The Restoration and Recreational Enhancement of

Lake Marion and the Black Earth Creek Corridor

2010 Water Resources Management Practicum
Nelson Institute for Environmental Studies
University of Wisconsin - Madison

THE UNIVERSITY of WISCONSIN MADISON

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Water Resources Management Workshop

2010

The Water Resource Management Workshop 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 members and graduate students in the analysis of a contemporary water resources problem.

For more information contact:

Nelson Institute for Environmental Studies
Community and Alumni Relations Office
40 Science Hall
550 North Park Street
Madison, WI 53706
608/265-2563
www.nelson.wisc.edu

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PREFACE

The Water Resources Management (WRM) Master's degree program in the Gaylord Nelson Institute of Environmental Studies at the University of Wisconsin–Madison hosts a year-long practicum as an applied learning opportunity for WRM graduate students. Using a hands-on approach, practicum participants tackle real world water resource issues through scientific study and community interaction, and the results are published professionally. Participants spend the fall planning the project and the spring and summer undertaking fieldwork, documenting results, and writing a report for the public. Graduate students in the Water Resources Management program must complete the WRM Practicum in order to earn a Master's Degree.

Since the 1960s, WRM students have addressed complex water resources management issues in a wide range of settings, from Native American Indian Reservations in rural northern Wisconsin to watersheds in urban areas.

FIGURE 1 – PHOTO OF LAKE MARION.

The 2010 WRM Practicum is a comprehensive study of Lake Marion in the Village of Mazomanie, Wisconsin. The students met with members of the community, researched the social and environmental history of the area, and undertook field studies. Combining community input and scientific data, planning options were drafted to improve the ecological and recreational quality of Lake Marion and to restore the Black Earth Creek Corridor adjacent to Lake Marion. The report has been edited and printed with $2,500 acquired by the Wolf Run Association through a Wisconsin Department of Natural Resources (WDNR) River Planning grant.

FIGURE 2 – GROUP PHOTO OF WRM STUDENTS: LEFT TO RIGHT, BOTTOM: PROFESSOR KEN POTTER, SAMANTHA GREENE, BARB GAJEWSKI, VANESSA COTTLE, CARA COBURN FARIS, ANDREA BACHRACH, LAUREN BROWN, BRADLEY VOWELS, JOE SHEFCHEK; TOP: MICHELLE BALK, LISA (YANJIAO) FENG, TINA WOLBERS, DAVID MOSHER, ERESHA DESILVA.

Participants in the 2010 WRM Practicum

Andrea Bachrach
Michelle Balk
Lauren Brown
Vanessa Cottle
Eresha DeSilva
Cara Coburn Faris
Lisa (Yanjiao) Feng
Barb Gajewski
Samantha Greene
David Mosher
Joe Shefchek
Bradley Vowels
Tina Wolbers

Faculty Advisor for the 2010 WRM Practicum

Professor Kenneth W. Potter, Nelson Institute, and the Department of Civil and Environmental Engineering

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We would like to thank the following organizations and governments for their hard work and continued support throughout the project:

Black Earth Creek Watershed Association

Dane County

Friends of Lake Marion

Jewell Associates Engineers

Mazomanie Historic Society

News Sickle Arrow

Southern Wisconsin Chapter of Trout Unlimited

Town of Mazomanie

U.S. Geological Survey – Wisconsin Water Science Center

University of Wisconsin-Madison

Village of Mazomanie

Wisconsin Department of Natural Resources

Wisconsin River Sportsmen's Club

Wolf Run Association

We would like to extend our gratitude to all of the individuals who have contributed hard work, endless effort, and enthusiasm to the project – without your support, the success of this project would not be possible.

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***Ron Boylan**, Town of Mazomanie Board*

***Daniel Brogan**, University of Wisconsin-Madison*

***Briana Burns** Black Earth Creek Association*

***Patricia Cicero**, Jefferson County Land and Water Conservation*

***Jim Craney**, Mazomanie Planning Commission, Adjacent Landowner*

***Sue Dietzen**, Village of Mazomanie Clerk*

***Emogene Dodsworth**, Concerned Citizen*

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***John Donaldson**, News Sickle Arrow*

***Dean Faber**, Concerned Citizen*

***Kevin & Diane Fisher,** Adjacent Landowners*

***Tom & Eleanor Flinn**, Adjacent Landowners*

***Dennis Franke**, Black Earth Creek Association*

***Chris Gellasch**, University of Wisconsin-Madison*

***Don Greenwood**, Jewell Associates Engineers*

***Mindy Habecker**, University of Wisconsin-Madison, Dane County Extension*

***Larry Hagen**, Wisconsin River Sportsmen's Club*

***Arnold Harris**, Western Dane Coalition for Smart Growth and Environment*

***Stefi Harris**, Western Dane Coalition for Smart Growth and Environment*

***Chad Heimerl**, University of Wisconsin-Madison*

***Lowell Holcomb**, Village of Mazomanie President*

***John Hoopes**, University of Wisconsin-Madison*

***Peter Huebner**, Village of Mazomanie Board of Trustees*

***Chris James**, Concerned Citizen*

***Greg Jewell**, Jewell Associates Engineers*

***Scott Johnson**, University of Wisconsin-Madison*

***Pete Jopke**, Dane County*

***Paul F.Juckem**, U.S. Geological Survey - Wisconsin Water Science Center*

***Grant Kniedler**, Village of Mazomanie Board of Trustees*

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***Bill Patton**, Concerned Citizen*

***Doug Peterson**, Remote Controlled Boat Club*

***Emily Pettis**, Concerned Citizen*

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***Emily Stanley**, University of Wisconsin-Madison*

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CEE 419 Spring 2010 – Hydrologic Design Course

CEE 411 Fall 2009 – Open Channel Hydraulics Course

CHAPTER 1
INTRODUCTION

PROJECT AREA

Lake Marion is a 16.9 acre lake located along Black Earth Creek, in the Village of Mazomanie, south of Highway 14 and east of Highway KP. It falls within the Black Earth Creek Watershed, a watershed of approximately 103 square miles located in western Dane County at the border between Wisconsin's unglaciated and glaciated regions. The creek runs for 27 miles in this watershed (WDNR 2001).

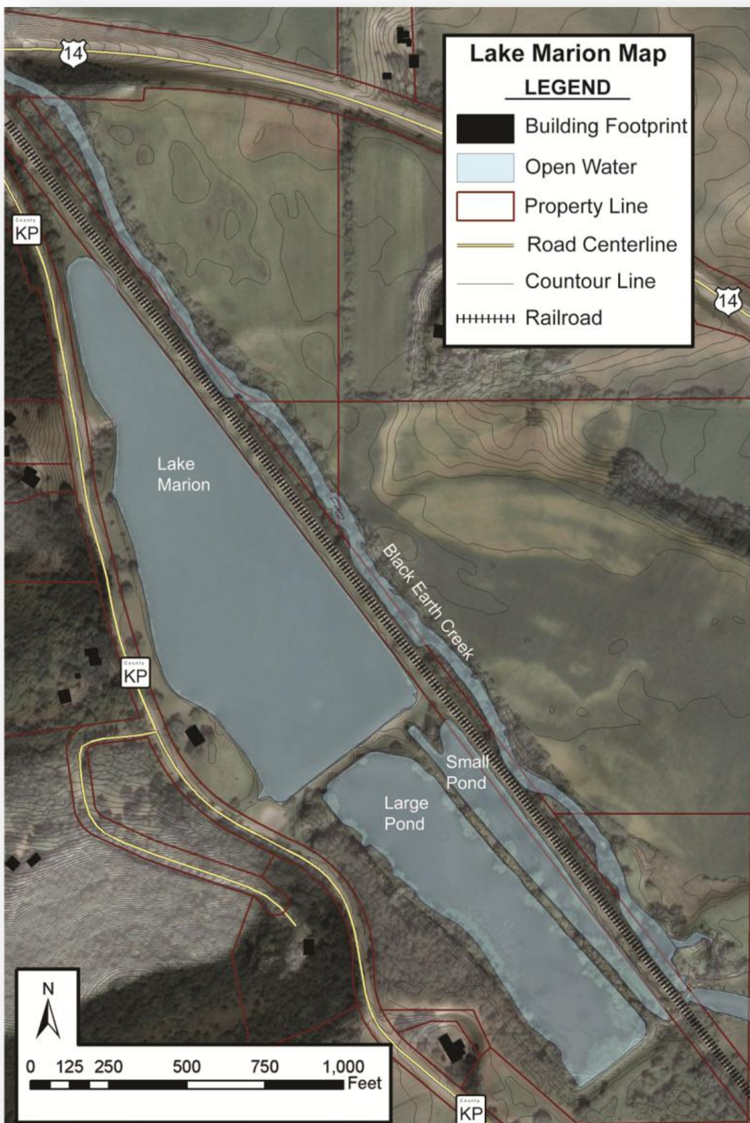

FIGURE 1.1 – MAP OF PRESENT DAY LAKE MARION 2010. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

Lake Marion's Watershed

A watershed is an area of land that catches precipitation and drains towards a body of water such as a lake or stream. It is delineated topographically based on ground elevations and slopes.

Lake Marion's watershed has an area of approximately 340 acres, see Figure 1.2. The watershed is bordered on the northeast by the railroad tracks and on the southwest by a moderately high hill. County Highway KP crosses the watershed from northeast to southwest. The water bodies within the watershed, composed of Lake Marion, the Large Pond and the Small Pond, cover an area of about 25 acres (or 10% of the watershed's area). The primary land use is forest, covering about 65% of the total ground area. Other land uses include agricultural fields (25%) and lawn (7%), which is mainly the grassed area around Lake Marion. There are ten private residences, mostly along Highway KP. The soils are generally silt loams, and, to a lesser extent, loamy sands, rocky land, and alluvial land (NRCS 2010).

For information on the Black Earth Creek watershed, please see Chapter 3, Water Supply and Quality.

Figure 1.2 - Map of Lake Marion's Watershed. Source: Dane County. Aerial Image 2008. Created by 2010 WRM Practicum.

MOTIVATION

Since its formation in the 1850s, Lake Marion has evolved from millpond to fish rearing station to recreational hub. However, today the dam that diverts water into Lake Marion is in disrepair and the Village has been ordered by the Wisconsin Department of Natural Resources (WDNR) to repair, replace, or remove it. On November 10th 2010, the Village Board of Mazomanie voted 6 to 1 to remove the dam on Black Earth Creek. As a result, the maintenance of the lake will require an alternative water source. In addition, the sediment and high levels of nutrients in the lake create an aquatic environment that does not support the plants and animals that are desirable to the lake community. Fortunately, the community recognizes the value of the lake and the adjacent stream corridor, and has organized to protect and enhance this value.

GOALS

Students in the WRM Program seek to learn while also serving the community's needs. The guiding principles of the Program are science, sustainability of water resources, and community service. The 2010 WRM practicum's six goals are to:

- Help preserve Lake Marion as a valued recreational and cultural resource for the project stakeholders.
- Assess current environmental conditions of Lake Marion, Black Earth Creek, and the surrounding area.
- Evaluate strategies for maintaining and improving Lake Marion when the dam is removed.
- Develop conceptual planning recommendations for the restoration of the Black Earth Creek Corridor.
- Work with project stakeholders to gather their ideas to incorporate into planning recommendations for the restoration and enhancement of Lake Marion and the Black Earth Creek Corridor.
- Develop conceptual layouts for a trail network linking community open space within the project boundaries.

HISTORY OF LAKE MARION

1855: LAKE MARION'S BEGINNINGS AS A MILL POND

Lake Marion was formed in 1855 when the Chicago Milwaukee Railroad constructed a dam on the Black Earth Creek to supply power for the Lynch and Walker Feed and Flour Mill. A diversion structure near the dam, southeast of where Lake Marion sits, fed the millpond that became known as Lake Marion.

The mills processed surplus grains for the community to use and distribute. Thanks to the hydropower they harnessed, the Village of Mazomanie, founded in 1842, grew along the railroad corridor that still runs from the lake to the Village's downtown. Previously, the Winnebago tribe of Native Americans (now known as the Ho Chunk) occupied this area and it is believed that their burial mounds are scattered throughout the region, including the Lake Marion area.

In the late 1800s and early 1900s, the Village of Mazomanie continued to develop. Community members and visitors used Lake Marion for fishing, boating, picnics, and wintertime ice skating. The lake even boasted an icehouse, which supplied ice to local taverns and milk houses.

Meanwhile, Lake Marion was regularly stocked with fish starting in 1876. A few major stocking events include 10,000 German carp in 1893, 300,000 walleyed pike in 1898, 3,000 black bass in both 1903 and 1908, and 10,000 bullhead fingerlings in 1939. In 1939 the lake was declared a Fish Refuge. This same year, the State Conservation Commission (the predecessor of the Natural Resources Board) removed two to three tons of carp from the lake.

The Black Earth Creek dam and Lake Marion were a source of pride for the community. Thanks to the power that the dam harnessed, the Village became one of the earliest communities in the region to have electric streetlights (Habecker, No Date). However, during the early 1900s and into the 1950s, the dam was blamed for causing troublesome downstream flooding.

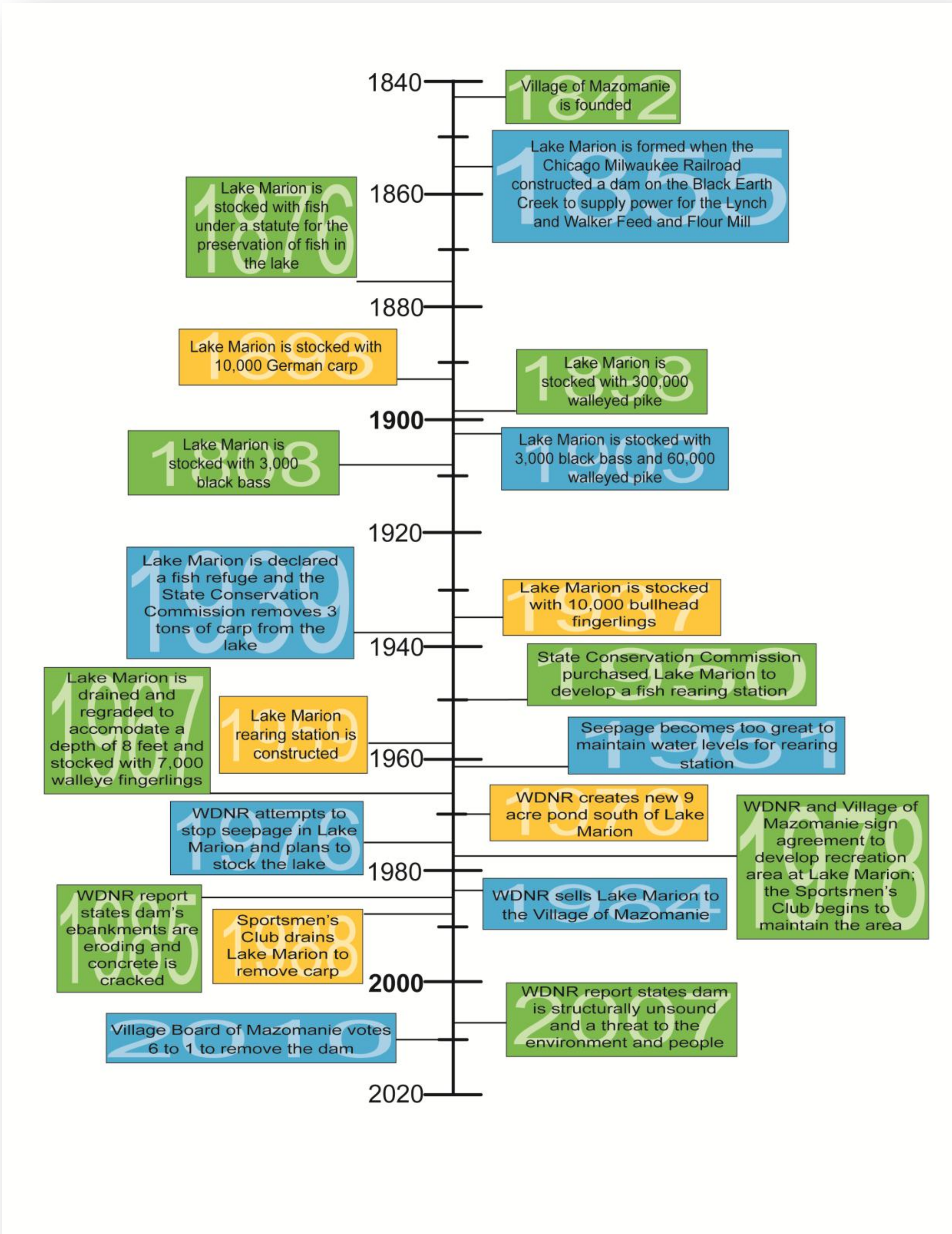

FIGURE 1.3 – TIMELINE OF LAKE MARION'S HISTORY.

Figure 1.4 –Aerial Imagery, 1937. Source: United States Department of Agriculture, University of Wisconsin Map Library.

Figure 1.5 – Photo of Lake Marion from Bluff, 1904. Source: Mazomanie Historical Society.

FIGURE 1.6 – PHOTO OF BLACK EARTH CREEK DAM, 1911. SOURCE: MAZOMANIE HISTORICAL SOCIETY.

1950: AFTER A MAJOR FLOOD, ATTEMPTS TO RESTORE THE FISH HATCHERY

Beginning in the 1950s, the WDNR put considerable effort into developing Lake Marion as a fish rearing pond. After multiple floods earlier in the century, a flood in 1950 caused the collapse of the banks of Black Earth Creek east of Lake Marion. The surrounding fields flooded, and a new path for Black Earth Creek, one that bypassed Lake Marion altogether, emerged. In 1950, the State Conservation Commission purchased Lake Marion to restore it as a fish hatchery. Plans called for a channel to be opened on the Wolf Farm, northeast of the lake, to maintain lake levels. Meanwhile, the dam, built of stone and wood, was found to be unsafe and in need of repair.

In 1959, the Lake Marion Rearing Pond was constructed to rear walleyed pike and northern pike fingerlings. In 1961, pond plans backfired when a layer of sand was exposed during lake construction. The sand created seepage that drained the lake of water. The WDNR reshaped the lake into three distinct segments to house various ages and species of fish, lined it with clay to limit seepage, and shifted the channel. The WDNR also fortified the dam by encasing it in concrete and steel. By the late 1960s, the Lake Marion Rearing Pond held water, but the fish hatchery was not operating effectively. In 1967, The WDNR started the process of draining and grading (adjusting the depth of) the lake using heavy equipment. Because of the high seepage rate, the decision was made to keep a constant flow of water into the lake from the creek. A three stage filter of screen mesh was installed on the inlet to keep fish from entering the lake. The lake was filled to a depth of 8 feet and stocked with 7,000 walleye fingerlings. Then, in 1969, the WDNR was able to remove 5000 walleye fingerlings from Lake Marion to a lake in Waukesha County.

FIGURE 1.7 –AERIAL IMAGERY, 1962. SOURCE: U.S. DEPARTMENT OF AGRICULTURE, UNIVERSITY OF WISCONSIN MAP LIBRARY.

In an effort to create habitat for the rearing of northern pike or muskies, in 1970, the WDNR bulldozed south of the lake to create a new 9-acre pond (today known as the Large Pond). However, in 1972, the WDNR grew concerned that the pond construction could cause wetland conditions on the surrounding agricultural land. A peripheral ditch was constructed along the south and west sides of the fish rearing pond (known today as the Small Pond) in order to protect the surrounding land from groundwater seepage. In the end the WDNR abandoned their plan to turn the second pond into a rearing pond. The WDNR turned their focus to Lake Marion and attempted to stop seepage; bulldozers were used to fill suspect seepage points. The DNR also added materials, such as clay and earth, to the lakebed and planted smartweed on the shoreline, hoping the plant's roots would act as a sealant. These actions failed to stop the seepage as well. In the end, the seepage problem prevented the WDNR from establishing a successful fish rearing station on Lake Marion, and in 1983 the WDNR officially sold the lake to the Village. Seepage is still a concern for maintaining the lake today (See Chapter 3, Water Supply and Quality).

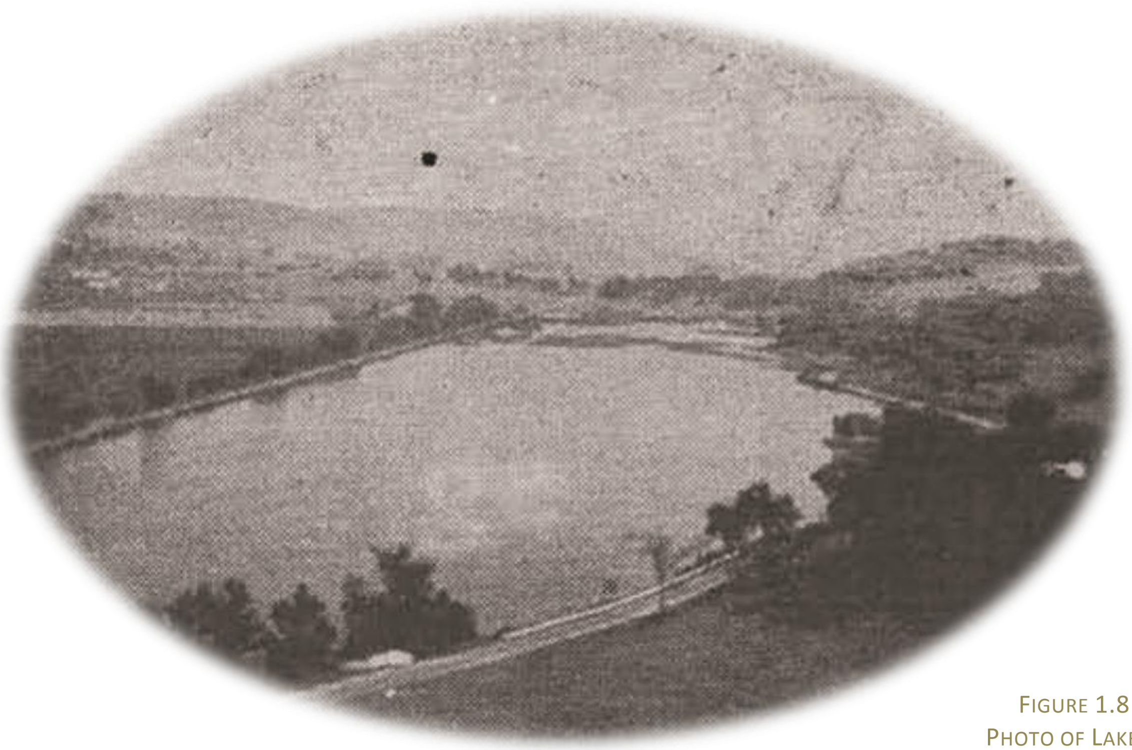

FIGURE 1.8 – PHOTO OF LAKE MARION FROM BLUFF, 1961. SOURCE: MAZOMANIE HISTORICAL SOCIETY.

1978: A Public Park Develops, and Dam Safety Becomes a Concern

Figure 1.9 – Photo of Black Earth Dam, 1967. Source: Mazomanie Historical Society.

In the summer of 1978, Lake Marion was described as "forlorn" and "choked with weeds and algae." The fish rearing mission had failed, and the WDNR agreed to let the Village of Mazomanie use the Lake Marion Rearing Pond area as parkland. In July, the WDNR and the Village signed an agreement permitting the Village to develop, operate, and maintain a multiple-use recreation area on the Lake Marion Rearing Station lands. This would include picnic grounds and parking areas. The Wisconsin River Sportsmen's Club (WRSC) took responsibility for maintenance of the area, a role that has grown to include building a picnic shelter, controlling the lake's water level, removing invasive fish, and sponsoring community events.

In the early 1980s, Mazomanie residents ice-skated on Lake Marion in the winter and raced electric boats there in the summer. The lake was touted as having a launch pier, electricity, a grill, and a picnic shelter with ample tables. In 1982, the WRSC sponsored canoe races on the lake. In 1984, the WDNR sold the 45-acre track, including Lake Marion, the smaller pond, and the larger pond, to the Village of Mazomanie for $1, with restrictions that it would be used solely for a public park and recreation. The Sportsmen's Club made enhancements to Lake Marion in the late 1980s by draining the lake to remove carp and fixing the walkway on the south end. Workers removed approximately 95% of the carp using pick-up trucks and nets, but they could not access the deeper pools. Nor did they remove carp from the Large Pond.

Unfortunately, as stated in a 1985 WDNR report on the Black Earth Creek dam, the dam's earthen embankments were eroding, and there was a large crack in its left concrete wall. The report said that the right embankment would continue to deteriorate but that a failure there probably would not result in massive downstream flooding since the amount of water stored upstream of the dam was small in comparison to the storage capacity of the three ponds. However, the WDNR recommended the Village repair the spillway and elevate the embankment to provide at least three feet of freeboard above normal water levels.

A 2007 DNR Dam Safety Inspection Report stated that the dam was structurally unsound and a threat to the environment and people. The report gave the Village three options: (1) to reconstruct the dam as a large dam, its current classification, which would probably require complete removal of the current structure; (2) to reconstruct it as a small dam; or (3) to remove the dam. On November 10th 2010, the Village Board of Mazomanie voted 6 to 1 to remove the dam on Black Earth Creek.

Today, the Lake Marion park exists as a recreational destination for those who live in the region, thanks to collaboration between the Village of Mazomanie and various stakeholder groups. Residents and visitors use the lake for fishing, bird watching, picnics, dog walking, ice skating, cross country skiing, electric boat racing, and canoeing. The lake hosts community events, which include the Depot-to-Depot Run and Family Fishing Day. The Village mows the grass around the lake and handles trash removal. The WRSC, Friends of Lake Marion, and the Wolf Run Association help to maintain the park and sponsor community events.

FIGURE 1.10 – AERIAL VIEW OF LAKE MARION IN 2000. SOURCE: UNITED STATES DEPARTMENT OF AGRICULTURE, UNIVERSITY OF WISCONSIN MAP LIBRARY.

FIGURE 1.11 - LAKE MARION, 2010.

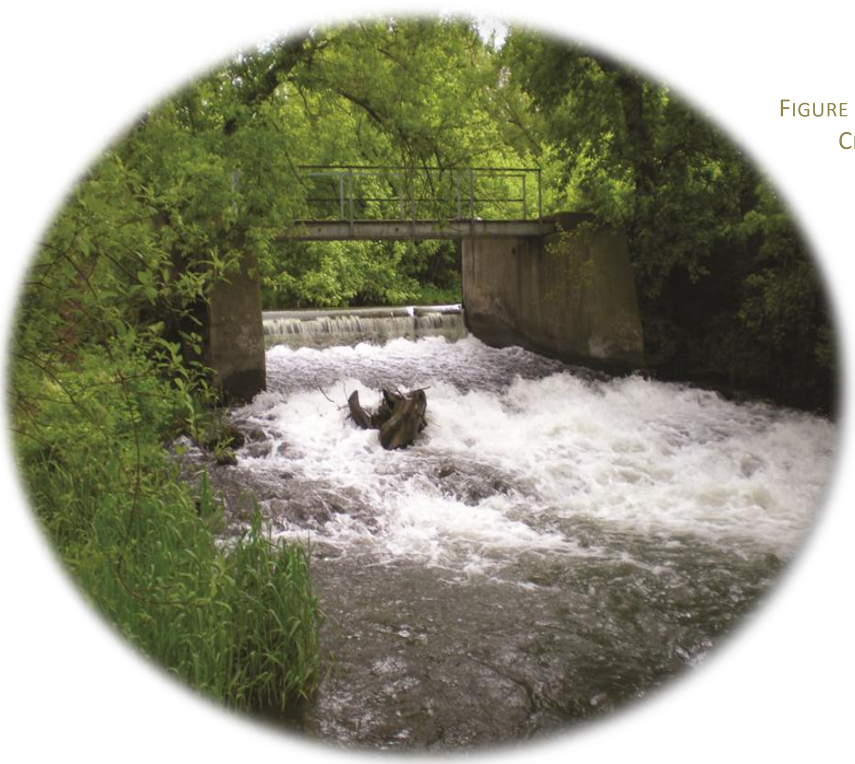

FIGURE 1.12 – BLACK EARTH CREEK DAM, 2010.

