Hatch Pond Water Quality Assessment, 2010 Update

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INTRODUCTION

Hatch Pond, a 71.5 acre lake located in the town of Kent, Connecticut, has been classified during previous studies as mesotrophic (DEP 1991) [1], and highly eutrophic (NEAR 2006) [2]. The terms, *mesotrophic* and *highly eutrophic*, refer to categories of lake condition Connecticut Department of Energy and Environmental Protection (DEEP) uses to classify degree of impairment due to excessive algae and weed growth in a lake.

Although an essentially natural water body, the water level was raised three feet by the construction of a masonry dam across the outlet, owned by the State of Connecticut and managed by the DEEP. Drainage from the roughly 2,324-acre watershed enters the lake by two principal streams, one located at the north end of the lake (Northern Inlet—1,412 acre sub basin, 61% of total), and one located at the south end of the lake (Southern Inlet—305 acre sub basin,13% of total). The outlet of Hatch Pond is at the south end of the lake, water leaving Hatch Pond becomes Womenshenuk Brook, a tributary of the Housatonic River.

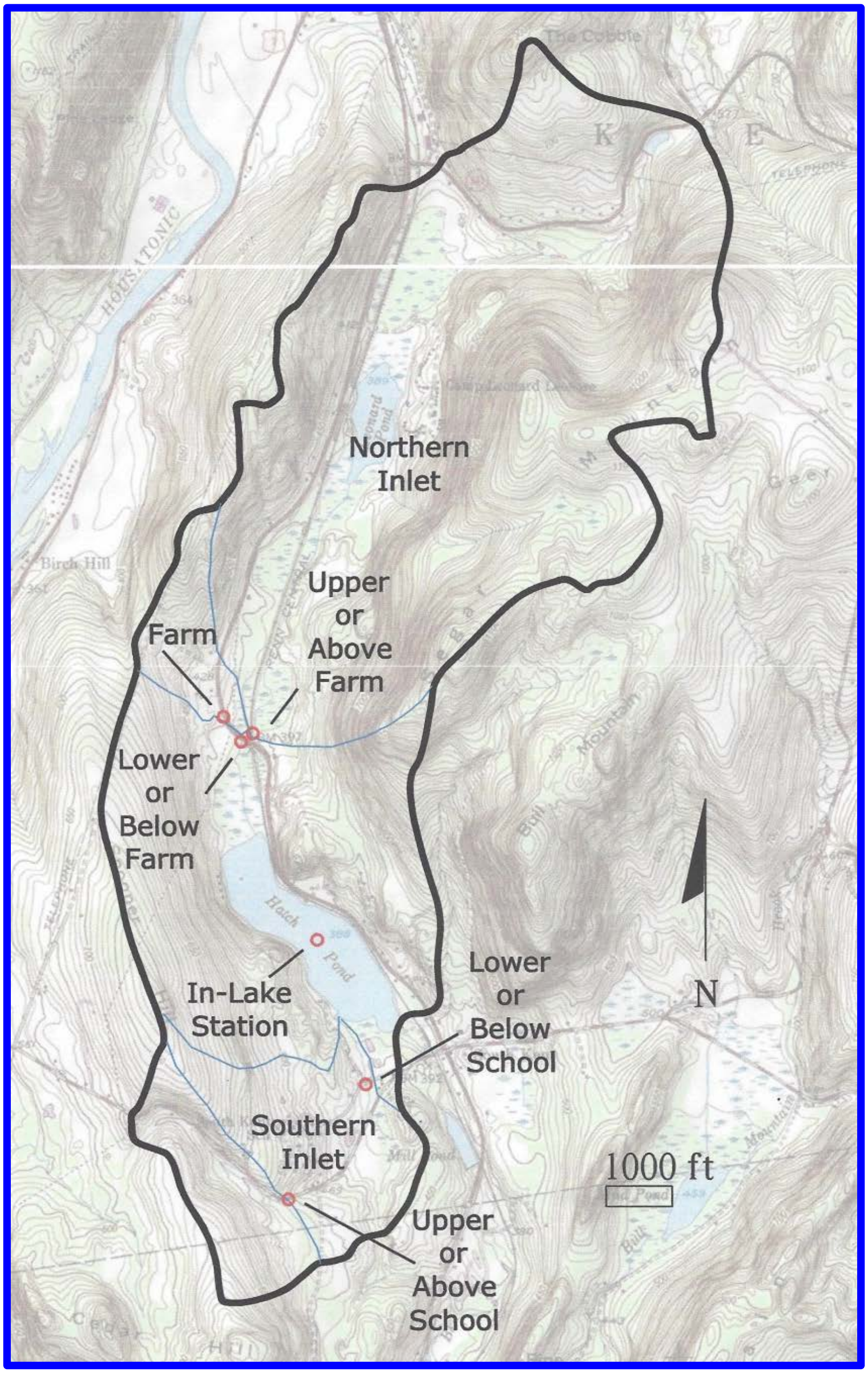
The Kent Land Trust (KLT), with funding from the Connecticut Department of Energy and Environmental Protection (DEEP) Bureau of Water Protection and Land Reuse, contracted Northeast Aquatic Research, LLC (NEAR) to conduct an assessment of Hatch Pond water quality in 2010 under a Clean Water Act section 319 grant.

NEAR conducted three field visits to the lake in 2010--July 13, August 25, and September 29, 2010. During each event; two lake stations, and 5 watershed stations were visited (see Map 1). At each lake station: water samples were collected for laboratory analysis for total phosphorus and total nitrogen concentrations; water clarity, water temperature, and dissolved oxygen were also measured. At each watershed station, water flow was measured and a water sample collected for laboratory analysis of total phosphorus and total nitrogen concentrations. Three additional visits to monitor storm-water conditions were made on August 23, 2010, March 31, and June 29, 2011. During each storm-water sampling event, the 5 watershed stations were visited to measure water flow and collect water samples for laboratory analysis of

[1] Trophic Classification of Forty-nine Connecticut Lakes. Connecticut Department of Environmental Protection 1991.
2 Diagnostic Study of Hatch Pond. Northeast Aquatic Research. September 2006

total phosphorus and total nitrogen concentrations. In addition, NEAR conducted a survey of aquatic plants in Hatch Pond on September 29, 2010.

Map 1 – Hatch Pond and watershed showing locations of sampling stations



Prior Condition of Hatch Pond - Explanation of Trophic Classification

CT DEP gave Hatch Pond a mesotrophic trophic classification based on data they collected from the lake in 1990[3] (DEP 1991). Subsequent studies by NEAR in 2004 and 2005 found Hatch Pond had become highly eutrophic (NEAR 2006). The two studies, roughly 15 years apart, showed Hatch Pond had deteriorated from moderate to very poor conditions. The trophic classification (see **Table 1)** system categorizes lakes based on the levels of nutrients, quantity of aquatic plants, and density of phytoplankton. Phytoplankton are microscopic plants suspended in the water column that cause the green water color in the summer.

The principal nutrients responsible for growth of plants in lakes are phosphorus and nitrogen. Phosphorus is generally considered the limiting nutrient for phytoplankton growth, while nitrogen, although an important nutrient for phytoplankton growth, is primarily responsible for aquatic plant growth.

Chlorophyll-*a* is used as a measure of phytoplankton density in the water column but can be predicted with Secchi disk depth. Aquatic plant area coverage and density is used to assess the relative importance of the plant community as a component of the total lake primary productivity.

Table 1 - CT DEEP lake trophic categories

Category	Phosphorus (ppb)	Nitrogen (ppb)	Chlorophyll –a (ppb)	Secchi (m)
Oligotrophic	0 – 10	0 – 200	0 – 2	> 6
Oligo-mesotrophic	10 – 15	200 – 300	2 – 5	4 – 6
Mesotrophic	15 – 25	300 – 500	5 – 10	3 – 4
Meso-eutrophic	25 – 30	500 – 600	10 – 15	2 – 3
Eutrophic	30 – 50	600 – 1,000	15 – 30	1 – 2
Highly Eutrophic	> 50	> 1,000	> 30	0 – 1

<table>
<tr><th>Category</th><th>Macrophyte Coverage as % of Surface Area</th></tr>
<tr><td>Oligotrophic</td><td>~~</td></tr>
<tr><td>Oligo-mesotrophic</td><td>~~</td></tr>
<tr><td>Mesotrophic</td><td rowspan="3">30 – 75%
plant data is used in conjunction with water column data</td></tr>
<tr><td>Meso-eutrophic</td></tr>
<tr><td>Eutrophic</td></tr>
<tr><td>Highly Eutrophic</td><td></td></tr>
</table>

3 Samples collected 6-8-90 and 8-28-90: total phosphorus 14 and 24 ppb in surface water, water clarity 2.4 and 1.5 meters, dissolved oxygen devoid below 2.5 meters. Although a sample drawn from 1.8 meters was reported to contain 110 ppb phosphorus.

STUDY RESULTS

The 2010 sampling results for in-lake parameters are for water clarity, water temperature, dissolved oxygen, phosphorus, and nitrogen. Drainage basin sampling results follow.

In-Lake Results

Water Clarity

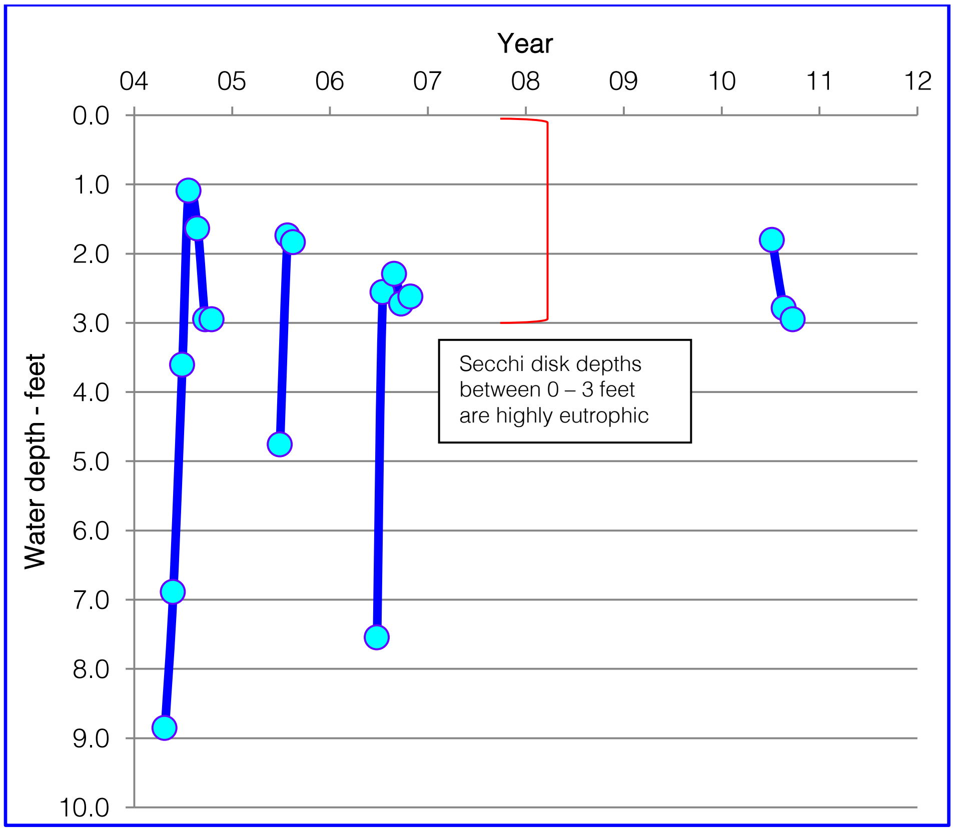
The Secchi disk was used to estimate water clarity of Hatch Pond water. Secchi disk depth was measured three times during the summer of 2010. The 2010 data is shown in **Table 2** together with all prior measurements NEAR has made at Hatch Pond between 2004-2006.

