# Water Quality in Western Rice County:
## A Study of Caron, Cedar, French, Hunt, Mazaska, Rice, Roberds, and Shields Lakes


GEOL 120, Dr. Bereket Haileab
Jenny Heathcote, Dustin Yager, Monica Diaz, James Sanna


November 27, 2004

## *Introduction:*

Lakes here in Minnesota are a valuable resource, as well as a key element in the state's system of watersheds. Beyond their ecological significance – as a part of the local ecosystem and as stopovers for migratory waterfowl, to list a few elements – the local lakes attract tourists and summer vacationers that provide a welcome summer boost to the local economy in many rural areas. In addition, as integral parts of any local community, watershed and water supply, polluting and otherwise damaging one lake can lead to much greater and far-reaching consequences for the entire area.

With the world's population growing, we are being faced with several problems in our precious lakes. Some of these problems include foul smell in the water, deformed aquatic life, landscape deterioration, and undrinkable water and are caused by eutrophication, sedimentation, water level reduction, toxic waste pollution, acidification, and a change in the surrounding ecosystem (Rice County). Just 0.007% of the earth's total water is in the form of lakes, while 97.5% is found in the seas. To learn how we can better protect our precious lakes, we need to develop a scientific understanding of their current chemistry and composition, a goal we hope to advance with this report.

The purpose of this study is to determine the water quality and general health of Caron, Cedar, French, Hunt, Mazaska, Roberds, Rice and Shields lakes located in Rice County (Figure 1). These are some of the major lakes in western Rice County Minnesota in the Cannon River watershed. We are continuing a project begun by Carleton Geology students to assess the water quality of the Cannon River watershed over a period of years. In addition to monitoring yearly or seasonal changes in water quality, we are interested in the effects of urbanization as the Twin Cities continue their southerly expansion.

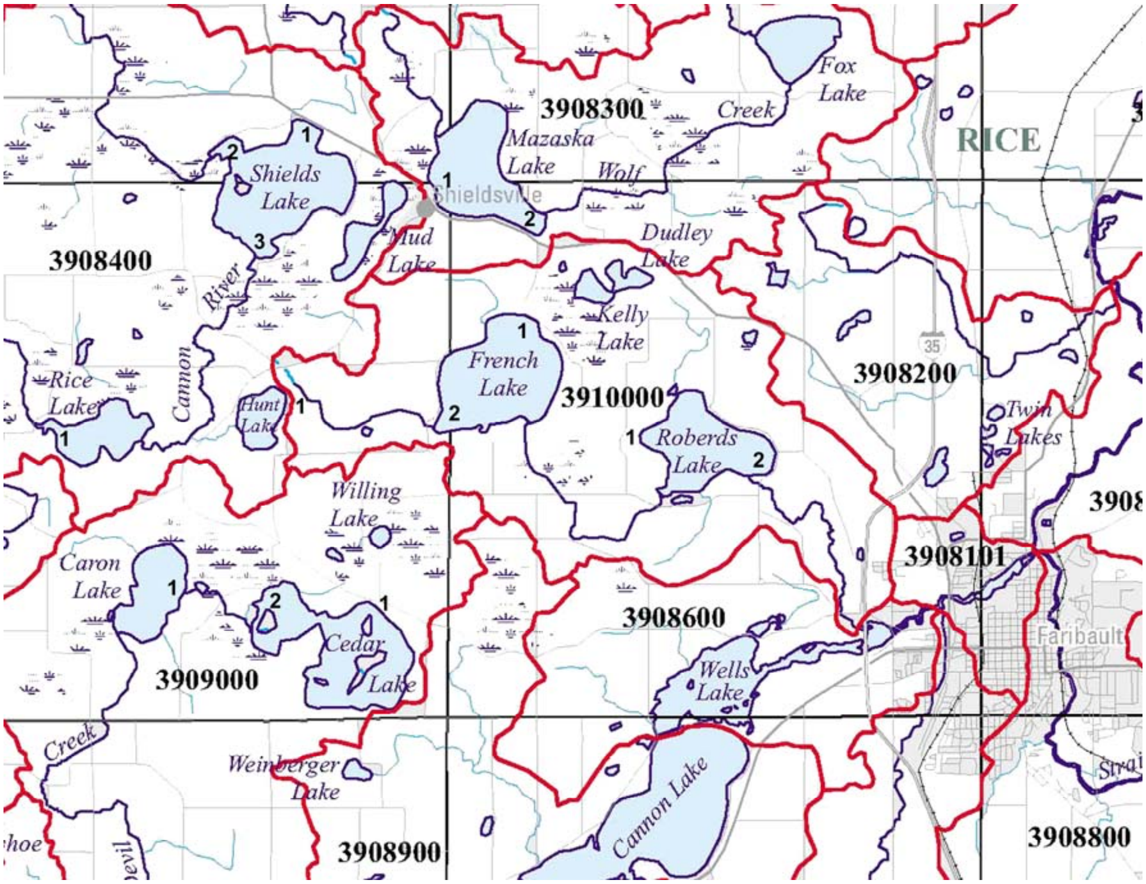

*Figure 1: Location of the eight lakes studied in Rice County. Modified from U.S. Geological Survey.*

## *Methods:*

We collected data from several different Rice County lakes in October 2004. We went to General Shields Lake and Mazaska Lake on October 5th, French Lake on October 12th, Hunt, Rice, Cedar and Caron lakes on October 19th, and Roberds Lake on October 26th. The lakes and the sites we visited are shown in Figure 1. As we did not have a boat, we could only reach the lakes at public access points and the private docks of a few kind residents.

