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Environmental Studies 102:
Final Independent Project

*Water Chemistry of Eph's Pond*


Abstract:

From April 17th to May 15th, 2006 we sampled water from Eph's Pond and tested its chemistry with regards to cations, anions, coliform, pH, ANC and conductivity. After comparing data to historical Eph's Pond data and Williamstown precipitation archives, we determined the effects that humans and weather have on Eph's Pond. For instance, road salt run-off contributes greatly to the high average conductivity of 335 μs/cm. Additionally, rainfall and snowfall both bear strong positives correlations with conductivity, and minor negative correlations with pH. In conclusion, while Eph's Pond is currently doing a sufficient job maintaining a stable pH (it only differs by only .5 between 1996-2006), its capacity is not limitless, so humans must be aware of their impact on the water.



Elissa Brown
Fara Rasoazanamparany
Liz Kantack

ENVI 102: Intro to Environmental Science
Professors Art, Dethier and Thoman
May 18, 2006

Environmental Studies 102: Independent Project
*Water Chemistry of Eph's Pond*

Introduction:

For our independent project we collected water samples from Eph's Pond, a small drainage pond with a watershed that covers a large portion of the Williams College campus North of Route 2. Using atomic absorption spectrometry (AAS), ion chromatography (IC), atomic emission spectrometry (AES) and tests for total and fecal coliform, conductivity, atomic neutralizing capacity (ANC) and pH, we drew conclusions about the cleanliness and sustainability of the pond water. With our data and a compilation of historical data, we've developed a comprehensive view of many aspects of the pond. Specifically, we have investigated the pond's chemistry and hypothesized probable causes for each variable we discovered in our research. In an attempt to get the most complete view possible of Eph's Pond we are investigating not only what arrives in Eph's Pond as runoff from campus, but also how the drainage from the pond into the Hoosic River affects the remainder of the watershed and how anthropogenic effects can be compounded by variations in weather and changes in season.

Materials and Methods:

Over the course of several weeks, from April 17$^{th}$ to May 15$^{th}$, we collected water samples from Eph's Pond and tested for a number of different indicators of water quality. The sampling location we chose was the same that was used for a prior class lab on water quality: five to ten feet from the outlet pipe at the North end of the pond that leads beneath the adjacent Cole Athletic Fields to the Hoosic River (Fig. 1). Two aerial shots of Eph's

Pond and Cole Field better depict the sampling location in relation to the geography of the Northern part of campus and the three inlets from different parts of campus (Fig. 2a, Fig. 2b). Careful observations were recorded with regard to the weather during the sampling time and weather from the previous days that could have played a role in the chemistry of the pond water. Upon return to the lab, we performed several laboratory procedures that provided us with data for a number of different indicators of water quality: AAS, AES and IC determine the presence of various cations and anions, pH (negative log of hydronium ion concentration in moles/liter), and ANC, the ability of water to neutralize acid to a given pH. Determining the quantity of total and fecal coliform allowed us to analyze the bacteriological quality of the pond water, and tests for conductivity reported the ability of a solution to conduct electricity. These procedures, performed in all of our class labs throughout the semester, are described in greater detail in Environmental Studies 102 Laboratory Manual.[1]

Results:

*Conductivity and Ion Correlations*

Compared to other 2006 samples of Williamstown bodies of water, Eph's Pond's conductivity is immense, at an average of 335 μs/cm (Table 1). The most prevalent ion is $Cl^-$ at an average concentration of 178.4 mg/L (Fig. 3). $Ca^{+2}$ and $Na^+$ follow, with averages of 55 mg/L and 52 mg/L respectively. $K^+$ is the present in the lowest quantity, at an average of only .7 mg/L.

[1] ENVI 102—Introduction to Environmental Science: Laboratory Manual and More. Spring 2006. Center for Environmental Studies. Williams College.

The $Cl^-$ and $Na^+$ ions in Eph's Pond, as collected in 2006, show a direct correlation of 61.8%, with a scalar coefficient of 2.2 (Fig. 4). The chloride concentrations range from 160.4 mg/L to 262.1, with an average of 178.5 mg/l. Sodium ions are present at an average concentration of 52 mg/L, ranging from 59.4 mg/L to 63.9 mg/L.

Correlations exist between concentrations of other ions, as well. For instance, $SO_4^{-2}$ and $Cl^-$ have a correlation coefficient of 81.9% (Fig. 5). The sulfate is present in an average concentration of 25 mg/L, with a maximum of 38.75 mg/L and minimum 15.97 mg/L. $Ca^{+2}$ and $Mg^{+2}$ have a correlation coefficient of 70% (Fig. 6) Calcium ions range from 40.2 mg/L to 74.2 mg/L, and magnesium—present in smaller quantities—range from 14.4 to 25.1 mg/L. Calcium ions also bear a strong inverse correlation with $SO_4^{-2}$, with a correlation coefficient of 85% (Fig. 7).

*Effect of Weather on Conductivity and pH*

In general, conductivity appears to increase and decrease with the corresponding changes in rainfall over the years (Table 2, Fig. 8). Since conductivity measurements were collected in the late spring—late April-early May—we only looked at rainfall for the months directly preceding (the total from February and March). It's unlikely that the effects of the fall's rain are as responsible for affects on data so far after date. Historic rainfall data were taken at the Hopkins Memorial Forest Weather Station 1, elevation 267 meters[2] and historic conductivity at the Eph's Pond Outflow from ES102 students on the

[2] "Williamstown Weather Archives". Hopkins Forest Weather Station. Williams College. Available online http://oit.williams.edu/weather/. Accessed 17 May 2006.

Hoosic River Flotilla from 1995 to 2006, with assorted lapses[3]. For instance, both demonstrate significant decreases between 1997 and 1998; Feb-March rainfall decreases by 26%, from 6.25 inches to 4.59, and conductivity drops by 23%, from 481 µs/cm to 370 µs/cm. The effect of rainfall on pH appeared minimal. From 1999-2000, as Feb-March rainfall nearly doubled from 4.26 inches to 7.75 inches, pH only dropped from 7.60 to 7.46. However, since pH is based upon a logarithmic scale, small variations can have a significant impact on the dynamics of a pond and the species that are able to thrive within.

Historically, snowfall also appears to be correlated with conductivity (Fig. 9). We only analyzed total snowfall measurements from January through March—the months that would most impact our water samples. From 1997 to 1998, there is a large decrease in snowfall—47.5 to 29 inches, or 39%—and then a large increase of increase of 32% to 38.3 inches in 1998, and a smaller increase of 9% to 41.7 in 1999. Conductivity showed a similar trend, decreasing by 23% from 1997 to 1998, increasing by 42% from 370 µs/cm to 525 µs/cm in 1998, and then by another 1% to 530 µs/cm in 1999.

