Status of Vermont's Inland Lakes: Phosphorus Trends and Protection

Kellie Merrell, Oliver Pierson

Clean Water Lecture Series

3 June 2021

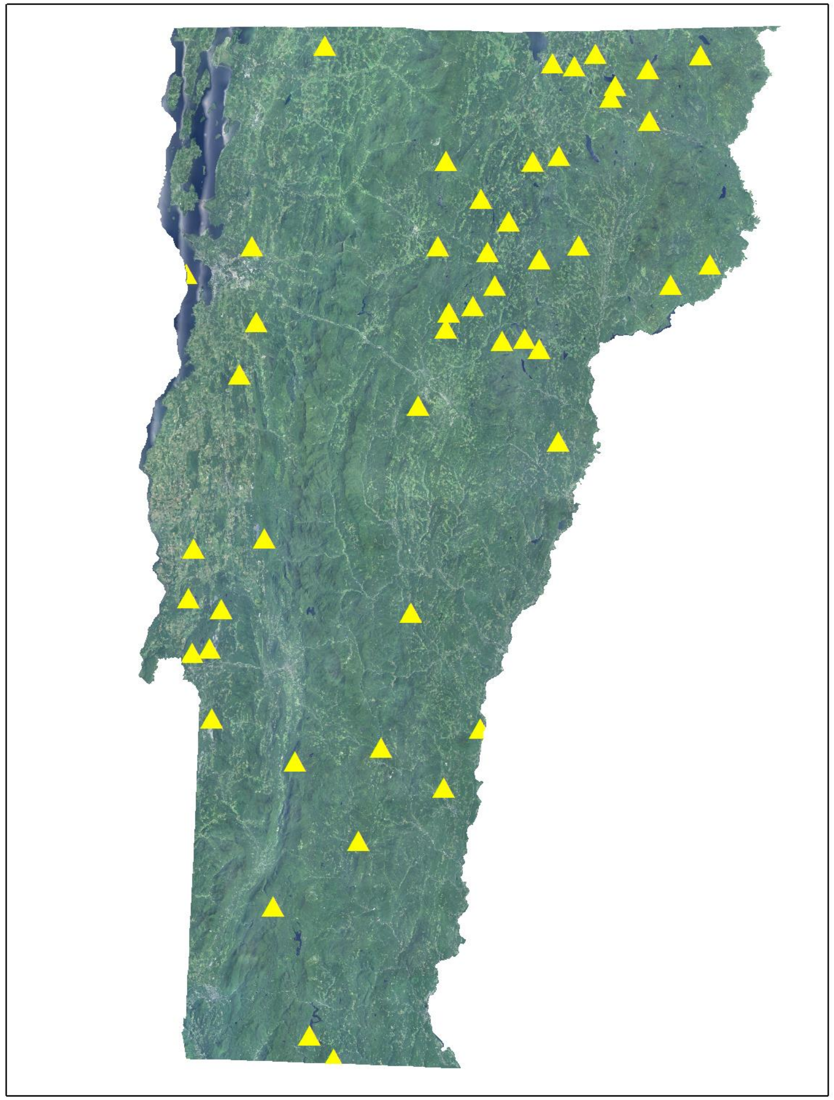
Virtual

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
LAKES & PONDS PROGRAM

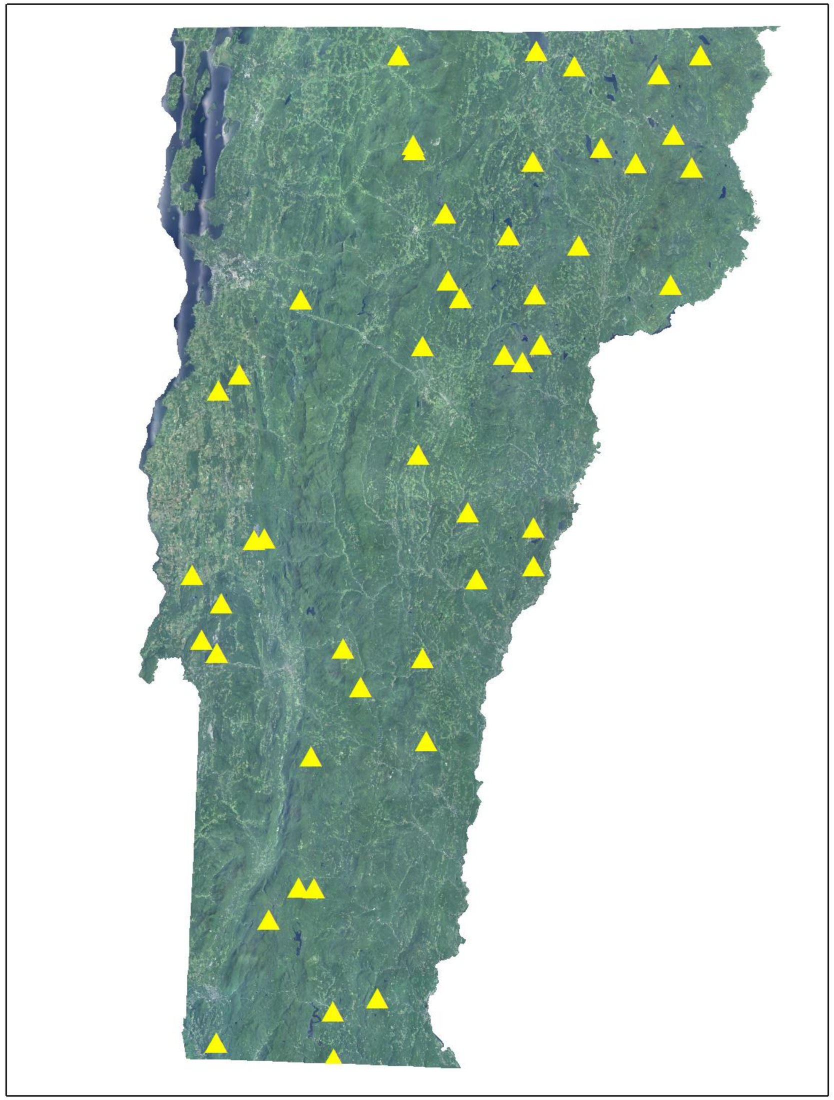
National Lake Assessment

(NLA)

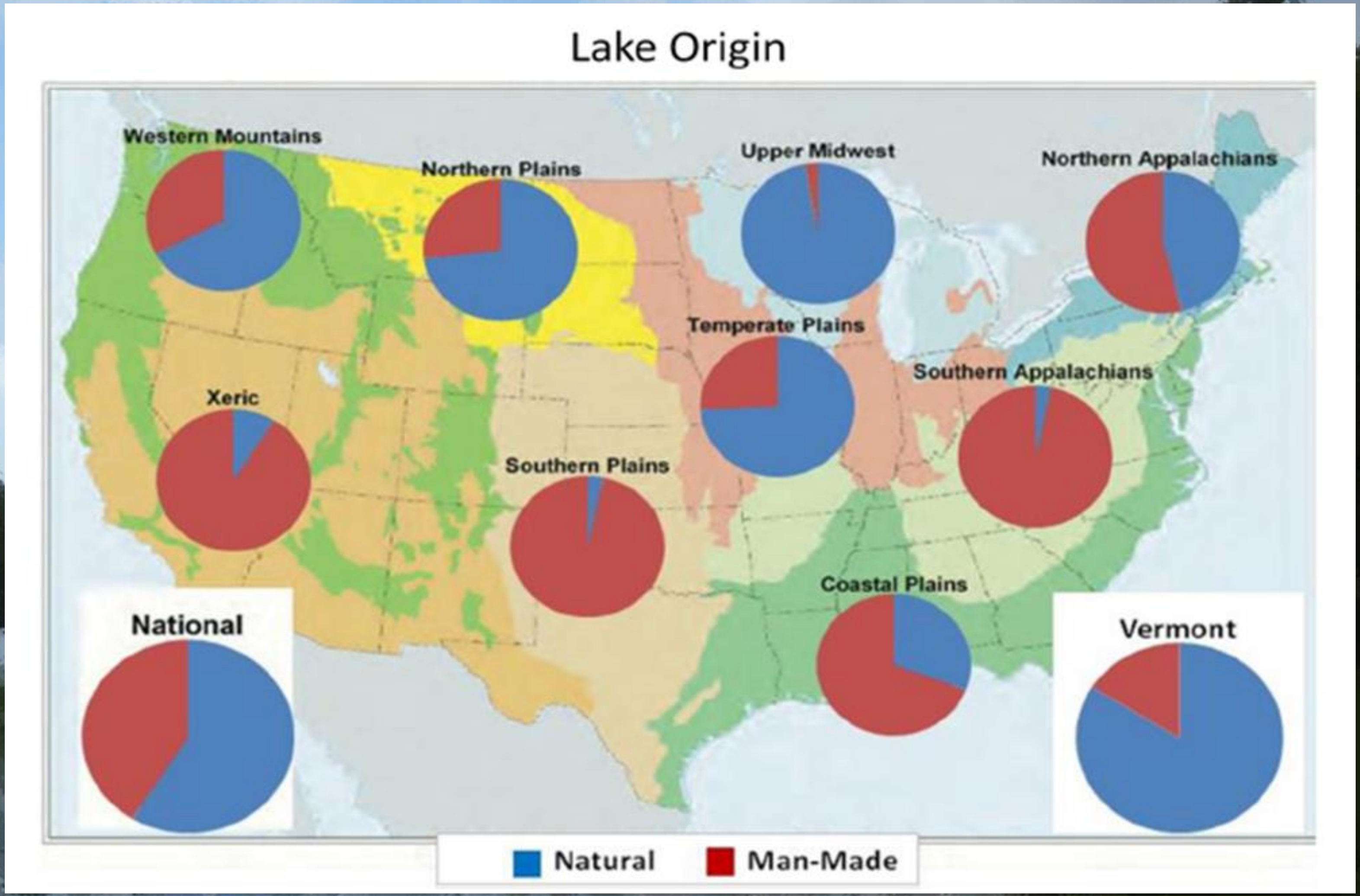
2007/2008



2012

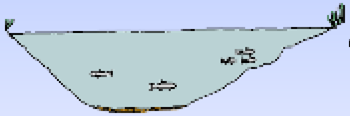


Vermont has a higher proportion of natural lakes than the nation and 8 other ecoregions



Vermont is Stewarding a Higher Proportion of Oligotrophic Lakes than the Nation, 2007 NLA

Oligotrophic Lakes



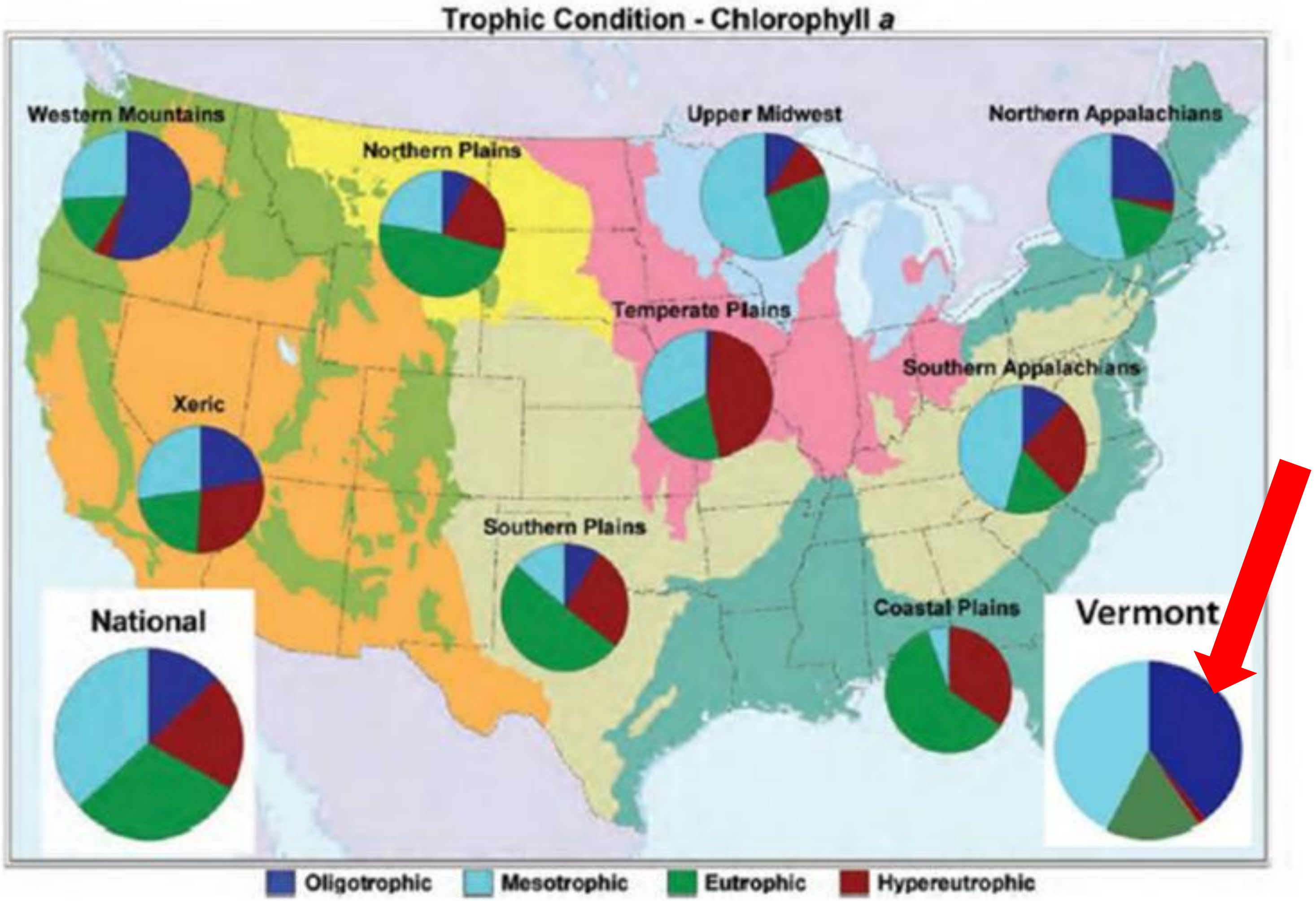
- Low nutrient enrichment = very little plant and algae growth
- Clear water
- Supports coldwater fish species

Mesotrophic Lakes

- Moderate nutrient enrichment = some plant and algae growth
- Moderate water clarity
- Supports mostly warmwater fish species

Eutrophic Lakes

- High nutrient enrichment = abundant plant and algae growth
- Reduced water clarity
- Only supports warmwater fish species



Vermont is Stewarding a High Proportion of Lakes in Good Condition for Phosphorus, 2007 NLA

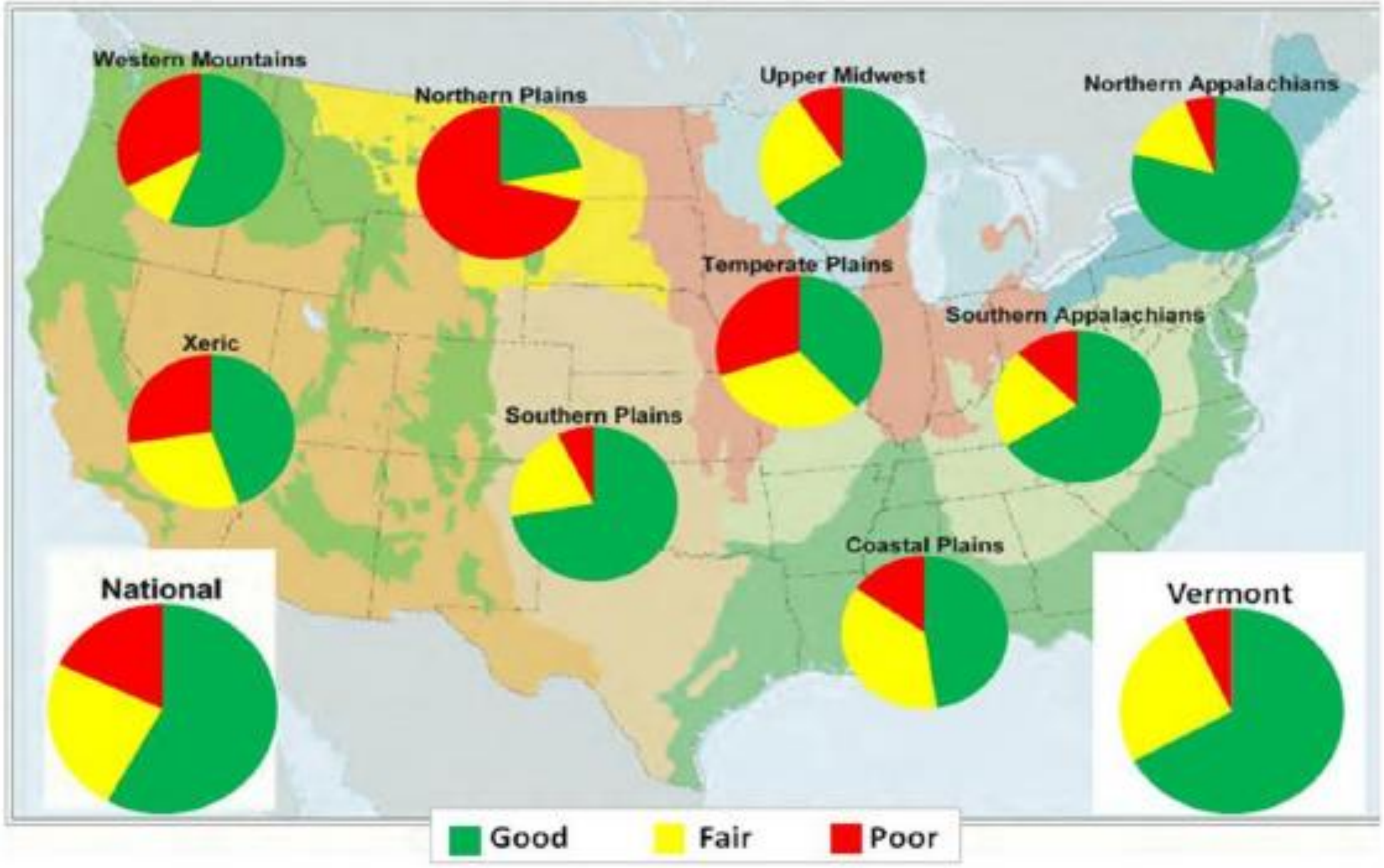
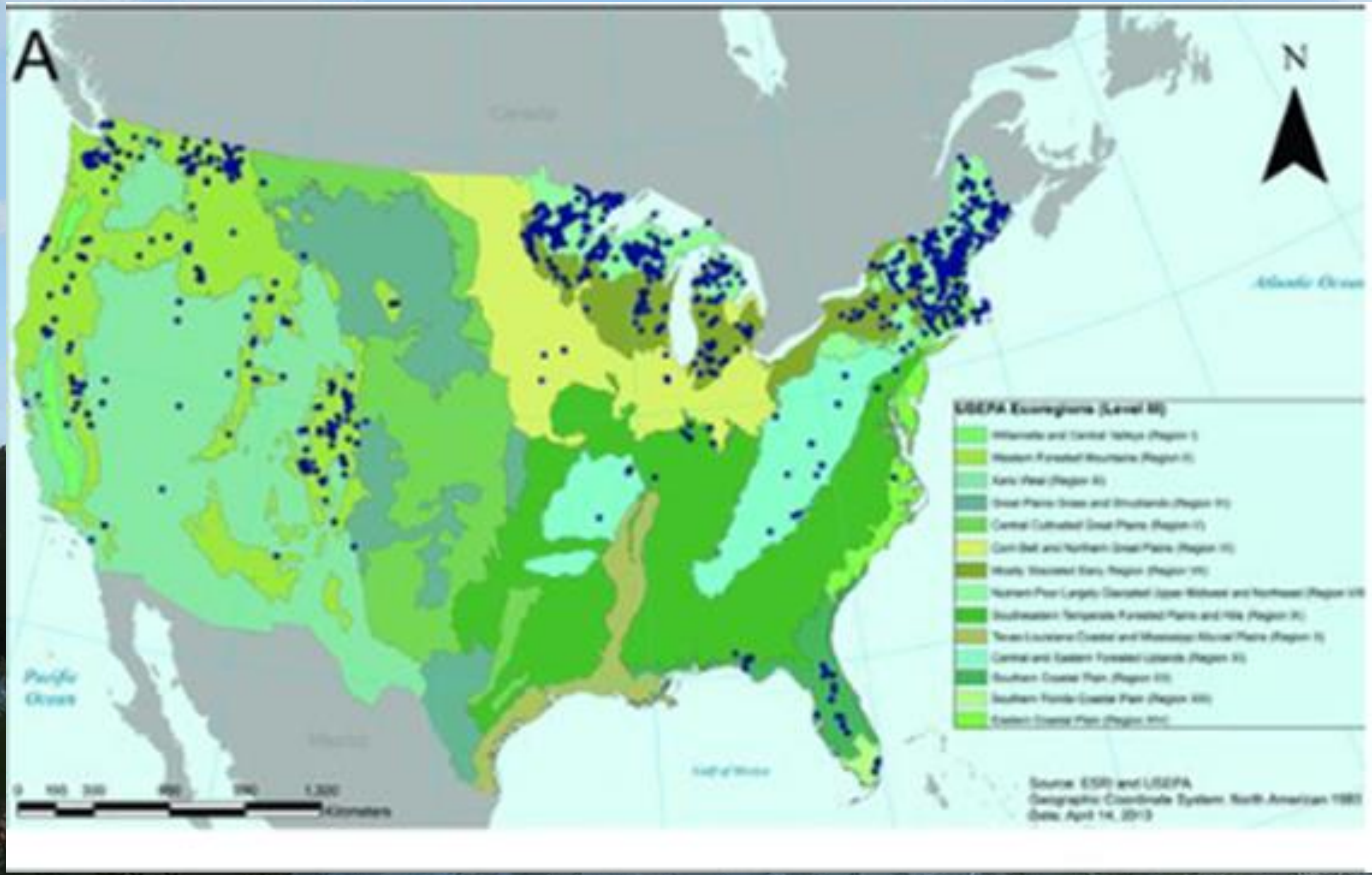
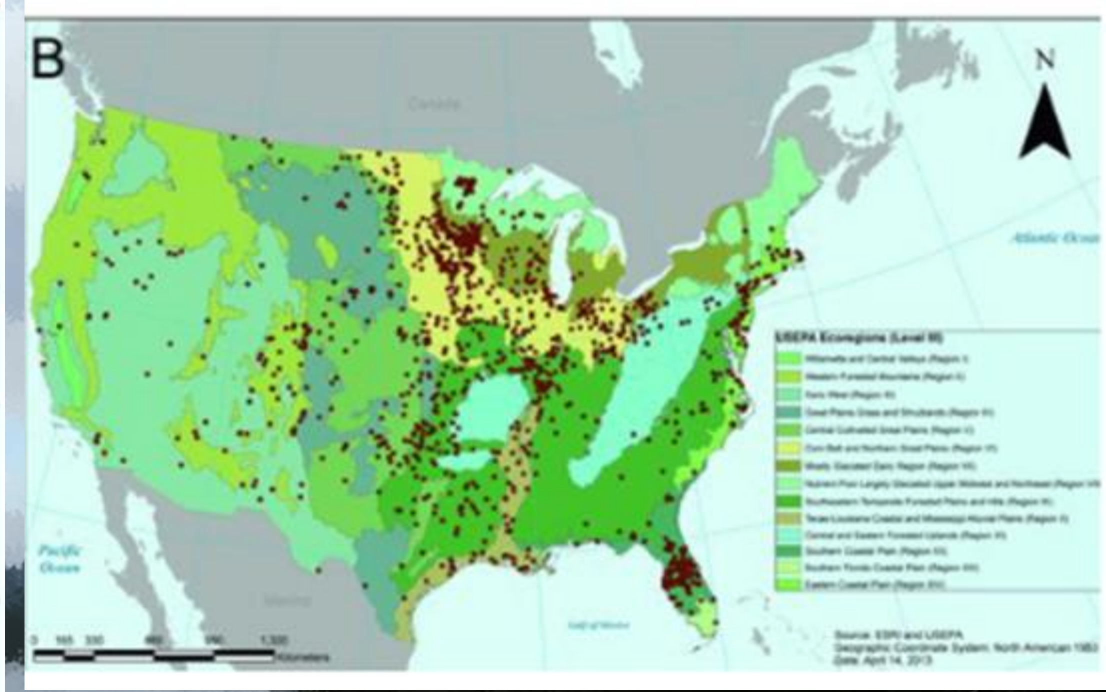


Figure 15. Proportion of lakes in Good, Fair, or Poor condition for Total Phosphorus across 9 Ecoregions, the Nation and Vermont.

Vermont is Stewarding Some of the Clearest Lakes in the Nation

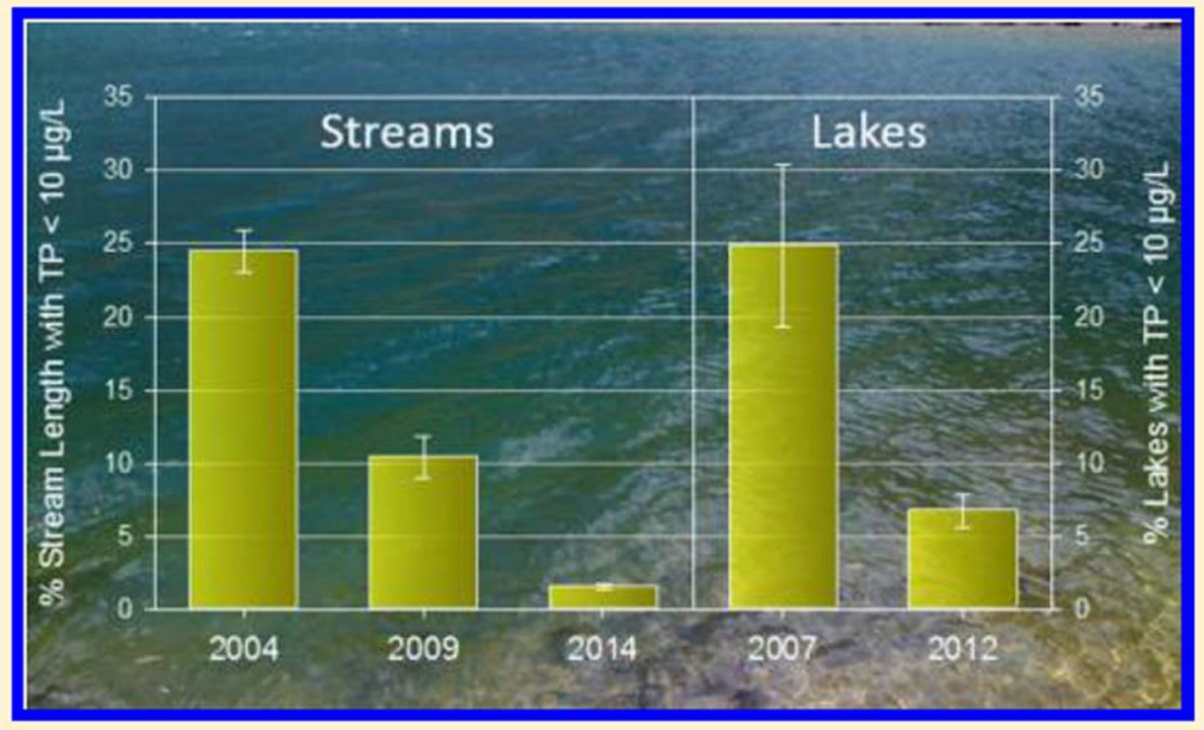




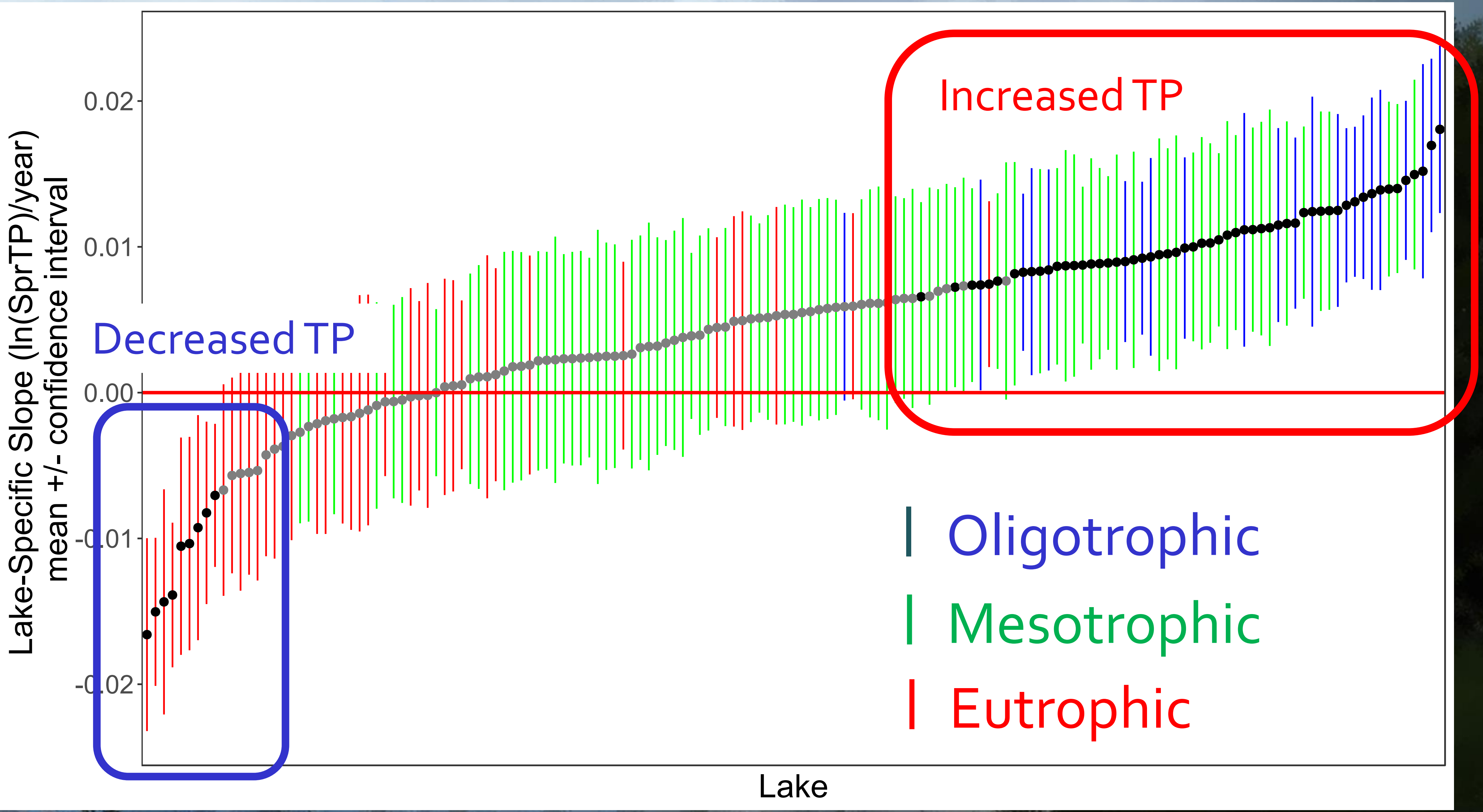
Stephens, et al., 2015

Continental-Scale Increase in Lake and Stream Phosphorus: Are Oligotrophic Systems Disappearing in the United States?

