APPENDIX C— ENVIRONMENTAL ANALYSES AND DATA

LAKES BROOKLYN AND GENEVA BASIN CHARACTERISTICS

Land Use

Limited residential development has occurred within the watershed of both lakes. Current (i.e., 2014) land use data indicate that residential, commercial, hardwood forest, and non-forested wetlands are adjacent to Lakes Brooklyn and Geneva (Figures 1 and 2). Bordering the residential development in Lake Brooklyn are industrial and commercial zones. Aerial photography from 2016 indicates low-density residential development adjacent to both lakes. According to US census data in 2010 the population density of Keystone Heights was 297 people per square mile. This is higher than Clay county (234 people per square mile) and lower than that of the state of Florida (351 people per square mile).

Wetlands

SJRWMD wetland coverage data for Lakes Brooklyn and Geneva are presented in Figures 3 and 4. Based on 2017 field work, current wetland communities adjacent to these lakes are different from those mapped by the district in 2014. The most common wetland communities adjacent to both lakes now include shallow marsh, deep marsh and submerged aquatic beds.

Hydric Soils

Lake hydrology is key to the development of hydric soils. Hydric soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA Soil Conservation Service 1987). Lake fluctuations over the past few decades have precluded the formation of thick, stable organic soils, but other hydric soils are present. No soils with deep (> 8 inches) organics (i.e., mucks) were mapped adjacent to either Lake Brooklyn or Lake Geneva.

Lake Brooklyn is bordered by the following soil types: Entisols, Penney (Thermic, uncoated Lamellic Quartzipsamments), Ortega, (Thermic, uncoated Typic Quartzipsamments) and Osier (Siliceous, thermic Typic Psammaquents; Figure 5). To the north, Rutlege (Sandy, siliceous, thermic Typic Humaquepts) underlays Alligator Creek. Osier and Rutlege are typically present in warm climates on flood plains, depressions, or stream terraces. Penney soils are typically located in uplands of warm, wet regions.

Lake Geneva is bordered by 27 soil series, according to Natural Resources Conservation Service (NRCS) soil survey data (https://websoilsurvey.sc.egov.usda.gov/; Figure 6). The Spodosol soil series Leon, Mascotte, Ona, Potsburg, and Sapelo fall into the Alaquod suborder. These soils are more typically hydric than other Spodosol suborders. Alaquods often have shallow fluctuating water tables and have plant species adapted to high water tables. The soil series Hurricane, Mandarin, and Ridgeland fall into the Alorthod suborder. These may exhibit similar pedology to the adjacent Alaquods but with more organic carbon within the spodic horizon and better drainage. The Entisol soil series Penney, Ortega, Foxworth, Ridgewood, Kershaw, Candler, and Chipley fall into the Quartzipsamments suborder. A Psammaquent, Scranton, was also observed. Entisols lack horizon development and the quartzipsamments are dominated by quartz sand. Multiple locations surrounding Lake Geneva involved excavation that may have disrupted other soil classes into Entisols. Scranton is likely hydric due to its Aquent classification. The Ultisol soil series Pelham, Stark, and Surrency are Paleaquaalts. The soil series Albany, Apopka, and Blanton are

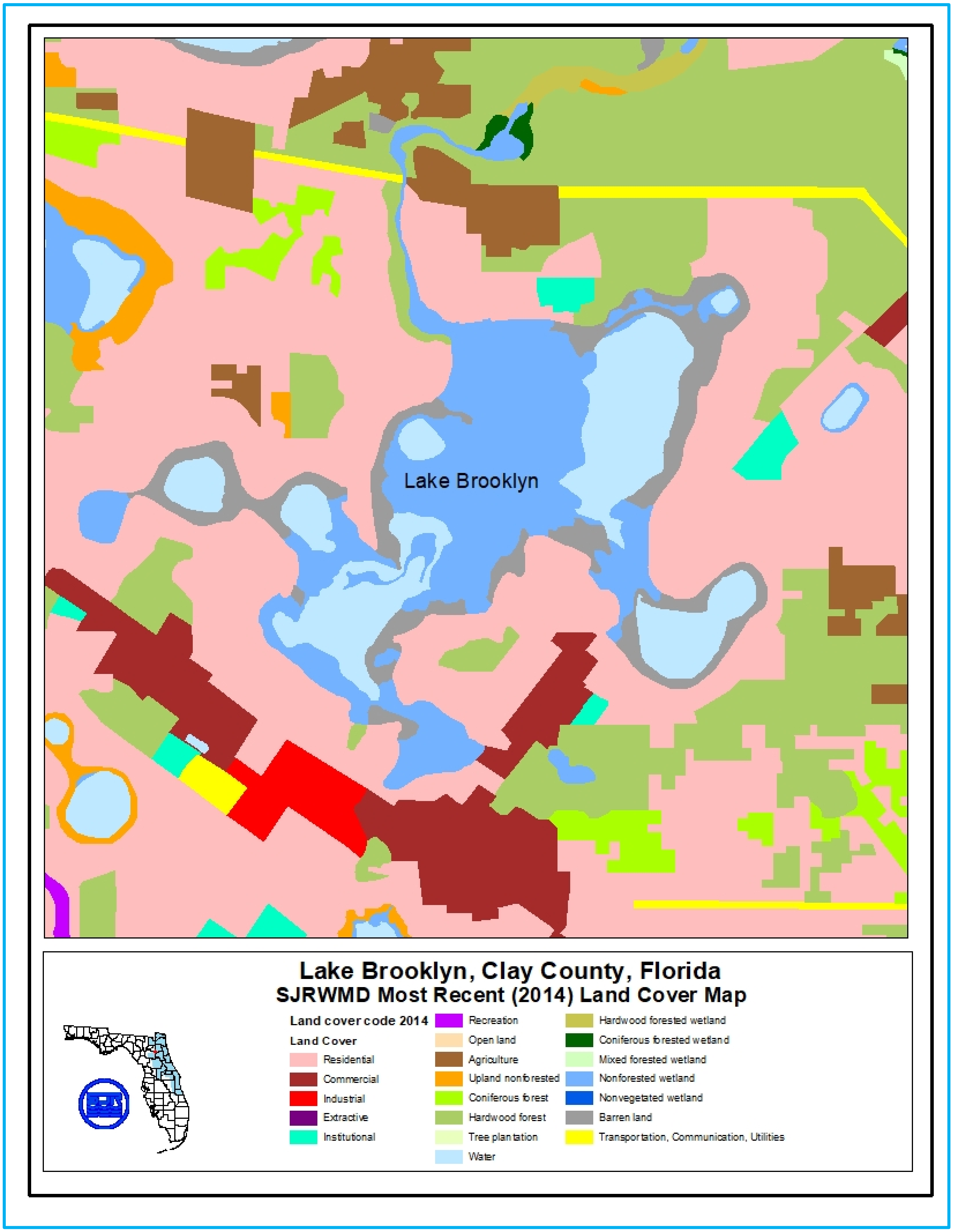

Figure 1. Map showing land use near Lake Brooklyn, Clay county, Florida

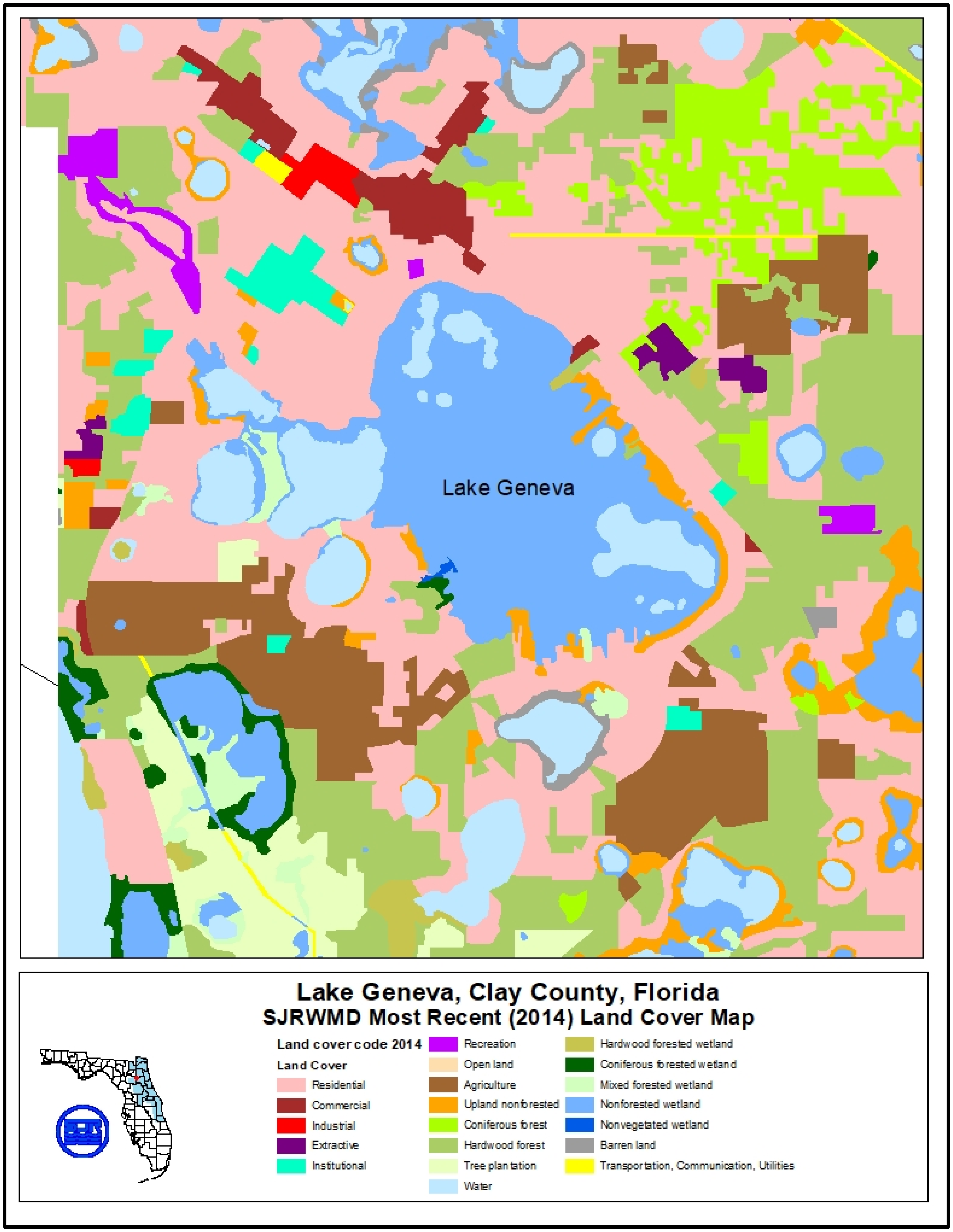

Figure 2. Map showing land use near Lake Geneva, Bradford and Clay counties, Florida

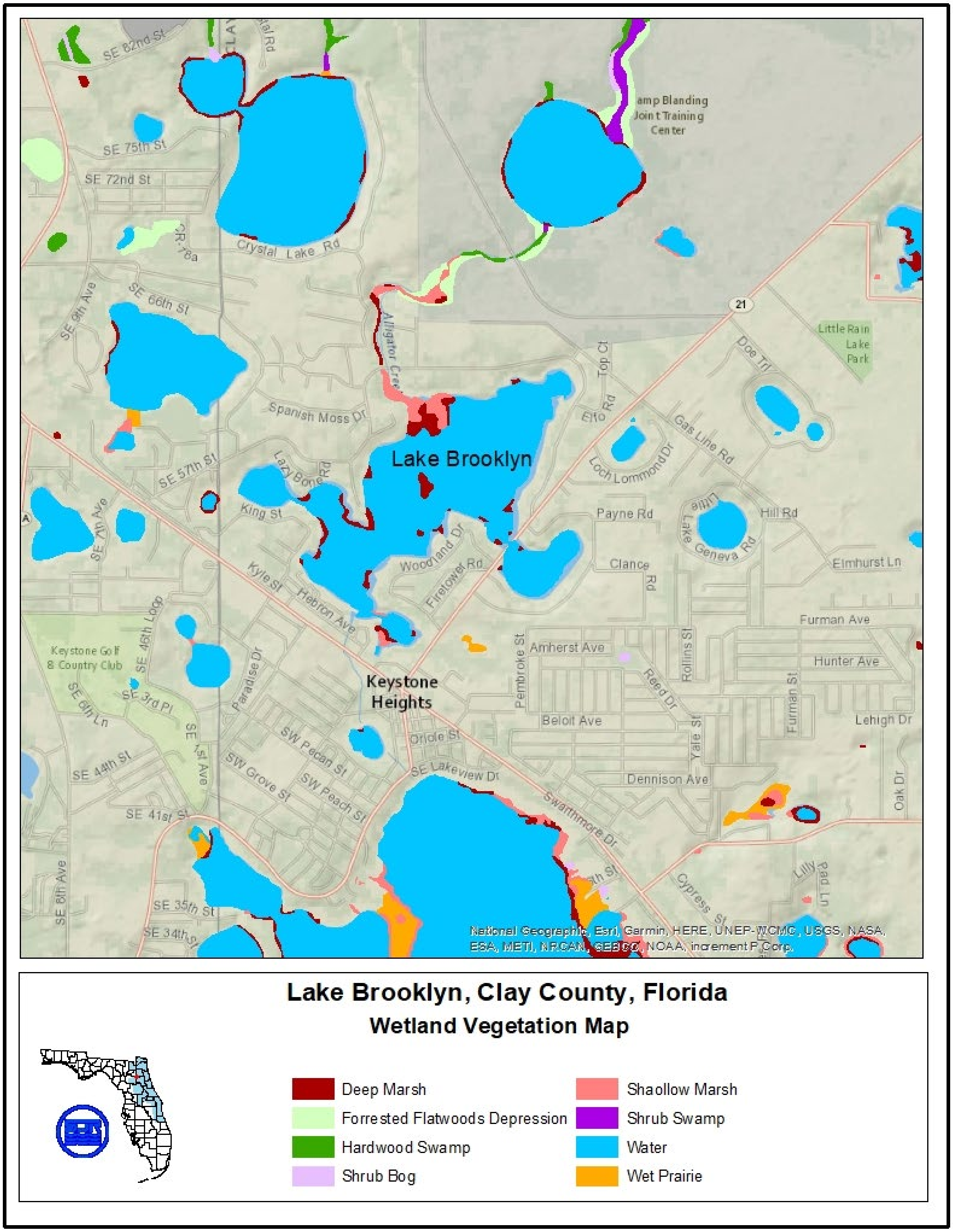

Figure 3. Map showing surveyed wetland vegetation surrounding Lake Brooklyn; Data source SJRWMD, 2014

