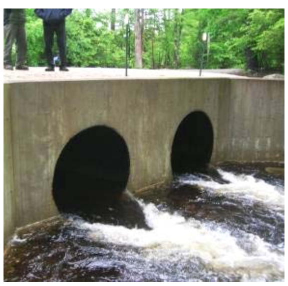
PAWTUCKAWAY LAKE WATERSHED BASED PLAN

MAY 2008



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1. INTRODUCTION

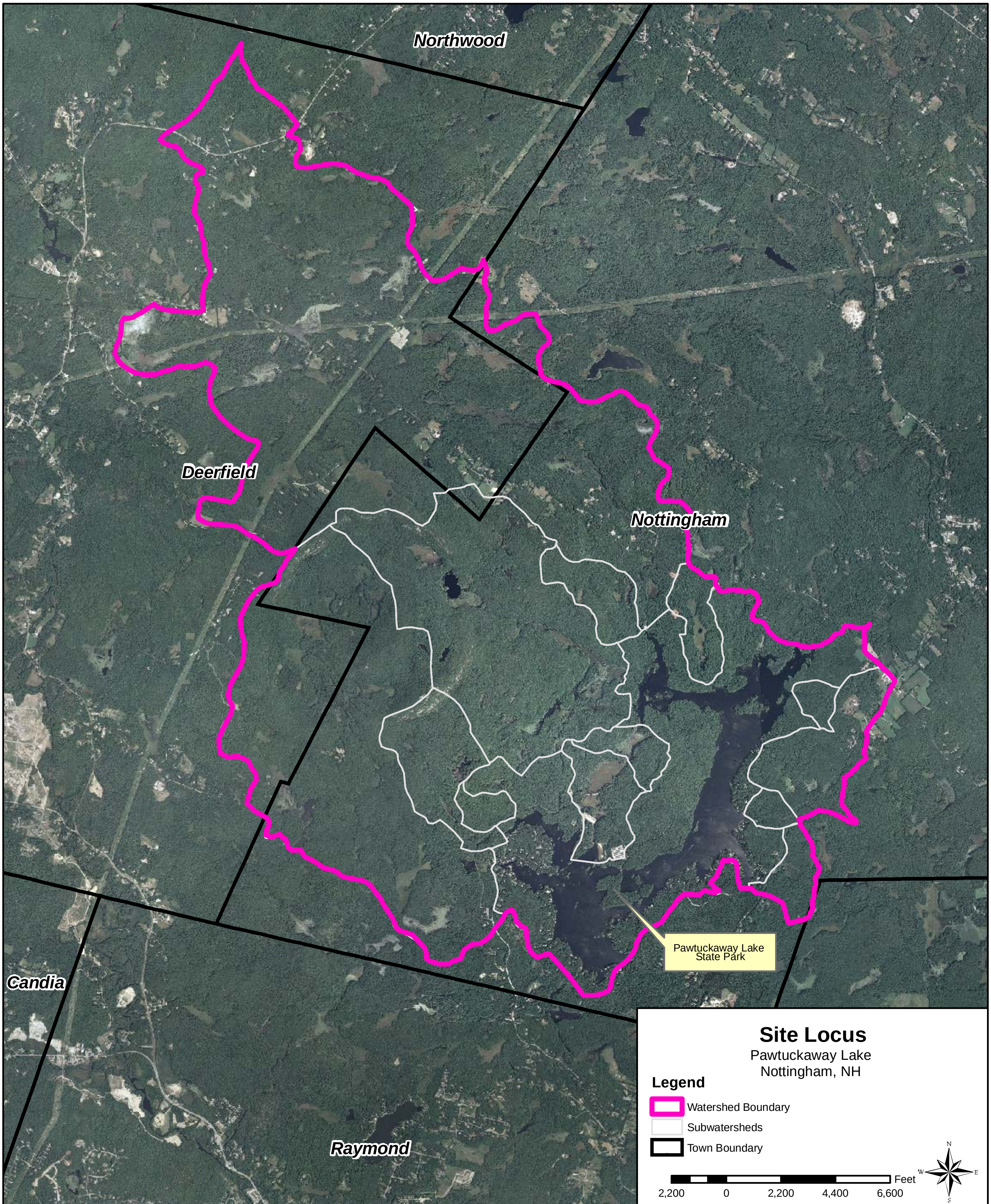
Geosyntec Consultants, Inc. (Geosyntec) was contracted by the New Hampshire Department of Environmental Services (NHDES) to develop a Watershed Based Plan (WBP) for Pawtuckaway Lake (1,180 acres), located in Nottingham, NH. The lake has an 18.5 square mile watershed, including Pawtuckaway Lake State Park and an estimated 309 year-round and seasonal homes located around the lake's perimeter.

Pawtuckaway Lake has experienced declines in water quality in recent years, as indicated by increasing in-lake phosphorus concentrations and increasing occurrences of nuisance blue-green algae blooms. In freshwater lakes, phosphorus is usually the most important nutrient determining the growth of algae and aquatic plants. Because phosphorus is typically relatively less abundant than nitrogen, it is considered the "limiting nutrient" for biological productivity. As such, increases in phosphorus levels tend to be strongly correlated with decreased water clarity, increased algal abundance and other indicators of declining water quality. The primary purposes of this WBP are:

1. to identify and quantify specific sources of phosphorus contributing to the lake's water quality impairments; and
2. to develop a management plan to reduce phosphorus loading to the lake to a targeted level that would significantly improve in-lake conditions.

To achieve the goals listed above, this WBP includes the following elements, in conformance with the U.S. Environmental Protection Agency's guidance for watershed based plans:

a. Identify Pollutant Sources (Section 2)
b. Pollutant Load Reduction Estimates (Section 3)
c. Describe Nonpoint Source Pollution Management Measures (Section 4)
d. Estimate Technical and Financial Assistance (Section 5)
e. Public Information and Education (Section 6 and Appendix A)
f. Implementation Schedule (Section 7)
g. Interim Milestones (Section 7)
h. Evaluation Criteria (Section 8)
i. Monitoring (Section 8)



Geosyntec consultants

ACTON, MASSACHUSETTS

FIGURE NO. 1

PROJECT NO. BW0085

DATE: 02/08/08

Pawtuckaway_Aerial.mxd

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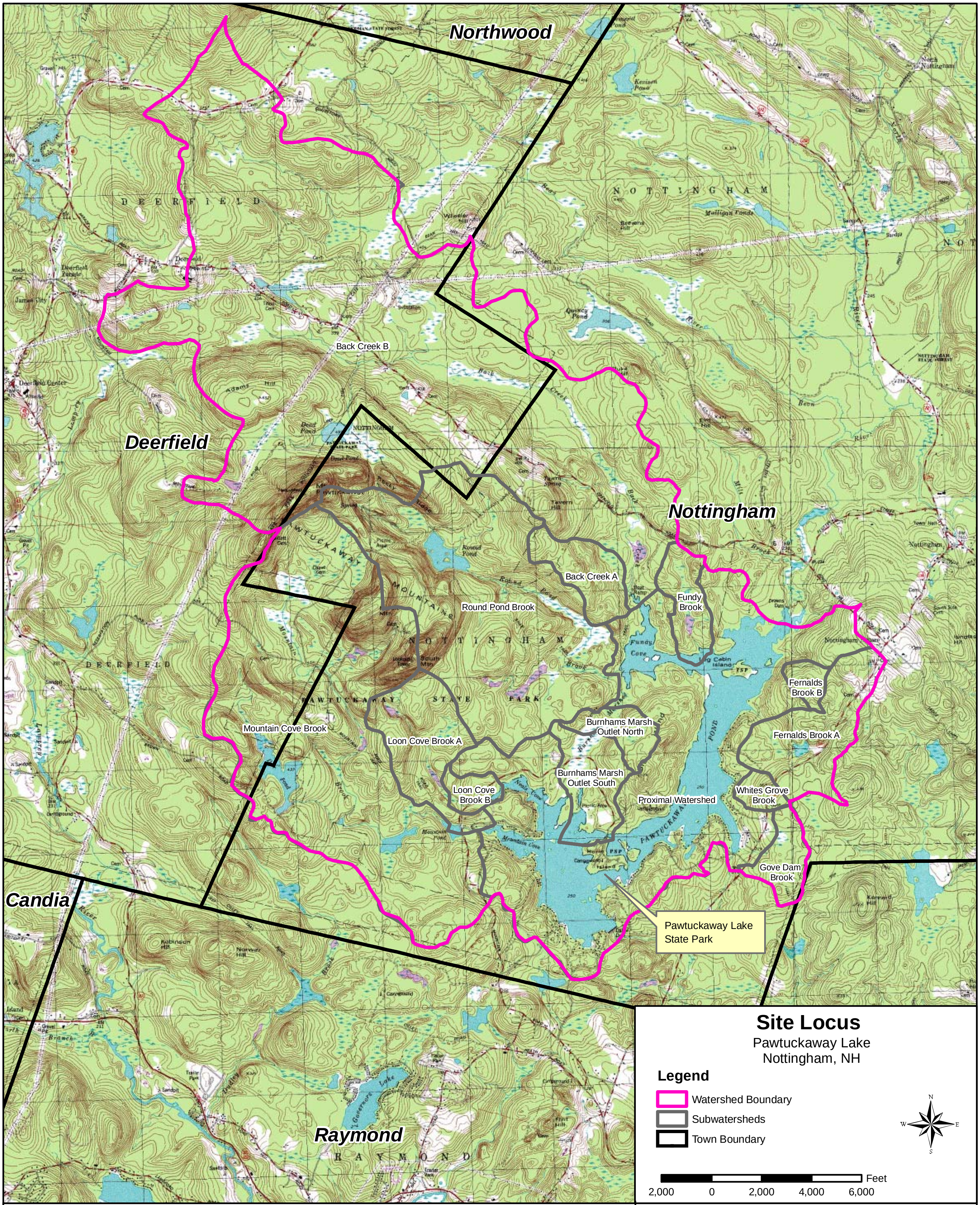

Site Locus

Pawtuckaway Lake
Nottingham, NH

Legend

- Watershed Boundary
- Subwatersheds
- Town Boundary

Feet: 2,000 0 2,000 4,000 6,000

Geosyntec consultants

ACTON, MASSACHUSETTS

FIGURE NO. 2	
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2. SUMMARY OF EXISTING WATER QUALITY CONDITIONS

2.1 Summary of Existing Water Quality Reports

The following is a brief summary of findings from two existing reports that address water quality conditions in Pawtuckaway Lake and its tributaries. A summary of in-lake total phosphorus data from these reports is presented in Section 2.1.1.

- New Hampshire Department of Environmental Services (NHDES), Pawtuckaway Lake Diagnostic/Feasibility Study, Final Report, June 1995.
    - The purpose of the diagnostic study was to determine sources of phosphorous and identify the paths entering Pawtuckaway Lake.
    - The purpose of the feasibility study was to assess watershed BMPs that could decrease the phosphorous loading into the lake and any possible lake restoration techniques that could be implemented to mitigate degraded lake quality.
    - The study identified Pawtuckaway Lake as a typical dimictic lake exhibiting thermal stratification into three layers during the summer months and mixing completely during the spring and fall overturns each year. The study also identified that during the summer months, the hypolimnion exhibited anoxic or very low dissolved oxygen conditions. Total phosphorus concentrations were elevated in the hypolimnion and increased as the summer progressed, indicating internal phosphorus loading occurs in the lake.
    - Trophic state models concluded that Pawtuckaway Lake could be classified as being in the oligotrophic/mesotrophic state.
    - Water quality sampling concluded that the hypolimnion in the north portion of the lake exhibited the highest in-lake total phosphorous concentrations.
    - The study identified that tributaries contribute the greatest inflow to the lake and represent 74.5% of the contributions to Pawtuckaway Lake's hydrologic budget.
    - This study determined that tributaries were the largest contributor of phosphorous loading representing 45% of the total phosphorus load to the lake. The primary tributaries that contribute the majority of this load are Back Creek B representing 33%, Mountain Cove Brook representing 24%, and Round Pond Brook representing 16% of the total phosphorous loading from tributaries. The study indicated that Fernalds Brook A is not a significant source of the hydrologic budget to the lake, however, represents 11% of the phosphorus loading from tributaries.
    - Maximum seasonal tributary phosphorus concentrations were recorded in Fernalds Brook A during the winter, spring, summer and fall.
    - The amount of phosphorous loading estimated from septic systems located adjacent to the lake was determined through concentrations measured in the groundwater phosphorous. The study concluded that 48% of the septic systems surrounding Pawtuckaway Lake require repair and may be a contributor to phosphorus loading to the lake.
    - The study identified that other sources of phosphorous to the lake include direct surface runoff from areas immediately adjacent to the lake (21%), septic system leachate/groundwater recharge (20%), and atmospheric inputs (i.e., wind transport and deposition) representing 14% of the total external phosphorus load.

- New Hampshire Department of Environmental Services, Volunteer Lake Assessment Program (VLAP), 2003 Biennial Report for Pawtuckaway Lake, Nottingham.
    - The most critical factor in measuring the water quality of New Hampshire lakes is the amount of phosphorous in the water.
    - Decreasing the amount of phosphorous in a lake will also decrease the alga that naturally grows in the lake.
    - When in-lake phosphorous levels increase, the possibility of algal blooms and nuisance levels of aquatic plant growth also increases.
    - Some possible sources of phosphorous near a lake include septic systems, waste from animals, run-off from lawns around the lake (especially when fertilizers are used), erosion from unpaved roads, construction site runoff and natural wetlands.
    - Increased phosphorous levels in a lake may also be caused by a release of insoluble phosphorus to the water column from lake bed sediments during very low in-lake dissolved oxygen levels (i.e., anoxic conditions).
    - Volunteer Lake Assessment Program recommended that one of the keys to reducing the amount of phosphorous loading to a lake is to educate the residents of the watershed about the sources of phosphorous and that increasingly the amount of phosphorus in a lake can result in negative ecological effects and reduce the value of the lake and adjacent properties.

