# APPENDIX E — WATER RESOURCE VALUES (WRVS) ASSESSMENT

## WATER RESOURCE VALUES (WRVS) ASSESSMENT:

The State Water Resources Implementation Rule (Rule 62-40.473, *Florida Administrative Code* [*F.A.C.*]) requires the St. Johns River Water Management District (SJRWMD) to consider "environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology." when establishing MFLs. Consequently, the SJRWMD considered 10 environmental values (also called water resource values [WRVs]) identified in Rule 62-40.473, *F.A.C.* The SJRWMD uses the following working definitions when considering these 10 environmental values:

1. Recreation in and on the water—The active use of water resources and associated natural systems for personal activity and enjoyment. These legal water sports and activities may include, but are not limited to swimming, scuba diving, water skiing, boating, fishing, and hunting.
2. Fish and wildlife habitat and the passage of fish—Aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally or commercially important, or keystone species; to live, grow, and migrate. These environments include hydrologic magnitudes, frequencies, and durations sufficient to support the life cycles of wetland and wetland-dependent species.
3. Estuarine resources—Coastal systems and their associated natural resources that depend on the habitat where oceanic saltwater meets freshwater. These highly productive aquatic systems have properties that usually fluctuate between those of marine and freshwater habitats.
4. Transfer of detrital material—The movement by surface water of loose organic material and associated biota.
5. Maintenance of freshwater storage and supply—The purpose of this environmental value is to protect, from significant harm due to water withdrawal, an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. This value encompasses all other environmental values identified in Rule 62-40.473 *F.A.C.* Because the overall purpose of the MFL 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.
6. Aesthetic and scenic attributes—Those features of a natural or modified waterscape usually associated with passive uses, such as birdwatching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation, that usually result in well-being and contentment.

7. Filtration and absorption of nutrients and other pollutants—The reduction in concentration of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these substances move through the water column, soil or substrate, and associated organisms.
8. Sediment loads—The transport of inorganic material, suspended in water, which may settle or rise. These processes often depend upon the volume and velocity of surface water moving through the system.
9. Water quality—The chemical and physical properties of the aqueous phase (i.e., water) of a water body (lentic) or a watercourse (lotic) not included in definition number 7 (i.e., nutrients and other pollutants).
10. Navigation—The safe passage of watercraft (e.g., boats and ships), which depends on adequate water depth and channel width.

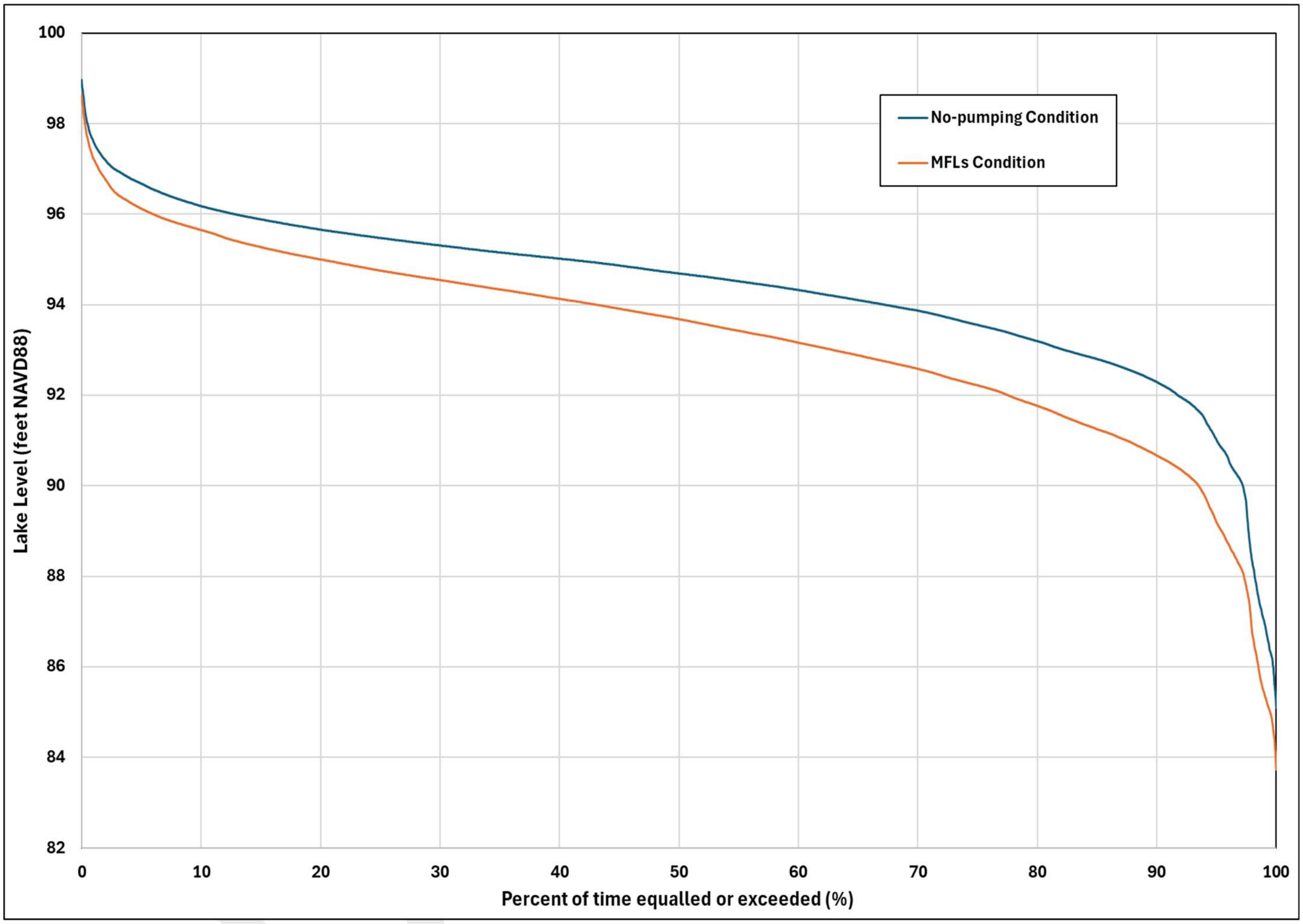
Consideration of these values is meant to ensure that recommended MFLs protect the full range of water-related functions that provide beneficial use to humans and ecological communities. However, all 10 WRVs are typically not applicable to a specific priority water body because of the varying hydrologic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

An exceedance curve based on the MFLs condition timeseries was created and compared to the no-pumping condition exceedance curve to assess whether the WRVs are protected (Figure E-1). The MFLs condition and no-pumping exceedance curves were created using the respective daily lake level timeseries. The no-pumping condition time series was simulated using the Johns Lake ICPR model, with the no-pumping groundwater level time series as an input (see Appendix B). The MFL condition lake level time series was simulated by adjusting groundwater levels incrementally in the surface water model until the model produced a lake level time series that just meets the most constraining MFLs metric (i.e., the ≥7ft open water hydroperiod tool metric)..

A significant harm threshold of 15% was used as the maximum allowable change, for a specific WRV, between the MFLs condition and the no-pumping condition. A threshold of 15% reduction in exceedance of critical elevations has been peer reviewed numerous times and has been the basis for numerous adopted MFLs within Florida (Munson and Delfino 2007; Mouzon et al. 2018; Sutherland et al. 2021). The WRVs assessment results indicate that none of the WRVs metrics assessed exceed the 15% reduction threshold and therefore are all protected by the MFLs condition, as discussed below."

Figure E–1. No-pumping condition and MFLs condition exceedance curves for Johns Lake. The MFLs condition is based on the allowable 15% reduction in open water area




## Group 1: WRV3, WRV8 and WRV10

The three WRVs in Group 1 were determined to be inapplicable and thus were not considered in this assessment.

**WRV 3 – Estuarine resources:**

This environmental value is inapplicable because Johns Lake is land-locked and has no surface water connection to any estuarine resources. Therefore, WRV-3 was not considered in this evaluation.

**WRV8 – Sediment loads:**

Transport of inorganic materials as suspended or bed load is considered relevant only in flowing systems, where riverine fluvial dynamics are critical to maintenance of geomorphic features (i.e. bed forms and the floodplain) and their associated ecological communities. Because lakes serve as sinks instead of sources of sediment load, WRV-8 was not considered in this evaluation.

**WRV10 – Navigation:**

The primary navigation on Johns Lake is by recreational boaters. As such, this WRV is addressed under WRV1 (Recreation in and on the water).

## Group 2: WRV2, WRV4, WRV5, and WRV7

The four WRVs in Group 2 are closely associated with and depend on the ecological functions and biochemical processes of the wetland communities surrounding Johns Lake. The event-based and hydroperiod tool (HT) metrics were developed to protect these important ecological functions and biochemical processes by protecting the resident wetland communities and open water habitats from significant harm. The two event-based metrics (i.e., two minimum Frequent High levels) were developed to ensure protection of the entire hydrologic regime and are based on the protection of 1) buttonbush (*Cephalanthus occidentalis)* communities and associated fish and wildlife habitat values; and 2) floating deep marsh communities and associated fish and wildlife habitat values. The suite of HT metrics (see main report for details) was developed to protect a range of habitat types and their areal coverages. These event-based MFLs and HT metrics provide protection for each of the four WRVs in this group.

**WRV 2 – Fish and wildlife habitat and the passage of fish:**

WRV 2 ensures the consideration and protection of aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally, or commercially important, or keystone species. The event-based metrics for Johns Lake are based on protecting fish and wildlife habitats, providing a sufficient frequency of high water (flooding) events and preventing excessive low water (drying) events to ensure existing wetland communities are maintained. In addition, the HT metrics protect the aerial extent of nearshore and open water habitats, including extensive shallow and deep marsh habitats, which s provide important refugia and forage habitat for invertebrates, fish, mammals, birds, and other twildlife.  These habitats are especially important for providing hat provide important refuge habitat for small forage fish and juveniles of game fish that form the base of production for larger fish, birds, and other wildlife. Shallow marshes provide important refugia and forage habitat for invertebrates, fish, mammals, birds, and other wildlife. The open water (≥7-foot) HT metric protects open water and deep-water habitats.  These open water habitats are valuable for nesting, foraging, refugia from avian predators, and thermal refuge.  Also, predatory fish hunt in the open water and sandy bottom habitats found in the non-vegetated portion of Johns Lake.  Therefore, compliance with both event-based MFLs (FH#1 and FH#2) and the HT metrics protects “fish and wildlife habitats and the passage of fish” for Johns Lake.

| Environmental Criterion | NP Condition area (acres) | MFLs Condition (CP-1.3 ft) area (acres) | Percent change in NP condition area based on most constraining metric |
|---|---|---|---|
| Small wading bird forage habitat | 46.0 | 51.1 | +11.1 |
| Large wading bird forage habitat | 105.5 | 116.6 | +10.5 |
| Sandhill crane nesting habitat | 59.5 | 65.5 | +10.1 |
| Emergent marsh habitat (≤7 ft) | 993.3 | 1079.5 | +8.7 |
| Lake area | 2488.5 | 2355.0 | -5.4 |
| Canoe area (≥ 20 in) | 2299.1 | 2146.1 | -6.7 |
| Open-water area (≥7 ft) | 1495.2 | 1275.5 | -14.7 |

**WRV 4 – The transfer of detrital material:**

WRV4 is meant to protect the transport of detritus, which is defined as the movement by water of loose organic particles and debris and associated decomposing biota. . These organic particles and debris consist of decomposing vegetation, including leaves and wood, processed by microbes (e.g., bacteria and fungi). Detrital material is an important component of aquatic food webs (Mitsch and Gosselink 2015). Wetland communities, such as transitional shrub swamp and shallow marsh, are important sources of detrital material for the Johns Lake systemA significant portion of detrital transfer occurs during high-water events, when accumulated detrital materials in floodplain wetlands are moved to the aquatic system. Thus, the FH is based on providing sufficient high-water (flooding) events to ensure that detrital material accumulated in the floodplain is transported to aquatic habitats downslope. Therefore, the "transfer of detrital material" is protected by the MFLs condition.

**WRV 7 – The filtration and absorption of nutrients and other pollutants:**

WRV7 ensures consideration of nutrient and pollution filtration and absorption (i.e., the removal of suspended and dissolved materials as these substances move through the water column, soil, or substrate and associated organisms). Existing wetlands around Johns Lake include transitional shrub, and marsh communities, which provide filtration and absorption of excess nutrients and other pollutants. The purpose of the event-based and HT metrics is to ensure the long-term maintenance of these wetland communities. Deep water zones are crucial for allowing settling of particulates which can be pollutants. Areas of Johns Lake that are deeper than the influence of boat wakes or wind-driven waves can benefit water quality since they allow for settling and sedimentation. Therefore, by protecting existing wetlands, and the open water metric (i.e., the most constraining metric), the MFLs Condition also provides protection for WRV7.

