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Amos Lake Abbreviated Watershed-Based Plan

Photo by ECCD

Prepared by the Eastern Connecticut Conservation District, Inc.

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Cover Photograph: A painted turtle suns itself in Amos Lake in Preston, CT (photo 2013 by ECCD staff).

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1 Executive Summary

1.1. Introduction

This document provides a summary of the *Amos Lake Abbreviated Watershed-Based Plan* (the Plan). The purpose of the Plan is to identify sources of nutrients that have degraded water quality in Amos Lake, and to provide management recommendations to improve water quality.

Amos Lake is located in Preston, Connecticut. Amos Lake has been listed for several cycles, most recently in 2014, in the State of Connecticut Integrated Water Quality Report to Congress as impaired for recreation due to high levels of chlorophyll-a, excess algal growth, and nutrient/eutrophication biological indicators believed to be associated with nutrient enrichment from potential sources including stormwater and other unidentified upstream sources.

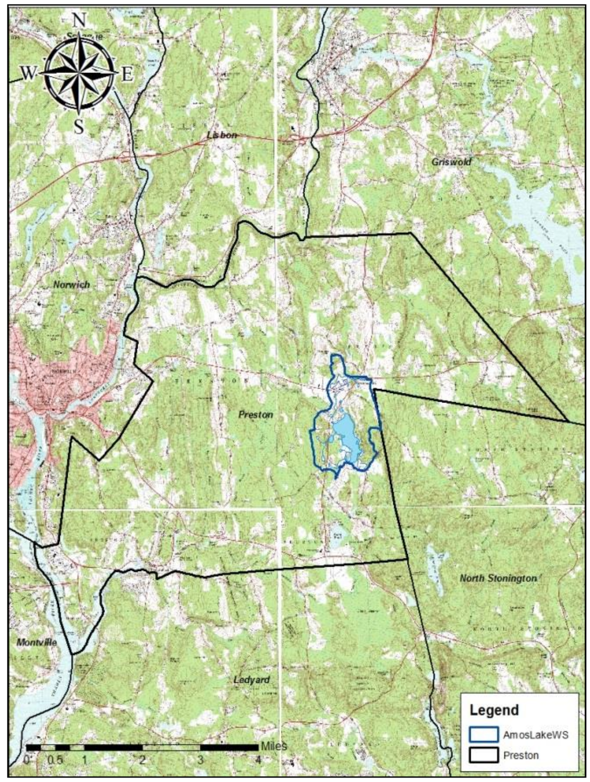
The Eastern Connecticut Conservation District (ECCD) conducted a water quality investigation of Amos Lake in order to identify potential sources of nutrient loading that have resulted in the observed water quality degradation. ECCD, in consultation with CT DEEP and Northeast Aquatic Research, LLC, designed a water quality investigation for Amos Lake. In 2012 and 2013, ECCD and local volunteers from The Last Green Valley Volunteer Water Quality Monitoring Program and the Amos Lake Association, collected water quality and quantity data and water samples from Amos Lake and its tributaries in order to determine both physiochemical water quality parameters and nutrient levels. ECCD partnered with researchers from Nichols College, in Dudley, Massachusetts and local volunteers to install stream gauges and collect stream flow data to determine nutrient flux. The collected data was used to calculate nutrient loading to Amos Lake and to determine if in-lake nutrient cycling played a role in the observed water quality conditions. ECCD used the water quality data that was collected to prepare the *Amos Lake Abbreviated Watershed-Based Plan.*

Funding to conduct this study was provided in part by CT DEEP through a US Environmental Protection Agency (US EPA) Nonpoint source grant under Section 319 of the Clean Water Act.

1.2. Watershed Description

The Amos Lake watershed is located in eastern Connecticut, in the town of Preston. The watershed is 1.5 square miles (960 acres) and is part of the Thames Main Stem regional watershed (CT3000). The northern limits of the Amos Lake watershed are located just north of Preston City at Prospect Hill. The western limits extend west of State Route 164 to Branch Hill. The southern and eastern limits generally follow Hollowell and Northwest Corner Roads.

Soils in the Amos Lake watershed are comprised of glacially-derived lodgment and melt-out tills in the upper elevations, and glacio-fluvial and organic soils in the lower elevations, with the minor placement of udorthent (urban land complex) soils along Route 165 in the northwest portion of the watershed. The central portion of the Amos Lake watershed, including Amos Lake, is underlain by an extensive northwest to southeast-trending layer of coarse-grained stratified drift comprised of sand and gravel overlying sand. Dominant soils in the watershed include Hinckley gravelly sandy loams (19%) in lower elevations, and Canton and Charlton soils (32%) in the upper elevations. Approximately 44% of soils in the Amos Lake watershed are designated as farmland soils. Of those, 22.2% are designated prime farmland soils, and 22.1% are designated statewide important farmland soils.



Amos Lake and the Amos Lake watershed within the Town of Preston, CT.

Vegetation in the Amos Lake watershed is comprised primarily of deciduous forest (34%) with a small amount of coniferous forest (4%). Turf lawns and other grassed spaces account for 11% of the watershed, and lands under agricultural use (cropland or pasture) comprise approximately 16% of the watershed. Forested wetlands (typically red maple swamps) comprise 5% of the watershed, while non-forested wetlands (scrub-shrub swamps) represent less than 1%. The remainder of the watershed is open water (12%) or developed land (17%).

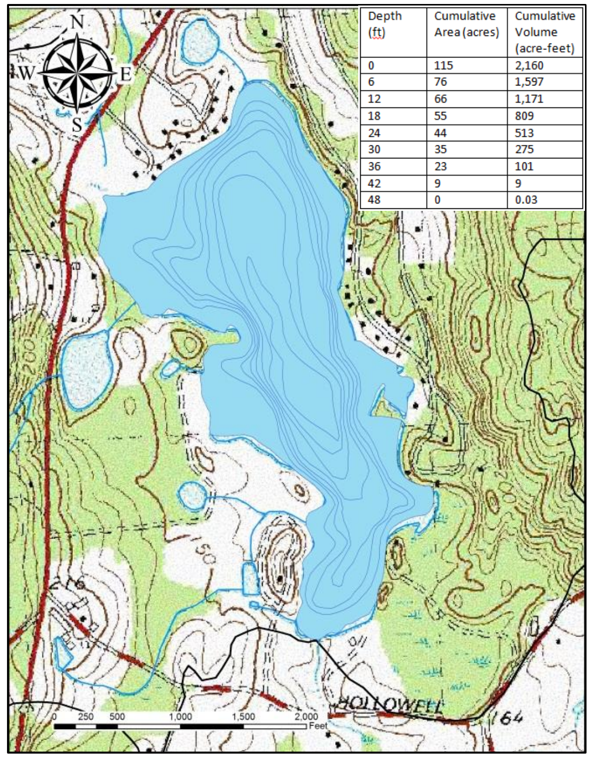
Perennial tributaries in the Amos Lake watershed have surface water quality classifications of AA. Designated uses in Class AA surface waters include existing or proposed drinking water supply; fish and wildlife habitat; recreational use (may be restricted); and agricultural and industrial supply. Groundwater within the Amos Lake watershed is classified as GAA. Designated uses for Class GAA groundwater include existing or potential public supply of water suitable for drinking without treatment; and baseflow for hydraulically-connected surface water bodies.

1.3. Amos Lake Description

Amos Lake is a 115-acre natural lake that is both stream and spring-fed. There are four defined stream channels that flow into Amos Lake. All are either first or second order streams and none are named. The primary perennial tributary to Amos Lake is an unnamed stream that originates in a wetland system north of State Route 165 in the Preston City section of Preston. The remainder streams were observed to dry up during the summer months. The outlet of

Amos Lake has a small run-of the-river type cobble and boulder dam. This small dam has replaced an older dam that was used to regulate water levels for a downstream mill. The outlet stream, which is unnamed, flows into Shewville Brook and eventually to the Thames River through Poquetanuck Cove, a tidal estuary of the Thames River.

Amos Lake has a surface area of approximately 115 acres (Figure 3-2). The mean depth is 18.8 feet. The maximum depth is 45.8 feet. Amos Lake is moderately to highly productive. The water quality investigation conducted by ECCD in 2013 indicated that Amos Lake is at the mesotrophic/eutrophic boundary. Spring/ summer total phosphorus concentrations averaged 27.4 parts per billion (ppb) and total nitrogen concentrations averaged 447 ppb, putting the lake in the middle to late mesotrophic state. Mid-summer chlorophyll-a concentrations averaged 22.2 ppb and Secchi disk measurements averaged 1.9 meters, placing the lake in the early eutrophic state (2011 CT Water Quality Standards).



Amos Lake Bathymetry

Amos Lake has a surface water quality classification of AA. Designated uses in Class AA surface waters include existing or proposed drinking water supply; fish and wildlife habitat; recreational use (may be restricted); and agricultural and industrial supply.

Amos Lake is a trophy bass/ trophy trout management area and is stocked annually by CT DEEP. It is a popular recreational destination, and hosts an annual fishing tournament.

1.4. Land Management Policies

Land management policies in the Amos Lake watershed exist on multiple jurisdictional levels, from state and regional to local levels.

State and regional planning documents include:

- *2013-2018 Conservation & Development Policies: The Plan for Connecticut*, prepared by the State of Connecticut Office of Policy and Management (OPM)
- Connecticut Department of Transportation *Draft Stormwater Management Plan (February 2004)*
- *Regional Plan of Conservation and Development 2007* and *Land Use 2011,* prepared by the Southeastern Connecticut Council of Governments

Town of Preston municipal planning documents include:

- Plan of Conservation and Development
- Planning and Zoning, Subdivision, and Inland Wetland regulations
- local ordinances

1.5. Watershed Conditions

The 1972 Federal Clean Water Act requires all states to designate uses for all waterbodies within their jurisdictional boundaries, and to test those waters to determine if they are meeting water quality criteria for those designated uses. Amos Lake is designated a Class AA surface water. The designated uses for Amos Lake include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Amos Lake has not been meeting its designated use for recreation due to excess algal growth, high levels of Chlorophyll-a, and other nutrient/eutrophication and biological indicators (CT DEEP 2012). Potential nutrient sources include stormwater runoff, and unspecified upstream sources.

The *State of Connecticut Water Quality Standards* (effective October 10, 2013) establishes water quality criteria for nutrients. For Class AA surface waters, "the loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses." The *Connecticut Water Quality Standards* also provide lake trophic categories based on nutrient concentrations and other parameters, including water clarity and productivity. Based on water quality data collected by ECCD, Amos Lake is located on the boundary between the late mesotrophic and early eutrophic lake trophic categories. In order to determine the natural trophic tendency of Amos Lake, ECCD utilized a methodology presented by Taylor in *A Connecticut Lakes Management Program Effort* (1979). Using Taylor's methodology, the natural trophic tendency of Amos Lake appears to be in the late oligotrophic state. For the purposes of this water quality investigation, ECCD used this natural trophic tendency as the target for water quality improvements in the Amos Lake watershed.

Amos Lake Trophic State

Water Quality Parameter	2013 Amos Lake Average Value	Trophic State - CT Water Quality Standards	CT Water Quality Standards Trophic State Defining Range
Total Phosphorus	27.4 µg/l * (spring and summer)	mesotrophic	10-30 µg/l (spring and summer)
Total Nitrogen	447 µg/l (spring and summer)	mesotrophic	200-600 µg/l (spring and summer)
Chlorophyll-a	22 µg/l (mid-summer)	eutrophic	15-30 µg/l (mid- summer)
Secchi Transparency	1.9 meters (mid-summer)	eutrophic	1-2 meters (mid-summer)
* 1 microgram per liter (µg/l) is equivalent to 1 part per billion (ppb)			

1.6. Identification of Pollutant Causes and Sources

In order to identify potential point and non-point sources of pollution to Amos Lake, ECCD conducted windshield surveys throughout the watershed. ECCD reviewed land use/land cover data for Connecticut (Center for Land Use Education and Research, 2010) to determine land uses in the Amos Lake watershed that might contribute to the observed water quality degradation of Amos Lake. ECCD reviewed available documentation including National Pollutant Discharge Elimination System (NPDES) permits and hazardous waste site permits, including CERCLA ("superfund"), underground storage tank (UST), and Resource Conservation and Recovery Act (RCRA) permits. Water quality data collected in 2013 from Amos Lake and tributary streams was used to quantify pollutant loading from various parts of the watershed. Potential nonpoint sources are provided in the table below.

Potential Sources of Nutrients and Other NPS Contaminants to Amos Lake

Potential Source	Location	Pollutant
Agriculture/Livestock	Watershed-wide	Nutrients, pesticides, herbicides, sediment, pathogens
Wildlife/Nuisance Waterfowl	Watershed-wide, Amos Lake	Nutrients, pathogens
Pets	Watershed-wide	Nutrients, pathogens
Septic Systems	Watershed-wide, Amos Lake shoreline	Nutrients, pathogens
Stormwater Runoff/Residential and Commercial Development	Watershed-wide	Nutrients, pesticides, herbicides, sediment, pathogens, oils, grease, heavy metals
Atmospheric Deposition	Watershed-wide	Nitrogen, dust, chemicals

1.7. Pollutant Load Assessment

ECCD evaluated nutrient loads from multiple sources, including in-lake sources, in-lake internal nutrient cycling, and stream, stormwater and watershed sources, using water quality data collected during the watershed investigation. A staff gauge installed at the perennial tributary to Amos Lake (sampling station AL-03) was used to determine nutrient loading to Amos Lake from that sub-watershed. Where no water quality or stream flow data was available, the Simple model (Schueler, 1987) was used to estimate pollutant loading.

Water quality data collected from Amos Lake in 2013 was evaluated by Northeast Aquatic Research, LLC (NEAR) to determine in-lake nutrient loads. NEAR utilized several models to determine average spring phosphorus loading of 193 kg P/year (or 426 lb P/year) based on water samples collected in April 2013.

Prediction of Annual Phosphorus (P) Load Based on Spring Phosphorus concentration of 26.7 ppb (µg/l) collected on 4/11/13.

Model Author	kg P/year	lb P/year
Kirchner and Dillon 1975	224	494
Vollenweider 1975	184	406
Jones and Bachmann 1976	106	234
Chapra 1975	258	570
Average	193	426

An analysis of the 2013 lake temperature and dissolved oxygen data indicated that the lake becomes highly stratified during the summer months. An examination of relative thermal resistance to mixing (RTRM) values demonstrates a high resistance to thermal mixing during June, July and August indicating that internal nutrient cycling during the summer months is likely not a contributing factor to nutrient loading.

Examination of stream nutrient data indicated that annual phosphorus loading to Amos Lake from tributaries could range from 36-60 kg/year, and annual nitrate loading was approximately 1224 kg/year. These values may be underestimated as no winter data (when disproportionally more run-off occurs) was collected.

To evaluate pollutant contributions from stormwater runoff, ECCD installed passive samplers at several locations on the perimeter of Amos Lake. An analysis of this data revealed that phosphorus and nitrogen concentrations contained in the stormwater runoff were significantly higher than concentrations found in tributary baseflow, indicating that pollutant loading from stormwater flow to Amos Lake could be considerable. Stormwater nutrient concentrations are provided in the table below.

Total Phosphorus (TP) and Total Nitrogen (TN) concentrations in stormwater runoff

Location	11/01/2013		11/18/2013		11/27/2013	
	TP (ppb)	TN (ppb)	TP (ppb)	TN (ppb)	TP (ppb)	TN (ppb)
AL-03						
Pre-storm grab sample	119	2762	24	1763	25	1678
Passive sampler	5930	1515	148	988	142	1170
Post-storm grab sample	27	1116	90	1131	127	802
Near 50 Lakeview Dr.						
Passive sampler	890	1603	327	1259	980	893
Post-storm grab sample					90	631
Near 57 Lakeview Dr.						
Grab sample	1580	1292	247	437	135	301
Near 76 Lakeview Dr.						
Grab sample	1665	1404	638	1023	207	929

Finally, ECCD evaluated watershed pollutant loads based on land use/land cover, using the Simple Method, which calculates pollutant loading in pounds per year, based on factors including the watershed drainage area, percent of impervious cover, annual precipitation and stormwater runoff pollutant concentrations associated with specific land cover types. Pollutant load concentrations for seven common pollutants associated with nonpoint source pollution, including total suspended solids (TSS), total phosphorous (TP), total nitrogen (TN), zinc (Zn) as an indicator for other metals, total petroleum hydrocarbons (TPH), and dissolved inorganic nitrogen (DIN), as an indicator of industrial, municipal and agricultural waste, were calculated. Results of the Simple Method model are provided in the two tables below.

Pollutant Load (lb/yr) and Percent Load by Sub-Watershed

Sub-Watershed	TSS lb/yr	% Load	TP lb/yr	% Load	TN lb/yr	% Load	Zn lb/yr	% Load	TPH lb/yr	% Load	DIN lb/yr	% Load
Bunny Lane WS (86 ac.)	24,979	9	29	7	368	9	2	3	27	4	34	6
Preston City WS (264 ac.)	97,517	34	148	34	1,389	33	19	31	173	27	174	31
Vineyard WS (68 ac.)	38,388	13	65	15	541	13	12	20	115	18	94	17
Fish Pond WS (102 ac.)	13,953	5	21	5	236	6	2	3	29	5	33	6
Hollowell Rd WS (100 ac.)	37,945	13	47	11	599	14	6	10	73	11	63	11
Remaining WS (342 ac.)	76,066	26	119	28	1,127	26	20	33	224	35	155	28
Total Load	288,847	100	430	100	4,261	100	61	100	640	100	553	100

Pollutant Load (lb/yr) and Percent by Land Use /Land Cover Type

LU/LC Type	TSS lb/yr	% Load	TP lb/yr	% Load	TN lb/yr	% Load	Zn lb/yr	% Load	TPH lb/yr	% Load	DIN lb/yr	% Load
Low Density Residential	10,295	4	65	15	360	8	27	45	86	13	88	16
Med. Density Residential	2,891	1	14	3	101	2	9	14	60	9	17	3
High Density Residential	30	0	0	0	1	0	0	0	1	0	0	0
Commercial Development	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	16,273	6	41	10	378	9	25	40	493	77	62	11
Turf and Grass	97,095	34	82	19	794	19	0	0	0	0	58	11
Pasture	33,989	12	70	16	516	12	0	0	0	0	152	28
Cultivated Crops	52,282	18	29	7	702	16	0	0	0	0	0	0
Forest	73,696	26	82	19	1,228	29	0	0	0	0	176	32
Wetlands	0	0	45	10	177	4	0	0	0	0	0	0
Bare Ground	2,295	1	1	0	3	0	0	0	0	0	0	0
Total Load	288,847	100	430	100	4,261	100	61	100	640	100	553	100

1.8. Watershed Goals and Objectives

The purpose and overall goal of this management plan is to improve the water quality of Amos Lake by reducing nutrient loading from sources throughout the watershed to the point that Amos Lake meets water quality standards for its intended uses, and is removed from CT DEEP's List of Impaired Waters. Whether or not this goal is met is dependent on the efforts of watershed managers to improve water quality conditions throughout the watershed.

Amos Lake is currently classified as being at the mesotrophic-eutrophic boundary, based on current water quality data. In order to determine the nutrient load reductions necessary to meet desired water quality standards for Amos Lake, ECCD utilized a methodology presented by Taylor in *A Connecticut Lakes Management Program Effort* (1979). This methodology is based on Vollenweider's conceptual models (Vollenweider, 1968 and 1974) and can be used to infer a lake's natural trophic state. Using Taylor's methodology, the natural trophic tendency of Amos Lake appears to be in the late oligotrophic state. ECCD compared average total phosphorus and nitrogen concentrations for water samples collected in the spring and summer of 2013 to the oligotrophic defining range to determine nutrient reductions necessary for Amos Lake to meet the target trophic state. Based on water quality data collected in Amos Lake in 2013, a phosphorus concentration reduction of 64% and a nitrogen concentration reduction of 55% are recommended to reduce nutrient levels to those consistent with Amos Lake's natural trophic state.

In-Lake Nutrient and Chlorophyll-a reductions recommended to meet target trophic state

Water Quality Parameter	2013 Amos Lake Average Value	Trophic State - CT Water Quality Standards	CT Water Quality Standards Trophic State Defining Range	Oligotrophic State Defining Range	Reduction needed %
Total Phosphorus	27.4 µg/l	mesotrophic	10-30 µg/l spring and summer	0-10 µg/l spring and summer	**64%**
Total Nitrogen	447 µg/l	mesotrophic	200-600 µg/l spring and summer	0-200 µg/l spring and summer	**55%**
Chlorophyll-a	22 µg/l	eutrophic	15-30 µg/l mid-summer	0-2 µg/l mid-summer	**91%**

Watershed pollutant load reductions have been provided to reduce common NPS pollutants in the Amos Lake watershed. In order to provide a baseline against which current pollutant loading could be compared, a pre-developed watershed load was calculated, using a forested condition as a typical pre-development land cover for Connecticut. Based on nutrient loads associated with various land covers and land uses that were determined using the Simple pollutant load model, phosphorus load reductions ranging from 56 – 92%, and nitrogen load reductions ranging from 52 – 81% are recommended throughout the sub-watersheds to bring nutrient loads within the pre-developed load range of the Amos Lake watershed.

Pre-developed pollutant loads and recommended load reductions to improve water quality in the Amos Lake Watershed.

Annual Load for Pollutant Type (lb/yr)	TSS	TP	TN	Zn	TPH	DIN
Pre-developed Amos Lake WS	60,053	109	1,079	0	0	126
Amos Lake WS at Current Development	256,201	470	4,219	53	599	494
Recommended Load Reduction (%)	77%	77%	74%	100%	100%	74%

Recommended Pollutant Load Reductions by Sub-Watershed

Sub-Watershed	TSS Load lb/yr	% Load Red.	TP Load lb/yr	% Load Red.	TN Load lb/yr	% Load Red.	Zn Load lb/yr	% Load Red.	TPH Load lb/yr	% Load Red.	DIN Load lb/yr	% Load Red.
Bunny Lane Watershed	24,979	76%	29	73%	368	74%	2	100%	27	100%	34	62%
Preston City Watershed	97,517	81%	148	83%	1,389	79%	19	100%	173	100%	174	78%
Vineyard Watershed	38,388	87%	65	92%	541	86%	12	100%	115	100%	94	89%
Fish Pond watershed	13,953	49%	21	57%	236	52%	2	100%	29	100%	33	54%
Hollowell Rd Watershed	37,945	81%	47	82%	599	81%	6	100%	73	100%	63	76%
Remaining watershed	76,066	78%	119	56%	1,127	66%	20	100%	224	100%	155	78%

1.9. Best Management Practice Recommendations

This Plan outlines management strategies intended to improve the water quality of Amos Lake by reducing the loading of phosphorus and nitrogen, as well as other nonpoint source (NPS) pollutants, as enumerated in Sections 6 and 7 of this Plan. A variety of management strategies are provided to target the pollutant sources identified in Section 5. Management strategies include short and long-term, non-structural and structural controls and actions that vary in relative effort and cost that can be adopted and implemented by a wide variety of stakeholders. Management recommendations are intended to address and reduce existing pollutant loads and prevent future sources of pollutant loading to Amos Lake.

Recommended BMPs include:

- Establishment of a Watershed Management Team to oversee the implementation of the Amos Lake Watershed-Based Plan
- Municipal Land-Use Regulation and Policies Review
- Implementation of Agricultural BMPs
- Adoption of Wildlife/Pet BMPs

- Septic System BMPs
- Municipal Stormwater/NPS Management
- Connecticut Department of Transportation (CTDOT) Stormwater/NPS Management
- Homeowner Stormwater/NPS Management
- In-lake Management
- Water quality monitoring

1.10. Education and Outreach

The objective of a successful education/outreach campaign is to raise awareness of the water quality issues associated with Amos Lake, in order to create an educated populace that understands the issues of nutrients and NPS and its effects on water quality, and actions that can be taken to address the problem. The table below provides potential outreach topics, as well as potential partners to assist with outreach. By successfully educating and engaging the public, this Plan should lead to behavioral change that should result in reduction of nutrients and other NPS pollutants to Amos Lake.

Amos Lake Watershed Outreach & Education Topics and Partners.

Outreach Topic	Potential Outreach Partner
Agricultural Best Management/ Conservation Practices	UConn Cooperative Extension System, NRCS, CT Department of Agriculture
Benefits of vegetated riparian buffers	CT SeaGrant
Boating BMPs	CT DEEP Boating Division
Integrated Pest Management	UConn Cooperative Extension System
Invasive plant identification and control	CT Invasive Plant Work Group (CIPWG), Invasive Plant Atlas of New England (IPANE)
Lake Health and Water Quality	CT DEEP, CFL, NALMS
Land Care	UConn Cooperative Extension System, NOFA-CT Chapter
Land Protection	Town of Preston, local/regional land trusts, Connecticut Farmland Trust, USDA NRCS, CT DEEP, CT Department of Agriculture
Low impact development (LID)/Green Infrastructure (GI) Planning	CT NEMO/CLEAR
Municipal Stormwater BMPs	CT DEEP, NEMO, SCCOG
Non-migratory Waterfowl BMPs	CT DEEP
Septic system BMPs for Homeowners	CT DPH, Preston Health Department
Small Farm BMPs	UConn Cooperative Extension System, ECCD
Understanding NPS Pollution	CT NEMO, Town of Preston, ECCD, CT DEEP

1.11. Financial and Technical Assistance

Watershed municipalities have local funding options, including bonding, capital improvement budgets, and department budget line items that can be utilized to fund water quality improvement implementations and municipal outreach efforts. Funds may also be available in the form of donations and in-kind services provided by local businesses, community and environmental organizations, and local volunteers. Financial assistance in the form of grants and cost sharing is available from multiple sources, including federal, state, and local sources, as identified in the table below.

Potential funding sources for management recommendations.

Funding Source	Contact Information
CT DEEP CWA §319 Grant Program http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325588&depNav_GID=1654	
CT DEEP Clean Water Fund http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325578&depNav_GID=1654	Susan Hawkins (860) 424-3325
CT DEEP Long Island Sound License Plate Program http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635	Kate Brown (860) 424-3034
CT OPM Small Town Economic Assistance Program (STEAP) http://www.ct.gov/opm/cwp/view.asp?a=2965&q=382970&opmNav_GID=1793	Barbara Rua (860) 418-6303
US EPA Healthy Communities Grant Program http://www.epa.gov/region1/eco/uep/hcgp.html	Jennifer Padula (617) 918-1698
NOAA Coastal Management Programs http://coastalmanagement.noaa.gov/funding/welcome.html	
US EPA Five Star Restoration Grant Program http://www.epa.gov/owow/wetlands/restore/5star	Myra Price (202) 566-1225
NFWF Grant Programs http://www.nfwf.org/whatwedo/grants/Pages/home.aspx#.VSw63ZNuOVo	
NRCS Wetlands Reserve Program (WRP) http://www.ct.nrcs.usda.gov/programs/whip/whip.html	Javier Cruz (860) 887-3604 x307
NRCS Environmental Quality Incentives Program (EQIP) http://www.ct.nrcs.usda.gov/programs/eqip/eqip.html	Javier Cruz (860) 887-3604 x307
Rivers Alliance of CT Watershed Assistance Small Grants Program http://www.riversalliance.org/watershedassistancegrantrfp.cfm	Rivers Alliance of CT (860) 361-9349

1.12. Monitoring and Assessment

Monitoring is an essential component to determining the effectiveness of Plan implementations, and whether adjustments need to be made within an adaptive management framework. On-going monitoring will provide necessary water quality data to allow watershed managers to assess the effectiveness of BMPs. Water quality monitoring should be coordinated with the implementation of management measures to determine if the desired results (a reduction in nutrient levels entering Amos Lake) are being achieved.

1.13. Plan Implementation Effectiveness

As implementations are undertaken and completed, water quality data should continue to be collected, evaluated and compared to water quality targets to determine if the implementations are achieving the desired results and that improvements to water quality are sustained. Implementation should be considered successful when the water quality targets are reached or exceeded. If implementations are not as effective as planned, watershed stakeholders should investigate the effectiveness of selected BMP practices, and may revise the watershed plan as necessary.

1.14. Next Steps

This section outlines steps to be taken once the Plan is adopted to launch implementation of Plan recommendations. Key among these is the distribution of the Plan to all stakeholders, the formation of a watershed management team to guide implementation efforts, the creation of a watershed identity or brand, and the promotion of the Plan to raise public awareness and increase public engagement in the watershed process.

The degradation of water quality in Amos Lake is a process that has occurred incrementally over many years. Likewise, the process of addressing water quality issues in Amos Lake will be a long term effort. The successful implementation of this watershed plan by a watershed management team that represents the interests of all stakeholders in Amos Lake watershed and the broader Preston community should result in the improvement of water quality in Amos Lake, allowing all the designated uses for this waterbody, including fishing and swimming, to be realized.

The Eastern Connecticut Conservation District intends to remain an active participant and central point of contact as the implementation of this Watershed-Based Plan is undertaken.

Any comments or questions regarding this Plan should be directed to:

Eastern Connecticut Conservation District
238 West Town Street
Norwich, CT 06360
(860) 887-4163 ext. 400

2 Introduction

2.1 Document Overview

Amos Lake is a 115-acre impoundment of an unnamed stream that originates in a wetland system north of State Route 165 in the Preston City section of Preston, Connecticut. Amos Lake has been listed for several cycles, most recently in 2014, in the State of Connecticut Integrated Water Quality Report to Congress, which is a biannual assessment of the quality of waters in the state required as part of the Clean Water Act, as impaired for recreation due to high levels of chlorophyll-a, excess algal growth, and nutrient/eutrophication biological indicators believed to be associated with nutrient enrichment from potential sources including stormwater and other unidentified upstream sources.

The Eastern Connecticut Conservation District (ECCD) conducted a water quality investigation of Amos Lake in order to identify potential sources of nutrient loading that have degraded water quality. ECCD, in consultation with CT DEEP and Northeast Aquatic Research, LLC, designed a water quality investigation for Amos Lake. In 2012 and 2013 ECCD and local volunteers from The Last Green Valley Volunteer Water Quality Monitoring Program and the Amos Lake Association, collected water quality and quantity data and water samples from Amos Lake and its tributaries in order to determine both physiochemical water quality parameters and nutrient levels. ECCD partnered with researchers from Nichols College, in Dudley, Massachusetts and local volunteers to install stream gauges and collect stream flow data to determine nutrient flux. The collected data was used to calculate nutrient loading to Amos Lake and to determine if in-lake nutrient cycling played a role in the observed water quality conditions.

Based on the information gathered, ECCD prepared this abbreviated nine-element watershed-based plan. This Plan recommends management practices for watershed managers that address the documented areas of concern, with the goal of reducing nutrient and NPS pollution contributions to Amos Lake, in order to meet Connecticut Water Quality Standards.

2.2 Watershed Management Plan Purpose and Process Used

The purpose of this document is to provide strategies to prevent further degradation of water quality and guidance to restore the quality of water in Amos Lake to meet Connecticut Water Quality Standards. The following pages will provide a description of the watershed including the current watershed condition. Potential pollution sources were assessed and described and the impacts to water quality estimated. Goals and objectives to reduce the pollution load were developed, and management strategies prepared to meet those goals are outlined.

2.2.1 Watershed Management Team

The watershed planning process is a collaborative and participatory process. The staff of the Eastern Connecticut Conservation District collaborated with the following organizations in the research and preparation of the Amos Lake Watershed-Based Plan:

Table 2-1. Organizations involved with the development of the Amos Lake Watershed-Based Plan.

Organization	Description
Eastern Connecticut Conservation District	Project Management, Water Quality Monitoring Team Leader, Education and Outreach, Watershed-Based Plan Development
Amos Lake Association	Local source of information, water quality monitoring volunteers, education and outreach.
The Last Green Valley	Support of Volunteer Water Quality Monitoring Efforts
CT Department of Energy and Environmental Protection Bureau of Water Protection and Land Reuse	Project oversight and guidance, professional consultation
US Environmental Protection Agency	Project funding through Clean Water Act §319 program, QAPP approval
CME Associates, Inc.	Project planning
Northeast Aquatic Research	Project planning, data interpretation
Town of Preston staff	Data acquisition and project updates
Connecticut Agricultural Experiment Station	Aquatic Vegetation Resurvey of Amos Lake
Connecticut Coast Guard Academy Cadets	Research and presentation of Low Impact Development/Green Infrastructure opportunities around Amos Lake
Dr. Mauri Pelto, Nichols College	Installation and calibration of stream staff gage rulers and development of flow curve from the volunteer-collected data

2.2.2 Public Participation

The participation of an engaged and committed public is critical to the successful implementation of a watershed plan. Local stakeholders have the greatest interest in the resource of concern, and will likewise derive the greatest benefit from the resolution of the concern in question. A well-balanced stakeholder team should consist of a variety of members of the community, and may include municipal officials and commissioners, business owners, landowners, environmental and civic organizations, as well as any other organizations, agencies or individuals with a stake in the preservation and improvement of water quality in the watershed.

In order to ensure successful implementation of a watershed-based plan, the Eastern Connecticut Conservation District engaged a variety of stakeholders to be involved in the development and implementation of the Amos Lake Abbreviated Watershed-based Plan. These stakeholders were variously involved with the water quality investigation, the development of this watershed plan, and the identification of potential implementation measures. Once the watershed plan has been approved, it will be incumbent upon the stakeholders to adopt the Plan and implement the management recommendations contained therein.

Table 2-2. Public participatory events conducted in conjunction with the development of the Amos Lake Watershed-Based Plan.

Date	Event	Description
Jan 2012	Preston Board of Selectman Meeting	Project introduction
Feb 2012	Amos Lake Association Meeting	Project introduction, volunteer recruitment
May 2012	Amos Lake Association Meeting	Education and Outreach, water quality monitoring volunteer training (annual event)
May – October 2012	Amos Lake Monitoring	Education and outreach, data collection
September 2012	Meeting with Coast Guard Academy Engineering Students and Amos Lake Association	Discuss project to review watershed for LID opportunities
April 2013	The Last Green Valley Water Quality Monitoring Program	Water quality monitoring training (annual event)
April 2013	Coast Guard Academy Cadets	Present LID opportunities to ALA.
April – October 2013	Amos Lake Monitoring	Education and outreach, data collection
May 2014	Amos Lake Association Meeting	Present recommendations in draft watershed-based plan to the local community; solicit plan input
December 2014	Northeast Aquatic Research Presentation	Presentation of analysis of water quality monitoring results

3 Watershed Description

3.1 Physical and Natural Features

Amos Lake is located in eastern Connecticut, in the town of Preston (Fig. 3-1). The Amos Lake watershed is 1.5 square miles (960 acres) and is part of the Shewville Brook sub-regional watershed (CT3002) and the Thames Main Stem regional watershed (CT3000). The northern limits of the Amos Lake watershed are located just north of Preston City at Prospect Hill. The western limits extend west of Route 164 to Branch Hill. The southern and eastern limits generally follow Hollowell and Northwest Corner Roads. Amos Lake is a natural lake that has been further impounded by a small cobble and boulder dam at the lake outlet. The primary perennial tributary to Amos Lake is an unnamed stream that originates in a wetland system north of State Route 165 in the Preston City section of Preston.

3.1.1 Amos Lake

Amos Lake is a natural lake with a surface area of approximately 115 acres (Table 3-1 and Fig. 3-2). The mean depth is 18.8 feet. The maximum depth is 45.8 feet. Amos Lake is moderately to highly productive. The water quality investigation conducted by ECCD in 2013 indicated that Amos Lake is at the late mesotrophic/early eutrophic boundary. Spring composite total phosphorus and total nitrogen concentrations were 27 parts per billion (ppb) and 409 ppb, respectively. Spring/summer total phosphorus and total nitrogen concentrations averaged 27 ppb and 447 ppb respectively. Summer surface total phosphorus and total nitrogen concentrations averaged 27 ppb and 501 ppb, respectively. This data places the lake in the middle to late mesotrophic state. Mid-summer chlorophyll-a concentrations averaged 22.2 ppb and Secchi disk measurements averaged 1.9 meters, placing the lake in the early eutrophic state (2011 CT Water Quality Standards).

Table 3-1. Morphometric characteristics of Amos Lake.

Parameter	English Units		Metric Units	
Lake Surface Area =	115	acres	465,389	m^2
Littoral Area =	46	acres	157,828	m^2
Profundal Area (< 10 ft.)	69	acres	307,561	m^2
Watershed Area (Total)	920	acres	3,723,111	m^2
Lake/Watershed Area	11.1	%		
Lake Volume	2,160	acre-ft.	951,625	m^3
Mean Depth	18.8	feet	5.7	m
Maximum Depth	45.8	feet	14.0	m
Mean Depth/Maximum Depth	0.410	Ratio		
Estimated Residence Time	436	Days		
Estimated Flushing Rate	0.84	times / year		

Source - NEAR (2014)

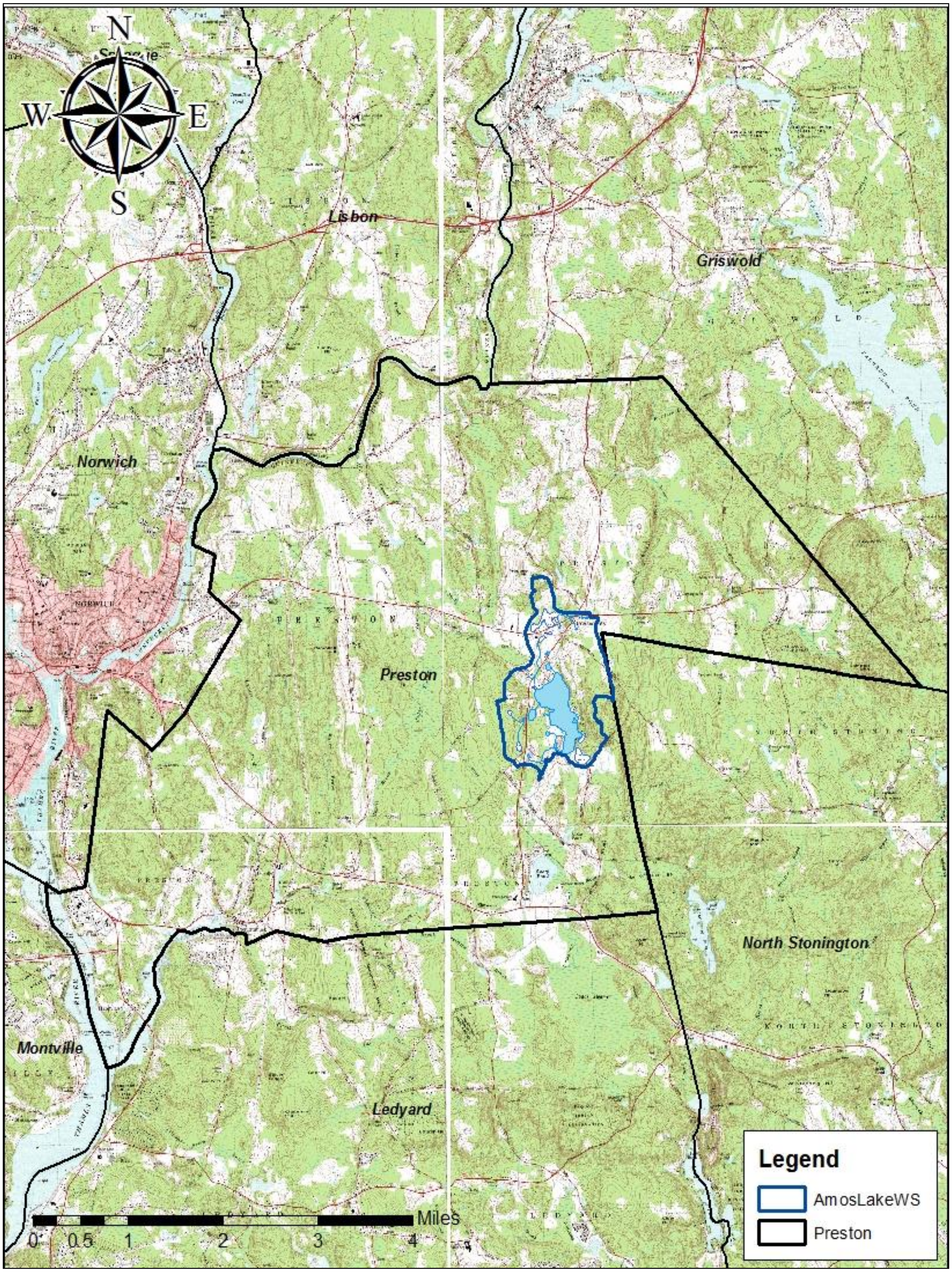
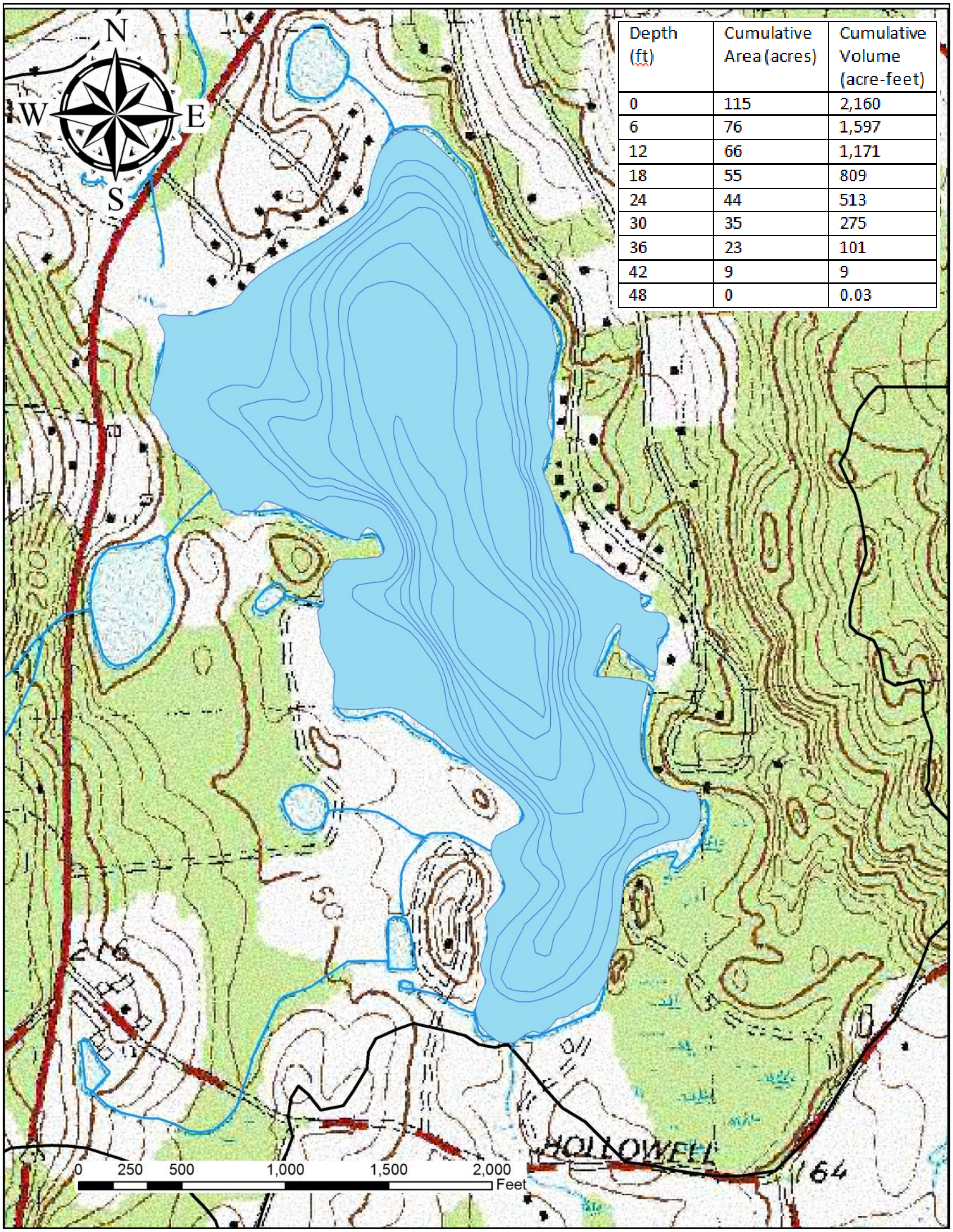


Figure 3-1. Amos Lake and the Amos Lake watershed within the Town of Preston, CT.



Depth (ft)	Cumulative Area (acres)	Cumulative Volume (acre-feet)
0	115	2,160
6	76	1,597
12	66	1,171
18	55	809
24	44	513
30	35	275
36	23	101
42	9	9
48	0	0.03

Figure 3-2. Amos Lake Bathymetry

3.1.2 Hydrology

The hydrology of the Amos Lake watershed is generally influenced by topography and the presence of substantial stratified drift deposits. There are four defined stream channels that flow into Amos Lake. All are either first or second order streams and none are named. Only one stream, which originates in a wetland system in the Preston City area, north of Route 165, appears to be perennial or flowing year-round. The remaining streams were observed to dry up during the summer months. The Amos Lake outlet stream flows into Shewville Brook and eventually to the Thames River through Poquetanuck Cove, a tidal estuary of the Thames River. Staff gauges were installed on the perennial stream just upstream of the inlet to Amos Lake and at the Amos Lake outlet to estimate inflow to and discharge from Amos Lake. Flows into Amos Lake from the perennial stream ranged from 0.3 to 4.4 cubic feet per second (cfs), and averaged 0.9 cfs. Flows from the outlet stream ranged from 0.08 to 14.7 cfs, with an average of 2.2 cfs.

3.1.3 Climate/Precipitation

Preston, CT has a humid continental climate, characterized by large seasonal temperature differences, with cold (sometimes frigid) winters and hot humid summers. Average annual rainfall in Preston is 48 inches a year. The average annual snowfall is 24 inches. Precipitation is generally well-distributed throughout the year. The average annual temperature range in the southeastern part of Connecticut is 29 – 87 degrees Fahrenheit (º F), although daily temperatures may range from below 0º F during the winter to above 100º F in summer. Average summer temperature is 68. Average winter temperature is 42.

3.1.4 Surface Water Resources

Amos Lake and its perennial tributaries have surface water quality classifications of AA based on use goals established through the Connecticut Water Quality Standards (Fig. 3-3). Water quality classifications serve to establish designated uses for surface and ground waters and identify criteria necessary to support those uses. Designated uses in Class AA surface waters include existing or proposed drinking water supply; fish and wildlife habitat; recreational use (may be restricted); and agricultural and industrial supply. Permitted discharges are restricted to discharges from public or private drinking water treatment systems; dredging and dewatering; and emergency and clean water discharges (State of CT Department of Environmental Protection Water Quality Standards, 2011). There are no known water quality impairments of the streams that flow to Amos Lake.

3.1.5 Groundwater Resources

Groundwater within the Amos Lake watershed is classified as GAA (Fig. 3-4). Designated uses for Class GAA groundwater include existing or potential public supply of water suitable for drinking without treatment; and baseflow for hydraulically-connected surface water bodies. Discharges in Class GAA waters are limited to treated domestic sewage, certain agricultural wastes, and certain water treatment wastewaters. A potential high yield stratified drift aquifer located between the Preston City area and Amos Lake has been identified by regional and state authorities. A review of existing records indicates no water diversion registrations or permits have been issued by CT DEEP in the Amos Lake watershed.

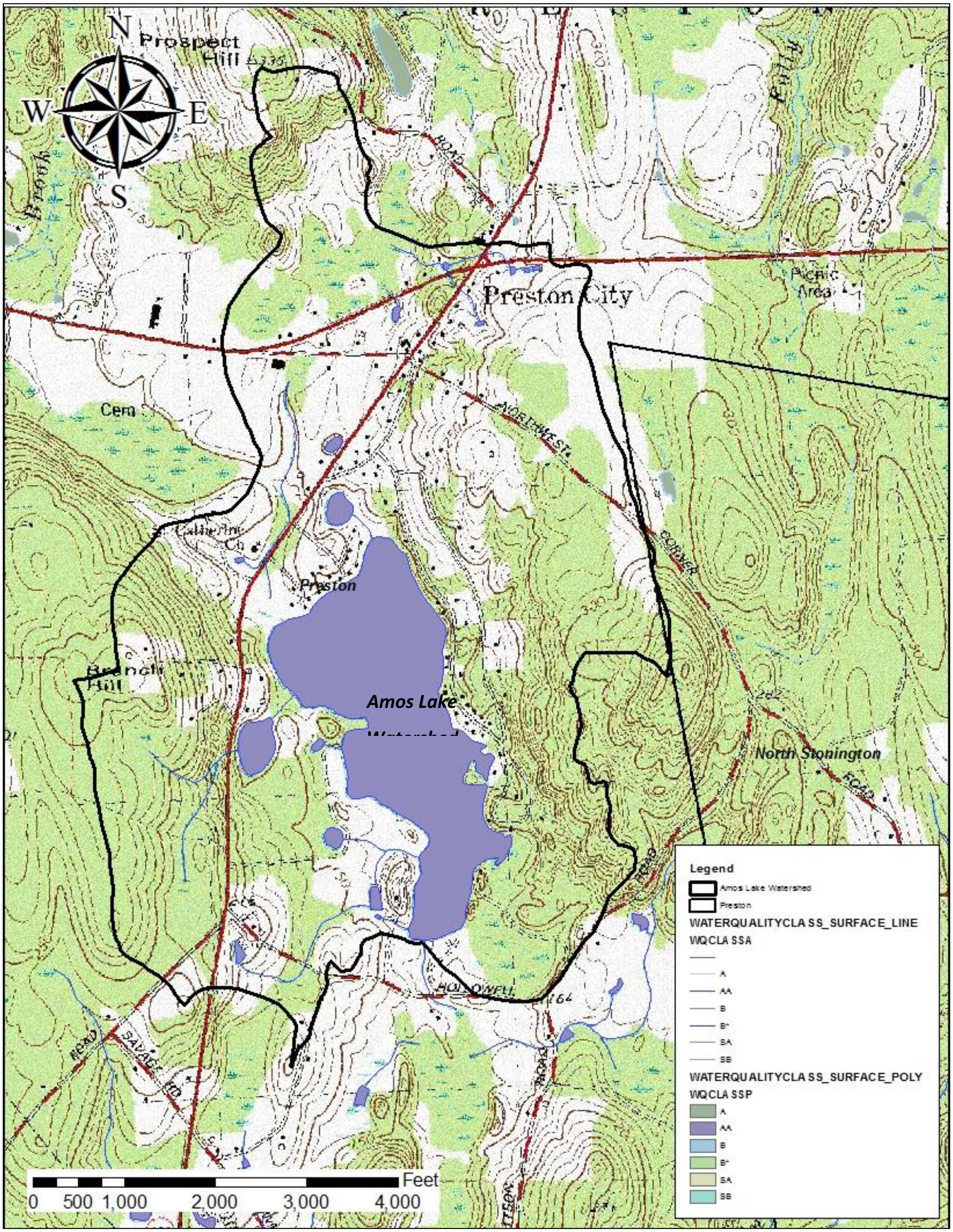


Figure 3-3. Amos Lake Surface Water Classification (CT DEEP 2012).

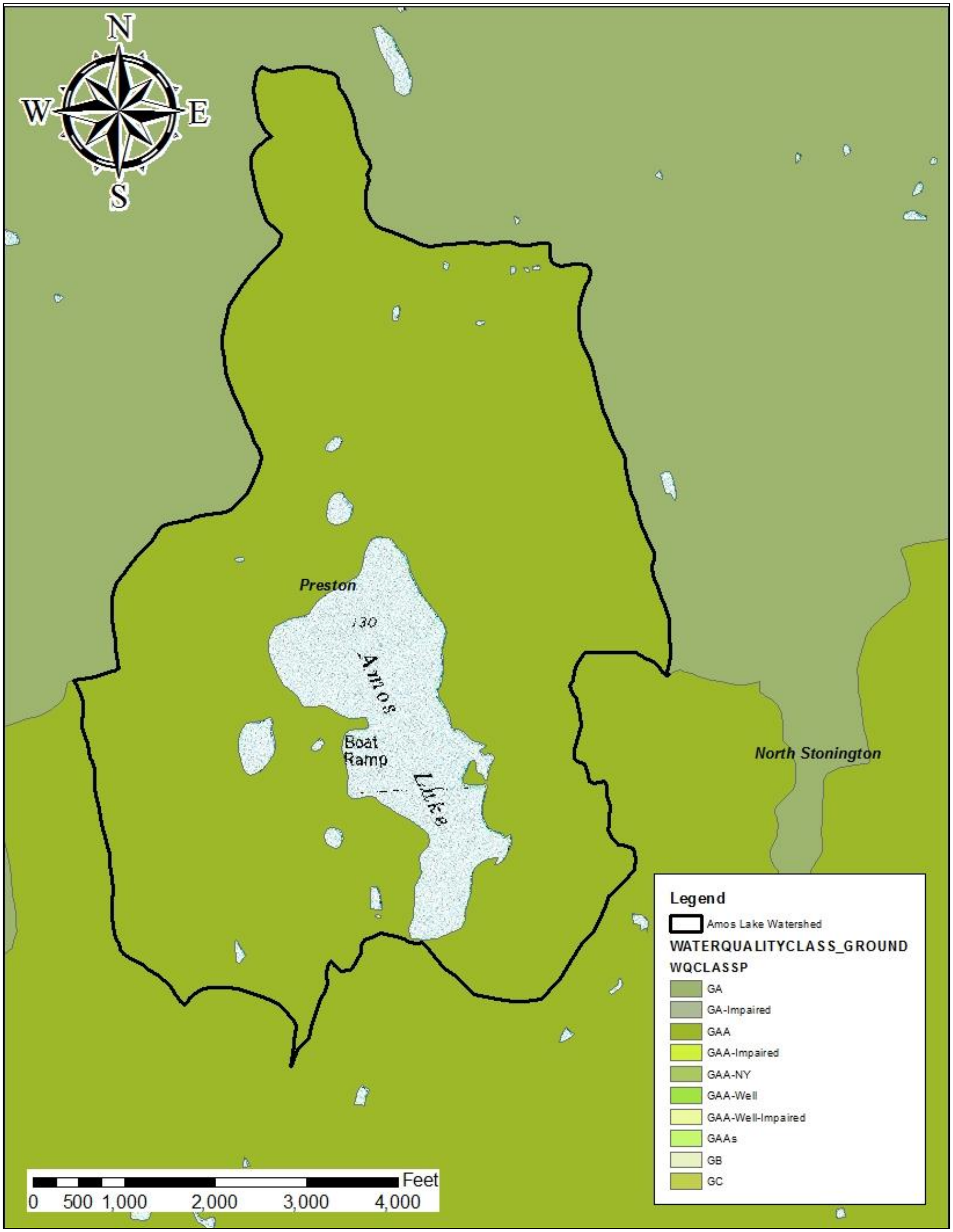


Figure 3-4. Amos Lake Ground Water Classification (CT DEEP 2012).

3.1.6 Wetlands and Floodplains

The Connecticut Inland Wetlands and Watercourse Act (Sections 22a-36 through 22a-45 of the General Statutes of Connecticut) defines wetlands by soil type and drainage classification. Wetland soils include poorly drained, very poorly drained, alluvial, and floodplain. There are approximately 53 acres of wetlands in the Amos Lake watershed. These wetlands are primarily small and wooded, and are scattered in low-lying areas throughout the watershed. There is one open marsh wetland located in the northern part of the watershed in Preston City. Figure 3-5 depicts the distribution of wetlands in the Amos Lake watershed. Figure 3-5 also depicts the location of flood hazard areas in the Amos Lake watershed. Floodplains are low-lying areas, typically located along watercourses, which are subject to periodic inundation. The Federal Emergency Management Agency (FEMA) identifies flood hazard areas that are subject to 100 year and 500 year floods.

3.1.7 Dams

Amos Lake is a natural lake which formed at the end of the last glacial period. At the south end of the lake, a small cobble dam owned by the Amos Lake Campground and Amos Lake Beach Club artificially elevates the lake surface by a few feet. There is no mechanism to raise or lower the water level of the lake, so the dam operates in a run-of-the-river manner. The age of the dam is unknown, but likely dates to the 19th century when the lake was dammed to provide water power to a downstream mill.

3.1.8 Topography/Elevation

Amos Lake is located among northwest-to-southeast-trending hills (Fig. 3-6). Elevation relief in the watershed is 270 feet. The highest elevation of 400 feet above mean sea level is located in the hills to the east of Amos Lake, while the lake itself is at 130 feet above mean sea level. As is typical of the glacially-influenced topography of Connecticut, landscape features trend northwest to southeast across the landscape.

3.1.9 Geology and Soils

Preston is located in the Eastern Uplands of Connecticut. Preston's surface features and topography were formed more than 12,000 years ago as the Laurentian ice sheet passed over New England, “grinding and gouging the earth to produce the present-day hills and valleys. The glaciers and the waters from the melting ice deposited layers of crushed stone, ranging in size from coarse- and fine-grained sand and gravel to boulders (2003 Preston Plan of Conservation and Development).” The bedrock geology of the Amos Lake watershed is comprised primarily of two formations of the Iapetos (Oceanic) Terrane dating from the Ordovician period (435-500 million years ago): the Quinebaug formation, a gray to dark-gray, medium-grained, well-layered gneiss, and the Tatnic Hill formation, a gray to dark-gray, medium-grained gneiss or schist. Minor amounts of Preston gabbro and a felsic gneiss member of the Quinebaug formation are located in northwest and southeast portions (respectively) of the watershed.

Soils in the Amos Lake watershed are comprised of glacially-derived lodgment and melt-out tills in the upper elevations, and glacio-fluvial and organic soils in the lower elevations, with the minor placement of udorthent (urban land complex) soils along Route 165 in the northwest portion of the watershed (Fig. 3-7). The central portion of the Amos Lake watershed, including Amos Lake, is underlain by an extensive northwest to southeast-trending layer of coarse-grained stratified drift comprised of sand and gravel overlying sand (Fig. 3-8). Dominant soils in the watershed include Hinckley gravelly sandy loams (19%) in lower elevations, and Canton and Charlton soils (32%) in the upper elevations (Fig. 3-9). Hinckley gravelly sandy loams are excessively drained, sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss. Canton and Charlton soils are somewhat excessively drained melt-out tills derived from granite and/or schist and/or gneiss. Approximately 44% of soils in the Amos Lake watershed are designated by the Natural Resources Conservation Service (NRCS) as farmland soils. Of those, 22.2% are designated prime farmland soils, and 22.1% are designated statewide important farmland soils (Fig. 3-10).

3.1.10 Vegetation

Vegetation in the Amos Lake watershed is comprised primarily of deciduous forest (34%) with a small amount of coniferous forest (4%). Turf lawns and other grassed spaces account for 11% of the watershed, and lands under agricultural use (cropland or pasture) comprise approximately 16% of the watershed. Forested wetlands (typically red maple swamps) comprise 5% of the watershed, while non-forested wetlands (scrub-shrub swamps) represent less than 1%. The remainder of the watershed is open water or developed land (CLEAR, 2010).

3.1.10.1 Aquatic Plant Survey

An aquatic plant survey of Amos Lake was conducted by the Connecticut Agricultural Experiment Station in 2006 and again in 2013 (Figs. 3-11 and 3-12). The 2006 CAES survey identified *Potamogeton robbinsii* (Robbin's pondweed, native) as the dominant submerged plant. *P. robbinsii* was found almost continuously around the perimeter of the lake. *Nymphaea odorata* (white water lily) was the most abundant floating-leaved plant, found in most protected coves and along the western shoreline. The only invasive plant species identified during the survey was *Myriophyllum heterophyllum X laxum* (variable watermilfoil). Other aquatic plant species identified in the northern half of the lake include *Potamogeton gramineus, Myriophyllum tenellum, Nuphar variegata, Potamogeton pulcher. Sagittaria sp*., and *Utricularia gibba.* Aquatic plant communities were more diverse in the southern part of the lake, particularly in coves, and included *Brasenia schreberi, Ceratophyllum demersum, Glossostigma cleistanthum, Myriophyllum heterophyllum x laxum* (invasive), *Najas flexilis, Nymphaea odorata, Nuphar variegata, Pontederia cordata, Potamogeton epihydrus, Potamogeton gramineus, Potamogeton pulcher, Potamogeton robbinsii, Utricularia purpurea, Utricularia radiate* and *Utricularia vulgari* .

