Lake Management Consultants
Experts in
Aquatic Vegetation Control

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Re: Pines Lake:
2020 Water Quality Monitoring and Analysis

Introduction

Over the past 14 years the following study has been conducted by Aquatic Technologies. This study examined the seasonal water quality and provided a database for future lake and watershed management programs. This report also includes data comparisons to results since the inception of this program in 2008.

Pines Lake, which is located in Wayne, Passaic County, New Jersey, is utilized for swimming, fishing, boating and provides aesthetic value to members of the Pines Lakes PLA. In recent years, members have become concerned with the water quality of Pines Lake. The P.L.A. decided to retain the services of Aquatic Technologies to examine the current water quality and provide a database for future lake and watershed management programs.

Objectives of water quality monitoring

Lake communities conduct water quality monitoring for reasons that are specific to the needs and concerns of their lake communities. The following are the primary reasons why this water quality-monitoring project was considered:

* To monitor the lake's nutrient loading
* To document chemical, physical and biological data
* To identify the current Trophic state of lake
* To have a better understanding of current water parameters

The Pines Lakes PLA acknowledged the above-mentioned concerns. This study will give the P.L.A. a valuable scientific database and assess the lake's current status as well as providing information which will help develop an accurate future watershed management plan.

Survey Program

Since 2008, Aquatic Technologies, Inc. has been retained by Pines Lakes PLA to gather data and collect water samples. The data, which is presented in this report, includes the following:

a) Monitoring collection
b) Water quality testing
c) Incorporation of results into the historical database
d) Data interpretation
e) Nutrient loading database (i.e. nutrient)
f) Trophic state analysis

Water samples were obtained from four locations within the lake. The samples included one sample from the upper water column and/or lower water column. The sites were chosen because of previous samplings taken from this site and recommendations for further investigation of the inflow stream (Haycock Creek). Water samples were collected and delivered to a New Jersey certified lab for

analysis. Since 2011, the use of the state of the art SRTC lab has provided results to the parts per billion where required for the lake management industry. The sampling parameters thresholds were given to the parts per billion when required and were delivered within days of the sampling. Unlike other labs that provided results based on the NJ drinking water standards, the SRTC lab provides the lake management industry with very accurate and precise results.

Methodology

Sample locations were chosen to obtain the most accurate overall water quality characteristics. These areas include the following:

1) Mid – Lake: Upper Water column
2) Mid – Lake: Lower Water column
3) Haycock Creek Area – Pines Lake Inflow Cove (PLIC)
4) Haycock Creek Area – Down Steam of Outflow of Lions Head Lake (DSLH)

Parameters:

Total Phosphorus
Ortho- Phosphorus
pH
Secchi
Thermal and Dissolved Oxygen Profile
Nitrite and nitrate

At the locations, samples were collected in multiple 500 ml calibrated sampling bottles. The bottles were lowered into the water to a depth of 1 foot and/or 24 feet, where the water samples were collected. The water samples were then chilled on ice and delivered to the SRTC certified laboratory. In-situ physical & chemical characteristics were recorded in the field. These included: visibility (Secchi disk transparency), pH, temperature and dissolved oxygen. Note: "In-Lake" averages comprise of values with the Haycock Creek- (DSLH) results removed from calculations. This was done to compare the values of the Creek verses the In-Lake results.

Results

Water analysis:

The following data can be examined in the attached Figures, Graphs and Maps. A portion of the data was recorded in non-metric units of feet, inches and degrees Fahrenheit. This decision was made to make the interpretation of the data more comprehensible to P.L.A.

Total Phosphorus - (Table 1 and Figures 2)

The total phosphorus/TP results ranged from 0.01 to 0.0318 ppm. The highest reading of 0.0318 ppm was recorded in the in the Lion Heads Haycock Creek in the September sampling date. The two of the highest in-lake value was recorded in the Lower-Mid Lake sampling of (0.0266 ppm) and in the Haycock Creek inflow (0.0274 ppm) sampling location during the May sampling events. The July samplings recorded some of the lowest TP levels for all of the sample sites. This sampling recorded a 0.01 ppm of total phosphorus. The lowest results were observed during the mid-season sampling, which recorded an average near 0.01 ppm-TP at all sampling stations. The average TP level for the lake was calculated at 0.0202ppm (20.2 ug/l). The average TP level In-Lake (Haycock Creek-(DSLH) values removed from calculations) was recorded as 0.0186 ppm (18.6 ug/l).

Ortho-Phosphorus - (Table 1 and Figure 3)

The Ortho-phosphorus results ranged from 0.004 ppm to 0.006 ppm. The highest Ortho-Phosphate values were recorded as 0.006 ppm at the July Haycock Creek-(DSLH) sampling. The lowest Ortho-Phosphate values of 0.004 ppm and 0.005 ppm were recorded at all other sampling sites during each month of sampling. The average Ortho-phosphorus level was recorded as 0.004ppm. It must be noted that Ortho-Phosphorus or Free Reactive Phosphorus is critical in plant uptake and growth. Nuisance blue-green and green algae populations thrive on this form of phosphorus. With the presence

of Free Reactive Phosphorus within a lake system, there is potential for the lake to sustain late season algal blooms. The average Ortho-Phosphorus recorded in 2017 was 0.010 ppm compared to 2020 average value of 0.004 ppm. The difference between the thre1 years was 60% decrease in ortho-phosphorus from 2017 to 2020.

Nitrogen Parameters - (Table 1, Figures 4)

The samplings of Nitrogen compounds were recorded as Nitrite and Nitrate. These samples results deviate from the 2010 and prior years, since the SRTC Labs' ability to correct the threshold range for the lake management industry and its water quality requirements. The limiting nutrient level threshold of nitrogen to influence plant growth is approximately 0.8 ppm. The Nitrite/Nitrate results ranged from less than 0.02 ppm to 0.2 ppm. The highest level of 0.1 came from the main lake during the May sampling and during the September sampling of the Haycock Creek-(DSLH). All of the other samplings results were 0.01 ppm and 0.1 ppm, which all fell below the threshold of concern. The average Nitrite/Nitrate level was recorded as 0.046 ppm. The average Nitrite/Nitrate level "In-Lake" (Haycock Creek-(DSLH) values removed from calculations) was recorded as less than 0.046 ppm.

pH - (Table 1and Figure 1)

The pH results were consistent with those of other waterbodies of Northern New Jersey. The pH ranged from 7.0 to 7.9. The average pH was 7.3. The highest recorded pH reading of 7.9 was observed in the Upper Mid Lake station during the month of May. The midsummer July sampling of the Mid Lake- Upper and Lower sampling site, recorded the lowest pH of 7.0.

Dissolved Oxygen and Temperature - (Table 2, Figures 5, 6, 7 and 8)

Dissolved oxygen readings remained consistent with seasonal averages for waterbodies of Northern New Jersey. Dissolved oxygen readings ranged from a high of 11.0 ppm in May to a low of 3 ppm on July. The Haycock Creek–(PLIC) ranged from 11 ppm in May, to 2 ppm on midsummer. The consistent fluctuations of the dissolved oxygen levels were closely related to the changing water temperatures. Dissolved oxygen levels were highest, when the water temperatures were the lowest. The Dissolved oxygen readings were lowest, when the water temperatures were the highest. However there is an exception to the level recorded on the lake bottom. The reduction-oxidation process that occurs within the soil-water interface directly influences these levels. The lowest Dissolved Oxygen results (2-4 ppm) were all identified on the bottom of the lake at the soil-water interface. The average of the dissolved oxygen at the Mid Lake Station was 8.2 ppm. The average of the dissolved oxygen at the Haycock Creek–(PLIC) Station was 8.2 ppm.

Similarly, the temperature of the lake remained consistent with the changing of the seasons. The May sampling recorded a low temperature of 57^{O} Fahrenheit and the August sampling a high temperature of 86^{O} Fahrenheit. The average temperature for the lake was recorded at 62.8^{O} Fahrenheit.

Visibility - Secchi Disk Transparency (Figure 11 and 12)

Visibility in the lake ranged from 7 to 16 feet. The visibility decreased in the August sampling to 7 feet from the May and September readings of 16 and 15 feet respectfully. The greatest visibility of 16 feet was recorded in the May sampling. The average visibility in the lake for the year was calculated at 12.6 feet (3.8 meters). Secchi readings for the sample stations on May, August and September are as follows: Mid Lake Station 16, 7 and 15 feet and Haycock Creek Area 8', 4, and 8' feet respectively.

The above data can be examined in Tables and Figures located in the addendum

Discussion

As we continue to evaluate the data over the years, the Pine Lake Community and Aquatic Technologies continues to gather data on the water quality of Pines Lake. There are a number of lake management goals to consider when reviewing the results of a water quality study. Some examples are:

- Improving the recreational access (i.e. boating and swimming)
- Understanding the lake's water chemistry characteristics
- Reducing soil erosion
- Improving water circulation
- Reducing nutrient loading values
- Understanding nutrient loading sources
- Controlling macrophyte and growth mechanisms (rooted plants)
- Determining toxic substance infiltration
- Improving fisheries and habitat

It must be understood that water quality is a term used to describe the condition of a water body in relation to human needs or values. Quality is not an absolute. The terms "good" or "poor" water quality only have meaning relative to the use of the water and the attitude of the user. An oligotrophic lake might have good water quality for swimming but be considered poor water quality for bass fishing. Confusion can ensue when the term trophic state is used to infer quality (Carlson, R.E. and J. Simpson. 1996).

