

memorandum

date December 10, 2021

to Matt Logan, Charlotte County

cc

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Rick Hagberg, P.G.

subject 2021 (Year 6) Annual Report for Sunshine Lake and Sunrise Waterway

Background

The Sunshine Lake/Sunrise Waterway system, located in Port Charlotte, previously experienced extensive and persistent algae blooms that resulted in noxious odors and deep organic-rich sediments. In prior years, the algae bloom, a mixture of different species of cyanobacteria (aka blue-green algae) was so intense that cyanobacteria filled up half the volume of the open waters of Sunshine Lake and the Sunrise Waterway (as illustrated in Figures 1 through 3).

Figure 1. Photo of northwest portion of Sunshine Lake. Photo from November 2010.



Figure 2. Photo of northeast portion of Sunshine Lake. Photo from January 2012.

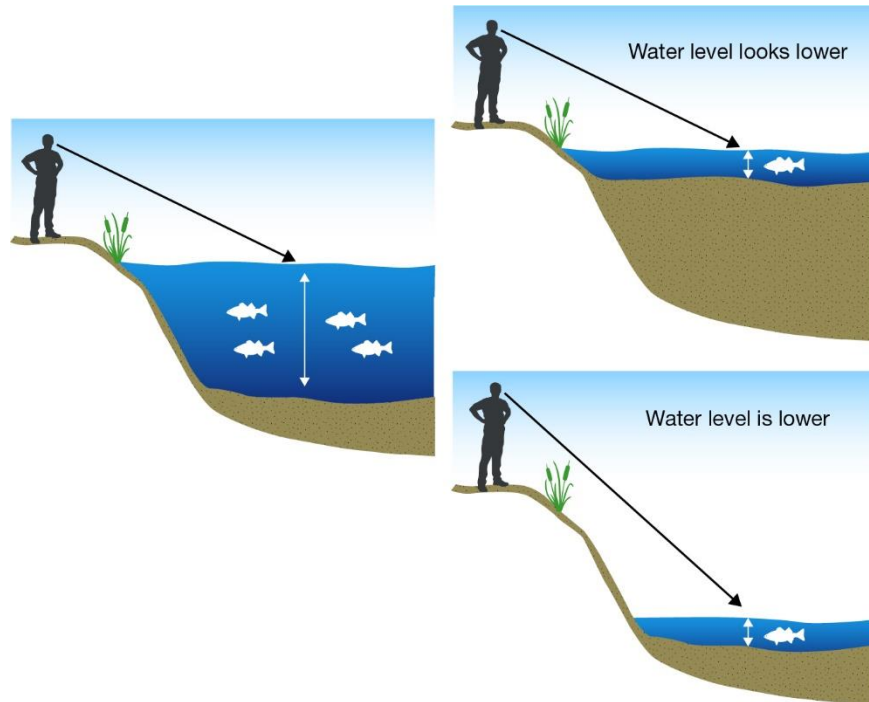


Figure 3. Photo of southern portion of Sunshine Lake. Photo from January 2012.



In response to these conditions, an initial assessment of the lake and waterway was conducted to evaluate potential causes (Atkins 2012). Prior to this initial investigation, several residents of the surrounding neighborhoods believed that the County might have lowered the lake and exposed the lake bottom. In fact, the algal bloom had been intense enough that the biomass of algae had actually filled in the lake from the bottom. The two scenarios are illustrated in Figure 4.

Figure 4. Illustration of prior condition in Sunshine Lake (left side image) compared to perceived condition of lake lower (bottom right image) vs. actual changes in the lake (top right image).



Field work conducted as part of the original investigation determined that the lake and waterway were filling up from the bottom by a mass of cyanobacteria dominated by the species *Aphanothece conglomerate* (Figure 5).

Figure 5. Photo of algal material along the bottom of Sunshine Lake. Photo from January 2012.



As suggested in the original assessment (Atkins 2012) Charlotte County then conducted a dredging project to remove the algal material from both the lake and waterway (Figure 6).

Figure 6. Photo of dredging operation in the Sunrise Waterway.



After the completion of the dredging project, the prior cyanobacteria mat was no longer found in Sunshine Lake (Figures 7 and 8).

Following completion of the County’s dredging project, a more-detailed Water Quality Management Plan (Atkins and ESA 2014) determined that the factors that helped to create the algal bloom include elevated levels of phosphorus in the surficial aquifer and in stormwater runoff due to the naturally phosphorus-rich surface geology in the surrounding watershed.

Due to the naturally phosphorus-rich surface geology, there is the potential that some sort of algal bloom may reoccur, as these nutrient inputs will likely continue in the future. In response, the County initiated a monitoring program as part of the Water Quality Management Plan. This technical memorandum presents the results of the sixth year’s quarterly water quality sampling events, which occurred in August 2020, March 2021 and May 2021. Due to unforeseen circumstances, only three sampling events were performed during this annual monitoring period.

Regulatory Implications

Water quality results listed in this report are presented such that the County can determine whether Sunshine Lake and the Sunrise Waterway are problematic in terms of regulatory criteria developed by the Florida Department of Environmental Protection (FDEP). For these results to be interpreted correctly, the basis for water quality criteria must be fully understood.

Based on data collected in prior efforts (e.g., Atkins and ESA 2014), both Sunshine Lake and the Sunrise Waterway are considered to be low-color and alkaline waterbodies, with a target chlorophyll-a value of 20 µg/L.

Figure 7. Photo of shallow waters along dredged portion of the shoreline of Sunshine Lake, during the County dredging project.

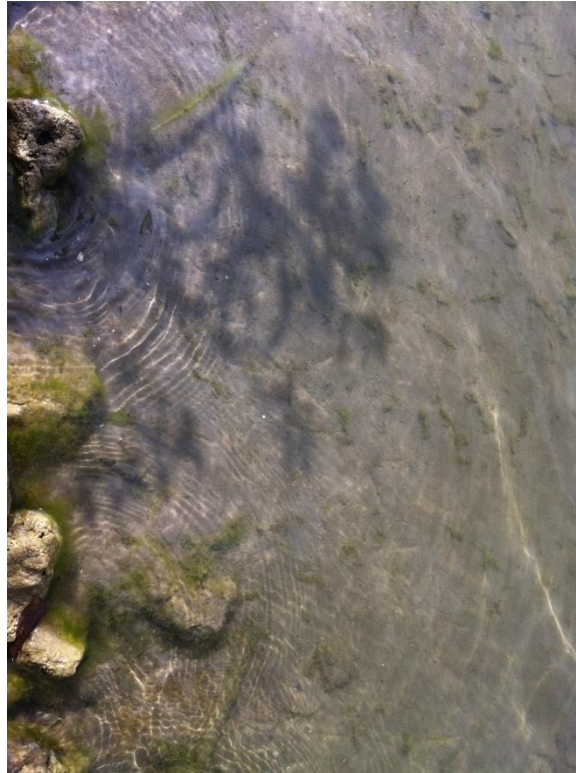


Figure 8. Photo of southern portion of Sunshine Lake, during the County dredging project.