The 2013 vegetative survey of Amos Lake was a resurvey from 2006. Similar to 2006, *Myriophyllum heterophyllum* was the only invasive found in the lake. It was found growing in a medium patch in the northwest portion of the lake and also as singular plants in two other locations. Also similar to 2006, *Potamogeton robbinsii* was the most commonly found plant. However, the area covered by *P. robbinsii, Vallinseria americana* (eelgrass), and *Nymphaea odorata* increased from the 2006 survey. Frequency of occurrence of *P. robbinsii* along 12 transects (120 points) increased from 36.7% to 47.5% from 2006 to 2013. Overall, vegetation seemed to increase in the 2013 survey. Dense plant populations tended to be found in the coves along the east and west shorelines of the lake. The north and south shorelines had less dense vegetation and also lower species richness. Generally, low-lying plants typical of shorelines were growing along the north and south shorelines. These plants included: *Elatine* species, *Eleocharis species, Glossostigma cleistanthum, Gratiola aurea*, and *Myriophyllum tenellum.* P. robbinsii and *V. americana* was found growing around the majority of the lake in greater than 1 meter of water. Floating leaf plants such as *Brasenia schreberi*, *Nuphar variegata*, and *N. odorata* were found most commonly in the coves around the lake. *Potamogeton bicupulatus* was found in only one location, growing in a medium size patch along the south shore.

Additional information can be found in Appendix A, and at the CAES website at: http://www.ct.gov/caes/cwp/view.asp?a=2799&q=437500

3.1.11 Exotic/Invasive Species

Asian clams (*Corbicula fluminea*), a non-native bivalve species, were documented near the Amos Lake boat launch and first reported to CT DEEP in 2013. When and how they were introduced to Amos Lake is unknown. Asian clams typically burrow into the bottom sediments of streams and lakes and have the ability to feed from both the water column and the substrate. They are both filter feeders, feeding predominantly on phytoplankton, and detritivores, capable of feeding on decaying organic material in the sediments. Their preferred substrate is sand and gravel, but they can survive in a variety of bottom materials. It is illegal to transport Asian clams on a boat or trailer in Connecticut pursuant to Public Act 12-167. No formal study of the distribution of Asian clams in Amos Lake has been conducted.

A small patch of Common Reed (*Phragmites australis*), a grass that can grow up to 20 feet tall, was documented in the northeastern end of the lake. A larger stand of *Phragmites* is located in a wetland system downstream of the Amos Lake outlet stream between the campground and the beach club area. *Phragmites* spreads both by seed and rhizomes. It can develop into dense monocultures that out-compete native plant species, have little food value to native wildlife, and can block lake views from the shoreline.

The invasive aquatic plant Variable Leaf Milfoil (*Myriophyllum heterophyllum X laxum*) was identified by the Connecticut Agricultural Experiment Station (CAES) in the northwest portion of Amos Lake during a 2006 aquatic weed survey and reconfirmed during a 2013 resurvey of the lake (refer to Figs. 3-11 and 3-12).

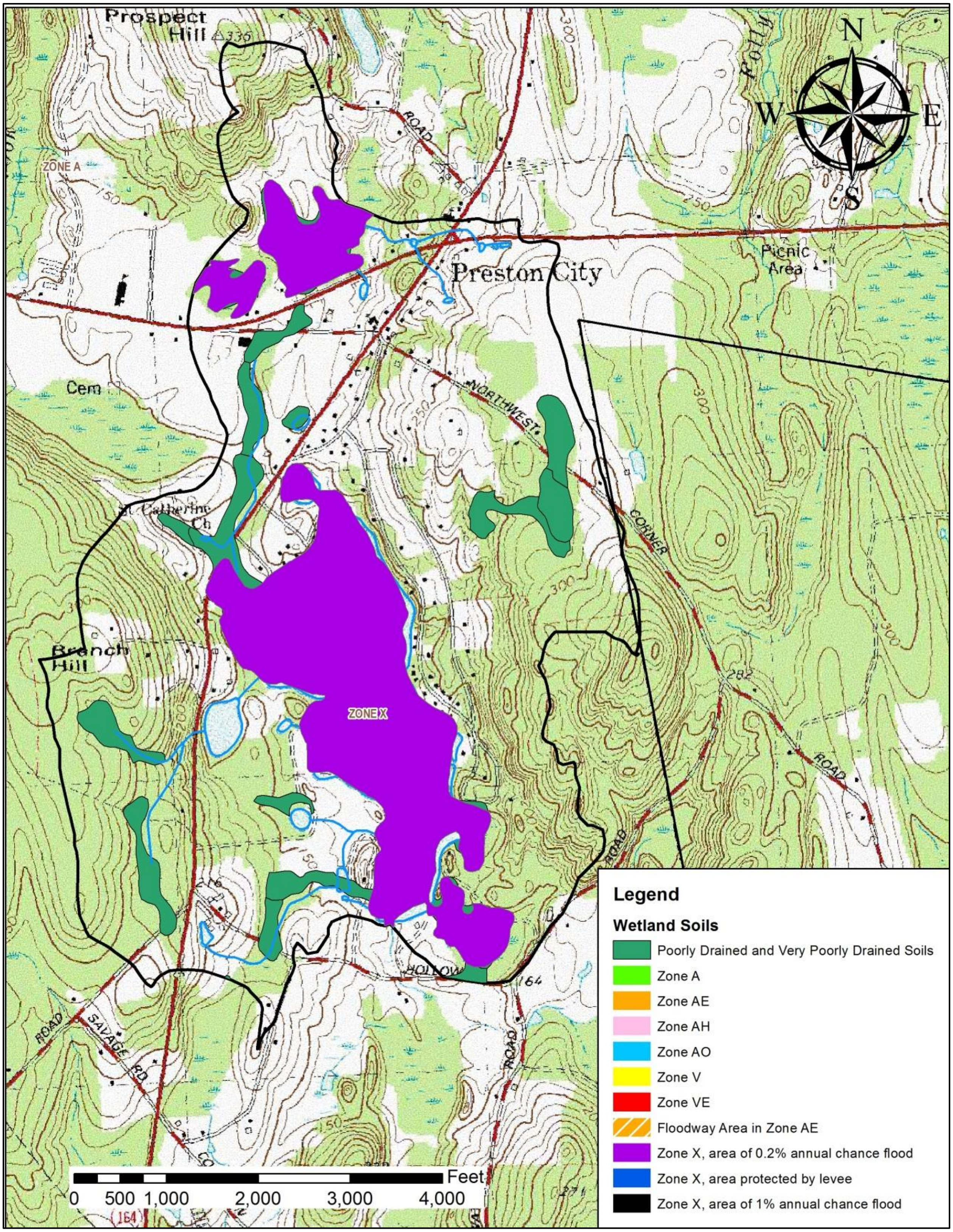


Figure 3-5. Wetland soils and FEMA flood zones in the Amos Lake watershed.

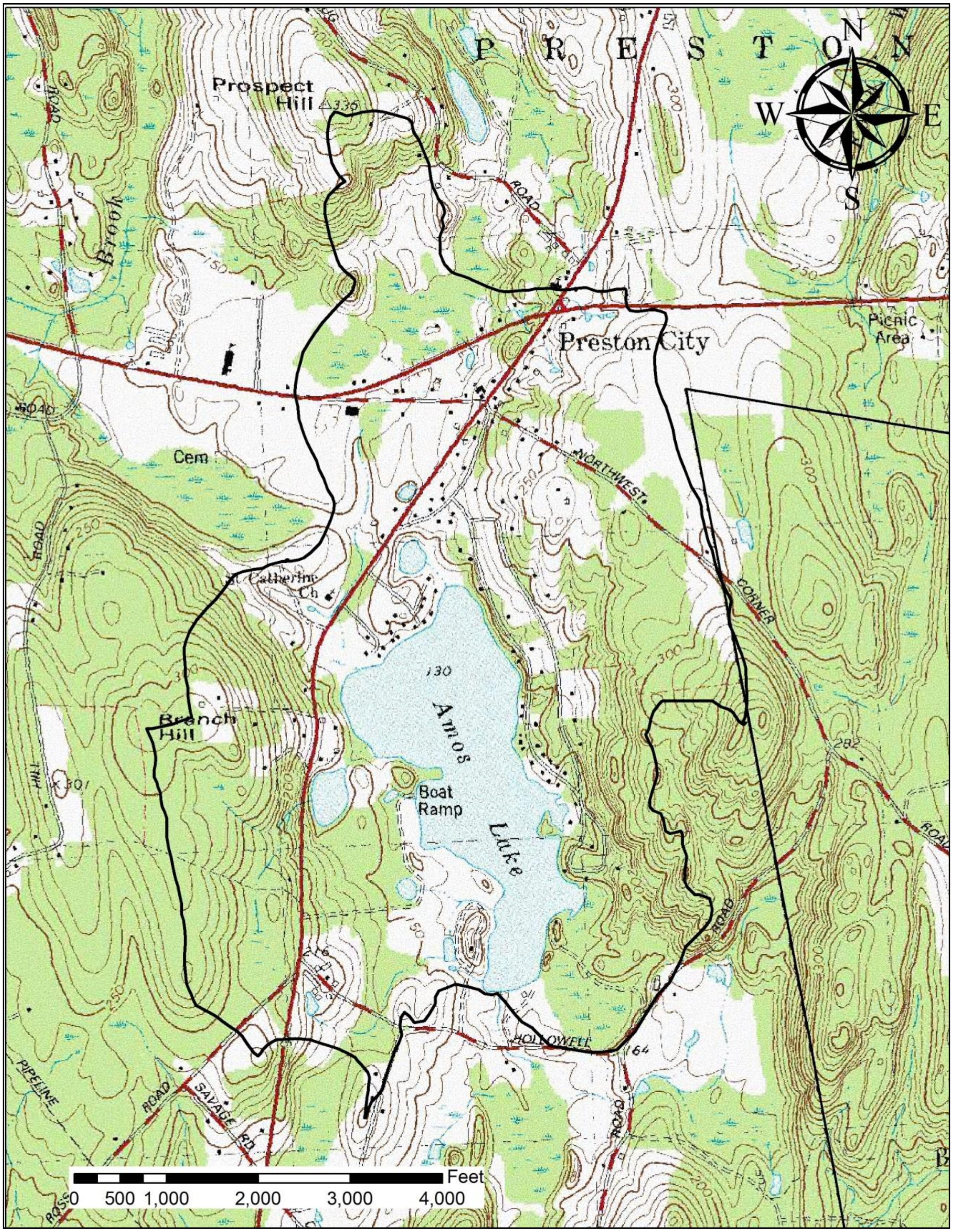


Figure 3-6. Amos Lake Watershed Topography

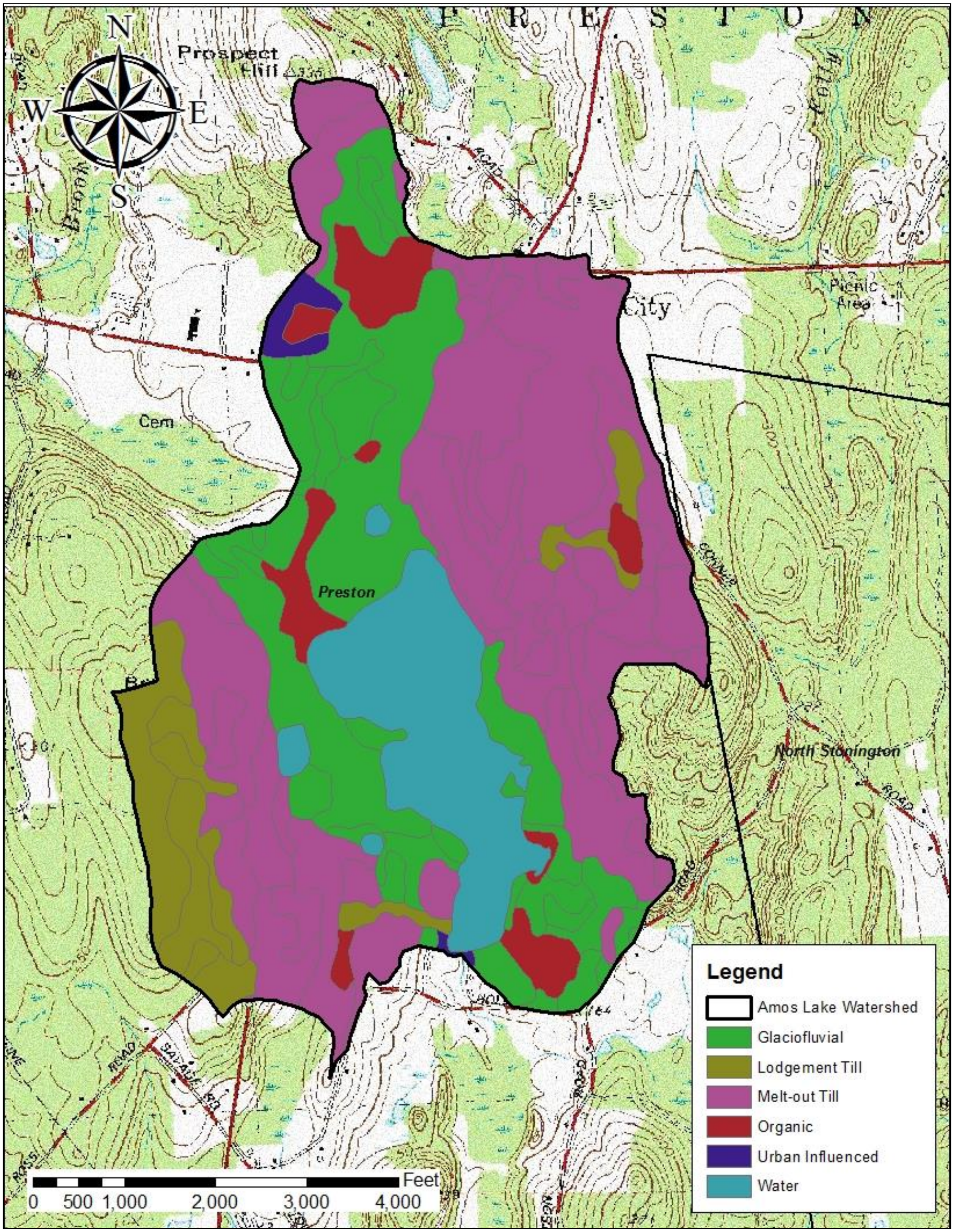


Figure 3-7. Surficial materials in the Amos Lake watershed (SSURGO 2011).

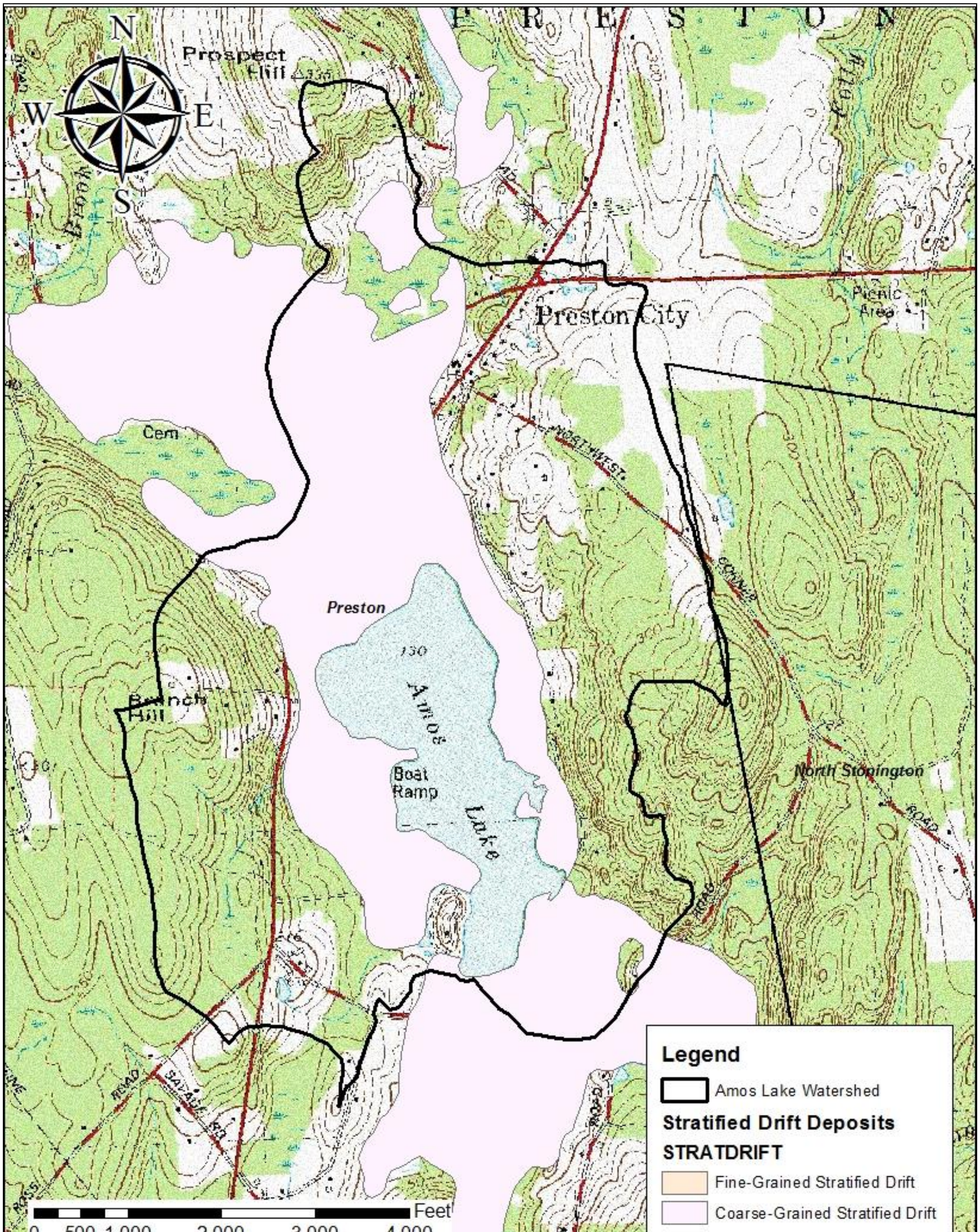


Figure 3-8. Stratified Drift deposits in the Amos Lake watershed.

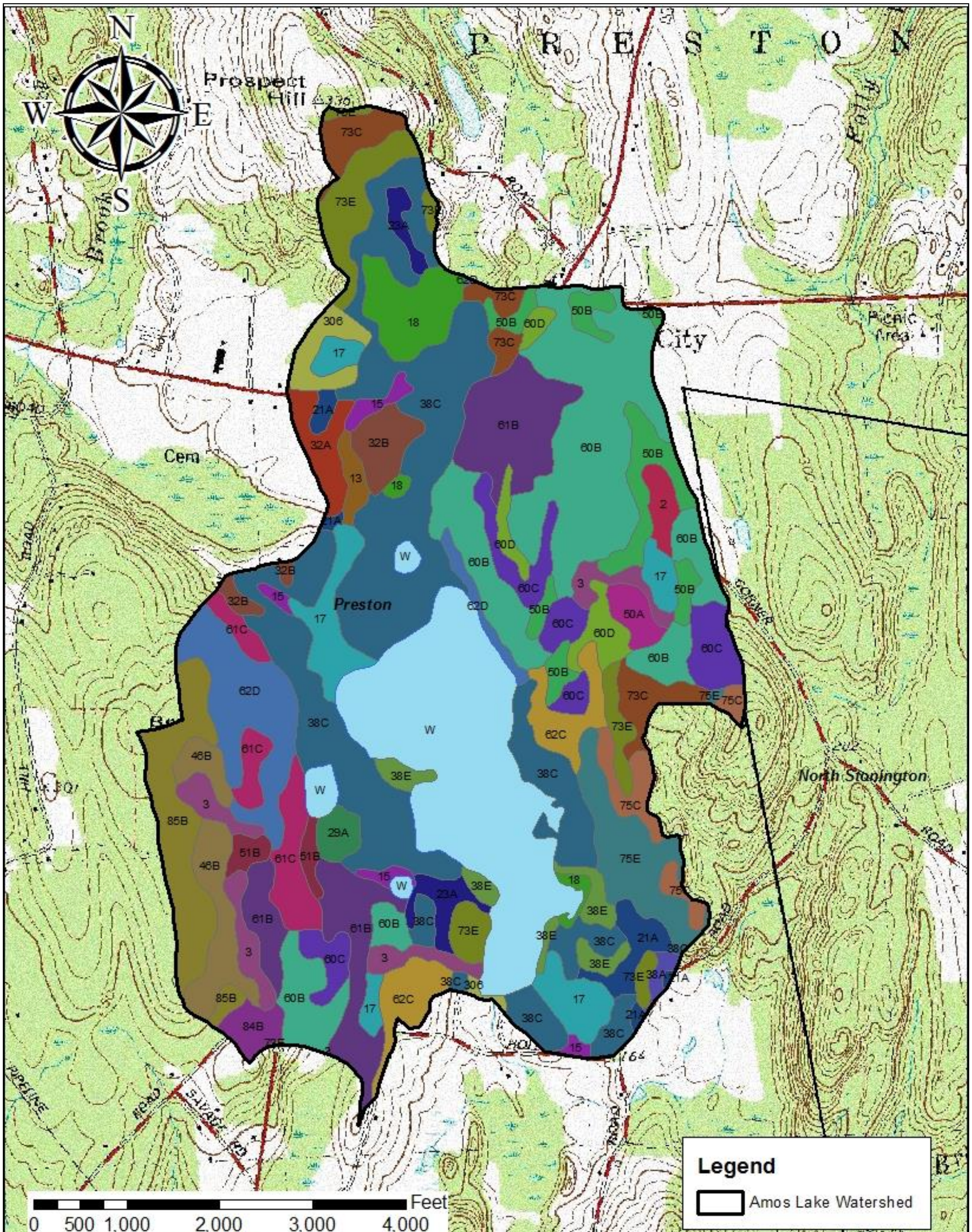


Figure 3-9. Soils in the Amos Lake watershed (CT DEEP).

Table 3-2. Amos Lake watershed soils (SSURGO 2011).

SYMBOL	Soil Description
2	Ridgebury fine sandy loam
3	Ridgebury, Leicester, and Whitman soils, extremely stony
13	Walpole sandy loam
15	Scarboro muck
17	Timakwa and Natchaug soils
18	Catden and Freetown soils
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes
23A	Sudbury sandy loam, 0 to 5 percent slopes
29A	Agawam fine sandy loam, 0 to 3 percent slopes
32A	Haven and Enfield soils, 0 to 3 percent slopes
32B	Haven and Enfield soils, 3 to 8 percent slopes
38A	Hinckley gravelly sandy loam, 0 to 3 percent slopes
38C	Hinckley gravelly sandy loam, 3 to 15 percent slopes
38E	Hinckley gravelly sandy loam, 15 to 45 percent slopes
46B	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
50A	Sutton fine sandy loam, 0 to 3 percent slopes
50B	Sutton fine sandy loam, 3 to 8 percent slopes
51B	Sutton fine sandy loam, 2 to 8 percent slopes, very stony
60B	Canton and Charlton soils, 3 to 8 percent slopes
60C	Canton and Charlton soils, 8 to 15 percent slopes
60D	Canton and Charlton soils, 15 to 25 percent slopes
61B	Canton and Charlton soils, 3 to 8 percent slopes, very stony
61C	Canton and Charlton soils, 8 to 15 percent slopes, very stony
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony
306	Udorthents-Urban land complex
W	Water

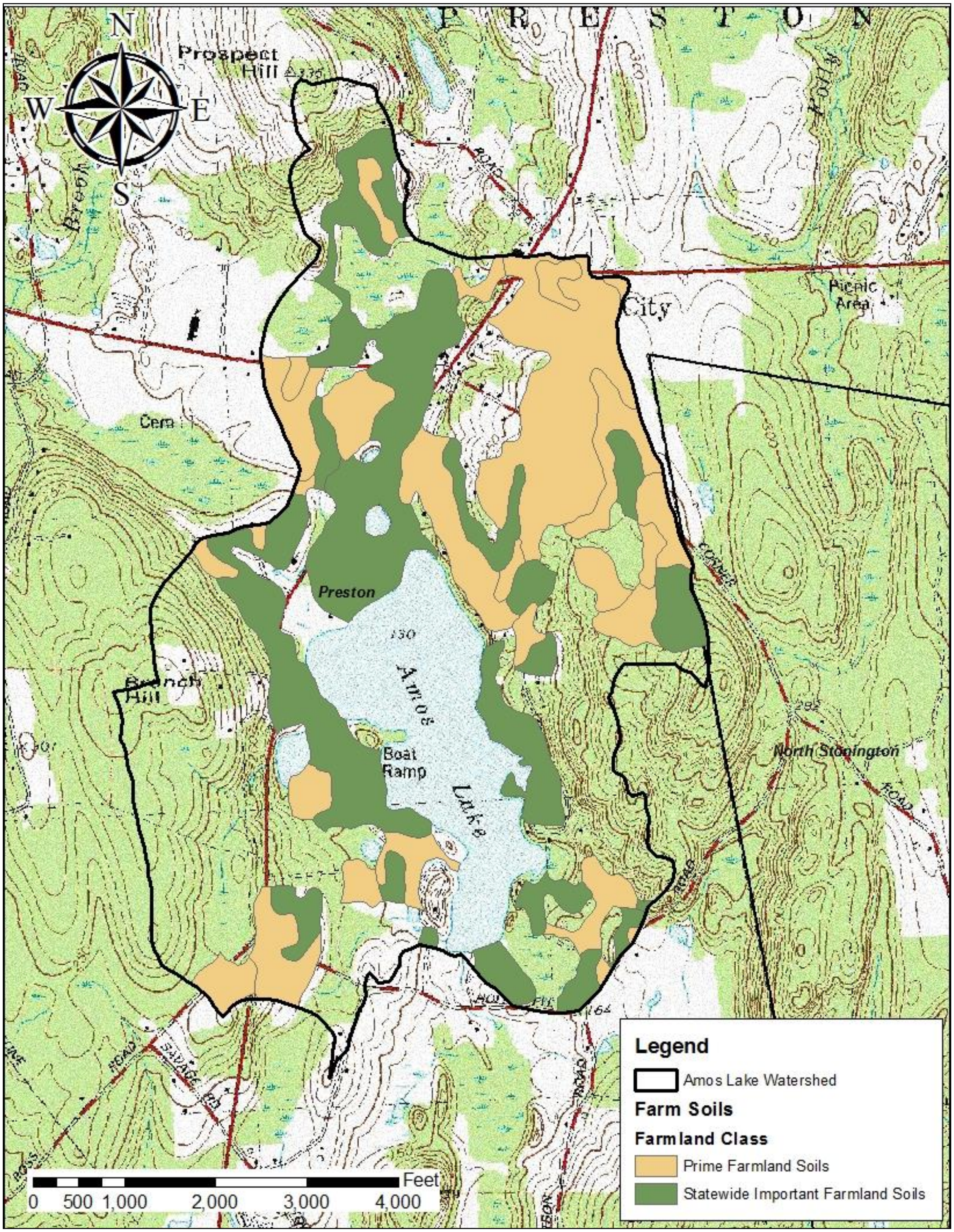


Figure 3-10. Farmland soils in the Amos Lake watershed (CT DEEP, 2011).

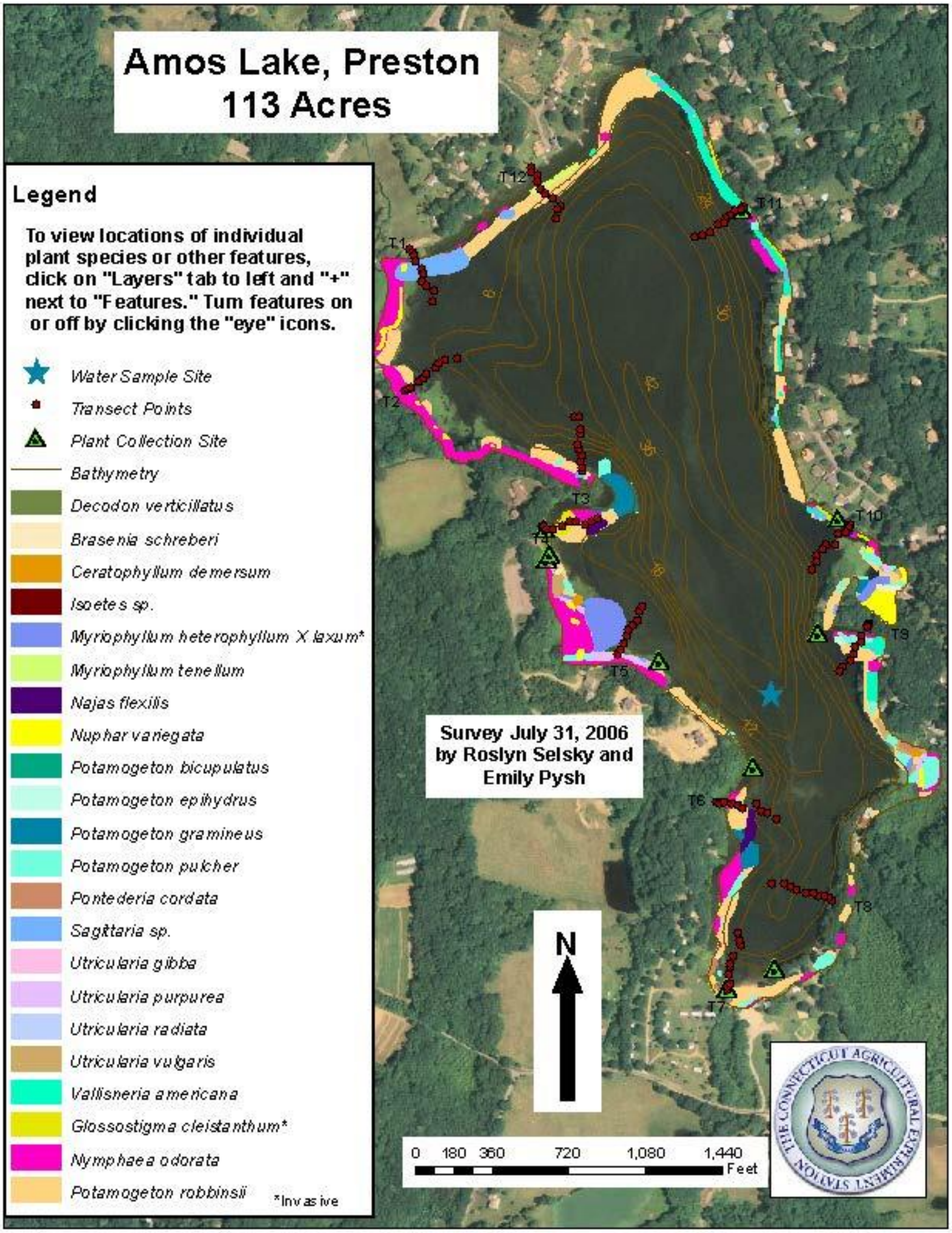


Figure 3-11. 2006 Aquatic Plant Survey by Connecticut Agricultural Experiment Station.

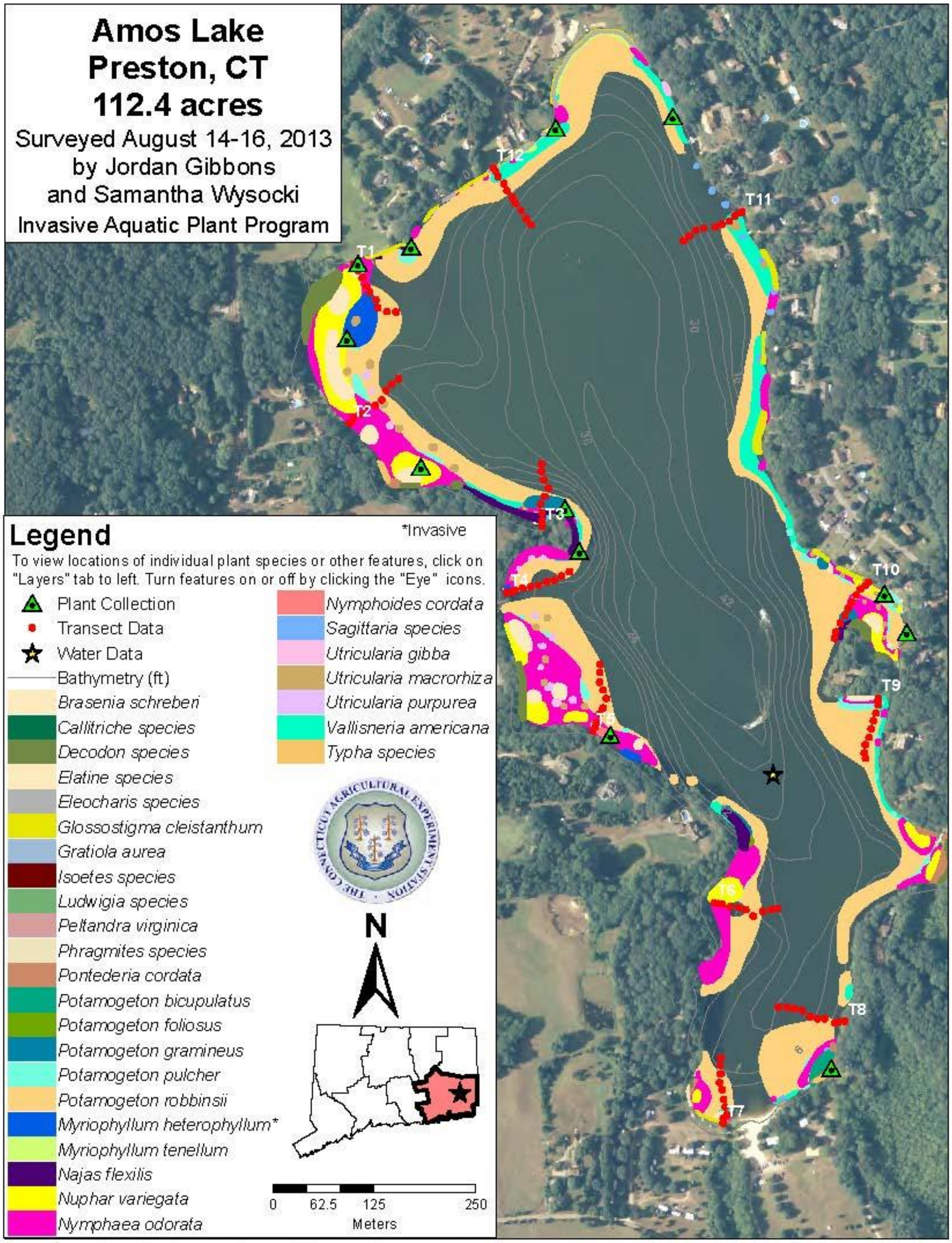


Figure 3-12. 2013 Aquatic Plant Survey by Connecticut Agricultural Experiment Station.

3.1.12 Wildlife/Waterfowl

Amos Lake is used by a wide variety of wildlife and waterfowl. Wildlife observed in and around the lake includes white-tailed deer (*Odocoileus virginianus*), North American river otter (*Lontra canadensis)*, muskrat (*Ondatra zibethicus*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), and opossum (*Didelphis virginiana*). Waterfowl observed by lake residents in 2013 and 2014 included American Coot (*Fulica americana*), Canada Geese (*Branta canadensis*), Double Crested Cormorant (*Phalacrocorax auritus*), Hooded Merganser (*Lophodytes cucullatis*), Mallard (*Anas platyrhynchos*), and Mute Swan (*Cygnus olor*). Large numbers of Canada Geese, estimated at up to 2000 birds in 2013, over-winter on the lake, staying until the lake freezes over in mid-January. These over-wintering birds often draw avian predators, including Bald Eagles (*Haliaeetus leucocephalus*), Golden Eagles (*Aquila chrysaetos*), falcons (*Falco* sp.) and Osprey (*Pandion haliaetus*). In the summer months, Great Blue and Little Blue Heron (*Ardea herodius* and *Egretta caerulea*, respectively) are commonly seen wading in the shallows for food.

3.1.13 Protected Species

A review of the Connecticut Department of Energy and Environmental Protection's Natural Diversity Database (NDDB) indicated the presence of multiple Natural Diversity Database sites in the vicinity of Amos Lake and the wetland system north of State Route 165 (Fig. 3-13). According to CT DEEP, these sites may include state-listed terrestrial and/or aquatic plant and animal species and significant natural communities that are endangered, threatened, or of special concern. The presence of these NDDB sites should be taken into consideration during any nearby site development or construction activity, and an NDDB review should be conducted prior to the issuance of any municipal land-use permit and commencement of construction activity. For more specific information on listed species, inquiries should be directed to CT DEEP's Natural Diversity Database program:

www.ct.gov/deep/cwp/view.asp?a=2702&q=323466&deepNav_GID=1628.

3.1.14 Sensitive Areas

North and west of Preston City is a wetland system that drains to an unnamed stream. This stream flows under Route 165, through agricultural land, and then turns east before it flows under Route 164 to Amos Lake. The wetland system is part of a preserve owned and managed by Avalonia Land Conservancy. The Connecticut Natural Diversity Data Base indicates the presence of species in or near the wetland system that are either endangered, threatened or of special concern. Amos Lake has also been identified as a sensitive area by the Connecticut Natural Diversity Data Base. A crayfish species of special concern resides in the lake. However, in a communication with CT DEEP staff (K. Zyko, April 22, 2014), the species is under consideration for delisting.

3.1.15 Cultural Resources

Preston City is a village and original town center north of Amos Lake that includes the area in the vicinity of the intersection of Routes 164 and 165 in Preston. A portion of the area is listed on the National Register of Historic Places as the Preston City Historic District. Historically, Preston City served as a social, business, and agricultural center. "The somewhat denser development, with a mixture of land uses, lesser setbacks, stonewalls, and historic buildings create a unique small town village. Various styles of architecture are found in the village, including Federal, Greek Revival, Queen Ann, Georgian Colonial, and contemporary housing interspersed. Preston City is located within the Amos Lake Watershed and is located over a potentially high-yielding aquifer. Historically, Preston City was one of three distinct settlements in the town, the others being Poquetanuck and Long Society. The first Congregational church in Preston City was founded in 1698. Preston City prospered in its early years when the town of Preston was an important supplier of agricultural products to the port of Norwich on the Thames River, from which local farm goods were shipped to other ports on the east coast. The period of greatest prosperity was between the American Revolutionary War and about 1830, and is reflected in the architecture of the homes built by successful local farmers and merchants (from Preston Plan of Conservation and Development 2003)."

3.2 Land Use and Land Cover

Land use in the Amos Lake watershed is primarily rural, with rural residential and agricultural land uses predominating. Land cover in the Amos Lake watershed is dominated by deciduous (34%) and coniferous (4%) forest. Wetlands and waterbodies comprise 18% of the watershed; 17% of the watershed is developed, comprised mainly of impervious cover including roadways, parking lots and structures; 16% is under agricultural use; and turf grasses and other grasses account for 11% of the watershed (Center for Land Use Education and Research, 2010, Figs. 3-14 and 3-15). There is a small commercial center in Preston City, which is located in the northern portion of the Amos Lake watershed, centered around the intersection of State Routes 164 and 165. Rural residential development is located primarily along main thoroughfares, including Routes 164 and 165, and secondary roads. More dense residential development is located along the north and east shoreline of Amos Lake.

A study conducted by the Center for Land Use Education and Research (CLEAR) at the University of Connecticut evaluated changes in land cover from 1985 to 2010. An evaluation of land use in the Amos Lake watershed from 1985 to 2010 (Table 3-3 and Figure 3-16) indicates that the amount of developed land has increased by 24%, while the amount of forest land and land under cultivation has decreased 8% and 11%, respectively.

3.2.1 Open Space

Open space in the Amos Lake watershed is comprised of a combination of protected and unprotected private, municipal and state-owned properties (Fig. 3-17), including the Avalonia Land Conservancy, Inc.'s Preston Nature Preserve; Downer-Doanes Park, which is owned by the Town of Preston; a boat launch owned by the State of Connecticut; and the privately owned Amos Lake Campground and Beach Club. This open space comprises approximately 58 acres, or 6% of the land area in the Amos Lake watershed. By comparison, the 2003 Plan of Conservation and Development identifies 598 acres of protected open space town-wide (3% of the total town area). The 2003 Plan of Conservation and Development recognizes the importance of open space as a component of sound land-use planning, recommends the preparation of an Open Space Plan (which the Town has completed), and supports the purchase of prime parcels identified in the Open Space Plan.

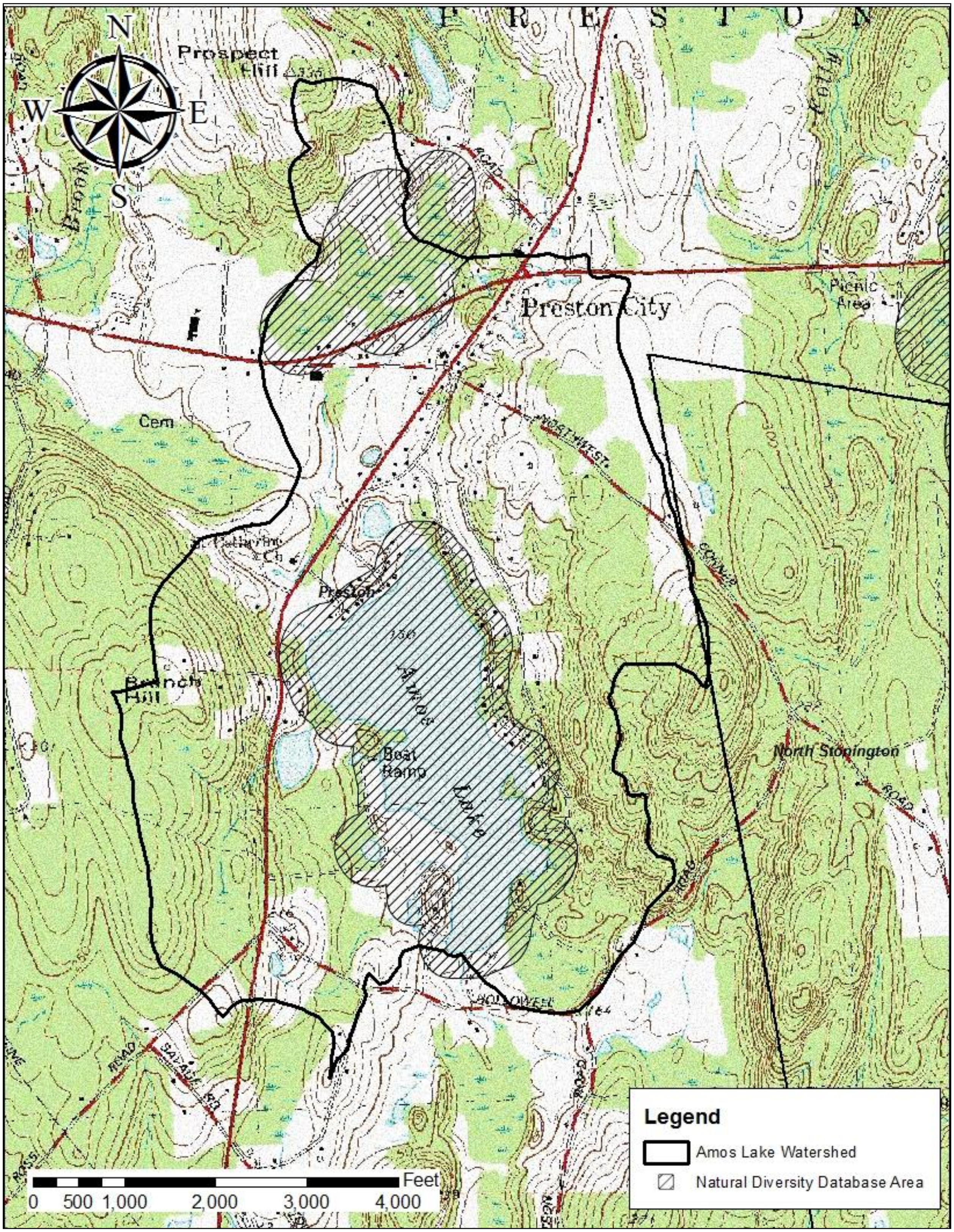


Figure 3-13. CT DEEP Natural Diversity Database areas in the Amos Lake watershed (CT DEEP, 2014).

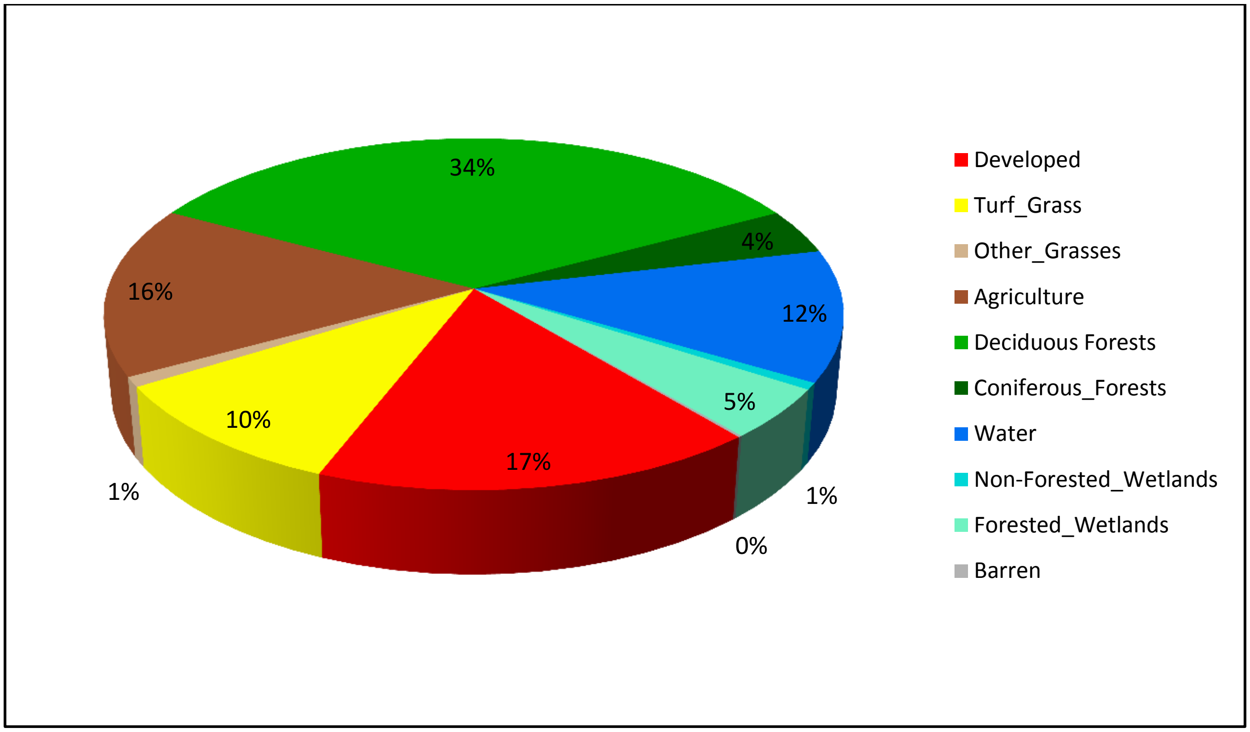


Figure 3-14. Percent land cover type for the Amos Lake watershed (derived from 2010 Center for Land Use Education and Research land cover data).

Table 3-3. Changes in land cover in the Amos Lake watershed from 1985 to 2010 (CLEAR).

Land Cover Class	1985 Land Cover		2010 Land Cover		Change in Land Cover	
	Acres	% of watershed	Acres	% of watershed	Acres	% Change
Developed	133	13.8	164	17.1	31	24
Turf and Grass	69	7.2	98	10.2	29	42
Other Grasses	6	0.6	9	0.9	3	41
Agriculture	171	17.8	151	15.7	-20	-11
Deciduous Forests	358	37.3	331	34.4	-27	-7
Coniferous Forests	40	4.2	40	4.2	0	-1
Water	128	13.4	116	12.1	-12	-9
Non-Forested Wetlands	7	0.8	6	0.6	-1	-19
Forested Wetlands	47	4.9	45	4.7	-2	-4
Barren	0.2	0.02	1	0.1	1	500

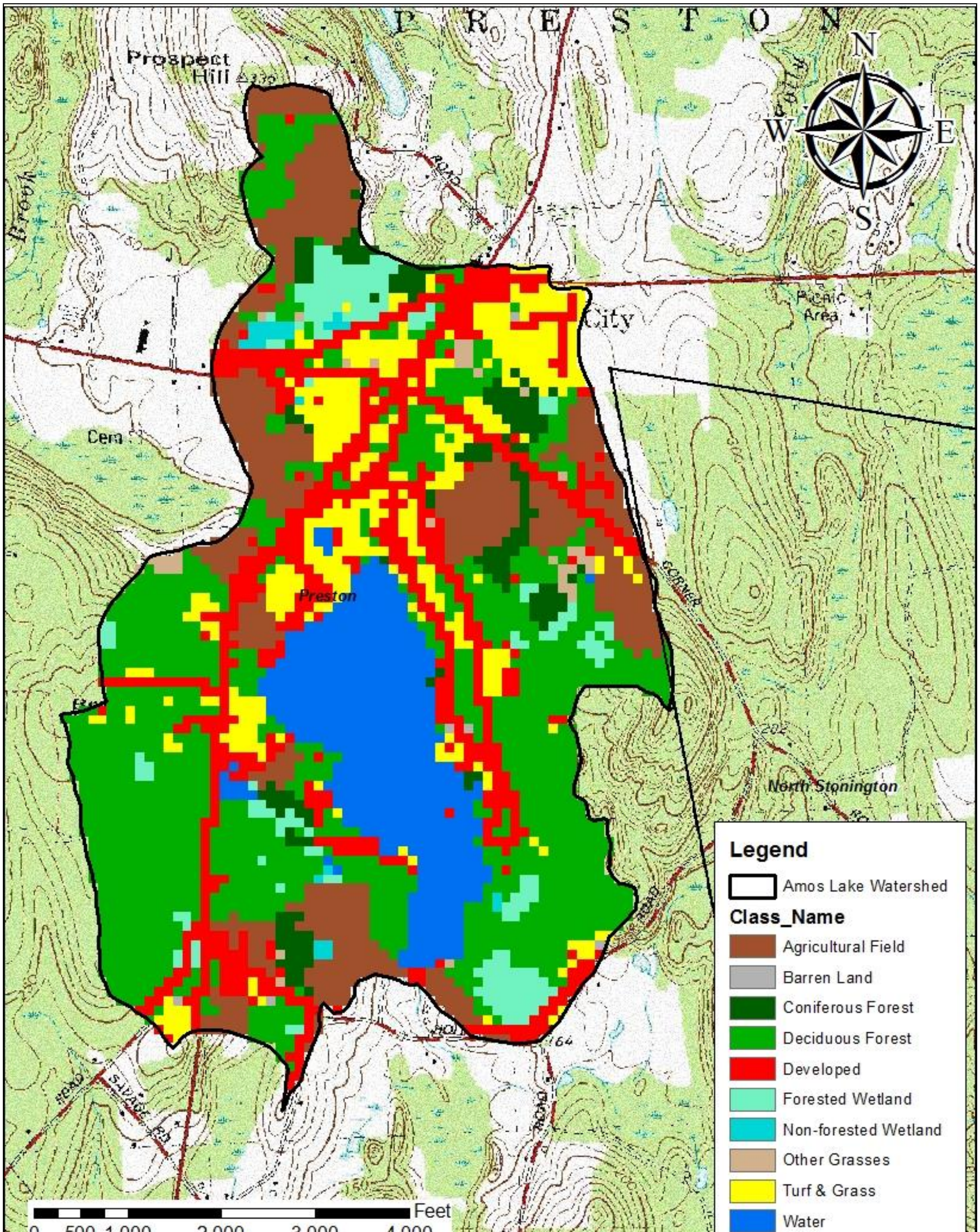


Figure 3-15. Land use and land cover in the Amos Lake watershed (CLEAR, 2010).

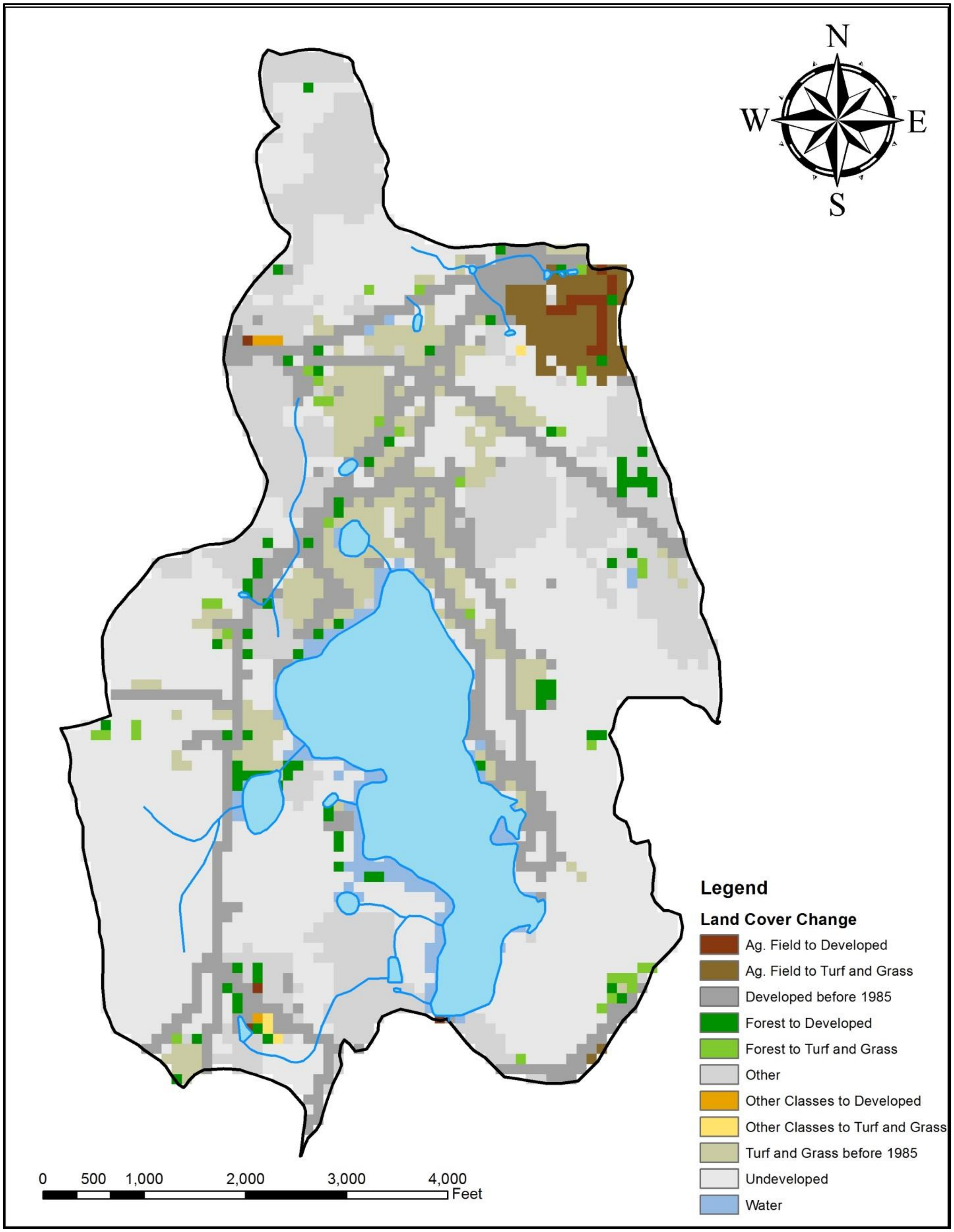


Figure 3-16. Changes in land-use in the Amos Lake watershed from 1985 to 2010 (CLEAR, 2010).

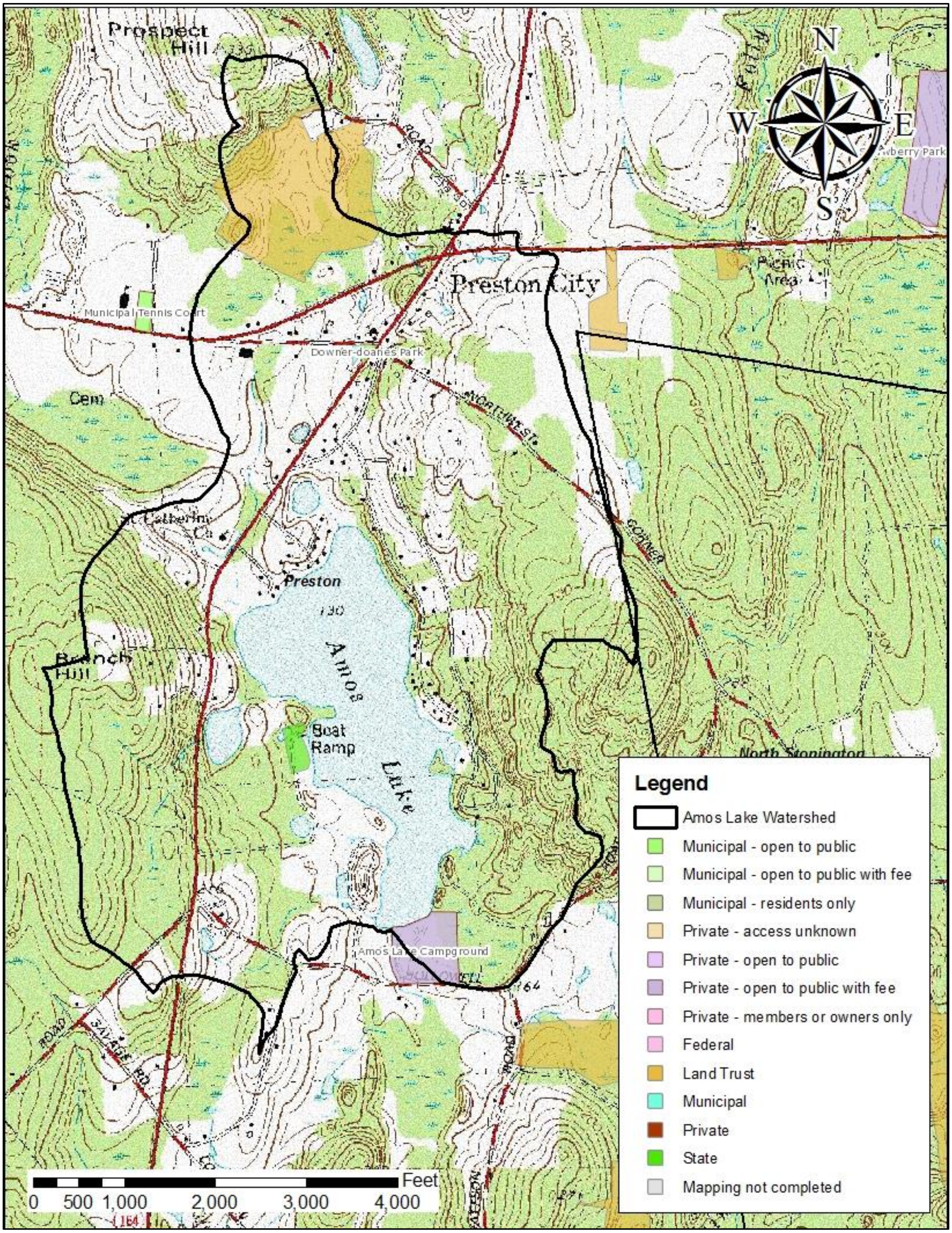


Figure 3-17. Open Space in the Amos Lake watershed (CT DEEP, 2011).

