HARMFUL ALGAL BLOOM ACTION PLAN SKANEATELES LAKE

Skaneateles Lake, 2017

www.dec.ny.gov

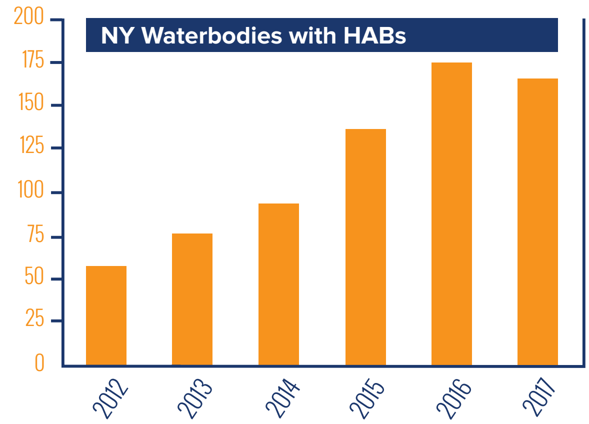
EXECUTIVE SUMMARY

SAFEGUARDING NEW YORK'S WATER

Protecting water quality is essential to healthy, vibrant communities, clean drinking water, and an array of recreational uses that benefit our local and regional economies.

Governor Cuomo recognizes that investments in water quality protection are critical to the future of our communities and the state. Under his direction, New York has launched an aggressive effort to protect state waters, including the landmark $2.5 billion Clean Water Infrastructure Act of 2017, and a first-of-its-kind, comprehensive initiative to reduce the frequency of harmful algal blooms (HABs).

New York recognizes the threat HABs pose to our drinking water, outdoor recreation, fish and animals, and human health. In 2017, more than 100 beaches were closed for at least part of the summer due to HABs, and some lakes that serve as the primary drinking water source for their communities were threatened by HABs for the first time.



GOVERNOR CUOMO'S FOUR-POINT HARMFUL ALGAL BLOOM INITIATIVE

In his 2018 State of the State address, Governor Cuomo announced a $65 million, four-point initiative to aggressively combat HABs in Upstate New York, with the goal to identify contributing factors fueling HABs, and implement innovative strategies to address their causes and protect water quality.

Under this initiative, the Governor's Water Quality Rapid Response Team focused strategic planning efforts on 12 priority lakes across New York that have experienced or are vulnerable to HABs. The team brought together national, state, and local experts to discuss the science of HABs, and held four regional summits that focused on conditions that were potentially affecting the waters and contributing to HABs formation, and immediate and long-range actions to reduce the frequency and /or treat HABs.

Although the 12 selected lakes are unique and represent a wide range of conditions, the goal was to identify factors that lead to HABs in specific water bodies, and apply the information learned to other lakes facing similar threats. The Rapid Response Team, national stakeholders, and local steering committees worked together collaboratively to develop science-driven Action Plans for each of the 12 lakes to reduce the sources of pollution that spark algal blooms. The state will provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

FOUR-POINT INITIATIVE

1. **PRIORITY LAKE IDENTIFICATION**
   Identify 12 priority waterbodies that represent a wide range of conditions and vulnerabilities—the lessons learned will be applied to other impacted waterbodies in the future.

2. **REGIONAL SUMMITS**
   Convene four Regional Summits to bring together nation-leading experts with Steering Committees of local stakeholders.

3. **ACTION PLAN DEVELOPMENT**
   Continue to engage the nation-leading experts and local Steering Committees to complete Action Plans for each priority waterbody, identifying the unique factors fueling HABs—and recommending tailored strategies to reduce blooms.

4. **ACTION PLAN IMPLEMENTATION**
   Provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

TO LEARN MORE ABOUT HABs, VISIT: on.ny.gov/hab www.health.ny.gov/HarmfulAlgae

SKANEATELES LAKE

Onondaga, Cayuga, and Cortland Counties

Skaneateles Lake, an 8,704-acre lake in central New York that is the fifth largest of the Finger Lakes, is one of the 12 priority lakes impacted by HABs. The lake is used for swimming, fishing, boating, and other water recreation. In addition, Skaneateles Lake is the primary drinking water source for the City of Syracuse (since 1894) and also provides drinking water to portions of the towns of DeWitt, Onondaga, Geddes, Camillus, Salina, and Skaneateles, and to the Villages of Skaneateles, Jordan, and Elbridge.

The significant sources of phosphorus loading in the lake are:

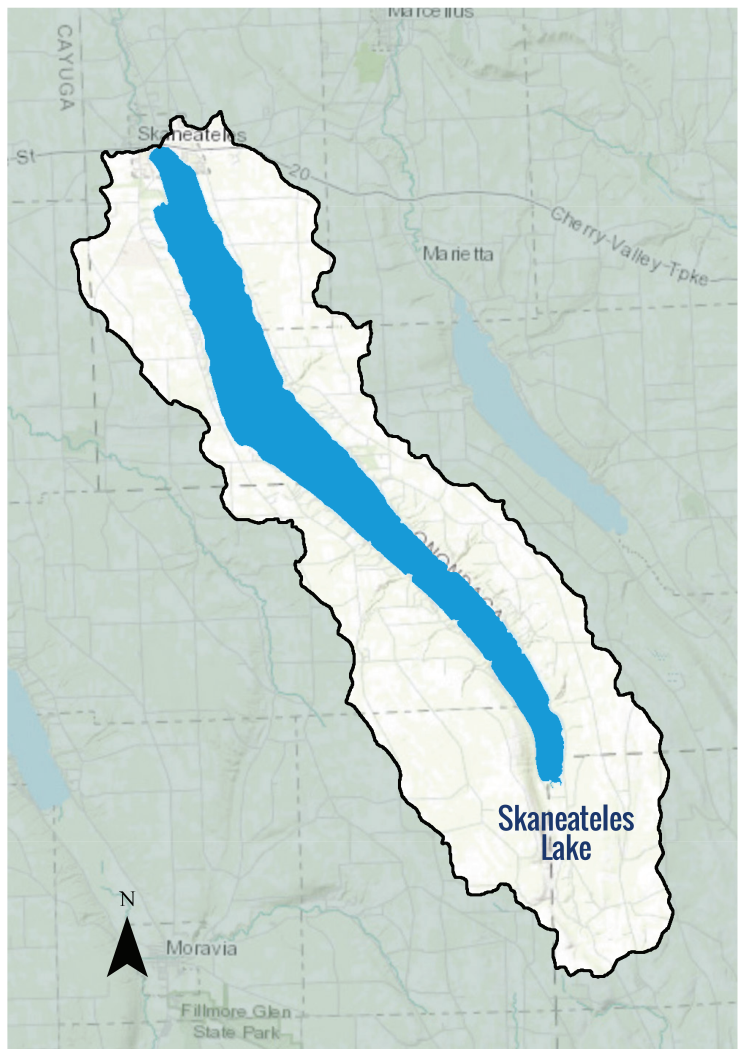
- Non-point source sediment and nutrient inputs from the contributing watershed (e.g., agricultural lands, stormwater runoff from developed lands and road ditches); and
- Stormwater runoff and failing septic systems from developed areas.

There were 4 confirmed HABs occurrences in the lake in 2017, including 2 with blooms that were widespread/lakewide. These likely represented a sustained bloom from mid-September to early October.

Although the causes of HABs vary from lake to lake, phosphorus pollution—from sources such as wastewater treatment plants, septic systems, and fertilizer runoff—is a major contributor. Other factors likely contributing to the uptick in HABs include higher temperatures, increased precipitation, and invasive species.

With input from national and local experts, the Water Quality Rapid Response Team identified a suite of priority actions (see Section 13 of the Action Plan for the complete list) to address HABs in Skaneateles Lake, including the following:

- Perform modeling of in-lake conditions and the contributing watershed to develop a nine element watershed plan;
- Implement runoff reduction Best Management Practices (BMPs) on croplands and non-agricultural lands, and implement a manure injection technology program;
- Continue to implement the program to inspect existing septic systems and provide public outreach about watershed management;
- Implement roadside ditch projects, stabilize riparian habitat, acquire and conserve lands to protect existing buffers, and enhance wetlands; and
- Study the possible extension of and/or additional public water intake into deeper water regions.



The black outline shows the lake's watershed area: all the land area where rain, snowmelt, streams or runoff flow into the lake. Land uses and activities on the land in this area have the potential to impact the lake.

SKANEATELES LAKE CONTINUED

NEW YORK'S COMMITMENT TO PROTECTING OUR WATERS FROM HABS

New York is committed to addressing threats related to HABs, and will continue to monitor conditions in Skaneateles Lake while working with researchers, scientists, and others who recognize the urgency of action to protect water quality.

Governor Cuomo is committed to providing nearly $60 million in grants to implement the priority actions included in these Action Plans, including new monitoring and treatment technologies. The New York State Water Quality Rapid Response Team has established a one-stop shop funding portal and stands ready to assist all partners in securing funding and expeditiously implementing priority projects. A description of the various funding streams available and links for applications can be found here: https://on.ny.gov/HABsAction.

This Action Plan is intended to be a 'living document' for Skaneateles Lake and interested members of the public are encouraged to submit comments and ideas to DOWInformation@dec.ny.gov to assist with HABs prevention and treatment moving forward.

NEW YORK STATE RESOURCES

Drinking Water Monitoring and Technical Assistance:

The state provides ongoing technical assistance for public water suppliers to optimize drinking water treatment when HABs and toxins might affect treated water. The U.S. EPA recommends a 10-day health advisory level of 0.3 micrograms per liter for HAB toxins, called microcystins, in drinking water for young children.

Public Outreach and Education:

The **Know It, Avoid It, Report It** campaign helps educate New Yorkers about recognizing HABs, taking steps to reduce exposure, and reporting HABs to state and local agencies. The state also requires regulated beaches to close swimming areas when HABs are observed and to test water before reopening.

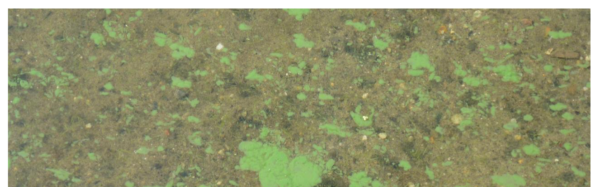
Research, Surveillance, and Monitoring:

Various state agencies, local authorities and organizations, and academic partners are working together to develop strategies to prevent and mitigate HABs. The state tracks HAB occurrences and illnesses related to exposure.

Water Quality and Pollution Control:

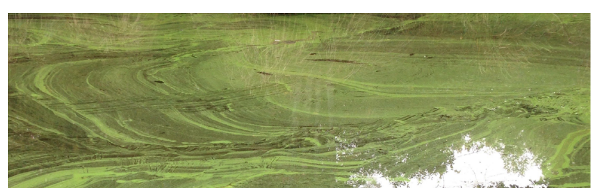
State laws and programs help control pollution and reduce nutrients from entering surface waters. State funding is available for municipalities, soil and water conservation districts, and non-profit organizations to implement projects that reduce nutrient runoff.

Pea soup appearance



Floating dots or clumps

Spilled paint appearance



Streaks on the water's surface

CONTACT WITH HABs CAN CAUSE HEALTH EFFECTS

Exposure to HABs can cause diarrhea, nausea, or vomiting; skin, eye or throat irritation; and allergic reactions or breathing difficulties.

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1. Introduction

1.1 Purpose

New York State's aquatic resources are among the best in the country. State residents benefit from the fact that these resources are not isolated, but can be found from the eastern tip of Long Island to the Niagara River in the west, and from the St. Lawrence River in the north to the Delaware River in the south.

These resources, and the plants and animals they harbor, provide both the State and the local communities a cascade of public health, economic, and ecological benefits including potable drinking water, tourism, water-based recreation, and ecosystem services. Harmful algal blooms (HABs), primarily within ponded waters (i.e., lakes and ponds) of New York State, have become increasingly prevalent in recent years and have impacted the values and services that these resources provide.

This HABs Action Plan for Skaneateles Lake has been developed by the New York State Water Quality Rapid Response Team (WQRRT) to:

- Describe the physical and biological conditions in Skaneateles Lake
- Summarize the research conducted to date and the data it has produced
- Identify the potential causative factors contributing to HABs in Skaneateles Lake
- Provide specific recommendations to reduce the frequency, duration, and intensity of HABs to protect the health and livelihood of its residents and wildlife.

This Action Plan represents a key element in New York State’s efforts to combat HABs now and into the future, both in Skaneateles Lake and in other lakes of similar morphology, hydrology, and background water quality.

1.2 Scope, Jurisdiction and Audience

The New York State HABs monitoring and surveillance program was developed to evaluate conditions for waterbodies with a variety of uses (public, private, public water supplies (PWSs), non-PWSs) throughout the State. The Governor’s HABs initiative focuses on waterbodies that possess one or more of the following elements:

- Serve as a public drinking water supply
- Are highly accessible to the public
- Have regulated bathing beaches

Based on these criteria, the Governor’s HABs initiative has selected 12 New York State waterbodies that are representative of waterbody types, lake conditions, and vulnerability to HABs throughout the State. Skaneateles Lake, with its recreational opportunities, long-standing reverence as a paragon of aesthetic beauty, importance as a long-standing source of unfiltered drinking water, and first documented HAB occurrence in 2017, was selected as one of the priority waterbodies, and is the subject of this HABs Action Plan.

Intended audiences for this HABs Action Plan are as follows:

- Members of the public interested in background information about the development and implications of the HABs program
- The City of Syracuse and Town of Skaneateles as the main water purveyors
- New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), and New York State Department of Agriculture and Markets (NYSDAM) officials associated with the HABs initiative
- New York State agency staff who are directly involved in implementing or working with the NYSDEC HABs Monitoring and Surveillance Program
- Local and regional agencies and organizations involved in the oversight and management of Skaneateles Lake (e.g., Onondaga, Cayuga, and Cortland County Soil and Water Conservation Districts [SWCDs]; Departments of Health [DOHs], Skaneateles Lake Watershed Agricultural Program [SLWAP], the Finger Lakes Land Trust [FLLT], and other land trust organizations)
- Skaneateles Lake Association
- Other Skaneateles Lake conservation and oversight organizations
- Lake residents, managers, consultants, and others that are directly involved in the management of land in the Skaneateles Lake watershed
- Academic and other researchers interested in the water quality of Skaneateles Lake and/or Harmful Algal Blooms

Analyses conducted in this Action Plan provide insight into the processes that potentially influence the formation of HABs in Skaneateles Lake, and their spatial extents, durations, and intensities. Implementation of the mitigation actions recommended in this HABs Action Plan are expected to reduce the occurrence of blooms in Skaneateles Lake.

1.3 Background

Harmful algal blooms in freshwater generally consist of visible patches of cyanobacteria, also called blue-green algae (BGA). Cyanobacteria are naturally present in low numbers in most marine and freshwater systems. Under certain conditions, including adequate nutrient (e.g., phosphorus) availability, warm temperatures, and calm winds, cyanobacteria may multiply rapidly and form blooms that are visible on the surface of the affected waterbody. Several types of cyanobacteria can produce toxins and other harmful compounds that can pose a public health risk to people and animals through ingestion, skin contact, or inhalation. The NYSDEC has documented the occurrence of HABs in Skaneateles Lake, and has produced this HABs Action Plan to identify the primary factors triggering HAB events, and to facilitate decision-making to minimize the frequency, intensity, and duration of HABs as well as the effects that HABs can have on both the users of the lake and its resident biological communities.

2. Lake Background

2.1 Geographic Location

Skaneateles Lake, meaning "long lake" from the Haudenosaunee, is in central New York State, and is the fifth largest of the Finger Lakes (**Figure 1**). The largest community adjoining the lake is the Village of Skaneateles in Onondaga County at the lake's north end, with approximately 7,200 residents. Other municipalities include the Hamlet of Mandana and the Town of Niles (Cayuga County), which lie west of the lake; Spafford (Onondaga County), which spans the lower half of the lake's eastern shoreline; and Scott (Cortland County) and Sempronius (Cayuga County) southeast and southwest of the lake, respectively (**Figure 2**).

Figure 1. Location of Skaneateles Lake within New York State.

2.2 Basin Location

Skaneateles Lake is located within Cortland, Cayuga, and Onondaga counties, within the Oswego River Drainage Basin Series, specifically the Skaneateles Creek Drainage Basin, encompassing approximately 59 square miles (37,760 acres) (SLA 2015).

2.3 Morphology

Skaneateles Lake is 16 miles long with a northwest orientation, a maximum width of 1.5 miles, average width of 0.75 miles and approximately 34 miles of shoreline. The lake is bordered along portions of its length by gorge-like cliffs. It is topographically elevated at 863 feet above mean sea level, and has a surface area of 13.6 square miles (8,704 acres), which is approximately one fourth of the basin area. This relatively low watershed to lake ratio is often associated with higher water retention times, as well as relatively low sedimentation rates and land-based loading of phosphorus. Skaneateles

Lake has a volume of 413 billion gallons, a maximum depth of approximately 96 meters (315 feet) and an average depth of 44.2 meters (145 feet) (NYSDEC 2018) (see **Figure 3**). The deepest waters in Skaneateles Lake are located approximately mid-lake from north to south, offshore of the Hamlet of Mandana, in the lake's central channel. Due to its steeply sloping, "U"-shaped bathymetry, the lake has a small littoral zone (i.e., nearshore zone of full sunlight penetration), and 80% of the lake exceeds 9 meters (30 feet) in depth (Murdock 2010).

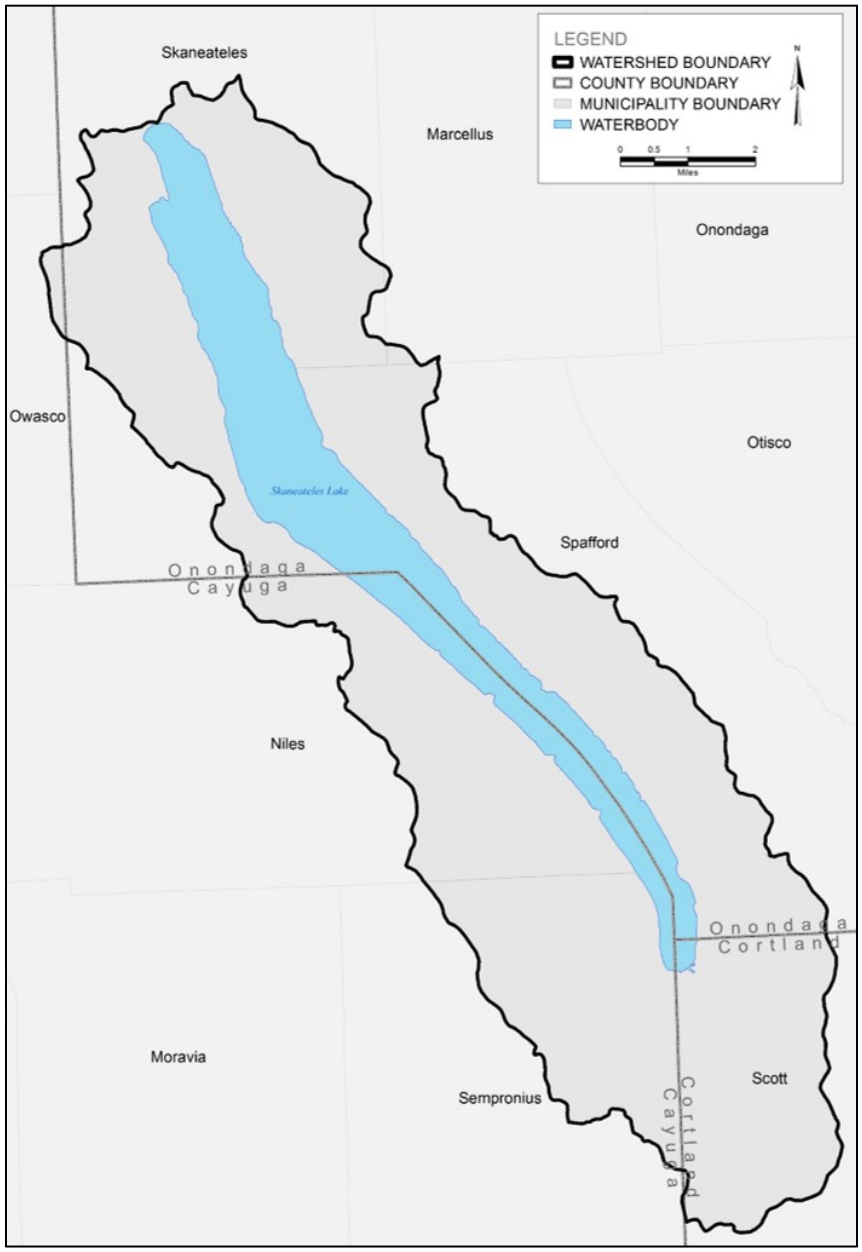


Figure 2. Political boundaries within the Skaneateles Lake watershed.

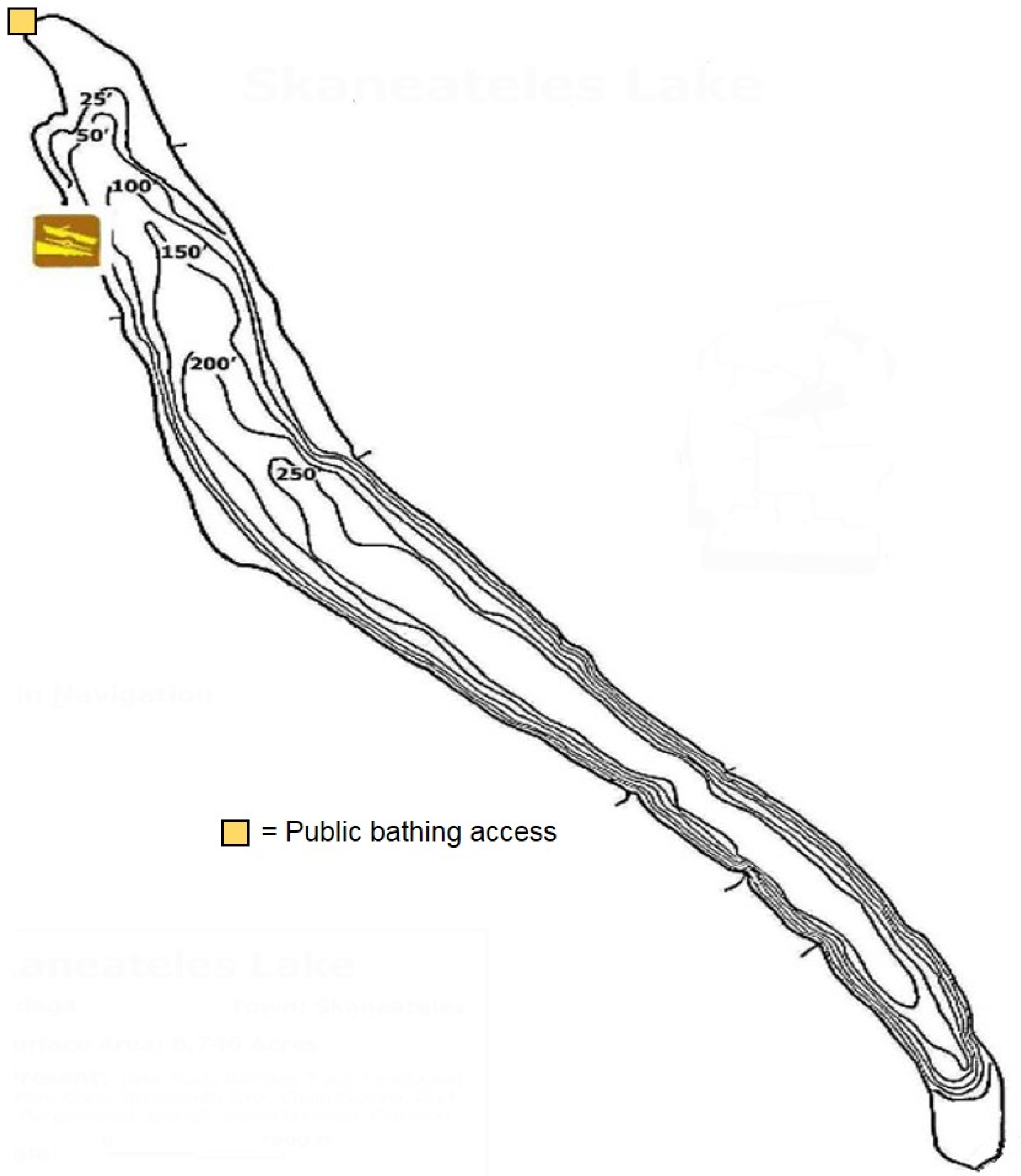


Figure 3. Bathymetric map for Skaneateles Lake (Source: NYSDEC). Public bathing access location depicted (yellow square).

A wind rose for Skaneateles Lake, depicting prevailing winds from 2010 to 2017, during the months of June through November (**Appendix A**), indicates that stronger winds were primarily from the west, as measured at the Syracuse Hancock International Airport. This pattern of prevailing winds can generate large fetch lengths, potentially influencing the spatial distribution of nutrients, algae, and HABs.

2.4 Hydrology

Skaneateles Lake's hydraulic retention time, or the average amount of time it takes water to pass through the lake, is approximately 16 years (NYSDEC 2002) on a fully mixed basis. The lake drains north to the Seneca River which joins the Oneida River downstream of Oneida Lake to form the Oswego River which drains to Lake Ontario. In 2002, the City of Syracuse Department of Water published a watershed map of the lake and its tributaries. According to this map, a total of 150 distinct watercourses, the majority of them high-gradient streams, flow into the lake along the entirety of the lake's shoreline. Six (6) of these tributaries are in Cortland County, 58 in Cayuga County, and 86 in Onondaga County (City of Syracuse 2002). Based on NHDplusV2 (McKay et al. 2012), approximately 80% of the tributaries draining to Skaneateles Lake are first order streams (i.e., a stream that has no permanent tributaries).

The NYSDEC-regulated Skaneateles Lake Dam (NY00414), located on Skaneateles Creek, was constructed in 1902 and is currently owned and controlled by the City of Syracuse. Lake level is controlled through changes in the dam's discharge rate. Approximately 9.0 billion gallons are discharged through the outlet of the lake to Skaneateles Creek annually in order to maintain elevations that satisfy many uses of the lake: public and private water supply, storage for seasonal runoff, fishery spawning areas and recreation. Three criteria are used to determine the rate of discharge through the lake's outlet for lake elevation management: current levels as compared to the drawdown guideline levels, current rates of precipitation, and the amount of water stored in the snowpack.