Table 2 – Water clarity readings (ft.) from Hatch Pond

Date	Feet
2004	
25-Apr	8.9
26-May	6.9
29-Jun	3.6
23-Jul	1.1
25-Aug	1.6
23-Sep	3.0
18-Oct	3.0
2005	
29-Jun	4.8
28-Jul	1.7
18-Aug	1.8
2006	
27-Jun	7.5
19-Jul	2.3
31-Aug	2.3
26-Sep	2.3
31-Oct	2.6
2010	
13-Jul	1.8
25-Aug	2.8
29-Sep	3.0

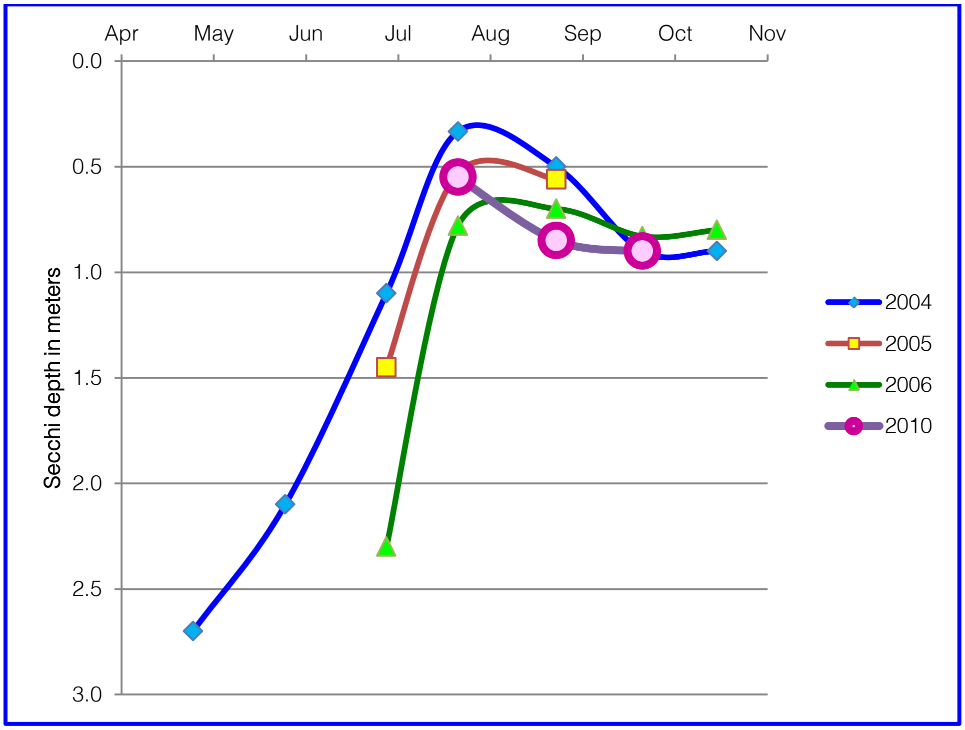
Long-term trend in water clarity for Hatch Pond is shown in **Figure 1**. 2010 readings were less than 3 feet--that is, below the threshold for highly eutrophic lakes of 1-meter clarity listed in **Table 1** (shown by the bracket 0-3 feet). The 2010 measurements were similar to readings made during the summers of 2004-2006--that is, between a range of 1 to 3 feet.

Figure 1 – Water clarity trends in Hatch Pond



The seasonal trend in water clarity in Hatch Pond is shown in **Figure 2**. Clarity is best earliest in the spring but declines rapidly with progression of summer. Poorest clarity readings occur during the summer months of July and August, clarity improves slightly-–about 0.5 meter during September and October. The 2010 data was similar to prior years suggesting nutrient levels in the lake have not decreased enough to affect phytoplankton growth.

Figure 2 – Seasonality of water clarity in Hatch Pond



Temperature and Oxygen

Temperature

The water temperature data was used to determine if the lake formed a thermal boundary, or *thermocline*, that separates a the water column into an upper mixed layer and a lower stagnant layer. The upper layer of a lake is mixed by the wind while the deeper water, below the thermal boundary, remains isolated and becomes stagnant. When bottom water becomes stagnant dissolved oxygen is depleted and water quality degrades. A strong thermal boundary between these two layers helps to retain poor water quality in bottom water instead of being dispersed throughout the water column.

Hatch Pond does form a thermocline, the layer in water column were water temperature drops rapidly with depth, between 3 and 4 meters during the summer (**Table 3)**. The table shows the depth in meters where thermal stratification occurred in Hatch Pond; for example in June of 2004 a thermocline existed at 4 meters from the surface. The thermocline moved upward during July and August of that year, from 3 and then to 2 meters. Stratification was brief in

2010; note in **Table 3** that a thermocline was present only in July and nearer to the surface in that year. Because summer clarity readings have been similar year-to-year, the lack of sustained thermocline formation was not due to differences in water clarity. Instead, lack of thermocline development in 2010 was probably due to climatic variation, such as more wind. The early loss of thermocline, that may have affected other trends and values in the 2010 data set.

Table 3 – Depth of thermocline (meters below surface) in Hatch Pond

Month	2004	2005	2006	2010
Apr	No Thermocline			
May	No Thermocline			
June	4	2	4	2
July	3	3	2	~
Aug	2	3	~	~
Sep	3	~	~	~
Oct	No Thermocline			

Dissolved Oxygen

Two important aspects of the dissolved oxygen data are considered--when concentrations are very high, exceeding 100% saturation, and very low concentrations when dissolved oxygen is less than 1 mg/L. The former is super-saturated and occurs as a by-product of abundant phytoplankton while the latter is anoxic or when dissolved oxygen has become exhausted in deepest waters.

Surface Dissolved Oxygen Saturation

Super-saturated dissolved oxygen conditions have been shown to occur in Hatch Pond during months of June and July (**Table 4**). Super saturation of dissolved oxygen indicates very high abundance and photosynthesis rates of plankton in the water column. The lake returns to near 100% saturation during late summer indicating a decrease in algae production. The data collected in 2010 shows high super-saturation of dissolved oxygen in July similar to prior years. Late summer saturation appears to have been lower during 2010 then prior years, suggesting dissolved oxygen consumption in the lake has increased. When the lake mixes in August and September the accumulated oxygen demand material under the thermocline in July is distributed throughout the lake, causing a pulse of lower dissolved oxygen readings.

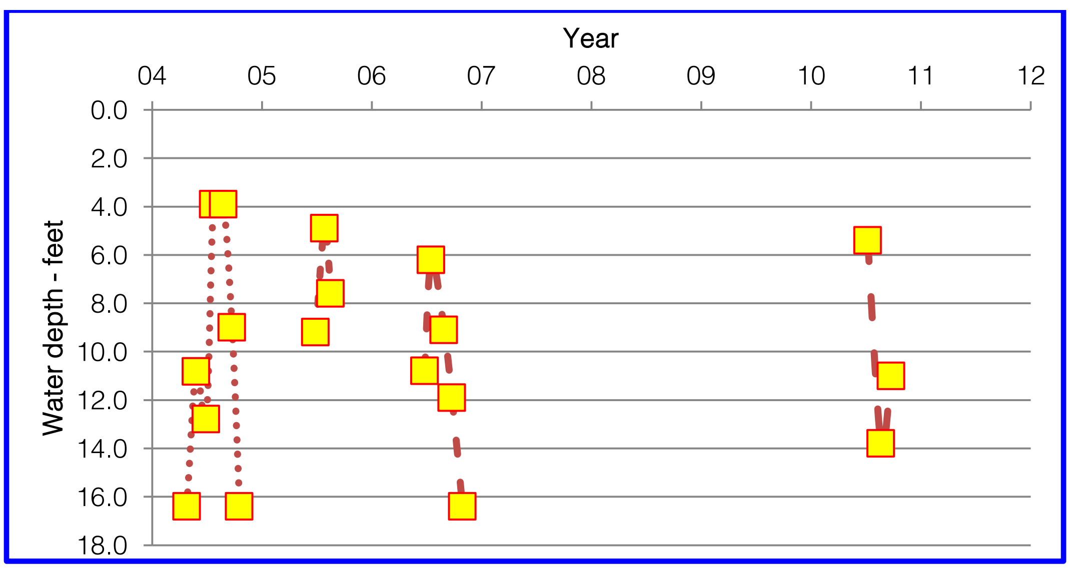
Table 4 - Average % oxygen saturation in upper 3 feet of Hatch Pond

2004						
April	May	June	July	August	September	October
88	76	115	142	96	98	87
2005						
		June	July	August		
		140	112	120		
2006						
		June	July	August	September	October
		76	147	103	86	96
2010						
			July	August	September	
			183	76	80	

