Geomorphology and Watershed Studies of the Cannon River and Its Tributaries: Wolf Creek, Rice Creek and Heath Creek

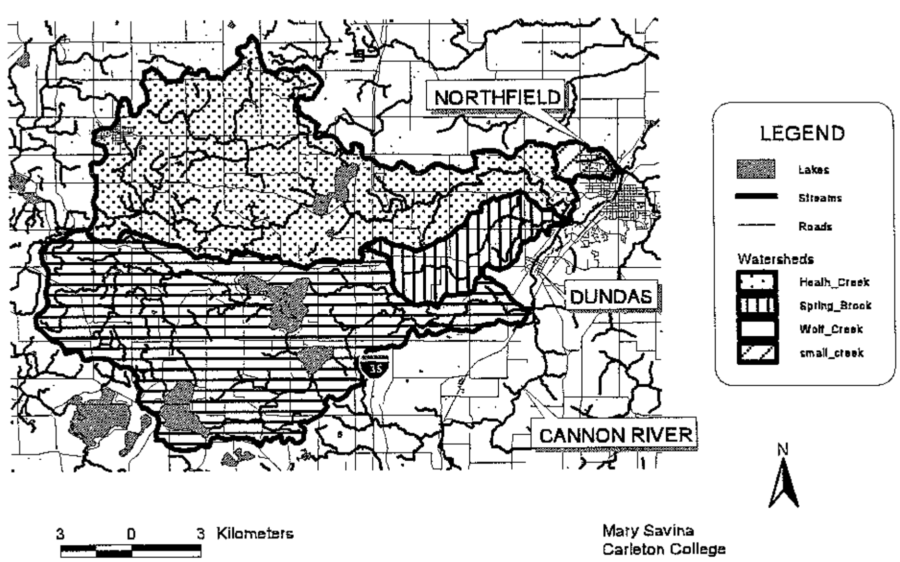
By Mary E. Savina, Department of Geology, Carleton College
Thomas Gardner, Department of Geosciences, Trinity University
Bereket Haileab, Department of Geology, Carleton College

INTRODUCTION AND CONTEXT

The Minnesota 2000 project focused on three tributaries of the Cannon River near Northfield, MN (figure 1). Students on this project worked in three groups to research the geomorphology, hydrology and water quality of three tributaries to the Cannon River: lower Heath Creek (lower catchment area 27.8 km^2 of a total basin area of 104km^2), lower Wolf Creek (22.2 km^2 of 107 km^2 total) and Rice Creek (also known as Spring Brook Creek; 17.4 km^2). Students walked and mapped reaches of the creeks; measured cross-section shape and discharge at several locations (monumenting them for later repeat measurements); sampled water for nutrient, coliform and cation analysis; installed and monitored continuous recording sites for stage, temperature and conductivity; measured changes over time in riparian buffer width using old air photos; and conducted a general survey of invertebrate fauna.

FIGURE 1

Minnesota Keck 2000 Study Area



The Cannon is one of only a few rivers in Minnesota designated by the state as wild and scenic. It is a popular canoeing and fishing river and a major tributary of the Upper Mississippi. Water quality and use of the Cannon River are threatened by pollution, especially non-point-source pollution, from agriculture and development. The Minnesota Pollution Control Agency has designated two Cannon River tributaries and the lower reaches of the Cannon itself as impaired waters (per section 303(d) Clean Water Act) because they do not meet the CWA standards for their intended uses (MPCA, 1999). Our results suggest that the list of impaired tributaries is not complete.

Past studies of water quality near Northfield have focused on lakes (Heiskary, 2000) and on Rice Creek, a cold-water trout stream (unpublished studies, Cannon River Watershed Partnership). However, little previous work has been done on the streams themselves. Sediment, especially suspended sediment, has been identified as one of the major pollutants of the Cannon system. The others are coliform bacteria and nutrients such as phosphates and nitrates, both associated with residential developments (septic and sewer systems) and agriculture, and sodium and chloride, associated with road de-icing. There is some additional contamination with organic chemicals, especially those used as herbicides (Markus, 1998;

Zischke and Robbins, 1998). Among the nutrients, phosphate (and secondarily nitrate) are of most concern locally as the presumed cause of eutrophication of lakes and streams while nitrate (and nitrite and ammonium) is the nutrient implicated in the hypoxia of the Gulf of Mexico, the ultimate sink for these streams (Heiskary, 2000; CAST, 1999; Ferber, 2001).