John L. Stoddard,[*,†] John Van Sickle,[†,‡] Alan T. Herlihy,[§] Janice Brahney,[‖] Steven Paulsen,[†] David V. Peck,[†] Richard Mitchell,[⊥] and Amina I. Pollard[⊥]



Estimated trends (slopes) from linear mixed effects model

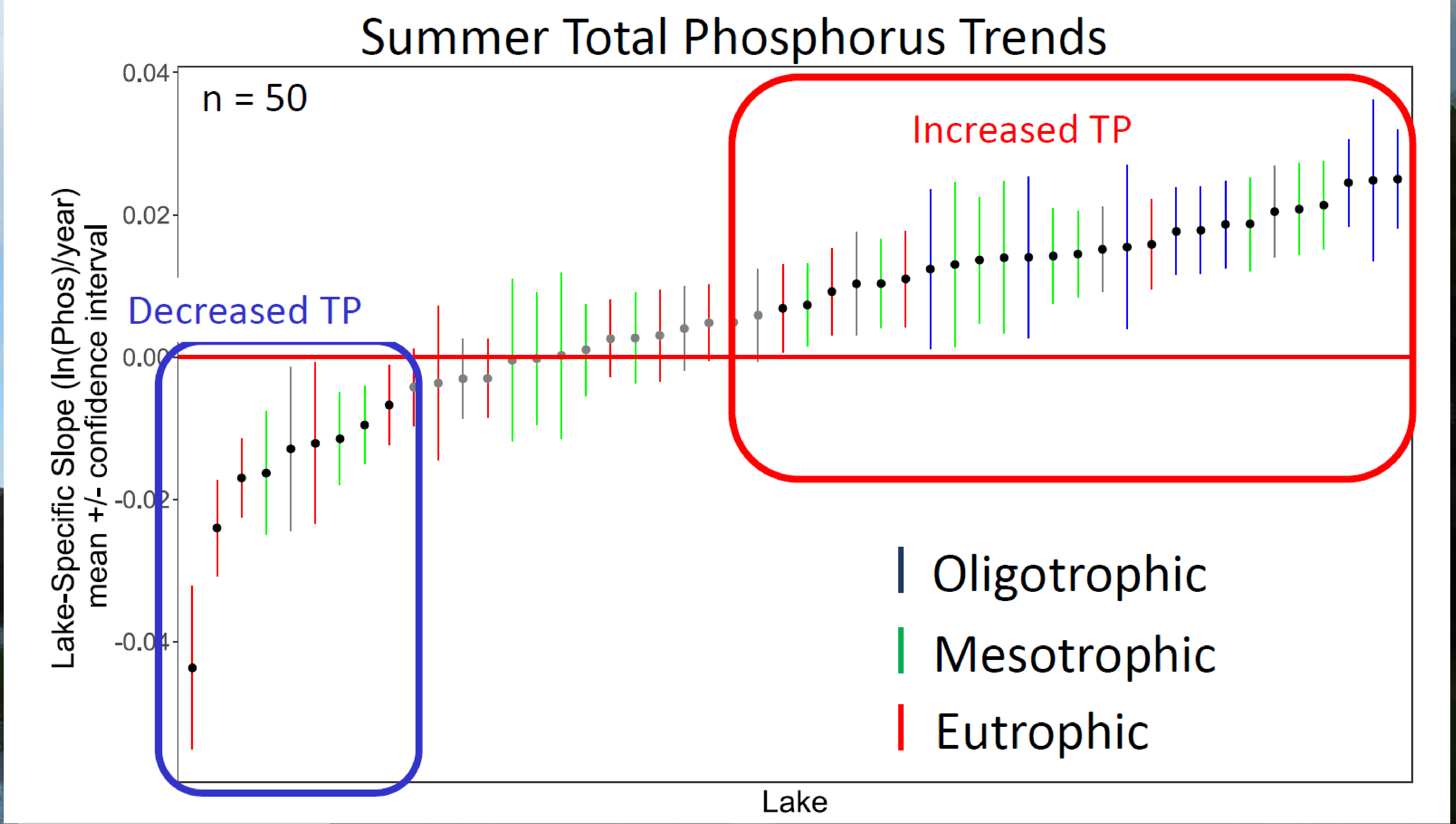


Summer Total Phosphorus

Vermont Lay Monitoring Program
1979

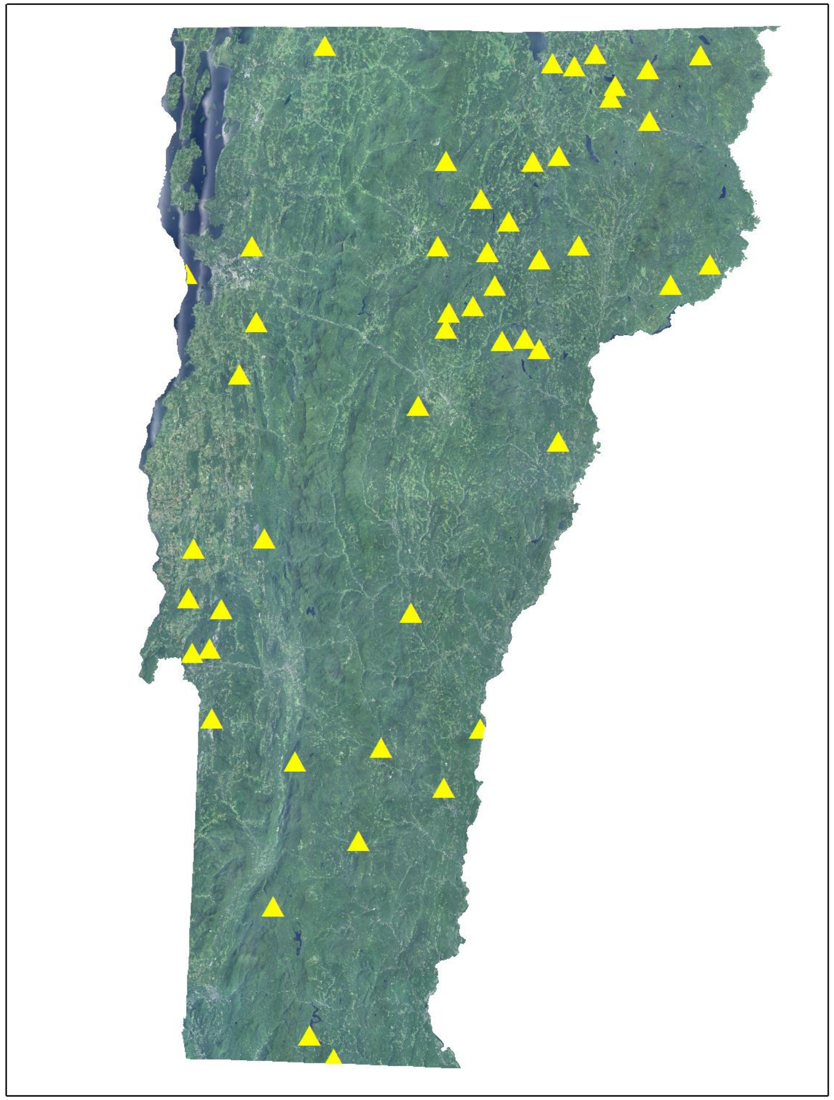
43 Lakes with continuous TP data going back to the late 1980s or 1990s:

15 Eutrophic
19 Mesotrophic
9 Oligotrophic

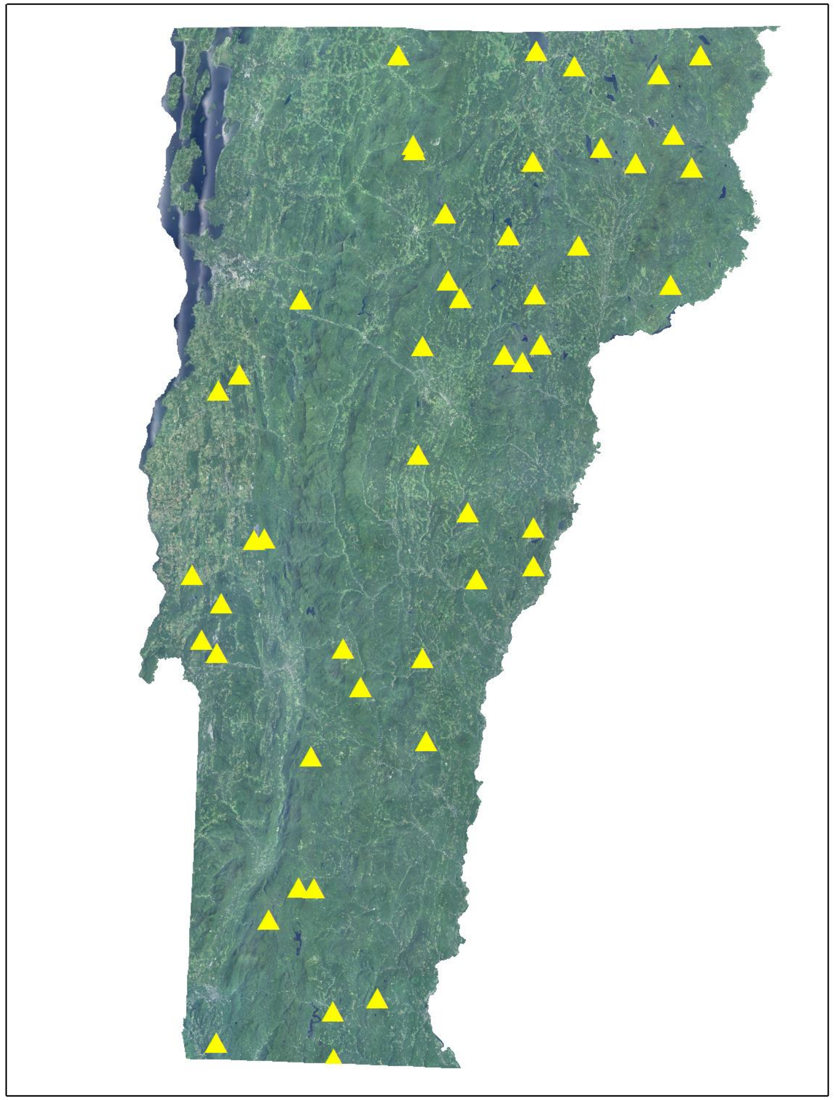

Summer Total Phosphorus Trends
n = 50
Increased TP
Decreased TP
0.04
0.02
0.00
-0.02
-0.04
Lake-Specific Slope (ln(Phos)/year)
mean +/- confidence interval
Lake
Oligotrophic
Mesotrophic
Eutrophic

National Lake Assessment (NLA)

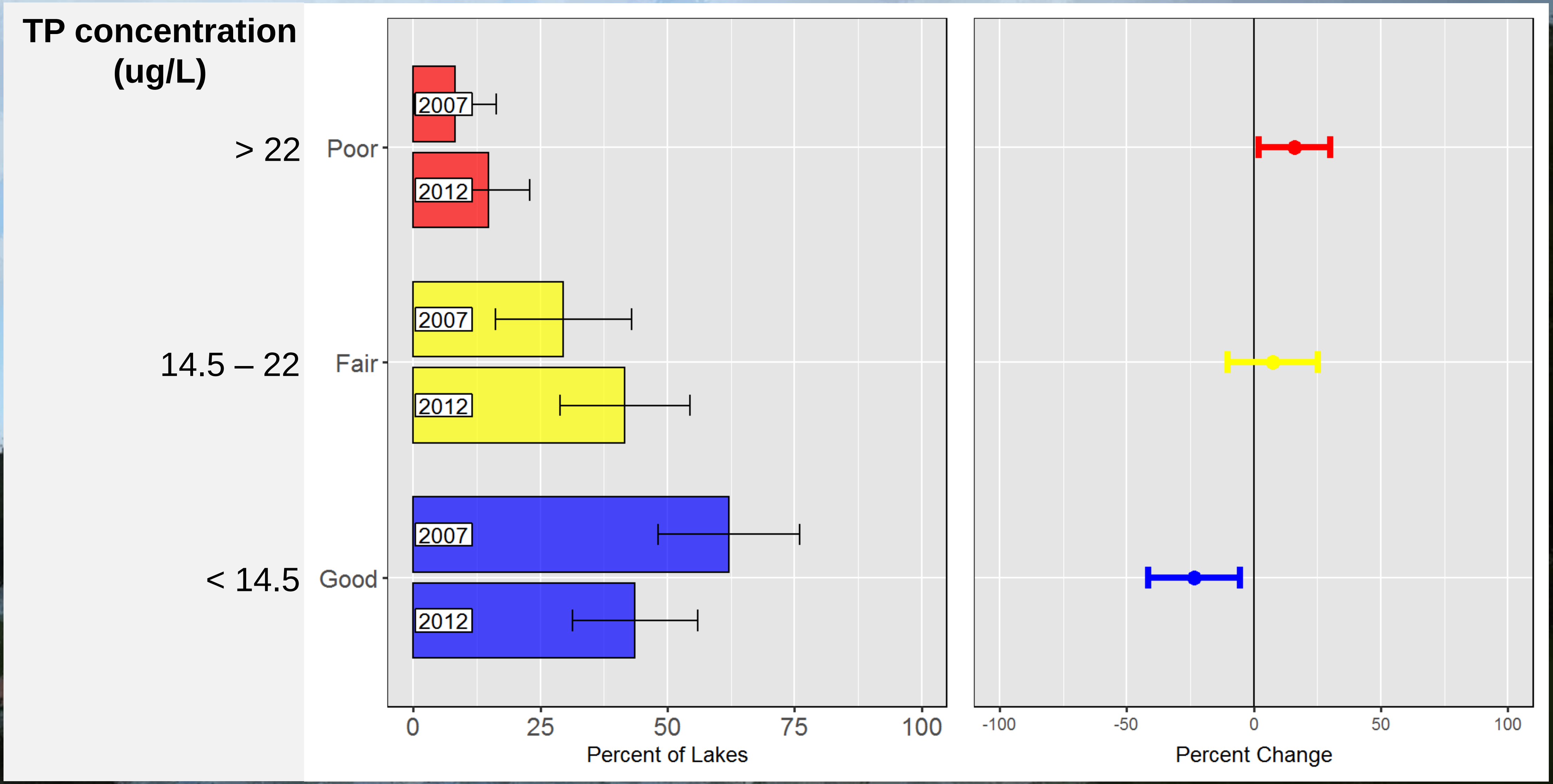
2007/2008



2012

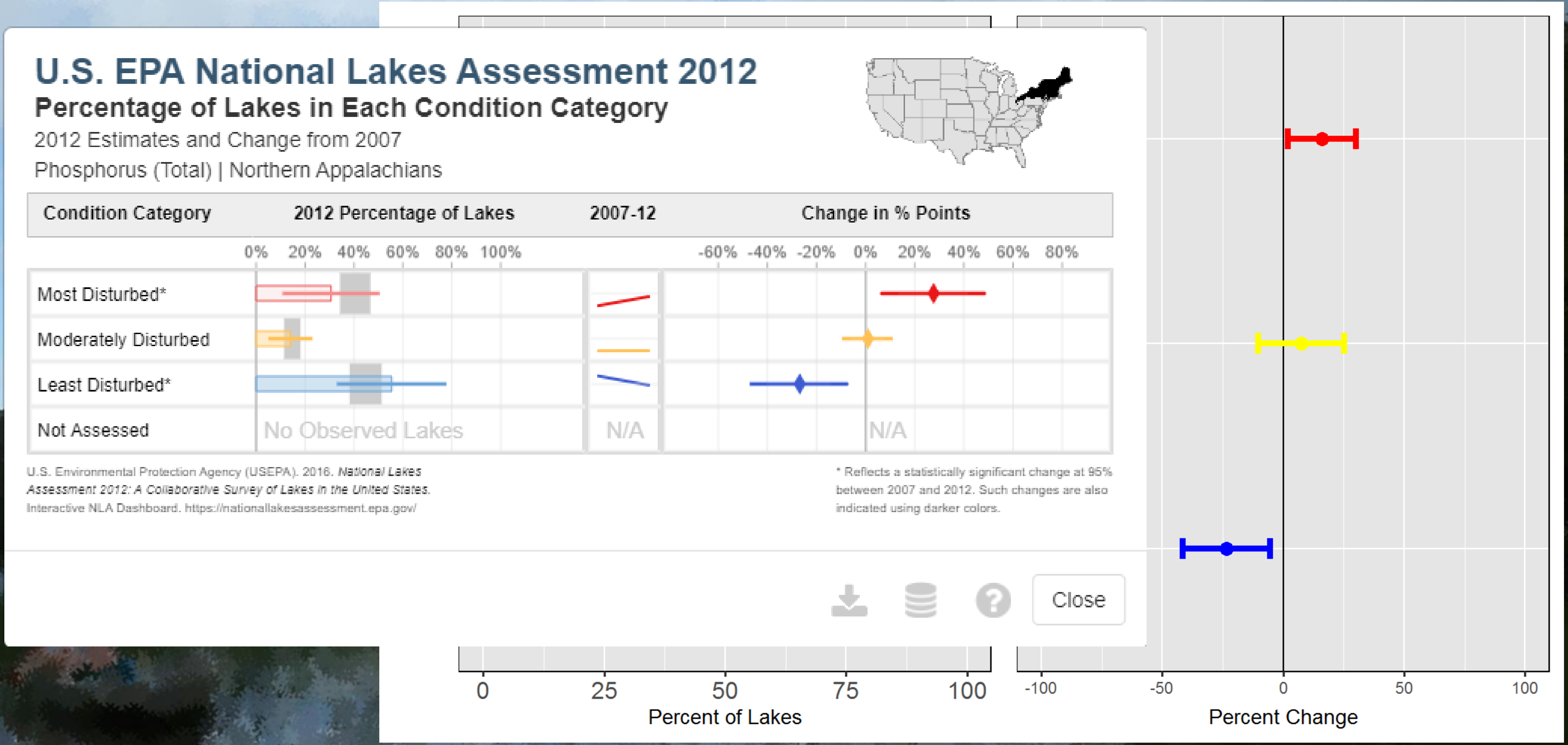


***Total Phosphorus**, Lakes Greater Than 10 Acres
2012 Northern Appalachian Region Thresholds



Preliminary results, Leslie J Matthews, leslie.matthews@vermont.gov

*Total Phosphorus, Lakes Greater Than 10 Acres
2012 Northern Appalachian Region Thresholds

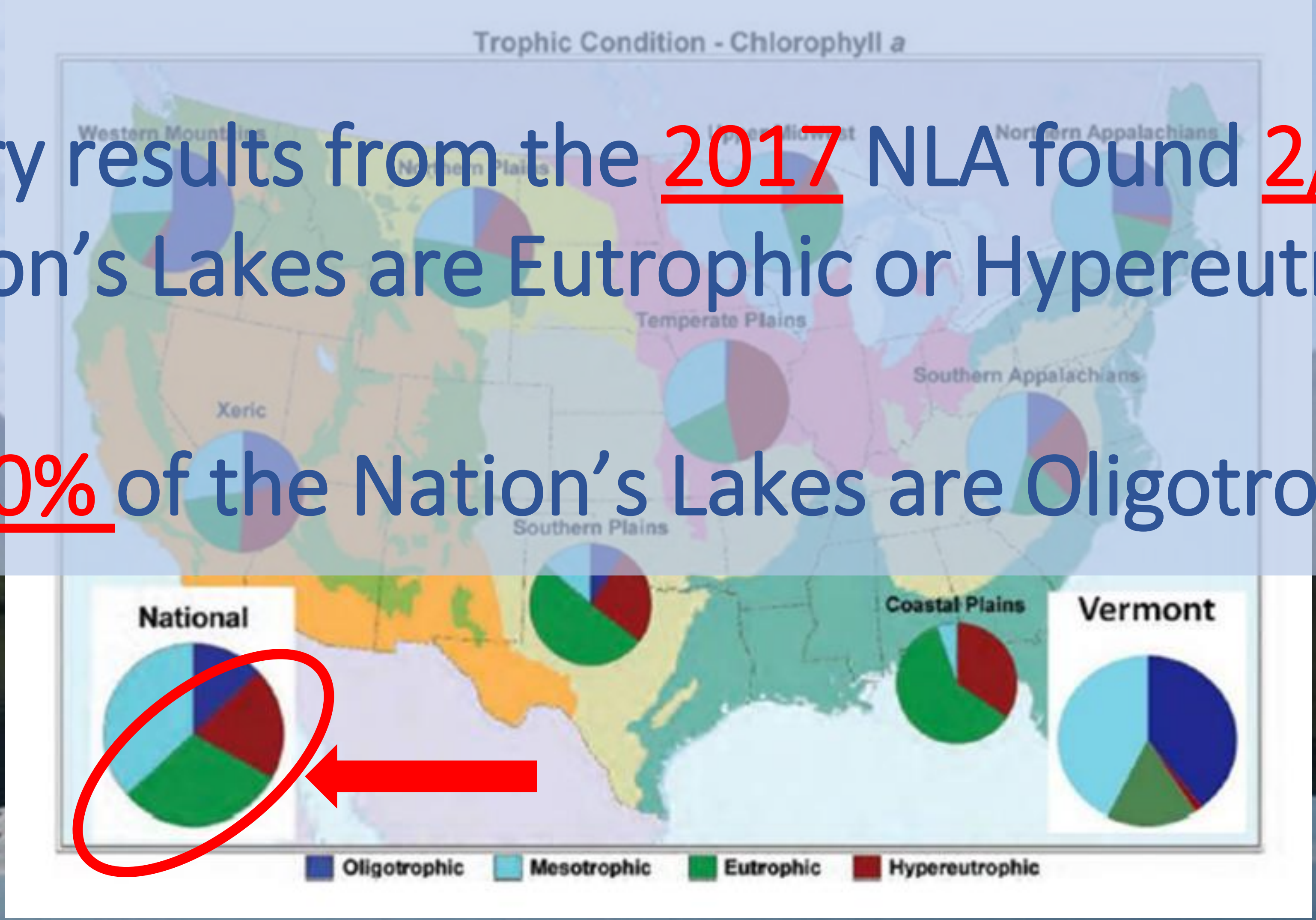


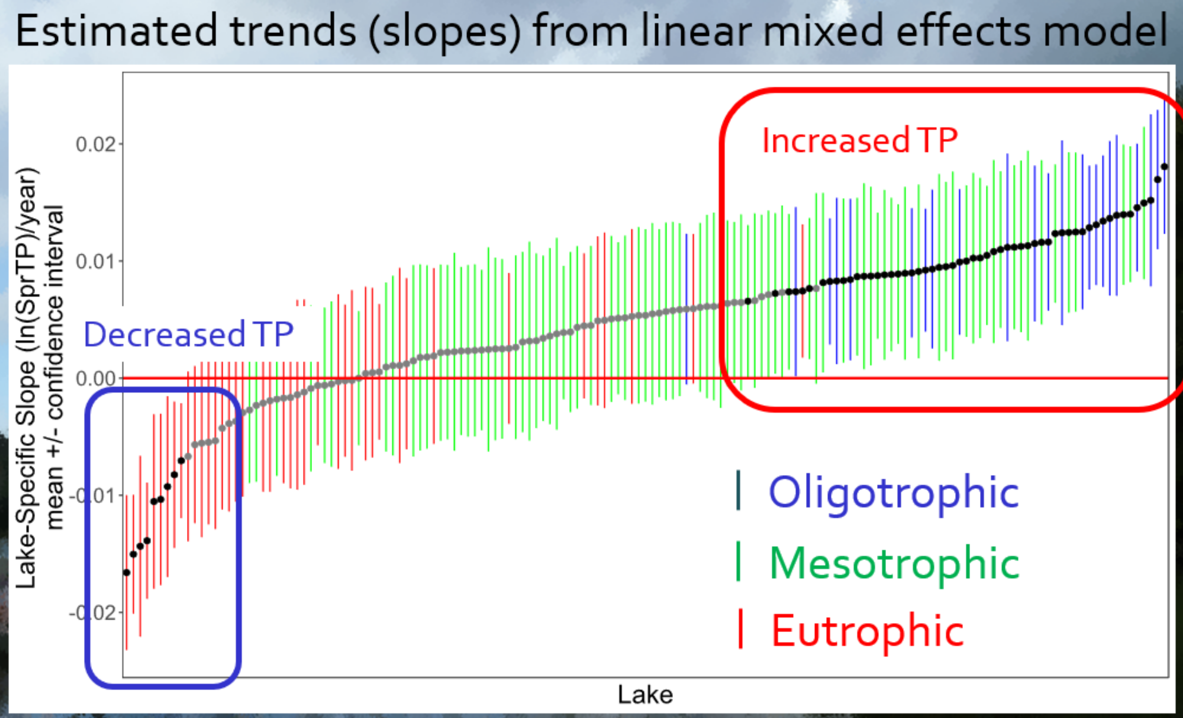
*Preliminary results, Leslie J Matthews, leslie.matthews@vermont.gov

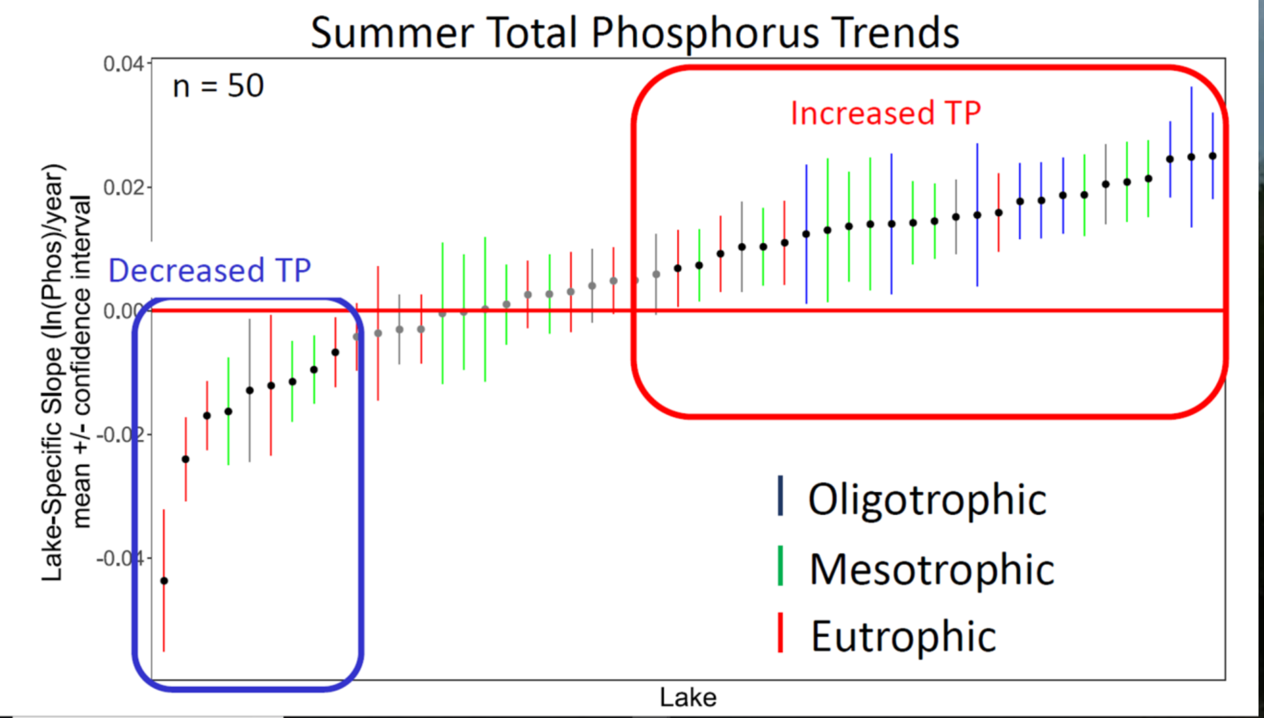
In 2007 HALF of the Nation’s Lakes were Eutrophic or Hypereutrophic

Preliminary results from the 2017 NLA found 2/3rds of the Nation’s Lakes are Eutrophic or Hypereutrophic

Only 10% of the Nation’s Lakes are Oligotrophic




Estimated trends (slopes) from linear mixed effects model
Lake-Specific Slope (ln(SprTP)/year)
mean +/- confidence interval
0.02
0.01
0.00
-0.01
-0.02
Increased TP
Decreased TP
Oligotrophic
Mesotrophic
Eutrophic
Lake


Summer Total Phosphorus Trends
n = 50
Lake-Specific Slope (ln(Phos)/year)
mean +/- confidence interval
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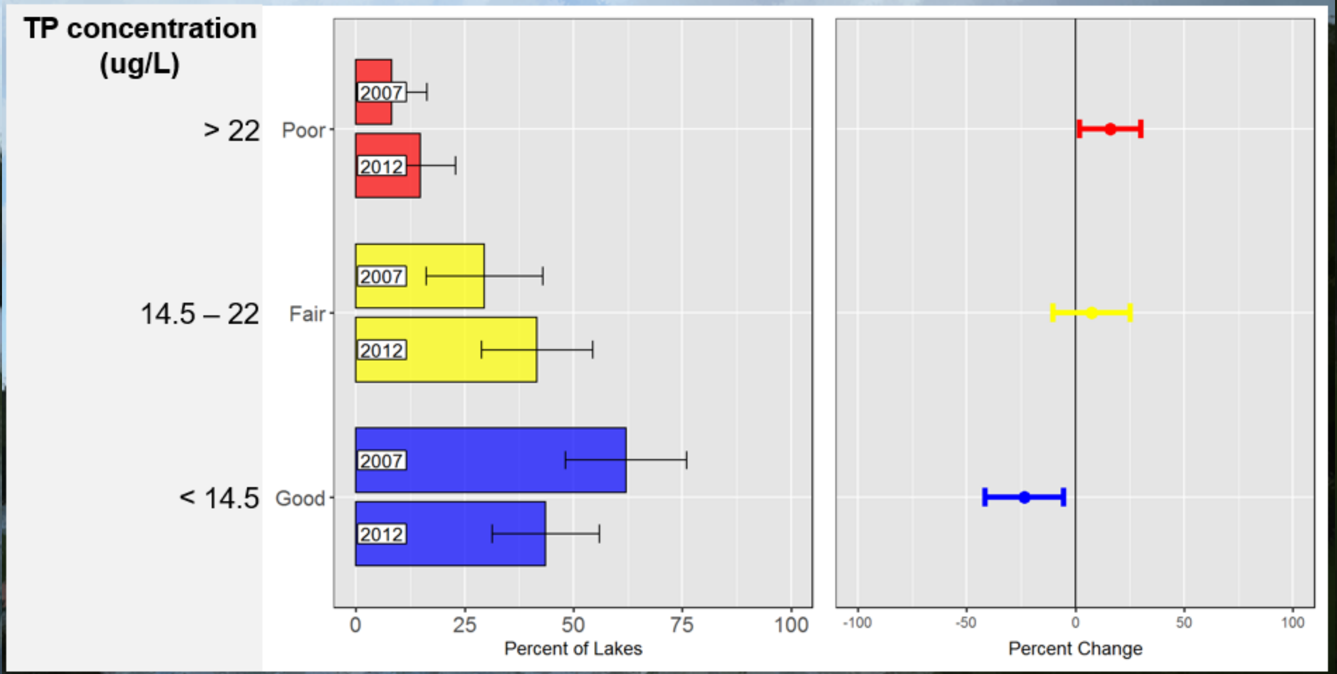
0.02
0.00
-0.02
-0.04
Increased TP
Decreased TP
Oligotrophic
Mesotrophic
Eutrophic
Lake


TP concentration (ug/L)
> 22
14.5 – 22
< 14.5
Poor
Fair
Good
2007
2012
0
25
50
75
100
Percent of Lakes
-100
-50
0
50
100
Percent Change


SO NOW WHAT
DO WE DO?

The primary goal of the Clean Water Act

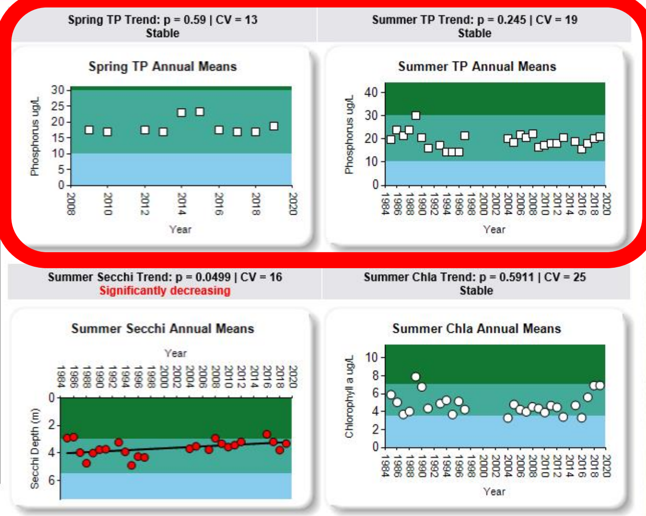
“restore and maintain the chemical, physical, and biological integrity of the Nation’s waters"

VT's 4 Inland Lakes that are/had been listed as impaired for phosphorus have stable or decreasing phosphorus trends

MEMPHREMAGOG - data through 2019

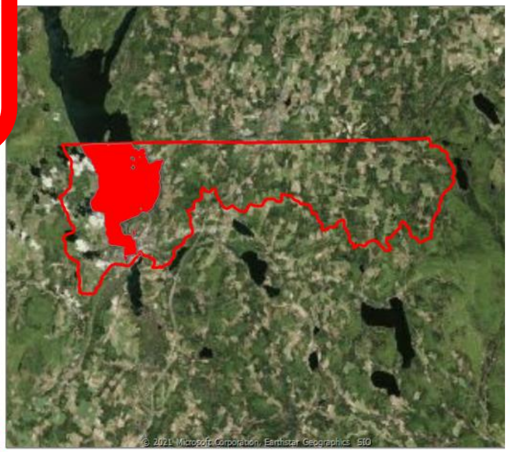
Learn How Lakes Are Scored

Lake Area: 5929.3 acres
Basin Lake Area Ratio: 69
Max Depth: 107 meters
Mean Spring TP: 18.4 ug/L
Mean Summer TP: 19.2 ug/L
Mean Summer Chla: 4.8 ug/L
Mean Summer Secchi: 3.6 meters



Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic

Trend Score: Fair
WQ Standards Status: Impaired
Watershed Score: Highly Disturbed



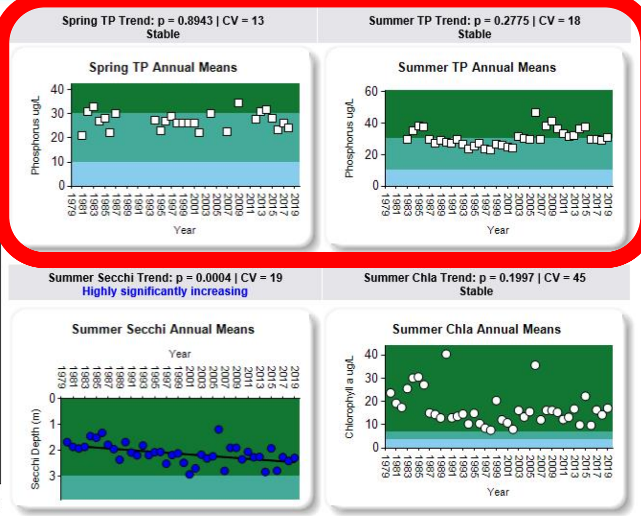
Stresses / Impairments

Impaired -- Phosphorus
Altered -- flow

CARMI - data through 2019

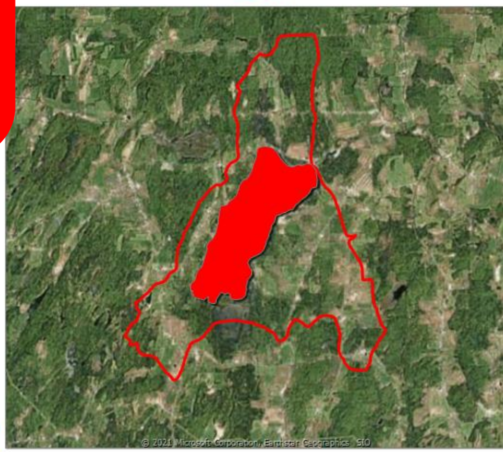
Learn How Lakes Are Scored

Lake Area: 1415.2 acres
Basin Lake Area Ratio: 5
Max Depth: 10.1 meters
Mean Spring TP: 27.1 ug/L
Mean Summer TP: 30.9 ug/L
Mean Summer Chla: 16.9 ug/L
Mean Summer Secchi: 2.1 meters



Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic

Trend Score: Good
WQ Standards Status: Impaired
Watershed Score: Highly Disturbed



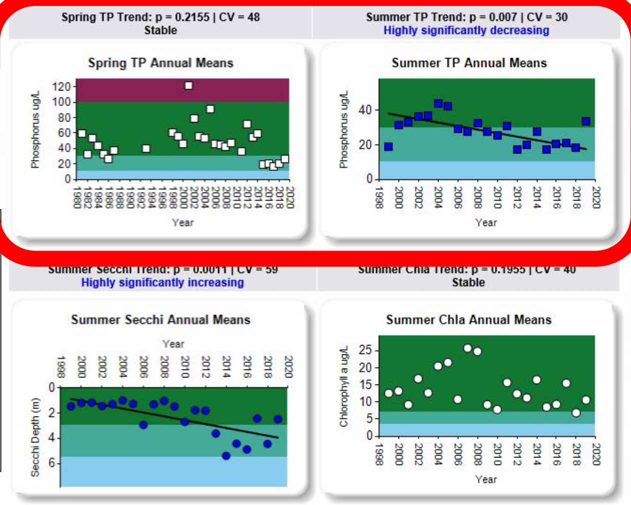
Stresses / Impairments

Stressed -- Escherichia coli
Stressed -- Flow alteration
Impaired -- Organic Enrichment - DO
Impaired -- Phosphorus

TICKLENAKED - data through 2019

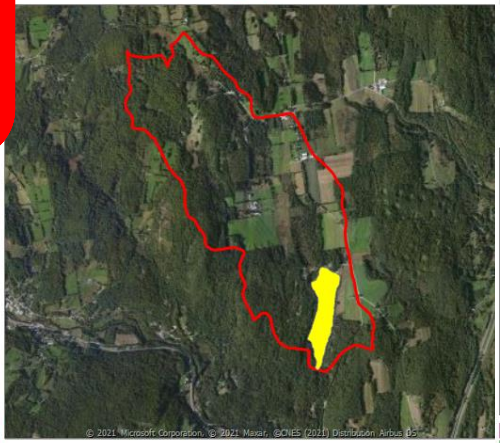
Learn How Lakes Are Scored

Lake Area: 55 acres
Basin Lake Area Ratio: 26
Max Depth: 15.5 meters
Mean Spring TP: 47.9 ug/L
Mean Summer TP: 28.2 ug/L
Mean Summer Chla: 14.1 ug/L
Mean Summer Secchi: 2.4 meters



Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic

Trend Score: Good
WQ Standards Status: Stressed
Watershed Score: Highly Disturbed



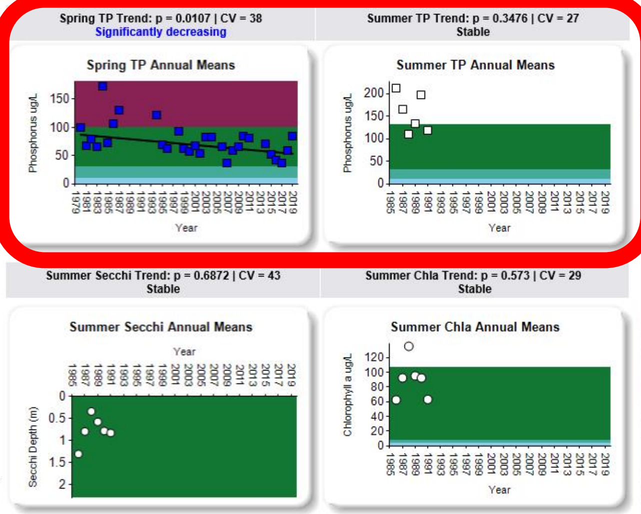
Stresses / Impairments

Stressed -- Phosphorus
Stressed -- Organic Enrichment - DO

SHELBURNE - data through 2019

Learn How Lakes Are Scored

Lake Area: 479.3 acres
Basin Lake Area Ratio: 10
Max Depth: 7.6 meters
Mean Spring TP: 76.2 ug/L
Mean Summer TP: 152 ug/L
Mean Summer Chla: 91.1 ug/L
Mean Summer Secchi: 0.8 meters



Hypereutrophic
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Mesotrophic
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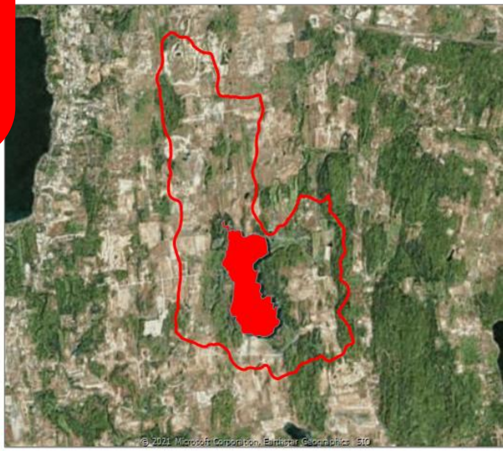
Trend Score: Good
WQ Standards Status: Impaired
Watershed Score: Highly Disturbed



Stresses / Impairments

Stressed -- Organic Enrichment - DO
Impaired -- Phosphorus

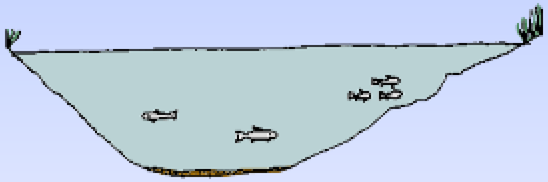

National Lakes Assessment

Is Vermont Losing Its Oligotrophic Lakes?

