Cyanobacteria Monitoring on Lake Champlain and Vermont Inland Lakes
Summer 2019

Annual Report for the Lake Champlain Basin Program

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Executive Summary

An annual cyanobacteria monitoring program has been in place on Lake Champlain since 2002. Since 2012, oversight of the program has been the responsibility of the State of Vermont. The program represents a strong partnership between the Vermont Department of Environmental Conservation (VT DEC), the Vermont Department of Health (VDH) and the Lake Champlain Committee (LCC). Funding is provided by the Lake Champlain Basin Program, the State of Vermont, the Center for Disease Control (CDC), and private donors. Data are collected by State staff and an extensive network of trained citizen volunteers. This report provides a summary of cyanobacteria monitoring efforts for Lake Champlain and for Vermont inland lakes, regardless of funding source, all of which is housed in the CyanoTracker database hosted by the VDH.

Cyanobacteria monitoring on Lake Champlain in 2019 continued to integrate qualitative observations, photographic documentation, and quantitative analysis of cyanobacteria populations into guidance for lake users. Analysis of water for the presence of microcystin and anatoxin, when warranted, provided additional data to inform public health decisions in response to the presence of cyanobacteria.

Objectives:

- monitor cyanobacteria at locations on Lake Champlain and select Vermont inland lakes through the established partnership between state staff, the Lake Champlain Committee and citizen volunteers,
- provide consistent quantitative data at selected locations around Lake Champlain and select Vermont lakes,
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at select monitoring locations,
- conduct 12 weeks of cyanobacteria toxin testing for drinking water facilities drawing from Lake Champlain in Vermont,
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage, and
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

Citizen volunteers, staff, and the general public submitted 2680 site-specific reports during 2019 from Lake Champlain and inland lakes in Vermont. Alert level conditions were reported 345 times on Lake Champlain during the monitoring period in 2019. Microcystin was detected at locations on Champlain and Lake Carmi in 2019. No locations exceeded the Vermont recreational guidance values for microcystin. Anatoxin was detected at one location in St. Albans Bay, also below Vermont's recreational guidance value.

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Introduction

Lake Champlain is one of the largest lakes in the United States and an important water resource for the states of Vermont and New York, and the province of Quebec. It is primarily a recreational lake, but also serves as an important drinking water source for all three jurisdictions. Cyanobacteria blooms have been documented in the lake since the 1970s, with some areas experiencing extensive annual blooms. In 1999, several dog deaths were attributed to cyanobacteria toxins, raising health and safety concerns regarding drinking water supplies and recreational activities such as swimming, boating, and fishing.

An annual cyanobacteria monitoring program has been in place on Lake Champlain since 2002 and continues to expand to inland lakes in Vermont. Monitoring is implemented through a partnership approach. Data are collected by State staff and an extensive network of trained citizen volunteers. Qualitative observations, photographic documentation, and quantitative analysis of phytoplankton populations are synthesized into guidance for lake users. Analysis of water - when warranted - for the presence of microcystin, anatoxin and/or cylindrospermopsin provides additional data to inform public health decisions.

Objectives:

- routinely monitor cyanobacteria at locations on Lake Champlain and Vermont inland lakes through the established partnership between Vermont state staff, the Lake Champlain Committee, citizen volunteers, and state/municipal staff in New York,
- provide consistent quantitative data to inform public health decisions and assess long-term trend,
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at selected monitoring locations,
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage,
- strengthen communication among the jurisdictions on Lake Champlain responsible for cyanobacteria response, and
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

Geographic Coverage and Funding

Responsibility for cyanobacteria response in the Champlain Basin is held by multiple jurisdictions. State or provincial departments of health and environmental protection typically lead response efforts while authority to close beaches and waterfront areas often resides with municipalities. The goal of this project is to provide data to assist in cyanobacteria response around the Basin. For consistency, Vermont utilizes the same protocols developed for Lake Champlain across the entire state.

Lake Champlain Basin Program (LCBP) funding supports the project coordinator, housed in the Vermont Department of Environmental Conservation's (VT DEC) Watershed Management Division, through the Lake Champlain Long-term Water Quality and Biological Monitoring Project (CLTM). LCBP funding also

supports volunteer coordination around Lake Champlain and several smaller Vermont lakes through a separate grant to the Lake Champlain Committee (LCC). In 2019, LCBP provided funding for cyanotoxin testing at Vermont drinking water facilities on Lake Champlain.

The Vermont Department of Health (VDH) and the VT DEC's Drinking Water and Groundwater Protection Division (DWGWPD) are strong partners in this monitoring program. Their funding is provided by the VDH and VT DEC, respectively, and occasionally includes grants from other sources. In 2019, sampling at shoreline quality assurance stations was supported by the Centers for Disease Control and Prevention through the Safe Water for Community Health grant to VDH.

VDH provides the technical support underlying the CyanoTracker website, shoreline monitoring at selected locations, toxin testing for locations on Lake Champlain and Vermont inland lakes, and bloom response in Vermont. Technical and public water system support for cyanotoxin response is provided by the DWGWPD.

The New York Departments of Environmental Conservation and Health support this monitoring effort by sharing information regarding cyanobacteria blooms on Lake Champlain when received by their offices. They are responsible for bloom response on the New York shores of Lake Champlain. New York maintains their own cyanobacteria reporting protocols for inland lakes including Lake George – see the New York Harmful Algal Blooms notification – and that information is not part of this monitoring project.

Several monitoring locations are located on Missisquoi Bay in Quebec and volunteers there submit reports through the CyanoTracker interface. Provincial and municipal officials there are responsible for bloom response. Quebec maintains a website of cyanobacteria reports received from around the province.

This report provides a summary of cyanobacteria monitoring efforts for Lake Champlain and for Vermont inland lakes, all of which is housed in the CyanoTracker database hosted by the VDH.

Methods

The 2019 cyanobacteria monitoring program was coordinated by the VT DEC and implemented in conjunction with the VDH and LCC. Visual data from Lake Champlain and other Vermont lakes monitored by LCC volunteers were collected following the project protocols utilizing materials developed and maintained by the LCC. VT DEC volunteers reporting from lakes outside the Champlain Basin followed the same project protocols. Water and cyanobacteria samples were collected by VT DEC staff at selected open water stations historically monitored by the CLTM on Lake Champlain. Shoreline quality assurance samples were collected routinely at select Vermont locations on Lake Champlain and Lake Carmi by citizen volunteers and VDH staff. Additional samples, primarily from lakes reporting blooms for the first time or at managed recreational areas, were also analyzed as part of this project. Reports from the monitoring partners and volunteers were uploaded via a controlled web interface directly to the Cyanobacteria Tracking map (CyanoTracker) maintained by the VDH.

Sampling Locations

During the summer of 2019, reports were routinely received from 173 monitored locations around Lake Champlain and from several Vermont inland lakes. Table 1 provides a summary of stations by region, evaluation protocol, and type of site. Full documentation of the sampling locations is provided in Appendix A.

Table 1. Location of routinely monitored stations and sampling method utilized in 2019. Stations were evaluated on a weekly or biweekly basis. Data compiled from the season summary spreadsheet available through the VDH CyanoTracker. Further information about each station is found in Appendix A.

Waterbody		**Monitoring Protocol**		
		Visual	**Visual/Quality assurance**	**open water protocol**
Adams Reservoir		2		
Caspian Lake		1		
Colchester Pond		1		
Coles Pond		1		
Emerald Lake		1		
Half Moon Lake		1		
Joes Pond		3		
Lake Carmi		6	2	
Champlain	Inland Sea	25		1
	Main Lake Central	31	2	4
	Main Lake North	15	1	2
	Main Lake South	27	1	2
	Malletts Bay	5		1
	Missisquoi Bay	3	1	3
	South Lake	1		2
	St. Albans Bay	8	1	1
Lake Dunmore		2		
Lake Iroquois		2		
Lake Memphremagog		8		
Lake Morey		1		
Lake Runnemede		1		
Mill Pond		1		
Norton Pond		1		
Shelburne Pond		1		
Winona Lake		1		
Total Stations		**149**	**8**	**16**

Monitoring Protocols

The Visual Monitoring Protocol

Volunteer Recruitment and Training

Volunteers were asked to commit to monitoring at least one location for the duration of the monitoring period (mid-June through early September). No volunteer was turned away. On Lake Champlain, this can lead to a cluster of observation points in more populated areas or areas with high interest. All volunteers attended a mandatory training session in person or online to learn to recognize cyanobacteria, become familiar with the assessment protocol, and learn how to submit their weekly reports. Partners interacted with volunteers in the weeks following the training to ensure consistency among volunteers and their assessment skills. Not all volunteers were able to use the internet-based reporting system and instead submitted their reports by telephone or email.

The LCC trained nearly 250 volunteer monitors and interested citizens in 23 formal training sessions during 2019. Additional informal training sessions were provided at roughly a dozen public presentations and tabling events throughout the year. LCC also conducted training for Vermont State Park staff who participated in the monitoring project. Over the course of the summer, LCC volunteer monitors reported from 123 different locations in 2019 (Appendix A).

VT DEC also recruited and trained volunteers to monitor at 13 sites on inland Vermont lakes following the project protocols. Training was conducted in person and by webinar. The webinar recording was posted on the VT DEC's cyanobacteria website as a resource for volunteers. VT DEC staff also interacted regularly with citizen volunteer monitors.

Weekly Observation Process - Volunteers

Monitoring by volunteers began the week of June 17. Volunteers committed to monitoring through September and were asked to continue longer if they could. Protocols for the observation process, supporting documentation and the submittal process are found in Appendix B. Volunteers were asked to provide a single observation each week, preferably between 10am and 3pm, on the same day of the week Sunday through Saturday. Supplemental reports could also be provided and volunteers were encouraged to report any blooms they witnessed, regardless of the reporting day, and to report daily for the duration of blooms whenever possible. Volunteers evaluated cyanobacteria conditions at their location using the prompts, photographs, and descriptions provided by the LCC and VT DEC, and assigned it one of the three categories:

- Category 1 – very few or no cyanobacteria observed, recreational enjoyment not impaired by cyanobacteria.
    - 1a – no cyanobacteria present, clear water
    - 1b – no cyanobacteria present, brown and turbid conditions
    - 1c – no cyanobacteria present, other plant material
    - 1d – little cyanobacteria present, generally safe conditions
- Category 2 – cyanobacteria present at less than bloom levels.
- Category 3 – cyanobacteria bloom in progress.

The description 'bloom' is not a well-defined scientific defined term. For the purposes of the visual monitoring protocol, blooms refer to very dense cyanobacteria accumulations resulting in highly colored water and/or visible surface scums. Dense accumulations of algae are also known as blooms but under this protocol are captured in Category 1.

Each volunteer was asked to provide three photographs whenever Category 2 or Category 3 conditions were observed. All reports were uploaded to the VDH tracking map via a secured interface or submitted to the LCC or VT DEC via their online forms. These online forms were also used when the VDH website interface occasionally was not functional. Partners reviewed all bloom reports and photos. They also conferred with volunteers as needed to verify the presence of cyanobacteria and appropriate status or when no reports were received. Tracker software automatically notifies partners of Category 2 and 3 reports so these can be reviewed and posted quickly.

Weekly Shoreline Quality Assurance Sampling

In addition to the visual observations, volunteers or VDH staff also collected water samples each week at 8 sites. These locations were areas with high recreational usage, prone to blooms, or located in the vicinity of drinking water facilities.

Volunteer sites:

North Beach – Burlington, VT
St. Albans Bay Park – St. Albans, VT
Red Rocks Park – South Burlington, VT
The Shipyard – Highgate, VT

VDH sites:

Alburgh Dunes State Park – Alburgh, VT
Lake Carmi State Park – Franklin, VT
Tri-Town Rd – West Addison, VT
Lake Carmi North Beach – Franklin, VT

These unfiltered samples were analyzed for microcystin and anatoxin at the Vermont Public Health Laboratory. Cyanobacteria and algae were identified and counted by DEC staff. A single whole water sample was collected by placing a 0.5-L bottle carefully at the surface and tipping to fill, avoiding dilution of the surface scum as much as possible. The sample was mixed thoroughly and decanted into sample bottles for subsequent cyanobacteria enumeration or toxin analysis. All samples were kept on ice in coolers or refrigerated until they reached the lab. These samples were used to evaluate the effectiveness of the visual assessment protocol when evaluating recreational risk.

The Open Water Protocol

Data on taxonomic distribution, cell density and the presence of toxins were collected by the VT DEC following the Open Water Protocol. VT DEC staff conducted cyanobacteria assessments during their biweekly monitoring for the Champlain Long-term Water Quality and Biological Monitoring Project (CLTM). At each monitoring site, staff utilized the visual assessment protocol to evaluate cyanobacteria conditions and collected a 3m plankton tow. Cyanobacteria observed during transit were also assessed using the visual assessment protocol. When category 3 conditions were observed, whole water surface

grabs were collected for the analysis of toxins (microcystin and anatoxin) and cyanobacteria density. At locations where blooms were uncommon, whole water surface grabs for toxin and cyanobacteria were also collected during category 2 conditions. Routine monitoring began June 10th and continued through early October.

VT DEC staff also routinely visited open water stations on Lake Carmi and Ticklenaked Pond in Vermont beginning in May. Visual assessments were made at these stations June to October. Taxonomic information on phytoplankton communities collected as part of routine DEC monitoring were shared through CyanoTracker. Water samples were collected from open water location during bloom events on Lake Carmi.

Field Methods

Plankton were collected as integrated 63 µm mesh plankton net for determination of cyanobacteria density. Net concentrates were obtained by lowering the plankton net opening to 3m and drawing it steadily back to the surface. At DEC stations on Lake Carmi and Ticklenaked Pond, plankton nets were lowered to twice the secchi to be consistent with historical data from these locations.

When alert level conditions were observed, a single whole water sample was collected by placing a bucket carefully at the surface and tipping to fill, avoiding dilution of the surface scum as much as possible. The sample was mixed thoroughly and decanted into sample bottles for subsequent cyanobacteria enumeration or toxin analysis. All samples were kept on ice in coolers until they reached the lab.

