A Water Quality Assessment of Lake Owassa

Prepared for:
Lake Owassa Community Association

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Water Quality Assessment of Lake Owassa:
A General Overview

1. Introduction

People are drawn to Lake Owassa for its tranquility, surrounding beauty, and most importantly, water. The quality of such water drives recreational activities (boating, fishing, and swimming), abundance of aquatic and terrestrial organisms, and household property values surrounding the lake (Boehlert *et al.*, 2015). Lake water quality is shown to have a positive relationship with property values, which means water quality not only influences recreational and environmental activities, but also has economic ramifications for every household on the lake (Krysel *et al.*, 2003). If the lake's water quality declines due to leachates from fertilizer, household detergents, and/or pesticides, septic leakage, or even recreational accidents (gasoline, oil, hydraulic fluid leaks/spills), it could potentially erode the ecological, economic, and aesthetic values that characterize Lake Owassa.

Lake Owassa is part of the headwaters of the greater Paulins Kill watershed. This means that discharging lake water, and any dissolved materials it contains, travels to other bodies of water. Limiting the amount of pollutants from the head waters in the watershed means less potential pollution each successive water basin receives (Nelson *et al.*, 2011). It is essential to keep our waters clean not only for the lake ecosystem and human pleasures, but also for the greater good of the hydrologic community of which Lake Owassa is a part of.

To protect our "natural wonder", the Lake Owassa Water Quality Committee monitors lake water quality during the spring, summer, and fall months in an effort to understand natural variations in water quality parameters, identify potential pollution sources, and educate association members on reducing potential pollution sources. The purpose of this report is to help:

- educate the association on current water quality monitoring activities on Lake Owassa;
- compare the past 12 years of data against known chemical and biological standards;
- compile the past 12 years of data to serve as baseline data for future monitoring;
- make a qualitative assessment of our water; and
- identify future efforts to maintain high water quality.

2. Methods

Les Holland began water quality monitoring on Lake Owassa in 1968 in an effort to better understand pollution threats the lake faces. His initial work, along with many others on the lake, set up the basis for our current monitoring program. Les identified the locations and influenced many of the parameters we use today. Though past methods of water analysis are different than today's, Lake Owassa has a long tradition of monitoring and maintaining water quality. More recently, over the past 12 years, Brad Batastini (C-20), Dave Claeys (H-30), and Mike Sarsfiled (I-01) have used modern instrumentation (a Sonde DS5X multi-parameter water probe rented from HACH Environmental) to continue monitoring water quality focusing on several parameters: nitrates (NO_3^-), dissolved oxygen (DO), specific conductivity, pH (acidity), and turbidity. Fecal coliform is measured independent of water chemistry parameters. Other parameters are also recorded, but are not included in this report (e.g. temperature, ammonium, and phosphates).

2.1 Data Collection. Data was collected three times a year from 2004 through 2016 and only represents a "snapshot" of water chemistry in any specific year. Lake water was sampled in May, August, and October, as these are the months when the lake has the greatest activity, both by organisms and people. Seven locations were sampled on the lake (see figure 1). All locations were sampled at 1 foot water depth except for the mid-lake reading (red pin on figure 1), which had 1 ft., 3 ft., 6 ft., 10ft., and 16 ft. depth readings. These locations were originally picked because they are major points (near the shoreline) where water enters the lake basin and potentially are the greatest point sources of pollution. The exceptions to near shoreline testing include the upper lake and mid-lake locations, which look at water chemistry in the center of the lake. The data for each parameter across all locations was averaged together to obtain a single number per sampling day (e.g. we had seven nitrogen readings for the sampling day in May 2004, which were averaged together to obtain one nitrogen reading for the lake in May 2004). These averages were then used in the boxplot graphs as shown throughout the report. Presenting the data in this fashion means that each box plot has a sample size of 12 readings.

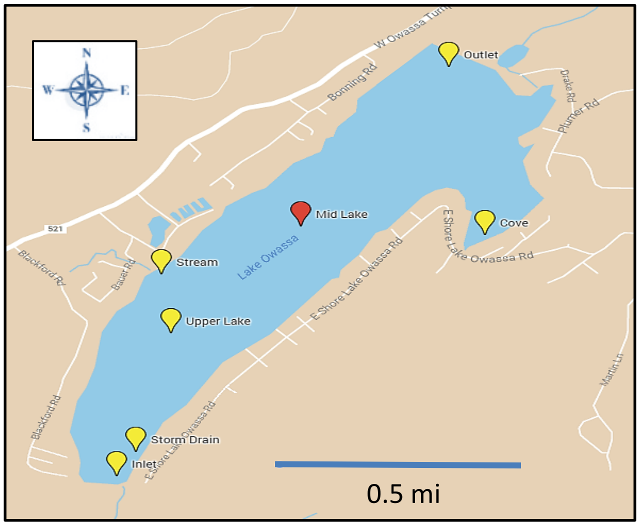


Figure 1. Map of Lake Owassa and locations sampled from 2004-2016. All locations measured at 1 foot water depth (yellow) except for mid-lake (red) which was measured at 1, 3, 6, 10, and 16 foot water depths. The inlet is the major point of water inflow to the lake during dry conditions (i.e. no rain) from Bear Swamp. The storm drain, cove and stream locations are points where storm water discharges into the lake. The Outlet is the location where the water flows out of Lake Owassa into Culvers Lake and eventually down through the Paulins Kill watershed. Map data from Google Maps.