At each site we used a Yellow Springs, Inc. Model 85 meter to measure the temperature, conductivity, dissolved oxygen and salinity of the water just under the surface. We took all of our measurements in shallow water along the shore.

We measured the turbidity of the lake water with a 1.2 m Secchi tube. The Secchi tube is filled with water and slowly drained until a black and white pattern at the bottom of the tube is visible. The height of the water in the tube is the measure of the lake's turbidity. We also collected water and sediment samples from each site to analyze at the lab.

In the lab we used an ion chromatograph and an atomic absorption spectrometer to analyze our samples for calcium, chloride, nitrate, nitrite, sulfate, phosphate, fluorine, and bromide. In the ion chromatograph, ions are separated through ion exchangers, and then changed into highly conductive acid forms. Anion species are determined by their retention times in the exchangers and concentration is measured by peak areas compared to known standards. The results generated give the amounts of the ions detected in mg/L, with an error of ±0.0001 mg/L. The atomic absorption spectrometer atomizes each sample in a flame and measures the light of a wavelength which corresponds to an atomized element. The amount of light absorbed in the flame is proportional to the concentration of the element in the sample (Standard Methods).

## *Previous Works:*

Previous studies of the water quality of these particular lakes in western Rice County have indicated that they are fairly clean and healthy (Carleton 2003, Heiskary 2000). In a study done in the spring of 2003, Carleton geology students determined that Cedar, Roberds, Hunt and Rice Lakes were very clean and suitable for agricultural use, drinking water, and wildlife use, according to the Environmental Protection Agency (EPA) standards (Table 2). The Minnesota Pollution Control Agency also published a status and trends report for some lakes in Rice County (Heiskary, 2000) which reached some conflicting conclusions with the Carleton report (Table 1). Both sources of data will provide a useful comparison for past trends, although we are sampling four lakes which neither report examined. In addition to contributing to the data set, we will compare our results to samples from Kelly Dudley Lake (a "clean" lake) and the Cannon River (reliably "dirty" water) to determine their relative status.

*Table 1: Comparison data from Heiskary 2000*

| | Cedar | Roberds |
|---|---|---|
| Total phosphorous (µg/L) | 105 | 281 |
| Total chlor-a (µg/L^3) | 84 | 123 |
| Secchi (ft) | 3 | 1.3 |
| Kjeldahl Nitrogen (mg/l) | 1.7 | 2.46 |
| Alkalinity (mg/l) | 128 | 117 |
| Conductivity (µmhos/cm) | 250 | 290 |

## *Results:*

The water in our lakes follows three paths to enter the Cannon River, and our results are grouped roughly according to these paths (Figure 1). Measurements from Mazaska progress to Shields, Hunt and Rice Lakes. Water from Cedar Lake flows into Caron Lake before entering the Cannon, and water from French Lake must go through Roberds Lake. Generally, the lakes farther down the path have higher concentrations of dissolved ions and less dissolved oxygen.

Conductivity (Figure 2) gives a quick determination of minerals. It is a measure of the electric current in the water carried by ionized substances. Raw and potable waters normally register about 50-500 micromhos/cm. Almost daily variation of solids

*Table 2: Data based on Carleton 2003 charts*

| Conductivity (μs) | Date 1 | Date 2 | Date 3 | Date 4 | Mean |
|---|---|---|---|---|---|
| Roberds | 305 | 335 | 310 | 305 | 313.75 |
| Cedar | 240 | 210 | 220 | | 223.33 |
| Rice | 235 | 220 | 220 | | 225.00 |
| Hunt | 285 | 275 | 275 | | 278.33 |
| | | | | | |
| Turbidity (cm) | | | | | |
| Roberds | 100 | 123 | 123 | 123 | 117.25 |
| Cedar | 123 | 100 | 83 | | 102.00 |
| Rice | 31 | 24 | 43 | | 32.67 |
| Hunt | 61 | 123 | 95 | | 93.00 |
| | | | | | |
| Chloride ion (ppm) | | | | | |
| Roberds | 0.055 | 0 | 0.09 | 0.16 | 0.08 |
| Cedar | 0 | 0 | | | 0.00 |
| Rice | 0 | 0.07 | 0.05 | | 0.04 |
| Hunt | 0 | 0 | 0.09 | | 0.03 |
| | | | | | |
| Sulfate ion (ppm) | | | | | |
| Roberds | 6 | 6 | 6 | 6 | 6.00 |
| Cedar | 0 | 3 | 3 | | 2.00 |
| Rice | 15 | 17.5 | 16 | | 16.17 |
| Hunt | 15 | 20 | 17.5 | | 17.50 |
| | | | | | |
| Nitrate (ppm) | | | | | |
| Roberds | 0.09 | 0.1 | 0.08 | 0.12 | 0.10 |
| Cedar | 0.04 | 0 | 0.07 | | 0.04 |
| Rice | 0.08 | 0.11 | 0.07 | | 0.09 |
| Hunt | 0.09 | 0.59 | 0.43 | | 0.37 |

concentration is expected (De Zuane). The standard test is conducted at 25º C. Here the figures are adjusted by the Yellow Springs instrument.