Plankton Enumeration

Plankton samples were analyzed using an inverted compound microscope at 200x in a Sedgewick Rafter (SR) cell. One mL aliquots were settled for 10 – 15 minutes before analysis. Estimates of cell density were obtained for all observed cyanobacteria and selected other taxa using the size categories noted in Table 2. Observed individuals or colonies were assigned to a unit category, or several categories, as needed. The number of units in each category is then multiplied by the cell factor to obtain an estimate of cell density/mL in the sample. During the analysis, all cyanobacteria were identified to the lowest possible taxonomic level while most other algae were identified simply at the division level, e.g. green algae or diatoms. Identical counting protocols were used for whole water and plankton concentrates. Plankton samples were counted by VT DEC staff or trained interns and data were uploaded to the VDH data interface, typically within 24 - 48 hours for open water stations. Alert level samples were analyzed and posted as soon as possible after samples were received at the laboratory.

Table 2. Size categories and cell factors used to estimate field densities of colonial algae.

Taxon	Unit Category	Estimated cells/unit	Cell factor
Anabaena *Aulocoseira* *Fragilaria*	Fragment Small Medium Large	< 20 20 – 100 100 – 1000 >1000	10 60 500 1000
Microcystis *Coelosphaerium* *Woronichinia*	Small Medium Large	<100 100 – 1000 >1000	50 500 1000

Taxon	Unit Category	Estimated cells/unit	Cell factor
Gloeotrichia	Fragment Small Medium Large	Single trichome Quarter of a colony Half of colony Entire colony	20 2500 5000 10,000
Aphanizomenon	Fragment Small Medium Large	Single trichome Small flake Medium flake Large flake	Measured 200 500 1000
Limnothrix *Lyngbya/Scytonema*	fragment	Single trichome	Measured

Source of Reports

In addition to the trained citizen volunteers and field staff in VT DEC and VDH, cyanobacteria reports were received from numerous other sources. The NY DEC and the NY Department of Health notified Vermont when blooms were reported on their shores. Vermont state park staff at several locations received training and provided reports. The general public provide reports by email and telephone. All reports were evaluated and confirmed utilizing photos, descriptive information, and available corroborating information before posting to the CyanoTracker map.

Toxin Analysis

Toxin analyses were conducted by the Vermont Public Health Laboratory in Colchester, VT. Whole water samples for microcystin were analyzed as received unless biomass was high enough to interfere with analytical procedures. In that event, samples were diluted prior to analysis of microcystin by ELISA.

Whole water samples for anatoxin analysis were concentrated using solid phase extraction cartridges unless large amounts of biomass were present. In that event, aliquots were diluted prior to extraction.

Toxin Monitoring at Vermont Drinking Water Facilities

In 2019, the DWGWPD and the VDH received funding from the Lake Champlain Basin Program to support 12 weeks of cyanotoxin monitoring at Vermont public drinking water systems drawing from Lake Champlain. Weekly raw and finished water samples were collected by facility staff and transported to the VDH Public Health Laboratory for analysis of microcystin and cylindrospermopsin by ELISA. All sample containers and labels were provided to the facilities. Sample drop-off and pick-up opportunities were also provided.

Sampling began July 8, 2019. All 22 public facilities participated, though several systems do not operate after Labor Day. Results were shared with operators by the VDH lab and DWGWPD.

Communication and Outreach

Members of the partner institutions (LCC, VT DEC, and VDH) comprised an internal communication group that shared all bloom reports upon receipt and coordinated response activities as needed. Partners received automated notification of category 2 and 3 reports posted to the tracking database, facilitating communication, and enabling volunteer reports to be reviewed and approved quickly. The group also

shared literature and other pertinent information. The LCBP, NY DEC, NY DOH, and Vermont State Parks staff were also kept apprised of cyanobacteria conditions through the automated notification system.

Weekly email updates summarizing reports, cell density, species composition and toxin data were provided to a group of stakeholders responsible for public health. These were primarily state and town health officials, state and town waterfront managers, Champlain water suppliers, and researchers. Updates were released typically on Friday mornings, but stakeholders also received email notification of extensive blooms as they occurred. The Lake Champlain Committee also provided weekly emails to LCC volunteer monitors and partner agencies as well as interested citizens, other agencies, and the media.

Notification of the Public

The Cyanobacteria Tracker, housed on the VDH website (http://healthvermont.gov/tracking/cyanobacteria-tracker), displayed the most up to date information on the presence of cyanobacteria blooms on Lake Champlain and in Vermont. On the website, a table listed all reports that had been received and approved during the 2019 season, and a map displayed the status of the most recent report for a given site.

Map status was based on the visual assessment. At locations where water had also been sampled and analyzed, the visual assessment was used to generate the map status unless subsequent toxin analysis results indicated that this should change. No changes were necessary in 2019.

Results of the assessments translated to one of three map status categories:

VDH Map Status	Visual
Generally Safe (green)	Category 1
Low Alert (yellow)	Category 2
High Alert (red)	Category 3

The CyanoTracker software occasionally experienced problems beyond VDH's control in 2019. VDH staff worked to restore functionality as soon as practical. In those situations, monitors used online reporting form to file reports or called in to verbally report information. These reports were added to the Tracker as soon as practical.

A list of locations where blooms had been reported for the previous week was also compiled and displayed on the VDH webpage each week (https://www.healthvermont.gov/health-environment/recreational-water/lake-conditions).

Response to Monitoring Reports

Three jurisdictions were covered by the monitoring program efforts (New York, Vermont, and Quebec). While the monitoring program provided a lake-wide system of assessing and reporting cyanobacteria conditions shared via email and the VDH webpage, response to specific events was coordinated and implemented by the appropriate jurisdiction following their respective response protocols.

Outreach

Partners maintained individual websites highlighting monitoring activities, the interactive CyanoTracker map and annual data. Partners also held trainings, made presentations upon request, and responded to inquiries from the public, lake users and the media. Additionally, LCC posted a link to their weekly report on Facebook, emailed a weekly report to monitors tailored to their needs, and another to interested citizens and the media.

Results

Overall effort

We received 2680 site-specific reports in 2019. These were provided by project partners, volunteers, and others (Table 3). Most were from Lake Champlain; however, regular reports were also provided from 13 inland lakes in Vermont by VDH staff and volunteers coordinated by LCC or VT DEC. Reports based on the visual assessment protocol represented 91% of all reports received. The remaining reports were obtained at the shoreline quality assurance stations or using the open water protocol.

Table 3. Summary of the 2019 cyanobacteria monitoring station reports. Supplemental reports are from locations other than regularly monitored sites or between regular reporting times. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Reports provided by the public and others outside of the monitoring program were interpreted using the visual assessment process. Further information about routine locations can be found in Appendix A.

Waterbody	Region	Monitor	Report Type	Assessment Method		
				Visual Assessment	Shoreline Quality Assurance	Open Water Protocol
Adams Reservoir		VT State Parks	Routine Weekly	24		
Arrowhead Mountain Lake		LCC Volunteer	Supplemental	1		
Bald Hill Pond		Other	Supplemental	1		
Caspian Lake		VT DEC volunteer	Routine - Weekly	9		
Colchester Pond		LCC Volunteer	Routine - Weekly	9		
			Supplemental	2		
Coles Pond		VT DEC volunteer	Routine - Weekly	10		
Crane Brook		Other	Supplemental	1		
East Long Pond		Other	Supplemental	1		
Emerald Lake		VT State Parks	Routine - Weekly	11		
Half Moon Lake		LCC Volunteer	Routine - Weekly	16		
		VT State Parks	Routine - Weekly	1		
Indian Brook Reservoir		VDH	Supplemental		1	
		Municipal staff	Supplemental	1		
Joes Pond		VT DEC volunteer	Routine - Weekly	32		
			Supplemental	3		
Knapp Pond No. 2		Other	Supplemental	1		
Lake Bomoseen		VT State Parks	Supplemental	3		

Waterbody	Region	Monitor	Report Type	Assessment Method		
				Visual Assessment	Shoreline Quality Assurance	Open Water Protocol
Lake Carmi		LCC Volunteer	Routine - Weekly	28		
			Supplemental	14		
		VDH	Routine - Weekly		28	
			Supplemental	2		
		VT DEC	Routine - Weekly	49		
		VT State Parks	Routine - Weekly	7		
			Supplemental	29		
Lake Champlain	Inland Sea	LCC Staff	Routine - Weekly	1		
		LCC Volunteer	Routine - Weekly	227		
			Supplemental	100		
		Other	Supplemental	8		
		VDH	Supplemental	2		
		VT DEC	Routine - Biweekly			8
		VT State Parks	Routine - Weekly	28		
			Supplemental	12		
		Bloom Alert	Supplemental	1		
	Main Lake Central	LCC Staff	Routine - Weekly	10	4	
			Supplemental	180		
		LCC Volunteer	Routine - Weekly	373	22	
			Supplemental	125	1	
		Other	Supplemental	1		
		VDH	Supplemental	1		
		VT DEC	Routine Biweekly			32
			Supplemental	1		
	Main Lake North	LCC Staff	Supplemental	2		
		LCC Volunteer	Routine - Weekly	171		
			Supplemental	39		
		Other	Supplemental	2		
		VDH	Routine - Weekly		10	
		VT DEC	Routine Biweekly			15
			Supplemental	1		
		VT State Parks	Routine - Weekly	5		
			Supplemental	1		
	Main Lake South	LCC Volunteer	Routine - Weekly	250		
			Supplemental	52		
		Other	Supplemental	3		
		VDH	Routine - Weekly		13	
			Supplemental		1	

Waterbody	Region	Monitor	Report Type	Assessment Method		
				Visual Assessment	Shoreline Quality Assurance	Open Water Protocol
Lake Champlain	Main Lake South	VT DEC	Routine Biweekly			14
			Supplemental	1		
	Malletts Bay	LCC Volunteer	Routine - Weekly	68		
			Supplemental	10		
		Other	Supplemental	1		
		VT DEC	Routine Biweekly			8
		VT State Parks	Routine - Weekly	33		
			Supplemental	2		
	Missisquoi Bay	LCC Volunteer	Routine - Weekly	29	14	
			Supplemental	10		
		VT DEC	Routine Biweekly			22
			Supplemental	1		1
	South Lake	LCC Volunteer	Routine - Weekly	5		
			Supplemental	1		
		Other	Supplemental	1		
		VT DEC	Routine Biweekly			16
	St. Albans Bay	LCC Staff	Supplemental	2	1	
		LCC Volunteer	Routine - Weekly	89	11	
			Supplemental	78		
		VDH	Routine - Weekly		4	
			Supplemental	1	1	
		VT DEC	Routine Biweekly			9
			Supplemental	1		
		VT State Parks	Routine - Weekly	3		
			Supplemental	1		
Lake Dunmore		LCC Volunteer	Routine - Weekly	8		
			Supplemental	1		
		VT State Parks	Routine - Weekly	7		
Lake Iroquois		LCC Volunteer	Routine - Weekly	33		
			Supplemental	4		
		Other	Supplemental	1		
Lake Memphremagog		LCC Volunteer	Routine - Weekly	7		
		MWA Volunteer	Routine - Weekly	36		
			Supplemental	30		
		Other	Supplemental	1		
		VT DEC volunteer	Routine - Weekly	31		
			Supplemental	7		
Lake Morey		VT DEC volunteer	Routine - Weekly	14		
			Supplemental	1		

Waterbody	Region	Monitor	Report Type	Assessment Method		
				Visual Assessment	Shoreline Quality Assurance	Open Water Protocol
Lake Runnemede		VT DEC volunteer	Routine - Weekly	8		
Lake Shaftsbury		VT State Parks	Supplemental	2		
Lake St. Catherine		LCC Volunteer	Supplemental	6		
Long Pond		VT DEC	Supplemental	1		
Mill Pond		VT DEC volunteer	Routine - Weekly	7		
			Supplemental	1		
Nichols Pond		Other	Supplemental	1		
		THO	Supplemental	2		
Norton Pond		VT DEC volunteer	Routine - Weekly	7		
Salem Lake		VT DEC volunteer	Supplemental	3		
Shelburne Pond		LCC Volunteer	Routine - Weekly	10		
		VDH	Supplemental		1	
Ticklenaked Pond		VT DEC	Supplemental	2		
		VT DEC volunteer	Supplemental	3		
Winona Lake		LCC Volunteer	Routine - Weekly	20		
			Supplemental	1		
Total Reports - 2680				**2443**	**112**	**125**

The number of samples analyzed in 2019 is summarized in Table 4. Two hundred sixty-three water samples were analyzed for phytoplankton density, 137 for microcystin and 115 for anatoxin. Most toxin samples were collected for quality control purposes and were not triggered by assessment reports. Cylindrospermopsin was not analyzed in 2019.

Table 4. Number of water and phytoplankton samples collected and analyzed in 2019. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.

Assessment Type	Phytoplankton		Microcystin	Anatoxin
	Plankton Net	Whole water	Whole water	Whole water
Open Water Protocol	121	1		
Visual	18	13	27	6
Quality Assurance Protocol		110	110	109
Total	**139**	**124**	**137**	**115**

Assessment Results – Recreational Monitoring

Summaries of the assessment results from regularly monitored sites in 2019 is presented in Figure 2. The highest monitoring category reached in each region of Lake Champlain and Vermont inland lakes is noted

in Table 5. The full list of records is available upon request or can be downloaded from the VDH website (http://www.healthvermont.gov/tracking/cyanobacteria-tracker).

Most reports (81%) received from Lake Champlain and Vermont inland lakes indicated that few or no cyanobacteria were present (category 1 of the visual protocol). In all, 483 reports of alert conditions (categories 2 and 3) were received during the summer of 2019, 18% of the total reports received. The highest density of potentially toxic cyanobacteria was observed at the North Beach at Lake Carmi on September 10, 2019 (131,666,700 cells/mL).

Figure 2. Summary of assessment reports received in 2019; 2a –Lake Champlain, 2b – Vermont inland lakes. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Dark shading indicates supplemental reports. NOTE the difference in scale between lakes. Category 1a = clear water, 1b = brown and turbid, 1c = other plant material, 1d = small amount of cyanobacteria. Category 2 = low alert. Category 3 = high alert.

