Hatch Pond Watershed Based Plan

South Kent School

South Kent, Connecticut

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FUSS & O'NEILL

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1 Introduction

1.1 Background

Hatch Pond, Summer 2014

Hatch Pond is an approximately 70-acre lake located in the Town of Kent, Connecticut *(Figure 1-1)*. The lake has an approximately 2,009-acre rural watershed located in Kent and New Milford and is fed by two streams, Womenshenuk Brook at the north end of the lake and another unnamed tributary at the south end of the lake. The outlet of Hatch Pond at the south end of the lake continues as Womenshenuk Brook, a tributary of the Housatonic River.

Hatch Pond is a popular fishing area in both the summer and winter with ice fishing, and offers a variety of wildlife and aquatic habitats. A Connecticut Department of Energy and Environmental Protection (CTDEEP)-owned public boat launch is located at the pond outlet, and several other docks exist around the pond, owned by South Kent School (SKS) and private residential landowners. The lake has experienced a severe decline in water quality and highly eutrophic conditions, which include infestation of aquatic plants, excessive algal growth, poor water clarity, sedimentation, and depleted oxygen in deeper parts of the lake. Hatch Pond is listed in the 2012 State of Connecticut Integrated Water Quality Report as “Not Supporting” for fish habitat, other aquatic life and wildlife, recreation, and non-native aquatic plants. Excessive nutrient inputs to the lake, primarily phosphorus loads, are believed to be responsible for the current highly eutrophic conditions.

Stakeholder groups and CTDEEP have been studying the poor conditions in Hatch Pond and the underlying causes of the problems for a number of years. CTDEEP originally classified the lake as moderately impaired in 1990, while water quality studies conducted by Northeast Aquatic Research (NEAR) in 2004 and 2005 (NEAR, 2006) showed Hatch Pond had deteriorated from moderate to very poor conditions in a 15-year period.

Additional water quality monitoring and aquatic vegetation surveys were conducted in 2010 by NEAR following the sale of the Arno Dairy Farm at the north end of the lake, a major historical source of sediment and phosphorus from agricultural activities. The resulting study (NEAR, 2012) found that Hatch Pond remains a highly eutrophic water body, although the decline in water quality conditions and active sedimentation may be stabilizing due to the removal of the agricultural phosphorus load associated with the former dairy farm operations. The study also found that Bull’s Bridge Golf Club and South Kent School are sources of nutrients to the lake’s southern tributary stream. Infestation of the lake by non-native aquatic plants (Eurasian milfoil) remains a significant problem.

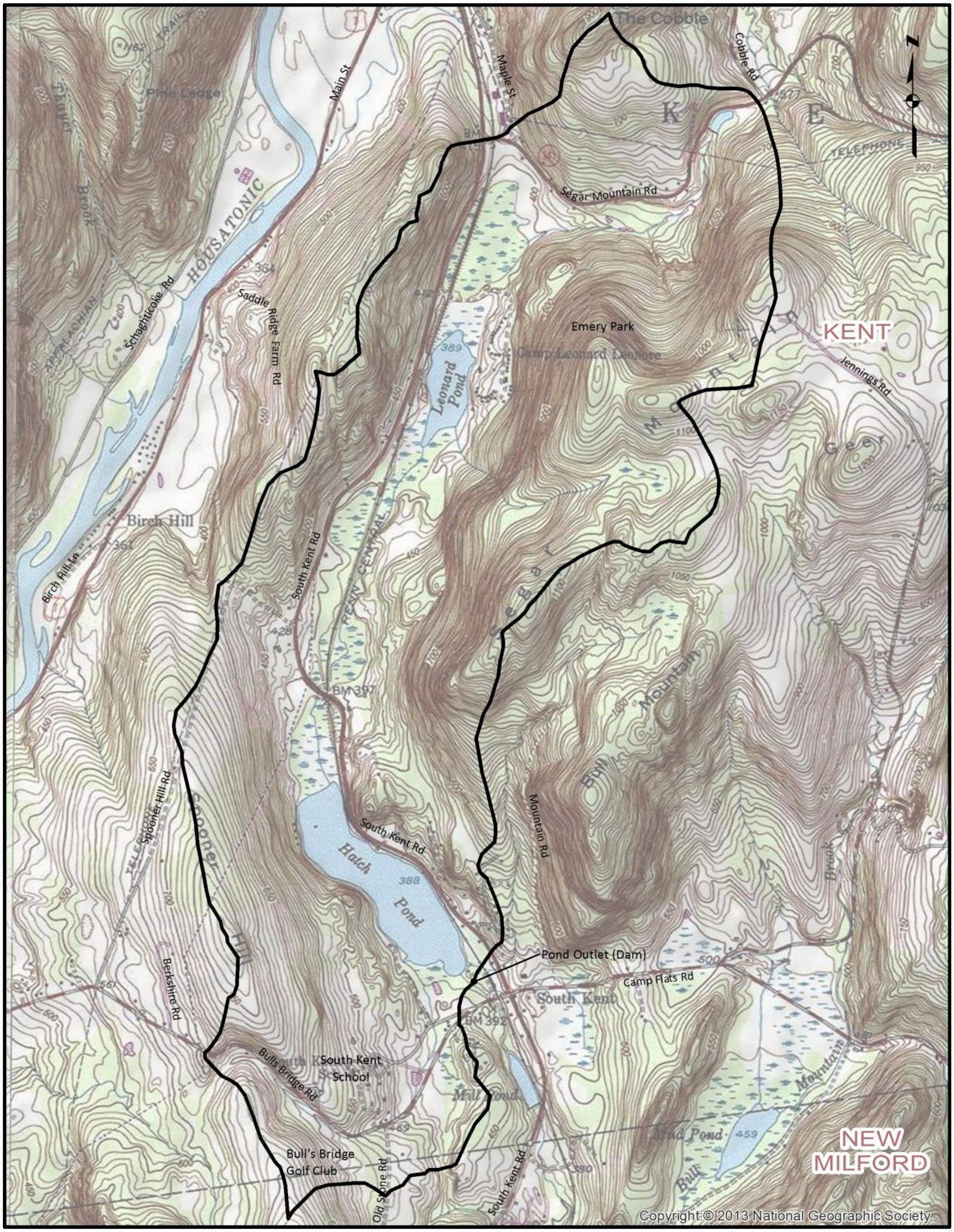

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Figure 1-1. Hatch Pond Watershed

Overall, the 2010 study (NEAR, 2012) recommends a significant reduction in phosphorus loads to the lake to realize substantial improvements in trophic conditions. The relative contribution of phosphorus from the Hatch Pond watershed versus internal recycling of phosphorus from bottom sediments has yet to be determined, which is critical for identifying effective strategies to further reduce phosphorus loads.

A more detailed limnological study was conducted in the summer of 2014, which included data collected on pond bathymetry, sediment depths, aquatic plant surveys, and water quality samples. The results of the limnological study are presented in "Hatch Pond Study 2014: In Lake Conditions, Processes and Possible Management Options" by Water Resources Services, Inc. and Northeast Aquatic Research, LLC (WRS and NEAR, 2014). A copy of this study report is included in *Appendix A* of this watershed plan.

The study findings indicate that the water quality and related algae community of Hatch Pond have been improving steadily since the 2010 elimination of the dairy farm near the north end of the pond. The internal phosphorus load from bottom sediments was estimated at less than 10 percent of the total load to the lake, which points to the watershed as a significant source of phosphorus to Hatch Pond and the importance of watershed management measures to further reduce the phosphorus loads to achieve desired water quality conditions in the lake. Rooted plant problems are also expected to continue or intensify in the coming years as water quality continues to improve, highlighting the importance of in-lake management measures to control rooted aquatic plants.

1.2 Watershed Planning Process

South Kent School, through its ongoing sustainability initiatives, received a Clean Water Act Section 319 Nonpoint Source Grant from CTDEEP to develop an EPA Nine Elements watershed based plan for Hatch Pond and its watershed. The watershed based plan builds upon the previous data collection efforts and studies of Hatch Pond and involved working with local stakeholders to identify prioritized management measures to reduce pollutant loading to Hatch Pond. Ultimately, the goal of the watershed based plan is for successful load reductions and improved water quality in Hatch Pond and its watershed.

The watershed planning process included several phases. The first phase was a review of existing conditions, which were summarized in "Hatch Pond and Its Watershed: An Assessment of Existing Conditions" (Fuss & O'Neill, 2014), as well as the 2014 in-lake study performed by WRS and NEAR. Both reports documented the existing conditions within Hatch Pond and its watershed, including synthesis of prior studies and data, new data collection, and estimates of in-lake and watershed pollutant loads.

EPA Nine-Elements of a Watershed Based Plan

a. Identify causes and sources of pollution
b. Estimate pollutant loading to the watershed and the expected load reductions
c. Describe management measures that will achieve load reductions and targeted critical areas
d. Estimated amount of technical and financial assistance and the relevant authorities needed to implement the plan
e. Develop and information/education component
f. Develop a project schedule
g. Describe the interim, measurable milestones
h. Identify indicators to measure progress
i. Develop a monitoring component

This watershed based plan incorporates the existing conditions assessments, along with stakeholder input, to identify short- and long-range management measures, an implementation plan for the management measures, and techniques for measuring the effectiveness of the watershed based plan.

The watershed plan has been developed consistent with EPA and CTDEEP guidance for the development of watershed based plans. The guidance outlines nine key elements that establish the structure of the plan, including specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act and improve the chances for funding through other State and Federal sources

A Project Steering Committee led by South Kent School and CTDEEP worked closely with the consultant team and a Watershed Planning Committee, which consisted of representatives from the Town of Kent, the Kent and Weantinoge Land Trusts, Housatonic Valley Association, Northwest Conservation District, South Kent School including the Center for Innovation, Bull's Bridge Golf Club, Club Getaway, and various Kent residents. The watershed plan reflects the combined efforts of the Project Steering Committee, Watershed Planning Committee, and the consultant team. Individuals and groups who were involved in the plan development process are listed in the Acknowledgments section at the beginning of this document.

2 Existing Conditions

2.1 Hatch Pond

The surface area of Hatch Pond is approximately 68.9 acres. Hatch Pond, which is considered a lake[1], is a natural water body that was augmented by the construction of a dam across the outlet by the CTDEEP, which raised the water level of the pond by three feet (NEAR, 2012). The dam is owned and managed by CTDEEP.

Designated as a mesotrophic (i.e., moderate nutrient enrichment) lake in 1991, NEAR (2006) found Hatch Pond to be highly eutrophic, with water clarity declining by 100%, total phosphorus increasing by 800% and total nitrogen increasing by 175% between 1991 and 2006. As of 2006, Hatch Pond was estimated to contain 492 acre-feet of water with a maximum depth of 17 feet. However, earlier publications report a volume of 1,117 acre-feet of water and maximum depths of up to 26 feet, indicating that the lake has undergone significant sedimentation in the past 50 years. This amounts to a loss of 9 feet in maximum depth and more than a 50% loss of volume in that time (2006, NEAR).

Current bathymetry data (*Figure 2-1*) indicate a maximum pond depth of approximately 14 feet (WRS and NEAR, 2014). Other physical characteristics of Hatch Pond can be found in *Table 2-1*, including the ratio of watershed area to lake area. If a lake is small relative to the size of its watershed (e.g., has a large watershed/lake area ratio, as does Hatch Pond), the watershed can potentially have a large influence on in-lake water quality, which is the case for Hatch Pond.

Table 2-1. Hatch Pond Physical Characteristics

Characteristic	Value
Area	68.9 acres
Maximum Depth	14 feet
Mean Depth	7.6 feet
Volume	522 acre-feet
Length of Shoreline	9,100 feet
Watershed Area/Lake Area Ratio	~30
Average Detention Time	49 days

Source: WRS and NEAR (2014)

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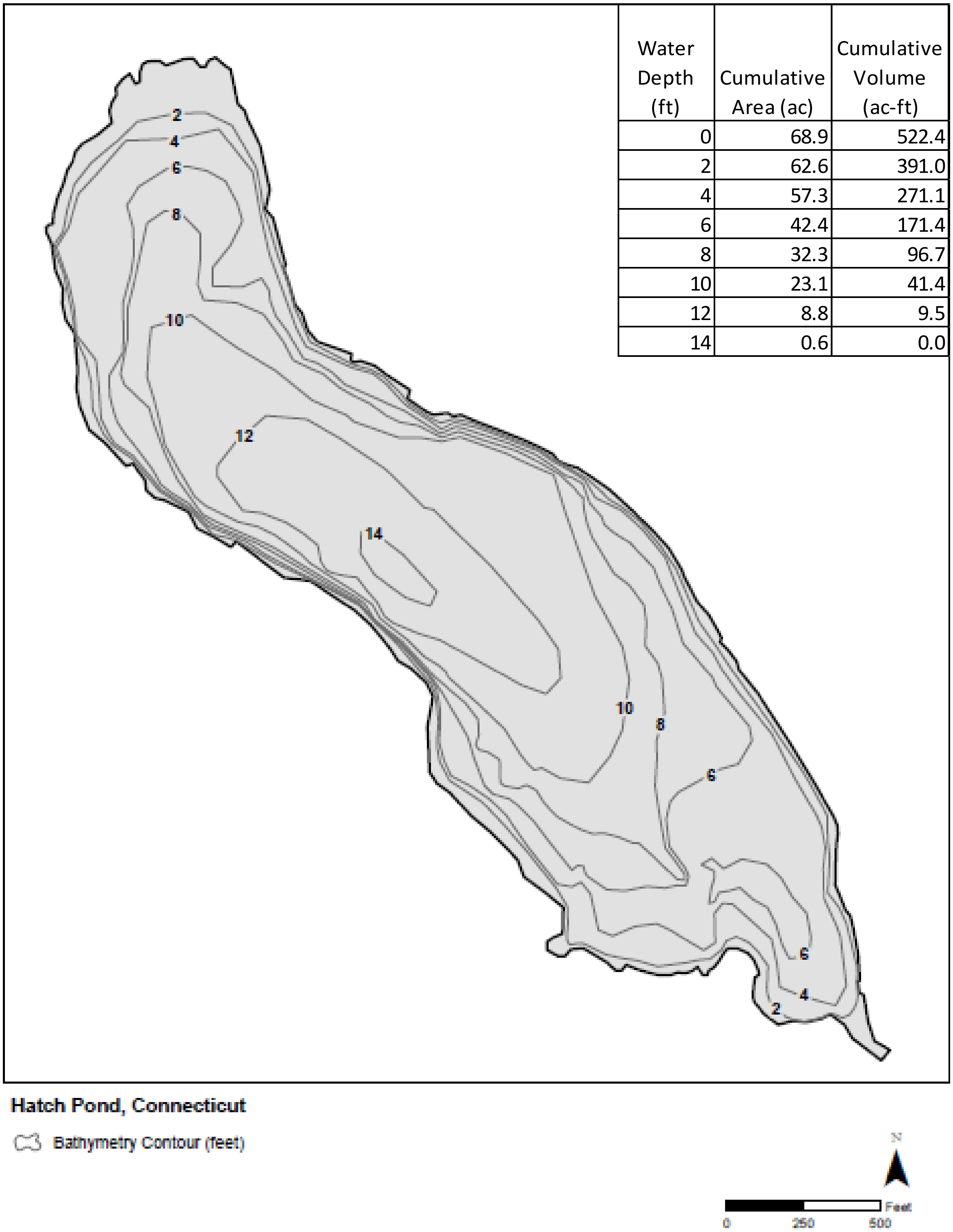
[1] There are no scientific or regulatory differences between lakes and ponds. However, defining characteristics of lakes include: (1) light does not reach the bottom of the deepest point of the water body, (2) waves are larger than 1 foot in height, and (3) variable vertical water temperature is present (Bronmark and Lars-Anders, 2004).



Water Depth (ft)	Cumulative Area (ac)	Cumulative Volume (ac-ft)
0	68.9	522.4
2	62.6	391.0
4	57.3	271.1
6	42.4	171.4
8	32.3	96.7
10	23.1	41.4
12	8.8	9.5
14	0.6	0.0

Figure 2-1. Bathymetry of Hatch Pond (WRS and NEAR, 2014)

2.2 Watershed

The Hatch Pond watershed is approximately 2,009 acres[2]. The watershed has steep topography along the ridgelines on the eastern and western edges of the watershed *(Figure 1-1)*. The northern boundary of the watershed is located near the intersection of Cobble and Segar Mountain Roads. The northern portion of the watershed drains to Leonard Pond, then through a large (74 acre) wetland complex bordering Womenshenuk Brook. Hatch Pond, impounded by Hatch Pond Dam, discharges back into Womenshenuk Brook which eventually discharges into the Housatonic River. Groundwater generally flows from the upland areas along the eastern and western sides of the watershed into the wetlands and ponds in the valley (King's Mark Environmental Review Team, 1991).

The Hatch Pond watershed is located within two towns: Kent and New Milford. The Town of Kent makes up 99% of the watershed area or approximately 1,988 acres (3.1 square miles). New Milford comprises the remaining 1% or approximately 21 acres (0.3 square miles) at the southernmost point in the watershed.

For the purposes of this study, the Hatch Pond watershed was subdivided into six major subwatersheds (*Figure 2-2*). *Table 2-2* lists the drainage area and abbreviation for each subwatershed. Womenshenuk Brook Subwatershed is located around Womenshenuk Brook, north of Hatch Pond and south of Leonard Pond. Wetlands are located along the length of the brook from north to south. It also contains the Center for Innovation, which is the site of the former Arno Farm. School Pond Subwatershed is the southernmost subwatershed, located just south of Hatch Pond. It includes School Pond and an unnamed stream. It also is the subwatershed where South Kent School and Bull's Bridge Golf Club are located, and is partially located within the Town of New Milford. The Headwaters Subwatershed is the northernmost subwatershed and is largely forested with residential areas and some agriculture in the north. It contains Emery Park. The Leonard Pond Subwatershed is located in the northwest portion of the Hatch Pond watershed. It includes Leonard Pond and its associated wetlands. The Segar Mountain Tributary Subwatershed is located just south of the Headwaters Subwatershed. It includes wetlands and a stream that discharges to Leonard Pond. It is also largely forested. The Hatch Pond Direct Drainage Subwatershed includes the immediate area around Hatch Pond. The primary land use in this area is residential and forest.

Table 2-2. Hatch Pond Subwatersheds

Subwatershed	Abbreviation	Area (acres)	Area (mi^2)
Womenshenuk Brook Subwatershed	WB	536	0.84
School Pond Subwatershed	SP	239	0.37
Headwaters Subwatershed	HW	365	0.57
Segar Mountain Tributary Subwatershed	SM	183	0.29
Leonard Pond Subwatershed	LP	347	0.54
Hatch Pond Direct Drainage Subwatershed	DD	339	0.53

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[2] Prior studies (King's Mark Environmental Review Team, 1991) have reported a larger watershed area because the small unnamed tributary that flows from the west side of Bull Mountain was thought to flow into Womenshenuk Brook upstream of the Hatch Pond Dam. However, the confluence of that stream and Womenshenuk Brook is downstream of the dam and outside of the Hatch Pond watershed.

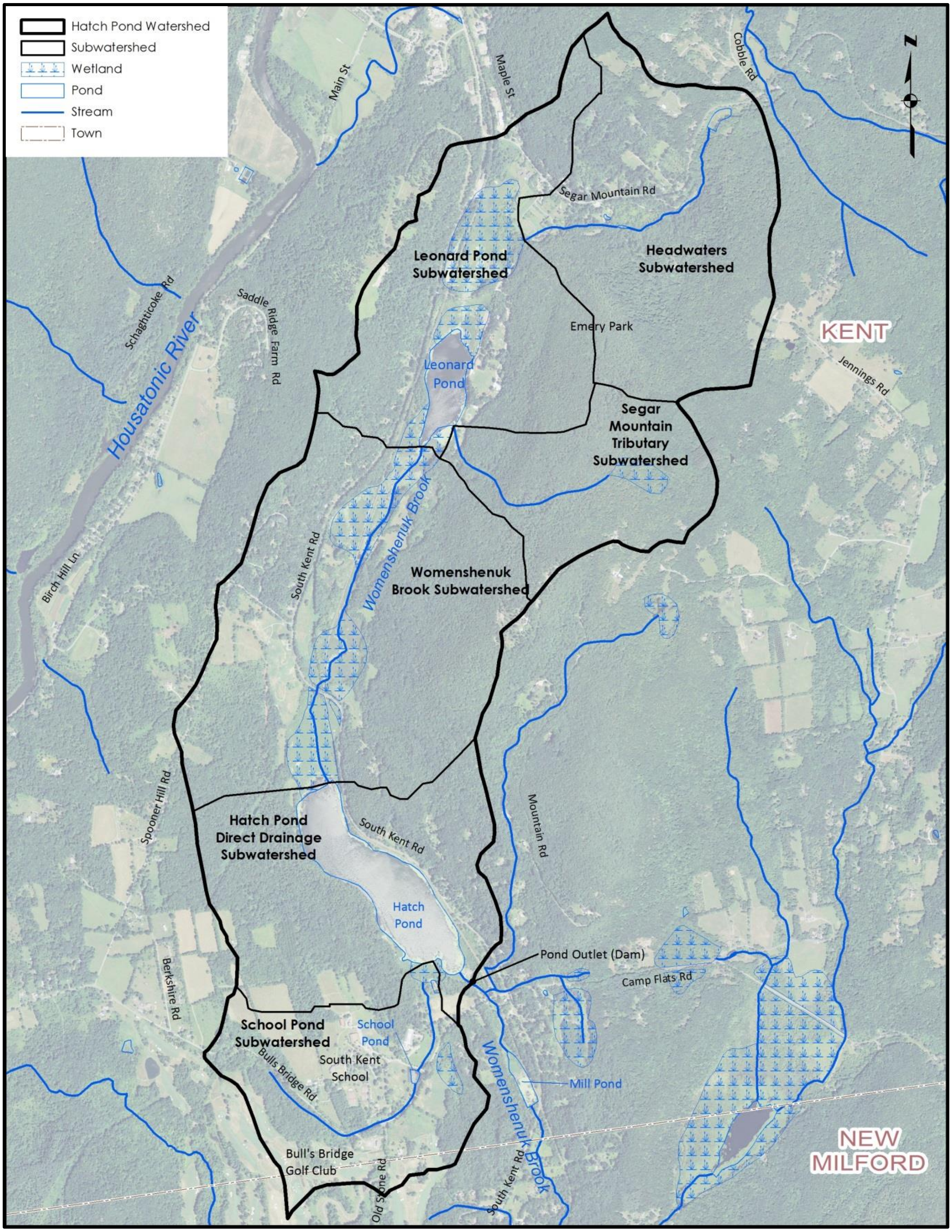

Figure 2-2. Subwatersheds

2.2.1 Hydrology

As described in the King's Mark Environmental Review Team Study (1991), the hydrologic characteristics of the Hatch Pond watershed are influenced by the combination of steep terrain, significant bedrock outcrops, and limited areas of stratified drift. These topographic and geologic characteristics result in conditions where rainfall is quickly converted to runoff from steep slopes, which only slows when reaching the flatter wetland areas in the valley bottom.

The northern portion of the watershed drains into Leonard Pond. The outflow of Leonard Pond becomes Womenshenuk Brook, which has a significant adjacent wetland complex and eventually discharges to Hatch Pond. A southern tributary to Hatch Pond flows generally from west to east from a wetland complex at the Bull's Bridge Golf Club. This tributary flows through School Pond (also called Lew's Lagoon) and discharges to Hatch Pond near its outlet.

Although flows into or discharging from the pond were not measured as part of this study, prior reported measurements by NEAR (2006) across spring, summer, and falls seasons in 2004 and 2005 show the total inflow to the pond to be very low to non-existent in the summer and higher in the spring and fall. The relative contribution of the flow from the north and south tributaries depends upon time of year and rainfall characteristics (NEAR, 2006). Under certain wet weather conditions, flow from the more developed School Pond subwatershed is of similar magnitude to flow from the less developed, but larger, subwatershed area that drains to the northern inlet of the pond. WRS and NEAR (2014) estimate an average surface water inflow of 5.3 cubic feet per second (cfs) for the Hatch Pond watershed, with low summer flows on the order of 0.6 to 1.0 cfs.

Groundwater flow in the watershed is anticipated to follow the same general path as surface water flows, moving via bedrock and surficial deposits from uplands downslope to valley bottoms, eventually discharging to wetlands and surface waters (King's Mark Environmental Review Team, 1991).

2.2.2 Geology and Topography

Topography in the Hatch Pond watershed is dominated by steep, rocky uplands with a narrow lowland comprised primarily of ponds and wetlands. The steep sides of Spooner Hill and Birch Hill form the west side of the valley, and the steep side of Segar Mountain forms the east side of the valley. The transition of land from the valley floor to the steep sides of Spooner Hill and Segar Mountain is very abrupt. Elevations range from 390 to 1,200 feet above mean sea level. The steep slopes observed in the upland topography around Hatch Pond apparently extended into the pond historically (WRS and NEAR, 2014).

Bedrock underlying the watershed consists of metamorphosed limestone or marble and metamorphic schist. The valley occupied by the ponds and wetlands occurs because it is underlain by the marble which is much less resistant to erosion. The eastern and western ridges of the watershed are underlain by schist, a strongly layered, weather resistant, dark colored, mica and quartz-rich rock (King's Mark Environmental Review Team, 1991).

Till and stratified drift are the two major surficial geologic deposits that occur within the watershed. The till is thick on Spooner Hill and consists of a hardpan material made up of a mixture of silt, sand, cobbles and boulders. Stratified drift deposits underlie the ponds and wetlands and a small area in the northern part of the watershed consisting primarily of sand and gravel. The glacial deposits are a major factor in determining the soil and drainage characteristics of the uplands because they form the parent material for soil development and influence the rate of water infiltration and subsurface flow (King's Mark Environmental Review Team, 1991).

2.2.3 Soils

The soils, as designated by the Natural Resources Conservation Service (NRCS), within the Hatch Pond watershed are mostly formed from glacial till deposits over schist, gneiss and granite bedrock. The most abundant soils are Canton and Charlton soils, Charlton-Chatfield complex, Hinckley gravelly sandy loam, Udorthents, Rock outcrop-Hollis complex, Haven and Enfield, Merrimac sandy loam, and various hydric[3] soil types.

The Hollis-Chatfield rock outcrop complex dominates the steep upland areas along the Segar Mountain ridgeline on the eastern slope of the watershed. The northern portion of the watershed contains a variety of soils, including the Charlton-Chatfield complex, Canton, and Merrimack sandy loam with some Hinckley throughout. The southwestern slope of the watershed, including the golf course and Spooner Hill, is dominated by Paxton and Montauk fine sandy loams. The northwestern slopes of the watershed contain a variety of soils, similar to the northern portion of the watershed. The valley of the watershed contains primarily hydric soils, which are characteristic of wetland areas and stream corridors.

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[3] Hydric soils are defined by NRCS as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop aerobic conditions in the upper part.

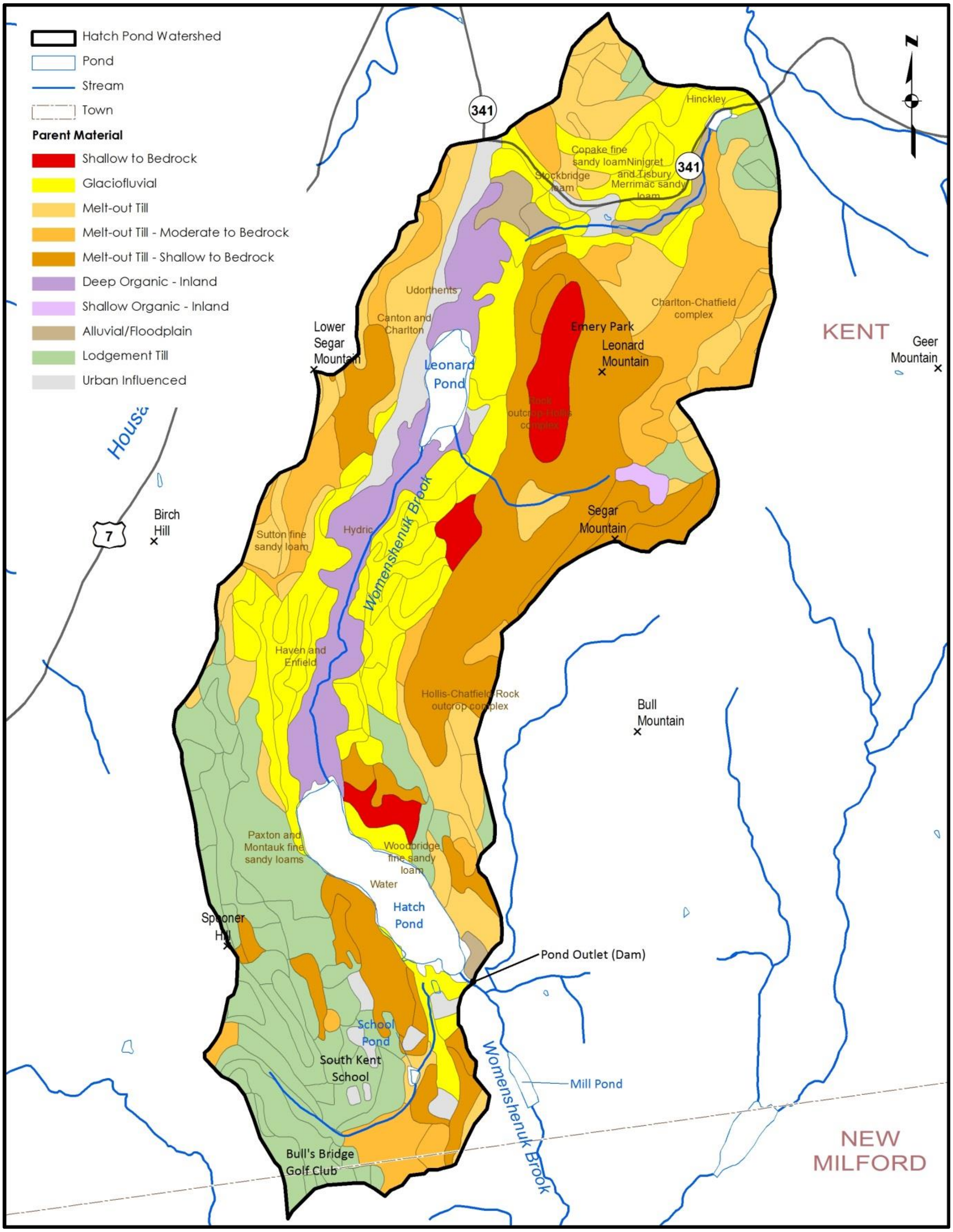

Figure 2-3. Parent Material

The primary soil types, corresponding parent material (i.e., the general physical, chemical, and mineralogical composition in which soil formed), and NRCS Hydrologic Soil Group (HSG) are presented in *Table 2-3*. The location of the parent material across the watershed is presented in *Figure 2-3*. Soils are classified into Hydrologic Soil Groups to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. Group A soils consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission. Group B soils consist of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures with a moderate rate of water transmission. Group C soils consist of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture with a low rate of water transmission. Group D consists chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material with a very low rate of water transmission. *Figure 2-4* shows the distribution of Hydrologic Soil Groups throughout the watershed.

Table 2-3. Soil Characteristics

Soil Type	Parent Material	NRCS Hydrologic Soil Group
Canton and Charlton soils	Melt-out Till	B
Charlton-Chatfield complex	Melt-out Till - Moderate to Bedrock	B
Hinckley gravelly sandy loam	Glaciofluvial	A
Udorthents	Urban Influenced	B
Rock outcrop-Hollis complex	Melt-out Till - Shallow to Bedrock	D
Haven and Enfield soils	Glaciofluvial	B
Merrimac sandy loam	Glaciofluvial	B
Hydric Soil Types	Alluvial Floodplain, Deep Organic – Inland, Shallow Organic – Inland, Glaciofluvial, Melt-out Till, Lodgement Till	Varies

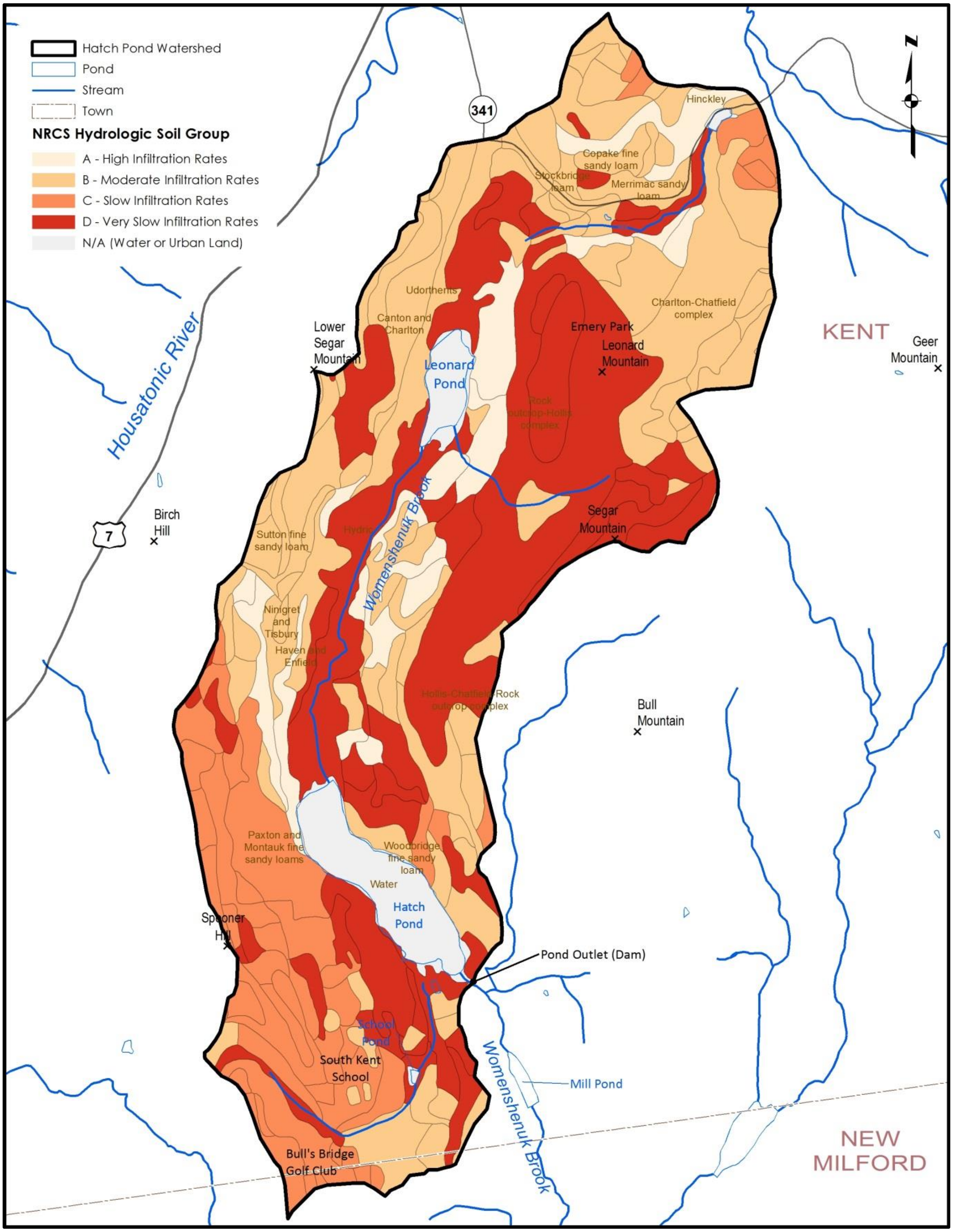

Figure 2-4. NRCS Hydrologic Soil Groups

2.2.4 Weather and Climate

The Hatch Pond watershed is located within a temperate climate characterized by relatively mild winters and warm summers. The average high temperature in July is 84 degrees, and the average low temperature in January is 15 degrees Fahrenheit (National Climatic Data Center, National Oceanic and Atmospheric Administration, 2014). Precipitation is distributed relatively evenly throughout the year, with total annual precipitation in the Kent, Connecticut area averaging approximately 50 inches over approximately 120 days (Connecticut State Climate Center, 2014). Snowfall averages 14 inches per year, with the majority of snow occurring in January and February, although significant snowfall events can occur in December and March (Connecticut State Climate Center, 2014).

2.2.5 Threatened and Endangered Species

The CTDEEP maintains Natural Diversity Data Base (NDDB) mapping that represent approximate locations of endangered, threatened and special concern species and significant natural communities in Connecticut. The locations of species and natural communities are based on data collected over the years by CTDEEP staff, scientists, conservation groups, and landowners. Therefore, the maps are intended to be a pre-screening tool to identify potential impacts to state-listed species, and they are updated approximately every 6 months as new information is continually being added to the database. NDDB areas are identified across much of the watershed area. Although the location of specific species cannot be shown for preservation of the species, the CTDEEP provided a list of known endangered, threatened and special concern species that occur within the watershed *(Table 2-4)*. This information is not necessarily the result of comprehensive or site-specific field investigations, and cannot be used for future permitting.

Table 2-4. Endangered, Threatened, and Special Concern Species within the Hatch Pond Watershed (August, 2014)

Scientific Name	Common Name	State Protection Status
Animals		
Aegolius acadicus	Northern saw –whet owl	Special Concern
Glyptemys insculpta	Wood turtle	Special Concern
Lasiurus borealis	Red bat	Special Concern
Parula americana	Northern parula	Special Concern
Progne subis	Purple martin	Threatened
Sylvilagus transitionalis	New England Cottontail	Federal Candidate
Valvata tricarinata	Turret snail	Special Concern
Plants		
Andromeda polifolia var. glaucophylla	Bog rosemary	Threatened
Carex alata	Broadwing sedge	Endangered
Hypericum ascyron	Great St. John's-wort	Special Concern
Potamogeton ogdenii	Ogden's pondweed	Endangered

During field work within the watershed in July 2014, wildlife observations included painted turtles and deer. Various bird species were also sighted, including blue heron, belted kingfisher, hawk, cedar waxing, and redwing blackbird. Black bears are also known to inhabit the area. Based on the types of habitat found in the watershed, including deciduous and coniferous forest, herbaceous lands, freshwater aquatic, and scrub/shrub wetlands, other wildlife may include eastern small footed bat, hoary bat, eastern ribbon snake, banded sunfish, American black duck and blue spotted salamander.

2.2.6 Wetlands and Floodplains

The State of Connecticut designates wetlands by soil drainage class and landscape position. The following classes of wetland soils are defined by the Connecticut Inland Wetlands and Watercourses Act (Sections 22a-36 through 22a-45 of the General Statutes of Connecticut).

- **Poorly drained soils** – These soils occur in places where the groundwater level is near or at the ground surface during at least part of most years. These soils generally occur in areas that are flat or gently sloping.
- **Very poorly drained soils** – These soils are typically characterized by groundwater levels at or above the ground surface during the majority of most years, especially during the spring and summer months. These areas are generally located on flat land and in depressions.
- **Alluvial and floodplain soils** – These soils form where sediments are deposited by flowing water, and thus typically occur along rivers and streams that are flooded periodically. The drainage characteristics of these soils vary significantly based on the characteristics of the flowing water, ranging from excessively drained where a stream tends to deposit sands and gravel to very poorly drained where a stream deposits silts or clays.

The Federal Clean Water Act definition for wetlands is based on soil characteristics, vegetation, and hydrology. The Federal wetland designation defines wetlands as (Cowardin et al., 1979):

> "Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water as some time during the growing season of each year."

Figure 2-5 depicts the extent and distribution of wetland soils in the Hatch Pond watershed based on Natural Resources Conservation Service soil classifications, following the State of Connecticut definition. *Figure 2-5* also shows wetland classifications available from the U.S. Fish & Wildlife Service National Wetlands Inventory, based on the Federal definition of wetlands. State-designated wetlands and surface waters comprise 17.2% of the overall watershed (approximately 345 acres), while 11.0% of the watershed area (approximately 220 acres) is mapped as Federally-designated wetlands and surface waters. It should be noted that these are not field-verified or delineated wetlands, but provide a general indication of possible wetland areas in the watershed.

Wetlands are an important hydrologic feature of the watershed and provide water quality benefits by removing nutrients and sediment and attenuating peak flows. Properly functioning wetlands remove significant amounts of nutrients during the growing seasons when the wetland plants are flourishing. However, wetlands have the potential to release nutrients during the fall and winter as the wetland plants die off. Therefore, wetlands essentially delay the transport of nutrients until after the growing season when the nutrients are less likely to contribute to algae blooms and aquatic weed growth in Hatch Pond (King's Mark Environmental Review Team, 1991). Areas of vegetation near a stream, known as riparian vegetation or riparian buffers, also help to protect water quality by reducing runoff and capturing sediment and nutrients.

Figure 2-5 also depicts flood hazard areas within the Hatch Pond watershed, including the 100-year and 500-year flood zones. Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified size.

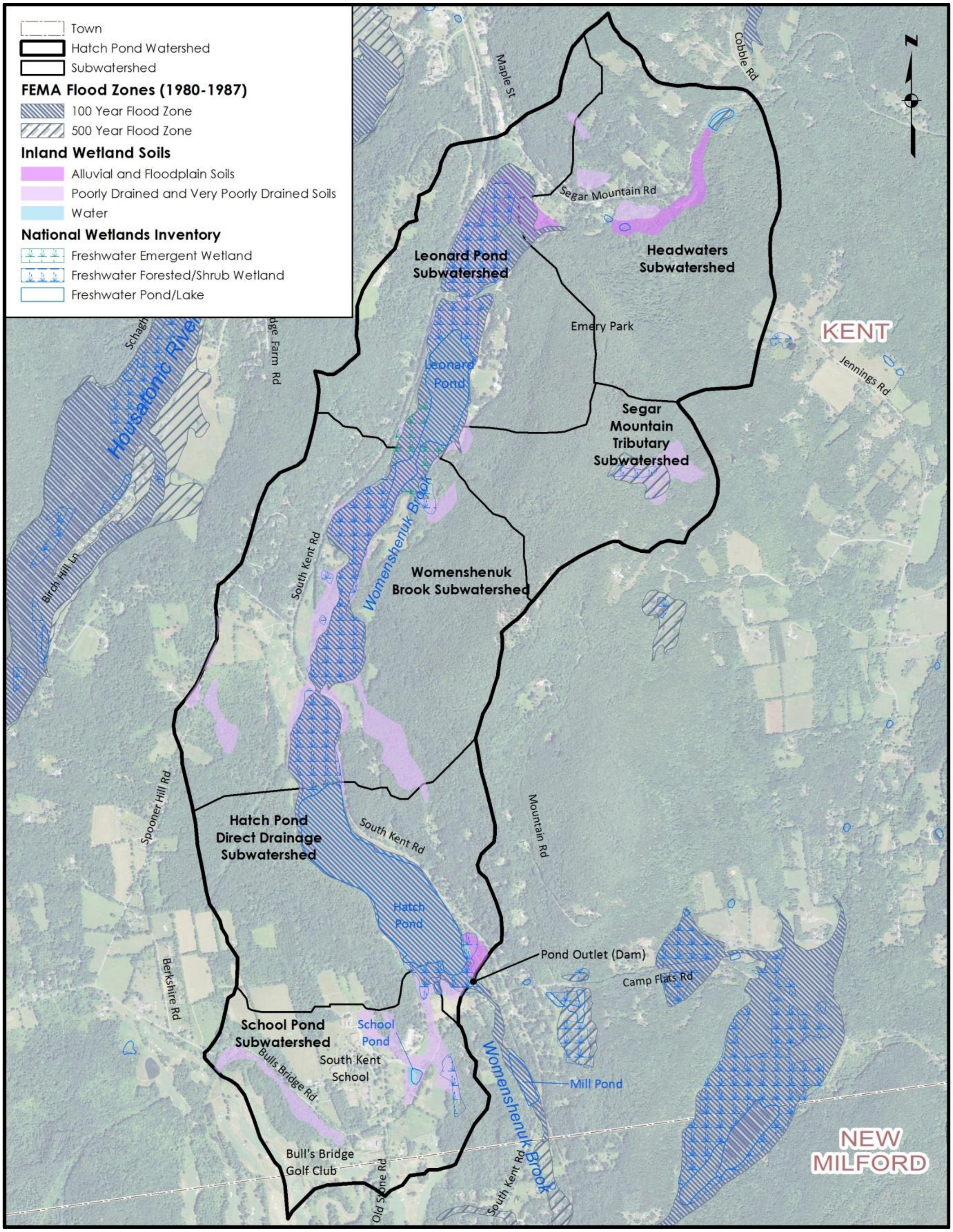

Figure 2-5. Wetlands and Floodplains

2.2.7 Land Use

2.2.7.1 Existing Land Use

The Hatch Pond watershed is sparsely developed, with nearly half of the watershed being forested (46.1%) (*Table 2-5*). Residential land use, which includes approximately 89 households over 20.9% of the watershed, is clustered near the central west and north edges of the watershed and along the eastern edge of Hatch Pond. South Kent School occupies nearly 4% of the watershed adjacent to Hatch Pond and boards approximately 160 high school and post-graduate students. Agricultural land uses comprise nearly 8% of the watershed including the former Arno Farm, which is now the SKS Center for Innovation.

Major roadways in the watershed include Route 341 (Segar Mountain Road), which is the main east-west route, and South Kent Road, which is the main north-south route in the watershed and passes along the east side of Hatch Pond. The Housatonic Railroad runs north-south and serves as a freight transportation line. Industrial uses include the Connecticut Department of Transportation's satellite salt storage facility near the intersection of South Kent Road and Route 341. A farm store associated with the orchard on Route 341 is the only identified commercial use within the watershed. Bull's Bridge Golf Club is another distinct land use in the watershed, occupying nearly 3% of the watershed at its southernmost extent.

Table 2-5. Land Use

Land Use	Acres	Percentage of Watershed
Agriculture	156	7.8%
Commercial	1.27	0.1%
Forest	926	46.1%
Golf Course	58.7	2.9%
Industrial	2.51	0.1%
Recreation	96.2	4.8%
Residential	420	20.9%
Road/Railroad	74.5	3.7%
School	77.5	3.9%
Water	86.6	4.3%
Wetland	109	5.4%

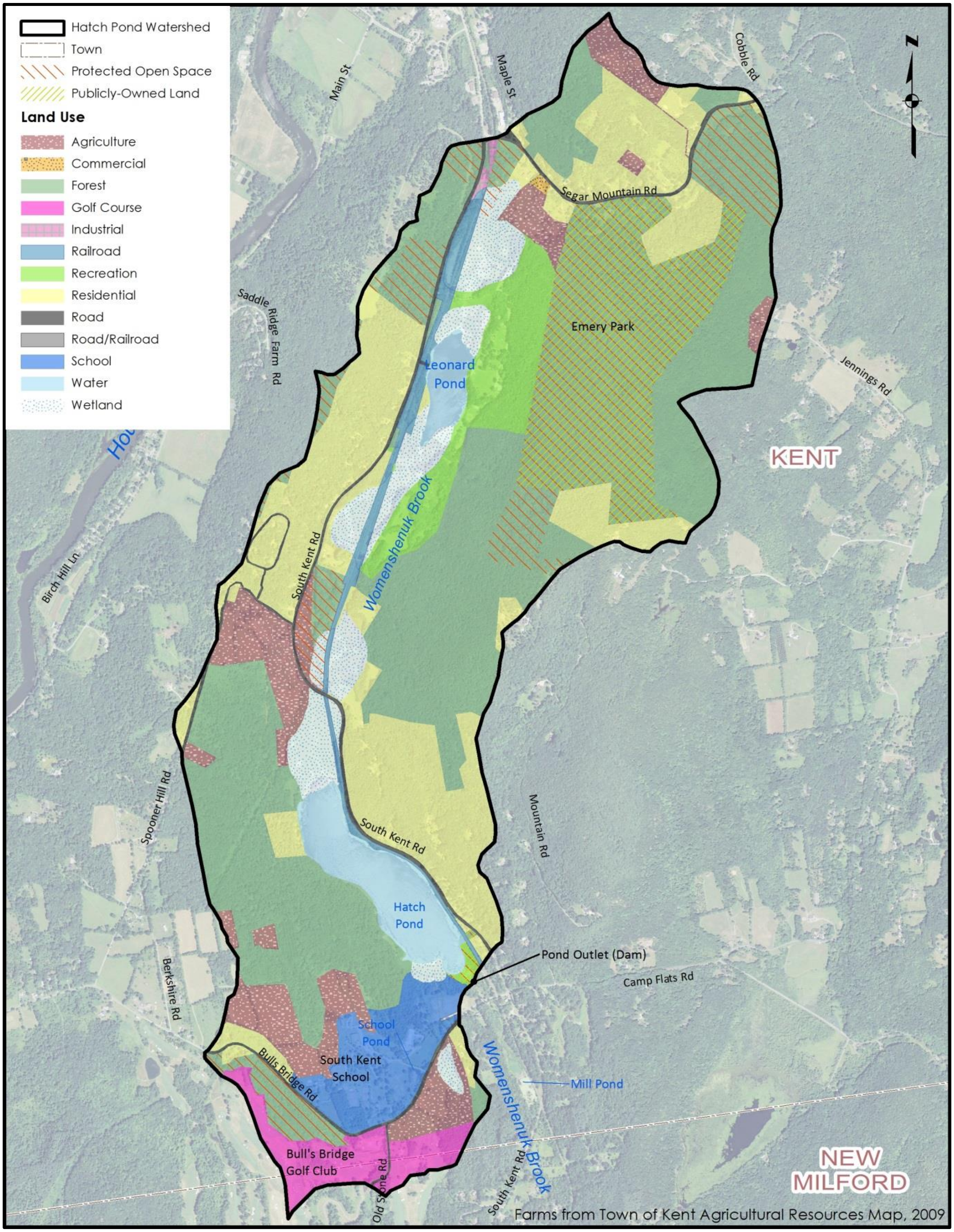

Figure 2-6. Land Use

The majority of the land within the Hatch Pond watershed is privately-owned. The large land owners within the watershed include:

- South Kent School – 330 acres
- Infinity Fields (South Kent School) – 120 acres
- Club Getaway – 259 acres
- Town of Kent (Emery Park) – 234 acres
- Kent Land Trust – 84 acres
- Bull's Bridge Golf Club – 80 acres

Large public parcels of land in the watershed include Emery Park, owned by the Town of Kent, and several tracts of preserved land owned by the Kent Land Trust. Other notable land owners include the Aquarian Water Company which owns 33 acres, and the Housatonic Railroad running through the center of the watershed, which totals 40 acres of land. Publicly-owned land is depicted on the land use *Figure 2-6*.

2.2.7.2 Historical Land Use

Historical land use in the watershed was dominated by agriculture. A comparison of aerial photographs in *Figure 2-7* shows watershed conditions in 1934 (left) and 2012 (right). Light-colored areas indicate cropland and pasture, with darker areas showing forested land. Most notable is the change from farmland to forested area in the southwest portion of the watershed between 1934 and 2012.

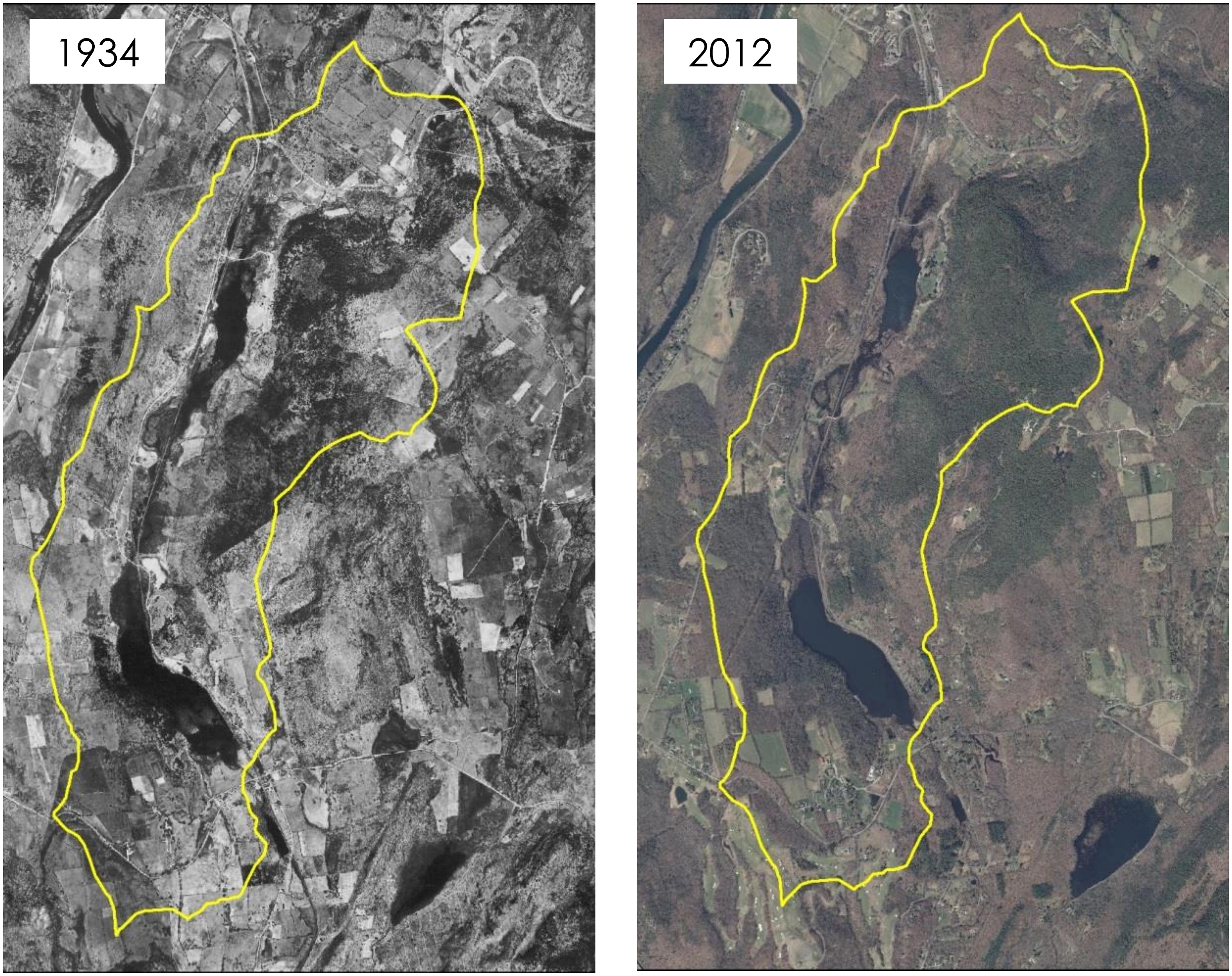

Figure 2-7. Hatch Pond Watershed Aerial Photography 1934 (left) and 2012 (right)

The approximately 128-acre Arno Dairy Farm was located at the northern end of Hatch Pond. From 1968 to 2010 the farm was owned by Detlev Vagts and leased and farmed by the Arno family. Previously, the Arno Farm raised horses, pigs (approximately 80), chickens (approximately 250) and dairy cows (230 to 240 at peak). In the past, the facility kept silage in an open bunker silo, causing concern over groundwater contamination when silage leachate infiltrated into the sandy soil below the bunker. Manure from cows and pigs was stored on-site in an unlined structure and used for fertilizer elsewhere in Kent. Milkroom waste was also discharged into an on-site waste storage facility. Cows grazed near the Hatch Pond marshland and in pastures to the north and south in winter. Additionally, the loafing areas between the cow and pig barns were concrete, with no runoff controls. Contaminated discharge from these areas was thought to pose a risk to groundwater. Based on typical practices during the period, it is assumed that dead animals were buried on the farm (Manes, 2014).

The Arno Farm received EQIP grants in 1996 and 2001 from the Natural Resources Conservation Service of the U.S. Department of Agriculture and the Connecticut Department of Agriculture to address resource concerns and to install an agricultural waste management system. In June 2003, a "Comprehensive Nutrient Management Plan" was developed. The plan included 15 practices to protect surface and groundwater from contamination from nutrients, pathogens, antibiotics, and other pollutants related to farming. Of these practices, documentation suggests that a roof was installed over the cow feeding area and a runoff diversion plan for the heavy use area was implemented. The lined waste storage facility was at least partially completed, but the planned lined outlet for clean stormwater diversion to the wetlands was not approved by the Town of Kent. It is unclear how many other practices were completed. Some may have been partially completed, but there was concern that the implemented improvements were not maintained properly (Manes, 2014).

After its sale in 2010, the property was managed and operated by South Kent School as part of the Center for Innovation. Existing structures were demolished, and some restoration practices were put in place. Currently, the Center for Innovation operates a small sustainable farm with bee hives, two oxen, four pigs, and ten chickens. In the future it will expand to have 35 chickens and several goats and sheep. There is currently no pesticide or herbicide use, and no salt or sand use for the gravel driveway (Taylor, personal communication, July 28, 2014). Soil testing was conducted in 2012, and plant-available phosphorus levels were found to range from 0.5 to 40 ppm (UCONN Soils Nutrient Laboratory, 2012).

2.3 Water Quality

Water quality is a primary indicator of the ecological health of a water body and its ability to support specific uses such as water supplies, recreation, habitat, and industrial uses. Water quality is also inherently linked to the activities that take place in a watershed. Hatch Pond and its watershed have been assessed for water quality several times over the past 35 years. This section reviews the water quality standards relevant to Hatch Pond and its tributary streams and summarizes prior monitoring results in the lake and watershed.

2.3.1 Classifications, Designated Uses, and Impairments

The Federal Clean Water Act (CWA) was established to protect the nation's surface waters. Through authorization of the CWA, the United States Congress declared as a national goal "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water wherever attainable." The CWA requires states to:

1. Adopt Water Quality Standards,
2. Assess surface waters to evaluate compliance with Water Quality Standards,
3. Identify those waters not currently meeting Water Quality Standards, and
4. Develop Total Maximum Daily Loads (TMDL) and other management plans to bring water bodies into compliance with Water Quality Standards.

Connecticut Water Quality Standards (CWQS) are established in accordance with Section 22a-426 of the Connecticut General Statutes and Section 303 of the CWA. The Water Quality Standards are used to establish priorities for pollution abatement efforts. Based on the Water Quality Standards, Water Quality Classifications establish designated uses for surface, coastal and marine and groundwaters and identify the criteria necessary to support these uses. The Water Quality Classification system classifies inland surface waters into three different categories, Class AA, Class A and Class B, with certain designated uses for each category (*Table 2-6*).

Table 2-6. Connecticut Surface Water Quality Classifications

Designated Use	Inland Surface Waters		
	Class AA	Class A	Class B
Existing or proposed drinking water supply	●		
Potential drinking water supply		●	
Habitat for fish, other aquatic life, and wildlife habitat	●	●	●
Recreation	●	●	●
Industrial and/or agricultural supply	●	●	●
Navigation	●	●	●

Water Quality Classifications of surface water and groundwater in the Hatch Pond watershed include Class AA and A. The headwaters stream, including the area of the former pond impounded by Segar Dam that is now a wetland, is classified as Class AA. The remainder of the streams within the Hatch Pond watershed are designated as Class A surface water bodies. Designated uses for both Class AA and Class A water bodies are listed in *Table 2-6*.

The groundwater classification within the majority of the watershed is Class GA - groundwater within the area of existing private water supply wells or an area with the potential to provide water to public or private water supply wells, suitable for drinking or other domestic uses without treatment. The northern portion of the watershed is classified as Class GAA, which is groundwater that is tributary to a public water supply reservoir. There is also a groundwater well located north of Leonard Pond that is classified as GAA-Impaired, for GAA designated groundwater not meeting the designated use *(Figure 2-8)*.

The CWA requires each state to monitor, assess and report on the quality of its waters relative to attainment of designated uses established by the CWQS. When waters are not suitable for their designated use, they are identified as "impaired." Every two years, the State of Connecticut assesses watercourses and water bodies in the state and provides to EPA a list of impaired waters.

According to the *2012 State of Connecticut Integrated Water Quality Report*, the most recent report available, Hatch Pond (CT6016-00-1-L3_01) is a freshwater lake listed as not supporting for aquatic life and recreation due to elevated levels of chlorophyll-a, low dissolved oxygen saturation, excess nutrient/eutrophication, and sedimentation or siltation. The potential sources were determined by the CTDEEP to include historic agricultural activities, which have been discontinued (CTDEEP, 2012).

Table 2-7. Designated Uses and Impairments for Hatch Pond

Designated Use	Cause of Impairment	Potential Sources
Habitat for Fish, Other Aquatic Life and Wildlife	Chlorophyll-a	Potential sources include historic agricultural activities - Note: activities have been discontinued, monitoring is ongoing to determine status
	Dissolved oxygen saturation	
	Excess Algal Growth	
	Nutrient/ Eutrophication Biological Indicators	
	Sedimentation/ Siltation	
Recreation	Chlorophyll-a	
	Excess Algal Growth	
	Nutrient/ Eutrophication Biological Indicators	
	Sedimentation/ Siltation	

No other impairments have been identified for water bodies in the Hatch Pond watershed. Leonard Pond (CT6016-00-1-L2_01) is a freshwater lake upstream of Hatch Pond with designated uses including aquatic life and recreation. Leonard Pond is Fully Supporting for aquatic life and is not been assessed for recreation.

Hatch Pond's impairment is closely linked to the fact that is it eutrophic. CTDEEP uses four water quality parameters to assign a lake or pond to a eutrophic class (*Table 2-8*).

