HYDROLOGIC STUDIES OF THE TURTLE CREEK AND SPRING BROOK BASINS, SOUTH-CENTRAL WISCONSIN

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Supporting Sophomore-Level Research in Hydrology, South-central Wisconsin

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INTRODUCTION

In the spring of 1990 a workshop was held at the O'Hare Hilton in Chicago to explore possible ways of increasing minority interest in geology. During this workshop and discussions which followed a plan evolved which would expand proposed sophomore-level research projects, and create additional positions to be filled with qualified students who also had minority status. The initial concept was to put these projects into place during the summer of 1992. An exploratory model was submitted to the National Science Foundation, which reacted very favorably to the proposal, and in turn generated pressure to initiate the project a year earlier than planned. While this created problems in formalizing the projects with little available time, in the interest of providing the additional research opportunities to students and to test the concept of the expanded sophomore projects, an effort was made to develop the hydrology project in south-central Wisconsin on short notice. The logistics were made somewhat more complex by the fact that the director, Richard Stenstrom, was already committed to the Gaspé project during June and the beginning of July, leaving about three days between ventures. That the project was, from the point of view of the director, so highly successful, reflects praise on the outstanding effort of the students involved, and the degree of support extended by the other faculty who participated.

LIVING ARRANGEMENTS AND PROJECT SELECTION

The participants came from seven institutions, and arrived on the Beloit campus July 7. Most came in by airport bus from O'Hare, and a number of students had made arrangements to meet first in Chicago. Upon their arrival they were introduced to their dorm, which was set aside exclusively for the geology department during the summer. Two cooks, Kate Lindaas and Rebecca Conant, were contracted to provide meals during the five week stay. Their efforts went far beyond that of providing food, and in a short time they had transformed what initially appeared as a rather grubby dining area into an attractive eating establishment complete with tablecloths, flowers, and even frequent musical accompaniment. There was generally a variety of food to chose from, and of excellent quality. No one seemed to complain or go hungry.

After the initial introductions and informal exchanges, a quick tour of the City of Beloit was arranged to provide some insight as to where shopping areas, movie theaters, and essential services were located. Also, a tour of the department of geology was organized to provide background on the facilities which were available for the research projects. The intention was then to concentrate most of the week on possible research projects, and by the end of the first week have students decide what direction they would like their research effort to take, and who they would like to work with. We wanted the research decision to be made by the student, to encourage a strong sense of "ownership" and commitment to the project. Much of the first two days were spent in the field examining different sites and discussing some of the hydrologic problems that could be studied. The Little Turtle sub-basin about nine miles east of Beloit was one of the areas covered, and represented a major source in the 1973 200-year flood that inundated downtown Beloit, Wisconsin, and adjacent South Beloit, Illinois (area 1 of fig. 1). The hydrologic character of this basin was poorly understood, and consisted of a number of tributaries coming together near the outlet of the basin. A gaging station had been previously established to monitor discharge, and records of flow left some question as to the proper hydrograph separation. There were also unexplained daily fluctuations in flow character that were unrelated to any precipitation events.

The main channel of Turtle Creek was also featured during the introductory tour (area 2 of fig. 1), and some possible point sources of pollution pointed out. This river runs through the east side of Beloit and enters the Rock River along the state line between Illinois and Wisconsin. The urbanized reach of the stream is characterized by numerous storm sewers along the banks, and some pipes of questionable origin. Industry, including a large salvage yard that has been active for many years, also borders the river as it approaches the point of confluence. The Turtle

Creek was the water course responsible for the flooding during the 1973 event, causing over 25 million dollars of damage in the Beloit area, and hastening the razing of much of downtown Beloit.

Another focus of the first two days was a smaller tributary to the Turtle Creek, Spring Brook, that flows through about eight miles of mostly rural setting before crossing under the I-90 system into urbanized Beloit (area 3 of fig. 1). Two gaging stations have produced hydrograph records over a long duration, recording the changes between the upstream rural setting and the developing area west of I-90, which includes the industrial park. Comparison of the hydrograph records makes it possible to identify urban input in terms of peak flow, and offers the challenge to work with the records to locate the character and origin of these discharges. Since a good portion of the reach between the two stations is still mostly undeveloped, the opportunity to isolate potential sources is enhanced. Major industry located in the industrial park behind which Spring Brook flows includes Frito Lay, Hormel, and Enzyme Biosystems. Also included is a large plant of Freeman Shoe, which adds extensive impervious surface to an area that previously contributed little runoff.