Bottom Depletion

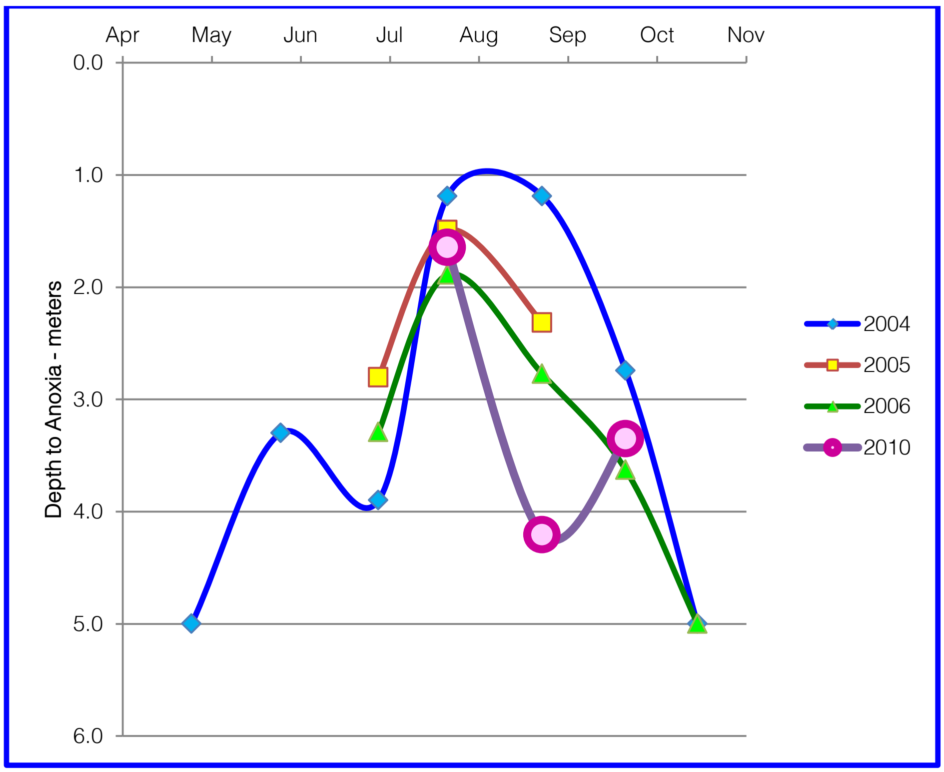
Hatch Pond has been shown (NEAR 2006) to lose dissolved oxygen in deepest water during the summer (**Figure 3**). New data, from 2006 and 2010 confirm that most of the lake volume becomes anoxic during summer months. The anoxic boundary ascended to between 5-6 feet below the surface, in 2006 and 2010. A small pulse of higher dissolved oxygen water occurred in August when anoxic boundary was forced downward due to mixing, probably coincident to the loss of stratification between July and August. The squares shown in **Figure 4** at 16 feet represent fully oxygenated water column conditions.

Figure 3 - Anoxic boundaries In Hatch Pond



Development of anoxic water in Hatch Pond begins immediately in the spring, at the bottom in deepest water (**Figure 4**). Between mid-June and mid-July most of the water volume of Hatch Pond becomes devoid of dissolved oxygen, only 3-5 feet of the surface layer retain oxygenated. Anoxic water persists until October when dissolved oxygen levels are replenished to the bottom. However, thermocline data shown in **Table 3** indicate that late August thermal boundaries may be insufficient to retain phosphorus generated by anoxic conditions at the bottom in late summer, indicating that internally-derived phosphorus could mix with upper waters.

Figure 4 – Seasonality of anoxic water in Hatch Pond



Nutrient Chemistry

Total Phosphorus

Hatch Pond in-lake phosphorus concentrations continue to exceed 50 ppb, the threshold for highly eutrophic lakes (**Table 5**). Testing results from 2010 show phosphorus averaged 62 ppb at the surface. Although prior surface average phosphorus concentrations were somewhat higher, the 2010 data indicate the lake still contains excess phosphorus--that is, greater than 30 ppb.

Phosphorus was measured in total form, i.e. all forms of phosphorus in the sample were measured collectively. This test is referred to as total phosphorus and for purposes of clarification, all mention of phosphorus in this report will mean total phosphorus. Unless otherwise stated, all phosphorus results will be presented as parts per billion (ppb). A ppb is equal to 1 thousandth of a milligram per liter (mg/L), or 1 ppb = 0.001 mg/L, 1 mg/L = 1,000 ppb.

Table 5 - Hatch Pond total phosphorus concentrations in ppb

2010

Depth (ft.)	April	May	June	July	August	September	October
1				69	61	57	
7				48	63	65	
14				265	57	100	
Mean				*127*	*60*	*74*	

2006

Depth (ft.)	April	May	June	July	August	September	October
1			54	75	126	90	42
7			71	94	80	72	56
14			344	845	590	246	63
Mean			*156*	*338*	*265*	*136*	*54*

2005

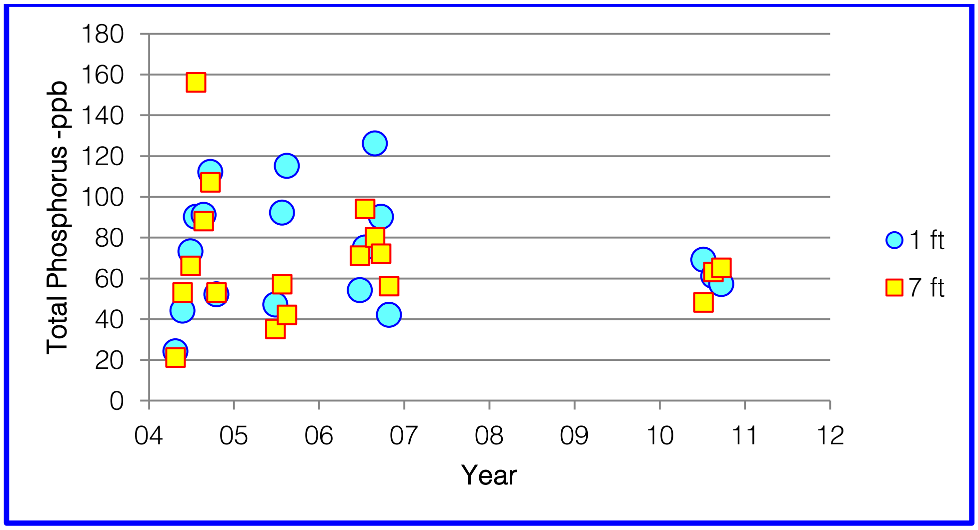
Depth (ft.)	April	May	June	July	August	September	October
1			47	92	115		
7			35	57	42		
14			363	470	680		
Mean			*148*	*206*	*279*		

2004

Depth (ft.)	April	May	June	July	August	September	October
1	24	44	73	90	91	112	52
7	21	53	66	156	88	107	53
14	26	44	520	690	560	66	47
Mean	*24*	*47*	*220*	*312*	*246*	*95*	*51*

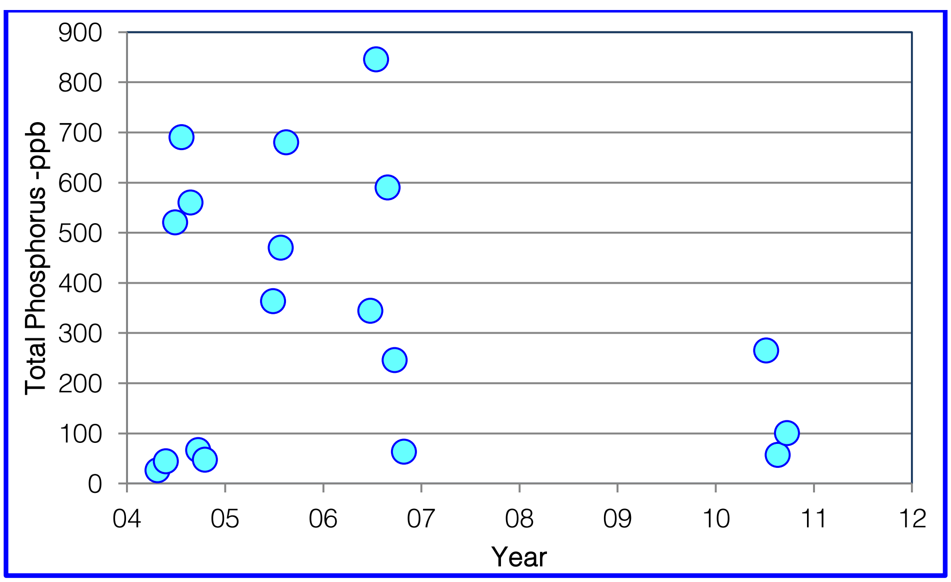
The trend in phosphorus concentrations in surface waters of Hatch Pond (the 1 foot and 7 foot samples) are shown in Figure 5. The data indicates a possible decrease in range of phosphorus concentrations in the lake during 2010; values ranged between 48-69 ppb, while prior data showed a range between 20-160 ppb. The 2010 phosphorus results suggest that highest concentrations in past seasons (values over 80 ppb) may have been due to farm loading, while other values (those below 80 ppb) represent internal recycling. This hypothesis suggests that phosphorus levels in the lake are going to remain in the range of 40-70 ppb due to internal recycling alone.

Figure 5 - Phosphorus concentration trends for Hatch Pond



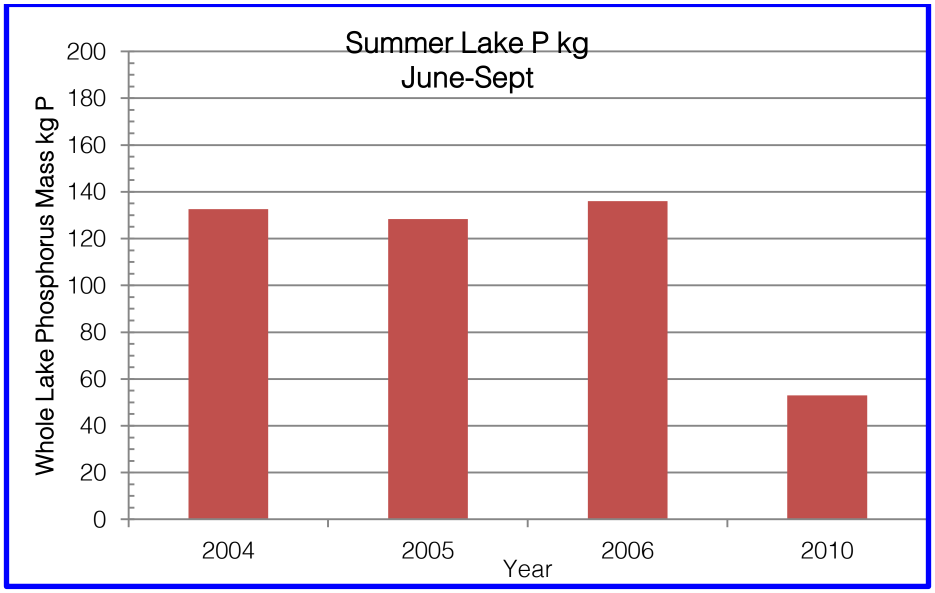
The highest phosphorus concentration typically occurs at 14 feet. Data from all bottom phosphorus samples, **Figure 6**, show concentration ranges between 26 ppb and 845 ppb. Maximum values occur in summer while lowest values occur in spring and late fall months. The 2010 bottom-phosphorus level was lower than that of prior years by more than half, indicating possible lower rates of internal recycling in 2010.

Figure 6 – Bottom water phosphorus concentrations in Hatch Pond



Using all water column data, 2010 phosphorus mass in Hatch Pond appears to have decreased by about 50% since 2004-2006 (Figure 7).

