The Future of Rowan Creek Watershed:

Connecting Land Use and Management with Water Quality

2003

WATER RESOURCES MANAGEMENT WORKSHOP 2002
GAYLORD NELSON INSTITUTE FOR ENVIRONMENTAL STUDIES
UNIVERSITY OF WISCONSIN–MADISON

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Abbreviations of agencies/organizations used in this document

FORC: Friends of Rowan Creek
SCS: Soil Conservation Service; now NRCS
NRCS: Natural Resources Conservation Service
USEPA: U.S. Environmental Protection Agency
USFWS: U.S. Fish and Wildlife Service
USGS: U.S. Geological Survey
WDNR: Wisconsin Department of Natural Resources
WGNHS: Wisconsin Geological and Natural History Survey

A note about Web sites

All URLs in this document were current at the time of publication.

The Water Resources Management workshop (WRM) is a regular part of the curriculum of the Water Resources Management graduate program at the University of Wisconsin-Madison. The workshop involves an interdisciplinary team of faculty and graduate students in the analysis of a contemporary water resources problem.

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FIGURES

PLATES (after page 40)

TABLES

PREFACE

The Water Resources Management Practicum

The project was conducted by students in the Water Resources Management (WRM) program at the Gaylord Nelson Institute for Environmental Studies at the University of Wisconsin–Madison. The WRM program is an interdisciplinary graduate program of the Nelson Institute. Annually, students in their final year in the program participate in an eight-month workshop focused on a contemporary local problem or issue in water resources management. Since the inception of the program more than 30 years ago, workshops have focused on aquatic systems such as Fox Lake, the Rock River, Black Earth Creek, Lake Wingra, the Nine Springs E–Way, the Sugar–Pecatonica River system, and Lake Mendota.

Water Resources Management Practicum 2002—Statement of Purpose

Rowan Creek, located in Columbia County in southern Wisconsin, drains parts of five townships: Arlington, Dekorra, Lowville, Lodi, and Leeds. The healthy status of this cold-water stream and its trout fishery makes it unique in the more urbanized southern part of the state.

Because of its proximity to the growing Madison metropolitan area and the Interstate 90/94 corridor, the Rowan Creek Watershed has the potential to become increasingly urbanized. It has been well documented that increased levels of development within a watershed can lead to the degradation of stream ecosystems. Fortunately, new techniques are being developed and implemented to counteract this potential problem. With good initial planning aimed at protecting this unique habitat, much of the damage normally associated with urbanization could be avoided.

In the interest of preventing degradation to Rowan Creek and its tributaries, we undertook a comprehensive study to provide information that can help to facilitate effective stormwater planning and management in the urbanizing Rowan Creek Watershed. Our study included a stream and watershed assessment, a stakeholder analysis, a compilation of effective stormwater-management practices, and outreach activities intended to be used by various stakeholders. This report contains the results of this undertaking.

WRM Workshop 2002 Participants and Affiliations

The WRM Workshop 2002 participants (left to right): Back row: Ben Hodapp, Chris Brown, Matt Kirkman, and Ezra Meyer. Middle row: Claire Aubourg, Joel Brieske, and Adam Gallagher. Front row: Kent Brander, Suzanne Hoehne, and Joe Grande.

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CHAPTER 1. INTRODUCTION

In the heart of south-central Wisconsin's Columbia County lie Rowan Creek and its main tributary, Hinkson Creek (fig. 1.1). These slow-moving, cold-water creeks drain approximately 60 square miles of hilly, glaciated, rural land. Forming within the townships of Leeds and Lowville, merging northwest of the Village of Poynette, and finally spilling into the Wisconsin River some 20 miles from their quiet beginnings, these vibrant streams are formative elements of the culture, the resource base, and the aesthetic character of this part of the state. Both creeks are well known by trout fishermen as ideal places for a day of fishing and by passersby as bucolic streams that highlight the natural beauty of the rolling hills.

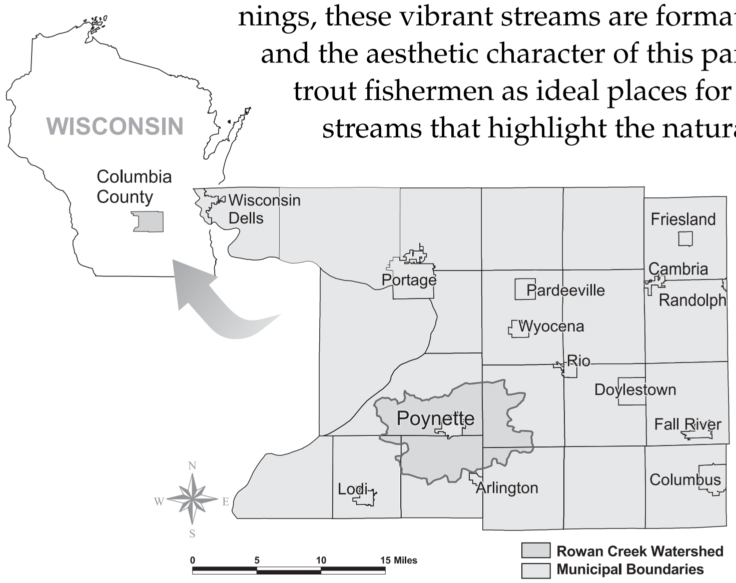

Figure 1.1. *Map showing location of the Rowan Creek Watershed within Columbia County.*

The land through which these creeks pass is dynamic. Fifteen thousand years ago, we would have seen glaciers covering nearly all Columbia County, carving valleys and pushing rocks and soil into hills, ridges, and moraines. As they slowly retreated, the glaciers left behind the highly varied landscape we see across the eastern half of Wisconsin today. Over time, organic matter accumulated in the wetlands, prairies, and oak savannas that developed on the post-glacial landscape. Eventually, these became excellent areas for supporting agriculture and human settlement.

Although the first explorers came to Wisconsin in the mid-1600s, it was not until the early 1800s that Europeans settled the area. With these settlers came European agricultural practices, such as tilling and livestock grazing, which were more intensive and disruptive than those used by the local Native Americans. Over time, agricultural practices changed with new technologies, becoming less disruptive in some ways, but more intensive in others.

Today, although the area surrounding Rowan and Hinkson Creeks remains largely agricultural, the nature of the land and its occupants continues to change. Not far to the south, the City of Madison is growing rapidly. Similarly, other areas in the region, including the Wisconsin Dells, Portage, and Baraboo, continue to expand. The countryside around the streams is a potentially attractive home for people wishing to work in one of these metropolitan areas while enjoying the tranquility and slower pace of rural life. An increase in the level of urban development can be the result of such circumstances, and among other changes, area citizens will likely have to deal with this new kind of pressure on local natural resources, such as the creeks and the lands surrounding them. As people commute longer distances to metropolitan workplaces, and as Arlington, Dekorra, Lowville, Lodi, Leeds, and Poynette continue to grow, new steps will have to be taken if the land and water resources are to be protected.

Overview

A *watershed* is an area of land on the landscape from which all surface water flows to a common stream or river. Rowan Creek and its tributaries drain a nearly 60-square-mile watershed encompassing parts of Poynette, Arlington, Lowville, Leeds, and Dekorra (fig. 1.1). Runoff water from within the watershed's boundaries is naturally and artificially conveyed into Rowan and Hinkson Creeks, which eventually empty into Lake Wisconsin on the Wisconsin River. This water then flows into the Mississippi River and ultimately into the Gulf of Mexico.

We selected the Rowan Creek Watershed for analysis because it is widely recognized as a unique and valuable resource. It is a place of beauty and recreation for the people living on or near it as well as those who come to visit it, and it supports a high quality trout stream, an ecosystem rare in Wisconsin and throughout the world.

However, this resource was not always as highly valued as it is today. Prior to the era of the Soil Conservation Service (SCS; this agency is now called the Natural Resources Conservation Service [NRCS]), the creeks were choked with sediments resulting from agricultural practices, including up-and-down tillage and pasturing livestock in the streams. Much improvement has been seen in the water quality of Rowan and Hinkson Creeks since the beginning of the conservation era in the 1930s. It is a foundational assumption of this paper that to keep Rowan Creek in this recently restored and healthy condition is a goal worth pursuing.

Indeed, few dispute that maintaining the quality of Rowan Creek is a worthy goal. One indication of this comes from a recent survey of resident opinion conducted as part of this study. Seventy-eight percent of respondents indicated that good water quality in Rowan and Hinkson Creeks is valuable to them. However, two important questions must be answered before expecting unanimous commitment to this goal. First, which management strategies are most appropriate for this watershed? Second, how much time, energy, and money are people prepared to devote to the task? People living in the watershed have other important needs and wants, and these must be considered along with the goal of a healthy Rowan Creek. Then local officials and other citizens will be able to make better decisions about how to progress into the future.

The motivation is strong for devoting time and energy to maintaining the quality of Rowan Creek. Parts of Rowan and Hinkson Creeks are classified as Class I and II trout waters by the Wisconsin Department of Natural Resources (WDNR), the agency's top two designations for such streams. Both creeks support introduced brown trout, and Hinkson Creek also supports native brook trout. Our survey results show that the trout fishery is a highly valued resource of local residents, and efforts to maintain it are supported by fishermen, citizen groups, and local WDNR representatives. In addition to an enjoyable fishing experience, the creeks and adjacent lands provide recreational opportunities such as hunting, hiking, cross-country skiing, picnicking, camping, sunbathing, and spiritual rejuvenation. Appreciation for the local scenic landscape is embodied in Poynette's village logo, "Poynette … naturally," and the results of a citizen opinion survey, performed as part of the research for this report, indicate that Rowan and Hinkson Creeks are particularly valued in this regard.

Now is the right time to recognize the importance of wise decisions regarding urbanization and other land-use changes in the Rowan Creek Watershed. On one hand, more urban and rural residential development is expected; on the other hand, partly as a result of recently passed Smart Growth legislation, citizen groups and policy makers are organized and prepared for spirited discussion and informed decision making about how such development should take place. The community plans and standards that emerge from this process will profoundly affect the goal of maintaining the healthy condition of Rowan Creek.

Report Objectives and Organization

To progress in the direction of a healthier watershed, objectives must be clearly defined, the factors affecting the creek must be understood, and those people who hold a stake in this process must discuss the trade-offs involved in maintaining stream quality. The broad goals of this report are to provide citizens, lawmakers, and other interested parties with specific information regarding the history and the current status of human use and impact in the Rowan Creek Watershed and to identify ways in which these and other groups may work collaboratively to protect the valuable resources in the Rowan Creek Watershed.

Significant background information about the natural processes that continually affect Rowan Creek is presented in Chapter 2. This provides a basis for the remainder of the report, which is organized into four key areas: 1) creek and watershed assessment (Chapter 3), 2) stakeholder analysis (Chapter 4), 3) community outreach (Chapter 4), and 4) an examination of stormwater-management practices and regulations (Chapter 5).

The purpose of the watershed assessment detailed in Chapter 3 was to evaluate relevant physical, chemical, biological, and human parameters, to place these measures within a historical context, and to provide a baseline picture of stream and watershed health for future comparison. We collected and summarized data for creek and watershed characteristics. For example, we examined stream baseflow and temperature, watershed impervious surface cover, and watershed land-cover type. These data are meant to serve as a baseline for future quantitative observations. Limited historical records demonstrating agricultural practices before and after the formation of the SCS documented the treatment of the land within the watershed. These historical references complement more quantitative observations such as fish surveys, chemical analyses, and flow measurements, which began in the mid-1960s and continue through this study.

Of course, the future of Rowan Creek is heavily dependent upon the current social and political setting in the watershed, and these issues are the subjects of the stakeholder analysis. In Chapter 4 we look into the individuals, citizen groups, and government officials and agencies that have an interest in the Rowan Creek Watershed, and we gauge the perspectives of a broad group of watershed residents through the use of a mail-in survey as well as telephone and personal interviews. This chapter also includes a community outreach component, meant to help educate and empower concerned citizens and citizen groups through the development of an educational curriculum and creek monitoring program.

Stormwater management describes engineering and other practices utilized to reduce and treat runoff that reaches a stream following a storm event. Managing stormwater is one of the most important components of maintaining the health of the creek. Chapter 5 provides information about specific legislative, planning, and engineering strategies that can be used to mitigate future human impacts on Rowan and Hinkson Creeks and the adjacent land.

The report concludes with a series of recommendations for people involved with education, development, and decision making within the watershed.

CHAPTER 2. RURAL SETTING, URBAN QUESTIONS

Many human activities have the potential to harm stream ecosystems such as that of Rowan Creek. Some of these activities occur on farms or in other rural settings; others are associated with urban (residential, commercial, or industrial) environments.

Clearly, the Rowan Creek Watershed could not be accurately characterized as urban. The largest municipality, the Village of Poynette, has a population of less than 3,000, and the remainder of the watershed is far less densely populated than the village. However, it is important to recognize that even moderate increases in population density, if not properly addressed, can have a significant impact on local water quality. The hydrologic problems of urbanization are not confined to large cities; they can appear wherever development accommodates a growing non-rural population.

There is an ongoing rise in residential and commercial development in Poynette and other local communities within the watershed, so the associated problems of urbanization are expected to increase in relation to those posed by agriculture. This report looks toward the future, and is aimed at groups responsible for the regulation and planning of agricultural and non-agricultural activities. Recent work in the area of urban stormwater management has revealed a number of effective methods for protecting streams while allowing development to take place, and it is important for community officials to have the latest tools and information at their disposal. The chapter of this report entitled *Stormwater Management and Regulation* (Chapter 5) highlights these techniques and compares them with those that have been used in the past. These practices are relatively new and therefore have yet to be widely adopted. This is not the case in the area of agriculture—many effective agricultural management practices have been available for some time and have therefore been successfully implemented.

Stormwater is the Key

The importance of stormwater and its management for the relative health of the stream cannot be overstated. Every drop of water in Rowan Creek was stormwater at one point, and more than any other factor, the path taken by local stormwater has determined the nature of the creek. To say that human activities such as development and agriculture pose a threat to the creek is, technically, to say that these human modifications to the natural environment can affect stormwater in ways that ultimately harm the creek.

Because this report includes specific recommendations for stormwater management in the Rowan Creek Watershed, it is important that local officials and other interested parties acquire some understanding of the physical processes behind these recommendations. A better grasp of the physical problem generally leads to more logical, balanced, and creative decisions, which better respect the rights of individuals and the value of the watershed environment. This improved understanding begins with an exploration of the hydrologic cycle—the continuous circulation of water between the atmosphere and the Earth's surface through the processes of evaporation, condensation, and precipitation.

The Hydrologic Cycle and its Human Connection

Flooding

Chances are that when most people think of stormwater problems, they think first of flooding. The Village of Poynette has had its share of flooding problems, and many people have contended with a flooded basement or a street or parking lot that was underwater after a significant rainstorm. When stormwater ends up where it does not belong, the typical results range from inconvenience to costly damage to safety hazards for the community.

People have long recognized that flooding in developed areas is often the result of development itself. When vegetated soils are replaced by concrete and rooftops, rainwater that once seeped into the ground runs off the surface. Therefore, when people develop property, they increase the likelihood that their neighbors will experience flooding. This is particularly true if the new landscape drains water directly onto neighboring property.

Recognizing that the burden of damages from such flooding should not, in principle, be placed on downstream municipalities and property owners, most communities require developers to control excess runoff from their land. Flooding, however, is only one part of a complex process—it just happens to be the part that impacts us most immediately and dramatically. If we step back and look at the larger picture, we can better understand flooding as well as other problems related to stormwater. This is an important step because some of these other problems, such as streambank erosion, fish-habitat degradation, and groundwater contamination, although just as real and potentially damaging, are not immediately apparent to the casual observer.

Just as in the case of flooding, the principle of respect for other property, whether private or public, can justify requiring people to address less familiar stormwater problems. In selecting appropriate practices and regulations, it is helpful to look at the entire stormwater process rather than just the separate elements composing it. In doing so, we may find opportunities to "kill two or more birds with one stone," by taking care of multiple problems with a single practice, or, conversely, we see how our treatment of one problem may make another problem worse. To confidently select a management strategy that addresses all valid concerns while respecting property rights, officials need to understand how stormwater travels through and interacts with constructed and natural environments.

Hydrologic Cycle Overview

It is well understood that water, in its various forms, moves continuously through the systems of the Earth and its atmosphere in a series of processes known as the hydrologic cycle (fig. 2.1). The energy of the sun works together with atmospheric and biological processes to transport water into the atmosphere, and after condensation, the gravitational pull of the Earth causes the water to fall as precipitation and move to the lowest surface elevation possible. If it encounters a permeable surface, the water can infiltrate the ground and eventually be stored in an *aquifer,* a saturated underground layer of porous sand or rock. Where the top of the saturated part of an aquifer, the area referred to as the *water table,* intersects a stream channel, the aquifer becomes a reliable source of cold, stable-temperature water to the stream. The part of streamflow that is contributed by groundwater discharge, and not from runoff by precipitation or snowmelt, is known as *baseflow.*

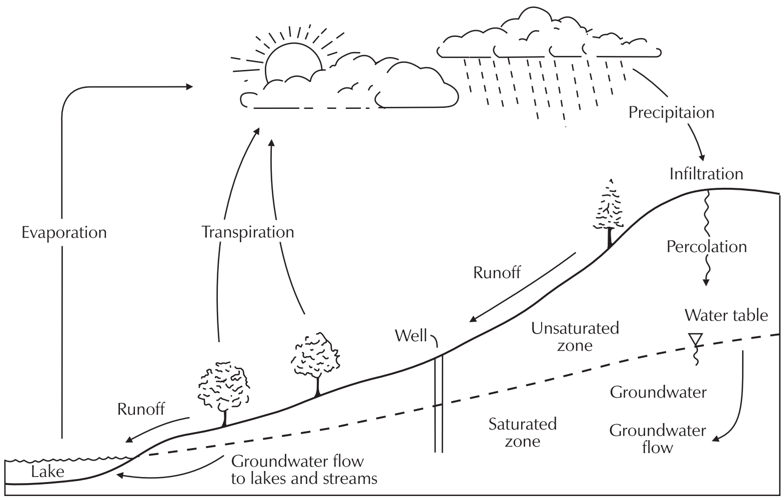

Figure 2.1. *The hydrologic cycle.*

Most of the water that does not infiltrate the ground evaporates into the atmosphere again as a result of transpiration by plants; the remainder flows over the surface of the Earth into streams and rivers. In southern Wisconsin, of the roughly 30 inches of precipitation that fall on average each year, 20 inches evaporate back into the atmosphere. Under natural conditions, very little precipitation becomes runoff, so the remaining 10 inches infiltrate the ground, recharging aquifers and eventually springs like those that feed Rowan and Hinkson Creeks. Lakes and oceans are the ultimate repositories of stormwater, and evaporation from the surface of these bodies provides additional water for precipitation.

All parts of the environment, including human, plant, and animal life as well as natural and constructed landscapes, interact with water traveling on the segment of the hydrologic cycle between precipitation and evaporation. To grasp this notion more fully, it helps to visualize the journey taken by the water falling to the ground in a rainstorm. First, rain falls to the Earth, landing on a particular patch of land. If the water falls onto an agricultural field, it picks up fertilizer chemicals. If the land is sufficiently permeable, the rainwater infiltrates into the ground. If it lands on concrete, it normally runs off into a storm sewer, carrying sediment or other contaminants with it. If the rainwater-turned-runoff travels over hot rooftops and streets, its temperature rises before it enters the local stream, potentially changing the temperature of the stream. If too much water enters the stream too quickly, the banks are likely to erode and other potential problems may result.

These interactions between stormwater and the environment are two-way relationships: The quantity and quality of the water entering a particular environment have a profound impact on that environment, and the characteristics of that environment similarly have an impact the quantity and quality of the water as it travels downstream. Over time, this back-and-forth relationship allows a watershed to move toward a state of balance, in which the biological and physical traits of the system have adapted to the typical amount and quality of water traveling through it.

The Hydrologic Cycle and Rowan Creek

The condition of Rowan Creek and its tributary, Hinkson Creek, is the result of the local hydrologic cycle. Stream characteristics, such as channel width, quality of fish habitat, and streambank stability, are largely the result of watershed characteristics. In general, watersheds that are relatively undisturbed by human activities produce streams that are considered closer to pristine, with stable banks, clean water, and vibrant aquatic life. This fairly describes the current condition of the Rowan Creek Watershed.

Of course, with the Rowan Creek Watershed becoming a more popular place for people to live and work, it is not helpful to strive for a "balance" of the system that excludes human beings. A better approach is to determine specifically how development causes problems, and then to look for benign methods of achieving the community's development-related goals. Historically, in general, the creative work of human society, whether in an urbanized area or on a farm, has included construction, dramatic alteration of the landscape, and the introduction of substances foreign to the natural environment. Our ability to do these things has brought us enormous benefits, but it has also allowed us to disrupt the hydrologic cycle in ways that can harm our property, our neighbors' property, and our highly valued stream ecosystems.

THE IMPACTS OF DEVELOPMENT

Land Cover and Water-Use Changes

In considering the idea of balance in a hydrologic system, the first traits to observe are related to the quantity, distribution, and temperature of water. These characteristics can be understood with the concept of the *water budget,* in which the total volume of precipitation in a watershed is accounted for, either as *evapotranspiration* (loss of water from the soil by evaporation and plant transpiration), infiltration, or surface runoff. The water that does run off does so very slowly because natural surfaces typically include many plants and small depressions, both of which tend to detain water.

The dramatic land-use changes accompanying development significantly alter the way precipitation is distributed throughout a watershed. Most important, impervious surfaces prevent water from infiltrating, causing a greater part of the water that does not evaporate to become surface runoff. This increased volume of runoff moves much more rapidly across impervious surfaces than it would over natural land cover, especially given the fact that it is a primary goal of the stormwater engineer to convey water away from property as quickly as possible to minimize the potential for local flooding and associated problems. Under these conditions, downstream land is more likely to be flooded, and as stream channels are forced to accommodate a larger volume of water over a much shorter period of time, streambank erosion is also likely to occur. Furthermore, reduced infiltration volumes, combined with the consumption of groundwater via pumping, result in the depletion of aquifers. In addition to being a potential cause of water-supply problems for local communities, depleted aquifers can also have an impact on local streams that are connected to the groundwater system, as is the case with Rowan and Hinkson Creeks. Diminished groundwater flow to these streams would result in higher water temperatures and decreased levels of baseflow; both are problems for cold-water fish such as trout.

Foreign Substances and Sediment

In addition to issues relating to stormwater quantity and temperature, concerned communities such as those in the Rowan Creek Watershed must also consider how human activities affect the quality of the water that ends up in local streams. Under natural conditions, of course, there are no foreign substances in a watershed, and even if some harmful substances are present, widespread infiltration and plant uptake serve as natural forms of treatment. Additionally, the relative lack of exposed soil and the general state of equilibrium in the watershed mean that runoff will not contain an inordinate amount of sediment. Altogether, these conditions mean that stream water is likely to be clear, clean, and favorable for fish and other aquatic life.

Human activities on the landscape can result in the release of foreign substances and excess sediment. Nutrients and other chemicals from farm fields and lawns, heavy metals and other pollutants from automobiles and roadways, and other potentially harmful substances travel through our watersheds and end up in local streams. Also, the exposed soils of agricultural fields and construction sites are much more likely to release sediment than natural, vegetated surfaces. Moreover, reduced infiltration through the ground and higher runoff velocities mean that chemicals and sediment are less likely to be removed by natural processes. Along with reducing the quality of water available to people, animals, and plants throughout a watershed, these conditions lead to the degradation of fish habitat and the impairment of aquatic life in general.

The Hope of Mitigation

Although the preceding section may seem to reflect a gloomy view of human activities, in actuality, identifying problem areas is the first positive step toward integrating our activities with the rest of the natural world. To find ways in which human development can take place while preserving the values of the rest of the environment is a justifiable goal. That way, people living today can enjoy nature and live with relatively few water-related catastrophes while also respecting the principle of intergenerational equity—that is, allowing future generations the same opportunity to experience the natural world that we have had, without burdening them with the costs of restoration and cleaning up after us. Finally, the goal of environmentally sound development is worthy insofar as there is inherent value in the unspoiled condition of nature itself.

Consequences in Other Watersheds

Throughout the country, our watersheds display the consequences, some favorable and others unfavorable, of the land-use, management, and development decisions that have been made in the past. The local examples of Lincoln and Black Earth Creeks illustrate the potential negative and positive effects humans can have on streams.

Lincoln Creek: The Exorbitant Costs of Wholesale Restoration

In many developed areas, through the middle of the twentieth century, efforts were made to mechanically alter streams, especially urban streams, for our needs. This often included lining them with concrete, channelizing them, straightening them, or some combination of these things. A well known example in Wisconsin of a watershed in which these kinds of alterations were made is Lincoln Creek in northern Milwaukee County.

Lincoln Creek extends approximately 9 miles through a heavily urbanized area of the metropolitan Milwaukee area. As was the case with many urban streams throughout the country, somewhere along the line it was decided to alter Lincoln Creek's natural stream channel in hopes of alleviating flooding problems. In general, the hope was that modifying the stream in such a way that it would convey stormwater runoff downstream as quickly as possible would help reduce local flooding problems. Unfortunately, this approach not only led to the near-total destruction of the natural condition of the stream ecosystem, but it also worked counter to its intended purpose, causing severe downstream flooding and huge economic repercussions in other areas.

In June 1997, a torrential rain fell in the Milwaukee area, causing local streams and rivers, including Lincoln Creek, to flood severely and sanitary sewers to back up into basements. Damages to private and public property from this storm alone totaled $87 million.

As a result of this and similar events, the Milwaukee Metropolitan Sewerage District is currently undertaking a $115 million project to restore the stream and its channel to a more natural state. The hope held by the District and surrounding communities is that these efforts, along with other flood-control measures, will better control stormwater runoff and its attendant problems, in addition to providing the recreational and aesthetic benefits associated with a natural stream that have long been missed by local residents.

This is an extreme example, but it shows that the costs, economic and otherwise, of working to make human development in a watershed compatible with the continued maintenance of stream and watershed health can be significantly lower over the long term than those associated with developing the watershed without paying careful attention to the impacts of development on the watershed land and the stream, as was the case with the Lincoln Creek watershed.

Black Earth Creek: Conservation, Planning, and Targeted Restoration Efforts Cost Less

Decisions and actions of a community can affect a watershed in more positive ways. A good example is the Black Earth Creek watershed, which is located just west of Madison in Dane County, Wisconsin. The Rowan Creek Watershed and the Black Earth Creek watershed feature roughly similar degrees of urbanization.

The 27-seven-mile long Black Earth Creek drains a watershed with an area of approximately 100 square miles. It originates between Cross Plains and Middleton and flows west and north through northwestern Dane County, eventually draining into the Wisconsin River just as Rowan Creek does farther upstream on the Wisconsin. The spring-fed Black Earth Creek has been described as a premier trout stream; it was even named one of the nation's "100 best trout streams" by Trout Magazine.

To get to this point, however, the local communities, along with governmental agencies and other concerned parties, have had to work hard to restore parts of the stream degraded by agricultural and urban development in the watershed and to put into effect measures designed to help keep the stream in good condition. This effort began as early as 1940, when the WDNR carried out habitat improvement projects on the stream. Over the years, land acquisition and dam-removal projects have been undertaken, best management practices have been installed, and controls on development, water pollution, agricultural activities, livestock operations, and construction-site runoff have been put into place.

In 1985 the state chose Black Earth Creek for one of its Priority Watershed Projects, which involved local landowners and communities and made funds available to help limit *nonpoint source pollution* (pollution that does not originate from a single, discrete location) from a variety of sources. "Out of over 60 such projects Black Earth Creek was ranked as one the most successful, primarily because the objectives of the Black Earth Creek Priority Watershed Plan were exceeded and this project had one of the highest landowner participation rates in the history of the program" (Wisconsin Department of Natural Resources, 2001). Many miles of streambank protection and fish-habitat improvements were installed, barnyard-runoff management systems were constructed, and many acres of fields were committed to conservation tillage as part of this project. In the end, more than $2 million of public and private funds was spent for the implementation of these practices with the overarching goal of maintaining or improving the health of Black Earth Creek. We have included this seemingly large dollar figure here to highlight the fact that stream and watershed protection have a cost; however, the expenditure required to allow development to occur while maintaining stream health was significantly lower than the expenditure associated with developing an area without worrying about stream protection and eventually turning to restorative activities to move back toward the healthy system that people value.

Our hope is that the citizens, policy makers, agencies, and others concerned with the future of the Rowan Creek Watershed can learn from these and other similar examples from around the State of Wisconsin and the nation. Poor management and planning in the Lincoln Creek watershed resulted in costs in the hundreds of millions of dollars in the long term. On the other hand, in the Black Earth Creek watershed, it has taken more than 60 years to develop a "successful" watershed protection plan, but the costs have been significantly lower than they might have been had things happened as they did on Lincoln Creek. Decisions must be made proactively in the Rowan Creek Watershed as development continues to occur so that the proper balance can be struck between the value that comes from human modification of the landscape and the value that citizens place on the preservation of a healthy stream for the enjoyment of generations to come.

Reference

Wisconsin Department of Natural Resources, [2001], *Report on the Black Earth Creek Fish Kill*. Available online at <http://www.dnr.state.wi.us/org/water/fhp/fish/pubs/blackearthck.pdf>.

CHAPTER 3. PHYSICAL ASSESSMENT

The Past

> Turning back the pages of time in the early 1830's, the site of Poynette was without houses, stores, or even streets. Simply acres and acres of woodland sloping down to a sparkling, spring fed creek. The forests of oak, hickory, and ash were softly green in the springtime, and glowed with crimson and gold in the autumn. To the south, hundreds of acres of fertile prairie untouched by the plow lay covered with lush grasses. To the north, toward Ft. Winnebago, thousands of wild ducks and geese filled the air, coming to feed on the rice in the vast marshes.
>
> —*From brochure commemorating the Pauquette–Poynette Sesquicentennial*

Settlers came to the frontier to earn a living and create their version of the American Dream. For farmers, this usually meant getting as much out of the soil as possible before it lost its fertility. The first European American farmer came to the Poynette area in 1838 and settled in the town of Lowville. The first major crop was wheat. Thus was the beginning of more than 150 years of a farming tradition in the area.

Because the area was a large producer of grain, an enterprising man by the name of A.P. Smith had the idea to dam Rowan Creek for a milling operation. In 1858 Smith built a gristmill and dam on Rowan Creek near the site currently occupied by the wastewater-treatment plant in Poynette. In 1867 a second mill was built farther upstream and was commonly known as the upper mill. The two dams were washed out in 1905 by floodwaters. The upper dam was never rebuilt, but the lower dam became a source of hydroelectric power in 1914 and continued to exist until its removal in 1940. Remnants of the lower dam are visible from the walking path between the wastewater-treatment plant and Paquette Park.

Many of the settlers who came to southern Wisconsin were from northern Europe, where farming practices were more aggressive than those needed in the previously untilled soil of Wisconsin. Little was known about conservation practices at this time, and these European practices caused severe soil erosion. Many farmers employed practices that included plowing the furrows in their fields 3 feet apart and against the slope of the land as well as letting livestock graze in the creek bed. These practices led to intense floods, frequent gully formation, valleys becoming less fertile because of the excess soil washing down from the uplands, and clogged streams with no trout (Helms, 1992). An early American example of the effects of pioneer land practices was given by one colonial naturalist, John Bartram, who noted in New England that pasturing the woodland caused little hollows which "wear to ye sand and clay which bears it away with ye swift current down to brooks and banks as it flows" (Helms, 1988).

The federal government initiated land-conservation efforts in the late 1800s by purchasing land to create federal forest reserves that would provide watershed protection. Formalized in the Weeks Act of 1911, the act permitted land purchases that would create national forests where forest cover influenced streamflow (Helms, 1988). In 1935, the Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS), became a federal agency under the Department of Agriculture. Its main purpose was to prevent the soil erosion that was destroying agricultural productivity by recommending land-conservation practices to farmers. These practices included contour farming, crop rotation, and growing grass swales within the fields where excessive drainage occurred. One watershed that was used as a test site for conservation practices was the Coon Valley watershed in southwestern Wisconsin. A restudy of this area in 1982 found that practices introduced by the SCS in the 1930s reduced soil erosion by 75 percent with only a 6 percent reduction in cropland (Helms, 1992). Many of these practices have since been introduced nationwide.

The WDNR also became an active player in the preservation of the creeks and their adjacent lands. Agency activities include purchasing stream frontage, monitoring and stocking fish populations, and promoting better management practices within the watershed.

