



5.4.5 HARMFUL ALGAL BLOOM

This section provides a profile and vulnerability assessment of the harmful algal bloom (HAB) hazard.

5.4.5.1 Profile

The profile contains a description of the HAB hazard, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences.

Hazard Description

Algae can be found in a wide range of environments, including fresh water, oceans, hot springs, and even on land. Algae are a diverse group of species ranging from single-celled organisms to kelp seaweeds that can grow to be over 50 yards long. Algae can be found in symbiotic relationships with other organisms, the most common being corals and lichens. Large species of algae that appear to grow off the lake or sea floor are referred to as macroalgae while smaller, microscopic species are referred to as microalgae. Microalgae can be free floating in the water column as phytoplankton or can rest on the bottom of the water body as periphyton.

Because of their incredible diversity and shared characteristics with plants, the taxonomy of algae has been much discussed. Originally classified as plants, algae are now found in the kingdom Protista. Algae are further broken down into groups commonly grouped by pigmentation. Most species of green algae are only found in fresh water while most species of red algae and brown algae are only found in salt water. Brown algae are among the most complex forms of algae while blue-green algae are one of the simplest forms of algae. Also referred to as cyanobacteria (a bacteria rather than a true algae), blue-green algae are either single celled or colonial. Blue-green algae are the most common form of algae to result in HABs in Onondaga County, impacting the county's lakes.

Algae blooms are caused by an excess of nutrients available in a waterbody, resulting in a rapid growth and reproduction of algae in what is commonly referred to as a “bloom.” Waterbodies that are impacted by runoff of nutrients at high levels of both naturally occurring and manmade, algae can experience overloading of nutrients and become more vulnerable to algal blooms.

Algae, like plants, photosynthesize, forming the basis of many aquatic and marine food chains. However, unlike plants, algae do not have roots for nutrient intake. Some species of macroalgae appear to have roots because they are attached to the bottom by a structure known as a holdfast, but the holdfast does not absorb and transfer nutrients in the same way that roots do. Instead, algae are able to draw their nutrients directly from the environment that surrounds them. Due to this phenomenon, high nutrients, warm temperatures, and low turbulence at the water's surface all increase the risk of algal blooms.

As the base of the food chain in aquatic systems, phytoplankton populations are under constant threat of being eaten by herbivores. Phytoplankton species employ a variety of natural defenses to limit the amount of population destruction that unabated grazing by herbivores can cause. These may include regulation of population size and seasonal occurrence, growth of spiny exteriors, and the creation of toxins. More than 40 cyanobacterial species are confirmed or suspected to produce toxins (Graham and Wilcox 2000). When these populations of algae grow out of control and produce toxins or have harmful effects, it is typically referred to as a *Harmful Algal Bloom* or *HAB*. Contact with water containing HABs can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (NYSDOH 2017).



Traditional methods of in-home treatment systems such as boiling, disinfecting with chlorine/ultraviolet (UV), and water filtration units are not effective in removing HABs and their toxins. Public water is always the best option for drinking, preparing food, cooking, washing, and bathing because water suppliers are required to treat, disinfect, and monitor their water supplies (NYSDOH 2017). However, in many cases along the Finger Lakes including Skaneateles Lake, public water supply is not an option and the drilling of wells may not be possible due to space limitations. In addition, some public water supplies, such as the Skaneateles Lake intake, the primary drinking water source for the City of Syracuse, may have a filtration waiver. Even after a HAB abates, toxins released by algae can remain in the water column for weeks. Water treatment plants with filtration systems can remove variable amounts of microcystin from drinking water; however, as much as 20 percent may escape the treatment process (Carmichael 1997), sometimes leading to plant and water system closures.

Numerous cases of seafood poisoning have been associated with the accumulation of toxins from algae by fish or shellfish and the subsequent ingestion of those species by humans. These cases include paralytic shellfish poisoning, ciguatera fish poisoning, and amnesiac shellfish poisoning. The majority of these cases are from fish found in HABs in coastal oceans, but fish should not be consumed from lakes that are impacted by these blooms.