3.2.2 Wetlands

Approximately 167 acres, or 17.4%, of the Amos Lake watershed is comprised of wetlands. Wetlands provide multiple important environmental functions and services, including groundwater recharge, water purification, flood attenuation and wildlife habitat. Of 167 acres of wetlands in the Amos Lake watershed, 116 acres are open water, including Amos Lake and several small ponds, 45 acres are forested wetlands, and 6 acres are non-forested wetlands. A wetland of note is located on the   Land Conservancy's 55.7 acre Preston Nature Preserve. This wetland area is identified as being the location of a rare or endangered plant or animal species in the State of Connecticut Natural Diversity Data Base. Land use change between 1985 and 2010, as depicted in Table 3-3 indicates a 23% loss of wetlands in the Amos lake watershed.

3.2.3 Forested Areas

Approximately 370 acres, or 38 percent, of the Amos Lake watershed is forested. Of that, approximately 34% is deciduous and 4% is coniferous. Deciduous forest is comprised primarily of mixed hardwoods, including oak, maple, hickory, elm and ash, with red maple stands in low-lying areas. Coniferous forest is composed of small stands of white pine in upper elevations, and hemlock in low-lying areas. A 2009 study conducted by the Center for Land Use Education and Research (CLEAR) at the University of Connecticut evaluated forest fragmentation – the fracturing of large forest blocks into smaller and smaller pieces - throughout Connecticut. According to the CLEAR study, between 1985 and 2006, core forest has decreased state-wide by 5.3% and by 3 to 4% in Preston. An analysis of forest fragmentation in the Amos Lake watershed by ECCD, utilizing CLEAR methodology, indicates that core forest in the Amos Lake watershed has decreased by 4%, which is consistent with Preston as a whole (Fig. 3-18). For more information about forest fragmentation, visit the CLEAR webpage at: http://clear.uconn.edu/projects/landscape/forestfrag/index.htm.

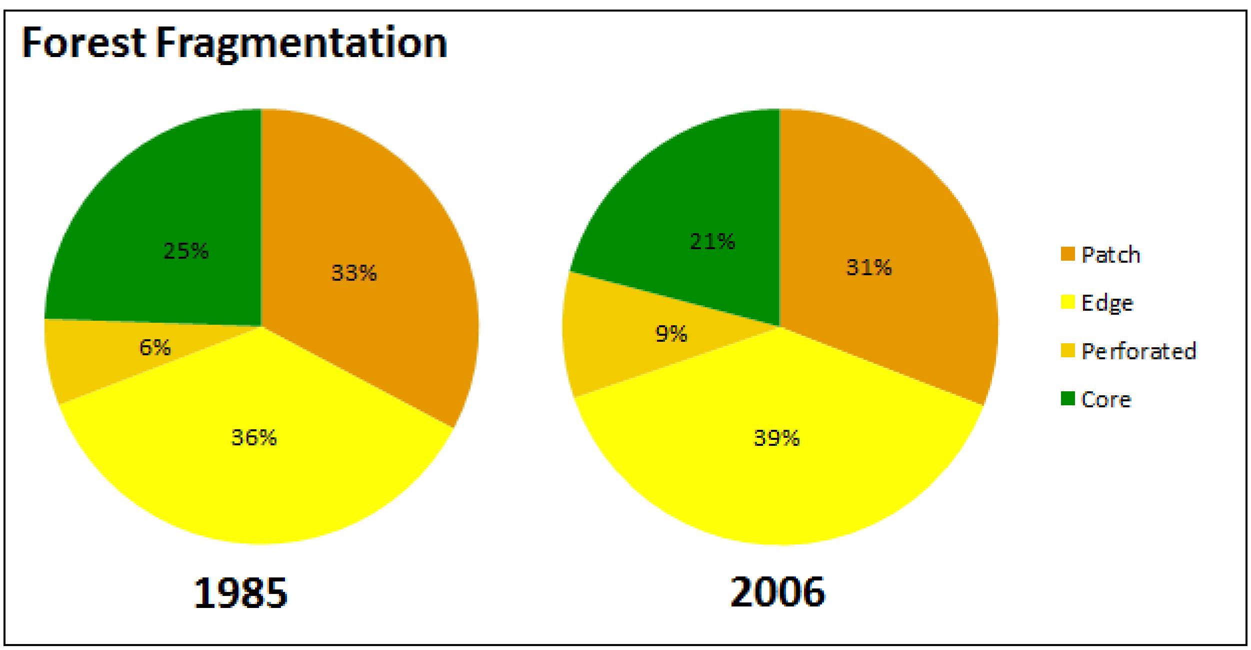


Figure 3-18. Forest fragmentation in the Amos Lake watershed in 1985 and 2006.

3.2.4 Agricultural Lands

The Amos Lake watershed has a diverse array of agricultural businesses, including dairy, equine, vegetable/greenhouse, viniculture, fruit/berry and Christmas tree production (Fig. 3-19). Approximately 151 acres (16%) of the watershed are used for agricultural activities (CLEAR, 2010). Of that land, approximately 59% is used as pasture, 18% is used to grow row crops and 23% is used for fruit production and viniculture.

3.2.5 Fisheries

Amos Lake is a trophy bass/ trophy trout management area and is stocked annually by CT DEEP. Amos Lake is evaluated periodically by CT DEEP Inland Fisheries Division. Game fish identified in recent DEEP fisheries surveys include largemouth bass (*Micropterus salmoides*), brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) and chain pickerel (*Esox niger*). Non-game fish include yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*), various sunfish species (*Lepomis gibbosus*, *L. macrochirus*, and *L. auritus*), golden shiner (*Notemigonus crysoleucas*), banded killifish (*Fundulus diaphanus*), alewife (*Alosa pseudoharengus*), creek chubsucker (*Erimyzon oblongus*), and American eel (*Anguilla rostrata*). The results of the fisheries surveys conducted in 1993, 1994, 1995 and 2003 can be seen in Table 3-4.

Table 3-4. Results of CT DEEP fisheries surveys of Amos Lake.

Table 2. Electrofishing catch rates (number of fish caught per hour) for two sizes of fish, greater than stock size[1] and greater than quality size[2] (in parentheses), caught by DEP Fisheries in Amos Lake from 1988 to 2012 compared to the state averages for important fish species from 123 public lakes.

AMOS L.

SPECIES	Date(s) / Effort (hrs)2 / Stock(Qual) size(cm)	5/04/88	6/14/90	10/27/92	10/30/97
	Effort (hrs)	1.71	1.46	1.17	1.17
				New Equipment increased efficiency After 1993	
GAMEFISH					
Largemouth bass	20(30)	27.5(13.5)	47.9(28.0)	45.2(29.9)	57.1(40.0)
Brown trout	20(33)	8.3(.8)	-	2.6(-)	-
Rainbow trout	20(33)	66.1(-)	-	.9(-)	4.3(-)
Chain pickerel	25(38)	3.5(.6)	18.5(6.2)	29.9(13.7)	32.4(17.0)
LARGER PANFISH					
Yellow perch	13(20)	8.2(8.2)	4.8(4.8)	4.3(4.3)	23.9(19.6)
Brown bullhead	15(23)	14.1(14.1)	41.7(41.7)	12.8(-)	1.7(1.7)
SUNFISH					
Bluegill	8(15)	166.8(98.4)	442.7(237.1)	749.0(346.3)	1502.5(310.2)
Pumpkinseed	8(15)	25.5(-)	121.0(4.8)	72.5(-)	43.2(-)
Redbreast sunfish	8(15)	-	-	4.0(-)	-
BG x PS hybrid	8(15)	-	4.8(2.4)	-	-
RS x BG hybrid	8(15)	-	-	4.0(-)	-
Unident. (<5cm)	8(15)	-	-	-	-
NON-GAME SPECIES					
Golden shiner		1.2(-)	.7(-)	2.6(-)	12.8(-)
Banded killifish		-	-	.9(-)	1.7(-)
Alewife		1252.2(-)	88.8(-)	53.8(-)	228.4(-)
Creek chubsucker		-	-	3.4(-)	.9(-)
American eel		2.9(-)	66.9(-)	41.8(-)	31.5(-)

1 "Quality size" is a length above which most anglers would consider the fish desirable to catch.

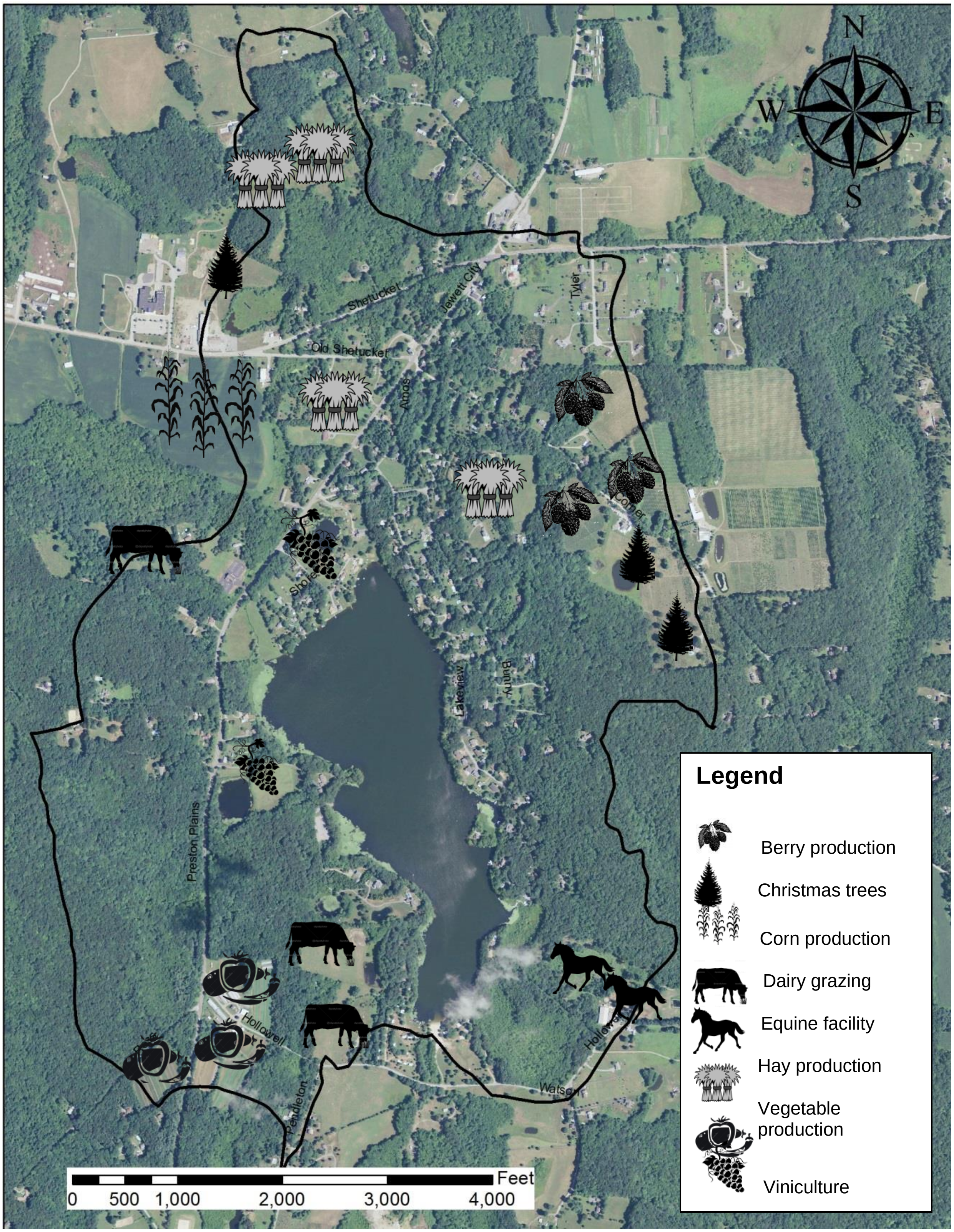


Figure 3-19. Agriculture/Crop Production in the Amos Lake Watershed.

3.2.6 Recreation

There are a variety of recreational opportunities in the Amos Lake watershed, as well as protected and unprotected open space (Fig. 3-17). Downer-Doanes Park owned by the Town of Preston, provides athletic fields for organized recreational activities, as well as open space for passive recreation. The Amos Lake Campground is located on Hollowell Road at the south end of the lake. The campground maintains 30 sites and is open seasonally. The Amos Lake Beach Club, a private beach club located along the southeast end of the lake, offers members a variety of activities including swimming, volleyball, and picnicking. The Avalonia Land Conservancy's Preston Preserve has several hiking trails that wind through 55.7 acres of forest, pasture and wetlands. The State of Connecticut maintains a public boat launch at Amos Lake, accessible from Preston Plains Road in Preston. This boat launch is open year round for trailered as well as car top boat access to the lake. Amos Lake is maintained by the CT DEEP as a both a Trophy Trout and Trophy Bass lake. Fishing tournaments are held there annually.

3.2.7 Developed Areas

The Amos Lake watershed is primarily rural, with forest land and agricultural uses predominating. Approximately 17% of the watershed is developed; these developed areas are comprised mainly of impervious cover including roadways, parking lots and structures. There is a small commercial center in Preston City, located in the northern portion of the watershed, in the vicinity of the intersection of State Routes 164 and 165. Rural residential development is located along the frontage of main thoroughfares, including Routes 164 and 165, and secondary roads. More dense residential development is located along the north and east shorelines of Amos Lake. Developed areas contribute stormwater runoff to local waterbodies due to the presence of impervious cover, hard surfaces such as roads, sidewalks, parking lots and roofs, which inhibit or prohibit the infiltration of rainwater into the ground. The presence of impervious cover has been linked to water quality. Research has indicated that land with impervious cover greater than 12% is linked to a decrease in water quality. DEEP has evaluated impervious cover in select towns throughout Connecticut, including Preston. Figure 3-20 depicts a map of impervious cover in Preston, prepared by DEEP. Additional information regarding impervious cover can be obtained from DEEP's *Stormwater Planning Tool for Impervious Cover* web page at: http://www.ct.gov/deep/cwp/view.asp?A=2719&Q=567354.

3.2.8 Transportation

Municipal roads and state highways form the primary transportation network in the Amos Lake watershed. State Routes 164 and 165 are the main thoroughfares in the watershed. State Route 164 runs north-south along the western side of Amos Lake, and Route 165 runs east-west through the northern part of the Amos Lake watershed. The two routes intersect in Preston City. Route 164 is a heavily traveled transportation corridor that conveys not only local traffic, but also traffic for tourists travelling to area casinos and Rhode Island beaches. The 2003 Plan of Conservation and Development evaluates transportation systems and traffic patterns in Preston, including traffic volume and safety concerns. The Plan provides an evaluation of future conditions and potential roadway infrastructure and safety improvements. It also identifies a portion of State Route 164 that is designated a "scenic road" by the Commissioner of CT DOT in accordance with Public Act 87-280.

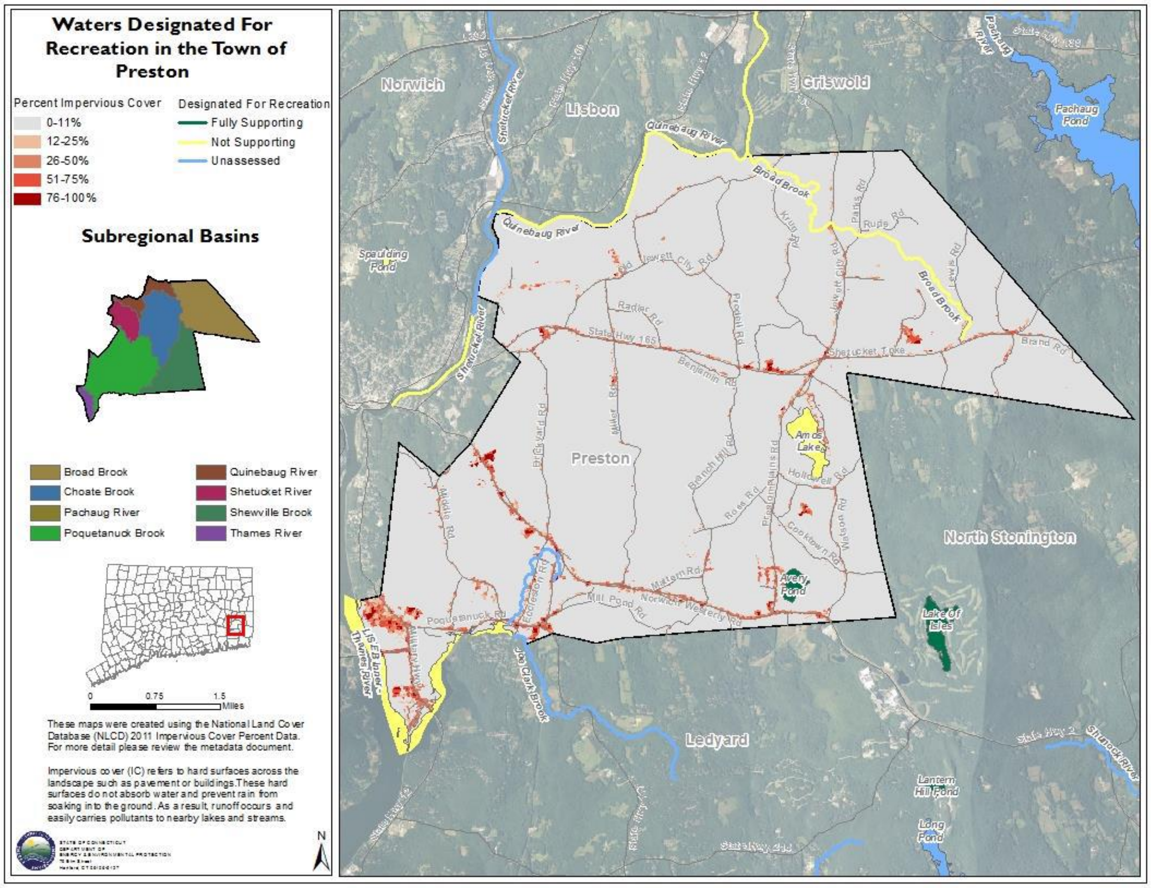


Figure 3-20. Impervious cover in Preston as assessed by CT DEEP (CT DEEP, 2014).

3.3 Relevant Authorities

Land use and management planning and policy development occur on multiple administrative levels, from state to local levels. These policies determine how land will be used and developed. Land management policies, especially in the form of municipal land use regulations, can play a significant role in the protection of water quality and other natural resources. The State of Connecticut conducts state-wide land use planning through the Office of Policy and Management (OPM). The State Plan of Conservation and Development serves as the official state policy in matters pertaining to land and water resources conservation and development, and directs and informs decision-making by the executive branch of government. Regional planning occurs through the Southeast Connecticut Council of Governments, of which Preston is a member. Planning documents prepared by the Southeast Connecticut Council of Governments identify regional goals for land use, development and natural resource protection. Local planning occurs via municipal plans of conservation and development and other planning documents, including local ordinances and municipal land use regulations, stormwater management plans, and watershed management plans administered by The Town of Preston Planning and Zoning Commission, Inland Wetlands and Watercourses Commission and Conservation Commission. Planning on the local level typically has the most direct impact on how conservation and development occur at the community level. Local land use planning is most effective when consistent with regional and state conservation and development policies and plans.

This section provides a review and summary of existing planning documents that affect and influence water quality protection.

3.3.1 Regional Land Planning Policies

3.3.1.1 State of Connecticut Office of Policy and Management

The *2013-2018 Conservation & Development Policies: The Plan for Connecticut*, prepared by the Office of Policy and Management in accordance with Connecticut General Statutes Section 16a-29, identifies six growth management principles to direct growth and development throughout the State of Connecticut. Growth management principles pertinent to the Amos Lake watershed include:

- Growth management Principle #2 – Expand Housing Opportunities and Design Choices to Accommodate a Variety of Household Types and Needs (Preston City Village Center Priority Funding Area)
- Growth Management Principle #4 - Conserve and Restore the Natural Environment, Cultural and Historical Resources, and Traditional Rural Lands
- Growth Management Principle #5 - Protect and Ensure the Integrity of Environmental Assets Critical to Public Health and Safety (potential public drinking water supply)

3.3.1.2 State of Connecticut Department of Transportation

The Connecticut Department of Transportation has developed and adopted a Stormwater Management Plan (2004) in compliance with Section 402(p) National Pollution Discharge Elimination System (NPDES) Phase II program of the Clean Water Act (CWA), for all of the department's highways, roadways and railways located within Urbanized Areas (UA) as indicated by the 2000 Census. Portions of the Town of Preston fall within the Norwich-New London Urbanized Area, although the population is less than 1000 within the urbanized area. The purpose of the Stormwater Management Plan (SWMP) is to:

> "Establish, implement and enforce a stormwater management program to reduce the discharge of pollutants from the department's highways, roadways, railways and facilities to the maximum extent practicable, to protect water quality, and to satisfy the appropriate requirements of the Clean Water Act.
>
> The SWMP will cover all of the department's highways, roadways and railways located within Urbanized Areas (UA) as indicated by the 2000 Census. Additionally, all interstate highways within the state will be covered under this SWMP regardless of location. Individual facilities such as airports, maintenance garages, ports, salt sheds and other miscellaneous facilities are or will be covered under general permits (industrial) with the Connecticut Department of Environmental Protection (CTDEP).

This SWMP also directly addresses the requirements of the NPDES Phase II program as implemented and administered by the CTDEP as the regulatory authority for the State of Connecticut. The NPDES Phase II program is implemented by the CTDEP through the use of the General Permit for the Discharge of Stormwater from Small Municipal Storm Sewer Systems.

The department currently has many practices and programs in place relating to stormwater management and pollution prevention. This plan will coordinate and incorporate these programs, policies, guidelines and practices into the SWMP document by reference. The plan outlines a program of best management practices (BMPs) and measurable goals for the following six minimum control measures:

· Public education and outreach
· Public involvement/participation
· Illicit discharge detection and elimination
· Construction site stormwater runoff control
· Post-construction stormwater management
· Pollution prevention/good housekeeping" (CT DOT SWMP 2004).

State roads within the Amos Lake watershed covered under the SWMP include Routes 164 and 165. DOT infrastructure connections of note include storm drainage from Routes 164 and 165 that discharge untreated storm water directly to the unnamed stream from Preston City that flows into Amos Lake from the west near St. Catherine of Sienna R.C. Church.

3.3.1.3 Southeastern Connecticut Council of Governments

The Southeastern Connecticut Council of Governments (SCCOG) identifies regional goals for conservation and development in the 2007 Regional Plan of Conservation and Development. Regional goals and recommended actions pertinent to the Amos Lake watershed include:

1) Strive to preserve the region's natural resource base by concentrating development where the fewest natural resource limitations exist and establish a process whereby resource-abundant towns begin dialogue with resource-deficient towns concerning future demand for the use of the resource.

Recommended Actions:

- Meet with local officials to discuss differences in regional and local land use policies.
- Conduct studies to identify properties with significant natural resources, especially those located near areas identified as potential high yield aquifer sites.
- Provide technical assistance and education to member municipalities in the development and administration of natural resource protection regulations and policies, and policies resulting in the preservation of the region's farmland.
- Encourage municipalities to periodically review their designated open space

within their jurisdiction, as delineated in their open space master plan, and to actively acquire open space through the subdivision approval process, using funding from state and federal grant programs, municipal appropriations, and providing the option of requiring developers to provide fees in lieu of open space, for this purpose.

- Protect sensitive resources by encouraging protective buffers between development and wetlands and identified existing and potential future water supply areas.
- Noting the success of projects like the Jordan Cove Low Impact Development subdivision in Waterford, encourage towns to protect valuable natural resources through innovative site design, best management practices with respect to stormwater treatment, and open space planning.
- Assist member municipalities in educating the public concerning the impact of stormwater pollutants and methods for reducing such impacts.

2) Provide a system of public utilities that will protect the health of the region's population and environment while allowing development to occur that meets the needs of the region's people, businesses and industries.

Recommended Actions:

- Assist the Southeastern Connecticut Water Authority in the implementation of the *Regional Water Supply Plan*, specifically in the development of new water supply and in the planned extension of the regional water network.
- Support land use policies that would concentrate new intensive development in areas served by public utilities.
- Encourage the utilization of best management practices and innovative technology for any new intensive development that significantly impacts the region.

3.3.2 Municipal Land Use Policies

The Town of Preston addresses land management policies in a variety of documents, including a Plan of Conservation and Development (2003), municipal ordinances and land use regulations, adopted to guide development, protect water quality and natural resources. Land use regulations include zoning, subdivision, and inland wetland regulations. Following is a summary of land management policies and regulations in effect at the time of the preparation of this document that address water quality concerns. Readers are advised that they should contact the Town of Preston to obtain the most current land use regulations and policies.

3.3.2.1 Plan of Conservation and Development

A Plan of Conservation and Development is a statement of policies, goals and standards for the physical and economic development of a municipality. The 2003 Town of Preston Plan of Conservation and Development addresses issues of water quality and natural resource protection, and makes recommendations to guide and inform future development in Preston while providing protection to valuable natural and manmade resources. Following is a summary of recommendations that address water quality protection (it should be noted that at the time of the preparation of this document, the Town was in the process of updating their POCD).

1) Open Space And Farmland Preservation
   Goal 2: Open space designations will successfully protect Preston's valuable natural resources, maintain the town's rural character, and, where appropriate, provide recreational opportunities.

Objective: Identify priority areas for open space protection.

2) Natural Resources
   Goal 1: Preston's coastal waters, surface waters, wetlands, and groundwater will be guarded against the degradation of their visual and ecological characteristics.

   Objectives:
   - Reduce impervious surfaces for new construction.
   - Revise stormwater standards and practices to ensure that stormwater does not impact sensitive resources.
   - Ensure that Amos Lake is protected for the enjoyment of future generations.
   - Adopt protection measures for particular uses allowed in Preston that have the potential to result in environmental impacts.
   - Educate residents and businesses of environmentally-friendly practices that they can employ.
   - Ensure that existing and future water supplies are adequately protected.

3.3.2.2 Zoning Regulations

Following is a summary of zoning regulations (revised November 11, 2013) that relate specifically to the protection of water resources:

- Section 3.1.4 - Special Amos Lake Protection District establishes a special district based on recommendations in the 2003 Plan of Conservation and Development to provide certain protections to Amos Lake: “This district provides protection of the water quality of Amos Lake, Preston’s largest waterbody. The uses and requirements are intended to limit intensive activities which might produce surface runoff and groundwater contamination that could harm the lake” (pg. 5).
- Section 4.1.4 - Permitted uses in the R-120 District require that “buildings housing animals and areas of concentrated storage of animal waste shall be not less than one hundred feet (100’) from any streams, pond or marsh or swamp area” (pg. 6).
- Section 7.1 - Special Amos Lake Protection District allows all uses permitted in Section 4.1 of the Zoning Regulations except that “cows, horses, steer, goats, or

more than twenty-five (25) in the aggregate of chickens, ducks, or other birds shall not be kept within one hundred feet (100') of a watercourse or within three hundred feet (300') of the edges of Amos Lake, and except accessory apartments, or conversions of residence pursuant to Section 13.8 on parcels less than sixty thousand (60,000) square feet" (pg. 11).

- Section 11d2 - Preston City Village District states that "the district, as delineated by the zone lines, is located within the watershed area for Amos Lake, a prominent and significant natural and recreational resource and also partially lies over a significant aquifer that may have the ability to provide a high yielding public water supply well for the community. To that end, incorporated in these Regulations, are provisions to protect the Amos Lake Watershed area and other important natural resources within the watershed" (pg. 34).
- Section 11D 3.4.1.s. - Protection of Natural Resources requires that submitted plans minimize runoff "from parking lots, roads, driveways, and sidewalks, so that water is allowed to infiltrate rather than runoff. All plans shall incorporate methods that help accomplish this goal. Examples of methods include developing landscaped islands for stormwater management and installing porous parking lots. All applicants shall implement Best Management Practices for the design of the project. All development shall be consistent with recommendations listed in DEP Bulletin #26 "Protecting Connecticut's Groundwater." The developer shall:
    - i. Show the location of the development within the watershed and aquifer;
    - ii. Minimize the disturbance of natural grades and vegetation;
    - iii. Protect natural wetland and stream buffers;
    - iv. Maximize infiltration of stormwater; and,
    - v. Minimize impervious surfaces" (pg. 39).
- Section 13.1.1 - Wetlands and Watercourses requires that "no building or disturbance to the land shall be located or completed within one hundred feet (100') of any waterbody, watercourses (*if subject to flooding its highest flood line*) or wetland, unless approved by the Inland Wetlands & Watercourses Commission" (pg. 52).
- Section 16.10 - Erosion and Sediment Control Plan requires the preparation of an E&S plan "whenever plans for the proposed development show that it will result in the disturbance of more than one-half (½) acre of land, the applicant will submit with the site plan an erosion and sediment control plan that presents, in a mapped and narrative form, the measure to be taken to control erosion and sedimentation during and after construction. The E&S plan shall be based on "Connecticut Guidelines for Soil Erosion and Sediment Control," available from the Connecticut Department of Environmental Protection" (pg. 99).

3.3.2.3 Subdivision Regulations

Following is a summary of subdivision regulations (revised September 22, 2012) that relate specifically to the protection of water resources:

- Section 5.5 - Erosion and Sediment (E&S) Control Plan requires that "whenever plans for a subdivision show construction of improvements or buildings related to the subdivision that will result in the disturbance of more than one-half (½) acre of land, the applicant will submit, as part of the subdivision plan, E&S control plan that presents, in mapped and narrative form, the measures to be taken to control erosion and sedimentation both during and after construction. The E&S plan shall be based on "Connecticut Guidelines for Soil Erosion and Sediment Control" available from the Natural Resources Center of the Connecticut Department of Environmental Protection" (pg. 15).

- Section 5.7.3 - requires that "when the subdivision includes any portion of a watercourse that is located within an A Zone on the Flood Hazard Boundary Map or the Flood Insurance Rate Map for Preston, and the subdivision would result in the alteration or relocation of that watercourse, the applicant shall submit a hydrological design by a registered professional engineer that indicates that the flood-carrying capacity of the watercourse will not be impaired by any construction or additional runoff resulting from the subdivision" (pg. 17).
- Section 6.5 - Drainage requires that "an adequate system of storm water drainage shall be provided and installed by the sub-divider and no natural watercourse shall be altered or obstructed in such a way as to reduce the natural runoff capacity unless substitute means of runoff are provided" (pg. 23).
- Section 6.8 - Open Space, Parks, and Playgrounds states that "The Commission may require open spaces, parks, and [sic] playgrounds in a proposed subdivision up to a maximum of ten percent (10%) of the gross site area. In determining the need for open spaces and recreation areas, the Commission shall take into account the density of the populations and existing public open spaces in the vicinity of the subdivision. The Commission should also make reference to the recommendations of the Plan of Development regarding recreation and open space and, if advisable, consult with the Conservation Commission and the Parks and Recreation Commission" (pg. 25).
- Section 6.9 - Fee in Lieu of Land for Open Spaces, Parks and Playgrounds states that "The Commission may require the applicant to pay a fee to the Town of Preston or pay a fee and transfer land to the Town of Preston in lieu of providing open spaces, parks and playgrounds" (pg. 26).

3.3.2.4 Inland Wetlands and Watercourses Regulations

The Inland Wetlands and Watercourses Commission of the Town of Preston, established in accordance with an ordinance adopted at the Preston Town Meeting on February 11, 1988, revised 11/5/13, is charged with enforcing the provisions of the Inland Wetlands and Watercourses Act, Sections 22a-36 through 22a-45, inclusive, of the Connecticut General Statutes, as amended. The Inland Wetlands Commission is authorized to regulate any activity within 100 feet of a wetland or watercourse "wherein a regulated activity is proposed and such activity is likely to impact or affect the wetlands or watercourses."

3.3.3 Future Land Use Considerations

There are relatively large tracts of undeveloped forested land in the Amos Lake watershed, located both to the east and west of Amos Lake. The 1049-acre area immediately surrounding Amos Lake has its own zoning designation, the Amos Lake Protection District. This district has a 60,000 square foot minimum lot size and prohibits the keeping of animals within 100 feet of a watercourse, or 300 feet from Amos Lake. All uses allowed in the R-120 Residential Zone, including single-family dwellings, home occupations, and farms are allowed in the Amos Lake Protection District. There are no published plans for future development on any of the undeveloped properties. However, there are no currently existing limitations such as conservation easements or other open space designations to prevent development of these lands in the future.

3.4 Demographic Characteristics

The town of Preston is located in New London County, in the southeastern region of Connecticut. The town encompasses a land area of 31.8 square miles, of which 30.9 square miles is land, and 0.9 square miles is water. Town governance is conducted via an elected, three-member board of selectmen which heads the administrative branch. The town meeting, in which all registered voters may participate, forms the legislative body.

3.4.1 Population/Economics

The population of Preston in 2012 was 4,736 individuals, occupying 1,854 households. The population density was 153 people per square mile. The median household income in 2012 was $76,296, which is above the state average of $69,519. Local industries include agriculture, forestry, fishing and hunting, construction, manufacturing, retail, and accommodation/food services (Table 3-5). Major employers in town are Strawberry Park Resort Campground, Preston Veteran Memorial School, Southeast Area Transit District, Hilton Garden Inn and Covanta Seconn (Connecticut Economic Resource Center, 2014).

Table 3-5. Preston, Connecticut Business Profile.

Preston, CT Economics – Business Profile 2013 (CERC Town Profile, 2014).		
	Units	Employment
Total - All Industries	108	836
Agri, Forestry, Fishing, Hunting	9	91
Construction	22	118
Manufacturing	4	11
Retail Trade	9	36
Accommodation and Food Services	14	195
Total Government	13	224
Local/Municipal Government	13	224

4 Watershed Conditions

4.1 Water Quality Standards

The 1972 Federal Clean Water Act requires all states to designate uses for all waterbodies within their jurisdictional boundaries, and to test those waters to determine if they are meeting water quality criteria for those designated uses. Amos Lake is designated a Class AA surface water. The designated uses for Amos Lake include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Amos Lake has not been meeting its designated use for recreation due to excess algal growth, high levels of Chlorophyll-a, and other nutrient/eutrophication and biological indicators (CT DEEP 2012). Potential nutrient sources include stormwater runoff, and unspecified upstream sources.

The *State of Connecticut Water Quality Standards* (effective October 10, 2013) establishes water quality criteria for nutrients as defined in Table 4-1. For Class AA surface waters, "the loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses." The *Connecticut Water Quality Standards* also provide lake trophic categories based on nutrient concentrations and other parameters, including water clarity and productivity. These standards are presented in Table 4-2. In order to determine the natural trophic tendency of Amos Lake, ECCD utilized a methodology presented by Taylor in *A Connecticut Lakes Management Program Effort* (1979). This methodology is based on Vollenweider's conceptual models (Vollenweider, 1968 and 1974) for the mass balance of nutrient loads in lakes, based on lake surface area, mean depth and flushing rate, from which lake trophic state may be inferred. Using Taylor's methodology, the natural trophic tendency of Amos Lake appears to be in the late oligotrophic state.

4.1.1 Anti-degradation Policy

The State of Connecticut has adopted an anti-degradation policy as required by the Clean Water Act and the Connecticut Surface Water Quality Standards. The purpose of this policy is to maintain and protect both water quality in high quality waters and existing uses in all cases. The Anti-degradation Policy establishes procedures to ensure that existing and designated uses of surface waters and the water quality necessary for their protection are maintained and preserved; that all wetlands and surface waters with an existing quality better than the Standards and Criteria established in these Water Quality Standards are maintained at their existing high quality; and that water quality in Outstanding National Resource Waters is maintained and protected.

The goal of the Amos Lake water quality investigation is to restore Amos Lake so that the lake meets its intended uses in compliance with the Anti-degradation policy.

Table 4-1. Surface Water Criteria by Classification (CT Water Quality Standards, 2013).

Parameter	Class AA	Class A	Class B	Class SA	Class SB
				Connecticut and Thames Rivers shall be consistent with the criteria for the non-tidal segments.	Connecticut and Thames Rivers shall be consistent with the criteria for the non-tidal segments.
Chemical constituents	None in concentrations or combinations which would be harmful to designated uses. Refer to Table 3 of this section and sections 22a-426-4(a)(5); 22a-426-4(a)(9); 22a-426-4(a)(9)(B); 22a-426-4(a)(11); 22a-426-4(l); 22a-426-4(m); 22a-426-9(a)(3); 22a-426-9(a)(4) and 22a-426-9(a)(5) of the Regulations of Connecticut State Agencies.				
Nutrients	The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses.	The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses.	The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses.	The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses.	The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses
Sodium	Not to exceed 20 mg/l.	None other than of natural origin.			

Table 4-2. Connecticut Lake Trophic State Guidelines (CT Water Quality Standards, 2013).

Table 1: Parameters and Defining Ranges for Trophic State of Lakes in Connecticut			
Trophic State Based on Water Column Data	**Description**	**Parameters**	**Defining Range**
Oligotrophic	May be Class AA, Class A, or Class B water. Low in plant nutrients. Low biological productivity characterized by the absence of macrophyte beds. High potential for water contact recreation.	Total Phosphorus	0-10 ug/l spring and summer
		Total Nitrogen	0-200 ug/l spring and summer
		Chlorophyll-a	0-2 ug/l mid-summer
		Secchi Disk Transparency	6 + meters mid-summer
Mesotrophic	May be Class AA, Class A, or Class B water. Moderately enriched with plant nutrients. Moderate biological productivity characterized by intermittent blooms of algae and/or small areas of macrophyte beds. Good potential for water contact recreation.	Total Phosphorus	10-30 ug/l spring and summer
		Total Nitrogen	200-600 ug/l spring and summer
		Chlorophyll-a	2-15 ug/l mid-summer
		Secchi Disk Transparency	2-6 meters mid-summer
Eutrophic	May be Class AA, Class A, or Class B water. Highly enriched with plant nutrients. High biological productivity characterized by occasional blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation opportunities may be limited.	Total Phosphorus	30-50 ug/l spring and summer
		Total Nitrogen	600-1000 ug/l spring and summer
		Chlorophyll-a	15-30- ug/l mid-summer
		Secchi Disk Transparency	1-2 meters mid-summer
Highly Eutrophic	May be Class AA, Class A, or Class B water. Excessive enrichment with plant nutrients. High biological productivity, characterized by severe blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation may be extremely limited.	Total Phosphorus	50 + ug/l spring and summer
		Total Nitrogen	1000 + ug/l spring and summer
		Chlorophyll-a	30 + ug/L mid-summer
		Secchi Disk Transparency	0-1 meters mid-summer

4.2 Available Monitoring/Resource Data

4.2.1 Water Quality Data

Water quality data was collected by ECCD with the assistance of volunteers from The Last Green Valley (TLGV) Volunteer Water Quality Monitoring Program and the Amos Lake Association in 2012 and 2013. Data was collected from Amos Lake, tributary streams, storm drains discharging to Amos Lake, and the lake outlet (Fig. 4-1). Data collected in 2012 included dissolved oxygen, pH, temperature, conductivity and turbidity utilizing an In-Situ Troll 9500 multi-parameter monitoring instrument. Stream water samples were analyzed for nitrate nitrogen concentrations using a LaMotte Smart2 Colorimeter. In 2013, the same physical parameters were collected using the In-Situ Troll 9500, but in addition, lake and tributary water samples were collected and analyzed for total nitrogen, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, NOx, total phosphorus, and orthophosphate. Lake water samples were analyzed for Chlorophyll-a concentrations, and in July and August, the samples were collected for phytoplankton identification and cell counts. In 2013, volunteers also collected stream gauge data at the inlet of the primary tributary to Amos Lake (AL-03) and the lake outlet (AL-06) to be used to estimate nutrient loading. The 2013 water quality data was reviewed by Northeast Aquatic Research, LLC (NEAR). An analysis of the data, including lake morphometric characteristics, thermal structure, geophysical properties and nutrient loads was conducted. A complete record of water quality data collected from Amos Lake and tributaries in 2013 is presented in Appendix B. Phytoplankton analysis results are presented in Appendix C. The 2013 Amos Lake and Watershed Monitoring Data Analysis by Northeast Aquatic Research, LLC, can be found in Appendix D.

Water quality data for Amos Lake and the tributary streams collected in 2013 are summarized in Tables 4-3 and 4-4 below. Lake water quality data has been compared to Connecticut Water Quality Standards to establish the trophic state of Amos Lake. Based on Connecticut Water Quality Standards, Amos Lake is mesotrophic, or moderately enriched with plant nutrients. However, certain biological indicators, including chlorophyll-a, indicate that the lake is becoming eutrophic, or highly enriched with plant nutrients, resulting in the lake becoming highly productive. While the current moderate levels of biological productivity afford good potential for water contact recreation, the apparent trend towards high levels of productivity may reduce or limit water contact recreation opportunities.

The State of Connecticut has not adopted nutrient standards for rivers and streams. Total phosphorus and total nitrogen concentrations in Amos Lake tributary streams are depicted in Fig. 4-2. An examination of Fig.4-2 indicates that total phosphorus concentrations are highest in the streams at sampling sites AL-01 (Bunny Lane sub-watershed) and AL-03 (Preston City sub-watershed). Total nitrogen concentrations are highest in the stream at AL-03.

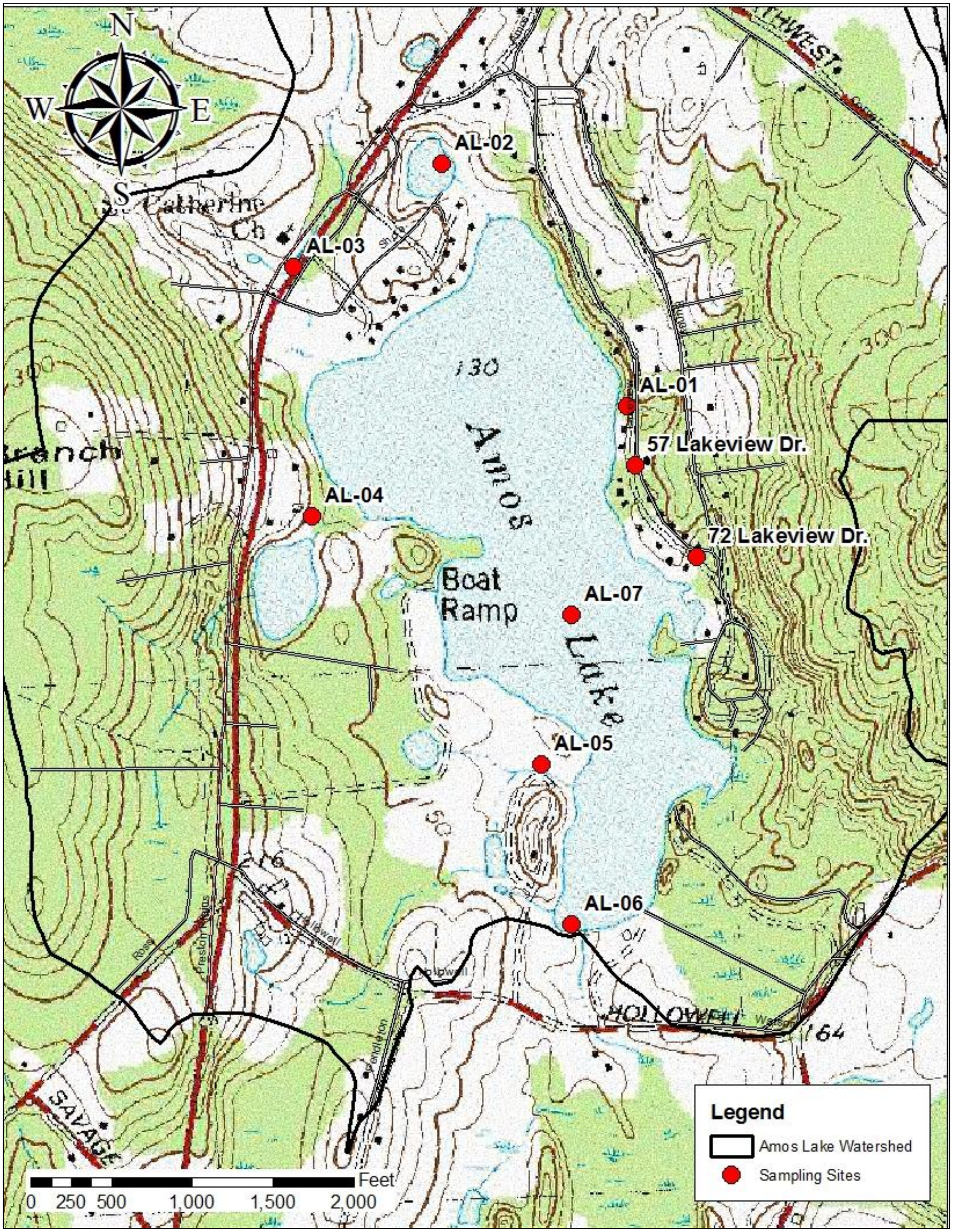


Figure 4-1. 2013 Amos Lake water quality sampling locations.

Table 4-3. Amos Lake Water Quality Sampling Results.

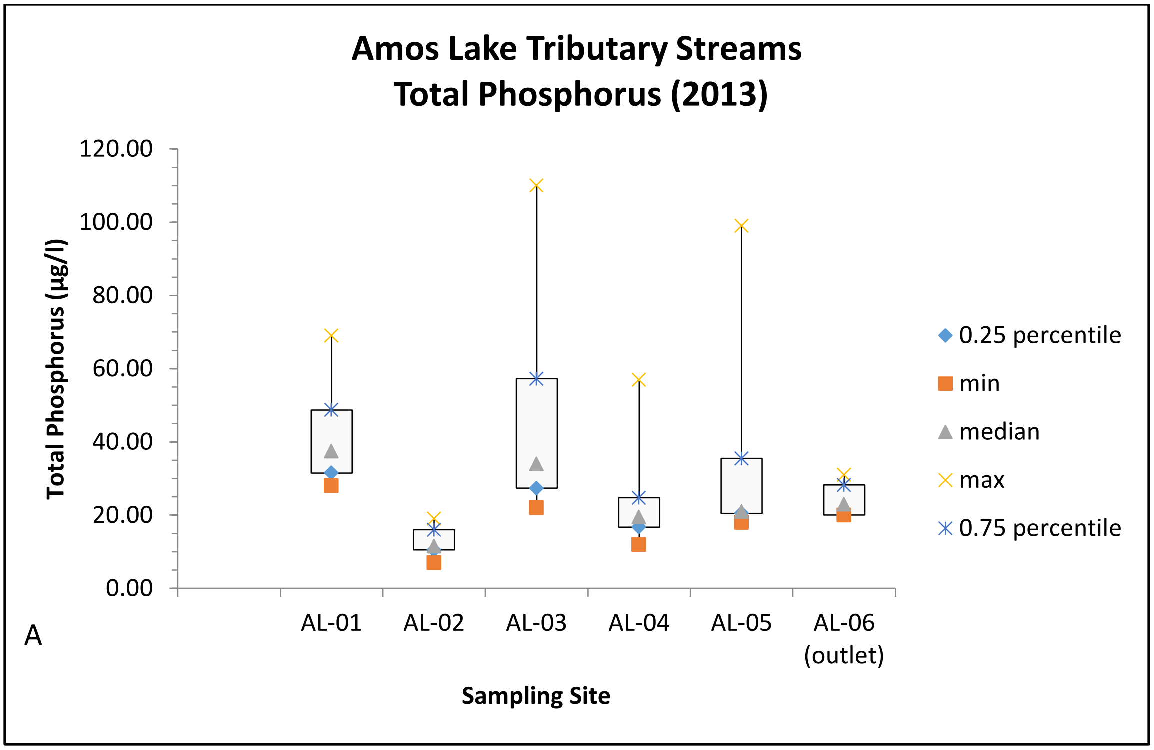
Water Quality Parameter	2013 Amos Lake Average Value	Trophic State - CT Water Quality Standards	CT Water Quality Standards Trophic State Defining Range
Total Phosphorus	27.4 µg/l * (spring and summer)	mesotrophic	10-30 µg/l (spring and summer)
Total Nitrogen	447 µg/l (spring and summer)	mesotrophic	200-600 µg/l (spring and summer)
Chlorophyll-a	22 µg/l (mid-summer)	eutrophic	15-30 µg/l (mid- summer)
Secchi Transparency	1.9 meters (mid-summer)	eutrophic	1-2 meters (mid-summer)

*one microgram per liter (µg/l) is equivalent to one part per billion (ppb)
one milligram per liter (mg/l) is equivalent to one part per million (ppm)
one part per million (ppm) is equivalent to 1000 parts per billion (ppb)

Table 4-4. Amos Lake Tributary Streams Water Quality Sampling Results.

Stream Sampling Site	Mean TP (µg/l) for monitoring period	Mean TN (mg/l) for monitoring period
AL-01	42.33	0.47
AL-02	12.63	0.44
AL-03	42.60	1.09
AL-04	24.45	0.16
AL-05	34.13	0.55
AL-06	24.25	0.43

ECCD deployed passive stormwater samplers at two locations near the shoreline of Amos Lake, and collected grab samples from two additional locations, in order to evaluate the contribution of stormwater runoff to nutrient loading. These sites included two storm drains on Lakeview Drive (see Fig. 4-1) and sampling sites AL-01 and AL-03. The unnamed stream sampled at AL-01 conveys stormwater runoff from Bunny Lane and Lakeview Drive. The unnamed stream at AL-03 conveys stormwater from the Preston City area as well as runoff from State Routes 164 and 165. When possible (e.g. if the streams had flow), grab samples were taken before and after each storm event to bracket the sample collected by the passive sampler during the storm. The results of the stormwater sampling are tabulated in Table 4-5. A review of this data indicates that nutrients picked up and conveyed as NPS during rainstorms may contribute significantly to nutrient loading to Amos Lake.



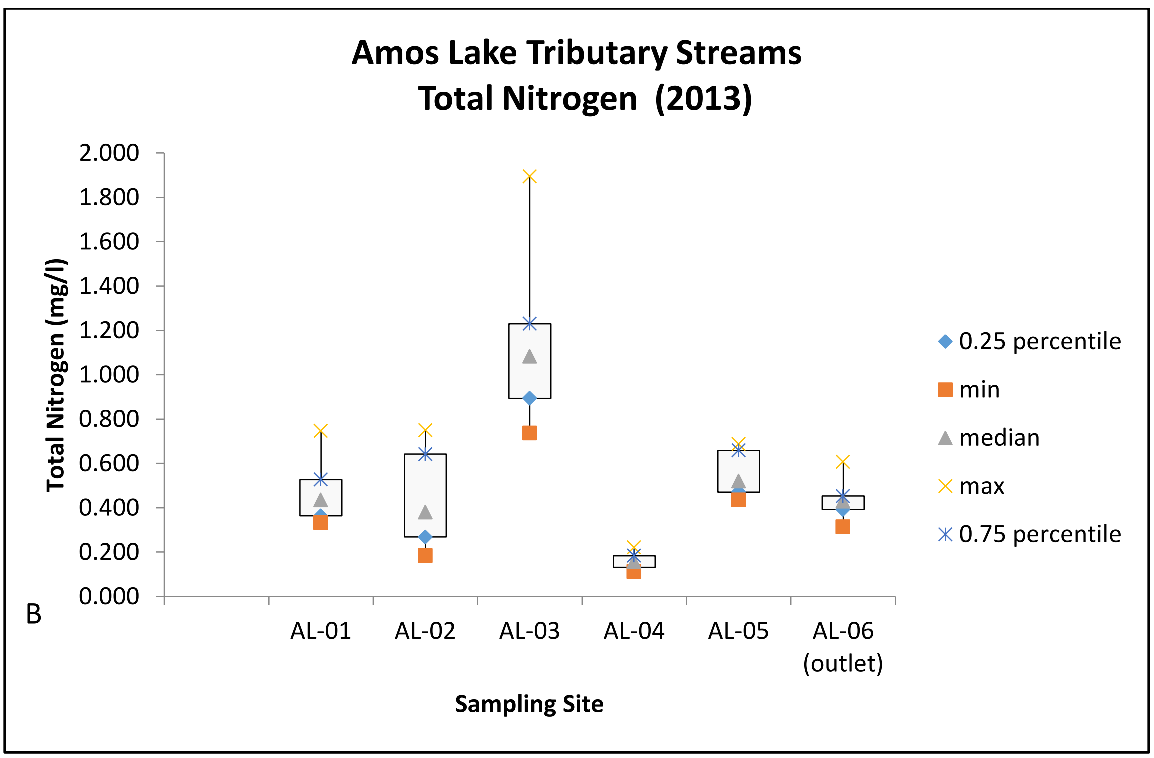


Figure 4-2. Total phosphorus (A) and total nitrogen (B) concentrations in Amos Lake tributary streams, April to October 2013.

Table 4-5. Summary of Passive Stormwater Sampler Data Results.

Sampling Site	Sample Type	Sample Date	TP (mg/l)	TN (mg/l)
AL-01 - PS	passive sampler	11/01/13	0.89	1.603
AL-01 - PS	passive sampler	11/18/13	0.327	1.259
AL-01 - PS	passive sampler	11/27/13	0.98	0.893
AL-01	post-storm grab	11/27/13	0.09	0.631
AL-03	pre-storm grab	10/31/13	0.119	2.762
AL-03 -PS	passive sampler	11/01/13	5.93	1.515
AL-03	post-storm grab	11/01/13	0.027	1.116
AL-03	pre-storm grab	11/17/13	0.024	1.763
AL-03 -PS	passive sampler	11/18/13	0.148	0.988
AL-03	post-storm grab	11/18/13	0.09	1.131
AL-03	pre-storm grab	11/26/13	0.025	1.678
AL-03 -PS	passive sampler	11/27/13	0.142	1.17
AL-03	post-storm grab	11/27/13	0.127	0.802
AL-PS-57	grab sample	11/01/13	1.58	1.292
AL-PS-57	grab sample	11/18/13	0.247	0.437
AL-PS-57	grab sample	11/27/13	0.135	0.301
AL-PS-76	grab sample	11/01/13	1.665	1.404
AL-PS-76	grab sample	11/18/13	0.638	1.023
AL-PS-76	grab sample	11/27/13	0.207	0.929

4.2.2 Review of Data by Others

Amos Lake has been the subject of numerous previous water quality investigations. While it is not practical to directly compare the results of previous studies to the current investigation due to differences in testing methodologies and the season of data collection, a review of this data has indicated a general declining trend in water quality over time.

Historical Analysis of Water Quality of Amos Lake, Preston, CT (Marsicano, 1996): In 1996, researchers at Connecticut College compiled a *Historical Analysis of Water Quality of Amos Lake, Preston, CT* at the request of the Amos Lake Association. This study included interpretation of data collected from two locations in Amos Lake in May, July, August and September of 1995. Parameters analyzed include total nitrogen, total phosphorus, Chlorophyll-a, and Secchi disk depth. Using the CT DEEP *Parameters and Defining Ranges for Trophic State for Lakes in Connecticut*, the data indicated that Amos Lake was in the early mesotrophic to mesotrophic state during this sampling period.

Historical Changes in Connecticut Lakes Over a 55-Year Period (Canavan and Siver, 1995): Amos Lake was one of 42 lakes in Connecticut reviewed for chemical and physical changes based on data obtained in the late 1930s, the 1970s and in 1990. Published in the study*, Historical Changes in Connecticut Lakes Over a 55-Year Period,* it was found that the chemistry of many Connecticut lakes had significantly changed since the 1930s, especially lakes where the surrounding land use transformed from forest to suburban development. Data from Amos Lake collected in the 1970s and the 1990s revealed a decrease of 1.3 meters in the secchi depth reading and a corresponding increase of total phosphorus concentration by 17 µg/l from the 1970s to the 1990s.

Amos Lake: A Watershed Management Approach for the Long Term Protection (CME Associates, Inc., 1994): This report was prepared by CME Associates, of Woodstock, CT in 1994. No water quality monitoring was conducted as part of this report. The report reviews potential problems and recommends management measures, but does not identify sources of nutrients.

Chemical and Physical Properties of Connecticut Lakes (Frink, 1984): In 1984, the Connecticut Agricultural Experiment Station compiled a report on the *Chemical and Physical Properties of Connecticut Lakes.* Data collected from Amos Lake in 1980 were included in the report. According to this data, Amos Lake was anoxic (lacking oxygen) below the thermocline (zone of rapidly decreasing water temperature), and would be categorized as mesotrophic by contemporary water quality standards.

Amos Lake Study, Preston, CT (SE CT Regional Planning Agency, 1980): In 1980, the Southeastern Connecticut Regional Planning Agency prepared a report entitled *Amos Lake Study, Preston, CT*. No water quality monitoring was conducted with this report. However, utilizing a methodology outlined in a *Lakes Management Handbook* developed by the Windham Regional Planning Agency and the Center for the Environment and Man, Inc., phosphorus loading was estimated.

5 Identification of Pollutant Causes and Sources

In order to identify potential point and non-point sources of pollution to Amos Lake, ECCD conducted windshield surveys throughout the watershed. ECCD reviewed land use/land cover data for Connecticut (Center for Land Use Education and Research, 2010) to determine land uses in the Amos Lake watershed that might contribute to the observed water quality degradation of Amos Lake. ECCD reviewed available documentation including National Pollutant Discharge Elimination System (NPDES) permits and hazardous waste site permits, including CERCLA ("superfund"), underground storage tank (UST), and Resource Conservation and Recovery Act (RCRA) permits. Water quality data collected in 2013 from Amos Lake and tributary streams was used to quantify pollutant loading from various parts of the watershed.

5.1 Nonpoint Sources

Nonpoint source pollution (NPS) is pollution that is not derived from a single point source, such as a pipe. NPS results from a diffuse and diverse array of pollutants found on the ground surface that are mobilized and transported via rain or snowmelt into streams, rivers, lakes, ponds and ultimately, the ocean, including:

- Excess or poorly managed fertilizers, herbicides and insecticides from agricultural lands and residential areas
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems
- Atmospheric deposition and hydromodification (*US EPA, 2014*).

Potential sources of NPS in the Amos Lake watershed are listed in Table 5.1 below.

Table 5-1. Potential Sources of Nutrients and Other NPS Contaminants to Amos Lake.

Potential Source	Location	Pollutant
Agriculture/Livestock	Watershed-wide	Nutrients, pesticides, herbicides, sediment, pathogens
Wildlife/Nuisance Waterfowl	Watershed-wide, Amos Lake	Nutrients, pathogens
Pets	Watershed-wide	Nutrients, pathogens
Septic Systems	Amos Lake shoreline	Nutrients, pathogens
Stormwater Runoff	Watershed-wide	Nutrients, pesticides, herbicides, sediment, pathogens, oils, grease, heavy metals
Residential and Commercial Lawn/Land Care	Watershed-wide	Nutrients, pesticides, herbicides, sediment, pathogens
Lake sediments	Amos Lake	Nutrients
Atmospheric Deposition	Watershed-wide	Nitrogen, dust, chemicals

5.1.1 Agriculture

Agricultural land use can contribute to both point and nonpoint source pollution. Common agriculture-related pollutants include sediment, nutrients from fertilizer and manure (particularly phosphorus and nitrogen), herbicides, pesticides, and pathogens from animal waste. Pollutant loading varies depending on the type of farming activity, and can be minimized through the selection of appropriate farm management practices and application methods. There is a significant amount of agricultural activity in the Amos Lake watershed, including four commercial agricultural producers and several small private farms. These agricultural uses are diverse, and include pasture, hay fields, crop land (corn and vegetables), berries/orchards, vineyards, and Christmas tree production, as well as animal husbandry (see Fig. 3-17).

5.1.1.1 Livestock

Livestock can contribute to NPS in several ways. Nutrient and pathogen loading can occur from poor or improper manure management practices. Sediment loading can occur via overgrazing and runoff from bare soils in confined paddock areas. Nutrient, pathogen and sediment loading can also occur in areas where livestock are kept near or allowed access to ponds and streams. Livestock in the Amos Lake watershed includes dairy cows, horses, chickens, sheep and goats.

