Nantucket Island Ponds and Their Water Quality

Chapter 3

Tom Nevers Pond - 2014

3.0 Introduction

This chapter presents a summary and discussion of the physical, chemical and biological data collected from Tom Nevers Pond by Nantucket Land Council staff during 2014.

3.1 Results

Tom Nevers Pond was sampled twice during 2014, on September 2nd and again on September 24th. The maximum water depth in the pond was 3.6 feet (43 inches) on September 2nd at the sampling location in the approximate center of the pond; the sampling depth on September 24th was 3.2 feet (38 inches). Following the collection of temperature and dissolved oxygen profile data on both dates, integrate samples were collected from the surface down to 3 feet of depth for the chemistry and phytoplankton samples. There were no other water samples collected from the pond on either sampling date. Observations recorded while on the pond included the following: there was an absence of any visible submerged attached aquatic vegetation and the bottom material was a dark organic material.

3.1.1 Physical characteristics

General. Tom Nevers Pond is an irregular shaped body of water with its axis oriented in a northwest-southeast direction (Figure 3.1). The surface area of the pond is about 10 acres. A single stream inlet, Phillip's Run, flows into the pond at the north end. The pond outlet at the south end drains toward the Low Beach area and the Atlantic Ocean (Figure 3-1).

Figure 3.1 Aerial view of Tom Nevers Pond (from *Google*™ earth)

Temperature. Temperature profile data were collected on both 2014 sampling excursions. Due to the pond's shallow depth, the temperature from the surface to the bottom essentially was isothermal (the same temperature) on both dates. The average temperature of the pond was 24.7°C on September 2nd and 19.1°C on September 24th.

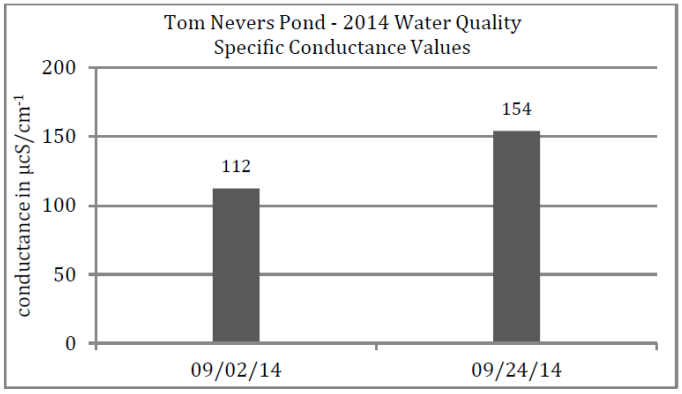
Transparency. The Secchi depth transparency measured at Tom Nevers Pond on both September sampling dates was 1.0 foot which is very shallow and indicates low light penetration from the pond surface down through the water column. Water color on both sampling dates was listed as 'brown' which is the color of small ponds such as Tom Nevers when there is a strong influence of bog-like vegetation growing around the

perimeter of the pond and also draining into the pond from areas within the watershed. In these situations, water color and transparency are strongly influenced by organic humic and fulvic acids leaching into the water from surrounding areas of vegetation.

3.1.2 Chemical characteristics

Specific conductance. Figure 3.2 presents the conductance values measured at Tom Nevers Pond during September 2014; the individual values measured were 112 and 154 $\mu S \cdot cm^{-1}$ on September 2nd and September 24th, respectively.