Adjacent to the college flowing in a southerly direction is the Rock River (area 4, fig. 1). This is the major drainage feature of south-central Wisconsin, and flows through the middle of Beloit, ultimately joining the Mississippi River at Rock Island, Illinois. It is bordered by heavy manufacturing in the form of Colt Industries, which builds diesel engines for ships, locomotives, and other heavy use; and by the Beloit Corporation, which is one of the major paper-making machinery firms in the world. Smaller industries also are found close-by, and some are known for the manufacture of chemical products. These all represent potential sources of pollution to a major drainage system. Downstream, at about the state line, the effluent from the old sewer treatment plant is discharged into the Rock River. On numerous occasions during the past few years the City of Beloit has been cited by the Department of Natural Resources (DNR) for illegal discharge of untreated effluent. The Rock River, therefore, represents the potential for a variety of research efforts relating to water quality.

As somewhat of an afterthought we included in the survey of potential projects an area about three miles west of Beloit known as Chamberlin Springs (area 5, fig. 1). This small wooded area, which extends a half mile from the road, represents part of the old homestead of Thomas C. Chamberlin, whose name is well known in the annals of geologic contributions. Near the far side of the woods is a small stream, Raccoon Creek, which originates in farmland to the northeast, and flows westward through the quarter mile width of the property. Within the woods the reach of the stream is characterized by many features at a small scale characteristic of stream development in late maturity. Also present are a number of springs, for which the area was well known in the late 1800s. Abundant rains in the late spring and early summer resulted in a prolific growth of brush and thorn bushes, making the traverse with the group to the stream a challenge. The heat and record hatch of deer and black flies added to the inhospitable character of the setting. Still, by twisting, careful stepping, and ignoring the pain induced by the briar patches, the features of Raccoon Creek were brought into focus and a variety of potential projects discussed.

By Tuesday evening Steve Burrell, Don Zenger and I decided to find out where people's thoughts were leading concerning possible research projects. We asked each student to put down two choices for research, and we would discuss them individually during the evening, and then make suggestions for them to consider in the next day or two, with the ultimate intention of coming up with firm ideas by the end of the week. Much to our surprise, most of the students had already developed a good idea of the work they would like to do. It also was apparent that even though Chamberlin Woods was not openly receptive to our visit, it held an allure for the students, and four out of the group wanted to do projects associated with Raccoon Creek. We ended up with only one pair working as a team, and they were Scott McMillin and Debra Piette, who selected to look at Spring Brook and possible discharges from the industrial park or other point source contributions to the stream that could be responsible for fluctuations seen on hydrographs. Christene Albanese selected the Little Turtle basin to the east of Beloit as her study, and would attempt to find out the cause of daily changes in discharge and possible influence of the tributary systems. Dave Lund was to focus on the water quality of Turtle Creek, and Seth Bacon chose the Rock River. Tony Wilburn wanted to examine the influx of ground water from spring activity in the Chamberlin Springs area, and planned to approach it by monitoring the volume of spring flow using various discharge measuring devices, and also by checking temperatures of the stream and ground water in an attempt to ascertain mixing ratios. Karyn Powers was also interested in the contribution from spring flow, but was planning an approach that would look at chemical signature and dilution factors. Veronica Diaz selected the numerous debris dams that obstructed the flow of Raccoon

Creek, and concentrated on the development of these dams and their impact on stream dynamics. LeAndra Archuleta focused her attention of bottom bedforms, and the relationship of these features to flow conditions.

RESEARCH LOGISTICS

The daily routine would start with breakfast at 7:00 a.m., and food would be set out on a table for people to make field lunches to their own specification. We would begin at 8:00 at Chamberlin Hall, where equipment to be sued for the day would be packed in vans for transportation to the field. We had two college vans for transportation and tried to arrange schedules the night before to allow those requiring measurements at a number of locations greater access to the vehicles. When projects needed more than one person, a schedule was worked out by the students to assure that help would be available. Faculty support was also available, and extensive use of the phone for long distance calls permitted students to gather information from external sources. Field data was frequently processed at night, and students had keys providing admission to the laboratory facilities in the evening.

We were well-equipped for carrying out most of the work, but because of the nature of some of the research the participants had to devise special methods of collecting the needed data. Weirs had to be constructed, portable stilling wells made, and a method for mounting the crane to the jon boat devised. Timing devices were constructed in an attempt to identify the passage of a discharge exceeding a given magnitude, and a method had to be developed for establishing the position of sampling sites while traversing a cross-section of the river by boat. Techniques for measuring bedforms without altering flow conditions were developed, and methods for determining the structure of debris dams had to be designed. In response to these challenges new skills were acquired. Carpentry, use of a welding torch, and metal work were among them. Also research tools such as the Inductively Coupled Argon Plasma (ICAP) spectrometer, the computer in drafting and data processing, and field instruments such as the pygmy meter, pH meter, and conductivity meter were employed. Research was heavily supplemented by contacts with residents of the area, government officials at the city, county, state, and even federal level, and the students interacted with major companies and their corporate headquarters even at the national level. In short, the students did a fantastic job!

