

# 2022 Shadow Lake Water Quality Monitoring Results: Lay Monitoring Program and LaRosa Partnership Program

Mark Mitchell, Lake Monitoring and Community Outreach Coordinator  
VT Department of Environmental Conservation, UVM Lake Champlain Sea Grant



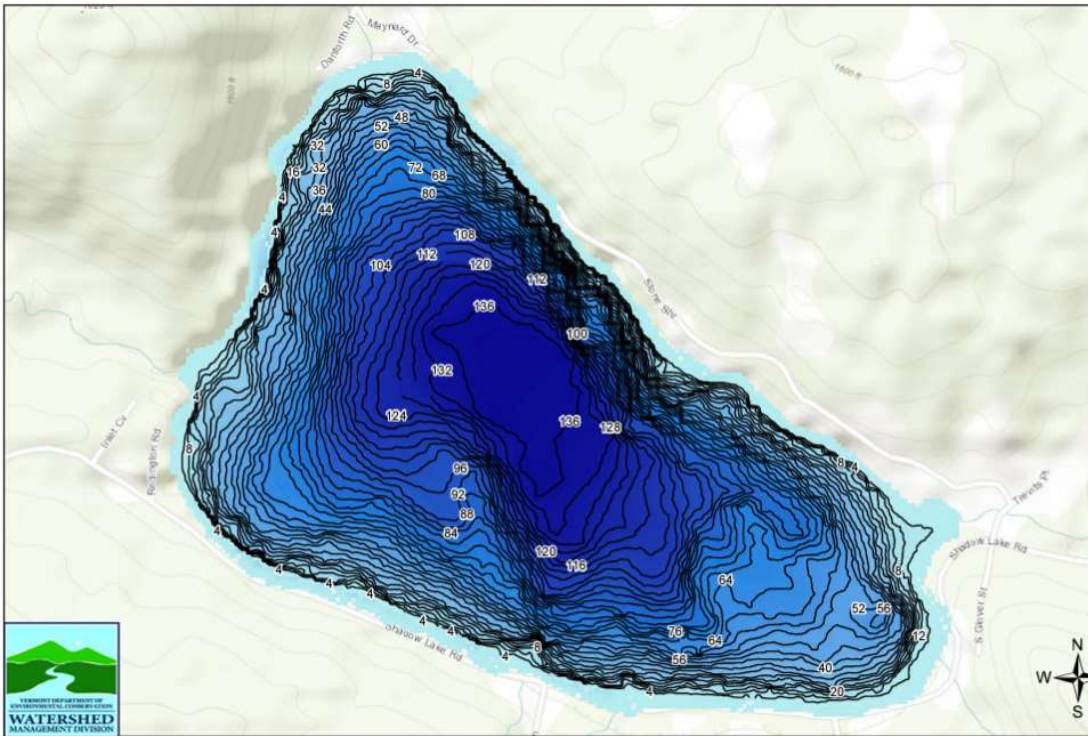


# Lay Monitoring Program (LMP) Lake Sampling Overview

- Weekly from Memorial Day to Labor Day (minimum of 8 samples for summer mean):
  - *Basic Sampling*: Measure Secchi disk transparency depth (clarity)
  - *Supplemental Sampling*: Collect water samples with hose at twice Secchi depth that are lab tested for total phosphorus (nutrient) concentration and chlorophyll-a (algae) concentration
  - Complete a lake sampling webform (and report cyanobacteria conditions)

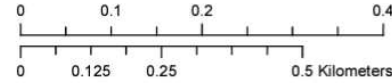


### Shadow Lake, Barton VT Depth Map



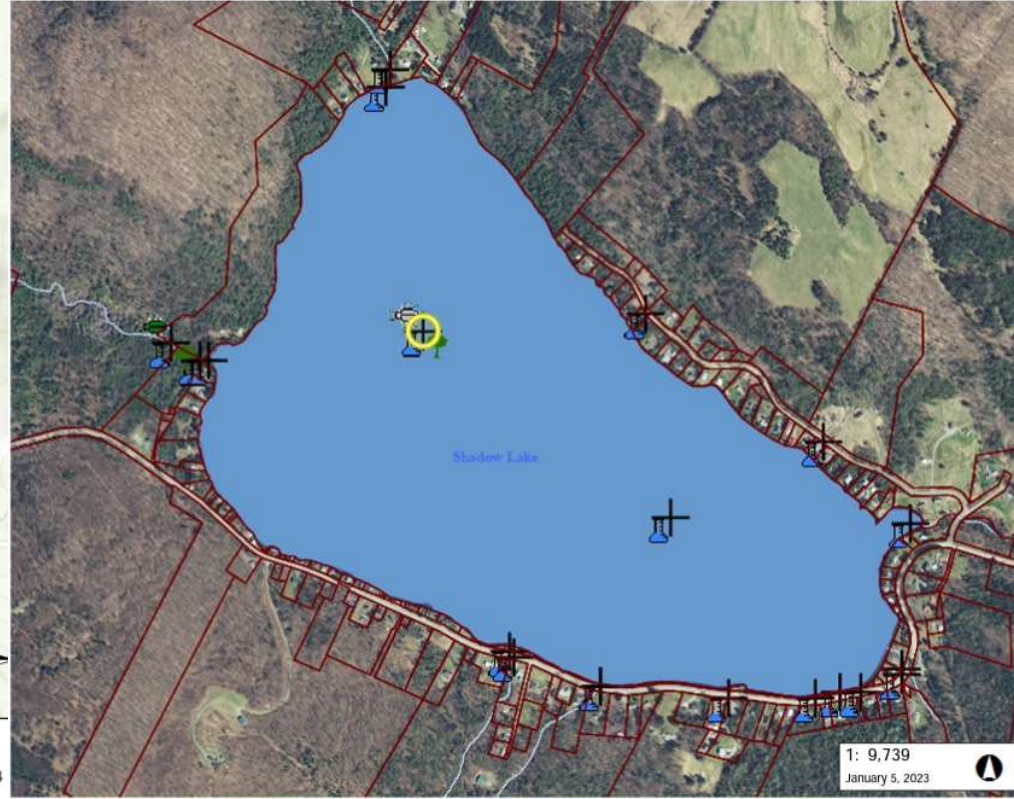
**Legend**  
**Shadow Lake Depth (Feet)**  
**Value**  
 High : -0.213579  
 Low : -139.284

Scale : 1:8,000  
 Map Created : 6/10/2019  
 Source Data Collected : 8/3/2018  
 Map Author : Tim Cassese



### Shadow Lake (Glover) Monitoring Station #1 Vermont Agency of Natural Resources

vermont.gov



1: 9,739  
 January 5, 2023

495.0 0 248.00 495.0 Meters  
 WGS\_1984\_Web\_Mercator\_Auxiliary\_Sphere 1" = 812 FT 1cm = 97 Meters  
 © Vermont Agency of Natural Resources THIS MAP IS NOT TO BE USED FOR NAVIGATION

**DISCLAIMER:** This map is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. ANR and the State of Vermont make no representations of any kind, including but not limited to, the warranties of merchantability, or fitness for a particular use, nor are any such warranties to be implied with respect to the data on this map.

