

April 28, 2023 (v2)

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EPA's Volunteer Monitor's Guide to Quality Assurance Project Plans

Element 1.

**Long-Term
Five Year: 2023-2027
QUALITY CONTROL/QUALITY ASSURANCE PROJECT PLAN
LAY MONITORING PROGRAM FOR VERMONT LAKES**

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April 2023

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Element 2.

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Element 3. Distribution List

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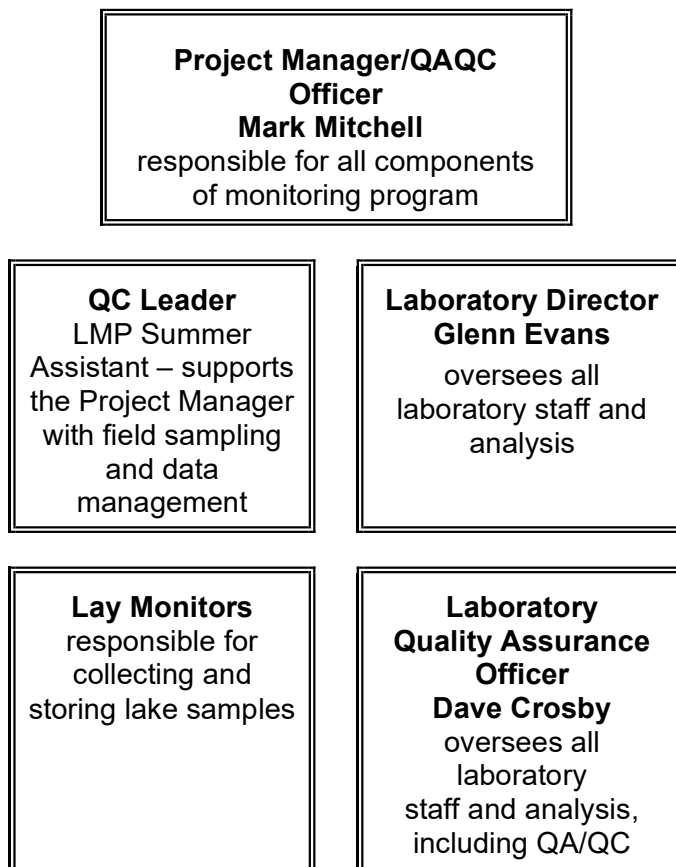
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Element 4. Project /Task Organization

Figure 1. Organizational Chart



The primary data users are the Vermont Department of Environmental Conservation (VTDEC), lake associations and citizen watershed groups.

Element 5. Problem/Definition/Background

General Description

This project is a continuation of the water quality monitoring on Vermont lakes, which has been conducted under the Vermont Lay Monitoring Program (LMP) since 1979 (<https://dec.vermont.gov/watershed/lakes-ponds/monitor/lay-monitoring>). Under the LMP, citizen volunteers are trained to measure water clarity and to collect water samples for chlorophyll-a and total phosphorus analysis. Through the use of volunteers, essential baseline water quality data is collected, and lake residents and users are better informed regarding lake biology and lake water quality protection.

Project Objectives

LMP staff train and equip volunteers (or Lay Monitors) to conduct periodic lake water quality sampling from their boat using quality-assured methods. Since the program's inception in 1979, the principal goals have remained the same:

- to establish baseline water quality conditions in Vermont lakes,
- to track long-term nutrient enrichment in Vermont lakes and assess monitoring data for compliance with [Vermont Water Quality Standards](https://dec.vermont.gov/watershed/map/assessment/waterqualitystandards) (<https://dec.vermont.gov/watershed/map/assessment/waterqualitystandards>)
- to teach lakeshore homeowners and lake users about lake ecology and stewardship.

In total, more than 100 inland lakes and 40 Lake Champlain stations have been monitored by this dedicated group of citizen scientists, with support from the Vermont Department of Environmental Conservation (VTDEC) and Lake Champlain Sea Grant (since 2021).