*Effect of Weather on Coliform Bacteria*

Sampling from four different dates gave us a chance to observe how the bacteriological quality of water evolves over time. As we analyzed our data, we looked at our results in conjunction with weather observations from the day of sampling and from the week prior in order to see if temperature and precipitation had an effect on the presence and quantity of total and fecal coliform. The first samples we took, on April 17th, followed a sunny, but cold weekend with temperatures that day around 18°C and even lower

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[3] ES102 Water Chemistry Data. Available online http://blackboard.williams.edu/webapps/portal/frameset.jsp?tab=courses&url=/bin/common/course.pl?course_id=_6663_1. Accessed 17 May 2006.

temperatures in the days prior to sampling. Precipitation in the days prior to sampling was minimal to nonexistent. About a week before, less than a quarter inch of rain had fallen on Williamstown, MA according to records from the Hopkins Forest weather station (Fig. 10, Fig. 11).[4] The quantities of total and fecal coliform were 209.8 colonies/100 mL and 16.4 colonies/100 mL, respectively (Table 3, Fig. 12). The next time we sampled, on May 7th, the temperature, now at 22˚C, averaged four degrees higher than our previous sample date, and the during the weekend prior to sampling, Williamstown experienced a period of rain totaling more than an inch. Temperature averages had also risen since the first sample was taken. The other samples, from our class lab, were taken two days apart—one on March 13th after a weekend of no precipitation and high temperatures and then again on March 15th after a day of high precipitation (over an inch of rain fell during the previous day) but also after temperatures had dropped 10˚C over the past 24 hours (Table 4, Fig. 13).

*Coliform Bacteria and Nitrate and Phosphate Concentrations*

Our analysis also showed a correlation between coliform bacteria and nitrate and phosphate concentrations. As coliform levels increased between April 17th and May 7th, the concentrations of nitrate and phosphate increased as well. In less than three weeks, nitrate concentrations increased from .19 mg/L to .22 mg/L (Table 5, Fig. 14), while phosphate concentrations increased from .94 mg/L to 1.08 mg/L (Table 6, Fig. 15). The changes, while small, are measurable and can be contributed to several different factors.

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4 Williamstown Weather Archives. Hopkins Forest Weather Station. Williams College. Available online http://oit.williams.edu/weather/. Accessed 17 May 2006.

Discussion:

Eph's Pond's water chemistry is a combined result of many factors—both anthropogenic and natural (Table 7, Fig. 17). In our analysis, we sought to identify which factors weighed in most prominently, and what sort of effect they had on the pond's overall health.

*Conductivity and Ion Correlations*

The high concentrations of sodium and chloride are likely due to the anthropogenic influence of road salt. The ions' correlation suggests that they may have come from related sources—or, in this case, the same one. During the winter, the city of Williamstown de-ices the streets with NaCl. Eph's Pond's watershed extends from Main St. to Park St. to Southworth St, so as the snow in that region melts, runoff is carried through gutters to the storm sewer on Church Street, to Eph's Pond's second inlet. The runoff contains large quantities of the $Na^+$ and $Cl^-$ from the salt, and since the pond is a relatively still body of water, the ions cannot be easily flushed from the system.

To clearly see the chemistry of the road salt inflow, we analyzed historic data of samples taken closer to the source. The storm drain on Main Street, below Hemlock Brook shows an enormous conductivity, an average or 1394 μs/cm between 1997 and 1999 (Fig. 16)[5]. As would be expected, the concentrations of both $Na^+$ and $Cl^-$ are gastronomical, at 141 mg/L and 242 mg/L respectively. Though the ions get more diluted before entering Eph's Pond, $Na^+$ and $Cl^-$ remain high.

[5] ES102 Student conductivity data, 1997-1999.

Chloride is also correlated with sulfate, albeit for a less straight-forward reason. $SO_4^{-2}$ is associated with acid rain[6], which flows over streets and parking lots before reaching storm sewers and going to Eph's Pond. In the early spring, this rain will accumulate remnants of road salt—including $Cl^-$ ions. With more precipitation there will be more runoff, and, hence, more ions. Since $Cl^-$ and $Na^+$ are directly correlated, we would alsowa expect to also see a correlation between $SO_4^{-2}$ and $Na^+$, yet none was evident.

Some of the ions in Eph's Pond are a result of natural forces. For instance, $Ca^{+2}$ and $Mg^{+2}$ are primarily derived from dissolved rocks—calcite, mica, and dolomitic marble—[7] that water passes over en route to Eph's Pond. When surface water flows through Williams campus, it already has significant levels of both mineral ions (Table 8). The water enters Eph's Pond through Inlet 1, and the ion concentration increases more due to clay minerals on pond bottom.

Calcium concentration is bears a strong inverse correlation with sulfate. Since $Ca^{+2}$ is from $CaCO_3$ and $CaCO_3$ is associated with Acid Neutralizing Capacity (ANC), it follows that samples with high calcium ion concentration also have a larger ANC. Samples with a larger ANC will resist change in pH, and will have a higher pH than low-ANC samples, even against acid rain. $SO_4^{-2}$ is associated with acid rain—but the calcium carbonate acts as a buffer for the sulfuric acid. The samples with less $Ca^{+2}$ (and also a lower ANC) are less successful, and there is more $SO_4^{-2}$ in them.

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[6] Greg Balco. A Study of Water Quality in Eph's Pond. (Environmental Studies 102. Williams College: May 12, 1989).

[7] Frits van der Leeden, Fred L. Troise and David Keith Todd. The Water Encyclopedia. (2nd ed. Lewis Publishers: Chelsea, Michigan, 1990). 422-425.

*Effect of Weather on Conductivity and pH*

Conductivity was correlated to precipitation levels, since rain is responsible for transporting ions to Eph's Pond. Although rainwater alone isn't heavy with any ions, as it flows over streets and parking lots—including ones with remnants of $Na^+$ and $Cl^-$ it accumulates them in the run-off as it makes its way down to the Hoosic River. With more extensive data, we would expect to see an increase in nearly all ions, even though they would arrive from different inlets. Rain would bring some of the ions present in each region of Williamstown—the nitrate of the field fertilizers, the road salt, the calcium and magnesium ions of dissolved rock.

Theoretically, historic snowfall data would be correlated most directly with levels of Na+ and Cl-. In years of heavy snow, Williamstown officials would need to use a greater quantity of road salt to keep the roads clean. Consequently, there would be a greater amount of ions in the run-off. Although we lacked historic data of $Na^+$ and $Cl^-$ ions; we did have total conductivity data in Eph's Pond, sodium and chloride are two of the top three most prevalent ions, so an increase in them would correspond with an increase in overall conductivity; hence, our comparison is reasonable.