# Vermont Lake Score Card

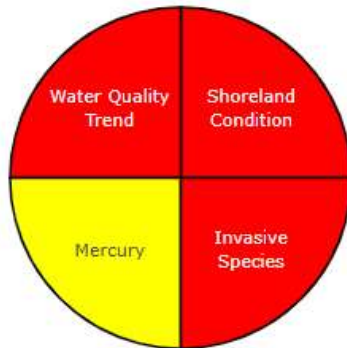
## Shadow Lake

<https://dec.vermont.gov/watershed/lakes-ponds/data-maps/scorecard>

Scores

Water Quality Data

Lake Information



Watershed: **Moderately Disturbed**

WQ Standards: Altered

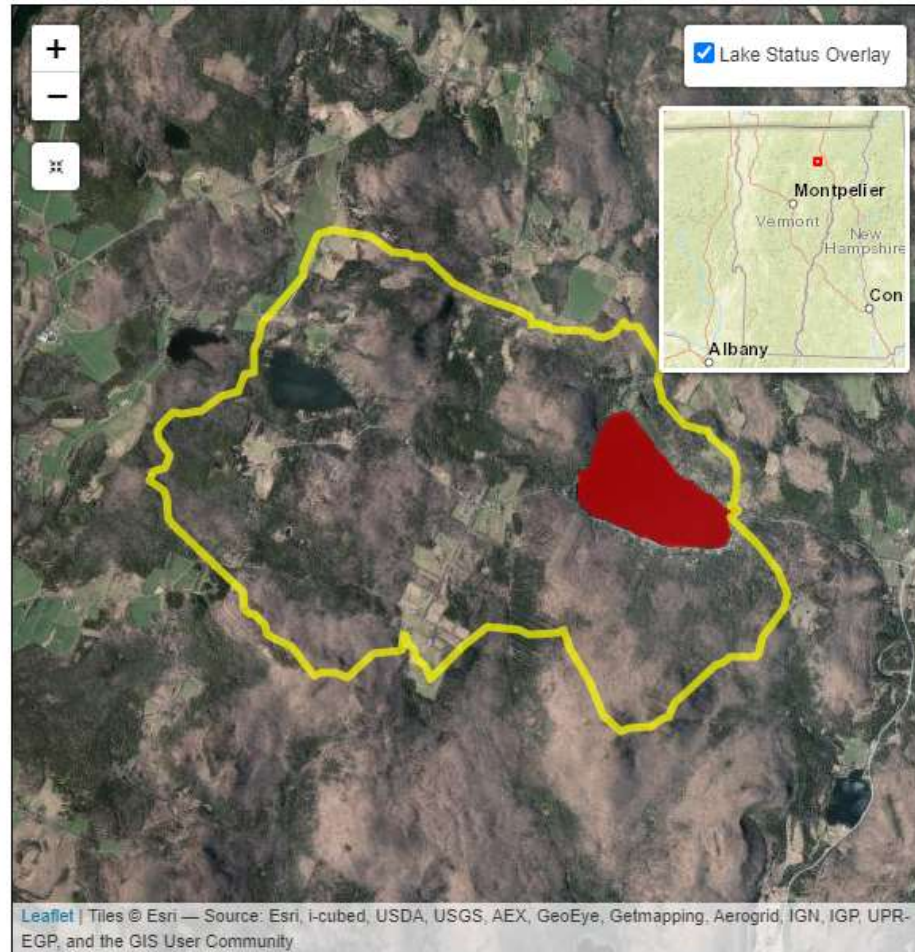
Details

Altered – Flow alteration

Color Scoring System

- Good Conditions
- Fair Conditions
- Poor Conditions
- Insufficient Data

[Learn How Lakes Are Scored](#)



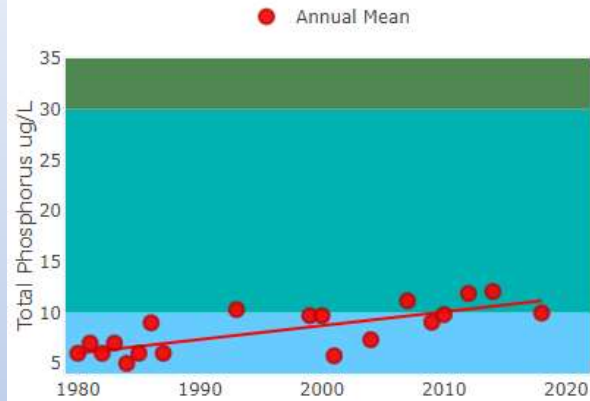
■ Hypereutrophic ■ Eutrophic ■ Mesotrophic ■ Oligotrophic

Click on "Daily Mean" or "Annual Mean" to toggle on or off the data layer.

## SHADOW LAKE (GLOVER) SCORE CARD WATER QUALITY ANNUAL MEANS

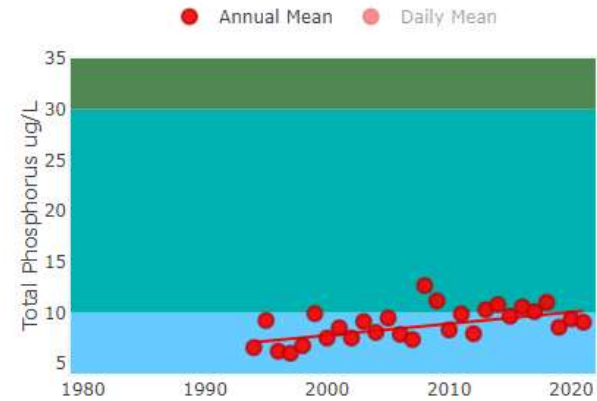
Spring Phosphorus

Trend: Highly Significantly Increasing (p-value=0.0014)



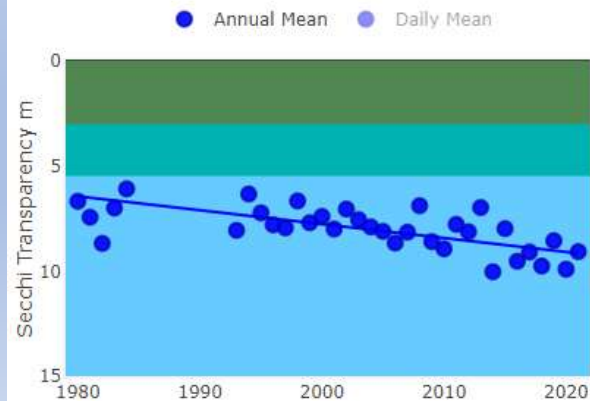
Summer Phosphorus

Trend: Highly Significantly Increasing (p-value=0.0032)



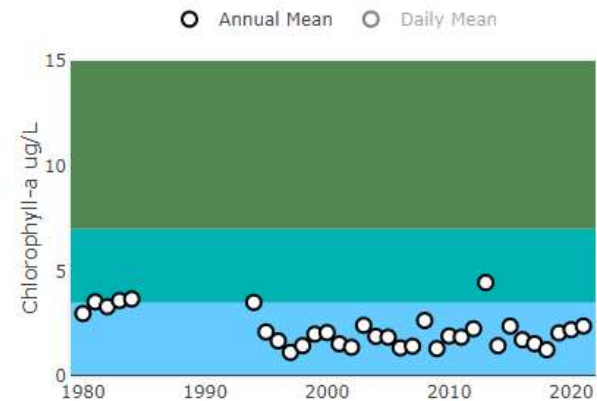
Summer Secchi

Trend: Highly Significantly Increasing (p-value=0)



Summer Chlorophyll-a

Trend: Stable (p-value=0.1289)



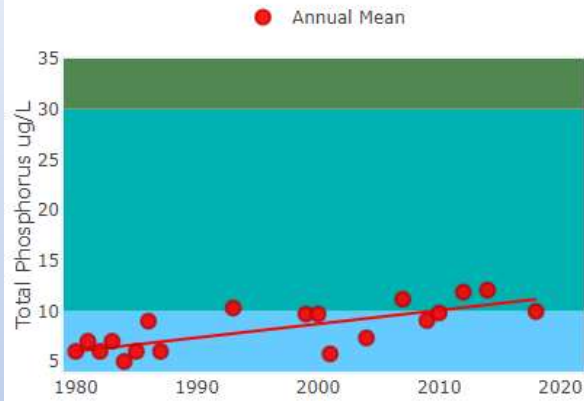
■ Hypereutrophic ■ Eutrophic ■ Mesotrophic ■ Oligotrophic

Click on "Daily Mean" or "Annual Mean" to toggle on or off the data layer.