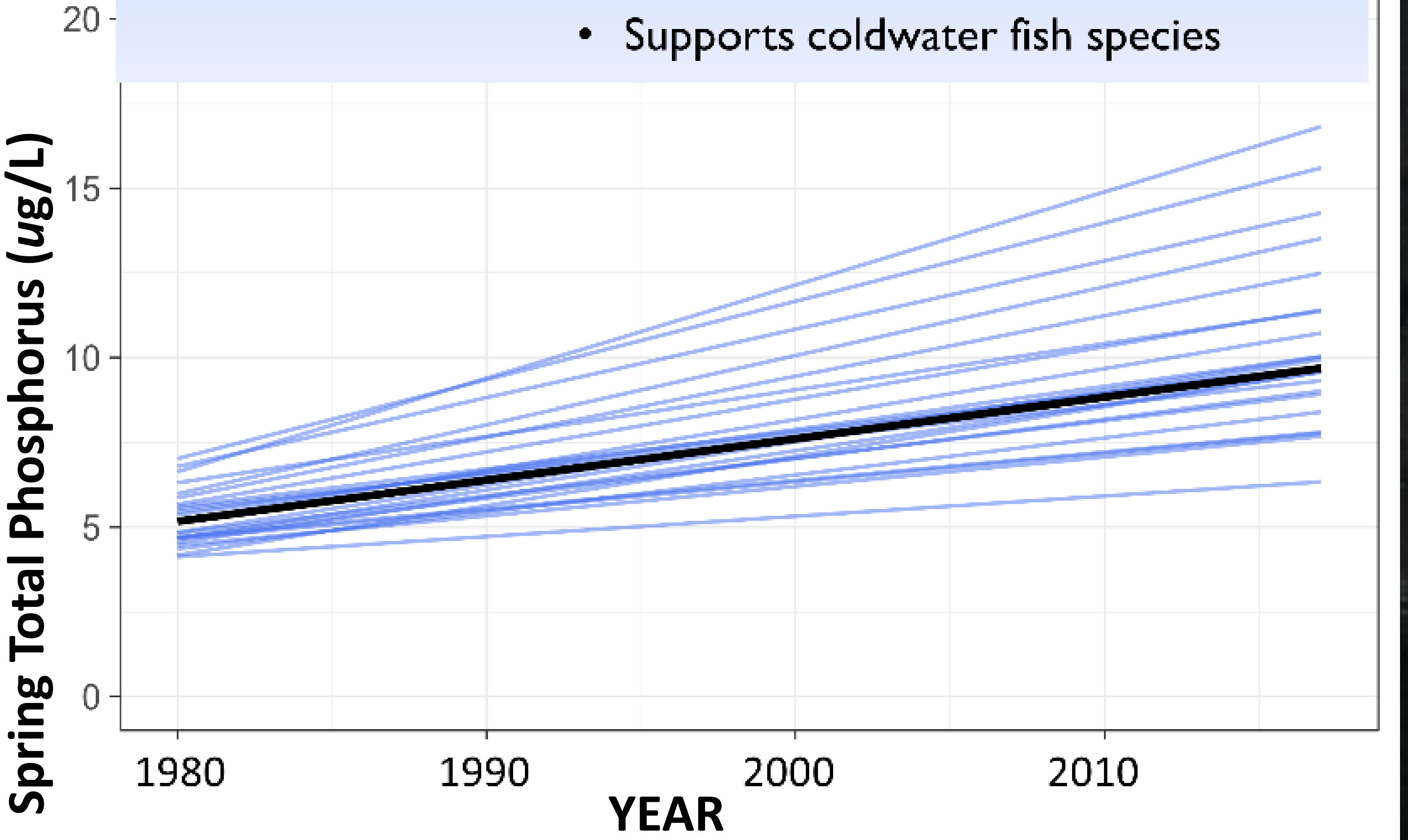
Leslie Matthews, Kellie Merrell, and Perry Thomas

LakeLine Summer2018

Oligotrophic Lakes



- Low nutrient enrichment = very little plant and algae growth
- Clear water
- Supports coldwater fish species

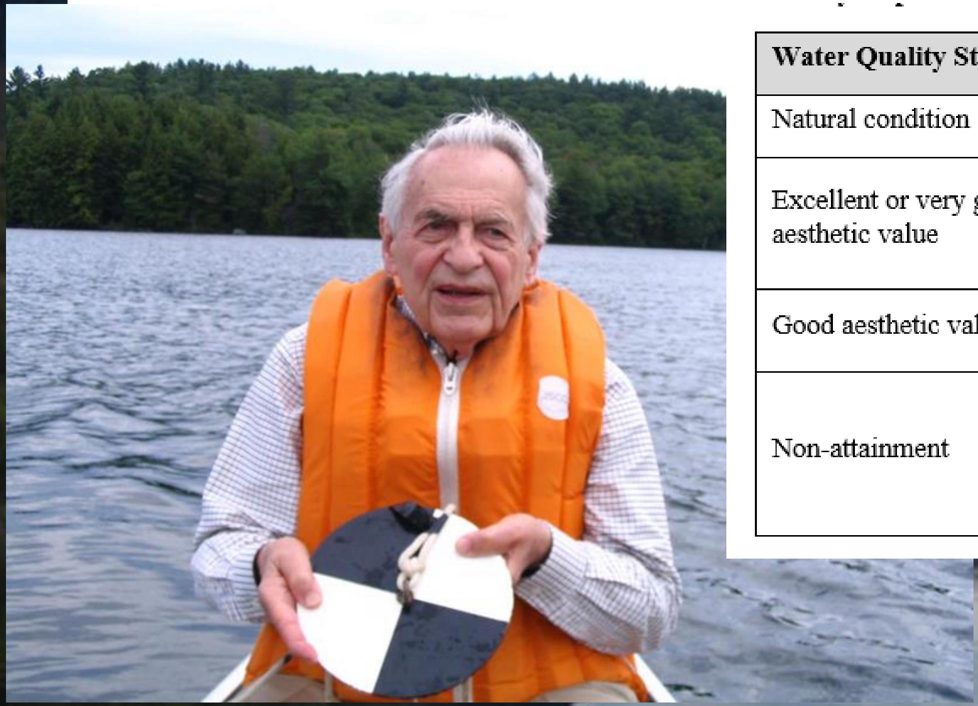


Taylor & Francis
Taylor & Francis Group

Lake and Reservoir Management

ISSN: 1040-2381 (Print) 2151-5530 (Online) Journal homepage: https://www.tandfonline.com/loi/ulrm20

Deriving nutrient criteria to minimize false positive and false negative water use impairment determinations



Water Quality Standard	Lake User Survey Response
Natural condition	The user survey was not used to define natural condition.
Excellent or very good aesthetic value	(1) Beautiful, could not be any nicer, or (2) Very minor aesthetic problems; excellent for swimming, boating, enjoyment.
Good aesthetic value	(3) Swimming and aesthetic enjoyment slightly impaired because of algae levels.
Non-attainment	(4) Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels, or (5) Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels.

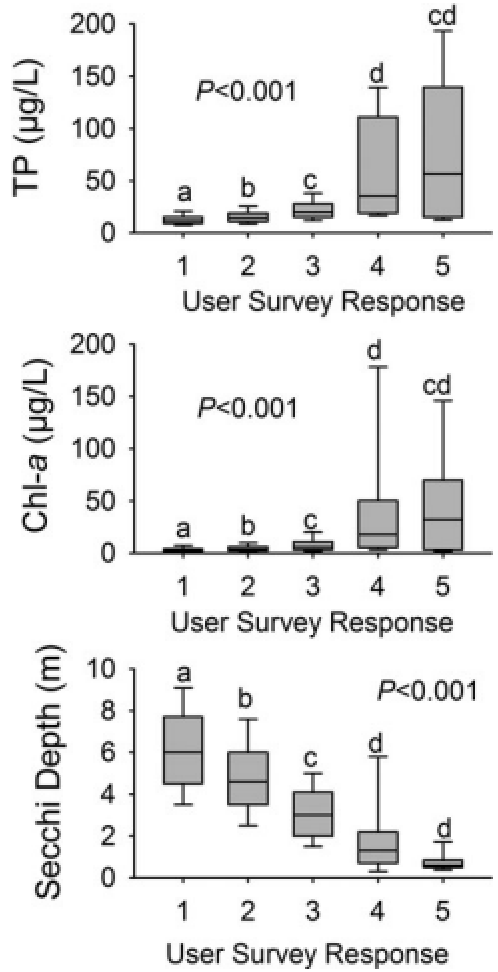


Figure 2. Distributions of individual TP, Chl-*a*, and Secchi depth observations associated with each lake user survey response choice from Table 1 (1 = excellent, 2 = good, 3 = slightly impaired, 4 = enjoyment substantially reduced, 5 = enjoyment nearly impossible). Box plots show the 25th, 50th, and 75th percentiles; 5th and 95th percentiles are shown as whiskers. Overall significance values (*P*) were based on a Kruskal–Wallis one-way analysis of variance on ranks. Medians without letters in common were significantly different, based on individual pairwise comparisons (Dunn's method, $\alpha = 0.05$).

https://www.tandfonline.com/doi/pdf/10.1080/10402381.2016.1149257

Smeltzer et al, 2016

Table 3. Combined Nutrient Criteria for Aesthetics Uses in Lakes, Ponds, and Reservoirs Except for Lake Champlain and Lake Memphremagog[1,2]

	Class A(1)	Classes A(2) and B(1)	Class B(2)
Nutrient Concentrations			
Total Phosphorus[3] (µg/L)	12	17	18
Nutrient Response Conditions			
Secchi Disk Depth (meters)[4]	5.0	3.2	2.6
Chlorophyll-a (µg/L)[3]	2.6	3.8	7.0
pH	Not to exceed 8.5 standard units.		
Turbidity	Consistent with the criteria in § 29A-302(4) of these rules.		
Dissolved Oxygen	Consistent with the criteria in § 29A-302(5) of these rules.		

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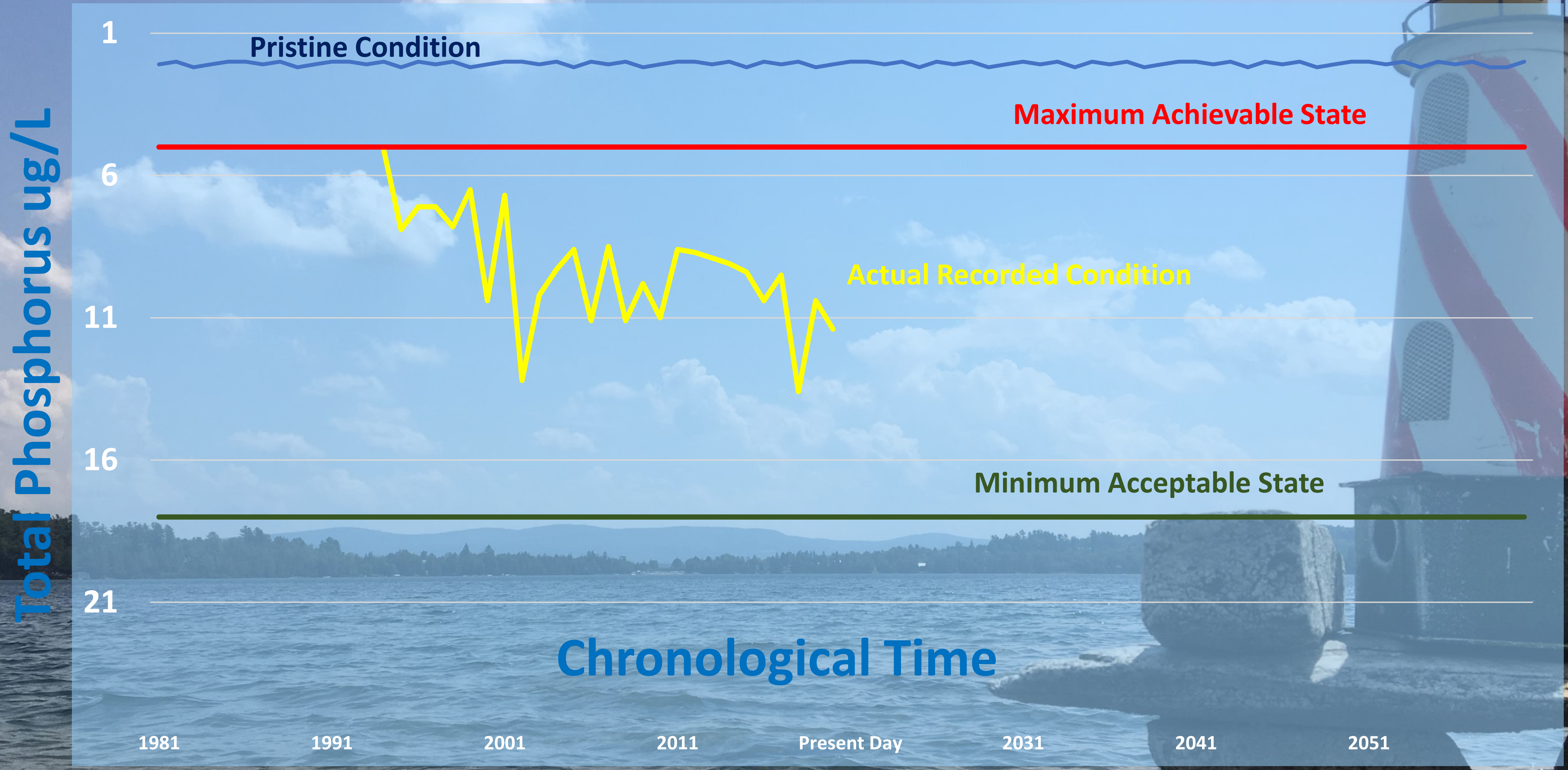
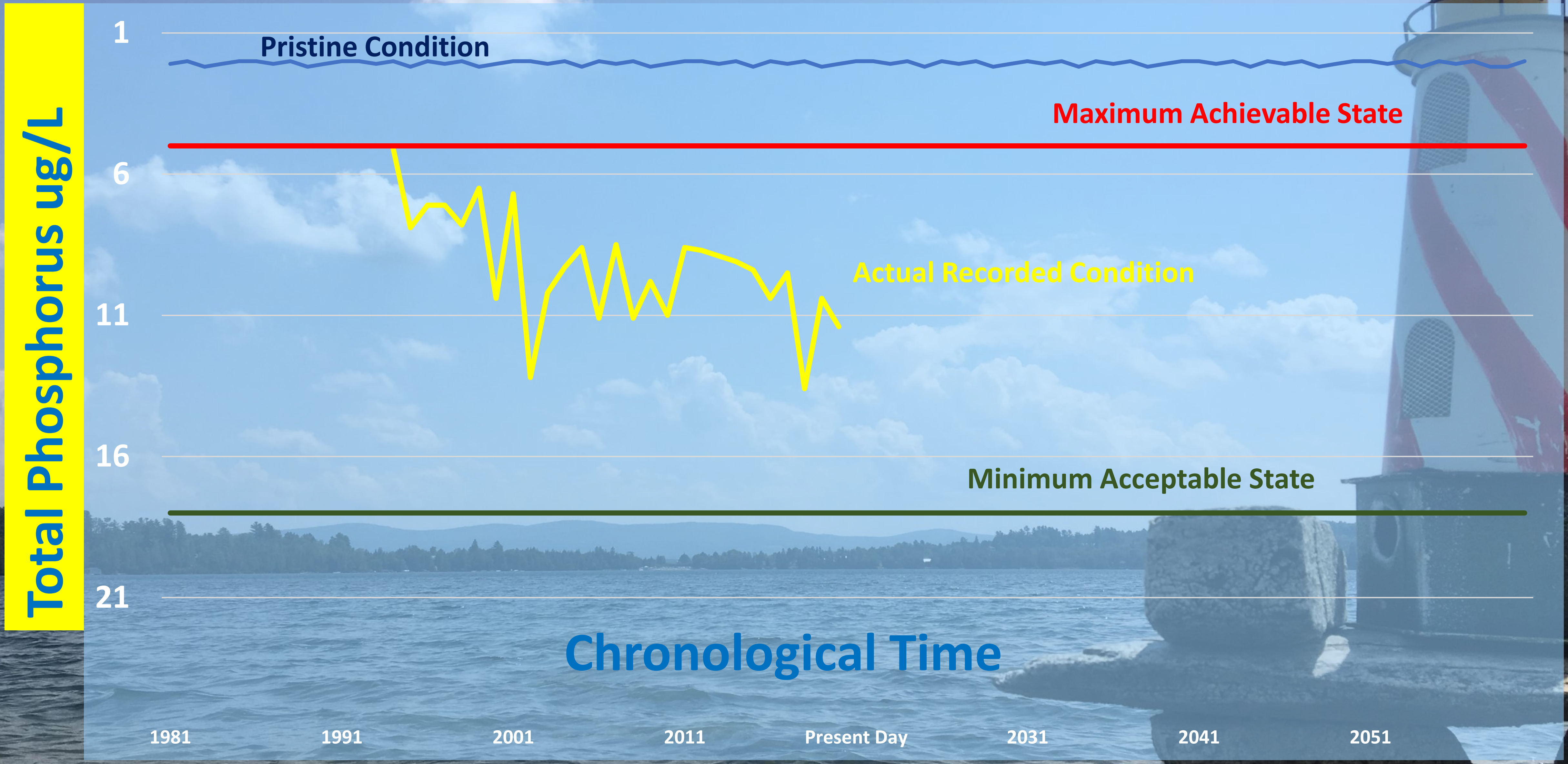
Monitoring the Health of an Ecosystem Over Time



Adapted from Cairns et al, 1993 https://link.springer.com/article/10.1007/BF00006084

Monitoring the Health of an Ecosystem Over Time



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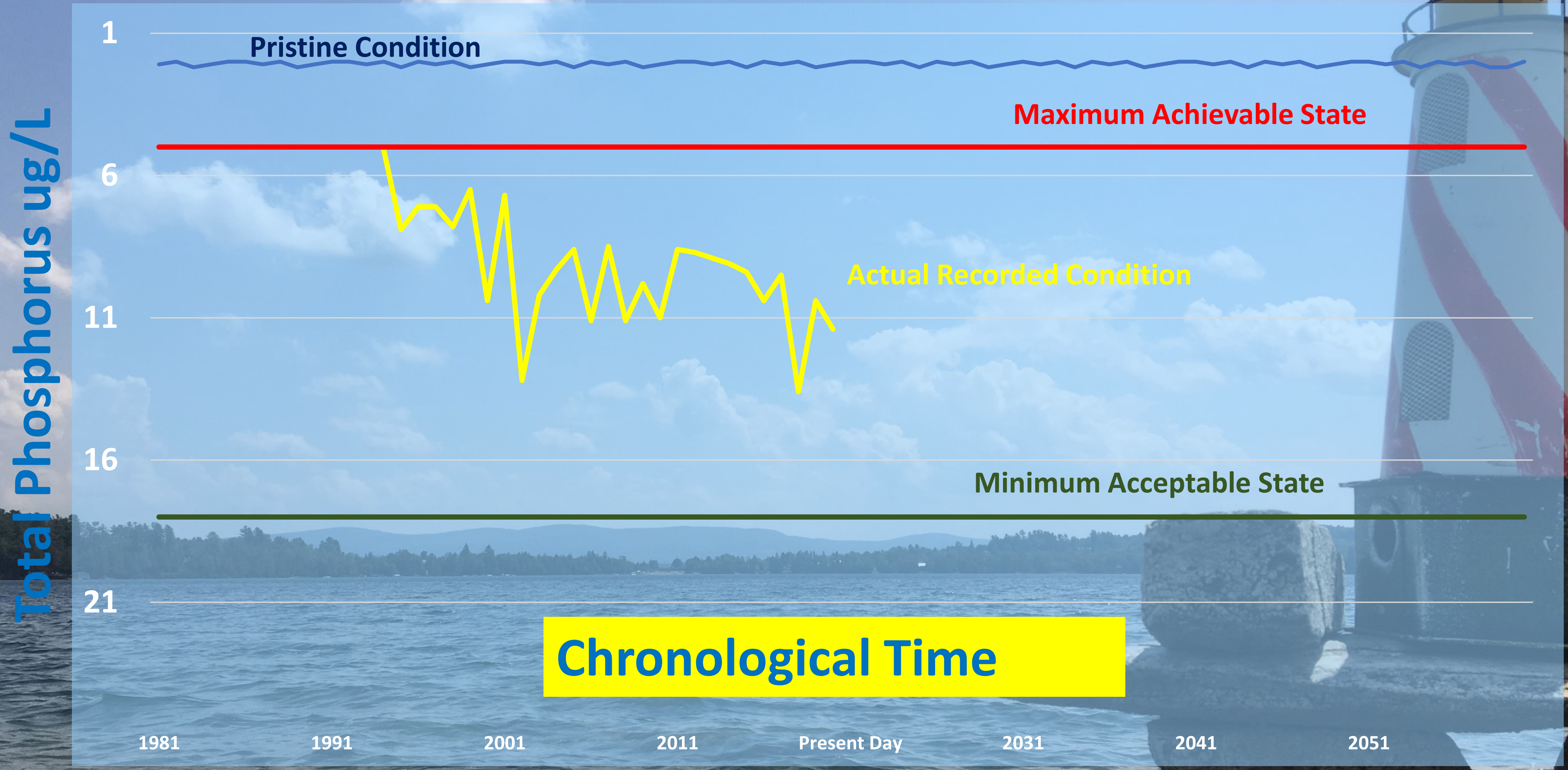

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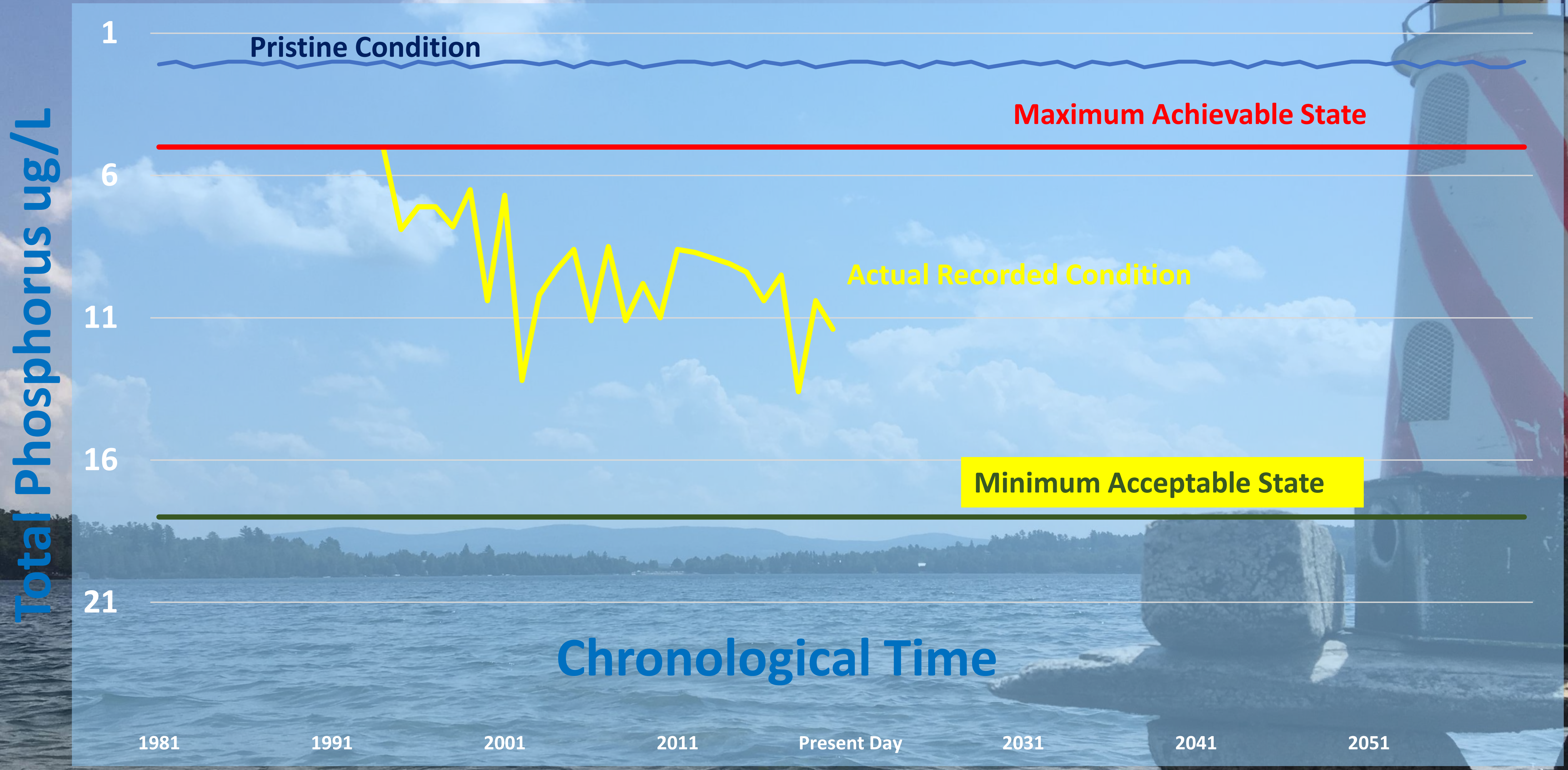

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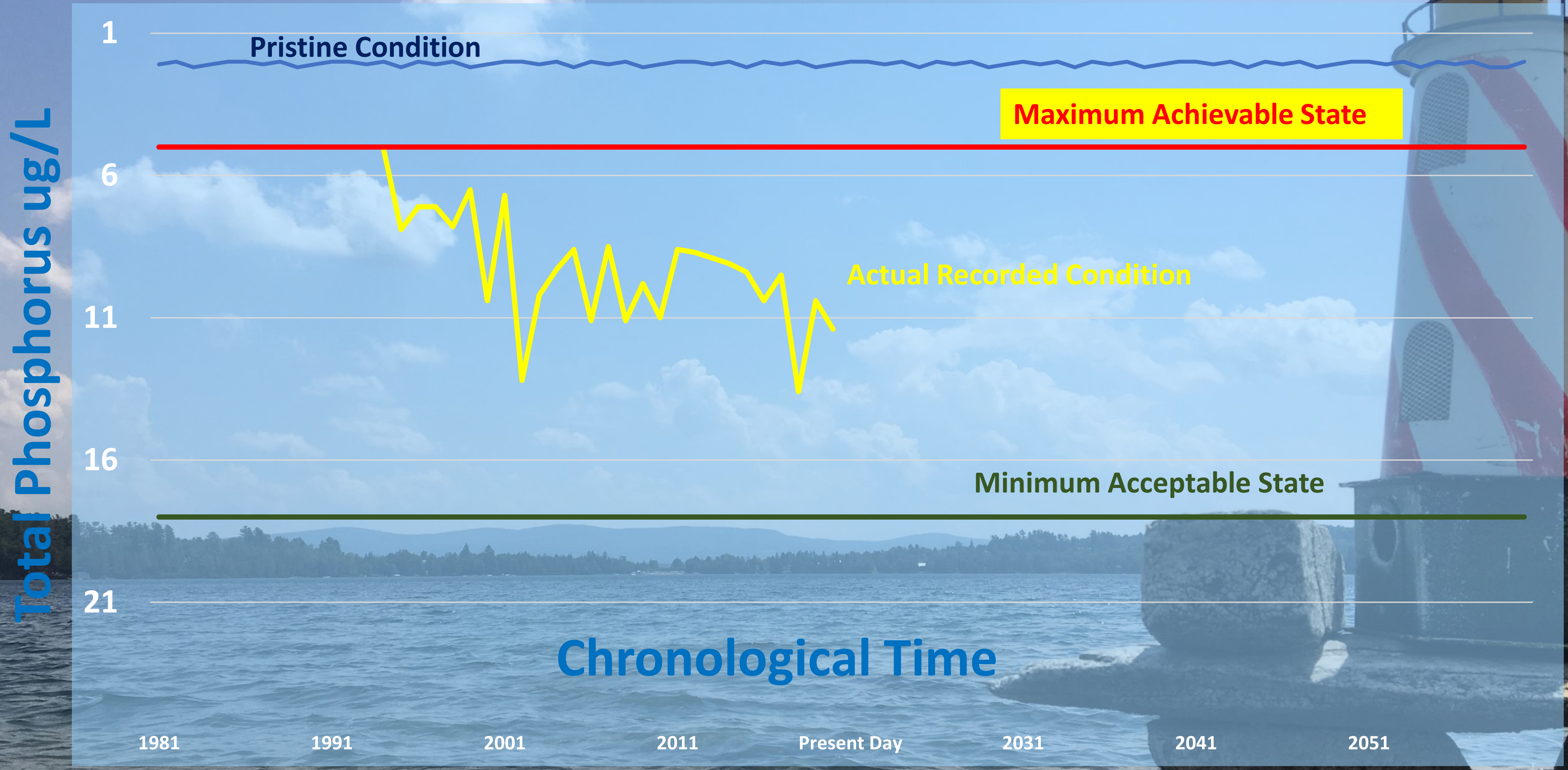

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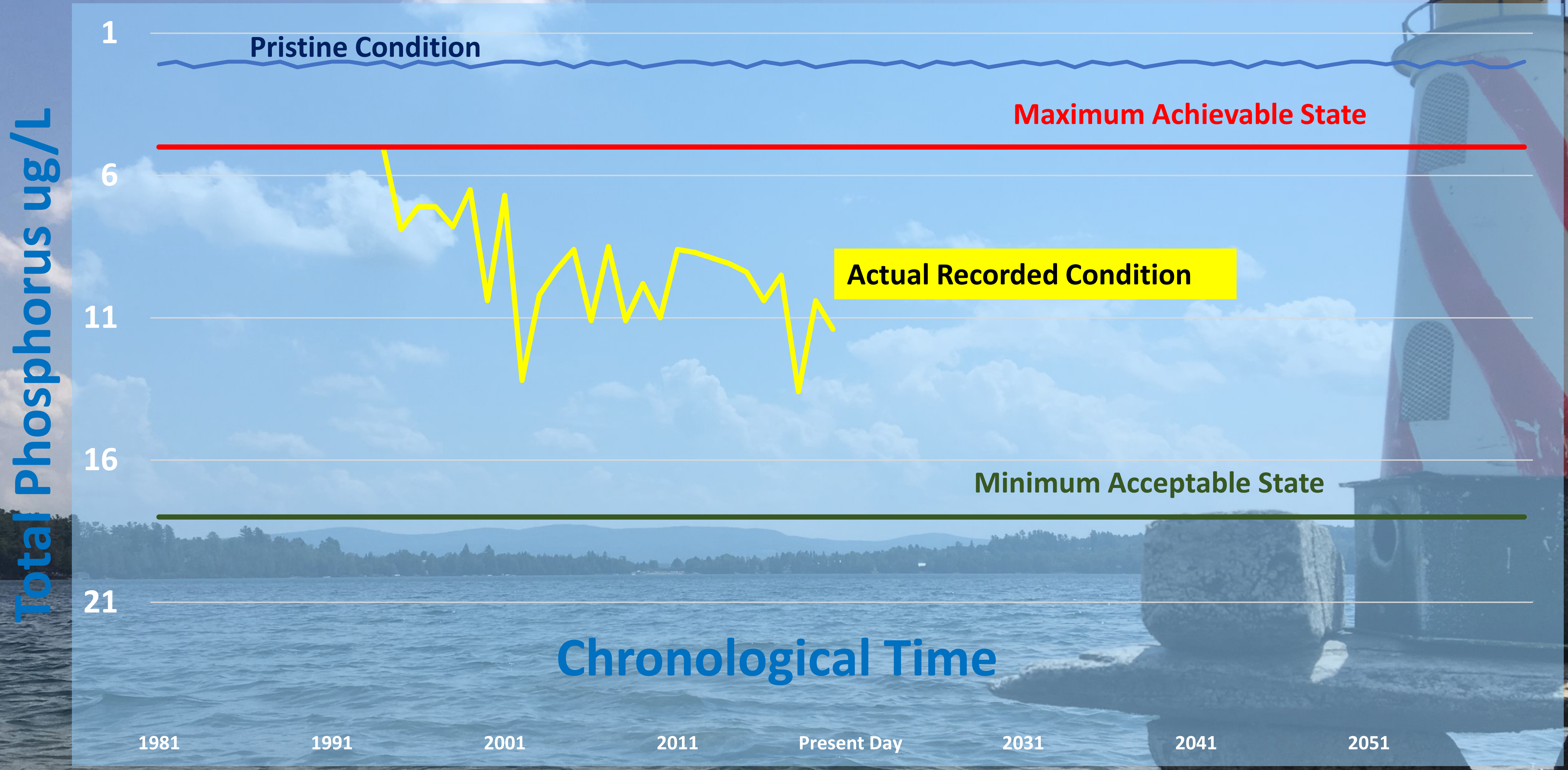

