The Water Quality of Rice Creek, Rice County, Minnesota
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Environmental Geology 120

By
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Introduction:

The Rice Creek Basin is part of the Cannon River Watershed, which feeds into the lower portion of the upper Mississippi River (Figure 1). The southeastern part of Minnesota, where Rice Creek is located, is believed to have a higher susceptibility for contamination than other parts of the state (Tester, 1995). Unfortunately, this is also the area of the state with the highest population density; almost 60,000 people live here. The area is made up of 66% cultivated land, 13% forested, and 17% open pasture lands (Guzman, 2002). Whatever contaminants are present in Rice Creek are most likely also present in the groundwater and irrigation systems at the farms where our food is grown.

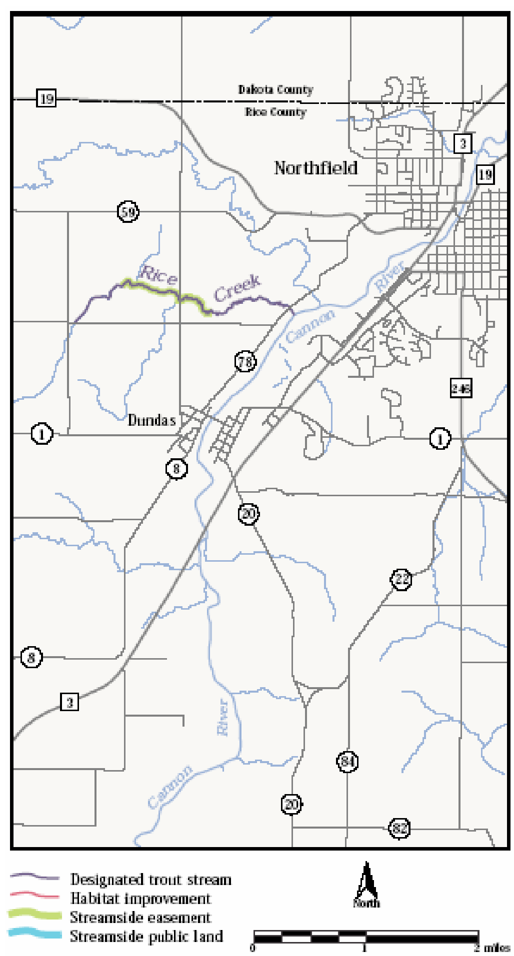


Figure 1- Rice Creek Watershed (http://files.dnr.state.mn.us/maps/trout_streams/6.PDF)

The area surrounding Rice Creek is heavily used for agriculture, and so it would seem that there is a large amount of human interference. Plowing fields releases soil nutrients into the creek, and the use of fertilizers further increases the presence of such chemicals as phosphate and nitrogen. The construction of bridges over the creek disrupts the natural habitat and introduces foreign sediments into the creek. Many people in the area rely on wells for drinking water, and after infiltration to groundwater, the pollutants from Rice Creek may be pumped up these wells. Because the creek has such an impact on the environment and the residents of the area, it is very important to monitor it. Students from Carleton College have been monitoring the water quality since 2001.

The purpose of this investigation is to continue collecting data on the water quality of Rice Creek, so we can observe any changes that may have occurred. If any water quality indicators suggest that the water is contaminated, we will look into possible sources of pollution, and determine ways the problems can be fixed. Our results will be shared with the Carleton College Geology Department and with the residents of Rice County, who are most directly affected by the quality of the water.

Methods:

We collected water samples from five different locations along Rice Creek during the month of October. On October 4th, we collected water samples from Cates Avenue, both before and after the tile. On October 11th and October 25th, we collected more water samples from these two sites, as well as from a site near the railroad, one beneath the bridge on Decker and 100th Street, and one next to a farm near the intersection of Cabot and Millersburg. Finally, on November 8th we collected water samples from the railroad site (Prawner), Decker and 100th Street, and Cabot and Millersburg. After collection, we tested each water sample for fluoride, chloride, Nitrite, Nitrate, Sulfate, Bromide, and Phosphate. All of these anions were tested in the Geochemistry laboratory using an ion chromatograph. In addition, we employed the use of Yellow Springs Instruments, Incorporated, Model 85 (YSI Meter) and a Secci meter during our onsite collection of water samples.

The YSI Meter provided readings on the various aspects of the creek's physical and chemical properties. Such properties include conductivity, salinity, dissolved oxygen, and temperature. The conductivity (μs) provides the "ability of an aqueous solution to carry an electrical current" (American Public Health Association, 1981) which can be an indicator of the amount of nutrients dissolved in the water. Salinity (ppt) provides information of "total solids in water after all carbonates have been converted to oxides, all bromide and iodide have been replaced by chloride, and all organic matter has been oxidized" (APHA, 1981). Dissolved oxygen content (mg/L) determines if the water quality can transport oxygen needed for aquatic life (Hunt 1996). Temperature °C affects the dissolved oxygen content, in warmer water the dissolved oxygen content lowers. We used the Secci meter to measure the turbidity of the samples. It evaluated the visibility of the water content of the samples by using a disk with black and white triangles located at the bottom. The visibility of the water was deemed as clear, semi clear, cloudy, or muddy depending on the water content.