## SHADOW LAKE (GLOVER) SCORE CARD WATER QUALITY ANNUAL RANGE

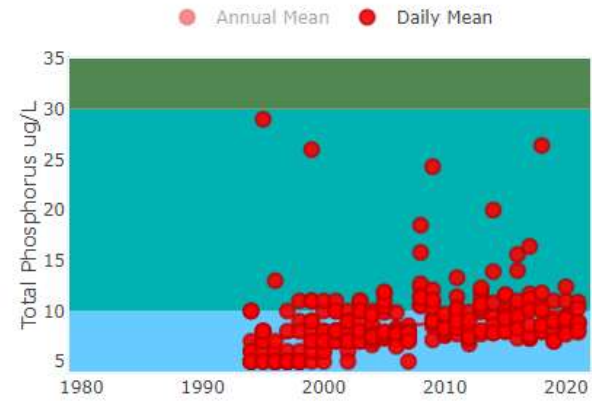
### Spring Phosphorus

Trend: Highly Significantly Increasing (p-value=0.0014)



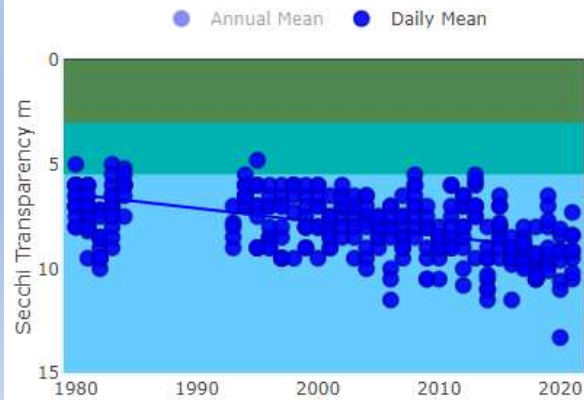
### Summer Phosphorus

Trend: Highly Significantly Increasing (p-value=0.0032)



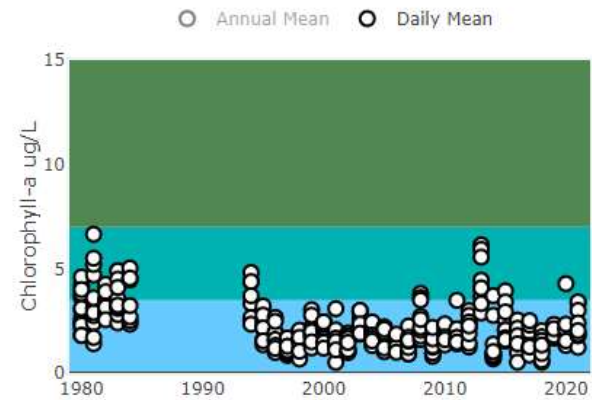
### Summer Secchi

Trend: Highly Significantly Increasing (p-value=0)

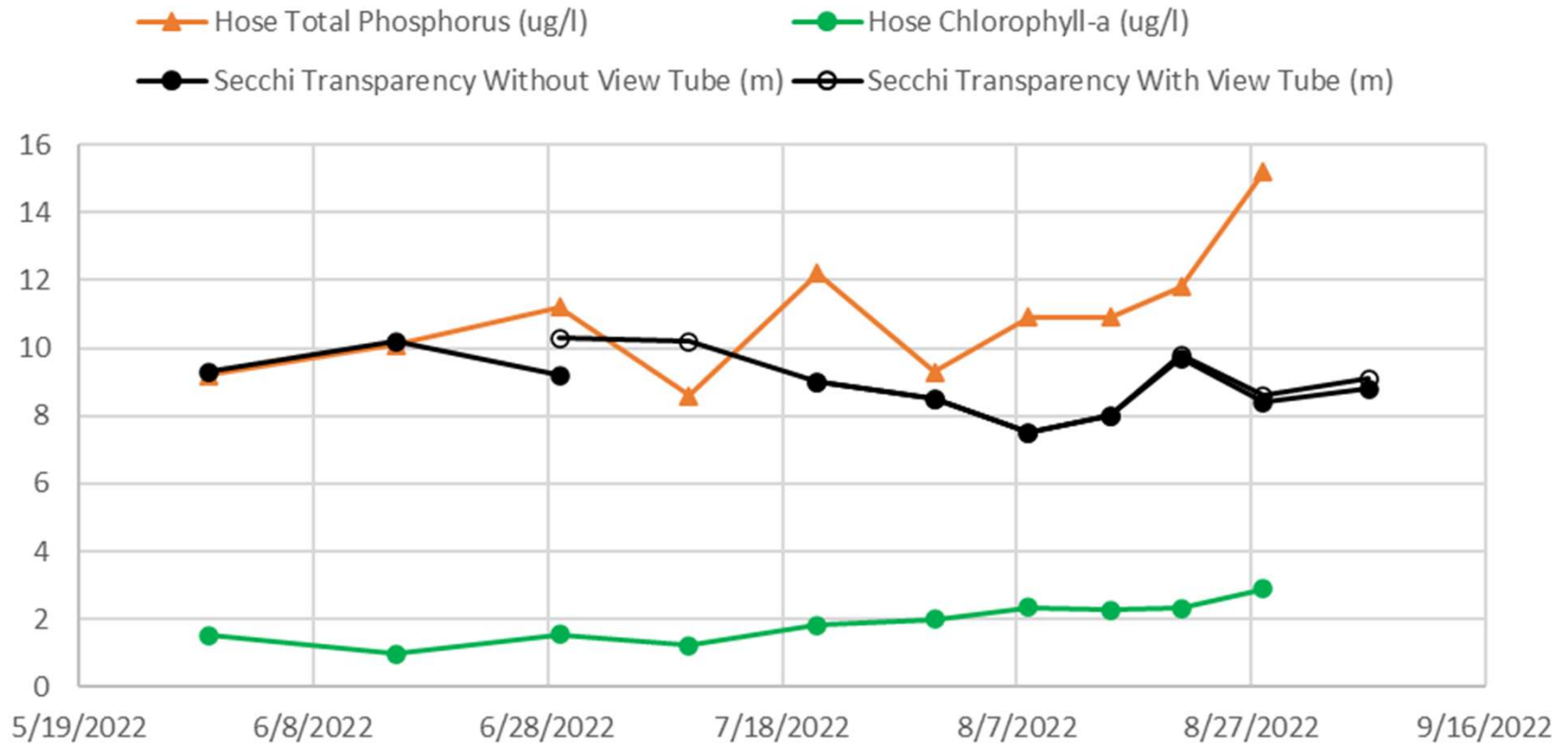


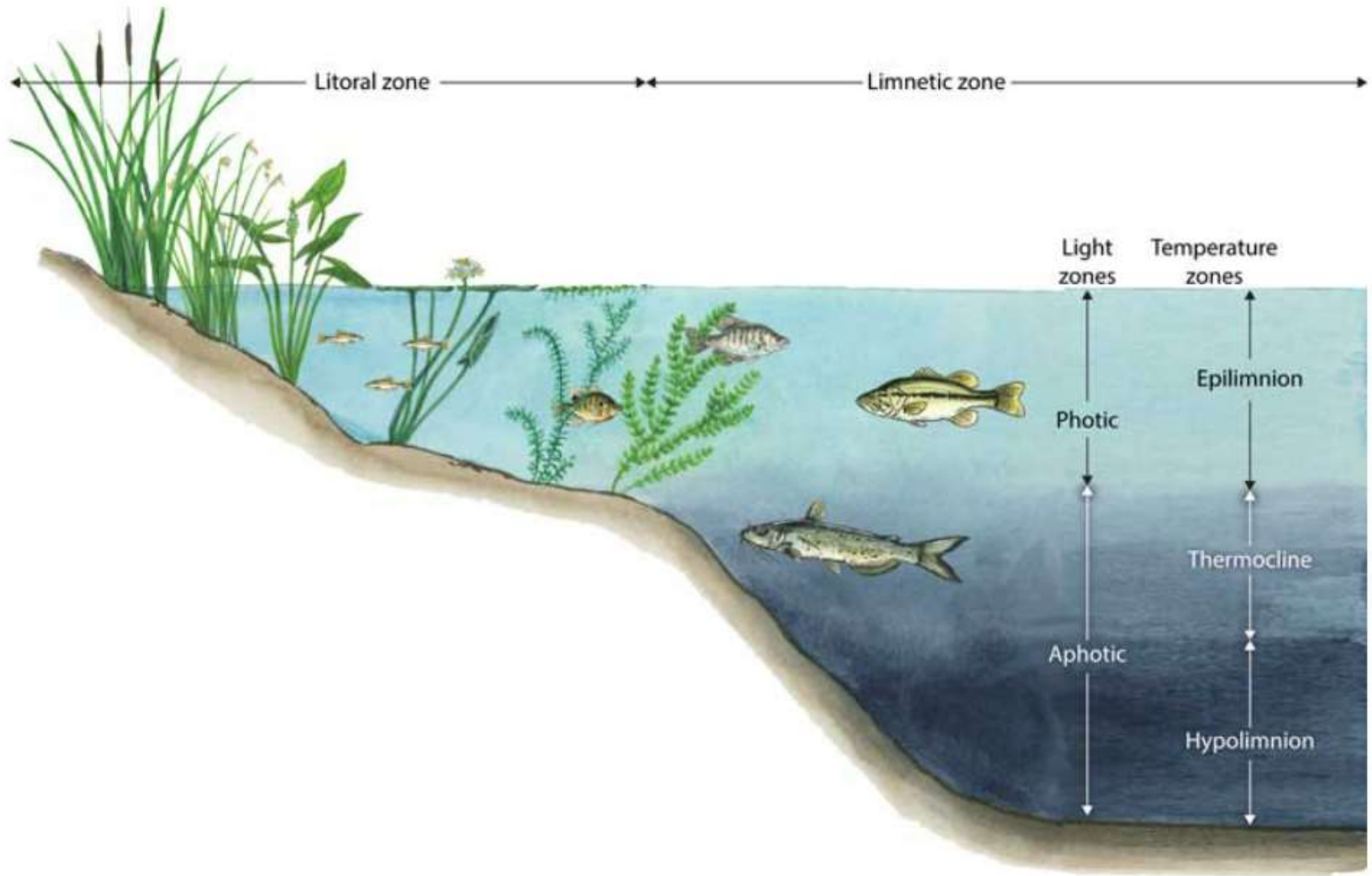
### Summer Chlorophyll-a

Trend: Stable (p-value=0.1289)