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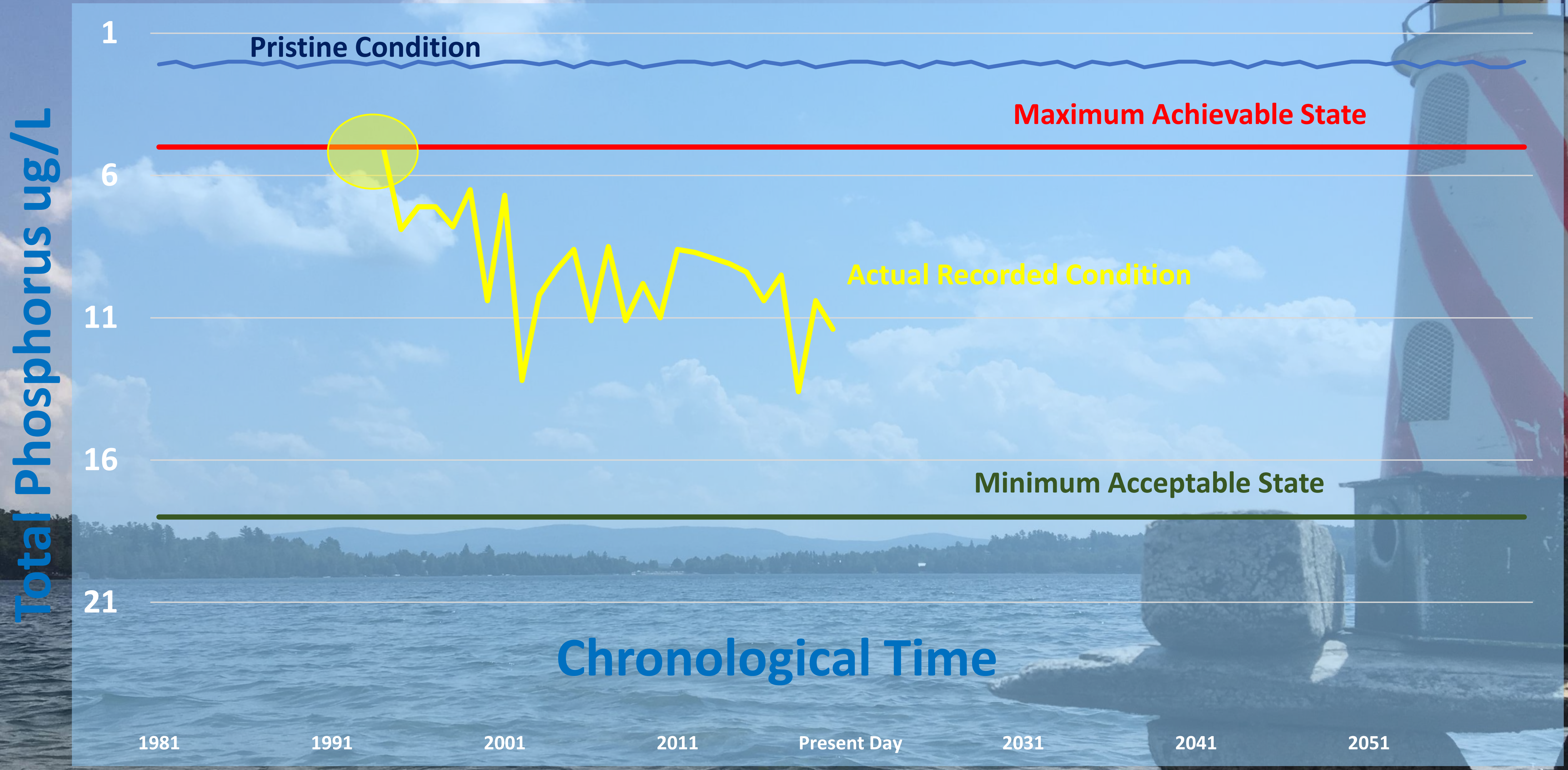

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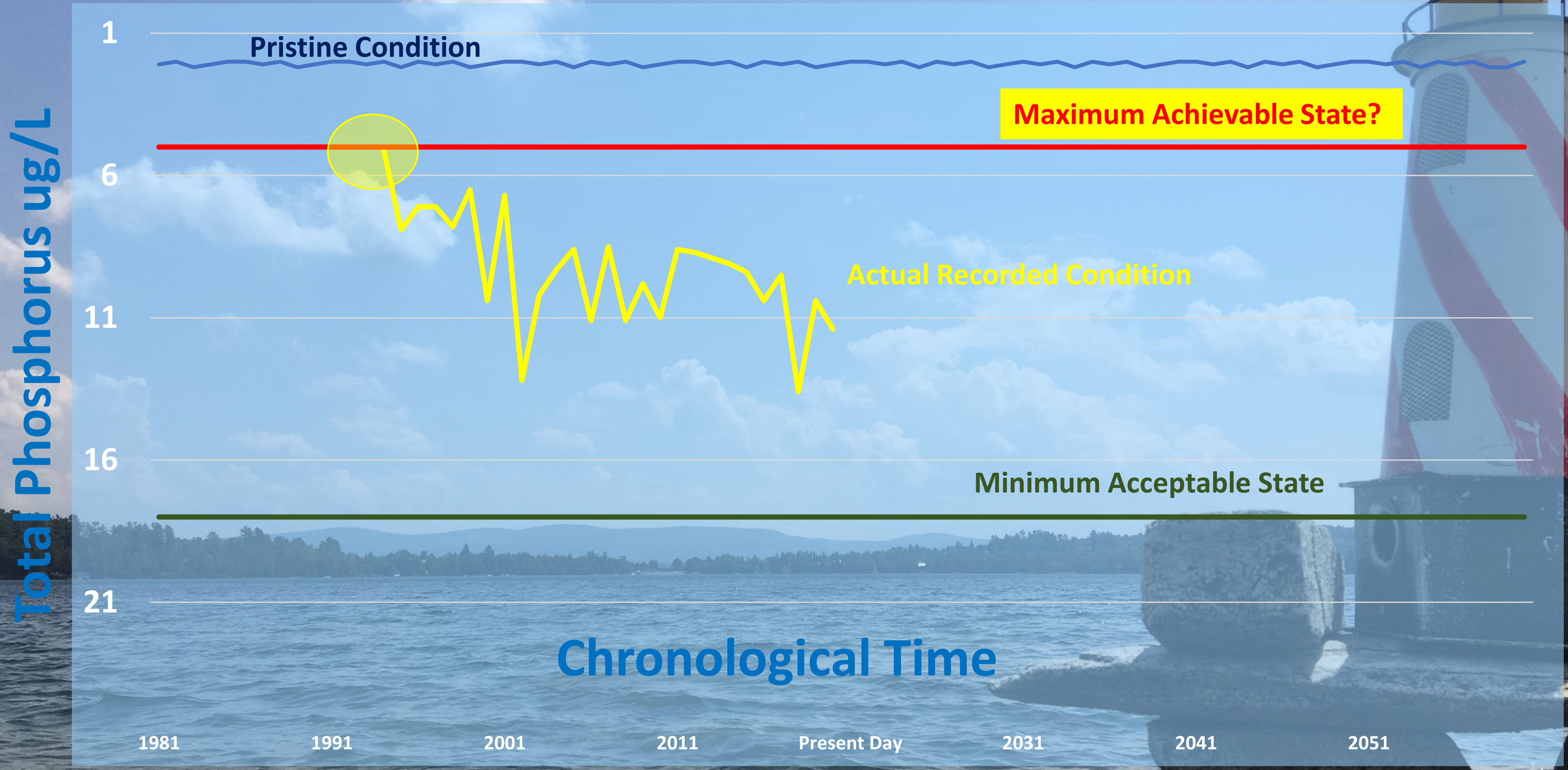

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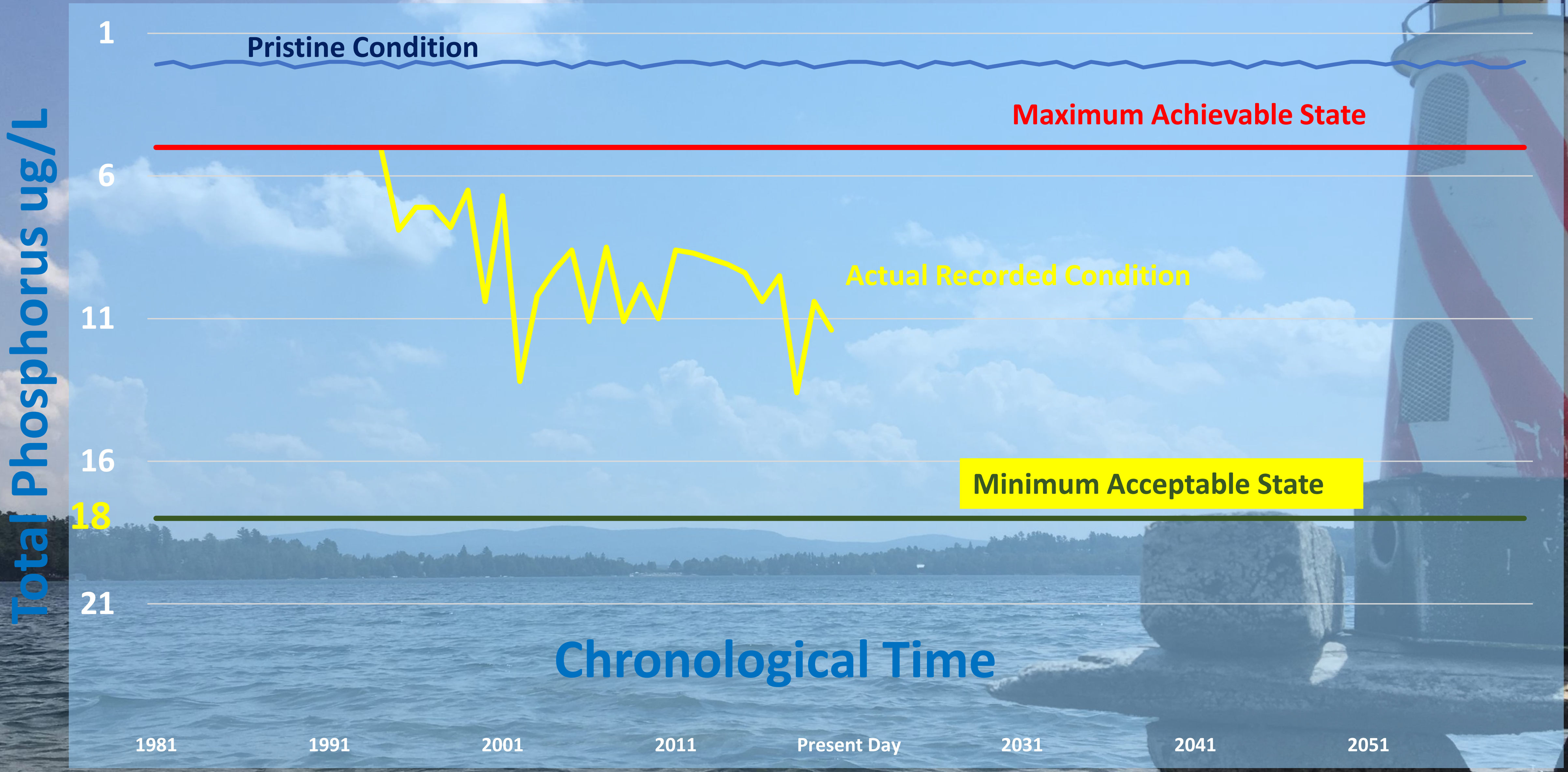

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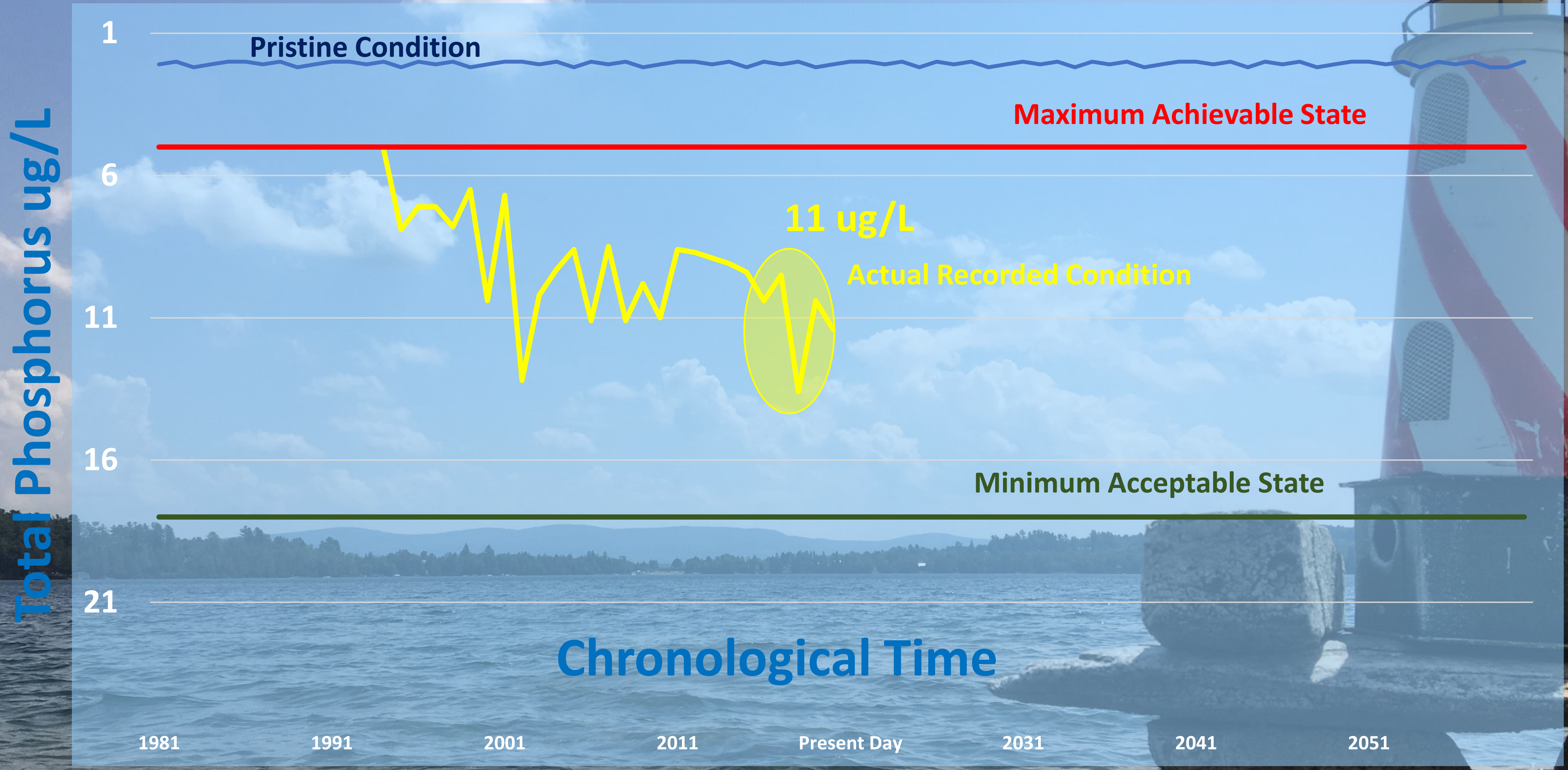


Adapted from Cairns et al, 1993 https://link.springer.com/article/10.1007/BF00006084

CASPIAN - data through 2020

Learn How Lakes Are Scored

Lake Area:
789.8 acres

Basin Lake Area Ratio:
6

Max Depth:
43.3 meters

Mean Spring TP:
7.4 ug/L

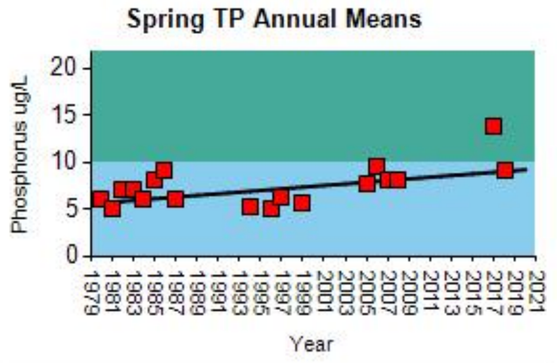
Mean Summer TP:
9.4 ug/L

Mean Summer Chla:
2.1 ug/L

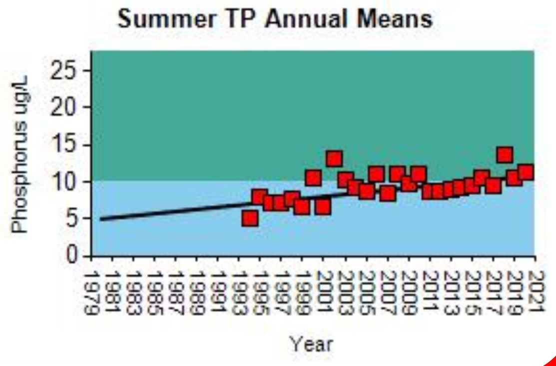
Mean Summer Secchi:
7.7 meters

Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic

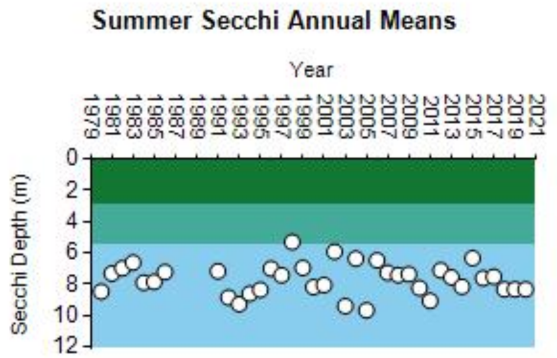
Spring TP Trend: p = 0.0182 | CV = 29
Significantly increasing



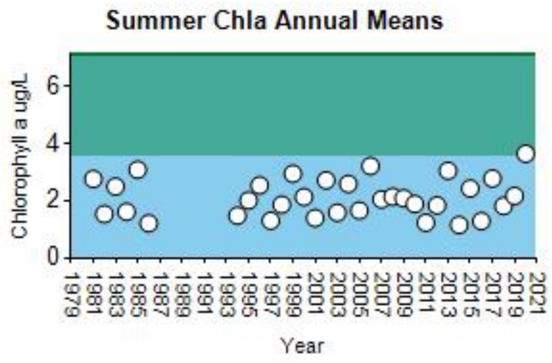
Summer TP Trend: p = 0.0012 | CV = 21
Highly significantly increasing



Summer Secchi Trend: p = 0.4632 | CV = 13
Stable



Summer Chla Trend: p = 0.6421 | CV = 31
Stable



Trend Score: Fair

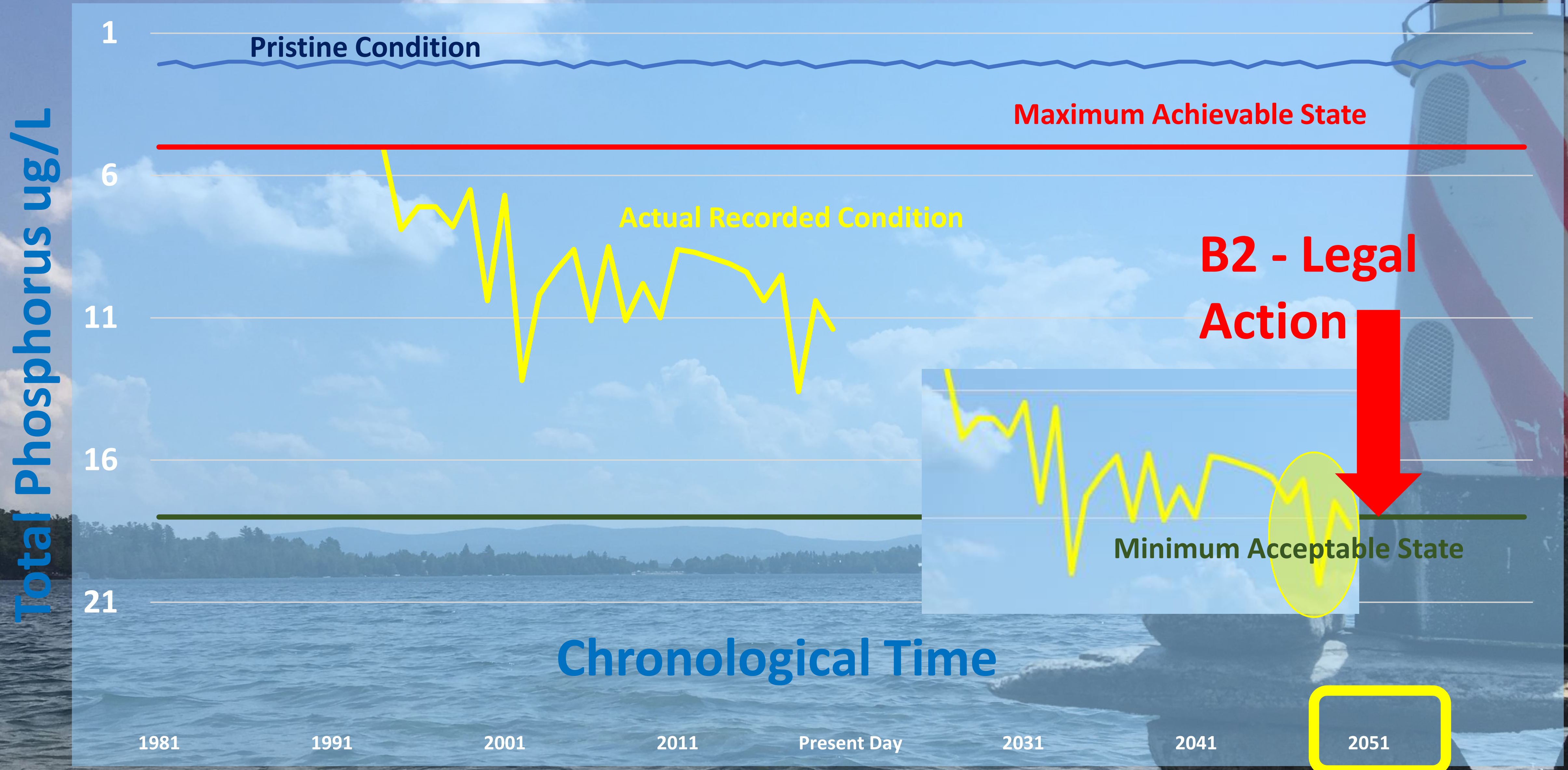
WQ Standards Status: Stressed

Watershed Score: Highly Disturbed

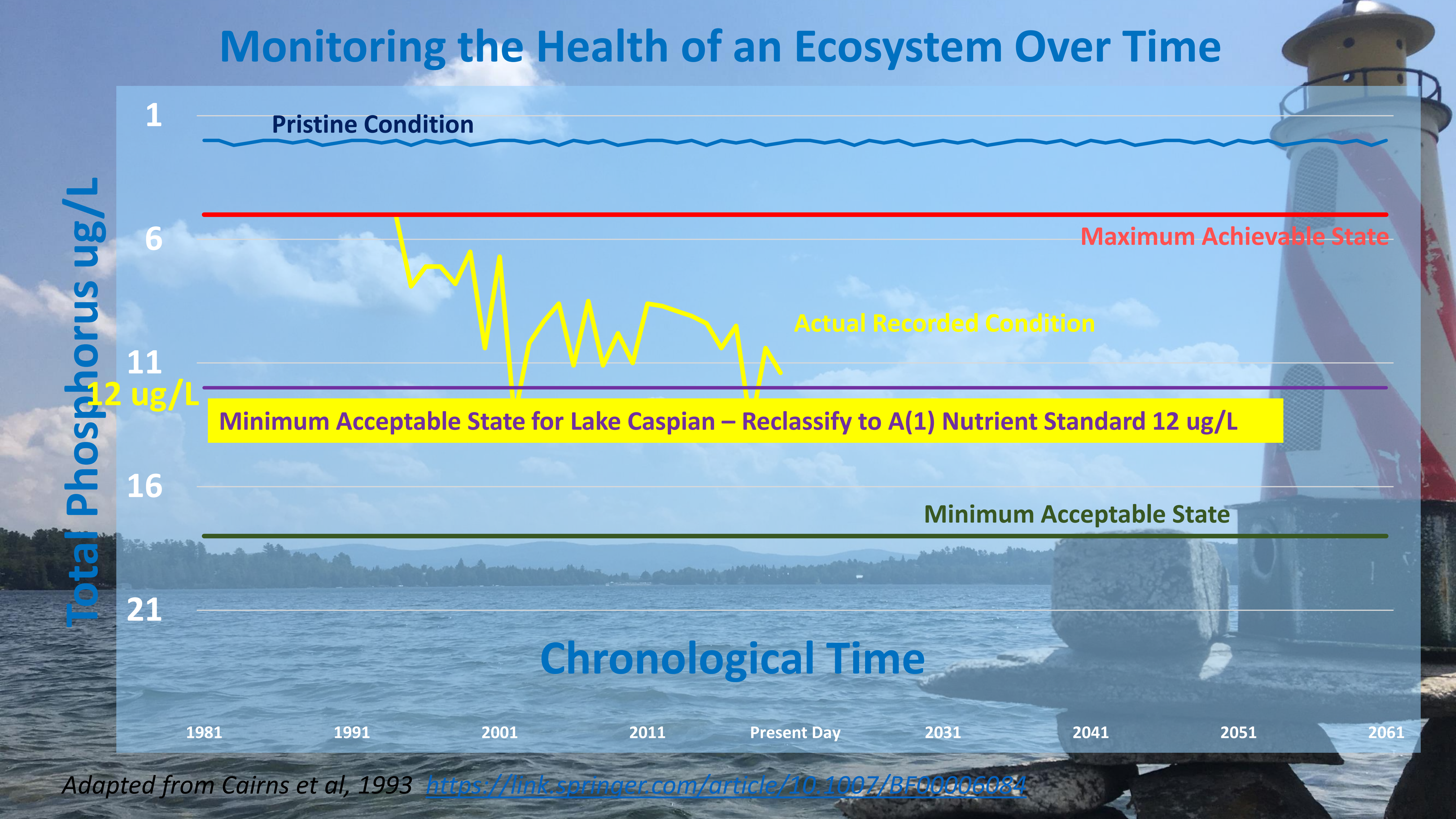
Stresses / Impairments

Stressed -- Flow alteration

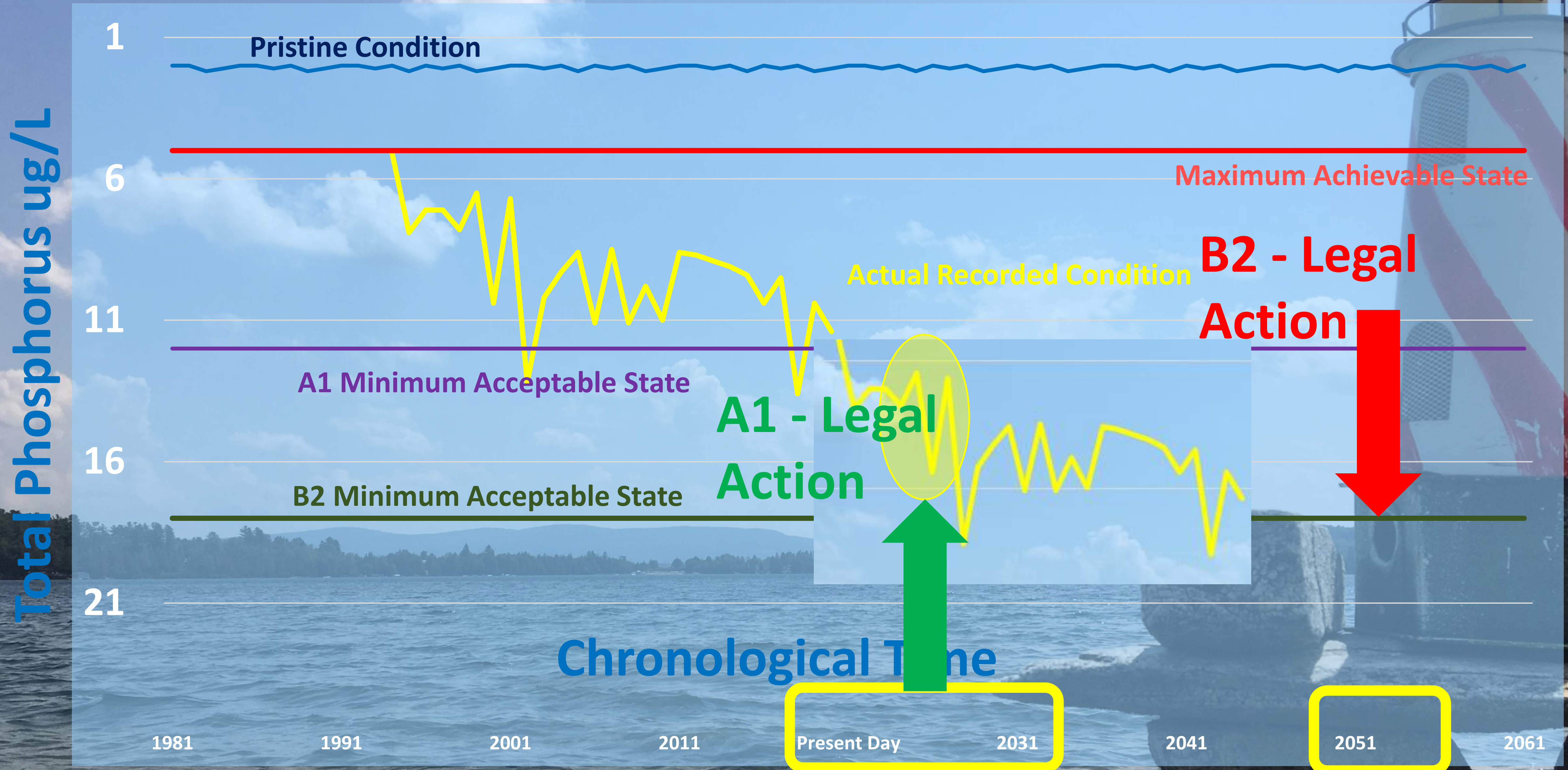
Monitoring the Health of an Ecosystem Over Time



Adapted from Cairns et al, 1993 https://link.springer.com/article/10.1007/BF00006084


Monitoring the Health of an Ecosystem Over Time
Total Phosphorus ug/L
1
6
11
12 ug/L
16
21
Pristine Condition
Maximum Achievable State
Actual Recorded Condition
Minimum Acceptable State for Lake Caspian – Reclassify to A(1) Nutrient Standard 12 ug/L
Minimum Acceptable State
Chronological Time
1981
1991
2001
2011
Present Day
2031
2041
2051
2061
Adapted from Cairns et al, 1993 https://link.springer.com/article/10.1007/BF00006084

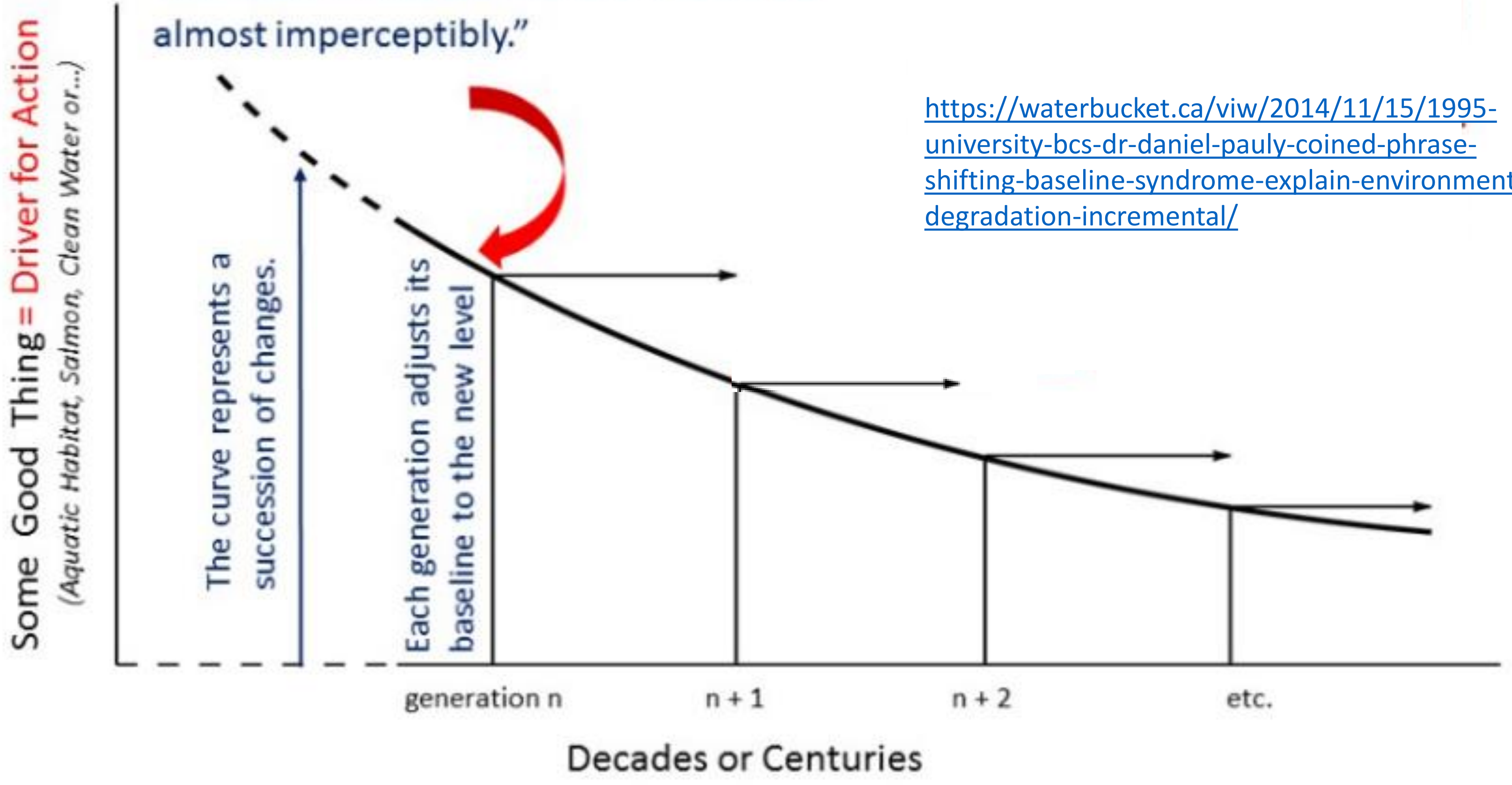
Monitoring the Health of an Ecosystem Over Time



Adapted from Cairns et al, 1993 https://link.springer.com/article/10.1007/BF00006084

In 1995, Dr. Daniel Pauly coined the phrase
"Shifting Baseline Syndrome"

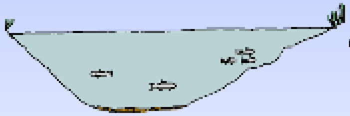
"With each new generation, the expectation of various ecological conditions shifts. The result is that standards are lowered almost imperceptibly."



https://waterbucket.ca/viw/2014/11/15/1995-university-bcs-dr-daniel-pauly-coined-phrase-shifting-baseline-syndrome-explain-environmental-degradation-incremental/

Vermont is Stewarding a Higher Proportion of Oligotrophic Lakes than the Nation, 2007 NLA