CHAPTER 2: ENGAGING THE STAKEHOLDERS

INTRODUCTION

Lake Marion has been an important community resource for Mazomanie since its creation as a mill pond in the mid-1850s. The lake, fed by Black Earth Creek, provided Mazomanie with the power necessary to process wheat and contributed to one of the earliest electricity systems in Wisconsin. According to newspaper articles, Lake Marion was, and still is, considered a place of “natural beauty” where anglers, bird watchers, boaters, and others come to enjoy nature.

Over the past 160 years, Lake Marion has changed significantly, yet it remains an important part of Mazomanie. Local residents use the lake on regular basis for fishing, walking, picnicking, photography, skiing, and other activities. Many local organizations use Lake Marion throughout the year for service and recreational activities. Some of these organizations contribute labor and financial support for maintenance of the lake and the surrounding park area. Other organizations are concerned with the maintenance, protection, and improvement of the Black Earth Creek and its watershed. Many organizations and residents of Mazomanie wish to better connect Lake Marion to the region and help promote the community as the “Gateway to the Driftless Region.”

Because of the significance of Lake Marion, we used several strategies to gather input from stakeholders, which include the individuals and organizations with interest in the lake and surrounding lands. Meetings, interviews and field days enabled us to engage the community and elicit important information about Lake Marion from those who use it the most. We conducted interviews at the beginning of the project to understand the importance of the lake and how it is used. We held public meetings in Mazomanie to update the community on project progress and to gather stakeholder input. In addition, we invited stakeholders to join us at Lake Marion during fieldwork to observe and ask questions. These events were instrumental in guiding fieldwork and final recommendations. The following chapter of this report outlines the interaction between the stakeholders of Lake Marion and our class. Appendix 1 provides a more detailed overview of stakeholder partnerships.

COMMUNICATING WITH THE STAKEHOLDERS

We regularly informed stakeholder groups of meeting and event dates and of other ways to get involved with the project. We communicated with stakeholders through various means including websites, newspaper articles, email, in-person events/meetings and research field days.

Website

We developed a website (https://sites.google.com/site/waterresources2010/) for the promotion of the Lake Marion project. The public website notified stakeholders of key events over the course of the project. We also used the site to post important documents and presentations from each of the four public meetings held in Mazomanie.

Newspaper

We posted announcements in the local newspaper, the *News-Sickle-Arrow*, about the progress of the project, public meeting times and locations, meeting agendas, and field day events. We also submitted articles discussing the history of the project, our role, and cooperation between the Village of Mazomanie and local organizations.

Email

We developed a stakeholder email list to share information about the project and important events. We collected email addresses during meetings of local organizations and WRM meetings concerning Lake Marion. We urged stakeholders to contact us at waterresources2010@gmail.com if they had any questions or concerns or were interested in joining the group for any of the many WRM events.

Research Field Days

Stakeholders were invited, by email, to join us on our many research field days. On some of these field days we distributed handouts that informed the lake users of the broader scope of the project. We also told stakeholders who attended field days about upcoming meetings and events.

Stakeholder Events

We participated in several events at Lake Marion and in Mazomanie. These included the Family Fishing Day at Lake Marion (May 2010), a Black Earth Creek Watershed Association presentation at Wisconsin Heights High School (May 2010), the Gandy Dancer Festival in Mazomanie (August 2010), and two presentations at the Wisconsin River Sportsmen's Club (July and October 2010). We also attended meetings of local community organizations including Wolf Run Association (March and September 2010) and the Good Neighbor Committee (November 2009 and January 2010). At these events and meetings, we spread the word about the ongoing project and further developed stakeholder contacts.

INTERVIEWS

We interviewed fifteen stakeholders to better understand the historical significance and current uses of Lake Marion, the importance of the area, and what changes each community member would like to see happen at the lake. These interviews occurred during the first few months of the project, from November 2009 to February 2010. The information generated by these interviews was invaluable for informing the practicum process, including field studies, presentations, surveys, and participation exercises. Appendix 2 lists questions asked during the interviews.

Our interviews, coupled with historic documents, uncovered varying uses and periods of significance in Lake Marion's history. Periods of significance include Lake Marion's Beginnings (1855 – 1950), Lake Marion as a Fish Hatchery (1950 – 1978), and Lake Marion as a Public Park (1978 – present day). Lake Marion's history gave the project a sense of place and a historical context within which to discuss our research with stakeholders. The history also guided our field studies, such as the investigation of the clay lining under Lake Marion.

The list of uses compiled during the interviews helped us understand how stakeholders experience Lake Marion and how the field studies could best benefit the users of the lake. Recreational uses discussed by stakeholders included:

- Canoeing
- Cross-Country Skiing
- Dog walking
- Family Gatherings
- Fishing
- Ice Skating
- Picnics
- Photography
- Remote Controlled Boat Racing
- Walking/Jogging
- Wildlife Observation

In addition, adjacent landowners appreciated the aesthetic value Lake Marion adds to the area. Local youth frequent the lake for social activities after school and during the summer. Some teachers at Wisconsin Heights High School also use the lake and creek area for education.

We used interviews to gauge interest in specific changes that could take place at Lake Marion. Changes we discussed during the interviews include:

- Construction of trails linking downtown Mazomanie to Wisconsin Heights High School.
- Restoration of natural habitat and environmentally sensitive areas.
- Promotion or preservation of the dam as a historical marker.
- Development of buffer areas to protect water quality within Lake Marion.

- Improvement of access to Lake Marion and the Black Earth Creek for fishing and boating.
- Restoration of Black Earth Creek to its original streambed.
- Development of more picnic areas away from County Road KP along the levees of Lake Marion.
- Addition of a larger gate to control traffic.
- Creation of restoration islands as habitat for birds and fish.

MEETINGS

We led a series of four community meetings between March and December of 2010. Three of the meetings occurred at the Mazomanie Community Building in downtown Mazomanie, and one took place outdoors at Lake Marion. Each of the first two meetings involved a student presentation followed by stakeholder input exercises. The third meeting was a gathering at Lake Marion during which we presented field studies and results. The fourth meeting took place at the Community Building and included a detailed overview of our results and recommendations. The primary objective of the meetings was to present results of our Lake Marion field studies and gather input from stakeholders.

MEETING ONE: MARCH 4TH, 2010

zWe held the first meeting on Thursday, March 4th, 2010. Thirty-eight project stakeholders attended. We presented an overview of the Lake Marion project and the stages of research we planned to complete during summer field work. Following the presentation, attendees engaged in a question and answer session.

FIGURE 2.1 – STUDENT PRESENTATIONS: ANDREA BACHRACH PRESENTS THE STUDIES BEING COMPLETED AT LAKE MARION TO STAKEHOLDERS AT THE FIRST OF FOUR PUBLIC MEETINGS.

Questions from the audience focused on what the studies would involve, what types of recommendations would be presented, the timeline of the project, how the project was being funded, and how studies and recommendations would impact adjacent landowners. The questions prompted us to study horizontal seepage at Lake Marion, funding opportunities for particular recommendations and using well water as an alternative water supply.

FIGURE 2.2 - PERSONAL REFLECTION: STAKEHOLDERS PARTICIPATE IN A DISCUSSION THAT FOCUSES ON PAST EXPERIENCES AND FUTURE SCENARIOS AT LAKE MARION. STICKY NOTES WERE USED TO ORGANIZE RESPONSES AND PROMOTE PARTICIPATION.

PERSONAL REFLECTION

In the second half of the meeting, we discussed with stakeholders their personal reflections on Lake Marion. Working in small groups, we asked meeting attendees to comment on two questions:

(1) Reflect on your past experiences with the Lake Marion park space. What are your fondest or most memorable experiences at the lake?

(2) What are your hopes and desires for the future of Lake Marion?

We compiled all responses and categorized them by common themes. Appendix 3 includes the 74 responses for question one and 61 responses for question two.

What are your fondest or most memorable experiences at the lake?

When reflecting on Lake Marion's past, stakeholders primarily discussed recreational activities. Most comments focused on using Lake Marion for walking, wildlife observation, and fishing. Other responses revealed personal ties to Lake Marion based on specific events, family and social gatherings, and the natural beauty of the area. Many responses talked about "relaxing in a beautiful setting" or "enjoying the wonderful area." Some responses mentioned Lake Marion's abundant wildlife, and some raised health and cleanliness concerns about goose droppings.

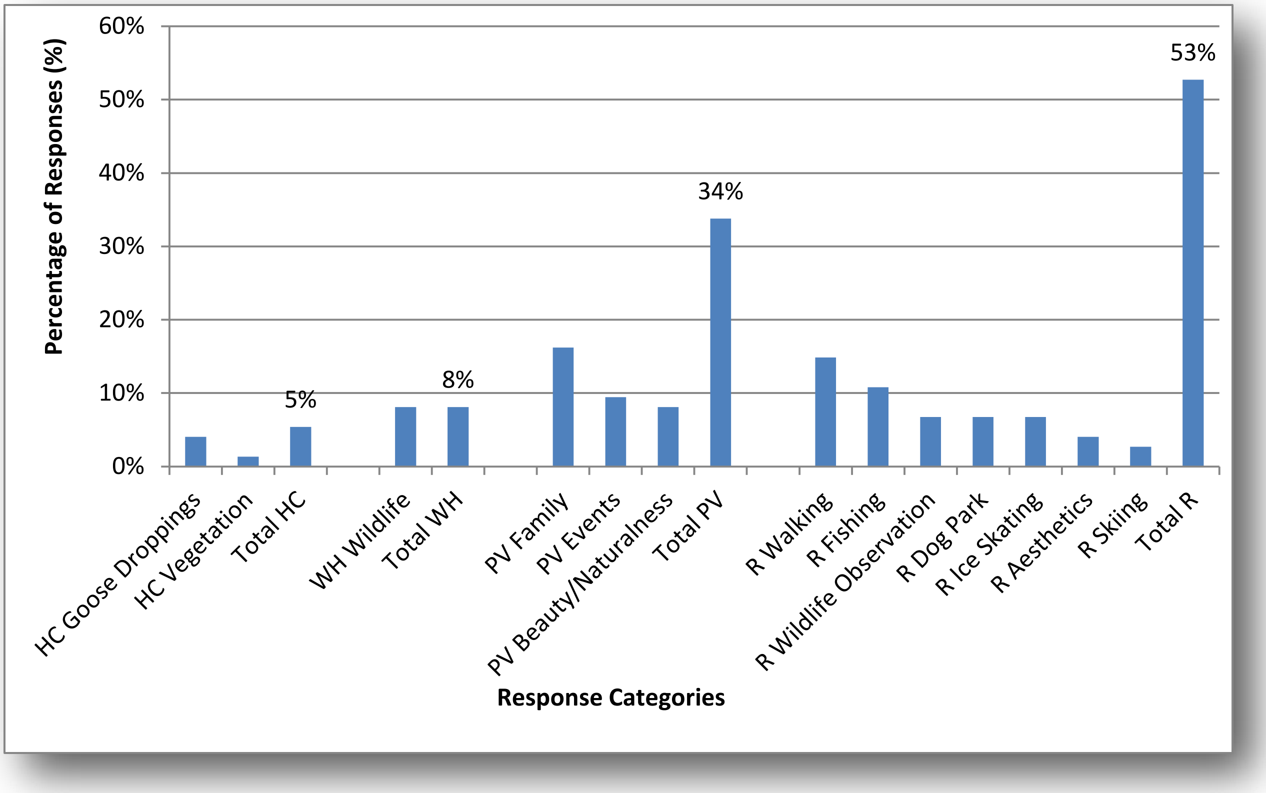

FIGURE 2.3 - MOST MEMORABLE EXPERIENCES: STAKEHOLDERS WERE PRIMARILY CONCERNED ABOUT RECREATIONAL ACTIVITIES (R) TAKING PLACE AT LAKE MARION. OTHER CONCERNS INCLUDED PERSONAL TIES (PV), WILDLIFE HABITAT (WH), AND HEALTH AND CLEANLINESS (HC).

What are your hopes and desires for the future of Lake Marion?

When envisioning the future, respondents were primarily concerned with continued recreational opportunities. Many responses focused on connecting Lake Marion to other local destinations with trails and bike paths. Many stakeholders felt that the area should be kept as natural as possible to allow for “general recreation” and “quiet contemplation.” Stakeholders presented the idea of “adding more trees,” increasing “wetlands or natural areas for wildlife,” and “improving the water quality” at Lake Marion. Most of the responses indicated that preserving and adding to Lake Marion’s naturalness would improve fish, bird, and mammal habitat; maintain aesthetic value; and better manage environmental conditions.

Respondents also expressed concern about the sustainability of Lake Marion and the cost of implementing and maintaining an alternative water supply. Some responses focused on “maintaining Lake Marion at a minimum cost to taxpayers.” Maintaining Lake Marion as “one of Western Dane County’s hidden treasures” was a shared sentiment among many of the responses.

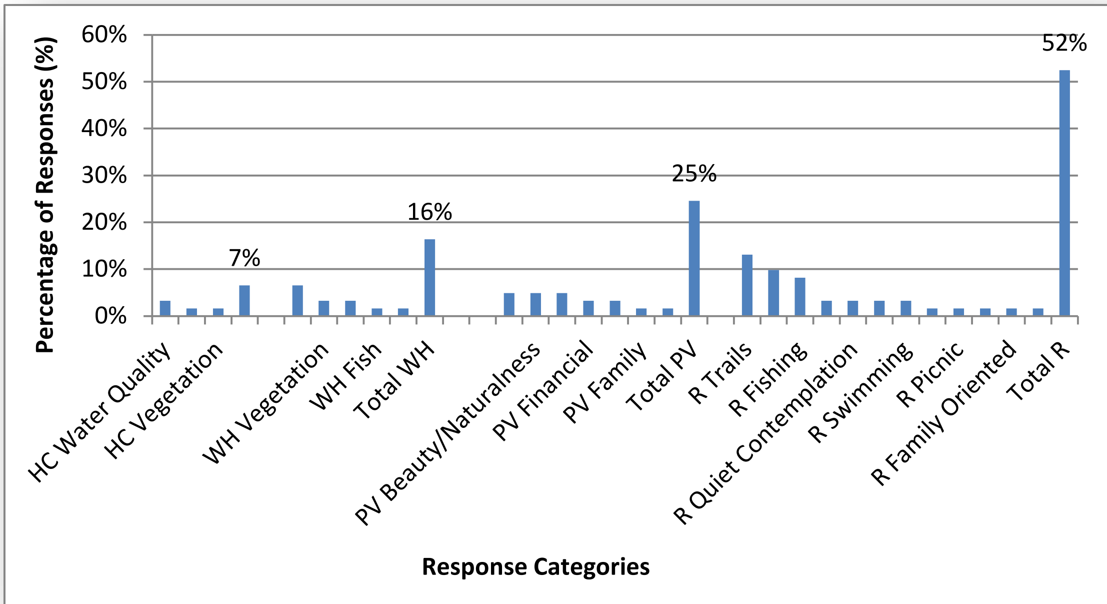

FIGURE 2.4 – HOPES AND DESIRES: STAKEHOLDERS SHOWED AN INTEREST IN MAINTAINING EXISTING RECREATIONAL USES (R) WHILE IMPROVING THE OVERALL HEALTH AND CLEANLINESS (HC) OF LAKE MARION. RESPONSES ALSO INDICATED THAT THE PERSONAL CONNECTIONS (PV) BE MAINTAINED WITH COMMUNITY EVENTS AND FAMILY OUTINGS WHILE MINIMIZING COSTS. OTHER COMMENTS FOCUSED ON PRESERVING, IMPROVING, AND EXPANDING EXISTING WILDLIFE HABITAT (WH) AREAS.

MEETING TWO: JUNE 17TH, 2010

We held the second meeting on Thursday, June 17th, 2010. Twenty-seven stakeholders attended. We reported on our current and upcoming studies and preliminary findings, and urged stakeholders to join us on our upcoming field study days. A short question and answer session followed the presentation. Attendees' questions focused on an alternative water supply for Lake Marion, responsibility for implementing planning recommendations provided by WRM students, the WDNR Dam Removal Grant, and studies taking place at the lake. Next, we led a hands-on mapping workshop to learn more about how stakeholders currently use the lake and what program elements they envision for the future.

MAPPING WORKSHOP

In designing the mapping workshop, we developed program elements from stakeholders' responses to the "Personal Reflection" exercise in Meeting One. We asked small groups of four to six people to fill in two maps of Lake Marion. On the first map, participants indicated current uses by writing or drawing on the map to show where and how they use the lake. On the second map, participants identified areas of the lake that are underutilized or need improvement. Small groups then presented their maps to the larger group, and participants discussed their results.

FIGURE 2.5 – MAPPING WORKSHOP: BRADLEY VOWELS AND CARA COBURN FARIS DISCUSS LAKE MARION WITH STAKEHOLDERS DURING OUR SECOND MEETING. MAPS WERE USED TO LOCATE CURRENT USES AND POTENTIAL PROGRAM ELEMENTS AT LAKE MARION SUCH AS PARKING, NATURAL AREAS, AND HABITAT ISLANDS.

Overall, the stakeholder presentations indicated a shared sentiment to keep Lake Marion as natural as possible with very few programmed or developed areas. Most of the groups explored changing one or more of the small ponds into restored prairie or wildlife observation areas. The groups also presented ideas for modifying the shoreline of Lake Marion and increasing fish habitat in the lake. Almost all of the options involved some type of island structure as a refuge for birds and fish. The plans suggested that the area next to County Road KP be kept mowed for passive recreation and be further developed for parking while other areas of the lakeshore, especially those along the railroad corridor, be planted with native vegetation and kept in a more natural state.

The stakeholders indicated interest in a pedestrian path weaving throughout the Lake Marion area connecting downtown Mazomanie, and Wisconsin Heights High School to the lake. Most maps suggested maintaining the wooded area next to County Road KP, or restoring it to an oak savannah to allow more views of the, and using boardwalk trails to preserve sensitive areas. Other options included installing a new gate to limit vehicle traffic, placing a picnic area between Lake Marion and the smaller ponds, and devoting more space along County Road KP to parking, especially adjacent to the shelter and other frequently visited areas. The stakeholders indicated that they wanted no playground, beaches, or swimming areas at the lake.

The maps illustrated three planning areas: Lake Marion, the smaller ponds, and Black Earth Creek. To summarize, stakeholders' suggestions were:

Lake Marion:

- Add a footbridge across the drainage swale from the parking lot to the shelter
- Dredge to make deeper areas for fish habitat
- Create more natural edges along the lakeshore
- Increase parking at current locations and develop more parking areas along County Road KP
- Add more natural grassland adjacent to the railroad tracks
- Maintain remote controlled boat racing areas adjacent to the shelter
- Create more shaded seating areas for rest and solitude
- Discourage vehicle access across the berm to the railroad tracks
- Add a kayak/canoe launch adjacent to the parking lots

Smaller Ponds Area:

- Restore an oak savanna landscape
- Fill in ponds with dredged material to create more land area around Lake Marion
- Create a wetland with boardwalks and wildlife observation decks
- Enhance bird habitat to create more bird watching opportunities
- Create more spaces, such as community gardens and picnic areas, to promote community interaction

Black Earth Creek

- Create access to Black Earth Creek for kayak/canoe launch
- Increase access to the dam from County Road KP
- Add trail connections to downtown Mazomanie and Wisconsin Heights High School

FIGURE 2.6 – MAP PRESENTATIONS: ONE OF THE MEETING ATTENDEES PRESENTS HIS GROUP'S DESIGN FOR LAKE MARION.

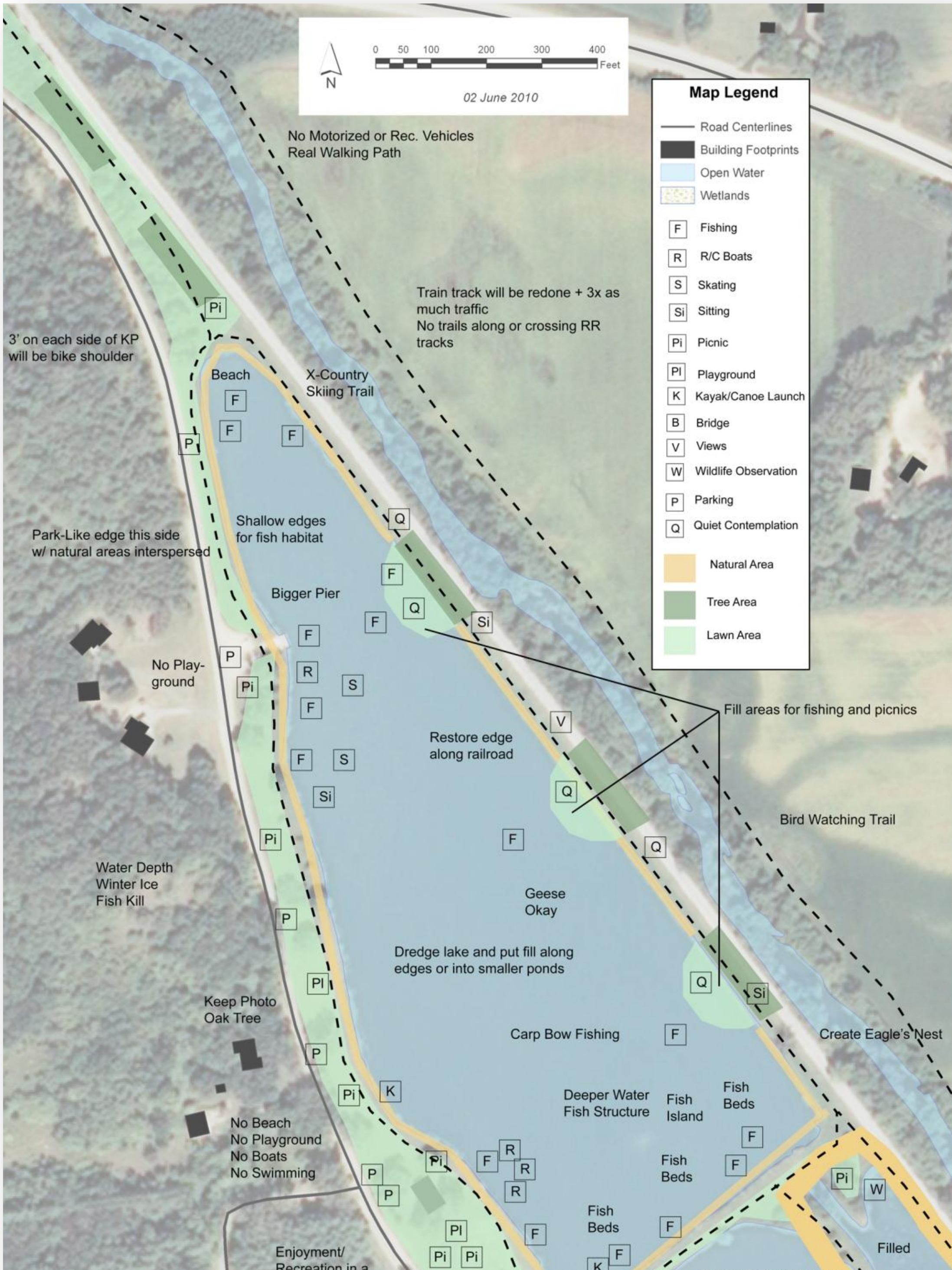

FIGURE 2.7.1 – LAKE MARION DESIGN: THIS MAP SHOWS THE DESIGN SOLUTIONS DRAWN FOR LAKE MARION. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM WITH INFORMATION COMPILED FROM STAKEHOLDER INPUT.

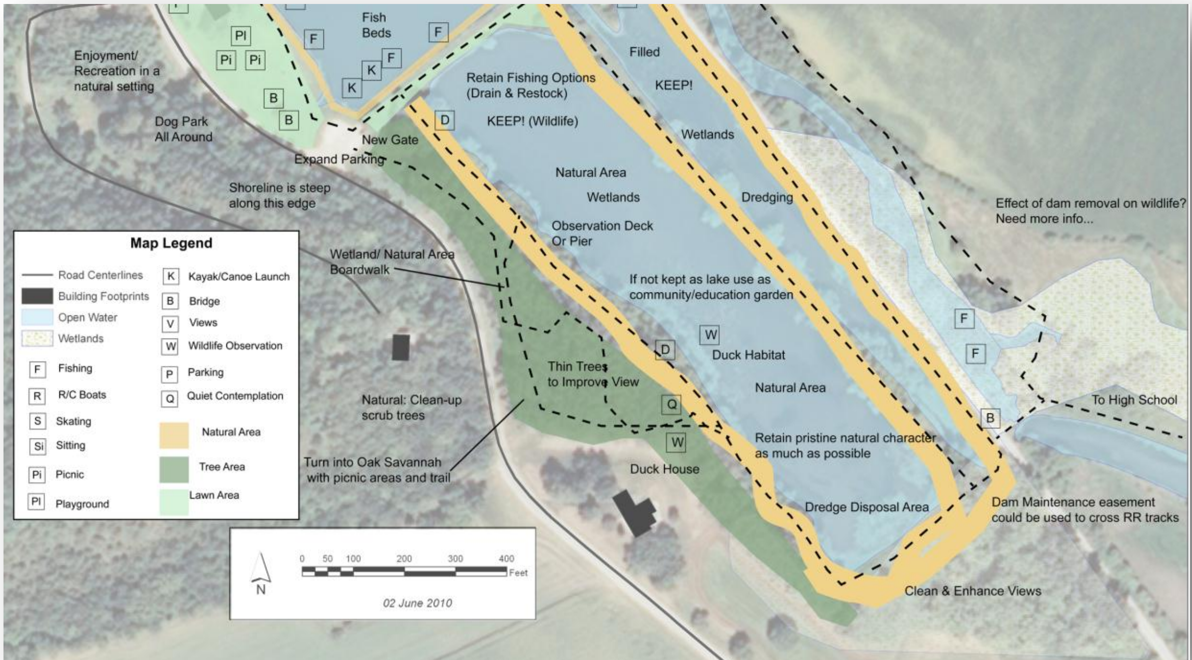

FIGURE 2.7.2 – SMALLER PONDS AREA DESIGN: THIS MAP SHOWS THE DESIGN SOLUTIONS DRAWN FOR THE TWO SMALLER PONDS SOUTH OF LAKE MARION. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009. CREATED BY 2010 WRM PRACTICUM WITH INFORMATION COMPILED FROM STAKEHOLDER INPUT.

The mapping workshop proved essential to developing our management and planning recommendations for Lake Marion. We made a composite of the stakeholders' maps to show all the options presented at the meeting. We considered potential new amenities while respecting current uses. We then generated planning scenarios to help the community visualize Lake Marion's possibilities. We drafted one comprehensive plan for Lake Marion and three alternative plans for the smaller ponds area. The Alternatives Chapter presents these plans in greater detail.

FIGURE 2.8 – PLANNING AND DESIGN: BRADLEY VOWELS, ANDREA BACHRACH, SAMANTHA GREENE, MICHELLE BALK AND OTHER WRM STUDENTS USE THE MAPS GENERATED DURING THE MAPPING WORKSHOP TO DISCUSS PLANNING AND MANAGEMENT RECOMMENDATIONS FOR LAKE MARION.

Meeting Three: October 2nd, 2010

We held the third meeting at Lake Marion to interactively showcase our work. For the thirty-four attendees, we demonstrated the work that we had completed over the summer and discussed how we were using our field studies to guide our planning and management recommendations. We set up four study booths to present study results and engage stakeholders in discussions.

Figure 2.9 – Lake Marion Field Day: David Mosher and Michelle Balk explain study results to stakeholders at Lake Marion during the third meeting.