The Present

Today, Rowan Creek and its tributary Hinkson Creek are high quality water resources. Evidence of the earlier abuse to the creek and surrounding watershed has been largely mitigated by time and the efforts of the SCS/NRCS. Improvements continue with efforts from the NRCS, WDNR, and citizen advocacy groups such as Trout Unlimited, Friends of Rowan Creek, and others. To get an idea of where the Rowan Creek Watershed fits into a comparison of healthy or unhealthy watersheds, and to document current conditions, we studied several parameters of the stream over a three-month period. The 15 sites chosen for data collection are described in table 3.1 and illustrated in figure 3.1.

Stream Characteristics: Physical Parameters

Streamflow

Streamflow is defined as the volume of water that moves past a designated location on a stream in a fixed period of time. A function of water velocity, streamflow is important because of its impact on water quality. Flow determines which organisms can live within the water, the amount of sediment carried in the stream, and the amount of dissolved oxygen present. Over time, changes in land use within a watershed can alter the flow of a stream.

Table 3.1. *Descriptions of stream-monitoring sites.*

Site	Location	Measured parameter: Temperature	Flow	Nutrients	pH/ Conductivity
1	Intersection of Highway J and Rowan Creek, 100 feet downstream of bridge	X	X		X
2	Intersection of Kent Road and Hinkson Creek, 20 feet upstream of bridge	X	X	X	X
3	0.25 mile north of Branton Road cul-de-sac, 50 feet upstream on Hinkson Creek	X	X		X
4	Intersection of McMillan Road and Hinkson Creek, 20 feet downstream of bridge	X	X	X	X
5	Intersection of Thompson Road and Hinkson Creek, 10 feet upstream of bridge	X	X		X
6	North of Kent Road, upstream of intersection of railroad tracks and Hinkson Creek, 20 feet upstream from bridge	X	X		X
7	Same location as Site 6, except 20 feet downstream of bridge on Hinkson Creek	X	X		X
8	1.5 miles east of I-94 on Highway CS at DNR land. From parking lot on north side of Highway CS, walk on trail to bridge across Rowan Creek. Measurements taken upstream and downstream of bridge.	X	X	X	X
9	0.5 mile east of Site 8 at Jamieson (Muir) Park off of Highway CS. Follow footpath north to Rowan Creek from NW corner of drive and then downstream 100 feet.	X	X		X
10	30 feet upstream of mill dam on Rowan Creek	X	X	X	X
11	50 feet downstream of wastewater-treatment plant tributary on Rowan Creek	X	X	X	X
12	From East Street directly south to Rowan Creek and upstream approximately 30 feet	X	X		X
13	Intersection of Loveland Road and Rowan Creek, south of bridge	X	X	X	X
14	Intersection of Goosepond Road and Rowan Creek, west of bridge	X	X	X	X
15	From Loveland Road at power lines, approximately 300 feet north to Rowan Creek	X	X	X	X

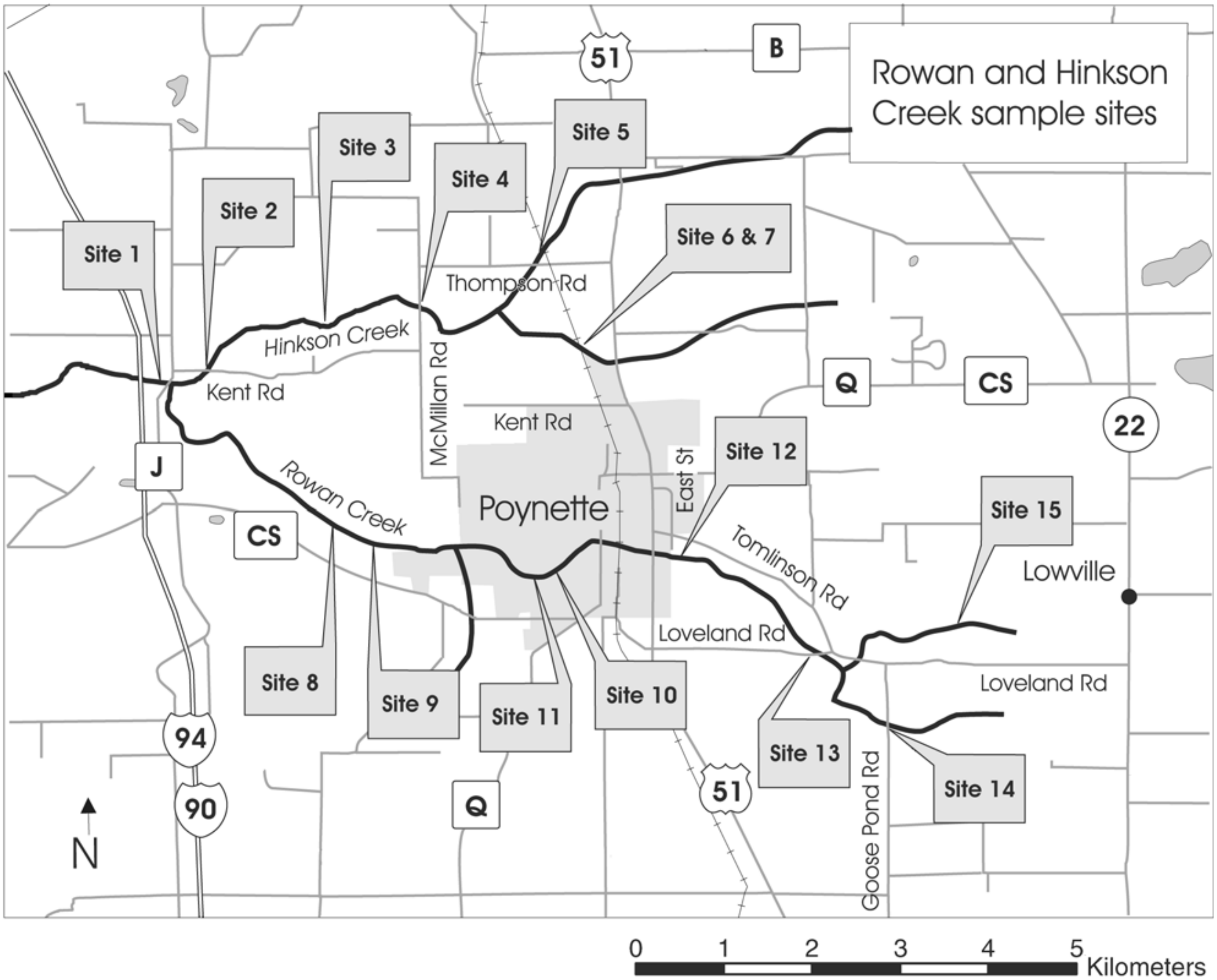

Figure 3.1. *Locations of 15 stream-monitoring sites on Rowan and Hinkson Creeks.*

Water contributing to flow in a stream comes from two sources: water contributed by groundwater (*baseflow*) and surface runoff (*stormflow*) from rainfall events. Baseflow is a more consistent supplier of water to a stream because surface-runoff amounts are greatly affected by the variability of precipitation. Baseflow is supplied to a stream by either seepages or springs, areas in which groundwater becomes surface water. Because the water supply to springs and seepages depends on groundwater, the amount of baseflow being supplied to the stream can change as an area becomes more developed. One of the greatest impacts on groundwater supply is from the drilling and subsequent pumping of private and municipal wells. Furthermore, as an area becomes developed, less water infiltrates the ground and recharges groundwater because of the increased amount of impervious area present in the watershed. If the amount of water removed from the aquifer increases to a point that results in the lowering of the water table, the springs and seepages will release less water and the baseflow of the stream will become lower. Sometimes an area becomes so developed that the springs and streams dry up completely. An additional consequence of altered hydrology is excessive flooding during storm events.

Table 3.2. *Measured streamflows under baseflow conditions in cubic feet per second (cfs) and annual baseflows in inches per year.*

		4/4/2002		7/12/2002	
Site	**Creek**	**cfs**	**in/yr**	**cfs**	**in/yr**
1	Rowan	35.08	8.88	29.65	7.51
2	Hinkson	10.53	8.59	7.39	6.03
3	Hinkson	7.03	6.42	5.28	4.82
4	Hinkson	4.86	4.70	3.32	3.21
5	Hinkson	1.85	3.95	0.65	1.39
6	Hinkson	1.25	7.58	0.67	4.06
8	Rowan	21.94	12.49	21.45	12.21
9	Rowan	19.48	11.84	19.42	11.80
11	Rowan	10.23	12.90	8.92	11.25
12	Rowan	9.38	12.62	8.1	10.89
13	Rowan	4.35	6.82	4.41	6.91
14	Rowan	1.08	4.20	0.86	3.35
15	Rowan	0.56	1.81	0.36	1.16

To gain a better understanding of the present flow conditions in Rowan and Hinkson Creeks and to contribute baseline data for future research and monitoring, we took flow measurements at 15 sites along the stream channel on two occasions. We took the flow measurements when the streams were in baseflow conditions, meaning that the main supply of water to the creeks was from groundwater. The only surface-water contribution to flow in Rowan Creek at the time of measurement would be that provided by the discharge from the wastewater-treatment plant. Table 3.2 contains the measured baseflow at each site on two occasions. For more information about the methods used to gather these data, please see Appendix A.

We also compared the flows obtained on Rowan Creek as part of this study and flows obtained by the U.S. Geological Survey (USGS) for a similar stream, Black Earth Creek in Dane County, Wisconsin. We chose Black Earth Creek for comparison because it has similar characteristics in drainage area, streambed slope, water storage within the watershed, forested area, soil permeability, and annual precipitation. The streamflow gage on Black Earth Creek, which has been recording daily streamflow since 1954, indicates an average daily streamflow at this site of 36 cubic feet per second over an area of 45.6 square miles. This represents about 11 inches of streamflow per year. Of these 11 inches, about 84 percent, or 9 inches per year, is baseflow (W.A. Gebert, U.S. Geological Survey, written communication, 2002).

The baseflow rates of 12 to 13 inches per year we measured at sites 8 through 12 on Rowan Creek (fig. 3.2) are much higher than the typical rates observed in this part of Wisconsin and particularly the rates measured in

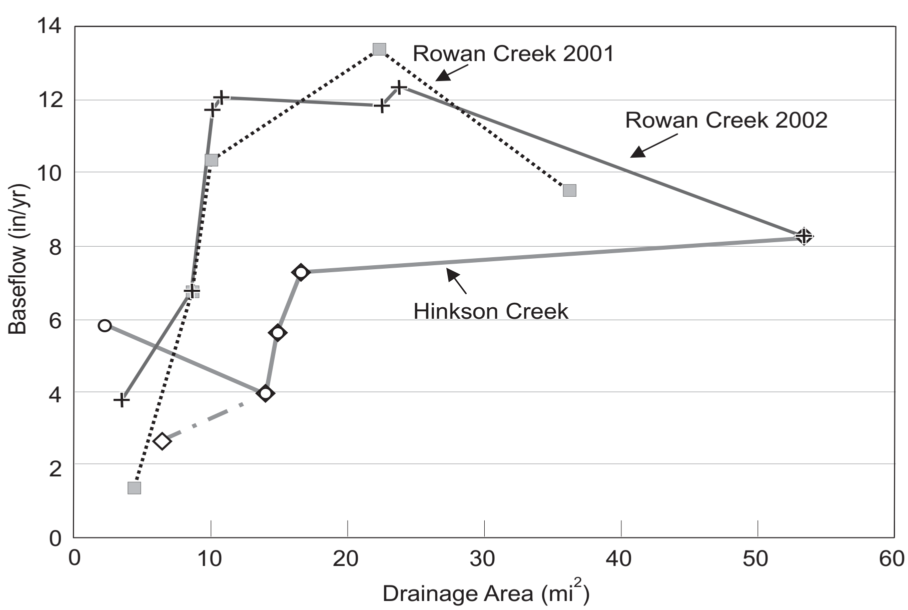

Figure 3.2. *Baseflow as a function of drainage area, Rowan and Hinkson Creeks. Rowan Creek 2001 data were collected by the WDNR.*

nearby Black Earth Creek (W.A. Gebert, U.S. Geological Survey, written communication, 2002). This may indicate that baseflow in Rowan Creek is partly supplied by groundwater recharge occurring outside of the watershed. One possible source of this water is the area of *closed watersheds* (watersheds that do not have a surface outlet for the water to escape) south of the Rowan Creek Watershed. The surface water in a closed watershed either evaporates or infiltrates into the ground. Schoenberg Marsh and Goose Pond, located just south of the Rowan Creek Watershed, are two closed watersheds that may be contributing groundwater flow to Rowan Creek. If they are, it would help explain the higher amount of baseflow near sites 8 through 12. Due to their proximity to this reach of Rowan Creek, these two watersheds, as well as any other closed watersheds in the vicinity, should be investigated further because of the potential for land-use changes to have an impact on their contributions to Rowan Creek.

What does this mean for the Rowan Creek Watershed? The areas with the greatest amount of contribution to flow at site 1 most likely have the highest amount of springs and seepages located within them and represent the best areas for high rates of groundwater recharge. These areas are also the most vulnerable to urbanization and should be watched most closely in the future.

Water Temperature

Water temperature is influenced by a variety of factors including air temperature, stream width and depth, proximity to and discharge rate of springs or seepages, stream grade, and riparian vegetation. Temperature influences many biological and chemical processes in streams. As water temperature increases, its ability to hold dissolved oxygen decreases, the rate of metabolism for aquatic plants and animals increases, and the sensitivity of organisms to toxic substances, parasites, and disease may be enhanced (U.S. Environmental Protection Agency, 1997).

The effects of varying temperature are even more critical in cold-water trout streams such as Rowan and Hinkson Creeks. Cold-water fish species, such as brook and brown trout, can only survive in a narrow thermal range. According to the WDNR, the preferred temperature range for brown trout is from 65° to 75° Fahrenheit (Wisconsin Department of Natural Resources, 1985a) and for brook trout is from 53° to 57° Fahrenheit (Wisconsin Department of Natural Resources, 1985b).

Although natural variations in temperature occur daily and seasonally in most streams, prolonged periods of time outside of a species' tolerance range may be fatal to that population. In general, stream-water temperature above 75° Fahrenheit is considered uninhabitable for brook trout (U.S. Environmental Protection Agency, 1997). Similarly, spawning and reproduction are temperature dependent and vary among species. For example, according to the U.S. Environmental Protection Agency (1997), brook trout require a maximum weekly average temperature of 48° Fahrenheit to spawn.

Land-use activities related to urban development can contribute to increased stream temperatures. A leading cause of warmer stream-water temperatures is an increase in the amount of impervious surface close to a stream. As stormwater moves over rooftops and asphalt pavement, for example, heat transfers from these surfaces to the runoff water. Then, because of the increased impervious surface area, the warmed runoff has a greater chance of flowing directly into the stream rather than infiltrating into the soil. Also, because less water is infiltrating into the ground in this kind of situation, baseflow in the stream can decrease over time.

Another way that stream temperature can be affected by development is by the removal of vegetation growing adjacent to the stream. This so-called *riparian vegetation* normally shades the stream from direct sunlight and prevents excessive warming. The combination of shallower water arising from diminished infiltration and less shade-generating streambank vegetation can significantly raise the water temperature of a stream.

Trends

To gain a better understanding of the current condition of Rowan and Hinkson Creeks, and to provide a baseline dataset for future use, we collected water-temperature data at 15 sites along the two creeks from May 28 to July 11, 2002. We collected additional data at some sites over shorter periods during April and May. Table 3.3 summarizes the data collected from May through July.

An analysis of the temperature data reveals a number of trends. They include daily stream temperature oscillations over different ranges at different locations, cooler water temperatures and narrower daily temperature ranges in headwater reaches compared to reaches farther downstream, and cooler water temperatures and narrower daily temperature ranges in Rowan Creek as compared to Hinkson Creek.

Like most small streams, Rowan and Hinkson Creeks experience daily temperature fluctuations. Water temperatures peak in the late afternoon, after being warmed by the ambient air temperature and radiant energy from the sun, and they are coldest just before dawn. Colder morning water temperatures are the combined result of cooler air temperatures and the naturally cool temperatures of groundwater discharging into the creek. Having a near-constant temperature around 50° Fahrenheit, groundwater discharge not only maintains the baseflow of both creeks, it also helps to maintain the cold-water fishery.

Figure 3.3 illustrates the daily temperature fluctuations at four locations on Rowan Creek (sites 2 and 6) and Hinkson Creek (sites 8 and 10). Daily water temperature oscillations were observed at all 15 sites in this study; however, the range varied considerably among the sites. For example, sites 6, 8, and 10 had a 10-degree difference between the daily high and low water temperature for the period from July 1 to July 7. During this same period, site 2 experienced nearly twice the daily temperature oscillation. Of further interest is the fact that the water temperature at sites 6 and 10 did not exceed 70° Fahrenheit, but the temperature at site 2 was nearly always greater than 70° Fahrenheit during this period and the temperature at site 2 peaked above 80° Fahrenheit for six of the seven days of record. These observations are of significance to parties interested in maintaining a trout fishery because 70° to

Table 3.3. *Summary of water-temperature data for 15 sites on Rowan and Hinkson Creeks, collected May 28 to July 11, 2002.*

Hinkson Creek

Site	Drainage area (mi²)	Average temperature (°F)	Maximum temperature (°F)	Average daily maximum (°F)	Average daily minimum (°F)
7	n/a	61.01	73.15	64.88	57.36
6	2.24	61.33	69.02	65.51	57.42
5	6.37	63.67	75.92	70.06	59.07
4	14.05	63.12	75.92	69.12	57.50
3	14.87	65.22	82.24	72.70	59.26
2	16.66	66.90	84.38	75.06	60.07

Rowan Creek

Site	Drainage area (mi²)	Average temperature (°F)	Maximum temperature (°F)	Average daily maximum (°F)	Average daily minimum (°F)
15	4.50	67.54	81.53	75.44	60.83
14	3.49	56.94	66.28	61.20	54.22
13	8.67	58.24	68.33	63.92	54.09
12	10.10	58.16	66.96	62.85	54.02
11	10.77	58.01	73.15	60.54	55.15
10	n/a	58.46	72.46	61.79	54.83
9	22.35	60.17	70.30	64.96	56.14
8	23.86	64.77	75.22	68.40	61.24
1	53.65	66.31	75.92	69.65	61.08

75° Fahrenheit is a threshold for trout, especially for the more temperature-sensitive native brook trout, which is found in Hinkson Creek.

Our temperature data also reveal that Rowan Creek has cooler water on average than Hinkson Creek. This observation may appear surprising because brook trout are found in Hinkson Creek but not Rowan Creek; however, Hinkson Creek's water moves more slowly due to its shallow slope. Hinkson Creek only drops 4 feet per mile from its headwaters to its confluence with Rowan Creek just east of County Highway J. Slow-moving water has more time to be warmed by the sun and the overlying air. The low volume and shallowness of the water in Hinkson Creek also contribute to its daily warming because they cause a greater fraction of the stream's water to be at the air–water interface where warming occurs. Rowan Creek, on the other hand, has a steeper grade, higher water velocity, greater volume of water, and greater depth that minimize the warming effects of the sun and air temperature. Between its headwaters and the Village of Poynette, Rowan Creek drops approximately 200 feet, or nearly 35 feet per mile.

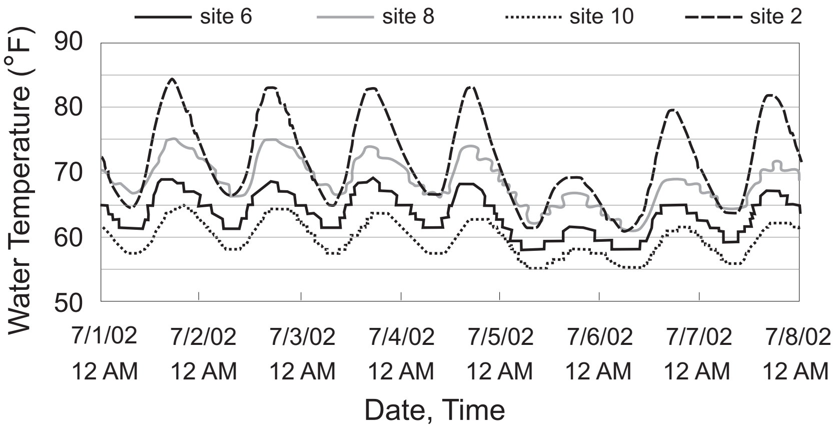

Figure 3.3. *Water-temperature recordings at four sites on Rowan and Hinkson Creeks, July 1–8, 2002.*

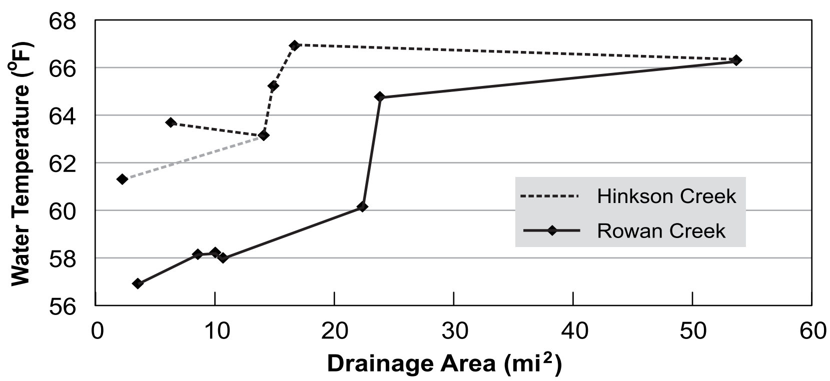

Figure 3.4. *Water temperature as a function of drainage area, Rowan and Hinkson Creeks.*

Not surprisingly, the headwater reaches of both creeks feature cooler water temperatures than reaches farther downstream. Upstream from Highway 51, the average water temperature in Rowan Creek was 58° Fahrenheit during the period from May 28 to July 11, 2002. The average water temperatures during this period were 60° and 64° Fahrenheit, respectively, at Jamieson (Muir) Park and the Rowan Creek Fishery Area off County Highway CS. We observed the same general trend for Hinkson Creek, where headwater temperatures were in the range of 61° to 63° Fahrenheit and average temperatures at the crossing of Kent Road, just upstream from the confluence with Rowan Creek, were around 67° Fahrenheit.

Figure 3.4 illustrates how average water temperatures changed as a function of drainage area for Rowan and Hinkson Creeks. Cooler water temperatures in upstream reaches are due primarily to the proximity of these areas to springs and seepages where groundwater discharge occurs. The cold water discharged in upstream reaches is warmed by the air and sun as it moves downstream. This highlights the importance of riparian vegetation that can provide shade to protect from excessive warming. However, springs and seepages are not solely located in the headwater regions of streams. For example, groundwater from a large grouping of springs near the Village of Poynette helps to maintain the cool water temperature of Rowan Creek. Only after the creek passes through the village and this region of abundant springs does the water temperature begin to rise. In the vicinity of the wastewater-treatment plant, water temperature in the creek is negligibly warmer than in upstream reaches. Farther downstream, water temperature begins to warm considerably, increasing from 58.5° Fahrenheit at site 10 to 64.8° Fahrenheit at site 8 in a little more than 1 stream mile.

Stream Cross Sections

Stream morphology, or the way that a stream channel is shaped, is a good indicator of how much change has occurred within a watershed. Morphology is controlled by two main factors, the amount of sediment and organic matter that the stream carries, and the amount and velocity of the water it carries. We recommend that one of the major stakeholders make it a priority to measure cross sections along the stream to establish a baseline for future reference. Then, by measuring the stream morphology over a period of years, the amount and location of erosion and deposition can be tracked, along with channel stability. Systematic changes in channel morphology may indicate human impacts. For example, urbanization can lead to channel enlargement unless suitable stormwater-management practices are adopted.

Streambed Material and Deposition

The material that makes up a stream bottom can include silt, sand, cobbles, boulders, and organic matter. The nature of this material influences many characteristics of a stream. Finer sediments, such as sand and silt, are generally the least favorable substrates for supporting aquatic organisms. Higher densities and greater abundances of organisms are found where gravel or cobbles are present (Odum, 1971). Although much of the material in a given streambed comes from the stream channel itself, additional sediment can enter a stream from eroded land within its watershed. When sufficient rainfall occurs to produce runoff, soil particles may erode from plowed fields, construction sites, and other unprotected areas and enter into streams. These suspended sediments eventually settle onto the stream bottom. When sediment accumulates, negative impacts can take place: The sediment may clog fish gills, suffocate fish eggs and aquatic insect larvae, and fill in the pore spaces between bottom cobbles where fish normally lay their eggs. In addition, the sediment may carry pollutants, such as nutrients or toxic chemicals, which may settle with the sediment or become dissolved in the water.

Observations made as part of this study showed that areas in the stream that have lower flow rates generally contained fine sand and silt; stretches that have higher flows had a variety of larger material including gravel, cobbles, and boulders. Water moving at a lower velocity allows for more particles to settle as compared with faster moving water. High-velocity reaches also reduce opportunities for settling and scour away any sediment that may have previously settled.

Bridges and culverts also have an effect on sediment in streams. The restricted openings of these structures cause water to obtain unnaturally high velocities while passing through them during and immediately after rain events. Water moves at a high rate in a culvert, but the velocity instantly decreases upon exit. The energy released by the dissipation of the velocity gained in the culvert is absorbed by the streambed directly below the culvert's opening. This action disturbs sediment and eventually creates large scour holes. During low flow periods, when water moves through culverts at lower velocities, the presence of these large holes slows the water down sufficiently for sediment to deposit around and just downstream of the hole.

It is the current policy of the Wisconsin Department of Transportation to build structures to be able to convey a 100-year storm, a storm whose magnitude is expected once on average every 100 years, and not to build any structure that would cause worse backwater effects than the structure already in place. However, most of the structures in the Rowan Creek Watershed were built before this policy was put into effect; therefore, many negative effects associated with their design are evident. During large storms the current structures cannot adequately convey the creeks' flow. The constricted bridge and culvert openings cause water to back up far upstream, and they cause sustained high velocities within the structures. As a result, scour holes are created downstream of these structures.

We conducted a survey as part of this study of all bridges and culverts in the Rowan Creek Watershed located east of Interstate 90/94 to determine their effect on sediment deposition. The survey found that many of the culverts in the watershed have large scour holes located directly downstream of the structure. These observations suggest that sediment deposition is occurring. At many locations, the depth of the water was too deep to be measured with our equipment. We measured the depth of sediment deposition downstream of those culverts in which large scour holes were not present. The typical sediment depth was between 4 and 10 inches. The presence of scour holes and the results from the sediment measurements suggest that there is significant erosion and sediment deposition taking place in Rowan and Hinkson Creeks. Continued efforts should be made to monitor and control the amount of sedimentation occurring in the Rowan Creek Watershed to help maintain and improve the condition of Rowan and Hinkson Creeks.

Stream Characteristics: Biological Parameters

To determine the general condition of an aquatic ecosystem, scientists or citizen advocacy groups can sample for fish and invertebrates living in a stream and use them as biological indicators of aquatic health. Because aquatic insects and their larvae have limited tolerances for water pollutants, the variety of pollution-sensitive and pollution-tolerant species in a given stream reach can indicate the level of water quality. In addition, the presence of brook trout and sculpin, species with a limited tolerance for warm water, identify a creek such as Rowan Creek or Hinkson Creek as a cold-water resource.

Several procedures have been developed to evaluate the biological integrity of an aquatic ecosystem. The Index of Biotic Integrity (IBI; Karr, 1981; U.S. Environmental Protection Agency, 2002) and the Hilsenhoff Biotic Index (HBI; Hilsenhoff, 1977) are commonly used by scientists and resource managers. The IBI and the HBI are quantitative measures of ecosystem health that can be used to compare two or more streams or the same stream at different times. In assessing biological quality, the IBI considers species abundance, food-chain composition, reproductive function, and fish abundance. A high index score indicates a minimally disturbed fish community; a lower score suggests low ecosystem health or greater disturbance to ecosystem structure. Unlike the IBI, which relies mostly on fish species, the HBI uses aquatic arthropods to evaluate water quality. These organisms are useful as indicators because they are common in most streams, easily collected, not very mobile, relatively easy to identify, and have life cycles up to a year or longer (Hilsenhoff, 1977). The tolerance value (ranging from 0 for species most sensitive to low dissolved oxygen concentrations to 10 for species with less sensitivity) for each species observed is recorded and a stream tolerance value is determined. Table 3.4 includes the biotic index values for the 1982 HBI values and the updated 1987 HBI values. Developed at the University of Wisconsin–Madison, the HBI has been used by WDNR since 1979 to assess water quality in streams and rivers as part of its nonpoint pollution monitoring programs (Shepard, 2002).

Table 3.4. *Water-quality classifications for the Hilsenhoff Biotic Index (Hilsenhoff, 1987).*

Hilsenhoff Biotic Index (1982)

HBI Value	Water-quality classification
0.00 - 1.75	Excellent
1.76 - 2.25	Very good
2.26 - 2.75	Good
2.76 - 3.50	Fair
3.51 - 4.25	Poor
4.26 - 5.00	Very poor

Current (1987)
Hilsenhoff Biotic Index

HBI Value	Water-quality classification
0.00 - 3.50	Excellent
3.51 - 4.50	Very good
4.51 - 5.50	Good
5.51 - 6.50	Fair
6.51 - 7.50	Fairly poor
7.51 - 8.50	Poor
8.51 - 10.00	Very poor

Community-based stream monitoring methods that use aquatic insects in water-quality assessment have also been developed. The Water Action Volunteer (WAV) program, a joint venture of the University of Wisconsin–Extension and the WDNR, has developed an index similar to the HBI that quantifies stream water quality. Similar to methods used in other states, this method (see Appendix A) groups invertebrates into four categories with respect to their sensitivity or tolerance to pollutants. The abundance (total number) of each insect type is less important than the diversity (number of different types of insects) within a sample. For example, a sample that has one mayfly nymph will be scored exactly the same as a sample in which 100 mayfly nymphs are identified. The numbers of different types of invertebrates in each group (1 = sensitive, 2 = semi-sensitive, 3 = semi-tolerant, 4 = tolerant) are totaled and the sample is given an index value. Stream health is determined by comparing the index score to the following scale: Excellent (3.6+), Good (2.6 – 3.5), Fair (2.1 – 2.5), and Poor (1.0 – 2.0).

Fish

Fish are sensitive to water temperature and the nutrient content of a stream. If changes occur that alter these factors, a related change in fish population and diversity may result. Many streams in Wisconsin and elsewhere have been altered by the addition of exotic species to provide a better sport-fishing stream. For example, brown trout were introduced into Wisconsin waters nearly a century ago (U.S. Geological Survey, 2002) and are annually added to Rowan Creek (T. Larson, Wisconsin Department of Natural Resources, oral and written communications, 2002). Management decisions may involve a balance between maintaining a healthy stream ecosystem and supporting a viable sport fishery that may include an exotic species like the brown trout. In this study, we examined fish data to evaluate the current and recent past status of the trout fisheries in Rowan and Hinkson Creeks.

Rowan Creek

Rowan Creek has been known as a good trout stream for the past 100 years. During the 1960s, the WDNR ranked the creek first in Columbia County for trout fishing. Currently, the upper reaches of the stream are designated by WDNR as Class I; the lower 8 miles are designated as Class II (Wisconsin Department of Natural Resources, 2002). Table 3.5 provides the WDNR's trout stream classification system.

Table 3.5. *Wisconsin Department of Natural Resources trout stream classifications.*

Classification	Definition
Class 1	These are high quality trout waters, have sufficient natural reproduction to sustain populations of wild trout at or near carry capacity. Consequently, streams in this category require no stocking of hatchery trout. These streams or stream sections are often small and may contain small or slow-growing trout, especially in the headwaters.
Class 2	Streams in this classification may have some natural reproduction, but not enough to utilize available food and space. Therefore, stocking is required to maintain a desirable sport fishery. These streams have good survival and carryover of adult trout, often producing some fish larger than average size.
Class 3	These waters are marginal trout habitat with no natural reproduction occurring. They require annual stocking of trout to provide trout fishing. Generally, there is no carryover of trout from one year to the next.

In addition, the upper 4 miles provide good spawning habitat for trout. Over the past 20 years, the building of overbanks and the installation of riprap along the streambank have enhanced this habitat. To help maintain the fishery, WDNR stocks the creek with brown trout and rainbow trout. Currently, 9,000 wild-strain brown trout fingerlings are annually added; that number is due to increase to 12,800 in upcoming years (T. Larson, Wisconsin Department of Natural Resources, oral and written communications, 2002). Until recently, the WDNR annually added 1,200 rainbow trout fingerlings to the creek; however, this stocking has been discontinued. Because natural spawning of brown trout occurs predominantly in the upper reaches, the WDNR only stocks trout in the lower reaches of the creek.

