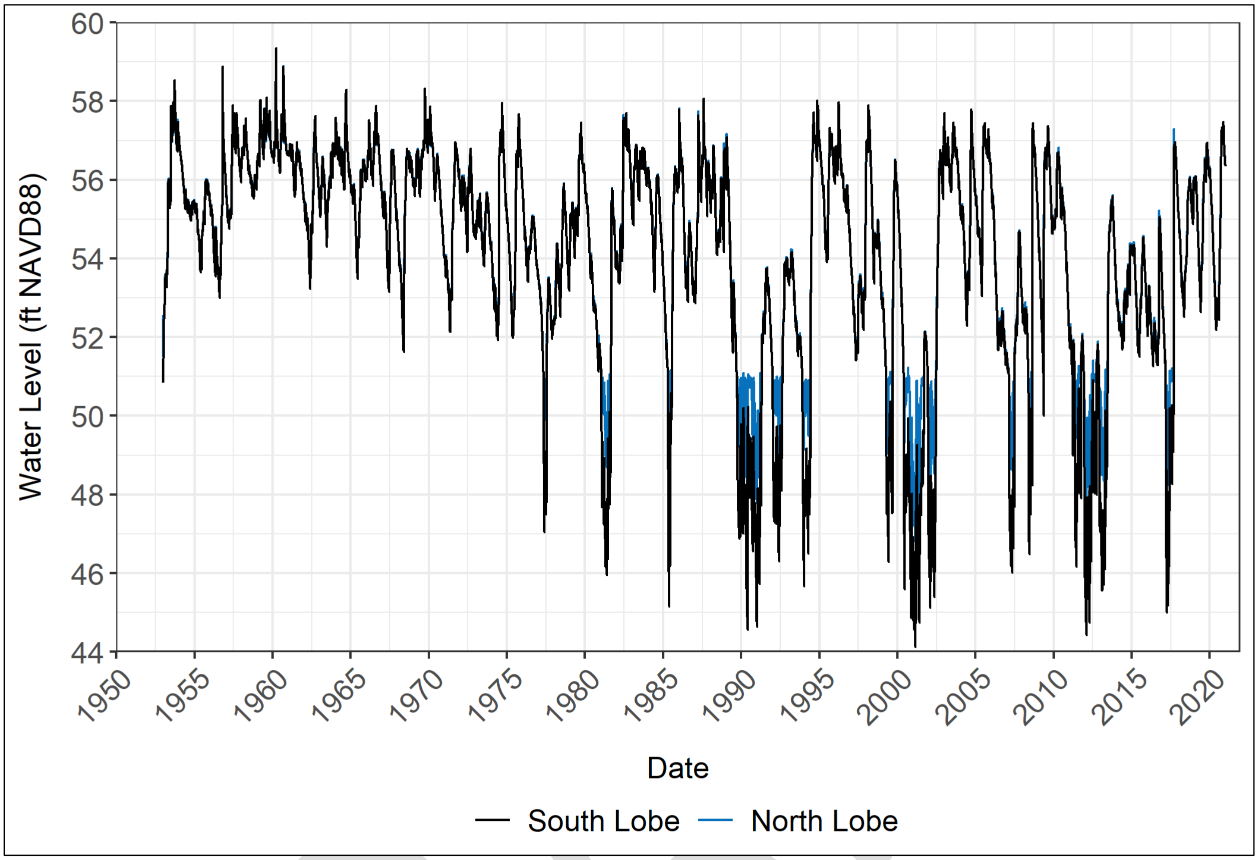


Figure 6. Historical water levels as reconstructed by the Lake Prevatt HSPF model for the North (blue) and South (black) lobes.

Rainfall and Evapotranspiration

Rainfall data were compiled from two different sources for analysis. Next Generation Weather Radar (NEXRAD) data were determined to be the most accurate source for rainfall within the Lake Prevatt watershed (Sarker et al. 2024), but it has a short POR that begins in 1995. Therefore, long-term rainfall from the Isle Win station was used to extend the rainfall record back to 1953 (Figure 7). The long-term annual average rainfall values were 49.8 and 49.4 inches for the Isle Win station and NEXRAD records respectively (Table 3). Long-term potential evapotranspiration (PET) data were available from the Lisbon station. The long-term PET average was 52.6 inches/year.

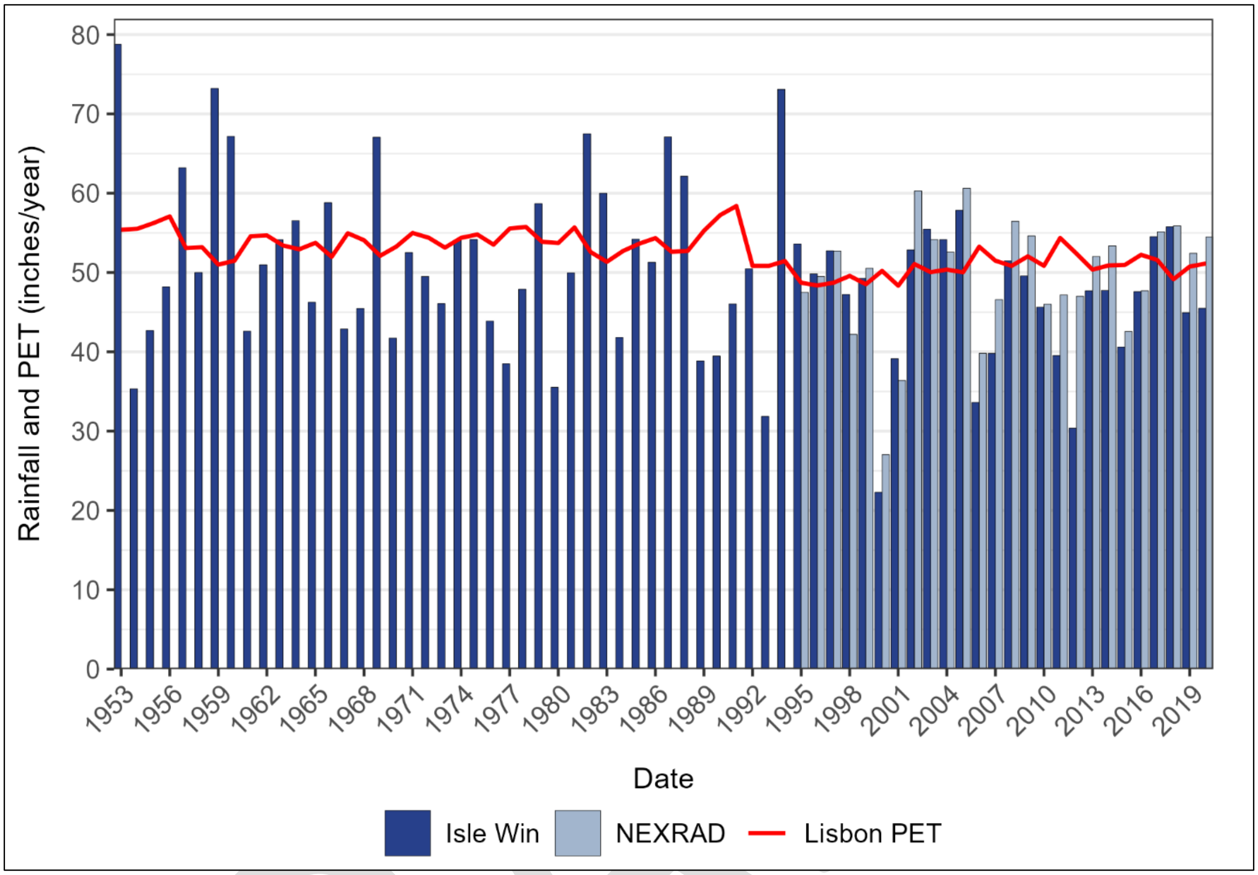


Figure 7. Annual rainfall for area around Lake Prevatt from Isle Win (dark blue) and NEXRAD (light blue) records, 1953 - 2019. Annual PET from Lisbon is shown as the red line.

Table 3. Descriptive statistics of rainfall and PET records from around Lake Prevatt.

	Isle Win Rainfall (in/year)	**NEXRAD Rainfall (in/year)**	**Lisbon PET (in/year)**
POR	1/1/1953 – 12/31/2020	1/3/1995 – 12/31/2020	1/1/1953 – 12/31/2020
Mean	49.8	49.4	52.6
1 Standard Deviation	10.5	7.5	2.3
Minimum	22.3	27.0	48.3
Median	49.5	51.3	52.7
Maximum	78.8	60.6	58.4
Range	56.5	33.6	10.0

Long-term UFA Groundwater Levels

UFA groundwater monitoring wells near Lake Prevatt include SJRWMD stations OR0893, OR0548, and S-0125 (Table 4). The OR0893 well is the closest to Lake Prevatt with the shortest POR; the remaining two wells were used to extend this record back to 1/1/1953 for use in the surface water model (Sarker et al. 2024). The extended UFA groundwater levels span from 1/1/1953 to 12/31/2020; Figure 8 displays this record with values appended from well OR0893 through May of 2024. The mean UFA elevation from 1953 – present near Lake Prevatt was 44.0 ± 4.7 ft NAVD88. A 28.5 ft fluctuation in UFA levels was also observed throughout this time (Table 5).

Table 4. UFA groundwater stations from which the long-term UFA record was constructed for Lake Prevatt.

Station Number	Station Name	Latitude	Longitude	POR Start Date	POR End Date
15474992	OR0893 Lake Prevatt (WL) FAS	28°42'27.57"N	81°29'17.22"W	1/1/2009	12/31/2020
30063052	OR0548 Wekiwa Springs State Park (WL) FA	28°42'40.89"N	81°27'58.51"W	11/19/1992	12/31/2020
09670943	S-0125 Seminole Observation Well (WL) FA	28°41'48.88"N	81°22'0.74"W	1/1/1953	12/31/2020

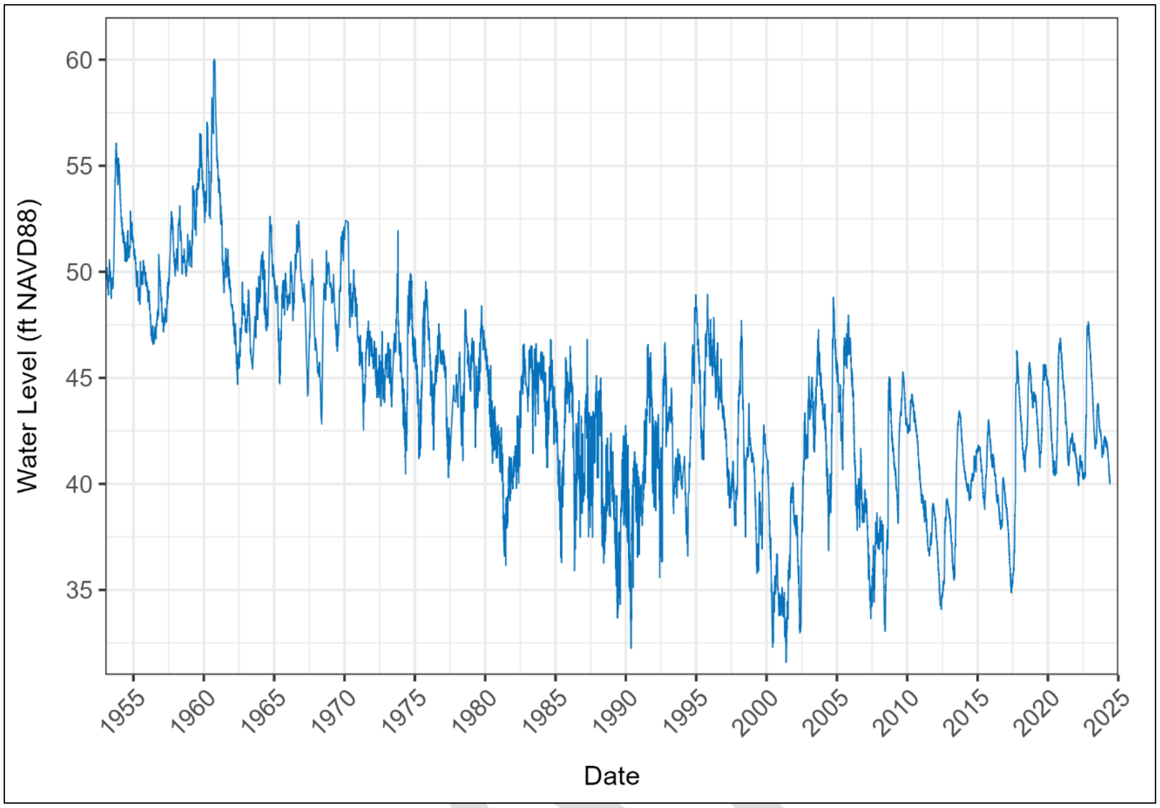


Figure 8. Long-term composite UFA record (1/1/1953 – 12/31/2020) with observed values appended from 1/1/2021 – 5/29/2024.

Table 5. Descriptive statistics of extended historic UFA levels around Lake Prevatt.

	UFA Level (ft NAVD88)
Mean	44.0
1 Standard Deviation	4.7
Minimum	31.6
Median	43.9
Maximum	60.0
Range	28.5

SURFACE WATER BASIN CHARACTERISTICS

Land Use

The most current land use data (SJRWMD 2014; Florida Land Use Classification Code System [FLUCCS]) indicate that the majority (> 52.1%) of the Lake Prevatt watershed is urban development, which includes residential, industrial, and commercial uses (Table 6; Figure 9). The second and third largest land use categories (Forested and Wetland) combined comprise over 35% of the watershed area. The remaining land use categories (Agriculture, Upland non-forested, Water, and Transportation, Communication, and Utilities) make up less than 10% of area within the watershed. Most of the development is located in the western and southern portions of the Lake Prevatt watershed, while the northeastern portion of the watershed remains largely undeveloped within Wekiwa Springs State Park (Figure 9).

Table 6. Land use as of 2014 within the Lake Prevatt watershed.

Land Use	Acres Within Watershed	% of Area Within Watershed
Urban	541.1	52.1
Forest	263.5	25.4
Wetland	149.6	14.4
Agriculture	49.0	4.7
Upland non-forested	18.2	1.7
Water	17.1	1.6
Transportation, Communication, and Utilities	0.3	0.03
Total	**1,038.8**	**100**

Mapped Vegetation

Wetland communities within an elevation contour of 67.3 ft NAVD88 around Lake Prevatt were mapped from 2021 aerial imagery (FDOT 2021) for a high-resolution approximation of vegetation communities around the lake (see Appendix C). The two most common vegetation communities occurring within this area are Deep Marsh – Floating and Oak Hammock, making up approximately 28.0% and 23.3% of the mapped area respectively (Table 7; Figure 10).

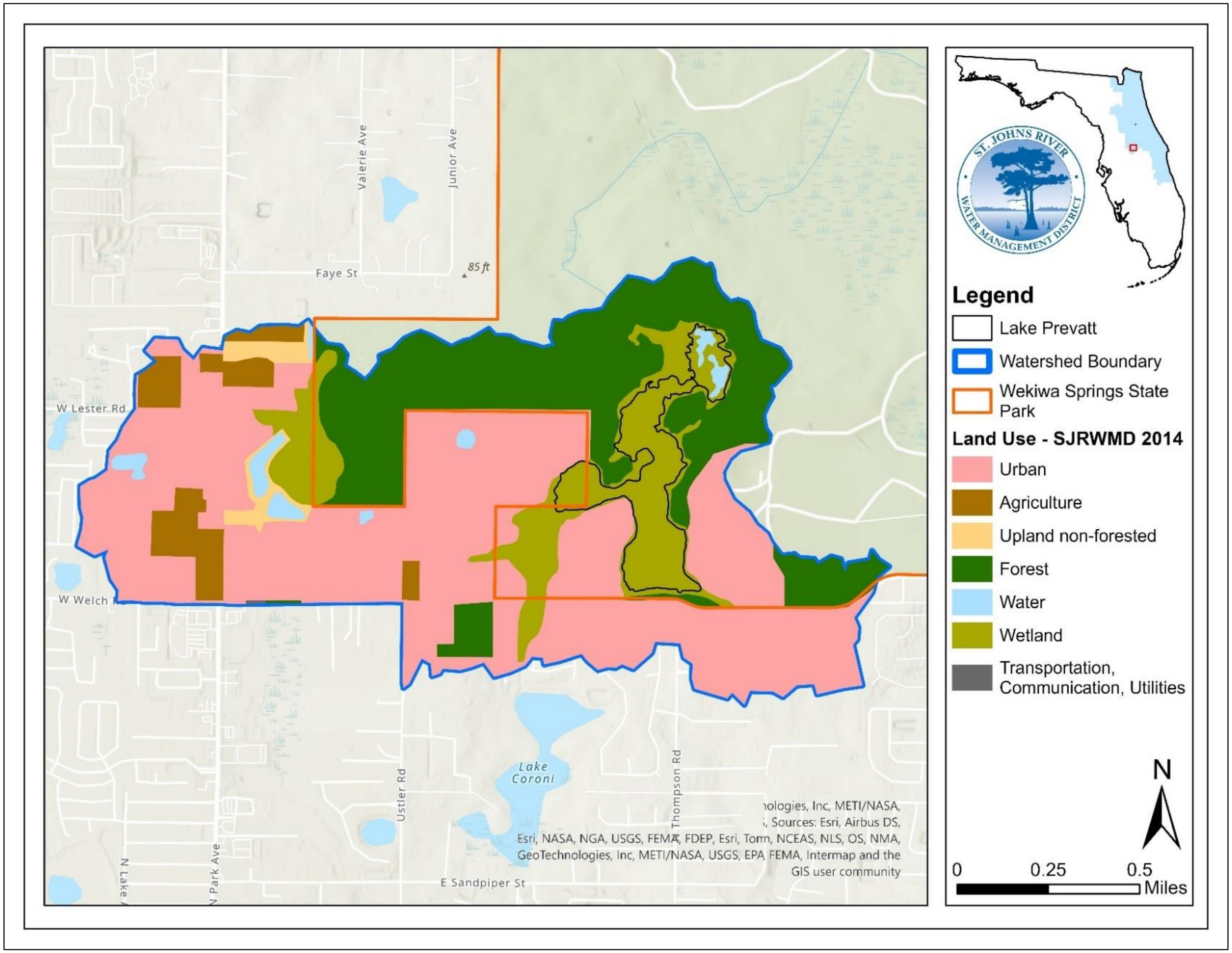


Figure 9. Land use within the Lake Prevatt watershed, Orange County, Florida (Source: SJRWMD 2014).