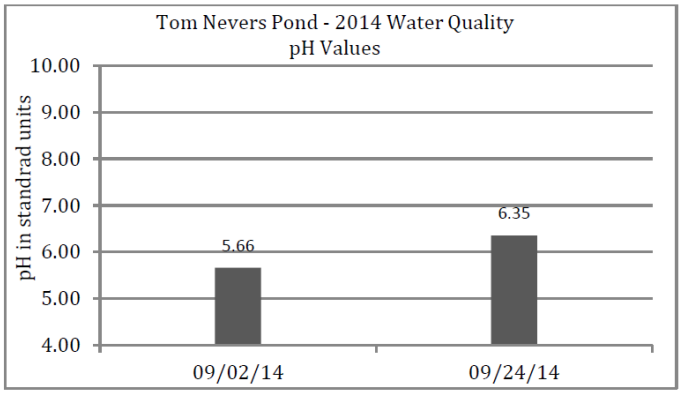
Figure 3.2 Specific conductance measured in Tom Nevers Pond, September 2014.



These values measured at Tom Nevers Pond are within the range of specific conductance values expected from ponds considered to be fresh water.

pH. The pH of Tom Nevers Pond was acidic (5.66 s.u.) on September 2nd and somewhat higher (6.35 s.u.) on September 24th (Figure 3.3). Both values reported from the pond, however, were less than pH 7.00 s.u., which is considered 'neutral' along the pH scale from 0.0-14.0 s.u.

Figure 3.3 pH measured in Tom Nevers Pond, September 2014.

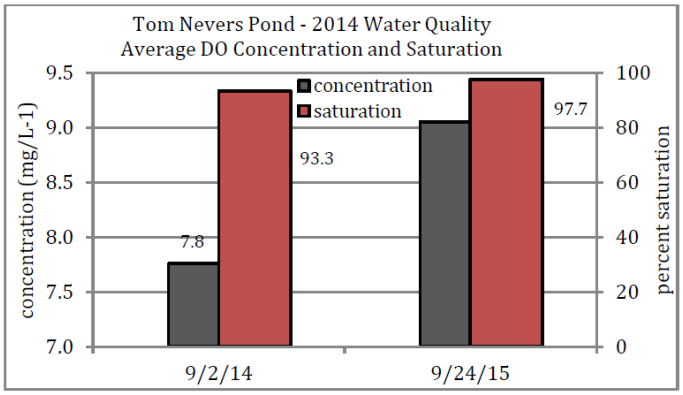


The pH documented in Tom Nevers Pond during early September 2014 is very similar to the year-round conditions that occur in small lakes and ponds in the Adirondack Region of New York State where leaching of humic and fulvic acids from the surrounding shorelines and watersheds imparts a dark brown coloration to the water and acid conditions. Based upon the very limited water clarity (low transparency) observed during

2014, most of the biological productivity (from phytoplankton) was occurring in the upper region of the pond where sufficient light is received to support photosynthesis.

Dissolved oxygen concentration-percent saturation. The oxygen concentration and saturation patterns in Tom Nevers Pond during September 2014 are shown in Figure 3.4.

Figure 3.4 Average dissolved oxygen concentration/saturation in Tom Nevers Pond, September 2014.

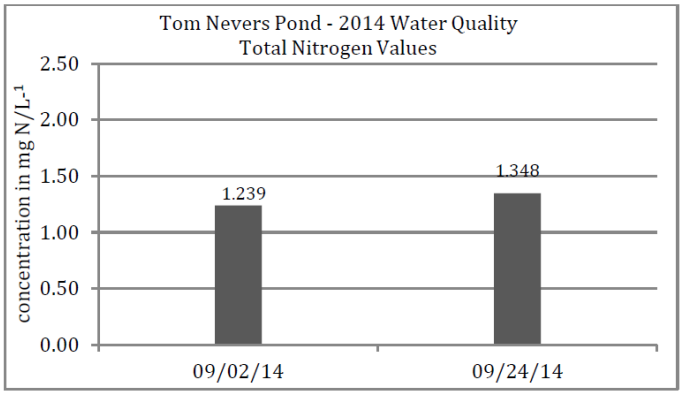


The values shown are average values for the individual readings taken from the surface down to 3 feet of depth since there was hardly any variation in the readings on either sampling date. There is nothing noteworthy about these oxygen concentration and saturation values measured in Tom Nevers Pond.

