Lake Pocotopaug Nine Elements Watershed Based Plan

Prepared for:

Town of East Hampton

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Introduction

Background and Purpose

This document incorporates results from prior studies, 1991–2009, and new lake and watershed data from 2014–2016 to develop a comprehensive US EPA Nine Elements Watershed-based Plan to reduce pollutant loading to improve the impaired water quality of Lake Pocotopaug.

Lake Pocotopaug experienced unprecedented intense cyanobacteria blooms during the summers of 1988 and 1989 triggering, the first in a series of in-depth studies of the lake in 1991. The Town of East Hampton had only recently, 1983, completed sewering of lakeside homes and businesses suggesting an improving water body but instead summer cyanobacteria blooms persisted.

Early studies focused on in-lake nutrient dynamics suggesting that internal loading of phosphorus from bottom sediments was the principal cause of excessive algae growth. Aluminum sulfate (Alum) was added to inactivate internal phosphorus first in 2000 and again in 2001. Neither application rendered any change in either bottom phosphorus concentrations or algae growths with the dominance of cyanobacteria in summer blooms virtually unchanged from prior years before the Alum.

With the lack of success with Alum, beginning in 2002 nonpoint watershed pollution was considered to be the driving contributor to the poor water quality of the lake. The AECOM 2009 report summarized 8 years of watershed studies into the Lake Loading Response Model (LLRM). The LLRM estimated phosphorus and nitrogen loads to the lake from each sub-basin allowing fine-tuned predictions of reductions due to improvement actions. The model used correction scenarios to change estimated loads from which it would predict different lake responses.

However, to meet any significant increases in water clarity and less frequent algae blooms the list of required improvements in all fourteen sub-basins was extensive—74--and costly—$1M. Additionally, the report recognized that much of the nutrient pollution originated on private property.

No lake or watershed monitoring was conducted between the fall of 2007 and summer of 2013. In September 2013, Lake Pocotopaug experienced its first beach posting following the recently released Guidance for Local Health Departments for blue-green algae blooms in recreational waters[1] protocols. The regular summer blooms that started in 1988 were now accepted as a human health risk due to possible exposure to cyanotoxins.

Beginning in 2013, the Town of East Hampton engaged Northeast Aquatic Research (NEAR) to resume water quality monitoring of Lake Pocotopaug and re-open the examination of the many watershed fix recommendations that have been made by reports written between 1991 and 2009.

[1] Department of Energy and Environmental Protection (CT DEEP), Department of Public Health (DPH) July 2013

This report begins by defining lake characteristics the impairment and current water quality classification. Next the report identifies specific sources of nutrient pollution and estimates pollutant loading using the LLRM (AECOM 2009) model. Sub-basins are examined in detail with updated field sampling and watershed analysis from 2014 to early 2016. A current nutrient mass balance model of the lake was created to supplement loading predictions. Following a description of pollution sources and loading estimates, a detailed outline of management measures and recommendations are provided for important sub-basins. This report also includes an outline of predicted costs and necessary financial assistance for implementation of LID in the watershed.

This report identifies 55 individual actions where there is either a site needing measures to control nutrient loading or recommended management protocols. Six are watershed wide so not applicable in Table 1 which gives the numbers of measures needed in each sub-basin according to priority rating. Total cost to implement all fixes is estimated to be between $450,000 $1,425,000.

Table 1 – Number of sites of each priority ranking in each sub-basin also shows range of expected costs

	Sub-basin	High	Moderate	Low	Low	High
Tier 1	E	6	1		$ 19,000	$ 55,000
	H	5			$ 50,000	$ 550,000
Tier 2	C		4	2	$ 20,000	$ 34,000
	A	5	5		$ 236,500	$ 485,000
	K	3			$ 18,000	$ 25,000
Tier 3	B		1	2	$ 2,700	$ 4,500
	N	1	1		$ 100	$ 500
	F	1	1	1	$ 4,800	$ 15,000
	G			1	$ 500	$ 2,000
	M	2	1		$ 84,000	$ 193,000
Tier 4	I				~	~
	D		2	4	$ 13,000	$ 71,200
	J				~	~
	L				~	~
Estimated Totals					$ 450,000	$1,425,000

Existing Impairment

Lake Pocotopaug and CT Water Quality Standards

Lake Pocotopaug is a 500+ acre lake located entirely within the Town of East Hampton, Connecticut. The Lake is currently listed on the State of Connecticut's 303(d) list as an "Impaired" waterbody because it does not 'Support' 'Recreational Use'. Support means the condition of the water allows or provides the designated use. Recreation subsumes the old designation of 'Swimmable' modified to include other forms of use including aesthetic appreciation and secondary contact. 'Habitat for fish and wildlife' has always been Fully Supported at the Lake. (see Table 2[2] for definition of Recreation and Habitat under the Federal Clean Water Act, there are eight other designated uses of marine and freshwater but only these two apply to recreation lakes.

Table 2 – Definition of Designated Use

Designated Use	Functional Definition
Recreation (human contact and non-contact)	Swimming, water skiing, surfing or other full body contact activities (primary contact), as well as boating, canoeing, kayaking, fishing, aesthetic appreciation or other activities that do not require full body contact (secondary contact).
Habitat (fish wildlife and other aquatic life)	Waters suitable for the protection, maintenance and propagation of a viable community of aquatic life and associated wildlife.

Source = 2014 State of Connecticut's Integrated Water Quality Report to Congress

Lakes can be listed as impaired in the State of Connecticut's Integrated Water Quality Report to Congress as having lost one or both of two functions; "Habitat" or "Recreation". Loss of Habitat represents degraded support of aquatic life in a lake. Loss of Recreation occurs when water condition degrades such that human contact is no longer considered safe. Water quality parameters algae growth and Chlorophyll-*a* can be used as one way of deterring suitability of water to support Recreational use. Recreation Use is Not Supported during periods of widespread blue-green algae or cyanobacteria blooms that make the lake green throughout (Table 3[3]). Lake Pocotopaug water has not supported Recreational Use since 2006 when it was first listed on 303(d) report for algae growth.

Table 3 – Reasons Recreation Use is Not Supported at Lake Pocotopaug

Cause	Potential sources
Chlorophyll-*a*	permitted and non-permitted stormwater
Excess Algal Growth	permitted and non-permitted stormwater

[2] http://www.ct.gov/deep/lib/deep/regulations/22a/22a-426-1through9.pdf
[3] http://www.ct.gov/deep/lib/deep/water/water_quality_management/305b/2014_iwqr_305b_303d_final

Nutrient/Eutrophication Biological Indicators	permitted and non-permitted stormwater

Source = 2014 State of Connecticut Integrated Water Quality Report, October 2014 -- Connecticut Impaired Waters List (EPA Category 5)-Lake Pocotopaug CT4709-04-1- L1_01

Existing Conditions

Data from 2014-2015 (**Table 4**) monitoring shows Lake Pocotopaug has elevated levels of nutrients, excess chlorophyll-*a*, and poor clarity. The CT DEEP gives parameters and defining ranges for Trophic State Classifications of Lakes in Connecticut in **Table 5**. The recent field measurements of Secchi disk depth, and total nitrogen place the lake in Highly Eutrophic category, however total phosphorus has rarely exceeded 30µg/L, less than suggested by Highly Eutrophic clarity readings. The chlorophyll-*a* level has also been less than the Highly Eutrophic clarity suggests. These data indicate that nitrogen loading is also important in controlling cyanobacteria at Lake Pocotopaug while sediments may be a significant factor in constant poor clarity. Water quality trends in Pocotopaug are considered in detail in **Appendix 1**.

Table 4 – 2014–2015 measured values of trophic indicators in Lake Pocotopaug

Parameter	Value	
Water clarity	Persistent summer clarity less than 1 meter, many *mid-summer* readings less than 0.5 meters	Highly Eutrophic
Direct cell counts	Maximum cyanobacteria numbers over 300,000 cells/mL	Closure
Chlorophyll-*a*	Most summer 15µg/L, some summers maximum of 25µg/L	Eutrophic
Phosphorus concentrations	Consistently over 20µg/L, some maximum summer values over 30µg/L. (20 or 10 ppb)	Meso- to Eutrophic
Nitrogen concentrations	Consistently over 600µg/L, some maximum summer values over 1,000µg/L	Eutrophic to Highly Eutrophic

Table 5 – CT DEEP parameters and defining ranges for trophic state of Lakes in Connecticut

Trophic State Category	Trophic State Indicator[4]	Defining Range TP and TN Avg. spring and summer samples Unless otherwise noted
Oligotrophic	Total Phosphorus	0 – 10 µg/l
	Total Nitrogen	0 – 200 µg/l
	Secchi Disk Transparency	6 + meters *mid-summer*
	Chlorophyll-a	0 – 2 µg/L *mid-summer*

[4] Trophic State also incorporates macrophyte growth and coverage but plants are sparse in Lake Pocotopaug

Mesotrophic	Total Phosphorus	10 – 30 µg/l
	Total Nitrogen	200 – 600 µg/l
	Secchi Disk Transparency	2 – 6 meters *mid-summer*
	Chlorophyll-a	2 – 15 µg/L *mid-summer*
Eutrophic	Total Phosphorus	30 – 50 µg/l
	Total Nitrogen	600 – 1000 µg/l
	Secchi Disk Transparency	1 – 2 meters *mid-summer*
	Chlorophyll-a	15 – 30 µg/L *mid-summer*
Highly Eutrophic	Total Phosphorus	50+ µg/l
	Total Nitrogen	1000+ µg/l
	Secchi Disk Transparency	0 – 1 meters *mid-summer*
	Chlorophyll-*a*	30 + µg/L *mid-summer*

Source: Regulation on Connecticut Water Quality Standards R-39 Rev. 03/2012

Restoration of Recreation as Supported Use

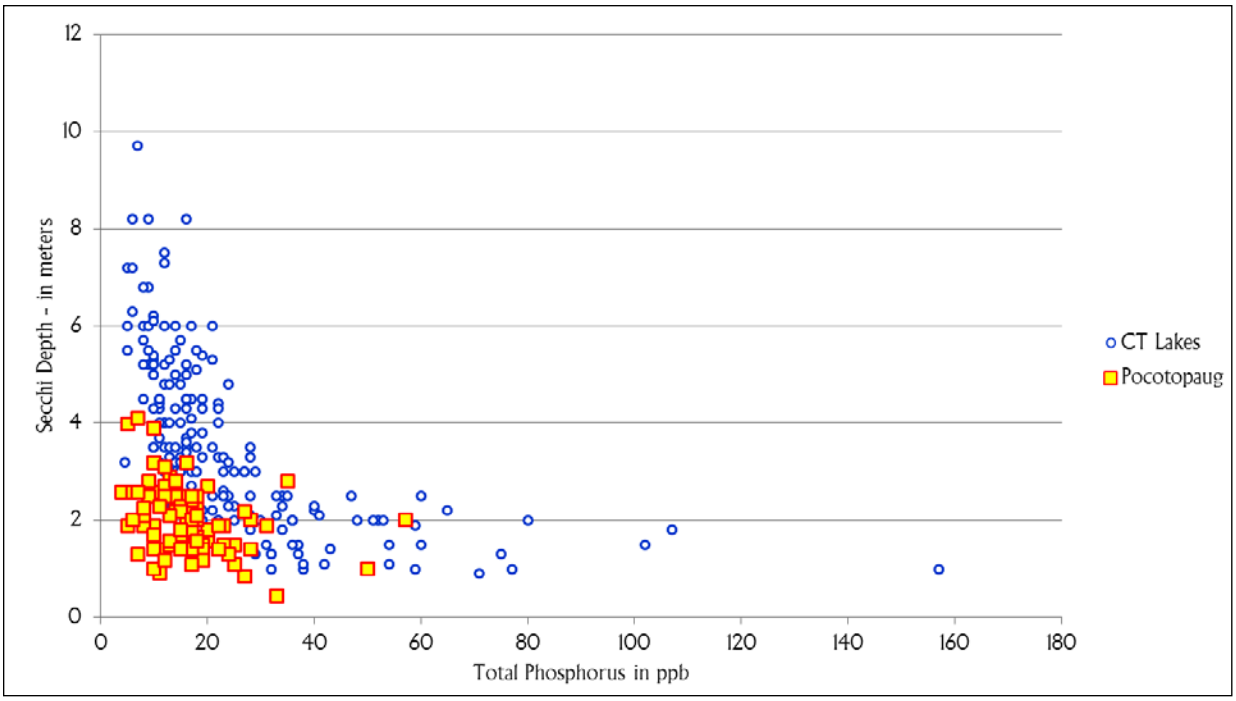
The cause of impairment has been listed as Chlorophyll-*a*, excess algae growth, and excess nutrient levels. These three causes of impairment have the same fundamental root-cause –excess nutrient levels in runoff from both Permitted and Non-permitted stormwater (Table 2)

To restore Lake Pocotopaug to mesotrophic classification the changes outlined in Table 6 are required. The water clarity would have to improve from current 0.5m summer Secchi disk depths to minimums of no less than 2m. The chlorophyll –*a* maximum concentration needs to be less than 15µg/L. Total phosphorus concentration needs to be <20 µg/L, and total nitrogen concentration to <500µg/L. However, Lake Pocotopaug phosphorus has generally been lower than observed clarity would indicate it should be (Figure 1) suggesting phosphorus nitrogen and sediment loading are also important factors in poor clarity at the lake. Data shown in Figure 1 indicate that reductions in phosphorus as low as ambient in lake concentrations of 10ppb would be needed before significant increases in Secchi disk would be realized.

Table 6 – Changes required to restore Recreational Use in Lake Pocotopaug

Parameter	Existing Levels	Required levels	Change Required
Water clarity	Minimum = 0.5 meters	Minimum summer reading of 2 meters	0.5 meters increased to 2 meters
Direct cell counts	Maximum cyanobacteria = 300,000 mL	Maximum cyanobacteria numbers 10,000 cells/mL	300,000 cells/mL decreased to 10,000 cells/mL
Chlorophyll –*a*	Summer maximums = 25 µg/L	Summer maximums <15µg/L	25 µg/L decreased to <15 µg/L
Phosphorus concentrations	Maximum summer = 30 µg/L	Consistent summer <20µg/L	30 µg/L decreased to <20 µg/L
Nitrogen concentrations	Maximum summer = 1,000 µg/L	Consistent summer <500µg/L	1,000 µg/L decreased to <500 µg/L

Figure 1 – Phosphorus / water clarity relationship in CT[5] lakes showing Lake Pocotopaug red squares



[5] = CT Agricultural Experiment Station Bulletin 817, 1984

Identified Causes of Impairment (element A)

Pollution Sources

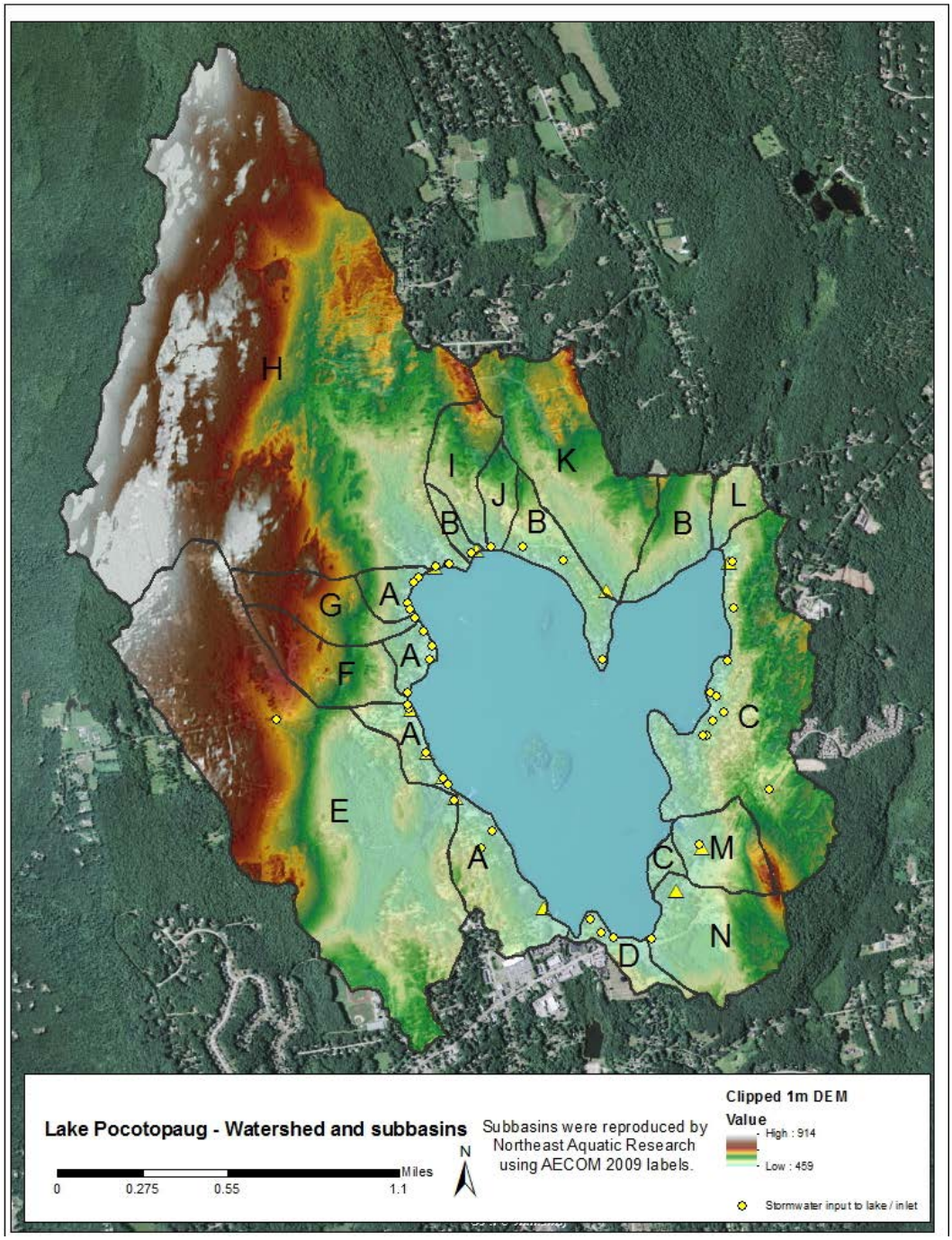
Watershed sub-basins

The AECOM 2009 report divided the Lake Pocotopaug watershed into fourteen sub-basins designated by topography and conveyance of water flow. The areas of each sub-basin are displayed in Table 7 below. Though these sub-basins have been referenced in historical reports with various names, this recent lettering system will be utilized for the purposes of this watershed nine elements plan. The corresponding map is provided in Map 1. Subbasins are ranked by size of catchment, with the first two—H, E--comprising 61% of the drainage basin. Remaining subbasins are small <10%, or very small <5% of the total area.

Table 7 – Watershed sub-basin of Lake Pocotopaug

Code	Name	Type	Hectares	Acres	% Area
H	Hales	Stream	360	890	39
E	Christopher	Stream	201	496	22
C	*Stormwater*	Direct	84	208	9
K	Fawn	Stream	58	144	6
A	*Stormwater*	Direct	50	122	5
B	*Stormwater*	Direct	38	94	4
N	Days	Brook	33	81	4
F	Clark Hill	Stream	25	61	3
G	*Stormwater*	Stream	20	50	2
M	O'Neill	Brook	19	46	2
I	Candlewood	Brook	18	44	2
D	*Stormwater*	Direct	14	34	1
J	*Stormwater*	Direct	9	22	1
L	Hazen	Brook	5	13	0.6
	Total Drainage Area		934	2,305	100

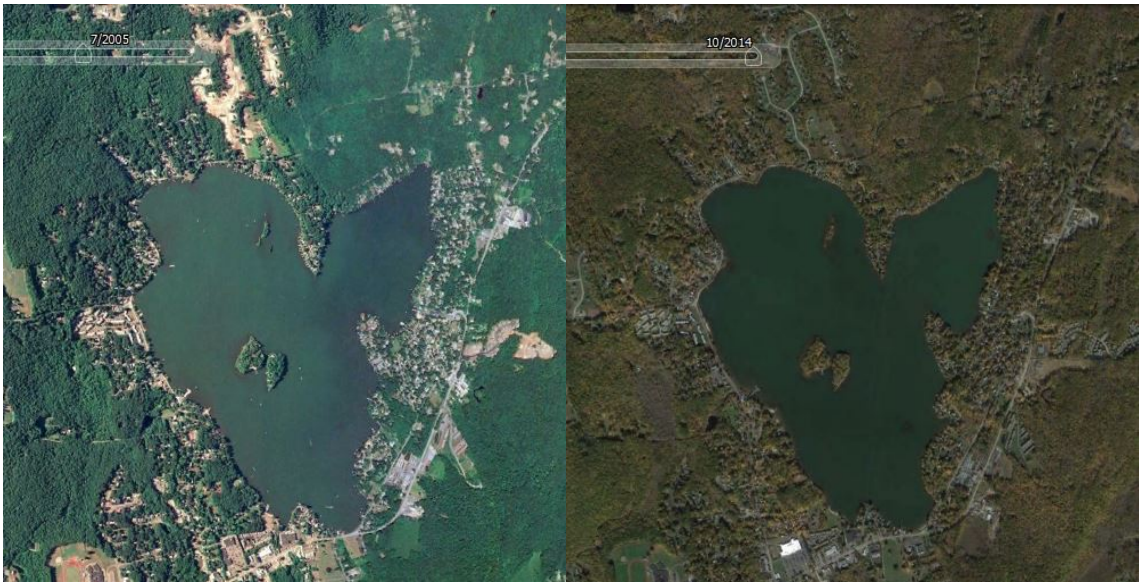
Map 1 – Lake Pocotopaug Watershed shown with color enhancements to show elevation and showing boundaries for each of 14 sub–basins labeled according to AECOM 2009



Land Use

Historical aerial images (**Map 2**) are available from the CT DEEP and UCONN MAGIC GIS clearinghouse. The images demonstrate that the immediate shore areas of Lake Pocotopaug were heavily developed throughout recent years. Note the 2005 large spans of open earth and construction in proximity to the lake. The visible green water is a product of cyanobacteria blooms occurring in the lake at the time of the photographs.

Map 2 – Four aerial images of Lake Pocotopaug Watershed, 1934, 2003, 2005, & 2014



Recent Updates and Current Land Use

The AECOM 2009 LLRM differentiates land-use into fourteen different land use types – nine of which are applicable to the Lake Pocotopaug basin (Table 8). The most recent land use GIS data available for the Lake Pocotopaug watershed is from 2006, which served as the base for updated 2009 land cover data used in the LLRM (AECOM 2009). Because there are inherent errors in using satellite and aerial imagery calculations to create large land cover GIS files, ground field data becomes incredibly important as supplementary information for more accurate land-use estimates when modeling watershed runoff and estimating nutrient loading. The directly downloaded 2006 GIS data contains possible flaws, NEAR confirmed that AECOM was able to appropriately reclassify raster pixels.

Table 8 – Land-use areas (ha) in Lake Pocotopaug drainage basin

LAND USE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	TOTAL
Urban 1 Light DR	29.8	19.9	43.7	6.7	47.4	10.9	2.2	31.8	6.7	4.5	18.1	0.4	8.7	6.7	237.5
Urban 2 Medium DR/Hwy	3.7	2.5	5.5	0.8	5.9	1.4	0.3	4.0	0.8	0.6	2.3	0.0	1.1	0.8	29.7
Urban 3 High DR/Com	3.7	2.5	5.5	0.8	5.9	1.4	0.3	4.0	0.8	0.6	2.3	0.0	1.1	0.8	29.7
Agric 1 Cvr Crop	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Forest 1 Upland	7.7	11.1	27.5	3.1	113.8	8.9	15.4	302.2	9.2	3.1	33.6	4.3	5.8	21.2	566.9
Forest 2 Wetland	0.0	0.0	0.2	0.0	14.5	0.0	0.0	6.1	0.0	0.0	1.9	0.0	0.2	2.7	25.7
Open 1 Wetland/Lake	2.5	1.5	0.6	0.6	0.1	0.0	0.0	3.1	0.0	0.1	0.0	0.0	0.2	0.1	8.7
Open 2 Meadow	2.0	0.5	1.3	1.8	10.2	2.1	1.9	7.0	0.1	0.0	0.2	0.7	1.4	0.3	29.5
Open 3 Excavation	0.1	0.0	0.1	0.1	2.3	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	4.4
TOTAL	49.5	38.0	84.3	13.9	200.9	24.6	20.1	360.0	17.6	8.8	58.3	5.4	18.6	32.8	932.7

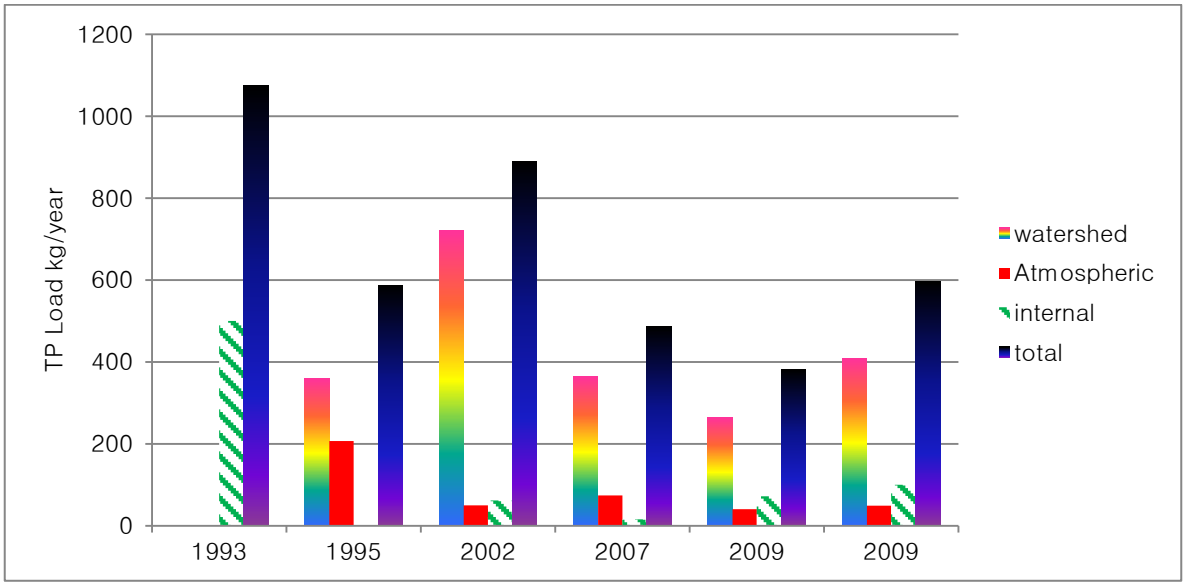
Estimating Total Nutrient Loading

Several attempts between 1993 and 2009 have been made at estimating nutrient loads to Lake Pocotopaug Table 9. The AECOM 2009 report presented the Lake Loading Response Model (LLRM) as the culmination of several years of data collection and watershed analysis. The LLRM estimates of phosphorus loading to Lake Pocotopaug are given in Table 9 (shown in gray) alongside prior modeling results and graphically in Figure 2. The LLRM total load of 382 kg/yr. is fractioned into 69% from watershed sources, 10% due to atmospheric deposition, which cannot be managed, 19% internal recycling, and 1% wildlife. Internal loading and atmospheric deposition are not covered in this report so background phosphorus un-manageable load to Lake Pocotopaug is about 113 kg/yr., while the 265 kg/yr. from the watershed is the manageable load. For nitrogen, total manageable load to Lake Pocotopaug is 5,662 kg/kr. Estimated un-manageable nitrogen load is 3,032 kg/yr. or 35%.