2.2 Fecal coliform sampling. Fecal coliform testing was (and still is) administered independent of water chemistry sampling and helps measure bacterial colonies in the lake water. Les Holland developed separate sampling methodology for coliform monitoring, which started in 1982. Most recently this work has been carried out by Jim Servidea (C-04) and now by Mark Vogel (C-11). Eight fecal coliform samples are typically taken once a month from May through September. At least one household area number is systematically selected from each area group (e.g. one household from H-1 through H-34) for each sampling date, unless otherwise requested. This system allows for every waterfront property to be sampled approximately once every 4 years. Samples are taken and sent out to MPL Laboratories in Sparta NJ for analysis. Data from each sampling date was averaged together to get an average fecal coliform count per sampling date.

2.3 Disclaimer for data presented. It is important to note that these sampling techniques only provide a “snapshot” of lake chemistry/coliform count for any given day at any given time. These readings do not provide a continuous (time series) data set, so the data cannot be used to assess trends over time and is substantially weaker than a continuous data set. One reading per month (May, August, and October) is not reflective of water quality for the entire season and can be heavily influenced by current/previous weather conditions, recreational/biological activities, temperature, and time of day (Manahan, 2010). In addition, 3 (for chemistry) or 5 (for fecal coliform) readings per year are not reflective of water quality for the entire year. Nonetheless, the data collected can provide useful, qualitative, information as to where the temporally random samplings sit compared to recognized water quality standards. This study is important for communicating current water monitoring activities and serves as baseline data for further studies.

3. Parameters

The section below gives a general overview of 5 inorganic water chemistry parameters measured on Lake Owassa since 2004, including: nitrates (NO_3^-) dissolved oxygen (DO), specific conductivity, pH (acidity), and turbidity. One biologic parameter (fecal coliform) was also measured independently of the inorganic parameters. Other inorganic parameters were collected during the sampling periods, however they are either not a complete data set or are not useful in understanding the general interpretations. General interpretations are made based on the data presented and in accordance with the disclaimer mentioned previously. Brief biological and chemical background is given to help in qualitative interpretations. All data is compared against known NJ State surface water quality standards or standards released by university water quality extensions (e.g. Penn State extension).

3.1 Reading the boxplot graphs. Box plot graphs (box-and-whisker graphs) were used to present the collected data because of the nature of the sampling technique (see section 2.1). The boxplot graphs portray the averaged distribution of each parameter from 2004 to 2016 and helps show where the majority of the data resides. For the following assessments, the most important aspect is the beige boxes, which represents where most of the data is grouped over a narrow numerical range.