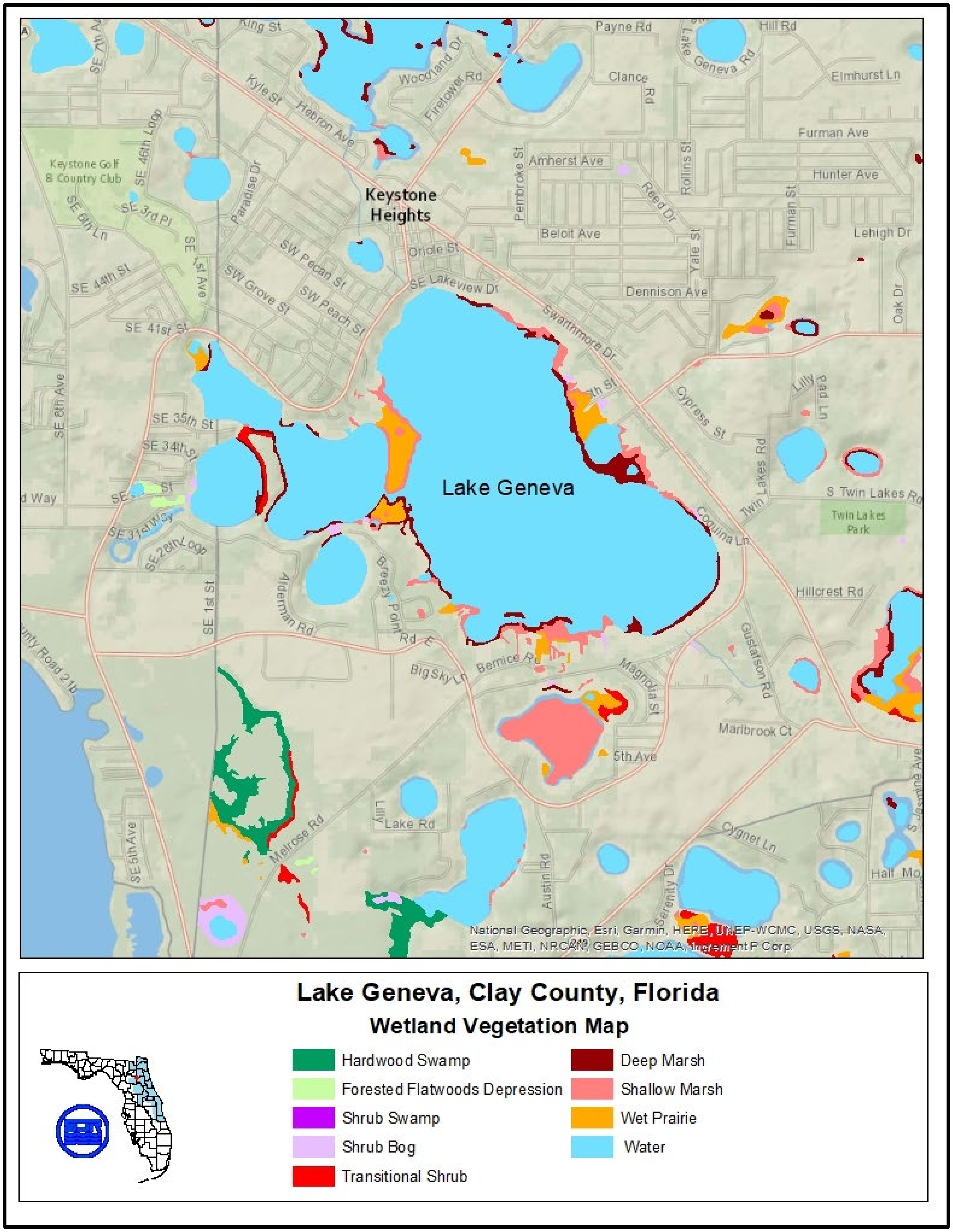

Figure 4. Map showing surveyed wetland vegetation surrounding Lake Geneva; Data source SJRWMD, 2014

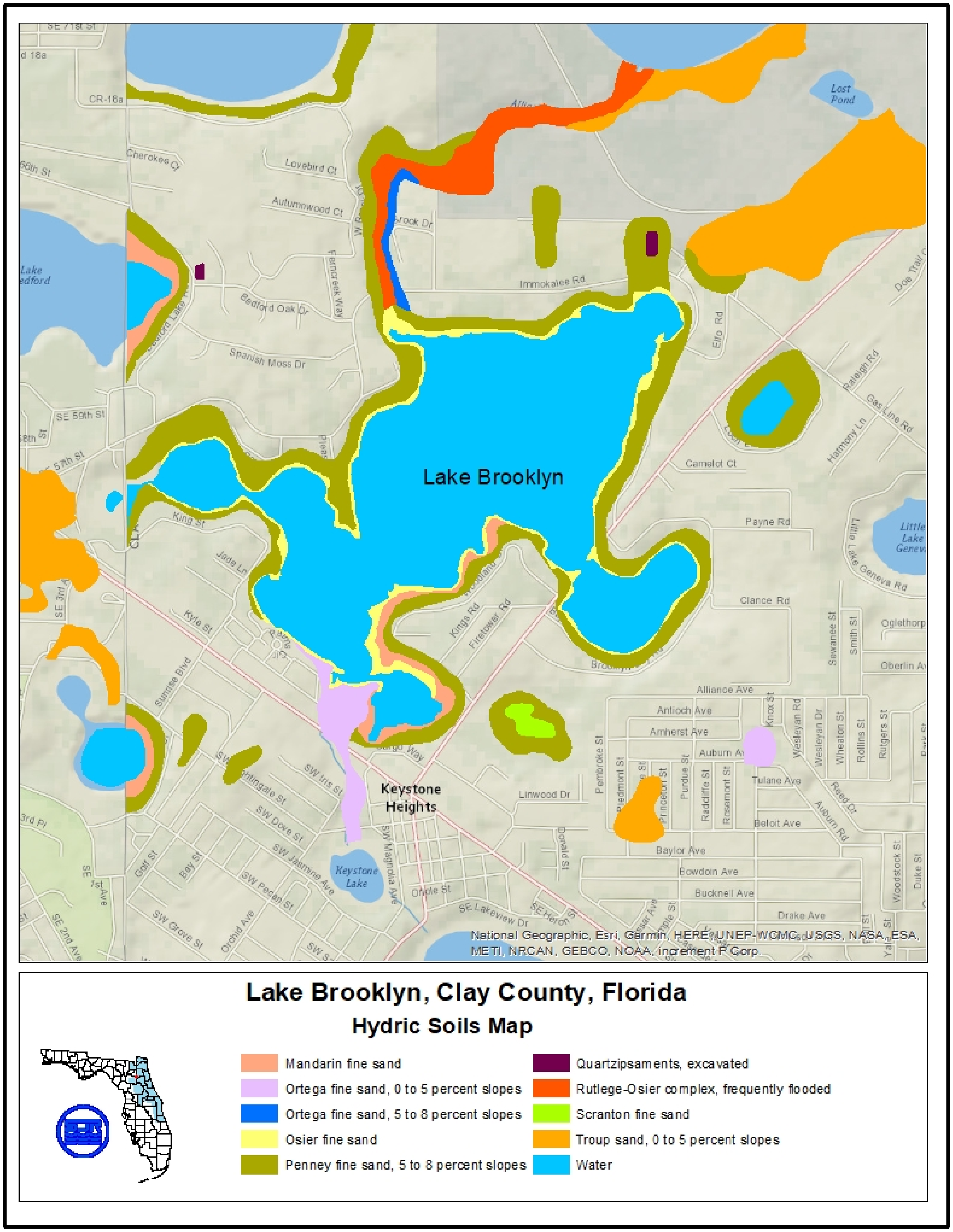

Figure 5. Map of hydric soils surrounding Lake Brooklyn

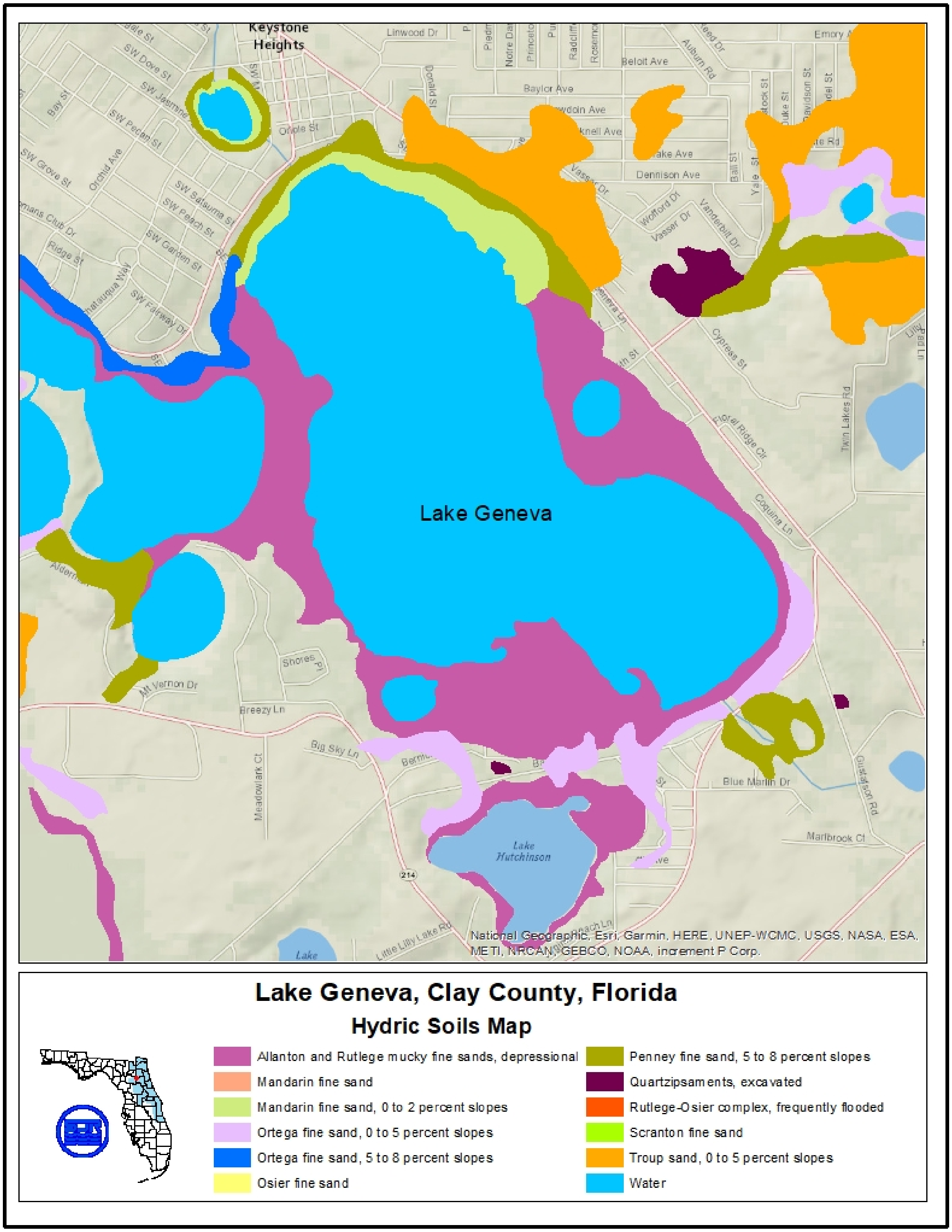

Figure 6. Map of hydric soils surrounding Lake Geneva

Paleudults. Troup was the only Kandiudult described. Hydric soil indicators are likely present in the Paleaquaalts.