We had expected to see pH vary inversely with rainfall. Since normal rain has a pH of 5.6, and acidic rain can be as low as 4.5[8], we hypothesized that particular wet seasons would also contribute to a lower pH. There appears to be no strong correlation, and there are several possible explanations. We used a total precipitation from February and March for our analysis, but if the samples were collected in the beginning of May, it's unlikely that any rain from February would not have already had its effect. Additionally, and

[8] "Acid Rain Spectrum" *Virtual Chembook.* Elmhurst. http://www.elmhurst.edu/~chm/vchembook/190acidrain.html Updated 2004. Accessed May 17 2006.

perhaps to the benefit of the lake, it could just have a healthy ability to buffer itself. Eph's Pond's average ANC of 2006 was 116, and its high $Ca^{+2}$ ion concentration resists change in pH.

*Coliform Bacteria and Weather*

A portion of our analysis included an evaluation of the bacteriological quality of Eph's Pond. Total coliform bacteria, catalysts of digestion, are essentially harmless microorganisms found in large quantities in the intestines of humans and most animals. Fecal coliform bacteria, in contrast, indicate the presence of fecal material of humans or animals and can be very harmful if ingested.[9] The Eph's Pond watershed region of the Williams College campus, bounded by Park Street, Main Street, and Southworth Street, as well as the Williamstown Elementary School and all the residential streets and storm drainages from the surrounding locations (Fig. 18). The proximity of this watershed to areas of high traffic and, therefore, locations at risk for significant anthropogenic impactsmakes the levels of coliform bacteria we encountered unsurprising.

We did see an increase in coliform bacteria quantity between the two sampling dates, approximately three weeks apart. This can be best explained after careful observation of weather patterns this spring. Prior to the first sampling date (April 17th), Williamstown experienced a period of cold weather accompanied by a lack of precipitation. Three weeks later, immediately after an influx of rain and a steady increase in temperature, both the total and fecal coliform levels had increased. After merely looking at the weather report from this spring, the trend in coliform bacteria quantity could

[9] Brian Oram. "Why Fecal Coliform Testing is Important". Wilkes University. Accessed 17 May 2006.

have been predicted. The rainfall prior to our second sampling date flushed out everything from campus and storm drainage system on the roads surrounding the elementary school directly into Eph's Pond and this was reflected in the increase in coliform quantity. Coliform bacteria thrive in warmer temperatures and as spring-like conditions prevailed, the average temperatures in Williamstown increased, which positively correlate with the coliform quantities in Eph's Pond.

The correlation between weather and coliform bacteria was less apparent in the data obtained from our class lab earlier in March. After a period of intense rain and plummeting temperatures, our data showed a decrease in total coliform and an increase in fecal coliform. (The increase in fecal coliform was from 0 colonies/100 mL to 13 colonies/100 mL and the accuracy of the sample with no colonies is disputed. Because only one sample was taken in both of these cases, the probability of experimental error is high.) Despite these apparent incongruities, the weather can still be held responsible for the lack of correlation. The sudden rainfall would lead one to expect an increase in bacteria quantity after flushing out the watershed into Eph's Pond, while the drop in temperature would provide a less hospitable environment for bacteria, causing the quantity to drop.

*Coliform Bacteria and Nitrate and Phosphate Concentrations*

As the quantities of total and fecal coliform increased in the three weeks between our sampling dates, the concentrations of nitrate and phosphate increased as well. This confirmed our expectation, as to the correlation between bacteria quantity and nitrate and phosphate concentrations since as we saw similar results in our earlier water quality lab for class,. These anions are indicators of sewage and high nutrient content and this correlation is best seen in our data from an earlier lab from the Hoosic River Water Quality District (HWQD) outflow from the sewage treatment plant. The effluent from the sewage treatment plant had the highest concentration of nitrate and phosphate of any sampling location and their presence was accompanied by elevated levels of total and fecal coliform. The presence of nitrate and phosphate in Eph's Pond can most likely be attributed to the fertilizers applied to the lawns and athletic fields on campus. According to David Fitzgerald, horticulturist and grounds supervisor for Williams College, the entire campus is fertilized once a year during late October to mid November. An organic fertilizer, Naturesafe, is used with the rate of approximately 1.5 pounds of nitrogen per 1,000 square feet . The athletic fields require higher standards of maintenance and receive fertilizing treatment three times a year—once at the beginning, again in mid to late August and one final time in late October before the snow falls. The fertilizer used on the athletic fields, a coated slow release fertilizer called Polyon, has the same nitrogen concentration as Nautresafe, but the frequency of the application in comparison results in a concentration of 3—3.5 pounds of nitrogen per 1,000 square feet of ground. While the Williams College campus has not been fertilized since at least last November, the presence of nitrate and phosphate can be attributed to the fertilizers used on the campus' lawns and athletic fields located in the watershed upstream from Eph's Pond.

<u>Conclusion</u>:

Our independent project gave us a comprehensive view of the overall health of Eph's Pond and a detailed look at the chemistry of the pond's water. We have come to several conclusions regarding the ways in which land use and weather impact the chemical composition of the pond.

1. Ions from similar sources (such as $Na^+$ and $Cl^-$ from road salt) or related sources (such as $SO_4^{-2}$ from acid rain and the $Cl^-$ that the rain washes down the sewer) show correlated concentrations in Eph's Pond, where they all accumulate.
2. Snowfall and rainfall are both positively correlated with conductivity. Snowfall warrants salting the roads, and the rainfall washes the sodium and chloride ions down the storm sewer to Eph's Pond, where those particular ions are among the three most concentrated.
3. Precipitation also bears a slight negative correlation to pH. While Eph's Pond is high in $Ca^{+2}$, and its high ANC prevents wild pH fluctuations, all the acidic rainwater that empties into the pond does cause minor changes.
4. The weather has an impact on daily variations in bacteria quantity. Warm temperatures provide a more hospitable environment for coliform growth and precipitation flushes out the watershed and transports large quantities of bacteria from upstream into the pond. Daily fluctuations in temperature and precipitation lead to changes in coliform bacteria quantities.
5. As coliform bacteria quantities increase, the concentrations of nitrate and phosphate increase. Nitrate and phosphate indicate the presence of sewage and this correlation was most strongly supported from our earlier class lab with data from the outflow at the HWQD. The presence of nitrate and phosphate can also be attributed to the nitrogen-rich fertilizers used on the campus lawns and athletic fields upstream from the pond.

In conclusion, while coliform and conductivity values are large, Eph's Pond is relatively sufficient at maintaining a stable pH. Since anthropogenic factors figure significantly in the pond's chemistry, though, we must be aware of our actions and their effects.

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Williamstown Weather Archives. Hopkins Forest Weather Station. Williams College. Available online http://oit.williams.edu/weather/. Accessed 17 May 2006.