3.1.3 Plant Nutrients

Nitrogen. The September concentrations of **nitrate-nitrogen** in the pond were below the limit of detection on both sampling dates which is not unusual since this form of nitrogen is readily taken up by phytoplankton in the water column when it is available. And although there were measureable levels of **ammonia-nitrogen** on both September sampling dates, the levels were low (September 2nd=0.024 mg $N \cdot L^{-1}$; September 24th=0.024 mg $N \cdot L^{-1}$), which is not unusual since this form of nitrogen is readily taken up by phytoplankton.

Figure 3.5 Total nitrogen concentrations measured in Tom Nevers Pond, September 2014.



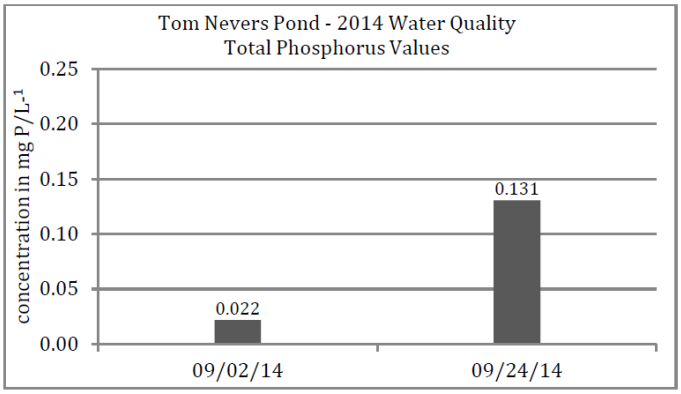
The **total nitrogen** (TN) measured in Tom Nevers Pond during September 2014 was similar on both sampling dates and is shown in Figure 3.5.

Based upon the low concentrations of **nitrate-** and **ammonia-nitrogen** measured during September 2014, essentially all of the **total nitrogen** measured in Tom Nevers Pond is contained in organic material in the form of phytoplankton and seston (other organisms and non-living particulate matter).

In addition, the **TN** concentrations measured in Tom Nevers Pond are elevated when compared with TN values measured in other Nantucket Island ponds. For example, the September 2012 **TN** value in *Hummock Pond* averaged 0.60 mg N·L^{-1} (Sutherland, 2013), while the September 2013 **TN** value in *Head of Hummock Pond* averaged 1.16 mg N·L^{-1} (Sutherland and MacKinnon, 2014).

Phosphorus. The **total phosphorus** (**TP**) concentrations measured in Tom Nevers Pond during September 2014 were 0.022 and 0.131 mg P·L^{-1} on the 2nd and 24th, respectively, and are shown in Figure 3.6.

Figure 3.6 Total phosphorus concentrations measured in Tom Nevers Pond, September 2014.



While these **TP** levels are not particularly high, it is interesting how the concentration on September 24th increased 6-fold over the concentration on September 2nd. In comparison to Tom Nevers Pond, average **TP** levels were 0.085 mg P·L^{-1} in *Hummock Pond* during September 2012 and 0.252 mg P·L^{-1} in *Head of Hummock Pond* during 2013.

3.1.4 Phytoplankton

Description of the assemblage. There were 42 taxa identified in the September 2014 phytoplankton samples collected from Tom Nevers Pond and all of the major algal groups were represented (Table 3.1).

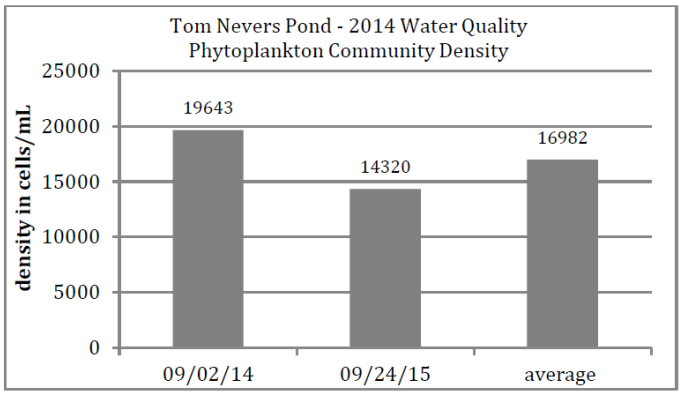
Table 3.1 Major groups and taxa of phytoplankton identified in Tom Nevers Pond, September 2014.