Attendees were interested in the results of the summer studies and made several recommendations for Lake Marion. In addition, the on-site meeting allowed community members, adjacent landowners, and government officials to discuss the option of dam removal in an informal setting. Many voiced concerns about maintaining Lake Marion. The meeting gave us an opportunity to discuss future research and recommendations.

Stakeholders were concerned with our assessment of current ecological conditions at Lake Marion, including the presence of invasive species and high nutrient levels in the water. Several questions and comments focused on how to improve water quality and wildlife habitat around the lake. Stakeholders asked what funding opportunities are available to implement recommendations. Other concerns included:

- Preserving the visual significance of Lake Marion as the origin of Mazomanie
- Preserving the dam structure as a monument of Lake Marion's history
- Combining the two smaller ponds with Lake Marion to restore the original lake configuration
- Constructing a regional trail connector along Lake Marion and the Black Earth Creek corridor
- Providing a feasible alternative water supply for Lake Marion and reducing lake seepage to decrease costs

STAKEHOLDER SURVEY

To assess stakeholders' views of the proposed management alternatives and to further assess stakeholders' interests, we conducted a survey. We sought to identify the various recreational uses of the lake, the perceptions of water quality and wildlife habitat, the support for different management recommendations, and the visual preferences of stakeholders. The survey circulated at the first three meetings and online yielded a combined total of 24 responses. All participants were consenting adults, and their responses remain confidential.

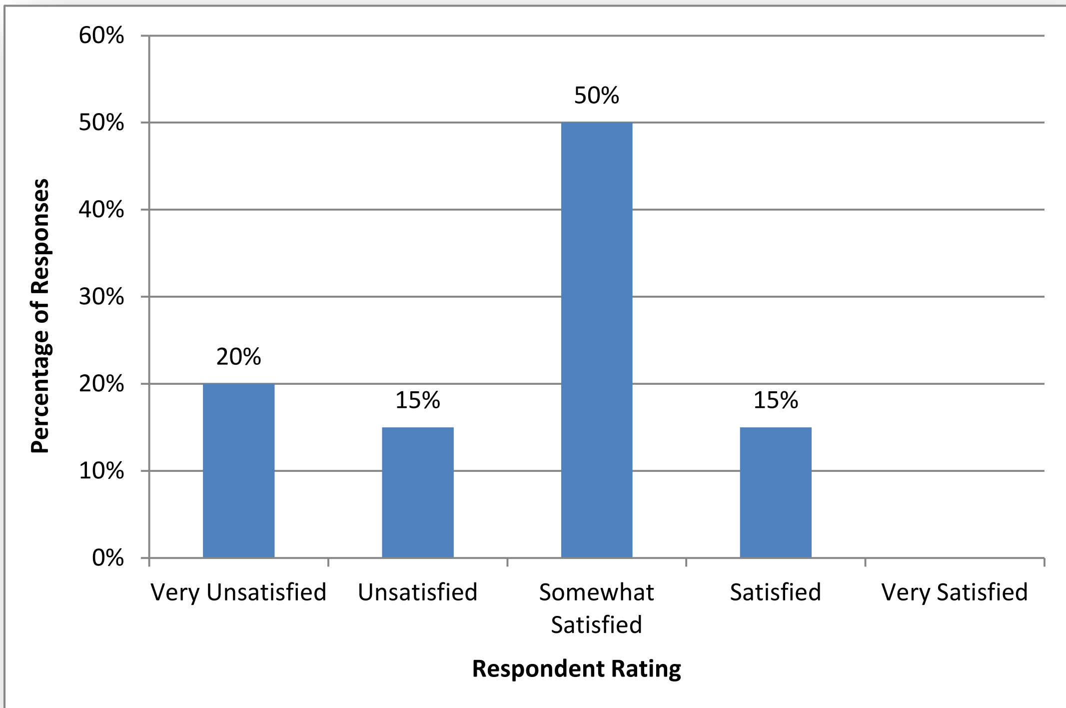

FIGURE 2.10 – QUALITY OF FISHING: REPONSES SHOWED LITTLE SATISFACTION FOR THE CURRENT FISHING CONDITIONS AT LAKE MARION.

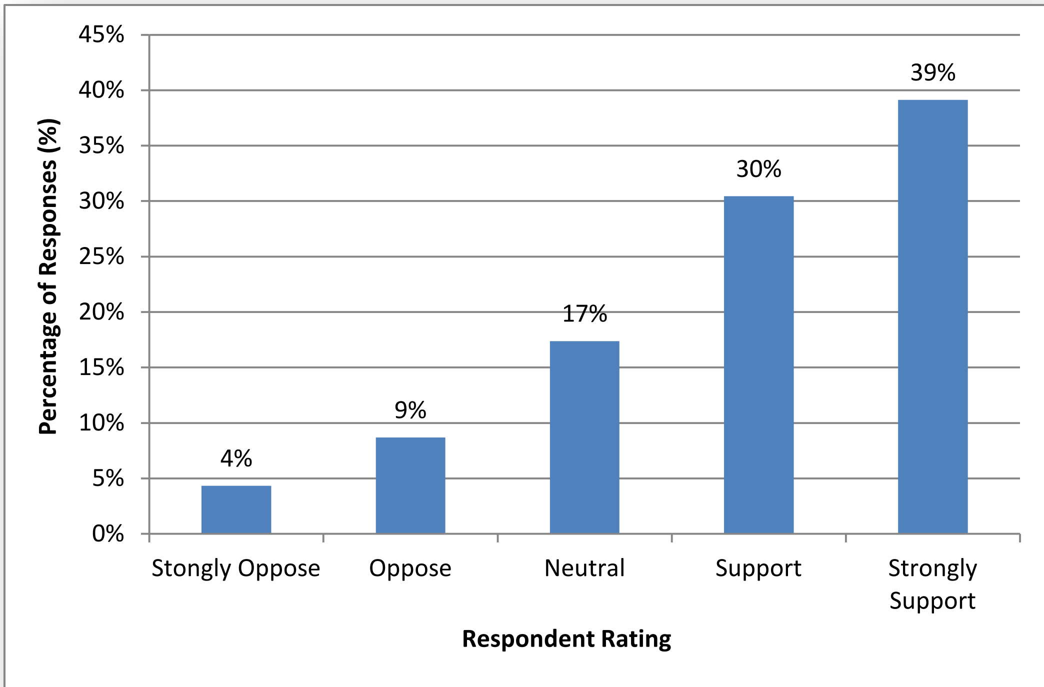

FIGURE 2.11 – GOOSE MANAGEMENT: SURVEY RESPONSES INDICATED A STRONG SUPPORT FOR CONTROLLING THE GOOSE POPULATION AT LAKE MARION.

Survey responses indicated that most Lake Marion visitors come from the Village or Town of Mazomanie. However, people also visit from Black Earth, Cross Plains, Blue Mounds, Arena, Merrimac, and the Town of Vermont. The lake's primary uses were, in order of preference, fishing, walking, relaxation, picnicking, wildlife observation, family gatherings, dog activities, general recreation, and photography. The area was also used for cross country skiing, remote controlled boating, canoeing, club events, ice skating, and the Village of Mazomanie Fire Department drills. Survey respondents mostly visited the lake a few times per year or a few times per month, but some visited weekly or daily. Most of the respondents spent less than half their time or no time at the two smaller ponds. The results of the survey show that Lake Marion, although used mostly by residents of Mazomanie, is a regional resource.

Stakeholders also responded to a series of focused questions about the quality of current conditions at Lake Marion and their support of specific recommendations. Most stakeholders were only "Somewhat Satisfied" with the current conditions at Lake Marion. Respondents favored removing the dam, provided the lake could be sustained; limiting the numbers of geese at the lake; and converting lawn areas to more natural vegetation. Survey respondents were divided on the issue of adding a playground on the lakeshore. They also strongly opposed adding any type of beach or swimming area to Lake Marion.

A section of the survey used photographs to determine the visual preferences of stakeholders. We showed them eight photos, each of a body of water and amenities that could potentially be located at Lake Marion, and asked them what they liked and disliked about each image.

Our analysis of the photo preference survey showed that stakeholders favored natural elements and amenities over a more developed look. Stakeholders often preferred photos showing built features, such as sidewalks and signs, which blended into the surrounding landscape. Responses also indicated that stakeholders disliked more developed elements such as playgrounds, piers, beaches, boating areas, and sidewalks. Stakeholders noted that additional trees and signage would be a "good, natural" addition at Lake Marion. Some preferred natural materials such as gravel, sand, and mulch to concrete or asphalt. Appendix 4 and Appendix 5 show more detailed survey results and photos with participants' corresponding comments.

FIGURE 2.12 – BEACH PHOTO: STAKEHOLDERS LIKED THE MULTIPLE USES FOUND IN THIS PHOTO, BUT DISLIKED THE USE OF LAKE MARION FOR SWIMMING. STAKEHOLDERS ALSO DISLIKED THE 'OVERDEVELOPED' LOOK PRESENT IN THIS PHOTO.

FIGURE 2.13 – TRAIL PHOTO: STAKEHOLDERS LIKED THE NATURAL BUFFER ALONG THE SHORE AND THE INCLUSION OF A TRAIL BUT DISLIKED THE USE OF CONCRETE AND THE ADJACENT RESIDENTIAL DEVELOPMENT IN THIS PHOTO.

MEETING FOUR: DECEMBER 9TH, 2010

We held the fourth meeting at the Mazomanie Community Building to present our final study results and recommendations. Over sixty stakeholders attended. The presentation included an overview of the project and information on habitat and water studies at Lake Marion; community input; park planning; smaller pond scenarios; floodplain restoration; and funding opportunities. A short question and answer session followed the presentation. Questions concerned the management of the goose population, the nutrient load of the creek and each pond, Lake Marion's seepage rate, and an alternative water supply for Lake Marion. There was a lively discussion after the presentation about future steps, funding opportunities, and who would be involved as the project continues.

CONCLUSIONS

Communicating with stakeholders of Lake Marion was essential to this project. Interacting with community members at meetings, field days, and other local events helped us understand what a valuable resource Lake Marion is for Mazomanie. The information we gathered from stakeholders played a crucial role in our development of the project goals and results.

Working with stakeholders, we were able to elicit opinions and preferences from the community to guide our recommendations and management strategies. This allowed stakeholders to have an impact on the planning recommendations that could directly affect them. Cooperation with the stakeholders was necessary to complete project goals such as lake seepage experiments, historical overviews of the lake and fishery, and design scenarios for the park area. The project would not have been meaningful or comprehensive without the support, contributions, and participation of local governmental officials, leaders and members of local organizations, adjacent landowners, and the residents of Mazomanie and other adjacent communities.

CHAPTER 3: WATER SUPPLY AND QUALITY

Lake Marion and its surrounding area provide valuable natural, scenic, and recreational opportunities that are used by the community year-round. In this chapter, we evaluate the current conditions of Lake Marion's hydrologic system. This evaluation will provide a snapshot of the area's physical characteristics and relate these physical characteristics to the biological quality of the area. Based on these findings, we will identify opportunities that could help the stakeholders maintain, improve and enhance Lake Marion.

LAKE MARION WATER SUPPLY

Based on a preliminary water balance for Lake Marion, we established that the lake's water level is determined by the amount of seepage from the lake. This was later confirmed by daily water balance modeling (see Appendix 6). Hence, the seepage rate largely dictates the amount of water that will be required to supply the lake after the dam on Black Earth Creek has been removed. We conducted two kinds of measurements to estimate lake seepage, primarily focusing on Lake Marion. We conducted lake shut-off experiments, which involved blocking surface flows into and out of the lake and neighboring ponds and then monitoring water levels. The isolation of Lake Marion allowed us to measure and to determine the amount of water lost through seepage. We also used seepage meters at various locations around the side and bottom of Lake Marion to make direct measurements of local seepage rates. These measurements helped us identify locations with high rates of seepage.

LAKE SHUT-OFF EXPERIMENTS

Three lake shut-off experiments were conducted. John Wick and Scott Stokes conducted the first two experiments in October 2009 and March 2010 and presented the results to us for analysis and interpretation. These experiments informed the design of our subsequent experiment, which was conducted in September and October 2010. All three experiments were performed by blocking off the inlet from Black Earth Creek, the outlet from Lake Marion, and the culverts between the ponds and Lake Marion (Figure 3.1). In the third lake shut-off experiment, water levels were measured daily at two locations in Lake Marion, a single location in the large pond, and a single location in the small pond. We used these measurements to calculate the daily drop in water level, also known as stage. The detailed methods and results of the lake shut-off experiment can be found in Appendix 7.

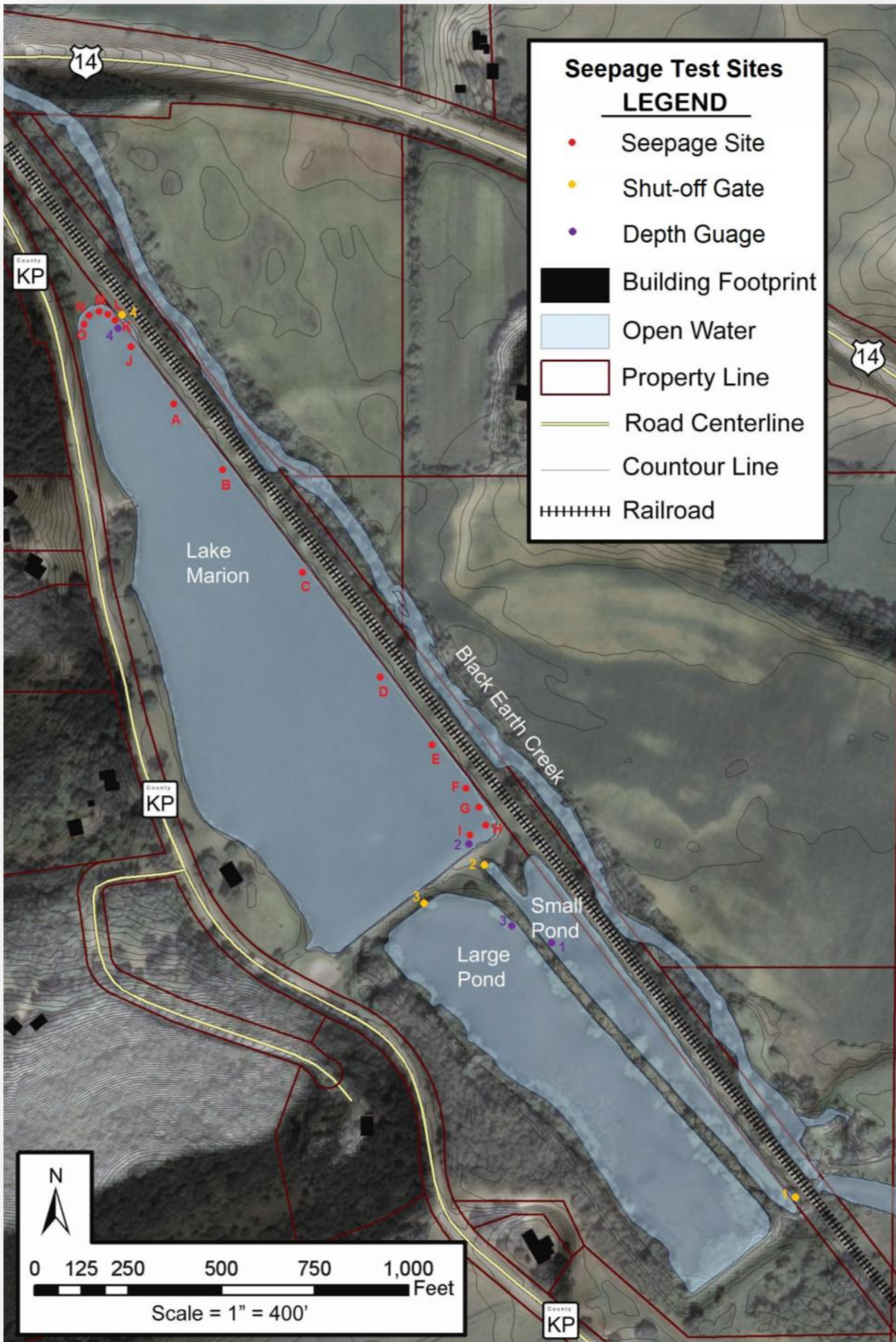

FIGURE 3.1 - LAKE SHUT-OFF AND SEEPAGE METERS SITES: MAP OF THE LOCATION OF LAKE SHUT-OFF GATES, DEPTH GAUGES AND SEEPAGE METERS. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

Seepage Meters

Seepage meters are simple devices that are used to measure the rate of seepage at a specific location on a lakeside or a lake bottom (Figure 3.2). The measurements are used to identify areas with unusually high or low seepage rates. We made 32 seepage measurements during the summer of 2010 (Figure 3.1). Measurements were made both on the side and bottom of Lake Marion. Detailed methods and results of the seepage meters can be found in Appendix 7.

Figure 3.2 - Seepage Meter: David Mosher and Bradley Vowels installing a seepage meter on a lake side of Lake Marion.

Seepage Results and Conclusions

The results of all of the shut-off experiments were consistent. The results of the third experiment are the most precise because the experimental design was based on the prior experiments and covered a significantly longer time period. As seen in Figure 3.3, the Lake Marion seepage rate is a function of stage and decreases significantly as the stage decreases. This decrease is partially due to the decrease in water pressure as the water level falls. However, the primary reason is that there is a greater seepage rate out of the sides of the lake rather than through the bottom. These varying seepage rates could be explained by the different materials composing the lake bottom and the lake sides. The bottom of the lake consists of consolidated lake sediments that overlay dense clay. This dense clay was emplaced in the 1950s to reduce seepage. The sides of the lake are composed of relatively unconsolidated sediment that was dredged from the lake bottom. The results from the seepage meter experiment support these conclusions.

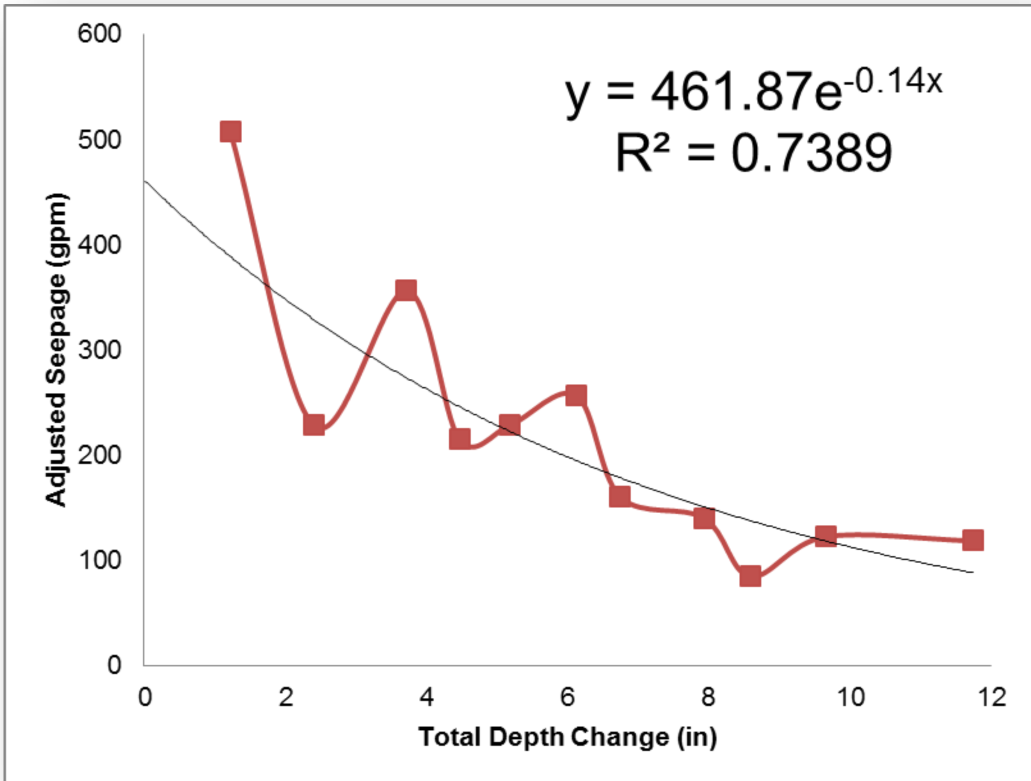

FIGURE 3.3 - LAKE MARION SEEPAGE: GRAPH OF SEEPAGE RATE AS A FUNCTION OF TOTAL WATER LEVEL DEPTH CHANGE FOR LAKE MARION. THERE IS A PRONOUNCED INVERSE RELATION, WITH SEEPAGE RATE SIGNIFICANTLY DECREASING AS THE DEPTH CHANGE (OR LAKE WATER LEVEL DROP) INCREASES.

Seepage from the large pond has a similar trend as seepage from Lake Marion (Figure 3.4); however, there is a more moderate seepage decrease as the water level drops. Even though we do not have information on the soil immediately around the large pond, we speculate that it is similar to the soil surrounding Lake Marion, i.e. consolidated sediments in the pond bottom and dredged unconsolidated sediments in the sides. This would result in greater seepage in the sides of the pond and be consistent with the observed seepage rates.

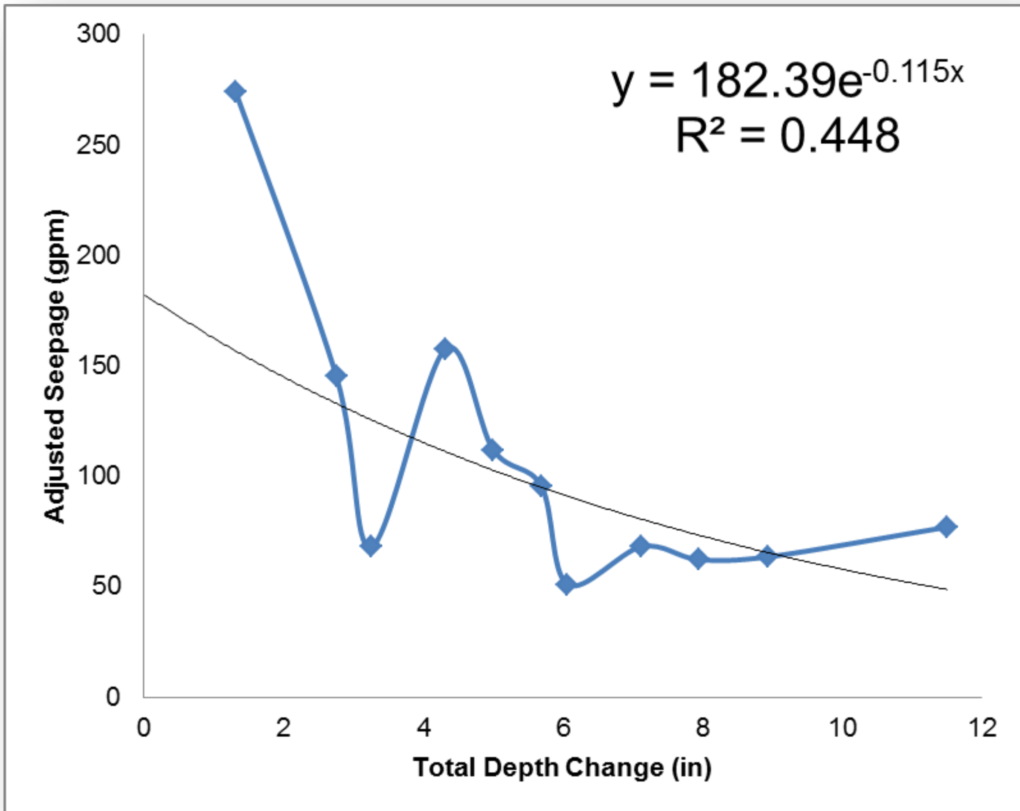

FIGURE 3.4 - LARGE POND SEEPAGE: GRAPH OF SEEPAGE RATE AS A FUNCTION OF TOTAL WATER LEVEL DEPTH CHANGE FOR THE LARGE POND. THERE IS AN INVERSE RELATION, WITH SEEPAGE RATE MODERATELY DECREASING AS THE DEPTH CHANGE (OR LAKE WATER LEVEL DROP) INCREASES.

The water level in Lake Marion is controlled by the weir at the northern corner; boards can be placed in the weir to raise the lake's water level. In the past, Lake Marion has typically been kept at a water level corresponding to two weir boards. Throughout the summer of 2010 Lake Marion was kept higher than normal by placing an additional board (a third board) in the weir. Based on the results shown in Figure 3.3, we computed seepage rates as a function of the number of boards in place. As can be seen from Table 3.1, the seepage rate at 3 boards (High Level) is almost twice the rate at two boards. Hence, seepage from Lake Marion could be decreased by simply keeping the lake level lower. Adding clay and grading the banks could reduce seepage to even lower rates. This is further discussed in Chapter 6, Alternatives and Recommendations.

TABLE 3.1: LAKE MARION SEEPAGE RATES.

Relative Water Level	Number of Boards in Weir	Seepage Rate	
High	3	1.8 in/day	462 gallons/minute
Average	2	0.7 in/day	214 gallons/minute
Low	1	0.3 in/day	99 gallons/minute

ALTERNATE LAKE MARION WATER SUPPLY

Lake Marion is a man-made lake with no natural water source; therefore to compensate for the seepage, an alternative water supply must be determined when the Black Earth Creek dam is removed. Jewell Associates Engineers, Inc. identified three possibilities for an alternative water supply for Lake Marion: (1) divert water through a pipe from an upstream location on Black Earth Creek, (2) pump water from Black Earth Creek at a location close to the lake, or (3) pump groundwater from a nearby well.

Although we did not carefully investigate the Black Earth Creek alternatives, we believe them to be inferior to a groundwater source. U.S. Geological Survey water quality data collected from Black Earth Creek document high concentrations of dissolved and total phosphorus as well as suspended sediment. Use of this water would continue to compromise the water quality of Lake Marion. Furthermore, the required conduit would be very long and would be subject to persistent sedimentation due to the high sediment concentrations in Black Earth Creek. However, in spite of these potential drawbacks, we recommend further investigation of a Black Earth Creek source.

We evaluated groundwater as a future source of water for Lake Marion. Our investigations included a review of information on the hydrogeology of the area, soil coring to determine the surface geology, groundwater level monitoring, groundwater sampling, and water quality analysis.

HYDROGEOLOGY

The hydrogeology of Lake Marion is greatly influenced by the regional glacial history. Lake Marion is situated in the floodplain of Black Earth Creek. This floodplain is composed of thick deposits of sand and gravel that were carried there by glacial meltwater. These deposits form an unconfined alluvial aquifer, which is a region of loose sediment saturated by groundwater. This unconfined aquifer discharges groundwater to Black Earth Creek.

With our assistance, the U.S. Geological Survey used a Geoprobe to install four monitoring wells around Lake Marion (Figure 3.5). The wells were approximately 1-inch in diameter and a maximum of 30 feet deep. During well construction, soil cores were collected and analyzed for texture, moisture and color. Approximately one week after the wells were installed, the water table depth was measured and groundwater samples were taken. Further method details and results can be found in Appendix 8.

FIGURE 3.5 - GEOPROBE DRILLING: JIM RAUMAN AND JASON SMITH OF THE U.S. GEOLOGICAL SURVEY INSTALLING A GROUNDWATER MONITORING WELL NEAR LAKE MARION.

Hydrogeology Results and Conclusions

Lake Marion is set above the water table (Figure 3.6), which corroborates the conclusion that it is a losing lake. Groundwater around Lake Marion flows in a northeastern direction, towards the lowest water table elevations. The soils near the land surface and immediately around Lake Marion are the old dredged sediments from the bottom of the lake. The clay lining beneath Lake Marion is about one foot thick and extends across the majority of the lake. However, the clay lining is absent at the wells adjacent to the outflow weir.