Table 9 – Results from prior loading models

TP Load (kg/yr.)							TN Load (kg/yr.)	
Source	Frugro 1993	LAC 1995	ENSR 2002	ENSR 2007	AECOM 2009 Model	AECOM 2009 Expected Range	AECOM 2009 Model	AECOM 2009 Expected Range
Atmospheric	574	207	25–50	74	**41**	33–49	**1,242**	1,201–1,283
Wildlife		20	20–40	20	**4**	4–40	**19**	19–190
Direct Groundwater			5–18	12	**265**	242–408	**5,662**	4,701–6,013
Watershed		360	280–720	318–364				
Internal	500	?	62	16	**72**	50–100	**1,790**	1,400–2,000
Total	1,074	587+ internal	392–890	441–487	**382**	329–597	**8,713**	7,321–9,486

Figure 2 – Range in phosphorus loading estimates from different sources



Sub-basin level Nutrient Loading

The Lake Loading Response Model estimates for total water load from each of the 14 sub-basins, shown ranked in **Table 10.** The table also gives the LLRM phosphorus and nitrogen export rates for each sub-basin using land-use runoff coefficients[6]. All references were reviewed as part of this work (**Appendix 2**). The column 'NEAR New Data' is from collections made in 2014-2016. to AECOM 2009 values are higher because estimates include groundwater and used first-flush nutrient numbers from storm events to estimate storm water loading.

Table 10 – Lake Potocotopaug sub-basin specifics

Basin Code and Name	Water load %	T. Phosphorus (kg/yr.) AECOM 2009	T. Phosphorus (kg/yr.) NEAR New Data	T. Nitrogen (kg/yr.) AECOM 2009	T. Nitrogen (kg/yr.) NEAR New Data
H- Hales	39	64.7	44.5	1,608.6	714.9
E- Christopher	21	48.3	23.8	962.3	738
C- Direct	9	39.0	16.6	878.3	780
A- Direct	5	24.9	35.1	564.5	117.3
K- Fawn	6	20.3	14.3	317.5	252.9
B- Direct	4	17.6	~*	397.3	?
F- Clark	3	10.2	14.28	231.1	?
N- Days	4	9.4	7.8	148.0	66.6
M- O'Neil	2	8.0	8.1	126.7	86.6
I- Candle	2	6.8	~*	106.6	?
D- Direct	1	6.0	~*	136.3	?
G- Unnamed	2	4.7	~*	104.4	?
J- Unnamed	1	4.0	~*	63.5	?
L- Hazen	1	1.1	~*	17.3	?
TOTAL		265.1	160.7	5,662.2	2,185.4

** = pending new data*

The sub-basins are ranked by percent water load contribution along with percent phosphorus and nitrogen loads in **Figure 3**. The chart shows that only the two large sub-basin -H & E--have percentage water load that exceeds the percent nitrogen and phosphorus load all other have nutrient loading at higher percent than its water contribution. This could be due to large portion of the sub-basin that is still wooded. Two of the smaller sub-basins—C & A--have phosphorus and nitrogen at twice the percent of contribution of water. These data suggest that smaller sub-basins particularly C and A have dis-proportionally more nutrient loading that water flow would suggest.

[6] Runoff coefficients drawn from referenced scientific literature

The LLRM predicts loading of phosphorus to be heavily weighted by urban land-use (**Figure 4**), suggesting that most efficient way to lower phosphorus export to the lake is to limit and modify runoff from existing urban land-use. Creation of new urban land-use will, based on these data, increase the runoff of phosphorus to the lake. This is also strong evidence that correcting phosphorus loading to the Lake will rely on LID strategies used in urban land-use areas.

Figure 3 – Percent water, phosphorus, and nitrogen loading from each sub-basin

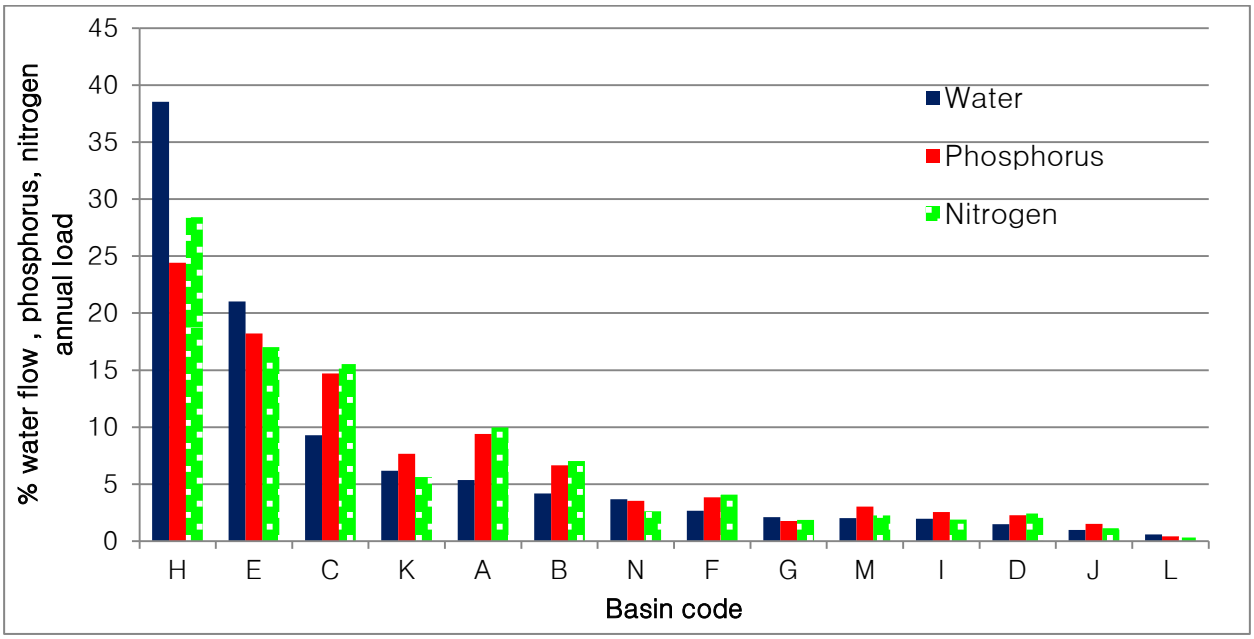
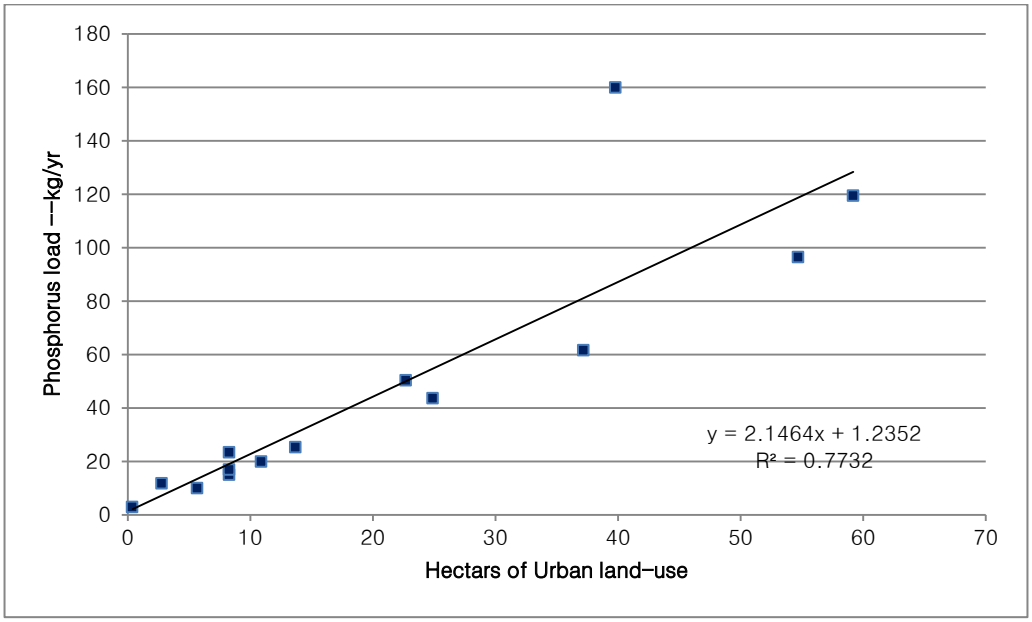


Figure 4 – Relationship between sub-basin phosphorus runoff and hectares of urban land-use



Sub-basin Priority Ranking

As denoted in **Table 10**, the largest sub-basins E – Christopher Brook and H – Hales Brook, contribute the majority of runoff to Lake Pocotopaug. Combined, these two streams make up 60% of the watershed water-load 42% of the phosphorus, and 50% of the nitrogen load to the Lake. Frequent monitoring of nutrient concentrations at these inlets is extremely important. Remaining flow is divided between 12 sub-basins, each contributing less than 10%, with nine contributing less than 5% of the water load. However, sub-basins C, A, and K contribute higher amounts of phosphorus and nitrogen than the lower flow suggest. Remaining sub-basins had phosphorus and loads that paralleled water load.

The majority of effort should go to high water and high phosphorus load basins E and H. Moderately high phosphorus load basins C A and K should have focus on remedial efforts and forest and wetland preservation as ranked in the **Table 11** below. Steps down in each tier represent sub-basins with slightly lower water and or nutrient load.

Table 11 – Priority ranking of sub-basins

Category	Sub-basin					Water and Phosphorus contribution
						60% water, 42% phosphorus 50% nitrogen
Tier 1	H					
		E				
Tier 2	C					20% water, 32% phosphorus 30% nitrogen
		A				
			K			
Tier 3	B					15% water, 19% phosphorus 18% nitrogen
		F				
			N			
				M		
					G	
Tier 4	I					5% water, 7% phosphorus 7% nitrogen
		D				
			J	L		

Critical Areas Requiring Nonpoint Management Measures (element C)

Management Measures

Best Management Practices & Low Impact Development

The following section discusses observed percent pollutant reductions of varying stormwater controls based on the scientific literature. Wherever possible, stormwater management should focus on increased infiltration and natural filtering; however, nutrient filtration systems are more appropriate where onsite infiltration is not feasible[7].

Rainwater Harvest Systems (rain barrels)

Based on a recent EPA literature review of 23 cities over varying climatic regions, onsite rainwater storage from roof gutter systems reduce long term stormwater runoff volumes from residential areas by about 20%. This percentage, however, is heavily dependent on local impervious surface cover and population density. In the case of Lake Pocotopaug, the high density residential areas in the direct watersheds A, B, & C would greatly benefit from onsite rainwater harvest barrels. Rain barrels capture roof runoff during storm events and temporarily store the water for household use, e.g. watering gardens and onsite infiltration.

Dry Detention Area

Dry detention basins are designed to store and infiltrate stormwater runoff in a level, vegetated depression. Nutrient reduction is variable but TP reductions are near 16-29%. Dry detention reduces TN by about 10-26% and TSS at 66-80%. The variation in nutrient decrease can be attributed to differing soil characteristics and is also dependent on the design of the dry detention system. Improper grading will prevent even dispersal of rainwater and reduce pollutant reduction. If water is allow to pool for long periods of time, phosphorus may be released from the sediments as biologically available ortho-phosphorus. To restate, proper design and construction are critical and pollution control can be further increased by manipulating underlying fill.

[7]: Jiang et al. 2015, Piza et al. 2011, Yang et al. 2014, Barret et al. 2004, U.S. EPA 2000, Young et al. 1996,

Wet Detention Ponds

Wet stormwater detention ponds, such as the ponds at Paul & Sandy's and Lake Vista, are designed to let particles settle out, thereby reducing TSS up to 94%. However, if the pond is not designed large enough to handle incoming stormwater it will merely act as a flow through system. Improperly designed wet detention ponds may also have the inflow and outflow too close together, negating any particulate-holding ability. On average, TN concentration reductions for these types of ponds are around 9-32%. Wet detention ponds are not designed to retain phosphorus; TP reductions in the scientific literature are recorded around 5% while there is research to suggest that orthoreactive P concentrations in effluent may be up to 266% greater than influent stormwater.

In the case of very large water volumes from impervious surface runoff, wet detention ponds may be necessary, but these systems should be combined with additional phosphorus reducing mechanisms to limit nutrient pollution to the Lake.

Constructed Wetlands

Constructed wetlands are similar to wet detention ponds in that they are consistently flooded, yet these marsh areas are designed to be shallow and well-vegetated. Stormwater nutrients in constructed wetland systems are partially used by plants. More robust wetland plants, such as cattails, uptake and store nutrients before they reach the Lake. Constructed wetlands create wildlife habitat and are aesthetically pleasing, but they also require periodic inspection to ensure proper pollutant filtering. Ongoing research suggests that initial TP reduction of constructed wetlands can be as high as 60%, but as nutrients saturate the system over 10-20 years, retention capacity declines (Micsh et al. 2000). Like all forms of stormwater treatment, an understanding of the underlying sediment is critical to initial design, maintenance, and lasting efficiency.

Floating Treatment Systems

Like traditional constructed wetlands, floating wetlands act by storing nutrients via vegetative uptake, but instead in a hydroponics treatment system. Existing wet stormwater retention ponds can be retrofitted with floating wetland systems for increased nutrient uptake. Published research suggests that floating wetlands can reduce TP outflow by approximately 27% (Borne 2014). Further studies indicate that some integrated floating wetland systems with biofilm carriers increase periphyton growth and TP uptake to over 80% (Zhang et al. 2015). This type of technology is relatively new, but experimental sites in Christopher Brook Pond or Paul & Sandy's retention pond may reduce the high inlet concentrations to Lake Pocotopaug, thereby limiting summer cyanobacteria blooms. Floating treatment systems, however, require more frequent maintenance than other types of stormwater controls.

Bio-retention (rain gardens)

The primary goal of a bi-retention system is to infiltrate stormwater onsite in a shallow depression. With proper design and construction rain gardens are excellent at reducing the overall water volume entering a lake system as road runoff or through underground culverts. Depending upon the design, rain gardens are also capable of reducing sediments and nutrients.

Porous Pavement /

Porous pavement systems are designed to infiltrate stormwater and reduce overland runoff during heavy rain. Typical sidewalks, parking lots, and roadways are built using impervious materials that do not allow rainwater to penetrate into the underlying soils. Porous pavement, made of either cement or asphalt, is constructed with tiny holes that allow water to filter through and infiltrate onsite, rather than being directed into storm drains. Flow reduction studies determined that permeable interlocking concrete and porous pavement with an underlying gravel sub-base reduce overland runoff by 33-38%. However, permeability relies on the void spaces in the pavement material and can be easily clogged if not maintained. Porous pavement should not be sanded during winter months and biennial vacuuming may be necessary.

Vegetated Swale

A dry vegetated swale is a depression in the land that captures stormwater runoff from impervious surfaces, such as roadways and sidewalks. Vegetated swales are designed in completely infiltrate the runoff and should not be a zone of standing water. Infiltrate capacity may be enhanced by manipulating the underlying sediments, but dry swales need to be engineered and constructed based on the estimated water load that they would be expected to handle. Recent studies have suggested that Total Phosphorus and Nitrogen reductions are near 30% for well-designed swales, but that a poorly designed system that creates standing water may actually increase dissolved P significantly.

Critical Management Areas

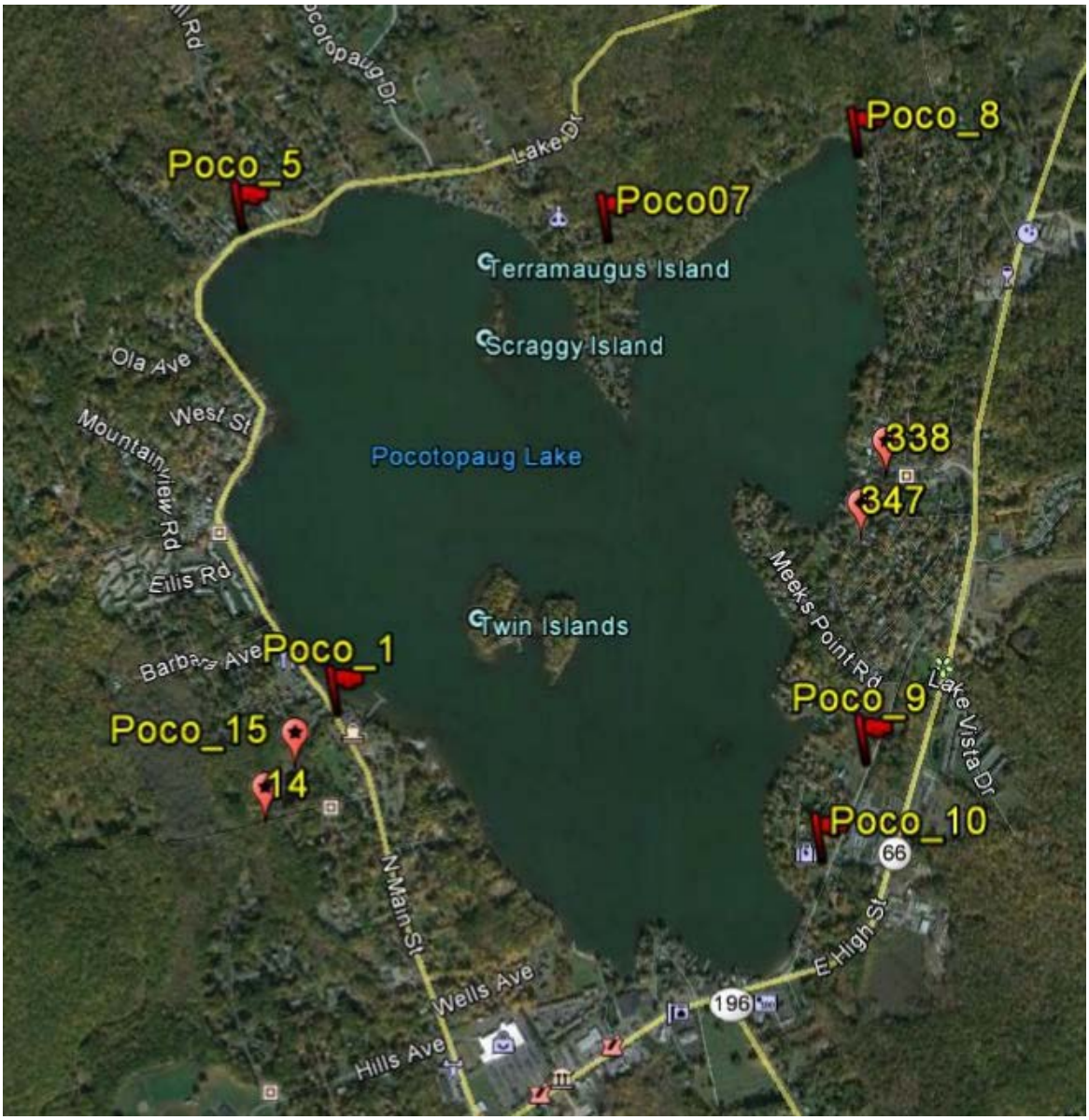
Sub-basin details

Several of the important sub-basins are discussed in-detail in this section (Table 12). Estimated loading values and reductions using proscribed measured are given. Where possible we show comparisons between 2014-2016 data and pre-2008 data. The location of the important sampling stations where stream flow and nutrient chemistry was tested are given in Table 12 and shown in Map 3.

Table 12 – Inlet stations

Sampling Location	Basin Name
Poco_14, Poco_15	Christopher Brook (E)
Poco_5	Hales Brook (H)
Poco_8, WPT_338, WPT_347	Sub-basin (C)
Poco_7	Fawns Brook (K)
Poco_1 – Poco_4	Sub-basin (A)
Poco_9	O'Neil's Brook (M)
Poco_10	Days Brook (N)

Map 3 – Location of watershed inlet sampling points referenced in the text



(H) Hales Brook

The Hales Brook sub-basin delivers nearly 40% of the watershed runoff to Lake Pocotopaug, making it a critical stream to monitor and ensure good water quality. Much of this watershed is forested and minimally disturbed, resulting in relatively low phosphorus and nitrogen concentrations in comparison to the other stormwater inlets. See Appendix 4 photos 67-70.

From 2014 to 2016, six samples were collected (Table 13) from our Poco_5 site. All of these samples had lower concentrations of total phosphorus (TP) and total nitrogen (TN) than 2008 samples. Recent stormwater samples were all less than 0.026 mg/L TP, much lower than values found in 2008. The Dissolved Phosphorus (DP) from 2008 and March 2016 were consistently low. The average storm TP from 2014-2016 was 0.020 mg/L (20ppb) and the non-stormwater conditions were only 8-10ppb, or very good water quality and representative of a forested stream. Similarly lower concentrations were found for TN in recent samplings than from 2008. LLRM predicted that this sub-basin contributes 64.7 kg TP per year. NEAR estimated the total annual load based on collected samples and flow measurements to be 44.5 kg TP per year, discussed in detail below.

Table 13 – Hales Brook water chemistry

Collector	Site	Date	Type	NH3	NOX	TKN	TN	TP	DP	Description
	Where					mg/L				
AECOM	LP-5 (11)	4/28/2008	Post-Wet	0.005	0.005	0.62	0.620	0.039	0.005	Hales before pool
AECOM	LP-5 (11)	4/28/2008	FF	0.005	0.055	1.11	1.165	0.042	0.002	Hales before pool
AECOM	LP-5 (11)	9/26/2008	Post-Wet	0.005	0.01	1.36	1.37	0.043	0.002	Hales before pool
AECOM	LP-5 (11)	9/26/2008	FF	0.018	0.10	5.50	5.60	0.168	0.004	Hales before pool
	Mean ->						2.19	0.073	0.003	
NEAR	Poco_5	10/1/2014	Storm				0.37	0.021		Hales outlet pool
NEAR	Poco_5	6/2/2015	Storm				0.24	0.016		Hales outlet pool
NEAR	Poco_5	6/15/2015	Storm				0.35	0.026		Hales outlet pool
NEAR	Poco_5	1/27/2016	Melt				0.18	0.010		Hales before pool
NEAR	Poco_5	3/28/2016	Storm	ND	0.10		0.25	0.018		Hales before pool
NEAR	Poco_5	5/13/2016	Dry	ND	0.072		0.131	0.008	0.007	Hales before pool
	Mean =>						0.25	0.017	0.007	

FF – First Flush, Storm – During precipitation event, Post-Wet – Morning after storm, Melt – Moist snow melt/not raining

Investigations of the campground in 2016 reveal that the stream is crossed by an ATV trail which could be a source of particulate phosphorus during heavy use. This type of use should be mitigated and reduced to ensure minimal disturbance to the stream bed. Though recent sample concentrations were low for Hales Brook (Table 14), there is still potential for the high human activity of this campground to periodically pollute the stream and continued monitoring is necessary to capture any such events.

The description of sample collection is included because Hales Brook enters the Lake through a small pooled area near lake level. It was difficult to obtain accurate measurements of water flow at the pond outlet due to occasional backflow or no measurable flow. The 2016 measurements, however, were taken upstream of the pool and can be appropriately used to calculate phosphorus loading estimates based on the volume of water and respective nutrient concentrations.

Table 14 – Hales Brook estimated loads

H: Hales Brook	Poco_5	Poco_5	Poco_5
Condition	Baseflow	Storm	Baseflow
Date	1/27/16	3/28/16	5/16/16
TP (µg/L)	10	18	8
P Load (kg/day)	0.09	0.60	0.065
P Load (mg/s)	1.02	6.93	0.602
TN (µg/L)	179	246	131
N Load (kg/day)	1.58	8.19	0.851

Despite relatively low nutrient concentrations, Hales Brook provides a significant nutrient mass load to the Lake because it is such a large volume of incoming water with respect to the other inlets. East Hampton 2014 and 2015 precipitation data was acquired from Weather Underground. Using the annual average number of storm events greater than one inch and the number of corresponding dry weather days with no precipitation, Hales Brook is capable of contributing a range of 23.4 kg TP/yr. during storm wet conditions, and 21.2 kg TP/yr. at baseflow. Combined, Hales Brook is expected to contribute approximately 44.6 kg of phosphorus annually, a prediction less than provided by the LLRM model, yet still the major nutrient load to the Lake. Nitrogen loading predictions based on 2014–2016 data were roughly 714.9 kg/yr. TN (319.2 kg TN as stormwater and approximately 395.7 kg via annual baseflow).

Stormwater TP samples from just upstream of the pool and from the outlet at the under-road culverts did not suggest that the pool was contributing or retaining nutrients. The pool seems to act mostly as a flow-through system with low concentrations.

The Hales Brook watershed should be preserved to ensure that the water quality does not further deteriorate. The Town can maintain the forested region in watershed H by partnering with local property owners and the Middlesex Land Trust to create 'watershed conservation areas' that are inaccessible to future development.

(E) Christopher Brook

The Christopher Brook watershed is the second largest sub-basin to Lake Pocotopaug. The LLRM predicts that Christopher Brook delivers approximately 20% of the runoff water from the watershed. LRM predicted that this sub-basin contributes 48.3 kg TP per year, and the corresponding TMDL

report recommends that the Town monitor the construction of Skyline Estates to minimize pollution impacts. However, during part of the 2016 watershed investigation and stormwater mapping, it was observed that the retention basins are insufficiently infiltrating runoff from the development. (Appendix 4 photos 39–44).

