What is Acidity?

Waterbodies exhibit a range of acidity, primarily reflected by the acidity level (or pH) of the water. Natural factors affecting a waterbody's pH include its landscape position, landscape slope, watershed size, bedrock and soil composition. Human activities can alter the acidity of a waterbody through long distant transport and deposition of atmospheric pollutants (commonly referred to as acid rain) and/or through mining activities. More detailed information concerning acidity can be found in Appendix B.

Long distant transport of atmospheric pollutants:
Acid rain occurs when sulfur dioxide (SO_2), and nitrogen oxides (NO_x) are emitted into the atmosphere from burning fossil fuels. These pollutants are known as acid-forming precursors, which combine with water and ozone to become sulfuric and nitric acid. Even though Vermont emits the lowest amount of acid-forming precursors in the nation, emissions from upwind states and provinces and blow eastward affecting the chemistry and biology of Vermont's lakes, streams, and forests.

The most obvious environmental effect of acid rain has been the loss of fish in acid sensitive lakes and streams. Acid sensitive lakes or streams have little or no buffering capacity, and because of the type of bedrock underlying these waterbodies, they cannot neutralize the acids. These lakes and streams are found in watersheds with granite bedrock which lack the buffering ions (like calcium) to neutralize the effects of acid rain. Many lakes in the Adirondack area of upper New York State are underlain with anorthsite (a type of granitic rock) and have suffered severe aquatic life loss because of acid rain; these lakes have been called "dead lakes." In reality, the lakes are not completely dead, but their biological communities have been so compromised that only the most tolerant fish, plants and insects can survive. In Vermont, we have also described some acid lakes as "dead" specifically in reference to their fish-less status. In poorly-buffered watersheds like these, scientists have documented significant incremental losses of buffering ions once present. In these areas, full recovery of surface waters may be difficult to achieve.

Fortunately, many lakes in Vermont have watersheds with calcium-rich bedrock (such as limestone), that protect surface waters by neutralizing the acidity of acid rain. Vermont surface waters that are most sensitive to acid rain are often smaller, at high elevation, and located in areas with low buffering bedrock. These acid-sensitive waters are mostly found in remote and undeveloped regions of the southern Green Mountains and in areas of the Northeast Kingdom.

Mining:
Vermont had three major copper mines operating from 1800-1958: Elizabeth, Ely and Pike Hill. All three mines are now closed, but the tailing piles left behind have caused acidification and the release of heavy metals in downstream waterbodies. Historically, sulfuric acid was used to extract copper from the ore, resulting in the release of acids and heavy metals from tailing piles. The leaching of acid mine drainage continues in some instances to the present day, even if the mines are no longer in operation. Four streams have been listed as acid-impaired due to the drainage from the former copper mines. The USEPA has designated Elizabeth and Ely Mines as Superfund sites. A comprehensive remediation effort at the Elizabeth Mine (Strafford and Thetford, VT) has resulted in recovery of several miles of the West Branch of the Ompompanoosuc River and Lord Brook. Additional remediation planned for 2017-2018 is intended to incrementally further restore the headwaters of Lord Brook. Acid mine leachate remediation activities are also planned for the Ely Mine (Thetford) to address acid mine drainage issues on Schoolhouse Brook. Also, water quality monitoring has determined that Pike Hill Brook and a portion of an unnamed tributary to Cookville Brook are impaired due to acid mine drainage from the defunct Pike Hill Mine (Corinth, VT).

How important is Acidity?