2.1.1 Phosphorus Concentrations in Pawtuckaway Lake

Eutrophication is the gradual process of nutrient enrichment in aquatic ecosystems such as lakes. Eutrophication occurs naturally as lakes become more biologically productive over geological time, but this process may be accelerated by human activities that occur in the watershed. Nutrients that contribute to eutrophication can come from many natural and anthropogenic sources, such as fertilizers applied to residential lawns and agricultural fields; septic systems; deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges. Land development not only increases the sources of nutrients, but also decreases opportunities for natural attenuation (e.g. uptake by vegetation) of such nutrients before they can reach a water body.

Nutrients such as phosphorus and nitrogen can stimulate abundant growth of algae and rooted plants in water bodies. Over time, this enhanced plant growth leads to reduced dissolved oxygen in the water, as dead plant material decomposes and consumes oxygen. Phosphorus is typically the “limiting nutrient” for freshwater lakes, which means that plant productivity is most often controlled by the supply of this nutrient. As such, increases in phosphorus load in a lake watershed are closely correlated with increases in plant productivity and accelerated eutrophication.

Surface water bodies are typically categorized according to trophic state as follows:

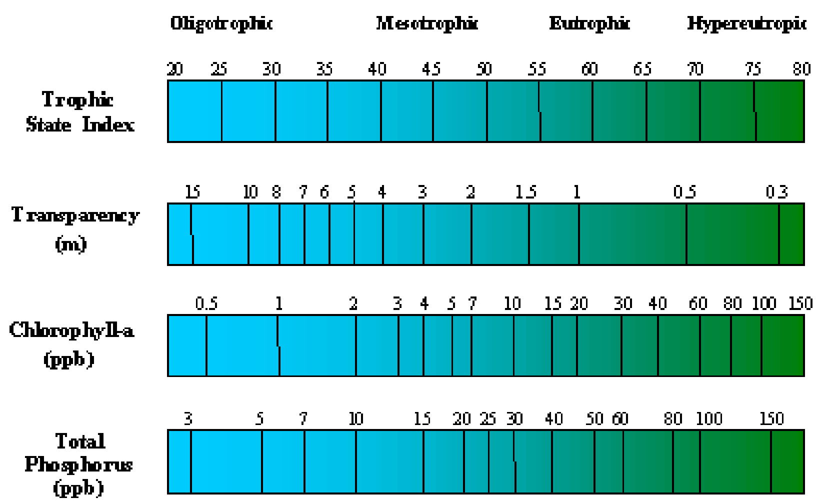
Oligotrophic: Low biological productivity. Oligotrophic lakes are very low in nutrients and algae, and typically have high water clarity and a nutrient-poor inorganic substrate. Oligotrophic water bodies are capable of producing and supporting relatively small populations of living organisms (plants, fish, and wildlife). If the water body is stratified, hypolimnetic oxygen is usually abundant.

Mesotrophic: Moderate biological productivity and moderate water clarity. A mesotrophic water body is capable of producing and supporting moderate populations of living organisms (plant, fish, and wildlife).

Eutrophic: High biologically productivity due to relatively high rates of nutrient input and nutrient-rich organic sediments. Eutrophic lakes typically exhibit periods of oxygen deficiency and reduced water clarity. Nuisance levels of macrophytes and algae may result in recreational impairments.

Hypereutrophic: Dense growth of algae throughout the summer. Dense macrophyte beds, but extent of growth is light-limited due to dense algae and associated low water clarity. Summer fish kills are possible.

Figure 3: Carlson Trophic State Index
(Figure from 1988 Lake and Reservoir Restoration Guidance Manual. USEPA. EPA 440/5-88-002.)



The Carlson Trophic State Index (TSI) is one of the most commonly used means of characterizing a lake's trophic state. As illustrated in the Figure 3 below, the TSI assigns values based upon formulas which describe the relationship between three parameters (total phosphorus, chlorophyll-a, and Secchi disk clarity) and the lake's overall biological productivity. As shown in the figure below, TSI scores below 40 are considered oligotrophic, scores between 40 and 50 are mesotrophic, scores between 50 and 70 are eutrophic, and scores from 70 to 100 are hypereutrophic.

The NH DES categorizes lakes into trophic state according to total phosphorus concentration, as follows:

Total Phosphorus Concentration (ug/L)	Trophic Status
<10	Oligotrophic
10-20	Mesotrophic
>20	Eutrophic

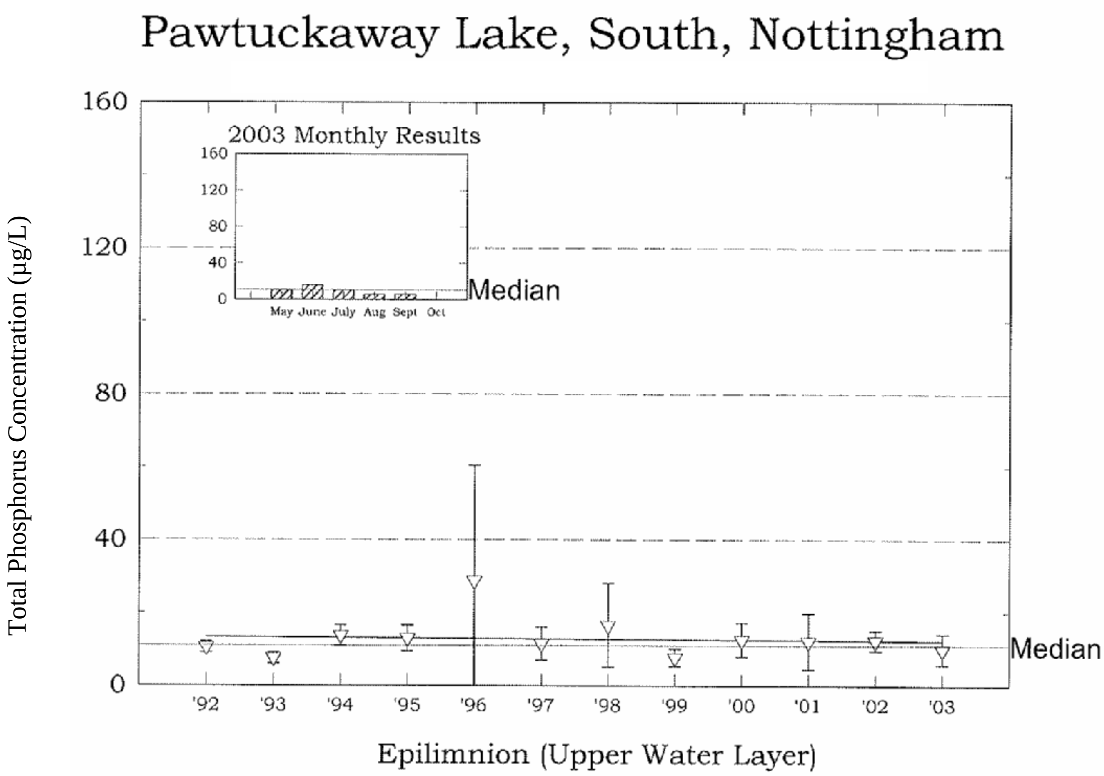
The NHDES 1995 Pawtuckaway Lake Diagnostic Feasibility Study reported the following information related to total phosphorus concentrations in Pawtuckaway Lake:

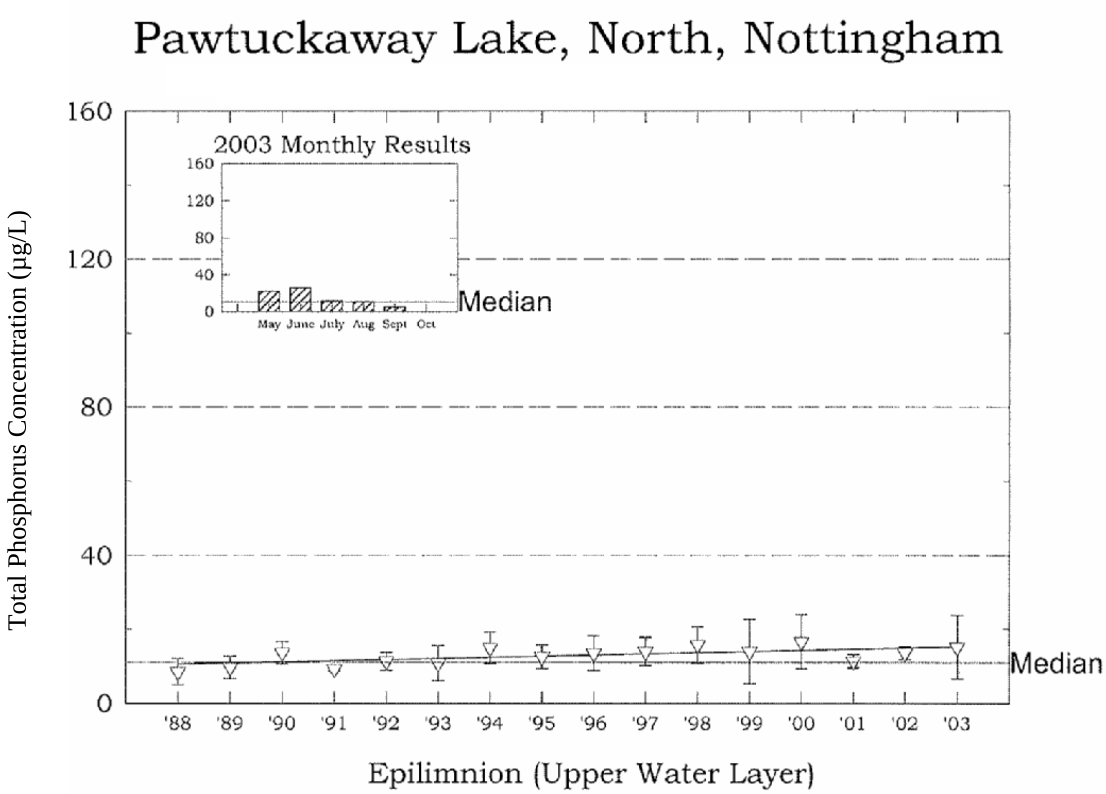
- Mean total phosphorus (TP) concentrations for Pawtuckaway Lake-North Station ranged from 11.5 µg/L in the epilimnion during the summer to 18.6 µg/L in the upper layer during the winter.
- Mean TP concentrations for Pawtuckaway Lake-South Station ranged from 8.3 µg/L in the lower layer during the fall to 16.0 µg/L in the lower layer during the summer.
- Overall, mean epilimnetic TP concentrations at both the North and South Stations were slightly higher than the New Hampshire median of 11.0 µg/L.

The NH-VLAP 2003 Biennial Report for Pawtuckaway Lake reported the following information related to total phosphorus concentrations in Pawtuckaway Lake:

- Historical TP concentrations in the epilimnion (upper water layer) of Pawtuckaway Lake are presented in Figure 2 on the following page.
- The 2003 mean epilimnetic TP concentration at North Station was slightly above the New Hampshire median of 11.0 µg/L. South Station was approximately equal to the state median.
- During the VLAP sampling period of 1988 to 2003, epilimnetic phosphorus concentrations at the North Station increased by an average of 2.7 percent per season. Hypolimnetic (deep water) TP concentrations at North Station increased by an average of 8 percent per season during the same period.
- During the VLAP sampling period of 1988 to 2003, the epilimnetic and hypolimnetic TP concentrations at the South Station have not changed significantly.

Figure 4: Historic Total Phosphorus Concentrations in the Epilimnion of Pawtuckaway Lake
(Figure from NH-VLAP 2003 Biennial Report for Pawtuckaway Lake)





3. ESTIMATES OF ANNUAL PHOSPHORUS LOADS TO PAWTUCKAWAY LAKE AND RECOMMENDED GOALS FOR IMPROVEMENT

3.1 Land-Use Based Pollutant Modeling

Geosyntec conducted land-use based modeling to estimate annual phosphorus export from fifteen subwatersheds within the Pawtuckaway Lake watershed. The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) land-use data was used to represent the current Watershed's land-use condition. C-CAP data was the most recently published land-use data available for public use. Land-use pollutant export coefficients (represented in lbs/acre-yr) were derived from New Hampshire GIS data (GRANIT) information.

Table 1: Phosphorus Export Coefficients by Land Use Category

C-CAP Land Use Code	C-CAP Land Use Category	Phosphorus Export Coefficient (lbs/ac-yr)
2	High-Intensity Developed	0.446
3	Low-Intensity Developed	0.446
4	Cultivated Land	0.535
5	Grassland	0.535
6	Deciduous Forest	0.178
7	Evergreen Forest	0.178
9	Scrub/Shrub	0.178
10	Palustrine Forested Wetland	0.045
11	Palustrine Scrub/Shrub Wetland	0.045
12	Palustrine Emergent Wetland	0.045
13	Estuarine Forested Wetland	0.045
14	Estuarine Scrub/Shrub Wetland	0.045
15	Estuarine Emergent Wetland	0.045
17	Bare Land	0.446
18	Water	0.000
19	Palustrine Aquatic Bed	0.000
20	Estuarine Aquatic Bed	0.000
21	Tundra	0.000

Land use based exports are an average measure of pollutant export and are typically reported for specific land use categories. These data were used in a land-use based pollutant model to predict annual phosphorus loading from the Watershed. The area of each land cover type is shown below in Table 2. A table summarizing the results of the land-use loading model is provided in Table 3.