We addressed two major problems with regard to the research efforts. One was equipment maintenance, and repairs were a constant part of the agenda. Nearly every day there was at least one item, and often several, that came back from the field in need of service. This often meant that Steve Burrell and I frequently were up until well after 10:00 p.m. in order to get instruments ready for the next day. The second problem was transportation. Initially we expected groups to be working on a given problem, decreasing the number of projects and limiting our transportation needs. With eight separate projects active simultaneously, we found that it was necessary to bring our personal cars into use. To supplement the two college vans, which were generally dedicated to those projects where considerable moving from one location to another was necessary, my Volkswagon Campmobile was placed in operation and made available for those projects where samples for chemical analysis were being collected. The ability to raise the top and the numerous table surfaces made field collection and treatment of samples considerably easier. Transporting students to their research locations was also accommodated by Steve Burrell using his van and me using my jeep. While we did manage to keep the projects going, it was not without cost. Some damage to the Volkswagon and loss of equipment resulted from a break-in during one of the sampling trips, and on another sampling trip the last week of the project Karyn Powers and Christene Albanese succeeded in creating a scene with billowing smoke and flames emanating from the engine compartment. Their fast action avoided a total calamity, but also pointed out the high cost of using personal equipment to sustain research projects.

Those involved in the research worked together marvelously. They were very willing to help each other when it was needed, and as a consequence everyone got to experience the research of others. Whether concrete results were obtained or not, from the perspective of facing problems associated with field research and testing ways to overcome those problems they understood the application of the scientific method. The students involved in the hydrology projects were inventive, hard work and resourceful. It was a major challenge to keep pace with the energy of the environment they established. Although working on individual projects, they functioned as a team. The following abstracts give you a sense of their accomplishments, but only by being with them in the field can you really recognize the high level of achievement they attained. If I have learned one thing from the effort during the summer, it is that sophomore research projects are the best learning device I have encountered in my quarter-century plus of teaching.