## Appendix 1—Figures and Tables

Figure 1: Eph's Pond Sampling Location

Oulet Pipe to the Hoosic River, May 1991

http://drm.williams.edu/cdm4/item_viewer.php?CISOROOT=/nhb&CISOPTR=20&REC=6

Figure 2a: Aerial View of Eph's Pond Watershed


http://drm.williams.edu/cdm4/item_viewer.php?CISOROOT=/nhb&CISOPTR=23&REC=2

**Figure 2b: Inlets and Outlets of Eph's Pond**

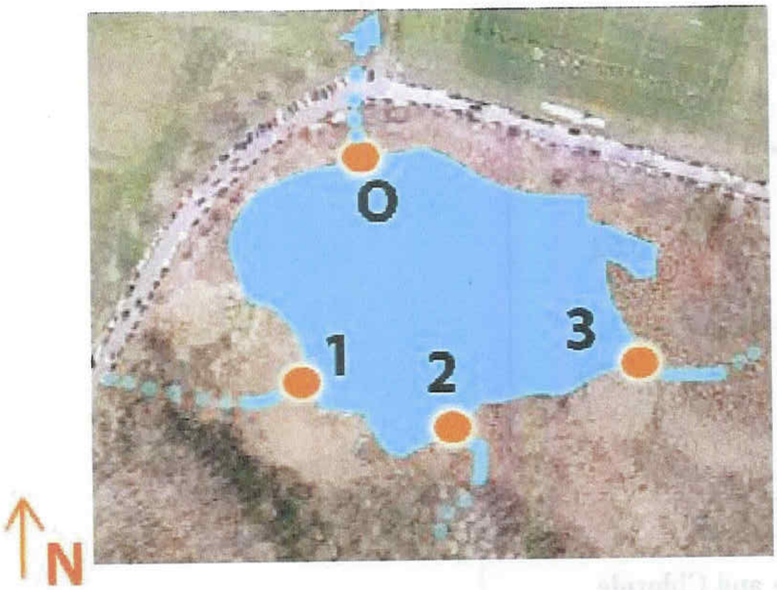



**Figure 3: Average Concentration of Various Ions in Eph's Pond (2006)**

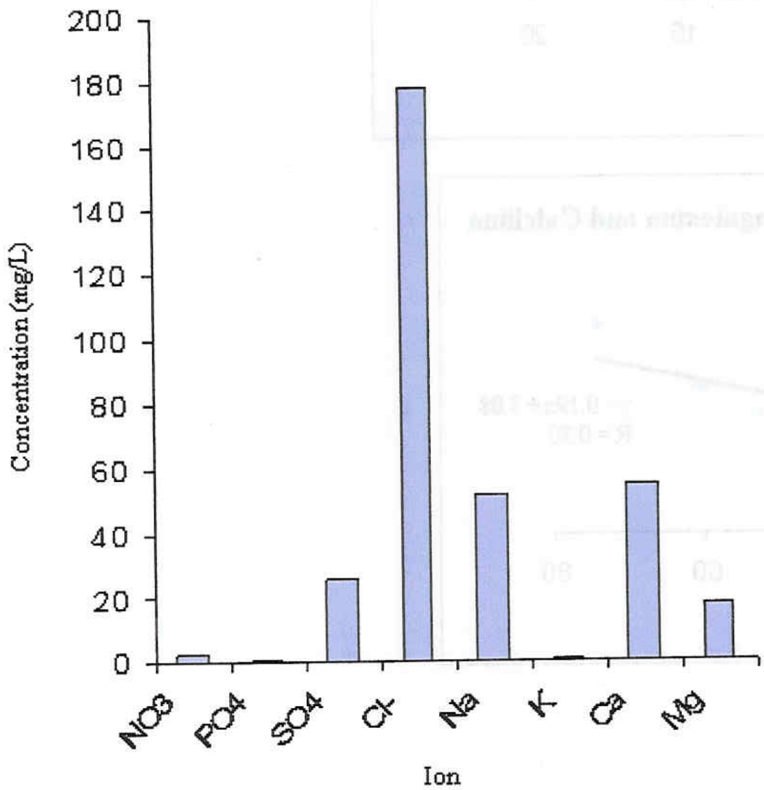


Figure 4: Correlation between Sodium and Chloride

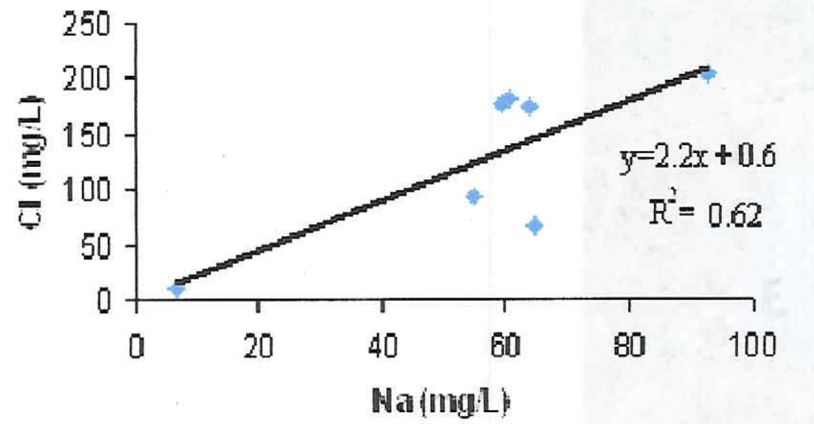



Figure 5 : Correlation between Sulfate and Chloride

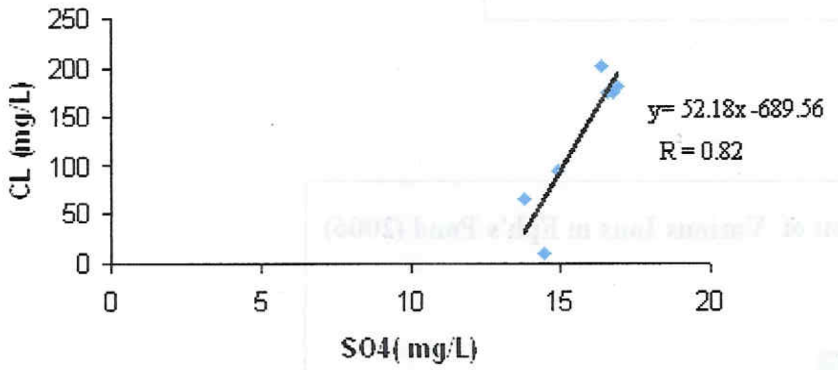



Figure 6: Correlation between Magniesum and Calclium

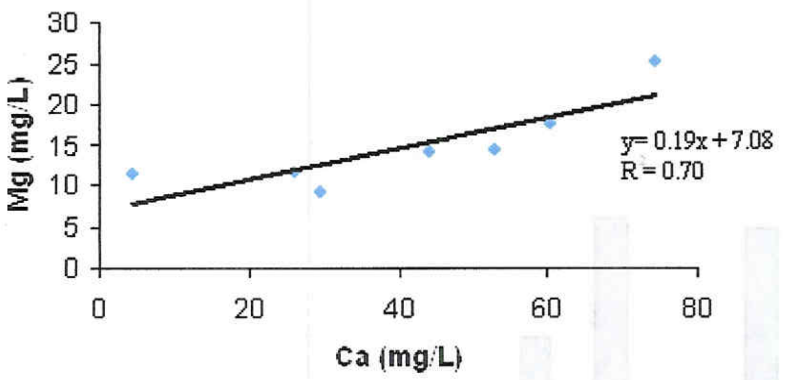


Figure 7: Correlation between Sulfate and Calcium

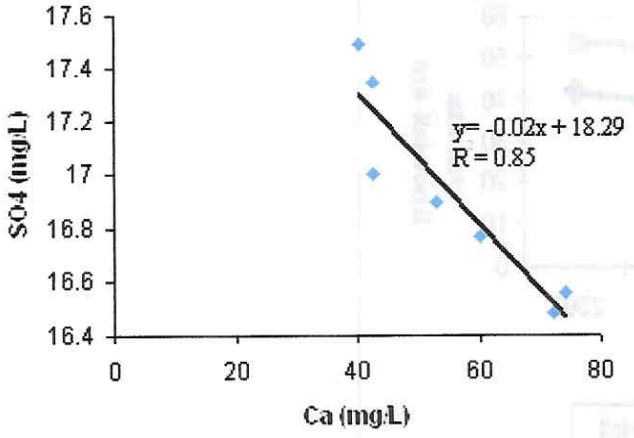