Trout favor a habitat that has cold water temperatures that remain relatively constant throughout the year. Rowan Creek has a stable temperature regime, maintained by a high number of springs that provide constant flow and near constant temperature. In addition, the presence of gravel and rubble in the streambed is ideal for spawning. The upper reaches of the creek fit these requirements; the lower sections have more sand and silt because of a slower current. The satisfactory thermal regime and presence of spawning habitat help to sustain the trout fishery in Rowan Creek.

The WDNR management plans for Rowan Creek call for maintaining good trout stream conditions. Current and past actions have included purchasing land parcels adjacent to the creek to reduce agricultural and urban runoff that otherwise would flow into the stream. The WDNR management also includes the continuation of habitat improvement efforts similar to those previously described.

Trout provide a good basis of comparison to observe how the creek might have changed over time because trout were the focus of most fish surveys. Fish surveys

Table 3.6. *Results of historic fish surveys of Rowan Creek.*

Year	Brown trout	Brook trout	White sucker
1963	38	0	common
1965	460	1	abundant
1966	185	0	abundant
1979	2,644	NA	NA
1980	1,249	NA	NA
1981	1,546	NA	NA
1982	2,115	NA	NA
1983	1,847	NA	NA
1984	1,179	NA	NA
1992	1,573	NA	NA
1995	84	1	55

were consistently performed in the reach immediately downstream of the snowmobile bridge off Tomlinson Road (sec. 36, T11N, R9E). Fish surveys from the late 1970s through the early 1990s, shown in table 3.6, revealed a near-absence of brook trout from this reach of Rowan Creek, but a relatively large brown trout population with numbers in excess of 1,000. The 1995 fish survey, the most recent one, netted only 85 trout. A reassessment of the trout population in this stretch of Rowan Creek might be in order.

In addition to trout, other fish species observed in the stream included mottled sculpin, creek chub, muddler, northern pike, musky, mudminnow, golden shiner, largemouth bass, chestnut lamprey larvae, blacknose dace, Michigan brook lamprey, Johnny darter, central common shiner, and fantail darter.

As part of the fish surveys, the WDNR annually assessed Rowan Creek from 1994 to 1999 using the IBI. This reach consistently scored an index value of 50 to 70, indicating a “fair” to “good” cold-water stream.

Hinkson Creek

Hinkson Creek is a tributary of Rowan Creek that extends 6 miles upstream from the confluence of the two creeks. Recognized as one of the few fishable brook trout populations in the region, Hinkson Creek is managed primarily as a trout fishery. Natural reproduction and *recruitment* (the process by which members of a species become part of the reproducing population) occur in the creek’s headwaters; however, heavy downstream fishing pressure requires annual stocking to maintain the fishery. From 1954 to 1978, 1,500 yearling brook trout were annually added to the creek. Currently, 1,200 wild strain brook trout fingerlings are added each spring (T. Larson, Wisconsin Department of Natural Resources, oral and written communications, 2002). This stocking of brook trout fingerlings takes place below MacMillan Road, where natural reproduction does not occur. Sufficient food and cover in Hinkson Creek enable brook trout to survive and grow upwards of 14 inches. The high-quality fishery is supported by abundant springs and surrounding wetlands. These two features respectively maintain cooler temperatures required by brook trout and high water quality.

The most recent fish survey of Hinkson Creek was conducted by the WDNR in 1992. A 1.3-mile reach extending upstream from the MacMillan Road crossing was examined. The survey netted 181 brook trout ranging from less than 3 inches to 10.9 inches. Fingerlings were the most frequent age class captured. Fish surveys of the creek were conducted by the WDNR in 1985, 1976, 1967, and 1952. In addition to brook trout, the fish surveys identified 14 other species, of which minnow and suck-

Table 3.7. *Results of the 1976 fish survey of Hinkson Creek.*

Species	Total	Percentage
White sucker	248	46.9
Sculpin	110	20.8
Pearl dace	128	24.2
Mud minnow	28	5.3
Redbelly dace	8	1.5
Creek chub	2	0.4
Fathead minnow	5	0.9

er species were most prevalent. Common species included the white sucker, northern muddler, creek chub, pearl dace, sculpin, mud minnow, and fathead minnow. The 1976 fish survey (table 3.7) indicated that white sucker, pearl dace, and sculpin were the most abundant non-trout species, representing 92 percent of total; other fish species were less common. Collectively, the WDNR reports indicate that the species present have remained relatively unchanged over time.

Causes of differences

Hinkson Creek carries warmer water than Rowan Creek. In addition, Hinkson Creek supports a natural population of brook trout; Rowan Creek does not. This is surprising, considering that brook trout require colder water than brown trout (J. Magnuson [emeritus], University of Wisconsin–Madison, Center for Limnology, oral communication, 2002). On the basis of these findings, one would expect to find brook trout in Rowan Creek rather than Hinkson Creek. These findings raise two questions: Why are brook trout not found in the colder waters of Rowan Creek, and more important, why are brown trout unable to successfully colonize Hinkson Creek?

The first question is relatively easy to answer. Introduced from Europe to support a trout fishery, brown trout are more tolerant of warmer water temperature than brook trout. In addition, brown trout are voracious feeders and superior competitors compared to the native brook trout. Once established, brown trout readily out-compete brook trout, the likely explanation for the absence of brook trout in the colder waters of Rowan Creek.

An answer to the second question is more speculative. A possibility is that the warmer water in the lower reaches of Hinkson Creek forms a temperature block, preventing colonization by brown trout. As this shallow-water creek meanders through an extensive wetland complex, the water is warmed, creating a zone of warmer water near the end of Hinkson Creek where it runs into Rowan Creek. We suggest that this warmer water acts as a barrier, restricting the brook trout population to the colder upstream reaches of Hinkson Creek and effectively blocking the brown trout in Rowan Creek from migrating into Hinkson Creek. The distribution of brook trout and brown trout fisheries in Hinkson and Rowan Creeks, respectively, highlights the importance of a fishery-management plan that should be aimed at conserving these two important, but isolated, local resources.

Macroinvertebrates

A macroinvertebrate survey may also be used to evaluate the water quality of a stream. This survey relies on the presence of invertebrates such as aquatic insects and larvae, freshwater clams and snails, and other arthropods that may be collected among gravelly bottom sediments. Similar to brook trout with their limited tolerance for warm water temperature, some varieties of insect larvae and nymphs have limited tolerance to water-borne pollutants. Those most sensitive to pollutants include the dobsonfly larva, water snipe fly larva, alderfly larva, and stonefly nymph. Other invertebrates, such as the pouch snail, aquatic sowbug, bloodworm midge larva, leech, and tubifex worm, are quite tolerant of pollutants.

Invertebrate sampling was conducted in 1980 as part of the Southern District Basin Assessment Survey Program. Water samples were collected on Rowan Creek upstream, near, and downstream of the wastewater-treatment plant. The eight samples ranged from 1.83 to 2.53 on the Hilsenhoff Biotic Index (1982 values; see table 3.4), indicating good or very good water quality. Additional routine sampling was conducted by the WDNR between 1993 and 1998. Collected upstream of Highway 51, these samples ranged from 2.88 to 5.05 (1987 values; see table 3.4), indicating good to excellent water quality.

Using the WAV program methods, macroinvertebrate surveys were conducted at four locations on Rowan Creek on July 11, 2002: Reddemen property at Goosepond Road, Snowmobile Bridge at Tomlinson Road, Paquette Park at Main Street, and the wastewater plant at Mill Street. The survey was not conducted on Hinkson Creek due to the absence of suitable streambed material for invertebrate attachment at the monitoring sites. The results suggest that three sites have either fair or poor water quality, and one site, the Reddeman property, has good water quality (table 3.8).

These observations are inconsistent with the “good” to “excellent” water-quality determinations from the 1993 and 1998 surveys conducted by the WDNR. However, one should be careful about placing too much credence in our assessment. Macroinvertebrate surveys are routinely performed in the spring or fall to coincide

Table 3.8. *Results of macroinvertebrate survey for Rowan Creek.*

	Reddeman Property (Goosepond Road)	Snomobile Bridge (Tomlinson Road)	Paquette Park (Main Street)	Wastewater Plant (Mill Street)
Group 1: Sensitive				
Dobsonfly larva			X	
Group 2: Semi-sensitive				
Caddisfly larva	X	X	X	X
Damselfly nypmh	X		X	
Fingernail clam		X		X
Riffle beetle	X	X	X	
Group 3: Semi-tolerant				
Amphipod (scud)	X	X	X	X
Blackfly larva				X
Non-red midge larva	X	X		X
Snails			X	X
Group 4: Tolerant				
Leech				X
Pouch snail		X	X	X
Tubifex worm			X	X
Biotic Index	2.60	2.33	2.38	1.9

with the biological cycles (such as hatching) of indicator species. It is no coincidence that very few, actually only one, sensitive species was observed during our sampling. Had this survey been conducted earlier in the spring or later in the fall, we would expect a higher biotic index score for each of the locations. In addition, upstream bed material and riparian vegetation and cover may affect invertebrate diversity.

Nevertheless, our survey did reveal several interesting observations. First, high frequencies of semi-sensitive and semi-tolerant species were identified at these locations. Caddisfly nymphs and amphipods, observed in high frequencies, were identified in all locations; riffle beetles and non-red midge larva were found in all but one sampling location. Second, the biotic index scores tended to decrease as one travels downstream. Located in the creek's headwaters and just downstream from a large wetlands complex, the Reddeman site had the highest index. Its upstream location probably contributes to the high biotic score. The Paquette Park location provides excellent habitat for insect attachment, but scored a low index score. Although the timing of the sampling may have contributed to this low score, future sampling is recommended to determine whether this is in fact the case or its downstream location from the Village of Poynette is possibly the cause. Finally, the "poor" index score downstream from the wastewater-treatment plant warrants further attention. Again, the low score may be a function of the timing of sampling, but the location's high incidence of tolerant species and near absence of sensitive species raises questions about the impact of the treatment plant on the aquatic flora and fauna.

Stream Characteristics: Chemical Parameters

Nutrients

Nutrients are any substances that promote growth in living things. In streams and on land, they are the elements that help plants such as algae or corn grow. Because nitrogen and especially phosphorus significantly affect freshwater plant growth, they are generally considered "limiting" nutrients; their absence limits a plants ability to grow. When excessive amounts of nutrients are introduced to streams, either from natural or human sources, nuisance growth of algae and other aquatic plants may occur. This overgrowth results in the stream experiencing lowered dissolved oxygen levels, unsightly looks and odors, and poor habitat conditions for aquatic organisms. Nutrients in streams are derived from natural sources, which include rocks, soil, and decomposing plant or animal matter, but are augmented by soil erosion from construction sites, effluent from wastewater-treatment plants, leachate from failing septic systems, and urban and agricultural runoff that may include fertilizer or animal waste.

The primary source of phosphorus is from weathered rock. As the parent material weathers, its chemical constituents become incorporated into soil. Elements needed for plant nutrition later dissolve in water and are utilized by plants. The phosphorus cycle continues as animals eat the plants. Their waste (and eventually their decomposing bodies) returns the phosphorus back to the soil. Natural systems retain most phosphorus in land-based cycles; a limited amount of phosphorus is delivered to surface water. Cultural landscapes generate soil erosion or runoff from fertilized lawns or manure-applied agricultural fields, which deliver additional phosphorus to streams and lakes. Nutrient-laden runoff contributes to nuisance plant growth and eutrophication, the over-enrichment of surface water by nutrients.

Nitrogen as nitrogen gas (N_2) is found primarily in the atmosphere, where it composes 78 percent of the total gases. Before being assimilated by plants, nitrogen gas must first be converted into a usable form such as ammonium (NH_4^+) or nitrate (NO_3^{2-}). This conversion, known as *nitrogen fixation,* is facilitated by lightning or, more commonly, by specialized nitrogen-fixing bacteria. These bacteria live in the soil or water or may form root associations with leguminous plants such as soybeans, clover, alfalfa or peas. The nitrogen cycle continues as plants die and decompose. Nitrogen is released back to the soil where it may be reabsorbed by plants or converted back to nitrogen gas by other soil bacteria and released to the atmosphere. Similar to phosphorus, natural systems are mainly closed loops that have few nitrogen losses to surface water. Cultural additions are largely responsible for excess nitrogen found in lakes and streams.

Water-quality monitoring is often used to determine the nutrient levels found in streams. Because phosphorus and nitrogen can occur in various forms, several measures have been developed to measure these two elements. A common test for phosphorus is *total phosphorus* (TP), which measures particulate (associated with soil particles) and soluble phosphorus. The U.S. Environmental Protection Agency (USEPA) has established a desired goal of less than 0.1 milligrams per liter (mg/L) of TP to prevent the nuisance plant growth in streams. Nitrogen is usually measured in its nitrate form, which is the primary type of nitrogen dissolved in streams. The USGS recommends a nitrate “background nutrient concentration” of less than 0.6 mg/L. “Background nutrient concentration” represents the level of nitrate–nitrogen found in water taken from areas unaffected by human land use.

We collected and analyzed water samples to determine the present nutrient levels in Rowan and Hinkson Creeks and to see how they compare to other Wisconsin streams. Results from our sampling were compared to USGS data from 160 Wisconsin streams, including Rowan and Hinkson Creek and data obtained from the Poynette wastewater-treatment plant. The results show that Rowan and Hinkson Creeks have average TP and average nitrate-nitrogen levels that are below the USEPA and USGS standards and below the average for all tested Wisconsin streams. However, it was found that some samples collected from two sites exceeded the 0.1 mg/L USEPA TP standard (fig. 3.5). From site 11, just upstream of the wastewater-treatment plant, to site 10 just downstream of the plant, TP increased from 0.044 mg/L to 0.133 mg/L. Farther downstream at site 8, the TP measured 0.103 mg/L. Although they are just above the 0.1 mg/L standard, TP more than tripled just downstream of the wastewater-treatment plant compared to water samples collected upstream of this point. Also, data collected by the wastewater-treatment plant show that from January 2000 to April 2002, the average TP being released into the stream was 1.12 mg/L. (Note, however, that this release was diluted by the much greater

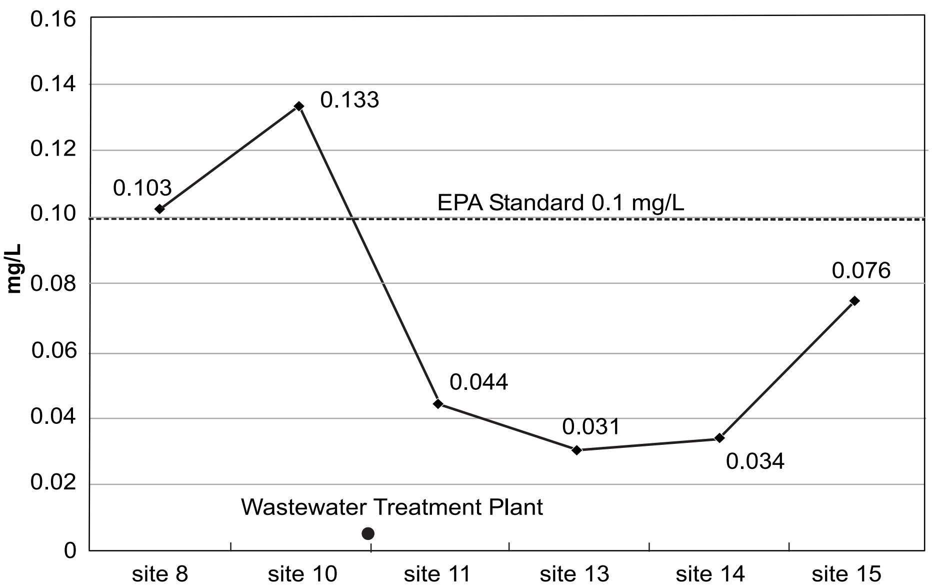

Figure 3.5. *Total phosphorus in Rowan Creek.*

flow in the stream.) In total, these results suggest that Rowan and Hinkson Creeks are not yet experiencing excessive nutrient levels, but continued monitoring is recommended. In particular, routine monitoring in the vicinity of the wastewater-treatment plant should be a priority.

pH

The *pH* of a liquid is a measure of the amount of hydrogen ions dissolved in it. Hydrogen ions are naturally found in liquids that contain water. This is due to the splitting of water molecules (H_2O) into hydrogen (H^+) and hydroxide (OH^-) ions. As a result, pure water has an equal amount of hydrogen and hydroxide ions and is said to be neutral. When liquids have more hydrogen than hydroxide ions they are said to be *acidic;* liquids that have more hydroxide ions are *alkaline.* The pH scale, which ranges from 1 to 14, is used to measure hydrogen ion concentrations. Pure water has a neutral pH of 7, acids have a pH less than seven, and alkaline liquids have a pH greater than 7.

Chemical and biological processes may add or remove hydrogen ions from solution and are responsible for changing the pH of a liquid. For example, water vapor condenses in the clouds to form water droplets that fall as rain. On their landward fall, raindrops dissolve some carbon dioxide, causing rainwater to become slightly acidic with a pH of 5.6, the natural pH of rainwater. Raindrops that also dissolve air pollutants such as dioxides of nitrogen and sulfur on their landward fall can produce acid rain, which has a pH less than 5.6. The local geology of a watershed may also influence the pH of stream water. The chemical makeup of surrounding bedrock may provide buffering action to help maintain the pH of water within a very narrow range.

Similar processes occur in streams. The amount of carbon dioxide dissolved in stream water influences pH. A higher amount of carbon dioxide results in lower pH and more acidic conditions. Carbon dioxide is naturally found dissolved in stream water; however, the amount that is dissolved is a function of biological activity. For example, the process of *photosynthesis,* a means by which green plants, algae, and some bacteria make their own food, extracts carbon dioxide from the stream during daylight hours. This activity reduces the amount of carbon dioxide in the water and increases pH. At night, pH levels begin to decrease as plants, aquatic animals, and bacteria generate carbon dioxide due to cellular respiration. A daily oscillation in

Table 3.9. *pH and conductivity measurements (in µS/cm at 82° F) for Rowan and Hinkson Creeks.*

Site	pH	Conductivity
1	8.02	562
2	8.06	479
3	8.00	512
4	7.92	438
5	7.83	537
6	7.79	478
7	7.77	541
8	8.12	580
9	8.14	605
10	8.00	669
11	8.04	584
12	8.01	582
13	8.03	555
14	7.77	644
15	8.01	684

the pH of stream water occurs as a result of these differences between the type and amount of biological activity that occurs in daylight and non-daylight hours.

We collected water samples at 15 sites on July 18, 2002, returned to the lab, and tested for pH. The results indicated the stream water was slightly basic (alkaline) when the grab samples were taken (table 3.9). Most readings hovered around pH 8. Although time and resources did not allow an exhaustive study of pH, future studies could include samples taken around the clock to get an indication of the daily range of pH values for the streams. An understanding of the pH is important because it determines the solubility and biological availability of nutrients (phosphorus, nitrogen, carbon), which may lead to eutrophication, and heavy metals (lead, cadmium, copper), which can be lethal to aquatic organisms.

Conductivity

Conductivity is a measure of the electrolyte content of water. In other words, it measures the ease with which an electric current can move through water. The more ions there are in solution, the more conductive the water. Conductivity can be used to help trace the source of natural waters; in this case, our relatively high conductivity values (table 3.9) point to the large extent to which these streams are fed by groundwater.

Watershed Characteristics

In addition to the important stream parameters just discussed, we also examined watershed characteristics that included land-cover type, impervious area cover, soil features, wetlands, and riparian buffers. A study of these properties is important in watershed-level planning because they can influence the quantity and quality of water entering Rowan and Hinkson Creeks. For example, wetlands play an important role in flood abatement and help to filter nutrients and sediment from surface water; impervious surfaces can help increase runoff. Therefore, changes in these parameters most likely will have an impact on the creeks and the water in them. We analyzed each of the watershed characteristics using the latest tools in geographic information systems (GIS). Results of this analysis provide important baseline information for watershed planners. By knowing the status of these parameters at a certain point in time, future planners will be able to see how changes in these parameters can have an impact upon the water quality of the creeks.

Land Cover

A wide range of physical attributes, including soil type, topography, and climate, and past and present human activity combine to influence the suitability of a given

Table 3.10. *Distribution of land-cover types in the watershed.*

Land-cover classification	Acres	Percentage of watershed
Urban/developed	292	0.8
Agriculture	20,371	56.9
Grassland	4,738	13.3
Forest	6,882	19.3
Open water	126	0.4
Wetland	2,753	7.7
Barren	480	1.3
Shrubland	112	0.3
TOTAL	**35,754**	**100.0**

piece of land for a particular vegetation type or land use. *Land cover* refers to the physical state of the land surface; in other words, what currently exists on a land parcel. It may be a natural vegetated community, such as wetland, forest, or prairie; a human-altered plant community, such as cropland or pasture; or a cultural feature, such as an industrial complex or residential development. (Refer to Appendix A, table A.1 for descriptions of land-cover types.

Land cover in the Rowan Creek Watershed is predominantly agriculture, which accounts for 57 percent of the watershed area (plate 3.1). (Please note: Plates 3.1 – 3.5 can be found after page 40.) Forest (19%) and grassland (13%) are well represented in the watershed. Areas adjacent to the creek channel are characterized by wetland. Wetlands account for 8 percent of the total watershed area. According to WISCLAND, the source of data for our analysis, 0.8 percent of the watershed is categorized as urban/developed. The two lowest land cover types in the watershed are open water (0.4%) and shrubland (0.3%). A summary of the data we generated from the WISCLAND database (Wisconsin Department of Natural Resources, 1998) on watershed land cover can be found in table 3.10.

Land-cover data can be used to develop models for predicting runoff or sources of nonpoint pollution, assess quality and quantity of wildlife habitat, identify potential locations for residential or industrial development, and analyze local development patterns. Understanding land cover within the Rowan Creek Watershed should provide baseline information that could facilitate and guide future land-use decisions.

Although natural events, including fire and ecological succession, can alter land-cover type, the principal modifier is human activity. Examples of human-directed changes include plowing prairies or draining wetlands for cropland production or removing trees from forests for residential and commercial development. A land-cover change caused by human use does not necessarily connote degradation to the land. Although changes such as draining a swamp or clearing woodland may generate a net benefit to the land owner, the subtle incremental damage of these individual actions multiplied by a large number of landowners in a watershed can lead to aggregate impacts that may result in air and water pollution, increased flooding, and loss of biodiversity. In addition to affecting the present and future supply of land resources, land-cover changes bring about environmental change through its "synergistic connection that can amplify their overall effect" (Meyer, 1995).

As population grows and areas become more urbanized, the amount of land used for development increases. Expansion of urban centers is in many cases unplanned, resulting in a haphazard arrangement of development that dots the landscape. Impacts from urbanization upon the remaining natural communities include the intro-

Table 3.11. *Center for Watershed Protection's Impervious Area Classification Standards (Zielinski, 2002).*

Category	Description	Percentage impervious area
Sensitive	Sensitive streams are typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of fish and aquatic insects.	0 to 10
Impacted	Impacted streams are clearly affected by greater storm flows that result in channel enlargement, a decline in the physical habitat, shifts in water quality into the fair/good category, and a stream biodiversity that declines to fair levels, with the most sensitive fish and aquatic insects disappearing from the stream.	11 to 25
Non-supporting	Non-supporting streams have reaches that experience severe channel enlargement, the physical habitat is practically eliminated; water quality is fair to poor with a marked increase in nutrient loads, and an aquatic community that is dominated by pollution tolerant insects and fish.	>25

duction of pollutants into the air, soil, and water. Loss of plant and animal diversity may result from habitat fragmentation in which natural areas are no longer contiguous tracts of land. Species are either reluctant or unable to cross these recently transformed lands.

Impervious Area

The amount of impervious surface area within a watershed can be an indicator of whether a watershed is in good condition. Primarily influenced by human development of land, impervious areas can include parking lots, houses, baseball fields, and quarries. These surfaces are harmful to water resources because they reduce groundwater recharge and increase stormwater runoff. Over time, these impacts may lead to local depletion of the available groundwater and a greater amount of runoff. A change in water quality and habitat along stream corridors may also become evident because greater amounts of surface water are released from the previously undeveloped area. Water-quality reductions can occur because of the higher concentration of pollutants entering the stream from nonpoint sources whose origins are too diffuse to pinpoint, such as agricultural fields, construction sites, or residential neighborhoods. Streambanks may become more eroded, and the stream channel may widen to accommodate the greater quantity of surface water entering the stream from stormwater runoff. Overall, stream-water quality generally deteriorates as an increasing percentage of the watershed is covered by impervious surfaces. The Center of Watershed Protection has identified three categories into which watersheds can be classed based on the percentage of watershed land that is covered by impervious surfaces (Zielinski, 2002): sensitive, impacted, and nonsupporting (table 3.11).

The percentage cover by impervious surfaces in the Rowan Creek Watershed was determined using 1995 orthophotographs and GIS. Our method, detailed in Appendix A, identified 1.46 square miles of impervious area (2.42%) within the 60-square-mile watershed, most of it in the Village of Poynette. For a visual comparison, consider three United States quarters on an 8.5 x 11-inch piece of paper: The quarters represent the total amount of impervious surface; the paper represents the Rowan Creek Watershed. This percentage of impervious surface may appear low, but it does not mean that the impervious areas do not have an impact on the stream. Each impervious surface can reduce groundwater recharge while causing runoff, erosion, and pollution. Looking ahead, the cumulative impacts of expanded impervious areas throughout the watershed, best addressed with a comprehensive stormwater ordinance, will have to be a key focus.

Table 3.12. *Properties of soils in each hydrologic soil group.*

Group A	Soils having a low runoff potential due to high infiltration rates. These soils consist primarily of deep, well drained sands and gravels.
Group B	Soils having a moderately low runoff potential due to moderate infiltration rates. These soils consist primarily of moderately deep to deep, moderately well drained to well drained soils with fine to moderately coarse textures.
Group C	Soils having a high runoff potential due to very slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water, or soils that have moderately fine to fine texture.
Group D	Soils having a high runoff potential due to very slow infiltration rates. These soils consist of primarily of clays with high water tables, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

Table 3.13. *Soil-texture classifications and corresponding hydrologic soil groups.*

Hydrologic soil group	Texture classification	Particle-size classification
A	Sand, loamy sand, sandy loam	Coarse grain
B	Silt loam, loam	Intermediate
C	Sandy clay loam	Intermediate
D	Clay loam, silty clay loam, sandy clay, silty clay	Fine grain

Soil Classification

Hydrologic Soil Groups

The NRCS has classified more than 4,000 soil types into four different Hydrologic Soil Groups (HSG) based on soil permeability and infiltration capacity (table 3.12). Soils in HSG A have the highest infiltration capacity (greater than 0.3 in/hr); those in group D have the lowest (less than 0.05 in/hr), usually because of a permanently high water table, a clay pan or clay layer at or near the soil surface, or a shallow soil that overlies impervious material. Groups B and C are intermediate in their capacity to transmit water with infiltration rates of 0.15 to 0.30 inches per hour (in/hr) and 0.05 to 0.15 in/hr respectively. The size of the soil particles accounting for its texture is a good indicator of this capacity. Soils that have a greater percentage of coarse-grained materials, such as sand and gravel, typically have the highest infiltration; those that have finer-sized particles, such as silts and clays, generally are associated with slower infiltration. Knowing a given soil's texture classification can be helpful in assigning it to one of the hydrologic soil groups. The relationship between the two is detailed in table 3.13.

Plate 3.2 shows the potential for infiltration of the soils across the landscape of the Rowan Creek Watershed. The Rowan Creek Watershed has soils that are predominantly classified in HSG B. Seventy-eight percent of the watershed area belongs to this class, which is characterized by moderately low runoff potential and moderate infiltration rates. Soils belonging to HSG A, which have low runoff potential and high infiltration rates, cover 11 percent of the watershed area and are mostly located in the central to western parts of the watershed. The remainder of the watershed area has soils belonging to HSG C and HSG D. Soils in these two groups are primarily found in upstream locations of the watershed.

Hydric Soils

Three attributes can be used to delineate jurisdictional wetlands: the presence of a *hydric soil* (a soil that forms under saturated or flooded conditions), the presence of water at or near the surface for a specified period of time, and *hydrophytic vegetation*, or wetland plants. Soil saturation during the growing season leads to *anaerobic conditions* (the absence of oxygen) in the upper soil layers and development of hydric soil indicators. In the Rowan Creek Watershed, 12 percent of the area meets this hydric soil designation.

Historically, wetlands have been drained to allow agricultural production in areas that otherwise would be too wet. However, drainage precludes the important services carried out by wetlands. Using GIS tools, we identified areas currently in agriculture that also have or had hydric soils (plate 3.3). An area having both of these attributes likely represents the best site for wetland restoration or habitat enhancement opportunities under programs such as the U.S. Department of Agriculture Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), and Conservation Reserve Enhancement Program (CREP). Our analysis revealed that 986 acres within the watershed, or 2.8 percent of the total area, meet these two conditions (plate 3.4).

Wetlands

Wetlands are important biological communities within a watershed. Acting as sponges and filters, they are responsible for flood abatement and water-quality improvements. In addition, wetlands provide food and habitat for a variety of wildlife. Wetlands make up only 5 percent of the total land surface of the United States; however, they contain 31 percent of the plant species and over half of all North American bird species either nest or feed in wetlands. Despite their importance to wildlife and human activities, more than 60,000 acres of wetland habitat are lost each year in the United States.

Table 3.14. *Percentage of wetland area covered by vegetation type.*

Vegetation type	Percentage
Wet meadow	36.2
Scrub	33.2
Forested	21.8
Open water	0.8
Other	8.0

Many wetlands scientists use the U.S. Fish and Wildlife Service's *Classification of Wetland and Deepwater Habitats of the United States* (Cowardin and others, 1979) to classify wetland types. We used data provided by WDNR that was generated using this classification system to analyze wetlands in the Rowan Creek Watershed and identified 24 classes of wetlands covering nearly 2,753 acres, or about 7.7% of the watershed (plate 3.5). The majority of the identified wetlands in the Rowan Creek Watershed was classified as wet meadow, scrub, or forested wetlands. Our analysis shows that wet meadow and scrub wetlands occupy nearly 70 percent of the total wetland area within the watershed. Table 3.14 summarizes the results of our analysis; a more comprehensive classification of wetland vegetation types can be found in table A.2 of Appendix A. (On a site-specific scale, these data should not be assumed to be highly accurate.)

Riparian Zones

*Riparian buffer strips***,** areas of vegetation that border a creek or river, can help to reduce nonpoint pollution. When used in combination with other best management practices, riparian buffers have been shown to lower stream water temperature, reduce nutrient and sediment runoff, provide habitat for wildlife, and aid in flood control.

Besides slowing runoff that enters the creek, riparian zones soak up excess water through their root systems. By reducing the flow and volume of water discharged, erosive power is also significantly reduced, which results in less erosion of the bank and channel. Although erosion is a natural process, human activities can accelerate it. Siltation and sediments can affect the water chemistry and ecology downstream as well as the geomorphology of the channel.

Wildlife habitat is another benefit of having natural vegetation along the creek. Because the riparian zone is a transition between water and upland, it supports species from both. The riparian zone provides food and cover for these species throughout or during some part of their life cycle. Additionally, continuous riparian buffer zones can also serve as natural "highways" or routes allowing species uninterrupted travel.

Low-flow periods are usually the most stressful times for aquatic species. Vegetated riparian areas allow rainwater to infiltrate the soil and slowly seep into the watercourse. This continuous seeping water provides baseflow to the stream that is critical to the survival of many aquatic species. Vegetated riparian areas additionally provide shade, which maintains cooler water temperatures that are vital during the low-flow periods typical of the warmest summer months.

Riparian zones consisting of natural vegetation act like a filter to intercept pollutants before they reach small creeks that, because of their size and flows, can be vulnerable to degradation due to nutrients, sedimentation, and other pollutants. Cohen (1997) stated that "streamside wetlands along smaller streams are more efficient at adsorbing nutrients and sediments from adjacent waterways than along the larger rivers because a greater proportion of the water in the smaller watercourses comes into direct contact with the cleansing action of streamside wetland plants and microorganisms."