Oligotrophic Lakes



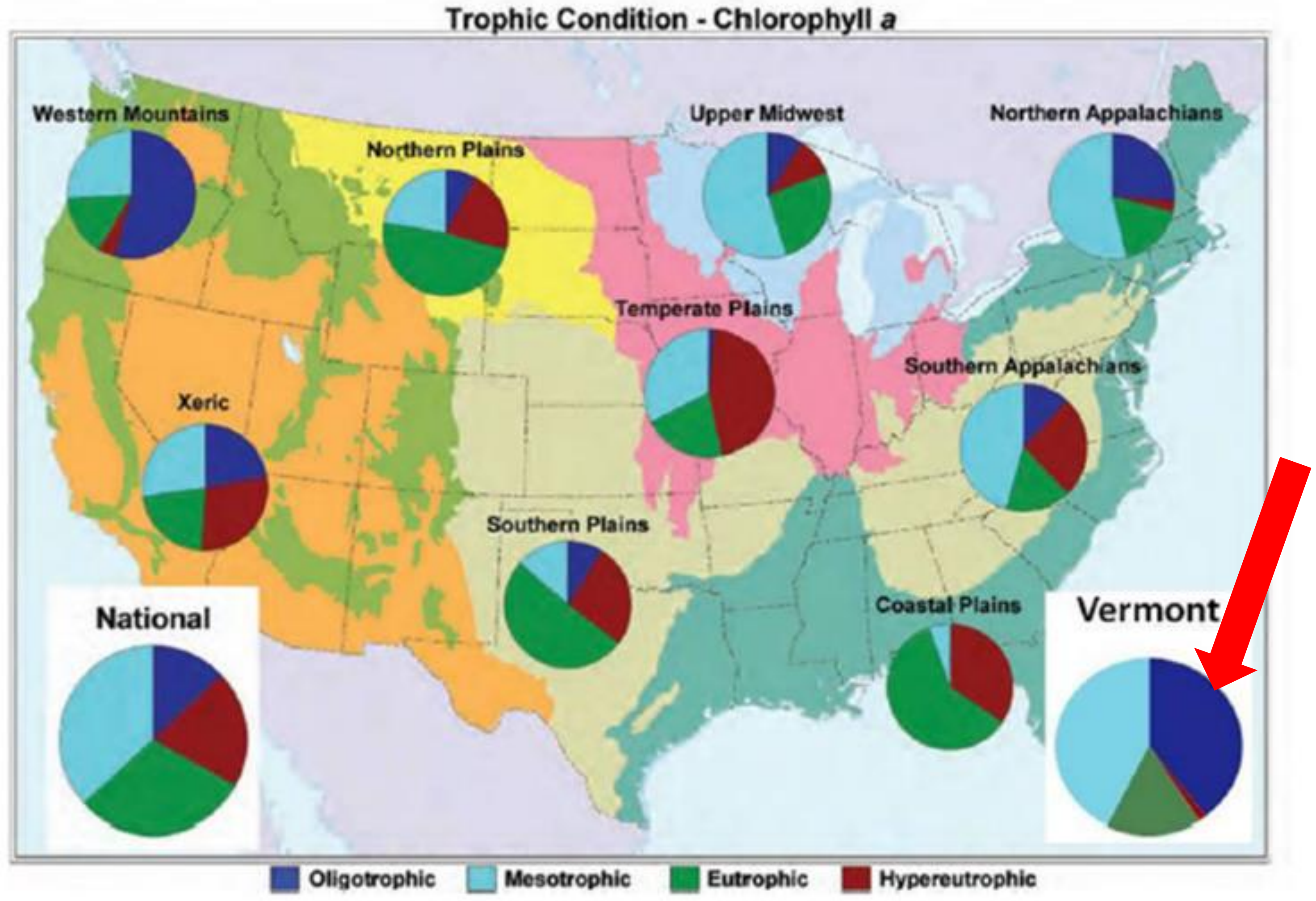
- Low nutrient enrichment = very little plant and algae growth
- Clear water
- Supports coldwater fish species

Mesotrophic Lakes

- Moderate nutrient enrichment = some plant and algae growth
- Moderate water clarity
- Supports mostly warmwater fish species

Eutrophic Lakes

- High nutrient enrichment = abundant plant and algae growth
- Reduced water clarity
- Only supports warmwater fish species



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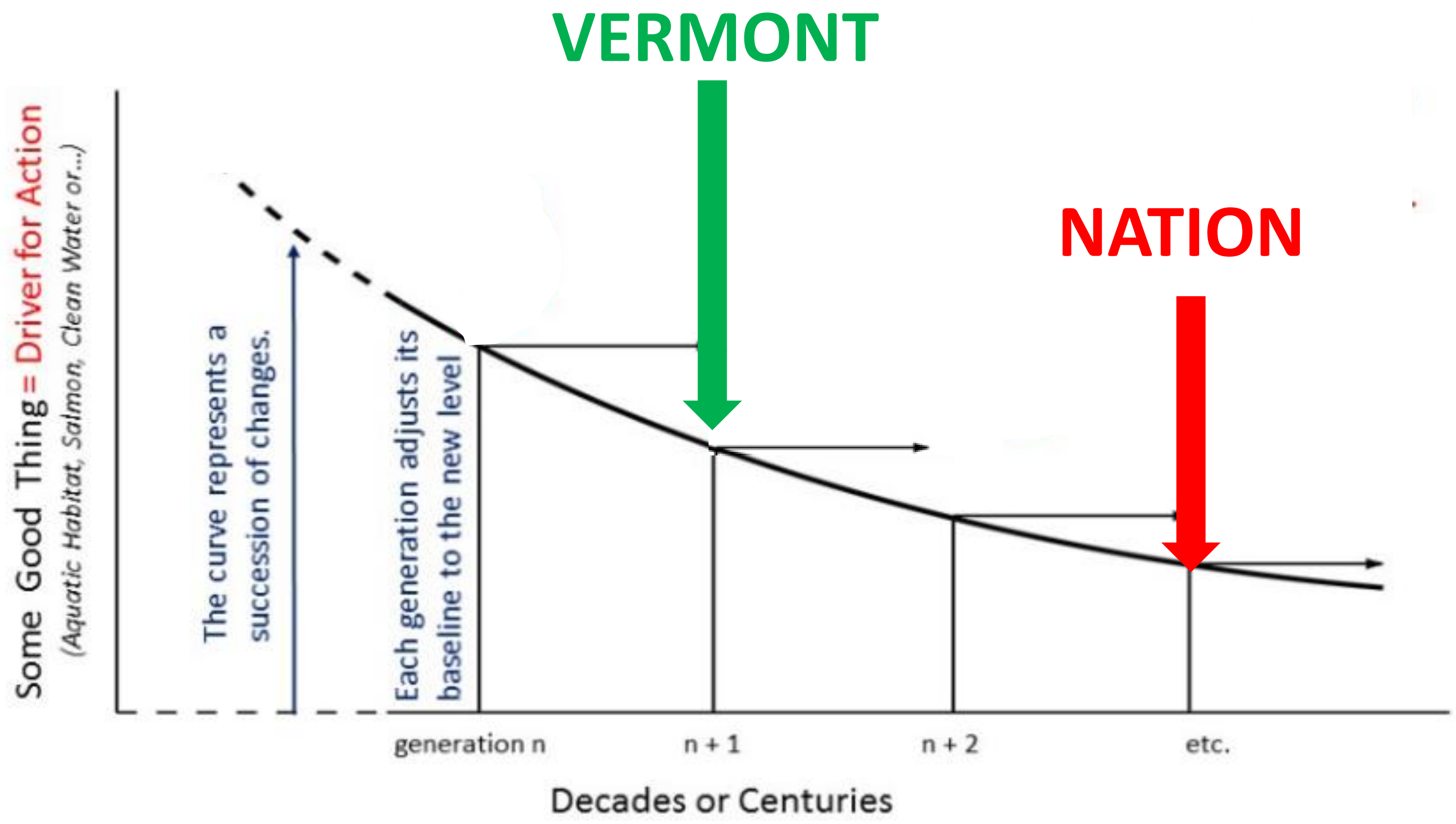
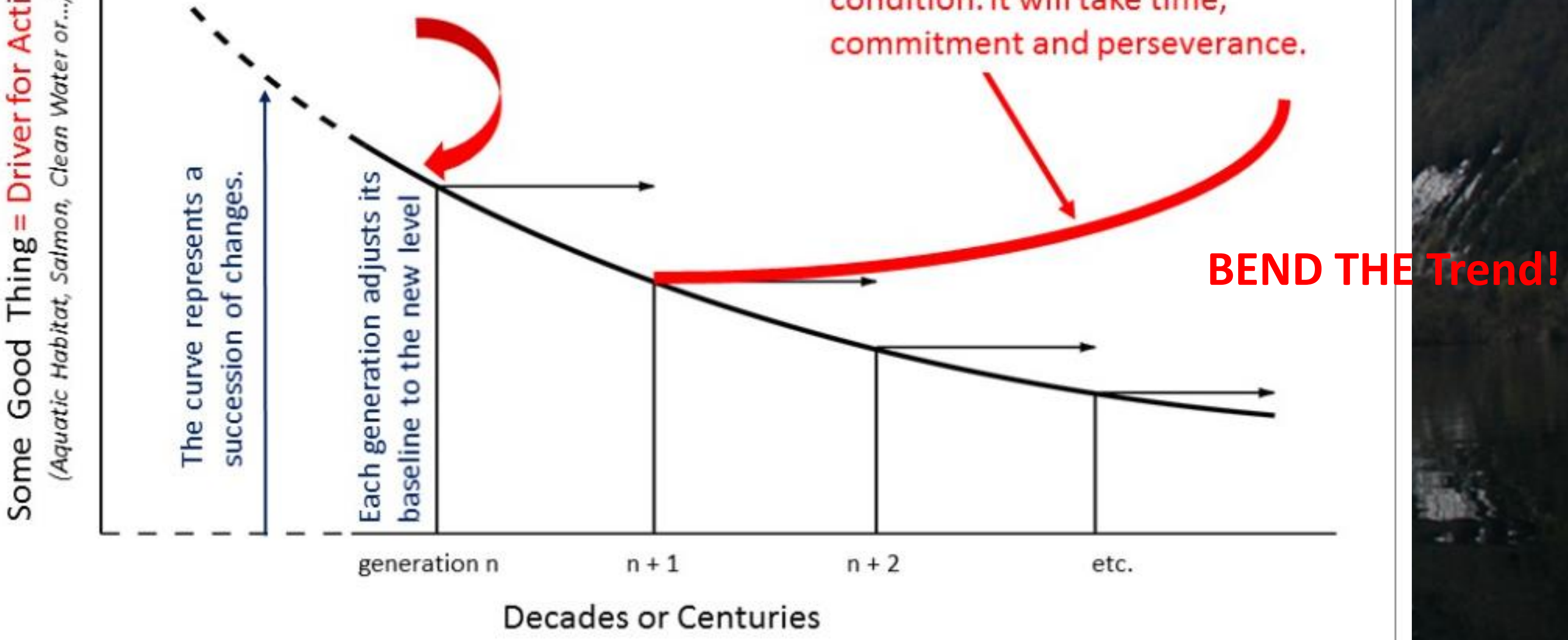


In 1995, Dr. Daniel Pauly coined the phrase

"Shifting Baseline Syndrome"

"With each new generation, the expectation of various ecological conditions shifts. The result is that standards are lowered almost imperceptibly."

We can shift the baseline by replicating a desired watershed condition. It will take time, commitment and perseverance.



Carmi is not Champlain is not Memphremagog is not Ticklenaked

“You’ve Seen One Lake…..You’ve Seen One Lake” Terry Rees - Executive Director - Federation of Ontario Cottagers' Associations GLEON Plenary 2019

Similarly, Willoughby is not Raponda is not Maidstone is not Caspian

‘One size fits all’ does not work for those lakes we list as not meeting the aesthetic criteria, nor will it work for lakes we list as meeting Tier 2 aesthetic A1 antidegradation criteria

So, what’s the plan? Use the same approach for reclassification that we do for listing a lake as impaired

- Reclassify (or list lake) as A1
- Set in motion the requirement that a **<u>protection plan</u>** be tailored to the lake, similar to our lake watershed action plans and TMDL phosphorus reduction plans

Example Protection Plan Steps

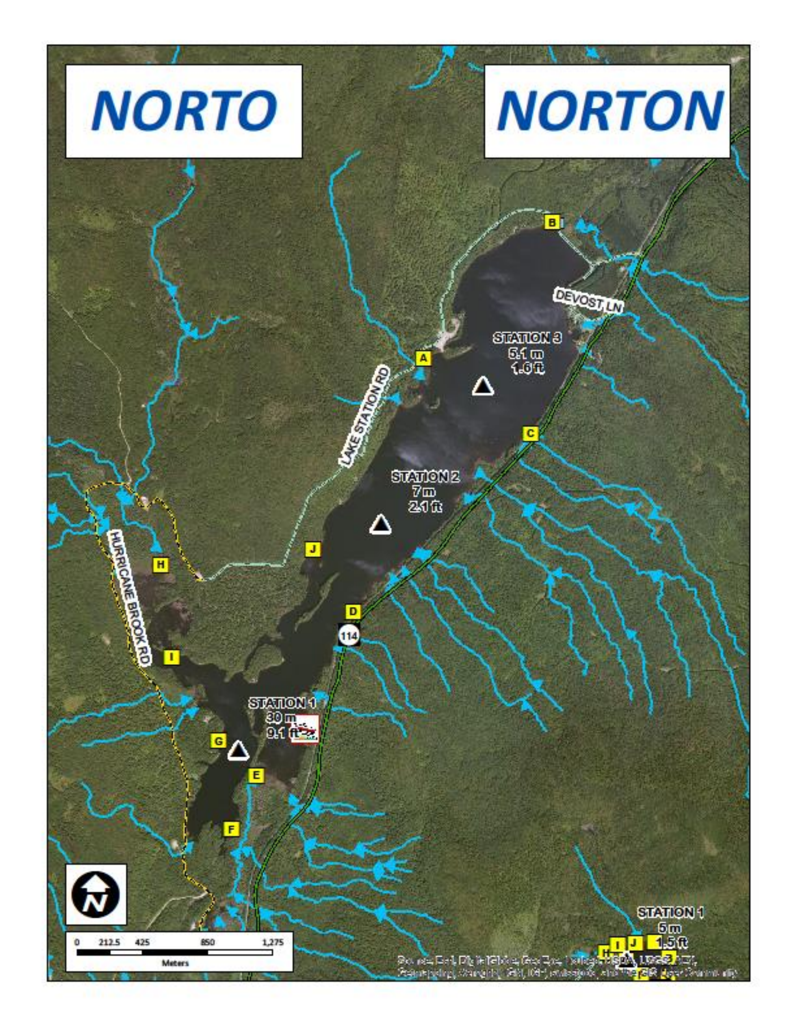
1. **Determine where the phosphorus is coming from** and a develop an action plan for the lake
2. Develop remedial intervention options
3. Implement the preferred options
4. Monitor for compliance and effectiveness

Determining where the phosphorus is coming from

1. Next Generation Lake Assessment Reports

2. High Resolution (0.5m) Mapping

VTDEC Summer Lake Assessment
Inland Lake Monitoring



- Purpose is to monitor status
- 5 – 50 lakes per year
- Semi-Quantitative Assessments since 1989
- Next Generation Quantitative Assessments since 2010, Samples
    - Index Site (Deep Hole)
    - 10 Physical Habitat (PHAB) sites
    - Inlets & Outlets

VTDEC Summer Lake Assessment
Inland Lake Monitoring Index Site (Deep Hole)

Parameter	Year Started
Gran Alk, Dissolved Oxygen, Secchi, Temperature, TP, Conductivity, pH	1989
Reg Alk	1991
TFe	1994
Chlorophyll *a*	1997
TCa, TMg, TK, TNa	1999
Color	2000
TN, DCl, TAl, TSO4	2001
TotalHardness, TMn	2004
NTU, DSi	2007
TCL & Sediment Diatoms	2011
DOC, DOM and Phytoplankton	2019

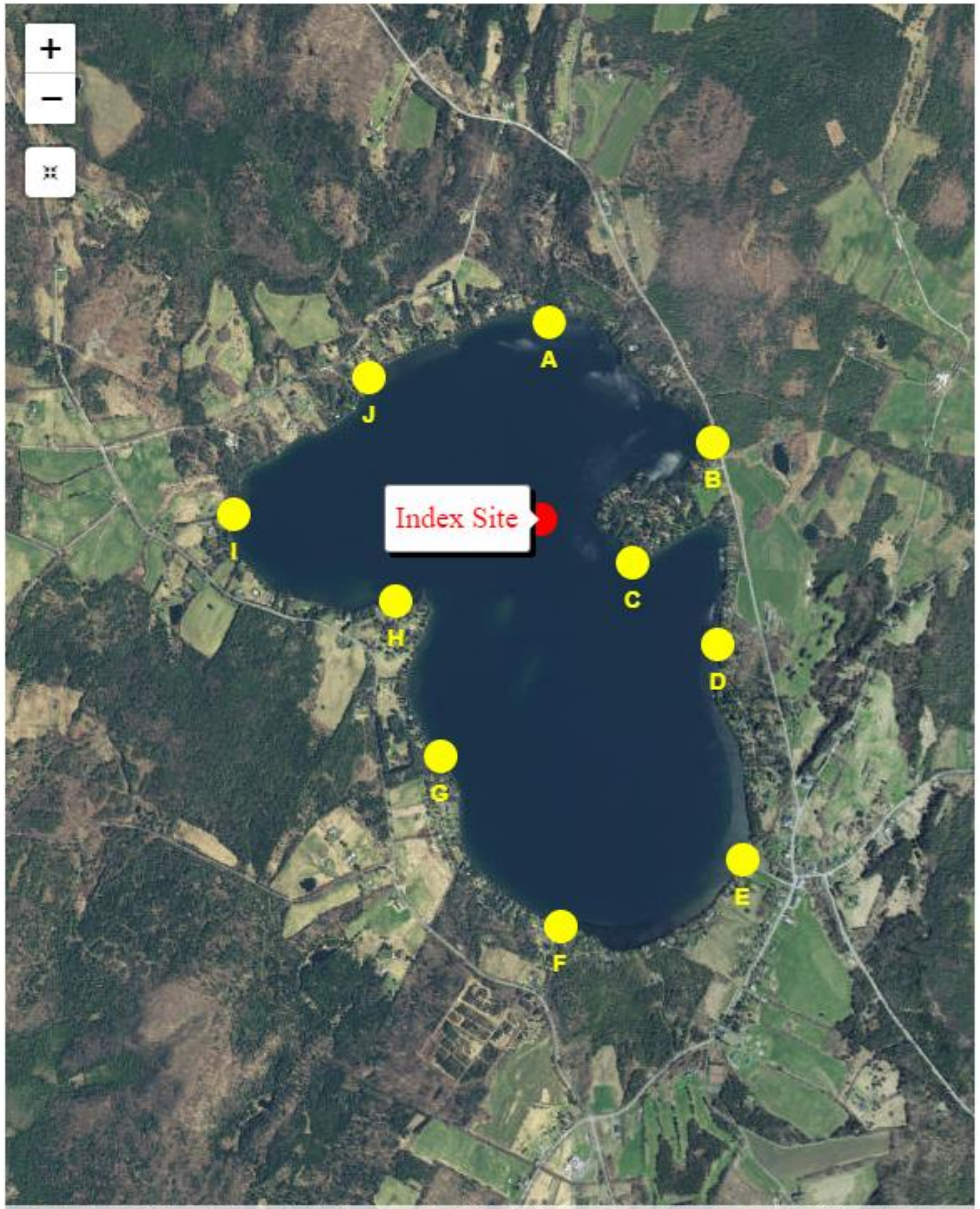
VTDEC Summer Lake Assessment Inland Lake Monitoring (Tribs and PHAB Sites)

Parameter	Location(s) measured
Conductivity, Dissolved Oxygen, DO%, pH, Temperature C, TN, TP, TCl, Chlorophyll a, & DOM	Tributaries and Outlet
Physical habitat complexity, shallow water habitat, lakeshore habitat, lakeshore disturbance, Embeddedness, % Sand, % trees along shore, and shading	10 random sites around the lake
Crayfish	3 sites with good crayfish habitat
Aquatic plants, algae	10 random sites around the lake and tributaries
Area and depth of deltas	Tributaries and sites of significant erosion

Next Generation Lake Assessment Reports

Lake Assessment Report | CASPIAN | Water Quality | Habitat | Inlets | Protection Classification | Data

Survey Date 07/29/2019



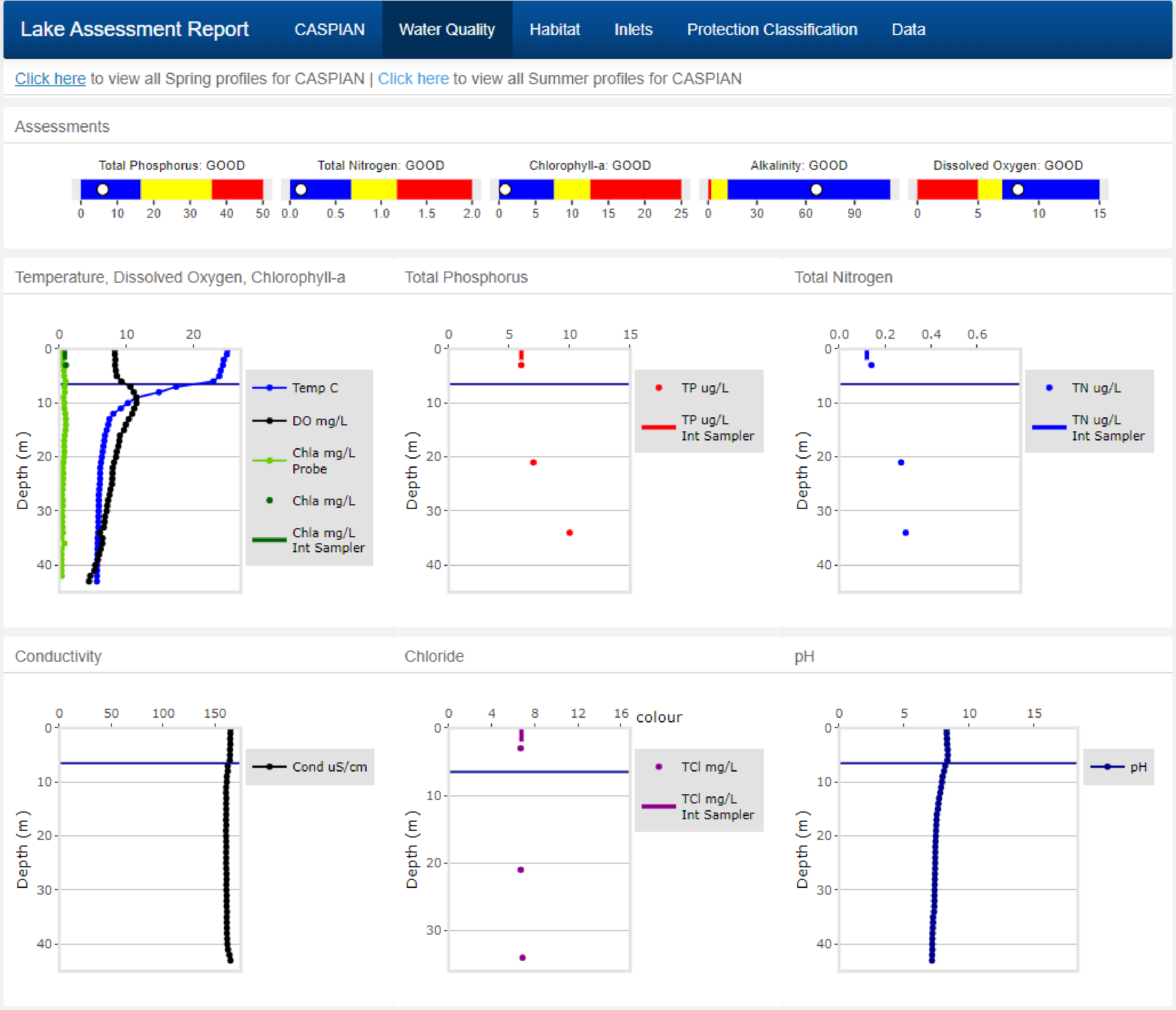
Leaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community

CASPIAN Report Card

Total Phosphorus	GOOD
Total Nitrogen	GOOD
Chlorophyll-a	GOOD
Alkalinity	GOOD
Dissolved Oxygen	GOOD
Lakeshore Disturbance	FAIR
Lakeshore Habitat	POOR
Shallow Water Habitat	POOR
Physical Complexity of Habitat	POOR

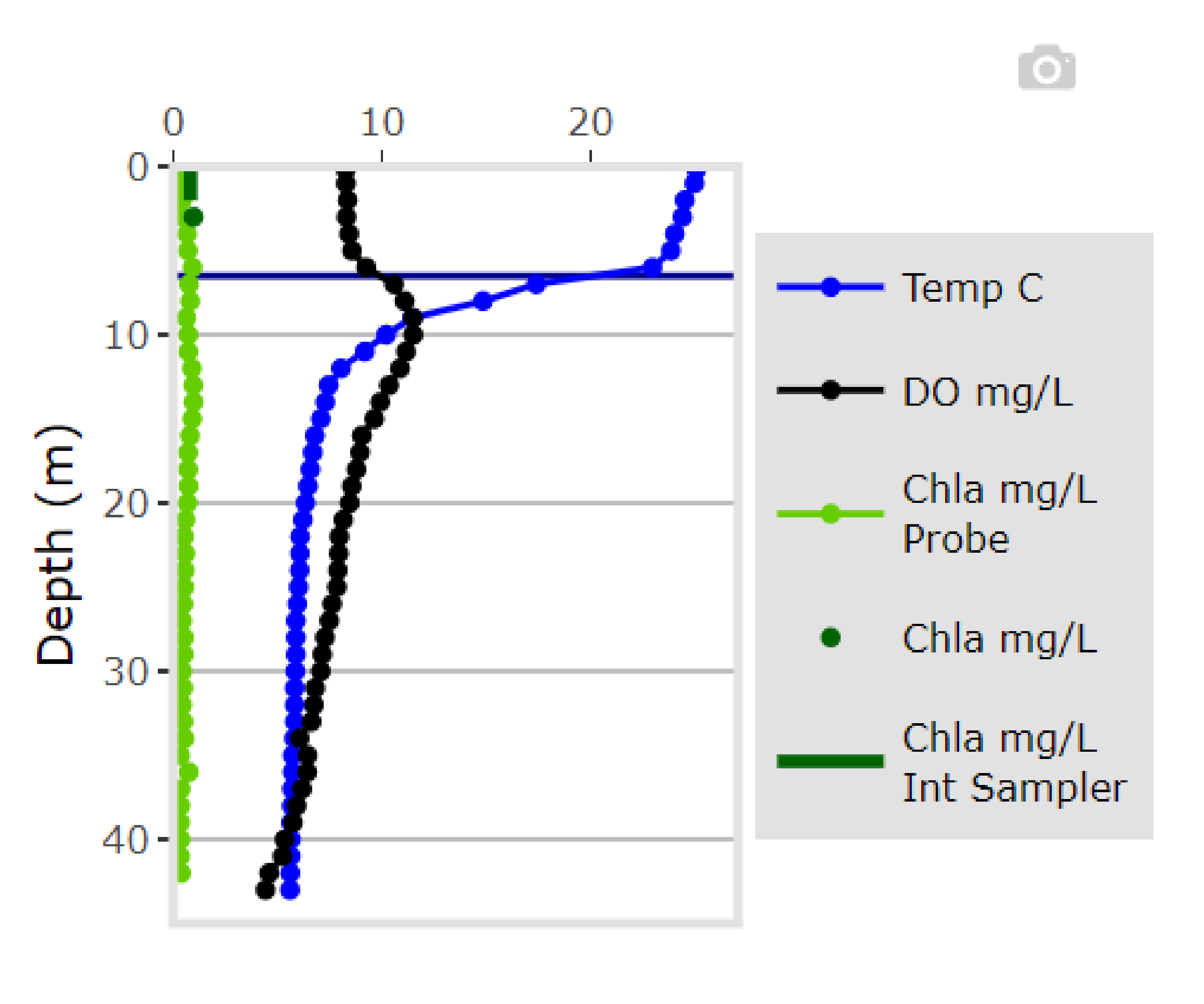
For more information about how lakes are scored, see: Gauging the health of Vermont Lakes: Results of the 2007 National Lake Assessment

Next Generation Lake Assessment Reports

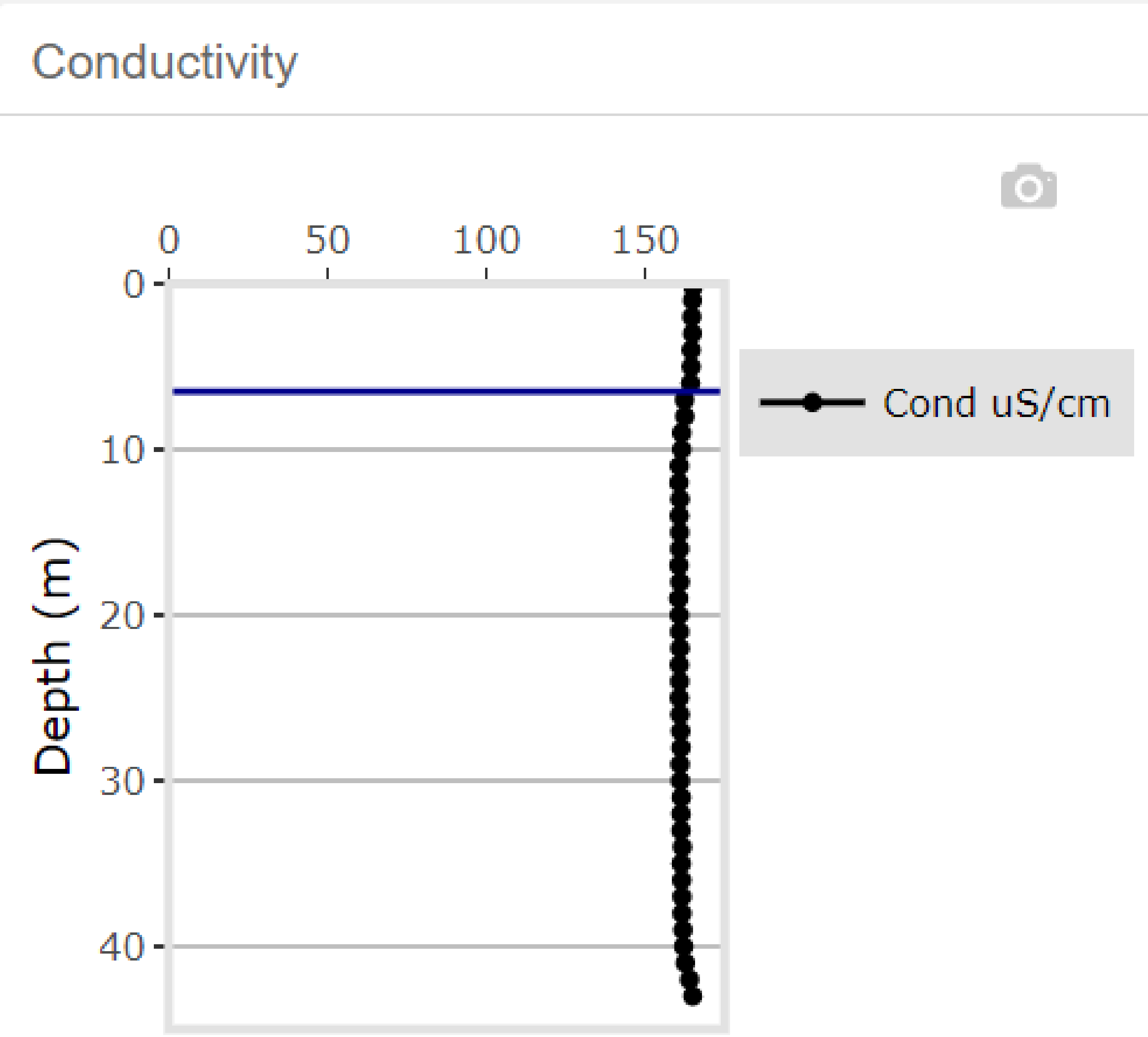


Next Generation Lake Assessment Reports

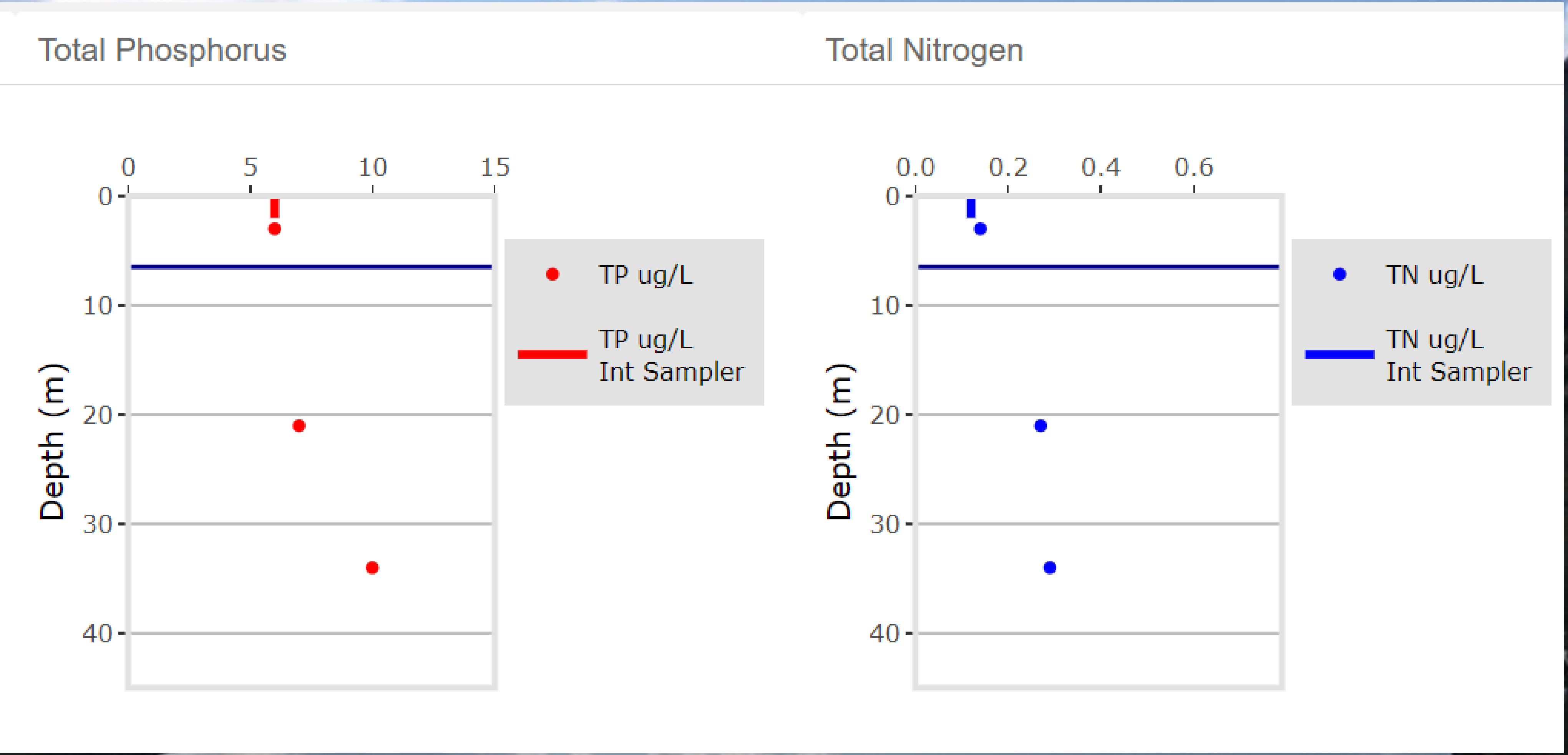
Temperature, Dissolved Oxygen, Chlorophyll-a