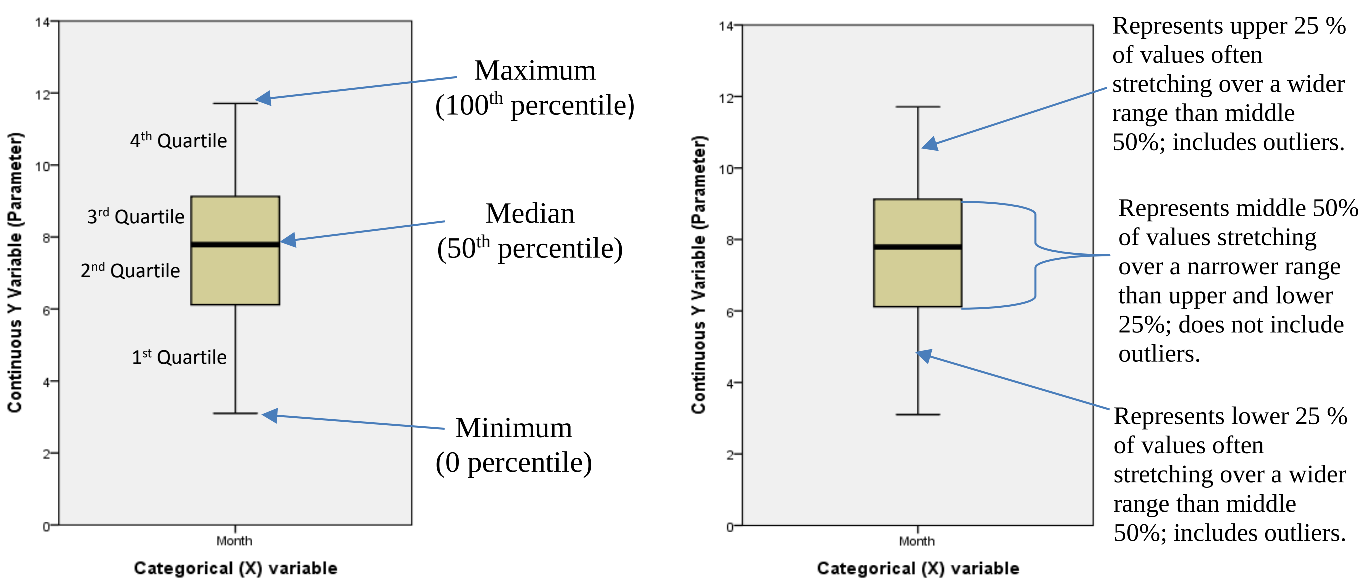


Figure 2: General overview of interpreting box plot graphs. Note: The Y axis represents the concentration of a specific parameter and is usually a continuous variable (can take on any positive value). The X axis represents the month when the measurement was taken. It is a categorical variable because measurements can be classified as being taken in one of three months (May, August, and October). Information adapted from (Gotelli & Ellison, 2004).

3.2 Nitrates

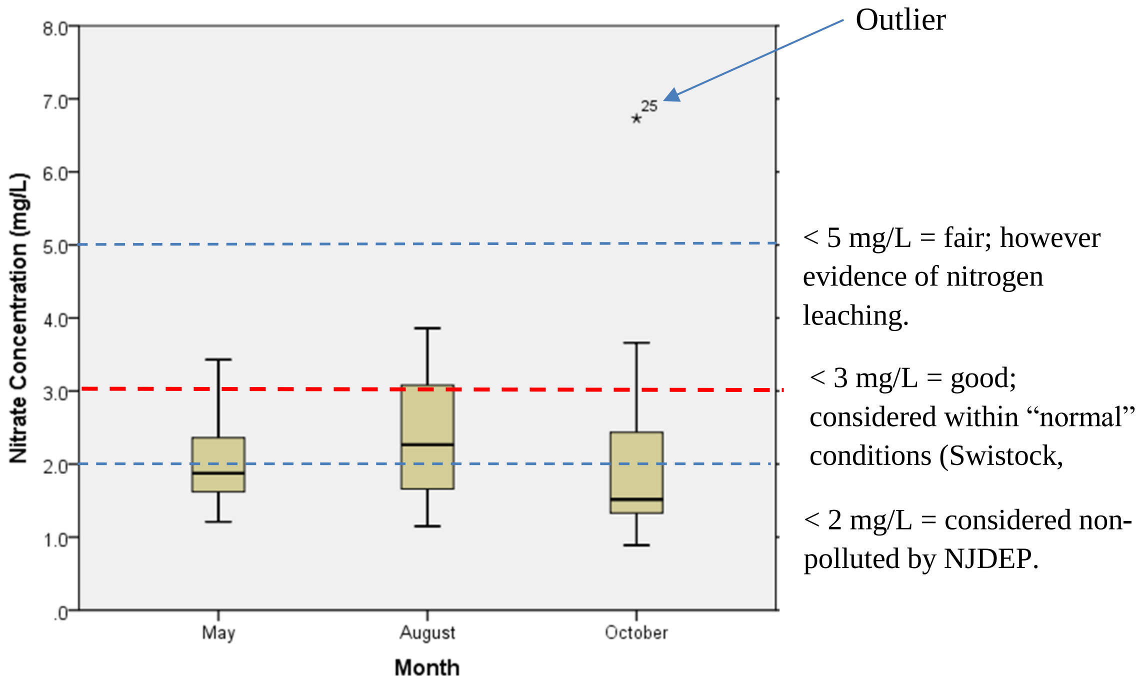


Figure 3: Box plots of average nitrate (NO_3^-) concentrations for all locations at one foot water depth. Data collected from 2004 – 2016.

Nitrates (NO_3^-) are essential nutrients supporting the aquatic food chain, mainly for the growth of aquatic plants and algae. However, too much influx of nitrates (or nitrogen loading) can cause an imbalance in the aquatic ecosystems. Nitrates are often a limiting nutrient to aquatic plant growth because of its relatively low concentration in natural lake waters (Girard, 2014). Naturally, nitrates enter into the water through decomposition of organic matter (e.g. leaves). When nitrates and phosphates are abundant in waters, rapid algal growth can occur which leads to an algal bloom (for our lake, it is often seen as a green film on the water surface in late summer). Eutrophication occurs when there is excessive growth of algae and plants (Girard 2014). As plant/algae growth eventually dies, decomposition by bacteria and fungi occurs, requiring oxygen. When algal and plant blooms decompose, great quantities of dissolved oxygen are used up thereby leaving less dissolved oxygen for fish. Most anthropogenic (human) causes of major algal blooms are a result from nitrogen fertilizers (for lawns or gardens) leaching, grass clippings from lawns, or human/animal (geese) manures entering the lake.