2.5 Lake Origin

The Finger Lakes, including Skaneateles Lake, were formed more than 2 million years ago during the Pleistocene Epoch. Glacial scouring carved deep slices into the land through the area, moving land and rocks southward. As the ice gradually melted and the glaciers receded, valleys of water dammed by unconsolidated glacial debris were left, which are now the Finger Lakes (Murdock 2010).

3. Designated Uses

3.1 Water Quality Classification – Lake and Major Tributaries

Skaneateles Lake is a Class AA waterbody according to the New York Codes, Rules, and Regulations (NYCRR). Class AA waterbodies are best utilized for drinking water, culinary or food processing purposes, primary and secondary contact recreation, and fishing. Class AA waters, if subjected to approved disinfection treatment, with additional treatment if necessary, will meet New York State Department of Health (NYSDOH) drinking water standards (6 CRR NY 701.5).

Tributaries to the lake have been designated by the NYSDEC as either Class AA or D. Class D waters are best used for aquatic organisms and wildlife survival, as well as primary and secondary contact recreation, but are not conducive to supporting fish propagation due to absence or intermittency of flow conditions, and/or unsuitable water quality or stream bed conditions.

Two primary tributaries to Skaneateles Lake and their corresponding New York State water quality classifications are described below.

- Grout Brook: Originally indexed as Skaneateles Inlet, Grout Brook is a Class AA stream that enters the southern terminus of the lake from the south. Grout Brook is also designated as a trout water (“T”), connoting that water quality standards, guidance values, or thermal criteria specifically related to trout survival are applicable.
- Bear Swamp Creek: This watercourse is also classified as Class AA(T), and originates from an extensive, but narrow, wetland complex in the Town of Niles, southwest of the lake. The creek discharges to Skaneateles Lake from the southwest at Carpenter Point.

In addition, numerous unnamed tributaries may be delivering large quantities of nutrients and sediment during rain events.

Skaneateles Creek, which drains Skaneateles Lake at its northern end, is a Class C(T) watercourse, indicating it is best used for fishing, fish propagation and survival, primary and secondary contact recreation, and must meet water quality standards set for trout survival.

More information about the New York state classification system is provided in **Appendix B**.

3.2 Potable Water Uses

Skaneateles Lake has been the primary source of drinking water for the City of Syracuse since 1894. Currently, it also provides drinking water to portions of the Towns of DeWitt, Onondaga, Geddes, Camillus, Salina, and Skaneateles, and to the Villages of Skaneateles, Jordan, and Elbridge (City of Syracuse 2017). The lake is classified as oligotrophic, characterized by low levels of nutrients and elevated dissolved oxygen, conditions favorable for potable use. The total permitted water withdrawal for the Finger Lakes is approximately 190 million gallons per day (MGD); in 2017, 41.2 MGD was withdrawn from Skaneateles Lake to serve the City of Syracuse water system (City of Syracuse 2017). A Filtration Avoidance Determination has been made and a filtration avoidance waiver issued for Skaneateles Lake by the NYSDOH due to the high quality of water from Skaneateles Lake and watershed protection programs. Approximately 43 MGD (~ 34 MGD used by the City of Syracuse) of unfiltered water is withdrawn from the lake via two 54-inch diameter steel intake pipes located 20 feet and 45 feet below the lake surface, which then flows 19 miles to Syracuse by gravity (SLWAP 2018). Feeder lines to the intakes convey chlorine used to prevent zebra mussel accumulations. The water is filtered only by coarse screens and treated with chlorination and fluoridation prior to reaching the City of Syracuse. Before entering the City's water system for use, the water from Skaneateles Lake is stored in two areas on the west side of the City; one area where the water is stored in two tanks (still referred to as the Westcott Reservoir for the abandoned reservoir that the tanks are located in) and the Woodland Reservoir (an open water reservoir). Before entering the tanks at Westcott Reservoir and exiting the Woodland Reservoir the water is treated using ultraviolet light systems. Copper sulfate is used to suppress algae densities in the Woodland Reservoir. For Skaneateles, withdrawn water from the lake flows from wet wells to reservoirs, where it is treated and gravity-fed to the Village and Town water systems (Village of Skaneateles 2017a). The City of Syracuse has one of the lowest water rates in the state, which is related to the lower cost of treatment of water from Skaneateles Lake.

HABs occurred in Skaneateles Lake in September and October of 2017. Microcystin toxins were detected at the drinking water intake pipes and gatehouse and caused concern to communities using the lake as a source of drinking water. Chlorination was increased at both the intakes and gatehouse, and microcystin was not detected in the distribution system (see **Section 7.2**).

As recommended by the NYSDOH, it is never advisable to drink water from a surface source unless it has been treated by a public drinking water system, regardless of the presence HABs. Surface waters may contain other bacteria, parasites or viruses that can cause illness. If you choose to explore in-home treatment systems, you are living with some risk of exposure to blue-green algae and their toxins and other contaminants. Those who desire to use an intake for non-potable use, and treat their water for contaminants including HABS, should work with a water treatment professional who should evaluate for credible third-party certifications such as National Sanitation Foundation standards (NSF P477; NYSDOH 2017).

The United States Environmental Protection Agency (USEPA) sets health advisories to protect people from being exposed to contaminants in drinking water. As described by the USEPA: "The Safe Drinking Water Act provides the authority for the USEPA to publish health advisories for contaminants not subject to any national primary drinking water regulation. Health advisories describe nonregulatory concentrations of drinking water contaminants at, or below, which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one-day, 10-days, several years, and a lifetime). Health advisories are not legally enforceable federal standards and are subject to change as new information becomes available."

Health advisories are not bright lines between drinking water levels that cause health effects and those that do not. Health advisories are set at levels that consider animal studies, human studies, vulnerable populations, and the amount of exposure from drinking water. This information is used to establish a health protective advisory level that provides a wide margin of protection because it is set far below levels that cause health effects. When a health advisory is exceeded, it raises concerns not because health effects are likely to occur, but because it reduces the margin of protection provided by the health advisory. Consequently, exceedance of the health advisory serves as an indicator to reduce exposure, but it does not mean health effects will occur.

In 2015, the USEPA developed two 10-day drinking water health advisories for the HAB toxin microcystin: 0.3 micrograms per liter (µ/L) for infants and children under the age of 6, and 1.6 µ/L for older children and adults (USEPA 2015). The 10-day health advisories are protective of exposures over a 10-day exposure period to microcystin in drinking water, and are set at levels that are 1,000-fold lower than levels that caused health effects in laboratory animals. The USEPA's lower 10-day health advisory of 0.3 µ/L is protective of people of all ages, including vulnerable populations such as infants, children, pregnant women, nursing mothers, and people with pre-existing health conditions. The NYSDOH has used the health advisory of 0.3 µ/L as the basis for recommendations, and a do not drink recommendation will be issued upon confirmation that microcystin levels exceeds this level in the finished drinking water delivered to customers.

In 2015, the USEPA also developed 10-day health advisories for the HAB toxin cylindrospermopsin (USEPA 2015). Although monitoring for cylindrospermopsin continues, it has not been detected in any of the extensive sampling performed in New York State. New York State HAB response activities have focused on the blooms themselves and microcystin given it is by far the most commonly detected HAB toxin.

Water system operators should conduct surveillance of their source water on a daily basis. If there is a sign of a HAB, they should confer with NYSDOH and NYSDEC as to whether a documented bloom is known. The water system operator, regardless of whether there is a visual presence of a bloom, should also be evaluating the daily measurements of their water system. If there is any evidence—such as an increase in turbidity, chlorine demand, and chlorophyll—then the water system operator should consult with the local health department about the need to do toxin measurement. The local health department should consult with NYSDOH central office on the need to sample and to seek additional guidance, such as how to optimize existing treatment to provide removal of potential toxins. If toxin is found then the results are compared to the USEPA 10-day health advisory of 0.3 µ/L, and that the results of any testing be immediately shared with the public. NYSDOH also recommends that if a concentration greater than the 0.3 µg/L is found in finished water, then a recommendation be made to not drink the water. NYSDOH has templates describing these recommendations that water system operators and local officials can use to share results with customers. Additionally, public water systems that serve over 3,300 people are required to submit Vulnerability Assessment /Emergency Response Plans (VA/ERP); in situations where a water system is using surface waters with a documented history of HABs, NYSDOH will require water system operators to account for HABs in their VA/ERP (which must be updated at least every five years).

3.3 Public Bathing Uses

Clift Park, located along the north shore of Skaneateles Lake (**Figure 3**), is open year-round and contains a bathing beach where swimming is permissible for swimmers when lifeguards are on duty from late-June to late-August (NYFalls.com 2018). Two other private bathing beaches on Skaneateles Lake are located at the Skaneateles Country Club and Lourdes Camp. Wind-driven accumulation of HABs on shorelines during blooms (or locally occurring blooms) have implications for public health, including public swimming locations such as Clift Park and private residence swimming areas.

3.4 Recreation Uses

Skaneateles Lake supports boating, swimming, fishing, birdwatching, hiking, bicycling, and other recreational uses through public and private access. The lake is surrounded by farms, numerous lake shore cottages, and one golf course. There are a few marinas or other commercial facilities along the lake. The overall lack of development within the watershed is purposeful and controls are stringent given that the lake is an important drinking water source for Syracuse and Skaneateles. Steep slopes surrounding the Lake's southern end also limits development in that area.

The Skaneateles Country Club, located along the northwest shoreline of the lake near Mile Point, is a private country club that has a boating center and marina, 18-hole golf course, tennis facilities, and a sailing club. The club's affiliated Skaneateles Sailing Club, located along the northeastern shore of the lake, was formed in 1931, and offers sailing lessons for children age 7-18 years for six weeks during the summer. The sailing club also hosts racing events and periodic regattas for members (SCC 2018).

Shotwell Memorial Park, located adjacent to and west of Clift Park along the lake's north shore, is dedicated to the local area's foreign war veterans. Both Clift Park and Shotwell Memorial Park offer lakeside viewing and fishing opportunities, as well as Village shopping and dining. Thayer Park, located near Clift Park to the east, offers a maintained lawn area with benches for lake side viewing, and fishing. Bahar Nature Preserve, a Finger Lakes Land Trust property, offers fishing and hiking opportunities lakeside and along the Bear Swamp Creek gorge (NYFalls.com 2018).

Boats may be launched from the NYSDEC public boat launch on the west side of the lake, immediately south of the Skaneateles Country Club marina, and at the Skaneateles Marina, located south of country club marina in the Hamlet of Mandana. The Town of Spafford has a public boat launch near the Hamlet of Borodino on the east side of the lake near the Skaneateles Sailing Club. At the lake's south end, the Hamlet of Glen Haven offers a marina, docking, lunch, dinner, and sightseeing cruises, and fishing charters.

3.5 Fish Consumption/Fishing Uses

Similar to other Finger Lakes, Skaneateles Lake is considered a two-story fishery that supports an assemblage of both coldwater and warmwater species, several of which are important recreationally and may be taken for consumption. Sought after species include but are not limited to:

Coldwater

- Atlantic salmon (*Salmo salar*)
- Lake trout (*Salvelinus namaycush*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Brown trout (*Salmo trutta*)
- Cisco (*Coregonus artedi*)

Warmwater

- Largemouth bass (*Micropterus salmoides*)
- Smallmouth bass (*Micropterus dolomieu*)
- Walleye (*Sander vitreus*)
- Chain pickerel (*Esox niger*)
- Yellow perch (*Perca flavescens*)
- Brown bullhead (*Ameiurus nebulosus*)
- White sucker (*Catastomus commersoni*)
- Panfish, including bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), rock bass (*Ambloplites rupestris*), and black crappie (*Pomoxis nigromaculatus*)

Skaneateles Lake is stocked annually with 9,000 Atlantic salmon and 20,000 rainbow trout (NYSDEC 2018). New York State fishing regulations are applicable to Skaneateles Lake, with special minimum size and take provisions for Atlantic salmon, lake trout, brown trout, and rainbow trout for the lake and its tributaries, and prohibition on the taking of alewife (*Alosa pseudoharengus*) (eRegulations 2017).

No fish consumption advisories specific to Skaneateles Lake have been issued by the NYSDOH. Note that a downstream advisory for Skaneateles Creek, from Skaneateles Lake to the Seneca River, has been posted based on elevated polychlorinated biphenyls (PCBs) levels. The creek advisory recommends that men over 15 years of age and women over 50 years of age limit their consumption of brown trout greater than 10 inches in length to no more than one meal per month, and brown trout less than 10 inches in length to no more than four meals per month. Children under 15 and women under 50 are recommended not to eat fish from Skaneateles Creek (NYSDOH 2018a).

3.6 Aquatic Life Uses

Skaneateles Lake is designated as a Class AA water, suitable for fish propagation and survival. Despite providing habitat for salmonid species such as rainbow trout, brown trout, lake trout, and Atlantic salmon, the lake is not designated with the standard “T” (supporting naturally reproducing trout populations) and therefore special requirements for sustaining these sensitive fisheries resources are not applicable. As described above, a variety of both warmwater and coldwater fish species are established in Skaneateles Lake. Lake trout populations have been reported to be relatively stable in the lake; however, the cisco population has declined precipitously since the late 1980s. In 2007, an outbreak of viral hemorrhagic septicemia (VHS) killed Skaneateles Lake smallmouth bass and rock bass (NYSDEC 2018).

Water quality monitoring conducted by the NYSDEC focuses primarily on support of general recreation (in lakes) and aquatic life (in streams and rivers). Although the Waterbody Inventory/Priority Waterbodies List (WI/PWL) assigned a threatened status for Skaneateles Lake, this designation is attributable more to provide a protective measure for its high-quality resources (e.g., drinking water) rather than any previously identified threats (NYSDEC 2008). No impairment of aquatic life uses in the lake has been identified.

Careful management of the sport fishery in Skaneateles Lake coupled with the absence of observable impairment to the aquatic life use in the lake suggests that the fish assemblage and its potential cascading regulating effects on lower trophic levels (e.g., zooplankton) is not a driver for HABs formations in the lake. However, the presence of common carp (*Cyprinus carpio*), an invasive cyprinid in the lake that forages on benthic macroinvertebrates in lakebed sediments, can increase sediment suspension and associated nutrients in the water column based on its feeding behavior. The increased suspended sediment in the water can be comprised of nutrients that may be utilized by blue green algae, which can lead to HABs (see **Section 6.3**).

3.7 Other Uses

Many taxa of birds and mammals rely on Skaneateles Lake and its shoreline as high quality foraging, roosting, and nesting habitat. While resident birds stay in the area year-round, the majority are found seasonally during breeding and migration seasons. Herons, loons, grebes, ducks, and geese are often observed utilizing the lake’s resources. Mammals that depend on the lake for foraging and den habitat include muskrat, mink, beaver, and river otter.

4. User and Stakeholder Groups

Skaneateles Lake is used by all age groups, including fulltime and seasonal homeowners of more than 1,000 lakeside properties, homeowner guests, day or extended stay recreationists, private clubs, and tourists. These user groups may engage in one or several of the recreational activities described in **Section 3.4**. Access to the lake is available to the public at several entry points, including marinas and public boat launches. Shoreline residents and their guests may also access the lake directly via private docks, piers, and boat launches.

The Skaneateles Lake Association (SLA), formed in 1969, comprises part-time and full-time residents of the Skaneateles Lake community. The SLA is a non-profit organization dedicated to preserving the current and future integrity of the lake and its watershed. In October 2017, a few weeks following the HAB that occurred in the lake, the SLA developed a Four Point Action Plan consisting of the following elements (SLA 2017):

1. Nutrient management committee: study and implement control of runoff/nutrient loading into the lake; develop and ensure the implementation of a plan to reduce the input of nutrients into Skaneateles Lake to levels that will greatly reduce the probability of a HAB.
2. Community involvement committee: focuses on short-term and long-term practices individual stakeholders can implement to maintain and improve the health of the lake; promote education and outreach; develop a best management practices (BMPs) booklet as a guide for citizen stakeholders' efforts to support lake health.
3. Watershed governance committee: study and develop a governance structure for implementing a watershed management plan to protect Skaneateles Lake. The governance structure would be designed to facilitate collaboration among the counties, towns, and the village in the watershed and the City of Syracuse to develop and implement an integrated, unified watershed management plan to protect the health of the lake.
4. SLA fundraising: establish a reserve fund to address specific issues related to HABs and invasive species as they arise, and to support the staffing of a full-time SLA executive director whose responsibilities would include watershed coordination activities in the watershed, promoting education, and serving as SLA liaison for all lake stakeholders.

Other lake stakeholder groups include the following:

- The Finger Lakes Land Trust (FLLT) is a non-profit organization comprising members, landowners, and volunteers whose mission is "...to conserve forever the lands and waters of the Finger Lakes region, ensuring scenic vistas, local foods, clean water, and wild places for everyone." The FLLT was founded in 1989 and has created four conservation preserves along the shoreline of Skaneateles Lake, including (FLLT 2018):
  - Bahar Preserve, a 51-acre forested gorge-dominated parcel, as discussed in **Section 3.4**.
  - Hinchcliff Family Preserve, a 206-acre hardwood-hemlock forested parcel heavily used for agriculture historically, and located along the southeast shoreline in Spafford.
  - Dickinson Conservation Area, a formerly agricultural, now heavily forested high bluff shoreline 21-acre tract located north of the Hinchcliff Preserve.
  - High Vista Preserve, a 139-acre forested hillside parcel located south of Hinchcliff Preserve.

- Sustainable Skaneateles is a group of Skaneateles town and village residents whose mission is to foster communication, education, collaboration, and action for achieving a sustainable community, including Skaneateles Lake, for current and future generations. Sustainable Skaneateles periodically sponsors events that raise awareness of threats to lake health, including HABs (Sustainable Skaneateles 2018).
- Finger Lakes-Lake Ontario Watershed Protection Alliance (FLLOWPA) stems from conservation efforts dating back to the mid-1980s, and facilitates processes that encourage partnerships and action plans to protect and enhance water quality through the sharing of information, data, resources, and approaches (FLLOWPA 2018).
- The FLRWA was formed in 2010 and is a collaboration between nine lake and watershed organizations representing the Finger Lakes whose mission is to preserve and protect the region's watersheds (FLRWA 2018).
- The SLWAP, which is described in **Section 12**.

5. Monitoring Efforts

5.1 Lake Monitoring Activities

Monitoring on Skaneateles Lake has been conducted as part of the Citizens Statewide Lake Assessment Program (CSLAP) from 1997-2001 and then again in 2017.

From 1997 to 2001, CSLAP monitoring efforts (**Figure 4**) were conducted at one location (139), near the center of the lake. In 2017, sampling was conducted at two locations in the northern (139.1) and southern (139.2) sections of the lake.

Other data collections conducted in Skaneateles Lake include the NYSDEC Disinfection By-Products (DBPs) Study (Callinan et al. 2013) in 2004, Finger Lakes Synoptic Water Quality Investigation (SWQI) in 1996, 1997 and 1999, the Finger Lakes Institutes Finger Lakes Survey (FLI/FLS) (Halfman 2017), and monitoring conducted by Upstate Freshwater Institute (UFI) in 2007, 2008, 2011, 2014 and 2017 on behalf of the Town of Skaneateles. In addition to these recent monitoring efforts, water quality in the Finger Lakes was investigated during the 1910s (Birge and Juday 1914) and 1960's and 1970s (Bloomfield 1978). The City of Syracuse conducts numerous tests of Skaneateles Lake water to monitor quality and to verify compliance with state and federal requirements. The monitoring program includes seven primary components: phytoplankton, bacteria, turbidity, chlorine residuals, organic and inorganic chemicals and radionuclides. Onondaga County also conducts monitoring.

Water quality summary reports are being developed for each Finger Lake and for the entire Finger Lakes region, including comparisons to historical NYSDEC data, as part of extended CSLAP reporting.

The DBPs study was conducted in 2004 in response to the USEPA initiation of a National Nutrient Strategy (USEPA 1998) that called on states to establish a numeric nutrient criteria (NNC). A total of 21 lakes, including Skaneateles Lake, were included in the NYSDEC DBPs study, which focused on lakes designated as potable water supplies. Nutrient enrichment in lakes used as potable water supplies are associated with increases in human health-risk factors such as increased generation of DBPs and production of cyanotoxins by certain species of cyanobacteria (Callinan et al. 2013). Sampling efforts focused on total phosphorus, chlorophyll-a, dissolved organic carbon (DOC), and the total trihalomethanes formation potential (THMFP - a measure of DBPs). The DBPs sampling efforts were conducted near the northern basin of the lake, to the south of CSLAP location 139.1 (**Figure 4**).

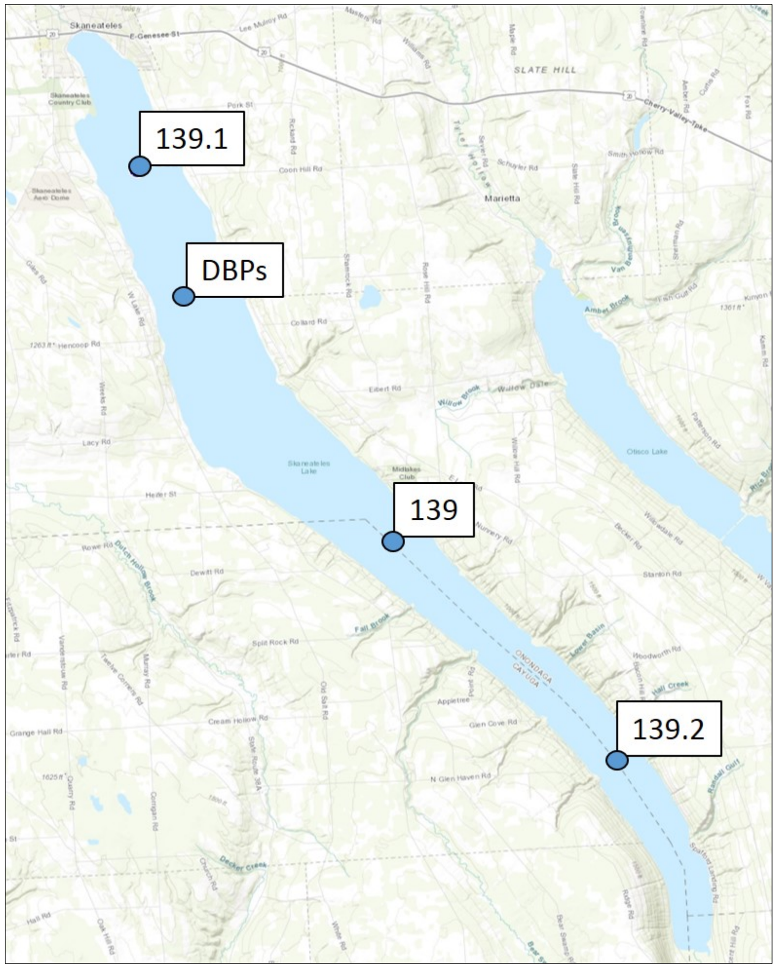


Figure 4. Map of Skaneateles Lake with CSLAP and DBPs sampling locations.

The NYSDEC Finger Lakes study in the late 1990s was an attempt to replicate comparative investigations of the Finger Lakes not conducted systematically on all eleven Lakes since at least 1970. This study included sediment coring and monthly water quality monitoring from 1996 to 1999 on at least one sample site per lake, as well as comparisons of water quality data to historical NYS sampling results.

The NYSDEC collects data as part of the Lake Classification Inventory (LCI) program to support water quality assessments and management activities, including identifying and responding to HABs. The LCI data set for Skaneateles Lake includes monthly samples collected in 2004 from May to September. Data collected during the LCI for Skaneateles Lake included depth profiles and monthly measurements of water quality parameters from just below the water surface, including:

- Surface water temperature

- Dissolved oxygen
- pH
- Specific conductivity
- Oxidation reduction potential
- Phosphorus (total)
- Nitrogen (total, dissolved total, and nitrogen oxides)
- Chlorophyll-a
- Calcium

UFI conducted monitoring programs in Skaneateles Lake in 2007, 2008, 2011, 2014, and 2017 to document seasonal and long-term patterns in water quality conditions. Both in-situ and laboratory measurements were made to assess thermal stratification, trophic state, and optical characteristics. Monitoring was conducted monthly, typically from April to October, at multiple sites and depths. The monitoring efforts were funded by the Town of Skaneateles.

The eight eastern most Finger Lakes have been sampled by Hobart William Smith College and the Finger Lakes Institute since 2005. This work involves monthly sampling from May through September sampling at least two sites per lake for several water quality indicators, plankton tows, and depth profiles. This program did not operate under a Quality Assurance Project Plan (QAPP) or laboratory certification under the NYS Department of Health (DOH) Environmental Laboratory Approval Program (ELAP), so these data cannot be used for this NYSDEC water quality assessment.

5.2 Tributary Monitoring Activities

Monitoring of nutrient and bacterial levels in Grout Brook, Bear Swamp Creek, Shotwell Brook, and the Harold Brook sub-watersheds was conducted to evaluate the efficacy of agricultural BMPs for maintaining water quality of contributing streams to the lake. The intent of this monitoring, conducted under the cooperative Project Watershed CNY, was to inform decisions regarding the continuance of rural BMPs in these sub-watersheds based on their effectiveness at minimizing agricultural runoff and nutrient flux to the tributaries and to the lake (Owusu-Ansah 2009).

A United States Geological Survey (USGS) gaging station is present on the lake's outlet stream, Skaneateles Creek, approximately 6 miles north (downstream) of the lake. Discharge and gage height are recorded at this station (USGS 2018). No USGS gaging stations are present on the lake's inflowing tributaries.

The Upstate Freshwater Institute conducted extensive monitoring of Shotwell Brook, a tributary in the northeastern section of the lake's watershed, during 2016 and 2017. The Institute presents its annual water quality findings for Shotwell Brook and portions of the lake to the Town of Skaneateles.