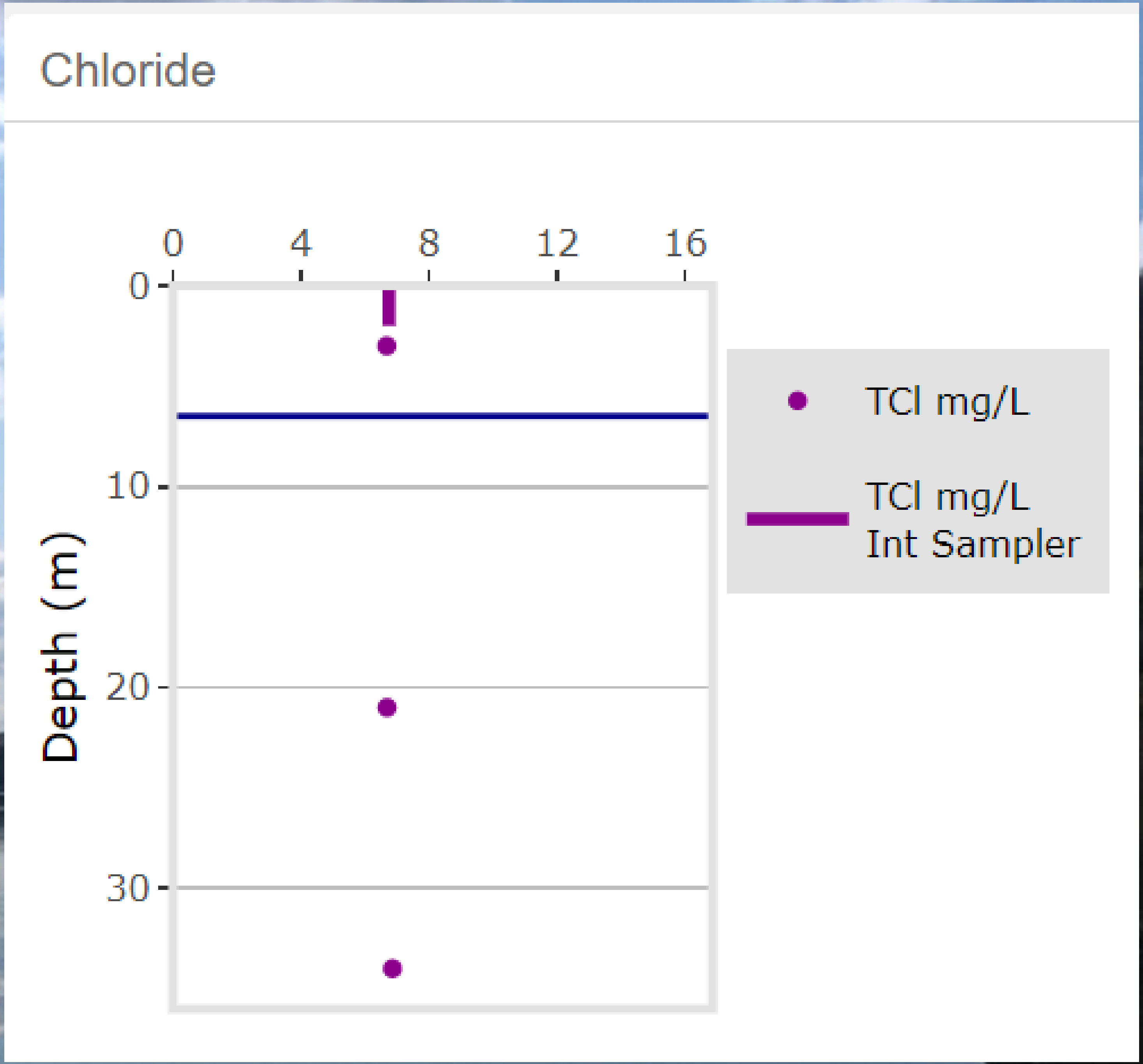
Next Generation Lake Assessment Reports



Next Generation Lake Assessment Reports

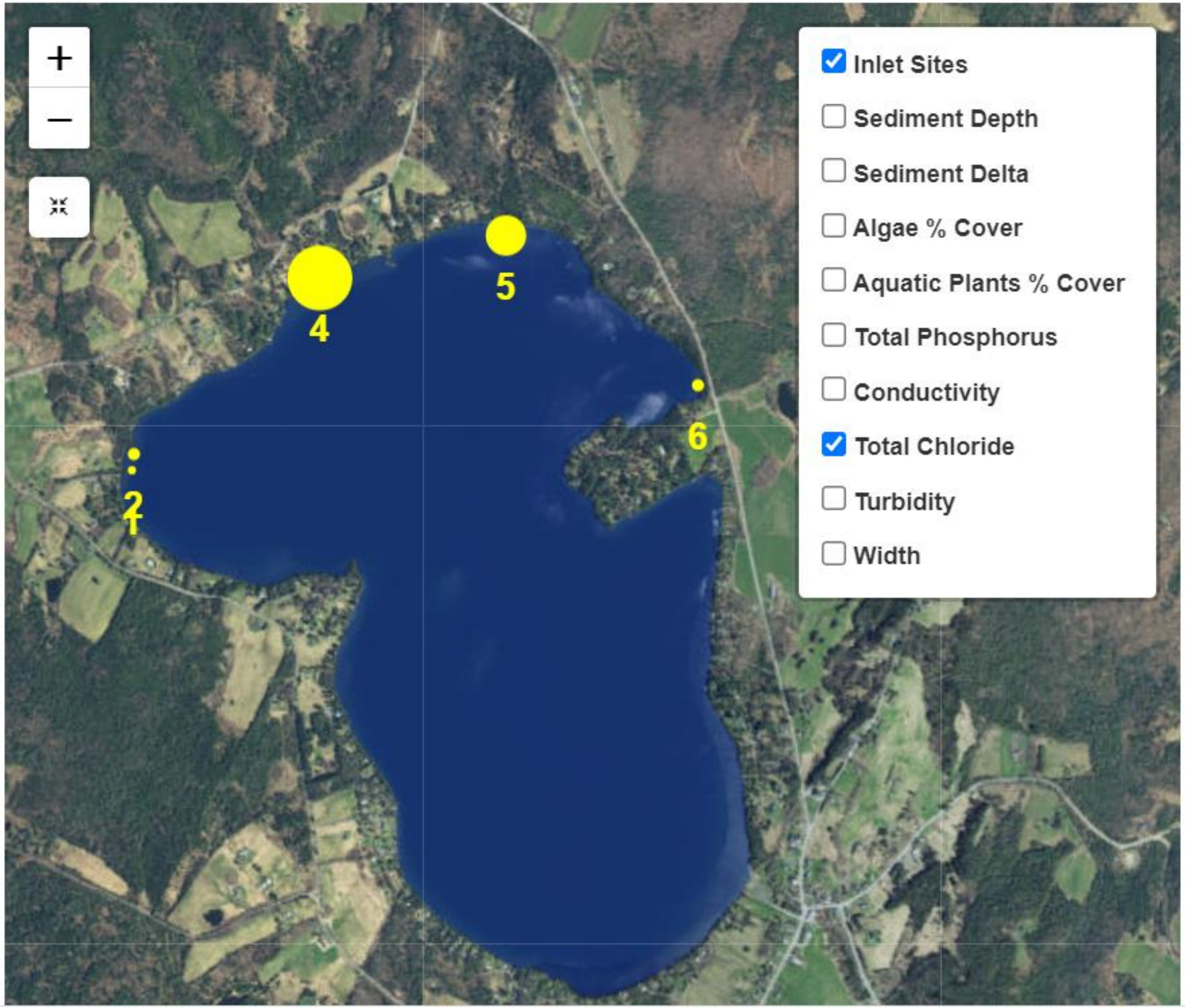


Next Generation Lake Assessment Reports



Lake Assessment Report | CASPIAN | Water Quality | Habitat | Inlets | Protection Classification | Data

Inlets Map



Water Quality Data | Physical Characteristics | Macrophyte

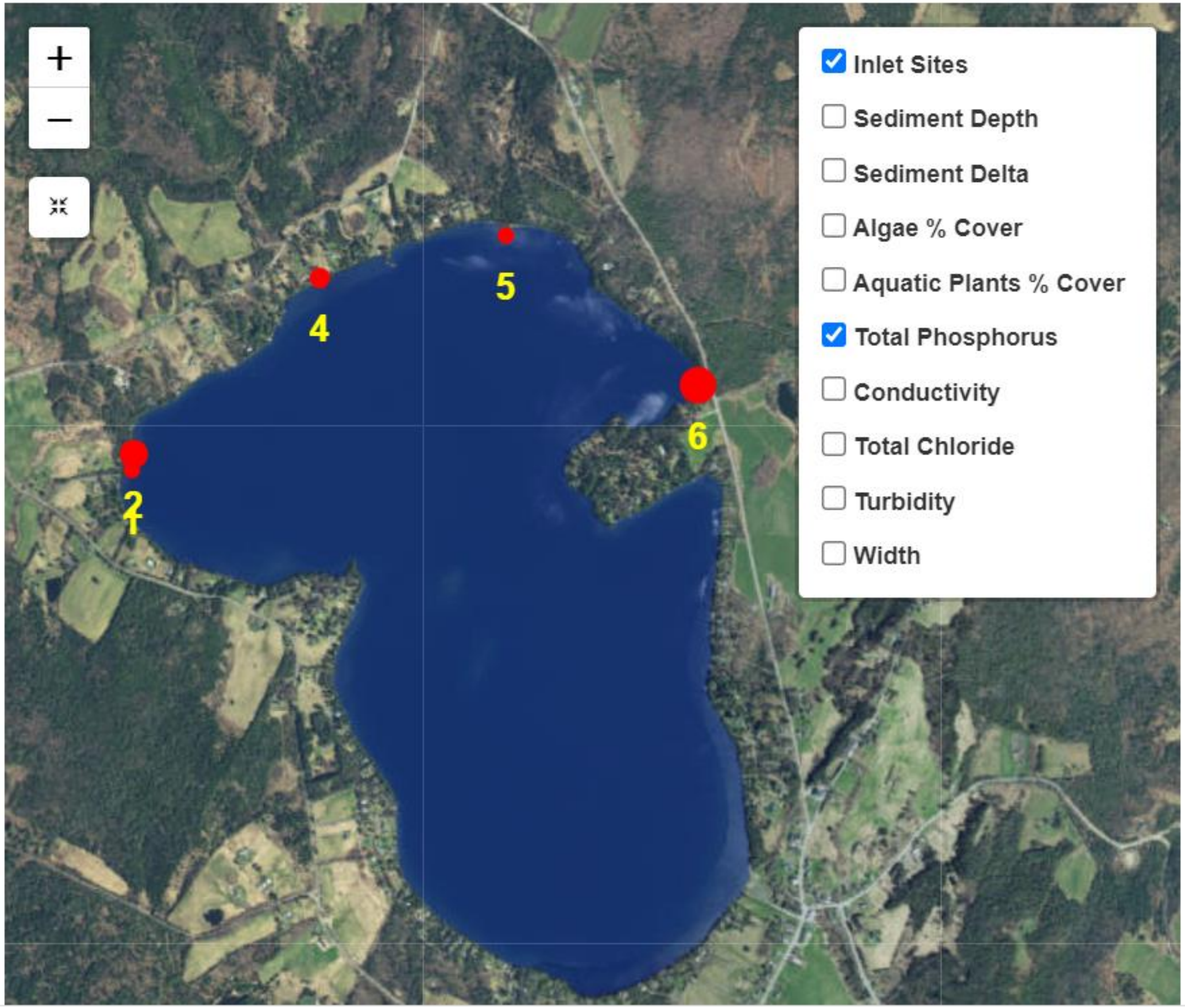
Analytical Data

InletNo	TP (ug/L)	TN (mg/L	TCl (mg/L)
1	12	0.28	2.00
2	22	0.58	3.12
4	16	0.29	15.50
5	12	0.57	9.96
6	28	0.36	2.93

Hydrolab Data

InletNo	Conductivity uS/cm	Turbidity NTU	Temp C	DO mg/L	DO %	pH	Chla (ug/L)
1	164.0	0.37	20.51	7.33	85.6	7.60	0.78
2	219.1	1.48	19.97	6.01	69.4	7.22	1.07
4	253.5	1.39	22.32	7.45	90.2	7.55	2.90
5	263.1	0.36	19.46	8.79	100.5	7.81	0.89
6	210.1	2.34	24.54	7.83	98.8	7.94	3.30

Inlets Map



Water Quality Data | Physical Characteristics | Macrophytes

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Lake Assessment Report | CASPIAN | Water Quality | Habitat | Inlets | Protection Classification | Data

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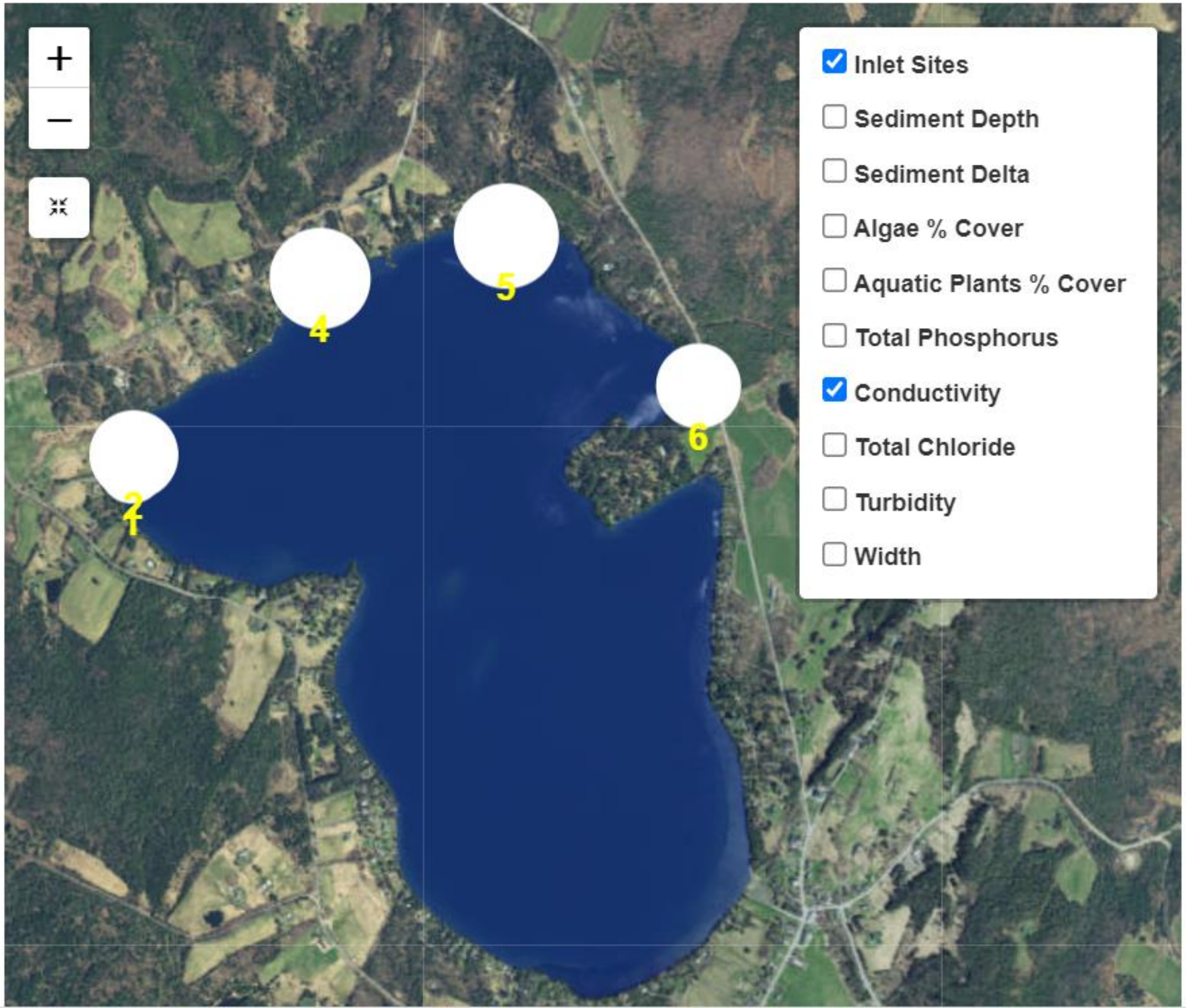

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Next Generation Lake Assessment Reports

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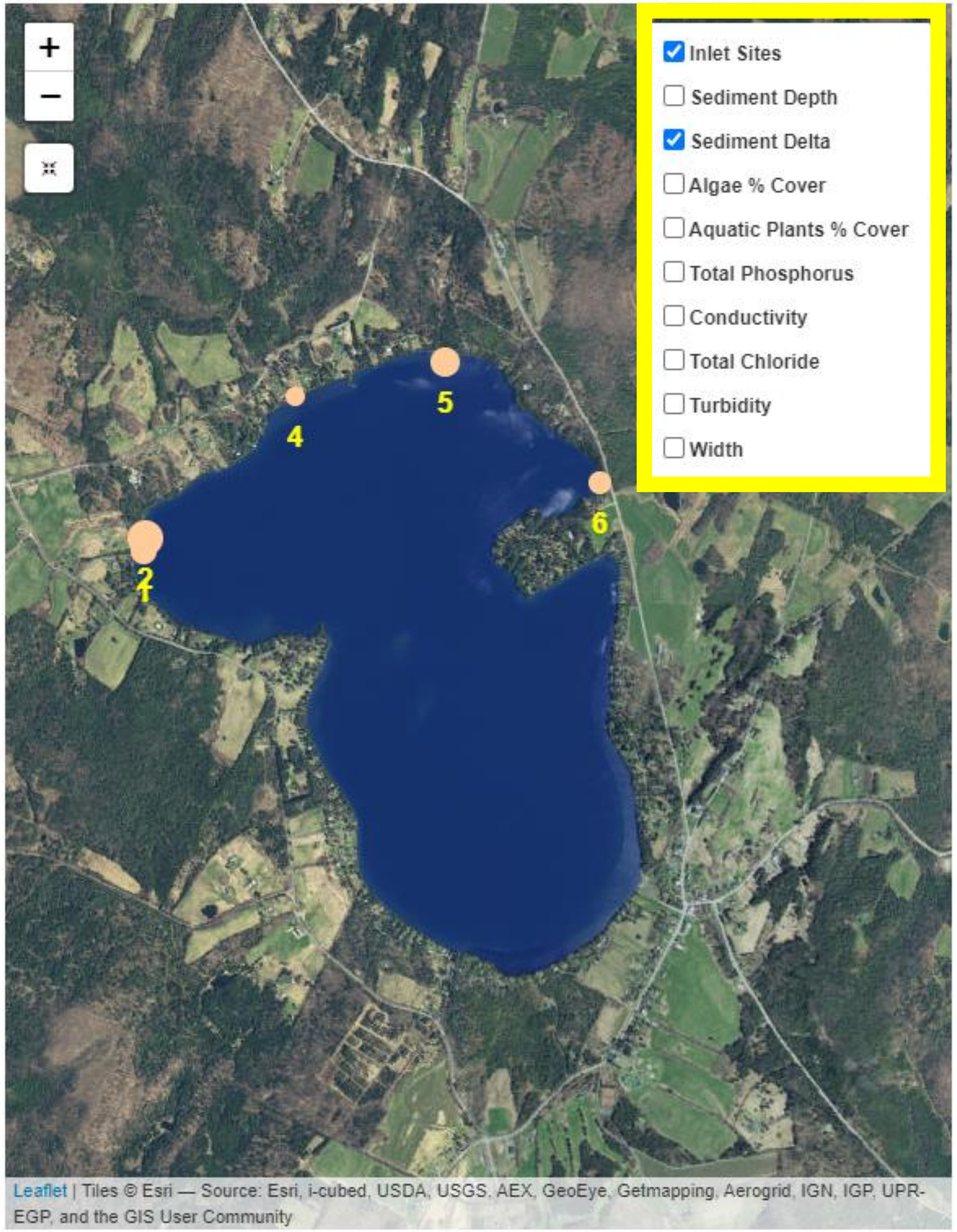


Water Quality Data | Physical Characteristics | Macrophytes

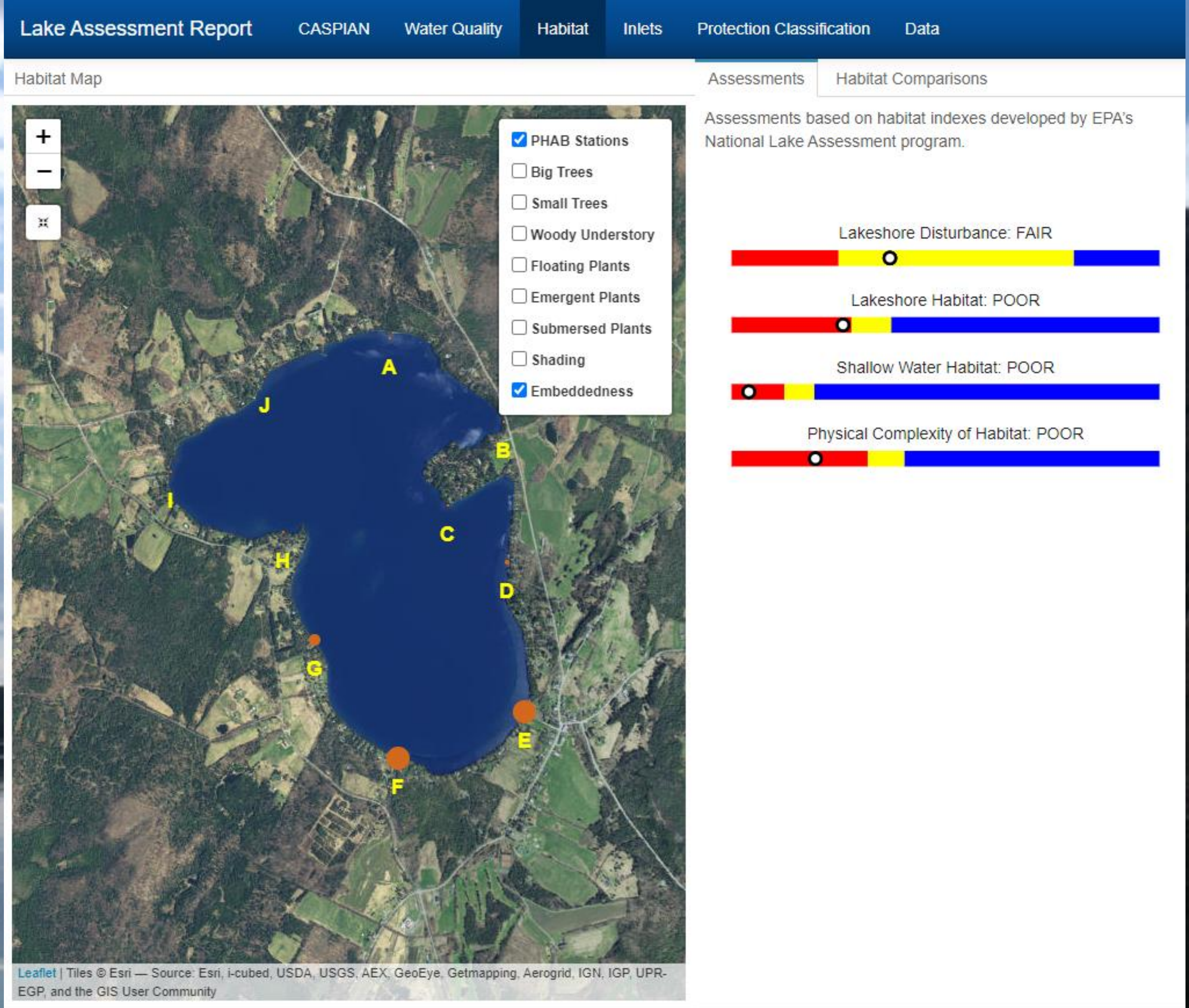
Sediment and Algae

InletNo	Sediment Depth (cm)	Sediment Delta (sq meters)	Algae %Cover
1	30	48	1
2	40	308	1
4	70	24	0
5	30	80	3
6	40	30	0

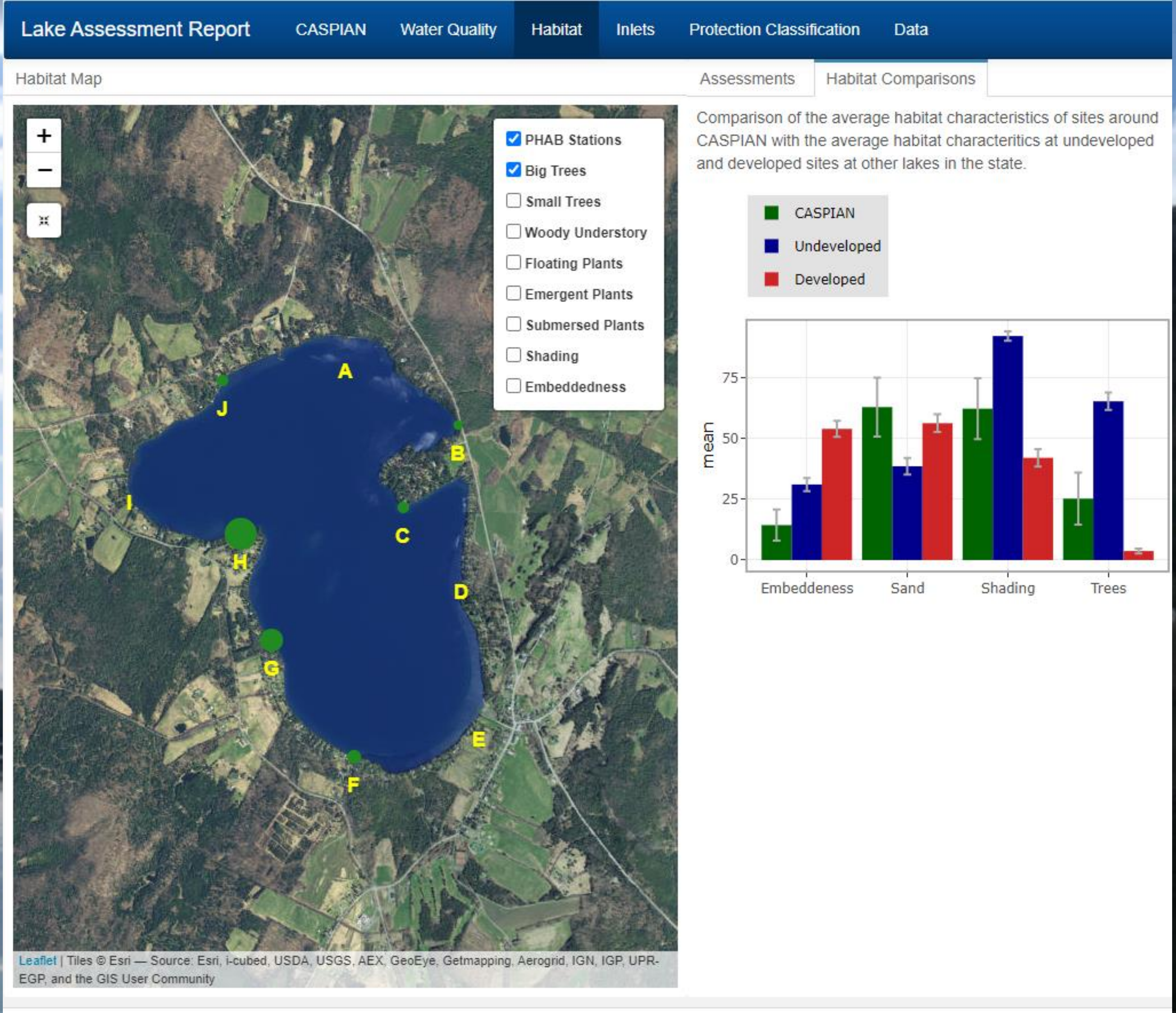
Aquatic Plants

InletNo	Plants %Cover	Dominant Plant 1	Dominant Plant 2	Dominant Plant 3
1	0.0	NA	NA	NA
2	3.6	Potamogeton zosteriformis	Najas sp.	Sparganium sp.
4	1.0	Chara sp.	NA	NA
5	3.0	Potamogeton zosteriformis	Potamogeton gramineus	Potamogeton epihydrus
6	0.0	NA	NA	NA

Next Generation Lake Assessment Reports



Next Generation Lake Assessment Reports



Lake Assessment Report | CASPIAN | Water Quality | Habitat | Inlets | Protection Classification | Data

CASPIAN Lake Protection Classification

Category	Score	Feature	Present
Wilderness Score	0	Beach	1
Wilderness-Like Score	0	Ledge	0
		Bouldered Shore	0
		Vegetation	0
		Islands	0
		Steep Slopes	0
		Peaks	0
		Scenic Bottom	1
		Cliffs	0
		# Total Features	2

Next Generation Lake Assessment Reports

Next Generation Lake Assessment Reports

Lake Assessment Report | CASPIAN | Water Quality | Habitat | Inlets | Protection Classification | Data

Chemistry | Lakeshore and Littoral Habitat | Inlet Habitat

Copy | CSV | Excel | Print | Show 10 entries | Search:

	LakeID	ProjectID	LakeStationNo	CharacteristicID	Depth	CollectionMethodID	Result	UnitCode
	All	All	All	All	A	All		
1	CASPIAN	LakeAsmt	1	Chla	2	IntSampler	0.8	ug/l
2	CASPIAN	LakeAsmt	1	Chla	3	PlasticKemm	1	ug/l
3	CASPIAN	LakeAsmt	1	ChlaProbe	0.2	Hydrolab	0.3	ug/l
4	CASPIAN	LakeAsmt	1	ChlaProbe	1	Hydrolab	0.4	ug/l
5	CASPIAN	LakeAsmt	1	ChlaProbe	2	Hydrolab	0.4	ug/l
6	CASPIAN	LakeAsmt	1	ChlaProbe	3	Hydrolab	0.5	ug/l
7	CASPIAN	LakeAsmt	1	ChlaProbe	4	Hydrolab	0.7	ug/l
8	CASPIAN	LakeAsmt	1	ChlaProbe	5	Hydrolab	0.7	ug/l
9	CASPIAN	LakeAsmt	1	ChlaProbe	6	Hydrolab	0.9	ug/l
10	CASPIAN	LakeAsmt	1	ChlaProbe	7	Hydrolab	0.8	ug/l

Showing 1 to 10 of 630 entries

Previous 1 2 3 4 5 … 63 Next

Determining where the phosphorus is coming from

1. Next Generation Lake Assessment Reports

2. **High Resolution (0.5m) Mapping**

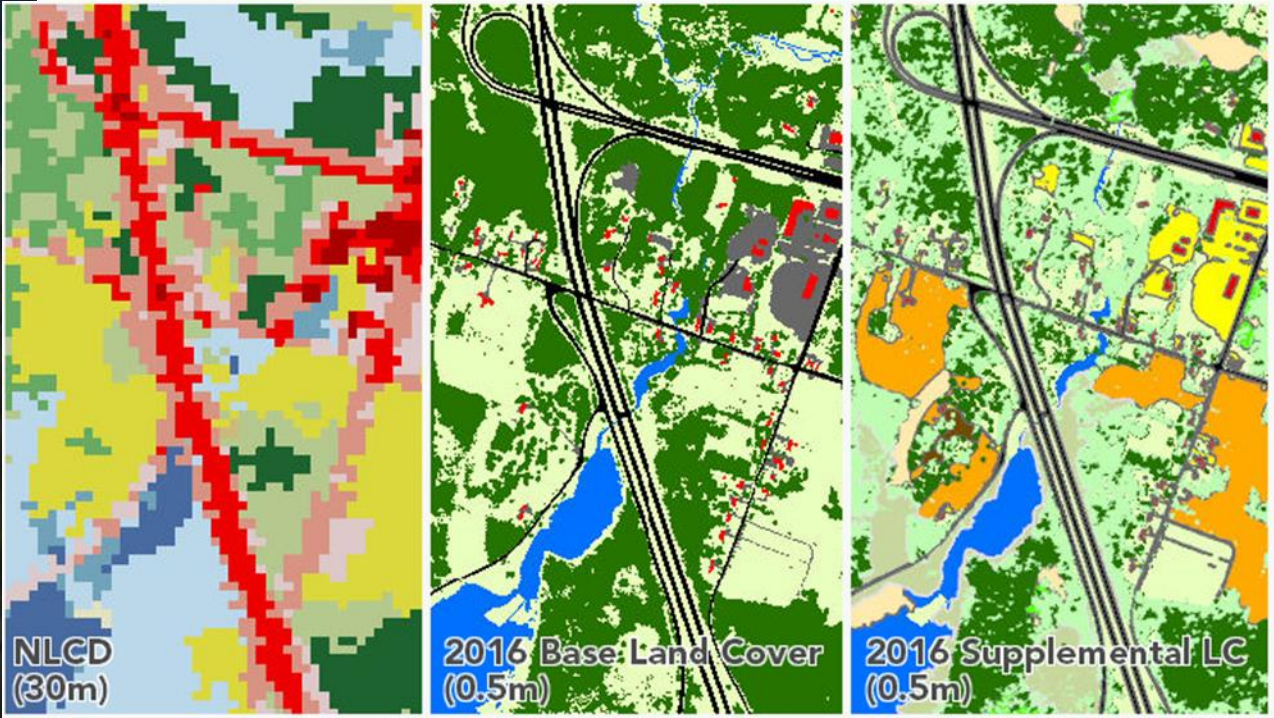
AGENCY OF DIGITAL SERVICES

Vermont Center for Geographic Information

DATA RELEASE

STATEWIDE HIGH-RESOLUTION VERMONT LAND COVER DATA NOW AVAILABLE

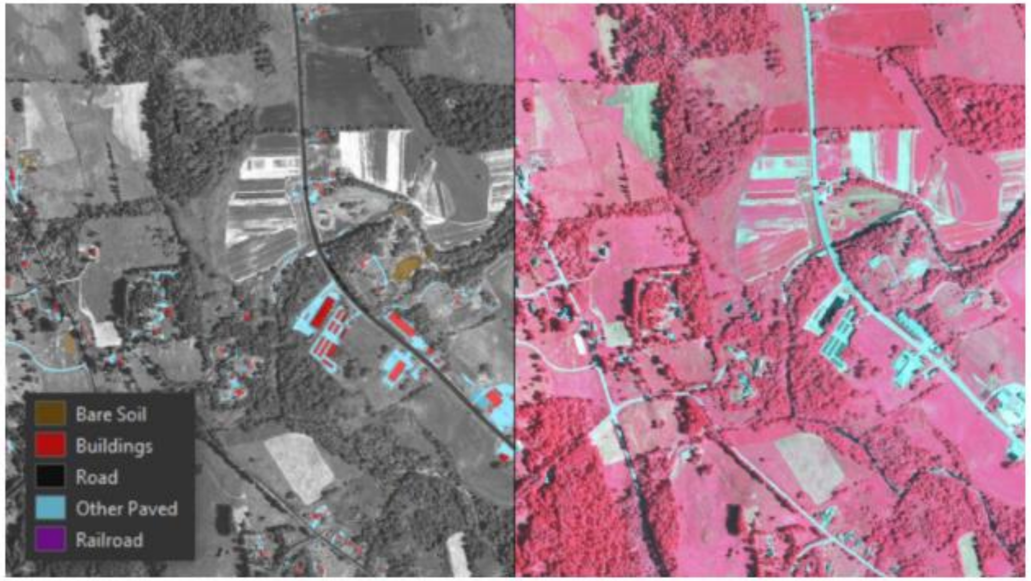
03 SEPTEMBER 2019



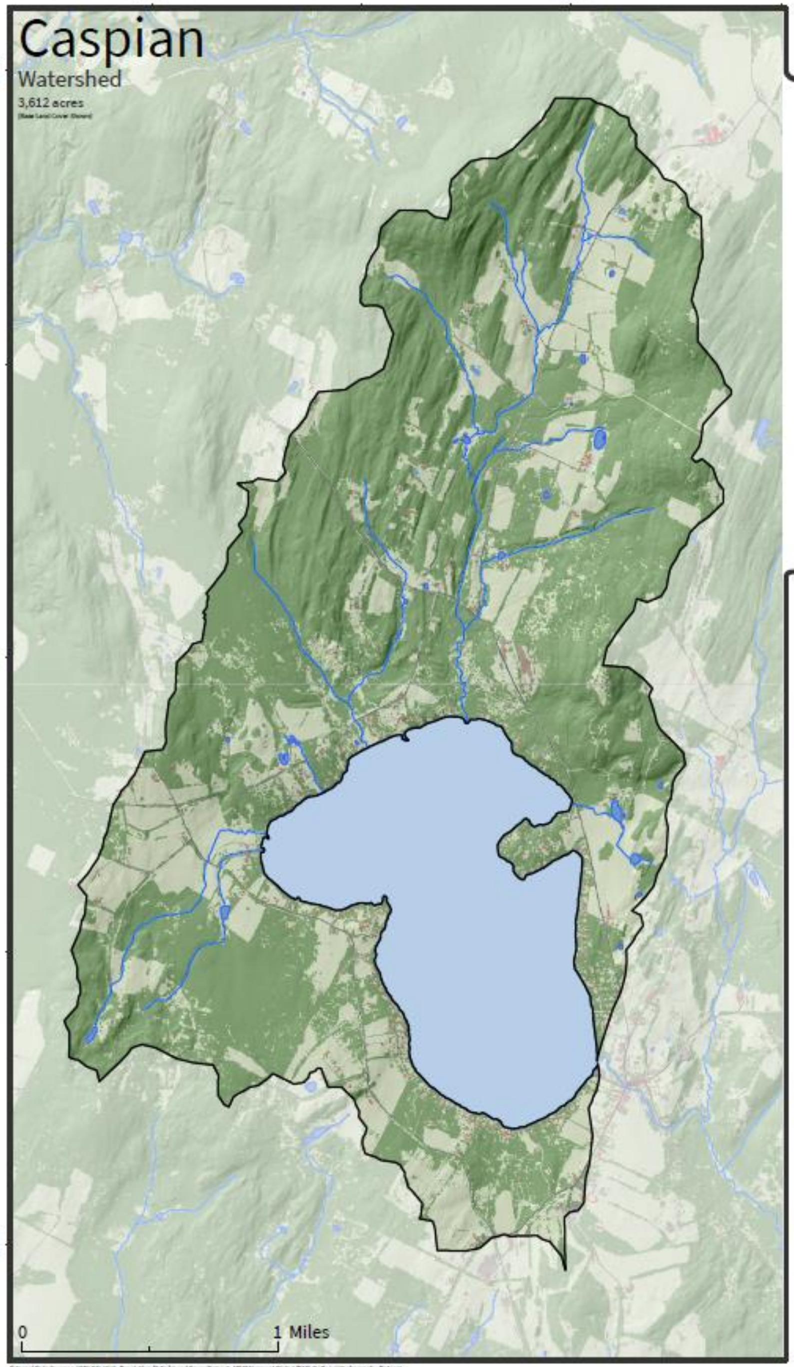
https://vcgi.vermont.gov/data-release/statewide-high-resolution-vermont-land-cover-data-now-available

- **Supplemental Land Cover**: Vector products that include shrub, agricultural, and wetland land cover types as individual layers. These are standalone delineations of base land cover features.