Open water makes up about 20.2% of the mapped area, and Deep Marsh – Emergent communities account for 14.4% of the lake area. An area of Mixed Hardwood – Oak Hammock community exists off the southwestern portion of the South Lobe’s western edge. The remaining communities (Buttonbush Shrub, Shallow Marsh, and Willow Scrub-shrub) exist in the littoral areas surrounding the lake and account for less than 12% of the mapped area.

This characterization is based on 2021 aerial imagery. Common vegetation communities were surveyed and characterized in-depth along field transects established as part of the MFLs Determination (see below). Detailed vegetation community descriptions at each transect are presented in Appendix C.

Table 7. Lake Prevatt vegetation communities within 67.3 ft NAVD88 and their respective coverage from 2021 aerial imagery.

Vegetation Community	Area (acres)	Percent Area
Deep Marsh – Floating	36.0	28.0
Oak Hammock	30.0	23.3
Open Water	26.0	20.2
Deep Marsh – Emergent	18.5	14.4
Buttonbush Shrub	11.1	8.6
Mixed Hardwood – Oak Hammock	3.5	2.7
Shallow Marsh	2.1	1.6
Willow Scrub-shrub	1.2	0.9
Disturbed (anthropogenic)	0.1	0.0008
Total	**128.5**	**100**

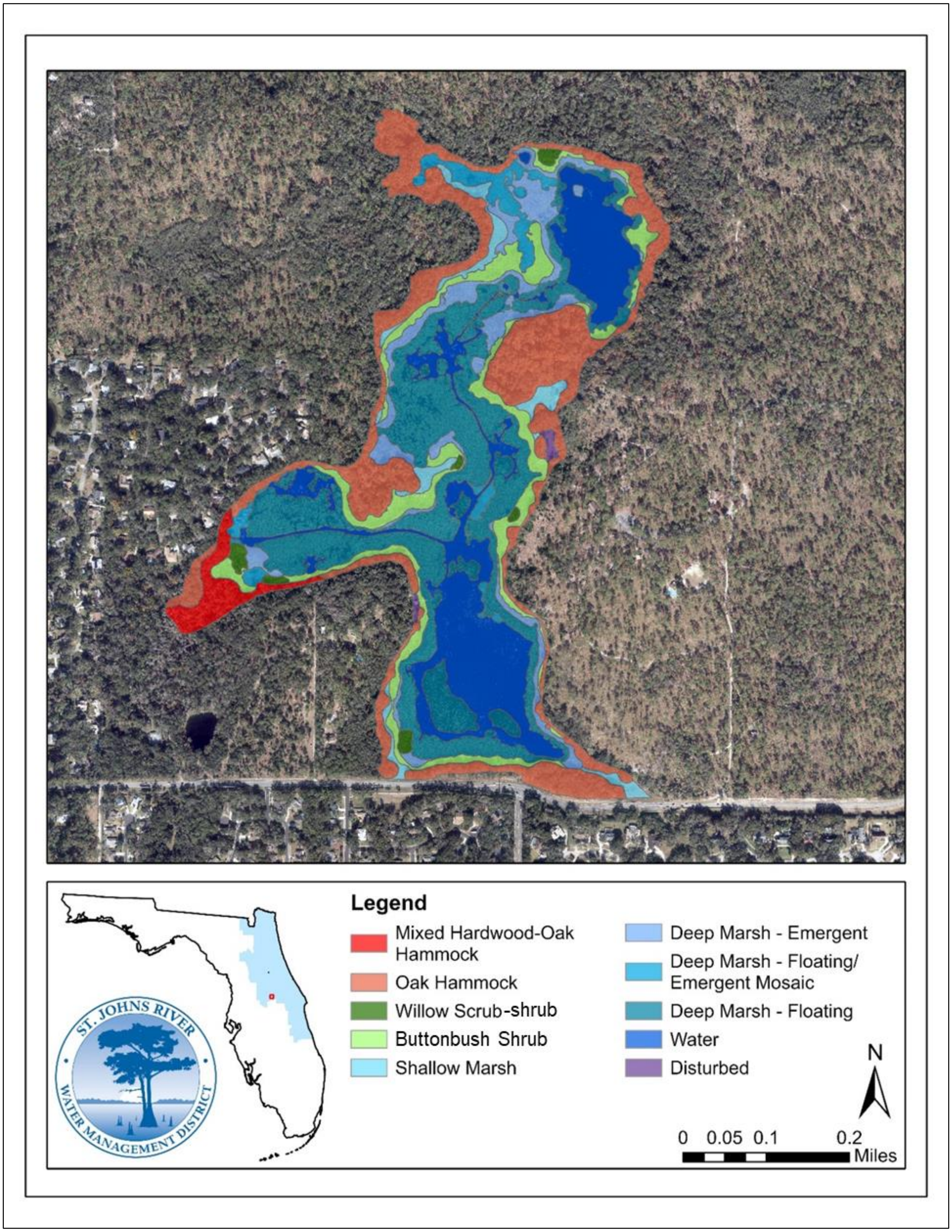


Figure 10. Mapped wetland vegetation communities surrounding Lake Prevatt, Orange County, Florida (Appendix C).

Mapped Hydric Soils

Hydric and non-hydric soils were mapped for the Lake Prevatt watershed using USDA NRCS Soil Survey Geographic (SSURGO) GIS data (Figure 11; USDA NRCS 2023). Most mapped hydric soils within the Lake Prevatt watershed are present directly around the lake; other hydric soils within the watershed are present in the undeveloped wetlands that cross the western boundary of Wekiwa Springs State Park. Most other soils within the watershed are non-hydric or predominantly non-hydric as they occur in areas of urban development or sandhill forest.

As with vegetation, site-specific soil samples were collected and characterized along multiple transects within the basin. Soils were characterized at multiple stations along each transect, and detailed soil descriptions are presented in Appendix C. Soils-related environmental metrics are discussed below (see *MFLs Determination* for details).

Water Quality

Lake Prevatt is designated as a Class III water body by the State of Florida. Designated beneficial uses for Class III waters include recreation and supporting the propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Pursuant to the Wekiva Parkway and Protection Act (Part III of Chapter 369, F.S.), the SJRWMD established pollution load reduction goals (PLRG) for the Wekiva Study Area (Mattson et al. 2006). Lake Prevatt lies within the Wekiva Study Area which includes the Wekiva River, Rock Springs Run, the Little Wekiva River, and other tributaries and springs collectively located in Seminole, Orange, and Lake Counties. Impairments documented in the PLRG were due to elevated nitrate and phosphorus concentrations and manifested through elevated algal biomass, dominance of benthic algal communities by blue-green algae (e.g., *Lyngbya wolli*), and depressed ecosystem metabolism.

Water quality for the Wekiva River and Rock Springs Run was designated by the state as impaired for nutrients in 2007 due to elevated total phosphorus and nitrate-nitrogen (FDEP 2015). Subsequently, the FDEP adopted nutrient Total Maximum Daily Loads (TMDLs) for the Wekiva River, the Little Wekiva River, and Rock Springs Run quantifying pollutant loads beyond which these waterbodies would no longer achieve their designated uses (Gao 2008). FDEP adopted a Basin Management Action Plan (BMAP) in 2015 to implement nutrient and biological oxygen demand (BOD) reductions in the Wekiva River basin. Lake Prevatt is designated as a supplemental surface water monitoring site within this BMAP area.

With this designation, periodic monitoring of nutrient concentrations is essential to calculate an annual geometric mean to assess if Lake Prevatt meets Class III surface water quality standards as defined in Florida's Numeric Nutrient Standards (Rule 62-302.531, *F.A.C.*; see Table E-3). To date, water quality data for Lake Prevatt include 52 data points for total nitrogen (TN) and 53 points for total phosphorus (TP) and dissolved oxygen (DO) available between 1981 and 2016 (USF Water Institute). Thirty-four data points for chlorophyll-a (Chl-a) are available

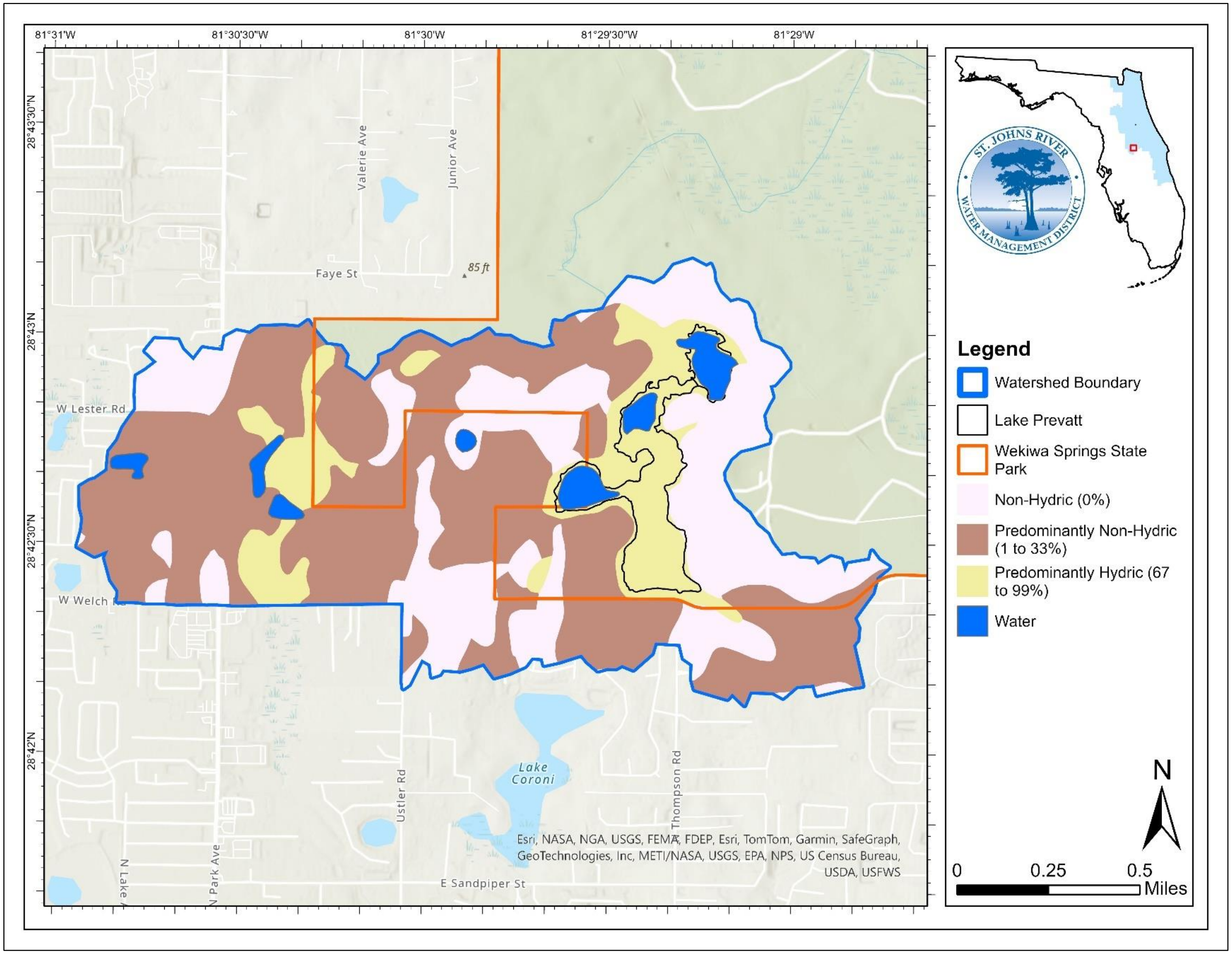


Figure 11. Hydric and non-hydric soils within the Lake Prevatt watershed (source USDA NRCS 2023).

between 1998 and 2016. Further water quality data collection is needed to determine if Lake Prevatt is impaired for nutrients by nutrient standards.

The most recent water quality data for Lake Prevatt were collected in 2016 (Table 8). According to the most recent sample, the Trophic State Index (TSI) classifies Lake Prevatt as having "fair" quality with high productivity. TSI is an indicator of lake integrity, and is calculated using total phosphorus (TP), total nitrogen (TN), and chlorophyll-a (Chl-a) data, with values above 70 considered poor water quality, 60-69 considered fair water quality, and values 59 or below considered good water quality (Friedemann and Hand 1989). From available data, Lake Prevatt has a mean TSI value of 50 and a most recent value of 62.

Table 8. Summary statistics of primary water quality parameters at Lake Prevatt.

Parameter	Minimum	Average	Maximum	Most Recent (10/11/2016)	N	POR
TSI	29	50	80	62	35	5/2008 – 10/2016
Color (PCU)	4.0	89.4	190.0	130	38	3/1998 – 10/2016
Chl-a µg/L	1.5	21.2	154.7	22.3	34	3/1998 – 10/2016
TP mg/L	0.01	0.05	0.16	0.08	53	6/1981 – 10/2016
TN mg/L	0.3	1.3	2.9	1.6	52	6/1981 – 10/2016
DO mg/L	0.0	4.8	29.4	1.0	53	6/1981 – 10/2016

Trends in primary water quality parameters at Lake Prevatt have varied over time. TSI (Figure 12), Chl-a (Figure 13), and TN (Figure 14) have all displayed major fluctuations, but these limited data suggest no increasing or decreasing trends. DO (Figure 15) and TP (Figure 16) also displayed major fluctuations but had slightly decreasing trends over time. No water quality parameter was significantly associated with lake stage (see Appendix E). Given data gaps between 1994 and 2004 and no data from 2016 to present, what appear to be trends are, at best, only estimations.

Note that water quality is an environmental value evaluated as part of the MFLs assessment process (see MFLs Assessment section below) pursuant to Rule 62-40.473, *F.A.C.*; of concern to MFLs are water quality issues that arise from consumptive use of water. However, for most lakes in Florida excessive nutrient enrichment is monitored and remediated, if necessary, by the FDEP by establishing TMDLs and BMAPs for affected systems.

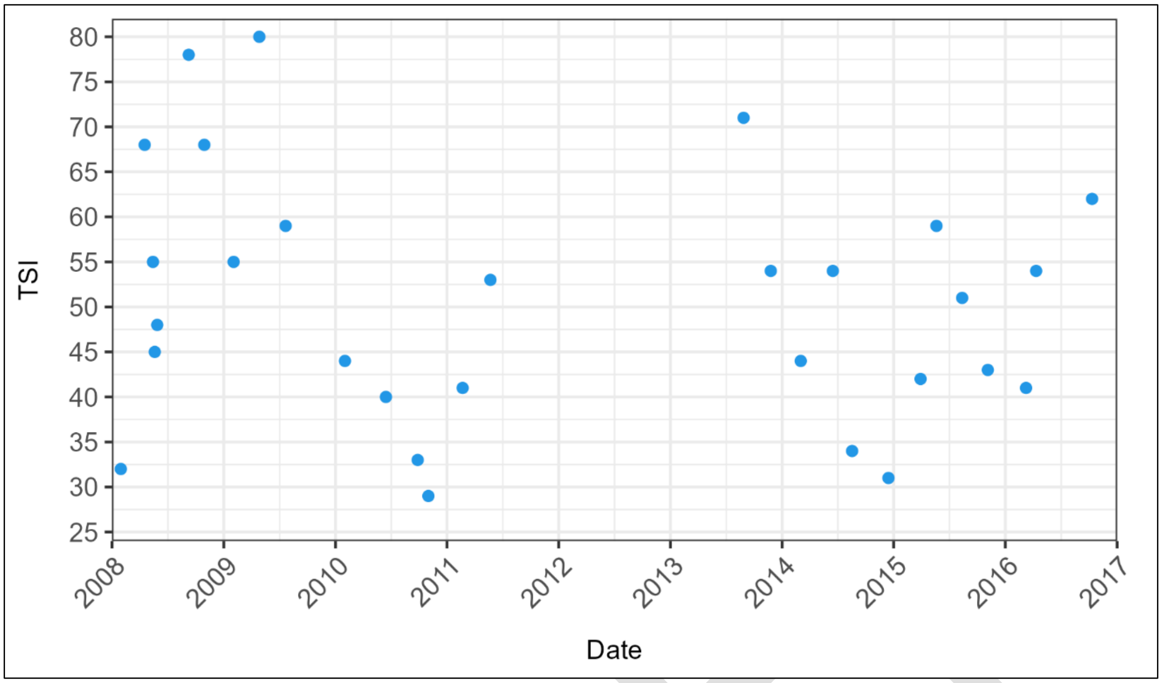


Figure 12. Trophic State Index (TSI) at Lake Prevatt from 2008 – 2016.