This annual report focuses on the interpretation of findings of both water quality and benthic sampling, with an emphasis on determining compliance with appropriate water quality criteria, as well as to discuss any trends and/or spatial patterns associated with the abundance of algae within the lake and waterway.

Methods

Surface Water Sampling

Water samples from quarterly monitoring of 8 surface water sites (5 in the lake and 3 within the waterway; Figure 9) were collected and analyzed for total and dissolved nutrients (nitrogen and phosphorus), chlorophyll-a, and *E.coli* bacteria.

Figure 9. Location of sampling sites for water quality assessment of Sunshine Lake and the Sunrise Waterway.



One blank and one replicate surface water quality sample were collected during each sampling event, for total of 10 samples collected each time water quality was sampled. *In situ* water quality profiles were performed using a YSI® instrument at each surface water sampling site. Water quality parameters measured included water temperature, dissolved oxygen, pH and conductivity. Secchi disk depth and total water depth were also measured.

Sediment Sampling

Submerged benthic vegetation in Sunshine Lake and the Sunshine Waterway was assessed during the March 2021 sampling event. No submerged vegetation was found, but accumulations of cyanobacteria were found and qualitatively assessed. The benthic assessment technique was revised to include collection and measurement of sediment core samples for the August 2021 sampling event. Potential cyanobacteria accumulation and/or growth on the lake and waterway bottom were documented on August 31, 2021 by collecting cylindrical core samples (Figure 10) at the eight water quality monitoring stations. Core samples were visually evaluated for the relative depths of accumulated cyanobacteria, other (non-cyanobacteria) organic material, sand, and clay. Cores samples were photographed and the relative depth of sediment constituents were measured. Photos of the cores are provided in the appendix.

Figure 10. Sediment core samples at LKWQ1 (left) and LKWQ5 (right).

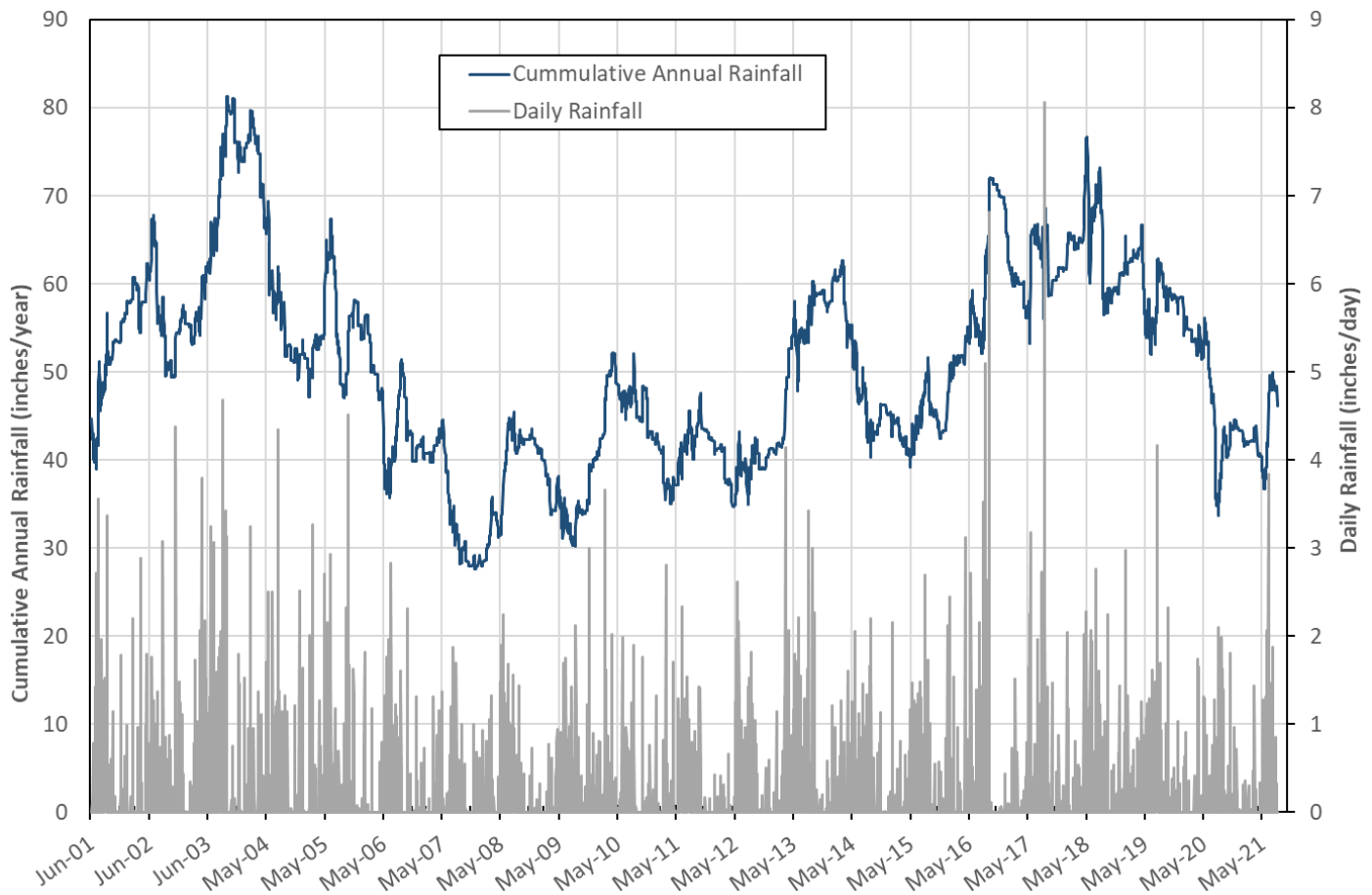


Results

Local Rainfall

Antecedent rainfall (both short and long term) is an important factor to consider when interpreting water quality data. Daily and cumulative annual rainfall at nearby Harbor Heights since 2001 are shown in Figure 11. Cumulative annual rainfall is equivalent to a running annual average for rainfall and indicates relative rainfall patterns over time. Rainfall in 2016 was notably above average. Rainfall in 2017 and 2018 was near average. Rainfall in 2019 and 2020 was below average, with the June through September 2020 period being well below average.

