The State of Hamilton County Lakes

A Statistical Analysis of Water Quality Trends

1993-2003

"A lake is the landscape's most beautiful and expressive feature. It is the earth's eye"
--Henry David Thoreau

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ACKNOWLEDGEMENTS

The Soil and Water Conservation District would like to take this opportunity to thank a few of the many people who have made this program and report possible:

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* Cover photo provided by: Caitlin Stewart

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INTRODUCTION

Water is necessary for life, not only for the physical health of Hamilton County, but also for our economic well being. The Thoreau quote once described water bodies as "…the Earth's eye." This is fitting to the situation here. Many of us are drawn to this area because of the abundance of water. Some prefer to paddle canoes, some fish, some like to water ski, others to swim or just gaze at the sparkling reflection of sunlight as it dances across the tops of the waves. Whatever the reason, this attraction to the water has resulted in residential development along the waters edge. While we enjoy the beauty of our lakes, keep in mind that we cannot let the rhythm of the wind swept waves lull us into a false sense of security that these waters are unchanging, healthy and clean. Over the past few decades, industry has developed increasingly complex chemicals used in manufacture and medicines. We have yet to realize the possible side affects these advances may bring to the environment. Regulations on emissions from cars, smokestacks and pipes have been increasing, but the timing of putting controls into effect falls behind the timing of the pollution. It is our duty to keep an eye on our impacts. We need not be remembered as the generation that despoiled our greatest asset.

Report Organization

This report has been organized to first present the history of the water monitoring program and methodologies used to help prepare the reader as to the scope and presentation.

The next section is the statistical analysis of water quality trends in Hamilton County Lakes 1993-2003, as prepared by Michael Martin, CLM of Cedar Eden Environmental LLC (Saranac Lake, NY). The Hamilton County Soil & Water Conservation District has added certain supplemental information for each lake to the statistical analysis section. This report closes with appendices, glossary and references.

> *This entire document is available to be downloaded from our website, www.hamiltoncountyswcd.com, in the Adobe PDF format. You may contact the Hamilton County Soil and Water Conservation District and make arrangements to obtain a copy on CD. Contact the Hamilton County Soil & Water Conservation District office if you have any questions.*

History

Recognizing the need to protect our vital water resources, the Hamilton County Board of Supervisors contracted with the Hamilton County Soil and Water Conservation District in 1993 to conduct a comprehensive water-monitoring program.

With great foresight, the elected officials of Hamilton County decided to keep an eye on the quality of water within their political boundary. This monitoring program follows efforts dating back to the mid-seventies when public management of septic systems became a necessary reality. Increasing development along shorelines and inadequate septic systems were beginning to take their toll on lake water quality. People began to take notice and the County and State took action. Local Law # 1 of 1976 was signed into effect and stated that no sewage could be discharged into the waters of Hamilton County. The enforcement of this law was in everyone's best interest and had a measurable impact on water quality.

Looking back at historical data our present water quality is now closer to data collected in the 1930's than data collected in the 1970's. Changes in lake water quality are expected over time, but they are supposed to happen over geologic time not within 20 years. In this case the change was positive due to the foresight of the local officials. Much is still unknown about the effect of lakefront and watershed growth, highway runoff and even acid precipitation. The monitoring program is in place to detect these changes.

In the beginning, the water-monitoring program had limited resources and equipment. The effort was admirable and relied on volunteers, like Jay Cummings of Raquette Lake and Bob Dechene Sr., to ferry the water monitoring crew out to the sampling locations where the 6 hp outboard on the water monitoring boat would prove to be inefficient.

In 1996, the Hamilton County Soil and Water Conservation District became a member of the Finger Lakes-Lake Ontario Watershed Protection Alliance. State funds are allocated to this group to further water quality efforts in the Finger Lakes and Lake Ontario watersheds. Funds are divided equally among the twenty-five member counties. In 1997, we received the first check and were able to hire additional staff, upgrade computers, equipment, new water monitoring boat and a pro-environmental (4 stroke) 25 hp outboard motor. We have continued to receive this vital funding allowing us to further our mission.

Purpose

The purpose of the water-monitoring program is to collect and record data over an extended period and keep a watchful eye out for any changes. This is called baseline data collection. The standard minimum period necessary to collect baseline data before analyzing for long-term trends is currently considered ten years.

