I (We), Nancy Gephart & Richard Redmond have created an original piece of work titled, "The Water Quality of Moore's Pond", (the "Student Paper") as part of my (our) studies at Williams College. As the author(s) of the Student Paper and the owner(s) of the various copyrights inherent in the Student Paper, I (we) authorize the Center of Environmental Studies at Williams College ("CES") to use the "Student Paper" as described below:

✓ I (We) grant CES the right, during the Term defined below, to reproduce, distribute, display, perform publicly, and create derivative works based on the Student Paper solely for the following purposes (check all that apply):

✓ To allow CES to reproduce, distribute, publish, display, and otherwise make the Student Paper available on internet websites affiliated with Williams College.

✓ To allow CES to reproduce and distribute copies of the Student Paper for academic and non-commercial purposes.

✓ To allow CES to use the Student Paper for any and all academic and non-commercial purposes.

______ To allow CES to ________________________________________________________________________________________________________________________.

______This grant of rights in the Student Paper to CES is valid and persists for the following Term:

__✓__This grant of rights is perpetual.

______ This grant of rights shall terminate ____________________.

______I (We) wish to retain the full scope of our exclusive rights in the Student Paper. Accordingly, we do not authorize CES to make any use the Student Paper in any manner that infringes these exclusive rights under copyright law in the Student Paper.

Nanny Gephart and Rick Redmond

**The Water Quality of Moore's Pond: 1991 to Today**

Performed Spring 2006
Submitted May 18, 2006
Advisor Professor Thoman
Environmental Studies 102

*A study of the overall health of Moore's Pond, located in Williamstown, MA. The proportional aquatic invertebrate populations, pH, Loss-on-Ignition, Lead concentration, and Chromium concentration were measured, and showed that the pond has gotten cleaner over the past 15 years, and is now in a generally healthy state.*

## Introduction

The primary focus of our study was the presence of heavy metals in Moore's Pond. Specifically, we have taken a very close look at the level of chromium in the pond, and have also looked at levels of lead and arsenic. The impetus for this research was two previous theses by Williams students (Nathalie Weicker and Chu Ri Shin) that examined the overall health of the pond, with particular attention to arsenic and chromium levels. Our goal was to see if there had been any change in the levels of those heavy metals, or any other water quality indicator. We measured the pH of several different spots in the pond, and have compared reported insect levels in the pond this year to the findings of years past. All told, our evidence strongly suggests that Moore's Pond is healthier now than it has been in the last twenty years. The recovery of the pond appears to be a trend that started when the neighboring garbage dump was capped, and though man's fingerprint can still be found in the pond, our findings and research suggest that Moore's Pond is a relatively healthy environment.

## Methods

The process of measuring for heavy metals, especially chromium, has actually consumed most of our energy in doing this project. Our first attempt to measure heavy metals involved using water samples and the Atomic Absorption Spectrophotometer. We collected water from five different sites around the pond, came back to the lab and filtered it. Then, we took the filtered water and ran it through the flame, using standards made up in water. This was the best way to test for Chromium in water; it was not the best way to test for Arsenic. However, we did not have the lamp required to do the more specific Arsenic test so we had to use the same method to test for it we used for Chromium. The test results proved inconclusive: most came out negative. In order to get a better sense of heavy metals in the pond, soil samples were needed.

We took soil samples from five different sites around the pond (see Figure 1), each sample coming from under the water about 3-4 feet away from shore. The samples were taken back to the lab where we proceeded to leave them to dry. After the samples were dry, we measured out approximately 2.5g of dry soil from each sample site and put them in the furnace, where they were left over night at a temperature of 600c. After all the organic materials had been incinerated, we dissolved .5g of ashed soil in a mixture of 10ml nitric acid and 5 ml sulfuric acid. We put the mixtures on hot plates and cooked them until approximately 5 ml of the solution remained. Then, we put the solution through a filter, and diluted the solution to 100ml by adding pure water. After this, our solution was ready for analysis.

In our first attempt at analyzing the new solution, we used the standards that were already made up in the lab. However, we were getting surprisingly high results, and it turned out that this was due to the high background detection of the acids in the AAS. Thus, in order to ensure we got good results, we went back and made a batch of standards more suited for our purposes. In order to make the standards, we made a "blank" of nitric and sulfuric acid mixed in a 2:1 ratio. Then, we took a sample with a known concentration of chromium (and lead) and mixed it with our samples in order to get a set of standards with a known concentration of the metals. Using the new blanks and standards, we analyzed our samples again and found inconclusive results. The flame was not sensitive enough to detect any concentration of chromium that may have been in our samples, so we had to reanalyze them using the graphite furnace instead. The furnace was completely automated (see Figure 2), and we only needed to prepare one standard because it dilutes other standards by itself. We also used the furnace to analyze for lead, and the results for both lead and chromium turned out to be very good. In order to calculate the amount of each heavy metal we had, we divided whatever the machine gave us by 5, which told us how much of the heavy metal could be found in a gram of ashed sediment. Then, we used the equation (X-(%loi*X)=1 to figure out how much dry sediment produced a gram of ashed sediment. To figure out how much heavy metal was in a dry gram of the sediment, we cross-multiplied X/(Cr in X)=1/(Cr in 1). These calculations gave us the amount of lead and chromium in the sediment, in parts per million.