Figure 11. Daily and cumulative annual rainfall at Harbor Heights.



Water Quality - Nutrients

The nutrient targets for low-color, alkaline lakes vary dependent upon whether or not the lake first meets (or exceeds) its relevant target for chlorophyll-a. FDEP concluded that if lakes do not exceed their relevant target for chlorophyll-a, then it would be possible for the lake to be considered “healthy” from a nutrient content standpoint even if it had higher levels of either Total Nitrogen (TN) or Total Phosphorous (TP). Conversely, if a waterbody

exceeds its chlorophyll-a target, it would be considered to have a potential nutrient problem, and its nutrient targets would be stricter than a lake that did not have elevated chlorophyll-a values. Consequently, the target nutrient concentration values for Sunshine Lake and the Sunrise Waterway vary as a function of its level of color, its alkalinity, and whether or not the waters meet or exceed their chlorophyll-a target.

Using the data collected on the three monitoring events, the lake and waterway are classified as a low-color, alkaline lake. Therefore, its water column algal biomass target is 20 µg chlorophyll-a/L. For the 8 stations combined (5 in the lake and 3 in the waterway), the annual geometric mean was calculated for the following parameters: chlorophyll-a, TN, TP and *E. coli* bacteria. Annual geometric means are different than arithmetic means (or “averages”) in that they reduce the influence of “outliers” or results that can strongly influence the mean value.

For the 8 sites, each of which was sampled three times (between February 2021 and September 2021), the geometric mean for chlorophyll-a was 9.5 µg/L. This value is below the target value for chlorophyll-a of 20 µg/L, and therefore the lake and waterway – considered either separately or as a whole – would not be considered “impaired” for chlorophyll-a (Table 1). Based on these findings, the appropriate water quality standards for nutrients for Sunshine Lake and the Sunrise Waterway are 0.09 and 1.91 mg/L for TP and TN, respectively. The results of the sampling efforts conducted between February 2021 and September 2021 are summarized in Table 1, with data displayed as geometric means for samples in the lake, the waterway, and the lake and waterway combined.

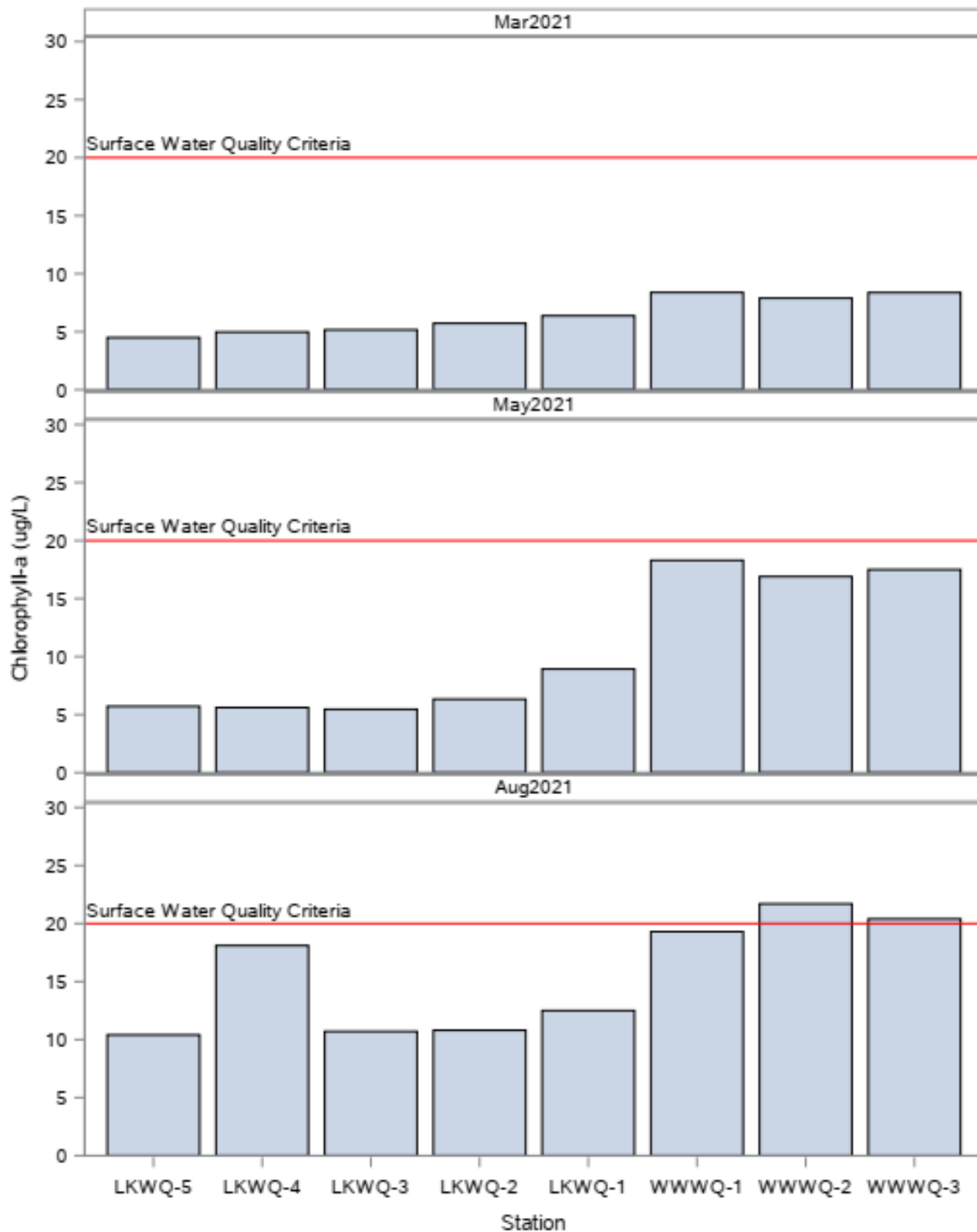
Table 1. Geometric mean values for chlorophyll-a, Total Nitrogen (TN), Total Phosphorus (TP) and *E. coli* bacteria for Sunshine Lake, the Sunrise Waterway, and all stations combined.