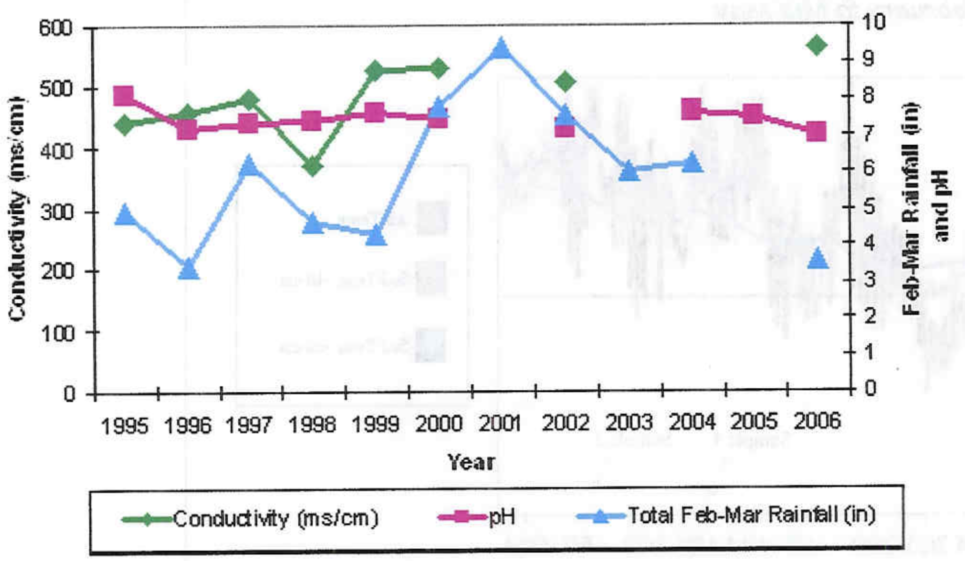



**Table 2: Historical Changes in pH, Conductivity, Rainfall, and Snowfall**

| Year | pH | Conductivity (ms/cm) | Total Feb-Mar Rainfall (in) | Total Jan-Mar Snowfall (in) |
|---|---|---|---|---|
| 1995 | 8.08 | 440 | 4.88 | 28.7 |
| 1996 | 7.15 | 454 | 3.38 | 52.2 |
| 1997 | 7.37 | 481 | 6.25 | 47.5 |
| 1998 | 7.4 | 370 | 4.59 | 29.0 |
| 1999 | 7.6 | 525 | 4.26 | 38.3 |
| 2000 | 7.46 | 530 | 7.75 | 41.7 |
| 2001 | | | 9.35 | 72.5 |
| 2002 | 7.17 | 504 | 7.55 | |
| 2003 | | | 6.02 | |
| 2004 | 7.65 | | 6.25 | |
| 2005 | 7.49 | | | |
| 2006 | 7 | 562 | 3.6 | |

Figure 8: Comparison between pH, Conductivity and Feb. to March Rainfall



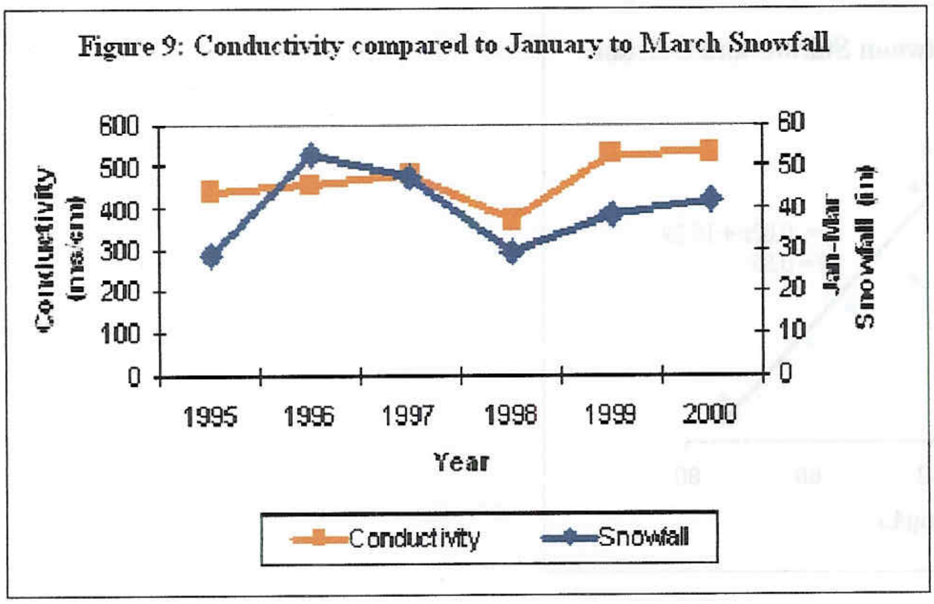


Figure 9: Conductivity compared to January to March Snowfall
Conductivity (mS/cm)
Jan-Mar Snowfall (in)
600
500
400
300
200
100
0
60
50
40
30
20
10
0
1995
1996
1997
1998
1999
2000
Year
Conductivity
Snowfall