Element 6. Project/ Task Description

Sampling

Sampling is designed to monitor trophic state parameters. Vermont lakes are known to have suffered declines in water quality due to accelerated eutrophication in some regions. The program therefore measures nutrient concentration and primary productivity. In total, more than 100 lakes have participated in the program for at least one year between 1979 and 2022 (<https://anrweb.vt.gov/DEC/DEC/LayMonitoring.aspx>).

Sampling Parameters

There are two types of sampling schedules, *Basic and Supplemental* ([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

Under the *Basic* program (typically new monitors), lakes are sampled bi-weekly from June 1st through August 31st for a total of six samples for Secchi disk transparency only.

Under the *Supplemental* program (depending on monitor and staff capacity), lakes are sampled bi-weekly from June 1st through August 31st for a total of six samples for the following:

- Secchi disk transparency reading with view tube/scope
- Chlorophyll-a concentration sample
- Total phosphorus concentration sample
- Caffeine concentration sample

A surface bottle grab sampling method (0.5 m) and optional deep water grab sampling method (20 m or 1 m above bottom in thermally stratified lakes) are used for all lakes for each sampling event under the *Supplemental* program to monitor and assess epilimnetic and hypolimnetic conditions separately at

consistent discrete depths (similar to New York DEC Citizens Statewide Lake Assessment Program Sampling Protocol at https://www.dec.ny.gov/docs/water_pdf/cslapsampro.pdf). Chlorophyll-a water samples are filtered at a lakeside site and filters are to be kept frozen until program staff pick them up. Total Phosphorus samples are stored in glass test tubes and kept cool. Caffeine samples are stored in polypropylene test tubes and kept cool. Duplicate Caffeine, Chlorophyll-a and Total Phosphorus samples are collected during the LMP staff field visits with the monitors. LMP staff transport and log in samples bi-weekly to the Vermont Agriculture and Environmental Laboratory (VAEL) in Randolph Center, Vermont (<https://agriculture.vermont.gov/vermont-agriculture-and-environmental-laboratory-vael>).

(See LMP Sampling Protocol at [https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

Timeline

Table 1. Timeline

Date	Task
May – June	Monitor training
June – August	Sample collection
June – August	Monitor quality checks
October	All lab analyses completed and submitted to Project Manager
October – December	Data processing and upload into state and EPA databases
January – March	Reports and website updated

Element 7. Data Quality Objectives for Measurement Data

Quantitative QA Objectives

Lab QA Protocol

Table 2. QA Objectives for Precision, Accuracy, and Quantitation Limit

Parameter	Sample Matrix	Practical Quantitation Limit (PQL) ^a	Estimated Accuracy (%Recovery) ^b	Estimated Precision (RPD) ^c	Lab RPD
TP	water	5.0 ug/l	85-115%	14	20 ^d
Chlorophyll-a	water	0.5 ug/l	-	17	10
Caffeine	water	0.5 µg/L	70-130	20	20
Secchi Disk	water	n/a	n/a	2.5	n/a

^a PQL is the minimum reported value.

- b VAEI Quality Systems Manual (<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)
- c Estimated from average relative percent difference of Lay Monitor field duplicates.
- d RPD for phosphorus calculated from instrument duplicates.

Qualitative QA Objectives

Field QA Protocol

LMP staff will accompany each monitor on one normal sampling day and observe monitor technique for error. At this time the sampling procedure is replicated and duplicates are taken by the LMP staff. Due to LMP staff capacity, weather, boat problems or monitor scheduling needs, seldom, but occasionally, a trained monitor cannot be revisited on the lake as part of the annual check system. If this occurs, visiting these monitors will be prioritized for the following season.

A total of approximately 10% of the field samples will be replicated and have blanks tested to validate the accuracy of lay monitoring. Monitors are asked to collect six bi-weekly samples (not including the duplicates) from June through August to calculate a summer mean for the Vermont Lay Monitoring Program

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)).

Completeness: The bi-weekly sampling frequency allows for adequate characterization of the productivity conditions in each lake.

Comparability: The Vermont Department of Environmental Conservation Laboratory Quality Assurance Plan, including the standard operating procedures, is consistent with current EPA methods. Lake stations are the same ones sampled since 1979, or since the year when lay monitoring first started on a lake (<https://anrweb.vt.gov/DEC/IWIS/ReportSearch.aspx>).