Location	No. of samples	Chlorophyll-a (µg/L)	TN (mg/L)	TP (mg/L)	<i>E. coli</i> (no. / 100 ml)
Sunshine Lake	15	7.4	0.70	0.047	34.9
Sunrise Waterway	9	14.3	0.74	0.047	133.0
All data	24	9.5	0.72	0.047	57.6

For the lake, the waterway, and the lake and waterway combined, there are no impairments for chlorophyll-a, TN or TP, as geometric means are below relevant regulatory criteria, as listed in FAC 62-302.531. Values of *E. coli* bacteria are also well below the relevant criterion for a Class III freshwater waterbody. While individual sampling events did exceed the monthly geometric mean criteria for *E. coli*, there were insufficient samples (i.e., fewer than 10 per month) to accurately apply that particular standard to this dataset.

Results for all date and location combinations over the past three quarterly sampling events are displayed below in Figures 11 through 14. As shown in Figure 12, levels of chlorophyll-a were well below the NNC criteria of 20 µg/L at most sampling sites on most occasions. As shown in Table 1, the geometric means of all samples fell below the level at which impairment would be determined. Of the 24 sample points shown in Figure 9 (8 stations visited 3 times), two locations exceeded the NNC criteria of 20 µg chlorophyll-a/L, in August 2021 in the Sunrise Waterway (WWWQ-2 and WWWQ-3).

Figure 12. Chlorophyll-a concentrations ($\mu\text{g/L}$) for each station for each sampling period. For sampling locations, see Figure 9. The relevant NNC criterion for chlorophyll-a ($20 \mu\text{g/L}$) is shown in red.



Based on NNC criteria, Sunshine Lake and the Sunrise Waterway would be considered to be impaired for phosphorous only if TP concentrations exceeded 0.09 mg TP/L, and if values exceeded that threshold value on a frequent enough basis. As shown in Table 1, the annual geometric mean values for the lake, the waterway and the lake and waterway combined are all lower than the relevant regulatory criterion for TP. Figure 13 shows that there was one location which exceeded the criterion during an isolated event (LKWQ-5 in March 2021). Figure 13 also shows that if chlorophyll-a values were to exceed 20 µg/L as a geometric mean, the relevant TP criterion would have been exceeded at all locations in the Waterway and most sampling events within the Lake (only exception was in August 2021). These results suggest that the County should continue to carefully manage and monitor the lake, lest the chlorophyll-a values increase to a level such that the annual geometric mean would exceed 20 µg/L. If such a condition was to arise, the target TP concentration would decrease to a value low enough that the lake and waterway would likely become impaired for phosphorus.

Based on the non-exceedance of the 20 µg chlorophyll-a/L NNC criterion, Sunshine Lake and the Sunrise Waterway would be considered to be impaired for nitrogen only if TN concentrations exceeded 1.91 mg TN/L, and if values exceeded that threshold value on a frequent enough basis. As shown in Table 1, the annual geometric mean values for the lake, the waterway and the lake and waterway combined are well below the appropriate regulatory criterion for TN. Figure 14 shows that there are no examples where a location or sampling event exceeded that criterion. As was the case with phosphorus, these results suggest that the County should continue to carefully manage and monitor the lake, lest the chlorophyll-a values increase to a level such that the annual geometric mean would exceed 20 µg/L.

Figure 15 displays the chlorophyll-a data as the averages of each quarterly trip over the entire monitoring effort, from October 2015 to August 2021. The data displayed in Figure 15 show a pattern of increased trends in chlorophyll-a from April of 2016 until May of 2018. This was followed by a stabilization in values from May 2018 to August 2018 in both the lake and waterway. Elevated chlorophyll-a concentrations were observed in August 2019 in both the lake and waterway. More recently, the majority of sampling events have concentrations below 20 µg/L.

Water Quality – Bacteria

Water quality criteria for bacteria have varied over time in Florida. In prior years, waterbodies were compared to criteria for both “total” and “fecal” coliform bacteria. Over time, FDEP had dropped the criterion for total coliform bacteria, and focused on fecal coliform bacteria. More recently, FDEP has adopted further changes in criteria such that Class III freshwater water bodies are now characterized based on the abundance of *E. coli* bacteria. The use of *E. coli* is based on findings that even “fecal” coliform bacteria are not specific to humans as a source. Related to this, a recent study conducted for Charlotte County determined that decomposing grass clippings appear to be the dominant source of “fecal” coliform bacteria in stormwater runoff to Sunshine Lake and the Sunrise Waterway (Atkins and ESA 2015).

When the water quality monitoring program for Sunshine Lake and the Sunrise Waterway was initiated, the appropriate criterion for tracking pathogens was that of fecal coliform bacteria. However, to be consistent with the revised FDEP surface water criterion, at the start of the Year 2 monitoring program effort *E. coli* bacteria was quantified in lieu of fecal coliform bacteria. The criterion for *E. coli* bacteria concentrations varies as a function of the number of samples in a month. If 10 or more samples are collected in a month, the annual geometric mean of those samples should not exceed 126 colony-forming units (cfu) / 100 ml, and no more than 10 percent of samples should exceed 410 cfu / 100 ml. Since most water quality sampling programs do not sample 10 times per month

Figure 13. Total Phosphorous concentrations (mg TP/L) for each station for each sampling period. For sampling locations, see Figure 9. The relevant NNC criterion for phosphorous (0.09 mg TP/L) is shown in red.

