

**Dudley Pond Water Quality Sampling Program**  
**March 29, 2018 Report**  
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This document is part of an ongoing Surface Water Quality Committee (SWQC) water quality sampling program initiated for Dudley Pond. The objectives of the Program are to gather Dudley Pond water quality data that will be used to:

- Compare to similar water quality data gathered in the past at Dudley Pond.
- Track the trophic index (health) of Dudley Pond during the spring, summer and fall of each year.

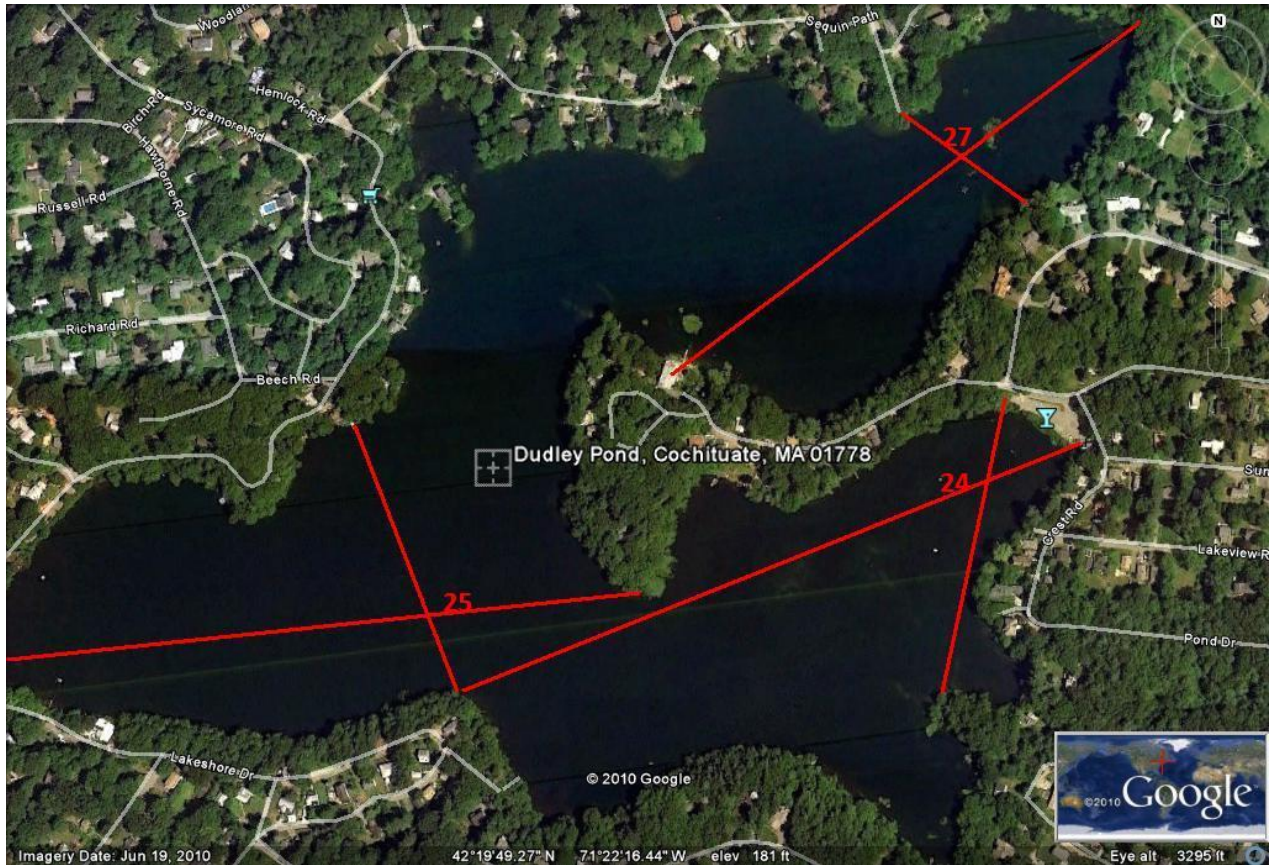
**Summary**

- On March 29, 2018 water quality data was gathered at three sample points and at three depths at each sample point.
- Water quality parameters such as, pH, oxidation – reduction potential (ORP), dissolved oxygen (DO), dissolved oxygen % saturation and temperature were measured at three depths at each of the three sample points by SWQC members using a YSI Multimeter. Water and Secchi depths were measured at each of the three sample points.
- Samples were gathered by SWQC members and analyzed by Nashoba Analytical LLC.
- Based on somewhat uniform parameter values top to bottom, the Pond was mixed and therefore it is assumed that the sampling occurred near the time of the spring turnover (water column mixing).
- The Secchi depth, which is a measure of visibility in the water column, was determined to be nineteen feet. This unusually good Secchi depth was facilitated by flat surface water and very little suspended solids (algae, fine soil particles) and tannins.
- Chlorophyll *a* concentrations, a measure of the algae concentration, was the lowest that has been found in the past eight years and is thought to be due to the low water temperature and a stretch of cloudy weather preceding March 29, 2018.
- As Dudley Pond is primarily used for recreational purposes a Trophic State Index (TSI) less than 50 is tolerable and less than 40 is very good. The TSI on March 29, 2018 for the three sample points ranged from approximately 22 to 36 indicating that the Dudley Pond TSI was in the oligotrophic, which is very good. This is the best TSI for the past eight years. Hopefully the low TSIs for spring 2017 and 2018 represents a positive trend in water quality for the Pond.

Date	TSI	Chlorophyll a	Secchi Depth	Total Phosphorus
April 4, 2011	31 - 49	2.72 – 3.99 ppb	12' 1"	10 – 40 ppb
March 18, 2012	39 - 47	1.98 – 4.62 ppb	12' 6"	10 – 20 ppb
March 24, 2013	35 - 43	1.39 – 4.46 ppb	14' 4"	Non-detect
April 2, 2014	39 - 54	2.24 – 5 ppb	9' 2"	10 – 20 ppb
April 21, 2015	41 - 46	0.74 – 4.53 ppb	11' 6"	Non-detect
March 23, 2016	35 - 40	0.89 – 5.13 ppb	15'	Non-detect
March 26, 2017	21 - 41	0.59 – 1.1 ppb	12'	0 – 10 ppb