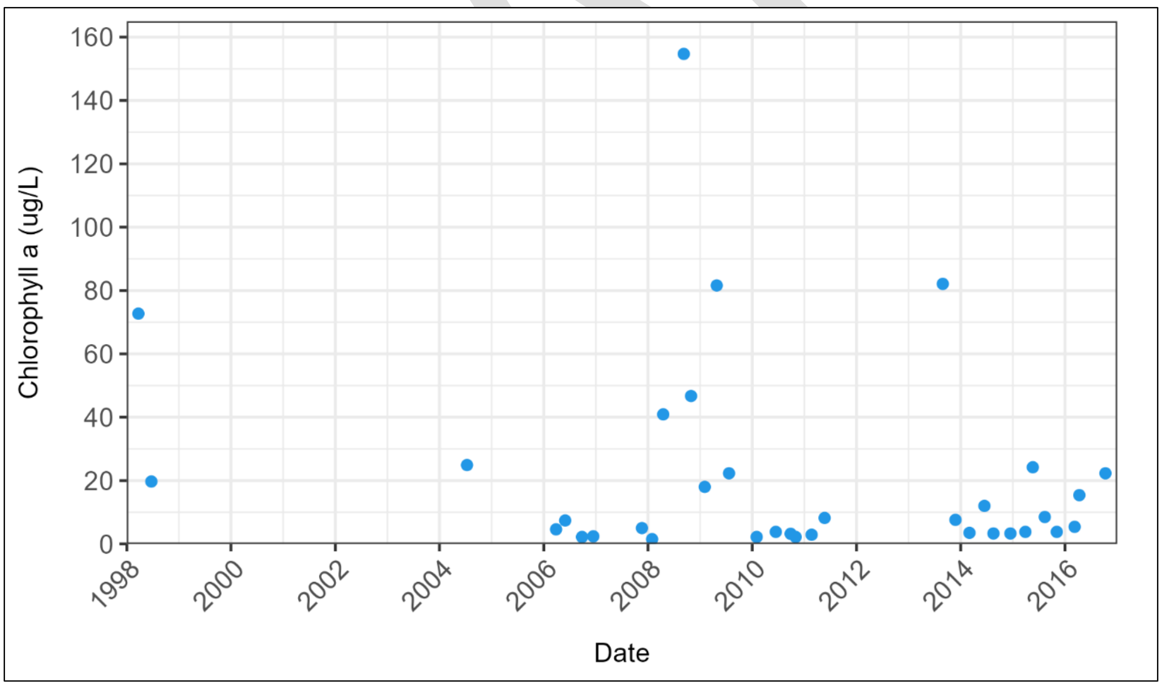


Figure 13. Chlorophyll a (Chl-a) at Lake Prevatt from 1998 – 2016.

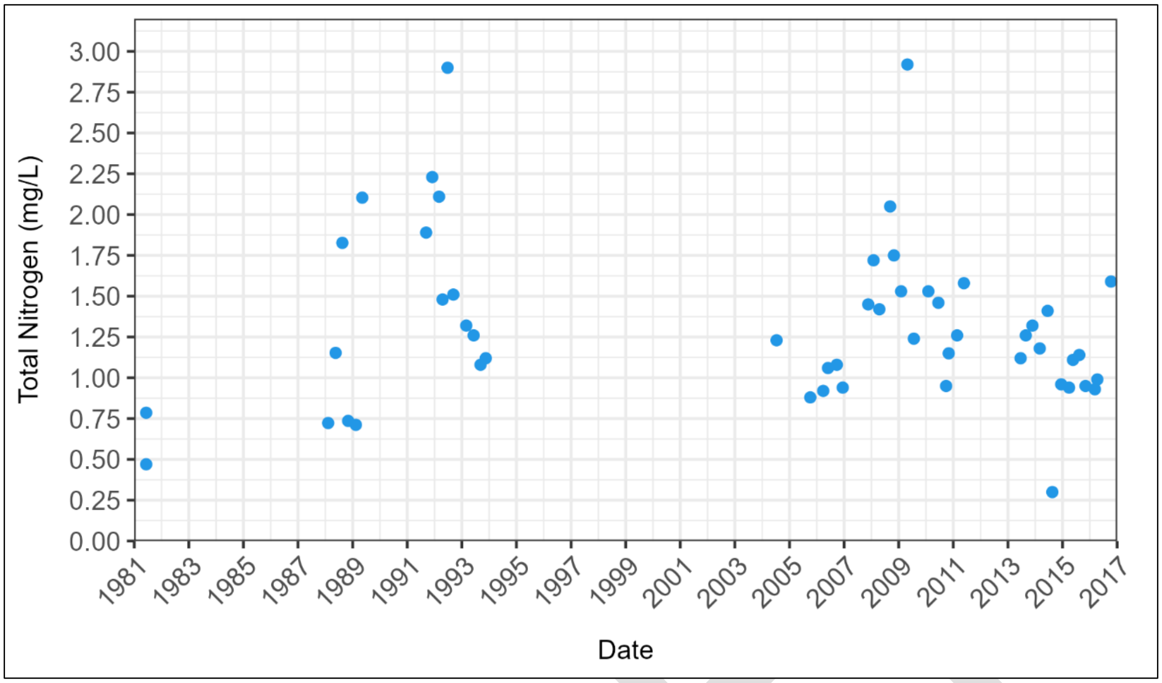


Figure 14. Total Nitrogen (TN) at Lake Prevatt from 1981 – 2016.

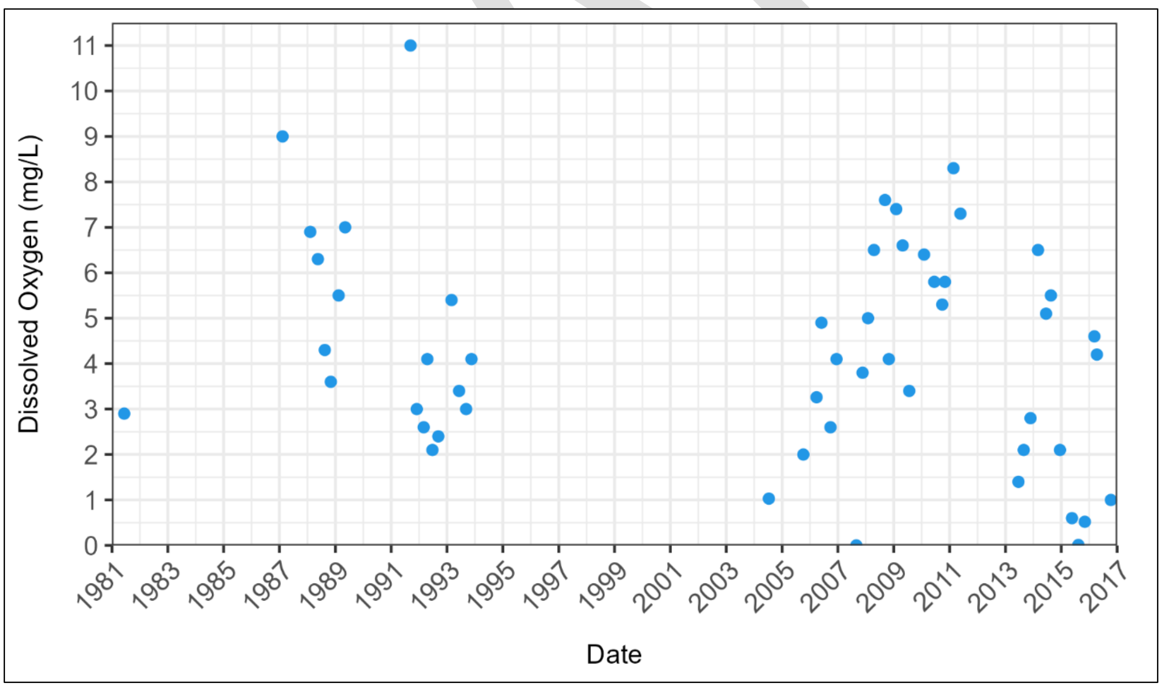


Figure 15. Dissolved Oxygen (DO) at Lake Prevatt from 1981 – 2016.

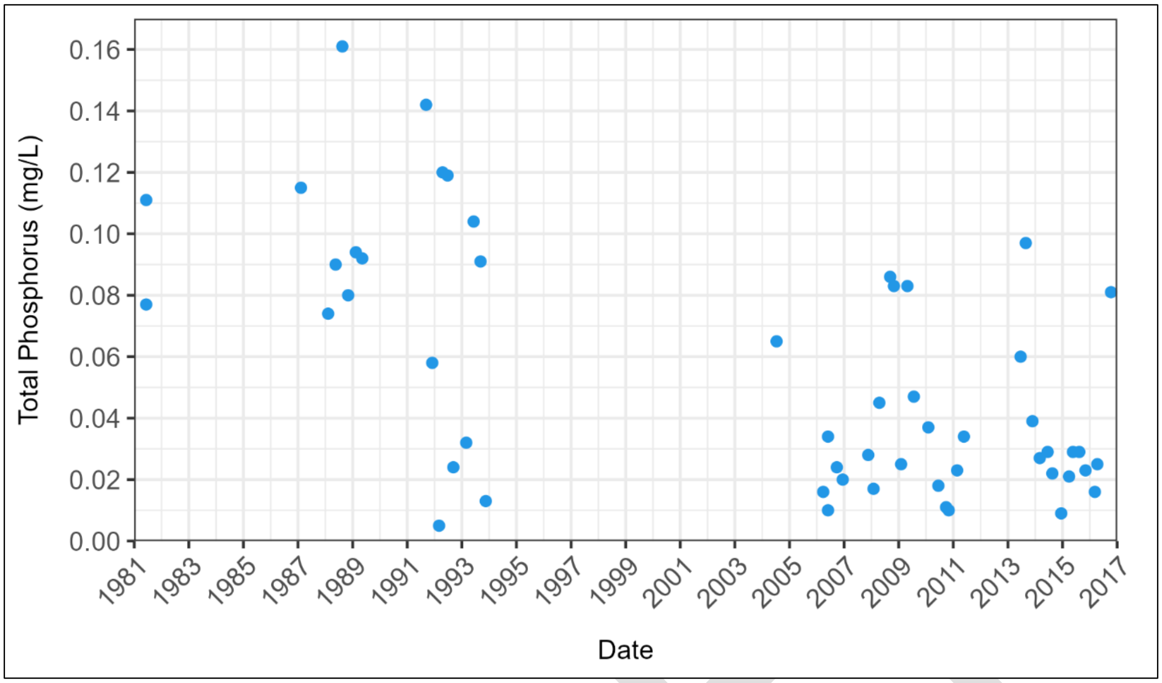


Figure 16. Total Phosphorus (TP) at Lake Prevatt from 1981 – 2016.

MFLs Determination

The MFLs determination for Lake Prevatt involved hydrological and environmental analyses. The *Hydrological Analyses* section below provides a brief description of modeling and data analyses used to develop long-term water level time series datasets which were used to develop minimum levels for Lake Prevatt. More details on hydrological analyses are provided in Appendix B.

The *Environmental Analyses* section provides a brief description of each of the environmental criteria evaluated as part of the MFLs determination for Lake Prevatt. In addition to methods descriptions, results are also presented, including the calculation of a recommended MFLs condition (i.e., threshold condition) for each criterion. Criteria were chosen to ensure the consideration and protection of both ecological structure and function as well as human beneficial uses.

Current status of the system, based on the most constraining criterion, is summarized in the *MFLs Assessment* section that follows this section (also see Appendix D). In addition to the development and assessment of primary criteria, on which the system's minimum levels are based, consideration was also given to the protection of a suite of 10 environmental values, listed in Rule 62-40.473, *F.A.C.* The evaluation of these Water Resource Values (WRVs) is summarized in the *MFLs Assessment* section below and details are provided in Appendix E. The general approach for determining minimum levels for Lake Prevatt is presented below and details regarding data and analyses are provided in Appendix B and Appendix C.

Hydrological Analyses

Significant hydrological analyses are required for establishing and assessing MFLs. The primary purpose of these analyses is to better understand the impact from groundwater pumping on water levels. This information is then used to develop no-pumping and current-pumping condition long-term level time series, which are then used for MFLs determination and assessment. Several steps were involved in performing these hydrological analyses, including:

1. Review of available data;
2. Historical groundwater pumping impact assessment;
3. Development of lake level datasets representing no-pumping and current-pumping conditions; and
4. Estimating available water (freeboard or deficit).

Water level data are discussed in the *Hydrology* section above. Groundwater impact analysis and development of no-pumping and current-pumping timeseries are summarized below. Additional details are available in Appendix B. Appendix D includes a description of the estimation of UFA freeboard (i.e., available water).

Historical Groundwater Pumping Impact Assessment

Groundwater levels in the vicinity of Lake Prevatt are susceptible to changes due to climate and/or water withdrawal. As described below, the contribution of climate versus pumping was estimated by developing a pre-withdrawal condition, termed the no-pumping condition, for Lake Prevatt.

Groundwater Use

MFLs are established to set the limit at which further water withdrawals would be significantly harmful to water resources. To estimate the impact on groundwater levels from historical pumping, monthly groundwater use data were compiled or estimated at all stations within a 15-mile radius of the Lake Prevatt centroid from 1930 to 2020. It should be noted that the groundwater pumping within the 15-mile lake buffer was only used as a proxy to understand the variation of regional groundwater pumping from 1953 to 2020. The impact of groundwater pumping on lake levels was assessed based on all groundwater pumping within the groundwater model domain. As shown in **Error! Reference source not found.**, the total groundwater use reached its highest level within the 15-mile lake buffer in approximately 2000 (~ 318 mgd) and declined until 2020 (~150 mgd). Average groundwater use over the five-year period of 2016–2020 is approximately 156 mgd, which is similar to groundwater use from the mid-1980s to mid-1990s.

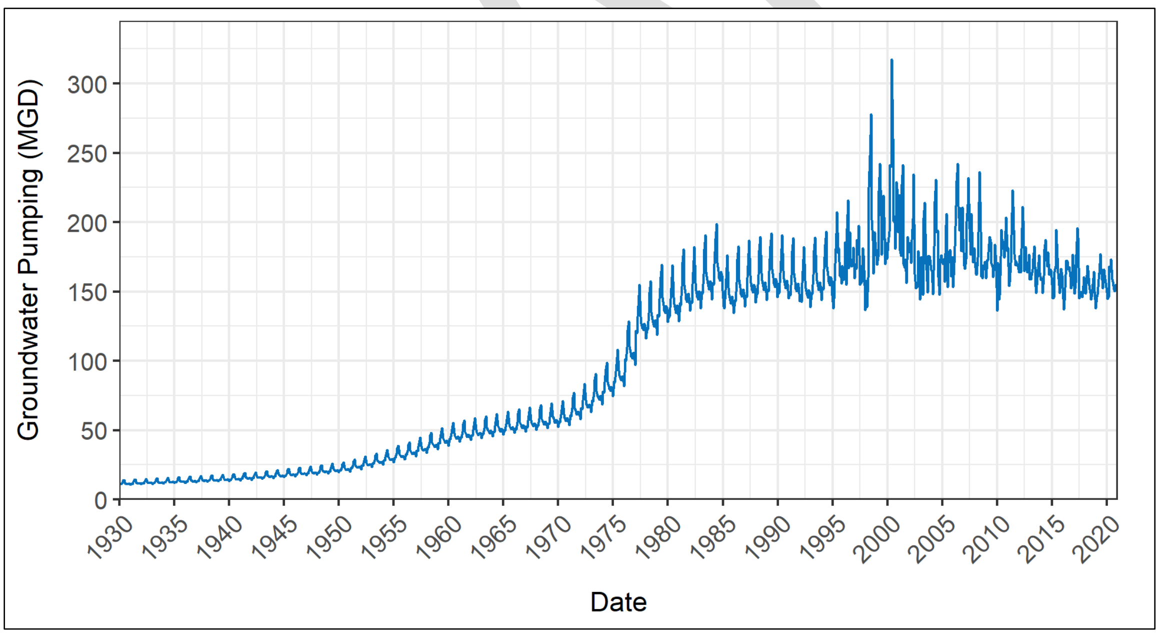


Figure 17. Estimated historical groundwater pumping within 15 miles of Lake Prevatt from 1930 to 2020.

Groundwater Modeling

The ECFTX groundwater flow model was developed by the CFWI to support regional water supply planning and understand groundwater resource limitations for sustainable water supplies while protecting natural systems (CFWI HAT 2020). The ECFTX model was recalibrated in 2022, referred to as ECFTX v2.0, to improve simulation of groundwater levels and flows within the Wekiva river basin (Gordu et al. 2022). ECFTX v2.0 was used for this pumping impact analysis.