Turbidity (Figure 3) is a measure of the cloudiness of water. The suspended matter causing turbidity is expected to be clay, silt, nonliving organic particulates, plankton, and other microscopic organisms in additions to suspended organic or inorganic matter (De Zuane, 2000). Higher turbidity levels can often indicate higher levels of disease-causing microorganisms (EPA). Since this measure indicates the height of a

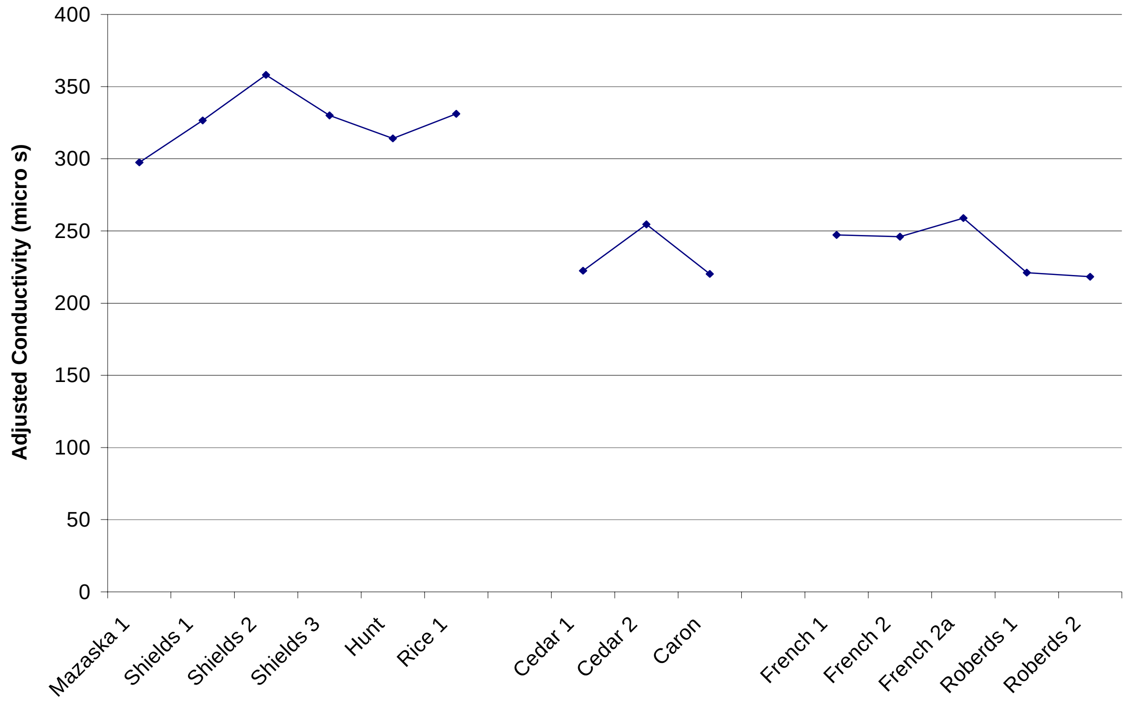


*Figure 2: Adjusted Conductivity*

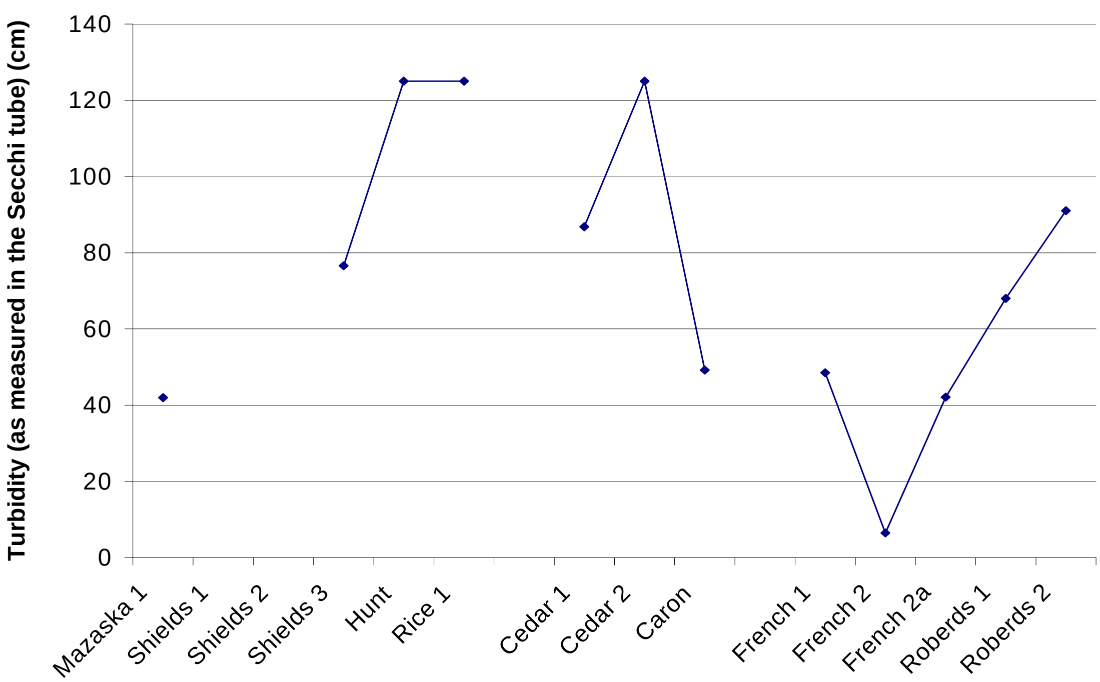


*Figure 3: Turbidity*

column of water which observers can see through, larger numbers indicate that the water is cleaner. The main cause of turbid water in this case is soil runoff.

Temperature measurements are provided in Table 3. Since we tested water over four weeks in the fall, the trend and variation is most likely indicative of October weather and not of significance to water quality measurements.

We measured the salinity to be 0.1 or 0.2 ppt at every lake (Table 3). Salinity measures salty impurities in the lake.

The dissolved oxygen content of the lakes we sampled is shown in Table 3. Oxygen is critical for the wildlife and plants growing in the lake and can be decreased by algal growth associated with high nitrogen and phosphate levels.

Calcium concentration measurements are shown in Figure 4. Calcium ranges in untreated waters from 0 to several hundred mg/L. Up to 1800mg/L is harmless, although abundant calcium may contribute to bladder and kidney stones. The World Health Organization (1963) used 75 mg/L as a maximal acceptable limit and 200 mg/L as an excessive limit, but did not renew these recommendations in 1984. The European Community uses 100 mg/L and the U.S. does not have a standard (De Zuane, 117-119).

Figures 5 and 6 show different ions present in the lake water. We found detectable quantities of chloride and sulfate in most of the lakes, and nitrate and nitrite in some of the lakes. We also analyzed our samples for fluorine, bromide, and phosphate, but the ion chromatograph did not detect any of these ions in our samples.