Representativeness: Lake sampling stations #1 are selected to give a representative sample of the lake (<https://anrweb.vt.gov/DEC/IWIS/ReportSearch.aspx>).

Performance and System Audits

The LMP staff will inform monitors of any technique errors during quality assurance visits. Staff will review with and demonstrate to monitors the proper technique when necessary. Staff will read monitor comments on data sheets bi-weekly and monitor questions will be answered and assistance given when needed. Monitors will be encouraged to email or call staff with any problems they have with any aspect of the program.

Performance and system audits for laboratory analytical centers are detailed in the VAEI Quality Systems Manual (<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>) and are the joint responsibility of the Laboratory Director and the Laboratory QA/QC Officer.

Element 8. Training Requirements and Certification

The LMP Summer Assistant is trained in all aspects of the program by the Project Manager of the program. Typically, a new LMP Assistant will spend two weeks shadowing the Project Manager in all aspects of the program.

All Vermont lay monitors are trained in the sampling procedures on their lake by the LMP staff. During training all parts of the sampling procedure are explained in detail and demonstrated. The LMP staff and the monitor take turns performing each part of the sampling procedure. Sections which present difficulties for the monitors are repeated several times until they are comfortable sampling on their own. Monitors are encouraged to take notes on procedures while following the LMP Sampling Protocol ([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)). Trainings typically take two to four hours for monitors, depending on the size of their lake and the sampling program.

Element 9. Documentation and Records

Monitors are trained to use the LMP webform (<https://dec.vermont.gov/content/lay-monitoring-program-secchi-depth-water-sampling-form>) and equipment when sampling. Samples are properly stored until LMP staff picks them up once every two weeks for login at the lab ([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)). Annual Excel spreadsheets are created and saved to document trainings, field audits, and corrective actions.

Sample Custody Procedures

Samples will be collected from monitors by program staff and brought to the lab bi-weekly in labeled containers. LMP staff are responsible for logging the samples into the lab data management system where a unique identification number is assigned to each sample. Program staff then delivers the sample containers to the appropriate storage area in the lab. Individual analysts are responsible for retrieving samples from the storage areas for analysis. Samples will not be used for enforcement purposes. All data results are maintained in the VTDEC Watershed Management Division database (<https://anrweb.vt.gov/DEC/IWIS/>).

Element 10. Sampling Process Design

Sampling Site Distribution

Lake sampling stations are located to give a representative sample of the lake. Station #1 is located at the deepest point in the lake. It is the location from which all *basic* and *supplemental* samples are collected.

Element 11. Sampling Methods Requirements

Sampling methods are covered in Element 6 of this QA/QC plan and described in the VTDEC Lay Monitoring Program Sampling Protocol

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)) and VTDEC Field Methods Manual

(<https://dec.vermont.gov/sites/dec/files/documents/WSMD-Field-Methods-Manual-2022.pdf>).

Table 3. Sampling Method and Quantity Requirements

Location of Weekly Sampling	Sampling Method	Analysis Parameter	Sample Volume (ml)	Sample Container	Field Procedures
Lake Station #1 Surface Water (0.5 m)	Secchi Disk With View Tube/Scope	Transparency	-	-	observation
	Surface Water Bottle Grab	TP	50	Glass tube	none
		Chlorophyll-a	100	Filter paper (Glass Microfiber particular retention 1.6um)	filtration
		Caffeine	50	polypropylene	none
Lake Station #1 Deep Water (20 m or 1 m above bottom)	Deep Water Grab Sampler (LaMotte Horizontal Water Sampler)	TP	50	Glass tube	none
		Chlorophyll-a	100	Filter paper (Glass Microfiber particular retention 1.6um)	filtration
		Caffeine	50	polypropylene	none
			-		

Element 12. Sample Handle and Custody Requirements

Reference – Element 9 of this QA/QC Plan.

Element 13. Analytical Methods Requirements

Sample Analysis

Table. 4 Parameter Table

Parameter	Number of Samples ^a	Sample Matrix	DEC (SOP) Reference ^b	EPA Analytical Method	Sample Preservation	Holding Time
TP	800	water	1.6	4500-P F ^c	none	22 days
Chlorophyll-a	800	water	5.4	445	freeze, dark	21 days

				Revision 1.2 ^d		
Caffeine	800	water		VAEL SOP 4.21	Cool 4°C	28

^a Includes field QC samples from Program Staff.