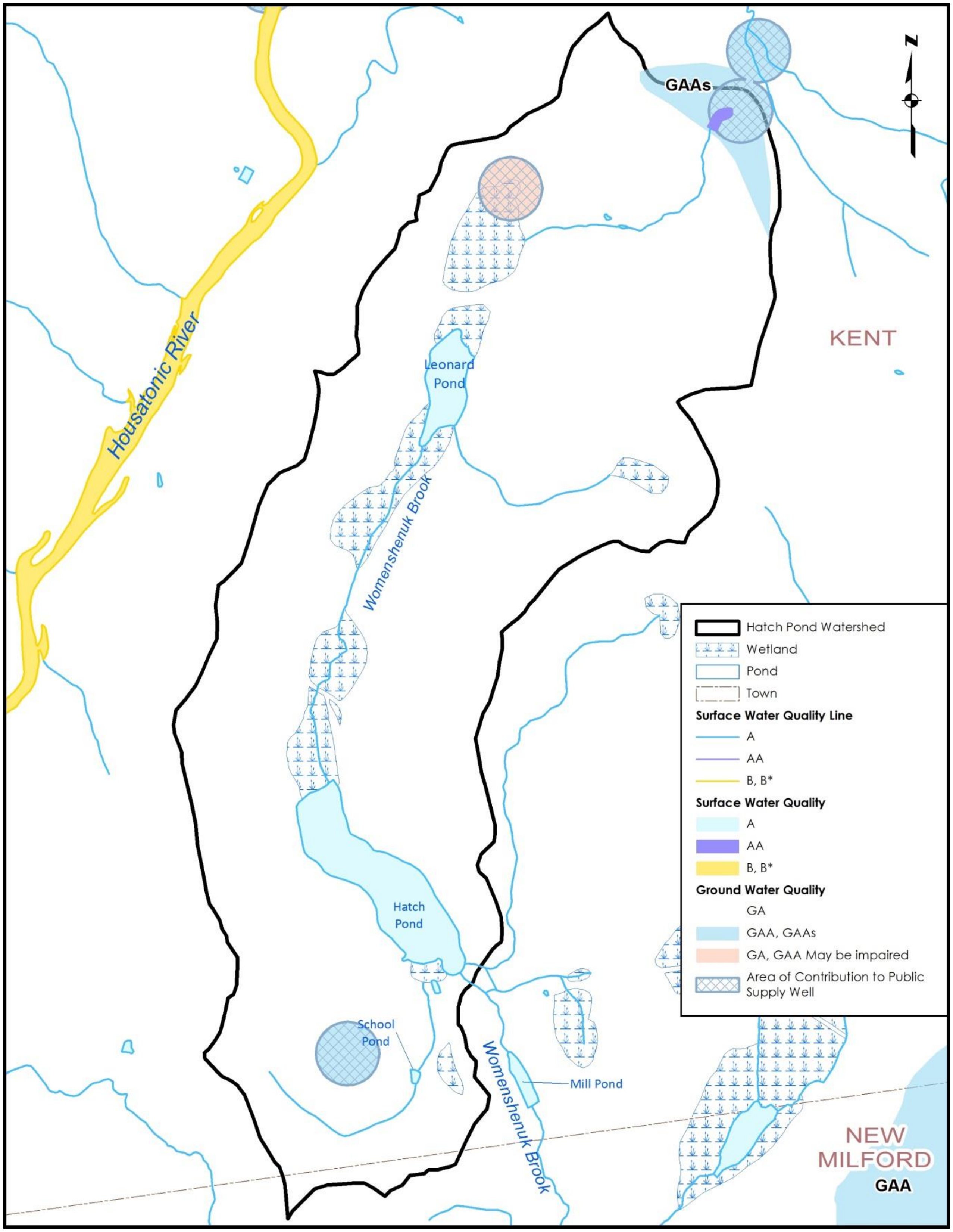

Figure 2-8. Water Quality Classifications

Table 2-8. Parameters and Defining Ranges for Trophic State of Lakes in Connecticut (CTDEEP, 2013)

Category	Total Phosphorus* (ppb)	Total Nitrogen* (ppb)	Chlorophyll-a** (ppb)	Secchi Disk Transparency** (m)
Oligotrophic	0 - 10	0 - 200	0 - 2	6+
Mesotrophic	10 - 30	200 - 600	2 - 15	2 - 6
Eutrophic	30 - 50	600 - 1,000	15 - 30	1 - 2
Highly Eutrophic	> 50	> 1,000	> 30	0 - 1

*****measured spring and summer, ******measured mid-summer, Note: µg/l = ppb

- Phosphorus and nitrogen are nutrients responsible for plant growth in water bodies. Nutrients, especially phosphorus, are frequently the key stimulus to increased and excessive algal biomass in many freshwaters.
- Secchi disk depth is a measure of water clarity. Decreased clarity, often due to increased algal biomass, is an indicator of eutrophication.
- Chlorophyll-a is a measure of phytoplankton biomass, which is elevated under eutrophic conditions.

Under this classification scheme, lakes and ponds range from oligotrophic (low productivity and nutrient content), to mesotrophic (intermediate level of productivity and nutrient content), to eutrophic (high productivity and nutrients) or highly eutrophic (extremely high productivity and nutrients, and very low visibility).

The U.S. EPA has also established guidance for total phosphorus (TP) concentrations for freshwater streams and lakes to limit the excessive growth of aquatic vegetation (EPA, 1986):

- No more than 0.1 mg/L for streams that do not discharge to lakes and reservoirs,
- No more than 0.05 mg/L for streams that discharge to lakes and reservoirs, and
- No more than 0.025 mg/L for lakes and reservoirs.

1 ppb is approximately equal to 0.001 mg/L. Therefore, CTDEEP's 30 ppb threshold for mesotrophic to eutrophic status in lakes is similar to, although slightly higher than, the U.S. EPA recommended 0.025 mg/L for lakes and reservoirs.

2.3.2 Water Quality Monitoring Data

Primary sources of water quality monitoring data for Hatch Pond and its watershed that were reviewed and are summarized in this section consist of:

- The Trophic Classifications of Forty-Nine Connecticut Lakes by the Connecticut Department of Environmental Protection (1991)
- Diagnostic Study of Hatch Pond by NEAR (2006)
- Hatch Pond Water Quality Assessment, 2010 Update by NEAR (2012)
- Hatch Pond Study 2014: In Lake Conditions, Processes and Possible Management Options (WRS and NEAR, 2014)

- Grab sample data for tributary streams collected by Fuss & O'Neill during July 2014.

The findings of these studies are summarized below, grouped by water quality parameter.

Phosphorus and Nitrogen

NEAR (2012) measured phosphorus and nitrogen concentrations at two in-lake and five watershed locations in July, August, and September 2010. In 2010, total phosphorus (TP) concentrations at the lake surface were approximately 62 ppb, a decrease from the highest concentrations observed in 2005 (115 ppb) and 2006 (126 ppb) (NEAR, 2006). As in prior years, the 2010 data showed a peak in TP concentration in the summer. The analysis presented by NEAR (2012) suggested that the highest concentrations of phosphorus could likely be attributed to nutrient loading from the Arno Farm, and approximately 40 to 70 ppb could be attributed to internal nutrient recycling alone.

In addition to the decline in surface TP concentrations, TP at depth (~14 feet) was significantly lower in 2010 than in prior years. NEAR (2012) concluded that the comparison of 2005-2006 data with 2010 data indicated that phosphorus mass in the water column decreased as much as 50% within the 4-5 year time span, which included the closing of agricultural operations at Arno Farm.

Measurement of TN and ammonia showed similar reductions, with TN concentrations dropping from 100-7800 ppb (2004-2006) to 900-2000 ppb (2010), suggesting an approximately 50% decrease in TN in Hatch Pond (NEAR, 2012). Ammonia, a form of nitrogen that can be discharged in waste waters and also liberated from sediment during anoxic conditions, also declined in Hatch Pond. While surface concentrations of ammonia were measured at approximately 400 ppb in 2004-2006, 2010 summer concentrations were approximately 100 ppb. Bottom concentrations also declined from 2000 to 3000 ppb (2004-2006) to less than 1000 ppb in 2010, a result NEAR (2012) attributed to both a decrease in nitrogen load to the pond and lower intensity anaerobic conditions and subsequent reduction in ammonia release from sediment.

The most recent water quality data collected by Water Resource Services, Inc. and Northeast Aquatic Research, LLC (WRS and NEAR, 2014) show that decreases in TP observed by NEAR (2012) have persisted. TP data was collected at the lake surface, at approximately 6 feet from the lake surface, and at the lake bottom (approximately 14 feet) from April – September, 2014. Maximum and average TP at the surface were 42 ppb and 32 ppb, respectively. At depth, maximum and average TP values were 147 ppb and 12 ppb, respectively. TN values at the surface showed a continuing decline with maximum and average surface concentrations of 669 ppb and 488 ppb, respectively. Similarly, TN values at depth were a maximum of 1047 ppb in August and averaged 574 ppb over the period of data collection in 2014, results that are consistent or slightly lower than 2010 data and less than half the value of concentrations observed in 2004-2006 at the lake bottom.

Sampling at tributary locations in both wet and dry weather was performed by NEAR in 2004-2005 (NEAR, 2006) and in 2010 (NEAR, 2012). NEAR (2012) provided a summary and comparison of the sampling results from the two time periods. The 2012 report concluded that following key points regarding nutrient water quality in the tributary locations:

- Wet weather (i.e., stormwater samples) collected from the discharge point of the Arno Farm showed a decreased in TP concentrations of at least two orders of magnitude, from >15,000 ppb (2005) to 297 ppb (2011).
- Differences in TP contributions upstream versus downstream of the Pond observed in 2004/2005 were not observed in 2010, indicating the contribution of the Arno Farm to nutrient loading while it was in operation.
- The southern tributary to the Pond has TP values between 10-185 ppb and concentrations were higher above South Kent School (SKS) than below it. NEAR (2012) concluded that phosphorus sources above SKS were likely attenuated by storage in stream channel sediments, in the SKS pond, or in wetlands downstream of the SKS pond.
- Samples collected upstream of the school at the discharge of the Bull's Bridge Golf Club, ranged from <50 ppb to 310 ppb over the period 2001-2010, with an average value of 122 ppb, indicating concentrations there were above the EPA guidelines for streams and a significant source of phosphorus.
- While ammonia was below detection limit in the tributary discharging to Hatch Pond in the south, the northern tributary had measurable values (typically less than 40 ppb) in 2010, which may be due to wetlands.
- As with TP, nitrate concentrations in the vicinity of the former Arno Farm decreased and were close to or below detection limit. In contrast, in the southern tributary, concentrations were higher in upstream portions of the stream (similar to the spatial distribution of TP) and had an average value of 602 ppb, indicating a significant source of nitrate.

Grab samples were collected by Fuss & O'Neill at five locations throughout the Hatch Pond watershed on July 24, 2014 (*Figure 2-9*). Unlike earlier samples taken by NEAR (2006, 2012), these included upstream locations. While all stream samples were above the recommended phosphorus concentration of 25 ppb, the highest observed TP was at Womenshenuk Brook at Kent Road, within the wetland complex. Similar to concentrations observed by NEAR (2012), TP concentrations of 10-185 ppb were observed throughout the watershed. NEAR (2012) found samples upstream of the school to have a mean concentration of 72 ppb TP, and samples downstream of South Kent School to have a mean of 44 ppb, with upstream school concentrations exceeding below school concentrations during sampling events. NEAR suggests that this may be due to a phosphorus source upstream, and phosphorus being stored in wetlands and/or channel sediments near the southern inlet of Hatch Pond. Similarly, Fuss & O'Neill samples show slightly higher concentrations at upstream location WQS-05 (139 ppb) than at WQS -03 (128 ppb).

Water Clarity

Measurement of Secchi disk depths in 2010 (NEAR, 2012) were less than 3 feet, indicating highly eutrophic conditions. As in earlier studies, 2010 water clarity was worst in the summer when phytoplankton growth was at its maximum, and improved in spring and fall (NEAR, 2012).

In 2014, water clarity was in excess of 10 feet through May, but declined in June to 7 feet and was between 4.3 and 5.3 feet for the summer. Most of the loss of clarity was due to algae in the water, but some resuspension of inorganic or non-living organic matter occurs as well and reduces clarity. The relatively higher clarity in spring allows rooted plants to grow, while lower clarity during summer limits additional growth. Past studies have suggested depths of plant colonization between 7 and 9 feet. Areas less than 9 feet deep had dense plant growth in 2014, with some growth to depths of 11 feet (WRS and NEAR, 2014).

Algae and Zooplankton

The phytoplankton of Hatch Pond have been dominated by blue-green algae (cyanobacteria) during summer for many years. Conditions in Hatch Pond have been ideal for cyanobacteria growth for many years, but started shifting with the cessation of dairy operations at the former Arno Farm. The phytoplankton in 2014 included cyanobacteria, but samples of the upper 6 to 8 feet of the water column were not dominated by cyanobacteria biomass. The reduction in blue-green blooms could be partly a function of weather, as summer 2014 was not as hot or as wet as other recent summers, but is more likely a consequence of reduced phosphorus concentrations and higher N:P ratios observed in 2014 (WRS and NEAR, 2014). Overall, the zooplankton community of Hatch Pond was considered to be in a desirable condition in 2014 (WRS and NEAR, 2014).

Macrophytes

Although not reported as present by CTDEEP in 1991, NEAR (2012) reported the presence of Eurasian milfoil *(Myriophyllum spicatum)* in 2000 and 2006 (approximately 20 acres of the Pond surface with a depth of 9 feet). In 2012, the coverage was reduced to approximately 16 acres and a decreased depth of 7 feet which NEAR (2012) concluded may be due to a decline in water clarity and or anoxic water present at depths greater than 7 feet. Non-native curly pond weed was also reported and NEAR (2012) noted a general decline in the diversity of aquatic plants. Similar plant coverage was observed in 2014. Most of the water column was filled with plants in water less than 9 feet deep, and dense plant growths represented the most obvious use impairment in 2014 (WRS and NEAR, 2014).

Temperature

The 2012 NEAR study concluded that Hatch Pond has consistently formed a thermocline in the summer months. The boundary occurs at depths of approximately 2 to 4 meters (6.6 to 13.1 feet) while it exists (NEAR, 2012). In 2014, only limited thermal stratification was observed (WRS and NEAR, 2014).

Dissolved Oxygen

Concentrations of dissolved oxygen in Hatch Pond are important for both aquatic life and nutrient recycling from bottom sediments. The CTWQS identify a criterion of 5 mg/L dissolved oxygen for the protection of aquatic life habitat. In addition, anoxic conditions allow for the release of nutrients from bottom sediments in the Pond. NEAR (2012) reported that anoxic conditions are present in most of the lake volume, beginning at the bottom in spring and expanding to within 3 to 5 feet of the water surface during summer months.

WRS and NEAR (2014) suggest that only temporary anoxia may have occurred in Hatch Pond in 2014. Without any true thermal stratification, the pond still managed to lose oxygen from the bottom through decomposition at a rate too rapid for atmospheric re-aeration to counter, and low oxygen conditions were encountered for about two months. This promotes release of phosphorus from bottom sediments (WRS and NEAR, 2014).

Total Suspended Solids and Conductivity

Total suspended solids (TSS) and conductivity were also measured in the grab samples collected by Fuss & O'Neill in July 2014. Conductivity, which is an indirect measure of the presence of inorganic dissolved solids, was measured over a relatively narrow range. Measured values north of Hatch Pond were 180-184 µhos/cm. Slightly higher values of 280-287 µhos/cm were measured at sampling locations in the southern part of the watershed. All measurements were within the range generally recommended for fish habitat (150 to 500 µhos/cm).

TSS is a measurement of particles larger than 2 microns found in the water column and can include sediment, silt, sand, plankton, algae and other organic particles. TSS is inversely related to water clarity – the higher the TSS concentration, the less clear the water will be (waters with TSS between 25 mg/L and 40 mg/L begin to appear "muddy"). For comparison, a USGS study of rivers in New England coastal basins show the majority of samples having suspended sediment concentrations of 20 mg/L or below (Campo et al., 2003). TSS concentrations in samples collected by Fuss & O'Neill in July 2014 ranged from 2.5 to 15 mg/L.

Bottom Sediment

Hatch Pond has experienced significant sedimentation over the past 50 years, with an estimated 50% loss of lake water volume[4]. WRS and NEAR (2014) estimates that a removal of soft sediment to a water depth of 15 feet would require removal of approximately 390,000 cubic yards (yd^3) of sediment from Hatch Pond. Removal to a water depth of 30 feet would require approximately 1.4 million yd^3 be removed. These are very large quantities of soft sediment for a relatively small water body, indicating the strong influence of watershed sediment sources over time, as well as more recent contributions from plant biomass. The depth of bottom sediments in Hatch Pond is shown in *Figure 2-1*.

2014 sediment quality data indicate that the sediment concentrations of metals, hydrocarbons, and pesticides are not a concern and would not restrict disposal of dredged sediment, but moderate levels of phosphorus are present (132 to 180 mg/kg), which are substantially high enough to support algal blooms (WRS and NEAR, 2014).

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[4] It is possible that the bathymetry measurements made about 60 years ago were made with weights on graduated lines that went considerably into the soft sediment before stopping, thereby overestimating water depth. The high level of internal organic production and the establishment of emergent wetland at the north end of the pond suggest substantial infilling even if water depths were overestimated (WRS and NEAR, 2014).

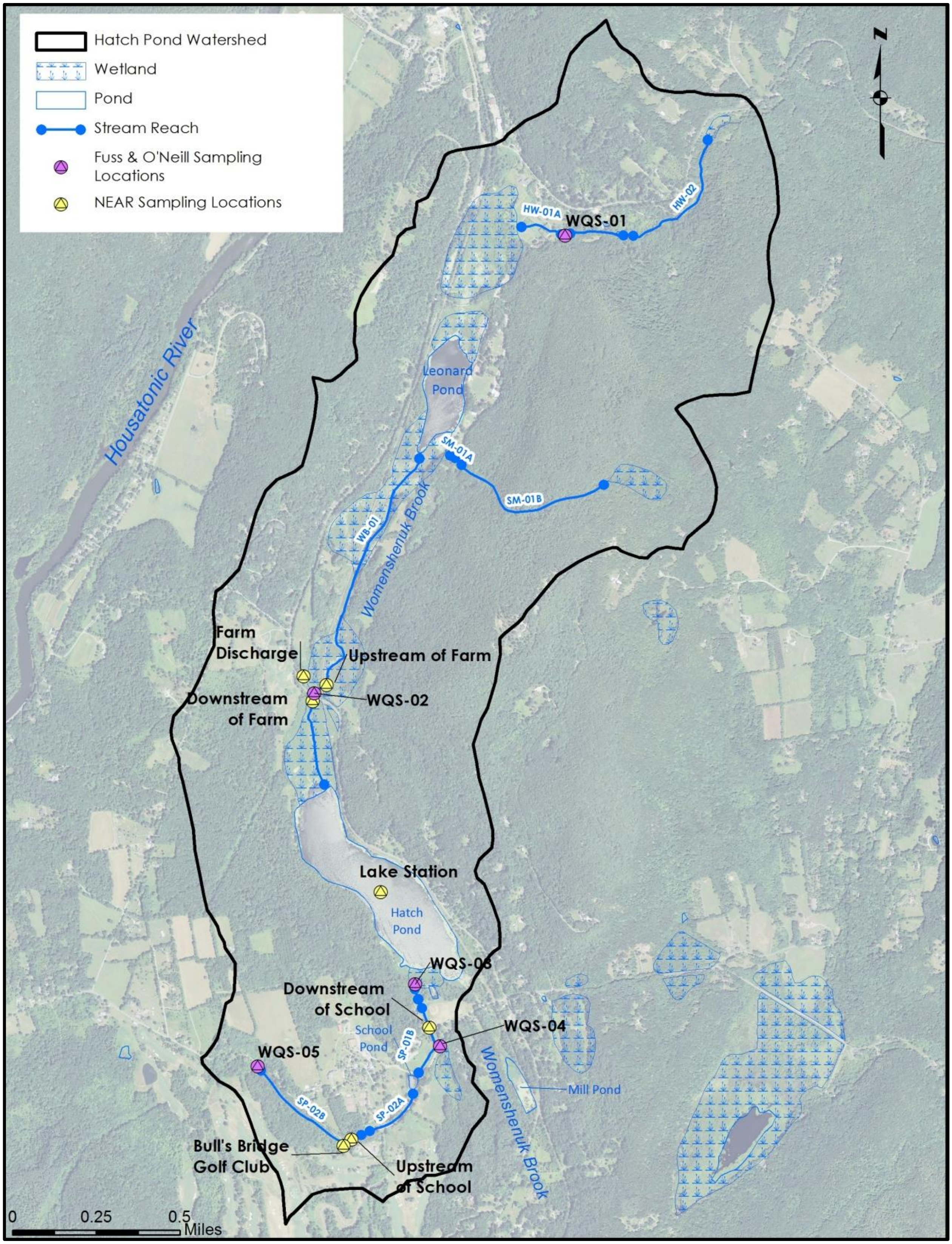

Figure 2-9. Water Quality Sampling Locations

Table 2-9. Summary of July 2014 Field Sampling Results

Location ID	Location Description	Reach	Conductivity (µmhos /cm)	TP (ppb)*	TSS (mg/L)
WQS-01	Emery Park	HW01B	184	55.2	2.5
WQS-02	Womenshenuk Brook at South Kent Road	WB01	180	257	15
WQS-03	School Pond tributary at Hatch Pond inlet	SP01	281	128	2.5
WQS-04	Discharge from soccer fields and eastern portion of golf course	SP01 Tributary	287	68.7	13
WQS-05	Bull's Bridge Golf Club, west wetland discharge	SP02	280	139	5.5

*1000 ppb = 1 mg/L

2.4 Field Assessments

2.4.1 Shoreline and Stream Assessments

The assessments described in this section evaluate stream reaches for conditions that indicate potential impact to stream health. The method used in this study consisted of a continuous stream walk for each reach, generally moving upstream within the channel or along the bank, to identify and evaluate the following conditions[5]:

- Reach Level Assessment (RCH), the average characteristics of each reach;
- Outfalls (OT), including stormwater and other manmade point discharges;
- Severe Bank Erosion (ER), such as bank sloughing, active widening, and incision;
- Impacted Buffer (IB), which is a narrowing or lack of natural vegetation;
- Utilities in the stream corridor (UT), such as leaking or exposed pipes;
- Trash and Debris (TR), such as drums, yard waste, and other illegal dumping;
- Stream Crossings (SC), which are hard objects, whether natural or artificial, that restrict or constrain the flow of water. These may include bridges, road crossings with the stream piped in a culvert, dams, and falls;
- Channel Modification (CM), where the stream bottom, banks, or direction have been modified; and
- Miscellaneous (MI), other impacts or features not otherwise covered.

The stream corridor assessment procedure used in this study is adapted from the U.S. EPA Rapid Bioassessment (RBA) protocol (EPA, 1999) and the Center for Watershed Protection's Unified Stream Assessment (USA) method (Kitchell & Schueler, 2005). Upland areas and activities that may impact stream quality were also assessed using methods adapted from the Center for Watershed Protection's

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[5] Conditions identifiers, such as OT for outfalls, are shown in parentheses.

Unified Subwatershed and Site Reconnaissance (USSR) techniques (Wright, Swann, Cappiella, & Schueler, 2005). This stream assessment method also includes a semi-quantitative scoring system as part of the reach level assessment to evaluate the overall condition of the stream, riparian buffer, and floodplain, based on a consideration of in-stream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation and habitat, and floodplain encroachment.

Field data forms were completed for each stream reach assessed (*Appendix B*). Photograph numbers in this section refer to the photographs in *Appendix B*. The information was compiled and used to quantify the overall condition of stream corridors in the watershed, and compare subwatersheds within the watershed to each other. Stream reaches were assigned a subwatershed abbreviation followed by a two-digit numerical identifier. Reaches were generally numbered sequentially from upstream to downstream in series by stream order. A reach was defined as a stream segment with relatively consistent geomorphology and surrounding land use. Impact conditions within each reach were numbered sequentially with an abbreviation followed by a two-digit number. For example, the second stream crossing in a reach would have the identifier SC-02.

Reach level assessment scores were assigned by field crews consisting of Fuss & O'Neill and SKS staff based upon the overall stream, buffer, and floodplain conditions. A subjective determination of eight criteria is assessed on a scale of 0 to 20; 0 indicating poor conditions and 20 being optimal conditions *(Table 2-10).*

Table 2-10. Reach Level Assessment Criteria

Category	Description	Score
Optimal	Greater than 70% of substrate favorable for fish habitat, 90% of the streambank vegetated with a buffer zone greater than 50 feet, stable banks, an accessible and vegetated floodplain with good habitat, and no floodplain encroachment.	125 - 160
Suboptimal	40-70% good in-stream habitat, 70-90% of the streambank covered in vegetation, stable banks with isolated erosion, a riparian buffer of 25-50 feet, an accessible and vegetated floodplain with good habitat, and minor encroachment into the floodplain area.	85 - 124
Marginal	20-40% good in-stream habitat, 50-70% of the banks covered with vegetation with some bare soil, evidence of down-cutting and erosion of the banks, a riparian buffer between 10 and 25 feet, high flows that are not able to enter floodplain, a floodplain which is primarily wetland, and there is moderate floodplain encroachment	45 - 84
Poor	Less than 20% stable in-stream habitat, less than 50% of the streambank is vegetated, evidence of active down-cutting and erosion, a deeply entrenched stream, a buffer of less than 10 feet, a floodplain which is primarily wetland, and significant encroachment into the floodplain area.	0 - 44

The total of the scores associated with these assessments provides a quantitative index of overall stream health and condition. The maximum possible number of points that would be assigned for a fully optimal stream reach is 160 points, with 80 points assigned to in-stream conditions and 80 points assigned to buffer and floodplain conditions. For the purposes of this assessment, total scores between 125 and 160 were considered "Optimal," scores between 85 and 124 were considered "Suboptimal," scores between 45 and 84 were considered "Marginal," and scores of 44 and below were considered "Poor" (*Table 2-11 and Figure 2-10*).

Table 2-11. Reach Level Assessments Performed and Stream Quality Rating

Stream Reach ID	Subwatershed	Stream Reach Length (ft)	In-stream Score	Buffer/ Floodplain Score	Total Score	Quality Rating
SP01A	School Pond	327	64	70	134	Optimal
SP01B	School Pond	1293	53	27	80	Marginal
SP02A	School Pond	1102	29	28	57	Marginal
SP02B	School Pond	2199	74	76	146	Optimal
HW01A	Headwaters	824	Not assessed (private property)			
HW01B	Headwaters	1014	66	65	131	Optimal
HW02	Headwaters	2392	66	55	121	Suboptimal
SM01A	Segar Mountain	242	35	31	66	Marginal
SM01B	Segar Mountain	2827	76	74	150	Optimal
WB01	Womenshenuk	6013	80	60	140	Optimal

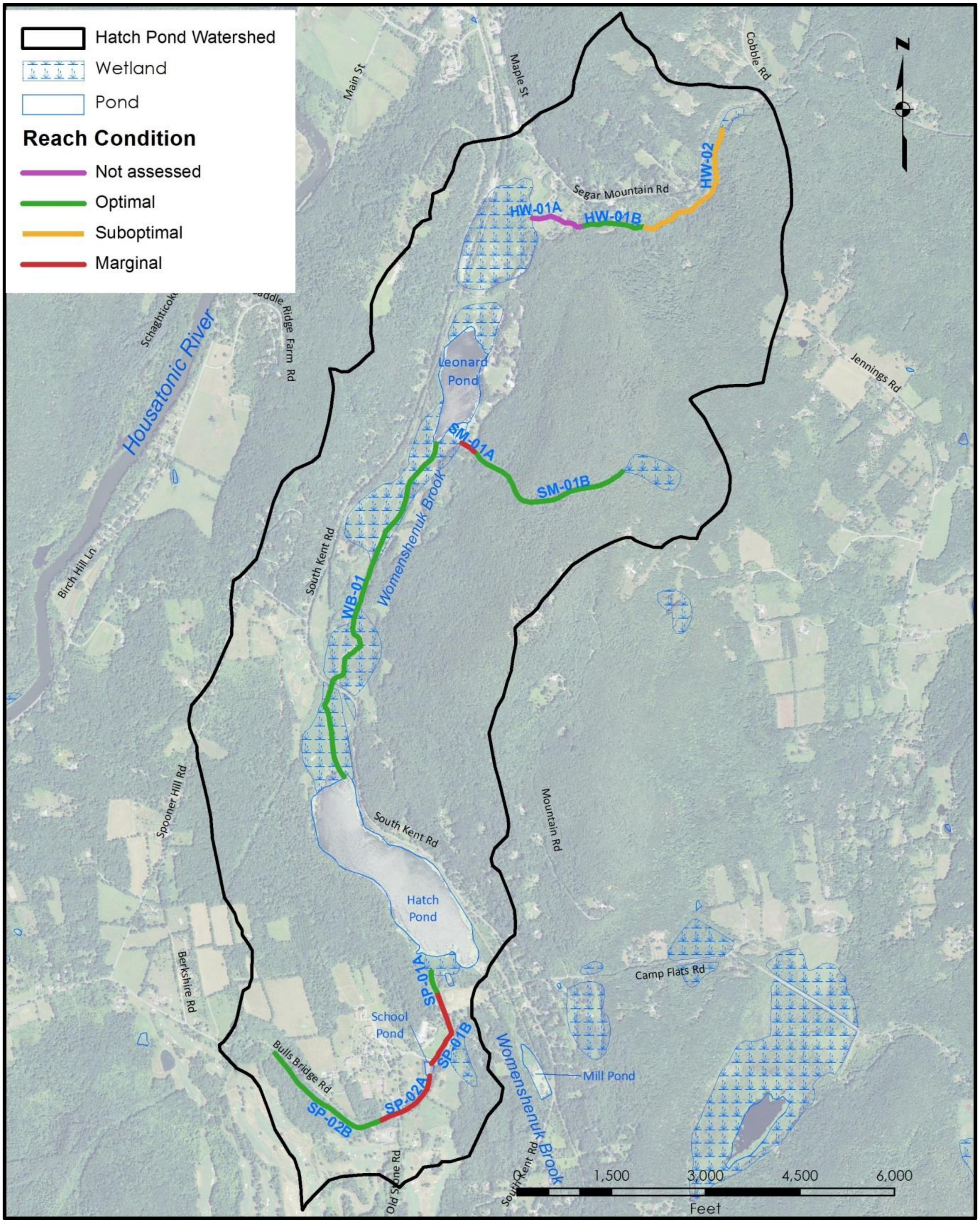

Figure 2-10. Reach Level Assessment Quality Ratings

2.4.1.1 School Pond Subwatershed

The School Pond Subwatershed contains the unnamed tributary with its headwaters originating on the golf course and flowing adjacent to Bull's Bridge Road. There is a diversion from the stream into School Pond (Lew's Lagoon). The stream then continues through the South Kent School campus and eventually discharges into Hatch Pond through a small wetland on the southern side of the pond. The reaches are generally described from upstream to downstream below.

Stream reach SP-02B originates in a wetland on the Bull's Bridge Golf Club and flows easterly toward Bull's Bridge Road. The stream crosses under a utility roadway and then under Bull's Bridge Road. There are several outfalls along the roadway directing road runoff into the stream. A rock stilling basin is located within the stream downstream of the Bull's Bridge Road crossing. The stream segment has good floodplain areas on both sides of the stream providing good canopy and floodplain connection (See Photo 46). The stream is mostly shaded and has a mixed sand, gravel and cobble streambed that provides good fish and amphibian habitat. There are some areas of invasive plant species identified, such as Japanese knotweed, but overall, this stream reach is in excellent condition.

Photo 46: Excellent canopy cover and in-stream habitat along reach SP-02B

Stream reach SP-02A begins at a driveway stream crossing and flows adjacent to Bull's Bridge Road ending at the Kent School Road crossing. There is a large patch of invasive Japanese knotweed located behind 62 Bull's Bridge Road, which is owned by SKS. Approximately 300 feet of the stream channel has been modified by adding stone riprap into the channel in front of the school. In addition, there is little buffer to the stream on the grounds of the school in this area since it is primarily turf up to the stream bank. Just upstream of School Pond (Lew's Lagoon), there is a diversion structure to feed the pond. The stream channel continues around the pond to the east, where the pond outfall discharges back into the stream, and then the channel flows under the South Kent School entrance driveway and discharges into a large wetland area. The most significant issues along this reach are the impacted buffer (managed turf down to the stream banks), stream modification to stabilize the channel upstream of School Pond, and the diversion associated with providing water to the pond.

Photo 37: Large stand of Japanese Knotweed behind 62 Bull's Bridge Road

Photo 17: Outlet structure in School Pond

Photo 25: Impacted buffer and channel modification on SKS lawn

Stream reach SP-01B begins at the large wetland complex north of the South Kent School entrance driveway and flows northerly through the wetland complex, which has an excellent riparian buffer. There is a stream crossing for a driveway south of the baseball field. The stream flows through the crossing and enters a natural channelized section alongside the baseball field. There is an impacted buffer in the segment, although some vegetation (10-15 feet) remains alongside the channel. There is no canopy cover within this reach.

Photo 20: Stream Crossing at SKS entrance driveway

Stream reach SP-01A flows from the edge of the baseball field into the woods, adjacent to the gravel road that provides access to the SKS boathouse. This reach is characterized by wetland vegetation and does not have a distinct channel, especially close to Hatch Pond.

2.4.1.2 Womenshenuk Brook Subwatershed

The Womenshenuk Brook subwatershed contains an approximately 1.1-mile segment of Womenshenuk Brook, which primarily consists of a large north to south flowing wetland complex between Leonard Pond and Hatch Pond. The subwatershed is bisected by both the Housatonic Railroad tracks and South Kent Road, which travel generally in a north-south direction. Several farms are located within the subwatershed, although they are outside of the riparian area. These are privately-owned farms that appear from aerial images to be hayfields, crops and/or orchards. It is unknown whether these farms contain livestock. The stream crossing at South Kent Road consists of a large box culvert with a trash rack. It was not clear from the field visit whether the culvert is serving as a hydraulic control for the wetland complex since the downstream area also contains standing water. Other areas of the stream segment were not evaluated since they are primarily wetland areas and are not easily accessible.

Photo 56: Box culvert stream crossing for South Kent Road and Womenshenuk Brook

2.4.1.3 Segar Mountain Subwatershed

The tributary that flows from Segar Mountain primarily consists of a very steep, forested stream that originates in a forested wetland near the top of Segar Mountain. Reach SM-01B flows through an undeveloped area, although SM-01A begins at the base of the mountain where Club Getaway has developed land around the stream segment.

Stream reach SM-01A flows from the base of the mountain where Club Getaway has developed a stream crossing for a gravel roadway (see Photo 108). The stream segment is very short, although shows evidence of impacted buffer and bank erosion, likely due to the flashiness of the mountain stream. The stream discharges into Leonard Pond.

Photo 108: Stream crossing for gravel roadway through Club Getaway

Photo 106: Bank erosion evident along segment SM-01A

Stream reach SM-01B is a mountain stream with cobble and boulder stream bed materials. The segment is undeveloped and has excellent canopy cover, riparian buffers, and in-stream habitat. Due to the steepness of the reach, the floodplain area is not distinct from the channel area, although there is significant riparian vegetation.

2.4.1.4 Headwaters Subwatershed

Womenshenuk Brook originates in a wetland area adjacent to Segar Mountain Road, which was formerly a small impoundment for the town's water supply. Stream reach HW-02 begins at the outlet of the small wetland area located on Aquarion Water Company property in the northern portion of the watershed and travels parallel to Segar Mountain Road (Route 341). The stream segment is generally in excellent condition. The stream is braided and has excellent canopy cover, in-stream habitat, and floodplain connection. The riparian area along this reach is typically greater than 200 feet in width. Evidence of fill was observed along the reach associated with the construction of the utility right-of-way for the water line. There were several stockpiles of abandoned 12-inch iron pipes leading up to the Aquarion Water Company-owned tank at the end of the right-of-way. The stream segment ends at a private road crossing downstream of a small forested wetland.

Photo 84: Braided stream with good canopy and in-stream habitat

Photo 87: abandoned iron pipes associated with the water line right-of-way

Stream reach HW-01B travels from the access trail in Emery Park to the private property line at the edge of the forested area to the south of Emery Park. A small stone dam located within the stream diverts water to a supply pond for the swimming pool at Emery Park. A second former diversion structure and dam have been abandoned downstream of the active structure and could be removed from the stream since they no longer serve a purpose (see Photo 71 below). There is a stream crossing for a trail within the park on this segment. Downstream of the trail crossing, the stream is in excellent condition.

Photo 71: Abandoned diversion structure and dam

Photo 62: Forested stream segment with excellent riparian buffer, canopy, and floodplain connection

Stream segment HW-01A flows through private residential and agricultural property and could not be accessed for evaluation. Based on aerial photographs, the stream segment has an impacted buffer with evidence of agricultural activities conducted close to the banks and no riparian buffer or canopy cover.

2.4.1.5 Leonard Pond Subwatershed

The Leonard Pond subwatershed contains a large wetland complex which drains to Leonard Pond. There are no distinct stream reaches within this subwatershed; therefore, no evaluations were conducted.

2.4.1.6 Hatch Pond Shoreline Assessments

Hatch Pond shoreline assessment surveys were conducted by Fuss & O'Neill on July 29, 2014. The methods used for the shoreline assessments were based on the National Lakes Assessment Field Operations Manual (2012) and included an evaluation of shoreline characteristics, riparian zone characteristics, and the locations and characterization of human development, such as docks, lawns, and outfalls. The Hatch Pond shoreline was divided into 10 segments that have substantially consistent shoreline characteristics *(Figure 2-11)*. Each segment was evaluated by traversing the pond in a canoe. Field data sheets and photographs are included in *Appendix B*.

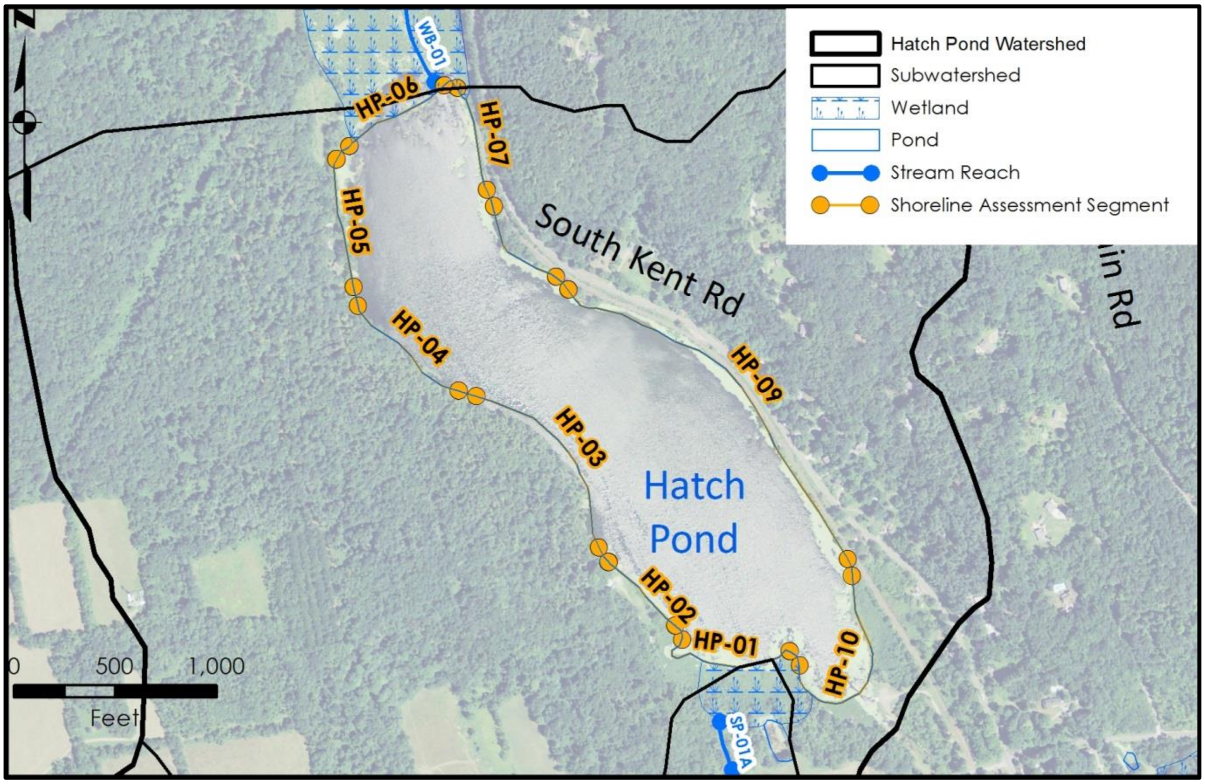

Figure 2-11. Hatch Pond Shoreline Assessment

Shoreline segment HP-01 consists of the shoreline area surrounding the inlet from the southern tributary, which is primarily a wetland area. The littoral zone is characterized by pollen and lilies, and the bottom substrate is silt/muck with heavy growth of macrophytes. The riparian area consists primarily of wetland species and woody shrubs. There are no developed areas along this segment of the shoreline.

Photo 272: Surface covered with lilies and pollen

Photo 274: Wetland species in riparian area

Segment HP-02 is characterized by pollen and macrophytes in the near shore area and small trees and some grasses and forbs in the riparian zone. The SKS boathouse, dock and shed are located in this reach (see Photo 283 below), and several outfalls were identified crossing the roadway that leads to the boathouse.

Photo 283: SKS boathouse and dock

Photo 291: Typical forested section of HP-03/04

Shoreline segment HP-03 and HP-04 are substantially similar segments. Both are undeveloped and have many small trees and woody saplings along the riparian area and less pollen and macrophytes in the near shore area, compared to other segments. The riparian area is moderately steep along these segments.

Shoreline segment HP-05 contains three cottages that are located approximately 50 feet from the shoreline. The homes each have a dock. Invasive plant species were observed along the shoreline near the homes, including bittersweet, multiflora rose and jewelweed.

Photo 292: There are three cottages and docks on the shoreline of HP-05

Shoreline segment HP-06 consists of the wetland area to the north of the pond. This area has been slowly filling in and transitioning to a wetland over the past few decades. The area near the shoreline is heavily covered in pollen, and algal scum was observed. The plant species are primarily wetland species.

Photo 307: Pollen covering the area near the shoreline of HP-06

Photo 308: Eurasian milfoil is prevalent around the shoreline and dominates much of the lake bottom cover.

Shoreline segment HP-07 and HP-08 were evaluated as one segment because their characteristics were similar. The segment is influenced by the presence of the railroad embankment. Several drainage outfalls from South Kent Road pass underneath the railroad and discharge to the pond (CTDOT, 1935); however, none were observed due to the heavy vegetation growth along the shore. A dock is located along this reach, which may be used by local residents (see Photo 317 below).

Photo 315: The shoreline is created by the railroad embankment in some locations along the eastern side of the pond.

Photo 317: Dock along segment HP-06/07

Shoreline segment HP-09 is located adjacent to the railroad embankment. The segment is characterized by some boulders along the bottom and by macrophytes and pollen along the near shore area. Woody shrubs and some small trees were present along the shore. The vegetation around the railroad appears to be managed with herbicides within the right-of-way. There is a structure located on the shore in one location (Photo 321).

Photo 321: Structure on the shore

Photo 324: small shrubs and samplings between the railroad and the shoreline.

Photo 334: Railroad and boulder fill creates the shoreline

Shoreline segment HP-10 is located around the Hatch Pond dam and includes a public boat launch. The segment is characterized by wetland plants 10 to 100 feet from the pond edge.

Photo 232: Hatch Pond Dam

Photo 231: Public boat launch and near shore area around HP-10

2.4.2 Upland Assessments

Fuss and O'Neill conducted upland assessments in the Hatch Pond watershed on July 28 and 29, 2014. The field observations gathered during the assessments assist in verifying pollutant sources related to land use activities in the watershed and pollution prevention opportunities. The upland assessments concentrated on land uses in the watershed that have the potential to contribute pollutants to Hatch Pond (i.e., phosphorus and sediment). The assessments consisted of site visits, visual observations, completion of field data forms, and photographs of areas of concern. Additional follow-up interviews with property owners and/or maintenance staff are discussed in the pollutant source assessments in *Section 4*.

The upland assessments were limited to those areas where permission for site access was granted by the property owner. These included most of the major developed land uses within the watershed – South Kent School, Center for Innovation, and Bull's Bridge Golf Club. The owners of Club Getaway were contacted numerous times for access to their property and to discuss the facility's activities relative to potential pollution sources and mitigation practices, but permission was not granted by Club Getaway. Agricultural activity on private property was not evaluated due to property access restrictions. In addition, the CTDOT salt storage facility was not evaluated since it is believed to be a relatively insignificant source of sediment or nutrients. Locations of the upland assessments are shown on the subwatershed maps in *Figure 2-12*. Field data forms that were completed during the upland assessments are provided in *Appendix B*.

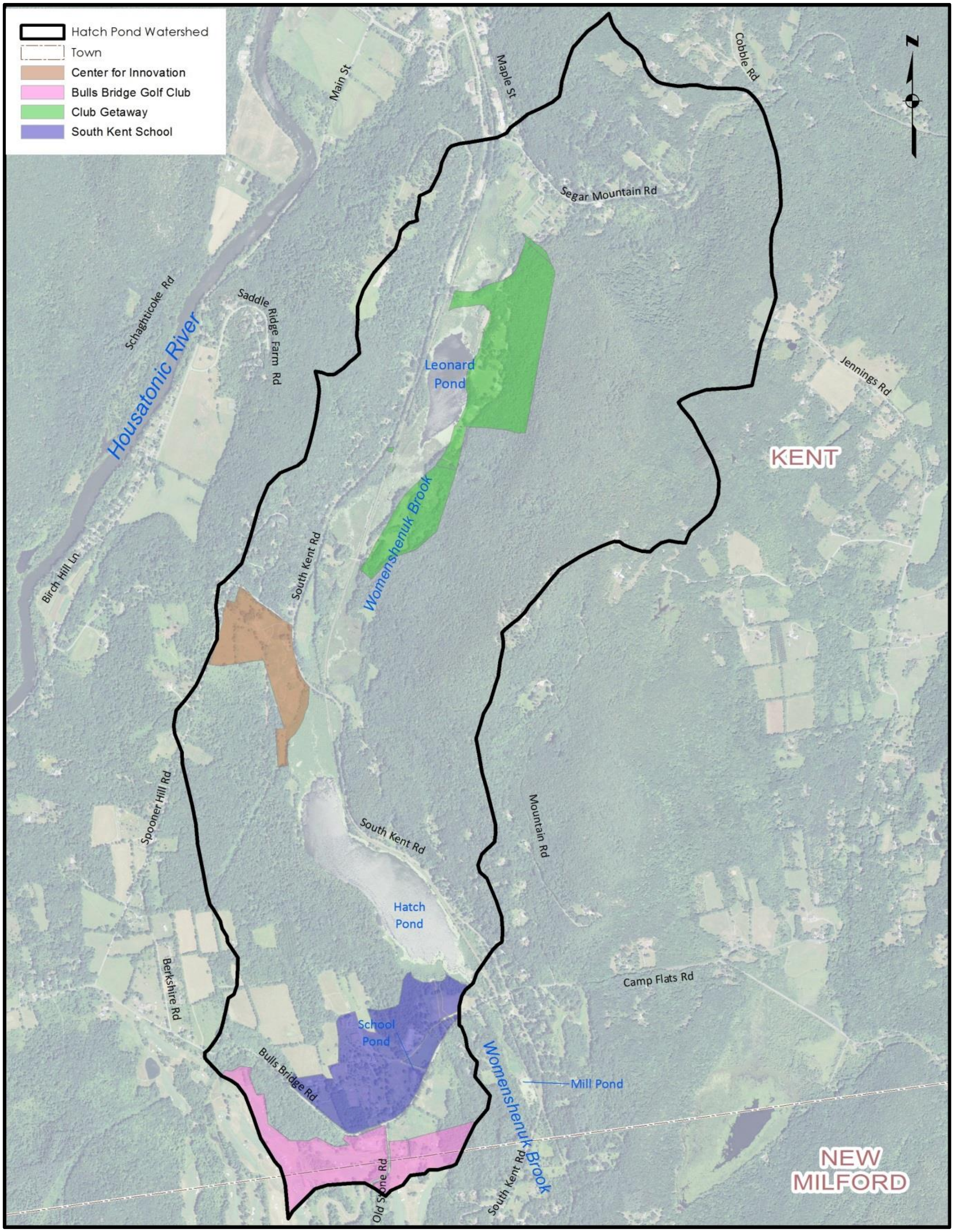

Figure 2-12. Locations of Upland Assessments

2.4.2.1 South Kent School

The assessment at South Kent School consisted of walking the grounds of the school, concentrating on drainage associated with impervious areas on the campus, including the driveways, walkways, and buildings. Turf management and storage practices were noted during the assessment. Issues that were identified during the assessment are primarily related to erosion issues around paved areas.

The campus drainage mainly consists of "country" drainage – runoff from paved areas discharges to roadside ditches, swales, or vegetated areas and does not enter a piped drainage system. Catch basins and storm drains were observed in some areas of the campus, including the paved areas north of the Old Building, the parking areas near the gymnasium, and several other areas adjacent to the driveways that traverse the campus. The catch basins that were inspected were observed to have minimal sediment accumulation.

Photo 124: Parking Lot east of Old Building

Photo 128: Drainage along roadway to Admissions Building

Photo 137: Admissions Building

Photo 142: Samuel S. Bartlett Building

Photo 155: Inlet to School Pond (Lew's Lagoon)

Photo 170: Fieldhouse Dormitory

Since there is limited piped drainage on campus, vegetated swales are located adjacent to many of the roadways throughout campus to convey stormwater. Vegetated swales should be maintained at a height of 3 to 4 inches to provide sediment and nutrient removal benefits. The observed vegetated swales on campus appeared to be mowed to the same height as the surrounding lawn areas (example in Photo 128).

Areas of erosion were observed along many of the roadways and paved areas throughout the campus (examples in Photos 128, 137, and 170). The erosion was more severe on steeper roadways throughout campus and could be a source of sediment into the nearby wetland area. Straw was laid down over the areas as an erosion control measure (Photo 170); however more aggressive maintenance may be required to repair the area permanently.

Lew's Lagoon (also called School Pond) is located just upstream of Hatch Pond and receives runoff from a portion of the school and golf course. The inlet to Lew's Lagoon has significant sediment accumulation (Photo 155). Routine maintenance dredging of the inlet area to Lew's Lagoon is important to the ability of the water body to function as a sediment and nutrient sink.

Several Low Impact Development (LID) stormwater management practices exist on campus, including a rock-lined infiltration swale located off the main parking lot near the Old Building (Photo 119 below), grass pavers on a parking area in front of Gilder Hall Dormitory (Photo 143 below), and a rain garden behind the faculty housing buildings that receives runoff from the adjacent impervious areas. The plants are newly planted and will mature to fill in the garden (Photo 144 below).

Photo 119: Rock-lined infiltration swale located off the main parking lot near the Old Building

Photo 143: Grass pavers on a parking area in front of Gilder Hall Dormitory

Photo 144: A rain garden behind the faculty housing buildings

2.4.2.2 Center for Innovation

The Center for Innovation is located to the northwest of Hatch Pond and consists of approximately 128 acres of land including a greenhouse, two barns, and several pens for livestock with associated internal gravel and dirt roadways and parking areas. Approximately 45 acres are currently used for livestock or active farming. The property is approximately bounded by Spooner Hill Road on the north and west and by South Kent Road on the east. The southern boundary is formed by a forested area and a wetland area that transitions to Hatch Pond.

The site generally slopes to the east from the upper portions of the agricultural fields adjacent to Spooner Hill Road. Site drainage is channelized west of the greenhouse. The vegetated drainage channel (Photo 200 below) flows southeast under several internal driveways and discharges into a wet pond located on the site (Photo 213 below). The pond may have originally served as a farm pond for irrigation and/or livestock. The pond currently provides some stormwater function, both as a retention basin and stormwater treatment. The pond experiences algal blooms throughout the growing season and could serve as a source of pollutant export during certain times of the year.

The wet pond has two outlets. The normal pool outlet is diverted to a second basin (a dry basin, see Photo 224 below) to the south via a grass drainage channel. The dry basin discharges into the wetland system north of Hatch Pond. The wet pond's high-level outlet discharges to the east under South Kent Road into a wetland system across the road.

Photo 200: Drainage channel that flows through the Center for Innovation property

Photo 213: Wet pond at the Center for Innovation

Photo 224: Dry basin at the Center for Innovation

Photo 185: Greenhouse is used for plants and equipment storage, which limits the amount of outdoor storage and minimizes contact with stormwater

Photo 195: Raised beds for growing organic produce and flowers

Stormwater issues and potential areas for stormwater retrofits or restoration identified during the site visit included:

- The wet pond is in need of maintenance. At the time of the site visit, and as reported by the resident farmers, the pond had an active algal bloom indicating high nutrient levels in the pond. There appeared to be significant mucky bottom sediments that should be dredged. The volume of sediment in the pond is unknown, and the area of the pond is approximately 10,000 square feet.
- The grass channel that connects the wet pond and dry basin was observed to be eroding and should be stabilized.
- The grass drainage swale that carries runoff from the upper agricultural fields and discharges to the wet pond could be retrofitted with check dams and additional plantings to more effectively capture sediment and nutrients.

Rainwater harvesting is planned for the barn/residential structure for use throughout the property. Several 250-gallon rain barrels will be connected to the roof leaders (Photo 226 below).

Photo 226: 250-gallon rain barrel at the Center for Innovation

2.4.2.3 Club Getaway

Club Getaway is a privately-owned recreational site located on the eastern side of Leonard Pond. The site is bounded by Leonard Pond to the west and the Segar Mountain range to the east. No formal stormwater drainage infrastructure was observed on-site. Fuss & O'Neill conducted a visual assessment of the site; however a representative of Club Getaway was not available to review operational and maintenance practices.

Photo 244: Overview of the northern portion of Club Getaway taken across Leonard Pond, with Segar Mountain in the background

Photo 96: Recreational equipment is located throughout the site

Photo 99: Limited riparian buffer along sections of the shoreline of Leonard Pond

2.4.2.4 Bull's Bridge Golf Club

The northern portion of Bull's Bridge Golf Club is located within the Hatch Pond watershed, including the maintenance building, the 3rd and 9th Hole Comfort Stations, and Holes 1, 2, 3, 6, 7, 8, 9, 10, 11, and 12, which are wholly or partially located within the watershed. Yard drains are located in low-lying areas around the course, which drain to nearby wetland areas. Drainage from a majority of the course is via overland flow and vegetated swales. The course is meticulously maintained and there were no signs of erosion around the paved cart paths or steep areas of the course. The maintenance building area contains a garage, parking area, and outdoor storage of materials, although the area was not assessed during the field assessment.

Photo 261 : Yard drain at Hole #5 that drains to a wetland on the opposite side of the green

Photo 267: Hole #12 is separated by the wetland area that flows toward Bull's Bridge Road

3 Pollutant Source Assessment

A pollutant source assessment synthesizes information gathered from the review of prior studies, recent data collected, and field investigations to identify potential pollutant sources in the watershed. The pollutant source assessment, together with insight gained from pollutant load modeling *(Section 4)* and stakeholder input, will help identify and prioritize watershed management actions.

For a lake, pollutant sources include both those found in the watershed and sources from within the lake, such as recycling of nutrients from bottom sediment. *Figure 3-1* illustrates typical in-lake and watershed sources of phosphorus. Watershed sources are the focus of this study and include various nonpoint sources from developed areas within the watershed, subsurface sewage disposal systems, agriculture, wetlands, and stream erosion. A separate report by Water Resource Services, Inc. and Northeast Aquatic Research, LLC (2014) describe in-lake pollutant sources.

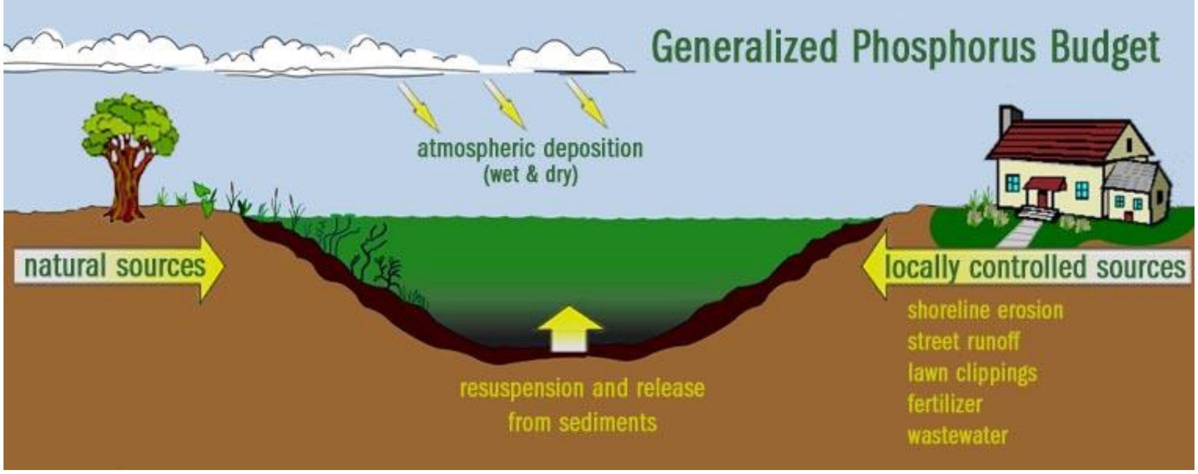

Figure 3-1. Typical Phosphorus Sources (Lake Access, 2014)

3.1 Watershed Sources

3.1.1 Runoff from Developed Areas

In developed areas, large portions of natural landscape cover have been replaced with impervious surfaces such as roads, driveways, parking lots, and buildings. Impervious cover changes the natural dynamics of the hydrologic cycle by causing water to remain on the land surface rather than infiltrating. Without slow percolation into the soil, water accumulates and runs off in larger quantities. This faster moving water washes away soil that is not securely held in place by structural means or healthy vegetation. When rain falls in developed areas, it flows quickly off these impervious surfaces, carrying soil, bacteria, nutrients, and other pollutants to nearby water bodies (CTDEEP, 2012). Developed areas in the Hatch Pond watershed include South Kent School, Bull's Bridge Golf Club, Camp Getaway, residential areas, and the transportation network.

3.1.1.1 South Kent School

Existing land use practices at SKS were determined from a site visit and interview with Bruce Carlson, the Facilities Director of SKS, on July 28, 2014. Stormwater management at SKS consists of primarily "country drainage," i.e., overland flow and vegetated swales. There are several stormwater catch basins and drainage lines adjacent to the roadways around campus, primarily around the Admissions Building and the Old Building in the center of the campus. The drainage system is maintained by SKS, and the catch basins are cleaned out twice per year in the spring and fall. SKS also removes sediment periodically from behind the small dam intake area into Lew's Lagoon (School Pond).

Herbicide treatment is performed twice per year on Lew's Lagoon (School Pond) using a combination of the algaecides/herbicides Clipper (active ingredient lumoioxazin) and Cutrine (active ingredient copper) to control aquatic vegetation including catermeal, filamentous algae, and curly-leaf pondweed. The SKS administration prefers to have the grass around the water features on campus mowed due to concerns about students accidentally stepping into the water as they frequently walk near the water features.

SKS uses the deicing product known as "Magic Salt" to treat the campus roadways and parking lots during the winter months. Magic Salt is a form of sodium chloride (rock salt) that has been treated with molasses and blended with magnesium chloride. SKS treats the driveways and walkways with a calcium chloride salt and sand mixture and uses approximately ten cubic yards of calcium chloride every two years.

Lawns, sports fields, and golf courses are managed turf areas that can contribute to nutrient loadings, depending upon fertilizer usage and management practices. Improper disposal of grass, leaves, and other yard wastes can also affect water quality by adding nutrients. There is minimal use of fertilizers at SKS. Small amounts of fertilizer are used on the soccer fields and gardens throughout the campus. All athletic fields are currently fertilized with phosphorus-free fertilizer. Grass clippings are mulched in place or occasionally composted.

Soil testing performed on the soccer and baseball fields in 2000 showed the soils have above optimum levels of plant-available phosphorus. Optimum phosphorus levels for turf growth are between 4 and 14 ppm (UMass, 2013); however higher levels may be optimal for athletic playing fields, between 30 and 50 ppm (Spectrum Analytic, 2000).[6] Plant-available soil phosphorus in the soccer fields ranged from 36 to 41 ppm, which is in an optimal range for athletic fields. However, soil from the baseball field was substantially higher at 145 to 158 ppm. Phosphorus levels in the soil are the result of naturally occurring phosphorus and/or inputs from historic agricultural uses as discussed in *Section 2.2.7*. Phosphorus in the soil from the baseball field is higher than that at the Center for Innovation, which ranged from 0.5 to 40 ppm.

The main subsurface sewage disposal system (SSDS) (i.e., septic system) at SKS was installed in 1965 and is located adjacent to the baseball field and Hatch Pond. Smaller SSDSs that serve individual buildings are also located on campus. Additional capacity was added to the main SSDS in 1970 and again in 1988. These additions were recently determined to be failing, and CTDEEP required SKS to perform

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[6] Note that soil testing conducted at CFI and SKS determined the plant-available forms of phosphorus, which is a fraction of the total phosphorus in the soil.

groundwater monitoring and replace the existing systems, which occurred in 2014. The new SSDS was sized for the entire campus so that any areas of the campus that are currently serviced by individual SSDSs may be tied into the main SSDS. For example, one system at 56 Bull's Bridge Road that is owned by SKS is known to be failing and will be connected to the new SSDS in the future.

3.1.1.2 Bull's Bridge Golf Club

The Bull's Bridge Golf Club has only minor drainage infrastructure. The drainage is primarily via overland flow to adjacent wetland areas located around the perimeter of the course. The wetlands surrounding the course effectively treat runoff prior to discharging from the property. Mowed grass areas and natural vegetated areas throughout the golf course function as vegetated buffers.

Annual water quality monitoring is conducted as a condition of the Town of Kent Special Permit to construct the golf course in 2002. The Natural Resource Management Plan (NRMP) for Bull's Bridge Golf Club requires monitoring of surface water and groundwater for general water quality parameters including pH, water temperature, dissolved oxygen, specific conductance total dissolved solids nitrate, nitrite, total phosphorus, and chloride. According to the 2010 annual monitoring report, additional sampling was triggered by exceedances of total phosphorus at surface monitoring location SW-2, located near the maintenance building at the entrance to the golf course. Other sampling parameters have been below the NRMP response thresholds (Leggette, Brashears & Graham, Inc., 2010).

According to Rob Giampietro, the course manager, during a telephone interview on July 29, 2014, phosphorus has not been used in the golf course fertilizers since 2002-2003, during the grow-in phase of the course development. The soil has adequate phosphorus for plant growth, and the soil amendments applied include urea, potassium sulfate, magnesium sulfate, iron sulfate, boron, and some others. The course conducts annual soil tests to balance soil calcium, magnesium, and sodium, and occasionally amends the soil with calcium carbonate and magnesium sulfate. The club uses mulching mowers and grass clippings are left in place.

3.1.1.3 Club Getaway

Club Getaway is a privately-owned recreational facility located on the eastern side of Leonard Pond. Several potential pollutant sources were observed during the field upland assessment described in *Section 2.4.2*. Attempts were made to interview facility operations personnel to gain information about operations at the site, but there was no response. The site includes approximately 18 small cabins and an administration building. The driveways and trails throughout the site are gravel. The majority of the site is mowed turf or natural vegetation. Since the site is not serviced by sewer, SSDSs are believed to be located on-site, although their age and condition is unknown. The facility is adjacent to Leonard Pond, so failing or malfunctioning SSDSs could impact the water quality of Leonard Pond and potentially downstream water bodies. Turf areas at the facility did not appear to be fertilized. Aquatic plant management is performed within Leonard Pond to allow recreational use of the pond during the summer.

3.1.1.4 Transportation - Roads and Railroad

Transportation-related land uses are potential sources of nonpoint source pollution, including stormwater runoff from impervious surfaces such as roads; runoff from the road maintenance facility within the watershed; winter deicing activities along roadways; and potential spills or releases during transport of materials through the watershed via rail or roadway.

Roadways contribute a wide range of pollutants to surface water and groundwater. Metals, hydrocarbons, bacteria, and chloride are common constituents of road runoff. Traditional piped drainage systems, such as those along South Kent Road, can result in the discharge of untreated road runoff to wetlands and watercourses, contributing to water quality impairments and erosion and flooding problems.

Nonpoint source pollution may result from road and bridge maintenance activities including road salt application, sanding, and sweeping of roads; paving; vegetation control; inadequate sediment and erosion controls; and maintenance and storage of equipment. Excessively applied or improperly stored road salt may leach into drinking water supplies and other ground or surface waters. The satellite salt storage facility constructed in 2003 along South Kent Road was originally designed to have a covered salt pile and an outdoor sand pile (CTDOT, 2003), although CTDOT has discontinued the use of sand for winter deicing. Snow can impact surface waters if improperly stored or disposed. Stormwater runoff may erode roadside soils, or transport fertilizers and pesticides from these areas to neighboring water bodies. In the Hatch Pond watershed, road sanding may be of particular concern given the high accumulation of sediment within the lake.