Land use in the study area is largely agricultural, mainly in soybean-corn rotation. Many fields are drained to the watercourses through tiles and some sections of the streams are ditched. Animal agriculture (cattle, dairy, swine, poultry, bison, horses) is also common with 274 registered animal facilities in the three watersheds ("animal unit" numbers at individual facilities range from zero to 1892). We observed a range of buffers (and lack of buffers) between agricultural areas and the creeks. There is also some existing residential development, notably in the lower Heath Creek basin. Because of their proximity to the cities of Northfield and Dundas, the lower parts of the Heath Creek and Rice Creek basins face development pressures. These include proposed bridge crossings of the Cannon River near the mouth of Heath Creek and of Heath Creek itself and a large-scale development proposal that includes residential housing, commercial development and a golf course. These areas, though undeveloped, are currently zoned industrial and will probably change to residential, with revisions of the comprehensive plans of both the City of Northfield and of Rice County in progress. We hope that our project will offer data on the sensitivity of the streams and basins and suggestions on how to protect them in the face of development proposals.

Bedrock in this region consists of Ordovician dolomite, the Prairie du Chien formation, which crops out in the lower reaches of all three basins. The bedrock is covered by calcareous glacial deposits which range in texture from coarse-grained outwash to mixed, sandy till.

PROJECT GOALS

The main scientific objectives for this project included establishing baseline geomorphic and environmental conditions for the three tributaries so that their status can be monitored in the future. We attempted to answer questions such as:

- What is the source of the surface water that flows through these creeks? How much water comes from lakes, surficial deposit aquifers, bedrock springs (and from which units) and how much from surface runoff during storms?
- What are the sources of the sediment transported by the streams and what is the sediment distribution along the stream channel?
- Where are the "hot spots" for pollution of water and sediment?
- What are the dimensions of measured cross-sections and what bank conditions prevail at this time?
- What happens to these creeks during severe summer storms?
- What is the "health" of these stream systems?
- How should the streams and watersheds be protected from agricultural runoff and sediment, from roads and from possible suburban development?

METHODS

Students used standard geomorphological methods to survey cross-sections and determine stream discharge. Table 1 describes the instrumental methods for water quality, stream velocity, and other parameters.

Table 1: Methods

Method	Units, Sensitivity	Instrument
Salinity	ppt	YSI130 SCT meter
Conductivity	µs = microsiemens	YSI130 SCT meter
Temperature	Tenths of degrees, C	YSI130 SCT meter
Conductivity (datalogger)	± 10%	Campbell 247 temp/conduc probe
Temperature (datalogger)	Degrees C, ± 0.02 degrees	Campbell 247temp/conduc probe
Stage	psi	Druck pressure transducer
Current velocity	M/s, ± 0.01	Marsh-McBirney current meter
Location		Trimble GeoExplorer II
pH	± 0.02 - ± 0.05	Orion Research SA250 pH meter
Phosphate	mg/l ± 0.05	Hach DR890 colorimeter –