Table 2: Subwatershed Land Cover Areas (all values in acres)

	Proximal Watershed	Burnhams Marsh Outlet South	Loon Cove Brook B	Burnhams Marsh Outlet North	Fundy Brook	Fernalds Brook B	Grove Dam Brook	Mountain Cove Brook	Back Creek B	Whites Grove Brook	Round Pond Brook	Fernalds Brook A	Loon Cove Brook A	Back Creek A
High-Intensity Development	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
Low-Intensity Developed	0.3	6.2	0.0	0.0	0.0	0.0	0.0	1.1	6.1	0.0	0.0	0.8	0.0	0.0
Cultivated Land	5.9	1.1	0.0	0.0	0.0	0.0	0.1	2.4	21.2	0.0	0.0	1.5	0.1	0.0
Grassland	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0
Deciduous Forest	3.6	0.0	0.0	0.0	0.0	0.0	0.0	2.0	26.7	0.0	0.0	2.1	0.0	0.0
Evergreen Forest	8.2	2.2	0.0	0.7	0.4	0.0	1.2	6.0	260.9	0.0	15.6	37.9	1.4	0.4
Mixed Forest	1.8	0.0	0.0	0.0	0.4	0.0	0.0	1.8	20.2	0.0	0.4	0.7	117.1	0.4
Scrub/Shrub	299.5	7.2	7.4	10.8	19.1	8.2	20.3	429.6	656.9	13.2	413.9	62.5	126.3	71.9
Palustrine Forested Wetland	651.5	98.8	28.5	44.8	66.3	13.1	29.4	852.3	1325.3	7.9	476.1	97.1	95.8	36.0
Palustrine Scrub/Shrub Wetland	575.3	98.2	33.1	45.0	63.7	33.4	73.2	878.0	2401.3	32.7	657.3	160.3	6.2	77.0
Palustrine Emergent Wetland	50.4	7.7	0.0	5.8	4.0	0.0	2.1	99.1	249.5	0.0	51.5	10.7	4.5	2.1
Bare Land	1.0	0.7	0.0	0.9	0.0	0.0	0.2	0.4	3.8	0.0	0.0	0.2	0.0	0.0
Water	0.9	0.4	0.0	0.4	0.0	0.0	0.4	3.3	17.6	0.0	2.9	1.6	3.3	0.0
Palustrine Aquatic Bed	753.6	10.4	0.0	3.9	1.1	0.0	0.0	25.7	41.6	0.0	22.4	1.1	0.0	0.0

Table 3: Subwatershed Pollutant Loading Summary

Subwatershed	Area (acres)	Estimated Annual Phosphorus Load (lbs/yr)		Estimated Annual Phosphorus Load (kg/yr)		% of Total Phosphorus Load
		Total	Per Acre	Total	Per ha	
Back Creek A	188	18	0.10	8	0.11	2%
Loon Cove Brook A	355	32	0.09	14	0.10	3%
Round Pond Brook	1640	130	0.08	59	0.09	14%
Fernalds Brook A	376	32	0.08	14	0.09	3%
Whites Grove Brook	54	4	0.08	2	0.09	1%
Back Creek B	5033	366	0.07	166	0.08	40%
Mountain Cove Brook	2302	162	0.07	74	0.08	18%
Gove Dam Brook	127	9	0.07	4	0.08	1%
Burnham's Marsh Outlet South	233	15	0.06	7	0.07	2%
Fundy Brook	155	10	0.06	4	0.07	1%
Burnham's Marsh Outlet North	112	7	0.06	3	0.07	1%
Loon Cove Brook B	69	4	0.06	2	0.07	<1%
Fernalds Brook B	55	10	0.06	2	0.07	<1%
Proximal Watershed	2354	118	0.05	53	0.06	13%
Pawtuckaway Lake Watershed	13053	908	0.07	412	0.08	100%

The land-use based pollutant loading model provides a tool for estimating and comparing (1) total annual pollutant loads (in pounds per year and kilograms per year) and (2) annual pollutant load rates normalized to the watershed area (in pounds per acre per year and kilograms per hectare per year) for each subwatershed within the Watershed. This type of land-use model cannot be used to accurately predict in-lake conditions (e.g., in-lake total phosphorus concentrations) because it does not reflect site-specific land management practices or other variables such as internal nutrient recycling, lake volume, etc. However, the land-use pollutant loading model estimates do provide a useful comparative measure of the relative impact that each subwatershed has on lake water quality, and therefore are a useful tool to prioritize sites for watershed improvements.

A brief summary of the land-use pollutant loading model results for each of the subwatersheds is provided below:

Back Creek A: The 188 acre Back Creek A subwatershed is located to the north of Fundy Cove. The primary tributary, Back Creek, drains into Fundy Cove. The majority of the subwatershed does not border the Lake. The subwatershed is entirely comprised of wetland and forest. The predicted annual phosphorus load for the subwatershed is 0.10 lbs P/acre/year (0.11 kg P/ha/yr), the highest of all predicted loads. Because of the small subwatershed area, this accounts for only 2% of the Lake's total predicted phosphorus load.

Loon Cove Brook A: The Loon Cove Brook A subwatershed is located northwest of the Lake and drains into Neals Cove. This subwatershed comprises 3% of the Lake's entire watershed area and is primarily characterized as undeveloped scrub-shrub and wetland. The predicted annual phosphorus load for the subwatershed is 0.09 lbs P/acre/year (0.10 kg P/ha/yr), accounting for approximately 3% of the Lake's total predicted phosphorus load.

Round Pond Brook: The 1,640 acre Round Pond Brook subwatershed is the fourth largest subwatershed and is located to the north of the Lake in the center of the Watershed. The primary tributary, Round Pond Brook, drains into the west portion of Fundy Cove. However, the majority of the subwatershed does not border the Lake. The subwatershed is entirely characterized as undeveloped wetland and forest. The predicted annual phosphorus load for the subwatershed is 0.08 lbs P/acre/year (0.09 kg P/ha/yr) and represents 14% of the Lake's total predicted phosphorus load.

Fernalds Brook A: The Fernalds Brook A subwatershed is approximately 376 acres and is located to the east of the Lake. Although Fernalds Brook drains into the eastern portion of the Lake, most of the subwatershed does not border the Lake. The subwatershed is primarily characterized by undeveloped forest and wetland with less than 1% of the land-use area comprised of low-density development and cultivated land. The cultivated land area is a portion of Fernalds Farm. The predicted annual phosphorus load for the subwatershed is 0.08 lbs P/acre/year (0.09 kg P/ha/yr) and accounts for approximately 3% of the Lake's total predicted phosphorus load.

Whites Grove Brook: The 54-acre Whites Grove Brook subwatershed is one of the smallest subwatersheds and is located immediately adjacent to the south side of the Lake. The subwatershed is primarily characterized by undeveloped forest and wetland. The predicted annual phosphorus load for the subwatershed is 0.08 lbs P/acre/year (0.09 kg P/ha/yr). However, due to the small subwatershed area, it accounts for less than 1% of the Lake's total predicted phosphorus load.

Back Creek B: The 5,033 acre Back Creek B subwatershed is the largest subwatershed and represents the majority of the northern portion of the Watershed. Although Back Creek drains into Fundy Cove, the majority of the subwatershed does not border the Lake. The subwatershed is primarily characterized as undeveloped wetland and forest, with less than 1% of the land-use area comprised of low-density development and cultivated land. The predicted annual phosphorus load for the subwatershed is 0.07 lbs P/acre/year (0.08 kg P/ha/yr) and represents 40% of the Lake's total predicted phosphorus load.

Mountain Cove Brook: The Mountain Brook Cove subwatershed is the third largest subwatershed and is in the western portion of the Watershed. The subwatershed includes Deer Pond as well as several unnamed impounded areas. The primary tributary, Mountain Brook, drains into the west end of the Lake. The subwatershed is primarily characterized by undeveloped scrub-shrub and wetland with less than 1% being characterized as low-intensity developed land use. The predicted annual phosphorus load for the subwatershed is 0.07 lbs P/acre/year (0.08 kg P/ha/yr), accounting for approximately 18% of the Lake's total predicted phosphorus load.

Gove Dam Brook: The Gove Dam Brook subwatershed is approximately 127 acres in area and is located to the south of the Lake in the southernmost portion of the watershed. The primary tributary is Gove Brook which drains into the southern portion of the Lake. However, the majority of the subwatershed is not located adjacent to the Lake. The subwatershed is primarily characterized by undeveloped wetland. The predicted annual phosphorus load for the subwatershed is 0.07 lbs P/acre/year (0.08 kg P/ha/yr), accounting for approximately 1% of the Lake's total predicted phosphorus load.

Burnham's Marsh Outlet South: The Burnham's Marsh Outlet South subwatershed is located immediately adjacent to the north side of the Lake. The subwatershed includes the majority of Burnham's Marsh as well as portions of the State Park. It comprises 2% of the Lake's entire watershed area and is primarily characterized as undeveloped wetland with less than 1% of the area characterized as low-intensity developed land use. The predicted annual phosphorus load for the subwatershed is 0.06 lbs P/acre/year (0.07 kg P/ha/yr), accounting for approximately 2% of the Lake's total predicted phosphorus load.

Fundy Brook: The 155 acre Fundy Brook subwatershed is located to the east of Fundy Cove. The primary tributary, Fundy Brook, drains into the east portion of Fundy Cove. However, the majority of the subwatershed does not border the Lake. The subwatershed is entirely characterized as undeveloped wetland and forest. The predicted annual phosphorus load for the subwatershed is 0.06 lbs P/acre/year (0.07 kg P/ha/yr) and represents 1% of the Lake's total predicted phosphorus load.

Burnham's Marsh Outlet North: The 112 acre Burnham's Marsh Outlet North subwatershed is located to the north of the Lake immediately south of Fundy Cove. It comprises 1% of the Lake's entire watershed area and is entirely characterized as undeveloped forest and wetland. The predicted annual phosphorus load for the subwatershed is 0.06 lbs P/acre/year (0.07 kg P/ha/yr), accounting for approximately 1% of the Lake's total predicted phosphorus load.

Loon Cove Brook B: The Loon Cove Brook B subwatershed is located adjacent to the west end of the Lake. This subwatershed comprises 1% of the Lake's entire watershed area and is primarily characterized as undeveloped wetland. The predicted annual phosphorus load for the subwatershed is 0.06 lbs P/acre/year (0.07 kg P/ha/yr), accounting for less than 1% of the Lake's total predicted phosphorus load.

Fernalds Brook B: The Fernalds Brook B subwatershed is one of the smallest subwatersheds (55 acres) and is located adjacent to the east side of the Lake. Fernalds Brook drains into the eastern portion of the Lake. The subwatershed is entirely characterized by undeveloped forest and wetland. The predicted annual phosphorus load for the subwatershed is 0.06 lbs P/acre/year (0.07 kg P/ha/yr). Due to the subwatershed's small area, it accounts for less than 1% of the Lake's total predicted phosphorus load.

Proximal Subwatershed: The proximal subwatershed is the second largest subwatershed and includes the areas directly adjacent to the Lake, including the Tuckaway Shores beach, Nottingham town beach, portions of Pawtuckaway Lake State Park and the Lakeview Drive. The proximal watershed does not have a primary tributary and generally drains via overland flow or through storm water drainage systems directly into the Lake. The subwatershed is primarily characterized by undeveloped scrub-shrub and wetland with less than 1% being characterized as low-intensity developed land use. The predicted annual phosphorus load for the subwatershed is 0.05 lbs P/acre/year (0.06 kg P/ha/yr), the lowest predicted for the entire Watershed. However, because the proximal subwatershed is the largest subwatershed, the predicted pollutant load represents 13% of the Lake's total load.

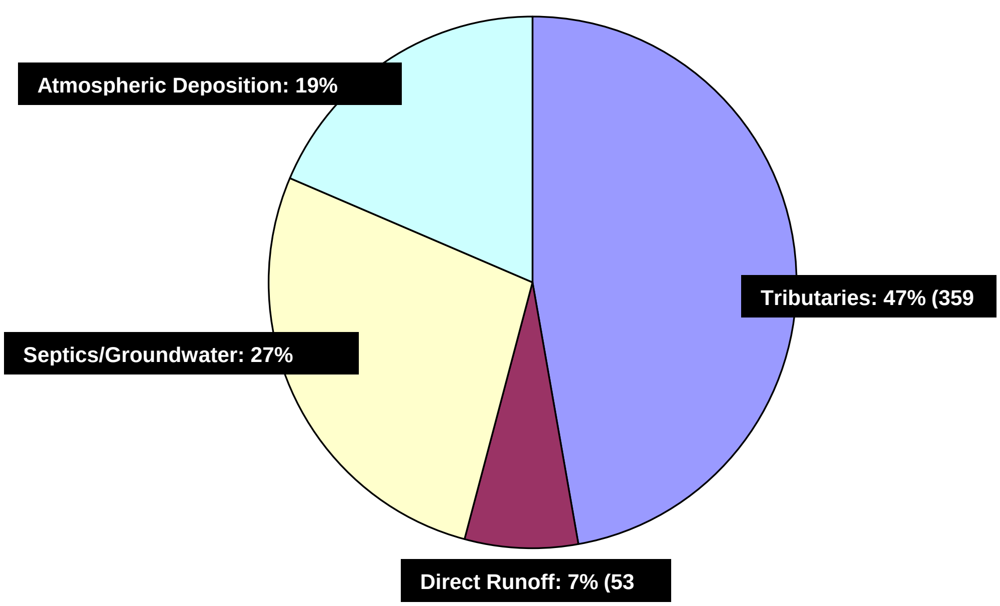
3.2 Estimated Annual Phosphorus Loading Budget

To estimate the Pawtuckaway Lake's annual external phosphorus loading budget, Geosyntec has combined estimates from the NHDES 1995 Diagnostic Feasibility Study for groundwater (including septic systems) and atmospheric sources of phosphorus with the watershed loading estimates derived from the land use pollutant loading model presented in Section 3.1 of this report.

The estimated annual external phosphorus budget of 761.3 kg/year is summarized below and presented in Figure 5. The estimated loads from this phosphorus budget are used in the Vollenwieder equation which predicts in-lake phosphorus concentrations in Section 3.3.