Figure 2a -Lake Champlain regions

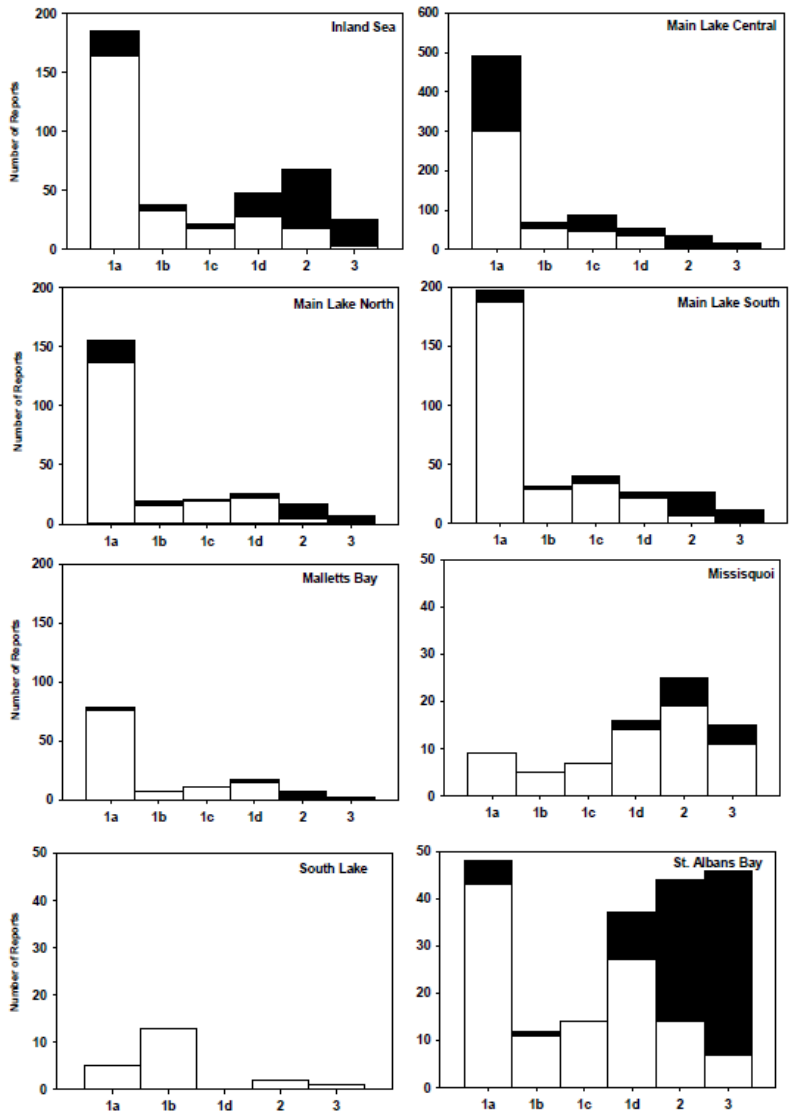
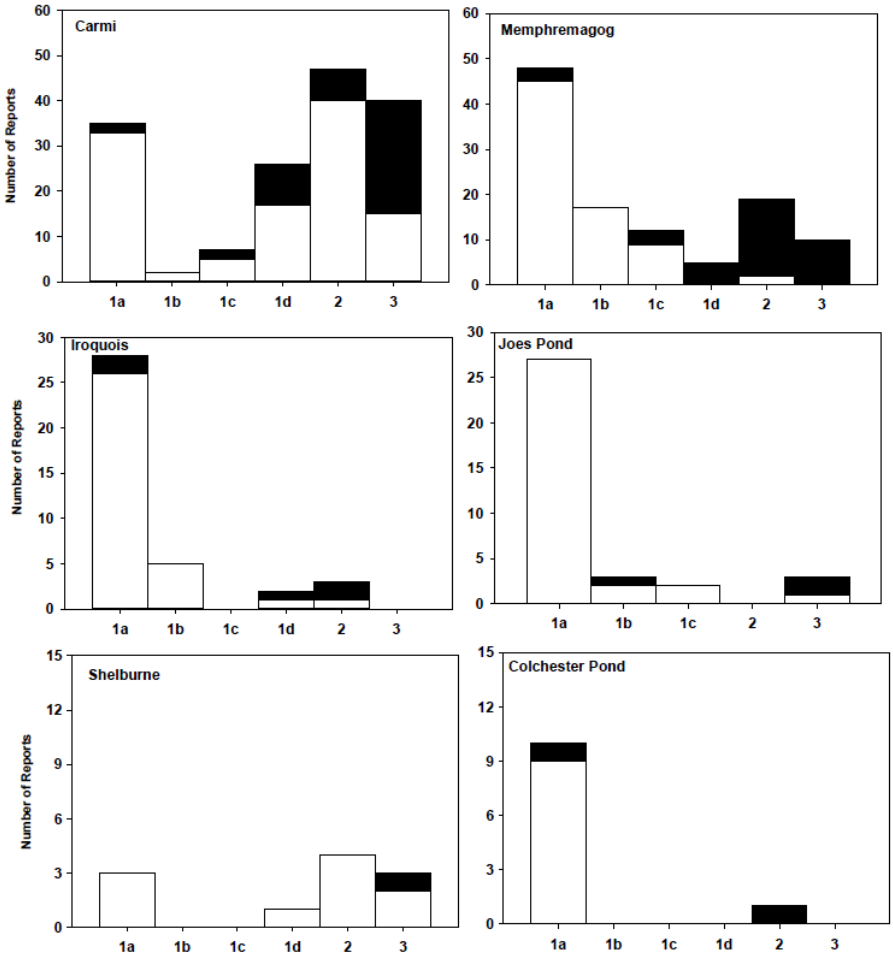


Figure 2b – Selected Vermont inland lakes



A total of 137 shoreline samples were analyzed for the presence of microcystin and 115 for anatoxin in 2019 (Table 4) from both routine sites and one-time reports at other locations. The number of samples tested for each waterbody is provided in Table 5. Microcystin was detected at three locations over the summer of 2019 – Missisquoi Bay and the Inland Sea on Lake Champlain, and Lake Carmi. The highest observed concentration of microcystin was measured on September 24 at North Beach on Lake Carmi (1.1 µg/L). Anatoxin was detected in three samples from St. Albans Bay Park – September 10 (0.63 µg /L), September 17 (0.78 µg /L) and September 24 (1.1 µg/L).

Table 5. Highest status reached in each waterbody in 2019. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Methods: V = visual, Q = quality assurance, O = open water protocol.

Waterbody	Region	#Reports	Assessment Method	Highest Status Observed	Highest Cell Density Observed, cells/mL	Highest Micro-cystin, µg/L (# Tested)	Highest Anatoxin, µg/L (# Tested)
Adams Reservoir		24	V	Generally Safe	not tested		
Arrowhead Mountain Lake		1	V	Generally Safe	not tested		
Bald Hill Pond		1	V	High Alert	not tested		
Caspian Lake		9	V	Generally Safe	not tested		
Colchester Pond		11	V	Low Alert	not tested	<0.16 (1)	not tested
Coles Pond		10	V	Generally Safe	not tested		
Crane Brook		1	V	High Alert	not tested		
East Long Pond		1	V	Low Alert	not tested		
Emerald Lake		11	V	Generally Safe	not tested		
Half Moon Lake		17	V	Generally Safe	not tested		
Indian Brook Reservoir		2	V	High Alert	24,400	<0.16 (2)	<0.5 (1)
Joes Pond		35	V	Low Alert	not tested		
Knapp Pond No. 2		1	V	Low Alert	not tested		
Lake Bomoseen		3	V	Generally Safe	not tested		
Lake Carmi		157	V, Q, O	High Alert	131,666,700	**0.22** (36)	<0.5 (28)
Lake Champlain	Inland Sea	387	V, O	High Alert	32,200	**0.36** (4)	<0.5 (3)
	Main Lake Central	750	V, Q, O	High Alert	56,700	<0.16 (36)	<0.5 (28)
	Main Lake North	246	V, Q, O	High Alert	217,200	<0.16 (11)	<0.5 (11)
	Main Lake South	334	V, Q, O	High Alert	150,100	<0.16 (14)	<0.5 (14)
	Malletts Bay	122	V, O	High Alert	265	<0.16 (1)	not tested
	Missisquoi Bay	77	V, Q, O	High Alert	94,966,600	**0.93** (14)	<0.5 (14)
	South Lake	23	V, O	High Alert	6800	not tested	
	St. Albans Bay	201	V, Q, O	High Alert	86,600	<0.16 (16)	**1.1** (15)
Lake Dunmore		16	V	Generally Safe	not tested		
Lake Iroquois		38	V	Low Alert	not tested		
Lake Memphremagog		112	V	High Alert	not tested		
Lake Morey		15	V	Generally Safe	not tested		
Lake Runnemede		8	V	Generally Safe	not tested		
Lake Shaftsbury		2	V	Generally Safe	not tested		
Lake St. Catherine		6	V	Generally Safe	not tested		
Long Pond		1	V	Low Alert	not tested		
Mill Pond		8	V	Generally Safe	not tested		
Nichols Pond		3	V	High Alert	not tested	<0.16 (1)	not tested
Norton Pond		7	V	Generally Safe	not tested		
Salem Lake		3	V	Generally Safe	not tested		
Shelburne Pond		11	V	High Alert	141,700	<0.16 (1)	<0.5 (1)

Waterbody	Region	#Reports	Assessment Method	Highest Status Observed	Highest Cell Density Observed, cells/mL	Highest Micro-cystin, µg/L (# Tested)	Highest Anatoxin, µg/L (# Tested)
Ticklenaked Pond		5	V	Generally Safe	1130	not tested	
Winona Lake		21	V	Low Alert	not tested		

Twenty-eight cyanobacteria taxa were observed in Lake Champlain or inland lakes during the 2019 monitoring period (Table 6). The majority have been identified as potential toxin producers in the scientific literature.

Table 6. Cyanobacteria taxa observed in Lake Champlain cyanobacteria monitoring samples. Year of first report refers only to the cyanobacteria monitoring program. *Prior to 2012, cyanobacteria were noted to genus only.

Name	Toxin producer	Present in 2019	Year of first report
Anabaena circinalis	yes	yes	2003*
Anabaena planctonica	yes	yes	2003*
Anabaena spp	yes	yes	2003*
Anabaena flos-aquae	yes	yes	2015
Aphanizomenon spp. (likely *A. gracile*)	yes	yes	2012
Aphanizomenon flos-aquae	yes	yes	2003*
Aphanocapsa spp.	no	yes	2004
Aphanothece spp.	yes	yes	2012
Arthrospira spp.	no	yes	2012
Chroococcus spp.	no	yes	2003
Coelosphaerium spp.	Yes	no	2003
Cyanodictyon spp.	no	no	2016
Gloeotrichia spp.	yes	yes	2003
Gloeocapsa spp.	yes	no	2004
Komvophoron spp.	yes	no	2016
Limnothrix spp.	possible	yes	2012
Merismospedia spp.	no	yes	2003
Microcystis spp.	yes	yes	2003*
Microcystis wesenbergii	yes	yes	2012
Oscillatoria spp.	yes	yes	2005
Planktothrix spp.	yes	yes	2017
Pseudanabaena spp	yes	yes	2012
**Radiocystis* spp.	possible	yes	2012
Romeria spp.	no	yes	2014

Name	Toxin producer	Present in 2019	Year of first report
Scytonema crispum (synonym *Lyngbya cinncinata*)	yes	yes	2012
Snowella spp	no	yes	2012
Trichodesmium spp	no	no	2015
Woronichinia spp (formerly *Gomphosphaeria* spp.)	yes	yes	2012
Filamentous cyanobacteria (Oscillatoriales)	possible	yes	2014
colonial taxon (likely *Cyanonephron* spp.)	no	yes	2014

Drinking Water Supply Monitoring

In 2019, the VDH offered, with support from the Lake Champlain Basin Program, free weekly microcystin testing for public drinking water facilities in Vermont from July 8 through September 27. The DWGWPD organized training sessions for facility operators, where LCC provided guidance on the visual assessment system, VDH provided an overview of Vermont's guidance for cyanotoxins in drinking water, and DWGWPD discussed treatment options for cyanobacteria and toxins in drinking water systems. Results of the summer's testing are can be found online at https://dec.vermont.gov/water/drinking-water/water-quality-monitoring/blue-green-algae/cyanotoxin-monitoring. There were no confirmed microcystin detections at these facilities in 2019.

Volunteer training

Volunteer trainings were conducted by LCC staff at locations around the Lake Champlain Basin. Twenty-three formal sessions trained nearly 250 potential monitors and interested citizens. Numerous media interviews and appearances alerted the public to the opportunity to become a volunteer monitor. LCC staff provided training for Vermont drinking water facility operators and for watershed organizations on Lakes Carmi and Iroquois. In 2019, LCC continued to train key personnel at Vermont State Parks and facilitate their reporting. In 2019, reports were provided from 16 Vermont and 1 New York state parks by staff, LCC volunteers, and VDH staff. VT DEC provided training for watershed associations and others on Vermont inland lakes located outside the Champlain Basin.

Training sessions provided information about cyanobacteria – causes, conditions that favor the development of blooms, appearance, associated health concerns, and management efforts aimed at reducing bloom frequency. Monitors were taught to distinguish cyanobacteria from other phenomena they might see in the lake such as green algae and pollen. Training sessions also introduced volunteers to the on-line LCC and VT DEC cyanobacteria resources and report forms, and the VDH Tracker reporting process.

The volunteer monitor program has an impact beyond the recruitment of volunteers and collection of data. As awareness of the possible health effects associated with cyanobacteria spreads, the interest in learning more about these organisms increases. While not all trained volunteers go on to report, all became familiar with cyanobacteria, potential health risks associated with them, and the water quality conditions that increase the likelihood of blooms.