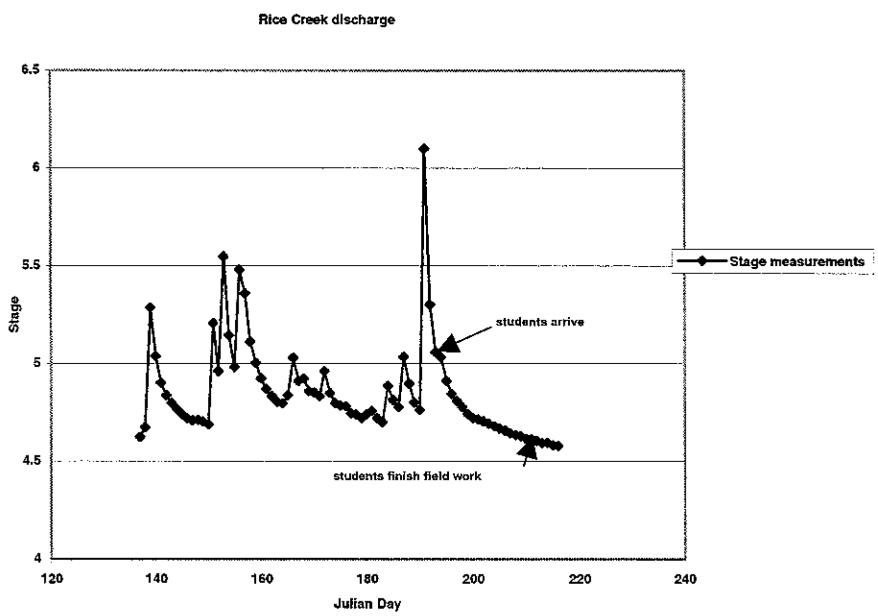
		PhosVer 3 (8048)
Nitrate	mg/l ± 0.05	Hach DR890 - High Range Cadmium Reduction (8309)
Nitrite	mg/l ± 0.05	Hach DR890 - High Range ferrous sulfate (8153)
Cations (Ca, K, Na, Fe, Pb)	mg/l ± 1.0	Perkin-Elmer Atomic Absorption Spectrophotometer
Fecal Coliform	1/10 and 1/100 dilutions	dilutions were filtered onto gridded 0.45 micron filter paper, placed on a growth medium and incubated for 24 hours at 98 deg. F and counted. A yes/no test using 2 mL of each sample in 2 mL of Laryl Tryptose Broth used as a backup method.

Water samples (cations and nutrients) for each group were collected and tested on a single day; all three sets were taken within four days of each other during a week when there was no precipitation. Chemical tests were chosen to give a variety of basic measurements, in part seeking the best and simplest ones to monitor in the future and in part replicating ones of public interest that had been measured in other systems (e.g. nutrients, coliform).The project goals included determining which methods were useful for streams in this area: we concluded that AA measurements of cations were not particularly helpful, we need to add some parameters to the testing (such as ammonium), and we need to use techniques to measure higher concentrations of nutrients, especially phosphate.

PROJECT SYNOPSIS

After a few days of group reconnaissance and introduction to field, lab and computer methods, students then split into three teams, one for each basin. The Rice Creek group studied their entire basin and

Figure 2



stream length, whereas the Heath Creek and Wolf Creek groups focused on the sections of streams and basins downstream of Union Lake and Circle Lake, respectively (fig. 1).

The geologic problems we tackled were somewhat limited by the discharge of the creeks. Thanks to a MN Department of Natural Resources datalogger on Rice Creek, we have a record showing the discharge variations during the project (Figure 2). All sampling and field work took place on a falling stage; rainfall during our study period did not affect stage though some groups saw local effects.

PRELIMINARY GENERAL CONCLUSIONS

The three creeks studied in 2000 were chosen because they are adjacent basins. They proved to be different from each other in more ways than we had anticipated:

- Rice Creek, the cold-water trout stream, is indeed consistently colder than the other two creeks.
- Rice Creek is channelized (a section is a County Ditch) and managed for agriculture. Much of the water that may originally have entered the stream through springs now enters through agricultural tile drains. The hydrograph (fig. 2) shows a flashy response to precipitation.
- Despite apparent geographic similarities (large watersheds including large lakes which feed the lower parts of the creeks), Heath Creek and Wolf Creek differ greatly in water quality. Some, but not all, of these differences can be attributed to water quality differences at the source lakes.
- Discharge in Wolf Creek doubles between Circle Lake and the confluence with the Cannon, but water quality does not improve.
- Although there are some discrete springs, much water apparently enters the streams through small seep sources in the lower reaches of the streams.
- Longitudinal changes in water quality in Heath Creek may be related to geomorphology (location of wetlands below Union Lake) and land use.
- Wooded riparian buffers are much more extensive now than at the time of the first aerial photo survey in 1938.
- All three creeks are impaired waters.

SURPRISES AND FUTURE WORK

Students collected data that provided some surprises about these creeks and watersheds; these will be good fodder for future work here at Carleton and perhaps for future Keck projects. In the geochemical realm, some pH values were much higher than we thought they would be; they are perhaps related to diurnal photosynthetic activity (see Wolf Creek abstract) but are within the range of pH measured on some Rice County Lakes (Heiskary, 2000). Some nitrite values seem unusually high: a future study could look closely at the nitrogen cycle dynamics in these systems by adding measurements of ammonium. We were surprised at the extent of manipulation of Rice Creek by ditches and tiles and amazed at the survival of the hardy brook trout. Future research could also look more closely at sediment accumulation and movement in the stream channels, especially along Rice Creek and Heath Creek, where measurements and anecdotal evidence from residents show stream depth decreasing with time. We were also surprised at the changes in landscape, especially riparian buffers, shown by changes between 1938 aerial photography, 1995 photography and our own observations.