Therefore, it is imperative to have a relative base line and guide to interpret historical data and build a time line for lake water quality. Thus, the use of Carlson's Trophic State Index and integrated interpretation of other parameters, (such as TP, ortho-phosphorus, dissolved oxygen, vegetation densities/species/diversity, soil remediation/movement and water level fluctuations) all need to be interpreted in the lake quality equation. This must be done so that a balanced assessment is made of the lake water quality.

Aquatic Technologies' monitoring programs balance the concerns of all interested parties; fisheries, property values, boating, environmental influences, lake access, swimming, etc. As a result, monitoring water quality in a lake is essential to identify problems and concerns within a lake in a scientific manner. Additionally, studying the entire watershed can help to identify problems in the area surrounding the lake which need to be addressed in order to improve water quality and/or nutrient loading. All studies need to be flexible and understand the changes within a watershed. It also must be able to understand the ability to which the Association can control factors within the study 's watershed and it water quality.

The 2020 Water Quality Monitor Program continued to use the state of the art SRTC lab to analyze samples. This lab was chosen because of its expertise in lake water quality lab sampling and because it is one of few labs dedicated to analyzing water for the lake management industry. It has the ability to run samples within the threshold parameters required in Limnology and within a proper lake management program. The SRTC Lab has the ability to run test samples very accurately and within a timely fashion.

For another consecutive year the Haycock Creek- (DSLH) – "Outflow of Lions Head Lake" was sampled. This allows for continued monitoring of the water between Lions Head Lake and the inflow of Pines Lake. This station was incorporated into the program with the need for more information of the impact of the stream's nutrient loading potential and/or water quality. It was assumed by the PLA, that the amount of residential housing, commercial buildings and surface runoff from impervious and pervious ground might be impacting the water entering the lake via the Haycock Creek. These historically higher result values continue to demonstrate the impact of the inflow streams on Pines Lake. Continued investigation will define these hypotheses and continue to demonstrate the nutrient load entering the lake from the creek.

Key water quality parameters have been reviewed in this study and the most significant data was included. The following paragraphs will discuss the importance of the above stated results.

The total phosphorus results provided a range that is below the critical levels of eutrophication. Total phosphorus concentration in *non-polluted natural waters* extends over a very wide range from less than 0.01-ppm to 200 ppm in some closed saline lakes. The total phosphorus concentration of most *uncontaminated surface waters* is between 0.01 and 0.05 ppm. (Wetzel 1983) Additionally, the amount of Total Phosphorus generally increases with lake productivity (Vollenweider 1968). EPA Clean Lakes Eutrophic Criteria indicates that a TP value of 0.03 ppm is enough for plant productivity and algal blooms, greater than 0.10 ppm the lake will show signs of accelerated eutrophication.

The average TP for the in-lake waters of Pines Lake was recorded as 0.0186 ppm TP. This was a deviation from the average of the past few years. The Average TP values within the lake continue to fluctuate minimally with a deviance of about 0.1 ppm. As seen in the 2014 of 0.032ppm yearly average, to the 2020 TP average of 0.0167ppm. The TP trend continues to decrease slightly and was below average compared to prior 2014. The 2020 TP average is consistent with the productivity of macrophytes (rooted plants) and especially the algal populations historically observed in Pines Lake, as well as those observed during the growing season. It can be noted that the 2020 season consisted of an average wet spring. The recorded rainfalls may have allowed for input of nutrient from the watershed into the lake. One correlation to the rainfall was the increased values of TP, Nitrate/Nitrite and ortho-phosphorus values demonstrated in the May sampling. These higher values may have increased the early May 2020 presence of nuisance planktonic algal bloom. Planktonic algae blooms are historically experienced in July and August at Pines Lake. However the bloom occurred early in May/June and was managed and controlled with effective quick-response algaecide treatments. The early and immediate treatment of the nuisance bloom, decreased the plant populations. The May sampling results also indicate that the bloom captured the early available phosphorus observed in the May sampling and this available TP and Ortho-Phosphors correlates to the observed algal bloom.

The highest TP result of 0.0293 and 0.0274 ppm was sampled in the Haycock Creek-(DSLH) rand the Upper Mid-Lake respectively during May. These higher reading can be attributed to the sampling of the stream after the multiple heavy rain events.

Some of the highest “in-lake” values were recorded at the Mid-lake sampling locations. The highest TP result occurred as 0.0274 ppm and 0.0266 ppm – Mid Lake Upper and Lowe. The 0.0318 ppm in the Haycock Creek-(DSLH) sampling location, all indicate the presence of TP available to the lake system and its plant communities. The May sampling results, within the all of the stations were consistent with the high nutrient values and can be attributed to the spring rains flushing the watershed and fertilizer entering the lake system.

SRTC Labs interpret Ortho-Phosphorus - Free Reactive Phosphorus (FRP) as the measure of inorganic dissolved reactive phosphorus (PO4-3, HPO4-2, etc.). This form is readily available in the water column for algae growth. The Ortho-Phosphorus-Free Reactive Phosphorus values are indicative of a mesotrophic/slightly eutrophic lake. It also can be noted that the values are correlated of the decomposition of the planktonic algal populations (which was observed during the samplings), the redox of those algal plant cells and the release of the free phosphorus within the lake system.

The July sampling of the Haycock Creek-(DSLH) recorded a reading of 0.006 ppm-Ortho-Phosphorus-Free Reactive Phosphorus. The average in lake value of 0.004 and 0.005 ppm were recorded in the all other sampling sites during the year. These values support the observation and the fact that we did not observe a large TP/Ortho-Phosphorus spike during the summer and late summer. This lack of a spike can be related to the current “Sonar Program” which controls the nuisance macrophytes (Rooted Aquatic Plants) very early in the season (thus decreasing the available biomass in the lake), as well as the successful control of the uncharacteristic early season planktonic bloom which was observed.

The observations and data results of the water quality reports demonstrated the influence the plant populations have on the water quality and its influence on the dynamics of the TP and Ortho-Phosphate values within Pines Lake. Once again for another season, Pines Lake demonstrated the textbook effects of seasonal planktonic algal blooms. After treatment of the algae population, the die-off, effects of the physical and chemical characteristic of a lake. All these factors, including algae treatment, temperature, dissolved oxygen, sunlight penetration and seasonal changes all played a role in the influence of the TP and Ortho- Phosphate values upon the plant communities within the lake.

Once again Pines Lake had one or more of the stations showed levels of TP to sustain potential plant growth. The lake's water quality result met the EPA's Clean Lakes Eutrophic Criteria of a TP value of 0.03 ppm, enough for plant productivity and algal blooms. The presence of the desirable native pondweeds, non-desirable invasive Eurasian Water Milfoil, Naiad and Curly Leaf Pondweed and the nuisance Blue-Green Algae blooms, support the lakes ability to sustain plant populations and productivity. It can be noted that Pines Lake's TP results are *relatively* low, however are within the threshold of the EPA's Clean Lakes Eutrophic Criteria's for a waterbodies' ability to sustain plant productivity. The fluctuations in TP Levels are closely related to the influence of: plant decomposition, increased/decreased rainfall events, water movements/wind action to the lake and to the organic bottom, thus releasing (oxidation/reduction) TP from the sediments. These factors all can negatively and/or positively change the dynamic of a specific cove or area of the lake.

As clearly demonstrated over the past years of monitoring and lake management Pines Lake can sustain plant populations due to its nutrient load within the water column and sediment layer. The 2020 season continued to see an increase of the beneficial native plants such as the Potamogeton species (Sago and Narrow-Leaf Pondweed) and Chara (vascular algae). The growth of native plants is very beneficial for the fisheries and invertebrates within the lake system. These beneficial native plants have flourished in specific locations throughout the lake. Some of these native populations caused nuisance levels in certain areas of the lake and required minor control.

It must be also noted that here has been the increase in newly established Water Star Grass and Native Pondweeds along the lake bottom and the shallow shorelines. The increase in these beneficial plants and their ability to uptake nutrients is a trend to a more balance lake ecosystem. The balance in which the rooted plants community competes with the nuisance planktonic algae for the available nutrients (TP/ Ortho-Phosphorus, Nitrogen - plant food source). There is always a pro and con to plant competition. The 2020 Season observed a very small population of the Non-Native invasive Water Chestnut with the Juniper inflow cove. Control and management was immediately initiated and the population did not flourish or cause any nuisance conditions. However, strict monitoring must be maintained so that this very invasive plant does not establish a community within the lake.

With the guidance and an Integrated-Vegetation Management Program along with a selective targeting of plant populations and their management; the native plant populations will continue to out–compete the aggressive non-native Eurasian Water Milfoil and other non-native plant species.

The Trophic State Index - TSI (Carlson 1977) was applied to the results obtained in the study of Pines Lake. This Index is based on the empirical relationship between total phosphorus, chlorophyll a and Secchi disk transparency. Dr. Carlson developed the TSI to summarize the Trophic status of a lake. TSI values range from 0-100, with 0 corresponding to the lowest productivity. The ranges are divided into mesotrophic, slightly productive lakes of TSI values between 37-51 and TSI values greater than 51 are classified as eutrophic, highly productive with increasing degrees of severity. Based on the formula below, Pines Lake can be categorized as a slightly eutrophic lake.

TSI_{SD} = 60-14.41ln SD
TSI_{TP} = 14.42ln TP+4.15
TP = Total phosphorus, ug/l
SD = Secchi Disk Transparency, meters

Pines Lake - Trophic State Index-2020
TSI_{SD} 40.7
TSI_{TP} 45.8

The TSI value of TSI_{SD} 40.7 and TSI_{TP} 45.8, indicates Pines Lake as being higher end of the mesotrophic scale. This index value is demonstrated by the populations of a planktonic algal bloom, moderate/large stands of Water Star Grass, Pondweeds, Eurasian Water Milfoil, Curly Leaf Pondweed, Naiads and other macrophytes which establish during the growing seasons, covering many parts of the photic zones of the lake.