Cyanophytes	**Chlorophytes**	**Chrysophytes (Bacillariophyceae)**
Chroococcus dispersus	*Monoraphidium contortum*	*Gyrosigma* sp.
Gomphosphaeria lacustris compacta	*Oocystis borgei*	*Navicula* spp.
Merismopedia glauca	*O. pusilla*	*Nitzschia* sp.
Chloromonadophytes	*Pediastrum duplex*	*Pinnularia* sp.
Gonyostomum semen	*Pyramimonas tetrarhyncus*	*Rhoicosphenia curvata*
Chlorophytes	*S. bijuga*	*Synedra acus*
A. convolutus	*S. quadricauda*	*S. fulgens*
Chlamydomonas sp.	*Spirulina* sp.	*S. ulna*
Closteriopsis longissima	*Staurastrum natator var. crassum*	**Chrysophytes (Chrysophyceae)**
Closterium sp.	**Chrysophytes (Bacillariophyceae)**	*D. divergens*
Coelastrum cambricum	*Achnanthes* sp.	*Mallomonas* sp.
Crucigenia quadrata	*Asterionella formosa*	**Euglenophytes**
Eudorina elegans	*Aulacoseria granulata*	*Phacus* sp.
Golenkinia radiata	*Cocconeis* sp.	*Trachelomonas* sp.
Kirchneriella lunaris	*Cyclotella* sp.	**Pyrrhophytes (Cryptophyceae)**
Micrasterias radiata	*Gomphonema* spp.	*Cryptomonas ovata*

There were 34 taxa identified in the pond's phytoplankton community on September 2nd and 16 taxa on September 24th; community richness for the 2 sampling periods was calculated to be 30.0 (±5.7) taxa.

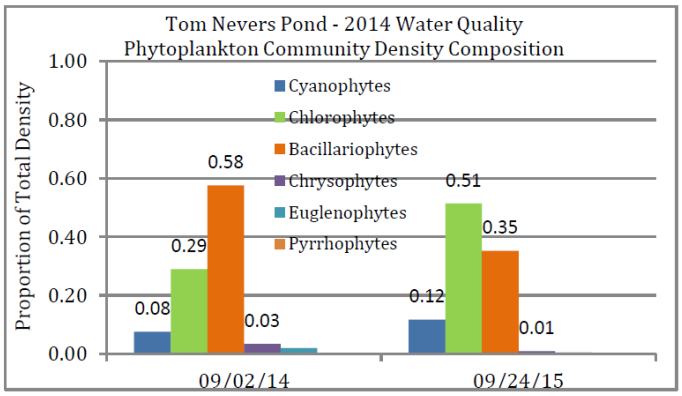
Density. The phytoplankton community density was 19,643 cells·mL^{-1} on September 2nd and 14,320 cells·mL^{-1} on September 24th, and averaged 16,982 cells·mL^{-1} for both sampling dates (Figure 3.7).

Figure 3.7 Phytoplankton community density in Tom Nevers Pond, September 2014.



The September 2nd phytoplankton assemblage in Tom Nevers Pond included primarily the Bacillariophytes (diatoms) with 58 percent of the community density and Chlorophytes (green algae) with 29 percent of the community density (Figure 3.8).

Figure 3.8 Density composition of the phytoplankton community in Tom Nevers Pond, September 2014.