Water Quality

Water chemistry in Lakes Brooklyn and Geneva is a function of direct precipitation and surficial groundwater from the immediate contributing area (Hendrickson et al, 2012). Available water quality data for both lakes are limited (collected 1989 – 2007). The maximum total dissolved solids (TDS) observed between 1957-1960 was 34 ppm (Clark, 1963). During Clark's (1963) data collection, chloride constituted the majority of dissolved solids and pH was low enough, at 5.5, to decrease aquifer pH in the immediate vicinity of the lake. Bentley (1977) described water in the Etonia Creek basin as "of good chemical quality."

Water quality data were collected for Lake Brooklyn from 1989 to 2007 as part of the University of Florida's Lakewatch program (Table 3). Water quality data were collected by SJRWMD for Lake Geneva from 1986 to 2011 (Table 3). Analyses by Hendrickson et al., (2012) suggest that Lakes Brooklyn and Geneva have low total dissolved solids, low turbidity, low dissolved organic carbon, and poor buffering capacity (Table 3). Similar oligotrophic systems in Florida tend to have clear water, low zooplankton, low fish density, and high faunal species diversity.

Table 1. Water quality summary statistics for Lake Brooklyn (1989 to 2007; source: Florida Lakewatch) and Lake Geneva (1986 to 2011: source: SJRWMD)

Parameter	**Lake Geneva**				**Lake Brooklyn**			
	Average	Median	Geo Mean	Correlation with Stage (Pearson CC)	Average	Median	Geo Mean	Correlation with Stage (Pearson CC)
pH	6.43	6.28	6.40	-0.32***	na	na	na	na
TDS mg/L	48.94	48.00	44.91	-0.28**	na	na	na	na
TOC mg/L	2.75	2.63	2.62	-0.29**	na	na	na	na
TP µg/L	10.3	10.0	10.4	0.03	14.1	12.5	12.7	-0.45***
TN µg/L	305.2	273.8	264.3	0.02	352.2	330.0	328.2	-0.45***
Chl a µg/L	1.9	1.3	1.0	0.09	6.8	5.0	4.9	-0.28***
SD m	1.22	1.10	1.10	0.44***	2.34	2.13	1.90	0.71***
TSI	29.17	28.60	27.43	-0.23*	35.53	34.88	34.67	-0.51***

*,**,*** indicate $P<0.05$, 0.01, and 0.001 respectively
na = data not available

These data suggest that some nutrient enrichment has occurred in both systems. In Lake Brooklyn, total nitrogen (TN) and total phosphorus (TP) concentrations have occasionally exceeded Florida Department of Environmental Protection (FDEP) minimum thresholds for clear, acidic sandhill lakes (TN: 510 µg/L; TP: 10 µg/L) (Figures 7 and 8; Table 3). Both TN and TP are strongly and negatively related to water level, with high nutrient concentrations associated with low lake levels (Table 3).

Chlorophyll *a* concentrations at Lake Brooklyn have also exceeded the state criterion for clear, acidic sandhill lakes (6 µg/L) on several occasions over the past 3 decades (Hendrickson et al., 2012; Figure 9). Based on these data, chlorophyll *a* is strongly and inversely related to lake stage, suggesting that increasing concentration of nutrients leads to increased primary productivity and algal biomass during periods of low water level.

At Lake Geneva TN and TP concentrations are not strongly correlated with water level, but there is an overall negative relationship with water level for both parameters (Figures 10 and 11). Chlorophyll *a* concentrations show a stronger negative relationship with water level, but concentrations are relatively low (below the state standard of 6 µg/L) for the period of record (Figure 12). The FDEP maximum threshold for TP, for clear, acidic lakes with chl-a < 6 µg/L, is 30 µg/L. All TP data for Lake Geneva are below this threshold. The FDEP threshold for TN, for clear, acidic lakes with chl-a < 6 µg/L, is 930 µg/L. All TN data for Lake Geneva are below this threshold.

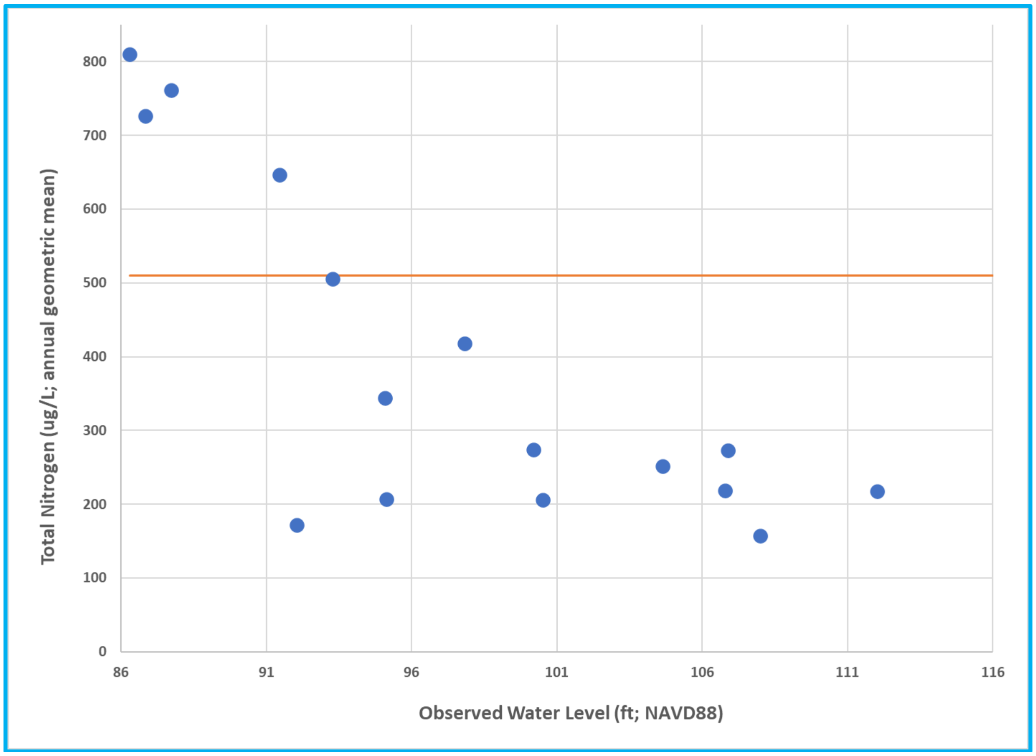

Figure 7. Annual geometric mean of total nitrogen concentration (TN; µg/L) versus observed water level at Lake Brooklyn. The orange line depicts the FDEP standard for TN (510 µg/L).

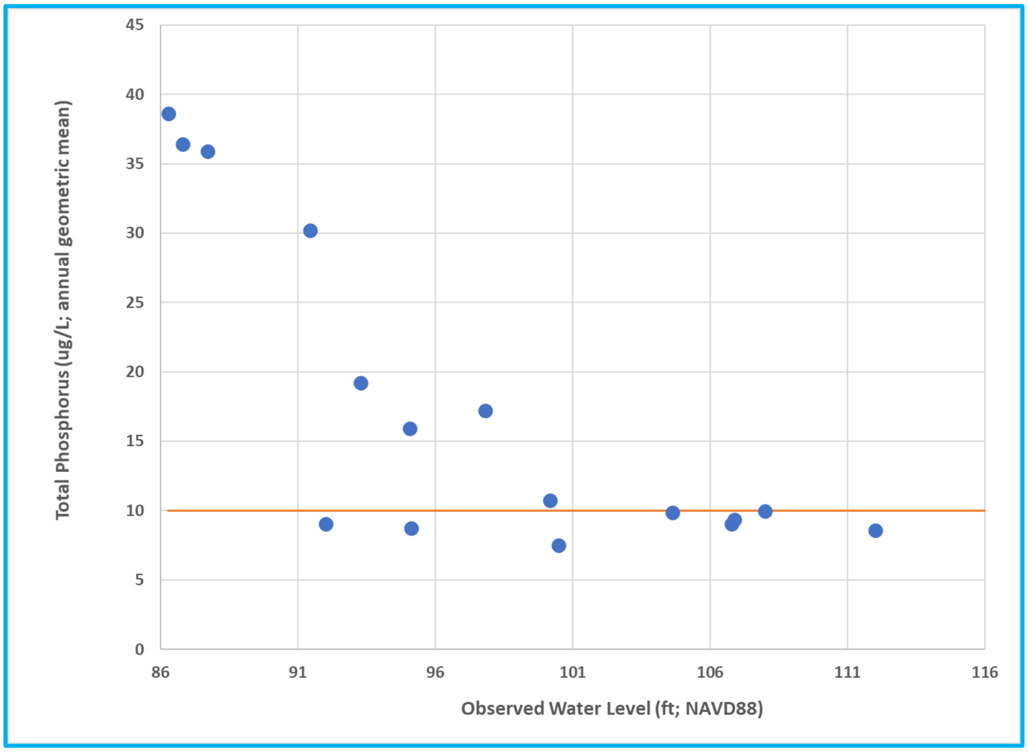

Figure 8. Annual geometric mean of total phosphorus concentration (TP; µg/L) versus observed water level at Lake Brooklyn. The orange line depicts the FDEP standard for TP (10 µg/L).

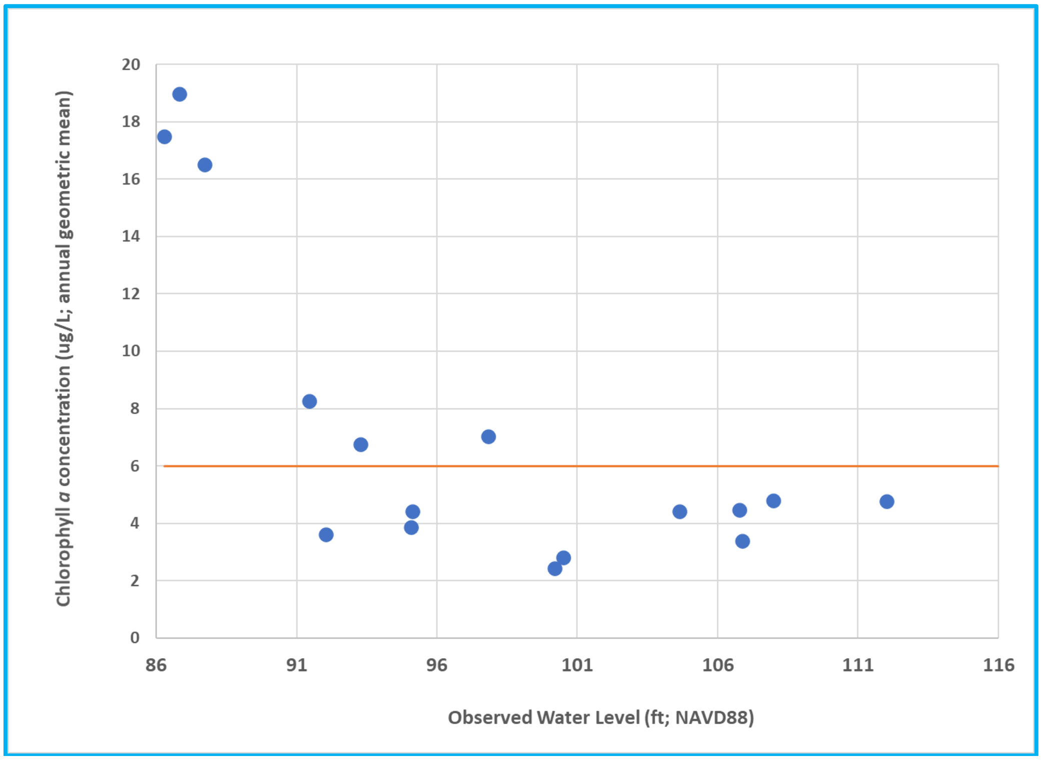

Figure 9. Annual geometric mean of chlorophyll a concentration (chla; µg/L) versus observed water level at Lake Brooklyn. The orange line depicts the FDEP standard for chla (6 µg/L).