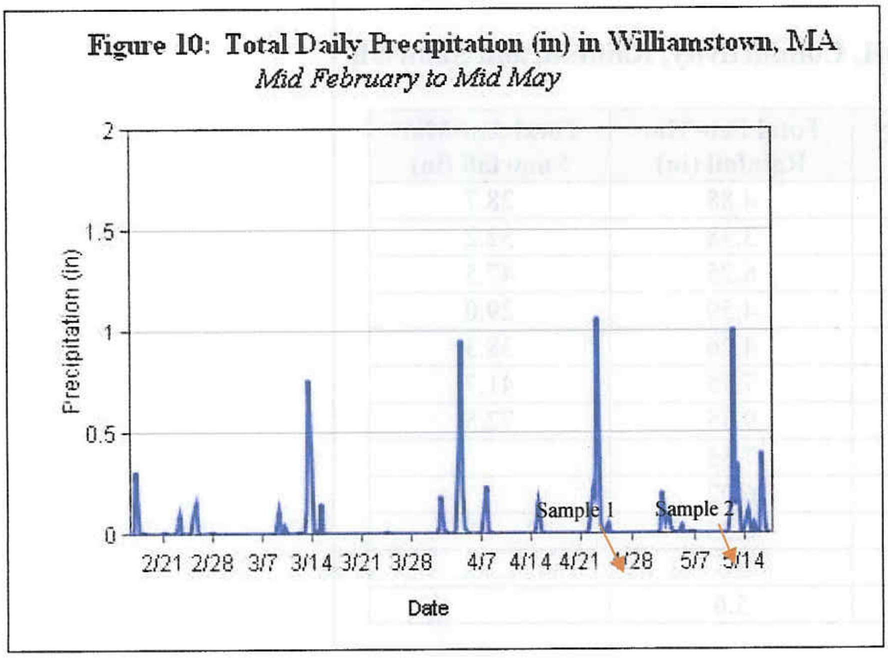


Figure 10: Total Daily Precipitation (in) in Williamstown, MA
Mid February to Mid May
Precipitation (in)
2
1.5
1
0.5
0
Sample 1
Sample 2
2/21 2/28 3/7 3/14 3/21 3/28 4/7 4/14 4/21 4/28 5/7 5/14
Date

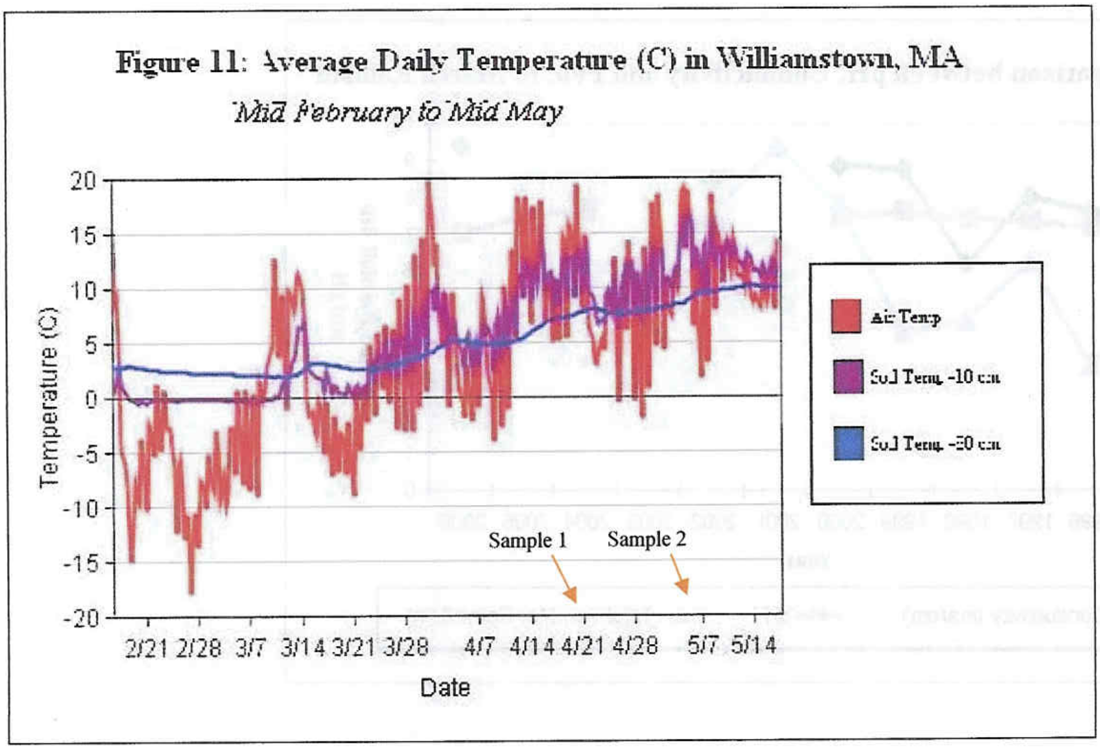


Figure 11: Average Daily Temperature (C) in Williamstown, MA
Mid February to Mid May
Temperature (C)
20
15
10
5
0
-5
-10
-15
-20
Sample 1
Sample 2
2/21 2/28 3/7 3/14 3/21 3/28 4/7 4/14 4/21 4/28 5/7 5/14
Date
Air Temp
Soil Temp -10 cm
Soil Temp -50 cm

**Table 3: The Effect of Weather on Coliform Bacteria Quantity**

*April 17th and May 9th*

| Sampling Date | Average Total Coliform (colonies/100mL) | Average Fecal Coliform (colonies/100mL) | Weather Observations |
|---|---|---|---|
| Monday April 17th | 209.8 | 16.4 | 18° C, breezy, sunny, cool, chilly weather earlier this week |
| Tuesday May 9th | 650 | 87.5 | 22°C, warm, sunny, rain and higher temperatures during the past weekend |

**Figure 12: The Effect of Weather on Coliform Bacteria Quantity**

*April 17th and May 9th*

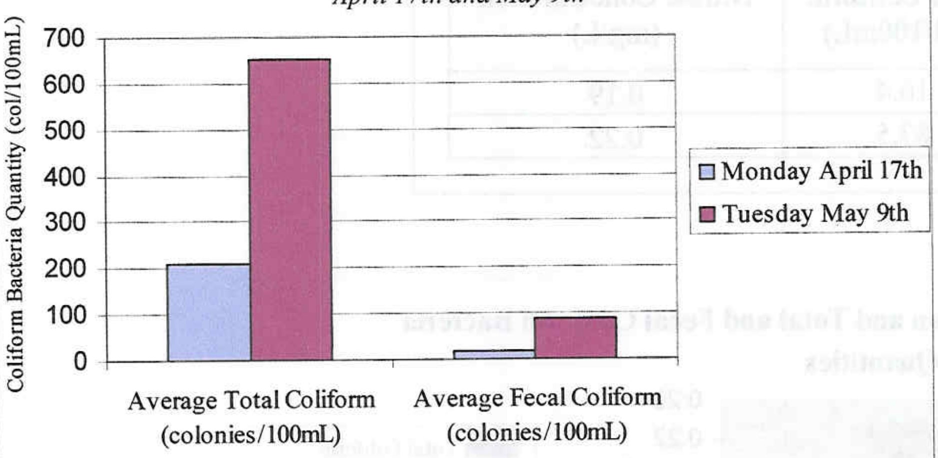



**Table 4: The Effect of Weather on Coliform Bacteria Quantity**

*March 13th and March 15th*

| Sampling Date | Average Total Coliform (colonies/100mL) | Average Fecal Coliform (colonies/100mL) | Weather Observations |
|---|---|---|---|
| Monday March 13th | 310 | 0 | 6°C, no precipitation over the weekend |
| Wednesday March 15th | 264 | 13 | (-1.78°C), over an inch of rain in the last 48 hours |