6. Water Quality Conditions

General long-term trends in water quality conditions were assessed using available data collected at locations depicted in **Figure 4**. Trends were evaluated using a nonparametric correlations coefficient (Kendall's tau, τ) to determine if time trends were significant (assumed for p-values less than 0.05). Water quality data used in this analysis were generally limited to those that were collected under a State-approved Quality Assurance Project Plan (QAPP) and analyzed at an ELAP-certified laboratory. Note that long-term trends presented below are intended to provide an overview of water quality conditions, and that continued sampling and analysis of data will better inform trend analyses over time.

In addition to CSLAP data, water quality data collected through the DBPs (2004) program, the SWQI (1996, 1997, and 1999), and UFI monitoring (2007, 2008, 2011, 2014 and 2017) were used to perform long-term trends analyses (all NYSDEC data sources).

Table 1. Regional summary of surface TP concentrations (mg/L, ± standard error) for New York State lakes (2012-2017, CSLAP and DBPs) and the average TP concentration (± standard error) in Skaneateles Lake (12 years [n = 131] between 1996 and 2017, CSLAP, DBPs, and UFI).

Region	Number of Lakes	Average TP (mg/L)	Average TP Skaneateles Lake (mg/L) 1996-2001, 2004, 2007-2008, 2011, 2014, and 2017
NYS	521	0.034 (± 0.003)	-
NYC-LI	27	0.123 (± 0.033)	-
Lower Hudson	49	0.040 (± 0.005)	-
Mid-Hudson	53	0.033 (± 0.008)	-
Mohawk	29	0.040 (± 0.009)	-
Eastern Adirondack	112	0.010 (± 0.0004)	-
Western Adirondack	88	0.012 (± 0.001)	-
Central NY	60	0.024 (± 0.005)	-
Finger Lakes region	45	0.077 (± 0.022)	-
Finger Lakes	11	0.015 (± 0.003)	0.004 (± 0.0002)
Western NY	47	0.045 (± 0.008)	-

In freshwater lakes, phosphorus is typically the nutrient that limits algal growth; therefore, when excess phosphorus becomes available from point or nonpoint sources, algal growth may be stimulated leading to algal blooms (although other factors influence overall productivity, e.g., light availability). Note that phosphorus form is an important consideration when evaluating management alternatives (**Section 13**).

The data provided in **Table 1** indicate that the TP concentration in Skaneateles Lake has historically been much lower compared to other Finger Lakes, and lakes within the Central New York region. In fact, phosphorus levels in Skaneateles Lake are usually among the lowest in the state. Additionally, the average TP concentration for Skaneateles Lake is approximately 5-times less than the New York State water quality guidance value of 0.02 mg/L for lakes. Thus, targeted TP concentrations for Skaneateles Lake likely need to be lake-specific, and below the Statewide threshold of

0.02 mg/L, when considering future management actions to limit the frequency and duration of HABs.

Skaneateles Lake is typically considered oligotrophic with low susceptibility to HABs. A summary of HABs in the lake is provided in **Section 7**. The presence of HABs in the lake in 2017 has raised concerns about long-term water quality and public health. Lake water clarity (based on Secchi depth), TP, and chlorophyll-a concentrations are used to assess trophic state using New York State criteria (**Table 2**). These indicators continue to reflect oligotrophic conditions in 2017.

Table 2. New York state criteria for trophic classifications (NYSFOLA 2009) compared to average 2017 values (± standard error) in Skaneateles Lake (CSLAP and UFI).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Skaneateles Lake (2017)
Transparency (m)	>5	2-5	<2	7.3 (± 0.6)
TP (mg/L)	<0.010	0.010-0.020	>0.020	0.005 (± 0.0003)
Chlorophyll-a (μg/L)	<2	2-8	>8	1.2 (± 0.1)

6.1 Physical Conditions

Water clarity can be related to the amount of suspended material in the water column including suspended sediment and phytoplankton. Water clarity data collected in Skaneateles Lake between 1997 and 2017 (**Figure 5a**) were typically greater than 6 m, indicating low productivity. Across all sample locations, average annual (p = 0.337, τ = -0.212) and the annual minimum water clarity (p = 0.681, τ = 0.091) trend analyses did not indicate significant long-term trends. Although long-term trends are difficult to identify from available data, average annual water clarity in 2017 (7.3 ± 2.7 m) was lower than the observed average between 1996 to 2014 (8.6 ± 2.2 m).

In 2017 (**Figure 5b**), water clarity dropped in June through early July, but increased later in July and into August before slightly decreasing again in late September and October. Drastic declines in water clarity in early July were likely related to high runoff due to heavy storm events around this time. These rain and runoff events were captured by multiple data collection programs:

- A Glenhaven Rd. (Sempronius) rain gauge maintained by the City of Syracuse captured rain events of 2.86 inches, 4.85 inches and 4.32 inches from June 4 to 6, June 30 to July 1 and July 11 to July 14, respectively.
- The July 1st event provided less (though still substantial) precipitation to the north end of the Lake where approximately 3.05 inches fell (Skaneateles, NY, station USC00307780 - NOAA National Center for Environmental Information, https://www.ncdc.noaa.gov/cdo-web/).
- These events caused severe flooding and likely resulted in increased runoff entering Skaneateles Lake. For example, the July 1 event was also captured in the United States Geological Service (USGS) stream gauge data from the Owasco Inlet (closest location to Skaneateles Lake) located in Moravia, NY. These stream gauge data indicated that this storm increased flow rates to a

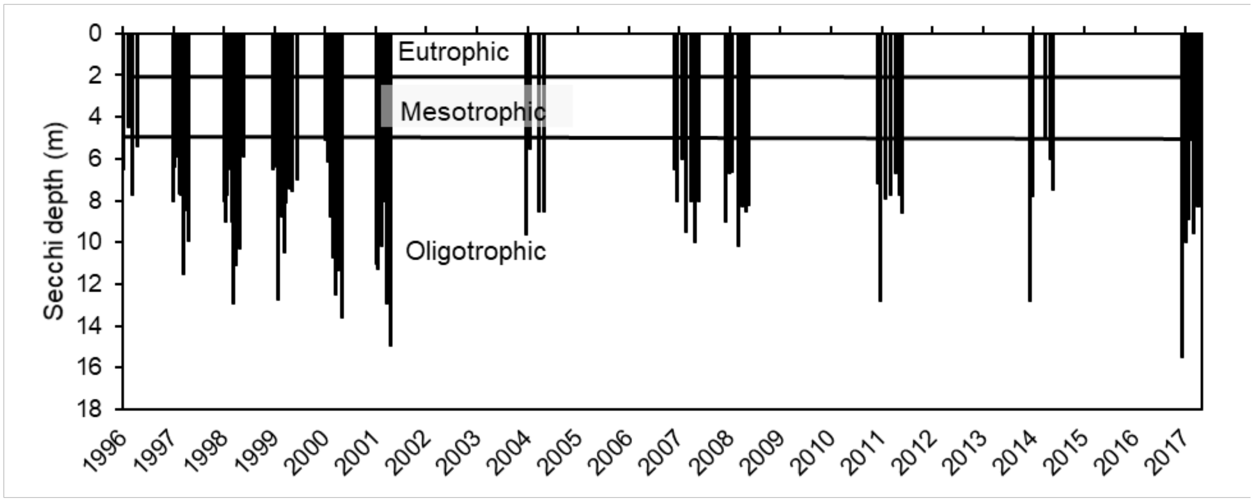
record high (records kept since 2009) of 4,220 cubic feet per second (cfs). These flow rates are nearly double the typical high spring flow rates which range between 2,000 and 3,000 cfs. Runoff events likely have had a direct effect on water clarity by increasing suspended sediment in the water column and indirectly by increasing algal growth.

Current data (1997-2017) suggest an increase in water clarity in the lake since the 1970s (Bloomfield 1978, average = 6.6 m). In 1910, water clarity measured in Skaneateles Lake was found to be 10.3 m (Birge and Juday 1914), similar to measurements observed between 1997 and 2001. The FLI began water clarity monitoring for Skaneateles Lake in 2005, and although the data do not indicate large changes, 2014 and 2015 did see a slight decrease in water clarity. This decrease was attributed to more turbid water potentially caused by an increase in early spring precipitation (Halfman 2017). All CSLAP Secchi disk transparency readings have exceeded the 1.2-meter (4 ft.) New York State Sanitary Code requirements for siting new bathing beaches (NYSDOH 2018). However, water clarity should continue to be monitored to document any changes over time.

Understanding temperature changes within a waterbody both within a season and among years is important to understanding HABs. Most cyanobacteria taxa grow better at higher temperatures than other phytoplankton which give them a competitive advantage at higher temperatures (typically above 77°F [25°C]) (Paerl and Huisman 2008). A non-significant decreasing trend in average growing season (June to October) water temperature ($p = 0.060$, $\tau = -0.497$) from 1996 to 2017 (sample size = 10) was observed in Skaneateles Lake, although, no trend in maximum temperature was observed ($p = 1.0$, $\tau = 0.0$). In 2017, warmer air temperatures between 26.7°C to 32.2°C (80°F to 90°F) in the region in late September (recorded at NOAA weather station in the City of Auburn) were above the 95th percentile for these days over the last 50 years, and likely resulted in increased lake surface water temperatures in late September and early October (**Figure 6b**). The City of Syracuse also recorded changes in lake surface water temperature; these data showed that 2017 late September surface water temperatures, up to approximately 75°F, were the highest on record (data collected since 2004). This temperature was approximately two degrees higher than the next highest surface water temperature on record and approximately 10 degrees higher than the median value for late September. These warmer temperatures coincided with the reporting of confirmed HABs (see **Sections 7** and **9**).

Temperature depth profiles for 2017 indicate that thermal stratification was strong in Skaneateles Lake throughout the growing season (May-September) (**Figure 7**). These profiles do not indicate any mixing events during the growing time-period, and the observed temperature profile in 2017 was typical for Skaneateles Lake dating back to 2005 (Halfman 2017).

a.



b.

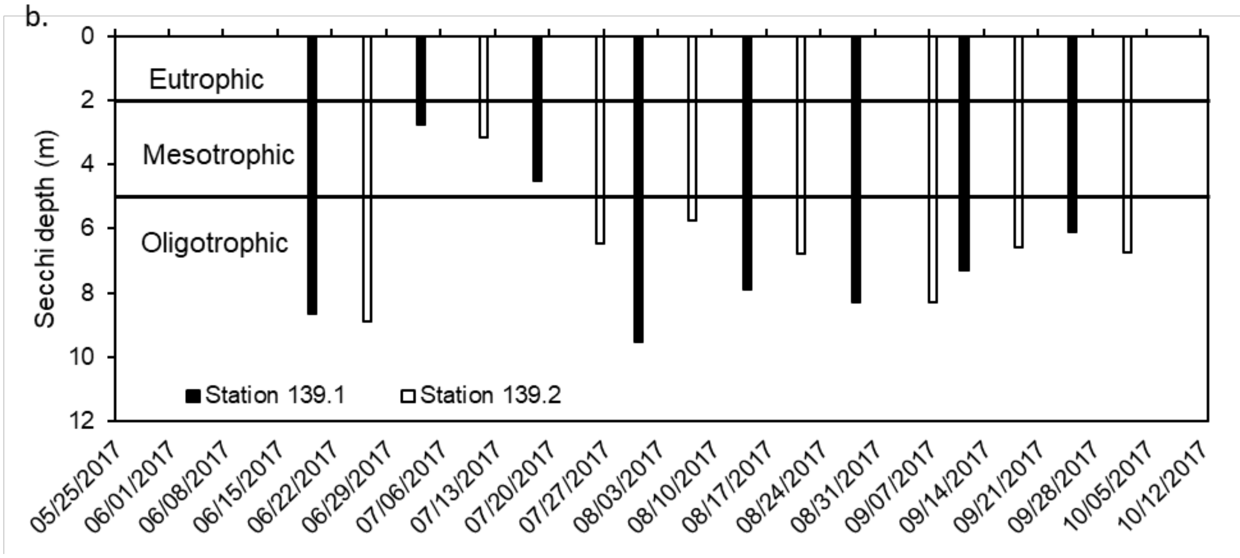
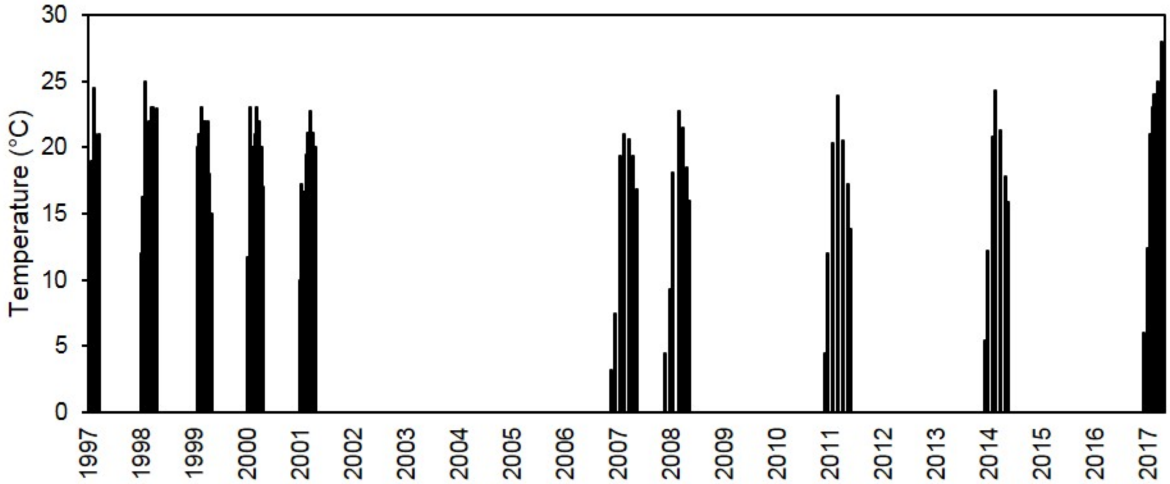


Figure 5. (a) Long-term (1996-2017) and (b) current (2017) water clarity, measured as Secchi depth (m), for Skaneateles Lake. Stations 139.1 (north site) and 139.2 (south site) are in the northern and southern portions of Skaneateles Lake, respectively.

a.



b.

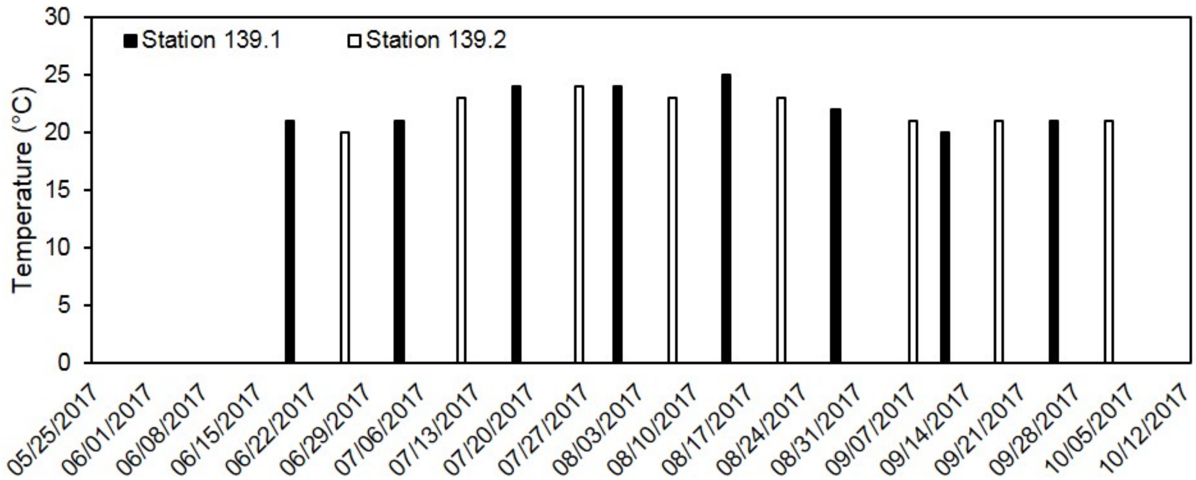
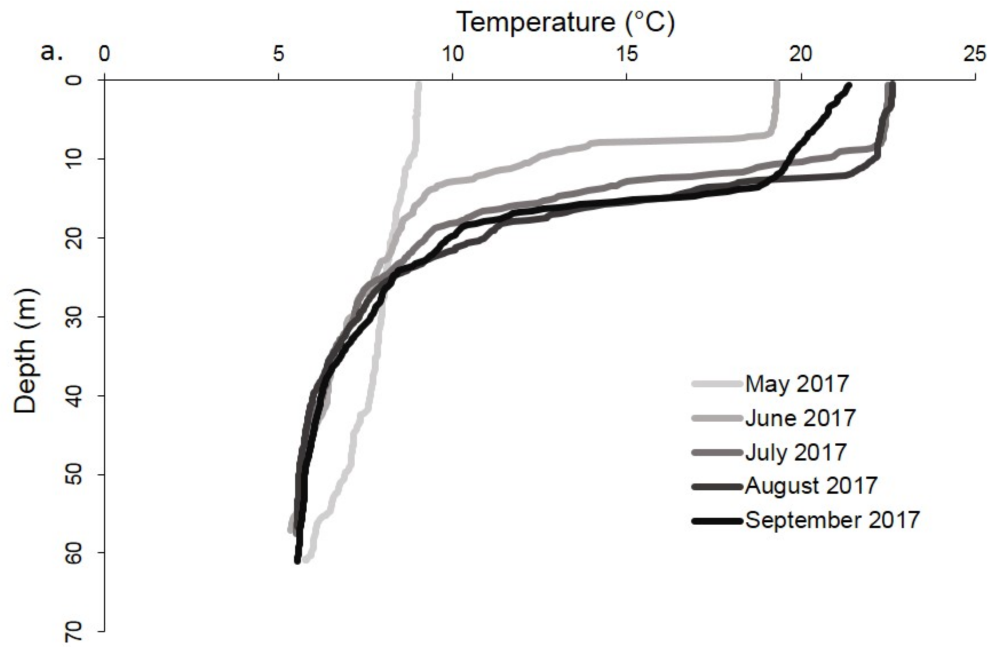


Figure 6. (a) Long-term (1996-2017) and (b) current (2017) surface water temperatures (°C) for Skaneateles Lake. Stations 139.1 and 139.2 are in the northern and southern portions of Skaneateles Lake, respectively.



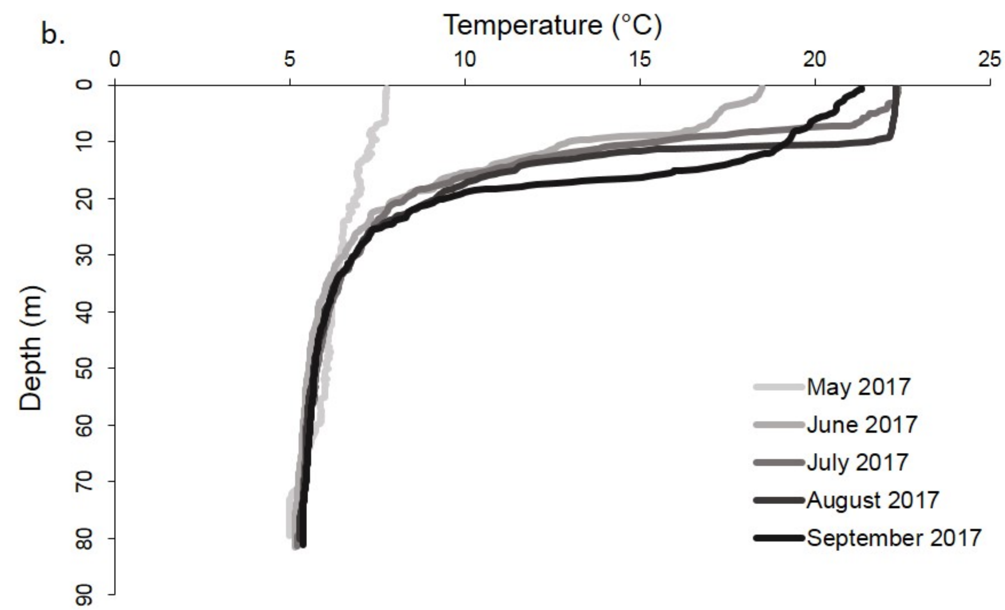


Figure 7. Water temperature profiles in Skaneateles Lake from May to September 2017, collected from (a) 42° 53.48"N, 76° 24.0"W and (b) 42° 50.5''N, 76° 20.75''W. Data provided by John Halfman, Hobart and William Smith Colleges.

6.2 Chemical Conditions

Total phosphorus (TP, **Figure 8**) concentrations are typically less than 0.01 mg/L throughout Skaneateles Lake, indicating low productivity). Although TP concentrations in 2017 were typically higher than previous years sampled, TP concentrations were still considered low and average summer concentrations were indicative of oligotrophic conditions. No significant trends were observed in average (p = 0.170, τ = 0.303) or maximum (p = 0.681, τ = -0.091) TP concentrations over time. Consistent seasonal patterns were not observed among years. In 2017, surface water (**Figure 8b**) TP concentrations increased from June to early July, with the maximum TP concentrations (0.0137 mg/L) observed on July 19th following heavy rains earlier in the month. Concentrations of TP declined in late July and August before increasing again in September. Deep (15 m) water TP concentrations (**Figure 8c)** followed a similar seasonal pattern as the surface water TP concentrations. The late season increase in TP concentrations started earlier in the deep-water samples, with TP increasing in late August. Concentrations observed in September, prior to the 2017 HABs events, were similar to previous years and were relatively low compared to other lakes in the region. Average TP concentrations in the 1970s (Bloomfield 1978) were higher (0.0061 mg/L) than the 1996 to 2017 average TP concentration (0.004 mg/L).

Total nitrogen concentrations in 2017 were highest early in the season, with concentrations decreasing in late summer (**Figure 9a**). TN concentrations in Skaneateles Lake ranged from 0.095 to 0.679 mg/L, but average annual TN concentrations in 2017 were less than the 0.6 mg/L threshold indicative of eutrophic conditions (Canfield et al. 1983).

Maximum nitrate plus nitrate (NO_x) concentration, from 1996 to 2001, significantly decreased between (p < 0.001, τ = -1.00), however long-term trends are difficult to assess given the low sample size (n = 6 years).

The relative concentrations of nitrogen and phosphorus can influence algal community composition and the abundance of cyanobacteria. Ratios of total nitrogen (TN) to total phosphorus (TP) in lakes can be used as a suitable index to determine if algal growth is limited by the availability of nitrogen or phosphorus (Lv et al. 2011). The ratio of nitrogen to phosphorus (TN:TP) may determine whether or not HABs occur, with cyanobacteria blooms rare in lakes where mass based TN:TP ratios are greater than 29:1 (Filstrup et al. 2016, Smith 1983). Certain cyanobacteria taxa are capable of utilizing atmospheric dinitrogen (N_2), which is unavailable to other phytoplankton, providing a competitive advantage to N-fixing cyanobacteria when nitrogen becomes limiting.

Ratios (by mass) of TN:TP (2017 only) indicate that algal growth in Skaneateles Lake is limited by phosphorus rather than nitrogen (**Figure 9b**). In 2017, TN:TP ratios decreased in late August in the southern (Station 139.2) portion of the lake and in September in the northern (Station 139.1) portion. These lower ratios towards the end of the growing season remain indicative of phosphorus limited algal growth during this time of the year. TN:TP ratios (by mass) estimated during the SWQI program also indicated that primary production was limited by phosphorus (average for all samples was 121:1).

Dissolved oxygen (DO) depth profiles for 2014 (the latest period for which validated data was available) indicate that oxygen concentrations were high throughout the water column in Skaneateles Lake from May to October (**Figure 10**). Increases in DO at the metalimnion are associated with colder water having higher saturation concentrations (relative to warmer surface water), and in part, is characteristic of clear lakes where algae can photosynthesize at depth (producing oxygen). High DO concentrations are maintained throughout the water column, allowing coldwater fish to inhabit even the deepest regions of the lake. The observed DO profile in 2014 was typical for Skaneateles Lake dating back to 2007 (Halfman 2017). However, it is not yet known if temperature or oxygen profiles in 2017 were similar to those documented in recent years.

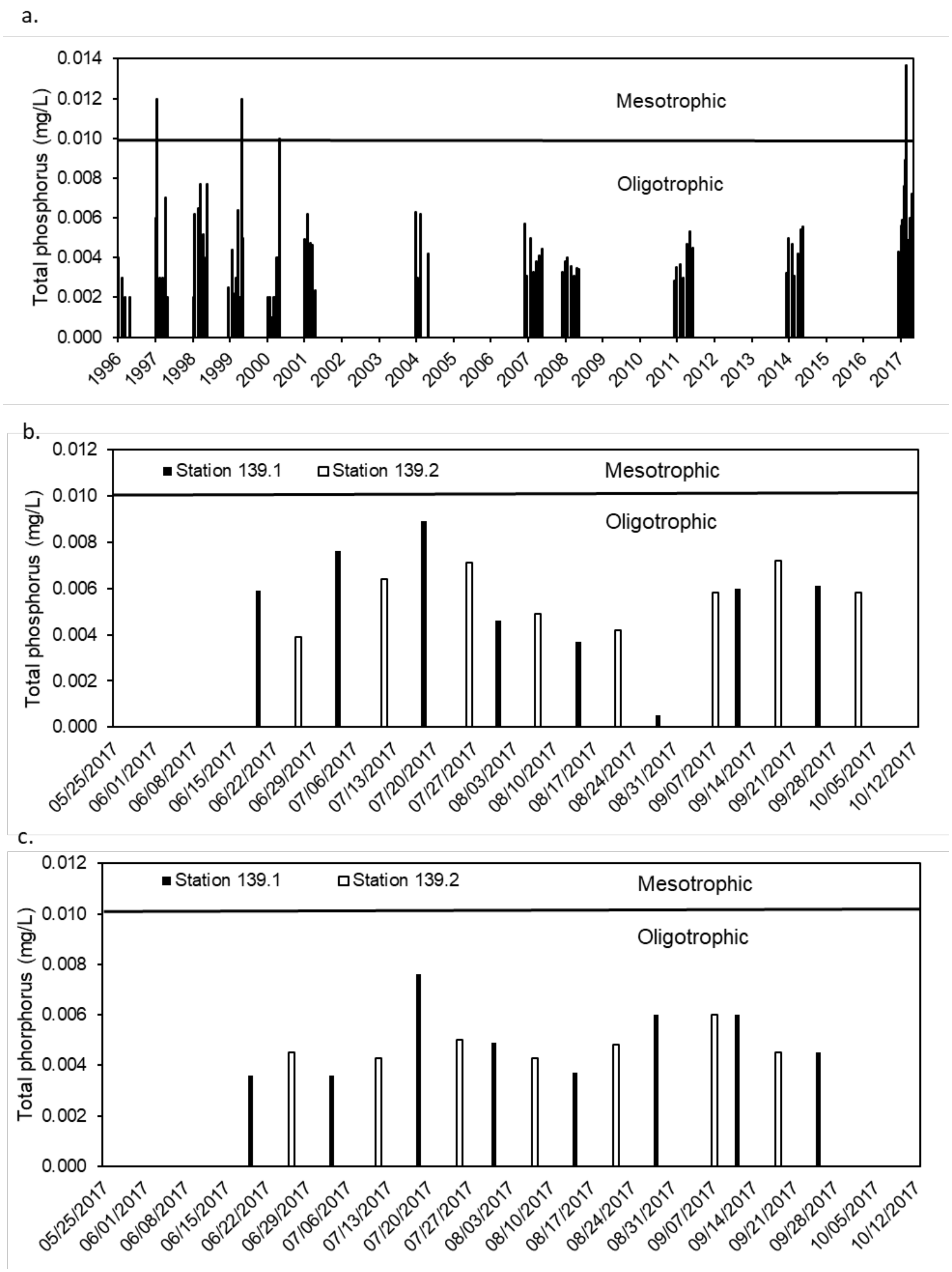


Figure 8. (a) Long-term (1996-2017), (b) current surface (2017) and (c) current bottom (2017, 15 m) concentrations (mg/L) of total phosphorus (TP) for Skaneateles Lake. Stations 139.1 and 139.2 are in the northern and southern portions of Skaneateles.

