Pond Water Quality Assessment of 23 Ponds in the Town of Barnstable using Pond and Lake Stewardship (PALS) Protocols

Dr. David R. Schlezinger,
Dr. Brian L. Howes
Ms. Sara Sampieri Horvet

Coastal Systems Program
School of Marine Science and Technology - UMD

February 17, 2017

Overview:
The Coastal Systems Program (CSP) within the University of Massachusetts-Dartmouth (UMD) School for Marine Science and Technology (SMAST) has developed and implemented water quality monitoring programs throughout all of southeastern Massachusetts and the Islands including estuarine specific programs in the majority of the estuaries as well as monitoring in the lakes/ponds of Cape Cod, Martha's Vineyard and Nantucket Islands. The long term water quality monitoring undertaken across the region was designed to collect necessary baseline nutrient related water quality data in freshwater systems and for determining estuarine specific nitrogen thresholds as well as tracking restoration and management "success" in each estuary relative to the established MassDEP/USEPA TMDL1. In addition, CSP scientists developed and implemented the Pond and Lake Stewardship (PALS) Program across Cape Cod whereby PALS Snapshots of water quality take place in 150 to 180 Cape Cod ponds each year. Over the past 15 years (2001-2016), these data have been collected through a network of town-based volunteers with laboratory services provided by the SMAST Coastal Systems Program Analytical Facility. More than 500 pond samples per year are analyzed following a consistent pond sampling protocol developed by CSP scientists. These data have been used to support larger more detailed assessments and modeling efforts to determine site-specific management plans for numerous

[1] TMDL or Total Maximum Daily Load is the regulatory requirement for restoration of an aquatic system under the Clean Water Act as proscribed by MassDEP and USEPA.

lakes and ponds, as well as to establish a long-term baseline of Cape Cod Ponds. This effort has recently expanded to include more than 30 lakes and ponds off-Cape (e.g. Plymouth, Carver, Wareham), that have eutrophication concerns related to phosphorus enrichment.

The sampling was undertaken by the CSP scientific staff and trained volunteers, where appropriate. All sampling and analysis was consistent with the protocols established for the Cape Cod Pond and Lakes Stewardship Program (PALS) and results from effort are directly cross comparable to previous PALS water quality snapshots completed in previous years.

Pond Sampling and Analysis:
This work included a total of 23 ponds listed below.

Mill Pond	West Barnstable,	13.83 ac.
Lamson Pond	Barnstable,	13.27 ac.
Fawcett's Pond	Hyannis,	12.77 ac.
Coleman Pond	Osterville,	9.74 ac.
Flowing Pond	Centerville,	8.61 ac.
Israel Pond	Barnstable,	8.45 ac.
Patty's Pond	Marstons Mills,	8.39 ac.
Simmon's Pond	Hyannis,	8.04 ac.
Flintrock Pond	Barnstable,	6.72 ac.
Upper Gate Pond	Hyannis,	6.22 ac.
Mill Pond	Centerville,	5.55 ac.
Sam's Pond	Osterville,	5.46 ac.
108 Pond, BA-372	West Barnstable,	5.27 ac.
Weathervane Pond	Marstons Mills,	4.98 ac.
Ben's Pond	Hyannis,	4.97 ac.
North Pond	Osterville,	4.85 ac.
Lewis Pond	Hyannis,	4.09 ac.
Fresh Hole Pond	Hyannis,	4.67 ac.
286 Pond, BA-799	Hyannis,	3.78 ac.
Campground Pond	Barnstable,	3.69 ac.
106 Pond, BA-382	West Barnstable,	3.31 ac.
Three Pond	Centerville,	3.17 ac.
Flax Pond	Barnstable,	3.16 ac.

Each pond received one sampling event during which field dissolved oxygen and temperature profiles and Secchi clarity readings were collected at the deepest point in each selected pond or lake in either August or September. All sampling was completed between August 15 – September 30. Samples were collected between 9 AM and 3 PM to maximize phytoplankton activity. The sampling period was selected in order to sample what is likely to be the worst nutrient related water quality conditions in the ponds. Individual sampling dates within the sampling period were based primarily on weather conditions (avoiding major storm events).

Additionally water color, weather and plant presence (emerged macrophyte coverage on percentage of pond surface area basis) was recorded in the field data sheets. For ponds for which there was no bathymetric map, the CSP science team conducted a moderately detailed bathymetric survey to locate the deepest point in the pond and use the field data to produce a bathymetric map.

Water quality samples were collected at a minimum of two depths in each pond (a 0.5 /surface sample and a sample 1 m off the bottom) and each pond had an additional QA sample. If the pond was less than 1.5 meters deep, two samples at the 0.5 meters depth were collected. In ponds deeper than 10 meters, a third sample at a 3 meter depth was added, and in ponds deeper than 11 meters, a fourth sample was added at a 9 meter depth. GPS coordinates were recorded for each pond sampling location. A maximum of 5 samples (4 depths+1 QA dup) were be collected at any pond.

The sampling protocol required locating the deepest location on the pond, collection of dissolved oxygen and temperature profiles (at 1 m depth intervals) at that location, measuring Secchi transparency, and collecting water quality samples at standardized depths. Dissolved oxygen and temperature profile readings were recorded using a YSI-55 meter (or similar) calibrated prior to each sampling event. Membranes or cartridges on the meter probe were changed according to recommendations in the meter operations manual. Sampling location GPS coordinates were determined for those ponds without prior sampling and past coordinates were followed for those stations where coordinates have been determined previously.

All water column samples for water quality analysis were collected with Niskin samplers and sub-samples were transferred to dark HDPE acid-washed 1 liter bottles and transported in coolers with ice packs (4°C) to the Coastal Systems Analytical Facility at the School for Marine Science and Technology (SMAST), University of Massachusetts Dartmouth in New Bedford which has a state-approved Quality Assurance Plan, and completes all water quality laboratory analyses for the Massachusetts Estuaries Project and the Cape Cod Pond and Lake Snapshots (approximately 150 ponds sampled per year). Chain of Custody, sample handling and transport followed procedures developed during SMAST/CSP's 15 years of Cape Cod Pond and Lake Snapshots. Samples were analyzed for: pH (stnd units), Total Phosphorus (µM or mg/L), Total Nitrogen (µM or mg/L), Alkalinity (mg $CaCO_3$/L), Chlorophyll a (µg/L), Phaeophytin (µg/L), Salinity (ppt).

Field Pondwater Sampling and Bathymetry:

A field team comprised of a water quality technical associate and an instrument specialist (bathymetry) deployed to each pond using guidance on access provided by the Town. For ponds that have a bathymetric map, the deepest part of the pond (the targeted sampling site) was located using the map and an acoustic depth finder. However, most of the ponds did not have available bathymetric information. Given the state-of-the-art bathymetric survey tools available within CSP-SMAST, CSP conducted low-moderate level bathymetric surveys of these ponds. Bathymetry located the deepest part of the pond as well as providing information needed for management, including key aspects such as the volume of the pond and how contaminants and water move within and through the pond. In addition, recent regulatory agency deliberations

have identified plant and freshwater mussel surveys as important considerations in review of pond management plans.

For each pond 3-4 cross pond transects were conducted, so as to cover as much of the pond bottom as possible. Surveys were referenced to a common datum (State Plane Mainland (m); NAVD88). The bathymetry surveys were performed using a shallow draft boat, capable of traversing the shallowest regions of each pond. Both parallel and crossing transects were assayed using a field portable bathymetric data acquisition system. A fathometer with depth resolution to 0.10 ft. was used in conjunction with a differential geographic positioning system (DGPS) or Real Time Kinetic system (RTK). This system records depth as a function of survey location. An integrated survey software package was used to record depth and position data simultaneously to a laptop computer.

Positions were recorded in Massachusetts State Plane 1983 coordinate system (X-Y) at an approximate rate of one value every two seconds. Depending upon boat speed during the survey (estimated at 3-5 knots), position measurements were made approximately every 10-15 feet along each survey line. Depth values were recorded continuously (approximately every 0.5 seconds, or every 3 feet along the survey line). While this data was used to locate the deepest portion of each pond for sampling, CSP-SMAST also used this data to construct bathymetric maps for each pond where bathymetry did not currently exist.

Determination of Pond Health or Trophic Status:
Previous work on Cape Cod ponds (Eichner, 2003) has used the trophic classification developed by Carlson (1977). The Carlson trophic state index (TSI) is used here for the sake of consistency and comparability. Using easily measured proxies of total biomass, Total Phosphorus, Chlorophyll a and Secchi depth, ecosystems are placed on a scale from 1-100 (Carlson and Simpson, 1996). The equations used and the associated pond characteristics can be found in Table 1. Individual TSI values are provided for each pond as well as means and standard deviations. Further explanation and limitations to using trophic indices can be found in the Cape Cod Pond Atlas (Eichner, 2003).

Table 3. – Carlson Trophic State Index (TSI)					
TSI Calculations					
TSI(SD) = 60 - 14.41 ln(SD)				SD = Secchi disk depth (meters)	
TSI(CHL) = 9.81 ln(CHL) + 30.6				CHL = Chlorophyll a concentration (µg/L)	
TSI(TP) = 14.42 ln(TP) + 4.15				TP = Total phosphorus concentration (µg/L)	
TSI values and likely pond attributes					
TSI Values	Chl a (µg/L)	SD (m)	TP (µg/L)	Attributes	Fisheries & Recreation
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	Salmonid fisheries dominate
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallower lakes may become anoxic	Salmonid fisheries in deep lakes only
40-50	2.6-7.3	4-2	12-24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer	Hypolimnetic anoxia results in loss of salmonids.
50-60	7.3-20	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	Warm-water fisheries only. Bass may dominate.
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70-80	56-155	0.25-0.5	96-192	Hypereutrophy: (light limited productivity). Dense algae and macrophytes	
>80	>155	<0.25	192-384	Algal scums, few macrophytes	Rough fish dominate; summer fish kills possible
after Carlson and Simpson (1996); Carlson TSI developed in algal dominated, northern temperate lakes					

Caveats to the 2016 Sampling:

The Summer of 2016 represented a severe drought for most of eastern Massachusetts. Water levels in lakes, ponds and reservoirs throughout the state were far below normal. On Cape Cod high water level marks were typically more than a meter above observed water lines. Low water levels made some ponds inaccessible, impossible to navigate, or in some cases the ponds had entirely dried up. Every attempt was made to collect data when possible. In the case of Lewis Pond, Uppergate Pond and 108 Pond there simply was not enough water to sample. In the cases of 286 Pond, Lamsons Pond, and Flowing Pond there was sufficient water for sample collection,

but insufficient water to support water craft required for a proper bathymetric survey. Upon discussion with the program administrators and steering committee members, we hope to form a plan to sample and survey the remaining ponds when conditions are favorable to produce good data that most benefits the aims and objectives of the project as a whole.

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography.* 22: 361-369.
Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society. 96 pp. (summarized at http://dipin.kent.edu/tsi.htm#A).
Eichner, E.M. et al. 2003. Cape Cod Pond and Lake Atlas Project 2000-02. Cape Cod Commission. Barnstable, MA. 50pp.

Mill Pond

Barnstable GIS ID: 105
CCC GIS ID: BA-391

Area (acres): 13.83
Bathymetry: CSP, 2016
Maximum Depth (m): 0.9
Lake Association:

PALS Sampling	9/22/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.9 m		
Total Depth	0.9 m		
Surface pH	6.88	6.5 – 8.3	MassDEP
Deepest DO	10.76 mg/L	5.0 mg/L	MassDEP
Shallow temp	24.9°C	28.3°C	MassDEP
Surface Chlorophyll-a	1.68 µg/L	1.7 µg/L	CCC
Surface TP	27.96 µg/L	10 µg/L	CCC
Surface TN	0.46 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