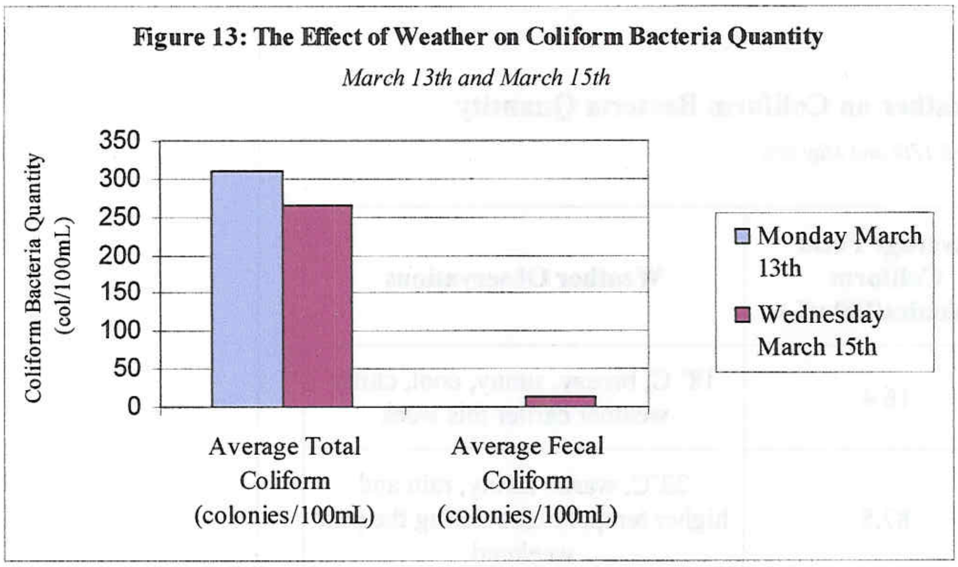



**Table 5: Nitrate Concentration and Total and Fecal Coliform Bacteria Quantities**

| Date | Total Coliform (col/100mL) | Fecal Coliform (col/100mL) | Nitrate Concentration (mg/L) |
|---|---|---|---|
| April 27th | 209.8 | 16.4 | 0.19 |
| May 10th | 650 | 87.5 | 0.22 |

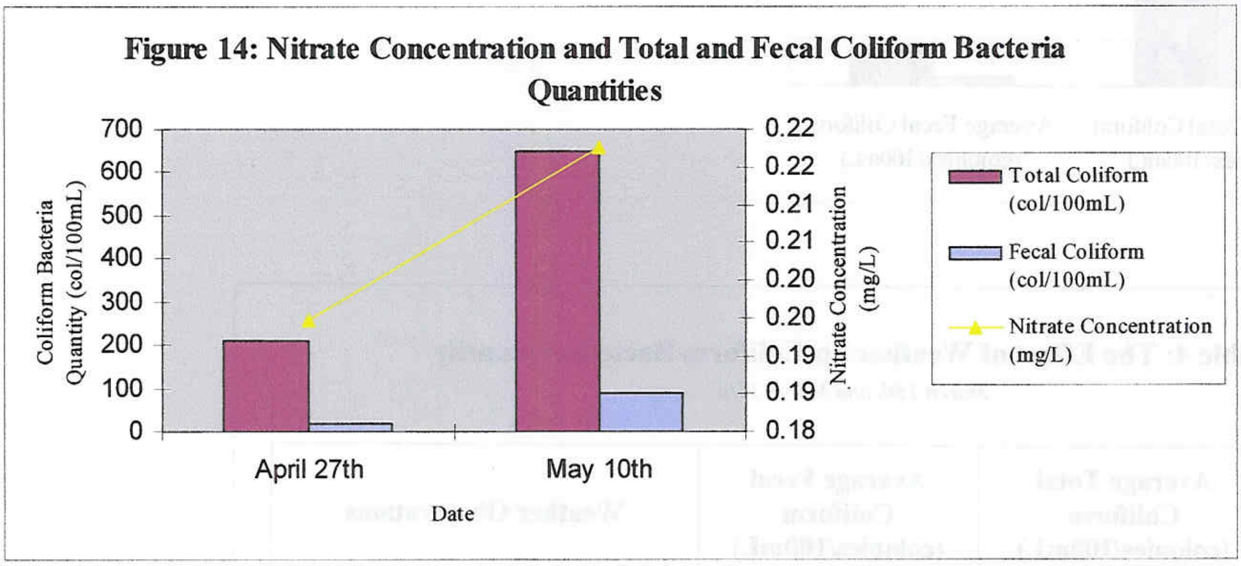


**Table 6: Phosphate Concentration and Total and Fecal Coliform Bacteria Quantities**

| Date | Total Coliform (col/100mL) | Fecal Coliform (col/100mL) | Phosphate Concentration (mg/L) |
|---|---|---|---|
| April 27th | 209.8 | 16.4 | 0.94 |
| May 10th | 650 | 87.5 | 1.08 |

**Figure 15: Phosphate Concentration and Total and Fecal Coliform Bacteria Quantities**

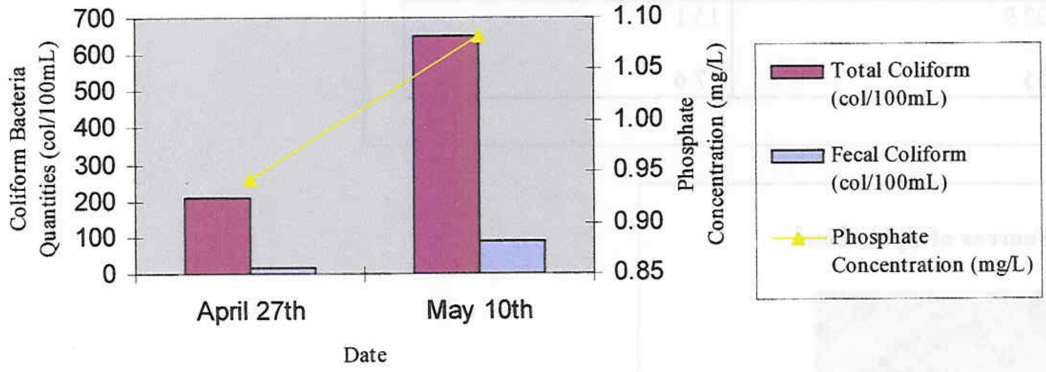



**Table 7: Chemical Makeup of Eph's Pond (2006)**

| | $NO_3^-$ | $PO_4^{-3}$ | $SO_4^{-2}$ | $Cl^-$ | $Na^+$ | $K^+$ | $Ca^{+2}$ | $Mg^{+2}$ |
|---|---|---|---|---|---|---|---|---|
| Average | 2.2 | 0.9 | 25.7 | 178.5 | 52 | 0.7 | 55. | 17.7 |
| Minimum | 0.57 | 0.1 | 16.0 | 160.4 | 59.4 | -2.4 | 40.2 | 14.4 |
| Maximum | 3.87 | 1.2 | 38.8 | 262.1 | 63.9 | 1.8 | 74.2 | 25.1 |
| Range | 3.29 | 1.1 | 22.8 | 101.7 | 4.5 | 4.2 | 34.0 | 10.7 |