We now have eleven years of data. Within our sampling years, we have had some strange weather, which invariably will increase the time necessary to reduce the "noise" caused by such events so that we might "hear" more clearly what the lakes are trying to tell us. With these facts in mind, please read this report carefully. The data set presented here comprises an eleven-year effort, yet is still considered young and full of "noise" that can only be sorted out by continuing to monitor the water quality over time. Instead of jumping to conclusions that the sky is falling or that all is fine, enjoy instead an insight into what lies ahead in our understanding of the water quality of lakes in Hamilton County.

Lakes are dynamic and complex ecosystems, and each one is different. We will often refer to the water quality of a lake compared to the overall average water quality of Hamilton County. The purpose of this is for reference only and comparison of trends. A little knowledge can be dangerous, and we caution you not to try to draw conclusions that aren't based on statistical analysis.

This report has been designed to be readable while providing a vast amount of technical support information. Realizing that definitions for each technical term would make the report cumbersome, a glossary of terms has been included in the appendix instead. Please refer to the glossary for definitions.

With that in mind we present to the people of Hamilton County this report on "The State of Hamilton County Lakes an Analysis of Water Quality Trends 1993-2003."

METHODOLOGY

Lakes are complex systems containing plants and animals, which interact in an environment created and impacted by geology and geography. The most extensive and expensive studies cannot completely account for all conditions within the lake. By looking at some basic chemical, physical, and biological properties, however, it is possible to gain a greater understanding of the general condition of a lake. The methodology of studying lakes has come from years of research and statistical modeling. Thanks to the effort of researchers, we are better able to understand and classify our lakes so that we have an even better understanding of our lakes and any changes that might occur.

The lakes involved in the study were chosen by the Hamilton County Board of Supervisors except for Fawn Lake in Lake Pleasant which was chosen for inclusion as a control since it has no development within it's watershed. A lake will remain in the study for a minimum time frame of five years before another lake can be "appointed" for monitoring in its place. To date the Soil and Water Conservation District has collected water quality data on 22 lakes and 19 of the 22 have been studied for all eleven years of the data set discussed in this report.

The following lakes have been involved in the study:

Lake	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Blue Mountain Lake	x	x	x	x	x	x	x	x	x	x	x
Eighth Lake	x	x	x	x	x	x	x	x	x	x	x
Fifth Lake	x	x	x	x	x	x	x	x	x	x	x
Fourth Lake	x	x	x	x	x	x	x	x	x	x	x
Indian Lake	x	x	x	x	x	x	x	x	x	x	x
Lake Adirondack	x	x	x	x	x	x	x	x	x	x	x
Lake Algonquin	x	x	x	x	x	x	x	x	x	x	x
Lake Durant	x	x	x	x	x	-	-	-	-	-	-
Lake Eaton	x	x	x	x	x	x	x	x	x	x	x
Lake Pleasant	x	x	x	x	x	x	x	x	x	x	x
Limekiln Lake	x	x	x	x	x	x	x	x	x	x	x
Long Lake	x	x	x	x	x	x	x	x	x	x	x
Morehouse Lake	x	x	x	x	x	x	x	x	x	x	x
Oxbow Lake	x	x	x	x	x	x	x	x	x	x	x
Piseco Lake	x	x	x	x	x	x	x	x	x	x	x
Raquette Lake	x	x	x	x	x	x	x	x	x	x	x
Sacandaga Lake	x	x	x	x	x	x	x	x	x	x	x
Seventh Lake	x	x	x	x	x	x	x	x	x	x	x
Sixth Lake	x	x	x	x	x	x	x	x	x	x	x
Spy Lake	x	x	x	x	x	x	x	x	x	x	x
Fawn Lake (control)	-	-	-	-	x	x	x	x	x	x	x
Lake Abanakee	-	-	-	-	-	x	x	x	x	x	x

("x" indicates the test that were preformed during that year)

At the request of the town of the Indian Lake Supervisor, Lake Durant was dropped from the sampling program schedule after a minimum 5 years of data had been collected. The removal of Lake Durant allowed for the addition of Lake Abanakee (designated a higher priority waterbody) to the lake monitoring schedule.

The water monitoring crew currently launches the water monitoring boat on all but one of these lakes once a month during the months of May to October. State law does not permit motor vehicle access to Fawn Lake. In order to sample Fawn Lake, the water monitoring crew hikes into the lake with a canoe full of equipment on a boat cart.