Nitrates are often released by the natural decomposition of organic matter and runoff from neighboring land (Girard 2014); however when nitrate concentration is consistently above 3 mg/L it may suggest an anthropogenic contribution to nitrogen leaching (Swistock, 2017a). Based on our surface water measurements over the past 12 years, we see the majority of the data sits just at or below the 3 mg/L line, which could be suggestive of efforts to limit nitrogen wastes from entering the lake. Continued effort and management of nitrogen runoff to the lake is essential to prevent aquatic plant population explosions of milfoil (*Myriophyllum spp.*) and coontail (*Ceratophyllum demersum*), which can be unpleasant for swimmers, boaters, and other recreational activities.

3.3 Dissolved Oxygen

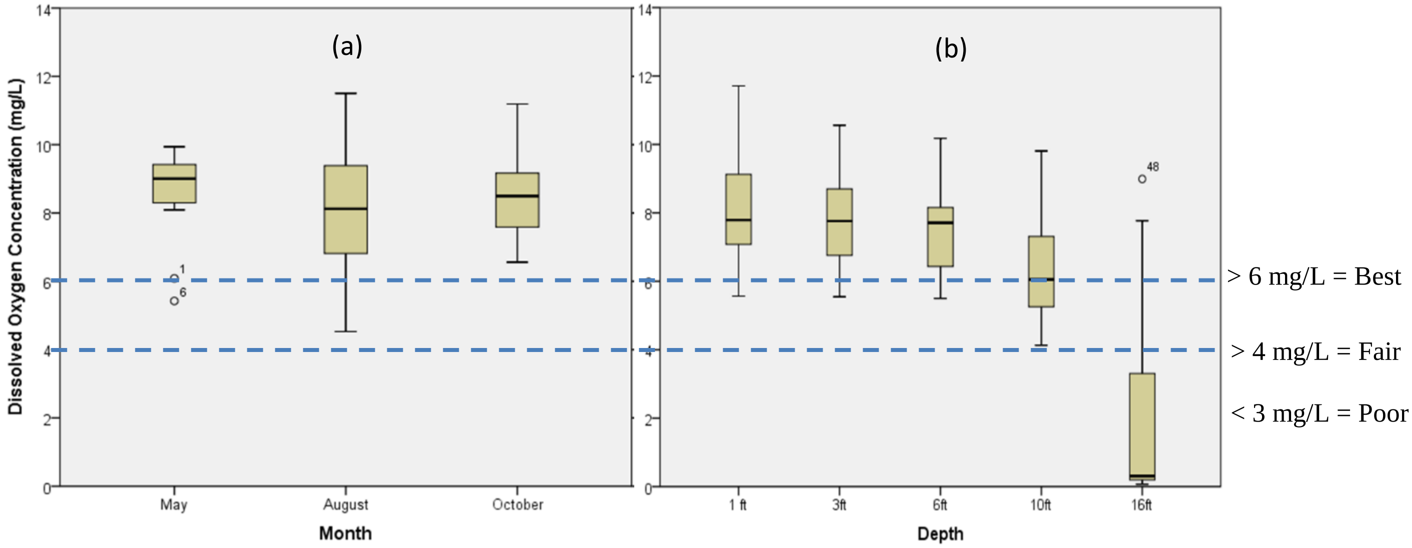


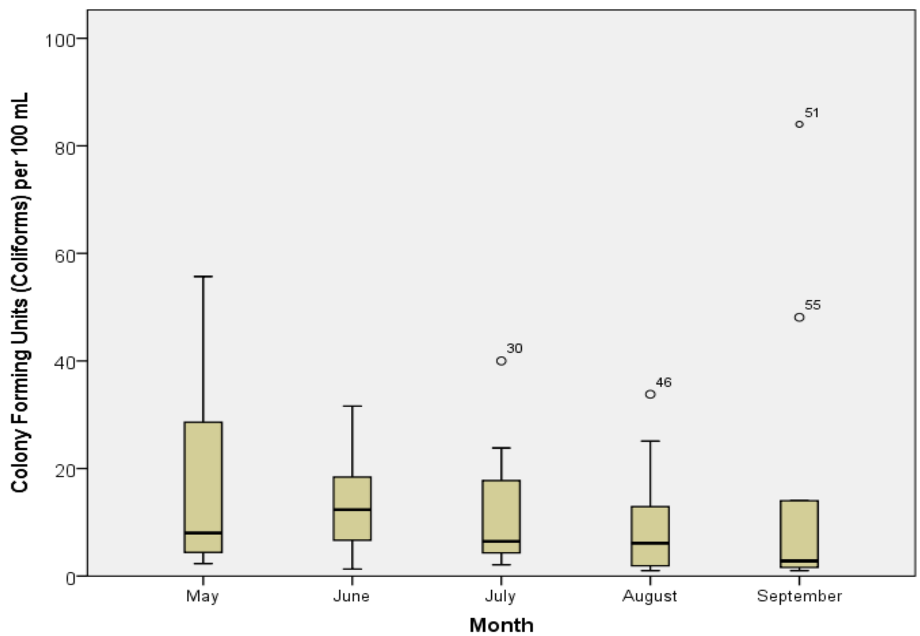
Figure 4: Box plots of average dissolved oxygen concentrations. (a) For all locations measured at one foot water depth in May, August, and October. (b) Dissolved oxygen measurements only made at the midlake location at 1, 3, 6, 10, and 16 foot water depths during the month of August. Data collected from 2004 – 2016.