The presence of HABs will trigger official beach closures, drinking water restrictions, advisory signs, press releases, and notifications on websites such as the NYSDEC Harmful Algal Blooms Notifications Page (NYSDEC 2017b). This page posts weekly notifications from late spring through fall. Children and animals should be kept away from waters suspected of containing HABs, and fishing or eating fish should be prohibited. In Onondaga County, the primary threat from HABs is drinking water source contamination, followed by recreational precautions (and associated economic impacts) and potential effects of the accumulation of toxins in fish for human consumption.

Identifying Harmful Algal Blooms

The appearance of HABs can vary greatly. According to the NYSDEC, colors can include shades of green, blue-green, yellow, brown, red, or white. The physical appearance of these blooms can include floating dots or clumps and streaks on the water's surface as illustrated in Figure 5.4.5-1. Some blooms can also resemble spilled paint on the water's surface or change the appearance of water to that of pea soup (NYSDEC 2017a).



Figure 5.4.5-1. Examples of Harmful Algal Bloom Visual Appearance



Source: NYSDEC 2016

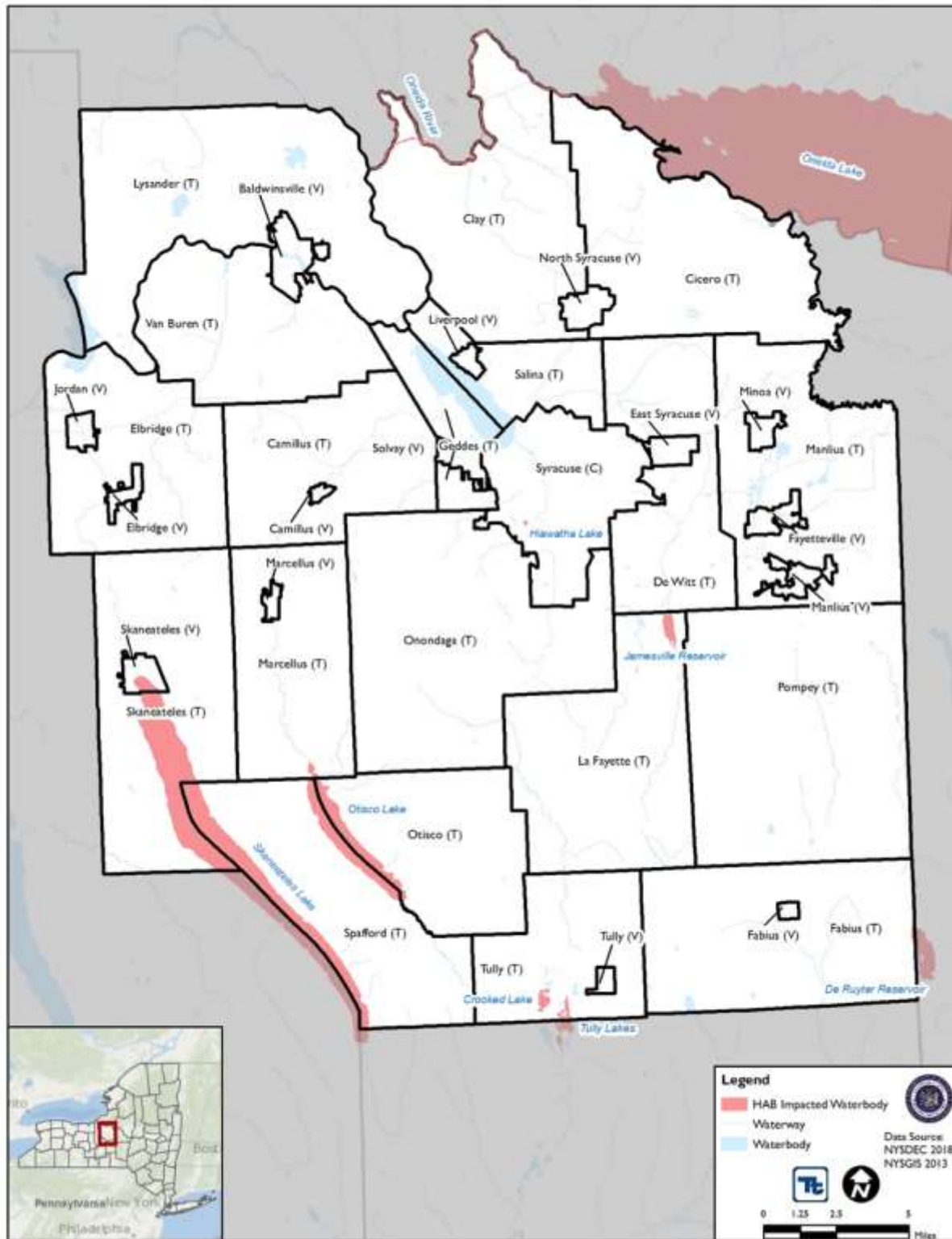
The NYSDEC Lake Classification and Inventory Program, Citizen Statewide Lake Assessment Program volunteers and partnered HAB monitoring programs collect and report information about the status of