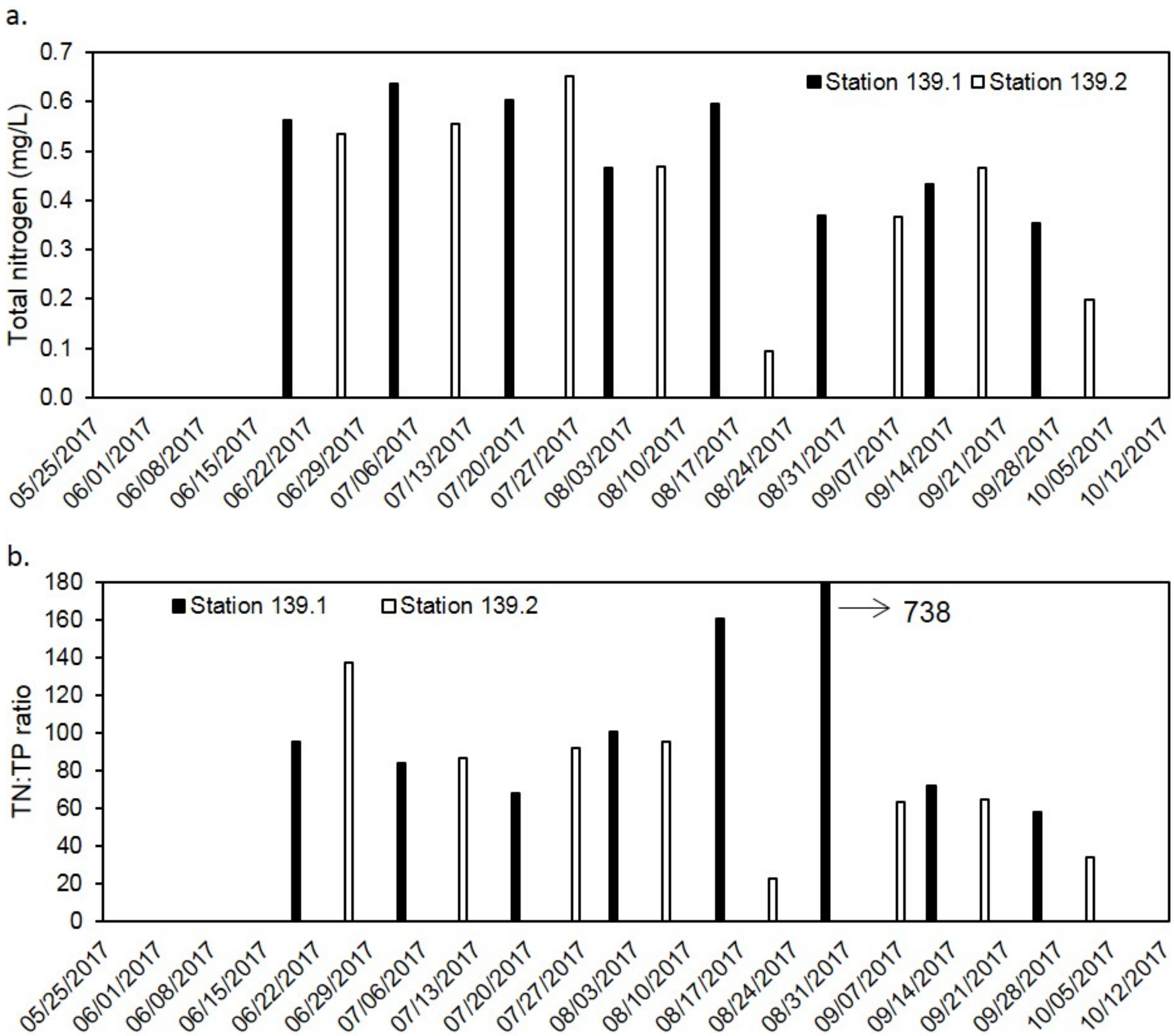


Figure 9. (a) Surface concentrations (mg/L) of total nitrogen (TN) and (b) TN to total phosphorus (TP) ratio (by mass) in Skaneateles Lake during 2017. Stations 139.1 and 139.2 are in the northern and southern portions of Skaneateles Lake, respectively.

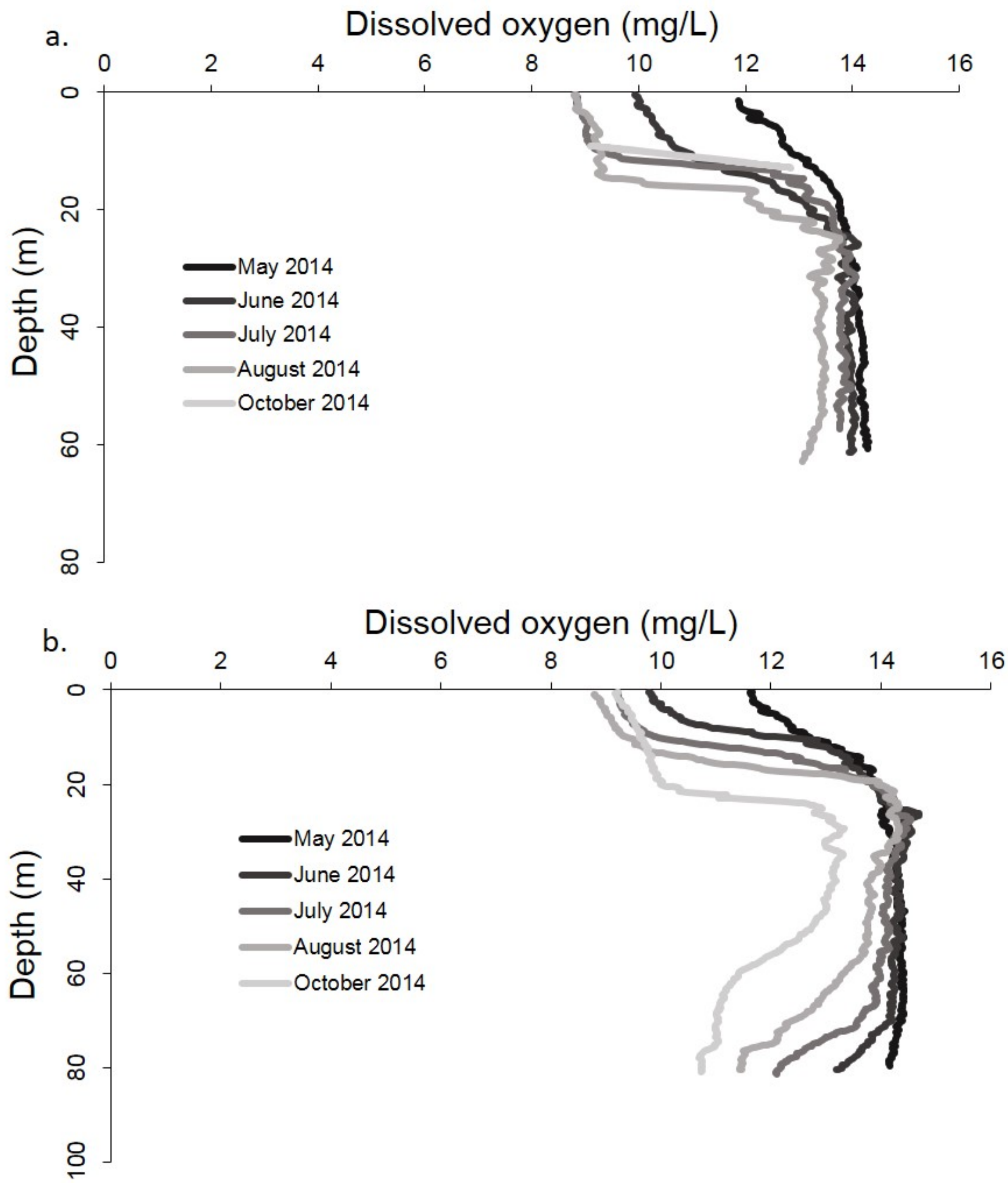


Figure 10. Dissolved oxygen profiles in Skaneateles Lake from May to October 2014, collected from (a) 42° 53.48” N, 76° 24.0” W and (b) 42° 50.5’’ N, 76° 20.75’’ W. Data provided by John Halfman, Hobart and William Smith Colleges.

6.3 Biological Conditions

Currently, Skaneateles Lake has fewer aquatic invasive species compared to other lakes in the area, with five known aquatic invasive species and one non-native species (SLA 2015):

- Eurasian watermilfoil, *Myriophyllum spicatum*
- Zebra mussel, *Dreissena polymorpha*

- Quagga mussel, *Dreissena bugensis*
- Common carp, *Cyprinus carpio*
- European rudd, *Scardinius erythrophthalmus*
- Rainbow trout, *Oncorhynchus mykiss*

Certain invasive species may influence the frequency and duration of HABs. For instance, cyprinid fish species – common carp and European rudd – can increase sediment suspension and associated nutrients in the water column based on their feeding behavior. These species feed on benthic macroinvertebrates found within the sediment and that sediment becomes suspended during active feeding. The increase in suspended sediment can include nutrients that may then be utilized by cyanobacteria.

Eurasian watermilfoil is of concern in Skaneateles Lake because the species often grows in large dense beds, outcompeting and crowding out native aquatic vegetation (Boylen et al. 1999). The dense beds of this aquatic invasive species can impede recreational activities such as boating, fishing, and swimming. When Eurasian watermilfoil is overly abundant, it may act as a nutrient pump, by bringing nutrients up from the sediment and back into the water column as plant biomass during the growing season. Some of these nutrients are then released into the water column during respiration and decay of plant material (e.g., Smith and Adams 1986). While several studies from the scientific literature discuss the role of milfoil as a potential nutrient pump, lake specific conditions can alter these dynamics including, local anoxic patches, trophic state, plant density, and plant decomposition rates (Carpenter 1983, Carpenter and Lodge 1986); further research is warranted to assess the variables on Skaneateles Lake.

Dreissenid mussels can influence phytoplankton composition by selectively filter feeding algae, preferentially selecting phytoplankton such as green algae, which can result in increased prevalence of cyanobacteria (Vanderploeg et al. 2001). Additionally, dreissenid mussels are often found in nearshore zones, and coupled with their high filtration rates of algae and subsequent elimination of wastes, can concentrate bioavailable nutrients in nearshore zones (Hecky et al. 2004). Shifting nutrient concentrations to nearshore areas may result in greater incidence of shoreline HABs.

Chlorophyll-a concentrations (**Figure 11a**) from 1997 to 2017 were indicative of low overall lake productivity (**Table 2**). No significant trends in annual average ($p = 0.170$, $\tau = 0.303$) or maximum annual ($p = 0.411$, $\tau = 0.182$) chlorophyll-a concentrations were observed in Skaneateles Lake. In 2017, two samples had chlorophyll-a concentrations greater than 2 μg/L, one in the south station (139.2) in July and one in the north station (139.1) in September (**Figure 11b**). The higher concentrations of chlorophyll-a at the northern station in late September (2.2 μg/L) occurred several days prior to a confirmed report of a lake-wide HAB on October 2, 2017. Note that a chlorophyll-a sample was collected on October 2, 2017 at the south sample location, and was low (0.5 μg/L, **Figure 11b**).

Average chlorophyll-a concentrations (1.95 μg/L, Bloomfield 1978) measured during 1971 to 1973 were nearly double the concentration of samples measured from 1996 to 2017, suggesting algal growth in Skaneateles Lake has likely decreased since the 1970s. This decrease in chlorophyll-a concentrations is likely a result of a ban on phosphorus detergents in the 1970s, management actions that have resulted in decreased agricultural runoff, and perhaps a result of the introduction of zebra mussels in the early 1990s. It also should be noted that during this timeframe SLWAP was established and has since achieved voluntary participation of 85% of the farmers (which collectively work 91% of the agricultural land) in the Skaneateles Lake Watershed. However, nearly all chlorophyll-a measurements in Skaneateles Lake are low, so any apparent changes may be similar to the normal variability associated with the collection and analysis of these samples.

Summer average chlorophyll-a concentrations in Skaneateles Lake were below the 4.0 μg/L threshold for Class AA lakes proposed by Callinan et al. (2013). Callinan et al. (2013) indicated that average annual chlorophyll-a concentrations between 4-6 μg/L would be sufficient to attain the existing USEPA maximum contamination level of 80 μg/L total trihalomethanes concentration for drinking water (USEPA 2006). Total trihalomethanes concentrations are used as a measure of DBPs in drinking water systems. During water treatment, DBPs form when an oxidizing agent (e.g. chlorine) reacts with natural organic matter (NOM). Sources of NOM in lakes includes external (e.g. leaves) and internal sources (e.g. algae).

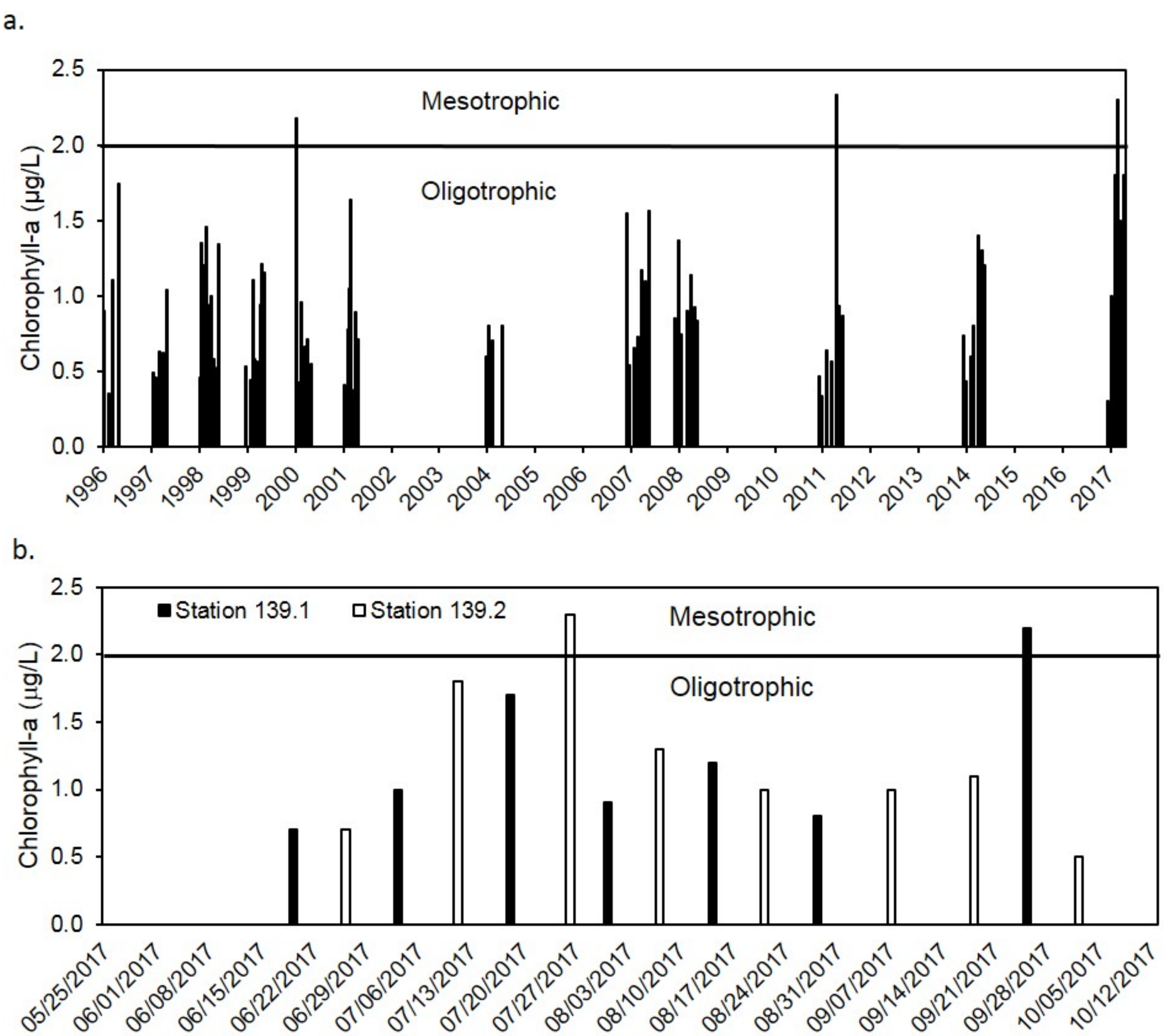


Figure 11. (a) Long-term (1996-2017) and (b) current (2017) chlorophyll-a concentrations (mg/L) for Skaneateles Lakes. Stations 139.1 and 139.2 are in the northern and southern portions of Skaneateles Lake, respectively.

6.4 Other Conditions

Lake foam in Skaneateles Lake has been a growing concern of residents over the last several years (SLA 2018). The stiff and sticky foam is commonly found along the shorelines and in bays after wind events. Foam is formed when surface tension is flexible enough to prevent bubbles that have been trapped underwater from bursting when they reach the surface. Increased surface tension can be a result of natural processes, such as surfactants from decomposing organic matter (algae and plants), or man-made products such as detergents. Tests conducted in Skaneateles Lake concluded that the anionic surfactants associated with foam productions are likely from the natural degradation of organic matter and that there is no evidence to suggest man-made contamination (SLA 2018).

7. Summary of HABs

New York State possesses one of, if not the most comprehensive, HABs monitoring and notification programs in the country. The NYSDEC and NYSDOH collaborate to document and communicate with New Yorkers regarding HABs. Within NYSDEC, staff in the Division of Water, Lake Monitoring and Assessment Section oversee HAB monitoring and surveillance activities, identify bloom status, communicate public health risks, and conduct outreach, education, and research regarding HABs. The NYSDEC HABs Program has adopted a combination of visual surveillance, algal concentration measurements, and toxin concentration to determine bloom status. This process is unique to New York State and has been used consistently since 2012.

The NYSDEC HABs Program has established four levels of bloom status:

- **No Bloom**: evaluation of a bloom report indicates low likelihood that a cyanobacteria bloom (HAB) is present.
- **Suspicious Bloom**: NYSDEC staff determined that conditions fit the description of a HAB, based on visual observations and/or digital photographs. Laboratory analysis has not been done to confirm if this is a HAB. It is not known if there are toxins in the water.
- **Confirmed Bloom**: Water sampling results have confirmed the presence of a HAB which may produce toxins or other harmful compounds (BGA chlorophyll-a levels ≥ 25 µg/L and/or microscopic confirmation that majority of sample is cyanobacteria and present in bloom-like densities). For the purposes of evaluating HABs sample, chlorophyll-a is quantified with a Fluoroprobe (bbe Moldaenke) which can effectively differentiate relative contributions to total chlorophyll-a by phytoplankton taxonomic group (Kring et al. 2014). BGA chlorophyll-a concentrations (attributed to most types of cyanobacteria) are utilized by the NYSDEC HABs Program for determining bloom status. This method provides an accurate assessment of cyanobacteria density and can be accomplished more quickly and cost effectively than traditional cell counts.
- **Confirmed with High Toxins Bloom**: Water sampling results have confirmed that there are toxins present in sufficient quantities to potentially cause health effects if people and animals come in contact with the water through swimming or drinking (microcystin ≥ 20 µg/L [shoreline samples] or microcystin ≥ 10 µg/L [open water samples]).

The spatial extent of HABs are categorized as follows:

- **Small Localized**: Bloom affects a small area of the waterbody, limited from one to several neighboring properties.
- **Large Localized**: Bloom affects many properties within an entire cove, along a large segment of the shoreline, or in a specific region of the waterbody.

- **Widespread/Lakewide**: Bloom affects the entire waterbody, a large portion of the lake, or most to all of the shoreline.
- **Open Water**: Sample was collected near the center of the lake and may indicate that the bloom is widespread and conditions may be worse along shorelines or within recreational areas.

7.1 Ambient Lake HABs History

Figure 12. Cyanobacteria bloom observed at the Skaneateles Country Club Marina - September 2017 (*photographed from drone*).

Skaneateles Lake has come into focus recently by state agencies, non-governmental organizations, community interest groups, lake users, water suppliers, and other stakeholders given the documented presence of HABs in the lake in 2017. Water quality information supporting HABs assessments has been reported to the NYSDEC by several data providers including NYSDEC staff, CSLAP, and members of the public. This information helps the NYSDEC to be able to rapidly communicate bloom location to regional stakeholders. When lake observations of potential HABs are collected, they are compiled and assigned a status, per NYSDEC's *Harmful Algal Blooms Program Guide* (NYSDEC 2017) and as described above.

According to NYSDEC-supplied water chemistry data and reported observations, HABs were first documented in Skaneateles Lake on September 12, 2017, then again on September 16 and 25, and finally on October 2. Although these reported observations are characterized as individual events, it is likely a sustained or continuous bloom event over multiple sampling periods in multiple locations in the lake. A photograph of a HAB that occurred in September 2017 is provided as **Figure 12**.

Both the September 12 and October 2 recorded HAB samples were reported as having "widespread/lakewide" extent and met the NYSDEC "Confirmed Blooms" criteria, as reported under CSLAP (**Table 3**). These samples were classified as "open water" blooms, the September 12 sample was collected off the eastern and western shores of the lake north of Station 139, and the October 2 sample was collected in association with Station 139.2 near the southern end of the lake (see **Figure 4**). However, these were more representative of conditions close to the shoreline in these locations. Two other shoreline bloom samples were collected on September 16 and September 25,

2017. The September 16 shoreline HAB was reported at Station 139 and was identified as "large localized" and "confirmed with high toxins" (microcystin concentration ≥ 20 µg/L for a shoreline bloom). The extent of the confirmed September 25 shoreline HAB was not noted, but a sample was collected at location "Bob Dean Camp (Skan 1)" in the vicinity of Station 139 (**Figure 4**), approximately mid-Lake.

Although 2017 represents the first formal documentation of HABs in Skaneateles Lake, Halfman (2017) reported that cyanobacteria are not uncommon in the lake, and that measurements taken from 2012 to 2016 "…detected them [cyanobacteria taxa] offshore, albeit at low concentrations…" Cyanobacteria commonly occur in all lakes at low concentrations that do not pose a health concern. NYSDEC and other researchers are continuing to evaluate whether blooms reported in 2017 represent surface shoreline concentrations of "normal" cyanobacteria densities usually distributed throughout the water column, or an unprecedented rise in cyanobacteria growth.

Table 3. History of HABs in Skaneateles Lake.

Date	Bloom Extent	Bloom location	Chl-a (µg/L)	Daily avg. air temp (ºC)	Water Temp (ºC)	Daily rainfall (mm)	10-day total rainfall (mm)	Max daily wind speed (m/s)	Water Quality data
9/12/2017	Widespread/ Lakewide	Open Water	NA	16	NA	0	29.7	3.6	Not available
9/16/2017	Large localized	Shoreline	374.8-631.6	20	NA	0	1.9	5.7	Not available
9/25/2017	Not Reported	Shoreline	48.37	23.3	21	0	0	3.6	Available
10/2/2017	Widespread/ Lakewide	Open Water	48.28	10.9	21	0	3.8	2.6	Available

7.2 Drinking Water and Swimming Beach HABs History

Across New York, NYSDOH first sampled ambient water for toxin measurement in 2001 and drinking water samples (raw and finished) beginning in 2010. Two public water supplies were sampled in a 2012 pilot study that included both fixed interval and bloom-based event criteria. While microcystin has been detected in pre-treatment water occasionally, rarely have any detects been found in finished water. To date, no samples of finished water anywhere in the state have exceeded the 0.3 µg/L microcystin Health advisory level. Many different water systems using different source waters have been sampled and drinking water HABs toxin sampling has increased substantially since 2015 when the USEPA released the microcystin and cylindrospermopsin Health Advisory levels. The information gained from this work and a review of the scientific literature was used to create the current NYSDOH HABs drinking water response protocol. This document contains background information on HABs and toxins, when and how water supplies should be sampled, drinking water treatment optimization, and steps to be taken if health advisories are exceeded (which has not yet occurred in New York State).

In 2018 the USEPA started monitoring for their Unregulated Contaminant Monitoring Rule 4 (UCMR 4) which includes several HAB toxins. In 2018 the USEPA will sample 32 public water systems in New York State. The UCMR 4 is expected to bring further attention to this issue leading to a greater demand for monitoring at PWSs. To help with the increasing demand for laboratory analysis of microcystin, the NYSDOH Environmental Laboratory Approval Program (ELAP) is offering certification for laboratories performing HAB toxin analysis. Public water supplies should only use ELAP certified labs and consult with local health departments (with the support of NYSDOH) prior to beginning HAB toxin monitoring and response actions.