- The combined phosphorus load from all 13 flowing tributaries to Pawtuckaway Lake accounts for 47% (359 kg) of the annual external phosphorus load to the lake.
- Direct runoff is estimated to account for 7% (53 kg) of the lake's annual external phosphorus load. Direct runoff includes storm water runoff flowing directly to the lake via lawns, roadside drainage structures (e.g. catch basins, pipes), and intermittent channels that flow directly to the lake.
- Groundwater seepage, including phosphorus loading from septic systems, is estimated to account for 27% (207 kg) of the annual external phosphorus load. As discussed further in Section 3.3, Geosyntec has estimated an annual load specifically from septic systems of 164 kg/year.
- Atmospheric deposition, including wet and dry deposition, is estimated to account for 19% of the annual external phosphorus load (143 kg/year).

Figure 5: Estimated Annual External Phosphorus Loading to Pawtuckaway Lake



3.3 Vollenweider Equation Estimates of In-Lake Phosphorus Concentrations

The Vollenweider model is commonly used to predict in-lake phosphorus concentrations as a function of annual phosphorus loading, mean lake depth and hydraulic residence time. The Vollenweider model is based on a five year study of about 200 waterbodies in Europe, North America, Japan and Australia. The Vollenweider Equation is provided below, with calculations for Pawtuckaway Lake based on phosphorus loading data from the NHDES 1995 Pawtuckaway Lake Diagnostic Feasibility Study and the land use pollutant loading model presented in Section 3.1. For this calculation, the NHDES 1995 study estimates of phosphorus loading from septics/groundwater (206.6 kg/year) and atmospheric deposition (142.6) have been added to the predicted watershed load (including tributaries and direct runoff) from the land use pollutant loading model (412 kg/year), resulting in a total predicted phosphorus load of 761.3 kg/year.

Vollenweider Equation:

$P = (Lp/qs) \times (1/(1+\sqrt{z/qs}))$;

Where:

P= mean in-lake phosphorus concentration (mg/L);

Lp=annual phosphorus load/lake area, (grams/m2/year);

z=mean depth (meters);

T=hydraulic residence time= lake volume/annual outflow volume

qs=mean depth /hydraulic residence time = z/T

Assuming:

Estimated P load is 761,300 grams/year and

Lake area is 4,775,291 m2, then 761,300 grams/4,775,291 m2 = 0.159 grams/m2/year;

z= 3.3 meters;

T= Lake volume= 15,812,628 m3 /annual outflow volume = 3,704,100 m3

= 15,812,628 m3/30,810,900 m3 = 0.51year;

qs= z/T = 3.3m /0.51yr = 6.471 m/yr

Thus:

In-lake P concentration = $(0.159 / 6.471) \times (1/1+ (\sqrt{3.3/6.471}))$ = 0.014 mg/L = 14.4 µg/L

Based on the predicted annual phosphorus load of 764.8 kg/year, the Vollenweider equation predicts an in-lake phosphorus concentration of 14.4 µg/L. This estimate is slightly higher than the observed historic mean epilimnetic total phosphorus concentrations for Pawtuckaway Lake (as reported from NHDES and VLAP data), which is slightly above the New Hampshire median of 11.0 µg/L.

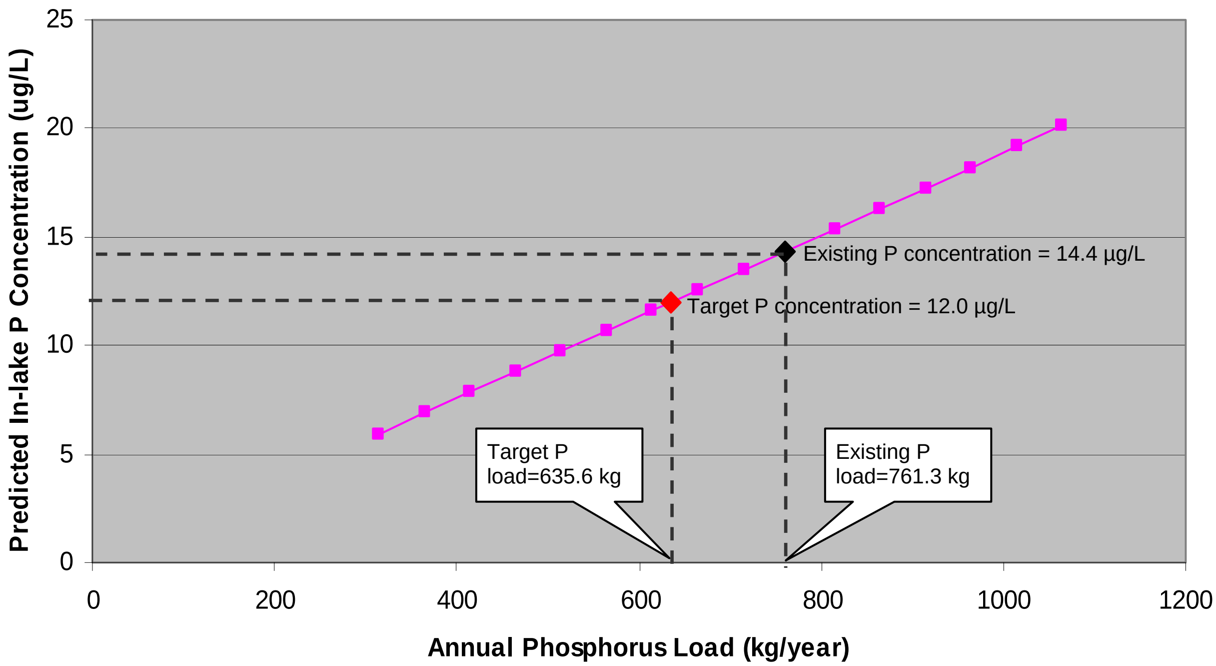
In assessing the result of the Vollenweider equation with regard to VLAP and NHDES monitoring data, it is important to note that the Vollenweider equation assumes that phosphorus concentrations are uniform throughout the lake. In thermally stratified lakes such as Pawtuckaway Lake, it is typical for summer phosphorus concentrations in the epilimnion to be lower than those found in the hypolimnion. The NHDES reports that the median summer total phosphorus concentration in the epilimnion of New Hampshire lakes and ponds is 11 µg/L, while the median hypolimnetic concentration is 14 µg/L. As such, it is reasonable that the Vollenweider equation would predict a lakewide phosphorus concentration that is somewhat higher than the levels observed in the epilimnion during summer.

3.4 Recommended Phosphorus Reduction Goal

To improve water quality conditions in Pawtuckaway Lake and reduce the occurrence of nuisance algal blooms, Geosyntec recommends targeting an in-lake total phosphorus concentration reduction of 2.4 µg/L, which would reduce the current predicted concentration from 14.4 µg/L to 12 µg/L. This reduction in in-lake phosphorus concentration would improve the lake to low mesotrophic status and could significantly improve in-lake conditions with regard to water quality indicators such as water clarity and algal abundance.

As shown in Figure 6, the Vollenweider equation predicts that the lake's phosphorus load would need to be reduced by 125.7 kg/year in order to achieve the recommended in-lake phosphorus concentration reduction of 2.4 µg/L. This recommended load reduction represents 16.5% of the lake's total annual phosphorus budget and approximately 20.3 % of the combined predicted load from watershed (tributaries and direct runoff) and groundwater (including septic systems) sources. Section 4 provides a discussion of how the recommended phosphorus load reduction may be achieved.

Figure 6: Predicted In-Lake Phosphorus Concentration (µg/L) vs. Annual Phosphorus Load from External Watershed



4. OPTIONS FOR REDUCING PHOSPHORUS LOADING TO PAWTUCKAWAY LAKE

This section presents a discussion of potential measures that could be implemented in the Pawtuckaway Lake watershed to reduce phosphorus loading to the Lake. As presented in the phosphorus loading budget in Section 3.2, external sources of phosphorus loading to Pawtuckaway Lake include flowing tributaries, direct runoff, groundwater sources (including septic systems), and atmospheric deposition (including wetfall and dryfall). This section provides a discussion of potential phosphorus reduction measures that relate to storm water management, septic systems, and watershed land uses. Table 5 (pp. 38-39) provides an overview and prioritization of all proposed measures to reduce phosphorus loading that are presented in Section 4.

4.1 Storm Water Management

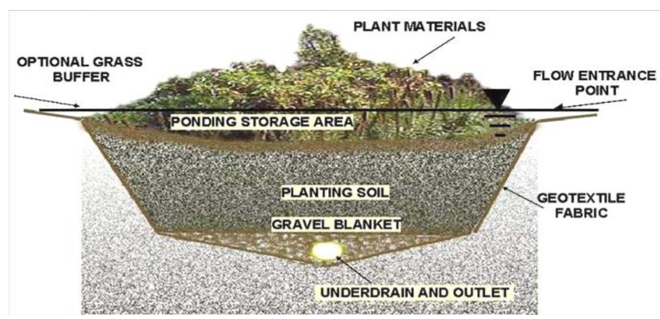
4.1.1 Description of Selected Storm Water Best Management Practices

Storm water best management practices (BMPs), including Low-Impact Development (LID) techniques, are management approaches that reduce storm water impacts through a variety of small-scale techniques that are distributed throughout a watershed. LID techniques aim to mimic pre-development hydrology by using small-scale practices that infiltrate, evaporate and transpire storm water. Examples of LID techniques include bioretention cells, rain gardens, and vegetated filter strips. These techniques can be incorporated directly into the design of new developments, or can be retrofit into existing developed areas, often replacing or enhancing direct pipe discharges to water bodies such as Pawtuckaway Lake. Examples of other storm water management BMPs include unpaved road management and stabilization techniques.

The sections below provide a general description of storm water BMPs and LID improvements that are recommended for use at specific sites within the watershed as described in Section 4.1.2.

Bioretention Cells/Rain Gardens

Bioretention cells are shallow landscaped depressions that incorporate plantings and an engineered soil mixture with a high infiltration rate. Bioretention cells are used to: control storm water runoff volume by providing storage capacity; reduce peak discharge by increasing the travel time of storm water through a watershed; and remove pollutants through physical, chemical and biological processes that occur in the plants and soil media.



A cross-section of a typical bioretention cell.

Storm water that drains into a bioretention cell accumulates in a shallow depression and infiltrates the engineered soil mixture. Bioretention cells are typically designed to provide an infiltration rate approximately equal to the peak discharge rate associated with the 10-year, 24-hour storm event. Infiltration rates are enhanced during the growing season by uptake from vegetation (i.e., evapotranspiration) within the cell.

A rain garden installed on a residential property.

Installed costs for engineering, materials and construction of a typical bioretention cell are estimated between $3,000 (for a small individual shallow cell) up to $30,000 (for a large retrofit cell that involves significant earth work). The installed costs also depend on site-specific requirements. Pre-fabricated bioretention cells (e.g., Filterra™) can treat storm water runoff from an area up to 0.25-acres and cost approximately $7,000 each (installed cost).

Rain gardens are small-scale bioretention cells. Rain gardens are shallow vegetated depressions designed to capture and infiltrate storm water runoff. Rain gardens are often appropriate for residential developments, to treat storm water from impervious areas associated with individual lots. The total installed cost of a typical rain garden is approximately $1,500 to $4,000, depending on garden size, soil conditions, type of plantings used, and other site-specific requirements.

Unpaved Road Best Management Practices

Unpaved roads, if not properly managed, can be a significant contributor of non-point source pollution. Structural BMP techniques and preventative maintenance practices can reduce unpaved road erosion and improve downstream water quality while potentially reducing the cost of road maintenance. Storm water or surface water accumulated on or adjacent to unpaved roads can create an unstable road bed, resulting in rutting, potholes, shoulder erosion, washouts, and clogged culverts. Poor drainage can also result in sediment deposits at culverts and in ditches and cause flooding. In addition, erosion of unpaved roads can result in sediment loads to downstream receiving waters. Unpaved road BMPs and preventative maintenance practices include:

- **Surface Grading** is one of the most important aspects of maintaining a gravel road surface. Surface grading is conducted to preserve and maintain a proper road crown for good drainage. When grading, maintain a safe distance (minimum one foot) from the ditch so that vegetation or rock ditch stabilization is not disturbed.
- **Shoulder Maintenance** is an important unpaved road management practice to maintain proper drainage of storm water from the traveled portion of the road to the side slope and into ditches. The shoulder should help separate the traveled way from the side slopes and ditches. The shoulder should be kept clear of vegetation so that water can freely drain from traveled portions into adjacent ditches.
- **Storm Water Ditches** are used to convey storm water runoff from the shoulders to an outlet without causing erosion or sedimentation. Ditches should be properly lined (e.g., rock or vegetation) to prevent erosion. Regular maintenance should be performed to keep ditches clear and stable, and maintain the original capacity.
- **Culverts** are closed conduits (e.g., pipes) typically used to convey storm water across unpaved roads. Culverts are important in preserving the road base by draining water from road side ditches and thereby keeping the road sub-base dry. Culverts should be inspected on a regular basis. The inlets and outlets of culverts should be protected by marking their location, stabilizing, and maintaining ditch linings (both up gradient and down gradient of culverts) to prevent erosion and clogging.
- **Bank Stabilization** is the vegetative or structural means used to prevent erosion and failure of any side slope or bank. Unpaved road banks should be carefully evaluated before selecting stabilization techniques. Vegetation should be used whenever possible as a cost-effective way to stabilize banks. Additionally, recently stabilized banks should be regularly maintained and inspected to ensure that adequate stabilization is established.

Stone Infiltration Trenches

Infiltration trenches are typically deep stone filled trenches lined with a non-woven geotextile. The base of the trench can be stepped to maximize storage capacity and promote infiltration. Infiltration trenches are used to: control storm water runoff volume by providing storage capacity; promote infiltration; and remove sediment and associated pollutants through filtration. Storm water that drains to an infiltration trench either infiltrates the stone immediately or flows on the stone surface a short distance before infiltrating. Storm water then filters through the stone and percolates to the base. The storm water then infiltrates the existing subsurface and recharges the aquifer.