Nutrient samples were collected upstream at Poco_14 and downstream at Poco_15 of Skyline Estates constructed wetland basins (Table 15) LID level-spreader beginning to deteriorate apparent construction results in the flooding of two of the and an overflow of sediment and nutrient-rich water directly into an upper segment of Christopher Brook. There is a in place, but the capacity is not sufficient and the wooden infrastructure is., where Christopher Brook flows from a large wooded wetland, under the road and into a private pond. Photos of the overflow are included in Appendix 4.

Table 15 – Christopher Brook Pond input output estimates

Christopher Bk	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Field Code	Poco_14	Poco_15	Poco_14	Poco_15	Poco_14	Poco_15	Poco_14	Poco_15	Poco_14	Poco_15
Date	10/1/14	10/1/14	6/2/15	6/2/15	6/15/15	6/15/15	1/27/16	1/27/16	3/28/16	3/28/16
CFS (volume)	1.71	0.10	2.87	5.29	6.39	8.33	1.41	0.99	5.54	6.44
TP (µg/L)	76	56	23	21	44	33	11	8	39	11
P Load (kg/day)	0.32	0.01	0.16	0.27	0.69	0.67	0.04	0.02	0.53	0.17
P Load (mg/s)	3.68	0.16	1.87	3.15	7.96	7.79	0.44	0.22	6.12	2.00
TN (µg/L)	404	221	391	439	692	524	587	665	524	455
N Load (kg/day)	1.69	0.06	2.75	5.68	10.82	10.68	2.03	1.61	7.11	7.17
Turbidity	19.1	8.6			6.9	6.2	0.8	0.7		

All stormwater samples demonstrate high TP concentrations at Poco_14. The January concentration, representing a value not during a precipitation event, is low at 11 ppb. These results suggest that there is high loading of phosphorus to Christopher Brook during rain storms as compared to base-flow. Updating the Skyline Estates property with appropriate LID has the potential to greatly reduce nutrient concentrations downstream at this sampling site. Poco_15, where Christopher Brook flows out of the private pond and into a wetland area, better represents the nutrient load of watershed E that reaches the Lake. Concentrations out of the pond in 2014–2016 were constantly lower than the water entering the pond at site Poco_14. This could be due to the pond retaining particulate phosphorus or a certain amount of dilution from direct drainage to the small pond. Concentration and flow volumes were used to calculate respective P loading mass.

(C) East Side Direct

Sub-basin C was estimated to contribute a total of 39 kg of annual TP to Lake Pocotopaug (AECOM 2009). The sub-basin is a large area of direct drainage and contains a span of a state owned highway, route 66 (Appendix 4 photos 17–28). It is characterized by medium to high density residential dwellings and has two apartment building complexes, one currently under construction

for expansion. There are eight known locations within sub-basin C that deliver surface water to the Lake. Three of these sites contain higher water flows and were measured during 2014-2016 (WPT347, WPT338) shown in Table 16.

Table 16 – Sub-basin C estimated flows

Sub-basin C	Clearwater Condos	Drains from route 66 /
Field Code	WPT338	WPT347
Date	3/28/16	3/28/16
TP (µg/L)	25	43
P Load (kg/day)	0.03	0.37
P Load (mg/s)	0.34	4.26
TN (µg/L)	618	201
N Load (kg/day)	0.73	1.72

The Laurel Ridge Estates development began circa 2004 and only a small portion of this complex is in the Lake Pocotopaug watershed. The new construction for Edgewater Hills began in 2014 and includes nearly 8 acres within sub-basin C. There was still much active construction on this site in April 2016 with spans of exposed sediment and piles of earth contained by one silt fence. Adjacent and downstream wetland pond found to have extremely high in iron and manganese and moderate TP. Water is discharged from this pond via plastic pipe to a detention basin along route 66. After settling, water is then routed to the Lake via an underground stormwater culvert matrix. The outlet of this water to the Lake is on private property at WPT347, Only one sample has been collected at this site so far--3/28/16--due to difficulty accessing the water because culvert is obstructed by large rock and above storm drain nearly 12ft deep with confluence of three pipes. Inflow to the lake via this conveyance shows evidence of large water flows with moderate to high TP levels. More investigation is necessary at this site.

From the concentration and flow data collected in 2014-2016, rough estimates can be made to quantify the phosphorus mass loading at WPT_338 and WPT_347. The loading estimates in Table 17 are useful in determining the relative magnitude of a nutrient pollution source. For instance, very high TP levels are inconsequential given minimal water flow and more attention should be paid to sources contributing high volumes of water with moderate to high TP. The calculated P load in mg/s can be used to more accurately estimate nutrient loading over the duration of a rainstorm. If the P loading during dry conditions from WPT347 are similarly high then this site could represent a massive loading to Lake that has never been addressed.

Sub-basin C also has a number of catch basins that flow directly from residential roadways into the Lake. The AECOM 2009 report recommends the installation of leaching catch basins and suggests that this form of infiltration would be capable of reducing the nutrient load by 33-60%. Leaching systems have not been installed in this area. Instead, catch basin "hoods" are in use in an attempt to reduce sediment loading. These devices must be maintained at least annually to ensure proper filtration.

Previous ENSR sampling at the corner drain at Mohigan Drive shows a large variation in TP concentrations, ranging from 13 to 925 µg/L in 2001. AECOM 2008 and NEAR 2014-2016 sampling revealed high levels of TP and TN, specifically during storm loading events (Table 18) NEAR samples and flow measurements were collected as outflow at the Lake Association beach.

Table 17 – Sub-basin C estimated flows

Collected by	Field	Date	TP (µg/L)	TN (µg/L)	Conditions
AECOM	22	4/28/08	90	1113	Post-Wet
AECOM	22	9/26/08	66	660	Post-Wet
NEAR	Poco_8	4/15/14	293	1165	Mid-precip.
NEAR	Poco_8	10/1/14	128	460	Mid-precip.
NEAR	Poco_8	6/2/15	39	782	Mid-precip.
NEAR	Poco_8	6/15/15	108	837	Mid-precip.
NEAR	Poco_8	8/11/15	168	968	Mid-precip.
NEAR	Poco_8	1/27/16	26	3242	Not raining
NEAR	Poco_8	3/28/16	50	1610	Mid-precip.

Table 18 – Loading estimates Mohigan Drive storm drain

Private beach from Mohigan Rd corner drain							
Field Code	Poco_8	Poco_8	Poco_8	Poco_8	Poco_8	Poco_8	Poco_8
Date	4/15/14	10/1/14	6/2/15	6/15/15	8/11/15	1/27/16	3/28/16
TP (µg/L)	293	128	39	108	168	26	50
P Load (kg/day)	*0.54*	0.002	0.002	0.07	0.003	0.000	0.01
P Load (mg/s)	*6.31*	0.03	0.02	0.82	0.04	0.001	0.15
TN (µg/L)	1165	460	782	837	968	*3242*	1610
N Load (kg/day)	2.17	0.01	0.03	0.55	0.02	0.01	0.41
Turbidity	*89.5*	15.7		4.3		5.8	

Most of the P loading estimates from this drain are low. Nevertheless, large nutrient quantities have been captured during high flow stormwater sampling in 2014, yielding possible loading of 0.54 kg/day TP. Beach erosion is evidence of high flow and high TN levels during the drier conditions in January 2016 suggest that nitrogen loading is not limited to storm events and may be linked to fertilizer use or decomposition of organic material in the unmaintained catch basin. Nitrogen pollution sources at this location should be further investigated.

(K) Fawn Brook

This watershed drains a large section of the Seven Hills residential development and flows into the Lake via Fawn Brook (also called Bay Road Brook in past reports, NEAR site ID Poco_7). The

stream originates at the development in a wetland area and stormwater detention basins before passing along a private agricultural property. No inspection of this private property has been done but aerial images reveal ongoing logging activities. Water samples were collected where the stream intersects Bay Road. From the available data (Table 19), the most recent samplings at this site are from 2001 and 2003 (ENSR) and range from 15 to 335 µg/L TP. Recent 2014 – 2016 sampling demonstrated low TP in January, not during a storm event, and moderate to high stormwater levels of TP. The water volume of this inlet accounts for approximately 6.2% of the annual watershed runoff water load to the Lake (AECOM 2009). Thus, high nutrient concentrations in this inlet are of greater importance than smaller inlets with comparable TP and TN levels.

Table 19 – Sub-basin K Brook near Spellmans Pt.

Brook near Spellman's Pt @ Bay Rd.							
Field Code	Poco_7	Poco_7	Poco_7	Poco_7	Poco_7	Poco_7	Poco_7
Date	4/15/14	10/1/14	6/2/15	6/15/15	8/11/15	1/27/16	3/28/16
TP (µg/L)	74	70	19	40	82	12	20
P Load (kg/day)	0.42	0.14	0.10	0.33	0.17	0.02	0.19
P Load (mg/s)	4.91	1.56	1.14	3.81	2.00	0.24	
TN (µg/L)	536	533	273	486	1,535	409	440
N Load (kg/day)	3.07	1.03	1.41	4.00	3.23	0.71	4.17
Turbidity	17.5	20		4.6		1.1	

On inspection of the Seven Hills development, there are various LID features such as large vegetated stormwater swales, and roadside infiltration areas to slow limit stormwater runoff. However, (photo 75) it appears that LID retention areas can be enhanced with updated engineering designs.

(A) West Side Direct

This sub-basin includes all direct drainage on the western side of Lake Pocotopaug. The area is highly developed and has several densely populated residential condominium and apartment complexes. The AECOM 2009 report estimates that this direct drainage area accounts for 5.4% of the watershed runoff and that it contributes approximately 24.9 kg/yr. TP to the Lake. Stormwater sampling and water flow observations illustrate that there is a large amount of road runoff flowing directly to the lake via poorly functioning catch basins near lake level. Because a large percentage of this sub-basin is private property, it is critical to involve public participation, specifically the owners of Edgemere Condominiums and Angelico's Lakehouse Restaurant. Both of these properties have large paved areas and could easily reduce stormwater runoff provided BMP/LID improvements.

Sampling in this sub-basin in 2014-2016 revealed very high concentrations of TP and TN. Stormwater runoff measurements at NEAR sites Poco_1 through Poco_4 are displayed below.

Specific sites have been identified for potential LID, all on private property (Appendix 4 photos 3–14).

(M) O'Neil's Brook

The TMDL report and LLRM predicts that sub-basin M, the O'Neil's Brook watershed, loads approximately 8 kg P to the Lake per year and represents only 2% of the total watershed runoff to the Lake (AECOM 2009). The O'Neil's Brook watershed contains the Lake Vista Condominiums and a large section of commercial property owned by Paul and Sandy's, a large plant nursery and mulch distributer. The AECOM 2009 report recommends monitoring the two detention basins, one at the bottom of the Lake Vista complex, the other next to the greenhouse facility at Paul and Sandy's. Both detention basins are for sediment and nutrient control but may not be functioning to their fullest abilities and would benefit from LID. AECOM estimates that a 33% P reduction is possible for this sub-basin.

This site O'Neil's Brook at Old Marlborough Road, was sampled and monitored during 2014–2016 (NEAR inlet ID Poco_9), downstream of both detention facilities in order to compare nutrient loading to previously collected data (Table 20). In 2015, the East Hampton Department of Public Works retrofitted the underground pipe that delivers the stream under Old Marlborough Road. New riprap and hay bales were installed as erosion control, yet high nutrient concentrations and visible algae downstream demonstrate that this area is still a pollution source to the Lake (photo 77). AECOM 2008 sampling results recorded a range of TP values from 94 to 201 µg/L; the highest concentrations were first flush samples. All data collected in 2014 – 2016 were lower than in 2008, but P loading estimates are still high during storm events, despite a small area for watershed runoff.

Table 20 – Sub-basin M O'Neil's Brook

O'Neil's Brook						
Field Code	Poco_9	Poco_9	Poco_9	Poco_9	Poco_9	Poco_9
Date	10/1/14	6/2/15	6/15/15	8/11/15	1/27/16	3/28/16
TP (µg/L)	79	47	71	88	25	49
P Load (kg/day)	0.100	0.105	0.261	0.226	0.005	0.234
P Load (mg/s)	1.158	1.220	3.016	2.617	0.059	
TN (µg/L)	379	720	670	844	457	470
N Load (kg/day)	0.480	1.615	2.459	2.168	0.093	2.242
Turbidity	62.6	10.4		6.3		6

It does not appear that any changes to the infiltration basins have been made since the AECOM 2009 recommendations. On 3/28/16, samples were also taken from the outlet of the Lake Vista retention pond. TP exiting the detention basin was 88 µg/L and volumes of water estimated the potential P load downstream from the complex to be 0.11 kg/day P during rainstorms events. No samples were taken from the outlet of Paul and Sandy's detention basin because it is fenced off as

private property. Action should be taken to work with the owners of both private detention facilities to maximize nutrient storage and infiltration using LID.

Before entering the Lake, O'Neil's Brook passes through a final wetland area on both sides of Old Marlborough Rd. It is likely that the wetland serves as a seasonal nutrient filter, trapping sediment and providing limited nutrient storage via trees and wetland plants. However, channelized flow in the wetland minimizes biotic uptake and nutrient storage. Maximum uptake can be attained through diffuse flow, or a greater water contact time with the wetland vegetation via engineering controls.

(N) Day's Brook

The AECOM TMDL report estimated the Day's Brook sub-basin (NEAR site ID Poco_10) to load 9 kg TP annually to Lake Pocotopaug. AECOM first flush and post-storm field samples ranged from 109 to 225 µg/LTP in 2008. Sampling in 2014 – 2016 revealed lower phosphorus concentrations than in previous years but phosphorus was still elevated during precipitation events (Table 21_note high turbidity in April 2014). LID should be used to mitigate runoff from the commercial and residential properties in this watershed (photo 83).

Table 21 – Sub-basin N Day's Brook

Day's Brook							
Field Code	Poco_10	Poco_10	Poco_10	Poco_10	Poco_10	Poco_10	Poco_10
Date	4/15/14	10/1/14	6/2/15	6/15/15	8/11/15	1/27/16	3/28/16
TP (µg/L)	128	56	24	60	70	11	28
P Load (kg/day)	0.516	0.041	0.107	0.134	0.064	0.002	0.098
P Load (mg/s)	5.97	0.47	1.22	1.55	0.74	0.02	
TN (µg/L)	501	433	313	479	1319	268	265
N Load (kg/day)	2.02	0.32	1.4	1.1	1.2	0.04	0.9
Turbidity	101.2	35.7		12.8		1.7	

Critical Needs Table

The following section provides a summary list of specific pollution sources and prospective fixes necessary for Lake Pocotopaug water quality improvement Table 22. The list identifies the priority and expected costs associated per each pollution source. LID in the watershed is expected to reduce phosphorus nutrient loading by approximately 17% and nitrogen loading by at least 30%. These percentages can be enhanced with innovative LID designs and reduce sediment loading (TSS) to the Lake by 30-60%.

Table 22 – Watershed management measures required listed by Sub-basin

Sub-basin	Pollution Source	Proposed Fixes	Cost Estimates	Priority
		Sub-basin A		
A	Sears Park Rain Garden	Soil test hole needed to determine depth of saturation zone/infiltration capacity		
	"	Improve existing rain garden with installation of a sediment forebay to trap sediment and prevent fine particles from inhibiting water infiltration	$5,000-10,000	Medium
	"	Potentially convert rain garden to constructed wetland with greater plant coverage		
A	Sears Park Parking Lot	Open cell pavers with pea gravel to avoid sediment runoff from open dirt parking lot – various products, varied durability reflected in total project costs	$180,000-250,000	Medium
A	Sears Park Field	Install a vegetated strip with good infiltration downhill of compacted field (from heavy day camp use)	$500-1,000	Medium
A	Angelico's Parking Lot	Bio-retention swale along back-side of parking lot with overflow to existing storm drain	$10,000-15,000	High
A	"	Ensure proper storage of gravel, do not let gravel pile clog or pollute storm drains		
A	Edgemere Condos	Catch roof runoff into rain barrels or a series of small rain gardens	$2,000-12,000	High
A	"	Create parking lot runoff catchment swale on south edge of property	$3,000-5,000	High
A	"	Create parking lot/road runoff bio-swale at Edgemere 2 grassy front lawn by main road – route water away from catch basins to lake	$20,000-$25,000	High
A	Lake Boulevard Road Runoff	Erosion control needed, LID on private property – rain barrels / onsite infiltration to reduce water runoff	$1,000-$2,000	Medium

A	Lake Drive Road Runoff	Redesign and fix Town catch basins that are not retaining suspended solids	$15,000–$32,000	High
A	Ola Avenue	Relocate housing gutters to back yards or to rain barrels	$2,000–3,000	Medium
		Sub–basin B		
B	Beach erosion on Lake Drive	Btw Candlewood Dr/Raymond Rd. – Improve buffer strip of woody wetland plants and good location for establishing a native aquatic emergent plant community	$700–1,000	Low
		Follow up research for founder colony aquatic emergent plants for future of lake littoral zone restoration	$2,000–3,500	Low
B	Limit private property logging activities	Partnership with private property owners to limit irresponsible land use practices (property extends to watershed K as well)	N/A	Medium
		Sub–shed C		
C	Mohigan Drive culvert	Hood drain needs to be maintained annually – good time to measure sediment load/yr	N/A	Medium
	"	Convert asphalt swale to vegetated swale and install new pipe from new leaching catch basin	$8,000–$12,000	Medium
C	Catch basin maintenance	Clean and maintain catch basins on Stevenson Road and surround area	N/A	Medium
C	Road runoff at top of South Wangonk	LID swale to catch road runoff and increase infiltration	$1,000–$2,000	Low
C	Drainage from Pine Trail seep	Minimize runoff and erosion at private boat ramp / beach area – LID open cell permeable pavers, determine source (could be seasonal only)	$10,000–15,000	Medium
C	Coco Daycare hillside erosion	Stabilize hillside of parking lot, clean catch basin (full of debris) and determine if it is connected to stormwater culvert system	$1,000–5,000	Low
		Sub–basin D		
D	CVS commercial area	Review stormwater LID designs, make improvements to existing and deteriorating designs for better infiltration	$2,000–30,000	Medium
D	"	More woody plantings needed	$2,000–3,000	Low
D	West Point Road catch basin	Outdated, infiltrating catch basin suggested	$3,000–4,000	Low
D	Route 66 erosion	Establish vegetation on open sediment	$0–200	Low
D	Island Coffee overflow area	Infiltration constructed wetland before apartment complex	$5,000–$20,000	Low
D	Cemetery runoff erosion	Maintain plantings and minimize erosion	$1,000–4,000	Medium
		Sub–basin E		

E	Sunrise Lane (Skyline Estates) BMP/LID improvements	Failing level-spreader improvements and increased retention capacity – prevent overflow to Christopher Brook	$2,000–5,000	High
E	"	Review design plans and improve 5 areas: dig forebays and improve outflow/nutrient retention of wetlands	$15,000–30,000	High
E	"	Inspect ongoing construction and cite violations as necessary	N/A	High
E	"	Stop fertilization of lawns in neighborhood	N/A	High
E	Christopher Pond	Good location for high school student's floating wetland/nutrient removal project	$2,000–20,000	High
E	"	Enhance nutrient removal with additional plants and funding to support partnership with local high school		
E	High School	Active monitoring of new construction, minimize erosion and protect catch basins from sedimentation using well maintained silt covers	N/A	Medium
E	'	Maintain minimal/appropriate fertilization of athletic fields near Christopher Brook	N/A	High
		Sub-basin F		
F	Mountainview Road	Maintain and replace old catch basins and minimize road runoff	$4,000–$8,000	Low
F	Old Clark Hill Road	Inspect and improve containment of private property large exposed sediment pile (produces runoff down Clark Hill Road)	$400–$6,000	High
F	"	Minimize sediment migration from dirt road via LID		
F	"	Dredge /clear outlet culvert to Lake (WPT108)	$400–$1,000	Medium
		Sub-basin G		
G	Back portion of Skyline Estates	Potential for wetland nutrient capture in small stream on private property through LID	$500–$2,000	Low
		Sub-basin H		
H	Mott Hill Road	Maintain newly installed curbing and roadside infiltration areas	N/A	High
H	Hales Brook Watershed	Town of East Hampton should buy and prevent building on as much land in this subbasin as possible.	$50,000–$700,000	High
H	Campground facility	Ensure no contamination of Hales Brook, critical for overall WQ of the Lake – work with private property owners for LID	N/A	High
H	Lakewood Road	Maintain catch basins and remove sediments	N/A	High

I/J/K	Private property lawns	Limit fertilization of lawns on private property in the watershed, particularly in Seven Hills development	N/A	High
		Sub-basin K		
K	Seven Hills LID improvements	Annual maintenance of drains	N/A	High
K		Improve existing stormwater catchment areas: regrade/level, make it not a flow-through systems for small storms	$8,000-10,000	High
K	Fawn Brook at Bay Road	High and shallow marsh in the wetland system to reduce nutrient loading from 7Hills and upstream private property, potentially maintain/export nutrients by seasonal vegetation cuttings	$10,000-15,000	High
		Sub-basin M		
M	Lake Vista Stormwater pond	Improve design and unclog drains - convert to constructed wetland and maintain with annual cuttings to remove nutrients seasonally	$75,000-130,000	Medium
M	Paul and Sandy's pond/wetlands	De-channelize wetland flow for O'Neil's Brook on both sides of Old Marlborough	$6,000-12,000	High
M		Improve stormwater/irrigation pond at Paul and Sandy's, install floating wetlands	$4,000-30,000	High
		Sub-basin N		
N	Exposed land load to Days Brook	Open sediment with no silt fences, protect storm drainage system and encourage LID. Planning and Zoning official needs to inspect frequently, taking regulatory action if necessary.	N/A	High
N	Days Brook stream bank stabilization	Minimize erosion as stream passes through private property on Old Marlborough Road - LID and vegetated buffer necessary	$100-$500	Medium
Lake Islands	Private property rental activities	Inspect and ensure proper capacity of onsite sewage treatment system	N/A	High

Technical, Financial, and Authoritative Assistance Needs (element D)

The successful execution and completion of the projects outlined in this report and the improvement of the water quality of Lake Pocotopaug will rely on assistance from several groups and experts. An initial exploration of different Technical, specific data or design type information, Authoritative/Institutional, expertise and construction conducted by the Town, and Financial, costs of the fixes, is included here:

Technical Assistance Needs include:

- CT River Coastal Conservation District,
    - Collaboration on habitat restoration, lake and stream bank vegetation, landscaping plant selection,
    - Assistance with public education and private property projects.
    - Open space planning and management.
- CT DEEP
    - Oversight on water quality standards at Lake Pocotopaug and progress of de-listing Lake Pocotopaug from the 303(d) list.
    - Assistance with
- University of Connecticut
    - Latest research into new LID and best management strategies.
    - Updated removal efficiency values for management measures.
    - Assistance with LID design strategies
- US EPA and USACE
    - Guidance with cyanobacteria blooms, permits for wetland and stream channel projects.
- Specialists in:
    - Low Impact Engineer and Soil Scientist for design and implementation of management measures/
    - Limnology and Lake Manager for collecting compiling data on the watershed to gauge improvement and to monitor the lake to track water quality standards.

- Chatham District Health Department
    - Guidance with cyanobacteria bloom conditions and beach postings.

Town of East Hampton Institutional Needs

- Public Works Department
    - Using design plans and materials, can probably implement a majority of the low cost hard surface fixes on public property.
    - Accomplish proscribed maintenance programs.
    - Assist with implementation of private property fixes.
- Park and Recreation Department
    - Using design plans and material, can probably implement low cost soft surface fixes.
        - Possible partner with CT River and Coastal Conservation District.
    - Provide assistance to private property fixes.
    - Help with education of environmental understanding and good stewardship practices
- Planning and Zoning / Inland Wetlands
    - Review new development applications for continuity with LID management measures being implanted throughout the watershed.
    - Regular inspections of sites of active development.
    - Routine inspections to determine proper functioning of management measures.
- High School Educators
    - Environment Club monitoring of aquatic insect populations and brook water quality important aspect of Monitoring Effectiveness of Implementation (element I).
    - Expand programs and curriculum to include lake and watershed examination and monitoring.
    - Assist with public education programs

Financial Assistance Needs:

- The costs of the management measures to be implemented in the Lake Pocotopuag watershed are summarized in Table 23.

Table 23 – Initial Total Cost Estimates

Total Estimated Costs	Total Implementation Costs for Watershed	$449,600 $1,425,200
Priority Costs Breakdown		
High Priority		$147,400 – $917,000
Medium Priority		$ 285,000 – $ 459,500
Low Priority		$ 17,200 – $ 48,700
	Total	$ 449,600 $ 1,425,200
From Total	Maintenance/implementation costs on Town Property	$ 200,500 – $ 295,700
	Town Costs for land acquisition in future	$ 50,000 – $ 700,000
Potential grant program	Estimated 30% Town funded private property grant program	$ 59,730 – $ 128,850
	Estimated 70% Private property funding necessary	$ 139,370 – $ 300,650
Additional Costs		
Lake and watershed WQ monitoring	Continued Water Quality Monitoring to track progress/Public Educational efforts	$ 18,000 – $ 32,000
Town Budget Increases	Ongoing Costs for Planning and Zoning, Inland Wetlands, Public Works Dept. education and increased budget	Town discretion

Pollutant Loading Reduction (element B)

Needed load reductions to restore water quality standards.

Water quality standards are predicated on the trophic classification of the lake with the Not Supporting status determined by the Highly Eutrophic lake conditions of very high growths of algae resulting in very poor water clarity. The typical limiting nutrient to algae growth in fresh-water is phosphorus but high nitrogen levels as a secondary nutrient often determines species presence. Table 24 shows increasing phosphorus and nitrogen lead to low water clarity and high chlorophyll-*a*, Comparison of parameter ranges for Eutrophic and Mesotrophic lakes is given in Table 25.