5.1.1.2 Cropland

Cropland can contribute to NPS through sedimentation from run-off from tilled fields, nutrient loading from fertilizer and manure application, bacteria/pathogen loading from manure application, and pesticide/herbicide application. Cropland in the Amos Lake watershed includes row crops (primarily corn), field and greenhouse-grown vegetable crops, vineyards, berry production/orchards, hayfields and Christmas tree cultivation. Approximately 151 acres (16%) of the watershed are used for agricultural activities. Of that land, approximately 59% is used as pasture or hayland, 18% is used to grow row crops and 23% is used for fruit production and viniculture.

5.1.2 Wildlife/Migratory Waterfowl

In undeveloped watersheds, wildlife can contribute to pollutant loading. However, unless a particular issue such as the overpopulation of a specific animal species is identified, pollutant loading associated with wildlife is typically considered to be a natural or background level and is not actively managed. Approximately 38% of the Amos Lake watershed is undeveloped. In human-dominated landscapes, the feeding of wildlife can promote artificially elevated and unsustainable population levels which can increase pollutant loading beyond acceptable background levels.

CT DEEP conservatively estimates the population of white-tailed deer (*Odocoileus virginianus*) in eastern Connecticut to be an average of 28 animals per square mile (Howard Kilpatrick, personal communication, March 11, 2014), contributing, along with other wildlife, to "background" or natural levels of bacteria found in the watershed. McGuiness (1997) reports that the Pennsylvania Game Commission determined that "mature forests, which provide good cover for deer and moderate amounts of browse and mast (food), can support about 20 deer per forested square mile over winter." McGuiness further states that "studies at the Forestry Sciences Lab in Irvine, PA, show that average over-winter deer densities higher than 20 deer per forested square mile have significant negative impacts on Allegheny hardwood forest communities" (1997). Mature hardwood forests in Connecticut are not significantly different from Alleghany hardwood forests and should support a similar deer population. Other wildlife that have been observed to use Amos Lake include river otter (*Lontra canadensis*), muskrat (*Ondatra zibethica*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), and opossum (*Didelphis virginiana*).

Amos Lake hosts a large flock of migratory Canada Geese each winter. Estimates of Canada Geese flock size were made by Amos Lake residents during the winters of 2012-13 and 2013-14 (Fig. 5-1). Canada Geese arrived in large numbers (an estimated 1000-1500 birds) around December 25 of each year. Flock size remained constant through January and into February. The birds were observed to leave each morning to forage and returned by dusk each night. By mid-February flock sizes were observed to dwindle to about 200 or so birds, and by the end of March all migratory geese had moved on. In addition to the Canada Geese, a small number of ducks, including Coot and Hooded Merganser, were observed. A small flock of approximately 20 Canada Geese stayed at the north end of the lake through the summer.

Figure 5-1. Migratory Canada Geese on Amos Lake in the winter of 2013.

Large flocks of waterfowl, including Canada Geese, can contribute significantly to nutrient and bacteria loading, and migratory geese can produce seasonal plugs of nutrient and bacteria, temporarily inflating nutrient and bacteria levels in waterbodies. Pettigrew and Hahn et al. (1998) found that "Canada geese feces contain 14 mg of phosphorus and 5.7 mg of nitrogen using dry weight with 80% moisture content" (Pettigrew, Hahn et al. 1998). A settling experiment conducted by Unckless and Marakewicz (2007) suggested that goose feces and associated nutrients settled quickly to the lake bottom sediment. As a result, the effects of the addition of this fecal material would not become evident until the occurrence of mixing between the upper and lower water column due to wind or other means.

5.1.3 Pets

In developed settings, pet feces, particularly dog feces, can be a significant source of nutrients and bacteria. Various studies have indicated that dog feces can contribute from 0.3 to 1.2 kg of phosphorus per year per dog. In 2013, 445 dogs were licensed in Preston (~14 dogs per square mile). Assuming a relatively even distribution of dogs throughout the town, this would equate to approximately 21 dogs in the Amos Lake watershed. However, during the watershed investigation, few dogs were noted and no areas such as kennels, breeding or training facilities, or dog parks, where dog populations might be concentrated, were identified.

5.1.4 Septic Systems

There are no public sanitary sewers in the Amos Lake watershed. Instead, all residences and businesses are served by individual subsurface sewage treatment systems (septic systems), which are regulated by the Town of Preston Health Department. Nutrient loading to shallow subsurface water and groundwater can occur as a result of malfunctioning or under-functioning septic systems. Factors that may contribute to nutrient loading include the age of the septic system, public health codes (if any) at the time of installation, the type of soil into which the system was installed and the level of septic system upkeep and maintenance. A review of building permits issued by the Preston Building Department indicated that most of the development adjacent to Amos Lake occurred between the mid-1970s and early 1980s. Septic systems installed during this time period may be reaching the end of their design life of 15 to 30 years. It is incumbent upon property owners to ensure their systems are properly maintained, and to affect repairs if their systems are malfunctioning or failing.

Soil surveys conducted by soil scientists at the Natural Resources Conservation Service (NRCS) include an assessment of soil septic suitability (Fig. 5-2). A review of the soil survey indicates that soils adjacent to Amos Lake generally have low septic potential based on soil characteristics including depth to groundwater and infiltration capacities. These soils include Timakwa and Natchaug soils, which are wetland soils; Sudbury sandy loams, which have a low depth to groundwater; and Hinckley gravelly sandy loams, which are excessively well-drained. By contrast, Charlton and Canton soils located along the northeast edge of Amos Lake, in the vicinity of Lakeview Drive and Bunny Lane, have medium to high septic potential. Two septic system repairs in the project area were documented between 2008 and 2013 by the Preston Health Department (Fig. 5-2). The documentation of these septic system repairs does not preclude the presence of additional septic systems which may be malfunctioning.

5.1.5 Stormwater Runoff

Numerous studies have established that the amount of impervious cover in a watershed directly impacts stream quality. Impervious cover is comprised of hardened surfaces, including roads, driveways, sidewalks, parking lots and buildings that shed, rather than infiltrate, stormwater. Recent studies, including a 2008 study conducted by CT DEEP (Bellucci et al), indicate that impervious cover as low as 12% can have a detrimental impact on aquatic habitat (Fig. 5-3). Approximately 17% of the Amos Lake watershed is developed, exceeding the recommended impervious cover of 12% for good stream quality.

Developed areas in the Amos Lake watershed are located primarily along main transportation corridors, including Routes 164 and 165. Suburban development also occurs along secondary roads such as Lakeview Drive and Bunny Lane, which are located on the eastern shore of Amos Lake.

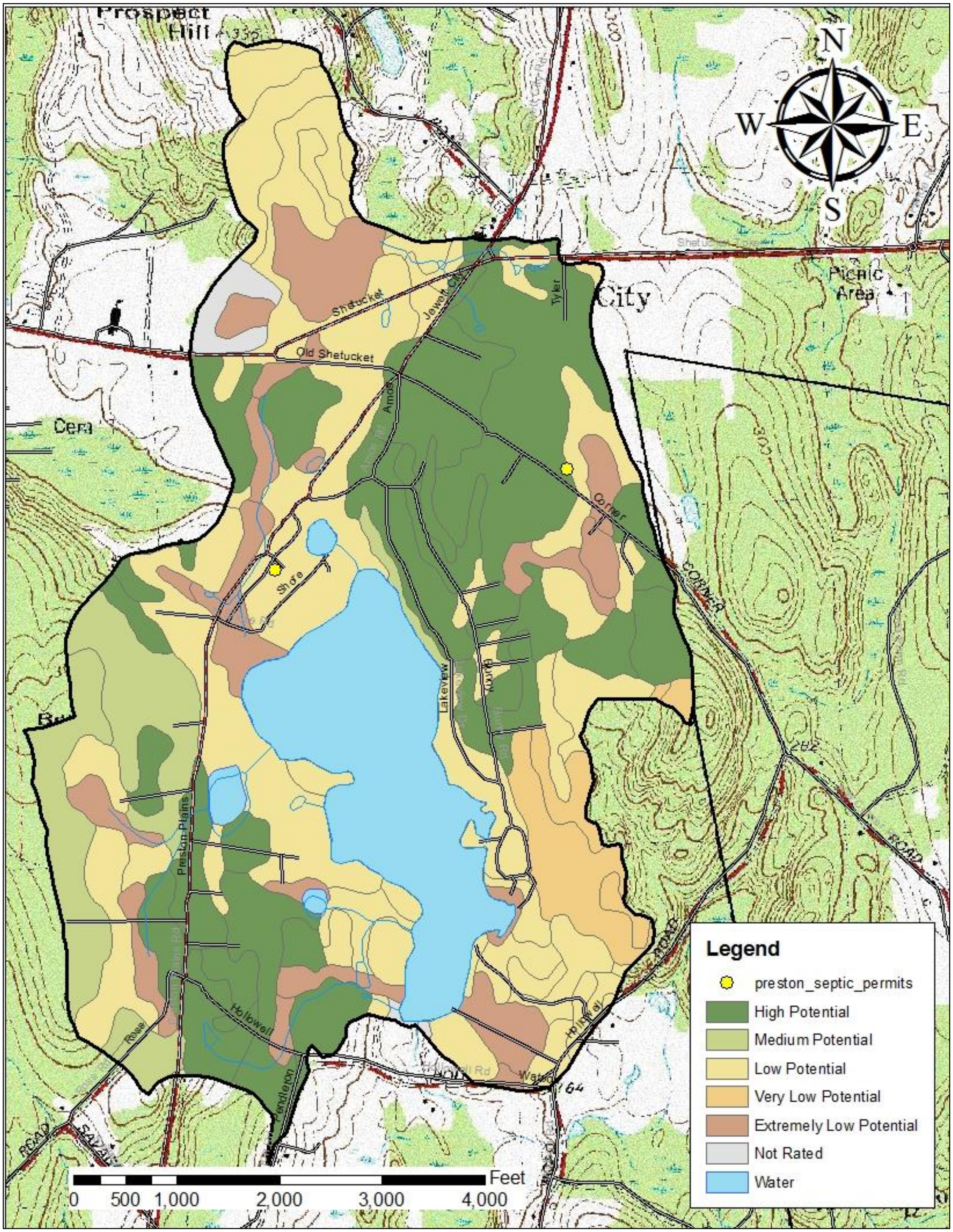


Figure 5-2. Septic Suitability of soils in the Amos Lake watershed (USDA-NRCS Web Soil Survey) with locatIons of septic system repairs conducted between 2008 – 2013.

Storm drainage systems associated with transportation networks have been widely demonstrated to be major vectors for the delivery of nonpoint source pollutants to waterbodies, including streams, ponds, and lakes. While the primary purpose of storm drainage systems is to remove water quickly and efficiently from road surfaces to ensure public well-being and safety, traditional storm drain systems do little to treat the wide variety of pollutants contained in stormwater. These pollutants can include nutrients from agricultural activities, pet waste and lawn care products; bacteria; oils, greases, chemicals and heavy metals from vehicles; and trash and debris.

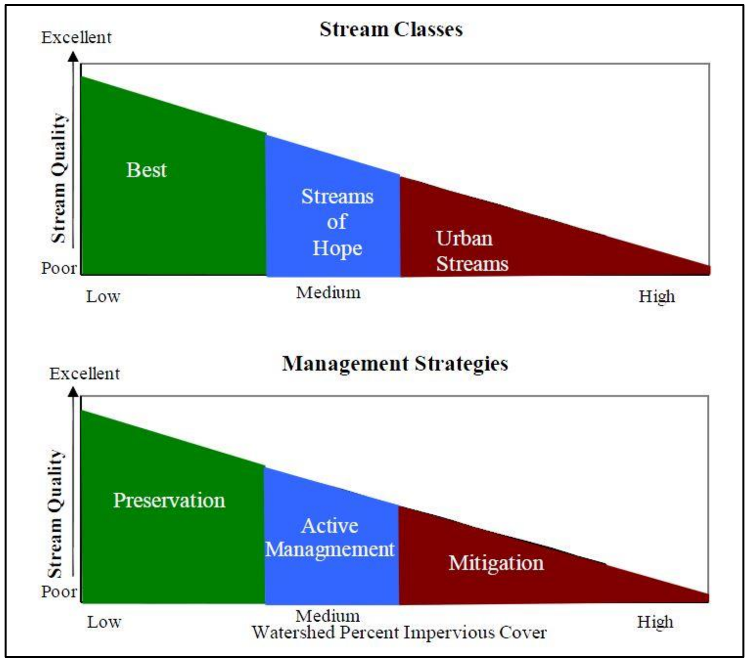


Figure 5-3. Relationship between impervious cover and stream quality (Bellucci et al, 2008).

Three direct stormwater outfalls to Amos Lake were identified as part of the water quality investigation (Fig.5-4). These outfalls discharge stormwater from the storm drain system located on Lakeview Drive on the east side of Amos Lake.

Indirect pollutant loading may also occur from stormwater discharges to streams that flow into Amos Lake. These indirect loading sources include stormdrain pipe outfalls, leak-offs, and catch basins that are placed directly over and discharge to stream channels. In particular, the unnamed stream that flows from the Preston City area into Amos Lake from the west collects stormwater from both Routes 164 and 165.

Figure 5-4. Storm water outfalls to Amos Lake.

5.1.6 Atmospheric Deposition

Atmospheric deposition is the deposition of airborne particles and pollutants under both wet (rain/snow) and dry conditions onto land and water surfaces. The atmospheric deposition of pollutants can have a substantial effect on aquatic ecosystems. Atmospheric deposition can be a significant source of nitrogen to streams (Smith et al, 2002), resulting in algae blooms and hypoxia. Primary sources of atmospheric nitrogen throughout the United States include emissions from combustion processes and agriculture (Puckett, 1994; Jassby et al., 1994). A study by Luo et al (2003) indicated that atmospheric deposition of nitrogen in rural southeastern Connecticut is approximately 1.2 $\mu g/m^3$/year. The 2002 study by Smith et al determined that deposition of atmospheric phosphorus is considered insignificant. These contaminants are difficult to manage once they become airborne. Management is most effective at the source.

5.2 Point Sources

Point source pollution is pollution that is discharged from a single, identifiable point, such as a sewage outfall or combined sewer overflow pipe, factory, or confined animal feedlot (National Water Quality Monitoring Council, 2007). Point sources may be regulated by state or federal authorities via the National Pollutant Discharge Elimination System (NPDES) permit program.

5.2.1 NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) is authorized by Section 402 of the Clean Water Act through the 1987 Water Quality Act. The NPDES program regulates direct discharges into navigable waters of the US, including point source discharges and nonpoint sources. NPDES permits may be issued directly by the US EPA or by states authorized by EPA. Connecticut is authorized to issue NPDES permits. Permits establish pollutant monitoring and reporting requirements, and may include pollutant discharge limits based on specific water quality criteria or standards (US EPA, 2015).

Stormwater discharges regulated by NPDES permits include:

- discharges permitted prior to February 4, 1987
- discharges associated with industrial activity
- discharges from large Municipal Separate Storm Sewer Systems (MS4s) (systems serving a population of 250,000 or more)
- discharges from medium MS4s (systems serving a population of 100,000 or more, but less than 250,000)
- discharges judged by the permitting authority to be significant sources of pollutants or which contribute to a violation of a water quality standard (*US EPA, 2014*).

5.2.1.1 Phase 1 and 2 Stormwater Permits

Stormwater permits issued under Phase 1 of the NPDES program include the categories of stormwater discharges listed above. Also included in Phase 1 are municipal separate storm sewer systems (MS4) program permits for medium and large MS4s; construction sites which disturb five or more acres; and for numerous types of industrial facilities. Stormwater permits issued under Phase 2 of the stormwater program include discharges not covered by Phase I, including small MS4s; construction sites of one to five acres; and industrial facilities owned or operated by small MS4s which were previously exempted under the Intermodal Surface Transportation Efficiency Act (US EPA, 2014).

Stormwater permits issued by the State of Connecticut under the NPDES program include:

- **General Permit for the Discharge of Stormwater Associated with Industrial Activity** (“Industrial General Permit”), which regulates industrial facilities with point source stormwater discharges that are engaged in specific activities according to their Standard Industrial Classification (SIC) code.
- **General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities** ("Construction General Permit"), which requires developers and builders to implement a Stormwater Pollution Control Plan to prevent the movement of sediments off construction sites into nearby water bodies and to address the impacts of stormwater discharges from a project after construction is complete.
- **General Permit for the Discharge of Stormwater Associated with Commercial Activity** ("Commercial General Permit"), found only in Connecticut, which requires operators of large paved commercial sites such as malls, movie theaters, and supermarkets to undertake actions such as parking lot sweeping and catch basin cleaning to keep stormwater clean before it reaches water bodies.
- **General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems** ("MS4 General Permit"), which requires each municipality to take steps to keep the stormwater entering its storm sewer systems clean before entering water bodies (*CT DEEP, 2014*).

The Town of Preston is in the Norwich-New London designated urban area (UA) as defined by the US Census Bureau. However, Preston is waived from MS4 permitting under current rules because the population in the Urbanized Area is less than 1000. Proposed changes to the MS4 General Permit by CT DEEP at the time of this writing may require all Connecticut towns to comply with the MS4 program in the future.

A review of existing CT DEEP and US EPA data indicated that no Phase 1 or Phase 2 stormwater permits have been issued in the Amos Lake watershed.

5.2.1.2 CAFO Permits

Confined Animal Feeding Operations (CAFOs) are agricultural operations where:

> Animals are kept and raised in confined areas for a total of 45 days or more in any 12-month period, and crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. CAFOs generally congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. Animal waste and wastewater can enter water bodies from spills or breaks of waste storage structures (due to accidents or excessive rain), and non-agricultural application of manure to crop land. CAFOs are point sources, as defined by the CWA Section 502(14) and are regulated through the NPDES program (*US EPA, 2014*).

Currently, in Connecticut, permits are not being issued for CAFOs, although DEEP does review Comprehensive Nutrient Management Plans (CNMPs) that are voluntarily submitted by producers enrolled in USDA-NRCS programs. DEEP is in the process of preparing a general permit under which CAFOs will be permitted in the future. There are no CAFOs in the Amos Lake watershed. NRCS did not report any CNMPs in the Amos Lake watershed at the time of the preparation of this document.

5.3 Hazardous Waste

EPA defines hazardous waste as "waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes" (US EPA, 2014). Authority for the State of Connecticut to regulate hazardous waste is prescribed through Connecticut General Statutes Section 22a-449.

5.3.1 CERCLA Sites

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund, was enacted by Congress on December 11, 1980. A CERCLA or Superfund site is an uncontrolled or abandoned place where hazardous waste is located (US EPA, 2014). There are no CERCLA sites in the Amos Lake watershed.

5.3.2 RCRA Sites

The Resource Conservation and Recovery Act (RCRA) was enacted by Congress in 1976. RCRA's primary goals are "to protect human health and the environment from the potential hazards of waste disposal, to conserve energy and natural resources, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner. RCRA regulates the management of solid waste (e.g., garbage), hazardous waste, and underground storage tanks holding petroleum products or certain chemicals" (US EPA, 2014).

There is one registered RCRA site in the watershed (Fig. 5-5). There is also one site listed in the CT DEEP *List of Contaminated or Potentially Contaminated Sites* (as defined by §22a-134f of the Connecticut General Statutes) in the Amos Lake watershed. The investigation of the site has been completed. A remediation plan is being developed and no offsite impacts are anticipated (M. Brogie, GEI Consultants, Inc., personal communication, 4-6-15).

5.3.3 Brownfields

A brownfield is a site for which the "expansion, redevelopment, or reuse…may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (US EPA, 2014). No brownfields have been identified in the Amos Lake watershed.

5.3.4 Underground Storage Tanks

The US EPA defines an underground storage tank (UST) as "a tank and any underground piping connected to the tank that has at least 10 percent of its combined volume underground" and that stores petroleum or certain hazardous substances (US EPA, 2014). This typically refers to underground tanks at gas and service stations and residential heating oil tanks. The State of

Connecticut regulates USTs through the Department of Energy and Environmental Protection Storage Tank Enforcement Unit. Registered underground storage tanks in the Amos Lake watershed are depicted in Fig. 5-5.

5.4 Other Potential Pollutant Sources

5.4.1 Winter Road De-icing

CT DOT maintains Route 164 which runs north-south along the western margin of Amos Lake and Route 165, which runs east-west through Preston City. In 2006, CT DOT switched to a winter de-icing program utilizing salt and liquid chemicals, and discontinued the use of road sand. Chlorides are prime constituents of de-icing compounds. Chlorides can negatively impact water quality as well as stormwater infrastructure. The development of best management practices to address chloride has been very challenging. The Town of Preston manages all municipal roads including Amos Road, Lakeview Drive, Bunny Lane and Hollowell Road, which are located along the eastern side of Amos Lake. Preston utilizes a salt-sand mix for winter road management.

5.4.2 Land Clearing/Development

Other potential sources of pollution include activities such as residential and/or commercial development, earth removal and logging operations. These operations can result in the clearing of large tracts of land and erosion and transport of soil. Land development and land clearing activities occur under the auspices of the Preston land-use commissions, including the Planning and Zoning and Inland Wetlands and Watercourses Commissions. Commissions are responsible for reviewing land development permit applications, ensuring the proposed activities comply with land-use regulations and issuing permit conditions as necessary. Typical permit conditions include proper use of on-site erosion and sediment control, and adoption of a stormwater management plan. Land-use staff are responsible for ensuring permitted activities are being conducted in compliance with the municipal regulations and the terms of the permits.

There were no residential and/or commercial development, earth removal or logging activities in the Amos Lake watershed at the time of the preparation of this Plan.

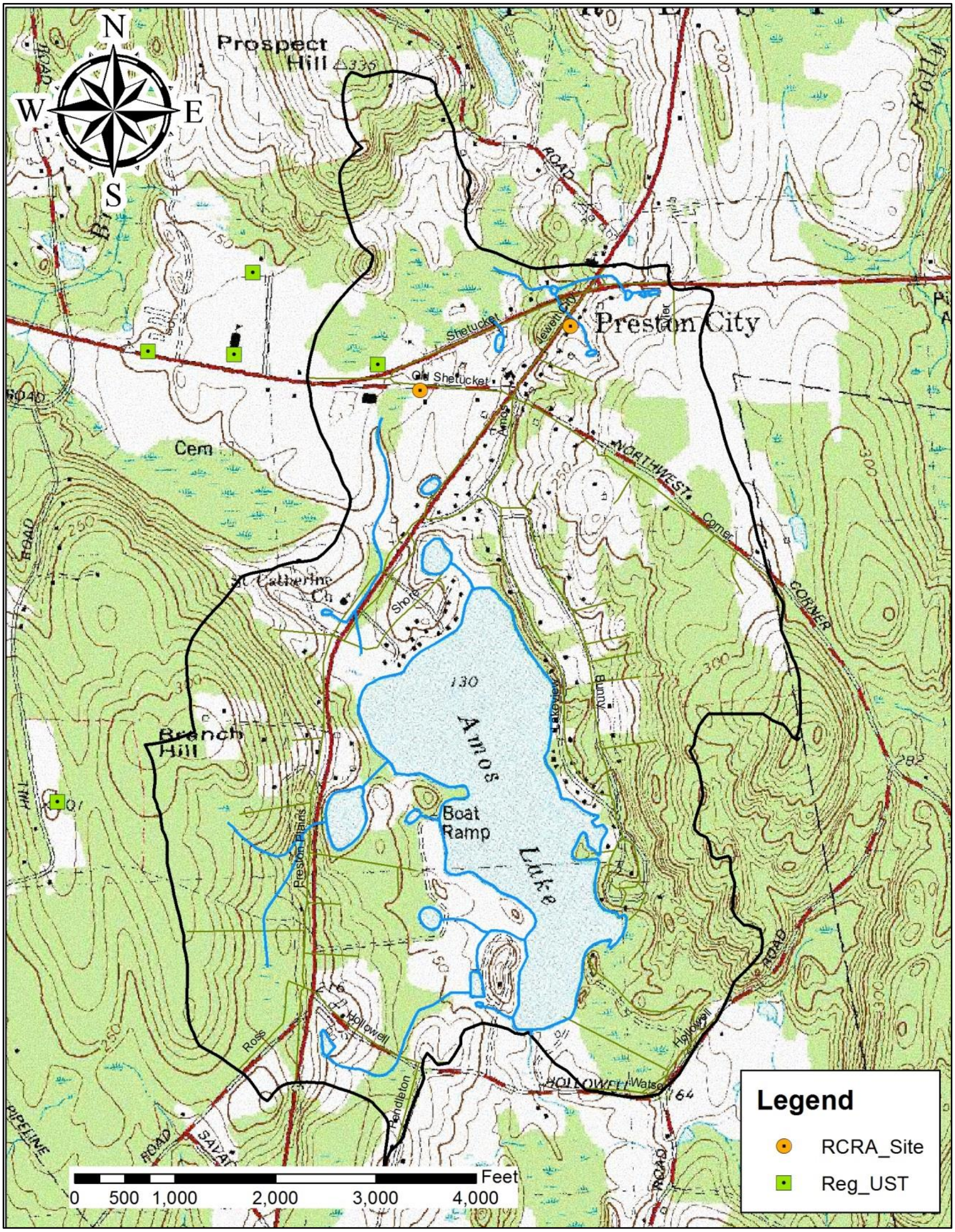


Figure 5-5. RCRA sites and underground storage tanks (UST) in the Amos Lake watershed.

6 Pollutant Load Assessment

6.1 Estimation of Pollutant Loads

The estimation of pollutant loads is a critical element in the overall watershed planning process necessary to determine the pollutant load reduction needed to restore the quality of an impaired waterbody. A pollutant load is the mass of a pollutant being delivered per unit of time to a waterbody, usually expressed as pounds or kilograms per year. In order to identify where pollutant load reductions may be applied to improve water quality, it is necessary to quantify the pollutant load contributions from the watershed. Where water quality measurements are made, it is possible to determine pollutant loading directly. When no water quality data is available, the use of models can be used to estimate pollutant loading. It should be noted that due to the complexity of watershed processes, models are inherently imprecise, and should be used to guide watershed management decision-making and not as a predictor of future water quality.

The primary pollutants of concern to Amos Lake are nutrients (phosphorus and nitrogen). However, the pollutant load assessment will also consider common pollutants associated with nonpoint source pollution, including total suspended solids (TSS), zinc (Zn) as an indicator for other metals, total petroleum hydrocarbons (TPH), and dissolved inorganic nitrogen (DIN), as an indicator of industrial, municipal and agricultural waste.

6.1.1 In-Lake Nutrient Loads

Water quality data collected from Amos Lake in 2013 was evaluated by Northeast Aquatic Research, LLC (NEAR) to determine in-lake nutrient loads. Research has demonstrated that spring phosphorus concentrations can be used to yield reasonable estimations of annual phosphorus loads. NEAR utilized several models to determine average spring phosphorus loading of 193 kg P/year (or 426 lb P/year) based on water samples collected in April 2013 (Table 6-1).

Table 6-1. Prediction of Annual Phosphorus (P) Load Based on Spring Phosphorus concentration of 26.7 ppb (μg/l) collected on 4/11/13.

Model Author	kg P/year	lb P/year
Kirchner and Dillon 1975	224	494
Vollenweider 1975	184	406
Jones and Bachmann 1976	106	234
Chapra 1975	258	570
Average	193	426

6.1.2 Internal Loading

Water quality data collected during 2013, including dissolved oxygen and temperature, indicate that Amos Lake becomes highly stratified during the summer months (Figs. 6-1 and 6-2), with warmer, well-oxygenated waters overlying colder, hypoxic and anoxic bottom waters. An examination of relative thermal resistance to mixing (RTRM) values demonstrates a high resistance to thermal mixing during June, July and August (Fig. 6-3). An examination of the 2013 Amos Lake nutrient data indicates that phosphorus concentrations in the lake remained constant from spring to summer. Spring composite total phosphorus concentrations were 26.7 parts per billion (ppb), spring/summer total phosphorus concentrations were 27.4 ppb, and summer surface total phosphorus concentrations were 26.5 ppb. This lack of significant variation among phosphorus concentrations from spring to summer indicates that internal nutrient cycling during the summer months is likely not a contributing factor to nutrient loading in Amos Lake. No water quality data was collected from November to March, so physio-chemical processes occurring during the winter months are unknown. Future winter water quality data collection may provide additional useful information.

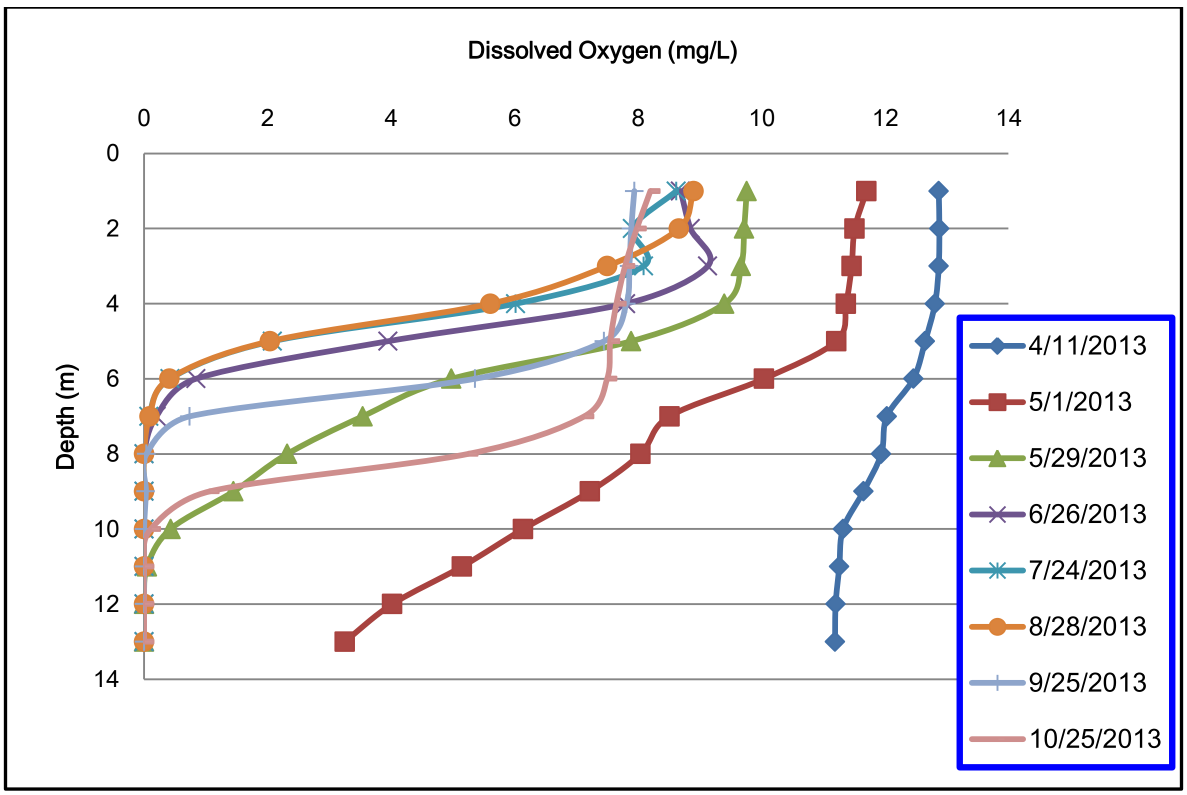


Figure 6-1. Dissolved oxygen profiles from Amos Lake during 2013 (NEAR, 2014).

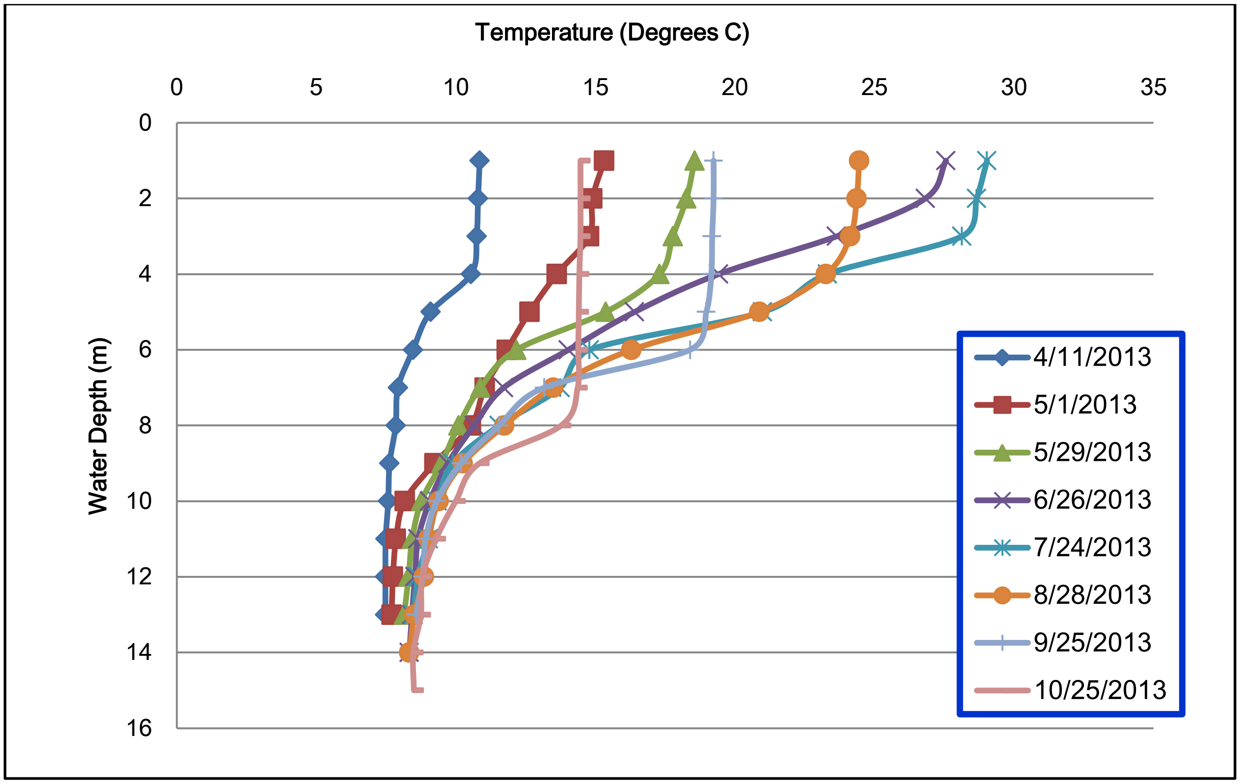


Figure 6-2. 2013 Amos Lake water temperature profiles (NEAR, 2014).

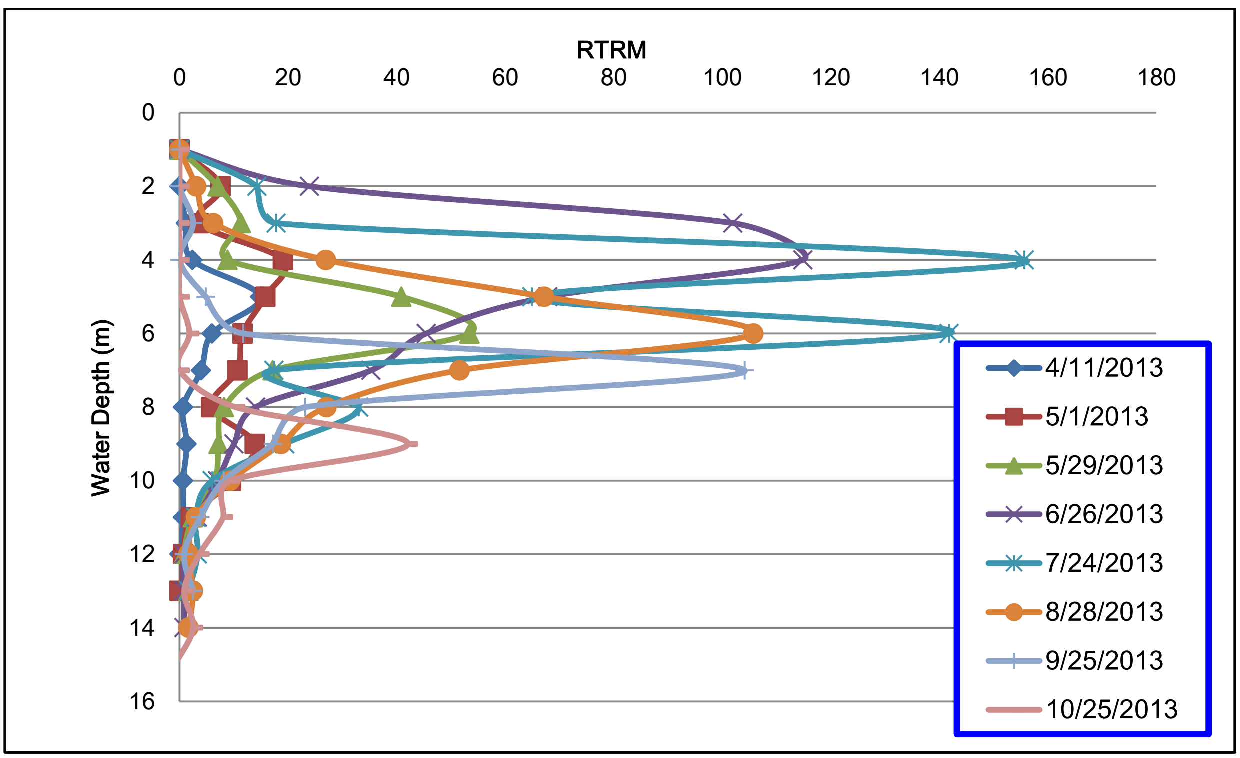


Figure 6-3. Relative Thermal Resistance to Mixing (RTRM) values in Amos Lake during 2013 season (NEAR, 2014).

6.1.3 Stream Nutrient Loads

Water samples were collected at the tributaries to Amos Lake monthly from April to October 2013 (table 6-2). These samples were analyzed for nutrient content. With the assistance of project partners from Nichols College in Dudley, MA, a staff gauge was installed at the perennial tributary to Amos Lake (sampling station AL-03). Discharge data collected at this gauge was used to determine nutrient loading to Amos Lake by NEAR. NEAR determined that annual phosphorus loading to Amos Lake could range from 36-60 kg/year (66-132 lb/yr), and annual nitrate loading was approximately 1224 kg/year (2699 lbs/yr).

Table 6-2. Nutrient Concentrations in Amos Lake tributaries in 2013.

TP (ppb)	4/11/13	5/1/13	5/29/13	6/26/13	7/24/13	8/28/13	9/25/13	10/23/13
AL-01	28	51	69	31	42	33	*	*
AL-02	16	16	7	12	19	11	11	9
AL-03	27.5	27	31	56	110	61	22	37
AL-04	12	18	13	19	33	57	22	20
AL-05	22	21	18	49	99	21	20	
NO3 (ppb)								
AL-01	136	175	295	528	222	144	*	*
AL-02	524	417	274	92	16	*	3	*
AL-03	555	842	1032	900	413	237	2015	1210
AL-04	46	120	54	22	36	18	4	*
AL-05	472	327	205	220	268	330	146	32
* No value indicates the tributary was dry at the time of sample collection.								

6.1.4 Stormwater Nutrient Loads

ECCD installed passive samplers at several locations on the perimeter of Amos Lake to collect stormwater runoff. These samplers are designed to capture the first flush of rainfall, which typically contains the highest pollutant load. An analysis of data by NEAR from the stormwater sampler installed in the perennial stream flowing from Preston City indicated that phosphorus and nitrogen concentrations contained in the stormwater runoff were significantly higher than concentrations found in tributary baseflow (groundwater contribution to streamflow) (Table 6-3). Based on this data, NEAR concluded that pollutant loading from stormwater flow to Amos Lake could be considerable.

Table 6-3. Total Phosphorus (TP) and Total Nitrogen (TN) concentrations in stormwater runoff during the 2013 sampling season.

Location	11/01/2013		11/18/2013		11/27/2013	
	TP (ppb)	TN (ppb)	TP (ppb)	TN (ppb)	TP (ppb)	TN (ppb)
AL-03						
Pre-storm grab sample	119	2762	24	1763	25	1678
Passive sampler	5930	1515	148	988	142	1170
Post-storm grab sample	27	1116	90	1131	127	802
Near 50 Lakeview Dr.						
Passive sampler	890	1603	327	1259	980	893
Post-storm grab sample	n/a	n/a	n/a	n/a	90	631
Near 57 Lakeview Dr.						
Grab sample	1580	1292	247	437	135	301
Near 76 Lakeview Dr.						
Grab sample	1665	1404	638	1023	207	929

6.1.5 Watershed Pollutant Loads

While nutrients, particularly phosphorus, are the primary pollutants of concern to Amos Lake, it is important to evaluate other pollutants that may degrade water quality as well. To estimate loads and load reductions, ECCD selected the Simple Method (Schueler, 1987) to estimate pollutant loads and load reductions in the Amos Lake watershed:

$L = 0.226(P)(P_j)(R_v)(C)(A)$, where:

L = pollutant loading in pounds per year
P = annual precipitation in inches
P_j = the fraction of annual rainfall that does not produce measurable runoff
R_v = runoff coefficient
C = pollutant concentration in mg/l
A = site area in acres
0.226 = conversion factor

The Simple Method calculates pollutant loading in pounds per year, based on factors including the watershed drainage area, percent of impervious cover, annual precipitation and stormwater runoff pollutant concentrations associated with specific land cover types. Pollutant concentration is defined as the pollutant mass per unit volume and is expressed as milligrams per liter (mg/l). Pollutant load contributions for various land uses/land covers were gleaned from several sources including the National Stormwater Quality Database (Maestre & Pitt, 2005), the National Urban Runoff Program (EPA, 1993) and the University of New Hampshire Stormwater Center (Table 6-4). Pollutant concentrations for runoff from agricultural land use, including pasture, hay land, tilled and untilled cropland, were derived from a literature review (Table 6-5). An average of the total phosphorus and total nitrogen concentrations in milligrams per liter was obtained. This value was calibrated to the total phosphorus load in the sampled watersheds and used to estimate nutrient loads in the un-sampled portions of the Amos lake watershed (sub-watershed 06). Pollutant load concentrations for seven common pollutants associated with nonpoint source pollution, including total suspended solids (TSS), total phosphorous (TP), total nitrogen (TN), zinc (Zn) as an indicator for other metals, total petroleum hydrocarbons (TPH), and dissolved inorganic nitrogen (DIN), as an indicator of industrial, municipal and agricultural waste, were also calculated.

In order to better isolate pollutant loading, the Amos Lake watershed was divided into six sub-watersheds. Five of the sub-watersheds are associated with tributaries where water sampling was conducted. The sixth sub-watershed was comprised of the remaining portions of the Amos Lake watershed where no tributaries existed to sample. The sub-watersheds are depicted in Fig. 6-4.

Based on the Simple Method, the Preston City sub-watershed contributed the highest loads of total phosphorus, 148 lbs/yr, or 34%, and total nitrogen, 1389 lbs/yr, or 33%, to Amos Lake. A summary of pollutant loads in pounds per year for each sub-watershed are depicted in Table 6-6 and Fig. 6-5.

Based on the Simple Method, pollutant loads in pounds per year for each land use/land cover type are depicted in Table 6-7 and Fig. 6-6. Complete Simple Method watershed pollutant loading results are included in Appendix E.

Table 6-4. Pollutant load contribution coefficients for each type of Land Use/Land Cover (pollutant concentration contained in runoff mg/l) for load modeling.

Land use/Land cover	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	60	0.38	2.1	0.16	0.5	0.51
Medium Density Residential	60	0.3	2.1	0.18	1.25	0.344
High Density Residential	60	0.3	2.1	0.22	1.5	0.344
Commercial Development	58	0.25	2.6	0.15	3	0.324
Industrial Development	50	0.23	2.1	0.17	3	0.324
Institutional Development	58	0.27	2.1	0.67	3	0.521
Transportation	99	0.25	2.3	0.15	3	0.375
Turf and Grass	357	0.3	2.92	0	0	0.215
Pasture	145	0.3	2.2	0	0	0.65
Cultivated Crops*	532	0.3	7.14			
Forest	90	0.1	1.5	0	0	0.215
Wetlands	0	0.38	1.5	0	0	0
Bare Ground	1000	0.38	1.5	0	0	0

Sources: 1) National Stormwater Quality Database (NSQD), v. 1.1-9/4/05 by Maestre &Pitt

2) National Urban Runoff Program (NURP), 1983

3) University of New Hampshire Stormwater Center

* derived from literature search (see table 6-5)

Table 6-5. Summary of sources of agricultural runoff concentration data.

Mean Runoff Concentrations from Agricultural Land (mg/l)					
Crop Type	**Location**	**TN**	**TP**	**TSS**	**Source**
unspecified agriculture	VT	1.01	0.2		Gustafson and Wang, 2002
tilled cropland	NE	2.44	0.46		Elrashidi et al, 2014
multiple agricultural uses	OK	8.89	2.17		Smith et al, 1988
dairy pasture, improved hay land and tilled cropland	NY		1.97	205	Hively et al, 2005
manured hayfield	CT	6.03	0.80		Clausen et al, 2008
row and forage crops	WI	14.98	3.51	859.17	Stuntebeck et al, 2011
multiple agricultural uses	NE and Mid-Atlantic US	9.5	10.5		Moore et al, 2011

Table 6-6. Pollutant Load (lb/yr) and Percent Load for each Sub-Watershed

Sub-Watershed	TSS lb/yr	% Load	TP lb/yr	% Load	TN lb/yr	% Load	Zn lb/yr	% Load	TPH lb/yr	% Load	DIN lb/yr	% Load
Bunny Lane WS (86 ac)	24,979	9	29	7	368	9	2	3	27	4	34	6
Preston City WS (264 ac)	97,517	**34**	148	**34**	1,389	**33**	19	**31**	173	**27**	174	**31**
Vineyard WS (68 ac)	38,388	13	65	15	541	13	12	20	115	18	94	17
Fish Pond WS (102 ac)	13,953	5	21	5	236	6	2	3	29	5	33	6
Hollowell Rd WS (100 ac)	37,945	13	47	11	599	14	6	10	73	11	63	11
Remaining WS (342 ac)*	76,066	**26**	119	**28**	1,127	**26**	20	**33**	224	**35**	155	**28**
Total Load	288,847	100	430	100	4,261	100	61	100	640	100	553	100

***Remaining watershed is defined as the portion of the Amos Lake watershed that lacked tributary streams and from which no direct water quality measurements were obtained.

Table 6-7. Pollutant Load (lb/yr) and Percent for each Land Use /Land Cover Type

Land Use/ Land Cover Type	TSS lb/yr	% Load	TP lb/ yr	% Load	TN lb/yr	% Load	Zn lb/ yr	% Load	TPH lb/yr	% Load	DIN lb/yr	% Load
Low Density Residential	10,295	4	65	15	360	8	27	**45**	86	**13**	88	16
Medium Density Residential	2,891	1	14	3	101	2	9	14	60	9	17	3
High Density Residential	30	0	0	0	1	0	0	0	1	0	0	0
Commercial Development	0	0	0	0	0	0	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	16,273	6	41	10	378	9	25	**40**	493	**77**	62	11
Turf and Grass	97,095	**34**	82	**19**	794	**19**	0	0	0	0	58	11
Pasture	33,989	12	70	16	516	12	0	0	0	0	152	**28**
Cultivated Crops	52,282	18	29	7	702	16	0	0	0	0	0	0
Forest	73,696	**26**	82	**19**	1,228	**29**	0	0	0	0	176	**32**
Wetlands	0	0	45	10	177	4	0	0	0	0	0	0
Bare Ground	2,295	1	1	0	3	0	0	0	0	0	0	0
Total Load	**288,847**	**100**	**430**	**100**	**4,261**	**100**	**61**	**100**	**640**	**100**	**553**	**100**

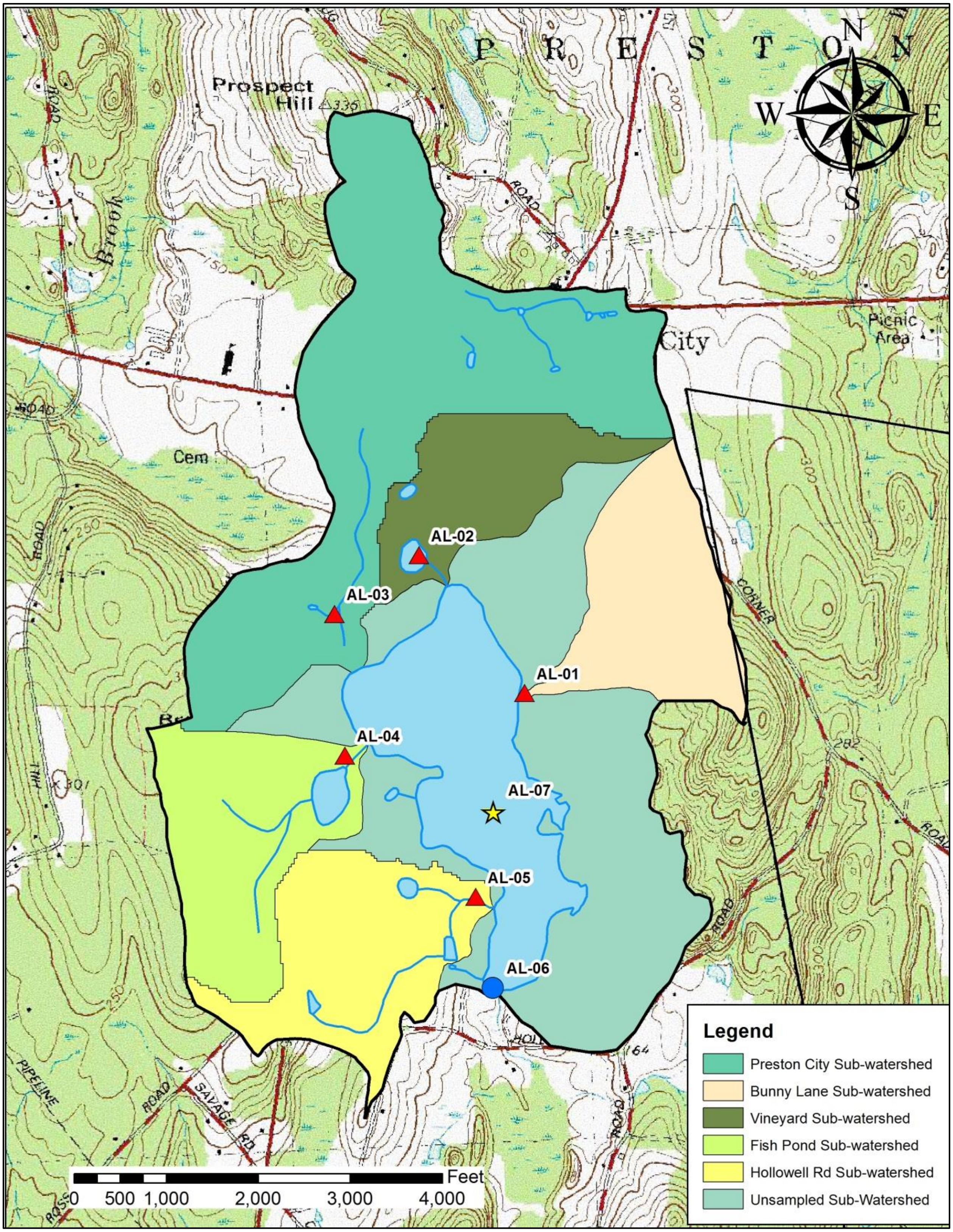


Figure 6-4. Delineation of sub-watersheds for pollutant loading estimations. Sampling sites are included for reference.

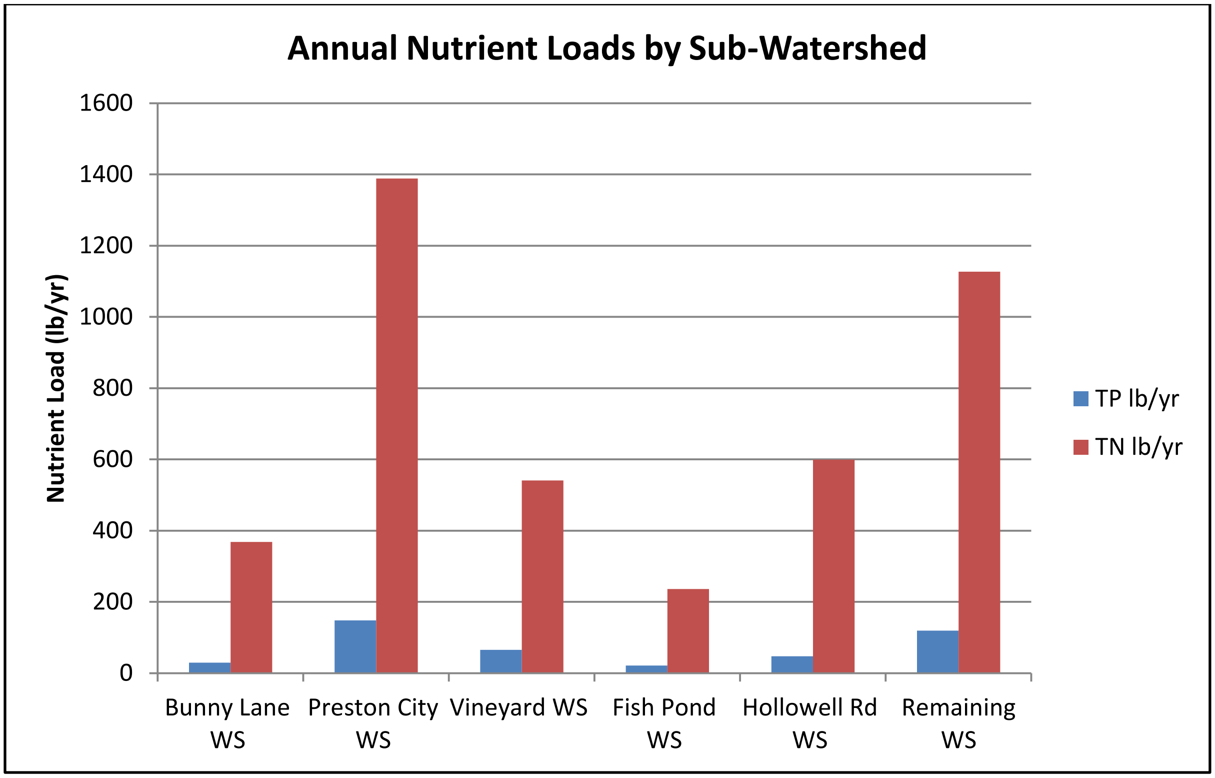


Figure 6-5. Annual nutrient loads in pounds per year by sub-watershed.

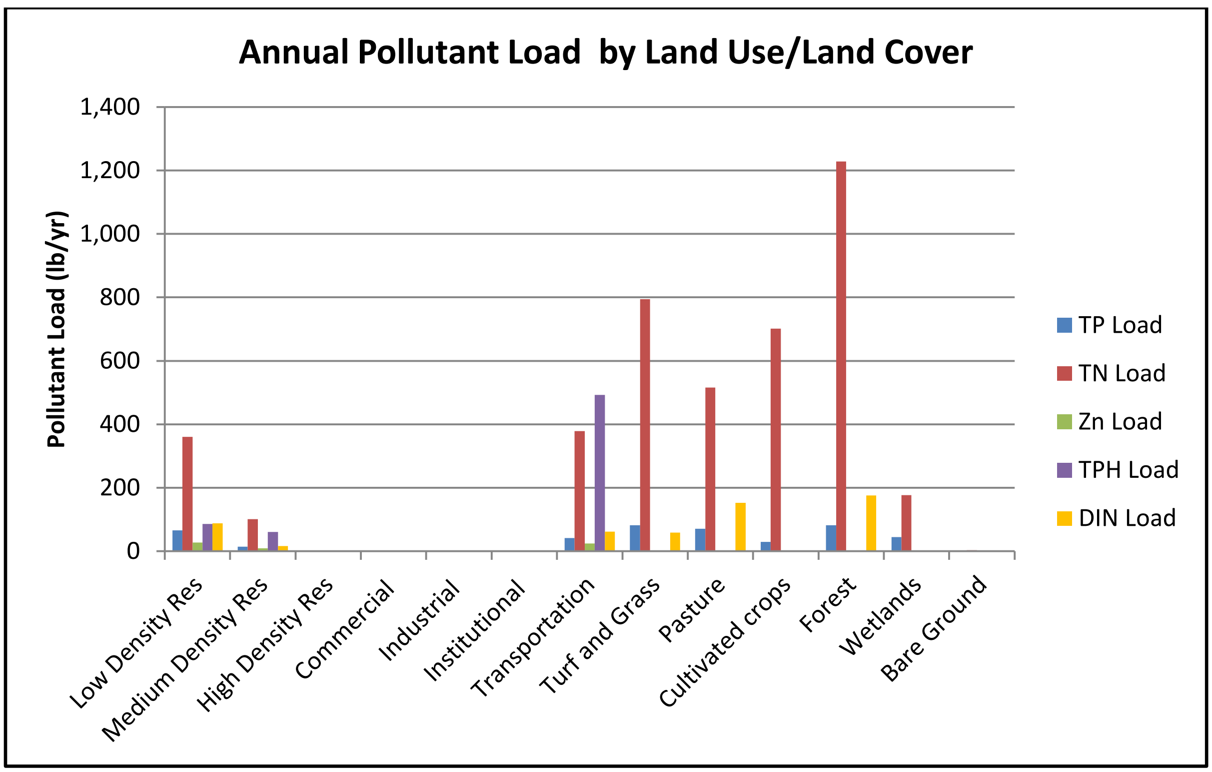


Figure 6-6. Annual Pollutant Load in pounds per year by Land Use/Land Cover Type

6.2 Identification of Critical Areas

Critical areas are generally defined as areas that contain sensitive resources or that provide important or unique environmental functions or services. Critical areas can include wetlands, watercourses, fish and wildlife conservation areas, groundwater recharge areas, riparian areas, floodplains and shorelines. Critical areas can also include developed areas with extenuating conditions or physical characteristics such as seasonal flooding, high groundwater or poor soils that may result in detrimental environmental impacts, and areas that have been identified as pollutant sources.

The identification of critical areas is important when considering where management practices are needed and aids in determining what types of best management practices (BMPs) will provide the greatest benefit.

Critical areas identified in Amos Lake watershed include:

- Amos Lake: Amos Lake is the receiving waterbody for all surface waters in the watershed. Water quality has been observed to have been degrading for many years, resulting in an increase in the growth of aquatic vegetation and the occurrence of summer algae blooms, including potentially harmful blue-green algae blooms. Since Amos Lake is an important recreational and economic resource to the people and Town of Preston, it is vital that water quality be protected in order to preserve both aquatic habitat and recreational opportunities. It is incumbent upon the residents of the watershed to be aware of both the impacts they have on the water quality of the lake and the role they can play in protecting that same water quality.

- Amos Lake shoreline: Development of the shoreline has increased both the nutrient load and the types of pollutants being conveyed into Amos Lake. The removal of vegetation along the shoreline has reduced the natural capacity of the shoreline environment to mitigate pollutants typically associated with residential development. Many of the houses on the northern shoreline were constructed prior to the adoption of modern septic system standards, and the type and age of the systems associated with these properties is largely unknown. Housing densities along the northern and eastern shores, coupled with the prevalence of stratified drift soils, which are poorly suited to provide optimal septic effluent treatment, make the Amos Lake shoreline a critical area for watershed best management practices.

- Wetland north of RT 165: This 36.5 acre forested wetland, which includes a 6.5 acre open marsh wetland, has a Natural Diversity Database site associated with it, indicating the presence of an endangered, threatened or special concern species. Care should be taken to manage stormwater in this area to protect the listed species.