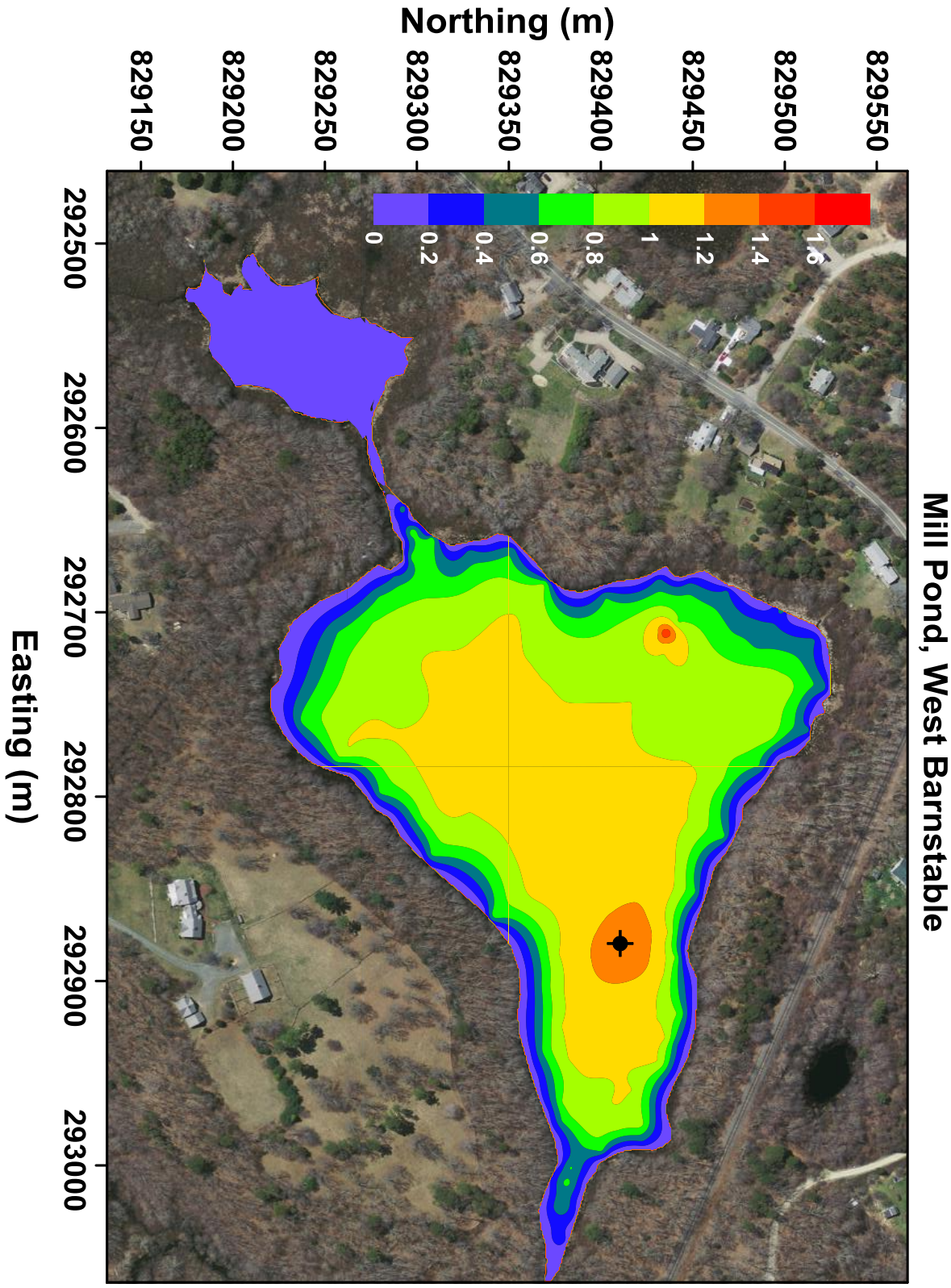
OVERVIEW

Mill Pond is located in West Barnstable, south of rail lines and east of Maple Street. Shoreline development is fairly sparse with five houses around its shoreline with most of these located along the western shore. There is no formal public access, though a winding trail at the end of Gemini Drive is used by neighbors as a landing for small fishing craft.

WATER QUALITY

Mill Pond is shallow with sunlight reaching the bottom at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a stratified water column with increasing DO near the sediments; surface saturation level was 89%, while 0.9 m depth level was 130%. A thick layer, >50cm in places, of macrophytes on the bottom provided an explanation of the inverted DO profile. Calm, cloudless conditions during sampling and the previous 48 hours likely contributed to the observed stratification. Total phosphorus concentration was well above the ecoregion threshold, while the chlorophyll-a concentration was just below its threshold. Shallow total nitrogen concentration was above its threshold.

Based on the available information, Mill Pond is mesotrophic according to the average TSI of 46±8.9 (P=52; Chl=40; Secchi=NA), however, the extensive coverage of macrophytes within this pond suggests eutrophic may be a better classification. Additional monitoring would be required to determine the extent of impairment.



Sampling Location (WGS84): N 41.709, W 70.384
(NAD83): E 29881, N 829411

Lamson Pond

Barnstable GIS ID: 084
CCC GIS ID: BA-596

Area (acres): 13.27
Bathymetry:
Maximum Depth (m): 0.65
Lake Association:

PALS Sampling	9/8/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.65 m		
Total Depth	0.65 m		
Surface pH	4.78	6.5 – 8.3	MassDEP
Deepest DO	7.86	5.0 mg/L	MassDEP
Shallow temp	22.4	28.3°C	MassDEP
Surface Chlorophyll-a	41.24 µg/L	1.7 µg/L	CCC
Surface TP	25.42 µg/L	10 µg/L	CCC
Surface TN	1.89 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

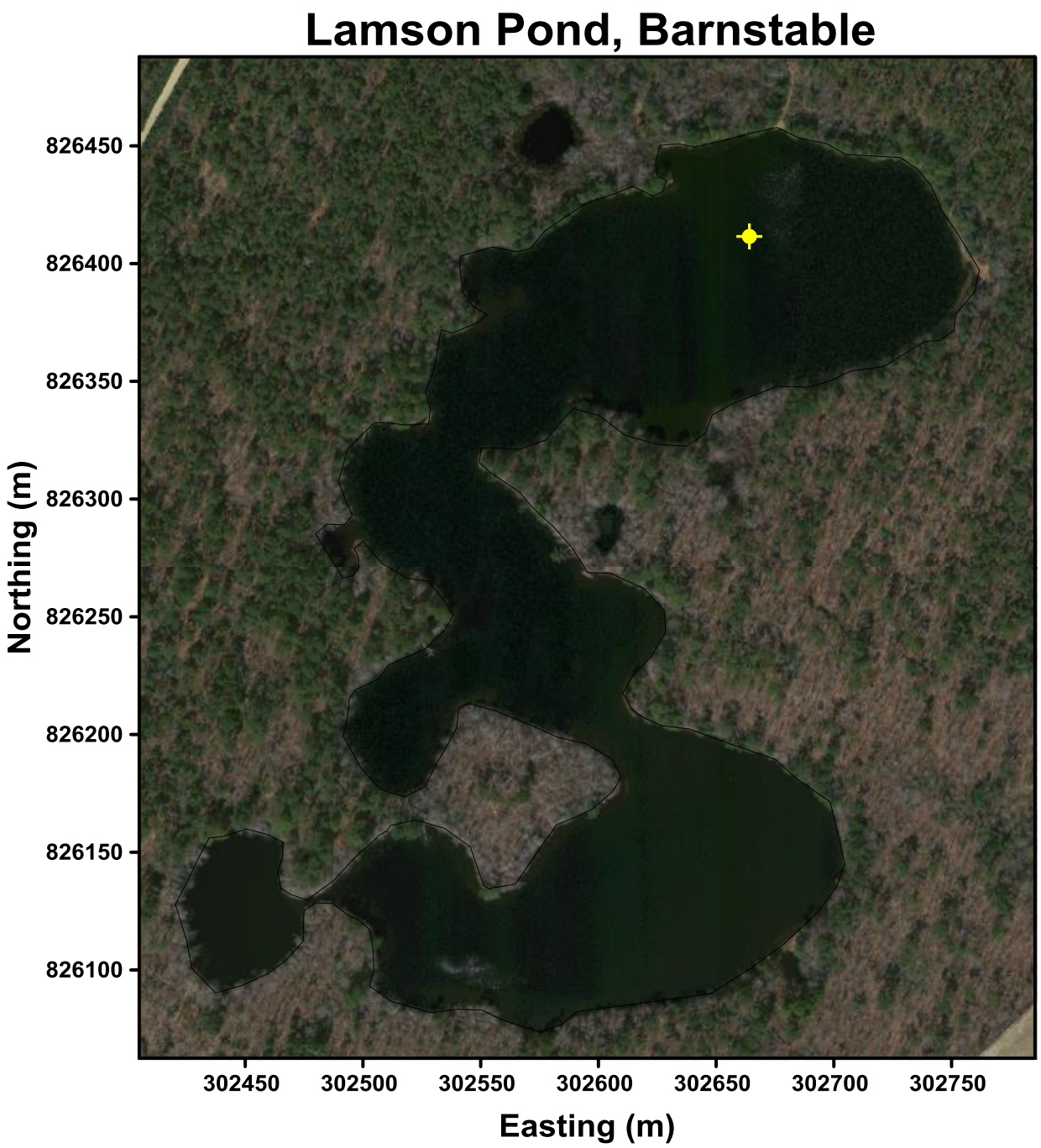
OVERVIEW

Lamson Pond is located in Barnstable, west of Campground Pond There is no shoreline development within the Fish and Game Wildlife conservation area. There is public access from Mary Dunn Road near Israel Pond..

WATER QUALITY

Lamson Pond was very shallow, less than 20cm. throughout most of the pond at the time of sampling in 2016. Reliable temperature and dissolved oxygen readings were impossible due to the shallow water and will need to be performed at a later date when water levels are higher. All nutrient neasures of water quality were well in excess of the ecoregion threshold. Though every care was taken, it is possible that the results reflect some resuspension of sediments which occurred while reaching open water. Sampling in the Spring or during normal PALS sampling in late summer will be required.

Based on the available information, Lamson Pond is eutrophic according to the average TSI of 60±13.3 (P=51; Chl=70; Secchi=NA).



Sampling Location (WGS84): N 41.6813, W 70.2672
(NAD83): E 302645, N 826411

Fawcett's Pond

Barnstable GIS ID: 057
CCC GIS ID: BA-748

Area (acres): 12.77
Bathymetry: CSP, 2016
Maximum Depth (m): 1.2
Lake Association:

PALS Sampling	8/30/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	1.20 m		
Total Depth	1.20 m		
Surface pH	7.38	6.5 – 8.3	MassDEP
Deepest DO	8.06 mg/L	5.0 mg/L	MassDEP
Shallow temp	27.1°C	28.3°C	MassDEP
Surface Chlorophyll-a	3.35 µg/L	1.7 µg/L	CCC
Surface TP	30.51 µg/L	10 µg/L	CCC
Surface TN	0.96 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

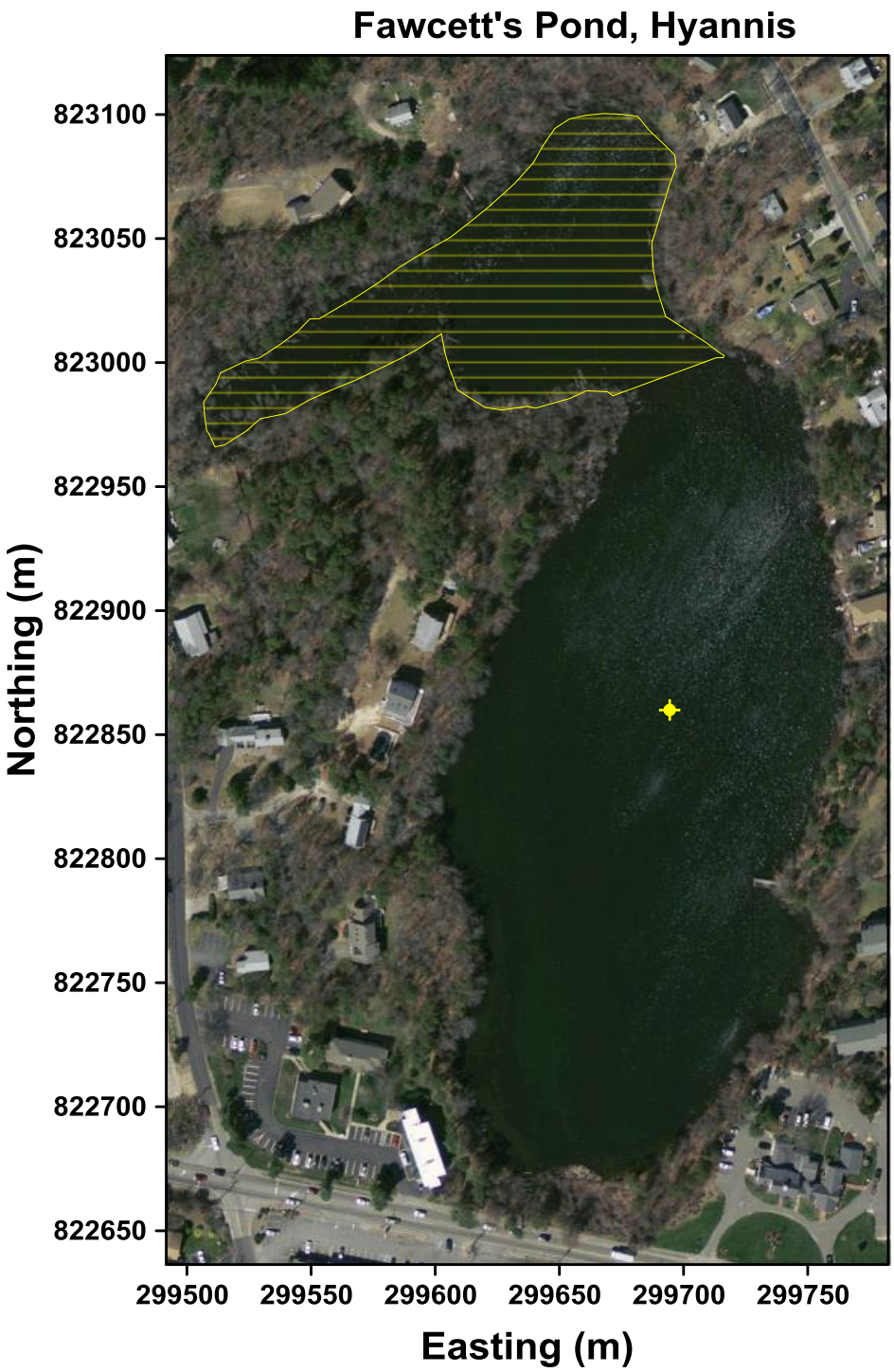
OVERVIEW

Fawcett's Pond is located in Hyannis just north of West Main Street and west of Aunt Bettys Pond. Shoreline development is extensive with commercial properties to the south along the road frontage and homes along the eastern and western shoreline. At the time of sampling the northern part of the pond was inaccessible as a result of emergent grasses and woody plants. Best access is through private property. Access from West Main Street is not recommended due to traffic hazards and the presence of a homeless encampment along the shoreline.