March 29, 2018	22 - 36	ND – 1 ppb	19'	ND

## Background

Historically Dudley Pond has been sampled most frequently at the “deep hole” (Sample Point 25) on Dudley Pond. In order to have data sets that are comparable to historical data, samples were gathered at locations 24, 25 and 27 as indicated in Figure 1. Two of these sample locations correspond to the sample locations used in the Larkin (1978) and IEP (1983) reports. Line-of-site intersections were used to locate sampling points.



**Figure 1 – Dudley Pond Sampling Points**

Sample Point 24 is located at the intersection of the lines-of-sight between Rocky Point – Bayfield Rd and Williams Point – “The Chat”. Sample Point 25 is located at the intersection of the lines-of-site between Mansion Beach –Southern point of the Dudley Rd. peninsula and Lowery’s dock – Williams Point. Sample Point 27 is located at the intersection of the lines-of-site between the Dudley Pond outlet – 107 Dudley Rd. and the foot of Maiden Lane – the 20” outfall adjacent 27 Bayfield Rd.

## Methods

Samples were gathered at depths of one foot (Top), at mid depth (Middle) and one foot off the bottom (Bottom) at Sample Points 24, 25 and 27. A water sampler as shown at <http://www.aquaticceco.com/subcategories/2912/Water-Sampler?green=12823266105> with a sample

volume of 1.0 – 1.5 liters was used to gather samples at various depths. Samples and data were/are to be gathered during March, August and November each year, in an attempt to understand seasonal variations.

Sample Handling - Multiple sample catches at each depth were composited from the sampler into a one-gallon container in order to get the volume of sample needed for the various analyses. The one-gallon container was mixed and aliquots were poured into sample bottles provided by the analytical laboratory. The labels on the sample containers were filled out. One of the sample bottles contained sulfuric acid necessary to “fix” (preserve) the sample for total phosphorus (TP) analysis. All of the samples were stored in a cooler containing ice and delivered with chain of custody documents to the analytical laboratory the day after the samples were gathered.

Sample Analyses - A SWQC owned YSI 556 Multimeter was used to measure the following parameters at the same time that the samples are collected.

Date  
Time  
Weather  
Barometric Pressure  
Location  
Depth  
pH  
ORP  
Dissolved Oxygen  
Dissolved Oxygen % Saturation  
Temperature  
Secchi Depth (<http://water.epa.gov/type/rs/monitoring/155.cfm>)

Nashoba Analytical, LLC was used to perform analyses of samples from Sample Points 24, 25 and 27. Analyses were performed by Nashoba Analytical, LLC for the following parameters.