^b VAEL Quality Systems Manual

(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

^c Standard Methods for the Examination of Water and Wastewater. 21st Edition. 2005

^d In Vitro Determination of Chlorophyll-a and Pheophytin-a in Marine and Freshwater Algae Fluorescence, 1997. National Exposure Research of Research and Development, USEPA.

Element 14. Quality Control Requirements

Laboratory Analytical Procedures

Reference – VAEL Quality Systems Manual

(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

Field Samples

Most Vermont Lakes, with the exception of Lake Champlain have a centrally located, deepwater station (station #1) (see Element 10 of this QA/QC Plan).

Monitors under the *Supplemental* program are required to collect water samples at station #1.

Collecting chlorophyll-a samples

A 100 ml portion of the sample bottle is filtered and analyzed for chlorophyll-a. Chlorophyll-a filter samples are collected in duplicate during the summer LMP staff QC visits (approximately 10% of all phosphorus samples).

Collecting phosphorus and caffeine samples

A 50 ml portion of the sample bottle, stored in a test tube, is analyzed for total phosphorus and caffeine. Total phosphorus and caffeine water samples are collected in duplicate and with blanks (deionized water) during the summer LMP staff QC visits (approximately 10% of all phosphorus samples).

Reference – VTDEC Lay Monitoring Program Sampling Protocol

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

Corrective Action

Upon joining the Lay Monitoring Program, all monitors will be referred to the Lay Monitoring Program website (<https://dec.vermont.gov/watershed/lakes-ponds/monitor/lay-monitoring>) and Sampling Protocol

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)). Monitors are required to follow the LMP sampling procedures in order to participate in the LMP program and are visited (checked) annually by program staff.

For laboratory use, corrective actions are defined in VAEL Quality Systems Manual

(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

Element 15. Instrument/Equipment Testing, Inspection and Maintenance Requirements

Laboratory Analysis QA/QC – Calibration Procedures, Analytical Procedures and Preventive Maintenance

Reference – VAEL Quality Systems Manual

(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

Field Sampling Equipment

The Vermont DEC supplies all the equipment except for a boat and anchor to the volunteer monitors. New filter papers and glass test tubes are provided at the start of each sampling season. Before any equipment is supplied to a volunteer, it is carefully checked by LMP staff. Secchi disk lines are measured and marked off in meters. All Nalgene 500 ml sample bottles, water samplers, hand filtering apparatuses, and graduated cylinders are thoroughly rinsed before being given to monitors. The 50 ml glass test tubes are disposable and provided clean and new from the VTDEC Laboratory. All equipment is checked during the annual LMP staff field visits with monitors. The monitors who plan to return to the program for the next season are instructed to store the equipment properly during the winter months.

Reference – VTDEC Lay Monitoring Program Sampling Protocol

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

Reference – VTDEC Field Methods Manual (<https://dec.vermont.gov/sites/dec/files/documents/WSMD-Field-Methods-Manual-2022.pdf>)

Element 16. Instrument Calibration and Frequency

Reference – Element 15 of this QA/QC Plan.

Element 17. Inspection and Acceptance Requirements for Supplies

All monitoring supplies used are either the exact same make as equipment used in past years or are comparable replacement products. Annual records of all equipment purchased and used by the LMP are kept to ensure consistency in selecting new sampling equipment.

Reference – Element 15 of this QA/QC Plan and the Vermont Lay Monitoring Program Manual, 2000.

Element 18. Data Acquisition Requirements

Monitors are trained how to locate their sampling stations using Google maps during their training session with the LMP staff

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf)).

Element 19. Data Management

All data results are maintained in the VTDEC Watershed Management Division database

(<https://anrweb.vt.gov/DEC/IWIS/>).

Reference – Element 9 of this QA/QC Plan.

Element 20. Assessments and Response Actions

Reference – Element 7 and Element 14 of this QA/QC Plan.