- Perennial stream from Preston City: This small unnamed stream has its headwaters in the open marsh located to the north of Rt. 165. Mixed commercial and residential development along State Routes 164 and 165 and Old Shetucket Turnpike in the Preston

City area contribute to impervious cover. This area has an older, traditional stormwater conveyance system that delivers untreated stormwater runoff to the stream. Due to the relatively high levels of impervious cover in the area, this stream is subject to high flow volumes and velocities from stormwater runoff. This stormwater runoff may contain nonpoint source pollutants including nutrients, sediments, automotive chemicals such as oil, gasoline and antifreeze, trash, and fecal bacteria from animal waste.

7 Watershed Goals and Objectives

7.1 Management Objectives

The purpose and overall goal of this management plan is to restore water quality conditions of Amos Lake to meet Connecticut Water Quality Standards by reducing nutrient loading from sources throughout the watershed. Attainment of this goal should result in the reduction of nuisance aquatic vegetation and mid-summer algae blooms, and increase the overall enjoyment of the lake by its users. The ultimate goal of this Plan is to improve the water quality of Amos Lake to the point that it meets water quality standards for its intended uses, and is removed from CT DEEP's List of Impaired Waters. Whether or not this goal is met is dependent on the efforts of watershed managers to improve water quality conditions throughout the watershed.

7.2 Pollutant Load Reductions

A summary of recommended pollutant load reduction targets is provided in the following sections. In-lake water quality targets are based on the CT Water Quality Standards for oligotrophic lakes, which is the natural trophic status of Amos Lake.

Watershed pollutant load reductions are based on the natural, undeveloped land cover for Connecticut. While it may be difficult to achieve these targets due to the current level of development in the Amos Lake watershed, even though it is largely rural, these targets provide guidance for pollutant load reductions that will result in an improvement of water quality that will benefit not only Amos Lake but also other waterbodies in the watershed.

7.2.1 In-Lake Load Reductions

In order to determine the nutrient load reductions necessary to meet desired water quality standards for Amos Lake, ECCD utilized a methodology presented by Taylor in *A Connecticut Lakes Management Program Effort* (1979). This methodology, which is based on Vollenweider's conceptual models (Vollenweider, 1968 and 1974) for the mass balance of nutrient loads in lakes based on lake surface area, mean depth and flushing rate, can be used to infer a lake's natural trophic state. Using Taylor's methodology, the natural trophic tendency of Amos Lake appears to be in the upper range of late oligotrophic state. The CT Water Quality Standards describe the oligotrophic state as having "high potential for water contact recreation." As the designated uses for Amos Lake include habitat for fish and other aquatic life and wildlife, recreation, and navigation, among other uses, it is reasonable to use water quality targets consistent with the defining range for the oligotrophic state. ECCD compared average total phosphorus and nitrogen concentrations for water samples collected in the spring and summer of 2013 to the oligotrophic defining range to determine nutrient reductions necessary for Amos Lake to meet the target trophic state.

Based on water quality data collected in Amos Lake in 2013, a phosphorus concentration reduction of 64% and a nitrogen concentration reduction of 55% are recommended to reduce nutrient levels to those consistent with Amos Lake's natural trophic level (Table 7-1).

Table 7-1. In-Lake Nutrient and Chlorophyll-a reductions recommended to meet target trophic state.

Water Quality Parameter	2013 Amos Lake Average Value	Trophic State - CT Water Quality Standards	CT Water Quality Standards Trophic State Defining Range	Oligotrophic State Defining Range	Reduction needed %
Total Phosphorus	27.4 µg/l	mesotrophic	10-30 µg/l spring and summer	0-10 µg/l spring and summer	**64%**
Total Nitrogen	447 µg/l	mesotrophic	200-600 µg/l spring and summer	0-200 µg/l spring and summer	**55%**
Chlorophyll-a	22 µg/l	eutrophic	15-30 µg/l mid-summer	0-2 µg/l mid-summer	**91%**

7.2.2 Watershed Load Reductions

Pollutant load reduction recommendations have been provided to reduce common NPS pollutants in the Amos Lake watershed. In order to provide a baseline against which current pollutant loading could be compared, a pre-developed watershed load was calculated, using a forested condition as a typical pre-development land cover for Connecticut (Table 7-2). No net gain of wetlands was assumed, and an impervious cover of 1% was used to represent ledge and naturally barren land. Current land cover and land uses are based on the 2010 CLEAR land cover dataset and the Multi-Resolution Land Characteristics Consortium (MRLC) 2006 National Land Cover Dataset (NLCD).

Based on nutrient loads associated with various land covers and land uses that were determined using the Simple pollutant load model, phosphorus load reductions ranging from 56 – 92% are recommended throughout the sub-watersheds to bring nutrient loads within the pre-developed load range of the Amos Lake watershed (Table 7-3). Nitrogen load reductions ranging from 52 – 86% are recommended to bring nutrient loads within the pre-developed load range of the Amos Lake watershed.

Table 7-2. Pre-developed pollutant loads and recommended load reductions to improve water quality in the Amos Lake Watershed.

Annual Load for Pollutant Type (lb/yr) - Simple Method	TSS	TP	TN	Zn	TPH	DIN
Pre-developed Amos Lake WS	60,053	109	1,079	0	0	126
Amos Lake WS at Current Level of Development	288,847	430	4,261	61	640	553
Recommended Load Reduction (%)	**79%**	**75%**	**75%**	**100%**	**100%**	**77%**

Table 7-3. Recommended Pollutant Load Reductions by Sub-Watershed.

Sub-Watershed	TSS Load lb/yr	% Load Red.	TP Load lb/yr	% Load Red.	TN Load lb/yr	% Load Red.	Zn Load lb/yr	% Load Red.	TPH Load lb/yr	% Load Red.	DIN Load lb/yr	% Load Red.
Bunny Lane Watershed	24,979	76%	29	73%	368	74%	2	100%	27	100%	34	62%
Preston City Watershed	97,517	81%	148	83%	1,389	79%	19	100%	173	100%	174	78%
Vineyard Watershed	38,388	87%	65	92%	541	86%	12	100%	115	100%	94	89%
Fish Pond watershed	13,953	49%	21	57%	236	52%	2	100%	29	100%	33	54%
Hollowell Rd Watershed	37,945	81%	47	82%	599	81%	6	100%	73	100%	63	76%
Remaining watershed	76,066	78%	119	56%	1,127	66%	20	100%	224	100%	155	78%

8 Best Management Practice Recommendations

This section outlines management strategies intended to improve the water quality of Amos Lake by reducing the loading of phosphorus and nitrogen as well as other nonpoint source (NPS) pollutants as enumerated in Sections 6 and 7 of this Plan. A variety of management strategies are provided to target the pollutant sources identified in Section 5. Management strategies include short and long-term, non-structural and structural controls and actions that vary in relative effort and cost that can be adopted and implemented by a wide variety of stakeholders. Management recommendations are intended to address and reduce existing pollutant loads and prevent future sources of pollutant loading to Amos Lake.

None of these recommendations taken in isolation will improve water quality conditions. It will take a unified watershed-wide management approach to improve water quality. Prior to the implementation of this Plan it is *strongly recommended* that stakeholders form a watershed management team to coordinate the implementation of the Plan recommendations. Further, it is intended that watershed stakeholders take an *adaptive approach* to implementing the recommendations contained in this Plan, evaluating implementation measures as they are conducted, and making necessary adjustments based on the results to improve outcomes.

In order to evaluate the effectiveness of the management practices as they are implemented, it is recommended that water quality monitoring in Amos Lake and the lake tributaries be continued over the next five to ten years. Future water quality monitoring will allow tracking of the effects of the implementation of the various Plan recommendations. It will also provide on-going data to ensure that the desired water quality levels are maintained once water quality targets are achieved.

8.1 Watershed Management Team

The success of this watershed plan is dependent on its adoption and implementation by an engaged and committed local stakeholder team. As a first step to the implementation of this Plan, it is recommended that stakeholders form a *watershed management team*. This team will be responsible for developing a *work plan* that identifies water quality goals and objectives for Amos Lake; reviewing, prioritizing and implementing Plan recommendations; and evaluating the results to determine if revisions to the implementation approach are required. The management team should devise a method to track the progress of Plan implementation, and should seek feedback from land owners, municipal staff/leaders and other stakeholders. The watershed management team will also be responsible for reporting initial steps and results to stakeholders and the broader community, and for celebrating successes throughout the community.

A well-balanced watershed management team should consist of a variety of members of the community, and may include municipal officials and commissioners, business owners, landowners, environmental and civic organizations, as well as any other organizations, agencies or individuals with an interest in the preservation and improvement of water quality in the watershed. It is recommended that at a minimum, the Amos Lake watershed management team include a limnologist, a land-use planner, members of the Preston Conservation Commission, the Amos Lake Association (ALA), lake residents and local watershed businesses such as Maple Lane Farm, Amos Lake Beach Club, Woodmansee Farm, LoPresti Farm and Dalice Elizabeth Winery. Watershed management guidance may be found at the CT DEEP Watershed Management web page:

http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325628&deepNav_GID=1654

Additional potential watershed team members are listed in Table 8-1. Watershed management team capacity building recommendations are provided in Table 8-2.

Table 8-1. Suggested Watershed Management Team Members

Team Member	Roles/Responsibilities
Town of Preston	Update and enforcement of land use regulations and/or ordinances, site plan review/permitting, public utilities maintenance
Preston Health Department	Review and approval of septic systems
Amos Lake Association	Water quality monitoring, education & outreach
Local Businesses	Conformance with local regulations, BMPs, assist with outreach and education
Watershed Residents	Conformance with local regulations, BMPs
Local Council of Government	Regional land use planning, grant writing, sharing of regional plan and implementation resources
Limnologist	Water quality program development, data analysis
ECCD	Technical assistance, Plan implementation
Thames River Basin Partnership or other watershed organization	Plan implementation, guidance, outreach and education
CT DEEP	Bacteria TMDL, Ambient WQM program
CT DOT	Maintenance of State highways/stormwater systems

Table 8-2. Watershed Management Team Capacity Building Recommendations.

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Create watershed management team: • Identify team partners • Obtain partner "buy-in" • Organize initial meeting • Review goals and objectives • Identify partner roles • Establish regular meetings	Town of Preston, (staff and land-use commissions), ALA, CT DEEP, ECCD, other stakeholders	2015	Establishment of lake management team; Establishment of regular meetings	$3,000	Town of Preston, ALA, community foundation grants, lake management organization grants
2. Establish a mechanism for outreach: • Identify key outreach elements to disseminate to public • Establish an outreach mechanism (website, report card, etc.) • Conduct outreach campaign	Watershed management team	2015	Identification of outreach needs; Identification of mechanism for outreach; Type/amount of outreach conducted	$7,500	Town of Preston, ALA, community foundation grants, lake management organization grants
3. Identify management goals: • Review watershed plan • Identify plan goals • Prioritize plan goals	Watershed management team	2015	Identification and prioritization of clear goals and objectives	$5,000	Town of Preston, ALA, community foundation grants, lake management organization grants
4. Identify sources of technical assistance: • Review goals to determine type of technical assistance needed • Identify organizations or agencies offering needed technical assistance • Contact/partner with appropriate agency/organization to obtain needed technical assistance	Watershed management team	2015	List of agencies/ organizations to provide technical (see table 10-1 for potential sources of technical assistance)	$5,000	Town of Preston, ALA, community foundation grants, lake management organization grants

Table 8-2. Watershed Management Team Capacity Building Recommendations (Cont.).

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
5. Identify sources of funding: • Identify potential sources • Review for applicability to projects • Prepare and submit funding applications	Watershed management team	2015-2016	List of potential funding sources (see Table 10-1 for potential funding sources)	$5,000	Town of Preston, ALA, community foundation grants, lake management organization grants
6. Implement management plan: • Identify and prioritize projects • Identify managing entity • Identify and obtain funding • Conduct implementation	Watershed management team, individual stakeholders (varies by implementation)	2016-2020	Number of successfully completed implementation projects	Cost will vary by implementation. Non-structural implementations may be as low as $1,000 while structural implementations may be $50,000 or more.	Town of Preston, NRCS, CWA §319 grant program, community foundation grants, lake management organization grants
7. Develop an assessment procedure: • Create an implementation completion tracking database • Review projects as they are completed • Determine if goals and objectives are being met Revise plan as objectives are completed or if goals are not being met	Watershed management team	2015-2020	Periodic review and evaluation of project success, refinement of goals and objectives, plan updates as needed	$5,000	Town of Preston, ALA, community foundation grants, lake management organization grants

8.2 Municipal Land-Use Regulation and Policies Review

Municipal land-use boards and commissions provide considerable local influence on land-use development and management through the planning and permitting processes. Land-use commissions in Preston include the Conservation Commission, the Inland Wetlands & Watercourses Commission (IWWC) and the Planning & Zoning Commission (PZC). Additionally, the Preston Conservation and Agriculture Commission, which is advisory in nature, provides support to the regulatory land-use commissions. Land-use commissions can provide important non-structural controls through land-use planning, including the preparation of Plans of Conservation and Development and establishment and periodic review of zoning districts; through land-use regulations and permit requirements; and through inspection and enforcement actions. Land-use commissions can provide resource protection and improve water quality by including language in their regulations to allow the incorporation of design elements such as green infrastructure planning and low impact development (LID) practices that promote management of stormwater at its source. Land-use commissions can also promote improved water quality by encouraging the use of structural stormwater management practices such as LID, which strive to mimic the pre-development hydrology of a site through decentralization and disconnection from traditional stormwater systems. Land-use commissions may benefit from reviewing municipal land use evaluation projects in the Farmington River watershed and Salmon River watershed to assess municipal barriers to LID and evaluate how they can be overcome.

The Town of Preston Plan of Conservation and Development was under revision at the time of the preparation of this report. The draft Plan included recommendations to revise PZC and IWWC regulations to provide stronger protections to natural resources and improve water quality. Those recommendations should be adopted.

The Town should review land-use regulations to incorporate Green Infrastructure and Low Impact Development practices into site plan design and development, and strengthen existing land-use regulations pertaining to sediment control and stormwater management.

The Town should also investigate opportunities where incentives can be developed to encourage the inclusion of GI and LID into site planning and development.

Municipal land-use recommendations are provided in Table 8-3.

Table 8-3. Municipal Land-Use Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Adopt land-use planning recommendations proposed in the draft Plan of Conservation & Development	Town of Preston, Land-use commissions	2015	Land-use regulations revised per POCD recommendation.	$$7,500	Town of Preston
2. Review and strengthen land use regulations pertaining to GI/LID, sediment control, stormwater management: • Form regulation review team • Review existing land-use regulations, municipal ordinances, etc. • Review sample/model regulations pertaining to GI/LID, E&S controls, stormwater mgmt. • Work with land -use staff and boards to develop revised regulations • Adopt new regulations	Town of Preston, Land-use commissions	2016	Revised land-use regulations	$10,000	Town of Preston, LISFF, Supplemental Environmental Project (SEP) funds
3. Promote use of/offer incentives for low impact development techniques (LID) in site development: • Identify eligible practices • Identify eligible incentives • Create mechanism to authorize incentives (ordinance or regulation)	Town of Preston, Land-use commissions	2017	Successful establishment of incentive program, number of practices implemented	$10,000	Town of Preston

8.3 Agriculture

There is a wide variety of agricultural activity occurring throughout the Amos Lake watershed. These include commercial operations and private farms, animal husbandry, and production of numerous crops, from feed corn to orchard crops. All of these activities can contribute to the loading of phosphorus and nitrogen to Amos Lake. There are a number of agencies, including the Natural Resource Conservation Service (NRCS), Connecticut Department of Agriculture, Connecticut Department of Energy and Environmental Protection (DEEP), the University of Connecticut Cooperative Extension System and the Connecticut Conservation Districts, that can provide financial and/or technical assistance to producers and private farm owners to manage their properties and businesses. Additionally, peer-to-peer farmer networking promoted or supported by the watershed management team or Preston Conservation and Agriculture Commission can potentially be significant source of information and assistance.

8.3.1 Dairy Production

Woodmansee Farm is an award-winning Holstein breeding and dairy operation that straddles the northwest watershed boundary. Much of the farm is located outside of the Amos Lake watershed, but a limited amount of farming activity occurs within the watershed boundaries, including corn production, hay production and field grazing for farrow cows.

A cornfield is located to the west of the unnamed stream that flows to Amos Lake from the Preston City area. A vegetated buffer strip that separates the stream from the cornfield should be maintained and increased if possible (Fig. 8-1). In order to avoid excessive sedimentation to the stream from field stormwater runoff, the use of cover crops and alternative tillage practices should be considered.

Fig. 8-1. Vegetated buffer strip between the unnamed tributary to Amos Lake and cultivated farmland.

There are numerous hayfields in the northern portion of the Amos Lake watershed, in the subwatershed of the unnamed stream from Preston City. It is not known if manure is spread on these fields. If so, best management practices such as soil testing and manure incorporation should be employed to ensure that nutrients are not being transported off the field during storm events.

Dry (resting) dairy cows are kept in several fields located near the southwest shoreline of Amos Lake. There are two small ponds in these fields that flow into Amos Lake through the Amos Lake Campground. The cows are allowed free access to these ponds to water. Exclusionary fencing should be installed to keep the cows out of these ponds, shoreline vegetation should be re-established, and alternative watering methods installed.

8.3.2 Fruit, Berry and Christmas Tree Production

Maple Lane Farm is located in the northeast section of the Amos Lake watershed. It produces pick-your-own crops including strawberries, blueberries, raspberries, apples, pumpkins and Christmas trees. It also produces oyster shell mushrooms and black currents. Dalice Elizabeth Winery is located on the north shore of Amos Lake and cultivates grapes for wine production (Fig. 8-2).

Fig. 8-2. Grapes being cultivated along the shore of the kettle pond north of Amos Lake.

These producers should adopt best management practices for fertilizer and herbicide application as well as other farm practices if they have not already done so to minimize the impacts on water quality.

8.3.3 Vegetable Production

LoPresti Farm is located on the south side of Amos Lake and produces fresh vegetables and bedding plants for sale at their farm stand. LoPresti Farm is enrolled in USDA Natural Resource Conservation Service (NRCS) programs, and should continue to participate in NRCS programs to ensure that water quality impacts are minimized.

8.3.4 Livestock

There are several property owners in the watershed that own livestock, including chickens, sheep and horses (Fig. 8-3). Often, private animal owners are less aware than commercial farmers about the potential water quality impacts of keeping their animals. Outreach efforts by the Preston Conservation and Agriculture Commission, Amos Lake Association, and other pertinent organizations should be undertaken to educate livestock owners about the potential impacts of livestock on water quality, with a focus on manure management to reduce inputs of phosphorus and nitrogen to Amos Lake. On-site farm evaluations with management experts such as University of Connecticut Extension System educators and Conservation District staff can identify management measures private farm owners can adopt to reduce water quality impacts.

Fig. 8-3. Sheep grazing on a lawn near the shore of Amos Lake.

Agriculture best management practice recommendations are provided in Table 8-4.

Table 8-4. Agricultural BMP Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Protect unnamed tributary stream from Preston City: • Maintain or expand existing vegetated buffer strip • Plant cover crops to prevent soil erosion • Adopt alternative tillage practices (no till, deep zone tillage, etc.)	Woodmansee Farm	2015-2020	Measured reduction in sediment, P and N in unnamed tributary stream and Amos Lake	$0 - $10,000+	CWA §319 program, NRCS programs
2. Fertilizer/Manure BMPS: • Conduct soil nutrient testing prior to fertilizer/manure application • Cover manure piles • Install exclusionary fencing	Producers/ livestock owners	2015-2020	Adoption of manure BMPs Measured reduction in P and N in Amos Lake	• $0 - $1000 • $100 - $10,000 depending on BMP • $15/linear ft. fencing	CWA§319 program, CT Dept of Agriculture, NRCS programs
3. Small farm BMP evaluations: • identify and prioritize potential BMPs • Identify and obtain funding • Develop construction design for BMP implementation • Obtain necessary permits • Construct structural measures	Preston Conservation & Agriculture Commission, small farm owners	2015-2020	Number of installed BMPs, Measured reduction in P and N in Amos Lake	$0 - $10,000+ depending on BMP selected	CWA§319 program, CT Dept of Agriculture, NRCS programs

8.4 Wildlife

Fig. 8-4. Non-migratory geese foraging on a lawn by Amos Lake.

A variety of wildlife, including white-tailed deer, river otter, muskrat, red fox, raccoon and opossum, are found in the Amos Lake watershed. These animals are not believed to exist in excessively large or unsustainable population numbers. As a result, the pollutant load that they contribute to Amos Lake is considered to be a natural background level. Migratory Canada Geese gather in large numbers (an estimated 1000-2000 birds) on Amos Lake during the winter months. These geese are transient and migrate north in the early spring. No water quality sampling was conducted during the winter months, so the nutrient load contributed by these animals is not known. Migratory geese are protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703–712), so management prospects are limited. Approximately 20 or so non-migratory Canada Geese remain through the summer months, congregating on a lawn area on the north shore of the lake where they nest and feed (Fig. 8-4). Non-migratory geese are not afforded the same stringent protection measures as migratory geese.

Outreach should be conducted throughout the watershed to educate residents about the link between water quality and pollutants from waterfowl waste, and to inform residents about best management practices to discourage non-migratory waterfowl. BMPs may include discouraging the feeding of non-migratory waterfowl and establishing vegetation along the shoreline to deter geese from entering onto lawns. If the geese are persistent, mechanisms exist for their permanent removal, including egg addling and selective or complete harvesting.

Wildlife management recommendations are provided in Table 8-5.

8.5 Pets

Pets, particularly dogs, were not noted to be prevalent in the Amos Lake watershed and the number of dog licenses issued in 2013-2014 indicated animal densities were fairly low. However, as a general practice, dog owners should employ good housekeeping practices and pick up after their pets to prevent the input of nutrients and bacteria from pet waste into the lake and/or other nearby waterbodies.

Pet management recommendations are provided in Table 8-5.

Table 8-5. Wildlife/Pet BMP Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Discourage non-migratory Canada Geese: • Prepare and distribute educational material regarding link between non-migratory geese and water quality • Discourage feeding of non-migratory geese • Plant or allow existing vegetation to grow along the shoreline to discourage geese from using lawn areas to feed and rest • Conduct egg addling using Geese Peace protocol • Conduct nuisance waterfowl harvest/removal	Town of Preston, ALA, Preston Health Dept., property owners, Geese Peace, CT DEEP Wildlife Division, USDA, USFWS	2015-2020	Preparation of education/outreach material, amount (#) of outreach material distributed, feet shoreline vegetation restored GeesePeace volunteers recruited/# eggs addled # geese harvested	$100 (100 brochures @ $1.00/pc) $0 - $2000 – shoreline restoration $3000 – Geese Peace workshop $3000 - Goose harvest	Town of Preston, community foundation grants, lake management organization grants
2. Encourage pet waste management BMPS: • Prepare and distribute educational material regarding links between pet waste and water quality • Install educational/informational signage and dog waste stations in areas of heavy dog use	Town of Preston, ALA, Preston Health Dept., pet owners, veterinary offices, pet stores	2015-2016	Preparation of education/outreach material, amount (#) of outreach material distributed, # pet owners reached #/Installation of dog waste stations	$500 (500 brochures @ $1.00/pc) $200-$500 – dog waste dispensers w/signs	Town of Preston, community foundation grants, lake management organization grants

8.6 Septic Systems

Septic systems along the shoreline of Amos Lake may be contributing to nutrient loading to the lake, although to what degree is not known. Soils along much of the shoreline are extremely permeable and may not provide adequate renovation of septic effluent. Any new septic systems being installed in these soils should be designed using the most current engineering methods to ensure that adequate effluent treatment takes place in these permeable shoreline soils.

It may not be practical or financially feasible for shoreline property owners to replace their existing septic systems with more modern engineered systems. Therefore, it is important that existing lakeshore septic systems be maintained in order to function to their maximum efficiency. Homeowners should be educated about septic system best management practices and encouraged to develop a record keeping system to document important routine system maintenance.

Older cottages built on poor soils along the north shore of Amos Lake have been converted to year-round habitation. It is not known if all septic systems have been upgraded. A survey should be conducted by the Preston Health Department to determine the age of shoreline septic systems and determine if systems are functioning properly. If break-outs or excessively fast drainage is suspected, dye tests should be conducted. Lake managers may want to refer to *Amos Lake: A Watershed Management Approach for the Long Term Protection* (1994) prepared by CME Associates, Inc. for additional information and guidance.

Finally, underperforming or failing septic systems should be replaced. The Town of Preston and the Preston Health Department may be able to provide property owner assistance through programs such as the Small Cities Rehabilitation Program funded by the US Department of Housing and Urban Development (HUD) and the CT Department of Economic and Community Development (DECD).

The Amos Lake Campground, which is located along the southern shore of Amos Lake on Hollowell Road, provides 30 camper sites (Fig. 8-5). Each site has a waste holding tank which is pumped regularly. Campground management should inspect the holding tanks on a regular basis to ensure they are intact, and repair or replace any tanks that are aged or malfunctioning.

Management recommendations for septic system maintenance are listed in Table 8-6.

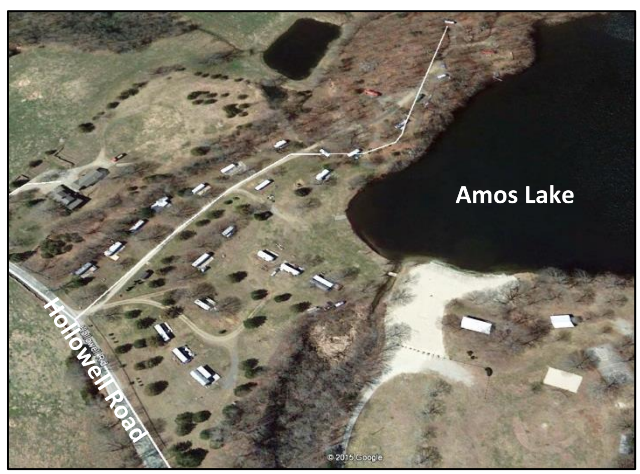


Fig. 8-5. Amos Lake Campground on Hollowell Road on the southern end of Amos Lake.

Table 8-6. Septic System BMP Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Conduct septic system BMP education program for homeowners: • Identify appropriate BMPs • Prepare BMP educational material • Distribute to property owners • Conduct educational workshops	Preston Health Department, ALA	2015	Distribution of educational material to property owners	$500 (500 brochures @ $1.00/pc)	CWA §319 program, community foundation grant programs, lake management organization grants
2. Develop record keeping system to facilitate routine maintenance (pump out, leach field inspection, etc,): • prepare Operations & Maintenance Plan for septic systems • create maintenance record checklist • distribute to property owners	Preston Health Department, Property owners	2016	Creation and distribution of record keeping packets to property owners	$3000 for record keeping packets	CWA §319 program, community foundation grant programs, lake management organization grants
3. Repair/replace aged or non-compliant systems: • conduct septic system inspections • identify aged or non-compliant systems • secure funding and replace systems	Preston Health Department, Property owners	2017	Replacement of underperforming and failing septic systems	Average $8000-$12,000 per system	Preston Health Department, HUD, CECD, property owners

8.7 Stormwater Runoff/NPS Management

High levels of nutrients in stormwater runoff from Lakeview Drive and State Route 164 were documented by water quality testing in 2013. This data indicates that stormwater runoff may contribute a far higher load of nutrients to Amos Lake than base flow. Stormwater runoff from roads, driveways, parking lots, rooftops, turf grass areas and farm land can contribute many types of pollutants to Amos Lake, including nutrients (phosphorus and nitrogen), bacteria, sediments, metals, petroleum products and trash. Thus the management of stormwater runoff through various best management practices may have the greatest impact in reducing nutrient loading to Amos Lake.

8.7.1 Municipal Stormwater/NPS Management

Municipal facilities can create NPS from normal activities such as facility, vehicle and equipment maintenance and grounds management. Vehicle fueling, material loading, unloading and storage can also be sources of NPS. Municipalities should adopt good housekeeping practices (GHPs) to minimize the impacts of NPS from these activities and should train staff to follow these practices (US EPA, 2014).

Good housekeeping practices can also encompass activities such as annual or bi-annual street sweeping and catch basin clean-out. These activities remove accumulated sediment, trash and leaves that may otherwise end up in waterways. Accumulated sediments can contain additional pollutants, including nutrients, bacteria, petroleum products and metals that can be harmful as well.

Fig. 8-6. Storm drain on Lakeview Drive completely filled with sand and debris.

Several storm drains on Lakeview Drive (Fig. 8-6) and Hollowell Road were observed to be almost completely filled with sediment and several outfall pipes were buried in sediment and appeared non-functional. The Preston Public Works Department should conduct street sweeping at last once a year, and inspect and clean catch basins. The catch basins on Lakeview Drive, Bunny Lane and Hollowell Road should be cleaned and accumulated sediments in the sumps and at the outfalls should be removed. Catch basins on these roads should be evaluated to determine if deep sumps should be installed to capture sediment and devices such as storm drain snouts installed to treat other types of pollutants. Opportunities to re-direct outfalls to areas where stormwater can be infiltrated away from Amos Lake should also be investigated.

Municipal stormwater/NPS management recommendations are provided in Table 8-7.

8.7.2 Connecticut Department of Transportation (CTDOT) Stormwater/NPS Management

The storm drain system on State Route 164, which runs north-south along the west side of Amos Lake, discharges to Amos Lake via the unnamed stream from Preston City (Fig. 8-7) and another small stream that enters Amos Lake to the south of the unnamed stream. The unnamed tributary also receives stormwater from RT 165 in Preston City. The passive sampler that was placed in the unnamed stream (sampling site AL-03) to capture storm flows captured the highest nutrient levels of the passive samplers deployed by ECCD (5930 ppb TP) from a rainstorm that occurred on November 1, 2013. Stormwater discharges from Routes 164 and 165 should be evaluated by DOT to determine if they can be re-directed so that stormwater is infiltrated rather than discharged to Amos Lake.

Fig. 8-7. Stormwater leak-off from RT 164 to the unnamed Amos Lake tributary stream.

CT DOT stormwater/NPS management recommendations are provided in Table 8-8.

8.7.3 Homeowner Stormwater/NPS Management

Residences along the shores of Amos Lake discharge stormwater via overland flow from lawns and driveways. This stormwater can be loaded with pollutants such as sediment, fertilizer, pesticides and herbicides, gasoline and oil, and pet waste. Additionally, runoff from yard waste (leaves, grass clippings) can be a significant source of nitrogen and phosphorus. Outreach should be provided to homeowners to make them aware of the link between typical household activities and water quality, and educate them about actions they can take, including planting rain gardens, installing rain barrels, and other LID practices, to reduce their NPS contributions.

Many property owners have removed riparian vegetation in order to improve lake views and make water access easier. Riparian vegetation provides a number of natural water quality services. Riparian vegetation acts as a barrier to stormwater flow and serves to slow surface flows, allowing water to infiltrate before reaching the lake. It traps sediments and takes up nutrients. Outreach should be conducted to educate lake residents about the benefits of riparian vegetation. Residents should be encouraged to restore riparian vegetation

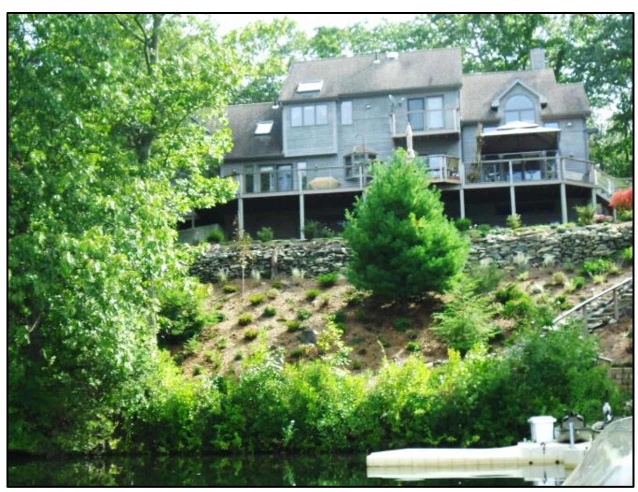


Fig. 8-8. Lakeshore property with restored riparian vegetation.

along their shorelines (Fig. 8-8).

Water quality sampling in 2013 has demonstrated that the unnamed tributary stream from Preston City delivers high loads of nutrients to Amos Lake under both base flow and storm flow conditions (Fig. 8-9). This stream flows through a field that was once wetland. Wetland systems have demonstrated significant ability to remove nutrients from stormwater. This wetland should be restored so that these ecosystem services are reestablished.

Homeowner stormwater/NPS management recommendations are provided in Table 8-9.

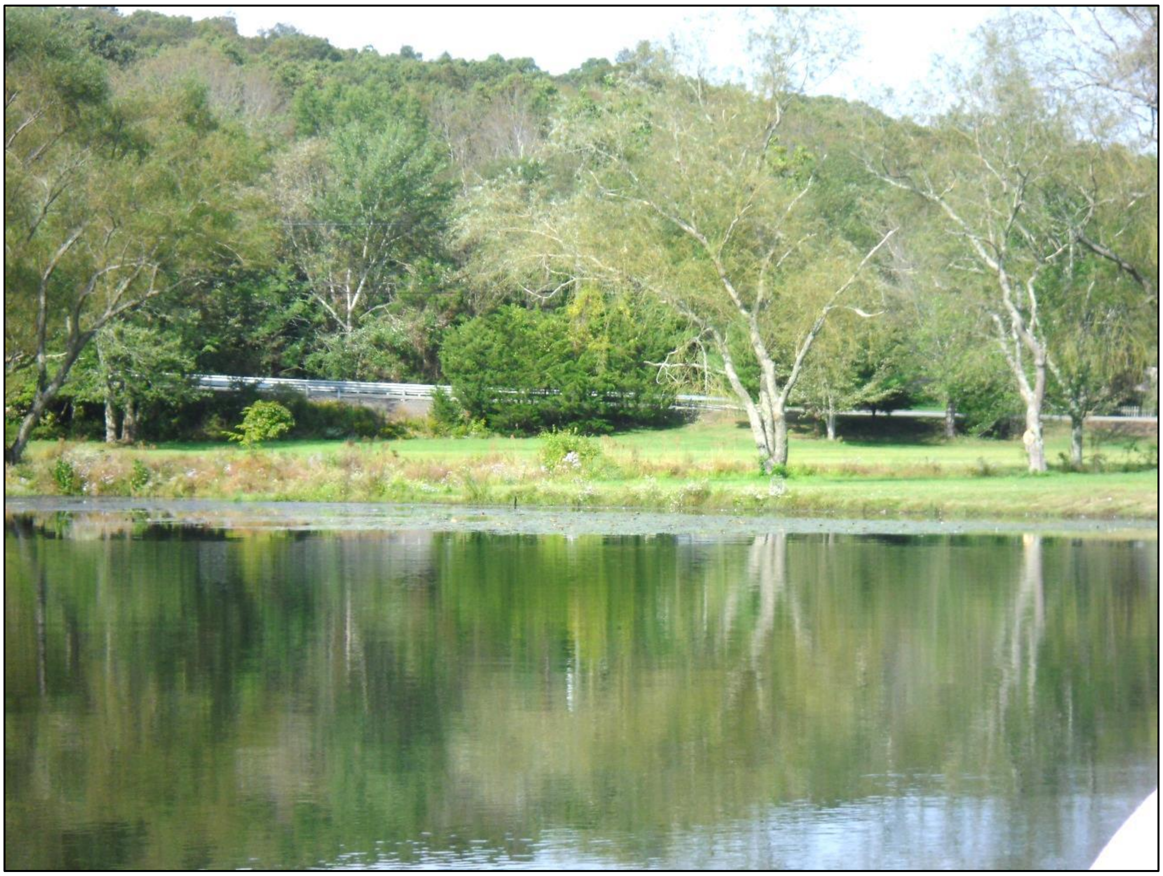


Fig. 8-9. View of the former wetland that was filled to create a hay field. The tall grass behind the two birch trees demarcates the path of the stream. Route 164 is visible in the background.

Table 8-7. Municipal Stormwater/NPS Management Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Employ municipal "good housekeeping" practices at municipal facilities: • Review municipal Good Housekeeping Practices (GHP) • Gather existing educational materials • Create new educational materials as needed • Provide staff training, as necessary • Adopt revised GHPs in priority areas identified in WBP	Town of Preston	2016	GHP education/ number staff trained	$0 - $5000	Town of Preston
2. Town Road Maintenance: • Conduct at least annual street sweeping • Conduct at least annual storm drain cleaning • Clean clogged storm drains and outfalls on Lakeview Drive and Hollowell Road	Town of Preston	2016	Minimum annual street sweeping and storm drain cleaning/ reduction in sediment to Amos Lake	Varies depending on method used	Town of Preston
3. Retrofit storm drains on Lakeview Drive, Bunny Lane and Hollowell Road: • Evaluate existing storm drains for retrofit opportunities • Evaluate potential to redirect outfalls to infiltrate stormwater away from Amos Lake • Install deep sumps to trap sediment • Install stormwater snouts (or similar) to trap trash, floatables, oil and sediment • Install infiltration basins at end of pipes where practicable to trap sediment and debris	Town of Preston	2016	Retrofits to storm drains/ number of retrofits installed	$3000 - $10,000 depending on practice	Town of Preston

Table 8-8. State Highway Stormwater/NPS Management Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1 . Route 164 stormwater discharges: • Evaluate stormwater discharges to the unnamed tributary stream t to determine if alternate discharge points can be identified • Design alternate discharge points • Install alternate discharge points	CT DOT	2017-2020	Redesigned stormwater outfall/ documented reduction in nutrient levels in unnamed stream	Varies, depending on practice selected	CT DOT, Federal Highway Dept.
2. RT 165 Stormwater discharges : • Evaluate stormwater discharges to unnamed stream in Preston City area to determine if alternate discharge points can be identified • Design alternate discharge points • Install alternate discharge points	CT DOT	2017-2020	Redesigned stormwater outfall/ documented reduction in nutrient levels in unnamed stream	Varies depending on practice selected	CT DOT, Federal Highway Dept.

Table 8-9. Homeowner Stormwater/NPS Management Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Promote homeowner NPS awareness: • Identify appropriate NPS topics • Prepare NPS outreach material • Conduct outreach campaign	Preston Conservation Commission, ALA, ECCD	2015-2016	NPS informational brochures/number of brochures distributed to homeowners	$500 (500 brochures at $1 each)	Community foundation grants, Town of Preston, lake mgmt. organization grants
2. Encourage homeowner BMP implementation: • Recruit homeowners • Identify potential BMPs • Identify funding sources • Design implementations • Obtain funding • Conduct BMP implementation	Preston Conservation Commission, Homeowners, ALA, ECCD	2015-2020	Number of BMPs installed by homeowners/ documented reduction in P & N levels In Amos Lake	Varies by practice: Rain barrel -$100+ Rain Gardens – $4/sf average Pervious pavers $1-$10/sq ft	CWA §319 grants, Community foundation grants, lake mgmt. organization grants
3. Revegetate Amos Lake shoreline buffer: • Evaluate and identify priority areas for buffer establishment • Select sites, contact landowners to determine level of interest and cooperation • Identify and obtain funding • Develop site design • Obtain necessary permits • Conduct buffer planting	Property owners, ALA, ECCD	2016-2020	Restored lakeshore vegetative buffer/ number of feet of shoreline restored	$100-$900 (0.2 acres @ $500 - $4500 per acre)	CWA §319 grants, Community foundation grants, lake mgmt. organization grants
4. Restore filled wetland at north end of Amos Lake: • Obtain landowner consent • Identify and pursue funding • Design wetland restoration • Obtain necessary permits • Conduct restoration	ECCD, CT DEEP, Property owner	2016-2020	Restored wetland/ documented reduction in P & N levels In Amos Lake	$100,000+	CWA §319 grant, Long Island Sound Futures Fund grant, NRCS

8.8 In-Lake Management

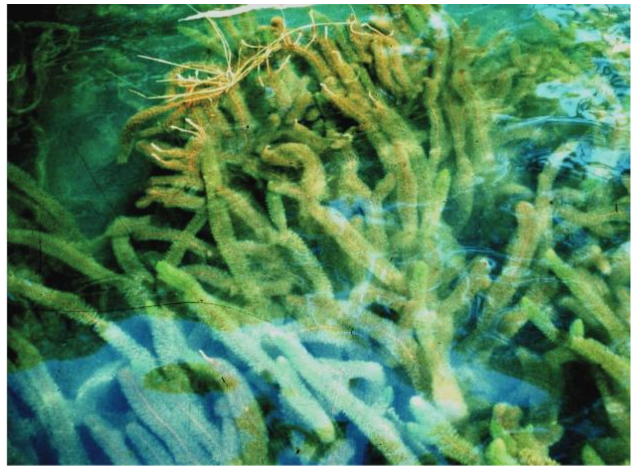


Figure 8-10. Variable Milfoil (CAES, 2005).

Although the primary management concern for Amos Lake is nutrient enrichment, which has impacted the quality of recreational use, the 2013 study of Amos Lake also evaluated aquatic habitat. Aquatic plant surveys conducted by the Connecticut Agricultural Experiment Station in 2006 and 2013 identified the invasive aquatic plant *Myriophyllum heterophyllum x Laxum* (Variable Milfoil) as well as numerous native aquatic plants (Fig. 8-10). The Variable Milfoil was found in the northwest part of the lake near the State boat launch and may have been introduced via a boat or boat trailer. The Town of Preston has been awarded DEEP's Control of Aquatic Invasive Species grant to treat Variable Milfoil. Lake managers should continue to monitor the Variable Milfoil and apply an aquatic herbicide to control it.

During the water quality investigation, the Asian clam *(Corbicula fluminea) w*as identified. Like the Variable Milfoil, this small clam was found in the northwest part of the lake at the boat launch. It is believed to have been introduced to the lake either by having hitchhiked on a boat or trailer, or released from bait buckets. This non-native clam has not been determined to be a threat to native shellfish. However, it should be monitored to see if it spreads beyond the boat launch area in the event that, in the future, it proves to be deleterious to native fauna.

Existing programs by CT DEEP and others educate boaters about lake management issues associated with invasive aquatic plant and animal species. On-site signage and other outreach material should be made available to boaters at the Amos Lake boat launch to encourage visitors to check their boats and trailers for hitchhikers before entering or leaving the lake, and to not dump bait.

The water quality investigation indicated that during the summer months, the lake becomes strongly stratified, and mixing does not occur between the lower and upper layers, so phosphorus stored in lake-bottom sediments does not likely contribute to algae blooms. If future late-season water quality monitoring indicates that phosphorus is released during or after fall turn-over, lake managers may want to treat the lake with alum to bind phosphorus. Alum (aluminum sulfate) is a salt that, when mixed with water, forms a precipitate that binds with phosphorus to form an insoluble aluminum phosphate compound. This phosphate compound settles to the lake bottom and becomes inert, making the phosphorus bound within it unavailable for use by algae and aquatic vegetation (Wisconsin DNR, 2003).

In-lake management recommendations are provided in Table 8-10.

Table 8-10. In-Lake Management Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Monitor Variable Milfoil: • Conduct periodic aquatic plant surveys • Identify and obtain funding to treat lake with aquatic herbicide • Treat lake with aquatic herbicide • Conduct aquatic invasive plant outreach including boating BMPs • Post "check your boats" signs at State boat launch	Preston Conservation Commission, ALA, Amos Lake residents	2015-2020	Aquatic plant survey, Herbicide treatment, outreach material for boaters	$500 (500 brochures at $1 each) Aquatic herbicide treatment: $3500	Community foundation grants, Town of Preston, lake 114gmt.. organization grants, DEEP Lake Management program
2. Monitor Asian Clam: • Monitor presence of non-native Asian clam • Encourage fishermen to not dump bait buckets in Amos lake • Notify DEEP if it becomes problematic	Preston Conservation Commission, ALA, Amos Lake residents	2015-2020	Location of Asian Clams/expansion in numbers or range	$0	NA
3. Treat lake with alum: • Determine through late-season or winter water quality monitoring if phosphorus releases occur • Analyze monitoring result to determine if releases contribute to nuisance aquatic vegetation growth • Obtain funding to conduct alum treatment • Obtain necessary permits • Conduct alum treatment	ALA, Amos Lake residents, Town of Preston	2017	Water quality data collection and analysis/confirmatio n that winter phosphorus release contributes to spring nuisance aquatic plant growth alum treatment/ observed or measured reduction in phosphorus concentrations and plant growth	$300-$700/acre treated	Community foundation grants, Town of Preston, lake 114gmt.. organization grants, DEEP Lake Management program

8.9 Water Quality Monitoring

The monitoring of water quality will be a critical aspect to the implementation of this Plan. Collection of water quality data from Amos Lake and the tributary streams will provide important information regarding the status of Amos Lake, including current nutrient levels, and will aid in determining if the Plan implementations are having the desired effects.

Water quality monitoring can be conducted by the Amos Lake Association in conjunction with technical support and guidance from a limnologist or other qualified environmental professional. Because Amos Lake is an important economic, recreational and aesthetic resource, it would be appropriate for the Town of Preston to provide support for the development of a monitoring program.

Monitoring should be conducted monthly from April through November, and should capture both spring and fall turn-overs. Lake parameters should include phosphorus, nitrogen, water clarity (Secchi disk), chlorophyll-a, water temperature and dissolved oxygen profiles, and redox potential. Phytoplankton and zooplankton sampling should also be conducted during that same time period. Tributary parameters should include phosphorus, nitrogen, turbidity and suspended solids from both base flow and storm flows.

Recent water quality monitoring indicated that by the end of May 2013, the bottom had become anoxic and remained anoxic through late fall. NEAR recommends additional bottom testing of anaerobic respiration by-products and redox potential to determine the magnitude of anoxia and verify if it is worsening (see NEAR report in Appendix C).

Water quality monitoring recommendations are outlined in Table 8-11.

Table 8-11. Water Quality Monitoring Recommendations

Actions	Entity	Schedule	Deliverable/ Evaluation Criteria	Cost Estimate	Potential Funding Sources
1. Conduct water quality monitoring of Amos Lake: • Recruit and train volunteers • Collect water data, including secchi depth, temperature and oxygen profiles, TP, TN, chl-a, algae samples, and bottom samples • Review and interpret results	ALA, Town of Preston	2015 – annually thereafter	Collection and analysis of water quality data	\$0- \$5000	Town of Preston, community foundation grants, lake management organization grants
2. Conduct water quality monitoring of lake tributaries: • Recruit and train volunteers • Collect water data, including physical parameters, TP, TN, TSS and turbidity • Review and interpret results	ALA, Town of Preston	2015 – annually thereafter	Collection and analysis of water quality data	\$0- \$5000	Town of Preston, community foundation grants, lake management organization grants
3. Evaluate water quality monitoring results to determine if implementation measures are providing positive results.	ALA, Town of Preston, watershed management team	2015 – annually thereafter	Analysis of water quality data and implementation effectiveness	\$0	Town of Preston, ALA

9 Education & Outreach

Education and outreach is a critical component to effecting behavioral changes among watershed residents in order to promote the reduction of pollutant loading to Amos Lake. The objective of conducting education and outreach is to raise awareness of the conditions that have led to the degradation of the water quality of Amos Lake. This is achieved by creating an educated populace that understands the sources of nonpoint source pollution, its effect on water quality, and actions that can be taken to address the problem. By successfully educating and engaging the public, including private and commercial property owners as well as municipal staff and land use commissioners, this Plan should lead to behavioral change that should result in reduction of NPS to Amos Lake.

Education and outreach recommendations have been included in the management recommendations in the section above. These outreach efforts may be watershed-scale, and seek to address issues that are watershed-wide. Such efforts may include homeowner best management practices such as encouraging recycling, washing cars on lawns or using a carwash, properly disposing of pet waste, encouraging composting, reducing the use of lawn chemicals, and discouraging the dumping or depositing of chemicals or other waste in storm drains. These efforts may target a broad spectrum of watershed residents through activities such as presentations at meetings or conferences (land-use commissions, civic organizations, schools), news articles or feature stories in local or regional newspapers or other media outlets, displays at festivals or field days, or work days, such as community clean-up days.

Outreach efforts may also be more small-scale or focused, and may be tied to specific implementation projects or target a water quality issue in a specific locale. Examples of these types of outreach efforts may include a rain garden or riparian buffer workshop conducted in tandem with the installation of a rain garden or riparian buffer at a targeted location; a workshop directed to a specific target audience, such as a manure management workshop for livestock owners; or the installation of educational signage at a location with a specific resource concern such as checking boats and trailers and not dumping bait buckets in local waters.

Table 9-1 reiterates outreach topics included above and suggests potential outreach partners.

Table 9-1. Amos Lake Watershed Outreach & Education Topics and Partners.

Outreach Topic	Potential Outreach Partner
Agricultural Best Management/ Conservation Practices	UConn Cooperative Extension System, NRCS, CT Department of Agriculture
Benefits of vegetated riparian buffers	CT SeaGrant
Boating BMPs	CT DEEP Boating Division
Integrated Pest Management	UConn Cooperative Extension System
Invasive plant identification and control	CT Invasive Plant Work Group (CIPWG), Invasive Plant Atlas of New England (IPANE)
Lake Health and Water Quality	CT DEEP, CFL, NALMS
Land Care	UConn Cooperative Extension System, NOFA-CT Chapter
Land Protection	Town of Preston, local/regional land trusts, Connecticut Farmland Trust, USDA NRCS, CT DEEP, CT Department of Agriculture
Low impact development (LID)/Green Infrastructure (GI) Planning	CT NEMO/CLEAR
Municipal Stormwater BMPs	CT DEEP, NEMO, SCCOG
Non-migratory Waterfowl BMPs	CT DEEP
Septic system BMPs for Homeowners	CT DPH, Preston Health Department
Small Farm BMPs	UConn Cooperative Extension System, ECCD
Understanding Non-Point Source (NPS) Pollution	CT NEMO, Town of Preston, ECCD, CT DEEP

10 Financial and Technical Assistance

Reasonable financial estimates for each management practice have been provided in the tables above, based on cost estimates available at the time of the preparation of this management plan. However, costs associated with the development and implementation of each proposed measure will need to be estimated individually as management strategies are undertaken, and as cost estimates may change over time. Technical assistance may be provided by organizations such as the USDA/NRCS, CT DEEP, Conservation Districts, US Fish & Wildlife Service, lake management organizations and others, depending on the nature of the implementation.

Financial assistance in the form of grants is available from multiple sources, including federal, state, and local sources, including but not limited to Community Development grants, Clean Water Act §319 grants, Long Island Sound program grants, National Fish and Wildlife Fund grants, and environmental and professional organizations grant programs. Funds may also be available in the form of donations and in-kind services provided by local businesses, environmental organizations, and local volunteers. Numerous grant applications are strengthened by the availability of such cost matches and in-kind services. Municipalities can build funding for stormwater management improvements into their operating budgets. The development of a municipal or inter-municipal stormwater authority or coalition modeled on pilot projects conducted in New Haven, New London and Norwalk, Connecticut and elsewhere, may provide funding sources beyond municipal operating budgets.

A sampling of funding opportunities is listed in Table 10-1.

Table 10-1. Potential funding sources for management recommendations.

Funding Source	Contact Information
CT DEEP CWA §319 Grant Program http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325588&depNav_GID=1654	
CT DEEP Clean Water Fund http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325578&depNav_GID=1654	Susan Hawkins (860) 424-3325
CT DEEP Long Island Sound License Plate Program http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635	Kate Brown (860) 424-3034
CT OPM Small Town Economic Assistance Program (STEAP) http://www.ct.gov/opm/cwp/view.asp?a=2965&q=382970&opmNav_GID=1793	Barbara Rua (860) 418-6303
US EPA Healthy Communities Grant Program http://www.epa.gov/region1/eco/uep/hcgp.html	Jennifer Padula (617) 918-1698
NOAA Coastal Management Programs http://coastalmanagement.noaa.gov/funding/welcome.html	
US EPA Five Star Restoration Grant Program http://www.epa.gov/owow/wetlands/restore/5star	Myra Price (202) 566-1225
NFWF Grant Programs http://www.nfwf.org/whatwedo/grants/Pages/home.aspx#.VSw63ZNuOVo	
NRCS Wetlands Reserve Program (WRP) http://www.ct.nrcs.usda.gov/programs/whip/whip.html	Javier Cruz (860) 887-3604 x307
NRCS Environmental Quality Incentives Program (EQIP) http://www.ct.nrcs.usda.gov/programs/eqip/eqip.html	Javier Cruz (860) 887-3604 x307
Rivers Alliance of CT Watershed Assistance Small Grants Program http://www.riversalliance.org/watershedassistancegrantrfp.cfm	Rivers Alliance of CT (860) 361-9349

11 Monitoring and Assessment

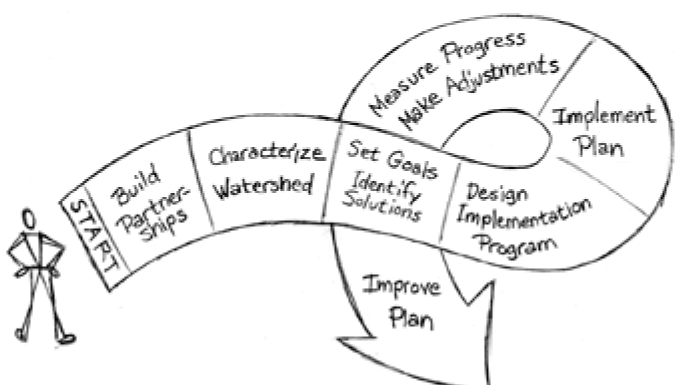
Monitoring is essential to determining the effectiveness of Plan implementations. On-going monitoring will provide necessary water quality data to allow the Watershed Management Team to assess the effectiveness of BMPs. Water quality monitoring should be coordinated by the Watershed Management Team with the implementation of management measures to determine if the desired results (achievement of water quality targets) are being achieved.

The following items should be included as part of the monitoring and assessment of Watershed Plan implementations:

- Establishment and implementation of monitoring activities should be coordinated with watershed project partners.
- If existing data is not available, BMP implementations should include pre- and post-implementation water quality monitoring, as practicable, to determine effectiveness of the BMP in reducing pollutant loading.
- Comparison of post- to pre-BMP water quality monitoring data to determine if water quality targets, especially phosphorus load reductions, have been achieved.
- If monitoring indicates load reduction expectations are not being achieved, the watershed management team may investigate the effectiveness of selected BMP practices, and may revise the watershed plan.

12 Plan Implementation Effectiveness

The implementation of a watershed management plan is necessarily an iterative process. As implementations are undertaken and completed, water quality data should continue to be collected, evaluated and compared to the desired water quality goals to determine if the implementations are achieving the desired results. Implementation should be considered complete when the targets are reached or exceeded. Once water quality targets have been achieved, periodic water quality sampling should be continued in Amos Lake and the tributary streams to ensure water quality improvements are sustained.



US EPA 2008

If implementations are not as effective as planned, e.g., implementation milestones are not being met, or progress is not being made toward reducing pollutant loads, watershed stakeholders should investigate the effectiveness of selected BMP practices, and may need to make adjustments or revisions to the watershed plan. Additionally, as management measures are completed, watershed stakeholders should review this Management Plan vis a vis changes and/or improvements to the watershed, and revise or update the Plan accordingly.

13 Next Steps

Addressing Amos Lake's water quality issues will be a long term effort. It took many years for Amos Lake to degrade from its natural trophic state at the oligotrophic/mesotrophic boundary to its current mesotrophic/eutrophic state. It will take the actions of many individuals, and community leaders and decision makers to address current water quality issues and reduce the levels of phosphorus and nitrogen currently entering Amos Lake. Periodic public events should be scheduled by the watershed management team to reach out to residents of the local lake watershed and the broader Preston community to promote the watershed plan, and inform the community about efforts being undertaken to improve conditions at Amos Lake.

Following the acceptance of the Amos Lake Abbreviated Watershed-Based Plan by the CT DEEP, this Plan should be distributed to all the watershed stakeholders for implementation. The Plan should also be made available to the general public via posting on the CT DEEP, ECCD and the Town of Preston websites.

The Eastern Connecticut Conservation District intends to remain an active participant and central point of contact as implementations recommended by this Watershed-Based Plan are undertaken.

Any comments or questions regarding this Plan should be directed to:

Eastern Connecticut Conservation District
238 West Town Street
Norwich, CT 06360
(860) 887-4163 ext. 400

14 References

Baker, L., (n.d.). *Sources of Urban Stormwater Pollution,* Water Resources Center University of Minnesota. Retrieved 4/15/15 from http://stormwater.safl.umn.edu/sites/stormwater. safl. umn.edu/files/102406baker.pdf

Bellucci, C.J., M. Beauchene, and M. Becker, 2008. Streams of Hope: Characterizing the Biological Potential of Moderately Urbanized Connecticut Streams. Connecticut Department of Environmental Protection, Hartford, CT 06106.

Capers, Robert S., Gregory J. Bugbee, Roslyn Selsky and Jason C. White, January 2005. A Guide to Invasive Aquatic Plants of Connecticut. The Connecticut Agricultural Experiment Station Bulletin No. 997.

Clausen, J.C., Gregoire, B.G., Turner, M.J. 2008. Introducing equipment to reduce movement of nutrients from farm fields (unpublished report).

CT DEEP, *2006/2007 Aerial Deer Survey Indicates Stable Deer Population*. Connecticut Wildlife, May/June 2007.

CT DEEP (n.d.), *Brownfield Sites in Connecticut*. Retrieved 1/22/14 from http://www.ct.gov/ deep/cwp/view.asp?a=2715&q=324930&deepNav_GID=1626

CT DEEP (n.d.), *List of Contaminated or Potentially Contaminated Sites*. Retrieved 1/22/14 from http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325018&deepNav_GID=1626

CT DEEP (n.d.). *Stormwater Management*. Retrieved 1/22/15 from http://www.ct.gov/ deep/cwp/view.asp?a=2721&q=325702

Connecticut Department of Transportation, *Stormwater Management Plan (Draft)*, February 2004, prepared by Maguire Group Inc., New Britain, CT.

Connecticut Geological and Natural History Survey, *Bedrock Geological Map of Connecticut*, 1985.

Connecticut's Changing Landscape, (n.d.). University of Connecticut Center for Land Use Education and Research. Retrieved 7/24/15 from http://clear.uconn.edu/projects/landscape/ project.htm

Conservation & Development Policies: The Plan for Connecticut - 2013- 2018, Prepared by the Connecticut Office of Policy and Management, 2013.

Elrashidi, M., Seybold, C., Delgado, J.A. 2014. Annual precipitation and effects of runoff-nutrient from agricultural watersheds on water quality, Soil Science, 178:679-688.

FEMA Flood Zones (n.d.). Retrieved 4/06/15 from www.fema.gov/floodplain-management/flood-zones

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.

Gustafson, S., Wang, D. 2002. Effects of Agricultural Runoff on Vegetation Composition of a Priority Conservation Wetland, Vermont, USA. J.Environ. Qual. 31:350-357.

Handbook for Developing Watershed Plans to Restore and Protect Our Waters, United States Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch, Washington, DC 20460, EPA 841-B-08-002, March 2008.

Hively, W.D., Bryant, R.B., Fahey, T.J. 2005. Phosphorus concentrations in overland flow from diverse locations on a New York dairy farm. Journal of Environmental Quality 34:1224-1233.

Jassby, A.D., Reuter, J.E., Axler, R.P., Goldman, C.R., Hackley, S.H., 1994. Atmospheric deposition of nitrogen and phosphorus in the annual nutrient load of Lack Tahoe (California-Nevada). Water Resources Research 30 (7), 2207–2216.

Kumar, Kuldip & Catherine O'Connor (n.d.). CSI Chicago: Tracking the Sources and Fate of Phosphorus in Chicago Area Waterways, Metropolitan Water Reclamation District of Greater Chicago. Retrieved 4.14.15 from http://iweasite.org/Conferences/gvt_affairs/gac_11_Source%20and%20Fate%20of%20P%20in%20CAWS.pdf

Manny, Bruce A.; Johnson, W.C.; Wetzel, R.G., 1994. Nutrient additions by waterfowl to lakes and reservoirs: predicting their effects on productivity and water quality, Hydrobiologia, 279/280: 121 – 132.