Total Phosphorus, ppm (as P) (Soluble + Insoluble) (ppm = mg/l)  
Orthophosphate, ppm (as P) (Soluble)  
Ammonia, ppm (as N)  
Nitrate/Nitrite, ppm (as N)  
Total Kjeldahl Nitrogen (TKN), ppm (as N)  
Chlorophyll *a*, ug/l (ppb)

Carlson Trophic State Index – TP concentrations, Chlorophyll *a* and Secchi depths were used to plot the Carlson Trophic State Index (TSI) for the three sample points in Dudley Pond. Since the Secchi Depths for Sample Points 24 and 27 were greater than the depth of the water, it was assumed that the Secchi Depths for all of the sample points were the same as Sample Point 25. In order to obtain a mean TP concentration for each sample point the three Total Phosphorus concentrations for the sample point were added and divided by three. In order to obtain a mean Chlorophyll *a* concentrations for each sample location, the mean chlorophyll *a* concentration at each sample point was calculated using the sum of the chlorophyll *a* concentrations at the three depths divided by three. (see [http://www.aslo.org/lo/toc/vol\\_22/issue\\_2/0361.pdf](http://www.aslo.org/lo/toc/vol_22/issue_2/0361.pdf) for information re Carlson Trophic State index)

**Results**

The results of the March 23, 2016 sampling are shown in Figure 2. The analytical data was plotted to determine the Trophic State Index (TSI) and is shown in Figure 3.

Figure 2 – March 29, 2018 Dudley Pond Water Quality Data

<b>Date / Time:</b>	3/29/18	11:26
<b>Samplers:</b>	Toni	
<b>Weather:</b>	PC, 54 F, Variable breeze	
<b>Barometric Pressure:</b>	30.08 mmHg	



	SP 24-top	SP24-mid	SP24-bot	SP 25-top	SP25-mid	SP25-bot	SP27-top	SP27-mid	SP27-bot
<b>Depth (ft)</b>	1'	3'	6'	1'	12'	22'	1'	3'	6'
<b>pH</b>	6.34	5.88	5.65	7.21	6.23	5.66	7.31	7.31	6.74
<b>ORP (mv)</b>	279.3	307.2	322.5	258.6	318.2	358.8	256.9	256.6	296.4
<b>DO (mg/l)</b>	14.9	14.59	14.32	13.26	14.22	14.12	15.15	14.91	14.49
<b>DO % Saturation</b>	124.5	122	120.9	117.7	114.7	111.6	127.5	124	120.4
<b>Temp C</b>	7.57	7.4	7.31	7.14	5.89	5.2	7.73	7.36	7.31
<b>Secchi Depth</b>	6.5'			19'			7'		SS in sample