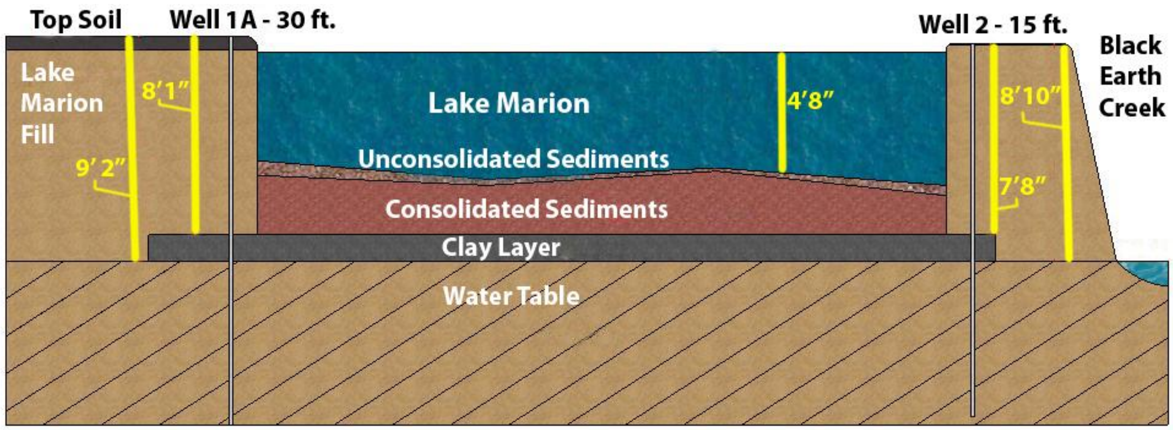

FIGURE 3.6 - HYDROGEOLOGY PROFILE: CROSS-SECTION PROFILE OF THE SOUTHERN PART OF LAKE MARION, CROSSING GROUNDWATER MONITORING WELLS 1A AND 2, BASED ON DATA FROM THE BATHYMETRY STUDY, SEDIMENT SURVEY AND HYDROGEOLOGY STUDY.

Groundwater Quality

To establish the feasibility of groundwater as an alternative water supply, we evaluated its water quality and considered the potential impact the water quality might have on Lake Marion. We tested seven water quality parameters in the monitoring wells installed by the Geoprobe: total dissolved phosphorus (TDP), total phosphorus (TP), dissolved oxygen (DO), iron, phosphates, conductivity, and temperature. Additionally, we took groundwater samples from four private drinking water wells since these wells are deeper than the monitoring wells and provide regional groundwater quality information. We tested the private drinking water wells for TDP, TP, nitrates and DO. The complete groundwater quality results are found in Table 3.2.

Table 3.2 - Groundwater Water Quality Results.

Well ID	Sample Date	Parameter								Well Depth (ft)	Water Table Depth (ft)
		TDP	TP	NO_2+ NO_3	DO	Iron	Phosph.	Cond.	T		
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm*	°F		
Groundwater Monitoring Wells											
Well 1A	08/18/10	-	0.27	-	0.3	1 - 2	0.6 - 0.8	620	61	30	9.0
	10/02/10	0.266	0.271	-	0.2 - 0.3	2.0	0.6 - 0.8	-	-	30	9.8
Well 1B	08/18/10	-	1.01	-	0.05 - 0.1	6 - 7	2.0	761	62	12	8.9
Well 2	08/18/10	-	0.40	-	0.2	0.2	1 - 2	446	79	15	9.5
Well 3A	08/18/10	-	0.21	-	3.0	<0.1	0.6 - 0.8	544	77	15	12.4
Private Drinking Wells											
Well 1	05/20/10	0.48	0.48	8.59	0.4	-	-	-	-	28	-
Well 2	06/24/10	0.02	0.02	0.08	0.6	-	-	-	-	80	-
Well 3	05/20/10	0.02	0.02	4.03	4.0	-	-	-	-	108	-
Well 4	06/24/10	ND	ND	1.27	6.0	-	-	-	-	250	-

*** µS/cm (micro Siemens per cm)**

Phosphorus

There is a tendency for lower TP concentrations with greater well depth. Local samples collected closer to Lake Marion and in shallower depths, such as monitoring well 1B, presented higher TP concentrations. We know that the lake water has high TP concentrations (see the Surface Water Quality Section), and the unconsolidated sediments at the bottom of the lake have very high concentrations of phosphorus (see the Sediment Section). Additionally, there are approximately 8 to 9 feet of old dredged sediments around the lake that have high concentrations of phosphorus. As lake water seeps from the bottom and sides of Lake Marion, it percolates through these phosphorus-rich sediments and collects phosphorus as it flows to the water table. At the deeper wells, such as private drinking wells 3 and 4, TP concentrations significantly decrease. These samples represent the regional groundwater in the area with a significantly lower nutrient load. For more information of the impacts of phosphorus on lake habitat, please see the Surface Water Quality Section below.

Nitrates and Nitrates

In the private drinking wells, the nitrate/nitrate concentration ranged from 0.08 mg/l to 8.59 mg/l, all below the Wisconsin and U.S. Environmental Protection Agency (USEPA) maximum of 10 mg/l for safe drinking water.

DISSOLVED OXYGEN

In general, groundwater tends to have low DO values. In the groundwater monitoring wells, DO ranges from 0.05 mg/l to 3 mg/l. The DO measurements from the drinking wells might be higher than actual groundwater concentrations since the sampled water was potentially aerated as it passed through the drinking well's pumping system. If groundwater were used as an alternative water source, additional considerations to increase DO, such as aeration, would need to be taken for Lake Marion. These options are discussed further in Chapter 6, Alternatives and Recommendations.

In conclusion, the groundwater closer to Lake Marion has a higher concentration of nutrients; however, this nutrient concentration decreases with groundwater depth. Groundwater is recommended for Lake Marion as an alternative water source because the lake currently suffers from excessive phosphorus concentrations (See the Surface Water Quality below). Providing low nutrient water to the lake will help avoid future eutrophic lake conditions and prevent algae blooms. Our data shows that low-nutrient regional groundwater is found at depths greater than 80 ft, a level that is still considered to be in the unconfined alluvial aquifer. However, a more detailed study will be needed to establish the best supply well location and the depth that take into account groundwater quality and cost of construction and pumping.

LAKE MARION'S SURFACE WATER QUALITY

Lake Marion's hydrologic system is comprised of Black Earth Creek, the small pond, the large pond and Lake Marion. The quality of surface water is a major determinant of ecosystem health because it affects the quality of aquatic life that can be supported within a water body. Surface water quality was assessed using a combination of biological, chemical, and visual parameters.

SURFACE WATER QUALITY

All of the water bodies were sampled to assess the surface water quality (Figure 3.7). Water samples were collected throughout the year to account for natural seasonal variation in water quality and quantity. In addition, two stormwater runoff samples were taken to evaluate the nutrients entering Lake Marion from the lake's watershed. Surface water quality was assessed by measuring total phosphorus (TP), total dissolved phosphorus (TDP), total suspended solids (TSS), dissolved oxygen (DO), water transparency, and chlorophyll a (chl a). Samples were collected according to standard procedures and analyzed at the State Lab of Hygiene (SLH). A complete description of water sampling procedures and analysis results can be found in Appendix 9.

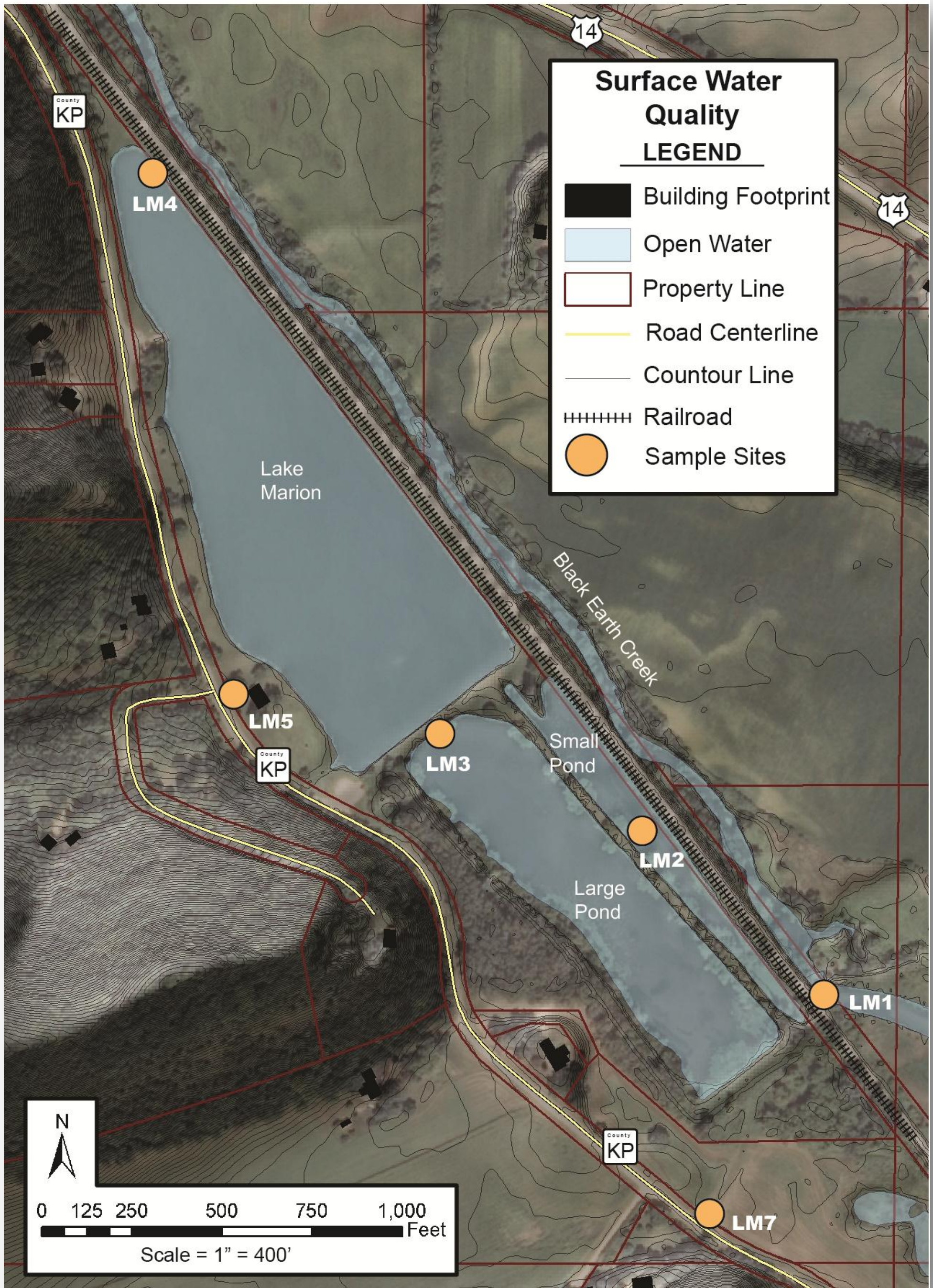

FIGURE 3.7 - SURFACE WATER QUALITY SAMPLING SITES: MAP OF THE SURFACE WATER QUALITY SAMPLING SITES. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

PHOSPHORUS

In aquatic habitats phosphorus is frequently the nutrient needed for growth and survival but is available in limited quantities. Therefore phosphorus is known as a limiting nutrient. While phosphorus is an uncommon element naturally, human sources now contribute excessive phosphorus inputs to aquatic systems. Excessive phosphorus concentrations in a lake are known to spur growth of nuisance algal blooms and excessive amounts of aquatic vegetation.

TP is a measurement of all forms of phosphorus in water, including dissolved (TDP) and particulate phosphorus. According to the WDNR, TP concentrations for Wisconsin lakes and impoundments are on average 0.02 mg/l to 0.03 mg/l and 0.06 to 0.07 mg/l, respectively. To avoid algal blooms, lakes should maintain TP concentrations at or below this range. In order to protect aquatic life, the WDNR Bureau of Watershed Management has set a maximum concentration of 0.04 mg/l of TP for Wisconsin shallow lakes and reservoirs (NR 102.06).

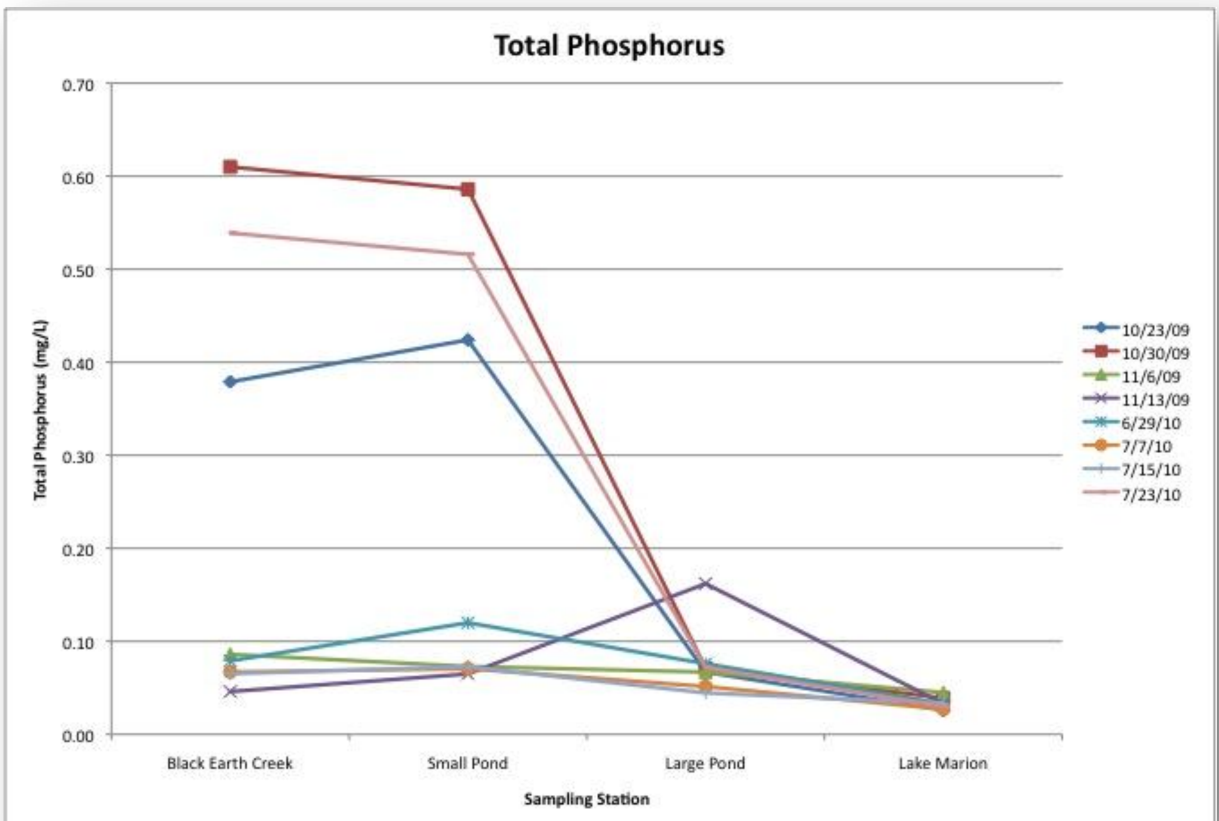

FIGURE 3.8 - TOTAL PHOSPHORUS: TP CONCENTRATION TENDS TO DECREASE AS WATER TRAVELS THROUGH THE SYSTEM FROM BLACK EARTH CREEK TO LAKE MARION.

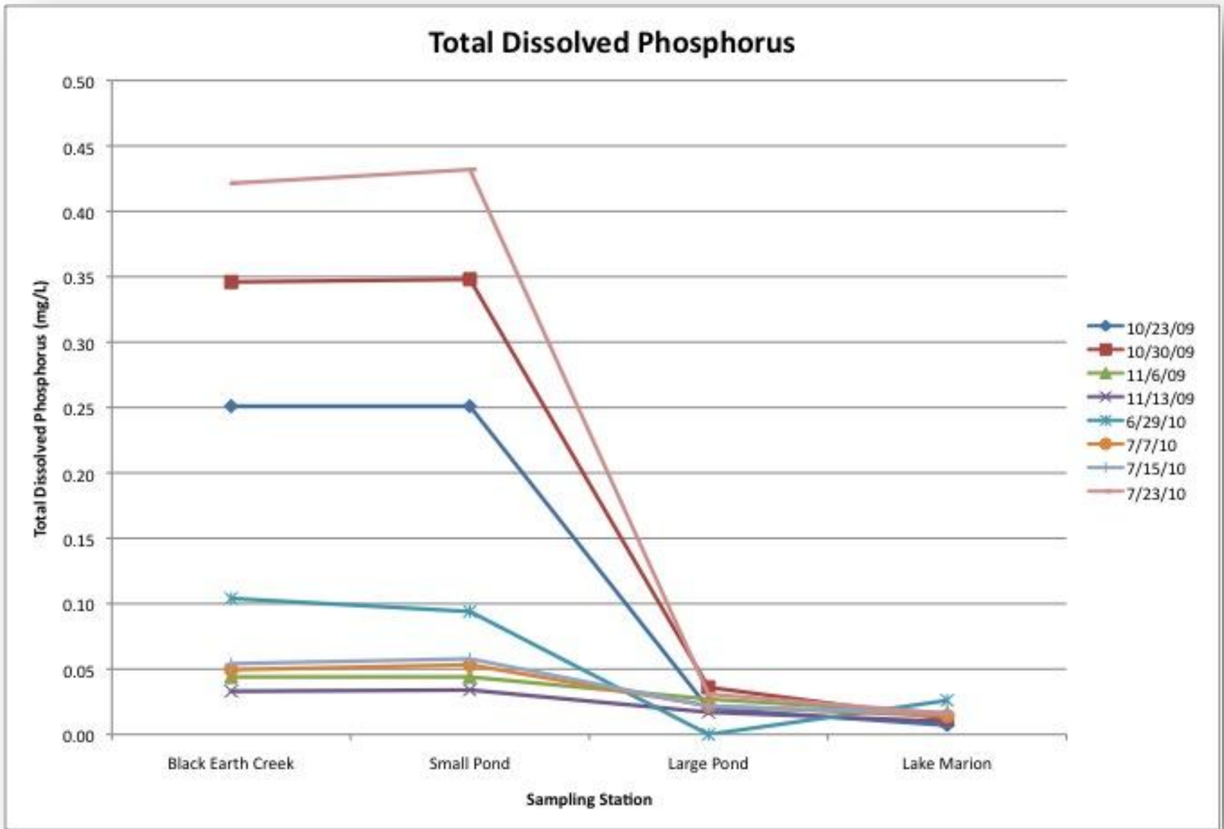

FIGURE 3.9 - TOTAL DISSOLVED PHOSPHORUS: TDP CONCENTRATION TENDS TO DECREASE AS WATER TRAVELS THROUGH THE SYSTEM FROM BLACK EARTH CREEK TO LAKE MARION.

The water sample results showed that the highest values of TP and TDP occurred in Black Earth Creek and the small pond. The lowest concentrations occurred at the outlet of Lake Marion. In general, as water travels through the system from the creek to the outlet of the lake, TP and TDP values tend to decrease. The TP value in Lake Marion averages at 0.033 mg/l, which slightly exceeds what the WDNR has observed as average TP values for Wisconsin lakes (0.02 mg/l to 0.03 mg/l). High nutrient levels allow for higher uptake rates by primary producers and lead to algae blooms and other plant growth. This growth hinders recreational use of the water body and induces anoxic conditions. Anoxia can lead to fish kills in extreme cases, especially in the winter months. Lake Marion TP levels should be maintained at less than 0.03 mg/l to avoid nuisance plant growth.

The stormwater TP and TDP water samples results were higher than the Lake Marion concentrations. However, given the relative size of the watershed to lake ratio, the amount of nutrients from stormwater runoff entering Lake Marion is relatively low. The major contributing factor to high nutrient levels is the agricultural runoff entering Black Earth Creek, which then feeds the ponds and Lake Marion. Other factors, such as goose droppings, could be a large source of phosphorus for Lake Marion. Integrated management practices would work to minimize the level of phosphorus entering Lake Marion. This would include minimizing storm water runoff, controlling the goose population, and reducing phosphorus from the water source that feeds the ponds and Lake Marion.

WATER CLARITY

TSS is a measurement of turbidity. High TSS concentrations indicate poor water clarity, affect benthic plant growth, and impair fish habitat because less light reaches the bottom of the lake. In general, reservoirs and impoundments have poorer water clarity than natural lakes.

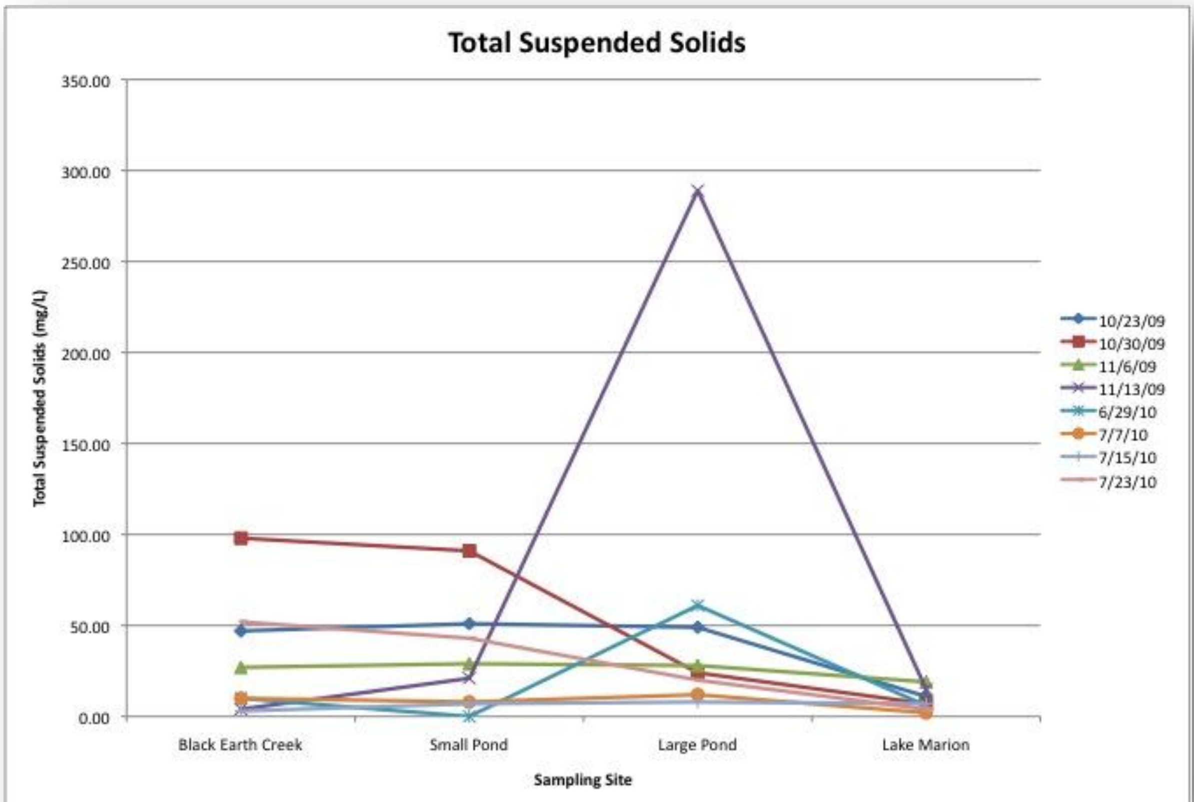

FIGURE 3.10 - TOTAL SUSPENDED SOLIDS: LAKE MARION PRESENTS THE LOWEST VALUES OF TSS, INDICATING BETTER WATER CLARITY.

The water samples did not show a significant trend in TSS concentrations as water traveled from Black Earth Creek to Lake Marion. However, Lake Marion presented the smallest range of TSS concentrations, which suggests that water clarity is better in Lake Marion compared to the other three water bodies. Currently, the ponds act as a retention system allowing sediment to settle out of the water column before traveling to the next water body. Additionally, carp activity in combination with size and shallow water depth increases the turbidity of the two ponds.

DISSOLVED OXYGEN

Within an aquatic system, DO fluctuates in response to changes in photosynthetic and respiratory activities of aquatic life, depth changes, and air-water interface. Photosynthetic and photorespiration activity change the concentration of DO within a lake on a 24-hour basis. In addition, DO tends to be higher at or near the surface of the lake, due to the proximity of the air-water interface, and decreases with depth. In general, 5 mg/l DO or less is stressful to aquatic vertebrates and most other aquatic life (WDNR). In some extreme cases, little to no DO, otherwise known as anoxia, can result in fish kills.

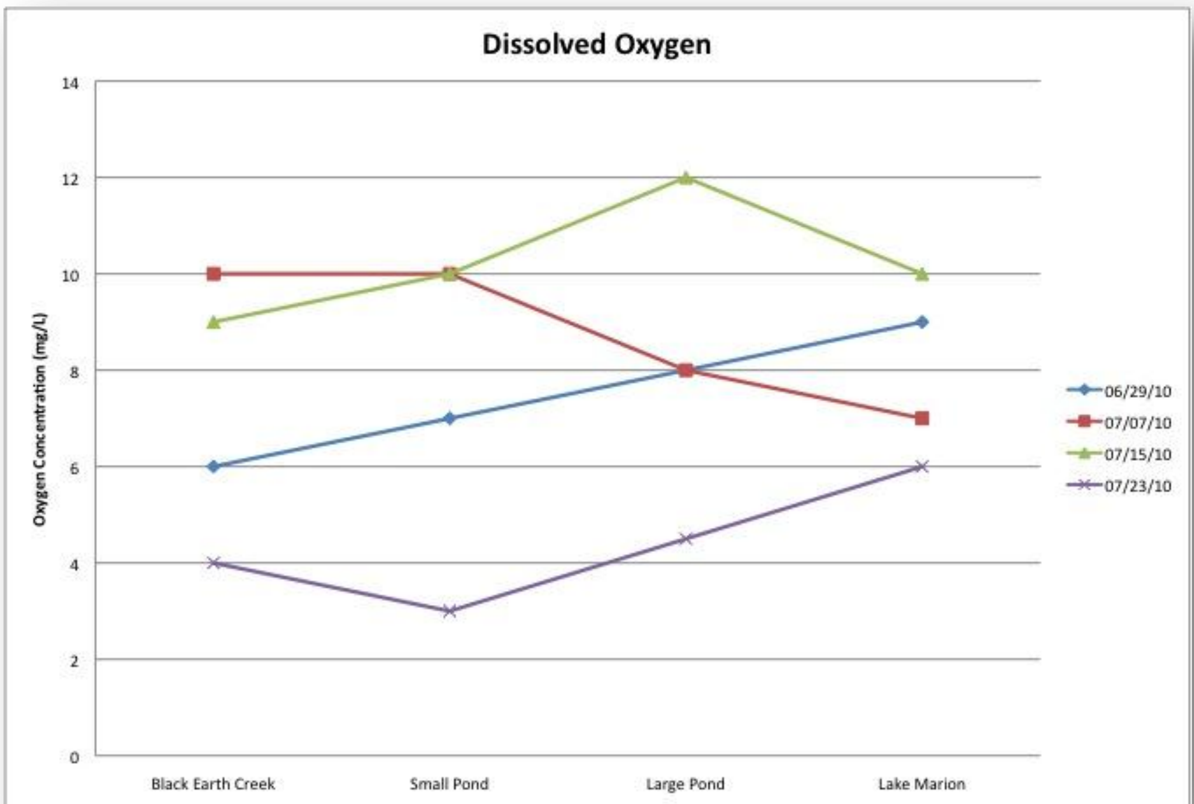

FIGURE 3.11 - DISSOLVED OXYGEN: DO LEVELS FLUCTUATE BETWEEN 6 MG/L AND 10 MG/L IN LAKE MARION.

Throughout the summer, there was a wide range of DO levels. The lowest reading for Lake Marion occurred in the early morning and showed levels dropping to as low as 3.5 mg/l. This level is below the recommended threshold for aquatic life. The readings collected indicate that DO can fluctuate up to 7 mg/l within a 24-hour period.