Table 24 – CT DEEP parameters and defining ranges for trophic states of lakes in Connecticut

Trophic State Category	Trophic State Indicator	Defining Range TP and TN Avg. spring and summer samples Unless otherwise noted
Oligotrophic	Total Phosphorus	0 – 10 µg/l
	Total Nitrogen	0 – 200 µg/l
	Secchi Disk Transparency	6 + meters *mid-summer*
	Chlorophyll-a	0 – 2 µg/L *mid-summer*
Mesotrophic	Total Phosphorus	10 – 30 µg/l
	Total Nitrogen	200 – 600 µg/l
	Secchi Disk Transparency	2 – 6 meters *mid-summer*
	Chlorophyll-a	2 – 15 µg/L *mid-summer*
Eutrophic	Total Phosphorus	30 – 50 µg/l
	Total Nitrogen	600 – 1000 µg/l
	Secchi Disk Transparency	1 – 2 meters *mid-summer*
	Chlorophyll-a	15 – 30 µg/L *mid-summer*
Highly Eutrophic	Total Phosphorus	50+ µg/l
	Total Nitrogen	1000+ µg/l
	Secchi Disk Transparency	0 – 1 meters *mid-summer*
	Chlorophyll-a	30 + µg/L *mid-summer*

Source: Regulation on Connecticut Water Quality Standards R-39 Rev. 03/2012

Table 25 – Eutrophic / Meso-trophic differences

	Eutrophic	Meso-trophic	Change Required
Total Phosphorus	30 – 50 µg/l	10 – 30 µg/l	<30 µg/l
Total Nitrogen	600 – 1000 µg/l	200 – 600 µg/l	<600 µg/l
Secchi Disk depth	1 – 2 meters *mid-summer*	2 – 6 meters *mid-summer*	>2 meters *mid-summer*
Chlorophyll-a	15 – 30- µg/L *mid-summer*	2 – 15 µg/L *mid-summer*	<15 µg/l *mid-summer*

The change in total mass of phosphorus in Lake Pocotopaug during 2014 and 2015 is shown in Figure 5. Periods of poorest water clarity are shown to occur when mass is highest. Summer high phosphorus mass, >150kg often have water clarities less than 1.5meters. Data in Figure 6 indicate at relationship between in-lake P mass and water clarity although the linearity is weak at this time,

the chart shows that below 150kg clarity is good, >1.5meters and that above 200kg clarity is less than 1meter.

Figure 5 – In-lake phosphorus mass and water clarity trends during 2014 and 2015

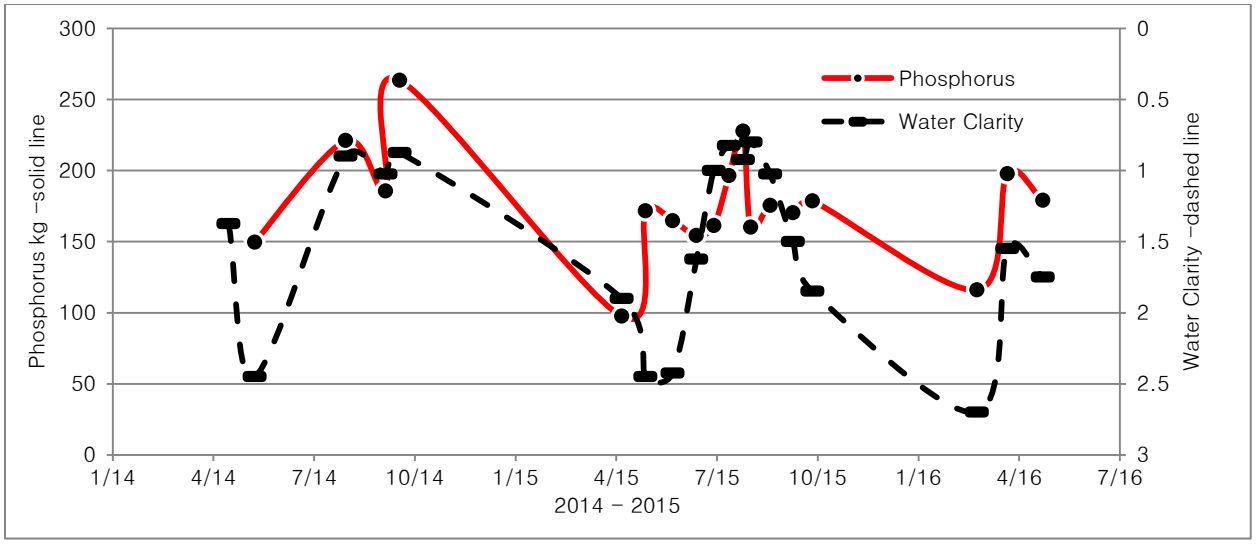
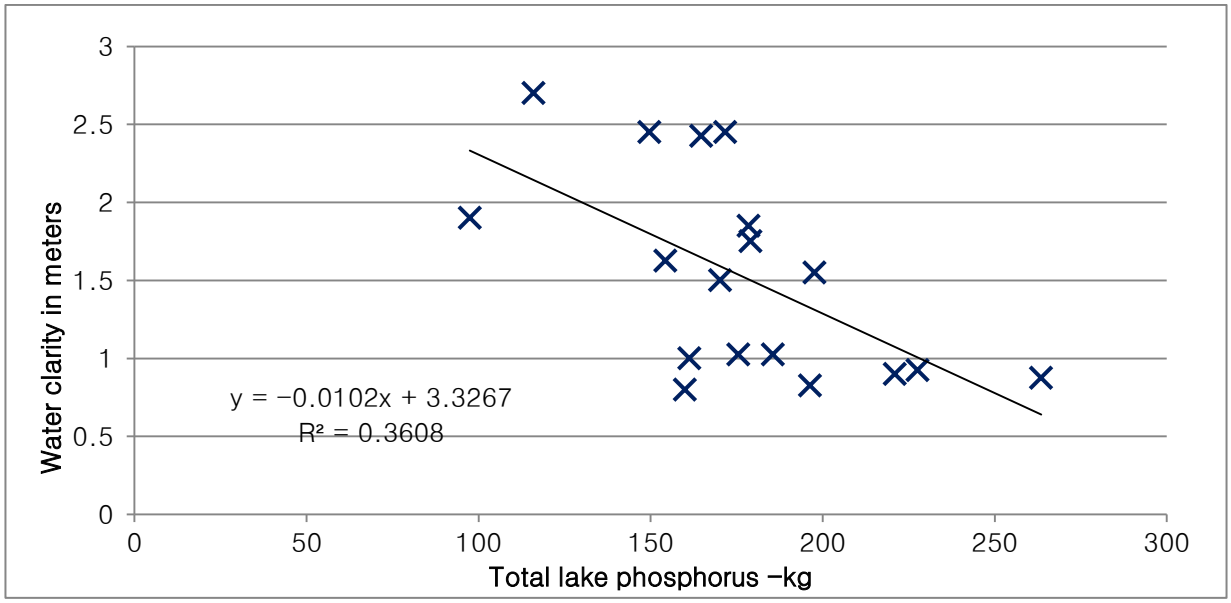


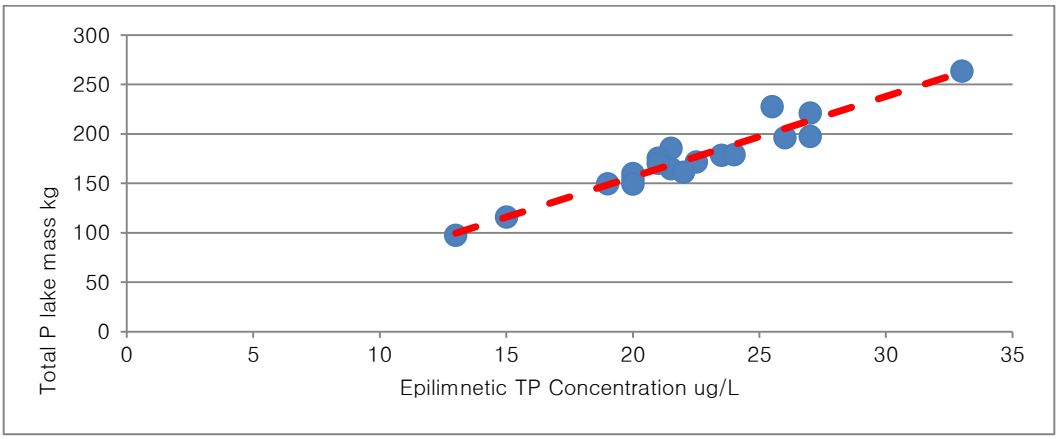
Figure 6 – Total in-lake phosphorus mass and water clarity



Data shown in **Figure 6** above suggests target in-lake mass of phosphorus should remain below 150kg. Increases in mass to 200kg and even 250kg are specifically targeted. Decreasing total mass in Lake Pocotopaug to <150kg requires decreasing the phosphorus concentration to <20 µg/L (**Figure 7**). Estimates of total P load to the lake from sub-basins (1991-2016) vary widely, between 160 and 700 kg/yr., while internal load estimates have a larger range, from 16 kg/yr. to 500 kg/yr. Data we collected over the last couple of years suggests total phosphorus load to be about 160

kg/yr. about half of the LLRM estimate of 265 kg/yr. However, decreasing the estimate of total phosphorus load increases the number of improvements needed and forces each to have high efficiency at removing pollutants in order to realize decreased in-lake phosphorus concentration.

Figure 7 – Total in-lake phosphorus concentration and mass



Total nitrogen loads have been estimated to be between 2,185 and 5,662 kg/yr. There is a strong relationship between in-lake nitrogen and water clarity (**Figure 7**) and especially cyanobacteria numbers (**Figure 8**). Water clarity is typically less than 1 meter when in-lake total nitrogen exceeds 4,000 kg. Relationship shown in **Figure 7** is statistically significant suggesting that nitrogen is important driver of algae numbers. Cyanobacteria numbers appear to increase rapidly when total nitrogen concentration exceeds 400 µg/L (**Figure 8**).

Figure 8 – Total in-lake nitrogen and water clarity

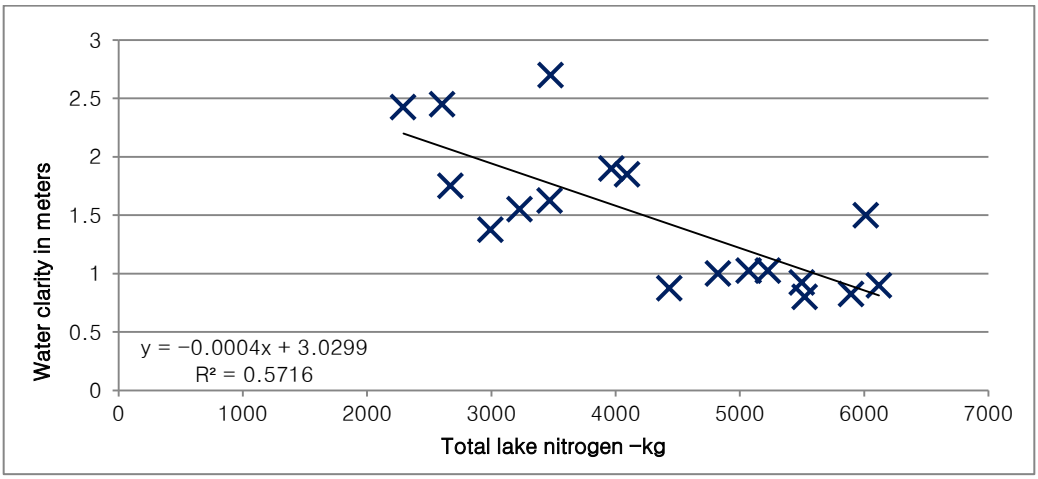
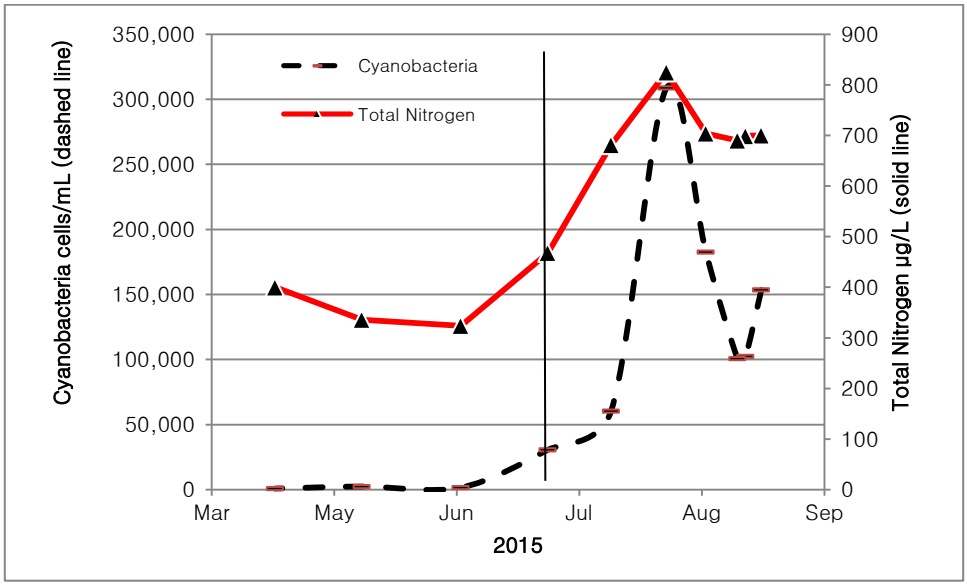


Figure 9 – Total in-lake nitrogen and cyanobacteria numbers



Specific predictions of lake water quality conditions made by LLRM model give different scenarios of watershed activity are shown in Table 26. The model predicted that in-lake phosphorus will be reduced to 14 µg/L and mean water clarity will be increased to 3+ meters if all measures are implemented. The changes predicted by LLRM would move Lake Pocotopaug out of Eutrophic and into Mesotrophic status providing water quality changes significant to restore Recreational Use The model also predicts that with full build out of the watershed and no management measures implemented water quality will continue to decline.

Table 26 – LLRM predictions of improved water quality standard for Lake Pocotopaug

Parameter	Existing Conditions	With Management Measures	No Management & Full Build-out
Phosphorus –µg/L	23	14	33
Nitrogen –µg/L	925	503	820
Mean Chlorophyll –µg/L	7.8	4.6	14
Max Chlorophyll –µg/L	25	16.5	46.6
Bloom Odds –%	32	3.7	66
Mean Secchi –m	1.5	3.1	1.6
Max Secchi –m	2.9	4.7	3.7

Implementation Milestones (elements F & G)

A total of 42 management measures have been identified to improve water quality runoff to Lake Pocotopaug. Drainage basin data collected between 1991 and 2007 was evaluated alongside drainage basin runoff data collected during 2014 and 2015. NEAR thoroughly investigated the drainage basin during 2015 to visit all sites where drainage basin controls had been recommended in prior reports, e.g. WMC 1994 report, as well as map existing conveyance and evaluate continuity of riparian habitats.

Combining prior site fixe recommendations and new 2015 survey data, NEAR produced the following list of 42 individual actions. Many 14, can be completed without costs (Table 25), a majority, 20, improvements have estimated to have low end costs of <$10,000 Table 26. There are only 8 more expensive improvements with low end costs of >$10,000 with one a long range capital project of purchasing undeveloped land (Table 27).

Tables 1, 2, and 3, that specify locations and actions needed in the drainage basin. In total are locations where management measures are needed in the watershed of Lake Pocotopaug. The first 14 action measures should be completed or incorporated into Town staff routine by end of calendar year 2016.

Tracking progress of LID/BMPs in the watershed will be facilitated by the working excel document (Appendix 4) and corresponding photo-documentation of existing conditions (Appendix 3). The PWD will be responsible for documenting catch basin maintenance, road sweeping, road-side curbing, and all construction in the watershed of Lake Pocotopaug. The excel document stresses the use of GPS and existing waypoints for transparency in ongoing Town development and watershed improvements projects.

The Watershed Planner shall be in charge of documenting observed and permitted construction on private property while the Friends of Lake Pocotopaug will be responsible for gathering information on homeowner shoreline manipulation and buffer zone improvements. Good communication among Town IW, P&Z, and Lake Conservation Commissioners will be facilitated by the pre-established monthly meetings to discuss progress and ensure proper documentation from all parties.

List of Measurable Milestones

- Updating Town of East Hampton websites with educational material
- PWD documentation of catch basin maintenance and construction
- Updates to watershed photo-documentation: LID projects on public and private property (provided homeowner approval)

- Serve as examples at public educational sessions

- Monthly Town watershed planning meetings, involve lake consultant and LID engineer
- Completion of grant applications for plan implementation
- Completion of materials for lake and watershed educational programs for incoming Commissioners and Councilmen
- High School environmental club continued participation
- Record curation of beach postings due to harmful cyanobacteria blooms
- Updates to Town IW regulations
- Town conservation budgeting approval rates may indicate growing public participation
- Increasing lakeside property values with water quality improvements
- Tracking progress of LID/BMPs in the watershed will be facilitated by the working excel document (Appendix 3) and
- corresponding photo-documentation of existing conditions (Appendix 4)

Five Year Action Plan for Watershed Improvement

The list of specific sites requiring fixes is presented grouped by cost. Table 27 lists 14 actions that can be done at no capital cost as they are part of regular maintenance or can be done with aid of volunteers or involves information sharing.

The second group (Table 28) are 21 locations where moderate priced projects of <$10,000 are needed. These fixes are both hard surface installations and re-vegetation enhancements that can be done by either Public Works or Park and Recreation Departments. The fixes have been grouped by sub-basin to estimate total cost per sub-basin.

The third group (Table 29) includes 8 locations where larger projects of >$10,000 have been identified.

The following is an outline of a potential five year action plan for enacting widespread watershed improvements to better the water quality of Lake Pocotopaug. The timeline serves as a project schedule that can be adapted given additional funding and resources. Items listed for 2016 begin with specific actions aimed at increasing public participation and knowledge, while planning for implementation in the years to come. Actions have been grouped by general location of where the work will be done.

2016

Town Office

1. Continue to hold monthly Lake planning meeting at town level.
2. Look into having a Town Watershed/Environmental Planner position.
3. Organize ongoing educational sessions for Town commissioners.
4. Investigate development of Town revolving fund for lakeside homeowner LID.
5. Apply for 319 and STEAP Grant funding for first tier of projects (bold in list of ID'ed pollution sources).

6. Town and Middlesex Land Trust cooperate to purchase land and acquire easements for LID
7. Hold end of year planning meeting set goals for next year.

Town Field

8. Enforce IW regulations and inspect current construction within the watershed, enlist CT DEEP for wetlands/construction enforcement if necessary.
9. Work with Town LID engineer to move forward with Christopher Brook road reconstruction project, involve lake consultant and ensure responsible construction and minimal erosion.
10. Determine wastewater treatment methods and capacity for the three lake islands – ensure proper disposal and minimize lake nutrient loading from onsite treatment systems.
11. Require soil testing and minimal fertilizer use on high school athletic fields, ensure runoff from high school construction is not impairing the bordering wetlands that lead to Christopher Brook.
12. Address and schedule maintenance of existing catch basins as identified in excel document, ensure ongoing record keeping.
13. Develop contacts and working relationship with local business owners, inspect private properties mentioned as nonpoint pollution sources and build partnerships to implement BMPs and LID in future.

Lake

14. Continue lake water quality sampling (as per element I below) to maintain ongoing dataset, gather more information on lake level and outlet flow durations,
15. Collect water depth measurements and construct a new bathymetry map.
16. Survey aquatic plant distribution with special attention on benthic cyanobacteria mats.
17. Monitor cyanobacteria cell numbers in open water off of beach.

Public Education / Information

18. Incorporate 501(3)c Friends of Lake Pocotopaug (FOLP) into action plan to garner public support, create communication list to reach homeowners and beach associations.
19. List educational materials from this watershed plan on Town Lake Conservation Commission and FOLP websites.
20. Hold informational open Town meeting for educating residents – floating workshop.
21. Engage Park and Recreation Department day camp at Sear's Park – lakeside science educational activities.
22. Partner with local high school and plan to budget Town funds to invest in "floating island technology" for nutrient uptake experimental sites: Christopher Brook pond, Hales Brook outlet pool, Paul & Sandy's detention basin.
23. Hold end-of-year presentation on State Of The Lake.

2017

Town Office

1. Continue to hold monthly Lake planning meetings at town level.
2. Town budget for PWD to construct bio-retention or vegetated swale at Edgemere 2 (pending easement).
3. Town budget for fund PWD to address failing catch basins/replace and clean as necessary

4. Town budget for Sear's Park parking lot & bioretention LID overhaul
5. Hold end of year planning meeting set goals for next year.

Town Field

6. Set up conservation no-building areas in Hales Brook watershed.
7. Continue to enforce IW regulations: improve LID in Sunrise Lane Skyline Estates development given working partnership with land developer, address open dirt and overland flow from Old Clark Hill Road, monitor Edgewater Hill construction and review stormwater plans with Town engineer/lake consultant.
8. Use Town budget for PWD to construct bio-retention or vegetated swale at Edgemere 2 (pending easement).
9. Town to fund PWD to address failing catch basins/replace and clean as necessary: updates recorded in excel document.
10. Continue to enforce IW regulations, focus to minimize erosion of exposed land that loads Day's Brook.
11. Town planning to budget for Sear's Park parking lot & bioretention LID overhaul – create appropriate signage for LID education.

Lake

12. Continue lake water quality sampling (as per element I below) to maintain ongoing dataset, gather more information on lake level and outlet flow durations.
13. Intensive wetlands inlet/outlet/sediment sampling to determine seasonal cycling of nutrients and potential for greater retention and biomanipulation.
14. Monitor cyanobacteria cell numbers in open water off of beach.
15. Continue seasonal inlet monitoring to determine proper functioning of new LID in watershed, concurrent in-lake water quality sampling.

Public Education / Information

16. Hold annual lake update meetings for public.
17. Build upon relationship with Hales Brook campground owners, follow up to ensure responsible wastewater management and ensure minimal stream disturbance.
18. Work with Lake Vista condo owner to redesign and improve stormwater constructed wetlands.
19. Enlist Paul & Sandy's to sell rain barrels to homeowners, provide educational material for use/importance in the Lake Pocotopaug watershed – potential lakeside homeowner requirement via Town regulatory changes in 150ft buffer zone.
20. Establish partnerships with Paul & Sandy's to sell native planting for local private property LID.
21. Work with local high school environmental club and FOLP to install floating islands in Christopher Brook Pond and Paul & Sandy's retention pond – monitor nutrient uptake and ensure maintenance.
22. Hold end-of-year presentation on State Of The Lake.

2018

Town Office

1. Continue to hold monthly Lake planning meetings at town level.
2. Hold an end-of-year planning meeting

Town Field

3. Work with LID engineer to design and construct bioretention system in back of Angelico's parking lot (pending easement and private property owner's approval).
4. Town PWD and LID engineer to design and implement large Sear's Park parking lot repairs

Lake

5. Continue lake water quality sampling (as per element I below) to maintain ongoing dataset, gather more information on lake level and outlet flow durations,
6. Review any LID updates/ constructed or floating wetland technology in the watershed; ensure proper functioning via ongoing water quality monitoring, inspection, and maintenance.
7. Based on wetland nutrient cycling data, implement wetland enhancement projects to increase natural nutrient uptake, e.g. de-channelization at Fawn Brook wetland (Bay Road), O'Neil's Brook, and Day's Brook.

Public Education / Information

8. Continue public education and push for LID in lakeside condominiums and apartment complexes.
    - Edgemere rain gardens/barrels, Chatham Apartments open cell pavers & infiltration swale, Island Coffee parking lot LID that flows to back of Chatham Apartments.
9. FOLP and Town may help homeowners form an association at Seven Hills development: need neighborhood social pressure to reduce lawn fertilizing and encourage responsible land use practices.
    - Combined with ongoing Town educational sessions for general public.
    - Town to partner with Seven Hills developer to ensure proper functioning and maintenance of stormwater infiltration basins.
10. Continue to work with nonprofit organizations and local Land Trusts to obtain land in Hales Brook watershed to limit development.
11. Hold end-of-year presentation on State Of The Lake.

2019

Town Office

1. Continue to hold monthly Lake planning meetings at town level
2. Hold end of year planning meeting set goals for next year.

Town Field

3. Further stormwater LID/BMPs in private condominiums and apartment buildings – maintain connections with private property owners in watershed.
4. Day's Brook at Old Marlborough Road, create vegetated buffer on private property with homeowner participation.
5. Address improvements to CVS parking lot stormwater infiltration and CT DOT catch basin easements – more woody plantings necessary.

6. Regular maintenance and cleaning of catch basins and any special Stormceptor® devices, potential to replace with improved nutrient retraining technologies.

Lake

7. Continue lake water quality sampling (as per element I below) to maintain ongoing dataset, gather more information on lake level and outlet flow durations,

Public Education / Information

8. Continue to expand upon public participation and ongoing educational programming: work into Town budget and plan of conservation and development.
9. Enlist private beach association to create vegetated swale in place of Mohigan Drive paved inlet from catch basin (Poco_8) – focus on nitrogen removal technologies and ID nearby sources of N pollution.
10. In concert with private homeowners and beach association, minimize runoff and erosion at Pine Trail boat ramp.
11. Hold end-of-year presentation on State Of The Lake.