## *Discussion:*

We must begin by comparing our data to previous studies of water quality in Kelly Dudley Lake and Cannon River taken in 2003. Kelly Dudley was relatively clean

| Table 3: 2004 data from Yellow Springs instrument | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample | date | Conductivity (ms) | Adjusted Conductivity | Turbidity (cm) | Temp °C | Dissolved O (mg/L) | (%) | salinity (ppt) | Depth (cm) |
| Mazaska 2 | 10/5 | 239.9 | 295.8 | 112 | 15.1 | 6.78 | 67.1 | 0.1 | 54 |
| Mazaska 1 | 10/5 | 241.1 | 297.5 | 42 | 15.1 | 6.52 | 62 | 0.1 | 28 |
| Shields 1 | 10/5 | 261.6 | 326.5 | N/A | 14.7 | 9.4 | 93 | 0.2 | N/A |
| Shields 2 | 10/5 | 271.7 | 358.2 | N/A | 12.1 | 5.07 | 48.2 | 0.2 | 0.3 |
| Shields 3 | 10/5 | 260 | 330.1 | 76.6 | 13.9 | 8.35 | 80.2 | 0.2 | 0.15 |
| Hunt | 10/19 | 220.1 | 314.1 | 125 | 9.3 | 9.3 | 83.4 | 0.2 | 40 |
| Rice 1 | 10/19 | 222.7 | 331.2 | 125 | 7.7 | 9.32 | 78.7 | 0.2 | 48 |
| Cedar 1 | 10/19 | 156.2 | 222.5 | 86.8 | 9.6 | 10.19 | 86.7 | 0.1 | 110 |
| Cedar 2 | 10/19 | 171.8 | 254.6 | 125 | 7.9 | 9.86 | 87.2 | 0.1 | 30 |
| Caron | 10/19 | 329.5 | 220.3 | 49.2 | 7.7 | 5.66 | 15.9 | 0.2 | 15 |
| French 1 | 10/12 | 207.4 | 247.3 | 48.5 | 16.7 | 11.73 | 124.2 | 0.1 | 65 |
| French 2 | 10/12 | 212.3 | 246.1 | 6.5 | 17.9 | 12.34 | 126 | 0.1 | 0.87 |
| French 2a | 10/12 | 208.7 | 258.9 | 42.1 | 14.9 | 6.93 | 79 | 0.1 | 0.65 |
| Roberds 1 | 10/26 | 306.7 | 221.1 | 68 | 10.4 | N/A | N/A | 0.1 | 60 |
| Roberds 2 | 10/26 | 303.7 | 218.3 | 91 | 10.4 | N/A | N/A | 0.1 | 125 |

as opposed to Cannon River, which contained high concentrations of many pollutants.

Chloride and sulfate concentrations in Kelly Dudley were 13.36 and 2.34 mg/L, respectively. When compared to Kelly Dudley, which was determined as the cleanest lake of those tested by Carleton geology students in 2003, Cedar Lake contained comparable amounts of sulfate and chloride. Our other water samples showed somewhat larger amounts of sulfate, and similar amounts of chloride (Table 4). While chloride and sulfate were the only minerals found in Kelly Dudley, some of our lakes also contained nitrite and nitrate. Those containing nitrate were Mazaska, Shields, Hunt and Caron. We only found nitrite in Mazaska and Shields (Table 4).