Figure 16: Correlation between Sodium and Chloride

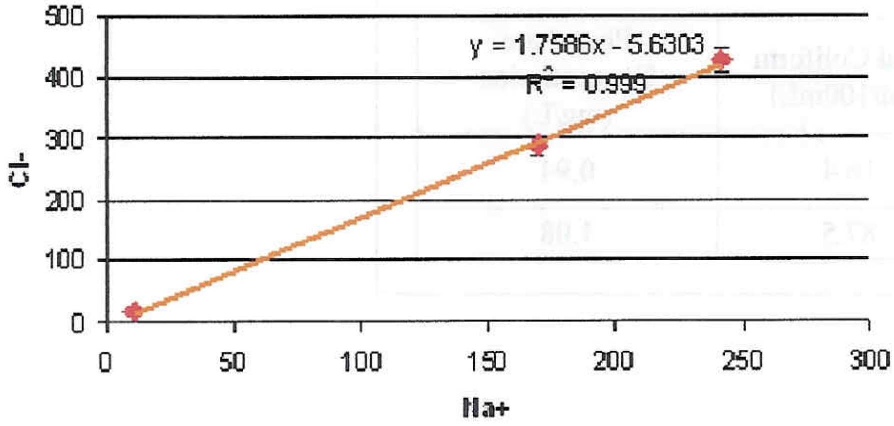



Table 8: Calcium and Magnesium Concentrations en route to Eph's Pond and at the Pond

| Location | $Ca^{+2}$ (mg/L) | $Mg^{+2}$ (mg/L) |
|---|---|---|
| Science Quad Tap Water (1995-2005) | 32.9 | 15.1 |
| Eph's Pond (2006) | 55 | 17.6 |

Figure 17: Water Chemistry Sources of Eph's Pond

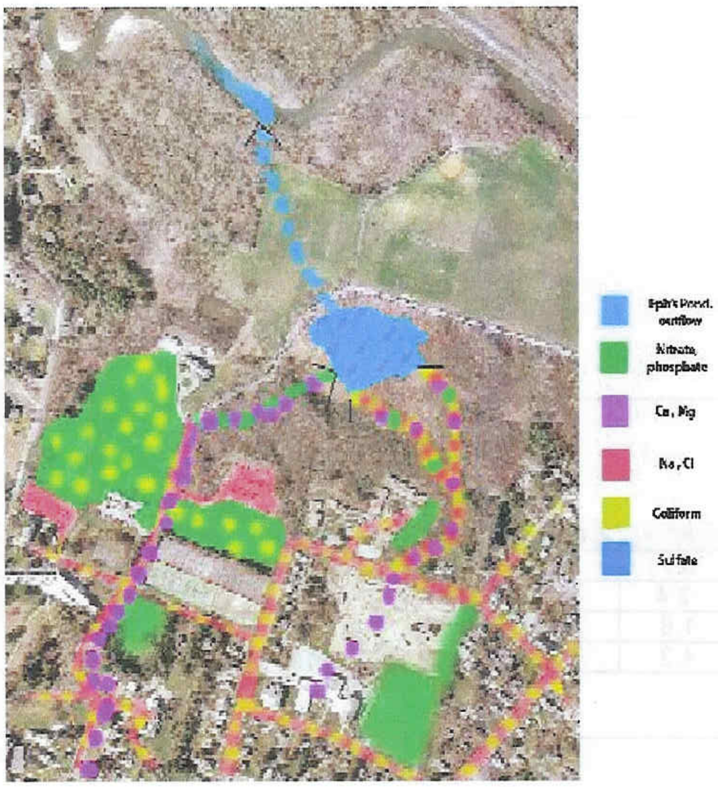
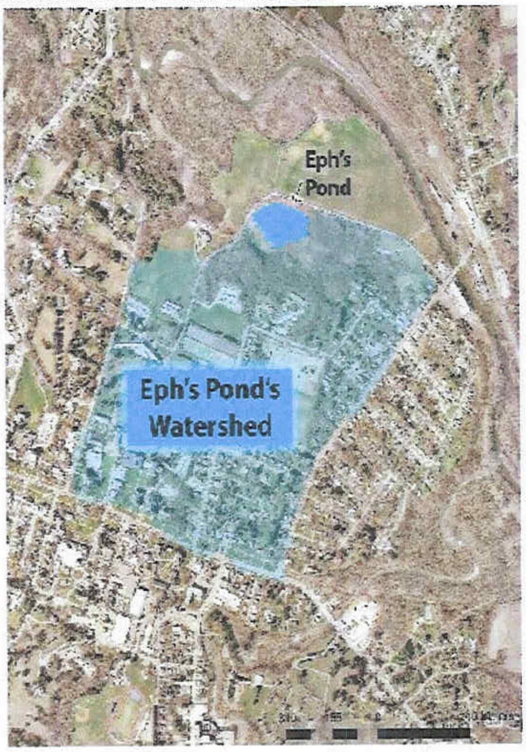


Figure 18: Eph's Pond Watershed



**Appendix 2: Song Lyrics**

**Eph's Pond Chemistry Song**
*To the Tune of Bob Dylan's "Blowin' in the Wind"*
by Elissa Brown

How many roads must we sprinkle with salt
Before all the street ice will melt?
And how much Na and Cl will run off
Before the impact is felt?
Yes, and how many years 'til we humans destroy
The cards Mother Nature has dealt

*The answer you'll see,*
*In Eph's Pond chemistry,*
*The answer's in Eph's Pond Chemistry*

How many owners neglect to clean up
The fields that their dogs fertilize?
And how many rainfalls 'till coliform counts
Reach a gargantuan size?
Yes, and how many years 'til the world learns to view
Our deeds through a scientist's eyes?

*The answer you'll see,*
*In Eph's Pond chemistry,*
*The answer's in Eph's Pond Chemistry*

We've tested for ions, we've checked the ph
We've tallied the coliform counts
And now we must ponder what human effects
Have influenced measured amounts.
And how much more time 'til we come to the point
Where Eph's Pond will never rebounce?

*The answer you'll see,*
*In Eph's Pond chemistry,*
*The answer's in Eph's Pond Chemistry*