<u>Surrounding Elements and Factors (Point and Non-point contamination):</u>

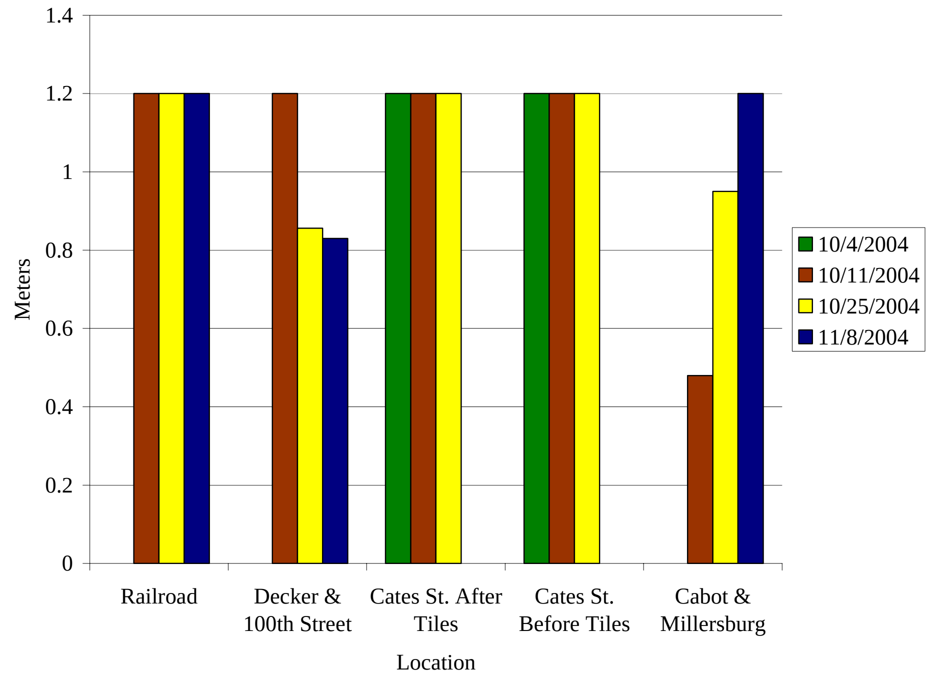
As Rice Creek flows through the cultivated farmlands of Minnesota it is incessantly vulnerable to a number of different contaminants from a number of destructive sources. The agricultural landscape surrounding mid-western watersheds continues to be the most threatening contaminant source of Rice Creek. The EPA found that nearly two-thirds of contaminated river-ways and nearly half of impaired lake areas in Minnesota were tainted by agricultural resources. As the farming community races to feed the world, the small tributaries become unstable and toxic through potent runoff; leading to the contamination of larger, more important river ways such as the Cannon River and the Mississippi River. Rice Creek has several tiles pouring directly into it allowing the flow of contaminated water from directly under the farmer's plots to flow through Rice into the Cannon and then into the Mississippi. Rice County farmland is considered a source of point pollution to Rice Creek, and thus, Rice Creek becomes a source of non-point pollution to the Cannon River and the Mississippi. Within the devastating agricultural runoff, one finds high concentrations of nitrate. Nitrate is a colorless, odorless and tasteless compound that is essential to all life; in moderate amounts it is a harmless part of food and water. In high concentrations it may cause methemoglobinemia, or 'blue baby syndrome,' a deadly condition most suffered by infants. Most crops require soil with large quantities of nitrate to sustain high yields, but other constituents also add to the excessive concentrations, such as fertilizer and manure, animal feedlots, municipal wastewater, and septic systems. The EPA's maximum content for nitrate as nitrogen levels in drinking water is 10 mg/L.

Most of southern Minnesota's landscape and geology are permeable, sandy soils, fractured limestone, and dolomite bedrock. Thus this area of land is extremely susceptible to groundwater contamination, having a dual threat of excessive agriculture and permeable soil. Other non-point sources of pollution for Rice Creek include acid rain, which creates dangerous levels of sulfate in waterways. Though levels of sulfate in Rice Creek have remained relatively low, we are entering an age of highly excessive production and excessive contamination through environmentally unfriendly corporate practices and it will be important to monitor the sulfate levels in the future. Although Rice Creek is not a vital waterway itself, it is the only freshwater trout stream in Minnesota, and it can tell us important information about surrounding land use and conditions, in an effort to one day ensure the survival of the environment as we ensure the survival of our species.

<u>Results:</u>

Turbidity

At three of the five sites (the railroad, Cates St. before the tile, and Cates St. after the tile) the turbidity remained a very clear 1.2 meters. At Cabot & Millersburg, the water was less turbid each time we went, changing from 0.48 m to 1.2 m, but at Decker and 100th St., the water became more and more turbid, changing from 1.2 m to 0.83 m.