Preserving natural corridors of vegetation along streams and creeks is important not only to the creek itself, but also to the larger rivers of which they are tributaries. The

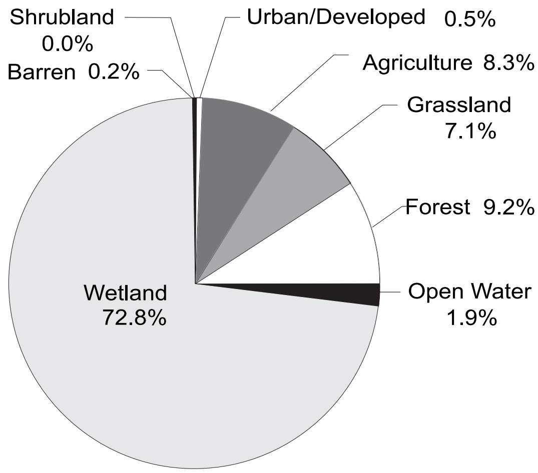

Figure 3.6. *Land cover within 100 feet of Rowan Creek.*

Table 3.15. Land cover within 100 feet of Rowan Creek.

Land cover	Acres
Urban/developed	5
Agriculture	71
Grassland	61
Forest	79
Open water	16
Wetland	626
Barren	2
Shrubland	0
TOTAL	**860**

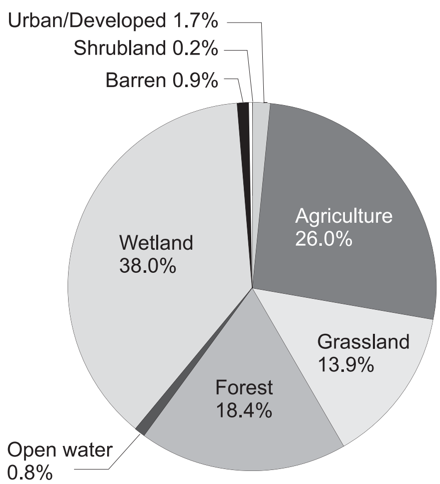

Figure 3.7. *Land cover within 1,000 feet of Rowan Creek.*

Table 3.16. Land cover within 1,000 feet of Rowan Creek.

Land cover	Acres
Urban/developed	94
Agriculture	1,401
Grassland	749
Forest	990
Open water	44
Wetland	2,047
Barren	48
Shrubland	10
TOTAL	**5,382**

quantity and quality of water in the larger rivers is influenced to a great degree by what the smaller creeks contribute. Tributaries having vegetated riparian areas can be contributors of clean, cool water; those lacking natural vegetation can contribute warmer water of degraded quality. Preserving riparian areas along the numerous smaller creeks and streams to maintain water quality is much more effective than trying to establish/preserve riparian areas along the larger river systems. The most sensitive riparian areas are located in the headwater reaches. It is here, in the uppermost part of the watershed, that small watercourses are most vulnerable and responsive to human alterations of the adjacent vegetation and land cover within the surrounding watershed.

For the Rowan Creek Watershed, two buffer widths (100 feet and 1,000 feet) were chosen for analysis. The 100-foot buffer width (fig. 3.6; table 3.15) effectively captures the land contributing runoff water, sediment, and nutrients directly to the creek channel. The predominant land cover within 100 feet of the creek channel is wetland (72.8%). Forest (9.2%), agriculture (8.3%), and grassland (7.1%) also account for significant acreage within 100 feet of the channel. The 1,000-foot riparian width (fig. 3.7; table 3.16) encompasses upland areas contributing surface runoff to the riparian zone nearer the creek channel. The most predominant land cover classification within the 1,000 feet zone is wetland (38%), followed by agriculture (26%) and forest (18.4%).

The Future

The physical attributes that a stream and its watershed exhibit allow us to gauge its health. The data that we collected and analyzed during this assessment suggest that the overall condition of Rowan Creek and its watershed is currently quite good. However, it is beginning to show signs of degradation from agricultural practices and increased urbanization. As was illustrated in the second chapter of this report, streams such as Black Earth Creek still experience the negative consequences related to watershed management, even though extensive amounts of money and resources have been invested in its protection. In contrast, little is presently being done to safeguard Rowan Creek and its watershed. This is understandable because Rowan and Hinkson Creeks are not showing obvious signs of degradation. But the potential for this to change in the next decade is great. Today, development and changing land use are taking place and will likely increase over the coming years. These changes can damage the creeks by reducing the ability of natural communities to buffer the impacts caused by human change.

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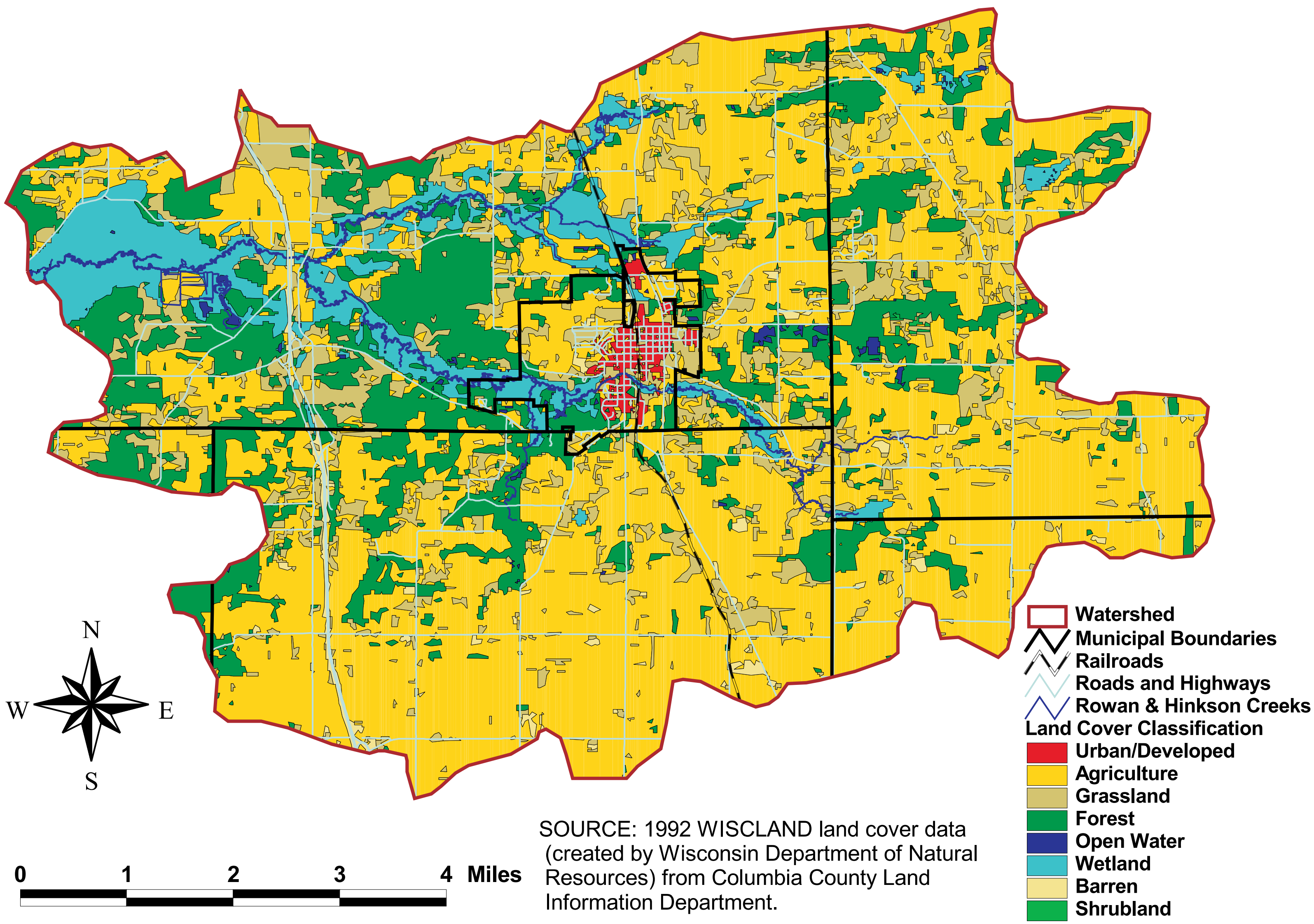

Plate 3.1. *Map showing land cover in the Rowan Creek Watershed.*

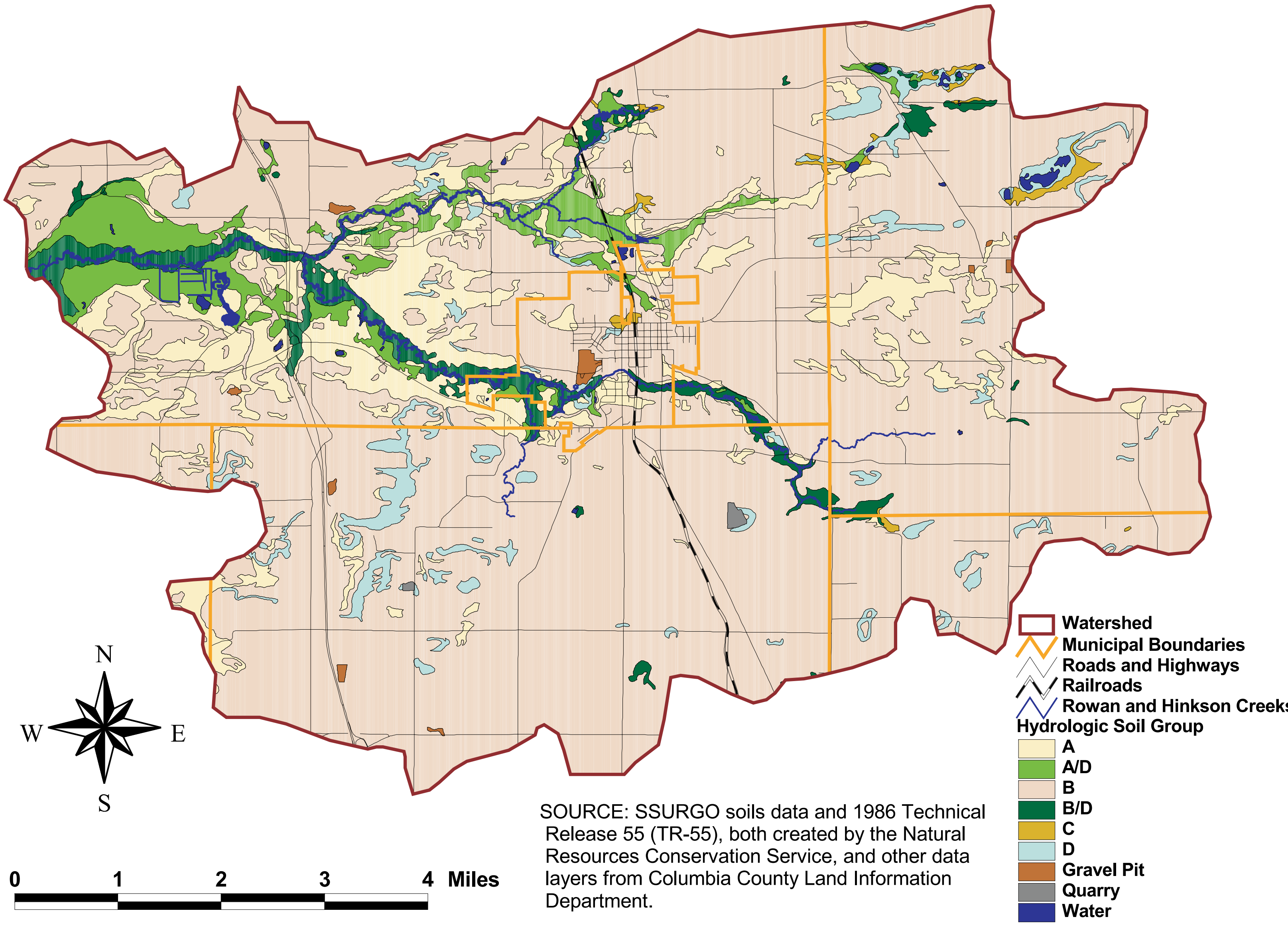

Plate 3.2. *Map showing soil infiltration potential in the Rowan Creek Watershed.*

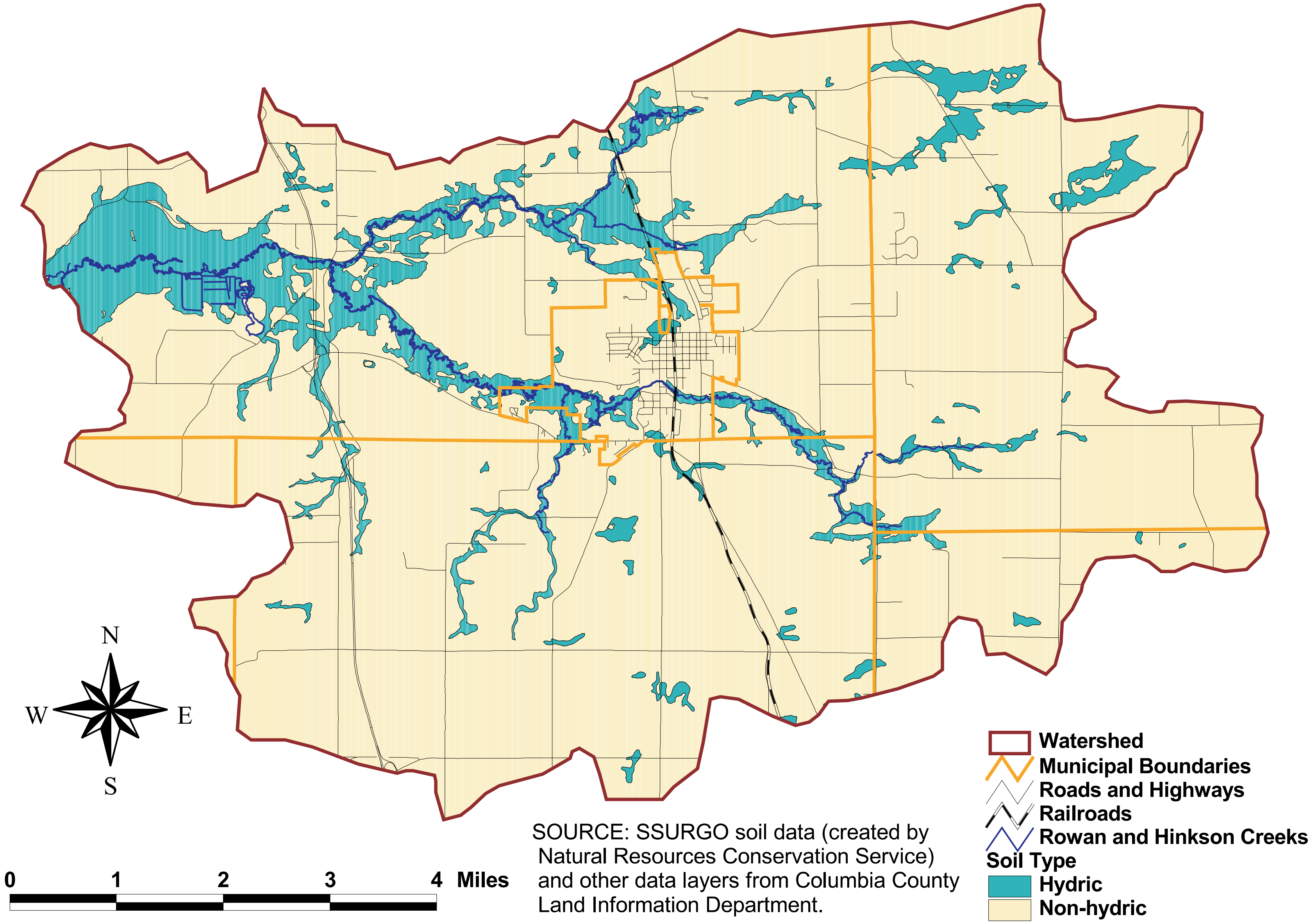

Plate 3.3. *Map showing hydric soils in the Rowan Creek Watershed.*

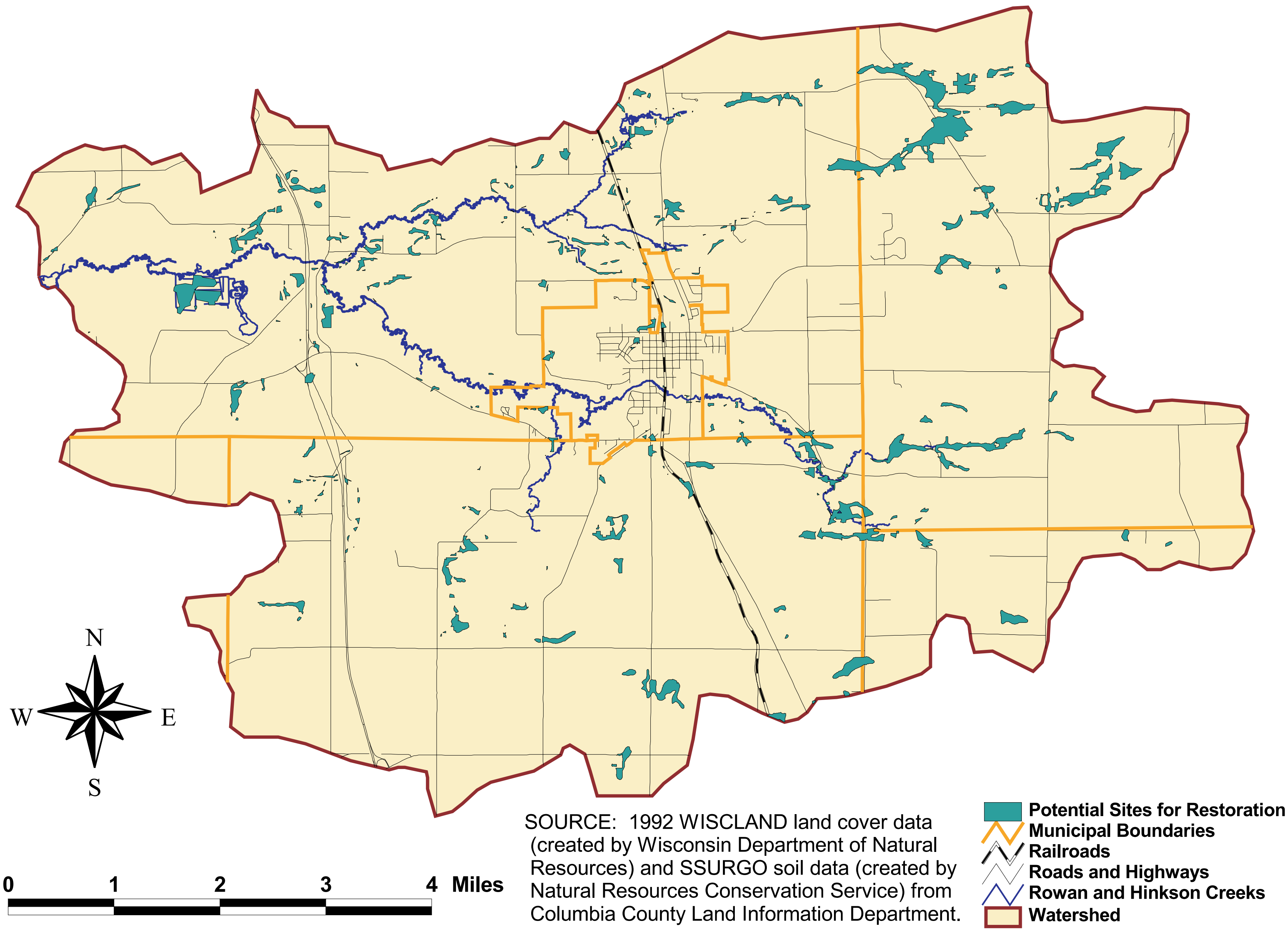

Plate 3.4. *Map showing sites with potential for wetland restoration or habitat enhancement in the Rowan Creek Watershed.*

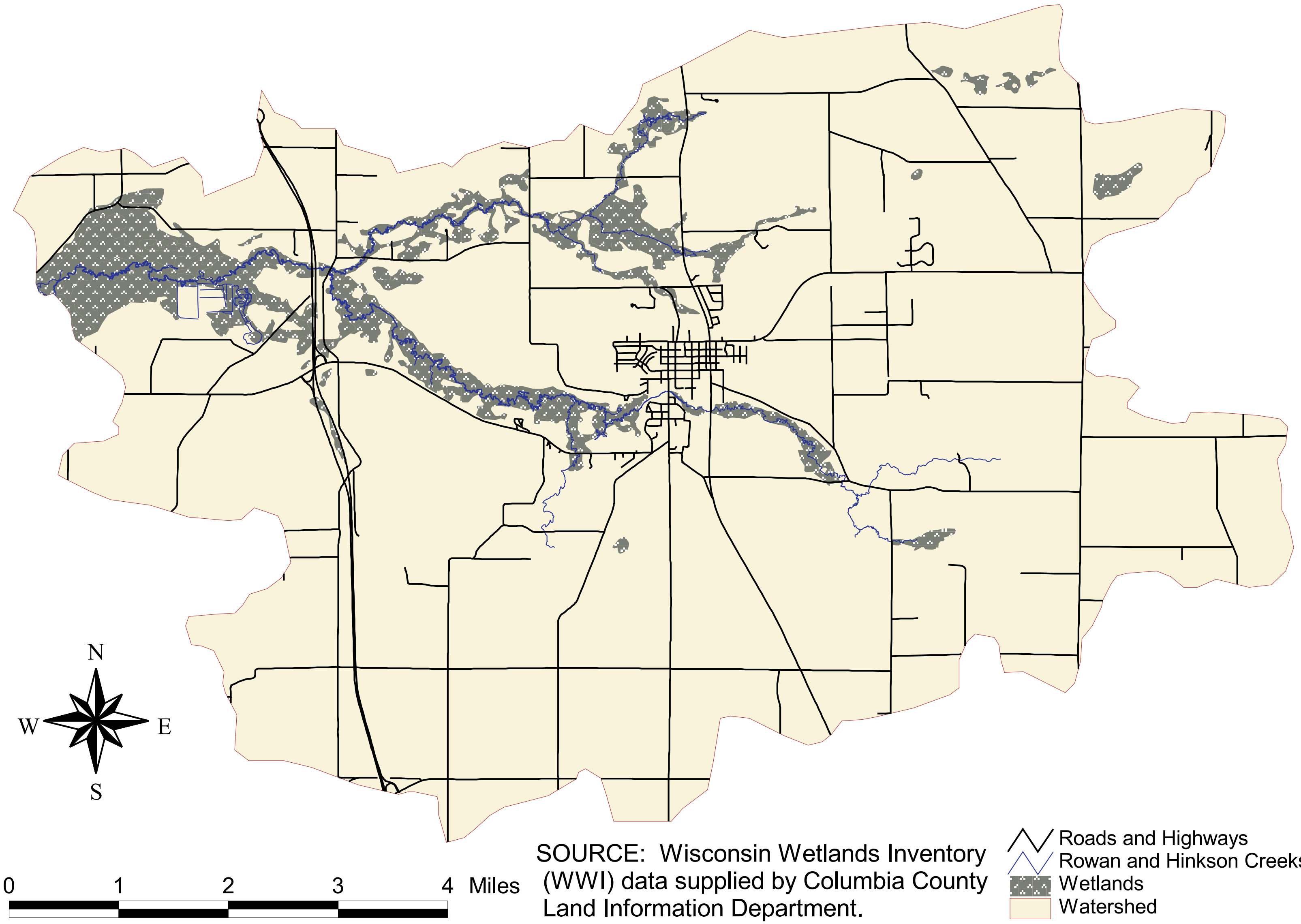

Plate 3.5. *Map showing wetlands in the Rowan Creek Watershed.*

CHAPTER 4. SOCIAL AND POLITICAL CONTEXT

Various entities—individuals, groups of people, and organizations—living, working, or operating within the Rowan Creek Watershed fill vital roles in determining the future of the watershed. They also stand to be affected in many ways themselves by the outcomes that ensue from the actions they take and the decisions they make as well as by forces operating within the context of the watershed that are outside of their control. These entities are what we will call stakeholders—they each hold an important stake in the future of the Rowan Creek Watershed.

Stakeholder Analysis

An important part of the work that went into this report included identifying and interviewing parties with potentially significant roles in the management of Rowan Creek and its watershed. Each of these organizations, groups, and individuals can be considered a stakeholder in the present and future condition of the watershed. No watershed-management plan can be successfully implemented without the input and acceptance of these stakeholders.

There are many types of stakeholders. Elected government officials, with their direct influence on everyday decisions for a variety of important issues at the local, county, state, and federal levels, play important roles in the watershed. State and federal agencies also play key roles in the watershed. The WDNR and the NRCS are two important examples of influential agencies operating at the state and federal levels, respectively. Nongovernmental organizations, such as Trout Unlimited, the Audubon Society, and Friends of Rowan Creek, may also play critical roles in directing management decisions. And, of course, private citizens have tremendous power to create change because they are the voters who elect the officials, who in turn create the policies that will ultimately determine the fate of the watershed.

Interview Methodology

Through the help of several individuals with knowledge about the Rowan Creek Watershed, we were able to generate a list of potential interview subjects. The list started out relatively small, but over time it grew. As the interviews progressed, interview subjects provided names of additional people with a stake in the watershed. We were not able to contact everyone, and those who were contacted were not always able to answer all the interview questions. In some cases, we simply could not track down potential interview subjects in time to include their perspectives in this report. In other cases, certain individuals were not willing to take part in the interview process. However, the group we interviewed represents a diverse cross section of the interests existing in the Rowan Creek Watershed. A list of many of the interview subjects we contacted can be found in Appendix B.

A subgroup of the practicum students developed the list of questions that we asked of each subject. This process was aided in part by consulting past WRM practicum reports, especially the Institute for Environmental Studies Water Resources Management Practicum (1999).

The interview questions were:

- What do you do and how does your work influence the management of the Rowan Creek Watershed?
- Are other agencies or groups doing work similar to yours?
- Are there other programs, either within or outside of your agency, that focus on the management of the Rowan Creek Watershed?
- Do you currently communicate with other agencies or groups whose work involves the Rowan Creek Watershed?
- What opportunities presently exist for community involvement in your programs?
- How do you encourage citizen participation?
- What partnerships, if any, exist?
- Are there roles for nonprofit or citizen groups?
- How do you use citizen feedback to adjust your management plans?
- Do you have any brochures or documents we could review or get copies of?
- What do you feel would help facilitate communication and coordination of stakeholders and managers in the watershed?

Appropriate follow-up questions were also asked as needed. Interviews were completed over the phone or in person. Each subject was given the option of remaining anonymous or consenting to have his or her name included in the contact list located at the end of this report.

Summary of Interview Responses

Municipalities

Five towns and one village are located within the Rowan Creek Watershed. They are the Towns of Arlington, Dekorra, Leeds, Lodi, and Lowville, and the Village of Poynette.

Currently, aside from the Village of Poynette's Erosion Control and Stormwater Runoff Standards, stormwater management—and thus the important connections between it, land use and management, and water quality—is not a topic that is widely addressed by local units of government in this region. Dekorra, Lowville, and Poynette, however, have created a joint planning commission and are working toward compliance with the Wisconsin Smart Growth legislation that was passed in 1999. Eventually, all the municipalities will likely begin working to create or update their plans because the Smart Growth law requires every Wisconsin community that makes basic land-use decisions to prepare and adopt a comprehensive plan by January 1, 2010. The comprehensive planning process could lead to a greater recognition of the connections between stormwater runoff, land use and land management, and water quality in Rowan Creek.

For example, the comprehensive land-use plan for the Town of Dekorra, which dates to 1997 and is therefore the most recent plan in the watershed, calls for the protection of shorelines and wetlands, upgrades of groundwater and surface-water quality within the town, preservation of natural landscape features, and the prevention of adverse effects of development on natural drainageways. The plan also includes recommendations for the protection of natural drainage areas, floodplains, and wetlands in an effort to avoid costly stormwater projects. The inclusion of these factors relating to stream and watershed health points to the possibility that local municipalities can indeed play an important role in the future health of the watershed, specifically by way of their ability to incorporate watershed health as a goal in their comprehensive plans.

For our stakeholder interviews, we contacted the chairperson of each town board as well as the President of the Village of Poynette. Despite the current efforts toward improving municipal comprehensive plans, the majority of the responses from elected local officials indicated a feeling that management of the watershed falls outside the scope of their jurisdictions. When asked to identify other agencies that focus on the management of the watershed, three of the six people we interviewed from local government responded that there were none. One person identified the WDNR and the Columbia County Conservationist, Kurt Caulkins, as interested parties. Two interviewees mentioned the Friends of Rowan Creek (FORC).

Interestingly, most local government respondents mentioned opportunities for public participation in watershed issues. Soil conservation work by farmers, attendance at public meetings or hearings concerning local water and Smart Growth planning-related topics, and the use of rotational committee members, were mentioned as ongoing opportunities for public involvement. It was also evident from the interviews that there is a need for improved dissemination of information to the public. These interviewees emphasized ideas such as newsletters, Web pages, email lists, report distribution, and community projects in their suggestions.

We also interviewed Dennis Linn, the acting Village of Poynette Administrator. His position is different from that of the Village President in that it is full-time, salaried, and appointed rather than elected. He works closely with the Village Planning Commission and the Village Board. Specifically, Linn oversees many of the day-to-day issues facing the Village, including those regarding proposed developments and other activities that can potentially affect the creek, such as those relating to public works and wastewater. Linn told us that he recognizes the serious threat that development poses to the watershed. He indicated that he is currently concerned with the level of scattered rural residential development occurring throughout the watershed and the surrounding region. In his opinion, development should be guided by planning. Furthermore, it should occur in areas such as the Village where there are adequate municipal services and better development controls. He acknowledged that development pressure is relatively high in the watershed, especially in areas featuring amenities that people find desirable. He also cited some of the potential problems that scattered rural residential development can lead to for farming, rural community character, and the health of the watershed and its streams. Finally, Dennis Linn told us that he believes that there is a need for greater coordination between all the municipalities in the watershed to address the important issues relating development and land use to water quality and overall stream health. Perhaps the ongoing multi-jurisdictional comprehensive planning activities of the Village of Poynette and the Towns of Dekorra and Lowville will serve this need.

Ron Moen is the current Superintendent of Plant Operations responsible for the operation of the Poynette wastewater-treatment plant. He monitors and reports to the WDNR the levels of several important effluent parameters, including nitrogen, phosphorus, dissolved oxygen, biological oxygen demand, pH, and suspended solids. At the time of the interview, he reported that the current parameter levels were within acceptable limits. He also pointed out that all local industrial waste discharge, such as that from the Chiquita Corporation's canning facility in Poynette, flows to the Village's treatment plant after passing through aeration lagoons on industrial property. During the interview, he stressed the importance of improved communication with local industries on best management practices (BMPs) and improved public awareness of the need to minimize phosphorus levels in stormwater as well as approaches for meeting that goal.

County Government

We also interviewed several Columbia County supervisors representing districts overlapping the watershed. At the time of the interviews, it appeared that most of the supervisors were more concerned with other issues and did not have much time to concern themselves with issues relating to the watershed. However, Andy Ross, District 21 Supervisor, stated that monitoring and controlling nonpoint source pollution within the county are the primary strategies currently being used for watershed management. He indicated that he has been working with the county's Land Conservation Department (LCD) to create runoff regulations. Ross' belief seemed to be that the biggest problem facing watershed management is that people are so emotionally involved in some issues that they simply cannot maintain an objective perspective. He further suggested that more rational thinking would improve management. Ross also recommended that information about BMPs be made readily accessible to the public to bring about a more objective approach to looking at important watershed-management issues.

Kurt Caulkins is the County Conservationist out of the Columbia County LCD in Portage. His position is key in relation to the health of the watershed—it entails working to control and monitor nonpoint source pollution and its impacts countywide. Projects in which Caulkins has been involved include work with farmland, animal waste, and land conservation. He works closely with the NRCS, but a lack of time and money limits many of his initiatives along that front. He also communicates with other stakeholders on an as-needed basis, mostly to share information.

It is of great importance to Caulkins that more emphasis be placed on education. In particular, he feels that proper management practices and their benefits must be effectively demonstrated at the local level and that school-based programs, publication, distribution, and promotional events would help educate people about appropriate BMPs.

Mike Stapleton is the Columbia County Zoning Administrator. In his work, he communicates directly with the LCD, local municipalities, and landowners on zoning issues. Although he feels that his role in the watershed is limited, he did affirm that zoning issues can be important, particularly as they help to determine allowable land uses and their locations. He discussed the importance of public input during hearings, but mentioned that constructive criticism and possible alternatives were often lacking. He very much supports and appreciates public input and notes that constructive input can lead to a hold on a decision until additional information is obtained. He hopes that the inclusion of all hearing notices on the county Web site, and an overall improvement in the public's ability to get information, will foster more participation in the making of important decisions.