We found that we need to search for spring locations at another time of the year with less vegetation. Apparently many small seeps such as were noted in lower Wolf Creeks and Rice Creeks contribute to the base flow rather than individual large springs. Changes in temperature and conductivity of stream water were also not enough to help locate spring sources, in part due to the great variability of properties of groundwater aquifers (MPCA, March 1998). In addition, we need more work on the relationships between wetlands and water quality in these basins.

Finally, the Keck 2000 Minnesota project helped energize lake and stream monitoring efforts, especially on Union Lake (Heath Creek basin) but elsewhere as well. Establishing and assisting these citizen monitoring efforts is a long-term project for Carleton and the Cannon River Watershed Partnership.

ACKNOWLEDGEMENTS

Many landowners who allowed access through their property; Lisa Lukis and Dale Oolman, Cannon River Watershed Partnership; Tim Cowdery, USGS, Mounds View, MN., Chris Robbins and Molly Woehrlin; Matt Drewitz, Trent McCorkell and Jeff Blomquist, Rice County planning and zoning; Carleton College geology and biology departments, especially Tim Vick and Gary Wagenbach and his students Martina Muehlegger and Jon Kenning; Doug Foxgrover, Carleton Physics Department; Corey Hanson, Minnesota Department of Natural Resources for access to Rice Creek datalogger results, Sean Fox and Paula Lackie, Carleton Information Technology Services.

REFERENCES CITED

Council for Agricultural Science and Technology (CAST), 1999, Gulf of Mexico Hypoxia: Land and Sea Interactions: CAST R134, 44 pp.

Ferber, Dan, 2001, Keeping the Stygian Waters at Bay: Science, v. 291, p. 968-973.

Markus, Howard, 1998, Fecal Coliform in the Cannon River Watershed, ***in*** Cannon River Watershed Partnership, Research and Monitoring in the Cannon River Watershed.

Minnesota Pollution Control Agency, June 1999, Final 1998 CWA Section 303(d) list: http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf

Minnesota Pollution Control Agency, March 1998, Baseline Water Quality of Minnesota's principal aquifers, 295 p. http://www.pca.state.mn.us/water/groundwater/gwmap/gwbaselinerpt.html

Heiskary, Stephen, 2000, Minnesota Pollution Control Agency, 1999, Status and Trend Monitoring Summary for Rice County Minnesota (Lakes: Cannon, Wells, Kelly, Dudley, Circle, Cedar and Roberds), 40 p. http://www.pca.state.mn.us/water/pubs/lar-riceco99.pdf

MPCA, 1998, MPCA data for the Straight and Cannon Rivers and Prairie Creek, ***in*** Cannon River Watershed Partnership, Research and Monitoring in the Cannon River Watershed.

Patterson, Carrie J. and Howard C. Hobbs, 1995, Surficial Geology, Rice County Geological Atlas: Minnesota Geological Survey, County Atlas Series, Atlas C-9, Part A, plate 3.

Stark, James R., et al., 1996, Water-Quality Assessment of Part of the Upper Mississippi River Basin, Minnesota and Wisconsin – Environmental Setting and Study Design: USGS Water-Resources Investigations Report 96-4098, 62 p.

Zischke, James and Chris Robbins, 1998, Assessment of Water Quality in Streams of the Cannon River, ***in*** Cannon River Watershed Partnership, Research and Monitoring in the Cannon River Watershed.