Figure 7 – Summer phosphorus mass in Hatch Pond



Nitrogen

The nitrogen in lake water occurs in two basic forms, inorganic and organic. The inorganic form is commonly represented by nitrate, and ammonia. All three forms were tested for in samples collected in Hatch Pond.

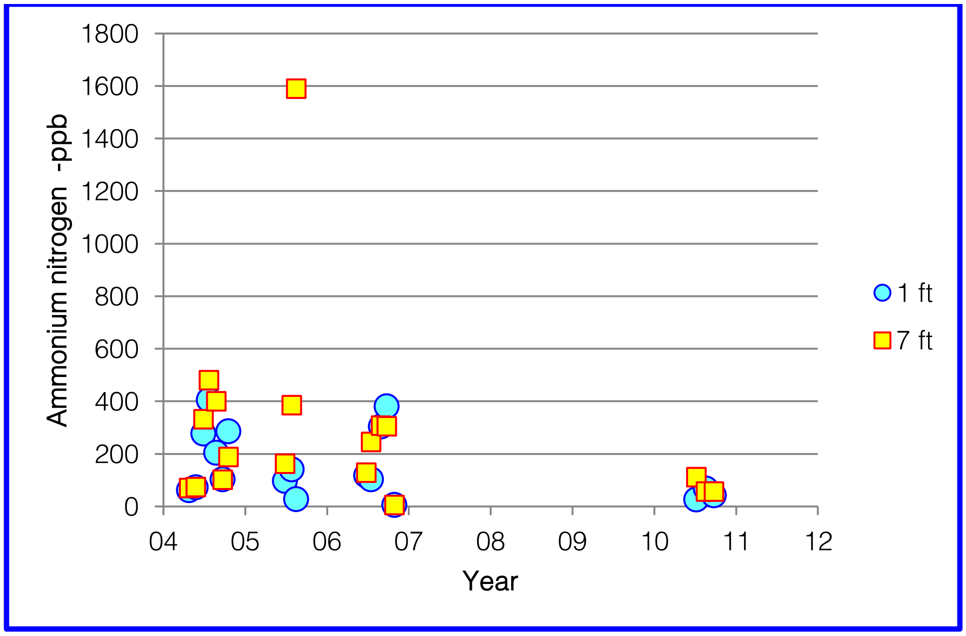
-- *Nitrate*

Nitrate was below the detection limit of 20 ppb in all lake samples.

-- *Ammonia*

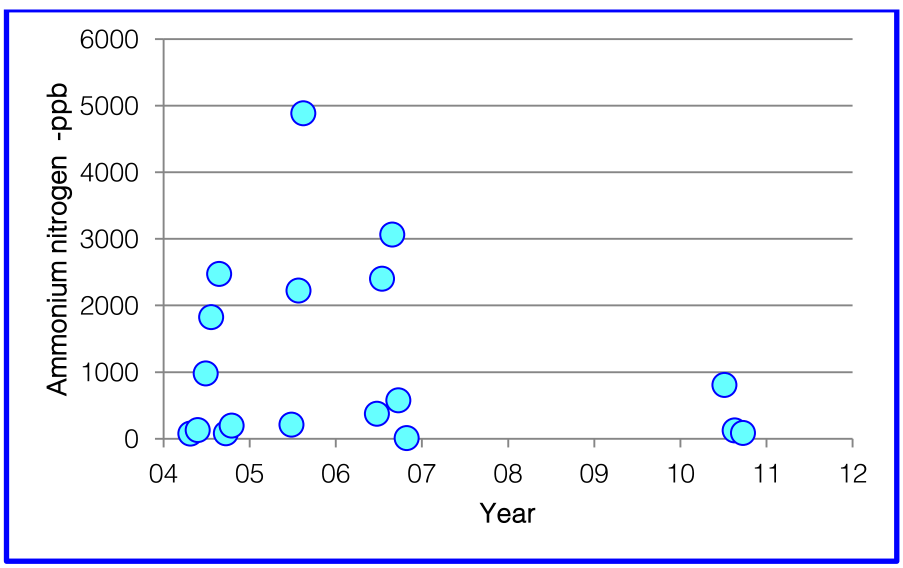
Ammonia is a by-product of the decomposition process and is liberated from sediments during anoxic conditions. In 2010, ammonia appeared lower than in prior years. Figure 8 shows that surface water ammonia typically reached levels of 400 ppb during the summer. In 2010, summer upper water column ammonia concentration remained below about 100 ppb.

Figure 8 - Ammonia nitrogen concentrations in surface waters of Hatch Pond



Ammonia has been shown to accumulate in bottom water during summer months (NEAR 2006), with concentrations as high as 2,000 to 3,000 ppb common during July and August (**Figure 9**). Data from 2010 show ammonia was less than 1,000 ppb in all bottom samples, suggesting a decreased load of ammonia to the lake from the watershed, as well as lower intensity of anaerobic conditions in bottom waters.

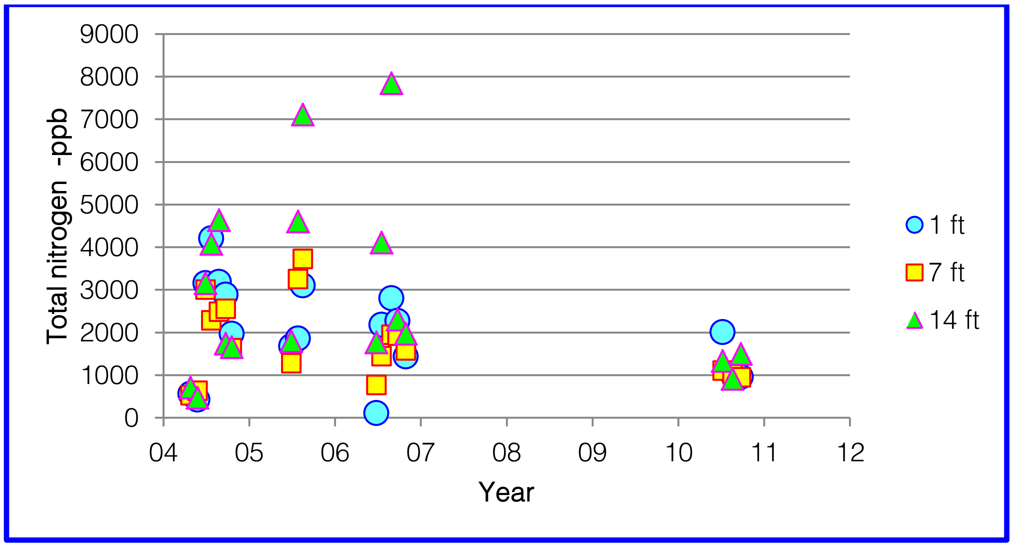
Figure 9 – Bottom water ammonia concentrations in Hatch Pond



Total Nitrogen

Total nitrogen levels in Hatch Pond have ranged between 100 ppb and 7,800 ppb (Figure 10). In 2010, total nitrogen was considerably lower than in prior years, ranging between 900 ppb to 2,000 ppb, suggesting a possible 50% decrease in total nitrogen in the pond.

Figure 10 - Total nitrogen concentrations in Hatch Pond



Aquatic Vegetation

Hatch Pond is infested with the non-native invasive aquatic plant Eurasian milfoil (Myriophyllum spicatum). A CT DEP survey of the lake in August 1990 did not list Eurasian milfoil as being present in the lake; instead, it reported coontail (Ceratophyllum demersum) as dominate aquatic plant in Hatch Pond. However, by 2000 Eurasian milfoil had become widespread in Hatch Pond as shown in NEAR distribution map made August 18, 2000 (Map 2). In 2006, NEAR reported that milfoil covered about 20 acres of the lake's surface. In 2004/2005, milfoil was found growing in waters to a maximum of 9 feet deep.

In 2010, milfoil was found to cover about 16 acres of the lake surface, a decrease of about 4 acres (Map 3). This decrease in distribution was predominantly found in water 2 feet shallower than in prior surveys, growing to 7 feet instead of 9 feet (see Figure 11). The loss of deep-water range of milfoil is speculated to be caused by sustained low water clarity during the growing season--summer water clarity varies between 1 and 3 feet--indicating that light would fail to reach the bottom in water much deeper than about 6 feet. One estimate of maximum depth of colonization (MDC) uses about 2x the Secchi disk depth (log MDC = 0.61 log SD + 0.26, Canfield et al., 1985). Using this equation with spring Hatch Pond water clarity data the estimated the maximum depth of milfoil colonization at 7 feet.

A second possibility is that milfoil plants growing in water deeper than 7 feet are stunted by anoxic water present there early in the growing season. For example, the anoxic boundary was found at 5.3 feet on July 13, 2010, indicating that the plants growing between 5 and 9 feet were exposed to oxygen devoid conditions.

Hatch Pond is also infested with the non-native invasive aquatic plant curly-leaf pondweed (Potamogeton crispus). This early-growing plant typically senesces from the water column in July, so no growing plants were found in 2010. However, many floating winter buds (turions) of curly-leaf pondweed were observed during the September 29, 2010 survey, suggesting that the lake contains a substantial population of curly-leaf pondweed that would need to be looked for in June.

Aquatic plant diversity appears to be declining in Hatch Pond. Results from the three NEAR surveys (2000, 2004/2005, and 2010) show a decline in species richness, or the number of species present in the pond. Seven species of native aquatic plants were noted in 2000, four in 2004/2005, and three in 2010. These counts refer to submersed species only, and don't include floating leaved species or shoreline emergents. Three native pondweeds (Potamogeton robbinsii, P. amplifolius, and P. epihydrus) found abundantly in 2000, have not been seen since, with no trace of these species found during the 2010 survey. In addition, flat-stem pondweed (Potamogeton zosteriformis), common waterweed (Elodea canadensis), and sago pondweed (Stuckenia pectinata), each found at moderate density and distribution during prior surveys, were rare—occurrence frequency of 5% of less--in 2010.