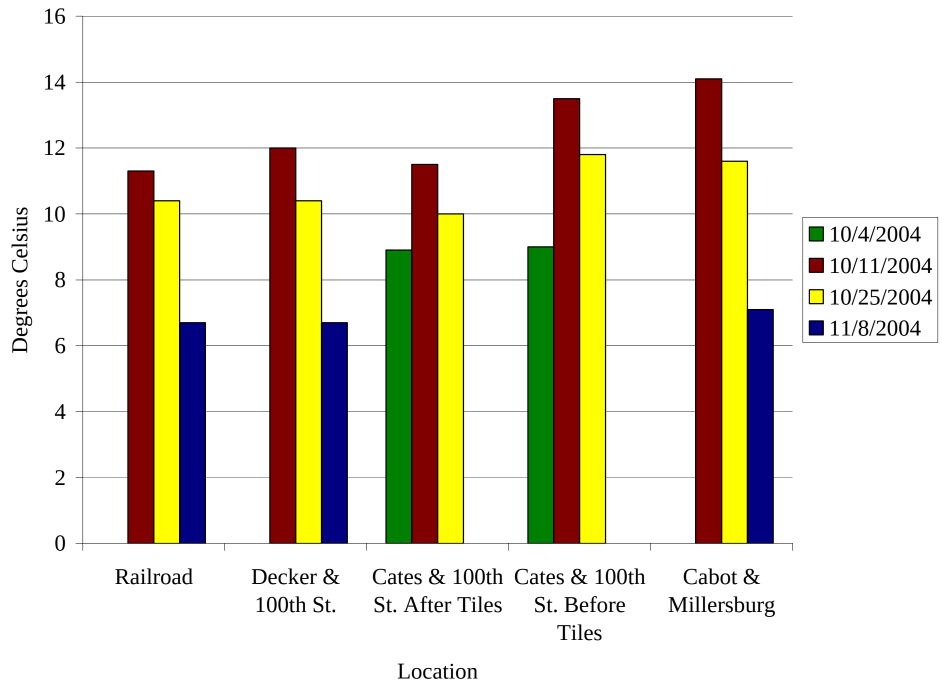
Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		1.2	1.2	1.2
Decker & 100th Street		1.2	0.856	0.83
Cates St. After Tiles	1.2	1.2	1.2	
Cates St. Before Tiles	1.2	1.2	1.2	
Cabot & Millersburg		0.48	0.95	1.2

Figure 2- Turbidity Measurements in Meters

Water Temperature

At three of the five sites (the railroad, Decker and 100^{th} St., and Cabot and Millersburg) the water temperature got decreasingly colder, which makes sense because, on average, the temperature of the air got colder. At the two sites near the tile on Cabot St., the water temperature rises between Oct. 4, 2004 and Oct. 11, 2004, and then cools between Oct. 11, 2004 and Oct. 25, 2004. Even then, however, the water temperature was still warmer than it was on Oct. 4, 2004.

Overall, the warmest temperature (14.1° Celsius) was on Oct. 11, 2004 at Cabot and Millersburg. The coldest temperature (6.7° Celsius) was on Nov. 8, 2004 at the railroad and at Decker and 100th St.

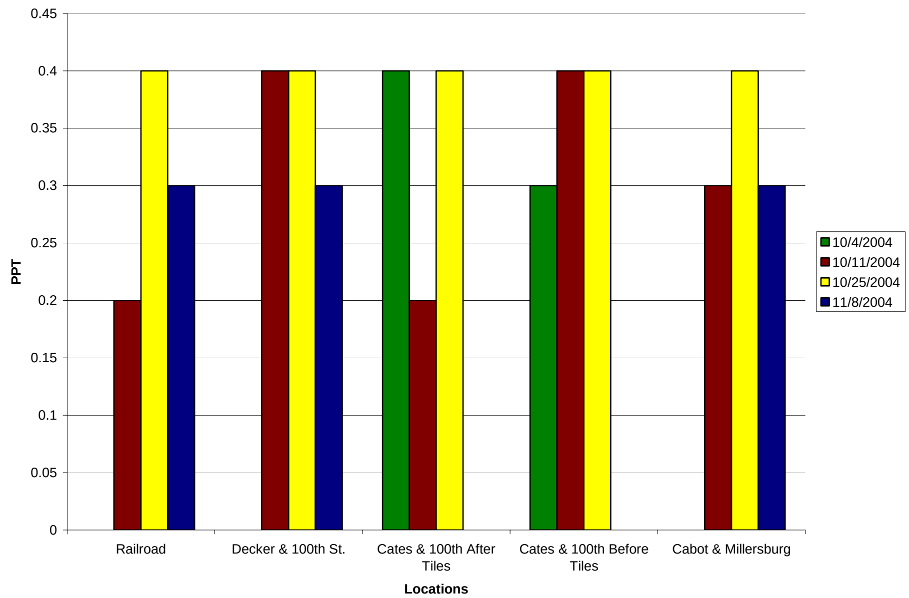


	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		11.3	10.4	6.7
Decker & 100th St.		12	10.4	6.7
Cates & 100th St. After Tiles	8.9	11.5	10	
Cates & 100th St. Before Tiles	9	13.5	11.8	
Cabot & Millersburg		14.1	11.6	7.1

Figure 3- Water Temperature in Degrees Celcius from 10/4 to 11/8, 2004

Salinity

In spring 2003, the salinity remained constant at 0.3 ppt, with one exception. This was not the case with our data. The only trend we noticed is that on Oct. 25, 2004, salinity at all five sites was 0.4 ppt. Because there were no patterns, neither by site over time, nor on certain dates at all the sites, we have decided that the differences are due to human error. Often, the readings on the YSI meter would fluctuate, so whoever took the numbers down may not have waited as long as the person who noted the numbers at another site.