State Government

One of the most important stakeholders in the Rowan Creek Watershed is the WDNR. Not only does WDNR maintain jurisdiction over the water resources in the watershed, but the agency also owns and manages a significant amount of stream frontage property and adjacent land. We interviewed several WDNR representatives for this project. Some of them work directly in the watershed; others work more peripherally. Nonetheless, all their efforts are important to the well being of the watershed.

The acting WDNR Property Manager and area forester for the Rowan Creek Watershed is Jim Bernett. As part of his duties, he oversees potential land purchases, vegetation-control activities, timber sales, habitat-restoration projects, and trail maintenance. Examples of past and ongoing projects in which he has been involved include oak savanna restoration, garlic mustard removal, and periodic workdays in partnership with the FORC. Bernett noted that in the past the LCD tried, unsuccessfully, to make Rowan Creek part of a "priority watershed" under the state program by the same name. He hopes that the LCD and NRCS can generate more interest in conservation programs in the watershed because it is clear that the WDNR cannot do it alone. In his opinion, outside help is needed to protect the watershed. Currently, Bernett is in constant communication with Tim Larson, the WDNR Fishery Biologist for the area including the Rowan Creek Watershed. Bernett also attends FORC meetings and offers technical assistance on FORC projects as needed. The FORC and the WDNR are finalizing a contract that will allow for greater collaboration in the future. As a member of FORC, Bernett is aware that FORC is in its infant stage, but believes that great opportunities exist for that organization to play a positive role in watershed management. He believes that most people are not aware of the potential problems facing the watershed and that education is needed. He also feels that people must understand what a healthy and valuable resource they have and what could potentially happen to it in the future.

As WDNR Fishery Biologist, Tim Larson monitors and manages the trout fishery in Rowan and Hinkson Creeks. Larson indicated that he feels that education would be the most valuable benefit from increased activity in the watershed. He mentioned, in the context of education, that all the reports he generates are available to the public, although they are not distributed unsolicited. He provides Rowan Creek fish data to University of Wisconsin–Stevens Point for a fishery class and will provide this information to any interested party on request. He also shares his expertise with groups of local children and adults through on-stream demonstrations. Through these activities he introduces local citizens to the valuable resources living in the creeks. Larson has also completed extensive habitat work on the creeks. In his opinion, the fishery is in fine shape, but he admitted that continued work is needed to ensure its status as one of the better trout fisheries in the state.

Larson stated that it is his belief that the county LCD is not particularly active in the area at this time. He also pointed out that he believes FORC is an ideal community group to take a lead role concerning watershed issues. He further noted that there is not an established network for communication between the many stakeholders in the Rowan Creek Watershed. This and other similar comments prompted our recommendation that some form of collaborative group forum be created to foster better communication between watershed stakeholders.

Doris Thiele is the WDNR Wastewater Engineer for the watershed. She handles all compliance and monitoring issues for the watershed's municipalities. She confirms that Poynette adheres to its Wisconsin Pollutant Discharge Elimination System permit by having her complete a monitoring review form and conduct an annual site visit to the sewage-treatment plant. She also is responsible for overseeing any spill responses that may occur. To date, she is not aware of any spills. She indicated that all local industry is now discharging waste to the sewage-treatment plant and not directly into the streams, although in certain cases, cooling water is discharged into the streams. Such discharges, according to Thiele, are allowed through a permit and are regulated for several parameters including temperature.

Jeff Schure is a WDNR Water Management Specialist for Columbia, Dane, and Sauk Counties. His work involves the issuance of various permits required for activities such as grading on banks, dredging, and dam or riprap placement. He noted that there has not been very much activity of this sort in the watershed over the last year and a half. Schure has worked with the NRCS and has issued permits for wetland restoration. He told us that there is a public comment period on these permits that lasts 30 days, and typically, he does not see a lot of negative feedback. He would like to see a better communication link between stakeholder groups. For example, in Schure's estimation, better permit coordination between the NRCS and the U.S. Fish and Wildlife Service (USFWS) would improve the situation. Additionally, more staff would allow for better permit review and less reliance on other agencies. In his opinion there is currently neither enough time, nor an adequate level of coordination to allow for the implementation of a comprehensive watershed-management approach for Rowan Creek.

Andy Morton, the Team Leader for the Lower Wisconsin River Basin, of which the Rowan Creek Watershed is a part, supervises much of WDNR's activity in the watershed. One of his main responsibilities is water-quality management in the area. He has helped to provide Conservation Reserve Enhancement Program (see Chapter 5 for more on this program) funding to the LCD and has also assisted the county in securing the River Planning Grant that partially funded this project. Morton sponsors workshops on grant procedures and provides additional staff for technical assistance. He indicated that he believes agricultural impacts on the stream are currently not too serious and emphasized that the most significant current threat to the stream is stormwater from new development. Morton also pointed out that a report detailing the state of the Lower Wisconsin Basin is soon to be published (currently available at <http://www.dnr.state.wi.us/org/gmu/lowerwis/lwbasinplan.html>). The report will include information on Rowan and Hinkson Creeks. Public meetings were held by the WDNR where citizens were encouraged to comment on the report's content. Morton also stressed the importance of FORC as a presence in the watershed and their ability to generate interest in local issues.

Roger Bannerman is a WDNR Environmental Specialist who specializes in nonpoint source pollution and stormwater-management issues as they relate to water quality. He promotes low impact development strategies and designs by completing demonstration projects around the state and giving talks on the subject at various venues. He has spoken to FORC and aided in the construction of a demonstration rain garden within the Rowan Creek Watershed. In our interview with him, Bannerman stressed the need for more demonstration projects that can serve as effective educational tools. He told us that he has seen an increased level of grassroots citizen activity and supports growth in that area as well as the input of grassroots organizations. He also noted that he perceives a need to move away from conventional stormwater strategies that are focused only on conveyance and toward those that focus more heavily on storage and infiltration. He understands that this is a difficult shift for engineers, who are more accustomed to older designs or who are nervous about liability issues. However, he stated that he has seen the shift occur successfully on projects he has been involved with in the past.

Bannerman also made the point that one major problem with stormwater issues is the lack of a sense of urgency. He argued that people will react if they are being flooded, but fail to see the smaller, less obvious changes that occur over time. It is important to him that people are also educated about the chronic problems that poor stormwater management can bring. Ultimately, he pointed out, the cost of preventing a problem will be less than the cost to fix it after it has happened.

Mike Miller is a Water Resources Specialist at WDNR in Madison; he acts as the statewide coordinator for stream monitoring. When we talked with him, he stressed the importance of macroinvertebrates as a strong indicator of stream health. In essence, he said, macroinvertebrates are the "canary in the coal mine" for stream ecosystems. Miller has conducted several invertebrate sampling demonstrations for schools outside the watershed and offered to do the same for schools within the watershed. He believes that watershed issues are too important for the government to manage alone. In his opinion, special interest groups such as the River Alliance, Trout Unlimited, the Wisconsin Waterfowl Association, and FORC must work together to accomplish common goals. Miller also told us that he believes education of the general public on these kinds of issues will help foster community initiatives to address watershed-related concerns.

The Wisconsin Geological and Natural History Survey (WGNHS) also conducts important watershed related research throughout the entire state. The WGNHS carries out projects addressing such topics as groundwater recharge and land-use impacts on groundwater in coordination with the WDNR, USGS, regional planning commissions, and various counties. The WGNHS is currently working on a stream temperature and groundwater flow model for Rowan and Hinkson Creeks.

Federal Government

The federal government's presence in the Rowan Creek Watershed is fairly limited. Due to the voluntary nature of certain programs, federal agency work in the watershed is sporadic. However, we were able to interview two individuals who work with federal agencies that are, or have been, active in the Rowan Creek Watershed.

Dale Peterson is a Soil Conservation Technician with the NRCS in Portage. His main duties include assisting landowners with inventory and evaluation, construction supervision, tillage practices, buffers, and cost sharing. His work takes place almost exclusively on private lands. The NRCS programs include the Conservation Reserve Program and Wetland Reserves Program. He works closely with the LCD and also communicates with the WDNR and USFWS concerning various projects. He told us that he is beginning to become more involved with watershed planning. He also indicated that cost-sharing money is now available for certain BMPs, including buffers, grass waterways, and terraces. Peterson has worked with landowners to design and implement appropriate BMPs. He provided us with several brochures and fact sheets, which are available to the public, detailing the current programs. He mentioned that bimonthly newsletters and mailings to landowners publicize current events, programs, and meeting dates relating to his work and that of the NRCS. He indicated that citizen feedback is encouraged at these meetings and pointed out that he often gets feedback from citizens during one-on-one discussions he has with them. Peterson has spoken at a FORC meeting and acknowledges the importance of that group as a local presence with the ability to take the lead in the community.

Rhonda Krueger is a USFWS wildlife biologist who works in the Leopold Wetland Management District. One of her objectives is to restore wetlands through the Partners for Fish and Wildlife program. Although she has not been involved in any work in the Rowan Creek Watershed lately, she noted that her agency was involved with two wetland restoration projects in the watershed. One was a 43-acre restoration in the Town of Dekorra; the other was a 12-acre restoration in Arlington. Krueger stated that she is always hoping to reach more landowners interested in future projects. She also pointed out that the Partners program only helps landowners to pay restoration costs; the NRCS programs also pay a landowner a per-acre sum. She told us that many grassland and wetland projects are, therefore, completed through the NRCS. It is also important to note, she said, that USFWS funds cannot be applied to state lands unless the WDNR is a working partner. If there were any interest on the part of Rowan Creek Watershed landowners in entering the program, Krueger indicated that she would be happy to be of assistance.

The USGS is not currently doing any work in the watershed, although it was involved in some recent work in the area. Beginning in the summer of 2001, Rowan and Hinkson Creeks were sampled as part of a statewide nutrient-impact study. The study set out to sample 160 stream sites with drainage areas of less than 50 square miles for flow, nutrient, chlorophyll, periphyton, macroinvertebrate, fish population, and habitat data. They sampled Rowan Creek at the Highway 51 crossing and Hinkson Creek at the location where it flows under Thompson Road (see Chapter 3 for detailed coverage of some of the data from this research). The USGS plans to sample streams with larger drainage areas over the next two years in an effort to help the WDNR set nutrient criteria across the state.

Nongovernmental Organizations

The Friends of Rowan Creek (FORC) is a newly formed group of concerned watershed residents who are working toward better public awareness of watershed issues. They began meeting in the spring of 2000 and were officially granted IRS nonprofit status in the fall of 2001. Nancy Braker is the current president of FORC (as well as the Director of Science and Stewardship for the Nature Conservancy's Wisconsin Chapter headquartered in Madison). She is concerned with current management practices and would like to see much of the land area around the creeks remain in a natural state. FORC typically offers two educational activities per year. This year, they held lectures that discussed native landscaping and Wisconsin amphibians. The group also hosts several volunteer work opportunities each year. They helped the Poynette High School plant a native prairie garden on school grounds, set up trail maintenance days, and put on creek clean up days. The group works regularly with the WDNR and the Village of Poynette on many of their initiatives, and they provide information to other municipalities in the watershed as well. The FORC distributes information via email, newsletters, newspaper articles, posted signs, flyers, and a Web site. The newsletter and Web site urge citizen feedback, although to date, we were told, there has not been a great deal of response.

Karen Etter Hall, Executive Secretary of the Madison Chapter of the Audubon Society, is another one of the people we interviewed. The local chapter of the Audubon Society owns Goose Pond, a prairie pothole wetland located just south of the Rowan Creek Watershed, and manages it as a wildlife sanctuary. Nationally, the Audubon Society participates in large-scale surface and groundwater-protection efforts through extensive lobbying and policy work. Locally, the Audubon Society conducts a Bird Count in Poynette every Christmas. Currently, the local chapter is working to start the Wisconsin Bird Conservation Initiative for all birds across the state. The Madison Chapter of the Audubon Society is not currently involved directly in any activities in the Rowan Creek Watershed.

We also interviewed Clint Byrnes, the Acting President of the Aldo Leopold Chapter of Trout Unlimited. He regretted to inform us that due to a lack of involvement, his chapter is virtually nonexistent. When the chapter was more active, he said, its members spent more of their time working on Rocky Run than on Rowan Creek. The Rocky Run watershed shares a boundary with the Rowan Creek Watershed and lies directly to the north. Although he still receives fish shocking reports from Tim Larson, Byrnes told us that he does not see the Aldo Leopold Chapter of Trout Unlimited exerting much influence on issues in the Rowan Creek Watershed. Personally, he is concerned about the use of fertilizers and other chemicals on household lawns within the watershed.

Developers and Realtors

Developers and realtors are important stakeholders in any watershed. They are in positions of great influence in the area of land use, and they may be significantly affected by watershed-management decisions with implications for land use. We contacted several people from this category for interviewing purposes, but we were only able to reach one developer and one realtor. Therefore, it is important to note that the opinions expressed below are not necessarily representative of all developers and realtors in the watershed. They merely represent the opinions of two people, each with his or her particular perspective.

The developer we spoke with stressed that the biggest problem he sees is other people telling landowners what to do with their property. He believes that decisions should be made on the local level, not on the county or state level. Additionally, he stated that putting in housing does not have much of an effect on the watershed because better planning can help direct water to the right place. He also told us that he is frustrated by the fact that the WDNR is automatically involved whenever there is any sort of land issue.

The realtor that we interviewed indicated that she believes houses built within 0.5 mile of the creek could affect the flow of the creek. She said that houses built adjacent to the creek could also cause problems. She indicated that she feels strongly that over-development is not a good thing and that people need to be very careful when developing. She made it clear that she is aware of FORC and pointed to the group as a provider of opportunities for the public to become involved in watershed development issues.

Perspectives and Recommendations on Stakeholder Coordination and Communication

The stakeholders we interviewed indicated that they are generally happy with current conditions in the Rowan Creek Watershed. However, several of the interviewees offered ideas about improving coordination and communication between watershed stakeholders. Many emphasized the need for better education as a critical step toward improved coordination and communication. We also heard many suggestions detailing methods for educating the stakeholders, including the use of newsletters, Web sites, newspaper articles, and advertisement campaigns.

Roger Bannerman stated that it is very important to implement learning activities that support and maintain peoples' interest and energy. He recommended workshops and demonstration projects as effective tools to accomplish that objective. In his opinion, setting attainable goals that allow participants to see what they have accomplished can be a powerful strategy, and publicizing such activities will allow for greater public exposure and education. Bannerman remarked that he thinks the press could distribute information across the watershed and beyond at little to no cost to the project sponsor. Regardless of the medium, the availability and distribution of information is a key component to better education on watershed issues.

We clearly heard a call for improved communication from several of the people we interviewed. The lack of any type of organized communication network seems to be a commonly perceived problem. The many groups that work in the watershed currently do communicate on an as-needed basis, but many interviewees noted that there is no constant line of communication between them. It appeared that some feel that there is no need for a structured vehicle for communication between stakeholders at this time; however, most of the people we interviewed seemed to believe that the need exists. Dale Peterson, for example, noted that communication has improved greatly over the last five years, but he felt that there was still a need for better communication. Similarly, Nancy Braker cited a need for more opportunities for people to engage in conversations about watershed issues and stressed the importance of face-to-face meetings.

The role of special interest groups was also widely discussed by our interviewees. Mike Miller noted that it is essential that different groups coordinate their efforts for maximum effectiveness. His comments indicated that he sees many groups with different agendas unknowingly duplicating one another's work. His thought is that a dialogue between these groups would help focus their efforts and allow them to be able to attain mutually desired goals more efficiently. Miller's conclusion was that it will be important for new groups like FORC to communicate with existing groups to facilitate more fruitful relationships.

In an effort to improve communication and coordination, Andy Morton suggested the formation of a watershed organization. Its members, he suggested, would consist of watershed stakeholders and would meet at least twice annually. Tim Larson mentioned a similar roundtable in which all stakeholders could meet to discuss past, present, and future activity in the watershed. Information would be shared so that everyone could know what was currently happening in the watershed. The suggestion was also made that FORC could be the moderator for such a meeting and that the proposed organization or forum could eventually evolve into an advisory committee for the entire watershed.

An example that we discovered in our research of just such an organization is the North Fork Pheasant Branch Watershed Committee, which deals with the watershed drained by the North Fork of Pheasant Branch, located in the Middleton, Wisconsin, area, northwest of Madison. Created in 1998, the Committee is made up of representatives from several stakeholder groups, including the Friends of Pheasant Branch, WDNR, USGS, and many local businesses. An annual report (North Fork Pheasant Branch Watershed Committee, 1999) detailed the formation of the committee and how it works. This group shows that by working together, interested parties operating elsewhere in the Wisconsin landscape have been able to contribute valuable input concerning watershed issues.

Citizen Survey

Methodology

We created a questionnaire in the spring of 2002 and mailed it to 1,000 people who live in the Rowan Creek Watershed to help us to assess the public perceptions of the condition, uses, changes, value, quality, and problems of the watershed. We chose the 1,000 people randomly from a mailing list that included households located throughout the watershed. The survey mailing included a letter indicating our intent and explaining what value we believed the surveys would be to our project. The mailing also included a postage-paid envelope in which the respondent could return the completed survey.

Many of the questions we asked were adapted from the 1999 WRM practicum project on the Lake Wingra Watershed in Madison. A version of the survey and the letter that accompanied the survey can be found in Appendix B.

Survey Results

Of the 1,000 surveys we mailed out, we received 191 responses, which is approximately a 19 percent response rate. One important point worthy of note here is that this was a self-responding survey. If people were not interested in responding, they simply did not respond. This introduces the potential for a selection bias. In other words, we may have heard mostly from people with strong feelings one way or the other on the issues we were asking about and not from those who are relatively ambivalent on these issues. So, although our findings do give a general idea of how people residing in the area feel about the Rowan Creek Watershed, this is by no means a comprehensive survey of resident opinion. By the same token, we do not make any claims as to the statistical significance of our findings. We do, however, believe that these results are useful in beginning to gauge public sentiment about the general health and condition of the watershed.

Highlighted Survey Responses

Please see Appendix B to view the questions asked in the survey.

- **Question 1.** We divided the watershed into three sections for the purpose of understanding where the respondents live. The majority (64.9%) live between Interstate 90/94 and Highway 51. This region includes much of the Village of Poynette. Nearly 30 percent (29.3%) of respondents live east of Highway 51; only 3.7 percent live west of the interstate.

- **Question 2.** Before receiving the survey, 86.1 percent of the survey respondents knew their home was in or near the Rowan Creek Watershed; 13.9 percent did not. This high affirmative response rate indicates that residents are at least aware of, and potentially interested in, their watershed surroundings.

- **Question 3.** The most common uses of Rowan and/or Hinkson Creeks and the associated recreational areas were nature appreciation (60.6%), hiking (56.9%), fishing (56.9%), bird watching (33.5%), and hunting (21.3%). Respondents were free to select as many activities as they wanted. Answers in the open-ended "other" section included cross-country skiing, biking, wild plant gathering, spiritual exploration, and a wedding ceremony.

- **Question 4.** The majority of respondents visit Rowan and/or Hinkson Creeks and the surrounding areas either weekly (25.4%) or several times a year (34.9%); a smaller percentage visit on a monthly basis (11.8%). Interestingly enough, 13.9 percent of the respondents never visit the creeks, yet they still hold enough interest in the area that they responded to the survey.

- **Question 7.** In assessing the value of the creeks and the surrounding areas as an asset, 81.7 percent indicated that they were "very valuable" or "valuable." This result indicates that most respondents feel that the creeks are an important part of their environment.

- **Question 8.** In assessing the value of the creeks and surrounding areas to the community, 81.3 percent again indicated that they were "very valuable" or "valuable."

- **Question 9.** This question asked respondents to rank the benefits they derive from the creeks and surrounding areas from the most important to the least important. Natural beauty (63.2%), wildlife (37.4%), and fish (23.6%) received the highest ranking while property value (14.6%) and community identity (6.9%) received the lowest ranking. These results reveal the importance to residents of the natural aspects of the creeks and surrounding areas.

- **Question** 10**.** Nearly two-thirds (64.9%) of the respondents feel that current water quality is good to fair; 26.1 percent indicated that they don't know.

- **Question** 11**.** More than 78 percent of respondents feel that high water quality is of value. The high level of response indicates that what happens to water quality is important to the residents.

- **Question** 12**.** More than half (51.6%) of the respondents have lived in the watershed for more than fifteen years. Residents for one to five years (16.0%) make up the next most frequent group. It should also be noted that many respondents (28.2%) chose not to answer this question. It was important for us to know this information because many of the questions in the survey rely on a respondent's knowledge of the area in which they live. The fact that more than half of all respondents have lived within the watershed for at least 15 years lends greater value to the answers we received for the next few questions.

- **Question** 13**.** The majority of respondents (62.7%) feel that water quality has stayed the same; 17.6 percent feel it has improved, and 19.6 percent feel it has worsened.

- **Question** 15**.** This question asked respondents to check those environmental issues believed to be problematic in the watershed. Respondents could check as many answers as they desired. The results indicate that agricultural and urban impacts to the creeks and the watershed are perceived as problems; however, there seemed to be more concern about urban impacts. Fertilizer and/or pesticide use on lawns and gardens (52.3%), stormwater runoff from streets and parking lots (51.1%), trash (43.2%), and increased development pressure (36.4%) were each checked more often than agricultural runoff (36.4%) and cattle in streams (23.9%). Although many of the issues included in this question could have been combined into three or four large groups, we felt that splitting rather than lumping issues would help us better gauge the environmental issues of concern to watershed residents. For example, stormwater runoff and agricultural runoff could have been placed into one general category; however, by creating two separate categories, we were able to understand exactly which type of runoff is of greater concern.

- **Question** 16**.** Most respondents would prefer to receive information regarding Rowan and Hinkson Creek in the form of newsletters (50.6%) or fact sheets (44.4%). Additionally, 14 people (7.3%) wrote that articles in the local and/or state papers would be an excellent way to reach people. This question was created to determine which forms of communication would be most well received in the Rowan Creek Watershed. Although not everyone in a community will be interested in every topic, understanding how the majority of a community would like to receive information, people, groups, and organizations taking leadership roles are better able to inform others in the format to which they are most apt to respond.

Conclusions

The results of our survey indicate that there is a significant level of interest in the health of the Rowan Creek Watershed on the part of the people who live within the watershed. Most of the respondents use the creeks and the recreational areas along the creeks in some way, whether for nature appreciation, hiking, or fishing. The fact that many people living within the watershed use these areas means that they are at least aware of the resource, whether they find it valuable or not. The results also show that though people are divided as to whether water quality has changed in the time that they have lived in the watershed, almost all respondents agree that there are environmental issues in the watershed that need to be addressed.

It might be interesting to compare the opinions of longtime residents in the watershed with those of individuals who have lived in the watershed for less time. These two groups of people might have different perspectives on the past and present health of the watershed as well as on future environmental concerns. However, due to the short duration of our project, in-depth statistical analyses of this sort were not possible.

Outreach and Education

According to the surveys and stakeholder analysis, stakeholders desire to see more outreach and education occurring in the watershed. Outreach activities include increasing public awareness of and involvement with watershed issues and project initiatives, coordination of watershed-management activities between stakeholders, communication of general concepts, and education on some of the more specific aspects of watershed management. Additionally, classroom curricula introduce watershed monitoring and management to students of all ages by supplying background information, activities, and simple monitoring techniques that can supplement textbook material and stimulate an interest in the watershed. Combining the outreach and education efforts put forth by stakeholders, volunteer citizens, teachers, and students could prove beneficial for working toward the goal of instituting some kind of watershed-management program.

Implementing a long-term monitoring program to chronicle changes, whether they are for the better or worse, can be a useful way to assess the progress of a watershed-management program. Through this project, we have provided a few tools to assist with continued stream monitoring by clubs, organizations, and local science classes. This section would not have been possible without the assistance of Ed Sommers (a science instructor at Poynette High School), the FORC, the WDNR, and the University of Wisconsin–Cooperative Extension. It is important for all groups interested in monitoring to ensure consistent—meaning year-round and long-term—observation.

Ongoing Efforts

Although we have placed great emphasis here on monitoring, outreach efforts should reach beyond monitoring to include a variety of activities that can help improve or maintain the quality of the Rowan Creek Watershed. The FORC has been involved in a number of activities along these lines concerning the creek and its watershed. FORC members have, for example, planted native vegetation and planned for the establishment of an interpretive nature trail in the Village of Poynette. They also distribute a newsletter to improve communication on watershed-management and creek-related projects. Finally, they have organized lectures on stormwater management, public fish shocking by the WDNR, and efforts such as cleanup days to help boost public interest and involvement and, ultimately, to maintain the quality of the trail and the creek.

Student Involvement

As part of our study we invited Ed Sommers, a Poynette High School science teacher, to participate in our creek-monitoring activities to encourage him to use similar activities in the ecology course he teaches and the conservation club at the Poynette High School, which he oversees. He and other local educators can include these activities in their curricula when they discuss the hydrologic cycle and the nutrient cycle, for example. While studying the hydrologic cycle, students could also discuss water flow across a landscape, monitor the baseflow of the creeks at several monitoring points, and produce creek profiles for those sites. Likewise, classroom material about the nutrient cycle could lead directly into collecting water samples from Rowan and Hinkson Creeks to determine the levels of nutrients, such as total phosphorous and nitrate–nitrogen, in the creeks. Additionally, students could collect macroinvertebrates as biological indicators to determine the relative quality of the creek. Repetition of these monitoring techniques building off the baseline information from our study could help stakeholders observe long-term changes in water quality and quantity.

These simple hands-on projects can also be expanded and incorporated into an environmental science or ecology curriculum to include monitoring of other stream parameters, such as temperature and turbidity (water clarity). Digital thermometers that take readings on a regular schedule could be placed in the creeks to collect temperature data. These data could be used to relate how water temperature changes over time because of impacts such as development and changes in agriculture. Like temperature, turbidity is easy to determine. Students could be assigned the task of collecting water samples before and after a storm event to compare baseline water clarity with the clarity of creek water following a major storm. Unlike the other assignments suggested, this one would be dependent upon a storm event, a natural phenomenon that may not necessarily occur within the timeframe of a given course.

Sample lab exercises are provided in Appendix C for each of the ideas listed above, and each of the suggested programs contains program-specific curriculum materials.

Interested readers can obtain suggestions for more comprehensive, school based materials by contacting the University of Wisconsin–Cooperative Extension and the Wisconsin Department of Natural Resources. Suzanne Wade from the UW–Extension highly recommends the handbook by Mitchell and Stapp (2000) for information about heavy metals testing, land-use practices, and computer networking as well as details about different water-quality tests, including dissolved oxygen, fecal coliform, pH, total solids, total phosphorous, nitrates, turbidity, biological oxygen demand, and temperature.

Water Education Curricula

All four programs listed below are useful tools for communities interested in developing projects within a watershed. The first two programs were designed for use with students from kindergarten to twelfth grade (K–12). The third program, Project WET, is a curriculum-sharing site for teachers of grades K–12. The fourth program, Water Action Volunteers (WAV), was designed for use by an entire community. All four programs, however, have sections that can be useful for any type of group that is interested in learning about and protecting their water resources.

We have provided a brief summary of each program below. For more detailed information, please visit the Web site listed or call the contact person listed with each program.

Adopt-a-Watershed

MISSION: To get students in grades K–12 interested in, and aware of, their surroundings though hands-on programs and community service and by using the world around them as a "living laboratory." Although this program is targeted at students in grades K–12, one of the main goals is to get the community involved in the school projects. Another strategy of this program is to use all the sciences together to develop an understanding of and respect for the outdoors.

AGE: K–12

FUNDED BY: Nonprofit

CONTACTS: Adopt-a-Watershed
P.O. Box 1850
Hayfork, CA 96041
Telephone: (530) 628-5334
Fax: (530) 628-4212
Web site: http://www.adopt-a-watershed.org

GLOBE

MISSION: The GLOBE (Global Learning and Observations to Benefit the Environments Education Program) program teaches students how to take "scientifically valid measurements" in a wide variety of fields while helping real scientists with data collection. The GLOBE program uses the Internet as a communication link between scientists and students all over the world. Through hands-on data collection, students are taught how scientists in four fields (atmospheric science, hydrology, soil science, and land-cover studies) create research projects and see that the data they have collected for the scientists are being used in actual, current studies.

AGE: K–12

FUNDED BY: National Aeronautic and Space Administration
National Science Foundation
U.S. Environmental Protection Agency
U.S. State Department
Colleges, universities, and state and local programs in more than 100 countries

CONTACTS: The GLOBE Program
Suite 800, 1800 G St., NW
Washington, D.C. 20006
Telephone: (800) 858-9947
Web site: http://www.globe.gov

Project Water Education for Teachers

MISSION: Project Water Education for Teachers (WET) was created to provide a place for teachers to get information on how to teach about Wisconsin's lakes, streams, and rivers. Although the initial function of Project WET was to "disseminate teaching materials," the biggest part of this program today is the Project WET Curriculum and Activity guide which contains more than 90 water-related activities for teachers to use with students in grades K–12. Additionally, Project WET holds teacher leadership workshops at both the regional and local level.

AGES: K–12, with a focus on teacher education

FUNDED BY: The Wisconsin Lakes Partnership (University of Wisconsin–Extension, Wisconsin Department of Natural Resources, and Wisconsin Association of Lakes)

CONTACTS: Mary Pardee, Coordinator
Project WET–Wisconsin
University of Wisconsin–Extension
College of Natural Resources
University of Wisconsin–Stevens Point
Stevens Point, WI 54481
Telephone: (715) 346-4978
Web site: http://www.uwsp.edu/cnr/uwexlakes/wet

Water Action Volunteers

MISSION: The Water Action Volunteers (WAV) program is for community members and groups that are interested in improving the quality of Wisconsin's lakes and streams though hands-on projects. The three biggest projects that WAV currently promotes are citizen stream monitoring, storm-drain stenciling, and river cleanups. The WAV has activity packets for each project and offers training sessions each spring for groups interested in leading programs.

AGES: All ages

FUNDED BY: Wisconsin Department of Natural Resources and the University of Wisconsin–Cooperative Extension

CONTACTS: Kris Stepenuck, Coordinator
Environmental Resources Center
216 Agriculture Hall
1450 Linden Dr.
Madison, WI 53706
Telephone: (608) 264-8948
Web site: http://clean-water.uwex.edu/wav

Other Resources

- MacKenzie Environmental Education Center
  Department of Natural Resources
  W7303 County Highway CS
  Poynette, WI 53955
  Telephone: (608) 635-8110
- Center for Watershed Protection: http://www.cwp.org/
- Low Impact Development Urban Design Tools: http://www.lid-stormwater.net/
- Low Impact Development Center, Inc.: http://www.lowimpactdevelopment.org/
- U.S. Geological Survey, Water Division: http://water.usgs.gov/
- U.S. Geological Survey, Learning Web: http://interactive2.usgs.gov/learningweb/teachers/lesson_plans.htm

Conclusions

We learned through our telephone interviews and questionnaire that there is a widely perceived need for improved coordination of watershed-management activities currently being undertaken by a variety of stakeholders. It is clear that such coordination should involve watershed managers and local citizens, including school-aged children. The FORC has served as an important catalyst for citizen involvement in watershed management. Our suggestions included implementation of educational activities in local schools and with citizen groups along with the encouragement of continued monitoring of the Rowan Creek Watershed over time as a way of increasing people's interest in watershed issues and as a means for gauging the relative health of the watershed as development and the kind of activities push and pull it in new directions.

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North Fork Pheasant Branch Watershed Committee, 1999, Pheasant Branch—Coming Together For the Future: Dane County Regional Planning Commission, 32 p.

CHAPTER 5. STORMWATER MANAGEMENT AND REGULATION

Introduction to Stormwater Management

People and the Hydrologic Cycle

Rowan and Hinkson Creeks are significantly affected by the characteristics of the watershed system in which they are located. This link exists because the quantity and quality of water entering the creek are influenced by the nature of the land over which the water passes after falling as precipitation.

This leads us once again to the fundamental problem: Given its preference, society would have a pristine creek, which is to say a creek that reflects undisturbed watershed conditions. There are, however, many benefits to be derived from "disturbances" to the watershed, such as agriculture and urban development. Two important values are, therefore, in conflict. The current strategy to resolve this conflict is to *mitigate,* that is, to allow the disturbance to take place, and then to come up with creative ways to deal with the negative effects.