**WRV 5 – The maintenance of freshwater storage and supply:**

The maintenance of freshwater storage and supply (WRV5) is also included in this group. This environmental value aims to protect, from significant harm due to water withdrawal, an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. This environmental value encompasses all other environmental values identified in Rule 62-40.473 *F.A.C*. Because the overall purpose of the MFLs 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.

## Group 3: WRV1, WRV6, and WRV9

The three WRVs in Group 3 are closely related to lake area and depth, in addition to the condition of the 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., a 15% reduction relative to the no-pumping condition) under the MFL condition, for specific criteria evaluated for each of these three WRVs. 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, as discussed below.

**WRV 1 – Recreation in and on the water:**

The purpose of this environmental value is to protect, from significant harm due to water withdrawal, the active use of water resources and associated natural systems for personal activity and enjoyment. Johns Lake supports various recreational activities including boating, water skiing, and fishing. More than 150 private docks plus a public boat ramp are located around the lake. Therefore, dock and ramp access by recreational boats was assessed as the representative function to be protected by this WRV.

To determine whether this WRV is protected by the recommended MFLs, the frequency of exceedance of a critical elevation necessary for boats to access residential docks was compared between MFLs and no-pumping conditions. Exceedance of this critical elevation was evaluated to determine if there was a 15% reduction under the MFLs condition relative to the no-pumping condition.

167 residential docks were surveyed around Johns Lake to determine the mean waterward piling (lake bottom) elevation (Figure E-2), which was 87.4 feet (ft) North American Vertical Datum 1988 (NAVD88). Most of the boats used for recreational activities on Johns Lake are ≤ 20 ft in length. For boats of this size, the typical draft (including their motors) is approximately 2 ft. To account for the typical boat draft and ensure access at docks, 2 ft was added to the mean waterward lake bottom elevation for the 167 private

docks surveyed. Based on this analysis, the average minimum boat access elevation for Johns Lake is 89.4 ft NAVD88 (Figure E-2; Table E-1).

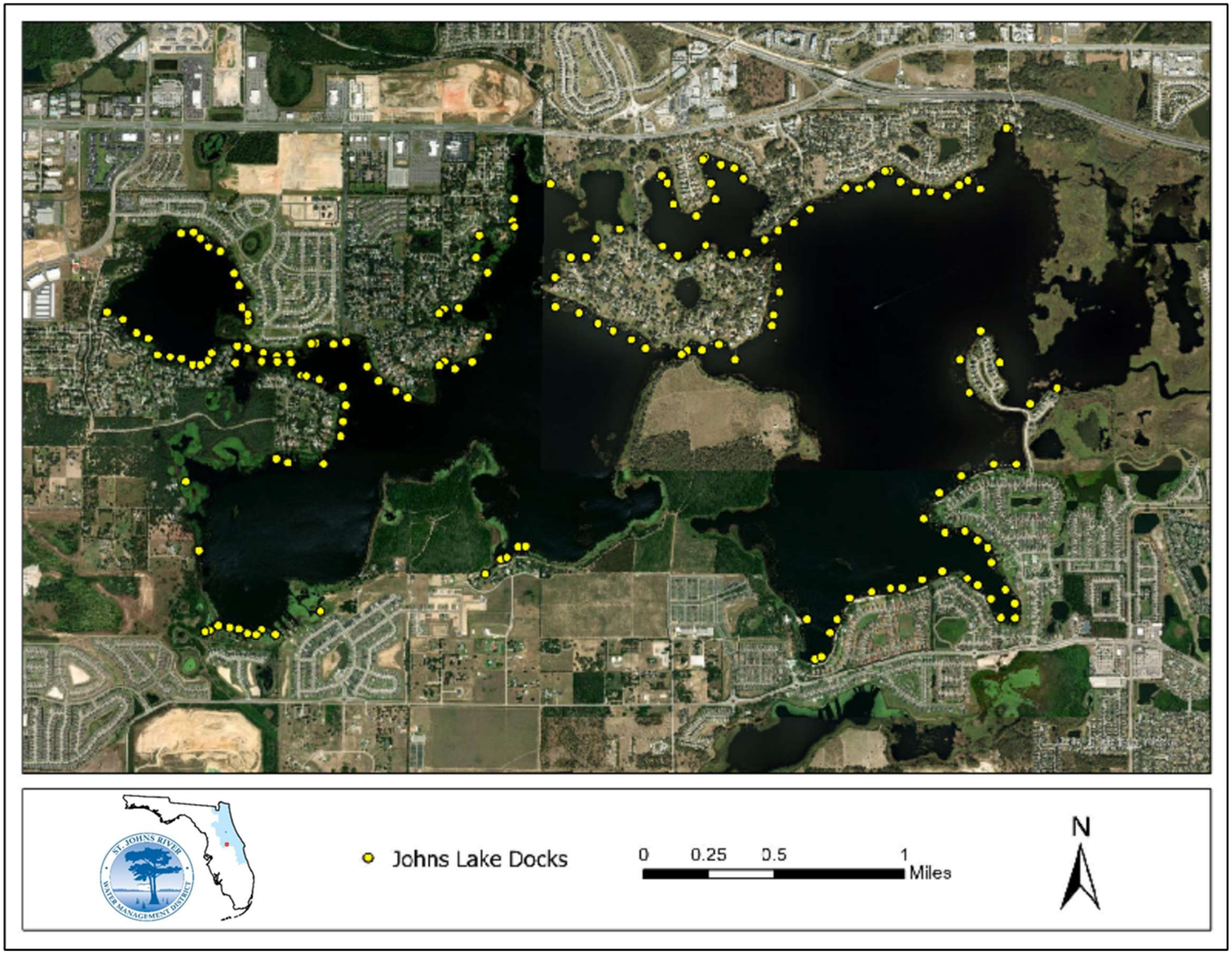



Figure E-2. Locations of surveyed docks on Johns Lake used for evaluating boat accessibility.

Table E-1. Average waterward (lake bottom) dock elevation and minimum boat accessible elevation in Johns Lake.

| Average waterward (lake bottom) dock elevation (ft, NAVD88) | Draft for 20' boat (ft) | Minimum boat accessible elevation (ft, NAVD 88) |
|---|---|---|
| 87.4 | 2 | 89.4 |

The comparison of exceedance of the boat access elevation indicates that there is a 2.8% change between the MFLs and no-pumping conditions (Table E-2; Figure E-3). The critical elevation (89.4 ft NAVD88) is exceeded slightly less often (10 days less) under the MFLs versus no-pumping condition. Based on these results, this environmental value is considered protected by the recommended minimum hydrologic regime (i.e., the MFLs condition).

Table E-2. Minimum boat access elevation at docks, and the percent reduction in exceedance over the elevation comparing the no-pumping and MFLs conditions.

| | Minimum access elevation (ft, NAVD88) | Average number of days per year that exceeds the min. access elevation (days/year) | | Percent reduction in exceedance of boat access/passage elevations under MFLs condition relative to no-pumping condition (%) |
|---|---|---|---|---|
| | | No-pumping | MFL | |
| Docks | 89.4 | 356 | 346 | 2.8% |

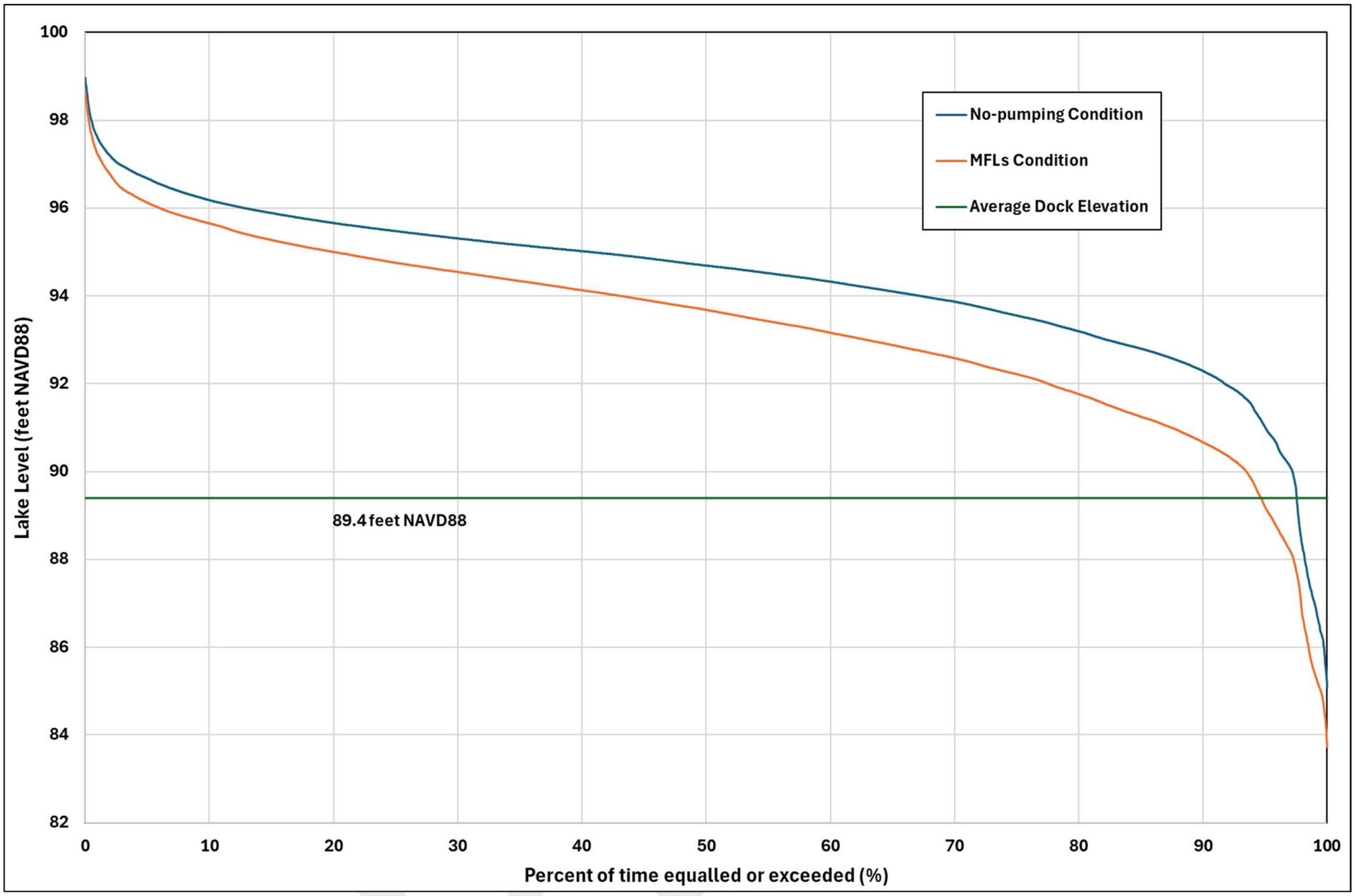



Figure E–3: Dock access elevation (89.4 feet NAVD88) and corresponding exceedance percentages of the no-pumping condition versus the MFLs condition.

The Johns Lake public boat ramp was surveyed to determine the elevation of the bottom of the concrete ramp, which was 85.0 feet NAVD88. As explained in the preceding paragraph, most boats used for recreational activities on Johns Lake are ≤ 20 ft long. For boats of this size, the typical draft (including their motors) is approximately 2 ft. To account for the typical boat draft and ensure access at the public boat ramp, 2 ft was added to the minimum elevation of the concrete ramp (Table E-3).

Table E-3: Minimum boat accessible elevation for the public boat ramp at Johns Lake.

| Bottom of the concrete ramp elevation (ft, NAVD88) | Draft for 20' boat (ft) | Minimum boat accessible elevation (ft, NAVD 88) |
|---|---|---|
| 85.0 | 2 | 87.0 |

The comparison of exceedance of the boat ramp access elevation indicates that there is a 1.0% change between the MFLs and no-pumping conditions (Table E-4; Figure E-4). The critical elevation (87.0 ft NAVD88) is exceeded slightly less often (4 days less) under the MFLs versus no-pumping condition. Based on these results, this environmental value is considered protected by the recommended minimum hydrologic regime (i.e., the MFLs condition).