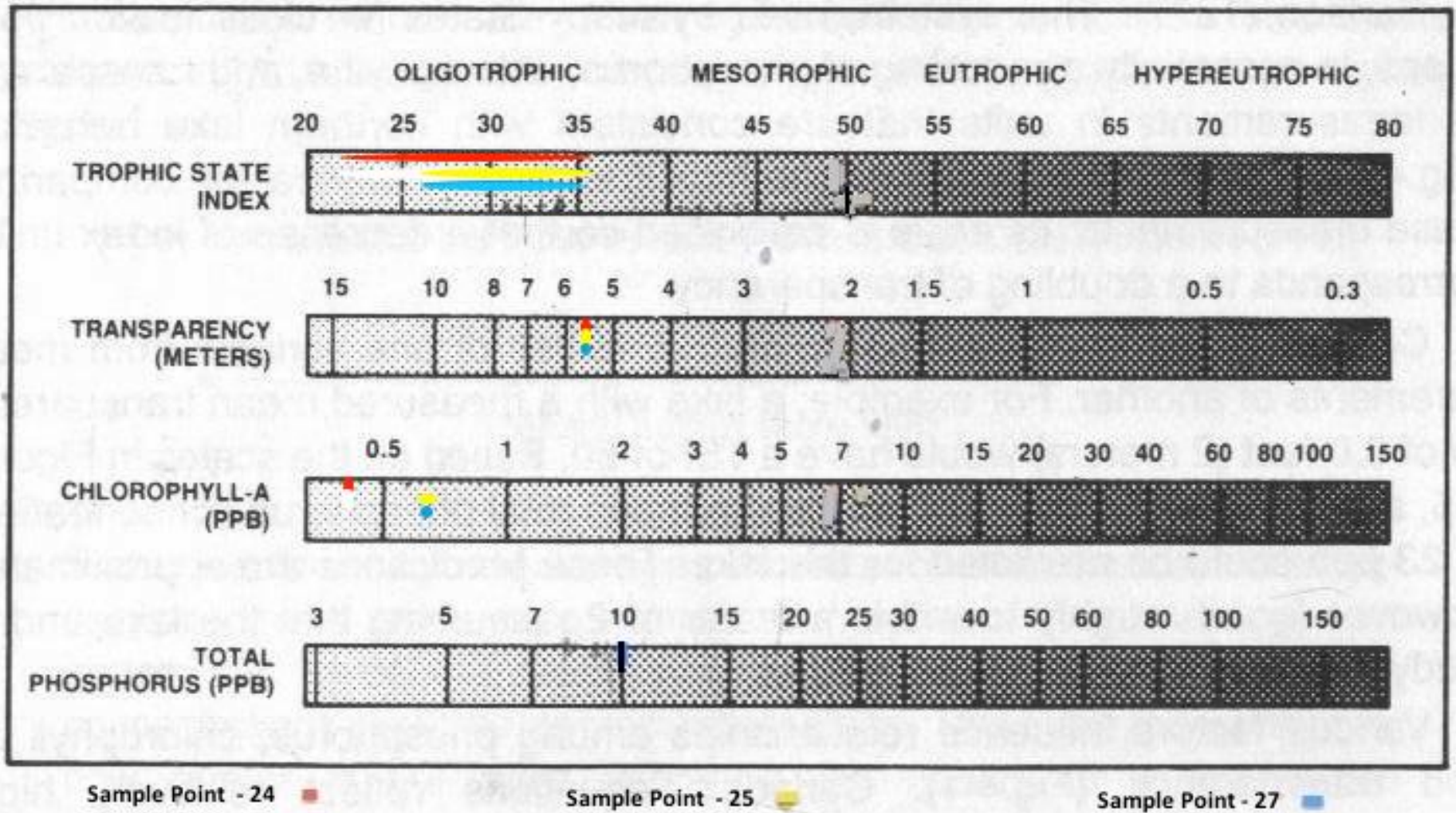
<b>Total Phosphorus (as P)</b>	ND	ND	ND	ND	ND	ND	ND	ND	0.02 mg/l
<b>OrthoPhosphate (as P)</b>	ND	ND	ND	ND	ND	ND	ND	ND	ND
<b>Ammonia (as N)</b>	ND	ND	ND	ND	ND	ND	ND	ND	ND
<b>Nitrate/Nitrite (as N)</b>	0.42 mg/l /ND	0.47 mg/l /ND	0.47 mg/l /ND	0.32 mg/l /ND	0.31 mg/l /ND	0.31 mg/l /ND	0.37 mg/l /ND	0.35 mg/l /ND	0.35 mg/l /ND
<b>TKN (asN)</b>	0.62 mg/l	0.48 mg/l	0.75 mg/l	0.41 mg/l	0.37 mg/l	0.47 mg/l	0.43 mg/l	0.65 mg/l	0.7 mg/l
<b>Chlorophyll a</b>	0.4 ug/l	ND	ND	0.4 ug/l	ND	1 ug/l	ND	ND	6.7 ug/l

ND = Non-detect

mg/l = ppm

ug/l = ppb

Figure 3 – Carlson Trophic State Index Ranges for March 29, 2018 at Sample Points 24, 25 & 27



## Discussion

YSI Measurements - Measurements taken with the YSI 556 Multimeter varied from location to location and by depth.

- pH – The pH for all three sample points ranged from 5.65 at six feet at Sample Point 24 to 7.31 at one and three feet at Sample Point 27. The pH values at Sample Point 24 were lower than the pH values at Sample Points 25 and 27; however, all trended lower with depth. The reason(s) for these variations are not known, although the low pH value may have been the result of minimal photosynthetic activity resulting in elevated carbon dioxide concentrations in the water column, particularly at depth.
- DO Percent Saturation – DO percent saturation measurements ranged from 111.6 % at the bottom (22') of Sample Point 25 to 127.5 % at the top of Sample Point 27. Super saturation is usually associated with photosynthesis. DO Percent Saturation values decreased marginally with depth at all three sample points, which corroborates the decreasing pH and photosynthesis with depth . A DO percent saturation reading of 111.6 mg/l at 22 feet at Sample Point 25 indicates mixing in the water column and minimal bacterial decomposition.
- Temperature – The temperature ranged from 5.2 C at 22 feet at Sample Point 25 to 7.73 C at one foot at Sample Point 27. With the exception of Sample Point 25, the vertical temperature gradient was not significant, indicating vertical mixing in the water column.
- Oxidation Reduction Potential (ORP) – The ORP values were relatively high throughout the water column at all sample points compared to previous year's data and increased with depth, which is unusual. ORP values ranged from a low of 256.6 mv at the three feet at Sample Point 27 to 358 mv at the bottom of Sample Point 25. This finding is most likely the result of vertical mixing causing oxygenated water near the surface to reach the bottom (22+') and very little anoxic biodegradation due to the relatively low temperature at the bottom. The following table indicates relative high ORP and DO % Saturation values at the bottom of Sample Point 25 are not unusual for the spring samplings done over the past seven years. Data from summer samplings usually indicate low ORP and DO % Saturation values at the bottom at Sample Point 25 resulting from no vertical mixing and active anoxic biodegradation of sludge.