WATER QUALITY

Fawcett's Pond is shallow with light penetration reaching the bottom. Temperatures and dissolved oxygen readings showed a well-mixed water column near saturation throughout. Total phosphorus d total nitrogen concentrations were two to three times the ecoregion threshold. Periodic inputs of nutrients from road runoff and other impermeable surfaces are likely to have a large impact on the pond.

Based on the available information, Fawcett's Pond is mesotrophic according to the average TSI of 49±6.6 (P=53; Chl=44; Secchi=NA). Most of the measures indicate that additional monitoring is warranted. Additional monitoring would be required to determine extent of impairment as well as the impact of extensive macrophytes. Bathymetry data collected during 2016 were suspect as apparent position was seen to change abruptly.



Sampling Location (WGS84): N 41.6497, W 70.3032
(NAD83): E 299695, N 822860

Coleman Pond

Barnstable GIS ID: 008
CCC GIS ID: BA-819

Area (acres): 9.74
Bathymetry: CSP, 2016
Maximum Depth (m): 3.85
Lake Association:

PALS Sampling	9/13/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	2.50 m		
Total Depth	3.85 m		
Surface pH	6.20	6.5 – 8.3	MassDEP
Deepest DO	7.23 mg/L	5.0 mg/L	MassDEP
Shallow temp	25.0°C	28.3°C	MassDEP
Surface Chlorophyll-a	2.08 µg/L	1.7 µg/L	CCC
Surface TP	16.95 µg/L	10 µg/L	CCC
Surface TN	0.48 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	1.1		

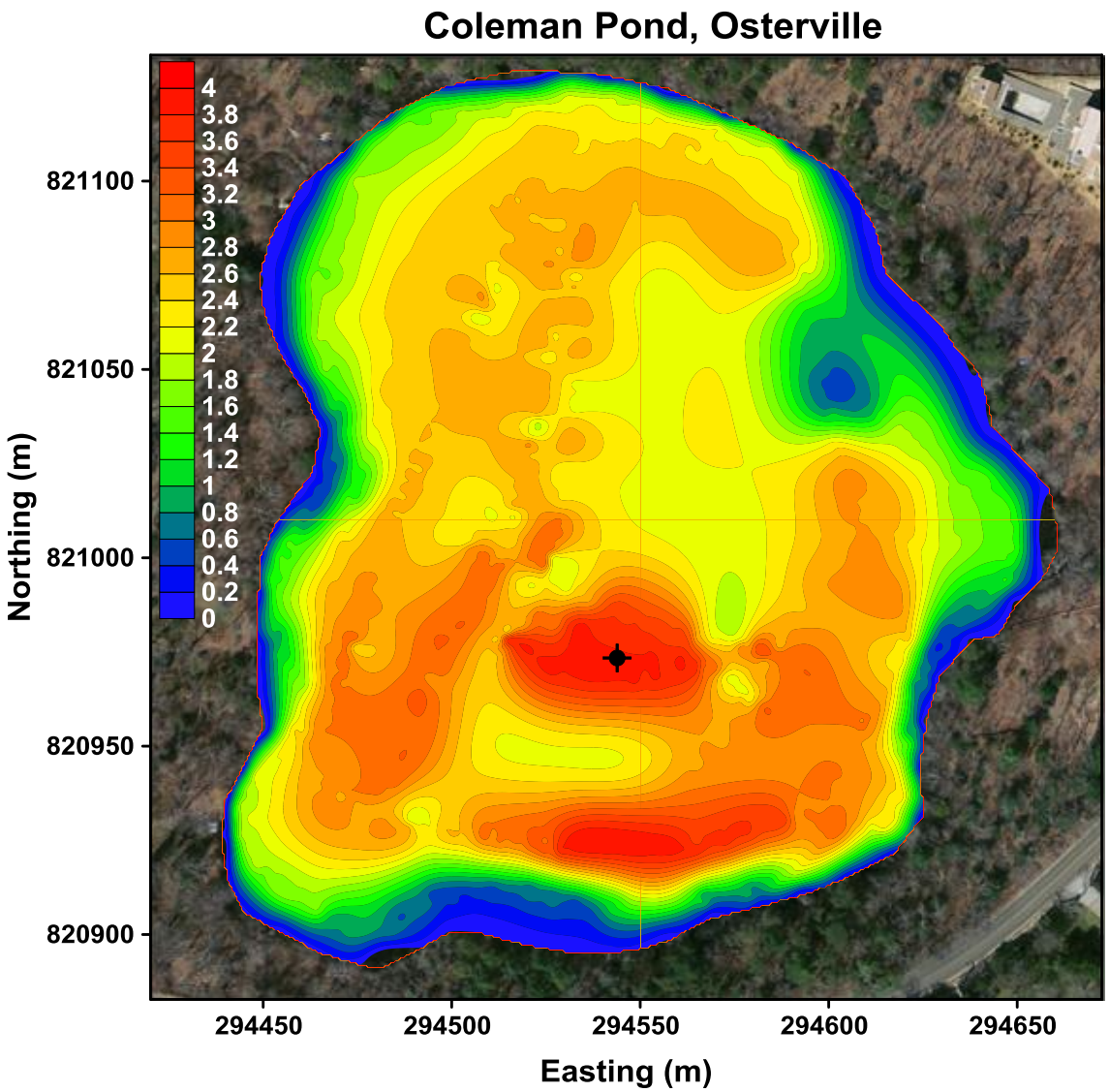
OVERVIEW

Coleman Pond is located in Osterville, north of Centerville River and east of Bumpus River. Shoreline development is fairly sparse with ten houses around its shoreline with most of these located along the western shore. There is no formal public access.

WATER QUALITY

Coleman Pond is relatively shallow with only a little loss in clarity at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a mixed water column with a slight increase in DO near the sediments due to rooted macrophytes; DO saturation levels were close to 85% throughout the water column. Shallow total phosphorus, total nitrogen and chlorophyll concentrations were just above the ecoregion threshold.

Based on the available information, Coleman Pond is mesotrophic according to the average TSI of 45±2.9 (P=45; Chl=41; Secchi=47).



Sampling Location (WGS84): N 41.633, W 70.365
(NAD83): E 294543, N 820972

Flowing Pond

Barnstable GIS ID: 029
CCC GIS ID: BA-733

Area (acres): 8.61
Bathymetry:
Maximum Depth (m): 0.4
Lake Association:

PALS Sampling	9/15/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.40 m		
Total Depth	0.40 m		
Surface pH	-	6.5 – 8.3	MassDEP
Deepest DO	4.25 mg/L	5.0 mg/L	MassDEP
Shallow temp	19.4°C	28.3°C	MassDEP
Surface Chlorophyll-a	- µg/L	1.7 µg/L	CCC
Surface TP	12.75 µg/L	10 µg/L	CCC
Surface TN	0.91 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

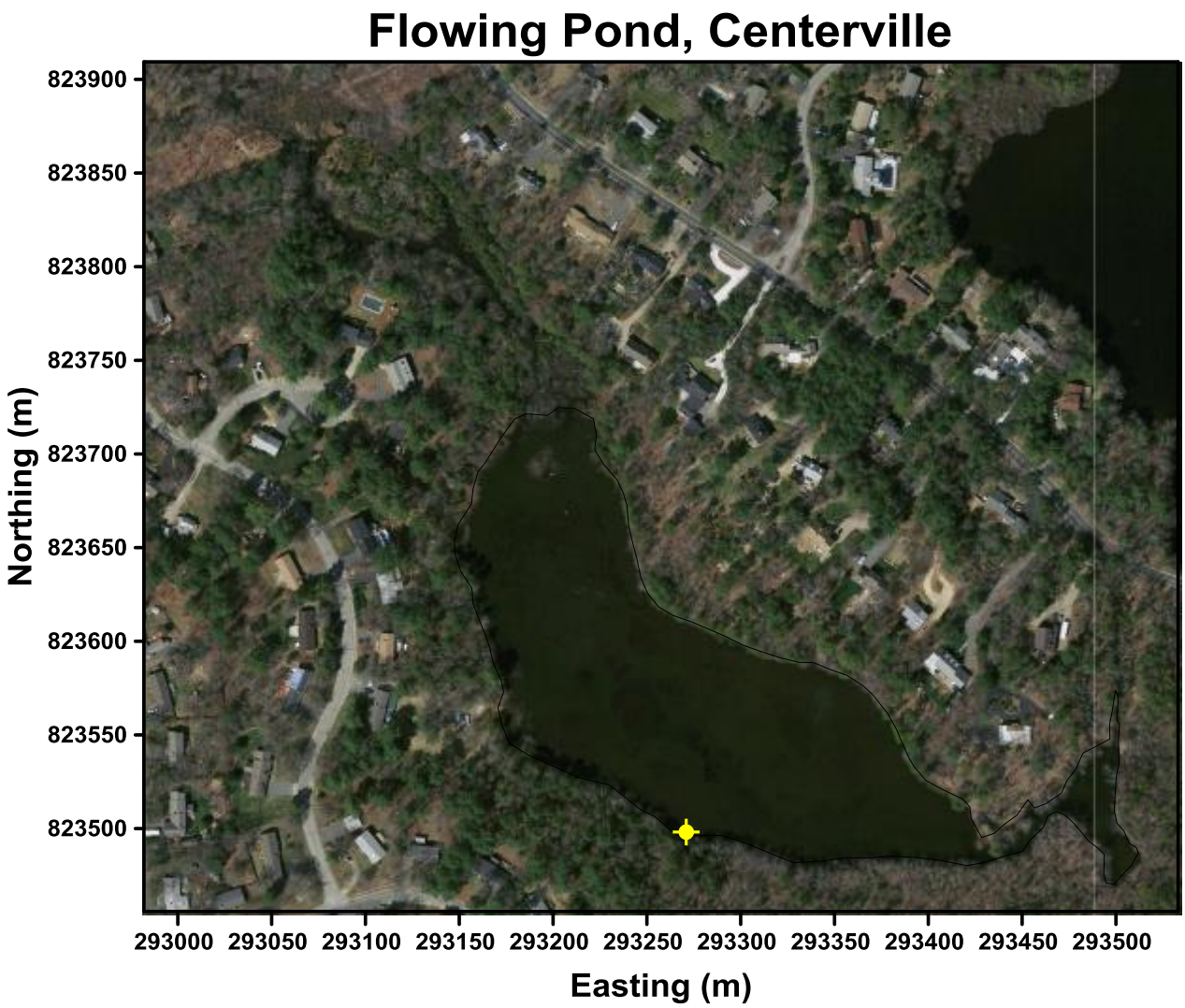
OVERVIEW

Flowing Pond is located in Centerville south of Lumbert Pond. Input from the pond comes from a small stream connecting it to Lumbert Pond. Water flow leaves the pond through a control structure where the sample was taken leaving most of the pond stagnant. Flowing Pond appears to be a holding pond for a long abandoned cranberry farm. There is formal public access from Lumbert Hill Road.

WATER QUALITY

Flowing Pond is very shallow with deepest point at the control structure. Temperatures and dissolved oxygen readings taken in flowing water at the control structure was at less than 50% saturation indicating extensive DO uptake within the pond system. Total phosphorus and total nitrogen concentrations were well above the ecoregion threshold. Additional sampling will be undertaken or during the next round of PALS sampling or in the spring in order to obtain a full suite of analyses for the pond. If water levels have risen bathymetry will also be attempted; at the time of the 2016 sampling shallow water depths, emergent grasses and snags made maneuverability in even the smallest craft impossible. Additionally, tree coverage made GPS positioning unreliable.

Based on the available information, Flowing Pond is mesotrophic according to the average TSI of 41±NA (P=41; Chl=NA; Secchi=NA). Additional measures will be required to make a more robust assessment.