Element 21. Reports

Data for each lake will be summarized and compiled into an annual online report for distribution to volunteer monitors, state agencies, and organizations and individuals interested in Vermont water quality. This annual report is the responsibility of Mark Mitchell, Project Manager.

New discrete surface and deep water grab sampling data will be analyzed and assessed for trends separately from the historical depth-integrated hose sampling data, as will Secchi depth with and without using a view tube/scope. However, new trends in surface (epilimnetic) and deep water (hypolimnetic) conditions can be calculated after only five years and compared to the old hose (depth-integrated) trends. For reference to a similar VTDEC monitoring and assessment methodology, the Lake Champlain Long-Term Monitoring Protocol also separates sampling and reporting of the epilimnion and hypolimnion as follows: “During stratified conditions, two samples will be obtained, representing the epilimnion and hypolimnion, respectively” (<https://dec.vermont.gov/watershed/lakes-ponds/lake-champlain>).

Element 22. Data Review, Validation and Verification Requirements

Data Reduction

Reference – VAEL Quality Systems Manual
(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

Element 23. Validation and Verification Methods

The validation of laboratory data is the primary responsibility of the Lab Director in conjunction with the Lab QA/QC Officer utilizing methods documented in the VAEL Quality Systems Manual (<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>).

At the program level, the Project Manager validates the data according to the following process: Secchi disk readings, chlorophyll-a, total phosphorus and caffeine concentrations from each lake are reviewed and compared to previous years' data. If any samples seem unusually high or low, then the monitor webforms (<https://dec.vermont.gov/content/lay-monitoring-program-secchi-depth-water-sampling-form>) are checked for that day's sampling comments (monitors might be emailed or called as well) and the Laboratory Staff are consulted about possible errors. Sample results that have potentially been contaminated are not validated and therefore not uploaded to state and EPA databases. Duplicate samples collected by LMP staff during QC visits are validated if RPD is no more than 30% using the following equation:

RPD of Monitor and LMP Staff Duplicate Samples:

$$RPD = \frac{(C^1 - C^2) \times 100\%}{(C^1 + C^2)/2}$$

RPD = relative percent difference
C1 = larger of the two observed values
C2 = smaller of the two observed values

If RPD is greater than 30%, the following guidance applies:

- If the lake is eutrophic or if algal blooms were present, both values may be kept.
- If both values are questionable, then both values are tossed.
- If only one value is questionable, that value will be tossed and the other used.

Element 24. Reconciliation with Data Quality Objectives

The LMP is a cooperative effort between the Vermont DEC and lake users to collect essential baseline water quality data on Vermont lakes. Monitors are asked to collect six samples during June, July and August – the number the program uses to calculate summer means. If less than six samples are collected during the summer months, no annual mean should be calculated for that year and the data should be used to describe only date-specific water quality conditions, and not for long term trend analysis of annual means. Monitors on over 100 lakes in Vermont have participated in the LMP and have contributed substantially to the understanding of water quality conditions and trends in Vermont lakes.

Reference – Element 14 of this QA/QC Plan.

Reference – VTDEC Lay Monitoring Program Sampling Protocol

([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

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Standard Methods for the Examination of Water and Wastewater. 21st Edition. 2005 (EPA Analytical Method, 4500-PF 445 Revision 1.2)

In Vitro Determination of Chlorophyll-a and Pheophytin-a in Marine and Freshwater Algae Fluorescence, 1997. National Exposure Research of Research and Development, USEPA.

Environmental Protection Agency. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans

Vermont Agriculture and Environmental Laboratory Quality Systems Manual 2021
(<https://agriculture.vermont.gov/sites/agriculture/files/documents/VAEL/QA-001.26%20VAEL%20QSM%20Uncontrolled.pdf>)

Vermont Department of Environmental Conservation Field Methods Manual 2022
(<https://dec.vermont.gov/sites/dec/files/documents/WSMD-Field-Methods-Manual-2022.pdf>)

Vermont Department of Environmental Conservation Lay Monitoring Program Protocol 2023
([https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20\(Final\).pdf](https://dec.vermont.gov/sites/dec/files/wsm/lakes/LMP/2023%20VT%20Lay%20Monitoring%20Program%20Protocol%20(Final).pdf))