The Housatonic Railroad is adjacent to the wetland areas and Hatch Pond as it traverses the watershed from north to south. Runoff from railroad lines can contribute to hydrocarbon and metal pollution to adjacent water bodies, although such runoff is unlikely to contribute nutrients or sediment into Hatch Pond. Unpublished sediment quality data (WRS and NEAR, 2014) indicated that the sediment concentrations of metals, hydrocarbons, and pesticides are not a concern in the Hatch Pond sediment and would not restrict disposal of dredged sediment.

3.1.2 Subsurface Sewage Disposal Systems

Inadequate or failed subsurface sewage disposal systems can impact groundwater and surface water by discharging pathogens, nutrients, and other pollutants. There are no public sewers in the Hatch Pond watershed; SSDSs are used for all wastewater disposal, including all private residences and at SKS, Bull's Bridge Golf Club, and Club Getaway. The historical issues and existing SSDSs at SKS are discussed in *Section 2.4.2.1*. The septic system at the Center for Innovation was replaced in 2013.

In June of 2012, a sanitary survey of the Hatch Pond neighborhood was conducted (Culbert, 2012). It was found that many older septic systems had been upgraded, and given the current density of the development and land use, there was little evidence that the septic systems would impact the pond in the future. However, this survey did not include areas of the watershed upstream of the residences adjacent to Hatch Pond. Failing SSDSs that are in close proximity to surface water bodies have the potential to leach nutrients into surface waters. There are no residences in close proximity to surface water bodies upstream of Hatch Pond, although the Club Getaway SSDS is likely within 300 feet of Leonard Pond.

3.1.3 Agriculture

Agricultural operations can be a major contributor to nonpoint source pollution. Water quality contaminants associated with agricultural operations include nutrients (nitrogen and phosphorus primarily from fertilizers and animal wastes), pathogens and organic materials (primarily from animal wastes), sediment (from field erosion), pesticides, salts, and petroleum products. These pollutants enter watercourses through direct surface runoff or through seepage to groundwater that discharges to surface water.

Agricultural land use accounts for approximately 7% of the Hatch Pond watershed. Small farms in the northern and southern portions of the watershed could affect water quality in Hatch Pond. These farms are privately-owned and generally include hayfields, crops and/or orchards. At South Kent School, the Center for Innovation is a small working farm that is used for educational purposes. The farm, on the site of the former Arno Farm, contains approximately 7,000 square feet of raised beds, approximately 52,000 square feet for vegetable production, and a pasture. The existing livestock at the farm include 2 oxen, 4 pigs, 10 chicken, and bee hives. The operation is anticipated to expand to 35 chicken and several goats/sheep.

Photo 205: Small pig pen located on the Center for Innovation property

The Center for Innovation does not use pesticides or herbicides on the farm, nor do they use salt or sand on the gravel driveway. Raised beds are fertilized with an organic-mineral blend with low phosphorus. Grass clippings from mowing are left on the lawn. Soil testing was conducted in 2012 in 7 areas across the Center for Innovation property. Plant-available phosphorous levels in soil ranged from 0.5 to 40 ppm, with five of the seven samples above the optimal phosphorus levels for plant growth, possibly due to its historical use as the larger Arno Farm. However, pollutant loading from the area has decreased dramatically. Wet weather (i.e., stormwater) samples collected from the discharge point of the Center for Innovation show a decrease in TP concentrations of at least two orders of magnitude, from greater than 15,000 ppb in 2005 when the Arno Farm was operational to 297 ppb in 2011 when it had become the Center for Innovation (NEAR, 2006 & NEAR, 2012).

3.1.4 Wetlands

Wetlands are typically beneficial to water quality because of their ability to remove sediment, nutrients, and chemicals from stormwater runoff; however, wetlands can also be sources of nutrients. When wetland plants die in late fall and early spring, nutrients can be returned to the water and sediment from decaying plant material and wetlands serve as a nutrient source. There is a major wetland complex located in the low-lying valley of the watershed that originates north of Leonard Pond and extends south to Hatch Pond (*Figure 2-5*). The wetland complex is approximately 2.7 miles long and about 600 to 800 feet wide. Other small wetlands are located throughout the watershed, including near the headwaters of Womenshenuk Brook, near Bull's Bridge Golf Club, north of SKS, and on Segar Mountain.

3.1.5 Stream Channel Erosion

Stream channel erosion is a natural process, but acceleration of this process can lead to a disproportionate sediment supply, stream channel instability, and other adverse impacts. Stream channel erosion contributes a large portion of the annual sediment yield in many streams. Stream channel erosion processes are influenced by stream bank characteristics and hydraulic forces. Land use activities such as increased impervious surfaces and loss of riparian vegetation can lead to accelerated channel erosion. Sediment and nutrients adsorbed onto sediment particles can be transported down the stream and into receiving water bodies.

Based on the watershed stream assessments described in *Section 2.4*, the Womenshenuk Brook subwatershed is relatively undeveloped and is characterized by stream segments with high bank stability and relatively steep slopes. Stream segments in the more heavily developed School Pond subwatershed have more exposed and unstable banks. Assessed streams in other portions of the Hatch Pond watershed have moderate stream bank stability. Stream channel erosion accounts for approximately 30 percent of the annual total phosphorus load to Hatch Pond based on modeled existing pollutant loads.

3.2 In-Lake Sources

The portion of nutrient inputs to the water column that comes from the sediment within the pond are considered "in-lake" or "internal" sources of nutrients. The primary concern is the direct release of nitrogen and phosphorus from bottom sediments in response to loss of oxygen, or anoxia. Anoxia causes phosphorus bound by iron to dissociate, and both iron and phosphorus levels will increase in the overlying water, which can translate into considerable algal growth potential. Lack of oxygen can also contribute to nitrogen compounds that can encourage algae and rooted plant growth. Oxygen approaches 0 mg/L near the bottom over a substantial portion of Hatch Pond. Although this is greatly reduced in 2014 compared to the previous decade, there is still a concern for possible nutrient releases from the pond sediments (WRS and NEAR, 2014).

4 Existing Pollutant Loads

4.1 Watershed Loading

Modeling of pollutant loading throughout a watershed can provide insight into the relative contributions of different land uses and land use practices. Pollutant load modeling is intended as a screening-level analysis to help identify and rank pollutant sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollutant control strategies. It is not intended to provide predictions of future water quality.

For the analysis of the Hatch Pond watershed, the Watershed Treatment Model (WTM), Version June, 2013, developed by the Center for Watershed Protection, was used. This model calculates annual watershed pollutant loads primarily based on nonpoint source (NPS) runoff from various land uses. It also can include pollutant loads and reductions from other sources such as subsurface disposal systems (septic systems), road sanding, livestock, and stream channel erosion. A model of existing conditions was developed for the Hatch Pond watershed using the land use data described in *Section 2.2.7* and information gathered about the watershed as discussed in *Sections 2.4 and 3*. Each subwatershed identified in *Figure 2-2* was analyzed individually to understand relative contributions, and combined results describe the entire Hatch Pond watershed.

Land uses that were identified in *Section 3.1.1* as developed areas that may contribute to higher runoff and pollutant loading and were incorporated into the model include:

- Commercial
- Residential
- Road
- Railroad
- Institutional (South Kent School)
- Golf course (Bull's Bridge Golf Club)

Land uses with lower runoff than developed areas, but identified as areas with potentially high pollutant loadings, include agricultural lands and wetlands. Forest, recreational areas, and open water make up the remaining land uses in watershed, and were also included in the model.

In addition to ascertaining information on loading and runoff from land use, the model was used to estimate additional pollutant loads from other sources within the watershed, including:

- Livestock (at the Center for Innovation)
- Subsurface disposal systems (SSDSs)
- Road sanding
- Stream channel erosion

Riparian buffers were included as a load reduction factor within the model, since these areas attenuate runoff flows from surrounding areas and capture nutrients and sediment, preventing pollutants from reaching the water body.

The pollutants modeled in this analysis are total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS). These pollutants are the major nonpoint source pollutants of concern for Hatch Pond, due to the eutrophic conditions and significant sedimentation in lake.

4.1.1 Model Inputs

4.1.1.1 Nonpoint Source Runoff

Land use data described in *Section 2.2.7* were adapted for use in WTM. The basis of the WTM is a pollutant loading calculation developed by Schueler (1987), called the Simple Method, which calculates nutrient, sediment, and bacteria loads from various land uses. The user specifies several model parameters for each land use type in the watershed and these parameters are used to estimate runoff quantity and pollutant load. These parameters include event mean concentrations (EMCs), which are literature values for the mean concentration of a pollutant in stormwater runoff for each land use type, and an average impervious cover percentage for each land use. A literature review was conducted to determine EMC values and impervious percentage values for use in the modeling. Impervious cover coefficients for each land use category were selected from WTM default impervious cover coefficients and literature values. EMC and impervious cover coefficient values used for the modeling of Hatch Pond watershed existing conditions are included in *Appendix C*.

4.1.1.2 Other Pollutant Sources and Reductions

In addition to nonpoint source runoff pollutant loads, WTM also provides the capability to model other nonpoint pollutant sources such as subsurface disposal systems, as well as watershed conditions or activities that may reduce pollutant loading to the watershed, such as the presence of riparian buffers. The following sections describe the model inputs and parameter values for other pollutant sources and reductions within the Hatch Pond watershed.

Subsurface Waste Disposal Systems

All properties within the Hatch Pond watershed rely on subsurface waste disposal systems (septic systems). As discussed in *Section 3.1.2*, the survey around Hatch Pond showed that no residential SSDSs were failing and that there were some known failures at South Kent School. The proportion of failing SSDSs was estimated at approximately 10% for the area surveyed, and this percentage was applied as the failure rate for all subwatersheds. Proximities of the systems to nearby water bodies were estimated using aerial photography, in which distances were measured from expected locations of septic system (within approximately 50 feet of a building visible on the aerial) to the water body.

Road Sanding

The Connecticut Department of Transportation (CTDOT) maintains South Kent Road and Segar Mountain Road (Route 341) in the winter without the use of sand. CTDOT uses magnesium chloride to pre-wet the calcium chloride it applies during snowstorms. CTDOT switched from a winter highway treatment program using a combination of sand and salt to one using liquid chemicals and salt in 2006 (Frisman, 2014). The Town of Kent also uses a salt mixture to treat local roadways (Osborne, 2014). Therefore, winter roadway de-icing activities in the watershed are not a significant source of sediment.

Stream Channel Erosion

WTM estimates stream bank erosion by allowing the user to specify an observed erosion condition, and the model supplies a typical estimate of sediment load for that condition. The user can specify channel erosion as low (25% of the subwatershed sediment load; channels stable or largely armored), moderate (50% of the subwatershed sediment load; channels show signs of degradation with some areas severely degraded), or high (75% of the subwatershed sediment load; channels have areas of severe degradation). Each of the Hatch Pond subwatersheds was assigned to one of these erosion categories according to the stream reach assessment data (discussed in *Section 2.4.1*). Based on these assessments, the Womenshenuk Brook subwatershed was modeled as having high bank stability, the School Pond subwatershed was modeled as having low bank stability, and the remaining subwatersheds were modeled as having average bank stability. Sediment nutrient concentrations were based on nutrient soil maps (Haith et. al, 1992).

Livestock

The livestock at the Center for Innovation in the Womenshenuk subwatershed were included in the model as nonpoint sources of pollution. WTM default values were used for nutrient loading and percent of livestock exposed to runoff. There may be small numbers of livestock on private farms in the watershed, although this information was unavailable and was not included in the model.

Riparian Buffers

The effects of riparian buffers on pollutant load reduction are calculated within the model by accounting for the buffer area of natural land between urban designated land (residential, commercial, industrial, roadway, etc.) and the stream in each subwatershed. The areas of riparian buffers were estimated from aerial photography and confirmed by the field assessments discussed in *Section 2.4.1*. Moderately-sized to large buffer areas were modeled for the Headwaters, Segar Mountain, and Womenshenuk Brook subwatersheds. Small buffer areas were modeled for the Leonard Pond and School Pond subwatersheds. Maintenance of all buffers was assumed to be 40% effective, accounting for areas with generally no restrictions on activities within the buffer.

4.1.1.3 Existing Pollutant Loads

Table 4-1 presents the existing modeled pollutant loads for the Hatch Pond watershed by pollution source. The greatest nitrogen loading is generated by residential, wetland, and agricultural areas, and phosphorus loading is dominated by residential, wetland, and institutional areas. Residential areas generate the greatest TSS load, although agricultural areas and roadways are also substantial contributors to the modeled TSS load.

Of the other pollutant sources discussed in *Section 4.1.2*, channel erosion accounts for approximately 8% of the TN loads, 33% of the TP loads and 53 of the TSS loads. However, riparian buffers reduce TN loads in the watershed by approximately 12%, TP loads by 15%, and TSS loads by 8%. They also reduce runoff volume by an estimated 4%. Given that the watershed is sparsely populated and has a relatively low percentage of developed land aside from residential use, channel erosion is expected to contribute a higher percentage of pollutant loading in this watershed than would normally be expected in a more urbanized watershed. This assumption is in alignment with field observations of the watershed described in *Section 2*.

After load reductions due to riparian buffers are accounted for, the overall annual loads from the watershed for the three modelled pollutants are 11,652 lb for TN, 1,264 lb for TP, and 643,303 lb for TSS.

Table 4-1. Modeled Annual Existing Pollutant Loads by Source

Source	**TN (lb)**	**TP (lb)**	**TSS (lb)**	**Runoff Volume (acre-feet)**	**TN (% of load)**	**TP (% of load)**	**TSS (% of load)**	**Runoff Volume (% of total)**
Land Use								
Agriculture	1,817	112	44,055	1,817	15.4	12.0	13.4	11.8
Commercial	28	2	739	28	0.2	0.2	0.2	0.4
Forest	525	32	15,029	525	4.5	3.5	4.6	11.4
Golf Course	256	13	6,412	256	2.2	1.4	1.9	5.0
Industrial	49	4	1,840	49	0.4	0.4	0.6	0.5
Railroad	477	71	26,484	477	4.1	7.6	8.0	6.8
Recreation	157	31	1,569	157	1.3	3.4	0.5	1.2
Residential	4,164	312	156,150	4,164	35.4	33.4	47.4	40.4
Road	836	124	46,469	836	7.1	13.3	14.1	12.0
Institutional/ School	708	74	18,977	708	6.0	8.0	5.8	9.2
Water	1,214	70	5,279	1,214	10.3	7.5	1.6	0.0
Wetland	1,531	89	6,659	1,531	13.0	9.5	2.0	1.4
Total Land Use	**11,763**	**935**	**329,662**	**951**				
Other Nonpoint Sources & Reductions								
Stream Channel Erosion	1,103	490	367,513	0	8.3	32.9	52.5	8.3
Livestock	72	9	0	0	0.5	0.6	0.0	0.5
Subsurface Disposal Systems	339	57	2,260	0	2.6	3.8	0.3	2.6
Riparian Buffer	-1,624	-226	-56,131	-37	-12.2	-15.2	-8.0	-3.9
Total other Nonpoint	-111	329	313,642	-37				
All Sources Total	**11,652**	**1,264**	**643,303**	**914**				

Table 4-2 presents a breakdown of estimated annual loadings of TN, TP, and TSS by subwatershed (which includes load reductions from existing practices).

Table 4-2. Subwatershed Annual Pollutant Loads and Yields

Subwatershed	Load (lb)			Runoff Volume (acre-feet)	Yield (lb/ac)			Runoff Depth (inches)
	TN	TP	TSS		TN	TP	TSS	
Hatch Pond Direct Drainage Subwatershed (339 acres)	2,548	253	108,907	138	7.5	0.7	321	4.9
Headwaters Subwatershed (365 acres)	1,356	137	92,582	113	3.7	0.4	253	3.7
Leonard Pond Subwatershed (346 acres)	1,920	213	96,379	150	5.5	0.6	278	5.2
School Pond Subwatershed (239 acres)	2,465	380	211,203	203	10.3	1.6	884	10.2
Segar Mountain Tributary Subwatershed (183 acres)	332	31	21,750	42	1.8	0.2	119	2.8
Womenshenuk Brook Subwatershed (536 acres)	3,030	250	112,484	267	5.6	0.5	210	6.0
Watershed Total (2,009 acres)	**11,652**	**1,264**	**643,303**	**914**				

Because the study subwatersheds vary in size, nonpoint source pollutant loads were also evaluated in terms of pollutant yield (i.e., pollutant load per acre of land area), as shown in *Table 4-2*. *Figures 4-1* through *4-3* depict the variability in pollutant yields among subwatersheds. A higher yield indicates relatively greater pollutant sources per unit area. Pollutant loads and yields for TN and TP by subwatershed are shown in *Figure 4-4* through *Figure 4-7*. The highest yields for TN, TP, and TSS, and the highest total runoff volume are associated with the School Pond subwatershed. Leonard Pond and Hatch Pond Direct Drainage subwatershed also have relatively higher yields for these four parameters.

- **School Pond Subwatershed** – The School Pond subwatershed is the second smallest subwatershed, but has the highest annual yield for TN, TP, and TSS as well as the greatest depth of runoff. It also has the highest load of TP, TSS, and TN as well as the second highest runoff volume. The South Kent School and Bull's Bridge Golf Club account for 56% of the watershed area, which are developed areas. Another 20% of the watershed consists mainly of agricultural lands, a land use modeled with higher pollutant loadings. Channel erosion contributes strongly to modeled TSS loading within this watershed.

- **Leonard Pond Subwatershed** – The Leonard Pond subwatershed is moderately-sized in terms of the Hatch Pond subwatersheds, but has the second highest yield for TSS and the third highest yield for TP. It also has the third highest runoff volume and TSS loading. The Leonard Pond subwatershed is the most diverse of the subwatersheds in terms of land use, with approximately 38% forested, 18% recreation, 16% residential, and smaller percentages of agriculture, industrial, railroad, roadway, and open water. It is the subwatershed with both the highest proportion (12%) and highest total amount of its area (40 acres) reported as wetland. Wetlands and residential areas appear to be the most significant contributors to the pollutant loading to the pond in this watershed. The model also indicates that channel erosion contributes strongly to TSS loading within this subwatershed.

- **Hatch Pond Direct Drainage Subwatershed** – The Hatch Pond Direct Drainage subwatershed is grouped between the Leonard Pond subwatershed and the School Pond subwatershed in size. It has the second highest yield of TP, TN and TSS. This watershed is mostly forested (43%) but also contains residential areas (25%). In addition to the area taken up by Hatch Pond itself (approximately 20% of the total subwatershed), the rest of the subwatershed has small areas devoted to agriculture, railroad, roads, wetland, and part of South Kent School. The WTM indicated that channel erosion appears to contribute strongly to TSS loading within this watershed.

- **Womenshenuk Brook Subwatershed** – The Womenshenuk Brook subwatershed is the largest of all of the subwatersheds. Because of this, the subwatershed has the second highest annual load of TP, TN, and TSS. Annual runoff volume is the largest of the subwatersheds, but depth of runoff on an annual basis for this less developed subwatershed is half of that of the smaller, but more developed, School Pond subwatershed. This watershed contains the Center for Innovation, whose livestock adds only marginally to the pollutant loading. Land uses contributing most to TSS load is residential areas (27% of the watershed) and roadways (2% of the subwatershed), while residential areas and wetlands (11% of subwatershed) are the largest contributors to TN and TP loading. Agriculture (9% of the area) contributes moderately to TSS, TN, and TP, while channel erosion also contributes strongly to TSS.

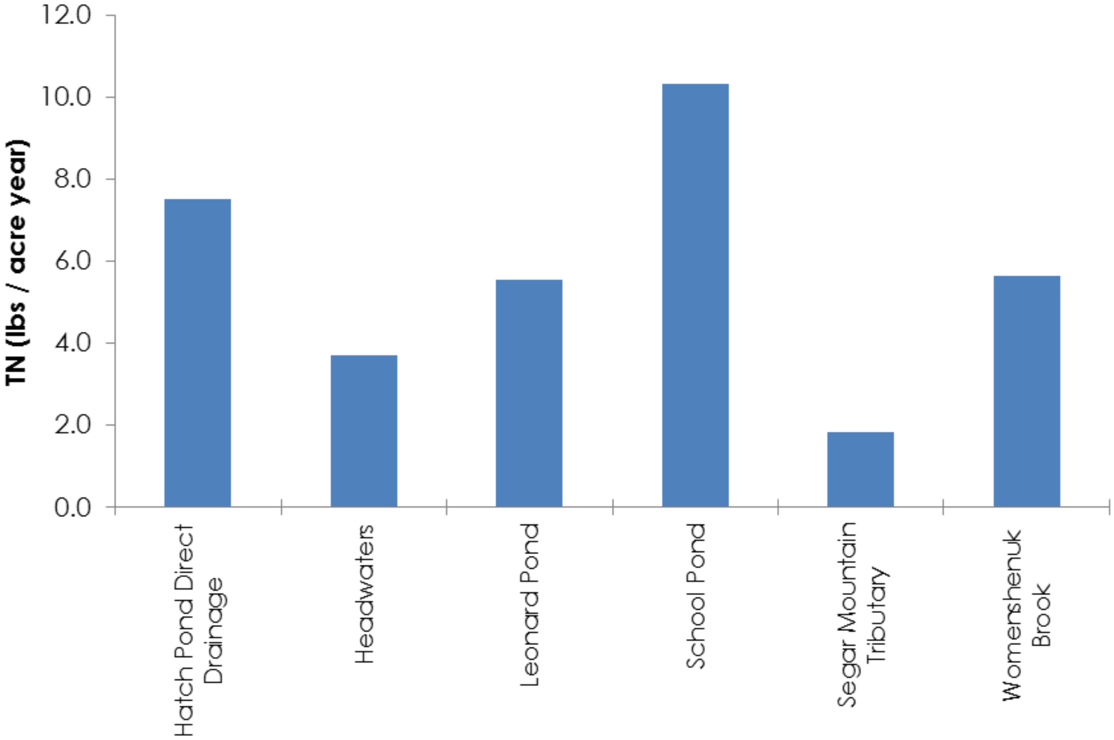

Figure 4-1. Graph of Annual TN Yields by Subwatershed

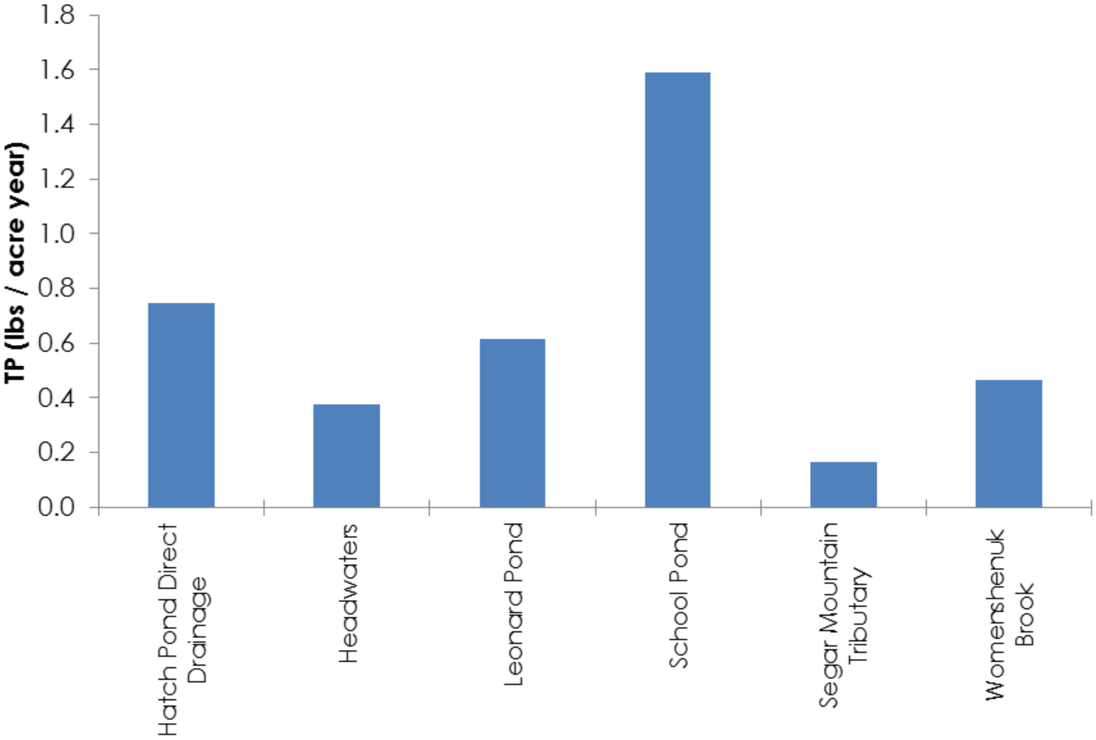

Figure 4-2. Graph of Annual TP Yields by Subwatershed

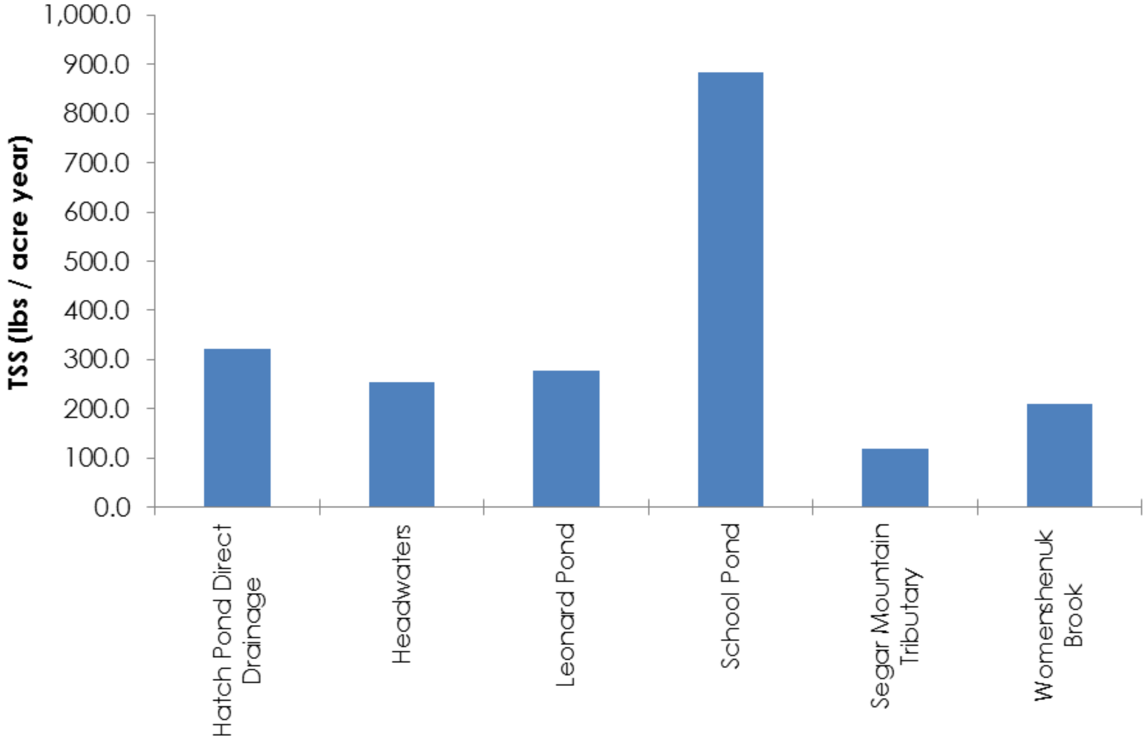

Figure 4-3. Graph of Annual TSS Yields by Subwatershed

In general, the School Pond watershed is more densely developed since it contains SKS and Bull's Bridge Golf Club and has more impervious area than the other subwatersheds; therefore, it would be expected to have a higher pollutant loading compared to the other less-developed subwatersheds.

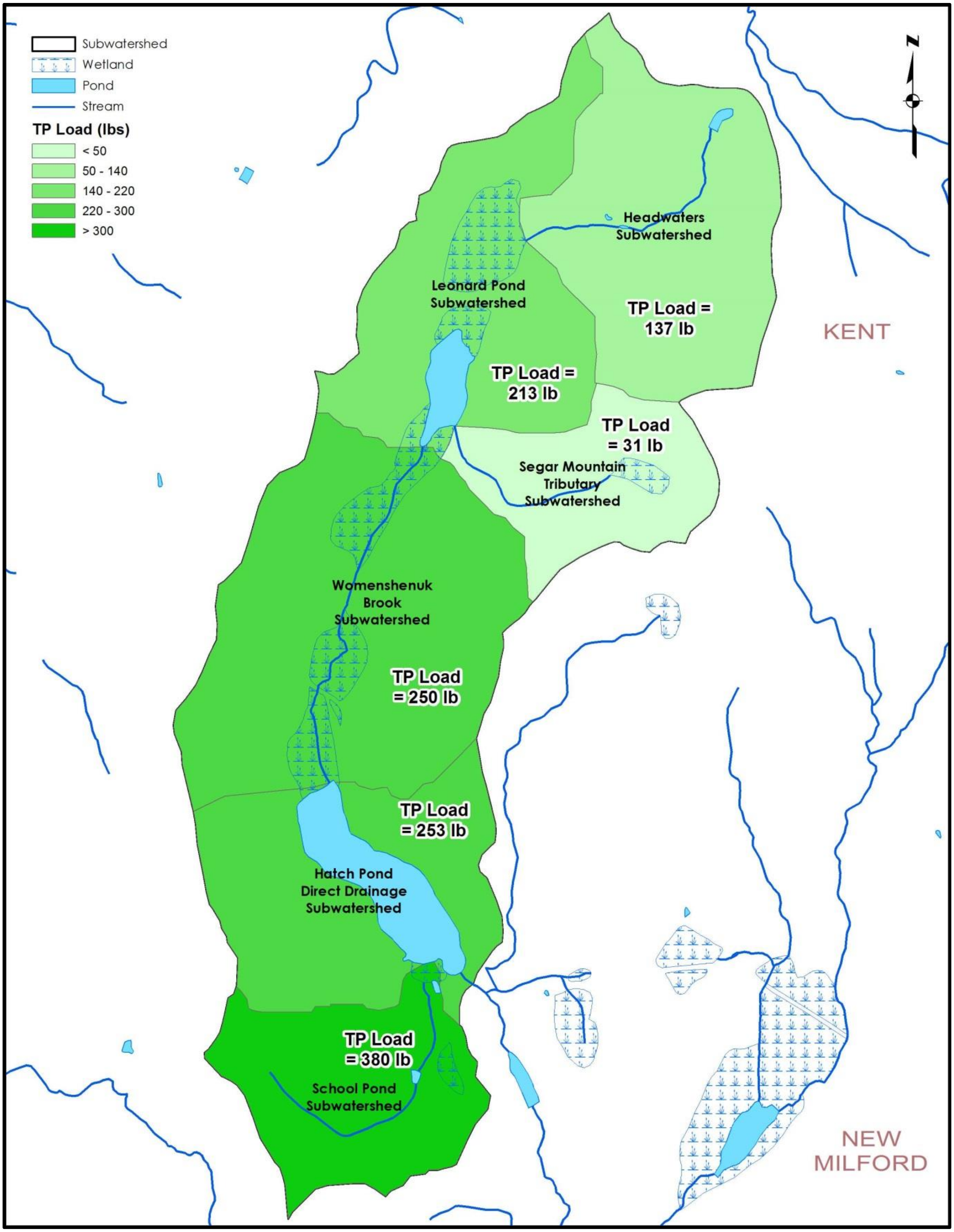

Figure 4-4. Map of Annual TP Loads by Subwatershed

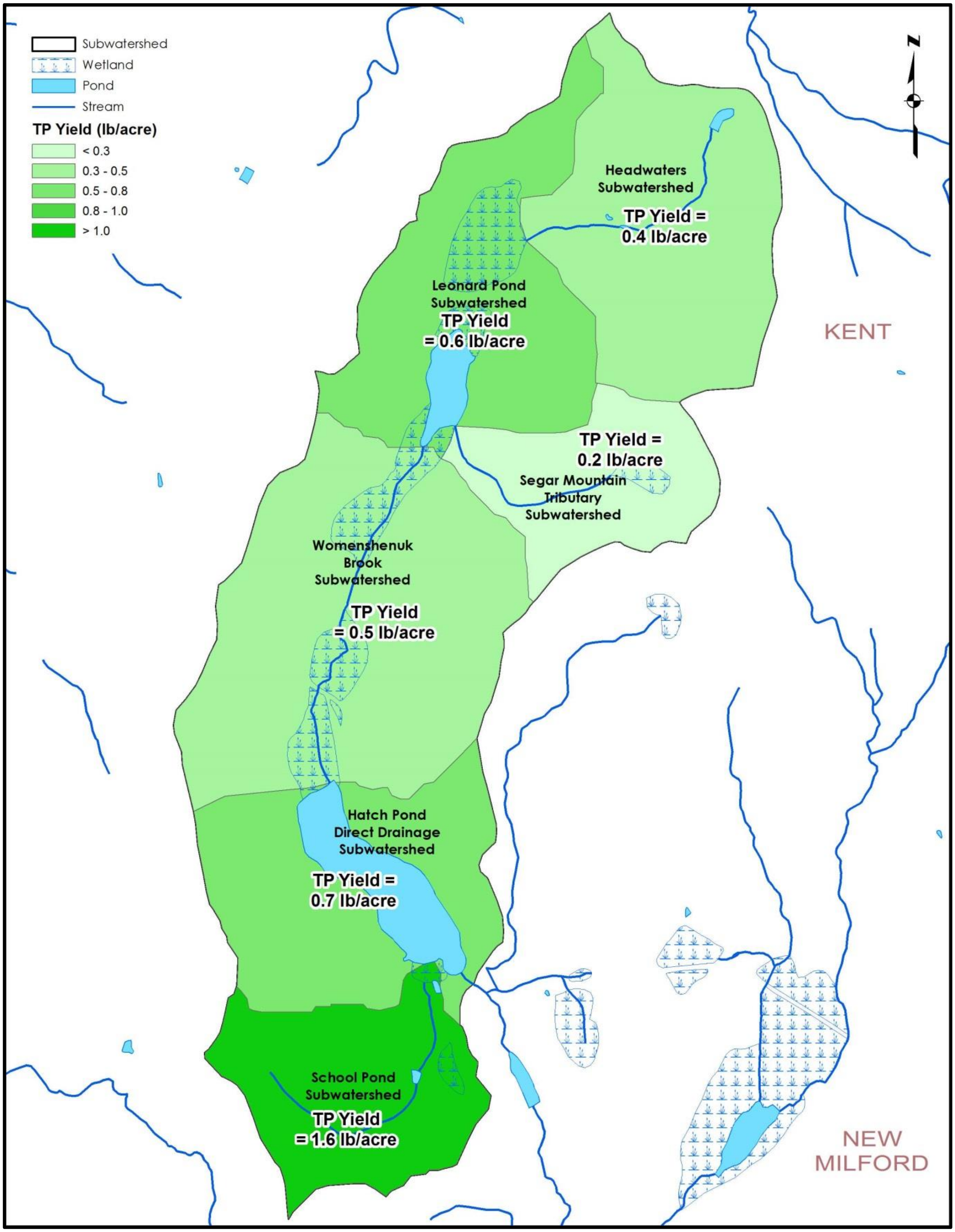

Figure 4-5. Map of Annual TP Yields by Subwatershed

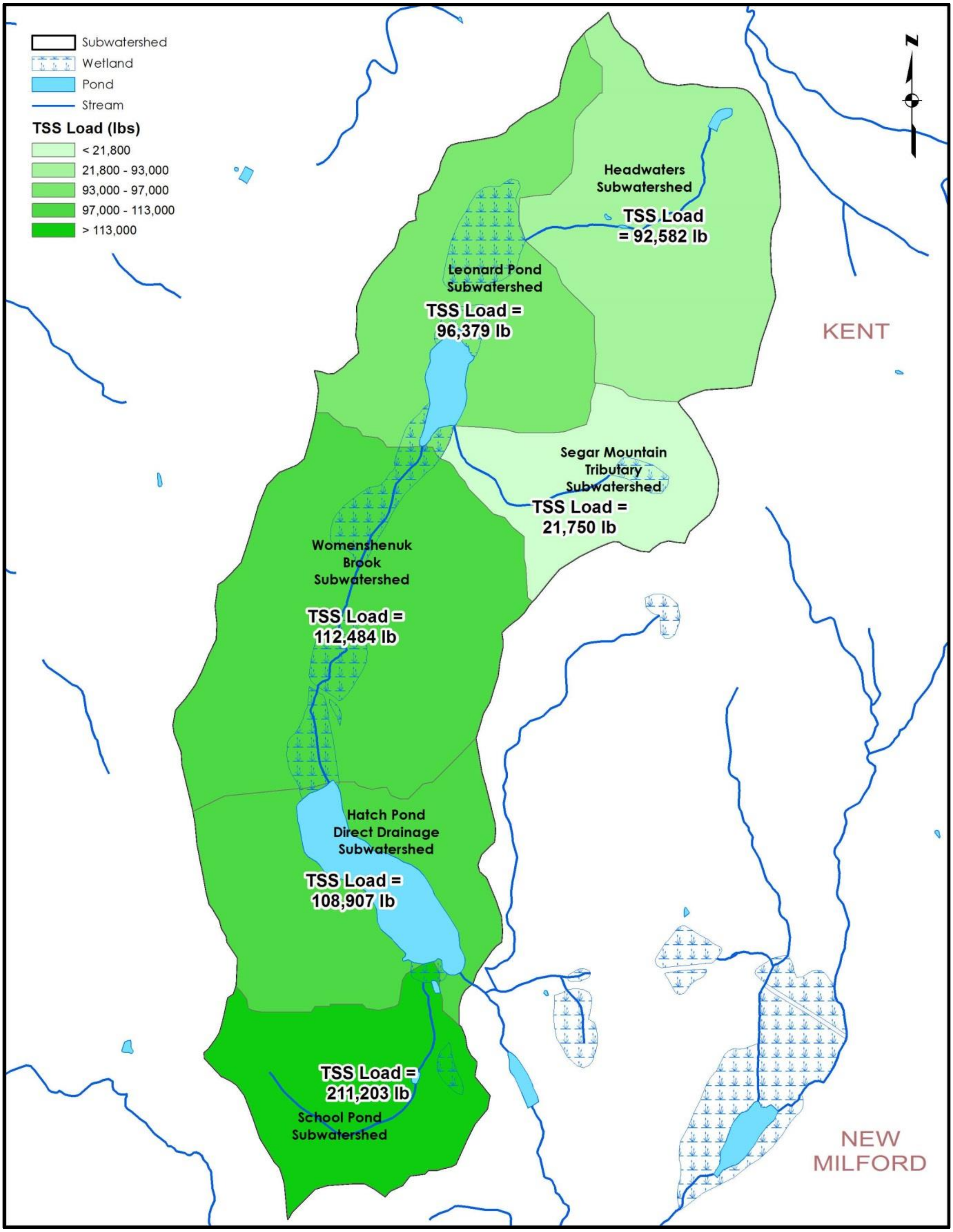

Figure 4-6. Map of Annual TSS Loads by Subwatershed

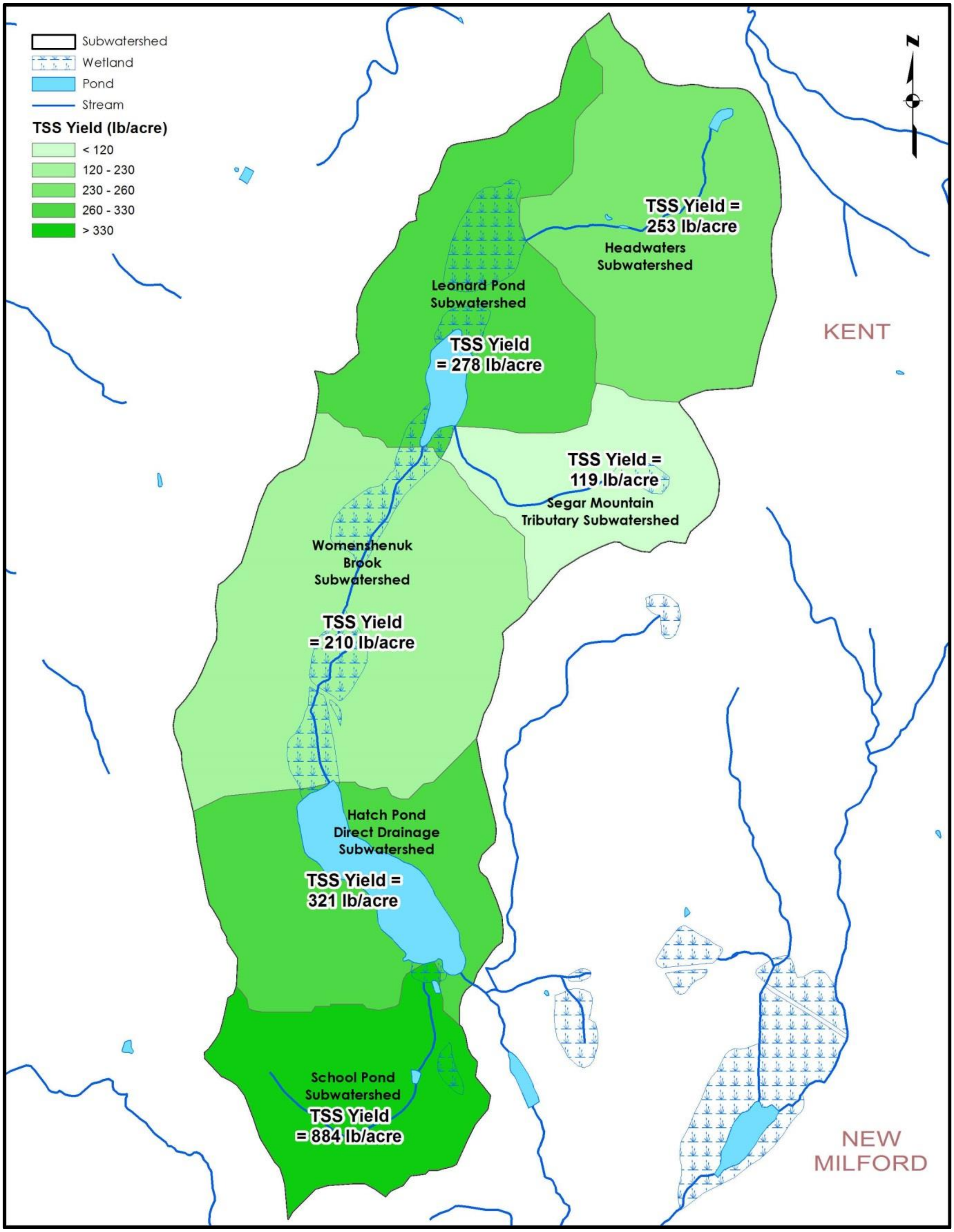

Figure 4-7. Map of Annual TSS Yields by Subwatershed

Additional pollutant reduction occurs as runoff from individual subwatersheds flows through wetland areas and ponds as it travels downstream to Hatch Pond. Actual pollutant loads to Hatch Pond are therefore lower than the subwatershed pollutant loading estimates and yields presented above. Further pollutant reduction factors were applied to the WTM modeled pollutant loads to account for the additional pollutant attenuation provided by wetlands and impoundments (i.e., Leonard Pond and School Pond) upstream of Hatch Pond. Pollutant removal efficiencies for the wetland areas and impoundments were estimated from literature values for TN, TP, and TSS. The removal efficiencies and resulting annual pollutant loads to Hatch Pond are summarized in *Table 4-3*.

Table 4-3. Modeled Existing Annual Pollutant Loads to Hatch Pond

Subwatershed	**TN**	**TP**	**TSS**	**TN Load**	**TP Load**	**TSS Load**
	(Annual Percent Reduction)			**(lb)**	**(lb)**	**(lb)**
Headwaters Subwatershed				1,356	137	92,582
Attenuation by Wetlands	40%	40%	60%	-542	-55	-55,549
Adjusted Loads				**814**	**82**	**37,033**
Leonard Pond Subwatershed				1,920	213	96,379
Segar Mountain Tributary Subwatershed				332	31	21,750
Attenuation by Leonard Pond*	50%	50%	80%	-1,533	-163	-124,129
Adjusted Loads				**1,533**	**163**	**31,032**
Womenshenuk Brook Subwatershed				3,030	250	112,484
Attenuation by Wetlands**	40%	40%	60%	-1,825	-165	-86,109
Adjusted Loads				**2,738**	**248**	**57,406**
School Pond Subwatershed				2,465	380	211,203
Attenuation by School Pond/Wetlands***	40%	40%	60%	-986	-152	-126,722
Adjusted Loads				**1,479**	**228**	**84,481**
Hatch Pond Direct Drainage Subwatershed				2,548	253	108,907
Annual Load to Hatch Pond				**6,765**	**729**	**250,794**

*Leonard Pond attenuation applied to adjusted Headwaters loads and loads from Leonard Pond and Segar Mt Tributary subwatersheds.

**Womenshenuk Brook wetlands attenuation applied to loads from Womenshenuk Brook subwatershed and upstream loads.

*** Attenuation by School Pond and wetlands applied to loads from School Pond subwatershed.

The resulting annual watershed pollutant loads to Hatch Pond are 6,765 lb for TN, 729 lb for TP, and 250,794 lb for TSS. WRS and NEAR (2014) also estimated total annual TP loads to Hatch Pond of between 550 and 660 lb. The modeled annual watershed TP loads to Hatch Pond are therefore supported by the empirical model estimates reported by WRS and NEAR (2014) given the accuracy of the pollutant load modeling and the empirical models used by WRS and NEAR.

4.2 Internal Loading

Multiple estimates of internal phosphorus loading by WRS and NEAR (2014) suggest a 2014 range of approximately 18 to 26 lb/yr. This load is less than 10% of the total estimated phosphorus load to Hatch Pond and appears to be declining each year following the cessation of the dairy farming activities at the northern end of Hatch Pond. Internal loading of phosphorus is believed to have been in excess of 110 lb/yr while the dairy farm was in operation, and may have approached 200 lb/yr. Internal loading may never have been a dominant source of phosphorus in Hatch Pond, but appears to be a minor source now (WRS and NEAR, 2014). The phosphorus load to Hatch Pond is therefore dominated by watershed sources.

5 Existing Conditions Summary

Based on the existing conditions assessment presented in the previous sections, the following key conclusions can be made, which guide the selection and prioritization of management actions to reduce and prevent water quality impacts to Hatch Pond.

- Elimination of the dairy farm at the northern end of Hatch Pond has resulted in steady, measureable improvement in the water quality and algae community of Hatch Pond. Further in-lake and watershed monitoring is recommended to determine what the new equilibrium water quality conditions will be in Hatch Pond (due to elimination of the dairy farm) before any substantial expenditures on water quality improvement are made.

- Internal phosphorus loads from bottom sediments are much smaller than phosphorus loads from watershed sources, pointing to the overall importance of watershed management for further reducing phosphorus loads to achieve desirable water quality conditions.

- Efforts should continue to focus on preventing erosion of historically-impacted soils from the former dairy farm, which is now the site of the South Kent School Center for Innovation.

- The School Pond subwatershed contains the most development and impervious area, and has the highest pollutant yields. Although a pollutant source area, the School Pond subwatershed offers the greatest potential for implementation of management practices (i.e., pollution prevention, retrofits, and restoration practices) given the existing development within the subwatershed.

- Although total phosphorus levels in the watershed soils have not been measured, recent soil testing in the School Pond subwatershed has shown high levels of plant-available phosphorus, which may be due to a combination of naturally-occurring phosphorus and anthropogenic sources. That observation, combined with the high rates of historic sedimentation to the pond, indicates that control of erosion and sedimentation in both developed and undeveloped areas will be important to limit further nutrient and sediment loadings to Hatch Pond.

- The link between sediment and phosphorus loading (from both developed and undeveloped areas) is important to keep in mind because of the tendency for nutrients to be associated with lighter organic matter and clay particles, which also tend to be more readily eroded than heavier silt and sand (Mills et al., 1985).

- While subsurface waste disposal systems were not identified as a major potential pollutant source watershed-wide, the possibility remains that failing or malfunctioning systems in proximity to water bodies could adversely impact water quality by contributing to nutrient loading via surface runoff or groundwater flow.

- Rooted plant problems are expected to continue or intensify in the coming years as water quality conditions in Hatch Pond improve. Management of rooted aquatic plants will be necessary to improve fish habitat and boating opportunities in the pond.

6 Watershed Management Objectives

This section discusses management objectives for Hatch Pond and its watershed. Recommended management actions, including watershed and in-lake management strategies, are presented in *Section 7* of this plan.

6.1 Management Objectives

The overall goal of this management plan is to improve water quality in Hatch Pond by reducing phosphorus and sediment loading to the lake. However, the specific management objectives will be dictated by the degree of water quality improvement and uses of the pond desired by the pond/watershed stakeholders. The spectrum of desired outcomes and therefore possible management objectives could range from modest improvements in water quality and aquatic plant conditions within the pond to allow for enhanced recreational use such as fishing and boating, to restoration of the pond such that it consistently meets water quality standards for nutrients, water clarity, and algae and is consequently removed from CTDEEP's list of impaired waters. These and intermediate outcomes will require varying levels of in-lake and watershed management effort and funding.

Based on the previous studies of Hatch Pond including the most recent in-lake study by WRS and NEAR in 2014, water quality and algae conditions in Hatch Pond appear to be improving steadily following the elimination of the dairy farm at the northern end of the pond. In-lake water quality is expected to reach a new equilibrium condition within the next 5 or 6 years, which is anticipated to be somewhere between the permissible (250 lb/yr) and critical (500 lb/yr) phosphorus load levels. The permissible load is the level of loading below which algal blooms and related water quality problems are expected to be minimal, while the critical load is the load above which frequent algal blooms and water quality impairment are expected.

Given the range of potential management objectives for the pond and the uncertainty in the amount of water quality improvement that can be expected from elimination of the dairy farm, an adaptive management[7] approach is recommended for implementing in-lake and watershed management recommendations. Specific management objectives for Hatch Pond should be developed through a refined stakeholder process, while systematic in-lake and watershed monitoring is recommended over the next 5 or 6 years to determine what the new equilibrium condition will be before any substantial expenditure on water quality improvement is made. Once desired water quality outcomes are identified by the stakeholders and additional monitoring data is available, load reduction targets can be refined and long-term management actions can be prioritized based on considerations of costs and benefits.

Following this adaptive management approach, the recommended management actions identified in this watershed plan will include a number of short-term actions that can be pursued during the next 1-5 years at relatively low cost, with longer-term actions requiring more extensive funding to be implemented, if determined to be necessary, following the recommended monitoring period.

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[7] Adaptive management is an iterative process for decision making in the face of uncertainty, with the goal of reducing uncertainty over time through monitoring and making adjustments based on monitoring results.

6.2 Load Reduction Targets

The anticipated new equilibrium phosphorus load to Hatch Pond resulting from elimination of the dairy farm is approximately 325 lb/yr, which is between the permissible (250 lb/yr) and critical (500 lb/yr) phosphorus loads (WRS and NEAR, 2014). Assuming that the permissible phosphorus load is a reasonable "restoration" water quality target for Hatch Pond, as it represents a level of loading below which algal blooms and related water quality problems are expected to be minimal, a reduction in annual phosphorus loads of between approximately 30% and 60% is required to reach the permissible phosphorus load. A 30% reduction is required from the estimated new equilibrium phosphorus load, while a 60% reduction is required from the current estimated load. The short-term and long-term watershed management recommendations presented in *Section 7* are intended to achieve a minimum annual phosphorus load reduction of 30%. Estimated load reductions are presented in *Section 8* of this plan.

7 Management Recommendations

The overall goal of improving water quality in Hatch Pond by reducing phosphorus and sediment loads will be achieved through the following actions over the next 10-year period, using an adaptive management approach:

- **Build local capacity for watershed stewardship** by forming a watershed plan implementation committee and identifying and pursuing funding and technical assistance.
- **Conduct ongoing assessment of lake and watershed conditions** by implementing a lake and watershed water quality monitoring program.
- **Reduce current sources of phosphorus and sediment loading** by providing targeted outreach and technical assistance and implementing retrofit and restoration projects throughout the watershed.
- **Prevent new sources of phosphorus and sediment loading** by facilitating improved land use practices and ongoing maintenance activities primarily through outreach and technical assistance.

The recommendations presented in this section focus on watershed management actions, since the phosphorus loads to Hatch Pond are dominated (greater than 90% of the total annual load) by watershed loads as opposed to internal phosphorus recycling from bottom sediments. The recommendations also include in-lake management recommendations to address the rooted aquatic plant problem facing Hatch Pond, which cannot be solved by watershed phosphorus load reductions.

The recommendations are organized by the major pollutant sources described in *Section 3* and include both short-term and long-term actions. Short-term actions are relatively low-cost actions that can be accomplished in the next 5 years, while long-term actions are more expensive actions that should be implemented, as necessary, following the recommended monitoring program that will help define new equilibrium water quality and phosphorus loading conditions for Hatch Pond. The long-term actions are generally meant to be implemented during years 6-10, as funding allows.

7.1 Capacity Building

The success of this watershed based plan will depend on local "buy-in" of the plan recommendations and active participation by the watershed stakeholders. Building local capacity to implement the plan recommendations is a critical first step in the process. Initially, SKS should form a watershed plan implementation committee consisting of the core members of the Hatch Pond Watershed Planning Committee (SKS, private land owners, land trusts, Town of Kent, etc.) and others who want to take an active role in the implementation of this plan. The committee would take the lead in implementing short-term actions, as well as help to refine specific water quality objectives for Hatch Pond. Longer-term consideration should also be given to forming a formal lake watershed group or lake association for Hatch Pond, depending on the ownership of the pond, which should also be confirmed. The recommended actions in this plan are only achievable with sufficient funding. Funding opportunities should be pursued to implement the recommendations outlined in this plan. *Table 7-1* outlines capacity building recommendations for the Hatch Pond watershed based plan.

7.2 Water Quality Monitoring

Water quality monitoring is recommended over the next 5 or 6 years to determine the new water quality equilibrium condition in Hatch Pond before any substantial expenditure on water quality improvement is made. Additional water quality monitoring will help to refine the understanding of the major watershed sources of phosphorus and sediment to the pond, the amount of phosphorus load reductions required to meet the desired water quality goals, and to measure progress of the short-term management actions. Water quality monitoring is therefore an essential component of the proposed adaptive management approach for the Hatch Pond watershed.

An in-lake monitoring program similar to that conducted by WRS and NEAR in 2014 is recommended, with 4 to 6 sampling events between April and October of each of the next 5 or 6 years or until stable conditions persist (WRS and NEAR, 2014). Each of the Hatch Pond tributaries should also be monitored 4 to 6 times per year during both wet and dry weather conditions for nutrients, sediment, and field parameters including instantaneous flow measurements. Monitoring should also be performed upstream and downstream of the major potential nutrient and sediment "sinks," including the wetland complex upstream of Hatch Pond, the existing basins at the Center for Innovation, and School Pond at SKS.

Monitoring could be conducted by SKS, members of the watershed plan implementation committee, or other volunteers to reduce costs. Some consultant assistance is anticipated to provide initial training, to update the existing Quality Assurance Project Plan (QAPP), and to assist with data interpretation and refinement of pollutant load reduction targets. *Table 7-2* outlines recommendations for implementing a systematic water quality monitoring program.

Table 7-1. Capacity Building Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Form implementation committee • Led by SKS Sustainability Director • Include key members of Watershed Planning Committee • Identify committee co-chair • Assign tasks and hold regular meetings	SKS	2015	Committee membership and work plan	$	SKS/Private
2. Refine management objectives • Identify specific management objectives and desired water quality endpoint for Hatch Pond	SKS and Implementation Committee	2015	Refined management objectives and water quality goals	$	SKS/Private
3. Identify and pursue funding • Review and prioritize funding sources • Prepare and submit grant applications	SKS and Implementation Committee	2015-2016	List of funding sources and funding pursued	$$	SKS/Private
4. Confirm lake ownership and consider more formal watershed or lake organization • Research and verify ownership of Hatch Pond • Consider forming a Hatch Pond watershed or lake association for effective long-term management of Hatch Pond water quality and land use issues	SKS and Implementation Committee	2015-2016	Confirmation of lake ownership and evaluation of alternative watershed/lake management organization options	$$	SKS/Private

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-2. Water Quality Monitoring Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Revise QAPP • Update QAPP for ongoing in-lake and watershed monitoring program by volunteers or consultant	SKS and Implementation Committee, DEEP, EPA	2015	Approved QAPP	$	SKS/Private
2. Train volunteers	SKS and Implementation Committee and/or consultant	2015 Annually (analyze data)	Training materials and trained volunteers	$	SKS/Private and DEEP (604b)
3. Conduct annual in-lake and watershed monitoring	Volunteers and/or consultant	Annually 2015-2020 or until new water quality equilibrium	Annual monitoring data summaries	$$ annually (volunteer monitoring) $$$ annually (consultant monitoring)	SKS/Private and DEEP (604b)
4. Analyze and interpret data	Volunteers and/or consultant	Annually and at end of monitoring period	Monitoring report	$$	SKS/Private and DEEP (604b)

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

7.3 South Kent School

7.3.1 School Pond

As described in previous sections of this plan, School Pond is located just upstream of Hatch Pond and receives flow diverted from the southern unnamed tributary, which drains a portion of SKS and Bull's Bridge Golf Club. The pond serves to remove sediment and phosphorus from the diverted portion of the southern tributary. The pond is therefore an important existing control measure for reducing sediment and phosphorus loads from the southern tributary, including the school, golf course, and other developed areas in the School Pond subwatershed.

The pollutant removal effectiveness of the pond is unknown. In addition to ongoing monitoring of the pond's inlet and outlet, an engineering evaluation of the pond is recommended to assess the pond's pollutant removal effectiveness by answering the following questions:

- What is the streamflow associated with the southern unnamed tributary?
- How much flow is diverted into the pond and how much bypasses the pond?
- How deep is the pond and what is its water volume and detention time?
- How much sediment is in the pond and what is its quality?
- What is the current condition and capacity of the pond inlet/diversion and outlet structure?
- What is the potential cost to design and construct potential improvements to the pond?

Routine maintenance of the pond should continue by SKS. However, the maintenance activities and frequency should be optimized to maximize the pond's sediment and phosphorus removal effectiveness. A number of modifications to the pond should also be considered to enhance sediment and phosphorus removal (see *Figure 7-1*), based on the findings of the recommended engineering evaluation:

- Increase pond volume and sedimentation efficiency by removing accumulated sediment
- Modify the diversion structure to optimize flow capture from the watershed
- Consider the addition of a sediment forebay at the inlet to the pond to help confine sediment to a smaller area and facilitate routine sediment removal
- Enhance or augment the existing vegetative buffer around the western shoreline to more effectively filter runoff from the adjacent lawn, while still providing access and views by students, faculty, and staff of SKS.
- Maintain a vegetative buffer along the stone-lined stream channel as it flows through the SKS campus upstream of School Pond.
- Conduct routine sediment removal from the pond forebay and main body of the pond and regular maintenance of the diversion/inlet and outlet structures, vegetative buffers, and aquatic vegetation control.

Table 7-3 contains recommendations for conducting an engineering evaluation of and implementing potential improvements to School Pond.

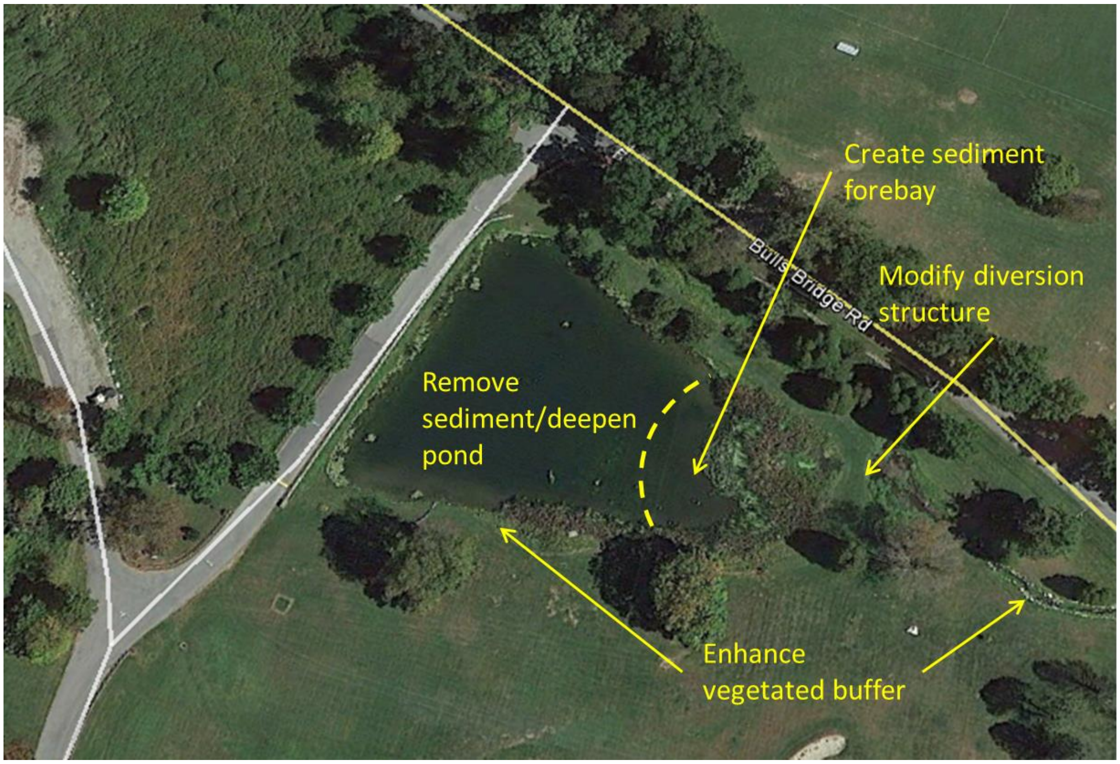

Figure 7-1. Potential Enhancements to School Pond

7.3.2 Green Infrastructure

As described in *Sections 2 and 3* of this plan, runoff from the SKS campus is a source of sediment and phosphorus to Hatch Pond. Although the campus is rural in nature and has minimal piped drainage, the existing impervious areas (roads, parking lots, buildings, etc.) and land use activities on the campus are a source of nonpoint source sediment and phosphorus loads. SKS has been addressing the potential water quality impacts of stormwater runoff by implementing "Low Impact Development"[8] or "Green Infrastructure"[9] practices on campus including bio-swales, permeable pavers, rain gardens, and rain barrels. SKS has also incorporated green infrastructure into its Center for Innovation curriculum focusing on sustainable resources and watershed management.

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[8] Low Impact Development (LID) is a land development approach that is intended to reduce development-related impacts on water resources through the use of stormwater management practices that infiltrate, evapotranspirate, or harvest and use stormwater on the site where it falls.

[9] Green Infrastructure is an approach to managing stormwater runoff while maintaining or restoring green features such as stream buffers, floodplains, rain gardens, porous pavements, and other man-made or natural features.