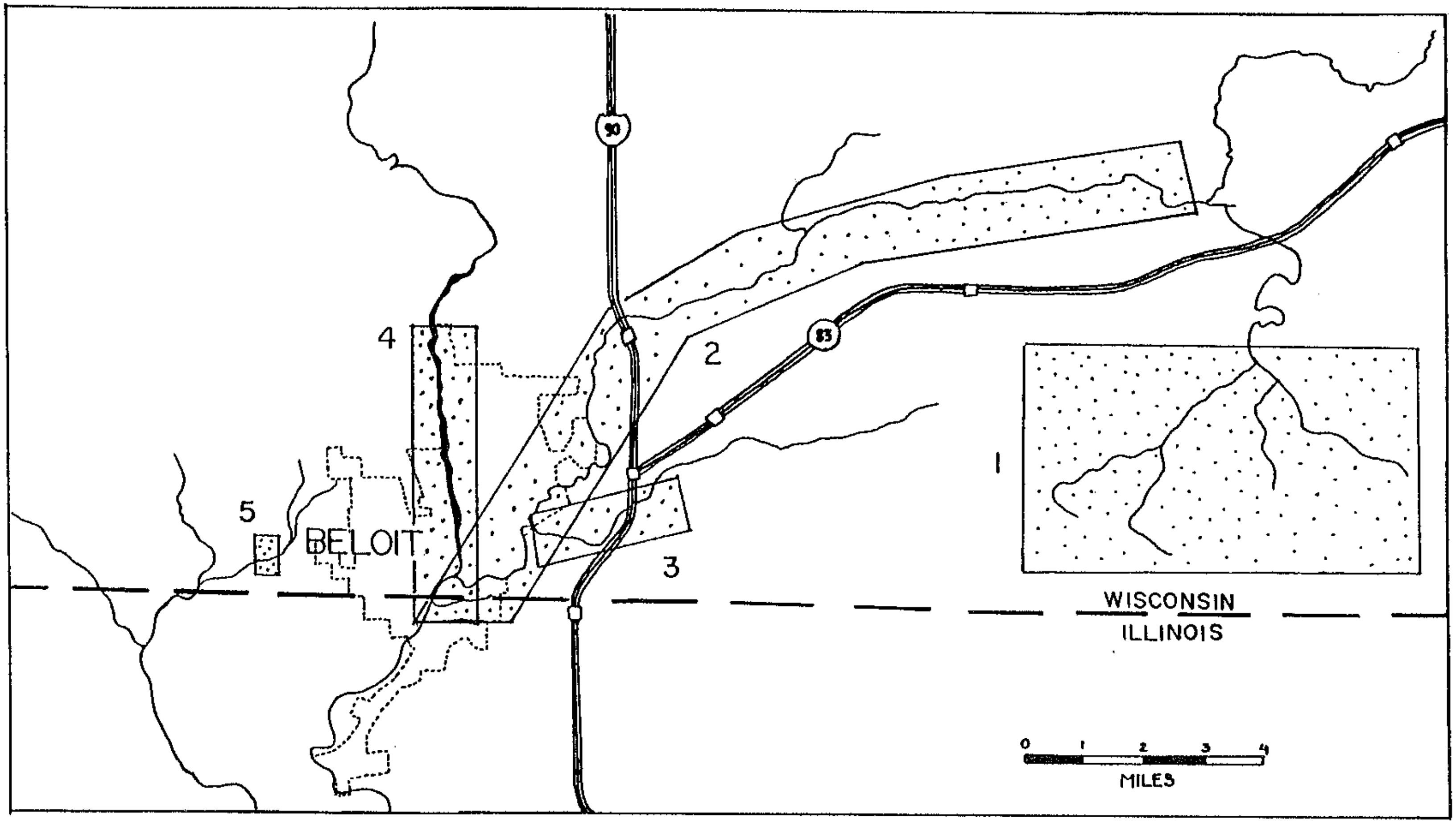

Figure 1. Hydrology research localities for the sophomore projects in south-central Wisconsin. Location numbers and research participants are: 1 - Little Turtle sub-basin, Christene Albanese; 2 - Turtle Creek, David Lund; 3 - Spring Brook, Debra Piette and Scott McMillin; 4 - Rock River, Seth Bacon; 5 - Chamberlin Springs and Raccoon Creek, LeAndra Archuleta, Veronica Diaz, Karyn Powers, and Tony Wilburn.

Watershed Analysis of Little Turtle Basin to determine origin of daily Fluctuations in Main Station Hydrograph

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Introduction

The main gaging station at the base of the Little Turtle Basin displays daily fluctuations in gage height. The gage height rises slowly in the morning, peaks a little before noon, and then slowly declines. The most obvious source of the daily fluctuations would be the water pumped through the Sharon Wastewater Treatment Plant directly into the Little Turtle Creek. By analyzing the major tributaries separately, fluctuations may then be isolated to a particular region of the watershed to determine their origin.

Methods

The watershed was first separated into catchment areas surrounding each of the main tributaries. The watershed was examined to find possible effects on base flow, such as irrigation wells and water treatment plants. The Sharon Wastewater Treatment Plant was the only outstanding mechanism for fluctuations in stream flow.

Stilling wells were then installed at the base of the two largest tributaries, Ladd Creek and the Upper Little Turtle (ULT). Selection of a gaging site was determined by several stream characteristics. First the site must be located on a fairly straight stretch of stream with no unusual meanders. Second the site must be near a physical control, such as water flowing through a rapids area. (Carter, 1968) These controls should be downstream of the gaging site, and if possible upstream also. The Ladd Creek site had controls up and down stream. The ULT site only had a nearby control downstream.

Gage height recorders were mounted on steel cylinders, open at both ends, with several holes in the side so water could pass freely in and out. The substrate of these streams was very hard as the underlying bedrock depth was very shallow. Positioning stilling wells directly in streams is only acceptable for short term, temporary projects. One was located downstream of the railroad bridge, at the base of the Upper Little Turtle, called the Steir Station into which the Sharon Wastewater Treatment Plant flowed and the other was located at the base of Ladd Creek called the Gunnink Station.

Gage height was recorded at each station using Stevens recorders. Due to limited resources two different models were used each recording at a different scale. The Gunnink station recorder was a continuous strip-chart recorder which showed much less detail than the Steir Station, a horizontal-drum recorder. (Buchanan, 1968) Gage height was then digitized so the data could be analyzed in Kaleidagraph™ (Version 2.1, Abelbeck Software), an advanced graphing system. The Steir data was typed in manually, points were recorded for each hour. The Gunnink station, because of the lack of detail in the time verse gage height recording, was digitized using a Kurta Digitizer Tablet Model IS/ADB (Digitize™ Rock Ware Inc.). Then this data was also transferred into Kaleidagraph.

Discharge readings were taken a different levels of gage height at each site. To determine an