Table E-4: Minimum boat access elevation at the public boat ramp, and the percent reduction in exceedance over the elevation comparing the no-pumping and MFLs conditions.

| | Minimum access elevation (ft, NAVD88) | Average number of days per year that exceeds the min. access elevation (days/year) | | Percent reduction in exceedance of boat access/passage elevations under MFLs condition relative to no-pumping condition (%) |
|---|---|---|---|---|
| | | No-pumping | MFL | |
| Public boat ramp | 87.0 | 361 | 357 | 1.0% |

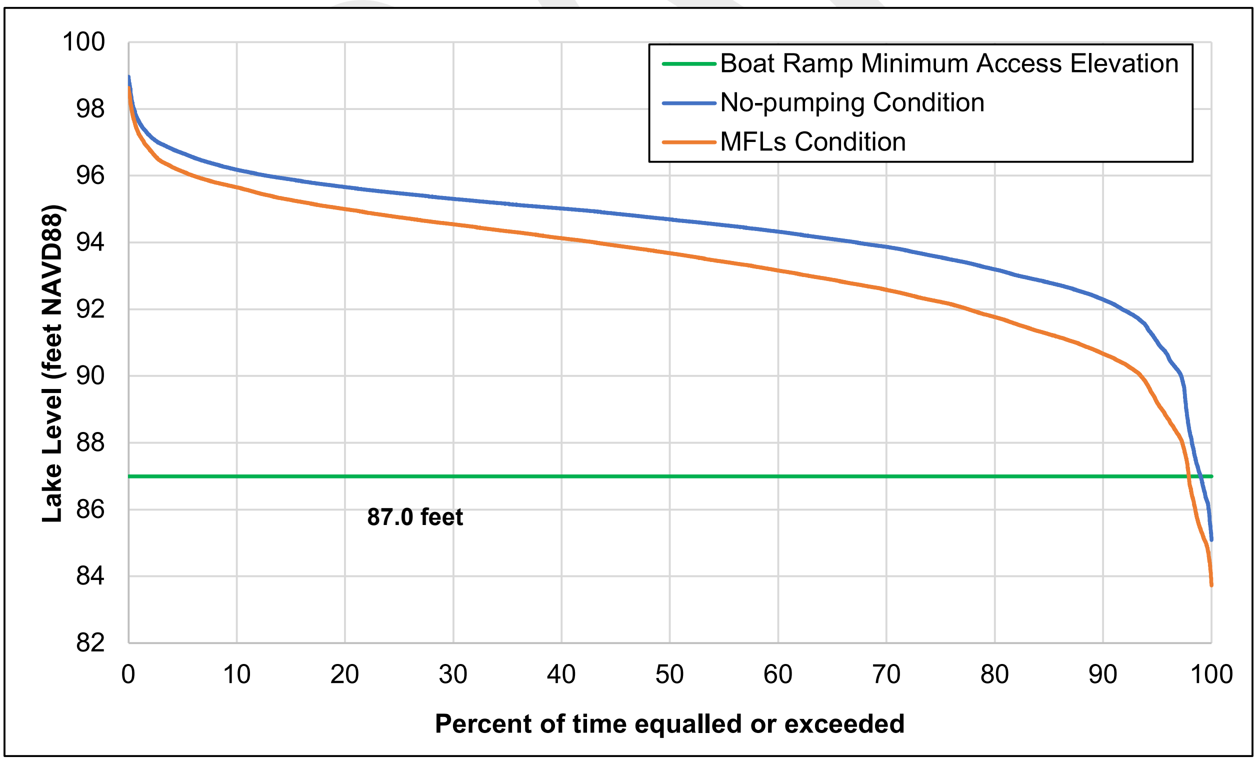



Figure E–4: Boat ramp access elevation (87.0 feet NAVD88) and corresponding exceedance percentages of the no-pumping condition versus the MFLs condition.

**WRV 6 – Aesthetics and scenic attributes:**

The purpose of this environmental value is to protect, from significant harm due to water withdrawal, those features of a waterbody typically associated with passive uses, such as birdwatching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation.

This WRV was evaluated based on the change to the total lake area at the median (P50) water level. The total lake area in acres at the P50 water level was compared between the no-pumping and the MFLs conditions.

The long-term median lake level is 94.7 feet NAVD88 for the no-pumping condition and 93.7 feet NAVD88 for the MFLs condition. The lake stage-area relationship developed for the Johns Lake hydrologic model was used to determine the difference in total lake area between these two elevations (Figure E-5).

The total lake area at the median stage under the no-pumping condition, is approximately 2,538 acres. The total lake area at the median stage under the MFLs condition is approximately 2,442 acres, representing an approximate 3.8% reduction in area at the long-term median lake level (Table E-5; Figure E-5). This reduction in total lake area is less than the 15%. threshold and therefore this WRV is considered protected by the recommended minimum hydrologic regime

Table E-5. Lake area at median stage elevation and percent change between the no-pumping and MFLs conditions.

| Hydrologic condition | Median stage (ft, NAVD) | Lake area at median stage (acres) | Lake area change between no-pumping and MFL at P50 (acres ) | Percent change in lake area between no-pumping and MFLs conditions at P50 (%) |
|---|---|---|---|---|
| No-pumping | 94.7 | 2538 | 96 | -3.80% |
| MFL | 93.7 | 2442 | | |

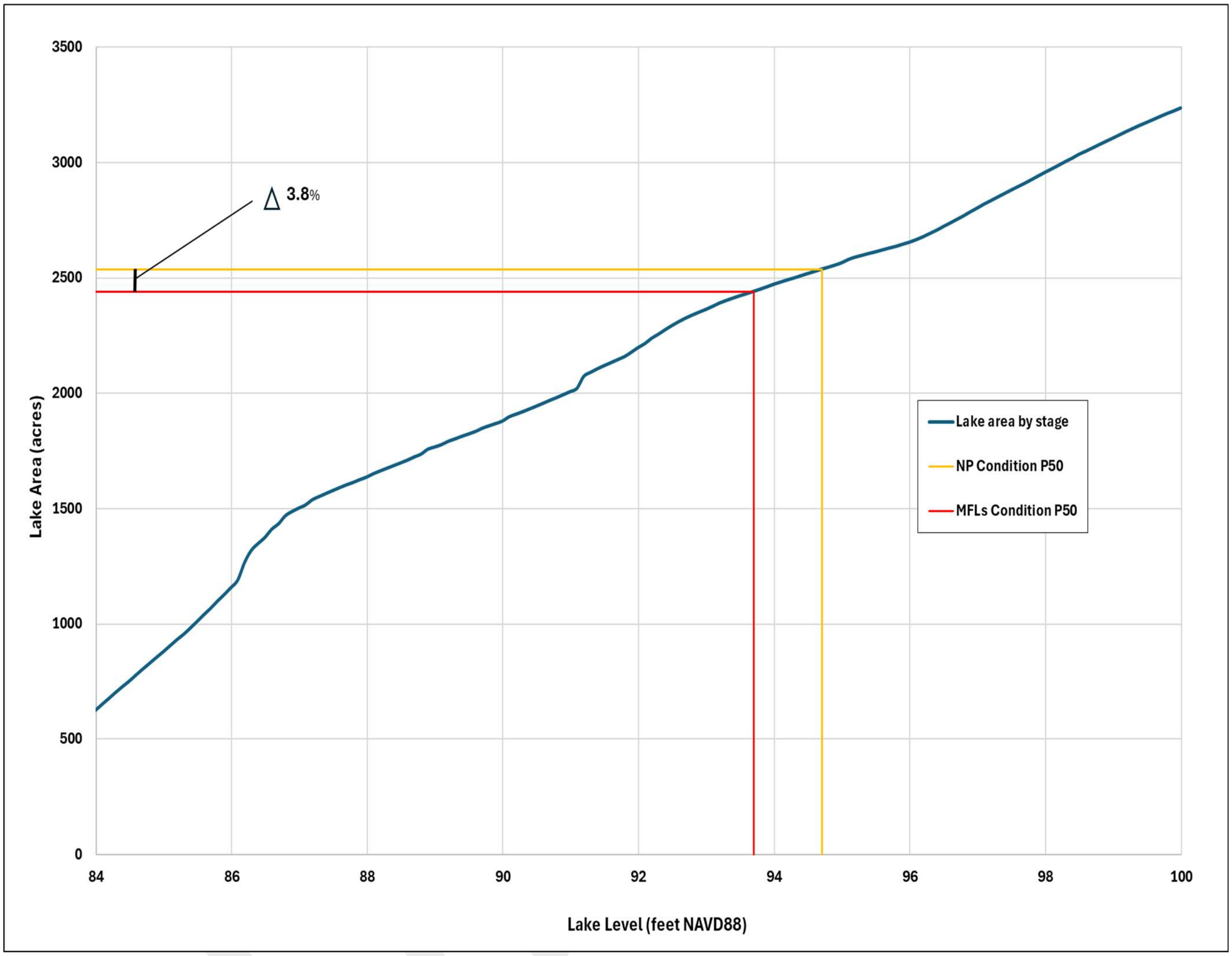



Figure E-5: Difference in lake area at the median water level (P50) for the No-pumping Condition versus the MFLs Condition.

**WRV 9 – Water quality:**

This environmental value aims to protect, from significant harm due to water withdrawal, the ambient chemical and physical properties of a waterbody. A waterbody with poor water quality cannot fulfill its designated uses, which are defined in Rule 62-302.400, *F.A.C.* As a Class III water body, Johns Lake should be safe and suitable for recreation, fish consumption, and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

To determine the role water quantity has on water quality, the SJRWMD investigated the relationship between lake levels and seven parameters, including color (PCU), chlorophyll *a*, total phosphorous (TP), total nitrogen (TN), Secchi depth (SD), Trophic State Index (TSI), and dissolved oxygen (DO). Lowering the water level in a lake can concentrate nutrients and increase mixing from wind-driven waves and boat wakes, which can further reduce water quality. Studies have indicated that total phosphorus and total nitrogen are negatively correlated with water level in many Florida lakes and lakes worldwide (Kratzer and Brezonik 1984; Nõges et al. 2003; Liu et al. 2016). This analysis aims to determine whether TP, TN or other parameters are related to water level at Johns Lake, and if so, whether water quality is protected by the MFLs condition.

Data for the seven water quality parameters listed above were obtained for Johns Lake from the Orange County Water Atlas website. These data were collected by Lakewatch volunteers, SJRWMD employees, Florida Department of Environmental Protection (FDEP) employees, and Orange County biologists. Data were collected from many locations around Johns Lake, but some data from specific sampling locations and events were removed from the data set. Data collected in canals, isolated lobes, and data collected very close to the shore were removed from the data set because they may not accurately reflect the water quality in the main lobes (i.e., the majority) of Johns Lake. Data collected during harmful algal blooms (HABs) were also removed. Many HABs samples are taken to assess water quality and nutrient concentrations after lake users complain about poor water quality or excessive algae growth. These samples were removed from the data set and not analyzed because they do not reflect the average condition of Johns Lake. In summary, the data used in this analysis were random samples taken by various groups from fifteen sites that are believed to accurately represent average conditions within the majority of Johns Lake.

The SJRWMD collected the water quantity data for this analysis, which is available on the SJRWMD website.

Water quality thresholds used in the following analyses were determined by the FDEP and are referred to as numeric nutrient criteria (NNC) (FDEP 2013), as described in Rule 62-302.531, *F.A.C.*

These are summarized in Table E-6, and the long-term averages and most recent values from Johns Lake are presented in Table E-7.

Table E-6: Numeric nutrient criteria (NNC) for Florida's waterbodies

| Long Term Geometric Mean Lake Color and Alkalinity | Annual Geometric Mean Chlorophyll *a* | Maximum calculated numeric interpretation | |
|---|---|---|---|
| | | Annual Geometric Mean Total Phosphorous | Annual Geometric Mean Total Nitrogen |
| **> 40 Platinum Cobalt Units** | **20 µg/L** | **0.16 mg/L** | **2.23 mg/L** |
| < 40 Platinum Cobalt Units and > 20 mg/L $CaCO_3$ | 20 µg/L | 0.09 mg/L | 1.91 mg/L |
| < 40 Platinum Cobalt Units and < 20 mg/L $CaCO_3$ | 6 µg/L | 0.03 mg/L | 0.93 mg/L |

Table E-7: Long-term average and most recent value for water quality parameters with established FDEP NNC at Johns Lake

| **Long Term Average Measured Value for Johns Lake (c. 1980 - 2023)** | | | |
|---|---|---|---|
| **Color** | **Chlorophyll *a*** | **Total Phosphorous** | **Total Nitrogen** |
| 62 PCU | 8.51 µg/L | 0.03 mg/L | 0.95 mg/L |
| **Most Recent Measured Value for Johns Lake (2023)** | | | |
| **Color** | **Chlorophyll *a*** | **Total Phosphorous** | **Total Nitrogen** |
| 21 PCU | 7.60 µg/L | 0.03 mg/L | 0.78 mg/L |

FDEP classifies lakes based on color because water transparency (i.e., how much sunlight can penetrate the water column) is a significant contributor to the formation of algal blooms.

