Vermont Lake Score Card

Background

The Lake Score Card provides a method to convey a range of simple to complex monitoring data in order to answer the commonly asked question "How is the lake doing?" Monitoring data is analyzed and interpreted to determine current lake status and the score card reports out this information in a simple, short and educational format. The score card rates conditions of Vermont lakes in terms of:

- Water Quality
- Aquatic Invasive Species
- Atmospheric Pollutants
- Shoreland Habitat

Vermont has over 800 lakes, with 220 of them larger than 20 acres in size. The Vermont Department of Environmental Conservation's Water Quality Division - Lakes and Ponds Section assesses lakes greater than 20 acres in size through several efforts.

Water Quality is monitored through the annual Spring Phosphorus Sampling Program, the summer Lay Monitoring Program, and by special lake assessment studies conducted through the Lakes and Ponds Monitoring.

Aquatic Invasive Species are monitored through the Aquatic Invasive Species Program.

The Atmospheric Pollutants scores are based on **mercury** data from long-term monitoring on fish throughout Vermont and the Lakes and Ponds Monitoring Program's study "Assessment of Mercury in Waters, Sediments, and Biota of VT and NH Lakes Project." **Acid rain** is monitored through the Vermont Long Term Monitoring (VLTM) of Acid Sensitive Lakes.

Shoreland and Lake Habitat scores are based on three studies – The Lake Assessment Program's Littoral Habitat Study , the National Lakes Survey for Vermont lakes, and the University of Vermont's Geographical Lakeshore Mapping.

Why a Score Card?

The score card answers the question of "how Vermont lakes are doing," which is commonly asked by the general public, municipalities, volunteer monitors, lake associations, students, and many others. The Score Card offers a great method for easy communication with the public about the status of Vermont lakes because it uses only three simple colors to convey the meaning of complex data sets (scores are calculated from the data). Red is used for low scores to show reduced conditions. Yellow is used to show moderate concern. Blue indicates high or good scores from stable or improving conditions. Additionally, the score card provides Guidance on Actions for the public to employ to better protect Vermont lakes.

Blue = Good Conditions

Yellow = Fair Conditions

Red = Reduced Conditions

Similar "score systems" are used in other states or nationally to present the current

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conditions for rivers, marine bays, and for air quality conditions. In Massachusetts, The Assabet River Steam Watch Program and The Coalition for Buzzards Bay use color-coded water quality indices to alert the public on the condition of the waters. The National Air Quality Index relies on colors to express the daily public health conditions of the air. For more information about the general use of score cards, visit the New England Regional Monitoring Collaborative, NERMC.

How the Vermont Lake Score Card is Calculated

Each of the four categories (water quality, aquatic invasive species, atmospheric deposition, and shoreland and lake habitat) is independently scored based on the relevant data collected to date. Within a category, an index may be used, which draws information from matrices built of parameters. The index calculates a final sum from all the matrices of parameters. Indices help summarize large amounts of data into simple terms (e.g., good, fair, reduced) for reporting to the public in a consistent manner. Listed below are the details for each of the four categories, including the indices used to calculate the score.

Parameter
One of a set of measurable factors (e.g. temperature, pH), that define a system and determine its behavior.
Metric
Parameters analyzed and summarized.
Index
A Metric or multi-metrics combined to yield an aggregated number used to judge condition.

Water Quality Index

The water quality score is based on the long-term nutrient enrichment trends from three monitoring programs:

- the Lay Monitoring Program
- the Spring Phosphorus Sampling Program
- Lake Assessment Special Studies

Within each of these programs, the data is interpreted to yield a score. The sum of the program scores reflect the Lake Score Card's grade for Water Quality. However, if data is NOT available from either the Spring Phosphorus or Lay Monitoring Program (whenever there is data from either of these sampling efforts, there also will be data from the Lake Assessment Special Studies), then the program data available gets scaled to fit the scoring system.

Lake Assessment Special Studies scores take into consideration comments from public meetings, from public reports, and from lake scientists. Because this program's information includes text files as well as data, the assessment database is not currently available to the public on the Vermont Water Quality web site. The LMP and Spring Phosphorus data sets are available on the web (links provided below).