Historically, the lake has been slightly eutrophic and therefore, the 2020 eutrophic TSI value continues to correlate to the existing aquatic vegetation productivity in the lake. Over the past decade, Pines Lake has been observed to be relatively free of filamentous algal blooms and has historically demonstrated minor planktonic blooms in the latter part of the growing seasons. As observed in past seasons, the growth of the planktonic algal bloom confirms the lake's nutrient load. The lakes overall nutrient loading sustained not only the macrophyte populations, but also algal populations. The 2020 season saw a "atypical" early planktonic bloom. This bloom was most likely attributed to record spring/summer rainfall and the influx of available phosphorus from runoff and watershed fertilizers.

Another index for Water Analysis and interpretation of Total Phosphorus results are described by SRTC Lab protocol and are as follows: Phosphorus: Essential nutrient often correlating to growth of algae in freshwaters. Total Phosphorus (TP) is the measure of all phosphorus in a sample as measured by persulfate strong digestion and includes: inorganic, oxidizable organic and polyphosphates. This includes what is readily available, potential to become available and stable forms. The SRTC Lab Interpretations for the trophic state index, based on TP, values are as follows:

- <12 µg/L oligotrophic;
- 12-24 µg/L mesotrophic;
- 25-96 µg/L eutrophic;
- > 96 µg/L hypereutrophic

All of the sampled TP values within Pines Lake, fall in the range 10 to 31.8 ug/l as P. These results confirm and indicate that the lake can be categorized as being mesotrophic to slightly eutrophic.

The relatively low nutrient values sampled over the years in this study and the relatively low historical TSI Index, supports the historical plant growth observations. The lake tends to have moderate plant populations, which sustain themselves throughout the growing season.

Historical and current nitrogen samplings, indicate that the nitrogen cycle in Pines Lake does not exercise a great role in the plant productivity of Pines Lake. The Nitrite/Nitrate values did not reach the critical limnological level for high productivity. Nor did the concentration indicate excessive algal growth that is attributed to nitrogen as the significant limiting nutrient. The critical threshold is based on a nitrogen levels above 0.8 ppm. The average nitrogen in Pines Lake was recorded at 0.046 ppm, well below the critical level. New data is showing that the increase in HAB-Harmful Algal Blooms, throughout NJ, The Nation and worldwide, is correlating the exponential growth of the Blue green blooms to not only phosphorus loading , but to the increase in nitrogen loading which is available to the plants. With this knowledge, it is important to continue to monitor and discuss the reduction of nitrogen (lawn fertilizers and etc.) in the lake watershed and system.

As discussed in the past, the correlation between the Phosphorus and Nitrogen values, it can be implied that the limiting nutrient for aquatic vegetation growth is Phosphorus. Thus making the limiting nutrient of concern in Pines Lake - phosphorus. As phosphorus loading to fresh waters increase and the lake becomes more productive, nitrogen often becomes the nutrient limiting to plant growth. Excessive loading of these nutrients permits increased plant growth until other nutrients or light availability becomes limiting (Wetzel 1983). Therefore, continued monitoring of the nitrogen levels will be necessary for a complete investigation of the waters in Pines Lake

Dissolved oxygen concentrations and temperature readings in Pines Lake were stable throughout the sampling year. Dissolved Oxygen in the upper water column rose with the cooler waters to 11.0 ppm and decreased to 7.0 ppm during the warmer summer months. This fluctuation is common and consistent with a productive lake. The concern with dissolved oxygen values is two-fold. A drop in concentration to below 5.0 ppm increases the stress on the fish populations. An extremely high Dissolved Oxygen reading can indicate an excessive algal bloom as the plants produce oxygen.

Pines Lake continues to maintain an ideal balance with respect to temperature and dissolved oxygen. It is common to see very low levels of dissolved oxygen on the soil-water interface along the bottom of the lake due to decomposition and microbial activity. This characteristic was observed during the midsummer sampling. This low level is typical and should cause no alarm when all factors of the lakes chemistry and physical attribute (i.e. lake volume, size and depth) are considered.

The visibility (Secchi) sampled in Pines Lake maintained an ideal level for a lake of its depth. An average of 12.6 feet (3.8m) of visibility was observed. It must be noted that these average Secchi reading are outstanding and are well above many lakes within New Jersey.

As demonstrated over the past years, there is a direct correlation to these results which can be tied to and comparatively attributed to the current use of Sonar Product for vegetation control. The dynamics of the Sonar Program (early systemic plant control) reduces the amount of decomposing organic matter caused from heavy plant densities. The early control of targeted plants reduced the available nutrients for algal populations and/or suspended solids, limiting algal population growth within the water column, therefore, increasing visibility (Secchi) readings throughout the seasons. This dynamic has been documented and illustrated in lakes throughout the country, and shows great success in plant management and management of nutrient cycling in Pines Lake.

Visibility did not decrease below 3 feet during the most productive months of the summer and inversely increased to 16 feet in the less-productive months. This fluctuation in visibility is common for lakes of its nature. It should be noted that an average visibility reading of 12.6 feet is extremely good for a lake with a TSI category of mesotrophic/slightly eutrophic, as well as for a lake located in northern New Jersey.

Summary

In conclusion, this water quality monitoring study is designed to provide the Pines Lakes P.L.A. with a scientific database to assess the present status of the lake. Based on the historical data collected, Pines Lake has been determined to be a mesotrophic/slightly eutrophic lake and has not changed significantly in the past ten years.

The monitoring program continued to support the issue of the negative influence of the Haycock Creek Area and inflow. It is highly recommended that the creek continue to be monitored, for the possible future influences on Pines' Lake water quality.

The Lake's general water chemistry and it's relationship and correlation to the aquatic vegetation has been compared over the past ten years. Aquatic Technologies has been obtaining water chemistry samples and live plant parameters during routine lake management site visits. 2020 observed the increase of the beneficial native plant populations (*Potamogeton species - native pondweeds*) and Chara population's along spot specific areas of the shorelines. These increases in plant populations, supports the scientific goals of the current "Sonar" vegetation management program and Aquatic Technologies' ability to re-establish the native plants communities within a lake with this lake management tool. The occurrence of the Water Star Grass and Naiad species was observed in the late summer. These plants were managed with spot-specific treatments to eliminate problematic populations in specific areas of the lake, while leaving the proper habitat for the fisheries and invertebrates.

The management and balance between water chemistry, vegetation management, and fisheries all provide Pines Lake with a beneficial and positive water quality and lake system.

Overall, the water quality at Pines Lake continues to be above average for lakes in the Northern New Jersey. This study supports the concern for the phosphorus concentrations within the lake as well as the possible concern of the negative influence of the Haycock Creek.

It is beneficial to the lake and it's water quality, to limit any existing and additional phosphorus loading in the lake. Lake productivity can be reduced through responsible watershed management, such as *best management practices* (BMPs) and education. Since Pines Lake is a mesotrophic/slightly eutrophic lake and sustains a moderate nutrient sump (load) to sustain macrophyte and algal populations, it is critical to continue to collect water quality data. These samplings will enable the lake association to immediately identify and eliminate any negative environmental impacts on the water quality. Additionally, Pines Lakes PLA must strive to reduce any existing negative water quality issues, specifically Phosphorus and Nitrogen loading, in an effort to slow the eutrophication process.

Future Lake Management Plan Recommendations

Based on the results of this study and past findings, Aquatic Technologies continues to recommend the following actions be carried out for the following years:

1) Education: Understanding the importance of watershed influences
2) Continued systemic "Sonar" aquatic vegetation control program. This program clearly demonstrates its ability to limit nutrient cycling (plant decomposition) through controlled and precisely timed vegetation management. As well as, re-establishment of native plants in the lake system.
3) 2020 discuss a fisheries study for general population and health of fisheries.
4) Continue the establishment of natives for nutrient uptake, competition with non-native and evasive plants species.
5) Continue the establishment of native plants for the fisheries habitat.
6) Continue dialogue with the Fisheries Management Team – Fishing Clubs; thus improving communication and fisheries program.
7) Continued removal of organics/sedimentation from shallows – Hydro-raking or dredging.
8) Continued water quality testing for the following parameters:
   - Total Phosphorus
   - Ammonia
   - pH
   - Secchi
   - Thermal and Dissolved Oxygen Profile
   - Ortho- Phosphorus
   - Nitrate
9) Discuss including additional sampling locations of storm drains and rivulets to determine possible nutrient loading values of these discharges.
10) Maintenance of "catch-basins" for inflow areas and storm-water runoff to reduce siltation and nutrient loading
11) Continue monitoring development within the watershed.
12) Strong recommendation to P.L.A. to use Non-Phosphorus fertilizers.
13) Contact the Passaic County Soil Conservation District for soil erosion concerns.
14) Continue the recommended Aquatic Technologies "Consultative-Service"™ Lake Management Program to assure proper vegetation management.

Implementing these recommendations, along with a pro-active role in watershed management will greatly influence the overall water quality of Pines Lake. The interest and actions of the P.L.A. has improved and sustained a healthier watershed. The continuation of these positive actions will maintain and/or improve the existing water quality of Pines Lake.

Should you have any further questions, please feel free to contact us at (973) 773-9567.

Sincerely,

Christopher Hanlon
Aquatic Technologies, Inc.