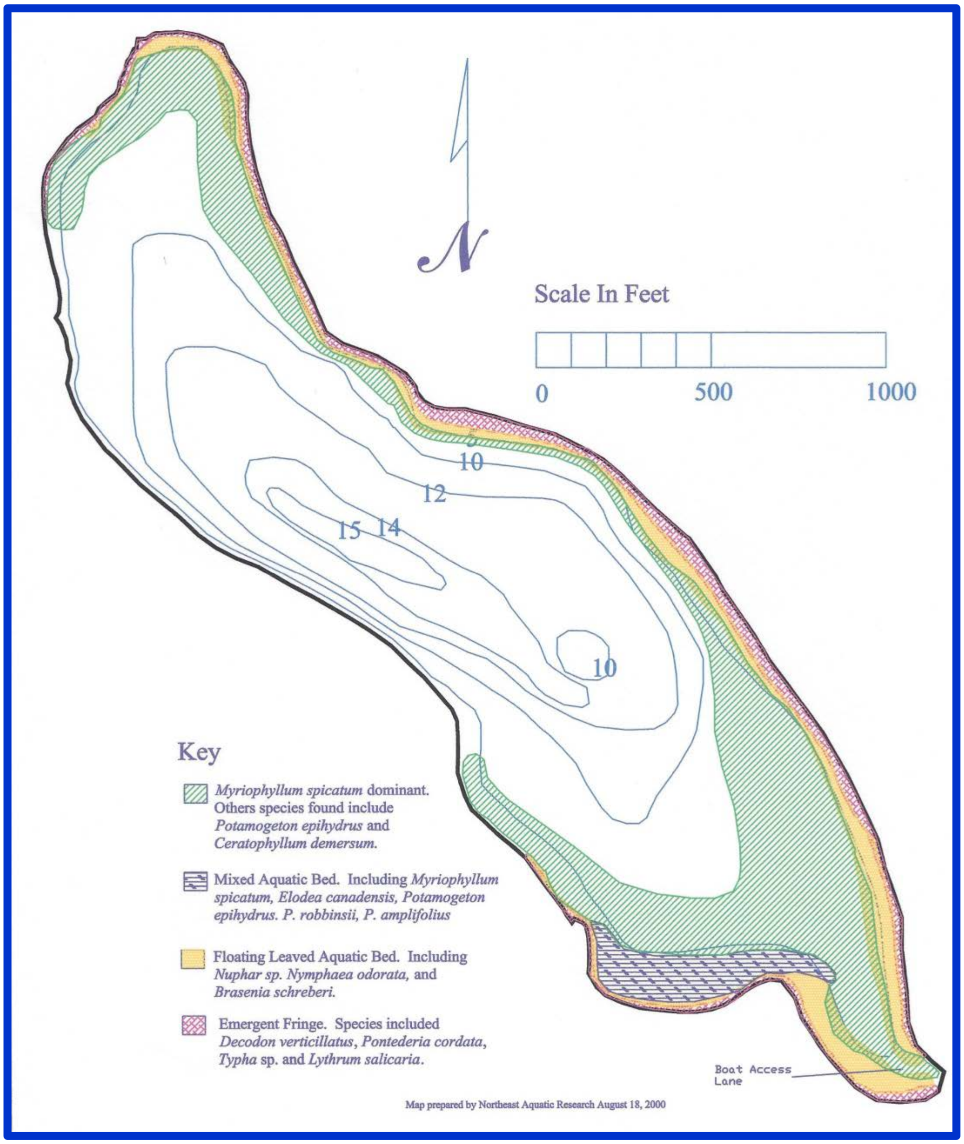
The list of aquatic plant species found in Hatch Pond during each of the three NEAR surveys (2000, 2004/2005, and 2010) are given in **Table 6**. The table lists the general area of the lake where each species was found and its relative abundance.

Table 6 – Aquatic plant species observed in Hatch Pond during 2000, 2004/2005, and 2010 surveys

Species	2000	2004 – 2005	2010
White water lily (Nymphaea odorata)	Dense along east and south shore	Dense along east and south shores	Dense along east and south shores
Yellow water lily (*Nuphar variegata*)	Dense along south shore	Dense along east and south shores	Dense along east and south shores
Filamentous algae	Dense along all shores	Very dense along all shores	Very dense along all shores
Eurasian watermilfoil (*Myriophyllum spicatum*)	Dense to about 9 feet of water	Dense to about 9 feet of water	Dense to about 7 feet of water
Curly-leaf pondweed (*Potamogeton crispus*)	Moderate to about 5 feet of water	Moderate to about 5 feet of water	Many turions
Flat-stem Pondweed (*Potamogeton zosteriformis*)	Dense to about 6 feet mostly along east and south end	Dense to about 6 feet mostly along east and south end	Rare
Coontail (*Ceratophyllum demersum*)	Sporadic	Sporadic	Abundant
Watermeal (*Wolffia sp*)	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore
Great Duckweed (*Spirodela polyrhiza*)	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore
Duckweed (*Lemna* sp)	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore	Very dense at north end and along eastern shore
Common Waterweed (*Elodea canadensis*)	Moderate to about 5 feet of water	Moderate to about 5 feet of water	Rare
Ribbon-leaf Pondweed (*Potamogeton epihydrus*)	Occasional with milfoil	Not observed	Not observed
Large-leaf Pondweed (*Potamogeton amplifolius*)	Moderate in southwest	Not observed	Not observed
Robbins Pondweed (*Potamogeton robbinsii*)	Dense coverage on bottom in southwest	Not observed	Not observed
Sago Pondweed (*Stuckenia pectinata*)	Moderate in southwest	Moderate in southwest	Very rare
Pickerelweed (*Pontedaria cordata*)	Along east edge	Along east edge	Along east edge
Purple Loosestrife (*Lythrum salicaria*)	Along east edge	Along east edge	Along east edge
Arrow head (*Sagittaria latifolia*)	Along east edge	Along east edge	Along east edge
Water-willow (*Decodon verticillatus*)	Along east edge	Along east edge	Along east edge

Red type indicates native submersed aquatic plant species

Map 2 - Map showing distribution of aquatic plants in Hatch Pond on August 18, 2000



Map 3 - Map showing distribution of aquatic plants in Hatch Pond on Sept. 29, 2010

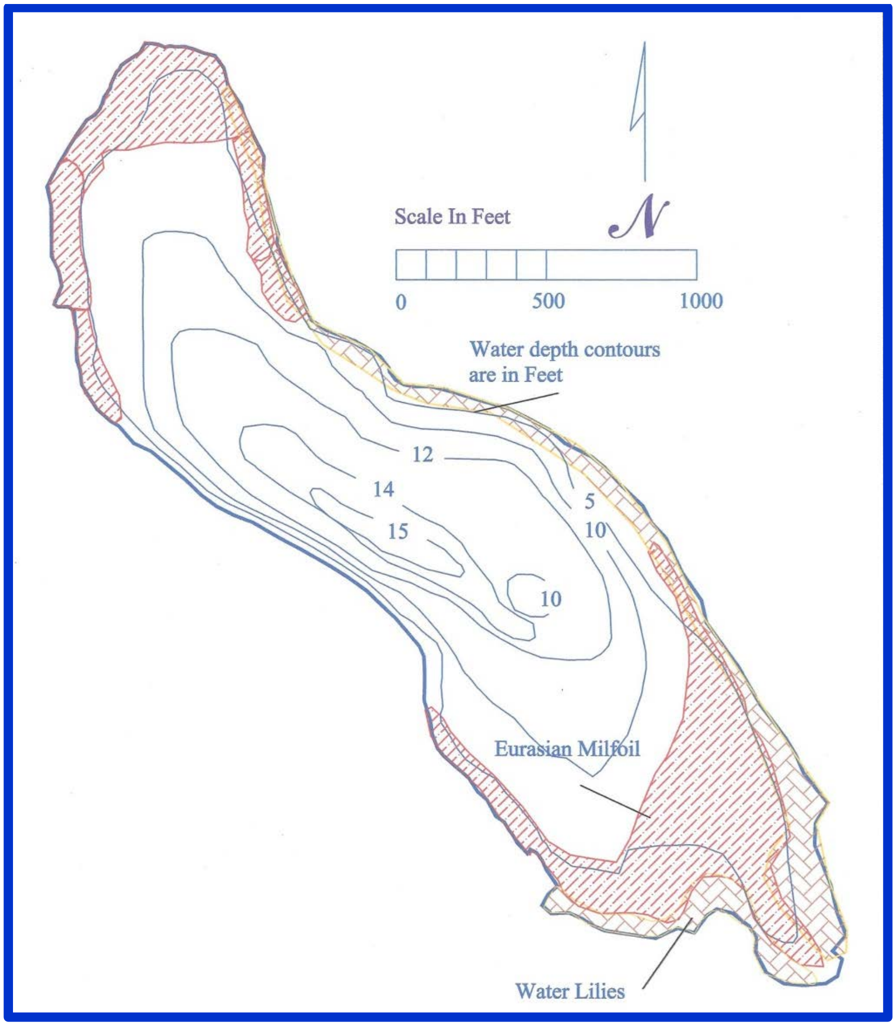
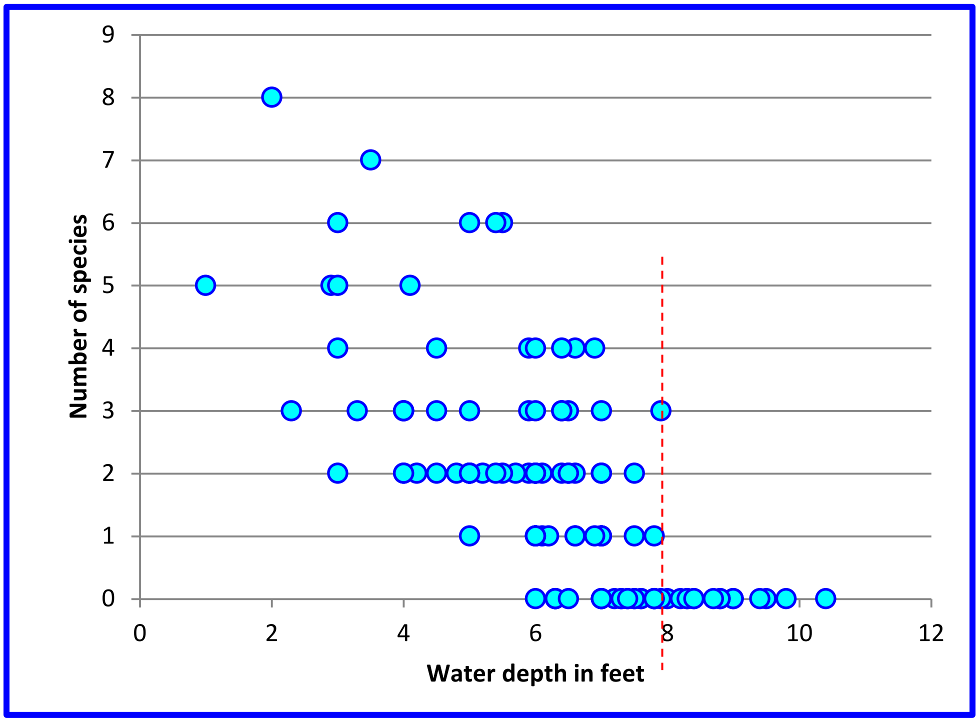