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Currently there are seven lakes in Vermont that are considered "impaired" and are included on the United States Environmental Protection Agency's 303(d) list of impaired waterbodies. In three of these cases, these lakes have been listed because of unnaturally high levels of phosphorus (several sections of Lake Champlain, Lake Carmi in Franklin and Ticklenaked Pond in Ryegate). To be consistent in reporting the status of Vermont lakes, the Score Card has given a unique "handicap" score to the impaired lakes of negative two, so they can not indicate a better condition than what the comprehensive lake assessment declares. The Lake Assessment Special Studies scores are based on the determination as to whether or not the lake is impaired, stressed or supporting of all designated uses. See Table 1. Water Quality Index for actual scoring methods.

Table 1. Water Quality Index

Lake Name	**Assessment** Impaired = -2 Stressed = 0 Supporting = 2	**LMP Trend** Decline p<0.01 = 0 Decline p<0.05 = 1 Stable/improve = 2	**Spring Phos. Trend** Decline p<0.01 = 0 Decline p<0.05 = 1 Stable/improve = 2	**Total Score** Declining <3 Some Concern 3-4 Stable/Improving >4	blue = stable/improving yellow = concern red = declining
Lake Healthy	2	2	2	6	**(blue) Good Conditions**
Lake Concern	2	0	2	4	**(yellow) Fair Conditions**
Lake Decline	0	1	0	2	**(red) Reduced Conditions**

Table 2. Water Quality Statistical Long Term Trends for: Total Phosphorus, Chlorophyll-a, Secchi Water Clarity

Statistical Probability (P value)	Statistical Trend Indication	Program Score 0 = reduced 1 = fair 2 = good
>0.05	**Not Significant**	**2**
.01 -.05	**Significant** - with improving slope - with declining slope	 **2** **1**
<0.01	**Highly Significant** - with improving slope - with declining slope	 **2** **0**

Table 3.

Combinations for Lay Monitoring Program Statistical Trend Scores for Phosphorus, Chlorophyll-a and Secchi Clarity

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Score only generated for lakes with two or three parameter trends (See Table 2. for scoring system) **Good = Blue** **Fair = Yellow** **Reduced = Red**				
Possible Chlorophyll-a, Phosphorus and Secchi Water Clarity Combination scores			Final LMP Score < 3 LMP = Red 3-4 LMP = Yellow 4 > LMP = Blue	Conversion of LMP score to The Water Quality Index Scoring System **< 3 LMP = 0 WQ Index points** **3-4 LMP = 1 WQ Index points** **4 > LMP = 2 WQ Index points**
0	1	1	2	0
0	2	0	2	0
0	2	2	4	1
0	0	1	1	0
2	2	1	5	2
0	2	1	3	1
0	0	0	0	0
2	2	2	6	2
1	1	1	3	1

LMP TREND

Lay Monitoring Program

Volunteers monitor total phosphorus, chlorophyll-a and Secchi water clarity during the summer months of June, July and August on more than 80 lakes throughout Vermont. Similar to the Spring Phosphorus Program, a statistical trend analysis is conducted on the long-term data set of annual summer means. (Annual summer means are calculated from at least eight samples taken during the summer). Scores for each of the three parameters are then combined into the LMP final score. Table 2. shows how the results from the statistical trend analysis are interpreted. Table 3. shows how the final LMP score was derived based on the statistical trends from all three parameters.

Note, when data is not available for all LMP parameters, then the score defaults to the “stable status,” or “good status,” since there would be no reason to assume otherwise, receiving a score of 2.

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Spring P Trend

Spring Phosphorus Sampling Program

Spring phosphorus sampling is conducted annually in the spring within two weeks of ice-out. Under natural conditions, the majority of phosphorus enters the lake during the spring when the flow of inlet streams is high due to snowmelt and spring rains. While the lake is in spring overturn, just after ice-out, the incoming phosphorus is distributed evenly throughout the lake. At this time, the total phosphorus concentration can be used to predict the amount of algal growth that will occur in the lake during the summer.