Enclosure

References Cited

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Vollenweider, R.A. 1966. Advances in defining critical loading levels of phosphorus in Lake Eutrophication. Mam.1st Ital.Idroniol: pp 425-457

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Addendum
Table and Figures

Figure 1: pH

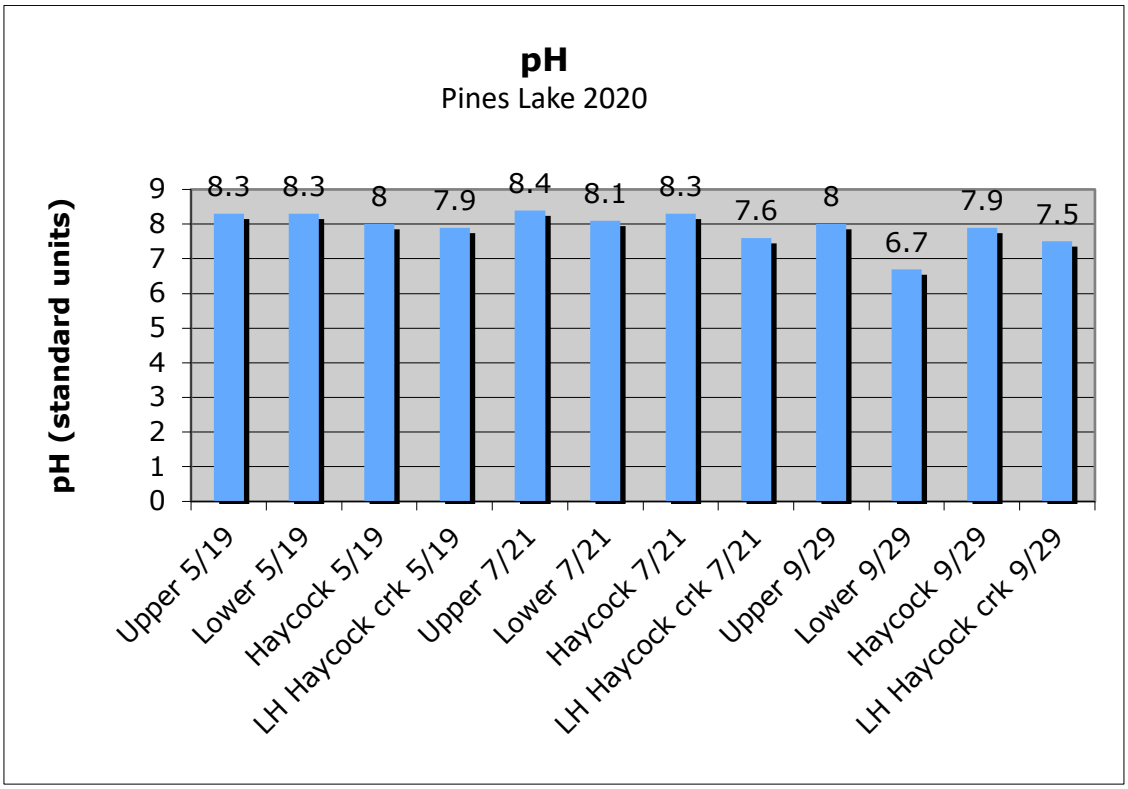


Figure 2