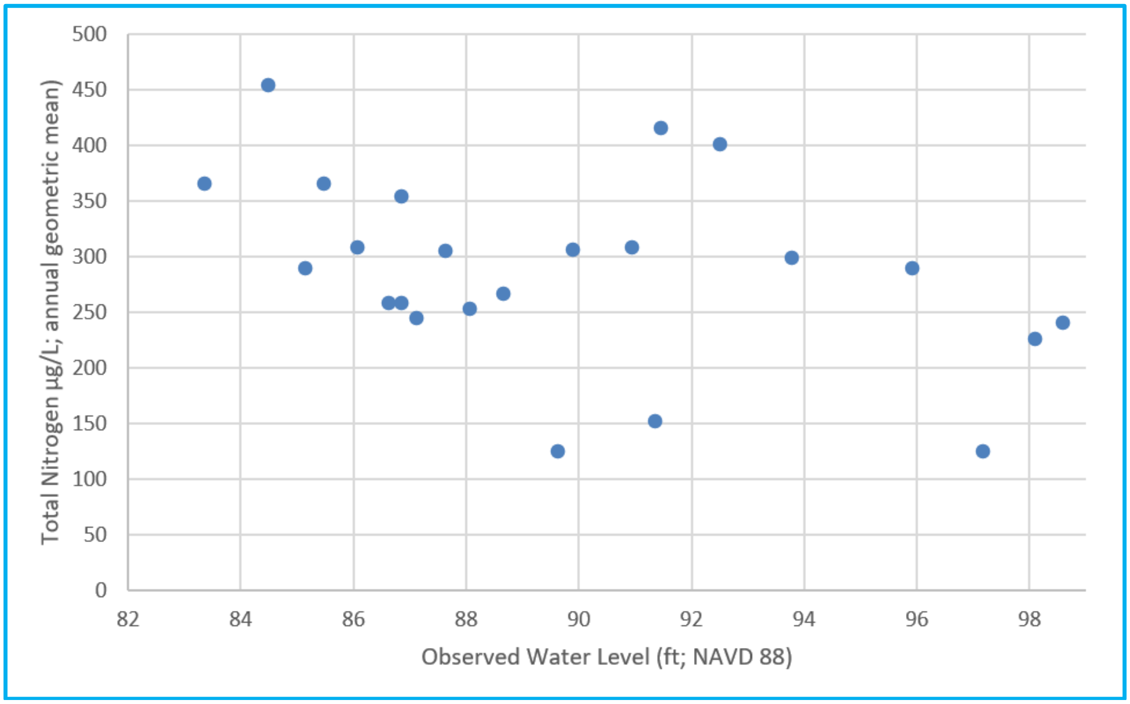

Figure 10. Annual geometric mean of total nitrogen concentration (TN; µg/L) versus observed water level at Lake Geneva. The FDEP standard for TN (for lakes with chl-a < 6 µg/L) is 930 µg/L.

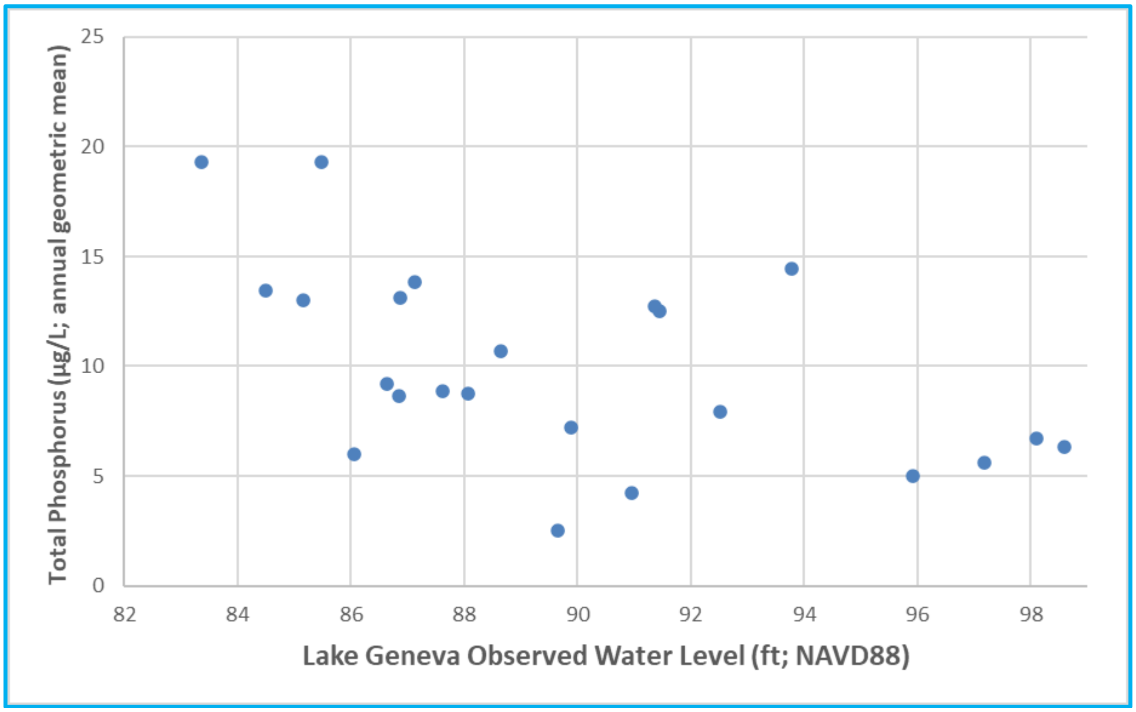

Figure 11. Annual geometric mean of total phosphorus concentration (TP; µg/L) versus observed water level at Lake Geneva. The FDEP standard for TP (for lakes with chl-a < 6 µg/L) is 30 µg/L.

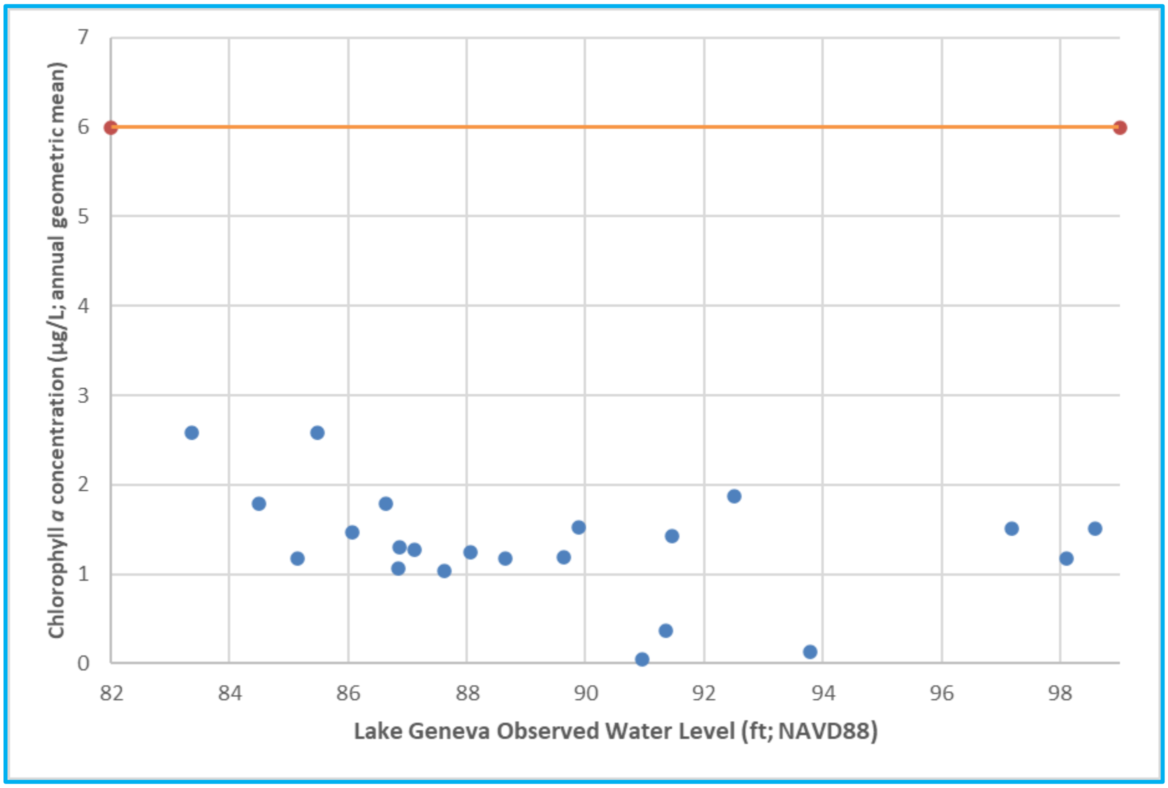

Figure 12. Annual geometric mean of chlorophyll a concentration (chla; µg/L) versus observed water level at Lake Geneva. The orange line depicts the FDEP standard for chla (6 µg/L).

SUMMARY OF MINIMUM INFREQUENT HIGH (IH) DETERMINATION

The goal of a Minimum Infrequent High (IH) event is to protect aquatic habitat within a lake by maintaining the location of the upland ecotone. In other words, preventing a downhill shift in uplands and a permanent loss of wetland or aquatic habitat, due to water withdrawals.

The location of the upland ecotone is maintained by infrequent flooding events that occur for a sufficiently long duration to kill upland plants that grow down slope during periods of less extreme high-water levels. The IH is based on the assumption that the upland ecotone will not shift down slope if withdrawals do not reduce the number of infrequent flooding events near the upland ecotone beyond the return interval threshold of the IH level.

The specific indicator of protection for the IH is a high water, infrequent flood event that corresponds to the elevation of the root zone of waterward saw palmetto plants. For Lake Brooklyn this elevation is 114.2 ft NAVD88, and for Lake Geneva this elevation is 105.2 ft NAVD88. The IH for both lakes recommend a continuously exceeded duration of 30 days and a return interval of 25 years.

IH Magnitude Component

Saw palmetto (*Serenoa repens*) is an upland plant species (Gilbert et al 1995) that can be used to define the upland/wetland boundary (Wise et al. 2000, pp. 258-259) or high-water mark (Brown et al. 1990, pg. 58) adjacent to lotic (i.e., flowing systems [e.g., rivers]) or lentic (non-flowing systems [e.g., lakes]). This species may live for more than 700 years (Abrahamson 1995) and is found in all Florida counties (Hilmon 1968). Saw palmetto has survived root inundation up to 15% of the time (Carr et al. 2006). Saw palmetto roots can conduct air if the stems remain above the water surface (Brown et al. 1990, pp. 58-59). In addition, this species does not migrate down slope during long (i.e., 25 years) dry periods (Carr et al. 2006, pg. 1017).

The IH level elevation component (114.2 ft NAVD88) was calculated by subtracting 1 ft from the land surface elevation (115.2 ft NAVD88) of the waterward saw palmetto. The ground surface elevations of the waterward saw palmetto were measured at the Rentz property, the Miller property, Host property, and the YMCA camp property located on Lake Brooklyn. A large range of elevations, relative to Lake Geneva, was measured among minimum elevations of saw palmetto.

Thus, an empirically developed difference between large waterward sand live oak ground elevations and waterward saw palmetto ground elevations was developed at Lake Geneva and applied to define the waterward saw palmetto “line” elevation at Lake Brooklyn *(see below for details on magnitude component at Lake Geneva)*. The recommended elevation component represents the lower elevation of the root zone of the waterward saw palmetto plants and allows this elevation to be continuously flooded for an appropriate duration (see below). Hilmon (1968, pg. 33) stated that 88-89% of saw palmetto roots exist in the top 1-ft of the root zone for this plant species. Main roots generally occurred between the three-and 12- in. depths (Hilmon 1968, pg. 37). Long horizontal roots had branch roots that grew up to the ground surface and others grew downward. Approximately 45-46% or roots occurred within the 0-6 in. soil zone (Hilmon 1968, pg. 36).

The waterward-most, large (two trees had 31 inch DBH and one tree had a 37 inch DBH) sand live oaks located at the city park at Lake Geneva were measured at 107.9, 107.9, and 108.4 ft NAVD88 (mean = 108.0 ft NAVD88, range = 0.57 ft or 6-7 inches). Applying a 0.20 in/year growth factor results in estimates that these 31 inch and 37 inch DBH trees became established in 1829 and 1859, respectively. These trees were established well before the 1940s extreme high-water level conditions and survived a short duration, possibly a 1-day flood of 107.9 ft NAVD88that was documented at Lake Geneva in 1948. The average saw palmetto elevation for the lowest three plants located in the eastern lobe of Lake Geneva was 106.2 ft NAVD88. The elevations of these three plants were 106.2, 106.3, and 105.9. The difference between the ground elevation for the average elevation of the lowest three large sand live oaks and the average elevation of the lowest three saw palmetto was 1.9 ft (108.07 ft NAVD88– 106.17 ft NAVD88= 1.9 ft).

Two size distributions of sand live oak trees occurred between 117.4 and 116.3 ft NAVD88at the YMCA and west lobe sites at Lake Brooklyn. Larger trees (15-24 inch DBH) occur at elevations between approximately 117.4 and 116.9 ft NAVD88. A second group of 10-12 inch DBH trees occurred between approximately 116.9 and 116.3 ft NAVD88. Using a 0.20 inch per year average growth factor, the larger DBH group of trees that occurred at a higher elevation was calculated to have become established during 1894-1939 period.

Thus, these trees survived the 1948 extreme high-water event (i.e., 117.1 ft NAVD88 [Clark and others 1963, pg. 8]) that occurred at Lake Brooklyn. The second group of slightly smaller DBH trees was calculated to have become established at during 1954-1964 period. These trees likely survived the high-water event measured during the 1960s (1-day maximum stage of 116.3 ft NAVD88on 10/1/1960). Two smaller trees were measured near 114.9 ft NAVD88. These trees were likely established after the 1973 high water event and survived the 1998 high water event (2-day maximum stage = 114.4 ft NAVD88).

A 1.9 ft correction factor developed at Lake Geneva *(see below for details on magnitude component at Lake Geneva)* was applied to the average elevation of the larger 15-24 inch DBH trees that occurred at mean elevation = 117.1 ft NAVD88 (range = 117.3-117.0 ft NAVD88 [≈3.5 inch range]) because these tree were established at Lake Brooklyn during pre-1940s period. Thus, a saw palmetto ground elevation component at Lake Brooklyn was calculated by subtracting 1.9 ft from the average elevation of sand live oaks that were ≥ 15in DBH (117.1 ft NAVD88– 1.9 ft = 115.2 ft NAVD88).