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waterbodies in New York that may be impacted by HABs (NYSDEC 2018). Figure 5.4.5-2 shows the location of waterbodies that are monitored in Onondaga County or bordering Onondaga County.

Figure 5.4.5-2. NYSDEC Lakes Monitoring Program Map





Location

Onondaga County has significant exposure and vulnerability to the HAB hazard, as described below.

- Shorelines of the Onondaga County waterbodies with documented HABs may be easily accessible by the public, which can increase the chance of exposure. Many of the county’s lakes are popular recreation lakes and have an abundance of lake users, tourism and shoreline development.
- HABs are generally limited to lakes and ponds but any surface water can experience harmful algal blooms as evinced by prior events in the Oneida River.
- Locations that rely on surface water intake for drinking water are most exposed to the impacts of HABs:
 - Filtered water intake systems such as the OCWA intake at Otisco Lake.
 - Private unfiltered water intake systems or public water intake systems that have received a filtration waiver. Skaneateles Lake is the primary source of drinking water for the City of Syracuse. Additionally, it provides drinking water to portions of the Town of DeWitt, the Town of Onondaga, the Town of Geddes, the Town of Camillus, the Town of Salina, the Town of Skaneateles, the Village of Skaneateles, the Village of Jordan, and the Village of Elbridge. Approximately 43 million gallons of water are drawn from the lake per day via two 54-inch diameter steel intake pipes located 20 feet and 45 feet below the lake surface. Private shoreline owners may also draw directly from surface water supplies with unfiltered systems.

NYS DEC records indicate eight waterbodies in Onondaga County had documented HABs in recent years. In total, these waterbodies have a combined 186.9 miles of shoreline, 89.2 miles of which are part of Onondaga County. Table 5.4.5-1 breaks down the total shoreline miles per lake and the shoreline miles per lake in Onondaga County.

Table 5.4.5-1. Shoreline of Major Waterbodies in Onondaga County with Documented HABs in recent years

Lake	Shoreline Miles (total)	Shoreline Miles (in Onondaga County)	Surface Area (Acres)
De Ruyter Reservoir	6.4	1.0	588.9
Hiawatha Lake	0.6	0.6	11.3
Jamesville Reservoir	4.0	4.0	216.9
Oneida Lake	73.9	15.9	51,271.7
Oneida River	41.6	21.1	820.2
Otisco Lake*	15.5	15.5	2,250.7
Skaneateles Lake*	34.2	24.6	8,765.6
Tully Lake/Crooked Lake	10.7	6.5	401.4
Total	186.9	89.2	64,326.9

Source: NYS GIS

Note: *- Indicates major drinking water source.

While most HAB contact occurs along shorelines, blooms can take place throughout surface waters. According to the 2010 Census, approximately 3.3 percent of Onondaga County is made up of surface water.