Standard limnological sampling protocol when gathering general water quality information for a large water body is followed for the water-monitoring program. In order to collect the most representative water quality data for a lake, while minimizing variation from boat traffic, recent rainfall, shoreline activities, and thousands of other variables, water samples are best collected from the deepest part of the lake. The deepest location of the lake has the greatest volume and therefore, represents the most stable water quality. The best picture of the overall water quality of a lake can be painted from data collected in this area. As the water quality data collected will not represent the water quality of each individual bay, any changes to water quality in those bays will eventually impact the overall water quality and be seen in analysis of the water quality data.

To travel to all the lakes in the study and collect samples takes about a week and a day. When you add the time in the laboratory for analysis and the computer data entry and management the entire process takes two to three weeks of time for two staff members.

The Hamilton County water-monitoring program as administered by the Soil and Water Conservation District takes into account chemical, physical and biological parameters. The core parameters that have been sampled for over the entire six years include: secchi disk transparency, pH, alkalinity, total phosphorous, nitrates, temperature and dissolved oxygen. Since our inclusion in the Finger Lakes-Lake Ontario Watershed Protection Alliance, we have added the following parameters: aluminum, calcium, and chlorophyll *a*. Water samples are collected with a bomb sampler or a Kemmerer bottle and brought back to the laboratory in a cooler for analysis for some of the parameters. Other parameters are more easily measured in the field. Equipment for measurement in the field will be described with the parameter specifically being tested.

Data exists for the following parameters in the laboratory data set:

Year	pH	Alk	Nit	Phos	DO	Temp	Secchi	Chl-a	Ca*	Al*
1993	x	x	x	x	x	x	x	-	-	-
1994	x	x	x	x	x	x	x	-	-	-
1995	x	x	x	x	x	x	x	-	-	-
1996	x	x	x	x	x	x	x	-	-	-
1997	x	x	x	x	x	x	x	x	-	-
1998	x	x	x	x	x	x	x	x	x	x
1999	x	x	x	x	x	x	x	x	x	x
2000	x	x	x	x	x	x	x	x	x	x
2001	x	x	x	x	x	x	x	x	x	x
2002	x	x	x	x	x	x	x	x	x	x
2003	x	x	x	x	x	x	x	x	x	x

Note: Samples were also collected during the winter of 1997-1998 on some of the lakes for all 10 parameters.

Transparency (Secchi)

Transparency is measured with a secchi disk, which is a circular plastic disk that is divided into quarters and painted alternately white and black. The disk is lowered into the water until it can no longer be seen and the depth is recorded, then the disk is raised until it returns to view and the depth is recorded. The average of these depths is then recorded as the secchi reading.

The secchi disk transparency relates directly to the depth of the photic zone within a lake. At two times the depth where the secchi disk can no longer be seen, there is only one percent of the light that penetrates the surface of the lake remaining. This is important to the plants of a lake whether rooted, or planktonic like algae or phytoplankton.

Since the depth of light penetration corresponds to particulate matter in the water, the secchi disk transparency is also a measure of the amount of plankton and algae in the water column. Plankton and algae populations are linked to nutrient levels and therefore, secchi disk transparency can be used as a measure of a lake's productivity. Since one simple measurement can provide a wealth of information, the secchi disk is a valuable tool in water quality monitoring.

The Soil & Water Conservation District provides secchi disks to volunteers who want to monitor their own lake.

pH

Measurements of pH are taken to compare lake water to neutral on a 14-point logarithmic scale where pH 7.0 is neutral. A pH less than 7.0 is acidic and a pH greater than 7.0 is basic. Since the scale is logarithmic, a pH change of one point represents a change of ten in the number of hydrogen ions, which determine a liquid's acidity or alkalinity. In plain terms, pH 7 is neutral, pH 5 is approximately 10 times more acidic than pH 6, pH 4.0 is approximately 100 times more acidic than pH 6.0 and so on. For the purpose of water quality monitoring, pH is important as a measure of a lake's natural state and a measure of any impact of acid rain. The measurement is taken by dipping a probe into water and recording the measurement. For the first five years, the Soil and Water Conservation District used an Orion pH meter and recently switched to a Yellow Springs Instrument (YSI) multi-probe. Both are low ionic strength probes acceptable for measuring waters typical in Hamilton County. The YSI multi-probe gives us the ability to record a pH profile in one-meter increments from the water surface to one meter from the lake bottom. The Orion instrument was limited to a one-meter water sample depth.