## 2022 Shadow Lake Lay Monitoring Results





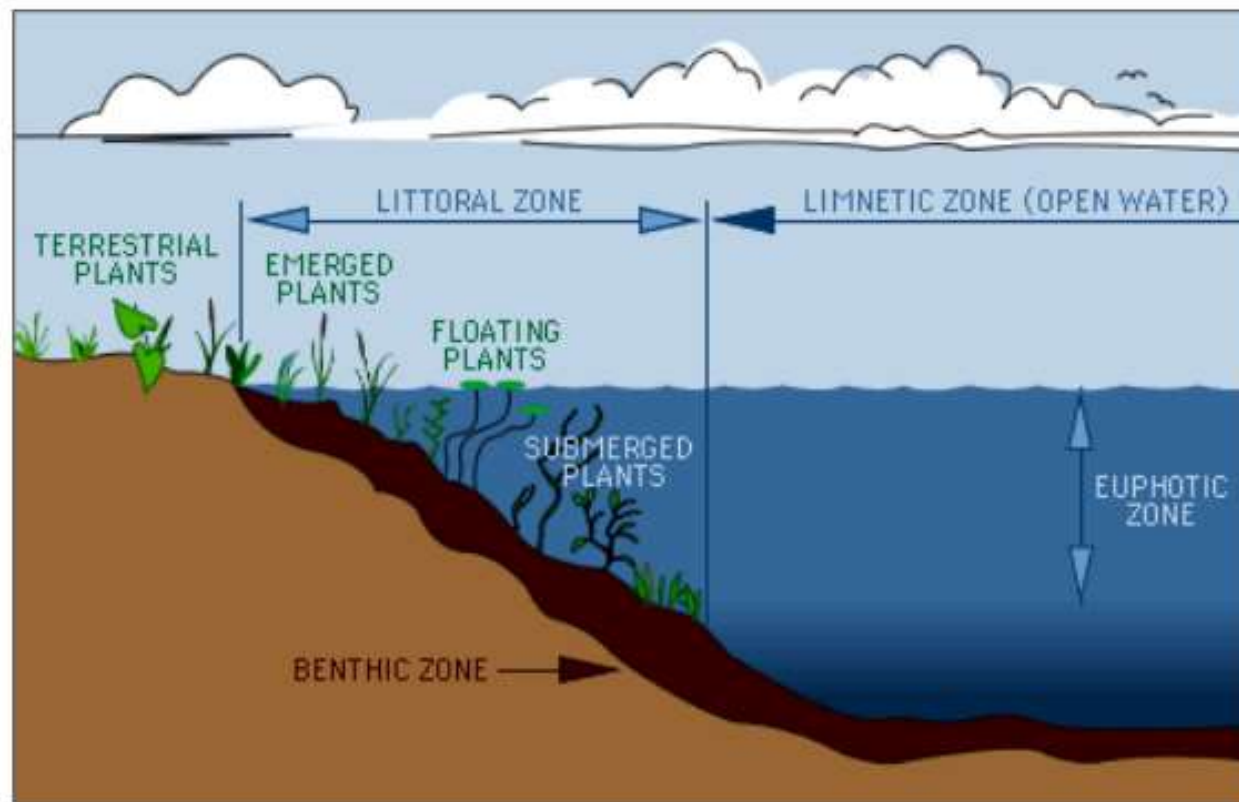
(Image courtesy of Kasco Marine)

<https://kascomarine.com/blog/pond-lake-zone-identification/>



## Lake Zones

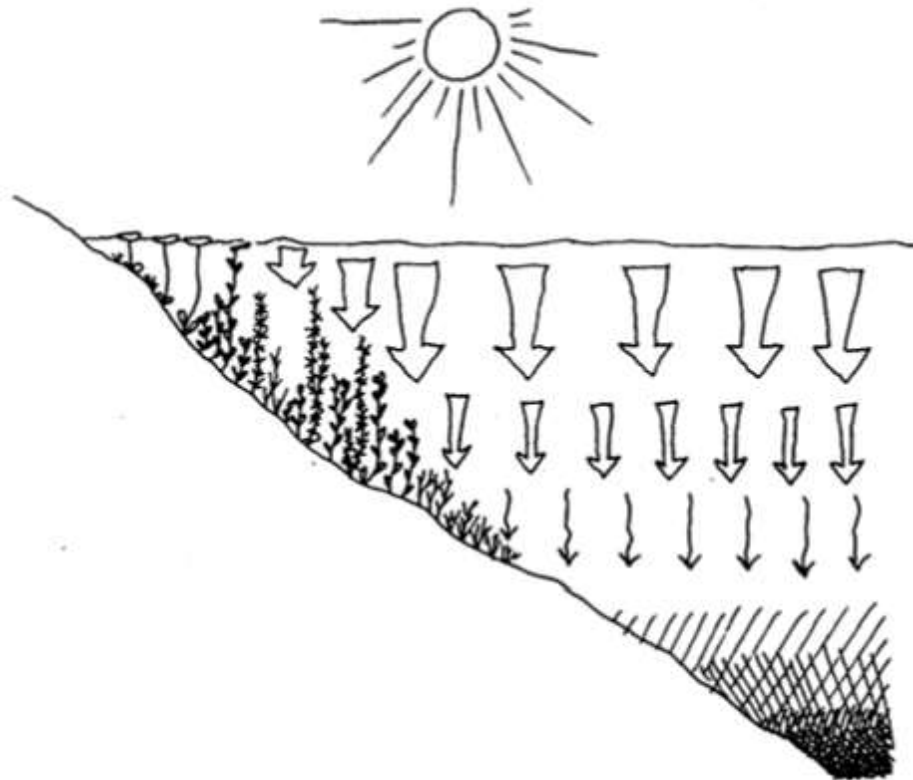
A typical lake has distinct zones of biological communities linked to the physical structure of the lake (Figure 10). The **littoral** zone is the near shore area where sunlight penetrates all the way to the sediment and allows aquatic plants (**macrophytes**) to grow. Light levels of about 1% or less of surface values usually define this depth. The 1% light level also defines the **euphotic zone** of the lake, which is the layer from the surface down to the depth where light levels become too low for **photosynthesizers**. In most lakes, the sunlit euphotic zone occurs within the **epilimnion**.