Trophic State Indices

The Trophic State Index (TSI), created by Carlson (1977), is used to classify the trophic state of a lake. The Index estimates the biological condition of a water body by analyzing chlorophyll *a* concentrations, water clarity, and/or TP concentrations. The Lake Marion TSI was calculated based on the TP concentrations. Three general trophic classifications define the overall productivity of a lake. An oligotrophic lake is low in nutrient availability, which results in low productivity. A mesotrophic lake has intermediate levels of productivity, nutrients, and plant growth; these lakes are commonly very productive fisheries. A eutrophic lake has high productivity, due to excessive nutrient levels, which results in algae blooms and reduced water quality. In cases of extremely low or high productivity, lakes are classified as dystrophic or hypereutrophic, respectively.

The Water Quality Index (WQI) of Wisconsin Lakes (Lillie & Mason, 1983) was used to determine the water quality of the water bodies relative to other Wisconsin lakes. The WQI ranks water bodies from very poor to excellent depending on TP concentration. Specific equations and classification descriptions of these indices can be found in Appendix 10.

TSI classifies Lake Marion as a eutrophic water body. TSI incidences of hypereutrophy were most prominent in the small pond (4 of 8 samples) compared to the large pond (1 of 8). In general, TSI improved as water moved through the system. According to WQI, Lake Marion generally ranked as having “good” water quality. The large pond ranked from “very poor” to “fair”. The small pond was ranked from “very poor” to “poor”. According to the WQI and TSI, Lake Marion is in better biological condition than the ponds. The ponds are considered hypereutrophic due to a combination of high phosphorus concentrations, low DO levels, and high turbidity.

Sediment, particles, and associated phosphorus molecules settle out as water travels through the system. An alternative water supply for Lake Marion should have desirable water quality with low levels of TP and TDP. The water quality of the new supply is especially important since the ponds will no longer act as a filter for Lake Marion.

Lake Marion Sediment

A lake’s water quality depends on the condition of the surface water and the amount and quality of sediment at the bottom of the lake. Lake sediments trap nutrients, which can be released back into the water column. Excessive phosphorus released from lake sediments have the potential to support excessive algae growth, even when surface water entering the lake is low in phosphorus. Over the years, sediment from Black Earth Creek's inflow has accumulated on the bottom of Lake Marion. This sediment is high in phosphorus due to the agricultural land-use practices in the watershed. While some of the sediment has been compressed into a consolidated layer, the top portion remains loose and unconsolidated. We conducted a sediment study both to determine the depth and amount of unconsolidated sediment at the bottom of Lake Marion and the large pond and to determine the sediment phosphorus concentration.

We created a 50 m by 50 m sampling grid for Lake Marion and a 30 m by 60 m sampling grid for the large pond to measure water depth and depth of unconsolidated sediment (Figure 3.12). Measurements were taken using a sediment sampling rod. In addition, this rod was used to collect sediment samples in a few representative locations in both water bodies. The sediment samples were sent to the State Hygiene Lab for analysis of the total phosphorus content. More information on the methods and results can be found in Appendix 11.

Results and Conclusions

We determined the deepest point in Lake Marion to be 6.5 ft. It is just south east of the outlet. The deepest point in the large pond is 3.3 feet and is located in the northern corner closest to Lake Marion and the small pond (Figure 3.13). We calculated the total volume of unconsolidated sediment to be approximately 14,300 cubic yards in Lake Marion and 8,500 cubic yards in the large pond. From the sediment samples, the average TP concentration of the sediment in Lake Marion is 593 mg/kg. The average TP concentration of the sediment in the large pond is 573 mg/kg (Table 3.3).

Table 3.3 - Sediment Phosphorus Concentration.

Sample Site	P (mg/kg)
Lake Marion	
H	580
EE	617
BB	526
AA	559
V	532
A	745
Average	593
Large Pond	
B	576
H	560
Q	582
Average	573

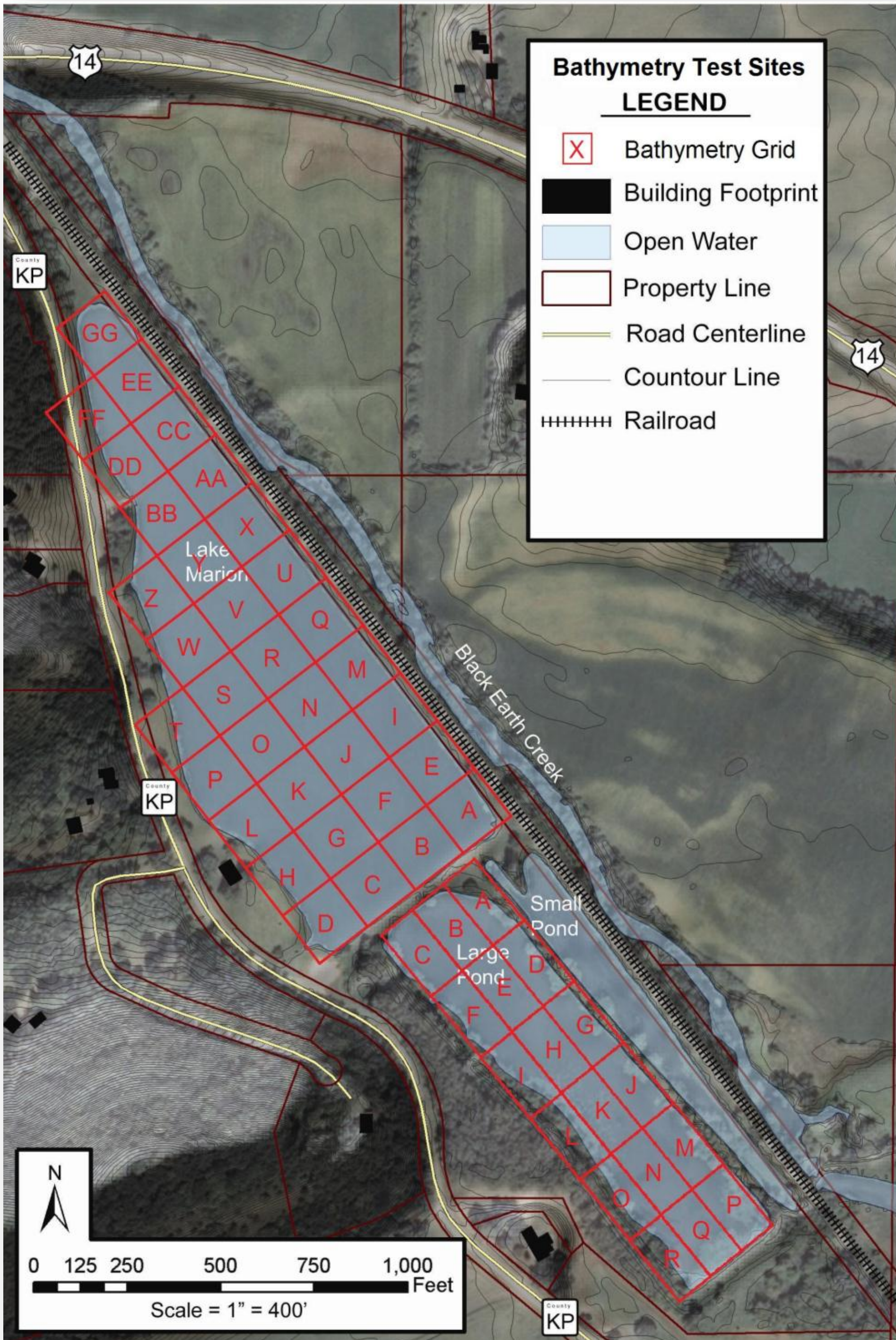

FIGURE 3.12 - SAMPLING GRID: MAP OF BATHYMETRY AND SEDIMENT SAMPLING GRID FOR LAKE MARION AND THE LARGE POND. RED LINES INDICATE DEPTH IN FEET. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

FIGURE 3.13 - BATHYMETRY MAP: LAKE MARION IS SHALLOWER IN THE SOUTH AND DEEPER IN THE NORTH. SOURCE: DANE COUNTY. AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

The bathymetry measures for Lake Marion and the large pond indicate that the current water depth profile for these water bodies is relatively shallow. Based on personal conversation, the depth of Lake Marion may have been about 10 feet when it was last dredged in the 1980s. Shallow lakes are susceptible to changes in environmental conditions and human impacts such as excessive plant growth, algae blooms and small stunted fish.

Sediment sampling indicated high phosphorus concentrations in Lake Marion and the large pond. This means that sediments are an important internal source of phosphorus to the system. As water moves through the system, sediment settles out of the water column. Since heavier sediment settles out first, when water reaches Lake Marion mainly fine clay like sediment is deposited. This fine sediment, which has the capacity to hold more phosphorus than larger coarse sediment, accounts for the higher phosphorus concentrations in Lake Marion.

Removing the unconsolidated sediments from Lake Marion will deepen the lake, remove the nutrient rich sediments, and help improve water quality by reducing the internal phosphorus loading. This will in turn improve Lake Marion as a fish habitat and enhance it as a biological and recreational resource.

CHAPTER 4: ECOLOGICAL EVALUATION

Lake Marion offers natural beauty and recreational opportunities; the community greatly values this local natural resource. Recognizing the importance of the area, we studied the ecological features of Lake Marion and the surrounding park to gain baseline data. We used the results of these studies to evaluate the ecosystem and identify areas where habitat improvements could benefit Lake Marion, local wildlife and park visitors.

We observed Lake Marion and the surrounding park throughout the 2010 growing season. We completed field work on both the aquatic and terrestrial habitat, which included documenting and mapping Lake Marion's aquatic vegetation and sampling and analyzing macroinvertebrates to understand the habitat quality throughout the Lake Marion system. We also reviewed the lake's fishery to detail the historical and current conditions. In the terrestrial habitat, we developed a species list to document both the native and invasive vegetation.

The data collected outlines the major ecological characteristics in the Lake Marion area. Combining the ecological data with the data previously discussed in the Water Supply and Quality chapter provides a more complete understanding of how the Lake Marion system functions. The Management Alternatives section, later in the report, suggests management opportunities and habitat improvement methods.

AQUATIC PLANTS

A vital region for life in all freshwater lakes is the zone near the shore, called the littoral zone (Figure 4.1). The littoral zone is the shallow region of a lake that houses most aquatic life because sunlight reaches the bottom and allows aquatic vegetation to grow. Native vegetation is a critical component to a healthy littoral ecosystem. Without vegetation, most of the habitat required for aquatic life disappears, and so do the organisms.

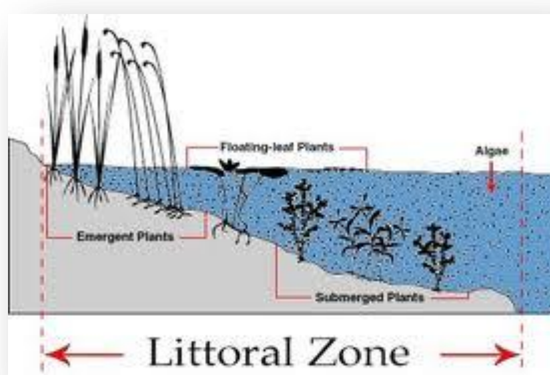

FIGURE 4.1 – CROSS SECTION OF A LAKE'S LITTORAL ZONE. SOURCE: HTTP://WWW.OCOEE.ORG/DEPARTMENTS/PR/IMAGES/LITTORAL_ZONE.JPG

There are several categories of aquatic plants, each serving a particular purpose within a lake (Figure 4.2).

Emergent plants are usually associated with the shallowest portion of the littoral zone. Examples of emergent plants include cattails, bulrushes, and irises. They tolerate fluctuating water levels and typically root along the edge of a lake. They provide erosion protection for the shoreline by reducing wave action, and the roots of these plants spread horizontally, creating a woven barrier that minimizes the re-suspension of sediments. These species are the least tolerant to habitat disturbances such as shoreline development.

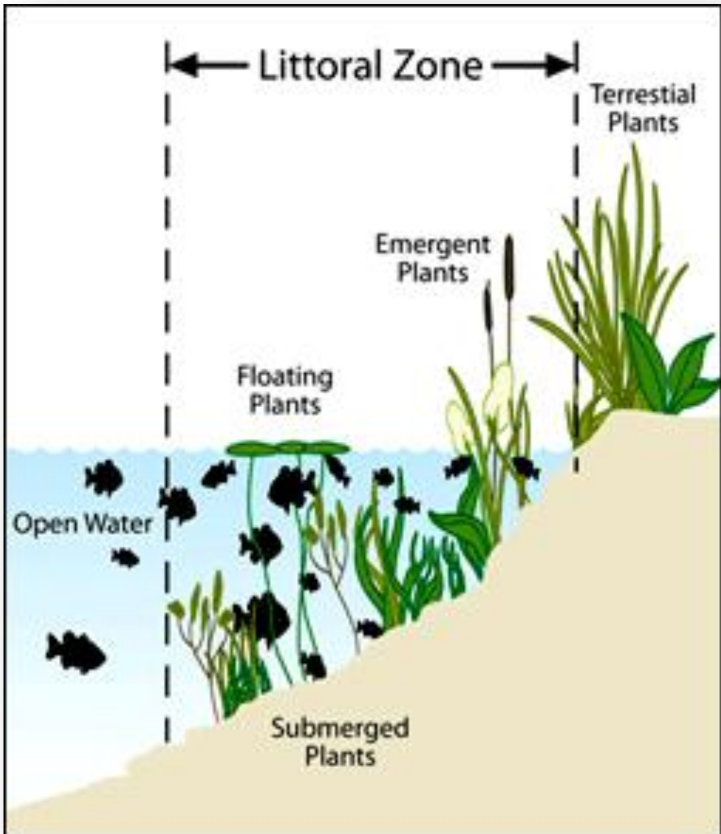

FIGURE 4.2 –DISTRIBUTION OF DIFFERENT AQUATIC PLANTS ACROSS THE LITTORAL ZONE. SOURCE: HTTP://WWW.THEPONDLADY.COM/BIOLOGICAL/PLANTS.HTML

FIGURE 4.3 EXAMPLE OF A HEALTHY AND DIVERSE SHORELINE WITH EMERGENT VEGETATION.

Floating leaf plants gradually replace emergent plants as water depth increases further from shore. Common floating leaf plants include white and yellow pond lilies, American lotus, and pickerel weed. The leaves of these plants are circular in shape and leathery in texture to resist tearing in the wind. This resistance to tearing makes these plants good at dissipating wave energy. Certain floating leaf plants, such as duckweed and some bladderworts, are free floating plants. This means that they are not rooted within the lakebed and can be transported to other portions of a lake. Free floating plants are an important food resource to waterfowl particularly dabbling ducks, mallards, and black ducks.

FIGURES 4.4 AND 4.5 - EXAMPLES OF FLOATING LEAF AQUATIC VEGETATION. *NELUMBO LUTEA*, AMERICAN LOTUS LILY AND *NYMPHAEA ODORATA*, AMERICAN WHITE WATER LILY. SOURCE: HTTP://WWW.CT-BOTANICAL-SOCIETY.ORG/GALLERIES/NYMPHAEAODOR.HTML

FIGURE 4.6 – SUBMERSED VEGETATION PROVIDES HABITAT FOR MANY FISH SPECIES.

The final category of plants is submersed aquatic plants. Examples include pondweeds, coontail, milfoil and *Elodea*. These plants are typically found in deeper water beyond the littoral zone. The leaves of these plants are thin and highly divided. This trait increases the surface area-to-volume ratio allowing these plants to live in areas of the lake that receive less light. These plants are important to small fish because they provide coverage and places to hide.

BENEFITS OF AQUATIC PLANTS

Today, it is common for many lake users to consider the presence of aquatic plants a recreational nuisance and aesthetically displeasing. However, aquatic plants are an integral component of a healthy lake. Without the presence of aquatic plants, many functions of a lake's ecosystem would be impaired or eliminated. The benefits provided by aquatic plants include:

- Acting as a source of oxygen for all organisms.
- Creating critical habitat, refuge, and nursery for fish and other animals.
- Preventing shoreline erosion by buffering wave action.
- Limiting the re-suspension of bottom sediment by locking sediments within their root masses.
- Reducing the release of nutrients from bottom sediments.
- Minimizing nuisance algal blooms by using nutrients in the lake that may otherwise be used by phytoplankton.

In addition to these physical benefits, aquatic plants provide important habitat for macroinvertebrates, fish communities, waterfowl, and mammals.

Benefits to Macroinvertebrates

Macroinvertebrates are organisms that do not contain a backbone. They live in a wide variety of aquatic habitats. Many macroinvertebrates depend on aquatic plants for life cycle stages and for food and shelter. For example, macroinvertebrates such as filter feeders attach themselves to aquatic plant leaves and take their food from the surrounding water. Snails and midges graze upon algae and diatoms that are attached to aquatic plant leaves. Other macroinvertebrates such as crayfish eat the leaves of aquatic plants directly.

Benefits to Fish Communities

Aquatic plants provide habitat and refuge for both young and adult fish. Certain fish species eat insects attached to aquatic plants, and aquatic plants in shallow areas of a lake are an important element of spawning grounds. For example, bluegills generally clear an area adjacent to a plant bed for their nesting sites. The plant bed acts as a buffer against strong wave action and this increases the likelihood of nesting success. Northern pike also require shallow vegetated areas for spawning and to provide shelter for young northern pike.

Benefits to Waterfowl and Mammals

Aquatic plants provide protection, shelter, and nesting material for a variety of birds and mammals. Migratory species, in particular waterfowl, rely on the carbohydrate-rich food in aquatic plants to refuel on their migration route. Many shorebirds wade in shallow vegetated areas while searching for small fish. Mammals and amphibians also rely on aquatic vegetation for shelter and food. For instance, muskrats use cattails to build their homes, and whitetail deer eat the tubers of white and yellow pond lilies.

Invasive Aquatic Plants

An invasive species is defined as a non-native species that is introduced into a new habitat and is able to excessively reproduce, thus upsetting the balance of the ecosystem it invades. Invasives can have detrimental impacts on ecological, economic, and social functions. In aquatic environments, invasive species often provide low value habitat for both fish and wildlife. Excessive plant growth in dense stands can disrupt the balance of the ecosystem by out-competing native plants and reducing their diversity and it can also limit human recreation and navigation on the water body. Aquatic invasive species have harmful and long-lasting effects on many Wisconsin lakes.

FIGURE 4.7 - *POTAMOGETON CRIPUS*, CURLY LEAF PONDWEED. SOURCE: HTTP://PONDSRX.COM/SUBMERGEDWEEDS.ASPX

CURLY LEAF PONDWEED

Curly leaf pondweed (*Potamogeton cripus*) is one of the most common invasive plants in Wisconsin waters. Curly leaf pondweed is a submersed aquatic plant that can easily be distinguished by its alternating, wavy, lasagna-like leaves. One plant can grow over 4 meters long and, leaves are normally ½ to 3 inches long. The leaves are dark green and at times may have a reddish hue.

Curly leaf pondweed can be found in almost any type of water body including lakes, rivers, and wetlands. It is a coldwater species and adapts easily to low light, allowing it to live in deep and turbid waters. It prefers high nutrient systems and feeds on phosphorus from the sediment and nitrogen and potassium from the water column. Curly leaf pondweed tolerates disturbance and low water quality; moreover, it is able to thrive in a range of sediments and even in polluted habitats.

Curly leaf pondweed differs from many other aquatic plants because it begins its life cycle in the winter and grows under the ice. Warming waters in early spring stimulate increased foliage growth and production of flowers and fruit. After peak growth in the spring, the plant will produce hearty buds called turions and then die back. The turions remain dormant until late fall when cool water causes germination of the winter foliage. This turion growth accounts for the majority of curly leaf pondweed reproduction; while curly leaf pondweed does produce seeds, germination occurs at a low rate and does not play an important role in reproduction.

FIGURE 4.8 - CURLY LEAF PONDWEED TURION. SOURCE: HTTP://WWW.INVASIVE.ORG/WEEDCD/SPECIES/6219.HTM

Curly leaf pondweed spreads through several methods. Natural dispersal of turions is most commonly aided by waterfowl. Human transportation, recreation, shipping, and horticultural activities also play a significant role in dispersal. Dispersal distances can be short, such as the distance between regional water bodies, or long, such as the distance traveled on migratory routes. Some populations of curly leaf pondweed were intentionally planted to increase waterfowl and wildlife habitat.

Aquatic Plant Survey

The aquatic plant sampling protocol we used on Lake Marion followed the Wisconsin Department of Natural Resources (WDNR) protocols outlined in "Recommended Baseline Monitoring of Aquatic Plants of Wisconsin, 2010" (WDNR, 2010). This protocol was repeated twice: once to survey native aquatic plants, and again to survey curly leaf pondweed. The WDNR created a grid of sampling points and overlaid it onto Lake Marion. We uploaded the sampling points onto a GPS unit that we used to navigate to each point during the survey. We sampled 288 points. With a double-headed rake attached to an 8' pole, we collected plant samples at each point. We recorded water depth, sediment type, individual plant species, and species density.

Figure 4.9 – Andrea Bachrach identifying aquatic plants on a rake sample.

Results and Discussion

The maximum depth of Lake Marion during the plant survey was 6.9 feet, and the minimum depth was 1.5 feet (Figure 4.10). The height set by the control structure at the northern end of Lake Marion will determine the maximum and minimum depth of Lake Marion. To account for this fluctuation, we took a stage reading at the northern corner of the control structure. The reading from the top of the control structure to the top of the water was 2 feet 2 inches.

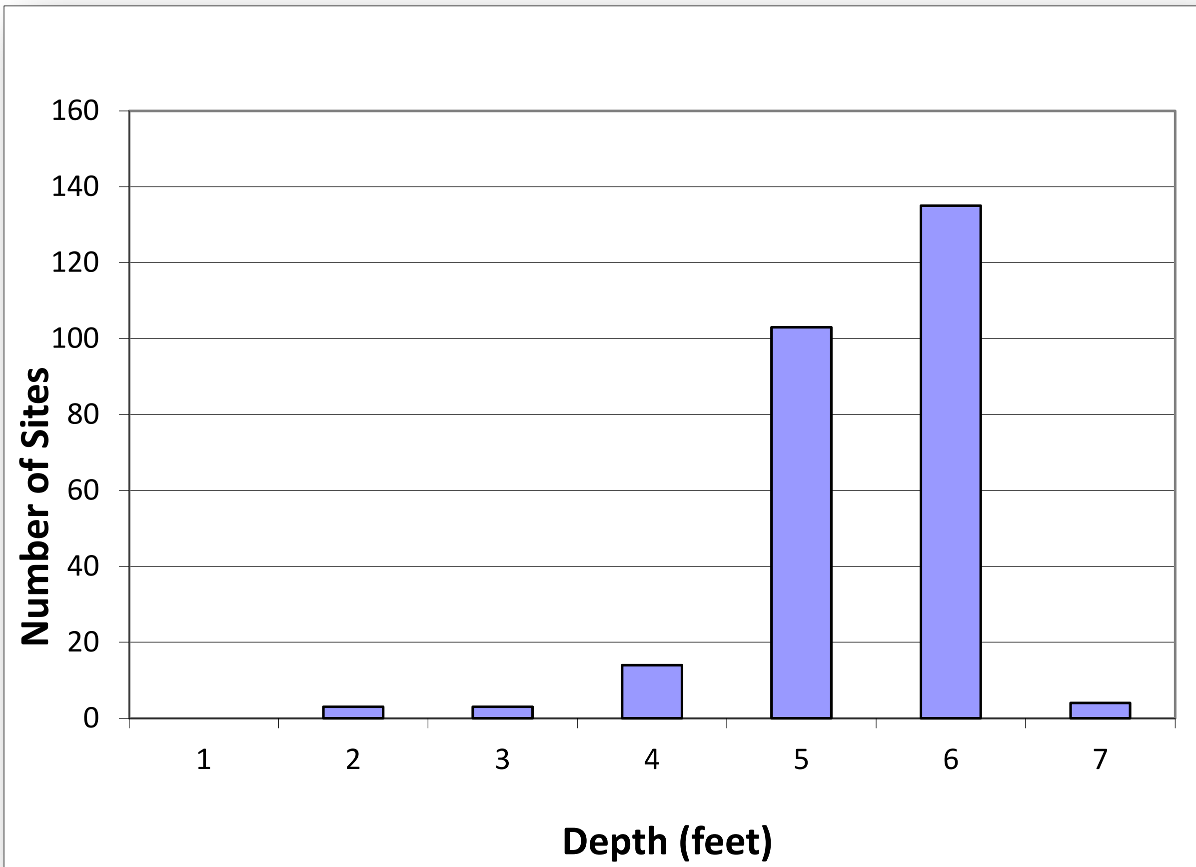

Figure 4.10 - Aquatic plant colonization based on depth on Lake Marion.

We determined that the predominant sediment type in Lake Marion is muck. There are a few areas of sand and rock located primarily along the edges of the lake and near the exposed concrete island at the southern end of the lake.

TABLE 4.1 - SUMMARY OF AQUATIC PLANT DATA.

Average depth	5.22 ft.
Number of sites with muck bottom	267
Number of sites with sand bottom	12
Number of sites with rock bottom	9
Total number of sites visited	288
Total number of sites with vegetation	262
Total number of sites without vegetation	26
Total number of sites with Curly-leaf pondweed	48
Percent of sites containing filamentous algae	48
Total number of sites shallower than maximum depth of plants	288
Frequency of occurrence	90.97
Maximum depth of plants (ft)	6.50
Average number of all species per site having vegetation	1.97
Average number of native species per all sites	1.62
Average number of native species per site having vegetation	1.80
Species Richness (native vegetation only)	6
Species Richness (including visuals)	9

Native Aquatic Plants

Of the 288 sampling points, 262 had vegetation. We recorded an average of 1.62 plant species at each sampling point and a total of 7 species. Six of these species are native to Wisconsin. The one non-native species, *Potamogeton crispus,* is an invasive that specializes in growing in cool water (Table 4.2).

TABLE 4.2 - PLANT SPECIES PRESENT IN LAKE MARION.

Scientific Name	Common Name	Coefficient of Conservatism
Potamogeton crispus	Curly-leaf pondweed	0
Elodea canadensis	Common waterweed	3
Najas flexilis	Slender naiad	6
Potamogeton pusillus	Small pondweed	7
Ranunculus aquatilis	White water crowfoot	8
Sagittaria latifolia	Common arrowhead	3
Stuckenia pectinata	Sago pondweed	3
Heteranthera dubia	Water star-grass	6

The majority of aquatic plants in Lake Marion tolerate disturbance and are very common throughout the state of Wisconsin. Small pondweed *(Potamogeton pusilus*), water star-grass (*Heteranthera dubia),* and common waterweed (*Elodea canadensis*) are the three most abundant species found across all sampling points in Lake Marion, making up 70%, 28%, and 26%, respectively.