Chloride and sulfate concentrations in the Cannon River were 75.05 mg/L and 60.81 mg/L, respectively. In addition, the Cannon River also contained 0.26 mg/L of fluoride, 1.24 mg/L of phosphate, 0.42 mg/L of nitrite, and 7.50 mg/L of nitrate.

Compared to data collected from our lakes, the amount of chloride collected in the Cannon River was six to seven times greater. The amount of sulfate in the Cannon River was on average five or six times greater than the sulfate contained in our lakes. We detected no fluoride or phosphate in any samples from our lakes. We only found small amounts of nitrite in two of our lakes, Mazaska and Shields, which were similar to the amounts found in the Cannon River. Quantities of nitrate, we found, were significantly higher in the Cannon River as well.

*Table 4: 2004 data from IC and AA*

| Sample | Date | Calcium (mg/L) | Chloride (mg/L) | Sulfate (mg/L) | Nitrate (mg/L) | Nitrite (mg/L) |
|---|---|---|---|---|---|---|
| Mazaska | 10/5 | 9 | 15.14 | 7.48 | 1.50 | 0 |
| Mazaska | 10/5 | 9 | 15.26 | 7.42 | 1.39 | 0.15 |
| Shields | 10/5 | 6 | 11.19 | 14.28 | 0.80 | 0 |
| Shields | 10/5 | 9 | 9.26 | 11.18 | 0 | 0 |
| Shields | 10/5 | 8 | 11.72 | 14.47 | 2.56 | 0.30 |
| Hunt | 10/19 | 10 | 17.76 | 11.47 | 0.52 | 0 |
| Rice | 10/19 | 11 | | | | |
| | | | | | | |
| Cedar | 10/19 | 7 | 11.67 | 3.6 | 0 | 0 |
| Cedar 2 | 10/19 | 8 | 13.49 | 2.60 | 0 | 0 |
| Caron | 10/19 | 13 | 9.87 | 7.62 | 1.26 | 0 |
| | | | | | | |
| French | 10/12 | 9 | 8.80 | 10.27 | 0 | 0 |
| French | 10/12 | 10 | 8.74 | 10.41 | 0 | 0 |
| French | 10/12 | | 8.50 | 13.52 | 0 | 0 |
| Roberds | 10/26 | 11 | 14.69 | 8.97 | 0 | 0 |
| Roberds | 10/26 | 11 | 14.01 | 9.06 | 0 | 0 |

Because the chemical composition of our lakes is similar to Kelly Dudley and not to the Cannon, we conclude that our lakes are relatively clean. We must also note that several of our figures indicate an increase in ion concentration from the mean Carleton 2003 data (Table 2). Whereas chloride's highest occurrence averaged to 0.08 mg/L in