Dissolved oxygen (DO) is one of the best indicators for water quality and is necessary for almost all aquatic life including fish, amphibians, mollusks, other invertebrates, and bacteria to name a few. DO in water comes from oxygen in the atmosphere, however atmospheric oxygen does not readily dissolve into water. Many factors are at play as to how much oxygen can dissolve into water including: temperature, elevation, amount of suspended solids, movement of water, and pollution (Girard, 2014; Manahan, 2010). At least 6 mg/L of DO is required for most fish populations to perpetually survive and reproduce in an aquatic ecosystem (Swistock, 2017a; Girard, 2014). Few fish, such as sunfish, yellow perch, and catfish can tolerate lower DO concentrations; however, almost all hardy fish will die when the DO concentration falls below 3 mg/L for an extended period of time (Girard, 2014; Manahan, 2010). Limiting leaching of nitrates, phosphates, sewage, and other chemicals into the lake can help keep DO levels high. With fewer nutrients for rapid plant and algal growth, less decomposition occurs, meaning more dissolved oxygen for aquatic life.

Our limited testing indicates that the lake is usually well oxygenated at surface levels (figure 4a), which is to be expected since this water depth is close to the air-water interface. To keep oxygen and nutrients cycling throughout the lake waters (vertically), the process of turnover occurs in the spring and autumn. Here, atmospheric temperatures cool the surface waters to about 4°C (39.2°F). At 4°C (39.2°F) the surface water reaches its point of maximum density and sinks to the bottom, carrying oxygenated water to benthic aquatic life. As surface waters sink, bottom (warmer) water is forced to the surface, which carries important nutrients to the surface to support the aquatic food chain. However, during summer and winter months, turnover does not occur and the lake stratifies in both temperature and dissolved oxygen. As depth and water temperature increase dissolved oxygen concentrations decrease. Figure 4b only looks at August dissolved oxygen readings at various depths because this is when the lake is expected to have the lowest dissolved oxygen values, thereby potentially being a critical period for aquatic life. August also coincides with warmest water temperatures and highest biologic/anthropogenic activity, which all influence DO levels.

For most of the water column, the dissolved oxygen readings are in an acceptable range, though a continuous (time series) data set would better indicate a change of DO with depth. The bottom depth (16 ft) seems to be quite low and at some points reaching anoxic conditions. Some of these reading may be an artifact of low water levels in the summer and/or the instrumentation hitting the bottom. Low values, however, are expected for the bottoms of eutrophic lakes where there is decaying organic matter and low light availability (Manahan, 2010).

3.4 Fecal Coliform.



> 200 colonies per 100mL = contaminated

Note: Maximum on scale bar only 100 colonies per 100mL

Figure 5: Box plots of average fecal coliform counts in lake water for all samples taken on the sampling day. Data collected once a month for five months (May, June, July, August, and September) from 2004 – 2016. Note: this test deviates from sampling procedures for the water chemistry parameters referenced in section 2.1.

Coliforms are a group of many different bacteria, generally harmless to human health, which are used as an indicator of sanitary conditions for lake water. Typical bacteria genera observed in total coliform tests include: *Citrobacter, Enterobacter, Hafina, Klebsiella* (bacteria of non-fecal origin) and *Escherichia* (genera that contains *E. coli*, a bacteria of fecal origin). Coliform testing on Lake Owassa specifically looks at fecal coliforms (figure 5) which contains fecal bacteria that mainly originate in the intestinal tract of warm-blooded animals (humans, dogs, cats, bears, deer, geese, ducks etc.) and generally enter the lake by leaching from land (Goldman & Horene 1983; Almeida *et al.*, 2012; Swistock 2017b). Low concentrations of fecal coliforms usually pose little harm to swimmers and are a part of "normal" water conditions (typically defined as "background levels"); however, when levels surpass the safe bathing limit of 200 coliforms per 100 mL of solution, human health is in jeopardy (Almeida *et al.*, 2012). The main purpose for this testing is to assess the suitability of waters for recreational use, ensure the safety of all swimmers in the lake, and help to monitor septic tanks around the lake (to prevent leakage and potential failure). One leaking septic tank can easily impact the entire lake community by not only overloading the lake with nutrients but potentially also harmful bacteria. With the systematic testing explained in section 2.2, approximately every 4 years each waterfront property on the lake is tested for fecal coliform.

It is important to note that fecal coliform tests can result in false positives due to some non-fecal bacteria (as mentioned above) registering as fecal bacteria during the incubation period (Doyle & Erickson, 2006). The best action to be taken if a sample result appears to be high is to retest. Lake Owassa has a policy that if fecal coliform counts for any location are five (5) times above the lake average for the sampling date, a retest will occur within 2 weeks.