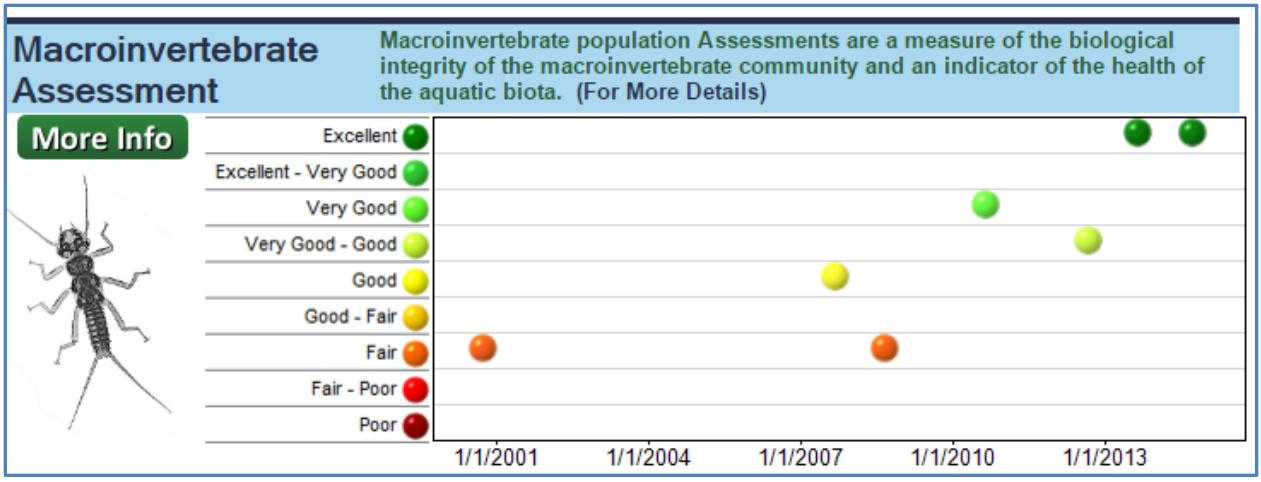

Figure 1. Recovery of biological integrity of Lord Brook, Thetford, VT, after partial remediation of the Elizabeth Mine's "South Cut."

Based on the Watershed Management Division's evaluation, acidity is a moderately ranked stressor, the effects of which are regional in scale, in that certain watersheds exhibit acid sensitivity. In other areas of the northeast, the effects of acidification are more pervasive. A 2010 NESCAUM project demonstrates the extensiveness and severity of acid-forming precursor deposition to northeastern States, concluding that ~30% of Vermont's forests receive excessive loads of acid-forming precursors. In these areas, acidity may be an intense stressor to surface waters with moderate to severe biological impacts. Based on a recent statistically-based survey, up to 16% of Vermont lakes may be stressed by acidity, while 3% of lakes are acid-impaired. The most recent statewide water quality assessment indicates that thirty eight ponds have been listed as acid impaired due to atmospheric pollutants, and ~160 miles of assessed streams are either stressed or impaired due to acidity. Two acid impaired lakes have improved enough to be taken of the TMDL list and moved to the acid strssed list. This is largely due to the federally mandated regulations associated ith the Clean Air Act and its amendments.

Long-term results from the volunteer Vermont Acid Precipitation Monitoring Program show trends of decreased acidity or improved pH as a result of the federal air pollution control regulations. With the passage of the 1990 Clean Air Act, sulfate levels in surface waters have been reduced, but there have been no significant trends observed for NO_x, which means it may be too early to detect decreased acidity levels in Vermont surface waters. However, these favorable trends may be too late for the most acidified lakes in Vermont. The reservoir of calcium and magnesium ions in watershed soils not only buffered the acidity of surface waters, but also provided for necessary essential minerals required by aquatic organisms. A decrease in calcium concentrations can be detrimental to the shell development of crustaceans and mollusks as well as to the ability of fish to respond to changes in water temperature and alkalinity. So for lakes like Branch Pond in Sunderland, the significant reduction in these beneficial minerals may prevent the full biological recovery once expected with the improving acidic conditions.

What objectives achieved by controlling Acidity?

Addressing and preventing acidity promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***
The acid-forming compounds of nitrogen oxides atmospherically deposited to Vermont's watersheds are themselves sources of nutrients. Atmospheric deposition of nitrogen oxides is responsible for a large proportion of the human-caused nitrogen load in undeveloped watersheds.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***
Acidified waters often exhibit high levels of mercury in fish tissue. As such, reducing acidity also reduces the impact of fish mercury contamination.

What are the causes and sources of Acidity

The causes of acidity include atmospheric deposition, which is widespread throughout Vermont, and runoff of so-called "acid mine leachate," which is much more localized. The sources of atmospheric deposition include a wide variety of industrial and mobile sources that emit nitrogen oxides and sulfur dioxides. Industrial facilities such as coal-fired power plants, waste combustors, and utility boilers are all stationary sources of acidity to the atmosphere. Mobile sources such as cars and trucks account for over half of the nitrogen oxide emissions. Abandoned mining operations are the source of acidity from mine leachate. In Vermont, only a small number of surface waters fall into this category.