[http://waterontheweb.org/under/lakeecology/10\\_biological\\_lakezones.html](http://waterontheweb.org/under/lakeecology/10_biological_lakezones.html)

#### 4. *Light*

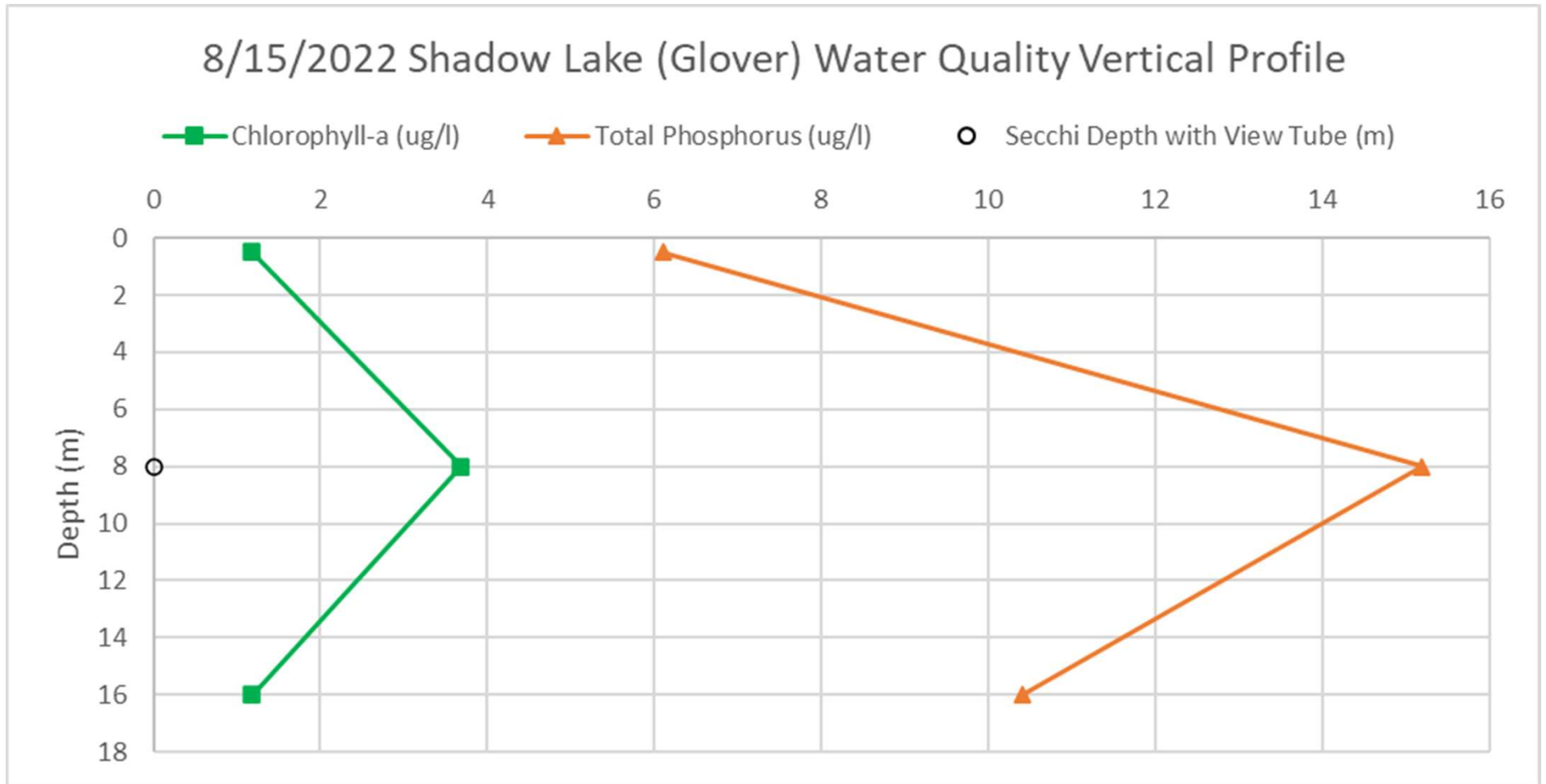
Plants need light to grow. Many lakes have deep water areas where rooted plants can't get enough light to survive. The maximum depth at which plants grow in a lake depends on the water clarity. In Vermont lakes, plants can generally be found growing out to water depths of **25 feet**.



**From Lake Champlain Long-Term Monitoring Protocol:**

During stratified conditions, two samples will be obtained, representing the epilimnion and hypolimnion, respectively.

<https://dec.vermont.gov/sites/dec/files/wsm/docs/20200605%20LTM%205yr%20QAPP-Workplan.pdf>



Sampling Date	Hose Sample Depth (m)	Hose Total Phosphorus (ug/l)	Hose Chlorophyll-a (ug/l)	Secchi Transparency Without View Tube (m)	Secchi Transparency With View Tube (m)
5/30/2022	18.6	9.2	1.52	9.3	
6/15/2022	20.4	10.1	0.98	10.2	
6/29/2022	20.6	11.2	1.55	9.2	10.3
7/10/2022	20.4	8.6	1.22		10.2
7/21/2022	18	12.2	1.81	9	9
7/31/2022	17	9.3	2	8.5	8.5
8/8/2022	15	10.9	2.34	7.5	7.5
8/15/2022	16	10.9	2.27	8	8
8/21/2022	20	11.8	2.32	9.7	9.8
8/28/2022	17	15.2	2.88	8.4	8.6
9/6/2022				8.8	9.1
<b>Mean</b>	<b>18.3</b>	<b>10.9</b>	<b>1.89</b>	<b>9.3</b>	<b>9</b>
<b>A1 Criteria</b>	<b>Euphotic Zone</b>	<b>12</b>	<b>2.6</b>	<b>5</b>	<b>5</b>

## SHADOW LAKE

### Annual Data (Station 1)

Year	Days Sampled	Secchi (m)	Secchi View Tube (m)	Chloro-a (µg/l)	Summer TP (µg/l)	Spring TP (µg/l)
1979	17	7.3		4.5		4.0
1980	14	6.7		3.0		6.0
1981	13	7.4		3.5		7.0
1982	13	8.7		3.3		6.0
1983	13	7.0		3.6		7.0
1984	9	6.1		3.7		5.0
1985						6.0
1986						9.0
1987						6.0
1993	5					10.3
1994	9	6.3		3.5	6.3	
1995	10	7.2		2.1	9.0	
1996	10	7.8		1.7	6.1	
1997	9	7.9		1.1	6.0	
1998	8	6.7		1.4	6.6	
1999	10	7.7		2.0	9.9	9.7
2000	10	7.4		2.1	7.5	9.7
<i>VT Standard*</i>		2.6		7.0	18.0	

\* VT Water Quality Standards Nutrient Criteria for Class B2 Lakes > 20 acres.

### Annual Data (Station 1)

Year	Days Sampled	Secchi (m)	Secchi View Tube (m)	Chloro-a (µg/l)	Summer TP (µg/l)	Spring TP (µg/l)
2001	10	8.0		1.5	8.5	5.7
2002	10	7.1		1.4	7.5	
2003	9	7.6		2.4	9.1	
2004	10	7.9		1.9	8.1	7.3
2005	9	8.1		1.9	9.5	
2006	9	8.7		1.3	7.9	
2007	10	8.2		1.4	7.4	11.2
2008	9	6.9		2.6	12.7	
2009	10	8.6		1.3	11.2	9.1
2010	9	8.9		1.9	8.3	10.1
2011	10	7.8		1.9	9.9	
2012	10	8.1		2.3	7.9	11.9
2013	9	7.0		4.5	10.3	
2014	9	10.0		1.4	10.8	12.1
2015	10	8.0		2.4	9.6	
2016	9	9.5		1.7	10.6	
2017	10	9.1		1.5	10.1	
2018	10	9.8		1.3	11.0	9.5
2019	9	8.6		2.1	8.6	
2020	8	9.9		2.2	9.4	
2021	8	9.1		2.4	9.1	
<i>VT Standard*</i>		2.6		7.0	18.0	

\* VT Water Quality Standards Nutrient Criteria for Class B2 Lakes > 20 acres.