McGuiness, Barbara, (October 1997). *Deer Carrying Capacity: Too Few, Too Many, and for Whom?* The Northern Logger & Timber Processor. Retrieved 11/11/14 from http://www.deerandforests.org/resources/Deer%20Carrying%20Capacity.pdf

Moore, Richard B., Craig M. Johnston, Richard A. Smith, and Bryan Milstead, 2011. Source and Delivery of Nutrients to Receiving Waters in the Northeastern and Mid-Atlantic Regions of the United States. Journal of the American Water Resources Association (JAWRA) 47(5):965-990. DOI: 10.1111 ⁄ j.1752-1688.2011.00582.x

National Water Quality Monitoring Council (2007). Glossary of water-quality monitoring terms: Advisory Committee on Water Information. Retrieved 2/02/15 from http://acwi.gov/monitoring/glossary.html

Pettigrew, C.T., B.J. Hahn, and L.G. Goldsborough. 1998. Waterfowl Feces as a Source of Nutrients to a Prairie Wetland: responses of Microinvertebrates to Experimental Additions. Hydrobiologia 362: 55-66.

Puckett, L.J., 1994. Nonpoint and Point Source of Nitrogen in Major Watersheds of the United States. USGS (United States Geological Survey) Water-Resources Investigations Report 94-4001.

Schueler, Thomas, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices*. MWCOG. Washington, D.C.

Schueler, Thomas, 1994. The Importance of Imperviousness. Watershed Protection Techniques 1(3): 100-111.

Smith, R.A., Schwarz, G.E., Alexander, R.B., 1997, Regional interpretation of water-quality monitoring data: Water Resources Research, v. 33, no. 12, p. 2781-2798.

Smith, S.J., Sharpley, A.N., Berg, W.A., Coleman, G.A., Welch, N.H. 1988. Proceedings 22nd Oklahoma Agricultural Chemicals Conference 13:23-26. Stillwater: Oklahoma State University Press.

State of Connecticut, Department of Energy and Environmental Protection, Water Quality Standards, October 2013.

Stuntebeck, T.D., Komiskey, M.J., Peppler, M.C., Owens, D.W., and Frame, D.R., 2011, Precipitation-runoff relations and water-quality characteristics at edge-of-field stations, Discovery Farms and Pioneer Farm, Wisconsin, 2003–8: U.S. Geological Survey Scientific Investigations Report 2011–5008, 46 p.

Taylor, Robert B. 1979. *A Connecticut Lakes Management Program Effort.* Proceedings: Lake Management Conference. CT Institute of Water Resources Special Reports, Paper 29: 31-46, 3-1-1979.

Town Of Preston, CT, 2013. Inland Wetlands & Watercourses Regulations, effective July 1, 1988, amended through October 10, 2013.

Town of Preston, CT, 2003. Plan of Conservation and Development, adopted by the Town of Preston Planning & Zoning Commission on December 2, 2003.

Town of Preston, CT, 2013. Subdivision Regulations, revised to August 28, 2012, effective September 22, 2012.

Town of Preston, Connecticut, 2013. Zoning Regulations, effective April 1964, revised through November 11, 2013.

Unckless, Robert L. and Joseph C. Makarewicz, 2007. The impact of nutrient loading from Canada Geese (Branta canadensis) on water quality, a mesocosm approach. Hydrobiologia 586:393–401.

US EPA (n.d.). *Animal Feeding Operations Overview.* Retrieved 1/22/15 from http://water.epa.gov/polwaste/npdes/afo/index.cfm

US EPA (n.d.). *Brownfields and Land Revitalization.* Retrieved 1.22.15 from http://www.epa.gov/brownfields/overview/glossary.htm

US EPA (n.d.). *Hazardous Waste*. Retrieved 1/22/15 from http://www.epa.gov/epawaste/hazard/index.htm

US EPA (n.d.). *NPDES Wastewater & Stormwater Permit*. Retrieved 1/27/15 from www.epa.gov/region09/water/npdes/stormwater.html

US EPA (n.d.). *Polluted Runoff: Nonpoint Source Pollution*. Retrieved 2/02/15 from http://water.epa.gov/polwaste/nps

US EPA (2014). *Pollution Prevention/Good Housekeeping for Municipal Operators.* Retrieved 4/16/15 from http://water.epa.gov/polwaste/npdes/swbmp/Pollution-Prevention-Good-Housekeeping-for-Municipal-Operatators.cfm

US EPA (n.d.). *Superfund: Cleaning up the Nation's Hazardous Waste Sites.* Retrieved 1/21/15 from http://www.epa.gov/superfund/policy/cercla.htm

US EPA (n.d.). *Underground Storage Tanks.* Retrieved 1/22/15 from http://www.epa.gov/oust/aboutust.htm

US EPA (n.d.). *What is RCRA?* Retrieved 1/21/15 from http://www.epa.gov/region2/waste/what.htm

University of Wisconsin Extension System (2000). *To Safeguard Livestock and Waterways*. Retrieved 3/17/14 from http://clean-water.uwex.edu/pubs/pdf/cattlewater.pdf
Urban Design Tools - Low Impact Development - Bioretention Costs. Retrieved 3/12/14 from http://www.lid-stormwater.net/bio_costs.htm

Walker, Mark and Lynell Garfield (2008). *Dog Wastes and Water Quality: Evaluating the Connection at Lake Tahoe*. University of Nevada Cooperative Extension Fact Sheet 08-18, 2008.

Wilson, Emily and Chester Arnold. *Forest Fragmentation in Connecticut: 1985 – 2006*. University of Connecticut Center for Land Use Education and Research (CLEAR), September 2009.

Wisconsin Department of Natural Resources (March 2003). *Alum Treatments to Control Phosphorus in Lakes.* Retrieved 4/15/15 from http://www.littlesaint.org/misc_documents/alum__phosphorous_control_dnr.pdf

Yuzhou Luoa, Xiusheng Yang, Robert J. Carley, Christopher Perkins, 2003. Effects of geographical location and land use on atmospheric deposition of nitrogen in the State of Connecticut, Environmental Pollution 124: 437–448.

Appendix A

Connecticut Agricultural Experiment Station

Aquatic Survey Reports

2006 and 2013

*Plant abundance is on scale of 1 – 5: 1 = present but rare (1 plant), 2 = occasional (a few plants), 3 = common (more than a few plants), 4 = abundant, 5 = extremely abundant or dominant

**Follow this link to convert decimal degrees to degrees minutes seconds http://www.fcc.gov/mb/audio/bickel/DDDMMSS-decimal.html

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0.1	Sand	sunny	1	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52043	-71.98034
Roslyn Selsky	0.25	Silt	sunny	1	2	5	lots of filamentous algae	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52039	-71.98030
Roslyn Selsky	0.5	Silt	sunny	1	3	10	lots filamentous algae	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52035	-71.98028
Roslyn Selsky	0.5	Silt	sunny	1	4	20	lots filamentous algae	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52027	-71.98025
Roslyn Selsky	1	Silt	sunny	1	5	30	filamentous algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52017	-71.98013
Roslyn Selsky	1.5	Silt	sunny	1	6	40	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52012	-71.98012
Roslyn Selsky	1.5	Silt	sunny	1	7	50	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.52002	-71.98013
Roslyn Selsky	1.75	Silt	sunny	1	8	60	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51995	-71.98007
Roslyn Selsky	1.8	Silt	sunny	1	9	70	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51989	-71.97992
Roslyn Selsky	1.8	Silt	sunny	1	10	80	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51975	-71.97995

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0.25	Silt	sunny	2	1	0		0	1	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51861	-71.98045
Roslyn Selsky	0.5	Silt	sunny	2	2	5		0	0	0	0	0	0	0	0	4	2	0	0	0	0	0	0	1	0	0	8/1/2006	41.51863	-71.98040
Roslyn Selsky	0.5	Silt	sunny	2	3	10		0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51865	-71.98034
Roslyn Selsky	1.25	Silt	sunny	2	4	20		0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51871	-71.98021
Roslyn Selsky	1.75	Silt	sunny	2	5	30		0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	8/1/2006	41.51875	-71.98013
Roslyn Selsky	1.9	Silt	sunny	2	6	40	fiil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/1/2006	41.51882	-71.98007
Roslyn Selsky	3	Silt	sunny	2	7	50	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51890	-71.97992
Roslyn Selsky	0		sunny	2	8	60	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51895	-71.97988
Roslyn Selsky	0		sunny	2	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51899	-71.97976
Roslyn Selsky	0		sunny	2	10	80	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51901	-71.97955
Roslyn Selsky	0.1	Sand	sunny	3	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51756	-71.97744
Roslyn Selsky	0.25	Sand	sunny	3	2	5		0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	1	8/1/2006	41.51758	-71.97743

Amos Lake, Preston | Transect Data | Survey by Roslyn Selsky and Emily Pysh

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	1	Gravel	sunny	3	3	10		0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	8/1/2006	41.51766	-71.97745
Roslyn Selsky	1.75	Silt	sunny	3	4	20		0	0	0	0	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	8/1/2006	41.51774	-71.97741
	2.25	Silt	sunny	3	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/1/2006	41.51784	-71.97747
Roslyn Selsky	3	Silt	sunny	3	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/1/2006	41.51790	-71.97751
Roslyn Selsky	0		sunny	3	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51803	-71.97745
Roslyn Selsky	0		sunny	3	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51809	-71.97744
Roslyn Selsky	0		sunny	3	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51825	-71.97754
Roslyn Selsky	0		sunny	3	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51825	-71.97748
Roslyn Selsky	0.25	Silt	sunny	4	1	0		0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	8/1/2006	41.51683	-71.97813
Roslyn Selsky	0.25	Gravel	sunny	4	2	5		0	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/1/2006	41.51683	-71.97808
Roslyn Selsky	0.75	Rock	sunny	4	3	10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51681	-71.97803
Roslyn Selsky	2.1	Silt	sunny	4	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/1/2006	41.51680	-71.97792

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	2.75	Silt	sunny	4	5	30	fil algae	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/1/2006	41.51684	-71.97776
Roslyn Selsky	2.8	Silt	sunny	4	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/1/2006	41.51690	-71.97765
Roslyn Selsky	3.5	Silt	sunny	4	7	50	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51690	-71.97754
Roslyn Selsky	0		sunny	4	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51685	-71.97739
Roslyn Selsky	0		sunny	4	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51689	-71.97728
Roslyn Selsky	0		sunny	4	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/1/2006	41.51694	-71.97716
Roslyn Selsky	0.1	Rock	sunny	5	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51519	-71.97683
Roslyn Selsky	0.3	Sand	sunny	5	2	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51525	-71.97680
Roslyn Selsky	0.75	Silt	sunny	5	3	10		0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51525	-71.97679
Roslyn Selsky	1.75	Silt	sunny	5	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/1/2006	41.51533	-71.97674
Roslyn Selsky	1.9	Silt	sunny	5	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/1/2006	41.51542	-71.97668
Roslyn Selsky	2	Silt	sunny	5	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/1/2006	41.51550	-71.97666

Amos Lake, Preston Transect Data Survey by Roslyn Selsky and Emily Pysh

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	2.75	Silt	sunny	5	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/1/2006	41.51557	-71.97657
Roslyn Selsky	0		sunny	5	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51563	-71.97649
Roslyn Selsky	0		sunny	5	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51574	-71.97646
Roslyn Selsky	0		sunny	5	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51580	-71.97642
Roslyn Selsky	0.1	Silt	sunny	6	1	0		0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51326	-71.97519
Roslyn Selsky	0.5	Silt	sunny	6	2	5	fil. algae	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51326	-71.97512
Roslyn Selsky	1	Silt	sunny	6	3	10	fil. algae	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51327	-71.97504
Roslyn Selsky	1.25	Silt	sunny	6	4	20	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51326	-71.97492
Roslyn Selsky	1.5	Silt	sunny	6	5	30	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51322	-71.97482
Roslyn Selsky	2.1	Silt	sunny	6	6	40	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51319	-71.97472
Roslyn Selsky	0		sunny	6	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51324	-71.97449
Roslyn Selsky	0		sunny	6	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51315	-71.97442

Amos Lake, Preston — Transect Data — Survey by Roslyn Selsky and Emily Pysh

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0		sunny	6	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51313	-71.97430
Roslyn Selsky	0		sunny	6	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/1/2006	41.51304	-71.97416
Roslyn Selsky	0.1	Gravel	sunny	7	1	0		0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51084	-71.97502
Roslyn Selsky	0.1	Gravel	sunny	7	2	5		0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51088	-71.97502
Roslyn Selsky	0.5	Sand	sunny	7	3	10		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51093	-71.97497
Roslyn Selsky	1	Sand	sunny	7	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51104	-71.97499
Roslyn Selsky	1.5	Silt	sunny	7	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51114	-71.97498
Roslyn Selsky	1.8	Silt	sunny	7	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51119	-71.97497
Roslyn Selsky	2.1	Silt	sunny	7	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51129	-71.97491
Roslyn Selsky	0		sunny	7	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51142	-71.97478
Roslyn Selsky	0		sunny	7	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51148	-71.97481
Roslyn Selsky	0		sunny	7	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51158	-71.97482

Amos Lake, Preston | Transect Data | Survey by Roslyn Selsky and Emily Pysh

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0.25	Rock	sunny	8	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51199	-71.97321
Roslyn Selsky	1	Rock	sunny	8	2	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51203	-71.97326
Roslyn Selsky	2	Rock	sunny	8	3	10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51205	-71.97334
Roslyn Selsky	2.75	Silt	sunny	8	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51204	-71.97346
Roslyn Selsky	3	Silt	sunny	8	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51208	-71.97354
Roslyn Selsky	4	Silt	sunny	8	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51209	-71.97367
Roslyn Selsky	0		sunny	8	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51212	-71.97382
Roslyn Selsky	0		sunny	8	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51217	-71.97392
Roslyn Selsky	0		sunny	8	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51221	-71.97404
Roslyn Selsky	0		sunny	8	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51220	-71.97423
Roslyn Selsky	0.1	Silt	sunny	9	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51555	-71.97254
Roslyn Selsky	0.25	Sand	sunny	9	2	5		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	8/2/2006	41.51553	-71.97256

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0.3	Sand	sunny	9	3	10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8/2/2006	41.51551	-71.97257
Roslyn Selsky	0.75	Sand	sunny	9	4	20		0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	0	0	0	2	8/2/2006	41.51541	-71.97266
Roslyn Selsky	1.5	Silt	sunny	9	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/2/2006	41.51531	-71.97268
Roslyn Selsky	1.75	Silt	sunny	9	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51525	-71.97278
Roslyn Selsky	1.8	Silt	sunny	9	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51516	-71.97280
Roslyn Selsky	1.8	Silt	sunny	9	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51509	-71.97285
Roslyn Selsky	1.9	Silt	sunny	9	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51501	-71.97299
Roslyn Selsky	2.1	Silt	sunny	9	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51494	-71.97303
Roslyn Selsky	0.25	Sand	sunny	10	1	0		3	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	8/2/2006	41.51682	-71.97285
Roslyn Selsky	1	Sand	sunny	10	2	5		2	0	0	0	0	0	0	0	2	0	0	0	3	3	0	0	0	0	0	8/2/2006	41.51679	-71.97286
Roslyn Selsky	1.75	Sand	sunny	10	3	10		0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	8/2/2006	41.51673	-71.97292
Roslyn Selsky	1	Sand	sunny	10	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	4	3	0	8/2/2006	41.51670	-71.97306

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	1	Silt	sunny	10	5	30		0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	2	2	2	0	8/2/2006	41.51658	-71.97312
Roslyn Selsky	1	Silt	sunny	10	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51656	-71.97327
Roslyn Selsky	1.5	Silt	sunny	10	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/2/2006	41.51652	-71.97333
Roslyn Selsky	1.5	Rock	sunny	10	8	60	fil. algae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.51644	-71.97341
Roslyn Selsky	1.75	Silt	sunny	10	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/2/2006	41.51636	-71.97344
Roslyn Selsky	2.1	Silt	sunny	10	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.51625	-71.97351
Roslyn Selsky	0.1	Gravel	sunny	11	1	0		0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52093	-71.97462
Roslyn Selsky	0.25	Sand	sunny	11	2	5		0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	3	8/2/2006	41.52092	-71.97467
Roslyn Selsky	1	Silt	sunny	11	3	10		0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	3	8/2/2006	41.52089	-71.97477
Roslyn Selsky	1.9	Silt	sunny	11	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.52083	-71.97485
Roslyn Selsky	2	Silt	sunny	11	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.52079	-71.97492
Roslyn Selsky	2.5	Silt	sunny	11	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/2/2006	41.52074	-71.97497

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0		sunny	11	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52071	-71.97507
Roslyn Selsky	0		sunny	11	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52061	-71.97520
Roslyn Selsky	0		sunny	11	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52057	-71.97532
Roslyn Selsky	0		sunny	11	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52057	-71.97546
Roslyn Selsky	0.1	Sand	sunny	12	1	0		0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52146	-71.97824
Roslyn Selsky	1	Sand	sunny	12	2	5		0	0	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	8/2/2006	41.52141	-71.97824
Roslyn Selsky	1.5	Sand	sunny	12	3	10		0	0	0	1	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	8/2/2006	41.52137	-71.97815
Roslyn Selsky	1.75	Sand	sunny	12	4	20		0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0	0	8/2/2006	41.52130	-71.97815
Roslyn Selsky	3	Silt	sunny	12	5	30		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/2/2006	41.52119	-71.97810
Roslyn Selsky	0		sunny	12	6	40		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52112	-71.97801
Roslyn Selsky	0		sunny	12	7	50		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52106	-71.97789
Roslyn Selsky	0		sunny	12	8	60		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52097	-71.97777

Amos Lake, Preston

Transect Data

Survey by Roslyn Selsky and Emily Pysh

Surveyor	Depth (m)	Substrate	Weather	Transect	Points	Meters from Shore	Notes	Brasenia schreberi*	Ceratophyllum demersum	Decodon verticillatus	Isoëtes sp.	Glossostigma cleitanthum	Myriophyllum heterophyllum	Myriophyllum tenellum	Najas flexilis	Nymphaea odorata	Potamogeton pulcher	Potamogeton bicupulatus	Potamogeton gramineus	Potamogeton foliosus	Potamogeton robbinsii	Sagittaria sp.	Utricularia gibba	Utricularia purpurea	Utricularia vulgaris	Valisneria americana	Date	Latitude**	Longitude
Roslyn Selsky	0		sunny	12	9	70		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52093	-71.97781
Roslyn Selsky	0		sunny	12	10	80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/2/2006	41.52081	-71.97783

Plant abundance is on scale of 1 – 5: 1 = present but rare (1 plant), 2 = occasional (a few plants), 3 = common (more than a few plants), 4 = abundant, 5 = extremely abundant or dominant

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Muck	1	1	.5		0	3	0	2	0	0	0	2	0	0	0	0	0	0	1	0	0	8/16/2013	41.52041	-71.98036
Jordan Gibbons	0.50	Muck	1	2	5.0		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52037	-71.98034
Jordan Gibbons	0.70	Muck	1	3	10.0		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52034	-71.98030
Jordan Gibbons	0.70	Muck	1	4	20.0		0	0	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	8/16/2013	41.52026	-71.98023
Jordan Gibbons	1.00	Muck	1	5	30.0		0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	8/16/2013	41.52016	-71.98018
Jordan Gibbons	1.20	Muck	1	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52009	-71.98012
Jordan Gibbons	1.60	Muck	1	7	50.0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8/16/2013	41.52001	-71.98004
Jordan Gibbons	1.20	Muck	1	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51992	-71.98001
Jordan Gibbons	1.30	Muck	1	9	70.0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8/16/2013	41.51988	-71.97988
Jordan Gibbons	2.00	Muck	1	10	80.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51988	-71.97975
Jordan Gibbons	0.50	Muck	2	1	.5		0	0	0	0	0	0	0	5	0	0	2	2	0	0	0	0	0	8/16/2013	41.51864	-71.98044
Jordan Gibbons	1.00	Muck	2	2	5.0		0	0	0	0	0	0	0	5	0	0	3	1	0	0	0	0	0	8/16/2013	41.51866	-71.98041
Jordan Gibbons	1.00	Muck	2	3	10.0		0	0	0	0	0	0	0	5	0	0	2	0	0	0	0	0	0	8/16/2013	41.51870	-71.98038
Jordan Gibbons	1.10	Muck	2	4	20.0		0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	8/16/2013	41.51875	-71.98026
Jordan Gibbons	1.80	Muck	2	5	30.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51883	-71.98017
Jordan Gibbons	1.80	Muck	2	6	40.0		0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	8/16/2013	41.51884	-71.98006
Jordan Gibbons	2.20	Muck	2	7	50.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51890	-71.97996
Jordan Gibbons	3.50	Muck	2	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51900	-71.97990
Jordan Gibbons	4.40	Muck	2	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51907	-71.97982
Jordan Gibbons	4.70	Muck	2	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51913	-71.97972

Plant abundance is on scale of 1 – 5: 1 = present but rare (1 plant), 2 = occasional (a few plants), 3 = common (more than a few plants), 4 = abundant, 5 = extremely abundant or dominant

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Organic	3	1	.5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51748	-71.97762
Jordan Gibbons	0.50	Sand	3	2	5.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51751	-71.97762
Jordan Gibbons	0.07	Muck	3	3	10.0		0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	8/16/2013	41.51755	-71.97762
Jordan Gibbons	1.80	Muck	3	4	20.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.51764	-71.97762
Jordan Gibbons	2.00	Muck	3	5	30.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51773	-71.97764
Jordan Gibbons	2.40	Muck	3	6	40.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51781	-71.97757
Jordan Gibbons	2.70	Muck	3	7	50.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51791	-71.97752
Jordan Gibbons	6.20	Muck	3	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51800	-71.97759
Jordan Gibbons	7.20	Muck	3	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51809	-71.97762
Jordan Gibbons	7.80	Muck	3	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51817	-71.97761
Jordan Gibbons	0.50	Gravel	4	1	.5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51676	-71.97815
Jordan Gibbons	1.00	Gravel	4	2	5.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51676	-71.97808
Jordan Gibbons	2.00	Muck	4	3	10.0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.51678	-71.97802
Jordan Gibbons	1.80	Muck	4	4	20.0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.51681	-71.97791
Jordan Gibbons	2.30	Muck	4	5	30.0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.51682	-71.97780
Jordan Gibbons	2.80	Muck	4	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51683	-71.97768
Jordan Gibbons	3.00	Muck	4	7	50.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51687	-71.97756
Jordan Gibbons	3.10	Muck	4	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51689	-71.97745
Jordan Gibbons	3.00	Muck	4	9	70.0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8/16/2013	41.51694	-71.97734
Jordan Gibbons	2.60	Muck	4	10	80.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51698	-71.97722

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Organic	5	1	.5		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8/16/2013	41.51522	-71.97689
Jordan Gibbons	1.00	Muck	5	2	5.0		2	0	0	0	0	0	0	5	2	0	0	0	0	0	0	0	0	8/16/2013	41.51526	-71.97686
Jordan Gibbons	1.20	Muck	5	3	10.0		0	0	0	0	0	0	0	4	0	0	0	3	0	0	2	0	0	8/16/2013	41.51531	-71.97685
Jordan Gibbons	1.10	Muck	5	4	20.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51541	-71.97680
Jordan Gibbons	1.20	Muck	5	5	30.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.51547	-71.97674
Jordan Gibbons	1.60	Muck	5	6	40.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51557	-71.97670
Jordan Gibbons	1.50	Muck	5	7	50.0		0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	8/16/2013	41.51567	-71.97674
Jordan Gibbons	1.50	Muck	5	8	60.0		0	0	0	0	0	0	0	0	0	0	0	4	0	2	2	0	0	8/16/2013	41.51575	-71.97679
Jordan Gibbons	1.60	Muck	5	9	70.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	8/16/2013	41.51587	-71.97678
Jordan Gibbons	1.50	Muck	5	10	80.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51596	-71.97679
Jordan Gibbons	0.50	Muck	6	1	.5		0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	8/16/2013	41.51330	-71.97513
Jordan Gibbons	0.50	Muck	6	2	5.0		0	0	0	0	0	0	0	5	0	0	2	0	0	0	0	0	0	8/16/2013	41.51329	-71.97508
Jordan Gibbons	0.70	Muck	6	3	10.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51329	-71.97502
Jordan Gibbons	1.20	Muck	6	4	5.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51326	-71.97490
Jordan Gibbons	1.10	Muck	6	5	30.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51325	-71.97477
Jordan Gibbons	1.80	Muck	6	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51322	-71.97467
Jordan Gibbons	2.80	Muck	6	7	50.0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.51316	-71.97456
Jordan Gibbons	4.90	Muck	6	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51320	-71.97441
Jordan Gibbons	5.60	Muck	6	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51322	-71.97429
Jordan Gibbons	5.90	Muck	6	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51323	-71.97419

Surveyed by Jordan Gibbons
and Samantha Wysocki

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Sand	7	1	.5		0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51086	-71.97503
Jordan Gibbons	1.00	Muck	7	2	5.0		0	0	0	0	0	0	0	4	0	0	0	2	0	0	0	0	0	8/16/2013	41.51092	-71.97503
Jordan Gibbons	1.50	Muck	7	3	10.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51095	-71.97498
Jordan Gibbons	1.50	Muck	7	4	20.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.51104	-71.97500
Jordan Gibbons	1.50	Muck	7	5	30.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.51113	-71.97502
Jordan Gibbons	1.70	Muck	7	6	40.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51123	-71.97504
Jordan Gibbons	1.80	Muck	7	7	50.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51131	-71.97508
Jordan Gibbons	2.60	Muck	7	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51141	-71.97506
Jordan Gibbons	3.50	Muck	7	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51150	-71.97506
Jordan Gibbons	4.20	Muck	7	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51159	-71.97505
Jordan Gibbons	0.50	Gravel	8	1	.5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51198	-71.97323
Jordan Gibbons	1.90	Gravel	8	2	5.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51197	-71.97331
Jordan Gibbons	2.10	Muck	8	3	10.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51196	-71.97337
Jordan Gibbons	2.40	Muck	8	4	20.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51201	-71.97352
Jordan Gibbons	2.50	Muck	8	5	30.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51201	-71.97363
Jordan Gibbons	2.90	Muck	8	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51203	-71.97374
Jordan Gibbons	4.80	Muck	8	7	50.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51210	-71.97385
Jordan Gibbons	5.50	Muck	8	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51212	-71.97397
Jordan Gibbons	5.60	Muck	8	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51214	-71.97407
Jordan Gibbons	5.70	Muck	8	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51214	-71.97420

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Muck	9	1	.5		2	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	3	8/16/2013	41.51555	-71.97268
Jordan Gibbons	0.70	Muck	9	2	5.0		0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	8/16/2013	41.51552	-71.97269
Jordan Gibbons	1.00	Muck	9	3	10.0		0	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	4	8/16/2013	41.51548	-71.97269
Jordan Gibbons	1.00	Muck	9	4	20.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51539	-71.97273
Jordan Gibbons	1.50	Muck	9	5	30.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51530	-71.97276
Jordan Gibbons	1.60	Muck	9	6	40.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51521	-71.97280
Jordan Gibbons	1.80	Muck	9	7	50.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51512	-71.97283
Jordan Gibbons	1.50	Muck	9	8	60.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51504	-71.97289
Jordan Gibbons	1.60	Muck	9	9	70.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.51494	-71.97290
Jordan Gibbons	2.00	Muck	9	10	80.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8/16/2013	41.51489	-71.97288
Jordan Gibbons	0.50	Gravel	10	1	.5		3	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	8/16/2013	41.51683	-71.97282
Jordan Gibbons	1.00	Muck	10	2	5.0		2	0	0	0	0	0	4	4	0	0	1	2	0	0	0	0	0	8/16/2013	41.51680	-71.97286
Jordan Gibbons	1.00	Muck	10	3	10.0		0	0	0	0	0	0	5	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.51676	-71.97294
Jordan Gibbons	0.70	Muck	10	4	20.0		0	0	0	0	0	0	0	3	0	0	2	3	0	0	1	1	0	8/16/2013	41.51670	-71.97300
Jordan Gibbons	1.00	Muck	10	5	30.0		0	0	0	0	0	0	0	5	0	0	2	0	0	0	0	0	0	8/16/2013	41.51662	-71.97306
Jordan Gibbons	1.00	Muck	10	6	40.0		0	0	0	0	1	0	0	3	0	0	0	3	0	0	0	0	0	8/16/2013	41.51655	-71.97312
Jordan Gibbons	1.00	Gravel	10	7	50.0		0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	8/16/2013	41.51647	-71.97316
Jordan Gibbons	1.00	Gravel	10	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.51638	-71.97323
Jordan Gibbons	1.80	Muck	10	9	70.0		0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	8/16/2013	41.51629	-71.97330
Jordan Gibbons	1.90	Muck	10	10	80.0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.51622	-71.97332

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Surveyor	Depth (m)	Substrate	Transect	Point	Distance from Shore (m)	Notes	*Brasenia schreberi*	*Eleocharis species*	*Glossostigma cleistanthum*	*Ludwigia species*	*Myriophyllum heterophyllum*	*Myriophyllum tenellum*	*Nuphar variegata*	*Nymphaea odorata*	*Nymphoides cordata*	*Potamogeton gramineus*	*Potamogeton pulcher*	*Potamogeton robbinsii*	*Sagittaria species*	*Utricularia gibba*	*Utricularia macrorhiza*	*Utricularia purpurea*	*Vallisneria americana*	Date	Latitude	Longitude
Jordan Gibbons	0.50	Gravel	11	1	.5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52095	-71.97463
Jordan Gibbons	0.50	Sand	11	2	5.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8/16/2013	41.52093	-71.97466
Jordan Gibbons	1.50	Muck	11	3	10.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.52090	-71.97473
Jordan Gibbons	1.50	Muck	11	4	20.0		0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	3	8/16/2013	41.52084	-71.97482
Jordan Gibbons	2.00	Muck	11	5	30.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.52082	-71.97493
Jordan Gibbons	2.40	Muck	11	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52078	-71.97503
Jordan Gibbons	4.60	Muck	11	7	50.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52077	-71.97519
Jordan Gibbons	5.80	Muck	11	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52075	-71.97531
Jordan Gibbons	6.80	Muck	11	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52068	-71.97541
Jordan Gibbons	7.00	Muck	11	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52063	-71.97550
Jordan Gibbons	0.50	Sand	12	1	.5		0	2	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52146	-71.97829
Jordan Gibbons	0.70	Sand	12	2	5.0		0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8/16/2013	41.52142	-71.97825
Jordan Gibbons	1.00	Muck	12	3	10.0		0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	8/16/2013	41.52136	-71.97822
Jordan Gibbons	1.60	Muck	12	4	20.0		0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8/16/2013	41.52128	-71.97814
Jordan Gibbons	2.50	Muck	12	5	30.0		0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8/16/2013	41.52120	-71.97809
Jordan Gibbons	6.20	Muck	12	6	40.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52113	-71.97801
Jordan Gibbons	8.30	Muck	12	7	50.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52106	-71.97796
Jordan Gibbons	9.20	Muck	12	8	60.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52098	-71.97788
Jordan Gibbons	9.60	Muck	12	9	70.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52089	-71.97781
Jordan Gibbons	10.40	Muck	12	10	80.0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8/16/2013	41.52082	-71.97774

Appendix B

Amos Lake and Tributary Streams

Water Quality Data

2013

2013 Amos Lake Physical Water Quality Parameters							
Date	Time	Depth (m)	T (º C)	pH	Cond (mS/cm)	RDO (mg/l)	Turbidity (NTUs)
4/11/2013	9:34	1	10.86	8.05	95.06	12.87	1.8
4/11/2013	9:38	2	10.80	8.05	95.06	12.88	1.7
4/11/2013	9:40	3	10.75	8.05	94.87	12.87	1.8
4/11/2013	9:41	4	10.55	7.96	94.59	12.81	1.9
4/11/2013	9:42	5	9.10	7.74	91.38	12.65	1.9
4/11/2013	9:43	6	8.47	7.61	89.63	12.46	2.1
4/11/2013	9:44	7	7.93	7.48	88.37	12.03	2.3
4/11/2013	9:45	8	7.85	7.43	88.16	11.94	1.9
4/11/2013	9:46	9	7.63	7.38	87.74	11.65	2.3
4/11/2013	9:50	10	7.58	7.24	87.56	11.32	2.6
4/11/2013	9:51	11	7.49	7.19	87.51	11.26	2.8
4/11/2013	9:52	12	7.48	7.19	87.51	11.2	2.7
4/11/2013	9:53	13	7.48	7.15	87.53	11.19	2.7
5/1/2013	10:30	1	15.32	8.54	107.8	11.7	3
5/1/2013	10:32	2	14.90	8.37	106.7	11.51	2.9
5/1/2013	10:33	3	14.78	8.36	106.1	11.46	2.8
5/1/2013	10:34	4	13.62	7.98	102.7	11.37	2
5/1/2013	10:35	5	12.65	7.7	100	11.21	2.7
5/1/2013	10:37	6	11.83	7.44	97.97	10.04	2.1
5/1/2013	10:39	7	11.04	7.07	96.1	8.51	1.8
5/1/2013	10:40	8	10.55	6.97	95.03	8.04	1.7
5/1/2013	10:41	9	9.24	6.88	92.01	7.22	2.8
5/1/2013	10:42	10	8.17	6.78	89.92	6.14	4.7
5/1/2013	10:43	11	7.86	6.69	89.43	5.15	7.1
5/1/2013	10:44	12	7.75	6.62	89.52	4.02	11.4
5/1/2013	10:45	13	7.70	6.55	89.61	3.25	13.9
5/29/2013	11:02	1	18.56	7.71	117.3	9.76	3.6
5/29/2013	11:04	2	18.27	7.67	116.1	9.72	1.8

2013 Amos Lake Physical Water Quality Parameters							
Date	Time	Depth (m)	T (º C)	pH	Cond (mS/cm)	RDO (mg/l)	Turbidity (NTUs)
5/29/2013	11:05	3	17.78	7.67	115.3	9.67	2.7
5/29/2013	11:06	4	17.30	7.57	114.1	9.4	3.1
5/29/2013	11:07	5	15.38	7.32	108.6	7.89	2.1
5/29/2013	11:08	6	12.18	6.99	100.1	4.98	2.5
5/29/2013	11:09	7	10.88	6.8	97.72	3.54	1.7
5/29/2013	11:10	8	10.10	6.68	96.42	2.32	2.4
5/29/2013	11:10	9	9.49	6.62	94.95	1.45	4
5/29/2013	11:12	10	8.77	6.54	93.97	0.43	5.2
5/29/2013	11:14	11	8.44	6.51	94.72	0.05	5.8
5/29/2013	11:15	12	8.31	8.31	96.33	0	7.4
5/29/2013	11:16	13	8.15	8.15	99.01	0	6.5
6/26/2013	9:43	1	27.57	7.61	135.3	8.69	1.6
6/26/2013	9:44	2	26.83	7.48	132.6	8.85	1.3
6/26/2013	9:45	3	23.65	7.43	122	9.13	2
6/26/2013	9:45	4	19.42	7.14	114.1	7.8	2.2
6/26/2013	9:46	5	16.41	6.86	110	3.95	2.4
6/26/2013	9:47	6	14.04	6.66	105.7	0.84	1.8
6/26/2013	9:48	7	11.72	6.56	101.1	0.2	2.8
6/26/2013	9:49	8	10.66	6.5	98.7	0	3.7
6/26/2013	9:49	9	9.72	6.48	97.62	0	7.2
6/26/2013	9:50	10	9.07	6.47	101.2	0	3.5
6/26/2013	9:51	11	8.65	6.49	105.2	0	2.5
6/26/2013	9:51	12	8.54	6.59	107.4	0	3.2
6/26/2013	9:52	13	8.43	6.64	110.1	0	2.3
6/26/2013	9:53	14	8.34	6.7	113.9	0	5
6/26/2013	9:56	1D	27.48	7.45	135.6	8.87	1.9
6/26/2013	9:57	2D	26.88	7.45	132.9	8.93	1.3
6/26/2013	9:58	3D	23.10	7.37	121.5	9.17	2
6/26/2013	9:58	4D	21.34	7.18	113.5	7.95	2.6
6/26/2013	9:59	5D	16.35	6.85	110	4.61	2.7
6/26/2013	9:59	6D	13.62	6.62	104.4	1.09	2.2
6/26/2013	10:00	7D	12.06	6.5	100.2	0.32	2.2
6/26/2013	10:00	8D	10.65	6.46	98.74	0.05	2.9
6/26/2013	10:01	9D	9.89	6.44	97.59	0	7.5
6/26/2013	10:01	10D	8.96	6.45	102.3	0	2.7
6/26/2013	10:02	11D	8.67	6.49	105.3	0	1.9
6/26/2013	10:03	12D	8.54	6.57	107.7	0	3.1
6/26/2013	10:03	13D	8.42	6.65	110.4	0	4
6/26/2013	10:04	14D	8.34	6.7	114.1	0	7.4

2013 Amos Lake Physical Water Quality Parameters							
Date	**Time**	**Depth (m)**	**T (º C)**	**pH**	**Cond (mS/cm)**	**RDO (mg/l)**	**Turbidity (NTUs)**
7/24/2013	9:59	1	29.04	8.11	139.3	8.62	3.3
7/24/2013	9:59	2	28.67	7.63	137.7	7.91	4.1
7/24/2013	10:00	3	28.14	7.41	135.3	8.09	2.2
7/24/2013	10:01	4	23.32	7.13	122.8	6.02	3.2
7/24/2013	10:01	5	21.00	6.75	114.4	2.08	2.8
7/24/2013	10:02	6	14.79	6.57	107.9	0.42	11
7/24/2013	10:03	7	13.75	6.48	105.5	0.08	3.7
7/24/2013	10:03	8	11.56	6.45	102.4	0	2.2
7/24/2013	10:04	9	9.90	6.46	103.7	0	1.6
7/24/2013	10:04	10	9.34	6.5	106.1	0	1.7
7/24/2013	10:05	11	9.02	6.55	110.9	0	2.8
7/24/2013	10:05	12	8.65	6.67	115	0	2.6
7/24/2013	10:06	13	8.48	6.76	120.8	0	4.1
8/28/2013	9:38	1	24.46	8.36	124.8	8.9	5.4
8/28/2013	9:39	2	24.37	8.17	124.5	8.66	5.4
8/28/2013	9:40	3	24.14	7.59	124	7.5	3.3
8/28/2013	9:42	4	23.27	7.12	124	5.61	3.9
8/28/2013	9:42	5	20.88	6.89	117.1	2.04	1.2
8/28/2013	9:43	6	16.30	6.64	113.8	0.41	7.6
8/28/2013	9:43	7	13.50	6.55	112.9	0.09	3.8
8/28/2013	9:44	8	11.74	6.55	109.7	0	2.2
8/28/2013	9:44	9	10.25	6.56	109.4	0	1.7
8/28/2013	9:45	10	9.39	6.61	111.8	0	2.1
8/28/2013	9:45	11	9.02	6.7	117.8	0	4.3
8/28/2013	9:46	12	8.86	6.83	124.2	0	5.3
8/28/2013	9:47	13	8.52	6.88	181.4	0	8.7
8/28/2013	9:48	14	8.34	6.99	205	0	2.2
9/25/2013	9:35	1	19.24	7.19	116.2	7.94	1.3
9/25/2013	9:37	2	19.24	7.1	116.2	7.89	1.6
9/25/2013	9:38	3	19.19	7.04	116.1	7.86	1.9
9/25/2013	9:38	4	19.16	7.04	115.8	7.81	1.5
9/25/2013	9:39	5	18.98	7.01	115.9	7.45	2.3
9/25/2013	9:39	6	18.4	6.89	116	5.36	2.2
9/25/2013	9:40	7	13.17	6.57	113.8	0.74	9.2
9/25/2013	9:41	8	11.56	6.48	118.3	0.04	6.2
9/25/2013	9:41	9	10.19	6.55	117.8	0.03	2.8
9/25/2013	9:42	10	9.32	6.64	121.9	0	4.1
9/25/2013	9:43	11	8.92	6.76	128.3	0	6.3
9/25/2013	9:44	12	8.82	6.81	135.7	0	9.1

2013 Amos Lake Physical Water Quality Parameters							
Date	**Time**	**Depth (m)**	**T (º C)**	**pH**	**Cond (mS/cm)**	**RDO (mg/l)**	**Turbidity (NTUs)**
9/25/2013	9:44	13	8.58	6.88	146.4	0	9.4
10/25/2013	12:04	1	14.47	7.41	106.2	8.2	2.2
10/25/2013	12:04	2	14.47	7.19	106.2	7.98	2
10/25/2013	12:05	3	14.47	7.11	106.2	7.79	3.2
10/25/2013	12:05	4	14.43	7.04	106.2	7.65	1.9
10/25/2013	12:06	5	14.41	7.03	106.2	7.55	1.9
10/25/2013	12:06	6	14.39	6.98	106.2	7.5	2
10/25/2013	12:07	7	14.37	6.94	106.3	7.13	2.4
10/25/2013	12:07	8	13.78	6.8	108.8	5.25	6.9
10/25/2013	12:08	9	10.85	6.63	123.1	1.06	4.6
10/25/2013	12:09	10	10.0	6.7	124.2	0.11	3.7
10/25/2013	12:09	11	9.29	6.82	130.0	0	5.1
10/25/2013	12:10	12	8.8	6.93	142.5	0	6.2
10/25/2013	12:10	13	8.75	6.98	155.7	0	6.5
10/25/2013	12:11	14	8.48	7.09	321.0	0	0
10/25/2013	12:12	15	8.5	7.13	322.4	0	-0.22

Amos Lake and Tributary Stream Nutrient Data

Date	Field #	LOCATION	NH3	NOX	NO2	NO3	TN	ORG N	TKN	OrthoP	TP	CHL-A
			mg/L	mg/L	mg/L	mg/L (calc)	mg/L	mg/L (calc)	mg/L (calc)	mg/L	mg/L	ug/L
4/11/2013	AL-01	50 Lakeview	0.029	0.14	0.004	0.136	0.353	0.184	0.213	0.01	0.028	NSS
4/11/2013	AL-02	Roaring Brook	0.068	***0.53**	0.006	0.524	0.749	0.151	0.219	0.006	0.016	NSS
4/11/2013	AL-03	trib under RT 164	0.046	****0.555**	ND	0.555	0.847	0.246	0.292	0.009	0.029	NSS
4/11/2013	AL-03D	trib under RT 164	0.041	****0.572**	0.004	0.568	0.831	0.218	0.259	0.008	0.026	NSS
4/11/2013	AL-04	stream from pond on Rt 164	0.022	***0.046**	ND	0.046	0.175	0.107	0.129	0.004	0.012	NSS
4/11/2013	AL-04B	stream from pond on Rt 164	0.015	0.007	ND	0.007	0.009	ND	0.002	0.006	0.009	NSS
4/11/2013	AL-05	stream north of campgrnd	0.066	0.478	0.006	0.472	0.682	0.138	0.204	0.011	0.022	NSS
4/11/2013	AL-06	outlet	0.11	0.044	0.004	0.04	0.411	0.257	0.367	0.013	0.029	NSS
4/11/2013	AL-07 SURF	Amos Lake	0.171	0.055	0.005	0.05	0.428	0.202	0.373	0.013	0.028	58.1
4/11/2013	AL-07 THERM	Amos Lake	0.074	0.084	0.004	0.08	0.393	0.235	0.309	0.011	0.025	NSS
4/11/2013	AL-07 BOT	Amos Lake	0.091	0.087	0.004	0.083	0.405	0.227	0.318	0.009	0.027	NSS
5/1/2013	AL-01	50 Lakeview	0.009	0.179	0.004	0.175	0.393	0.205	0.214	0.012	0.051	NSS
5/1/2013	AL-02	Roaring Brook	0.014	0.423	0.006	0.417	0.7	0.263	0.277	0.009	0.016	NSS
5/1/2013	AL-03	trib under RT 164	0.014	0.847	0.005	0.842	1.014	0.153	0.167	0.008	0.029	NSS
5/1/2013	AL-3D	trib under RT 164	0.018	0.786	0.003	0.783	0.979	0.175	0.193	0.008	0.025	NSS
5/1/2013	AL-04	stream from pond on Rt 164	0.016	0.123	0.003	0.12	0.208	0.069	0.085	0.006	0.018	NSS
5/1/2013	AL-04B	stream from pond on Rt 164	0.022	ND	0.003	ND	ND	0	0.022	0.004	0.006	NSS
5/1/2013	AL-05	stream north of campgrnd	0.013	0.331	0.004	0.327	0.471	0.127	0.14	0.007	0.021	NSS
5/1/2013	AL-06	outlet	0.016	ND	0.004	ND	0.335	0.319	0.335	0.009	0.028	NSS
5/1/2013	AL-07 1M	Amos Lake	0.016	ND	0.004	ND	0.467	0.451	0.467	0.014	0.033	59.2
5/1/2013	AL-07 7M	Amos Lake	0.015	0.03	ND	0.03	0.296	0.251	0.266	0.011	0.023	NSS
5/1/2013	AL-07 13M	Amos Lake	0.388	0.046	0.004	0.042	0.471	0.037	0.425	0.01	0.04	NSS
5/29/2013	AL-01	50 Lakeview	0.009	0.295	ND	0.295	0.544	0.24	0.249	0.017	0.069	*ND
5/29/2013	AL-02	Roaring Brook	0.061	0.279	0.005	0.274	0.622	0.282	0.343	0.005	0.007	*ND
5/29/2013	AL-03	trib under RT 164	0.037	**1.038**	0.006	1.032	1.219	0.144	0.181	0.01	0.031	*ND
5/29/2013	AL-04	stream from pond on Rt 164	0.032	0.054	ND	0.054	0.135	0.049	0.081	0.003	0.013	*ND
5/29/2013	AL-05	stream north of campgrnd	0.018	0.209	0.004	0.205	0.509	0.282	0.300	0.007	0.018	*ND
5/29/2013	AL-05	stream north of campgrnd	0.022	0.223	0.003	0.220	0.530	0.285	0.307	0.009	0.018	*ND
5/29/2013	AL-06	outlet	ND	ND	ND	ND	0.473	0.47	0.473	0.013	0.025	*ND
5/29/2013	AL-07 - 1M	Amos Lake	ND	0.004	ND	0.004	0.475	0.471	0.471	0.011	0.024	6.2
5/29/2013	AL-07 - 1MD	Amos Lake	NSS	NSS	NSS	NSS	NSS	NSS	NSS	NSS	NSS	10
5/29/2013	AL-07 - 6M	Amos Lake	0.036	0.042	ND	0.042	0.329	0.251	0.287	0.006	0.012	*ND
5/29/2013	AL-07 - 12M	Amos Lake	**0.632**	0.007	ND	0.007	0.69	0.051	0.683	0.005	0.018	*ND
6/26/2013	AL-02	Roaring Brook	0.009	0.095	0.003	0.092	0.418	0.314	0.323	0.004	0.012	NSS
6/26/2013	AL-03	trib under RT 164	0.019	0.904	0.004	0.9	1.17	0.247	0.266	0.017	0.056	NSS
6/26/2013	AL-04	stream from pond on Rt 164	0.017	0.022	ND	0.022	0.222	0.183	0.2	0.003	0.019	NSS
6/26/2013	AL-05	stream north of campgrnd	0.046	0.277	0.009	0.268	0.635	0.312	0.358	0.012	0.049	NSS
6/26/2013	AL-05B	stream north of campgrnd	0.012	ND	ND	ND	0.019	0.007	0.019	0.002	0.002	NSS
6/26/2013	AL-06	outlet	0.012	ND	ND	ND	0.426	0.414	0.426	0.007	0.02	NSS
6/26/2013	AL-06D	outlet	0.011	ND	ND	ND	0.436	0.425	0.436	0.008	0.02	NSS
6/26/2013	AL-07 - 1M	Amos Lake	0.011	0.003	ND	0.003	0.419	0.405	0.416	0.009	0.023	4.4
6/26/2013	AL-07 - 5M	Amos Lake	0.059	0.01	ND	0.01	0.497	0.428	0.487	0.009	0.03	NSS
6/26/2013	AL-07 - 13M	Amos Lake	0.865	ND	ND	ND	0.893	0.028	0.893	0.002	0.024	NSS
7/24/2013	AL-01	50 Lakeview	0.009	0.222	ND	0.222	0.477	0.246	0.255	0.020	0.042	NSS
7/24/2013	AL-02	Roaring Brook	0.007	0.016	ND	0.016	0.343	0.320	0.327	0.009	0.019	NSS
7/24/2013	AL-03	trib under RT 164	0.026	0.420	0.007	0.413	0.912	0.466	0.492	0.048	0.110	NSS
7/24/2013	AL-04	stream from pond on Rt 164	0.036	0.036	ND	0.036	0.145	0.073	0.109	0.002	0.032	NSS
7/24/2013	AL-04D	stream from pond on Rt 164	0.036	0.035	ND	0.035	0.160	0.089	0.125	0.006	0.034	NSS
7/24/2013	AL-05	stream north of campgrnd	0.045	0.337	0.007	0.330	0.688	0.306	0.351	0.014	0.099	NSS
7/24/2013	AL-06	outlet	0.004	ND	ND	ND	0.446	0.442	0.446	0.010	0.021	NSS
7/24/2013	AL-07-1M	Amos Lake	0.005	ND	0.010	ND	0.444	0.439	0.444	0.015	0.029	18.7
7/24/2013	AL-07-5M	Amos Lake	0.010	0.012	ND	0.012	0.355	0.333	0.343	0.012	0.031	NSS
7/24/2013	AL-07-5M-B	Amos Lake	0.011	ND	ND	ND	0.016	0.005	0.016	0.001	0.002	NSS
7/24/2013	AL-07-12.5M	Amos Lake	**1.160**	0.008	ND	0.008	1.064	ND	1.056	ND	0.074	NSS
8/28/2013	AL-01	50 Lakeview	0.009	0.144	ND	0.144	0.332	0.179	0.188	0.017	0.033	NSS
8/28/2013	AL-02	Roaring Brook	0.006	ND	ND	ND	0.184	0.178	0.184	0.007	0.011	NSS
8/28/2013	AL-02B	Roaring Brook	0.014	ND	ND	ND	ND	ND	0.014	0.003	0.004	NSS
8/28/2013	AL-03	trib under RT 164	0.019	0.241	0.004	0.237	0.736	0.476	0.495	0.033	0.061	NSS
8/28/2013	AL-04	stream from pond on Rt 164	0.049	0.018	ND	0.018	0.112	0.045	0.094	0.001	0.057	NSS
8/28/2013	AL-05	stream north of campgrnd	0.017	0.146	ND	0.146	0.435	0.272	0.289	0.015	0.026	NSS
8/28/2013	AL-06	outlet	0.009	ND	ND	ND	0.607	0.598	0.607	0.009	0.02	NSS
8/28/2013	AL-07-1M	Amos Lake	0.01	ND	ND	ND	0.558	0.548	0.558	0.016	0.024	21
8/28/2013	AL-07-1M-D	Amos Lake	0.011	ND	ND	ND	0.605	0.594	0.605	0.016	0.022	27
8/28/2013	AL-07-5M	Amos Lake	0.006	ND	ND	ND	0.459	0.453	0.459	0.017	0.036	NSS
8/28/2013	AL-07-12.5M	Amos Lake	1.687	ND	ND	ND	1.578		1.687	0.005	0.215	NSS

Amos Lake and Tributary Stream Nutrient Data

Date	Field #	LOCATION	NH3 mg/L	NOX mg/L	NO2 mg/L	NO3 mg/L (calc)	TN mg/L	ORG N mg/L (calc)	TKN mg/L (calc)	OrthoP mg/L	TP mg/L	CHL-A ug/L
9/25/2013	AL-02	Roaring Brook	ND	*0.0003*	ND	0.003	0.216	0.213	0.213	*0.002*	0.011	NSS
9/25/2013	AL-03	trib under RT 164	0.034	**2.02**	0.005	2.015	1.895	ND	ND	*0.007*	0.022	NSS
9/25/2013	AL-04	stream from pond on Rt 164	0.045	*0.004*	ND	0.004	0.113	0.064	0.109	*0.003*	0.022	NSS
9/25/2013	AL-04-D	stream from pond on Rt 164	0.045	*0.004*	ND	0.004	0.122	0.073	0.118	*0.003*	0.022	NSS
9/25/2013	AL-05	stream north of campgrnd	0.037	0.032	ND	0.032	0.471	0.402	0.439	*0.008*	0.02	NSS
9/25/2013	AL-06	outlet	*0.009*	*0.003*	ND	0.003	0.313	0.301	0.31	*0.006*	0.02	NSS
9/25/2013	AL-06-B	outlet	0.021	*0.004*	ND	0.004	0.056	0.031	0.052	*0.001*	*0.004*	NSS
9/25/2013	AL-07-1M	Amos Lake	ND	ND	ND	ND	0.321	0.321	0.321	*0.006*	0.021	5.2
9/25/2013	AL-07-7M	Amos Lake	0.151	ND	ND	ND	0.257	0.106	0.257	*0.006*	0.028	NSS
9/25/2013	AL-07-13M	Amos Lake	**2.89**	ND	*0.004*	ND	**2.068**	ND	2.068	0.011	0.388	NSS
10/23/2013	AL-01	50 Lakeview				no sample dry						
10/23/2013	AL-01-B	50 Lakeview	ND	ND	ND	ND	0.008	0.008	0.008	ND	ND	NSS
10/23/2013	AL-02	Roaring Brook	*0.01*	ND	0.005	ND	0.285	0.275	0.285	*0.003*	*0.009*	NSS
10/23/2013	AL-03	trib under RT 164	0.017	1.22	*0.01*	1.21	1.264	0.027	0.044	*0.007*	0.037	NSS
10/23/2013	AL-04	stream from pond on Rt 164	0.033	ND	ND	ND	0.131	0.098	0.131	ND	0.019	NSS
10/23/2013	AL-04-D	stream from pond on Rt 164	0.033	*0.004*	*0.004*	ND	0.191	0.154	0.187	ND	0.021	NSS
10/23/2013	AL-05	stream north of campgrnd				NO FLOW						
10/23/2013	AL-06	outlet	*0.008*	*0.003*	ND	ND	0.421	0.41	0.418	0.011	0.031	NSS
10/25/2013	AL-07-1M	Amos Lake	0.019	*0.003*	ND	0.003	0.271	0.249	0.268	*0.008*	0.018	7.1
10/25/2013	AL-07-8M	Amos Lake	0.104	0.005	ND	0.005	0.23	0.121	0.225	*ND*	0.018	NSS
10/25/2013	AL-07-8M-B	Amos Lake	0.011	ND	*0.004*	ND	ND	ND	ND	ND	ND	NSS
10/25/2013	AL-07-13M	Amos Lake	2.92	ND	*0.005*	ND	2.009	ND	2.009	*0.013*	0.45	NSS
10/25/2013	AL-07-13M-D	Amos Lake	2.92	ND	*0.007*	ND	1.894	ND	1.894	0.015	0.449	NSS
11/1/2013	AL-03 -PS	trib under RT 164 -passive sampler	0.471	0.864	*0.01*	0.854	1.515	0.18	0.651	0.025	5.93	NSS
11/1/2013	AL-03	trib under RT 164 -post-storm grab	ND	1.18	*0.007*	1.173	1.116	ND	ND	*0.009*	0.027	NSS
11/1/2013	AL-01 - PS	passive sampler at Monahan's	0.049	0.121	0.053	0.068	1.603	1.433	1.482	0.297	0.89	NSS
11/1/2013	AL-PS-57	passive sampler near 57 Lakeview	0.035	0.013	0.019	ND	1.292	1.244	1.279	1.11	1.58	NSS
11/1/2013	AL-PS-76	passive sampler near 76 Lakeview	0.04	*0.007*	0.018	ND	1.404	1.357	1.397	1.31	1.665	NSS
11/17/2013	AL-03	trib under RT 164 -pre-storm grab	0.028	**1.77**	*0.006*	1.764	1.763	ND	ND	*0.005*	0.024	
11/18/2013	AL-03 -PS	trib under RT 164 -passive sampler	0.11	**0.74**	*0.006*	0.734	0.988	0.138	0.248	0.019	0.148	
11/18/2013	AL-03	trib under RT 164 -post-storm grab	0.012	**0.774**	0.012	0.762	1.131	0.345	0.357	0.029	0.09	
11/18/2013	AL-01 - PS	passive sampler at Monahan's	0.007	0.183	0.012	0.171	1.259	1.069	1.076	0.147	0.327	
11/18/2013	AL-PS-57	passive sampler near 57 Lakeview	0.007	*0.003*	*0.005*	-0.002	0.437	0.427	0.434	0.174	0.247	
11/18/2013	AL-PS-76	passive sampler near 76 Lakeview	0.017	*0.004*	*0.009*	-0.005	1.023	1.002	1.019	0.248	**0.638**	
11/26/2013	AL-03	trib under RT 164 -pre-storm grab	0.034	**1.75**	*0.005*	1.745	1.678	ND	ND	*0.007*	0.025	
11/27/2013	AL-03 -PS	trib under RT 164 -passive sampler	0.096	**1.04**	*0.004*	1.036	1.17	0.034	0.13	0.016	0.142	
11/27/2013	AL-03	trib under RT 164 -post-storm grab	0.027	0.343	0.012	0.331	0.802	0.432	0.459	0.055	0.127	
11/27/2013	AL-01 - PS	passive sampler at Monahan's	0.032	0.311	0.017	0.294	0.893	0.55	0.582	0.054	**0.98**	
11/27/2013	AL-01	Monahan's - post-storm grab	*0.006*	0.29	*0.007*	0.283	0.631	0.335	0.341	0.04	0.09	
11/27/2013	AL-PS-57	passive sampler near 57 Lakeview	ND	0.038	*0.006*	0.032	0.301	0.263	0.263	0.091	0.135	
11/27/2013	AL-PS-76	passive sampler near 76 Lakeview	0.011	0.392	0.014	0.378	0.929	0.526	0.537	0.132	0.207	

Bold = Diluted; *Italics* = between MDL and PQL and are to be used for reference only; ND = not detected; NSS = no sample sent

* 2x dilution; ** 5x dilution; D = Duplicate sample; B= Blank

Appendix C

Phytoplankton Analysis

Northeast Laboratories, Inc.