These results were then compiled with the results of various other tests we had performed on the water and sediment samples. Earlier this year during the Monday lab section, aquatic invertebrates were also collected from Moore's Pond, which are good indicators of the overall health of the pond. This data was compared to data from ES 102 projects in years past, and used to study sweeping trends in water quality. Through incinerating the sediment samples, we were able to calculate the Loss-on-Ignition (LOI) of each sample as well, which indicates the amount of organic matter present. The last measurement that we did was simply measuring the pH of each water sample collected to establish a base line and ensure that there was nothing wrong with our collection sites or method of collection.

## Results

The results that we collected were pretty consistent with our hypothesis and with the results collected in years past. Even the simplest of measurements such as pH turned out to be consistent with the findings of Shin and Weicker (Figure 3). Almost all of the pH measurements showed that the pond was slightly basic, but not enough to affect its overall health. The only sample with significant variance was sample 12, which was probably the result of an error in collection or pH measurement. Though we had no previous data for LOI, the data that we collected was interesting because it showed the level of organic matter in the bottom of Moore's pond. On average, roughly 20% of every sediment sample we collected turned out to be organic matter. The LOI ranged from 12% to 30%, mostly depending on our method of collection and the depth of the water (see Table 2). Though these measurements alone are insignificant to determining the health of the pond, they were essential and used when calculating the chromium and lead concentrations at each site.

After a long and arduous process of perfecting our chromium measuring skills, we finally came out with data this is generally consistent with that of Weicker and Shin. We discovered that while there is some chromium still in the Moore's Pond Sediment, it is an irrelevantly small amount and has been decreasing over the past 15 years. While the average chromium level in parts per million per gram of dry sediment in 1991 was 31.925, it decreased to 25.58 in 1994, and today it is at a level of roughly 17.499. Thus, it is evident that there has been a steady decline in the chromium concentration of Moore's Pond (see Figures 4 and 5) since 1991. Though there is some variation (especially at Site 3), it is safe to assume that this is probably due to error, because of the overall trend is clear. The already low levels of chromium in Moore's Pond have decreased further over time, emphasizing the pond's continued water quality improvements.

While there is no historical data to compare our calculated lead levels to, they work well with the chromium data to highlight the relative health of Moore's Pond. All of the lead levels found were less than 5 parts per million, and together the measurements averaged 3.28 ppm (see Figure 6). This is an extremely low level of lead, especially for a pond that was once heavily polluted. The levels of heavy metals in the pond are the most important factor when deciding whether or not fishing should be prohibited to catch and release only, because these metals can be found in fish fillets, even after cooking. Thus, the very low levels of chromium and lead indicate that the pond is probably safe for all types of fishing.

Overall, the most telling aspect of our experiment was proportional population of the aquatic invertebrates collected. As we expected to see, the Biotic Index of the water has improved since the capping of the garbage dump in the mid nineties. According to data gathered by other ES 102 students, the Biotic Index goes to as low as 1.24 on the Hilsenhoff scale, as compared to a 2.615 that was recorded in 1995. However, the trend has reversed in recent years, and the Biotic Index has climbed back up to 2.22. That being said, we do not yet see this as a cause for concern as it has not been a trend (in 2004 the Biotic Index was 1.34) and our method of measuring Biotic Index is far from perfect. Because the data available to us was presented in terms of families, such as Plecoptera, we could not use the Biotic Values of the individual species within the families. Thus, while on our scale all Diptera are assigned a value of 3, individual species within the family have values ranging from 0-5. This is also why our scale is out of 3 instead of 5; no individual family we measured merited a ranking of greater than 3. While we do not think the high Biotic Index measured this year is a cause for concern, if the pattern continues than the problem deserves much more attention.

It is also safe to overlook the jump in Biotic Index this year because of the trend seen when looking at the actual insect data. Since the late 1990's Plecoptera (stoneflies) have been seen in the pond, showing improvement, because this species doesn't survive in heavily polluted waters. We have also seen an increase in Ephemeroptera and Odonata, as seen in Table 4 and Figure 7. These are all species with an average Biotic Index of fewer than 3, showing that, according to King, the water quality is pretty good. The higher proportion of these intolerant insects, the healthier the water must be. Thus, it is clear that Moore's Pond has become cleaner since the mid-1990's because of the increase in aquatic invertebrates such as Plecoptera.