The IH level elevation component for Lake Brooklyn (114.2 ft NAVD88) was calculated by subtracting 1 ft from the land surface elevation of the waterward saw palmetto line that represents the saw palmetto root zone elevation. The IH elevation was calculated in the same manner for Lake Geneva (105.2 ft NAVD88). The assumption of the IH is that infrequent flooding at these two elevation thresholds will result in lethal (anaerobic) soil conditions in the root zones of all upland species that may have become established at lower elevations.

Duration

The recommended duration component of the IH event is at least 30-days, continuously exceeded. As stated above, the magnitude component is associated with the root zone of saw palmetto. This elevation is proximal to the location of waterward live oak at both lakes. The 30 day duration is based on the continuous exceedance required to kill mature (and thus also younger) live oak trees. Information regarding live oak flood duration tolerances are summarized in Table 1 and are based on Ware (2003). Live oak can tolerate moderately well drained soils but cannot tolerate poorly drained soils. It will withstand only occasional deep inundation. While live oak may withstand flood durations that occur for a cumulative 10 percent of the growing season (Hook, 1984), they probably cannot withstand flood durations that extend to 20 percent (Larson et al, 1981).

Table 1. Summary of scientific literature regarding the waterward extent of live oak (Ware 2003)

Source	End of Live Oak Waterward Extent	Beyond Live Oak Waterward Extent
Hook (1984)	Soils waterlogged for 1-4 weeks usually accounting for 10% of the growing season	Soils waterlogged for about 50 % of the time
Light et al. (1993)	Found end of range in high terraces having approximately 4-10% range of total flooding events per year Soils moderately well drained	Not found in low terraces having approximately 19-33% range of total flooding events per year Soils poorly drained
Larson et al. (1981)	Soil inundation or saturation of 1-2 months during growing season	Soil inundations or saturation during a major part of growing season
Moore (1980)	Thrived in well drained beds	Barely grew in generally poorly drained soils
Vince et al. (1989)	Higher, drier areas of hydric hammocks Withstands occasional inundation	Wetter areas of hydric hammocks Cannot withstand prolonged soil saturation

However, other studies suggest live oak can survive an average annual longest flood duration of 24.2 days (Light et al. 1993). These literature sources suggest that a 30-day flooding duration is the approximate threshold to kill mature oak trees.

Return Interval

Mean radial growth rate of oak trees, in general, is ~0.2 in/yr (Table 2). However, live oak growth rate could be up to twice as fast (0.4 in/yr) based on published rates. Considering that the waterward edge of the uplands is often characterized by open sites with higher sunlight, growth rates may be towards the high end of the range. Therefore, live oaks could reach a 2.0 ft DBH within a much shorter period, closer to 20 to 30 years.

Studies suggest that a stand of oaks can become established, having completed the “initiation stage”, within 20 years of a disturbance (Johnson et al. 2002). The growth rate data cited above suggest that live oaks that are 20 to 30 years old years may have a DBH of 1.3 to 2.0 ft. This diameter represents a relatively large tree. Live oaks with a DBH of 2.0 ft can reach heights between 35 and 80 ft tall (Coder 2015). Even at the low end of the range, this represents large, well established trees, at age 30. However, laurel oak, which also occurs at both lakes, grows faster than live oak and has a much shorter life span. Laurel oaks show signs of senescence (e.g. rotting or hollow trunks) by 50 years and do not live longer than 70 years (Gilman and Watson, 1994). Growth and yield data on other oak species (Johnson et al., 2002, pp. 435-436) show that growth in tree height slows substantially by the time oaks reach 12 inches DBH. Laurel oak in Florida are likely to reach this diameter within 25 years and then enter a phase of slower growth marked by increasing girth. This decrease in growth rates marks a transition from a stage when trees are fast growing, metabolically active, and more susceptible to flood driven mortality. Presumably, as growth rates slow they become more resistant to the stresses imposed by flood events. Therefore, flood events at a 25 year return interval will be more effective in maintaining the upland ecotone than would longer return interval events.

Based on live oak growth characteristics, years necessary for stand establishment, and flood frequency necessary to kill faster growing hardwood species associated with live oak (e.g., laurel oak), the infrequent high flood frequency deemed necessary to reset the upland boundary, is at least every 25 years, over the long term.

Table 2. Observed 10-year diameter growth rates of oaks average over a wide range of initial tree diameters for various oak species with associated annual average growth rates (from Johnson et al 2002).

Common name of oak species	Average DBH Growth (inches/decade)	Years to grow 1 inch in DBH	Inches of growth /yr
Northern red oak	1.63-2.90	3-6	0.33-0.17
Black oak	1.50-2.26	4-7	0.25-0.14
Shingle oak	1.82	5	0.2
Scarlet oak	1.55-1.92	5-7	0.2-0.14
White oak	1.12-1.78	6-9	0.17-0.11
Chestnut oak	1.05-1.60	6-10	0.17-0.1
Swamp white oak	1.4	7	0.14
Bur oak	1.3	8	0.13
Chinkapin oak	0.82-1.09	9-12	0.11-0.08
Blackjack oak	0.93	11	0.09
Post oak	0.79	13	0.08
California black oak	0.67	15	0.07
Average	1.58	7.4	0.16
Average + std dev			0.20

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PRELIMINARY CRITERIA – *NOT USED IN FINAL MFLS DETERMINATION*

Prior to peer review, numerous environmental criteria were evaluated in an effort to develop protective minimum levels for Lakes Brooklyn and Geneva. Criteria were chosen based on their potential to protect non-consumptive environmental values and beneficial uses (also called WRVs), as mandated by Rule 62-40.473, F.A.C.. These preliminary criteria were:

1. Minimum Infrequent High (IH): Using the conventional event-based method typically used by the SJRWMD, an infrequent flood (IH) criterion was developed, based on preventing a downward shift in the upland boundary at Lakes Brooklyn and Geneva;
2. Southwest Florida Water Management District (SWFWMD) standards: Six SWFWMD "significant change standards" for Category 3 lakes were evaluated;
3. Fish and wildlife habitat: The effect of water level decline on five fish and wildlife habitats was evaluated using a GIS-based hydroperiod tool;
4. Recreational uses: Recreation was evaluated in several ways. Dock access and lake lobe connection (i.e., full pool) elevations were evaluated; and the effect of water level decline on boater/swimmer safety depths was evaluated using the hydroperiod tool;
5. Aesthetics and scenic attributes: Public survey results were used to determine a threshold of allowable change to median lake level exceedance; and
6. Sandhill lake MFLs comparison: A threshold of allowable change to median lake depth was evaluated, based on 33 previously adopted MFLs for sandhill lakes within SJRWMD and SWFWMD.

Independent scientific peer review and assessment by staff demonstrated that several preliminary criteria were not appropriate for use and not sufficient to protect relevant functions and values in Lakes Brooklyn and Geneva. Five of the six SWFWMD standards were found to be inappropriate for highly fluctuating lakes because they result in minimum median (P50) lake levels that are either above the no-pumping (i.e., pre-withdrawal) condition P50 levels, or extremely low in the lake (i.e., allow for very large lake level reductions). The sixth SWFWMD standard (Species Richness Standard), was found by peer reviewers to be inappropriate for use because the scientific studies on which the standard is based are not applicable to highly fluctuating lakes. The peer reviewers also found that the aesthetics metric was was inappropriate because the study on which is was based was not applicable to Lakes Brooklyn and Geneva. The dock access metric was found to be inappropriate for use because the critical elevations used for this metric are a function of when docks were constructed, and the resulting allowable water level reduction varies significantly based on whether docks were built during wet or dry periods. Finally, the sandhill lake comparison was removed from consideration because of the differences in how each of the 33 MFLs were set.

SWFWMD Category 3 Lake Standards

Aesthetics Standard

The SWFWMD Aesthetics Standard was briefly reviewed but not used because the method for setting this standard typically sets an initial elevation at the historical P90 (lake level equaled or exceeded 90 percent of the time), and then uses relevant information to set the MLL. For Lake Brooklyn, the P90 elevation is approximately 13 feet below the P50, making the resulting MLL significantly lower than the historical (no-pumping condition) P50 (*see Hydrological Analyses section for details on the no-pumping condition*). A similar large change would be experienced at Lake Geneva, so this metric was not pursued further. Although the SWFWMD Aesthetics Standard was not used, another aesthetics criterion was evaluated; this is described in section 5.

Lake Mixing Standard

The second standard briefly reviewed, but ultimately not used, is the SWFWMD Lake Mixing Standard. This criterion involves determining the elevation at which there is a threshold in what is termed the "dynamic ratio." For some lakes, this is the elevation where the lake area/depth ratio changes, and where the lake switches from deep and stratified to shallow and well-mixed. It is calculated as the square root of lake surface area divided by the mean depth, with the latter calculated as lake volume divided by lake surface area. The elevation for this standard is set where the dynamic ratio (mixing threshold) is 0.8. This metric is not appropriate for Lakes Brooklyn and Geneva because they are very deep relative to their surface area. For example, Lake Brooklyn has a dynamic ratio of ~0.29, which would require a very large reduction (~15 feet) in average depth to shift the dynamic ratio until it exceeds 0.8. This metric is very insensitive to all but very large changes in depth for lakes that are deep relative to their surface area. Therefore, it was not used for Lakes Brooklyn and Geneva.

Dock-Use Standard

The purpose of SWFWMD's Dock-Use Standard is to prevent a significant change in dock access, relative to historical conditions. This standard is meant to provide sufficient water depth at the end of existing docks to permit mooring of boats, dock access and to prevent adverse impacts from boats to benthic plants and animals.

The SWFWMD Dock-Use Standard for Lakes Brooklyn and Geneva was calculated by first adding a two-foot boat draft to the difference between the no-pumping P50 and no-pumping P90 elevations. This offset was added to the elevation exceeded by the P10 of waterward dock piling elevations (i.e., lake bottom elevation at waterward piling). The P10 of waterward dock piling (lake bottom) elevations were based on a survey of 46 docks at Lake Brooklyn and 40 docks at Lake Geneva (Figures 13 and 14).

For Lakes Brooklyn and Geneva, the Dock-Use Standard MLL (recommended long-term minimum P50 lake elevation) equals 124.4 ft NAVD88 and 111.6 ft NAVD88, respectively (Table 3). The Dock-Use Standard MLL for both lakes are higher than the no-pumping P50 elevations (Table 3). While this metric works for lakes with a smaller range of fluctuation, it is not appropriate for Lakes Brooklyn and Geneva because of the combination