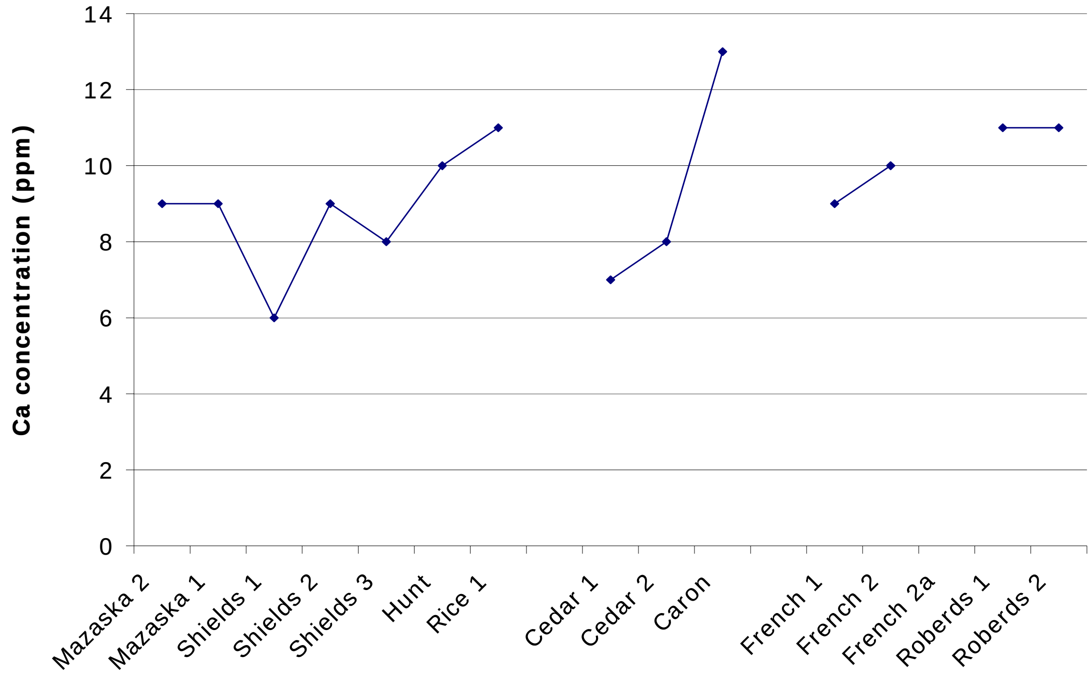


*Figure 4: Calcium Concentration*

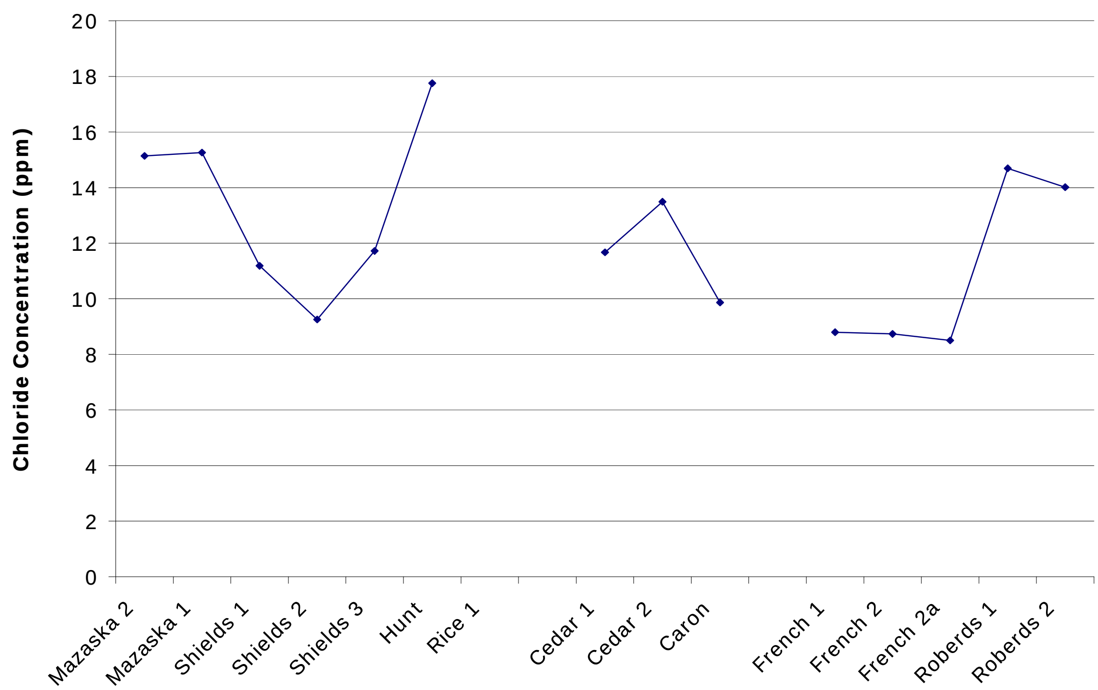


*Figure 5: Chloride Ion Concentration*

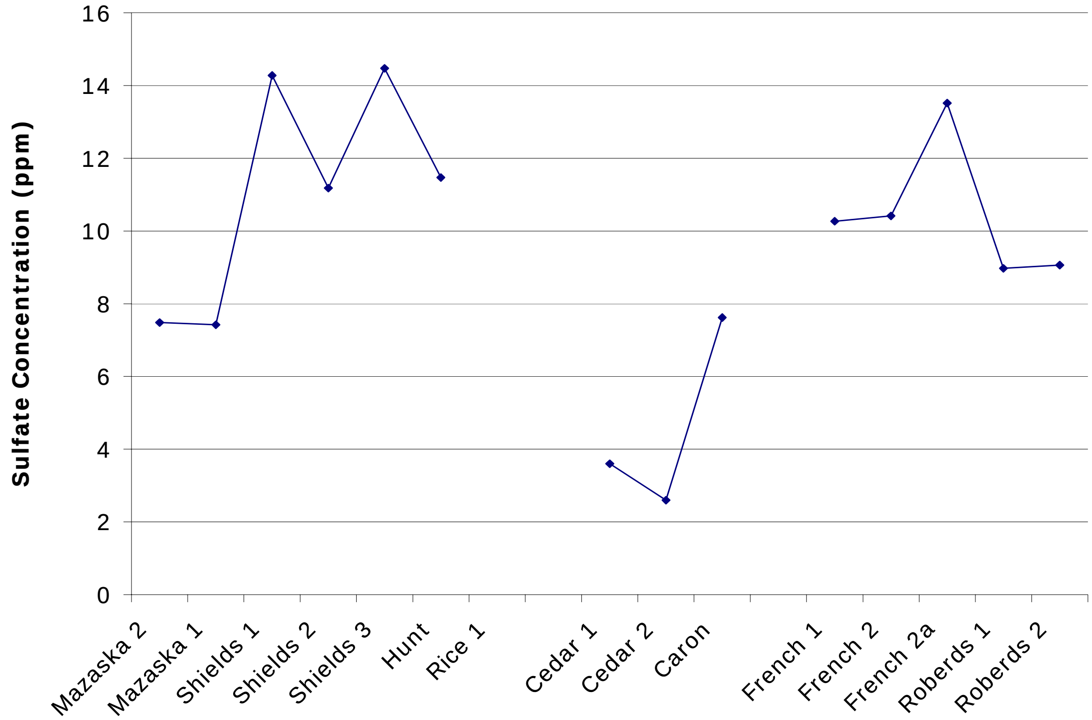


*Figure 6: Sulfate Ion Concentration*

2003, our average is closer to 10 mg/L and chloride in Roberds Lake is as high as 14 mg/L. Roberds Lake also has a higher incidence of sulfate, up to 9 mg/L from 6 mg/L in 2003. However, the other lake from which we have comparison data, Hunt Lake, has seen a decrease of about 6 mg/L. Since the sulfate data varies from 2.60 mg/L to 14.47 mg/L this year and from a mean of 2 mg/L to 17.5 mg/L in 2003, the differences may be highly dependent on the location of each lake and their respective changes in drainage rather than a regional trend. Nitrate is also higher in the data we collected than in the Carleton 2003 data. While our highest concentration is in Shields Lake with 2.56 mg/L of nitrate, we do not have comparison data for this lake. Hunt Lake sees an increase of roughly 0.15 mg/L and since the samples we collected generally had higher concentrations of nitrate, it may be safe to conclude that nitrate concentration is on the rise for some lakes in this area. A decrease, however, is seen in Roberds Lake, from 0.10

mg/L in 2003, to 0.00 mg/L this year. Such a minimal amount may not be significant and could even be attributed to an error in analysis. Since we lack a good series of data, none of these trends can be said to be significant at this point.

While we are concerned about the health of the lake, we are also interested in these results because these lakes are connected to aquifers from which local municipalities draw their water. While some of the seven chemicals we looked for can have negative effects on the lake ecosystem, others have associated health risks.

Of the chemicals we tested for, nitrate and fluoride are subject to federal standards. Nitrate is required to be less than 10 mg/L. Infants exposed to water containing more nitrate may become seriously ill or die. Nitrate is transformed into nitrite in the human body and can be carcinogenic, especially in babies. Nitrite oxidizes quickly, so it is not usually found in surface water. Lakes usually contain less than 2 mg/L of nitrite, ground water up to 20 mg/L and much more in shallow aquifers. Nitrate is a fertilizer, a preservative, and is used in chemical industry. Sources of this nitrogen include fertilizer, sewage, and erosion from natural deposits (De Zuane, 87-90). Fluoride can strengthen one's teeth in doses up to 3 mg/L, but it starts causing asymptomatic osteosclerosis at 4 mg/L. In doses from 10-40 mg/L it causes crippling fluorosis. The .25 mg/L in the Cannon River is most likely naturally occurring and causes no harm in this trace amount (De Zuane, 74-79).