## Discussion

The data that we collected was generally consistent with our thesis, showing low levels of heavy metals in Moore' Pond, and an overall healthy environment. From the data, we can conclude that the pond is no longer being polluted by the landfill, and that much of the polluted sediment is being covered up, and thus made inaccessible to marine life. Beside the logic of knowing that a landfill would pollute a pond, we can see that much of the chromium and lead in the pond came from the dump because of the levels at different sample sites. Sites 2, 4 and 5 (See Figure 1) were closest to the dump, and seemed to consistently have very high levels of pollution. All three sample sites contained a large amount of organic matter, indicating that we probably took the top (and presumably cleanest) layer of sediment in the pond. The LOI's of these three sites averaged to roughly 24.08%, which is pretty high compared to the 20.67% mean of all of the LOI calculations. These three sites also had the highest levels of chromium and lead in their sediment. Their lead levels were 2.9564 (for Site 2), 3.9382 (for Site 4), and 4.6826 (for Site 5), which are significantly higher than the lead levels of the site farther away from the dump, each with a level of under 2.5 ppm. While all of the levels are still very low, it is interesting and telling that the sites closest to the dump still seem to be the most polluted.

Trends in sample site measurements and water quality improvements were very indicative of the Moore's Pond situation. Though we are able to make generalizations from these data, there are still many sources of error that could have contributed to some of the unusual numbers that we got. There was much potential for error within this project, especially when measuring the heavy metal content of the soil samples. Measuring out the soil, adding the acid to it, and diluting all could have been done incorrectly and negatively contributed to our results. We suspect that one specific problem in our experiment was the calibration of the scales that we used to measure soil, and therefore Loss-On-Ignition. We discovered post-ashing that the scale we had used to measure the unashed soil wasn't calibrated, and thus tried to use an equally uncalibrated scale when measuring the ashed soil. While this isn't the most scientific of processes, it was the best that we could do, given the faulty resources that we started with.

As we learned early on in our process, another important factor was the standards that we used in the AAS. These measures lead to much confusion early on in the experiment, however we believe that we finally figured out how to make the correct standards and automatically dilute them in the graphite furnace. The state of the tube in the graphite furnace was also a problem, as our acid based samples and standards proved to be very corrosive to it. We managed to overcome this problem by replacing the tube frequently. These were original sources of error that were worked out over the course of the experiment, and should have lead to more accurate results. Less significant errors could have also arose when measuring the pH of the samples, such as not calibrating the pH meters effectively. However, we don't think that such mistakes would contribute a lot to the overall conclusions of our study.

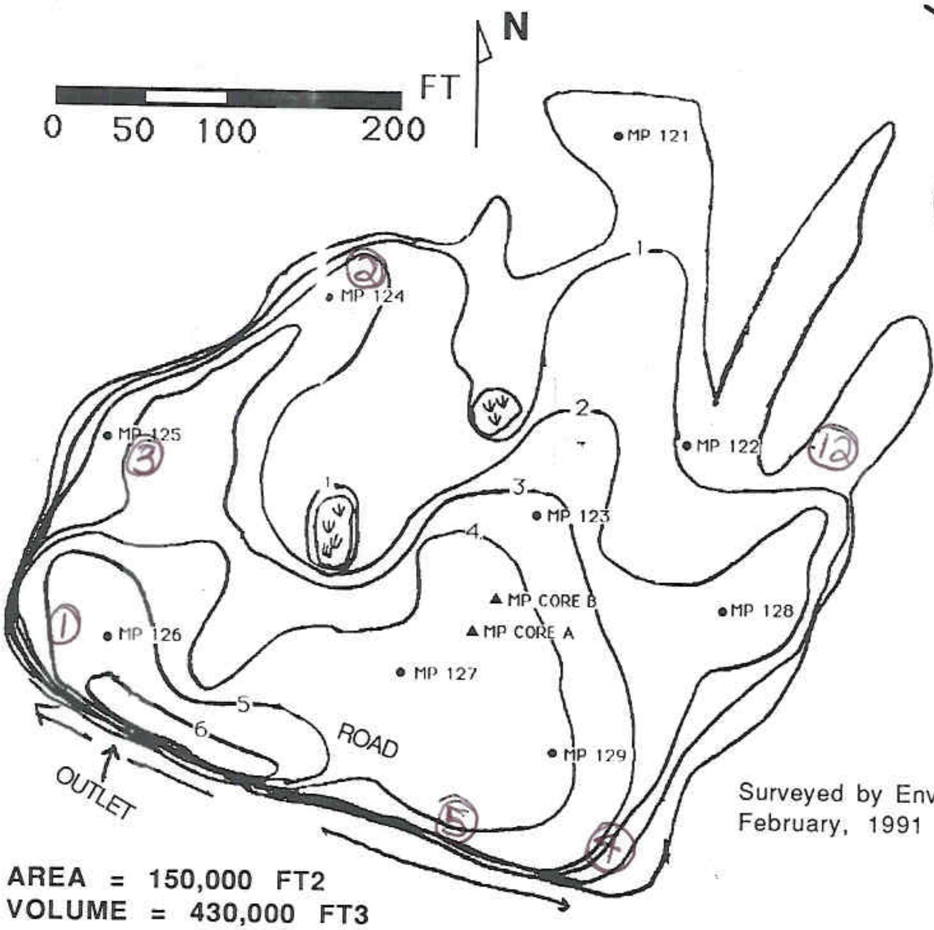
The aspect of the experiment where we had the most telling and accurate success were the aquatic invertebrate measurements. While there is a chance that some insects may have been identified incorrectly, we believe that for the most part, this data is pretty accurate. It is clear that since insects started to be collected in the early 1990's, great improvements have been made in the water quality of the pond. As is especially evident in the first data column of Table 4, the stonefly population of the pond has been drastically increasing. This is promising because stoneflies are extremely intolerant to pollution, and therefore wouldn't be living in the pond if it were substantially polluted. There have also been large increases in other types of intolerant aquatic invertebrates, including mayflies and dragonflies. The proportional increases of all three of these species become especially high in the mid-1990's, which was directly after the municipal dump was capped. Especially when seen in the context of our other data, this shows that the dumping was significantly contributing to the water quality of the pond. However, since it has stopped, the health of Moore's Pond has turned around, showing decreased levels of heavy metals and increased populations of intolerant insects.