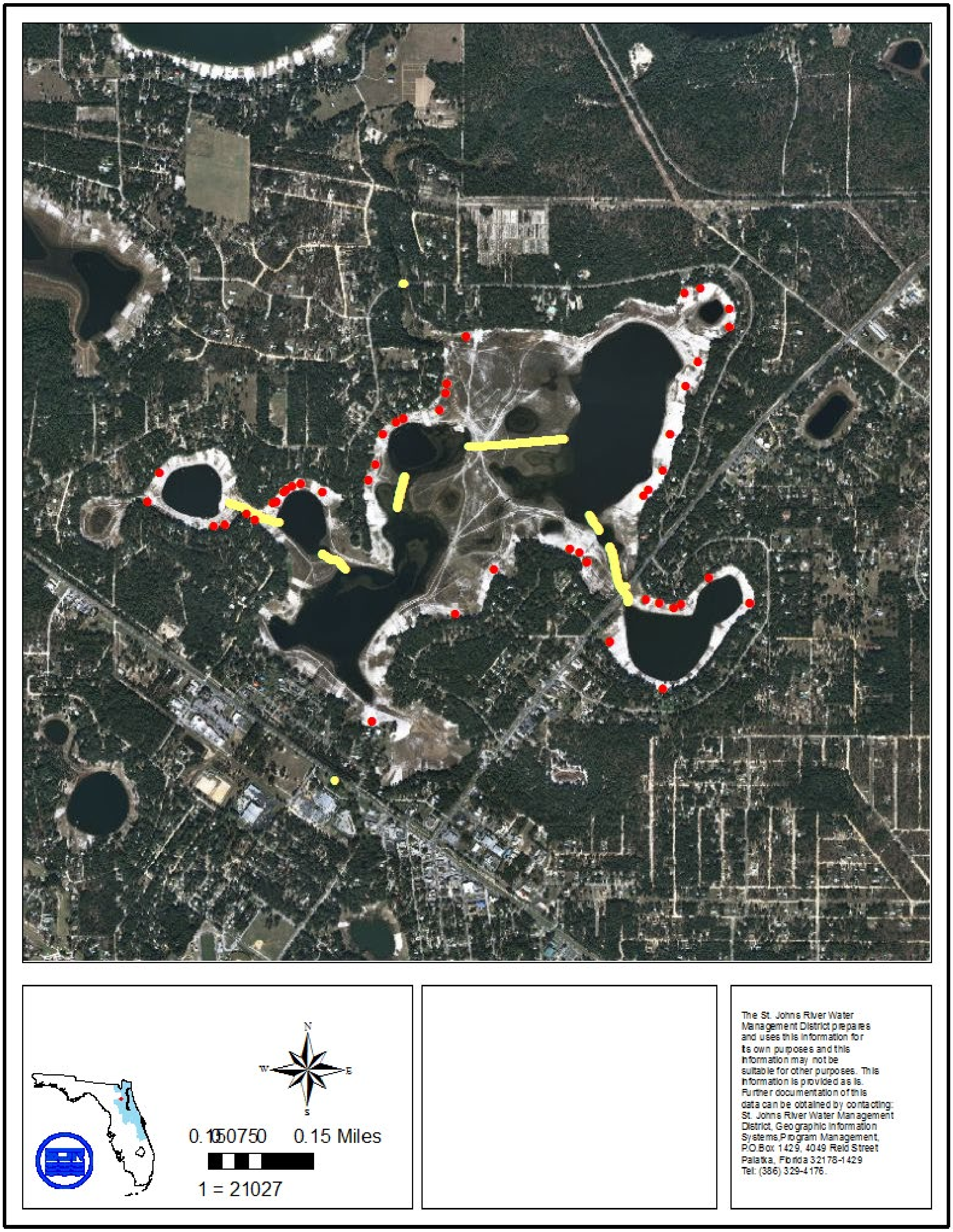

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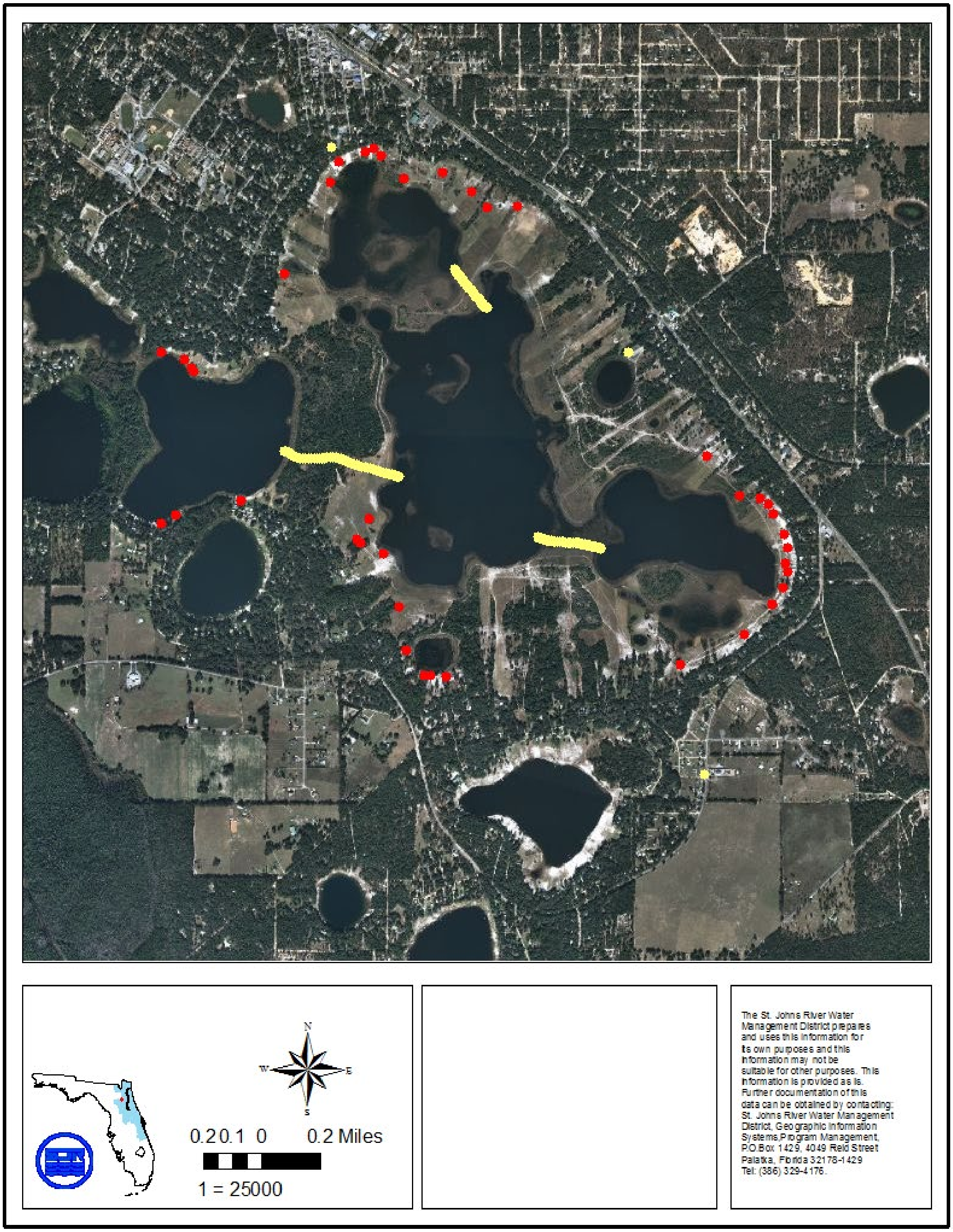
Figure 13. Dock and lake lobe connection transects at Lake Brooklyn, surveyed March and April 2017. Red dots represent dock locations and yellow lines represent lake lobe connection surveys.



The St. Johns River Water Management District prepares and uses this information for its own purposes and this information may not be suitable for other purposes. This information is provided as is. Further documentation of this data can be obtained by contacting: St. Johns River Water Management District, Geographic Information Systems,Program Management, P.O.Box 1429, 4049 Reid Street Palatka, Florida 32178-1429 Tel: (386) 329-4176.

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Figure 14. Dock and lake lobe connection locations at Lake Geneva, surveyed March and April 2017. Red dots represent dock locations and yellow lines represent lake lobe connection surveys.

Table 3. No-pumping condition 50th and 90th percentile water levels, 10th percentile waterward dock piling elevations and Dock-Use Standard MLLs for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida

System	No-pumping P50 water level (ft NAVD88)	No-pumping P90 water level (ft NAVD88)	P10 Waterward dock piling elevation plus 2’ boat draft (ft NAVD88)	Dock-Use Standard Minimum Lake Level (MLL; ft NAVD88)
Lake Brooklyn	109.1	95.9	111.2	124.4
Lake Geneva	100.7	91.2	102.1	111.6

of two factors: 1) high-water level fluctuation, which results in a P50-P90 difference that is very large; and 2) dock locations are at high elevations, relative to median (P50) lake levels. When the P50-P90 difference is added to the P10 of waterward dock piling (lake bottom) elevations (plus 2 feet boat draft), it yields a recommended minimum P50 that exceeds the highest elevation in the lake under a no-pumping condition (Figure 15). Because of this, lake freeboards were not assessed for this metric.

Basin Connectivity Standard

The purpose of SWFWMD’s Basin Connectivity Standard is to prevent a significant change, relative to historical conditions, in the duration of continuous surface-water connections between sub-basins (i.e., lobes) within a lake. This standard is based on the minimum water depth required for lake lobe connectivity (i.e., a full pool, or connected lake), to which an offset (boat draft) is added to provide sufficient depth for boating or other forms of recreation.

Similar to the Dock-Use standard, the Basin Connectivity Standard is calculated by adding a two-foot water depth for boat draft to the difference between the historical P50 and historical P90 elevations. This offset is then added to the highest elevation of the lake bed, above which all lake lobes are connected (critical high spot).

Linear surveys were conducted between lake lobes to determine critical high elevations for Lakes Brooklyn and Geneva (Figures 13 and 14). The highest lake connection elevation was used for the critical high spot for each lake. The resulting elevation represents the recommended long-term minimum P50 lake elevation (MLL), based on the Basin Connectivity Standard.

As with the Dock-Use Standard, the P50 and P90 for Lakes Brooklyn and Geneva are based on the no-pumping exceedance curves for each lake. For Lakes Brooklyn and Geneva, the Basin Connectivity Standard MLL equals 115.2 ft NAVD88 and 108.0 NAVD88, respectively (Table 4). Similar to the Dock-Use Standard, the Basin Connectivity Standard MLL for both lakes are higher than the no-pumping P50 elevations (Table 4). Therefore, this metric is also inappropriate for use at these two lakes because of the large water level fluctuation range, which results in a P50-P90 offset that is very large.

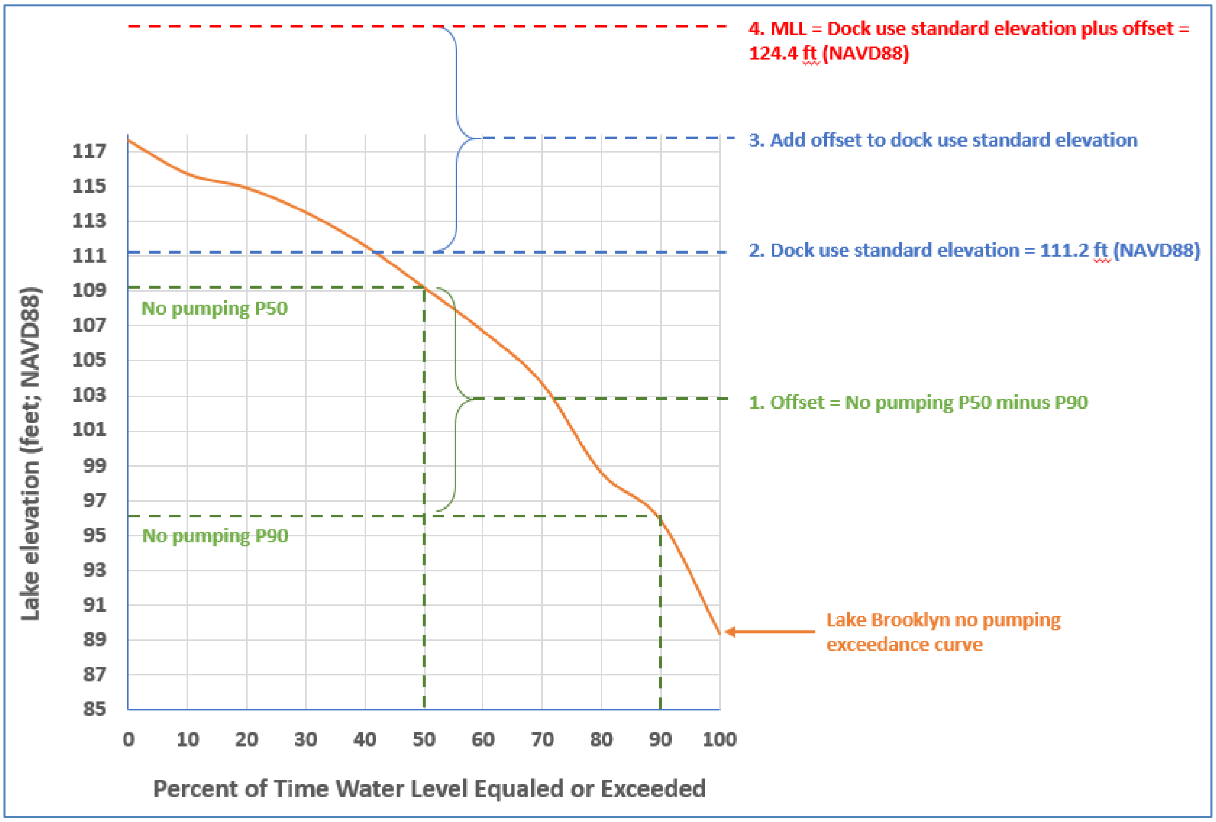

Figure 15. No-pumping exceedance curve for Lake Brooklyn, showing SWFWMD Dock Use standard calculation, including offset (no-pumping P50 minus P90) and MLL. This figure illustrates why this metric is not appropriate for lakes with large stage fluctuation – because the resulting MLL (minimum P50) is higher than the historical (no-pumping condition) P50.

Table 4. No-pumping condition 50th and 90th percentile water levels, critical high spot elevations and Basin Connectivity Standard MLLs for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida

System	No-pumping P50 water level (ft NAVD88)	No-pumping P90 water level (ft NAVD88)	Critical high spot elevation (ft NAVD88)	Basin Connectivity Standard Minimum Lake Level (MLL; ft NAVD88)
Lake Brooklyn	109.1	95.9	102.0	115.2
Lake Geneva	100.7	91.2	98.5	108.0

Recreation/Ski Standard

The purpose of SWFWMD's Recreation/Ski Standard is to prevent a significant change, relative to historical conditions, in the provision of sufficient area and depth for safe recreational water sports (i.e., water skiing, etc.). This minimum elevation ensures that a "ski corridor" is maintained with the dimensions 2,000-ft long by 200-ft wide by 5-ft deep. This is supported by water ski safety organization recommendations of water ski course size and minimum depth for the safe operation of recreational boating or for water skiing (IWSF 1999).

The first step is to determine the minimum lake elevation that can contain a ski corridor. The Recreation/Ski Standard elevation is then set by adding to the minimum corridor elevation the difference between the historical P50 and historical P90 elevations. SWFWMD uses this standard only if it is the most constraining metric and is at a lower elevation than the historical P50 (i.e., if standards are all above the historical P50, the MLL is set at the latter).

