4.3.8 Harmful Algal Bloom

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the harmful algal bloom hazard in Morris County.

2020 HMP Changes

- Harmful Algal Bloom is a new hazard of concern for Morris County.

4.3.8.1 Profile

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 saltwater. 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 Harmful Algal Blooms (HABs) in Morris 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). 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.

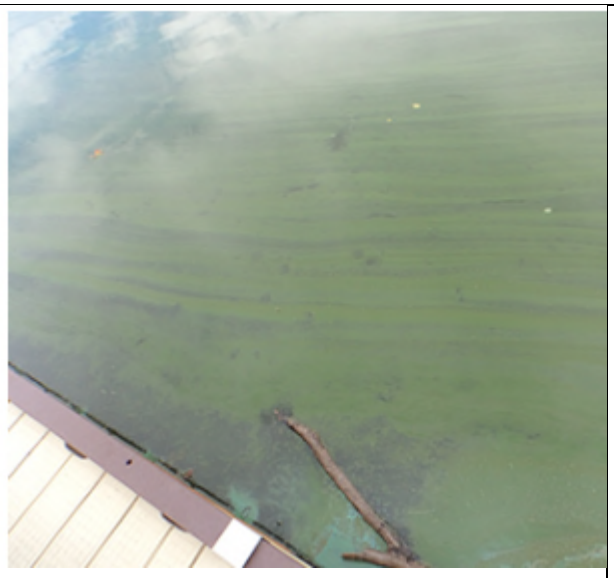
Numerous cases of seafood poisoning have been associated with the accumulation of toxins from algae by fish or shellfish and the subsequent ingestion of those species by humans. These cases include paralytic shellfish poisoning, ciguatera fish poisoning, and amnesiac shellfish poisoning. The majority 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 NJDEP Harmful Algal Blooms webpage (NJDEP 2019). Children and animals should be kept away from waters suspected of containing HABs, and fishing or eating fish should be prohibited. In Morris 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 NJDEP, 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 4.3.8.1-1. Some blooms can also resemble spilled paint on the water's surface or change the appearance of water to that of pea soup (NJDEP 2019).

Figure 4.3.8.1-1. Examples of Harmful Algal Bloom Visual Appearance



HABs may look like parallel streaks, usually green, on the water surface.

HABs may look like green dots, clumps, or globs

	on the water surface.
 *HABs may look like blue, green, or white spilled paint on the water surface.*	 *HABs may make the water look bright green or similar to pea soup.*

Source: NJDEP 2019

Location

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

- Shorelines of the Morris 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 a prior event in the Pompton 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 Boonton Reservoir which provides water for Jersey City.
    - Private unfiltered water intake systems or public water intake systems that have received a filtration waiver.

The NJDEP records indicate six waterbodies in Morris County had documented HABs in recent years. While most HAB contact occurs along shorelines, blooms can take place throughout surface waters.