Because clearer water bodies are more susceptible than dark ones to algal bloom formation, darker water bodies have higher nutrient thresholds. Johns Lake is considered a colored lake with greater than forty platinum cobalt units (PCUs); (see Table E-6 for corresponding NNCs). Color, Chlorophyll *a*, TP, and TN values are calculated as annual geometric means (AGMs), in accordance with 62-303.350, F.A.C. which states that to calculate annual geometric mean, there must be at least four temporally independent samples per year with at least one sample collected between May 1 and September 30 and at least one sample collected during the other months of the calendar year.

<u>Color</u>

There is a weak ($R^2 < 0.01$) and statistically insignificant ($p = 0.64$) relationship between water level and color at Johns Lake (Figure E-6). Though the trendline has a slightly positive slope, these data suggest that water level reductions are not likely to have an impact on lake color.

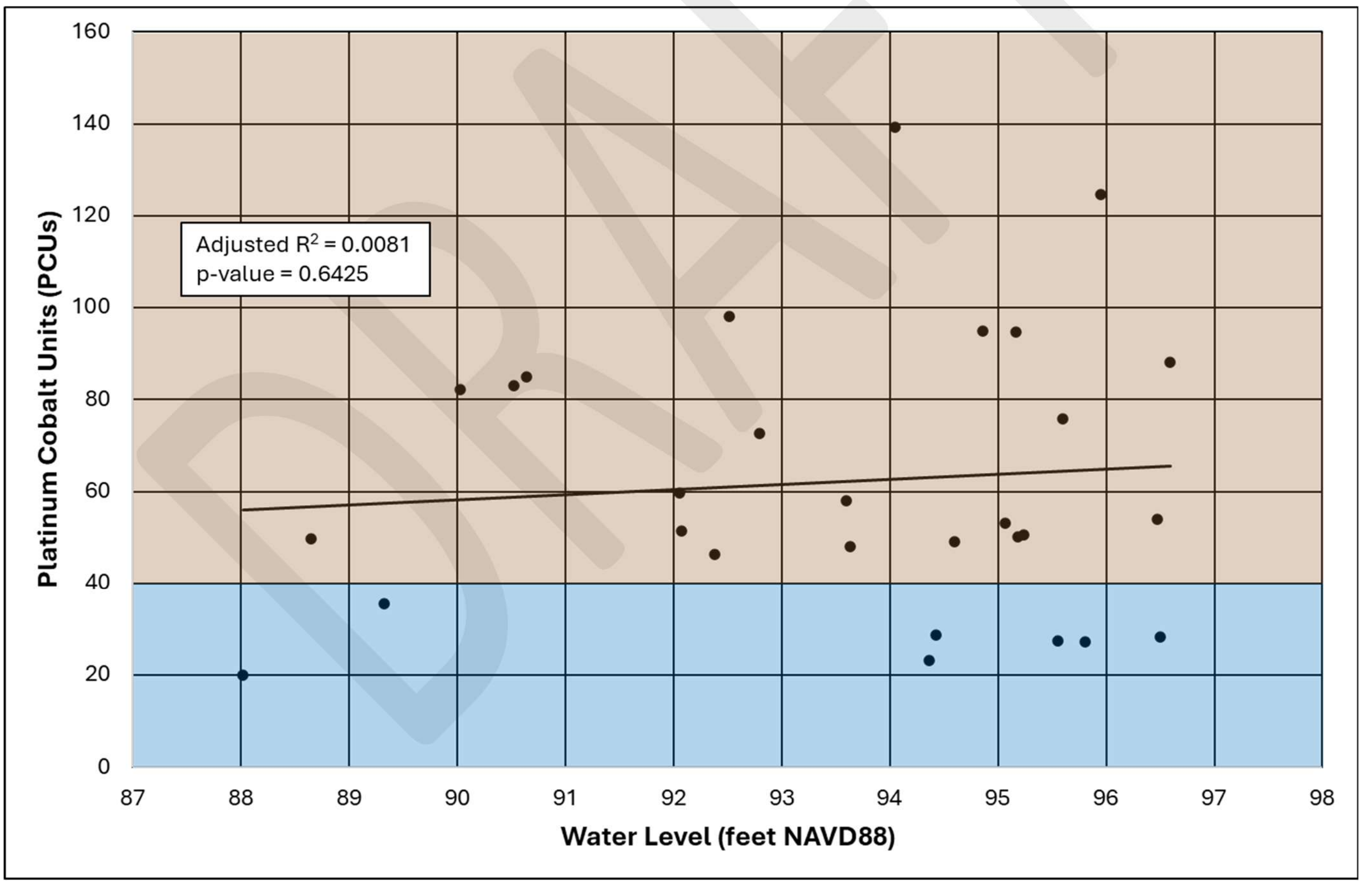



Figure E-6:: The relationship between color AGMs measured in platinum cobalt units (PCUs) and water level (ft; NAVD88) with values below 40 PCUs depicted in blue and those above in brown. FDEP designates lakes below 40 PCUs as having clear water and therefore must comply with more stringent nutrient criteria. Since the long-term color average at Johns Lake is above 40 PCUs, it is considered a dark water lake.

Johns Lake's color has decreased (i.e., water clarity has increased) since the early 2000s (Figure E-7). The long-term average color is 62 PCUs but the most recent AGM was 28.75 PCUs in 2023. If this trend continues, Johns Lake may switch color classes and need to be assessed using the clear water NNCs listed in Table E-6.

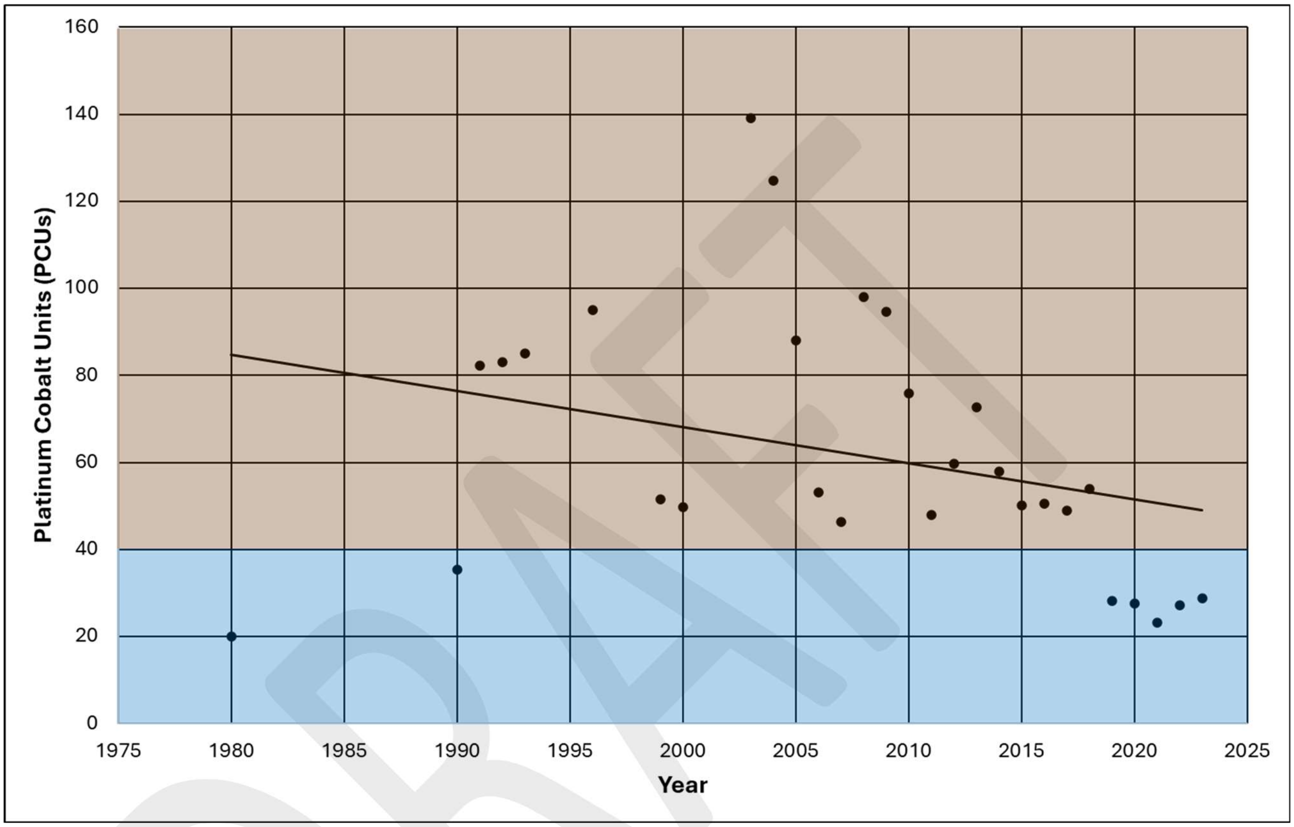



Figure E-7: Color AGMs measured in platinum cobalt units (PCUs) recorded from 1980-2023. Observations in blue are below FDEP's clear water threshold of 40 PCUs while those in brown are above.

Chlorophyll *a*

Chlorophyll *a* concentration is a standard index used to estimate the amount of algal biomass in a waterbody. As one of the parameters used to calculate TSI, chlorophyll *a* is used to classify the trophic condition of a waterbody. Although algae are a natural part of freshwater ecosystems, excessive algal growth can impair lake aesthetics and scenic values, causing problems such as green lake surface scums and foul odors. Decomposition of excessive algae can also result in increased decomposition, decreased levels of dissolved oxygen and fish kills. Some algal species also produce toxins that can be of public health concern when found in high concentrations (EPA 2025).

In lakes, chlorophyll *a* concentration often increases in response to low water conditions because the nutrients required for its production are concentrated and suspended in the water column more frequently. Furthermore, increased sunlight reaches more of the water column under low water conditions. Chlorophyll *a* data at Johns Lake illustrates this phenomenon. However, the relationship between water level and chlorophyll *a* concentration (Figure E-8) is fairly weak ($R^2 = 0.27$) and statistically significant ($p = 0.019$). In analyzing this relationship, there is a low number of observations; AGMs are only available from 2006-2023.

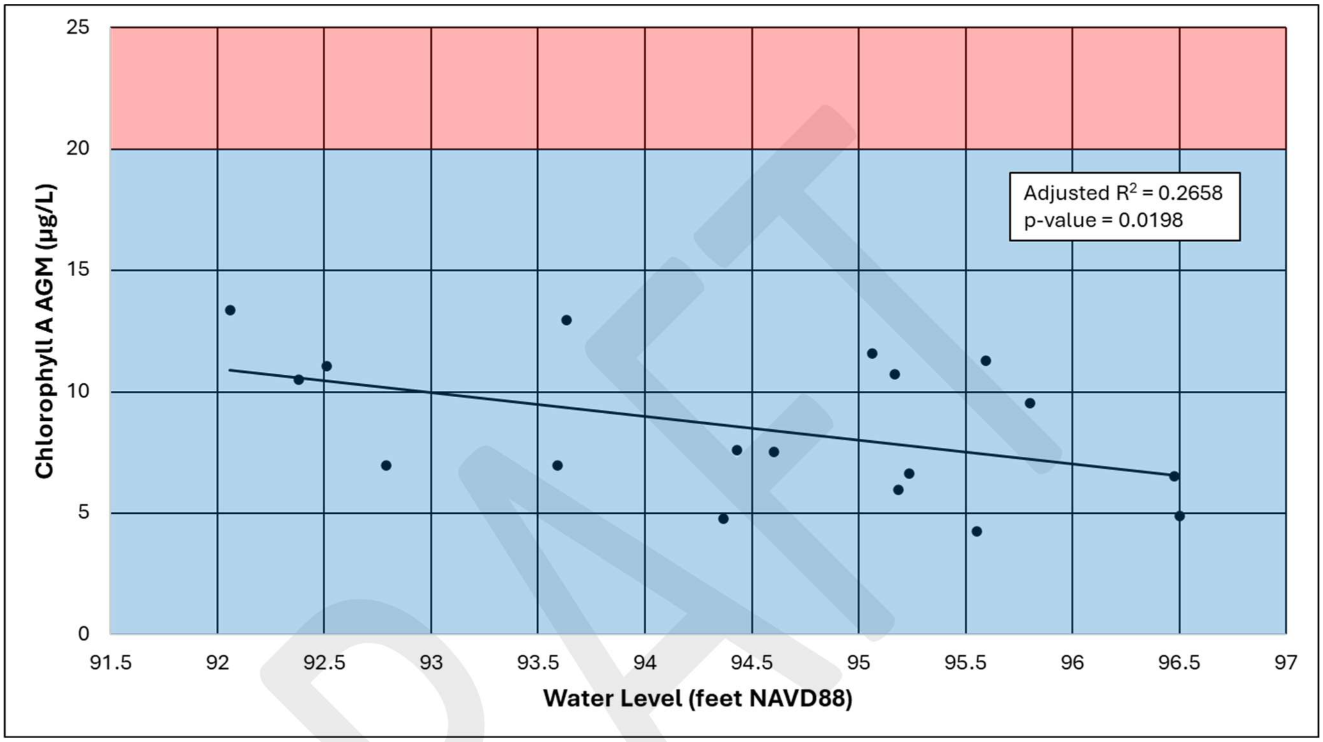



Figure E-8: Johns Lake chlorophyll *a* AGMs (in micrograms per liter), compared to yearly average water levels (in feet NAVD88). All chlorophyll *a* values are below FDEP's 20 ug/L threshold, which is displayed in red.