## Conclusion

In general, our data point to a healthy future for Moore's Pond. With the capping of the garbage dump, chromium in the water seems to have been slowly decreasing; a result consistent with what you would expect as new sediment slowly fills over old sediment. Lead levels in the pond are reassuringly low, and we did not find any evidence that eating fish from the pond would be dangerous in any way, though we would need to do further research before making a firm recommendation to that effect. The aquatic invertebrates found in the pond indicate that it has become a healthier environment since the early 1990's, despite the recent deterioration of the Biotic Index. While collecting samples at the pond we saw many species of both birds, including a great blue heron (*Ardia Herodias*) and a largemouth bass (*Micropterus Salmoides*) that indicate the pond is a healthy, thriving ecosystem. All things considered, despite its proximity to many potential pollutants, Moore's Pond is a relatively healthy place and should not be considered a bio-hazard in any way (though drinking the water is highly discouraged.)

Figure 1

## FIGURE 8
## MAP OF MOORE'S POND
### SHOWING LOCATIONS OF SEDIMENT SAMPLE COLLECTION POINTS




**EXPLANATION**

- 2 Depth of water, ft
- ● Surface Sampling Point
- ▲ Core Sample
- Island

Surveyed by Environmental Studies 102
February, 1991

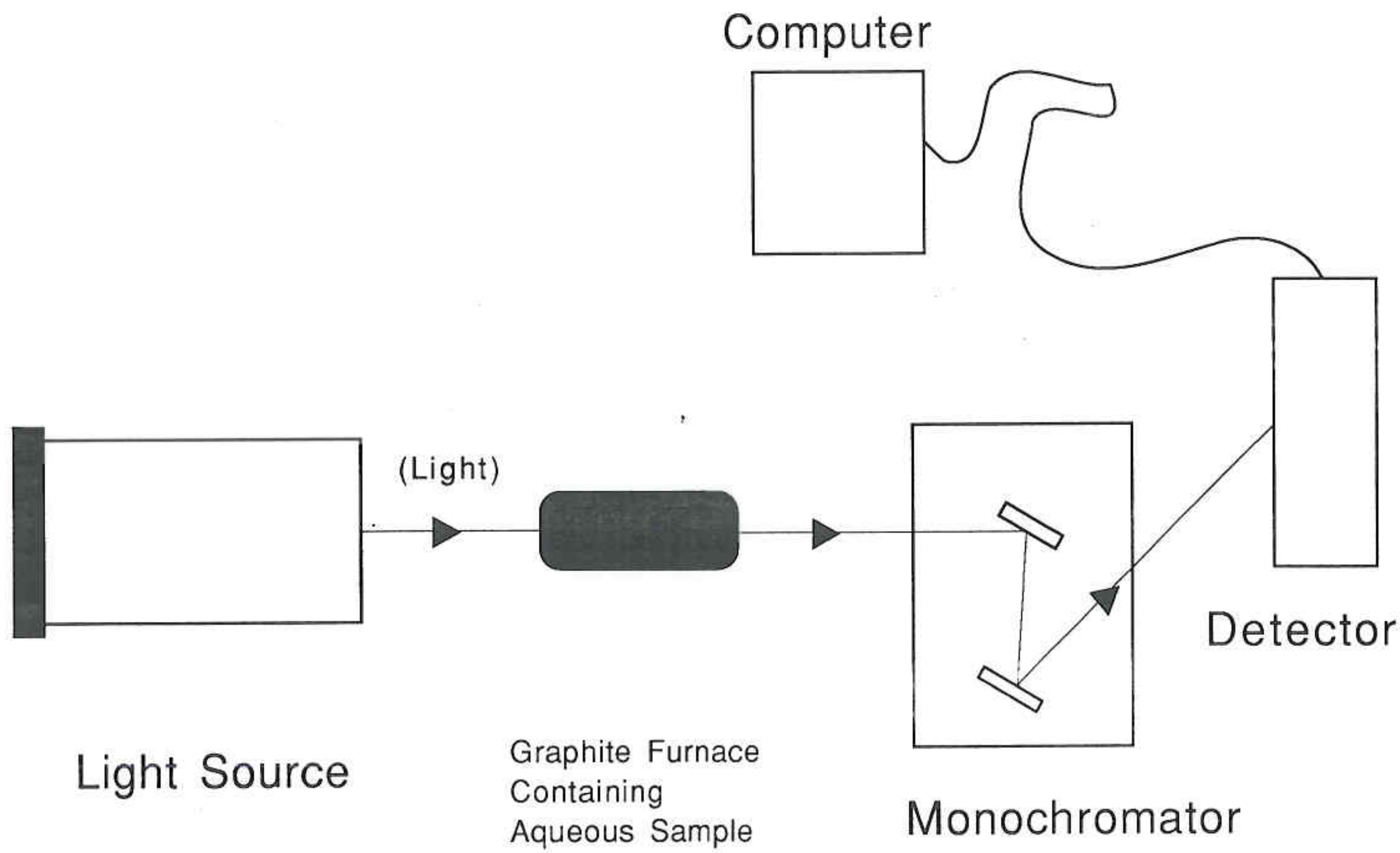
AREA = 150,000 FT2
VOLUME = 430,000 FT3
SEDIMENT VOLUME = 225,000 FT3

~~Surface samples collected 3 November, 1990~~
~~Core samples collected 15 January, 1991~~

(Weicker, 1991)

Figure 2

# FIGURE 13
## SCHEMATIC DIAGRAM OF THE ATOMIC ABSORPTION SPECTROPHOTOMETER




(Weicker, 1991)

<u>Figures and Tables</u>

*Table 1: Overall Data*

***SEDIMENT***

| Sample # | LOI | % LOI | Cr Average in ppm | Pb Measurement in ppm |
|---|---|---|---|---|
| 1 | 0.48 | 18.75 | 20.8962 | 2.3026 |
| 2 | 0.58 | 23.29 | 20.6005 | 2.9564 |
| 3 | 0.31 | 12.35 | 17.3583 | 2.5348 |
| 4 | 0.78 | 30.71 | 19.1434 | 3.9382 |
| 5 | 0.46 | 18.25 | 9.4947 | 4.6826 |
| **Average** | **0.522** | **20.67** | **17.49862** | **3.28292** |

***WATER***

| Sample # | pH |
|---|---|
| 1 | 7.44 |
| 2 | 7.64 |
| 3 | 7.41 |
| 4 | 7.12 |
| 12 | 6.69 |
| **Average** | **7.26** |