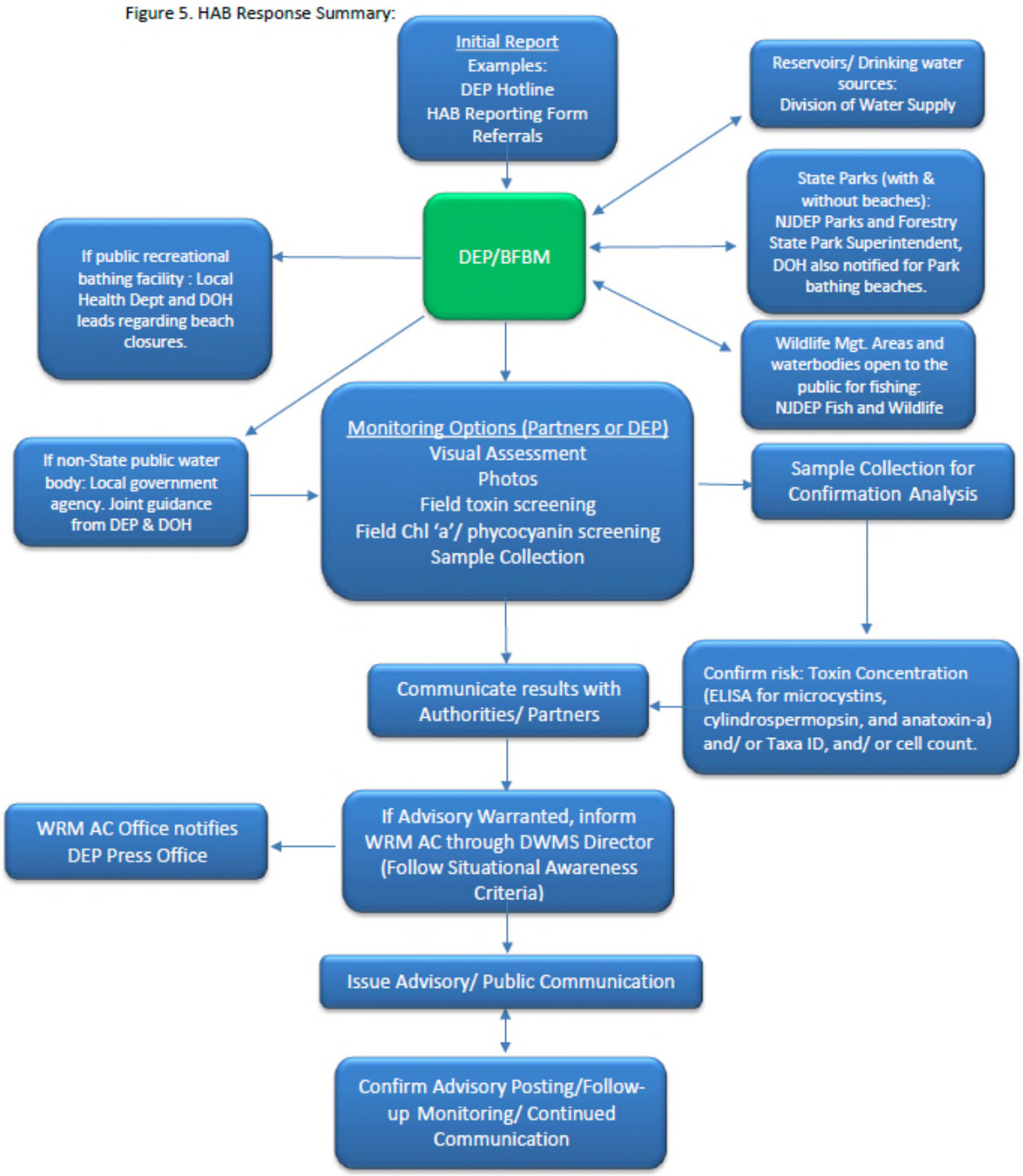
1. Pompton River
2. Lincoln Park Community Lake
3. Budd Lake
4. Lake Hopatcong
5. Boonton Reservoir

Extent

The NJDEP uses visual observations, photographs, and laboratory sampling results to determine if blooms are comprised of cyanobacteria or other types of algae. Suspicious blooms are reported to NJDEP or local health

departments (NJDEP 2019). The NJDEP has a Cyanobacterial Harmful Algal Freshwater Recreational Response Strategy which includes the DEP Division of Water Supply and Geoscience's Emergency Response Plan. This response plan is outlined below in Figure 4.3.8.1-2.

Figure 4.3.8.1-2. NJDEP/BFBM HAB Response Plan



Source: NJDEP 2018

The NJDEP has previously identified HABs in six waterbodies in Morris 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.

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

Between 1954 and 2019, the State of New Jersey did not experience FEMA declared harmful algal bloom-related disasters (DR) or emergencies (EM) (FEMA 2019). Harmful algal bloom events that have impacted Morris County between 2014 and 2019 are identified in Table 4.3.8-1. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality, where available.

Table 4.3.8-1. Harmful Algal Bloom Incidents in Morris County, 2017 to 2019

Date(s) of Event	Location	FEMA Declaration Number (if applicable)	Morris County Designated?	Description
October 17, 2017	Lincoln Park, Wayne	N/A	N/A	The Pompton River had a confirmed harmful algal bloom. The Lincoln Park Health Department and Wayne Health Department posted an advisory from October 20 – 26, 2017.
October 24, 2017	Lincoln Park Borough	N/A	N/A	Lincoln Park Community Lake had a confirmed harmful algal bloom. An advisory was posted by the Lincoln Park Health Department from October 25 through November 15, 2017.
November 15, 2017	Mount Olive Township	N/A	N/A	Budd Lake had a confirmed harmful algal bloom. An advisory was posted by the Mount Olive Township Health Department from November 16 to December 20, 2017.
June 1, 2018	Lincoln Park Borough	N/A	N/A	Lincoln Park Community Lake had a confirmed harmful algal bloom. An advisory was posted by the Lincoln Park Health Department from June 1 - 22, 2018.
July 30, 2018	Lincoln Park Borough	N/A	N/A	Lincoln Park Community Lake had a confirmed harmful algal bloom. An advisory was posted by the Lincoln Park Health Department from July 31 to August 8, 2018.
September 5, 2018	Mount Olive Township	N/A	N/A	Budd Lake had a confirmed harmful algal bloom. An advisory was posted by the Mount Olive Township Health Department from September 6 to December 4, 2019.
September 15, 2018	Roxbury Township	N/A	N/A	Lake Hopatcong had a confirmed harmful algal bloom. No advisory was posted.
September 27, 2018	Boonton Township	N/A	N/A	Boonton Reservoir had a confirmed harmful algal bloom. No advisory was posted as recreation in the reservoir is prohibited.
July 29, 2019	Mount Olive Township	N/A	N/A	Budd Lake in Mount Olive Township had a confirmed harmful algal bloom. An advisory was posted by the Mount Olive Township Health Department on August 1, 2019.
August 10, 2019	Mount Arlington Borough	N/A	N/A	Rogerene Lake in Mount Arlington Borough had a confirmed harmful algal bloom. An advisory was posted by the Mount Arlington Health Department from August 14 to September 13, 2019. The bathing beach was closed.