Outreach and Assistance

Project partners continue to provide outreach and assistance to individuals and municipalities, primarily through phone calls and email. In addition, the LCC sends out a weekly update on conditions to their volunteers and provides separate weekly emails to a list-serve of interested citizens and agencies along with media reports throughout the season. Guidance and assistance to town health officers, beach managers, and residents was provided by partners during bloom events. All partners had webpages with resources and contacts for anyone seeking information about cyanobacteria. Partners also responded to media inquiries.

Regional and National Activities

Project partners are active at the local, regional, and national level. Partners continue to work closely with state and provincial staff in New York and Quebec to share monitoring information and bloom reports. VT DEC field staff continue to participate in EPA Region 1 efforts to develop a field screening method for cyanobacteria based on phycocyanin, a photosynthetic pigment found in cyanobacteria but few other algae. VT DEC also provided samples from Lake Champlain for a regional USGS project focused on assessing cyanobacteria community composition by eDNA.

The project manager continues to be a member of the Great Lakes HABS Collaboratory, an effort in the Great Lakes Region to leverage relationships among universities, states and federal partners to share cutting edge research and develop collaborative approaches to cyanobacteria monitoring. She continues to serve as a co-chair of the Inland HABS Program of the North American Lake Society (NALMS).

In 2019, the Interstate Technology and Regulatory Council (ITRC) began development of a technical document intended to summarize and identify resources supporting cyanobacteria management around the country. The HCB Team of the ITRC anticipates completion of the technical document in late 2020 with training to begin in 2021. Several members of the team come from the Lake Champlain Basin, including the project manager who serves as one of two team co-leaders. The LCBP has provided financial support for the team's work and at least one training on the resulting document will be held in the Basin.

Team project leads in Vermont (A. Shambaugh, B. O'Brien, L. Fisher, and H. Campbell) collaborated to write an article for the Summer 2019 issue of Lake Line magazine, a publication of the North American Lake Management Society (NALMS). The article is open access and available on line.

Communication with the Stakeholders and the Public

Results of the weekly assessments were communicated via email to a variety of stakeholders. The 154 recipients who received the VT DEC emails were largely associated with the states of Vermont and New York. Other recipients included federal officials and LCBP (14); provincial officials in Quebec (5); water

facilities, local governmental organizations, or municipal staff (30); non-profits and universities (15, including partners), and unknown recipients (3). As noted earlier, LCC also provided weekly emails to all monitors and partner agencies as well as separate weekly emails to a list-serve and regular emails to the media once blooms began.

Information was shared with the public via the VDH cyanobacteria webpages - see table below. Between June and December 2019, the VDH Cyanobacteria website received nearly 10,000 visits (Table 7). Activity was greatest in July and August, peak months of recreational activity. The monitoring data was also accessible through the VDH's Environmental Public Health tracking portal at http://healthvermont.gov/tracking/index.aspx.

VDH Cyanobacteria Webpages	URL
VDH Cyanobacteria Landing Page	healthvermont.gov/cyanobacteria
VDH Cyanobacteria Lake Conditions Page	healthvermont.gov/health-environment/recreational-water/lake-conditions
EPHT CyanoTracker Landing Page	healthvermont.gov/tracking/cyanobacteria-tracker
VDH Climate Change and Cyanobacteria Page	http://www.healthvermont.gov/health-environment/climate-health/cyanobacteria

Table 7. Usage of the VDH Cyanobacteria webpages in 2019

2019 Month	VDH Cyanobacteria Landing Page - Unique Page Views*	VDH Cyanobacteria Tracker - Unique Page Views**
June	450	692
July	3265	12,052
August	4621	5,758
September	855	1,174
October	368	779
November	231	281
December	171	117
Total:	9961	20,853

* www.healthvermont.gov/cyanobacteria

Challenges

Each year, project partners trains citizen volunteers to recognize cyanobacteria using visual cues and knowledge gained over the 18 year life span of the monitoring effort. Our focus is on the typical appearance of cyanobacteria blooms and other aquatic phenomena. We remind our monitors that there are always exceptions and encourage them to share unusual observations with us. In turn, these are

shared by the LCC with the wider team of volunteers and continue to enhance their ability to distinguish cyanobacteria from other aquatic phenomena.

This year, an unusual brownish tan scum was reported by volunteers and others in the St. Albans Bay and Inland Sea area during July. Several samples were provided by volunteers which allowed VT DEC to identify the scum as carapaces shed by zooplankton and containing ephippia (overwintering eggs). While these are not uncommon, this was the first time extensive scums of this material had been reported. Later in the summer, similar scums were observed on Lake Memphremagog by a cyanobacteria volunteer and confirmed to be from zooplankton.

Discussion

The primary role of the cyanobacteria monitoring program is to provide data on cyanobacteria occurrence and abundance to the VDH and other partners for the protection of public health. The data provided by the program assists drinking water facilities around Lake Champlain to evaluate the quality of their raw and finished water, and, in Vermont, provides operators with specific information about the presence/absence of selected cyanotoxins. The program serves an education and outreach role, helping volunteers and others recognize situations when recreational activities might not be prudent. Data also provide insight as to the effectiveness of the monitoring approach and contribute to a historical perspective of bloom events in the Basin.

Effectiveness of the visual monitoring protocol

Quantitative data collected during 2019 in conjunction with visual assessments at selected sites continue to support the visual assessment protocols as an effective tool to assess potential recreational risk. The majority of reports from quality control sites reported Category 1 (generally safe conditions), with correspondingly low concentrations of potentially toxic cyanobacteria (Appendix C).

Anatoxin was detected in three quality control samples with a visual assessment in Category 1d – Little cyanobacteria present. Microcystin was detected in several samples in Categories 2 and 3 reports (alert level conditions). All were well below the Vermont recreational guidance level of 6 µg/L for microcystin and 10 µg/L for anatoxin. Potentially toxic cyanobacteria were present in all samples with microcystin or anatoxin detections.

Each year, there are unusual observations that challenge our monitors as they utilize the visual protocol. We continue to update training materials to include the unusual as well as common appearance of cyanobacteria and other aquatic phenomena.

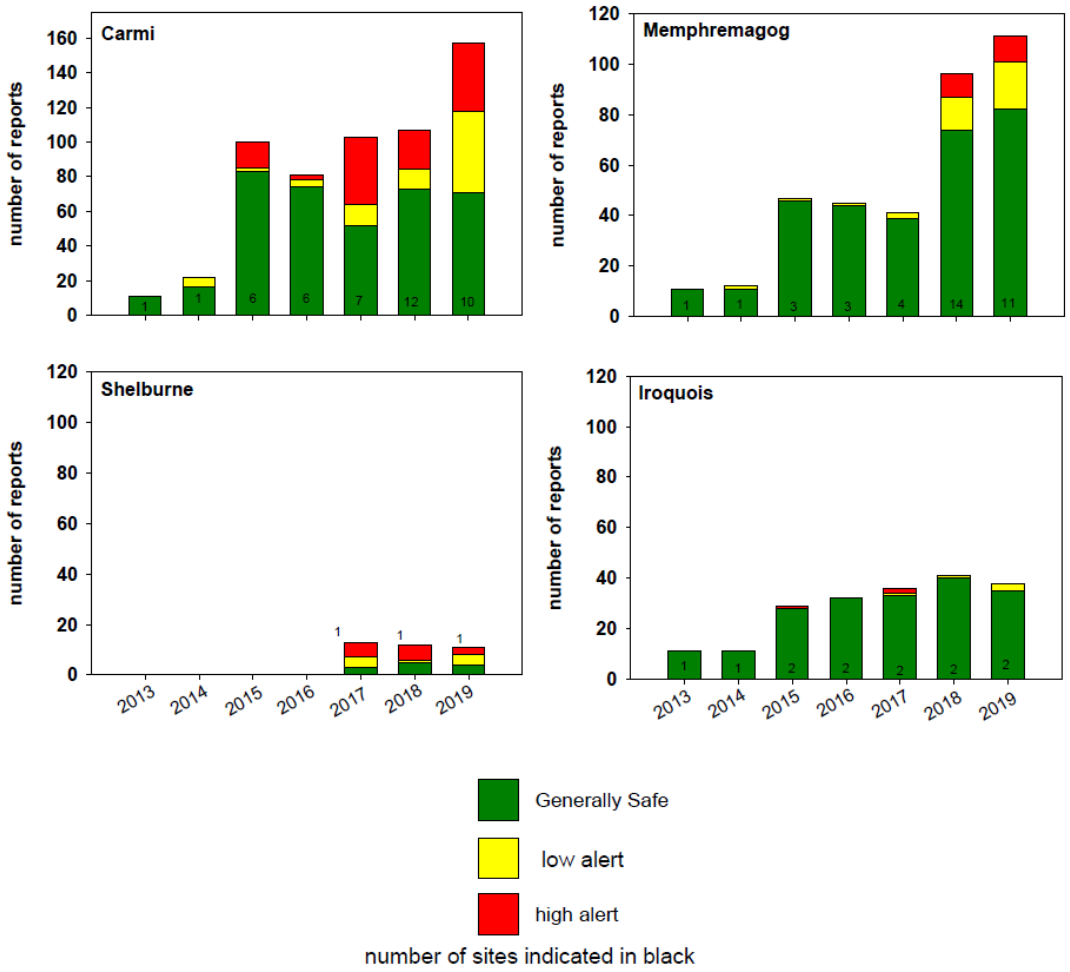
Cyanobacteria conditions in 2019

Vermont inland lakes

Historical data from routinely monitored Lake Carmi, Shelburne Pond, Lake Iroquois, and Lake Memphremagog are presented in Figure 4. Both Carmi and Memphremagog experienced a larger number of reports in the alert level categories when compared to previous years. While this may occur due to an increase in the number of sites or volunteers, similar increases also occurred some regions on Champlain

and are consistent with regional cyanobacteria information, indicating that blooms affected these lakes more frequently in 2019.

Figure 4. Webpage status reports on selected inland lakes since 2013. Supplemental reports are included.



Other waterbodies experiencing blooms in Vermont included:

- Bald Hill Pond
- Colchester Pond
- East Long Pond
- Indian Brook Reservoir
- Joes Pond
- Knapp Pond No. 2
- Long Pond
- Nichols Pond
- Lake Iroquois
- Lake Winona
- Shelburne Pond

Table 8 summarizes microcystin concentrations observed at Lake Carmi since 2013, the only inland Vermont lake currently monitored routinely for cyanotoxins. Samples for cyanobacteria testing were

collected weekly at two locations on Lake Carmi by the VDH and additional samples were collected during blooms. Microcystin was detected three times on Lake Carmi this year. All were below Vermont's recreational guideline of 6 µg/L.

Table 8. Microcystin concentrations in Lake Carmi, 2013 - 2019. The reporting limit is 0.16 µg/L.

Lake		2013	2014	2015	2016	2017	2018	2019
Lake Carmi	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 0.21	<0.16 - 0.39	<0.16 – 0.40	<0.16	<0.16 – 4.4	<0.16 – 1.19	<0.16 – 1.1
	#samples	10	19	17	25	35	32	36
	#stations tested	1	4	2	3	3	4	4

Cyanobacteria Conditions on Lake Champlain:

Eighty-four percent of the Champlain reports from 2019 indicated generally safe conditions (n=1796, Figures 5 and 6). Alert-level conditions were reported 345 times, many of which were supplemental reports (n=254, 39% supplemental). Alert level conditions were reported most frequently in the Inland Sea (n=93), St. Albans Bay (n=90), and Main Lake Central (n=48). As observed on Lakes Carmi and Memphremagog, most Champlain regions experienced an increased number of alert level reports in 2019 (Figure 7), consistent with anecdotal reports from around the Northeast.

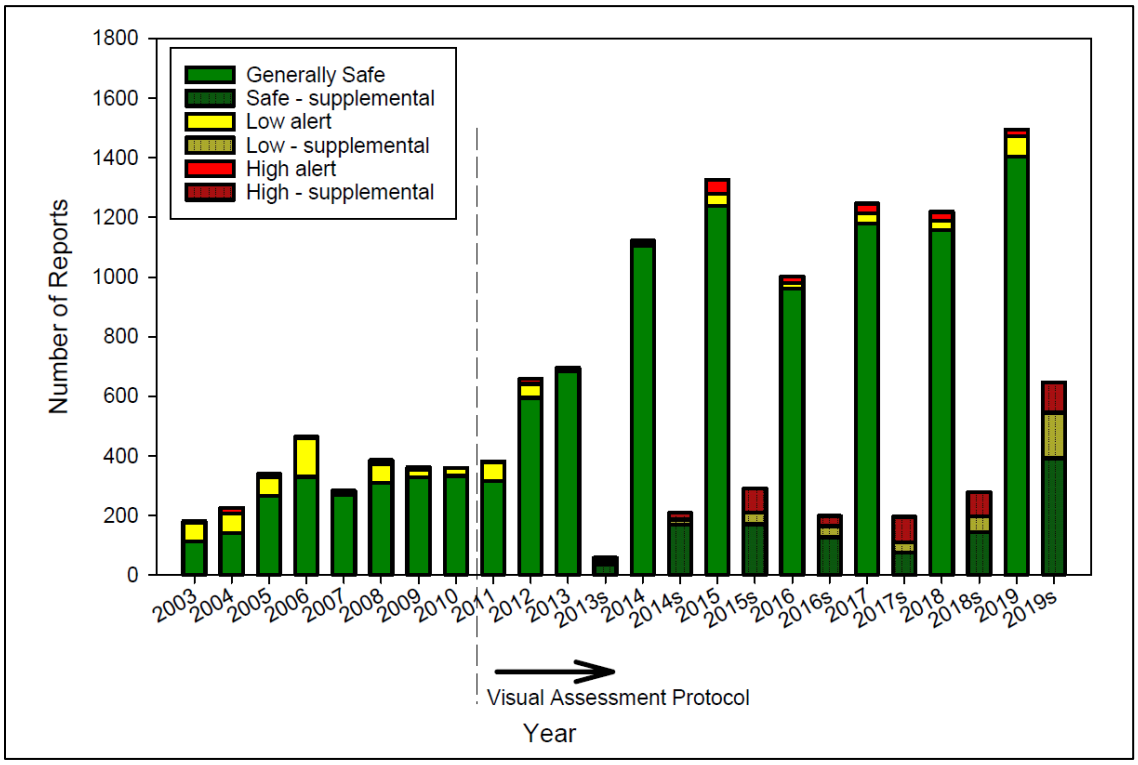


Figure 5. Number of yearly cyanobacteria status reports for Lake Champlain by category. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 's' following the year on the x axis.