Extent

The NYSDEC uses visual observations, photographs, and laboratory sampling results to determine if blooms are comprised of cyanobacteria or other types of algae. Figure 5.4.5-3 is a photograph of a cyanobacteria bloom at Skaneateles Country Club Marina in 2017. NYS DEC staff will set bloom statuses for waterbodies that are being investigated for harmful algal blooms:

- **Suspicious Bloom:** NYSDEC staff have determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs. Laboratory analysis has not been conducted to confirm whether this suspicious bloom is a HAB. It is not known if toxins are present in the water.
- **Confirmed Bloom:** Water sampling results have confirmed the presence of a cyanobacteria HAB, which may produce toxins or other harmful compounds.
- **Confirmed with High Toxins Bloom:** Water sampling results have confirmed that toxins are present in enough quantities to potentially cause health effects if people and animals come in contact with the water through swimming or drinking (NYSDEC 2018).

Suspicious blooms are reported to NYSDEC, local health departments, or the NYSDOH (NYSDOH 2017).

Figure 5.4.5-3. Cyanobacteria Bloom at Skaneateles Country Club Marina, 2017

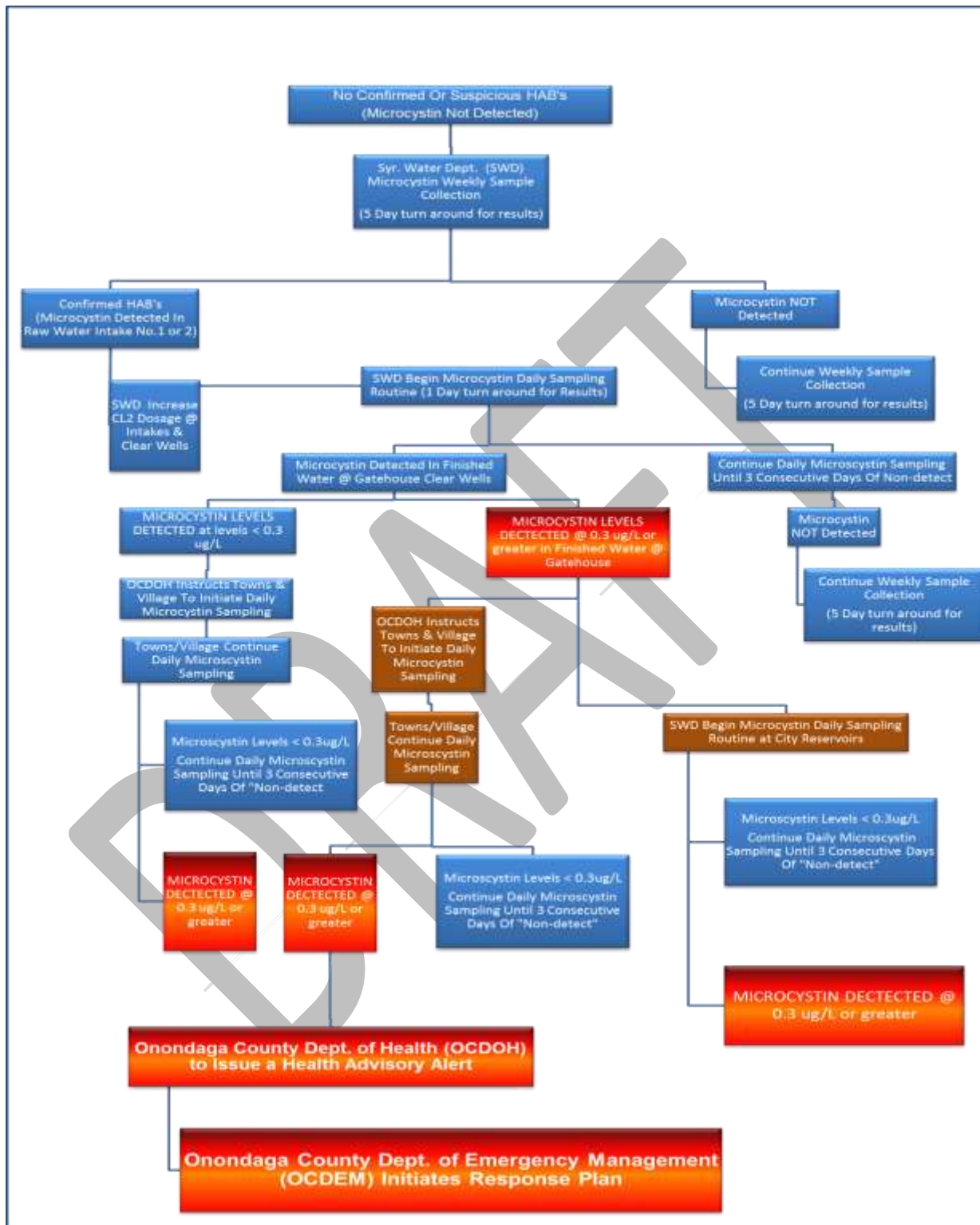


Source: NYSDEC 2017d

The Syracuse Department of Water has a Harmful Algal Bloom Response Plan which outlines the steps from sampling to action based upon testing results. This response plan is outlined below in Figure 5.4.5-4.



Figure 5.4.5-4. Syracuse Department of Water Harmful Algal Bloom Response Plan



Source: City of Syracuse 2018





The NYSDEC has previously identified HABs in eight waterbodies in Onondaga County; however, it is possible that other waterbodies may have been impacted as well but were not identified in monitoring programs. The extent of a harmful algal bloom is an estimate of the area of the waterbody that is impacted. The NYSDEC has four categories to classify extent within their monitoring program (NYSDEC 2018):

- **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. Special precautions should be taken in situations when a “Confirmed with High Toxins Bloom” is reported with an open water extent because toxins are likely to be even higher in shoreline areas.

Wind currents can play a large role in the concentrations of algae that float at or near the water surface. Consistent winds can accumulate algae at downwind shorelines. Shorelines containing coves or other features that could capture floating algae may be more susceptible to HABs. In instances where freshwater intakes are impacted by these blooms, the extent may also include the area that is serviced by the impacted water utility or the private/residential intake.

Previous Occurrences and Losses