The minimum ski corridor elevations for Lakes Brooklyn and Geneva were determined using the SJRWMD hydroperiod tool (*see above for description of tool*) (Figures 16 and 17). The hydroperiod tool was used to estimate the minimum elevation, at each lake, that contains a ski corridor (of the dimensions described above). The difference between the no-pumping P50 and no-pumping P90 was added to the minimum ski corridor elevation to yield the Recreation/Ski Standard elevation for each lake. These Recreation/Ski Standard elevations represent the recommended long-term minimum P50 lake elevations (MLL) for each lake. For Lakes Brooklyn and Geneva, the Recreation/Ski Standard MLL equals 99.7 ft NAVD88 and 90.5 NAVD88, respectively (Table 5).

Minimum elevations for public boat ramps at Lakes Brooklyn and Geneva are 102.0 ft NAVD88, and 93.3 ft NAVD88, respectively. Adding a two-foot boat draft to these minimum elevations, to represent functional minimum elevations for boat ramp access at Lakes Brooklyn and Geneva, yields 104.0 ft NAVD88 and 95.3 ft NAVD88, respectively. The minimum ski corridor elevations for Lakes Brooklyn and Geneva (Table 5) are well below these public boat ramp elevations, and below the majority of dock elevations, at each lake. As such, it was determined the this SWFWMD metric was not appropriate for use at these lakes, where lake areas suitable for skiing safety may be available, but where access from boat ramps is not possible at these minimum elevations.

Figure 16. Aerial photo of Lake Brooklyn with hydroperiod tool output data showing water level based on minimum ski corridor elevation (86.5 ft NAVD88).

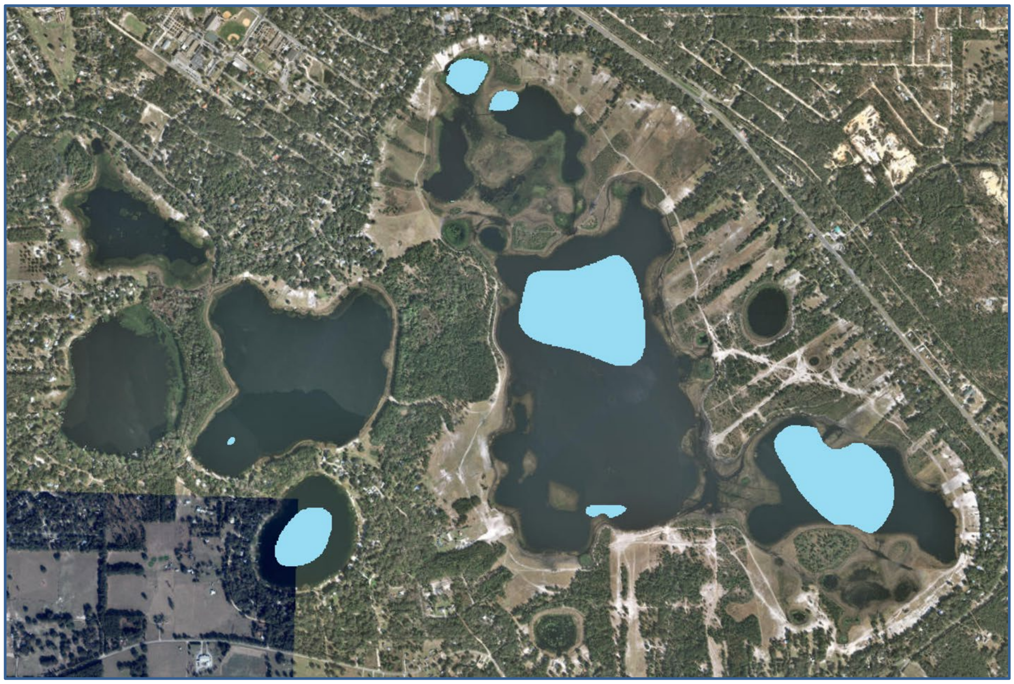

Figure 17. Aerial photo of Lake Geneva with hydroperiod tool output data showing minimum water level based on minimum ski corridor elevation (81.0 ft NAVD88).

Table 5. No-pumping condition 50th and 90th percentile water levels, minimum ski corridor elevations and Recreation/Ski Standard MLLs for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida

System	No-pumping P50 water level (ft NAVD88)	No-pumping P90 water level (ft NAVD88)	Minimum ski corridor elevation (ft NAVD88)	Recreation/Ski Standard Minimum Lake Level (MLL; ft NAVD88)
Lake Brooklyn	109.1	95.9	86.5	99.7
Lake Geneva	100.7	91.2	81.0	90.5

Species Richness Standard

The peer reviewer for the draft Lakes Brooklyn and Geneva MFLs (Cardno, Inc) raised the following concerns regarding the use of SWFWMD's Species Richness Standard for Lakes Brooklyn and Geneva:

> Concern 1: *The types of habitats around [Brooklyn and Geneva] are very different from the habitats around lakes sampled in the previous studies. In particular, while the Emery et al. study focused on lake area, the study strongly emphasized lake edges. Lake edges…generally included bands of cypress trees and sometimes areas of marsh, some of them extensive, and for some lakes, suburban lawns. By contrast, at most water levels, the lake edge for Lake Brooklyn is best described as bare, white sand. The edge for Lake Geneva is generally low grasses / forbs generally those associated with rapid (weedy) growth.*
>
> Concern 2: *There may be technical issues with the sampling design used in the SWFWMD study. The survey results were assumed to represent species richness, yet no analysis was done of sample adequacy for determining richness, especially on the smaller lakes in the study. The larger a lake is the more species it is likely to support because (all things being equal) it provides more niches. However, we are unsure if the greater number of species encountered with increasing lake area was due to the greater area or to the greater sampling effort that appears was used on large lakes.*
>
> Concern 3: *The lakes assessed in the SWFWMD study that were used to develop the criterion varied substantially in diversity (and lack thereof) of shoreline environments among lakes of similar size. A component of the study suggested that there was a significant reduction in species diversity for lakes surrounded by development, and that the change in species richness with change in lake size was significantly different for lakes surrounded by urbanization than those not surrounded by urban areas. This suggests that even among lakes of similar size, the predictive relationship may change,*

> *although we support the assumption that all things being equal, larger lakes would exhibit greater diversity than smaller.*
>
> Concern 4: *The assumption that bird species diversity will change within an individual lake if lake surface area is permanently reduced from some average condition must be accepted.*

The district agrees that these are valid concerns. Regarding concern 4, the district finds this assumption difficult to make for such highly fluctuating lakes, when the studies supporting the metric analyzed data from lakes that are very different from Lakes Brooklyn and Geneva. Because of this and the other concerns raised by Cardno, we agree that this metric is not appropriate for use at these lakes.

SJRWMD dock access criterion

The peer reviewer raised the following concerns regarding the district's minimum dock access criterion:

> Concern 1: *A large proportion of the permanent docks in the Property Appraiser's database appear to have been built during or shortly after the end of the period of high rainfall that characterized the 1960s and early 1970s with a few additional docks built during and after more recent brief high-water events. As a result, we have concerns with the use of a mean end-of-dock elevation in the methodology used to develop the criterion.*
>
> Concern 2: *Assuming that most docks, especially the ones with permanent pilings, were constructed primarily under "wet conditions" such as occurred from the late 1950s to the early 1970s, the waterward dock piling elevation would be located relatively high in the landscape compared to what might have occurred under "dry conditions." If this hypothetical were true, the standard could be viewed as protecting an artificially high condition.*

To address Cardno's concerns, the district evaluated whether the assessment of the dock access metric would yield significantly different results (i.e, allowable lake level reduction) for docks built at different times (i.e., under wetter, drier or average conditions). A sensitivity analysis was conducted to determine if the allowable shift (15% reduction in exceedance) varies significantly from the mean dock elevation to +/- 1 standard deviation (SD) above/below mean elevation. The standard deviation for dock elevations (waterward dock piling elevations) at Lake Brooklyn and Lake Geneva is 1.7 ft and 3.7 ft, respectively (i.e., a range of 5.4 feet).

The sensitivity analysis, based on draft hydrological data, showed that the freeboard/deficit calculation varied significantly from the mean elevation minus 1 SD to the mean elevation plus 1 SD; there was an approximate doubling of freeboard/deficit, based on draft hydrological data. Therefore, the district agrees with the concerns raised by Cardno about using the mean dock elevation for such a highly fluctuating system, where freeboard/deficit calculations are very sensitive to small changes in elevation. The district also agrees that the critical elevation for this metric (i.e., dock elevation) is subject to when the homeowner happened to build their dock, and the resulting allowable water level reduction varies significantly based on whether docks were built during wet or dry periods. For these reasons the district will not use this the dock access metric.

SJRWMD Aesthetics criterion

Cardno raised the following concerns regarding the district's aesthetics criterion, and the public survey in the the Hoyer et al. 2006 Lake User Perception Study:

> *The Panel, however, has concerns about the applicability of the survey to Lakes Brooklyn and Geneva and to other high fluctuation lakes, primarily due to the wide natural fluctuation regimes in these lakes and the under-representation of such lakes in the survey. It appeared from the survey results that some of the most common uses of the lakes were likely dependent on aesthetics, for instance, sitting and enjoying the lake was the most common activity recorded in the survey. Bird and wildlife watching were also common activities reported in the survey. Hoyer et al. (2006) included in their survey a list of lakes that the respondents live on or use. The overwhelming majority of these lakes are described by respondents as relatively shallow lakes with gradually sloping shorelines, and to our knowledge, few, if any have natural fluctuations as broad as those found on Lakes Brooklyn and Geneva. The Panel is unaware of any studies of user preferences that would be more appropriate to these lakes and fully acknowledges that MFLs are to be based on best available information. The Hoyer et al. (2006) study did not address the area of the lake pool and the width of dry shoreline above the water, both of which could affect user perceptions of aesthetics on Lakes Brooklyn and Geneva. While clearly these opinions would also affect no pumping conditions, the Panel believes that incorporating some aspect of pool size into the criteria, or adding pool size as an additional criteria would be beneficial in protecting aesthetic values on these lakes.*
>
> *The Panel questions the appropriateness of using the aesthetic standard.*

The district agrees with concerns about the applicability of results from the Hoyer et al. (2006) survey to an aesthetics standard/threshold for Lakes Brooklyn and Geneva. As noted by Cardno, the survey respondents lived on lakes with very different characteristics from Lakes Brooklyn and Geneva. The majority lived on much more stable, shallow lakes with low bank slopes, such that even small changes in water levels would have large effects on exposed shoreline and pool area. Because none of the lakes in the survey are similar to Lakes Brooklyn and Geneva, we agree that using this study is not appropriate. As such, the aesthetics standard is not appropriate. The district agrees that incorporating a threshold of change open water acreage would protect multiple functions and values, including aesthetics; this is protected by the open-water area metric (*see main report for details*).

LAKE BROOKLYN FISH DATA

Table 6. Summary of species and abundance of fish collected at Lake Brooklyn in 2019 by FWC, as part of the Freshwater Fisheries Long Term Monitoring Program.

Common name	**Scientific name**	**Total**
Largemouth Bass	*Micropterus salmoides*	46
Bluegill	*Lepomis macrochirus*	87
Dollar Sunfish	*Lepomis marginatus*	2
Redear Sunfish	*Lepomis microlophus*	11
Warmouth	*Lepomis gulosus*	9
Brown Bullhead	*Ameiurus nebulosus*	2
Redfin Pickerel	*Esox americanus americanus*	1
Chain Pickerel	*Esox niger*	5
Florida Gar	*Lepisosteus platyrhincus*	10
Bowfin	*Amia calva*	1
Brook Silverside	*Labidesthes sicculus*	358
Eastern Mosquitofish	*Gambusia holbrooki*	49
Golden Shiner	*Notemigonus crysoleucas*	19
Lake Chubsucker	*Erimyzon sucetta*	7
Least Killifish	*Heterandria formosa*	1
Lined Topminnow	*Fundulus lineolatus*	30
Swamp Darter	*Etheostoma fusiforme*	1
Total		**639**

Table 7. Trophy (> 8 lb.) largemouth bass caught at Lakes Brooklyn and Geneva. Fish catch data submitted to FWC as part of their Trophy Catch angler recognition program. https://www.trophycatchflorida.com/search-catches.aspx

Lake Brooklyn

Catch ID	Species	Lake	Date fish caught	Fish Weight	Fish length (in.)	Fish girth (in.)
33214	Largemouth Bass	Lake Brooklyn	27 Mar, 2020	9 lbs 7 oz	24	
25949	Largemouth Bass	Lake Brooklyn	4 Feb, 2017	9 lbs 13 oz		
25279	Largemouth Bass	Lake Brooklyn	15 Nov, 2016	9 lbs 13 oz		
25217	Largemouth Bass	Lake Brooklyn	1 Nov, 2016	8 lbs 3 oz	25.625	
25004	Largemouth Bass	Lake Brooklyn	14 Sep, 2016	10 lbs 10 oz		
23958	Largemouth Bass	Lake Brooklyn	25 May, 2016	10 lbs 2 oz		
23030	Largemouth Bass	Lake Brooklyn	18 Mar, 2016	8 lbs 7 oz	26	
22546	Largemouth Bass	Lake Brooklyn	23 Feb, 2016	9 lbs	25.25	
22458	Largemouth Bass	Lake Brooklyn	20 Feb, 2016	11 lbs 4 oz		
19620	Largemouth Bass	Lake Brooklyn	13 Mar, 2015	11 lbs	25.5	0