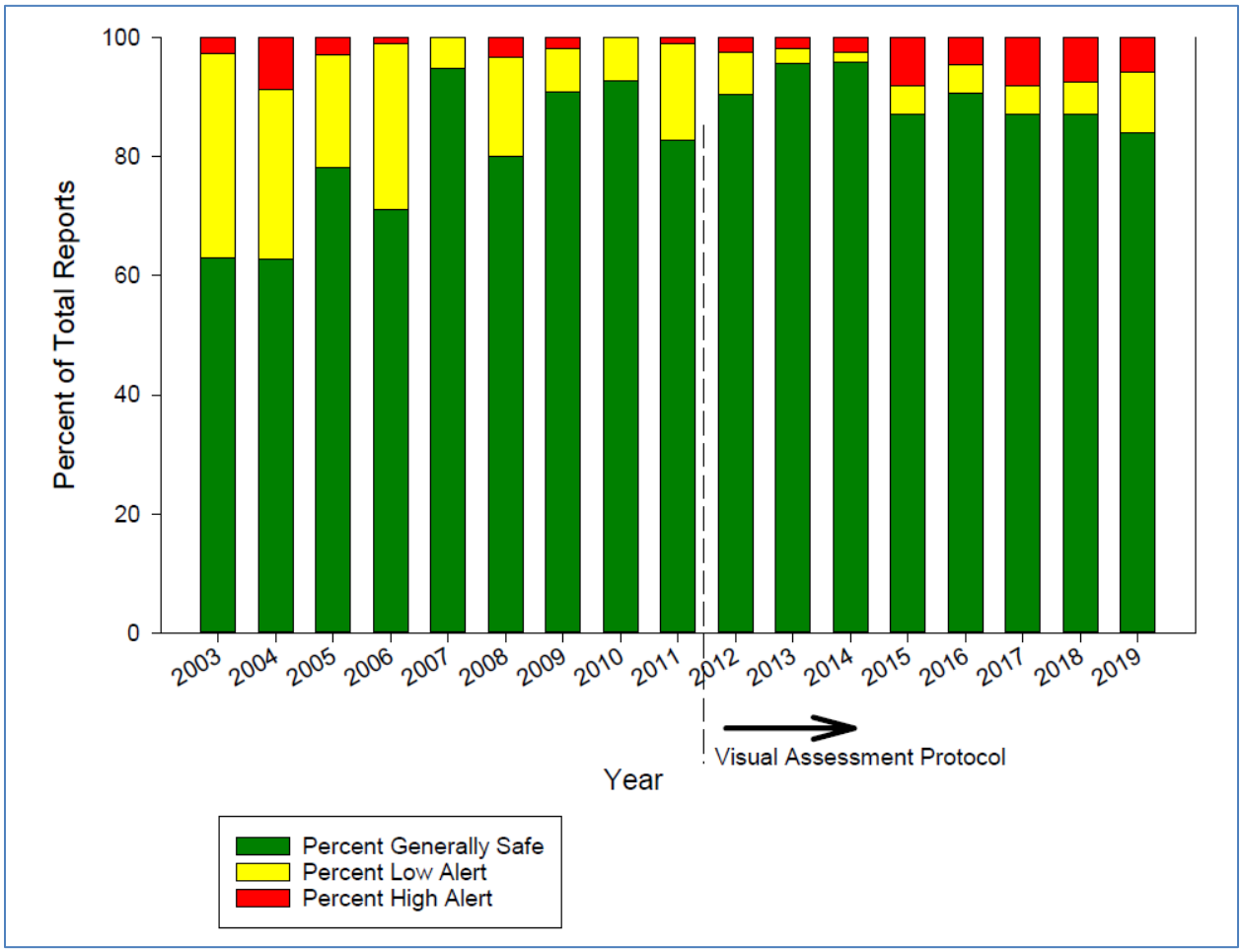


Figure 6. Cyanobacteria status reports Lake Champlain by category, percent of total reports received. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included but not reported separately.

Figure 7. Number of yearly cyanobacteria reports for Lake Champlain by region, 2013 – 2019. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 's' following the year on the x axis.

Cyanotoxin sample efforts on Lake Champlain continue to target bloom situations whenever possible. Because microcystin concentrations are expected to be highest in these situations, this targeted sampling increases the opportunity to capture high microcystin events. Microcystin concentrations exceeding Vermont's recreational guideline of 6 µg/L are rarely documented in these 'worst case' events and have not been exceeded on Lake Champlain since 2012 (Table 9). In 2019, microcystin was detected at two sites on Lake Champlain. The Vermont recreational guidance value was not exceeded:

- Inland Sea on August 27
    - Graveyard Point – 0.36 µg/L
- Missisquoi Bay – Shipyard, Highgate Springs
    - June 24 – 0.93 µg/L
    - August 27 – 0.26 µg/L

Anatoxin was detected in St. Albans Bay Park on three dates – September 10 (0.63 ug/L), September 17 (0.78 µg/L) and September 24 (1.1 µg/L). All were below the Vermont recreational guidance value of 10 µg/L.

Table 9. Microcystin concentrations in major lake segments, 2003 – 2019. Data are from routine monitoring locations and bloom events. Data do not distinguish between net plankton, which were tested through 2012, and whole water samples. ND = not detected. Shaded boxes = not applicable. Detailed data for 2003 - 2013 can be found in Appendix D.

Lake Region		Max 2003 - 2013	2014	2015	2016	2017	2018	2019
Inland Sea	median	1.10	<0.16	<0.16			<0.16	<0.16
	range	0.01 – 22.5	<0.16 - 0.28	<0.16 – 0.02			All <0.16	<0.16 – 0.36
	#samples		56	26	0	0	5	4
	#stations		4	4			5	4
Main Lake Central	median	7.42	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	0.01 -23.3	<0.16 -0.19	All <0.16	All <0.16	<0.16 – 1.25	All <0.16	All <0.16
	#samples		31	27	26	31	36	36
	#stations		2	2	2	4	4	6
Main Lake North	median				<0.16	<0.16	<0.16	<0.16
	range	0.01 – 1.56			All <0.16	All <0.16	All <0.16	All <0.16
	#samples		0	0	12	10	11	11
	#stations				1	1	1	2
Main Lake South	median	0.04	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 3.47	<0.16-0.51	All <0.16	All <0.16	<0.16 – 4.25	All <0.16	All <0.16
	#samples		33	28	12	16	21	13
	#stations		3	2	1	3	4	1
St. Albans Bay	median	0.30	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 22.48	<0.16 - 0.2	<0.16 – 0.77	All <0.16	<0.16 – 0.35	<0.16 – 0.38	All <0.16
	#samples		4	12	15	21	13	16
	#stations		2	2	3	3	1	3
Malletts Bay	median	0.04					<0.16	<0.16
	range	0.04 – 0.08					All <0.16	NA
	#samples		0	0	0	0	6	1
	#stations						3	1
South Lake	median	0.96						
	range	0.53 – 1.86						
	#samples		0	0	0	0	0	
	#stations							
Missisquoi Bay	median	2.56	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 6490	<0.16 -2.29	<0.16 – 0.43	All <0.16	<0.16 – 5.6	<0.16 – 0.38	<0.16 – 0.93
	#samples		40	38	19	18	16	14
	#stations		7	5	6	3	4	1

Evaluating Change over Time – A Cyanobacteria Severity Index for Vermont

One of the most frequent question asked about cyanobacteria is whether conditions are becoming worse over time. While the cyanobacteria monitoring approach used in Vermont can provide insight into long-term change, annual variation in the number and location of sites and frequency of reporting by volunteers creates challenges for answering this question. Satellite imagery can be used to evaluate change in open water locations but cannot detect cyanobacteria through cloud cover and is not currently reliable for shorelines where most contact recreation tends to occur.

The VDH and VT DEC have developed a simple index that utilizes the visual assessment data to characterize cyanobacteria severity for an annual index period from June 15 to September 15, when recreational use and volunteer participation is highest.

For Carmi sites with at least 4 routine reports and Champlain locations with at least 5, each week during the index period is characterized as "affected" when one or more alert level reports were received and can be summarized as a seasonal index of "percent affected weeks". Additionally, the overall severity during the index period can be evaluated by assigning each week a severity value of 1 – 3 based on the highest visual assessment category reached that week and calculating the average for the index period for each year.

Figure 8 presents the draft cyanobacteria severity index through 2018 for five stations that have strong long-term data sets. Sites 30 and 31, in Missisquoi and St. Albans Bays respectively, represent locations with historically frequent and intense blooms while sites 22 and 27 in the Burlington area experience fewer events. Lake Carmi site 201 is also subject to frequent blooms events.

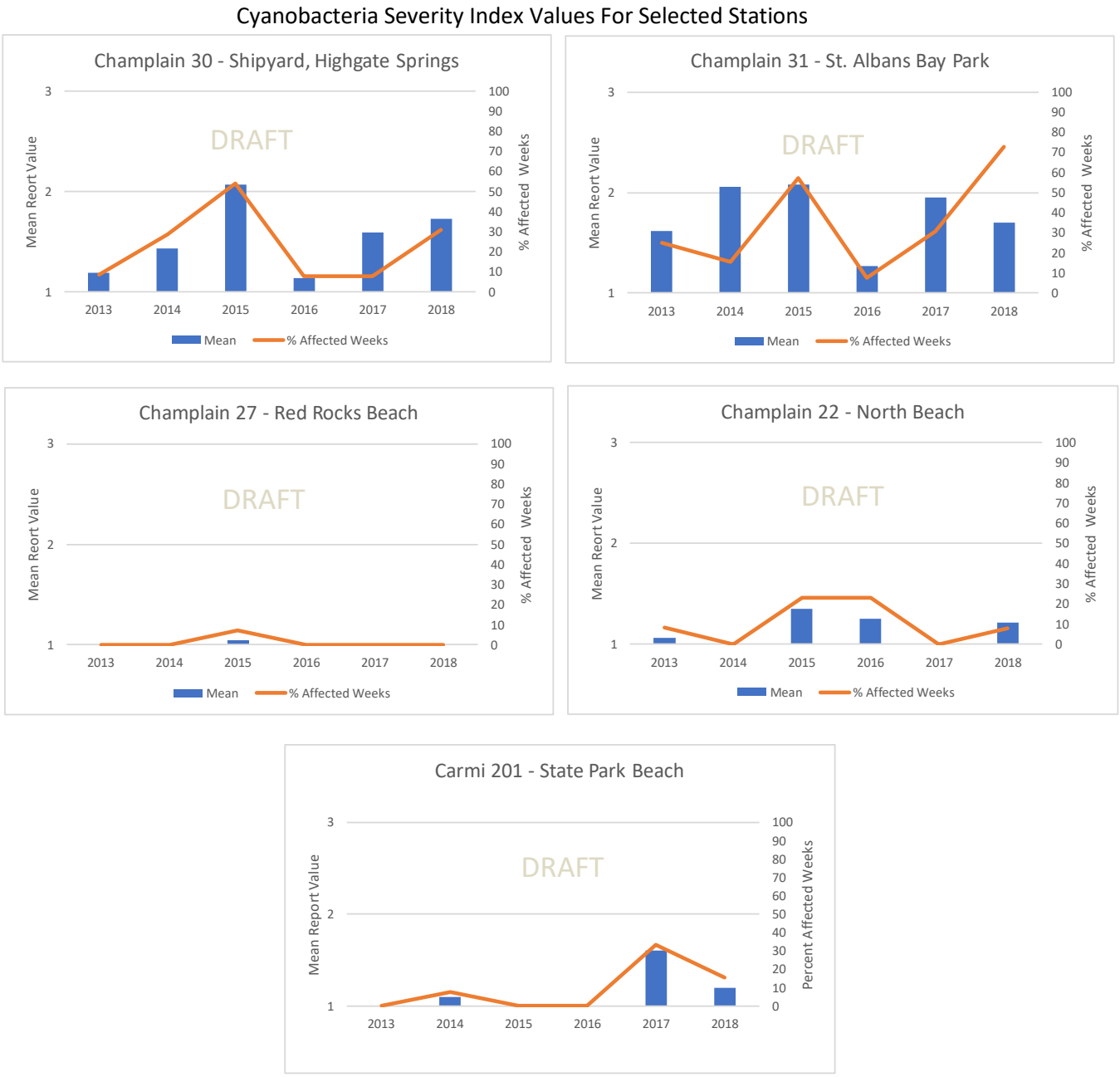


Figure 8. Cyanobacteria severity index values for five stations on Lake Champlain and Lake Carmi. The index period is defined as June 15 to September 15. Data is not yet available for 2019. Report values are defined as 1 = generally safe, 2 = low alert, and 3 = high alert. The index is still in development and these data are subject to change.

VDH and VT DEC will continue to evaluate use of these severity metrics for outreach and as a tool to explore the influence of environmental conditions on the occurrence of cyanobacteria blooms.

Summary

The cyanobacteria monitoring program continues to operate through a strong partnership between the State of Vermont, the Lake Champlain Committee, and the Lake Champlain Basin Program. As in years past, the majority of monitoring reports documented generally safe conditions on Lake Champlain and selected Vermont inland lakes. Consistent with anecdotal regional information, many locations on Champlain and some Vermont inland lakes did experience a higher number of alert level events in 2019 compared to previous years. Microcystin and anatoxin detections were infrequent and observed concentrations were all below the Vermont recreational guidance levels in 2019.

Partners continue to use the visual assessment protocol to communicate cyanobacteria conditions across Lake Champlain, supported by taxonomic and toxin data collected routinely at key locations. The visual assessment protocol also facilitates outreach on inland lakes, providing a common way to visually evaluate and communicate conditions to individuals who may be experiencing cyanobacteria for the first time. Outreach continues to be an important component of the monitoring program.