Chlorophyll *a* concentration in Johns Lake has gradually decreased throughout the period of record (2006 to 2023) (Figure E-9). This decrease may have resulted from recent higher-than-average water levels diluting the nutrients required for chlorophyll *a* production by algae, or a gradual decrease in loading over time. In the period of record, chlorophyll *a* concentration has never exceeded FDEP's numeric nutrient criteria. It should be noted that this analysis includes limited data as AGMs are only available from 2006-2023 due to a low number of observations

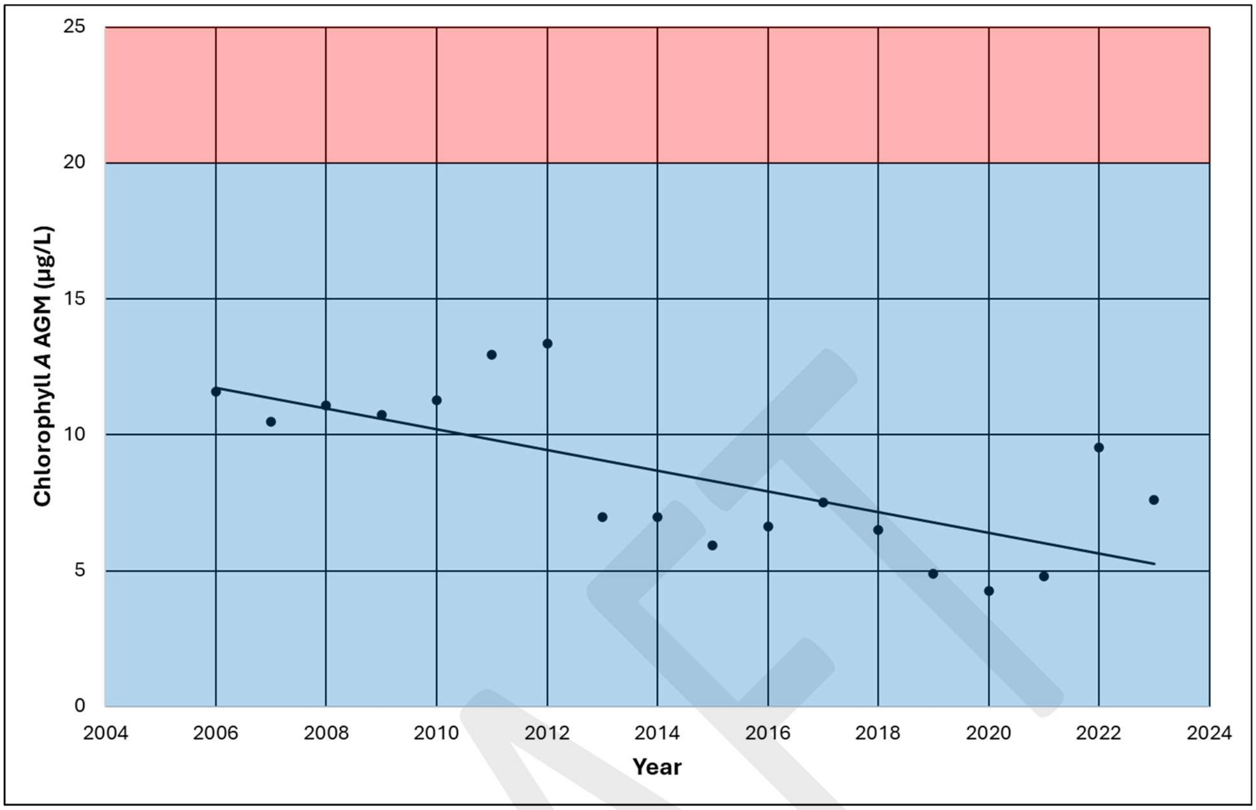



Figure E-9: Johns Lake chlorophyll *a* AGMs (in micrograms per liter), from 2006 to 2023. All chlorophyll *a* values are below FDEP's 20 ug/L threshold, which is displayed in red.

<u>Total Phosphorous (TP)</u>

Like many other lakes in Florida, phosphorous is the limiting nutrient in Johns Lake (Orange County 2024). Therefore, increases in phosphorous concentration may lead to increased productivity, increasing the TSI and potential for eutrophication. The total phosphorus (TP) concentrations evaluated are yearly average values and are considered independent. A regression analysis of these data suggests that water level is statistically significantly ($p = 0.018$) but weakly related ($R^2 = 0.128$) to TP concentration (Figure E-10).

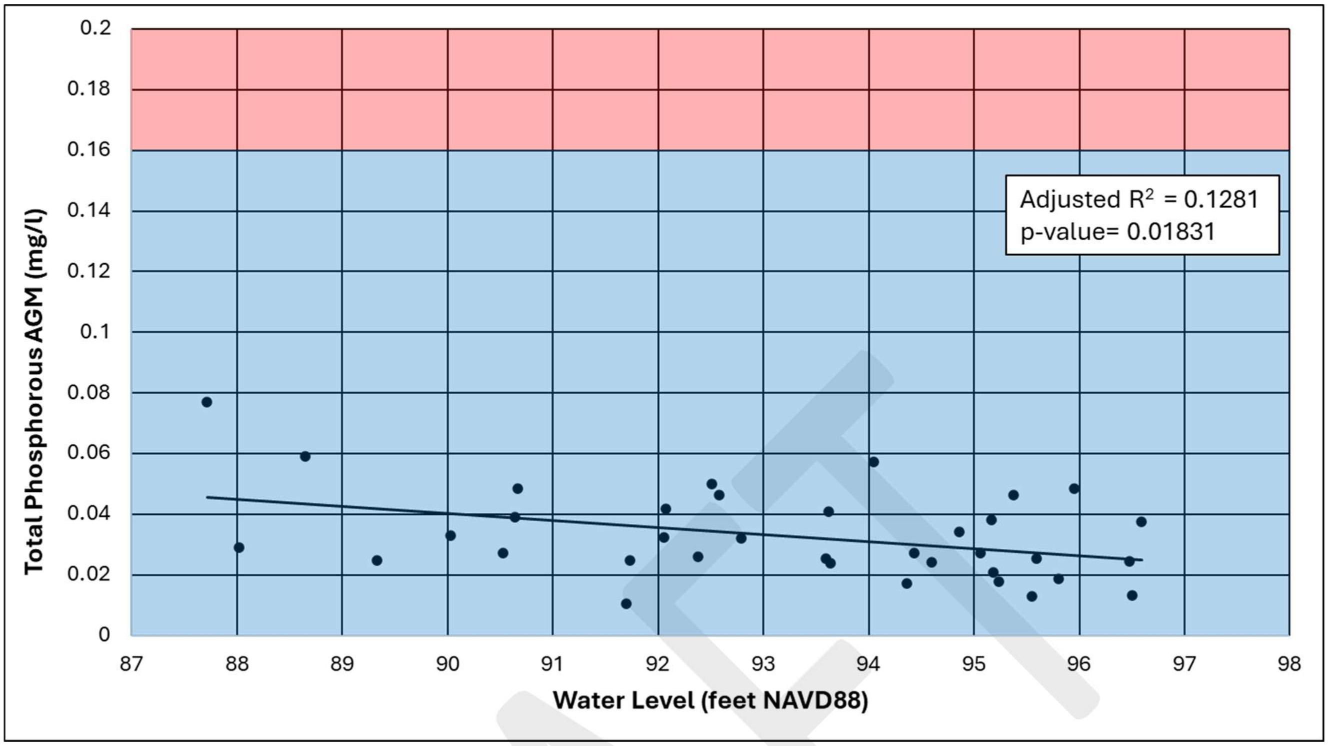



Figure E-10: Johns Lake total phosphorous concentration (milligrams per liter-mg/L) compared to water level (feet NAVD88). An AGM for TP has never reached FDEP's 16 mg/L limit (shown in red) and has been within the acceptable range at every water level in the POR.

Johns Lake TP concentration has decreased over the period of record (1980-2023) time (Figure E-11). Consistent with TSI, TP concentrations peak in the early to mid-2000s and then gradually decline. AGM TP concentrations at Johns Lake have never exceeded FDEP's numeric nutrient criteria for lakes of this type (Table E-6) and even Even at Johns Lake's lowest observed water levels, TP concentrations have not exceeded FDEP's numeric nutrient criteria. This, plus the weak relationship between water level and TP concentration suggest that impacts due to this nutrient will not be caused by the recommended MFLs condition.

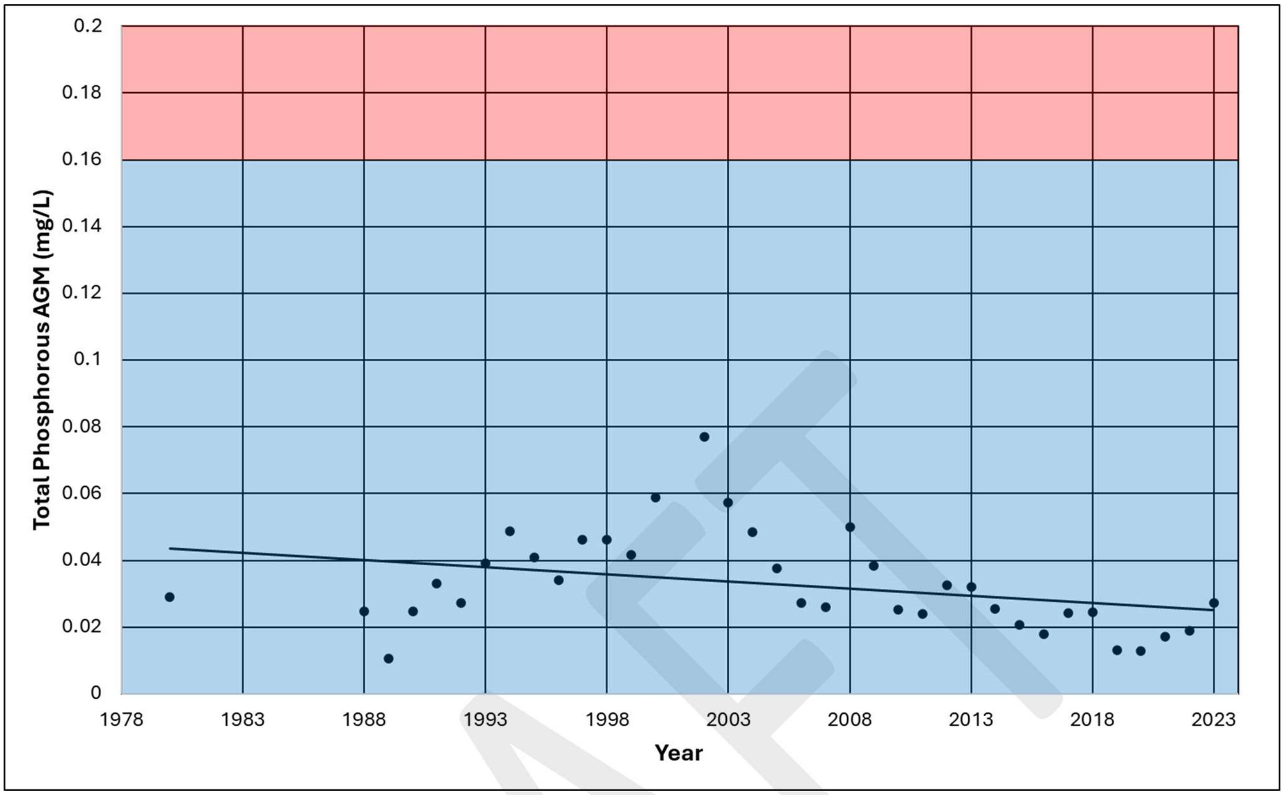



Figure E-11: Annual geometric means of total phosphorous concentration in Johns Lake (in milligrams per liter) during the period of record (1980 to 2023. An AGM for TP has never reached FDEP's 16 mg/L limit (shown in red) and has been within the acceptable range (blue) every measured year in the period of record.