The score is based on a statistical trend analysis, where the closer the total phosphorus concentrations, measured over the years, are to one another, then the closer the probability (P value) would be to 1.0 – or the closer the data points would all be to one another (not scattered on a plot). For the Lake Score Card interpretation of the statistical trend analysis for spring phosphorus, the P values are divided into three classes:

- P values > 0.05 = Not Significant
- P values between 0.01 and 0.05 = Significant
- P values < 0.01 = Highly Significant

A value of "not significant" indicates stability in the spring phosphorus in the lake over time, which is considered a good trend and earns a top score of 2 (scores range from 0 to 2). (A stable, long-term phosphorus trend means there has been no negative nor positive change in lake nutrient enrichment.)

If spring phosphorus is decreasing (significant or highly significant probability with a decreasing slope), then the water quality trend is good and the score is 2. If phosphorus is increasing significantly the water quality trend is fair and gets a score of 1 and if the increase in phosphorus is highly significant the water quality trend is poor and it gets a score of 0 (see Table 2).

Assessment Trend

Lakes and Ponds Monitoring

All other water quality data that is collected on a lake over the years is grouped under the header of Lake Assessment. Usually lake assessments are designed to evaluate the extent to which lakes meet designated uses for Federal reporting purposes (305B Report), and to gather information to focus lake protection efforts. In general, under lake assessment field work, lakes are circumnavigated and detailed observations are made regarding in-lake and shoreline conditions with respect to designated uses and threats to lake water quality; the extent and composition of the macrophyte community; and samples are taken for total phosphorus, alkalinity, Secchi disk transparency, dissolved oxygen, temperature, as well as additional parameters.

Based on the lake assessment a lake scores negative two (-2) when considered impaired, zero (0) when stressed and a score of two (2) when the lake is determined to support all uses.

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Aquatic Invasive Species

There are only two possible scores for a lake concerning aquatic invasive species:
Blue = No known invasive species
Red = Invasive species present
The color blue indicates the lake does not have a known invasive species and the color red indicates the lake does have at least one known infestation of an invasive species regardless of its abundance or "nuisance" level.

Lake Score Card Aquatic Invasive Species Index	
Blue =	**No, no known invasive species in lake**
Red =	**Yes, invasive species confirmed in lake**

To find out what aquatic native and/or invasive plants are known in your lake, in **Google Earth, click on the "Aquatic Plants"** listing from the left side tab.

Aquatic Invasive Species Management DOES Matter!
For those lakes with invasive species that have excellent management plans, controlling the spread of the invasive, a red color may seem misleading. Management plans for reducing and controlling invasive plants and animals are extremely important, but to keep the Lake Score Card as simple as possible, it was decided not to try and showcase effective management plan trends. Management trends would be a great addition to this Score Card and perhaps in the future will appear as positive arrows on top of the red color to indicate "Yes" invasive species are present, but also fantastic local management actions are taking place. Therefore, the aquatic Invasive species quadrant color, Red or Blue, indicates current status only, without taking into consideration the degree of local management actions or the current abundance of that species.

Vermont Aquatic Invasive Species Program
Invasive species are non-native species with the potential to cause harm to the environment, economy, and or human health. The Vermont Department of Environmental Conservation manages the Vermont Aquatic Nuisance Control Program to prevent or reduce the environmental and socio-economic impacts of nuisance (primarily non-native) aquatic plant and animal species.

Aquatic invasive species are a huge public concern and the Lake Score Card reports out the status of a lake, based on the presence or absence of invasive species. The invasive species considered for the Lake Score card are:

- Eurasian watermilfoil
- variable watermilfoil
- water chestnut
- zebra mussel
- alewife
- rusty crayfish
- didymo

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Atmospheric Pollutant Status Index

This score is based on the highest threat from either mercury or acid rain.

Threats from atmospheric pollutants considered in this index are acid rain and mercury deposition. Each pollutant is scored according to its impact on Vermont lakes. Possible scores range from 0 = Impaired; 1 = Stressed; and 2 = Supporting (in terms of lake uses). However, unlike the Vermont Lake Score Card Water Quality Index, the parameter scores are not added together. The overall score for this index is based on the LOWER of the two scores (the lowest score represents the highest threat). This method is how the The National Air Quality Index reports to the public with their daily air advisories. Table 4. shows the atmospheric index used in the Vermont Score Card.