Routine monitoring occurs on one day each week and alert level conditions are most likely to be captured in supplemental reports made during the rest of the week, requiring extra effort on the part of our monitors. Because of their diligence and the increasing number of volunteers gathering data for this project, we have a good understanding of cyanobacteria conditions on Lake Champlain and several Vermont inland lakes. VDH and VT DEC are developing two cyanobacteria severity metrics to assist with outreach and investigation of bloom frequency temporal patterns.

Acknowledgements

Project funding was provided by the Lake Champlain Basin Program, the State of Vermont, CDC grants to the VDH, and private funding to the Lake Champlain Committee. This project is very much a collaborative effort and we'd like to thank all those who have contributed to its successful implementation – Jeremy Howland, Pete Stangel, and Kelcie Bean (VT DEC Watershed Management); Sasha Rosen and Bennett Truman (VDH); Marie Sawyer and Suzy Stanton (VDH Laboratory); Jan Leja and Dan Jarvis (developers of the Tracker map); Lauren Sopher and Alexa Hachigian (LCC); staff at VT State Parks; and especially the citizen volunteer monitors who continue to be the backbone of this monitoring effort.

Literature Cited

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Appendix A – 2019 Routine Sampling locations

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Adams Reservoir	Woodford State Park - Day Beach	Bennington	VT	VT State Parks	443	42.889003	-73.038348
	Woodford State Park - Camper Beach	Bennington	VT	VT State Parks	444	42.884778	-73.039083
Caspian Lake	Caspian Lake	Greensboro	VT	VT DEC Volunteer	306	44.587710	-72.310363
Colchester Pond	Colchester Pond Paddlecraft Access	Colchester	VT	LCC Volunteer	458	44.550574	-73.123656
Coles Pond	Coles Pond	Walden	VT	VT DEC Volunteer	311	44.508800	-72.215750
Emerald Lake	Emerald Lake State Park - Day Beach	East Dorset	VT	VT State Parks	441	43.277639	-73.005139
Half Moon Lake	Half Moon State Park - Camper Beach	Hubbardton	VT	VT State Parks	437	43.694528	-73.219083
Joes Pond	The Narrows, Joes Pond	West Danville	VT	VT DEC Volunteer	463	44.408902	-72.211416
	Town Beach, Joes Pond	West Danville	VT	VT DEC Volunteer	464	44.410048	-72.198161
	Clubhouse Circle, Joes Pond	West Danville	VT	VT DEC Volunteer	465	44.417293	-72.220855
Lake Carmi	Lake Carmi, Black Woods	Franklin	VT	LCC Volunteer	164	44.975297	-72.885460
	Lake Carmi State Park South / Area A	Franklin	VT	VT State Parks	165	44.956922	-72.877290
	Lake Carmi, Dewing Road	Franklin	VT	LCC Volunteer	166	44.982139	-72.853540
	Lake Carmi, North Beach	Franklin	VT	VDH	167	44.990535	-72.870310
	Lake Carmi State Park	Franklin	VT	VDH/ VT State Parks	201	44.960813	-72.876742
	Carmi DEC01- Central Open Water	Franklin	VT	VT DEC	409	44.972600	-72.874500
	Carmi DEC02- Southern Open Water	Franklin	VT	VT DEC	410	44.959200	-72.886900
	Carmi DEC03- Northeastern Open Water	Franklin	VT	VT DEC	411	44.983280	-72.859880
Champlain - Inland Sea	Grand Isle State Park	Grand Isle	VT	VT State Parks	11	44.686021	-73.289124
	Pelots Bay	North Hero	VT	LCC Volunteer	24	44.825370	-73.299149
	LTM 34	Milton	VT	VT DEC	34	44.708167	-73.226833
	Burton Island State Park	St. Albans Town	VT	VT State Parks	37	44.776860	-73.196317
	The Gut	Grand Isle	VT	LCC Volunteer	49	44.751374	-73.290260
	Sand Bar State Park	Milton	VT	LCC Volunteer	57	44.628758	-73.239937
	City Bay - Rt 2	North Hero	VT	LCC Volunteer	78	44.815894	-73.289081

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Champlain – Inland Sea (from the RT 78 bridge in Swanton VT to the RT 2 causeway between Milton and South Hero VT; includes the Gut, Alburgh Passage and Carry Bay)	Knight Point State Park	North Hero	VT	LCC Volunteer/ VT State Parks	80	44.768669	-73.294455
	South Hero Fish and Wildlife Boat Access	South Hero	VT	LCC Volunteer	110	44.636405	-73.265227
	Marycrest Beach	Grand Isle	VT	LCC Volunteer	116	44.723362	-73.281545
	Cedar Ledge	North Hero	VT	LCC Volunteer	131	44.846952	-73.262188
	Keeler Bay East	South Hero	VT	LCC Volunteer	134	44.654142	-73.291958
	Maquam Beach	Swanton	VT	LCC Volunteer	139	44.920807	-73.161356
	Woods Island State Park	St. Albans Town	VT	LCC Volunteer	145	44.804871	-73.204525
	Knight Island State Park	North Hero	VT	LCC Volunteer	146	44.810722	-73.258077
	South Alburgh - Squires Bay	Alburgh	VT	LCC Volunteer	182	44.903005	-73.271732
	Everest Rd.	Milton	VT	LCC Volunteer	185	44.649832	-73.213102
	Dunham Bay	North Hero	VT	LCC Volunteer	186	44.885619	-73.273367
	Lapan Bay	St. Albans Town	VT	LCC Volunteer	385	44.815365	-73.177842
	Maquam Shore (Swanton, VT)	Swanton	VT	LCC Volunteer	386	44.901564	-73.167081
	Knight Point State Park – the Point	North Hero	VT	LCC Volunteer/ VT State Parks	419	44.767255	-73.298751
	Carry Bay - East Shore	North Hero	VT	LCC Volunteer	420	44.835079	-73.272726
	Idlewild Road	South Hero	VT	LCC Volunteer	427	44.664462	-73.277574
	Fee Fee Point	North Hero	VT	LCC Volunteer	461	44.895854	-73.267445
	Graveyard Point	North Hero	VT	LCC Volunteer	473	44.831823	-73.286133
	Allen Point	South Hero	VT	LCC Volunteer	189	44.599195	-73.311435
Champlain - Main Lake Central	Ausable Point Campground Beach	Peru, NY	NY	LCC Volunteer	376	44.572130	-73.426570
	Ausable Point Road - Lake side	Peru, NY	NY	LCC Volunteer	434	44.572869	-73.432738
	Beech Bay	South Hero	VT	LCC Volunteer	190	44.632500	-73.342900
	Burlington Inner Dock	Burlington	VT	LCC Volunteer	381	44.482000	-73.224638
	Burlington, VT - Texaco Beach	Burlington	VT	LCC Volunteer	72	44.487636	-73.232126
	Community Sailing Center	Burlington	VT	LCC Volunteer	107	44.482060	-73.225524
	Corlear Bay, Port Douglas Boat Launch	Chesterfield, NY	NY	LCC Volunteer	160	44.486116	-73.411743
	Delta Park	Colchester	VT	LCC Volunteer	405	44.536704	-73.277491
	Essex Road	Willsboro, NY	NY	LCC Volunteer	382	44.343764	-73.357744
	Hills Point	Charlotte	VT	LCC Volunteer	384	44.339163	-73.281818

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Champlain - Main Lake Central (from the Grand Isle/Plattsburgh ferry crossing south to the Charlotte/Essex ferry)	LaPlatte River mouth, Shelburne Bay	Shelburne	VT	LCC Volunteer	55	44.400342	-73.233455
	Leddy Park	Burlington	VT	LCC Volunteer	54	44.500826	-73.253409
	LTM 16	Shelburne	VT	VT DEC	16	44.425000	-73.232000
	LTM 19	South Burlington	VT	VT DEC	19	44.471000	-73.299000
	LTM 21	Burlington	VT	VT DEC	21	44.474833	-73.231667
	LTM 33	Plattsburgh, NY	NY	VT DEC	33	44.701167	-73.418167
	North Beach	Burlington	VT	LCC Volunteer	22	44.491058	-73.240373
	North Shore Beach	Burlington	VT	LCC Volunteer	391	44.520757	-73.269584
	Oakledge Park - Blanchard Beach	Burlington	VT	LCC Volunteer	42	44.457440	-73.225507
	Oakledge Park - Rocky Shoreline	Burlington	VT	LCC Volunteer	44	44.456715	-73.228030
	Oakledge Park - South Cove	Burlington	VT	LCC Volunteer	43	44.454958	-73.230043
	Ordway Shore Road	Shelburne	VT	LCC Volunteer	459	44.353909	-73.270787
	Perkins Pier	Burlington	VT	LCC Volunteer	392	44.472752	-73.220755
	Peru Boat Launch	Peru, NY	NY	LCC Volunteer	159	44.618839	-73.440433
	Point Bay Marina	Charlotte	VT	LCC Volunteer	162	44.274628	-73.284886
	Port Kent Beach	Chesterfield, NY	NY	LCC Volunteer	152	44.528651	-73.403473
	Red Rocks Beach	South Burlington	VT	LCC Volunteer	27	44.441999	-73.224133
	Shelburne Beach	Shelburne	VT	LCC Volunteer	48	44.363061	-73.267611
	Shelburne Farms	Shelburne	VT	LCC Volunteer	123	44.404449	-73.268312
	South Beach Road	South Burlington	VT	LCC Volunteer	467	44.423968	-73.217839
	South Cove Beach	Burlington	VT	LCC Volunteer	173	44.449835	-73.231576
	Starr Farm Beach	Burlington	VT	LCC Volunteer	108	44.513764	-73.271397
	Sunset/Crescent Beach	South Hero	VT	LCC Volunteer	132	44.608883	-73.315846
	Teddy Bear Point Cove, Willsboro NY	Willsboro, NY	NY	LCC Volunteer	63	44.442723	-73.374283
	Triangle Beach	Burlington	VT	LCC Volunteer	466	44.464789	-73.219562
	Whiskey Bay	Charlotte	VT	LCC Volunteer	426	44.270241	-73.301477
	White's Beach in Crescent Bay	South Hero	VT	LCC Volunteer	114	44.621145	-73.323442
Champlain - Main Lake North	Alburgh Dunes State Park	Alburgh	VT	VDH/ VT State Parks	35	44.864624	-73.301956
	Holcomb Boat Launch	Isle la Motte	VT	LCC Volunteer	129	44.854684	-73.331620

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Champlain - Main Lake North (north of the Grand Isle/Plattsburgh ferry to the VT/QC border)	Horicans Fish and Wildlife Access	Alburgh	VT	LCC Volunteer	127	44.914084	-73.314491
	Lighthouse Point Road	Isle la Motte	VT	LCC Volunteer	472	44.906840	-73.344017
	LTM 36	Grand Isle	VT	VT DEC	36	44.756167	-73.355000
	LTM 46	Rouses Point, NY	NY	VT DEC	46	44.948333	-73.340000
	Mud Point	Alburgh	VT	LCC Volunteer	389	44.931647	-73.312126
	Oliver Bay	Plattsburgh, NY	NY	LCC Volunteer	45	44.737454	-73.402344
	Pelots Point West	North Hero	VT	LCC Volunteer	130	44.826076	-73.310125
	Plattsburgh City Beach	Plattsburgh, NY	NY	LCC Volunteer	47	44.719494	-73.430751
	Pt. Au Roche Boat Launch	Plattsburgh, NY	NY	LCC Volunteer	109	44.804399	-73.362971
	Pt. Au Roche State Park - Deep Bay	Beekmantown, NY	NY	LCC Volunteer	84	44.777511	-73.378863
	Pt. Au Roche State Park Beach	Beekmantown, NY	NY	LCC Volunteer	26	44.774136	-73.393798
	Rouses Pt	Rouses Point, NY	NY	LCC Volunteer	28	44.991474	-73.362137
	RPt DEC Old Beach	Rouses Point, NY	NY	LCC Volunteer	395	44.999109	-73.357842
	Stoney Point, Isle la Motte	Isle la Motte	VT	LCC Volunteer	128	44.871482	-73.359440
	Treadwell Bay, Beekmantown NY	Beekmantown, NY	NY	LCC Volunteer	64	44.760077	-73.407520
	Vantines Boat Launch	Grand Isle	VT	LCC Volunteer	115	44.719813	-73.341888
Champlain - Main Lake South	Beggs Park Beach, Essex NY	Essex, NY	NY	LCC Volunteer	60	44.308462	-73.347324
	Bulwagga Bay/Port Henry	Port Henry, NY	NY	LCC Volunteer	138	44.036878	-73.454751
	Burgey Farm Road	Addison	VT	LCC Volunteer	380	44.055940	-73.417176
	Button Bay Boat Launch	Ferrisburg	VT	LCC Volunteer	74	44.176162	-73.352250
	Button Bay South	Ferrisburg	VT	LCC Volunteer	183	44.168634	-73.355595
	Button Bay State Park	Ferrisburg	VT	LCC Volunteer	180	44.180831	-73.359292
	Button Bay State Park - the Point	Ferrisburg	VT	LCC Volunteer	421	44.178117	-73.370721
	Camp Dudley, Westport NY	Westport, NY	NY	LCC Volunteer	75	44.143222	-73.415671
	Camp Greylock	Ferrisburg	VT	LCC Volunteer	118	44.243147	-73.292495
	Charlotte Town Beach	Charlotte	VT	LCC Volunteer	76	44.334725	-73.282902
	Chimney Point	Addison	VT	LCC Volunteer	143	44.034809	-73.422602
	Converse Bay	Charlotte	VT	LCC Volunteer	184	44.293795	-73.289676
	DAR State Park	Addison	VT	LCC Volunteer	39	44.054526	-73.418253