Sampling Location (WGS84): N 41.6562, W 70.308
(NAD83): E 293271, N 823498

Israels Pond

Barnstable GIS ID: 094
CCC GIS ID: BA-585

Area (acres): 8.45
Bathymetry: IEP, 1990
Maximum Depth (m): 0.45
Lake Association:

PALS Sampling	9/8/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.45 m		
Total Depth	0.45 m		
Surface pH	4.78	6.5 – 8.3	MassDEP
Deepest DO	-	5.0 mg/L	MassDEP
Shallow temp	-	28.3°C	MassDEP
Surface Chlorophyll-a	18.96 µg/L	1.7 µg/L	CCC
Surface TP	21.19 µg/L	10 µg/L	CCC
Surface TN	1.01 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

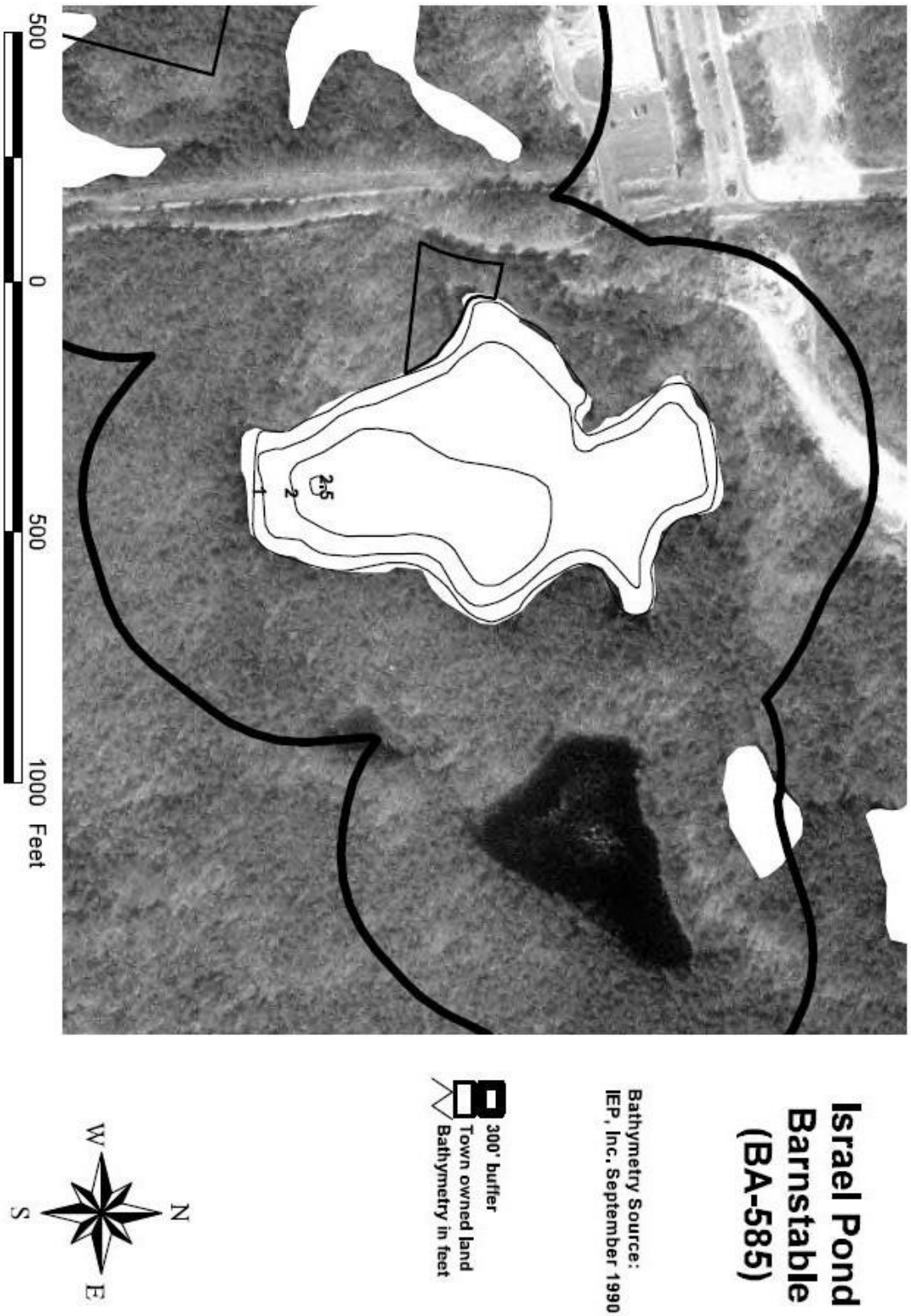
OVERVIEW

Israel Pond is located in Barnstable, west of Mary Dunn Way. There is no shoreline development since the pond is located on conservation land. Access by foot from Mary Dunn Way.

WATER QUALITY

Israel Pond was very shallow. Extensive muddy shoreline was covered with water lilies and other rooted SAV's. DO measurements could not be obtained, though given the shallow water concentrations values were likely within 10% of saturation. Nutrient and chlorophyll measures ranged from 2-3 times (nitrogen and phosphorus) to more than ten times (chlorophyll a) the ecoregion threshold. Shallow water and abundance of macrophytes complicated both sampling and interpretation of results.

Based on the available information, Israel Pond is mildly eutrophic according to the average TSI of 55±9.8 (P=48; Chl=62; Secchi=NA). Additional monitoring at higher water levels seems warranted. Additional monitoring would be required to make an enduring assessment.



Sampling Location (WGS84): N 41.6809, W 70.2789
(NAD83): E 301670, N 826355

Patty's Pond

Barnstable GIS ID: 030
CCC GIS ID: BA-731

Area (acres): 8.39
Bathymetry: CSP, 2016
Maximum Depth (m): 5.5
Lake Association:

PALS Sampling	9/20/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	2.1 m		
Total Depth	5.5 m		
Surface pH	6.93	6.5 – 8.3	MassDEP
Deepest DO	0.19 mg/L	5.0 mg/L	MassDEP
Shallow temp	24.1°C	28.3°C	MassDEP
Surface Chlorophyll-a	4.01 µg/L	1.7 µg/L	CCC
Surface TP	20.34 µg/L	10 µg/L	CCC
Surface TN	0.58 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	0.39		

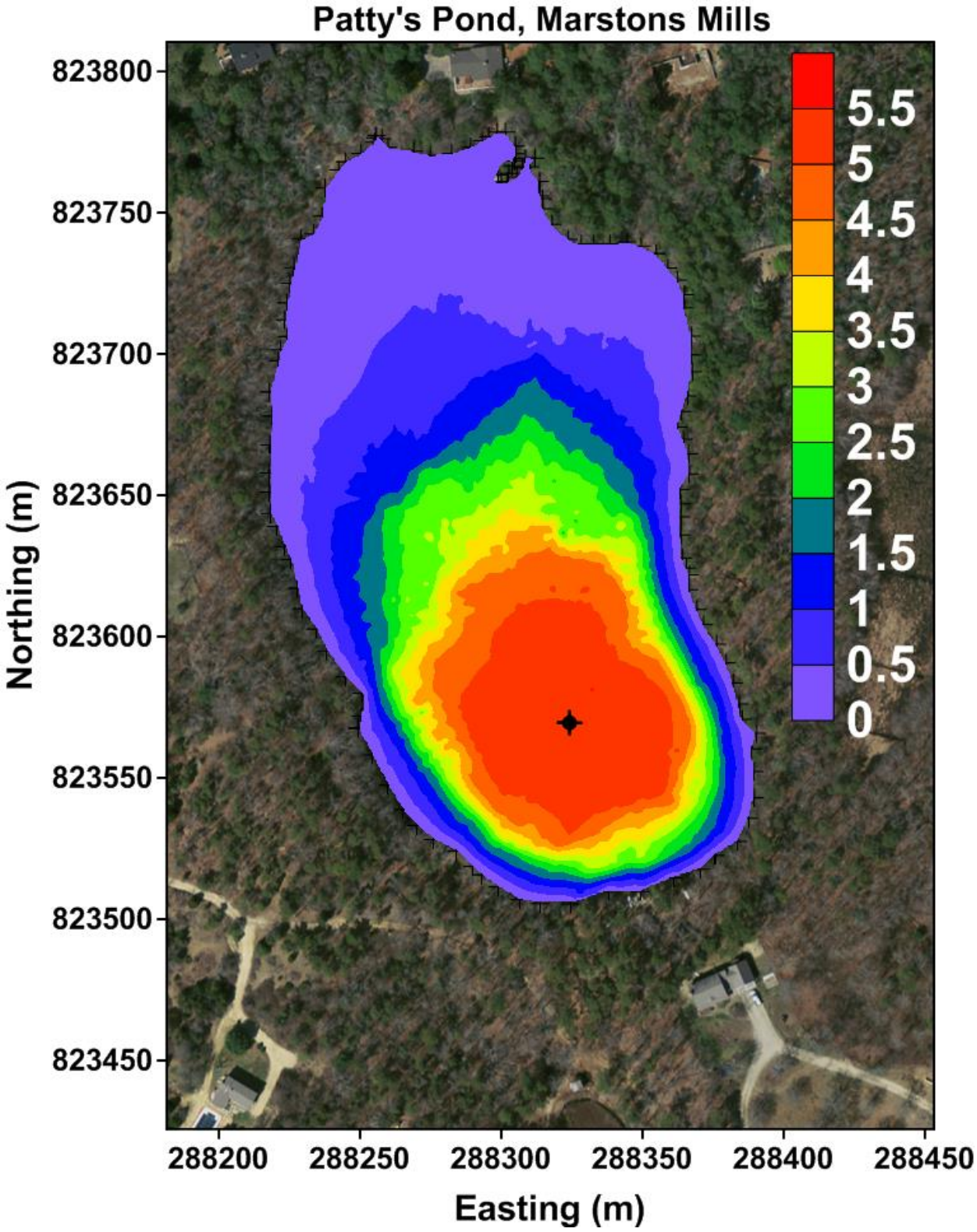
OVERVIEW

Patty's Pond is located in Marstons Mills north of Lovells Pond. Shoreline development is fairly sparse with eight houses around its western and northern shoreline. There is no formal public access.

WATER QUALITY

Patty's Pond is relatively shallow. At the time of the 2016 sampling light penetrated nearly to the bottom. Temperatures and dissolved oxygen readings showed a stratified water column with anoxia occurring just above the bottom at 5 meters. Surface water DO was at saturation. Shallow total phosphorus concentration was two times above the ecoregion threshold, as was the shallow chlorophyll-a concentration. Shallow total nitrogen concentration was above its threshold by a factor of two as well. The deep total phosphorus concentration was slightly lower than the shallow concentration, while the deep total nitrogen was the same. These values would not be expected if the anoxic conditions were persistent suggesting that the anoxia had developed recently.

Based on the available information, Patty's Pond is mesotrophic according to the average TSI of 46±2.6 (P=44; Chl=46; Secchi=49). Additional monitoring would be required to confirm the extent of impairment.



Sampling Location (WGS84): N 41.6574, W 70.4396
(NAD83): E 288324, N 823569

Simmons Pond

Barnstable GIS ID: 052
CCC GIS ID: BA-7891

Area (acres): 8.04
Bathymetry: CSP, 2016
Maximum Depth (m): 3.4
Lake Association:

PALS Sampling	9/14/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	2.0 m		
Total Depth	3.40 m		
Surface pH	7.08	6.5 – 8.3	MassDEP
Deepest DO	0.08 mg/L	5.0 mg/L	MassDEP
Shallow temp	24.2°C	28.3°C	MassDEP
Surface Chlorophyll-a	3.1 µg/L	1.7 µg/L	CCC
Surface TP	29.6 µg/L	10 µg/L	CCC
Surface TN	0.74 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	0.63		