2020

Town Office

1. Continue to hold monthly Lake planning meetings at town level.
2. Push for private property vegetated buffer zones and revisit lake buffer zone Town guidance or regulations.
3. Maintain new LID and track progress in excel document, keep updated records given GPS waypoints and use to create educational maps for public demonstration of Town progress.
4. Continue Town and private investment in new wetlands improvement and nutrient retention technologies, partner with high school environmental club and Scout Troups for any routine maintenance.
5. Further public education, critical for incoming Town Council members and Commissioners.
6. Hold end-of-year planning and goal setting meeting

Town Field

7. Construct vegetated swale at top of South Wangonk Road to minimize overload stormwater flow

Lake

8. Continue lake water quality sampling (as per element I below) to maintain ongoing dataset,
9. Organize volunteer water quality monitoring program with professional limnological oversight

Public Education / Information

10. Hold end-of-year presentation on State Of The Lake.

Table 27 – Management Measures without cost
Ranked by loading Tier and priority

Sub	Name	Measure Required	P
E		Inspect ongoing construction and cite violations as necessary	H
E	"	Stop fertilization of lawns in neighborhood	H
E		Maintain minimal/appropriate fertilization of athletic fields near Christopher Brook	H
H	Mott Hill Road	Maintain newly installed curbing and roadside infiltration areas	H
H	Campground facility	Ensure no contamination of Hales Brook, critical for overall WQ of the Lake – work with private property owners for LID	H
H	Lakewood Road	Maintain catch-basins and remove sediments	H
I/J/K	Private property lawns	Limit fertilization of lawns on private property in the watershed, particularly in Seven Hills development	H
K	Seven Hills LID improvements	Annual maintenance of drains	H
Lake Islands	Private property rental activities	Inspect and ensure proper capacity and disposal of onsite sewage treatment system	H
N	Exposed land load to Days Brook	Open sediment with no silt fences, protect storm drainage system and encourage LID. Planning and Zoning official needs to inspect frequently, taking regulatory action if necessary.	H
B	Limit private property logging activities	Partnership with private property owners to limit irresponsible land use practices (property extends to watershed K as well)	M
C	Mohigan Drive culvert	Hood drain needs to be maintained annually – good time to measure sediment load/yr.	M
C	Catch basin maintenance	Clean and maintain catch basins on Stevenson Road and surround area	M
E	High School	Active monitoring of new construction, minimize erosion and protect catch basins from sedimentation using well maintained silt covers	M

Table 28 – Management Measures with Low Cost Fixes Ranked by loading Tier and cost

Sub	Location	Management Measure	Cost Low	Cost High
D	Route 66 erosion	Establish vegetation on open sediment	0	200
F	Old Clark Hill Road	Inspect and improve containment of private property large exposed sediment pile (produces runoff down Clark Hill Road)	400	6,000
A	Sears Park Field	Install a vegetated strip with good infiltration downhill of compacted field (from heavy day camp use)	500	1,000
A	Sears Park Rain Garden	Soil test hole needed to determine depth of saturation zone/infiltration capacity	500	1,000
B	Beach erosion on Lake Drive	Btw Candlewood Dr/Raymond Rd. – Improve buffer strip of woody wetland plants and good location for establishing a native aquatic emergent plant community	700	1,000
A	Lake Boulevard Road Runoff	Erosion control needed, LID on private property – rain barrels / onsite infiltration to reduce water runoff	1,000	2,000
C	Road runoff at top of South Wangonk	LID swale to catch road runoff and increase infiltration	1,000	2,000
C	Coco Daycare hillside erosion	Stabilize hillside of parking lot, clean catch basin (full of debris) and determine if it is connected to stormwater culvert system	1,000	5,000
D	Cemetery runoff erosion	Maintain plantings and minimize erosion	1,000	4,000
A	Edgemere Condos	Catch roof runoff into rain barrels or a series of small rain gardens	2,000	12,000
A	Ola Avenue	Relocate housing gutters to back yards or to rain barrels	2,000	3,000
D	CVS commercial area	Review stormwater LID designs, make improvements to existing and deteriorating designs for better infiltration	2,000	30,000
D		More woody plantings needed	2,000	3,000
E	Christopher Pond	Good location for high school student's floating wetland/nutrient removal project	2,000	20,000
A	Edgemere Condo's	Create parking lot runoff catchment swale on south edge of property	3,000	5,000
D	West Point Road catch basin	Outdated, infiltrating catch basin suggested	3,000	4,000
F	Mountainview Road	Maintain and replace old catch basins and minimize road runoff	4,000	8,000
D	Island Coffee overflow area	Infiltration constructed wetland before apartment complex	5,000	20,000
C	Mohigan Drive	Convert asphalt swale to vegetated swale and install new pipe from new leaching catch basin	8,000	12,000

	K	Seven Hills LID improvements	Improve existing stormwater catchment areas: regrade/level, make it not a flow-through systems for small storms	8,000	10,000

Table 29 – Management Measures with High Cost Fixes Ranked by loading Tier and cost

Sub	Location	Management Measure	Cost Low	Cost High
A	Angelico's Parking Lot	Bio-retention swale along back-side of parking lot with overflow to existing storm drain	10,000	15,000
C	Drainage from Pine Trail seep	Minimize runoff and erosion at private boat ramp / beach area – LID open cell permeable pavers, determine source (could be seasonal only)	10,000	15,000
K	Fawn Brook at Bay Road	High and shallow marsh in the wetland system to reduce nutrient loading from 7Hills and upstream private property, potentially maintain/export nutrients by seasonal vegetation cuttings	10,000	15,000
A	Lake Drive Road Runoff	Redesign and fix Town catch basins that are not retaining suspended solids	15,000	32,000
E	Sunrise Lane (Skyline Estates)	Review design plans and improve 5 areas: dig forebays and improve outflow/nutrient retention of wetlands	15,000	30,000
A	Edgemere	Create parking lot/road runoff bio-swale at Edgemere 2 grassy front lawn by main road – route water away from catch basins to lake	20,000	25,000
H	Hales Brook Watershed	Town of East Hampton should buy and prevent building on as much land in this sub-basin as possible.	50,000	70,0000
M	Lake Vista Stormwater pond	Improve design and unclog drains – convert to constructed wetland and maintain with annual cuttings to remove nutrients seasonally	75,000	130,000

Criteria to determine load reduction and change in water quality (element H)

Determining Degree of Load Reduction

LID in the watershed is expected to reduce phosphorus nutrient loading. In addition LID is expected to reduce sediment loading (TSS) to the Lake by 30-60% causing further reductions in nutrient loading . More specific nutrient pollution reduction capabilities are outlined in section)))).

1. All inlets to the lake will be monitored for water flows and total phosphorus and total nitrogen monthly.
2. At least three stormwater collections nutrient concentrations at inlets where improvements have occurred show values generally below the mean for that sub-basin.
    a. Maximum values should not exceed prior maximum values.
    b. Values should show long-term decline to more background conditions.
3. Sub-basins where no improvements have taken place should show consistency with prior averages and ranges.
4. Water flows at 13 established inlets to the lake will be monitored monthly. flow measurements: at minimum 1 stormwater sampling, 1 dry sampling of all identified inlet
5. Measure nutrient retention and cycling within existing wetlands and at constructed LID sites, focus on vegetative storage and possible increased uptake rates at experimental locations by manipulating sediment storage capacities
6. Update nutrient loading models to reflect BMP/LID and land use changes and zooplankton sampling, toxin analysis and beach sampling, phycocyanin and chlorophyll pigment fluorometry
7. Storm water with be collected from fifteen known sites where storm water enters the lake will be visited during 3 storm events. All inlets samples will be analyzed for total phosphorus, total nitrogen, total suspended solids, and water flow.

Indicators to Measure Change in Water Quality

- Water clarity

Lake Pocotopaug water clarity will be measured at the two established stations monthly in March, April, October and November and twice monthly May through September.

- Show Lake water clarity is increasing, Measure water clarity at least monthly and track attainment of these goals:

Summer Secchi Disk =	>1.5 meters
Maximum annual Secchi disk depth =	>2.5 meters

- Cynobacteria population numbers
  - Lake Pocotopaug cyanobacteria numbers will be estimated monthly in March, April, October and November and twice monthly May through September.
  - Show cynobacteria population numbers are declining.
    - Summer and Fall cyanobacteria numbers below 50,000 cells/mL.
    - Spring and fall diatom numbers declining below X cells/mL

- Dissolved oxygen content
  - Lake Pocotopaug dissolved oxygen content will be measured from top to bottom of the water column at each of the two established lake stations. Profiles will be measured monthly in March, April, October and November and twice monthly May through September. Dissolved oxygen content improving.
    - Anoxic boundary should remain below 4 meters during Summer.
    - Long term goal of anoxic water only below 5 meters depth.

- Nitrogen and phosphorus concentrations
  - Lake Pocotopaug Total Phosphorus, nitrate-Nitrogen, Ammonia-Nitrogen and Total-Nitrogen will be measured at top middle and bottom depths of the water column at each of the two established lake stations. Profiles will be measured monthly in March, April, October and November and twice monthly May through September.
      - Nitrogen and phosphorus concentrations in Markham and Oakwood deep water basins show declining values with TP less than 20 µg/L and TN less than 400 µg/L and values on-average lower than the long-term average.

Monitoring effectiveness of implementation (element I)

Excel Spreadsheet

The Town of East Hampton has had several watershed studies over the past 21 years that each effectively identified various pollution sources in the Lake Pocotopaug watershed. However, a list of locations in need of watershed improvements are only valuable if they are used appropriately and can be easily interpreted and adapted. The ability to track construction and improvements over time is exceedingly important to measuring progress.

This report includes an organized, user-friendly excel document that lists every catch basin in the watershed by WPT# (Appendix 3). The excel file lists the inflows and outflow connections for every catch basin where connections were visible (questionable connections are indicated) and describes the condition of the site. There are supplemental maps and a GPS file that are intended for continued use by the Public Works Department and the Watershed Planner. As LID and BMP are implemented, this file will serve as a way to update stormwater maintenance information.

Additionally, the excel document highlights the catch basins that receive greater amounts of road runoff, indicating that they are in need of more frequent cleaning. This file can be added to in order to track the catch basin cleaning schedule over the years.

General Recommendations

- Appoint an individual responsible for overseeing progress and Town interdepartmental communication for watershed planning
- Create lake science and watershed management educational program for incoming Town commissioners and councilmen
- Organize water quality info sessions and ongoing community educational events in conjunction with local nonprofits and lake associations – focus on LID
- Establish a lake LID buffer zone of 150ft (in accordance with IWA buffer zone definition) around the perimeter of the lake – limit activities and building within buffer zone, all IW applications should be reviewed by Town lake consultant
- Enforce watershed lawn fertilizer limitations, bolster with educational outreach
- Establish good Town communication with private property owners in the watershed – acquire necessary easements for LID and stormwater management
- Encourage an active network of Town residents and participation in financial planning for watershed improvement

- Allocate Town funds in budget to Public Works Department for LID construction on Town property and future easements – provide PWD access to GPS for high level record keeping of all major and minor construction within watershed with appropriate locations, dates, costs, and names of outside contractors (include private property fixes identified in this plan). Information shall not be lost if there is a change in Town personnel.
- Incentivize LID on private property through Town funding assistance – potential revolving LID grant program
- Work with local high school and environmental club to incorporate their rapid bio-assessment data into watershed improvement efforts and monitoring
- Utilize high school student/college research programs to study effectiveness of vegetated floating islands for nutrient removal in Hales Brook outlet pond, Christopher Brook Pond, and other locations.
- Determine potential outside funding sources and apply for grant programs
- Establish conservation areas for forested property in Hales Brook watershed
- Involve the Middlesex Land Trust in enhancing natural wetlands to improve nutrient retention in watershed K
- Continue active watershed water quality monitoring and in-lake sampling for long term adaptive lake management

Organizational Changes

The Town of East Hampton needs to appoint a Town employee as an interdepartmental planning agent whose responsibility is implementing, inspecting, and maintaining the watershed fixes of this plan on public property. This individual will also be in charge of communication with private property owners to encourage BMPs and LID as specified in this document.

Specific Duties of Town Watershed Planning Appointee

- Communication with the Town PZ/IW, Lake & Conservation commissions, PWD, Lake consultant, Town Manager, and Town Council
- GIS experience and GPS mapping abilities for tracking progress in watershed – update the catch basins excel document as necessary
- Work with the Town's hired LID engineer and lake consultant
- Oversee all construction sites to ensure BMP and limit exposed sediment
- Communicate with lake homeowner and beach associations
- Communicate with apartment and condominium managers
- Communicate and educate the Friends of Lake Pocotopaug nonprofit and the Middlesex Land Trust
- Work with private property owners and be in charge of a Town revolving LID fund/ matching grant program
- Communicate with State Department of Transportation (DOT) for Route 66 maintenance and stormwater culvert design improvements

- Make improvements to Town Inland Wetland regulations to limit development in watershed and lakeside activities
- Engage Local Health Department and State Representatives to discuss future lake protection legislation on a state level
- Assist Town in applying for grant funding for LID in the watershed

Public Information and Education (element E)

Information and Education

A cohesive effort is critical in order to move forward with implementing the pollution fixes specified in this Nine Elements Watershed Plan. Watershed improvement hinges on public environmental education and involvement. The Town of East Hampton owns approximately five acres of the entire 2,315-acre Lake Pocotopaug watershed. Without a community effort and ongoing educational activities to encourage responsible land-use practices, there will be no improvements in the water quality of the Lake. This dilemma is the essence of nonpoint source pollution and it can only be solved with considerable effort towards public participation. The Town must work with all stakeholders to incentivize LID in the watershed, while maintaining close connections to community leaders. In the case of private property, motivation and guidance for BMPs is essential.

High School Student Activities

Current curriculum at East Hampton High School includes water quality sampling and testing at 13 different inlet stations around the lake. Students test the water at this stations for pH, Conductivity, Water temperature, Dissolved oxygen, Total Dissolved Solids and Turbidity. Rapid bioassessment of aquatic insects has been done at one location once seasonally since 2006 representing 10 years of indicator organisms tracking. The Rapid bioassessment involves counting 14 different stream animals including insects and fish larvae. There is interest in high school students building and maintaining floating wetlands.

Educating within Town Government

The Town must require all P&Z, IWW, and the Conservation Lake Commissioners to attend a LID and nonpoint source pollution educational session. The session can be offered by a qualified contract organization, or it can be offered through the Town if a capable person is hired as watershed planner. The educational sessions can also be open to and modified for homeowner association members and business owners within the Lake Pocotopaug watershed.

The Park and Recreation Department may utilize future funds to incorporate watershed educational activities into their summer day camp and community events. Educational signage should be erected at LID sites on public property.

Educational handouts developed for Lake Pocotopaug and designed for public education are included in Appendix _. There is also a list of web-links to various stormwater management and LID publications that are freely available as online educational documents.

Educational Flyer:

WHAT CAN YOU DO TO HELP CLEAN UP LAKE POCOTOPAUG?

What you do in your own back yard can impact the entire watershed, including the health of Lake Pocotopaug.

If your home has a roof, a lawn, or a driveway, chances are your property creates stormwater runoff. Property owners can play a role in improving water quality by soaking up stormwater runoff to prevent it from reaching nearby lakes, streams, and other waters.

Some easy, important steps you can take:

- **Soak up rain at its source.** Rain that falls on your roof, driveway, and other hard surfaces flows into storm drains and then into Lake Pocotopaug, picking up contaminants along the way. If rain soaks directly into the ground, the soil absorbs the contaminants, keeping them out of the lake

  Ways to reduce runoff:

  - Reduce impermeable surfaces.
  - Rainwater is a resource: Cut down on your water use by capturing and using rainwater in the garden by redirecting your gutter downspouts into rain barrels
  - Install a rain garden and plant bare areas in your yard with natural vegetation.
- **Create a buffer garden of natural vegetation along the lakeshore.** Buffer gardens slow the flow of water from your lawn into the lake and will absorb nutrients and fertilizers before they can enter the lake.
- **If you must fertilize, do so very sparingly** Fertilizer makes your lawn green, and it makes the lake green! Use low phosphate, slow release nitrogen fertilizer on vegetated areas only.
- **Maintain a natural lake shoreline.** Clearing trees, erecting walls, and dumping sand can disturb the ecosystem and negatively affect lake health.
- **Never dump anything into storm drains.** Storm drains flow directly into Lake Pocotopaug.

Appendix 1

Limnology and Water Quality

Lake Pocoptapaug has a surface area of approximately 501 acres with a watershed area of 2,315 acres[8] (Table 30). The watershed to lake size ratio is small (4.6:1), why is there relatively low water recharge due to limited amount of water flowing to the lake. Flushing rate, or the estimated residence time, is agreed by prior studies and this work at about 1.0 per year. Much 61% of the Lake Pocotopaug watershed is forested, but a large portion 25% of the drainage surrounding the lake is high density residential or commercial usage. Building within the watershed has been tremendous since the 1980s and there are multiple developments that have been constructed post 2006.

Table 30 – Basin Statistics of Lake Pocotopaug

Surface Area	501	Acres
Total Volume	6,064	Ac-ft.
Maximum Depth	38.0	Feet
Mean Depth	12.1	Feet
Watershed	2,315	Acres

The bathymetric data available was published in the *CT Fisheries Guide to Lakes and Pond* (1959) and passed on to (*Frink and Norvell 1984*), is likely originally surveyed in the early 1930s. The contour lines were georeferenced in a GIS program and assigned an appropriate coordinated system (Map 3). Acreages of each depth were then used to create a table of surface area and volume for each layer of water, information necessary to update nutrient mass balance estimates for the lake (Table 31 & 32). The surface area and water volume is shown in Figure 10.

[8] Estimates on the area of the watershed and surface area vary

Map 4 – Bathymetric map of Lake Pocotopaug

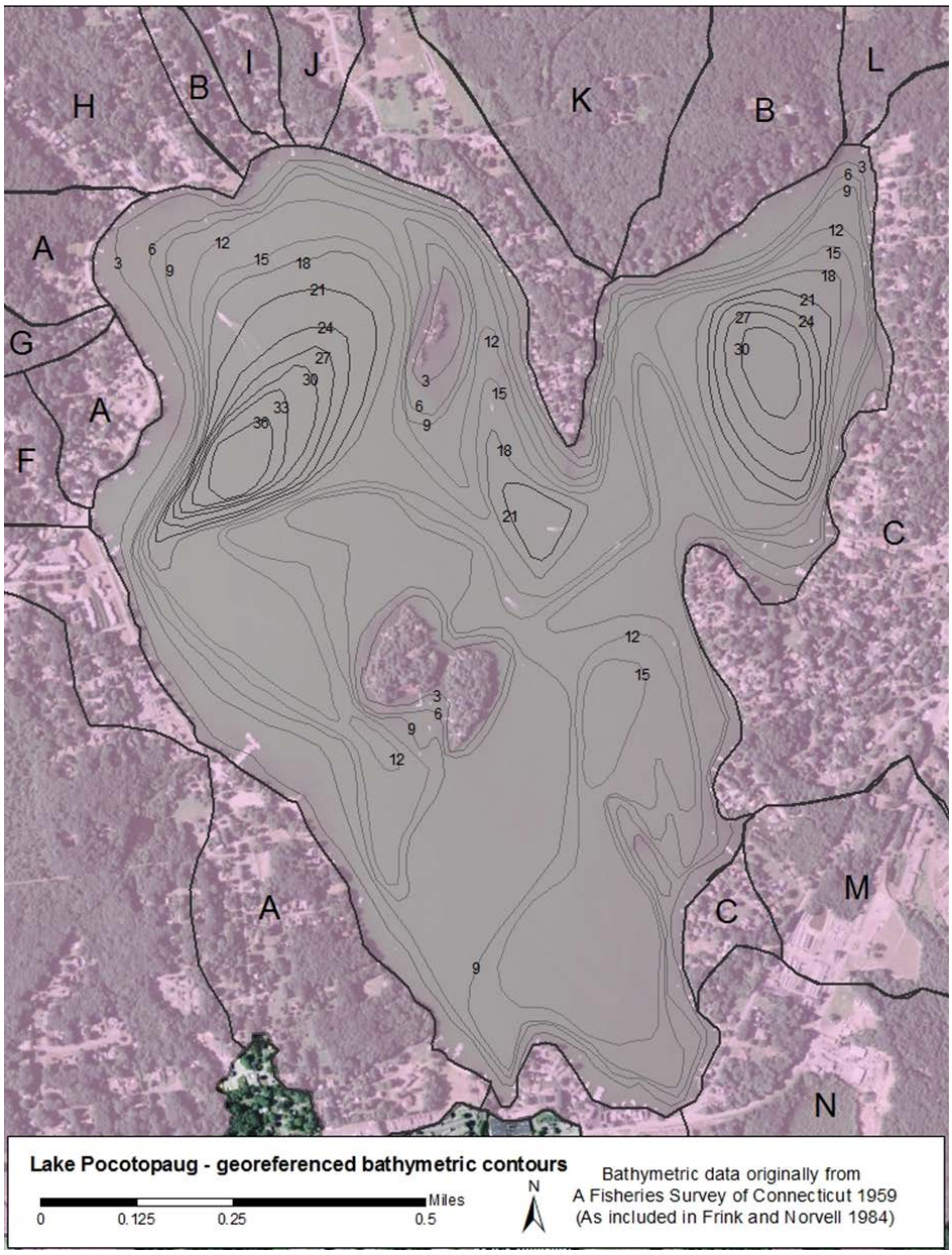


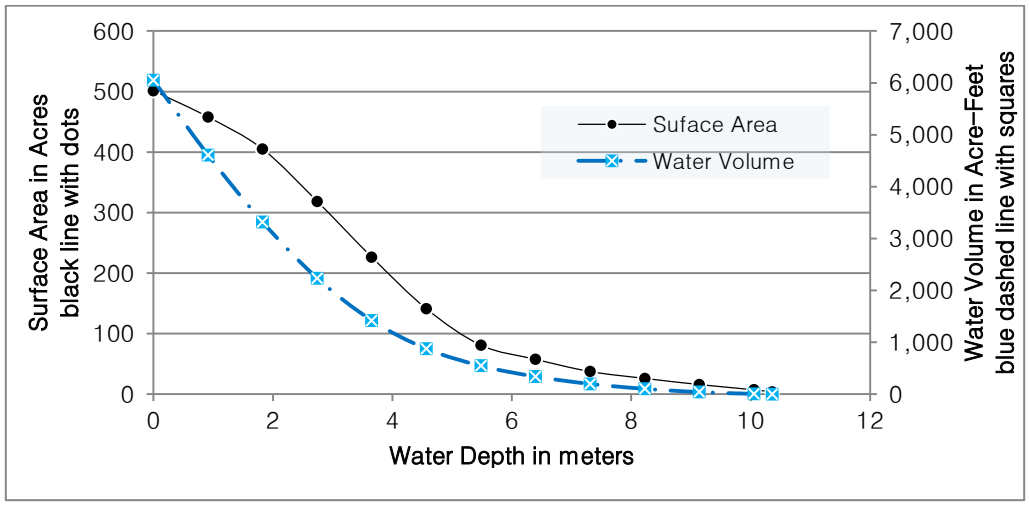
Table 31 – Surface area by depth of Lake Pocotopaug basin

DEPTH	SURFACE AREA			
	Cumulative From Bottom		Of Each Stratum	
(feet)	(acres)	(percent)	(acres)	(percent)
0	501	100	43	8.7
3	458	91	53	10.6
6	405	81	87	17.3
9	318	64	92	18.4
12	226	45	85	17.0
15	141	28	60	12.0
18	81	16	23	4.6
21	58	12	20	4.0
24	37	8	11	2.3
27	26	5	10	2.0
30	16	3	9	1.7
33	7	2	4	0.7
36	4	0.7	4	0.7
	TOTAL =		501	ACRES

Table 32 – Water volume by depth at Lake Pocotopaug basin

DEPTH	VOLUME			
	Cumulative From Bottom		Of Each Stratum	
(feet)	(acre- feet)	(percent)	(acre- feet)	(percent)
0	6,064	100.0	1,438	23.7
3	4,626	76.3	1,293	21.3
6	3,333	55.0	1,082	17.8
9	2,250	37.1	813	13.4
12	1,437	23.7	546	9.0
15	892	14.7	329	5.4
18	563	9.3	207	3.4
21	356	5.9	141	2.3
24	215	3.5	95	1.6
27	120	2.0	62	1.0
30	58	0.9	34	0.6
33	24	0.4	16	0.3
36	7	0.1	7	0.1
	TOTAL =		6,064	AC-FT

Figure 10 – Surface area and water volume at depth in Lake Pocotopaug basin



Water Quality Monitoring Results

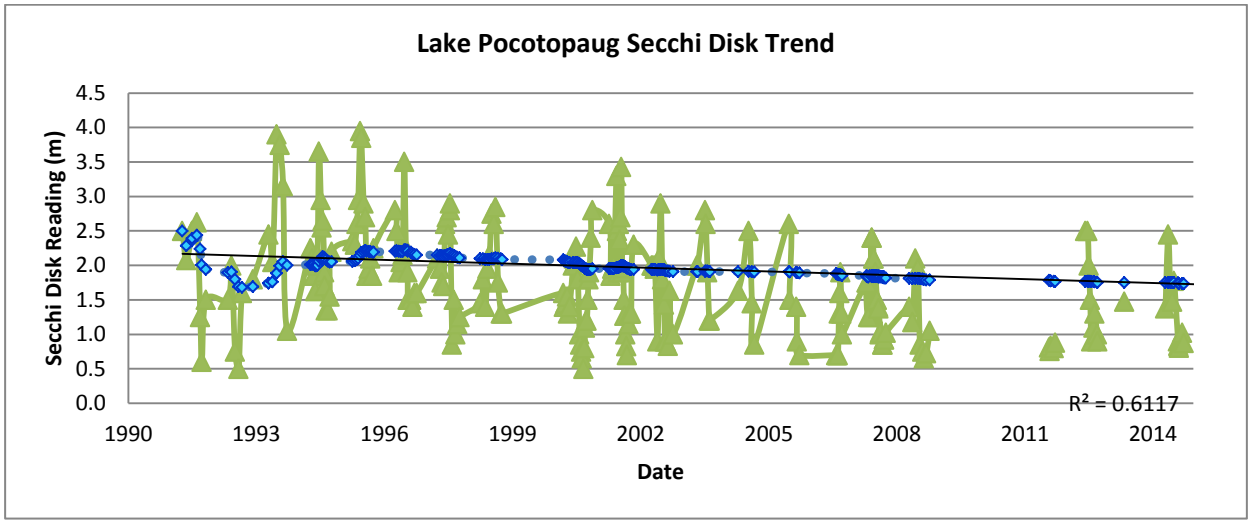
Water quality data were acquired from the aforementioned lake study reports and updated with recent 2014-2016 sampling results. The following section is an overview of historical water quality at Lake Pocotopaug.

Water Clarity as Secchi Disk Transparency

Secchi disk transparency estimates light penetration, with declining Secchi disk depth caused by increased water cloudiness. The increase in turbid water is caused by increasing phytoplankton numbers or (and) fine suspended sediments in the water column. If the decline of Secchi disk is caused by phytoplankton (algae) then typical phosphorus loading and in lake response can be used because phosphorus is the limiting nutrient. Long term Secchi disk transparency for Lake Pocototaug is shown in Figure 11. The chart shows a green line as measured Secchi depth and the long term running average in blue. The chart shows a generally declining trend in water clarity with a period of good clarity between 1993 and 1996 and poorer clarities after 2002:

1. Maximum seasonal water clarity has consistently occurred in June,
2. Maximum seasonal clarity has declined from 3.9m in 1993 to 2.4m in 2015
3. Poorest has consistently occurred rapidly after seasonal maximums between 1.0 and 0.5 meters.
4. Poorest clarity has not shown significant long term decreases, although a period between 1993 and 2000 minimum clarity was rarely less than 1m.