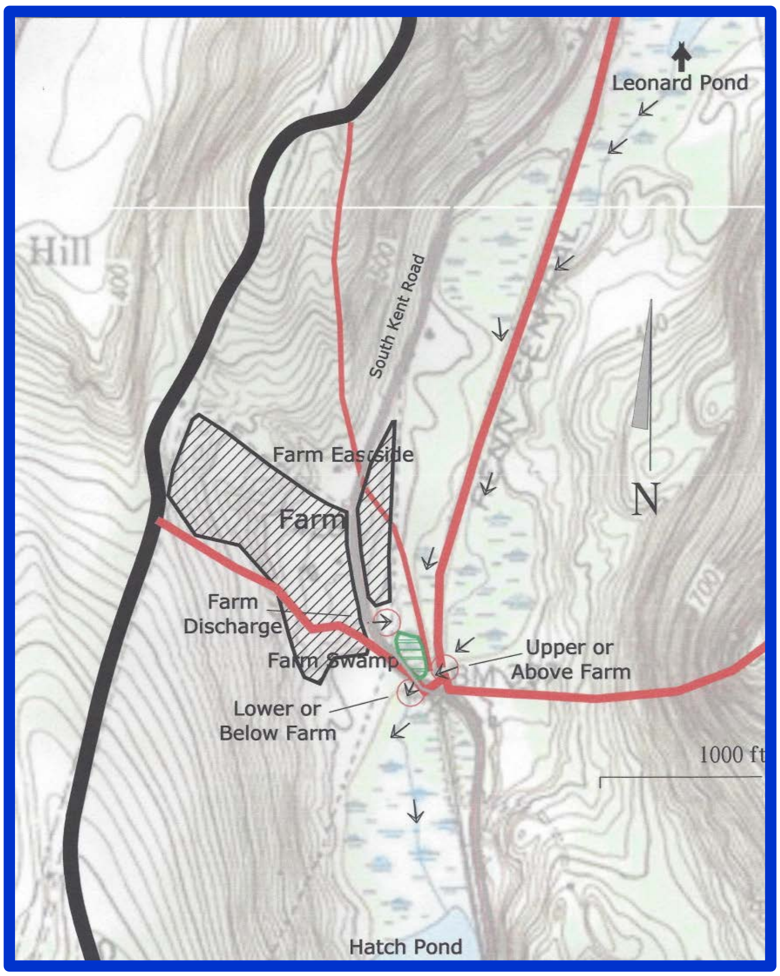
Figure 11 – Aquatic plant occurrence as a function of water depth, red dashed line shows outer depth limit (8 feet) of plant growth in 2010 survey



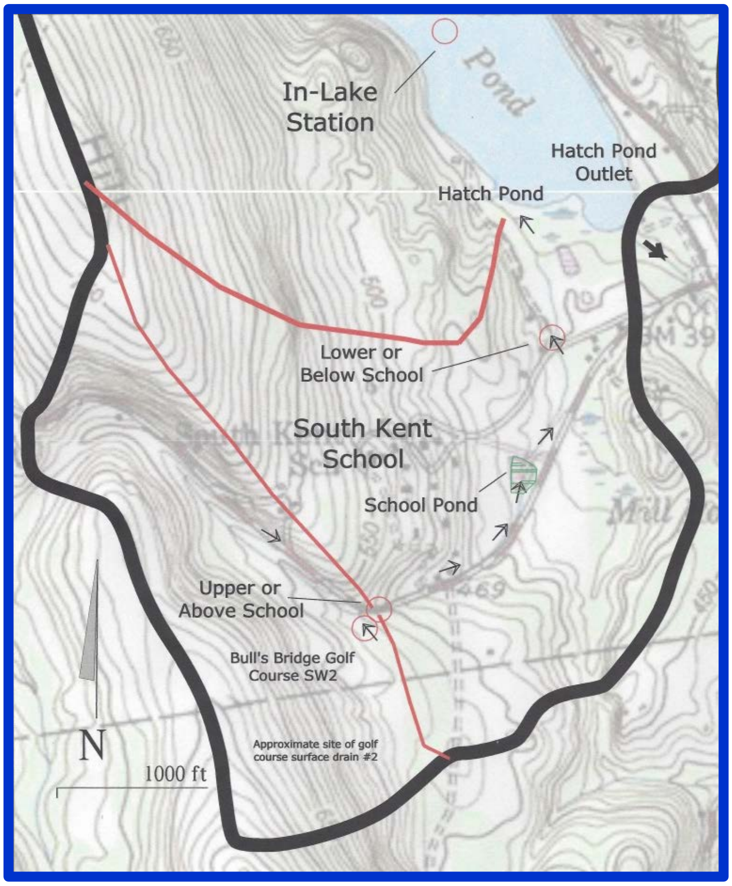
Drainage Basin Results

The water flows and nutrient concentrations have been measured at five locations in the drainage basin of Hatch Pond (**Maps 4 & 5**). In 2004, three northern inlet stations; above and below the farm, and discharge from the farm, were sampled. In 2005, watershed sampling expanded to include the southern inlet near where water enters the lake. In 2006, a second up-stream location on the southern inlet was added. Also included in this report are results from Bull's Bridge Golf Course tributary, testing at the site (SW2) where water leaves the course and enters the southern inlet stream.

Map 4 – Detail of watershed showing northern inlet sampling stations



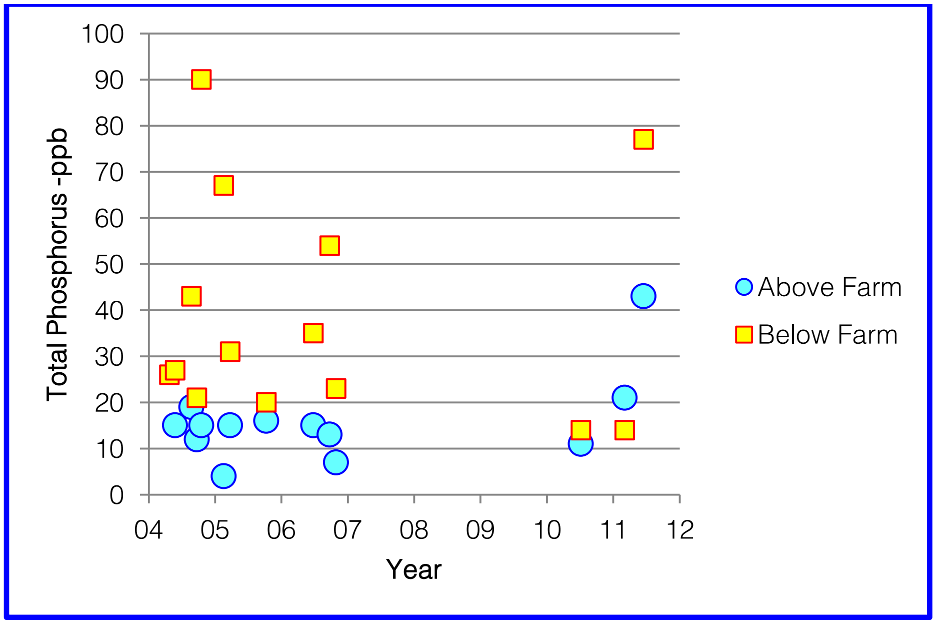
Map 5 - Detail of watershed showing southern inlet sampling stations



Phosphorus

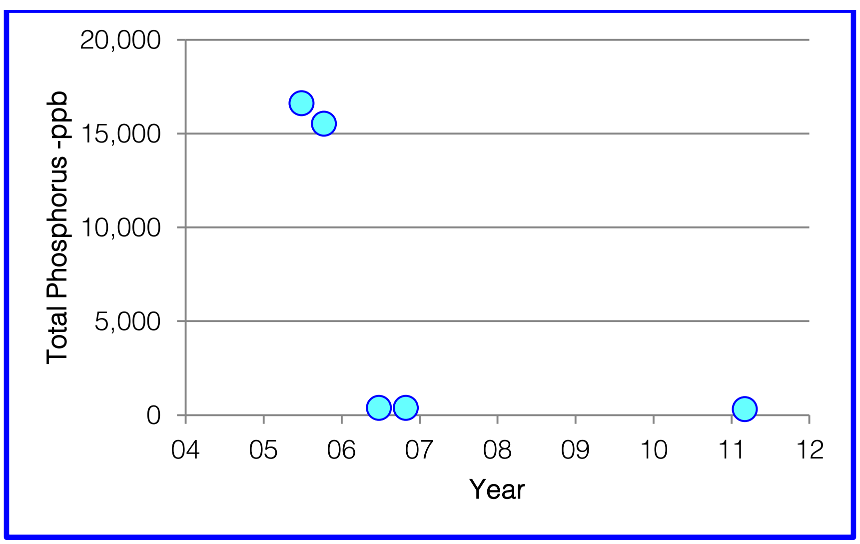
The average phosphorus concentrations from the northern inlet at Above and Below Farm stations are shown in Figure 12. The data in the chart show that phosphorus concentrations at the Below Farm site had been higher than at the Above Farm site during 2004-2006 sampling. Data collected in 2010 indicate that phosphorus has decreased at the Below Farm site with concentrations becoming similar to Above Farm conditions. The similarity of phosphorus concentrations at the two sites indicates that no increase in load occurred in 2010 between the two sites, as was common in the past when the farm contributed nutrients to the stream prior to the water reaching the Below Farm sampling location.

Figure 12 - Phosphorus concentrations in northern inlet



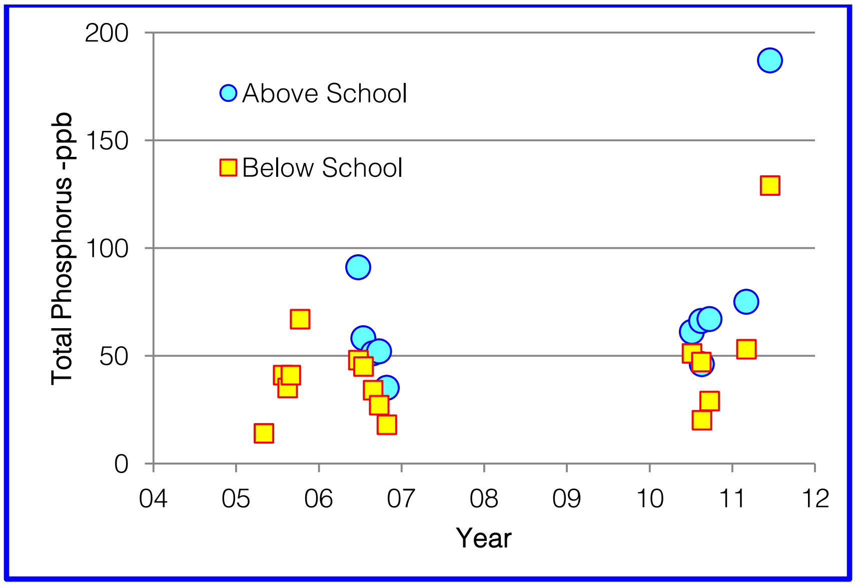
Phosphorus concentration in water collected at the Farm Discharge station has decreased, (see **Figure 13**). Phosphorus concentrations in storm-water samples collected in 2005 were extremely high (>15,000 ppb), while recent storm-water data collected on March 11, 2011, show considerably lower concentrations—297 ppb. Runoff from the Farm parcel occurred only during the large storm on March 11, 2011; during all sampling visits in 2010 the stream running through the farm property was dry.