For this HMP update, HAB events were researched from 1972 to 2018. The NYSDEC began HAB testing and issuing notifications for New York waterbodies in 2012. The 2018 DEC Lake Monitoring Program includes the Lake Classification and Inventory Survey (LCI), the Citizens Statewide Lake Assessment Program (CSLAP) and several individual lake sampling programs. Table 5.4.5-2 lists events identified by the NYSDEC HAB Program between 2012 and 2018. This table includes events specific to Onondaga County as well as events listed for neighboring counties but on a shared waterbody, keeping in mind that algal blooms can spread on connected waterways.

Table 5.4.5-2. Harmful Algal Bloom Events in Onondaga County or Lakes Bordering Onondaga County, 2012 to 2018

Dates of Listing of Event	Waterbody	Description
2012	Oneida River	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs
2013	Oneida Lake	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2013	Oneida River	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs
2014	Oneida Lake	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs
2015	Oneida Lake	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs
2015	Otisco Lake	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs
2016	Hiawatha Lake	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2016	Oneida Lake	S (Suspicious Bloom) DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs



Dates of Listing of Event	Waterbody	Description
2016	Oneida River	HT (Confirmed with High Toxins Bloom) Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water
2016	Tully Lake	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2017	De Ruyter Reservoir	HT (Confirmed with High Toxins Bloom) Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water
2017	Hiawatha Lake	HT (Confirmed with High Toxins Bloom) Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water
2017	Jamesville Reservoir	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2017	Oneida Lake	HT (Confirmed with High Toxins Bloom) Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water
2017	Otisco Lake	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2017	Skaneateles Lake	HT (Confirmed with High Toxins Bloom) Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water
2017	Tully Lake	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds
2018	Hiawatha Lake	No additional information available
2018	Jamesville Reservoir	C (Confirmed Bloom) Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds. Bloom reported to have ended on June 23.
2018	Skaneateles Lake	C (Confirmed Bloom) Bloom reported to have ended on August 6.
2018	Oneida Lake	S (Suspicious Bloom) Bloom initially identified in mid-September.

Source: NYSDEC 2017d, NYSDEC 2018, Cornell Cooperative Extension 2018, CNY Central 2018

Probability of Future Events

HABs appear to be a recent occurrence in Onondaga County or have only recently been officially reported and recorded. Even with these blooms becoming increasingly common, season and year-to-year fluctuations make predicting their occurrence difficult (U.S. Environmental Protection Agency [EPA] 2017). Despite this uncertainty, the impact of HABs on the environment, human health, and local economies cannot be discounted.