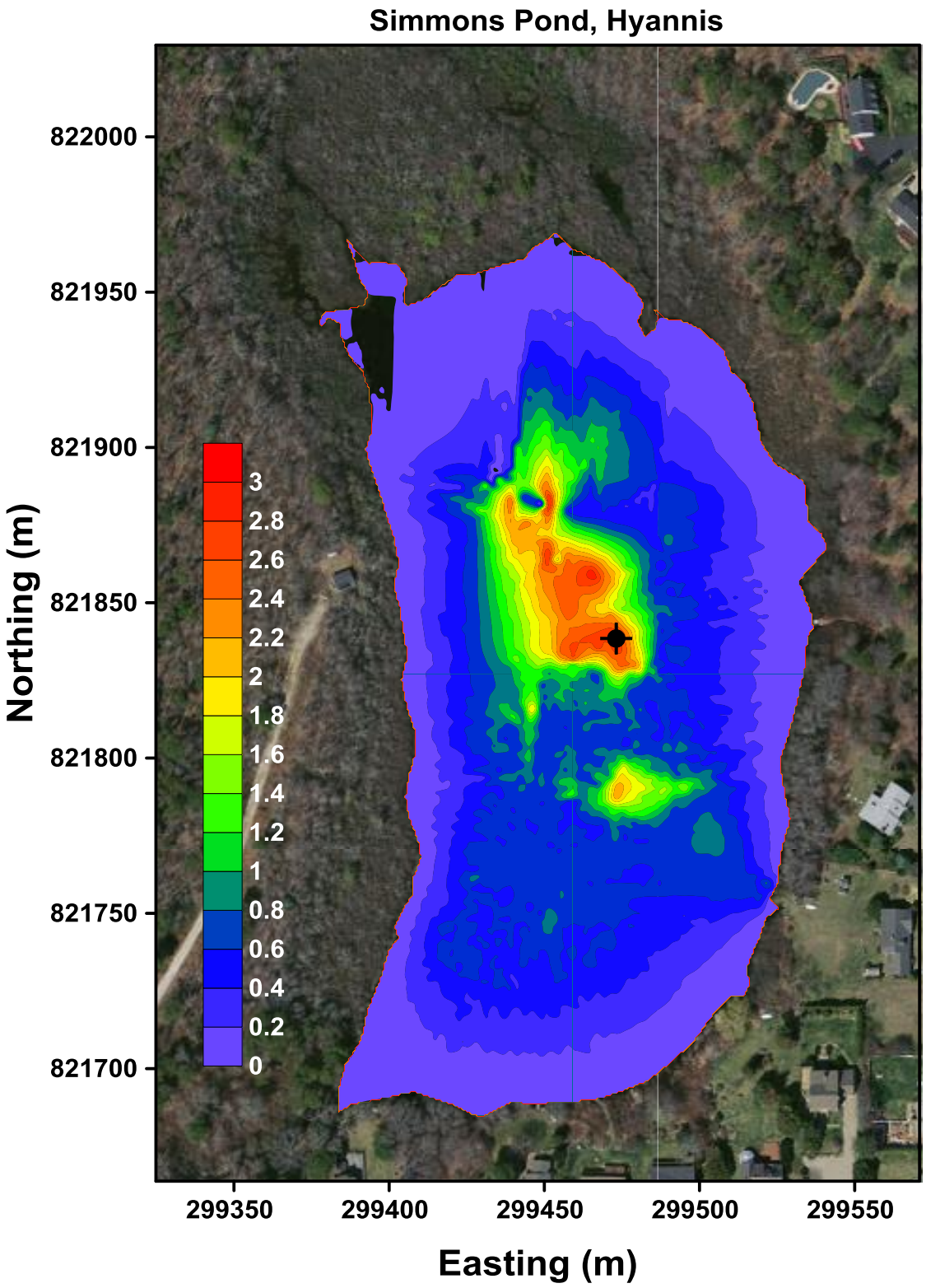
OVERVIEW

Simmons Pond is located in Hyannis, just south of Ben's Pond on a water department parcel. Shoreline development is moderate with fifteen houses around its southern and eastern shoreline. There is no formal public access.

WATER QUALITY

Simmons Pond is relatively shallow with a moderate loss in clarity at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a stratified water column with anoxic conditions extending from the sediment up to 2.5 m depth. Total phosphorus, total nitrogen and Chlorophyll-a were all above the ecoregion threshold. Review of nitrogen to phosphorus ratios particularly in the bottom water sample suggests that the anoxic conditions were persistent.

Based on the available information, Simmons Pond is mildly eutrophic according to the average TSI of 50±2.1 (P=51; Chl=47; Secchi=50).



Sampling Location (WGS84): N 41.6405, W 70.3060
(NAD83): E 299473, N 821828

PALS Sampling	9/7/2016		

Flintrock Pond

Barnstable GIS ID: 108505
CCC GIS ID: BA-614

Area (acres): 6.72
Bathymetry: CSP, 2016
Maximum Depth (m): 3.1
Lake Association:

Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.70 m		
Total Depth	3.10 m		
Surface pH	5.94	6.5 – 8.3	MassDEP
Deepest DO	1.61 mg/L	5.0 mg/L	MassDEP
Shallow temp	25.5°C	28.3°C	MassDEP
Surface Chlorophyll-a	31.7 µg/L	1.7 µg/L	CCC
Surface TP	50.84 µg/L	10 µg/L	CCC
Surface TN	1.57 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	1.17		

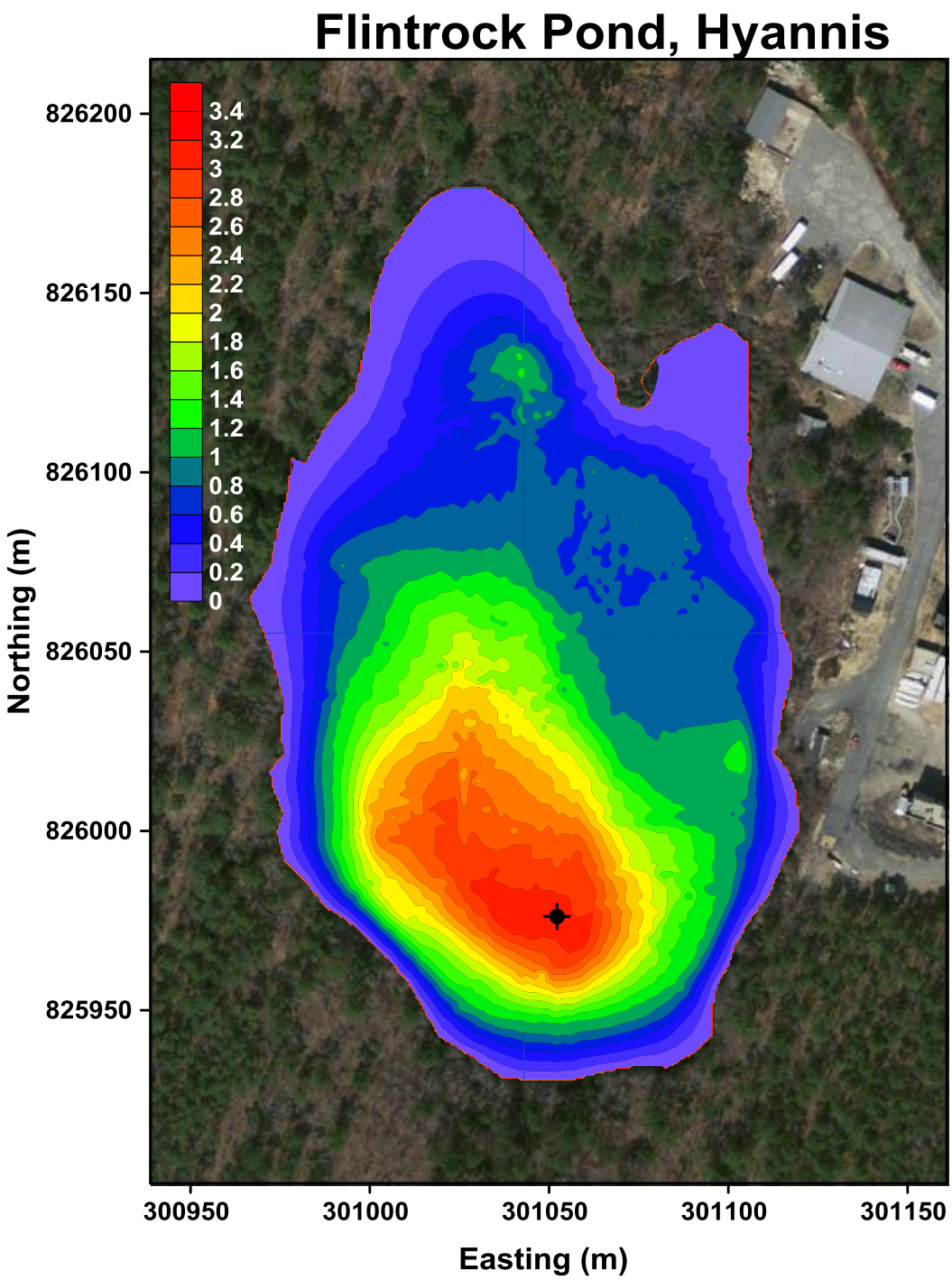
OVERVIEW

Flintrock Pond is located in Hyannis, adjacent to the county fire fighting academy. There are no houses along the shoreline and only four structures which are used in training exercises. Access to the pond is through county land used by the academy.

WATER QUALITY

Flintrock Pond is relatively shallow with poor water clarity at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a temperature stratified system with DO concentrations dropping quickly below the depth of light penentration to anoxia at the bottom. Shallow total phosphorus and nitrogen concentrations were five times the ecoregion threshold, while the shallow chlorophyll-a concentration was fifteen times higher than the ecoregion threshold. The deep total phosphorus and total nitrogen concentrations were similar to the shallow totals.

Based on the available information, Flintrock Pond is eutrophic according to the average TSI of 65±3.1 (P=62; Chl=68; Secchi=65).



Sampling Location (WGS84): N 41.6776, W 70.2864
(NAD83): E 301052, N 825976

Mill (Filenes) Pond

Barnstable GIS ID: 019
CCC GIS ID: BA-750

Area (acres): 5.55
Bathymetry: CSP, 2016
Maximum Depth (m): 1.7
Lake Association:

PALS Sampling	9/8/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	1.7 m		
Total Depth	1.7 m		
Surface pH	6.68	6.5 – 8.3	MassDEP
Deepest DO	9.86 mg/L	5.0 mg/L	MassDEP
Shallow temp	23.3°C	28.3°C	MassDEP
Surface Chlorophyll-a	0.7 µg/L	1.7 µg/L	CCC
Surface TP	30.51 µg/L	10 µg/L	CCC
Surface TN	2.53 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	1.22		

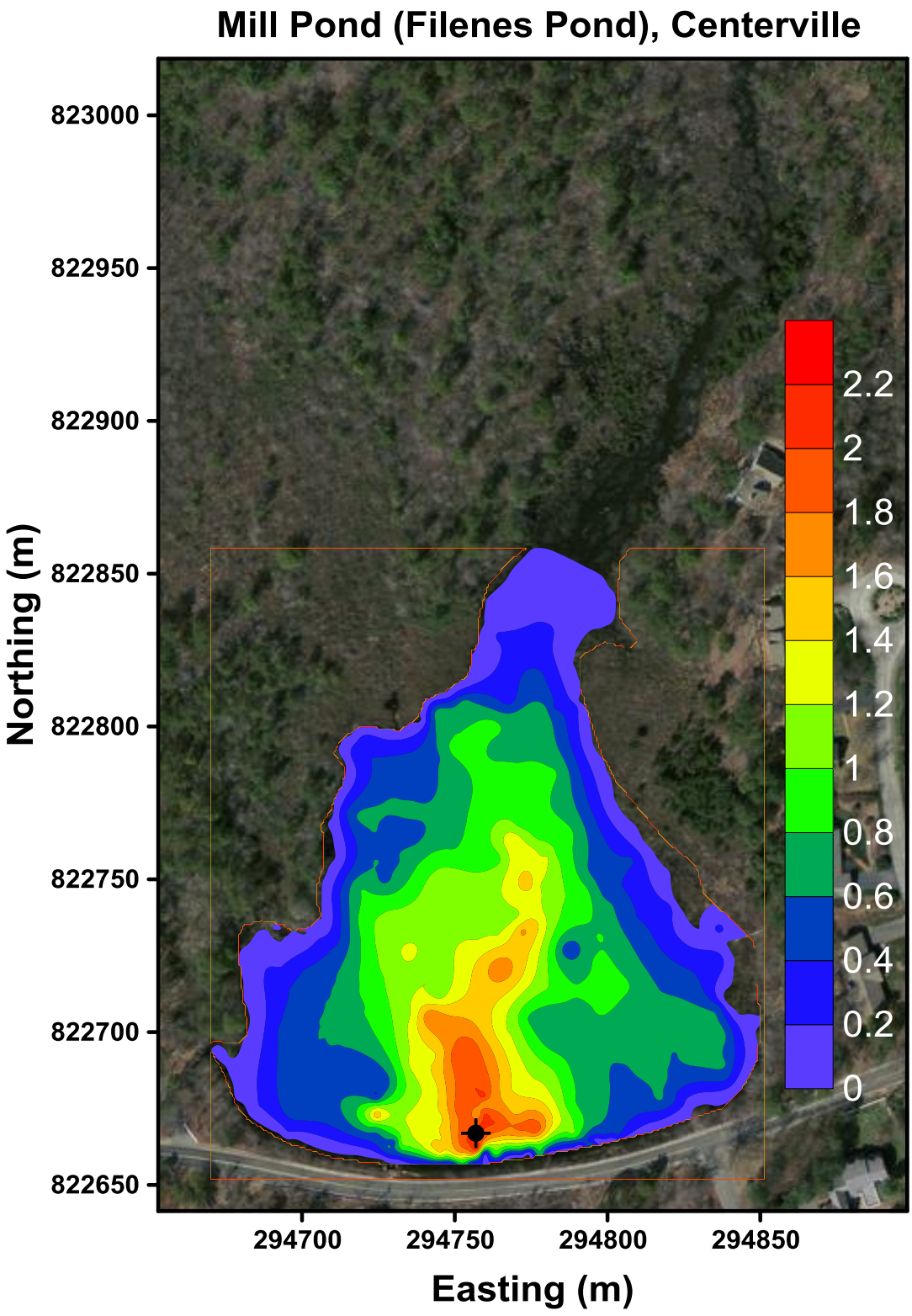
OVERVIEW

Mill Pond is located in Centerville, north of Scudder Bay into which it flows. Shoreline development is fairly sparse with six houses around its shoreline located along the eastern and western shore. To the north the Bumps River provides a water source that passes through open land occupied by untended cranberry bogs. There is no formal public access.

WATER QUALITY

Mill Pond is very shallow and had good water clarity at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a mixed water column with surface warming and rooted macrophytes contributing to an inverted water column oxygen gradient. Elevated DO near the sediments was 106% of saturation while the near surface water was under-saturated by 6%; mid-depth DO was at saturation. Both total phosphorus and total nitrogen concentrations were above the ecoregion threshold, while the chlorophyll-a concentration was just below its threshold.