Figure 13 – Phosphorus concentrations at Farm Discharge station



Phosphorus concentrations in the southern stream have varied between 10 and 185 ppb, with values from the Above School station (mean 72 ppb) tending to exceed the Below School station (mean 44 ppb) as shown in **Figure 14**. Decreases in phosphorus from the upper to lower stations suggests sources of phosphorus exist above the Above School station. Because concentrations are higher above the school than below the school, phosphorus is being stored in the southern inlet channel sediments, the bottom sediments of the Kent School pond, or wetland vegetation immediately downstream of the school pond.

Figure 14 – Phosphorus concentrations from southern inlet stations



Bull's Bridge Golf Course maintains a water quality record of stream water leaving the course at site SW2. The site SW2 stream flow apparently enters the main on the upstream side of Bull Bridge Road from where the Above School sampling site is located. In this way, the samples collected at Above School reflect additions of nutrients from the golf course. Charts below (**Figure 15 & 16** and **20 & 21**) show Bull's Bridge Golf Course testing results from the SW2 site.

Figure 15 shows phosphorus concentrations from the SW2 site between March 2002 and December 2010. Concentrations range from <50 ppb to 310 ppb. The average concentration, 122 ppb, represents a significant source of eutrophication to downstream waters including Hatch Pond. **Figure 16** shows stream phosphorus data when sampling overlapped in 2006. Data suggests that concentration results detected during NEAR survey were similar to results from the golf course.

Figure 15 – Phosphorus concentrations in stream water leaving the course at SW2

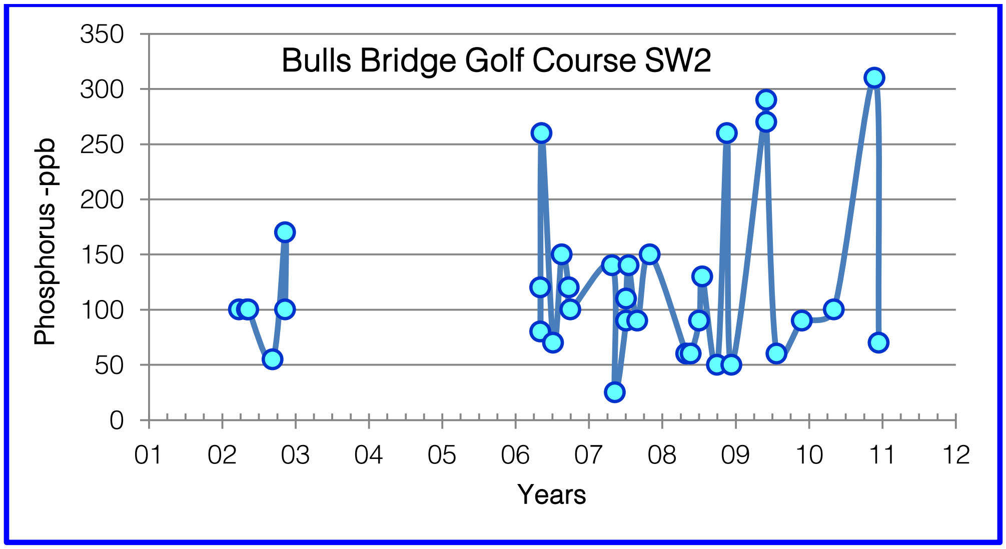
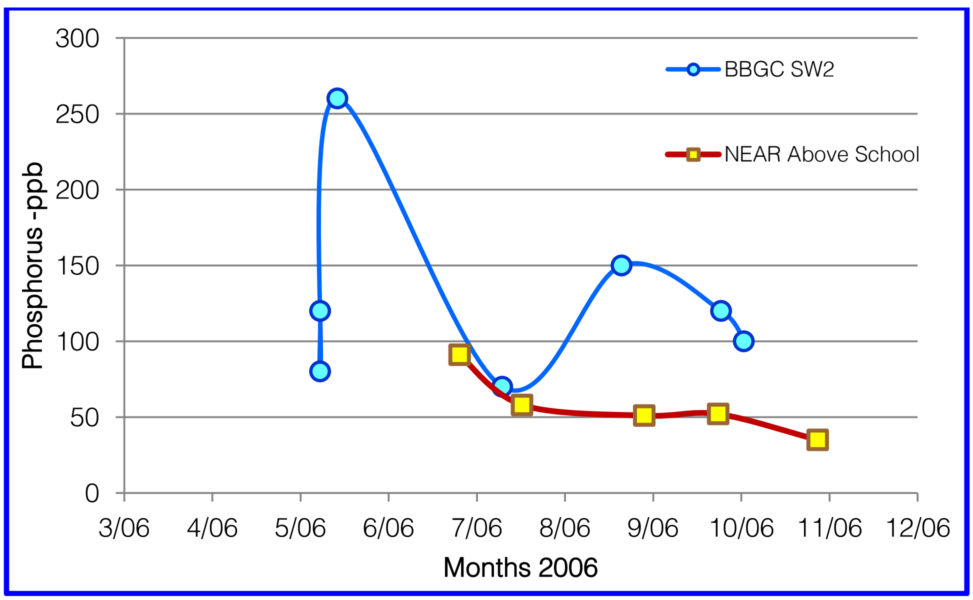


Figure 16 – Phosphorus concentrations at Bull's Bridge Golf Course water quality site SW2 and NEAR water quality site Above School during 2006

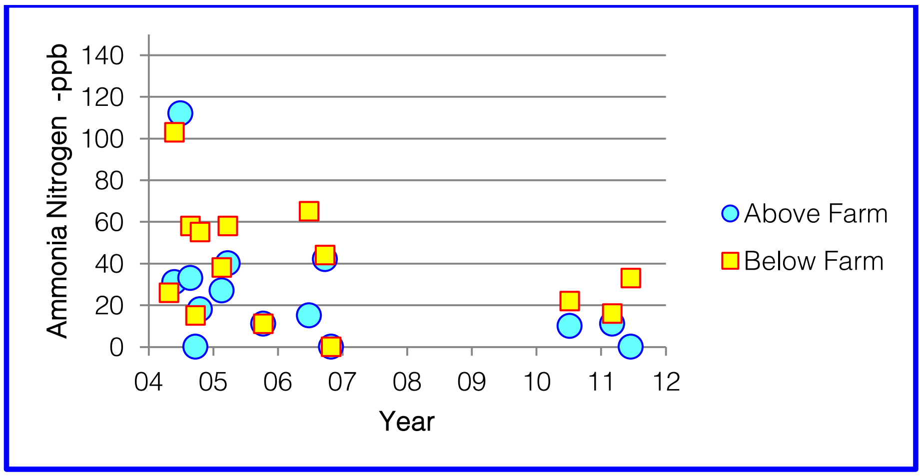


Nitrogen

Ammonia Nitrogen

The ammonia concentrations in the northern stream appear to have decreased at the Below Farm station (**Figure 17**). Prior data from Below Farm station was as high as 110 ppb, while recent, 2010 data shows ammonia was below 40 ppb in all samples. Although there is still ammonia in the inlet waters, this may be due to extensive wetlands of the northern inlet. It is possible that ammonium levels of 20-40 ppb are background for the inlet.

Figure 17 – Ammonia nitrogen concentrations in northern inlet

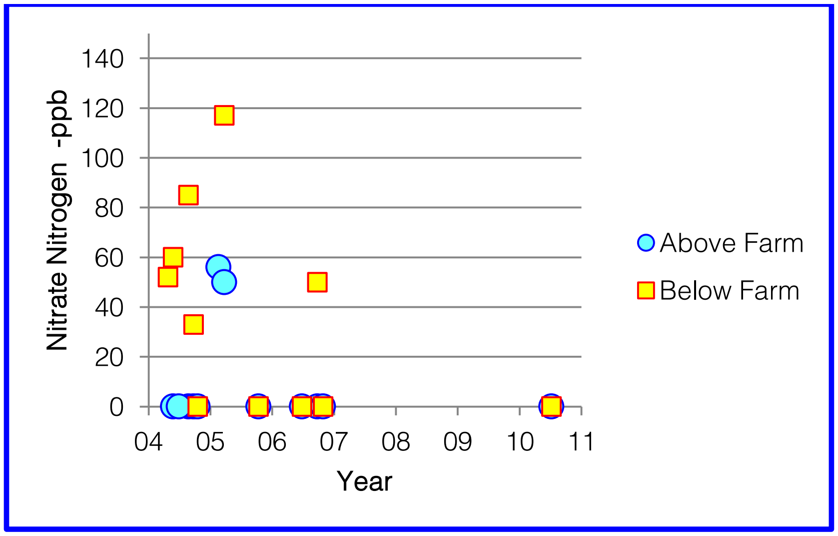


Ammonia was low or below detection in all southern inlet samples during this and prior studies.

Nitrate Nitrogen

Nitrate was low or below detection at the Above Farm Station in samples collected in 2010 (**Figure 18**). Prior sampling, (2004-2006), showed that nitrate concentrations at the Below Farm station were as high as 120 ppb. All data collected from either northern inlet station had nitrate concentrations close to the level of detection. This indicates that nitrate levels in the northern inlet have decreased because the Farm is no longer contributing nitrate to the inlet.

Figure 18 – Nitrate concentrations in northern inlet



Nitrate in the southern stream has been higher at the upper station than at the lower station (Figure 19). Data shows that average concentration at the upper station was 572 ppb, as opposed to 168 ppb at the lower station.