Estimated Historical Impact on Water Levels

An estimate of monthly UFA reduction at Lake Prevatt resulting from regional groundwater pumping for the period of 1953 to 2020 was used to establish the no-pumping condition lake levels. The monthly estimated historical impact due to pumping was disaggregated to a daily time series extending from 1953 to 2020 using linear interpolation. The daily estimated historical impact from pumping at Lake Prevatt within a 15-mile buffer area for the period of 1953 to 2020 is shown in Figure 18.

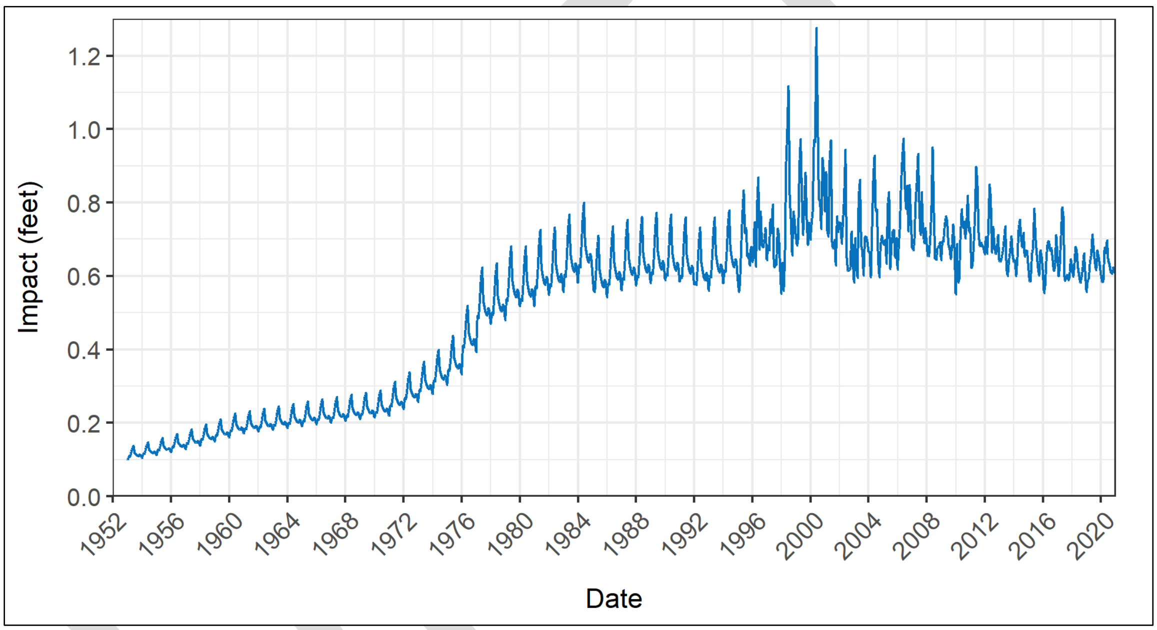


Figure 18. Daily estimated historical impact from pumping on UFA levels near Lake Prevatt using the 15-mile buffer area.

No-pumping and Current-pumping Condition Water Levels

Long-term level time series, representative of a no-pumping condition and a current-pumping condition, are needed for both MFLs determinations and assessments. Estimated historical water level decline caused by groundwater pumping (described above) is added to the observed dataset to create the no-pumping condition UFA level dataset. The no-pumping condition time series represents the hydrologic conditions of Lake Prevatt in which impacts from groundwater pumping are assumed to be minimal.

The current-pumping condition UFA level dataset was developed by subtracting an estimate of impact due to current groundwater pumping (average 2016–2020) from the no-pumping UFA level time series. No-pumping and current-pumping UFA levels are used as boundary conditions in the Lake Prevatt HSPF model, which is then used to simulate corresponding lake levels. See Appendix B for more details on the calculation of impact due to pumping and creation of the no-pumping condition lake level time series.

The current-pumping condition dataset represents a reference hydrologic condition for a particular water body in which the total regional groundwater pumping impact is assumed to be constant from 1953 to 2020. Figure 19 shows the daily no-pumping and current-pumping condition lake stages in the south lobe of Lake Prevatt. Water levels were also expressed as exceedance probabilities to facilitate evaluation of certain MFLs criteria. Figure 20 depicts the no-pumping and current-pumping conditions water level exceedance curves for South Lobe of Lake Prevatt.

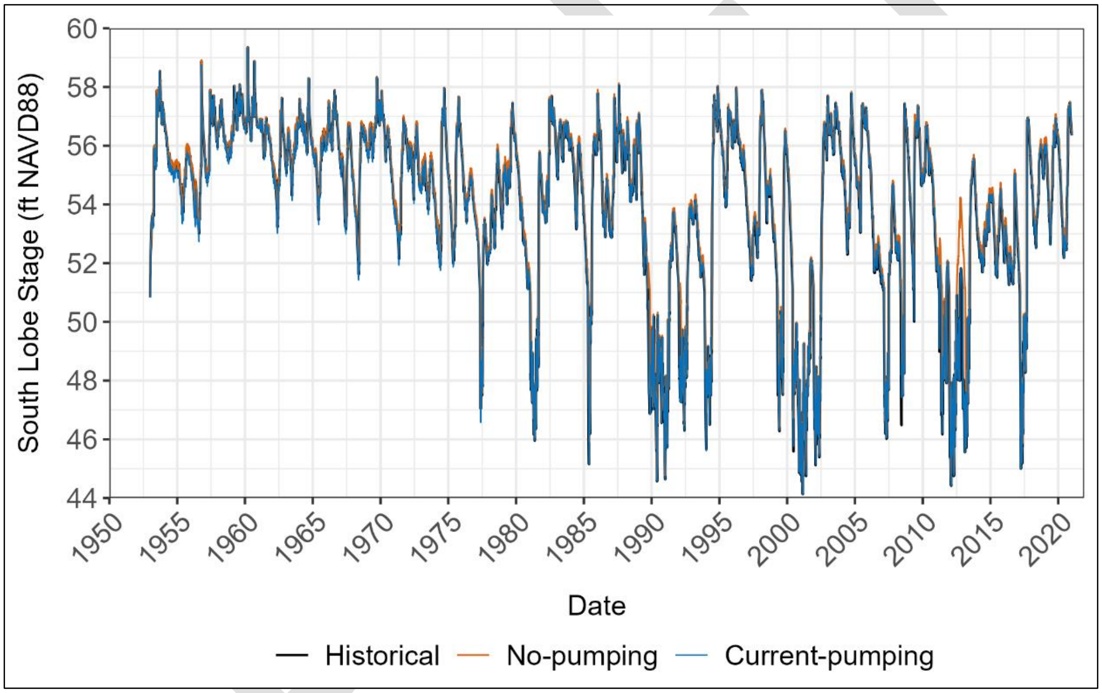


Figure 19. Estimated historical (black), no-pumping (orange), and current-pumping (blue) condition levels for the South Lobe of Lake Prevatt.

Assuming climatic, rainfall, and other conditions present from 1953 to 2020 are repeated over the next 70 years, the current-pumping condition reflects the future condition of water levels if the average regional groundwater pumping does not change from the 2016–2020 condition. The current-pumping time series can then be used to determine current available water (i.e., freeboard or deficit) by assuming that future climatic variability is similar to the past and that future pumping impact is held constant at the current condition. Our understanding of possible future climatic conditions is limited and there are significant uncertainties in global climate model predictions. According to the Florida Climate Institute, the climatic cycles such as El Niño Southern Oscillations (ENSO), Atlantic Multidecadal Oscillation (AMO), and the Pacific Decadal Oscillation (PDO) have the strongest influence on Florida's climate variability (Kirtman et al. 2017). ENSO cycles typically range from three to seven years, PDO cycles typically range from 20 to 30 years and AMO cycles typically range 60 to 80 years (Schlesinger and Ramankutty 1994; Obeysekera et al. 2011; Kuss and Gurdak 2014).

There are strong relationships of short- and long-term climatic cycles such as ENSO and AMO with rainfall and groundwater levels in Florida (Enfield et al. 2001; Kelly 2004; Kuss and Gurdak 2014). These strong relationships are not expected to disappear in the foreseeable future. Because of this, MFLs determinations require the use of long-term level simulations to capture the effects of short- and long-term climatic variations such as ENSO and AMO.

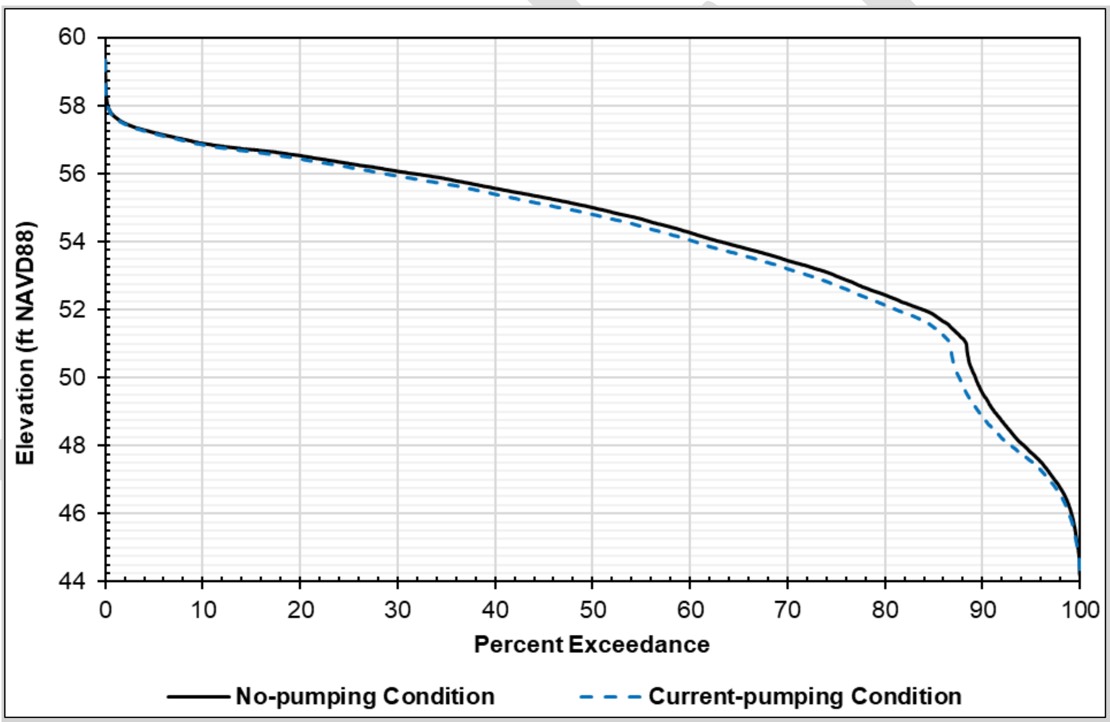


Figure 20. No-pumping (black) and current-pumping (blue, dashed) condition percent exceedance curves for Lake Prevatt south lobe water levels.

SJRWMD acknowledges that the MFLs analyses assume that hydrological history will repeat itself. Given the uncertainties in future rainfall and temperature predictions by global climate models, this assumption is thought to be appropriate but needs to be regularly tested by implementing an adaptive management strategy.

The SJRWMD implements an adaptive management strategy (described later in this report) to address continuing challenges and uncertainties in ecohydrological data and tools. Moreover, MFLs are established to prevent water bodies from being significantly harmed by water withdrawals, not changes in rainfall conditions. Therefore, using historical conditions to generate current-pumping condition time series is considered reasonable.

Environmental Analyses

MFLs environmental analyses are focused on the determination of relevant environmental attributes (e.g., fish and wildlife habitat) and beneficial uses (e.g., recreational value) for a given water body, as well as determining criteria and thresholds to protect these functions and values. This process typically includes consideration of:

- site-specific field-based ecological and soils data;
- non-ecological environmental data (e.g., data used to assess recreational values);
- topographical information;
- historical, remotely sensed and mapped data, aerial photographs; and
- scientific literature and agency reports.

Using this information, a determination is made of the most important environmental values for a given water body. Next, appropriate criteria are determined to represent these environmental values, and a minimum hydrologic regime (MFLs condition) is determined, that ensures their protection.

Environmental Criteria

A variety of environmental criteria were evaluated to ensure protective minimum levels were developed for Lake Prevatt. SJRWMD's standard event-based criteria were first evaluated to determine whether this approach was appropriate for Lake Prevatt. In recent years, it has been demonstrated that this conventional approach may not be appropriate for all systems (e.g., see Sutherland et al. 2021). Where appropriate, event-based metrics are typically developed to protect ecological and soils-based functions and values in floodplain and near-shore environments (e.g., see Sutherland et al. 2017).

Vegetation, soils, and elevation data for Lake Prevatt were collected along 3 transects. A literature and data search were conducted prior to establishing field transects. Vegetation and soil sampling followed standard field procedures. Detailed information on field transect selection and data collection methods are provided in Appendix C.

The preliminary environmental criteria assessed were chosen based on their potential to protect nonconsumptive environmental values and beneficial uses (also called WRVs), as mandated by Rule 62-40.473, *F.A.C.* The final recommended environmental metrics, used to establish minimum levels for Lake Prevatt, are described below.

Event-based Approach

A water body's hydroperiod is the primary driver of wetland plant distribution and diversity, hydric soils type and location, and to a varying degree freshwater fauna (Foti et al. 2012; Murray-Hudson et al. 2014). A system's natural hydrologic regime, represented by variable flooding and/or drying events, is necessary to maintain the extent, composition, and function of wetland and aquatic communities (Poff et al. 1997; Thorp et al. 2008; Arthington 2012). Wetland and aquatic species, and hydric soils require a minimum frequency of critical hydrologic events for long-term persistence (Richter et al. 1997; Winemiller 2005; Arthington 2012).

Event-based MFLs metrics are developed to protect a minimum hydroperiod necessary for the maintenance of specific environmental values. They are described with a magnitude component (i.e., water level or flow), a duration, and a return interval; the latter is also expressed as frequency of exceedance or non-exceedance. SJRWMD's conventional event-based approach defines ecologically relevant events as the combination of their magnitude and duration components. The return interval/frequency of these events is often described as the manageable component (i.e., minimum thresholds are associated with an allowable change in the frequency of events; Neubauer et al. 2008); however, it is recognized that a minimum hydroperiod could be developed that holds magnitude and frequency constant and associates a change in duration with significant harm; both methods would still (theoretically) arrive at the same minimum hydroperiod.

The aim of SJRWMD's event-based metrics is to prevent significant harm due to an excessive change in event frequency caused by water withdrawal. Significant harm is associated with impairment or loss of ecological structure (e.g., reduction in wetland acreage) or function (e.g., insufficient fish reproduction or nursery habitat).

Protective event frequencies (i.e., recommended return intervals) are determined using hydrologic event probabilities called Surface Water Inundation and Dewatering Signatures (SWIDS). SWIDS of vegetation species or communities provide a hydrologic range for a population of water bodies, that exhibit a transition from drier conditions on one side of the range to wetter conditions on the other side. A primary assumption is that these hydrologic signatures are for a group of hydrologically similar water bodies and thus provide an estimate of the shift in return interval of flooding or drying events that can occur before causing significant harm to the species or community in question. See Appendix C for details regarding SWIDS analysis and event frequency calculations.

Because hydroperiods vary spatially and temporally (Mitsch and Gosselink 2015), and because species and communities are adapted to different parts of a system's hydrologic regime, multiple event-based (or other) criteria are typically used to protect different portions of a system's ecological structure and function (Neubauer et al. 2008). For many systems, SJRWMD sets three MFLs; minimum frequent high (FH), minimum average (MA), and minimum frequent low (FL) water levels. In some cases, a minimum infrequent high (IH) and/or minimum infrequent low (IL) water level may also be set (Figure 21).

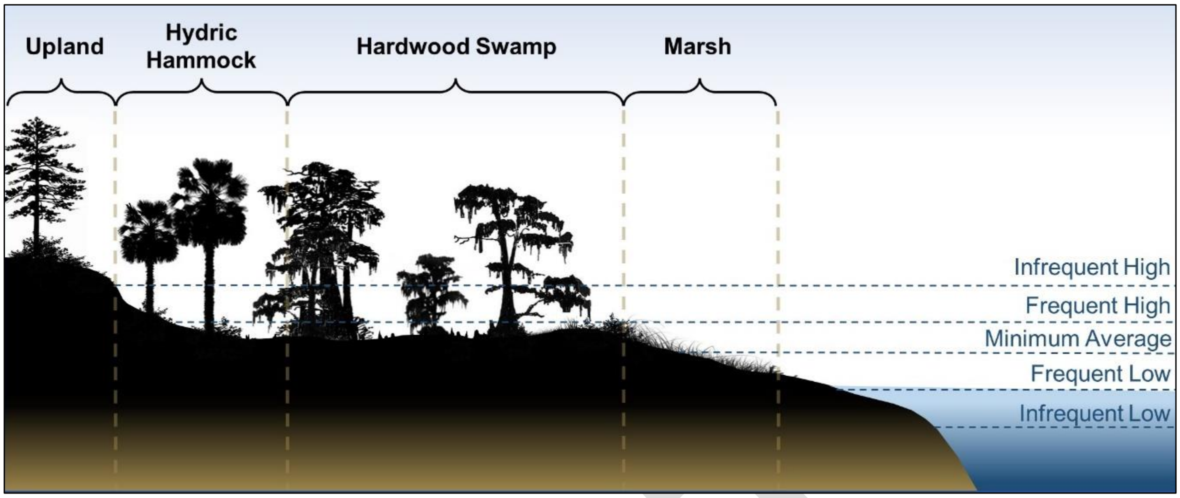


Figure 21. Conceptual drawing showing the five most common minimum flows and/or levels developed using SJRWMD's event-based approach.