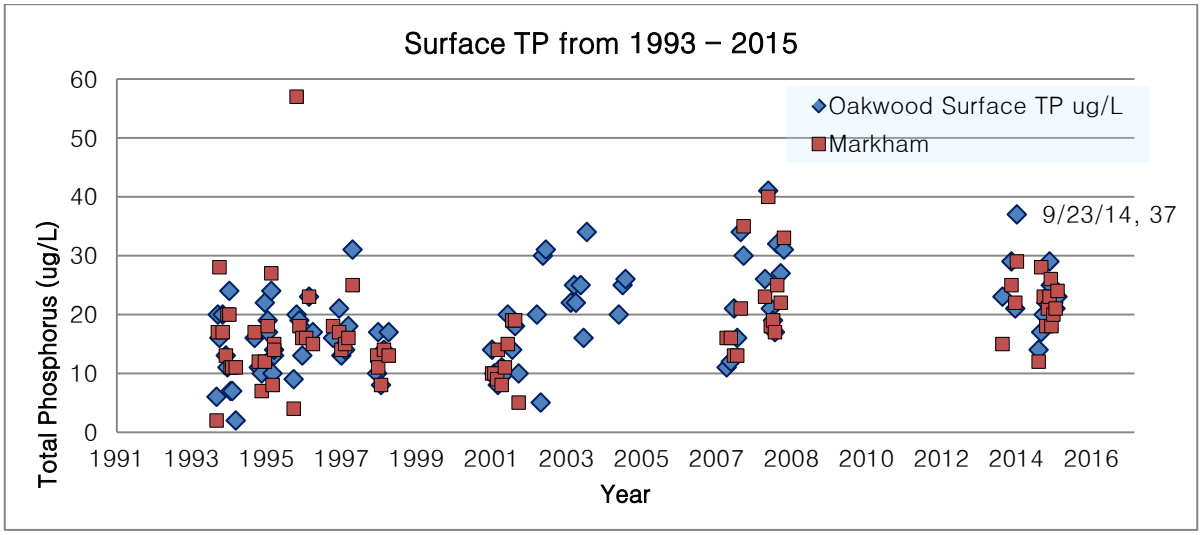
Figure 11 – Long-term Secchi disk trend in Lake Pocotopaug 1991–2015



Surface Total Phosphorus (TP)

TP has been measured at two locations: Oakwood Bay >30ft on west side and Markham Bay >30ft on east side (see Map 3). Surface total phosphorus results ranged from 10ug/L to 30ug/L, although mid to high 30's (reaching 40ug/L in 2007) have been noted (Figure 12). .

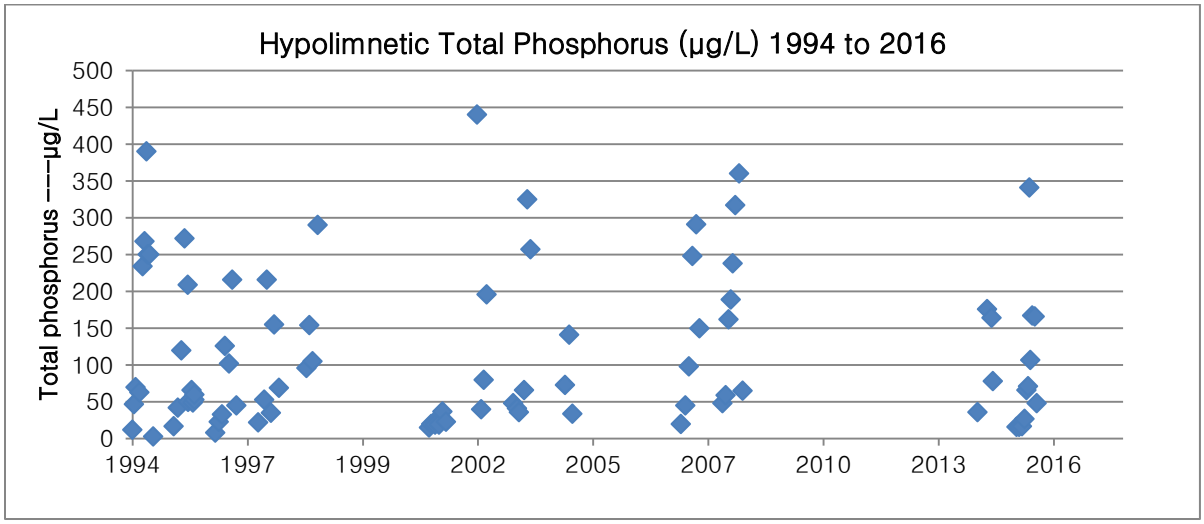
Figure 12 – Lake Pocotopaug total phosphorus trend 1994–2015



Bottom Total Phosphorus (TP)

Bottom total phosphorus results (**Figure 13**) ranged from near zero to 450µg/L. Data from 2001 shows lowest seasonal bottom phosphorus of <50µg/L seemingly out of place against all other years that show bottom phosphorus exceeding 100 µg/L. Recent data 2014–2015 show comparable results with maximum phosphorus between 174 and 341 µg/L.

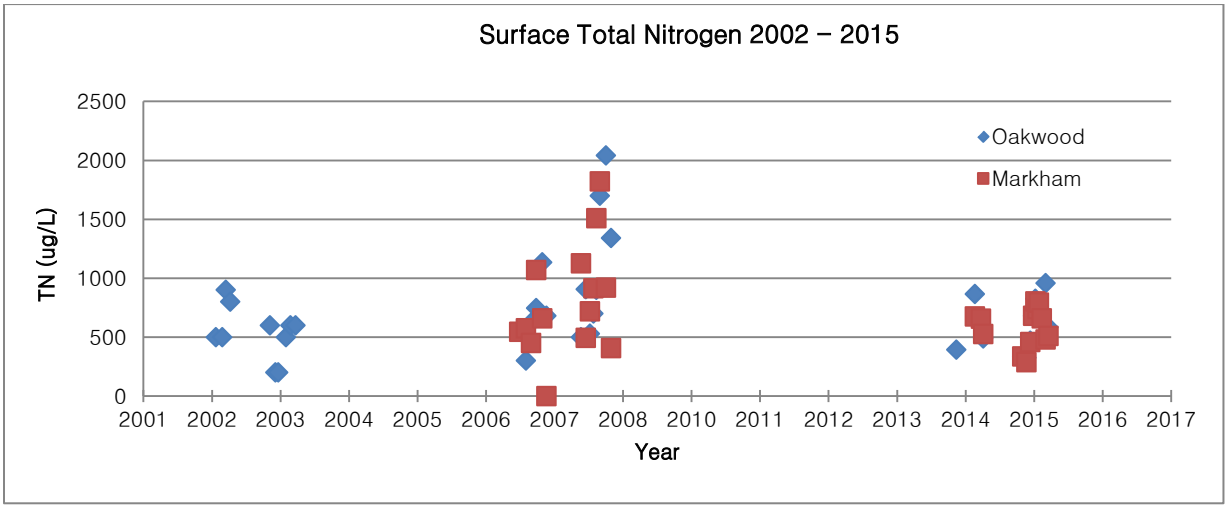
Figure 13 – Lake Pocotopaug bottom water total phosphorus 1994–2015



Surface Total Nitrogen (TN)

There are large gaps in nitrogen data because it was historically measured less frequently than phosphorus. Though phosphorus is the commonly accepted nutrient that limits productivity in freshwaters, Lake Pocotopaug has very high TN concentrations in surface waters (**Figure 14**).

Figure 14 – Long–term trend in Total Nitrogen in Lake Pocotopaug 2002 –2015



Dissolved Oxygen

Dissolved oxygen profiles representing seasonal dynamics of Lake Pocotopaug were measured through the 1990's but sporatically between 1998 and when NEAR started monitoring again in 2014. Accumulation of organic matter, mostly as dead algae cells, at the bottom of lakes leads to dissolved oxygen depletion. Once all dissolved oxygen has been consumed by bacteria the water is labeled anoxic. Data in **Figure 15** suggests that volume of anoxic water in Lake Pocotopaug during summer months has increased over time. Prior data shows that anoxic water rarely reached to 5 meters below the surface while in 2015 anoxic water was found above 4 meters[9].

Figure 15 – Long-term trend in anoxic boundary Lake Pocotopaug

Phytoplankton

Plankton has been measured infrequently in the historical literature reviewed during this study. Only a few of the many years that either watershed of in-lake monitoring was conducted included seasonal algae collections. Frequent cyanobacteria collections made during 2015 (**Table 33** and **Figure 16**) show that water clarity decreased rapidly when cyanobacteria numbers increased from <2000 to 50,000 cells/mL. Cell numbers higher than 50,000/ml did not lead to further decreases in clarity (**Figure 16**). Instead, water clarity remained constant over a wide range of cell numbers (50,000 cells/mL–300,000cells/mL).

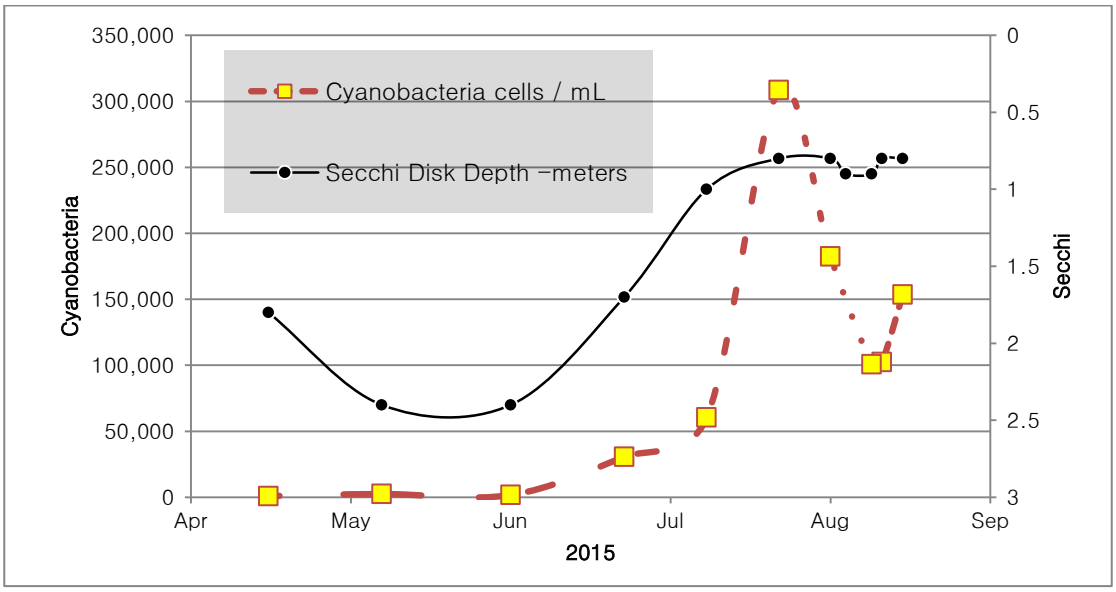
Table 33 – Phytoplankton and water clarity in Lake Pocotopaug during 2015

Date	Secchi Depth		Cyanobacteria	Taxa
8/17/2015	0.8	2.6	153,469	Chrysosoporum
8/13/2015	0.8	2.6	102,446	Chrysosoporum

[9] The anoxic boundary is measured down from the surface to the first occurrence of dissolved oxygen of 1 mg/L. Below this depth all water is devoid of dissolved oxygen.

8/11/2015	0.9	2.9	100,612	Chrysosoporum
8/6/2015	0.9	2.9		Chrysosoporum
8/3/2015	0.8	2.6	182,480	Chrysosoporum
				(name change)
7/24/2015	0.8	2.6	308,603	Aphanizomenon
7/10/2015	1.0	3.3	60,408	Aphanizomenon
6/24/2015	1.7	5.6	30,671	Aphanizomenon
6/2/2015	2.4	7.5	1,700	Anabaena
5/8/2015	2.4	7.5	2,500	Anabaena
4/16/2015	1.8	5.9	918	Anabaena

Figure 16 – Trend in cyanobacteria cell numbers during 2015



Aquatic macrophytes

NEAR conducted an aquatic plant survey of Lake Pocotopaug on September 21, 2015, the first since CT Agricultural Experiment Station surveyed aquatic plants in 2006[10]. During our survey we found only 7 species of aquatic plants sparsely scattered most were found at less than 10% of the survey points Table 34. Instead much of the littoral zone was covered in a thick benthic mat of cyanobacteria (bottom dwelling blue-green algae), identified as species of *Oscillatoria* and *Lygnbya* (Map 5). These findings are consistent with CAES who only found two species of aquatic plants at only 4 of over 250 search points surrounding the shoreline of the lake. No aquatic non-native invasive species were found in that survey.

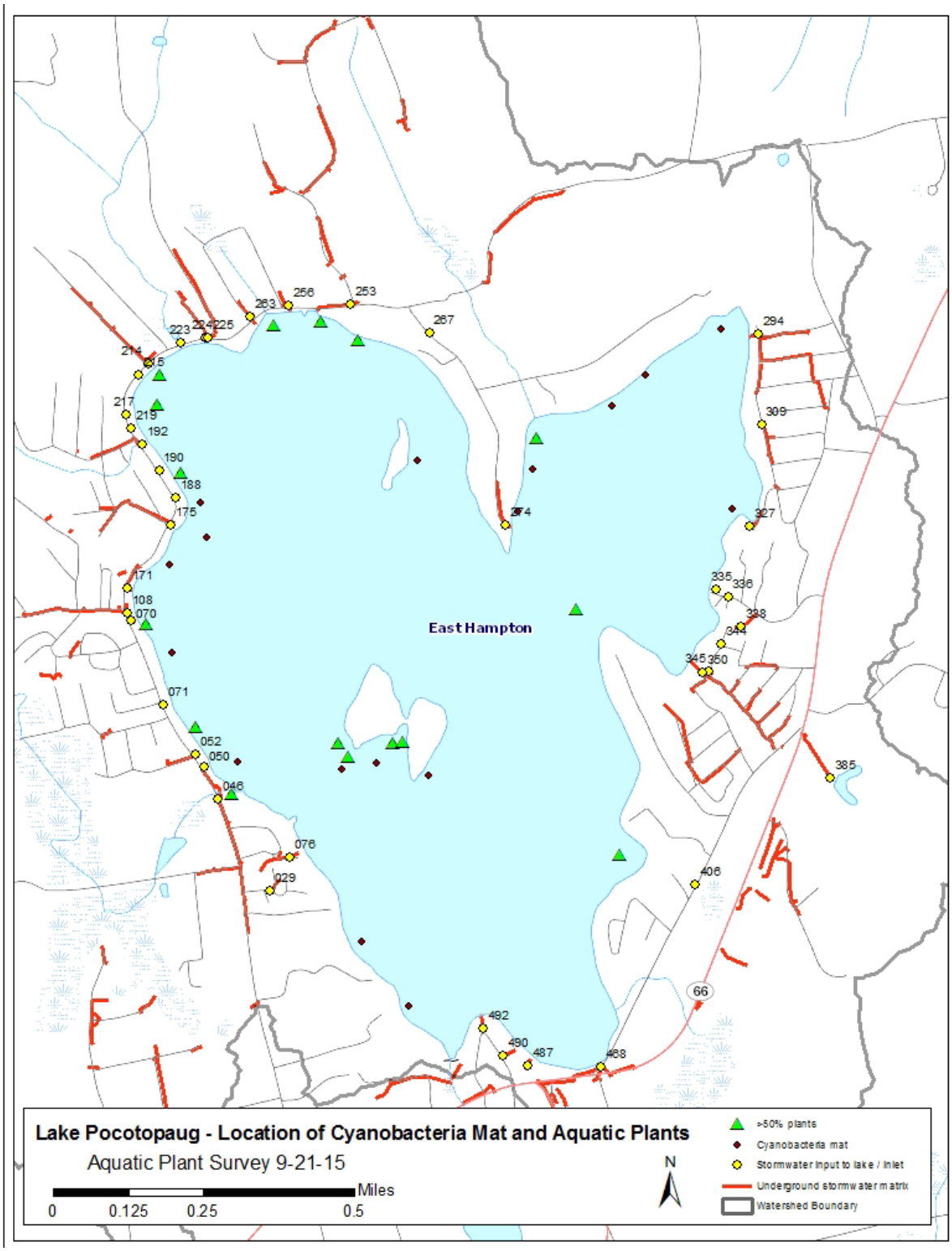
Percent occurrence is a value representing the number of waypoints where a species was documented divided by the total number of waypoints. Average percent cover represents the mean density of each species in areas where it was located. The percent cover of the littoral zone takes into account the average density and frequency of occurrence to calculate an approximate coverage of the entire survey area. Based on the depths at which plants and cyanobacteria mats were located, the littoral zone extends to roughly 7.5 ft. The littoral region where plants are capable of growing was then calculated as 72% of the lake's surface area. However, much of this surface area consists of barren rocky sediments, and 41% is dominated by cyanobacteria mat instead of rooted aquatic plants.

Table 34 – Aquatic plants found in Lake Pocotopaug on September 21 2015

Species # Key	Name	% Occurrence	AVG% Cover	% Cover Littoral Zone
1	Benthic cyano mat	30	39	41
2	Najas flexilis	5	8	1
3	Vallisneria americana	12	37	17
4	Potamogeton bicupulatus	8	31	9
5	Nitella	8	6	2
6	Elodea nuttallii	9	14	4
7	Potamogeton berchtoldii	3	25	3
8	Potamogeton epihydrus	1	5	0.2

[10] http://www.ct.gov/caes/lib/caes/invasive_aquatic_plant_program/pdfmaps/pocotopaug_lake.pdf

Map 5 – Locations of aquatic plants (triangles) and benthic cyanobacteria mats (dots) on September 21 2015



Appendix 2

Document Summary

There is an extensive list of monitoring reports and in-lake management publications for Lake Pocotopaug. Those reviewed in detail during this study are given in Table 35. Initial work was done by E. Deevey in the 1930's, and CAES in 1974. Since the early 1990's lake and watershed monitoring has been done by multiple citizen organizations, as well as consulting scientists and engineers. Predictive phosphorus and nitrogen load modeling started in 1995 and culminated in the Lake Loading Response Model in 2009. Generally most years between 1991 and 2007 have some information from either the lake or the watershed but not all testing was done consistently during each of those years leaving some holes in long-term trend analysis. All sampling stopped at the end of 2007 with no data collected[11] until monitoring resumed in 2014.

Table 35 – List of reports reviewed in this study

	Author	Date
A	Frink and Norvell	1984
B	Fugro-McClelland	1993
C	Ad Hoc Lake Advisory Committee	1995
D	Lake Advisory Committee (Phosphorus Modeling and Mitigation)	1995
E	WMC Consulting Engineers	1995
F	ENSR (Analysis of first Alum treatment performed by Aquatic Control Technologies in 2000)	2001
G	Aquatic Control Technologies (Post-Alum treatment)	2001
H	ENSR (Lake and Watershed Restoration Evaluation)	2002
I	ENSR (Investigation of Nutrient Flux and Sediment Oxygen Demand of Shallow Sediments)	2002
J	ENSR (In-Lake Water Sampling and Algal Assay Results)	2003
K	ENSR (2003 In-lake Water Sampling Results)	2004
L	AECOM (Lake Loading Response Model in TMDL Development for Lake Pocotopaug)	2009

[11] Secchi disk data was collected continuously during that period

A. *Frink and Norvell (1984)*

Monitoring conducted on 4 dates, 2 in 1973–1974 & 2 in 1979–1980. Lake classified as mesotrophic with an average Secchi disk transparency of 3.6 meters (11.8 feet).

B. *Fugro-McClelland (1993)*

Monitoring period 1977 & 1987–1992. Rainfall erosion event in 1987 following large land clearing on Baker Hill for development cased highly turbid water to flow into Lake Pocotopaug[12]. The Lake Area Task Force was formed. Continued pollution from this development was documented through 1989. The first recorded severe algal bloom (cyanobacteria) occurred in September 1990. CT DEP and CT Department of Health Services (CT DHS) became involved. A volunteer Lake Study Group began a more in-depth monitoring program.

C. *Ad Hoc Lake Advisory Committee (1995)*

The Town Council of East Hampton formed the Lake Advisory Committee (LAC) to organize information and provide recommendations for a lake and watershed management plan. The LAC report encouraged a permanent monitoring program and LAC. The report also suggested hiring a town planer and securing a continuous funding supply for lake improvement projects. The LAC recommended ongoing education to Inland Wetlands and Planning and Zoning commissioners and stressed the importance of a cooperative plan for managing lake water level via a privately owned dam.

D. *LAC Phosphorus Modeling and Mitigation Plan Report (1995)*

First attempt to model TP loading to the Lake from sources other than internal loading were made in this report. Estimates for atmospheric loading (207 kg/yr) and wildlife (20kg/yr) are extremely high. NEAR investigation of references used for LAC 1995 report showed estimates used for model construction were likely drawn from case studies that were unaligned with the conditions of Lake Pocotopaug.

E. *WMC Consulting Engineers (1995)*

Stormwater Renovation and Management Plan reviewed the Town of East Hampton Planning & Zoning and Inland Wetlands & Watercourses regulations and suggested the following:

- Required referral to the Wetlands Commission for any proposed activity in the watershed.
- P&Z regulation to include a requirement for approved designs of LID for building in the watershed, including a maximum impervious area requirement and frequent inspections to ensure compliance.
- IWW regulations should have a buffer zone requirement that limits certain land use and activities in the watershed, needs strict enforcement.

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[12] Who can document this

- Utilize an erosion and sedimentation control checklist for any development in watershed

The WMC report also provides a detailed list of stormwater detention hydraulic inadequacies and suggests specific fixes to catch basins, driveways, parking lots, roof drains, and channel stabilization. Total estimated costs were $3,122,000.

F. ENSR International: Analysis of first Alum treatment performed by Aquatic Control Technologies in 2000 (2001)

Frugro McClelland (1993) was the first to suggest that internally generated phosphorus contributes significant phosphorus load to Lake Pocotopaug annually. Aluminum sulfate (Alum) was proposed option for reducing internal loading. Following this suggestion, and lake nutrient data provided by Volunteer Lake Study Group data collection through 1998, the Town contracted with Aquatic Control Technologies (ACT) to plan an Alum treatment for the summer of 2000. The original plan was to treat all areas greater than 15-feet deep. However, despite the use of a sodium aluminate buffer and a relatively stable pH, an unexpected fish kill occurred after treating only 22 of the proposed 177 acres **[IN REVIEW]** at a dosage of 40 g/m^2 **[IN REVIEW]**. The remaining areas were untreated in 2000. Treatment maps demonstrate that the 22 acres treated were on average only 16-feet deep and not located in either of the deep holes where the internal loading had been documented as occurring. Thus, the 2000 Alum treatment may have occurred in areas not likely to release phosphorus during the summer (Lake data shown later indicates that the ALUM failed to inactivate phosphorus loading in the deeper anoxic waters (ENSR 2002).

G. Aquatic Control Technologies Post-Alum treatment report (2001)

In 2001, a second Alum treatment plan was proposed. In a combined effort, ENSR and ACT took appropriate planning measures to calculate a treatment dosage between 42-48 g/m2 of aluminum sulfate to bottom waters in a modified treatment area of 140 acres. The Alum:Aluminate (buffer) **[IN REVIEW]** ratio was reduced to half that used in the 2000 treatment resulting in stable pH and alkalinity, and no fish toxicity. The ACT report makes mention of improving Secchi disk transparency on the days of treatment (spread out per CT DEEP permit requirements from May 22nd - June 8th) from 5.5 feet to 10.5 feet, but it seems there is little data available. ENRS collected water quality samples prior to the treatment on 5/17/01 and following the treatment on 6/13/01 (Table 36).

The pre and post-Alum treatment water quality data showed that the treatment did not have a lasting effect on Secchi disk transparency, nor phytoplankton and chlorophyll concentrations. Note that by 8/23/01 water transparency declined to 3.5 feet and phytoplankton concentrations rose to 15912 µg/L, despite any reduction in bottom water Total Phosphorus (TP) - likely resulting from the Alum treatment and sediment inactivation.

Table 36 – Water quality data from May and June 2001 before and after Alum Treatment

Date	Sample Location	TP (ug/L)	Turbidity (NTU)	Secchi (ft)	Chlorophyll (ug/L)*	Phytoplankton (ug/L)*
5/17/01	LP-1 Surface	10	1.9	6.0	3.29	3,876
5/17/01	LP-1 Bottom	21	3.4	~	~	~
5/17/01	LP-2 Surface	10	1.9	6.0	2.55	3,312
5/17/01	LP-2 Bottom	20	2.2	~	~	~
6/13/01	LP-1 Surface	9	1.7	8.5	1.5	4,449
6/13/01	LP-1 Middle	14	1.7	~	~	~
6/13/01	LP-1 Bottom	19	2.0	~	~	~
6/13/01	LP-2 Surface	9	1.7	7.5	6.34	4,472
6/13/01	LP-2 Middle	17	2.2	~	~	~
6/13/01	LP-2 Bottom	23	3.3	~	~	~

H. ENSR International Lake and Watershed Restoration Evaluation (2002)

The first comprehensive lake study included extensive in-lake monthly water quality sampling, as well as phytoplankton and zooplankton population analyses. The study concluded that in-lake surface phosphorus is relatively low given the observed algal blooms and poor water clarity. ENSR suggested that watershed phosphorus loading should be reduced by 60%. The study addressed the potential internal loading of phosphorus and notes that future Alum treatments may still be necessary. Specific reference is made to the non-algal turbidity affecting water clarity as a result of suspended sediments from poor watershed management practices. The report included with multiple descriptions of BMPs for catch basin sumps and detention and infiltration system improvements.

Concluding recommendations included stocking Walleye, a piscivorous fish species, to provide "top-down" control of phytoplankton by reducing the large population of zooplanktivorous fish. This method of trophic biomanipulation was expected to produce visible increases in zooplankton and decreases in phytoplankton over a course of 3 to 5 years.

I. ENSR Investigation of Nutrient Flux and Sediment Oxygen Demand of Shallow Sediments (2002)

This report specifically investigated the possibility of nutrients leaching from shallow lake sediments in the oxic zone and not previously treated with Alum. By measuring the shallow-water sediment oxygen demand (SOD) in three locations around the lake, ([IN REVIEW]. it was determined that the sandy sediments have a very low oxygen demand. Results are indicative of very low sediment bacterial decomposition and use of oxygen in shallow waters, fitting to sandy sediments with low organic material. Nutrient flux was measured using a DPA analyzer and results showed no release of phosphate nor nitrate/nitrite. One of the three sites removed ammonia from the water-column, while the other two sites did not.