Figure 19 – Nitrate concentrations in southern inlet

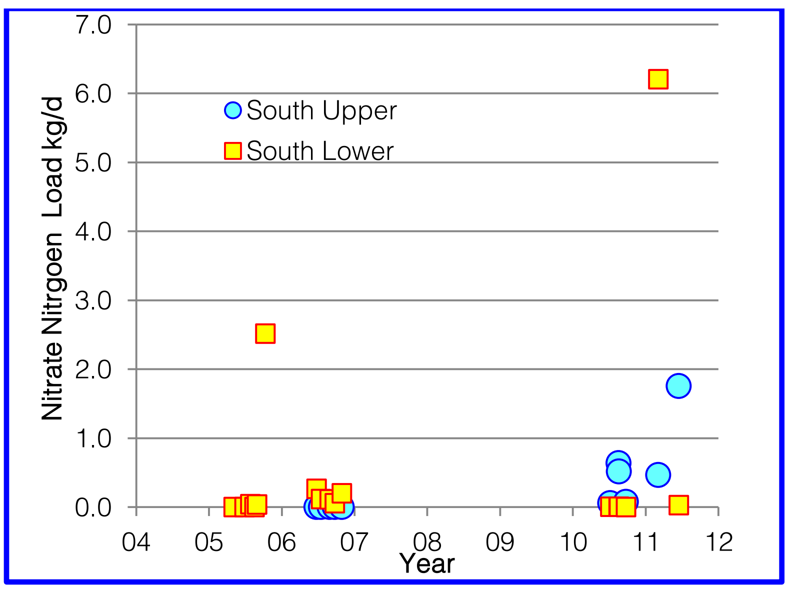
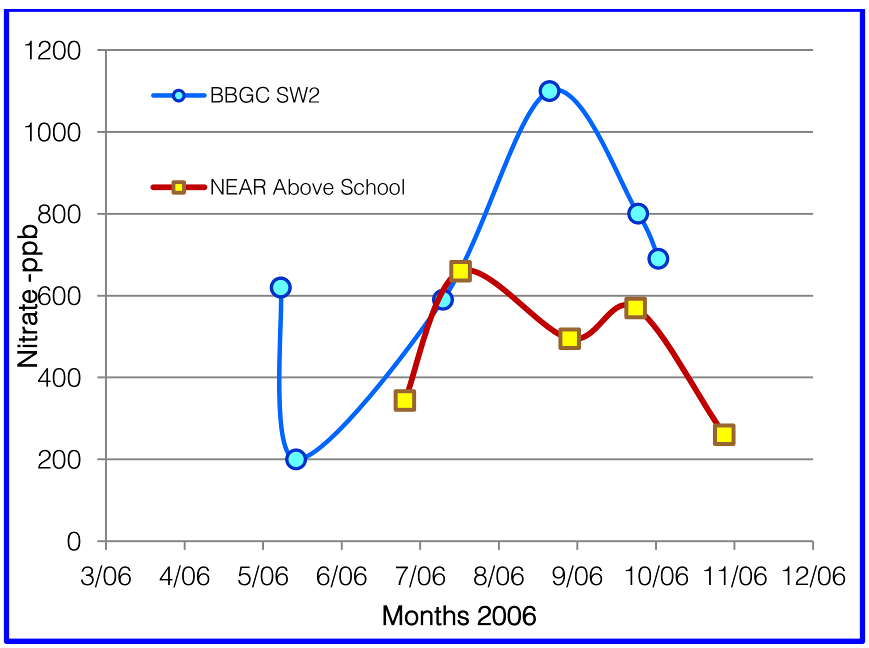


Figure 20 shows nitrate concentrations from the SW2 site between March 2002 and December 2010. Concentrations range from 50 ppb to 1300 ppb. The average concentration, 602 ppb, represents a significant source of eutrophication to downstream waters including Hatch Pond. **Figure 21** shows stream phosphorus data when sampling overlapped in 2006. Data suggests

that concentration results detected during NEAR survey were similar to results from the golf course.

Figure 20 - Nitrate concentrations in stream water leaving the course at SW2

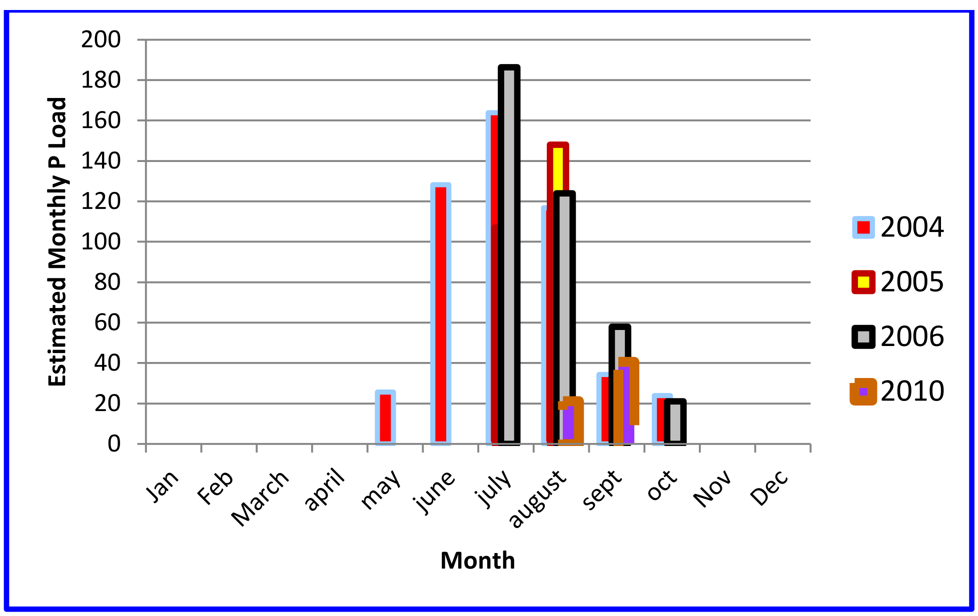
Figure 21 – Nitrate concentrations at Bull's Bridge Golf Course water quality site SW2 and NEAR water quality site Above School during 2006



Nutrient Loading

Not enough data was collected during the last few years to estimate phosphorus loads to the lake using methods presented in NEAR 2006. Instead, a novel way of estimating phosphorus loading to Hatch Pond is presented in **Figure 22**. The chart shows estimated load as difference between expected concentrations due to dilution and observed in-lake concentrations. The lake has an theoretical flushing rate of about 80% of the total volume each month. So each month about 80% of the phosphorus should be lost over the dam if no new phosphorus replaced it. If all of the new water entering the lake contained no phosphorus, there would be an expected decay of the phosphorus concentration each month. By comparing the expected concentration after 80% dilution with observed concentrations, estimates of new phosphorus entering the lake were made. The chart in **Figure 22** shows that during June, July, and August observed concentrations of phosphorus exceed expected diluted concentrations, suggesting that monthly load of new phosphorus was between 120 and 180 kg P/month. Concentration changes in April, May, September and October were much lower, suggesting that phosphorus load during those months was between 20 and 40 kg P/month. Lake phosphorous concentrations in 2010 show monthly phosphorus load to the lake may have been significantly lower in 2010 than prior years.

Figure 22 - Hatch Pond phosphorus loading kg P / month



SUMMARY

The following list of threats and impairments to the water quality of Hatch Pond were given in the NEAR 2006 report. Hatch Pond was found to face five serious problems at that time:

1) agricultural loading from the northern inlet
2) storm water runoff in the southern inlet
3) oxygen depletion and associated internal nutrient recycling within the lake
4) invasive aquatic plant infestation within the lake and
5) accumulating sediments, either organic or inorganic, causing filling

1) Agricultural loading from the northern inlet

New data and recent land-use changes suggest that this load has been reduced to near zero. In 2010 the dairy farm at the north end of the lake was sold and removed. The property became part of the South Kent School. All aspects of the farm except for the farm house were removed. During field visits to collect storm water samples in 2011, the stream running through the property was dry.

The northern inlet, comprising discharge from the farm and sources above the farm such as Leonard's Pond, have shown inconsistent trends, making it difficult to determine if phosphorus levels have decreased. However, little nitrate and ammonia was found in the northern inlet samples in 2010 and 2011.

Data from 2010 and 2011 indicate that nutrient loading from farm is now very low to nonexistent. However, under certain future weather conditions, sequestered nutrients may be released to the stream running through the property. The wetland where the farm discharge emptied into may release nutrients into the northern inlet for several years. It is possible that excess ammonia and nitrate have washed through the wetland. Total nitrogen showed no conclusive decrease in levels.

In 2010, the bottom phosphorus concentration was 30% of that seen in prior years, and estimated summer phosphorus mass was about 50% of that calculated for prior year's (2004-2006). In 2010 lake phosphorus concentration did not steadily increase, as was common in prior years, suggesting the loading rate of new phosphorus to the lake was lower that year.

2) Storm water runoff in the southern inlet

Phosphorus in the southern inlet has exceeded 20 ppb in all samples, and concentrations between 50-100 ppb were common, indicating that southern inlet phosphorus is high enough to affect the lake condition. Phosphorus was generally higher at the up-stream station.

Nitrate levels in the southern stream were also high, again generally higher at the up-stream station. Total nitrogen at the lower station often showed decreases, suggesting that the large pond at the entrance to the South Kent School is accumulating nitrogen, and phosphorus

3) Oxygen depletion and associated internal nutrient recycling within the lake

Anoxic water was found to reach about the same level in the lake during the summer as prior years.

4) Invasive aquatic plant infestation in the lake

Aquatic plants showed two possible changes, neither good. First, several native plant species noted in earlier surveys were not found in 2010. This suggests extensive beds of thick milfoil canopy may have significantly repressed the growth of these native species. Second, milfoil was found to reach a slightly shallower depth than that found in prior surveys. In 2010 milfoil beds extended to about 7.8 feet of water, depth as opposed to 8 and 9 feet found during prior surveys.

5) Accumulating sediments, either organic or inorganic, causing filling

Water depths were measured at station 1 location on the first field visit in 2010. 28 depth soundings were made to locate deepest water. The deepest of all the measurements was 15.5 feet, while the mean was 13.7 feet. These depths agree with maximums of 14 and 15 feet found during earlier visits (2004-2006). The similarity of maximum water depths noted between 2004-2010, a span of 6 years, suggests the lake filling rate made in 2006 report was overestimated. The similarity of water depth over the last 6 years suggest that all filling had already occurred between the depth contour map made in the 1950's and the one made in 2004, with no new filling occurring since 2004.

Conclusions

Lake sampling in 2010 found that Hatch Pond remains a highly eutrophic water body. Although nutrient levels may have decreased in the northern inlet, the level of phosphorus in the lake remained highly eutrophic (see Table 1), sufficient to cause poor water clarity and continued loss of dissolved oxygen in deeper waters. Preliminary estimates of phosphorus load to the lake show there may have been a possible decrease of new phosphorus load during the summer months. However, because 2010 phosphorus concentrations in the lake were still 2 to 3 times higher than necessary to realize substantial improvements, the existing load should be considered too high. Improving trophic condition of Hatch Pond would require a decrease of in-lake phosphorus to less than 20 ppb. It is not clear how much of the total load to the lake is caused by watershed sources and which fraction is caused by internal recycling.

Aquatic plant surveys showed that the invasive non-native plant Eurasian milfoil remains the dominant submersed aquatic plant in the lake, although curly-leaf pondweed may also be problematic in the spring. Significant loss of littoral habitat has occurred due to proliferation of the Eurasian milfoil so that other submersed aquatic plant species have been lost or are now very rare.

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