Monitoring and assessment activities to track Acidity

Most of the WSMD activities involved with acidity are associated with monitoring and assessment. This is due to the nature of the problem which is mostly created from long distance, out of state sources or from historical land uses. For acid lakes, VTDEC tracks responses to the Clean Air Act (See Vermont Long- Term Monitoring Project. This program has been critical to demonstrating the effectiveness of the Clean Air Act, determining TMDLs for acid lakes and in winning a major settlement with a mid-western coal powered utility, American Electric Power, to reduce emission of acid- forming pollutants. By providing long-term monitoring of water chemistry, the Division has demonstrated the benefits of the federal regulation and the need for further reductions to achieve biological recovery.

Other programs which assess the acidic conditions of Vermont waters or track precipitation chemistry include the following:

- Vermont Ambient Biomonitoring Program for acid streams (both from acid mines and acid deposition)
- Vermont Acid Precipitation Monitoring Program to track pH changes in precipitation
- National Atmospheric Deposition Program tracks changes in atmospheric chemistry nationwide

WSMD Scientist Jim Kellogg monitoring acid-impaired Levi Pond in Groton, VT. Jim has tracked acidification of Vermont surface waters since 1980.

- Vermont Air Monitoring Network tracks air pollution concentrations in Vermont

Technical assistance programs to address Acidity

Technical assistance for acidity is limited due to the nature of the stressor. For acid lakes, the WSMD has avoided actively treating lakes with lime or other alkaline substances to increase their pH. Research from experimental lakes in Europe and Canada showed that treating lakes would only temporarily increase the pH and buffering capacity. These lakes would require ongoing treatments and would provide a chemically unstable habitat, due to fluctuating pH, alkalinity and aluminum. Instead, Vermont acid lakes are monitored to assess the changes over time to the lakes and their watersheds from air pollutant emissions. For acid mine drainages, there are only a handful of former mining sites which have caused downstream impacts. These sites are coordinated by the VTDEC Hazardous Waste Management Program in cooperation with the US EPA Superfund program.

Regulatory programs to address Acidity

The Watershed Management Division does not regulate emissions from acid precursors. Instead, the Air Quality and Climate Division (AQCD) maintains up to date Air Pollution Control Regulations that comply with EPA's regulations issued under the Clean Air Act. These regulations confer to AQCD regulatory and permitting authority on several air emissions source types, both mobile and stationary, that have potential impacts to surface waters. AQCD maintains Air Quality Standards that are used similarly to Water Quality Standards to limit emissions of air contaminants to safe levels. Depending on the volume emitted, individual permits may be required. AQCD also issues a general permit for smaller emissions sources.

The VTDEC Waste Management and Prevention Division, Sites Management Program regulates the disclosure and cleanup of environmental contamination and spill sites.

Funding programs to address Acidity

Vermont has received funding from the US EPA, Office of Air and Radiation, Clean Air Markets Division, to monitor acid lakes for over 30 years. This funding has allowed consistent data collection and assessment of acid lakes in Vermont and the northeast. A grant for this program has been awarded to the VTDEC for 2015-2020.

The US EPA has provided funding through the Comprehensive Environmental Response, Compensation, and Liability Act (a.k.a. Superfund) since 2000 for acid mine drainage remediation in Vermont.

The Vermont Environmental Contingency Fund, Waste Management Division, Sites Management Section, has also provided significant funding for the treatment and clean-up of acid mine drainages.

There are specific no funding programs aimed at alleviating acidity in Vermont. The vast majority of acid-forming pollutants are emitted from out of state sources. As a result, the State of Vermont has lobbied the US Congress for strict pollution control emission regulations and successfully joined litigation with EPA, 8 states and 12 environmental organizations against a major coal powered utility. This settlement mandated the adoption of new pollution control methods which will significantly reduce the amount of nitrogen oxide and sulfur dioxide released to the air.

Information and education programs to address Acidity

VTDEC provides information and education about acid rain through the Vermont Long-Term Monitoring Project for acid-sensitive lakes and the Vermont Acid Precipitation Monitoring Program monitors the pH of precipitation on an event basis utilizing volunteer monitors.

The Waste Management and Prevention Division's Sites Management Program provides information and education to the public about acid mine drainages. They hold public meetings and inform the legislature about the current status and remediation efforts.

In addition, the Vermont Watershed Management Division's Tactical Basin Planning Program provides education through basin planning activities with the public.