Hydrologic Problems Caused by Development

Physical problems related to stormwater generally fall into two categories: harm to people or property and harm to habitat or the environment. There is, however, a great deal of overlap between the two groups of problems. As the idea of *sustainable development* (development that is economically viable, environmentally sound, and socially just) begins to take on a larger role in policy discussions and decision making, it increasingly makes sense to address stormwater problems in a holistic fashion, addressing both kinds of problems at once.

In Chapter 2, we discussed the following stormwater problems caused by development that are relevant to our discussion here:

- Local and regional flooding
- Excess sediment and polluted runoff
- Streambank erosion and habitat loss
- Increased stream temperature
- Diminished groundwater supply
- Lower levels of baseflow in streams

The root causes of these problems are landscape alterations, land- and water-use changes, and the use of foreign or concentrated substances on the land. These basic activities occur in agricultural and urban settings, and they can be illustrated more clearly with the following specific examples:

- Urbanization typically leads to increased impervious surface area. Impervious surfaces prevent precipitation from infiltrating into the ground and instead turn it into surface runoff. During large storms, this can result in local and regional downstream flooding, leading to property and habitat damage.
- Agricultural fields and construction sites may have large areas of exposed soil. When sufficient rain falls to generate runoff, it washes away much more soil than it would if natural vegetation were in place. This erosion and resulting sedimentation can be costly to humans and catastrophic for aquatic life.
- The combined effect of decreases in groundwater recharge due to the introduction of impervious surfaces and the drawdown of aquifers (lowering of the water table) through pumping and/or reduced recharge can cause problems for fish living in streams fed by groundwater. Streams fed by groundwater tend to have stable flow and cool temperatures, in contrast to the highly variable flows and warmer temperatures of streams fed by surface water.
- Streambanks typically become eroded when cattle or other livestock frequently trample them. This erosion damages habitat for aquatic plants and animals, releases sediment into the stream, and introduces nutrients from animal waste.

Stormwater-Management Processes

Just as a few fundamental types of activities can cause many specific stormwater-related problems, a few fundamental stormwater-management strategies, or processes, can be incorporated into a wide array of specific management tools. The following strategies logically correspond to the disruptive activities of development that they are intended to counterbalance:

- *Conveyance*—moving stormwater away from where it originates, typically to prevent local flooding.
- *Storage*—temporarily holding stormwater, often in a basin, and releasing it slowly, which helps to prevent downstream, or regional, flooding.
- *Settling*—allowing suspended particles and pollutants to drop out of stormwater held in storage; if stormwater is held in place long enough, heavier particles settle and remain in the basin rather than polluting the downstream water body.

- *Filtration*—directing stormwater through some kind of structure that will remove harmful substances either physically or chemically.
- *Infiltration*—allowing stormwater that might otherwise turn into surface runoff to seep into the ground and recharge aquifers.

Urban Stormwater-Management History in Brief

The sequence of processes outlined in the preceding section, from conveyance to infiltration, roughly follows the order in which stormwater-management techniques have been developed over recent history. Flooding, because it has such a clear, massive impact that hits people directly in the pocketbook, was the first major stormwater problem to be identified and addressed by stormwater engineers in their designs of conveyance and storage structures. Later, the desire to address water-quality concerns became more prevalent, and the goal of particle settlement was integrated into the design of storage facilities. More recently, filtration devices were added to provide more thorough treatment of the water leaving a developed site.

The next step in the progression of stormwater management is to ensure that infiltration is maintained when development modifies the natural hydrologic system. In particular, local infiltration (allowing would-be stormwater runoff to enter the ground close to where it lands) is a way to address a disruption in the hydrologic cycle quickly and effectively, allowing the problem to remain at a manageable scale. With this strategy, the distribution of precipitation between infiltration and runoff shifts back toward a natural balance. Infiltration practices control runoff volume, not just the peak flow (the maximum flow rate of runoff for a given precipitation event), as is the case with storage techniques such as retention and detention. Increased infiltration also leads to greater groundwater recharge, increased baseflow in local streams, and lower stream temperatures.

Researchers and engineers are currently working to develop, test, and fine-tune a variety of local infiltration strategies, some of which have already been proven effective in practice. Similarly, the regulatory community, including the Wisconsin Department of Natural Resources, is developing rules and guidelines that will make infiltration a fundamental aspect of stormwater planning. Some communities have already implemented these new strategies, and as information becomes more widely available, the number of participants will increase.

Urban Stormwater-Management Practices

Infiltration is a cornerstone of an increasingly popular approach known as low-impact development. In general, the goal of low-impact development is to use available scientific knowledge to allow development to take place while protecting the character and the quality of the natural environment. This requires an awareness of the many ways in which habitat, water quality, and natural resources are affected by changes to a particular system. Although low-impact development encompasses more than just hydrology, and although some low-impact development strategies do not result in hydrologic benefits, the goal of maintaining infiltration is consistent with the spirit of this approach.

Water Quantity: Local Flooding and Property Damage

Traditional Conveyance Infrastructure

As stated earlier, the primary concern of the stormwater engineer has been to eliminate the costs of flooding brought on by development. The first step in this process has been to move stormwater away from property as quickly as possible. The tools for doing this are streets, sidewalks, curbs, gutters, storm sewers, and culverts. When properly designed, these hard, sloped, and relatively smooth surfaces effectively move water away from a developed area. Although stormwater runoff can overwhelm this kind of conveyance system, the drainage pattern built into and around the local transportation network usually serves as the first line of defense against flooding in developed areas.

Detention Basins

In traditional designs, stormwater is carried to a predetermined location, where it is stored in a *detention* (retention) basin. The increased amount of impervious surfaces in developed areas generally leads to higher peak flows to the downstream channel; detention basins are a common method of reducing these flows to pre-developed levels, or some other desired level.

The principle underlying detention basins is simple. Given that the volume of runoff will increase by some determined amount, the basin is constructed so that it can store the excess runoff and release it at an acceptable rate through some kind of outlet-control structure, which regulates the flow of water exiting a detention basin.

Detention basins vary significantly in size, depending on the size of the area they serve as well as the storm for which they are designed. In Poynette, for example, the established "design storm" is the 10-year storm (a storm that has a 1 in 10 chance of occurring in a given year; for Poynette, this is approximately 4.1 inches of rain in a 24-hour period).

Within the limits of what it is meant to address, the stormwater detention basin is generally effective. It is advantageous in that it is conceptually simple, its design methods are well established, and when properly designed, it can accomplish the goal of reducing peak stormwater flow rates. On the other hand, detention basins are generally costly in terms of the space they require, they are usually designed without sufficient attention to aesthetics, and they do not address the issue of regional flooding. Additionally, detention basins do not fully address concerns over pollution and sediment. They can, however, contribute somewhat to the improvement of water quality by slowing down stormwater and allowing sediment and attached pollutants to settle out. In combination with other practices, detention can be an effective water-quality improvement technique.

Water Quality: Sediment and Pollutant Removal

Construction-Site Erosion and Sediment Control

Construction sites are potential locations for serious human alterations to natural hydrology, causing stormwater runoff and related detrimental impacts on local water bodies. The impacts can be especially serious due to the large areas of disturbed land left exposed to potential soil erosion and sediment loss during construction.

Due to the importance of addressing the issues of sediment and erosion control from construction sites, many local jurisdictions have in place ordinances encouraging and/or requiring the use of management practices appropriate for dealing with these potential problems. In the Village of Poynette, for example, controls to keep erosion at predevelopment levels must be in place for anything qualifying as a "land-disturbing activity," a term broadly defined by the ordinance.

Construction-site erosion and sediment-control practices can be structural or vegetative in nature. In either case, erosion- and sediment-control practices should be coordinated and planned for in advance of the start of construction. The U.S. Department of Transportation's Urban Drainage Design Manual (1996) lists the following basic principles that should be followed when creating and implementing a plan for successful construction-site erosion and sediment control:

- Plan the project to fit the particular topography, soils, drainage patterns, and natural vegetation of the site.
- Minimize the extent of the area exposed and the duration of exposure.
- Apply erosion-control practices within the site to prevent on-site damage.
- Apply perimeter-control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.
- Keep runoff velocities low and retain runoff on the site to the extent possible.
- Stabilize disturbed areas immediately after final grade has been attained.
- Implement a thorough maintenance and follow-up program. Erosion and sediment controls should be inspected and repaired as necessary following each significant rainfall event.

Some practices for construction-site erosion and sediment control include the following:

- Mulch and/or seed areas that have disturbed soils to prevent erosion and reduce stormwater-flow velocity.
- Construct sediment basins to detain runoff and allow sediment to settle out before water runs into local water bodies or storm-drainage infrastructure.

- Construct check dams across drainage ditches to reduce runoff velocities and remove sediment from stormwater flowing through the ditches.
- Install silt fences at the base of slopes and around the perimeter of the site to keep sediment from leaving the site and to reduce the velocity of stormwater runoff. Silt fences are the most common construction-site erosion and sediment-control practice.
- Use *brush barriers* (piled-up brush cleared from the site) to bar sediment from leaving a site and earthen diversion dikes to divert runoff water to appropriate locations for treatment.
- Install temporary slope drains (flexible tubing or conduits) to convey runoff water from the top of a disturbed slope to the bottom so that the slope will not erode. These devices can also be used to transfer runoff to an appropriate place for treatment.

Two important aspects of construction-site erosion and sediment control, without which all the recommendations above might prove ineffective, are proper enforcement and adequate penalties for noncompliance. Once a community has decided upon a stormwater-management approach, the responsible governmental representative, municipal or otherwise, must have the authority and the tools required to effectively encourage people to carry out the actions that lead to watershed health.

For construction activities that may take place in the Rowan Creek Watershed, the Wisconsin Construction Site Best Management Practice Handbook may be the best reference (Wisconsin Department of Natural Resources, 1990). This guide is available from the State of Wisconsin at a minimal cost. The State's Bureau of Document Sales can be reached at 202 S. Thornton Ave. P.O. Box 7840, Madison, Wisconsin 53707-7840, telephone (608) 266-3358.

Other Urban Stormwater-Management Practices for Sediment and Pollutant Removal

Beyond the specific set of practices and approaches that can be used to address construction-site erosion and sediment control, several specific urban stormwater-management practices can address problems relating to sediment and other pollutants and their impacts on water quality. The practices included in this category meet their objectives by filtering out sediment and other pollutants either by mechanical means or by relying on the natural filtering capabilities of various forms of vegetation.

Water-Quality Swales. *Water-quality swales* are vegetated, open channels that are carved out of the soil and that collect and convey stormwater runoff. They are in many cases used along roadways as an alternative to curbs and gutters, especially in more rural developed areas. They can be dry, wet, or vegetated depending on local soil and groundwater conditions.

Water-quality swales address water quality directly by removing some pollutants. They also aid in controlling peak stormwater volume, by way of storage, and water quantity, by fostering infiltration.

Filter Strips. A *filter strip* is a kind of non-structural, vegetative practice that can be used to deal with stormwater runoff in urbanized and rural/agricultural environments. Generally, filter strips do not stand alone; rather, they are incorporated into an overall stormwater-management system. This system can include structural components, such as storm sewers and detention basins, or non-structural alternatives, such as grass swales and constructed wetlands.

A grass swale is a vegetated channel designed to convey stormwater and remove sediment from it; a filter strip is a flat, wide, open, vegetated space designed to handle sheet flow of runoff water instead of concentrated channel flow. Filter strips otherwise act in similar ways to grass swales, relying on grasses and other vegetation to keep soil from eroding, to filter out sediments and other insoluble pollutants before they reach a natural water body, and to reduce runoff velocity and volume slightly. According to the U.S. Department of Transportation (1996) "[f]ilter strips are also of great value in preserving the riparian zone [along a stream or other water body] and stabilizing streambanks." Other secondary benefits of filter strips include the wildlife habitat they can provide, their relatively low cost, and the aesthetic benefits they can provide.

Constructed Wetlands. *Constructed wetlands* are manmade systems designed to collect stormwater and remove pollutants, including soluble nutrients, with the help of wetland vegetation. They do not have the same ecological functions as natural wetlands. Several wetland design types are suited for various conditions, including shallow marsh systems, pond/wetland systems, extended detention wetlands, and pocket wetlands. In addition to controlling stormwater volume and reducing flooding, constructed wetlands maximize pollutant removal through a combination of biological uptake and particle settling.

Sediment Traps. A *sediment trap* is a constructed pool featuring a filtering device at its outlet, which leads to the primary local stormwater-management structure (detention basin, pond, or wetland). Sediment traps are designed to be used in conjunction with, and to increase the effectiveness of, a primary stormwater-management structure. They work by slowing and collecting stormwater, allowing suspended solids to settle and pollutants to be filtered out before the water exits the trap.

Inline and Vegetative Filters. *Inline and vegetative filters* can be installed in and at the end of storm sewer pipes, respectively. The aim of each is to reduce the amounts of sediment and other pollutants reaching the water body into which the storm sewer eventually drains. These structural stormwater-management features generally require frequent maintenance and/or cleaning, but they may be a viable option in situations where there are no alternatives available for minimizing pollutant loads in stormwater headed for a nearby water body.

Sand and Organic Filters. *Sand and organic filters* consist of beds of sand or peat, or combinations of these and other materials, either underlain with perforated drains or designed with cells and baffles with inlets and outlets. As stormwater runs off impervious surfaces, it can be diverted to the filter and allowed to settle. The stormwater would then be filtered and, finally, allowed to infiltrate the ground or sent to another stormwater-management structure. These devices can be used in areas with thin soils, high evaporation rates, low infiltration rates, and/or limited space. Sand and organic filters can be utilized in densely populated urban locations with small, completely impervious drainage areas.

Sand and organic filters can be used to address two problems. In highly urban areas that have a high concentration of impervious surfaces, these filters can be used to allow stormwater runoff to recharge the groundwater. This reduces the total stormwater discharge volume and allows the replenishment of local aquifers. At the same time, filtering stormwater contaminants addresses water-quality concerns in relation to surface water and groundwater.

Sand and organic filters are designed as off-line stormwater-management practices, meaning that they perform a secondary task in the overall system to control stormwater, in this case improving water quality. However, careful design or an increased number of filters could allow for the control of peak discharge rates, addressing water quantity to some extent as well. These filters provide a high removal rate of sediment and trace metals and a moderate reduction of nutrients, biological oxygen demand, and coliform bacteria, pollutants of concern in many agricultural settings.

Underground Retention Systems. *Underground retention systems*, such as water-quality inlets and deep sump catch basins, are designed only to remove trash, debris, and some amount of sediment, oil, and grease from stormwater runoff. As a result, the water reaching downstream stormwater-management structures is less contaminated, and ultimately local water resources are impacted to a lesser extent.

Water-quality inlets commonly consist of three settling chambers. The first chamber is a permanent pool of water about 4 feet deep in which floatable debris is trapped and sediment settles to the bottom. Connected at about half that depth is the second chamber with another permanent pool of water of about equal depth. Stormwater passes through screened orifices and is deposited into this chamber. Here, oil and grease float to the surface or attach to sediments and settle out. The stormwater then passes through the bottom opening of an inverted pipe and into a third chamber. If the outlet of the third chamber is above the water-quality inlet's deepest point, another permanent pool will form for settling. The remaining stormwater is routed out of the final chamber and into a storm-drain system or another stormwater-management structure.

A deep sump catch basin uses a similar approach, but without chambers. The deep sump design allows stormwater to enter at the top of the basin. The outflow point is at least 4 feet below the inflow and is generally four times the diameter. Stormwater moves through screened orifices to the basin, where lighter pollutants float and the heavier pollutants settle out. The remaining stormwater must pass through the bottom opening of an inverted pipe.

Typical locations for water-quality inlets and deep sump catch basins include gas stations, parking lots, convenience stores, and other areas with high levels of vehicular traffic. Sites that might be appropriate include areas that have high amounts of impervious surface and sites that are expected to receive large amounts of sediment and/or hydrocarbon loadings.

Water-quality inlets and deep sump catch basins are best used to provide pretreatment for downstream management structures and in retrofit situations; they provide water-quality treatment for small urban lots where larger structures are not feasible because of site constraints. These underground detention systems have limited storage capacity, detention time, and pollutant removal so they cannot be used to meet stormwater-management standards alone. They are, however, recommended as pretreatment tools for other technologies. Provided they are designed and maintained properly, these devices can provide effective pretreatment of sediment, oil, and grease that may otherwise damage downstream stormwater-management structures or natural resources.

Water Quantity: Restoring the Hydrologic Cycle

The following practices attempt to restore the predevelopment hydrologic cycle by facilitating infiltration to reestablish predevelopment levels of groundwater recharge and reduce the amount of surface runoff caused by human activities.

Infiltration Basins

Infiltration basins are excavations that collect and temporarily store stormwater runoff. They are constructed in permeable soils so that the stored water can infiltrate the local aquifer. Because of concerns about clogging and groundwater contamination, infiltration basins are recommended for use in small drainage areas and for stormwater with low sediment and pollutant loads.

In addition to the benefits of standard detention and retention basins, infiltration basins return a part of precipitation to the local aquifer. Also, local flooding is reduced and pollutants are removed as water percolates through the soil.

Infiltration Trenches

Infiltration trenches are shallow, narrow ditches filled with stone and lined with filter fabric. They collect stormwater and allow it to slowly infiltrate the soil below. Trenches are best suited for small drainage areas with limited space.

Infiltration trenches aid in controlling stormwater volume and water quality by diverting would-be runoff into the ground and by removing pollutants.

Rain Gardens

Rain gardens, like infiltration basins and infiltration trenches, encourage the infiltration of runoff water that drains into them. In rain gardens, that water typically comes from roof downspouts, sump pump outlets, and other small-scale impervious surfaces. Rain gardens are usually used in a residential setting, although this technique is applicable in other urban and rural situations as well.

A rain garden is a flat-bottomed depression in a lawn area adjacent to, and just down-slope of, the impervious surfaces whose runoff the rain garden is intended to manage. This can even include the lawn itself, a semi-impervious surface when compared with natural vegetation. The depression is planted with natural wildflowers and grasses whose roots help to encourage the water captured in the rain garden during and after a rain event to infiltrate down to the groundwater as it would have under more natural conditions. Runoff water from roof downspouts, sump pumps, lawns, and even driveways is directed into the rain garden for temporary storage and eventual infiltration into the ground.

Reliance on rain gardens throughout a neighborhood can significantly restore the natural hydrologic balance, minimizing the impacts of the development on a local stream's flow regime and water quality while maintaining near predevelopment levels of groundwater recharge. This is especially important in areas where aquifers are the primary source for drinking water and where local citizens view groundwater-fed cold water streams, such as Rowan and Hinkson Creeks, as valuable natural resources. This can also potentially reduce the cost of stormwater-management infrastructure for development because it can be designed at a small scale.

The primary benefits of incorporating rain gardens into a single residential lot, or an entire subdivision or neighborhood, relate to their ability to manage stormwater. These benefits include reduced runoff volumes in local stormwater-management facilities, which can allow for reduced expenditures on infrastructure such as storm sewers and detention ponds; reduced flow volumes in nearby streams, which help reduce the streambank erosion and loss of wildlife habitat that come with increased flow in streams; increased infiltration of stormwater, which helps to restore natural levels of groundwater recharge to replenish aquifers and maintain stream baseflow and temperatures during dry periods; reduced pollutant and sediment loads to nearby water bodies; and reduced chances of local flooding. Secondary benefits of rain gardens include increased wildlife habitat, enhanced aesthetics, and improved home values.

Porous Pavement

Porous pavement is a fairly self-explanatory stormwater-management practice: It is pavement that allows water to soak through into the ground rather than simply running off. There are a number of specific types of porous pavement, but they all share the same basic goal of establishing a surface firm enough to be used by cars, but constructed with gaps to allow stormwater to infiltrate.

Up to 70 percent of the problematic impervious area associated with development can be considered “automobile habitat,” constructed primarily to accommodate the needs of a society that relies heavily upon the car (Scheuler, 1995). Porous pavement is an attempt to address at the source the hydrologic problems associated with this aspect of development.

Dry Wells

A *dry well* is an excavated pit that is backfilled with aggregate rock containing 30 to 40 percent void space. Its purposes are to facilitate the infiltration of good quality stormwater runoff, such as uncontaminated roof runoff, and to reduce the total quantity of stormwater runoff.

Increasing the total amount of stormwater infiltrating the ground results in a reduction in stormwater runoff volume. As a result, downstream stormwater-management and conveyance structures can be made more effective and less costly. Dry wells are also applicable to areas where stormwater drains are not available.

Site Planning

Site planning is different from the other stormwater-management practices described in this section because it does not involve the construction of any kind of structure to deal with stormwater runoff. It also differs from some of the non-structural practices we have described, although it is related to these in some ways. Site planning occurs one step earlier in the development process than the design of the other practices, structural and non-structural, that we have detailed. Site planning is a process of thinking in advance about how the goals for a given development can be met while keeping in mind the development’s eventual impacts on the hydrology of the site and designing the development specifically to minimize those impacts.

Site planning may involve determining the planned uses for the roads, sidewalks, parking lots, and other impervious areas that are desired in a given development and then reducing the area of those impervious surfaces to just the amount that is truly needed to meet their intended uses. Roads in residential subdivisions, for example, are sometimes built much wider than necessary to handle the traffic and parking needs of residents. This comes at significantly increased cost to the developer in the short term and increased maintenance, plowing, and replacement costs for the local municipality over the long term. Likewise, parking lots in commercial shopping centers are in many cases built larger than necessary, especially if there is available parking in adjacent lots in an area featuring several shopping destinations. These wider roads and larger parking lots obviously contribute to greater areas of impervious surface, which, in turn, may cause problems for local streams and groundwater resources.

Site planning also involves paying close attention to the local topography, hydrology, and ecology of an area in designing a development, whether it is single-family housing, multi-family housing, or a commercial or industrial building, to minimize impacts on local hydrology and ecology. For example, not constructing buildings or roads on steep slopes makes sense from a stormwater-management perspective because those steep slopes, if they were developed, could easily erode, causing a variety of runoff-related problems. Another site-planning approach involves the idea of leaving intact natural drainageways and the buffer areas that exist around them so that nature's stormwater-management "infrastructure" can be allowed to continue playing its role in conveying and treating stormwater runoff before it reaches a local stream or other water body. In these ways, the impacts of human developments on the natural hydrologic cycle can be minimized. This can be done in many cases without any additional costs and possibly at a cost savings.

Some site-planning techniques that are not primarily designed to address stormwater management can play a secondary role in the overall plan to control stormwater runoff from a given development. One example for residential subdivisions is cluster design, a technique also referred to as "conservation-subdivision" design. In conservation-subdivision design, the amount of area covered by impervious surfaces and disturbed by construction activities is reduced by concentrating (clustering) lots and buildings in areas away from valuable natural resources such as rivers and streams, viable farmland, or open space. This preserves valuable natural resources, but also reduces the amount of impervious surface area. This benefits local streams and other water bodies by reducing stormwater runoff volumes and limiting the potential for polluted runoff to diminish local water quality. Conservation-subdivision design inherently incorporates site-planning techniques, such as avoiding building on steep slopes, maintaining intact natural drainageways, and thinking about local topography in the design of the development.

Agricultural Runoff-Management Practices

One of the goals of this report is to provide information for people who will likely be dealing with an increased amount of urban development in the Rowan Creek Watershed. However, agricultural runoff continues to be the most significant threat to the health of Rowan and Hinkson Creeks, due to the ever-present threats of erosion and nutrient pollution associated with farming activities. This is not to say that the current state of agricultural activities in the Rowan Creek Watershed is dire from the perspective of the creeks; that is not the case. However, to protect local water resources, those watershed stakeholders involved with stormwater management will need to maintain their focus on the problems of agricultural runoff as they increasingly bring knowledge of urban stormwater issues into their field of vision.

Many agricultural best management practices have been and continue to be used on farms throughout the Rowan Creek Watershed, and they are probably familiar to many people responsible for making decisions about watershed management (table 5.1). We have divided the agricultural practices into the following three categories; each category focuses on a related set of problems that the management strategies are meant to address:

- physical impairments to a stream associated with soil erosion and the associated introduction of sediment;
- problems caused by the introduction of nutrients from farming activities into a stream; and
- practices that address sediment and nutrient problems while also providing other benefits.

The following descriptions of these agricultural practices were taken from Natural Resources Conservation Service (2002) and summarized for the sake of convenience and completeness. The reader should turn to that document for a more in-depth discussion of each practice and its implementation.

Soil Erosion and Sedimentation

The introduction of sediment into a stream can dramatically affect its physical characteristics. For example, habitat for fish and other aquatic animals can be destroyed. The following practices attempt to reduce soil erosion from agricultural fields and its subsequent deposition as sediment in streams.

Table 5.1. *Comparison of agricultural best management practices.*

Management practice	Effectiveness	Capital cost	On-site benefit
Waste-management system	High	Moderate	Moderate
Long-term manure storage facility	High	High	Moderate
Short-term manure storage facility	High	Moderate	Moderate
"Critical area stabilization (conservation cover, mulching, tree/shrub establishment, crop residue use)"	High	Low	Moderate
Contour farming/cropping	High	Low	Moderate
Reduced tillage	High	Low	Moderate
Field diversions	High	Moderate	Moderate
Riparian forest buffers	High	High	Low
Grade stabilization structures	High	High	Low
Grassed waterways	High	Moderate	Moderate
Animal trails and walkways	High	Low	Low
Strip cropping (on the contour)	High	Low	Moderate
Terracing	High	Moderate	Moderate

Source: Water Resources Management Practicum (1997)

Conservation Cover

Conservation cover describes perennial vegetative cover established and maintained to protect soil and water resources on land that has been retired from agricultural production. By establishing native vegetation on retired agricultural land, especially those areas that are closest to streams or on steep, erodible slopes, soil erosion and sedimentation can be significantly reduced.

Cover Crops/Green Manure

Cover crops are close-growing grasses, legumes, or small grains grown on agricultural fields primarily for seasonal erosion protection and soil improvement. These crops are planted outside the growing season to control erosion during periods of the year when major crops do not furnish adequate cover to protect the soil from erosion. These crops also add organic material to the soil and improve infiltration, aeration, and tilth. A cover crop can be converted into a *green manure* by turning it over into the soil (prior to its decomposing fully) to enrich the soil. Plants not grown on-site can also be mixed into the soil as green manure.

Crop-Residue Management

Managing the distribution, orientation, and amount of plant residue left over from previous plantings protects cultivated fields during critical erosion periods. Several specific types of tilling practices accomplish this management objective. The most common practices are *no till* (or *strip till), mulch till,* and *ridge till.* Each practice addresses an uncultivated field in a way that leaves crop residue at the surface of the soil to provide tilled soil with a cover from eroding wind, to lessen the impact of pounding raindrops, to impede water runoff, and to provide habitat for local wildlife. As a result, soil moisture is conserved, infiltration is increased, soil loss is reduced, soil tilth is improved, and wildlife food and cover are provided.

Mulching

Mulching is the application of plant residues or any other suitable material not produced on the site to the soil surface to conserve soil moisture, prevent surface compaction or crusting, reduce runoff and erosion, control weeds, and establish plant cover. This practice creates a cover that protects bare soil from the elements. Wind and water have a more difficult time taking away the topsoil, and water is allowed to infiltrate the soil. As a result, more soil is available to retain soil moisture and less water can run off.

Contour Farming

In *contour farming*, land preparation, planting, and cultivation of sloping land are done in a curving pattern rather than straight up and down the slopes. Farming the land by plowing and planting up and down the slopes allows water to flow unimpeded down the rows. Subsequently, the water gains speed and erodes away the soil. Following the natural contours of the land, on the other hand, minimizes erosion by limiting the length of the pathways runoff water can follow as it moves down a slope. Placing furrows and rows of crops in the way of the water limits the length of these pathways and slows runoff water. This fosters infiltration and reduces the ability of the water to erode the soil.

Strip Cropping

Strip cropping involves growing crops in a systematic arrangement of strips or bands along the contour across the slope to reduce water erosion. Crops are arranged so that a strip of grass or some other close-growing crop is alternated with a strip of clean-tilled crop, or a strip of grass can be alternated with a close-growing crop. By alternating crops, runoff is slowed down, stormwater quantity is reduced through infiltration, and runoff is filtered. In the end, less sediment is allowed to move downslope.

Terracing

Terracing is the construction of an earthen embankment, a channel, or a combination of a ridge and a channel across a slope to reduce erosion. Terracing reduces the length of the slope across which runoff water can travel. Reducing slope length prevents runoff water from achieving erosive velocities, thus precluding the sedimentation of nearby streams. There are also some secondary benefits of terracing agricultural fields. The soil on a terrace is better able to conserve moisture. The farmer is potentially safer operating his or her machinery on the flatter slopes of a terrace than he or she would be on the steeper slopes the terrace replaced. Additionally, terracing also helps to reduce flooding of low areas of farm fields.

Diversions

During periods of intense precipitation, runoff mobilizes topsoil and moves it downhill, eventually leaving upslope fields unproductive. After a rain event, runoff can also pool in downslope locations, drowning crops. A *diversion* is a channel that is constructed across agricultural slopes and that features a supporting ridge on the lower side. Diversions address excessive water by conveying it away from areas of the field that are susceptible to ponding and erosion and toward other areas where water is welcome, such as grassed waterways.

Grade-Stabilization Structures

Grade-stabilization structures are used to control the grade and head cutting in natural or artificial channels. They flatten or stabilize the slope of a water pathway and subsequently slow down runoff, reducing the slope's erodibility. The water conveyed by these structures carries less sediment and is, therefore, less likely to cause stream sedimentation problems. Grade-stabilization structures can be either a combination of earth embankments and mechanical spillways, or full-flow detention-type structures, which prevent the formation or advance of gullies, enhance environmental quality, and reduce pollution hazards.

Sediment- and Water-Control Basins

Sediment- and water-control basins are designed to collect and store waterborne debris or sediment. As water moves off an agricultural field, it flows into the basin and its speed is reduced. As the water slows, debris and sediment are released and settle to the bottom; the purer water is either stored or conveyed to a safe disposal area. This process abates silt, gravel, stone, agricultural wastes, or other detritus that might otherwise pollute nearby water bodies. Sediment- and water-control basins also preserve the capacity of reservoirs, ditches, canals, diversions, waterways, and streams.

Grassed Waterways

Grassed waterways are natural or constructed channels that are graded and vegetated for the conveyance of runoff from terraces, diversions, or other areas in agricultural fields where water is concentrated. The vegetative cover in a grassed waterway allows virtually no soil erosion to occur and removes pollutants. Runoff water that is conveyed into a stream via grassed waterways will have a lower concentration of sediment and other pollutants, resulting in a healthier stream ecosystem.

Animal Trails and Walkways

Animal trails and walkways are special travel lanes that facilitate the movement of livestock across or near streams without causing the kinds of erosion and pollution that animals can cause in these areas. When designed properly, they can provide or improve access for livestock to food, water, or shelter livestock away from ecologically sensitive or erodible sites, such as streambanks and steep slopes. Minimizing livestock access to these sensitive areas benefits the ecosystem tremendously.

Nutrient Runoff Control

Excess nutrients, such as nitrogen and phosphorus, arising from agricultural activities, such as cropland fertilization, barnyard management, and manure spreading, can cause water-quality problems in streams. For example, excess nutrients can lead to nuisance plant and algae growth. One consequence of excessive plant growth is a reduction in dissolved oxygen levels, which can have damaging effects on fish and other aquatic organisms. The following practices aim to control the amount of nutrients that can potentially run off into a stream.

Waste-Management System

A *waste-management system* is a multi-component system for managing liquid and solid waste, including runoff from concentrated waste areas, in which all components are installed in a manner that does not degrade air, soil, or water resources. The components of a waste-management system can include dikes, diversions, fencing, filter strips, grassed waterways, irrigation systems, irrigation-water conveyance, pond sealing or lining, roof-runoff management, sediment basins, and subsurface drains.

Waste-Storage Facilities

Waste-storage facilities are impoundments that are made by constructing an embankment and/or excavating a pit or dugout or by fabricating a structure. The purpose of these facilities is to temporarily store wastes, such as manure, wastewater, and contaminated runoff, in a manner that safeguards the environment. These wastes are subsequently removed from the impoundment and either taken to a proper disposal facility or applied to the land as fertilizer. When properly built, waste-storage facilities can do an adequate job of storing waste for further use without the risks inherent in storing unconfined waste in a place where rain and runoff might lead to pollution of a nearby stream.