For more stable systems, event-based MFLs are based on either protecting a minimum number of flooding events (FH) or preventing more than a maximum number of drying events (MA, FL) to protect stable wetland communities and organic soils. Due to the shallow morphology of the lake, Lake Prevatt maintains permanent wetland communities despite having highly fluctuating lake levels. Therefore, three event-based metrics were evaluated for Lake Prevatt (a FH, MA, and FL; see below and Appendix C for details).

Site Selection and Data Collection

Vegetation, soils, and elevation data were collected along three transects for the Lake Prevatt MFLs (Figure 22). Transects typically extended from uplands, across multiple wetland communities, to open water. A search of aerial photographs, and remotely sensed data (e.g., mapped vegetation, soils, and other data) was conducted prior to establishing field transects. Proposed transects were inspected prior to intensive data collection to confirm the presence of desired features, including:

- representative examples of common wetland communities;
- unique or high-quality wetlands;
- edge of uplands or open water; and
- deep organic and other hydric soils.

Vegetation and soil sampling followed standard field procedures. More information on field transect selection and data collection methods is provided in Appendix C.

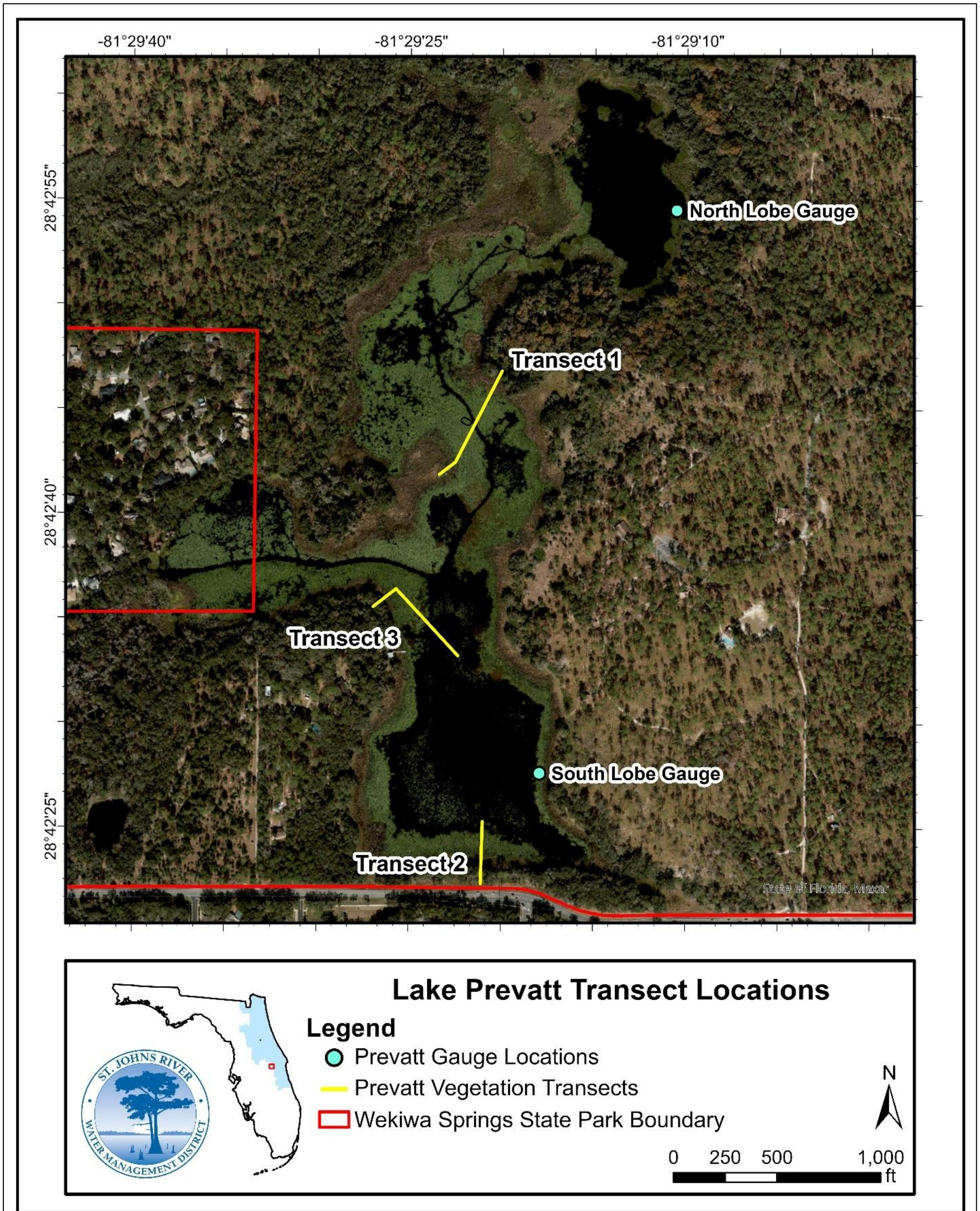


Figure 22. Transect and gauge locations used in establishing MFLs for Lake Prevatt, Orange County, FL.

Minimum Frequent High (FH)

The FH is typically associated with a seasonally flooded hydroperiod "…where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, lake levels causing inundation are expected to occur several weeks to several months every one to two years" (Rule 40C-8.021, *F.A.C.*).

The purpose of the FH is to ensure frequent inundation in seasonally flooded wetlands, sufficient to maintain species composition, vegetative structure, and associated ecological functions. The FH is meant to maintain a sufficient occurrence of high surface water levels during typical periods of normal or above normal rainfall.

At Lake Prevatt, transitional shrub swamp communities are the highest elevation (most upslope) seasonally inundated wetlands. The recommended frequent high (FH) level for Lake Prevatt is 53.8 ft NAVD88 (Table 9), with an associated exceedance duration of 30 continuous days and a return interval of 1.3 years (approximately 77 events per 100 years on average).

<u>FH Magnitude</u>

The FH level of 53.8 ft NAVD88 equals the average elevation of the transitional shrub swamp communities from all Lake Prevatt transects. The goal of the recommended FH level is to maintain the spatial extent and functions of the transitional shrub swamp and the contiguous wetlands at Lake Prevatt. Maintaining water levels at this average elevation will promote inundation and/or saturation conditions sufficient to support hydrophytic (i.e., obligate, facultative wet, and facultative) plant species (Ahlgren and Hansen 1957; Menges and Marks 2008; Mace 2015), thus preventing a permanent downward shift of the shrub swamp and other wetland communities.

The FH level represents a high lake stage that generally occurs during moderate high water events and typically results in inundated wetlands with ecological benefits. At Lake Prevatt, the FH level of 53.8 ft NAVD88, corresponding to a level exceeded 62.2% in the historical record, is lower than a P50 elevation of 54.9 ft in the historical record. Due to the flashy nature of water levels at Lake Prevatt, water often stages higher than the FH level but is usually not maintained for the recommended FH duration described below.

<u>FH Duration</u>

The duration component of the FH is a minimum of 30 days continuously flooded at or above 53.8 ft NAVD88. A 30-day continuous flooding event represents a sufficient period of soil saturation or inundation needed to protect the structure and functions of seasonally flooded wetland plant communities (Hill et al. 1991). The life cycles of many fishes are related to seasonal water level fluctuations, particularly annual flood patterns (Guillory 1979). Several months of flooding should be provided to ensure fish access to the floodplain and ensure nesting success (Knight et al. 1991).

The 30-day flooding duration roughly corresponds to the duration of saturation that defines the upper boundaries of many wetlands. From a regulatory standpoint, the U.S. Army Corps of Engineers (USACE) uses durations of saturation between 5% and 12.5% of the growing season in most years as the standard in their wetland delineation manual (Environmental Laboratory 1987). Given the year-round growing season in Florida, this corresponds to durations of 18 to 46 days. However, the National Research Council (NRC 1995) has recommended a shorter duration hydroperiod to define wetland hydrology: saturation within 1 ft of the soil surface for a duration of 2 weeks (14 days) or more during the growing season in most years. In addition, the 30-day flooding duration is sufficient to cause the mortality of young upland plant species that have become established in the transitional shrub swamps during low water events, maintaining the hydrophytic structure and diversity (Ahlgren and Hansen 1957; Menges and Marks 2008).

FH Return Interval

The FH is typically associated with a "seasonally flooded" hydroperiod as previously defined. For many MFLs systems, an FH return interval of 2 to 3 years is typical. For lake Prevatt, the return interval for the FH was based on a SWIDS analysis of wetland vegetation communities (see Appendix C). The SWIDS analysis for Lake Prevatt was conducted using hydrologic signatures for communities most similar to the Lake Prevatt transitional shrub communities. This analysis resulted in the FH return interval with a mean + SE of 1.3 years. The frequency of this event occurring every 1.3 years is more often than many FH events at other MFL sites; however, this is due to the highly fluctuating nature of Lake Prevatt water levels, previously described. The lower elevation of the FH at Lake Prevatt results in a more frequent flooding event as higher lake stages that are reached within the POR are not commonly maintained for at least a 30-day duration.

Table 9. Environmental criteria and minimum levels for Lake Prevatt, Orange County, FL.

Minimum Levels	Environmental Criteria	Minimum Level Components		
		Level (ft NAVD88)	Duration (days)	Return Interval (years)
FH	Transitional shrub swamp communities; fish and wildlife habitat	53.8	30	1.3
MA	Organic soils; seasonally flooded wetland habitat	49.7	180	3.5

Minimum Average (MA)

The goal of the recommended MA is to prevent excessive drying of deep organic soils within Lake Prevatt, which could cause soil oxidation and subsidence and other adverse environmental impacts. The general indicator of protection is a low water level during typical years that, while exposing the surface of organic soils, keeps the average elevation saturated or inundated frequently enough to maintain natural structure and associated ecological functions. These events are usually associated with dry season conditions during periods of normal precipitation. For many systems the MA event recurs, on average, every year or two for approximately six months during the dry season. The purpose of the MA is to ensure groundwater withdrawals do not increase the number of these low water events beyond the recommended return interval of this event.

The specific indicator of protection is a low water level that is 0.3 foot below the average surface elevation of histosols and histic epipedons (i.e., soils with organic layers ≥ 8 inches thick) within the floodplain. The recommended MA level for Lake Prevatt is 49.7 ft NAVD88 (Table 9), with an associated average non-exceedance duration of 180 days and a return interval of 3.5 years (approximately 29 events per 100 years on average).

<u>MA Magnitude</u>

The MA level of 49.7 ft NAVD88 equals 0.3 ft below the average ground surface elevation of the histic epipedon and histosols in the shallow marshes and/or deep marshes of Lake Prevatt observed in 2021 at Transect 1 (50.0 ft NAVD88). Maintaining saturation at this elevation will help prevent decomposition of soil organic matter (loss of soil carbon) that could occur if wetlands soils are drained or hydrologically altered, resulting in lowered land surface elevations (i.e., subsidence). Work by Osborne et. al (2014) in the upper basin of the St. Johns River supports the use of an approximate 0.3 ft offset for soils saturation necessary to prevent oxidation and subsidence. Their work suggests a maximum drawdown from average organic soil of 0.28 ft, very similar to the standard MA offset of 0.3 ft. Periodic flooding to the MA elevation will maintain saturated soil conditions across the majority of the deep organic soils within Lake Prevatt (See Appendix C for details).

Despite the presence of extensive and continuous wetlands in Lake Prevatt, the high fluctuation in lake levels results in organic accumulation more similar to that observed in sandhill lakes. The fluctuating water table creates an occasionally flooded transitional zone that cannot build up organic matter due to its relatively frequent drying (Figure 23; JEA 2006). Therefore, the deeper areas of Lake Prevatt contain all of the deep organic material present from the settlement of detrital material in areas of lower elevation and the ability to maintain those soils at lower elevations as a result of less frequent exposure to aerobic conditions. At Lake Prevatt, organic material only remains saturated for sufficient periods within deep marsh or open water habitats. Despite accumulating lower in the lake's elevation profile, the organics that accumulate in deeper portions of the lake still support important ecological functions that rely on the maintenance of sufficiently high soil water table levels to prevent accelerated oxidation of organic matter (Maushbach 1992; Pant and Reddy 2001; Price et al. 2002; Schipper and McLeod 2002; Morris et al. 2004; Blodau et al. 2004).

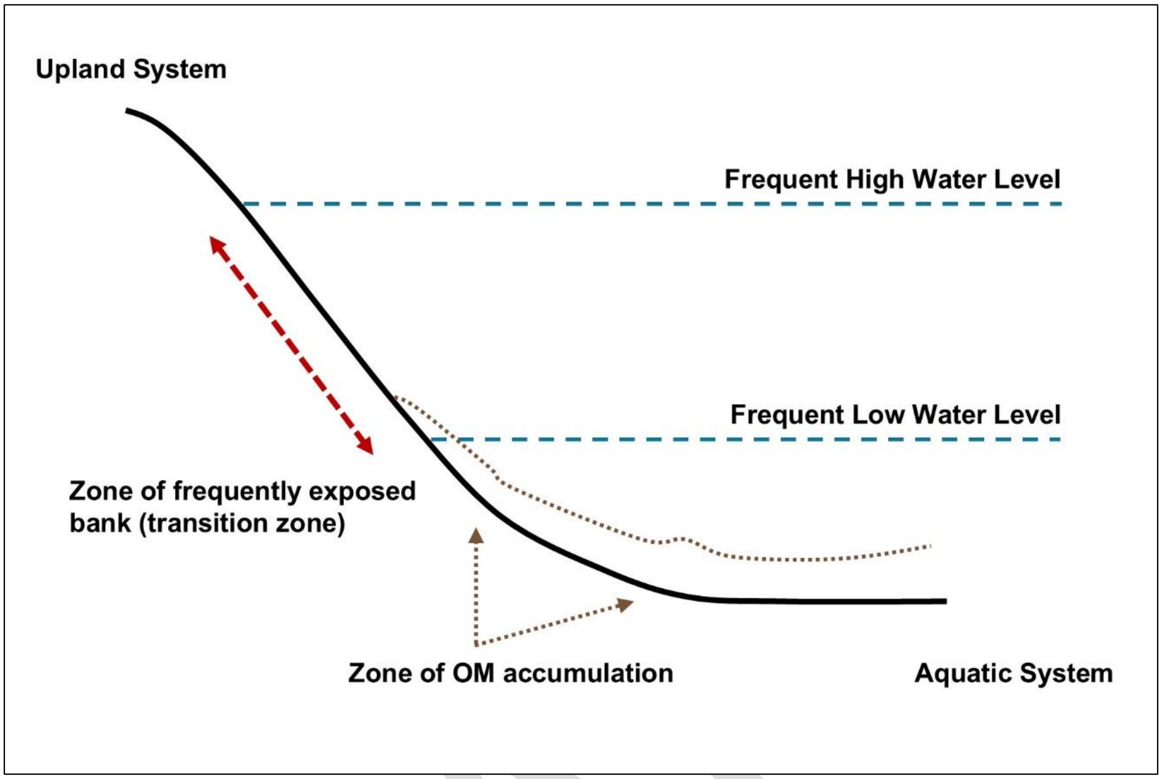


Figure 23. Pattern of organic matter (OM) accumulation in sandhill lakes. Adapted from JEA Inc. (2006).

<u>MA Duration</u>

The recommended duration for the average non-exceedance water level for the MA is 180 days. The 180-day average duration will typically allow for numerous, short duration, alternating aerobic and anaerobic conditions of the organic soil surface elevation. Field and laboratory experiments by Reddy et al. (2006) with organic soils in the Upper St Johns River Basin found that shorter duration dewatering events, alternating aerobic and anaerobic conditions, are less likely to result in oxidation of organic matter. The wicking action of the capillary fringe in these soils likely inhibits soil oxidation.

The recommended MA 180-day duration is also supported by the flooding and dewatering characteristics described by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Official Soil Series Descriptions website (NRCS 2018) for the soils identified in the Lake Prevatt basin. The majority of soils within Lake Prevatt are characterized as Basinger fine sand. Most soils within the Lake Prevatt basin are sandy except for those in the deepest portion of the lake where organic matter accumulates. The Basinger series is described as ponded under natural conditions very frequently for very long durations (6 to 9 months). The 180-day duration is within this corresponding non-exceedance duration.

Wetland soils are a medium for denitrification, which can promote improved aquatic/wetland water quality. The denitrification process is most effective in wetlands that are subject to alternating aerobic and anaerobic conditions because the aerobic conditions allow for conversion of ammonium to nitrate (nitrification), which is then subject to denitrification (Payne 1981; Reddy and DeLaune 2008) under anaerobic conditions. The benefits of alternating wet and dry events supports the use of a 180-day average event duration, rather than a continuous flooding or drying event.

<u>MA Return Interval</u>

The MA event defines a surface water level and/or flow that usually occurs during normal dry seasons. The MA is usually associated with the "typically saturated" hydroperiod category:

> "…where for extended periods of the year the water level should saturate or inundate. This results in saturated substrates for periods of one-half year or more during non-flooding periods of typical years. Water levels causing inundation are expected to occur fifty to sixty per cent of the time over a long-term period of record. This water level is expected to have a recurrence interval, on the average, of one or two years over a long-term period of record…" (Rule 40C-8.021, *F.A.C.*).