The averages for the data between 2004 and 2016 are well below the 200 coliform limit, which seems to suggest most of the fecal coliform detected is “background levels” and not anthropogenic. However, there have been some isolated accounts where results were above 200 coliforms and those areas were retested and monitored. In most cases the results from retesting have all been well below 200. To prevent any spikes of fecal bacteria concentrations, it is important for homeowners pump their septic on a consistent basis. Size of household, age of septic tank, and amount of usage all factor into the frequency of pumping (Goldman & Horene 1983). Also, homeowners should prevent pet and animal feces (e.g dogs and geese) from entering the lake via their property or neighboring drainage culverts. Bagging and properly disposing of pet feces is imperative to maintain a healthy ecosystem.

3.5 Specific Conductivity

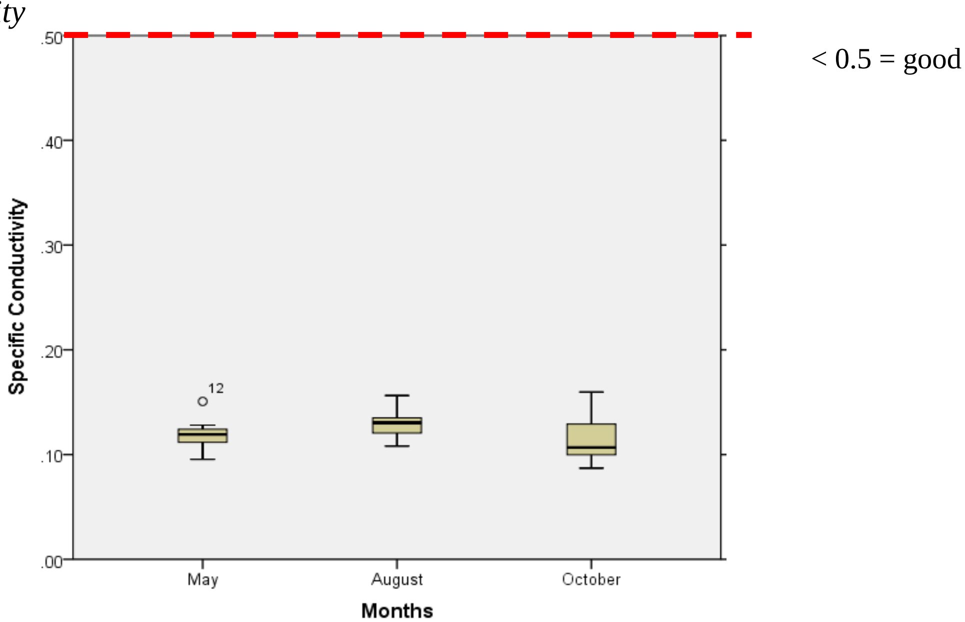


Figure 6: Box plots of average specific conductivity measurements for all locations at one foot water depth. Data collected from 2004 – 2016.

Specific conductivity (SC) measures the ability of water to conduct an electrical current, which can be used to approximate some dissolved solids (Girard 2014). Deionized water (pure water) does not conduct electricity, however when ions (positive/negative charged atoms or molecules) are introduced in the sample, electricity can be conducted. This measurement is influenced by the number of positive or negative ions in the water (Girard 2014). Significant increases may indicate a point of discharging pollution, often from nitrates, phosphates, or sodium chloride (Behar, 1997). Our testing shows relatively condensed boxplots which potentially indicates little variation of measurements within a season and across seasons. Ions are essential to the growth and gas exchange of aquatic life forms but if ion levels are too high, gas (oxygen) exchange can be inhibited (Girard 2014). Normal levels of specific conductivity for lake waters fall within 0.05 and 1 mS/cm (Behar, 1997). All of our readings from the past 12 years fall within this range.