Total Nitrogen (TN)

For lakes with a long-term geometric mean color and alkalinity of 40 PCUs or greater, FDEP's total nitrogen (TN) concentration threshold is 2.23 milligrams per liter, measured as an AGM. There relationship between water level and TN at Johns Lake is weak ($R^2 = 0.08$) and is not statistically significant ($p = 0.056$) (Figure E-12).

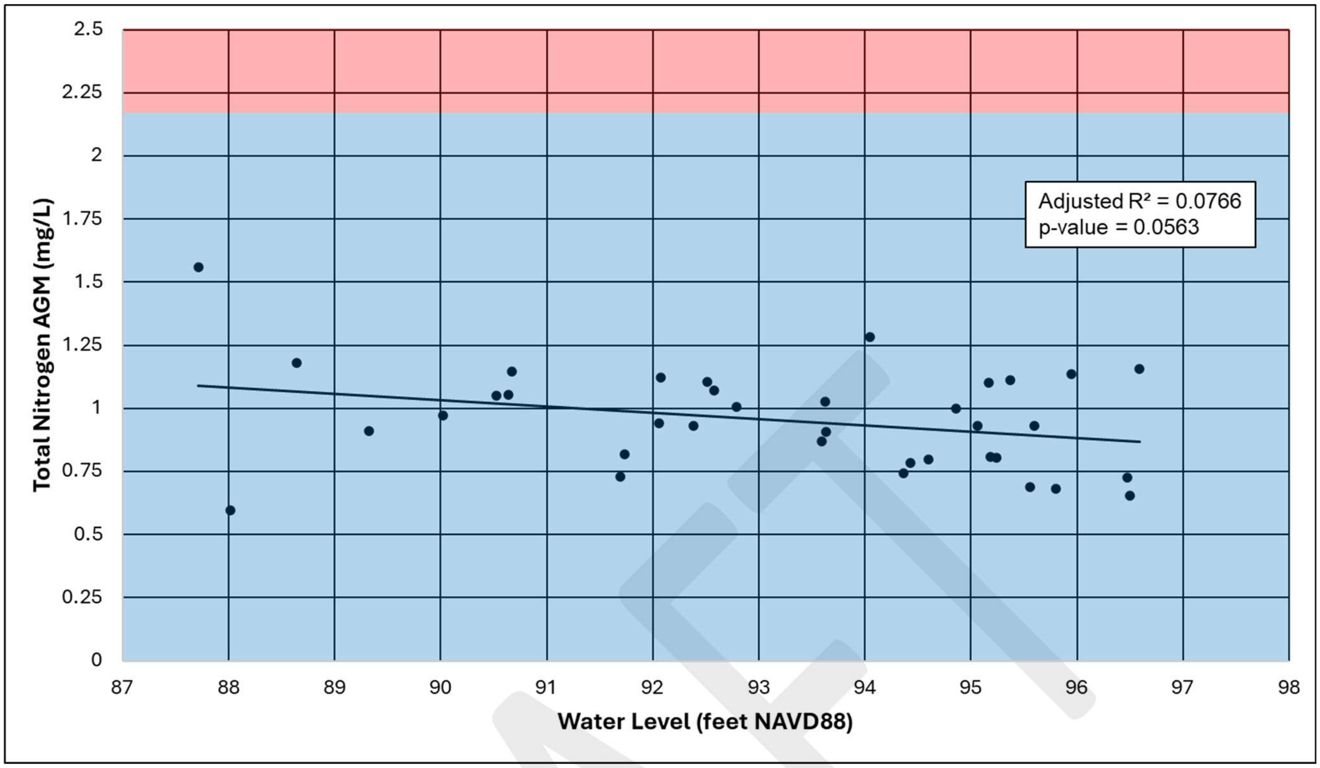



Figure E-12: Johns Lake TN AGMs (mg/L) compared to water level (feet NAVD88). FDEP's TN threshold = 2.23 mg/L. For each measured yearly average water level, the TN at Johns Lake has been in the acceptable range (blue).

The highest AGM nitrogen concentration measured at Johns Lake was 1.55 milligrams per liter. This measurement was taken in 2002 when the average water level for the year was 87.7ft NAVD88 (Figure E-13). This is the third lowest yearly average water level in the period of record (1980-2023), surpassed only by the ones in 2001 and 1981. The two-year drought (in 2001 and 2002) may have contributed to this relatively high nitrogen concentration.

Johns Lake TN concentration has decreased over the period of record  (Figure E-13)nd has not exceeded FDEP's numeric nutrient criteria for any measured year in the period of record. The weak relationship between water level and TN suggests that changes in water level due to the recommended MFLs condition will not impact Johns Lake nitrogen concentrations.

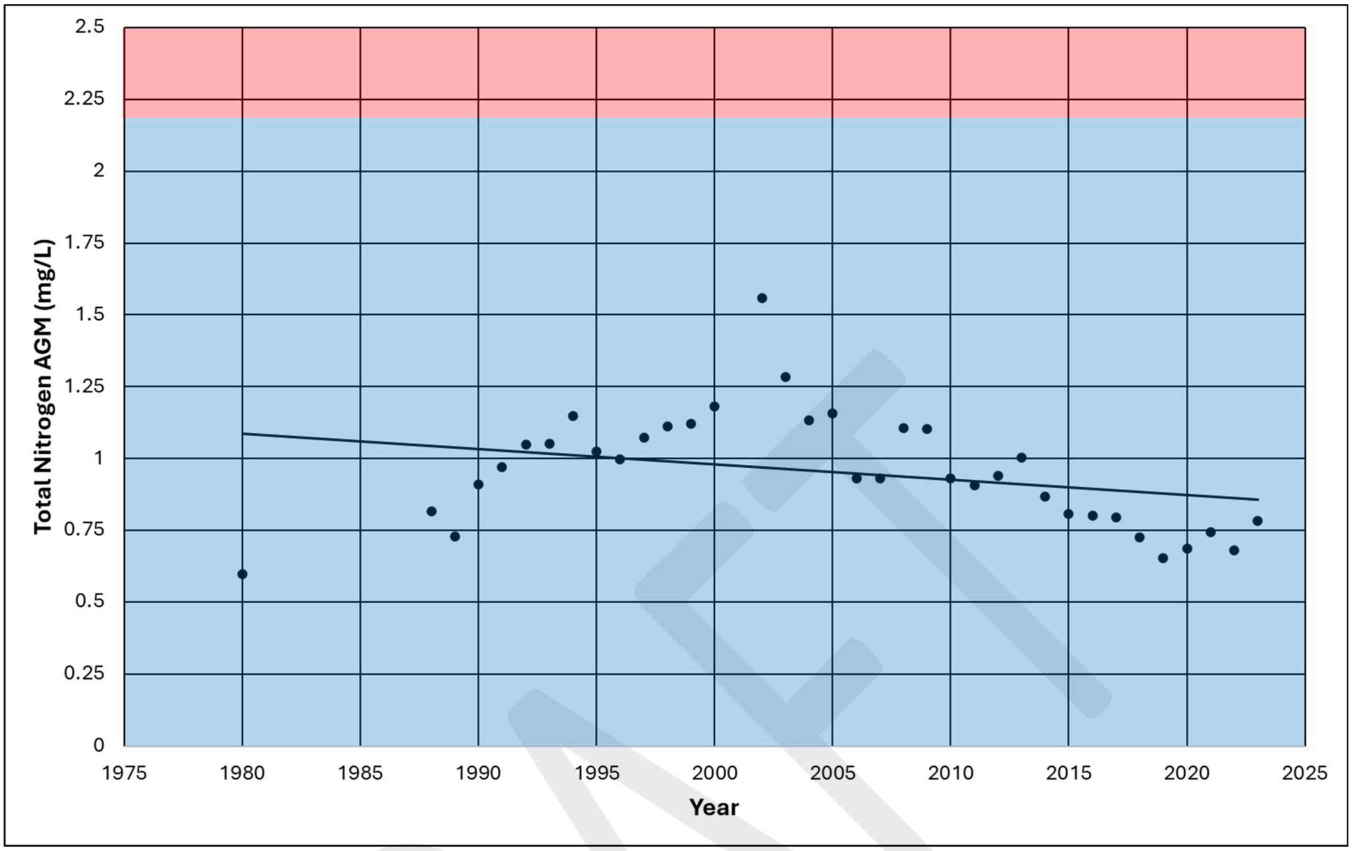



Figure E-13: Johns Lake TN AGMs (milligrams per Liter) from 1980-2023. All TN AGMs over the POR have been in the acceptable range (blue) and have not exceeded FDEP's threshold of 2.23 mg/L (red).

<u>Secchi Depth</u>

Water clarity is an aesthetic attribute that many lake users value, and for some systems, it may provide insights into the ecological and chemical health of the lake. Since Secchi depth observations were sporadic and not temporally independent, they were not compared to water levels with regression analysis. However, there does appear to be a slight positive relationship between water level and water clarity (Figure E-14). There is, however, a large spread in the data, indicating that there are likely factors other than water level that influence water clarity.

These data also suggest that Secchi depth has increased over time (Figure E-15). This is likely associated with the corresponding decrease in nutrient concentrations over time (Figures E-11 and E-13).

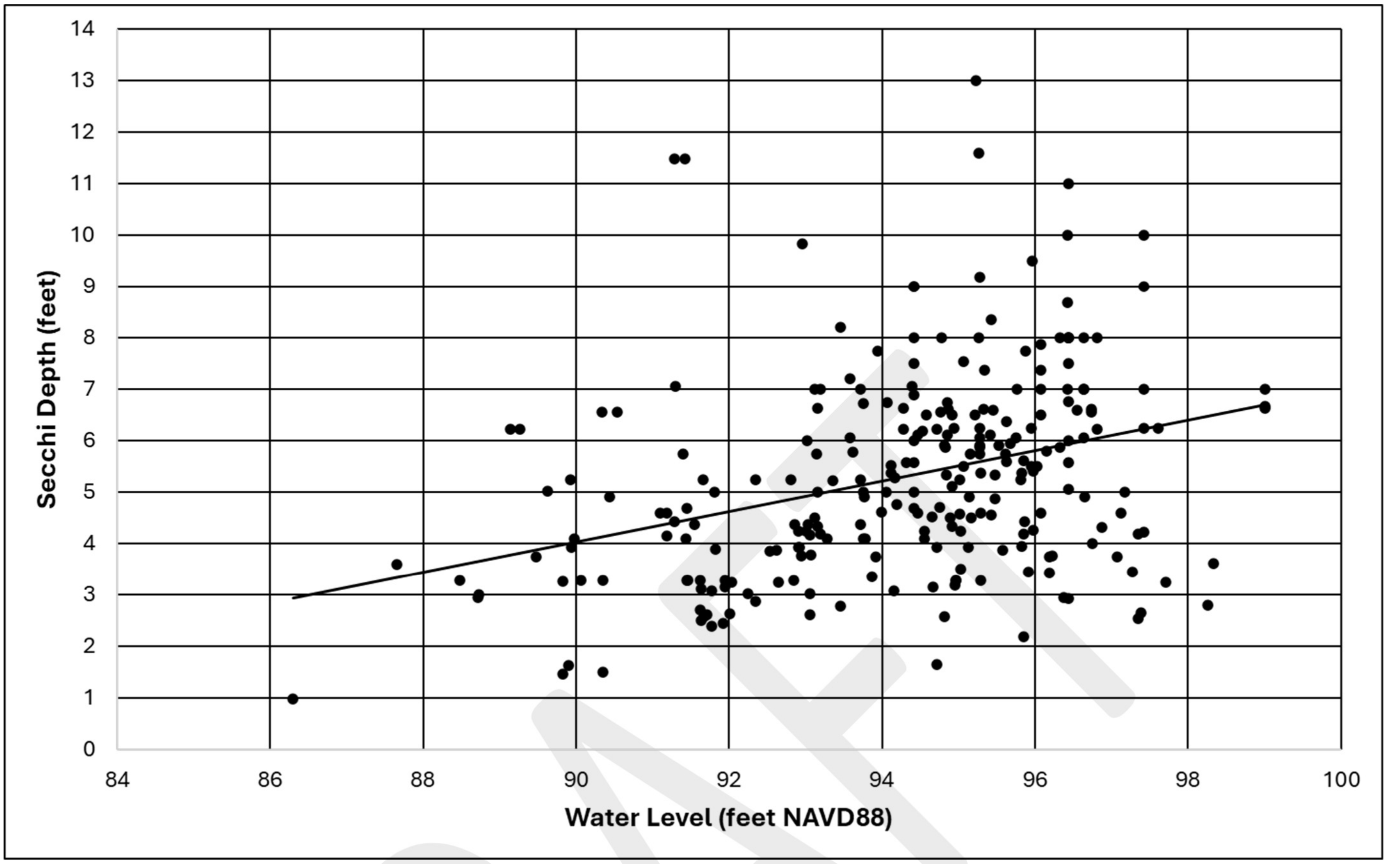



Figure E-14: Secchi depth measurements (in feet) at Johns Lake compared to the water level at the time of measurement (in feet NAVD88)