- **Impervious Surfaces**: Vector product created through a "bottom up" approach to map surfaces obscured by tree canopy. Includes buildings, roads, other paved, bare soil, and railroad classes.

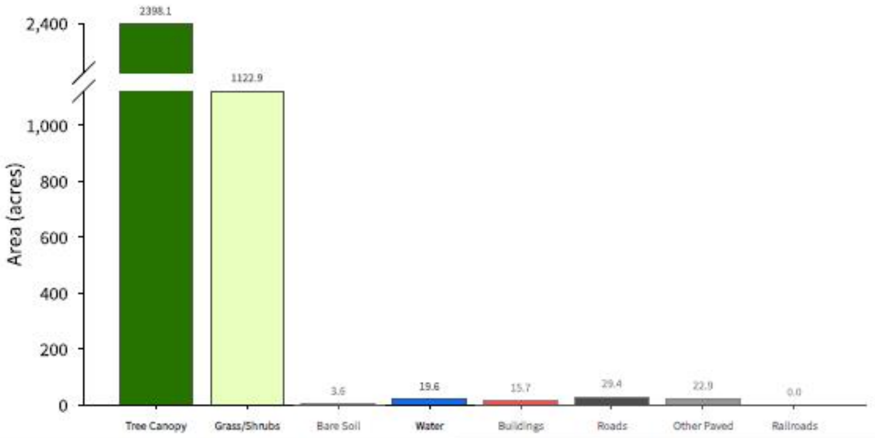


Example of the impervious surfaces land cover layer. Image: UVM Spatial Analysis Lab



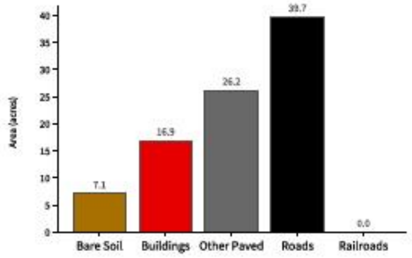
High-Resolution Land Cover Summary

Base Land Cover (Top-Down*)

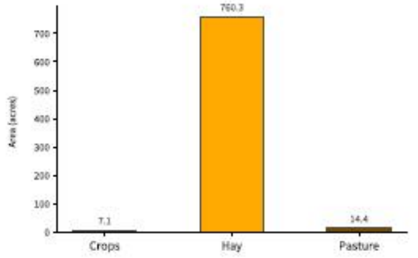


Supplemental Land Cover

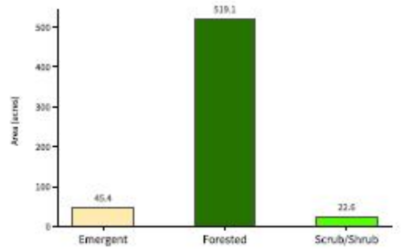
Impervious Surfaces (89.89 acres - 2.5 % of total) (Bottom-Up**)



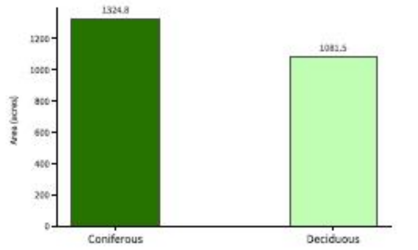
Agriculture (781.85 acres - 21.6 % of total)



Wetlands (587.03 acres - 16.3 % of total)



Tree Canopy (2,406.28 acres - 66.6 % of total)



*Top-Down: A traditional land cover mapping approach - land cover is mapped as the uppermost land cover class.
**Bottom-Up: A new land cover mapping approach - land cover is mapped as the lowermost land cover class. This approach results in improved mapping of features overlapped/obscured by other features.
See UVM SAL High-Resolution Land Cover 2016 Report for more detail.

External Data Sources: UVM SAL High-Resolution (0.5m) Land Cover Dataset, VCGI Vermont State LiDAR, National Hydrography Dataset

High-Resolution Land Cover Summary

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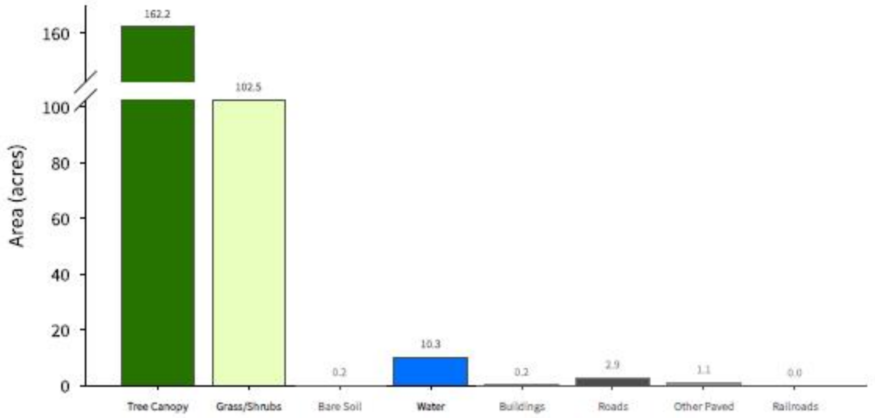
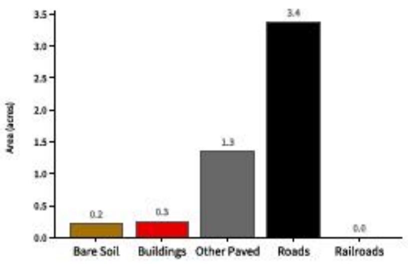
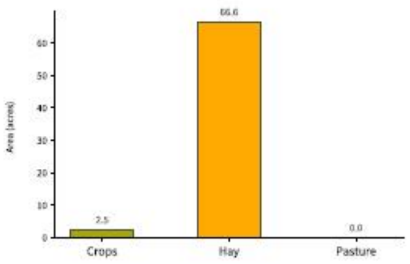


Supplemental Land Cover

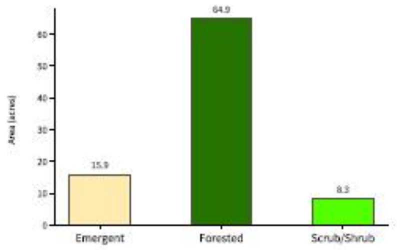
Impervious Surfaces (5.19 acres - 1.9 % of total)
(Bottom-Up**)



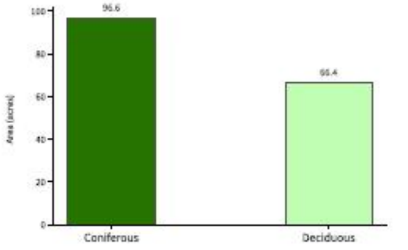
Agriculture (69.13 acres - 24.7 % of total)



Wetlands (89.08 acres - 31.8 % of total)



Tree Canopy (162.99 acres - 58.2 % of total)



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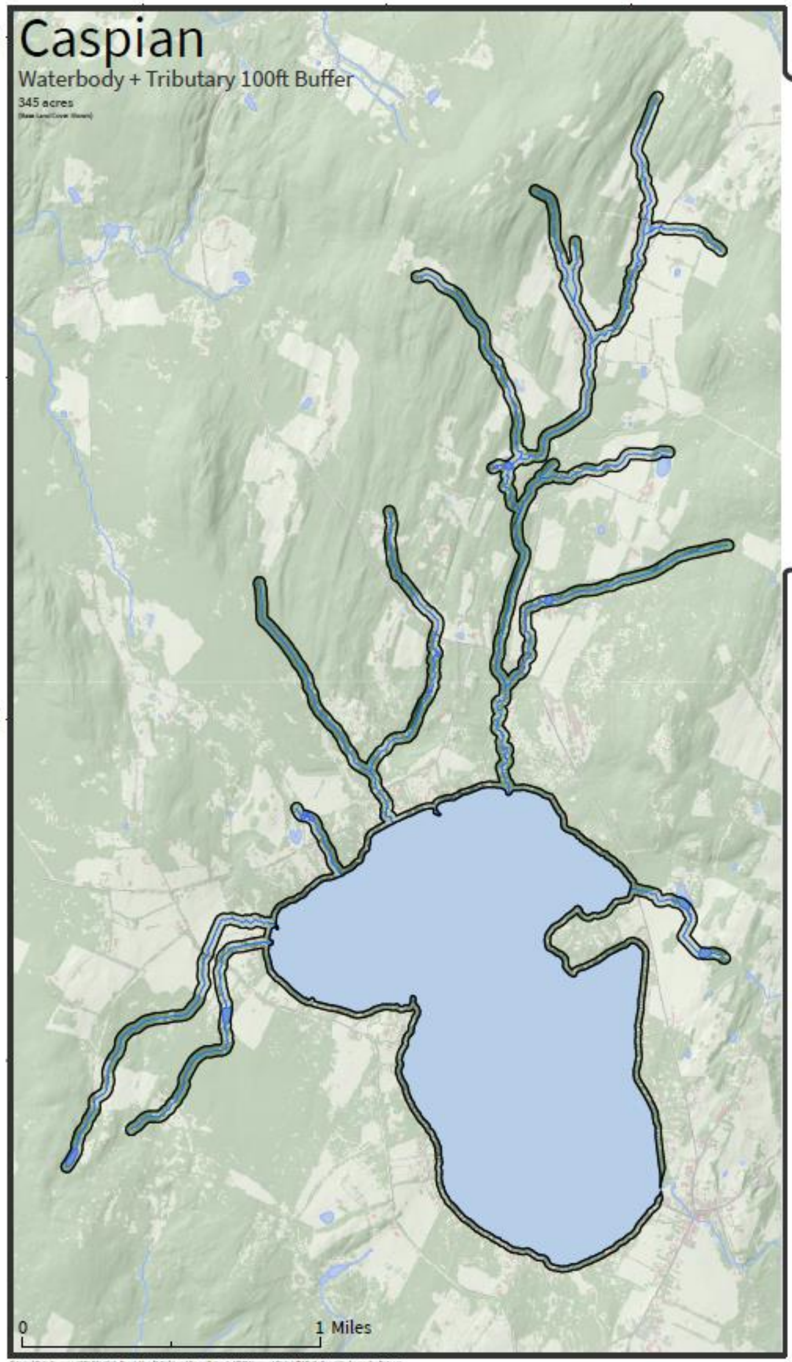

External Data Sources: UVM SAL High-Resolution (0.5m) Land Cover Dataset, VCGI Vermont State LIDAR, National Hydrography Dataset

High-Resolution Land Cover Summary

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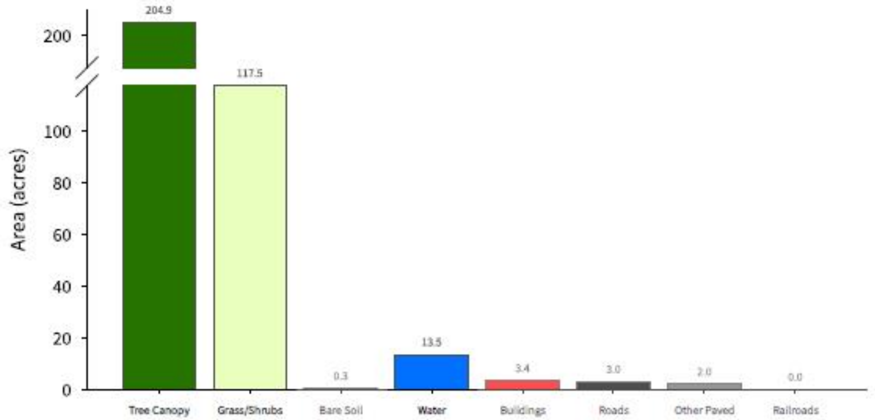
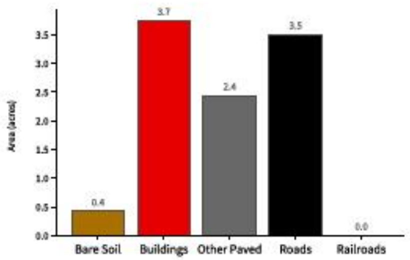
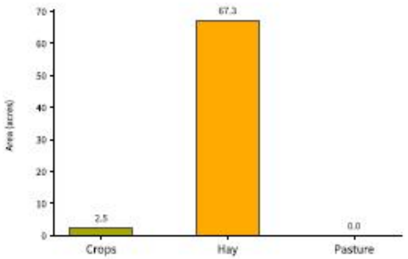


Supplemental Land Cover

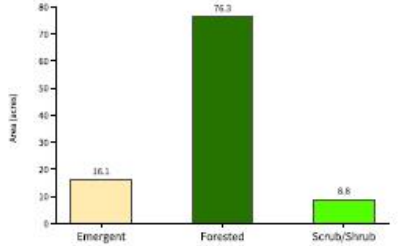
Impervious Surfaces (10.11 acres - 2.9 % of total) (Bottom-Up**)



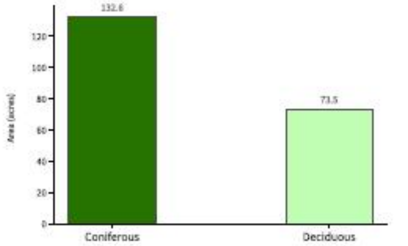
Agriculture (69.8 acres - 20.2 % of total)



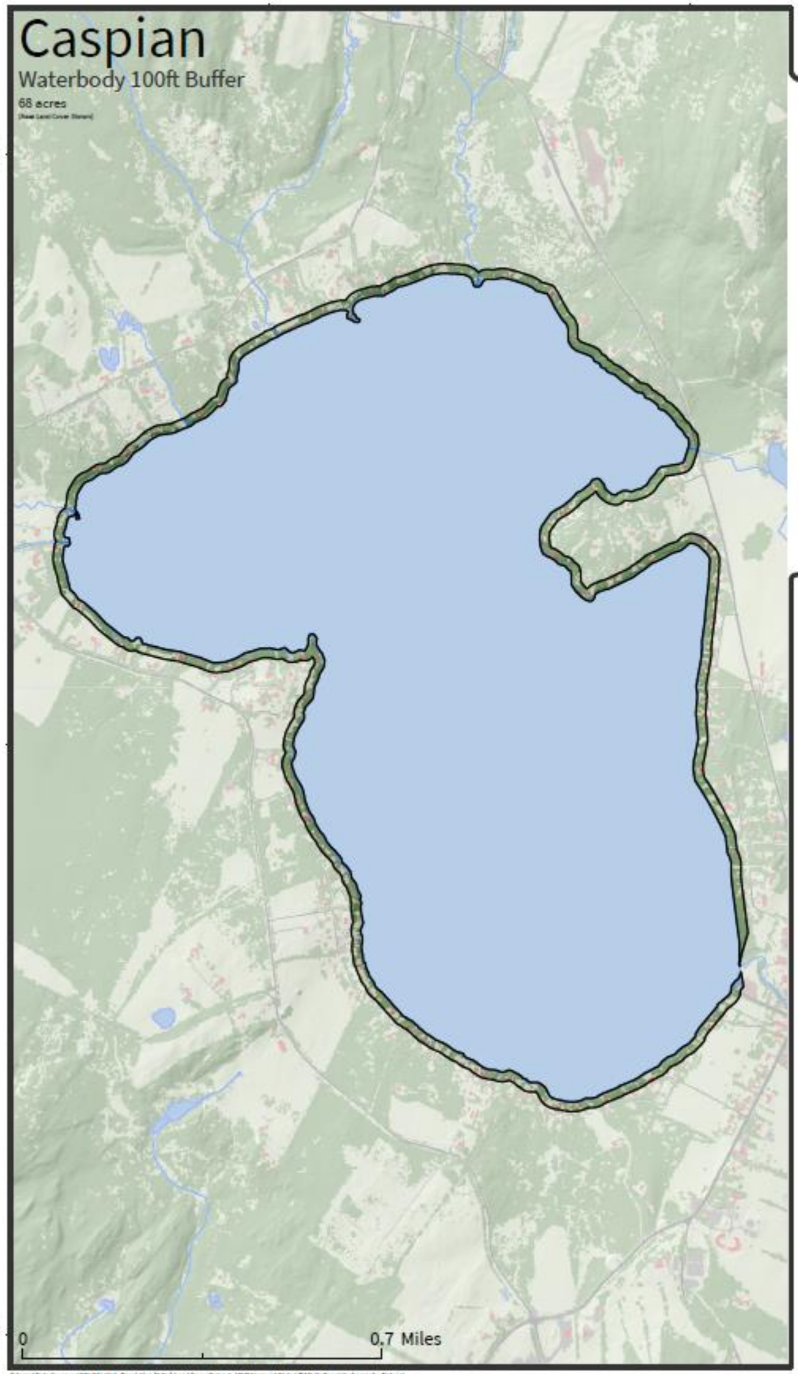
Wetlands (101.19 acres - 29.3 % of total)



Tree Canopy (206.08 acres - 59.7 % of total)



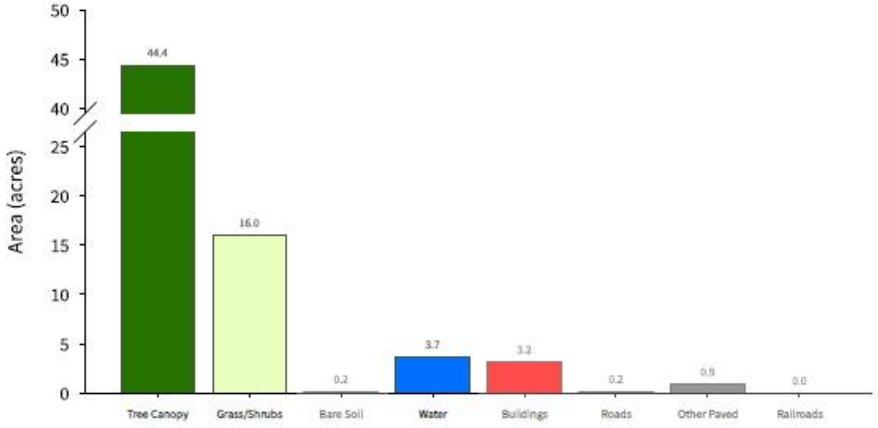
*Top-Down: A traditional land cover mapping approach - land cover is mapped as the uppermost land cover class.
**Bottom-Up: A new land cover mapping approach - land cover is mapped as the lowermost land cover class. This approach results in improved mapping of features overlapped/obscured by other features.
See UVM SAL High-Resolution Land Cover 2016 Report for more detail.



External Data Sources: UVM SAL High-Resolution (0.5m) Land Cover Dataset, VCGI Vermont State LiDAR, National Hydrography Dataset

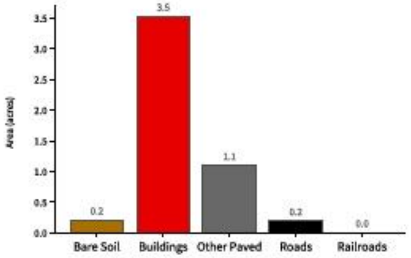
High-Resolution Land Cover Summary

Base Land Cover (Top-Down*)

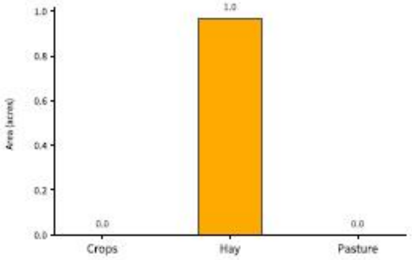


Supplemental Land Cover

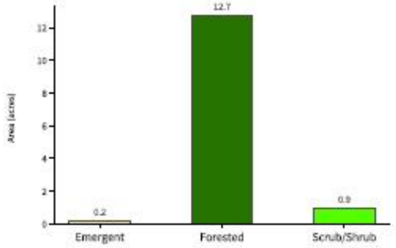
Impervious Surfaces (5.01 acres - 7.4 % of total)
(Bottom-Up**)



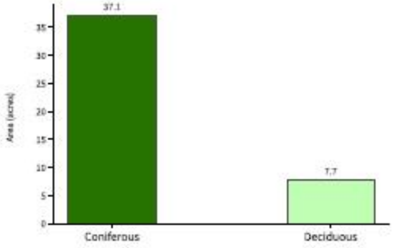
Agriculture (0.97 acres - 1.4 % of total)



Wetlands (13.8 acres - 20.3 % of total)



Tree Canopy (44.84 acres - 65.9 % of total)



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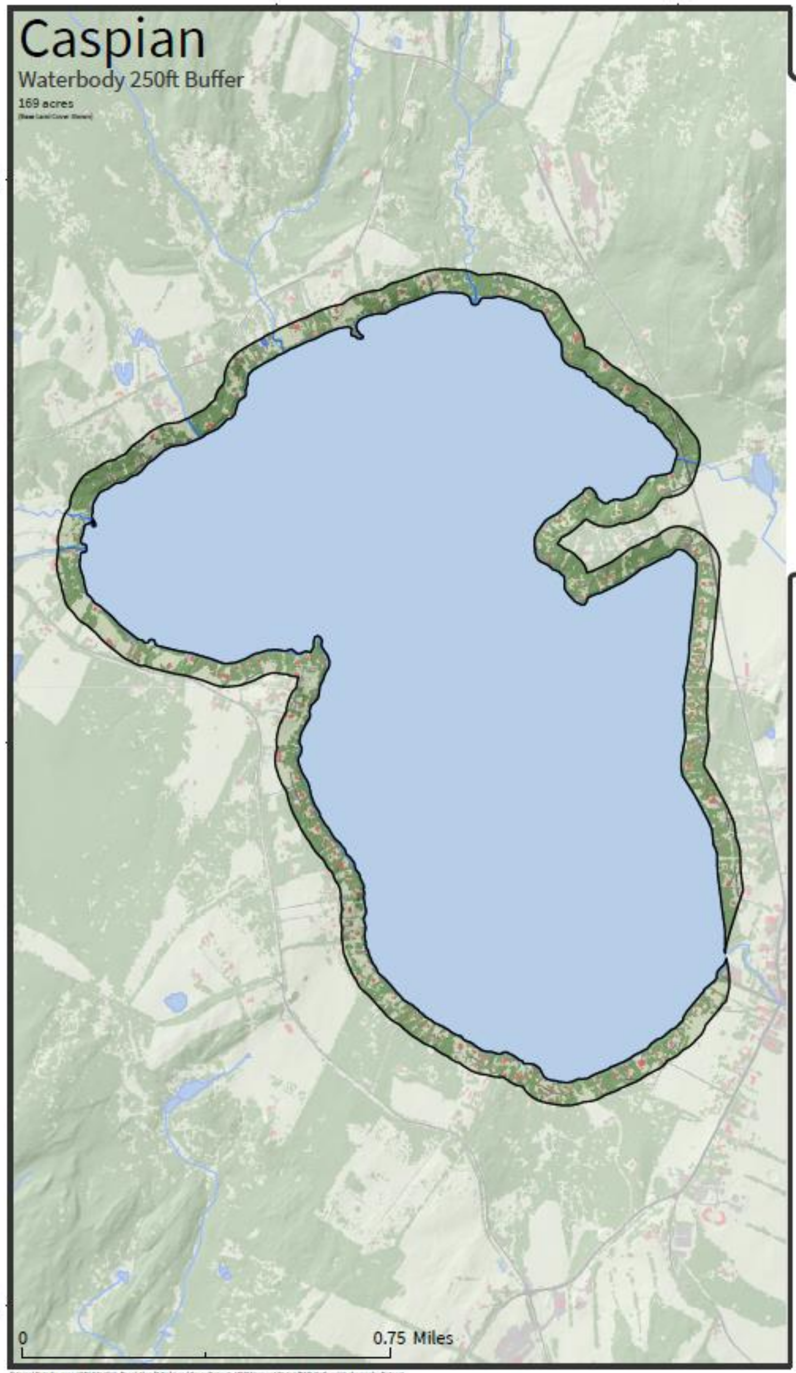
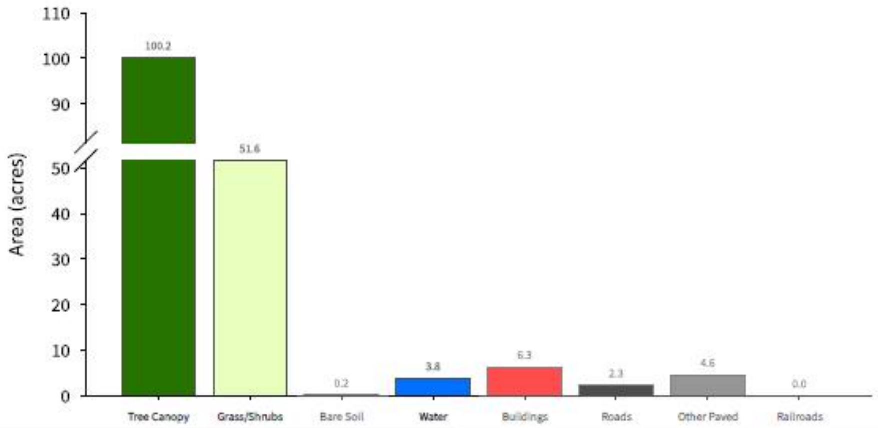


External Data Sources: UVM SAL High-Resolution (0.5m) Land Cover Dataset, VCGI Vermont State LiDAR, National Hydrography Dataset

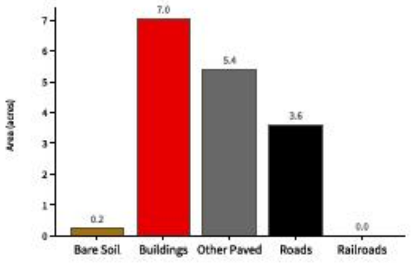
High-Resolution Land Cover Summary

Base Land Cover (Top-Down*)

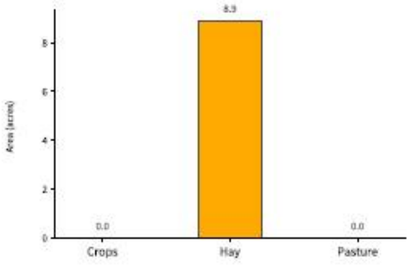


Supplemental Land Cover

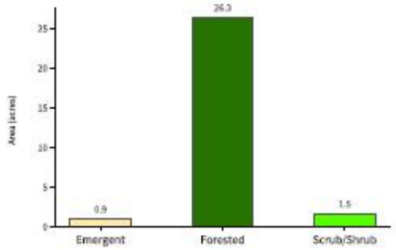
Impervious Surfaces (16.28 acres - 9.6 % of total) (Bottom-Up**)



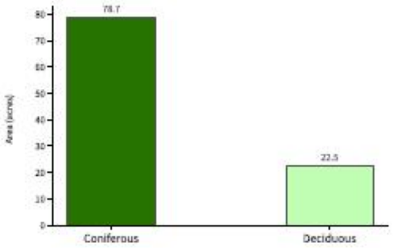
Agriculture (8.92 acres - 5.3 % of total)



Wetlands (28.72 acres - 17 % of total)



Tree Canopy (101.18 acres - 59.9 % of total)



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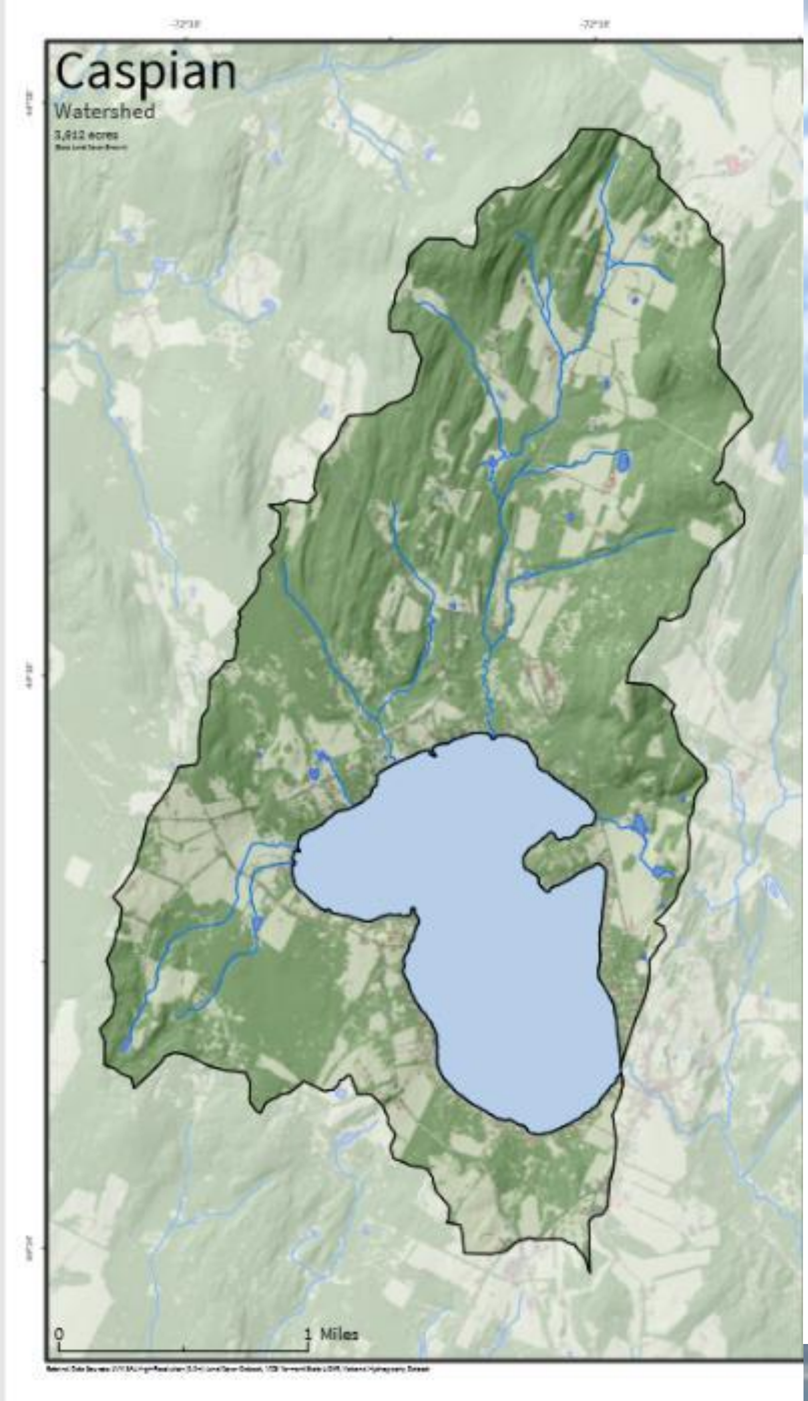
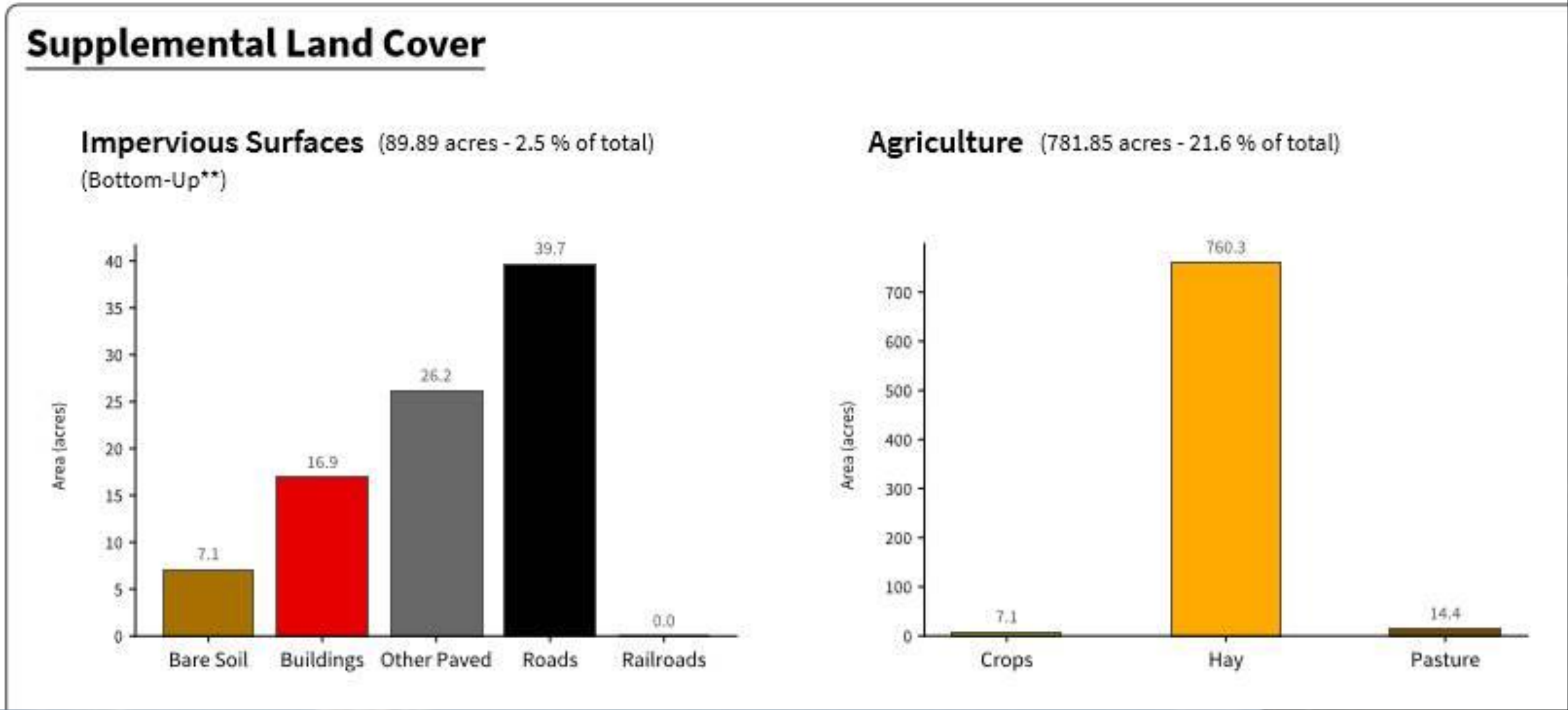
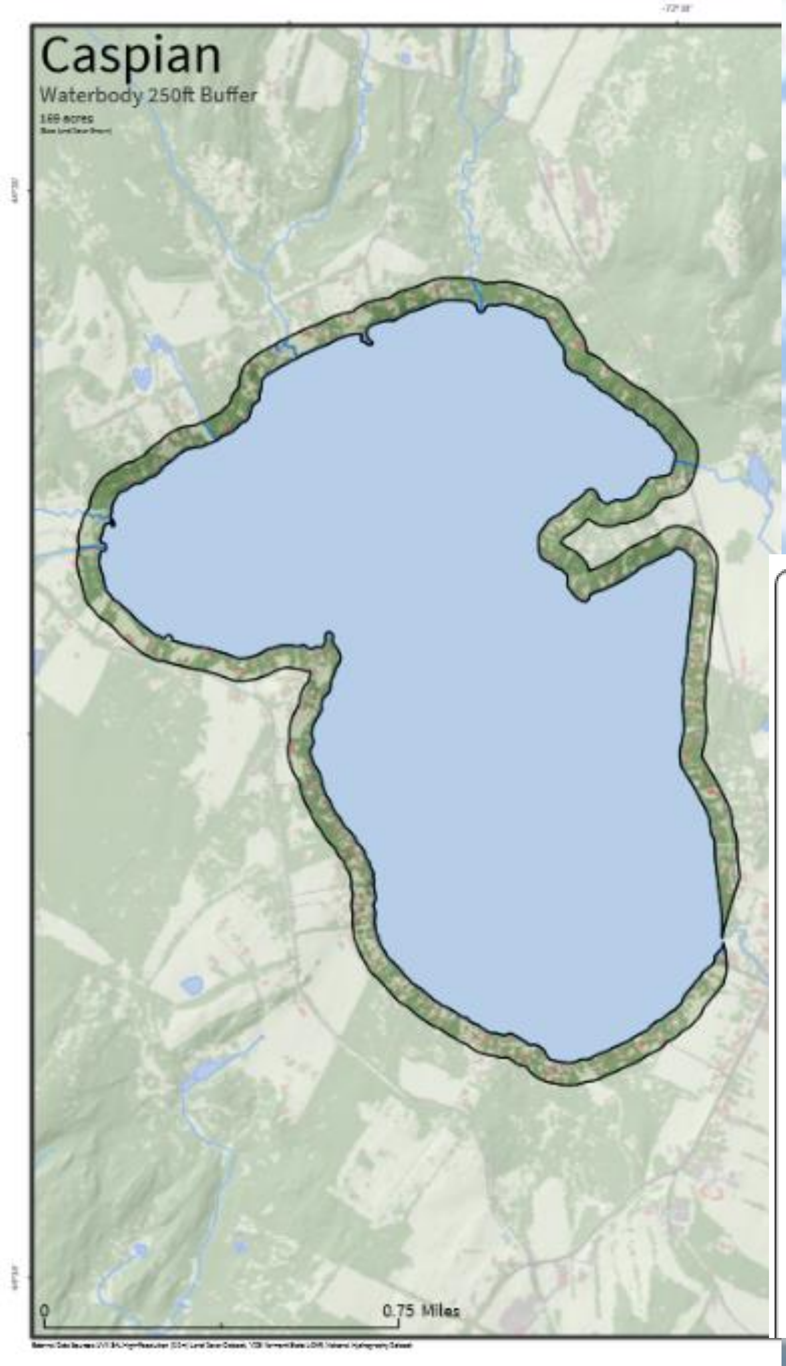


At the watershed level, **impervious surfaces** make up only **2.5% of** the land cover or roughly 90 acres.