3.6 pH

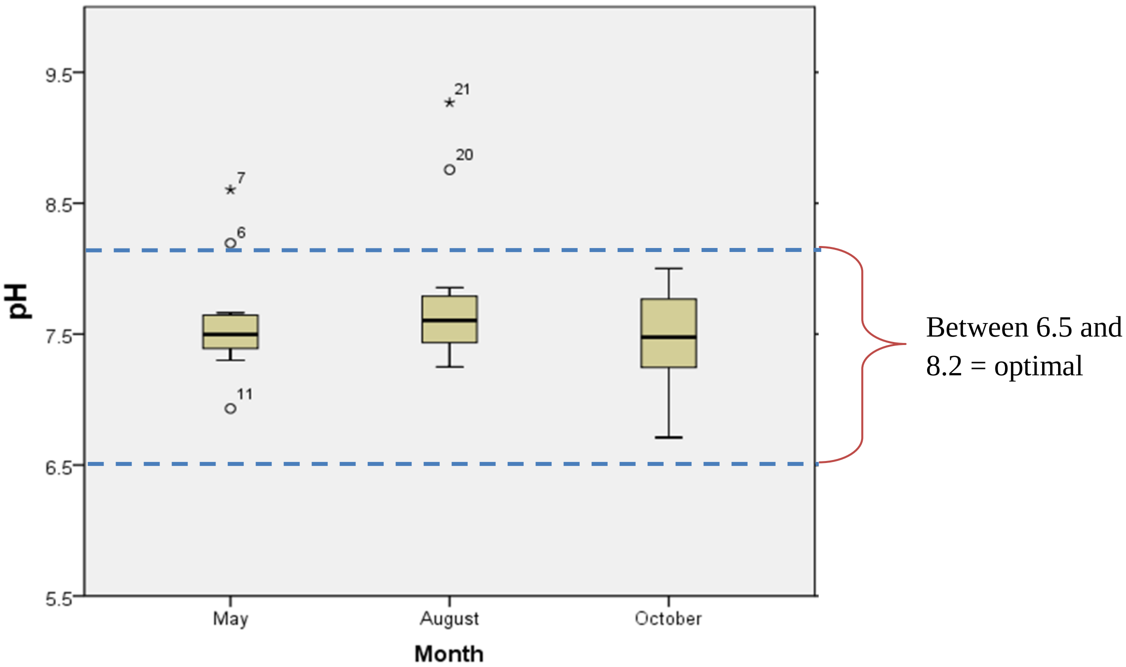


Figure 7: Box plots of average pH (acidity) measurements for all locations at one foot water depth. Data collected from 2004 – 2016.

pH measures the acidity of a solution, specifically the hydrogen ion (H^+) concentration. Acidic solutions are less than pH 7, basic solutions are greater than pH 7, and neutral is pH 7. Maintaining a certain pH is essential for aquatic life and most fish do best in neutral waters of pH 7 (Behar, 1997). A lake's pH affects the solubility (amount of a substance dissolved in water) and biological availability (amount of a substance utilized by aquatic life) of nutrients such as phosphorus, nitrogen, carbon, calcium; and metals such as copper and iron (Nelson *et al.*, 2011). The most significant source of natural lake acidity is the dissolving of atmospheric carbon dioxide (CO_2) into water (Girard 2014; Behar, 1997). Here CO_2 dissolves into water and forms carbonic acid (a weak acid), altering the pH to be more acidic. Lake water buffers (or resists the change in pH) with the bicarbonate ion (HCO_3^-) which can accept an H^+, when an acid (such as carbonic acid) is introduced to the water, or release an H^+ when a base (such as limestone or other carbonates) are added to solutions (Manahan, 2010).

Lake pH can fluctuate slightly from morning to night by the daily occurrence of plant photosynthesis. During aquatic plant photosynthesis, dissolved carbon dioxide is removed from the water, creating slightly basic conditions. During respiration CO_2 is released into the water forming carbonic acid and slightly acidic conditions (Girard 2014). Bedrock geology, such as the dissolution of limestone or weathering of granitic minerals, can also be a factor in a lake's pH (Nelson *et al.*, 2011). Acid rain, leaching of nitrogen fertilizers, and acid mine drainage can cause waters to become more acidic, while leaching of phosphate fertilizers, household detergents, and fireplace ash can cause water to become more basic (Girard 2014). The "bulk" of the pH results shows that our lake stays well within the optimal pH range for aquatic life, most of the time.

3.7 Turbidity

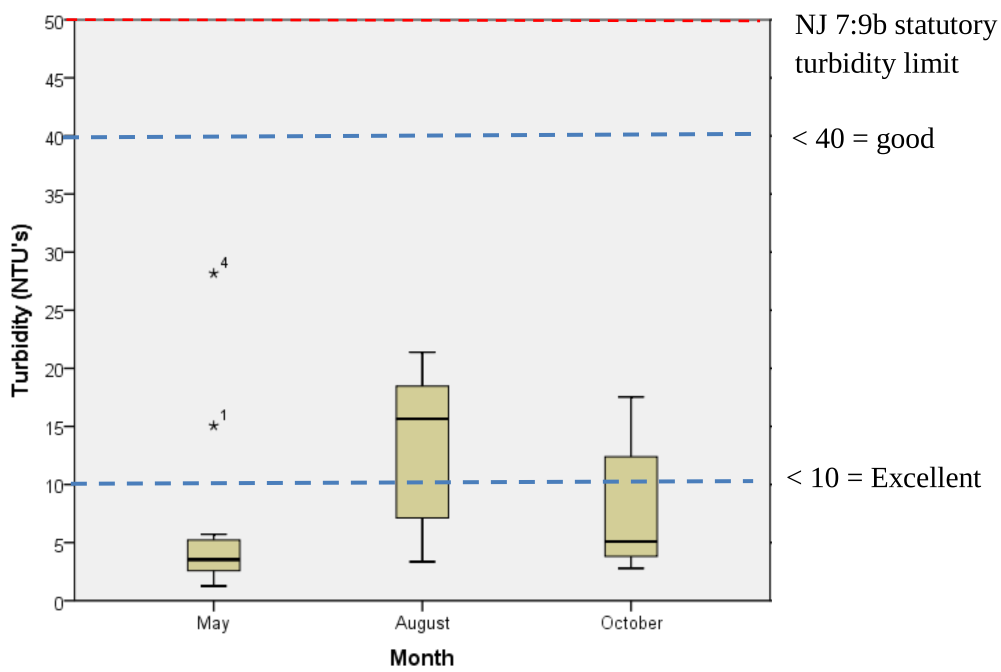


Figure 8: Box plots of average turbidity of the lake water for all locations at one foot water depth. Data collected from 2004 – 2016.