*Figure 3*

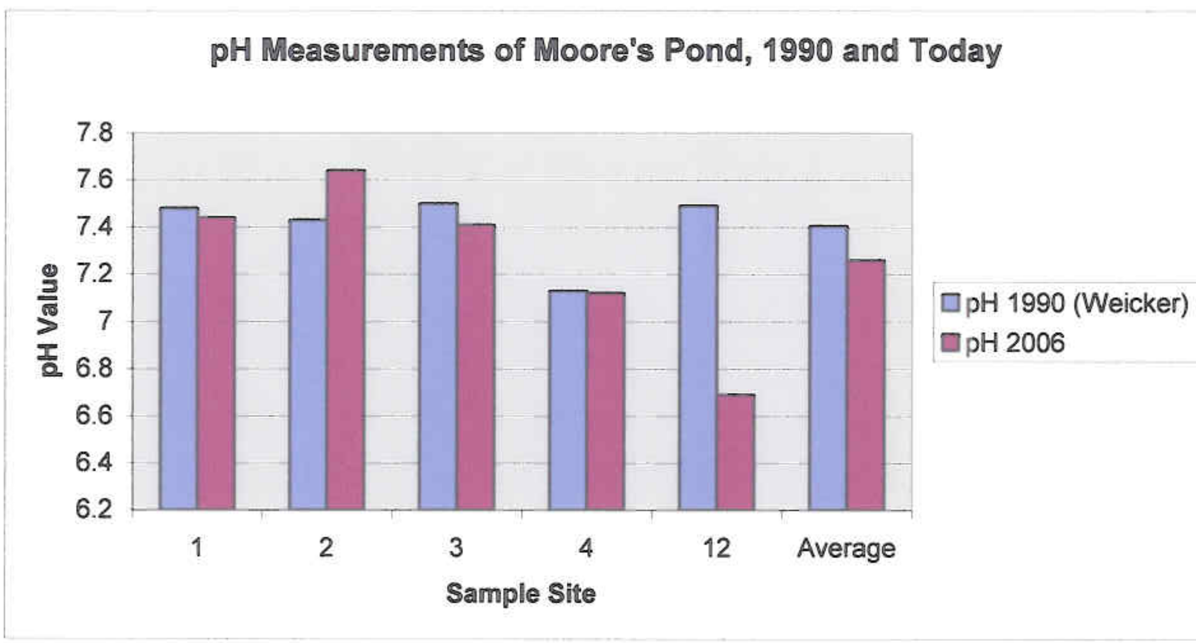


*Table 2*

| ***SEDIMENT*** Sample # | LOI | % LOI |
|---|---|---|
| 1 | 0.48 | 18.75 |
| 2 | 0.58 | 23.29 |
| 3 | 0.31 | 12.35 |
| 4 | 0.78 | 30.71 |
| 5 | 0.46 | 18.25 |
| **Average** | **0.522** | **20.67** |

*Table 3 (Cr in ppm per gram of dry sediment)*

| ***SEDIMENT*** Sample # | Cr 1991 in ppm (Weicker) | Cr 1994 in ppm (Shin) | Cr 2006 in ppm |
|---|---|---|---|
| 1 | 41.8 | 41.2 | 20.8962 |
| 2 | 21.1 | 23.9 | 20.6005 |
| 3 | 25 | 11.65 | 17.3583 |
| 4 | 39.8 | N/A | 19.1434 |
| 5 | N/A | N/A | 9.4947 |
| **Average** | **31.925** | **25.58** | **17.49862** |