HYDROLOGY AND GEOCHEMISTRY OF HEATH CREEK, RICE COUNTY, MINNESOTA

SARAH BARGER
Department of Geoscience, Williams College
Faculty Sponsor: David Dethier, Williams College

MARY CHEN
Geology Department, Amherst College
Faculty Sponsor: Anna Martini, Amherst College

EPIFANIO FIGUEROA
Department of Geosciences, Franklin and Marshall College
Faculty Sponsor: Dorothy Merritts, Franklin and Marshall College

BILAL HARRIS
Dept.of Geology and Geography, Georgia Southern University
Faculty Sponsor: James Reichard, Georgia Southern University

BENTLEY KNIGHT
Department of Geology, Washington and Lee University
Faculty Sponsor: David Harbor, Washington and Lee University

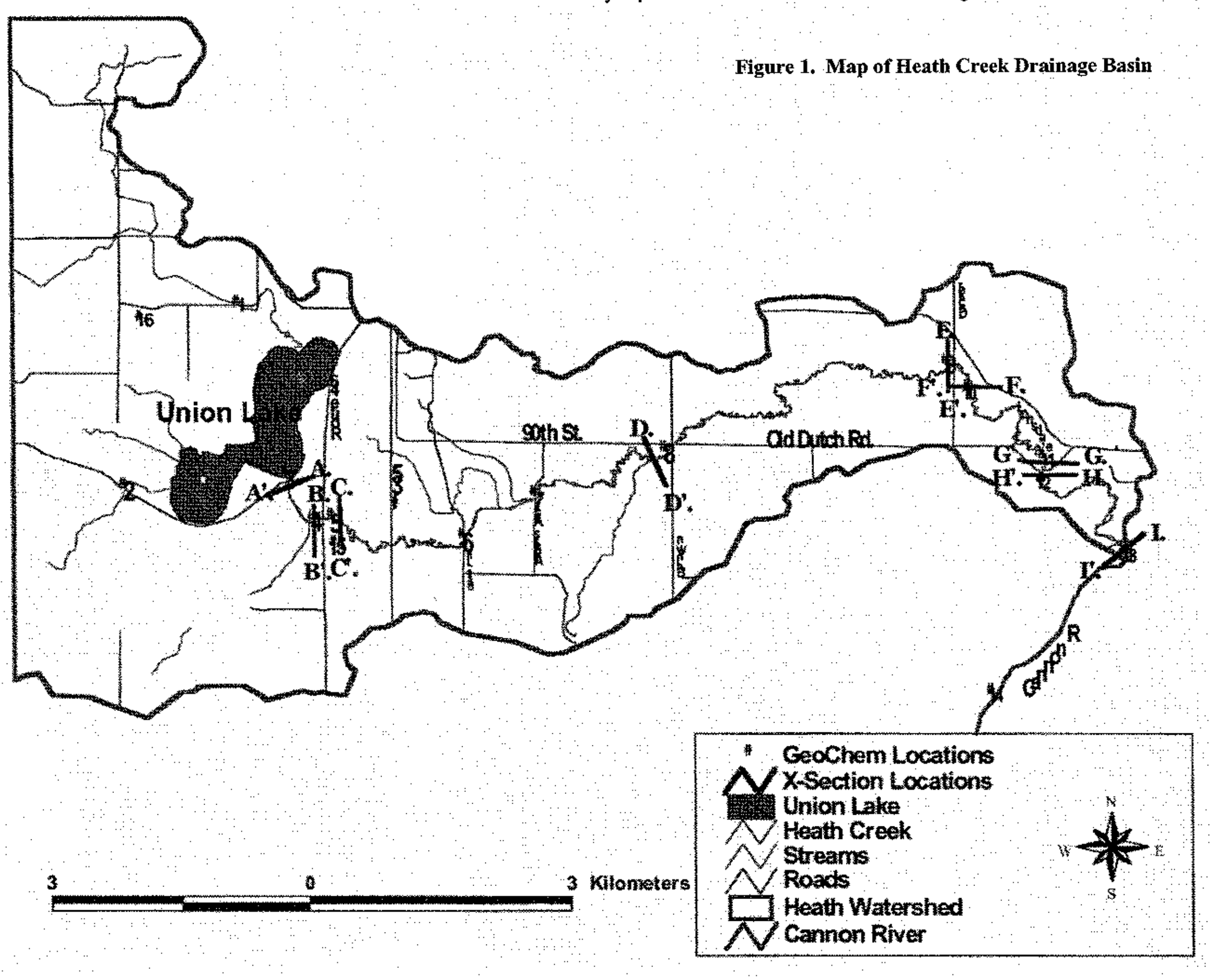


Figure 1. Map of Heath Creek Drainage Basin