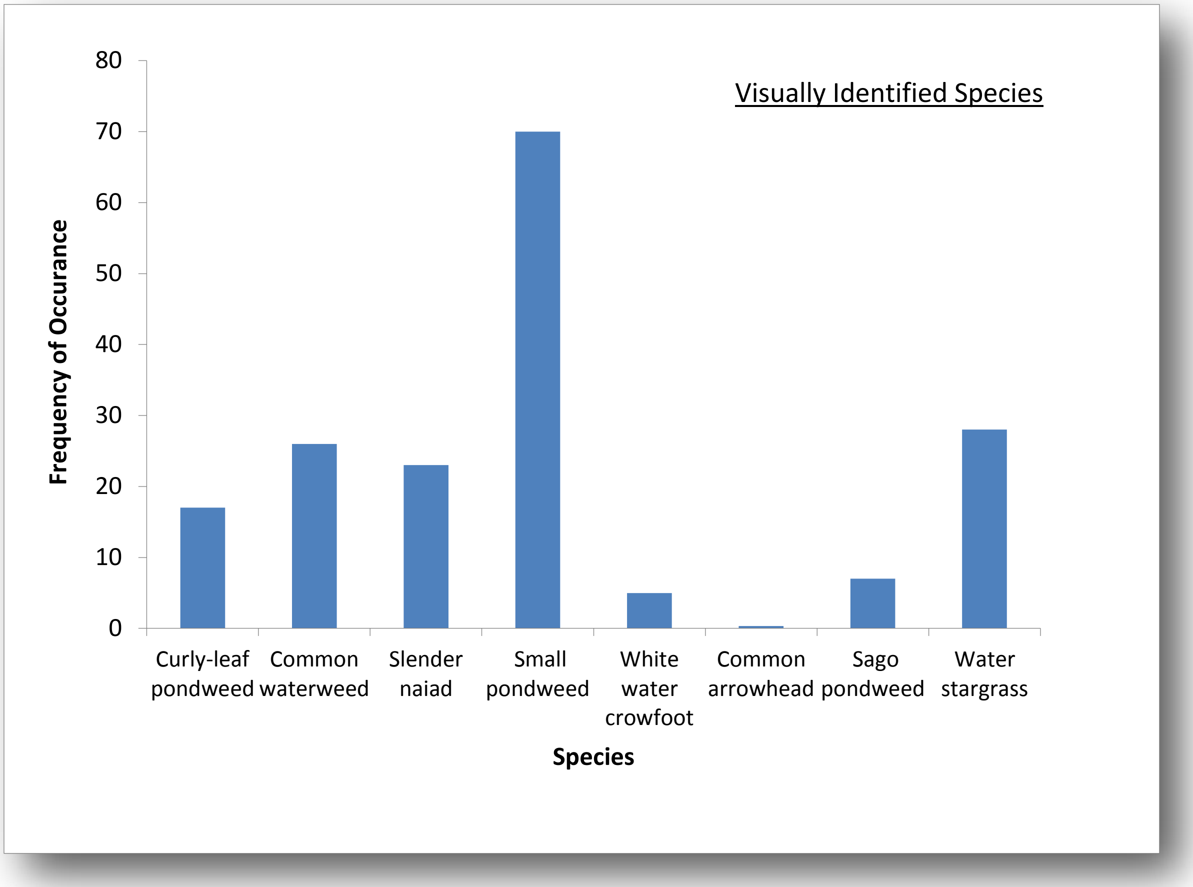

FIGURE 4.11 - FREQUENCY OF PLANT SPECIES IN LAKE MARION.

Small pondweed can grow in depths up to 8.5 feet and is turbidity tolerant (Nichols, 1999). It is most abundant in Lake Marion between 5 to 6 feet of water. Water star-grass can grow in depths up to 10 feet, shows no substrate preference, and is turbidity tolerant (Nichols, 1999). It is most abundant in Lake Marion between 4 to 6 feet of water. Common waterweed, the second most commonly occurring plant in Wisconsin lakes, second to coontail (*Ceratophyllum demersum),* is typically found in depths up to 12.5 feet. Common waterweed prefers a soft substrate and is turbidity tolerant (Nichols, 1999). It is most abundant in Lake Marion between 3.5 to 5.5 feet of water.

A Floristic Quality Assessment (FQA) is a tool used to assess the similarity of a lake's aquatic plant community to that of relatively undisturbed systems. This assessment uses species richness and the average species coefficient of conservatism. Species richness is the total number of species found within a lake. The species richness of Lake Marion is 7. Coefficient of conservatism is a numerical designation from 1 to 10 that is assigned to each plant. A conservatism ranking of 10 indicates that the plant is typically only found in undisturbed or pristine systems and does not tolerate environmental disturbance. A conservatism ranking of 1 indicates that the plant tolerates disturbance and shows little habitat preference. A conservatism ranking of 0 indicates that the plant does not belong in the natural system and is considered either noxious or invasive. The average of the coefficients of conservatism for Lake Marion's 7 plants is 5.14 (Figure 4.12).

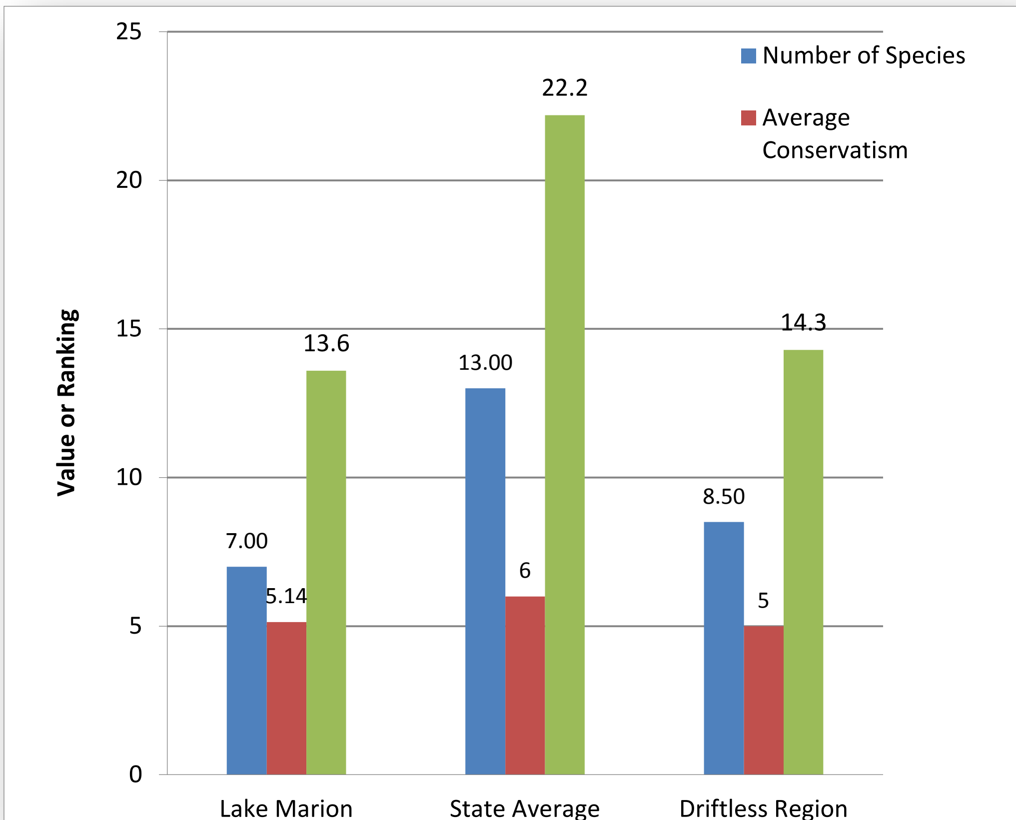

FIGURE 4.12 – AQUATIC PLANT DIVERSITY OF LAKE MARION.

Floristic quality comparisons across lakes are done by region. Lake Marion is located within the Driftless Region of Wisconsin, so floristic statistics from this region were used to determine Lake Marion's floristic quality. The Driftless Region has rolling hills and steeper topography than the rest of Wisconsin because, unlike the rest of the State, glaciers did not cover the landscape. Agriculture, coupled with a highly dissected landscape, has made this region more sensitive to erosion (Knox 2001). Few natural lakes exist in the Driftless Region; the majority of lakes are small, eutrophic impoundments of generally poor water quality (Nichols, 1999).

Lake Marion ranks fairly consistently with the average species richness and average conservatism for the Driftless Region. Lake Marion's species richness of 7 puts it 1.5 species below the Driftless Region average, while Lake Marion's average conservatism, 5.14, is slightly higher than the Driftless Region average of 5.0. In addition, Lake Marion's floristic quality of 13.6 is just slightly lower than the Driftless Region average of 14.3. In general, Lake Marion ranks fairly predictably within the floristic statistics for the Driftless Region.

Invasive Aquatic Plants

Curly leaf pondweed is an aquatic invasive species that probably entered Lake Marion via the connection between Black Earth Creek and the lake. The curly leaf pondweed in Lake Marion is not excessively dense; however, the plant is dispersed throughout the lake.

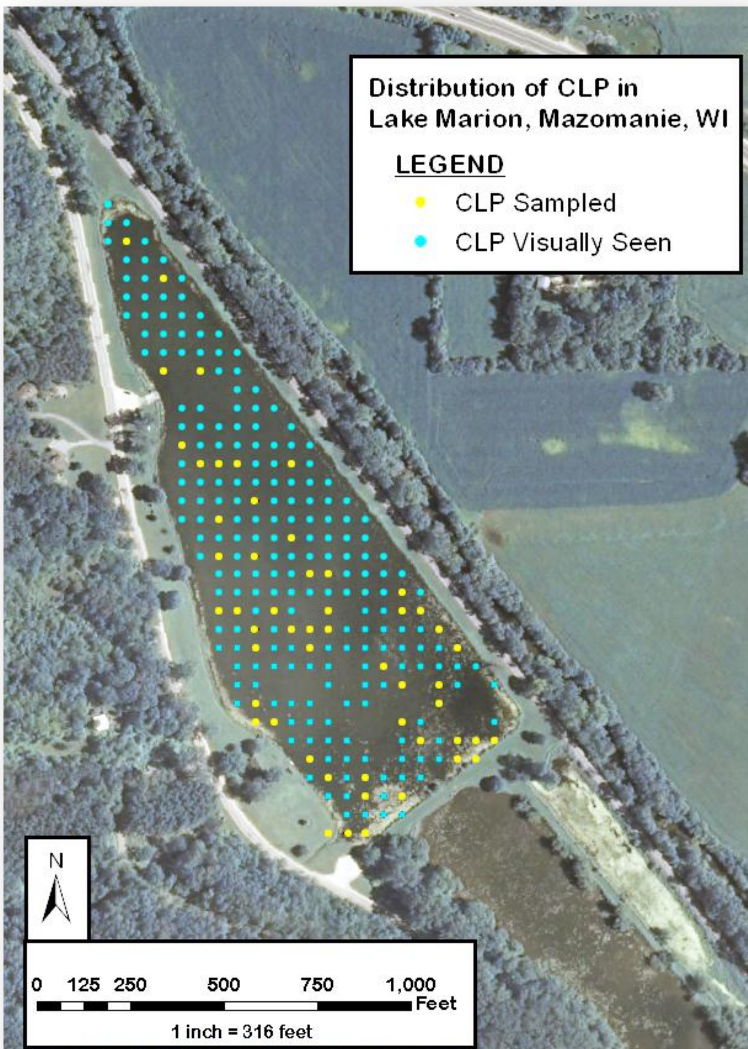

FIGURE 4.13 - VISUAL DISTRIBUTION OF CURLY LEAF PONDWEED IN LAKE MARION. SOURCE: DANE COUNTY. AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

Table 4.3 - Calculated distribution of Curly Leaf Pondweed in Lake Marion.

Frequency	20.56%
Frequency of Visual Occurrence	90%

While the impacts of curly leaf pondweed in Lake Marion are not excessive at this time, it does have the potential to out-compete native vegetation and create a monotypic aquatic plant community. The future effects of this species are difficult to determine. Curly leaf pondweed can have low populations one season and then exponentially increase the next season with little or no change in conditions. Drastic growth could decrease the environmental, social, and economic value of Lake Marion.

Environmental

- When CLP reaches the surface, it can create dense stands that shade out native vegetation and make it difficult for native vegetation to establish and grow.
- Dense matting of CLP can adversely affect water temperature. As heat rises within the water column, the surface matting of CLP can prevent the warm surface water from interacting with air to release heat. Early season warm water can harm other organisms within the lake.
- The presence of non-native aquatic plants decreases the diversity of food and habitat available to fish and wildlife.
- Large stands of CLP can affect internal nutrient loading. CLP begins to die back in early summer, and the midsummer decomposition adds nutrients into the system.

Social/Recreation

- Dense stands of CLP can be a nuisance when they interfere with navigating canoes, kayaks, or remote controlled boats.
- The value of the fishery can decrease due to poor habitat and tangling of lines in the excessive stands.
- CLP can stimulate unsightly and smelly algal blooms, which decreases the aesthetic value.

Economic

- The poor fish and wildlife habitat can lower local enjoyment and tourism in the area and force regular visitors to go elsewhere.
- The decreased aesthetic value has negative impacts on the park and the surrounding land value.

FIGURE 4.14 - LOCAL DIVER REMOVING CURLY LEAF PONDWEED FROM LAKE MARION.

CONCLUSIONS

Aquatic plants play a key role in the maintenance of a healthy lake. Often, changes in plant communities such as the introduction of an invasive species, the elimination of species from a system, and changes in species composition are the first indicators of aquatic ecosystem stress. Two significant areas of concern for Lake Marion's plant community are the lack of littoral zone and the water turbidity.

Most of Lake Marion's edges are steep and do not provide habitat diversity for plants and aquatic organisms that require different water depths. Restoring this critical zone could greatly improve ecosystem function and aquatic life in Lake Marion.

The water clarity in Lake Marion is fair to poor. Poor water clarity means less light reaches the bottom of the lake and plants are not able to survive. The poor water clarity is probably due to carp stirring up sediments as they feed. Carp also uproot vegetation in the lakebed, which makes bottom vegetation difficult to establish. Future management and enhancement of Lake Marion will need to address the effect of carp on the lake's aquatic ecosystem.

FIGURE - 4.15 - BERRIES PROVIDE A NUTRITIONAL FOOD RESOURCE FOR MANY BIRDS.

TERRESTRIAL VEGETATION

INTRODUCTION

Terrestrial vegetation includes all woody and herbaceous plants located on the shoreline of Lake Marion or in the surrounding park. These plants can vary greatly in size, shape, growing pattern, and ecological importance. A healthy ecosystem has a variety and natural balance of native species growing throughout the ecosystem. The presence of high-quality terrestrial vegetation benefits the landscape in many ways.

Wildlife: Terrestrial vegetation provides both habitat and food for wildlife survival.

Erosion Control: The vegetation and root systems of terrestrial plants provide erosion control during storms. First, the vegetation reduces the force of falling rain before the water reaches the soil. Then the root system stabilizes the soil when storms result in overland flow.

Nutrient Removal: Nutrient removal is especially important on the shoreline of water bodies. A large buffer of vegetation around a water body, a riparian buffer, will slow runoff and eliminate a large portion of the nutrients that are carried by the runoff from entering the water. Therefore, a riparian buffer can often decrease nutrient loading and algae blooms in water bodies.

Aesthetic: Lake Marion is a beautiful area that many enjoy. Invasive species could decrease plant diversity and habitat and lower visitors' aesthetic enjoyment of the area.

METHODS

We performed a qualitative terrestrial plant survey of Lake Marion Park by walking the property and recording the presence of all native and non-native plant species. We performed two surveys, one in the Spring of 2010 and one in late Summer 2010. The two survey periods enabled us to record the growth of different dominate species throughout the summer. To record our results, we divided the property into the Lake Marion Shoreline Zone and Lake Marion Park. We recorded trees, shrubs, vines, grasses, and forbes (Table 4.4.1 and 4.4.2).

RESULTS

TABLE 4.4.1 - TERRESTRIAL SPECIES IDENTIFIED AT LAKE MARION IN THE RIPARIAN ZONE.

	Scientific Name	Common Name
TREE	*Acer negundo*	box elder
	Fraxinus pennsylvanica	green ash
	Rhus hirta	staghorn sumac
SHRUB	*Hamamelis virginiana*	witch hazel
	Vitis rotundifolia	wild grape
VINE	*Glechoma hederacea*	creeping charlie
	Parthenocissus quinquefolia	virginia creeper
GRASS	*Phalaris arundinaceae*	
FORBE	*Asclepias syriaca*	common milkweed
	Cerastium fontanum	mouse eared chickweed
	Daucus carota	queen ann's lace
	Rumex crispus	curley dock
	Impatiens capensis	orange jewelweed
	Iris pseudacorus	yellow water iris
	Linaria vulgaris	butter and eggs
	Lythrum salicaria	purple loosestrife
	Ranunculus acris	tall buttercup
	Silene latifolia	bladder campion
	Taraxacum officinale	dandelion
	Tragopogon dubius	Greater goat's beard
	Typha sp.	cattail sp.
	Urtica dioica	stinging nettle
	Asclepias incarnata	swamp milkweed
	Chenopodium album	lamb's quarters
	Carduus acanthoides	spiny plumeless thistle
	Symphyotrichum lanceolatum	white panicle aster
	Solidago canadensis	canadian goldenrod
	Physalis subglabrata	long leaved or smooth ground cherry
	Pastinaca sativa	wild parsnip
	Bidens vulgata	tall begger's tick
	Torilis japonica	japanese hedge parsley
	Polygonum persicaria	spotted lady's thumb
	Persicaria hydropiper	water pepper
	Cirsium vulgare	bull thistel
	Amaranthus rudis	tall amaranth
	Abutilon theophrasti	velvetleaf piemaker
	Typha angustifolia	narrow leaved cattail
	Lycopus americanus	american water horehound
	Erigeron strigosus	daisy fleabane
	Aster ericoides	heath aster

TABLE 4.4.2 - TERRESTRIAL SPECIES IDENTIFIED AT LAKE MARION ON THE SOUTH SIDE.

	Scientific Name	Common Name
TREE	*Acer negundo*	box elder
	Acer platanoides	norway maple
	Fraxinus pennsylvanica	green ash
	Populus deltoides	Eastern cottonwood
	Prunus pensylvanica	pin cherry
	Quercus macrocarpa	bur oak
	Rhus hirta	staghorn sumac
	Salix sp.	willow sp.
	Viburnum opulus subsp. Opulus	Easter highbush cranberry
SHRUB	*Lonicara sp.*	honeysuckle
	Rhamnus cathartica	common buckthorn
VINE	*Galium aparine*	cleavers bedstraw
	Galium triflorum	sweet scented bedstraw
	Glechoma hederacea	creeping charle
	Parthenocissus quinquefolia	virginia creeper
	Solanum dulcamara	bittersweet
	Vitis riparia	wild grape
	Convolvulus arvensis	field bindweed
GRASS	*Bromus sp.*	brome grass
	Phalaris arundinaceae	reed canary grass
FORBE	*Agrimonia parviflora*	southern agrimony
	Alliaria petiolata	garlic mustard
	Arctium minus	burdock
	Asclepias syriaca	common milkweed
	Centaurea biebersteinii	spotted knapweed
	Cerastium fontanum	mouse eared chickweed
	Geranium maculatum	wild geranium
	Hesperis matronalis	dames rocket
	Impatiens capensis	orange jewelweed
	Leonurus cardiaca	motherwort
	Morus sp.	mullberry
	Myosoton aquaticum	giant chickweed
	Nepeta cataria	catnip
	Polgonatum biflorum	giant solomon's seal
	Ranunculus recurvatus	hooked crow foot
	Rhus sp.	Briar sp.
	Ribes missouriense	Missouri gooseberry
	Silene latifolia	bladder campion
	Taraxacum officinale	dandelion
	Toxicodendron radicans	poison ivy
	Tradescantia ohiensis	common spiderwort
	Triosteum perfoliatum	tinker's weed
	Urtica dioica	stinging nettle
	Verbascum thapsus	mullein
	Viola sororia	common blue violet
	Oxalis stricta	common yellow wood sorrel

DISCUSSION

Non-native invasive species dominate Lake Marion's shoreline and park area. Once again, a non-native invasive species is one that was introduced accidentally or deliberately into a new habitat and out-competes native species for resources. This affects the balance of the ecosystem it invades. Once these species are established it is difficult for native species to compete and results in a loss of native species and an ecosystem imbalance. The abundance of invasive species has resulted in a poor quality plant community along the shoreline areas of Lake Marion and within the greater Lake Marion Park.

The low plant diversity around Lake Marion has a number of impacts on the native ecosystem including:

- Degraded wildlife habitat, which limits the number of wildlife species that can live within the park.
- Limited resistance to pest and disease. Monotypic communities of invasive plant species provide little resistance to pests and disease. As new pests and diseases move into an area, the remaining less healthy native species, have difficulty resisting these pests and diseases.

There is great potential to improve the Lake Marion shoreline and park. The natural habitat of Lake Marion's shoreline zone and park could be enhanced by:

Increasing Biodiversity: Introducing native species and controlling the current invasive species will increase the ecological complexity of the shoreline and the surrounding park area. Biodiversity will improve water quality, because the roots of plants provide a mechanism for the assimilation of nutrients that may enter the lake from runoff. Plant biodiversity also provides a diversified patchwork of critical habitat for birds and wildlife.

Shade: Planting trees and bushes along the shoreline will provide shade over the water. These areas of shade are important to the fishery because they provide refuge during hot summer days when water temperatures in the direct sun can stress fish. In addition, coarse particulate matter, in the form of leaves that fall into the water, provide food for small macroinvertebrates that are a critical part of the food supply for fish.

Woody Debris: Allowing trees to fall or placing downed trees perpendicular to the shoreline will increase fish and wildlife habitat. Healthy fisheries need woody shoreline habitat for small fish and amphibians to take refuge from predation. Research shows a direct relationship between the amount of coarse woody debris in a lake and the presence of green frogs (Woodford & Meyer, 2003).

Buffer width: Reducing the mowed lawn area around the shoreline adjacent to Lake Marion will help decrease erosion, lower nutrient input, and increase wildlife habitat. Additionally, geese select mowed grass areas over taller grass to congregate, because mowed grass provides food and allows geese to see predators easier. By reducing the mowed grass area, geese will be less likely to congregate in higher concentrations.

The quality of shoreline vegetation significantly influences the overall ecological health of a shoreline and a water body. The shoreline area of Lake Marion is very narrow and dominated by reed canary grass, a highly aggressive invasive grass. The state of Wisconsin recommends a minimum of 35 feet of non-mowed, intact vegetation along all inland lakes to provide water quality protection and wildlife habitat. The narrow width of Lake Marion's shoreline buffer provides little wildlife habitat within the shoreline zone.

MACROINVERTEBRATES

INTRODUCTION

Macroinvertebrates are integral to freshwater ecosystems. As a major source of food for fish and wildlife, they are necessary part of a healthy food web. Macroinvertebrates play a major role in food web dynamics, from non-predatory filter feeders to aggressive predators. Certain macroinvertebrates are sensitive to environmental disturbance such as pollution, sedimentation, wind and ice scouring. By documenting the types of macroinvertebrates that are present, we can assess the environmental condition of the Lake Marion system. In addition, changes in abundance and species composition throughout the system may help detect changes that might not be evident through other water quality measures.

Each specific taxa of macroinvertebrates prefer certain environmental conditions such as habitat, pH, temperature, salinity, turbulence, or tolerance to pollutants. Some taxa are generalists and can live in a wide range of environmental conditions and habitats. Others may require high amounts of nutrients or very clear, clean water to survive. For example, leeches tolerate nutrient rich water and may be found in a wide range of conditions. On the other hand, stoneflies prefer cold, highly oxygenated water and are sensitive to warm water and low oxygen levels. A healthy freshwater system will have a diversity of organisms and include taxa that are intolerant of pollution. An impaired system may have fewer taxa or an over representation of disturbance tolerant taxa, such as those that tolerate anoxia and high nutrient levels.

The objective of our macroinvertebrate study for the Lake Marion system was to assess the current environmental condition of Lake Marion, the small pond, the large pond, and nearby Black Earth Creek. Studying macroinvertebrates allows us to determine the types of habitat present in the Lake Marion system and to provide a general account of the ecological condition of the two ponds and Lake Marion. For example, habitat factors may lead to more or less species diversity and abundance. Certain macroinvertebrates require pea gravel, cobble or gravel to survive while other macroinvertebrates require vegetation, sand or a supply of detritus.

Site Identification

We sampled in four distinct areas: Black Earth Creek, the small pond, the large pond, and Lake Marion. We chose sampling sites that offered easy accessibility, a variety of substrate types for complete macroinvertebrate representation, and a lack of disturbances such as obvious pollution. Sites were numbered as follows and are shown on Figure 4.16.

Sampling Methods

At each of the nine sampling sites we identified three microhabitats. Microhabitats are habitats within each site that differ from one another in some physical or biological aspect. For example, the shoreline of the lake and the benthic sediment ten meters from the shoreline are two different microhabitats.

We sampled from each microhabitat using two D-nets. D-net collecting methods include dragging the D-net along the benthic sediment or shoreline or using the D-net as a kick net in riffle habitats. Once we had samples from the microhabitat in both of the nets, we placed the organisms in an ice cube tray for later identification. We noted total time spent picking organisms out of the D-nets.

We used the dichotomous key from the *Streamkeeper's Field Guide* to identify the organisms down to order. After identification, we released all organisms back into the microhabitats from which we collected them. We sampled each site three separate times—in May, June, and July 2010. We calculated biodiversity based on the taxa data from each sampling date and site using the Shannon-Weaver Index and the Simpson's Index. The Shannon-Weaver Index is used to measure biodiversity. The index uses species richness and abundance to create a numeric value for the amount of biodiversity that is present. Unlike the Simpson's Index, the Shannon-Weaver Index considers species evenness and number of unique species. The Simpson's Index measures biodiversity by accounting only for species richness and abundance.

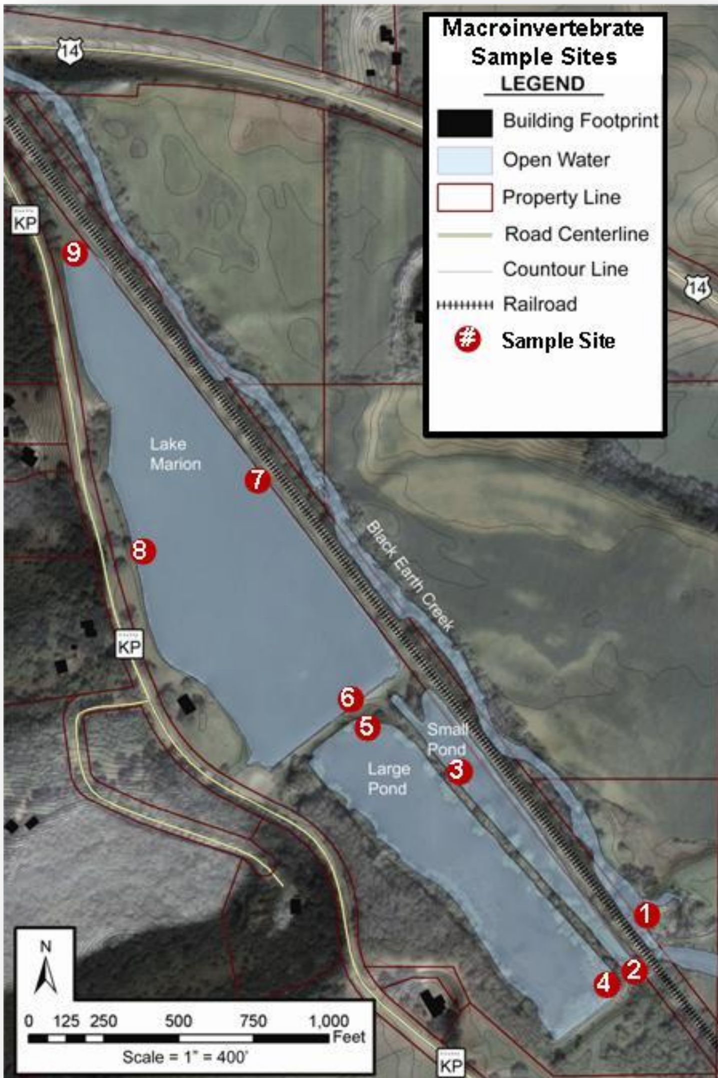

Figure 4.16 - Macroinvertebrate Sampling sites. Source: Dane County. Building Footprints 2009, Open Water 2008, Parcels 2009, Road Centerlines 2008, 2' Contours 2009, Aerial Image 2008. Created by 2010 WRM Practicum.

***Site 1**:* Below the dam on Black Earth Creek. This site is on the eastern bank of Black Earth Creek downstream from the dam. Substrate type: cobble and rock.