During and following the HABs occurrences in September and October 2017, concerns were raised over the potential for cyanotoxins to be withdrawn through the lake's intakes and incorporated into the water supply systems for Syracuse, Skaneateles, and neighboring Villages of Jordan and Elbridge. Microcystin samples were collected daily (320 total) and made available to the public using a graphic showing when and where the samples were collected. The Village and Town of Skaneateles are continuing to work closely with the NYSDOH, the Onondaga County Department of Health, and the City of Syracuse in monitoring the water quality of Skaneateles Lake.

Untreated water samples collected by the NYSDOH before entering the water gatehouses in Skaneateles indicated cyanotoxin concentrations greater than the EPA's 10-day health advisory of 0.30 μg/L between 9/18/2017 and 10/26/2017. Measurements taken from finished water treated with chlorine had non-detectable levels of cyanotoxin. Although samples collected by the City of Syracuse from the finished water distributed in the Skaneateles municipal water system indicated non-detectable levels of cyanotoxins associated with the blooms, the Village of Skaneateles is moving forward with developing short-term and long-term plans to update the Village drinking water system for treating future blooms that may exceed health advisory levels (Village of Skaneateles 2017b). Other public press reports indicate that microcystin was detected in both lake intake pipes (at 20 and 45 feet water depths), but additional chlorination with a longer contact time was administered to reduce microcystin to non-hazardous levels prior to reaching the Syracuse water supply. It should be noted that cyanotoxins were detected in samples run by the Wadsworth Laboratory on September 29, 2017 (0.141 μg/L) in waters as deep as 85 feet below the surface.

The Skaneateles bloom which occurred in September and October 2017 occurred after regulated beaches had closed for the season. If the bloom had occurred earlier, it is likely closure due to the bloom would have occurred. Because the onset of HABs in 2017 occurred after beaches were closed for the season, no reports of closures to the swimming area at Clift Park were identified. Despite the closures of beaches prior to the bloom, contact recreational activities were still common due to warm weather conditions. The NYSDOH visual bloom criteria for beach closure was met during the 2017 HABs event.

Bathing beaches are regulated by NYSDOH District Offices, County Health Departments and the New York City Department of Health and Mental Hygiene in accordance with the State Sanitary Code (SSC). The SSC contains qualitative water quality requirements for protection from HABs. NYSDOH developed an interactive intranet tool that provides guidance to County, City and State District DOH staff to standardize the process for identifying blooms, closing beaches, sampling, reopening beaches and reporting activities. The protocol uses a visual assessment to initiate beach closures as it affords a more rapid response than sampling and analysis. Beaches are reopened when a bloom dissipates (visually) and samples collected the following day confirm the bloom has dissipated and show toxin levels are below the latest guidance value for microcystins. Sample analysis is performed by local health departments, the Wadsworth Laboratory in Albany or academic institutions.

Table 4 provides a summary of the guidance criteria that the NYSDEC and NYSDOH use to advise local beach operators.

Table 4. HABs guidance criteria.			
NYSDEC Bloom Categories			
Confirmed	**Confirmed w/ high toxins**		**Suspicious**
	Open water	**Shoreline**	
[BGA chlorophyll a] >25 µg/L	[Microcystin] > 10 µg/L	[Microcystin] > 20 µg/L	Visual evidence w/out sampling results
NYSDOH Guidelines			
Closure		**Re-open**	
Visual evidence (sampling results not needed)		Bloom has dissipated (based on visual evidence); confirmatory samples 1 day after dissipation w/ microcystin < 10 µg/l or < 4 µg/l (USEPA 2016) starting in 2017.	

7.3 Other Bloom Documentation

Cyanobacteria cell counts, chlorophyll-a concentrations (e.g., BGA chlorophyll-a), and/or cyanotoxins as well as visual assessments can be used to trigger HABs alert and advisory systems. As presented in **Section 6.3**, major trophic state indicators over the last 20 years have been indicative of oligotrophic conditions in Skaneateles Lake, characterized by low nutrient levels, high transparency, and low biotic productivity. Such conditions are not conducive to the formation of HABs, which are typically observed when more eutrophic waters that are rich in nutrients, have high biological productivity and reduce clarity.

Cyanobacteria (BGA) Chlorophyll-a

BGA chlorophyll-a levels, measured with a Fluoroprobe, were quantified during three of the four confirmed blooms in 2017 and during periods of unconfirmed blooms (“not reported” status) in late-September 2017, as follows:

- September 12 (confirmed, open water, widespread/lakewide): not measured
- September 16 (confirmed with high toxins, shoreline, large/localized): 330.7-449.0 µg/L
- September 25 (confirmed, shoreline): 45.5 µg/L
- September 25-27 (unconfirmed): 1.53-12.5 µg/L

- October 2 (confirmed, open water, widespread/lakewide): 42.9 μg/L

Note that shoreline bloom sampling is intended to capture worst case conditions. Thus, these reported concentrations are likely not representative of general water quality conditions in the open waters of the lake.

BGA chlorophyll-a exceeded the 25 µg/L HAB Confirmed Bloom status threshold on the four dates that shoreline bloom samples were collected, but was below the threshold during the period of unconfirmed (not reported) blooms.

Cyanotoxins

Some cyanobacteria taxa produce toxins (cyanotoxins) that are harmful to people and pets. As a result, several different toxins are monitored during blooms. Microcystin was the most commonly detected cyanotoxin in HABs in New York (NYSDEC 2017). The 20 μg/L microcystin "high toxin" threshold for shoreline blooms was, like the BGA chlorophyll-a standard, established by NYSDEC based on WHO criteria. The 20 μg/L microcystin standard was exceeded during the HABs identified as "confirmed with high toxins," with sample concentrations ranging from 108-171 μg/L; however, these toxin concentrations were likely not representative of general water quality conditions due to target skim sampling of shoreline blooms intended to capture worst-case scenario conditions. Levels associated with all confirmed status events were also higher than the USEPA's 2016 draft human health recreational swimming advisory threshold of 4 μg/L (USEPA 2016), although it is likely that some portions of these blooms had lower toxin levels. Sample results below this threshold value are consistent with what is currently prescribed by NYSDOH guidance to allow a regulated bathing beach to reopen. Microcystin levels in samples collected during other events were less than 20 μg/L. However, NYSDEC and NYSDOH believe that all cyanobacteria blooms should be avoided, even if measured microcystin levels are less than the recommended threshold level. Other toxins may be present, and illness is possible even in the absence of toxins.

Cyanobacteria Taxa

Microcystis, a common unicellular colony forming, buoyancy regulating genus of cyanobacteria was reported in samples collected during confirmed HABs. *Chroococcus*, a unicellular colonial cyanobacteria were also detected during the period of unconfirmed blooms. As discussed previously, cyanobacteria are not uncommon to Skaneateles Lake, despite the persistent state of oligotrophy and pre-2017 absence of documented HABs. Birge and Juday (1914) collected water samples at various depths in Skaneateles Lake in 1910, and reported that cyanobacteria were detected at measurable levels up to 260 feet below the surface, with the greatest cyanobacteria density observed at a depth interval of 0-66 feet (Birge and Juday 1914). Taxa observed include *Microcystis*, *Dolichospermum* (formerly *Anabaena*, filamentous, nitrogen-fixing), *Aphanocapsa* (spherical, colonial), and *Coelosphaerium* (colonial, buoyancy regulating). Halfman (2017) also reports that in the Finger Lakes from 2012 to 2016 revealed that

Skaneateles Lake, along with Honeoye, Canandaigua, and Keuka Lakes, had the highest percentages of cyanobacteria taxa relative to other algae. However, overall cyanobacteria and overall algae levels at this time were very low.

7.4 Use Impacts

As discussed in **Section 3.2**, the primary use concern for Skaneateles Lake is drinking water given the reliance on the lake by lakeside residents, portions or all of the outlying communities of Skaneateles, Elbridge, Nedrow, Onondaga, Salina, Southwood, DeWitt, Geddes, Camillus, and Jordan, and the City of Syracuse for their potable supply. Outfitting existing water treatment facilities to treat toxins in lake water potentially withdrawn for potable use would be a comprehensive and costly undertaking, particularly for an unfiltered water supply. As noted in **Section 3.2** it is never advisable to draw drinking water from a surface source unless it has been treated by a public drinking water system regardless of the presence of HABs (NSF P477; NYSDOH 2017).

In addition, there is the potential for impacts to recreational use of the lake in areas where blooms have concentrated along the shoreline.

8. Waterbody Assessment

The WI/PWL is an inventory of water quality assessments that characterize known/and or suspected water quality issues and determine the level of designated use support in a waterbody. It is instrumental in directing water quality management efforts to address water quality impacts and for tracking progress toward their resolution. In addition, the WI/PWL provides the foundation for the development of the state Section 303(d) List of Impaired Waters Requiring a TMDL.

The WI/PWL assessments reflect data and information drawn from numerous NYSDEC programs (e.g. CSLAP) as well as other federal, state and local government agencies, and citizen organizations. All data and information used in these assessments has been evaluated for adequacy and quality as per the NYSDEC Consolidated Assessment and Listing Methodology (CALM).

8.1 WI/PWL Assessment

The current WI/PWL assessment for Skaneateles Lake (**Appendix C**) reflects data collected in 2017. Skaneateles Lake is required to support best uses as a water supply source for drinking, primary and secondary contact recreation use, and fishing use. Skaneateles Lake is assessed as having minor impacts due to occurrence of harmful algal blooms with the presence of high levels of algal toxins during September and October 2017. Water supply use is assessed as threatened and recreational uses are assessed as stressed due to the cyanotoxin found at intake depth. However, it is not confirmed if the cyanotoxin were found at near the public water intake. Skaneateles Lake is not included on the NYS Section 303(d) List of Impaired Waters Requiring a TMDL.

Table 5. WI/PWL severity of use impact categorization (Source: NYSDEC 2008).	
Impairment Classification	**Description**
Precluded	*Frequent/persistent* water quality, or quantity, conditions and/or associated habitat degradation *prevents all aspects* of a specific waterbody use.
Impaired	*Occasional* water quality, or quantity, conditions and/or habitat characteristics *periodically prevent* specific uses of the waterbody, or; Waterbody uses are not precluded, but some aspects of the use are *limited or restricted*, or; Waterbody uses are not precluded, but *frequent/persistent* water quality, or quantity, conditions and/or associated habitat degradation *discourage* the use of the waterbody, or; Support of the waterbody use *requires additional/advanced* measures or treatment.
Stressed	Waterbody uses are not significantly limited or restricted (i.e. uses are *Fully Supported*), but *occasional* water quality, or quantity, conditions and/or associated habitat degradation *periodically discourage* specific uses of the waterbody.
Threatened	Water quality supports waterbody uses and ecosystem exhibits no obvious signs of stress, however *existing or changing land use patterns* may result in restricted use or ecosystem disruption, or; *Data reveals decreases in water quality* or presence of toxics below the level of concern.

8.2 Source Water Protection Program (SWPP)

The NYSDOH Source Waters Assessment Program (SWAP) was completed in 2004 to compile, organize, and evaluate information regarding possible and actual threats to the quality of public water supply (PWS) sources based on information available at the time. Each assessment included a watershed delineation prioritizing the area closest to the PWS source, an inventory of potential contaminant sources based on land cover and the regulated potential pollutant source facilities present, a waterbody type sensitivity rating, and susceptibility ratings for contaminant categories. The information included in these analyses included: GIS analyses of land cover, types and location of facilities, discharge permits, CAFOs, NYSDEC WI/PWL listings, local health department drinking water history and concerns, and existing lake/watershed reports. A SWAP for the Skaneateles Lake public drinking supply sources was completed. Although the information provides a historical perspective, the drinking water systems and/or land uses may have changed. Skaneateles Lake public drinking supply sources need updated assessments to understand the current impacts to best protect water quality. NYSDEC and NYSDOH are working with stakeholders to build a sustainable statewide program to assist and encourage municipalities to develop and implement Source Water Protection Programs (SWPP) in their communities.

The SWAP conducted in 2004 identified Skaneateles Lake as being moderately susceptible to contamination. A high potential for protozoan contamination, based on the amount of pasture in the watershed, was the only likely source of contamination to the lake.

Currently, the State is meeting with a working group of stakeholders to develop the SWPP structure and potential tools (e.g., templates, data sets, guidance and other resources) that will be pilot tested in municipalities. Following the pilot, the state will roll out the program and work with municipalities as they develop and implement their individual SWPP and associated implementation program. The goal of the SWPP is for municipalities to not merely assess threats to their public water supply but to take action at the local level to protect public drinking water.

8.3 Lake Scorecard

Results from CSLAP activities are forwarded to the New York State Federation of Lake Associations (NYSFOLA) and NYSDEC and are combined into a scorecard detailing potential lake use impact levels and stresses. The scorecards represent a preliminary assessment of one source of data, in this case CSLAP. The WI/PWL updates include the evaluation of multiple data sources, including the CSLAP scorecard preliminary evaluations.

The 2017 CSLAP scorecard for Skaneateles Lake suggests algae blooms may stress potable water use and aesthetic conditions and threaten swimming and recreation (**Figure 13**).

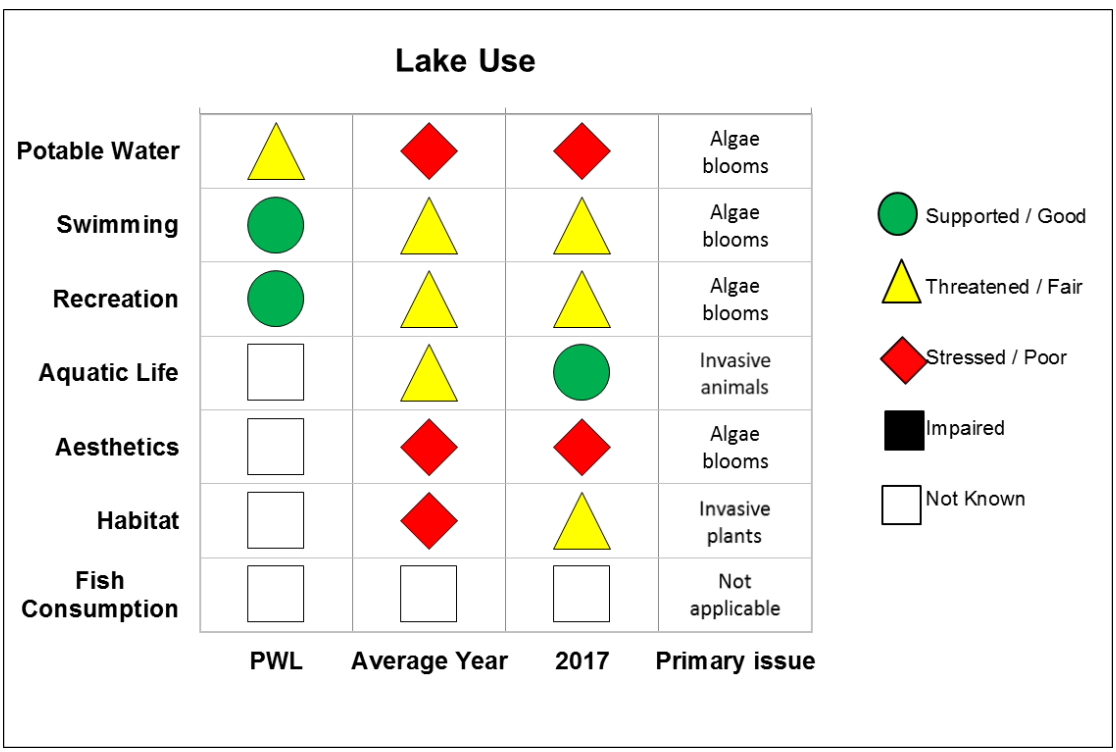


Figure 13. Skaneateles Lake 2017 CSLAP scorecard.

8.4 Lake Processes Influencing Nutrients Availability and HABs

Lake processes such as water column mixing and lake circulations can greatly influence the spatiotemporal availability of nutrients and resulting HABs. Mixing events, either wind driven or seasonal mixing, can result in large fluxes of nutrient concentrations by bringing nutrient rich water up from deeper parts of a lake to the surface layers. A large portion of Skaneateles Lake is very deep (150 to 200 ft, or 45 to 75 m), which prevents the lake from fully mixing in the summer months, even during high wind events. In contrast to these deep portions of the lake, the southern and northern basins of the lake are relatively shallow (approximately 25 ft deep), making these portions more susceptible to mixing and upwelling events related to high winds and internal waves (waves that are present under the surface water).

9. Conditions triggering HABs

Resilience is an important factor in determining an ecosystem’s ability to respond to and overcome negative impacts (Zhou et al. 2010), including the occurrence and prevalence of HABs. Certain lakes may not experience HABs even though factors hypothesized to be “triggers” (e.g., elevated P concentrations) are realized (Mantzouki et al. 2016), and conversely, lakes that have historically been subject to HABs may still be negatively affected even after one or more triggers have been reduced. Thus, phytoplankton dynamics may cause the presence of HABs to lag behind associated triggers (Faassen et al. 2015). Further, unusual climatic events (*e.g.*, high TP input from spring runoff and hot calm weather in fall) may create unique conditions that contribute to a HAB despite implementation of management strategies to prevent them (Reichwaldt and Ghadouani 2012).

Ecosystems often exhibit a resistance to change that can delay outcomes associated with HABs management. This system resilience demands that prevention and management of these triggers be viewed long-term through a lens of both watershed and in-lake action. It may take significant time following implementation of recommended actions for the frequency, duration, and intensity of HABs to be reduced.

A dataset spanning 2012 to 2017 of 163 waterbodies in New York State has been compiled to help understand the potential triggers of HABs at the state-scale (CSLAP data). This dataset includes information on several factors that may be related to the occurrence of HABs, e.g., lake size and orientation (related to fetch length, or the horizontal distance influenced by wind); average total phosphorus and total nitrogen concentrations; average surface water temperatures; as well as the presence of invasive zebra and quagga mussels (i.e., dreissenid mussels). This data set has been analyzed systematically, using a statistical approach known as logistic regression, to identify the minimum number of factors that best explain the occurrences of HABs in NYS. A minimum number of factors are evaluated to provide the simplest possible explanation of HABs occurrences (presence or absence) and to provide a basis for potential targets for management. One potential challenge to note with this data set is that lakes may have unequal effort regarding HABs observations which could confound understanding of underlying processes of HABs evaluated by the data analysis.

Across New York, four of the factors evaluated were sufficiently correlated with the occurrence of HABs, namely, average total phosphorus levels in a lake, the presence of dreissenid mussels, the maximum lake fetch length and the lake compass orientation of that maximum length. The data analysis shows that for every 0.01 mg/L increase in total phosphorus levels, the probability that a lake in New York will have a HAB in a given year increases by about 10% to 18% (this range represents the 95% confidence interval based on the parameter estimates of the statistical model). The other factors, while statistically significant, entailed a broad range of uncertainty given this initial analysis. The presence of dreissenid mussels is associated with an increase in the annual HAB probability of 18% to 66%. Lakes with long fetch lengths are associated with an increased occurrence of HABs; for every mile of increased fetch length, lakes are associated with up to a 20% increase in the annual probability of HABs. Lastly, lakes with a northwest orientation along their longest fetch length are 10% to 56% more likely to have a HAB in a given year. Each of these relationships are bounded, i.e., the frequency of blooms cannot exceed 100%, meaning that as the likelihood of blooms increases the marginal effect of these variables decreases. While this preliminary evaluation will be expanded as more data are collected on HABs throughout New York, these results are supported by prior literature. For example, phosphorus has long known to be a limiting nutrient in freshwater systems and a key driver of HABs, however the potential role of nitrogen should not be overlooked as HABs mitigation strategies are contemplated (e.g., Conley et al. 2009). Similarly, dreissenid mussels favor HABs by increasing the bioavailability of phosphorus and selectively filtering organisms that may otherwise compete with cyanobacteria (Vanderploeg et al. 2001). The statistically-significant association of fetch length and northwest orientation with HABs may suggest that these conditions are particularly favorable to wind-driven accumulation of cyanobacteria and/or to wind-driven hydrodynamic mixing of lakes leading to periodic pulses of nutrients. While each of these potential drivers of HABs deserve more evaluation, the role of lake fetch length and orientation are of interest and warrant additional study.

There is continuing interest in the possible role of nitrogen in the occurrence and toxicity of HABs (e.g., Conley et al. 2009), and preliminary analysis of this statewide data set suggests that elevated total N and total P concentrations are both statistically significant associates with the occurrence of toxic blooms. When total N and total P concentrations are not included in the statistical model, elevated inorganic nitrogen (NH4 and NOx) concentrations are also positively associated with toxic blooms. The significant association of inorganic N forms with toxic blooms may provide a more compelling association than total N, which may simply be a redundant measure of the biomass associated with toxins.

With regard to Skaneateles Lake, it is interesting to note that the lake exhibits three of the four conditions associated with HABs in the statewide data set (i.e., presence of dreissenid mussels, relatively long fetch length and northwest orientation). Although Skaneateles Lake has very low total phosphorus concentrations, these other conditions may have contributed to the Lake’s susceptibility to HABs following unique meteorological events in 2017.

The first ever confirmed HAB in Skaneateles Lake was reported on September 12, 2017. As described in **Section 6**, water clarity in Skaneateles Lake declined in mid-summer and again in late September 2017, perhaps driven by frequent and intense storm events. Additionally, late-growing season maximum air temperatures in the region were historically high, with six days that exceeded 80°F (each day greater than the 95^{th} percentile over the last 50 years) between early September and early October. The last report of a confirmed HAB occurred on October 2, 2017.

Thus, a seasonally wet growing season, a stretch of calm winds, extremely warm September surface water, and increased total daily precipitation (**Section 6**) just prior to the first reported HAB may have triggered the first documented bloom. However, there are many other factors that could have caused this bloom. These meteorological and other potential drivers of HABs warrant additional investigation and study, particularly in lakes with a history of low nutrient concentrations such as Skaneateles Lake.

Remote sensing images from 2015 to 2017 were evaluated for Skaneateles Lake to investigate patterns of chlorophyll-a concentrations. The remote sensing approach utilized a statistical algorithm to model chlorophyll-a concentrations, and was developed based on data collected in Lake Champlain (see Trescott 2012). The model estimated that chlorophyll-a concentrations were consistently higher than the measured in-lake concentrations, perhaps due to higher water clarity of Skaneateles Lake. Thus, the remote sensing approach for Skaneateles Lake is not included as part of this Action Plan. Collecting in-lake water quality measurements in alignment with future overpasses of satellite imagery (see **Section 13.3**) could support the development of a Skaneateles Lake-specific model to further understand the spatial distribution of chlorophyll-a.

10. Sources of Pollutants (triggering HABs)

NYSDEC’s Loading Estimator of Nutrient Sources (LENS) screening tool was used to estimate land use proportions and identify potential nutrient pollutant sources in the Skaneateles Lake watershed. Existing data and model estimates indicate that much of the nutrient loading (e.g., TP) to Skaneateles Lake is from nonpoint sources. Nutrients enter the lake directly from the surrounding watershed via overland flow, tributaries, and other sources, where they can potentially be used by cyanobacteria and aquatic plants, or deposited and stored in lakebed sediments.

10.1 Land Uses

Skaneateles Lake has a watershed area of approximately, 37,760 acres, with a watershed to lake ratio of approximately 4.3 acres of watershed to each acre of lake. The watershed comprises the following land use types (**Figure 14**):

- Natural areas = 40%
- Agriculture = 36%
- Open water = 19%
- Developed land = 5%

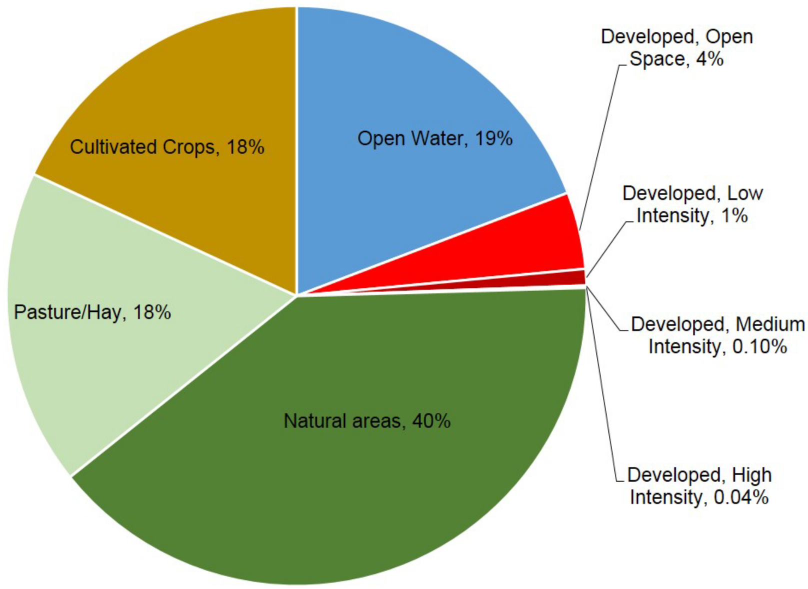


Figure 14. Land use categories and percentages for the Skaneateles Lake watershed. Natural areas include forests, shrublands, grasslands, and wetlands.

If open water is excluded from the Skaneateles Lake watershed land use breakdown, approximately 50 percent of the watershed is natural area land, with the remaining majority in agricultural production (~ 45%). Phosphorus loading from the major tributaries can be estimated based on watershed area and land use information. Much of the contiguous forested land use surrounding Skaneateles Lake is found in the southern portion of the watershed, while a greater percentage of agricultural land use is found in the northern half of the lake as well as within the sub-watersheds of tributaries located in the south (**Figures 15a**, **16**).