Infiltration trenches are typically designed to provide an infiltration rate approximately equal to the peak discharge rate associated with the 10-year, 24-hour design storm event. Infiltration trenches typically include a maintenance stone layer at the top of the trench that can be easily removed, cleaned and replaced.

The installed cost for engineering, materials and construction of a typical infiltration trench is estimated between $200 to $800 per linear foot of trench, depending on trench size, material and site-specific requirements.

A stone-filled infiltration trench constructed to intercept runoff from the adjacent unpaved road in the Silver Lake watershed (Harrisville, NH).

4.1.2 Field Watershed Investigation

Robert Hartzel (Senior Water Resources Scientist, Certified Lake Manager) and Daniel Bourdeau (Water Resource Engineer) of Geosyntec conducted a field watershed investigation on 8 June 2006. Mr. Hartzel and Mr. Bourdeau are both Certified Professionals in Sediment and Erosion Control (CPESC). A CPESC is a recognized specialist in soil erosion and sediment control, with certification by the Soil and Water Conservation Society and the International Erosion Control Association. Mr. Hartzel and Mr. Bourdeau were assisted in their field investigation by Tom Duffy and Therese Thompson of the Pawtuckaway Lake Improvement Association (PLIA).

The field investigation was conducted during a rain event that occurred on 7 and 8 June 2006 that resulted in a 24-hour accumulation of 1.3 and 0.2 inches of rain, respectively. During the field investigation, Geosyntec identified several sites that were potential sources of pollutants and potential sites for implementing storm water BMPs and LID improvements.

The following pages provide descriptions of the sites identified on the 8 June 2006 field investigation and recommended improvements. It is important to note that the sites discussed in this section are not intended to be a comprehensive listing of recommended stormwater improvements in the Pawtuckaway Lake watershed. Rather, these sites are representative examples of potential stormwater improvements and retrofits that could be implemented at numerous sites throughout the watershed.

SITE #1: #99 LAKEVIEW DRIVE

Site Summary:

Storm water run-off from the area of #99 Lakeview Drive collects in small topographical depressions in the gutter line of the unpaved road (Photo 1-1). The accumulated storm water drains into a drop inlet structure located adjacent to Lakeview Drive. Accumulated leaf litter was observed on the grate and sediment was observed in the sump of the drop inlet structure (Photo 1-2). The drop inlet structure apparently discharges via two 4-inch diameter PVC culverts directly into Neals Cove (Photo 1-3).

Photo # 1-1

Proposed Improvement:

A <u>bioretention cell</u> is recommended at this drop inlet structure to reduce pollutant discharges directly to Neals Cove. The retrofit may include:

- A trenched ring around the device that would be lined with stone overlain by a bioretention soil mixture with plantings. The cell would provide filtration and promote infiltration.
- In addition, improvements may include cleaning and increasing the structure's sump to provide additional sediment capture. Bioretention cells are described in Section 2.0.

Photo # 1-2

Estimated Cost: $3,000 to $4,000

Estimated Pollutant Load Reduction: 0.2 kg P/yr

Photo # 1-3

SITE #2: FERNALD'S CREEK CROSSING AT BARDERRY LANE

Site Summary:

Storm water runoff from Barderry Lane in the area of Fernalds Creek drains via a road side ditch (Photo 2-1) toward the Creek. The ditch drains from Barderry Lane into the area adjacent to Fernalds Creek, transporting sediment from the unpaved road surface to the Creek (Photo 2-2). Accumulated sediment was observed in this area adjacent to Fernalds Creek (Photo 2-3).

Proposed Improvement:

Structural bank stabilization is recommended along the west side of Barderry Lane. The wall would be constructed from stone-filled gabion baskets in combination with coir fiber rolls. Gabion basket walls provide cost effective bank stabilization while also providing stone media for storm water filtration.

The gabion basket retaining wall would include:

- Coir fiber rolls along the exterior toe that will promote vegetation growth. The vegetation will provide additional treatment of storm water runoff that filters through the stone filled gabion baskets.
- The gabion baskets will also establish a defined road edge and will provide both a channel to control storm water and a boundary for road maintenance activities.

Estimated Cost: $12,000 to $16,000

Estimated Pollutant Load Reduction: 3.8 kg P/yr

Photo # 2-1

Photo # 2-2

Photo # 2-3

Example of gabion basket wall

SITE #3: CORNER OF LAKEVIEW DRIVE/LOOKOUT POINT

Site Summary:

Storm water runoff from paved portions of Lakeview Drive drains via overland flow onto the unpaved Lookout Point (Photo #3-1). These flows concentrate along the unpaved eastern side of Lakeview Drive in an undefined road ditch. The undefined ditch apparently drains along a paved driveway toward Mountain Brook Cove (Photo #3-2). Accumulated sediment was observed at the down gradient end of the paved driveway, adjacent to Mountain Brook Cove (Photo #3-3).

Photo # 3-1

Proposed Improvement:

A stone drainage channel is recommended to be installed along the eastern side of Lakeview Drive/Lookout Point and continued along the paved driveway shown in Photo3-2. The drainage channel would ultimately discharge to Mountain Brook Cove and consist of:

- A deep rock-lined trench that would provide a well defined storm water conveyance to provide filtration and promote infiltration.
- The trench would function to capture storm water runoff from the paved portions of Lakeview Drive and either infiltrate these flows or convey flows in a controlled, non-erosive manner to Mountain Brook Cove.

Photo # 3-2

Estimated Cost: $10,000 to $12,000

Estimated Pollutant Load Reduction: 0.3 kg P/yr

Photo # 3-3

SITE #4: JASPER TRAIL

Site Summary:


Photo # 4-1

Jasper Trail is an unpaved road as shown in Photo #4-1. Storm water runoff from Jasper Trail drains into undefined ditches along both sides of the Trail. In addition, a small unnamed tributary drains from Sax Hill toward Jasper Trail. The stream drains across the road via a 12" diameter culvert. The culvert apparently has caused flooding that has resulted in Jasper Trail being eroded (i.e., washed-out). The culvert inlet (Photo #4-2) is not protected and sediment from the unpaved road run-off has accumulated at the culvert inlet, thereby reducing the capacity of the culvert. In addition, accumulated sediment was observed immediately down gradient of the culvert outlet (Photo #4-3). The stream discharges from the culvert and drains south along Jasper Trail and then east toward Pawtuckaway Lake.


Photo # 4-2

Proposed Improvement:

Recommended storm water improvements in the area of the Jasper Trail culvert include:

- Improvements to the inlet and outlet of the culvert as well as stream channel improvements of the unnamed tributary.
- Outlet improvements would include a gabion basket headwall and grading a rock lined channel to convey flows from the culvert along Jasper Trail to the existing stream channel.
- Inlet improvements include stabilizing the channel up gradient of the culvert and constructing stone or coir fiber roll check dams to reduce flow velocities and trap sediment.
- Additionally, a headwall may be constructed at the culvert inlet to reduce erosion and provide hydraulic control at the inlet.


Photo # 4-3

Estimated Cost: $8,000 to $10,000

Estimated Pollutant Load Reduction: 0.2 kg P/yr

SITE #5: # 105 LAKEVIEW DRIVE

Site Summary:

Storm water runoff from the paved portions of Lakeview Drive in the area of #105 Lakeview Drive drain via a 12" diameter culvert located on the north side of the road (Photo #5-1). The area adjacent to the culvert inlet was not stabilized and rills were observed in adjacent side slopes (Photo #5-2). The culvert apparently drains into one of two catch basin structures that capture storm water runoff from the paved driveway of #105 Lakeview Drive (Photo #5-3). These catch basin structures appear to discharge to Neals Cove via a culvert through private property.

Photo # 5-1

Proposed Improvement:

Recommended storm water controls in the area of #105 Lakeview Drive include retrofit LID technologies to improve storm water quality discharging to Neals Cove. Recommended improvements include:

- Constructing a bioretention cell at the exiting culvert inlet. This would provide stabilization to the area as well as filtration and storm water treatment prior to discharging through the culvert.
- A pre-manufactured bioretention cell (i.e., Filterra) installed with the homeowner's approval at the northernmost catch basin structure.
- The combination of bioretention units would provide a multiple barrier approach to treat storm water runoff prior to discharging to Neals Cove.

Photo # 5-2

Estimated Cost: $12,000 to $18,000

Estimated Pollutant Load Reduction: 0.1 kg P/yr

Photo # 5-3

SITE #6: #47 LAKEVIEW DRIVE

Site Summary:

Storm water runoff in the area of #47 Lakeview Drive apparently accumulates and can cause flooding of Lakeview Drive (Photo #6-1). The accumulated storm water discharges across Lakeview Drive. These flows discharge from the pavement onto unstabilized side slopes before draining overland toward Mountain Brook Cove. Evidence of erosion was observed in the unstabilized areas down gradient of the pavement (Photo #6-2). These flows then drain overland to a series of topographical depressions and eventually drain into Mountain Brook Cove (Photo #6-3).

Photo # 6-1

Proposed Improvement:

Storm water runoff in the area of #46 Lakeview should be controlled to reduce flooding and erosion caused by flow over unstabilized surfaces within close proximity to the lake. Recommended controls and improvements include:

- Installing a conveyance such as a culvert across Lakeview Drive to drain accumulated storm water.
- Clean the flooding area of accumulated tree/yard debris that has apparently been dumped in the area and is a potential source of pollutants (i.e., nutrients).
- Installing a bioretention cell along the west side of Lakeview Drive in the area of flooding to provide storm water runoff storage and promote infiltration.
- Additional recommended improvements include installation of an energy dissipation device and level spreader at the proposed culvert outlet to reduce flow velocities and promote non-erosive flows to drain overland through the forested area before discharging into Mountain Brook Cove.

Photo # 6-2

Photo # 6-3

Estimated Cost: $8,000 to $12,000

Estimated Pollutant Load Reduction: 0.1 kg P/yr

SITE #7: BARDERRY LANE

Site Summary:

Barderry Lane is an unpaved road that crosses a wetland complex that drains toward Gove Cove. The wetland along the east side of Barderry Lane drains west via several culverts. However, grading activities associated with unpaved road maintenance have apparently caused sediment to accumulate and block the inlets of at least one culvert (Photo #7-1). Flooding occurs in the area up gradient of the blocked culvert.

Photo # 7-1

Proposed Improvement:

Approximately 500 linear feet of Barberry Lane in the area of the blocked culverts should be maintained according to unpaved road BMPs and improvements including:

- Maintaining this are of Barberry Lane so that sediment is not transported to adjacent storm water controls (e.g., ditches, culverts).
- Cleaning the accumulated sediment that has clogged the culverts along this portion of road.
- Installing culvert headwalls to define the locations of culverts and provide stabilization to the road in these areas.
- Installing a well-defined ditch along the approximate 500 linear feet of Barberry Lane.
- Stabilizing ditches with rock or installing a deep rock-lined trench, to define the road boundary as well as treat and infiltrate storm water runoff. The trench would either infiltrate storm water runoff or convey these flows to one of the exiting culverts that drain west toward Gove Cove.

Photo # 7-2

Estimated Cost: $8,000 to $12,000

Estimated Pollutant Load Reduction: 0.5 kg P/yr

Photo # 7-3

SITE #8: PAWTUCKAWAY LAKE STATE PARK

Site Summary:

Pawtuckaway Lake State Park is located along the west shore of the Lake, to the north of Neals Cove. There is a grassed picnic area located to the south of the main beach of the Park (Photo #8-1). Storm water runoff from this grassed area either infiltrates or drains via overland flow toward the Lake. Two catch basin structures capture the runoff and apparently discharge these flows to the Lake. The catch basin structures appear to not properly drain and flooding was observed in the area of both structures (Photo #8-2).

Photo # 8-1

The Park's secondary parking lot is located to the east of the main beach. Storm water runoff from the paved parking lot either drains into catch basins or discharges from the southeast corner of the parking lot via a paved spillway (Photo #8-3). The spillway discharges into an unstabilized channel and erosion was observed immediately down gradient of the spillway.

Photo # 8-2

Proposed Improvement:

Recommended for the State Park include:

- Install bioretention cell at each of the drop inlet structures located to the south of the grassed picnic area. The bioretention cells would provide storm water filtration and storage capacity while promoting infiltration.
- Install an energy dissipation and level spreader device at the paved spillway at the southeast corner of the secondary parking lot. The energy dissipation device will reduce flow velocities prior to discharging runoff in a non-erosive manner to the unstabilized channel.
- Stabilize the existing channel down gradient of the paved spillway located in the southeast corner of the secondary parking area.

Photo # 8-3

Estimated Cost: \$8,000 to \$12,000

Estimated Pollutant Load Reduction: 0.2 kg P/yr

SITE #9: TUCKAWAY SHORES BEACH AREA

Site Summary:

The unpaved road adjacent to the Tuckaway Shores beach area appears to be a source of sediment loading to the lake. Road grading had been conducted several days before Geosyntec's site visit on 13 October 2006, resulting in roadside berms and a road surface of relatively fine-grained and erodible material (Photo # 9-1). Sediment transported along the road by storm water collects in an area between the road and the beach area fencing (Photo #9-2). From this area, storm water and associated sediment are directed to the lake via a paved flume (Photo # 9-3).

Photo # 9-1

Proposed Improvement:

Proposed improvements for this area include:

- Surface the road section proximal to the beach area with either pavement or a specification hard-pack.
- In conjunction with any road surfacing improvement, construct rock-lined infiltration trenches to define the road boundary and infiltrate storm water runoff. The trench would either infiltrate storm water runoff or convey flows to the sediment trap and vegetated swale described below.
- Construct a stone-lined sediment trap in the roughly triangular area between the paved flume and the roadway. Regular maintenance will be required to remove fine-grained sediment as it accumulates in the sediment trap.
- Replace the paved flume with a densely vegetated water quality swale.