ANALYTICAL REPORT

Report To: **EASTERN CONNECTICUT CONSERVATION DIST.**
Attn: Jean Pillo
& Kate Jackson
218 Day Rd – PO BOX 11
Pomfret Center CT 06259-0011

EMAIL ADDRESS: jean.pillo@conserveCT.org
& kate.johnson.eccd@comcast.net

Report Date:	**7/29/2013**	**Date Sampled:**	**7/24/2013 10:10**
Laboratory ID#:	**N1356830 – 01**	**Date Received:**	**7/24/2013 16:38**
		Date Tested:	**7/26/2013**

Sample Site: AMOS LAKE, PRESTON CT

MICROSCOPIC EXAMINATION

ORGANISM	#/ml	ORGANISM	#/ml	ORGANISM	#/ml	ORGANISM	#/ml
Diatomaceae		**Chlorophyceae**		**Cyanophyceae**		**Protozoa**	
Amphora		Actinastrum		Anabaena*	680	Actinophrys	
Asterionella*		Arthrodesmus		Anabaenopsis		Amoeba	
Amphiprora		Ankistrodesmus		Aphanocapsa		Arcella	
Cocinodiscus		Chorella		Aphanizomenon*		Bursaria*	
Cyclotella*		Closterium		Aphanothece		Ceratium	
Cymbella		Coelastrum		Aulosira		Cercomonas	
Diatoma*		Cosmarium		Arthrospira		Chilomonas	
Frustulia		Dictyosphaerium*		Chroococcus		Chlamydomonas	80
Fragilaria		Eudorina*		Clathrocystis*		Codonella	
Gyrosigma		Elakatothrix		Coelosphaerium*		Cryptomonas*	
Gomphonema		Gleocystis		Cylindrospermum		Difflugia	
Melosira		Micrasterias		Cuspidothrix		Dinobryon*	
Meridion*		Mougeotia		Dactylococcopsis		Euglena	
Navicula		Pandorina*		Eucapsis		Glenodinium*	
Nitzschia		Pediastrum		Gleocapsa		Gonium	
Pleurosigma		Protococcus		Galucocystis		Halteria	
Stephanodiscus		Quadrigula		Gloeothece		Mallomonas*	
Stephanodiscus		Scenedesmus	80	Gomphosphaeria		Monas	
Surirella		Sphaerocystis		Hydrocoleum		Peridinium*	40
Synedra	120	Sphaerozosma		Microcystis	100	Synura*	
Tabellaria*	40	Spirogyra		Merismopedia		Trachelomonas	
		Staurastrum	200	Nostoc		Uroglenopsis*	
		Tetraspora		Nodularia		Vorticella	
Rotifera		Westella		Oscillaria			
Anuraea		Ulothrix		Pseudanabaena			
Asplanchna		Volvox*		Spirulina			
Brachionus		Xanthidium		Rivularia*			
Conochilus		Zygnema		Xenococcus		**Schizomycetes**	
Euchlanis						Crenothrix	
Keratella							
Notholca		Xenococcus		**Miscellaneous**			
Polyarthra				Acarina			
Rotifer				Anguillula			
Synchaeta				Bosmina			
				Canthocamptus		* Odor Producing	
				Cyclops			
				Daphnia			
				Diaptomus			

Conclusions:

Total: 1300 per mL

Comments: Results are based on sample, as submitted to Northeast Laboratories, Inc. on: 7/18/2013

Approved by: Alan C. [signature]

Laboratory Director

Northeast Laboratories, Inc.

ANALYTICAL REPORT

Report To: EASTERN CONNECTICUT CONSERVATION DIST.
Attn: Jean Pillo
& Kate Jackson
218 Day Rd – PO BOX 11
Pomfret Center CT 06259-0011

EMAIL ADDRESS: jean.pillo@conserveCT.org
& kate.johnson.eccd@comcast.net

Report Date:	8/30/2013	**Date Sampled:**	8/28/2013 09:55
Laboratory ID#:	N1357170 – 01	**Date Received:**	8/28/2013 14:20
		Date Tested:	8/29/2013

Sample Site: AMOS LAKE, PRESTON CT = PO #: ECCD-02

MICROSCOPIC EXAMINATION

ORGANISM	#/ml	ORGANISM	#/ml	ORGANISM	#/ml	ORGANISM	#/ml
Diatomaceae		**Chlorophyceae**		**Cyanophyceae**		**Protozoa**	
Amphora		Actinastrum		Anabaena*	80	Actinophrys	
Asterionella*		Arthrodesmus		Anabaenopsis		Amoeba	
Amphiprora		Ankistrodesmus		Aphanocapsa		Arcella	
Cocinodiscus		Chorella		Aphanizomenon*		Bursaria*	
Cyclotella*		Closterium		Aphanothece		Ceratium	
Cymbella		Coelastrum		Aulosira		Cercomonas	
Diatoma*	160	Cosmarium		Arthrospira		Chilomonas	
Frustulia		Dictyosphaerium*		Chroococcus		Chlamydomonas	20
Fragilaria		Eudorina*		Clathrocystis*		Codonella	
Gyrosigma		Elakatothrix		Coelosphaerium*		Cryptomonas*	
Gomphonema		Gleocystis		Cylindrospermum		Difflugia	
Melosira		Micrasterias		Cuspidothrix		Dinobryon*	
Meridion*		Mougeotia		Dactylococcopsis		Euglena	
Navicula		Pandorina*		Eucapsis		Glenodinium*	
Nitzschia		Pediastrum		Gleocapsa		Gonium	
Pleurosigma		Protococcus		Galucocystis		Halteria	
Stephanodiscus		Quadrigula		Gloeothece		Mallomonas*	120
Stephanodiscus		Scenedesmus	180	Gomphosphaeria		Monas	
Surirella		Sphaerocystis		Hydrocoleum		Peridinium*	
Synedra		Sphaerozosma		Microcystis		Synura*	
Tabellaria*	120	Spirogyra		Merismopedia		Trachelomonas	
		Staurastrum	80	Nostoc		Uroglenopsis*	
		Tetraspora		Nodularia	1100	Vorticella	
Rotifera		Westella		Oscillaria			
Anuraea		Ulothrix		Pseudanabaena	80		
Asplanchna		Volvox*		Spirulina			
Brachionus		Xanthidium		Rivularia*			
Conochilus		Zygnema		Xenococcus		**Schizomycetes**	
Euchlanis						Crenothrix	
Keratella							
Notholca		Xenococcus		**Miscellaneous**			
Polyarthra				Acarina			
Rotifer				Anguillula			
Synchaeta				Bosmina			
				Canthocamptus		* Odor Producing	
				Cyclops			
				Daphnia			
				Diaptomus	20		

Conclusions:

Total: 1900 per mL

Comments: Results are based on sample, as submitted to Northeast Laboratories, Inc. on: 8/28/2013

Approved by: [signature]

Laboratory Director

Appendix D

2013 Amos Lake and Watershed Monitoring Data Analysis,

Northeast Aquatic Research, LLC.

Amos Lake
Analysis of 2013 Lake and Watershed Monitoring Data

Prepared For:

Eastern Connecticut Conservation District
Brooklyn, CT

Prepared By:

George W. Knoecklein
Northeast Aquatic Research, LLC
Mansfield, CT

December 12, 2014

LAKE ASPECTS

1: Morphometric details

1.1 Amos Lake has a surface area of 115 acres and a watershed area of 920 acres.

1.2 The lake has mean and maximum depths of 18.8 feet and 45.8 feet respectively.

1.3 Amos Lake water volume is estimated to be 2,160 acre-feet or 951 thousand cubic meters.

1.4 Amos Lake has a theoretical retention time of 1.2 years, and a flushing rate of 0.84 times per year.

1.5 The lake has a large littoral zone of approximately 46 acres or 40% of the lake surface area (using 10 feet as the depth to which rooted aquatic plants will grow--however this was not investigated).

1.6 The lake surface area between shore and 6 feet of water depth—habitat for floating-leaved plants—is large at 37 acres or about 33% of the total surface area of the lake.

Table 1 - Morphometric characteristics for Amos Lake

Parameter	English Units		Metric Units	
Lake Surface Area =	115	acres	465,389	m^2
Littoral Area =	46	acres	157,828	m^2
Profundal Area (< 10 ft.)	69	acres	307,561	m^2
Watershed Area (Total)	920	acres	3,723,111	m^2
Lake/Watershed Area	11.1	%		
Lake Volume	2,160	acre-ft.	951,625	m^3
Mean Depth	18.8	feet	5.7	m
Maximum Depth	45.8	feet	14.0	m
Mean Depth/Maximum Depth	0.410	Ratio		
Estimated Residence Time	1.194 436	Years Days		
Estimated Flushing Rate	0.84	times / year		

DEPTH	SURFACE AREA			
	Cumulative From Bottom		Of Each Stratum	
(feet)	*(acres)*	*(percent)*	*(acres)*	*(percent)*
0	115	100	37	33
6	76	67	10	9
12	66	59	11	10
18	55	48	11	9
24	44	39	9	8
30	35	31	12	11
36	23	20	14	13
42	9	8	9	8
45	0.04	0.03	0.04	0.03

DEPTH	VOLUME			
	Cumulative From Bottom		Of Each Stratum	
(feet)	*(acre- feet)*	*(percent)*	*(acre- feet)*	*(percent)*
0	2,160	100	563	26
6	1,597	74	426	20
12	1,171	54	362	17
18	809	37	296	14
24	513	24	238	11
30	275	13	173	8
36	101	5	92	4
42	9	0.4	9	0.4
45	0.03	0.002	0.03	0.002

<u>2: Thermal Structure</u>

2.1 Water temperature of Amos Lake during 2013 is shown in the following four graphs.

2.2 Figure 1 gives surface and bottom water temperature trends during 2013 season. Surface water increased from low of 10 ^{o}C in April to maximum of 29 ^{o}C in July, while bottom water temperature—about 13 meters—remained constant between 8 and 9 ^{o}C between April and October.

2.4 Figure 2 shows water temperature with depth at time of each profile reading, and Figure 3 shows Resistance to Thermal Mixing (RTM) values associated with water temperatures measured during profile readings. Figures show Amos Lake stratified between 4 and 7 meters during summer 2013. Water column profiles (Figure 2) show that most water temperature changes occurred above 6 meters, with little to no seasonal changes below about 10 meters. Thermal resistance values (Figure 3) show highest thermal resistance values were between 100 and 150 RTM during June, July, and August. Other months had either weak or no thermal resistance.

2.5 Figure 4 shows approximate position of the thermocline—depth of highest RTM values--in Amos Lake during 2013. Graph shows thermocline between 5 and 6 meters in spring, then gradually deepening during September and October.

Figure 1 - 2013 Amos Lake water temperature trends at surface (1 meter) and bottom (13 meters) depths

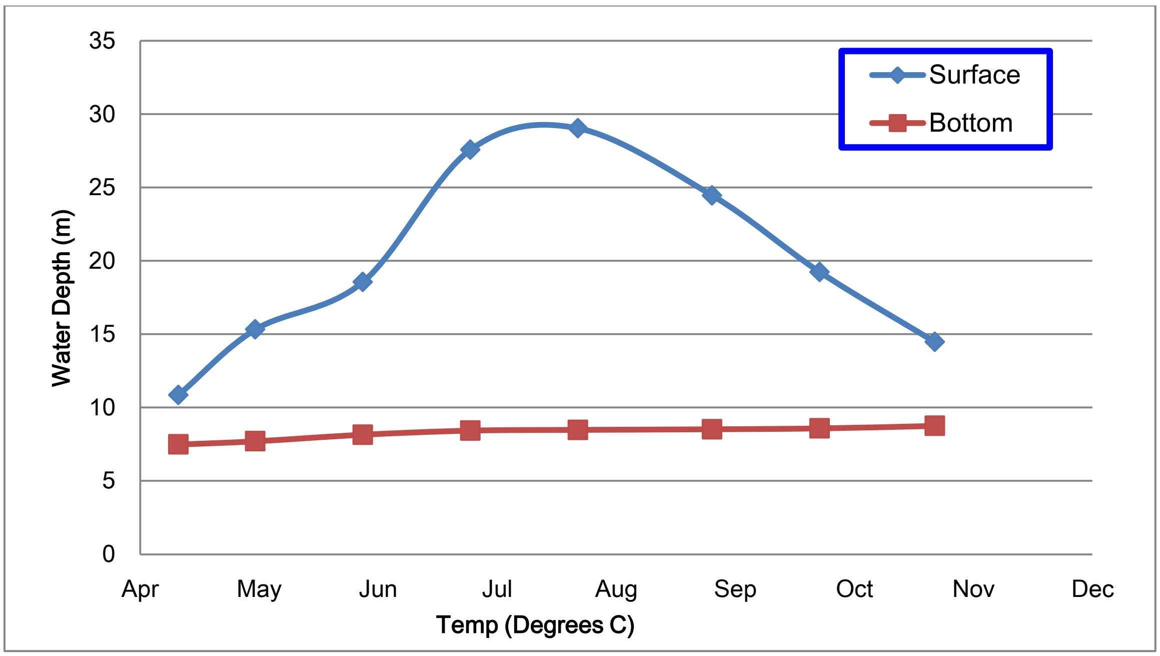


Figure 2 – 2013 Amos Lake water temperature profiles

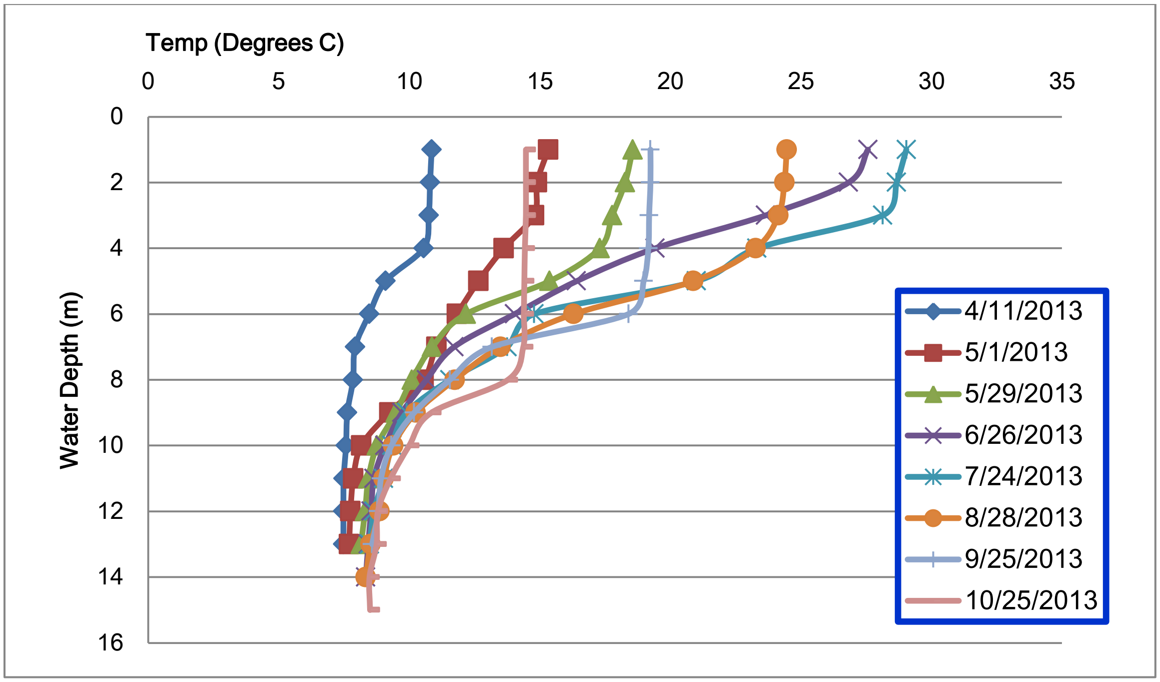


Figure 3 – Relative Thermal Resistance to Mixing (RTRM) values in Amos Lake during 2013 season

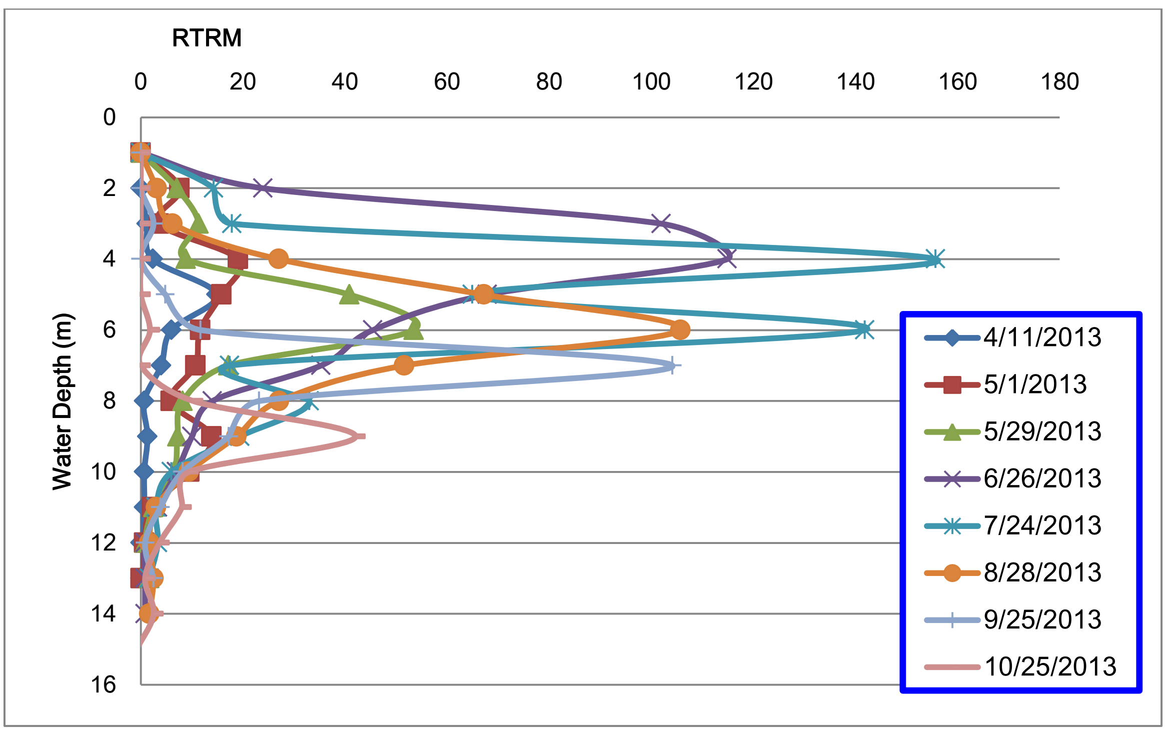
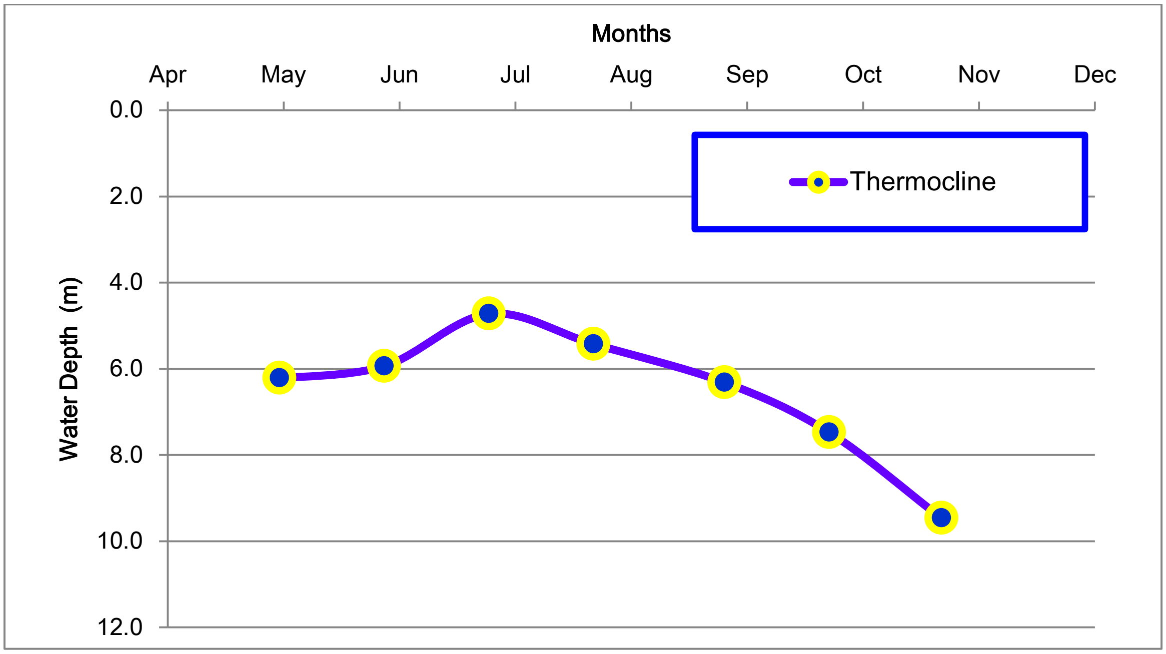


Figure 4 – Thermocline depth in Amos Lake during 2013



3: Dissolved Oxygen

3.1 Aspects of dissolved oxygen in Amos Lake during 2013 are shown in the following 4 graphs.

3.2 Figure 5 shows dissolved oxygen concentration at surface and bottom depths in Amos Lake during 2013. Surface concentration of dissolved oxygen declined after April as water temperature increased. Warmer water lowers the saturation of dissolved oxygen in water. Bottom water becomes devoid of dissolved oxygen immediately in May, with bottom water remaining devoid of dissolved oxygen during the remaining sampling dates.

3.3 Figure 6 shows dissolved oxygen profiles in Amos Lake during 2013.

3.4 Figure 7 shows position of the anoxic boundary--1 mg/L dissolved oxygen—during 2013 season. Anoxic boundary rapidly ascends to 6 meters during May and June where the boundary remained until mixing in September and October.

3.5 Anoxic boundary, shown in Figure 8, meets the thermocline in July and remains at thermocline depth for remainder of the season.

3.6 The lake was not completely mixed at time of last sampling visit. Anoxic boundary was located at 9 meters in October indicating that fully mixed and oxygenated conditions were not documented.

Figure 5 –Surface and bottom dissolved oxygen concentrations in Amos Lake during 2013

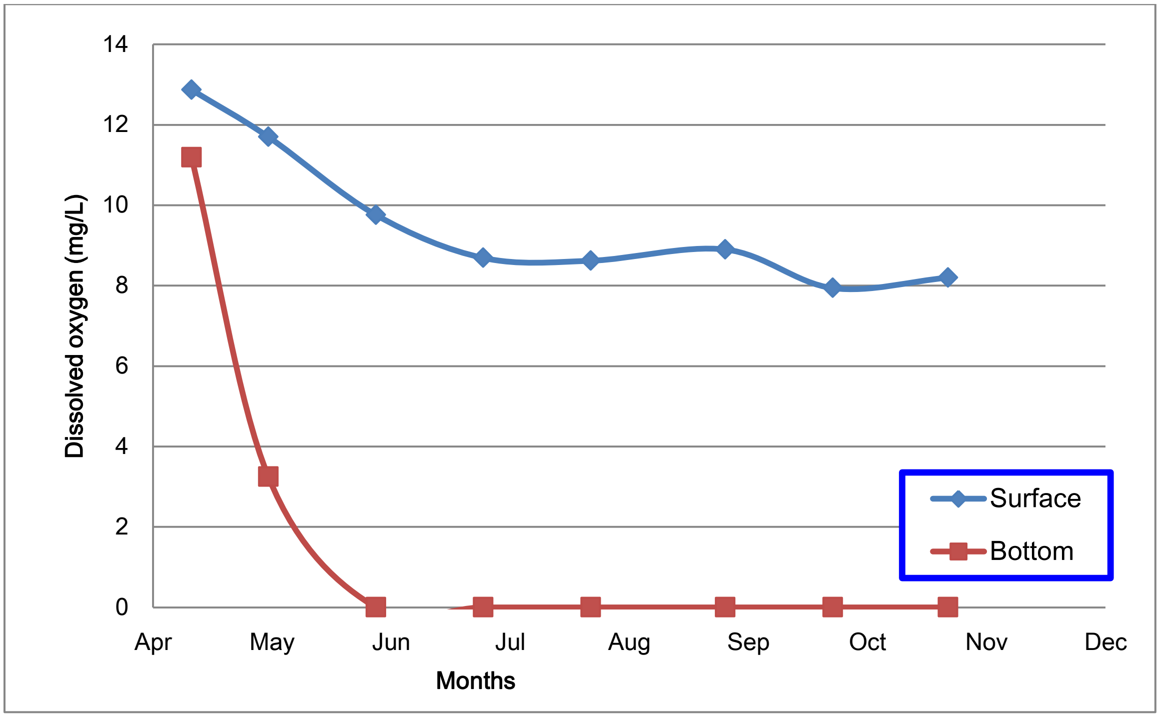


Figure 6 – Dissolved oxygen profiles from Amos Lake during 2013

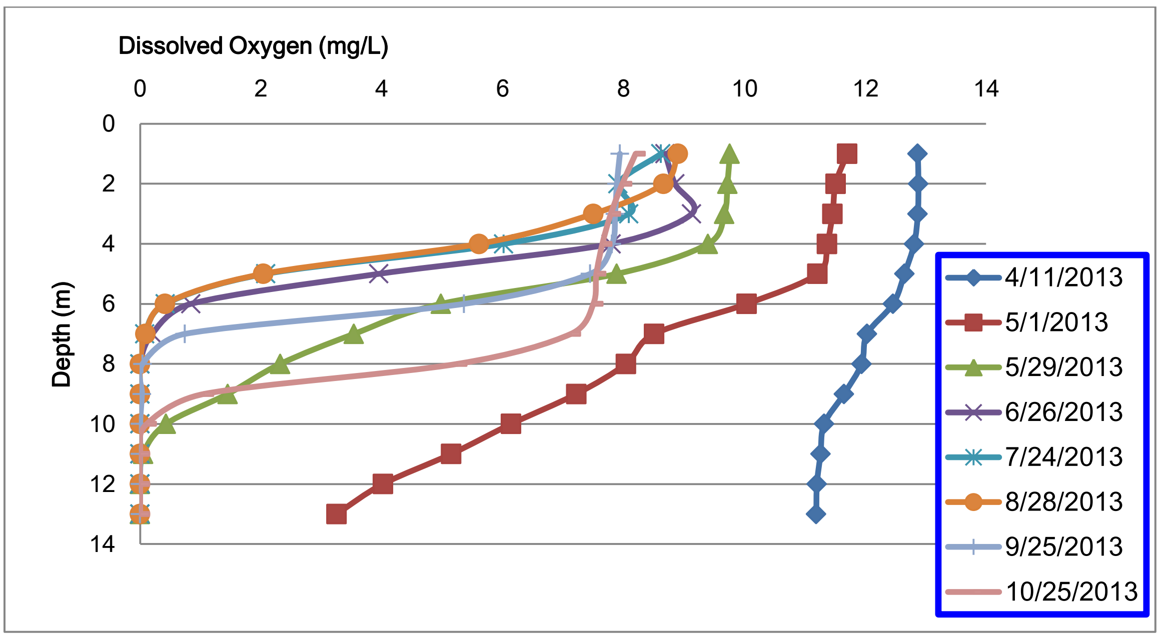


Figure 7 – Trend of anoxic boundary in Amos Lake during 2013

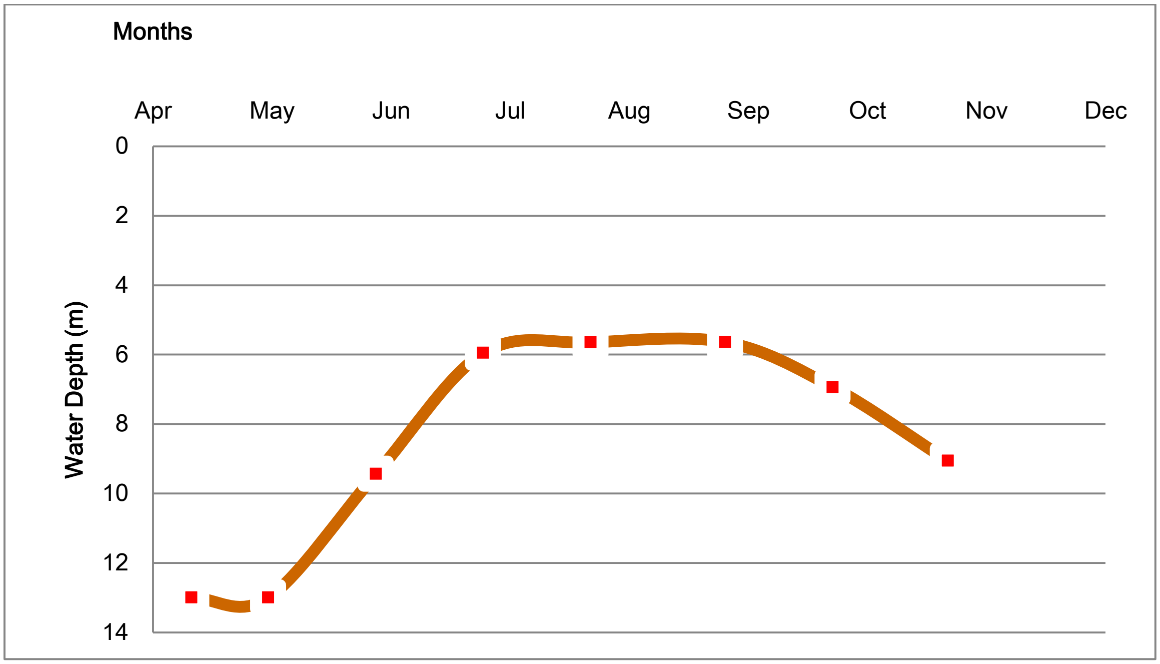
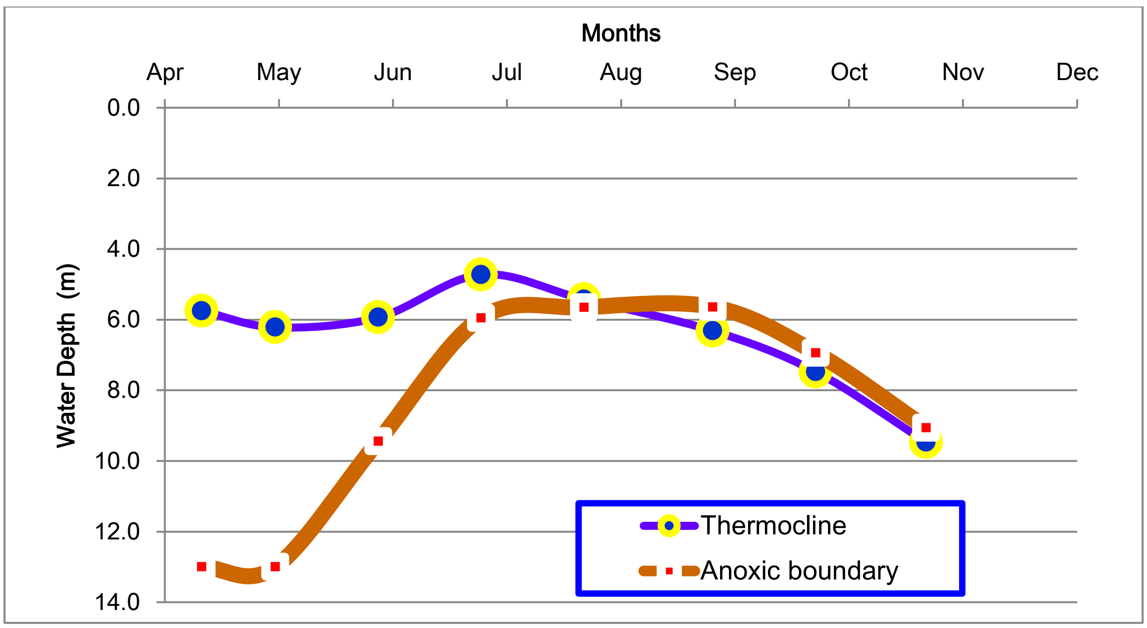


Figure 8 – Anoxic boundary and thermocline in Amos Lake during 2013



4: Water Clarity

4.1 Water clarity in 2013—Figure 9—varied between a low of 1.7 meters (August) and a high of 3 meters (June).

4.2 Water clarity was poor—less than 2 meters in April and May.

4.3 Water clarity was good—3 meters--briefly in June.

4.4 Figure 10 shows chlorophyll-*a* and water clarity trends in Amos Lake during 2013, read separately on both vertical axis. Chlorophyll-*a* tended to mimic the changes in clarity except during spring months of April and May when chlorophyll-*a* was significantly higher than water clarity, suggesting non-alga turbidity at that time.

4.5 Chlorophyll-*a* values in June, July, August and September suggest that changes in water clarity during those months were due to phytoplankton abundance. October had poor clarity while chlorophyll-*a* was also low suggesting non-algae turbidity.

4.7 Anoxic boundary and thermocline positions in summer may have influenced changes in clarity at that time. Improved water clarity in fall may have been due to increased mixing depth.

Figure 9 – Water clarity (Secchi disk depth) trend in Amos Lake during 2013

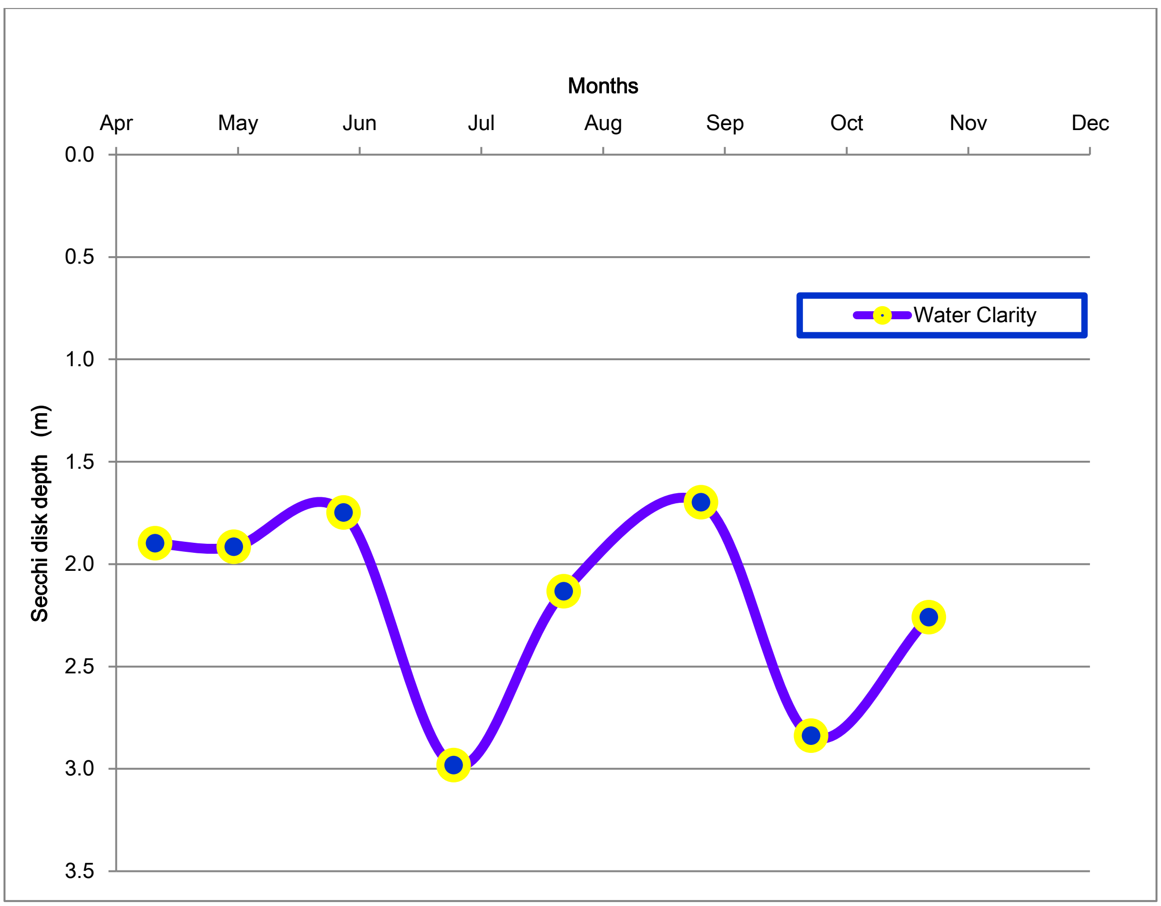


Figure 10 – Chlorophyll a and water clarity (Secchi disk depth) trends in Amos Lake during 2013

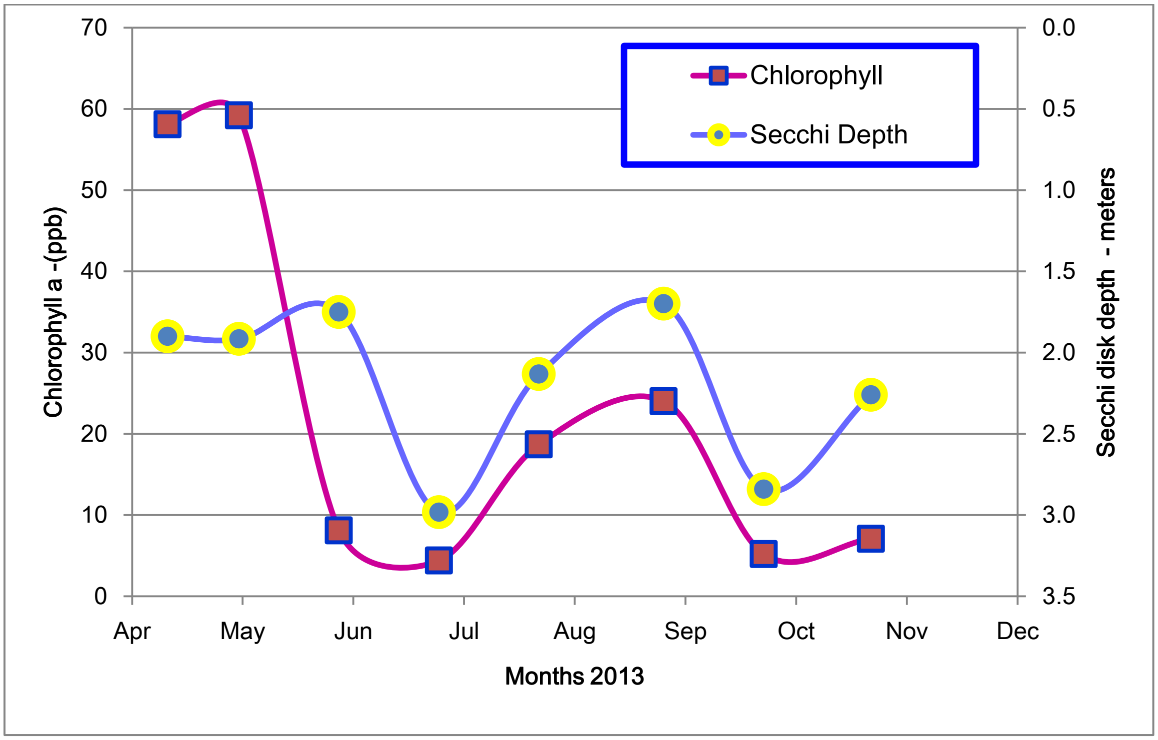
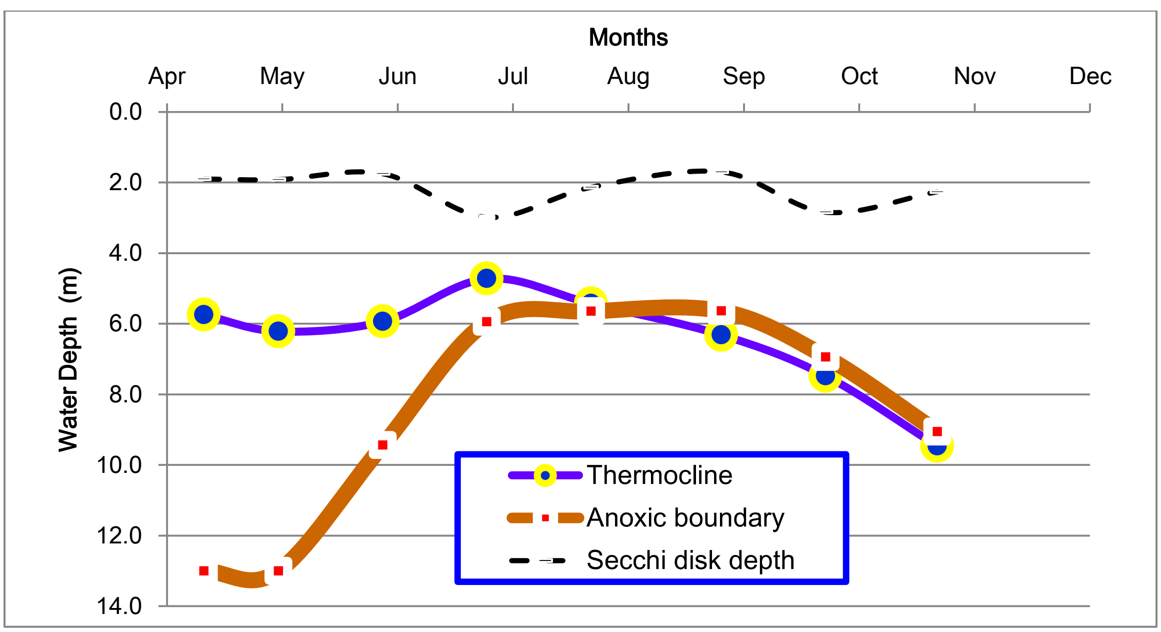


Figure 11 – Interaction between water clarity, anoxic boundary and thermocline depths in Amos Lake during 2013



5: Phosphorus Results

5.1 Total phosphorus concentrations (Figure 12) in top and middle depths (1 meter and between 5 and 7 meters) varied between a low of 12 ppb and a high of 36 ppb.

5.2 Phosphorus at the surface varied between 18 ppb and 25 ppb.

5.3 Surface phosphorus appeared to be highest in spring and again in July, with slight decreases during the season, lowest value occurred in October.

5.4 Middle depth phosphorus was often the same as concentrations at the top but showed slightly higher values in August and September and slightly lower values in May.

5.5 Bottom phosphorus concentrations (Figure 13) increased dramatically in July, August, and September.

5.6 Bottom phosphorus was still increasing in October, reaching highest concentration--450 ppb—on that date. No samples were collected after that date.

5.7 Ortho phosphorus concentrations (Figure 14) at all depths ranged from non-detectable to 17 ppb.

5.8 Ortho phosphorus at bottom depth was 8-9 ppb in early spring, decreased to non-detectable levels in July followed by an increase to 14 ppb in October. The lack of increase in ortho phosphorus in bottom water during the summer suggests that total phosphorus increases noted in Figure 13 and again in Figure 15 was not as dissolved phosphorus.

5.9 Phosphorus mass (Figure 16) was calculated by multiplying concentration by the water volume of the representative water layer.

5.10 Total mass of phosphorus in Amos Lake varied between lows of 50-70 kg P in the spring and 260 kg P in October.

5.11 Bottom water showed the largest change in P mass, going from lows of 2-14 kg in April-June to 222 kg in October.

5.12 Top and middle P mass were similar during the season. Changes in P mass in each were slight compared to bottom water changes.

5.13 Changes in phosphorus mass (Figure 17) suggest that increases in bottom phosphorus were not transferred to either middle of surface depths. So although there was a large build-up of phosphorus at the bottom during the summer, that phosphorus was not responsible for changes in top and middle phosphorus concentrations.

Figure 12 - Total phosphorus concentrations in top and middle depths in Amos Lake during 2013

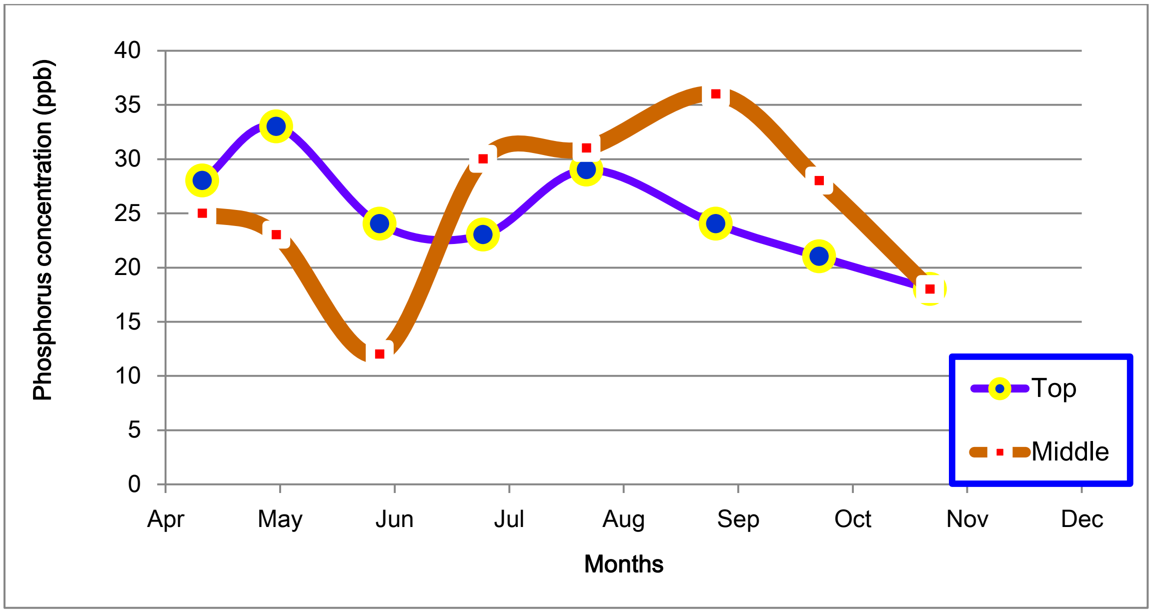


Figure 13 - Total phosphorus concentrations in Amos Lake during 2013

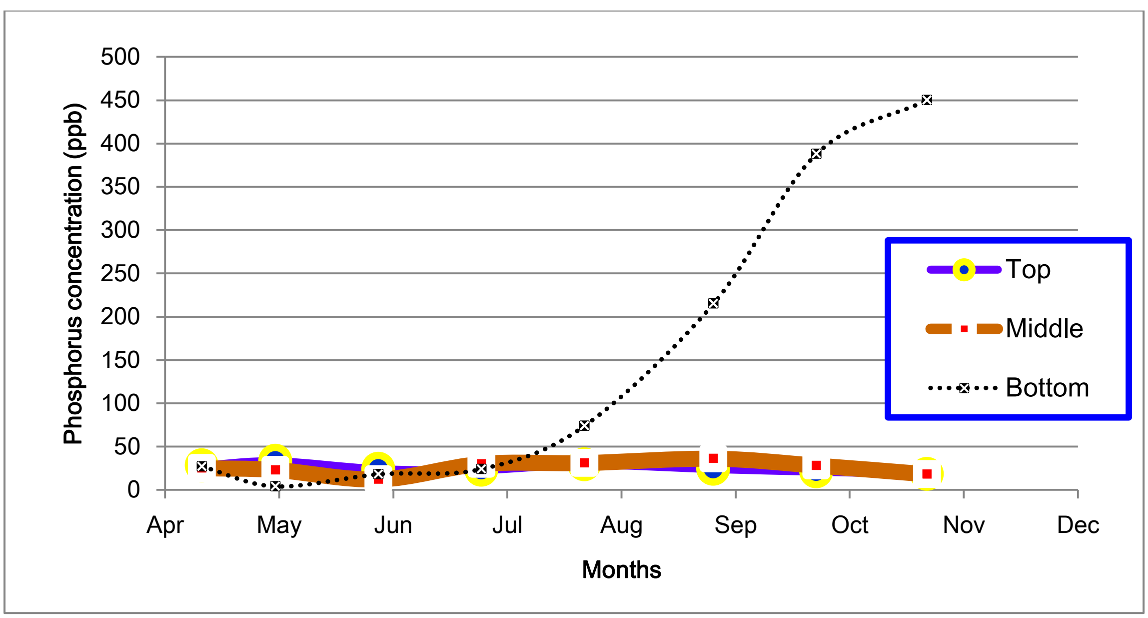


Figure 14 – Ortho-phosphorus concentrations in Amos Lake during 2013

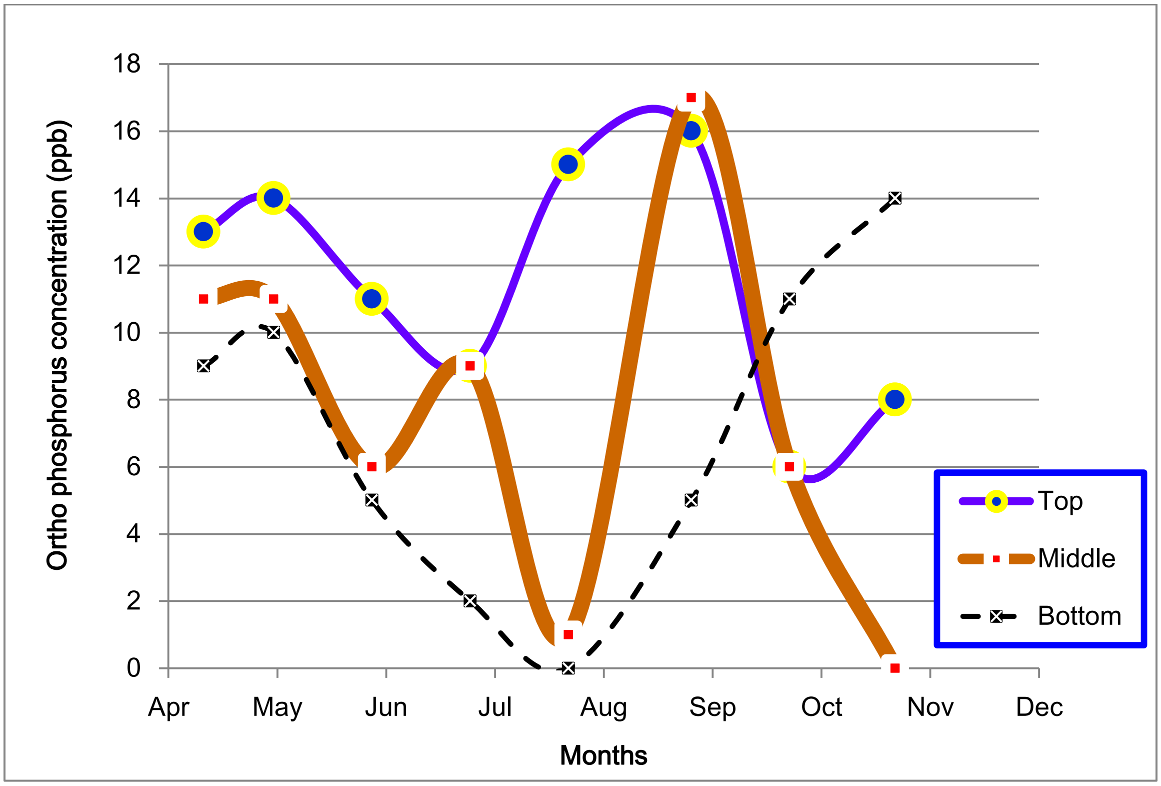


Figure 15 – Ortho-phosphorus in Amos Lake and total phosphorus from bottom sample as comparison

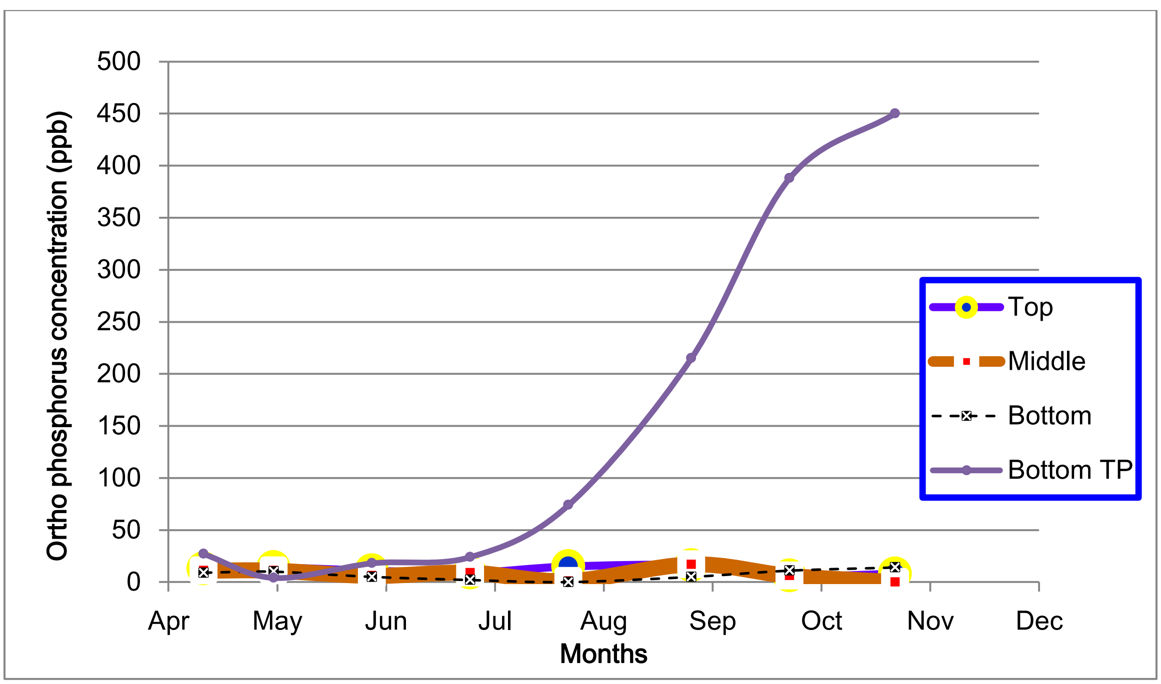


Figure 16 – Total phosphorus mass in Amos Lake during 2013

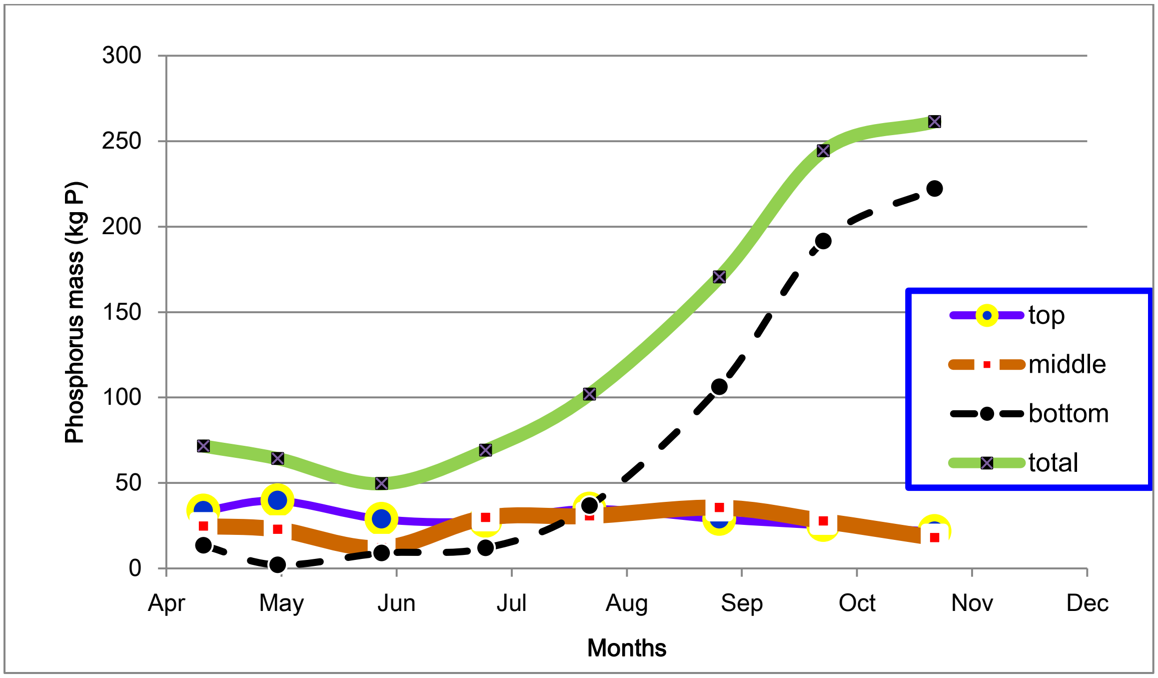
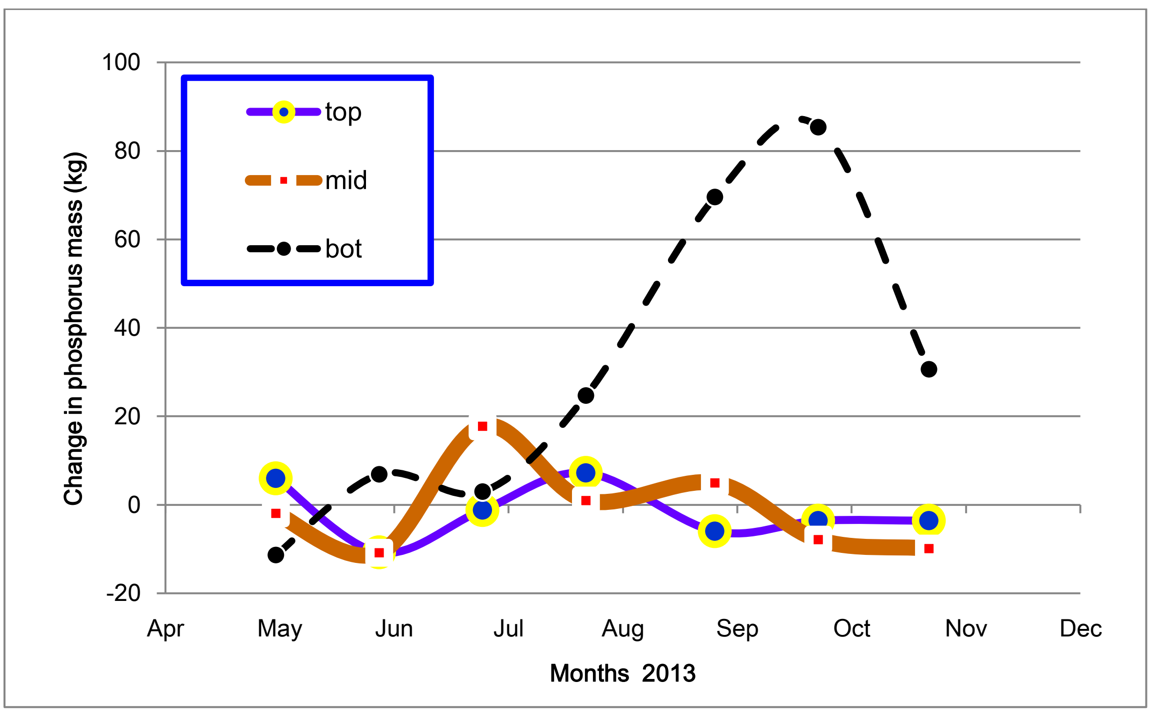


Figure 17 – Change in phosphorus mass in Amos Lake during 2013



6: Nitrogen Results

6.1 Total nitrogen concentrations (Figure 18) in top and middle depths (1 meter and between 5 and 7 meters) varied between a low of 230 ppb and a high of 558 ppb.

6.2 Total nitrogen concentrations at the bottom increased steadily from a low of 405 ppb in April to a high of 2,068 ppb in September. October total nitrogen was similar to September at 2,009 ppb.

6.3 Nitrate nitrogen (Figure 19) was high in April and early May with concentrations between 46 ppb and 87 ppb. Nitrate appeared to remain high at mid-depth though to late May. Concentrations were low to non-detectable at all depths after that time.

6.4 Ammonia nitrogen (Figure 20) was low to non-detectable in surface and mid-depth samples but showed a steady increase in bottom samples between April and October with highest concentration of 2,920 ppb at that time. The ammonia concentrations show that all total nitrogen detected in bottom samples was as ammonia.