Alkalinity (Alk)

Alkalinity is a measurement of the ability of a substance to buffer or neutralize acid. If a lake has a high enough alkalinity, acid rain will not cause the pH of the water body to drop. Inorganic carbon is present in the water column as carbon dioxide (CO_2), bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}). The ever-changing levels between these various forms, is the major pH buffering system for lakes. The underlying geology of a watershed will determine the natural levels of these compounds and each lake will have a unique normal alkalinity. Once a lake's buffering capacity is used up, the lake will become acidic because since acid rain will continue to fall and more easily influence the pH of the lake.

The Hudson Headwaters River Watch Program method is used for testing alkalinity. A digital titrator and the Orion pH meter are used to slowly add acid to a sample of lake water until the pH reaches 4.5. The amount is recorded in digits, more acid is added until the pH reaches 4.2, and the digits are recorded. The digits to 4.5 are multiplied by 2 and the digits to 4.2 are subtracted. This number is multiplied by 0.1 and the result is alkalinity in mg/L.

The following table is used to rank lakes by their alkalinity:

$\leq$0 * mg/L:	Acidified * - and pH less than 5.0
0-2 mg/L:	Critical
2-5 mg/L:	Endangered
5-10 mg/L:	Highly Sensitive
10-20 mg/L:	Sensitive
>20 mg/L:	Not Sensitive

Total Phosphorus (Phos)

Excess concentration of the nutrient phosphorus is the most common cause of water quality problems in New York. However, some phosphorus is essential as a nutrient for plant growth and as a fundamental element in the metabolic reactions of both plants and animals. In New York, phosphorus is the nutrient that most often controls productivity of lake systems. It is often considered the "limiting" nutrient in NYS lakes, since growth is "limited by the amount of phosphorous". In other words, any addition of phosphorous to a lake system would result in more growth. Therefore, many lake management plans are centered on phosphorus controls.

Phosphorus is perhaps the most frequently sampled nutrient in any water-monitoring program. Total phosphorus is a measure of all forms of phosphorus, both organic and inorganic. Total phosphorus concentrations are often directly related to the trophic condition of a lake. Excessive amounts of phosphorus lead to algae blooms and loss of oxygen in lakes. Epilimnetic total phosphorus concentrations less than 10 micrograms per liter (µg/L) are associated with oligotrophic conditions and concentrations greater than 25 µg/L are associated with eutrophic conditions.

Total phosphorus was tested using a HACH DR/3000 spectrophotometer from 1993-98, which only had a minimum detection limit of 0.010 µg/L +/- 0.010 µg/L. With the purchase of a HACH DR/4000 in 1998, it allowed a lower detection limit of 0.0001-µg/L +/- 0.001 µg/L to receive results that are more accurate. The EPA approved Acid Persulfate Digestion Method test to hydrolyze condensed phosphate forms to reactive orthophosphates. This procedure is followed by an EPA-approved reactive phosphorus (orthophosphate) analysis method (low range 0-0.2 mg/L PO4) test, known as the ascorbic acid (PhosVer 3) method (standard method 425F), to determine the phosphorus concentration in the sample.

Nitrate (Nit)

Nitrogen is much more common than phosphorus so it rarely limits plant growth. Nitrate is an inorganic form of nitrogen that occurs naturally. Ammonia is oxidized biologically to nitrate, the final oxidation state of nitrogen compounds. Plants use nitrate as a nutrient source, but water bodies are not as sensitive to additions of nitrates as they are to phosphorus. In the form of ammonia and nitrates, nitrogen contributes to lake eutrophication. In addition, nitrates are a component of atmospheric pollution and elevated concentrations in lakes and ponds may be associated with acidification. Elevated concentrations of nitrate may also be indicative of wastewater pollution.

> *Nitrate, a form of nitrogen, is an element needed by all living plants and animals to build protein. Nitrogen is one of the three main nutrients of life, along with phosphorus and carbon. In aquatic ecosystems, nitrogen is present in many forms. It is commonly found in its molecular form (N2), which makes up 79 percent of the air we breathe. This form, however, is useless for most aquatic plant growth. Colorimetric analysis was utilized to determine nitrate levels. From 1993-98, a HACH DR/3000 spectrophotometer was used to measure nitrate levels using a low range (0-0.50 mg/L NO3 –N) test. Now with the HACH DR/4000 spectrophotometer, nitrate levels can be read to 0.001-mg/L +/- 0.01 mg/L.*