*Figure 4*

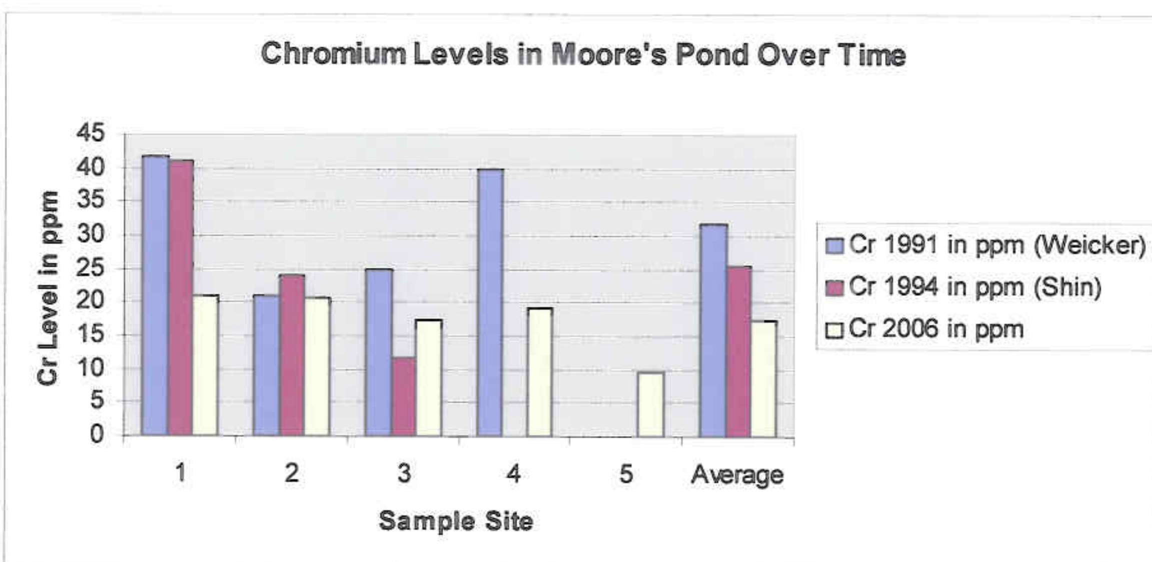


*Figure 5*

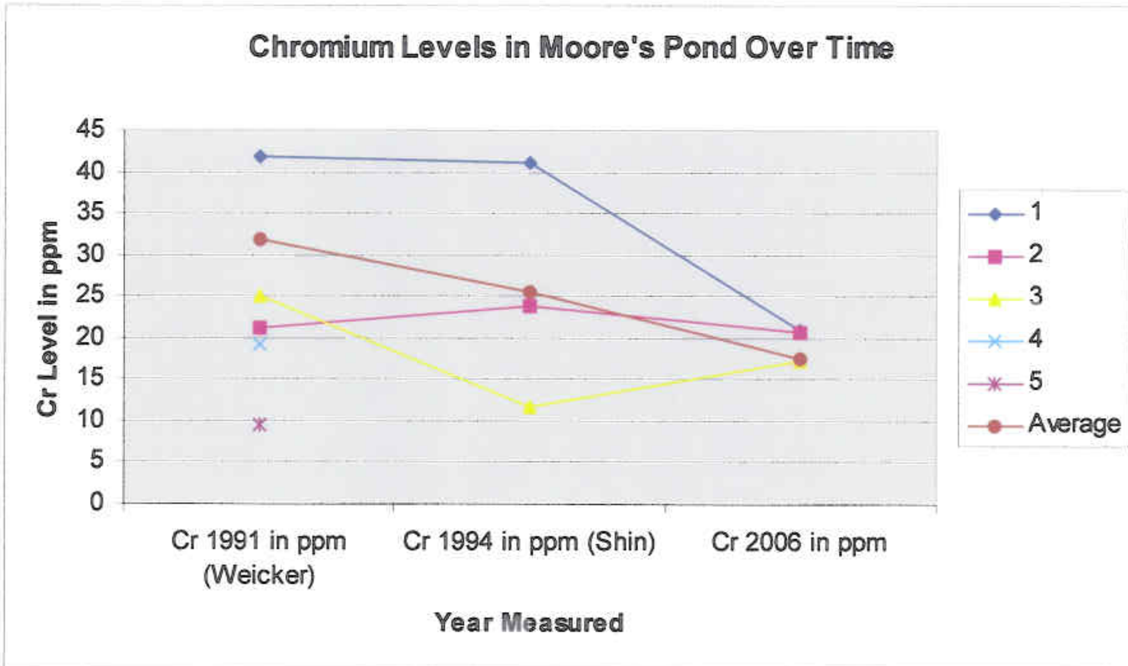