Based on the available information, Mill Pond is mesotrophic according to the average TSI of 47±11.5 (P=55; Chl=39; Secchi=NA).



Sampling Location (WGS84): N 41.639, W 70.376
(NAD83): E 294760, N 822667

Sam's Pond

Barnstable GIS ID: 007
CCC GIS ID: BA-820

Area (acres): 5.46
Bathymetry: CSP, 2016
Maximum Depth (m): 3.5
Lake Association:

PALS Sampling	9/20/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	1.3 m		
Total Depth	3.5 m		
Surface pH	5.58	6.5 – 8.3	MassDEP
Deepest DO	0.22 mg/L	5.0 mg/L	MassDEP
Shallow temp	23.6°C	28.3°C	MassDEP
Surface Chlorophyll-a	11.01 µg/L	1.7 µg/L	CCC
Surface TP	27.96 µg/L	10 µg/L	CCC
Surface TN	0.74 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	1.15		

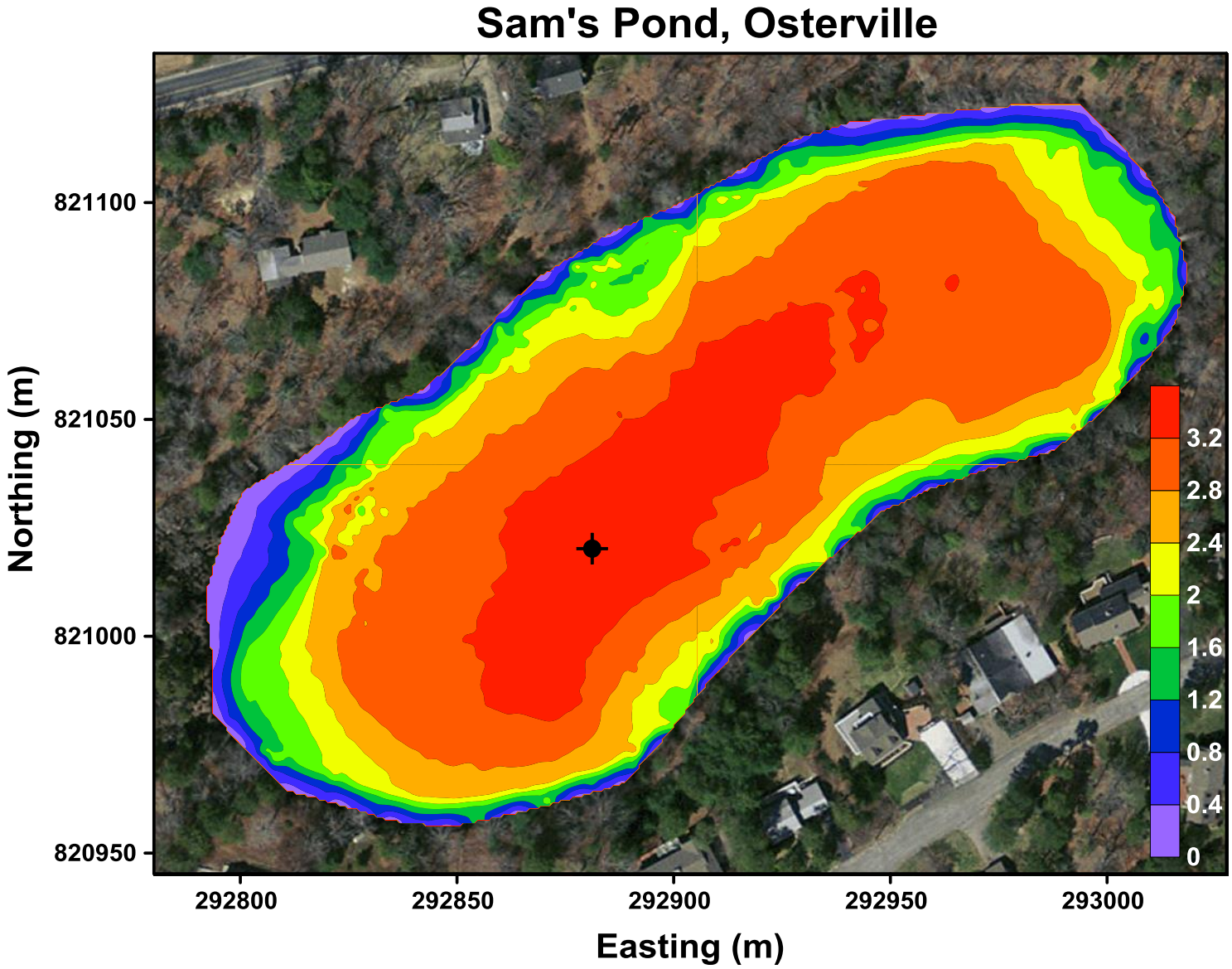
OVERVIEW

Sam's Pond is located in Osterville, south of Joshua Pond. Shoreline development is extensive with twenty-one houses around the shoreline. The southwest corner of the pond merges with a swamp. There is no formal public access.

WATER QUALITY

Sam's Pond is relatively shallow with light penetration nearly to the bottom. Temperatures and dissolved oxygen readings showed a stratified water column with anoxia beginning at a depth of 2.5 m; surface water was fully saturated. Shallow total phosphorus and total nitrogen concentrations were a little over two times higher than the ecoregion threshold. Shallow chlorophyll-a concentration was more than six times its threshold. The deep total phosphorus and deep total nitrogen concentrations were similar to those observed near the pond surface. Bottom water sampling, it should be noted, occurred immediately above the DO minimum, a deeper sample may have shown elevated TN and TP depending on how long the pond had been stratified.

Based on the available information, Sam's Pond is mildly eutrophic according to the average TSI of 56±3.0 (P=53; Chl=59; Secchi=56). Duration of pond stratification would be critical to determine if additional monitoring is warranted. Additional monitoring would be recommended.


Sam's Pond, Osterville
Northing (m)
821100
821050
821000
820950
292800
292850
292900
292950
293000
Easting (m)
3.2
2.8
2.4
2
1.6
1.2
0.8
0.4
0

Sampling Location (WGS84): N 41.6340, W 70.3853
(NAD83): E 292881, N 821020

Weathervane Pond

Barnstable GIS ID: 033
CCC GIS ID: BA-699

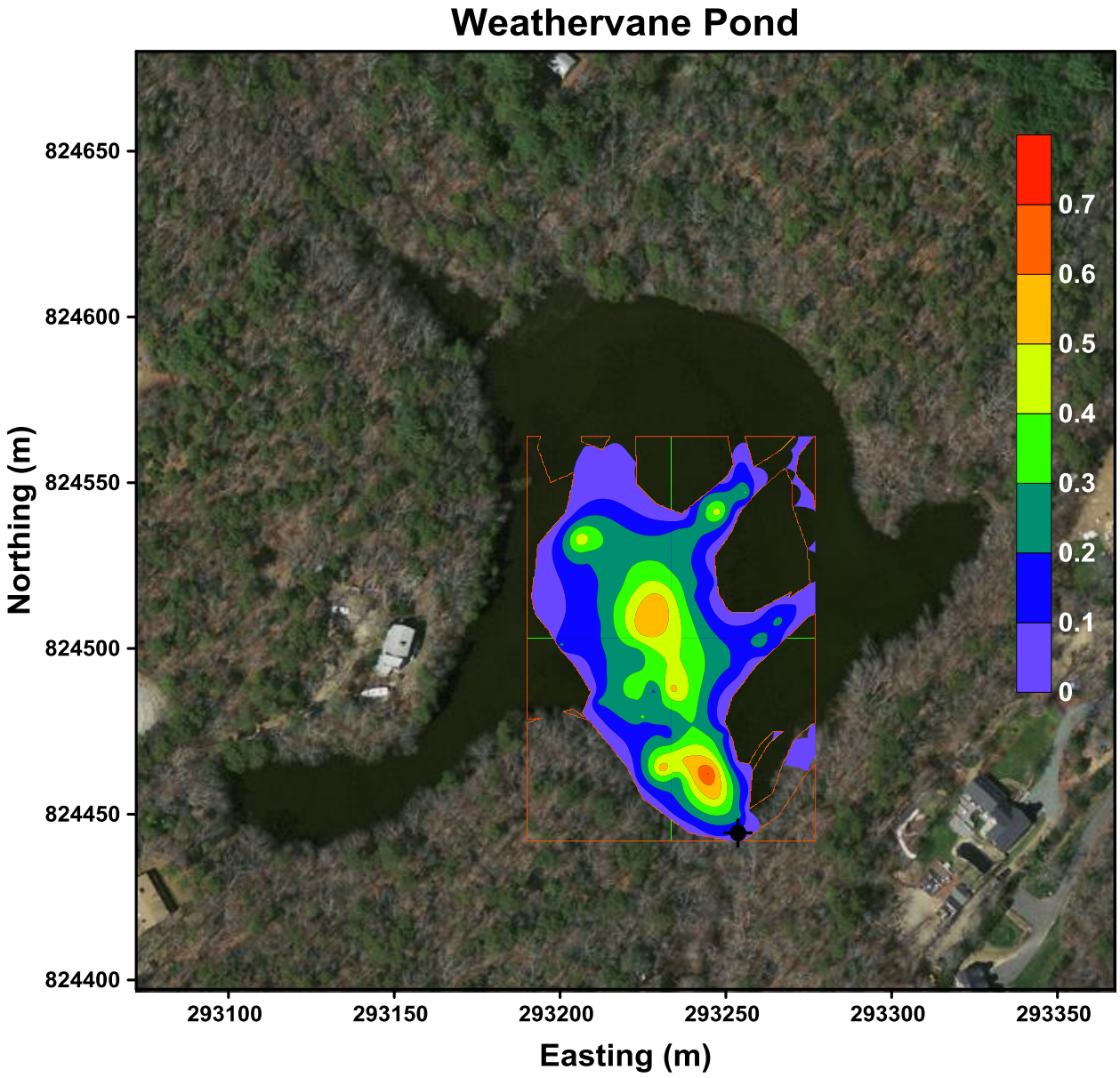
Area (acres): 4.98
Bathymetry: CSP, 2016
Maximum Depth (m): 0.9
Lake Association:
:

PALS Sampling	Sept 2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.65		
Total Depth	0.65		
Surface pH	6.21	6.5 – 8.3	MassDEP
Deepest DO	8.86	5.0 mg/L	MassDEP
Shallow temp	19.6	28.3°C	MassDEP
Surface Chlorophyll-a	1.99 µg/L	1.7 µg/L	CCC
Surface TP	31.35 µg/L	10 µg/L	CCC
Surface TN	0.98 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

OVERVIEW
Weathervane Pond is located in Marstons Mills, north of Lumbert Pond. Shoreline development includes only four houses located along the southern and western shore. Water enters the Pond from a stream in the north and exits through a control structure where the samples were taken. The pond is an abandoned cranberry bog. At the time of sampling more than half the pond was dry. Access was through trail system located off Weathervane Way.

WATER QUALITY
Weathervane Pond was very shallow with clear water during the 2016 sampling. Temperatures and dissolved oxygen readings showed a well-mixed water column with DO near saturation. Shallow total phosphorus concentration was three times the ecoregion threshold, while the shallow chlorophyll-a concentration was just above its threshold. Shallow total nitrogen concentration was also three times its threshold.

Based on the available information, Weathervane Pond is mesotrophic according to the average TSI of 46±6.7 (P=50; Chl=41; Secchi=NA). Additional monitoring at higher water levels would be required to confirm this assessment.