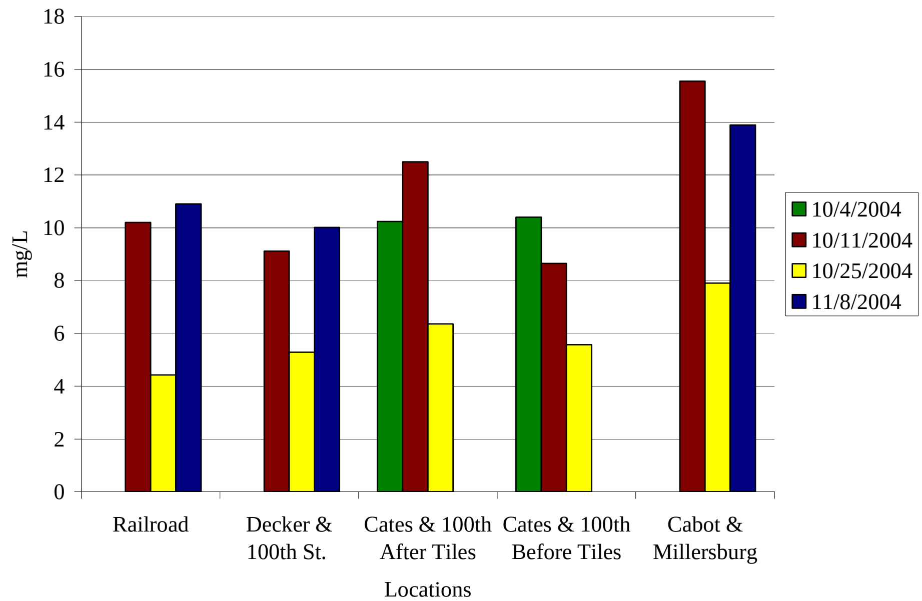


Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		0.2	0.4	0.3
Decker & 100th St.		0.4	0.4	0.3
Cates & 100th After Tiles	0.4	0.2	0.4	
Cates & 100th Before Tiles	0.3	0.4	0.4	
Cabot & Millersburg		0.3	0.4	0.3

Figure 4- Salinity in ppt

Dissolved Oxygen

On all days that we tested, the Cabot and Millersburg site had the highest concentration of dissolved oxygen. Also, at all sites, dissolved oxygen decreased between Oct. 11, 2004 and Oct. 25, 2004 and then increased between Oct. 25, 2004 and Nov. 8, 2004. Overall, the highest amount of dissolved oxygen was at Cabot and Millersburg on Oct. 11, 2004. The lowest amount was at the railroad on Oct. 25, 2004.

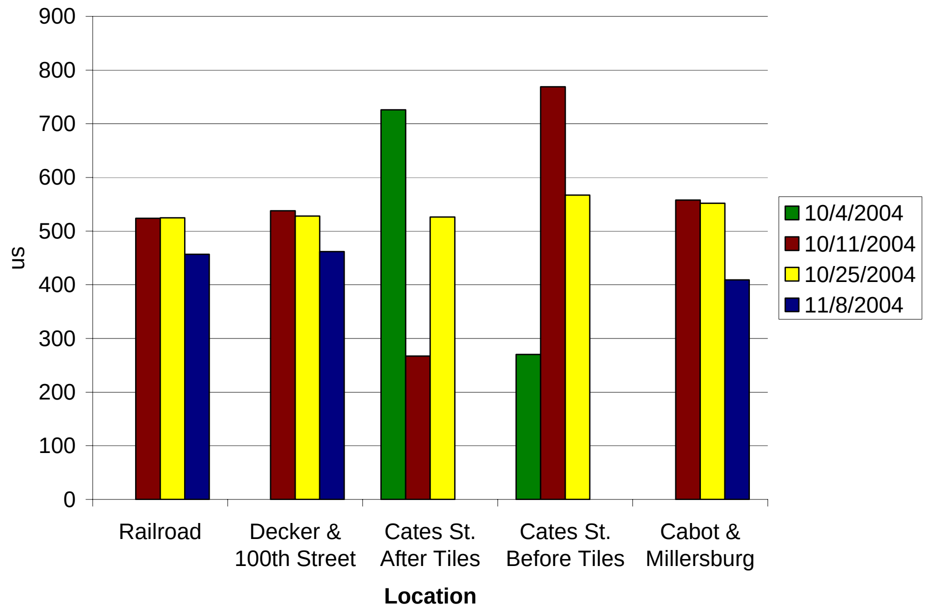


Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		10.2	4.43	10.9
Decker & 100th St.		9.12	5.29	10.01
Cates & 100th After Tiles	10.24	12.5	6.36	
Cates & 100th Before Tiles	10.4	8.65	5.57	
Cabot & Millersburg		15.55	7.91	13.89

Figure 5- Dissolved Oxygen in mg/L

Conductivity

The three sites not near the tile remained constant, and within the same range of each other, all three days. At the tile, though the conductivity was the same before and after the tile on Oct. 25, 2004, there were dramatic differences on the other two test days. There was high conductivity after the tile on Oct. 4, 2004, and low conductivity before the tile. On Oct. 11, 2004, the opposite was true. The highest recorded conductivity, 769 µs, was on Oct. 11, 2004, at Cates before the tile. The lowest, 267.2, was on the same day, but after the tile. However, as is explained later in the discussion session, there is reason to believe this data is inaccurate.