*Figure 6*

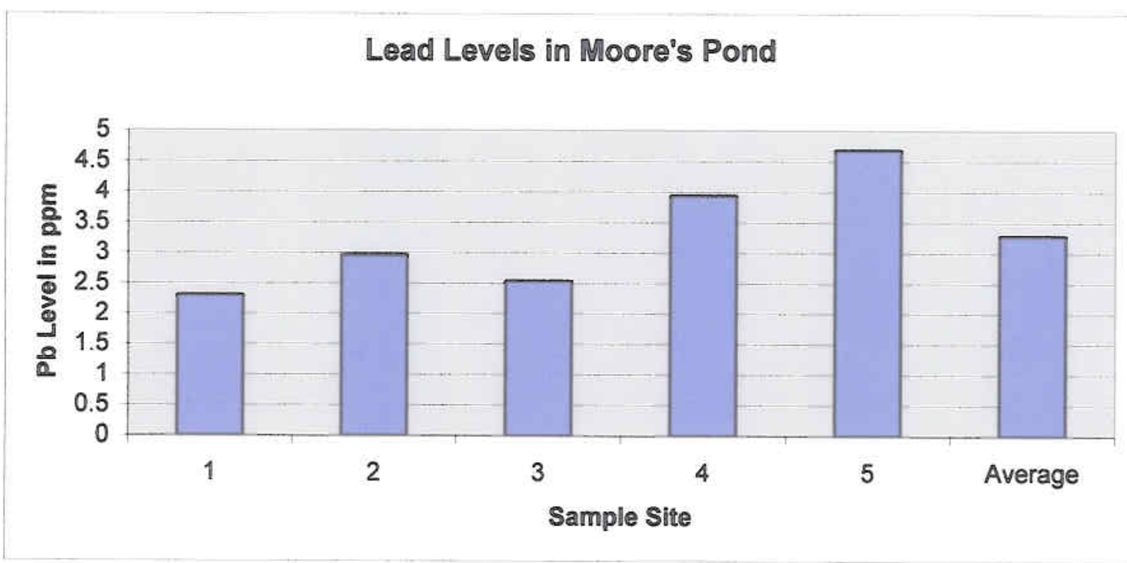
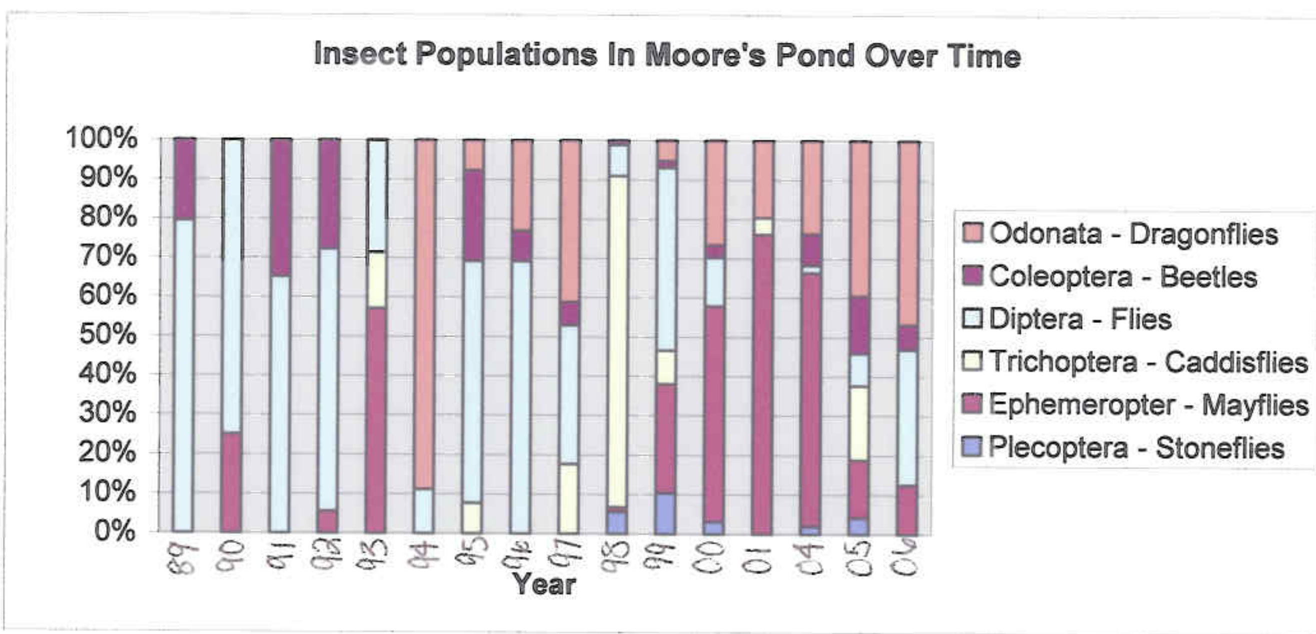