Table 7-3. School Pond Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Conduct engineering evaluation**	SKS and consultant	2015-2020	Evaluation report	$$$	SKS/Private
2. **Construct pond enhancements** • Design and permitting • Dredge pond • Modify diversion structure • Add sediment forebay • Enhance vegetative buffers	SKS and consultant	2020 Following engineering evaluation and monitoring period	Design and construction of proposed enhancements, post-construction monitoring	$$$$	SKS/Private and EPA/DEEP (319)

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-4. Green Infrastructure Recommendations for the SKS Campus

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Develop green infrastructure master plan for the SKS campus**	SKS and consultant	2015-2017	Master plan, campus stormwater management standards, site-specific project concepts	$$$	SKS/Private
2. **Implement master plan projects**	SKS	Ongoing retrofits and larger projects following completion of master plan	Design and construction of proposed projects	$$$$	SKS/Private and EPA/DEEP (319)

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

SKS should continue to promote and implement LID and green infrastructure projects through the development and implementation of a campus-wide green infrastructure master plan. The master plan should include the following elements:

Recommended Green Infrastructure Practices for the SKS Campus

- Drywells and infiltration systems (decentralized, small-scale practices distributed throughout the site)
- Bioretention systems and rain gardens (infiltration or filtration designs)
- Downspout disconnection
- Permeable pavement
- Vegetated filter strips between developed areas (lawn, parking, roads) and water bodies
- Vegetated swales/channels
- Rainwater harvesting (e.g., rain barrels and cisterns) for landscape irrigation and gray water reuse
- Green roofs

- Stormwater management policy framework that identifies guiding principles and stormwater management standards for future construction projects and post-construction stormwater management on the SKS campus.

- The types of green infrastructure Best Management Practices (BMPs) that should be considered for campus projects. BMP performance for capturing phosphorus varies considerably depending on BMP type and design. Infiltration systems have the highest phosphorus removal efficiencies, while BMPs that include a filtering medium such as bioretention/filtration systems, gravel wetlands, and permeable pavement are the next best performers for removing phosphorus. Infiltration and filtration systems sized for one inch of runoff will capture most of the annual phosphorus load from impervious surfaces. Infiltration practices offer other benefits including recharging groundwater, peak runoff rate attenuation, reduced thermal impacts to receiving waters, and enhanced stream base flow.

- Recommendations for site-specific green infrastructure projects including retrofit of existing campus infrastructure and opportunities to incorporate green infrastructure into future campus development projects. Site-specific project recommendations should build upon the green infrastructure concepts recently developed as part of the SKS CFI "Sustainable Resources and Watershed Management" class projects.

Table 7-4 contains recommendations for continued implementation of green infrastructure on the SKS campus.

7.3.3 Campus Maintenance Practices

Turf areas, roadways, parking lots, septic systems, and the campus drainage system can contribute sediment and nutrients to Hatch Pond depending on campus maintenance practices. SKS currently implements a number of good management practices that contribute to a reduction in nonpoint source pollution – minimal use of fertilizers on turf areas as necessary, no pesticide use, use of phosphorus-free fertilizer, mulching or composting of grass clippings, and recent upgrade of the campus' main subsurface sewage disposal system. Additional or modified practices are recommended to further reduce sediment and phosphorus loads from the SKS campus, including:

- Regular inspection of older subsurface sewage disposal systems, and upgrade or tie-in to the recently upgraded main system as necessary

- Regular inspection and cleaning of catch basins
- Maintaining vegetation in grass-lined drainage ditches and swales at a height of 3 to 4 inches to provide sediment and nutrient removal benefits
- Repair of eroded areas that can contribute sediment to the campus drainage system or water bodies such as along school roads and parking lots
- Use of appropriate erosion and sediment controls during campus construction projects
- Maintaining vegetated buffers between developed areas (lawn, roads, parking lots, etc.) and water bodies. Buffers are recommended along the unnamed southern tributary as it flows through the SKS campus and along School Pond.

SKS CFI faculty and facilities/maintenance staff should meet on a regular basis to review existing and recommended campus maintenance practices to reduce sediment and phosphorus loads. Suggested topics include:

- Turf management and low fertilizer usage
- Grass clippings management and leaf/brush waste management
- Maintenance of grass swales and riparian buffers
- Parking lot and road maintenance (deicing, snow management)
- Drainage system maintenance (catch basins, storm drains, stormwater BMPs)
- Erosion and sedimentation controls
- Septic system inspection and maintenance

Table 7-5 contains recommendations relative to campus maintenance practices.

7.3.4 South Kent School Educational Programs

Hatch Pond and its watershed provide a real-world classroom and opportunities for experience-based learning. SKS, through its Center for Innovation, should continue its educational programs in sustainability and watershed management, with a focus on the water resource management issues surrounding Hatch Pond. Future courses in sustainability and watershed management should incorporate activities associated with implementation of the Hatch Pond Watershed Based Plan, including water quality monitoring, follow-up watershed assessments (e.g., evaluation of School Pond), and design and construction of various campus retrofit/restoration projects.

7.3.5 Center for Innovation

Conversion of the former dairy farm at the northern end of Hatch Pond to the SKS Center for Innovation (CFI) site has eliminated a major source of sediment and phosphorus to Hatch Pond, while creating a state-of-the-art environmental and educational site. The sustainable farming practices at the CFI site are a significant improvement over the former dairy farm operations in terms of impacts to Hatch Pond. The CFI site offers several opportunities to further reduce sediment and nutrient loads to the pond:

Table 7-5. South Kent School Campus Maintenance Practices Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Hold initial training workshop for SKS facilities/maintenance staff	SKS CFI faculty and facilities/maintenance staff	2015	Training materials, number of SKS staff receiving training	$	SKS
2. Meet regularly to review and modify campus maintenance practices	SKS CFI faculty and facilities/maintenance staff	Annually or semi-annually	Meeting notes and followup implementation actions	$	SKS

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-6. South Kent School Center for Innovation Site Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Conduct engineering evaluation of wet pond and dry basin	SKS and consultant	2015-2020	Evaluation report	$$	SKS/Private
2. Construct pond/basin improvements • Design and permitting • Sediment removal • Structural modifications • Enhance vegetative buffers to on-site drainage channels	SKS and consultant	2020 Following engineering evaluation and monitoring period	Design and construction of proposed improvements, post-construction monitoring	$$$	SKS/Private and EPA/DEEP (319)

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

- Where possible, maintain a 20 to 30-foot vegetative buffer along the drainage channels that flow through the site.
- Conduct an engineering evaluation of the on-site wet pond and dry basin to assess the pollutant removal effectiveness of these controls (see recommendations for School Pond).
- Consider retrofits to the on-site wet pond and dry basin for enhanced sediment and phosphorus removal, including initial and periodic removal of accumulated sediment.
- The grass channel that connects the wet pond and dry basin was observed to be eroding and should be stabilized.
- The grass drainage swale that carries runoff from the upper agricultural fields and discharges to the wet pond could be retrofitted with check dams and additional plantings to more effectively capture sediment and nutrients.
- Continue to implement rainwater harvesting at the site for irrigation.
- Implement best practices for manure nutrient management and soil erosion control.

Table 7-6 lists recommendations for the CFI site.

7.4 Bull's Bridge Golf Club

Bull's Bridge Golf Club implements a variety of management practices that contribute to a reduction in sediment and nutrient loads. Phosphorus has not been used in golf course fertilizers since the course was initially built in 2002/2003 since the soils at the site have adequate phosphorus for plant growth. Bull's Bridge Golf Club should continue to implement golf course nutrient and water management best practices to minimize potential impacts to Hatch Pond. The Hatch Pond watershed plan implementation committee should request and review the results of routine surface water and groundwater monitoring conducted by the Golf Club as part of its Natural Resource Management Plan and Town of Kent Special Permit to construct the golf course.

7.5 Municipal and State Roads

Roads within the Hatch Pond watershed are a source of sediment and nutrient loads to Hatch Pond. Although CTDOT and the Town of Kent have discontinued the use of sand for roadway deicing, significantly reducing winter sediment loads, roads remain a significant source of runoff and pollutants to Hatch Pond and upstream water bodies. Runoff from South Kent Road is discharged directly to Hatch Pond through approximately 15 separate outfalls (*Figure 7-2*).

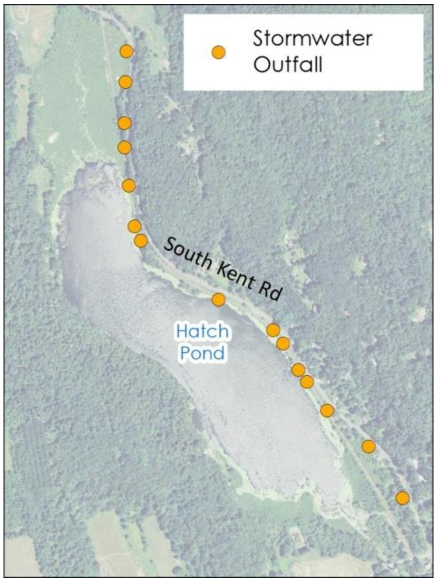

Figure 7-2. South Kent Road Stormwater Outfalls

The watershed plan implementation committee should work with CTDOT to ensure that the catch basins and storm drainage system along South Kent Road in the vicinity of Hatch Pond are inspected and maintained on a regular basis. The implementation committee should also work with CTDOT to evaluate the feasibility of implementing stormwater treatment for the outfalls to Hatch Pond, either as retrofits to the existing catch basins and outfalls or as part of future upgrades to South Kent Road and the associated drainage system. Stormwater treatment options may be limited given the lack of available land area between the road, rail line, and the pond and the small vertical separation between the South Kent Road drainage system and the normal water elevation of Hatch Pond. Catch basin inserts and similar proprietary stormwater treatment devices should be considered if other LID practices are not feasible due to site constraints.

Areas of roadside erosion were also noted along several roads in the watershed during the watershed field assessments, including:

- Roadside erosion was observed at six areas along Bull's Bridge Road. These areas include outfalls associated with stone "catch basins" that collect runoff and sediment from the road and convey it under the road through a culvert. These areas were identified to be actively eroding and contributing sediment to the nearby stream (southern tributary to Hatch Pond), between Old Stone Road (at the Bull's Bridge Golf Club entrance) and the location where the tributary from Bull's Bridge Golf Club crosses Bull's Bridge Road, including along the SKS driveway to the tennis courts. The stone catch basins were also full of sediment at the time of the inspections. *Figure 7-3* shows a catch basin and erosion area along Bull's Bridge Road.

- Roadside erosion was observed along Segar Mountain Road (Route 341) near the northern limit of the watershed. This area was observed to be actively eroding and contributing sediment to the adjacent wetlands. *Figure 7-4* shows the area of erosion along Segar Mountain Road.

Figure 7-3. Area of Erosion and Catch Basin along Bull's Bridge Road

Figure 7-4. Area of Erosion along Segar Mountain Road

The watershed plan implementation committee should work with the Town of Kent to address areas of erosion along town-maintained roads in the watershed and with CTDOT to address areas of erosion along state-maintained roads, and to ensure that road drainage structures are inspected and maintained regularly. The Town of Kent and CTDOT should maintain the roads in the watershed in ways that support water quality by performing regular street sweeping, catch basin cleaning, managing use of salts and other winter highway maintenance materials, and maintaining vegetative buffers along roads where feasible. *Table 7-7* lists recommendations for municipal and state roads in the Hatch Pond watershed.

7.6 Homeowners

Residential land use activities, particularly residential properties that are located along or near surface water bodies, can have a significant impact on water quality as a result of lawn care practices, yard waste management, shoreline development, and failing septic systems. Pollution prevention and source controls are the most effective approaches for addressing nonpoint source pollution associated with residential activities.

SKS and the watershed plan implementation committee, in conjunction with the Town of Kent, should conduct a survey of residential property owners in the watershed to evaluate current homeowner practices relative to lawn care, yard waste management, septic system maintenance, and backyard or shoreline development/buffers. The results of the survey can be used to develop a homeowner outreach program for the Hatch Pond watershed. Successful homeowner outreach programs have been developed by other watershed groups, including the Norwalk River Watershed Initiative (NRWI). A number of good educational brochures for homeowners are available on the NRWI website http://conservect.org/southwest/Education/tabid/267/itemid/121/Default.aspx.

Potential topics to be addressed through a homeowner education and outreach program for the Hatch Pond watershed include:

- The Connecticut law banning the application of fertilizers containing phosphorus on established lawns, which went into effect on January 1, 2013. The law requires that a soil test be performed within the previous two years indicating phosphate is needed before phosphorus from fertilizer, amendments, or compost can be applied to established lawns. Fertilizers containing phosphate cannot be applied to established lawns between December 1 and March 15, near water resources, or to any impervious surface. Golf courses and agricultural land are exempt from this regulation.

- Organic lawn care practices. Homeowners are encouraged to use environmentally-friendly lawn care practices such as reducing or eliminating fertilizer and pesticide usage through the use of slow release fertilizers and fertilizer application timing; utilizing alternative landscaping that decreases maintenance; soil testing and non-chemical lawn care measures. The UConn Cooperative Extension has a number of programs related to sustainable lawn care and gardening practices including the Home & Garden Education Center, Master Gardener Program, and "Sustainable Landscaping for Clean Waters" certification program. CT DEEP and the Connecticut Chapter of the Northeast Organic Farming Association are additional sources of information on organic lawn care resources in Connecticut.

- Backyard and shoreline habitat including lake and stream buffer guidelines. CTDEEP and other groups continue to promote landscape stewardship by homeowners. Extensive outreach programs and materials have been developed to encourage the creation of backyard habitat in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public. Homeowners should be encouraged to maintain unfertilized buffer strips between lawns and gardens and water courses. Examples of existing programs include the Quinnipiac River

Watershed Association's Streamside Landowners' Guide to the Quinnipiac Greenway, Audubon's backyard program, the City of Milford's Freedom Lawn program, and programs from the EPA Long Island Sound Study and Connecticut Sea Grant.

- Septic system care and maintenance for homeowners. Regular inspection and maintenance (i.e., pumping of septic tanks) is important to ensure that septic systems function properly and to identify conditions that can contribute to water quality problems. Homeowner guidance on septic system maintenance is available from the Connecticut Department of Public Health and EPA.

A homeowner education and outreach program could be implemented in conjunction with the Town of Kent to satisfy the "Public Education and Outreach" and "Public Involvement/Participation" minimum measures in the MS4 General Permit. The Town of Kent would be regulated under the proposed draft MS4 General Permit as a Tier 2 community.

Table 7-8 lists homeowner outreach recommendations for the Hatch Pond watershed.

7.7 Club Getaway

Club Getaway is a potential source of nonpoint source pollution to Leonard Pond and downstream water bodies. Site access was limited and only minimal information on facility practices could be obtained from the owners of Club Getaway during the watershed assessments. Further investigation into facility practices and potential pollution sources is recommended (see *Table 7-9*). In particular, the following information should be obtained:

- Existing fertilizer use, if any, and the type of fertilizer used
- Information about the on-site septic systems – how many, ages, maintenance, and any known system failures or issues
- A concrete structure was observed in or near the upstream tributary approximately 20 feet from the inlet to Leonard Pond. Is there any available information about the purpose or use of this structure?

7.8 Undeveloped Land

Approximately 55 percent of the watershed land area consists of undeveloped land, including forests, wetlands, and water bodies. Much of this land is either protected open space or has limited development potential due to steep slopes, wetlands, and other physical or regulatory restrictions. New land development or redevelopment activities have the potential to further impact water quality in Hatch Pond and upstream water bodies. Proper management of the existing forests in the watershed is also important to maintain the water quality benefits provided by these areas.

Table 7-7. Recommendations for Municipal and State Roads

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Inspect and maintain catch basins and drainage systems along:** • South Kent Road • Segar Mountain Road • Bull's Bridge Road • Spooner Hill Road	CTDOT, Town of Kent	Annually initially, appropriate maintenance frequency to maintain catch basins no more than half full	Inspection findings and routine catch basin cleaning, as needed	$$	State/Town
2. **Evaluate feasibility of implementing stormwater treatment for the South Kent Road outfalls to Hatch Pond**	CTDOT, SKS, and Implementation Committee	2015-2017	Evaluation findings and recommendations	$$	State
3. **Implement stormwater treatment for the South Kent Road outfalls to Hatch Pond**	CTDOT	2017-2020	Retrofits or drainage system re-design	$$$$	State
4. **Inventory local and state roads to identify additional areas of roadside erosion**	SKS and Implementation Committee	2015-2016	Inventory findings report	$	SKS/Private
5. **Work with Town of Kent and CTDOT to address areas of roadside erosion**	SKS, Implementation Committee, Town of Kent, CTDOT	2016-2020	Design and construction of erosion mitigation	$$$	State/Town

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-8. Homeowner Outreach Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Develop and conduct homeowner survey	SKS, Implementation Committee, Town of Kent	2015-2016	Survey findings - existing homeowner practices and recommended outreach targets	$$	SKS and Town of Kent
2. Develop homeowner outreach program	SKS, Implementation Committee, Town of Kent	2015-2016	Outreach materials and targets	$	SKS and Town of Kent
3. Implement homeowner outreach program	SKS, Implementation Committee, Town of Kent	2016-2020	Number of materials distributed and messages delivered	$$	SKS and Town of Kent

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-9. Club Getaway Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Interview facility owners to further investigate facility practices and potential pollutant sources	SKS and Implementation Committee	2015	Interview findings and recommendations	$	SKS/Private
2. Develop and implement follow-up action items, if necessary	SKS and Implementation Committee	2015-2020	Completion of follow-up action items	Unknown	Unknown

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

7.8.1 Municipal Land Use Regulatory Controls

Land use regulatory controls are an important mechanism for avoiding or mitigating potential water quality impacts associated with future development or redevelopment activities in the watershed. Basic zoning practices can have a huge impact on water quality by limiting uses that may contribute to pollutants reaching water resources and providing performance requirements for others. The primary land use regulatory mechanisms in the Town of Kent that influence water quality and water resource management are the Zoning Regulations, Subdivision Regulations, Inland Wetlands and Watercourses Regulations, and Floodplain Management Regulations.

The Town of Kent Planning and Zoning Commission has recently proposed revisions to its Zoning Regulations, including proposed stormwater management requirements that would apply to any development within the Town of Kent that requires Site Plan approval, except for development of a single-family dwelling and any related accessory structures or uses. The proposed stormwater management requirements require projects to follow the performance standards and design criteria contained in the *Connecticut Stormwater Quality Manual* and encourage the use of Low Impact Development (LID) stormwater management techniques.

The Town of Kent should adopt the proposed changes to the Zoning Regulations and consider any necessary changes to the Subdivision and Inland Wetlands and Watercourses Regulations consistent with the new stormwater management requirements in the proposed Zoning Regulations.

The Town should also consider establishing a Hatch Pond Watershed Overlay District, similar to the Lake Waramaug and Housatonic River Overlay Districts that already exist in the Town's current zoning and associated regulations. The purpose of the overlay district is to further protect the water quality of Hatch Pond, which is an important natural and recreational resource for the Town and the State. The overlay district, which would correspond to the area encompassed by the Hatch Pond watershed, could specify permitted uses, uses permitted by special permit, and other provisions including stormwater management, septic systems, vegetative buffers, and earth disturbance.

Lastly, future updates to the Town of Kent Plan of Conservation and Development (POCD) should identify Hatch Pond as an important natural and recreational resource and reference the Hatch Pond Watershed Based Plan. The POCD should emphasize that the Town's land use boards consider the long-term protection and use of Hatch Pond and its watershed when implementing their statutory authority to balance resource protection and development.

Table 7-10 identifies municipal land use regulatory recommendations for the watershed.

7.8.2 Forestry Management

Forest cover, including natural forest soils with irregular topography, provides numerous benefits. In addition to providing habitat for terrestrial and aquatic wildlife, watershed forest cover also reduces stormwater runoff and flooding, improves regional air quality, reduces stream and channel erosion, improves soil and water quality, and reduces summer air and water temperatures (USDA Forest Service, 2005). Through green infrastructure approaches, vegetation and natural systems are considered a key tool in the protection and restoration of watersheds.

SKS and the watershed plan implementation committee should partner with the UConn Cooperative Extension System, Connecticut Agricultural Experiment Station, and the Kent and Weatinogue Heritage Land Trusts to develop management recommendations for the large tracts of public and/or conservation forested land in the watershed. The management recommendations would include education projects and programs to help achieve the water quality protection goals for Hatch Pond and other important environmental benefits.

To further protect the privately-owned forested land in the watershed, SKS and its partners should provide outreach and training to private land owners, municipal officials, and land use commissions in the value and importance of forests to water quality and protecting forest riparian areas and forest cover within watershed.

Table 7-11 identifies recommendations related to forestry management.

Table 7-10. Municipal Land Use Regulatory Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Adopt proposed changes to Town of Kent Zoning Regulations	Town of Kent	2015	Adopted regulations	N/A	N/A
2. Consider establishing a zoning overlay district for the Hatch Pond watershed	Town of Kent	2015-2016	Potential new overlay district	$$	Town
3. Include reference to Hatch Pond and Hatch Pond Watershed Based Plan in future POCD updates	Town of Kent	Next POCD update	Updated POCD	$	Town

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 7-11. Forestry Management Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Develop management recommendations for public/conservation forested land in the watershed	SKS, UConn Cooperative Extension, CT Agricultural Experiment Station, Land Trusts	2017-2020	Management recommendations and implementation projects	$$$	SKS, Great Mountain Forest Foundation, State
2. Provide outreach and training to private land owners, municipal officials, and land use commissions	SKS, UConn Cooperative Extension, CT Agricultural Experiment Station, Land Trusts	2017-2020	Outreach and training materials , number of individuals receiving training or educational messages	$$	SKS, Great Mountain Forest Foundation, State, Town of Kent

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

7.9 In-Lake Management Recommendations

The 2014 in-lake study of Hatch Pond (WRS and NEAR, 2014) evaluated potential in-lake management options for improving water quality and aquatic plant conditions in Hatch Pond. Although dredging would be beneficial by restoring the pond to an earlier, more pristine condition, dredging would be extremely expensive ($12 million or more to achieve desired conditions) and likely cost-prohibitive. Phosphorus inactivation to control internal phosphorus loadings from surficial sediments is unlikely to provide substantial benefits, although inactivation to control incoming phosphorus loads from the Hatch Pond tributaries may be warranted if watershed source controls are unable to achieve desired water quality conditions. The capital and operating cost of oxygenation/circulation methods is not justified until a new equilibrium condition is reached and the benefits can be further evaluated. Algaecide treatment does not appear to be warranted at this time since the algae community is in an apparent transition to more desirable species and fewer blooms of lesser severity. As stated previously, further monitoring is recommended to determine the new equilibrium condition in Hatch Pond before any substantial expenditure on water quality improvement or algae control is made (WRS and NEAR, 2014).

In-lake management approaches are necessary to address the rooted plant problems, which are expected to persist or intensify as water quality in the pond continues to improve. Watershed management actions to reduce nutrient loadings to Hatch Pond will not address this issue. Reduction of plant density is primarily intended to improve the fishery and provide boating opportunity on a maintenance basis. Potential in-lake options to reduce and manage rooted aquatic plants in Hatch Pond include:

- Benthic barrier used on a small scale
- Mechanical harvesting (initial harvesting and annually thereafter)
- Herbicide treatment (initial and repeat applications)

Individual management methods or a combination of methods could be performed on a trial basis to evaluate the actual benefits and effectiveness of the methods for Hatch Pond. Estimated costs, anticipated benefits, and other considerations are described in more detail in the 2014 study report (WRS and NEAR, 2014).

Table 7-12 contains in-lake management recommendations for Hatch Pond.

Table 7-12. In-Lake Management Recommendations

Actions	Who	Schedule	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Evaluate, select, and implement measures to address rooted aquatic plants	SKS and Implementation Committee, Consultant	2015-2017	Management measures implemented, evaluation of results, follow-up actions	Varies (refer to 2014 in-lake study report)	SKS, Town of Kent, CTDEEP
2. Evaluate need for in-lake measures to further improve water quality and algae conditions	SKS and Implementation Committee, Consultant	Following monitoring period	Evaluation findings and recommendations based on consideration of costs, benefits, and funding availability	$$$$	SKS, Town of Kent, CTDEEP

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

8 Pollutant Load Reductions

Pollutant load reductions were estimated for the watershed plan recommendations for which pollutant loads can be reasonably quantified. Pollutant load reductions were estimated for the following actions:

- **Water Quality Improvements to School Pond** – Enhanced pollutant removal efficiencies were assumed as a result of the recommended water quality improvements to School Pond, including physical improvements to the pond (i.e., dredging, creation of a sediment forebay, establishing a vegetated buffer, and modification of the inlet/outlet structures) and regular maintenance.

- **Implementation of Green Infrastructure on the SKS Campus** – Pollutant load reductions were estimated for a variety of possible green infrastructure practices on the SKS campus. These projects could be implemented as retrofits or as part of future campus development or redevelopment. Bioretention, permeable pavement, and infiltration practices were modeled using the Watershed Treatment Model, assuming that approximately 50% of the impervious area on the campus could be retrofitted with green infrastructure practices.

- **Retrofit of South Kent Road Outfalls** – The Watershed Treatment Model was used to estimate pollutant load reductions resulting from stormwater treatment retrofits of the South Kent Road stormwater outfalls. Relatively low removal efficiencies were assumed for total nitrogen and total phosphorus (5%) and total suspended solids (25%), consistent with pollutant removal efficiencies associated with deep sump catch basins, including regular maintenance. Greater pollutant removal efficiencies and load reductions may be possible if the drainage system can be retrofitted with infiltration or other green infrastructure BMPs.

- **Water Quality Improvements to the CFI Stormwater Basins** - Enhanced pollutant removal efficiencies were assumed as a result of the recommended water quality improvements to the wet and dry basins at the CFI site.

Collectively, the above recommendations are estimated to result in a 21% reduction in annual total phosphorus loads to Hatch Pond, as well as a 15% reduction and 23% reduction in the annual loads of total nitrogen and total suspended solids, respectively (see *Appendix C*). As described in *Section 6.2*, an approximately 30% reduction in annual phosphorus loads will likely be required (from the estimated new equilibrium phosphorus load) to reach the permissible phosphorus load.

Other watershed management recommendations identified in this plan could not be quantified due to inherent limitations of WTM and/or the lack of reliable input data or information on the pollutant removal effectiveness of certain practices. Additional, unquantified load reductions are anticipated from:

- Mitigation of roadside erosion areas
- Regular street sweeping and catch basin cleaning
- Homeowner education and outreach
- Education and outreach to SKS maintenance staff
- Enhancement of vegetated buffers on the SKS campus, CFI site, and private property

- Strengthened municipal land use regulatory controls

A 30% reduction in annual phosphorus loads is believed to be achievable by implementing the watershed management practices recommended in this plan. However, monitoring should continue for the next few years to better characterize variability in loadings and in-lake conditions.

Potential reductions in internal nutrient loadings from the Hatch Pond sediment due to in-lake management options were not quantified. The need for in-lake measures (in addition to watershed management) to achieve desired water quality and algae conditions in Hatch Pond should be evaluated based on the new equilibrium water quality condition in the lake over the next few and the effectiveness of short-term watershed management recommendations.

9 Funding Sources

A variety of local, state, and federal sources are potentially available to provide funding for the implementation of this watershed based plan. The following programs are potential sources of public funding, in addition to private and local financial assistance and in-kind support:

- **Section 319 Grant Program:** CTDEEP administers a grant program with EPA Clean Water Act Section 319 funds to address nonpoint source pollution. Section 319 grants are available to municipalities, nonprofit environmental organizations, regional water authorities/planning agencies, and watershed associations. This program requires a 40% match, and applications are competitively ranked. Section 319 funds are typically awarded to implement on-the-ground watershed restoration projects that have been identified in a watershed based plan and that are intended to address water quality impairments.

- **Clean Water Section 604b Water Quality Planning Management Grants:** Under the federal Clean Water Act, EPA Section 604(b) funds are awarded to CT DEEP to carry out water quality management planning including revising water quality standards; performing waste load allocation/total maximum daily loads, point and non-point source planning activities, water quality assessments and watershed restoration plans. Additional monitoring and assessment of Hatch Pond may be eligible for a 604(b) grant.

- **Connecticut Lakes Grant Program:** Funding from the CTDEEP Bureau of Water Protection and Land Reuse "Grants to Improve Water Quality of Lakes Used for Public Recreation." Often called the Lakes Grant Program, this program provides matching grants for lake restoration projects to municipalities, lake authorities, and lake taxing districts at lakes that are available to the general public for recreation. Funds for the Lakes Grant Program are made available through authorizations of the State Legislature and allocated by the State Bond Commission. The Lakes Grant Program requires a 25% match for studies and a 50% match for implementation of control measures. When funding is available, notification is provided to every municipality in Connecticut and to groups who have previously inquired about funding for lake management projects.

- **STEAP Funds:** The Small Town Economic Assistance Program (CGS Section 4-66g) funds economic development, community conservation and quality-of-life capital projects for localities that are ineligible to receive Urban Action (CGS Section 4-66c) bonds. This program is managed by the Office of Policy and Management, and the grants are administered by various state agencies. STEAP funds are issued by the State Bond Commission and are generally used for capital projects, although several lake evaluation and improvement projects have received STEAP funds including an ongoing evaluation of Bolton Lakes. The Town of Kent has been identified as an eligible community to receive STEAP funds.

Additional grant programs and other funding may also be available to supplement or leverage the funding sources listed above. A list and description of these funding sources is provided in Appendix E of the *Connecticut Nonpoint Source Management Program Plan* http://www.ct.gov/deep/lib/deep/water/nps/planupdate/ct_nps_plan_final.pdf.

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Appendix A

Hatch Pond Study 2014: In Lake Conditions, Processes and Possible Management Options (WRS and NEAR, 2014)

Hatch Pond Study 2014: In Lake Conditions, Processes and Possible Management Options

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December 2014

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Introduction

Hatch Pond is in South Kent, Connecticut, slightly east of Route 7 and north of the South Kent School (Figure 1). The pond currently covers about 70 acres in an elongate, northwest-southeast alignment. It is bordered on the east by a railroad and South Kent Road, while the western shoreline is largely steep, forested terrain. Womenshenuk Brook flows from Leonard Pond from the north and exits Hatch Pond from the south. Additional land, including part of the South Kent School and the Bulls Bridge Golf Club, is drained by smaller tributaries, with a total watershed area of slightly more than 3 square miles.

Land use is varied, including forest, wetland, agriculture and residential area as well as the school and golf club (Figure 2). Slopes are steep in much of the watershed. A large emergent wetland has formed over time at the inlet of the pond, covering about 20 acres south of South Kent Road that was probably open water at some time in the distant past. There is a dam at the south end of Hatch Pond that raised the water level several feet at some point in the past, but it is apparent that the pond has experienced substantial infilling over many decades.

Reports by NEAR, the most recent in 2012, document excessive nutrient loading and related biological problems over the last decade, driven largely by inputs from the Arno Farm, a dairy operation at the north end of the lake. Concentrations of nitrogen (N) and phosphorus (P) were very high in water discharged from the dairy farm, while concentrations upstream were more moderate or even low. Inputs from the unnamed tributary the drains the South Kent School, part of the golf course, and some additional lands have also been elevated at times, but the load from the dairy farm stands out as far greater than all other sources. The CT DEP had assessed Hatch Pond in 1990 (CTDEP 1991) and considered it to be moderately fertile. Water quality deterioration over a 15 year period was apparent.

Most striking is the apparent change in the depth of Hatch Pond. Mean and maximum depths were reported in 1959 as 11.5 ft (3.5 m) and 26.2 ft (7.9 m), respectively (State Board of Fisheries and Game 1959). More recent measurements (NEAR 2012) indicated a maximum depth of less than 15 ft (4.5 m). Watershed inputs during large storms, manure from the dairy farm, and internally generated and retained organic matter are all possible sources of the sediment. It is also possible that the measurements made about 60 years ago were made with weights on graduated lines that went considerably into the soft sediment before stopping, thereby overestimating water depth. The high level of internal organic production and the establishment of emergent wetland at the north end of the pond point to substantial infilling even if water depths were overestimated, but little change in water depth was noted between 2004 and 2010 (NEAR 2012).

Hatch Pond experiences both rooted plant nuisance growths and algae blooms dominated by cyanobacteria. Clarity was low through 2006 and there was enough of a thermal difference over the relatively shallow depth to allow moderately stable water layers to develop. Oxygen was lost near the bottom, and the anoxic zone extended upward to depths as shallow as 5 ft (1.5 m). Hatch Pond has long been popular for fishing and rowing, but became virtually unusable during the summer through the combination of rooted plant and algae growths.

South Kent School purchased the Arno Dairy Farm in 2010 and terminated dairy farming; the improvement in water quality in the pond was quickly evident (NEAR 2012). Conditions remained impaired, but decreased loading was documented and water quality increased slightly. Unfortunately,

Figure 1. Map of Hatch Pond area.

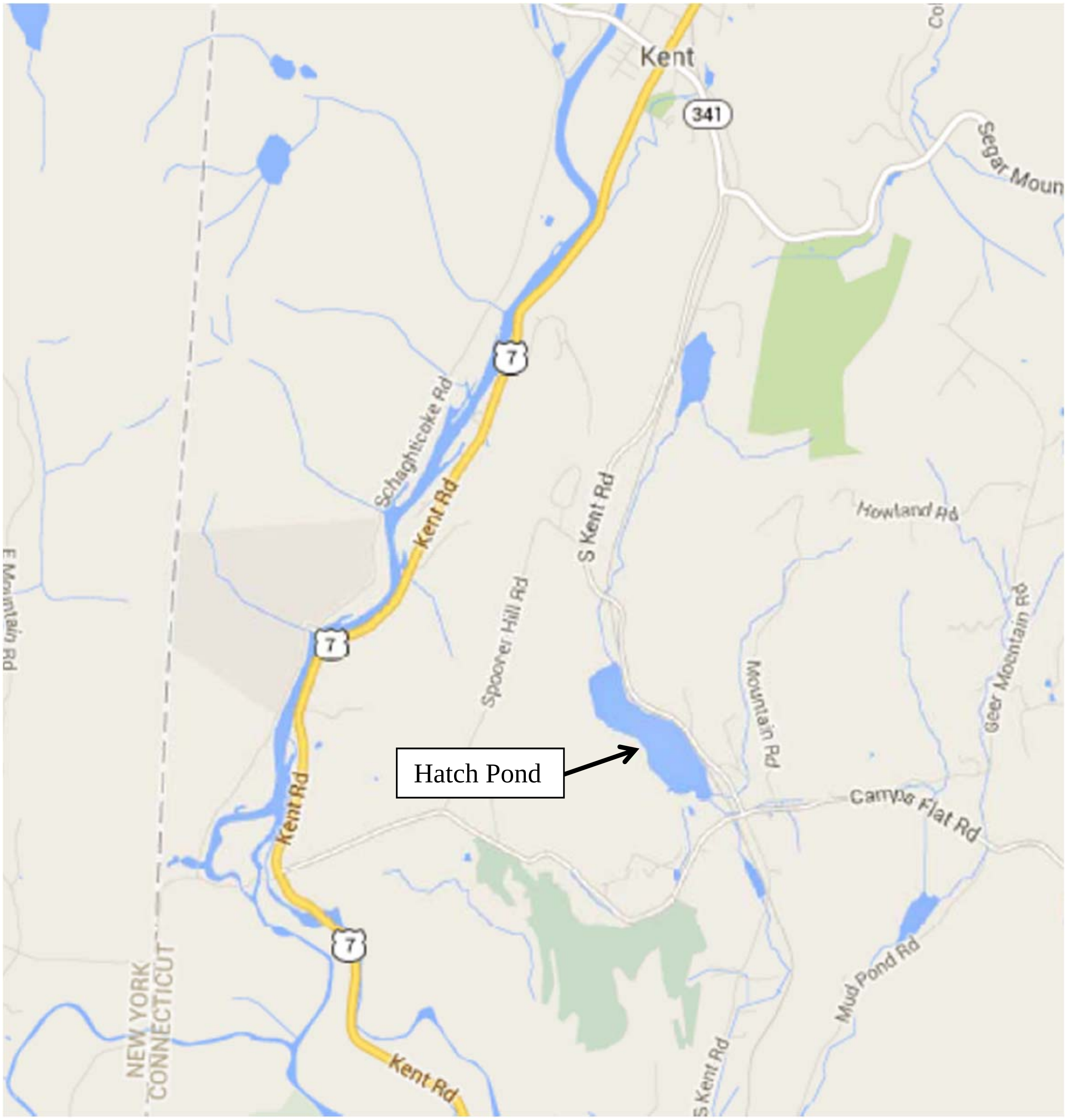


Figure 2. Aerial view of Hatch Pond and its immediate area.

the increased clarity allowed plants, most notably the invasive species Eurasian water milfoil (*Myriophyllum spicatum*) to extend into deeper water.

This study was undertaken to assess water quality changes 4 years after conversion of the dairy farm to a sustainable farming operation as part of the South Kent School curriculum. The loss of inputs from the dairy farm is perceived to have substantially lowered nutrient loading, but the importance of other watershed sources and internal recycling from sediment reserves has not been adequately characterized. Evaluation of possible management actions to address water quality issues require greater understanding of existing conditions and nutrient loading than was available prior to this study. A Section 319 grant from the CT DEEP supported this effort. Fuss & O'Neill evaluated watershed conditions and processes, while WRS and NEAR provided inlake assessments. This report covers the inlake portion of the scope of work and resultant watershed projections.

Study Elements

Temperature and oxygen profiles were collected on 9 dates between late April and mid-September, with an emphasis on the spring period, when oxygen demand can be most accurately measured. Additional water quality variables were assessed on 5 dates between April and September of 2014. Phytoplankton and zooplankton were assessed with water quality. Sediment quantity and quality were evaluated in June and July of 2014. Water depths were obtained with sediment probing, allowing a new bathymetric map to be generated. All sampling and analyses were conducted in accordance with an approved Quality Assurance Project Plan (QAPP). The approved QAPP is a separate document but is incorporated into this report by reference and fully explains the methods and approach.

Nutrient loading from internal sources was assessed by multiple approaches to bracket possible loads. Nutrient loading from all sources was estimated as a total based on empirical models that apply inlake concentrations and physical features to generate the loads required to achieve the observed inlake concentration.

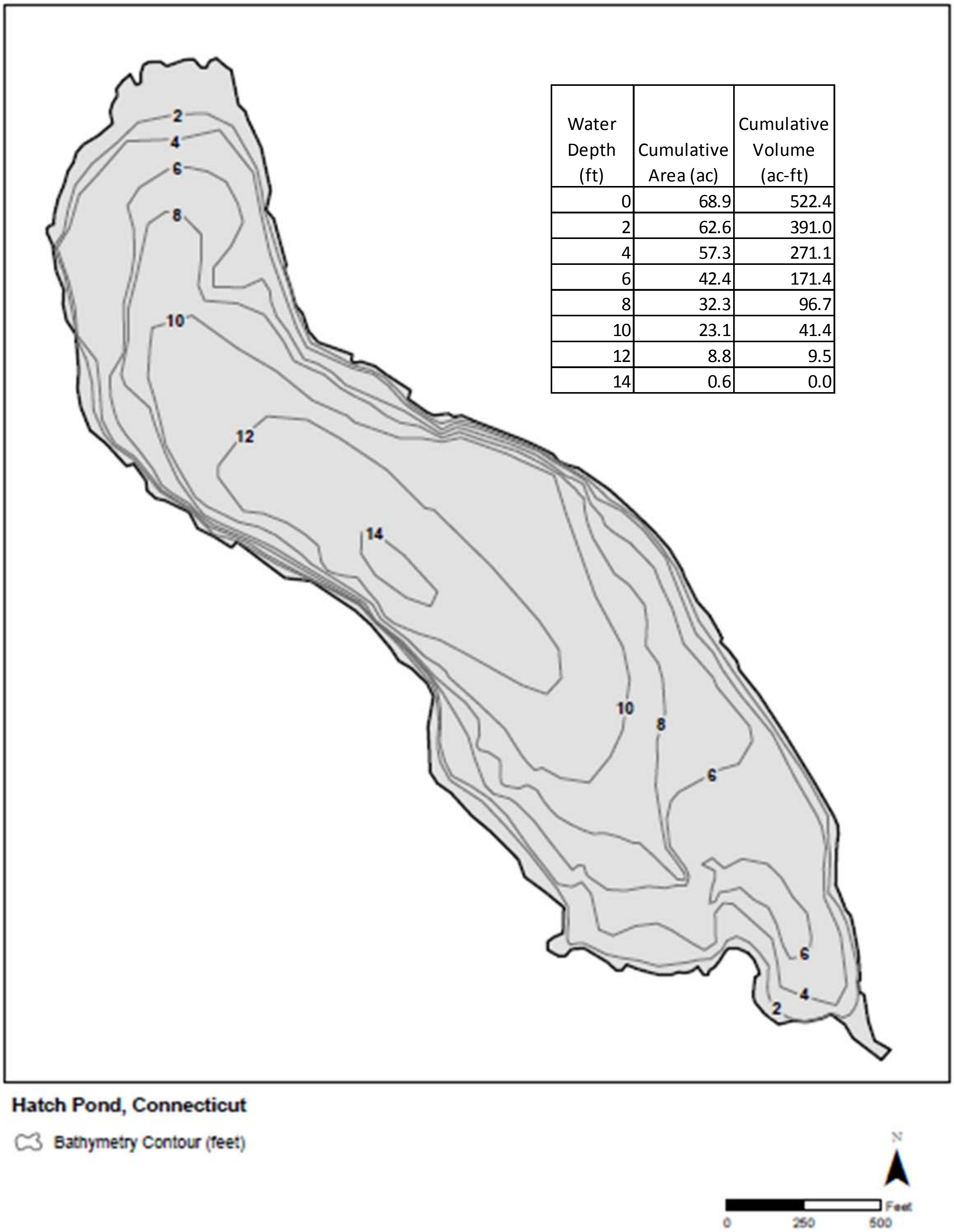
Management options were evaluated in light of current conditions and trends over time.

Physical Pond Features

Current bathymetry of Hatch Pond (Figure 3) indicates a mean depth of 7.6 ft (2.3 m) and a maximum depth of no more than 15 ft (4.5 m). Pond area was measured as 68.9 ac (27.8 ha), within the range of past estimates; changing water level will affect area estimation. Pond volume was calculated as 522.4 acre-feet (645 million m^3). This is similar to conditions observed since 2004 but is dramatically different than the depth contours reported in 1959.

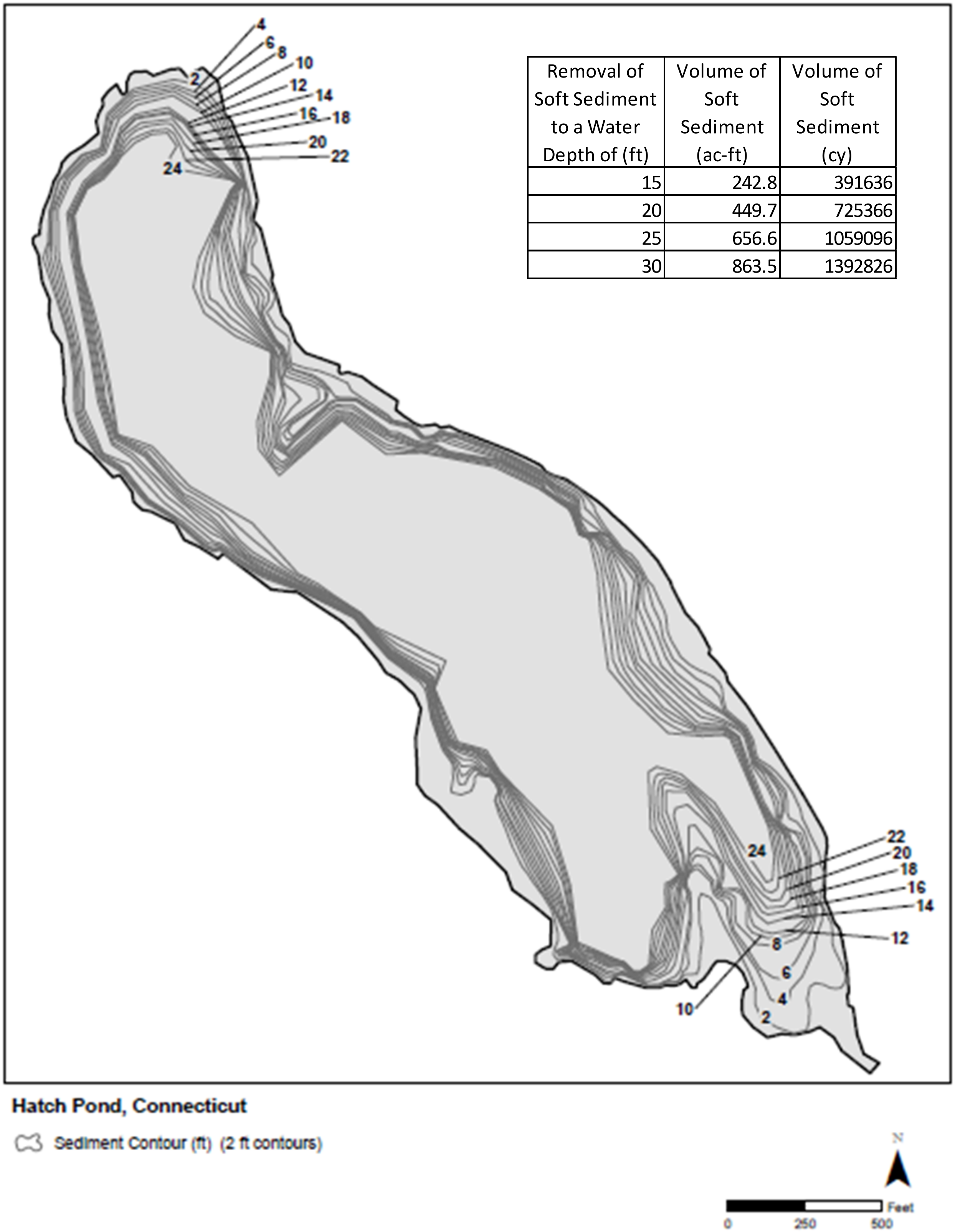
Sediment probing revealed very deep soft sediment deposits (Figure 4). A 40 foot probe did not reach a hard substrate in most central areas, where water depths ranged from 10 to 14 ft. Assuming removal of sediment (dredging) as a management option to achieve water depths of 15 to 30 ft, the associated quantities of sediment range from 392,000 cy to 1,393,000 cy. These are very large quantities of soft sediment for a relatively small water body. The steep slopes observed in the upland topography apparently extended into the pond historically, and sediment has accumulated in the submerged "valley", greatly reducing the original depth, which exceeded 40 ft (12.1 m) in some areas.

Figure 3. Hatch Pond bathymetry as of 2014.



Water Depth (ft)	Cumulative Area (ac)	Cumulative Volume (ac-ft)
0	68.9	522.4
2	62.6	391.0
4	57.3	271.1
6	42.4	171.4
8	32.3	96.7
10	23.1	41.4
12	8.8	9.5
14	0.6	0.0

Figure 4. Hatch Pond soft sediment distribution as of 2014.



Removal of Soft Sediment to a Water Depth of (ft)	Volume of Soft Sediment (ac-ft)	Volume of Soft Sediment (cy)
15	242.8	391636
20	449.7	725366
25	656.6	1059096
30	863.5	1392826

This portion of the overall study did not assess watershed conditions or even inlet conditions, so flow data were not generated. To estimate detention time, a water yield for northeastern watersheds of 1.7 cubic feet per second (cfs) per square mile of watershed (Higgins and Colonel 1972) was applied. With a current watershed area estimate of 2009 acres, this suggests an average flow of 5.3 cfs. Low summer flows may be as low as 0.2 to 0.3 cfs/square mile, suggesting low flows on the order of 0.6 to 1.0 cfs.

Based on the estimated flow through Hatch Pond, the volume of the pond would be replaced 7.4 times per year, indicating a detention time of 49 days on average. During summer low flows the water in the pond may not be replaced even once; summer inflow may be only 40% of the pond volume.

Chemical Pond Features

Water Quality

Temperature and oxygen profiles were collected on nine dates in 2014 (Table 1). Water clarity was assessed with a Secchi disk on each date as well. Conditions were nearly uniform from top to bottom on April 29 and May 7 (Figures 5 and 6), but exhibited development of stratification on May 13 (Figure 7). Mixing by wind or inflow created uniform conditions again on May 20 (Figure 8). From May 27 through September 18, temperature varied from top to bottom, with colder water on the bottom, but the thermal gradient was never strong and resistance to mixing was not large (Figures 9-13). Despite limited stratification, oxygen depression developed near the bottom by May 27 (Figure 9) was similar or slightly less on June 16 (Figure 10), and intensified through July (Figure 11). Oxygen depression was observed at depths >5 ft and oxygen was lower than desirable for aquatic life at depths >7 ft by August 1. Complete oxygen depletion did not occur, but values <1 mg/L occurred at depths >9 ft. These conditions persisted through August (Figure 12), but mixing in September lead to improved but not uniform conditions by September 18 (Figure 13).

Summer of 2014 was fairly mild, with few large storms or wind events. With dense aquatic plant growths and limited summer inflow, vertical mixing in Hatch Pond was limited. Without any true thermal stratification, the pond still managed to lose oxygen from the bottom through decomposition at a rate too rapid for atmospheric re-aeration to counter, and low oxygen conditions were encountered for about two months. Low oxygen promotes release of phosphorus and other undesirable compounds from bottom sediments, although it is actually the reduction-oxidation (redox) potential that governs that release. As oxygen declines, so does redox potential, with lower redox promoting chemical reactions that liberate phosphorus, iron, manganese, sulfur and other contaminants. Although oxygen cannot decline below 0 mg/L, the demand for oxygen can still increase and redox potential continues to decrease and becomes negative, indicating the strength of those chemical interactions. Redox potential was not measured in this study, but may vary over time even after oxygen has reached 0 mg/L.

Water clarity (Table 1) was in excess of 10 ft (3.0 m) through May, but declined in June to 7 ft (2.1 m) and was between 4.3 and 5.3 ft (1.3-1.6 m) for the summer. Most of the loss of clarity was due to algae in the water, but some resuspension of inorganic or non-living organic matter occurs as well and reduces clarity. The relatively higher clarity in spring allows rooted plants to grow, while lower clarity during summer limits additional growths. Past studies have suggested depths of plant colonization between 7 and 9 ft; areas <9ft deep had dense plant growth in 2014, with some growth to depths of 11 ft.

Table 1. Water clarity, temperature, oxygen and thermal resistance to mixing for Hatch Pond in 2014.

Water Clarity									
Date	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
Secchi (m)	3.0	3.8	3.9	3.7	3.0	2.1	1.3	1.6	1.4
Water temperature (C)									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	13.1	15.2	18.9	18.3	23.4	23.3	26.6	25.8	19.5
1	13.1	15.2	18.8	18.3	23.2	23.1	26.5	25.6	19.5
2	13.2	15.1	18.8	18.3	22.5	22.8	25.5	24.7	19.1
3	13.2	15.0	18.7	18.3	21.5	22.4	25.5	24.6	18.9
4	13.2	14.9	18.6	18.3	21.1	21.9	25.2	24.0	18.8
5	13.2	14.5	18.5	18.3	20.6	21.9	24.9	23.7	18.8
6	13.2	14.3	18.4	18.3	20.3	21.7	24.8	23.1	18.8
7	13.2	14.3	18.3	18.3	19.9	21.6	24.6	22.7	18.7
8	13.2	14.2	17.1	18.2	19.5	21.6	24.3	22.6	18.7
9	13.2	14.2	16.6	18.2	19.2	21.4	24.0	22.4	18.7
10	13.2	14.1	16.2	18.2	18.9	21.3	23.8	22.0	18.7
11	13.2	14.1	15.6	18.2	18.6	21.2	23.8	21.7	18.6
12	13.2	14.1	15.2	18.2	18.2	21.0	22.4	21.5	18.3
13	13.1	14.1	15.0	18.2	17.9	20.5	22.0	21.2	18.1
14	13.2	14.1	14.8	18.1	17.6	19.5	21.6	20.9	17.9
15		14.1	14.5		17.3	19.0	20.9		17.9
Dissolved Oxygen (mg/L)									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	10.0	9.8	9.6	8.6	9.9	9.0	9.5	10.7	8.4
1	10.0	9.8	9.6	8.7	9.9	9.0	9.7	11.0	8.4
2	10.0	9.8	9.7	8.7	10.0	9.0	9.7	11.4	8.5
3	10.0	9.8	9.7	8.7	10.6	9.0	9.7	11.4	8.5
4	10.0	9.9	9.7	8.7	10.8	9.0	9.5	11.7	8.5
5	10.0	9.9	9.8	8.7	12.0	8.8	8.2	11.5	8.3
6	10.0	9.9	9.8	8.7	11.9	8.4	6.4	8.6	8.3
7	9.9	9.9	9.8	8.7	11.8	8.4	3.3	4.0	8.3
8	9.9	9.9	8.7	8.7	10.6	8.1	1.1	2.1	8.2
9	9.9	9.9	8.6	8.7	9.8	7.7	0.3	0.8	8.0
10	9.9	9.9	8.5	8.7	6.8	7.1	0.2	0.4	7.9
11	9.9	9.9	7.2	8.7	4.9	6.5	0.1	0.3	6.6
12	9.9	9.8	6.1	8.7	2.1	4.5	0.1	0.3	2.4
13	9.9	9.7	5.5	8.7	1.6	1.8	0.1	0.2	2.6
14	9.9	9.6	4.7	8.6	1.0	0.4	0.1	0.2	0.5
15		9.2	3.7		0.5	0.2	0.1		0.3
Percent saturation of DO									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	95	98	103	91	116	106	118	131	91
1	95	98	103	92	116	105	121	135	91
2	95	97	104	92	115	105	118	137	92
3	95	97	104	92	120	104	118	137	91
4	95	98	104	92	121	103	115	139	91
5	95	97	105	92	134	100	99	136	89
6	95	97	104	92	132	96	77	100	89
7	94	97	104	92	130	95	40	46	89
8	94	96	90	92	115	92	13	24	88
9	94	96	88	92	106	87	4	9	86
10	94	96	86	92	73	80	2	5	85
11	94	96	72	92	52	73	1	3	71
12	94	95	61	92	22	50	1	3	26
13	94	94	55	92	17	20	1	2	28
14	94	93	46	91	10	4	1	2	5
15		89	36		5	2	1		3
RTRM									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0									
1	0	0	2	0	6	6	3	6	0
2	-2	2	0	0	20	9	33	29	10
3	0	2	2	0	28	11	0	3	5
4	0	2	2	0	11	14	10	19	2
5	0	7	2	0	13	0	10	9	0
6	0	4	2	0	8	5	3	18	0
7	0	0	2	0	10	3	6	12	2
8	0	2	27	2	10	0	9	3	0
9	0	0	11	0	7	5	9	6	0
10	0	2	8	0	7	3	6	11	0
11	0	0	12	0	7	3	0	8	2
12	0	0	8	0	9	5	41	5	7
13	2	0	4	0	7	13	11	8	5
14	-2	0	4	2	7	25	11	8	5
15		0	5		7	12	19		0
Total RTRM	-2	20	92	5	158	116	172	145	38

Figure 5. Hatch Pond temperature, oxygen and resistance to mixing profiles: 4/29/14

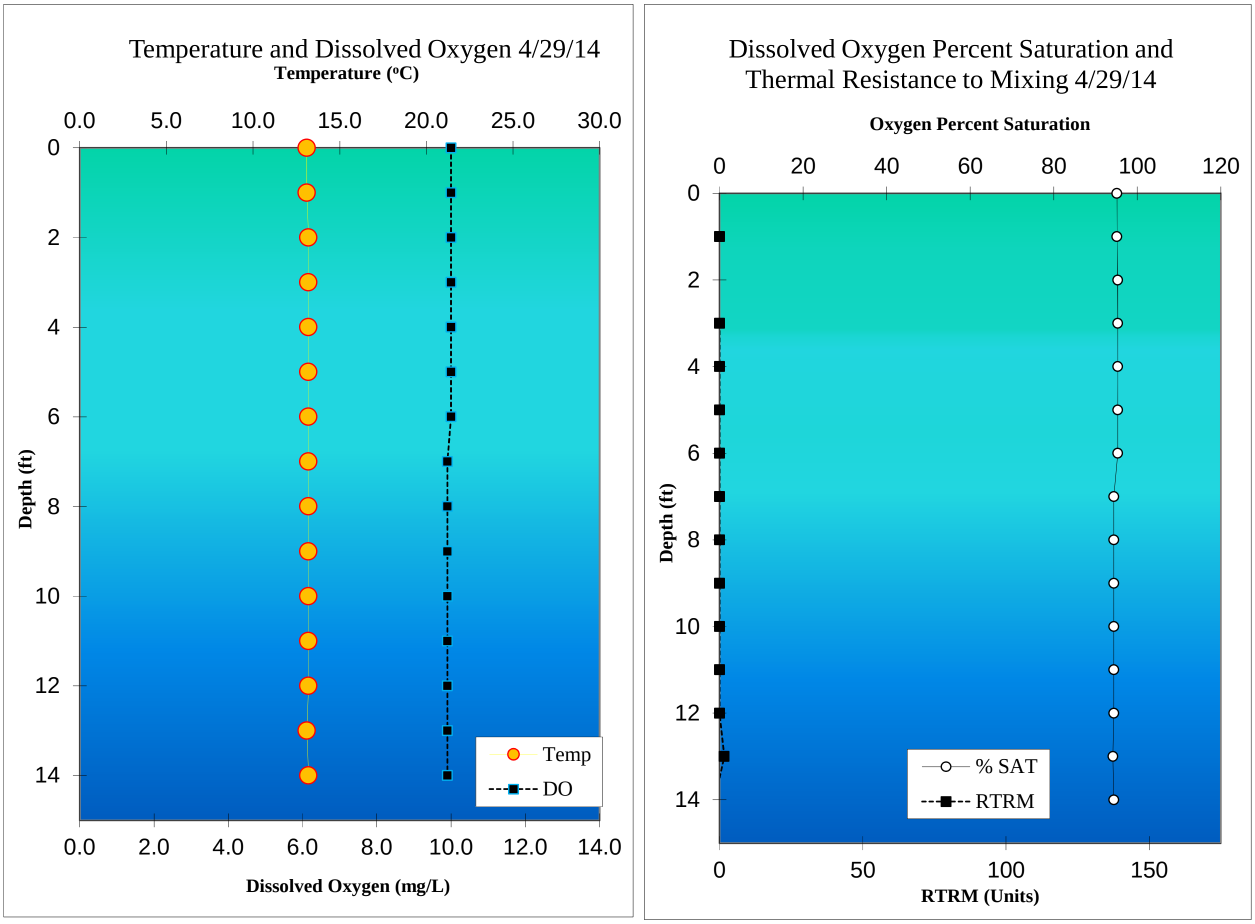
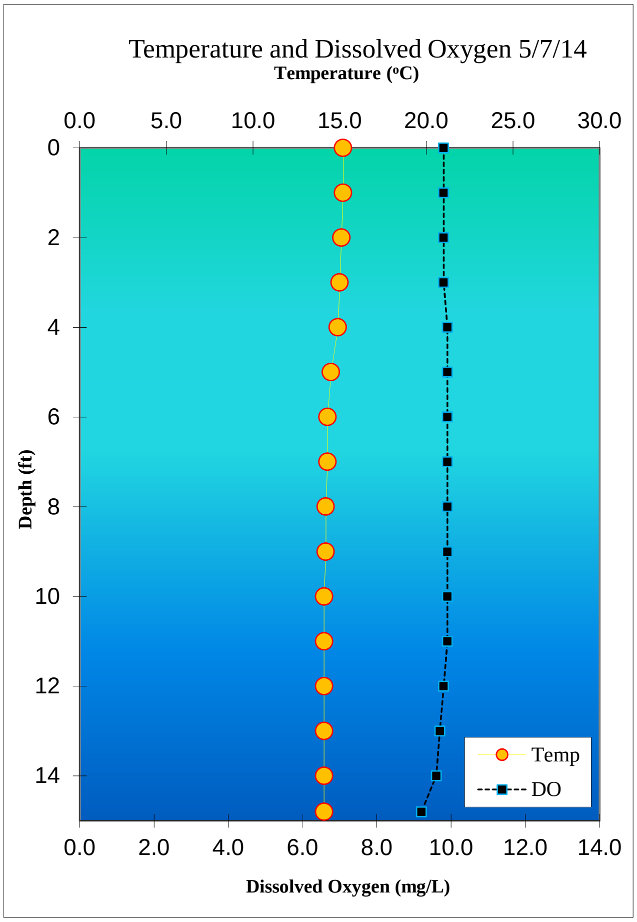