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Champlain – Main Lake South (south from the Charlotte/Essex ferry to the Champlain bridge at Crown Point/Chimney Point)	Ferrisburg Town Beach	Ferrisburg	VT	LCC Volunteer	117	44.235937	-73.300976
	Hawkins Bay	Ferrisburg	VT	LCC Volunteer	105	44.243757	-73.283361
	Kingsland Bay State Park	Ferrisburg	VT	LCC Volunteer	15	44.240302	-73.298734
	Lane's Lane Landing	Charlotte	VT	LCC Volunteer	121	44.273405	-73.288894
	Long Point	Ferrisburg	VT	LCC Volunteer	18	44.258135	-73.277644
	Long Point Beach	Ferrisburg	VT	LCC Volunteer	460	44.2529	-73.2796
	Long Pt, (Wood) Ferrisburg	Ferrisburg	VT	LCC Volunteer	41	44.256623	-73.283074
	LTM 07	Ferrisburg	VT	VT DEC	7	44.126000	-73.412833
	LTM 09	Ferrisburg	VT	VT DEC	9	44.242167	-73.329167
	North Harbor	Ferrisburg	VT	LCC Volunteer	147	44.199725	-73.358821
	North Shore Road	Charlotte	VT	LCC Volunteer	462	44.277462	-73.293157
	Port Henry Boat Launch	Port Henry, NY	NY	LCC Volunteer	153	44.052777	-73.450585
	Town Farm Bay	Charlotte	VT	LCC Volunteer	119	44.269164	-73.288749
	Tri-Town Road, West Addison	Addison	VT	VDH	210	44.085383	-73.407909
	Westport Boat Launch	Westport, NY	NY	LCC Volunteer	59	44.188732	-73.432835
	Whallons Bay	Essex, NY	NY	LCC Volunteer	122	44.273258	-73.346144
	Bayside Beach	Colchester	VT	LCC Volunteer	377	44.545655	-73.215944
Champlain - Malletts Bay (south of the Rt 2 causeway between Milton and South Hero VT, west to the Malletts Bay causeway)	Camp Kiniya	Colchester	VT	LCC Volunteer	142	44.606441	-73.229078
	LTM 25	Colchester	VT	VT DEC	25	44.582000	-73.281167
	Malletts Bay Boat Launch	Colchester	VT	LCC Volunteer	120	44.554162	-73.231003
	Niquette Bay State Park	Colchester	VT	VT State Parks	67	44.581294	-73.188891
	Niquette Bay State Park - Cove Beach	Colchester	VT	VT State Parks	416	44.580375	-73.196118
	Rosetti Park	Colchester	VT	LCC Volunteer	111	44.555009	-73.252797
Champlain - Missisquoi Bay (north of the Rt 78 bridge, including Quebec waters)	Highgate Springs	Highgate	VT	VT DEC	14	44.991767	-73.113383
	Larry Greene F&W Access, RT 78	Swanton	VT	LCC Volunteer	87	44.967967	-73.221117
	LTM 50	Alburgh	VT	VT DEC	50	45.013333	-73.173833
	LTM 51	Philipsburg, QC	QC	VT DEC	51	45.041667	-73.129667
	Phillipsburg, QC	Philipsburg, QC	QC	LCC Volunteer	58	45.039064	-73.078692
	Shipyard, Highgate Springs	Highgate	VT	LCC Volunteer	30	44.980760	-73.107881

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
	Venise en-Quebec	Venise en-Quebec	QC	LCC Volunteer	399	45.070500	-73.145100
Champlain - South Lake (south of the Champlain Bridge at Chimney/Crown Points to Benson VT)	LTM 02	Benson	VT	VT DEC	2	43.714000	-73.383000
	LTM 04	Bridport	VT	VT DEC	4	43.951000	-73.407000
	Mud Flats-Addison	Addison	VT	LCC Volunteer	456	44.031529	-73.408288
Champlain - St. Albans Bay (Black Bridge in the inner Bay to Kill Kare Point on the north; just west of Melville Landing on the Georgia VT shore)	Black Bridge	St. Albans Town	VT	LCC Volunteer	191	44.810300	-73.151800
	Ferrand Rd. St. Albans	St. Albans Town	VT	LCC Volunteer	113	44.791711	-73.142541
	Georgia Beach	Georgia	VT	LCC Volunteer	383	44.768200	-73.162600
	Hackett's Way	St. Albans Town	VT	LCC Volunteer	402	44.784388	-73.173965
	Hathaway Point Road	St. Albans Town	VT	LCC Volunteer	403	44.796369	-73.163121
	Kill Kare State Park	St. Albans Town	VT	LCC Volunteer/VT State Parks	56	44.777702	-73.180801
	LTM 40	St. Albans Town	VT	VT DEC	40	44.785333	-73.162167
	Melville Landing	Georgia	VT	LCC Volunteer	176	44.761999	-73.167402
	St. Albans Bay Park	St. Albans Town	VT	LCC Volunteer	31	44.808658	-73.144361
	St. Albans Boat Launch	St. Albans Town	VT	LCC Volunteer	32	44.793721	-73.171428
Lake Dunmore	Branbury State Park - Day Beach	Brandon	VT	VT State Parks	436	43.908167	-73.068417
	Lake Dunmore Boat Launch	Salisbury	VT	LCC Volunteer	401	43.905611	-73.083084
Lake Iroquois	Lake Iroquois	Williston	VT	LCC Volunteer	203	44.378068	-73.086737
	Lake Iroquois Southwest	Hinesburg	VT	LCC Volunteer	169	44.363273	-73.085641
Lake Memphremagog	Derby Bay	Derby	VT	MWA Volunteer	211	44.994345	-72.188561
	Eagle Point, Derby, VT	Derby	VT	VT DEC Volunteer	445	45.002421	-72.201456
	Holbrook Bay	Newport Town	VT	MWA Volunteer	212	44.964178	-72.239919
	Newport City Dock	Newport City	VT	MWA Volunteer	342	44.937345	-72.211851
	Prouty Beach	Newport City	VT	VT DEC Volunteer	204	44.946537	-72.208702
	South Bay F&W Access, Newport VT	Newport City	VT	VT DEC Volunteer	425	44.929133	-72.212672
	Strawberry Acres, Newport VT	Newport Town	VT	MWA Volunteer	448	44.95523	-72.234081
	Sunset Acres, Derby Bay	Derby	VT	VT DEC Volunteer	423	44.983510	-72.186256
Lake Morey	VT Fish and Wildlife Access, Lake Morey VT	Fairlee	VT	VT DEC Volunteer	451	43.921556	-72.15922
Lake Runnemede	Lake Runnemede (Evarts Pond)	Windsor	VT	VT DEC Volunteer	354	43.483116	-72.391567
Mill Pond	Kayak Access, Mill Pond VT	Windsor	VT	VT DEC Volunteer	452	43.476368	-72.396311

Waterbody	Station	Municipality	State/ Province	Monitor Affiliation	Site #	Latitude	Longitude
Norton Pond	Norton Pond Fish and Wildlife Access	Warrens Gore	VT	VT DEC Volunteer	447	44.923887	-71.87136
Shelburne Pond	Shelburne Pond Boat Launch	Shelburne	VT	LCC Volunteer	396	44.377204	-73.162095
Winona Lake	Winona Lake (Bristol Pond Fishing Access)	Addison	VT	LCC Volunteer	455	44.181956	-73.099917

Appendix B. Visual assessment protocols - Lake Champlain Committee

https://www.lakechamplaincommittee.org/get-involved/volunteers/cyanobacteriamonitors/algaebloomintensity/

General Instructions
Category 1a: No cyanobacteria present - clear water
Category 1b - No cyanobacteria present - brown and turbid conditions
Category 1c - No cyanobacteria present - other plant material
Category 1d - Little cyanobacteria present - Generally safe conditions
Category 2: Cyanobacteria present, but at less than 'bloom' levels - Low alert conditions
Category 3: Cyanobacteria bloom in progress - High alert conditions

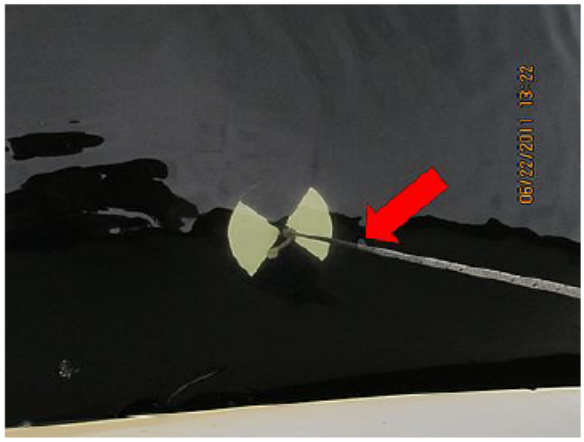
General Instructions

Observations should be made at the same location once per week. Observations must be made between 10:00 AM and 3:00 PM. At that time the algae have had a chance to rise from lower in the water column, but cells are not yet likely to have ruptured from the heat of mid-day. All observations submitted and approved will be posted on the Vermont Department of Health cyanobacteria tracker. Anyone providing reports should include information on the extent and type of algae and plant growth, the color of the water, and rate the algae intensity. The rating scale runs from one (a, b, c, or d) to three, with one being clear water with little to no cyanobacteria present and three being a cyanobacteria bloom in progress.

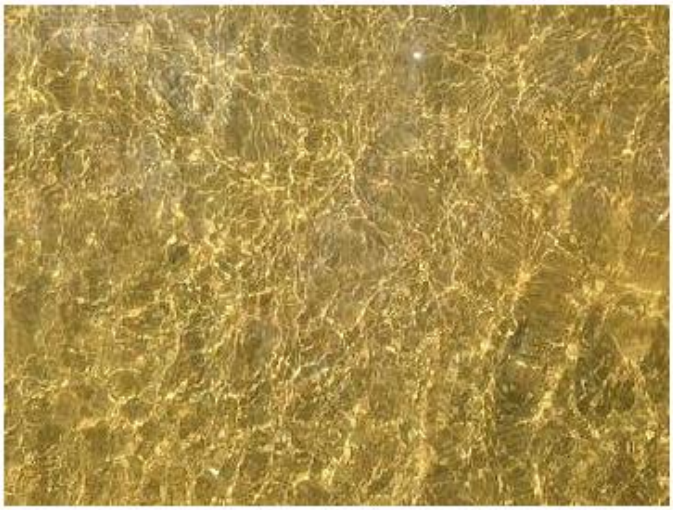
For category 2 and 3 conditions, three digital photographs should be submitted via the online form. Remember to avoid direct contact if the bloom is well developed.

Category 1a: No cyanobacteria present - clear water

Any organisms floating in water column are clear (e.g. insect 'skins') rather than green. Leafy or grass-like plants (including duckweed) may be present. Foam may be present.



Objects sitting lower in the water column are clearly visible (red arrow indicates water surface)



Overall appearance of water is clear

Category 1b - No cyanobacteria present - brown and turbid conditions

Brown turbid low visibility through water column

Brown and cloudy does not indicate presence of cyanobacteria

Category 1c - No cyanobacteria present - other plant material

Other material that doesn't count as cyanobacteria might include:

Long strands that tangle around paddles or boat hooks

Small bright mustard yellow (pollen) or grass green (duckweed) particles

Algae attached to rocks or the lake bottom.

Green dots are duckweed; stringy algae are not cyanobacteria

From a distance duckweed may look like green algae or cyanobacteria

Stringy algae attached to the bottom are not cyanobacteria

Duckweed up close

Category 1d - Little cyanobacteria present - Generally safe conditions

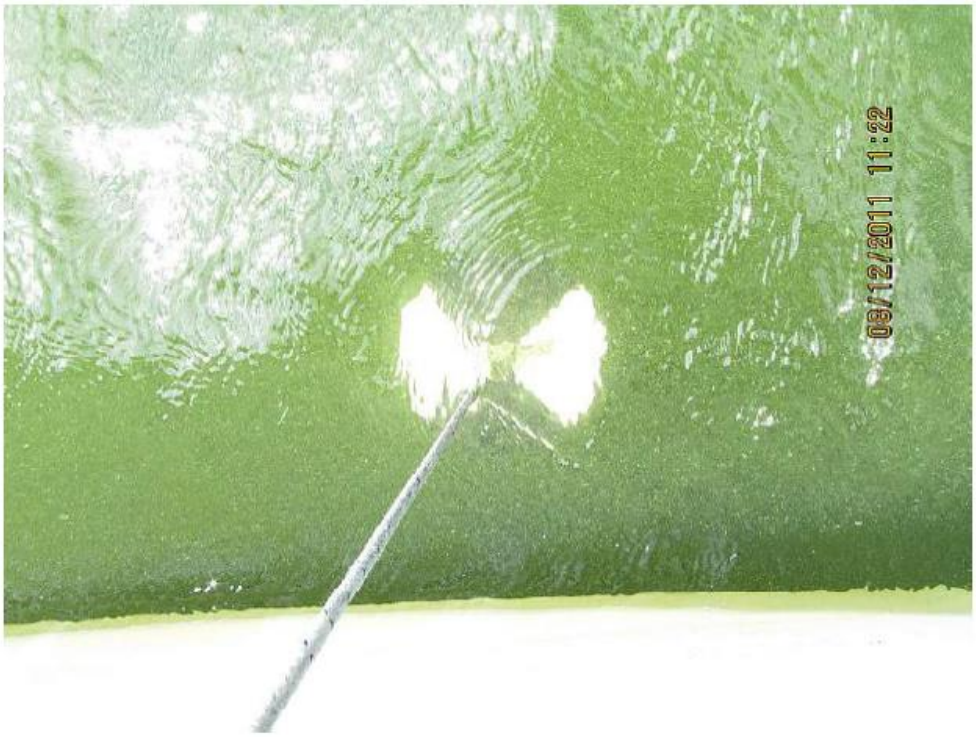
Green floating balls may be visible, but only on close inspection and in densities so low that they do not impair recreational enjoyment of the water. There are no surface or near shore accumulations of cyanobacteria.

Water appears perfectly clear

But close inspection shows some cyanobacteria present

Category 2: Cyanobacteria present, but at less than 'bloom' levels - Low alert conditions

Numerous green balls (pinhead size or larger) floating in water column, but not accumulated at water surface. Possible small (smaller than a softball) patches of algae accumulation. Open water color **not** green. Possible narrow band of cyanobacteria accumulation at shoreline.