*Table 4*

| Year | % Plecoptera - Stoneflies | % Ephemeroptera - Mayflies | % Trichoptera - Caddisflies | % Diptera - Flies | % Coleoptera - Beetles | % Odonata - Dragonflies |
|---|---|---|---|---|---|---|
| 1989 | 0 | 0 | 0 | 79.5 | 20.5 | 0 |
| 1990 | 0 | 25 | 0 | 75 | 0 | 0 |
| 1991 | 0 | 0 | 0 | 65.2 | 34.8 | 0 |
| 1992 | 0 | 5.6 | 0 | 66.7 | 27.8 | 0 |
| 1993 | 0 | 57.1 | 14.3 | 28.6 | 0 | 0 |
| 1994 | 0 | 0 | 0 | 11.1 | 0 | 88.9 |
| 1995 | 0 | 0 | 7.7 | 61.5 | 23.1 | 7.7 |
| 1996 | 0 | 0 | 0 | 69.2 | 7.7 | 23.1 |
| 1997 | 0 | 0 | 17.6 | 35.3 | 5.9 | 41.2 |
| 1998 | 5.6 | 1.1 | 84.3 | 7.9 | 1.1 | 0 |
| 1999 | 10.3 | 27.6 | 8.6 | 46.6 | 1.7 | 5.2 |
| 2000 | 3.1 | 54.7 | 0 | 12.5 | 3.1 | 26.6 |
| 2001 | 0 | 76.1 | 4.3 | 0 | 0 | 19.6 |
| 2004 | 2 | 64.4 | 0 | 2 | 7.9 | 23.8 |
| 2005 | 4.2 | 14.6 | 18.8 | 8.3 | 14.6 | 39.6 |
| 2006 | 0 | 12.5 | 0 | 34.4 | 6.3 | 46.9 |

*Figure 7*



## Resources

http://blackboard.williams.edu/webapps/portal/frameset.jsp?tab=courses&url=/bin/common/course.pl?course_id=_6663_1, accessed 5/4/06, HOORWA

http://epa.gov/wastewise/wrr/updates.htm, accessed 5/5/06, Environmental Protection Agency

Hilsenhoff, William L. / *Using a biotic index to evaluate water quality in streams* (1982) http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=turn&entity=EcoNatRes000101320021&isize=M (accessed May 17th)

Shin, Chu Ri Determination of Chromium and Arsenic in Bridges and Moore's Ponds in Williamstown, MA and Hopkins Memorial Forest. Williams College, 1994.

Weicker, Nathalie S. Arsenic and Chromium in Bridges and Moore's Ponds of Williamstown, Massachussettes. Williams College, 1991.

The advice and understanding of Professors Art, Thoman and Dethier

The patience and help of Jay Racela

ES 102 Lab Manual and Class Data