Figure 6. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/7/14



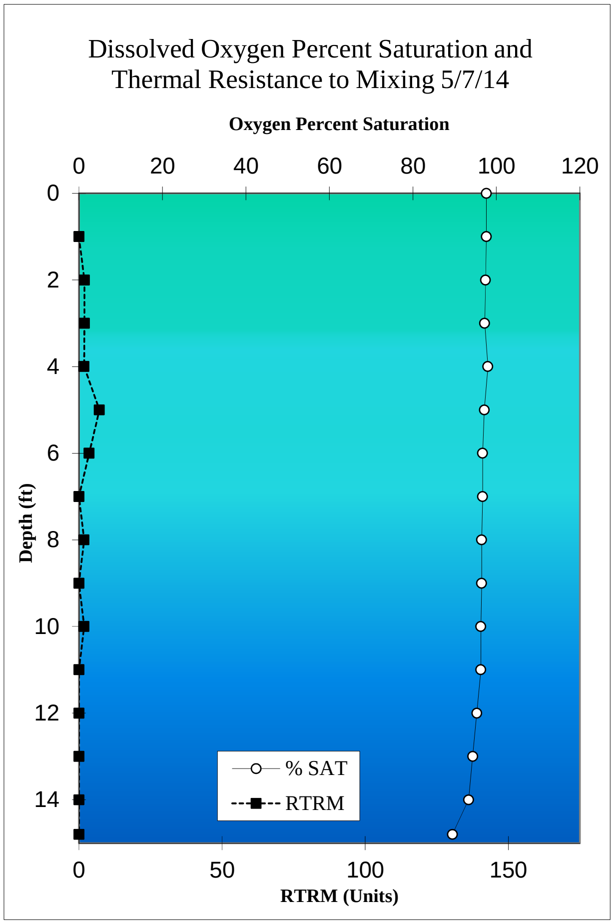


Figure 7. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/13/14

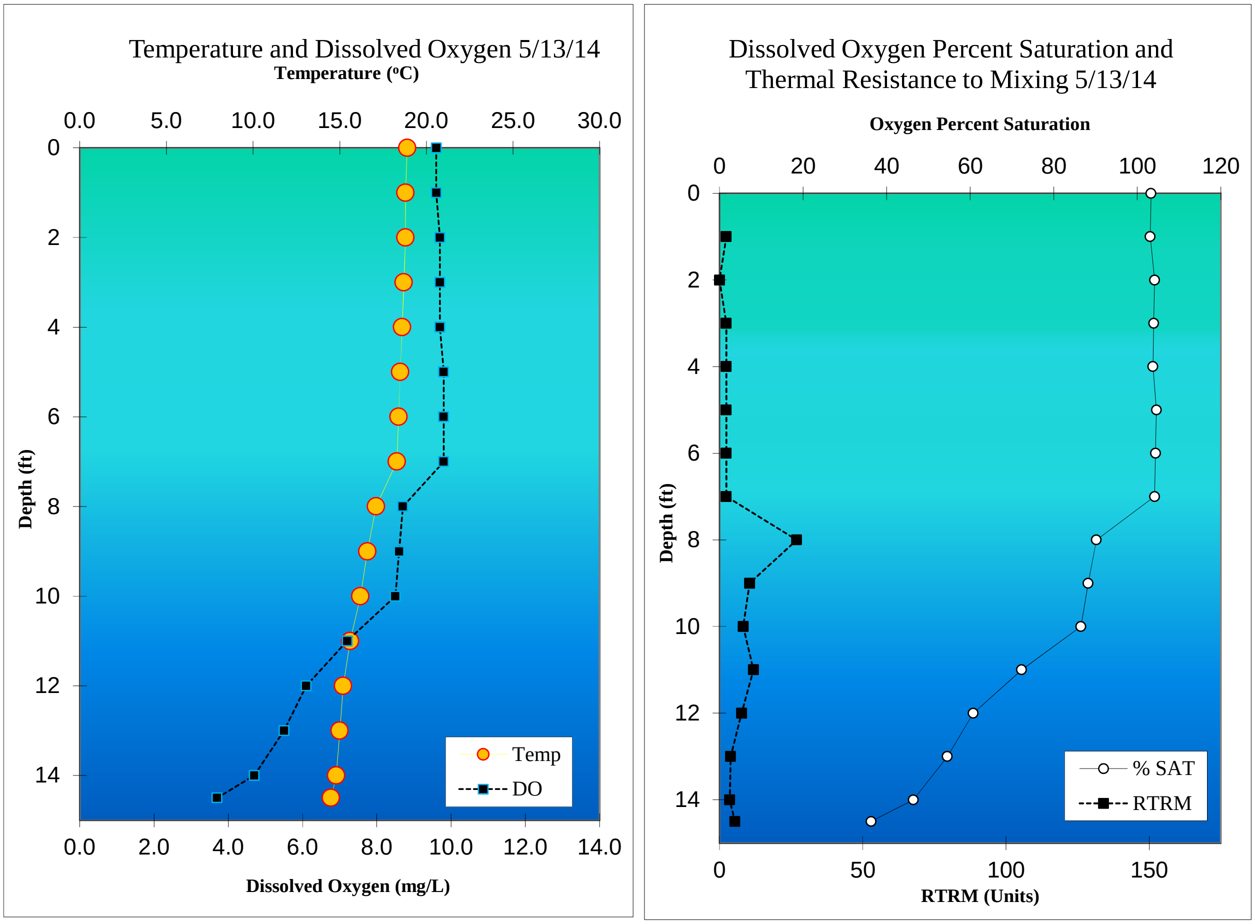


Figure 8. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/20/14

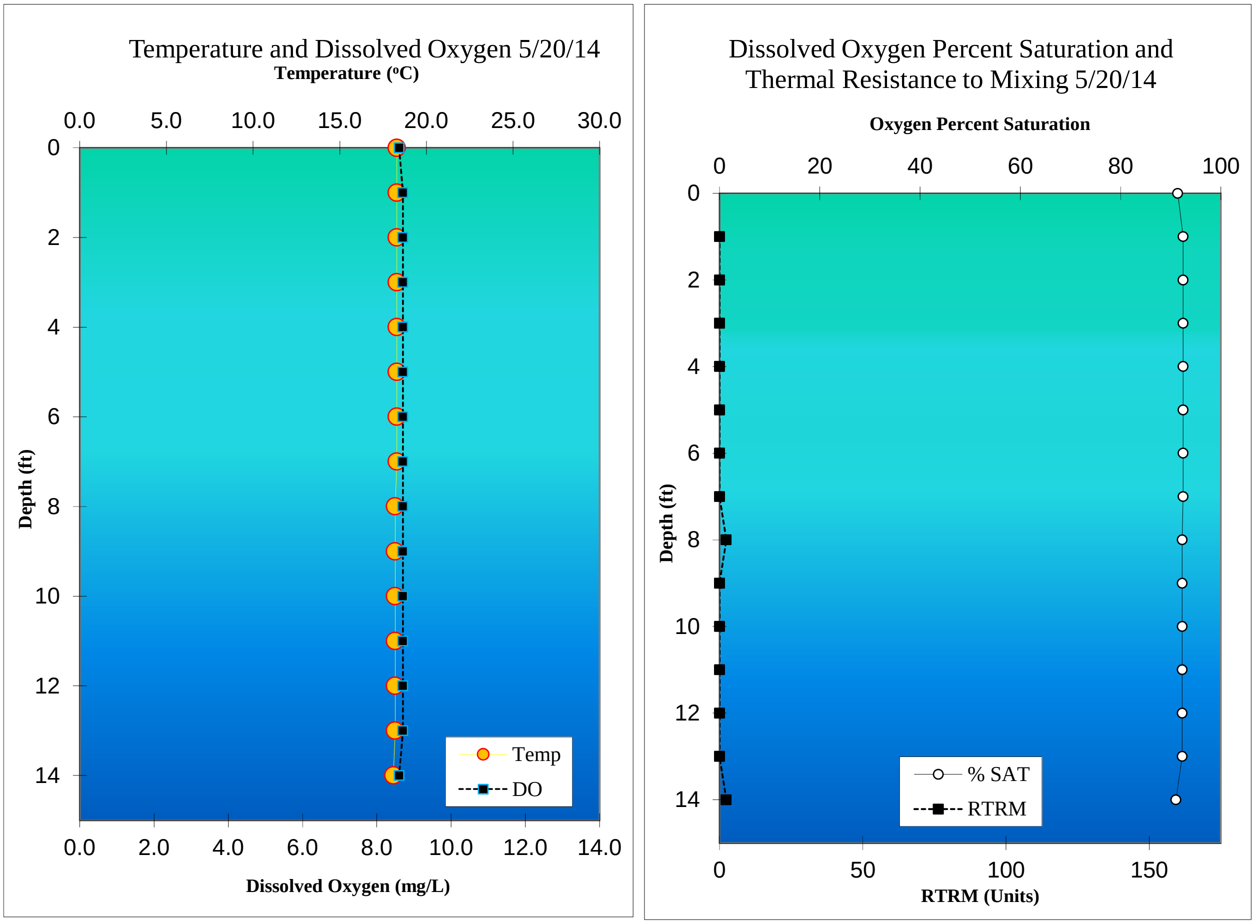


Figure 9. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/27/14

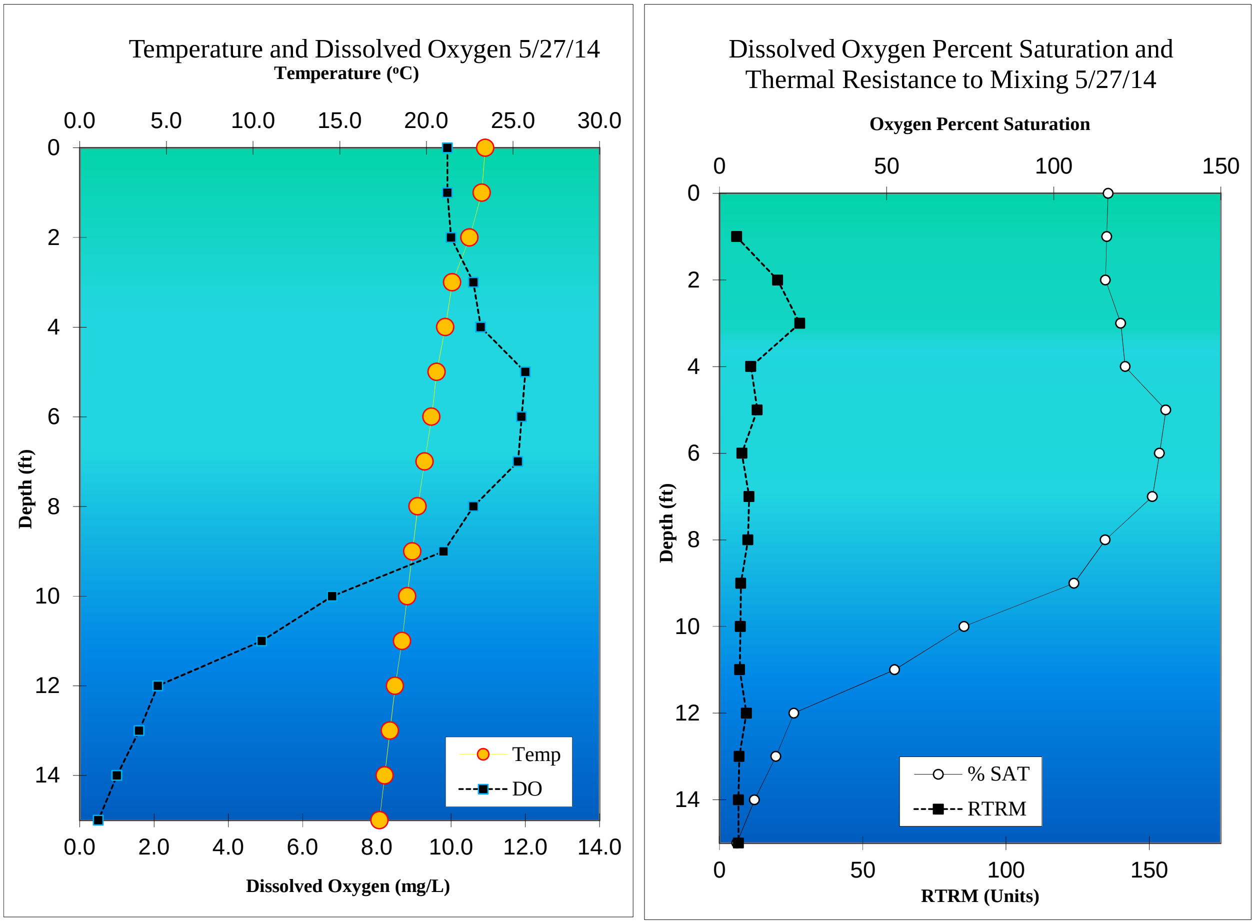


Figure 10. Hatch Pond temperature, oxygen and resistance to mixing profiles: 6/16/14

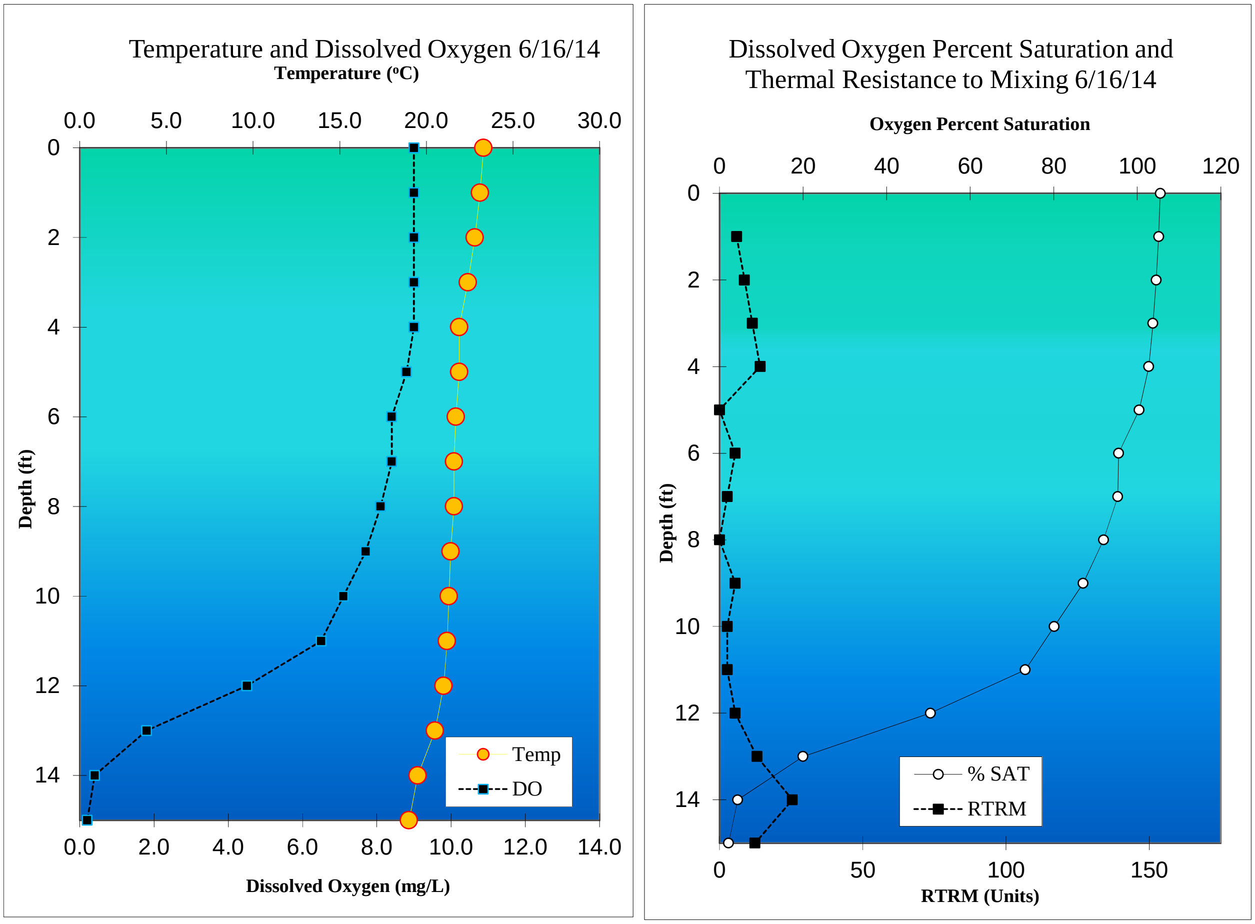


Figure 11. Hatch Pond temperature, oxygen and resistance to mixing profiles: 8/1/14

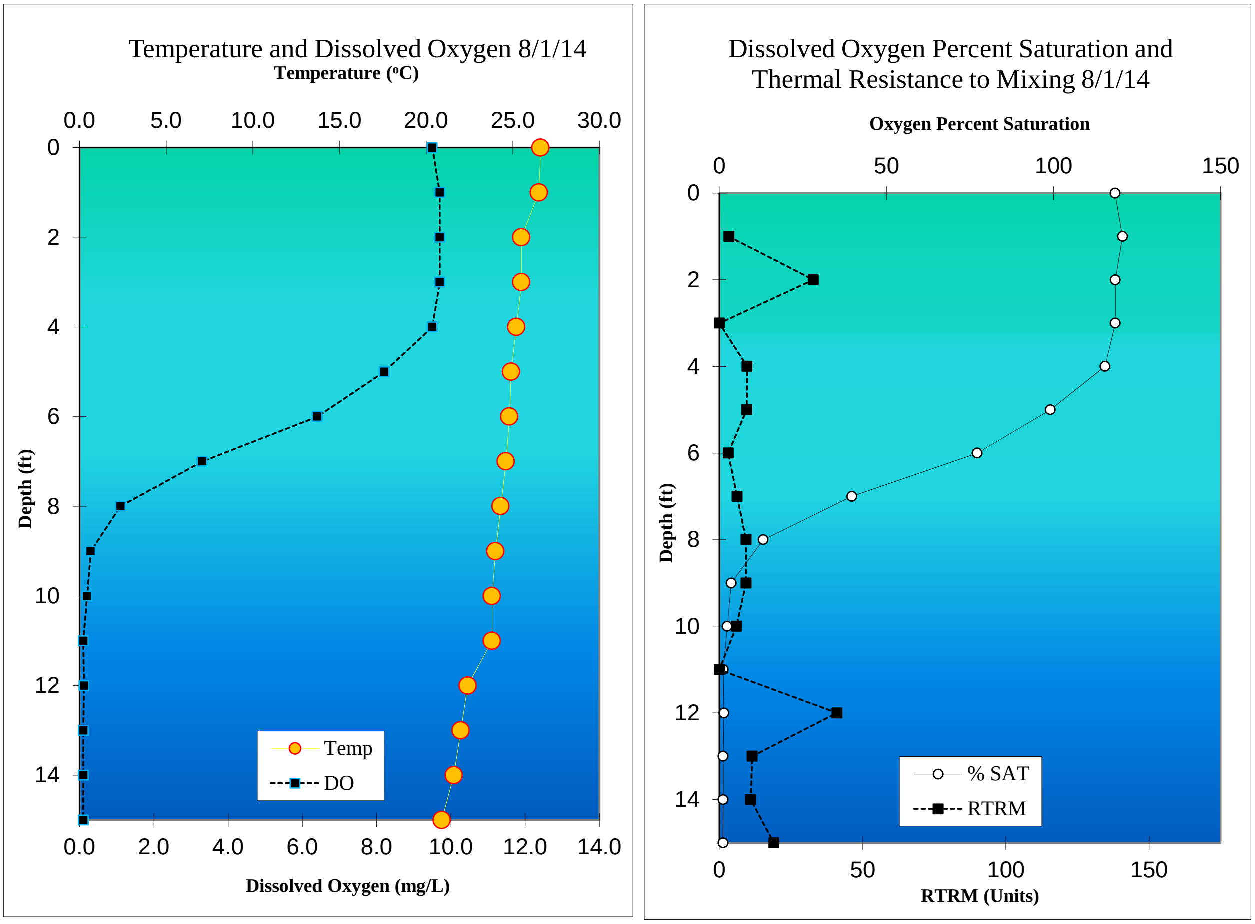


Figure 12. Hatch Pond temperature, oxygen and resistance to mixing profiles: 8/27/14

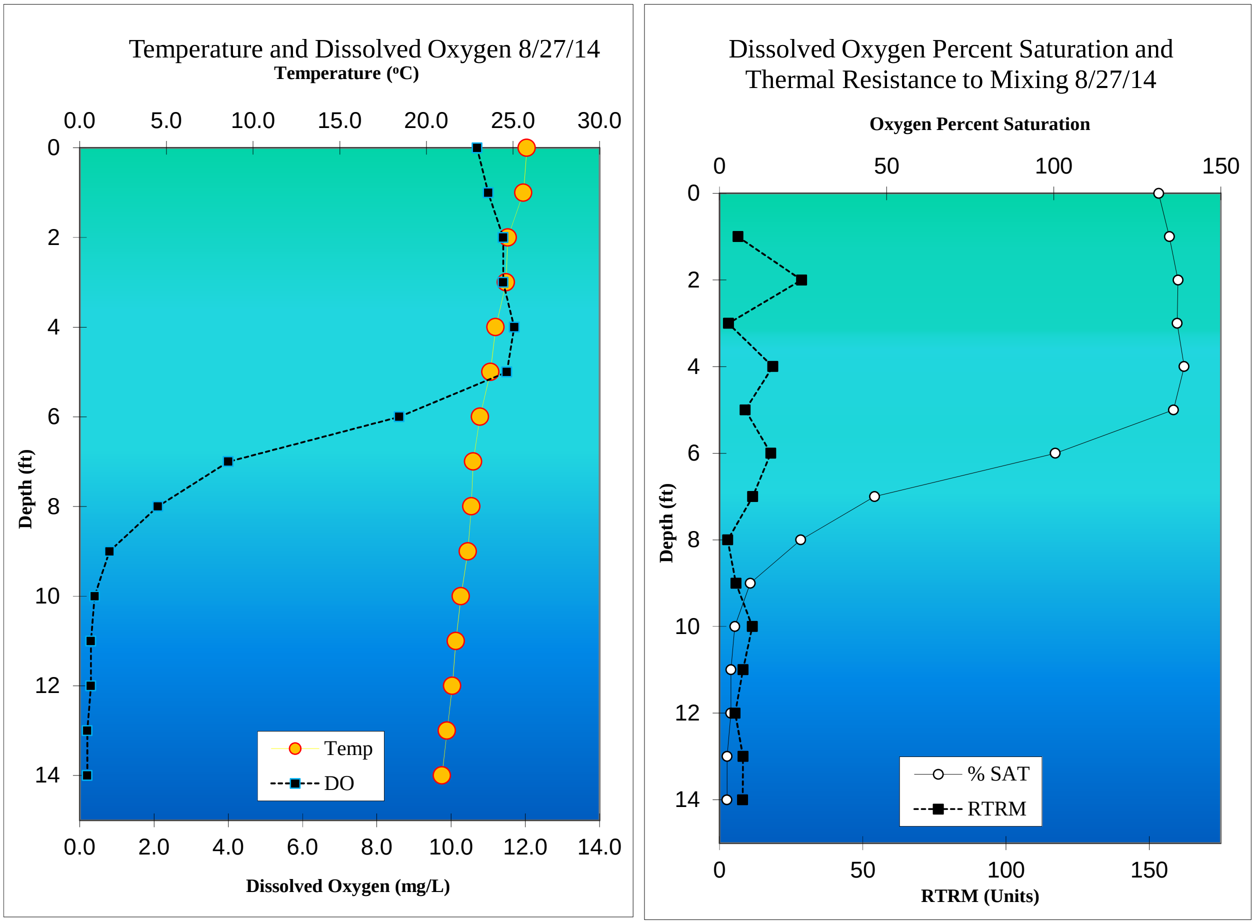
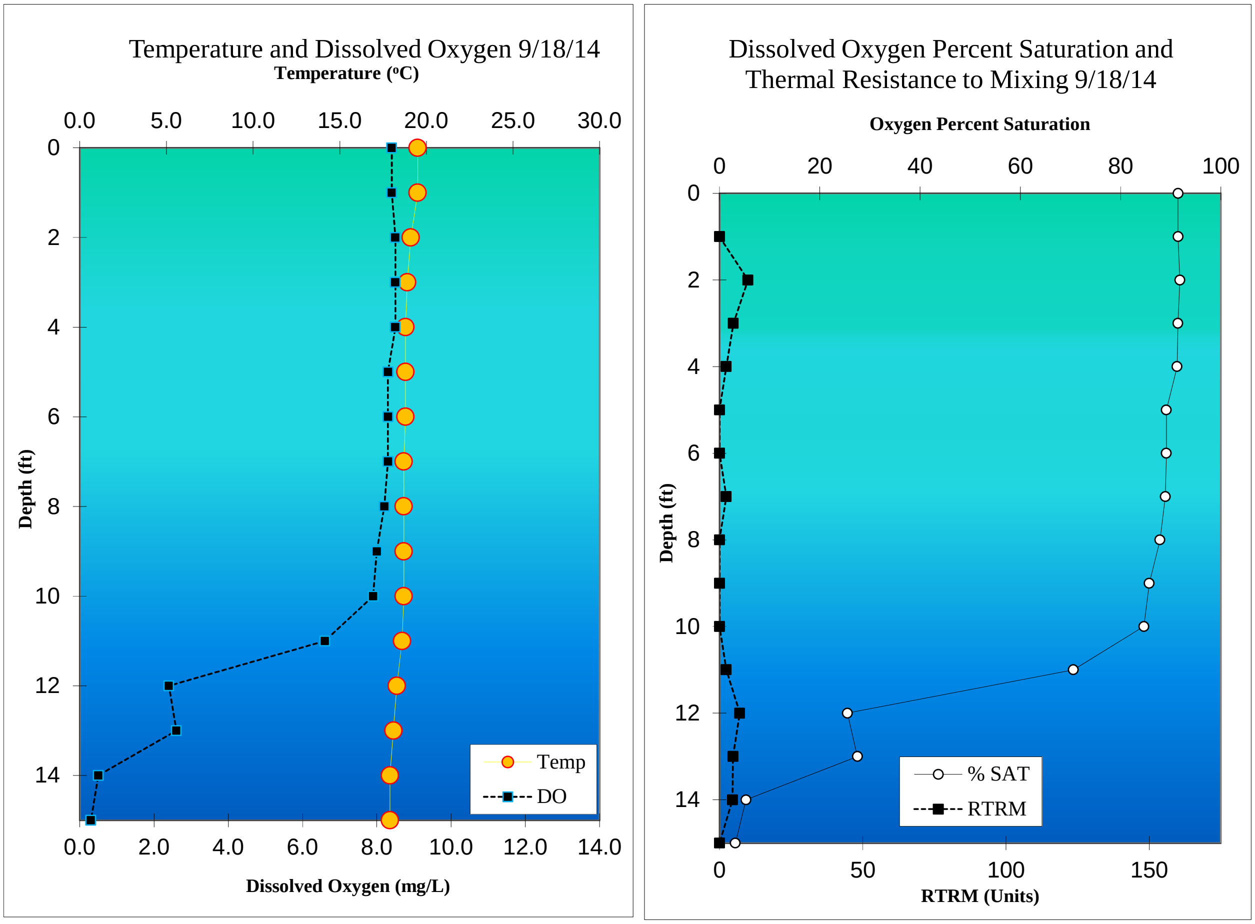


Figure 13. Hatch Pond temperature, oxygen and resistance to mixing profiles: 9/18/14



Nutrient chemistry in 2014 (Table 2) indicates moderate levels of total nitrogen with no strong surface to bottom gradient at any time. Ammonium nitrogen was low to moderate except at the bottom during the period of low oxygen, when it increased to almost 0.9 mg/L by late August. This accumulation is related to both release from sediment and lack of conversion of settling organic particulate nitrogen beyond ammonium to nitrite and nitrate due to oxygen shortage. Nitrate was scarce everywhere all the time; this is not unusual in freshwater aquatic habitats, but does favor cyanobacteria that can utilize dissolved nitrogen gas. Total nitrogen levels are moderate and are mostly organic forms.

Total phosphorus levels were moderate to high, increasing through the summer and showing an increase from surface to bottom during the period of low oxygen in deeper waters. The summer increase at a time of lower inflow and vertical gradient is indicative of internal release from sediments, although the change is not extreme in 2014. Dissolved P exhibits some increase from spring into summer, but is fairly static through the summer; dissolved P is a subset of total P and is often utilized rapidly when available, so lower and fluctuating values are expected for this water quality variable.

The pH was between 7.2 and 8.4, typical for ponds in this region, and was higher at the surface than at the bottom as a consequence of more photosynthesis near the top (removes CO_2 and increases pH) and more decomposition at the bottom (releases acids that depress pH).

Table 2. Water quality data collected in 2014.

WQ Variable	Total Nitrogen					Ammonium Nitrogen					Nitrate + Nitrite Nitrogen				
Measurement Units	mg/L					mg/L					mg/L				
EPA Method #	353.2					350.1					353.2				
Practical Quantitation Limit	0.050					0.010					0.010				
Method Detection Limit	0.008					0.003					0.003				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Hatch 1 1ft	0.313	0.323	0.669	0.589	0.548	0.011	<0.003	0.004	0.013	0.006	0.009	<0.003	<0.003	<0.003	<0.003
Hatch 1 6ft	0.275	0.394	0.689	0.819	0.662	0.010	<0.003	0.013	0.013	0.012	<0.003	<0.003	<0.003	<0.003	<0.003
Hatch 1 13ft	0.210	0.409	1.047	0.810	0.396	0.017	0.064	0.466	0.896	0.023	0.003	<0.003	<0.003	<0.003	<0.003

WQ Variable	Total Dissolved Phosphorus					Total Phosphorus				
Measurement Units	mg/L					mg/L				
EPA Method #	365.4					365.4				
Practical Quantitation Limit	0.010					0.010				
Method Detection Limit	0.001					0.001				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Hatch 1 1ft	0.008	0.015	0.014	0.011	0.013	0.020	0.031	0.042	0.033	0.032
Hatch 1 6ft	0.009	0.020	0.014	0.013	0.014	0.026	0.034	0.046	0.050	0.046
Hatch 1 13ft	0.009	0.018	0.030	0.082	0.016	0.026	0.044	0.147	0.280	0.032

WQ Variable	pH					Turbidity					Conductivity				
Measurement Units	Std Units					NTU					µS				
EPA Method #	150.1					180.1					120.1				
Practical Quantitation Limit	1 to 12					0.3					1.0				
Method Detection Limit	1 to 12					0.1					1.0				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Hatch 1 1ft	7.8	8.0	8.0	8.4	7.5	1.7	2.3	7.0	4.6	17.4	249	237	236	284	227
Hatch 1 6ft	7.9	8.1	7.7	8.2	7.6	1.4	2.8	7.5	10.3	10.1	244	247	240	286	268
Hatch 1 13ft	7.9	7.7	7.5	7.2	7.2	2.9	3.1	9.6	8.5	4.1	236	250	249	297	266

Turbidity measures light scattering by particles and represents water clarity somewhat differently than Secchi disk, although the two measurements are related. Turbidity was moderate overall, but high enough to be considered an impairment with values as high as 17 nephalometric turbidity units (NTU). Turbidity is linked to algae and other particles in the water, but the same mass of small particles will impart more turbidity than the same mass of larger particles, so size distribution of particles as well as overall number of particles affects turbidity. Values <1 are very low, while values >5 suggest some visible cloudiness to the water. Values were <5 NTU into June and >5 NTU thereafter.

Conductivity measures dissolved substances without determining what those substances are, and does so as a measure of electrical potential, with more dissolved solids providing more electrical conductivity. Values <100 umhos/cm are considered low, while values >500 umhos are generally considered high. Road salt can raise conductivity without affecting nutrient levels, so this measure requires additional information for complete interpretation, but it is used as a general indictor of fertility. Values were between 236 and 297 umhos/cm, a fairly narrow range considered moderate overall.

Quality Assurance for Water Quality Data

The QAPP was followed to the extent possible, which was very closely with regard to methods, but with some deviation on timing. No contract was issued in time to perform late winter sampling, so one sampling event was missed. Temporal spacing of sampling events was not quite even, with a gap in July owing to a perceived need to focus on late summer conditions. Study goals were not compromised.

Duplicate samples for nutrient chemistry (Table 3) indicated just a few values outside the accepted precision range (set at 25%), owing mainly to low values overall and precision being expressed as a percentage (small deviations with low values yield greater percentages). Deviations have little effect on data use in this case, as much larger changes are needed to signify significant differences for purposes of management planning and evaluation.

Table 3. Duplicate sample comparisons for water quality data collected in 2014.

Duplicate Results	TN	TN	% diff	NH3	NH3	% diff	NOX	NOX	% diff
4/29/2014	0.313	0.249	20.4%	0.011	0.011	0.0%	0.009	<0.003	66.7%
6/16/2014	0.394	0.371	5.8%	<0.003	<0.003	0.0%	<0.003	<0.003	0.0%
8/1/2014	0.689	0.716	3.9%	0.013	0.011	15.4%	<0.003	<0.003	0.0%
8/27/2014	0.819	0.851	3.9%	0.013	0.011	15.4%	<0.003	<0.003	0.0%
9/18/2014	0.662	0.596	10.0%	0.012	0.003	75.0%	<0.003	<0.003	0.0%

Duplicate Results	TDP	TDP	% diff	TP	TP	% diff
4/29/2014	0.008	0.008	0.0%	0.020	0.023	15.0%
6/16/2014	0.020	0.013	35.0%	0.034	0.034	0.0%
8/1/2014	0.014	0.015	7.1%	0.046	0.065	41.3%
8/27/2014	0.013	0.011	15.4%	0.050	0.055	10.0%
9/18/2014	0.014	0.014	0.0%	0.046	0.038	17.4%

Duplicate Results	pH	pH	% diff	TURB	TURB	% diff	Cond	Cond	% diff
4/29/2014	7.8	7.9	1.3%	1.7	1.6	5.9%	249	249	0.0%
6/16/2014	8.1	7.9	2.5%	2.8	2.6	7.1%	247	234	5.3%
8/1/2014	7.7	7.8	1.3%	7.5	7.1	5.3%	240	244	1.7%
8/27/2014	8.2	8.2	0.1%	10.3	9.7	5.7%	286	279	2.4%
9/18/2014	7.6	7.5	1.3%	10.1	10.4	3.0%	268	259	3.4%

Trip blank analysis indicated some issues with the quality of distilled water on the first two trips, but no significant issues thereafter (Table 4). Even with some detectable values in the distilled water blank, comparison with the average pond sample value for the day indicates minimal possible influence on data quality for management evaluation purposes.

Lab spike and recovery data indicated no laboratory problems with accuracy within the defined parameters of the QAPP. Additionally, side by side comparison of temperature and oxygen measurements using two different field meters during the June sampling revealed very close agreement, within 0.1 C for temperature and within 0.2 mg/L for oxygen.

Table 4. Evaluation of trip blanks for water quality sampling in 2014.

WQ Variable	Total Nitrogen					Ammonium Nitrogen					Nitrate + Nitrite Nitrogen				
Measurement Units	mg/L					mg/L					mg/L				
EPA Method #	353.2					350.1					353.2				
Practical Quantitation Limit	0.050					0.010					0.010				
Method Detection Limit	0.008					0.003					0.003				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Blank (distilled water)	0.043	0.053	<0.008	0.012	<0.008	0.055	0.062	<0.003	0.008	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Average Value for Day	0.266	0.375	0.802	0.739	0.535	0.013	0.064	0.161	0.307	0.014	0.006	<0.003	<0.003	<0.003	<0.003

WQ Variable	Total Dissolved Phosphorus					Total Phosphorus				
Measurement Units	mg/L					mg/L				
EPA Method #	365.4					365.4				
Practical Quantitation Limit	0.010					0.010				
Method Detection Limit	0.001					0.001				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Blank (distilled water)	0.004	0.003	0.005	0.007	0.004	0.008	0.003	0.004	<0.001	0.001
Average Value for Day	0.009	0.018	0.019	0.035	0.014	0.024	0.036	0.078	0.121	0.037

WQ Variable	pH					Turbidity					Conductivity				
Measurement Units	Std Units					NTU					µS				
EPA Method #	150.1					180.1					120.1				
Practical Quantitation Limit	1 to 12					0.3					1.0				
Method Detection Limit	1 to 12					0.1					1.0				
Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14
Blank (distilled water)	5.4	6.6	7.2	5.9	7.0	0.2	0.4	0.5	0.2	0.2	0.5	0.5	0.4	0.4	0.3
Average Value for Day	7.8	7.9	7.7	8.0	7.4	2.0	2.7	8.0	7.8	10.5	243	245	242	289	254

Sediment Quality Data

Sediment cores were collected in three locations to allow assessment of material quality from the perspective of a possible dredging project. Surficial sediment samples were collected in the same areas to allow measurement of available sediment phosphorus for release into the water column under anoxic conditions.

At this time, Connecticut does not have published criteria for disposal of dredged sediments. In the absence of such criteria, sediment data from Hatch Pond were compared to the Massachusetts disposal criteria. Based on the Massachusetts criteria, Hatch Pond sediments (Table 5) did not exceed standards relating to sediment disposal. Metals, hydrocarbons, pesticides and PCBs were all below thresholds that would trigger disposal restrictions, based on core samples. This is partly due to the cores being rather long and incorporating considerable material that undoubtedly dates back to pre-settlement times. Yet dredging would mix this material, so assessing quality from core samples is appropriate. There may be some higher levels of contamination in surficial sediment, but the overall average quality of the cores was very high. Physically, the sediment had high fibrous peat content below a relatively thin layer of looser muck, suggesting much older and different origin. The pond was much deeper at one time, after

Table 5. Sediment quality data from Hatch Pond in 2014 (thresholds from MA standards).

Parameter	Units	Method	Background Soil Data Set 90th Percentile	Unrestricted Disposal Limit	Sample 1	Sample 2	Sample 3
Total Metals							
Aluminum	ppm	6010B, SW-846			5620	7690	9070
Arsenic	ppm	6010B, SW-846	11-16.7	30	<25	<24.5	<20
Cadmium	ppm	6010B, SW-846	1.63-3.0	30	<8.33	<8.15	<6.65
Chromium (total)	ppm	6010B, SW-846	28.6-43.9	1000	<16.7	<16.3	15.4
Copper	ppm	6010B, SW-846	37.7-47.5	1000	<16.7	22.1	29.4
Iron	ppm	6010B, SW-846	17,000		8330	11200	13600
Lead	ppm	6010B, SW-846	78.9-640	300	<25	<24.5	20.2
Manganese	ppm	6010B, SW-846	300		170	255	217
Mercury	ppm	7471, EPA 1986	0.28-1.4	20	<0.548	<0.507	<0.407
Nickel	ppm	6010B, SW-846	16.6-67.5	300	<16.7	<16.3	<13.3
Vanadium	ppm	6010B, SW-846	28.5				
Zinc	ppm	6010, EPA 1987	103-340	2500	50.1	76.5	74.8
Total Petroleum Hydrocarbons	ppm	ASTM D3328		200			
Extractable Petroleum Hydrocarbons							
C9-C18 Aliphatics	ppm	EPH		1000	<185	<178	<146
C19-C36 Aliphatics	ppm	EPH		2500	<185	<178	<146
C11-C22 Aromatics	ppm	EPH		200	<185	<178	<146
Polynuclear Aromatic Hyrdocarbons							
Acenaphthene	ppm	EPA 8270	1.9	20	<1.2	<1.2	<1.0
Acenaphthylene	ppm	EPA 8270	1	100	<1.2	<1.2	<1.0
Anthracene	ppm	EPA 8270	3.8	1000	<1.2	<1.2	<1.0
Benzo(a)anthracene	ppm	EPA 8270	2.39-17.6	0.7	<1.2	<1.2	<1.0
Benzo(a)pyrene	ppm	EPA 8270	2.02-15.3	0.7	<1.2	<1.2	<1.0
Benzo(b)fluoranthene	ppm	EPA 8270	6.78-11.0	0.7	<1.2	<1.2	<1.0
Benzo(k)fluoranthene	ppm	EPA 8270	3.35-11.4	7	<1.2	<1.2	<1.0
Benzo(g,h,i)perylene	ppm	EPA 8270	1.2-3.1	1000	<1.2	<1.2	<1.0
Chrysene	ppm	EPA 8270	2.1-20.3	7	<1.2	<1.2	<1.0
Dibenzo(a,h)anthracene	ppm	EPA 8270	0.49-1.1	0.7	<1.2	<1.2	<1.0
Fluoranthene	ppm	EPA 8270	4.2-14.0	1000	<1.2	<1.2	<1.0
Fluorene	ppm	EPA 8270	2.3	400	<1.2	<1.2	<1.0
Indeno(1,2,3-cd)pyrene	ppm	EPA 8270	1.5-6.3	0.7	<1.2	<1.2	<1.0
2-Methylnaphthalene	ppm	EPA 8270	0.96		<1.2	<1.2	<1.0
Naphthalene	ppm	EPA 8270	1.4	4	<1.2	<1.2	<1.0
Phenanthrene	ppm	EPA 8270	2.7-15.0	100	<1.2	<1.2	<1.0
Pyrene	ppm	EPA 8270	4.29-16.0	700	<1.2	<1.2	<1.0
Pesticides							
aldrin	ppb	EPA 8081		30	<94.1	<89.1	<75.2
alpha-BHC	ppb	EPA 8081		50,000	<94.1	<89.1	<75.2
beta-BHC	ppb	EPA 8081		10,000	<94.1	<89.1	<75.2
delta-BHC	ppb	EPA 8081		10,000	<94.1	<89.1	<75.2
gamma-BHC (Lindane)	ppb	EPA 8081		100	<56.5	<53.5	<45.1
chlordane	ppb	EPA 8081		1,000	<376	<357	<301
4,4'-DDD	ppb	EPA 8081		2,000	<94.1	<89.1	<75.2
4,4'-DDE	ppb	EPA 8081		2,000	<151	<143	<120
4,4'-DDT	ppb	EPA 8081		2,000	<151	<143	<120
dieldrin	ppb	EPA 8081		30	<94.1	<89.1	<75.2
endosulfan I	ppb	EPA 8081		50	<94.1	<89.1	<75.2
endosulfan II	ppb	EPA 8081		50	<151	<143	<120
endosulfan sulfate	ppb	EPA 8081		50	<151	<143	<120
endrin	ppb	EPA 8081		600	<151	<143	<120
endrin ketone	ppb	EPA 8081		600	<151	<143	<120
endrin aldehyde	ppb	EPA 8081		600	<151	<143	<120
heptachlor	ppb	EPA 8081		100	<94.1	<89.1	<75.2
heptachlor epoxide	ppb	EPA 8081		60	<94.1	<89.1	<75.2
methoxychlor	ppb	EPA 8081		30,000	<151	<143	<120
toxaphene	ppb	EPA 8081		10,000	<1880	<1780	<1500
Hexachlorobenzene	ppb	EPA 8081					
Polychlorinated Biphenyls							
PCB-1016	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1221	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1232	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1242	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1248	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1254	ppb	EPA 8082		2,000	<365	<354	<301
PCB-1260	ppb	EPA 8082		2,000	<365	<354	<301
Total Solids	%	2540B SM			5.3	5.6	6.6
Total Volatile Solids	%	2540G SM			98.7	97.9	98.4
Total Phosphorus	ppm	6010B, SW-846			517	691	570
Loosely Sorbed Phosphorus	ppm	Custom extraction			2.6	2.1	1
Iron-bound Phosphorus	ppm	Custom extraction			132	180	172

the last glaciation, but may have been a wetland prior to dam installation. The vast majority of sediment collected with cores was peat.

Surficial samples also contained some peat, but also contained more typical pond muck with brown to gray color and much finer texture. Solids content was low (<10%) and organic content was high (>97%). Total P in the sediment ranged from 517 to 691 mg/kg, a fairly narrow range (Table 5). Loosely sorbed P levels were negligible (<3 mg/kg), while iron-bound P ranged from 132 to 180 mg/kg, also a fairly narrow range. Available sediment P, the sum of loosely sorbed and iron-bound P, is above the level of some concern, but is not high relative to many other lakes, where values often exceed 500 mg/kg and sometimes 1000 mg/kg. If most of the iron-bound P was released under anoxia, the quantity would be large and greatly increase water P levels, but it is rare for more than 10% of the iron-bound P to be released from more than the upper 4 inches (10 cm) of sediment.

Bringing a dredging project to fruition will likely require further sampling and testing. Identification of disposal areas is essential, and sediment data will have to be compared to current, applicable disposal criteria for chosen disposal areas. The depth to which Hatch Pond might be dredged may influence average quality of sediments to be removed. Use of a Licensed Environmental Professional would be advisable to ensure compliance with applicable regulations. A nutrient inactivation program for surficial sediments could be planned based on the data generated in this study, but it is not clear that such inactivation is needed, given better oxygen conditions in 2014 and the continued dominance of external sources of phosphorus.

Biological Pond Features

Phytoplankton

Phytoplankton are algae that float in the water. With adequate nutrients and light, they photosynthesize, multiply, and cause algae blooms. Some types produce toxins and specific taste and odor compounds, and almost any type of algae can cause odor by decay upon death. While algae can cause nuisance conditions and use impairment, they are also essential elements of the food web. Ideally, algae that are produced are grazed by zooplankton that are consumed by small fish that are consumed by larger fish, creating desirable water clarity and fishing at the same time. However, maintaining ecological balance is not an easy task, with all biological components of the aquatic system in constant flux and elevated nutrient levels driving high productivity. If low oxygen or cyanobacteria toxicity problems can be avoided, the fishing may still be good even without ecological balance, but algae blooms are expected and will cause at least occasional water quality impairment.

The phytoplankton of Hatch Pond have been dominated by blue-green algae, more properly cyanobacteria, during summer for many years. Many cyanobacteria have gas pockets in their cells that allow them to float, creating surface scums. They thrive on high phosphorus and are not nearly as negatively affected by a lack of inorganic nitrogen as other algae. Conditions in Hatch Pond have been ideal for cyanobacteria growth for many years, but started shifting with the cessation of dairy operations in 2010. The phytoplankton in 2014 included cyanobacteria, and some surface scums were noted, but samples of the upper 6-8 ft of the water column were not dominated by cyanobacteria biomass (Tables 6 and 7, Figure 14).

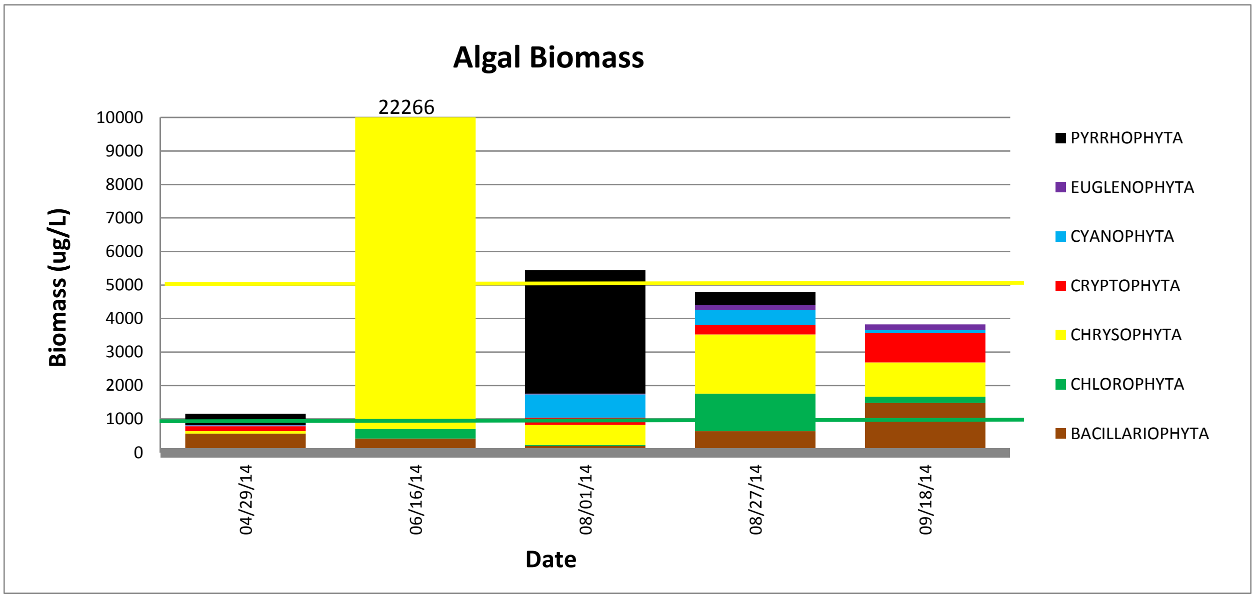
Table 6. Phytoplankton raw data collected in 2014.

	PHYTOPLANKTON DENSITY (CELLS/ML)						PHYTOPLANKTON BIOMASS (UG/L)				
	Hatch	Hatch	Hatch	Hatch	Hatch		Hatch	Hatch	Hatch	Hatch	Hatch
TAXON	**04/29/14**	**06/16/14**	**08/01/14**	**08/27/14**	**09/18/14**		**04/29/14**	**06/16/14**	**08/01/14**	**08/27/14**	**09/18/14**
BACILLARIOPHYTA											
Centric Diatoms											
Aulacoseira	156	256	0	45	168		46.8	76.9	0.0	13.5	50.4
Cyclotella	0	0	0	0	980		0.0	0.0	0.0	0.0	1106.0
Stephanodiscus	0	0	72	0	0		0.0	0.0	180.0	0.0	0.0
Araphid Pennate Diatoms											
Asterionella	78	512	0	0	0		15.6	102.5	0.0	0.0	0.0
Fragilaria/related taxa	488	256	0	270	336		146.3	76.9	0.0	81.0	100.8
Synedra	78	37	0	68	28		343.2	161.0	0.0	540.0	224.0
Monoraphid Pennate Diatoms											
Biraphid Pennate Diatoms											
Gomphonema/related taxa	0	0	18	0	0		0.0	0.0	18.0	0.0	0.0
Navicula/related taxa	20	0	0	0	0		9.8	0.0	0.0	0.0	0.0
CHLOROPHYTA											
Flagellated Chlorophytes											
Coccoid/Colonial Chlorophytes											
Coelastrum	0	0	0	360	0		0.0	0.0	0.0	72.0	0.0
Golenkinia	0	0	36	45	0		0.0	0.0	7.2	9.0	0.0
Lagerheimia	0	0	0	23	0		0.0	0.0	0.0	2.3	0.0
Oocystis	0	73	54	540	224		0.0	29.3	21.6	216.0	89.6
Scenedesmus	0	0	0	720	112		0.0	0.0	0.0	72.0	11.2
Schroederia	0	55	0	0	28		0.0	137.3	0.0	0.0	70.0
Sphaerocystis	0	586	0	0	0		0.0	117.1	0.0	0.0	0.0
Tetraedron	0	0	0	23	28		0.0	0.0	0.0	13.5	16.8
Treubaria	0	0	0	45	0		0.0	0.0	0.0	36.0	0.0
Filamentous Chlorophytes											
Desmids											
Mougeotia/Debarya	0	0	0	45	0		0.0	0.0	0.0	706.5	0.0
CHRYSOPHYTA											
Flagellated Classic Chrysophytes											
Dinobryon	20	0	198	585	336		58.5	0.0	594.0	1755.0	1008.0
Mallomonas	39	0	0	23	28		19.5	0.0	0.0	11.3	14.0
Non-Motile Classic Chrysophytes											
Haptophytes											
Tribophytes/Eustigmatophytes											
Pseudostaurastrum	0	18	0	0	0		0.0	219.6	0.0	0.0	0.0
Tribonema	0	8052	0	0	0		0.0	18519.6	0.0	0.0	0.0
Raphidophytes											
Gonyostomum and related taxa	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA											
Cryptomonas	722	55	54	68	476		144.3	36.6	223.2	279.0	873.6
CYANOPHYTA											
Unicellular and Colonial Forms											
Aphanocapsa	0	0	14400	4500	0		0.0	0.0	144.0	45.0	0.0
Gomphosphaeria	0	0	1800	2700	0		0.0	0.0	18.0	27.0	0.0
Microcystis	780	0	1440	3375	1120		23.4	0.0	43.2	101.3	33.6
Woronichinia	0	0	1800	5625	5040		0.0	0.0	18.0	56.3	50.4
Filamentous Nitrogen Fixers											
Anabaena	0	0	2340	1080	0		0.0	0.0	468.0	216.0	0.0
Filamentous Non-Nitrogen Fixers											
EUGLENOPHYTA											
Euglena	20	0	18	0	0		9.8	0.0	9.0	0.0	0.0
Phacus	0	0	0	23	0		0.0	0.0	0.0	6.8	0.0
Trachelomonas	0	0	18	45	56		0.0	0.0	18.0	141.8	176.4
PYRRHOPHYTA											
Ceratium	20	18	72	23	0		339.3	318.4	1252.8	391.5	0.0
Peridinium	0	55	54	0	0		0.0	2470.5	2430.0	0.0	0.0

Table 7. Phytoplankton summary data collected in 2014.

	PHYTOPLANKTON DENSITY (CELLS/ML)						PHYTOPLANKTON BIOMASS (UG/L)				
	Hatch	Hatch	Hatch	Hatch	Hatch		Hatch	Hatch	Hatch	Hatch	Hatch
TAXON	04/29/14	06/16/14	08/01/14	08/27/14	09/18/14		04/29/14	06/16/14	08/01/14	08/27/14	09/18/14
DENSITY SUMMARY											
BACILLARIOPHYTA	**819**	**1061.4**	**90**	**382.5**	**1512**		**561.6**	**417.2**	**198.0**	**634.5**	**1481.2**
Centric Diatoms	156	256.2	72	45	1148		46.8	76.9	180.0	13.5	1156.4
Araphid Pennate Diatoms	643.5	805.2	0	337.5	364		505.1	340.4	0.0	621.0	324.8
Monoraphid Pennate Diatoms	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	19.5	0	18	0	0		9.8	0.0	18.0	0.0	0.0
CHLOROPHYTA	**0**	**713.7**	**90**	**1800**	**392**		**0.0**	**283.7**	**28.8**	**1127.3**	**187.6**
Flagellated Chlorophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	0	713.7	90	1755	392		0.0	283.7	28.8	420.8	187.6
Filamentous Chlorophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Desmids	0	0	0	45	0		0.0	0.0	0.0	706.5	0.0
CHRYSOPHYTA	**58.5**	**8070.3**	**198**	**607.5**	**364**		**78.0**	**18739.2**	**594.0**	**1766.3**	**1022.0**
Flagellated Classic Chrysophytes	58.5	0	198	607.5	364		78.0	0.0	594.0	1766.3	1022.0
Non-Motile Classic Chrysophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Haptophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0	8070.3	0	0	0		0.0	18739.2	0.0	0.0	0.0
Raphidophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	**721.5**	**54.9**	**54**	**67.5**	**476**		**144.3**	**36.6**	**223.2**	**279.0**	**873.6**
CYANOPHYTA	**780**	**0**	**21780**	**17280**	**6160**		**23.4**	**0.0**	**691.2**	**445.5**	**84.0**
Unicellular and Colonial Forms	780	0	19440	16200	6160		23.4	0.0	223.2	229.5	84.0
Filamentous Nitrogen Fixers	0	0	2340	1080	0		0.0	0.0	468.0	216.0	0.0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	**19.5**	**0**	**36**	**67.5**	**56**		**9.8**	**0.0**	**27.0**	**148.5**	**176.4**
PYRRHOPHYTA	**19.5**	**73.2**	**126**	**22.5**	**0**		**339.3**	**2788.9**	**3682.8**	**391.5**	**0.0**
TOTAL	**2418**	**9973.5**	**22374**	**20227.5**	**8960**		**1156.4**	**22265.6**	**5445.0**	**4792.5**	**3824.8**
DIVERSITY	**0.72**	**0.37**	**0.54**	**0.87**	**0.67**		**0.79**	**0.30**	**0.71**	**0.94**	**0.79**
EVENNESS	**0.70**	**0.34**	**0.46**	**0.65**	**0.59**		**0.75**	**0.27**	**0.61**	**0.70**	**0.69**
NUMBER OF TAXA											
BACILLARIOPHYTA	**5**	**4**	**2**	**3**	**4**						
Centric Diatoms	1	1	1	1	2						
Araphid Pennate Diatoms	3	3	0	2	2						
Monoraphid Pennate Diatoms	0	0	0	0	0						
Biraphid Pennate Diatoms	1	0	1	0	0						
CHLOROPHYTA	**0**	**3**	**2**	**8**	**4**						
Flagellated Chlorophytes	0	0	0	0	0						
Coccoid/Colonial Chlorophytes	0	3	2	7	4						
Filamentous Chlorophytes	0	0	0	0	0						
Desmids	0	0	0	1	0						
CHRYSOPHYTA	**2**	**2**	**1**	**2**	**2**						
Flagellated Classic Chrysophytes	2	0	1	2	2						
Non-Motile Classic Chrysophytes	0	0	0	0	0						
Haptophytes	0	0	0	0	0						
Tribophytes/Eustigmatophytes	0	2	0	0	0						
Raphidophytes	0	0	0	0	0						
CRYPTOPHYTA	**1**	**1**	**1**	**1**	**1**						
CYANOPHYTA	**1**	**0**	**5**	**5**	**2**						
Unicellular and Colonial Forms	1	0	4	4	2						
Filamentous Nitrogen Fixers	0	0	1	1	0						
Filamentous Non-Nitrogen Fixers	0	0	0	0	0						
EUGLENOPHYTA	**1**	**0**	**2**	**2**	**1**						
PYRRHOPHYTA	**1**	**2**	**2**	**1**	**0**						
TOTAL	**11**	**12**	**15**	**22**	**14**						

Figure 14. Hatch Pond phytoplankton in 2014



Algae biomass was still elevated in 2014, with a chrysophyte (golden) algae bloom in June, pyrrhophytes (dinoflagellates) at the start of August, and mixed assemblages in later August and September. There were substantial blue-greens present in the August samples, including problem bloom formers, and clumps were visible at the surface of the pond at times, but the extent of any blooms by blue-greens was much less than in past years. This could be partly a function of weather, as summer 2014 was not as hot or as wet as other recent summers. However, it is a likely consequence of reduced P concentrations and higher N:P ratios observed in 2014, both of which favor other types of algae. While nutrient levels were still elevated, they were less than half of what was observed prior to 2010.

Zooplankton

Zooplankton are small to microscopic animals that swim in the water column and eat algae or each other. Larger zooplankton can be seen with the naked eye and are important food sources for small fish. There are three main groups of zooplankton, the Cladocera, Copepoda, and Rotifera. Cladocerans include larger filter feeding zooplankters like *Daphnia* that can clear the water of most algae and are highly preferred fish food. Copepods are more selective feeders and are harder for fish to catch. Rotifers are too small to eat many types of algae and represent less of a food resource for fish.

Hatch Pond zooplankton (Table 8, Figures 15 and 16) included the three main groups plus some protozoans and other zooplankton. Biomass was moderate on average, and size distribution, while not optimal, was not skewed toward smaller individuals. *Daphnia* were at least present in all samples. Lower biomass and smaller average individual size are most likely functions of predation by small fish, which are plentiful in Hatch Pond, but there are enough refuges and a rapid enough reproduction rate that the zooplankton community was not decimated over the summer, which is common in many ponds. Overall, the zooplankton community of Hatch Pond was considered to be in a desirable condition in 2014.

Table 8. Zooplankton data collected in 2014.

	ZOOPLANKTON DENSITY (#/L)						ZOOPLANKTON BIOMASS (UG/L)				
	Hatch	Hatch	Hatch	Hatch	Hatch		Hatch	Hatch	Hatch	Hatch	Hatch
TAXON	4/29/14	6/16/14	8/1/14	8/27/14	9/18/14		4/29/14	6/16/14	8/1/14	8/27/14	9/18/14
PROTOZOA											
Ciliophora	0.0	0.0	8.7	0.0	0.0		0.0	0.0	4.3	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
ROTIFERA											
Anuraeopsis	0.0	0.0	1.6	0.0	2.1		0.0	0.0	0.0	0.0	0.1
Filinia	0.0	0.0	4.7	0.0	0.0		0.0	0.0	0.2	0.0	0.0
Kellicottia	0.3	0.0	0.0	2.1	9.1		0.0	0.0	0.0	0.1	0.4
Keratella	4.2	0.0	25.3	0.5	2.3		0.4	0.0	2.3	0.0	0.2
Polyarthra	0.0	2.4	2.4	0.5	0.5		0.0	0.5	0.2	0.0	0.0
Trichocerca	0.0	0.0	11.1	0.0	0.0		0.0	0.0	0.4	0.0	0.0
COPEPODA											
Copepoda-Cyclopoida											
Cyclops	0.5	0.0	0.0	0.0	0.3		1.3	0.0	0.0	0.0	0.6
Mesocyclops	1.3	2.4	2.4	1.1	0.5		1.6	3.0	14.1	5.1	0.7
Copepoda-Calanoida											
Diaptomus	1.0	0.8	0.0	0.0	0.0		0.5	0.4	0.0	0.0	0.0
Other Copepoda-Nauplii	5.2	3.2	0.0	4.2	1.0		13.8	8.4	0.0	11.2	2.8
CLADOCERA											
Bosmina	1.0	1.6	0.0	0.0	0.0		1.0	1.5	0.0	0.0	0.0
Ceriodaphnia	0.0	0.0	17.4	3.2	2.1		0.0	0.0	45.2	8.3	5.4
Chydorus	0.0	0.8	0.0	0.0	0.0		0.0	0.8	0.0	0.0	0.0
Daphnia ambigua	0.3	6.3	3.2	8.5	3.6		0.4	10.2	5.1	38.5	14.1
OTHER ZOOPLANKTON											
Ostracoda	0.0	0.0	0.0	3.2	1.0		0.0	0.0	0.0	31.8	10.4
SUMMARY STATISTICS											
DENSITY											
PROTOZOA	0.0	0.0	8.7	0.0	0.0		0.0	0.0	4.3	0.0	0.0
ROTIFERA	4.4	2.4	45.0	3.2	14.0		0.4	0.5	3.2	0.2	0.7
COPEPODA	8.1	6.3	2.4	5.3	1.8		17.2	11.7	14.1	16.3	4.0
CLADOCERA	1.3	8.7	20.5	11.7	5.7		1.4	12.6	50.3	46.7	19.5
OTHER ZOOPLANKTON	0.0	0.0	0.0	3.2	1.0		0.0	0.0	0.0	31.8	10.4
TOTAL ZOOPLANKTON	13.8	17.4	76.6	23.3	22.6		19.0	24.8	71.9	95.0	34.7
TAXONOMIC RICHNESS											
PROTOZOA	0	0	1	0	0						
ROTIFERA	2	1	5	3	4						
COPEPODA	4	3	1	2	3						
CLADOCERA	2	3	2	2	2						
OTHER ZOOPLANKTON	0	0	0	1	1						
TOTAL ZOOPLANKTON	8	7	9	8	10						
S-W DIVERSITY INDEX	0.70	0.75	0.79	0.76	0.80						
EVENNESS INDEX	0.78	0.88	0.83	0.84	0.80						
MEAN LENGTH (mm): ALL FORMS	0.31	0.43	0.24	0.54	0.28						
MEAN LENGTH: CRUSTACEANS	0.40	0.48	0.55	0.63	0.61						

Figure 15. Hatch Pond zooplankton composition in 2014

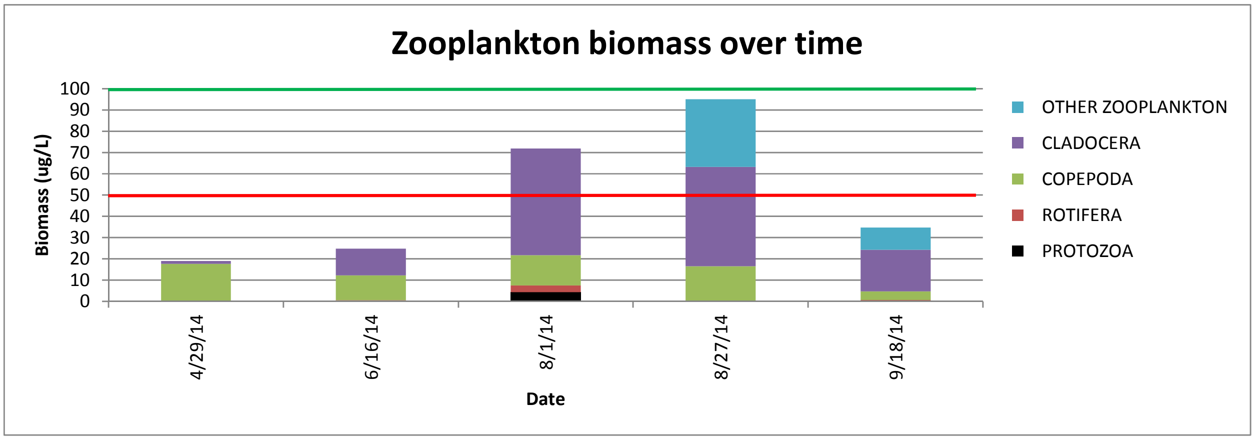
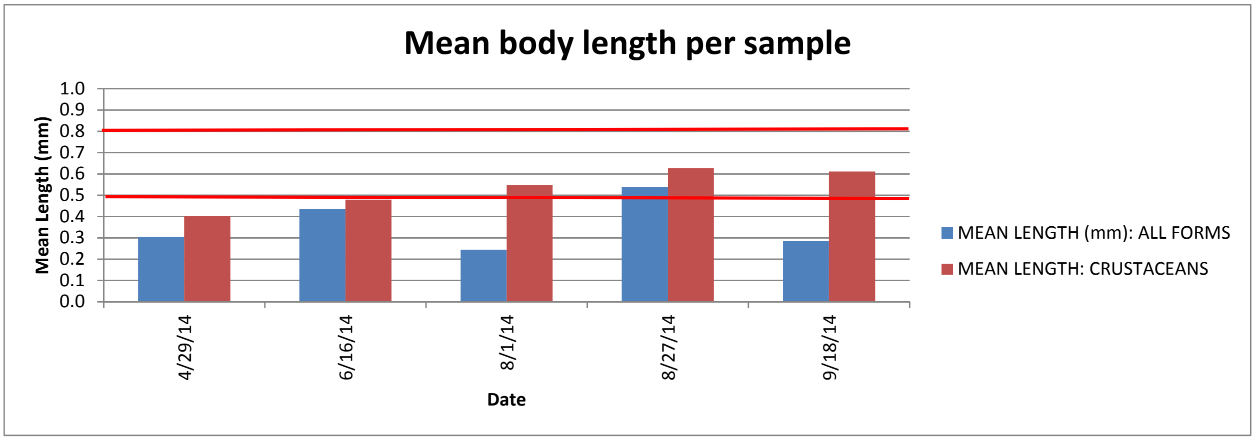


Figure 16. Hatch Pond zooplankton mean length in 2014



Macrophytes

Macrophytes, or larger plants, were not the focus of this investigation, but this component of the Hatch Pond system has been studied extensively in the past and observations were made in 2014. In 1990 the CT DEP reported no invasive species in the pond, but by 2000 NEAR reported both Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*) at high densities and coverage (NEAR 2012). In 2004, 2005 and 2010 milfoil was found to be dominant in 16 to 20 acres of this roughly 70 acre lake. Similar coverage was observed in 2014. Curlyleaf pondweed reaches peak density in late spring and is not typically abundant after early summer, and unusual ecology that limits nuisances at the time of peak recreational use. Other plants observed in 2014 matched the 2010 list closely, with substantial surface cover by white and yellow water lilies, watermeal, duckweed and great duckweed, and dense submergent growths of coontail in addition to the dominant Eurasian watermilfoil. Filamentous green algae mats and clouds were also abundant. Flatstem pondweed was more abundant in 2014 than noted in 2010, and a few other pondweed species were observed in 2014, but only rarely. Most of the water column was filled with plants in water <9 ft deep, and dense plant growths represented the most obvious use impairment in 2014.