Source: NJDEP 2019
N/A = Not applicable

Probability of Future Occurrences

Based on the historical occurrences for harmful algal bloom, it is estimated that Morris County will continue to experience direct and indirect impacts of harmful algal blooms on occasion. 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.

In Section 4.4 (Hazard Ranking), the identified hazards of concern for Morris County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for harmful algal blooms in the County is considered 'frequent'.

Climate Change Impacts

The climate of New Jersey is already changing and will continue to change over the course of this century. From 1900 to 2014 annual average temperatures in New Jersey have increased approximately 3°F (NOAA NCEI, 2017). In terms of winter temperatures, the northeast region has seen an increase in the average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F, and by 2080 projections show an increase of 4°F to 7.5°F (Sustainable Jersey Climate Change Adaptation Task Force 2011).

According to the NJDEP, New Jersey is experiencing increased intensity, frequency and duration of storm events (NJDEP 2019). Northern New Jersey's 1971-2000 precipitation average was over five inches (12-percent) greater than the average from 1895-1970 (Sustainable Jersey Climate Change Adaptation Task Force [CATF] 2011). The heaviest 1% of daily rainfalls have increased by approximately 70% between 1958 and 2011 in the Northeast (Horton et al. 2015). Average annual precipitation is projected to increase in the region by four to 11-percent by the 2050s and five to 13-percent by the 2080s (New York City Panel on Climate Change [NPCC] 2015).

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).

4.3.8.2 Vulnerability Assessment

To understand risk, a community must evaluate its assets that are exposed or vulnerable to the identified hazard. The following discusses Morris County's vulnerability, in a qualitative nature, to the harmful algal bloom hazard.

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 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 waterbodies is at risk for

exposure to HABs as well as those that use those waterbodies for recreation, fishing, and water supply. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but visitors to Morris County lakes as well. 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 2018).

Cyanobacteria blooms are one of the most common freshwater HABs and have been identified by NJDEP as being present in Morris County blooms. Cyanobacteria are known to produce toxins from the following classes:

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.

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 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.

The EPA has established an incident checklist for HAB incidents impacting water utilities (EPA 2017). This tool is available to help utilities detect, identify, and monitor a bloom. Locations in Morris County that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Purchasing water may make some users more vulnerable if the utility has less control over the quality of the source. Coordinating with the supplier to ensure that the water is clear of harmful algae, thus maintaining the safety of users of the purchased water, is recommended.

Impact on the Economy

Economic costs from HAB events are difficult to quantify in Morris 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 Morris County would largely focus on the recreation sector. News of a closure of a body of water or beach can result in visitors avoiding the area. Even after closures are lifted, negative public reaction can persist and continue to impact local revenue and property values. For example, recently the Freeholder boards in Morris and Sussex Counties have agreed to provide matching funds to protect Lake Hopatcong (a value of $100,000), a lake that these counties share a shoreline to (Morris County 2020). The Freeholders explain that Lake Hopatcong suffered several season-long harmful algal blooms and hurt local businesses in these lake towns. When a lake is impacted as seen with Lake Hopatcong, tourism activities that take place in Morris County including swimming, recreational fishing, hiking, boating bird watching, and bicycling are slowed and sometimes put to a halt. Consequentially, frequent occurrences of harmful algal blooms can impact property values along the waterfront and local business in the region.

As mentioned, there is a price tied to programs that protect water bodies from harmful algal blooms. The cost to operate and monitor these programs will vary depending on the extent of the blooms. Additional costs may include money spent on purchasing backup water sources and costs to implement advanced drinking water treatment.

Impact on the Environment

Harmful algal blooms can release toxins that can kill fish and invertebrate. 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.

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 Changes in Population

As discussed in Section 3 (County Profile), 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 the population continues to increase along with development, 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.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency, and intensity of weather events. Both globally and in Morris County, climate change may alter prevalence and severity of HABs. Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. Increased alternation of drought and heavy precipitation could result in additional nutrient runoff into local waterbodies, providing more fuel for algal blooms. Higher carbon dioxide levels in the atmosphere and surface waters could create a more favorable growing environment for HABs (EPA 2017a).

Change in Vulnerability Since the 2015 HMP

Harmful algal blooms is a new hazard added to Morris County's HMP. More frequent events of blooms have made this hazard an area of interest that will be monitored more frequently in municipalities throughout the County, particularly those that contain major bodies of water that are used for drinking water, recreation, and economic purposes.