Lake Geneva

Catch ID	Species	Lake	Date fish caught	Fish Weight	Fish length (in.)	Fish girth (in.)
32449	Largemouth Bass	Lake Geneva	9 Jan, 2020	10 lbs 13 oz	28	19.75
32443	Largemouth Bass	Lake Geneva	7 Jan, 2020	11 lbs 8 oz	26	20
32332	Largemouth Bass	Lake Geneva	12 Dec, 2019	9 lbs 7 oz	25	18.25
32331	Largemouth Bass	Lake Geneva	11 Dec, 2019	10 lbs 13 oz	23	19
32222	Largemouth Bass	Lake Geneva	26 Oct, 2019	8 lbs 9 oz	24.25	
31942	Largemouth Bass	Lake Geneva	27 Aug, 2019	8 lbs 4 oz	25.75	0
31900	Largemouth Bass	Lake Geneva	11 Aug, 2019	10 lbs 3 oz	26.75	
30581	Largemouth Bass	Lake Geneva	10 Feb, 2019	9 lbs 7 oz	25	18.5
30493	Largemouth Bass	Lake Geneva	28 Jan, 2019	8 lbs 11 oz	26	17
30487	Largemouth Bass	Lake Geneva	26 Jan, 2019	8 lbs 7 oz	27	15.75

30433	Largemouth Bass	Lake Geneva	13 Jan, 2019	9 lbs 5 oz	25.75	18.5
27909	Largemouth Bass	Lake Geneva	2 Sep, 2017	8 lbs 1 oz	26	
26799	Largemouth Bass	Lake Geneva	1 Apr, 2017	9 lbs 2 oz	26	
24429	Largemouth Bass	Lake Geneva	6 Jul, 2016	8 lbs 2 oz	25	
23017	Largemouth Bass	Lake Geneva	18 Mar, 2016	10 lbs 4 oz	25.5	
21836	Largemouth Bass	Lake Geneva	21 Dec, 2015	9 lbs 2 oz	26	19
21335	Largemouth Bass	Lake Geneva	13 Sep, 2015	8 lbs 1 oz	25.25	
19490	Largemouth Bass	Lake Geneva	7 Mar, 2015	10 lbs	25.5	

HYDROPERIOD TOOL OUTPUT DATA – RELATIONSHIP BETWEEN STAGE AND METRIC AREA/DEPTH

Open water area metric:

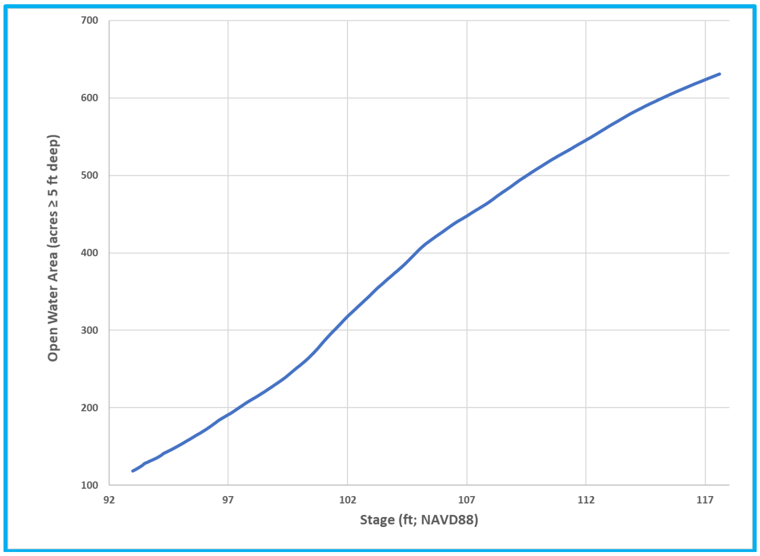

Figure 18. Relationship between stage and open water area (acres ≥ 5 ft deep) for Lake Brooklyn, Clay County, Florida generated from the Hydroperiod tool.

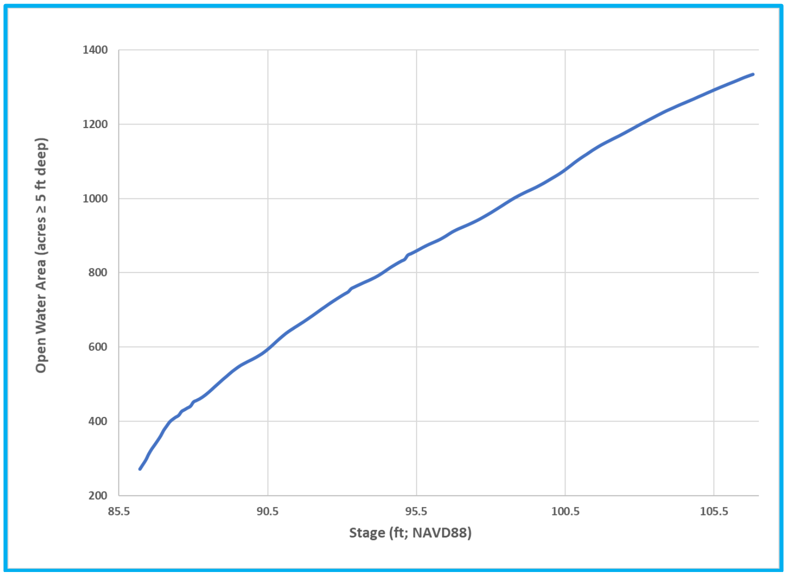

Figure 19. Relationship between stage and open water area (acres ≥ 5 ft deep) for Lake Geneva, Clay and Bradford Counties, Florida generated from the Hydroperiod tool.

Lake surface area metric:

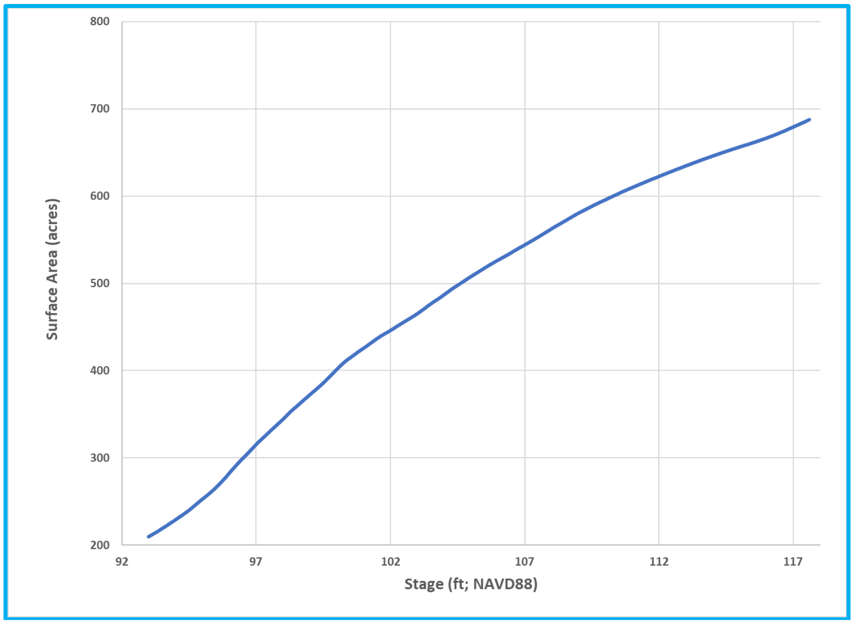

Figure 20. Relationship between stage and lake surface area for Lake Brooklyn, Clay County, Florida generated from the Hydroperiod tool.

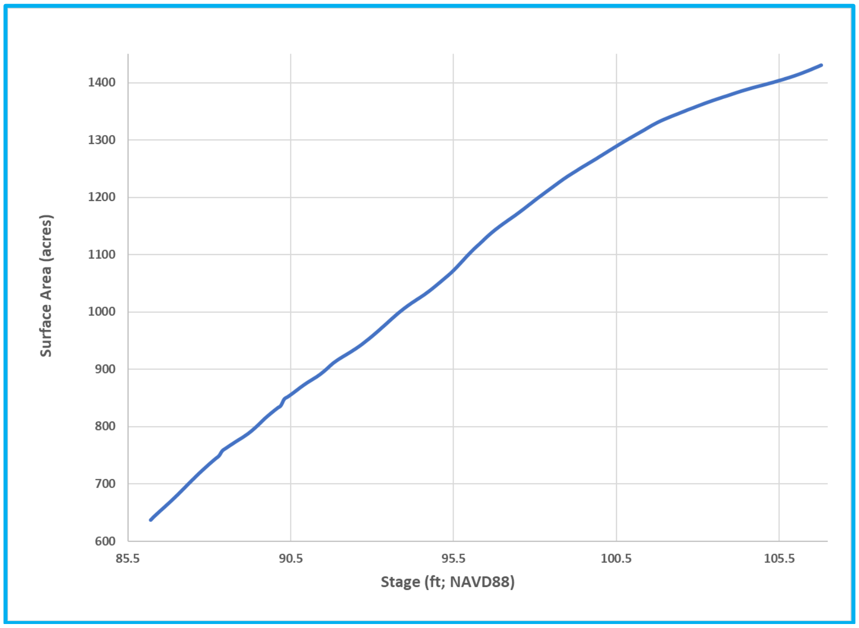

Figure 21. Relationship between stage and lake surface area for Lake Geneva, Clay and Bradford Counties, Florida based on hydroperiod tool output data.

Average lake depth metric:

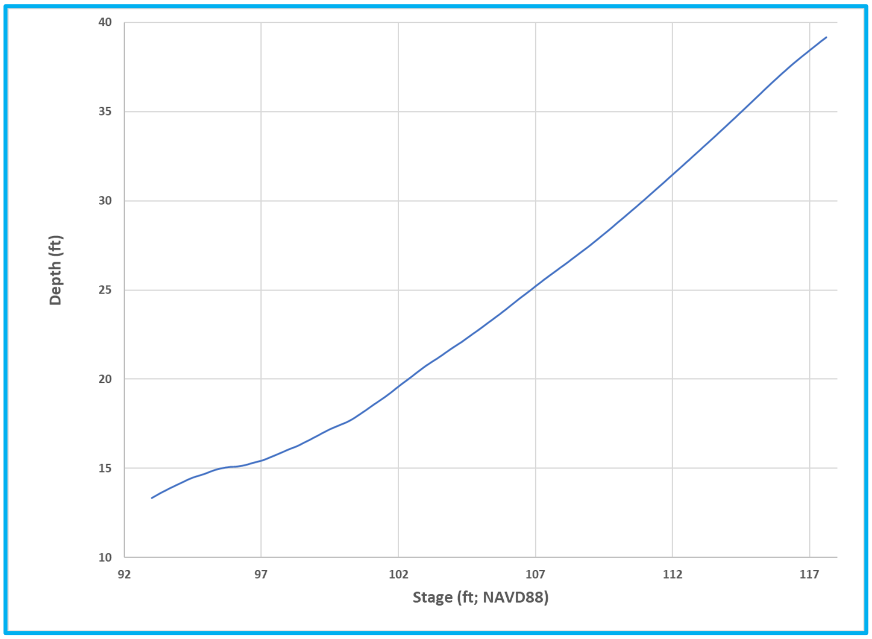

Figure 22. Relationship between stage and lake depth for Lake Brooklyn, Clay County, Florida, based on hydroperiod tool output data.

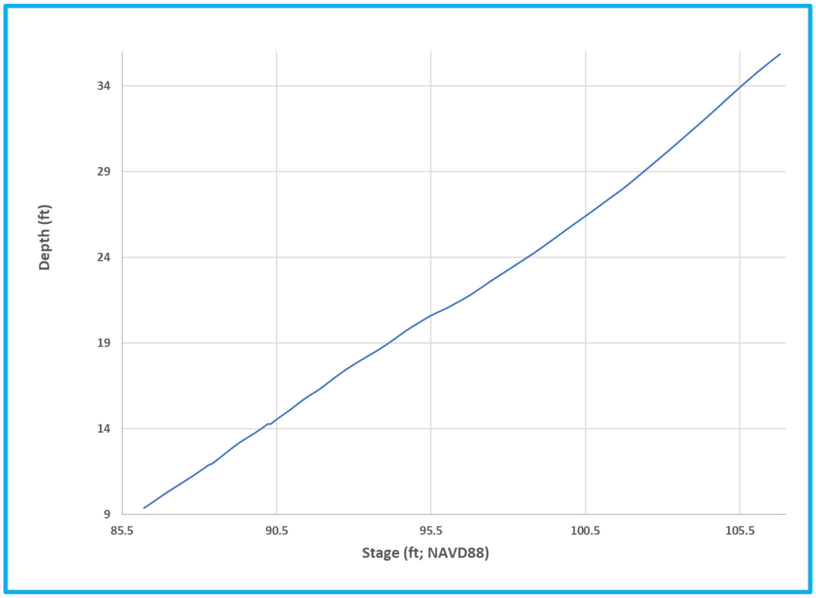

Figure 23. Relationship between stage and lake depth for Lake Geneva, Clay and Bradford Counties, Florida, based on hydroperiod tool output data.