For many MFLs systems, an MA return interval of 1.7 to 1.8 years is typical. For Lake Prevatt, the MA return interval was based on hydroperiod data collected for other organic soils data from similar MFL sites (see Appendix C). Based on this analysis, an MA return interval of 3.5 years (~29% probability) was calculated for Lake Prevatt and equals the mean (minus standard error) return interval for these other Florida lakes. The calculated return interval for the Lake Prevatt MA is approximately twice that of what is typically recommended for this metric in lakes with low lake level fluctuation. However, Lake Prevatt is a highly fluctuating system and the larger calculated return interval was a result of Lake Prevatt MA elevations being compared with other lakes with similar levels of high lake level fluctuation. While the frequency of the dewatering event is decreased as compared with lower fluctuation lakes, a drawdown to 49.7 ft NAVD88 would represent a substantial water drawdown unlikely to occur at Lake Prevatt at a higher frequency. Therefore, the longer return interval calculated from hydrologically similar systems in combination with the lower MA elevation is a more realistic representation of the natural hydrologic regime at Lake Prevatt (see Appendix C for SWIDS calculation details).

Frequent Low (FL)

The FL level is defined in Rule 40C-8.021, *F.A.C.*, as "…a chronically low surface water level…that generally occurs only during periods of reduced rainfall. This level is intended to prevent deleterious effects to the composition and structure of floodplain soils, the species composition and structure of floodplain and instream biotic communities, and the linkage of aquatic and floodplain food webs."

At Lake Prevatt the purpose of the minimum frequent low (FL) is to prevent an excessive number of frequent drying events to protect the shallow and deep marsh habitats and their associated ecological functions; however, the inclusion of this metric was deemed inappropriate for the site and ultimately removed. With the highly fluctuating lake levels at Lake Prevatt, the shallow marsh – deep marsh boundary is more representative of short-term rainfall trends than a long-term interaction between climate and lake hydrology (see Appendix C for details regarding fluctuating shallow marsh boundary).

Therefore, while still assessed and discussed in appendices, the FL at Lake Prevatt was not considered as a final event-based metric. Compared to the FH and MA, based on a longer-lived vegetation community (transitional shrub swamp composed of mainly buttonbush) and organic soils respectively, the FL may be considered a less reliable metric at Lake Prevatt. Such transient communities are not ideal for the creation of MFL metrics relying on long-term trends. This has also been documented at other lakes with high water level fluctuation (see Sutherland et al. 2021). Additionally, the draft FL originally developed is ultimately protected by the hydrologic regimes required to protect other metrics. Please see Appendix C for more information on the FL and Appendix D for a comparison of the FL assessment with other metrics.

Hydroperiod Tool – Fish and Wildlife Habitat Metrics

In an effort to ensure that MFLs developed for Lake Prevatt will adequately protect *all* relevant ecological and human-use values, it was deemed prudent to develop other metrics to augment the event-based criteria described above. Using the recently developed “hydroperiod tool” approach, seven ecological and recreational criteria were developed and assessed. This approach has been used to set MFLs for other lakes in SJRWMD (Jennewein et al. 2020; Sutherland et al. 2021). Using the Geographic Information System (GIS)-based hydroperiod tool, it is possible to evaluate the effects of water level decline on the average area of various fish and wildlife habitats or areas with specific depths important for recreation (see Appendix C and G for details).

The hydroperiod tool functions primarily with raster (grid-based) representations of the environment, in which elevation values from a DEM are subtracted from an interpolated water surface elevation on a grid cell by grid cell basis, producing a new raster surface containing elevation or depth of water for each grid cell (Figure 24. Conceptual diagram of the hydroperiod tool used to estimate the relationship between lake stage and habitat area.). A DEM for Lake Prevatt was developed using 2018-2019 LIDAR data, acoustic doppler current profiler data, aerial photography, and survey data (see Appendix F for more details). The hydroperiod tool was used to estimate habitat area for different fish and wildlife habitats as well as for important recreational values, represented by specific depth ranges. With the hydroperiod tool, the effect of bathymetry and water level reduction on habitat area is quantifiable. Using this tool, habitat and recreational areas were compared under different pumping conditions (e.g., no-pumping versus current-pumping condition; Figure 19).

The significant harm threshold used for this metric is a 15% change in areal extent (acreage) of different habitats. A 15% reduction of habitat availability has been used by other water management districts as a significant harm threshold for MFLs (Munson and Delfino 2007). This threshold has been peer reviewed and has been the basis for numerous adopted MFLs (see SJRWMD MFLs developed for Lakes Brooklyn and Geneva or SWFWMD MFLs developed for Crystal River, Gum Slough, Chassahowitzka River, and Homosassa River, among others). While many MFLs using this threshold are for flowing systems, a 15%

reduction in habitat has also been used as a critical threshold for lakes and is based on bird species richness studies (Hoyer and Canfield 1994; Leeper et al. 2001; Emery et al. 2009). This threshold is also within the range (10 to 33%) of percent allowable change documented in other studies (Munson and Delfino 2007).

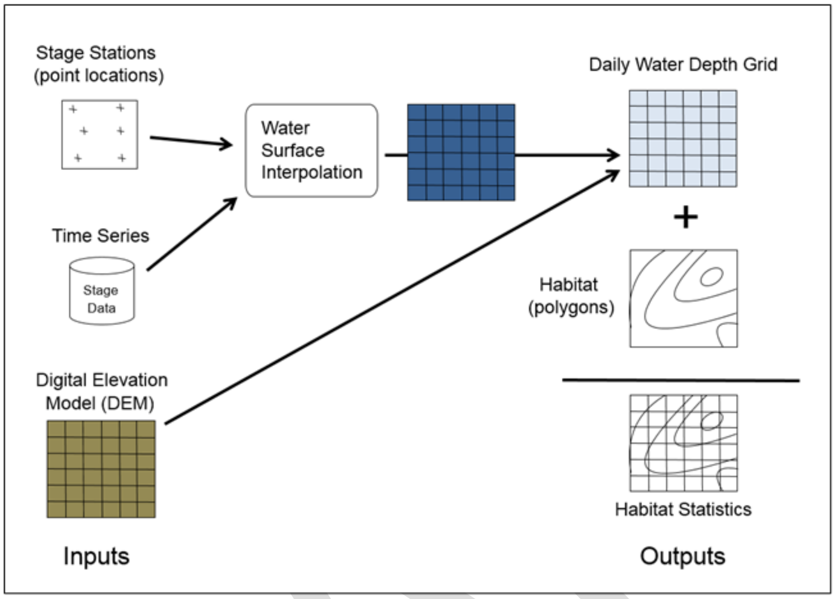


Figure 24. Conceptual diagram of the hydroperiod tool used to estimate the relationship between lake stage and habitat area.

Hydroperiod Tool Metric Results

Average area was calculated for the 7 hydroperiod tool metrics (See Appendix C for details regarding fish and wildlife habitats and recreational metrics evaluated). Average habitat area was calculated for each day in the POR, using the stage/habitat area relationship derived from the hydroperiod tool and the simulated water surface elevations for the no-pumping condition. The MFLs condition for the hydroperiod tool metrics equals a 15% reduction in average habitat area under the no-pumping condition (i.e., habitat area averaged across the entire no-pumping condition lake level timeseries). Assessment of habitat metrics is then the comparison of the average habitat area under no-pumping condition to the average habitat area under the current-pumping condition (see *MFLs Assessment* for details).

<u>Nearshore Fish and Wildlife Habitat</u>

At Lake Prevatt, the four fish and wildlife habitats have varying trends with increases in water levels (Figure 25). Shallow water metrics including Small Waders (0.1 – 0.5 ft) and Large Waders (0.1 – 1.0 ft) peak in maximum area at around 52 ft (equivalent to a P81). Above 52 ft in water elevation, as depths increase, these metrics generally decrease in area. Game Fish Spawning (1.0 – 4.0 ft) peaks between 52 and 55 ft (equivalent to a P46). Emergent vegetation (0.1 – 6.0 ft) peaks at about 56 ft (equivalent to a P28). The wide, flat shape of the Lake Prevatt basin plays a large role in these trends, with shallow water habitat area increasing as low water exposes normally flooded areas and thus becomes available to wading birds and other wildlife.

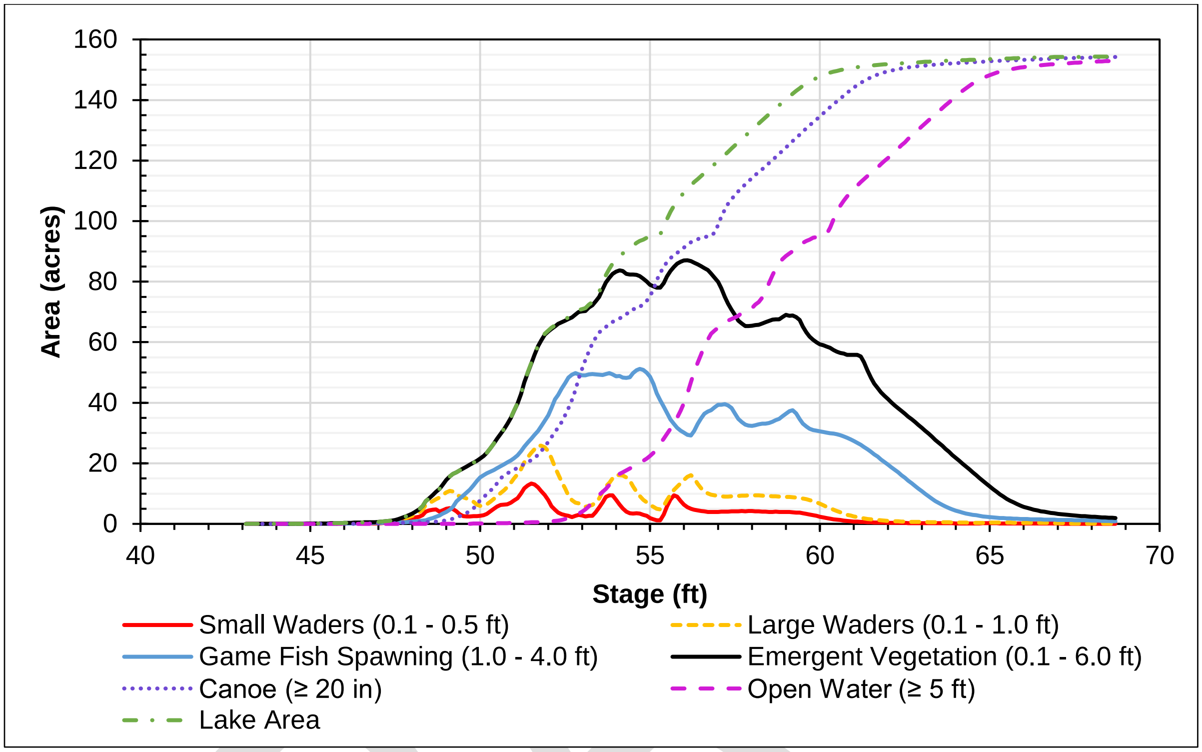


Figure 25. Stage-area trends for Lake Prevatt hydroperiod tool metrics.

Recreation and Lake Area Metrics

Recreation and lake area metrics have similar trends as they all continue to increase with increasing lake stage. Lake area (> 0 ft) begins to increase around 48 ft as the majority of lake bottom at Prevatt has an elevation at or above 48 ft (Figure 25). The Canoe metric (≥ 20 in) begins to increase dramatically around 49.5 ft as much of the lake becomes available for canoeing at this elevation (Figure 25). Canoeing is a common recreation at Lake Prevatt by surrounding youth camps; the water is accessed either by a floating dock on the west side of the lake or by the lake edge.

Open water area (≥ 5 ft) is essential for the maintenance of deep marsh habitats, deep water habitat, and water quality. Open water habitats begin to increase in acreage around 53 ft stage elevation when the lake transitions from an open wetland system to a larger, contiguous water body (Figure 25). Table 10 displays the area of each Hydroperiod Tool metric if the minimum metric condition (15% reduction from the NP condition) were to occur.

Table 10. Hydroperiod tool area calculations under a no-pumping condition and the minimum metric condition (15% reduction from NP).

Habitat	No-pumping Condition Habitat Area (average acres)	Minimum Metric Condition (15% reduction from average NP acres)
Small Waders	4.6	3.9
Large Waders	10.7	9.1
Game Fish Spawning	36.0	30.6
Emergent Vegetation	70.0	59.5
Canoe	66.9	56.9
Open Water	27.2	23.1
Lake Area	85.7	72.8

MFLs Determination Summary

The MFLs determination for Lake Prevatt involved the evaluation of critical environmental features applying two different methods: an event-based approach and a hydroperiod tool approach. Using the event-based approach, a frequent high (FH) and a minimum average (MA) were established and involved determining a minimum hydroperiod to maintain key environmental features (e.g. transitional shrub swamp). The hydroperiod tool method utilized a stage-area analysis of the lake in relation to key lake habitat or recreational features (e.g. emergent marsh, open water, etc.). The minimum metric condition (i.e., recommended threshold or habitat reduction) for the Lake Prevatt environmental criteria are summarized below (

Table 11). The assessment of environmental criteria (i.e., whether they are being met currently) is discussed below in the *MFLs Assessment* section.

Table 11. Summary of environmental criteria and MFLs condition for each criterion for Lake Prevatt.

Environmental Criterion	Environmental Value(s) Protected	MFLs Condition		
Event-based Metrics		**Level (ft)**	**Duration (days)**	**Return Interval (years)**
FH Average Transitional Shrub Swamp	Transitional shrub communities; fish and wildlife habitat	53.8	30	1.3
MA Mean elevation of organic soils minus 0.3 ft	Organic soils; seasonally flooded wetland habitat	49.7	180	3.5
Hydroperiod Tool Metrics		**No-pumping (average acres)**		**Minimum Metric Condition (15% reduction from NP condition)**
Small Waders	Fish and wildlife habitat	4.6		3.9
Large Waders	Fish and wildlife habitat	10.7		9.1
Game Fish Spawning	Fish and wildlife habitat	36.0		30.6
Emergent Vegetation	Fish and wildlife habitat	70.0		59.5
Canoe	Recreation/Aesthetics/Water Quality/Fish Habitat	66.9		56.9
Open Water	Recreation/Aesthetics/Water Quality/Fish Habitat	27.2		23.1
Lake Area	Recreation/Aesthetics/Water Quality/Fish Habitat	85.7		72.8

MFLs Assessment

MFLs are not meant to represent optimal conditions but rather set a limit to water withdrawals beyond which significant harm would occur. A fundamental assumption of SJRWMD's approach is that alternative hydrologic regimes exist that are lower than a priority water body's historical (i.e., pre-withdrawal) regime but that still protect important environmental functions and values from significant harm caused by water withdrawals. The MFLs determination described above defined a minimum metric condition necessary to protect each relevant environmental criteria (

Table 11. Summary of environmental criteria and MFLs condition for each criterion for Lake Prevatt.

Table 11).

The MFLs assessment involves comparing the minimum metric condition for each metric with the hydrologic regime subject to impacts from current groundwater withdrawals (termed the current-pumping condition). This comparison determines whether each criterion at each system is being achieved under the current-pumping condition and if there is water available for additional withdrawal (freeboard), or whether water is necessary for recovery (deficit). If any of the MFLs environmental criteria are not being achieved under the current-pumping condition, indicating a deficit of water, a recovery strategy is necessary. If the MFLs are currently being achieved, but a deficit is projected within the 20-year planning horizon, a prevention strategy is needed. No-pumping and current-pumping condition water level datasets developed for Lake Prevatt were used to calculate freeboard or deficit and determine whether the system is in recovery, prevention, or neither (see *Hydrological Analyses* section above and Appendix B for more details).

Current Status Assessment

Current MFLs status for Lake Prevatt was based on the 2016–2020 current-pumping condition (see Appendix B for details) and was assessed for each of the environmental criteria used in the MFLs determination. The minimum metric required to protect each of the final criteria was compared to the current-pumping condition to determine a UFA freeboard for each criterion. UFA freeboards were compared to determine the most constraining environmental criterion for the system. The most constraining criterion is the basis for recommended minimum levels for Lake Prevatt.

Event-based metrics

Current status for event-based metrics (i.e., FH and MA) was assessed using frequency analysis. The current-pumping condition frequency of each event was compared to the recommended minimum frequency to determine if the level was met under current conditions. The difference between the current-pumping condition water level and MFLs magnitude represents the freeboard or deficit in the lake (see Appendix D for details). UFA freeboards represent the amount of allowable change in the aquifer and are calculated after determining the lake freeboard. UFA freeboard calculations are provided below and details are provided in Appendix D.

Frequent High (FH)

Under the current-pumping condition, the FH flooding event (53.8 ft NAVD88, duration of 30 days) has a probability of 83.3% (1.2-year return interval). The MFL condition would allow for this event to occur at a probability of 76.9% (1.3-year return interval). Based on the current-pumping elevation and return interval, the FH is met under current conditions and has a UFA freeboard of 2.5 ft (

Table *12*). See Appendix D for details regarding UFA freeboard calculations.