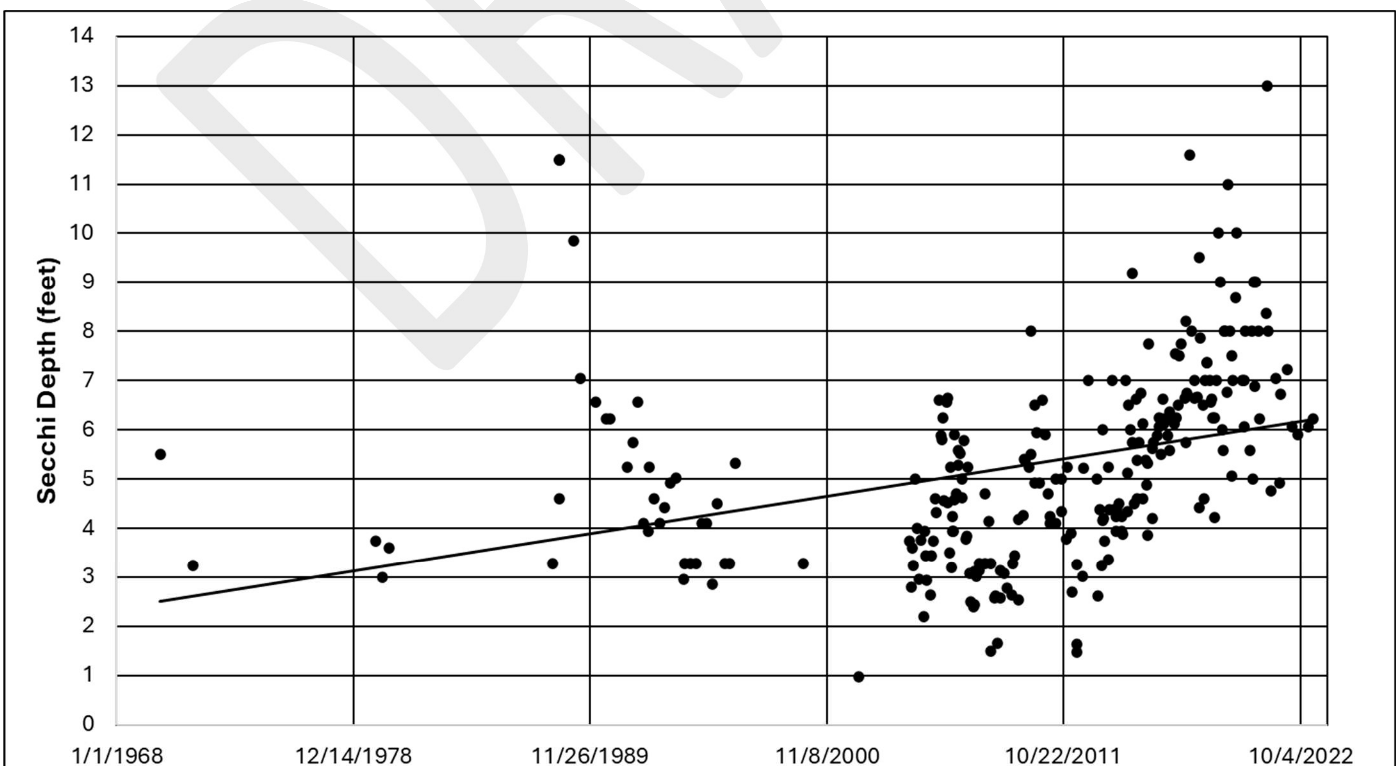


Figure E-15: Secchi depth measurements (in feet) at Johns Lake from 1970 – 2023

Trophic State Index (TSI)

The Trophic State Index (TSI) is considered an indicator of lake health or integrity, and is calculated using TP, TN, Secchi depth, and chlorophyll *a* data. The TSI value also indicates the biological diversity a lake can sustain (USF 2024). Values above 70 are considered poor water quality, values between 60 and 69 are considered fair water quality, and values 59 or below are considered good water quality (Friedemann and Hand 1989) (Table E-8). . Lakes with a very low TSI value are considered oligotrophic and are characterized by low nutrient concentrations and low productivity. These lakes are typically clear and have low species richness, but some consider their " quality " to be high for recreation and aesthetics. Lakes with higher TSI values are considered eutrophic and characterized by high nutrient concentrations and high productivity. They typically have lower water clarity and have higher species richness than oligotrophic lakes However, species richness can decline sharply if the lake becomes too eutrophic. Eutrophication due to excessive nutrient inputs has been a problem in many of Florida's lakes, which has prompted regulation and restoration efforts. TSI values vary from lake to lake but can rise dramatically in a lake experiencing drought which can cause an increased concentration of nutrients, increased algal biomass, and the potential for increased algal decomposition and anoxia. This analysis aimed to determine whether TSI is related to water level and whether water level reduction could significantly impact TSI at Johns Lake.

Table E-8: TSI value range for each trophic state classification

| Trophic State Index value | Trophic State Classification | Water Quality |
|---|---|---|
| 0-59 | Oligotrophic through Mid-Eutrophic | Good |
| 60-69 | Mid-Eutrophic through Eutrophic | Fair |
| 70-100 | Hypereutrophic | Poor |

TSI values for Johns Lake were compared to the corresponding water levels for each day for which their constituent components were collected. Sampling dates were largely sporadic and sometimes very close together. Due to the latter, these data are not considered independent and therefore violate the assumption necessary to perform a linear regression preventing the ability to statistically assess the relationship between water levels and TSI. However, the data's general scatter indicates no relationship between water level and TSI; at both high and low water levels, TSI remains relatively constant. For most of the available period of record (1979 to 2022), and most water levels, Johns Lake has had TSI values below 60 and is thus considered of good quality based on this index (Figure E-16).

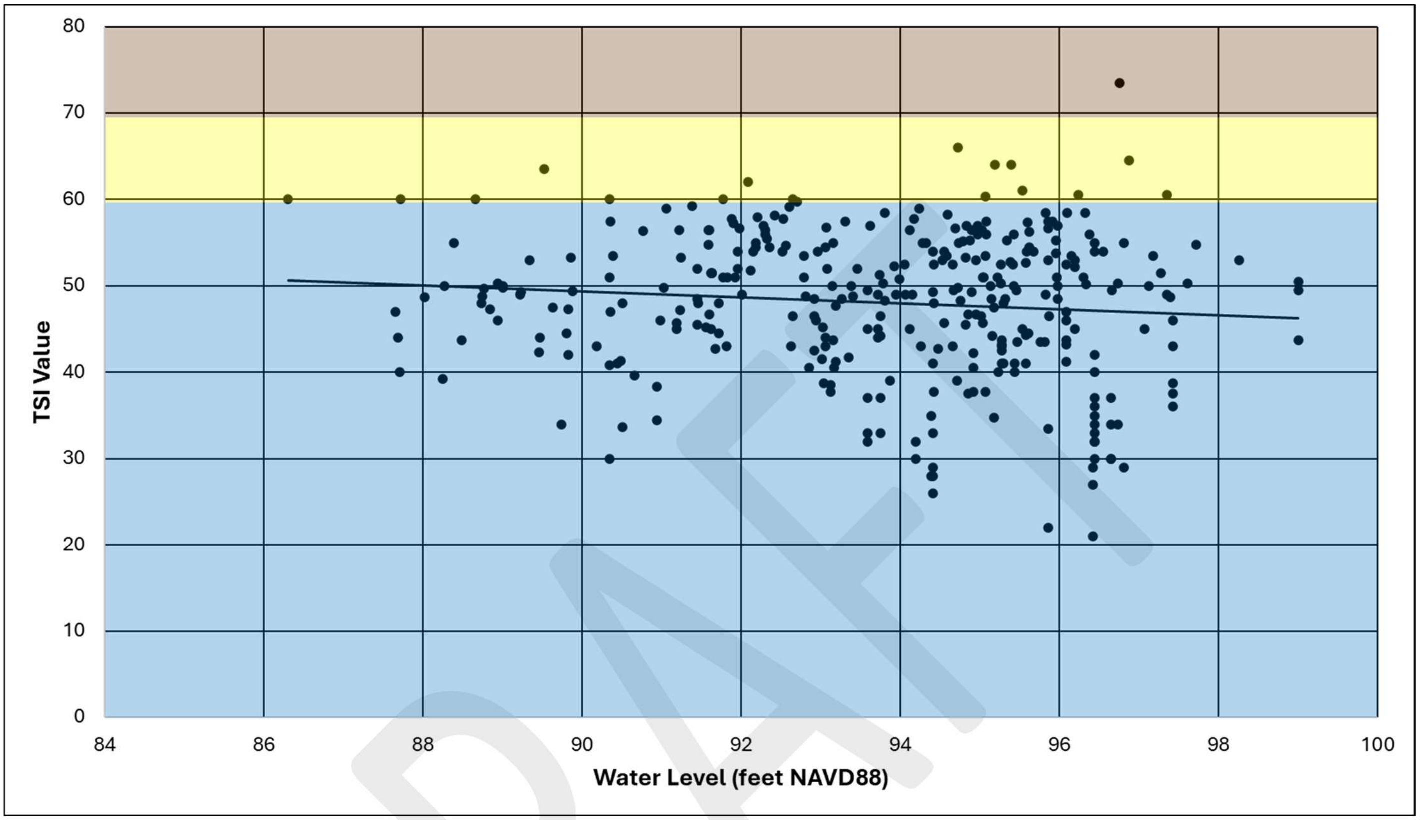



Figure E-16: TSI values at Johns Lake compared to water levels (feet NAVD88). Most values are in the 0-59 range (blue), fourteen values are in the 60-69 range (yellow), and one value is in the 70-100 range (brown). This indicates that Johns Lake is normally oligotrophic through mid-eutrophic

Johns Lake TSI data were available from 12/19/1979 to 8/15/2022 (Figure E-17). The general TSI trend over this period of record suggests that productivity in Johns Lake has gradually decreased since the early to mid-2000s.

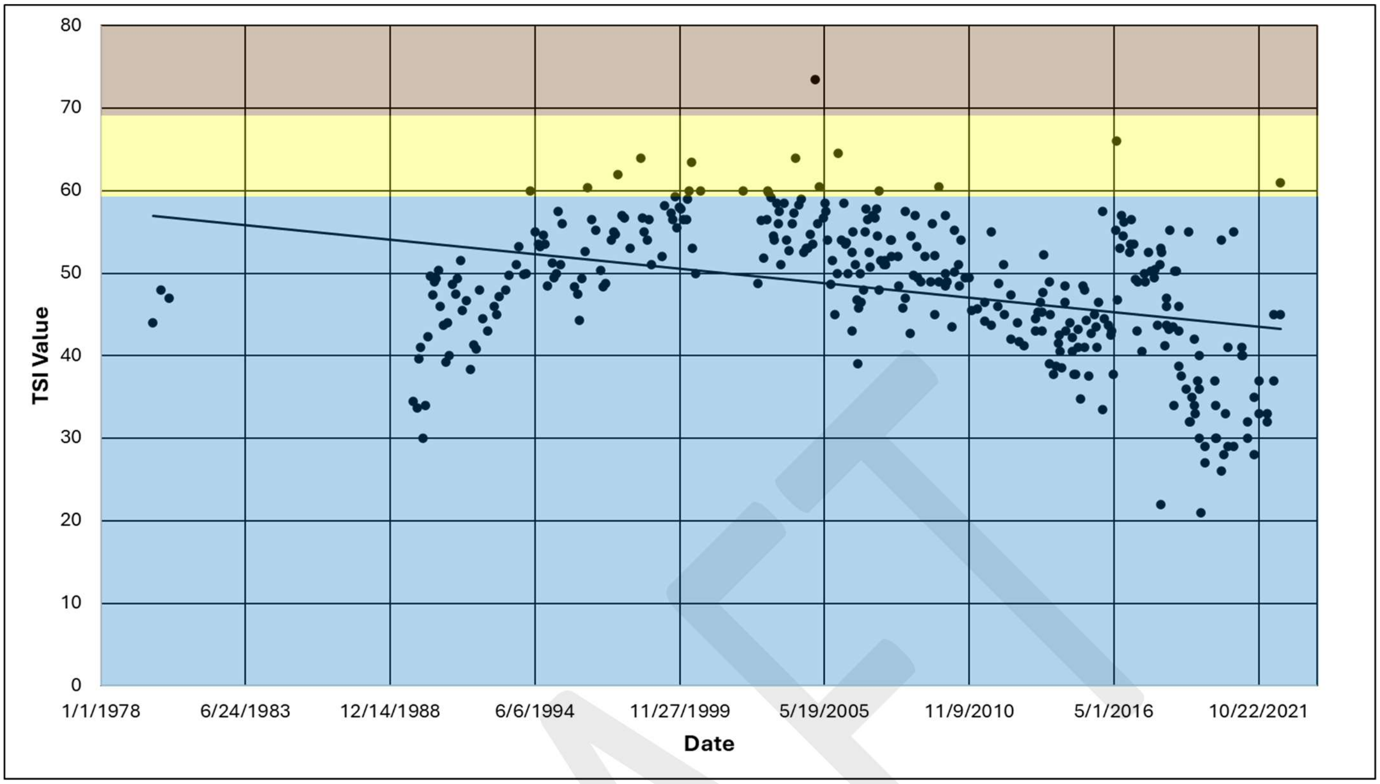



Figure E-17: TSI values at Johns Lake from 1979-2022. Most values are in the 0-59 range (blue), fourteen observation are in the 60-69 range (yellow), and one value is in the 70-100 range (brown). This indicates that Johns Lake is normally oligotrophic through mid-eutrophic.