Fish

Fish were not the focus of this investigation, but are an important component of the Hatch Pond system, both ecologically and in terms of uses, with fishing being the greatest use of Hatch Pond at this time. Hatch Pond hosts a warmwater fishery, being too shallow to hold cold water necessary for trout or other coldwater species. High oxygen demand during summer from sediments depresses oxygen in water deeper than 5-7 ft, so fish habitat is limited to shallower water during that period. Largemouth bass, chain pickerel and calico bass are the primary game species. There may be smallmouth bass as well, as these have been stocked in the past (State Board of Fisheries and Game 1959). A variety of panfish are present, including yellow and white perch, golden shiners, and several sunfish species. Brown bullheads are also known from this pond.

Even in 1959 (or earlier) the density of rooted plants was considered excessive, and growth rates for fish were considered below average. It remains difficult for game fish to capture prey species in the dense vegetation, and competition for food resources by abundant panfish populations stunts their growth. Vegetation control has long been viewed as a need of Hatch Pond.

Conditions and Processes

Problems with sediment accumulation

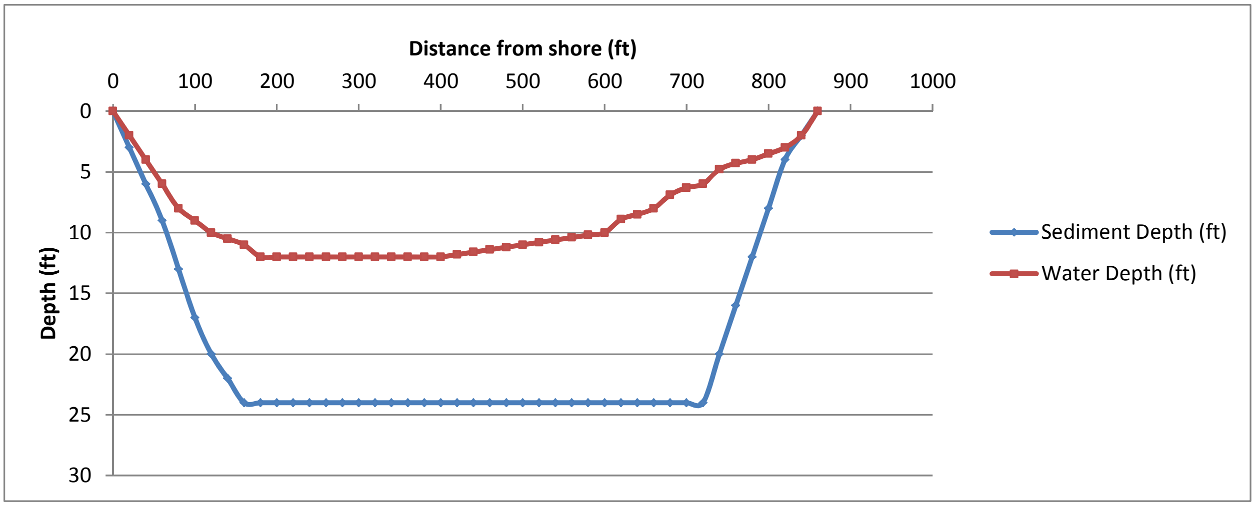
Historic depth change

Several centuries ago Hatch Pond may have been much deeper than it is today, with soft sediment depths of up to 30 ft recorded without hitting a hard bottom. The probe, made of sections of ¾ inch metal conduit, penetrated as much as 20 ft of soft sediment without applying pressure, indicating how loose the muck sediments are. A cross section from the middle of the pond (Figure 17) illustrates the change in depth from its origin after the last glaciation (10,000+ years ago) to the present. However, the loss of depth is not a recent phenomenon; sediment was deposited over many, many years. There is no evidence of any significant change in depth in over a decade, and even the advancement of the northern bordering wetland has not changed in several decades.

Erosion in the watershed is certainly a source of sediment, but much of the sediment is peaty in nature, indicating a wetland origin. Hatch Pond may have had varying water level, and may have been a vegetated wetland at one time. No paleolimnological study was conducted, but the existence of a dam at the south end suggests that impounding additional water was viewed as necessary at some time, and if the pond had anything approaching its maximum possible natural depth, it is unlikely that more water would have been needed. Additionally, the sediment cores revealed very high quality sediment, almost devoid of human-derived contamination and likely to pre-date settlement and development.

As it is now, Hatch Pond is underlain by more sediment than there is currently water in the pond, and that sediment is of a high organic content and low contamination level. It is moderately fertile, allowing for significant but not excessive internal loading when exposed to anoxia, but having plenty of nutrients to allow rooted plant growth to thrive. With a maximum depth of no more than 15 ft, all of the pond could be subject to plant growth. The surficial sediments are more recently derived, but were not tested separately for contamination. Solids content is low, organic content is very high, and nutrient levels are moderate. It is likely that the surficial sediment is largely derived from deposited plant matter.

Figure 17. Hatch Pond central area cross section from 2014



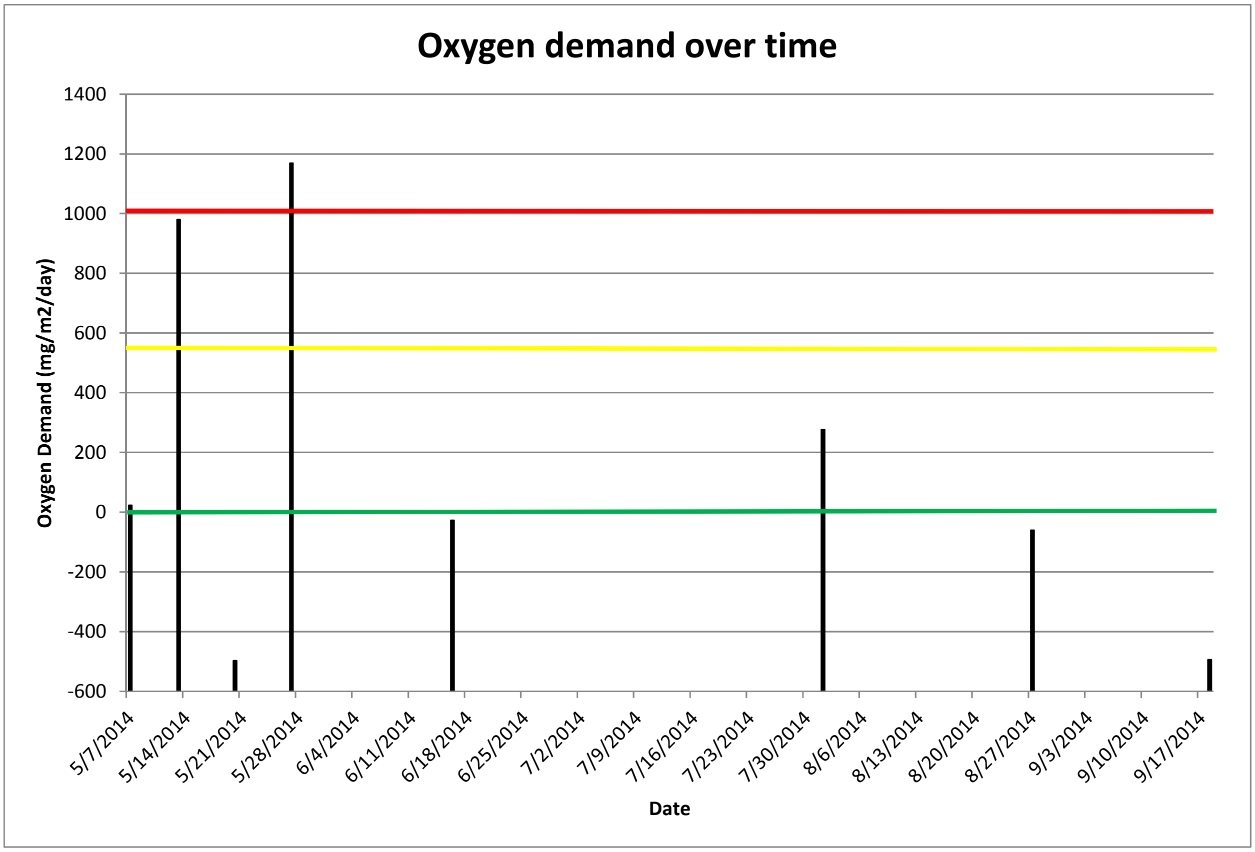
Oxygen demand

The organic nature of the sediment creates an oxygen demand that can exceed the rate of atmospheric input and downward transport in Hatch Pond. This is a common situation in ponds, with those deeper than about 15 ft usually experiencing some anoxia by late in the summer. However, Hatch Pond has expressed an oxygen demand that causes oxygen depletion in as shallow as 5 ft of water, a rather severe situation that negatively impacts habitat and water quality. Past studies have noted loss of dissolved oxygen beginning in mid-spring, with anoxic conditions developing in just a few weeks. It was not certain that all of this demand came from the sediment, as discharge from the dairy operation carried substantial quantities of oxygen demanding substances into the pond, but the overall demand was high.

Estimation of oxygen demand requires dissolved oxygen concentration to be greater than 2 mg/L at all depths. Changes in dissolved oxygen below this concentration result in an underestimate of actual demand. The best estimates of demand tend to come from spring data, when oxygen levels are high but can decline rapidly and substantially in response to oxygen demand. The period from early to mid-May provided a reliable estimate (Figure 18). A mixing event prior to May 21 increased dissolved oxygen throughout the pond, temporally quenching demand and oxygen depletion. From May 21 to May 28 dissolved oxygen consumption in deeper water resumed and the measured loss of oxygen provided was very similar to the early May estimate (Figure 18). Those two estimates, 980 and 1170 mg/m^2/d, represent the best available estimate of oxygen demand in Hatch Pond as of 2014.

There can be enough atmospheric oxygen input and downward transfer in shallow ponds to prevent a complete loss of oxygen, but it is likely that oxygen depression will result (values well below 100% saturation) in all but the shallowest ponds or highest flow systems. Values in excess of 550 mg/m^2/d can cause anoxia, although maybe not until later in summer, while values >1000 mg/m^2/d can cause anoxic conditions to develop in just a matter of a few weeks. The values in Hatch Pond are high enough to cause anoxia, although atmospheric re-aeration and oxygen input from algae and plant photosynthesis should reduce the impact, and mixing events in this relatively shallow pond could erase any deficit in a short period. Yet oxygen demand will persist during the warmer months (being temperature dependent) and create suboptimal conditions on an annual basis.

Figure 18. Hatch Pond oxygen demand in 2014



Data from past studies is not suitable for calculation of oxygen demand, as measurement either started after anoxia developed or was not conducted frequently enough to capture a period of declining oxygen but with no or even few 0 mg/L values. Anoxia developed quickly in past years; this could be partly a function of calmer or warmer weather that facilitates spring expression of oxygen demand, but it is likely that oxygen demand was very high during dairy operations from the related inputs to the pond from the farm. Oxygen depression was observed in 2014, but no true anoxia (values of 0.0 mg/L) developed. Values <1 mg/L were recorded at depths >9 ft (Table 1), but conditions were much improved over those observed in prior studies. Lack of anoxia will affect sediment chemistry and internal loading of phosphorus in desirable ways, and may be responsible for less than expected internal loading in 2014.

Internal nutrient loading

The internal load is the portion of N and P inputs to the water column that comes from the sediment within the pond. This is a complicated area of study, as there are active fluxes much of the time, with nutrients being added to and expelled from the sediment. Most release is biologically mediated, either by bacterial activity in surficial sediments, or by uptake and release by plants. Carp, catfish and other bottom feeders can stir up sediment, adding nutrients as well as solids to the water column. Wind may even resuspend sediment and associated nutrients in shallow ponds. The primary concern, however, is the direct release of N and P from bottom sediments in response to loss of oxygen, or anoxia. Anoxia causes P bound by iron to dissociate, and both iron and P levels will increase in the overlying water. In a shallow pond this will translate into considerable algal growth potential. Lack of oxygen will halt the oxidation of nitrogen compounds from amino acids, urea, ammonium and other reduced forms to nitrite and then nitrate, the oxidized form. Ammonium usually builds up with phosphorus, and is a preferred form of N for algae and rooted plants.

Oxygen approaches 0 mg/L near the bottom over a substantial portion of Hatch Pond, less in 2014 than in the previous decade, but still enough to be a concern for possible nutrient releases. Direct measurement of iron-bound phosphorus as mg P/kg dry weight sediment reveals values of 132 to 180 mg/kg with a mean of 161 mg/kg (Table 4). The relevant scale is about 20 to 2000 mg/kg, with values >50 mg/kg being of concern and values in excess of 1000 mg/kg considered very high. The values obtained are near the low end of the scale, but less release is necessary in a shallow pond to cause a meaningful increase in the P content of overlying water.

The sediment depth which interacts with the overlying water is typically between 1.5 to 4 inches (4 to 10 cm), and the specific gravity of very soft, muck sediment is about 1.1 (a cubic meter of water would weigh 1000 kg, while a cubic meter of wet muck will weigh about 1100 kg). On average, an area of 16.8 ac (67,800 m^2) is exposed to very low oxygen on a regular basis during summer. All the iron-bound P is not released at once, or even over the course of the summer; the amount released is often no more than 10% of the iron-bound sediment phosphorus total. Based on this situation, we would expect at least 47 kg/yr of release from sediment (16.8 ac X 4000 m^2/ac X 0.04 m X 1100 kg/m^3 X 161 mg P/kg sed X 10%) and possibly 94 kg/yr (twice as much for additional depth or release %). Yet the actual release process is even more complicated; low but non-zero oxygen levels can minimize release and periodic addition of oxygen disrupts P release and/or transport into upper water layers.

The accumulation of P in different water layers over the course of the summer is helpful in visualizing the process of P release (Figure 19). P in surface and mid-depth layers increased from late April into August then levelled off. P in the bottom layer increased slowly from late April until the start of August, then increased rapidly. Upon more complete mixing in late August and September, the mass in deeper water declined while the mass in upper waters did not increase. This suggests that oxidization caused the P to precipitate out, most likely with dissolved iron that was released concurrently with the P. The “effective” internal load was therefore very low, and only a small part of the 47 to 94 kg of potentially available P calculated above was probably actually available to algae and plants.

An alternative internal load calculation involves comparison of the mass of P in the bottom water layer with the amount in the water above, working with the assumption that flux between those layers is small or at least of equal magnitude in each direction. This approach (Table 9) was applied to the 5 years for which we have data and suggests that prior to 2010 the mass attributable to release from sediment was on the order of 42 to 49 kg. As the flushing rate during summer is typically low and the bottom water may be thermally separate and unaffected unless there is a mixing event, this may be a reasonable estimate. Yet assuming that the affected volume is 40% larger (about 40% of the lake volume is replaced during summer) yields estimates of 59 to 68 kg/yr, consistent with the 47 to 94 kg/yr range estimated from available sediment P and expected release processes. In 2010 and 2014, however, the release estimated by this approach is much lower, not greater than 12 kg/yr. P simply did not accumulate as much in those years, and there is evidence that only a small portion moved into upper waters (Figure 19). Greater oxygen levels are likely responsible, even on an intermittent basis, with precipitation of P to the sediment.

Figure 19. Hatch Pond phosphorus mass in different water layers during 2014.

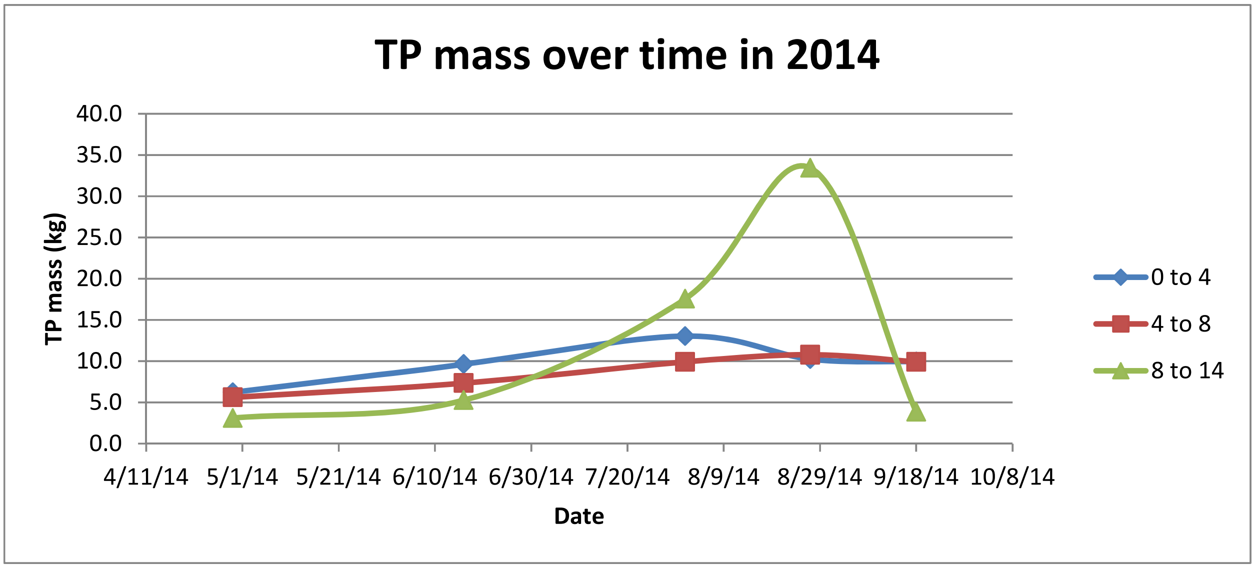


Table 9. Internal load estimation from phosphorus mass.

Year	Depth	ug/L	kg/vol	Total kg	Internal Load (kg)	Internal Load + 40% (kg)
2004	Surf	85	26.4	119	46.1	64.6
	Mid	103	22.2			
	Bott	590	70.4			
2005	Surf	85	26.4	96	42.1	59.0
	Mid	45	9.7			
	Bott	504	60.1			
2006	Surf	85	26.4	115	48.8	68.3
	Mid	82	17.6			
	Bott	593	70.8			
2010	Surf	70	21.7	53	2.3	3.3
	Mid	56	12.1			
	Bott	161	19.2			
2014	Surf	35	11.0	39	8.6	12.0
	Mid	43	9.3			
	Bott	157	18.7			

The same approach can be applied to nitrogen (Table 10). While P is considered most influential on the quantity of primary production, the types of plants and algae involved in primary production is highly dependent on both the quantity and forms of N found. Calculation of internal N load suggests annual internal loads between 1262 and 2828 kg/yr for 2004-2006, but much lower values in 2010 (-229 kg, suggesting net sedimentation of N) and 2014 (244 kg). There is an apparent change in loading and processes between 2006 and 2010.

Table 10. Internal load estimation from nitrogen mass.

Year	Depth	ug/L	kg/vol	Total kg	Internal Load (kg)	Internal Load + 40% (kg)
2004	Surf	3510	1088.5	2117	901.5	1262.1
	Mid	2587	556.7			
	Bott	3950	471.3			
2005	Surf	2207	684.4	1812	2020	2828.0
	Mid	2747	591.2			
	Bott	4497	536.6			
2006	Surf	1690	524.1	1367	3031	4243.4
	Mid	1382	297.4			
	Bott	4567	545.0			
2010	Surf	1507	467.3	827	-163.5	-228.9
	Mid	1054	226.8			
	Bott	1117	133.3			
2014	Surf	527	163.4	390	174.5	244.3
	Mid	634	136.4			
	Bott	755	90.1			

Using the estimates of internal mass change from Tables 8 and 9, we calculate release rates based on the area exposed to low oxygen and the duration of that exposure on an average basis (Table 11). P release rates range from 7 to 8 mg/m^2/d prior to 2010, while they are <2 mg/m^2/d in 2010 and 2014. Values between 6 and 12 mg/m^2/d are common (Nurnberg 1987, 1988), so conditions in 2004-2006 are consistent with expectations. Release rates in 2010 and 2014 are much lower and suggest less of a problem with anoxia, or at least higher redox potential. Redox potential decreases as oxygen declines and is the reason iron and P dissociate; lower redox potential signifies a greater demand for oxygen. However, while oxygen cannot be lower than 0 mg/L, redox potential can continue to decrease after oxygen is depleted and cause greater P release. Oxygen still approaches 0 mg/L in 2010 and 2014, but the demand is lower and clearly erratic in 2014, and redox potential was not likely as low (as negative) as in prior years.

Table 11. Calculated internal load release rates.

Contrib.	Year	TP	TN
Area (m2)		mg/m2/d	mg/m2/d
67948	2004	7.55	147.42
67948	2005	6.89	330.32
67948	2006	7.97	495.64
67948	2010	0.38	-26.74
67948	2014	1.41	28.53

Yet another approach to internal load estimation involves utilizing the area subject to low oxygen during our 2014 survey, then applying a release rate to those areas for the duration of exposure (Table 12). The area experiencing anoxia between measurement dates is estimated by interpolation. Release rates of 12, 6 and 1.41 mg/m^2/d were chosen because 6 and 12 define the range expected under anoxic conditions (Nürnberg 1987, 1988), while 1.41 mg/m^2/d is the value derived for 2014 from our data.

Table 12. Detailed internal load estimation.

	Day	Anoxic Area (ac)	Anoxic Area (m2)	P release at 12 mg/m2/d (g)	P release at 6 mg/m2/d (g)	P release at 1.41 mg/m2/d (g)
June	16	1	4000	48.0	24.0	5.6
	17	2	6400	76.8	38.4	9.0
	18	2	8800	105.6	52.8	12.4
	19	3	11200	134.4	67.2	15.8
	20	3	13600	163.2	81.6	19.2
	21	4	16000	192.0	96.0	22.6
	22	5	18400	220.8	110.4	25.9
	23	5	20800	249.6	124.8	29.3
	24	6	23200	278.4	139.2	32.7
	25	6	25600	307.2	153.6	36.1
	26	7	28000	336.0	168.0	39.5
	27	8	30400	364.8	182.4	42.9
	28	8	32800	393.6	196.8	46.2
	29	9	35200	422.4	211.2	49.6
	30	9	37600	451.2	225.6	53.0
July	1	10	40000	480.0	240.0	56.4
	2	11	42400	508.8	254.4	59.8
	3	11	44800	537.6	268.8	63.2
	4	12	47200	566.4	283.2	66.6
	5	12	49600	595.2	297.6	69.9
	6	13	52000	624.0	312.0	73.3
	7	14	54400	652.8	326.4	76.7
	8	14	56800	681.6	340.8	80.1
	9	15	59200	710.4	355.2	83.5
	10	15	61600	739.2	369.6	86.9
	11	16	64000	768.0	384.0	90.2
	12	17	66400	796.8	398.4	93.6
	13	17	68800	825.6	412.8	97.0
	14	18	71200	854.4	427.2	100.4
	15	18	73600	883.2	441.6	103.8
	16	19	76000	912.0	456.0	107.2
	17	20	78400	940.8	470.4	110.5
	18	20	80800	969.6	484.8	113.9
	19	21	83200	998.4	499.2	117.3
	20	21	85600	1027.2	513.6	120.7
	21	22	88000	1056.0	528.0	124.1
	22	23	90400	1084.8	542.4	127.5
	23	23	92800	1113.6	556.8	130.8
	24	24	95200	1142.4	571.2	134.2
	25	24	97600	1171.2	585.6	137.6
	26	25	100000	1200.0	600.0	141.0
	27	26	102400	1228.8	614.4	144.4
	28	26	104800	1257.6	628.8	147.8
	29	27	107200	1286.4	643.2	151.2
	30	27	109600	1315.2	657.6	154.5
	31	28	112000	1344.0	672.0	157.9
Aug	1	28	112000	1344.0	672.0	157.9
	2	28	111200	1334.4	667.2	156.8
	3	28	110400	1324.8	662.4	155.7
	4	27	109600	1315.2	657.6	154.5
	5	27	108800	1305.6	652.8	153.4
	6	27	108000	1296.0	648.0	152.3
	7	27	107200	1286.4	643.2	151.2
	8	27	106400	1276.8	638.4	150.0
	9	26	105600	1267.2	633.6	148.9
	10	26	104800	1257.6	628.8	147.8
	11	26	104000	1248.0	624.0	146.6
	12	26	103200	1238.4	619.2	145.5
	13	26	102400	1228.8	614.4	144.4
	14	25	101600	1219.2	609.6	143.3
	15	25	100800	1209.6	604.8	142.1
	16	25	100000	1200.0	600.0	141.0
	17	25	99200	1190.4	595.2	139.9
	18	25	98400	1180.8	590.4	138.7
	19	24	97600	1171.2	585.6	137.6
	20	24	96800	1161.6	580.8	136.5
	21	24	96000	1152.0	576.0	135.4
	22	24	95200	1142.4	571.2	134.2
	23	24	94400	1132.8	566.4	133.1
	24	23	93600	1123.2	561.6	132.0
	25	23	92800	1113.6	556.8	130.8
	26	23	92000	1104.0	552.0	129.7
	27	23	92000	1104.0	552.0	129.7
	28	22	87200	1046.4	523.2	123.0
	29	21	82400	988.8	494.4	116.2
	30	19	77600	931.2	465.6	109.4
	31	18	72800	873.6	436.8	102.6
Sept	1	17	68000	816.0	408.0	95.9
	2	16	63200	758.4	379.2	89.1
	3	15	58400	700.8	350.4	82.3
	4	13	53600	643.2	321.6	75.6
	5	12	48800	585.6	292.8	68.8
	6	11	44000	528.0	264.0	62.0
	7	10	39200	470.4	235.2	55.3
	8	9	34400	412.8	206.4	48.5
	9	7	29600	355.2	177.6	41.7
	10	6	24800	297.6	148.8	35.0
	11	5	20000	240.0	120.0	28.2
	12	4	15200	182.4	91.2	21.4
	13	3	10400	124.8	62.4	14.7
	14	1	5600	67.2	33.6	7.9
	15	1	4000	48.0	24.0	5.6
	Total kg			75.0	37.5	8.8

Under release rates of 6-12 mg/m^2/d, the internal P load would be between 37.5 and 75 kg/yr, while at the observed 1.41 mg/m^2/d the load is <9 kg/yr.

It is clear that internal loading has decreased markedly in 2010 and more recently. This timeframe corresponds exactly with the purchase of the dairy farm and cessation of dairy operations. Several factors may be at work, most notably reduced loading of oxygen demanding organic matter that previously caused more severe anoxia, more negative redox potential, and greater release of phosphorus from iron compounds. The legacy load of phosphorus in the sediment is substantial but not extreme, as evidenced by sediment chemistry results; this is unusual for a pond impacted by dairy operations, but may be a function of shallowness and flushing events.

Internal loading of P is believed to have been in excess of 50 kg/yr while the dairy was in operation, and may have approached 100 kg/yr. In 2010 and 2014 the internal load is much reduced, likely not greater than 15 kg/yr. Internal loading may never have been a dominant source of P in Hatch Pond, but appears to be a minor source in 2014.

Rooted plant growth

Rooted plants grow very densely in Hatch Pond, and have done so for many years. The 1959 report from the State Board of Fisheries and Game cited dense plant growths as a problem even then, and the arrival of Eurasian watermilfoil by 2000 signaled further deterioration of conditions. With a favorable substrate and maximum depth of no more than 15 ft, the entire pond is susceptible to rooted plant growth. Light is the limiting factor such that low clarity has kept rooted aquatic plant growths restricted to water depths less than about 9 ft, sometimes shallower. However, some rooted plants float on the surface and are less dependent on the sediment for nutrition. Further, algal mats start on the bottom and can float to the surface when light becomes limiting. Less than half of the pond surface is covered by plants, but considerably more of the pond bottom experiences plant growth and a substantial portion of the pond volume is full of plants. Fishing is difficult, and boat access from the launching area to the open water is greatly impaired. Boating is restricted to a small central area and swimming is not a realistic option.

Problems with water quality

Low oxygen

Low oxygen has been a serious issue for Hatch Pond for many years, but in 2014 oxygen status was better than it has been for a long time. Weather may have played a role, and less desirable conditions might return, but there is indication that the oxygen demand has been reduced by the cessation of dairy operations near the pond. Oxygen is still too low to support a desirable fish community in water deeper than 7 ft on a continuous basis, but it was above 0 mg/L in all 2014 measurements and this may have greatly limited internal P loading. Continued improvement is possible, but oxygen demand exerted by internally produced organic matter would be expected to keep conditions suboptimal during summer.

Nitrogen and Phosphorus Loading

The total mass of P and N in the pond during the summer has been calculated for each of 5 years for which we have adequate data (Tables 9 and 10). The decline between 2004-2006 and 2010-2014 is evident (Figure 20) and an exponential regression on these points suggests that 94% of the variation is explained by the time period. That is, one need only know the year to predict what the P load would be with a surprisingly reasonable level of confidence. For N, the correlation between mass and year is even tighter at 99% (Figure 21). Interesting but unexplained is the apparent decline in N mass in the successive years 2004, 2005 and 2006. P mass was more similar in those 3 years. For 2014, the mass of P was 39 kg. With a flushing rate of 7.4 times per year, this suggests a current total P load of 289 kg/yr (39 kg mass X 7.4 volume turnovers). The mass of N in 2014 was 390 kg, which at 7.4 flushings equates to a load of 2886 kg/yr.

Based on the trajectory of the regression line, the P mass will decline to just under 20 kg in about 2021 if the exponential relationship is correct, but the load will level off at that point and will not get much lower. Assuming 7.4 flushings per year, this suggests a total P load of 148 kg/yr. The same approach with nitrogen suggests that the current load of 2886 kg/yr will decline to a new equilibrium load of about 1500 kg/yr in about 2021. The anticipated nutrient loads will be considerably lower than what Hatch Pond has experienced in the past, but may still be too high to prevent productivity problems. This must be addressed within the context of goals and associated loading targets. However, continued monitoring of P mass in Hatch Pond is necessary to confirm the exponential relationship shown here.

Figure 20. Hatch Pond phosphorus mass over years

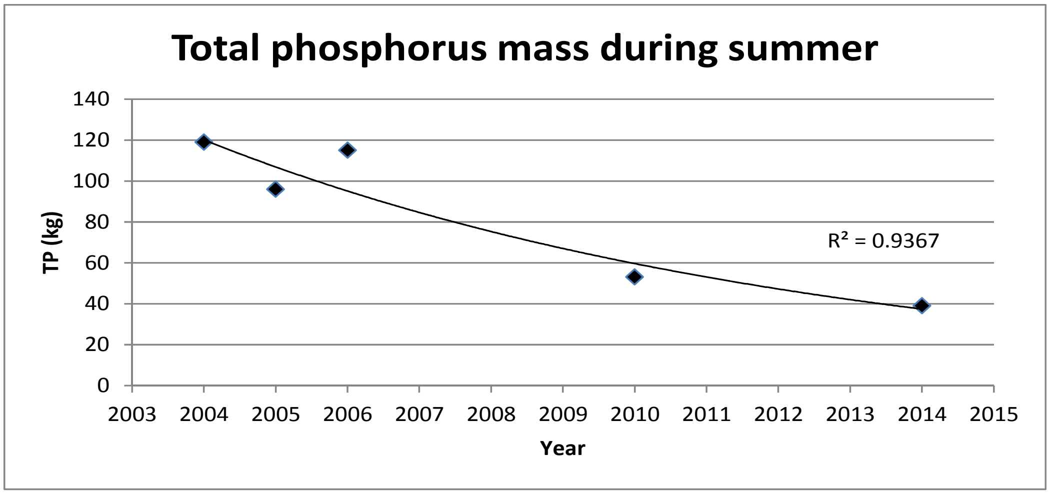
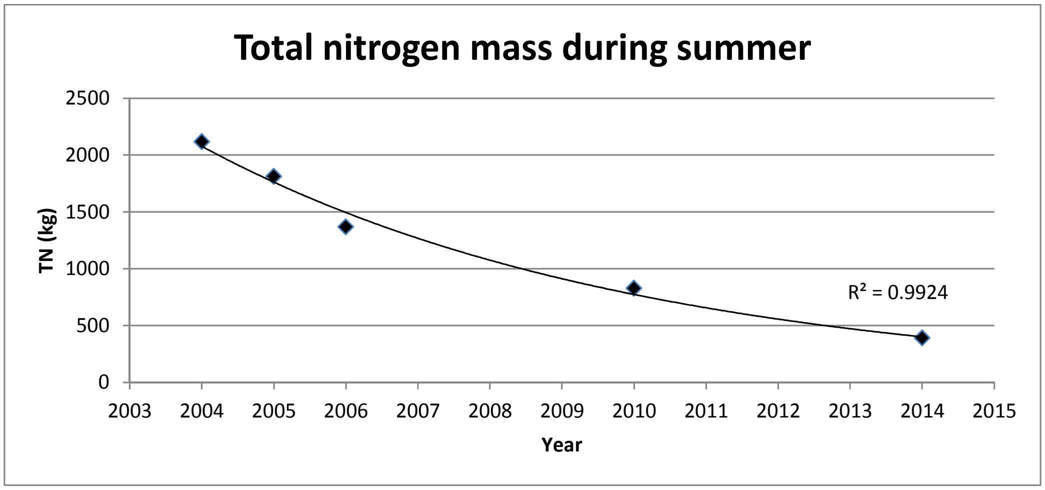


Figure 21. Hatch Pond nitrogen mass over years



Internal Phosphorus Load

Internal loading has been discussed as part of the section on issues with sediment accumulation. With consistent low oxygen over a large portion of the pond, values in excess of 50 or even 100 kg/yr are possible, but that does not appear to be the case in 2010 or 2014. Multiple estimates of internal P loading suggest a 2014 range of 8 to 12 kg/yr. This load is all delivered during summer, so it is disproportionately important, but it is a minor factor in Hatch Pond conditions and appears to be declining each year. The total P load is on the order of 250 to 300 kg/yr, so internal P load is <10% of the total.

Phosphorus Load from Models

While there is a separate component of this project to evaluate current watershed loading, it is possible to estimate total loading to the pond using empirical models that relate physical pond conditions such as depth and flushing rate and P in the pond to the load necessary to maintain that observed P concentration. For any one pond there may be considerable deviation from predicted loading, but as a general estimator of likely loading this approach has been very successful. Each of 5 empirical models was applied (Table 13) and the results were averaged. One can also predict P concentration from a P load, so future projections relating to management actions with expected loading reduction can be estimated. Additional empirical equations are used to convert P concentrations to Secchi transparency and chlorophyll-a distribution, allowing a more complete evaluation of expected conditions.

Application to conditions in 2004-2005 (Table 14) represents a period with active dairy farming and related loading, and estimates the total P load at 538 kg/yr (1184 lb/yr). Current conditions suggest major improvement (51% decrease in P load), consistent with 2012 NEAR report, with an estimated load of 262 kg/yr (576 lb/yr). This is reasonably close to the 289 kg/yr estimate derived from the P mass times the flushing rate.

Possible future scenarios (Table 14) represent changes in P load and concentration without itemizing what might be done to cause those changes. Various watershed or inlake management techniques might be applied. For the 4 hypothetical scenarios chosen, we simply set the new P concentration at one of 4 levels (25, 20, 15 and 10 ug/L) and determined the load necessary to achieve it and the water clarity and chlorophyll levels that would be expected to accompany those P concentrations. Loads necessary to reach the hypothetical P concentration targets range from 67 kg (P=10 ug/L) to 168 kg (P=25 ug/L), all well below the current load of 262 kg that yields an average P concentration of 39 ug/L.

The permissible load is the level of loading below which algal blooms and related water quality problems are expected to be minimal, while the critical load is the load above which frequent algal blooms and water quality impairment are expected. The permissible load for Hatch Pond is estimated at 115 kg/yr, while the critical load is projected to be 230 kg/yr. The current load of about 262 kg/yr is above the estimated critical load so will continue to result in undesirable conditions. However, P loading rate does not appear to have reached an equilibrium yet after elimination of the dairy farm load, so P load is projected to continue to decline to as little as 148 kg/yr. That would put the average P concentration close to 22 ug/L and while some algae problems might still be expected with this concentration, that projected equilibrium P concentration represents a major improvement over past conditions and would be solidly between the permissible and critical load levels, even considering annual variation and uncertainty in the loading estimates.

Table 13. Empirical model application for current conditions

THE TERMS					
SYMBOL	**PARAMETER**	**UNITS**	**DERIVATION**	**VALUE**	
TP	Lake Total Phosphorus Conc.	ppb	From data or model	15	Enter Value
L	Phosphorus Load to Lake	g P/m2/yr	From data or model	0.36	Enter Value
TPin	Influent (Inflow) Total Phosphorus	ppb	From data	21	Enter Value
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data	13	Enter Value
I	Inflow	m3/yr	From data	4771000	Enter Value
A	Lake Area	m2	From data	278000	Enter Value
V	Lake Volume	m3	From data	645000	Enter Value
Z	Mean Depth	m	Volume/area	2.320144	Calc.
F	Flushing Rate	flushings/yr	Inflow/volume	7.396899	Calc.
S	Suspended Fraction	no units	Effluent TP/Influent TP	0.619048	Calc.
Qs	Areal Water Load	m/yr	Z(F)	17.16187	Calc.
Vs	Settling Velocity	m	Z(S)	1.43628	Calc.
R	Retention Coefficient (from TP)	no units	(TPin-TPout)/TPin	0.380952	Calc.
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.298943	Calc.
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.268837	Calc.

		PREDICTION				**EST**
THE MODELS		**CONC.**	**LOAD**			**LOAD**
NAME	**FORMULA**	**(ppb)**	**(g/m2/yr)**		**MODEL**	**(kg/yr)**
Mass Balance	TP=L/(Z(F))*1000	21			*Phosphorus*	
(minimum load)	L=TP(Z)(F)/1000		0.26		Mass Balance (no loss)	72
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	15				
(K-D)	L=TP(Z)(F)/(1-Rp)/1000		0.37		Kirchner-Dillon 1975	102
Vollenweider 1975	TP=L/(Z(S+F))*1000	19				
(V)	L=TP(Z)(S+F)/1000		0.28		Vollenweider 1975	78
Reckhow 1977 (General)	TP=L/(11.6+1.2(Z(F)))*1000	11				
(Rg)	L=TP(11.6+1.2(Z(F)))/1000		0.48		Reckhow 1977 (General)	134
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	15				
(L-M)	L=TP(Z)(F)/(1-Rlm)/1000		0.35		Larsen-Mercier 1976	98
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	16				
(J-B)	L=TP(Z)(0.65+F)/0.84/1000		0.33		Jones-Bachmann 1976	93
Average of Model Values		15			Model Average	
(without mass balance)			0.36		(without mass balance)	101
Reckhow 1977 (Anoxic)	TP=L/(0.17(Z)+1.13(Z(F)))*1000	18				
(Ra)	L=TP(0.17(Z)+1.13(Z(F)))/1000		0.30		Reckhow 1977 (Anoxic)	83
From Vollenweider 1968						
Permissible Load	Lp=10^(0.501503(log(Z(F)))-1.0018)		0.41		Permissible Load	115
Critical Load	Lc=2(Lp)		0.83		Critical Load	230

THE PREDICTIONS		
Mean Chlorophyll (ug/L)	**Value**	**Mean**
Carlson 1977	4.6	
Dillon and Rigler 1974	3.8	
Jones and Bachmann 1976	4.4	
Oglesby and Schaffner 1978	5.9	
Modified Vollenweider 1982	7.7	5.3
Peak Chlorophyll (ug/L)		
Modified Vollenweider (TP) 1982	22.5	
Vollenweider (CHL) 1982	13.3	
Modified Jones, Rast and Lee 1979	16.1	17.3
Secchi Transparency (M)		
Oglesby and Schaffner 1978 **(Avg)**	2.8	
Modified Vollenweider 1982 **(Max)**	4.5	
Bloom Probability		
Probability of Chl >10 ug/L **(% of summer)**	6.3%	
Probability of Chl >15 ug/L **(% of summer)**	1.0%	
Probability of Chl >20 ug/L **(% of summer)**	0.2%	
Probability of Chl >30 ug/L **(% of summer)**	0.0%	
Probability of Chl >40 ug/L **(% of summer)**	0.0%	

Table 14. Summary of model loading results

Variable	Units	2004-05	2014	Future 1	Future 2	Future 3	Future 4
Average TP in Hatch Pond	ppb (ug/L)	80	39	25	20	15	10
Average TP in inflow	ppb	113	55	35	28	21	14
Annual load	kg/yr	538	262	168	134	101	67
Average chlorophyll-a	ppb	45.3	17.5	9.8	7.7	5.3	3.1
Chl-a >10 ppb	% of time	99.7%	80.6%	38.6%	21.8%	6.3%	0.4%
Chl-a >15 ppb	% of time	97.5%	52.1%	13.6%	5.6%	1.0%	0.0%
Chl-a >20 ppb	% of time	91.7%	30.1%	4.7%	1.5%	0.2%	0.0%
Chl-a >30 ppb	% of time	71.7%	9.1%	0.6%	0.1%	0.0%	0.0%
Chl-a >40 ppb	% of time	49.9%	2.8%	0.1%	0.0%	0.0%	0.0%
Average Secchi transparency	m	0.8	1.4	2.0	2.3	2.8	3.9

Reaching the point where algae blooms were infrequent and the magnitude of chlorophyll peaks was acceptably low for most pond uses requires a P load <100 kg/yr. This represents a 62% decrease from the current estimated loading and a 32% reduction from the projected new equilibrium load, expected about 2021. It is uncommon for watershed management to achieve and sustain load reductions in excess of 50%, but a 32% decrease is within the range of practical management applications. It is important to continue monitoring for a few years before taking any expensive action, to better characterize variability in loading and conditions and determine if the projected loading decline continues.

N:P Ratio

The ratio of N to P is a very important determinant of the types of algae that will be present and/or dominant in a pond. On a mass basis, N:P ratios <10:1 tend to favor cyanobacteria, or blue-green algae, and values <7:1 strongly favor cyanobacteria. Values >20:1 tend to favor green algae, with values >30:1 strongly favoring greens. N:P ratios have been low in Hatch Pond, but the 2014 data (Table 15) exhibits values >10:1 at all times in water <6 ft deep. Values were lower in the deepest water, a phenomenon often observed with internal loading, which tends to dominate deep water quality. Light limitation will restrict algal production in deep water within Hatch Pond, and it appears that much of the phosphorus in the deep water precipitates out upon mixing (Figure 19).

Dairy inputs tend to have very low N:P ratios, and the cessation of dairy operations near the lake may be the cause of the observed increase in N:P ratio. The rise in N:P ratio is another factor in the reduced dominance by cyanobacteria in Hatch Pond. N and P levels are still high enough to support algae blooms, but types of algae other than cyanobacteria are currently favored.

Table 15. Nitrogen to phosphorus ratios for sampling dates in 2014.

Sample Date/Location	4/29/14	6/16/14	8/1/2014	8/27/14	9/18/14	Mean
Hatch 1 1ft	15.7	10.4	15.9	17.8	17.1	15.4
Hatch 1 6ft	10.6	11.6	15.0	16.4	14.4	13.6
Hatch 1 13ft	8.1	9.3	7.1	2.9	12.4	8.0

Algae Blooms

Elevated algal productivity is not always a negative influence on pond conditions. If the algae are consumed by zooplankton and the food web processes photosynthetic outputs into desirable fish, algae blooms can be minimized, water clarity will be maximized, and fish production will be maximal. However, too much fertility almost always winds up creating ecological imbalance and an excess of algae, creating bloom conditions (large quantities of algae in the water). High nutrients with a low N:P ratio is a recipe for cyanobacteria blooms, and Hatch Pond has suffered from such blooms for many years.

The reduction in nutrient levels since the dairy farm was purchased and decommissioned is striking, but N and P levels are still high enough to promote blooms. The shift toward a higher N:P ratio is a likely factor in the shift away from cyanobacteria, although bloom forming cyanobacteria are still present. The algae that bloomed in Hatch Pond in 2014 included non-cyanobacteria that are difficult for zooplankton to consume, mostly large or colonial aggregated cells of dinoflagellates or golden algae, so much of the algal production is still going into benthic pathways for energy flow and contributing to both internal nutrient reserves and oxygen demand in the sediments. But the severity and frequency of blooms appears to be declining, and may signal better conditions overall in Hatch Pond in the coming years.

Suggested Target Conditions

Levels of N and P

The permissible (desirable) load for phosphorus is 115 kg/yr, below which algae blooms and related water quality impairment should be minimized. The critical (undesirable) load is 230 kg/yr, above which blooms and water quality problems are expected on a regular basis. The current P load is estimated at 262 kg/yr, with an expected annual range of about 250 to 300 kg. This represents a major reduction (at least twofold) from pre-2010 loading levels, but is still higher than desirable. The projected equilibrium load from all data to date is about 148 kg/yr, expected in about 2021. This would be solidly in between the permissible and critical loads. Achievement of the permissible load would yield TP between 15 and 20 ug/L. Remaining below 20 ug/L is a generally accepted target for avoiding algae blooms and is recommended.

Chlorophyll and Secchi Transparency Targets

At 15-20 ug/L for P, it is estimated that the mean chlorophyll-a would be around 6 ug/L. Chlorophyll values would exceed 10 ug/L only about 10% of the time and exceedances of 15 ug/L would be rare. Secchi transparency would exceed 8 ft (2.5 m) on average. This would be a very desirable range for Hatch Pond, providing adequate productivity to support fish production and fishing, but avoiding major blooms, especially by cyanobacteria.

Algae Composition

Elimination of cyanobacteria blooms would be the primary goal, although an overall reduction of algae is also needed to meet typical recreational and habitat use goals. To minimize algae blooms and avoid cyanobacteria dominance, we need to keep P under 20 ug/L and the N:P ratio should be greater than 10:1, preferably >20:1.

Plant Community

Expansion of plants, especially Eurasian water milfoil, is probably the greatest threat to habitat and recreational use at this point, and is likely to get worse as water quality and clarity improve. Eliminating invasive species will be extremely difficult at this point, as at least two invasive aquatic plant species have become well established. Maintaining dominance by native species and bottom cover of about 20 to 40 % with no high density surface cover would be appropriate goals. This will require some action to control growths, probably on a maintenance (repeated) basis.

Fish Community

Increasing fish growth rates is the primary need, as current growth rates are below the state average for most species. The assemblage has not been surveyed for some time, but it seems likely that stunting of panfish and limited feeding success by gamefish among dense plant growths continue as major fishery issues in Hatch Pond. Control of vegetation density should allow achievement of better growth rates for fish.

Inlake Options for Achieving Desired Conditions

There are several dozen inlake options for management of algae, rooted plants, sediment accumulation, and fish community features, but not all are applicable to Hatch Pond and some are either infeasible or unproven. For example, the use of dyes to further limit light and reduce algae and plants would require repeated addition and would not likely make conditions much better than at present. The use of bacterial support systems to decay organic sediments, involving oxygenation, engineered bacteria, and/or enzymes to break down complex organic compounds, has virtually no peer reviewed literature to support claims. Stocking of grass carp can control most plant species, but is not typically approved in water bodies with flowing outlets and will increase nutrient availability for algae. Narrowing the range of actions to those that might meet some of the goals suggested in the last section, six groups of inlake management actions warrant further discussion.

Dredging

Dredging would remove accumulated sediment and related plants, including root systems and seeds. This would increase depth, reduce nutrient reserves for internal loading, potentially limit algae and increase water clarity, and limit plant growths. The sediment of the pond is largely clean, requiring no special disposal methods, and there are farm fields to the west of the pond, some owned by South Kent School, that could accept dredged material. Dredging represents true restoration, setting a pond to an earlier condition. It will not reduce ongoing inputs from the watershed, but will aid processing of inputs to minimize negative impacts.

The amount of material to be removed would depend on what depth was desired and how much it would cost. Possible dredged material volumes for Hatch Pond are listed on Figure 4, and range from just under 400,000 cubic yards (cy) to reach a hard bottom in all areas up to 15 ft of water depth to almost 1.4 million cy to remove all soft sediment to a water depth of 30 ft. Reaching a hard bottom around the edge to water depths of 15 ft is attractive in terms of plant control, fishery management, and limiting oxygen demand; going deeper would probably not improve oxygen levels, as the pond would thermally stratify and likely lose oxygen in deeper water anyway. However, even removing 400,000 cy is a very big project, with a price tag on the order of $12,000,000. Without some commitment from the state, the town, or the school, for this very large sum, moving forward with planning for a dredging project seems ill advised. However, if funding can be found, this would be very beneficial to the pond.

Phosphorus Inactivation

Inactivation of P can be accomplished with aluminum, calcium or lanthanum, binding P that is currently tied to iron and can be released under low oxygen conditions. The more permanent binding in these alternative compounds will limit internal recycling and has worked very well in other ponds in New England and elsewhere. However, the current estimate of internal loading is low, and even at the height of projected internal loading, the internal load was less than 40% of the expected total. Control of internal loading from direct sediment release does not appear to be a high probability action for improving water quality in Hatch Pond and meeting possible goals.

It is likely that a substantial amount of P is moved from sediment to water by rooted plants, either directly through “leaky” transport processes or upon senescence of plants in the autumn, but this mechanism would be unaffected by available P inactivation methods. Algal mat formation at the sediment-water interface might be reduced, but most plants with roots in the sediment draw nutrients from well below the zone likely to be impacted by a P inactivation treatment. Inactivation of P in the surficial sediments of Hatch Pond is not likely to provide substantial benefits in terms of expected goals.

However, P inactivation can also be used to minimize the availability of incoming P from the watershed. A dosing station could be set up at any inlet, with higher flows usually associated with storms treated with aluminum or calcium to bind up incoming P. This approach has worked well in a number of applications, with some in the northeast. It is less desirable than controlling P inputs at the sources, but if watershed management proves difficult for source identification, access, or economic reasons, P inactivation at either the Womenshenuk (northern) or unnamed brook from the school and golf course (southern) location would warrant consideration.

A typical dosing station costs between $80,000 and $130,000, including chemical storage tanks, pumps, and instrumentation, and has an annual operating cost proportional to the amount of water treated. Lack of detailed hydrologic data for inputs prevents more detailed estimation of costs, but other projects have experienced annual cost on the order of $10,000 to $25,000.

Oxygenation/circulation

Getting more oxygen into deeper water in Hatch Pond would reduce internal loading and enhance habitat for fish and other aquatic organisms. This can be done through the addition of pure oxygen or air into chambers that oxygenate the deep water, or by mixing the entire volume of the pond to get more interaction between the water and the atmosphere. Mixing can be accomplished with compressed air released slightly above the bottom sediment or with pumps that move water up or push it down. Costs are extremely variable, but a reasonable system could be constructed for about $140,000 in Hatch Pond with an annual operating cost on the order of $10,000 to $20,000.

It is not obvious that more oxygen needs to be added at this point; 2014 oxygen levels were suboptimal but there was little true anoxia (completely exhausted oxygen), and conditions may continue to improve for several years. Additionally, it does not appear that the internal load is the main source of P or N; reduction in loading to meet goals would have to involve watershed activities beyond oxygenation or circulation technologies. The capital and operating cost of these methods is not justified until some new equilibrium condition is reached and the benefits can be more completely evaluated.

Herbicides/Algaecides

Herbicides and algaecides are chemicals used to kill plants and algae. They represent maintenance methods that provide desirable conditions when other means to affect more permanent biological changes are not feasible. Herbicides and algaecides are not preferable to source controls and sediment removal, but will be far less expensive, and used intermittently, can be major aids in achieving use goals in the pond. In terms of rooted plant management, herbicides may be the only applicable and affordable method.

Algaecides seem less appropriate here, as the algae community is in an apparent transition to more desirable species and fewer blooms of lesser severity. Use to prevent algae blooms is far preferable to killing off a bloom once it occurs, as oxygen demand can be high when a bloom is treated. To prevent blooms, algae community features must be tracked on about a weekly basis, a daunting task without considerable training or expensive to accomplish with professional aid. Continued monitoring to determine if cyanobacteria remain minor components of the algae community and if total algae levels will decline seems advisable for a few years before any algaecide treatment is further considered.

Herbicide use would be appropriate, however, to gain some control over the expansive, dense plant assemblages in Hatch Pond. A whole lake treatment with fluridone could be conducted for about $50,000 and would greatly reduce plant biomass for up to 4 years. Eurasian watermilfoil is especially sensitive, and while eradication may not be possible, making this invasive species a minor component of the plant assemblage should be possible. A dose of about 15-20 ug/L, bumped back to 10-15 ug/L when monitored levels drop below 10 ug/L and held above 10 ug/L for at least two months should produce substantial results. Seed producing species can be expected to recover within 2 years, including the pondweeds (*Potamogeton* spp other than *P. crispus*, the invasive curlyleaf pondweed) that have become so rare.

Reduction in plant biomass should reduce internal recycling of P by plant action, will reduce oxygen demand through lower organic matter fluxes to the sediment, and will improve fish habitat for gamefish, allowing them to find panfish prey more easily. Maintained at very low levels for several years, low plant biomass may eventually cause gamefish to depress panfish populations to a degree that limits gamefish growth, but this is not a permanent condition. Retreatment can be performed on as needed basis, with monitoring of both the plant and fish communities.

Alternative treatments could include flumioxazin or diquat, contact herbicides with desirable track records for opening up selected areas of dense plant growth, or use of the systemic herbicide triclopyr to focus on the milfoil. Contact herbicides would be much less expensive, but would require annual application, as they do not kill root crowns and allow easier recovery of rooted plants. Spot treatment of up to 10 acres of Hatch Pond with diquat could allow opening of key areas for habitat enhancement and human use (mainly boating and fishing) at a cost of <$20,000.

Harvesting

Direct removal of rooted plants would benefit the fish community and may impact water quality in positive ways, including lower P inputs and higher oxygen levels. Harvesting can be by hand or with mechanical equipment, and offers very flexible application. Hand harvesting is very effective for removing pioneer infestations or keeping invasive species in a sparse growth mode in check. Hand harvesting is less feasible for expansive, dense growths, as the manpower necessary to make a difference in any year and maintain the improvement is very large and the cost is commensurate. It is generally not advisable to harvest Eurasian watermilfoil with mechanical equipment because further rapid spreading of that plant occurs due to incomplete collection of fragments. However, where milfoil has already spread throughout a pond, mechanical harvesting simply becomes mowing the aquatic lawn. This may be an acceptable way of maintaining open water for habitat and recreation, although it is still an expensive option.

In some cases, repeated harvesting of Eurasian watermilfoil has favored other low growing plants to become dominant, although we are unaware of any case where harvesting or other controls have become unnecessary over time through mechanical harvesting. Because mechanical harvesting only removes the upper portion of the stems, it may stimulate lateral branch formation and shoot development, making the plants bushier and more robust. This can cause the density of plant material to increase dramatically, making conditions worse if mechanical harvesting is not aggressively pursued.

For Hatch Pond, the use of a mechanical harvester to open areas of the lake for habitat, boating and fishing would be a possible means of meeting use goals. The capital cost for appropriate equipment would be on the order of $200,000 annual operation would cost between $30,00 and $50,000 for a complete harvesting, less if only selective areas were addressed.

Benthic Barriers

Materials can be used to cover areas of the bottom and make them less hospitable for rooted plant growth. Two major types of benthic barriers are available: 1) porous mats that allow some gas transfer but through which plants can root, requiring at least annual maintenance, and 2) non-permeable sheets that restrict plant growth until covered by new sediment, but that may billow up if enough gas from decomposition accumulates underneath. Eurasian watermilfoil will be killed by either benthic barrier type if placed on top of the milfoil, but porous barriers will support dense milfoil growths if fragments settle on the barrier surface. Non-porous barriers can be slit to allow gas to escape, but will eventually need to be cleaned or replaced, so there is no perfect barrier system.

For Hatch Pond, non-porous barriers would probably be the best choice, providing more complete prevention of plant growth. Some maintenance would be needed, but open water could be established for several years or more with well-laid barrier panels. This is a labor intensive process, and the cost is on the order of $50,000 per acre, so a large number of acres would not likely be covered. A channel from the boat launch to current open water could be created, and several lanes into dense plant growths could be created with an acre of barrier. Controlling rooted plants over a significant portion of the pond would likely be cost prohibitive, however.

Recommendations

Overall recommendations should consider the complete evaluation of Hatch Pond and its watershed; this component of the study considers only inlake options. What is apparent is that the water quality and related algae community of Hatch Pond have been improving since the 2010 elimination of the dairy farm near the north end of the pond. Further monitoring is recommended to determine what the new equilibrium condition will be before any substantial expenditure on water quality improvement or algae control is made. A monitoring program similar to that conducted by WRS and NEAR in 2014 is strongly urged, with 4-6 sampling events between April and October of each of the next 6 years or until stable conditions persist. South Kent School could conduct sampling to minimize costs.

Rooted plant problems are expected to continue or intensify in the coming years. Pond use will be compromised by rooted plant density and especially by invasive species no matter what watershed actions are taken to reduce nutrient loading to Hatch Pond. Reduction of plant density may enhance water quality, but would be performed mainly to improve the fishery and provide boating opportunity on a maintenance basis. Benthic barrier could be used on a small scale (one or two acres) at an initial cost of <$100,000 with just a few thousand dollars of maintenance each year. Mechanical harvesting could be employed to aquascape the pond on a repeated basis at an initial capital cost of about $200,000 and an annual operating budget of at least $30,000. However, it would be reasonable to employ a contract harvester for a year or two to allow evaluation of results, and the cost would be on the order of $25,000 per year. Herbicides could be used to reduce rooted plant density at a cost of no more than $20,000 per year, using a herbicide with diquat or flumioxazin as the active ingredient, representing the most cost effective option. However, as herbicides are not favored in some communities as a consequence of perceptions about the use of chemicals in the environment, cost is not the only consideration, and even if accepted, repeat applications can be expected on an annual basis. Yet on a one or two year basis as a means to attempt rooted plant control and allow evaluation of resulting conditions, application of a herbicide is a rational option for Hatch Pond.