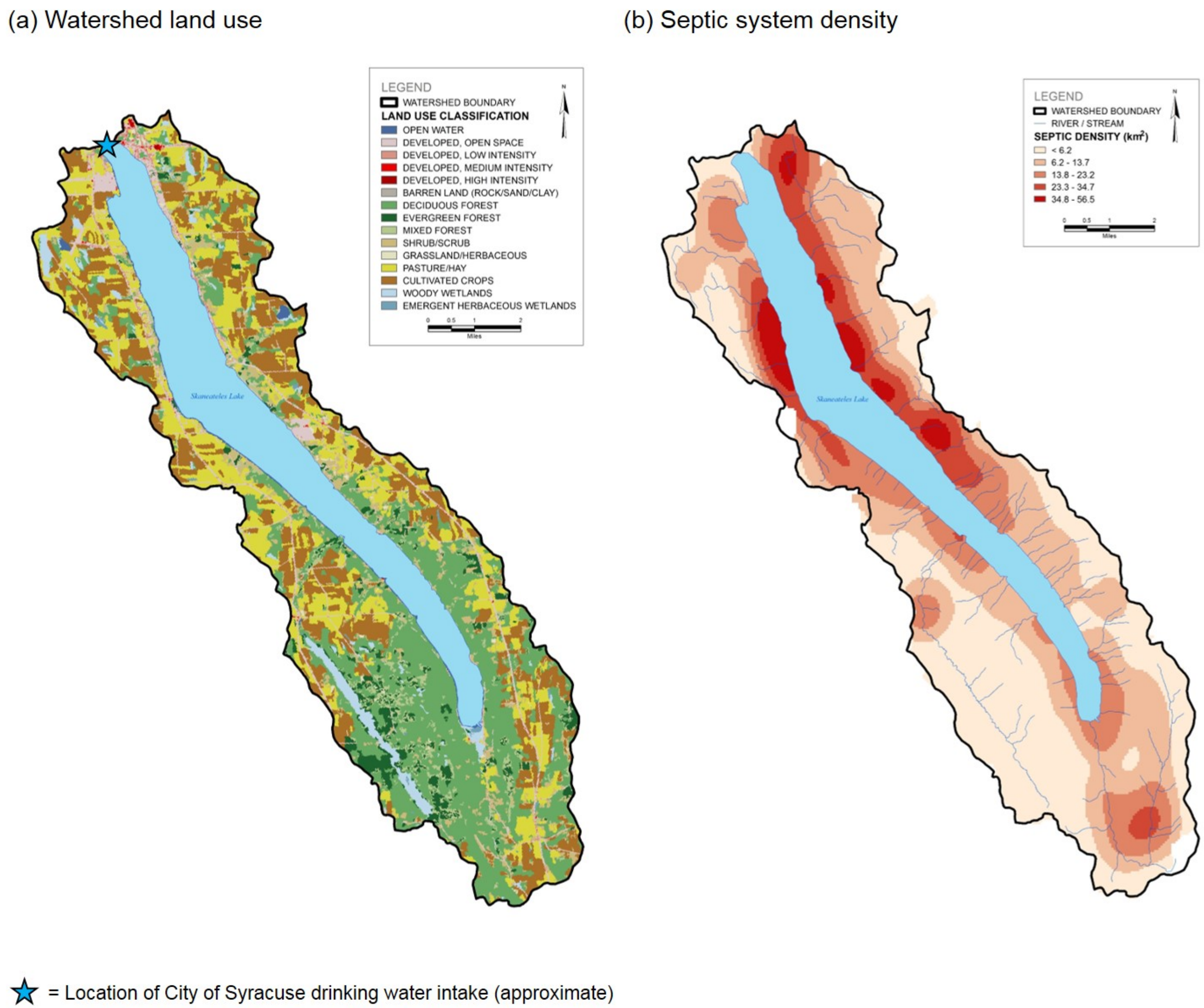


Figure 15. (a) Watershed land use and (b) septic system density (number/km^2) for Skaneateles Lake.

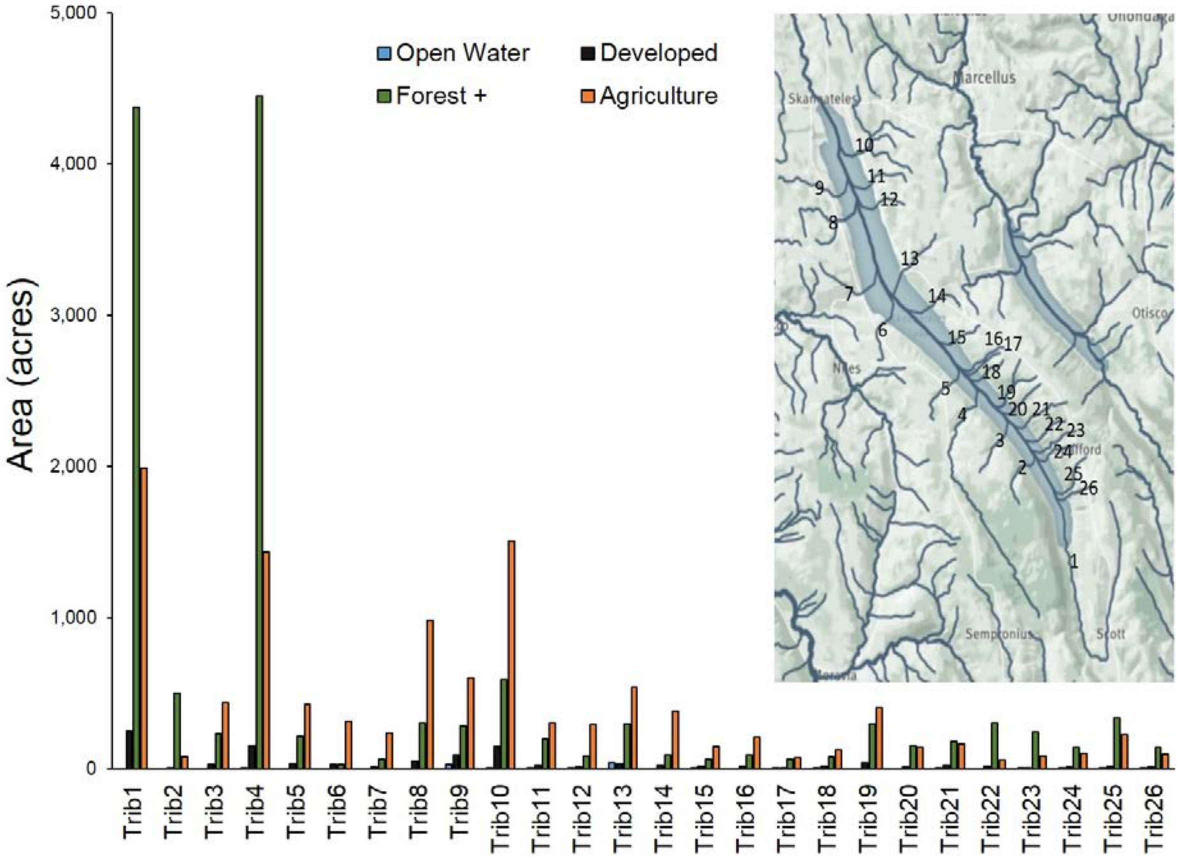


Figure 16. Watershed land use for each tributary to Skaneateles Lake. Map show the location of each tributary.

10.2 External Pollutant Sources

NYSDEC's LENS tool is a simple watershed model that uses average, assumed meteorological conditions, estimated average annual loading rates from nonpoint sectors based on accepted literature values, and estimates of point source contribution. It employs the most recent data from the National Land Cover Dataset, septic density information collected by NYS Office of Real Property and Tax, and State Pollution Discharge Elimination System (SPDES) permits. LENS is a screening tool, used by the NYSDEC, intended to assess the relative load contributions by watershed source to help determine the most appropriate watershed management approach (i.e., a TMDL or 9E plan; https://www.dec.ny.gov/docs/water_pdf/dowvision.pdf) and, for purposes of this Action Plan, support prioritization of water quality improvement projects and allocation of associated resources to mitigate HABs (presented in Section 13).

LENS is not designed to be a comprehensive watershed analysis and does not include all data requirements for a Total Maximum Daily Load (TMDL) or Nine Element (9E) Plan. Although LENS output has shown to be consistent with more comprehensive watershed analyses in New York State, there is uncertainty in the watershed loading estimates presented in this Action Plan. For example, LENS does not take into consideration: (1) other potential contributors of nutrients to the lake such as groundwater, consistently underperforming septic systems, and streambank erosion, (2) internal sources of nutrients (e.g., sediments, dreissenid mussels), and (3) existing best management practices (BMPs) and other nutrient reduction measures being implemented by the municipalities, agricultural community, Soil and Water Conservation Districts, and other stakeholders.

Therefore, LENS results discussed here and in subsequent sections should be considered a ***preliminary approximation*** of external nutrient sources to the lake. Precise quantification of nutrient sources from the watershed is needed and should be determined through: (1) a detailed inventory of nutrient sources – ***from all suspected sectors*** within the watershed, (2) complete a detailed analysis of nutrient load and budget that includes critical factors not accounted for in LENS, (3) the development of a robust land-side nutrient loading model, and (4) completion or update of a NYSDEC approved clean water plan.

This Action Plan should be considered the first step of an adaptive management approach to HABs in Skaneateles Lake. Any completed TMDL or 9E plan developed for Skaneateles Lake will supplement the loading assessment included in this report. A that time, this Action Plan can be updated to reflect current and better understanding of Skaneateles Lake.

NYSDEC’s LENS model analysis for Skaneateles Lake indicates that annual phosphorus loading occurs from nonpoint sources, with no existing point source inputs. Phosphorus loading estimates derived from the LENS model (NYSDEC, undated) are attributable to:

- Septic load = 6%
- Agricultural land = 80%
- Natural areas = 9%
- Developed land (such as lawns and hardened surfaces) = 5%

Regarding agricultural contributions of phosphorus to the lake, approximately 46 farms are identified in the watershed (as of 2018). The majority are dairy farms, and many of these are small family farms. One dairy-based Concentrated Animal Feeding Operation (CAFO) is located completely in the watershed, and parts of four other CAFOs are within the watershed border (Gullick et al. 2006).

Septic system loading has been estimated to be 6% of the total phosphorus load, and the highest septic system density surrounding Skaneateles Lake is found at the northern end of the lake (**Figure 15b**).

It should be noted that NYSDEC’s LENS screening tool is intended to be used to assess the relative load contributions by source to help determine the most appropriate watershed management approach and support prioritization of projects. The LENS tool is a simple steady state model that uses average, assumed conditions and estimated average annual loads from nonpoint sources and point sources, and employs the most recent data for the National Land Cover Dataset, septic information collected by NYS Office of Real Property and Tax, and State Pollution Discharge Elimination System (SPDES) permit and discharge monitoring report information. The LENS tool does not include all the data requirements for detailed watershed load analysis that would be completed for a Total Maximum Daily Load (TMDL) or Nine Element (9E) Plan, and does not take into consideration existing BMPs and other nutrient reduction measures potentially implemented by the agricultural community and other potential contributors of nutrients to the lake. Consequently, the land use percentages and loading estimates presented above for Skaneateles Lake should be interpreted with caution.

10.3 Internal Pollutant Sources

Internal loading from legacy phosphorus likely does not contribute significantly to observed water column total phosphorus levels in Skaneateles Lake. However, possible data gaps in our understanding of nutrient dynamics in Skaneateles Lake include the extent of phosphorus concentrations found within the lake sediments, and dissolved oxygen concentrations at depth during the summer months, although reports from others indicate high concentrations of oxygen throughout the water column (Halfman 2017). Studying and monitoring these parameters explicitly will provide a better understanding about sources of nutrients for algal growth, permit a comprehensive evaluation of factors contributing to HABs, and provide better insight into how to best manage the Skaneateles Lake system in the future. However, at this time, it is assumed that internal loading is not a significant source of nutrients for Skaneateles Lake.

10.4 Summary of Priority Land Uses and Land Areas

As discussed in **Section 10.2**, loading occurs via nonpoint sources. Of these nonpoint sources, 80% is estimated to originate from agricultural land use within the Skaneateles Lake watershed.

11. Lake Management / Water Quality Goals

The primary lake management/water quality goal for Skaneateles Lake is to understand the causes of HABs that occurred in 2017, and the potential trigger(s) for HABs in the future. Robust watershed and in-lake modeling are needed to determine the likely causal factors in this oligotrophic lake.

Given the preliminary assessment of the LENS Tool, management actions for Skaneateles Lake should continue to prioritize reducing contributions of nutrients delivered to the lake via agricultural runoff to the many streams that feed the lake. Acute and long-term nonpoint sources of phosphorus loads should be minimized, to the extent practicable, through the existing efforts of County Soil and Water Conservation Districts including the Skaneateles Lake Watershed Agricultural Program. These existing efforts should be continued and expanded to apply agricultural and non-agricultural BMPs in sub-watersheds most responsible for storm event (especially intense storm event) loading. Control of residential phosphorus sources (e.g., septics, lawn fertilizer) is also a vital aspect component of comprehensively managing Skaneateles Lake water quality.

12. Summary of Management Actions to Date

12.1 Local Management Actions

In 1994, the City of Syracuse created the Skaneateles Lake Watershed Agricultural Program (SLWAP) to assist in the control of agricultural nutrient loading to the lake (OCSWCD 2018). The SLWAP is a stand-alone program that is under the Onondaga County SWCD umbrella. The SLWAP has its own dedicated funding source (provided by City of Syracuse) dedicated staff exclusively for Skaneateles Lake. This program was created as part of the source water filtration avoidance criteria which was established by the NYSDOH for the City of Syracuse (see **Section 3.2**). The primary goal of this fully voluntary program is to implement BMPs to reduce sediment erosion on local farms and the loading of nutrients to streams through collaborative efforts between farmers and the conservation partnership. These BMPs are individualized for each farm depending on their needs. SLWAP is the first, and only, program in NYS that has a dedicated Agricultural Spill Response protocol with the NYSDEC and the Onondaga County 911 Center. The SLWAP has had this program formally in place with the OCSWCD since 2004.

The OCSWCD entered into agreement with several conservation partners to implement the SLWAP including the;

- SWCD’s of Cayuga and Cortland counties
- Cornell Cooperative Extension Associations of Onondaga
- Cayuga and Cortland counties
- USDA Natural Resources Conservation Service (NRCS)

In addition, a Watershed Agricultural Program Review Committee (WAPRC) was formed to give guidance, develop and recommend SLWAP policy and give approval of Whole Farm Plans developed by SLWAP for approval by SWCD boards. The WAPRC consists of seven watershed farmers and one representative from the City of Syracuse.

The New York State Department of Agriculture and Markets (NYSDAM) and Soil and Water Conservation Committee facilitate the New York State Climate Resilient Farming (CRF) Program, which is intended to reduce the impact of agriculture on climate change (mitigation) and to increase the resiliency of local farms in the face of a changing climate (adaptation).

In an effort to monitor lake use and control invasive species movement into Skaneateles Lake, the SLA initiated the Invasive Species Prevention Program in August 2012 (SLA 2018). Data collection for this program includes information on the number of boats using the lake, if the boats had used another waterbody prior to their trip on Skaneateles, and if any invasive species were collected off the boats. Monitoring and data collections in 2012 were conducted at the New York State Boat Launch on West Lake Road and the Town of Skaneateles Boat Launch at Mandana during August and Labor Day weekend. In 2013, the program expanded to include two additional boat launches in the south end of the lake (Town of Scott and Glen Haven) and provided coverage at the State launch daily, the others on weekends from Memorial Day through Labor Day. In 2016, 4,210 boats were inspected with 3% containing some type of aquatic vegetation or organism.

The SLA began the Milfoil Project in 2006 in an effort to gain control over the expanding Eurasian watermilfoil (nearly 3-fold increase in number of patches from 2001 to 2006). Eurasian watermilfoil was at first hand harvested, and later covered with benthic matting to reduce the number of patches. By 2013, it was estimated that 90% of the lake was milfoil free with remaining patches now primarily located around tributary mouths where silt has accumulated. The project is now in maintenance mode with removal of larger areas by benthic matting and suction harvesting occurring each summer. While connections between introduction of aquatic invasive species (AIS) and HABs are not well established, this work may help to re-establish native plants and improve public education about the importance of a balanced ecosystem in support of favorable water quality and lake use.

The City of Syracuse enforces watershed rules and regulations including strict construction storm water regulations and a septic system inspection program.

12.2 Funded Projects

The OCSWCD is funded by the City of Syracuse to conduct and manage the SLWAP, which is key to the City's efforts to prevent or minimize agricultural runoff from reaching the lake, and represents a cornerstone partnership between the City and the lake watershed farming community. The SLWAP provides guidance to develop and implement plans that protect the lake, as well as funding for some BMPs. Various grants provide additional funding for other BMPs (Gullick et al. 2006). The SLWAP provides environmental protection plans for qualifying farms in the watershed. Once the plans are prepared, financial assistance is provided such that farmers and other landowners can install lake protection improvement measures designed to minimize nutrient levels in storm and snow melt runoff water (City of Syracuse 2017). To date, the SLWAP staff have authored 19 grant applications to the NYS EPF and have received $1.6 Million with the City of Syracuse and watershed farmers providing local match funds. Staff has also authored 16 successful grant applications to the USEPA and received $2.6 Million with the City of Syracuse and watershed farmers providing local match funds. The staff have also authored three Climate Resilient Farming grant applications to NYS and secured $293,946 again with the City of Syracuse and watershed farmers providing local match funds. There are numerous other smaller grants that have been received, such as, but not limited to, NYSDEC Water Quality Improvement Program (for municipal road ditch seeding after clean out) and Great Lakes Restoration Initiative funding sources.

Additional funding is provided through programs specifically targeting water quality improvement and the agricultural community in New York State, such as the Water Quality Improvement Program (WQIP) and Agricultural Nonpoint Source Abatement and Control Program (ANSACP) program. These programs have supported the implementation of BMPs within the Skaneateles Lake watershed. Examples of BMP systems implemented that contribute to an improvement in water quality include manure storage systems, barnyard runoff management, access road improvement, and protection of critical areas.

The City of Syracuse has funded the Skaneateles Lake Watershed Education Program, developed and delivered by Cornell Cooperative Extension (CCE) of Onondaga County since 1996. This program works in conjunction with CCE's Farm Business Management Service, a component of the SLWAP.

The New York State Agricultural Environmental Management (AEM) program also supports farmers in their site-specific efforts to protect water quality and conserve natural resources, while enhancing farm viability (AEM 2018). AEM uses a five-tiered framework to categorize on-farm activities that have been prioritized by a committee of resource professionals and stakeholders. The following list includes important elements associated with each tier (NYSSWCC 2018):

- **Tier 1** – Inventory current activities, future plans, and potential environmental concerns
- **Tier 2** – Document current land stewardship, assess and prioritize areas of concern
- **Tier 3** – Develop conservation plans addressing concerns and opportunities tailored to farm goals
    - **Tier 3A**: Component Conservation Plan
    - **Tier 3B**: Comprehensive Nutrient Management Plan (CNMP)
- **Tier 4** – Implement plans utilizing available financial, educational, and technical assistance
- **Tier 5** – Evaluate to ensure the protection of the environment and farm viability
    - **Tier 5A**: Update Tier 1 and 2
    - **Tier 5B**: Plan evaluation/update, BMP system evaluation

Many AEM-sponsored activities have been undertaken within the Skaneateles Lake watershed to address important environmental challenges including improving water quality (**Table 6**). There are currently 46 farms in the watershed (grossing over $10,000 annually over a two-year period). Seven farms do not voluntarily participate in the program. Of those seven farms, four self-implement BMPs supported by the SLWAP.

Table 6. Total number of AEM projects conducted in the Skaneateles Lake watershed (2011-2017).					
	Tier 1	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Total Number of AEM Projects	39	38	37	37	37

Numerous BMPs (**Table 7**) have been implemented (Tier 4) within the Skaneateles Lake watershed through the efforts of the OCSWCD, SLWAP, and farmers.

Table 7*.* Best Management Practices (BMPs) that have been constructed on farms in the Skaneateles Lake Watershed (SLWAP 2018).	
BMP	**Quantity Implemented**
Pathogen Management Systems	27
Barnyard Runoff Management Systems	30
Temporary Manure Storage/Composting systems	21
Nutrient Management Systems	36
Alternative Water Supply	42
Buffer Strips	40 acres
Access Road Improvement Sites	70
Contour Farming	71.6 acres
Diversions	26,713 feet
Fencing	127,819 feet
Milking Center Waste Water Treatment and Disposal Systems	15
Short Duration Grazing Systems	12
Stripcropping Systems	96 acres
Water and Sediment Control Systems	66
Waterways – grass, stone lined	46,291 feet
Critical Area Protection – vegetation control	394 acres
Critical Area Protection - Streambank stabilization	7,254 feet
Nutrient Management Reviews (annually)	26
Mortality Composting Systems	10
Cover Crops (cumulative acres)	1,244.4 acres

*** BMP Data Provided by the SLWAP**

12.3 NYSDEC Issued Permits

Article 17 of New York's Environmental Conservation Law (ECL) entitled "Water Pollution Control" was enacted to protect and maintain the state's surface water and groundwater resources. Under Article 17, the State Pollutant Discharge Elimination System (SPDES) program was authorized to maintain reasonable standards of purity for state waters. NYSDEC provides on-line information for the SPDES Permit Program for all nine regions in the state. The Skaneateles Lake watershed is located within NYSDEC Region 7. The discharge of sanitary or industrial wastewater to the lake is prohibited. NYSDEC has issued 69 SPDES Individual Permits in the Cayuga County portion of the Skaneateles Lake watershed and 11 in the Onondaga County portion. None of these are direct discharges of waters or materials to Skaneateles Lake.

NYSDEC also issues Multi-Sector General Permits (MSGPs) under the SPDES Program for stormwater discharges related to certain industrial activities. Numerous active facilities have been authorized under the MSGP in Onondaga and Cayuga Counties. Of these facilities, only two border Skaneateles Lake (Town of Skaneateles), neither of which were determined to be associated with direct discharges of waters or materials to the lake. For more information about NYSDEC's SPDES program and to view MSGP and Individual SPDES permits issued in the Skaneateles Lake watershed visit http://www.dec.ny.gov/permits/6054.html.

CAFO permits, issued under the SPDES Program, are required for animal feed programs that meet animal size (number of animal) thresholds. Of the 46 farms located in the Skaneateles Lake watershed in 2018, the majority were family owned small dairy farms that did not meet the animal size threshold requiring CAFO permitting. One large dairy farm that was located wholly within the watershed required a CAFO permit and four other CAFO permitted farms were partially located in the watershed in 2006 (Gullick et al. 2006).

In 2017, NYSDEC issued two new CAFO general permits which specifically prohibit liquid manure applications on saturated soils and also include additional restrictions for liquid manure applications on frozen, ice, and snow covered soils. More information about the CAFO permits is on NYSDEC's website (https://www.dec.ny.gov/permits/6285.html).

12.4 Research Activities

The Disinfectant By-Product (DBPs) study, Citizen's Statewide Lake Assessment Program (CSLAP), Finger Lakes Synoptic Water Quality Investigation (SWQI, 1996, 1997 and 1999), and the Finger Lakes Water Hub early-year sampling are the primary research activities conducted on Skaneateles Lake by the NYSDEC to monitor water quality conditions. In addition to these efforts taken by the NYSDEC, several other research groups have monitored the water quality of Skaneateles Lake since the early 2000's (see **Section 5**).

Finger Lakes Water Hub early-year sampling

Initial review of Finger Lakes water quality datasets in early 2017 showed that almost no data had been gathered on the state of the lakes in wintertime (November to April). Additional data collection during the winter months may provide additional information on overall water quality and potential for HABs formation during the growing season.

Staff from NYSDEC's Finger Lakes Water Hub, a group focused on HABs and other water quality threats in the Finger Lakes Region, collected water quality samples in February and April 2018 on all 11 Finger lakes. These sampling efforts were undertaken to characterize important indicators of lake health during winter-early spring and to provide early-year information that can be used for HABs management planning. Temperature, conductivity, pH, dissolved oxygen, and chlorophyll were measured from the surface to the bottom of the lake using a YSI probe; Secchi depth also was recorded. Water samples were collected from just below the surface (1.5-meter depth) and near the bottom (2/3 total depth) at one CSLAP site on each lake for analysis of the standard CSLAP parameters (e.g., TP, TN, NOx, ammonia, chloride, calcium, and chlorophyll-a). Samples were either collected from a boat or through the ice. For lakes with surface ice, samples were collected through a hole created by hand-auguring through up to 12 inches of ice. In addition to monitoring water quality, samples also were collected for researchers at SUNY ESF for analysis of algal toxins, zooplankton and phytoplankton, and lake sediments.

While data analysis is ongoing, highlights of observations in the field include: inverse stratification (warmer at the bottom than the top) in the ice-covered lakes, while those remaining ice-free were isothermal (all the same temperature) and well mixed; dissolved oxygen was lower, although not hypoxic, in the lower third of Honeoye and Canadice Lakes than the surface during ice cover, whereas the remaining lakes, even those under ice, were well oxygenated; and water clarity was generally high with Secchi Disk depths greater than 15m in both Skaneateles and Seneca lakes (both are generally less than 10 m during the growing season).

12.5 Clean Water Plans (TMDL, 9E, or Other Plans)

Clean water plans are a watershed-based approach to outline a strategy to improve or protect water quality. TMDLs and 9E Plans are examples of clean water plans; these plans document the pollution sources, pollutant reduction goals, and recommend strategies/actions to improve water quality:

- A TMDL calculates the maximum amount of a single pollutant that a waterbody can receive and still meet water quality standards. TMDLs are developed by determining the amount that each source of a pollutant can discharge into the waterbody and the reductions from those sources needed to meet water quality standards. A TMDL is initiated by NYSDEC for waterbodies that are on the 303d impaired waters list with a known pollutant.

- 9E Watershed Plans are consistent with the USEPA's framework to develop watershed-based plans. USEPA's framework consists of nine key elements that are intended to identify the contributing causes and sources of nonpoint source pollution, involve key stakeholders in the planning process, and identify restoration and protection strategies that will address the water quality concerns. The nine minimum elements to be included in these plans include:

  A. Identify and quantify sources of pollution in watershed.
  B. Identify water quality target or goal and pollutant reductions needed to achieve goal.
  C. Identify the best management practices (BMPs) that will help to achieve reductions needed to meet water quality goal/target.
  D. Describe the financial and technical assistance needed to implement BMPs identified in Element C.