Minimum Average (MA)

Under the current-pumping condition, the MA drying event (49.7 ft NAVD88, duration of 180 days) has a probability of 21.3% (4.7-year return interval). The MFL condition would allow for this event to occur at a probability of 28.6% (3.5-year return interval). Based on the current-pumping elevation and return interval, the MA is met under current conditions and has a UFA freeboard of 2.1 ft (Table 12).

Hydroperiod Tool metrics

Current status was assessed for seven hydroperiod tool metrics at Lake Prevatt. Hydroperiod tool metrics were assessed by estimating the reduction in area (acreage) over the simulated POR under the current-pumping condition, relative to the no-pumping condition. The impact threshold for these metrics is an allowable 15% reduction in average area under the no-pumping condition over the entire POR.

All hydroperiod tool metrics at Lake Prevatt had freeboard available under the current-pumping condition. Small waders, large waders, and game fish spawning all had >3.5 ft of UFA freeboard. Emergent vegetation and lake area freeboard values were consistent with those calculated from the event-based metrics, while the canoeable area and open water area metrics had lower UFA freeboards (

Table *12*). The result of the same calculated freeboard of 2.5 ft for the emergent vegetation metric and the FH (transitional shrub swamp) further supports that emergent vegetation and shrub communities are protected by the MFLs condition (open water).

Summary of UFA Freeboard

The status assessment for Lake Prevatt indicates that all evaluated environmental criteria are met under the 2016 – 2020 current-pumping condition. All metrics have freeboard in the UFA (i.e., do not have a deficit), and therefore the waterbody is not in recovery (

Table *12*). The most constraining of the hydroperiod tool metrics, and all metrics overall, was the open water 5 ft metric with 0.9 ft UFA freeboard. Therefore, the MFLs condition for Lake Prevatt is based on a UFA drawdown of 0.9 ft; this minimum hydrologic regime will ensure protection of the open water area metric and all other less constraining metrics.

Table 12. UFA freeboard for Lake Prevatt MFLs.

Environmental Criterion	Environmental Value(s) Protected	UFA Freeboard (ft)

Event-based Metrics		
FH Average Transitional Shrub Swamp	Transitional shrub communities; fish and wildlife habitat	2.5
MA Mean elevation of organic soils minus 0.3 ft	Organic Soils	2.1
Hydroperiod Tool Metrics		
Small Waders	Fish and wildlife habitat	> 3.5
Large Waders	Fish and wildlife habitat	> 3.5
Game Fish Spawning	Fish and wildlife habitat	> 3.5
Emergent Vegetation	Fish and wildlife habitat	2.5
Canoe	Recreation/Aesthetics/Water Quality/Fish Habitat	1.7
Open Water	Recreation/Aesthetics/Water Quality/Fish Habitat	0.9
Lake Area	Recreation/Aesthetics/Water Quality/Fish Habitat	2.2

Future / Projected Status

MFLs water bodies currently being achieved but projected to not be achieved within the 20-year planning horizon, are in "prevention" and require a prevention strategy to be developed concurrently with the MFLs. Whether MFLs are being achieved within the planning horizon is determined by comparing the current-pumping condition UFA freeboard of the most constraining environmental criterion to the amount of projected UFA drawdown at the planning horizon.

Water withdrawal information used to assess future status was based on water supply planning projections for the planning horizon (i.e., not current CUP allocations). The projected UFA drawdown at the 20-year planning horizon (2045) was estimated for Lake Prevatt using the ECFTX v2.0 groundwater model. Assuming all future pumping is equal to projected 2045 water demand, the predicted UFA drawdown is 0.16 ft.

Under current-pumping conditions, all Lake Prevatt MFLs are met, and the most constraining (open water ≥ 5 ft) has a UFA freeboard of 0.9 ft. The additional 0.16 ft of drawdown at the planning horizon results in a remaining UFA freeboard of 0.74 ft at 2045. Therefore, Lake Prevatt is not in prevention or recovery.

Water Resource Values

The following section provides a summary of the WRVs assessment conducted for Lake Prevatt. See Appendix E for details regarding the WRVs metrics used and how they were analyzed.

Rule 62-40.473, *F.A.C.* requires that "consideration shall be given to…environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology." The environmental values described in Rule include:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation.

Consideration of these values is meant to ensure that recommended MFLs protect the full range of water-related functions that provide beneficial use to humans and ecological communities. However, all 10 WRVs are typically not applicable to a specific priority water body because of the varying hydrologic characteristics (e.g., riverine vs. lake systems or the presence/absence of tidal influence). The suite of 10 WRVs listed above were divided into the following three groups based on relevance to Lake Prevatt and are also based on whether they protect ecological versus non-ecological structure and function.

- Group 1: WRVs 3, 8, and 10
- Group 2: WRVs 2, 4, 5, and 7
- Group 3: WRVs 1, 6, and 9

Group 1: WRV 3, WRV 8, and WRV 10

The three WRVs in Group 1 were determined not applicable and thus were not considered as part of this assessment. WRV 3 (Estuarine resources) is not relevant because Lake Prevatt is land-locked and generally has no surface water connection to any estuarine resources. WRV 8 (Sediment loads) is not applicable because lakes typically serve as sinks instead of sources of sediment loads. Since the transport of inorganic materials as bed load is relevant only in flowing systems, this WRV was not considered for this evaluation. WRV 10 (Navigation) is not considered for these lakes because this WRV is for the navigation of large watercraft, which is not possible at Lake Prevatt.

Group 2: WRV 2, WRV 4, WRV 5, and WRV 7

The four WRVs in group 2 (Fish and wildlife habitat and the passage of fish, the transfer of detrital material, the maintenance of freshwater storage and supply, and the filtration and absorption of nutrients and other pollutants) are associated with and depend on the ecological functions and biochemical processes provided by the wetland communities surrounding Lake

Prevatt. The two event-based metrics (FH and MA) and the hydroperiod tool metrics (i.e., fish and wildlife habitats) evaluated are designed to protect these important ecological functions and biochemical processes by protecting resident habitats from significant harm. The FH, MA, and hydroperiod tool metrics were developed to ensure the protection of a minimum hydrologic regime necessary to protect these functions and values. The Lake Prevatt MFLs conditions were determined based on the most constraining metrics out of all those evaluated with the assumption that protecting the most constraining metric would be protective of the other, less constraining metrics.

The MFLs condition (based on a 15% reduction in open water area; Figure 26) results in less than a 15% change in area for all other hydroperiod tool metrics (i.e., less than the significant harm threshold for these metrics; Table *13*; See Appendix E for details). The MFLs condition also ensures that the FH and MA are met because the available water for the MFLs condition (0.9 ft) is less than that available with the FH (2.5 ft) or MA (2.1 ft). The MFLs condition of 15% reduction in open water area therefore provides protection for each of the four WRVs in this group.

Group 3: WRV 1, WRV 6, and WRV 9

The three WRVs in Group 3 (Recreation in and on the water, Aesthetic and scenic attributes, and Water quality) are closely related to lake area and depth; in addition to these, WRV 6 is also related to the condition of wetland vegetation communities in and around the lake. The determination of whether these WRVs are protected was based on whether there was significant harm (i.e., defined as 15% reduction) from the no-pumping condition to the MFLs condition, for specific criteria evaluated for each WRV. The MFLs condition represents the minimum hydrologic regime necessary to protect all the minimum levels (i.e., it is based on the most constraining levels for Lake Prevatt). The WRVs assessment results indicate that all three WRVs in this group do not exceed the 15% reduction threshold and are therefore protected by the MFLs condition (Table *14*; See Appendix E for details).

Table 13. Percent change in habitat area relative to NP condition for each habitat type based on the most constraining environmental metric (15% in open water area).

Environmental Criterion	NP Condition area (average acres)	MFLs Condition area (average acres)	Percent change in NP condition area based

			on most constraining metric
Small wading bird forage habitat	4.6	4.6	0.3
Large wading bird forage habitat	10.7	10.5	1.1
Game fish spawning habitat	36.0	35.1	2.5
Emergent marsh vegetation	70.0	66.6	4.8
Canoe	66.9	61.5	8.0
Open water (≥ 5 ft)	27.2	23.3	14.2
Lake area	85.7	80.0	6.6

Table 14. Criteria evaluated to determine protection of Rule 62-40.473 environmental values by the recommended MFLs condition for Lake Prevatt.

WRV	Environmental Criteria Evaluated	Protected by the MFLs Condition?
Recreation in and on the water	Canoe paddling depth	Yes
Fish and wildlife habitats and the passage of fish	FH, MA, small wader habitat, large wader habitat, game fish spawning habitat, emergent marsh vegetation, and open water	Yes
Estuarine resources	As the lake is land locked and has no surface water connection to estuarine resources, this environmental value is not relevant.	NA
Transfer of detrital material	Compliance with the recommended FH provides for the protection of flooding events necessary for the transfer of detrital material at Lake Prevatt.	Yes

WRV	Environmental Criteria Evaluated	Protected by the MFLs Condition?
Maintenance of freshwater storage and supply	Because the overall purpose of the event-based MFLs, hydroperiod tool metrics, and other WRVs is to protect environmental resources, and other non-consumptive beneficial uses while also providing for consumptive uses, this environmental value is considered protected if the remaining relevant values are protected.	Yes
Aesthetic and scenic attributes	Lake area and open water metrics	Yes
Filtration and absorption of nutrients and other pollutants	Compliance with the recommended FH and MA levels provides for the protection of wetland communities which will maintain filtration and absorption of nutrients and other pollutants at Lake Prevatt.	Yes
Sediment loads	Transport of inorganic materials such as suspended or bed load is considered relevant only in flowing systems. Therefore, it is not considered for this evaluation.	NA
Water quality	Water quality nutrient standards and open water	Yes
Navigation	Navigation of large watercraft not possible. The primary navigation on Lake Prevatt is by recreational boaters. This WRV is addressed under WRV 1.	NA

CONCLUSIONS AND RECOMMENDATIONS

Minimum levels were originally adopted for Lake Prevatt in 1997 (Chapter 40C-8.031, *F.A.C.*; Hupalo 1997). Upon review, it was determined that minimum levels for the system should be reevaluated to ensure that they are based on the latest data and most up to date methods. Lake Prevatt is an important resource within the CFWI's regional network of MFLs and critical indicators of potential impacts due to groundwater pumping.

As a part of Wekiwa Springs State Park, and a water body within the Wekiva River Basin, Lake Prevatt is designated as an Outstanding Florida Water. In addition to this designation, Lake Prevatt is used for recreational purposes, offers foraging area for a diverse array of avian and other wildlife, and is connected to the UFA. The minimum levels recommended herein were developed to protect these outstanding biological, scenic, and recreational resources.

This work has resulted in the recommendation to modify the adopted MFLs for Lake Prevatt. These recommendations are based on current SJRWMD MFLs determination and assessment methodologies, including analysis of an additional 28 years of hydrologic data collected since the original MFLs were adopted and the development of a hydrologic regime under current and no-pumping conditions using the most recent surface and groundwater models.

RECOMMENDED MINIMUM LEVELS

Minimum levels were developed for Lake Prevatt using a variety of metrics that were developed to protect important ecological structures and functions, as well as human beneficial uses. The assessment of the recommended minimum levels included evaluating primary ecological metrics as well as assessing a comprehensive suite of both ecological and human-use criteria (see Water Resource Values section and Appendix E). These criteria were developed to ensure that both the main lake body and surrounding wetland attributes and functions are protected by the recommended MFLs condition.

Three minimum levels, a minimum P25, P50, and P75, are recommended for Lake Prevatt (Figure 26; Table 15). These three percentiles were calculated from the MFLs condition lake-level time series data. This is the lake-level time series is based on the protection of open-water habitat, and is associated with a UFA freeboard of 0.9 ft (Figure 27; Table 12). Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average, and high levels for Lake Prevatt.

A suite of 10 environmental values, listed in Rule 62-40.473, *F.A.C.*, were considered to ensure that the MFLs condition protects all relevant WRVs for Lake Prevatt. Based on this evaluation, the SJRWMD concludes that the recommended minimum levels for Lake Prevatt will also protect all relevant WRVs.

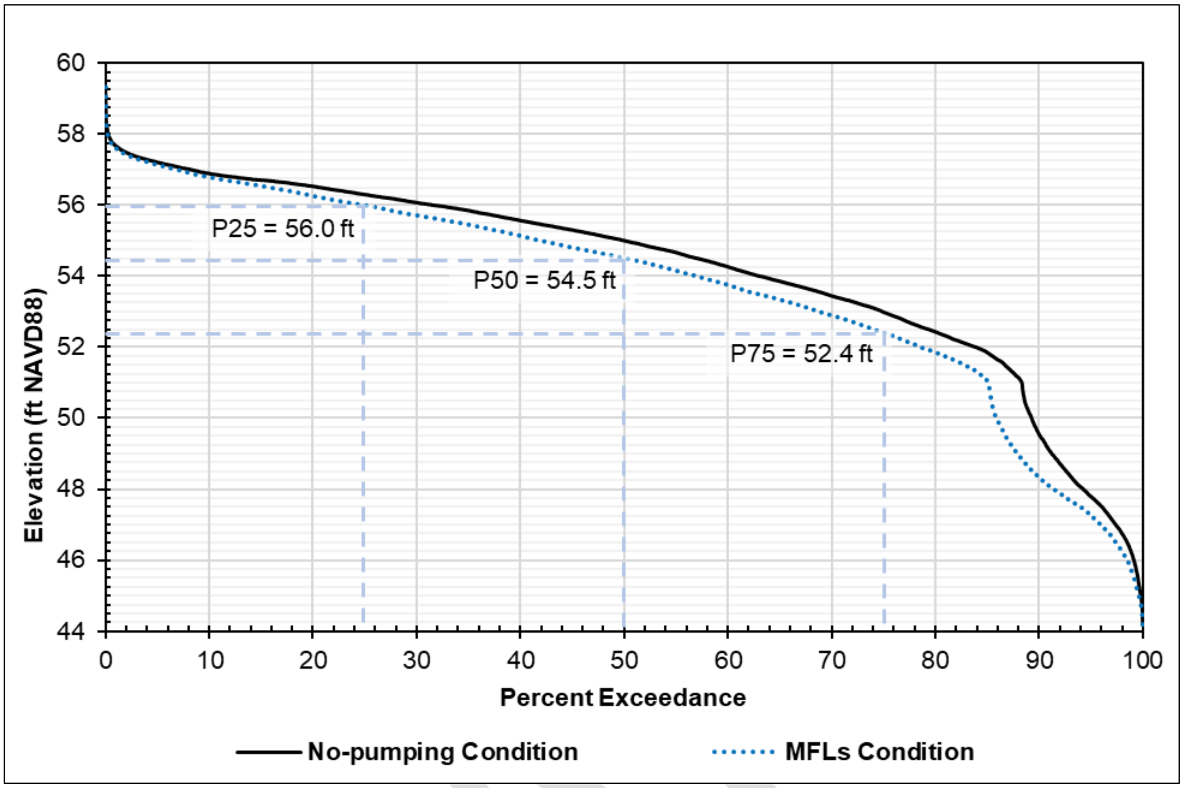


Figure 26. MFLs condition exceedance curve (blue, dotted) based on most constraining environmental metric as compared to the no-pumping condition exceedance curve (black, solid). Dashed lines indicate the recommended minimum P25, P50, and P75 elevations for Lake Prevatt, Orange County, Florida.

Table 15. Currently adopted and recommended Minimum Levels for Lake Prevatt, Orange County, Florida.