National secondary drinking water regulations are non-enforceable guidelines for contaminants that may have cosmetic and aesthetic effects. These regulations recommend less than 250 mg/L of both sulfate and chloride. Sulfates are related to mining and industrial wastes and it is produced as a byproduct of fossil fuel combustion.

Detergents also add sulfate to sewage. Consumption is safe up to 500 mg/L, but the taste threshold is about 200 mg/L. After a period of diarrhea and dehydration, doses up to 3000 have been tolerated (De Zuane, 107-110). Usually chloride contamination of under 10 mg/L is expected. Higher rates come from salts used for snow and ice removal in nearby areas. Industrial effluents and sewage can also be sources. Concentrations are generally detected by taste starting at 500 to 800 mg/L. The limit for consumption is set at 250 mg/L, but it is not related to disease (De Zuane, 120-121).

High levels of nitrogen and phosphate in the water can disrupt water ecosystem. Ecosystems flourish when nutrients are kept in balance and can sustain a variety of species. An abundance of either chemical results in increased algal growth (De Zuane, 132-134). Disproportionate growth of algae deprives others species of other nutrients (especially oxygen) needed for survival. This eutrophication can cause dead zones in lakes and parts of the oceans.

Many of the chemical concentrations we are finding are occurring in greater than natural amounts, suggesting some outside influence. Figure 7 shows substantial tracts of farmland surrounding the lakes we surveyed. The Rice County Board of Commissioners' Water Management Plan also shows numerous feedlots in the area we studied (Rice County Board, 81-82). Given the high amounts of chemical and natural fertilizers most farmers employ today, and the high nutrient content of feedlot runoff, we were surprised that we did not find more dramatic evidence of the nearby agricultural land use. The key seems to be buffer areas which provide a substantial barrier to pollutants and runoff seeking to enter surface waters by slowing water runoff and trapping sediments and other harmful contaminants and pathogens (Rice County Board, pp. 79-80). Rice County has