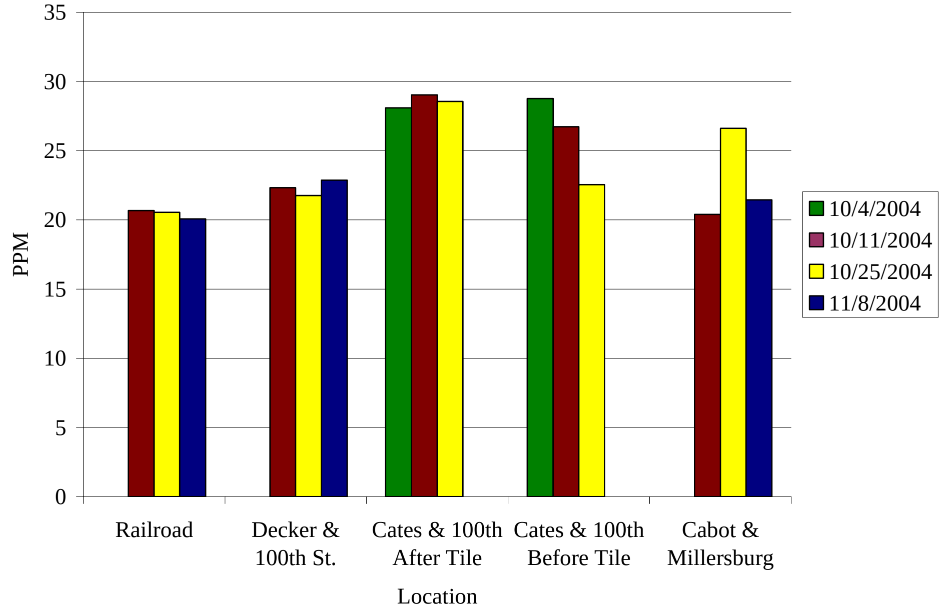


Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		524	525	457
Decker & 100th Street		538	528	462
Cates St. After Tiles	726	267.2	526	
Cates St. Before Tiles	270	769	567	
Cabot & Millersburg		558	552	409

Figure 6- Conductivity in µs

Chloride

Of the five sites we tested, the sites at Cates and 100th St. both before and after the tile had the most chloride. The only exception was on Oct. 25, 2004, when the chloride level before the tile was substantially lower than it had ever been previously. On the same day, the chloride level at Cabot and Millersburg jumped dramatically, but had fallen back to its previous level by Nov. 8, 2004. The chloride level at the two other sites remained consistently low.

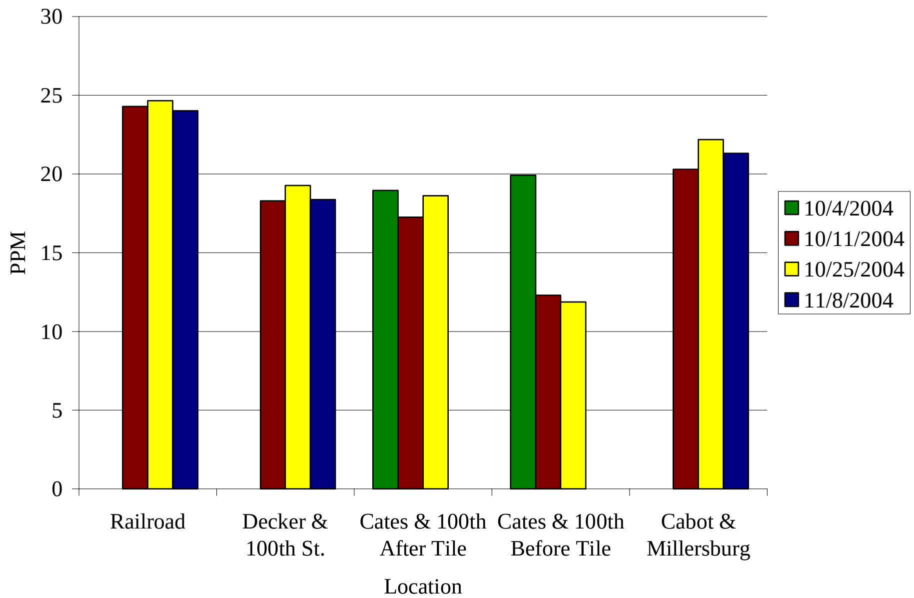


Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		20.6737	20.554	20.0754
Decker & 100th St.		22.3356	21.7668	22.8699
Cates & 100th After Tile	28.1054	29.0422	28.5657	
Cates & 100th Before Tile	28.7676	26.7384	22.5596	
Cabot & Millersburg		20.4115	26.6187	21.4546

Figure 7- Chloride in mg/L

Sulfate

Interestingly enough, the sites where chloride was present in the largest concentrations have the least amount of sulfate, and vice versa. In four of the five sites, there was not a significant change in the level of sulfate over the testing period. However, on Cates and 100th before the tile, the level of sulfate decreased almost by half after Oct. 4, 2004. This is odd because no other site experienced a change, not even Cates and 100th after the tile. The site before the tile had the lowest levels of sulfate, and the site at the railroad had the highest.