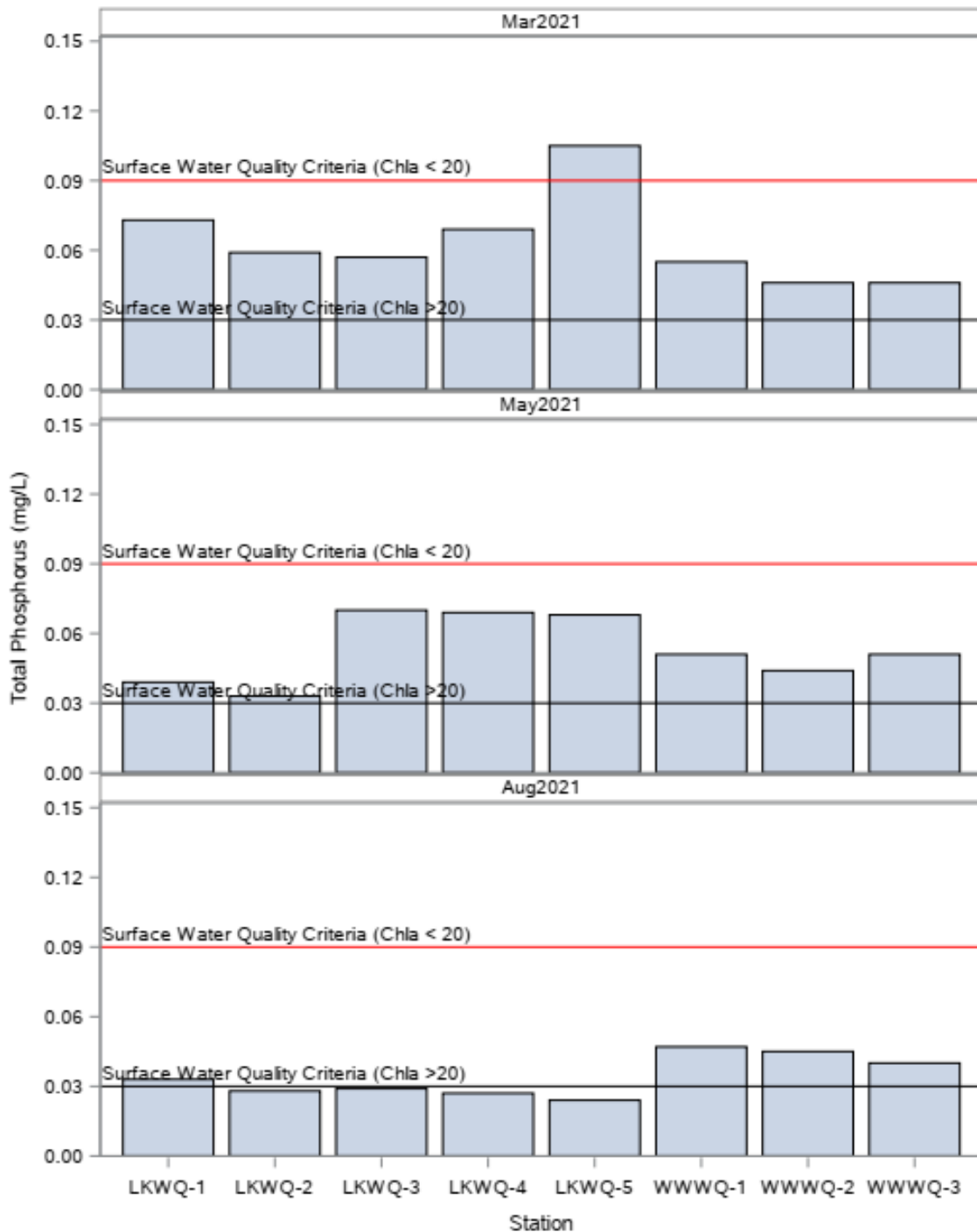
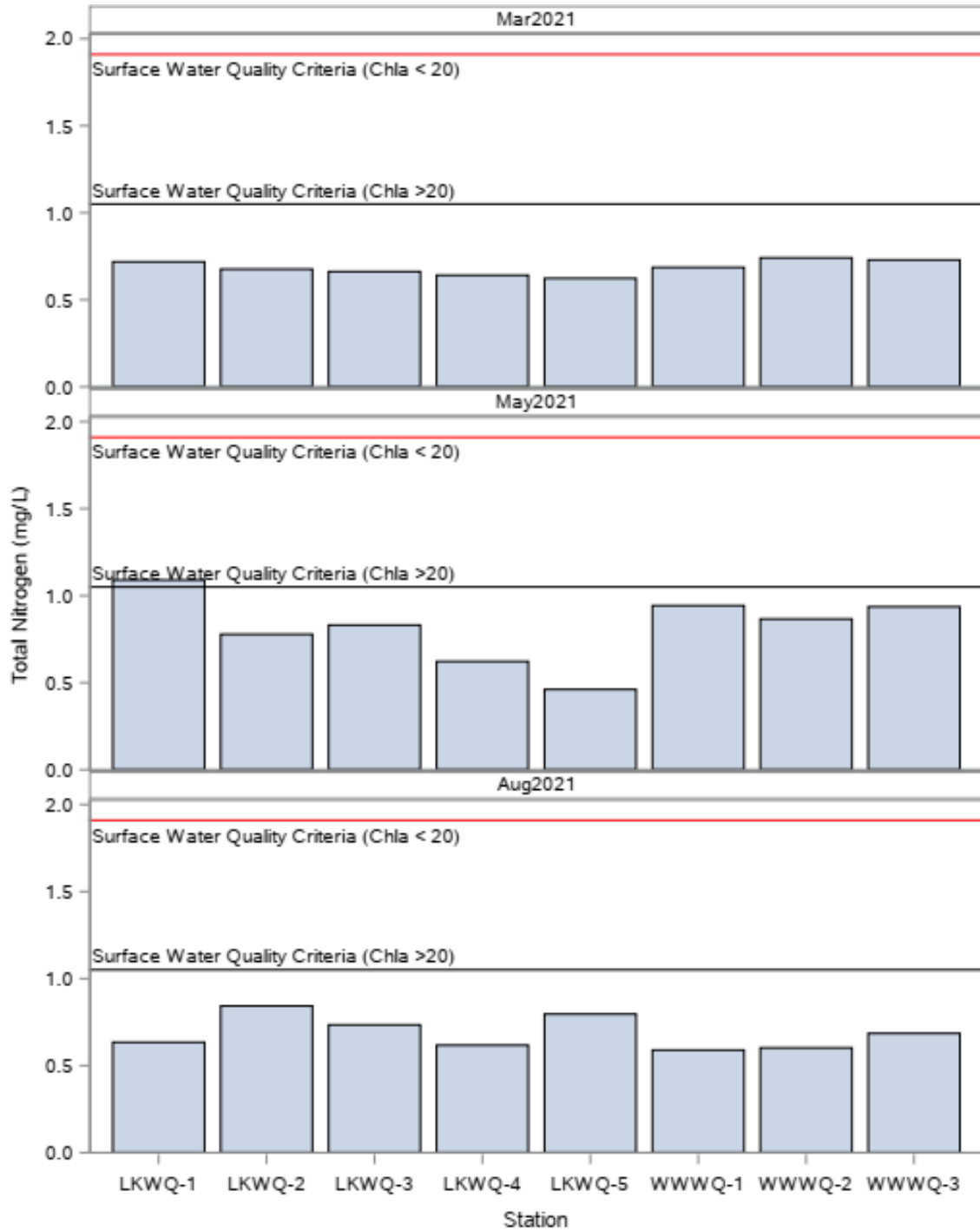


Figure 14. Total Nitrogen concentrations (mg TN/L) for each station for each sampling period. For sampling locations, see Figure 9. The relevant NNC criterion for nitrogen (1.91 mg TN/L) is shown in red.