E. Describe the outreach to stakeholders and how their input was incorporated and the role of stakeholders to implement the plan.
F. Estimate a schedule to implement BMPs identified in plan.
G. Describe the milestones and estimated time frames for the implementation of BMPs.
H. Identify the criteria that will be used to assess water quality improvement as the plan is implemented.
I. Describe the monitoring plan that will collect water quality data need to measure water quality improvement (criteria identified in Element H).

9E Plans are best suited for waterbodies where the pollutant of concern may be well understood and nonpoint sources are likely a significant part of the pollutant load; the waterbody does not need to be on the 303d impaired waters list to initiate a 9E Plan.

The Town of Skaneateles is sponsoring a state grant application to develop a 9E Plan for Skaneateles Lake and its associated watershed, according to a February 2018 public press article. As part of the 9E Plan, the Skaneateles Lake watershed and its nutrient loading sources, as well as target areas where BMPs should be implemented to reduce nutrient flux to the lake, will be identified and mapped. The SLA, City of Syracuse, SLWAP, and the Central New York Regional Planning & Development Board are already working on data collection for the Skaneateles Lake 9E Plan.

13. Proposed Harmful Algal Blooms (HABs) Actions

13.1 Overarching Considerations

When selecting projects intended to reduce the frequency and severity of HABs, lake and watershed managers may need to balance many factors. These include budget, available land area, landowner willingness, planning needs, community priorities or local initiatives, complementary projects or programs, water quality impact or other environmental benefit (e.g., fish/habitat restoration, flooding issues, open space).

Additional important considerations include (1) the types of nutrients, particularly phosphorus, involved in triggering HABs, (2) confounding factors including climate change, and (3) available funding sources (discussed in **Section 13.2**).

13.1.1 Phosphorus Forms

As described throughout this Action Plan, a primary factor contributing to HABs in the waterbody is excess nutrients, in particular, phosphorus. Total phosphorus (TP) is a common metric of water quality and is often the nutrient monitored for and targeted in watershed and lake management strategies to prevent or mitigate eutrophication (Cooke et al. 2005).

However, TP consists of different forms (Dodds 2003) that differ in their ability to support algal growth. There are two major categories of phosphorus: particulate and dissolved (or soluble). The dissolved forms of P are more readily bioavailable to phytoplankton than particulate forms (Auer et al. 1998, Effler et al. 2012, Auer et al. 2015, Prestigiacomo et al. 2016). Phosphorus bioavailability is a term that refers to the usability of specific forms of phosphorus by phytoplankton and algae for assimilation and growth (DePinto et al. 1981, Young et al. 1982).

Because of the importance of dissolved P forms affecting receiving waterbody quality, readers of the Action Plan should consider the source and form of P, in addition to project-specific stakeholder interest(s), when planning to select and implement the recommended actions, best management practices or management strategies in the Action Plan. Management of soluble P is an emerging research area; practices designed for conservation of soluble phosphorus are recommended in Sonzogni et al. 1982, Ritter and Shiromohammadi 2000, and Sharpley et al. 2006.

13.1.2 Climate Change

Climate change is also an important consideration when selecting implementation projects. There is still uncertainty in the understanding of BMP responses to climate change conditions that may influence best management practice efficiencies and effectiveness. More research is needed to understand which BMPs will retain their effectiveness at removing nutrient and sediment pollution under changing climate conditions, as well as which BMPs will be able to physically withstand changing conditions expected to occur because of climate change.

Where possible, selection of BMPs should be aligned with existing climate resiliency plans and strategies (e.g., floodplain management programs, fisheries/habitat restoration programs, or hazard mitigation programs). When selecting BMPs, it is also important to consider seasonal, inter-annual climate or weather conditions and how they may affect the performance of the BMPs. For example, restoration of wetlands and riparian forest buffers not only filter nutrient and sediment from overland surface flows, but also slow runoff and absorb excessive water during flood events, which are expected to increase in frequency due to climate change. These practices not only reduce disturbance of the riverine environment but also protect valuable agricultural lands from erosion and increase resiliency to droughts.

In New York State, ditches parallel nearly every mile of our roadways and in some watersheds, the length of these conduits is greater than the natural watercourses themselves. Although roadside ditches have long been used to enhance road drainage and safety, traditional management practices have been a significant, but unrecognized contributor to flooding and water pollution, with ditch management practices that often enhance rather than mitigate these problems. The primary objective has been to move water away from local road surfaces as quickly as possible, without evaluating local and downstream impacts. As a result, elevated discharges increase peak stream flows and exacerbate downstream flooding. The rapid, high volumes of flow also carry nutrient-laden sediment, salt and other road contaminants, and even elevated bacteria counts, thus contributing significantly to regional water quantity and quality concerns that can impact biological communities. All of these impacts will be exacerbated by the increased frequency of high intensity storms associated with climate change. For more information about road ditches, see **Appendix F**.

For more information about climate change visit NYSDEC's website (https://www.dec.ny.gov/energy/44992.html) and the Chesapeake Bay Climate Resiliency Workgroup Planning Tools and Resources website (https://www.chesapeakebay.net/documents/Resilient_BMP_Tools_and_Resources_November_20172.pdf).

13.2 Priority Project Development and Funding Opportunities

The priority projects listed below have been developed by an interagency team and local steering committee that has worked cooperatively to identify, assess feasibility and costs, and prioritize both in-lake and watershed management strategies aimed at reducing HABs in Skaneateles Lake.

Steering committee members:

- Doug Kierst, Cayuga County Soil and Water Conservation District (SWCD)
- Rich Abbott, City of Syracuse
- Shannon Fabiani, Cornell Cooperative Extension
- Amanda Barber, Cortland County SWCD
- Zack Odell, Finger Lakes Land Trust
- Patrick Jackson, Global Energy Management at Corning, Inc.
- Jim Greenfield, Greenfield Farms
- PJ Emerick, NYSDAM
- Aimee Clinkhammer, NYSDEC
- Karen Stainbrook, NYSDEC
- Matt Kazmierski, NYSDEC
- John Strepelis, NYSDOH
- Lloyd Wilson, NYSDOH
- Shawn Rush, Onondaga County Health Department
- Travis Glazier, Onondaga County Office of the Environment
- Mark Burger, Onondaga County SWCD/Skaneateles Lake Watershed Agricultural Program
- Bob Werner, Skaneateles Lake Association (SLA)
- Neil Murphy, SLA/SUNY ESF
- Rich Abbott, Syracuse Water Department
- Dave Matthews, Upstate Freshwater Institute

These projects have been assigned priority rankings based on the potential for each individual action to achieve one of two primary objectives of this HABs Action Plan:

1. *In-lake management actions:* Minimize the internal stressors (e.g., nutrient concentrations) that contribute to HABs within Skaneateles Lake.
2. *Watershed management actions:* Address watershed inputs that influence in-lake conditions that support HABs.

As described throughout this HABs Action Plan, the primary factors that often contribute to HABs and represent conditions within the Skaneateles Lake watershed that can be controlled through management actions include:

- Nonpoint source sediment and nutrient inputs from the contributing watershed (e.g., agricultural lands, forests, ditch and streambank erosion).
- Stormwater runoff and failing septic systems from developed areas.

The management actions identified below have been prioritized to address these sources. Projects were prioritized based on the following cost-benefit and project readiness criteria: local support or specific recommendation by steering committee members, eligibility under existing funding mechanisms, and expected water quality impacts as determined by the interagency team. Additionally, nutrient forms and the impacts of climate change were considered in this prioritization as described above.

The implementation of the actions outlined in this Plan is contingent on the submittal of applications (which may require, for example, landowner agreements, feasibility studies, funding match, or engineering plans), award of funding, and timeframe to complete implementation. Due to these contingencies, recommended projects are organized into broad implementation schedules: short-term (3 years), mid-term (3-5 years), and long-term (5-10 years).

Funding Programs

The recommended actions outlined in this Section may be eligible for funding from the many state, federal and local/regional programs that help finance implementation of projects in New York State (see https://on.ny.gov/HABsAction). The New York State Water Quality Rapid Response Team stands ready to assist all partners in securing funding. Some of the funding opportunities available include:

The New York State Environmental Protection Fund (EPF) was created by the state legislation in 1993 and is financed primarily through a dedicated portion of real estate transfer taxes. The EPF is a source of funding for capital projects that protect the environment and enhance communities. Several NYS agencies administer the funds and award grants, including NYSDAM, NYSDEC, and Department of State. The following two grant programs are supported by the EPF to award funding to implement projects to address nonpoint source pollution:

The Agricultural Nonpoint Source Abatement and Control Program (ANSACP), administered by the NYSDAM and the Soil and Water Conservation Committee, is a competitive financial assistance program for projects led by the Soil and Water Conservation Districts that involves planning, designing, and implementing priority

BMPs. It also provides cost-share funding to farmers to implement BMPs. For more information visit https://www.nys-soilandwater.org/aem/nonpoint.html.

The Water Quality Improvement Program (WQIP), administered by the NYSDEC Division of Water, is a competitive reimbursement program for projects that reduce impacted runoff, improve water quality, and restore habitat. Eligible applicants include municipalities, municipal corporations, and Soil and Water Conservation Districts.

The Environmental Facilities Corporation (EFC) is a public benefit corporation which provides financial and technical assistance, primarily to municipalities through low-cost financing for water quality infrastructure projects. EFC's core funding programs are the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund. EFC administers both loan and grant programs, including the Green Innovation Grant Program (GIGP), Engineering Planning Grant Program (EPG), Water Infrastructure Improvement Act (WIIA), and the Septic System Replacement Program. For more information about the programs and application process visit https://www.efc.ny.gov/.

Wastewater Infrastructure Engineering Planning Grant is available to municipalities with median household income equal to or less than $65,000 according to the United States Census 2015 American Community Survey or equal to or less than $85,000 for Long Island, NYC and Mid-Hudson Regional Economic Development Council (REDC) regions. Priority is usually given to smaller grants to support initial engineering reports and plans for wastewater treatment repairs and upgrades that are necessary for municipalities to successfully submit a complete application for grants and low interest financing.

Clean Water Infrastructure Act (CWIA) Septic Program funds county-sponsored and administered household septic repair grants. This program entails repair and/or replacement of failing household septic systems in hot-spot areas of priority watersheds. Grants are channeled through participating counties.

CWIA Inter-Municipal Grant Program funds municipalities, municipal corporations, as well as soil and water conservation districts for wastewater treatment plant construction, retrofit of outdated stormwater management facilities, as well as installation of municipal sanitary sewer infrastructure.

CWIA Source Water Protection Land Acquisition Grant Program funds municipalities, municipal corporations, soil and water conservation districts, as well as not-for-profits (e.g., land trusts) for land acquisition projects providing source water protection. This program is administered as an important new part of the Water Quality Improvement Project program.

Consolidated Animal Feeding Operation Waste Storage and Transfer Program Grants fund soil and water conservation districts to implement comprehensive nutrient management plans through the completion of agricultural waste storage and transfer systems on larger livestock farms.

Water Infrastructure Improvement Act Grants funds municipalities to perform capital projects to upgrade or repair wastewater treatments plants and to abate combined sewer overflows, including projects to install heightened nutrient treatment systems.

Green Innovation Grant Program provides municipalities, state agencies, private entities, as well as soil and water conservation districts with funds to install transformative green stormwater infrastructure.

Readers of this Action Plan interested in submitting funding applications are encouraged to reference this Action Plan and complementary planning documents (i.e., TMDLs or 9E Plans) as supporting evidence of the potential for their proposed projects to improve water quality. However, applicants must thoroughly review each funding program's eligibility, match, and documentation requirements before submitting applications to maximize their potential for securing funding.

There may be recommended actions that are not eligible for funding through existing programs, however, there may be opportunities to implement actions through watershed programs (https://www.dec.ny.gov/chemical/110140.html) or other mechanisms.

13.3 Skaneateles Lake Priority Projects

13.3.1 Priority 1 Projects

Priority 1 projects are considered necessary to manage water quality and reduce HABs in Skaneateles Lake, and implementation should be evaluated to begin as soon as possible.

Short-term (3 years)

1. Perform modelling of both in-lake conditions and the contributing watershed for use in developing a 9E Plan.
2. Implement a cost sharing program for utilization of manure injection technology to reduce the impacts associated with liquid dairy manure and for installation of cover crops.
3. Continue to support and implement the program to monitor and inspect existing septic systems within the Skaneateles Lake watershed to maximize the functional capacity of these systems and minimize their nutrient contributions. Systems that are not functioning properly should be replaced through a cost sharing program.

Mid-term (3 to 5 years)

The following items are incorporated in the SLWAP and Home*A*Syst Program (water quality education program cooperatively sponsored by Cornell Cooperative Extension (CCE) of Onondaga and the City of Syracuse):

1. Implement roadside ditch and culvert improvement projects on currently failing ditch systems to reduce and capture sediment. Best management practices could include:
    a. Timing of cleanout to minimize soil erosion.
    b. Properly sizing culverts and channels to avoid headcuts and other erosion.
    c. Use of erosion control practices to assist in ditch stabilization.
    d. Installation of check dams or other facilities to reduce flow velocities, minimize erosion, and promote sedimentation.

2. Provide public outreach and education to homeowners and lake-shore residents about watershed management and nonpoint source pollution, including encouraging proper lawn management to minimize watershed impacts. This work could be performed by organizations such as CCE and local SWCDs.

3. Implement runoff reduction BMPs on croplands and non-agricultural lands to reduce stormwater and nutrient runoff and soil erosion within the watershed, including:
    a. Establishing cover crops on cropland that is prone to erosion and nutrient runoff when left unprotected. Cover crops are a specific type of vegetative cover that is carefully planted on a field that would otherwise be left bare after a cash crop is harvested. A cover crop diffuses heavy rainfall, protecting the soil surface from erosion. In addition, a cover crop allows for living roots to be present throughout much of the year adding rich organic matter to the soil and trapping nutrients that would otherwise be prone to runoff if the soil is left bare after harvest.
    b. Implementing field erosion control systems (grassed waterways, shaping and grading, and water and sediment control basins (WASCoBs) to promote stormwater retention and minimize concentrated runoff (e.g., rills, gullies).
    c. Stabilizing drainage swales through establishment of vegetation and/or installation of check dams.
    d. Stabilizing stream banks using both hard armoring and natural stream design methods to lessen the potential for severe and sudden sedimentation from large and/or re-occurring storm events.
    e. Installing control facilities at the outlets of drainage swales (prior to entering the lake or tributaries) to promote sediment and nutrient capture.
    f. Implementing runoff reduction BMPs for farmsteads: roof runoff management, barnyards, laneways/access roads, and bunk silos.
    g. Conducting a pilot test on drainage tile BMPs.
    h. Establishing vegetated riparian buffers to inhibit or reduce nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams.

i. Rehabilitating degraded vegetated buffers to improve riparian habitat function on tributaries to Skaneateles Lake.

4. Construct wetlands or enhance/restore existing wetlands in high priority sub-watersheds (e.g., Shotwell Brook) to reduce sediment and nutrient loads. **Figure 17** shows the locations within the Skaneateles Lake watershed that have either hydric, very poor, or poorly drained soils, but are not currently mapped wetland habitats according to the National Wetland Inventory (NWI) database. These locations should be targeted for proposed wetlands as they are more likely to support wetland hydrology and vegetation.
5. Plant trees and shrubs, on available municipal lands and willing landowner properties, along the lake shoreline and along tributaries (e.g., Trees for Tribs program) to stabilize riparian habitat and to reduce solar heat load.

Long-term (5 to 10 years)

1. A study of a possible extension and/or additional public water intake into a deeper water location to limit the potential for algal toxin entering the intake and affecting the City of Syracuse and Village of Skaneateles public drinking water supplies. This project would also investigate enhancing interconnections with the Onondaga County Water Authority during a HAB event.
2. Acquire and conserve lands within the watershed to protect and maintain existing buffers before increased subdivision and land conversion impacts these functioning systems.

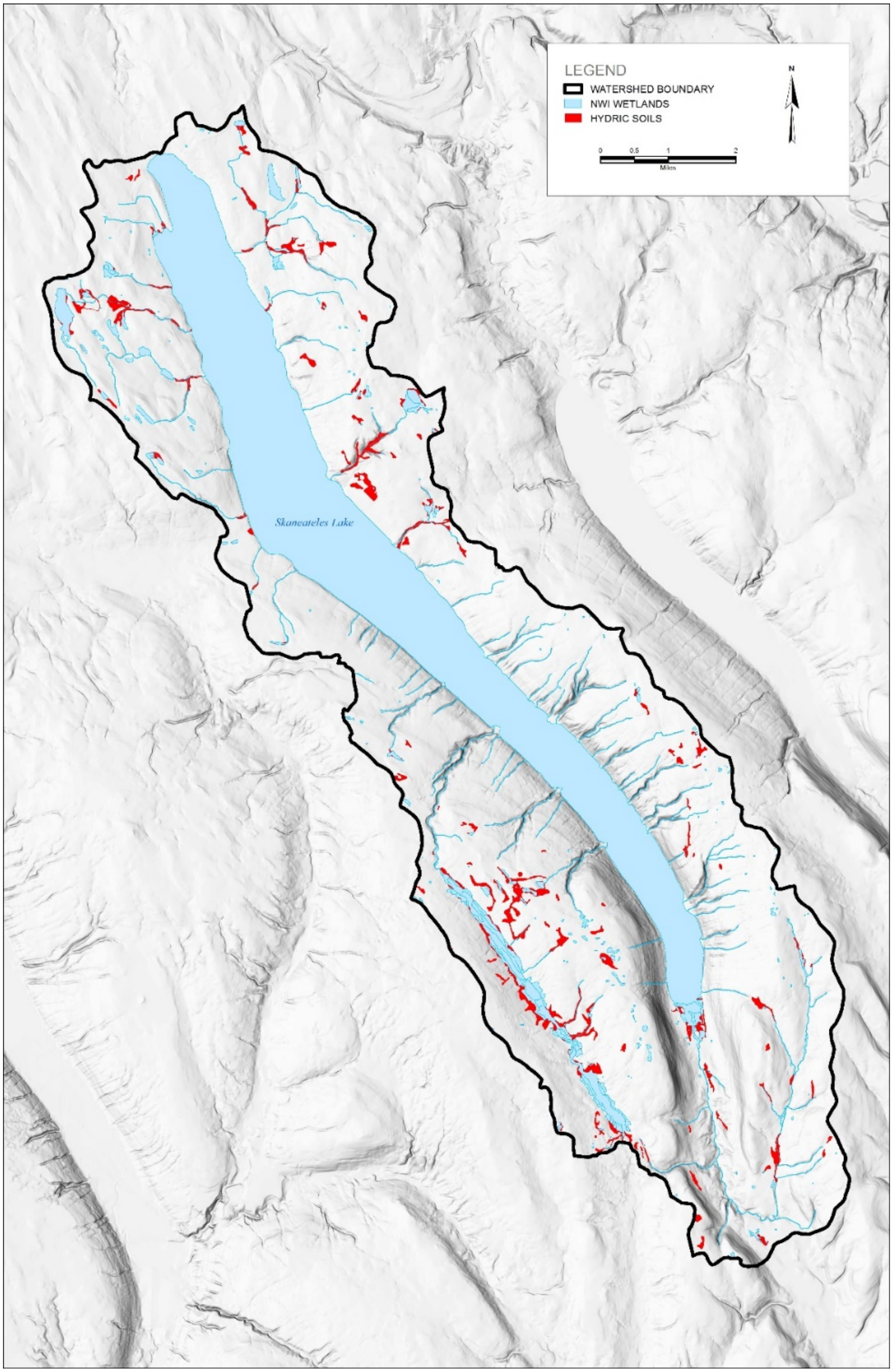


Figure 17. Locations (depicted in red) of either hydric, very poor, or poorly drained soils in the Skaneateles Lake watershed, which are not mapped as wetlands per the National Wetland Inventory (NWI).

13.3.2 Priority 2 Projects

Priority 2 projects are considered necessary, but may not have a similar immediate need as Priority 1 projects.

Short-term (3 years)

1. Increase SWCD staffing at Onondaga County SWCD (and other watershed SWCDs) under the Watershed Agricultural Program to implement BMP work, increase education/outreach, perform site inspections for municipalities, and conduct upland water management (stormwater/green and gray infrastructure) projects on both public and private lands.

2. Purchase equipment (in addition to supporting programs) to implement reduction/management as well as erosion and sediment control measures, including (items b, d, e, and g are incorporated in the SLWAP and Home*A*Syst Program):

    a. Bark blowers to effectively mulch soils and stabilize large highly erodible critical areas
    b. Wood waste recycling equipment to convert municipal and culvert debris into useful material
    c. Specialized seeders for cover crop applications, including independent Highboy seeders or high horsepower tractors for tow behind models
    d. Straw mulchers
    e. Hydroseeders
    f. Manure handling equipment (injection, boom spreader, drag line for immediate incorporation of manure to minimize runoff potential).
    g. Satellite manure storage systems.

Mid-term (3 to 5 years)

1. Continue to implement AEM Tier 3A Plans for crop farmers and Nutrient Management Plans (NMPs) for livestock operations (incorporated in the SLWAP and Home*A*Syst Program).

2. Continue to evaluate the presence of forest pests that affect hemlock (*Tsuga spp.*), ash (*Fraxinus spp.*), spruce (*Picea spp.*), and other tree species that are currently integral to watershed stabilization. Implement pro-active pest prevention and/or management to reduce the impacts of the pests. Recommended strategies include (incorporated in the SLWAP and Home*A*Syst Program):

    a. Work with CCE on establishing hemlock hedges within biological control field stations.

    b. Use systemic insecticides (imidacloprid and dinotefuran) and/or introduce natural enemies such as the predatory beetle *Laricobius nigrinus* that is used to control the hemlock wooly adelgid (*Adelges tsugae*), a destructive invasive pest of the eastern hemlock, in hemlock-dominated forest/woodlands.

13.3.3 Priority 3 Projects

Priority 3 projects are considered important, but may not have a similar immediate need as Priority 1 and 2 projects.

Long-term (5 to 10 years)

1. Continue to prepare NMPs that include manure storage management, financial and technical assistance for both CAFO and non-CAFO farms (incorporated in the SLWAP and Home*A*Syst Program).

13.4 In-Lake Management Actions

The available evidence indicates that contributions from internal phosphorus loading are negligible in Skaneateles Lake, and investment is better focused elsewhere at this time.

13.5 Monitoring Actions

To help determine the stresses that lead to potential HABs in Skaneateles Lake and to assess improvements associated with management actions, the following monitoring actions are recommended for evaluation:

Short-term

1. Continue annual CSLAP sampling and expand it to include:
    a. Analysis of soluble reactive phosphorus (SRP) concentrations.
    b. Evaluation of impacts from acute storm events and long-term trends in phosphorus loading and occurrences of HABs in the lake.
    c. Alignment of in-lake water quality data collection efforts with overpasses of NASA's Landsat 8 satellite (**Table 8**), to the extent possible. This alignment will allow for the effective use of satellite imagery when characterizing lake conditions based on corresponding field data. In addition, applications of remote sensing may be improved by collecting chlorophyll-a field samples over the depth of light transmission (e.g., twice the Secchi depth to the water surface) due to the high water clarity of Skaneateles Lake.

Table 8. Landsat 8 overpasses of Skaneateles Lake from May through October 2018.

Month	Dates			
May	May 5	May 12	May 21	May 28
June	June 6	June 13	June 22	June 29
July	July 8	July 15	July 24	July 31
August	August 9	August 16	August 25	
September	September 1	September 10	September 17	September 26
October	October 3	October 12	October 19	October 28

2. Evaluate the benefit of remote sensing using multi-spectral and hyper-spectral scanners in monitoring lake water quality including sediment loading and chlorophyll concentrations and changes in water shed land use.
3. Expand sampling locations to nearshore zones. Current sample locations are offshore and may not provide the most useful data and information for identifying area-specific triggers for HABs in the lake.
4. Supplement the understanding of the algae species contributing to blooms through taxonomic analysis of samples collected during conditions favorable for HABs formation (i.e., still conditions, elevated water temperatures, recent nutrient inputs). Knowledge of the dominant cyanobacteria in the lake allows for development of species-specific implementation strategies for controlling and managing their abundance.
5. Supplement data on cyanotoxin concentrations during confirmed blooms.
6. Continue water quality study/monitoring efforts in lake tributaries to:
    a. Provide a long-term data set of nutrient levels and other water quality parameters that can be used to support defensible estimates of nutrient loading.
    b. Install pressure transducers and data loggers at critical tributary monitoring locations to allow a continuous record of tributary flows; develop and implement a corresponding sampling strategy to better understand the contribution is small/ephemeral tributaries during runoff events.
    c. Develop and validate a watershed model to better understand loading and resulting effects on water quality from BMPs and other actions outlined herein.
    d. Conduct an evaluation to quantify the particulate and dissolved forms of phosphorus.
7. Maintain and enhance community and/or volunteer monitoring efforts of water quality conditions in the lake, in conjunction with SLA and CSLAP, particularly during the growing season.
8. Start an Enhanced HAB Surveillance Monitoring Network on Skaneateles Lake where trained volunteers look for and sample suspected HABs.

Collectively, these data can be used to enhance capabilities for predicting HABs occurrences.

13.6 Research Actions

To help understand the stresses that lead to HABs and develop management strategies to prevent the potential formation of HABs in Skaneateles Lake, the following research actions are recommended for evaluation:

Short-term

1. Conduct pilot studies to document effectiveness of site-specific nonpoint source load abatement and precision agriculture. This includes an evaluation of the best approach(es) to document the effectiveness of management action, and quantifying conditions *before* actions are conducted (e.g., baseline conditions) to accurately assess their effectiveness. The potential application of precision agriculture, with the objective of targeting agricultural nutrients to specific areas of need, could provide a cost savings to the agriculture community while reducing the environmental impact associated with excessive application.
2. Conduct water quality sampling in tributaries and/or in discharge points in the lake during or following heavy rainfall events, as permissible, to document nutrient inputs that may contribute to localized HABs facilitated by storm events. Priority for such sampling efforts should be given to sub-watersheds with larger catchment areas and where land use is predominantly agricultural.
3. Document lakefront septic systems that are not functioning properly (e.g., dye tests, optical brightener surveys). Lakefront properties are the highest priority for testing. Information gleaned from dye testing should be compiled into a database to permit priority-based decisions regarding septic contributions and remediation (incorporated in the SLWAP).
4. Collect water samples of total soluble phosphorus in the lake to quantify phosphorus bioavailability for cyanobacteria. In addition, evaluate the speciation of phosphorus from various nonpoint sources to the lake. The speciation should include organic and inorganic particulate phosphorus and ortho phosphate, organic phosphate, and poly phosphate forms of soluble phosphorus, which is the form readily available for algal growth (in contrast to particulate forms).
5. Document the extent of phosphorus currently found within the sediment at various spatial locations in Skaneateles Lake (southern, middle, and northern extents) and study the sediment/water column exchange of phosphorus. Understanding how phosphorus concentrations may vary at different locations in the lake and the sediment/water column exchange will help to evaluate whether cyanobacteria are extracting nutrients from surficial sediments rather than from the water column.
6. Sediments removed and accumulated in water and sediment control basins should be analyzed for nutrient and organic composition.