Some cyanobacteria in water but not a uniform layer

Open water not green.

Band of cyanobacteria at shoreline

Category 3: Cyanobacteria bloom in progress - High alert conditions

Extensive surface scum on water – color may range from green to electric blue (not yellow/pollen). Usually accompanied by a thick accumulation at shoreline. Open water appears green.

Continuous layer of cyanobacteria at the surface - not stringy

Thick surface scum present

Instructions for Photographing Cyanobacteria Blooms & Taking Water Samples

Please take digital photographs of the water when category 2 or 3 bloom conditions are observed.

We need three photographs:

1. A close-up of the water surface,
2. A broad view of water in the vicinity, and
3. A close-up of a water sample in a clear container and placed against a solid contrasting background so objects in water are visible. A white background is preferable. Download LCC's Cyanobacteria Reporting Photo Card to use as a background and record information on for your jar test photos!

1.Use your camera's date stamp, or hold up a card in the photo with time, date, and location and category if possible.

2. Photograph both a close-up and a broad view.

3. Close-up of jar water sample after performing 30-minute jar test.

When collecting a water sample to photograph take care to avoid exposure to cyanobacteria. Wear gloves, don't wade or immerse yourself in the water and wash any exposed portions of your body immediately after collecting the sample. After sampling wash the gloves before reusing them. It is okay not to collect a physical sample for photography if you are uncomfortable doing so.

For best results, collect samples in water about knee deep. Invert the container before submerging it into the water and then tilt it once it is under water. This gives a more representative sample by collecting more than just the surface scum.

All photographs should include the time, date, and location. This information can be added by using the date stamp in your camera or by holding a piece of paper with the relevant information in the picture. Name the photograph file with the year-month-day-photographer's name-location-photo type-category.

Example photo file name: 2017-07-15_JaneDoe_DonaldsonPt_Closeup_category2

Appendix C – Quality Assurance Sample Data for 2019

Waterbody	Station	Report Date	Bloom Intensity	Density	Microcystin	Anatoxin
Lake Carmi	Lake Carmi State Park	25-Jun	1a - Little or no BGA present - clear water	800	<0.16	<0.5
		2-Jul	1a - Little or no BGA present - clear water	2000	<0.16	<0.5
		9-Jul	1a - Little or no BGA present - clear water	4000	<0.16	<0.5
		16-Jul	1a - Little or no BGA present - clear water	6880	<0.16	<0.5
		23-Jul	3 - BGA bloom in progress (include photos)	314900	<0.16	<0.5
		30-Jul	1a - Little or no BGA present - clear water	30100	<0.16	<0.5
		6-Aug	1d - Little BGA present - recreation not impaired	31900	<0.16	<0.5
		13-Aug	1d - Little BGA present - recreation not impaired	142200	<0.16	<0.5
		20-Aug	2 - BGA present - less than bloom levels (include photos)	87900	<0.16	<0.5
		27-Aug	3 - BGA bloom in progress (include photos)	130800	<0.16	<0.5
		4-Sep	1d - Little BGA present - recreation not impaired	69400	<0.16	<0.5
		10-Sep	3 - BGA bloom in progress (include photos)	142500	<0.16	<0.5
		17-Sep	3 - BGA bloom in progress (include photos)	141300	<0.16	<0.5
		24-Sep	1d - Little BGA present - recreation not impaired	8130	<0.16	<0.5
	Lake Carmi, North Beach	25-Jun	1a - Little or no BGA present - clear water	293	<0.16	<0.5
		2-Jul	1a - Little or no BGA present - clear water	1090	<0.16	<0.5
		9-Jul	1a - Little or no BGA present - clear water	6760	<0.16	<0.5
		16-Jul	1c - Little or no BGA present - other material present	42600	<0.16	<0.5
		23-Jul	1b - Little or no BGA present - brown or turbid water	50100	<0.16	<0.5
		30-Jul	3 - BGA bloom in progress (include photos)	0	<0.16	<0.5
		6-Aug	3 - BGA bloom in progress (include photos)	88200	<0.16	<0.5
		13-Aug	1c - Little or no BGA present - other material present	73000	<0.16	<0.5
		20-Aug	3 - BGA bloom in progress (include photos)	1771600	0.21	<0.5
		27-Aug	3 - BGA bloom in progress (include photos)	58200000	<0.16	<0.5
		4-Sep	2 - BGA present - less than bloom levels (include photos)	233400	<0.16	<0.5
		10-Sep	3 - BGA bloom in progress (include photos)	131666700	<0.16	<0.5
		17-Sep	1d - Little BGA present - recreation not impaired	77600	<0.16	<0.5
		24-Sep	3 - BGA bloom in progress (include photos)	5870	1.1	<0.5
Lake Champlain	Alburgh Dunes State Park	25-Jun	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		2-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		9-Jul	1a - Little or no BGA present - clear water	1	<0.16	<0.5
		16-Jul	1a - Little or no BGA present - clear water	80	<0.16	<0.5
		23-Jul	2 - BGA present - less than bloom levels (include photos)	31600	<0.16	<0.5
		30-Jul	1a - Little or no BGA present - clear water	4120	<0.16	<0.5
		6-Aug	1a - Little or no BGA present - clear water	8760	<0.16	<0.5

Waterbody	Station	Report Date	Bloom Intensity	Density	Microcystin	Anatoxin
Lake Champlain	Alburgh Dunes State Park	13-Aug	1a - Little or no BGA present - clear water	217200	<0.16	<0.5
		20-Aug	1d - Little BGA present - recreation not impaired	19900	<0.16	<0.5
		27-Aug	1d - Little BGA present - recreation not impaired	26000	<0.16	<0.5
	North Beach	1-Jul	1a - Little or no BGA present - clear water	533	<0.16	<0.5
		8-Jul	1a - Little or no BGA present - clear water	3280	<0.16	<0.5
		15-Jul	1a - Little or no BGA present - clear water	560	<0.16	<0.5
		22-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		29-Jul	1b - Little or no BGA present - brown or turbid water	133	<0.16	<0.5
		6-Aug	1c - Little or no BGA present - other material present	2600	<0.16	<0.5
		12-Aug	1a - Little or no BGA present - clear water	973	<0.16	<0.5
		19-Aug	1a - Little or no BGA present - clear water	56700	<0.16	<0.5
		26-Aug	1a - Little or no BGA present - clear water	38900	<0.16	<0.5
		3-Sep	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		9-Sep	1a - Little or no BGA present - clear water	5330	<0.16	<0.5
		16-Sep	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		23-Sep	1a - Little or no BGA present - clear water	4640	<0.16	<0.5
	Red Rocks Beach	24-Jun	1c - Little or no BGA present - other material present	0	<0.16	<0.5
		1-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		8-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		14-Jul	1a - Little or no BGA present - clear water	6320	<0.16	<0.5
		22-Jul	1a - Little or no BGA present - clear water	800	<0.16	<0.5
		29-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		5-Aug	1a - Little or no BGA present - clear water	1920	<0.16	<0.5
		12-Aug	1b - Little or no BGA present - brown or turbid water	1000	<0.16	<0.5
		19-Aug	1c - Little or no BGA present - other material present	4630	<0.16	<0.5
		26-Aug	1a - Little or no BGA present - clear water	4480	<0.16	<0.5
		3-Sep	1a - Little or no BGA present - clear water	9090	<0.16	<0.5
		9-Sep	1a - Little or no BGA present - clear water	2990	<0.16	<0.5
		16-Sep	1c - Little or no BGA present - other material present	373	<0.16	<0.5
		23-Sep	1c - Little or no BGA present - other material present	0	<0.16	<0.5
	Shipyard, Highgate Springs	24-Jun	2 - BGA present - less than bloom levels (include photos)	182900	0.93	<0.5
		2-Jul	1c - Little or no BGA present - other material present	14200	<0.16	<0.5
		9-Jul	1b - Little or no BGA present - brown or turbid water	8300	<0.16	<0.5
		16-Jul	1a - Little or no BGA present - clear water	2660	<0.16	<0.5
		23-Jul	1a - Little or no BGA present - clear water	1330	<0.16	<0.5
		30-Jul	1a - Little or no BGA present - clear water	387	<0.16	<0.5
		6-Aug	1d - Little BGA present - recreation not impaired	2280	<0.16	<0.5

Waterbody	Station	Report Date	Bloom Intensity	Density	Microcystin	Anatoxin
Lake Champlain	Shipyard, Highgate Springs	13-Aug	1a - Little or no BGA present - clear water	1960	<0.16	<0.5
		20-Aug	1a - Little or no BGA present - clear water	10200	<0.16	<0.5
		27-Aug	3 - BGA bloom in progress (include photos)	94966600	0.26	<0.5
		3-Sep	1c - Little or no BGA present - other material present	0	<0.16	<0.5
		9-Sep	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		16-Sep	1c - Little or no BGA present - other material present	560	<0.16	<0.5
		23-Sep	1a - Little or no BGA present - clear water	0	<0.16	<0.5
	St. Albans Bay Park	25-Jun	1a - Little or no BGA present - clear water	3390	<0.16	<0.5
		2-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		9-Jul	1c - Little or no BGA present - other material present	1200	<0.16	<0.5
		15-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		23-Jul	1c - Little or no BGA present - other material present	2770	<0.16	<0.5
		30-Jul	1b - Little or no BGA present - brown or turbid water	4030	<0.16	<0.5
		6-Aug	1d - Little BGA present - recreation not impaired	42500	<0.16	<0.5
		13-Aug	1d - Little BGA present - recreation not impaired	42500	<0.16	<0.5
		20-Aug	1d - Little BGA present - recreation not impaired	79000	<0.16	<0.5
		27-Aug	1d - Little BGA present - recreation not impaired	74800	<0.16	<0.5
		2-Sep	1d - Little BGA present - recreation not impaired	59400	<0.16	<0.5
		10-Sep	1c - Little or no BGA present - other material present	54000	<0.16	<0.5
		17-Sep	1d - Little BGA present - recreation not impaired	41400	<0.16	0.78
		24-Sep	1d - Little BGA present - recreation not impaired	86600	<0.16	1.1
	Tri-Town Road, West Addison	1-Jul	1a - Little or no BGA present - clear water	520	<0.16	<0.5
		8-Jul	2 - BGA present - less than bloom levels (include photos)	116800	<0.16	<0.5
		15-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		22-Jul	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		29-Jul	1c - Little or no BGA present - other material present	573	<0.16	<0.5
		5-Aug	1a - Little or no BGA present - clear water	240	<0.16	<0.5
		12-Aug	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		19-Aug	1c - Little or no BGA present - other material present	38400	<0.16	<0.5
		26-Aug	1d - Little BGA present - recreation not impaired	9150	<0.16	<0.5
		3-Sep	1b - Little or no BGA present - brown or turbid water	6480	<0.16	<0.5
		9-Sep	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		16-Sep	1d - Little BGA present - recreation not impaired	293	<0.16	<0.5
		23-Sep	1a - Little or no BGA present - clear water	0	<0.16	<0.5

Appendix D – Historical Microcystin Data for Lake Champlain

Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08		<0.16
	range	0.05 - 0.18	0.08-17.56	0.01-0.19	0.04-42.14	0.04-0.07	0.03-22.50	0.06-0.08	0.03-0.13	0.01-0.82		<0.16 - 0.43
	#samples	6	8	8	16	4	11	2	3	9	0	45
	#stations	1	3	3	7	3	4	2	2	4		4
Main Lake Central	median	0.05	NA	7.42	NA	2.82	0.25	0.03	0.10	0.02	0.13	<0.16
	range	0.01-0.12	NA	6.04-8.80	NA	0.02-5.61	0.03-0.47	0.03-23.36	0.02-0.14	0.01-0.03	0.13-0.64	<0.16 -0.17
	#samples	19	0	2	0	2	2	6	8	4	3	23
	#stations	4	NA	1	NA	2	2	3	5	4	1	2
Main Lake North	median	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	range	NA	NA	NA	NA	NA	1.56	0.03	NA	0.01		
	#samples	0	0	0	0	0	1	1	0	1	0	0
	#stations	NA	NA	NA	NA	NA	1	1	NA	1		
Main Lake South	median	NA	NA	0.04	NA	NA	NA	NA	NA	0.01		<0.16
	range	0.07	NA	ND - 0.07	3.47	NA	NA	NA	NA	0.01		<0.16 - 0.16
	#samples	1	0	2	1	0	0	0	0	2	0	22
	#stations	1	NA	1	1	NA	NA	NA	NA	2		2
St. Albans Bay	median	0.05	0.05	0.30	0.06	0.05	0.04	0.02	0.05	0.04	0.03	0.032
	range	0.01-0.41	ND - 22.48	0.06-0.82	0.01-0.43	0.02-0.54	0.02-0.12	0.01-0.17	0.01-0.80	0.02-0.14	0.03-0.04	0.002-0.062
	#samples	32	29	18	36	20	10	4	10	12	5	2
	#stations	1	2	1	2	4	3	2	3	2	1	2
Malletts Bay	median	NA	NA	NA	0.04	NA	NA	NA	NA	NA		
	range	NA	NA	NA	0.04-0.08	NA	NA	NA	NA	0.04		
	#samples	0	0	0	7	0	0	0	0	1	0	0
	#stations	NA	NA	NA	2	NA	NA	NA	NA	1		
South Lake	median	0.96	NA	NA	NA	NA	NA	NA	NA	NA		
	range	0.53-1.38	NA	0.01	NA	NA	NA	NA	NA	0.02		
	#samples	2	0	1	0	0	0	0	0	1	0	0
	#stations	2	NA	1	NA	NA	NA	NA	NA	1		
Missisquoi Bay	median	0.09	0.84	0.66	0.52	NA	2.56	0.54	0.03	0.65	0.99	<0.16
	range	ND - 23.91	0.01-6490.06	ND - 22.11	0.01-21.29	NA	0.06-94.58	0.03-54.16	0.01-0.12	0.02-180.2	0.26-54.76	<0.16 - 1.3
	#samples	341	228	146	152	0	81	29	10	59	36	30
	#stations	14	11	10	12	NA	10	8	7	8	3	6