J. ENSR In-Lake Water Sampling and Algal Assay Results (2003)

Algal and zooplankton population analysis revealed similar trends in 2002 as in 2001. Spring and fall were dominated by diatoms and chrysophyte algae, while the cyanobacteria genera Anabaena aphanizomenoides (currently taxonomically reclassified as Aphanizomenon spp.) prevailed in the summer months. Similar low zooplankton trends were observed with declines in population it late summer.

An algal assay was performed in the laboratory using water collected from the surface (epilimnion) and bottom (hypolimnion) waters of Lake Pocotopaug to determine phytoplankon response to phosphorus dilution. Results for epilimnetic waters demonstrated that severe dilutions resulted in phytoplankton die off, and moderate dilution yielded no growth. However when hypolimnetic water was used instead of epilimnion water dilution did not decrease algae growth, showing that the cyanobacteria did not actively grow in hypolimnetic water. These studies indicate that the species of cyanobacteria dominant in Lake Pocotopaug may be adapted to low phosphorus conditions and when phosphorus is below a threshold level that algae doesn't grow, and that phosphorus may not be limiting at higher concentrations. **[IN REVIEW]**

K. ENSR 2003 In-lake Water Sampling Results (2004)

While the 2002 ENSR report makes reference to poor watershed practices and high turbidity in stormwater sampling, it is this 2004 report that specifically analyzed the field data collected inlets between 2001 and 2003. Samples were collected from 15 inlet sites. Only three samples were collected during a 'Dry' weather event in September 2003 because additional tributaries were not flowing. Passive stormwater samplers were used to collect first flush 'Wet' weather data, and 'Post-wet' samples were collected the morning after the rain event.

Two sites are identified as significant sediment and nutrient pollution sources: LP-10 (renamed to O'Neill's Brook in later reports) had very high nutrient concentrations and turbidity despite a small watershed area. The report suggests that the two stormwater retention basins in this sub-watershed were likely insufficient at retaining nutrients. The second pollution location was identified as the Clark Hill storm drain. In an attempt to quantify the efficiency of newly installed Stormceptor® devices, samples were taken upstream and at the downstream discharge. It appears that these BMPs reduce Total Phosphorus and turbidity, but dissolved phosphorus and nitrogen were reduced by a lesser amount. However, ENSR makes note that some reduction may be attributed to downstream dilution from road runoff and no true conclusions were made about actual removal capacities.

Overall, the AECOM 2009 report recommends more stormwater sampling and attention to watershed pollution and the unknown volume of water flowing into the Lake during baseflow and storm conditions.

Phytoplankton and zooplankton were quantified via monthly sampling. Cyanobacteria remains dominant during the summer months and zooplankton populations were still considered low. Final recommendations include treating the lake with a copper-based algaecide when cyanobacteria cells begin to dominate. It is suggested that a treatment would halt a bloom before it fully develops. A hypolimnetic copper treatment was also proposed based on a hypothesis that algal resting cells are migrating from bottom waters and transporting nutrients. (hill wants a paper on this) NEAR notes that this phenomenon is credible for certain species of cyanobacteria but that it has not been confirmed in Lake Pocotopaug.

L. 12 AECOM Lake Loading Response Model in TMDL Development for Lake Pocotopaug (2009)

LLRM is the most recent and most thorough watershed model of nutrient loading to the Lake. Using GIS land use data acquired from UCONN and the State of Connecticut, the sub-watersheds were broken down into fourteen classifications representing varying levels of development, agricultural use, and forested or wetland cover. Water runoff coefficients and rainwater infiltration rates were utilized in predicting runoff from varying precipitation events. Nitrogen and phosphorus runoff coefficients were used to then model specific nutrient contributions for each land cover type in each sub-basin. This model was the first for Lake Pocotopaug to factor in infiltration, subterranean flow, and nutrient attenuation in the watershed to yield more accurate loading estimates. LLRM then predicts potential improvements in water quality based on watershed nutrient loading reductions from LID and BMPs. Multiple chlorophyll and water clarity models from the literature were employed.

NEAR reviewed the LLRM model and compared predictions to on-the-ground 2014-2016 sampling results and flow readings. Loading estimates from the LLRM model were supplemented by NEAR calculated loading events, and the same general sub-basins were identified as pollution sources in 2016 as in 2009. The following section identifies specific locations of nutrient pollution and makes multiple references to the AECOM LLRM model.

Appendix 3

Culvert GPS Waypoint File Separate Document

Excel worksheet of watershed existing condition and recommendations. Developed to be a working document the spreadsheet can be altered as measures are implemented as both sub-basin and total water progress can be tracked. Northeast Aquatic Research, LLC: Lake Pocotopaug Stormwater / Descriptions.

Appendix 4

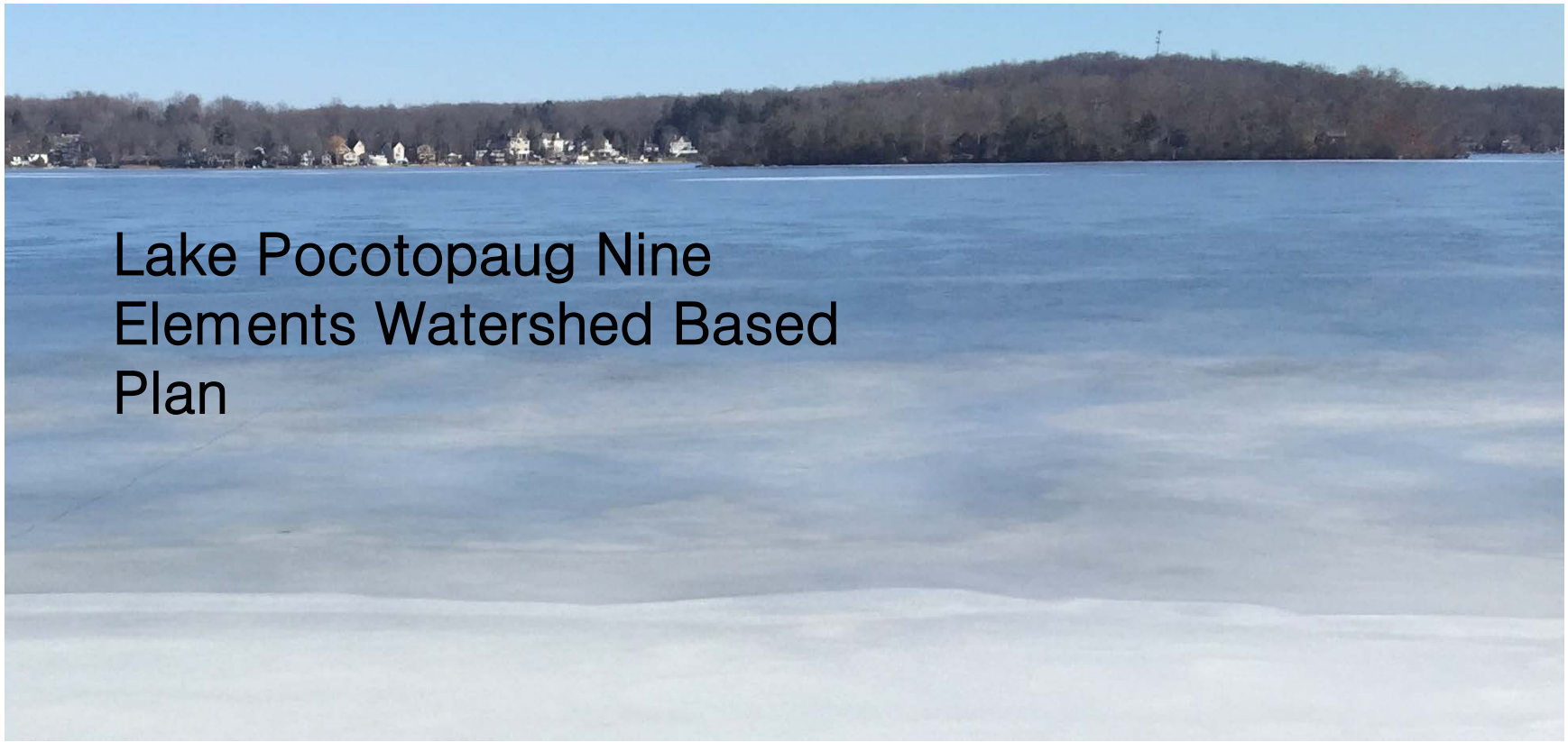
Watershed Reconnaissance PowerPoint Separate Document

Appendix 4 is a PowerPoint presentation showing locations where management measures are needed. Slides show photos of pollution sources arranged by sub-basin. Assisting this slide show are the corresponding GPS file and culvert document.

Appendix 4
Watershed Reconnaissance
Lake Pocotopaug

Photos taken by Northeast Aquatic Research, Aerial and Satellite images range in date between 2012-2016

Photos are organized by sub-basin
Show both areas in need of management measures well as recent improvements and good stormwater practices



Lake Pocotopaug Nine Elements Watershed Based Plan

Sub-basin A - Edgemere Condos

Sub-basin A – road runoff from Edgemere Condos

Sub-basin A - Stormwater drainage at NEAR POCO_4 Outflow of runoff from Edgemere Condos

4/14/15

Very high TP but manageable water volume. Water could be retained onsite using LID instead of flowing into stormwater culverts to the Lake.

See highlighted areas on aerial image of Edgemere Condos

Sub-basin A – Scouring from inlet draining road runoff from Lake Dr.

WPT 171: Catch basin near lake level and frequently full of water, may not be retaining any incoming sediment or garbage in road runoff.

3/28/16

Sub-basin A - Drainage from north of Clark Hill Rd.

WPT 171: Catch basin is routinely full of water, near lake level, and improperly functioning

Flow measurements difficult, low volume of water, very high TP

2/2/2016

Sub-basin A: Stormwater retention at the end of Wells Rd.

Ensure that it is functioning properly. Potentially use as a test site.

Sub-basin A - Angelico's Parking lot poor stormwater management, LID needed

4/14/15

WPT 75

Sub-basin A – Sears Park Rain Garden LID

6/2/15

Rain garden created to minimize runoff and nutrient input to the Lake but had design and construction flaws – after 2015 improvements, now functioning properly and vegetation taking hold

4/14/15

Sub-basin A – Lake Boulevard Road Runoff

4/14/15

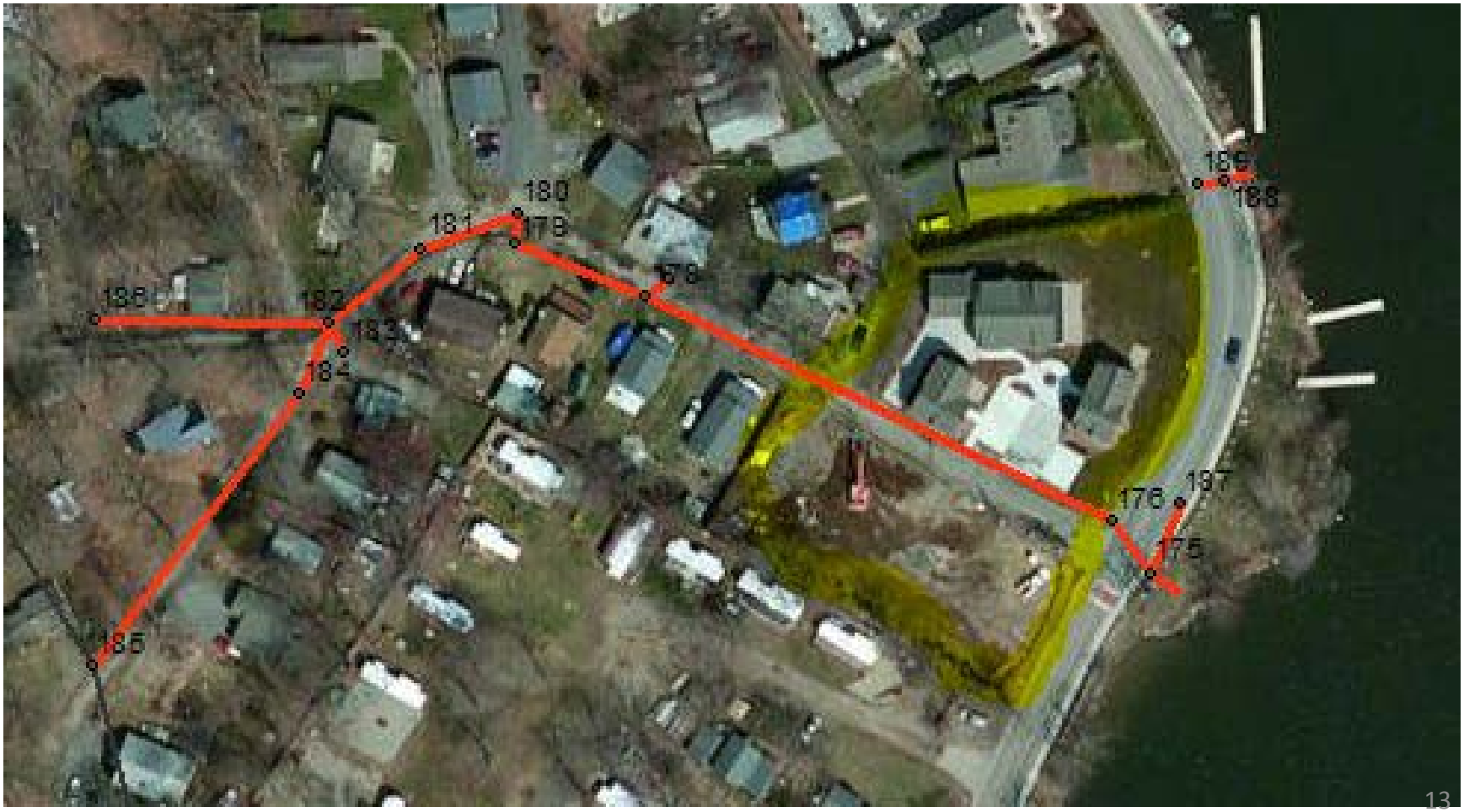
WPT 55: Erosion control needed, potential LID on private property to minimize road runoff to Lake

Sub-basin A – Catch basins at lake level

New sidewalk 2010? to reduce road erosion to lake but catch basins have inadequate sediment trapping ability near lake level

Not sampled due to water stagnation

Sub-basin A – West Street impervious cover / example of new construction, increasing housing density in watershed



Sub-basin A – Ola Ave WPT205 needs infiltration, becomes road runoff

WPT193
Underground stream into culvert to lake

Potential LID in highlighted areas (private property)

Sub-basin B - Pocotopaug Dr. Seven Hills Development roadside infiltration

Ensure maintenance of all Stormceptor® devices in Seven Hills development

2/3/2016

Sub-basin B – Beach erosion along Lake Dr. Between Candlewood Dr. and Raymond Rd.

Improve buffer strip. Plant emergent sand tolerant wetland plants.

Sub-basin C - Brook Draining Pond behind Laurel Ridge Estates crossing Tennyson Rd.

2/18/2016

WPT 369 and 370: catch basins covered in sediment, need maintenance. Potential nutrient maintenance area through minimizing erosion.

Sub-basin C - Underground Catch Basin

WPT 371: Unknown brook comes from Educational Playcare building area. Much water flow for dry conditions, stream is diverted under road and then out again to Whittler Rd. Above preschool parking lot has high erosion and sediment catch basins.

Sub-basin C – 2016 new development, Edgewater Hills

Much exposed land and some sediment runoff to highlighted pond. Needs town zoning enforcement. Planning and Zoning official has been notified.

Sub-basin C – Rt 66 Detention Pond

5/13/2016
Wpt 384

Sub-basin C: Outflow of Edgewater Hills Wetland Pond

WPT 385: Wetland pond receives road runoff from new construction site (silt curtains are in place but need future inspection as development continues).

Water flows through plastic pipe underground to route 66 roadside detention area. Water is eventually routed to Sub-basin C stormwater culverts and directly to the Lake.

Tested exceedingly high in Iron and Manganese, low to moderate TP

Sub-basin C – Covered Catch basin on Stevenson Rd.

WPT397 – Overland flow from Chaucer Rd, example of specific catch basins that need more frequent maintenance

Sub-basin C – Mohigan Drive catch basin needs to be updated

WPT 295 drains to private beach, very high TP from runoff of surrounding residential roads

WPT 299 private boat ramp direct overland flow to lake

WPT 310 Private Property on cliff, unable to sample

Sub-basin C – Mohigan Drive catch basin needs to be updated

Poco 8: Street runoff during dry sampling from someone washing their car.

5/13/2016

Sub-basin C – 2016 New infiltration devices reduce severe road runoff

LID still needed at WPT328 and surrounding area on private property, ideal location for roadside infiltration swale

Sub-basin C – Drainage from Seep on Pine Trail

WPT338: Seep from side of road near telephone pole pictured

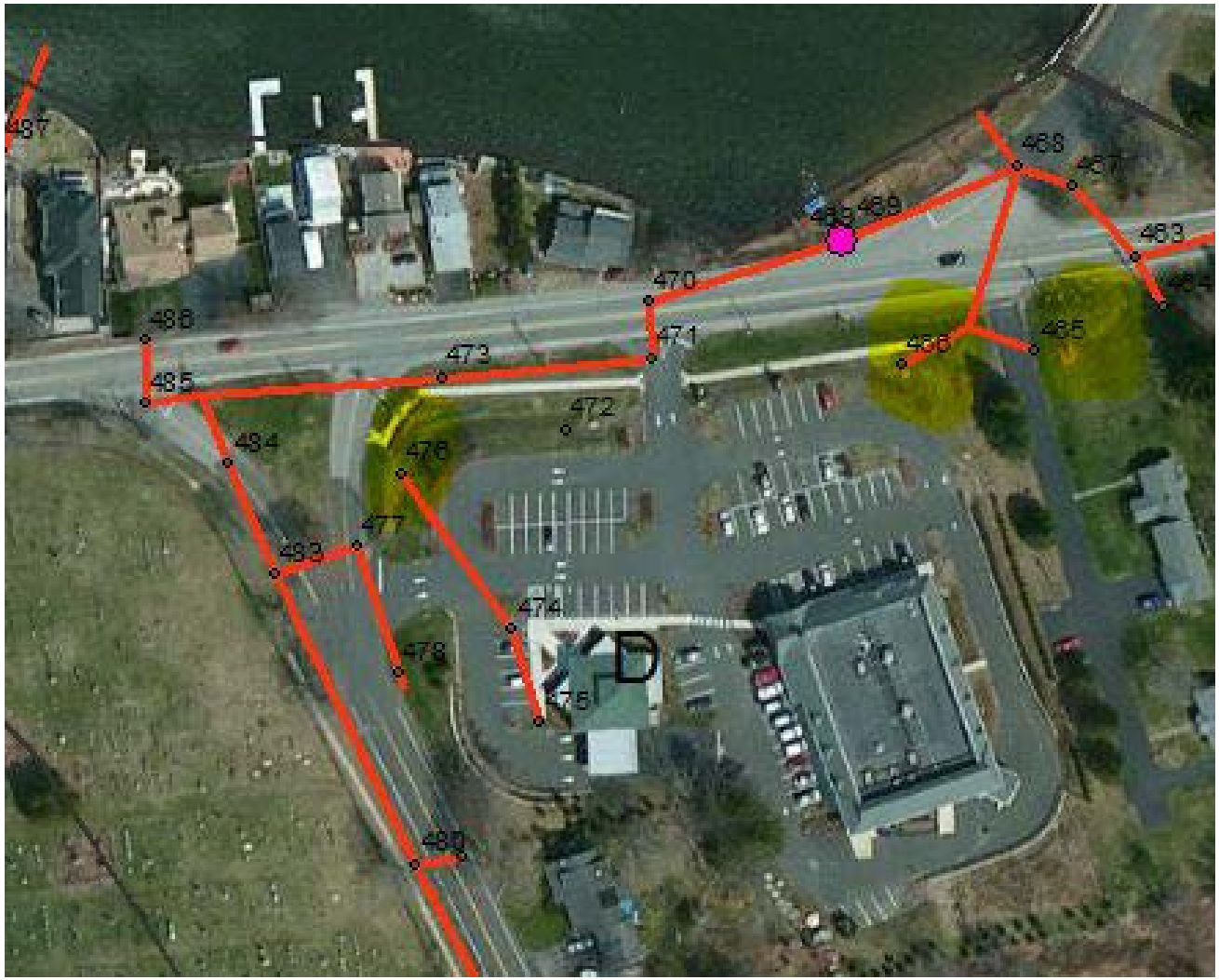
WPT 336: Creates large muddy area near lake, unknown origin of seepage, Moderate-High TP (shown on aerial image on next slide)

Sub-basin C – Unknown spring emerges from ground and flows downhill creating much runoff and road erosion towards boat ramp

WPT338 moderate TP spring – not always flowing, minimize erosion with LID infiltrating road

WPT335-336 muddy boat ramp area from runoff – LID needed to reduce erosion of continuous use

Sub-basin D – Monitor new CVS roadside detention basins at WPTs466 & 465



WPT469: location of large erosion event during DOT construction

New culvert system, 2016 TP levels moderate to high from road runoff, more LID potentially needed on Lakeview St. (State Highway 196)

Sub-basin D – Erosion of new fill along Route 66

Sub-basin D – New DOT stormwater outflow, drains Rt. 66 and Rt.196

WPT 469: Moderately high Total Phosphorus (TP) numbers and some suspended solids.
CT DOT District 2 #41-113

3/16/16

Sub-basin D – New DOT stormwater outflow

WPT 469: Unknown if sediment due to loading or lake water level fluctuation.

Sub-basin D – New catch basins along Rt. 66 with plastic sediment barriers to catch erosion.

WPT 465

3/16/16

Sub-basin D – Stormwater management of runoff from CVS parking lot

3/16/16

WPT 473?

Sub-basin D – West Point Rd.

- WPT 492: Outdated catch basin draining West Point Rd. Needs to be updated.

Sub-basin D – Island Coffee Traders parking lot

WPT 488: Water accumulates in the depression of the northeast corner of the parking lot; overflows and travels across West Point Rd. to discharge along the side of the Chatham Apartments. LID infiltration needed on private property.

3/28/16

Sub-basin D – Runoff from Island Coffee Traders at Chatham Apartments

3/28/16

WPT 489: Runoff moderately high in phosphorus.

Sub-basin D – LID on private property needed to reduce overland flow

WPT491 storm drain completely full of sediment, no longer functions to drain

WPT487 direct runoff from road/parking lot into lake

WPT488 overflowing curb from coffee shop lot floods onto road, much erosion at apartment building below

Sub-basin - D
Cemetery Erosion along Rt. 196 & 66

New tree plantings are good but rain runoff from cemetery escapes under fence to road, need more vegetation to stop runoff and prevent erosion.

2/25/16

Sub-basin E – Skyline Estates Insufficient Stormwater Management Practices

2/1/16

LID needed on private property to reduce gulley erosion, failed silt fence

Town PWD needs to monitor and enforce responsible development

Sub-basin E – Skyline Estates failed stormwater retention basin

Inadequate detention basin capacity, overflow into Christopher Brook during small moderate – large precipitation events

Increase volume of detention and ensure flow to lowest catchment areas, that are frequently dry and not utilized

Sub-basin E – Skyline Estates failed stormwater detention basins after snowmelt

Very high turbidity and nutrients flowing into Christopher Brook

2/25/2016

Sub-basin E – Skyline Estates Failed Stormwater Detention Basins (cont.)

Lower basin does not receive flow, improper drainage or connection. Inspection and maintenance necessary.

Sub-basin E – Skyline Estates, roadside infiltration needs to be maintained in future.

2/2/2016

Sub-basin E – Stormwater Detention Basins at Skyline Estates (cont.)

2/2/2016

Sub-basin E – Christopher Brook Downstream of Skyline Development (on left) meeting road runoff from Clark Hill Rd. (on right)

WPT 169: Note highly turbid waters polluting Christopher Brook from Skyline failed detention pond

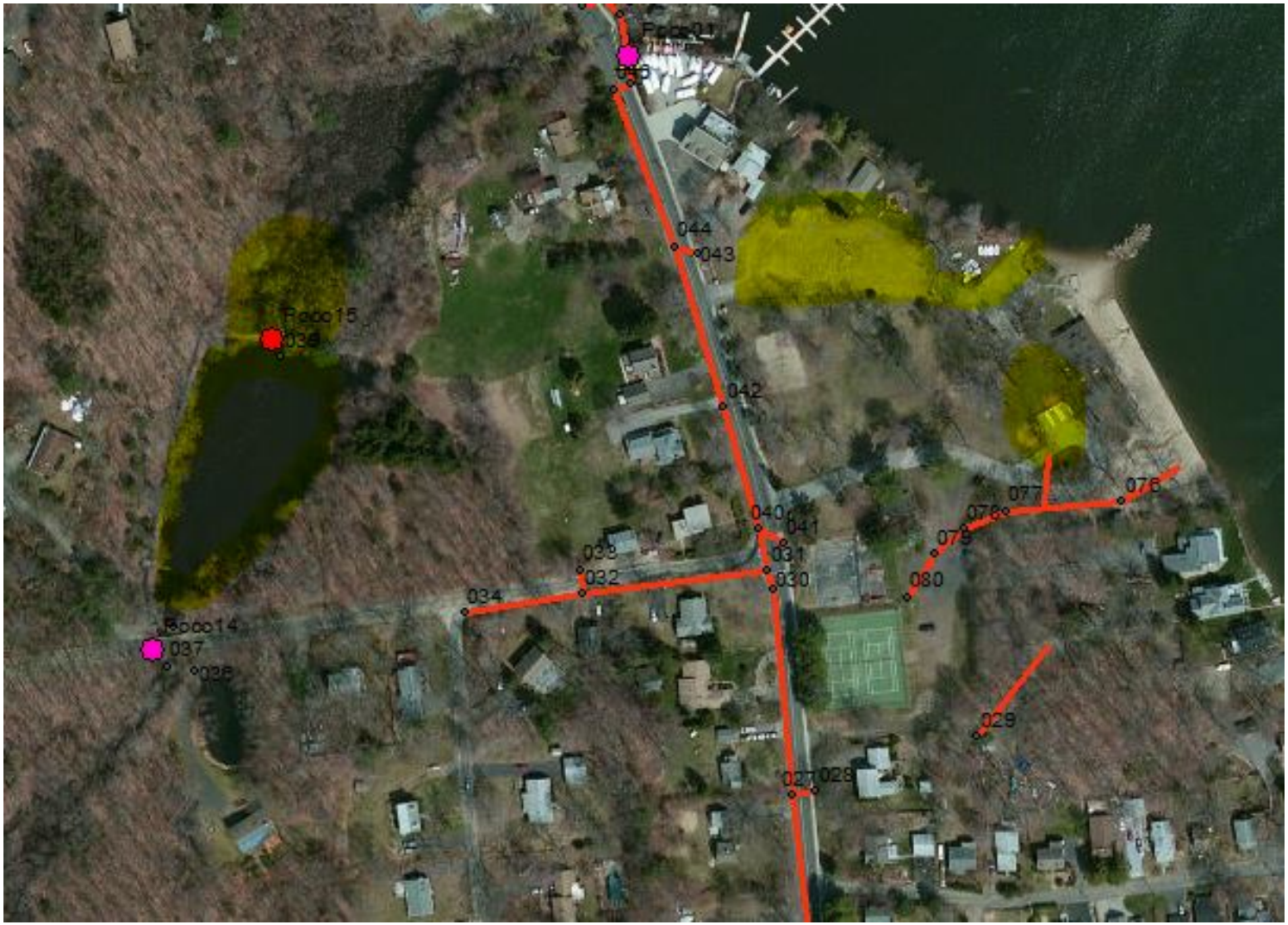
2/25/2016

Sub-basin E – Roadside Ditch Drainage on Clark Hill Rd. near Skyline Estates.