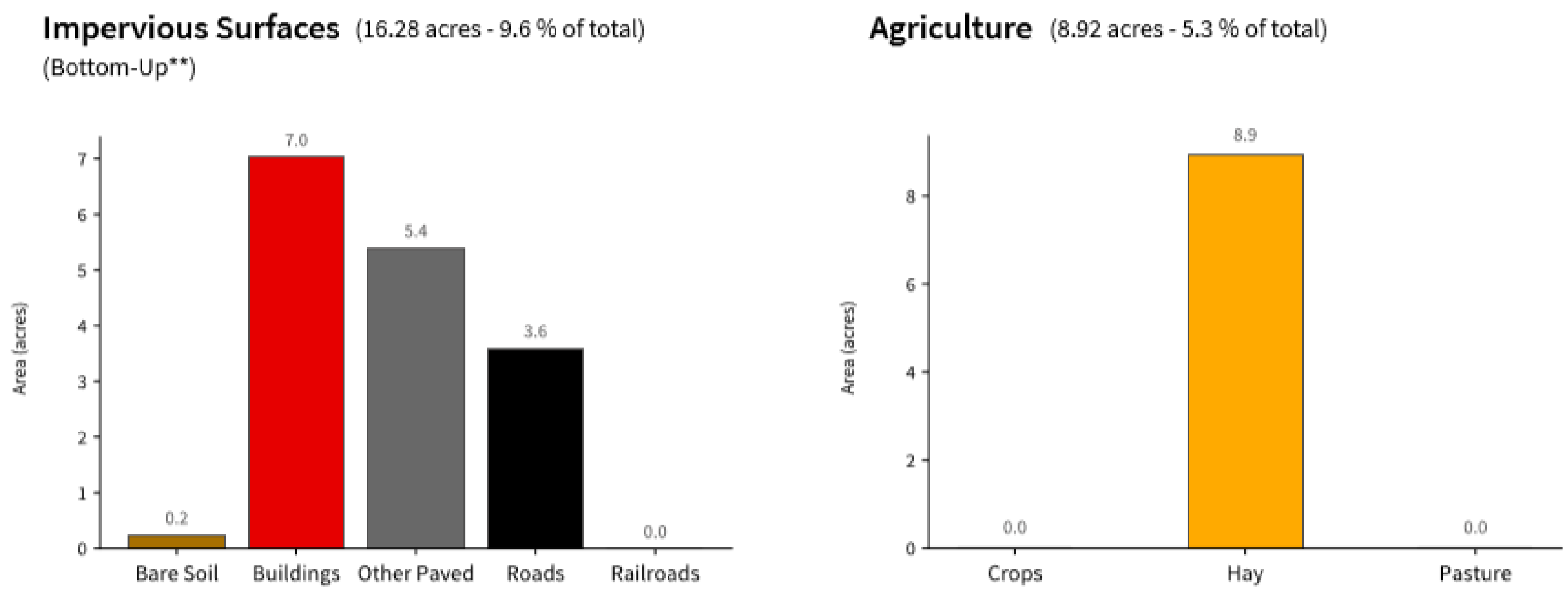
Whereas, **'agriculture'** makes up 781 acres or **22%** of the watershed.



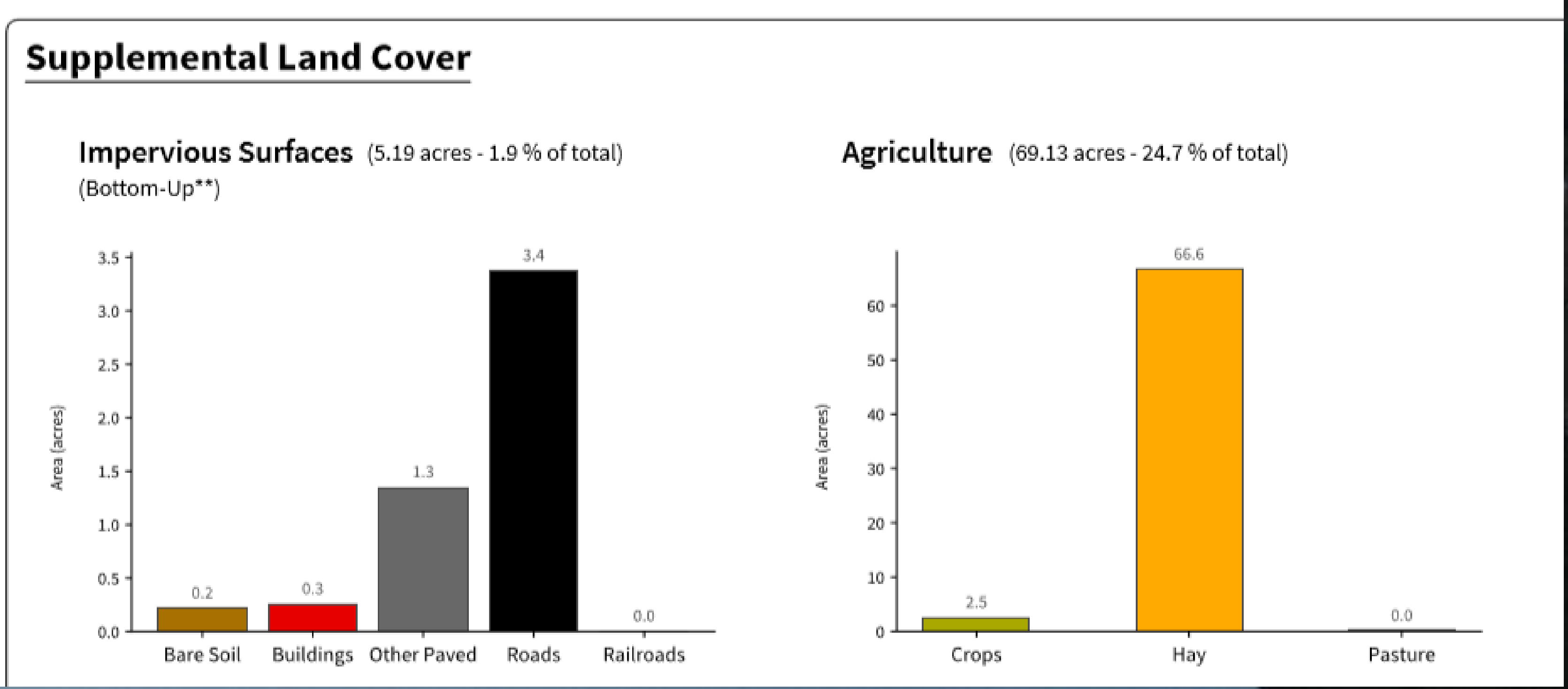


Within the 250' buffer around the lake, impervious surface makes up 10% of the area equating to roughly 16 acres, while **'Agriculture'** makes up a lower percentage than in the watershed at **5%** or 9 acres.

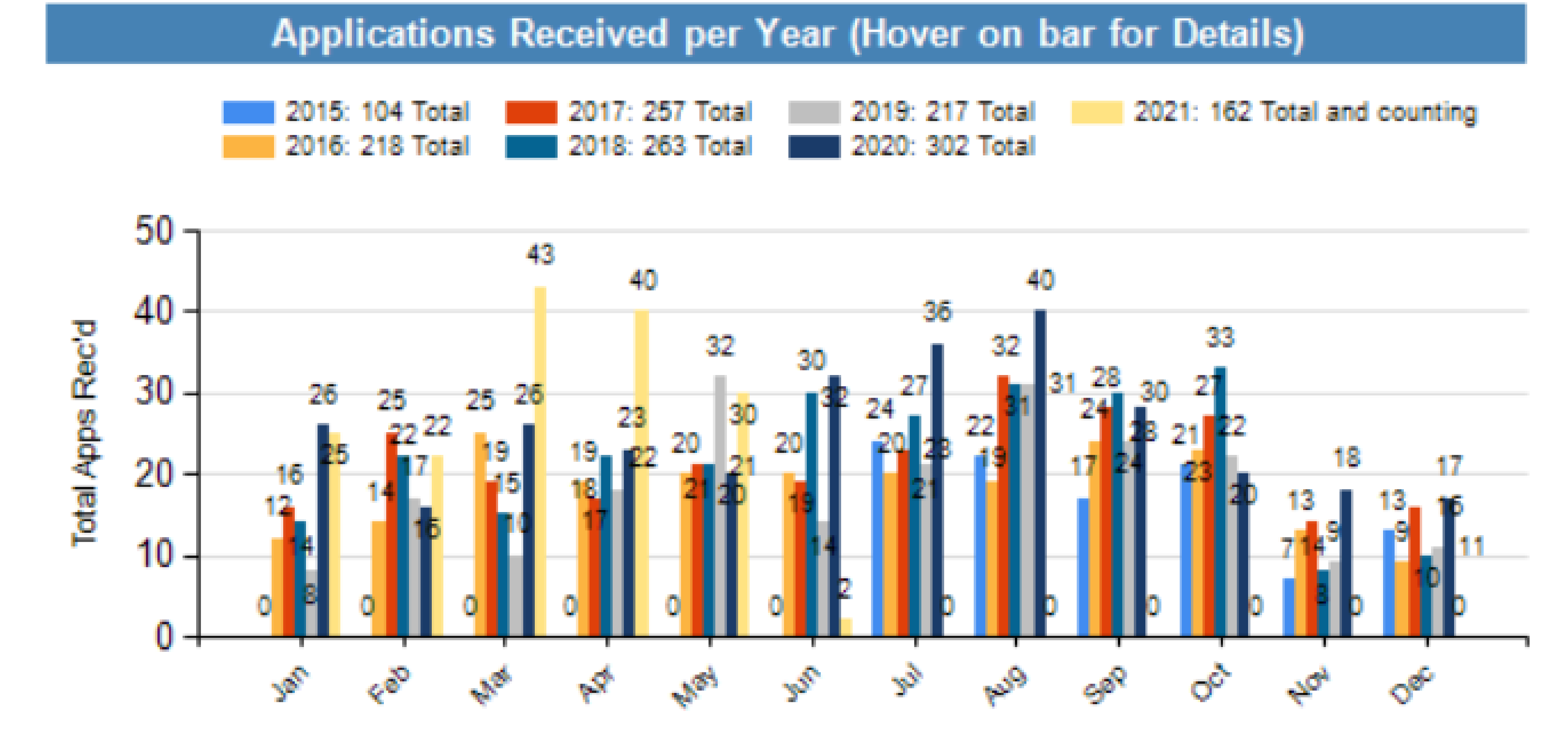
Supplemental Land Cover



Within 100’ of the tributaries draining into the lake, only about **2%** is **impervious surface** (or 5 acres), but 25% of the tributary buffers are ‘Agriculture’ totaling 70 acres of ‘Ag’ within 100’ of the tributaries draining into the lake.



Part 2: New approaches for Lake Protection



Part 2: New approaches for Lake Protection

- Lake Watershed Action Plans
- Reclassification to A(1) Status for Aesthetics Uses under Vermont’s Water Quality Standards using the Combined Nutrient Criteria

Lake Watershed Action Plan

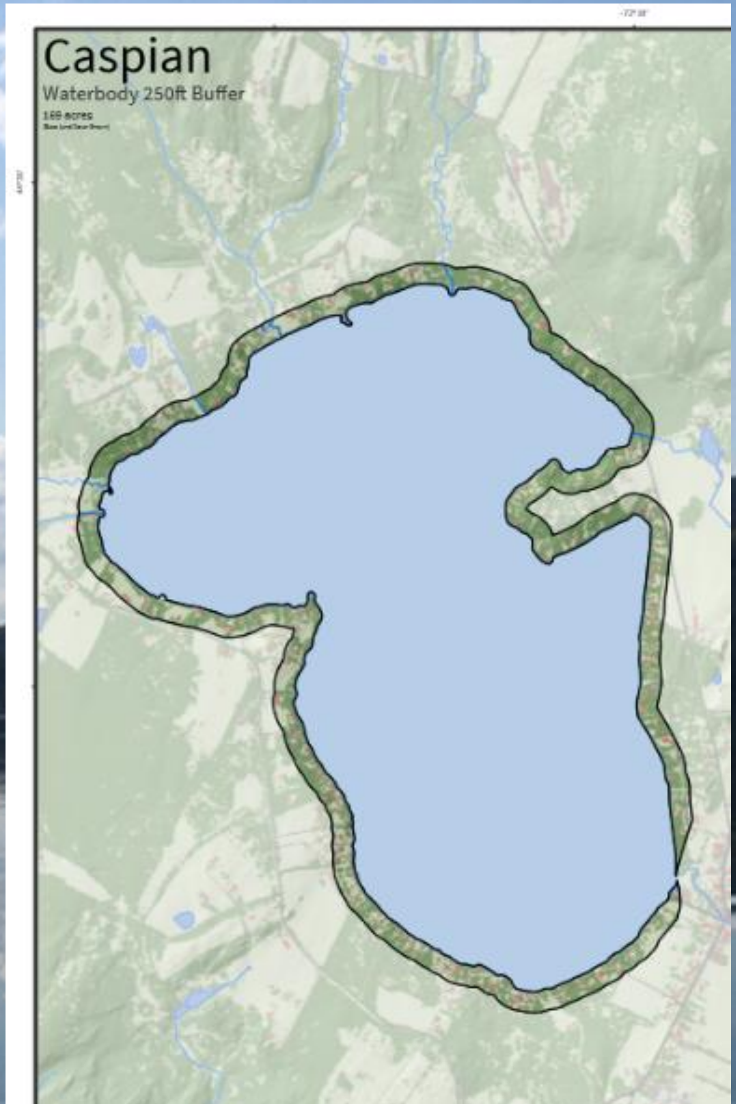
- A Lake Watershed Action Plan (LWAP) is an assessment to identify the highest nutrient/sediment pollution loading from a lake's watershed that are resulting in water quality and habitat degradation.
- The LWAP results in a prioritized list of projects and strategies to address the sources of pollution and habitat degradation identified in the assessment.
- The plan may also contain recommendations to preserve natural features and functions, encourage use of low impact green stormwater infrastructure, and maintain the aesthetic and recreational uses of lakes.
- Prioritized list of projects can feed into DEC Watershed Projects Database and be considered for Clean Water Initiative Program Funding

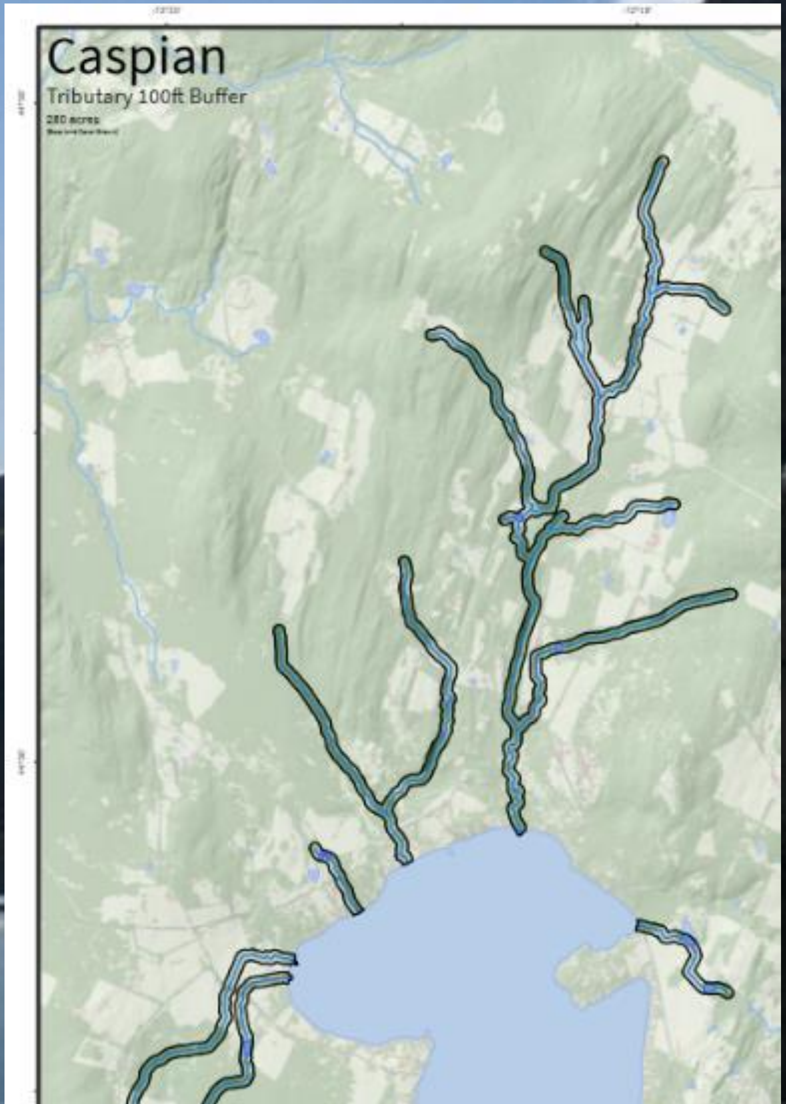
Lake Watershed Action Plan

- Lake Watershed Action Plans are a relatively new approach in Vermont, completed on 3 lakes: Eden, Elmore and Dunmore
- DEC just awarded a grant to the Essex County Conservation District to develop these plans at Maidstone and Fairlee
- Lake Champlain Basin Program just awarded grants for 4 more plans:
  - Lake Iroquois, Caspian Lake, Lake St Catherine, and Fairfield Pond
- LWAPs: a participatory and consultative process involving a multi sector assessment with 3 core elements: Shoreland, Roads, and Tributaries.
  - Answer what are the greatest threats to lake conditions, water quality and habitat
- Scale is more focused than tactical basin plan but can contribute to broader goals
  - Plans in Champlain Basin can contribute to meeting Phosphorus Reduction Targets in TMDL

Lake Watershed Action Plans: Caspian Example

- Lakeshore AND the watershed should be focus (tribs, roads)
- 10% of the 250’ buffer around the lake is impervious surface
- 25% (70 acres) of the 100’ buffer around the streams draining into lake Caspian are classified as Agriculture





Lake Watershed Action Plan
Remedial Intervention Options for Caspian

1. Enhance support for Lake Wise
2. Incentivize septic upgrades
3. Employ tools within the Shoreland Protection Act and MRGP that reduce existing runoff
4. Reduce runoff to tributaries from roads, agriculture, forestry and development

Lake Reclassification under VT Water Quality Standards

The Vermont Water Quality Standards establish designated uses, management objectives, and minimum criteria for all surface waters; waters are classified independently for each designated use:

- **Aquatic biota and wildlife** that are present in the waters;
- **Aquatic habitat** to support aquatic biota, wildlife, or plant life;
- The use of waters for **swimming, boating, fishing**
- The use of waters for the enjoyment of **aesthetic conditions**;
- The use of the water for **public water source** or for **irrigation** of crops and agricultural uses.

Lake Reclassification
under VT Water Quality Standards

There are four possible classifications of Vermont surface waters:

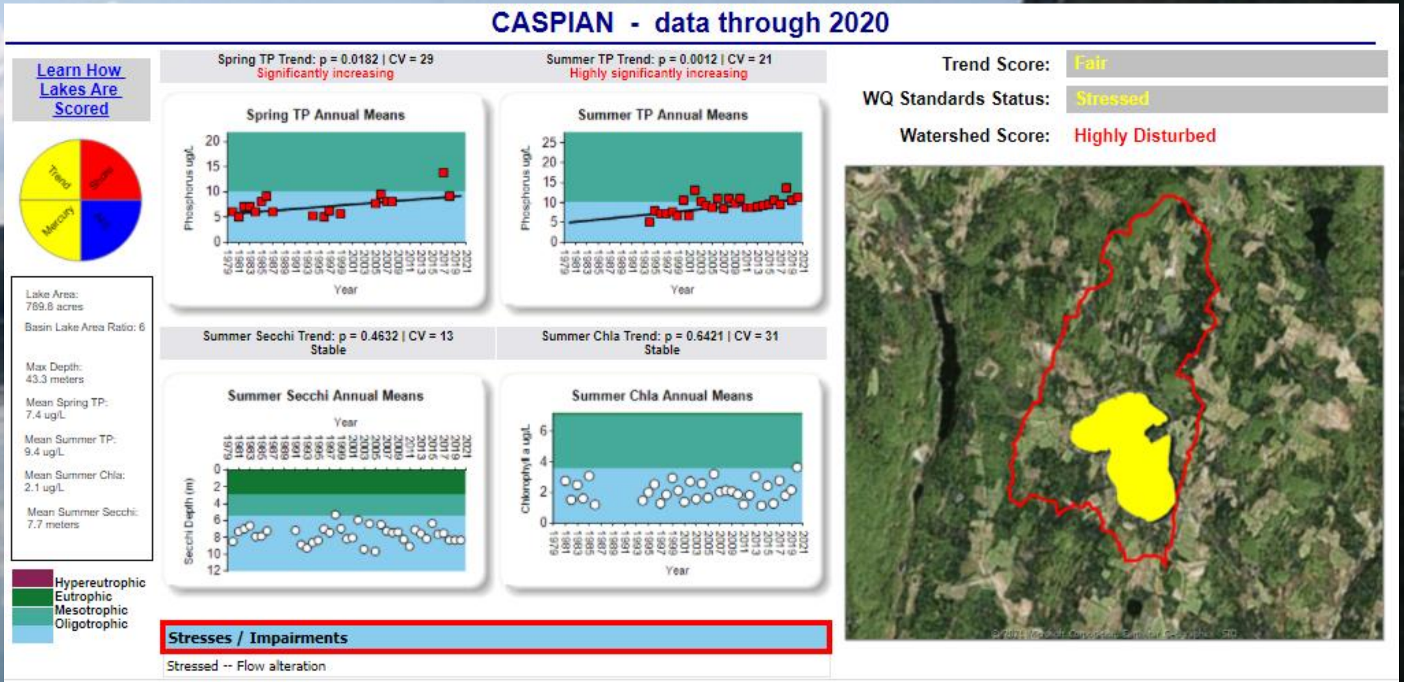
A(1) excellent.	**A(2) public water source;**
B(1) very good;	**B(2) – good;**

- All waters below 2,500 ft are designated Class B(2) for all uses, unless ***designated*** via reclassification as Class A(1), A(2), or B(1) for any use.
- All waters above 2,500 ft are designated Class A(1) for all uses
- All waters must continue to meet their classification criteria, otherwise they are ***listed as impaired***, and a restoration plan must be implemented

Data for Reclassification: Vermont Lay Monitoring Program

Lay Monitoring Program has trained volunteers since 1979 to conduct lake water quality sampling on more than 100 lakes and 40 stations in Champlain

- Program leads to summer mean values for Total Phosphorus, Chlorophyll A, Secchi (water clarity) calculated from ≥8 samples
- This data is used to monitor trends on lakes, for designating lakes as impaired, as the basis to establish policy and statute, and now for reclassification!



VT WQS:
Combined Nutrient Criteria

- Combined Nutrient Criteria provides guidelines for lake (re)classification
- Numeric Criteria established for Aesthetics Uses: Total Phosphorus & Response Variables
- Use LMP data to determine what lakes currently meeting or failing B2 criteria, but also which lakes are meeting / exceeding B1 or A1 criteria.
- State can reclassify eligible lakes “upwards” if data shows they exceed A(1) or B(1) requirements
- Consistent w/ VT’s Tier 2 Antideg Program

Table 3. Combined Nutrient Criteria for Aesthetics Uses in Lakes, Ponds, and Reservoirs Except for Lake Champlain and Lake Memphremagog[1,2]

	Class A(1)	Classes A(2) and B(1)	Class B(2)
Nutrient Concentrations			
Total Phosphorus[3] (µg/L)	12	17	18
Nutrient Response Conditions			
Secchi Disk Depth (meters)[4]	5.0	3.2	2.6
Chlorophyll-a (µg/L)[3]	2.6	3.8	7.0
pH	Not to exceed 8.5 standard units.		
Turbidity	Consistent with the criteria in § 29A-302(4) of these rules.		
Dissolved Oxygen	Consistent with the criteria in § 29A-302(5) of these rules.		

Rationale for Reclassification of Lake Caspian

- Does A(1) classification better match expectations for Caspian's Aesthetic Use?
- Is 12 ug/L TP a more appropriate threshold for impairment?

Parameter	Mean Value (since '79)	A(1) Threshold	B(2) Threshold
Summer TP mean	9.4 ug/L Significantly increasing	<12 ug/L	<18 ug/L
Secchi	7.7 m	>5.0 m	>2.6 m
Chlorophyll A	2.1 ug/L	<2.6 ug/L	< 7.0 ug/L

So, how does reclassification increase lake protections?

- While reclassification does not guarantee that the total phosphorus levels (early detection indicator) will not be exceeded, it puts into place a mechanism for action sooner, when more likelihood of restoration success could be achieved at much lower cost
- Reclassification gets Caspian the tool of legal requirements that come with listing a water as impaired and in particular helps make funds available sooner for restoration work
- This ‘increased protection’ is afforded the lake even if no other legal protections are afforded the lake

Management Implications of Reclassification

Management Implications – Existing Prohibitions in Class A waters:

- A direct discharge of any wastes that contained organisms pathogenic to human beings.
- Indirect discharge systems (septic systems) with a design flow greater than 1,000 gallons per day
- Solid waste management facilities and application of biosolids or septage

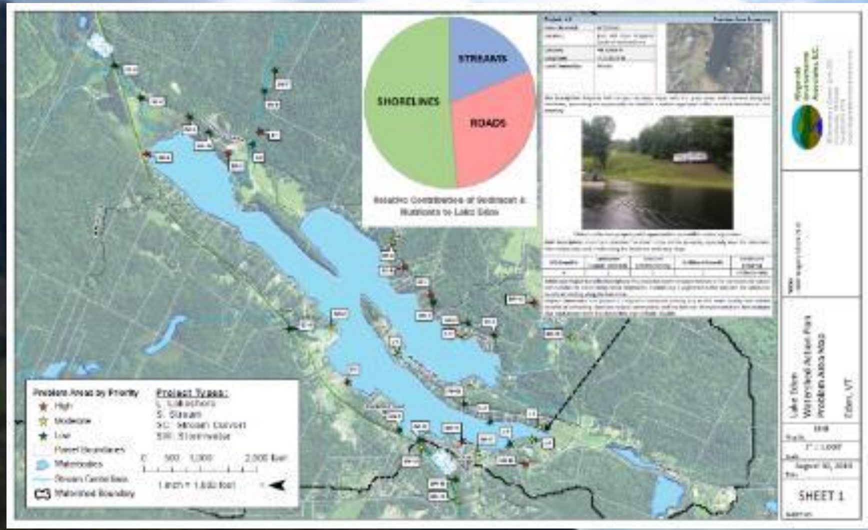
Possible New Management Implications for A(1) Waters?:

- In lakes w/ increasing TP due to external nutrient loading, require riparian buffers on all lake tribs?
- Other ideas? Incentives for use of AMPs / BMPs?
- No exemptions to ban on winter manure spreading?

Reclassification Approach: Lake Specific

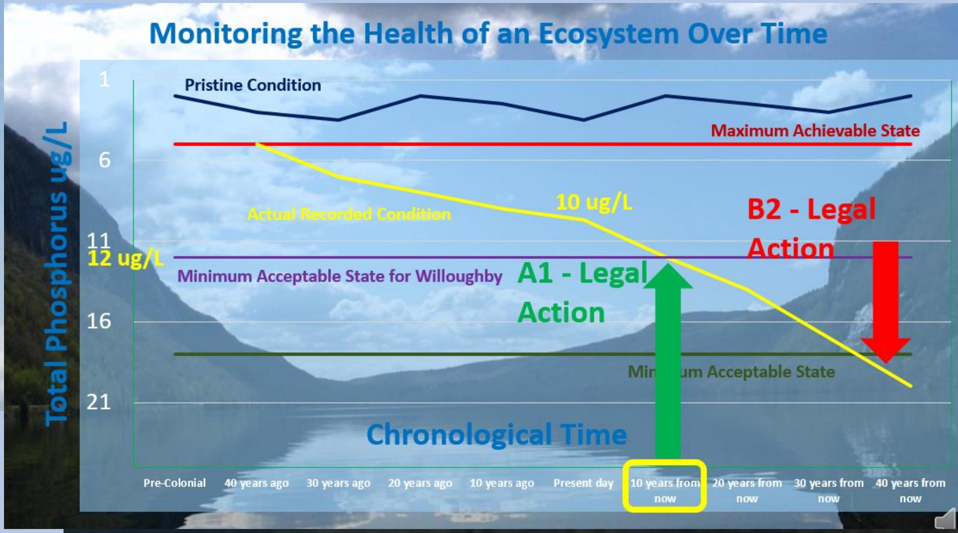
- When listing a lake as impaired, we list the lake based on the evidence that the lake is failing our water quality standards
- We don’t articulate what will and won’t be allowed activities in the watershed; not germane to the finding that the lake is not meeting the water quality standards.
- Listing then established process for TMDL development, which is tailored to lake ‘s unique characteristics and sources of phosphorus
- We propose a similar approach for reclassification: develop a lake specific approach to establish A(1) protections, enshrine through rule-making process

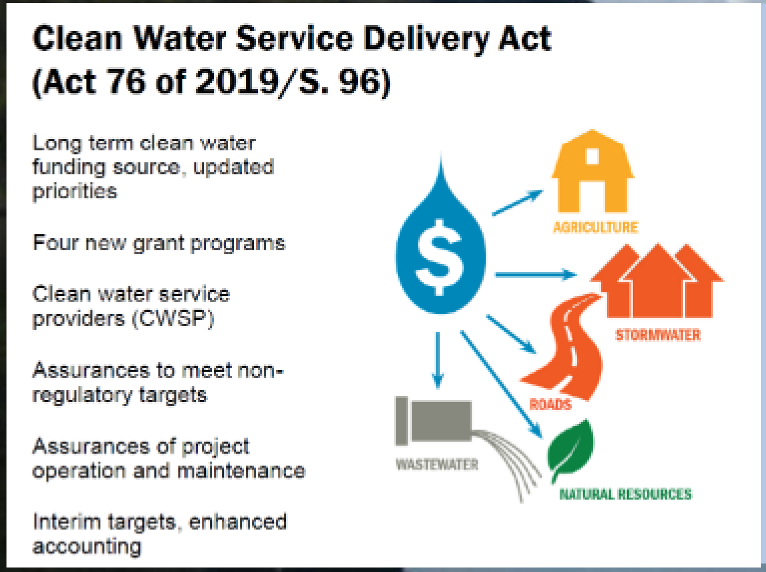
What will reclassification offer to a lake (that isn't already possible?)



Lake Specific Protections, possibly a Lake Watershed Action Plan

Action Sooner!





Projects & Funding

- Act 76 (Water Quality Enhancement Grants)
- CWIP
- LCBP

Next Steps: Engagement w/ Towns & Lake Associations

- Reclassification can be initiated by Vermont DEC or via petitions from the public
- Increasing lake protections via reclassification, while not a new idea, has only been used once in VT
- VT DEC: outreach to interested / eligible lake communities and towns about lake reclassification,
- Identified seven eligible lakes w/ increasing TP and active lake associations
  - Maidstone, Caspian, Raponda, Willoughby, Shadow (Glover), Seymour, Echo (Charleston)
  - Substantial local interest, some concerns over management restrictions
- Exploring reclassifying same lakes for fishing uses to generate additional support
- Expect first petitions to reclassify high-quality lakes later this year
- Petitions kick off a rulemaking process, involving public hearings, legislative review, & decision


Thanks for your attention!
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Kellie.Merrell@vermont.gov