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Appendix B

Watershed Field Assessments

Reach Level Assessment **RCH**

SURVEY REACH ID: SP-01A	**WTRSHD/SUBSHD:** SCHOOL POND	**DATE:** 7/24/14	**ASSESSED BY:** KMB

START **TIME:** 9:55 [✓ AM]/PM **LMK:** ____ **LAT** 41° 40.'881" **LONG** 73° 28.619" **DESCRIPTION:** wetland inlet to Hatch Pond	*END* **TIME:** ___:___ AM/PM **LMK:** ____ **LAT** 40° 40.759" **LONG** 73 28.'546" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☒ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☒ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☒ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☒ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☐ some ☒ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☒ Sed. deposition
☐ Bed scour
☐ Bank failure
☐ Bank scour
☐ Slope failure
☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1 (ft)
RT bank 1 (ft)
Width: Bottom 25 (ft)
Top >50 (ft)

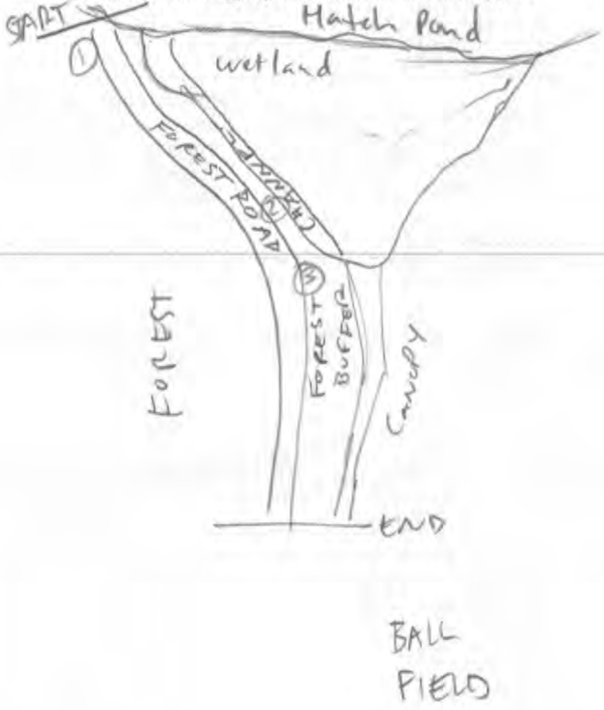
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 3 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*
mucky sediments

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	[✓ 10] 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 64 /80 + Buffer/Floodplain: 70 /80 = **Total** Survey Reach 134 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: SP-01B	**WTRSHD/SUBSHD:** School Pond	**DATE:** 7/24/14	**ASSESSED BY:**

START **TIME:** 10:25 [✓ AM]/PM **LMK:** ____ **LAT** 41° 40.759" **LONG** 73° 28.546" **DESCRIPTION:** @ Ball field	*END* **TIME:** __:__ AM/PM **LMK:** ____ **LAT** 41° 40.567" **LONG** 73° 28.531" **DESCRIPTION:** Lew's Lagoon	**GPS ID:**

RAIN IN LAST 24 HOURS ☒ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☒ Institutional ☐ Golf course ☒ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☒ 75-100%

DOMINANT SUBSTRATE ☒ Silt/clay (fine or slick) ☒ Sand (gritty) ☐ Gravel (0.1-2.5") ☐ Cobble (2.5 –10") ☐ Boulder (>10") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☒ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface) ☐ Mostly shaded (≥75% coverage) ☐ Halfway (≥50%) ☐ Partially shaded (≥25%) ☒ Unshaded (< 25%)

CHANNEL DYNAMICS ☐ Unknown ☐ Downcutting ☐ Widening ☐ Headcutting ☐ Aggrading ☐ Sed. deposition ☐ Bed scour ☐ Bank failure ☐ Bank scour ☐ Slope failure ☒ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2 natural (ft)
RT bank 2 (ft)
Width: Bottom 5 (ft)
Top 10 (ft)

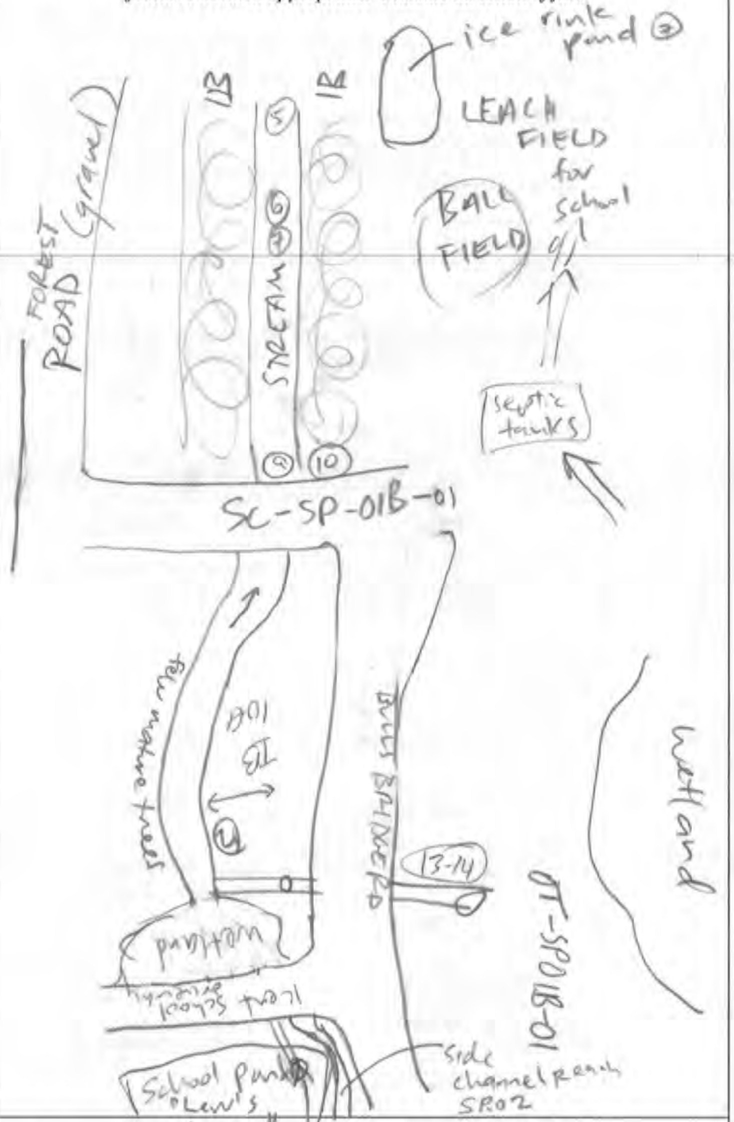
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

[✓ 5] 4 3 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*

Impacted Buffer / no canopy cover

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 [✓ 13] 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
	Right Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
	Right Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 [✓ 3]	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 [✓ 6]	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 [✓ 3] 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 13 12 11	[✓ 10] 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 53 /80 + Buffer/Floodplain: 27 /80 = **Total** Survey Reach 80 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: SP02A	**WTRSHD/SUBSHD:** School Pond	**DATE:** 7/24/14	**ASSESSED BY:** KMB

START **TIME:** 11:25 [✓ AM]/PM **LMK:** ____ **LAT** 41° 40.552" **LONG** 73° 28.536" **DESCRIPTION:** Kent School Driveway	*END* **TIME:** __:__ AM/PM **LMK:** ____ **LAT** 41° 40.433" **LONG** 73° 28.732" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☑ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☒ Institutional ☐ Golf course ☒ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick)
☒ Sand (gritty)
☒ Gravel (0.1-2.5")
☐ Cobble (2.5 –10")
☐ Boulder (>10")
☐ Bed rock

WATER CLARITY ☑ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☒ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☐ Bed scour
☐ Bank failure
☒ Bank scour
☐ Slope failure
☒ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank natural 8 (ft)
RT bank 8 (ft)
Width: Bottom 3 (ft)
Top 30 (ft)

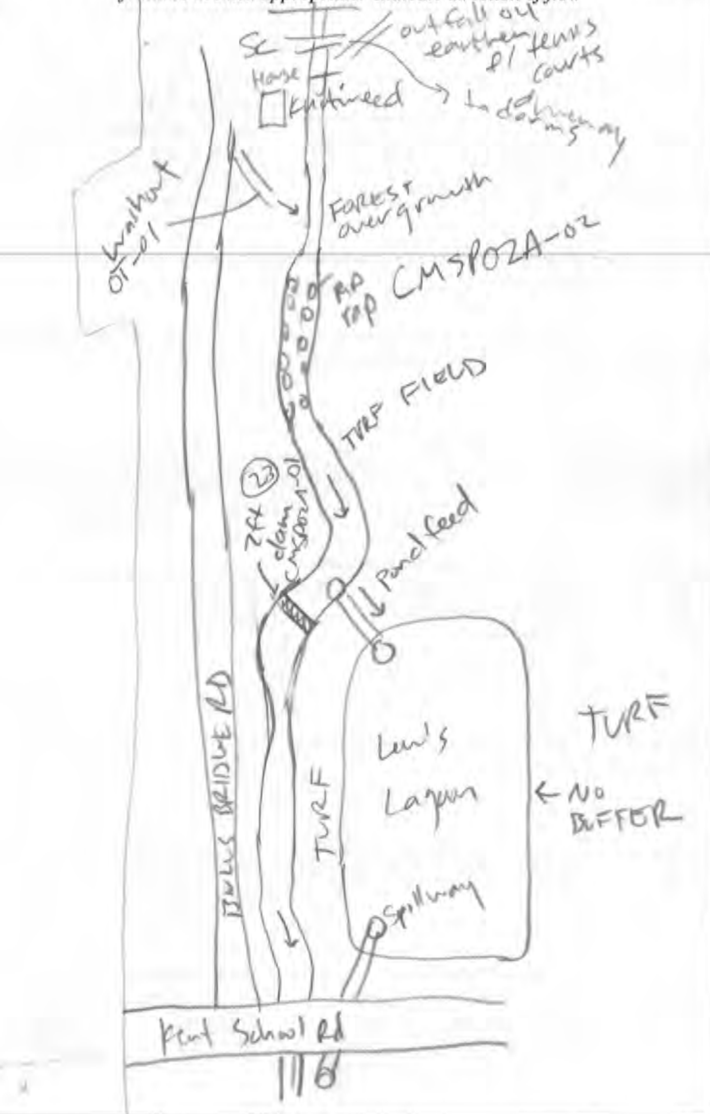
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 3 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*
channelized, down cutting, little riparian buffer, road encroachment
Bank scour

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 [✓ 8] 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	[✓ 2] 1 0
	Right Bank 10 9	8 7 6	5 4 3	[✓ 2] 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
	Right Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 16	15 14 13 12 11	10 9 8 [✓ 7] 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 [✓ 1] 0
	Right Bank 10 9	8 7 6	5 4 3	2 [✓ 1] 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	15 14 13 12 11	10 9 8 [✓ 7] 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 16	15 14 13 12 [✓ 11]	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 13 12 11	10 9 [✓ 8] 7 6	5 4 3 2 1 0

Sub Total In-stream: 29 /80 + Buffer/Floodplain: 28 /80 = **Total** Survey Reach 57 /160

Reach Level Assessment

RCH

SURVEY REACH ID: SP-02B **WTRSHD/SUBSHD:** School Pond **DATE:** 7/24 14 **ASSESSED BY:** KMB

START **TIME:** 12:40 AM/[✓ PM] **LMK:** ____
LAT 41° 40,433 " **LONG** 73° 28.737"
DESCRIPTION: driveway to darms

END **TIME:** ___:___ AM/PM **LMK:** ____
LAT use map " **LONG** ___°____'____"
DESCRIPTION: ~~not end just SC-Utitr~~

GPS ID:

RAIN IN LAST 24 HOURS ☒ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☑ Other: ROADWAY

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☒ 0-25% ☐ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick)
☒ Sand (gritty)
☒ Gravel (0.1-2.5")
☒ Cobble (2.5 –10")
☐ Boulder (>10")
☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☒ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☐ Bed scour
☐ Bank failure
☐ Bank scour
☐ Slope failure
☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2 (ft)
RT bank 2 (ft)
Width: Bottom 20 (ft)
Top >50 (ft)

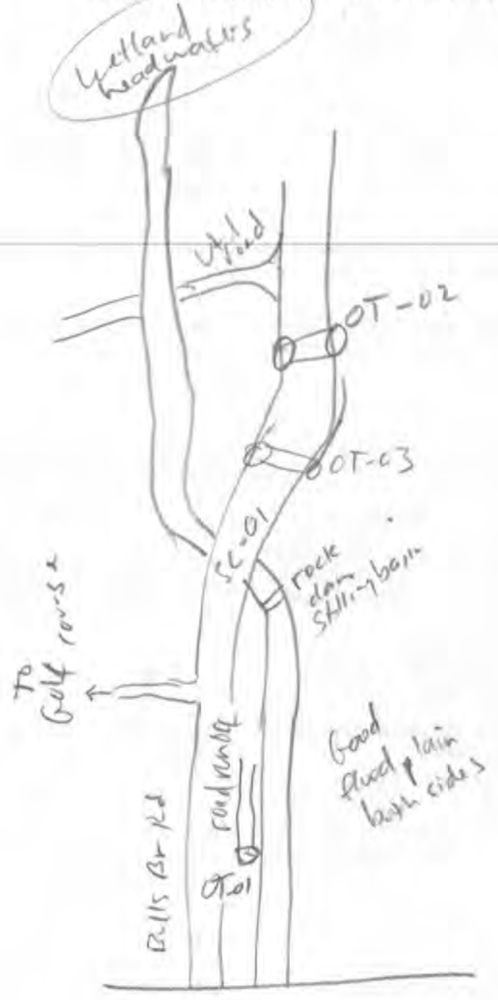
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 [✓ 4] 3 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*

Reference stream w/ some crossings and invasives

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	[✓ 8] 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 [✓ 17] 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

ROADWAY RT

Sub Total In-stream: 74 /80 + Buffer/Floodplain: 72 /80 = **Total** Survey Reach 146 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: WB-01 **WTRSHD/SUBSHD:** Womenshenuk Brk **DATE:** 7/24/14 **ASSESSED BY:** KMB

START **TIME:**___:___AM/PM **LMK:** _____
LAT___°_____'_____" **LONG** ___°_____'_____"
DESCRIPTION: use map

END **TIME:** 3:00 AM/[✓ PM] **LMK:** _____
LAT___°_____'_____" **LONG** ___°_____'_____"
DESCRIPTION: use map

GPS ID:

RAIN IN LAST 24 HOURS ☒ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☐ Pasture ☒ Other: wetland

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☒ 75-100% wetland

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☒ some ☐ lots
Floating: ☐ none ☐ some ☒ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%) NA
☒ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☒ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)* NA
Height: LT bank _________(ft)
RT bank _________(ft)
Width: Bottom _________(ft)
Top _________(ft)

REACH ACCESSIBILITY

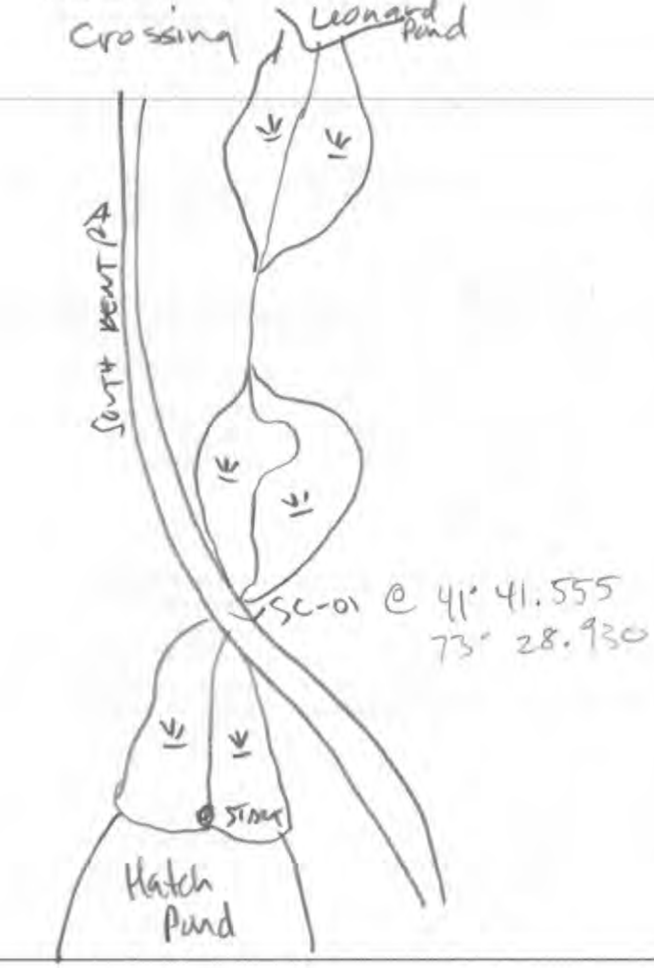
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 3 2 [✓ 1]

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Assessed f/ South Kent Road Crossing



NOTES: *(biggest problem you see in survey reach)*

No defined channel—wetland complex

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	[✓ 20] 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched. wetland	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	[✓ 20] 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet; little or no riparian vegetation due to human activities.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION wetland	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	[✓ 15] 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 16	15 14 13 12 11	[✓ 10] 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	[✓ 15] 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 80 /80 + Buffer/Floodplain: 60 /80 = **Total** Survey Reach 140 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: HW-01B **WTRSHD/SUBSHD:** Headwaters **DATE:** 7/24/14 **ASSESSED BY:** KMB

START **TIME:** 4 : 00 AM/[✓ PM] **LMK:** ____
LAT 41° 42.760" **LONG** 73° 28.065"
DESCRIPTION: property line @ fence

END **TIME:** __ : __ AM/PM **LMK:** ____
LAT 41° 42.770" **LONG** 73° 27.849"
DESCRIPTION:

GPS ID:

RAIN IN LAST 24 HOURS ☒ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick)
☒ Sand (gritty)
☒ Gravel (0.1-2.5")
☒ Cobble (2.5 –10")
☒ Boulder (>10")
☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☐ Bed scour
☐ Bank failure
☐ Bank scour
☐ Slope failure
☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3 (ft)
RT bank 3 (ft)
Width: Bottom 10 (ft)
Top 30 (ft)

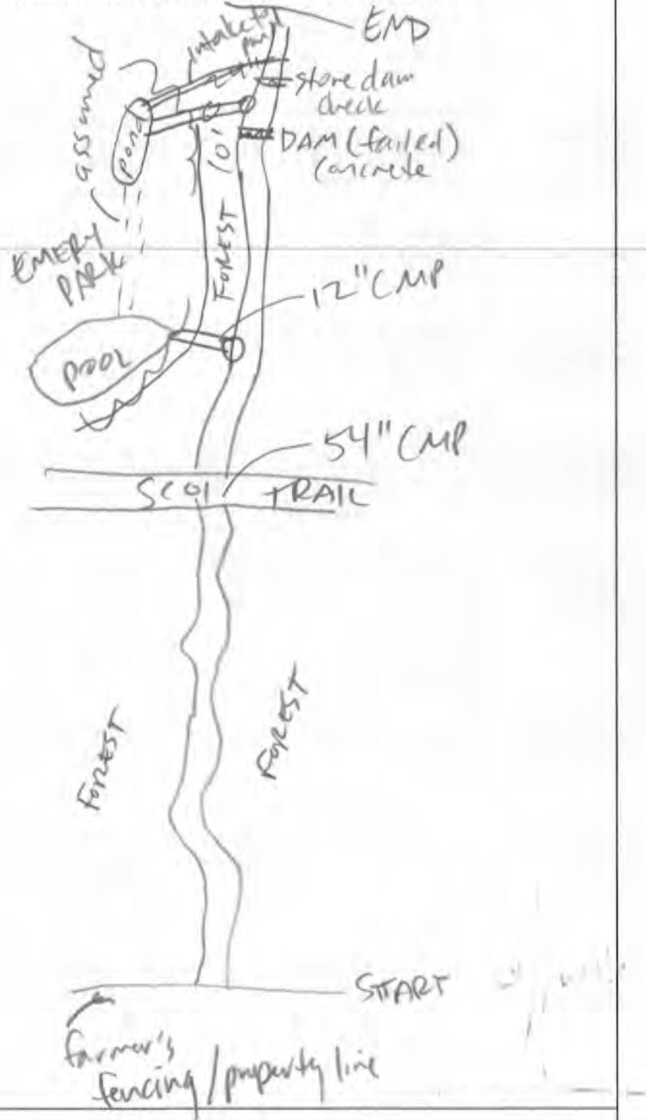
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 [✓ 3] 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*
Diversion for pool & abandoned concrete dam

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
	Right Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 [✓ 17] 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 [✓ 13] 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 66 /80 + Buffer/Floodplain: 65 /80 = **Total** Survey Reach 131 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: HW02 **WTRSHD/SUBSHD:** Headwaters **DATE:** 7/25/14 **ASSESSED BY:** KMB

START **TIME:** 9:55 [✓ AM]/PM **LMK:**
LAT 41° 42.813" **LONG** 73° 27.649"
DESCRIPTION: ROAD crossing

END **TIME:** __:__ AM/PM **LMK:**
LAT 41° 43.077" **LONG** 73° 27.436"
DESCRIPTION:

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☒ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick)
☒ Sand (gritty)
☒ Gravel (0.1-2.5")
☒ Cobble (2.5 –10")
☐ Boulder (>10")
☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☐ Bed scour
☐ Bank failure
☒ Bank scour
☐ Slope failure
☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1 (ft)
RT bank 1 (ft)
Width: Bottom 5 (ft)
Top 15 (ft)

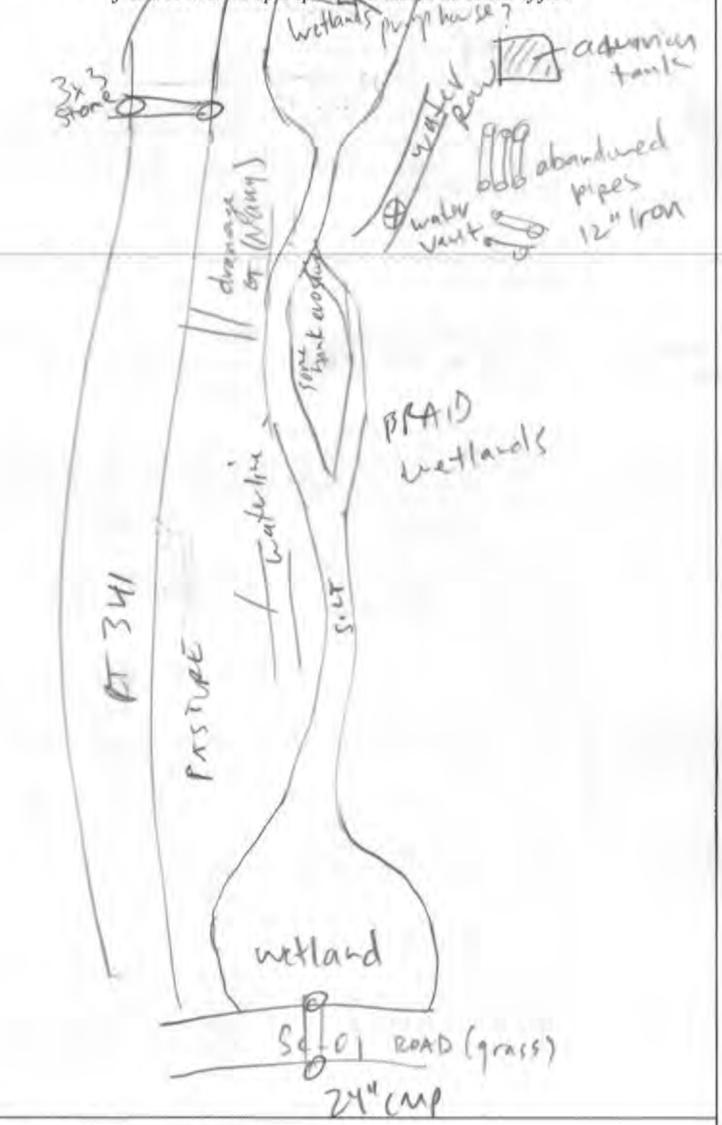
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 3 [✓ 2] 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB, SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*

Utility Row has fill / mowed access along stream

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 [✓ 17] 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
	Right Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 [✓ 17] 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
	Right Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	15 [✓ 14] 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 13 12 [✓ 11]	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 66 /80 + Buffer/Floodplain: 55 /80 = **Total** Survey Reach 121 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: SM01A **WTRSHD/SUBSHD:** Sugar Mtn **DATE:** 7/25/14 **ASSESSED BY:** KMB

START **TIME:** 12:45 AM/[✓ PM] **LMK:** ____
LAT 41° 42.182" **LONG** 73° 28.482"
DESCRIPTION: mouth to Leonard Pond

END **TIME:** 1:00 AM/[✓ PM] **LMK:** ____
LAT 41° 42.172" **LONG** 73° 28.429"
DESCRIPTION: road crossing

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☒ Other: Rec- Club Getaway

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☒ 75-100%

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick)
☒ Sand (gritty)
☐ Gravel (0.1-2.5")
☐ Cobble (2.5 –10")
☐ Boulder (>10")
☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☒ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☒ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☒ Bed scour
☐ Bank failure
☒ Bank scour
☐ Slope failure
☐ Channelized

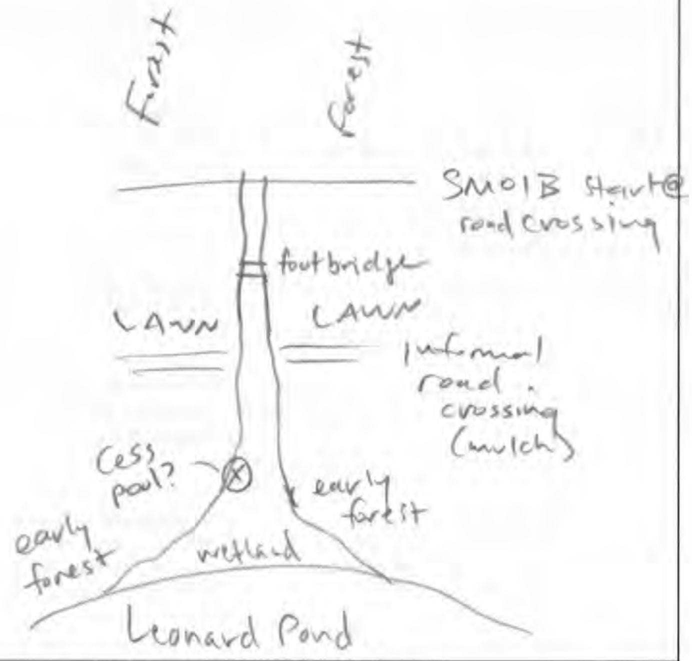
CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1 (ft)
RT bank 1 (ft)
Width: Bottom 10 (ft)
Top 15 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.		Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.		Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5	[✓ 4]	3	2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*
bank erosion f / limited buffer / little canopy

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 [✓ 6]	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
	Right Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 7 6	5 [✓ 4] 3	2 1 0
	Right Bank 10 9	8 7 6	5 [✓ 4] 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 16	15 14 13 12 [✓ 11]	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 [✓ 3]	2 1 0
	Right Bank 10 9	8 7 6	5 4 [✓ 3]	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	15 14 13 [✓ 12] 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	[✓ 5] 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 13 12 11	10 9 [✓ 8] 7 6	5 4 3 2 1 0

Sub Total In-stream: 35 /80 + Buffer/Floodplain: 31 /80 = **Total** Survey Reach 66 /160

Reach Level Assessment **RCH**

SURVEY REACH ID: SM01B	**WTRSHD/SUBSHD:** Segar Mountain	**DATE:** 7/25/14	**ASSESSED BY:** KMB

START **TIME:** 1:00 AM/[✓ PM] **LMK:** ____
LAT 41° 42.172" **LONG** 73° 28.429"
DESCRIPTION: road crossing SC-01

END **TIME:** ___:___ AM/PM **LMK:** ____
LAT ___° ___' ___" **LONG** ___° ___' ___"
DESCRIPTION: See map

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☒ 0-25% ☐ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick)
☐ Sand (gritty)
☐ Gravel (0.1-2.5")
☒ Cobble (2.5 –10")
☒ Boulder (>10")
☐ Bed rock

WATER CLARITY ☑ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☑ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other: FROGS

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting
☐ Widening
☐ Headcutting
☐ Aggrading
☐ Sed. deposition
☐ Bed scour
☐ Bank failure
☐ Bank scour
☐ Slope failure
☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3 (ft)
RT bank 3 (ft)
Width: Bottom 20 (ft)
Top 7 30 (ft)

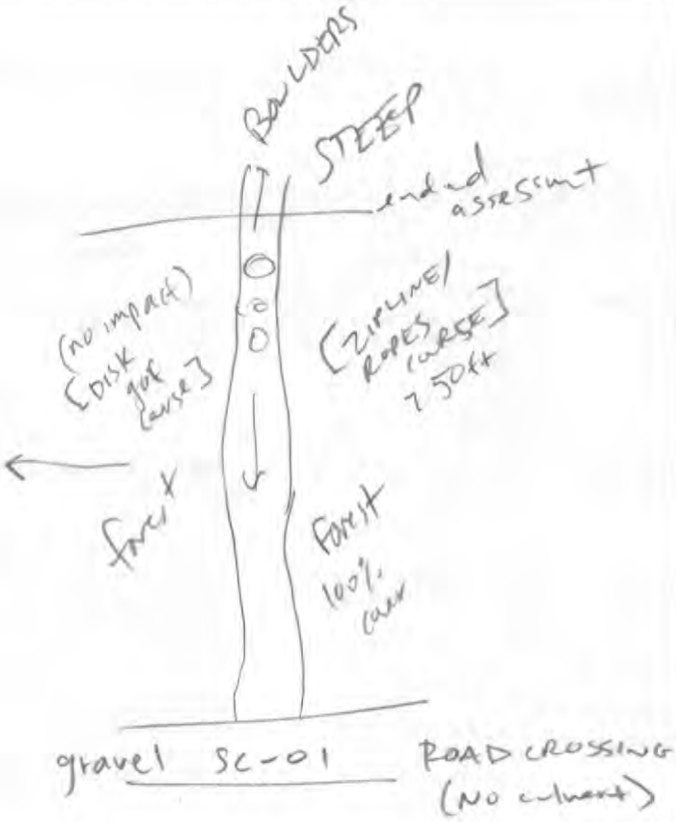
REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 [✓ 3] 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB, SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow



NOTES: *(biggest problem you see in survey reach)*
d/s ROAD crossing may cause sedimentation

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) not able to enter floodplain. Stream deeply entrenched.
	[✓ 20] 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 [✓ 18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 [✓ 19] 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 76 /80 + Buffer/Floodplain: 74 /80 = **Total** Survey Reach 150 /160

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 01

Date: 7/29/14 Time: 9:05 am

Assessed By: KMB, KEC

ID (HP-##): HP- 01 **Photo #s:** 271 - 282 / 359 - 366

Start Location (decimal degrees): Latitude: ____ Longitude: ____

End Location (decimal degrees): Latitude: ____ Longitude: ____

SHORELINE CHARACTERISTICS

lilies

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: [✓ Flat (<5%)] / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /Silt-Clay-Muck

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / [✓ None]

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy	**Understory**
Big Trees (Trunk >1 ft DBH): 1	Woody Shrubs & Saplings: 5
Small Trees (Trunk <1 ft DBH): 2	Tall Herbs, Grasses & Forbs: 2
Ground Cover Same as canopy	
Woody Shrubs & Saplings: ____	Standing Water or Inundated Vegetation: ____
Tall Herbs, Grasses & Forbs: ____	Barren, Bare Dirt or Ground Litter: ____

Comments

Water depth = 4-5 ft

wetland banks

FUSS & O'NEILL

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 02

Date: 7/29/14 Time: 9:15 am

Assessed By: KMB, KEC

ID (HP-##): HP- 02 **Photo #s:** 283-284

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: [✓ Flat (<5%)] / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /Silt-Clay-Muck

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / [✓ None]

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy

Big Trees (Trunk >1 ft DBH): 2

Small Trees (Trunk <1 ft DBH): 5

Understory

Woody Shrubs & Saplings: 1

Tall Herbs, Grasses & Forbs: 1

Ground Cover

Woody Shrubs & Saplings: ______

Tall Herbs, Grasses & Forbs: 5

Standing Water or Inundated Vegetation: ______

Barren, Bare Dirt or Ground Litter: ______

Comments

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 2 ID: HP- 02A

HUMAN INFLUENCE

Document the following: Docks, Boats, Trash or Debris, Buildings, Commercial Activities, Parks, Retaining Walls, Rip Rap, Roads, Railroads, Power Lines, Agriculture, Lawns, other disturbance. For stormwater or other outfalls, document material and dimensions.

Human Influence #1

Type: Boathouse, dock & Shed
Description: __________
Size: __________
Photo #s: __________
Location: Latitude: ________ Longitude: ________

Human Influence #2

Type: __________
Description: __________
Size: __________
Photo #s: __________
Location: Latitude: ________ Longitude: ________

Human Influence #3

Type: __________
Description: __________
Size: __________
Photo #s: __________
Location: Latitude: ________ Longitude: ________

Use additional pages as necessary.

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Form based on National Lakes Assessment Field Operations Manual, May 2012.

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 2 ID: HP- 02-B

HUMAN INFLUENCE

Document the following: Docks, Boats, Trash or Debris, Buildings, Commercial Activities, Parks, Retaining Walls, Rip Rap, Roads, Railroads, Power Lines, Agriculture, Lawns, other disturbance. For stormwater or other outfalls, document material and dimensions.

Human Influence #1

Type: outfall/SC

Description: South of boat house

Size: 24" CMP

Photo #s: 359-362

Location: Latitude: 41' 40.906 Longitude: 73' 28.661

Human Influence #2

Type: outfall/SC

Description: under road to boathouse drains to pond f/ forest

Size: 8 or 12"?

Photo #s: 363-366

Location: Latitude: 41' 40.883' Longitude: 73' 28.644'

Human Influence #3

Type:

Description:

Size:

Photo #s:

Location: Latitude: Longitude:

Use additional pages as necessary.

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP-03/04

Date: 7/29/14 Time: 9:25 am

Assessed By: KMB, KEC

ID (HP-##): HP-03/04 **Photo #s:** 285 - 291

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

less than other segments

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: Flat (<5%) / [✓ Moderate (5-25%)] / [✓ Steep (> 25%)]

Lake Bottom Substrate (only 1 ea): Some ~5-10%

Dominant Type: Bedrock / Boulders / [✓ Cobble] / Gravel / Sand /Silt-Clay-Muck

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /[✓ Silt-Clay-Muck]

Lake Bottom Cover (only 1 ea):

Dominant Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy

Big Trees (Trunk >1 ft DBH): 2

Small Trees (Trunk <1 ft DBH): 5

Understory

Woody Shrubs & Saplings: 4

Tall Herbs, Grasses & Forbs: 1

Ground Cover

Woody Shrubs & Saplings: 4

Tall Herbs, Grasses & Forbs: 1

Standing Water or Inundated Vegetation: ______

Barren, Bare Dirt or Ground Litter: ______

Comments

Form based on National Lakes Assessment Field Operations Manual, May 2012.

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 05

Date: 7/29/14 Time: 9:30AM

Assessed By: KMB/KEC

ID (HP-##): HP- 05 **Photo #s:** 292 – 304

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

little

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: Flat (<5%) / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / [✓ Cobble] / Gravel / Sand / Silt-Clay-Muck

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy

Big Trees (Trunk >1 ft DBH): 2

Small Trees (Trunk <1 ft DBH): 1

Understory

Woody Shrubs & Saplings: _____

Tall Herbs, Grasses & Forbs: 5 Invasives

Ground Cover

Woody Shrubs & Saplings: _____

Tall Herbs, Grasses & Forbs: 5

Standing Water or Inundated Vegetation: _____

Barren, Bare Dirt or Ground Litter: 5 yards/turf

Comments

Houses - accessible by boat

bittersweet & MF rose / jewelweed

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 2 ID: HP- 05

HUMAN INFLUENCE

Document the following: Docks, Boats, Trash or Debris, Buildings, Commercial Activities, Parks, Retaining Walls, Rip Rap, Roads, Railroads, Power Lines, Agriculture, Lawns, other disturbance. For stormwater or other outfalls, document material and dimensions.

Human Influence #1

Type: Docks, Houses (x3)

Description:

Size:

Photo #s:

Location: Latitude: Longitude:

Human Influence #2

Type:

Description:

Size:

Photo #s:

Location: Latitude: Longitude:

Human Influence #3

Type:

Description:

Size:

Photo #s:

Location: Latitude: Longitude:

Use additional pages as necessary.

FUSS & O'NEILL

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 06

Date: 7/28/14 Time: 10:00 AM

Assessed By: KMB, KEC

ID (HP-##): HP- 06 **Photo #s:** 305 - 311

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

some on milfoil 100%

Surface Film: None / [✓ Algal Scum] / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: [✓ Flat (<5%)] / Moderate (5-25%) / Steep (> 25%) wetland

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /Silt-Clay-Muck

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

~~Canopy~~	**~~Understory~~**
Big Trees (Trunk >1 ft DBH): 0	Woody Shrubs & Saplings: 0
Small Trees (Trunk <1 ft DBH): 0	Tall Herbs, Grasses & Forbs: 0
Ground Cover	
Woody Shrubs & Saplings: 2	Standing Water or Inundated Vegetation: 5 wetland
Tall Herbs, Grasses & Forbs: 5	Barren, Bare Dirt or Ground Litter: 0

Comments

wetland area north of pond

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Form based on National Lakes Assessment Field Operations Manual, May 2012.

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 07/08

Date: 7/29/14 Time: 10:10 AM

Assessed By: KMB/KEC

ID (HP-##): HP- 7/8 **Photo #s:** 312 – 317

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: Flat (<5%) / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /Silt-Clay-Muck

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy

Big Trees (Trunk >1 ft DBH): 2

Small Trees (Trunk <1 ft DBH): 2

~~Understory~~

Woody Shrubs & Saplings: _____

Tall Herbs, Grasses & Forbs: _____

Ground Cover

Woody Shrubs & Saplings: 4

Tall Herbs, Grasses & Forbs: 4

Standing Water or Inundated Vegetation: 5 wetland

Barren, Bare Dirt or Ground Litter: 0

Comments

wetland in pond incl. cattails / red maple / arrowleaf
then oak & tree of paradise in upland
ad; to railroad & then road

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Form based on National Lakes Assessment Field Operations Manual, May 2012.

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Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 2 ID: HP-07/08

HUMAN INFLUENCE

Document the following: Docks, Boats, Trash or Debris, Buildings, Commercial Activities, Parks, Retaining Walls, Rip Rap, Roads, Railroads, Power Lines, Agriculture, Lawns, other disturbance. For stormwater or other outfalls, document material and dimensions.

Human Influence #1

Type: Railroad then Roadway

Description: Rail then South Kent Rd

wetland obscuring outfalls

Size:

Photo #s:

Location: Latitude: Longitude:

Human Influence #2

Type: DOCK

Description:

Size:

Photo #s: 316-317

Location: Latitude: 41 41.249 Longitude: 73 28.829

Human Influence #3

Type:

Description:

Size:

Photo #s:

Location: Latitude: Longitude:

Use additional pages as necessary.

FUSS & O'NEILL

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 09

Date: 7/29/14 Time: 10:25 AM

Assessed By: KMB, KEC

ID (HP-##): HP-______ **Photo #s:** 318 – 351

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: Flat [✓ (<5%)] / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck]

Secondary Type: Bedrock / [✓ Boulders] / Cobble / Gravel / Sand /Silt-Clay-Muck

All along railroad

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / [✓ Woody Debris] / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

Canopy

Big Trees (Trunk >1 ft DBH): 2

Small Trees (Trunk <1 ft DBH): 2

Understory

Woody Shrubs & Saplings: 3

Tall Herbs, Grasses & Forbs: 2

Ground Cover

Woody Shrubs & Saplings: 3

Tall Herbs, Grasses & Forbs: 2

Standing Water or Inundated Vegetation: 3

Barren, Bare Dirt or Ground Litter: _____

Comments

wetland adj to railroad

home on bank

F:\P2011\0148\A20\Field Work\SHORELINE Assm Field Sheet.Docx

Form based on National Lakes Assessment Field Operations Manual, May 2012.

FUSS & O'NEILL

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 2 ID: HP- 09

HUMAN INFLUENCE

Document the following: Docks, Boats, Trash or Debris, Buildings, Commercial Activities, Parks, Retaining Walls, Rip Rap, Roads, Railroads, Power Lines, Agriculture, Lawns, other disturbance. For stormwater or other outfalls, document material and dimensions.

Human Influence #1

Type: House w/ doc

Description:

Size: 319 concrete foundation

Photo #s: 320 - 323

Location: Latitude: 41 41.151 Longitude: 73 28.732

Human Influence #2

Type: House - Red across street

Description:

Size:

Photo #s: 337

Location: Latitude: 41 41.083 Longitude: 73 28.560

Human Influence #3

Type: Potential outfall? Concrete headwall

Description:

Size:

Photo #s: 346

Location: Latitude: 41 41.042 Longitude: 73 28.518

Use additional pages as necessary.

dock 41 40.963 73 28.456 Photo 350

Stream Assessment Field Data Form – Hatch Pond Watershed

Shoreline Assessment Field Data Sheet

PAGE 1 ID: HP- 10

Date: 7/29/2014 Time: 11:30 AM

Assessed By: KMB, KEC

ID (HP-##): HP- 10 **Photo #s:** 352 – 358

Start Location (decimal degrees): Latitude: ______ Longitude: ______

End Location (decimal degrees): Latitude: ______ Longitude: ______

SHORELINE CHARACTERISTICS

Surface Film: None / Algal Scum / Foam / Oil Sheen / [✓ Pollen] / [✓ Macrophytes] / Duckweed

Land Slope Entering Lake: [✓ Flat (<5%)] / Moderate (5-25%) / Steep (> 25%)

Lake Bottom Substrate (only 1 ea):

Dominant Type: Bedrock / Boulders / Cobble / Gravel / Sand / [✓ Silt-Clay-Muck] wetland

Secondary Type: Bedrock / Boulders / Cobble / Gravel / Sand /Silt-Clay-Muck

Lake Bottom Cover (only 1 ea):

Dominant Type: [✓ Macrophytes] / Woody Debris / Leaf Pack / Benthic Algae / None

Secondary Type: Macrophytes / Woody Debris / Leaf Pack / Benthic Algae / None

RIPARIAN ZONE CHARACTERISTICS (up to 50 feet from the shoreline)

Ratings: 1 = Absent (0%); 2 = Sparse (<10%); 3 = Moderate (10-40%); 4 = Heavy(40-75%); 5 = Very Heavy (>75%)

~~**Canopy**~~	**Understory**
Big Trees (Trunk >1 ft DBH): ______	Woody Shrubs & Saplings: 4 30-100 ft
Small Trees (Trunk <1 ft DBH): ______	Tall Herbs, Grasses & Forbs: 4 10-50 ft
Ground Cover	
Woody Shrubs & Saplings: 4	Standing Water or Inundated Vegetation: 5 wetland
Tall Herbs, Grasses & Forbs: 4	Barren, Bare Dirt or Ground Litter: 0

Comments

wetland area 10-100 ft f/ pond edge

Appendix A: Field Assessment Results

Legend

- Outfalls (OT), including stormwater and other manmade point discharges;
- Severe Bank Erosion (ER), such as bank sloughing, active widening, and incision;
- Impacted Buffer (IB), which is a narrowing or lack of natural vegetation;
- Utilities in the stream corridor (UT), such as leaking or exposed pipes;
- Trash and Debris (TR), such as drums, yard waste, and other illegal dumping;
- Stream Crossings (SC), which are hard objects, whether natural or artificial, that restrict or constrain the flow of water. These may include bridges, road crossings with the stream piped in a culvert, dams, and falls;
- Channel Modification (CM), where the stream bottom, banks, or direction have been modified;
- Miscellaneous (MI), other impacts or features not otherwise covered; and
- Water Quality Sample (WQ), surface water quality sample collected.

Table A-1. School Pond Subwatershed Impact Condition Assessment

Reach	Type	ID	OT/SC Size	Photos
SP01B	SC	SC-SP01B-01	4 ft	9, 10, 11
SP01B	SC	SC-SP01B-02	4 ft	18,19,20
SP02A	SC	SC-SP02A-01	48"	30, 31
SP02A	SC	SC-SP02A-02	48"	40
SP02A	CM	CM-SP02A-01		23
SP02A	CM	CM-SP02A-02		25
SP02A	CM	CM-SP02A-03		32, 33
SP01B	OT	OT-SP01B-01	36"	13, 14
SP02A	OT	OT-SP02A-01	12"	28
SP02A	OT	OT-SP02A-02	24"	29
SP02A	OT	OT-SP02A-03	24"	38, 39
SP02A	OT	OT-SP02A-04	36"	40, 41
SP02B	OT	OT-SP02B-01	24"	42, 43, 44
SP02B	OT	OT-SP02B-02	24"	49, 50, 51
SP02B	OT	OT-SP02B-03	24"	54
SP02B	OT	OT-SP02B-04	24"	55
SP02B	SC	SC-SP02B-01	48"	47
SP02B	SC	SC-SP02B-02		52, 53
SP02A	CM	CM-SP02A-04		37
SP01B	IB	IB-SP01B-01		5, 6, 7
SP02A	IB	IB-SP02A-01		24, 25
SP01	WQ	1027140424-01		
SP02	WQ	1027140428-05		

Appendix A: Field Assessment Results

Table A-2. Womenshenuk Brook Subwatershed Impact Condition Assessment

Reach	Type	ID	OT/SC Size	Photos
WB01	SC	SC-WB01-01	3 FT	56
WB01	WQ	1027140424-03		

Table A-3. Segar Mountain Subwatershed Impact Condition Assessment

Reach	Type	ID	OT/SC Size	Photos
SM01A	UT	UT-SM01A-01		103, 104
SM01A	SC	SC-SM01A-01		106
SM01B	SC	SC-SM01B-01		108, 109

Table A-4. Headwaters Subwatershed Impact Condition Assessment

Reach	Type	ID	OT/SC Size	Photos
HW01B	OT	OT-HW01B-01	12"	69
HW01B	OT	OT-HW01B-02	24"	72
HW01B	OT	OT-HW01B-03		
HW01B	SC	SC-HW01B-01	54"	66, 67
HW01B	CM	CM-HW01B-01		71
HW02	UT	UT-HW02-01		86, 87
HW02	UT	UT-HW02-02		88, 89
HW02	OT	OT-HW01-01		93, 94
HW02	SC	SC-HW02-01	2-4"	76, 77, 78
HW02	SC	SC-HW02-02	36"	
HW01B	WQ	1027140424-04		

Photograph 001

Photograph 004

Photograph 002

Photograph 005

Photograph 003

Photograph 006

Photograph 007

Photograph 010

Photograph 008

Photograph 011

Photograph 009

Photograph 012

Photograph 013

Photograph 016

Photograph 014

Photograph 017

Photograph 015

Photograph 018

Photograph 019

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Photograph 020

Photograph 023

Photograph 021

Photograph 024


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Photograph 026


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Photograph 030


Photograph 031


Photograph 032


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Photograph 034


Photograph 035


Photograph 036


Photograph 037


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Photograph 096


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Photograph 100


Photograph 098


Photograph 101


Photograph 099


Photograph 102

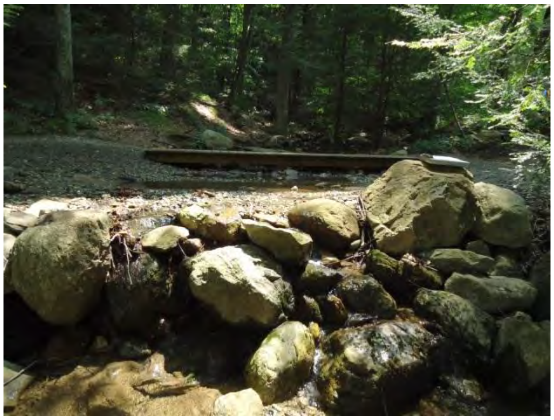

Photograph 103


Photograph 106


Photograph 104


Photograph 107


Photograph 105


Photograph 108


Photograph 109


Photograph 112


Photograph 110


Photograph 113


Photograph 111


Photograph 114


Photograph 115


Photograph 118


Photograph 116


Photograph 119


Photograph 117


Photograph 120


Photograph 121


Photograph 124


Photograph 122


Photograph 125


Photograph 123


Photograph 126


Photograph 127


Photograph 130


Photograph 128


Photograph 131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Photograph 135


Photograph 138

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Photograph 143

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Photograph 144

Photograph 145

Photograph 148

Photograph 146

Photograph 149

Photograph 147

Photograph 150


Photograph 151


Photograph 152


Photograph 153


Photograph 154


Photograph 155


Photograph 156

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Photograph 158

Photograph 161

Photograph 159

Photograph 162

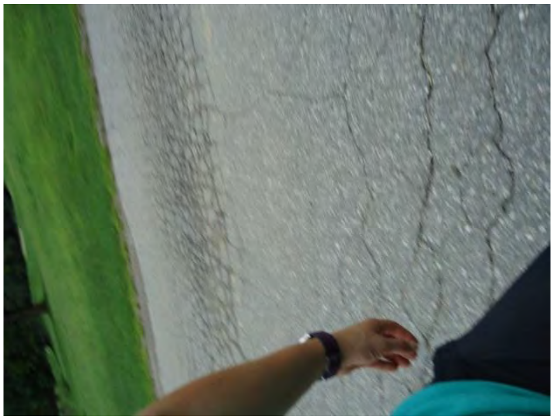

Photograph 163


Photograph 166


Photograph 164


Photograph 167


Photograph 165


Photograph 168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Photograph 181

Photograph 184

Photograph 182

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Photograph 223


Photograph 226


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Photograph 262


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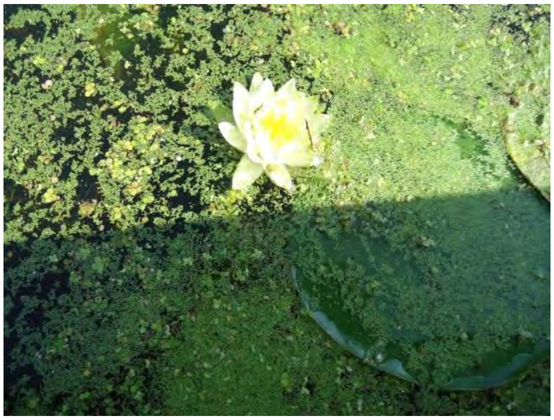
Photograph 269


Photograph 270


Photograph 271


Photograph 272


Photograph 273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Photograph 284


Photograph 287


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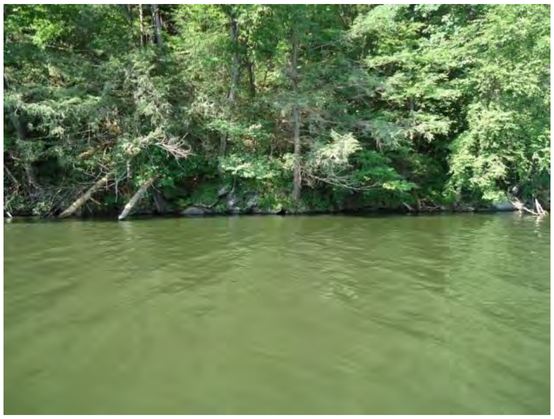
Photograph 289



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Photograph 300

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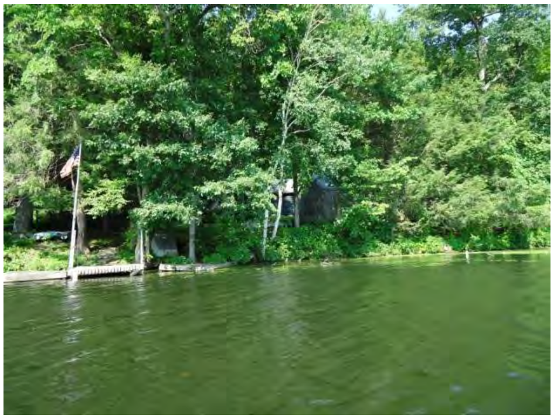
Photograph 304



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Photograph 317


Photograph 315


Photograph 318


Photograph 319


Photograph 322


Photograph 320


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Photograph 321


Photograph 324


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Photograph 331

Photograph 334

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Photograph 335

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Photograph 336

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Photograph 340

Photograph 338

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Photograph 362


Photograph 363


Photograph 364


Photograph 365


Photograph 366

Photograph 367

Photograph 370

Photograph 368

Photograph 371

Photograph 369

Photograph 372

Photograph 373

Photograph 374

Photograph 375

Photograph 376

Photograph 377

Photograph 378


Photograph 379


Photograph 380


Photograph 381

Appendix C

Pollutant Loading Analysis

Table C-1. Impervious Cover Coefficients for Modeled Land Uses

Source	New York State Stormwater Design Manual	Sleavin et al. (2000)	Prisloe et al. (2003)	WTM (2013)	Selected
Agriculture	0.02	0.022 - 0.045	0.003 - 0.037	-	0.03
Commercial	0.70 -0.74	0.54	0.26 - 0.56	0.72	0.7
Forest	-	0.01 - 0.068	0.007 - 0.197	-	0.01
Golf Course	0.09	-	-	-	0.05
Institutional/ School	0.31 - 0.38	-	-	-	0.15
Industrial	0.50 - 0.56	0.53	0.32	0.53	0.4
Low density residential	0.11-0.33	0.08 - 0.14	0.088-.26	0.12-0.21	0.1
Railroad	-	-	-	-	0.4
Recreation/Open Space	0.09	0.050 - 0.094	0.036 - 0.056	-	0.05
Roadway	-	0.433	0.088-.26	0.8	0.8
Water	-	-	-	-	0
Wetland	-	-	-	-	0

Sources:
Center for Watershed Protection (CWP), 2013. *Watershed Treatment Model (WTM) 2013 Documentation*. Prepared by Deb Caraco, P.E. and the Center for Watershed Protection. Updated June, 2013.

New York State Department of Environmental Conservation, 2001. New York State Stormwater Management Manual. Appendix A: The Simple Method to calculate Urban Stormwater Loads. Accessed at http://www.dec.ny.gov/docs/water_pdf/simple.pdf

Prisloe, Michael, Emily Hoffhine Wilson, & Chester Arnold (2003), *Final Report Refinement of Population-Calibrated Land-Cover-Specific Impervious Surface Coefficients for Connecticut.* Accessed at http://nemo.uconn.edu/tools/impervious_surfaces/pdfs/Prisloe_etal_2003.pdf

Sleavin, William J., Daniel L. Civco, Sandy Prisloe, & Laurie Giannotti, 2000. *Measuring Impervious Surfaces for Non-Point Source Pollution Modeling.*

Table C-2. Runoff Event Mean Concentrations (EMCs) for Modeled Land Uses

Source	NH Stormwater Manual			NY State Stormwater Design Manual			WTM Defaults			Selected		
Pollutant	**TN (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**	**TN (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**	**TN (as noted)**	**TP (as noted)**	**TSS (as noted)**	**TN (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
Agriculture	5.98	0.37	145	-	-	-	-	-	-	5.98	0.37	145
Commercial	2.97	0.33	77	2.1 -27	0.14 -0.15	1.9 - 9	2.1 mg/L	0.31 mg/L	43 mg/L	3	0.2	80
Forest	1.78	0.11	51	-	-	-	2.5 lbs/acre	0.2 lbs/acre	100 lbs/acre	1.78	0.11	51
Golf Course	1.74	0.11	51	0- 9.1*	0 - 2.1*	37- 602*	-	-	-	2	0.1	50
Institutional/ School	2.97	0.33	77	-	-	-	-	-	-	3	0.3	80
Light Industrial	3.97	0.32	149	-	-	17- 228	2.2 mg/L	0.25 mg/L	81 mg/L	4	0.3	150
Low Density Residential	5.15	0.52	85	1.5 - 9.1	0.11 - 2.1	1.5 - 602	2.1 mg/L	0.31 mg/L	49 mg/L	5	0.5	50
Railroad	-	-	-	-	-	-	-	-	-	2.7	0.4	150
Recreation/Open Space	1.74	0.11	51	0- 9.1*	0 - 2.1*	37- 602*	-	-	-	5	1	50
Roadway	2.65	0.43	141	1.4 - 22	0- 0.55	51-468	2.3 mg/L	0.25 mg/L	81 mg/L	2.7	0.4	150
Water	1.38	0.08	6	-	-	-	12.8 lbs/acre	0.5 lbs/acre	155 mg/L	1.38	0.08	6
Wetland	1.38	0.08	6	1.7**	0.2**	22**	-	-	-	1.38	0.08	6

Sources:
McCarthy, Jillian, 2008. *New Hampshire Stormwater Manual Volume 1: Stormwater and Antidegradation,* December 2008. http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_apxd.pdf.

New York State Department of Environmental Conservation, 2001. New York State Stormwater Management Manual. Appendix A: The Simple Method to calculate Urban Stormwater Loads. Accessed at http://www.dec.ny.gov/docs/water_pdf/simple.pdf

Notes:
TP - Total Phosphorus
TN - Total Nitrogen
TSS - total suspended solids

Table C-3. Existing Land Use Composition by Subwatershed in Acres

Subwatershed	Agriculture	Commercial	Forest	Golf Course	Industrial	Railroad	Recreation	Residential	Road	School	Water	Wetland
Hatch Pond Direct Drainage Subwatershed (339 acres)	20	0	147	0	0	5	3	86	5	4	66	2
Headwaters Subwatershed (365 acres)	35	0	230	0	0	0	0	1	94	5	0	0
Leonard Pond Subwatershed (346 acres)	4	1	131	0	3	19	64	56	9	0	20	40
School Pond Subwatershed (239 acres)	48	0	31	59	0	0	0	14	7	73	0	7
Segar Mountain Tributary Subwatershed (183 acres)	0	0	152	0	0	0	3	27	0	0	0	0
Womenshenuk Brook Subwatershed (536 acres)	49	0	234	0	0	13	25	143	13	0	0	61
Total (Watershed)	156	1	926	59	3	36	95	327	127	83	87	109

Table C-4. Existing Land Use Composition Percentages

Subwatershed	Agriculture	Commercial	Forest	Golf Course	Industrial	Railroad	Recreation	Residential	Road	School	Water	Wetland
Hatch Pond Direct Drainage Subwatershed (339 acres)	6%	0%	43%	0%	0%	1%	1%	25%	1%	1%	20%	1%
Headwaters Subwatershed (365 acres)	10%	0%	63%	0%	0%	0%	0%	0%	26%	1%	0%	0%
Leonard Pond Subwatershed (346 acres)	1%	0%	38%	0%	1%	5%	18%	16%	2%	0%	6%	12%
School Pond Subwatershed (239 acres)	20%	0%	13%	25%	0%	0%	0%	6%	3%	31%	0%	3%
Segar Mountain Tributary Subwatershed (183 acres)	0%	0%	83%	0%	0%	0%	2%	15%	0%	0%	0%	0%
Womenshenuk Brook Subwatershed (536 acres)	9%	0%	44%	0%	0%	2%	5%	27%	2%	0%	0%	11%
Total (Percentage of Watershed)	8%	0%	46%	3%	0%	2%	5%	16%	6%	4%	4%	5%

Figure C-1. Existing Land Use Composition

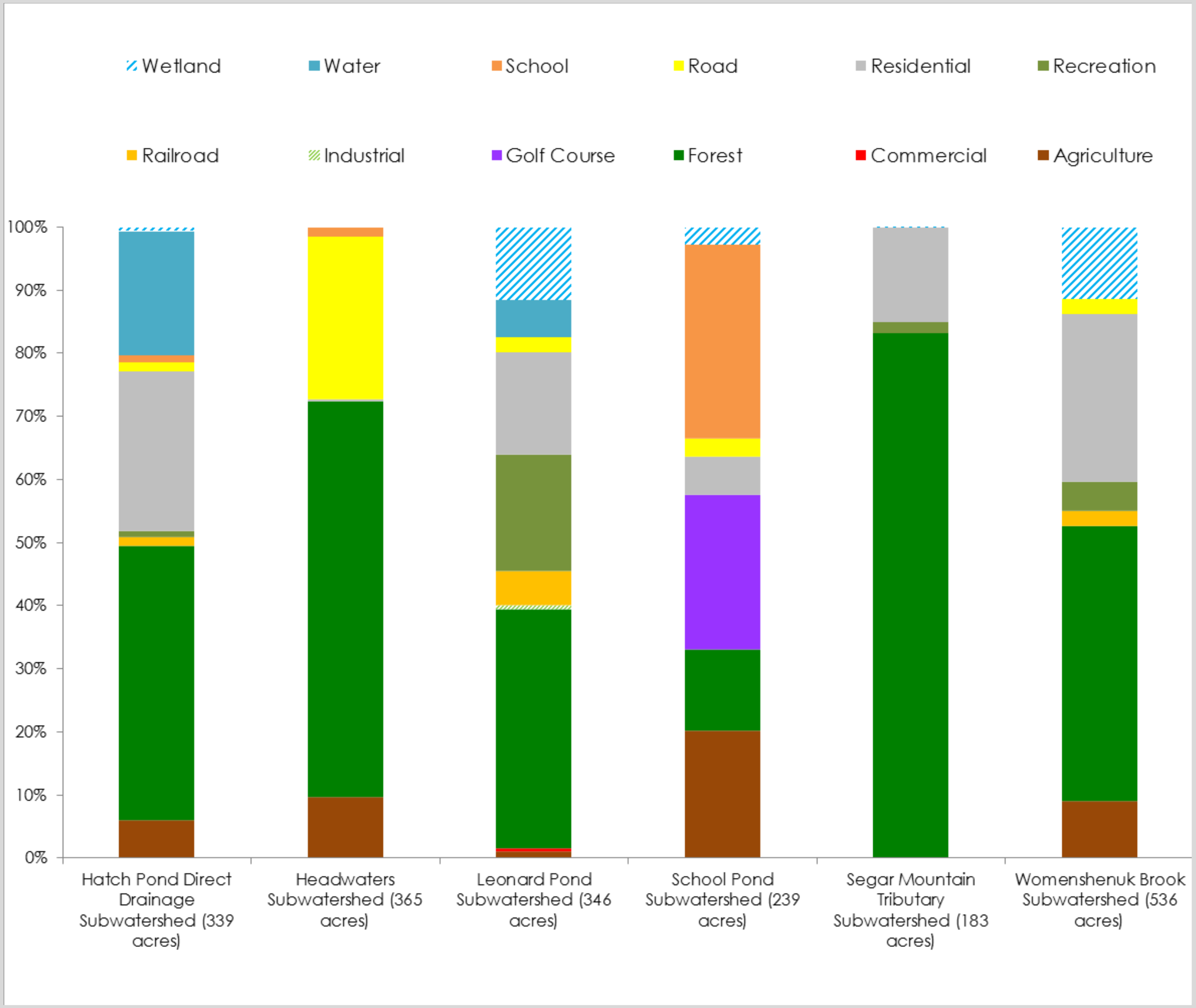

Table C-5. Model Input Data – Riparian Buffer, Bank Stability, Subsurface Waste Disposal, and Livestock

Subwatershed	**Dwelling Units**	**Sum of Riparian Buffer Area (acres)**	**Livestock**	**Bank Stability**
Hatch Pond Direct Drainage Subwatershed (339 acres)	26	0		Moderate
Headwaters Subwatershed (365 acres)	16	29		Moderate
Leonard Pond Subwatershed (346 acres)	44	51		Moderate
School Pond Subwatershed (239 acres)	74	2		Low
Segar Mountain Tributary Subwatershed (183 acres)	2	32		Moderate
Womenshenuk Brook Subwatershed (536 acres)	28	25	2 dairy cattle, 10 layers, 4 pigs	High
Watershed Total (2,009 acres)	**190**	**139**		

Sources and Notes:

1. Leonard Pond dwelling units includes estimate of equivalent for Club Getaway at 2 guests per room during half the year. School Pond dwelling units includes estimate of equivalent for year-round operation of South Kent School.

2. Sum of riparian buffer area is the sum of areas of individual riparian buffer segments along the stream as estimated from aerial photography.

Table C-6. Modeled Existing Annual Pollutant Loads by Source Type

	TN (lb)	TP (lb)	TSS (lb)	Runoff Volume (acre-feet)
Land Use	11,763	935	329,662	951
Channel Erosion	1,103	490	367,513	0
Livestock	72	9	0	0
Septic Systems	339	57	2,260	0
Total BEFORE existing load reductions	**13,276**	**1,490**	**699,435**	**951**
Riparian Buffer Load Reduction	*-1,624*	*-226*	*-56,131*	*-37*
Total AFTER load reductions	**11,652**	**1,264**	**643,303**	**914**

Table C-7. Modeled Existing Annual Pollutant Loads by Land Use

Land Use	TN (lb)	TP (lb)	TSS (lb)	Runoff Volume (acre-feet)	TN (% of contribution to total land use load)	TP (% of contribution to total land use load)	TSS (% of contribution to total land use load)	Runoff Volume (% of contribution to total land use load)
Agriculture	1,817	112	44,055	112	15.4%	12.0%	13.4%	11.8%
Commercial	28	2	739	3	0.2%	0.2%	0.2%	0.4%
Forest	525	32	15,029	109	4.5%	3.5%	4.6%	11.4%
Golf Course	256	13	6,412	47	2.2%	1.4%	1.9%	5.0%
Industrial	49	4	1,840	5	0.4%	0.4%	0.6%	0.5%
Railroad	477	71	26,484	65	4.1%	7.6%	8.0%	6.8%
Recreation	157	31	1,569	12	1.3%	3.4%	0.5%	1.2%
Residential	4,164	312	156,150	384	35.4%	33.4%	47.4%	40.4%
Road	836	124	46,469	114	7.1%	13.3%	14.1%	12.0%
School	708	74	18,977	87	6.0%	8.0%	5.8%	9.2%
Water	1,214	70	5,279	0	10.3%	7.5%	1.6%	0.0%
Wetland	1,531	89	6,659	13	13.0%	9.5%	2.0%	1.4%
Total	**11,763**	**935**	**329,662**	**951**				

Table C-8. Modeled Existing Annual Pollutant Loads and Yields by Subwatershed

Subwatershed	TN Load (lb)	TP Load (lb)	TSS Load (lb)	Runoff Volume (acre-feet)	TN Yield (lb/ac)	TP Yield (lb/ac)	TSS Yield (lb/ac)	Runoff Depth inches
Hatch Pond Direct Drainage Subwatershed (339 acres)	2,548	253	108,907	138	7.5	0.7	321	4.9
Headwaters Subwatershed (365 acres)	1,356	137	92,582	113	3.7	0.4	253	3.7
Leonard Pond Subwatershed (346 acres)	1,920	213	96,379	150	5.5	0.6	278	5.2
School Pond Subwatershed (239 acres)	2,465	380	211,203	203	10.3	1.6	884	10.2
Segar Mountain Tributary Subwatershed (183 acres)	332	31	21,750	42	1.8	0.2	119	2.8
Womenshenuk Brook Subwatershed (536 acres)	3,030	250	112,484	267	5.6	0.5	210	6.0
Watershed Total (2,009 acres)	**11,652**	**1,264**	**643,303**	**914**				

Table C-9. Modeled Existing Annual Pollutant Loads to Hatch Pond

Subwatershed	**TN**	**TP**	**TSS**	**TN Load**	**TP Load**	**TSS Load**
	(Annual Percent Reduction)			**(lb)**	**(lb)**	**(lb)**
Headwaters Subwatershed				1,356	137	92,582
Attenuation by Wetlands	40%	40%	60%	-542	-55	-55,549
Adjusted Loads				**814**	**82**	**37,033**
Leonard Pond Subwatershed				1,920	213	96,379
Segar Mountain Tributary Subwatershed				332	31	21,750
Attenuation by Leonard Pond*	50%	50%	80%	-1,533	-163	-124,129
Adjusted Loads				**1,533**	**163**	**31,032**
Womenshenuk Brook Subwatershed				3,030	250	112,484
Attenuation by Wetlands**	40%	40%	60%	-1,825	-165	-86,109
Adjusted Loads				**2,738**	**248**	**57,406**
School Pond Subwatershed				2,465	380	211,203
Attenuation by School Pond/Wetlands***	40%	40%	60%	-986	-152	-126,722
Adjusted Loads				**1,479**	**228**	**84,481**
Hatch Pond Direct Drainage Subwatershed				2,548	253	108,907
Annual Load to Hatch Pond				**6,765**	**729**	**250,794**

*Leonard Pond attenuation applied to adjusted Headwaters loads and loads from Leonard Pond and Segar Mt Tributary subwatersheds.