Photo # 9-2

Estimated Cost: $10,000 - $12,000

Estimated Pollutant Load Reduction: 0.2 kg P/yr

Photo # 9-3

SITES #10-12: SHORELINE STABILIZATION SITES

Site Summary:

The shoreline used for lake access at 16 Indian Run (Photo #10-1) appears to be unstable and eroding. An approximate 15-foot wide area which slopes down to the lake is comprised of unstabilized earth which receives storm water runoff from the property. This area was identified by members of the Pawtuckaway Lake Improvement Association (PLIA) as a priority for improvement.

Photo # 10-1

Proposed Improvement:

Proposed improvements for this area include:

Conduct minor grading to direct storm water flows away from access area and towards adjacent vegetated areas via a shallow vegetated swale.

Stabilize the eroding slope with grading, plantings, and bioengineering techniques as appropriate. It will be critical to obtain permission from the home owner for any improvements and to work cooperatively with the home owner to ensure that the restoration design is compatible with the owner's use of the area.

Photo # 10-2

Other sites identified by the PLIA as requiring similar erosion control and shoreline stabilization improvements include the following:

- 51 Mooer's Road (Photo #10-2).
- Pawtuckaway State Park campsites #111 and 112 (Photo #10-3).

Photo # 10-3

Estimated Cost: $4,000 - $6,000 per site

Estimated Pollutant Load Reduction: <0.025kg P/yr (per site)

4.1.3 Estimated Storm Water BMP Pollutant Load Reduction

Pollutant load reductions were estimated for each of the proposed improvements described above in Section 2. The phosphorus load reductions were estimated using published pollutant reduction rates for BMPs as follows: The predicted phosphorus load entering each BMP was estimated based on the land cover in the drainage area contributing flows through the BMP. Each BMP drainage area was delineated based on United States Geological Survey (USGS) topography maps. Next, land use categories were interpreted from aerial maps and assigned to the drainage area. An annual pollutant load was estimated for each catchment using the land-use based model as described in Section 3.1. This pre-BMP annual pollutant load represents the amount of pollutant expected to enter the Lake if the BMP was not in-place. Next, published BMP reduction values were used to estimate the total amount of phosphorus which is expected to be removed (provided that the improvement is properly installed and maintained). The post-BMP pollutant load represents the pollutant load predicted to enter the Lake if the BMP was installed. The results of the land-use loading model are provided in Table 4 below.

The BMPs proposed for Sites 1-12 would reduce the annual phosphorus load to Pawtuckaway Lake by an estimated 6.2 kg/year. This load reduction represents about 5% of the targeted phosphorus load reduction (125.7 kg/year) for Pawtuckaway Lake as discussed in Section 3.4. However, as previously stated, Sites 1-9 are not intended to be a comprehensive listing of recommended stormwater improvements in the Pawtuckaway Lake watershed. Rather, these sites are representative examples of potential stormwater improvements and retrofits that could be implemented at numerous sites throughout the watershed. Significantly greater phosphorus load reductions could be attained from a watershed-wide effort to improve stormwater management through LID practices (e.g. raingardens on residential lots) and improvements to existing storm water drainage features. As such, we estimate that a realistic range of potential phosphorus load reduction from a watershed-wide effort to install storm water BMPs is between 6.2 and 30 kg/year.

Table 4: Estimated Phosphorus Removal for Stormwater Improvement Sites

Site Number	Site Description	Estimated Drainage Area (acres)	Annual Export (lbs/yr)	Annual Export (kg/yr)	BMP Type/Category	BMP Reduction (% Capture)	Estimated Phosphorus Removal (kg/yr)
1	99 Lakeview Drive	2.8	0.6	0.3	Vegetated Filters	75%	**0.2**
2	Fernalds Creek at Barderry Lane	161.6	28.0	12.7	Grassed Swales/Infiltration	30%	**3.8**
3	Lakeview Drive and Lookout Point	2.6	2.3	10.4	Grassed Swales/Infiltration	30%	**0.3**
4	Jasper Trail	13.6	2.8	1.3	Open Vegetated Channel	15%	**0.2**
5	105 Lakeview Drive	2.3	0.5	0.2	Filtration Systems	45%	**0.1**
6	47 Lakeview Drive	4.0	0.8	0.4	Filtration System	45%	**0.1**
7	Barderry Lane	29.1	5.4	2.5	Grassed Swales	20%	**0.5**
8	Pawtuckaway Lake State Park						
8.1	*Picnic Area*	18.0	3.6	1.6	Filtration System	45%	**0.6**
8.2	*Parking Area*	5.6	2.5	1.1	Open Channel Vegetated	15%	**0.2**
9	Tuckaway Shores	4.5	1.1	0.5	Basin/Infiltration	45%	**0.2**
10	16 Indian Run	<0.5	<0.2	<0.1	Vegetated Shoreline Stabilization	75%	**<.025**
11	51 Mooers Road	<0.5	<0.2	<0.1	Vegetated Shoreline Stabilization	75%	**<.025**
12	Pawtuckaway State Park campground (sites 111 and 112)	<0.5	<0.2	<0.1	Vegetated Shoreline Stabilization	75%	**<.025**
						Total Estimated Phosphorus Removal (kg/yr):	**6.2**

4.2 Phosphorus Loading from On-Site Sanitary Systems

4.2.1 Estimated Total Phosphorus Load from On-Site Sanitary Systems

Geosyntec conducted an assessment to estimate phosphorus loads from on-site sanitary systems located in developed areas around the Lake. The model and assumptions used for this assessment were adapted from the NHDES 1995 Diagnostic/Feasibility Study. On-site sanitary systems considered in the analysis included septic tanks with leaching fields, septic tanks with chambers, cesspools, holding tanks, chemical toilets, dry-wells, and outhouses. The Nottingham Zoning Board reported that there are currently 309 residential properties around the Lake, with an estimated 2.83 persons per residence. For the purpose of this analysis, all of the 309 residential properties were assumed to be serviced by a septic systems as the best available information indicated that there were no shared sanitary sewer systems within the proximity of the Lake. In order to account for seasonal residences, the loading from septic systems was estimated based on an assumption that each of the 309 residences was occupied for 9 months out of the year.

The estimated phosphorus load to the Lake from on-site sanitary systems was 361 lbs P/yr (164 kg P/yr), as calculated using the following equation:

$$M=(ES)(\#\ \text{Capita Years})(1-SR)$$

Where:

M is the predicted phosphorus loading;
Es is the phosphorus export coefficient of 1.1 lbs P/capita-year;
Capita Years is the product of the number of parcels (309 parcels) multiplied by the average number of residents per parcel (2.83 residents/parcel) and the average occupancy (9 of 12 months or 0.75);
SR is the soil retention coefficient (0.5). ES was determined based on literature published by the US Geological Survey and the University of Delaware extension program. The soil retention coefficient used is the same soil retention coefficient used in the 1995 Pawtuckaway Lake Diagnostic Feasibility Study.

The estimated total phosphorus load from septic systems (164 kg/year) represents 21.5% of the total annual estimated phosphorus load to the Lake.

4.2.2 Potential Community Septic System Locations

Geosyntec conducted a preliminary review to identify potential areas for community septic systems (Table 5). The review was based on (1) the density of existing homes in close proximity to the Lake and tributaries and (2) data on soil types and soil drainage classes in the areas surrounding the Lake. An orthophoto map with existing soils information and the locations of the eight potential sites for community septic systems are shown below in Figure 7. The majority of the soils surrounding the Lake are characterized as a well-drained Chatfield-Hollis-Canton Complex soil, which tend to be suitable for siting wastewater treatment facilities. The drainage characteristics of Pawtuckaway Lake soils are shown below in Figure 8.

Geosyntec identified the eight areas described below as potential sites for community septic systems. Four High Priority sites were identified based on parcel density, proximity to the Lake, and the presence of an existing community association structure (e.g. Tuckaway Shores).

Table 5: Potential Community Septic System Locations

Area	Estimated # of Homes	Location
Tuckaway Shores Area	28	This area is a private community association at the southern end of the Lake.
Lakeview Drive Area	64	This area is located on the western side and includes all properties on Lakeview Drive and Lookout Point Lane.
Barderry Lane Area (north of Gove Cove)	56	This area is located north of Gove Cove in the northeastern portion of the Lake. The northern portion of this area is bounded to the east by Barderry Lane. The southern portion is bounded to the north by White's Grove Road.
Lamprey Drive/ Shore Drive Area	27	This area is located at the southeastern end of the Lake. This area includes properties to the west of Lamprey Drive and along the southern portion of Shore Drive.
Mooers Road/ South Road Area	28	Located at the southern end of the Lake, this area includes the lakefront properties on Mooers Road and all properties in the South Road area.
Highland Avenue Area	16	This area is located along the eastern side of Gove Cove. The area is bounded on the east by Raymond Road and includes all properties along Highland Avenue.
Area South of Mountain Brook Cove	33	This area is located in the western portion of the Lake to the south of Mountain Brook Cove. This area includes all properties along Head Road and lakefront properties in the northern portions of Sach's Road and Jampsa Trail.
Lake Shore Dr. /Cahill Lane Area	27	This area is located in the eastern portion of the Lake and includes the properties along the northern portion of Shore Drive and along Cahill Drive.
Seaman Point Road/Cove Road	30	This area is located in the eastern portion of the Lake and includes all properties along Seaman Point Road and properties along the northern portion of Cove Road.

The installed cost for a community septic system can vary widely depending on site specific conditions such as soils, slopes, piping distances, etc. In general, the cost of a community system per household will decrease significantly as the number of homes sharing the system increases. For general costing purposes, a cluster mound system servicing 25 homes will cost about $400,000 to install ($16,000 per house). This cost includes $150,000 to install the system and $250,000 to install piping connections, assuming an average of 100 feet of small diameter pipe per home at $10 per linear foot. Annual maintenance costs for this type of system are estimated at $5,000 ($200 annually per home).

The potential phosphorus load reductions that may be achieved by installing community septic systems can vary widely depending on variables including: the proximity and condition existing on-site septic systems; the location of the proposed community septic systems (e.g. distance from the lake); and treatment technology of the systems. For the 309 homes located within the eight potential community septic system locations described above, a conservative estimated phosphorus removal efficiency range of 25%-60% would result in an estimated total phosphorus load reduction of 41 to 98 kg/year. This reduction would represent 33% to 78% of the targeted annual phosphorus load reduction discussed in Section 3.4.

4.2.3 On-Site Wastewater Management Program

To help address issues related to proper ongoing maintenance and management of existing septic systems around Pawtuckaway Lake, the either the Pawtuckaway Lake Improvement Association (PLIA) and the Town of Nottingham should consider establishment of an On-site Wastewater Management Program (OWMP). Program elements may include:

- Conduct a survey and GPS mapping of to obtain updated in formation on the location, age and type of septic systems around the perimeter of the Lake;
- development of a municipal bylaw requiring regularly scheduled system inspections;
- development of a bylaw requiring more stringent treatment standards in environmentally sensitive areas; and
- development of homeowner education materials and related outreach efforts.

Initial costs that associated with development of an OWMP are estimated to be in the range of $10,000 to $15,000, including an estimated $6,000 to $9,000 for survey and GPS mapping efforts, and $4,000 to $6,000 for development, printing, and distribution of public education materials. These could be significantly lower with contributions of volunteer labor from the PLIA and/or town committees. The cost estimate above does not include any cost sharing or rebates related to septic system pump-outs, although these types of incentives may be considered. No costs associated with development of bylaws or other regulatory activities are included in the above cost estimate.

A phosphorus reduction efficiency of 5-10% is estimated for homes involved in an OWMP, resulting in a phosphorus load reduction estimate of 8.2 to 16.4 kg/year.

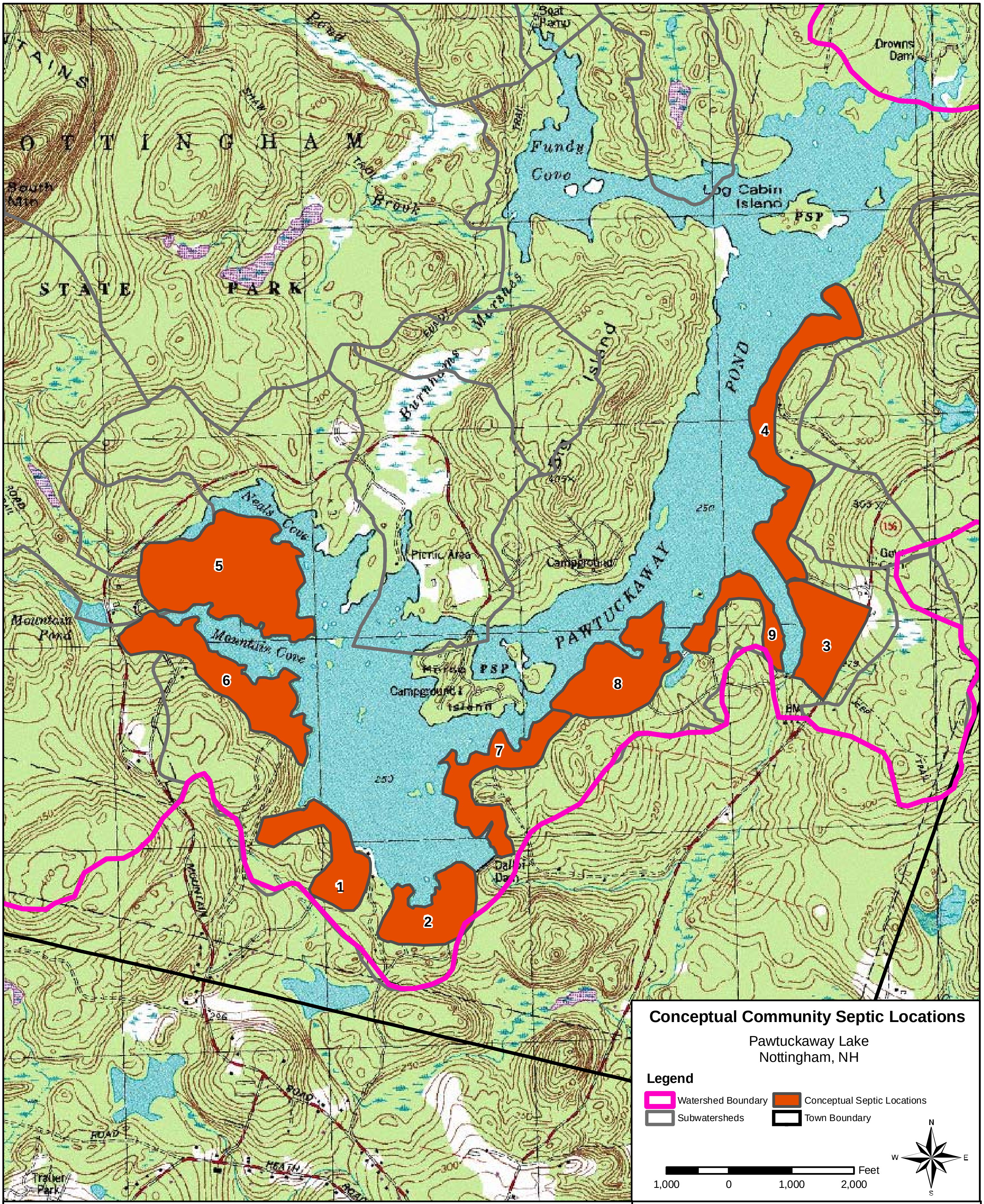


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FIGURE NO. 7	
PROJECT NO.	BW0085
DATE:	02/08/08
Pawtuckaway_SepticLoc.mxd	