Sampling Location (WGS84): N 41.6647, W 70.5802
(NAD83): E 293256, N 824443

Ben's Pond

Barnstable GIS ID: 105
CCC GIS ID: BA-391

Area (acres): 13.83
Bathymetry: CSP, 2016
Maximum Depth (m): 0.9
Lake Association:

PALS Sampling	9/14/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.65 m		
Total Depth	0.65 m		
Surface pH	6.72	6.5 – 8.3	MassDEP
Deepest DO	6.87 mg/L	5.0 mg/L	MassDEP
Shallow temp	23.2°C	28.3°C	MassDEP
Surface Chlorophyll-a	2.97 µg/L	1.7 µg/L	CCC
Surface TP	30.51 µg/L	10 µg/L	CCC
Surface TN	1.15 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

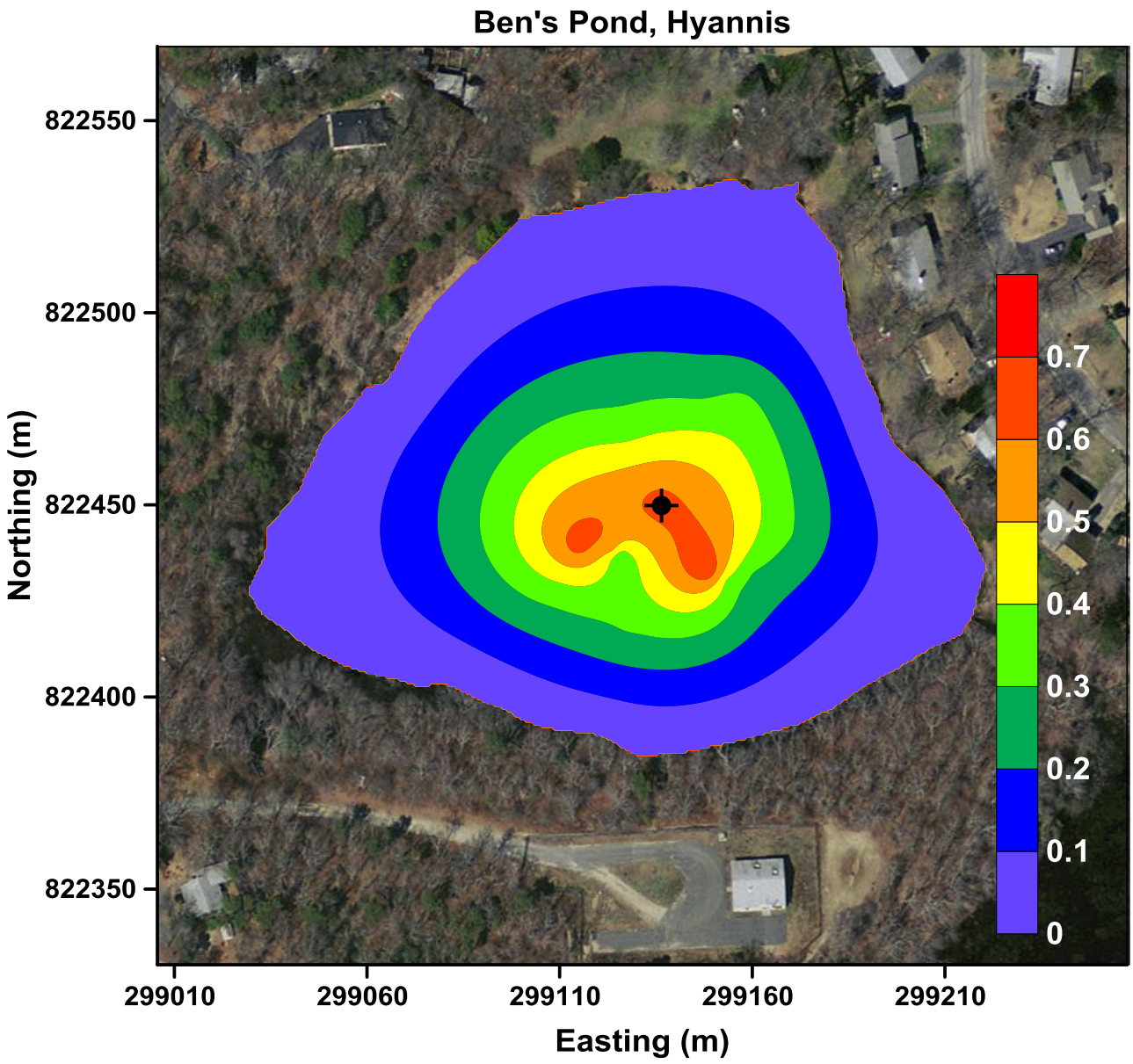
OVERVIEW

Ben's Pond is located in Hyannis, north of water department parcel which includes Simmons Pond. Shoreline development is sparse with seven houses on the eastern shoreline. Abutters claim that Ben's Pond was once connected to a small bog to the south. There is no formal public access.

WATER QUALITY

Ben's Pond is very shallow, generally less than 30cm deep at the time of the 2016 sampling. Temperatures and dissolved oxygen readings were within the standard limits, however, the values for DO were surprisingly depressed considering the extremely shallow depth (78% of saturation). Total phosphorus and total nitrogen concentrations were three times the ecoregion threshold, while the chlorophyll-a concentration was twice the threshold. The water surface was almost entirely covered with water lilies, milfoil, and emergent grasses.

Based on the available information, Ben's Pond is mesotrophic according to the average TSI of 50±4.5 (P=53; Chl=47; Secchi=NA). Additional monitoring would be required to confirm this assessment as water levels were extremely low and the extent of macrophytes was difficult to assess. .



Sampling Location (WGS84): N 41.646, W 70.310
(NAD83): E 299136, N 822451

North Pond

Barnstable GIS ID: 009
CCC GIS ID: BA-816

Area (acres): 4.85
Bathymetry: CSP, 2016
Maximum Depth (m): 3.4
Lake Association

PALS Sampling	9/13/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	1.45 m		
Total Depth	3.40 m		
Surface pH	6.10	6.5 – 8.3	MassDEP
Deepest DO	0.18 mg/L	5.0 mg/L	MassDEP
Shallow temp	24.0°C	28.3°C	MassDEP
Surface Chlorophyll-a	7.07 µg/L	1.7 µg/L	CCC
Surface TP	33.9 µg/L	10 µg/L	CCC
Surface TN	0.73 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	2.35		

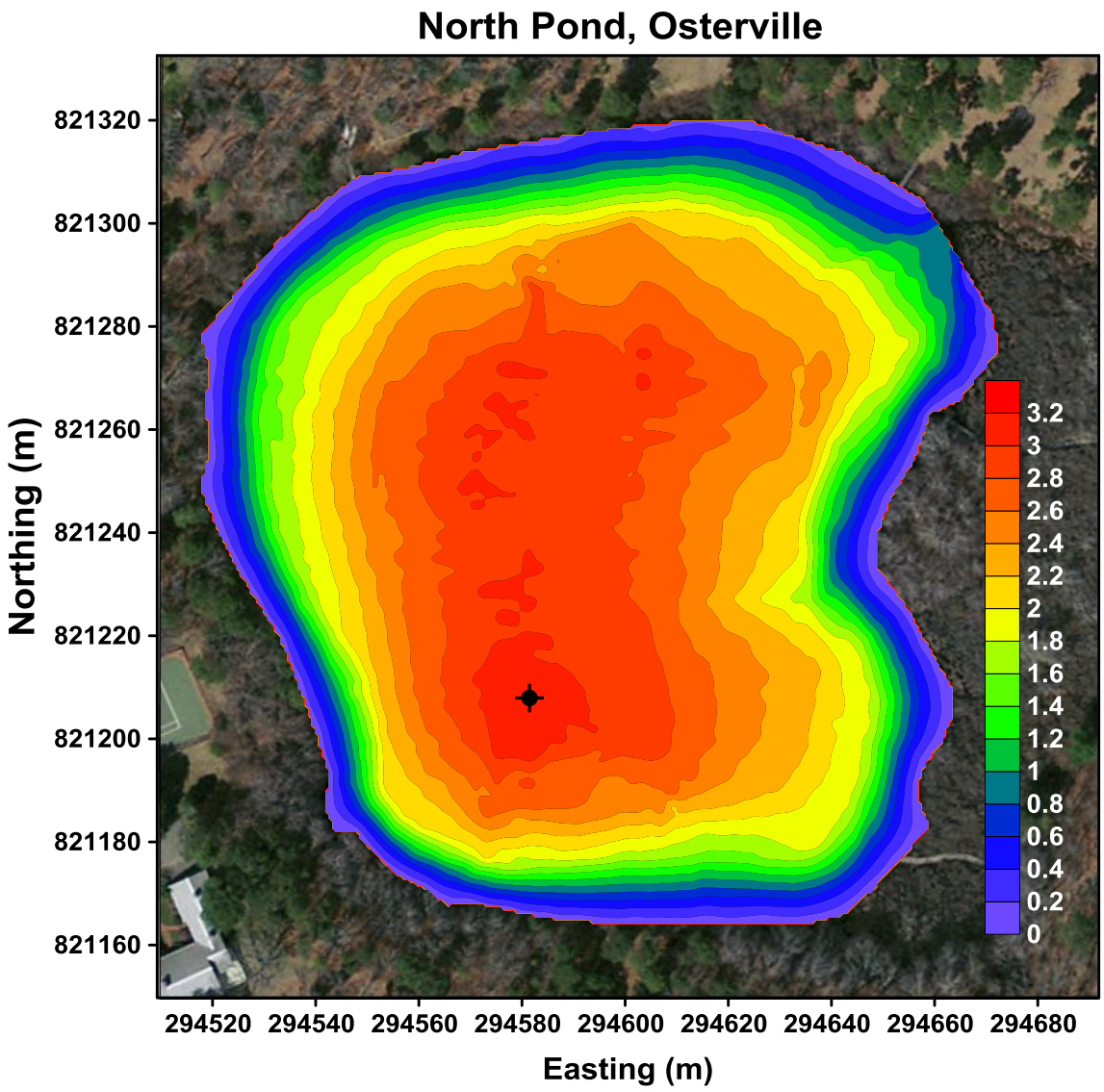
OVERVIEW

North Pond is located in Osterville just north of Coleman Pond. Shoreline development is fairly sparse with eight houses around its shoreline with most of these located along the southern, western and northern shore. A large bog covers most of the eastern shoreline. There is no formal public access.

WATER QUALITY

North Pond is relatively shallow with light nearly penetrating to the bottom at the time of the 2016 sampling. Temperatures and dissolved oxygen readings showed a stratified water column. DO at the surface was near saturation, however the mid water column was supersaturated (107%). The water column became anoxic at a depth of 2.5 m. Shallow total phosphorus concentration was three times above the ecoregion threshold, while the shallow chlorophyll-a concentration was nearly four times its threshold. Shallow total nitrogen concentration was above its threshold by a factor of two and a half. The deep total phosphorus and total nitrogen concentrations were highly elevated above the shallow concentration, which indicated some sediment regeneration of nutrients due to prolonged anoxia. Deep chlorophyll concentrations more than twenty times the ecoregion threshold suggests that an algal bloom developed in response to phosphorus release from the anoxic sediments.

Based on the available information, North Pond eutrophic according to the average TSI of 62±6.3 (P=64; Chl=67; Secchi=55).



Sampling Location (WGS84): N 41.6354, W 70.3648
(NAD83): E 294582, N 821208

Fresh Hole Pond

Barnstable GIS ID: 076
CCC GIS ID: BA-662

Area (acres): 4.67
Bathymetry: CSP, 2016
Maximum Depth (m): 1.3
Lake Association:

PALS Sampling	9/7/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	1.30 m		
Total Depth	1.50 m		
Surface pH	6.16	6.5 – 8.3	MassDEP
Deepest DO	7.69 mg/L	5.0 mg/L	MassDEP
Shallow temp	23.4°C	28.3°C	MassDEP
Surface Chlorophyll-a	1.1 µg/L	1.7 µg/L	CCC
Surface TP	27.12 µg/L	10 µg/L	CCC
Surface TN	0.81 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

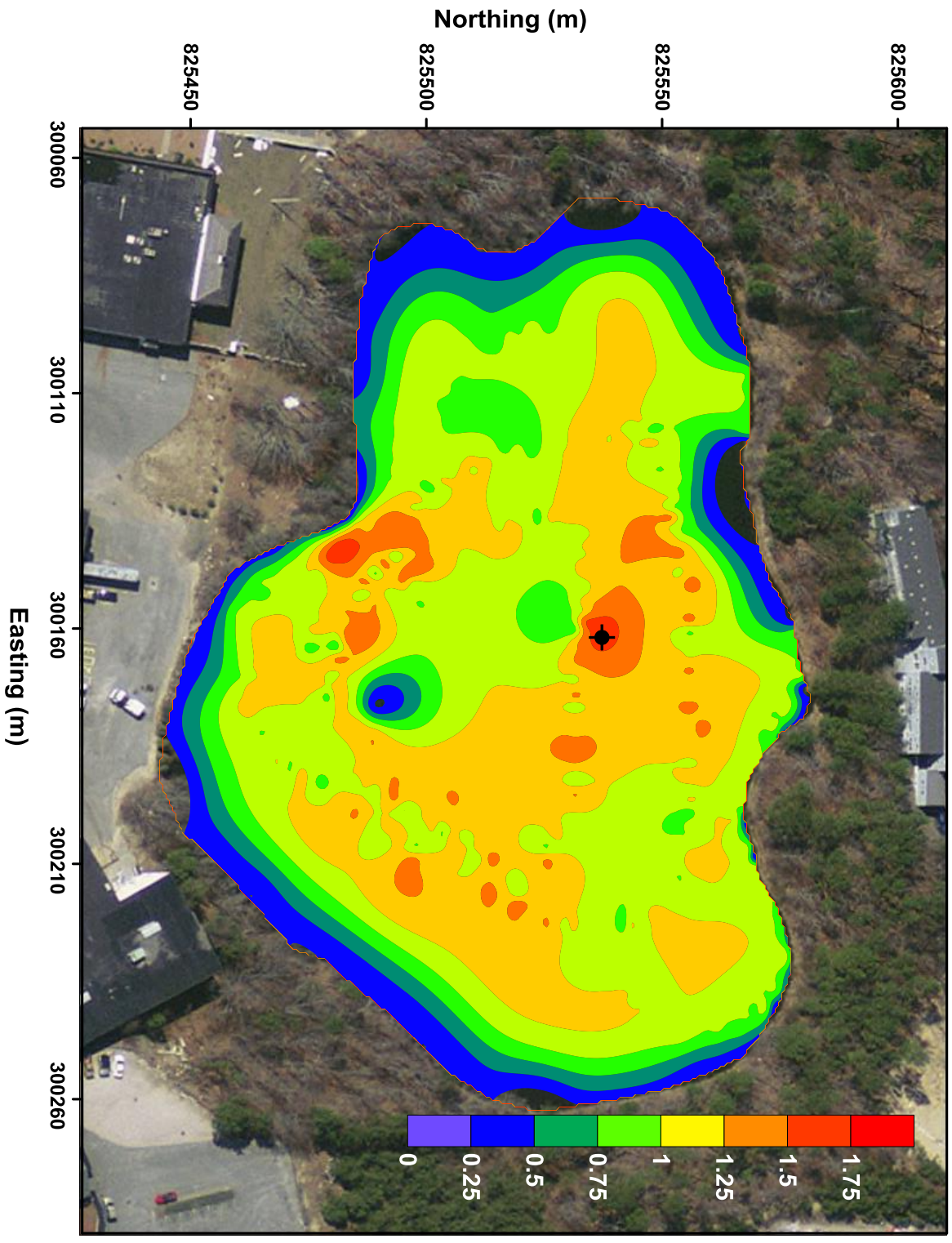
OVERVIEW

Fresh Hole Pond is located in Hyannis between Attucks, Independence, and Airport Roads. Shoreline development is primarily commercial with large swaths of parking lots contributing to significant storm runoff and the presence of trash and floatables along the shore.. There is no formal public access, though the commercial parking lots and loading areas provide an easy place to potage small craft.