***Site 2**:* Small Pond. Inlet at the southern edge of the pond. Substrate type: silt.

***Site 3**:* Small Pond. Northern edge, closest to Lake Marion. Substrate type: silt.

***Site 4**:* Large Pond. Southeastern edge, close to the small pond. Substrate type: silt.

***Site 5**:* Large Pond. Northern side, facing Lake Marion. Substrate type: silt.

***Site 6**:* Southern edge of Lake Marion, by the inlet from large pond. Substrate type: boulders and sand.

***Site 7**:* Eastern edge, halfway along the length of Lake Marion that borders the railroad tracks. Substrate type: sand and clay.

***Site 8**:* Western edge, halfway along the length of Lake Marion that borders Highway KP. Substrate type: sand and clay.

***Site 9**:* Northern edge, the rocky substrate that is at the narrowest point of Lake Marion, by the outlet. Substrate type: sand and silt.

RESULTS

The macroinvertebrate community composition changes as it moves through the system from the creek to the lake (Figure 4.17). In general*, tricoptera* (caddisflies) dominate the creek, *hemiptera* (aquatic bugs) and *coleoptera* (water beetles) dominate in the ponds, and *odonata* (dragonfly and damselfly nymphs) dominate Lake Marion. A small number of orders make up the majority of the macroinvertebrate composition of the entire system.

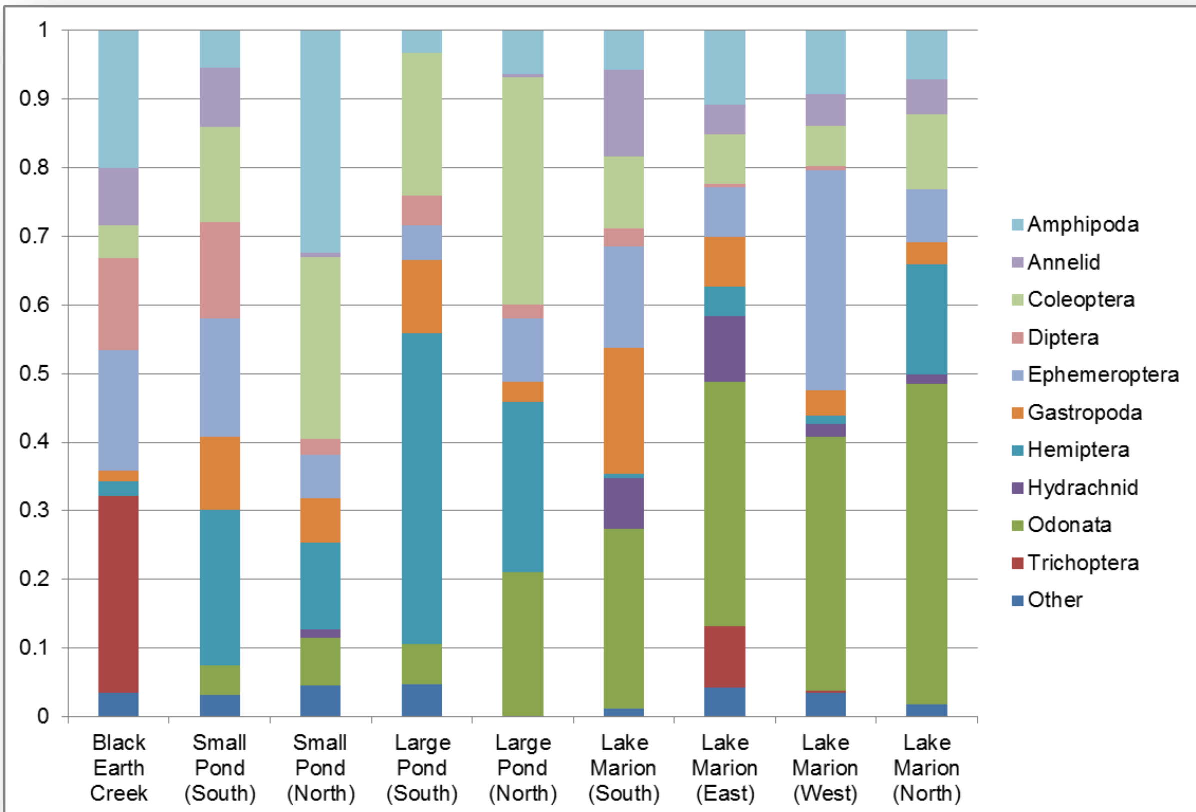

FIGURE 4.17 - AQUATIC MACROINVERTEBRATE TAXA COMPOSITION BY SITE.

We calculated t-values to test for significant differences between all possible site combinations and used both the Shannon-Weaver Index results and the Simpson's Index results (Figure 4.18). Using a p-critical value of 0.05, we found no significant differences between any two site's calculated indices. In other words, we found no significant difference in diversity between any two sample sites. This suggests that the macroinvertebrate community diversity is homogeneous throughout the system.

Figure 4.18 shows taxonomic order composition by site, represented in percent captured from total sample. The colors on the graph correspond sequentially to the list of taxa (orders) in the key on the right. For instance, the annelid taxon is at the top of the key and is therefore on the top of the bar chart indicated by light purple. Annelids are followed by the *tricoptera* taxon in light green and so on. Note that not all taxa were observed at every site and organisms in the "*annelid*" taxon could only be identified down to taxonomic phylum, not order.

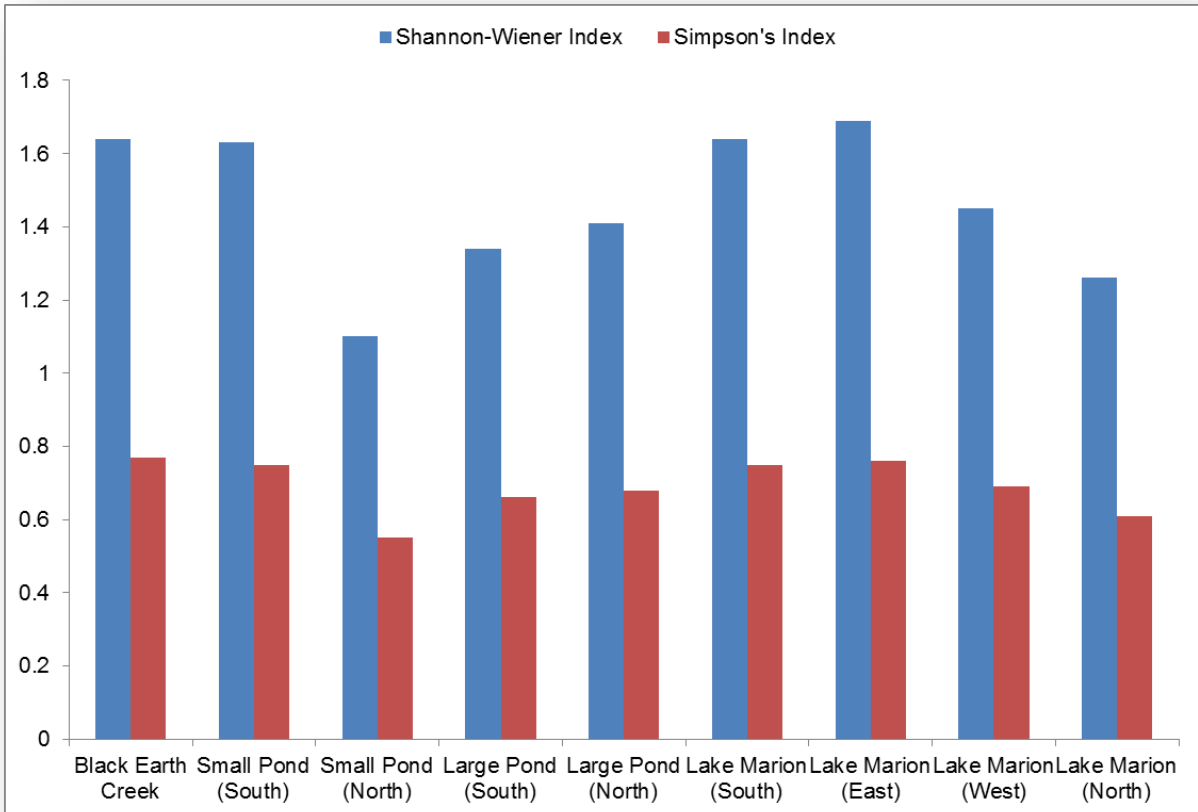

FIGURE 4.18 - AQUATIC MACROINVERTEBRATE DIVERSITY INDICES BY SITE.

DISCUSSION

Macroinvertebrate community diversity can be an indicator of water and habitat quality. Community indices take into account relative richness and population amongst organisms (orders) in order to gauge a location's overall biodiversity. A location with multiple species with high populations will have higher values, while areas with very few orders that are dominated by a few species will have lower values. Thus, higher values correlate with better water and habitat quality, and lower values correlate with degraded water and habitat quality.

The goals of the macroinvertebrate survey were to determine if and how the macroinvertebrate diversity vary at different points throughout the Black Earth Creek and Lake Marion system. According to the diversity indices, our extensive macroinvertebrate survey shows that there is no significant difference in community diversity between Lake Marion, Black Earth Creek, the Small Pond, and the Large Pond.

There are many reasons why the lake, ponds, and creek do not differ in macroinvertebrate diversity. Factors such as habitat structure, water source, connectedness, and water body proximity could affect macroinvertebrate diversity. Black Earth Creek is not only a source of water; it is a source of all aquatic life for the ponds and Lake Marion. Since the system is supplied with the same source water and is connected by a series of culverts, organisms can easily travel from one end of the system to another. In addition, since the water bodies are so close in proximity to one another and to Black Earth Creek, it is logical to hypothesize that macroinvertebrates that have a terrestrial life stage can travel from one water body to another relatively easily. Overall, the creek, ponds, and lake are a system connected in many ways. These connections, along with similar habitat structure, allow for easy travel and establishment of similar macroinvertebrate communities.

Another factor to consider is the extent of the surveys themselves. The goal of the surveys was to get a general understanding of the macroinvertebrate community present in the Lake Marion system. With the equipment and time constraints of the project, we were only able to identify organisms down to taxonomic order. A more specific taxonomic classification would certainly increase the number of groups since we'd expect to find multiple families within an order. However, the abundance of organisms found would go down for each of these new groups because the data would be split up even further. Therefore the data would be more specific, but this specificity would not necessarily change the results of the diversity tests. This is certainly a limitation to our study, but not necessarily an explanation for our results.

It is important to note that even though there was no significant difference in diversity between the sites, the surveys indicate there is a shift in the proportion, or dominance, of specific orders. In other words, there may not be a significant difference in the number of orders present at each site, but there is a visible difference in proportionality depending on the sample site. Survey results show that the dominant order(s) change as you move from one water body to the next. This shift in community composition could be due to slight changes in habitat or water quality conditions specific to the sample site. For instance, aquatic bugs and beetles dominate the ponds and have different habitat preferences and feeding habits than the damselfly and dragonfly nymphs that dominate the lake. Water beetles and bugs typically eat vegetation whereas the nymphs are larger, predatory insects. This shift in dominance could not only impact the macroinvertebrate community dynamics, but it could also impact Lake Marion's fishery. Since different macroinvertebrates are fed upon by different species of fish, as community composition of macroinvertebrates shift from the creek to the lake, the fish species composition may shift as well. Shifts in fish community compositions may alter the recreational fishing opportunities provided by the water bodies. Disconnecting the ponds and lake from the creek may alter the macroinvertebrate composition and thus the fish composition. These surveys do not indicate how the macroinvertebrate diversity will change when the dam is removed.

CHAPTER 5: FLOODPLAIN ASSESSMENT

While the first portion of this report is dedicated to evaluating enhancements to Lake Marion, the floodplain section investigates issues in the Black Earth Creek floodplain upstream of the Mazomanie dam. The Village's decision to remove the Mazomanie dam presents a number of environmental and recreational opportunities for the adjacent Black Earth Creek floodplain and stream channel. WRM students investigated the impact of the dam upon the immediate upstream floodplain and developed stream and floodplain restoration options for consideration.

The Mazomanie dam has impounded Black Earth Creek for over 150 years and is currently located on the Wolf family property. When the dam was constructed, the meandering stream was straightened and has become wider and shallower. In addition, cultural (post-settlement) soils have deposited behind the dam and these soils have raised the elevation of the ground surface in that location. The Wolf family has been an active proponent for removing the dam and restoring the stream, wetland, and floodplain within their property. They are interested in dedicating a significant portion of private property along the creek for stream enhancement, wetland creation, and public recreational amenities, such as nature observation, angling, canoeing, and a hike and bike trail system.

We studied the area where Black Earth Creek is currently impounded, which is located upstream of the Mazomanie Dam on Mr. Wolf's property. This frequently saturated area, referred to as the study area, has been identified by Mr. Wolf as a location for re-meandering Black Earth Creek and for wetland creation. When the function of the dam is retired, Black Earth Creek will need to be reconnected upstream and downstream of the dam. This will require carving into a thick wedge of accumulated soils that has accreted behind the dam. Reconnecting the stream will also result in a lower stream channel and groundwater table. To establish a healthy relationship between the stream channel and the floodplain, some of this accumulated sediment must be removed. Therefore, we concentrated our study on exploring the depth and quality of the accumulated sediments and developed conceptual plan options for floodplain and stream restoration.

ASSESSMENT OF THE DAM'S IMPACT ON THE FLOODPLAIN

The Mazomanie dam impacts the immediate floodplain approximately 1330 stream feet upstream of the dam. The deposition of sediment behind the dam has decreased the slope of the stream and caused it to straighten. With the reconstruction of the dam in the 1960s, the creek was further straightened and a concrete retaining wall and earthen berm were constructed to help contain floodwaters. The location of the abandoned channel is evident in both the existing contours and an aerial photograph from 1937. For the purpose of restoration, the study area is the reach of Black Earth Creek upstream of the Mazomanie dam extending to Mr. Wolf's southern property line. To assess the impact of the dam on the study area, we studied historical documents, conducted field surveys, examined the extent of sediment accumulation, and compared the study area to a reach of Black Earth Creek relatively unaffected by the dam or other human activity.

HISTORICAL DOCUMENT REVIEW

Historical maps and government survey notes from the 1830s indicate that the stream once meandered through the Lake Marion area. However, restoring Black Earth Creek to its original, historic morphology is impractical due to the location of the railroad infrastructure and the cultural significance of Lake Marion. Therefore, stream enhancement will only occur on the east side of the railroad and within the easement dedicated by the Wolf family.

In addition to historic maps and government notes, we also studied aerial photography taken in 1937 and a two-foot contour topographic map provided by the Dane County Department of Land and Water Resources. We used the photograph to note terrain and stream patterns and to help choose a relatively natural stream reach, labeled the 'reference reach.' This information was then compared with the study area. From the aerial photography and the two-foot contour topographic map, we determined that: (1) Black Earth Creek in the study reach meandered through the northeastern part of the study area, (2) groundwater-filled depressions in the landscape are likely remnants of the abandoned channel, and (3) the reference reach has changed little in its plan morphology over the past 73 years (Figure 5.1).

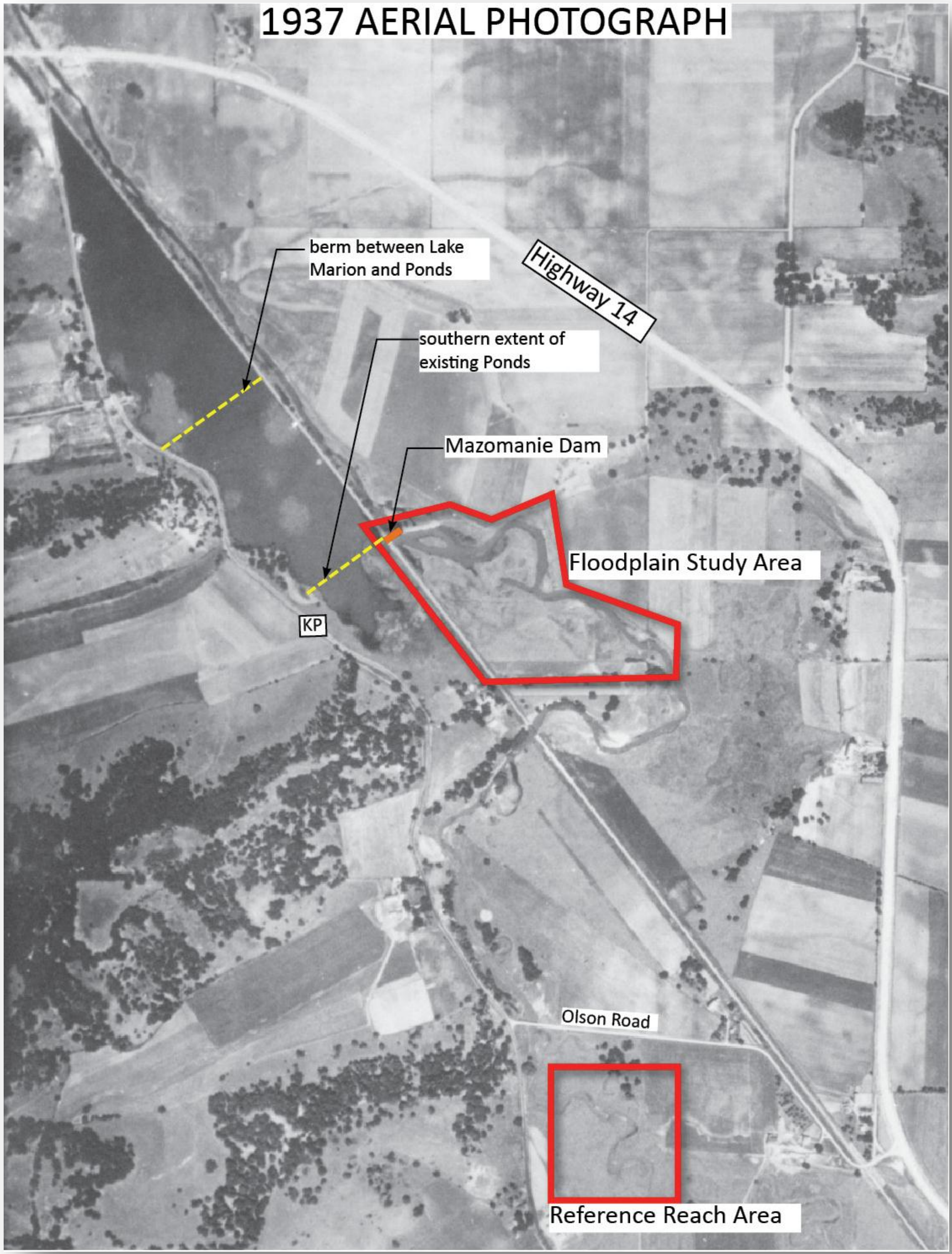

FIGURE 5.1 – 1937 AERIAL PHOTOGRAPH. SOURCE: U.S. DEPARTMENT OF AGRICULTURE, UNIVERSITY OF WISCONSIN MAP LIBRARY. CREATED BY 2010 WRM PRACTICUM.

FIGURE 5.2 – STUDY AREA FLOODPLAIN AND ABANDONED STREAM CHANNEL.

FIGURE 5.3 – IMPOUNDED BLACK EARTH CREEK UPSTREAM OF THE MAZOMANIE DAM.

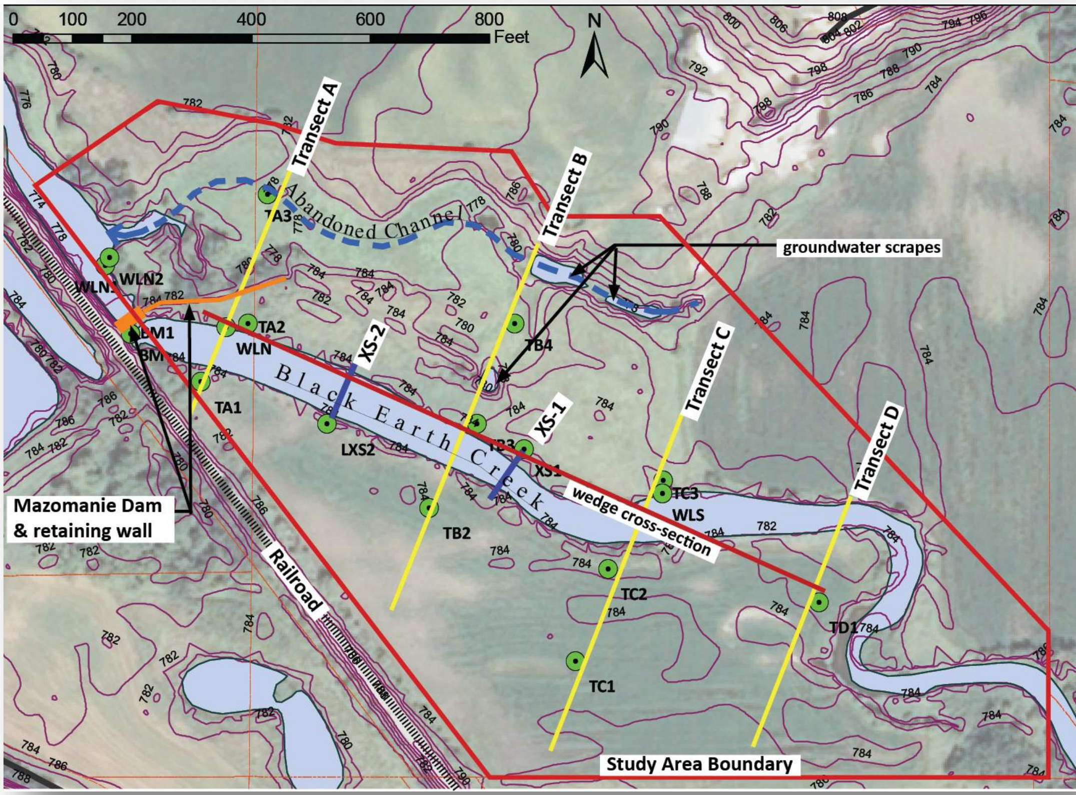

FIGURE 5.4 – PLAN OF STUDY AREA. SOURCE: DANE COUNTY. AERIAL PHOTO (N_4308950_SE_16_1_20080829.TIF), CONTOURS (FLY DANE PARTNERSHIP, 2009). DATA TRANSFERRED BY PAUL F. JUCKEM, U.S. GEOLOGICAL SURVEY – WISCONSIN WATER SCIENCE CENTER: GPS-RTK_JULY_8_2010, GPS-RTK_JULY_6_2010. CREATED BY 2010 WRM PRACTICUM.

EXTENT OF ACCUMULATED SEDIMENT

Land surface elevation was determined using a GPS-RTK (Real Time Kinematic) surveying device. This satellite-based technology is accurate in the one to twenty centimeter range. Groundwater table elevation was determined by measuring the depth from the surface to the groundwater. We waited at least 30 minutes after augering was complete to allow the groundwater level to become relatively stabilized. The meander plain surface was identified as the depth below the surface where the auger blade hit gravel (Figure 5.5).

Because we could not see the exact interface of the gravel surface and the floodplain sediments, there is a margin of error of several inches. The pre-dam floodplain was identified based on the presence of a buried fibric soil. Fibric soils provide evidence of undecomposed plant material typically found in anaerobic wetland conditions. At two sites we found buried wetland soil consistent with the Public Land Survey records from the 1830s (Figure 5.6). We used the fibric soil as an indicator of the approximate elevation of the pre-dam floodplain surface.

FIGURE 5.5 – MEANDER PLAN SURFACE GRAVEL FROM SOIL CORE IN FLOODPLAIN.

FIGURE 5.6 - FIBRIC SOILS FROM THE BURIED, HISTORIC WETLAND.

Using the measured elevation of the land surface and the measured depths below the land surface, we calculated the elevations of the groundwater table, meander plain surface, and pre-dam floodplain. We entered the elevation data for the land surface, groundwater table, and meander plain surface into Surfer8, a surface mapping program. Surfer8 uses a statistical method (kriging) to interpolate elevation based upon given points. To calculate the volume of sediment above the pre-dam floodplain, we used Surfer8 to calculate the volume between the pre-dam floodplain elevation and the land surface. As expected, a "wedge" of sediment has accumulated behind the dam during the past 150 years. A section, drawn from the dam and along the impounded reach of Black Earth Creek, shows that accumulated sediments are roughly six and half feet directly behind the dam and taper to about 2 feet at the furthest transect from the dam (Table 5.1 and Figure 5.7).

TABLE 5.1 – FLOODPLAIN TRANSECT ELEVATION TABLE

	Transect A			Transect C			
Sample Point	TA1	TA2	TA3	TC1	TC2	TC3	
Land Surface Elevation (LSE)	783.54	783.56	778.20	783.37	784.63	783.56	feet
Meader Plain Elevation (MPE)	778.95	776.89	778.11	778.45	779.80	780.97	
Water Table Elevation (WTE)	778.95	777.72	777.78	780.04	781.46	780.97	
Pre-settlement surface (PSS)				780.84			
	Transect B			Transect D			
Sample Point	TB2	TB3	TB4	TD1			
Land Surface Elevation (LSE)	783.91	784.42	780.58	784.58			
Meader Plain Elevation (MPE)	779.99	779.50	779.74	782.66			
Water Table Elevation (WTE)	780.20	780.31	779.54	782.23			
	Transect I	TA2	TB3	TC3	TD1		
depth from LSE to MPE		6.67	4.92	2.58	1.92	WEDGE EFFECT	
depth from LSE to WTE		5.83	4.10	2.58	2.35		
		0.83	0.81	0.00	-0.44		

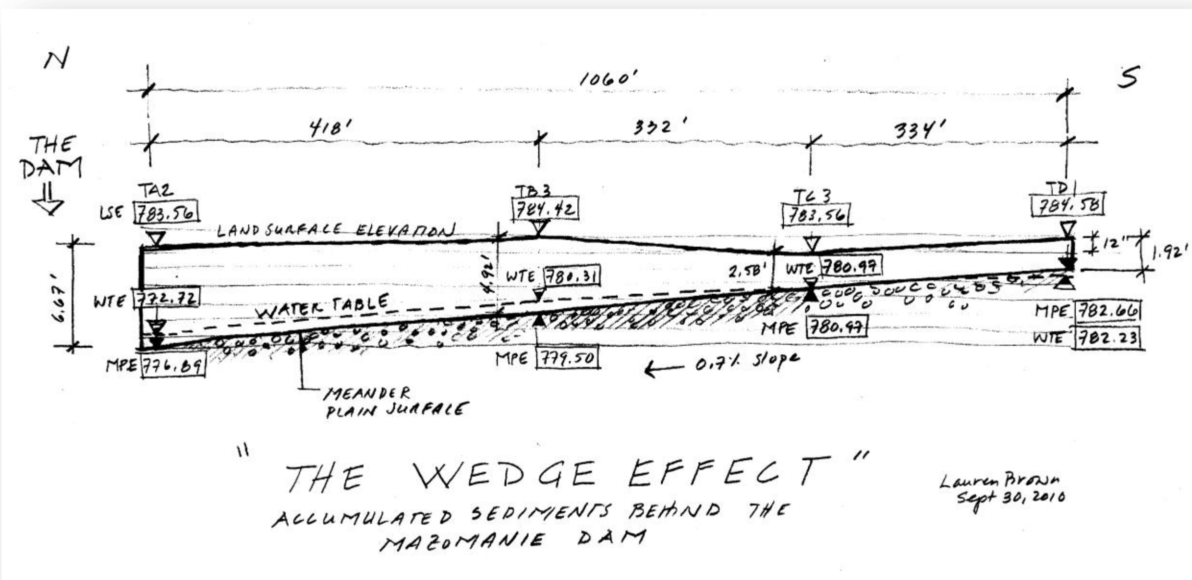

FIGURE 5.7 – THE WEDGE EFFECT. DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

Consistent with expectations, the meander plain surface shows a constant slope of 0.7% along the channel while the land surface elevation is relatively flat over this area. The groundwater table tends to follow the slope of the meander plain surface. Groundwater elevation adjacent to the stream is lower than the surface water elevation and, in some locations, lower than the creek bottom. This indicates that the impounded reach of Black Earth Creek is actually a losing stream and that, unlike the natural conditions of Black Earth Creek, groundwater is not contributing to base flow along this stretch. Instead, groundwater is moving from the stream to the groundwater. Results from the Surfer8 model indicate that the dam structure may also be impounding groundwater upstream of the dam (Figure 5.8).