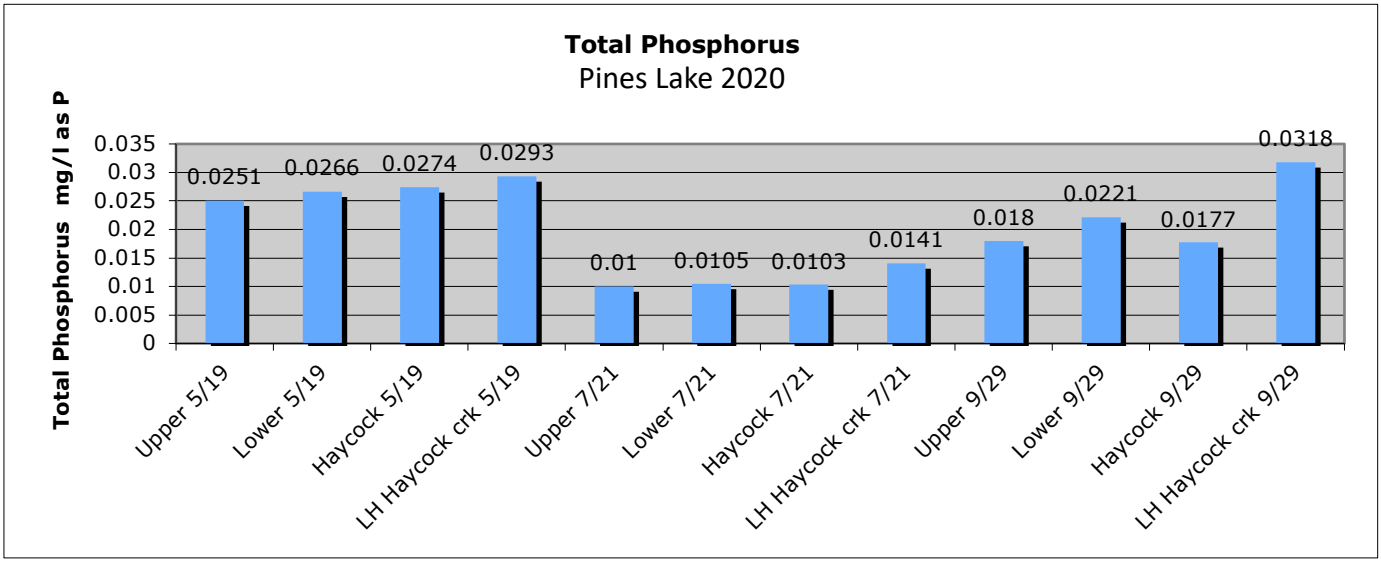


Figure 3

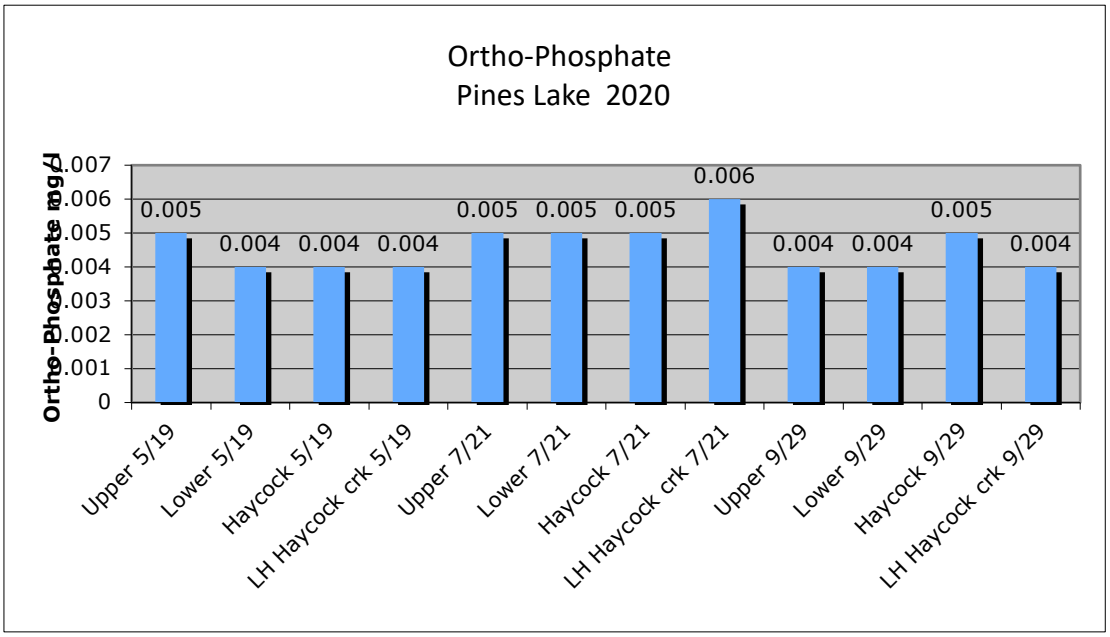


Figure 4

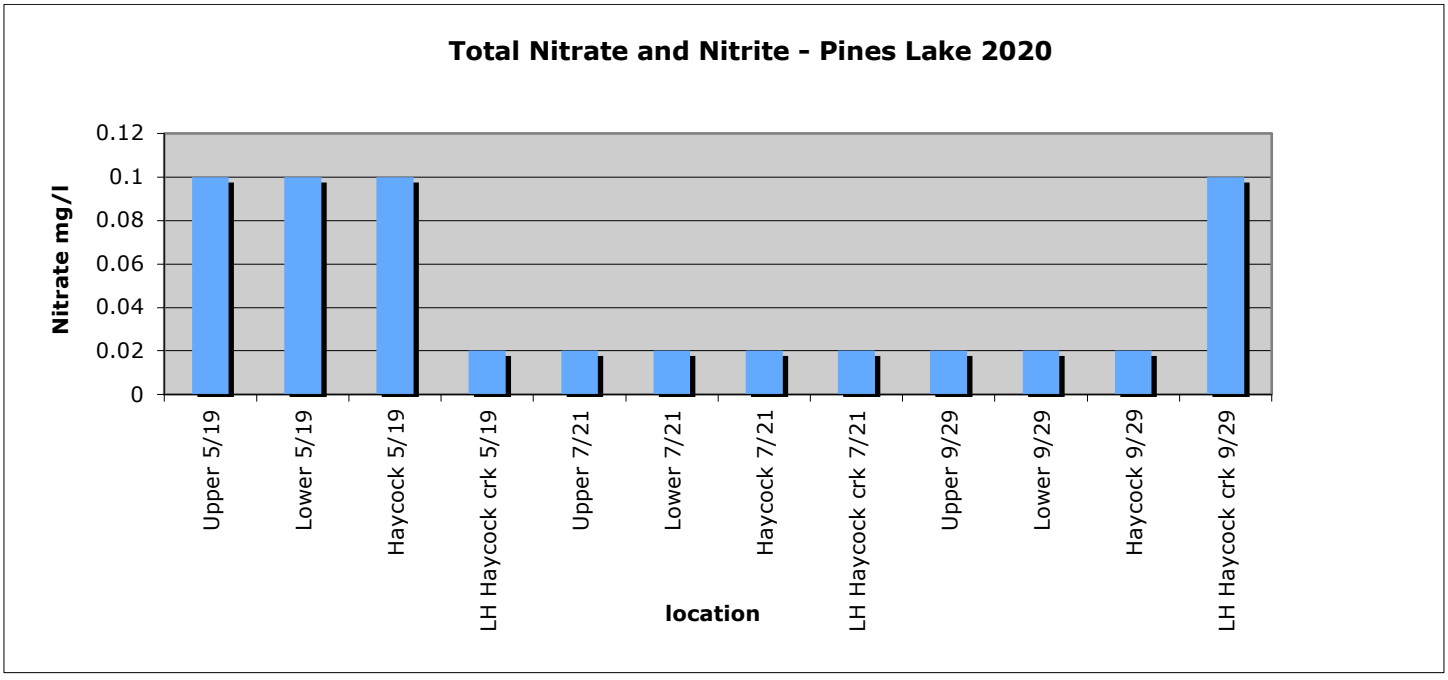
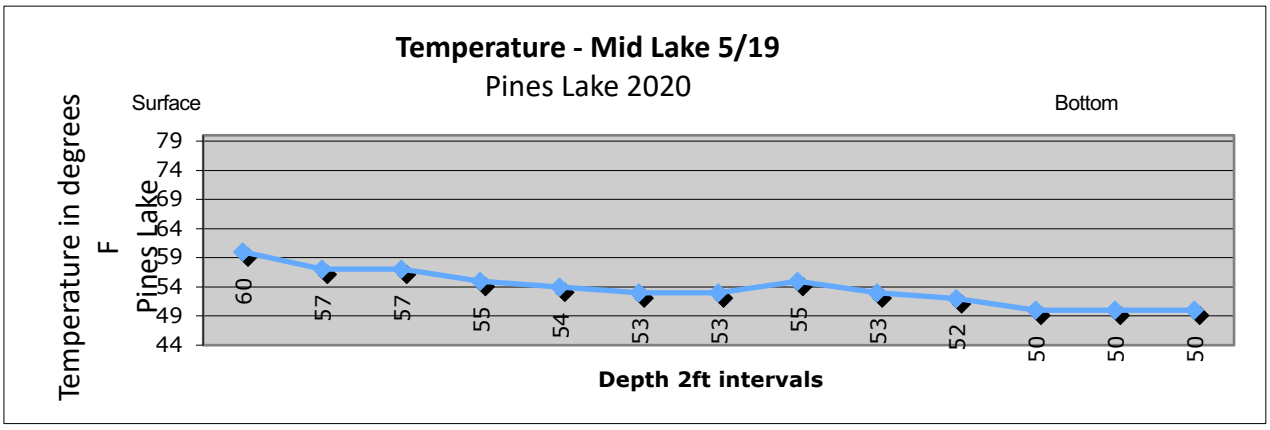
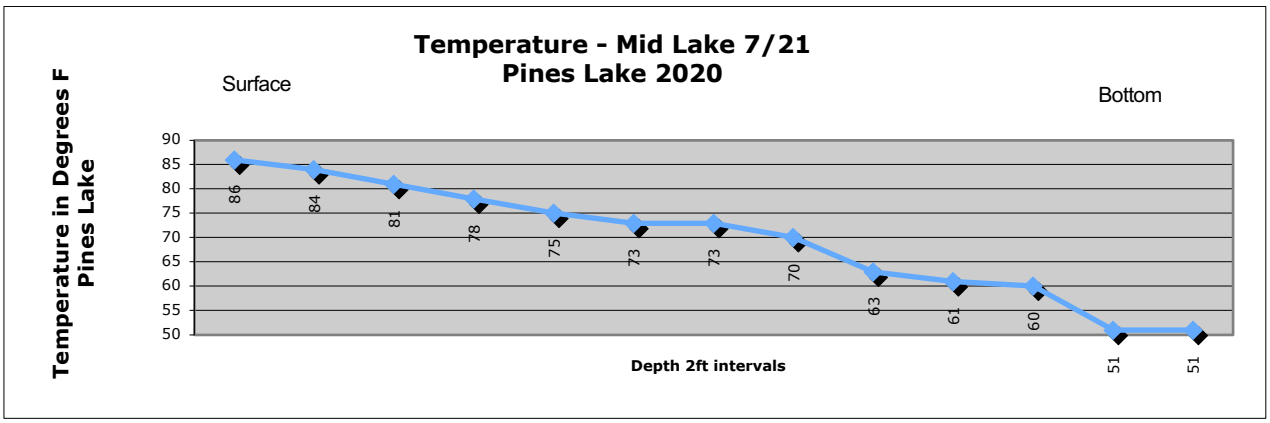


Figure 5. Mid-Lake Station: Temperature





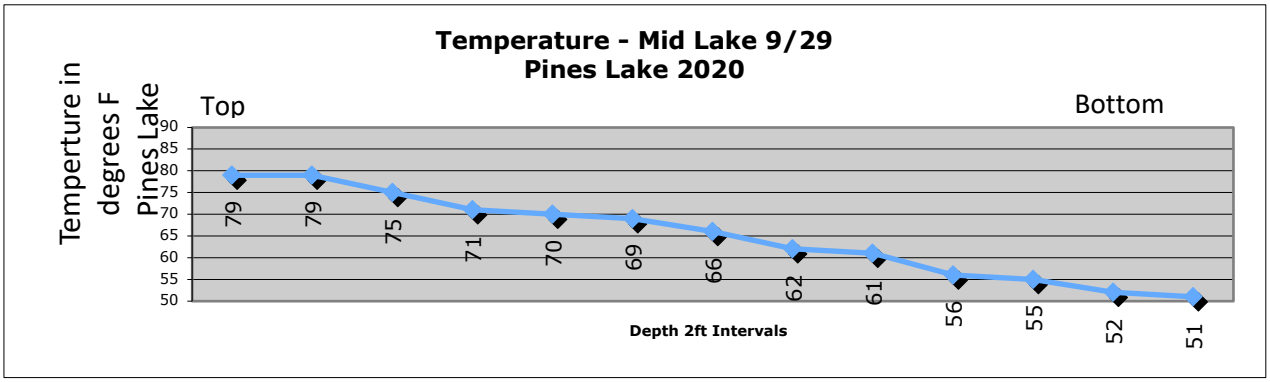
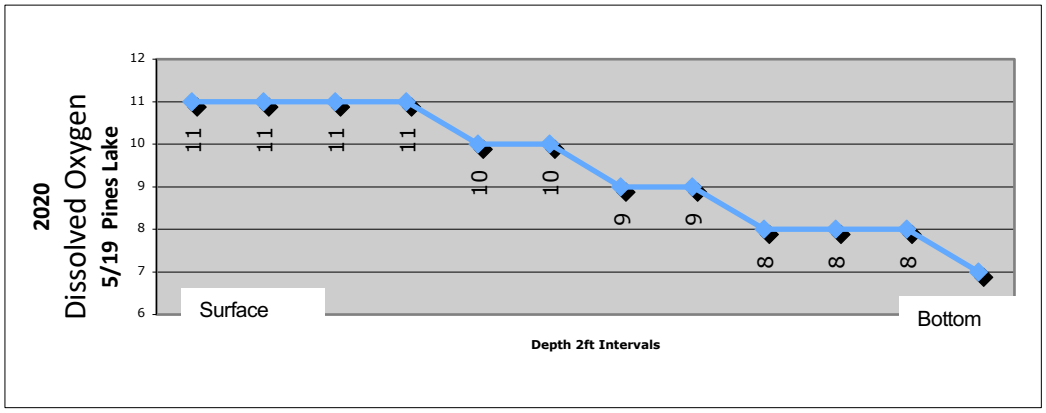
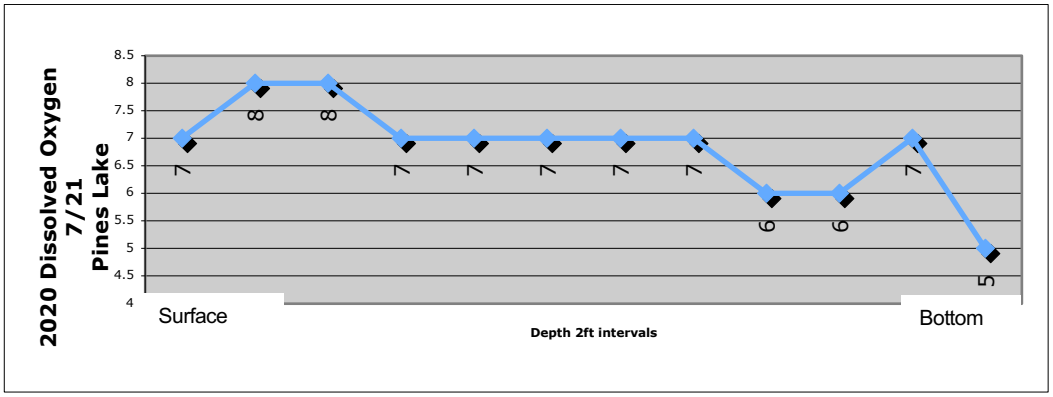