WATER QUALITY

Fresh Hole Pond is very shallow with light penetration to the bottom.. Temperatures and dissolved oxygen readings showed a well-mixed water column with 89% saturation throughout. Total phosphorus and total nitrogen concentrations were two and a half times the ecoregion threshold, while the chlorophyll-a concentration was just below its threshold. This apparent anomaly may be due to the particularly high concentration of floating algae near the sampling station.

Based on the available information, Fresh Hole Pond is mildly eutrophic according to the average TSI of 51±5.4 (P=52; Chl=46; Secchi=56). Quantification of storm runoff from impermeable surfaces would be an important addition to identify nutrient loading into the pond.



Sampling Location (WGS84): N 41.6737, W 70.2971
(NAD83): E 300162, N 825537

Campground Pond

Barnstable GIS ID: 096
CCC GIS ID: BA-574

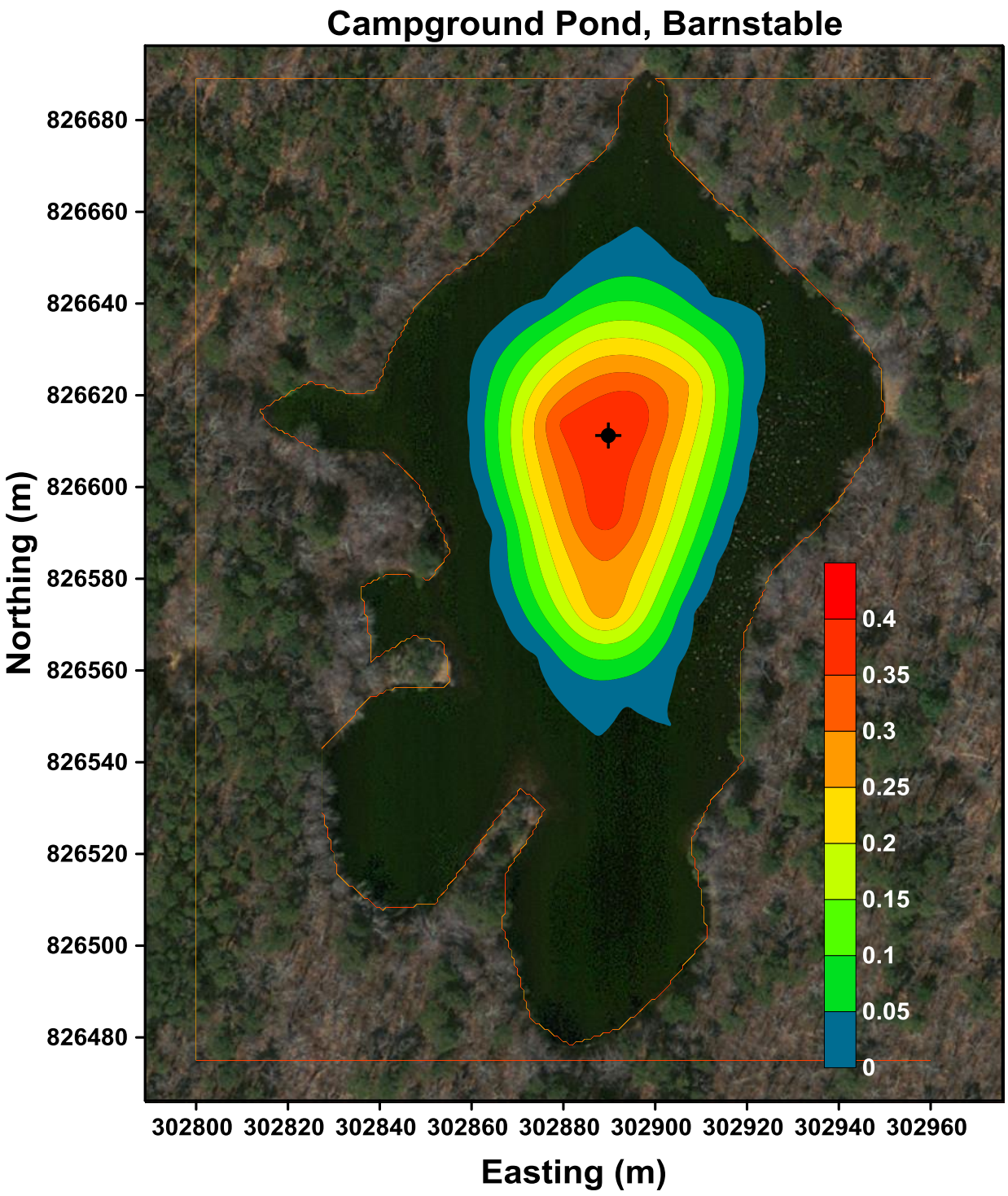
Area (acres): 3.69
Bathymetry: CSP, 2016
Maximum Depth (m): 0.4
Lake Association:
:

PALS Sampling	9/7/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.40 m		
Total Depth	0.40 m		
Surface pH	4.42	6.5 – 8.3	MassDEP
Deepest DO	-	5.0 mg/L	MassDEP
Shallow temp	-	28.3°C	MassDEP
Surface Chlorophyll-a	1.40 µg/L	1.7 µg/L	CCC
Surface TP	0.85 µg/L	10 µg/L	CCC
Surface TN	84 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

OVERVIEW
Campground Pond is located in Barnstable north of Lamsons Pond. Shoreline development is limited to 10 houses along the northeast. Access is off Oak Avenue with permission of home owners association.

WATER QUALITY
Campground Pond is very shallow; at the time of sampling the pond occupied less than half of its high water area. Temperatures and dissolved oxygen readings were not able to be taken, but were unlikely to have varied more than 10% from saturation. Shallow total phosphorus concentration was well below the ecoregion threshold, while the shallow chlorophyll-a concentration was just below its threshold. Shallow total nitrogen concentration was well above its threshold. The nutrient concentrations seem anomalous. Since the pond was too shallow for any boat it is possible that samples were contaminated by detritus resuspended by footsteps.

Based on the available information, Campground Pond health cannot be determined. Additional monitoring is suggested.



Sampling Location (WGS84): N 41.6830, W 70.2642
(NAD83): E 302889, N 826611

Flax Pond

Barnstable GIS ID: 102
CCC GIS ID: BA-473

Area (acres): 3.16
Bathymetry: CSP, 2016
Maximum Depth (m): 0.75
Lake Association:

PALS Sampling	9/9/2016		
Parameter	Pond	Standard/ Limit	Standard Source
Secchi	0.75 m		
Total Depth	0.75 m		
Surface pH	5.71	6.5 – 8.3	MassDEP
Deepest DO	5.01 mg/L	5.0 mg/L	MassDEP
Shallow temp	23.1°C	28.3°C	MassDEP
Surface Chlorophyll-a	21.48 µg/L	1.7 µg/L	CCC
Surface TP	47.45 µg/L	10 µg/L	CCC
Surface TN	1.13 mg/L	0.31 mg/L	CCC
TP ratio (deep/shallow)	-		

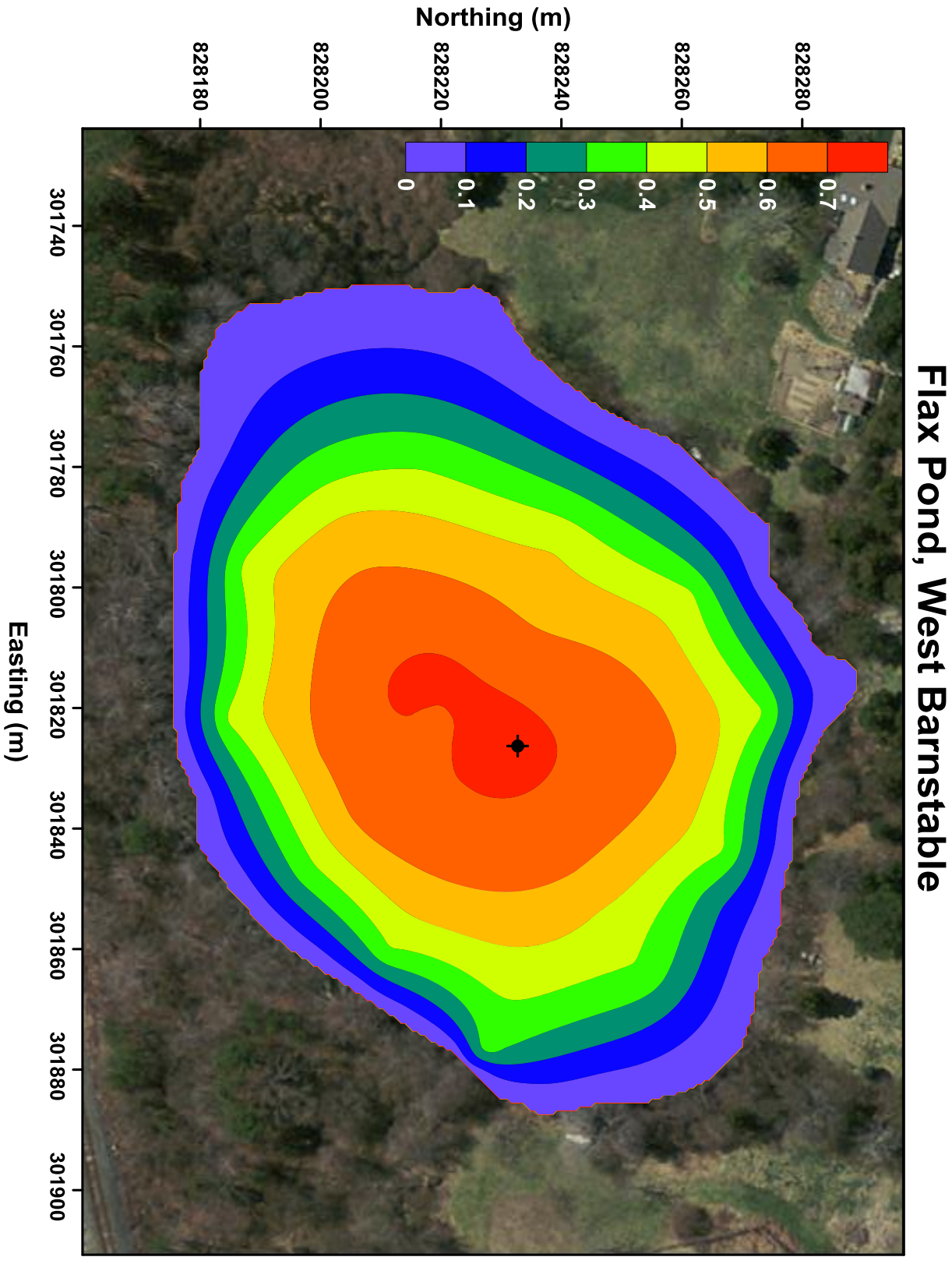
OVERVIEW

Flax Pond is located in West Barnstable, south of Rt 6A and west of Mary Dunn Rd. Shoreline development is fairly sparse with seven houses around its shoreline, with some lots undeveloped. Most of these houses are located to the north and west of the pond. There is no formal public access, rehabilitation center fronting Rt. 6A provided permission for easy access.

WATER QUALITY

Flax Pond is very shallow with nearly 100% coverage by macrophytes at the time of sampling. Temperatures suggest that mixing occurs but, dissolved oxygen readings showed depressed DO values throughout the water column with bottom levels 70% of saturation. All nutrient values were well in excess of the standards. .

Based on the available information, Flax Pond is eutrophic according to the average TSI of 62±3.0 (P=60; Chl=64; Secchi=NA). All measures indicate that additional monitoring is warranted.



Sampling Location (WGS84): N 41.704, W 70.274
(NAD83): E 301826, N 828233