**Table 1 - ORP and DO % Saturation Values at Sample Point 25 at 22+ Feet**

Date	ORP (mv)	DO % Sat
April 4, 2011	251	97.9
March 18, 2012	214.6	95
March 24, 2013	196.4	106.0
April 2, 2014	140.7	27.5
April 21, 2015	132.1	119.7
March 23, 2016	182.6	97.1
March 26, 2017	227.2	110.4
March 29, 2018	358.8	111.6

- Secchi Depths – Secchi depth (water transparency) is affected by color, turbidity and suspended solids, such as tannins algae and fine soil particles. At Sample Point 25 the Secchi depth on March 29, 2018 was 19' (5.79 m), which is the best Secchi disc value that SWQC has found in Dudley Pond. The unusually good Secchi value is thought to be in part due to flat water conditions (No wind), a minimum of turbidity/algae/tannins. Accurate Secchi depths at Sample

Point 24 and 27 could not be obtained because the Secchi disc was clearly visible on the bottom, implying the Secchi depth was greater than the bottom depth.

Phosphorus Concentrations – Phosphorus is generally accepted as the growth limiting nutrient in fresh water systems. Total phosphorus is a measure of orthophosphate, condensed phosphates and organic phosphate. No measurable concentrations of Total Phosphorus were found at all sample points with the exception of the sample taken at the bottom of Sample Point 27. As noted the sample taken at the bottom of Sample Point 27 contained suspended solids, which are thought to be weed fragments, which may have caused elevated Total Phosphorus and Chlorophyll *a* concentrations to and as a result was not used to calculate the Trophic State Index.

Nitrogen Compounds – Nitrate concentrations ranged from a low of 0.31 mg/l at 12 and 22 feet at Sample Point 25 and a high of 0.47 mg/l at 3 and 6 feet at Sample Point 24. The concentrations of nitrate found were relatively the same for all depths and sample points indicating water column mixing. The presence of nitrate indicates an oxidizing environment and very limited bacterial decomposition going on in the water column supported by relatively high ORP and DO Percent Saturation values. As the season progresses nitrate concentrations disappear as a result of the nitrogen moiety being incorporated as a nutrient into algae/weeds and/or via bacterial de-nitrification of nitrate to gaseous nitrogen, which bubbles out of the Pond as nitrogen gas. Ammonia was not detectable in the water column. TKN, (total Kjeldahl nitrogen) includes ammonia and organic nitrogen compounds and were present in all samples and concentrations ranged from 0.37 mg/l at 12 feet at Sample Point 25 to 0.75 mg/l at six feet at Sample Point 24.

Alpha Chlorophyll (Chlorophyll *a*) – Chlorophyll *a* is an indirect measure of the algae concentration and other chlorophyll containing compounds. On March 29, 2018 the majority of Chlorophyll measurements were non-detects, of the detectable measurements, a low Chlorophyll *a* concentration of 0.4 ug/l was found at one foot at Sample Points 24 and 25 and a high concentration of 1 mg/l was found at 22 feet at Sample Point 25. The Chlorophyll *a* concentration of 6.7 ug/l was neglected because the sample was contaminated with suspended material, probably weed fragments. These are the lowest Chlorophyll *a* concentrations measured in the last eight years.

Carlson Trophic State Index – The Trophic State Index TSI is a measure of the health of the Pond and a function of the combination of the Total Phosphorus concentration, Chlorophyll *a* concentration and the Secchi depth for the three sample points. As Dudley Pond is primarily used for recreational purposes a TSI less than 50 is tolerable and less than 40 would be great. The TSI on March 29, 2018 for the three sample points ranged from approximately 22 to 36 indicating that the Dudley Pond TSI was in the oligotrophic range, which is very good. It is thought these TSI values were driven by low Chlorophyll *a*, and low Total Phosphorus concentrations and an exceptionally good Secchi depth. This is the best TSI for the past eight years.