7. Demonstrate the benefit of remote sensing using multi-spectral and hyper-spectral scanners in monitoring lake water quality including sediment loading and chlorophyll-a concentrations and changes in watershed land use.
8. Quantify coverage of dreissenid mussels in Skaneateles Lake and assess their impacts on algal growth via nutrient recycling and speciation via selective feeding. While an in-lake model will be useful in this regard, it should be supported by detailed survey data and process studies.
9. The issue of climate change and its effects on nutrient loading (e.g., more intense runoff events) and phytoplankton community composition (e.g., higher water temperatures, increased water column stability) should be included as a research action or woven into the projects.

Mid-term

1. Use data from ongoing nutrient monitoring studies in Grout Brook, Shotwell Creek, Bear Swamp Creek, and Harold Brook to help prioritize sub-watersheds for phosphorus reduction BMPs.
2. Conduct localized studies of groundwater quality and hydrology. Although general information on groundwater resources, utilization, and management approaches are available at the watershed level, detailed assessments of near-lake groundwater nutrient levels, elevations, and lake infiltration rates are lacking.

Long-term

1. Build a long-term database of physical and chemical water quality parameters to permit a multivariate statistical analysis of the drivers most responsible for HABs in the lake.

NYSDEC should support research to better understand how to target dissolved phosphorus with traditional and innovative nonpoint source best management practices.

The NYSDEC should continue to coordinate with local organizations and research groups to maximize the efficacy of research efforts with the shared goal of maintaining the water quality within Skaneateles Lake. Specifically, the role of nitrogen concentrations in the production of toxins by cyanobacteria should be studied and management actions targeted at optimizing the nutrient levels to minimize the production of toxins associated with HABs.

The NYSDEC should support research to better understand how to target dissolved phosphorus with traditional and innovative nonpoint source best management practices. This applied research would guide selection of appropriate BMPs to target dissolved phosphorus in the future.

The NYSDEC should support research to understand and identify which best management practices will retain their effectiveness at removing nutrient and sediment pollution under changing climate conditions, as well as which BMPs will be able to physically withstand changing conditions expected to occur as a result of climate change. This applied research would guide selection of appropriate BMPs in the future and determination of the likely future effectiveness of existing BMPs.

The NYSDEC should support research to investigate the role of climate change on lake metabolism, primary production, nutrient cycling, and carbon chemistry.

The NYSDEC should encourage and support research into management options for dreissenids and better understanding of their natural population cycles.

13.7 Coordination Actions

The following actions are opportunities for stakeholders, general public, steering committee members, federal, state, and local partners to collaborate, improve project or program integration, enhance communication and increase implementation. The actions are intended to increase collaboration and cooperation in the overall advancement of this HABs Action Plan. These actions will likely change or expand as the Action Plan is implemented and/or research is completed, or when opportunities for coordination are identified.

Short-term

1. Consider establishing a watershed intermunicipal organization (IO) to advance watershed projects. Members should include all municipalities in the watershed; Cayuga, Cortland and Onondaga Counties; and the City of Syracuse. The IO should work collaboratively with other watershed stakeholders including soil and water conservation districts, the Skaneateles Lake Association, and other partners.
2. Encourage public participation in initiatives for reducing phosphorus and documenting/tracking HABs, such as volunteer monitoring networks and/or increasing awareness of procedures to report HABs to NYSDEC.
3. Improve coordination between NYSDEC and owners of highway infrastructure (state, county, municipal) to address road ditch management; including, identify practices, areas of collaboration with other stakeholder groups, and evaluation of current maintenance practices.
4. Continue to support and provide targeted training (e.g., ditch management, emergency stream intervention, sediment and erosion controls, prescribed grazing, conservation skills, etc.) to municipal decision makers, SWCDs, and personnel in order to underscore the importance of water quality protection as well as associated tools and strategies.

Long-term

1. Pursue acquisitions of conservation easements to implement watershed protection strategies, harnessing available funding opportunities related to land purchases for water quality protection. The City of Syracuse has purchased conservation easements to establish riparian buffers designed to

preserve the exceptional lake water quality, so far avoiding the need to install and operate a costly water filtration plant (Azzaino et al. 2002). The past conservation easement purchase program within the watershed should be resumed through a partnership between the City of Syracuse, the FLLT, and the NYSDEC.

2. Support Land Trusts through volunteering and financial support to facilitate land protection measures as well as purchases/acquisitions of conservation preserves within the Skaneateles Lake watershed.
3. Support the SLA and CCE on education and outreach efforts to homeowners in the watershed and residents on the lake shore about how their actions effect water quality.
4. Identify opportunities to encourage best management practice implementation through financial incentives and alternative cost-sharing options.
5. Coordinate with Department of Health to support the local health departments to implement onsite septic replacement and inspection activities.
6. Identify areas to improve efficiency of existing funding programs that will benefit the application and contracting process. For example, develop technical resources to assist with application process and BMP selection, identify financial resources needed by applicants for engineering and feasibility studies.
7. Support evaluation of watershed rules and regulations.

13.8 Long-term Use of Action Plan

This Action Plan is intended to be an adaptive document that may require updates and amendments, or evaluation as projects are implemented, research is completed, new conservation practices are developed, implementation projects are updated, or priority areas within the watershed are better understood.

Local support and implementation of each plan’s recommended actions are crucial to successfully preventing and combatting HABs. The New York State Water Quality Rapid Response Team has established a one-stop shop funding portal and stands ready to assist all localities in securing funding and expeditiously implementing priority projects.

Communities and watershed organizations are encouraged to review the plan for their lake, particularly the proposed actions, and work with state and local partners to implement those recommendations. Individuals can get involved with local groups and encourage their communities or organizations to take action.

Steering committee members are encouraged to coordinate with their partners to submit funding applications to complete implementation projects. For more information on these funding opportunities, please visit https://on.ny.gov/HABsAction.

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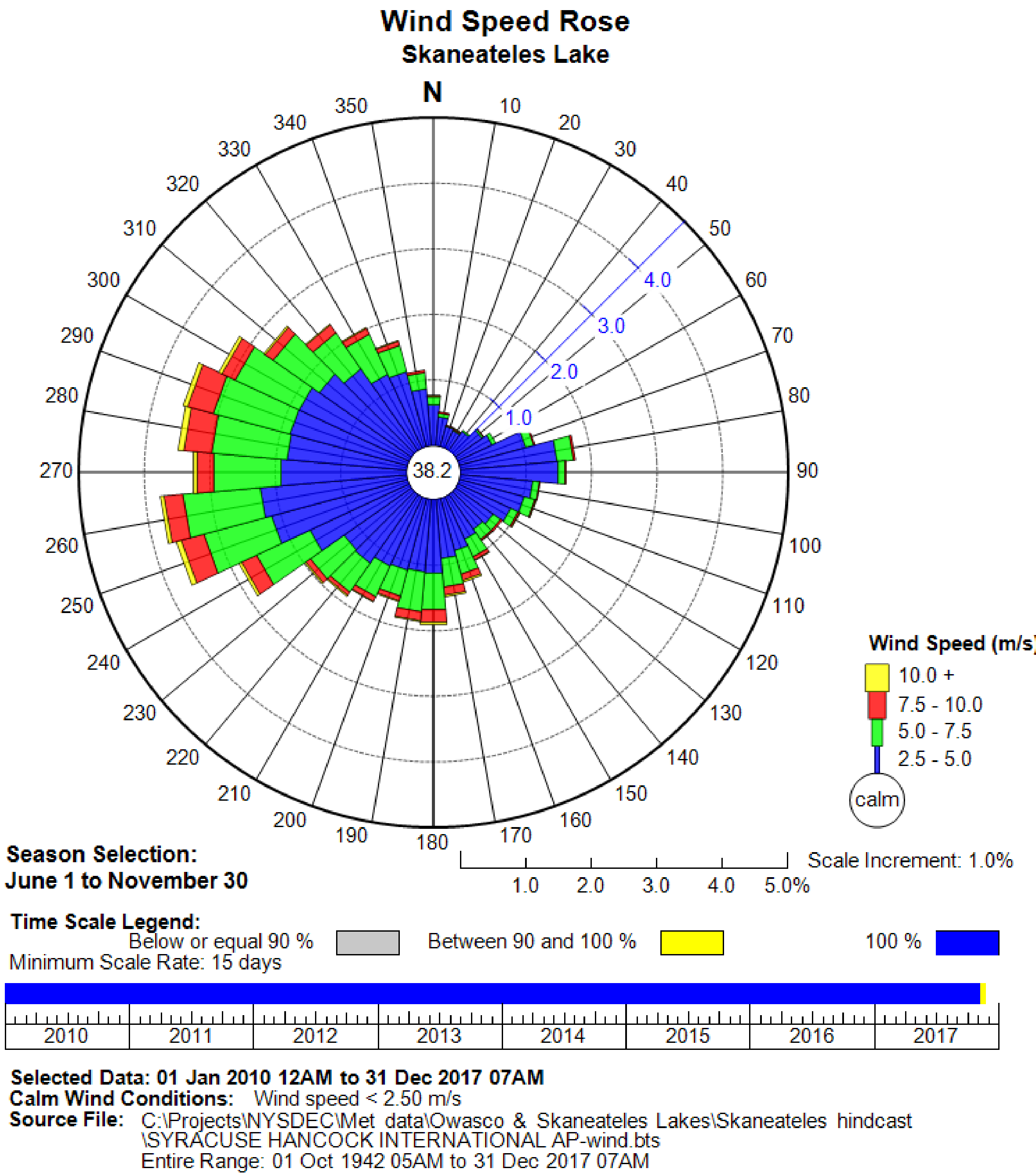
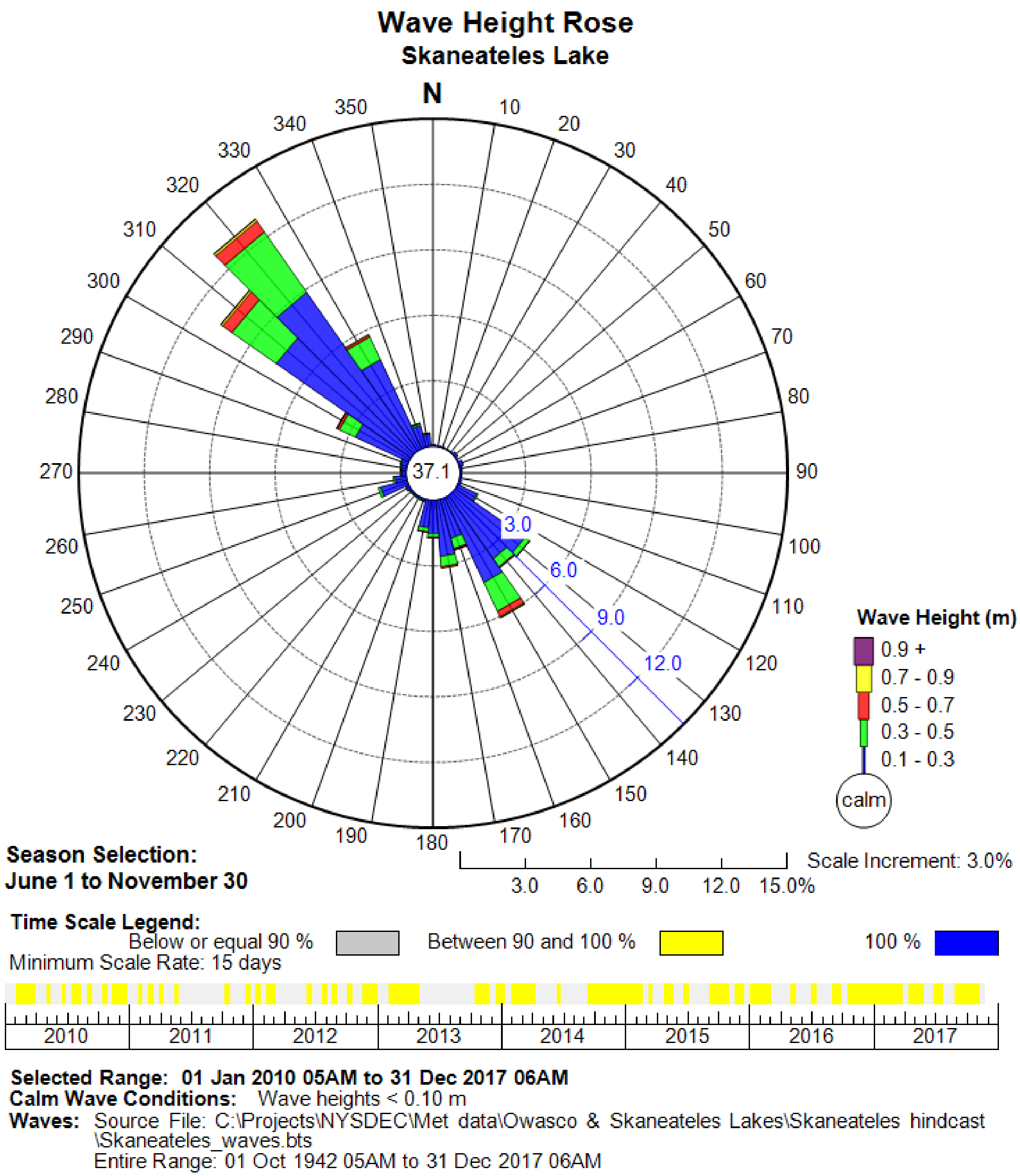
Appendix A. Wind and Wave Patterns



Wind speeds in Skaneateles Lake from 2010 to 2017, during the months of June through November, indicate that stronger winds were most common out of the west.



Wave height patterns from 2010 to 2017, during the months of June through November, indicate wave heights were greater in the northwestern portion of Skaneateles Lake.

Appendix B. Waterbody Classifications

Class N: Enjoyment of water in its natural condition and where compatible, as source of water for drinking or culinary purposes, bathing, fishing and fish propagation, recreation and any other usages except for the discharge of sewage, industrial wastes or other wastes or any sewage or waste effluent not having filtration resulting from at least 200 feet of lateral travel through unconsolidated earth. These waters should contain no deleterious substances, hydrocarbons or substances that would contribute to eutrophication, nor shall they receive surface runoff containing any such substance.

Class $AA_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival, and shall contain no floating solids, settleable solids, oils, sludge deposits, toxic wastes, deleterious substances, colored or other wastes or heated liquids attributable to sewage, industrial wastes or other wastes. There shall be no discharge or disposal of sewage, industrial wastes or other wastes into these waters. These waters shall contain no phosphorus and nitrogen in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.

Class $A_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These international boundary waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class AA: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These waters, if subjected to approved disinfection treatment, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class A: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival.

These waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class B: The best usage is for primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival

Class C: The best usage is for fishing, and fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class D: The best usage is for fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class (T): Designated for trout survival, defined by the Environmental Conservation Law Article 11 (NYS, 1984b) as brook trout, brown trout, red throat trout, rainbow trout, and splake.

Class (TS): Designated for trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies.

Appendix C. WI/PWL Summary

Skaneateles Lake (0707-0004) — Minor Impacts

Waterbody Location Information

Revised: 05/01/2018

Water Index No:	Ont 66-12-29-P193	**Water Class:**	AA
Hydro Unit Code:	Lower Seneca River (0414020116)	**Drainage Basin:**	Oswego-Seneca-Oneida
Water Type/Size:	Lake/Reservoir 8720.3 Acres	**Reg/County:**	7/Onondaga (34)
Description:	entire lake		

Water Quality Problem/Issue Information

Uses Evaluated	Severity	Confidence
Water Supply	Threatened	Known
Public Bathing	Stressed	Known
Recreation	Stressed	Known
Aquatic Life	Fully Supported	Suspected
Fish Consumption	Unassessed	-
Conditions Evaluated		
Habitat/Hydrology	Unknown	
Aesthetics	Unknown	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: Algal/Plant Growth, Sediment and Turbidity
Suspected: ---
Unconfirmed: Other Pollutants

Source(s) of Pollutant(s)

Known: ---
Suspected: Agriculture, Urban/Storm Runoff, Onsite/Septic Systems, Streambank Erosion
Unconfirmed:

Management Information

Management Status: Strategy Implementation Scheduled or Underway
Lead Agency/Office: DOW/BWAM
IR/305(b) Code: Water Attaining Some Standards Data (IR Category 2)

Further Details

Overview
Skaneateles Lake is assessed as having minor impacts due to primary and secondary contact recreation uses that are known to be stressed due to the occasional occurrence of harmful algal blooms.

Use Assessment
Skaneateles Lake is a Class AA waterbody, required to support and protect uses as a water supply source for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing.

Evaluation of the use of this lake for public water supply includes conditions of the lake water prior to treatment, not the quality of water and does not necessarily reflect the quality distributed for use after treatment. Monitoring of water quality at the tap is conducted by local water suppliers and public health agencies. Water supply use in Skaneateles Lake is considered to be threatened due to the occurance of harmful algal blooms (HABs) with the presense of high levels of algal toxins (cyanotoxins) during September and October 2017. Cyanotoxins have been found at and below the intake depth, although it is not known if there are HABs near the public water intakes. Skaneateles Lake is the unfiltered public water supply for the City of Syracuse and the Village of Skaneateles. HAB toxins were found at both intakes and in the distrubution system but were never detected above the state health advisory of 0.3 µg/l in chlorinated drinking water. A large number of private home water intakes were also impacted during the bloom. (NYSDOH, September, 2017; NYSDEC/DOW, BWAM, April 2018)

Primary and secondary contact recreation uses are known to be stressed. However, it is not yet known if the widespread HABs documented in the fall of 2017 are indicative of a more persistent problem, since similar blooms had not been previoulsy reported on the lake. Secondary contact recreation use (boating, fishing) may be affected by the presence of invasive plant growth (Eurasian watermilfoil, curly leafed pondweed); this is managed through the Milfoil Eradication Project conducted by the Skaneateles Lake Association since 2007. Fishing use is believed to be fully supported based on a 2012 NYSDEC fish survey indicating no impacts to the fishery but a full biological assessment is needed to confirm use support. Several invasive animals are found in the lake, including zebra mussels, quagga mussels and scud. These organisms may threatened aquatic life (NYSDEC/DOW, BWAM, April 2018).

Fish Consumption use is considered to be unassessed. There are no health advisories limiting the consumption of fish from this waterbody (beyond the general advice for all waters). However due to the uncertainty as to whether the lack of a waterbody-specific health advisory is based on actual sampling, fish consumption use is noted as unassessed. (NYS DOH Health Advisories and NYSDEC/DOW, BWAM, April 2018)

Water Quality Information

Skaneateles Lake was sampled as part of the NYSDEC Citizen Statewide Lake Assessment Program (CSLAP) beginning in 1997 and continuing through 2001, and was sampled at two lake locations in 2017. An Interpretive Summary report of the findings of this sampling was published in 2002. This report characterized the lake as oligotrophic, or highly unproductive. The very high water clarity of the lake was the result of very low nutrient and algae levels. Phosphorus levels in the lake were consistently below the state guidance values indicating impacted/stressed recreational uses. Corresponding transparency measurements easily exceeded what was recommended for swimming beaches. In fact, a September 2001 clarity reading of 15 meters was among the highest ever recorded in a NYS lake. These results were confirmed through water quality sampling by NYSDEC through the Finger Lakes Water Quality Study in the late 1990s, and additional NYSDEC sampling of the lake in 2004 through an EPA-sponsored disinfection-by-product study of lakes throughout the state.

CSLAP was expanded to include all eleven Finger Lakes in 2017. Two sites in Skaneateles Lake were sampled biweekly from June through September. Chlorophyll/algal levels were below the criteria of 4 µg/L for Class AA waters corresponding to threatened water supply use, phosphorus concentrations are also low. Lake clarity measurements indicate water transparency always exceeds the minimum criteria for swimming beaches. Readings of pH fall within the range eestablished in the state water quality standards for protection of aquatic life.

Source Assessment

Specific sources of pollutants to the waterbody have not been identified. Source of pollutants that are suspected include non-point source runoff from episodic (high intensity- short duration) storm events as potentially a contributing source of nutrients and silt/sediment from agriculture and streambank and ditch erosion. Very intense storms in July 2017, led to increases in nutrients and turbidity in the lake as seen in CSLAP 2017 data. These events may have contributed to the HAB in the lake in September 2017. High levels of turbidity threaten the City of Syracuse’s drinking water filtration avoidance determination.

There is an active City of Syracuse Watershed inspection program. Several years ago, they completed an innovative on-site septic treatment system implementation program, although there are still potential impacts from on-site septic systems in this watershed.

Management Actions

This waterbody is considered a highly valued water resource due to its drinking water supply classification and because it has a filtration avoidance determination. The lake is a multi–use waterbody, but is also the primary source of water for several communities including the City of Syracuse. There are significant watershed protection measures in place to protect this water supply, including the Skaneateles Lake Watershed Agricultural Program. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Skaneateles Lake was identified for inclusion in this initiative as it is vulnerable to HABs and is a critical drinking water source.

Section 303(d) Listing

Skaneateles Lake is not included on the current (2016) NYS Section 303(d) List of Impaired Waters Requiring a TMDL.

Segment Description

This segment includes the entire portion of the Lake.

Appendix D. NYSDEC Water Quality Monitoring Programs

Additional information available from http://www.dec.ny.gov/chemical/81576.html.

Appendix E. SWAP

The NYSDOH has evaluated the Onondaga County Water Authority's (OCWA) susceptibility to contamination for Skaneateles Lake under the SWAP. A summary of its findings are as follows:

> *This assessment found a moderate susceptibility to contamination for this source of drinking water. The amount of pasture in the assessment area results in a high potential for protozoa contamination. No permitted discharges are found in the assessment area. There are no likely contamination threats associated with other discrete contaminant sources, even though some facilities were found in low densities.*

Appendix F. Road Ditches

In New York State, ditches parallel nearly every mile of our roadways and in some watersheds, the length of these conduits is greater than the natural watercourses themselves. Although roadside ditches have long been used to enhance road drainage and safety, traditional management practices have been a significant, but unrecognized contributor to flooding and water pollution, with ditch management practices that often enhance rather than mitigate these problems. The primary objective has been to move water away from local road surfaces as quickly as possible, without evaluating local and downstream impacts. As a result, elevated discharges increase peak stream flows and exacerbate downstream flooding. The rapid, high volumes of flow also carry nutrient-laden sediment, salt and other road contaminants, and even elevated bacteria counts, thus contributing significantly to regional water quantity and quality concerns that can impact biological communities. All of these impacts will be exacerbated by the increased frequency of high intensity storms associated with climate change. Continued widespread use of outdated road maintenance practices reflects a break-down in communications among scientists, highway managers, and other relevant stakeholders, as well as tightening budgets and local pressures to maintain traditional road management services. Although road ditches can have a significant impact on water quality, discharges of nutrients and sediment from roadways can be mitigated with sound management practices.

Road Ditch Impacts

Roadside ditch management represents a critical, but overlooked opportunity to help meet watershed and clean water goals in the Skaneateles Lake watershed by properly addressing the nonpoint sources of nutrients and sediment entering the New York waters from roadside ditches. The three main impacts of roadside ditch networks are: (1) hydrological modification, (2) water quality degradation, and (3) biological impairment.

Mitigation Strategies to Reduce Impacts

Traditional stormwater management focused on scraping or armoring ditches to collect and rapidly transport water downstream. The recommended mitigation strategies described below focus on diffusing runoff to enhance sheet flow, slowing velocities, and increasing infiltration and groundwater recharge. This approach reduces the rapid transfer of rainwater out of catchments and helps to restore natural hydrologic conditions and to reduce pollution while accommodating road safety concerns.

These strategies can be divided into three broad, but overlapping categories:

1. **Practices designed to hold or redirect stormwater runoff to minimize downstream flooding.**
    - Redirect the discharges to infiltration or detention ponds.

    - Restore or establish an intervening wetland between the ditch and the stream.
    - Divert concentrated flow into manmade depressions oriented perpendicular to flow using level lip spreader systems.
    - Modify the road design to distribute runoff along a ditch, rather than a concentrated direct outflow.
2. **Practices designed to slow down outflow and filter out contaminants.**
    - Reshape ditches to shallow, trapezoidal, or rounded profiles to reduce concentrated, incisive flow and the potential for erosion.
    - Optimize vegetative cover, including hydroseeding and a regular mowing program, instead of mechanical scraping. Where scraping is necessary, managers should schedule roadside ditch maintenance during late spring or early summer when hydroseeding will be more successful.
    - Build check dams, or a series of riprap bars oriented across the channel perpendicular to flow, to reduce channel flow rates and induce sediment deposition while enhancing ground water recharge.
    - Reestablish natural filters, such as bio-swales, compound or "two-stage" channels, and level lip spreaders.
3. **Practices to improve habitat.**
    - Construct wetlands for the greatest potential to expand habitat.
    - Reduce runoff volumes to promote stable aquatic habitat.

The Upper Susquehanna Coalition (USC) is developing a technical guidance document in the form of a Ditch Maintenance Program Guide that can be used by any local highway department. The guide will include an assessment program to determine if the ditch needs maintenance and what is necessary to stabilize the ditch. It will also contain a group of acceptable and proven management guidelines and practices for ditch stabilization. In addition, the USC is developing a broad-based education and outreach program to increase awareness and provide guidance to stakeholder groups. This program will take advantage of existing education programs, such as the NY's Emergency Stream Intervention (ESI) Training program, USC, Cornell University and the Cornell Local Roads program. This new program will be adaptable in all watersheds.