Table 5.4.5-3 lists probabilities of occurrences of HAB events. The information used to calculate probabilities of occurrences is based on NYSDEC database records that only date back to 2012. It is possible that HABs were present in waterbodies before 2012 but were not identified or monitored. It is also possible that events have taken place in waterbodies that went unreported.

Table 5.4.5-3. Probability of Occurrence of Harmful Algal Bloom-Related Events

Hazard Type	Number of Occurrences Between 2012 and 2018	Rate of Occurrence	Recurrence Interval	Probability of Event Occurring in Any Given Year	Percent Chance of Occurrence in Any Given Year
Harmful algal bloom	19	3.17	0.37	2.71	100%

Sources: NYS DEC 2018

Note: Probabilities were calculated from years 2012 to 2018. NYS DEC data only included harmful algal bloom events back to 2012.





During the September 27, 2018 Planning Partnership meeting, the occurrence of harmful algal blooms was discussed. The Onondaga County Planning Department also provided documentation of the occurrence of HAB's in the county. In Section 5.3, the identified hazards of concern for Onondaga County were ranked. Probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence of HAB in Onondaga County is considered "frequent" (hazard event has 100% annual probability and may occur multiple times per year).

Climate Change Impacts

Increases in temperature may result in increased frequency of HABs. Most HABs take place during the summer months when water temperatures are warmest. Cyanobacteria in particular prefer warmer water. When lakes are at their warmest, mixing of the water column is less likely. When lakes are stagnant, algae are able to grow thicker and faster. In addition, the lower density of warm water allows algae to float to the surface faster. As algae grow and reproduce, they absorb more sunlight at the surface, further increasing the lake temperature and promoting more blooms (EPA 2017a).

Annual average precipitation is projected to increase by 1 to 8 percent by the 2020s, by 3 to 12 percent by the 2050s, and 4 to 15 percent by the 2080s. During the winter months, additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Northern parts of New York State are expected to see the greatest increases in precipitation (NYSERDA 2014).

The projected increase in precipitation is expected to occur via heavy downpours and less in the form of light rains. Rising air temperatures intensify the water cycle by increasing evaporation and precipitation, which can cause an increase in rain totals during storm events, with longer dry periods between those events. Alternating periods of drought and heavy rainfall increase the likelihood of nutrient runoff into waterways, which can fuel algal blooms (EPA 2017a).

Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. In addition to warmer temperatures and heavy precipitation events, carbon dioxide levels are forecast to continue to increase. Higher levels of carbon dioxide in the atmosphere and water can lead to increased algal growth, particularly for cyanobacteria that float at the surface (EPA 2017a).

5.4.5.2 Vulnerability Assessment

To understand risk, a community must evaluate assets that are exposed and vulnerable to the identified hazard. All assets surrounding and relying on the waterways and water in the county are exposed to the HAB hazard. The following text evaluates and estimates the potential impact of the HABs hazard on the county.

Impact on Life, Health, and Safety

Impacts of HABs on life, health, and safety depend on several factors, including the severity of the event and whether or not citizens and tourists have become exposed to waters suspected of containing a HAB. Routes of exposure include consumption, inhalation, and dermal exposure. The population living near or visiting waterbodies is at risk for exposure as well as those that use those waterbodies for recreation, fishing, and water supply. Contact with water containing HABs can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (NYSDOH 2017).



Cyanobacteria blooms are one of the most common freshwater HABs and have been identified by NYSDEC as being present in Onondaga County blooms. Cyanobacteria are known to produce toxins from the following classes and have impacts on human health.