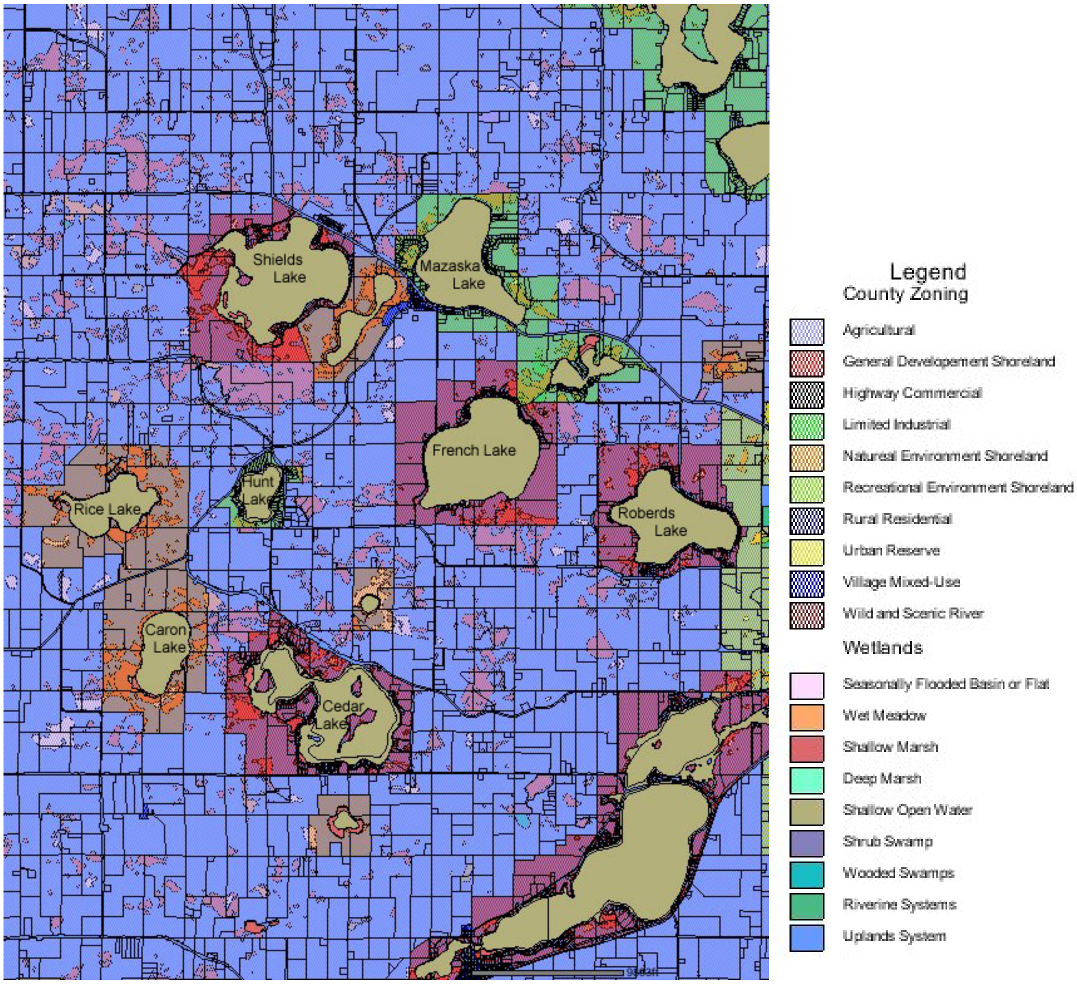

*Figure 7: Land use and zoning in field area. Modified after Promap.*

also set up a series of regulations and standards for land management and pollutant control. Since 1992, Rice County has been very active in educating its residents about the dangers of surface water contamination, soil erosion and runoff, and what individuals can do to help minimize their impacts. Further research could be done to determine the extent of these programs and their impact on lake water quality.

## *Conclusion:*

Based on our data, we believe the lakes we tested to be generally healthy. Chemical analysis do not show advanced eutrophication or pollution, and indicate that the water could be made drinkable with little purification. Local aquifers probably get few contaminants from these lakes, based on our data. We recommend more research and support many of the recommendations in the Heiskary report. Future research should carefully sample similar lakes, and analyze them to look for trends as the Twin Cities expand, and Faribault, Northfield and outlying areas become more developed.

*Acknowledgements:*

We wish to thank our colleagues Erin, Susan, Pat H., and Caleb for doing our calcium analysis. Our thanks to the kind citizens of Rice County who let us use their property to access various lakes. We enjoyed our conversations with them. Thank you, Carleton College, for providing financial and material support to make this study possible. This project would not have been possible without the guidance of Professor Haileab and our teaching assistances, Jon and Colin. We thank the three of them as well.

# *References*


Carleton College Geology students. "Study of 5 Rice County Lakes." Carleton College, 2003.

Haileab, Bereket. Personal correspondance, fall 2004.

Heiskary, Steve. "Status and Trend Monitoring Report for Rice County, Minnesota." Minnesota Pollution Control Agency, 2000.

Minnesota Pollution Control Agency. “A Citizen’s Guide to Lake Protection.” Available online: http://www.pca.state.mn.us/water/lakeprotection.html

Promap. “Rice County, MN Real Estate Data and GIS”, available online: http://rice.promap.com/pmc/

Rice County Board of Commissioners. “2003 Rice County Water Resource Management Plan”.

Rice County Department of Planning and Zoning. “Zoning and Subdivision Ordinance.” available online: http://www.co.rice.mn.us/planning/Zoning%20Ordinance%20Web%20Link%20Page1.htm

"Standard Methods", 17th ed.

United States Environmental Protection Agency. “List of Drinking Water Contaminants & MCLs” available online: http://www.epa.gov/safewater/mcl.html#mcls.

United States Geological Survey and Minnesota Department of Transportation. “Open file report 99-472: Streams, Subbasins and Gaging Stations in the Cannon River Basin.”

De Zuane, John. “Handbook of Drinking Water Quality.” Van Nostrand Reinhold New York. 1990.