Dissolved Oxygen (DO)

The amount of oxygen dissolved in a lake can be related to many different factors, and it can provide a useful tool in understanding organic production and decomposition. The main source of oxygen for all aquatic ecosystems is the atmosphere. Much of this atmospheric oxygen readily enters the water when mixing occurs, such as through wave action. Additional oxygen is released during photosynthesis. Hence, higher levels of dissolved oxygen are found in the photic zone and lower levels are found deeper in the water. Since sunlight is needed for photosynthesis at night. The photosynthesis and dissolved oxygen production stops. Plants and animals continue to consume oxygen through respiration at night including bacteria in lake sediment. In the morning dissolved oxygen levels are the lowest.

> *Most aquatic plants and animals require dissolved oxygen for survival. Certain fish require high levels of oxygen to survive, such as trout and pike. Other aquatic organisms, such as carp and catfish, exist in waters of low dissolved oxygen. Some Hamilton County lakes may experience*

anoxic (low oxygen levels) conditions within the bottom few meters during portions of the summer. Phosphorus is released from the bottom sediments during anoxic conditions. Fish can cope with these changes in oxygen by moving up the water column in the lake where they are able to get the oxygen they need, but may be pushed into areas with less desirable temperatures. However, over time, depletion in dissolved oxygen can cause major changes in the aquatic organism populations. Those species that are able to tolerate the low levels may replace species that cannot tolerate low oxygen levels. Dissolved oxygen readings are taken with a YSI multi-probe at one-meter intervals.

Chlorophyll a (Chl-a)

Chlorophyll a is the primary photosynthetic pigment found in green plants, and measuring it provides information on the amount of algae in lakes. Chlorophyll a is the only form of algae that can pass electrons, excited by light energy, to produce chemical energy in photosynthesis. In some eutrophic lakes, most chlorophyll is contained in large clumps of blue-green algae. Other phytoplankton is dispersed throughout the water as individuals or short filaments. Chlorophyll a concentrations can be used to classify a lake's trophic state. Chlorophyll a levels directly correlate with phosphorous and secchi disk readings and can be used to cross check data sets and to determine a lake's trophic level. Chlorophyll a concentrations less than 2 micrograms per liter (µg/L) are associated with oligotrophic conditions, while concentrations greater than 8 µg/L are associated with eutrophic conditions. Water samples are collected by the Soil and Water Conservation District and taken to a contracted outside lab for analysis.

Calcium (Ca*)

Calcium is one of the buffering materials to acidity that occurs naturally. It is often in short supply in Adirondack lakes and ponds, making these bodies of water susceptible to acidification by acid precipitation. A measure of the amount of calcium in a lake provides additional information on the buffering capacity of that lake, and can assist in determining the timing and dosage for acid mitigation (liming) activities. Adirondack lakes containing less than 2.5 mg/L of calcium are considered sensitive to acidification. Calcium is also important to the development of mollusks, especially such as Zebra Mussels. Low calcium levels may keep invasive mollusks, such as Zebra Mussels, from establishing themselves in our lakes. Water samples are collected by the Soil and Water Conservation District and taken to a contracted outside lab for analysis.

Aluminum (Al*)

Aluminum is one of the most abundant elements found in the earth's crust. Acid rainwater leaches the aluminum from the soils, where it then may flow into nearby streams and lakes. Aluminum is also deposited through atmospheric deposition. If a lake becomes acidified, Aluminum may be leached from the sediments in the bottom of the lake as well. Elevated concentrations of aluminum can be toxic to fish in acidified water bodies, depending on the type of aluminum available, the pH, and the amount of dissolved organic carbon available to bind inorganic aluminum. Values are reported as mg/L of total dissolved aluminum. Water samples are collected by the Soil and Water Conservation District Water and taken to a contracted outside lab for analysis.

Aluminum levels over 200 mg/L in waters with a pH less than 6.2 are toxic to fish. At these levels, an aluminum ion precipitates on the fish's gills and interferes with mineral transfers between the blood and water. The fish then produces mucus to remove the toxic aluminum ions from the gills, but this also prevents an efficient transfer of oxygen. The build up of mucus does not allow proper ion transfer between the fish and the water and eventually causes respiratory stress and an imbalance of blood minerals that kills the fish.

Statistical Analysis

Raw sample data for analysis were provided by the Soil and Water Conservation District in digital form (spreadsheets and database files) to Cedar Eden Environmental, LLC.

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