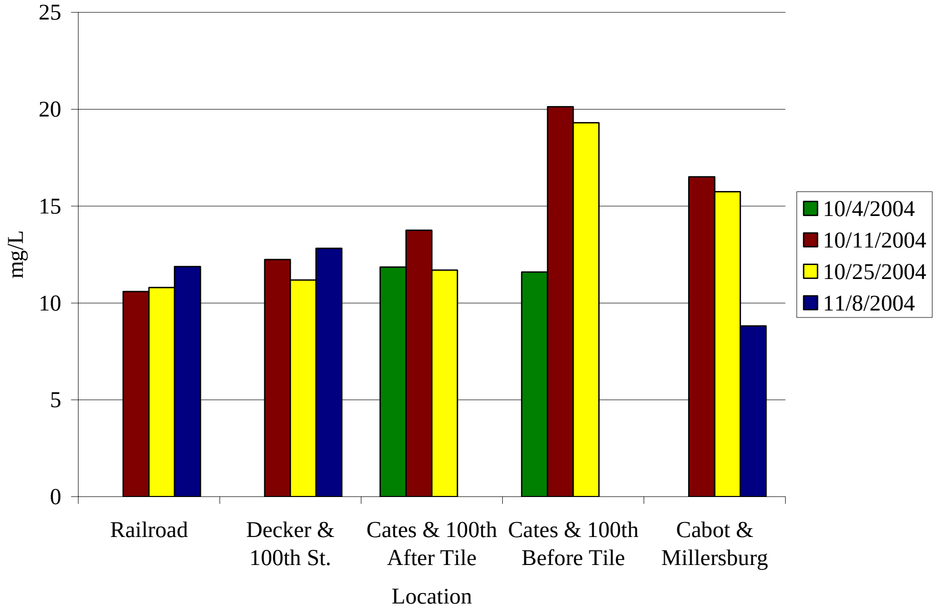


Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		24.2813	24.6543	24.0116
Decker & 100th St.		18.2926	19.2735	18.3658
Cates & 100th After Tile	18.9535	17.2608	18.6207	
Cates & 100th Before Tile	19.9146	12.2971	11.8716	
Cabot & Millersburg		20.3018	22.1835	21.317

Figure 8- Sulfate in mg/L

Nitrate as Nitrogen

At three of the four sites, the level remained consistent at just over 10 mg/l. At Cabot and Millersburg, the first reading was 16.51, but then dropped the next two test days to end at 8.81. At Cates and 100th before the tile, the nitrogen level was 11.60 on Oct. 4, 2004, and nearly doubled the next week, after which it remained high.



Location	10/4/2004	10/11/2004	10/25/2004	11/8/2004
Railroad		10.5914	10.7999	11.8835
Decker & 100th St.		12.2487	11.1803	12.8229
Cates & 100th After Tile	11.8522	13.7546	11.6981	
Cates & 100th Before Tile	11.6038	20.1369	19.304	
Cabot & Millersburg		16.5104	15.7443	8.8175

Figure 9- Nitrogen in mg/L

Discussion:

Turbidity

This is a measurement of the clearness of the water. Water discoloration or a lot of suspended solids will affect this reading, as will run-off from streets and sewers, farming deposits, and soil erosion. If the reading is very low, indicating turbid water, however, it does not necessarily mean the water is contaminated- a lot of leaves in the water will make it murkier, as will people who are disturbing the bed of the creek (as we were sometimes by dropping in the YSI meter).

Water Temperature

It is important to monitor the temperature of the water because it has a large impact on what lives in the water. Every species has a zone of tolerance, and when the temperature exceeds or does not meet that level, the species cannot survive. In a creek, this is especially true of the animals because most animals that live in a habitat like this are cold blooded and so have a very narrow zone of tolerance.

The problem with evaluating our results is that there is no data at the tile for November 11th. It is very possible that the water temperature dropped, along with the temperature at all the other sites. And because there is no data on 10/4 at the three sites with constantly decreasing temperature, we do not know if there would have been a spike in temperature between Oct. 4, 2004 and Oct. 11, 2004 there, as well.

Salinity

In an agricultural area like the land surrounding Rice Creek, the level of salt in the water is very important. The more salt present in the water, the worse the effect on the crops. Rice Creek is sometimes used for irrigation purposes (it is sometimes hard to tell whether the water running alongside a field is Rice Creek, or if it is just an irrigation ditch), and the water from the creek will become groundwater that feeds the plant roots, so maintaining a low level of salinity is very important. This is especially true because corn, which is the major crop in the area around Rice Creek, is classified in the third out of four tolerance levels to salinity, with the fourth level being the least tolerant. Also, too much salt in the water may cause aquatic plants to become dehydrated.