## LaRosa Partnership Program Tributary Sampling Overview

- Tributaries first sampled in 2021  
~biweekly (8X) from April/May to August + ~2 storm events
- Baseline total phosphorus and total nitrogen concentrations
- 522768-Trib 1 Town
- Beach522761-Burke Culvert
- 522769-Trib 2 Cermak
- 522766-Trib 3 Dudley
- 522770-Trib 4 Inlet
- 522767-Trib 5 Lussier

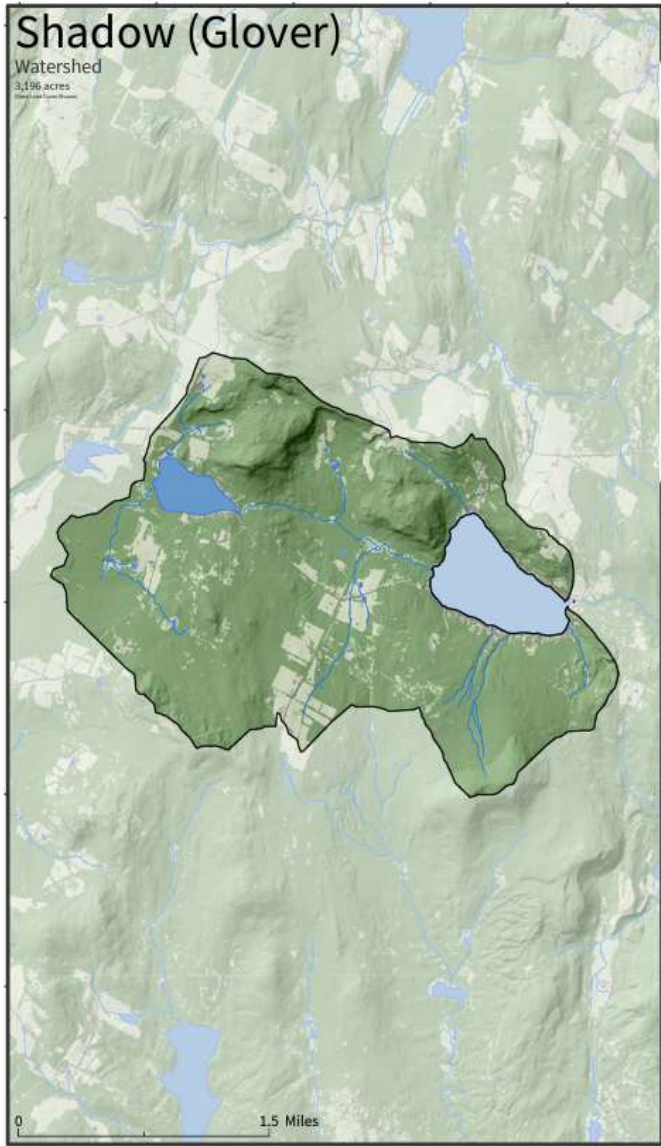
# LPP Sample Parameters Overview

## Total Phosphorus

- *Impacts*
  - Feeds plants, algae and cyanobacteria
  - Aquatic Biota, Aesthetics, Recreation Uses
- *Human Sources*
  - Runoff from roads, lawns, agriculture, logging
  - Malfunctioning septic systems
- *Vermont Water Quality Standards Nutrient Criteria for Aquatic Biota Use (+ Biological Criteria)*
  - Not to be exceeded at low median monthly flow (baseflow) during June through October
  - 12 ug/L for small high gradient streams (SHG)
  - 15 ug/L for medium high gradient streams (MHG)
  - 27 ug/L for warm-water medium gradient streams and rivers (WWMG)

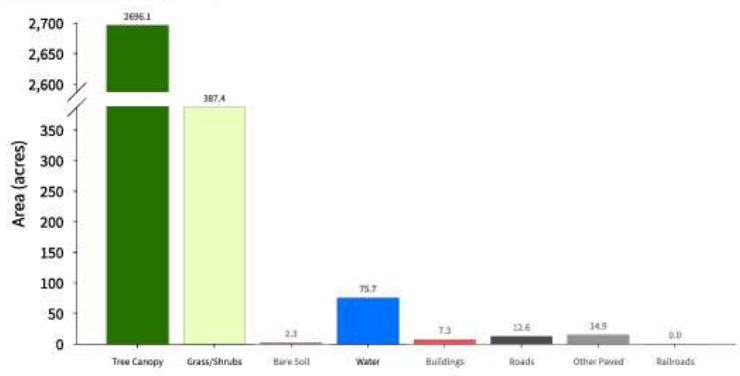
## Total Nitrogen

- *Impacts*
  - Feeds plants, algae and cyanobacteria
  - Aquatic Biota, Aesthetics, Recreation Uses
- *Human Sources*
  - Runoff from roads, lawns, agriculture, logging
  - Malfunctioning septic systems
- *Vermont Water Quality Standards*
  - Not to exceed 5.0 mg/l as NO<sub>3</sub>-N at flows exceeding low median monthly flows, in Class B(1) and B(2) waters.
  - Not to exceed 2.0 mg/l as NO<sub>3</sub>-N at flows exceeding low median monthly flows, in Class A(1) and A(2) waters at or below 2,500 feet elev.



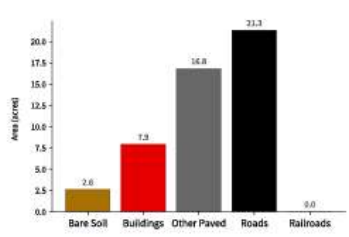
## High-Resolution Land Cover Summary

### Base Land Cover (Top-Down\*)

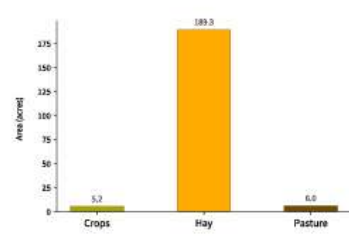


### Supplemental Land Cover

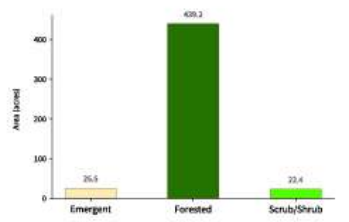
#### Impervious Surfaces (48.64 acres - 1.5 % of total) (Bottom-Up\*\*)



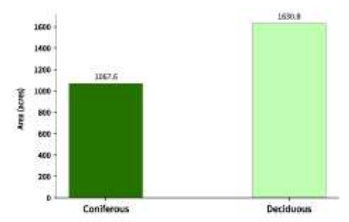
#### Agriculture (200.6 acres - 6.3 % of total)



#### Wetlands (487.09 acres - 15.2 % of total)

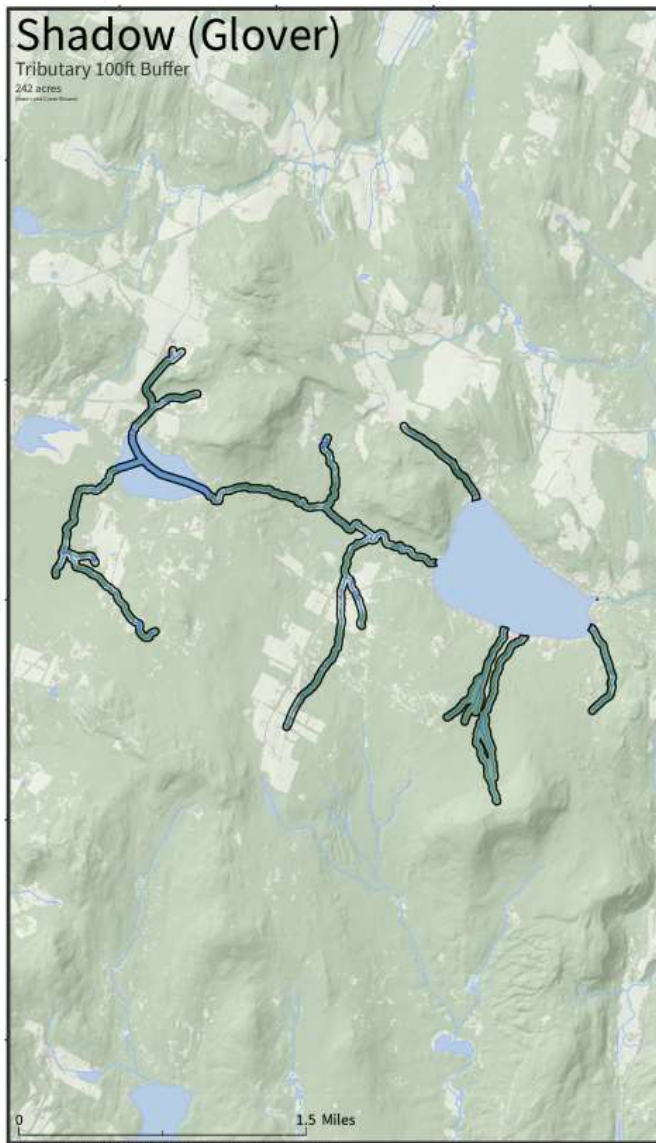


#### Tree Canopy (2,698.34 acres - 84.4 % of total)



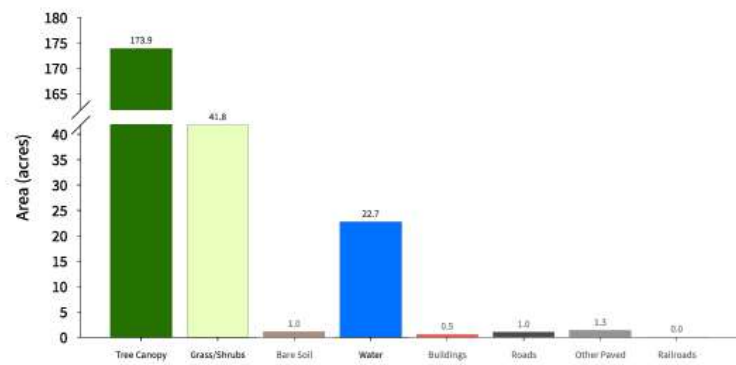
\*Top-Down: A traditional land cover mapping approach. Land cover is mapped at the regional level first. \*\*Bottom-Up: A more detailed mapping approach. Land cover is mapped at the local level first. This approach results in improved accuracy of land cover maps compared to the traditional top-down approach. Source: USGS, High-Resolution Land Cover (2014) Report for more details.