Figure 18 – Total Nitrogen concentration in Amos Lake during 2013

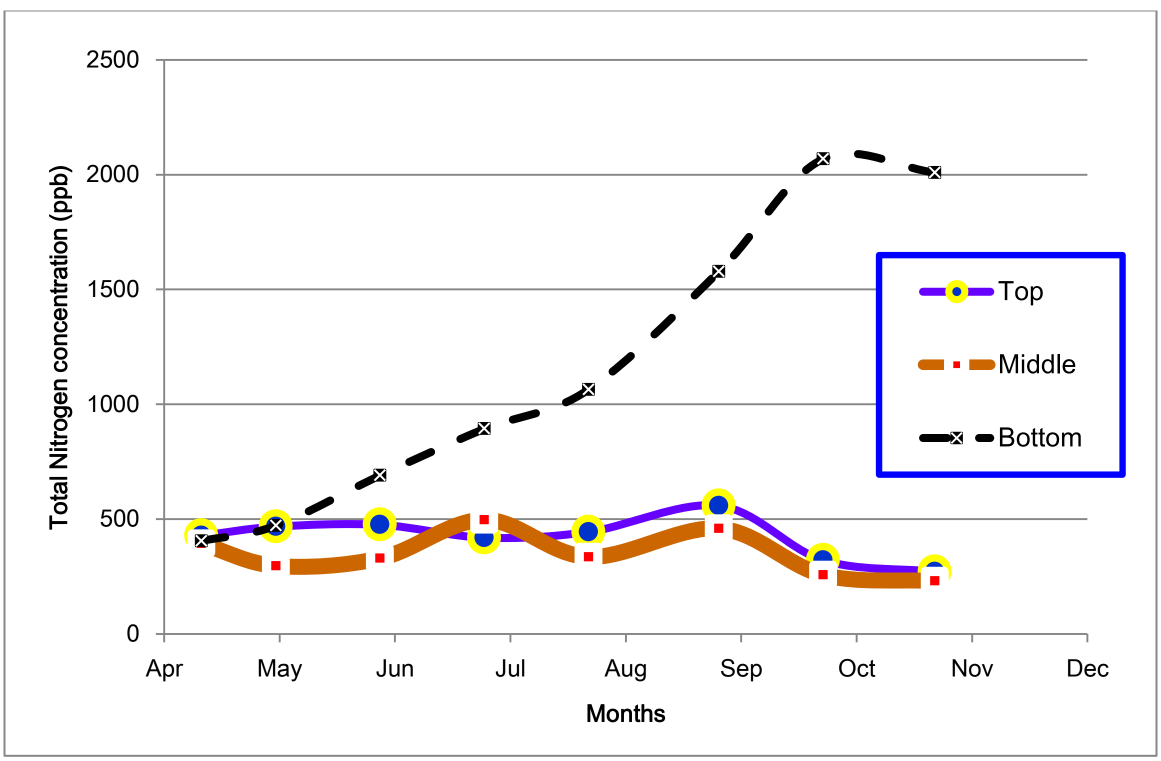


Figure 19 – Nitrate nitrogen concentration in Amos Lake during 2013

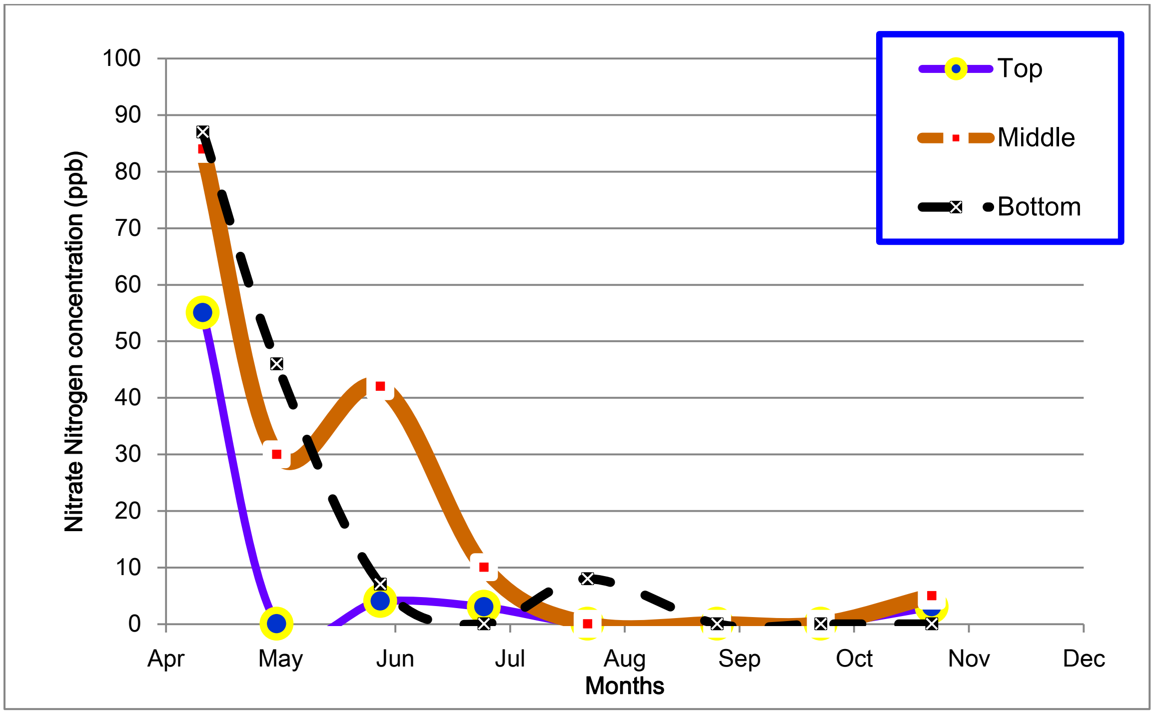
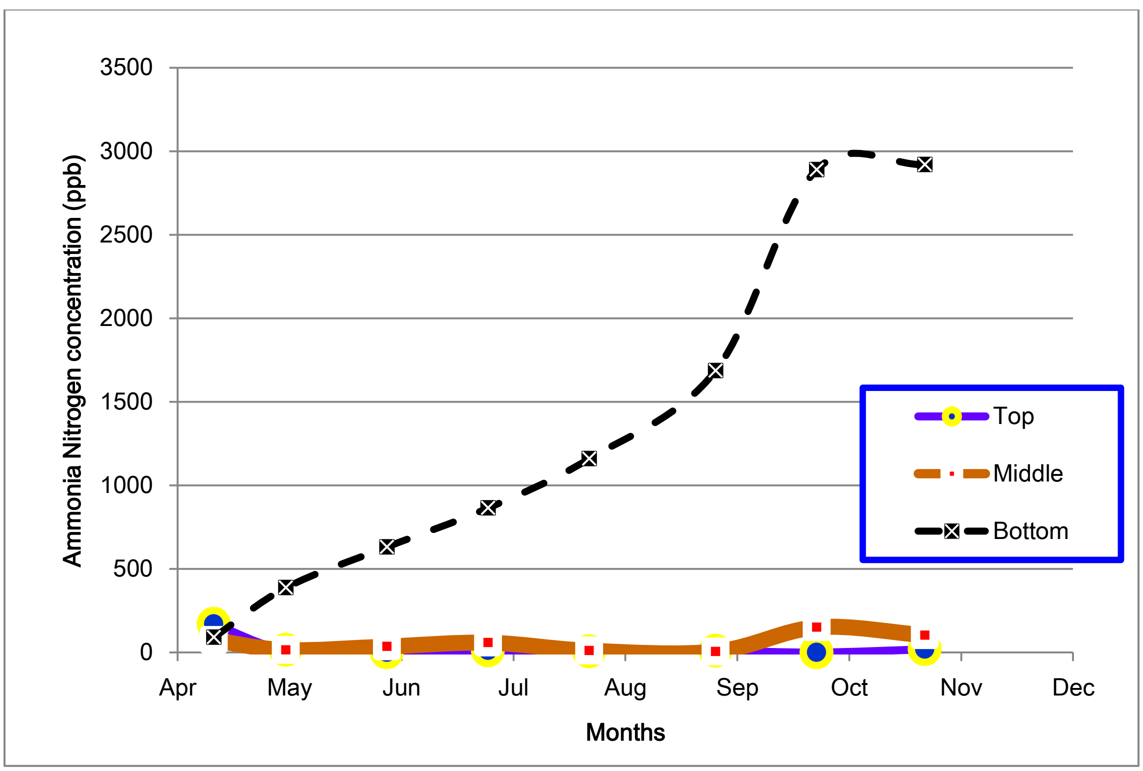


Figure 20 – Ammonia nitrogen concentration in Amos Lake during 2013



WATERSHED ASPECTS

7: Watershed sub-basins

7.1 Five tributaries to Amos Lake were monitored for nutrients during 2013, labeled AL-01 to AL-05 as shown on map in Figure 21.

7.2 Tributary drainage basins (Figure 22) areas range in size from 30 acres to 267 acres (Table 2).

7.3 Largest tributary was AL-03 at 267 acres.

7.4 Monitored tributaries totaled about 615 acres or about 66.8% of the drainage basin of Amos Lake (Table 2).

7.5 Most watershed drainage area to the north and west of the lake was accounted for by tributary monitoring. Most area on the east and southeast side of the lake was not (Figure 22).

7.6 Tributary AL-03 was monitored for water flow with a stage height hydrograph prepared to estimate daily water flow.

7.7 Graphs below show gaps in trend lines when no flow conditions occurred at sample sites.

Table 2 – Watershed sub-basin areas

Site Number	Site Label	Approx. Drainage Area -Acres	Percentage
AL-01	Stream at 50 Lakeside	30	3.3
AL-02	Vineyard Kettle Pond outflow	121.03	13.2
AL-03	Unnamed stream by church	267.25	29
AL-04	Lambert Pond outflow	101.8	11
AL-05	Stream by campground	96.95	10.4
AL-06	Outlet	920 (includes lake area)	

Figure 21 Tributary sampling sites visited around Amos Lake during 2013 monitoring

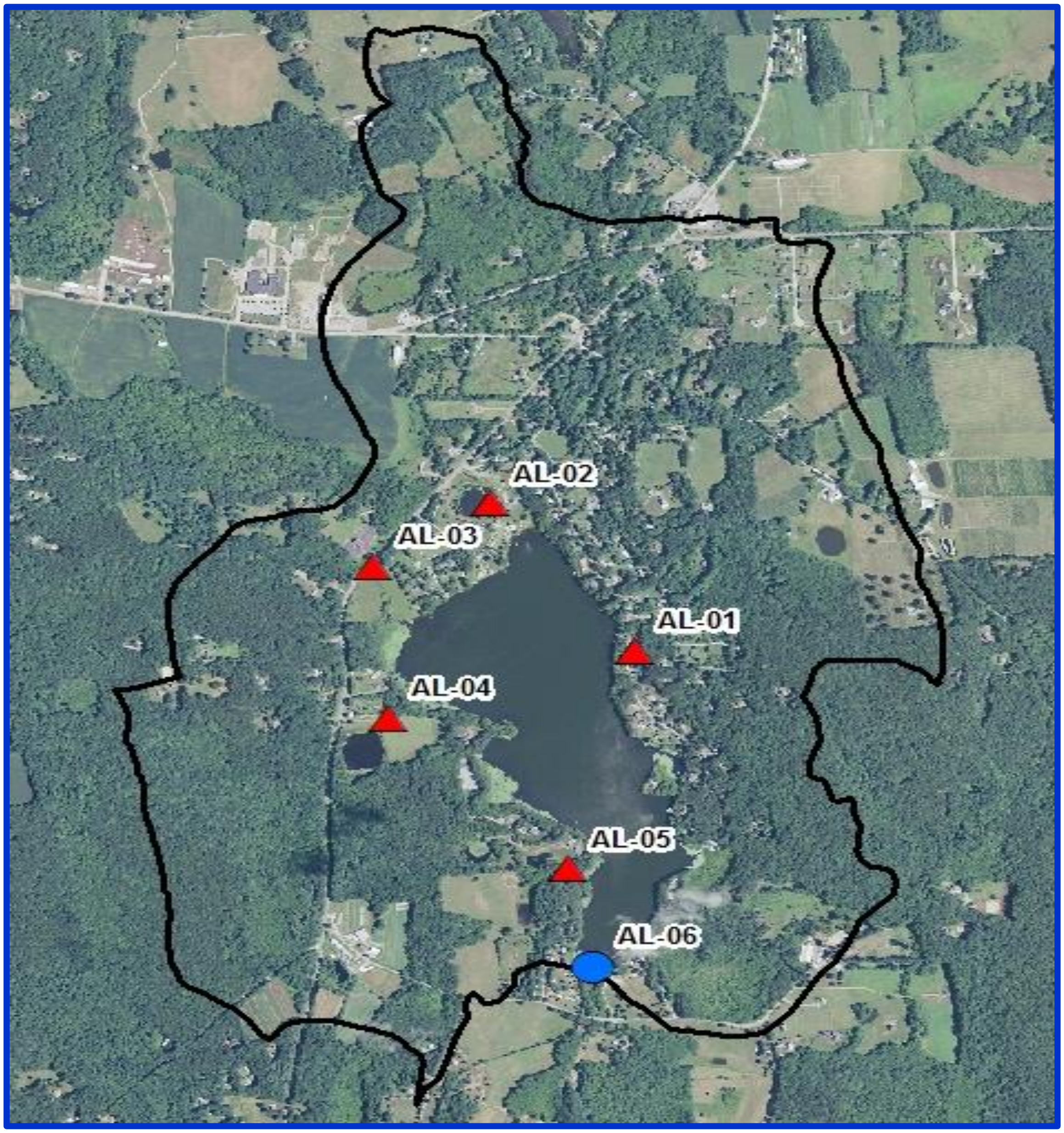
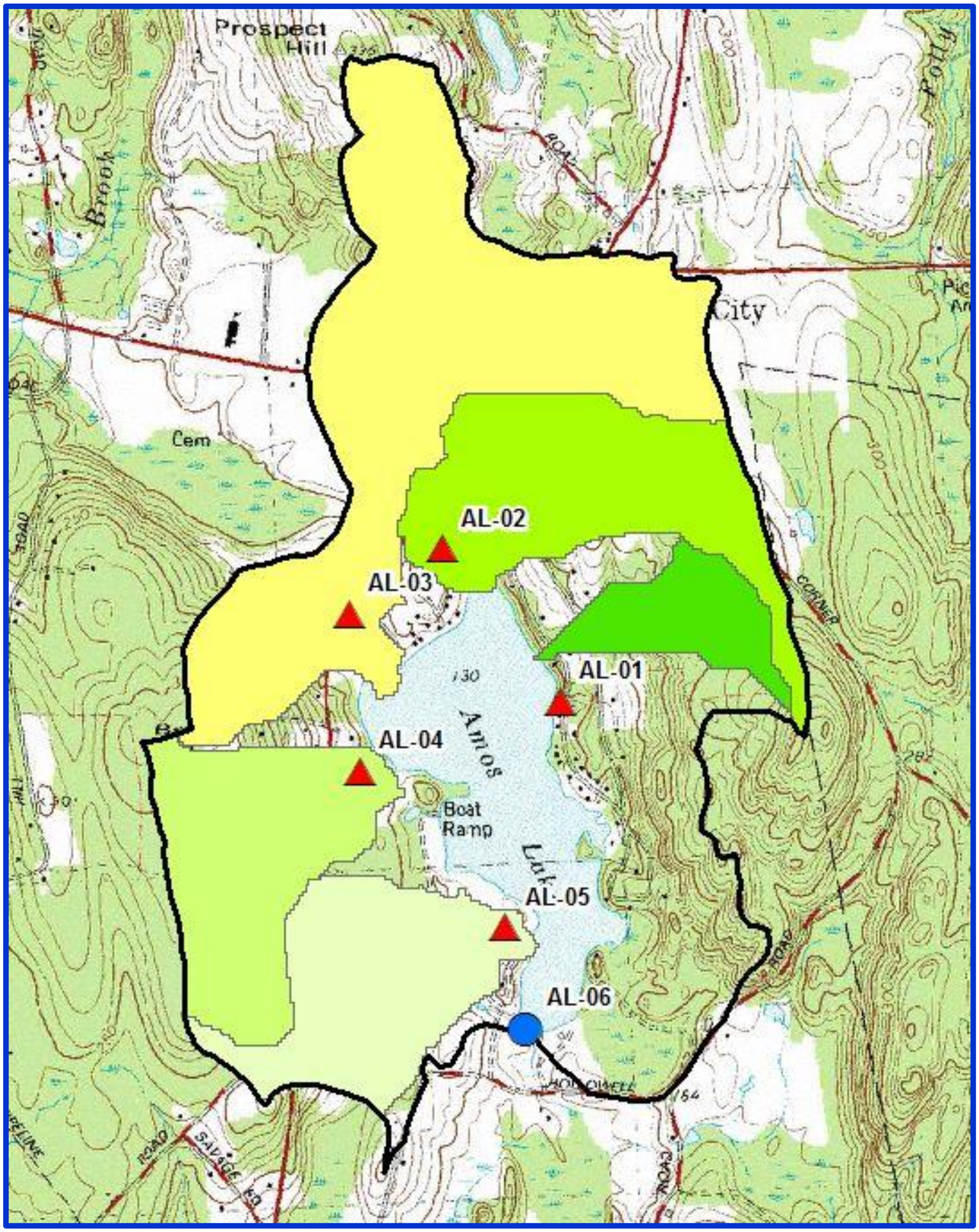


Figure 22 Tributary sub basin areas for monitored inlet sites visited around Amos Lake during 2013



8: Watershed Phosphorus

8.1 Phosphorus concentrations in the five tributaries to Amos Lake during 2013 varied between 7 ppb and 110 ppb.

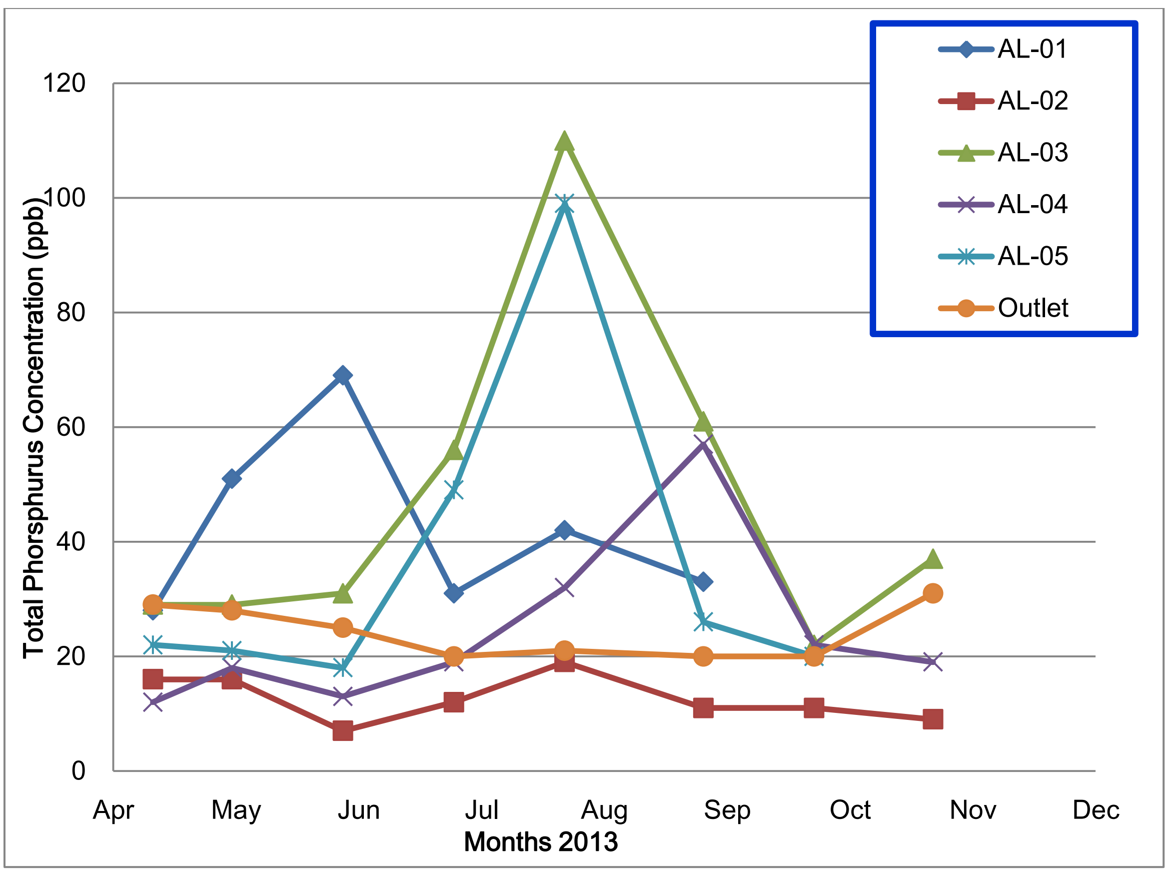
8.2 Tributary AL-03 and AL-05 (Stream by Church & Stream by Campground) had highest concentrations, with both having maximum values of about 100 ppb occurring in July.

8.3 Stream at 50 Lakeside (AL-01) had highest values of all monitored inlets in May at 51 and 69 ppb.

8.4 Stream from Lambert Pond outflow (AL-04) had highest value of measured inlets in August at 57 ppb.

8.5 Vineyard Kettle Pond outflow (AL-02) had low values throughout the sampling period with all concentrations less than 20 ppb.

Figure 23 - Total phosphorus concentrations in Amos Lake tributaries during 2013



9: Watershed Nitrogen

9.1 Total nitrogen concentrations (Figure 23) in the five tributaries to Amos Lake during 2013 varied between 117 ppb and 1,895 ppb.

9.2 Nitrate nitrogen concentrations (Figure 24) in the five tributaries to Amos Lake during 2013 varied between non-detect and 2,020 ppb.

9.3 Ammonia nitrogen concentrations (Figure 25) in the five tributaries to Amos Lake during 2013 varied between non-detect and 110 ppb.

9.4 The unnamed tributary by the church (AL-03) had highest total nitrogen with nitrate nitrogen accounting for most if not all of the total. Nitrate in this inlet was at high concentrations all season with highest concentrations occurring in June and September.

9.5 Nitrate was also high in Vineyard Kettle Pond outflow (AL-02) and Stream North of Campground (AL-05) in April. Nitrate in Vineyard Kettle Pond outflow diminished by June but Stream by the Campground (AL-05) showed summer increases. Nitrate in 50 Lakeside (AL-01) showed a peak in June but other months had lower levels. Nitrate in Lambert Pond outflow (AL-04) had low to non-detectable levels throughout the season.

9.6 Ammonia was highest in most streams in April, but afterward showed large fluctuations during the season. Although all values were generally low, with most concentrations during the late spring and summer below 50 ppb, ammonia was still detectable in almost all the stream samples.

Figure 24 Total nitrogen concentrations in Amos Lake tributaries during 2013

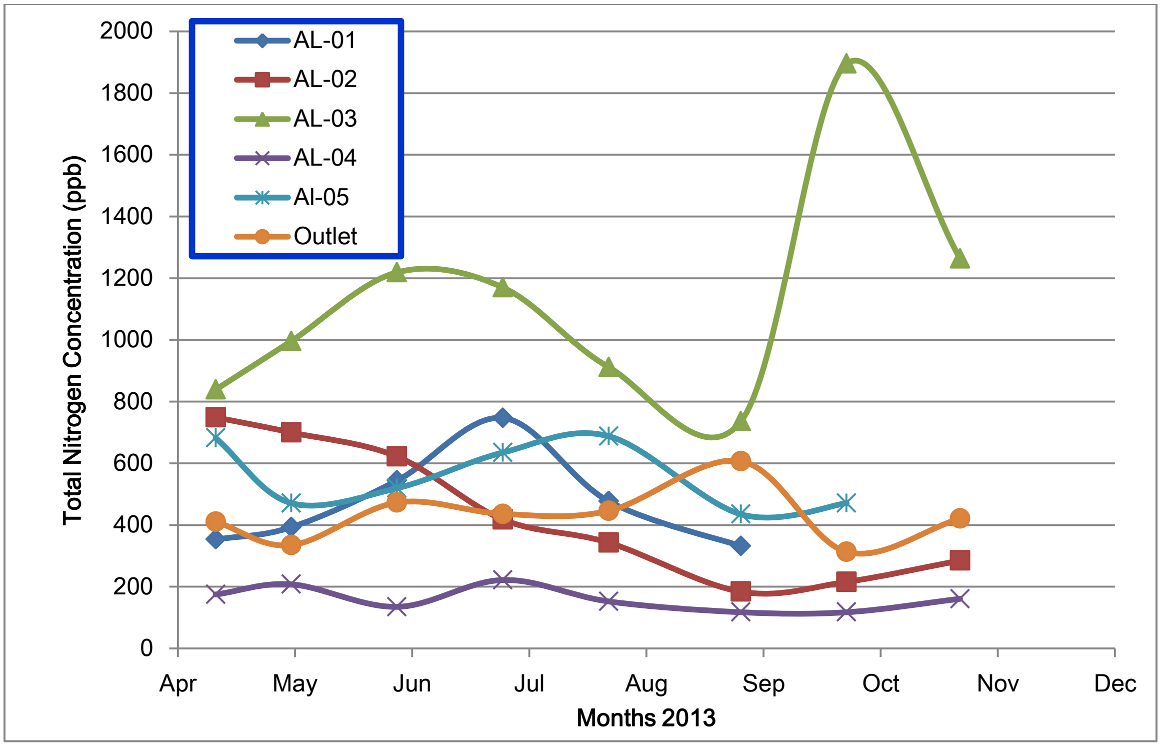


Figure 25 Nitrate nitrogen concentrations in Amos Lake tributaries during 2013

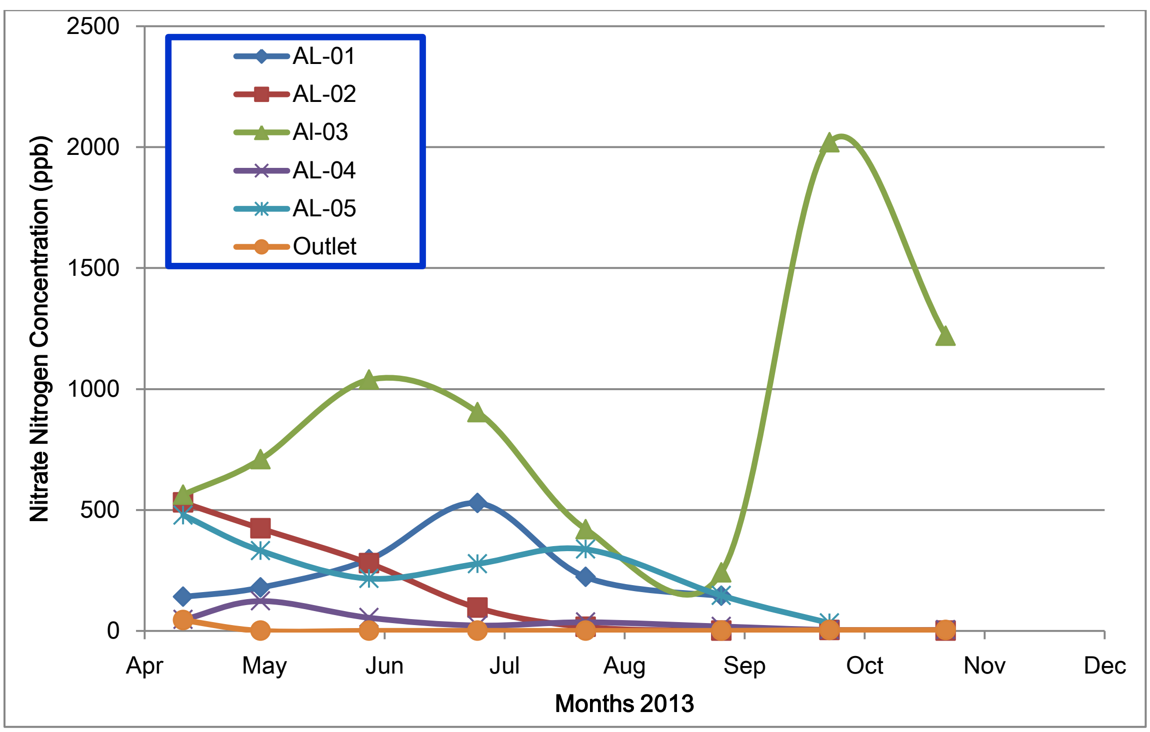
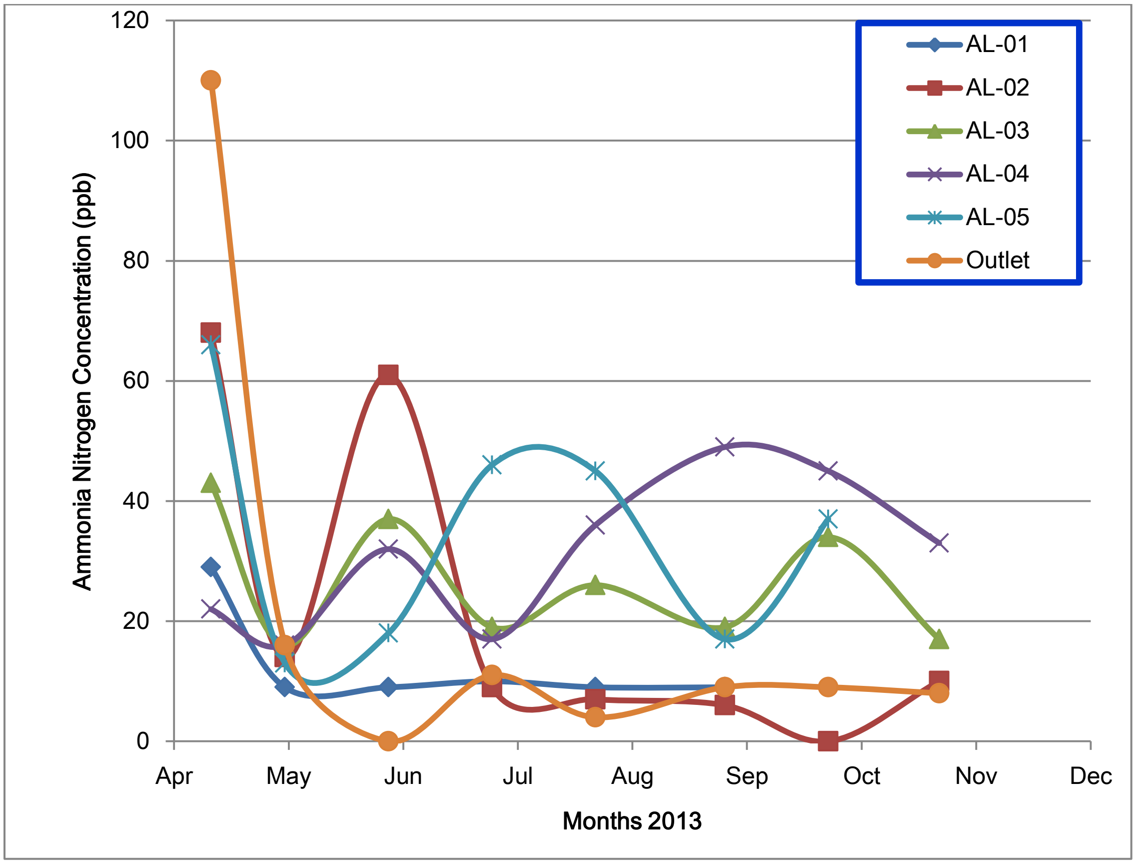


Figure 26 – Ammonia nitrogen concentrations in Amos Lake tributaries during 2013



10: Watershed Nutrient Loading

10.1 Water flow was estimated at (Figure 27) the unnamed stream by the church (AL-03) and the outlet during the 2013 study by developing flow rating curve—that is, using measured water flows and monitored stage height to calibrate water level as an estimate of water flow.

10.2 Estimated total flow using the rating curve at AL-03 was the gauged period (4-24-2013 to 10-29-2013) was 304,229 cubic meters. Estimated flow at the outlet (4-12-2013 to 10-22-2013) was 984,862 cubic meters.

10.3 Using watershed size and average rainfall, the estimated total annual discharge from the lake will average about 2,346,439 cubic meters/year with about 1,007,354 cubic meters (m^3) discharged during the monitored period (April 12th and October 22nd). The gauged value of 984,862 m^3 was very close (about 2 % error) indicating that discharge estimates made at the outlet during this study are accurate.

10.4 Using data from stream AL-03, the monthly load of phosphorus to Amos Lake was between 0.3 and 5.4 kg P/month for a seasonal (April 24-October 29) total of 18 kg P (Figure 28). Factoring for 12 months, the total annual load of phosphorus could have been about 36 kg/year. This is an underestimate of true total load from this inlet because typically disproportionally more runoff water enters the lake between October and April than between April and October.

10.5 Considering that stream AL-03 is about 29% of the total watershed, the total annual load of phosphorus to Amos Lake would have been higher than 36 kg P, perhaps at least 60 kg/yr. Again this would be an underestimate of true load because more flow will occur during the winter.

10.6 Estimate P load from AL-03 during the 2013 is shown together with Amos Lake P mass in the lake during the same time interval in Figure 29. Data show that 7 and 40 times more phosphorus in the lake than it received from the stream.

10.7 Phosphorus concentrations from storm water sampling conduced in November 2013 (Table 3) indicate that storm water phosphorus load is considerably higher than base-flow. Higher phosphorus concentrations in storm water show that total load estimates made from base flow concentrations are underestimates. Storm water flows could produce at least 15000 cubic meters of water during a day as noted by hydrograph data in Figure 27. A concentration of 5930 ppb (Table 3) during runoff event of 15,000 cubic meters would yield phosphorus load 90 kg during one storm, more than the total annual estimated phosphorus load. This indicates that storm water loading to Amos could be considerable and certain the when the major of the load occurs.

10.8 Nitrate nitrogen loading to Amos Lake during 2013 varied between 9 and 116 kg N/months with a seasonal total of 306 kg N. The total annual load of nitrate is about 1,224 kg N/year.

10.9 Total phosphorus load to Amos Lake as predicted by four loading models Table 4) is between 106 and 258 kg P/year with a mean of 193 kg/yr., using spring phosphorus concentration of 26.7 ppb collected in April 2013.

10.10 Total phosphorus load to Amos predicted by loading models indicates about 3x more phosphorus enters the lake than estimated by base flows concentrations. Storm water load could easily account of the difference.

Figure 27 – Estimated water discharge at stream AL-03 and the outlet during April – October 2013

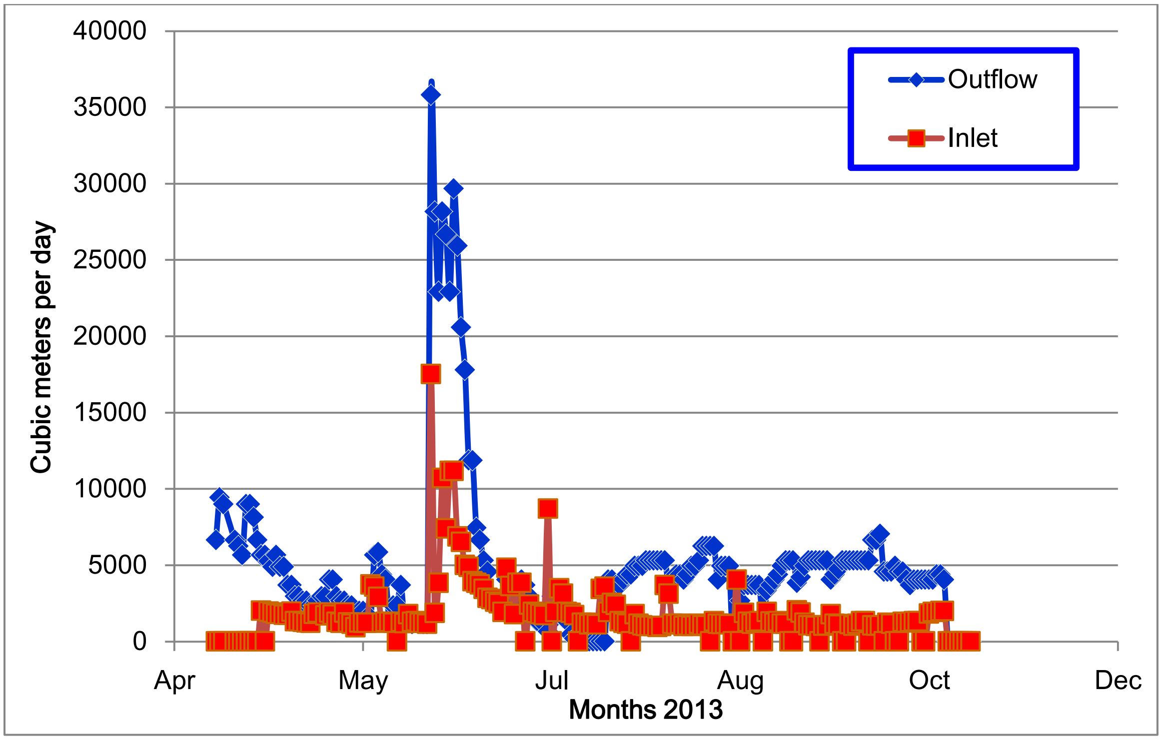


Figure 28 Estimated phosphorus load from AL-03 during 2013

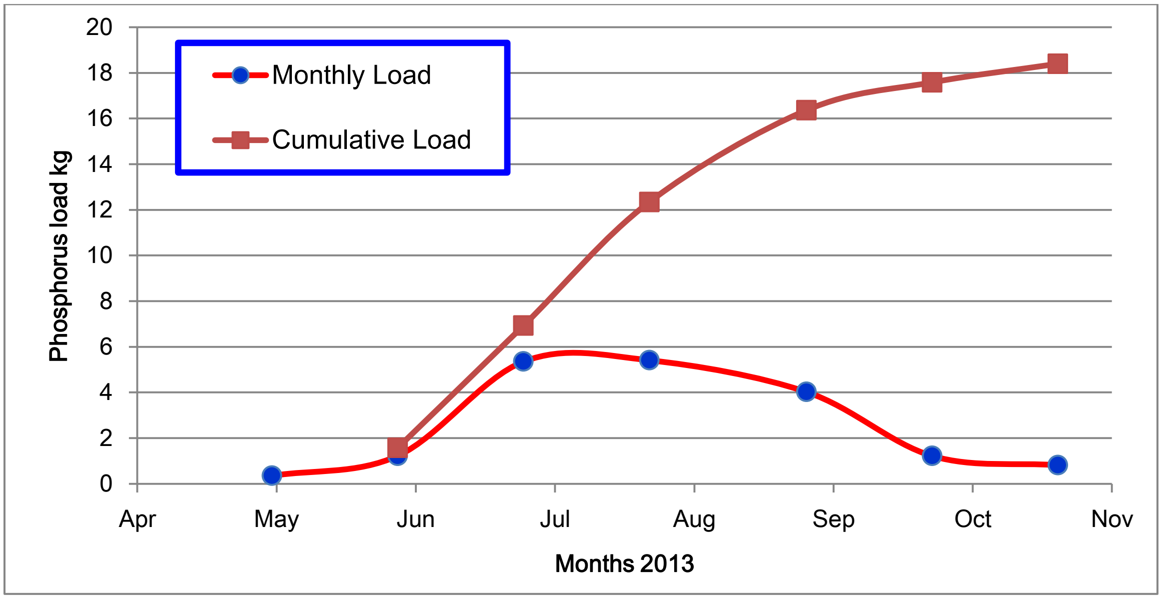


Figure 29 – Inflow P mass per month and lake P mass on sampling date in top water layer

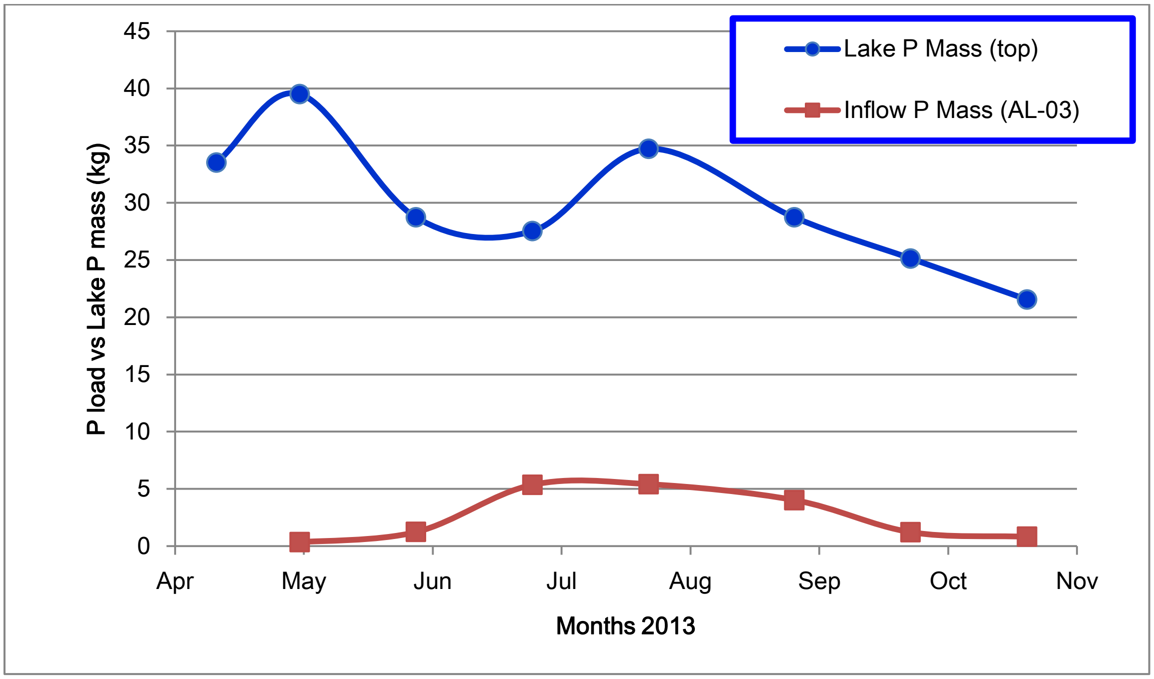


Figure 30 Estimated nitrate load from AL-03 during 2013

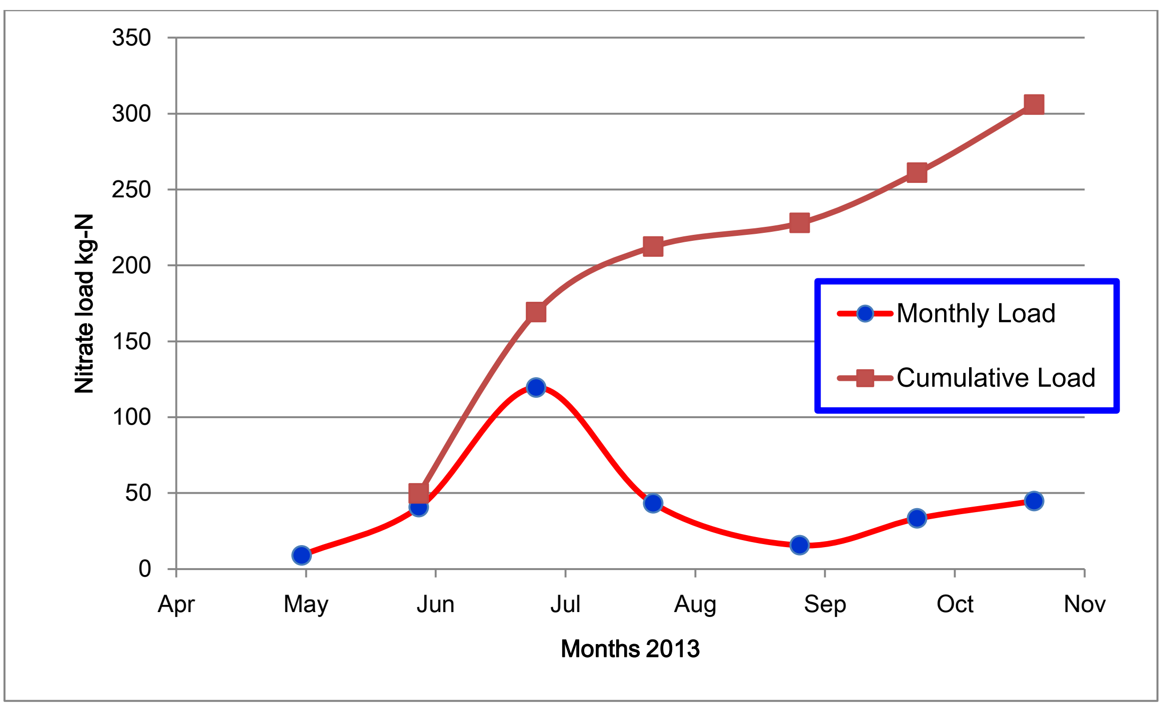


Table 3 - Storm water phosphorus concentrations (ppb) collected in November 2013

Total phosphorus (ppb)	11/1/2013	11/17/2013	11/26/2013
AL-03-storm grab	119	24	25
AL-03--passive sampler	5,930	148	142
AL-03 -post-storm grab	27	90	127
passive sampler at Monahan's	890	327	980
passive sampler near 57 Lakeview	1,580	247	135
passive sampler near 76 Lakeview	1,665	638	207

Table 4 – Estimated annual phosphorus load to Amos Lake based on spring phosphorus concentration

Prediction Of annual P load based on spring phosphorus of 26.7 ppb collected on April 11, 2013:	
Model Author	Kg P/year
Kirchner and Dillon 1975	224
Vollenweider 1975	184
Jones and Bachmann 1976	106
Chapra 1975	258
Average =	**193**

11: Summary and Recommendations

11.1 Amos Lake developed strong stratification during the 2013 season with a thermocline located between 3 and 8 meters. Although surface water warmed normally during the season, bottom water temperature remained at a constant 8-9 degrees C suggesting constant spring water flushing.

11.2 Amos Lake lost dissolved oxygen in bottom water very early in the season with water deeper than about 6 meters remaining devoid of oxygen during the summer and into the fall. At the time of the last sampling (October 25) there was still several meters of anoxic water at the bottom. Anoxic boundary and thermocline were at the same depth during late summer.

11.3 Water clarity varied between poor and good with most months having poor clarity. Chlorophyll measurements showed varied values in the spring that were not consistent with water clarity readings at that time suggesting phytoplankton anomaly such as high biomass of tiny organisms that may not cause poor clarity but were at high enough numbers to cause high chlorophyll.

11.4 Total phosphorus was generally high in upper water with most values over 20 ppb, and some over 30 ppb. Surface water phosphorus was high enough to cause cyanobacteria blooms during summer months.

11.5 Bottom water had very high phosphorus exceeding 200 ppb in August, 300 ppb in September, and 400 ppb in October.

11.6 Transference of high bottom phosphorus into upper water layer appeared not to occur since the middle and top water samples showed no change during the period of very high phosphorus loading at the bottom.

11.7 Ortho-phosphorus was generally low in all samples and showed no correlation with increases noted at the bottom suggesting that bottom water phosphorus was not dissolved.

11.8 Total nitrogen was moderate in the top and middle layers but very high at the bottom. Most—if not all—the nitrogen at the bottom appeared to be as ammonia.

11.9 Nitrate was detected in the lake in spring but rapidly disappeared probably due to assimilation by phytoplankton. However, a slight peak of nitrate in the middle depth in May suggests that nitrate may enter the lake in the groundwater.

11.10 Five inlet streams were monitored during 2013.

11.11 Total phosphorus was generally low to moderate in base flow but high to extremely high in storm water. Total load of phosphorus to the lake was estimated at between 106 - 258 kg/L by loading models that use the spring phosphorus concentration. Using base flow phosphorus concentrations and flow readings, total phosphorus load to the lake was about 60 kg. Storm water is implicated as being a significant source of phosphorus to the lake.

11.12 Nitrogen in the form of nitrate was variable in the inlet streams with AL-01 and AL-03 having consistently high values.

11.13 The 2013 monitoring revealed several important threats to the long term condition of Amos Lake.

1. Generally high levels of total phosphorus in upper waters most of the season.

2. Rapid loss of dissolved oxygen and very high phosphorus and ammonia accumulation in the deeper waters.

3. Poor clarity and high chlorophyll during the summer and high chlorophyll during the spring.

4. High phosphorus in storm water and high nitrate in some streams during base flows.

5. Nitrate anomaly in middle depth lake water suggests nitrate loading to the lake via groundwater.

11.14 A monitoring plan needs to be adopted to regularly track parameters included during this study.

1. Monitoring should be conducted monthly, as done during this study, but should also include November to capture data that shows the lake to be fully mixed and oxygenated at the end of the season.

2. Parameters that should be included in the routine annual testing include phosphorus, nitrogen, water clarity, chlorophyll, water temperature, dissolved oxygen in the lake and nitrogen and phosphorus turbidity and suspended solids during base flow and storm events from the inlets.

3 Bottom water testing could be improved to include anaerobic respiration by-products sulfide, manganese, iron and redox potential to determine the magnitude of anoxia and verify if this condition is worsening.

4 Phytoplankton and zooplankton sampling should be conducted monthly.

5 When cyanobacteria cell numbers and types exceed 70,000 cells per mL water should be tested for the presence of cyano-toxins.

6 Watershed requires further investigation to determine sources of phosphorus and nitrogen.

7 Examination of storm water conveyance should be conducted to determine how to best approach remediation of poor water quality during rain events and where and how Low Impact Development best management practices could be implemented.

Appendix

Raw Data used for this report.

Red zeros indicate a reading of Non-Detect reported by the laboratory.

Water Temperature (degrees C)								
Depth (m)	4/11/2013	5/1/2013	5/29/2013	6/26/2013	7/24/2013	8/28/2013	9/25/2013	10/25/2013
1	10.86	15.32	18.56	27.57	29.04	24.46	19.24	14.47
2	10.80	14.90	18.27	26.83	28.67	24.37	19.24	14.47
3	10.75	14.78	17.78	23.65	28.14	24.14	19.19	14.47
4	10.55	13.62	17.30	19.42	23.32	23.27	19.16	14.43
5	9.10	12.65	15.38	16.41	21.00	20.88	18.98	14.41
6	8.47	11.83	12.18	14.04	14.79	16.30	18.4	14.39
7	7.93	11.04	10.88	11.72	13.75	13.50	13.17	14.37
8	7.85	10.55	10.10	10.66	11.56	11.74	11.56	13.78
9	7.63	9.24	9.49	9.72	9.90	10.25	10.19	10.85
10	7.58	8.17	8.77	9.07	9.34	9.39	9.32	10.0
11	7.49	7.86	8.44	8.65	9.02	9.02	8.92	9.29
12	7.48	7.75	8.31	8.54	8.65	8.86	8.82	8.8
13	7.48	7.70	8.15	8.43	8.48	8.52	8.58	8.75
14				8.34		8.34		8.48
15								8.5

Dissolved Oxygen (mg/L)								
Depth(m)	4/11/2013	5/1/2013	5/29/2013	6/26/2013	7/24/2013	8/28/2013	9/25/2013	10/25/2013
1	12.9	11.7	9.8	8.7	8.6	8.9	7.9	8.2
2	12.9	11.5	9.7	8.9	7.9	8.7	7.9	8.0
3	12.9	11.5	9.7	9.1	8.1	7.5	7.9	7.8
4	12.8	11.4	9.4	7.8	6.0	5.6	7.8	7.7
5	12.7	11.2	7.9	4.0	2.1	2.0	7.5	7.6
6	12.5	10.0	5.0	0.8	0.4	0.4	5.4	7.5
7	12.0	8.5	3.5	0.2	0.1	0.1	0.7	7.1
8	11.9	8.0	2.3	0.0	0.0	0.0	0.0	5.3
9	11.7	7.2	1.5	0.0	0.0	0.0	0.0	1.1
10	11.3	6.1	0.4	0.0	0.0	0.0	0.0	0.1
11	11.3	5.2	0.1	0.0	0.0	0.0	0.0	0.0
12	11.2	4.0	0.0	0.0	0.0	0.0	0.0	0.0
13	11.2	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Anoxic Boundary	13.0	13.0	9.4	6.0	5.7	5.6	6.9	9.1

% Oxygen Saturation								
Depth(m)	4/11/2013	5/1/2013	5/29/2013	6/26/2013	7/24/2013	8/28/2013	9/25/2013	10/25/2013
1	116	117	104	110	112	107	86	80
2	116	114	103	111	102	103	85	78
3	116	113	102	108	104	89	85	76
4	115	109	98	85	71	66	84	75
5	110	105	79	40	23	23	80	74
6	106	93	46	8	4	4	57	73
7	101	77	32	2	1	1	7	70
8	100	72	21	0	0	0	0	51
9	97	63	13	0	0	0	0	10
10	94	52	4	0	0	0	0	1
11	94	43	0	0	0	0	0	0
12	93	34	0	0	0	0	0	0
13	93	27	0	0	0	0	0	0
14				0		0		0
15								0

Relative Thermal Resistance to Mixing								
Depth(m)	4/11/2013	5/1/2013	5/29/2013	6/26/2013	7/24/2013	8/28/2013	9/25/2013	10/25/2013
1	0	0	0	0	0	0	0	0
2	0	8	7	24	14	3	0	0
3	1	4	11	102	18	6	2	0
4	2	19	9	115	156	27	0	0
5	15	16	41	68	65	67	5	0
6	6	12	53	45	142	106	12	2
7	4	11	17	35	17	52	104	0
8	1	6	8	14	33	27	23	10
9	1	14	7	10	19	19	17	42
10	1	9	7	7	6	9	8	9
11	1	2	2	3	3	3	4	8
12	0	1	1	1	3	2	1	4
13	0	0	2	1	2	2	2	1
14				1		2		2

TP (ppb)	11-Apr	1-May	29-May	26-Jun	24-Jul	28-Aug	25-Sep	25-Oct
Amos Lake Top	28	33	24	23	29	24	21	18
Amos Lake Mid	25	23	12	30	31	36	28	18
Amos Lake Bottom	27	4	18	24	74	215	388	450
AL-01 = 50 Lakeside	28	51	69	31	42	33	No flow	No flow
AL-02 = Vineyard Kettle Pond outflow	16	16	*7*	12	19	11	11	*9*
AL-03 = Unnamed stream by church	29	29	31	56	110	61	22	37
AL-04 = Lambert Pond outflow	12	18	13	19	32	57	22	19
AL-05 = Stream by Campground	22	21	18	49	99	26	20	No flow
Outlet	29	28	25	20	21	20	20	31

Ortho P (ppb)	11-Apr	1-May	29-May	26-Jun	24-Jul	28-Aug	25-Sep	25-Oct
Amos Lake Top	13	14	11	9	15	16	6	8
Amos Lake Mid	11	11	6	9	1	17	6	0
Amos Lake Bottom	9	10	5	2	0	5	11	14
AL-01 = 50 Lakeside	10	12	17	17	20	17	No flow	No flow
AL-02 = Vineyard Kettle Pond outflow	6	9	5	4	9	7	2	3
AL-03 = Unnamed stream by church	8.5	8	10	17	48	33	7	7
AL-04 = Lambert Pond outflow	4	6	3	3	4	1	3	0
AL-05 = Stream by Campground	11	7	8	12	14	15	8	No flow
Outlet	13	9	13	8	10	9	6	11

TN (ppb)	11-Apr	1-May	29-May	26-Jun	24-Jul	28-Aug	25-Sep	25-Oct
Amos Lake Top	428	467	475	419	444	558	321	271
Amos Lake Mid	393	296	329	497	355	459	257	230
Amos Lake Bottom	405	471	690	893	1064	1578	2068	2009
AL-01 = 50 Lakeside	353	393	544	747	477	332	No flow	No flow
AL-02 = Vineyard Kettle Pond outflow	749	700	622	418	343	184	216	285
AL-03 = Unnamed stream by church	839	996	1,219	1170	912	736	1,895	1,264
AL-04 = Lambert Pond outflow	175	208	135	222	152.5	117.5	117.5	161
AL-05 = Stream by Campground	682	471	519.5	635	688	435	471	No flow
Outlet	411	335	473	436	446	607	313	421

NOx (ppb)	11-Apr	1-May	29-May	26-Jun	24-Jul	28-Aug	25-Sep	25-Oct
Amos Lake Top	55	0	4	3	0	0	0	3
Amos Lake Mid	84	30	42	10	0	0	0	5
Amos Lake Bottom	87	46	7	0	8	0	0	0
AL-01 = 50 Lakeside	140	179	295	528	222	144	No flow	No flow
AL-02 = Vineyard Kettle Pond outflow	530	423	279	95	16	0	3	0
AL-03 = Unnamed stream by church	563	710	1,038	904	420	241	2,020	1,220
AL-04 = Lambert Pond outflow	46	123	54	22	35.5	18	4	4
AL-05 = Stream by Campground	478	331	216	277	337	146	32	No flow
Outlet	44	0	0	0	0	0	3	3

NH3 (ppb)	11-Apr	1-May	29-May	26-Jun	24-Jul	28-Aug	25-Sep	25-Oct
Amos Lake Top	171	16	ND	11	5	10	ND	19
Amos Lake Mid	74	15	36	59	11	6	151	104
Amos Lake Bottom	91	388	632	865	1,160	1,687	2,890	2,920
AL-01 = 50 Lakeside	29	9	9	10	9	9	No flow	No flow
AL-02 = Vineyard Kettle Pond outflow	68	14	61	9	7	6	0	10
AL-03 = Unnamed stream by church	43	16	37	19	26	19	34	17
AL-04 = Lambert Pond outflow	22	16	32	17	36	49	45	33
AL-05 = Stream by Campground	66	13	18	46	45	17	37	No flow
Outlet	110	16	0	11	4	9	9	8

Chlorophyll-*a*

Date	ug/L
4/11/2013	58.1
5/1/2013	59.2
5/29/2013	8.1
6/26/2013	4.4
7/24/2013	18.7
8/28/2013	24
9/25/2013	5.2
10/25/2013	7.1

Appendix E

SIMPLE Method

Pollutant Loading Data

Sub-Watershed Pollutant Loading for each Land Use/Land Cover Type

Bunny Lane WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	421	3	15	1	4	4
Medium Density Residential	0	0	0	0	0	0
High Density Residential	0	0	0	0	0	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	764	2	18	1	23	3
Turf and Grass	3,383	3	28	0	0	2
Pasture	3,003	6	46	0	0	13
Cultivated crops	12,511	7	168	0	0	0
Forest	4,896	5	82	0	0	12
Wetlands	0	3	13	0	0	0
Bare Ground	0	0	0	0	0	0
Σ =	**24,979**	**29**	**368**	**2**	**27**	**34**

Preston City WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	3,669	23	128	10	31	31
Medium Density Residential	1,031	5	36	3	21	6
High Density Residential	30	0	1	0	1	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	3,954	10	92	6	120	15
Turf and Grass	39,162	33	320	0	0	24
Pasture	13,707	28	208	0	0	61
Cultivated crops	20,170	11	271	0	0	0
Forest	15,287	17	255	0	0	37
Wetlands	0	19	77	0	0	0
Bare Ground	506	0	1	0	0	0
Σ =	**97,517**	**148**	**1,389**	**19**	**173**	**174**

Vineyard WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	2,798	18	98	7	23	24
Medium Density Residential	0	0	0	0	0	0
High Density Residential	0	0	0	0	0	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	3,022	8	70	5	92	11
Turf and Grass	19,378	16	158	0	0	12
Pasture	7,622	16	116	0	0	34
Cultivated crops	0	0	0	0	0	0
Forest	5,570	6	93	0	0	13
Wetlands	0	2	6	0	0	0
Bare Ground	0	0	0	0	0	0
Σ =	**38,388**	**65**	**541**	**12**	**115**	**94**

Fish Pond WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	214	1	7	1	2	2
Medium Density Residential	0	0	0	0	0	0
High Density Residential	0	0	0	0	0	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	899	2	21	1	27	3
Turf and Grass	2,201	2	18	0	0	1
Pasture	565	1	9	0	0	3
Cultivated crops	0	0	0	0	0	0
Forest	10,074	11	168	0	0	24
Wetlands	0	3	14	0	0	0
Bare Ground	0	0	0	0	0	0
Σ =	**13,953**	**21**	**236**	**2**	**29**	**33**

Campground WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	940	6	33	3	8	8
Medium Density Residential	0	0	0	0	0	0
High Density Residential	0	0	0	0	0	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	2,146	5	50	3	65	8
Turf and Grass	413	0	3	0	0	0
Pasture	5,463	11	83	0	0	24
Cultivated crops	19,601	11	263	0	0	0
Forest	9,383	10	156	0	0	22
Wetlands	0	3	11	0	0	0
Bare Ground	0	0	0	0	0	0
Σ =	**37,945**	**47**	**599**	**6**	**73**	**63**

Remaining WS	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	2,253	14	79	6	19	19
Medium Density Residential	1,860	9	65	6	39	11
High Density Residential	0	0	0	0	0	0
Commercial Development	0	0	0	0	0	0
Industrial Development	0	0	0	0	0	0
Institutional Development	0	0	0	0	0	0
Transportation	5,488	14	128	8	166	21
Turf and Grass	32,559	27	266	0	0	20
Pasture	3,630	8	55	0	0	16
Cultivated crops	0	0	0	0	0	0
Forest	28,487	32	475	0	0	68
Wetlands	0	14	56	0	0	0
Bare Ground	1,789	1	3	0	0	0
Σ =	**76,066**	**119**	**1,127**	**20**	**224**	**155**