**Womenshenuk Brook wetlands attenuation applied to loads from Womenshenuk Brook subwatershed and upstream loads.

*** Attenuation by School Pond and wetlands applied to loads from School Pond subwatershed.

Table C-10. Modeled Future Annual Pollutant Loads to Hatch Pond and Load Reductions

Subwatershed	**TN**	**TP**	**TSS**	**TN Load**	**TP Load**	**TSS Load**
	(Annual Percent Reduction)			**(lb)**	**(lb)**	**(lb)**
Headwaters Subwatershed				1,356	137	92,582
Attenuation by Wetlands	40%	40%	60%	-542	-55	-55,549
Adjusted Loads				**814**	**82**	**37,033**
Leonard Pond Subwatershed				1,920	213	96,379
Segar Mountain Tributary Subwatershed				332	31	21,750
Attenuation by Leonard Pond*	50%	50%	80%	-1,533	-163	-124,129
Adjusted Loads				**1,533**	**163**	**31,032**
Womenshenuk Brook Subwatershed				3,030	250	112,484
Attenuation by Wetlands and Upgraded CFI Basin**	43%	43%	62%	-1,962	-178	-88,980
Adjusted Loads				**2,601**	**236**	**54,536**
School Pond Subwatershed with Green Infrastructure on SKS Campus				2,358	358	207,083
Attenuation by Upgraded School Pond/Wetlands***	75%	75%	85%	-1,769	-268	-176,021
Adjusted Loads				**590**	**89**	**31,062**
Hatch Pond Direct Drainage Subwatershed with South Kent Road Outfall Retrofits				2,545	253	108,259
Annual Load to Hatch Pond				**5,735**	**578**	**193,857**

*Leonard Pond attenuation applied to adjusted Headwaters loads and loads from Leonard Pond and Segar Mt Tributary subwatersheds.

**Womenshenuk Brook wetlands attenuation applied to loads from Womenshenuk Brook subwatershed and upstream loads.

*** Attenuation by School Pond and wetlands applied to loads from School Pond subwatershed.

Total Reduction in Annual Loads to Hatch Pond		
TN	TP	TSS
15%	21%	23%

Hatch Pond Study 2014: In Lake Conditions, Processes and Possible Management Options

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Introduction

Hatch Pond is in South Kent, Connecticut, slightly east of Route 7 and north of the South Kent School (Figure 1). The pond currently covers about 70 acres in an elongate, northwest-southeast alignment. It is bordered on the east by a railroad and South Kent Road, while the western shoreline is largely steep, forested terrain. Womenshenuk Brook flows from Leonard Pond from the north and exits Hatch Pond from the south. Additional land, including part of the South Kent School and the Bulls Bridge Golf Club, is drained by smaller tributaries, with a total watershed area of slightly more than 3 square miles.

Land use is varied, including forest, wetland, agriculture and residential area as well as the school and golf club (Figure 2). Slopes are steep in much of the watershed. A large emergent wetland has formed over time at the inlet of the pond, covering about 20 acres south of South Kent Road that was probably open water at some time in the distant past. There is a dam at the south end of Hatch Pond that raised the water level several feet at some point in the past, but it is apparent that the pond has experienced substantial infilling over many decades.

Reports by NEAR, the most recent in 2012, document excessive nutrient loading and related biological problems over the last decade, driven largely by inputs from the Arno Farm, a dairy operation at the north end of the lake. Concentrations of nitrogen (N) and phosphorus (P) were very high in water discharged from the dairy farm, while concentrations upstream were more moderate or even low. Inputs from the unnamed tributary the drains the South Kent School, part of the golf course, and some additional lands have also been elevated at times, but the load from the dairy farm stands out as far greater than all other sources. The CT DEP had assessed Hatch Pond in 1990 (CTDEP 1991) and considered it to be moderately fertile. Water quality deterioration over a 15 year period was apparent.

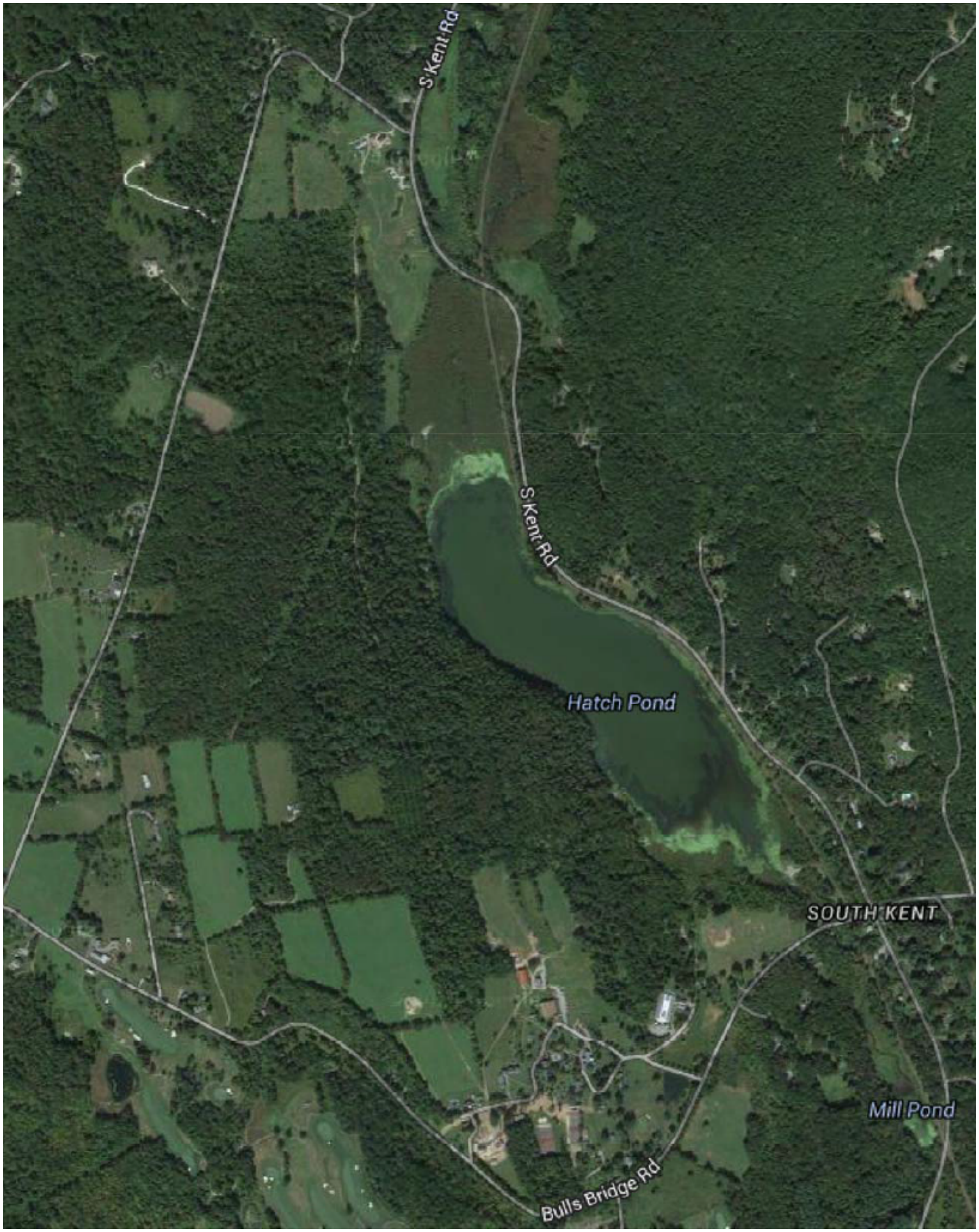
Most striking is the apparent change in the depth of Hatch Pond. Mean and maximum depths were reported in 1959 as 11.5 ft (3.5 m) and 26.2 ft (7.9 m), respectively (State Board of Fisheries and Game 1959). More recent measurements (NEAR 2012) indicated a maximum depth of less than 15 ft (4.5 m). Watershed inputs during large storms, manure from the dairy farm, and internally generated and retained organic matter are all possible sources of the sediment. It is also possible that the measurements made about 60 years ago were made with weights on graduated lines that went considerably into the soft sediment before stopping, thereby overestimating water depth. The high level of internal organic production and the establishment of emergent wetland at the north end of the pond point to substantial infilling even if water depths were overestimated, but little change in water depth was noted between 2004 and 2010 (NEAR 2012).

Hatch Pond experiences both rooted plant nuisance growths and algae blooms dominated by cyanobacteria. Clarity was low through 2006 and there was enough of a thermal difference over the relatively shallow depth to allow moderately stable water layers to develop. Oxygen was lost near the bottom, and the anoxic zone extended upward to depths as shallow as 5 ft (1.5 m). Hatch Pond has long been popular for fishing and rowing, but became virtually unusable during the summer through the combination of rooted plant and algae growths.

South Kent School purchased the Arno Dairy Farm in 2010 and terminated dairy farming; the improvement in water quality in the pond was quickly evident (NEAR 2012). Conditions remained impaired, but decreased loading was documented and water quality increased slightly. Unfortunately,

Figure 1. Map of Hatch Pond area.

Figure 2. Aerial view of Hatch Pond and its immediate area.



the increased clarity allowed plants, most notably the invasive species Eurasian water milfoil (*Myriophyllum spicatum*) to extend into deeper water.

This study was undertaken to assess water quality changes 4 years after conversion of the dairy farm to a sustainable farming operation as part of the South Kent School curriculum. The loss of inputs from the dairy farm is perceived to have substantially lowered nutrient loading, but the importance of other watershed sources and internal recycling from sediment reserves has not been adequately characterized. Evaluation of possible management actions to address water quality issues require greater understanding of existing conditions and nutrient loading than was available prior to this study. A Section 319 grant from the CT DEEP supported this effort. Fuss & O'Neill evaluated watershed conditions and processes, while WRS and NEAR provided inlake assessments. This report covers the inlake portion of the scope of work and resultant watershed projections.

Study Elements

Temperature and oxygen profiles were collected on 9 dates between late April and mid-September, with an emphasis on the spring period, when oxygen demand can be most accurately measured. Additional water quality variables were assessed on 5 dates between April and September of 2014. Phytoplankton and zooplankton were assessed with water quality. Sediment quantity and quality were evaluated in June and July of 2014. Water depths were obtained with sediment probing, allowing a new bathymetric map to be generated. All sampling and analyses were conducted in accordance with an approved Quality Assurance Project Plan (QAPP). The approved QAPP is a separate document but is incorporated into this report by reference and fully explains the methods and approach.

Nutrient loading from internal sources was assessed by multiple approaches to bracket possible loads. Nutrient loading from all sources was estimated as a total based on empirical models that apply inlake concentrations and physical features to generate the loads required to achieve the observed inlake concentration.

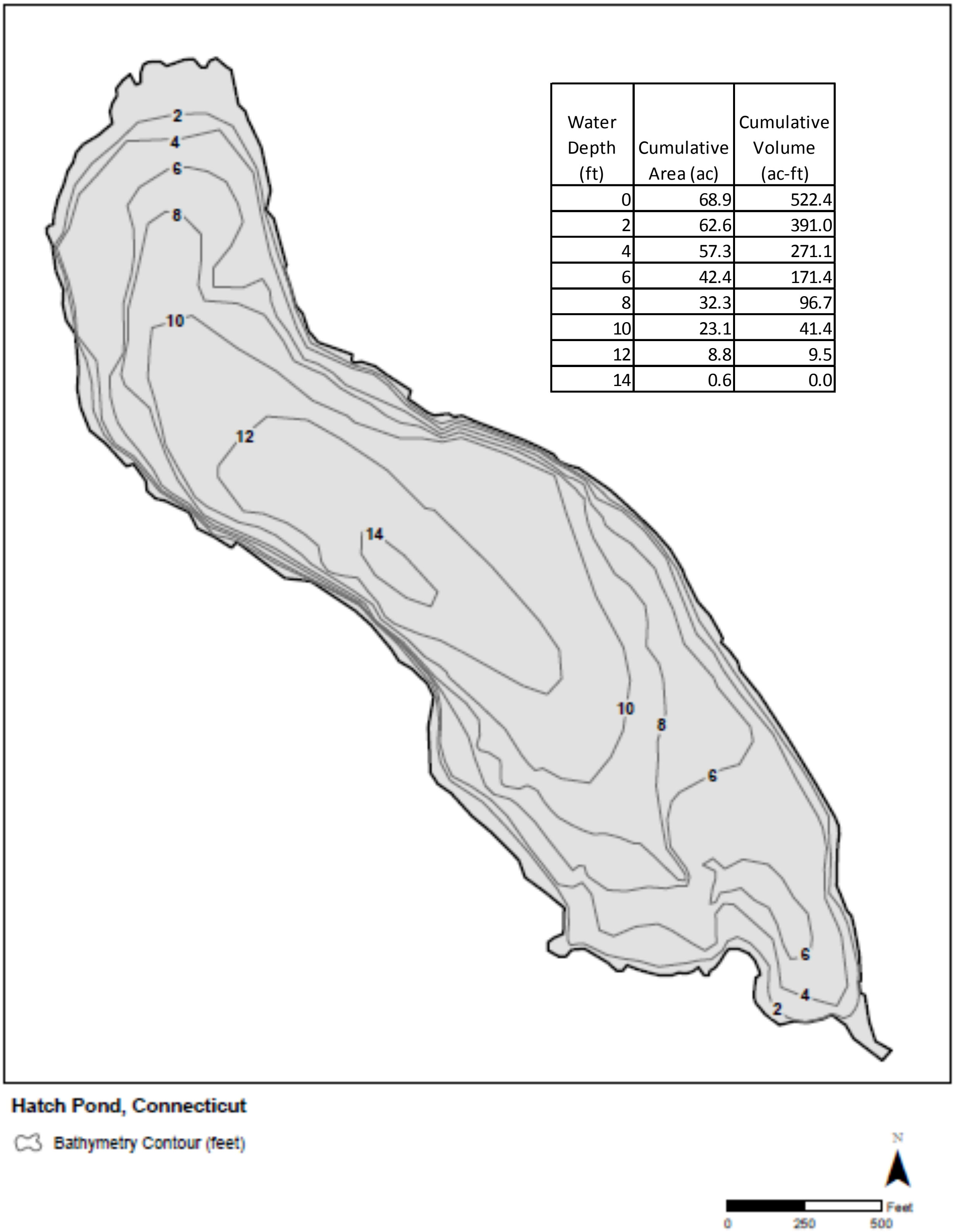
Management options were evaluated in light of current conditions and trends over time.

Physical Pond Features

Current bathymetry of Hatch Pond (Figure 3) indicates a mean depth of 7.6 ft (2.3 m) and a maximum depth of no more than 15 ft (4.5 m). Pond area was measured as 68.9 ac (27.8 ha), within the range of past estimates; changing water level will affect area estimation. Pond volume was calculated as 522.4 acre-feet (645 million m^3). This is similar to conditions observed since 2004 but is dramatically different than the depth contours reported in 1959.

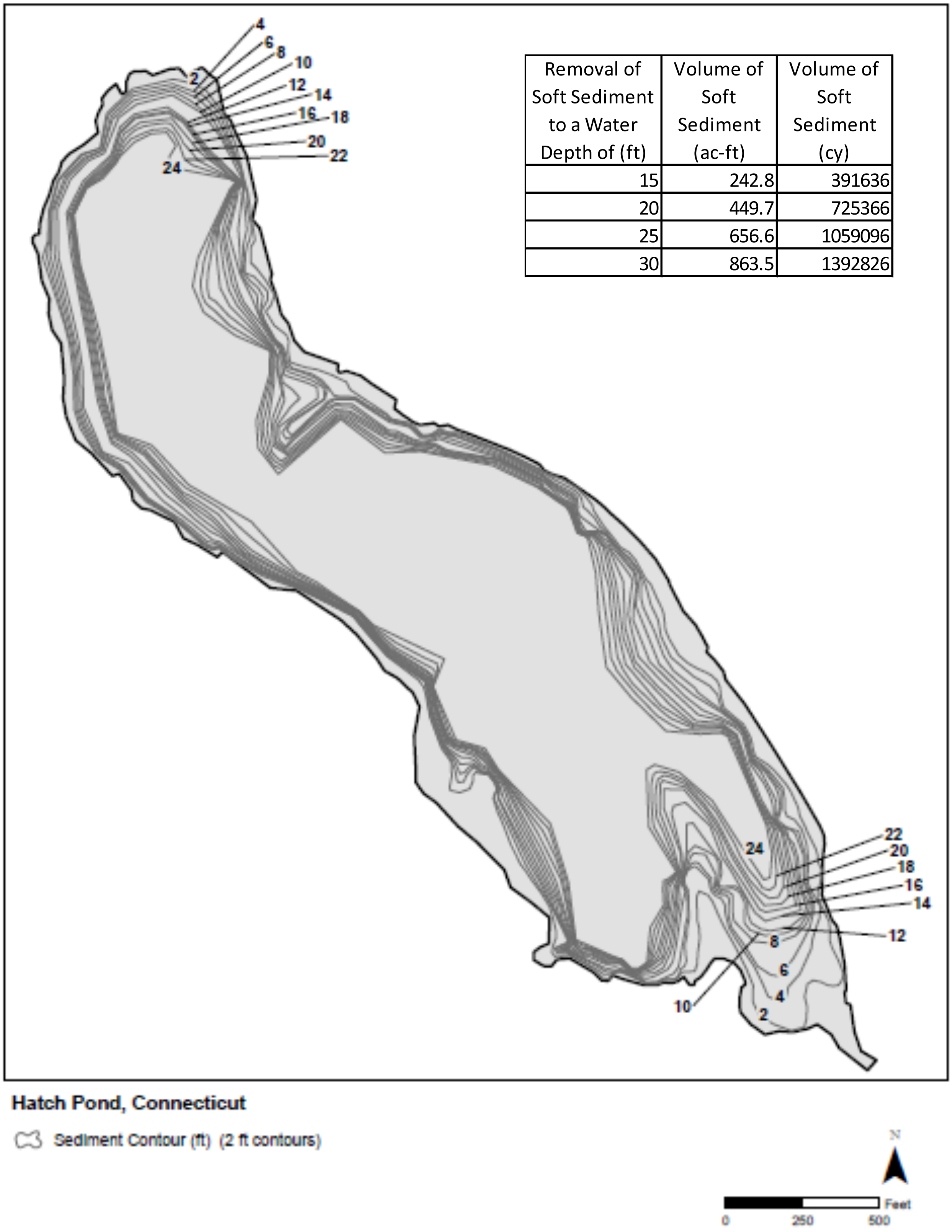
Sediment probing revealed very deep soft sediment deposits (Figure 4). A 40 foot probe did not reach a hard substrate in most central areas, where water depths ranged from 10 to 14 ft. Assuming removal of sediment (dredging) as a management option to achieve water depths of 15 to 30 ft, the associated quantities of sediment range from 392,000 cy to 1,393,000 cy. These are very large quantities of soft sediment for a relatively small water body. The steep slopes observed in the upland topography apparently extended into the pond historically, and sediment has accumulated in the submerged "valley", greatly reducing the original depth, which exceeded 40 ft (12.1 m) in some areas.

Figure 3. Hatch Pond bathymetry as of 2014.



Water Depth (ft)	Cumulative Area (ac)	Cumulative Volume (ac-ft)
0	68.9	522.4
2	62.6	391.0
4	57.3	271.1
6	42.4	171.4
8	32.3	96.7
10	23.1	41.4
12	8.8	9.5
14	0.6	0.0

Figure 4. Hatch Pond soft sediment distribution as of 2014.



Removal of Soft Sediment to a Water Depth of (ft)	Volume of Soft Sediment (ac-ft)	Volume of Soft Sediment (cy)
15	242.8	391636
20	449.7	725366
25	656.6	1059096
30	863.5	1392826

This portion of the overall study did not assess watershed conditions or even inlet conditions, so flow data were not generated. To estimate detention time, a water yield for northeastern watersheds of 1.7 cubic feet per second (cfs) per square mile of watershed (Higgins and Colonel 1972) was applied. With a current watershed area estimate of 2009 acres, this suggests an average flow of 5.3 cfs. Low summer flows may be as low as 0.2 to 0.3 cfs/square mile, suggesting low flows on the order of 0.6 to 1.0 cfs.

Based on the estimated flow through Hatch Pond, the volume of the pond would be replaced 7.4 times per year, indicating a detention time of 49 days on average. During summer low flows the water in the pond may not be replaced even once; summer inflow may be only 40% of the pond volume.

Chemical Pond Features

Water Quality

Temperature and oxygen profiles were collected on nine dates in 2014 (Table 1). Water clarity was assessed with a Secchi disk on each date as well. Conditions were nearly uniform from top to bottom on April 29 and May 7 (Figures 5 and 6), but exhibited development of stratification on May 13 (Figure 7). Mixing by wind or inflow created uniform conditions again on May 20 (Figure 8). From May 27 through September 18, temperature varied from top to bottom, with colder water on the bottom, but the thermal gradient was never strong and resistance to mixing was not large (Figures 9-13). Despite limited stratification, oxygen depression developed near the bottom by May 27 (Figure 9) was similar or slightly less on June 16 (Figure 10), and intensified through July (Figure 11). Oxygen depression was observed at depths >5 ft and oxygen was lower than desirable for aquatic life at depths >7 ft by August 1. Complete oxygen depletion did not occur, but values <1 mg/L occurred at depths >9 ft. These conditions persisted through August (Figure 12), but mixing in September lead to improved but not uniform conditions by September 18 (Figure 13).

Summer of 2014 was fairly mild, with few large storms or wind events. With dense aquatic plant growths and limited summer inflow, vertical mixing in Hatch Pond was limited. Without any true thermal stratification, the pond still managed to lose oxygen from the bottom through decomposition at a rate too rapid for atmospheric re-aeration to counter, and low oxygen conditions were encountered for about two months. This promotes release of phosphorus and other undesirable compounds from bottom sediments, although it is actually the reduction-oxidation (redox) potential that governs that release. As oxygen declines, so does redox potential, with lower redox promoting chemical reactions that liberate phosphorus, iron, manganese, sulfur and other contaminants. Although oxygen cannot decline below 0 mg/L, redox potential continues to decrease and becomes negative, indicating the strength of those chemical interactions. Redox potential was not measured in this study, but may vary over time even after oxygen has reached 0 mg/L.

Water clarity (Table 1) was in excess of 10 ft (3.0 m) through May, but declined in June to 7 ft (2.1 m) and was between 4.3 and 5.3 ft (1.3-1.6 m) for the summer. Most of the loss of clarity was due to algae in the water, but some resuspension of inorganic or non-living organic matter occurs as well and reduces clarity. The relatively higher clarity in spring allows rooted plants to grow, while lower clarity during summer limits additional growths. Past studies have suggested depths of plant colonization between 7 and 9 ft; areas <9ft deep had dense plant growth in 2014, with some growth to depths of 11 ft.

Table 1. Water clarity, temperature, oxygen and thermal resistance to mixing for Hatch Pond in 2014.

Water Clarity									
Date	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
Secchi (m)	3.0	3.8	3.9	3.7	3.0	2.1	1.3	1.6	1.4
Water temperature (C)									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	13.1	15.2	18.9	18.3	23.4	23.3	26.6	25.8	19.5
1	13.1	15.2	18.8	18.3	23.2	23.1	26.5	25.6	19.5
2	13.2	15.1	18.8	18.3	22.5	22.8	25.5	24.7	19.1
3	13.2	15.0	18.7	18.3	21.5	22.4	25.5	24.6	18.9
4	13.2	14.9	18.6	18.3	21.1	21.9	25.2	24.0	18.8
5	13.2	14.5	18.5	18.3	20.6	21.9	24.9	23.7	18.8
6	13.2	14.3	18.4	18.3	20.3	21.7	24.8	23.1	18.8
7	13.2	14.3	18.3	18.3	19.9	21.6	24.6	22.7	18.7
8	13.2	14.2	17.1	18.2	19.5	21.6	24.3	22.6	18.7
9	13.2	14.2	16.6	18.2	19.2	21.4	24.0	22.4	18.7
10	13.2	14.1	16.2	18.2	18.9	21.3	23.8	22.0	18.7
11	13.2	14.1	15.6	18.2	18.6	21.2	23.8	21.7	18.6
12	13.2	14.1	15.2	18.2	18.2	21.0	22.4	21.5	18.3
13	13.1	14.1	15.0	18.2	17.9	20.5	22.0	21.2	18.1
14	13.2	14.1	14.8	18.1	17.6	19.5	21.6	20.9	17.9
15		14.1	14.5		17.3	19.0	20.9		17.9
Dissolved Oxygen (mg/L)									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	10.0	9.8	9.6	8.6	9.9	9.0	9.5	10.7	8.4
1	10.0	9.8	9.6	8.7	9.9	9.0	9.7	11.0	8.4
2	10.0	9.8	9.7	8.7	10.0	9.0	9.7	11.4	8.5
3	10.0	9.8	9.7	8.7	10.6	9.0	9.7	11.4	8.5
4	10.0	9.9	9.7	8.7	10.8	9.0	9.5	11.7	8.5
5	10.0	9.9	9.8	8.7	12.0	8.8	8.2	11.5	8.3
6	10.0	9.9	9.8	8.7	11.9	8.4	6.4	8.6	8.3
7	9.9	9.9	9.8	8.7	11.8	8.4	3.3	4.0	8.3
8	9.9	9.9	8.7	8.7	10.6	8.1	1.1	2.1	8.2
9	9.9	9.9	8.6	8.7	9.8	7.7	0.3	0.8	8.0
10	9.9	9.9	8.5	8.7	6.8	7.1	0.2	0.4	7.9
11	9.9	9.9	7.2	8.7	4.9	6.5	0.1	0.3	6.6
12	9.9	9.8	6.1	8.7	2.1	4.5	0.1	0.3	2.4
13	9.9	9.7	5.5	8.7	1.6	1.8	0.1	0.2	2.6
14	9.9	9.6	4.7	8.6	1.0	0.4	0.1	0.2	0.5
15		9.2	3.7		0.5	0.2	0.1		0.3
Percent saturation of DO									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0	95	98	103	91	116	106	118	131	91
1	95	98	103	92	116	105	121	135	91
2	95	97	104	92	115	105	118	137	92
3	95	97	104	92	120	104	118	137	91
4	95	98	104	92	121	103	115	139	91
5	95	97	105	92	134	100	99	136	89
6	95	97	104	92	132	96	77	100	89
7	94	97	104	92	130	95	40	46	89
8	94	96	90	92	115	92	13	24	88
9	94	96	88	92	106	87	4	9	86
10	94	96	86	92	73	80	2	5	85
11	94	96	72	92	52	73	1	3	71
12	94	95	61	92	22	50	1	3	26
13	94	94	55	92	17	20	1	2	28
14	94	93	46	91	10	4	1	2	5
15		89	36		5	2	1		3
RTRM									
Date/Depth (ft)	4/29/2014	5/6/2014	5/13/2014	5/20/2014	5/27/2014	6/16/2014	8/1/2014	8/27/2014	9/18/2014
0									
1	0	0	2	0	6	6	3	6	0
2	-2	2	0	0	20	9	33	29	10
3	0	2	2	0	28	11	0	3	5
4	0	2	2	0	11	14	10	19	2
5	0	7	2	0	13	0	10	9	0
6	0	4	2	0	8	5	3	18	0
7	0	0	2	0	10	3	6	12	2
8	0	2	27	2	10	0	9	3	0
9	0	0	11	0	7	5	9	6	0
10	0	2	8	0	7	3	6	11	0
11	0	0	12	0	7	3	0	8	2
12	0	0	8	0	9	5	41	5	7
13	2	0	4	0	7	13	11	8	5
14	-2	0	4	2	7	25	11	8	5
15		0	5		7	12	19		0
Total RTRM	-2	20	92	5	158	116	172	145	38

Figure 5. Hatch Pond temperature, oxygen and resistance to mixing profiles: 4/29/14

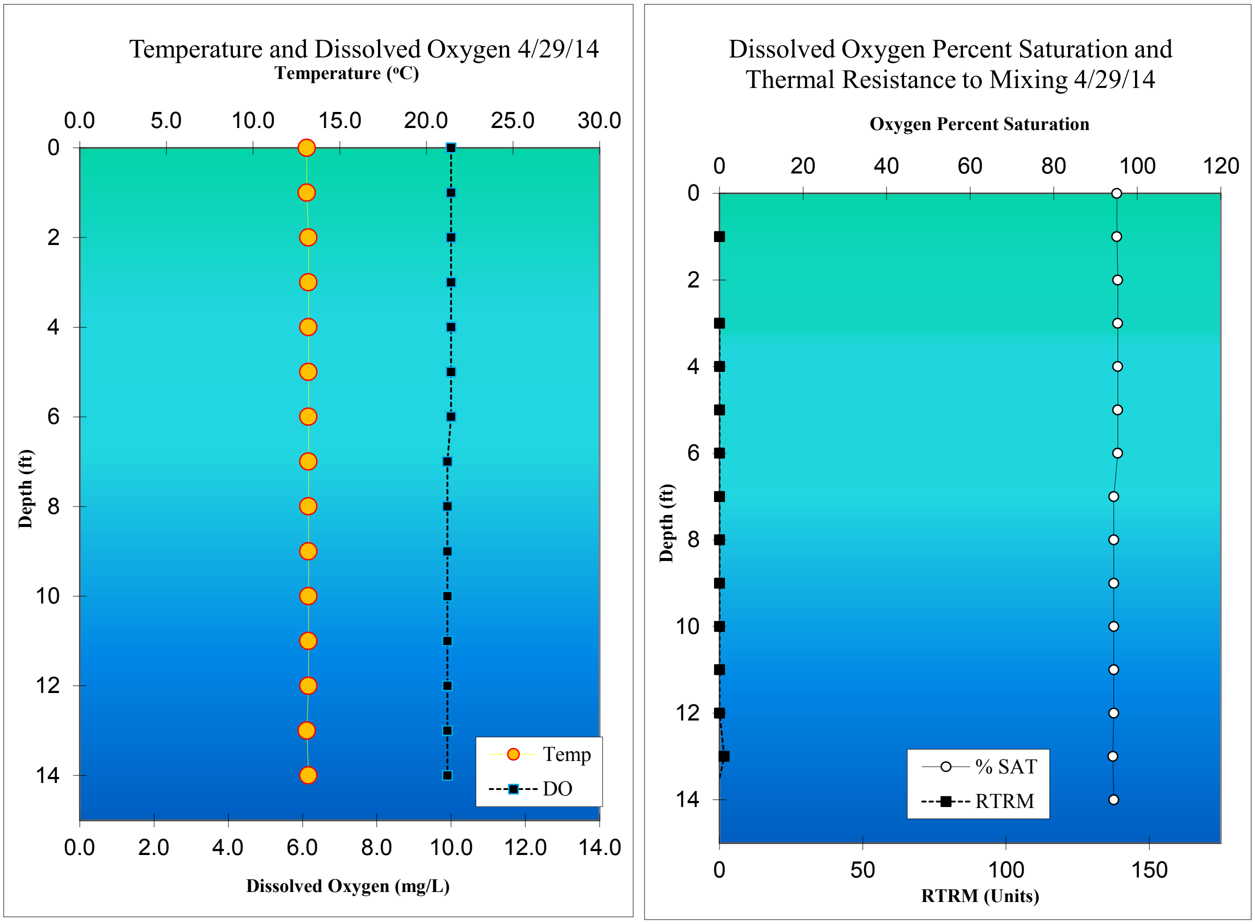


Figure 6. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/7/14

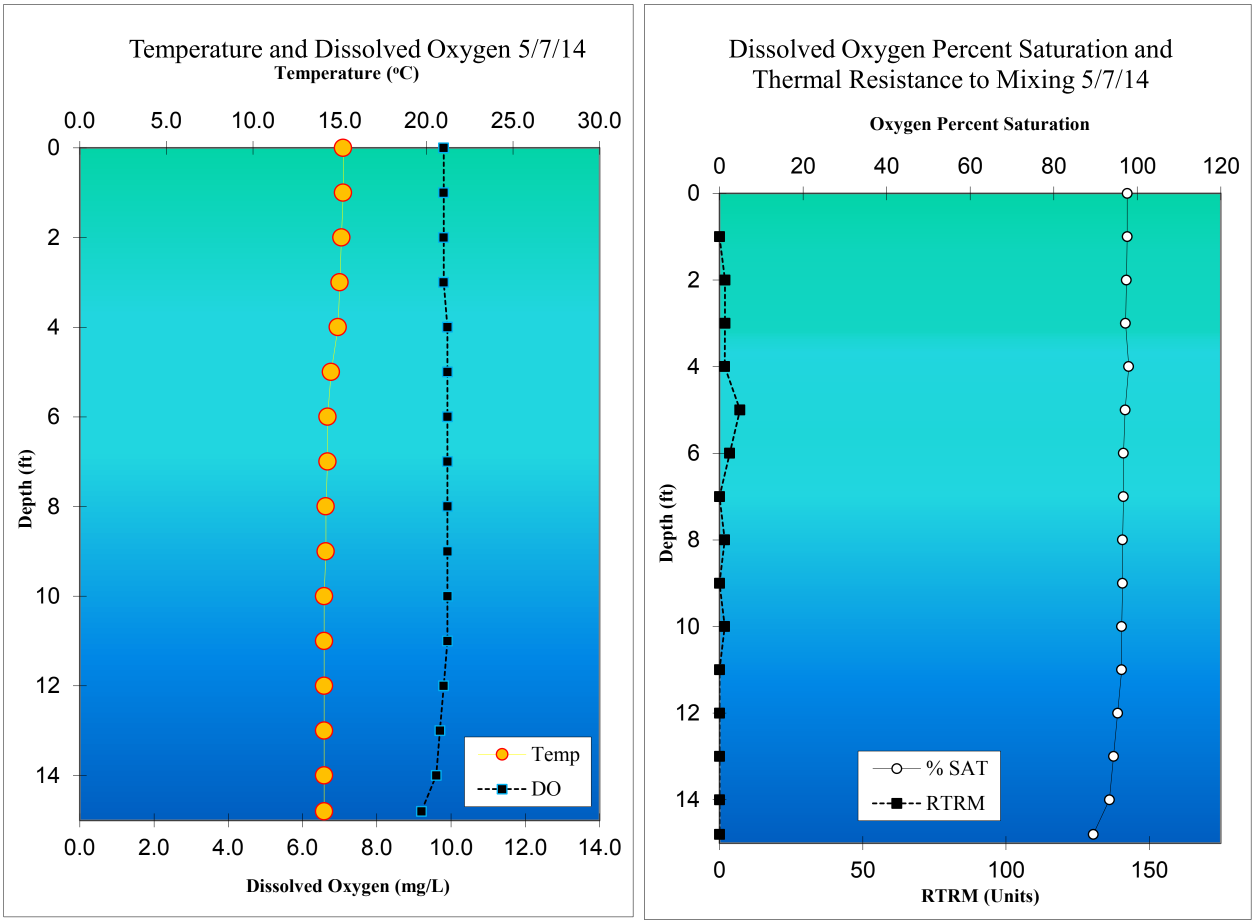


Figure 7. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/13/14

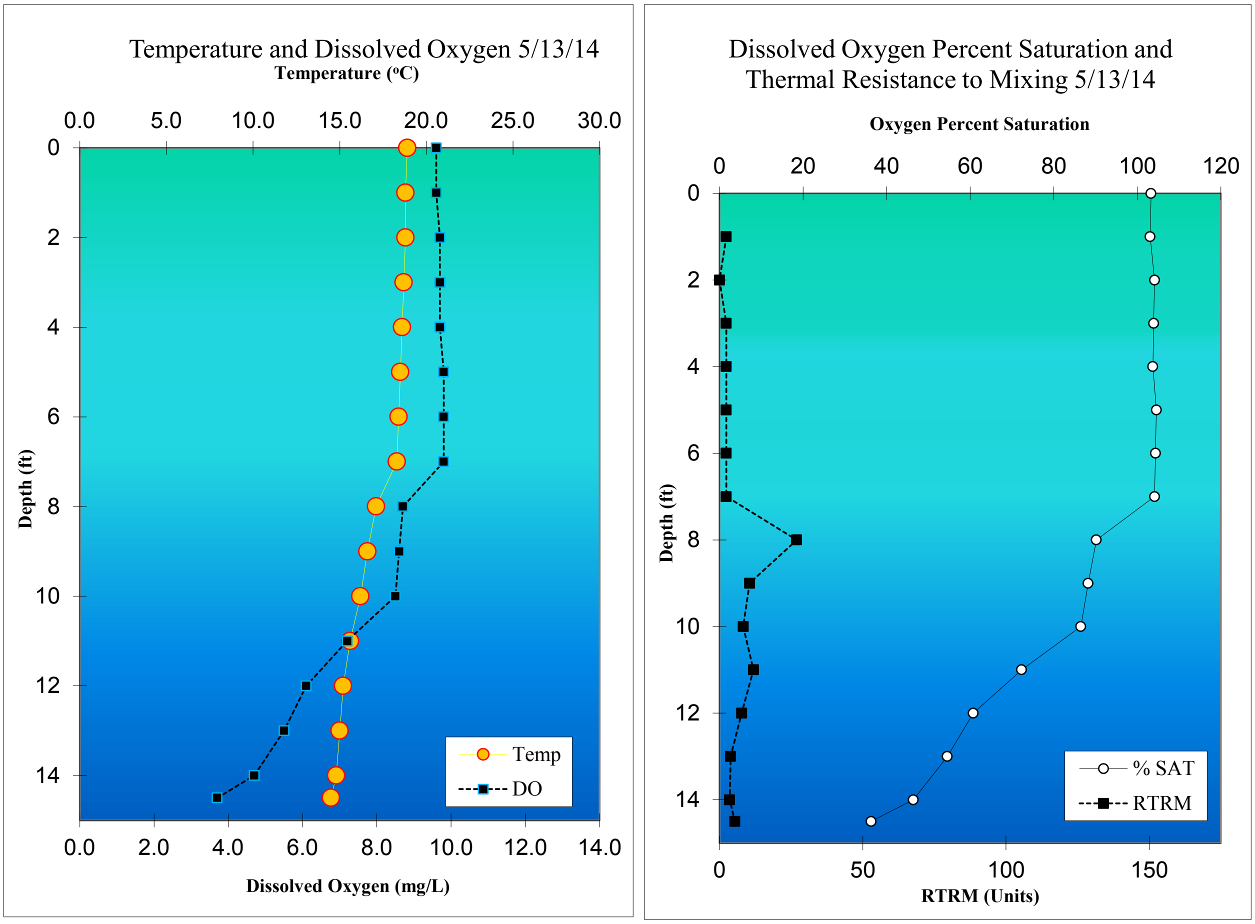


Figure 8. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/20/14

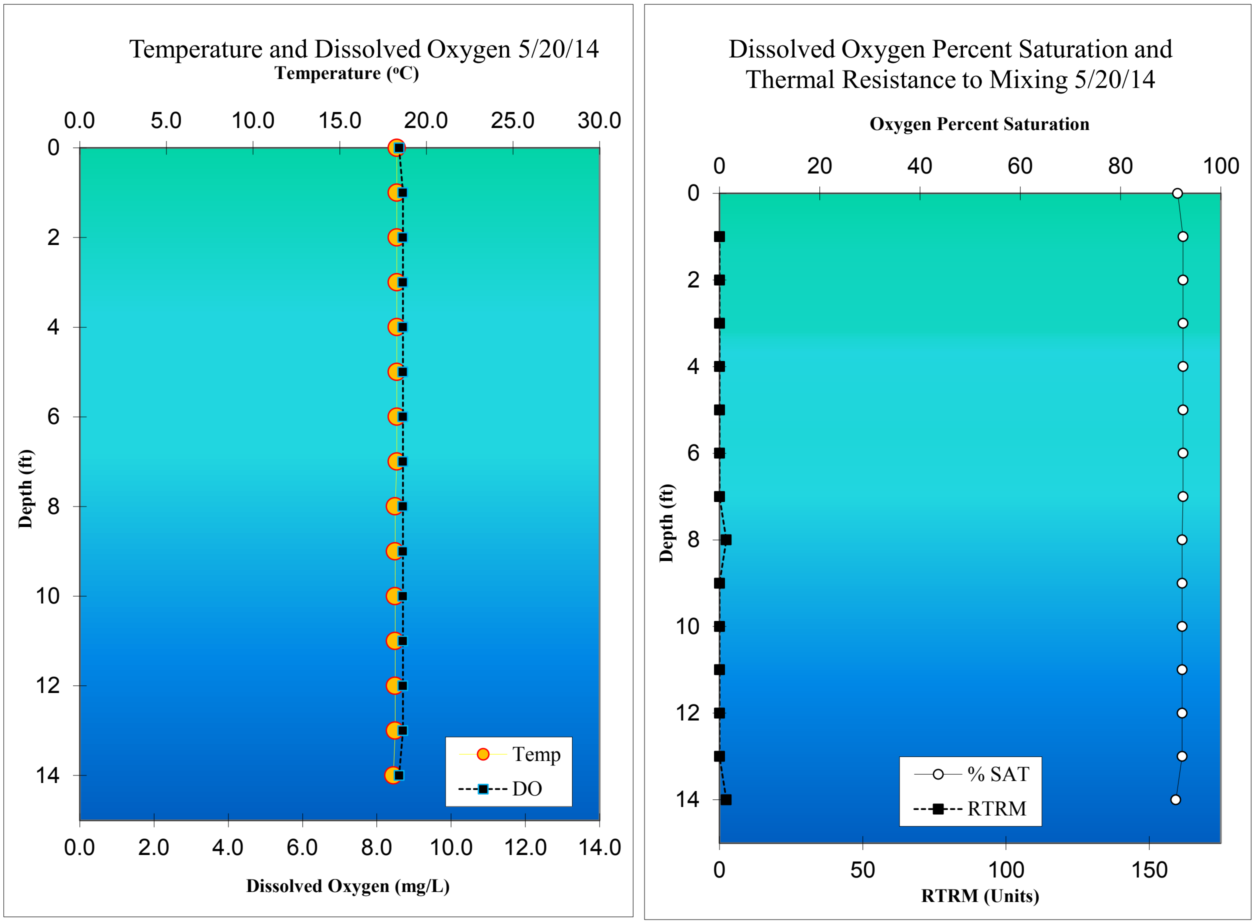
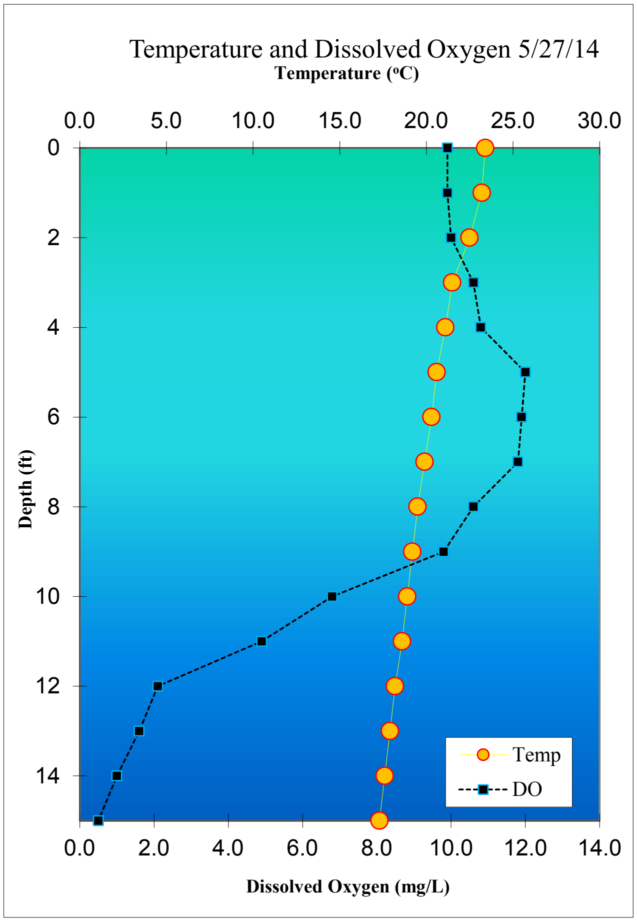


Figure 9. Hatch Pond temperature, oxygen and resistance to mixing profiles: 5/27/14



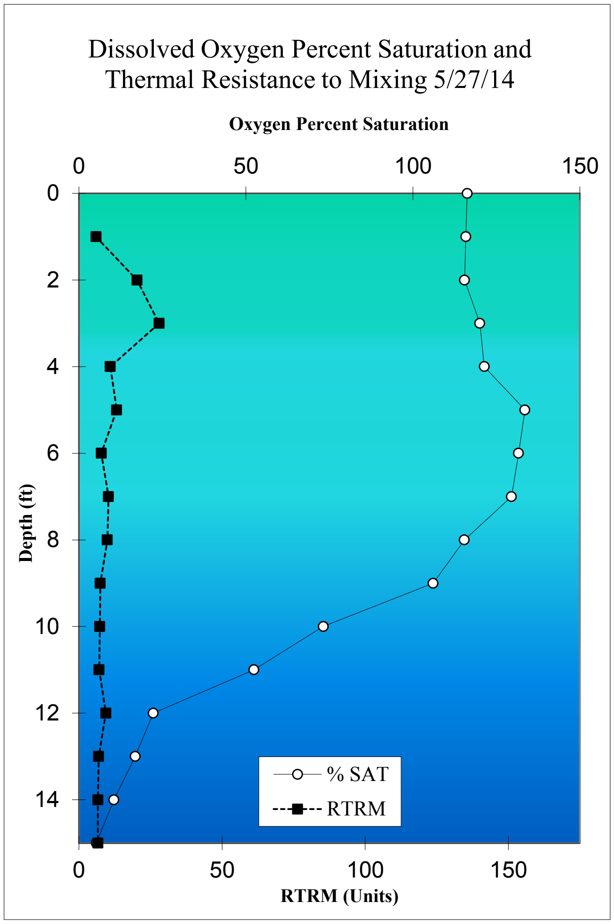


Figure 10. Hatch Pond temperature, oxygen and resistance to mixing profiles: 6/16/14

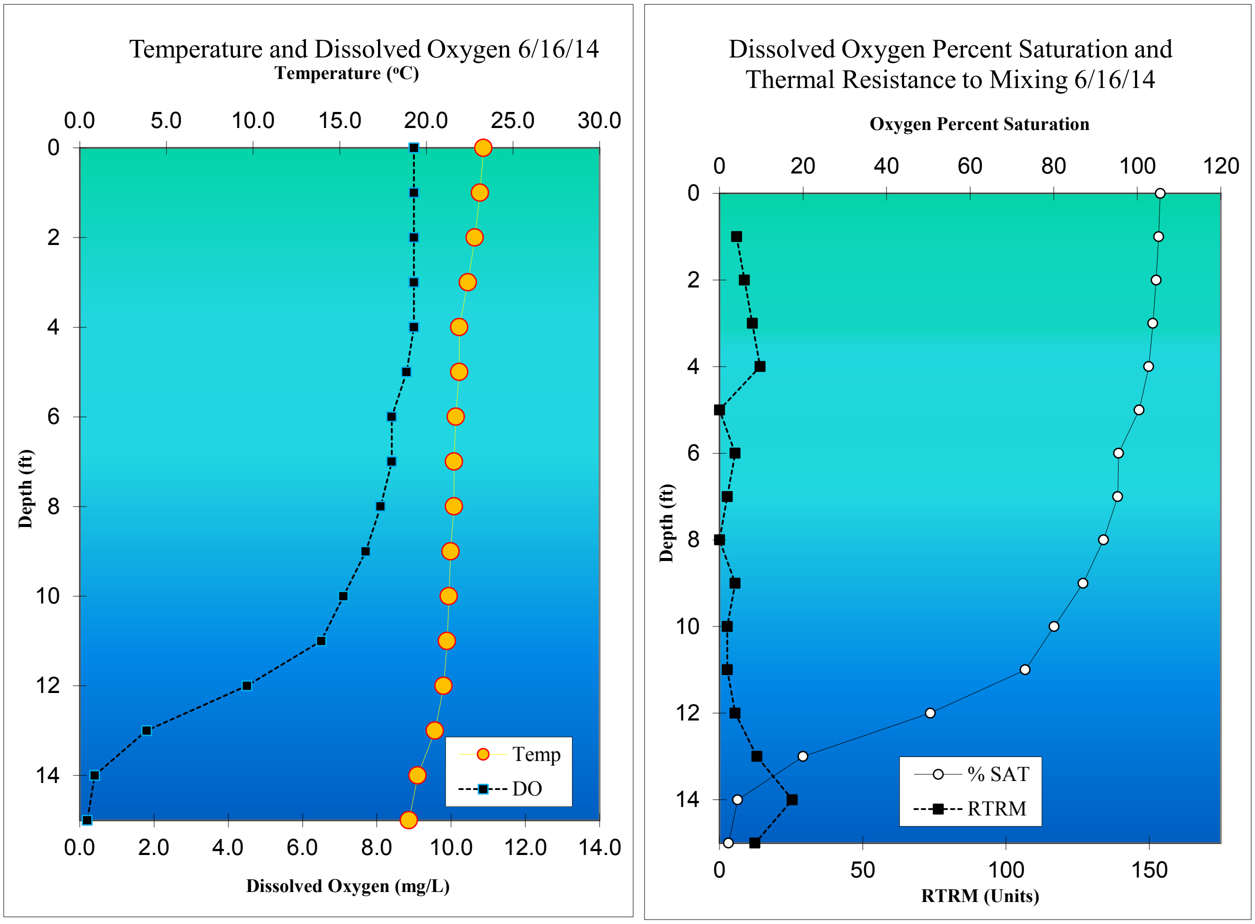


Figure 11. Hatch Pond temperature, oxygen and resistance to mixing profiles: 8/1/14

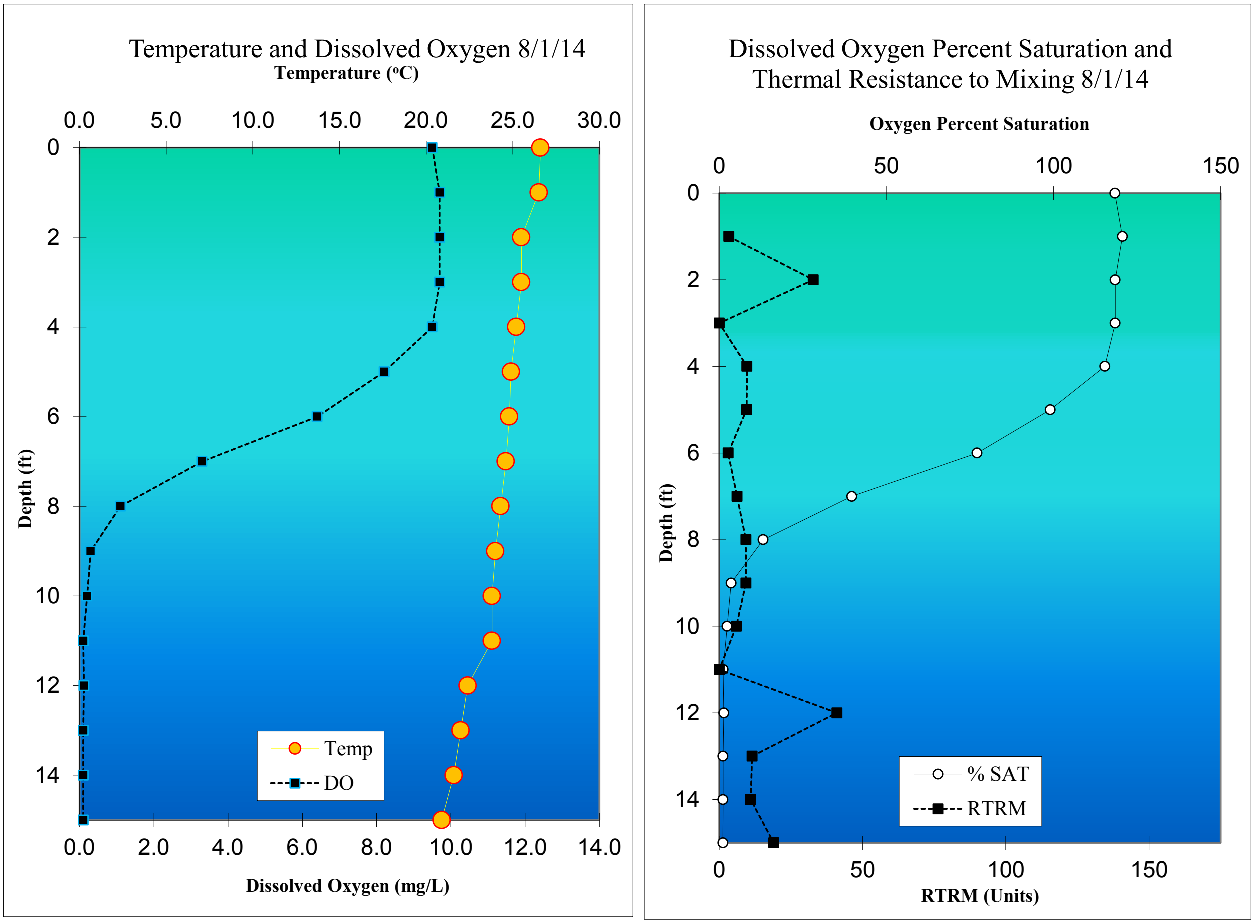
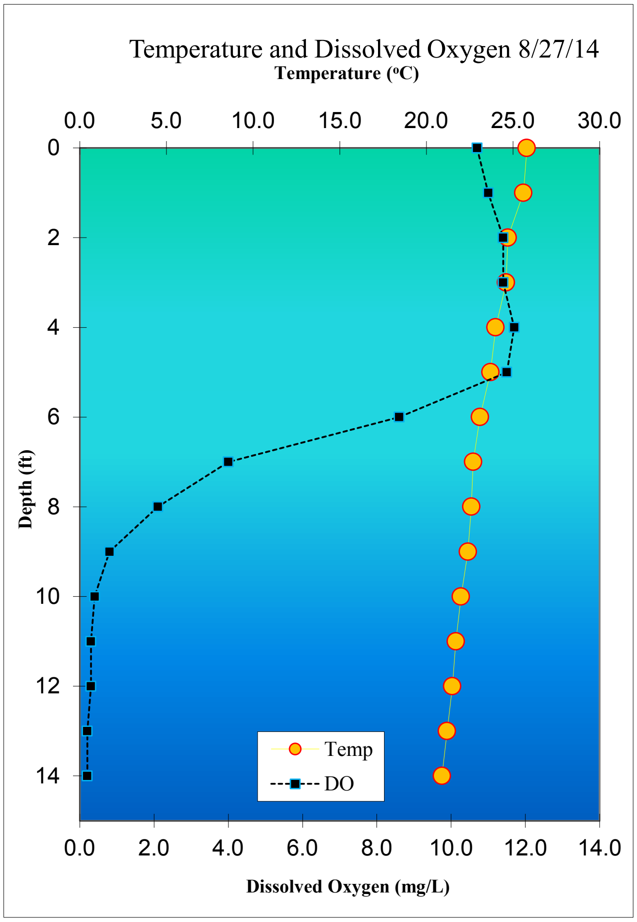


Figure 12. Hatch Pond temperature, oxygen and resistance to mixing profiles: 8/27/14



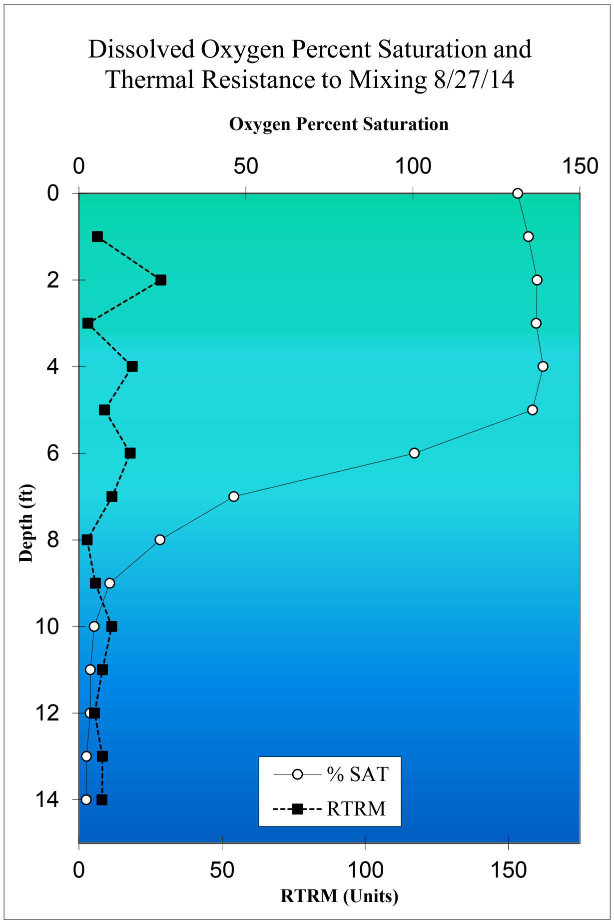
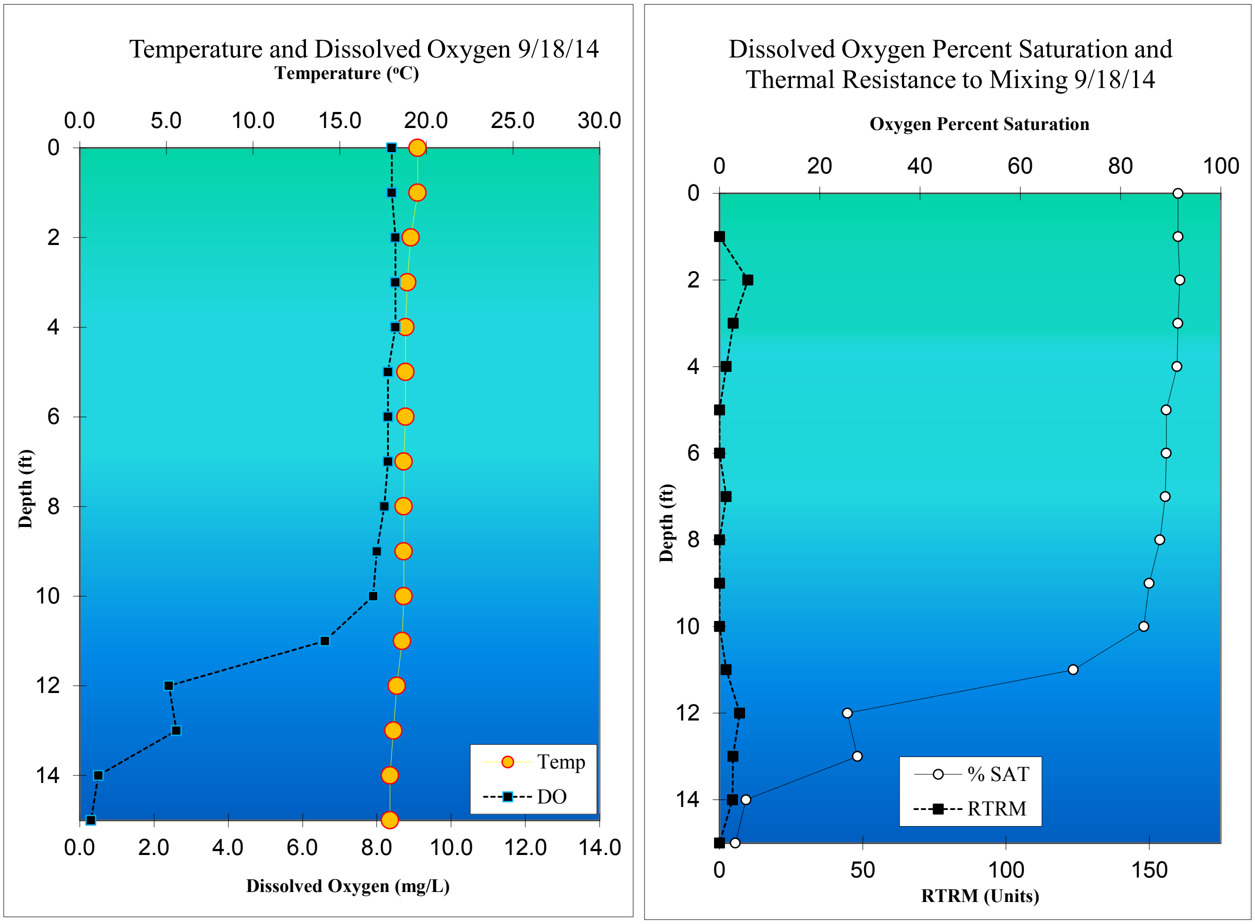


Figure 13. Hatch Pond temperature, oxygen and resistance to mixing profiles: 9/18/14



Nutrient chemistry in 2014 (Table 2) indicates moderate levels of total nitrogen with no strong surface to bottom gradient at any time. Ammonium nitrogen was low to moderate except at the bottom during the period of low oxygen, when it increased to almost 0.9 mg/L by late August. This accumulation is related to both release from sediment and lack of conversion of settling organic particulate nitrogen beyond ammonium to nitrite and nitrate due to oxygen shortage. Nitrate was scarce everywhere all the time; this is not unusual in freshwater aquatic habitats, but does favor cyanobacteria that can utilize dissolved nitrogen gas.

Total phosphorus levels were moderate to high, increasing through the summer and showing an increase from surface to bottom during the period of low oxygen in deeper waters. The summer increase at a time of lower inflow and vertical gradient is indicative of internal release from sediments, although the change is not extreme in 2014. Dissolved P exhibits some increase from spring into summer, but is fairly static through the summer; dissolved P is a subset of total P and is often utilized rapidly when available, so lower and fluctuating values are expected for this water quality variable.

The pH was between 7.2 and 8.4, typical for ponds in this region, and was higher at the surface than at the bottom as a consequence of more photosynthesis near the top (removes CO_2 and increases pH) and more decomposition at the bottom (releases acids that depress pH).