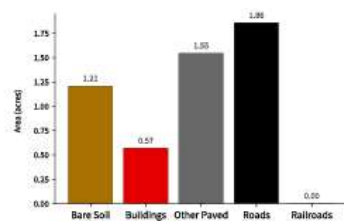
## High-Resolution Land Cover Summary

### Base Land Cover (Top-Down\*)

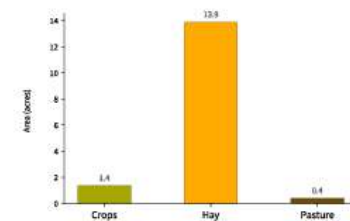


### Supplemental Land Cover

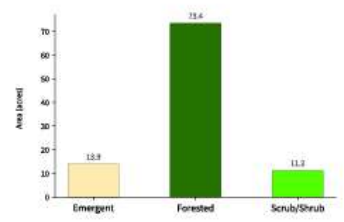
#### Impervious Surfaces (5.18 acres - 2.1% of total) (Bottom-Up\*\*)



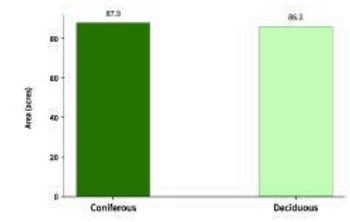
#### Agriculture (15.62 acres - 6.5% of total)



#### Wetlands (98.52 acres - 40.7% of total)

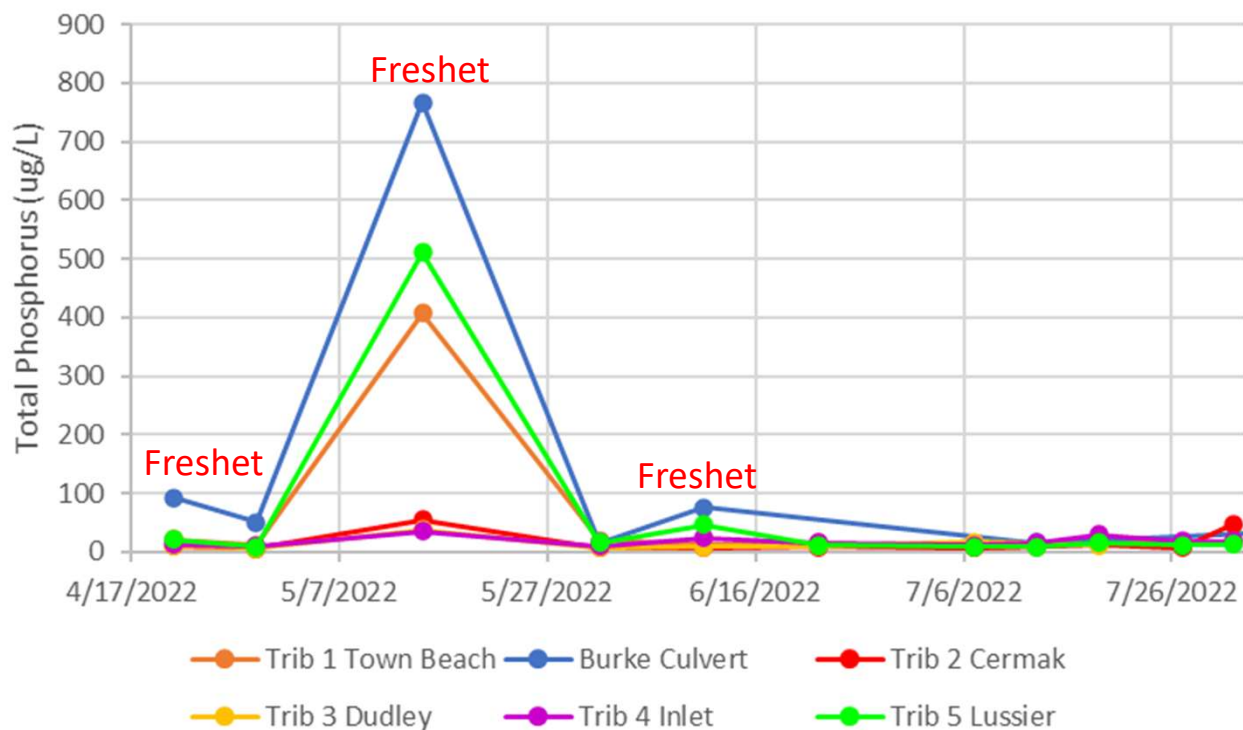


#### Tree Canopy (174.13 acres - 72% of total)



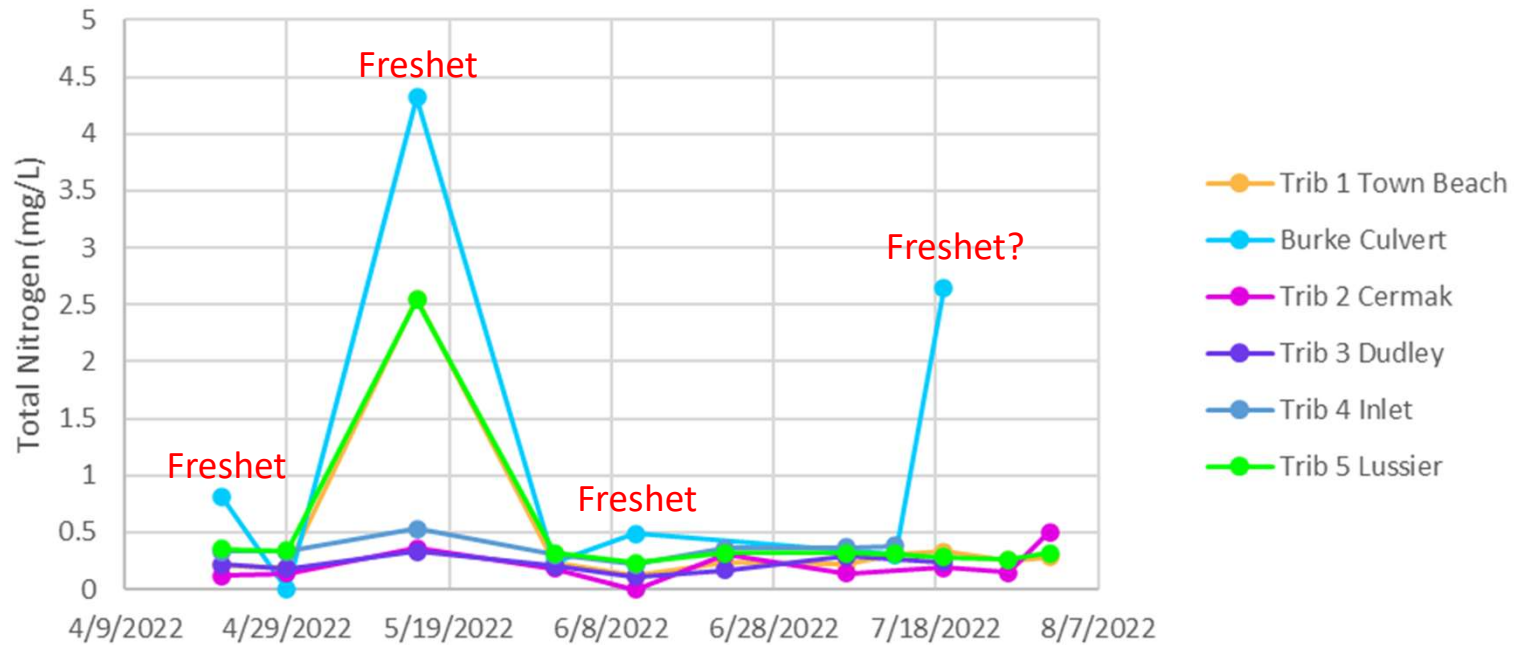
\*Top-Down: A traditional land cover mapping approach. Land cover is assigned to the appropriate land cover class.  
 \*\*Bottom-Up: A more detailed land cover mapping approach. Land cover is assigned to the most detailed land cover class. This approach results in improved mapping of land cover types (dictated by the Bottom-Up data).  
 Data: USGS, High-Resolution Land Cover 2016, Revised by user/analyst.