Turbidity measures the clarity of a water body (Perlman, 2016). It is measured in nephelometric turbidity units (NTU) which looks at the ability of light to pass through a water sample. The more time it takes for light to pass, the cloudier the water sample is. Turbidity is influenced by the amount of clay, silt, finely grained inorganic and organic matter, algae, and other microscopic organisms suspended in the water column (Perlman, 2016). High turbidity levels can affect light penetration through the water column, plant and fish productivity, and habitat quality. High turbidity values are often linked to increased sedimentation into the lake, which can occur naturally due to erosion of land or from intended beach nourishment (dumping sand along a shoreline to create an artificial beach). Increased sedimentation and siltation can result in harm to habitats for fish and other aquatic life, basically "choking" aquatic life. Suspended or deposited particles also provide places for metal ions or bacteria to attach (Perlman, 2016).

Part of the increase in the mean turbidity levels in the summer months (August in figure 8) can be attributed to greater recreation from boating. Though turbidity in the summer seems to be significantly greater than in May, the levels are well within reasonable ranges. NJ 7:9b-1.14, which explains surface water quality requirements, stipulates that turbidity should not exceed 50 NTU's at any time and the monthly average should not be greater than 15 NTU's. Because of the nature of our sampling (only one data point per month per year) we cannot conclude that the 30 day average for August exceeded 15 NTU's for any year and we expect to see great variation in the graphs. Weather conditions and lake level can affect turbidity, which may help explain the greater variation in data for August and October than for May. Readings conducted over a weekend during the summer may also indicate higher results than readings taken during the week due to more boater activity occurring on weekends.

4. Conclusion

In all, the condition of Lake Owassa seems to be well within “normal” conditions to support healthy fish populations and a robust aquatic ecosystem. Continued monitoring is essential to ensure that we maintain water quality at current conditions. If repeated measures indicate a problem, it is easier to identify and mitigate the potential problem in the early stages than waiting. If there comes a time where subsequent readings significantly vary from the baseline results presented throughout the report, a higher frequency of testing may be needed. The best initiative to maintain high water quality is to urge all homeowners on the lake to limit source of pollution from their property into the lake and to limit erosion (sedimentation) into the lake from their property. The easiest and most effective way to mitigate these issues is through limiting the use of fertilizers on lawns, the use of riparian buffers, and incorporating native plants near the shoreline.

Creating a plant/rock buffer of just a few feet between a lawn and the lake can easily help limit fertilizer, sediment, and organic matter (lawn clippings) from entering the lake. Converting artificial sand beachheads to stone/gravel beachheads would reduce the rate of sedimentation into and suspended solids within the lake. Since gravel is larger than sand, it erodes into the lake much slower and requires more energy to be eroded (or “moved”) via natural processes (wind, rain, and wave action). Reducing and removing artificial sand beachheads also reduces the ability for harmful bacteria and heavy metals to attach to such sediment. If a beachhead is needed on the shoreline the use of stone (instead of sand) helps mimic the natural habitat for organisms around the shoreline, creates spawning habitat for some fish species, and requires less maintenance overall.

Native plants around the shoreline help reduce erosion and nutrient leaching into the lake, and at the same time beautifies the shoreline. Plants such as cattails (*Typha latifolia*), sweet-pepper bush (*Clethra alnifolia*) and winterberry (*Ilex verticillata*) act as phytoremediators (which extract metals/nutrients from the soil before entering the lake), reduce sedimentation into the lake, and provide habitat/food for land based organisms, especially song birds (Leopold, 2005). Other native emergent aquatic plants such as cardinal flower (*Lobilia cardinalis*), pickerelweed (*Pontederia cordata*), and duck potato (*Sagittaria latifolia*) can also help reduce erosion of land into the lake and provide beneficial habitat for aquatic amphibians and fish (Leopold, 2005). All of these plants mentioned currently exist in many areas around the lake.

Lake Owassa is truly a “little piece of heaven” and continuing efforts by all homeowners to keep our waters “clean” benefit everyone that uses the lake for recreation or visual serenity. Everyone shares the lake; so any point of pollution can have a lake wide effect and can contribute to further pollution through the Paulins Kill watershed. It is in the best interest for everyone to conserve, maintain, and monitor this natural resource for the present time and for generations in the future.

5. Acknowledgements:

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