(nor does this program), FDEP has determined impairment based on the 10 percent exceedance threshold. Therefore, the appropriate threshold value used to determine the degree of impairment for bacteria in the lake and waterway is that of 410 cfu of *E. coli* bacteria / 100 ml (Figure 15).

E. coli bacteria levels were consistently below the regulatory standard of 410 units per 100 ml in both the Lake and Waterway (Figure 16). Due to the lack of exceedances, the bacteriological status of the lake and waterway would be classified as unimpaired.

Figure 15. Average values of chlorophyll-a in both Sunshine Lake and the Sunrise Waterway over the period of October 2015 to August 2021. Values are means for the lake (n=5) and the waterway (n=3) for each quarterly sampling effort.

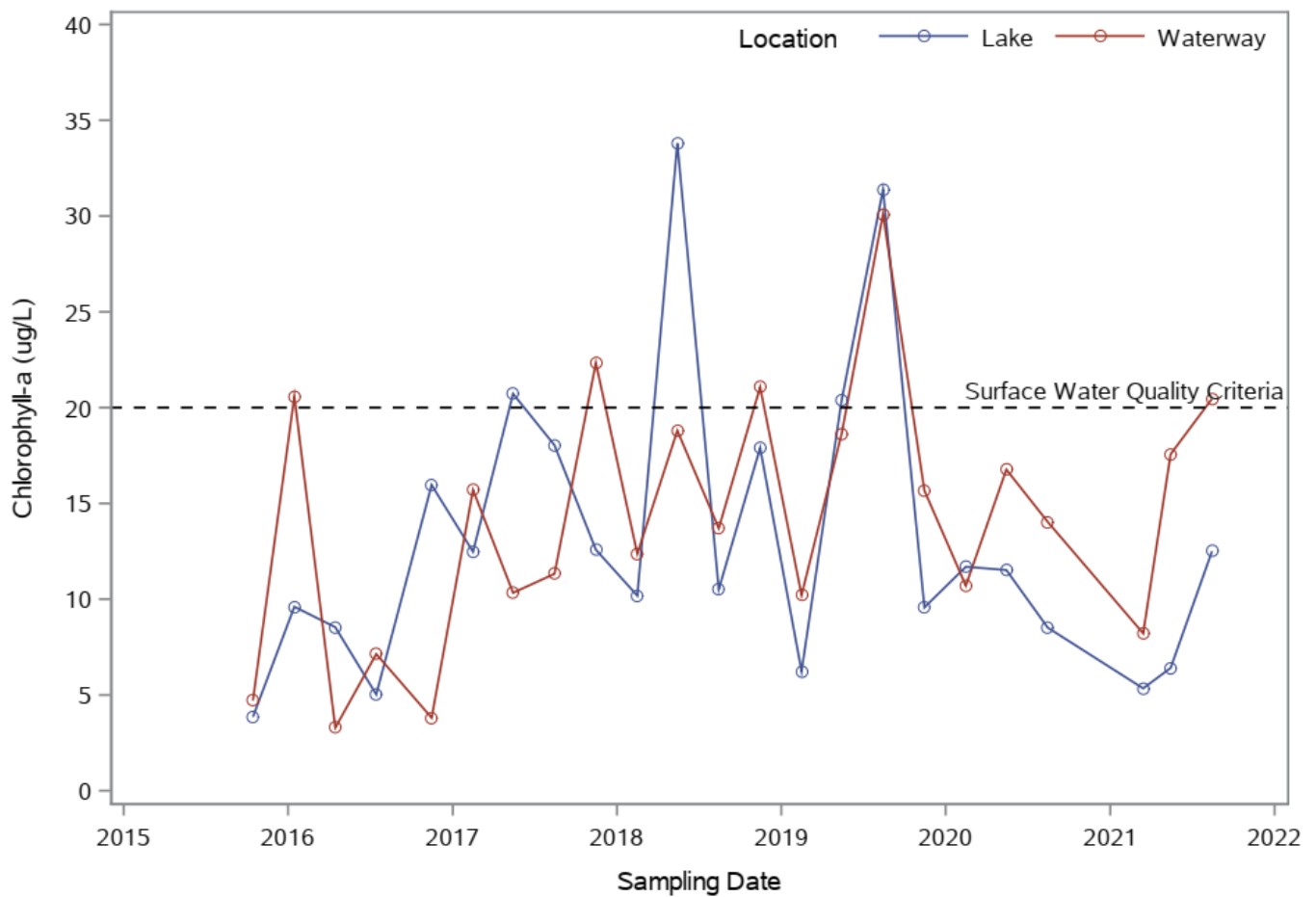
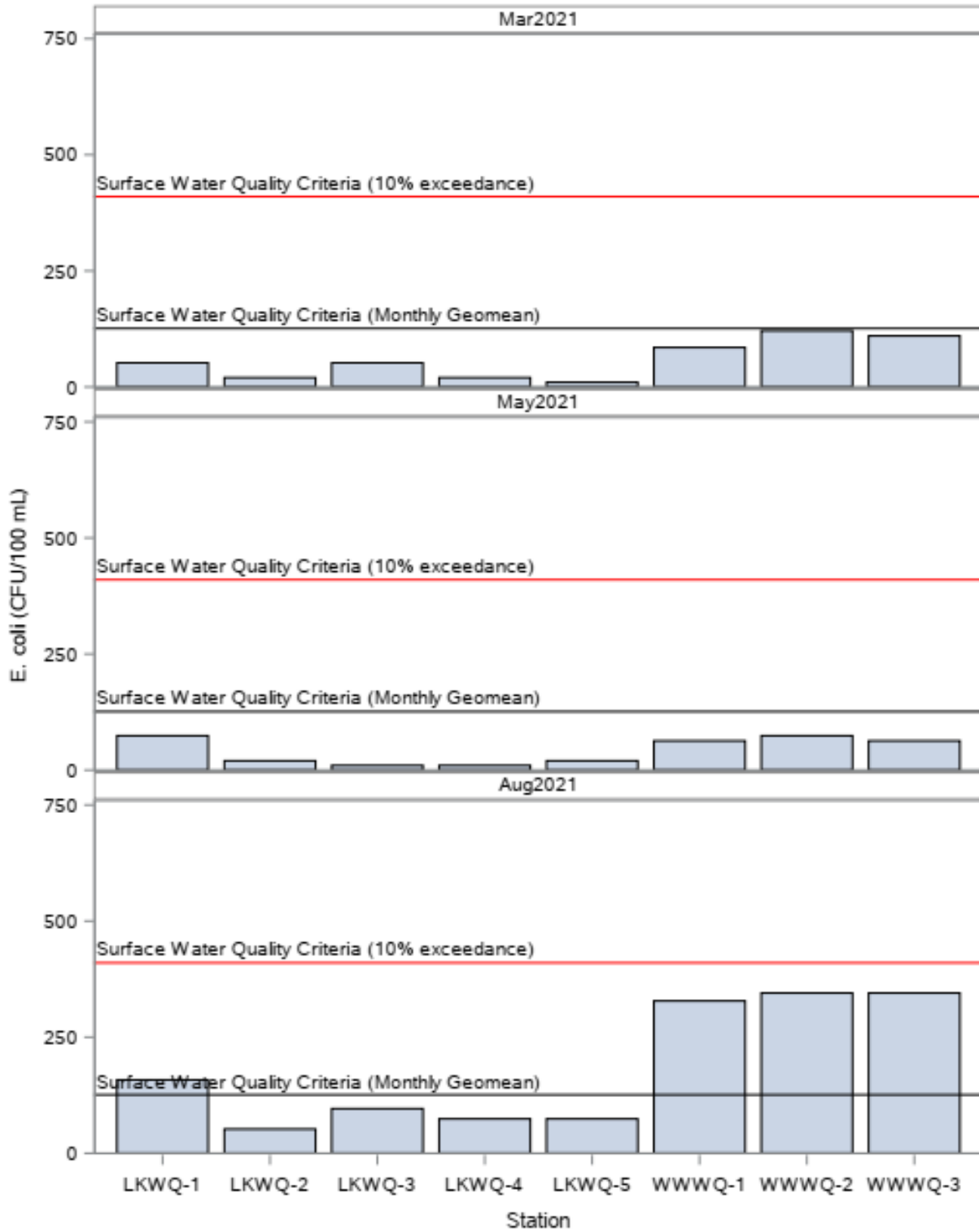