Original (adopted)			Recommended	
Level	**Level (ft NAVD88)**	**Hydroperiod Category**	**Percentile**	**Recommended minimum lake level (ft NAVD88)**
Minimum Frequent High	55.0	Seasonally Flooded	25	56.0
Minimum Average	52.0	Typically Saturated	50	54.5
Minimum Frequent Low	49.9	Semipermanently Flooded	75	52.4

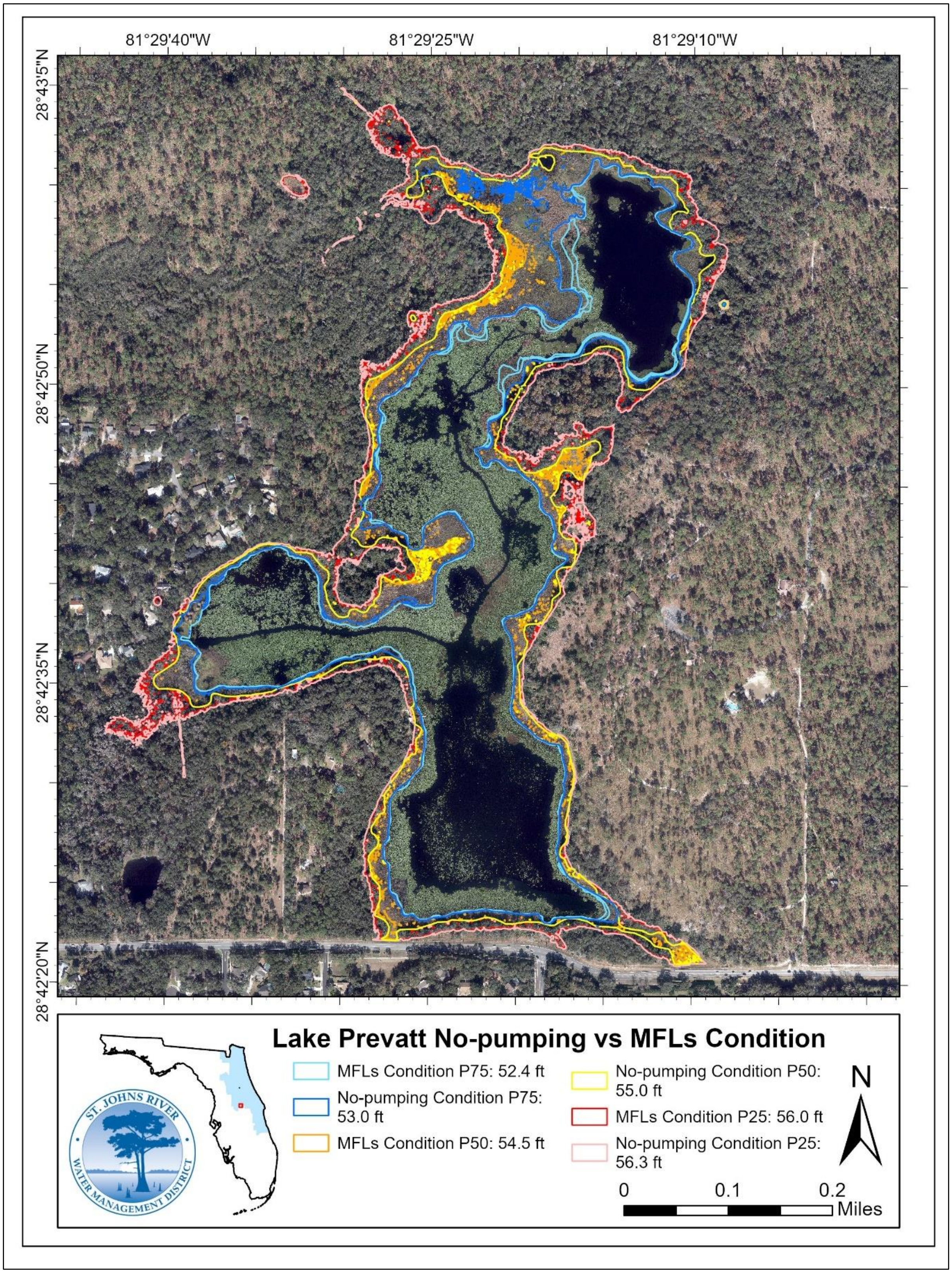


Figure 27. Differences between no-pumping and MFLs condition lake levels at above normal (P25), normal (P50), and below normal (P75) lake levels at Lake Prevatt. All elevations are in ft NAVD88.

The ECFTX v2.0 groundwater model was used for the Lake Prevatt groundwater pumping impact analysis. This impact analysis was used to develop the current-pumping condition time series data used in the MFLs assessment (See Appendix B for details of the groundwater pumping impact analysis). Assuming climatic, rainfall, and other conditions present from 1953 to 2020 are repeated over the next 70 years, the current-pumping condition reflects the future condition of water levels if the average regional groundwater pumping does not change from the 2016–2020 condition.

Because the recommended MFLs condition in the lake is less than current-pumping condition, Lake Prevatt has freeboard available. Out of the three event-based metrics and seven hydroperiod tool metrics analyzed, the open water (≥ 5 ft) metric was most constraining, resulting in a UFA freeboard of 0.9 ft. Because the projected UFA drawdown at 2045 is less than the available freeboard, Lake Prevatt is not in prevention. The information presented in this report is preliminary and will not become effective until adopted by the SJRWMD Governing Board and incorporated in Rule 40C-8.031, *F.A.C.*

Ongoing Status / Adaptive Management

Given data, modeling and other ecohydrological analysis uncertainties, it is prudent to test implicit assumptions made as part of setting and assessing MFLs. The SJRWMD acknowledges that the MFLs determination and assessment methods, described herein, assume that the Lake Prevatt system hydrological history will repeat itself in the future.

Given the lack of information about the future, and substantial uncertainties in future rainfall and temperature predictions by global climate models, this assumption is thought to be appropriate but needs to be regularly tested by implementing an adaptive management strategy.

The SJRWMD will implement an adaptive management strategy to address continuing challenges and uncertainties in ecohydrological data and tools. This screening level analysis, considering changes in rainfall and temperature trends and uncertainty, will be performed to monitor the status of the adopted P25, P50, and P75 for Lake Prevatt.

This analysis will be performed approximately every five years as part of regional water supply planning efforts or as needed. MFLs status will also be monitored periodically by reviewing the status of system-specific constraining metrics. If the average long-term observed levels fall below the adopted minimum level, this will trigger a more detailed analysis. This analysis will determine whether reductions in lake levels are caused by groundwater pumping or rainfall and whether a further evaluation of the MFLs is necessary. If the screening level analysis shows that MFLs are still being met, then no further actions are required beyond continued monitoring.

LITERATURE CITED

Ahlgren, C. E. and H. L. Hansen. 1957, Some effects of temporary flooding on coniferous trees. Journal of Forestry 59: 647-650.

Arthington A.H. 2012. Environmental Flows: Saving rivers in the third millennium. University of California Press: Berkeley.

Blodau, C., N. Basiliko, and T. Moore. 2004. Carbon Turnover in Peatland Mesocosms Exposed to Different Water Tables. Biogeochem. 67: 331-351.

Boniol, D., and K. Mouyard. 2016. Recharge Areas to the Floridan aquifer in the St. Johns River Water Management District. GIS Layer. Supplemental information to Boniol, D., and K. Mouyard, 2016a: Recharge to the Upper Floridan quifer in the St. Johns River Water Management District, Florida. Technical Fact Sheet SJ2016-FS1, St. Johns River Water Management District.

Brooks, H.K. 1982. Guide to the Physiographic Divisions of Florida. Compendium to the map Physiographic Divisions of Florida, 8-5M-82. Univ. of Florida, Institute of Food and Agricultural Sciences, Cooperative Extension Service, Gainesville, FL.

[CFWI HAT] Central Florida Water Initiative Hydrologic Analysis Team. 2020. Model Documentation Report. East-Central Florida Transient Expanded (ECFTX) Model Report. Retrieved from https://cfwiwater.com/pdfs/ECFTX_Model_Final_Report_Feb_2020.pdf

Emery, S. D. Martin, D. Sumpter, R. Bowman, and R. Paul. 2009. Lake surface area and bird species richness: analyses for minimum flows and levels rule review. Technical report prepared for the Southwest Florida Water Management District.

Enfield, D. B., Mestas-Nunez, A. M., Trimble, P. J., 2001. The Atlantic Multidecadal Oscillation and its relationship to rainfall and river flows in the continental U.S. Geophysical Research Letters. Vol 28. Pg. 2077–2080.

Environmental Laboratory. 1987. Corps of Engineers wetland delineation manual, Technical Report Y-87-1 US Army Engineers Waterways Experiment Station. Vicksburg, MS.

Epting, R. J., Robison, C. P., & Reddi, R. C. 2008. Gauge record hydrologic statistics: Indicators for lake classification. Environmental Bioindicators, *3*(3-4), 193-204.

[FDEP] Florida Department of Environmental Protection 2015. Final Basin Management Action Plan for the Implementation of Total Maximum Daily Loads for Nutrients by the Florida Department of Environmental Protection in the Middle St. Johns River Basin for Wekiva River, Rock Springs Run, and Little Wekiva Canal. Adopted by the FDEP Division of Environmental Assessment and Restoration, Watershed Restoration Program, Tallahassee FL in cooperation with the Wekiva Basin Management Action Plan Working Group. October 2015. 211 p.

FDOT. 2021. Orange County. 0.25 ft resolution. Tallahassee, FL: Florida Department of Transportation.

Foti, R., M. del Jesus, A. Rinaldo, and I. Rodriguez-Iturbe. 2012. Hydroperiod regime controls the organization of plant species in wetlands. Proceedings of the National Academy of Sciences, November 27, 2012. 109(48) 19596-19600

Friedemann and Hand. 1989. Typical water quality values for Florida's lakes, streams and estuaries. Florida Department of Environmental Regulation.

Gao, X. 2008. Nutrient TMDLs for the Wekiva River (WBIDs 2956, 2956A, and 2956C) and Rock Springs Run (WBID 2967). TMDL report. Tallahassee, FL: Division of Water Resource Management, Florida Department of Environmental Protection.

Gordu, F., Sisco, L., Basso, R., Zhang, H., Patterson, J., Kwiatkowski, P., & Obeysekera, A. 2022. East-Central Florida Transient Expanded (ECFTX) V2.0 Model Report. Retrieved from https://cfwiwater.com/pdfs/ECFTX_2.0_Report_040522_final.pdf

Guillory, V. 1979. Utilization of an Inundated Floodplain by Mississippi River Fishes. Florida Scientist 42(4):222–228.

Hill, M.T., W.S. Platts, and R.L. Besches. 1991. Ecological and geological concepts for instream and out-of-channel flow requirements, Rivers 2(3):198-210.

Hoyer, M.V. and D.E. Canfield, Jr. 1994. Bird abundance and species richness on Florida lakes: influence of trophic status, lake morphology, and aquatic macrophytes. Hydrobiologia 297/280: 107-119.

Hupalo, R.B. 1997. Minimum surface water levels determined for Prevatt Lake, Orange County. St. Johns River Water Management District, Palakta, FL.

JEA Inc. 2006. Sandhill lakes minimum flows and levels values, functions, criteria, and thresholds for establishing and supporting minimum levels. *Prepared for:* ST. JOHNS RIVER WATER MANAGEMENT DISTRICT P.O. Box 1429 Palatka, Florida 32178-1429 *Prepared by:* JONES EDMUNDS & ASSOCIATES, INC.

Jennewein, S., J. Di, F. Gordu, O. Leta, R. Deschler, and A. Sutherland. 2020. Minimum levels determination for Lake Butler, Volusia County, Florida. St. Johns River Water Management District Technical Publication SJ2022-03.

Kelly, M.H. 2004. Florida River Flow Patterns and the Atlantic Multidecadal Oscillation. Draft report. Ecologic Evaluation Section. Southwest Florida Water Management District. Brooksville, FL. 80 pp. + appendix.

Kirtman, B. P., V. Misra, R.J. Burgman, J. Infanti, and J. Obeysekera. 2017. Florida climate variability and prediction. In E. P. Chassignet, J. W. Jones, V. Misra, & J. Obeysekera (Eds.), Florida's climate: Changes, variations, & impacts (pp. 511–532). Gainesville, FL: Florida Climate Institute. https://doi.org/10.17125/fci2017.ch17

Knight, J. G., M. B. Bain, and K. J. Scheidegger. 1991. Ecological characteristics of fish assemblages in two seasonally inundated wetlands. Prepared for U.S. Fish and Wildlife Service, National Ecology Research Center, Auburn, AL.

Kuss, A. J. M. and Gurdak, J. J., 2014. Groundwater level response in U.S. principal aquifers to ENSO, NAO, PDO, and AMO. J. Hydrol., 519, pp. 1939-1952.

Leeper, D., M. Kelly, A. Munson, and R. Gant. 2001. A Multiple-Parameter Approach for Establishing Minimum Levels for Category 3 Lakes. Southwest Florida Water Management District. June 14, 2001. Draft Technical Report.

Mace, J.W. 2015. Minimum levels reevaluation: Lake Melrose, Putnam County, Florida. Technical Publication SJ2015-1. St. Johns River Water Management District, Palatka, FL.

Mattson, R.A., E.F. Lowe, C.L. Lippincott, J. Di, and L. Battoe. 2006. Wekiva River and Rock Springs Run Pollutant Load Reduction Goals. Report to the Florida Department of Environmental Protection. St. Johns River Water Management District, Palatka, FL.

Maushbach, M. 1992. *Soil Survey Interpretations for Wet Soils*. Proceedings of the Eighth International Soil Correlation Meeting. 172-178.

Menges, E.S., and P.L. Marks. 2008. Fire and Flood: Why are South-central Florida Seasonal Ponds Treeless? American Midland Naturalist 159(1): 8-20.

Mitsch, W.J. and J.G. Gosselink. 2015. Wetlands. 5th ed. John Wiley & Sons, NY.

Morris, D.R, B. Glaz and S.H. Daroub. 2004. *Organic Soil Oxidation Potential Due To Periodic Flood and Drainage Depth Under Sugarcane*. Soil Scientist 169:600-608.

Munson, A.B. and J.J. Delfino. 2007. Minimum wet-season flows and levels in southwest Florida rivers. Journal of American Water Resources Association 43(2):522-532.

Murray-Hudson, M., P. Wolski, F. Murray-Huson, M.T. Brown, and K. Kashe. 2014. Disaggregating hydroperiod: components of the seasonal flood pulse as drivers of plant species distribution in floodplains of a tropical wetland. Wetlands 34(5):927-942.

[NRC] National Research Council, 1995. Wetlands: Characteristics and Boundaries. National Academy Press. Washington, DC.

[NRCS] United States Department of Agriculture, Natural Resources Conservation Service. 2018. Official Soil Series Descriptions. Available online at http://soils.usda.gov/technical/classification/osd/index.html.

Neubauer, C.P., G.B. Hall, E.F. Lowe, C.P. Robison, R.B. Hupalo, and L.W. Keenan. 2008. Minimum Flows and Levels Method of the St. Johns River Water Management District, Florida. Environmental Management 42:1101-1114.

Obeysekera, J, J. Park, M. Irizarry-Ortiz, P. Trimble, J. Barnes, J. VanArman, W. Said, E. Gadzinski 2011. Past and Projected Trends in Climate and Sea Level for South Florida. Interdepartmental Climate Change Group. South Florida Water Management District, West Palm Beach, Florida, Hydrologic and Environmental Systems Modeling Technical Report.

Osborne, T.Z., A.M.K. Bochnak, B. Vandam, S. Duffy, L. Keenan, K.S. Inglett, P.W. Inglett, and D. Sihi. 2014. Hydrologic effects on soil stability – loss, formation and nutrient effects. Final Report submitted to St. Johns River Water Management District. University of Florida Wetland Biochemistry Laboratory.

Pant, H.K. and K.R. Reddy. 2001. Hydrologic Influence On Stability Of Organic Phosphorus In Wetland Detritus. J. Environmental Quality 30:668-674.

Payne, W. J. 1981. Denitrification. John Wiley & Sons, New York, NY.

PEC. 1997. Lakes McCoy, Coroni, and Prevatt Drainage Basin Study. Volume 1, March 1997. Professional Engineering Consultants, Inc. Orlando, FL.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime—A Paradigm for River Conservation and Restoration. Bioscience 47(11):769–784.

Price, J., L. Rochetort, and S. Campeau. 2002. Use of Shallow Basins to Restore Cutover Peatlands: Hydrology. Restoration Ecology 10: 259-266.

Reddy, K.R., T.Z. Osborne, K.S. Inglett, and R. Corstanje. 2006. Influence of the Water Levels on Subsidence of Organic Soils in the Upper St. Johns River Basin. Final Report Contract SH45812.

September 2006. Special Publication SJ2007-SP5. St. Johns River Water Management District, Palatka, FL.

Reddy, K. R. and R. D. DeLaune. 2008. Biogeochemistry of Wetlands – Science and Application. CRC Press, New York, NY.

Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? Freshwater Biology 37:231-249.

Sarker, Shiblu, A. Karama, H.N. Capps Herron, and T. Jobes. 2024. Hydrological Modeling of Lake Prevatt, Orange County, Florida. SJRWMD. Palatka FL.

Schipper, L.A. and M. McLeod. 2002. Subsidence Rates and Carbon Loss in Peat Soils Following Conversion to Pasture in the Waikato Region, New Zealand. Soil Use and Management 18:91-93.

Schlesinger ME and Ramankutty N., 1994. An oscillation in the global climate system of period 65-70 years. Nature 367:723–726

[SJRWMD] St. Johns River Water Management District. 2014. Land cover Land use 2014. GIS Layer. Available online at https://data-floridaswater.opendata.arcgis.com/datasets. Accessed 2023.

Sutherland, A.B., R. Freese, J.B. Slater, F. Gordu, J. Di, and G.B. Hall, 2017. Minimum flows determination for Silver Springs Marion County, Florida. Technical Publication SJ-2017-2. St. Johns River Water Management District, Palatka, FL.

Sutherland, A.B., F. Gordu and S. Jennewein. 2021. Minimum levels reevaluation for Lakes Brooklyn and Geneva, Clay and Bradford counties, Florida. St. Johns River Water Management District Technical Publication SJ2021-04. p. 82.

Thorp J.H., M.C. Thoms and M.D. Delong. 2008. In Thorp J.H., M.C. Thoms and M.D. Delong. (Eds.), The riverine ecosystem synthesis: Toward conceptual cohesiveness in river science (1st ed.). London, UK: Academic Press/Elsevier.

[USDA NRCS] United States Department of Agriculture, Natural Resource Conservation Service. 2023. Official Soil Series Descriptions, USDA – NRCS Soil Survey Division. Available online at url: http://soils.usda.gov/technical/classification/osd/index.html

USF Water Institute, School of Geosciences, University of South Florida. (n.d.). *Lake Prevatt – Orange County Water Atlas.* https://orange.wateratlas.usf.edu/waterbodies/lakes/14038

Winemiller, K.O. 2005. Life history strategies, population regulation, and implications for 1033 fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 62:872–885.