- **Endotoxins:** Endotoxins associated with cyanobacteria have been tied to fever and inflammation in humans that have come in contact with water that contains cyanobacterial blooms.
- **Hepatotoxins:** Hepatotoxins are commonly tied to animal poisonings that are associated with cyanobacterial blooms. Animals may exhibit weakness, heavy breathing, paleness, cold extremities, vomiting, diarrhea, and bleeding in the liver. In humans, hepatotoxins have been indicated to promote tumors and may lead to increases in liver cancer. Some types of hepatotoxins, such as microcystin, can persist in fresh water for up to 2 weeks before being naturally broken down (algae).
- **Neurotoxins:** Neurotoxins act to block transfers between neurons. Extreme cases can result in paralysis.

Populations in Onondaga County that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Skaneateles Lake is the primary source of drinking water for the City of Syracuse (population of 145,170) and is accessed using an unfiltered system. Additionally, it provides drinking water to portions of the Town of DeWitt, the Town of Onondaga, the Town of Geddes, the Town of Camillus, the Town of Salina, the Town of Skaneateles, the Village of Skaneateles, the Village of Jordan, and the Village of Elbridge. The combined population of these municipalities is 120,341 although not all residents of these municipalities rely on Skaneateles Lake for drinking water. Some recreational lakes, such as Skaneateles Lake, have shoreline housing with many residents drawing directly from surface waters without filtration systems in place. The OCWA serves a large population in the county with water drawn from Otisco Lake as well as Lake Ontario, which is not located in Onondaga County but is also vulnerable to HABs, though there are filtration systems in place for both of these lakes,

Impact on Critical Facilities

The typical impact of HABs on critical facilities is due to shut down of water intakes from surface waters that are impacted by blooms and their toxins. Water treatment plants such as the OCWA system at Otisco Lake can remove variable amounts of microcystin from drinking water, but as much as 20 percent of these toxins may escape the treatment process (Carmichael 1997), sometimes leading to plant closures. Unfiltered systems such as the Syracuse system at Skaneateles Lake are at higher risk. The Syracuse system implemented their HAB Action Plan in the summer of 2018 after identification of a HAB, resulting in the city increasing the chlorine dosage at the water treatment plant, transitioning from weekly to daily sampling for microcystin, and increasing the level of visual lake monitoring for HAB's and sampling/algal identification of raw water from both lake water intakes and open water around water intakes. Newer technologies involving ultrasonic systems may also be effective at limiting the amount of chemical treatments necessary. However, these systems are most effective for small water bodies and likely would be inefficient for treating HABs in the main sources of public water in Onondaga County (Otisco Lake and Skaneateles Lake) (LG Sonic, 2015).

Approximately 43 million gallons of water are drawn from Skaneateles Lake per day via two 54-inch diameter steel intake pipes located 20 feet and 45 feet below the lake surface. The Syracuse Department of Water has a Harmful Algal Bloom Response Plan which outlines the steps from sampling to action based upon testing results (Figure 5.4.5-4). The OCWA also has a monitoring program in place for the Otisco Lake water intake and has a treatment plan in place if HABs are detected. The EPA has also established an incident checklist for harmful algal bloom incidents impacting water utilities (EPA 2018).



Impact on the Economy

Economic impacts from HAB events are difficult to quantify in Onondaga County. Nationally, these events have caused significant economic loss. For example, a 1976 red tide event in New Jersey was estimated to have caused losses near \$1 billion (in 2000 dollars) and a 1997 outbreak of *Pfiesteria* in Chesapeake Bay is estimated to have resulted in \$46 million in lost sales of seafood (PCM HAB Research Plan). The costs of these events were largely estimated to be the result of closed fisheries or impact on consumer choices to purchase seafood.

Economic impacts on Onondaga County would largely focus on the tourism sector and public drinking water infrastructure. News of a closure of a body of water or beach can result in tourists avoiding the area. Even after closures are lifted, negative public reaction can persist and continue to impact tourism revenue and property values.

Swimming locations in Skaneateles Lake include Clift Park (public), Skaneateles Country Club (private), and Lourdes Camp (private). The Country Club also includes a golf course and affiliated sailing club. Jamesville Reservoir and Oneida Lake also have swimming beaches with another beach being considered for Onondaga Lake, which is a centerpiece in the Onondaga County parks system. Recreational fishing is popular in Skaneateles Lake and Oneida Lake and several species are able to be taken for consumption. Other recreational activities in the area include hiking, boating, bird watching, and bicycling (NYDEC 2017d). Property values at lakefront properties, many of which are rental properties, could also be impacted. Waterfront property traditionally is highly assessed, with Skaneateles Lake's shoreline housing generally the most highly assessed in the County.