Figure 16. *E. coli* bacteria concentrations (cfu / 100 ml) for each station for each sampling period. For sampling locations, see Figure 1. The relevant criterion for *E. coli* bacteria (410 cfu / 100 ml) is shown in red.



Sediment Quality

Sediment characterization data are shown in Figure 17. August monitoring efforts were entirely consistent with the March qualitative observations. Photographs of the sediment cores are included in the appendix. No submerged, benthic plants were found in the lake or waterway. Benthic algae (algae layers on the bottom of the lake and waterway) ranged from 15 cm thick at the northernmost end of Sunshine Lake to 3 to 4 cm thick at the southern end of the lake (Figure 16). Measurable benthic algae were not present in Sunshine Waterway. The algae layer was underlain by a thick layer of clay in Sunshine Lake. Sunshine Waterway was characterized by a thin layer of non-algae organic matter underlain by a thick layer of clean sand. The lake algae layers appear to be moderate close to the SolarBee, thicker at a greater distance from the SolarBee, and thinnest at the farthest distance from the SolarBee. This is consistent with SolarBee induced water flow moving existing algae towards the edges of the lake but not pushing the algae into the farthest reaches of the lake. It is likely that a small amount of algae either remained in the lake after dredging or has grown since dredging and that the location of this algae has been reworked by SolarBee flow such that the algae accumulates at the edge of the SolarBee flow field. Future monitoring will be required to document that algae in Sunshine Lake is not increasing however.