New roadside swale and infiltration area leads to newly constructed storm drain, LID constructed in 2015-2016 by East Hampton PWD

2/1/16

Sub-basin E – Christopher Brook Pond and outflow to wetlands needs to be maintained

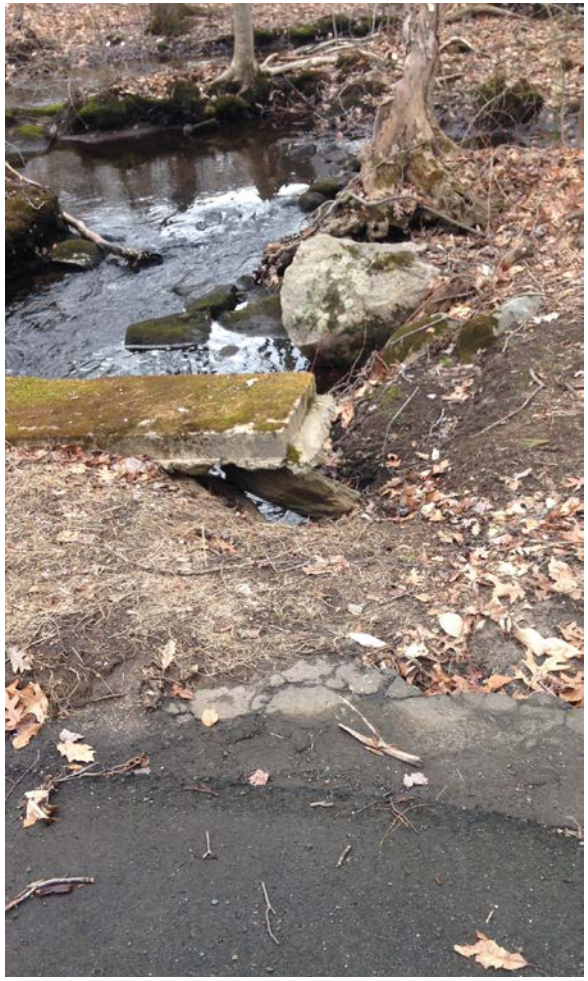


Sub-basin E – Christopher Brook Pond

5/13/2016
NEAR POCO 14

Sub-basin E – Erosion of Bridge over Christopher Brook at Christopher Rd.

NEAR POCO_14



4/14/2015

Sub-basin E – Christopher Brook Pond Outlet

5/13/2016
NEAR POCO 15

Sub-basin E – Sears Park newly renovated rain garden and functioning LID

Large highlighted parking lot area and boat ramp need LID to minimize ground compaction and runoff, Town Property

Sub-basin E – Older image, new construction at High School needs oversight from DPW

WPT 540: high TP despite highlighted catch basins with sediment traps

Circled area has two new infiltration areas, unknown if proper drainage

Sub-basin E – Downhill from High School Construction

WPT 540: high TP despite catch basins with sediment traps

Sub-basin E – Construction at the High School

WPT 547: Open earth, high potential for erosion and runoff.
Needs oversight from Town official

3/16/16

Sub-basin E – Nutrients in runoff from high school construction

5/13/2016
Wpt 540

Sub-basin E – Sediment accumulation at end of North Maple St

5/13/16

Sub-basin E –Sediment Accumulation

WPT 534: Road runoff from North Maple St. causing sediment accumulation.

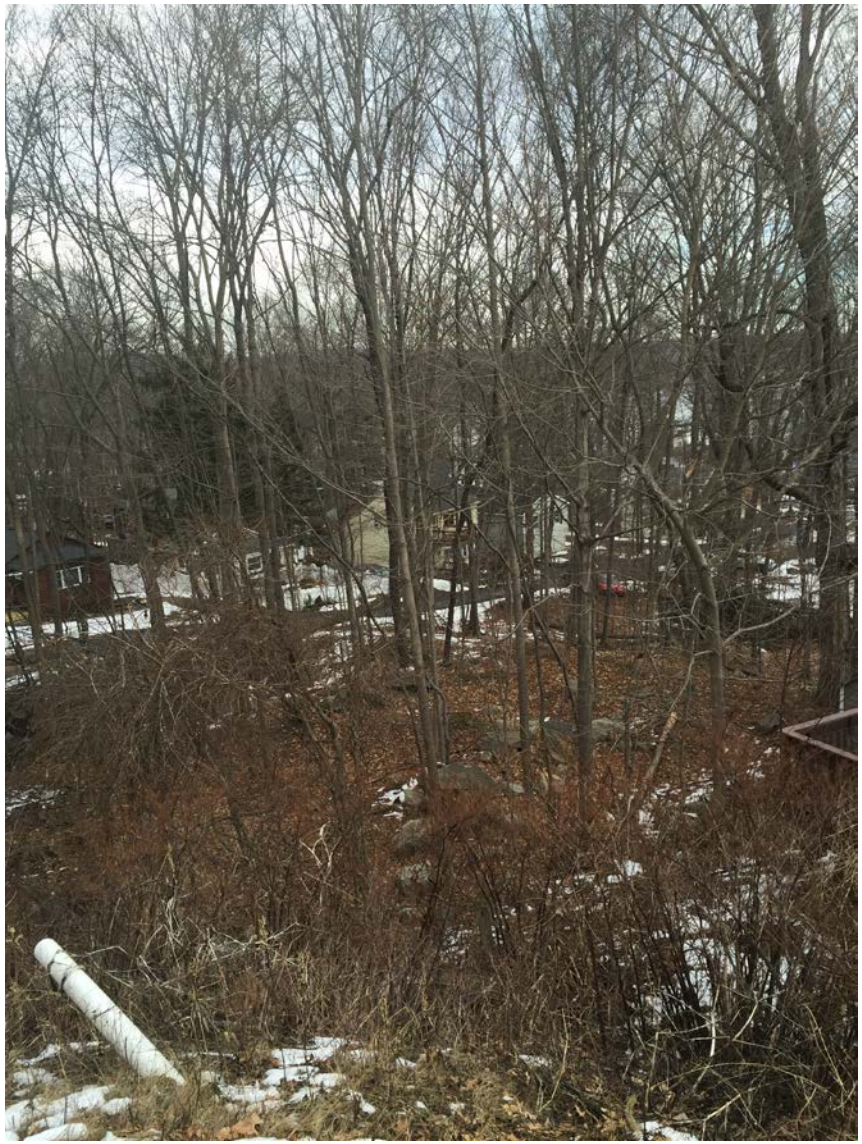
5/13/16

Sub-basin E – Stream draining stormwater runoff from North Maple St.

WPT 531: Sediment and filamentous algae indicate nutrient loading.

Sub-basin F – White pipe draining unknown. Mountainview Rd. East Hampton

2/1/16



Sub-basin F – Old Catch basin at Mountainview Rd. road runoff

2/1/16

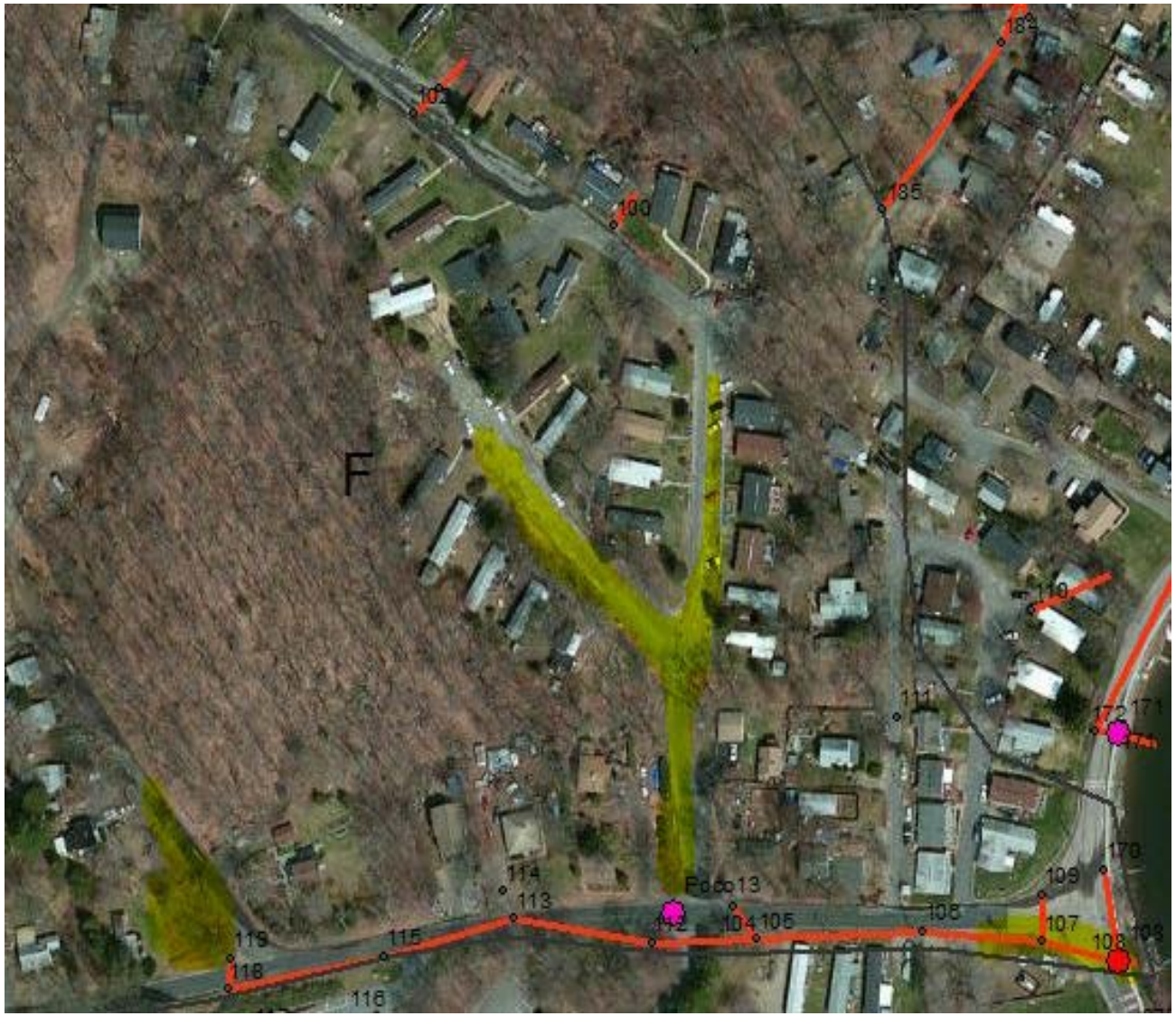
Sub-basin F – Dirt pile and eroding driveway at Old Clark Hill Rd.

WPT 119: Private property creates much road runoff that flows down to Clark Hill towards lake, sampled - very high phosphorus

2/1/16

Sub-basin F – Dirt Road, Old Clark Hill Rd. additional photos, WPT 119

Sub-basin F – Road runoff from Mountainview Road to Clark Hill



Clark Hill Road has large volumes of sheet flow/runoff – midstorm sampling extremely high TP direct to lake

Potential infiltration area on private property near WPT 107

Sub-basin F – Road Runoff from Clark Hill Rd. at Mountainview Rd.

6/2/15 near WPT 104

Sub-basin F – Inlet into Lake

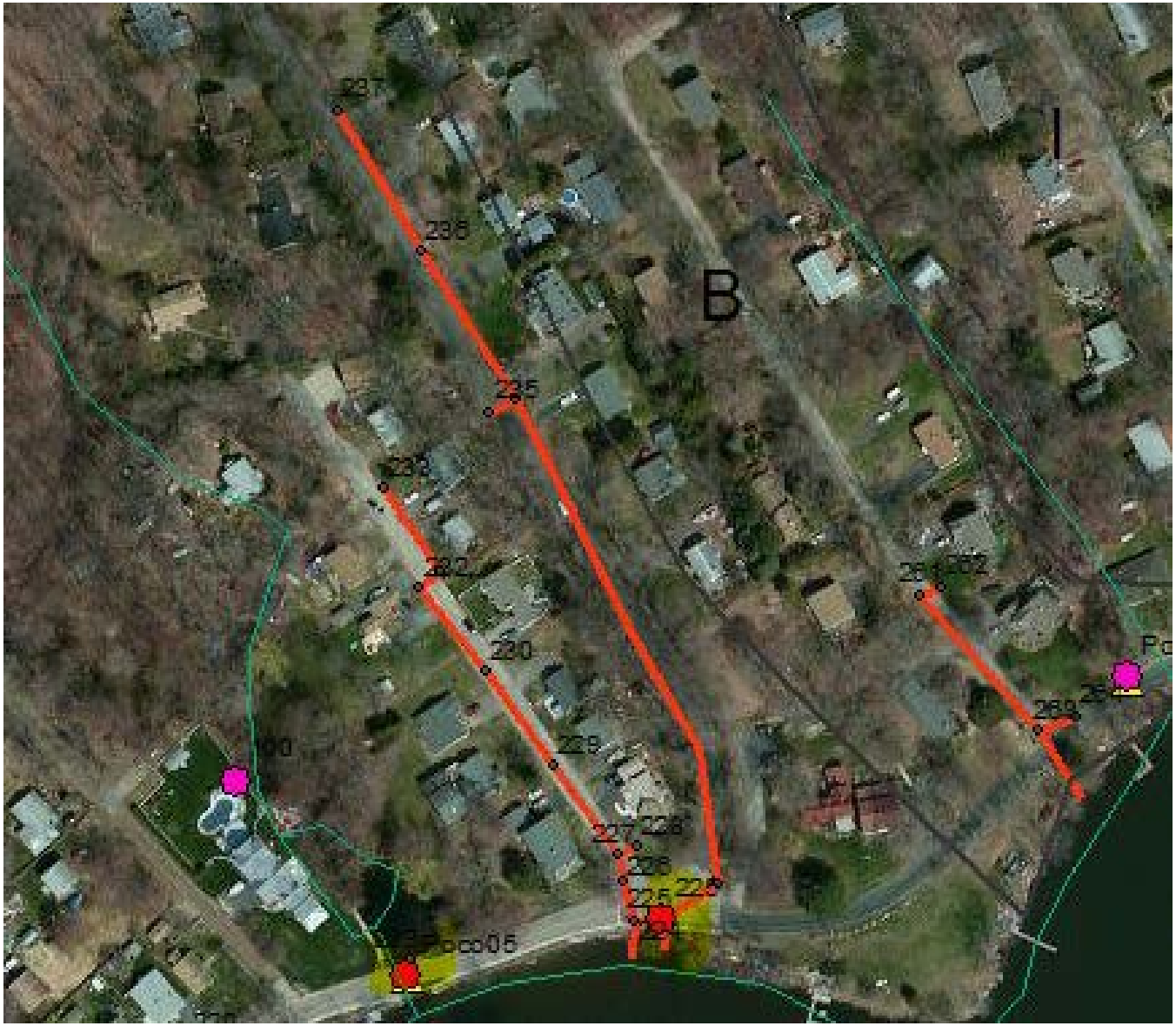
WPT 108: Culvert outlet of Clark Hill Rd. runoff is highly sedimented with several blue barrels

3/16/16

Sub-basin G – Algae observed in stream through woods and residential dwellings

WPT207 – filamentous algae indicates elevated nutrients in stream, flow from back portion of Skyline Estates

Sub-basin H – Hales Brook



Hales Brk has relatively low TP, but private pond is at lake level and often floods

WPT100 – flow measurements, before pond sampling

Sub-basin: H - Filled Catch basin on Lakewood Rd.

2/2/2016

WPT212: bottom of hill

Runoff can be reduced via installation of roadside swales

Sub-basin H – Mott Hill Rd

Mott Hill used to have high runoff but reduced with new curbing / breaks to allow periodic roadside infiltration

WPT225 very high TP from Mott Hill and Hale Road

Sub-basin H – Hales Brook Outlet Pool

5/13/2016
Poco 5

Sub-basin I / B – good infiltration from Seven Hills development

WPT249 routes road runoff to highlighted detention basin

WPT247 – highlighted roadside infiltration LID reduces water volume at WPT255 to Lake

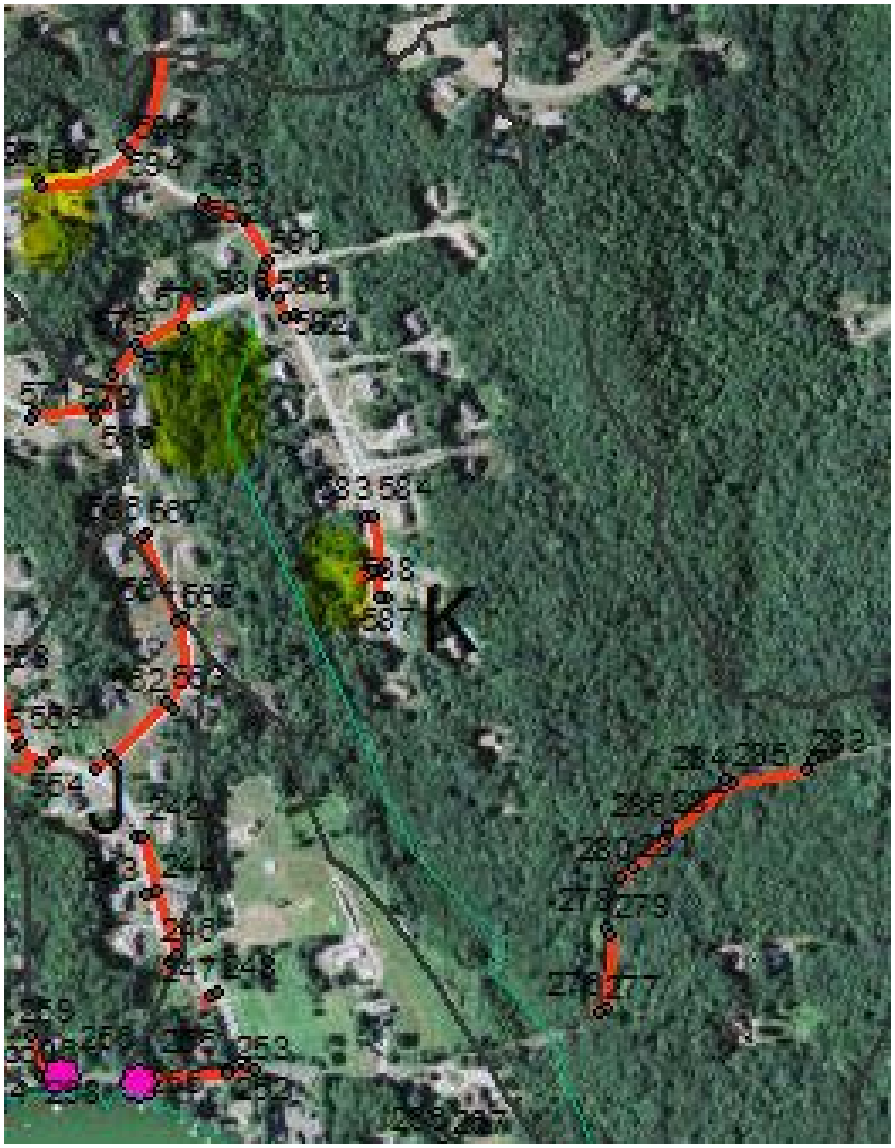
Sub-basin I – Well vegetated stormwater retention basin in Seven Hills Development

WPT 553 & 554: Stormdrain technology needs to be maintained

Sub-basins I, J, K – Lawns in the Seven Hills Development

No fertilizers should be used in the watershed.

Sub-basin K – Seven Hills development



Moderate to High TP & TN at Fawn Brook from Seven Hills development and private property (potential agricultural/ logging activities)

Large variability in flow and nutrient concentrations may indicate deficient nutrient retention in development stormwater ponds – inspect LID practices on private property

Sub-basin K – Well vegetated stormwater retention basins in Seven Hills

WPT 576: Periodically inspect to ensure proper functioning

Sub-basin M – Unknown private property, water source to Paul and Sandy's detention basin

Sub-basin M – Erosion from road runoff forming a second O'Neil's Brook on Old Marlborough Rd.

NEAR POCO_9: roadside infiltration swale needed to route water off road

Sub-basin M – Brook abutting Paul and Sandy's mulch and gravel parking lot

WPT431, 2/25/2016

Sub-basin M - Lake Vista Stormwater retention pond

2/25/2016

Drains to Paul and Sandy's Retention Pond into O'Neil's Brook

WPT420: High TP, Moderate-High dissolved P – needs LID improvements / maintenance

Sub-basin M –Groundwater seep into catch basin at upper Lake Vista

Community well (water treatment building to right) may be treated with phosphorus

Inspect water source and if LID infiltration area would be an adequate replacement for this catch basin

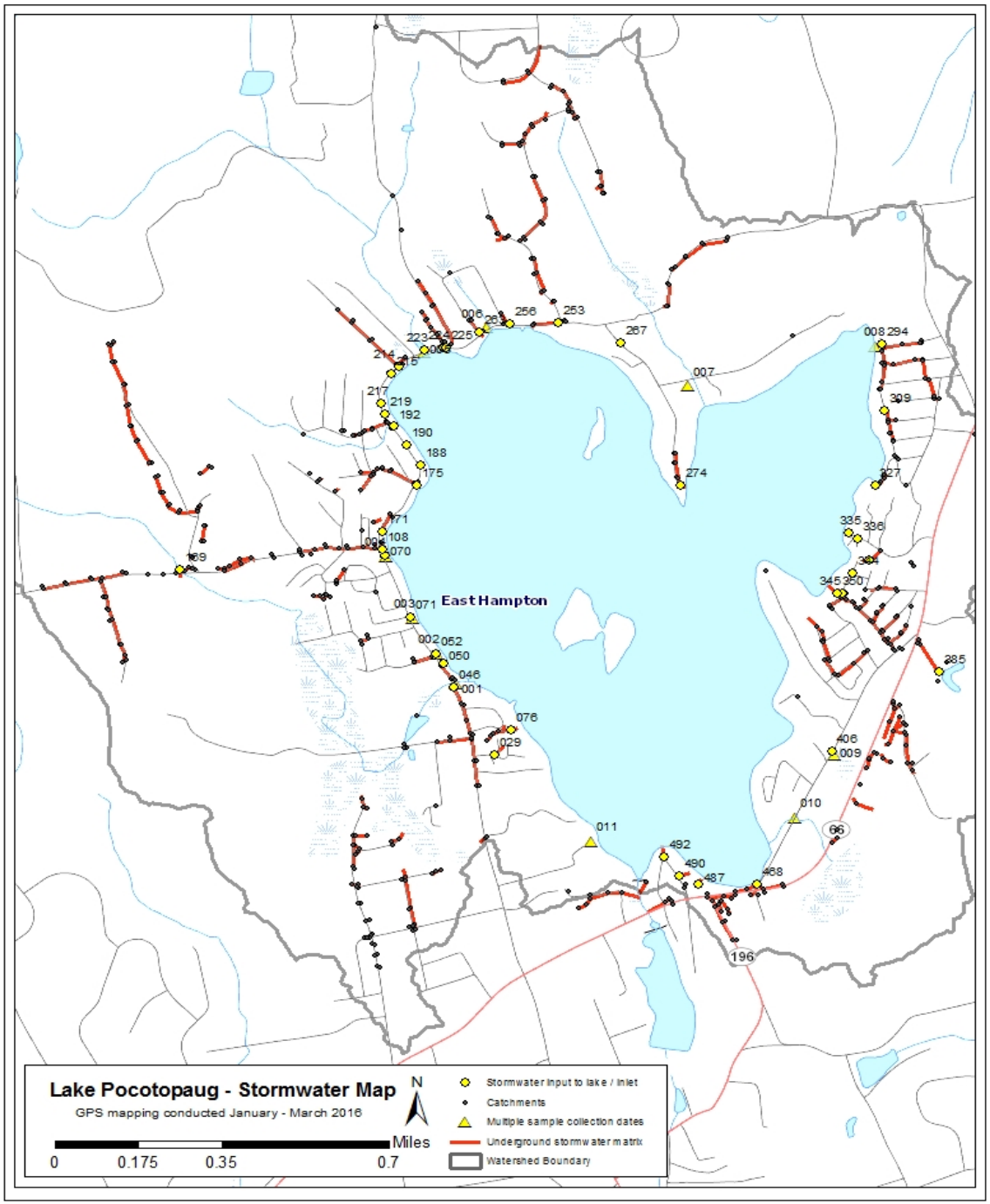
Sub-basin N – Much exposed land, variable nutrient loading to Days Brook

Private property has large area of open sediment with no silt fences

Stormdrain flow direction appears to be under road, through wetlands to Day's Brook – variable TP. Newly constructed roadside riprap traps sediment at Poco10

Encourage further LID on private property

Twin Islands – inspect/monitor wastewater treatment system

Private summer rental properties with central onsite sewage treatment system – unknown capacity and condition

Watershed map showing location of referenced GPS waypoints and lines of piped stormwater conveyance