The relative importance of these two major groups was reversed on September 24th, with the Chlorophytes comprising 51 percent and the Bacillariophytes representing 35 percent of the community density.

Given the shallow depth of Tom Nevers Pond and the greatly reduced water clarity caused by the 'brown stain' of the water color, the phytoplankton community cell density measured in Tom Nevers Pond during 2014 is considered normal for a pond with these characteristics.

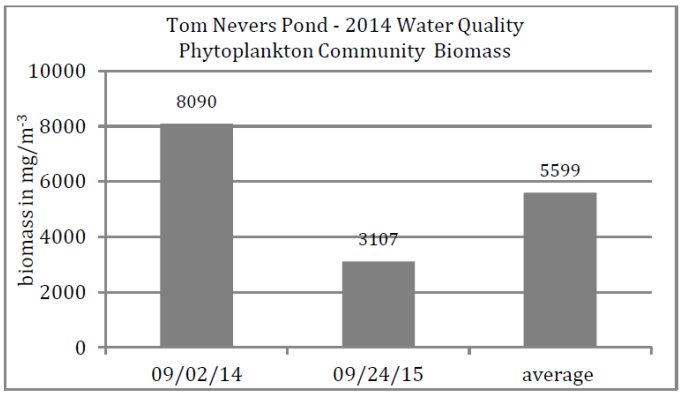
Biomass. Cell biovolume also was used to evaluate phytoplankton taxon biomass, or productivity, since cell counts and conversion into density does not account for the significant size difference among the various phytoplankton taxa that occur in the pond.

The misleading nature of density as a reliable community descriptor is evident when reviewing cell biomass values and noting the substantial difference between the size of, for example, the green algae *Crucigenia*

quadrata cells (93.3 mg·m^{-3}) and *Closterium* sp. cells (4000.0 mg·m^{-3}). These differences in relative biomass (the size of individual cells) can explain how small numbers of cells with an exceptionally large biovolume can make a particular taxon a dominant member in the phytoplankton community.

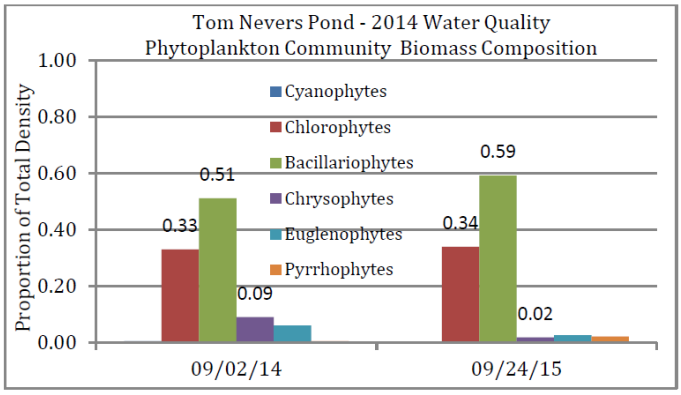
The phytoplankton community biomass was 8,090 mg·m^{-3} on September 2nd and 3,107 mg·m^{-3} on September 24th, and averaged 5,599 mg·m^{-3} for both sampling dates (Figure 3.9).

Figure 3.9 Phytoplankton community biomass in Tom Nevers Pond, September 2014.



With regard to biomass, the September 2nd phytoplankton assemblage in Tom Nevers Pond included primarily the Bacillariophytes (diatoms) with 51 percent of the community density and the Chlorophytes (green algae) with 33 percent of the community (Figure 3.10).

Figure 3.10 Biomass composition of the phytoplankton community in Tom Nevers Pond, September 2014.



The relative importance of these two major groups essentially remained the same on September 24th, with the Bacillariophytes comprising 59 percent and the Chlorophytes representing 35 percent of the total community biomass.