## 2022 Shadow Lake Tributary Total Phosphorus



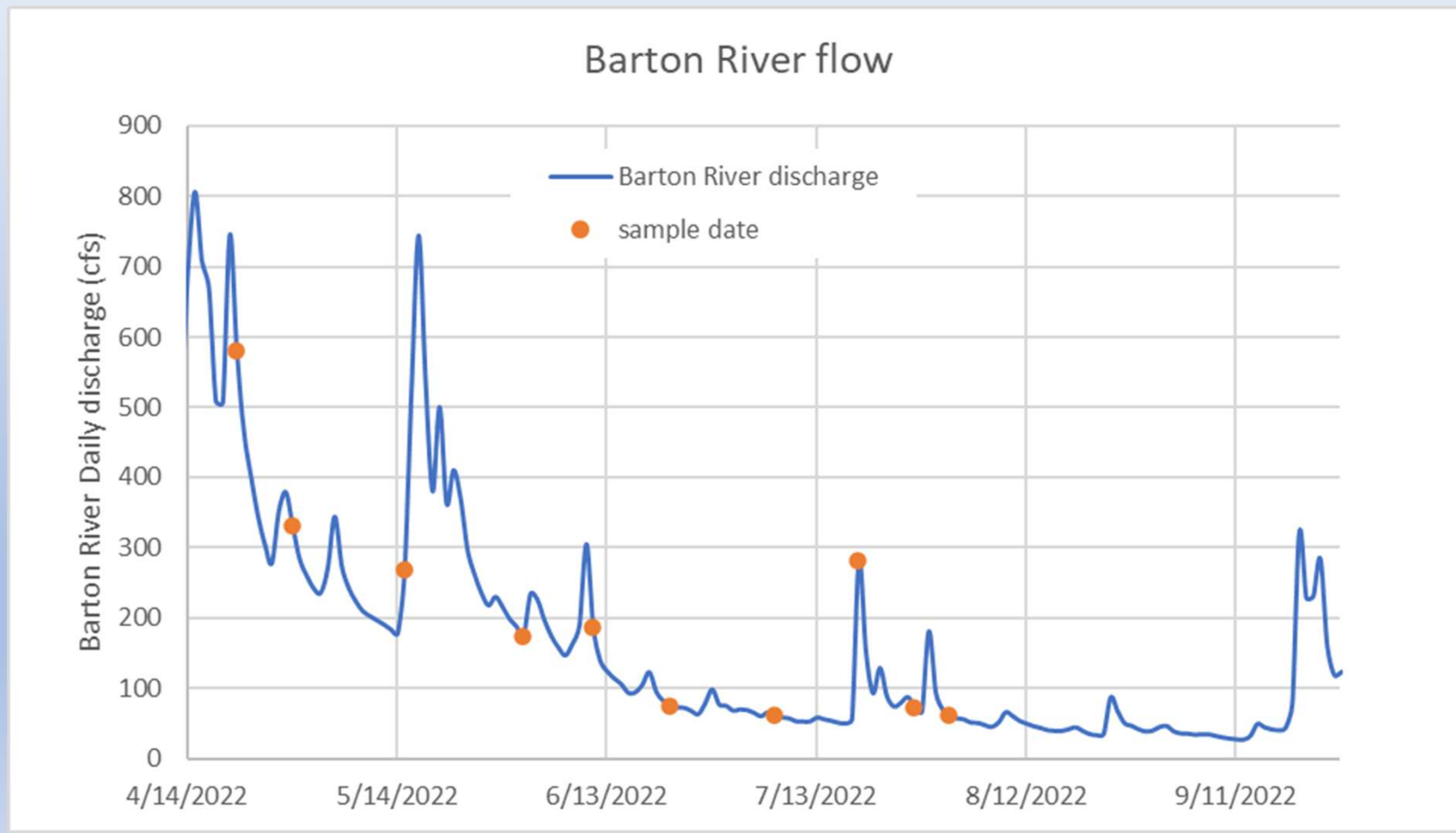
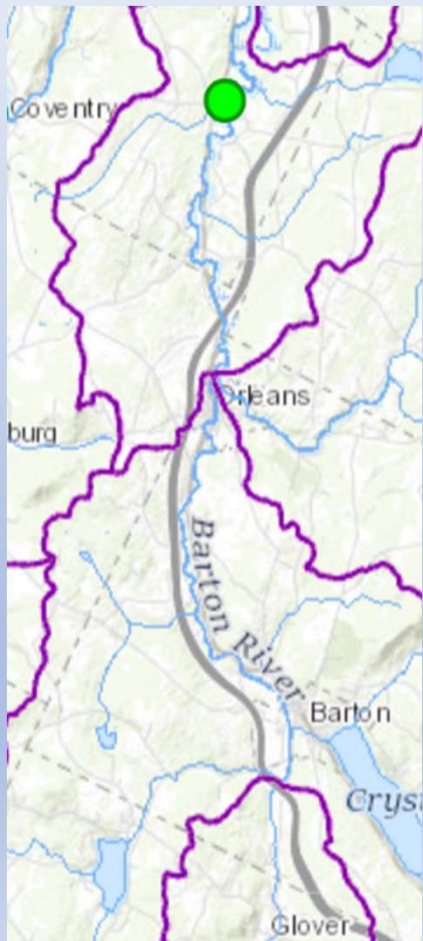
Tributary	Minimum TP (ug/l)		Base/Low Flow Avg. TP (ug/l)		Average TP (ug/l)		Maximum TP (ug/l)	
	2022	2021	2022	2021	2022	2021	2022	2021
Trib 1 Town Beach	7.6	7.6	13.4	11.4	50	23.4	407	78.4
Burke Culvert	15	15.2	41.7	45.4	138.7	54.7	767	111
Trib 2 Cermak	5.6	5.7	12.8	12.7	16.7	12.2	55.2	36.5
Trib 3 Dudley	6.2	5.4	9.9	6.7	13.3	6.9	37.2	9.2
Trib 4 Inlet	9.3	8.7	16.8	12.3	18.04	12.9	34.6	17.7
Trib 5 Lussier	8.2	7.2	15.2	8.5	60.71	8.7	510	10

## 2022 Shadow Lake Tributary Total Nitrogen



Tributary	Minimum TN (mg/L)		Average TN (mg/L)		Maximum TN (mg/L)	
	2022	2021	2022	2021	2022	2021
Trib 1 Town Beach	0.12	0.14	0.45	0.32	2.55	0.67
Burke Culvert	0.24	0.4	1.5	1.9	4.32	5.85
Trib 2 Cermak	0.12	0.1	0.23	0.17	0.5	0.27
Trib 3 Dudley	0.11	0.13	0.22	0.17	0.33	0.27
Trib 4 Inlet	0.22	0.29	0.36	0.32	0.53	0.37
Trib 5 Lussier	0.23	0.21	0.51	0.27	2.54	0.36

# USGS Streamflow – Barton River, Coventry



# 2022 Monitoring Summary & 2023 Next Steps

- Lay Monitoring Program (LMP)
  - 2022 Summary: Hose samples have higher total phosphorus concentrations than surface samples, but surface samples better reflect Secchi depth for class A1 lake
  - 2023 Next Steps: LMP volunteer collects biweekly surface samples and optional deep-water (20 m) samples; LMP staff collects vertical profile data during annual visit; add caffeine testing as human wastewater indicator (i.e. septic systems)
- LaRosa Partnership Program (LPP)
  - 2022 Summary: Highest TP/TN in Burke Culvert, Trib 1 Town Beach, Trib 5 Lussier
  - 2023 Next Steps: LPP volunteers continue collecting biweekly samples through August at all sites with a focus on Burke Culvert, Trib 1 Town Beach, Trib 5 Lussier