Figure 6. Mid Lake Station: Dissolved Oxygen





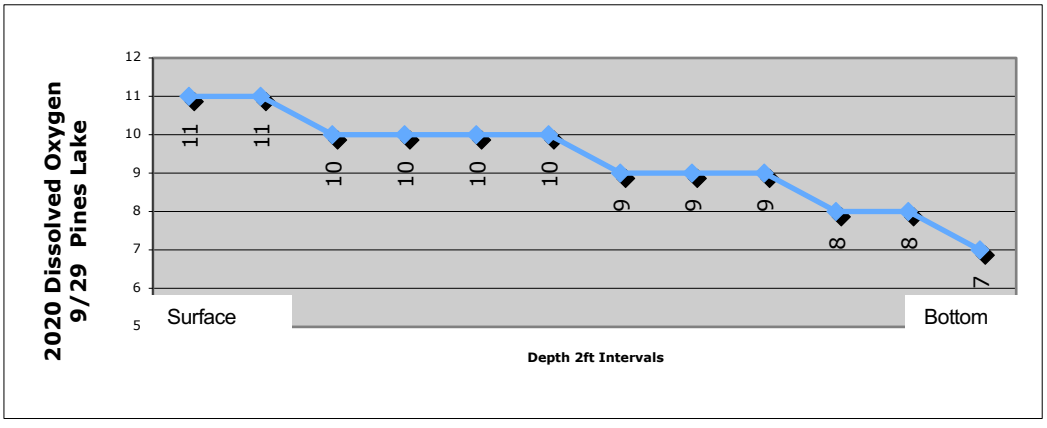
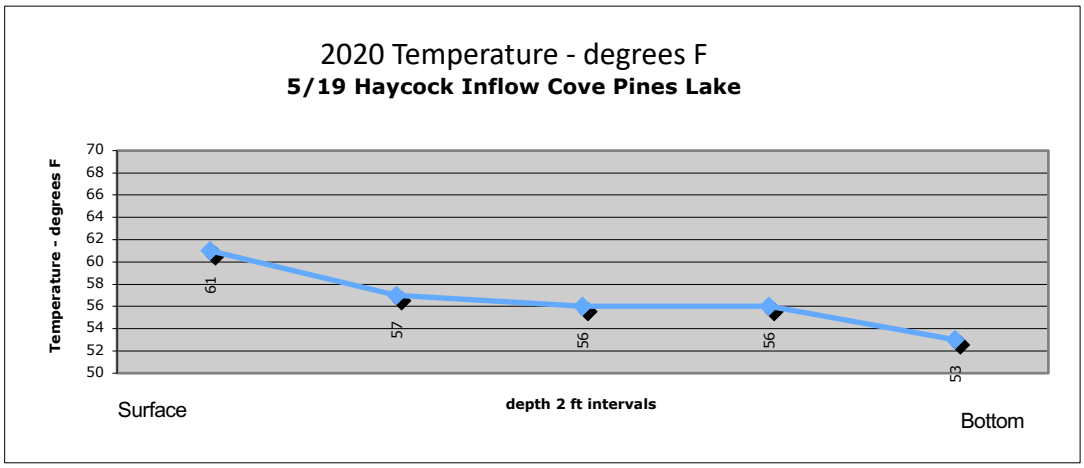
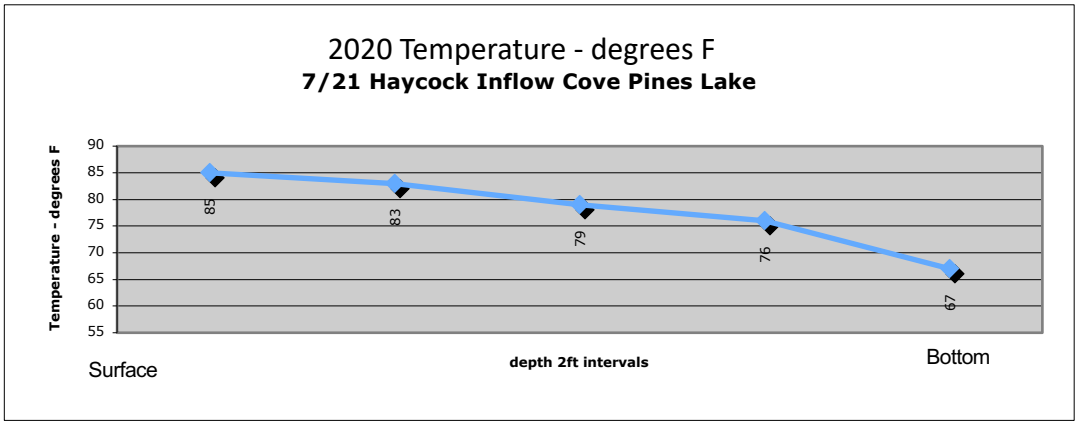


Figure 7. Haycock Area Station: Temperature





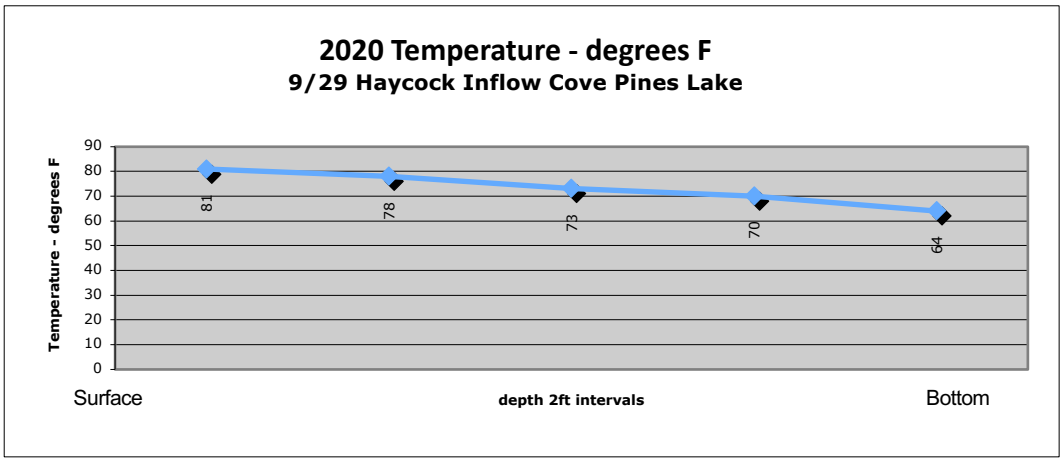
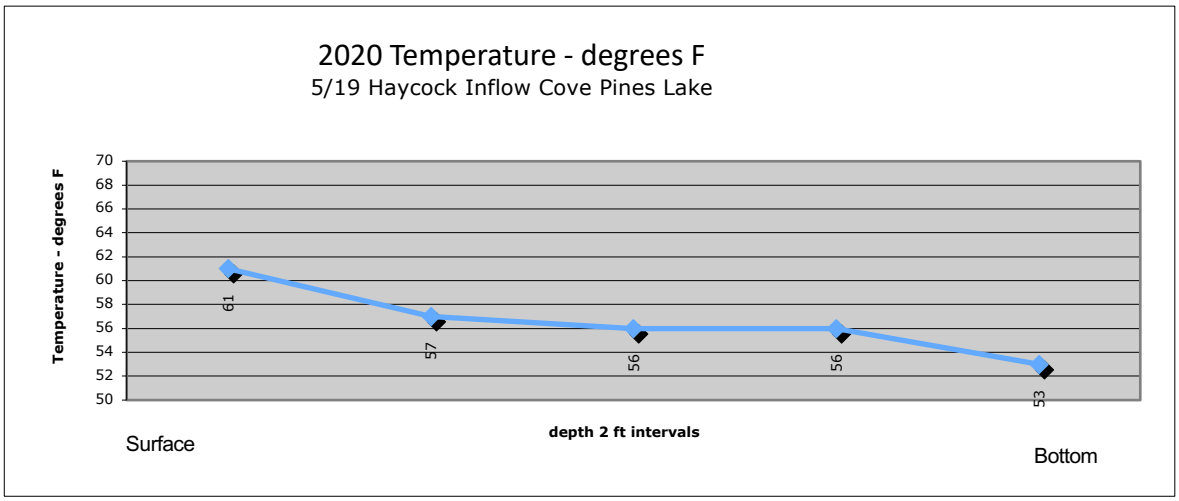
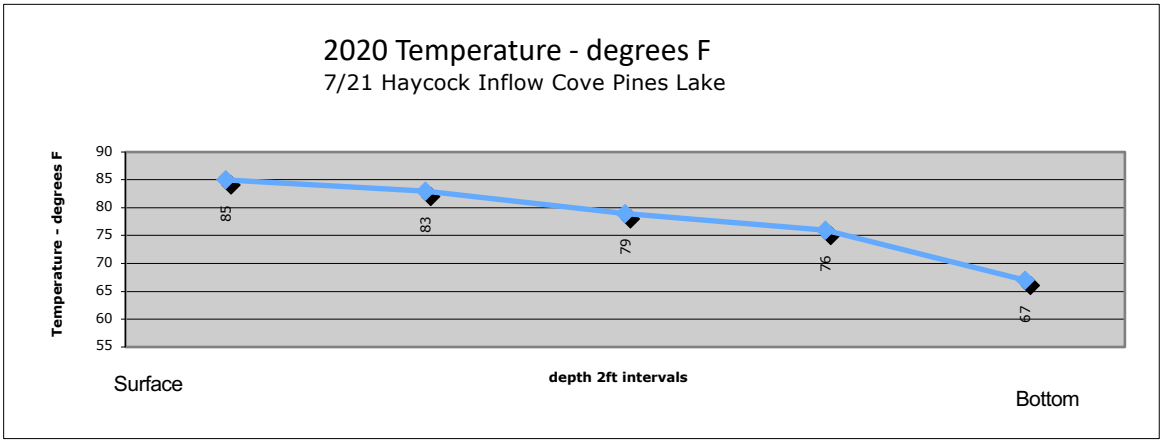