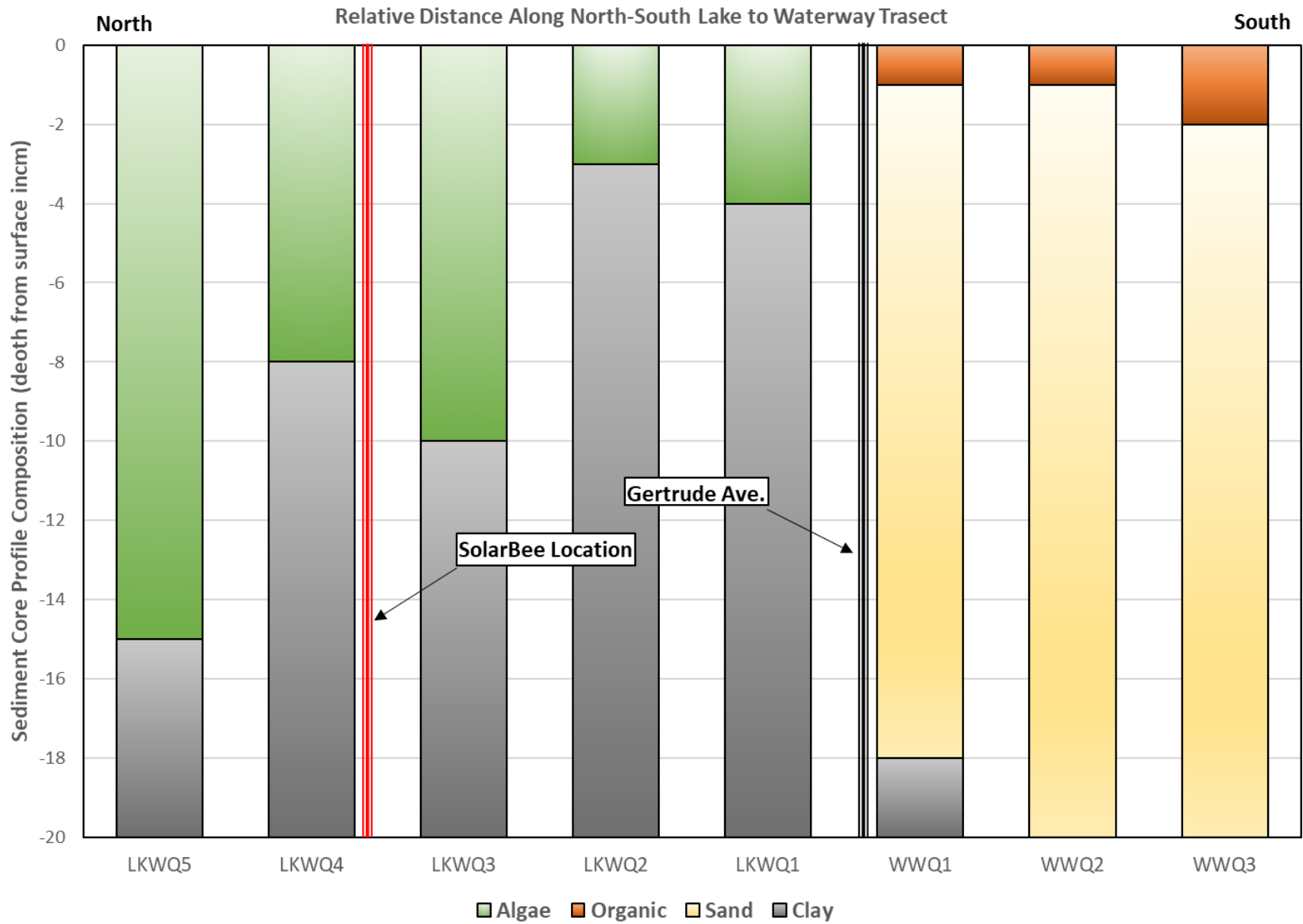
Discussion

FDEP's regulatory protocols for assessing water quality are based on multiple units of a calendar-year (e.g., minimum of four quarterly events). However, the data presented in this report are from only three quarterly sampling events. Nonetheless, the results shown here are representative of what was observed during the current monitoring year. In addition, FDEP does not consider a water body to be impaired until annual geometric means exceed regulatory criteria more than once in a given three-year period, even if a single year was to have values of TN or TP greater than their relevant regulatory criteria. In this way, at least two years of exceedance (out of three) are required for a water body to be classified as impaired.

Based on the results obtained from the three sampling events, Sunshine Lake and the Sunrise Waterway are not impaired for either chlorophyll-a, or nutrients, using guidance in FAC 62-302.531. However, the regulatory criteria for nutrients that are applicable for the lake and waterway would become more stringent if the amount of algae in the water column increases to problematic levels. If, for example, the geometric mean for chlorophyll-a should rise above 20 µg/L, then the phosphorus target would decrease by 67%, from 0.090 to 0.030 mg TP/L. Over the past four sampling events, the geometric mean for phosphorus for the lake and waterway combined was 0.041 mg TP/L, a value that would have exceeded that more restrictive TP target. Similarly, should the geometric mean for chlorophyll-a exceed 20 µg/L, the nitrogen target would decrease by 45%, from 1.91 to 1.05 mg TN/L. Over the past four sampling events, the geometric mean for nitrogen from the lake and waterway came to 0.75 mg TN/L, a value that remains below the lower TN target.

As was documented in the Water Quality Management Plan (Atkins and ESA 2014) phosphorous levels in stormwater runoff from the watershed are likely to continue to be elevated for at least the near future, as they are influenced by the local naturally phosphorous-rich geology. As phosphorus concentrations in stormwater runoff are not likely to decrease over time, the challenge for managing Sunshine Lake and the Sunrise Waterway will include managing the "destination" of those incoming nutrient loads. Prior to the County's dredging efforts, incoming phosphorous loads likely allowed for the proliferation of the cyanobacteria bloom that was found associated with the bottom of the lake, and which had previously occupied approximately 50 percent of the lake's volume (Atkins 2012). This prior nuisance algal mass – the bottom dwelling bloom of cyanobacteria – has not been found since the County's dredging project was completed.

Figure 17. Sunshine Lake and Waterway sediment core profile composition from north to south (collected 8/31/21).



Up until May of 2018, incoming nutrient loads were contained within the biomass of *Chara* and phytoplankton in the water column. Since the summer of 2018, the lake and waterway have both lost, for some reason, the previously substantial *Chara* along the lake bottom, which had previously occupied about a third of the water column. In Florida, the historical default response to an over-abundance of “nuisance” plants such as *Hydrilla* would involve controlling the vegetation through the application of herbicides. However, this has often been associated with “flipping” a lake from a clear lake with macrophytes (aka “large plants”) to one with no macrophytes but with a newly-created phytoplankton bloom (e.g., Atkins and ESA 2014). In 2019, a test project was performed to try and reestablish SAV in the lake by planting SAV transplants, due to water and herbivory the transplanting effort was unsuccessful. As such, a more comprehensive, larger-scale SAV transplanting effort is not justified, likely due to insufficient water clarity.

Conclusions and Recommendations

Currently, Sunshine Lake and the Sunrise Waterway are much improved, compared to the conditions experienced in 2010 to 2012. There is little or no evidence of significant recurrence of the prior algal growth in the lake, and the lake is in compliance with existing water quality standards developed by the state of Florida for both nutrients and pathogens.

To continue to successfully manage the lake, the County should to continue to adhere to the main recommendations of the Water Quality Management Plan (Atkins and ESA 2014). These recommendations, most of which have been implemented already, include the following:

- Raising the lake level, and maintaining a higher lake level in the dry season through the use of supplementing the lake and waterway through the use of groundwater from deeper, less nutrient-rich waters of the surficial aquifer
- The County should continue to use the whole-lake circulation features currently in the lake, which appear to be capable of enhancing phosphorous sequestration in the sediments via the maintenance of better oxygenated bottom waters
- The County should continue to monitor the water quality and benthic algae in Sunshine Lake and the Sunrise Waterway to ensure that ongoing management actions continue to be successful

As was noted in the prior annual reports, there is no question that the lake and waterway are healthier and more aesthetically appealing than was the case several years ago. These improvements have been noted by a number of lakeside residents, who regularly speak with our scientists during these monitoring events. Also, there is no evidence of the recurrence of the prior algal mat along the bottom of the lake and waterway, which suggests that the prior conditions, which required dredging of the lake, has been successfully dealt with by the County.

Although the lake and waterway remain susceptible to future algal blooms, due to the naturally phosphorus-rich local geology, there is no doubt that Sunshine Lake and the Sunrise Waterway are healthier ecosystems than they were back in 2010 to 2012. While continued management is appropriate, and monitoring is needed to ensure that the lake does not revert back to its formerly impaired condition, the County should be proud of the progress made in the restoration of the water quality and ecological health of Sunshine Lake and the Sunrise Waterway.

Literature Cited

Atkins. 2012. Sunshine Lake / Sunrise Waterway Study. Final Report to Charlotte County. 33 pp.

Atkins and ESA. 2014. Sunshine Lake/Sunrise Waterway Water Quality Management Plan. Final Report to Charlotte County. 60 pp.

Atkins and ESA. 2015. Bacteria Source Identification for Sunshine Lake and the Sunrise Waterway. Final Report to Charlotte County. 12 pp.

Appendix – August 31, 2021 Sediment Cores – Identified by Water Quality Station Location



LKWQ1



LKWQ2



LKWQ3



LKWQ4



LKWQ5



WWWQ1



WWWQ2



WWWQ3