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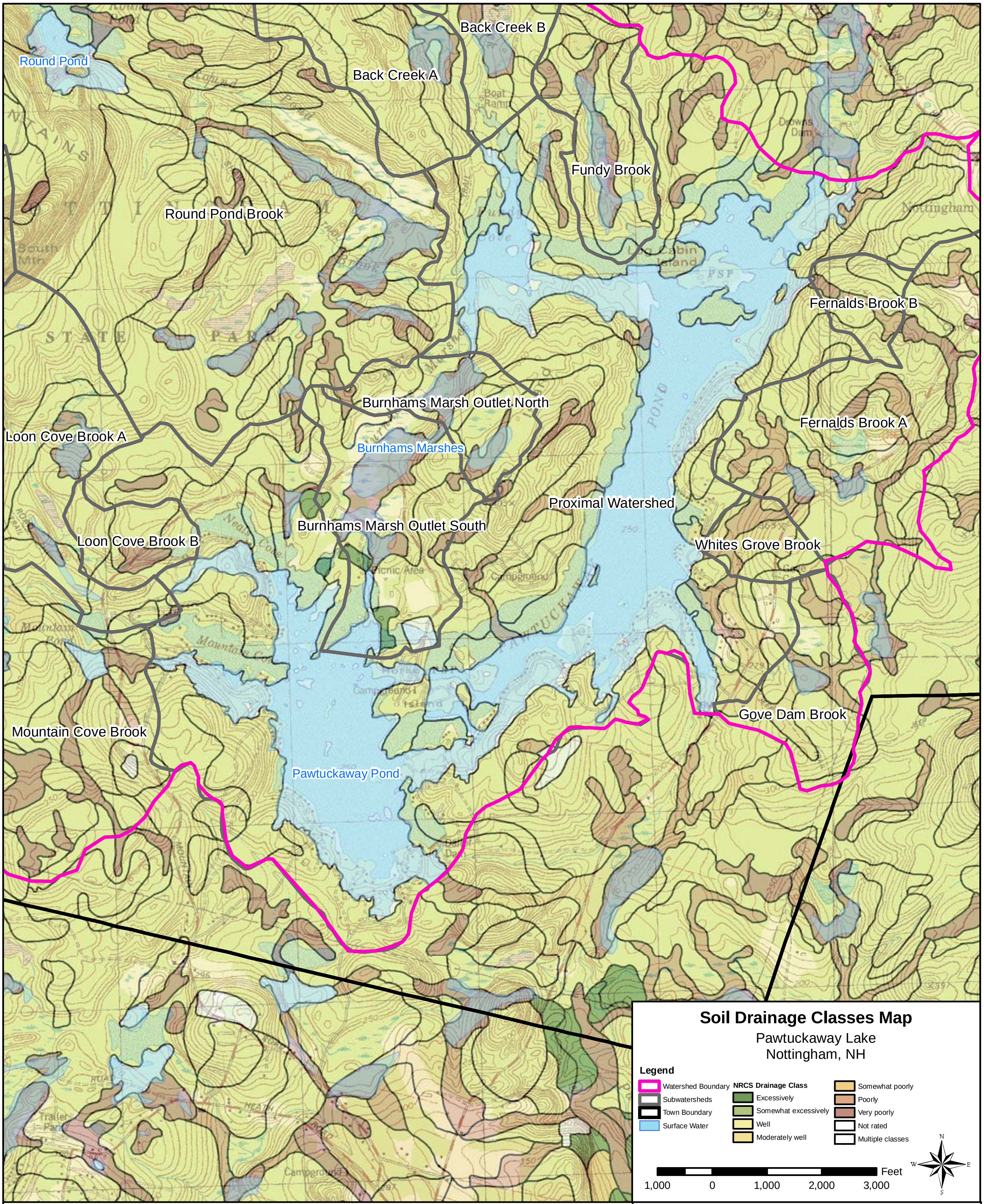

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ACTON, MASSACHUSETTS

FIGURE NO. 8

PROJECT NO. BW0085

DATE: 02/08/08

Pawtuckaway_Soils.mxd

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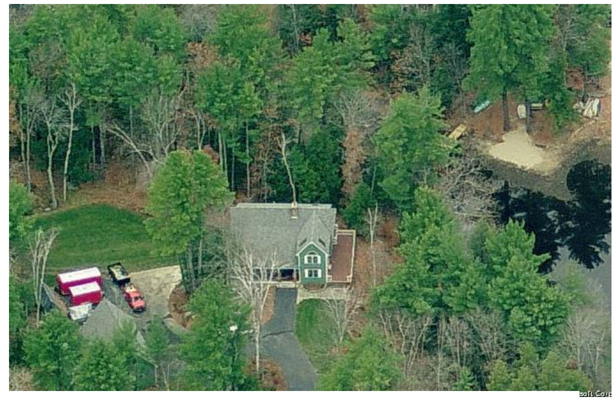
4.3 Phosphorus Loading From Watershed Land Uses

Landscaping/Lawn Fertilizers

Landscaping fertilizers can be a significant source of phosphorus from areas of residential development and other areas where grass lawns are maintained (e.g. office parks, schools, sports fields, etc.). The Pawtuckaway Lake Improvement Association and/or the Town of Nottingham could develop a program to reduce pollution from fertilizer applications within the watershed. Aspects of this program could be modeled after similar efforts that have been implemented successfully in other communities and include the following:



Landscaping fertilizers from grassed lawns, such as this property adjacent to Pawtuckaway Lake, can be a significant source of phosphorus to water bodies.

- As an incentive to promote the use of phosphorus-free fertilizers, the Town could offer this type of fertilizer to homeowners at a reduced price. Fertilizer providers (e.g. local hardware stores, etc.) would be selected to provide reduced-priced fertilizer for homeowners living in targeted watershed areas. The retailers would be subsidized by the Town for the balance of the fertilizer cost. Homeowners using the fertilizer would be provided signage (optional) to post in their yard, which would educate neighbors about the phosphorus-free fertilizer, and its role in protecting pond water quality. A follow up survey is recommended to evaluate the performance of the program. Printed public outreach materials (e.g., brochure, flyer) are also recommended to ensure that watershed residents are informed of the program, including a discussion of the benefits of and options for a "no-fertilizer" approach to landscaping.
- Develop landscaping fertilizer bylaws or ordinances to reduce the amount of phosphorus fertilizer that is applied to landscaped portions of each watershed. There have been numerous successful local ordinances regulating the use of phosphorus fertilizer on lawns. Some examples include the statewide programs in Maine and Minnesota, and portions of states including Dane County, Wisconsin, Muskegon County, Michigan, and Ottawa County, Michigan. A report was prepared for the Minnesota legislature on the law's effectiveness. That report and related information on the law is available at: www.mda.state.mn.us/phoslaw.

The phosphorus load reductions that can be achieved by a fertilizer reduction program are expected to vary widely depending on how the program is structured and implemented. For purposes of developing a load reduction estimate for this report, we have assumed that the program would be targeted to the estimated 309 residential homes around the perimeter of Pawtuckaway Lake, and that one third of these homes fertilize a 2,000 square foot lawn area twice per growing season using 10-10-10 (N-P-K) formula fertilizer at a typical application rate of 3.5 lbs per 1000 square feet. If 25% to 50% of the homes using fertilizer are convinced to switch to phosphorus-free fertilizer, the amount of phosphorus applied to lawns around Pawtuckaway Lake would be reduced by approximately 58 to 116 kg per year. If 10% of the applied fertilizer phosphorus washes into the lake via storm water runoff, then the estimated annual phosphorus load reduction would range from 5.8 to 11.6 kg/year.

Costs for a one-year fertilizer reduction program as described above are anticipated to be in the range of $8,000 to $10,000. These costs include printed outreach materials (brochure, signage, homeowner survey), and costs associated with providing a rebate or subsidy for purchase of phosphorus–free fertilizer. Assuming that 155 homes participated and purchased two bags of fertilizer, and assuming a rebate of $15 per bag, the total cost of the rebate would be $4,650.

4.3.1 Agricultural Best Management Practices (BMPs)

Section 319 funds could potentially be used for the following tasks related to agricultural BMPs in the Pawtuckaway Lake watershed:

Manure fertilizer from Batchelder's Farm being sold from a roadside.

1. Install additional fencing and buffer plantings at priority locations such as Batchelder's Farm, which is located near Fernald's Brook.
2. Continue ongoing coordination between NHDES and NRCS to ensure that BMPs installed at Batchelder's Farm over the past several years are properly maintained. As reported in the 2003 VLAP report, recent data indicates that these BMPs have improved storm water runoff conditions such that "minimal surface water runoff from Batchelder Farm directly impacts the lake during the summer and fall".
3. Conduct a more detailed nutrient management assessment related to all agricultural activities the Pawtuckaway Lake watershed. This assessment could involve a development of more accurate nutrient runoff estimates, based on field sampling and a site-by-site assessment of ongoing practices related to nutrient management, manure/fertilizer application, the number of livestock on site, etc.

The estimated cost for the tasks listed above could range from $10,000-20,000, with the biggest variable being the extent of additional BMP installation/construction (fencing, buffer plantings etc.). Based on limited existing information related to runoff conditions at Batchelder Farm and other agricultural sites in the watershed, it is difficult to project the net phosphorus reduction that could be achieved from the measures listed above.

Table 6: Pawtuckaway Lake Water Quality Improvement / Implementation Plan

Source	Site	Proposed Improvements	Estimated Cost [1]	Estimated P Load Reduction (kg)	Cost per kg of P Reduced (x 1,000)	Priority
Road Runoff	Site #1: #99 Lakeview Dr.	Install a bioretention cell at the drop inlet structure.	$3-4K	0.2	$15 - 20	High
	Site#2: Fernald's Creek crossing at Barderry Lane	Install structural bank stabilization consisting of stone-filled gabion baskets and coir fiber rolls along the west side of Barderry Lane.	$12-16K	3.8	$3 - 5	High
	Site #3: Lakeview Dr./Lookout Pt.	Install stone drainage channel along the eastern side Lakeview Drive and a paved driveway, ultimately discharging to Mountain Brook Cove.	$10-12K	0.3	$33 – 40	High
	Site #4: Jasper Trail Culvert	Improve inlet/outlet of culvert by installing a gabion basket headwall. Stabilize the upstream and downstream channel of the unnamed tributary.	$8-10K	0.2	$40 - 50	Medium
	Site #5: #105 Lakeview Dr.	Install a bioretention cell at the exiting culvert inlet in the area of #105 Lakeview Drive. Install a pre-manufactured bioretention cell (i.e., Filterra) at the northernmost catch basin structure in the # Lakeview Drive driveway.	$12-18K	0.1	$120 - 180	Medium
	Site #6: #47Lakeview Dr.	Install bioretention cell with culvert draining across Lakeview Dr. Install energy dissipation/level spreader at culvert outlet. Remove tree and debris in this area.	$8-12K	0.1	$80 - 120	Medium
	Site #7: Barderry Lane	Install a rock-lined ditch to define the road boundary. Construct culvert headwalls to mark culvert locations at this section of Barberry Lane.	$8-12K	0.5	$160 - 240	Low
	Site #8: Pawtuckaway State Park	Install bioretention cells at each drop inlet south of the grassed picnic area. Install energy dissipation device/level spreader at the spillway at the southeast corner of the secondary parking lot. Stabilize channel downgradient of the spillway.	$8-12K	0.8	$10-15	High
	Site #9: Tuckaway Shores Beach Area	Stabilize road near beach with pavement or hardpack. Install rock-lined roadside infiltration trenches. Install a sediment trap between the road and beach fence. Replace paved flume with vegetated water quality swale.	$10-12K	0.2	$50 - 60	High
	Site 10: 16 Indian Run	Shoreline stabilization, including grading, plantings and bioengineering techniques.	$4-6K	<.025	>$160	Low
	Site 11: 51 Mooers Lane	Shoreline stabilization, including grading, plantings and bioengineering techniques.	$4-6K	<.025	>$160	Low
	Site 12: Pawtuckaway S.P. campsites #111,112	Shoreline stabilization, including grading, plantings and bioengineering techniques.	$4-6K	<.025	>$160 - 240	Low