Figure 8. Haycock Area Station: Dissolved Oxygen





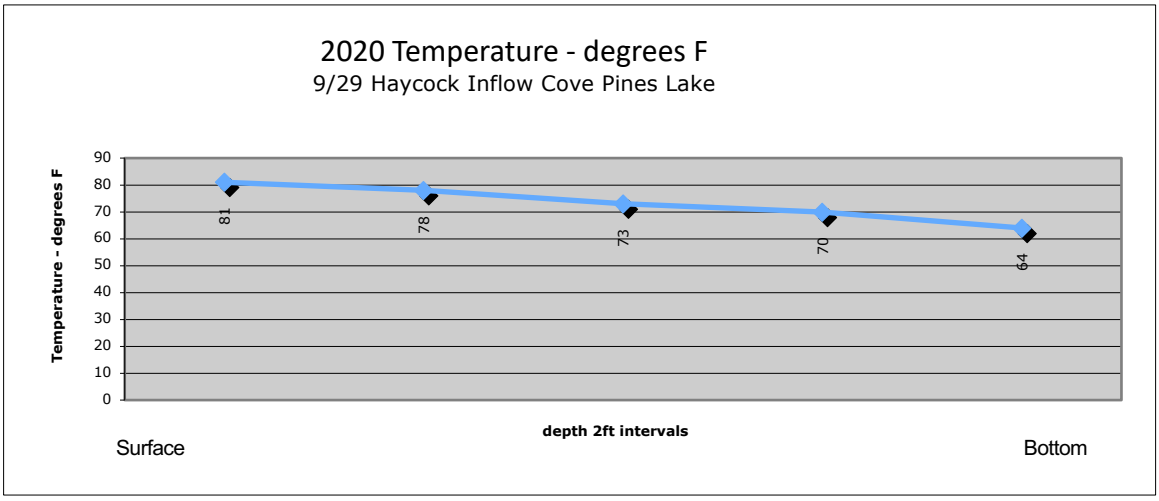


Figure 9. TSI: Yearly Comparison

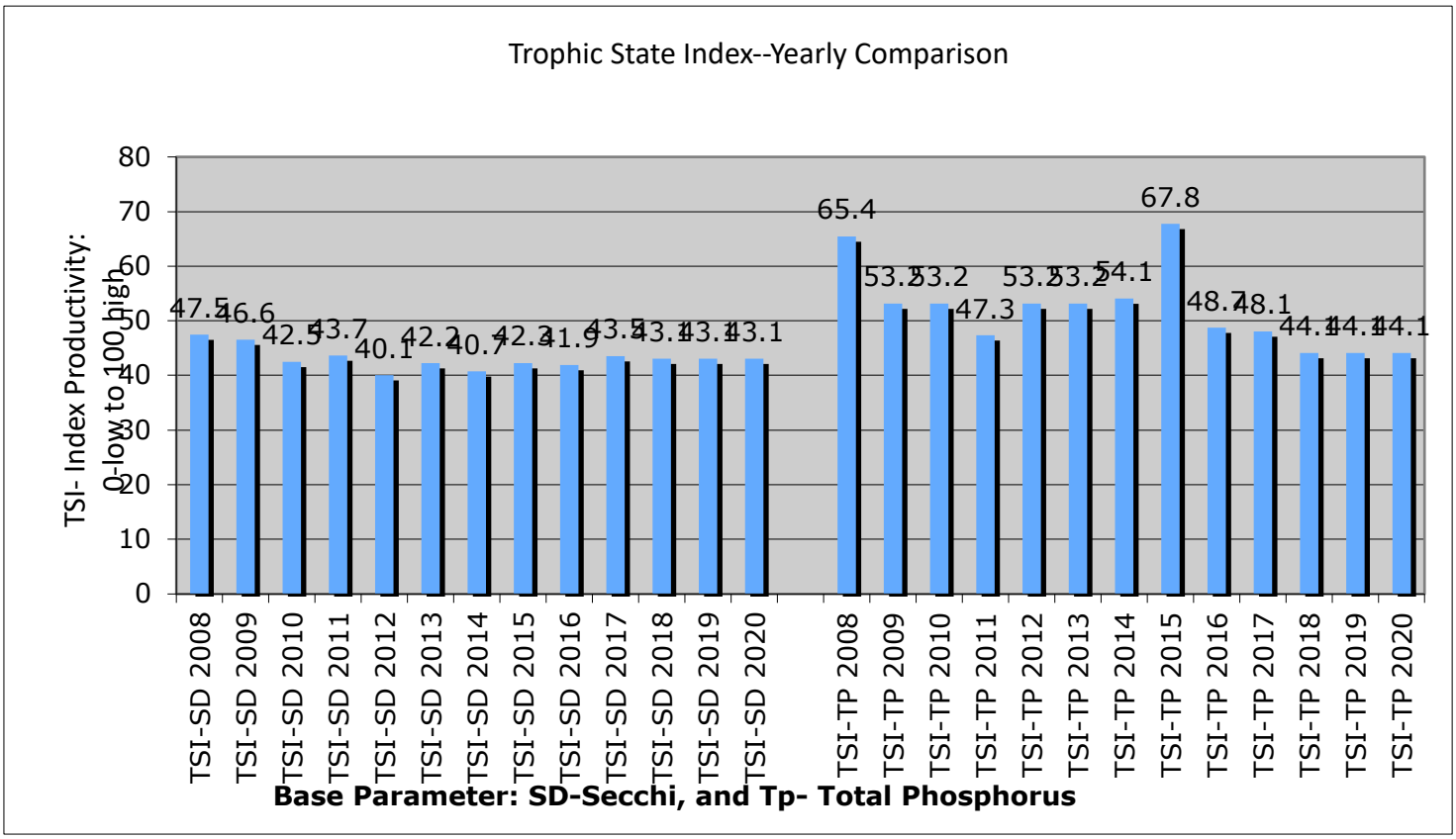


Figure 10. TP yearly comparison

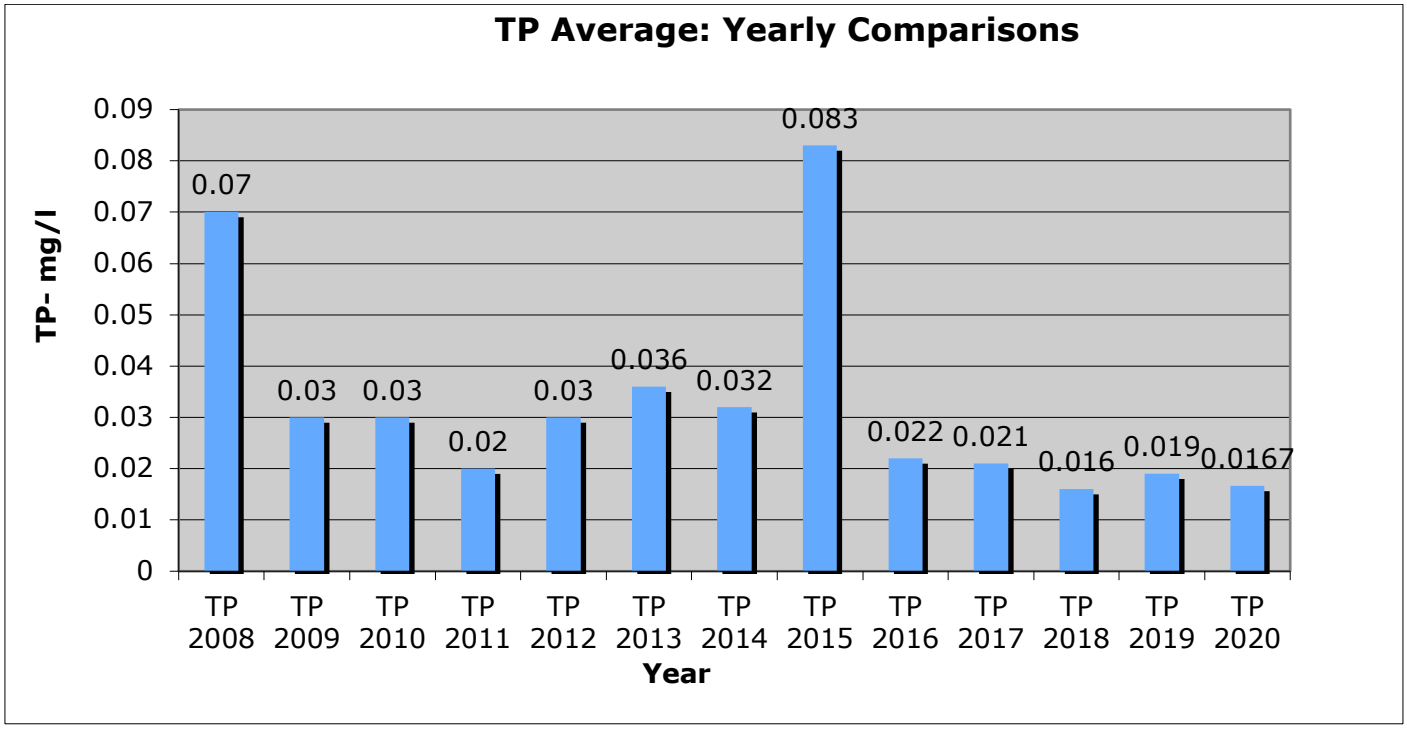


Figure 11. Secchi yearly comparison

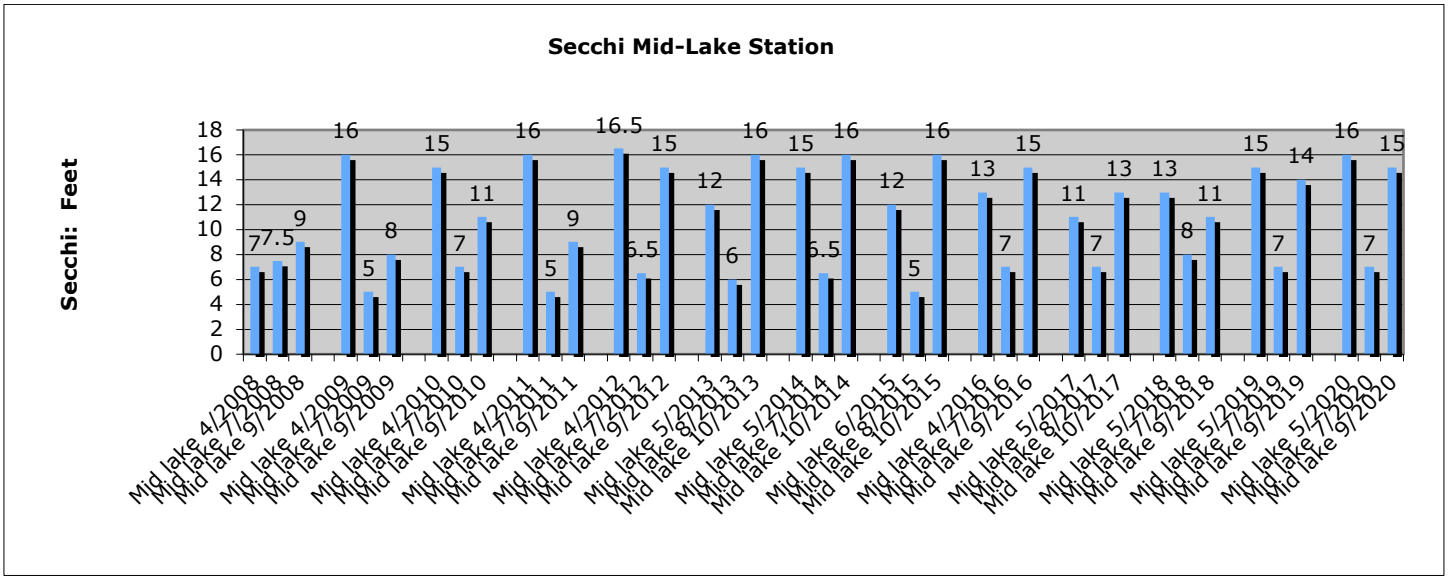


Figure 12. Secchi – Mid Lake yearly comparison

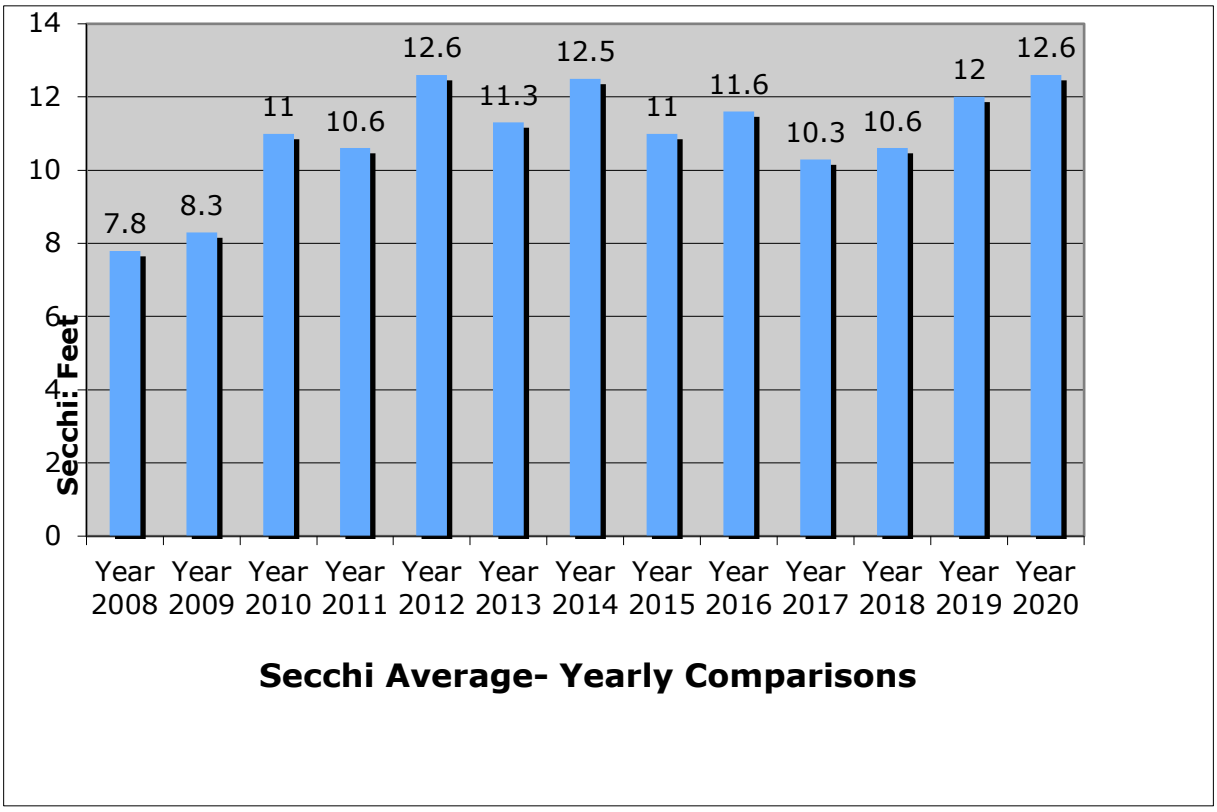


Figure 13


2020 Sample Locations.
Marked by RED X and Yellow Square:
Locations:
1. Mid Lake Station
2. Haycock Creek Inflow Area
Pines Lake, NJ 07470
Alder Ave
Bodie Rd
Colona Rd
Ridge Rd
Glen Rd
Knoll Rd
Green Knolls Dr
Pines Lake Dr W
Terrace
Vale Rd
Shoshone Trail
Apache Rd
Commanche Dr
Tower Rd
Algonquin Trail
Mohawk Trail
Pines Lake Dr
Beech Terrace
Osceola Rd

Figure13b


2020 Sample Locations.
Marked by RED X and Yellow Square
Note: Sample location of Haycock Creek at Lions Head Outflow
Tamarack Rd
Briarwood Rd
Lions Head Dr E
Lions Head Dr W

Table 1 – Parameter Results all Stations

Parameter	units Standard	Upper 5/19	Lower 5/19	Haycock 5/19	Lions Head -Haycock Crk 5/19
Ph	units	7.9	7.8	7.8	7.6
Total Nitrate and Nitrite	mg/l	0.02	0.02	0.02	0.1
Ortho Phosphate	mg/l as P	0.004	0.005	0.004	0.009
T. Phosphorus	mg/l as P	0.0169	0.0141	0.015	0.028