## Dissolved Oxygen

Dissolved oxygen (DO) is among the most important water quality parameters for aquatic life. The EPA's DO threshold suggests that the daily minimum concentration (in milligrams per liter) needed to support warmwater mature aquatic organisms is 3 mg/L. Early life stages, which are more susceptible to hypoxia, typically require at least 5 mg/L for survival. The EPA (2021) "1 Day Minimum" was used in this analysis because it is the only criteria that is listed for both early and mid-to-late life stage aquatic organisms (Table E-9).

Table E-9: EPA dissolved oxygen (DO) recommended thresholds based on aquatic organism life stage

| Warmwater Criteria | | |
|---|---|---|
| **Span** | **Early Life Stages (DO in mg/L)** | **Other Life Stages (DO in mg/L)** |
| 30 Day Mean | NA | 5.5 |
| 7 Day Mean | 6.0 | NA |
| 7 Day Mean Minimum | NA | 4.0 |
| **1 Day Minimum** | **5.0** | **3.0** |

There were two measurements collected at Johns Lake in 1998 and one measurement in 1994 with DO concentrations below this 5mg/L threshold (Figure E-18; Figure E-19). These low DO concentrations all occurred during relatively low water levels (91.42, 91.28, and 88.48 respectively). However, there are instances of high DO concentration at these same water levels (Figure E-18). This indicates that water level may not be a good predictor of DO concentration in Johns Lake. Other factors such as temperature and photosynthesis may influence DO concentrations more than water levels.

Sampling dates were largely sporadic and sometimes very close together. Due to the latter, these data are not considered independent, violating the assumption necessary to perform a linear regression and preventing the ability to statistically assess the relationship between water levels and DO.

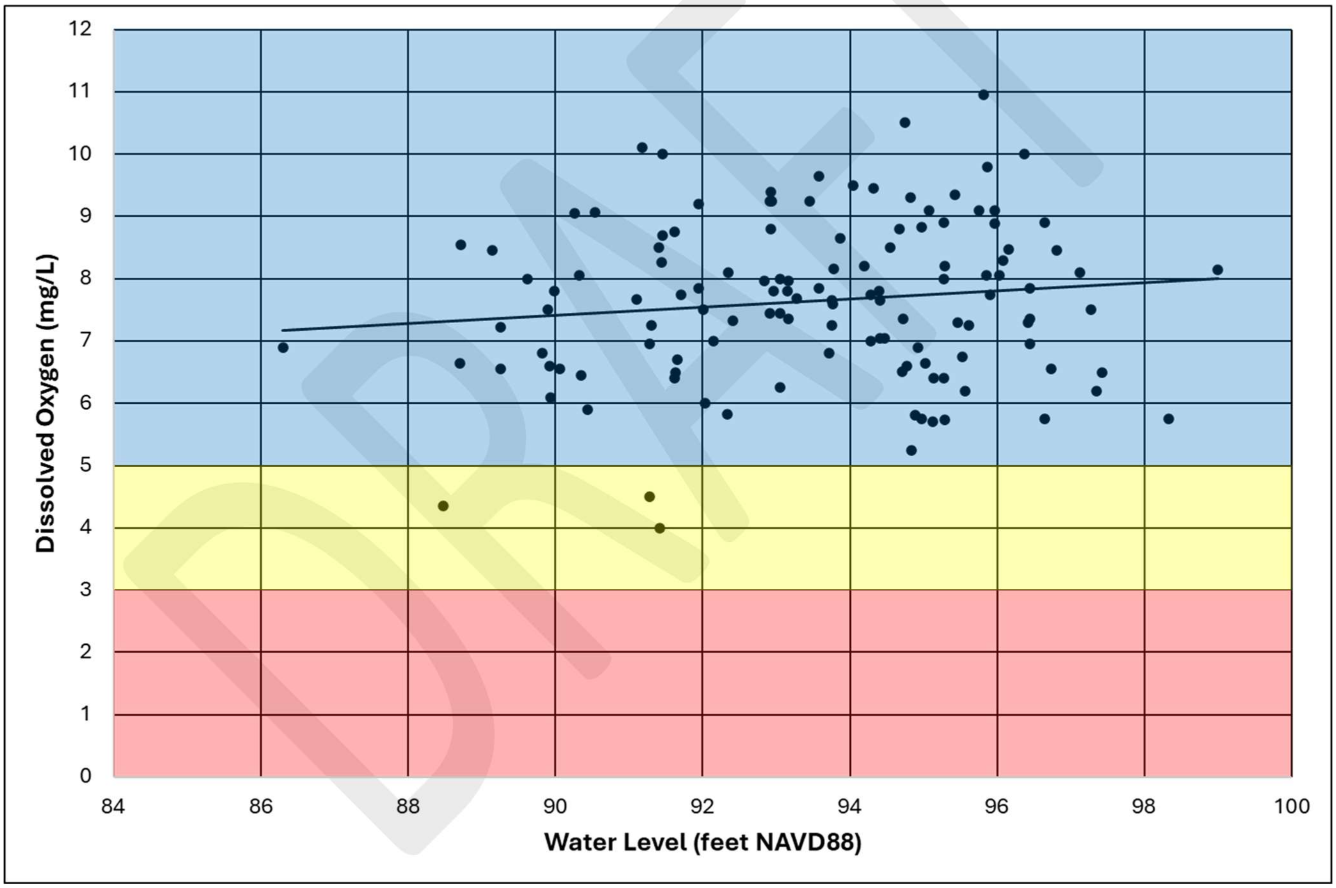



Figure E-18: Johns Lake DO concentrations (in milligrams per liter) compared to water level (in feet NAVD88). All DO measurements at Johns Lake are above the 5.0 mg/L EPA threshold (in blue), except for three (in yellow). The red area of the graph depicts the threshold below which aquatic organisms of any life stage can survive (<3 mg/L).

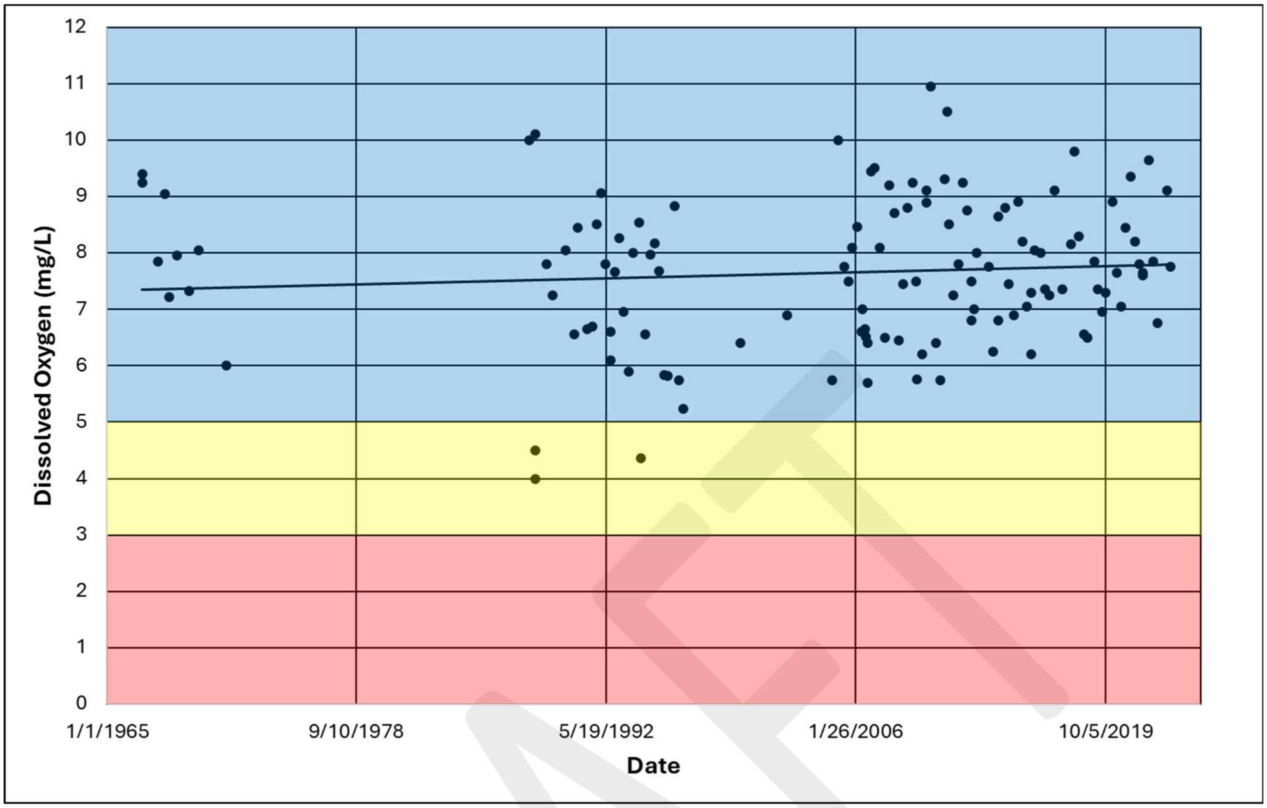



Figure E-19: Johns Lake DO concentrations (in milligrams per liter) from 1966 to 2023



Water Quality Summary

This analysis suggests that water quality has improved over time at Johns Lake. Chlorophyll *a*, TP, TN, and TSI have decreased, and Secchi depth and DO have increased over the period of record. In addition, this analysis suggests a slight improvement in water quality with increasing water levels. However, all relationships assessed were weak (Table E-10). It is also worth noting that the data analyzed were collected over a relatively short period of record, from roughly 1980 until 2023.During this period there has been a prolonged drought and drastic land use change within the Johns Lake watershed.

All water quality parameters analyzed had their highest values (or lowest for Secchi depth) during the early-to-mid 2000s, a time associated with extreme drought. (Figures E-6 – E-19). This analysis suggests that though water level may affect water quality in Johns Lake to a small degree, other factors (e.g., nutrient inputs) are likely responsible for the variation seen in the data.

Table E-10: $R^2$ value and p-value of each parameter for which a linear regression was performed and their interpretation.

| Parameter | $R^2$ | Strength of Relationship to Water Level | p-value | Significant? (Y/N) | Frequency of Threshold Exceedance |
|---|---|---|---|---|---|
| **PCU** | 0.01 | Weak | 0.643 | No | NA |
| **Chl *a*** | 0.27 | Weak | 0.019 | Yes | Not seen in POR |
| **TP** | 0.13 | Weak | 0.018 | Yes | Not seen in POR |
| **TN** | 0.08 | Weak | 0.056 | No | Not seen in POR |
| **Secchi** | NA | NA** | NA | NA | NA |
| **TSI** | NA | NA** | NA | NA | Rare |
| **DO** | NA | NA** | NA | NA | Rare |

** A linear regression could not be used to analyze the relationships between water level and Secchi depth, TSI, or DO observations. However, relationships can be roughly estimated based on the scatterplots.

The water in Johns Lake rarely violates the FDEP NNC  or the EPA DO threshold, and the trend over time is improving for every parameter analyzed. Also, the regression analyses and the data analyzed showed a weak or no relationship between water level and the parameters. Therefore, a slight decrease in water level would not impact the parameters and the water quality at Johns Lake should not be negatively affected by the MFL condition.

## WRVs Assessment Summary

Numerous criteria were evaluated to ensure that the recommended MFLs condition is protective of important, relevant environmental functions and values. The WRVs assessment included an evaluation of recreational metrics, fish and wildlife metrics, and water quality analyses. The WRVs assessment results indicate that the seven WRVs relevant to Johns Lake are protected by the recommended MFLs.

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