Closure of Waste Impoundments

All too often, waste-storage facilities are not properly designed or are not used for their intended purpose. In these cases, the continued operation of the waste-storage facility should be stopped and the facility should be closed, in an environmentally safe manner, for the purposes of protecting surface-water quality and groundwater resources, eliminating a safety hazard for humans and livestock and safeguarding human health.

Rural Roof-Runoff Management

A *rural roof-runoff management system* is any facility that collects, controls, and disposes of runoff water from the roofs of rural buildings. These techniques prevent roof runoff from flowing across concentrated livestock-waste areas, such as barnyards, roads, and alleys. They can help reduce pollution and erosion, improve water quality, prevent barnyard flooding, and improve drainage.

Nutrient Management

Managing the amount, form, placement, and timing of applications of nutrients to crop fields is known as *nutrient management*. In the past, some nutrient-application practices oversupplied crop fields with nutrients such as nitrogen and phosphorus, making it easier for nearby water bodies to receive excessive amounts of these nutrients. Nutrient-management techniques ensure the supply of nutrients necessary for crop production and minimize the entry of excess nutrients to surface water and/or groundwater.

Combined Practices

Riparian Forest Buffers

Riparian forest buffers are areas planted with trees, shrubs, and herbaceous plants that together function as a vegetated boundary between two adjacent ecosystems. Usually, one ecosystem is either a lake or a stream and the other is a planted agricultural field. These buffers intercept runoff from agricultural lands before it can flow into nearby water bodies. Generally, they provide the following benefits:

- They improve water quality by reducing amounts of sediment, organic matter, nutrients, pesticides, and other pollutants in surface runoff and by reducing the amounts of nutrients and other chemicals in shallow groundwater.
- They improve water quality by establishing permanent tree and herbaceous cover in floodplain areas subject to out-of-bank flow and/or scour erosion.
- They increase transpiration and infiltration, resulting in slower groundwater discharge to streams and reduced flood flows, both of which help to mitigate flood damage.
- They provide shade that lowers water temperatures and facilitates high stream dissolved-oxygen concentrations, thus improving habitat for aquatic organisms.
- They provide a source of detritus and large woody cover for aquatic organisms.
- They provide habitat and corridors for aquatic and terrestrial flora and fauna.
- They increase the biodiversity of plant and animal species in riparian areas.

Tree or Shrub Establishment

Establishing woody plants and trees by transplanting or seeding is another practice that has several benefits. This practice

- provides erosion control by stabilizing the subsurface;
- reduces air pollution and provides for the uptake of soil and waterborne chemicals and nutrients;
- provides wildlife habitat;
- establishes woody plants for forest products;
- beautifies an area; and
- restores woody communities.

Wetland Restoration

Wetland restoration can be done on sites that were historically wetlands, but that have been farmed or otherwise modified. By converting a site back to wetland, sometimes just by ceasing agricultural activities and other times by re-engineering the hydrology on the site, wetland functions such as flood control, sediment and nutrient trapping, and wildlife habitat can be restored as well.

Existing Funding Programs for Farmers

Many farm operators try to enroll in government cost-sharing programs to offset the costs of installing recommended runoff-management practices. Governments at levels from local to state to federal offer programs to provide incentives for farmers to implement practices that are in the best interests of society as a whole.

Conservation Reserve Program

The Food Security Act of 1985 established the Federal Conservation Reserve Program (CRP) to offer landowners annual rental, incentive, and cost-share payments in return for taking approved cropland out of production and planting long-term, resource-conserving covers for the purposes of improving soil quantity, water quality, and wildlife resources. The CRP program is implemented through the Commodity Credit Corporation and administered through the Farm Service Agency. These entities make this assistance available in an amount equal to not more than 50 percent of the landowner's costs in establishing approved practices.

Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is an offshoot of CRP in which landowners can enroll agricultural lands into conservation practices, such as riparian buffers, filter strips, wetland restorations, and grassed waterways, for economic benefit. This program is administered by a federal–state–local partnership between the U.S. Department of Agriculture, the Farm Service Agency, the Natural Resources Conservation Service, the Department of Natural Resources, and the local county Land Conservation Department. In the Rowan Creek Watershed, the townships of Dekorra, Lowville, Arlington, Lodi, and Leeds are eligible for this program. Participants in CREP receive annual rental payments for their land and 50 to 90 percent of the cost to implement the desired conservation practice(s).

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) provides landowners cost sharing and/or long-term permanent easements for the restoration of certain agricultural lands back to permanent wetlands. The 2002 Farm Bill has increased the number of acres nationwide that is eligible for this program from 1.075 million to 2.275 million acres.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) provides technical assistance, cost sharing, and incentive payments to assist livestock and crop producers with conservation and environmental improvements. The 2002 Farm Bill has increased the annual funding for this program from $220 million to $1.3 billion. Additionally, $220 million has been earmarked to provide for the installation of groundwater and surface-water conservation practices.

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program (WHIP) provides cost sharing and incentives to people who own or control land and want to develop and improve wildlife habitat. This program is administered through the Natural Resources Conservation Service, which provides technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. The 2002 Farm Bill provides $700 million for this program over the next 10 years.

Farmland Protection Program

The Farmland Protection Program (FPP) provides funding for state, local, tribal, and private organizations to purchase development rights and help keep productive farmland in agricultural use. This program is slated to receive $1 billion over the next 10 years.

These are just a few of the many programs in which landowners can enroll to aid with the installation of recommended stormwater-management practices. For further information on these and other programs contact the Wisconsin Office of the Natural Resources Conservation Service (telephone, 608/276-8732; online at <http://www.wi.nrcs.usda.gov/>).

Barriers to Better Stormwater Management

As they have just been presented, innovative and environmentally friendly stormwater-management practices seem to have no real drawbacks. Using these techniques, individual landowners and communities can balance development and environmental protection, and they can do so in ways that are aesthetically and economically acceptable. This naturally begs the question: Why are these practices not already being implemented on a broad scale?

In general, any new initiative takes some time to catch on. However, there is more to the explanation for the current lack of implementation of best management practices than "it takes some time." If the residents of the Rowan Creek Watershed want to move with confidence in adopting top-of-the-line community standards, local officials would be well served by an improved understanding of the specific issues standing in the way.

Urban Barriers

We believe that increasing infiltration is the next important step in stormwater management, and it should be understood that this is an innovative approach that will not come about without some effort. Recently, researchers from the University of Wisconsin have been working to identify the barriers to implementation of infiltration practices. This research was conducted in Dane County, as well as in other parts of Wisconsin and Minnesota, so there are not likely to be any geographical factors that prevent application of the conclusions to the Rowan Creek Watershed.

Although the barriers were found to vary significantly depending upon the specific practice in question, two general categories of barriers emerged that applied in a variety of circumstances: 1) barriers related to change and 2) barriers related to the development process itself.

Barriers Related to Change

First and foremost are the barriers resulting from change in general. These may be thought of as the specific elements that work together to create "inertia" in the system. This category includes the issues of liability, habits of thought, existing regulations, and barriers within the engineering community.

It is easy to see how the issue of liability could stand in the way of change. A great deal of engineering work is based on published standards and manuals, and over time, these methods and approaches become widely accepted as "the way it's done." If an engineer goes to court, and she is able to show that she performed her work in a manner consistent with the engineering community at large, she has a strong defense against liability. However, if she tries something new, judging it to be a better approach, she places herself at risk because her work is no longer consistent with either tradition or the work of other professionals. Of course, some engineering firms, particularly larger ones, can bear liability better than others can, but in general there are substantial legal barriers to experimentation.

In overcoming system inertia, people desiring change also face the barriers of current habits of thought and prevalent discourses in stormwater management. At present, people are not accustomed to thinking about what makes a practice better or worse in terms of its effect on the water budget. For example, it is common to refer to regulating the "amount" of runoff, without clearly understanding whether this refers to a *peak flow rate* (a volume per unit of time), or an actual volume of runoff.

Perhaps the biggest change-related obstacles that must be overcome are those related to existing regulations. From the developer's perspective, it makes the most economic sense to conscientiously follow the existing regulations to obtain necessary approvals. The limited expense associated with compliance is much less than the potential costs of delays in the building process. Currently, to manage stormwater innovatively requires venturing outside of regulations, which requires developers to seek variances. Under the current regulatory system in most places, the inherent cost in pursuing uncommon approaches acts as a disincentive to innovate.

For several reasons, existing regulations of any kind are slow to change. In many cases, they are the result of hard-fought political battles, and the same people who instituted the regulations may still be influential in their communities. It is understandable that these people would do what they can to prevent changes to the rules they worked so hard to establish. Even in communities without such conflicts, regulations are generally very slow to change because of slow processes and competing agenda items.

Along with these general obstacles to changing regulations, attempts to encourage more infiltration are met with specific challenges of their own. For one thing, additional infiltration requires the use of space that is also useful for other municipal services, such as fire protection, street parking, snow plowing, and trash collection. Even if a community does recognize the value of infiltration, it cannot simply ignore these other priorities. Going along with this is the somewhat more abstract issue of the self-image of the community. If local citizens have an affinity for a particular development density or form of development, they may feel slighted if neighborhood designs are required to feature less desirable elements.

The final change-related barrier has to do with the engineering community. Typically, engineers in private practice or government who have experience with current methods will uphold and defend these methods because they have been shown to have merit, and practitioners are more comfortable using methods that have proven effective, or at least not catastrophic, in the past. Even when developers wish to try an innovative strategy, they may find that engineers are reluctant to deviate from the methods they have used with success in the past.

On the other hand, engineers generally will learn what is requested of them by community regulations, so this barrier can be overcome. A somewhat more difficult barrier arises from the fact that infiltration is a site-specific phenomenon. What works in one location may fail miserably elsewhere, and this makes it very difficult to craft reasonable legislation for an extensive political jurisdiction.

Barriers Resulting from the Development Process

The development process includes many stages, and this complexity adds difficulty to the process of implementing innovative strategies in two ways. First, the nature of the development process makes it easier to design stormwater treatment at the subdivision or plat level, but generally the most effective strategy would be to design it for a single lot or parcel. Second, the large number of players and phases associated with development bring many openings for failure, in that elements implemented by one party at a given stage of development are at risk of being undermined by people involved at a later stage.

Agricultural Barriers

The implementation of best management practices (BMPs) in agricultural settings is largely a function of economics. If the farm operator concludes that it is in his or her best economic interest to use BMPs, and if the specific practices are not too difficult to install or maintain, then the chances are good that he or she will do so. If not, then the activity that threatens to degrade the water resource will likely continue. Most farm operators are concerned about protecting the well being of water and other natural resources, but they must balance that concern with that of making a living. See table 5.1 for a comparison of several BMPs in terms of each practice's effectiveness, capital costs, and benefits to the farmer.

Stormwater-Management Regulation

Overview of Stormwater-Management Regulation

Broadly speaking, stormwater-management regulations are those policies that require or encourage solutions to the problems created by human disruptions in the hydrologic cycle. Historically, the primary goal of stormwater regulation has been prevention of flood damage, but governmental policy has a place in dealing with other hydrologic problems as well.

Recognizing that the burden of damages from flooding should not be placed on downstream property owners and municipalities, many communities require people to control excess runoff from their developed land. The typical approach to regulation has been to require management of the expected runoff from a specified rainfall (known as a *design storm)*, such that the peak flow from that storm would be equal to what it was prior to development.

In Poynette developers subject to the Village's Erosion Control and Stormwater Runoff Standards are required to include enough detention storage to control the 10-year storm. (The 10-year storm has a 1 in 10 chance of being equaled or exceeded in any given year and is equal to approximately 4.1 inches in a 24-hour period for Poynette.) Poynette's rules also require that runoff be released at a velocity that will not cause excessive downstream channel erosion.

The principles underlying flood-control regulation can also justify requiring people to address less familiar stormwater problems, such as water pollution and streambank erosion. In selecting a regulatory strategy that addresses all valid concerns and respects property rights, officials would benefit greatly from an understanding of the various processes involved as stormwater travels through and interacts with constructed and natural environments.

Past and Present Stormwater Regulation

Federal Level

An important distinction in environmental regulation is that between *point* (discrete) and *nonpoint* (diffuse) sources of pollution. Generally, contaminated stormwater runoff can be considered nonpoint-source pollution, although it may also be concentrated at a single discharge point. Since the inception of the Clean Water Act (CWA) in 1972, many regulations have been passed at the federal and state levels to address the issue of nonpoint source pollution. The Clean Water Act directed the Environmental Protection Agency (EPA) to issue permits for stormwater discharges, but it focused the USEPA on the most contaminated stormwater dischargers first. The first implementation measure of the CWA was the Federal Phase I program, which was designed to regulate medium to large municipal and industrial dischargers. After this initial effort, smaller municipal storm sewer systems and construction sites of 1 acre or more in size were brought under the Phase II program. Under the Phase II program, the USEPA developed a permitting system by which specific stormwater requirements must be met and the permit holder must provide an annual assessment and report to the USEPA (Kent, 2000)

However, although there is federal legislation focusing on stormwater, it does not specifically protect Rowan Creek. The number of communities to which the above-mentioned Phase II applies is limited, and neither Poynette nor Columbia County qualifies to be included in the program. Therefore, no federal regulations apply directly to this watershed.

State Level

WDNR Clean Water Act Authority

The Clean Water Act also provides that implementation and enforcement can be delegated to the state level if a given state enacts legislation comparable in scope to the federal act. Wisconsin was delegated this authority in 1974, and its stormwater-management program is administered by the WDNR under Wisconsin Administrative Code, Chapter NR 216.

However, the rules associated with NR 216 do not apply to the Rowan Creek Watershed. So, following the delegation of Clean Water Act authority to the WDNR in 1974, no federal or state stormwater laws were applicable to the Rowan Creek Watershed.

Wisconsin's New Polluted Runoff Rules

Motivated by a desire to increase protection of the state's water resources, an effort has been underway for several years to redesign Wisconsin's administrative rules relating to nonpoint source pollution and polluted runoff. The Nonpoint Source Program Redesign Initiative Report was the result of this effort, the final draft of which was issued in September 1999 (Kent, 2000). This report and additional information on the WDNR's Runoff Management Rules and Program can be found at the WDNR Web site, <http://www.dnr.state.wi.us/org/water/wm/nps/>. The revised nonpoint source pollution rules went into effect on October 1, 2002, and they require property owners and developers to more effectively manage stormwater runoff in agricultural and urban settings.

The new agricultural runoff rules consist of performance standards to control cropland soil erosion, riparian field soil loss, manure storage and management, and nutrient management. These rules also deal with implementation issues such as cost sharing, soil and water conservation programs, county and local government grants, and enforcement. According to the WDNR (2003), "Implementation of the standards and prohibitions will occur primarily through the counties, although the Department will be the main implementation authority for permitted facilities."

The new rules relating to non-agricultural runoff require stormwater discharge permits for construction sites, industrial facilities, and municipalities. The new permitting programs encourage the use of best management practices, which will reduce the amount of sediment and other pollutants in stormwater runoff. Local governments are responsible for implementation of the non-agricultural rules, and interagency coordination is the main element of the implementation strategy (Kent, 2000).

Other State Laws Relating to Stormwater Runoff

Along with the new administrative rules, other state laws relate to stormwater management and protection of hydrologic systems. State drainage laws, for example, address private drains, road and railroad embankments, obstructions to drainage, and the formation of drainage districts. The state also requires permits for certain activities occurring in and near navigable waterways, such as the placement of structures in waterways, the construction or enlargement of waterways, grading or removal of topsoil near navigable waters, channelization or dredging of navigable waters, or bridge building. Each activity has its own standards for approval, but two standards generally apply: 1) The activity must not materially impair navigation and 2) the activity must be in the public interest. The most significant standard from an environmental perspective is that of public interest (Kent, 2000).

Wisconsin's Comprehensive Planning Legislation

Another state law with stormwater-management implications is Wisconsin's comprehensive planning legislation, often referred to as "Smart Growth," which originally passed in 1999. This legislation updated state laws enabling local units of government to prepare and follow comprehensive plans for future development. The planning activities it requires have the potential to influence the health of Rowan Creek. As emphasized throughout this report, the connection between land use and water quality is direct and significant. As guides for land-use decision making, the newly required comprehensive planning activities can be a useful tool for stream protection in the Rowan Creek Watershed and elsewhere.

The new comprehensive planning law (s. 66.1001, Wis. Stats.) states the following: "Beginning on January 1, 2010, any program or action of a local governmental unit that affects land use shall be consistent with that local governmental unit's comprehensive plan."

The law goes on to list the kinds of programs and actions that must be consistent with an adopted comprehensive plan. These include, among many other activities, zoning, annexation, and land subdivisions.

The comprehensive planning law also defines the contents of an acceptable comprehensive plan. Most importantly, a plan must include the following nine elements:

1. issues and opportunities;
2. housing;
3. transportation;

4. utilities and community facilities;
5. agricultural, natural, and cultural resources;
6. economic development;
7. intergovernmental cooperation;
8. land use; and
9. implementation.

By way of example, the following is the full definition of the agricultural, natural, and cultural resources element:

> A compilation of objectives, policies, goals, maps and programs for the conservation, and promotion of the effective management, of natural resources such as groundwater, forests, productive agricultural areas, environmentally sensitive areas, threatened and endangered species, stream corridors, surface water, floodplains, wetlands, wildlife habitat, metallic and nonmetallic mineral resources, parks, open spaces, historical and cultural resources, community design, recreational resources and other natural resources.
>
> —*From s.* 66.1001, *Wisconsin Statutes*

The Statute defines each of the nine elements in detail, explaining what areas must be covered and requiring objectives, policies, goals, maps, and programs relating to all those areas.

Section 16.965, Wis. Stats., also outlines a state grant program for communities or groups of communities beginning the process of creating or updating their comprehensive plans. Most important, this section outlines 14 local planning goals that must be addressed in all grant applications to the state and that ostensibly should be sought by communities that have been awarded grant funding in their **comprehensive** planning processes.

- Promotion of the redevelopment of lands with existing infrastructure and public services and the maintenance and rehabilitation of existing residential, commercial and industrial structures.
- Encouragement of neighborhood designs that support a range of transportation choices.
- Protection of natural areas, including wetlands, wildlife habitats, lakes, woodlands, open spaces and groundwater resources.
- Protection of economically productive areas, including farmland and forests.
- Preservation of cultural, historic and archaeological sites.

- Encouragement of land uses, densities and regulations that promote efficient development patterns and relatively low municipal, state governmental and utility costs.
- Encouragement of coordination and cooperation among nearby units of government.
- Building of community identity by revitalizing main streets and enforcing design standards.
- Providing an adequate supply of affordable housing for individuals of all income levels throughout each community.
- Providing adequate infrastructure and public services and an adequate supply of developable land to meet existing and future market demand for residential, commercial and industrial uses.
- Promoting the expansion or stabilization of the current economic base and the creation of a range of employment opportunities at the state, regional and local levels.
- Balancing individual property rights with community interests and goals.
- Planning and development of land uses that create or preserve varied and unique urban and rural communities.
- Providing an integrated, efficient and economical transportation system that affords mobility, convenience, and safety and that meets the needs of all citizens, including transit-dependent and disabled citizens.

Early in 2002, a group of Rowan Creek Watershed communities (the Towns of Lowville and Dekorra and the Village of Poynette) were awarded funding to work together to create a joint comprehensive plan. According to Meagan Yost, chair of the Lowville planning commission and a member of the steering committee for the joint planning effort, other watershed communities may eventually join in the multi-jurisdictional planning effort. In fact, she believes that would be an excellent idea, considering the shared interests of the watershed communities, including a core service area (the Village of Poynette), a school district, fire and emergency medical services, and a rural agricultural landscape with Rowan Creek as its centerpiece.

As all communities statewide that wish to make land-use decisions after January 1, 2010, each of the communities within the watershed will be required to create and adopt a comprehensive plan that meets the requirements of the law. The comprehensive planning process may be an effective tool for these communities, helping them to achieve their visions for the region, the watershed, and local municipalities. One of the goals of this report is to provide information that is useful to the citizens and decision-makers of the watershed communities as they go through the comprehensive planning process.

For more information on the comprehensive planning law, please refer to the Web site for the Wisconsin Department of Administration's Office of Land Information Services, <http://www.doa.state.wi.us/pagesubtext_detail.asp?linksubcatid=359>. The Office of Land Information Services is the organization responsible for administering the comprehensive planning grant program and for evaluating completed comprehensive plans as they are submitted by municipalities.

Local Level

Along with the stormwater-management and comprehensive planning requirements placed on local governments by the state, Wisconsin also gives local governments (cities, villages, towns, and counties) general authority to construct and maintain facilities to manage stormwater. These governmental entities are authorized to enact ordinances to govern construction site erosion and stormwater management. A section in Wisconsin statutes authorizes the WDNR to establish, by rule, minimum standards for activities related to construction site erosion and stormwater management. The WDNR is responsible for preparing a model construction site erosion control and stormwater-management zoning ordinance in the form of an administrative rule (Kent, 2000).

Village of Poynette Erosion Control and Stormwater Runoff Ordinance

Currently, local regulation of stormwater in the Rowan Creek Watershed is limited to the Village of Poynette. Chapter 19 of the Village's ordinances, entitled "Erosion Control and Stormwater Runoff Standards," includes many of the important elements of an effective stormwater-management regulation. Because Poynette is currently the most populous area in the watershed, it is helpful as a starting point to understand some of the components of their current ordinance. For more details, please refer to the ordinance itself, which is available online[1].

The highlights of the ordinance are as follows:

> **Flood Control.** The peak flow from the post-development, 10-year, 24-hour storm shall not exceed that of the predevelopment conditions. Or, if that is not stringent enough, the allowable peak rate must be based upon what the drainage system can safely handle. Detention storage requirements and the release rate of runoff must be determined according to these criteria, along with some secondary design requirements, such as a release velocity that does not cause erosion.
>
> **Erosion and Sediment Control.** The Poynette ordinance essentially indicates that neither erosion nor sedimentation shall occur in developed sites beyond that which would have occurred naturally. This is a brief section, and it is included here in its entirety:
>
>> <u>Standard for Erosion and Sediment Control for Land Disturbing Activities</u>. The Village Engineer shall not approve plans nor shall the Village Administrator issue any permit required by this Ordinance for

land disturbing activities unless erosion and sedimentation during and after the land disturbing activity will not exceed that which would have been eroded if the land had been left in its pre-developed state and/ or are controlled in accordance with the Village of Poynette Erosion and Sediment Control Specifications, or other Technical Guidelines as developed by the U.S. Department of Agriculture, Soil Conservation Service (TR-55), or the Wisconsin Department of Natural Resources.

—*From Village of Poynette ordinance, Chapter* 19*, p.* 7–8
(Village of Poynette, 2002*)*

Infiltration. While there are no quantitative infiltration standards in the Poynette ordinance, it does indicate the importance of this aspect of stormwater management by generally requiring that infiltration be maximized. Again, here is an example taken directly from the text of the ordinance:

Development Design. Streets, blocks, lots, parks, and other public grounds shall be located and laid out in such a manner as to minimize the velocity of overland flow and allow maximum opportunity for infiltration of stormwater into the ground, and to preserve and utilize existing and planned streams, channels, and detention basins, and include whenever possible, streams and floodplain within parks and other public grounds."

—*From Village of Poynette ordinance, Chapter* 19*, p.* 9
(Village of Poynette, 2002*)*

Citizen Level

If all efforts to regulate stormwater runoff fail, the individual citizen can look to the judicial system for help. If a citizen is adversely affected by unplanned development or stormwater runoff, he or she can potentially rely on common-law remedies. The three legal theories commonly used in these instances are nuisance, inverse condemnation, and negligence. Landowners can use these approaches to seek monetary compensation for damages, or they can seek to restrain the party causing the problem by way of injunctive relief. (Kent, 2000).

Future Stormwater Regulation

More than ever before, communities are making an effort to prevent the serious environmental problems of urban development, and stormwater management is increasingly understood to be a key part of this effort. Researchers, engineers, and government officials each have a role in developing and implementing stormwater-management rules that reflect the latest scientific and engineering knowledge.

In Wisconsin, the results of this effort are partially seen at the state level with the creation of the new stormwater runoff rules. Stormwater ordinances, however, are traditionally promulgated by village or city governments, as is the case in Poynette. In other cases, countywide ordinances have been adopted. As with any law, there are advantages and disadvantages to adopting a stormwater ordinance in either a smaller or larger jurisdiction. Local ordinances can be adapted specifically to the geographical region in question, which is a benefit. On the other hand, in the case of stormwater, rules promulgated at a larger geographic level such as the county would eliminate the problem of one area being more attractive to developers because of laxer regulations. The stakeholders in the Rowan Creek Watershed must weigh the benefits and costs of each approach and decide which level of government can most effectively address stormwater issues.

Columbia County's government might be the appropriate entity to implement a new stormwater ordinance. Just south of Columbia County, Dane County has adopted a new stormwater ordinance that incorporates many of the important principles of state-of-the-art stormwater management. As indicated in the earlier section discussing the barriers to implementation of infiltration-oriented stormwater-management practices, countywide uniformity would prevent the problem of developers choosing a site for its community's lenient stormwater rules. In addition, the Columbia County Department of Conservation has expressed an interest in adopting a countywide stormwater ordinance as an important tool in preserving the natural resources of this part of the state.

As the communities of the Rowan Creek Watershed and the rest of Columbia County make plans for stormwater management and regulation, they will need to consider what would go into an effective stormwater ordinance, regardless of the level of government at which it is implemented. Among people working in the field of stormwater mitigation, there is a growing consensus that the following components should be present:

Peak Control Over a Range of Flows. Traditional stormwater ordinances have concentrated primarily on maintaining the peak flow from a given amount of rainfall at the predevelopment level. This continues to be a fundamental element of any effective stormwater ordinance, and more specifically, it is important to maintain predevelopment flows over a range of storm frequencies. This is due to the fact that different watershed characteristics are controlled by different flood magnitudes.

Generally, the runoff peak for a 1- to 2-year storm determines the size of a stream channel. If there is a significant increase in the amount of runoff from these relatively frequent events, erosion will occur in the downstream channel.

On the other hand, the extent of the floodplain is determined by much less frequent runoff events, such as that which results from the 100-year storm. Therefore, if upstream development causes an increase in the magnitude of this flow, downstream property that was once outside the floodplain will now be within it.

Defining Predevelopment Curve Numbers. Compliance with stormwater ordinances is typically determined using NRCS hydrologic modeling techniques, the results of which depend heavily upon the selection of a parameter known as the curve number (CN), with which the land use and soil characteristics of a given area are represented as a single number, ranging from 1 to 100 in theory, but from approximately 40 to 98 in practice. Higher numbers represent less pervious surfaces, with 98 typically representing an impervious surface. (Leaks, surface wetting, and depression storage prevent the use of CN = 100.) The difference between the predevelopment and post-development curve numbers in the model reflects the hydrologic changes associated with new development. Therefore, the selection of the predevelopment curve number greatly influences whether or not a site meets a particular standard.

It is currently very common for agricultural fields to be purchased by developers and transformed into residential or commercial neighborhoods. In determining whether these new developments comply with stormwater ordinances, it makes a big difference whether one uses the curve number of the agricultural field or the curve number of the site before it was farmed. The natural site will generally have a lower curve number, and will therefore require more effort on the part of the developer to comply with stormwater regulations. A regulation will be more effective if "predevelopment" is explicitly defined to be "pre-agriculture."

Increasing the Curve Number to Account for Soil Disturbance During Construction. Typically, landscapes are severely disturbed during the construction process. Even if a particular area eventually becomes lawn or open space, the removal of topsoil and the compaction from construction equipment drastically reduces the permeability of a site. A truly reliable stormwater ordinance will take this into account, and the simplest way to do so is to increase the curve number of the site in a way that accurately reflects the disturbance. Of course, if steps were taken to mitigate the negative effects of construction, it would be logical to reduce or eliminate the unfavorable adjustment.

Sedimentation and Pollutant Removal Standards. Sedimentation standards have become a standard part of stormwater regulation. The new Dane County ordinance, for example, calls for:

- An 80 percent reduction in the amount of sediment that washes from a newly developed site, as compared to the same site with no sediment control.
- A 40 percent reduction in the amount of sediment that washes from a site being redeveloped, as compared to the same site with no sediment control.

The Dane County ordinance also suggests goals for reducing the amount of sediment running off existing development.

Limits on Development in High-Slope Areas. The higher the slope of an area, the more susceptible it is to many of the hydrologic problems relating to stormwater runoff. Flowing water has more energy, and thus a greater potential to erode, when it is running down a hill than it does on a flat surface. When vegetation is removed from sloped areas during construction, the result is the release of more sediment. In short, following development, higher slopes exacerbate flooding and pollutant transport. A good stormwater ordinance will recognize this and take specific steps to limit development in areas of high slope. In many cases, a slope of 12 percent is used as a cutoff between moderate and high slope areas. Dane County, for example, uses this figure in their new ordinance.

Consideration of a Volume Standard. As has been suggested, truly progressive stormwater management should control volumes as well as peak flows. This is the fundamental strategy for preventing regional flooding, and it also significantly impacts the issue of stream temperature, another important standard or guideline for stormwater regulation. The WDNR's runoff rules provide volume standards, and the implementation of these kinds of standards will require action on the part of individual communities.

This is still a relatively new frontier, and the best way to write a quantitative volume standard is not entirely clear. However, this is currently an active area of research, and it is certainly feasible for communities in the Rowan Creek Watershed to find a specific rule that works for them. Regardless of the specific regulatory path taken, it is likely that site development strategies (e.g., preserving wooded areas, clustered development, reducing impervious area, etc.) will play a significant role in controlling runoff volumes.

Conclusions

There are specific, concrete actions that the communities of the Rowan Creek Watershed can take to prevent stream damage from increased development; in selecting the appropriate regulations, it is helpful to look at the entire stormwater process. Ongoing experimentation with different treatment methods is providing valuable guidance toward the best strategy for the preservation of water quality, and awareness of these methods (as well as the best ways to encourage them) will ultimately protect Rowan Creek and preserve its benefits for future generations.

More specifically, as the big picture of stormwater becomes more widely understood, it becomes clear that the next natural step in the progression of stormwater regulation is the requirement that some level of infiltration be maintained. This is the cutting edge of stormwater management, and researchers and engineers are currently at work developing and testing a variety of local infiltration strategies. As certain practices and combinations of practices are proven effective, informed communities will incorporate this new knowledge into their overall stormwater-management plans and regulations.

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CHAPTER 6. KEY FINDINGS AND RECOMMENDATIONS

Key Findings

The preceding chapters of this report contain many facts and observations that we hope will be of use to a variety of interested parties throughout and beyond the Rowan Creek Watershed. From the local resident who wants to understand more about his environment and the role he can play in shaping its future to the concerned policymaker who understands that her decisions will have a significant impact on the future direction of the watershed to the developer or other business-person who wishes to add to the economic vitality of the region while helping to maintain ecological balance, many people will be able to use the information in this report.

To facilitate this process, we present in abbreviated form our most important findings that can serve as a convenient starting point for people wishing to better understand the watershed.

- Overall, the water quality in Rowan and Hinkson Creeks is good. Both creeks have average total phosphorus and average nitrate-nitrogen levels that are below U.S. Environmental Protection Agency (USEPA) and U.S. Geological Survey standards as well as below the average for all tested Wisconsin streams. These two cold-water streams support viable populations of trout; Rowan Creek supports non-native brown trout and Hinkson Creek supports the native brook trout.

- There is a significant increase in baseflow in the vicinity of the Village of Poynette. We believe that this indicates that the land area contributing to baseflow here includes some land outside of the watershed, possibly a part of the closed watersheds to the south. Ongoing study by the Wisconsin Geological and Natural History Survey should help to resolve this issue.

- Hinkson Creek tends to be warmer than Rowan Creek, and both creeks warm significantly in their lower sections, including at the junction. This temperature pattern may prevent brown trout from migrating into Hinkson Creek and hence may protect the brook trout population there from domination by the more aggressive brown trout.

- In one of our measurements, we recorded total phosphorous levels in Rowan Creek just below the wastewater-treatment plant that were triple what we measured above the plant. If these measurements accurately depict the typical situation at those locations, the levels below the plant are above the USEPA's standard for nuisance aquatic plant growth. This combined with the relatively flat slope of the stream in the reaches below the plant could exacerbate nuisance plant growth in that area.