Parameter	units Standard	Upper 7/21	Lower 7/21	Haycock 7/21	Lions Head -Haycock Crk 7/21
pH	units	7	7	7.2	7.3
Nitrites/Nitrates	mg/l	0.02	0.02	0.02	0.2
Ortho Phosphate	mg/l	0.005	0.004	0.005	0.004
T. Phosphorus	mg/l	0.0298	0.015	0.0161	0.0165

Parameter	units Standard	Upper9/29	Lower9/29	Haycock/9/29	Lions Head - Haycock Crk 9/28	Total Averages
pH	units	7.1	7.3	7.3	7.2	7.38
Nitrites/Nitrates	mg/l	0.02	0.02	0.02	0.1	0.05
Ortho Phosphate	mg/l	0.004	0.004	0.004	0.004	0.004
T. Phosphorus	mg/l	0.01	0.009	0.009	0.009	0.016

Table 2. DO & Temp – Mid Station Main Waterbody

Mid Lake Station

Depth	DO 5/19	temp 5/19	DO 7/21	Temp 7/21	DO 9/29	Temp 9/29
0	11	60	7	86	11	79
2	11	57	8	84	11	79
4	11	57	8	81	10	75
6	11	55	7	78	10	71
8	10	54	7	75	10	70
10	10	53	7	73	10	69
12	9	53	7	73	9	66
14	9	55	7	70	9	62
16	8	53	6	63	9	61
18	8	52	6	61	8	56
20	8	50	7	60	8	55
22	7	50	5	51	7	52
24	7	50	3	51	4	51

Table 3. DO & Temp – Haycock Area Station Main Waterbody and Lion head Haycock Creek Area

Haycock DO

Depth	DO 5/19	temp 5/19	DO 7/21	Temp 7/21	DO 9/29	Temp 9/29
0	11	61	8	85	10	81
2	11	57	8	83	10	78
4	10	56	7	79	9	73
6	9	56	7	76	8	70
8	8	53	2	67	5	64

LH Haycock DO

Depth	DO 5/19	temp 5/19	DO 7/21	Temp 7/21	DO 9/29	Temp 9/29
Surface	11	59	7	82	9	77