Dominance. A ranking of phytoplankton taxa dominance in Tom Nevers Pond on both of the September sampling dates is summarized in Table 3.3. Taxa are considered dominant in the community if they comprise at least 5 percent of the total community biomass. There were 7 dominant taxa in the phytoplankton community on September 2nd and 6 dominant taxa in the community on September 24th (Table 3.2). As discussed above, the diatoms and the green algae comprised the major portion of the phytoplankton community biomass with the diatoms averaging about 50 percent of the total on both sampling dates.

Table 3.2 Rank of phytoplankton taxa dominance, using biomass, in Tom Nevers Pond, September 2014.

Sampling Date	Taxon (Major Group)	Biomass Rank	% of Total Biomass
9/2/14	*Synedra acus* (Bacillariophyte)	1	30
	Cyclotella sp. (Bacillariophyte)	2	12
	Closterium sp. (Chlorophytes)	3	10
	Staurastrum natator var. *crassum* (Chlorophyte)	4	9
	Mallomonas sp. (Chrysophyte)	5	9
	Asterionella formosa (Bacillariophyte)	6	7
	Trachelomonas sp. (Euglenophyte)	7	5
9/24/14	*Cyclotella* sp. (Bacillariophyte)	1	22
	Synedra acus (Bacillariophyte)	2	21
	Asterionella formosa (Bacillariophyte)	3	13
	Kirchneriella lunaris (Chlorophyte)	4	11
	Closterium sp. (Chlorophytes)	5	8
	Staurastrum natator var. *crassum* (Chlorophyte)	6	6

There were a total of 8 different taxa (3 diatoms, 4 greens, and 1 euglenoid) that comprised at least 80 percent of the total community biomass on both September sampling dates (Table 3.2).

Diversity. Phytoplankton diversity in Tom Nevers Pond was measured using the Shannon-Wiener function[1] which calculates diversity, **[H]**, using number of taxa and the portion of individuals among the taxa on each sampling date. An increase in either factor will increase the value of the diversity index. Calculated values that approach 1.0 indicate conditions of maximum diversity in the distribution of the population.

The diversity calculated for Tom Nevers Pond during September 2014 was 0.989 on September 2nd and 0.858 on September 24th, indicating that the portion of individuals was distributed quite evenly throughout the community and that dominance did not reside with a single taxa or only a few taxa.

Cyanophytes. As a major phytoplankton group, Cyanophytes were identified in both September samples collected from Tom Nevers Pond; however, only 3 taxa were identified (*Gomphosphaeria lacustris compacta*, *Chroococcus dispersus*, *Merismopedia glauca*), and none of these taxa are known to produce algal toxins.

Chlorophyll *a*. The chlorophyll ***a*** concentrations measured in Tom Nevers Pond were 6.23 µg·L^{-1} on September 2nd and 2.12 µg·L^{-1} on September 24th, indicating a low level of algal productivity in the pond on both occasions.

In comparison to Tom Nevers Pond, chlorophyll ***a*** levels measured in other Nantucket Island ponds during recent years include 6.98 µg·L^{-1} in *Hummock Pond* during September 2012 and an average of 143.93 µg·L^{-1} in *Head of Hummock Pond* during September 2013.

3.1.5 Trophic Status

'Trophic' means nutrition or growth. The trophic state of ponds refers to biological production, plant and animal, that occurs in the pond and the level of production is determined by several factors but primarily phosphorus supply to the pond and by the volume and residence time of water in the pond. Different indicators are used to describe trophic state such as phosphorus, water clarity, chlorophyll, rooted plant growth and dissolved oxygen.

[1] $H = -\sum_{i=1}^{s} (p_i)\,(log_2)(p_i)$, in units of information per individual per unit volume or area, where p_i is the proportion of the total samples belonging to the *i*th species and S is the number of species.

The reader is referred to Chapter 1 for a more thorough explanation of trophic status and the process of calculating this important indicator of lake and pond productivity.