- All the stakeholder group representatives we interviewed indicated that they are relatively satisfied with the current level of communication and coordination in the watershed. They also indicated that it is the Wisconsin Department of Natural Resources that currently plays the most major role in watershed decision making, mostly due to the facts that the agency owns large tracts of land in the watershed and that it manages the trout fishery.
- Stakeholder interviews also revealed that there is a perception on the part of many that the watershed and its stakeholders could benefit by the creation of a forum for communication and coordination between the various watershed stakeholders.
- Education is believed by most stakeholders to be key to protecting the resources in the watershed. Specifically, many believe that educational efforts must focus on the current high quality of the watershed and on current and future threats to that high quality.
- Our survey indicated that many people use the creeks for a variety of recreational pursuits, that natural beauty is viewed as one of the greatest benefits of the creeks, that current water quality is deemed to be good but not excellent, that excellent water quality is important to people, that people wish for environmental issues to be addressed, and that the residents of the watershed desire more information on the health of the creeks and the watershed in their local papers and other appropriate venues.
- The Village of Poynette is currently the only jurisdiction within the watershed with a stormwater-management ordinance in place. Columbia County is reportedly considering creating an ordinance in the next few years. Stormwater ordinances are important tools that communities can use to strike a balance between the beneficial aspects of development and the potential negative impacts development can have on streams and watersheds.
- Three watershed communities (the Towns of Lowville and Dekorra and the Village of Poynette) have begun the process of creating a comprehensive plan. Comprehensive planning under the state's recently modified law is another important tool communities can use to guide future growth while maintaining those aspects they desire to preserve.

Recommendations

- Those watershed communities that have yet to begin the comprehensive planning process should plan in coordination with the three communities that have already begun the process. All the watershed communities should incorporate consideration for the future health of the watershed ecosystem into their decision making on future land uses and management within their jurisdictions.

- Stakeholder groups that are involved in various activities relating to the creeks and their watershed should form a broad-based coalition focused on the long-term management of the creeks and the watershed. This coalition could meet periodically to discuss group activities, maintain open communication, and reduce the potential for duplication of efforts. It may be important for one group to take the lead in creating this entity and fostering its ongoing efforts; because of their leadership in the past, the WDNR or the Friends of Rowan Creek may be appropriate entities to take on this role.
- If better information on stream-water quality is desired, we would recommend the development of a comprehensive, long-term water-quality monitoring program that would include physical, chemical, and biological parameters. Multiple stakeholder groups including school groups, citizen organizations, and agencies could carry out such a program in a collaborative fashion. Long-term monitoring is important in that it allows the stakeholder community to gauge the effectiveness of management activities over time and to assess the impact of land-use changes.
- Stakeholders including local communities, Columbia County, state agencies, and the Friends of Rowan Creek should respond to the call for more information from residents by publishing newsletters, making public presentations, and offering articles in the local papers. Local students could also be encouraged to help with this endeavor.
- Columbia County should create a stormwater-management ordinance addressing the newest thinking in the area of stormwater-management practice and regulation, perhaps along the lines of Dane County's recently passed ordinance. Local municipalities may also wish to adopt similar ordinances.
- Developers, engineers, landowners, and farmers should be encouraged to utilize watershed-friendly land management techniques wherever practicable, whether those practices are required by law or not.
- People should pursue local, state, and federal programs, some of which are outlined in this report, that can potentially provide funding and/or other resources to help implement watershed-friendly management practices.
- Communities should consider "leveling the playing field" between traditional developments and those that implement innovative design and stormwater-management techniques by streamlining the approval process for innovative proposals.
- Local decision-makers, engineers, developers, and citizens should inform themselves about the latest techniques in stormwater management, farmland preservation, economic development, and conservation. One way to do this would be to invite experts in these areas from academia and from the private sector to present before plan commissions, town and village boards, and citizen groups.

- School administrators and teachers interested in incorporating water quality and local streams into their curricula might look into the curriculum programs we highlight in the report and utilize them if it is deemed appropriate.

CHAPTER 7. CONCLUDING THOUGHTS

The municipalities and the people in the Rowan Creek Watershed stand at an important crossroads today. We see two main options; both are based on the assumption that continued urban development of the Rowan Creek Watershed is likely to occur into the future.

- Proactive choices can be made now to address the potential for future urbanization in the watershed, or
- Watershed stakeholders can wait and react to these likely future changes after the fact, when minimizing urbanization's social and environmental impacts will be more difficult.

Our hope is that the momentum generated by the creation of this report, the ongoing activities of the Friends of Rowan Creek, WDNR, and other stakeholders, and the initiation of comprehensive planning activities in several watershed communities will continue and build, resulting in proactive, forward-thinking stormwater-management regulations that are put into place with sufficient time to prevent whatever development should occur in the future from significantly impacting the highly valued resource that is the Rowan Creek Watershed.

APPENDIX A. PHYSICAL ASSESSMENT METHODOLOGIES AND ADDITIONAL DATA

1. Physical assessment methodologies

Flow measurement

We measured the flow of Rowan and Hinkson Creeks to obtain an idea of the baseflow of the watershed. We chose 13 sites throughout the watershed (two additional sites were later added; see fig. 3.1) on the basis of criteria including location and accessibility. These sites were also used for temperature measurement. Eight of the sites were located on Rowan Creek, and five (plus the additional two sites) were on Hinkson Creek. We obtained the flow measurements using a Pygmy flow meter. On April 6, 2002, when we took the first set of measurements, we were able to measure all sites except site 4 because we had not yet gained access permission from the owner.

A cross section of the creek was taken perpendicular to the flow at that location. We then divided the creek cross section at that location into 10 to 20 equidistant subsections and took flow readings at each of these locations. To obtain measurements using a Pygmy meter, one counts the clicks that are produced when the spinner makes one full revolution for at least 40 seconds. After the completion of the cross-section measurements, one notes the bank-full size. By using the following equation, one finds the calibrated velocity of the subsection: (the parameters differ according to the individual meter used) 1.0189 * (Clicks/S)-0.0474. The calibrated velocity is then used in the following equation to find the corresponding flow for that subsection: [((cross sectional distance in the subsection)/2)* depth of subsection* calibrated velocity]. The sub-sectional flows (q) are summed to obtain the total flow (Q) at that location for the stream.

When the flows were taken on April 6, the region had not received rain for the past two days, the temperature was around 40^{o}F and there was not a brisk wind. The flows were again measured on July 12, 2002. It had not rained for three weeks, temperature was around 80^{o}F, and there was not a brisk wind.

Nutrients

The Wisconsin State Laboratory of Hygiene (in Madison) tested water samples for total Kjedahl nitrogen and total phosphorus.

pH and Conductivity

Water samples were collected on July 18, 2002 from all fifteen sites. The samples were then tested for pH and conductivity in the lab that afternoon.

Land Use

Rowan Creek land-cover maps were produced using WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data) data available for download on the Wisconsin Department of Natural Resources website, <http://www.dnr.state.wi.us/org/at/et/geo/data/wlc.ht>.

WISCLAND land-cover data were derived from satellite imagery generated by over-flights during the period from August 1991 to May 1993. On the basis of the reflectance values recorded by the satellite's sensors, the entire state of Wisconsin was classified into the eight unique land cover categories shown in table A.1.

The WISCLAND land-cover data were clipped to the extent of the Rowan Creek Watershed boundary using ESRI's ArcView™ software, version 3.2a. The resulting map, Rowan Creek land cover, is shown in plate 3.1. The area of each land cover category was then computed using the ArcView extension, XTools, available for download at several places on the Internet.

Hydric Soils

We identified and mapped hydric soils within the Rowan Creek Watershed from SSURGO database in a similar manner as the Hydrologic Soil Groups (see below). Hydric soils were identified utilizing the NRCS Cropland Interpretations—Erosion Factors and Soil Groups for Columbia County, Wisconsin. The XTools extension for ArcView (see above) was again used to compute the land area of each classified soil type, hydric or non-hydric.

Hydrologic Soil Groups

Rowan Creek Watershed soils information was taken from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database as supplied by the Columbia County Land Information Department; it also available for download at <http://www.ftw.nrcs.usda.gov>. The countywide soils data was clipped to the extent of the Rowan Creek Watershed boundary using ArcView, version 3.2a. The soil types included within the boundaries of the watershed were assigned a Hydrologic Soil Group (A, B, C, or D) according to the NRCS Cropland Interpretations—Erosion Factors and Soil Groups for Columbia County, Wisconsin, which can be found at <http://www.wi.nrcs.usda.gov>.

Table A.1. *Descriptions of land-cover types.*

Land cover	Description
Urban/ developed	Structures and areas associated with intensive human activity and land use.
Agriculture	Land under cultivation for food or fiber.
Grassland	Lands covered by non-cultivated herbaceous vegetation predominated by grasses, grass-like plants or forbs. Examples: restored prairie, pasture, CRP land, idle farmland.
Forest	Upland area of land covered with woody perennial plants, trees reaching mature heights of at least 6 feet tall with a definite crown.
Open water	Areas of water with no vegetation present.
Wetland	An area that has water at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and that has soils indicative of wet conditions.
Barren	Land of limited ability to support life and in which less than one-third of the area has vegetation or other cover. If vegetation is present, it is more widely spaced and scrubby than that in shrubland. Examples: Sand, bare soil, exposed rock.
Shrubland	Vegetation with a persistent woody stem, generally with several basal shoots, low growth of less than 20 feet, and coverage of at least one-third of the land area. Less than 10 percent tree cover interspersed. Examples: Scrub oak, buckthorn, sumac.

Impervious Area

We obtained 1995 aerial orthophotographs of the Rowan Creek Watershed from the Columbia County Land Information Department. To calculate the impervious area, we first generated an outline of the watershed from watershed polygon data obtained from the U.S. Geological Survey. Then we delineated impervious surfaces within the watershed digitally using ArcView. We considered buildings and other structures, paved surfaces, or quarries to be impervious. Finally, we generated a map of all the impervious areas in the watershed for our analysis. Using the map and ArcView software, we calculated the percentage of the total watershed land area covered by impervious surfaces.

2. Additional Data

Table A.2. *Percentage of wetland area covered by vegetation type*

Wetland vegetation type	Percentage of area
Aquatic floating lake	0.7
Wet meadow persistent standing water	1.0
Wet meadow persistent wet soil	10.2
Wet meadow persistent wet soil abandoned cropland	1.9
Wet meadow persistent wet soil grazed	1.4
Wet meadow persistent wet soil excavated	0.9
Wet meadow narrow leaved persistent/open water	0.3
Wet meadow narrow leaved persistent standing water	15.5
Wet meadow narrow leaved persistent wet soil	1.1
Wet meadow narrow leaved persistent wet soil grazed	3.8
Wet meadow nonpersistent/aquatic floating	0.1
Scrub broadleaved deciduous/wet meadow narrow leaved persistent wet soil	0.4
Scrub broadleaved deciduous/wet meadow narrow leaved persistent standing water	4.2
Scrub broadleaved deciduous standing water	0.6
Scrub broadleaved deciduous standing water grazed	0.7
Scrub broadleaved deciduous wet soil	30.1
Scrub broadleaved deciduous wet soil grazed	1.9
Forested needle-leaved deciduous	0.5
Forested broad-leaved deciduous/wet meadow persistent wet soil	1.2
Forested broad-leaved deciduous/scrub broadleaved deciduous wet soil	1.6
Forested broad-leaved deciduous wet soil	16.0
Forested broad-leaved deciduous wet soil floodplain complex grazed	5.2
Open water	0.7
Open water excavated	0.1

3. Wisconsin Department of Natural Resources Recording Form for the Citizen Monitoring Biotic Index

Recording Form for the Citizen Monitoring Biotic Index

Name:____ Date:_____________

Watershed and Stream Names:______________________________________ Time:_____________

Location:____ Site ID:________________

(County, Township, Range, Section, Road, Intersection, Other)

At this point, you should have collected a wide variety of aquatic macroinvertebrates from your three sites. You will now categorize your sample, using the chart (other side) to help you identify the macroinvertebrates found. The number of animals found is not important; rather, the variety of species and how they are categorized tells us the biotic index score. Before you begin, check off the sites from which you collected your sample (see right).

- ☐ Riffle Sampling
- ☐ Snag Areas, Tree Roots, Submerged Logs
- ☐ Leaf Packs
- ☐ Undercut Banks

1. Check the basin with the debris to see if any aquatic macroinvertebrates crawled out. Add these animals to your prepared sample.
2. Fill the ice cube tray half-full with water.
3. Using plastic spoons or tweezers, (be careful not to kill the critters -- ideally, you want to put them back in their habitat after you're finished) sort out the macroinvertebrates and place same species together in their own ice cube tray compartments. Sorting and placing same species together will help insure that you find all varieties of species in the sample.
4. Refer to the "Key to Macroinvertebrate Life in the River" and the Citizen Monitoring Biotic Index to identify the macroinvertebrates:

   A. On the back of this page, circle the animals on the index that match those found in your sample.

   B. Count the number of circled animals in each category and write that number in the box provided.

   C. Enter each boxed number in work area below.

   D. Multiply the entered number from each category by the category value.

   E. Do this for all categories.

   F. Total the number of animals circled.

   G. Total the values for each category.

   H. Divide the total values by the total number of animals: total values (b) / total animals (a).

   I. Record this number.

   SHOW ALL MATH (Use space below to do your math computations)

No. of animals from group 1 _________ x 4=_________

No. of animals from group 2 _________ x 3=__________

No. of animals from group 3 _________ x 2=__________

No. of animals from group 4 _________ x 1=__________

TOTAL ANIMALS(a)______TOTAL VALUE(b)________

Return form to:

Divide totaled value (b)_____by total no. of animals (a) _____for index score:

Index score:

How Healthy is the Stream?

Excellent-------3.6+
Good----------2.6 - 3.5
Fair-----------2.1 - 2.5
Poor-----------1.0 - 2.0

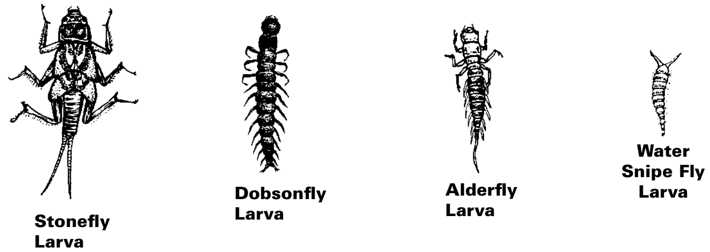
Call your local Monitoring Coordinator if you have questions about sampling or determining the Biotic Index Score.

Relative Size Key:

(+) =larger than picture

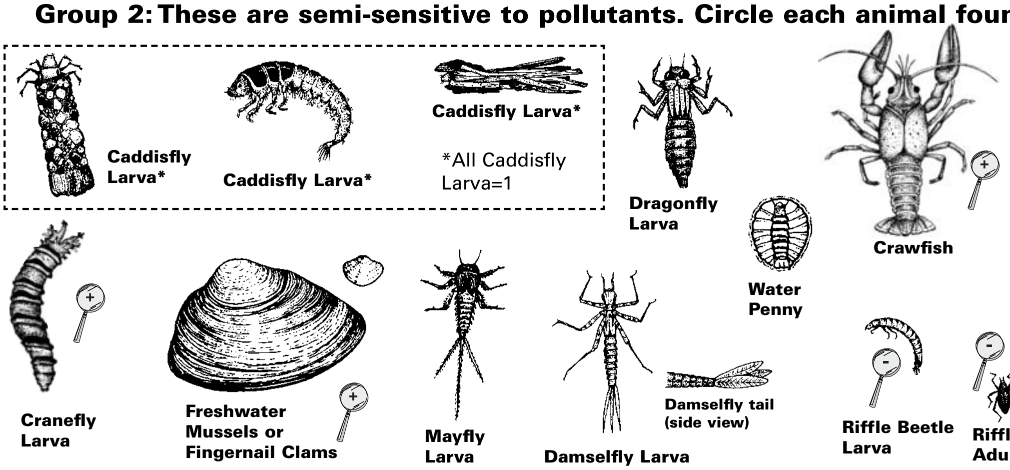
(-) =smaller than picture

Group 1: These are sensitive to pollutants. Circle each animal found.



No. of group 1 animals circled: ☐

Group 2: These are semi-sensitive to pollutants. Circle each animal found.

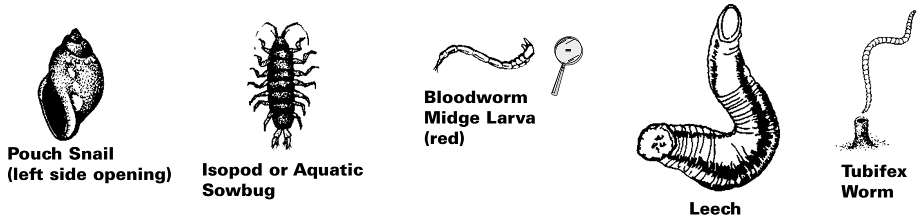


No. of group 2 animals circled: ☐

Group 3: These are semi-tolerant of pollutants. Circle each animal found.

No. of group 3 animals circled: ☐

Group 4: These are tolerant of pollutants. Circle each animal found.



No. of group 4 animals circled: ☐

Water Action Volunteers

APPENDIX B: CITIZEN SURVEY LETTER, QUESTIONNAIRE, AND INTERVIEW CONTACT LIST

1. Citizen Survey Letter

WRM Practicum
Institute for Environmental Studies
70 Science Hall
550 N. Park Street
Madison, Wisconsin 53706-1491
April 14, 2002

Dear Resident:

The enclosed survey is part of a larger study about Rowan Creek, Hinkson Creek, and the surrounding watershed. This study is being conducted by the Water Resources Management (WRM) Program, an interdisciplinary graduate program of the Institute for Environmental Studies at UW–Madison. Students participate in a workshop involving an actual water management scenario. Since the inception of the program over 30 years ago, workshops have focused on aquatic systems such as Fox Lake, Black Earth Creek, Lake Wingra, Nine Springs E–Way, and Lake Mendota.

You will be making a significant contribution to this project by completing this survey. With the information you provide, we will be able to better understand the perspectives of residents such as yourself with regard to Rowan and Hinkson Creeks. By completing this survey, you will help us understand how residents are involved in the watershed and how local watershed managers can best plan for the future.

Before you begin, we want to assure you that **ALL the information you provide is confidential**, and **NO information will be released that could identify you or your household**. Although participation is voluntary, we would appreciate you completing this survey and returning it in the stamped and addressed envelope provided. Personal comments are always welcome.

On the back is a map showing the boundary of the watershed and three zones referred to in the survey. Please fill out both sides of the survey and return it before June 1, 2002. Thank you very much for your time.

Sincerely,

WRM Practicum Students

Rowan Creek Watershed Assessment

Purpose:

The Rowan Creek Watershed, located in Columbia County, drains portions of five townships: Arlington, Dekorra, Lowville, Lodi, and Leeds. The 60 square mile watershed supports the state endangered ornate box turtle and the state threatened Blandings turtle. The relatively undeveloped southern part of the watershed is unique in this highly urbanized portion of the state.

As a result of its scenic beauty and proximity to Madison, the Rowan Creek Watershed is likely to become increasingly urbanized in the immediate future. Evidence from around the country shows that streams degrade as the watershed urbanizes, largely because of harmful changes in the quantity and quality of stormwater. Fortunately, new techniques for managing stormwater can reduce these harmful effects.

In the interest of preventing stream degradation in the Rowan Creek Watershed, a comprehensive study is being undertaken to provide information that will facilitate effective stormwater planning and management. The study will include a stream and watershed assessment, a stakeholder analysis, a compilation of effective stormwater management practices, and outreach activities intended to communicate the study findings.

Terms:

- Watershed – land that drains surface runoff into a stream, river, or lake
- Stormwater – extra water produced by a storm in a watershed which cannot be absorbed into the ground as it falls and must be disposed of by alternative methods
- Urbanization – development of an area from low impact development (i.e. farming) to a higher impact development (i.e. neighborhoods)

Map:

Zone 1: west of 90/94

Zone 3: east of 51

Zone 2: between 90/94 & 51

2. CITIZEN SURVEY QUESTIONNAIRE

1. Using the map provided as a reference, in which zone is your residence located?
   ___1 ___2 ___3 ___none of the above

2. Before receiving this survey, did you know that your home was in or near the Rowan and Hinkson Creeks watershed?
   _____Y _____N

3. Do you use Rowan and/or Hinkson Creeks and the associated recreational areas for any of the following? (check all that apply)
   ___boating ___ picnicking ___ swimming ___ hiking ___ fishing
   ___ hunting ___ birdwatching ___ nature appreciation
   ___ other (please explain) ____
   ___ never use

4. How often do you visit Rowan &/or Hinkson Creeks and the surrounding areas?
   ___ weekly ___ monthly ___ several times a year ___ yearly
   ___ less than once a year ___ never use

5. When you visit the creeks and the surrounding areas, do you generally go to the same location? If yes, why?
   ___ Y ___ N WHY?____

6. Which creek do you spend more time on/near?
   ___ Rowan Creek ___ Hinkson Creek ___ other creek within the watershed

7. How valuable an asset are the creeks and the surrounding areas to you?

very valuable				not valuable at all	don t know
1	2	3	4	5	6

8. In your opinion, how valuable an asset are the creeks and the surrounding areas to your community?

very valuable				not valuable at all	no opinion
1	2	3	4	5	6

9. If you find the creeks and surrounding areas valuable, rank the following benefits from the most important (1) to you , to the least important (7).

____ recreation
____ natural beauty
____ property value
____ wildlife
____ fish
____ community identity
____ other (please describe) ____

10. How do you rate the current water quality of the creeks?

outstanding		fair		poor	don t know
1	2	3	4	5	6

11. How valuable is high water quality in the creeks to you?

Very valuable		mildly valuable	not valuable		no opinion
1	2	3	4	5	6

12. How many years have you lived within the watershed?
___ less than 1 year ___ 1-5 years ___ 5-15 years
___ 15-30 years ___ 30+ years

13. In the time you have lived in the watershed, do you think the water quality has changed? If the water quality has changed, please explain in what way is has changed.
____ Improved ____ stayed the same ____ worsened
Explain changes:____

14. Do you think there are any environmental issues concerning the creeks and the surrounding areas that need to be addressed?
___ Y ___ N

15.Please check those environmental issues you believe to be a problem in the watershed:
____ smell of the water ____ clarity of the water ____ too many weeds
____ cattle in streams ____ overfishing ____ streambank erosion
____ flooding ____ exotic/invasive plants ____ decline in the fishery
____ trash ____ decreased flow from springs
____ groundwater drawdown ____ increased development pressure
____ declining groundwater quality ____ agricultural runoff
____ fertilizer and/or pesticide use on lawns, gardens, fields, etc.
____ stormwater runoff from streets, parking lots, buildings, etc.
____ other (please explain)____
____ none

15. In what format would you prefer information to be provided to you regarding Rowan and Hinkson Creeks? (check all that apply)
___ fact sheets ___ brochures ___ newsletters ___ workshops
___ meetings ___ personal letters ___ e-mail ___ community activities
___ video tapes ___ phone calls ___ website ___ visits to your home
___ radio ___ neighborhood demonstrations of projects/products
___ other (please explain)____
___ not interested

16. Please indicate the gender and age of the person completing this survey:
a. ___ female ___ male
b. ___ under 18 ___ 18-39 ___ 40-65 ___ 65+

17. Number of people in the household:
___ adults ___ children

18. Would you like to be sent information regarding the outcome of our project?
___ Y ___ N

19. May we contact you to ask you questions about the watershed? If yes, please provide contact information.
___ Y ___ N CONTACT INFO.:___________________________________
____
____

If you have any questions about this survey or our project, feel free to contact:
Professor Ken Potter
Department of Civil and Environmental Engineering
University of Wisconsin
1261C Engineering Hall, 1415 Engineering Dr.
Madison, WI 53706
e-mail: kwpotter@facstaff.wisc.edu, phone: (608)262-0040

3. Interview Subjects Contact List

Local Municipalities:

Dekorra, Town of	Michael Dorshorst	*Chairman*	608-635-2294
Lodi, Town of	Charlaine P. Brereton	*Chairwoman*	608-592-3369
Lowville, Town of	Eldon Saager	*Chairman*	608-635-7811
	Meagan Yost	*Supervisor*	608-635-7181
Poynette, Village of	Herb Werner	*President*	608-635-7550
	Dennis Linn	*Administrator*	608-635-7524
	Ron Moen	*Superintendent of Plant Operations*	608-635-7524
Poynette High School	Edwin Sommers	*Teacher*	608-846-8261

Columbia County:

District 19	Neil M. Ford	*Supervisor*	608-592-5574
District 21	Andy Ross	*Supervisor*	608-635-7373
Land Conservation	Kurt Caulkins	*County Conservationist*	608-742-9671
Planning and Zoning Dept.	Mike Stapleton	*County Zoning Administrator*	608-742-9660
Land Information Dept.	Kristin Anderson	*Deputy Director/Geospatial Technologies Coordinator*	608-742-9882

State Agencies:

WDNR	Roger Bannerman	*Environmental Specialist*	608-266-9278
	Jim Bernett	*Property Manager/Forester*	608-635-8113
	Carol Holden	*Education Coordinator*	608-266-0140
	Tim Larson	*Fish Manager*	608-635-8122
	MacKenzie Center		608-635-8110
	Mike Miller	*Statewide Coordinator for Baseline Wadeable Stream Monitoring*	608-267-2753
	Andy Morton	*Team Leader for Lower Wisconsin Basin*	608-275-3311
	Jeff Schure	*Water Management Specialist*	608-275-3228
	Doris Thiele	*Wastewater Engineer*	920-387-7864
UW-Extension	Kris Stepanuck	*UWEX Volunteer Coordinator for Statewide Monitoring*	608-265-3887
	Suzanne Wade	*Rock River Basin Educator*	920-674-8972

Federal Agencies:

NRCS	Dale Peterson	*Soil Conservation Technician*	608-742-5361
US Fish & Wildlife Service	Rhonda Krueger	*Wildlife Biologist*	608-742-7100

Organizations:

Audubon Society	Karen Etter Hale	*Madison Chapter Executive Secretary*	608-255-BIRD
FORC	Nancy Braker	*President*	608-635-4040
Trout Unlimited	Clint Byrnes	*Aldo Leopold Chapter President*	920-885-5335

APPENDIX C: WATERSHED EDUCATIONAL ACTIVITIES

Educational Activity 1

The Hydrologic Cycle and the Rowan Creek Watershed
Flow measurements and cross sections

Objectives

This exercise provides hands-on experience in determining the base flow of Rowan and Hinkson Creeks, and it allows students to compare seasonal fluctuations in the water flow with previously taken measurements. Data collection over several years will help establish awareness of the effects of development. Similarly, in taking flow measurements a creek profile can be produced and compared to previous profiles to observe the changes that take place over time.

Tools

- Minimum of 3 students (best with 4)
- Flow meter (may be purchased or borrowed)
- Tape measure (long enough to reach across the creek at the study site)
- Yard stick
- Graph paper
- Pencil
- Eraser
- Waders (if possible)

Steps

1. Read the instructions on how to use the flow meter prior to going into the field.
2. Pull the tape measure taut from one side of the creek at the edge of the water to the other to prevent miscalculations.
3. Divide the width of the creek into 10 equal sections. A flow measurement will be taken at each of the 10 spots across the creek. The width of the creek and depth at each flow-measurement location will be used to create a cross section of the creek back in the classroom.
4. At each spot, insert the flow meter and start timing after the first click. Take flow measurements for 60 seconds at each location indicated. Continue measuring until you hear 1 click after the 60-second limit, and note the time. Record the time (in seconds) and the number of clicks counted in the table provided.
5. In the classroom, use the measurements taken in step 3 to draw a cross section of the creek, and use the instructions provided with the meter to calculate the flow velocity at the study site. This can be calculated easily using a spreadsheet on the computer.

6. Compare the flow and profile to previously taken data.
7. Write a brief lab summary describing the raw and calculated data (charts, graphs, sketches, etc.), changes from previously collected data, difficulties encountered, and possible flaws in the measurements.

The Hydrologic Cycle and the Rowan Creek Watershed Record Sheet

Name:

Date:

Study site:

Days since last rainfall:

Width of creek:

Distance from edge (inches)	Depth at location (inches)	Number of clicks	Time (seconds)	Clicks per second	Velocity (flow meter directions)

Educational Activity 2

The Nutrient Cycle and the Rowan Creek Watershed
Water samples and bug collections

Objectives
This exercise provides hands-on experience obtaining water samples from Rowan and Hinkson Creeks, and it allows students to use the bug population to determine the quality of the creek through chemistry and biological indicators. Variations in data over several years will help establish awareness of the changes occurring in the watershed.

Tools
- Minimum 3 students
- Two clean, sealable containers
- Phosphorous chemistry testing kit
- Nitrogen chemistry testing kit
- Wisconsin Department of Natural Resources Recording Form for the Citizen Monitoring Biotic Index (see appendix A)
- A fine-meshed net with a long handle per group of 3 students
- One white tray per group of 3 students
- Water shoes or old shoes

Water-sample steps
1. Water samples can be taken anywhere, but for the purposes of this lab, select a site that has shallow (3–12 inches), fast-moving water, and move to the center of the creek at the chosen study site.
2. Lower one container into the water, keeping fingers away from the opening. Only water should flow easily over the lip of the container (not other substances).
3. Overfill the container and cover to prevent air bubbles.
4. In the classroom, follow the instructions on the nitrogen and phosphorous tests to determine the amount of each in the sample.

Bug-collection steps
1. Proceed with these steps in the same location chosen for the steps above.
2. Place the net downstream tightly against the bottom of the creek to prevent water from flowing under it.
3. An arm’s length upstream from the net, shuffle around the creek bed to dislodge the bugs and allow them to flow into the net. Scrubbing rocks with your hands may help as well.
4. Scoop the net upstream to keep collected material and organisms in and dump the contents into a tray.

5. Sift through the debris to locate living organisms.
6. Repeat steps 2 through 5 until you have collected 100 bugs.
7. On the stream banks, separate the organisms into groups of similar-looking specimens, and use the macroinvertebrate tally (page 2 of the Citizen Monitoring Biotic Index) to help identify them and record what was caught.
8. Return the contents to the creek, and once in the classroom follow the instructions on the sheet for the rating scale to determine the water quality of the creek.
9. Write a brief lab summary describing the ancillary data, the raw and calculated data (charts, graphs, sketches, etc.), changes from previously collected data, difficulties encountered, and possible flaws in the measurements.

EDUCATIONAL ACTIVITY 3

Rowan Creek: Temperature and Turbidity Monitoring

Objectives
This exercise provides students with a chance to monitor daily temperature fluctuations, as well as compare them to previously obtained data. The students will experience the visual affects of development and land management along the creek by comparing baseline water turbidity with the turbidity of water following a storm event. Changes in the data over several years help to establish the quality of the watershed when compared to earlier data.

Tools

- Minimum of 3 students
- One HOBO temperature logger (with NEW batteries) (Temperature loggers can be purchased from field-equipment suppliers.)
- One HOBO temperature logger housing (waterproof container)
- Rubber gasket (fits HOBO housing—to keep the HOBO watertight) and grease
- 1 metal stake (recycled rebar works well) and heavy-duty zip ties (to attach logger to stake)
- Computer (with software & hardware to download data)
- Pen or pencil
- Two clean, sealable containers
- Water shoes or old shoes

Temperature steps

1. Read the instructions on how to use the software and HOBO temperature logger, and set the logger to take 15-minute readings.
2. Locate a shaded study site in the water in which to place the HOBO temperature logger, and on the worksheet provided describe the exact location in detail for Day 1.
3. Lightly grease the rubber gasket that accompanies the housing, and seal the HOBO temperature logger in the container. Make sure the HOBO is closed tightly!
4. Pound the stake into the creek bed at the described location and use the zip ties to secure the logger to the stake.
5. After a week, return to the location and retrieve the HOBO temperature logger, the HOBO housing, the zip ties, the stake, etc.
6. Once at a computer, download the data and compare it to data from previous data.

NOTE: For further data collection, simply leave the logger in place for a longer period of time, making sure to download the data once every other week.

Turbidity steps

1. Before leaving the site used for temperature data collection, collect water in one of the two containers and seal it.
2. After a major storm event:
   - Return to the study site.
   - Write down the data for Day 2 requested on the worksheet.
   - Collect water in the second container and compare it to the initial sample.
3. Write a brief lab summary describing the ancillary data, the raw and calculated data (charts, graphs, sketches, etc.), changes from previously collected data, difficulties encountered, and possible flaws in the measurements.

Rowan Creek: Temperature and Turbidity Monitoring Record Sheet

DAY 1:

Name:

Date:

Study site:

Days since last rainfall:

DAY 2:

Name:

Date:

Study site:

Days since last rainfall:

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