More traditional economic impacts can be associated with the costs of operating monitoring programs, shutdowns of water supplies and associated backup water source costs, and the costs of advanced drinking water treatment (NYSDEC 2017c). A significant economic risk would be the loss of the current filtration waiver for the Lake Skaneateles water intake. This would trigger the need for a filtration plant that could cost \$100 million. In February 2019 the City of Syracuse requested \$12 million in partial initial funding from New York State to help the city extend its Skaneateles Lake water intake pipe.

Impact on the Environment

Harmful algal blooms can release toxins that lead to fish and invertebrate kills. Animals that prey on fish and invertebrates in surface waters, such as birds and mammals, may be affected if they ingest impacted prey. Both harmful and non-harmful algal blooms can have drastic impacts on oxygen levels in surface waters. When algae begin to die off following a bloom, bacteria begin to decompose the organic material. This decomposition consumes dissolved oxygen and releases carbon dioxide. If the bloom and die off is large enough, dissolved oxygen levels in aquatic systems can rapidly crash. Anoxic conditions connected to algal blooms have resulted in large fish and invertebrate kills (Graham and Wilcox 2000).

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.



Projected Development and Change in Population

As discussed in Section 4, areas targeted for future growth and development have been identified across the county. HABs could impact any areas of growth located near waterbodies that are vulnerable to harmful algal blooms. As increased development is often associated with stormwater and runoff issues, harmful algal blooms may become more likely in areas of increased development. The specific areas of development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

According to population projections from the Cornell Program on Applied Demographics, Onondaga County will experience a slight population decrease through 2040 (less than 10,000 people in total by 2040). Population change is not expected to have a measurable effect on the overall vulnerability of the county's population over time. As discussed in *Long Range Transportation Plan 2050: Moving Towards a Greater Syracuse*, the population of Syracuse has decreased as the other municipalities in the county have seen an increase (Syracuse Metropolitan Transportation Council, 2015). Those moving from areas of lower vulnerability to higher will increase their vulnerability, though not in a dramatic fashion.

Climate Change

Onondaga County will see an increase in both temperature and precipitation amounts as a result of climate change. As discussed above, a warming climate will allow for an extended growing period for algal blooms. Additionally, increases in precipitation will generate more stormwater runoff, which can lead to increased nutrient loads entering waterways from leached nutrients in the soil or fertilizers on agricultural lands. Warmer temperatures and increased nutrient loads will allow for algal blooms to grow and spread more rapidly. These changes will increase the county's overall vulnerability to HABs.

Change of Vulnerability since the 2013 HMP

The 2013 version of this HMP did not identify HABs as a hazard. Onondaga County and its municipalities have only recently been impacted by these blooms and it is possible that HAB events had taken place previously but were undetected. It appears likely that these blooms will continue to pose a hazard in the future.

Issues Identified

HABs present a significant health risk in Onondaga County. NYS DEC has documented HABs in eight waterbodies in Onondaga County in recent years. In total, these waterbodies have a combined 186.9 miles of shoreline, 89.2 miles of which are part of Onondaga County.

HABs threaten the county's public water supply and private water supply in areas where water is taken from surface water sources. To protect the water supply and prevent the need for more expensive filtration systems to be installed, water intakes may need to be moved into deeper water away from shorelines. HABs can negatively impact the recreational and tourism economy and reduce waterfront property values.

Efforts need to be made to reduce the amount of excess nutrients entering local waterbodies which can fuel HABs. Nutrient pathways exist from agriculture, septic tanks, and lawns. Outreach efforts and stormwater improvements may help lower the amount of excess nutrients making their way into the county's waterbodies, reducing the likelihood of HABs.

NYSDEC will continue to monitor information regarding HABs. Specific mitigation actions addressing improved data collection and further vulnerability analysis are included in Volume II, Section 9 of this plan update.