Sufficient water quality data were collected from Tom Nevers Pond during 2014 to calculate the Carlson Trophic State Index (TSI) using all three variables (chlorophyll ***a***, total phosphorus, Secchi depth transparency). Average values were calculated for each variable for the September sampling dates. The average values then were substituted into the appropriate equations (Chapter 1) to calculate the TSI values for each variable.

The stepwise calculation and results of the analysis are as follows:

Chlorophyll *a*
Average mid-summer chlorophyll *a* = 4.18 µg/L^{-1}
Chlorophyll *a* TSI = 9.81*[ln (4.18)] + 30.6
TSI = (9.81)(1.43) + 30.6
TSI = 44.6

Total phosphorus
Average mid-summer total phosphorus = 75.98 µg/L^{-1}
Total phosphorus TSI = 14.42*[ln (75.98)] + 4.15
TSI = (14.42)(4.33) + 4.15
TSI = 66.6

Secchi depth
Average mid-summer Secchi depth = 0.30 m
Secchi TSI = 60 – [14.41*[ln (0.30)]
TSI = 60 – (14.41)(-1.20)
TSI = 77.3

The TSI of 44.6 calculated for chlorophyll ***a*** was just above the threshold of 40 for the oligotrophic-to-mesotrophic region (see Table 3.3 below), while the TSI calculated for total phosphorus (66.6) was at the upper region of the eutrophic region and just below hyper-eutrophic conditions. The average 2014 Secchi depth (0.3 meters) resulted in a calculated TSI value of 77.3 which is within the hyper-eutrophic region.

Table 3.3 Relationships among Trophic Index, chlorophyll *a*, phosphorus, Secchi depth and Trophic Class.

Trophic Index	Chlorophyll (µg L^{-1})	TP (µg L^{-1})	Secchi Depth (m)	Trophic Class
< 30 - 40	0.0 – 2.6	0.0 - 12	> 8 - 4	Oligotrophic
40 - 50	2.6 – 7.3	12 - 24	4 - 2	Mesotrophic
50 - 70	7.3 - 56	24 - 96	2 – 0.5	Eutrophic
70 – 100+	56 – 155+	96 – 384+	0.5 - <0.25	Hyper-eutrophic

Taken at face value, the TSI values calculated for Tom Nevers Pond portray water quality during September 2014 that ranges between mesotrophic and hyper-eutrophic conditions, depending upon which independent water quality variable is used as a reference.

There are certain limitations that should be considered, however, when interpreting the 2014 TSI numbers calculated for Tom Nevers Pond. For example, the extremely low transparency measured at the pond (0.3 m on both sampling dates) was the result of organic material (humic and fulvic acids) in the water and not the result of algal productivity which is the basis for using Secchi depth to calculate a TSI value. In addition, the average 2014 **TP** concentration (75.98 µg/L^{-1}) used in the calculation was heavily biased by the very high September reading (130.3 µg/L^{-1}) which could have resulted from a wind event, mixing water from the pond surface to the bottom and re-suspending nutrient material contained in the sediments.

Taking all of the above into consideration, it seems most appropriate to use the TSI value calculated for chlorophyll a (44.6) as the most accurate indicator of the pond's trophic state during 2014.

3.2 Summary

Tom Nevers Pond can be characterized as a low-to-moderate productivity dystrophic body of water that is strongly influenced by drainage from surrounding areas that contain bog-like vegetation and give the pond water its characteristic 'stained' appearance. There are many small lakes and ponds in the Adirondack Mountain region of New York State that have similar water quality characteristics. Aside from the limited transparency of the water, the other primary characteristic of dystrophic waters includes low pH which also is from the influence of the surrounding vegetation. Based upon the limited depth of light penetration in the water column, only certain taxa of phytoplankton can adapt to the restrictive conditions in these waters and the taxa that are present must be situated just below the water surface to receive the optimum amount of incident radiation in order to successfully photosynthesize.

3.3 Literature Cited

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