The Vermont Department of Health has issued a "Health Alert" on fish consumption from Vermont waters based primarily on mercury contamination (to a lesser extent the warning includes contamination from PCBs or polychlorinated biphenyls). The monitoring results that this health warning is based on also provide the science used for the atmospheric pollution in the Lake Score Card. Currently, all but two Vermont lakes are threatened by mercury contamination (Shelburne Pond in Shelburne and Lake Carmi in Franklin do not have high Mercury levels). Therefore, for the purposes of the Lake Score Card, it is impossible for a lake to receive a blue color for atmospheric deposition, with the exception of just two lakes. The "Fair" and "Yellow" rating for mercury in all, but two lakes, is the best rating reported in the Lake Score Card for atmospheric deposition.

Read the individual parameters below for more specific information, such as how Vermont acid rain lakes have shown improved conditions since the 1990 U.S. Clean Air Act Amendments.

Table 4. Atmospheric Index

Lake Name	Mercury Impaired	Acid Rain Impaired	Assessment Color	Assessment Score (is the lowest value, not a combined score)
Grey Lake	STRESSED	SUPPORTING	**Yellow**	1
Silver Lake	IMPAIRED	SUPPORTING	**Red**	0
Safe Lake	SUPPORTING	SUPPORTING	**Blue**	2

Acid Rain

Acidification of lakes remains a serious threat for Vermont, the northeastern United States and eastern Canada. Acid rain occurs when sulfur dioxide, SO_4, and nitrogen oxides (NOx) are emitted into the atmosphere from burning fossil fuels. These pollutants combine with water and oxidants like ozone to become sulfuric and nitric acid. These acids may travel long distances before falling to the earth in the form of rain or snow, and affecting the chemistry and biology of lakes, streams, forests, and other ecosystems. Acid rain was first noticed in the 19th century, but was not considered a serious problem until the 1970s.

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The VT Department of Environmental Conservation has been monitoring acid rain since 1983. Based on the alkalinity, a measure of the buffering or acid neutralizing capacity of the water, lakes are “scored” from extremely sensitive to not sensitive to acidification.

- Extremely sensitive to acidification: alk < 2.5 mg/L $CaCO_3$
- Moderately sensitive to acidification: 2.5 < alk >12.5 mg/L $CaCO_3$
- Not sensitive to acidification: alk > 12.5 mg/L $CaCO_3$

Table 5. Sensitivity to Acid Rain Metric

Lake Name	IMPAIRED USES (0) Extremely Sensitive to Acidification Alk < or = 2.5 mg/L CaCo3	STRESSED USES (1) Moderately Sensitive to Acidification Alk >2.5 but < or +12.5 mg/L CaCO3	SUPPORTING USES (2) Not Sensitive to Acidication Alk > 12.5 mg/L CaCo3
High Alk Lake			
Some Alk Lake			
Low Alk Lake			

Mercury

Mercury (Hg) pollution is a serious environmental problem, contaminating forests, soils, rivers and lakes in Vermont and throughout the world. An extensive study between 1998 and 2004 measured total mercury and total methylmercury (the toxic form of mercury) in surface sediments and waters of 93 randomly-selected Vermont and New Hampshire lakes. The same lakes were tested for a variety of naturally occurring chemical constituents. From a subset of these lakes also several biological compartments were measured for mercury. These included large-bodied zooplankton, small (plankton-eating) yellow perch, large (fish-eating) yellow perch, and fish eating birds, such as loons, mergansers, and kingfishers. The project findings indicate that across VT and NH, 40% of lakes are likely to have relatively small fish that exceed EPA limits for allowable fish-tissue mercury. This study has produced a large dataset that is compatible to those already existing in the State of Maine, and in the Adirondack region of New York. The results of this study provide baseline chemical and biological indicators against which future reductions of atmospherically emitted mercury can be measured.

Click here, to read more about this study.

Mercury is reported in concentrations of parts-per-trillion (ppt) and in Vermont lakes the average water-column total mercury (Hg) concentrations were 1.78 (± 0.1) ppt for shallow-water samples, and 11.52 (± 0.81) ppt in deep lake waters.