Dissolved Oxygen

These results are an indicator of the oxygen level of the water, which is important because all the aquatic organisms in the area need dissolved oxygen to survive. Variables such as temperature and plant life affect the dissolved oxygen level. This statistic mostly indicates the type of animals that live in the water, because every species has a different tolerance level. It needs to be monitored because a drastic change will result in fish kill. Our results, like in 2003, do not show any trends.

Conductivity

This measures how well the water conducts electricity. Conductivity is affected by salinity and by the amount of solid material suspended in the water. When the levels of conductivity change suddenly, it usually means that there is a new water source, containing some additional sort of waste, being diverted into the creek (www.sausalcreek.org).

When we tested conductivity, the YSI meter showed two results. In general, the first number would be around four or five hundred, and then would jump to over seven hundred. This fluctuation was typical of all the sites, on each test day. It was not until we were done testing that we learned that the second measurement is adjusted for temperature. However, because we were not consistent with which reading we recorded, it is sometimes difficult to compare the data.

Chloride

This is a naturally occurring, nontoxic. When present in smaller concentrations, it is not harmful. However, the presence of chloride is often an indicator of other, more toxic, chemicals. Excess chloride in the water may be an indicator that runoff containing pesticides or oil entered the creek. Also, rock salt used on the roads in winter is a large contributor of chloride to the water. An abundance of chloride can interfere with plant photosynthesis. (http://fenwick.pvt.k12.il.us)

The abrupt changes on Oct. 25, 2004 could be partially explained by the light rain that fell for the two days prior. It did not rain immediately before any other testing days, so that is one reason why a change might have occurred. However, it would make sense for the chloride levels to increase after a rainfall, due to excess nutrients in the runoff, but that did not occur. Regardless, these levels are not so high that we should worry about them too much.

Sulfate

Like chloride, this is a naturally occurring nutrient in water. However, it can also be the result of runoff from fertilized farms. Still, the concentration of sulfate must be extremely high before it has a direct effect on the plant and animal life exposed to it. The problem is that sulfates can become acid, which would change the pH level of the water. This would have a large affect on aquatic life (kywater.org).

All our results except for one remained consistent and within the same range of one another. Therefore, we conclude that the spike on Oct. 4, 2004 was the result of human error. Overall, these sulfate levels are not dangerous.

Nitrate as Nitrogen

The presence of nitrates in the water can cause an increase in the growth of algae, and can lower the amount of oxygen available for aquatic life. Again, nitrates are naturally occurring but may be found in higher concentrations due to runoff from fertilized farms (www.geocities.com/Waterose_Test/creek3).

The levels of nitrate as nitrogen in the creek are very high. The highest level the EPA deems safe in drinking water is 10 mg/L. In Rice Creek, the concentration is sometimes twice as high. Only once, on Nov. 8 at Cabot and Millersburg, was the level of nitrate as nitrogen below 10 mg/L. At three of the four sites, the level remained consistent at just over 10 mg/l.

As mentioned earlier, the water from Rice Creek will make its way into our water supply in some way or another. So these high levels of nitrogen are extremely dangerous. It is very difficult to extract nitrogen from the water, it cannot be boiled away. Though this will not affect adults very much, it can be dangerous for elderly people with weaker immune systems. As mentioned earlier, it can also lead to "blue baby" disease, because babies may ingest the nitrates through breast feeding. (http://ianrpubs.unl.edu/water/g1369.htm)

Additional Information:

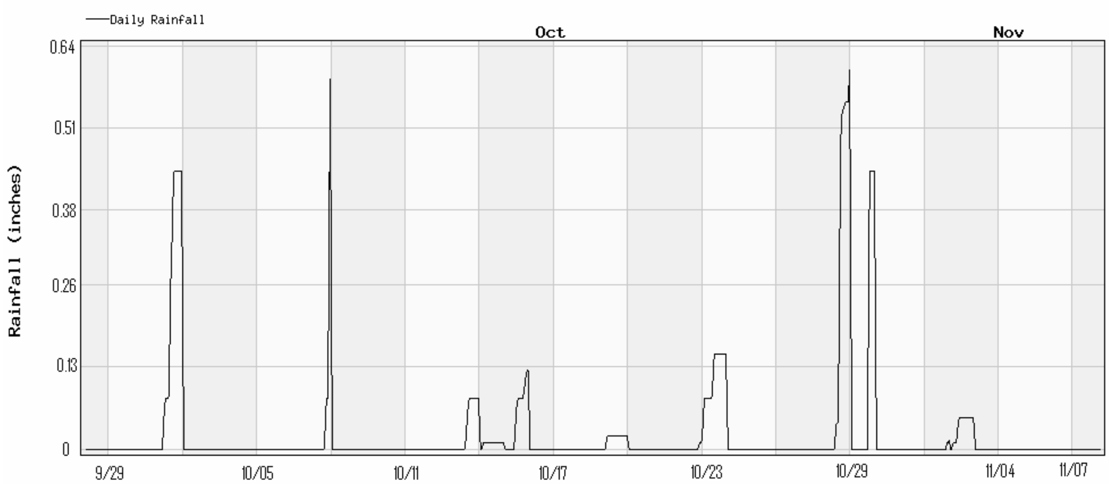
We tested water at a variety of sites, so the factors affecting each vary:

- Railroad- at this site, there were two bridges crossing the creek- a bridge for the railroad and a bridge for cars. The nearest farmland was roughly 75 feet away. Bordering the creek on both sides were small wild lands.
- Decker and 100th St.- this site was beneath a very sturdy concrete bridge. Prairie lands border the creek on both sides. Of the sites we tested, this was the farthest from any farmland.
- Cates and 100th after the tile- the creek here ran through a wooded area. Of the sites we tested, this had the thickest trees. On one side of the creek, after passing through the trees, there was a farmhouse. On the other side, passed the trees, was a prairie. We tested about twenty feet passed the tile.

- Cates and 100th before the tile- at this point, the creek was in a ditch running between the road and the crop fields. We tested about five feet before the tile.
- Cabot and Millersburg- this site also ran between corn fields and the road. This site was even closer to the farmland than when we tested before the tile.

Generally, these are all relatively close to farmland, and runoff from farms is the largest contaminant of Rice Creek. It should also be noted that the only rain immediately preceding testing days was before Oct. 25, 2004. However, there was a larger storm three days before we tested on Oct. 11, 2004 (Figure 10). Also, when we went back to test the last three sites on Nov. 8, 2004, the corn had been harvested completely.

Figure 10- Rainfall, Sept. 29, 2004-Nov. 7, 2004



(Graph created at http://weather.carleton.edu)

Conclusion:

Based on our observations and data, we conclude that the biggest threat to the water quality of Rice Creek is the high presence of nitrates. The presence of nutrients, most importantly nitrates, has increased since the spring of 2003. Though this may indicate an increase in contamination, one must also take into account seasonal differences. We did our testing at the end of the harvest season, after a lot of fertilizer had been applied. In the spring, the only additional pollutants would be the result of the rock salt used in the winter.

It is imperative that the community of Rice County take action in regards to the water quality in Rice Creek. This should include a change of agricultural practices; more specifically, developing an improved method of fertilizer use. Farmers can implement fertilizer in stages throughout the year as opposed to all at once, which is called a split application (Braden, 2000). It is incredibly important that the Best Management Practices suggested in previous studies are employed. To make sure this happens, Rice County and the state of Minnesota should have a meeting discussing ways to decrease the amount of waste that runs off from farms into the Creek. New fertilizers should be tested in order to find one that will result in less nitrate pollution. Newsletters can be distributed to farmers surrounding Rice Creek, informing them and reminding them that the health of Rice Creek is crucial to the people, animals, and farms in the surrounding area. It is also important to stress in these conferences or newsletters that farmers have considerable power in regards to Rice Creek, and that power is attached to a great responsibility. The farmers have an obligation to protect and improve the water quality of Rice Creek. In addition, agents of the State's agricultural department or those authorized from the conference can make personal visits to residences that have a great impact on the health of Rice Creek. The creek is greatly affected by those who live in the area, and it is extremely crucial that the residents understand how much their actions impact the water quality of Rice Creek.

Recommendations for further study:

After analyzing and assessing samples taken from the various points along Rice Creek, we have proposed recommendations that can further the study of Rice Creek. As pervious studies of Rice Creek have suggested, the amount and type of fertilizer used is important. The methods used in disposing and applying fertilizer on agriculture should be taken into account. Due to high levels of nitrogen found in our sample analysis, the investigation of nitrates is crucial. Investigating the agricultural practices of farmers would facilitate the understanding of various elements and their affects on Rice Creek. In addition, the topography of the land should also be taken into account. Investigation on topography stems from the idea that rain fall can erode the Creek banks, and this movement of soil and waste would affect the level of nutrients in the Creek. Rainfall can also carry substances, like salt and other chemicals used for roads, into Rice Creek (Burks, Holmes, Isaacson, Johnson, 2003).

A continuous study of Rice Creek will also be beneficial for those who inhabit or live near the Creek. With continuous study, further details and information can be gathered to better assess and provide recommendations needed in order to keep Rice Creek healthy. A multiyear and seasonal study of Rice Creek can offer variables that may have not been taken into account yet.

If a group decides to continue to monitor Rice Creek, they should read this report and benefit from our suggestions as to how this investigation can be improved. Water samples should be taken from a wider variety of areas. This can help illuminate other factors that affect the high levels of chloride and nitrate found in the Creek. It is also important to take note that many of the measurements taken from the sampling sites may have a degree of human error. Further monitoring would be useful in case our readings were inaccurate. Lastly, more advanced technology can also be used in order to find more accurate information about Rice Creek (Burks, Holmes, Isaacson, Johnson, 2003).

Acknowledgements:

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Additional Web Sites:

http://fenwick.pvt.k12.il.us/Creek/webpage/experimt/chloride/chloride.html

http://ianrpubs.unl.edu/water/g1369.htm

http://kywater.org/ww/ramp/rmso4.htm

http://www.geocities.com/Waterose_Test/creek3.html

http://www.sausalcreek.org/pdf/FOSC_WQMonitoring.pdf