1. Estimated ranges in cost are approximate and represent installed cost where applicable.

Table 5: Pawtuckaway Lake Water Quality Improvement / Implementation Plan (continued)

Source	Site	Proposed Improvements	Estimated Cost [1]	Estimated P Load Reduction (kg)	Cost per kg of P Reduced (x 1,000)	Priority
Septic Systems	Tuckaway Shores Area	Community septic system (28 homes).	$448K	4 - 11	$40- 120	Medium
	Lakeview Drive Area	Community septic system (64 homes).	$1,024K	8 – 25	$40- 120	Medium
	Barderry Lane Area (north of Gove Cove)	Community septic system (56 homes).	$896K	7 – 22	$40- 120	Medium
	Lamprey Drive/Shore Drive Area	Community septic system (27 homes).	$432K	4- 11	$40- 120	Medium
	Mooers Road/ South Rd. Area	Community septic system (28 homes).	$448K	4 – 11	$40- 120	Medium
	Highland Avenue Area	Community septic system (16 homes).	$256K	2 – 6	$40- 120	Medium
	Area South of Mountain Brook Cove	Community septic system (33 homes).	$528K	4 – 13	$40- 120	Medium
	Lake Shore Dr. /Cahill Ln. Area	Community septic system (27 homes).	$432k	4 – 11	$40- 120	Medium
	Seaman Point Rd./Cove Rd.	Community septic system (30 homes).	$480K	4 - 12	$40- 120	Medium
	Pawtuckaway Lake watershed	On-site Wastewater Management Program.	$10 – 15 (1 year)	8.2 – 16.4	$1.8 - 0.6	High
Land Use Activities	Pawtuckaway Lake watershed	Fertilizer reduction program.	$8-10K (1 year)	5.8 - 11.6	$.0.7 - 1.7	High
	Batchelder Farm, other agriculture sites	Agricultural BMPs.	$10-20	NA	NA	----
		TOTALS:	$5,073,000 (low) $5,115,000 (high)	64.2 (low) 156 (high)	$33 (low) $80 (high)	

5. SUMMARY OF TECHNICAL AND FINANCIAL SUPPORT

5.1 Technical Support

Most of the phosphorus loading reduction measures described in Section 4.0 will require a moderate to high level of technical support. Moderate to high technical support may include a site topographic survey, preparation of existing conditions base plans, and preparing definitive site drawings by an Engineer that would be used for permitting and construction.

Storm water management improvements (described in Section 4.1) that will require a moderate to high level of technical support include: Site 1 (99 Lakeview Drive), Site 2 (Fernald's Creek Crossing at Barderry Lane), Site 3 (Corner of Lakeview Drive at Lookout Point), Site 5 (105 Lakeview Drive), Site 6 (47 Lakeview Drive), Site 8 (Pawtuckaway Lake State Park), Site 9 (Tuckaway Shores Beach Area) and Sites 10-12 (Shoreline Stabilization sites). The remaining sites require a low level of technical support and include Site 4 (Jasper Trail) and Site 7 (Barderry Lane). A low level of technical support includes design-build construction using field manuals. In addition to the technical support described above, construction of some of the projects described in Section 3 may require a Minimum Impact Wetlands Application to the NH DES Wetlands Bureau. Wetlands were not delineated as part of this project. As such, technical support from a New Hampshire certified wetland scientist may be required for wetland delineation and permitting support.

Improvements related to wastewater management and the proposed community septic systems discussed in Section 4.2 will require a high degree of technical support from a wastewater engineering firm. Such support is expected to include a feasibility study with detailed investigations and recommendations on siting options and costing for the proposed community systems. Detailed engineering plans for the systems will then be required.

Other types of technical support that may be required for the required for the measures discussed in Section 4 include graphic design and printing support for public outreach and educational materials, septic system inspection services, and support with development of regulatory language for new municipal bylaws.

Financial Support

Improvements and management techniques described in Section 4 above will require funding to install and complete. Sources of funding to be considered shall include, but are not limited to, Section 319 funding, NH DES Small Outreach and Education Grants, NH DES Agricultural Nutrient Management Grant Program, USDA's Environmental Quality Incentives Program and USDA's Conservation Reserve Program. Alternative funding may be in the form of donated labor from the Nottingham Department of Public Works as well as local volunteer groups and contractors from communities around the lake. Brief descriptions of potential funding sources are provided below:

Section 319 Grant Funding: Funds for NH DES Watershed Assistance and Restoration Grants are appropriated through the U.S. Environmental Protection Agency under Section 319 of the Clean Water Act (CWA). Two thirds of the annual funds are available for restoration projects that address impaired waters and implement watershed based plans designed to achieve water quality standards. A project eligible for funds must plan or implement measures that prevent, control, or abate no-point source (NPS) pollution. These projects should: (1) restore or maintain the chemical, physical, and biological integrity of New Hampshire's waters; (2) be directed at encouraging, requiring, or achieving implementation of BMPs to address water quality impacts from land-use; (3) be feasible, practical and cost effective; and (4) provide an informational, educational, and/or technical transfer component.

The project must include an appropriate method for verifying project success with respect to the project performance targets, with an emphasis on demonstrated environmental improvement.

Nonprofit organizations registered with the N.H. Secretary of State and governmental subdivisions including municipalities, regional planning commissions, non-profit organizations, county conservation districts, state agencies, watershed associations, and water suppliers are eligible to receive these grants. More information on the NH DES Watershed Assistance and Restoration Grants can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

Small Outreach and Education Grant: The NHDES provides funding to promote educational and outreach components of water quality improvement projects. This program provides small grants of $200 to $2,000 for outreach and education projects relating to NPS issues that target appropriate audiences with diverse NPS water quality related messages. These small grants are available year round on an ongoing basis, which allows applicants to move forward with outreach and education projects without having to wait for annual application deadlines. The NH DES Watershed Assistance Section administers the grant program using $20,000 each year from the U.S. EPA under Section 319 of the CWA. More information on the Small Outreach and Education Grant can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

Agricultural Nutrient Management Grant Program: This grant program seeks to provide financial, educational and technical assistance for livestock and agricultural land operations and related organizations with implementing BMPs and such other measures necessary to prevent or mitigate water pollution. Applicants may apply for cost assistance of up to $2,500 per year. There is no match required, however, in-kind services such as labor provided by the applicant will enhance the application. The majority of funding will be used for on-farm projects that address or prevent water pollution. Funding may also be utilized by organizations for educational projects. This grant program is administered through the N.H. Department of Agriculture, Markets and Food, Bureau of Markets with support from NH DES. Applications are due by June 1 and December 1 each year. More information on the Agricultural Nutrient Management Grant Program can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

USDA's Environmental Quality Incentives Program: The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement BMPs on eligible agricultural land.

EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.

EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. However, limited resource producers and beginning farmers and ranchers may be eligible for cost-shares up to 90 percent. Farmers and ranchers may elect to use a certified third-party provider for technical assistance. An individual or entity may not receive, directly or indirectly, cost-share or incentive payments that, in the aggregate, exceed $450,000 for all EQIP contracts entered during the term of the Farm Bill. More information on the USDA EQIP can be found at: http://www.nrcs.usda.gov/Programs/eqip/.

USDA's Conservation Reserve Program: The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation (CCC). CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. The program encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices. More information on the USDA CRP can be found at: http://www.nrcs.usda.gov/Programs/crp/.

6. PUBLIC INFORMATION AND EDUCATION

Public information and education will be used to enhance public understanding of the phosphorus loading reduction projects. Public awareness encourages the use of storm water improvements and other measures throughout a watershed. Public information and education about the BMPs implemented in the watershed are provided via a project website (listed below) and informational brochure. State grants are available, as described above, to assist with public information and education.

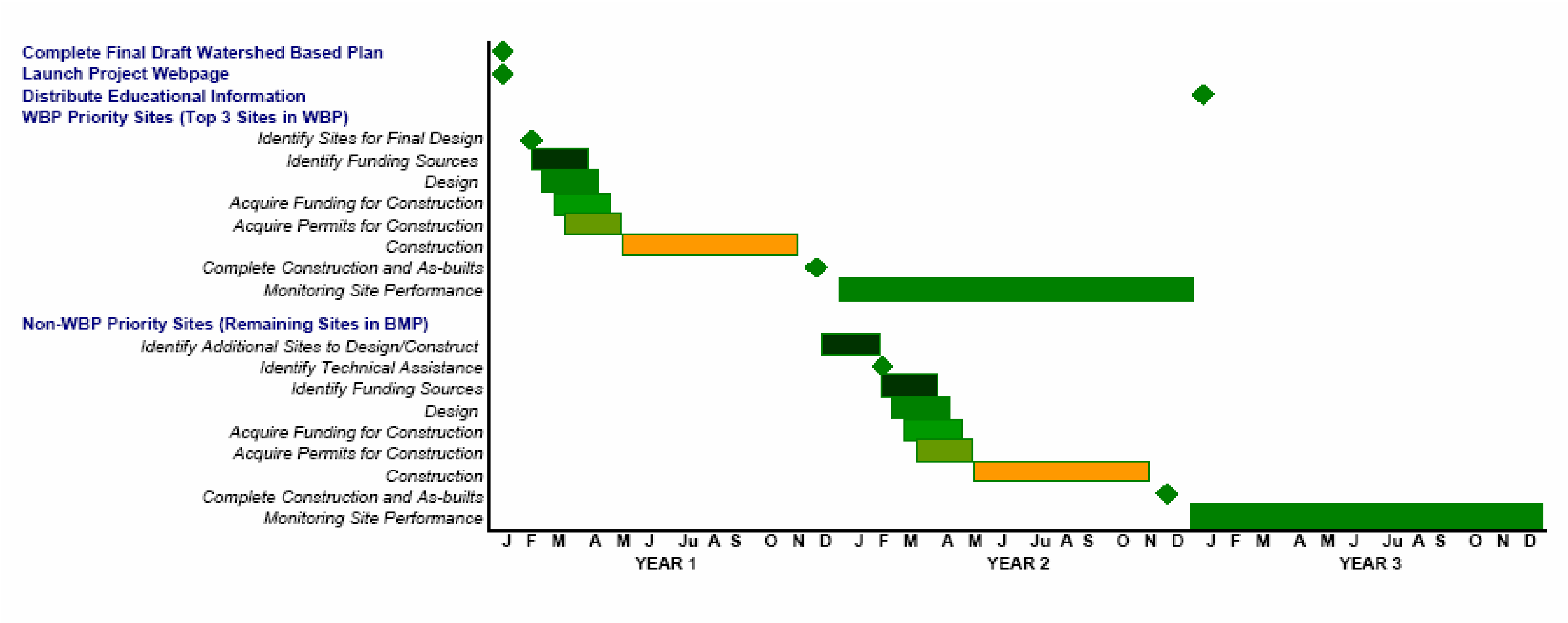
Project Website: A project web site is available to provide the public with access to all project-related documents and reports. The website is a convenient method for reviewing and commenting on this watershed management plan and other project deliverables. The project website can be accessed at: **http://projects.geosyntec.com/BW0085/**.

Brochure: In cooperation with the PLIA, Geosyntec developed an educational brochure specific to the Pawtuckaway Lake watershed and potential improvements and practices to reduce phosphorus loading to the lake. A copy of the brochure developed through this project is available from NHDES and the PLIA.

7. SCHEDULE AND INTERIM MILESTONES

The improvements recommended for the Pawtuckaway Lake watershed are ranked in order of priority as described in Section 4 of this report. A proposed schedule and associated interim milestones for these improvements are shown in Figure 9.

Figure 9: Planning and Interim Milestones Schedule



8. EVALUATION CRITERIA AND MONITORING

As discussed in Section 3.4, this watershed based plan recommends targeting an in-lake phosphorus concentration for Pawtuckaway Lake of 12 μg/L. To achieve the recommended in-lake phosphorus concentration, the Vollenweider equation in Section 3.4 predicts that the annual phosphorus load to the lake must be reduced by an estimated 125.7 kg/year. Section 4 of this report describes management measures that may be implemented to achieve this targeted phosphorus load reduction. To determine the effectiveness of these proposed measures in reducing in-lake phosphorus concentrations and improving the water quality of Pawtuckaway Lake, the following monitoring and evaluation criteria are recommended:

Phosphorus Monitoring: Continued monitoring of in-lake phosphorus concentrations should be conducted through the NH-VLAP program. In-lake phosphorus measurements will provide the most direct means of evaluating the effects of measures which have been implemented specifically to reduce phosphorus loading to the lake. As discussed in Section 3.4, the in-lake phosphorus concentrations predicted by the Vollenweider equation are based on an assumption that the lake is uniformly mixed. As such, the results of epilimnetic phosphorus monitoring during the summer (when the lake is stratified) are likely to understate the phosphorus levels that would be measured if the lake was uniformly mixed. However, regular monitoring of phosphorus levels from a profile (samples from the epilimnion, metalimnion and hypolimnion) at the North Station and South Station monitoring locations will provide useful data on phosphorus concentration trends in response to implementation of the measures recommended in Section 4.

Algae Monitoring: In recent years, an increase in the reported incidence of nuisance blue-green blooms has been one of the most notable and visible symptoms of nutrient enrichment and declining water quality in Pawtuckaway Lake. Annual monitoring of the abundance and composition of the lake's algal community would provide a useful metric for understanding water quality trends in response to implementation of the measures recommended in Section 4.

Public Outreach, Education and Land Use Activities: In addition to the monitoring efforts described above, the effectiveness of recommended measures related to public outreach and land use activities can be evaluated with several simple metrics, including:

- Quantify the number of public education brochures that are printed and distributed to watershed residents;
- Quantify the number of homes involved in the proposed On-site Wastewater Management Program, including the number of septic system inspections and pump-outs conducted, the number of septic system locations mapped through the GPS survey effort, etc.; and
- Quantify the number of homes involved in the proposed fertilizer reduction program, including information on specific program elements such as the quantity of no-phosphorus fertilizer applied within the watershed.