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Shoreland and Lake Habitat Status

Lake Protection Program

Three studies were used to determine the status of the Vermont lake shorelands and the adjacent shallow water.

1. The Littoral Habitat Study provides comprehensive measurements on shoreland characteristics and the adjoining shallow water (littoral) zone from 50 lakes.
2. The National Lake Survey assessed 30 lakes in Vermont, including shoreland habitat.
3. The University of Vermont through its program in Geographical Information Systems has produced more than 97 maps on lake shore development using 2003 satellite orthophotos.

After compiling the results from the first two studies, it was discovered that wherever the shallow water habitat was degraded, there was a positive correlation to lakeshore lawns, as mapped by the UVM GIS work. Degraded and poor habitat existed wherever lawns were present down to the lake. Because of this finding, the GIS mapping alone can be used to determine the score for shoreland and lake habitat, allowing many more lakes to be assessed for lake and shoreland habitat in a short period of time. How this simple conclusion is supported by complex science, is best understood by reading more about the Littoral Habitat Study and the National Lakes Study.

Shoreline alteration is one of the highest and most widespread stressors in lakes in the United States, as the National Lake Survey concludes. Often when shorelands are developed, the natural, native vegetation along the shore is cleared, which literally removes the ability of a lake to buffer itself from pollution run-off, as well as changes the lake's ecology.

Shoreland buffer strips have multiple values. These areas can filter out pollutants, stabilize shorelands, provide a protected corridor for wildlife to access the water, and shade the water's edge, keeping the water temperature cooled. A wooded shore provides terrestrial habitat for the myriad of bird and mammal species that live or feed near water.

The buffer's duff and ground vegetation slow the runoff on the ground, increase the absorption into the soil and catch sediment in the runoff. Some of the pollutants are also removed from the runoff by the duff layer. The buffer layers gently transport the rain and decrease the energy of raindrops, reducing erosion.

Rocky and cobblestone lake bottom areas provide hiding places and surfaces for aquatic insects and other animals to feed and live on. If the spaces between the rocks get filled in with eroded soil from adjacent land uses, the habitat quality becomes degraded. The depth at which rocks and pebbles are buried in finer sediment is known as the "embeddedness". A vegetated shore helps prevent sediments from entering and smothering a lake bottom. Buffers also supply fallen trees and branches, known as "woody habitat," and leaf litter to form important habitat structure for insects to live on, small fish to hide in and feed on, and larger carnivorous fish to patrol. Trees hanging over the water shade the shallows keeping them cool, and insects that fall off the branches are good fish food. Generally, in the shallows adjacent to a wooded shore, aquatic plant growth is not as dense as those nearshore areas where clearing has brought in more light and nutrients.

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Nymphs, the aquatic phase of flying insects, such as dragonflies, mayflies, damselflies and craneflies live in protected spaces among the woody and leafy debris in shallow water. They need to be able to crawl out onto surfacing plants or shore vegetation to shed their exoskeleton and emerge as flying adults. Dragonflies and other flying insect eaters consume thousands of mosquitoes! Many aquatic species spend some life stage in the duff layer of the shore, including the weevil known to feed on Eurasian watermilfoil.

A naturally vegetated shore provides bank stability through a complex mix of root depths and patterns. Removing shore trees and shrubs exposes the adjacent shallow water to more sun and to increased sediment and phosphorus runoff. The increased light, warmer water and additional nutrients result in increased algae and nuisance plant growth in the immediate nearshore area. In addition, a lake without, or with little buffering vegetation will experience an overall increase in phosphorus concentration, meaning more algae growth everywhere and less water clarity.

A naturally vegetated buffer along lakes can provide numerous benefits to people as well. People generally agree that shoreland vegetation increases the beauty of a lake and it provides privacy to your lakefront property. Compared to natural vegetation mown grass has shallow roots and cannot withstand the erosive forces of waves and high water, and it is not able to filter out pollutants carried by run-off.

WHAT IS MEASURED

Explaining the Parameters

To understand surface water monitoring and assessment, the Vermont Water Quality Division has published the Vermont Volunteer Surface Water Monitoring Guide, which is available on the web. Within this Guide, Section Three explains water quality parameters and Vermont monitoring examples are shown throughout the Guide.