According to our assessment, the pre-dam floodplain is covered with about two to three feet of accumulated sediments that would need to be removed and relocated in order to restore the floodplain. Using the Surfer8 model, we estimated that a volume of approximately 122,000 cubic feet (37,000 cubic meters) of sediment exists on top of the pre-dam floodplain. Note that these numbers are estimates and do not include topographic changes, such as berms and depressions, across the study area. However, the volume represents the rough quantity of sediment that may need to be excavated and relocated to restore the wetland floodplain when the stream is realigned.

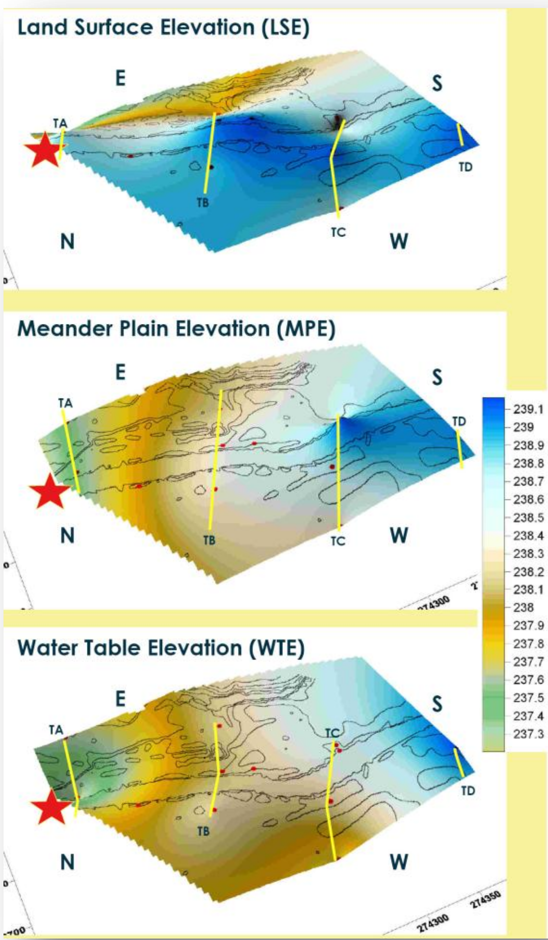

FIGURE 5.8 – SURFER 8 MODEL RESULTS.

Quality of Accumulated Sediment

Since soil excavation and removal may be a significant portion of a floodplain restoration project, it is important to develop a plan for addressing soil relocation. In addition to volume, the quality of the sediment is also important for determining the feasibility of sediment relocation options. Although we can surmise that a large portion of the sediments behind the dam originated from agricultural fields in the watershed, we used soil sample analysis to test this assumption and to determine the quality of soils.

Soil samples were collected from the hand-augered soil pits along the floodplain transects and sent to the UW Plant and Soil Analysis Laboratory for analysis. The laboratory analyzes soils for nutrient content, soil bulk density, pH, organic matter and texture and provides recommendations for nutrient applications to improve crop productivity. In general, the soil tests show that the top one to two feet of soil would be of high quality for agricultural use and require little additional fertilizer to be productive for cash crops such as corn. Soil below the top one to two feet is also of adequate quality, but would require some additional phosphorus and potassium to reach maximum crop yield potential for use as agricultural topsoil. All of the soil tests showed an optimum pH level; therefore the soils require no pH adjustments. Soil organic matter was generally higher than 2.0%. Overall, there is an adequate concentration of soil organic matter throughout the study reach for both the shallow top soils and deeper soils. Soil bulk density is a measure of pore space within the soil. As pore space within a soil increases, so does the soil's ability to hold and transmit water through the soil column. A desirable bulk density is less than 1.6. All of the soils tested have bulk densities lower than 1.6 and generally lower 1.0, which is a sign of a soil with high organic matter content (Table 5.2).

Most soil excavated would come from the top three feet and these results show that all soil could be applied to fields as fertile topsoil. The soil would need to be fertilized with nitrogen, phosphorus, and potassium if they were put on crop fields. However, the overall soil quality is high, with high percentages of organic matter, optimum pH, and low bulk density.

Soil Relocation Options

Hauling sediment off-site can be energy intensive and costly. Plans that involve relocation to an area adjacent to the floodplain are therefore preferred. Local relocation options include moving the excavated soil to adjacent farm fields, selling it off as topsoil, moving the soils on-site to create landforms, or using the resource as fill material for the ponds at Lake Marion Park. As detailed in the Ponds Section of the report, the WRM practicum recommends filling the small pond when the dam function is removed. If the Village decides to fill the ponds as part of the Lake

Marion Park master plan, then the floodplain sediments would provide a valuable local resource for that effort.

TABLE 5.2 - RESULTS OF SOIL TESTS.

Field Location	Sample Depth (in)	pH	O.M. %	P	K	Bulk Density	Applications (lbs./acre)	Notes
TC1	0-6	7.7	10.3	8	26	0.71	K= 85; P = 90	optimum pH and very low K and P
TB4	0-12	8.2	2.1	23	85	1.06	K = 40; P = 30	optimum pH and lower part of optimum range for K and P
TA1	2-9	8	1.9	37	48	1	K = 85	optimum P and pH, very low K
TA1	8-20	8	5.4	72	125	0.89	K = 20	optimum pH, K, and P
TB4	11-23	8.3	1.5	8	76	1.1	K = 70; P = 80	optimum pH and very low K and P
TC2	24-29	8.1	2.8	1	42	0.92	K = 85; P = 90	optimum pH and very low K and P
TC3	29-37	8.3	4.1	3	48	0.83	K = 85; P = 90	optimum pH and very low K and P
TA2	36-48	8.3	3.5	4	43	0.91	K = 85; P = 90	optimum pH and very low K and P
TB3	44	8.4	2.6	1	33	0.88	K = 85; P = 90	optimum pH and very low K and P
TC3	91	8.1	4.2	5	79	0.83	K = 70; P = 80	optimum pH and very low K and P

STREAM AND FLOODPLAIN RESTORATION OPTIONS

WHY THE FLOODPLAIN SHOULD BE RESTORED

The Village's decision to remove the function of the dam opens up the potential for the restoration and enhancement of both Black Earth Creek and the Black Earth Creek floodplain that is immediately upstream of the dam structure. The impounded reach of Black Earth Creek currently drops roughly six feet in elevation from the dam structure to the stream elevation below. When the stream is realigned it will cut down (or be excavated) into the wedge of accumulated sediments behind the dam. This will create a channel with unnaturally high banks that will be vulnerable to erosion. Removing sediment adjacent to the stream will reduce erosion, create a floodplain wetland that is connected to the stream, and provide diverse habitats for amphibians, birds, small mammals and wetland plants (Figure 5.9).

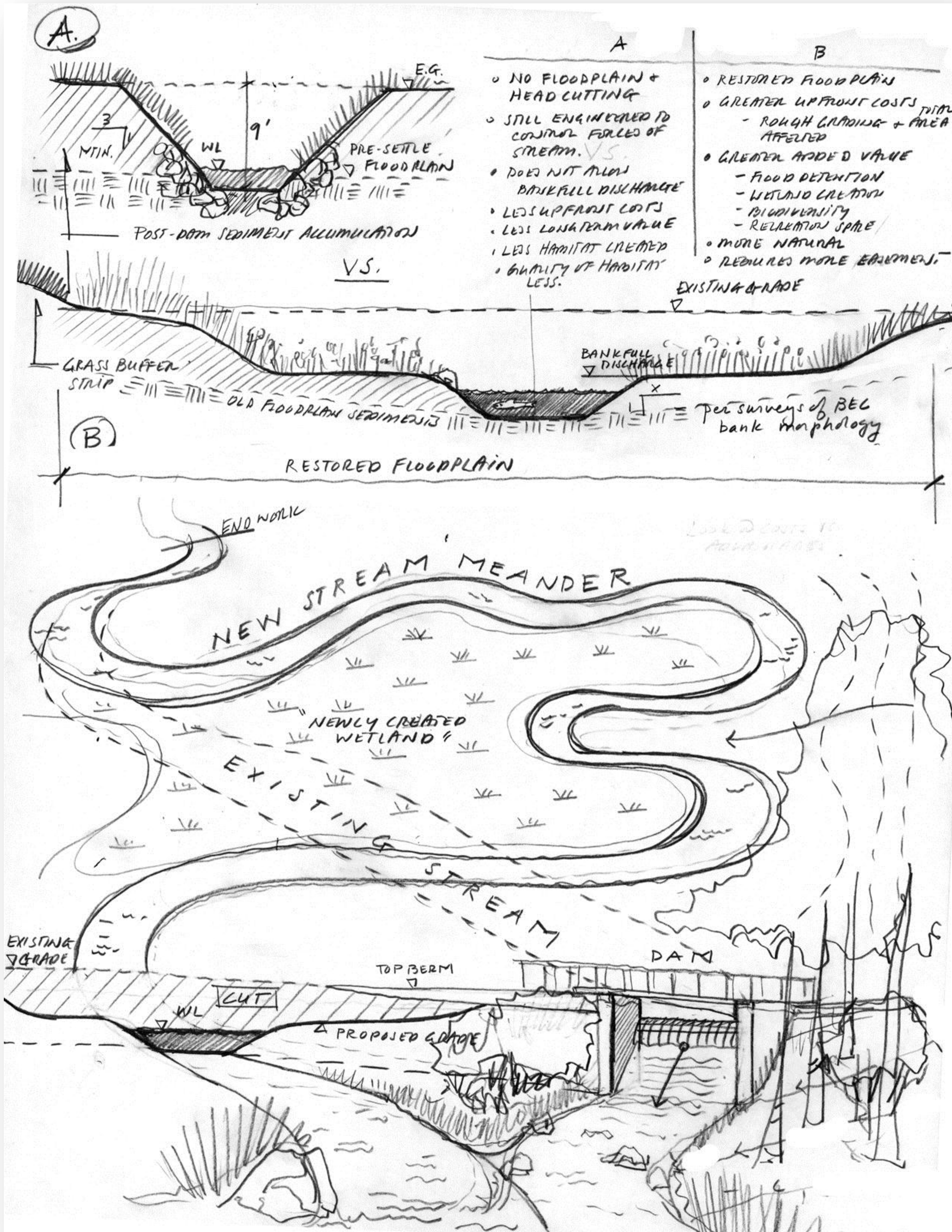

FIGURE 5.9 – SKETCH OF FLOODPLAIN RESTORATION. DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

PRECEDENTS: EAST BRANCH PECATONICA RIVER

The East Branch Pecatonica River restoration is a local and novel precedent for the removal of post-settlement soils for stream and floodplain restoration. The project is a collaboration between The Nature Conservancy (TNC) and the WI Department of Natural resources and was completed in 2006. The project is also located in the Driftless Region and is south of Mazomanie near Blue Mounds, WI. Similar to our reach of Black Earth Creek, the natural floodplain in the East Branch Pecatonica was buried under a thick layer (2-1/4 feet) of accumulated 'cultural' sediments - primarily erosion from agricultural land. The increased surface of the floodplain changed the relationship between the soil surface and the groundwater and resulted in a vegetation shift from a wet prairie to a box elder and shrub community. The restoration involved removing trees and shrubs, as well as excavating and removing the two foot layer of cultural soils. The sediment removed from the site was donated to the county highway department and several private landowners who were willing to haul it away. The scraped floodplain was then stabilized with a cover crop and replanted with a diverse seed mix of native mesic and wet prairie species.

The restoration is considered a success by the stakeholders. Two years after restoration construction and following two large scale floods, the stream naturally reestablished a stable morphology by narrowing its banks and re-defining its meander pattern. In addition, the floodplain reestablished as a diverse wet sedge meadow. The East Brach Pecatonica restoration is managed by The Nature Conservancy. By employing both controlled burns and selective chemical applications, they have been able to control invasive species, such as reed canary grass, and restore a diversity of plant species. Scrapes in the floodplain where groundwater is high have developed into shallow ponds, which prove to be excellent habitat for native amphibians (Booth correspondence).

FIGURE 5.10 – RESTORED EAST BRANCH PECATONIC RIVER FLOODPLAIN.

FIGURE 5.11 – EAST BRANCH PECATONIC RIVER IMMEDIATELY UPSTREAM OF THE RESTORATION SITE (BOX ELDER TREES ON THE BANKS).

Black Earth Creek Reference Reach Assessment

Unlike the East Branch Pecatonica River, the stream channel in the Black Earth Creek study area has been significantly altered by human activities. Restoring the stream will require more than simply restoring floodplain elevations. In order to develop stream alignment plans, we chose to assess the plan and cross-sectional geometries of a 'reference reach' of Black Earth Creek that is located upstream of our study area. A Reference Reach is a stretch of the stream that is observed to be a natural stream reach or is relatively unimpacted by anthropogenic activity. We identified a location just south of Olson Road on Rettenmund property, which appeared from aerial photographs and ground surveying to exhibit a more natural morphology (Figure 5.12).

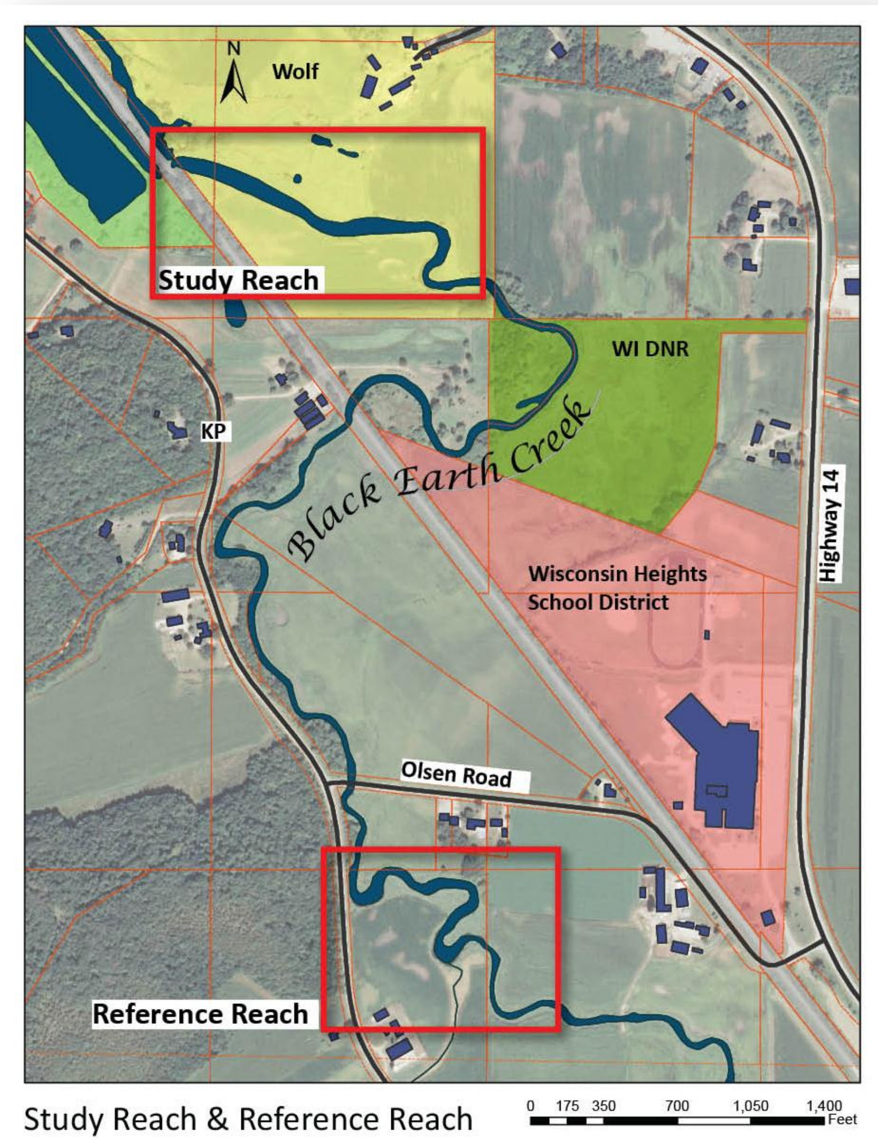

Figure 5.12 – Relationship map showing study reach and reference reach of Black Earth Creek. Dane County. Aerial Photo (N_4308950_SE_16_1_20080829.tif), Parcels 2009, Ownership 2009, HydroLine & HydroPoly 2008, Building Footprints 2008, Road Centerline 2008. Created by 2010 WRM Practicum.

Stream cross sections were field-surveyed at the meander crest and the upstream and downstream meander bend arms. We documented the top of the bank, bank profile, stream bed profile, thalweg (the deepest channel of the stream), and the bankfull discharge height (flow that marks the onset of floodplain inundation) (Figure 6.14).

In addition, plan geometries and slope characteristics were analyzed from GIS plans (Figure 5.13).

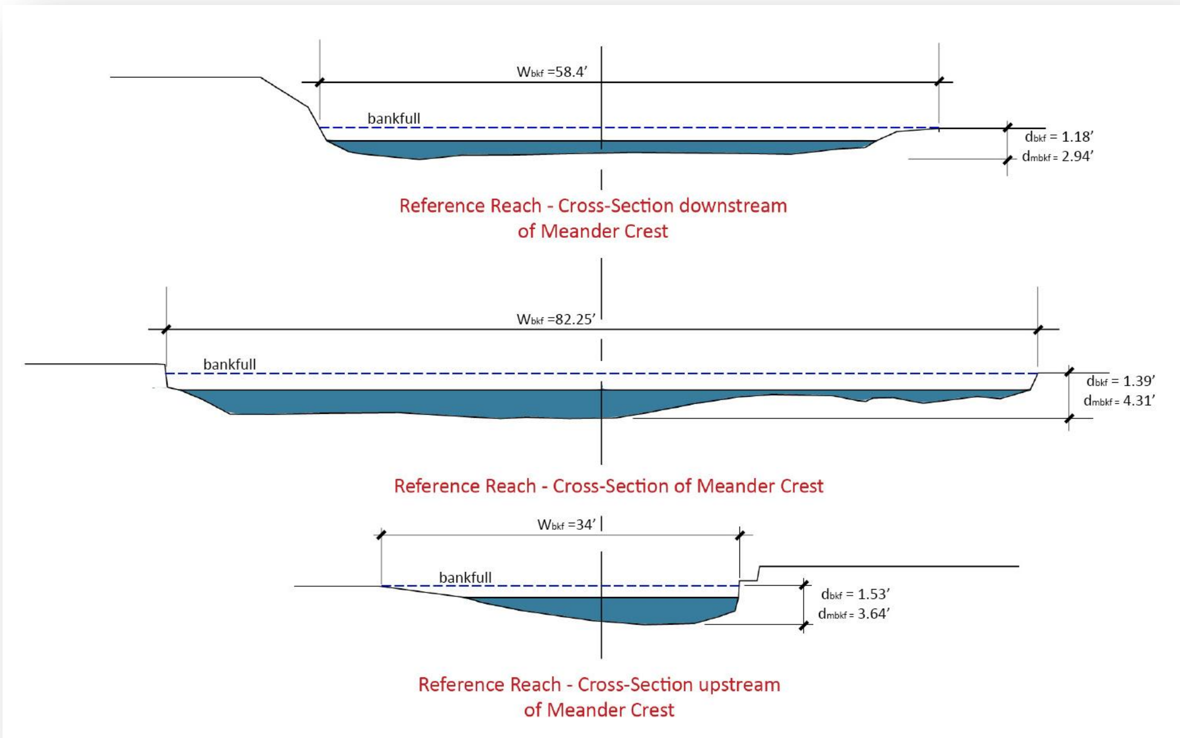

FIGURE 5.13 – REFERENCE REACH STREAM CROSS-SECTIONS.

Plan geometries from the reference reach were used to inform the conceptual stream alignment. For example, radius of curvature (which varied from 50 – 90 feet) and belt widths (which ranged from 200-250 feet) informed the plan layout, while width-to-depth ratios (ranging from 12-27) informed stream width and cross-sectional shape. For the floodplain grading plan, cross-sectional information such as bankfull width and height were used to determine stream width as well as a rough bankfull height. Per the reference reach cross-sections, the average bankfull height above water level was 1.2 feet.

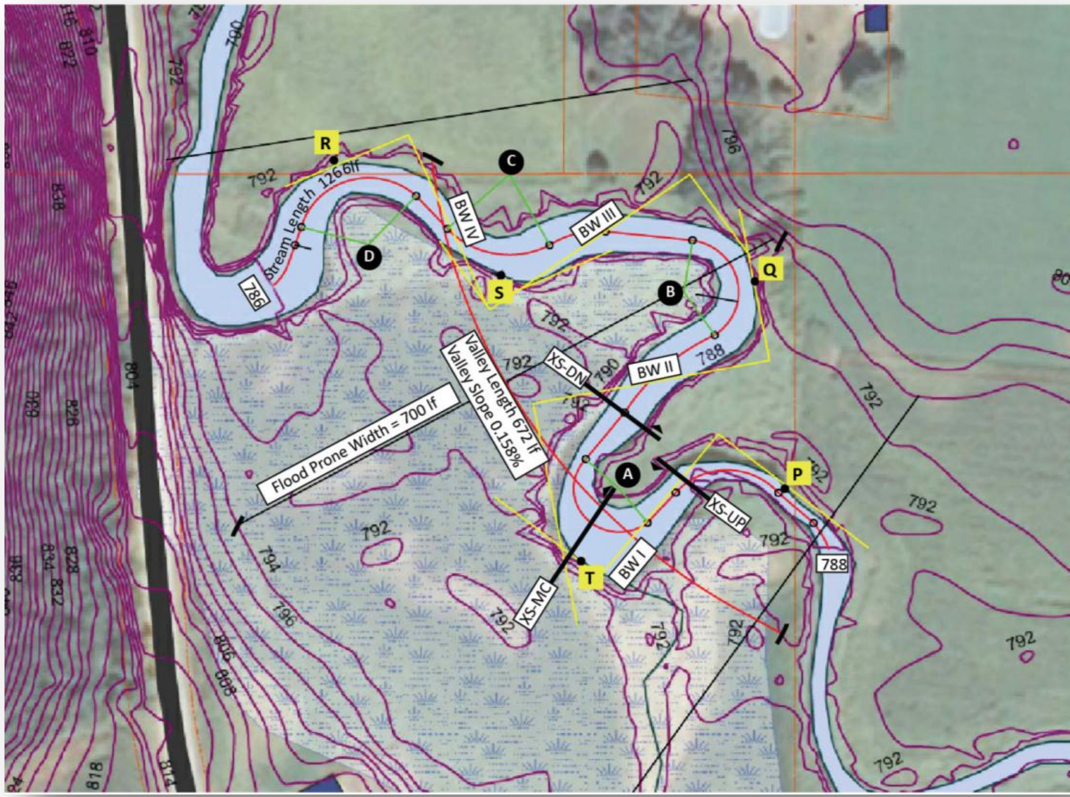

FIGURE 5.14 – REFERENCE REACH PLAN GEOMETRIES. SOURCE: DANE COUNTY. AERIAL PHOTO (N_4308950_SE_16_1_20080829.TIF), CONTOURS (FLY DANE PARTNERSHIP, 2009), BUILDING FOOTPRINTS 2008, ROAD CENTERLINES 2008, HYDROLINE & HYDROPOLY 2008. CREATED BY 2010 WRM PRACTICUM.

Stream Alignment Options

Two conceptual stream alignments were explored. Both plan options begin and end at the same stations, resolve the 7.25 foot grade differential between the upstream and downstream points, and use the abandoned stream channel to meander around the existing dam structure.

Option A attempts to emulate the Black Earth Creek reference reach as closely as possible. The high sinuosity channel allows a maximum stream meander and develops stream length to take up elevation change. However, to match the reference reach channel slope, the high sinuosity channel has a low slope, 0.0016 (0.16%). This slope is not sufficient to transition to the existing stream elevation below the dam. A less sinuous, steeper stream reach with a 0.00625 (0.625%) slope was therefore used to transition to Black Earth Creek below the dam. The point of transition is located perpendicular to the dam structure and takes advantage of the constricted space between the existing structure and adjacent farm field slopes. The total channel length for stream option A is 3000 feet, with 2400 linear feet using the shallow slope morphology and the downstream 600 lf using the steeper morphology (Figure 5.15).

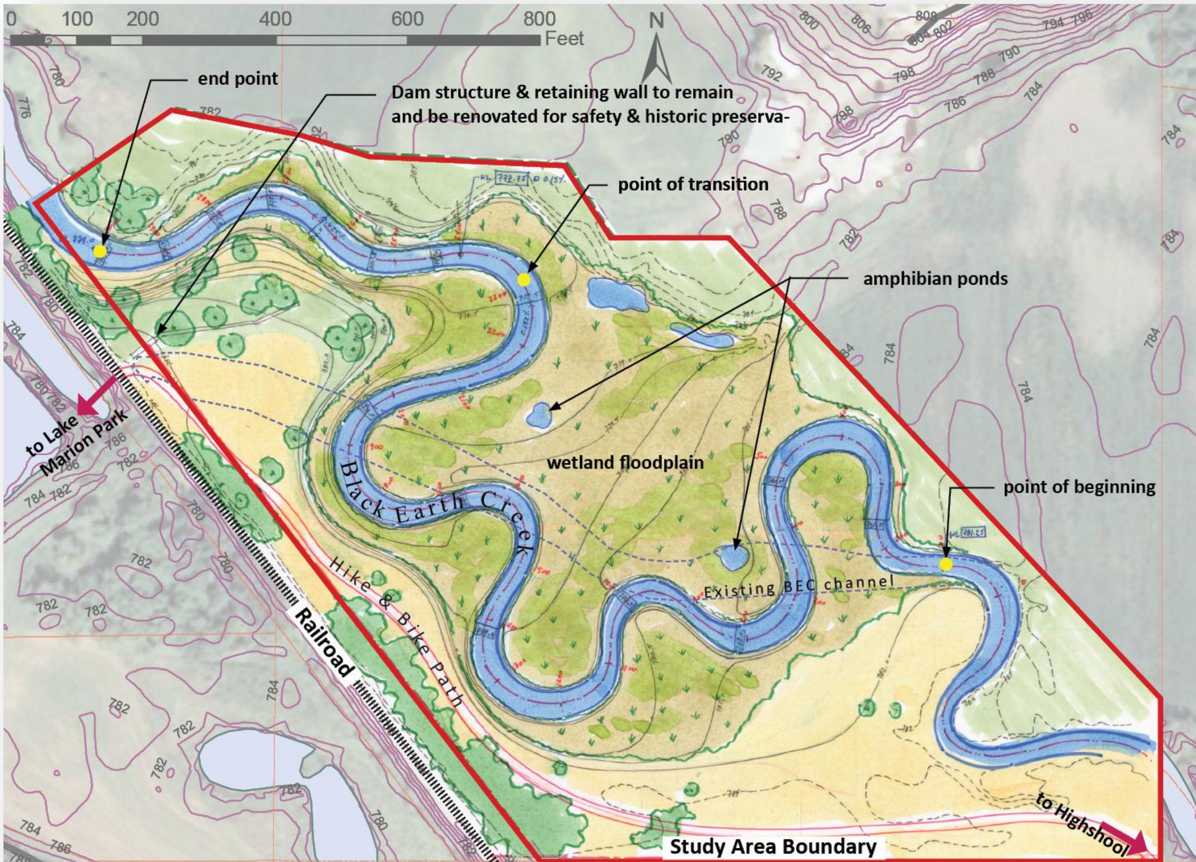

FIGURE 5.15 – FLOODPLAIN AND STREAM RESTORATION OPTION A. SOURCE: DANE COUNTY. AERIAL PHOTO (N_4308950_SE_16_1_20080829.TIF), CONTOURS (FLY DANE PARTNERSHIP, 2009). DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

The second stream alignment, Option B, explores using a single gradient stream with less sinuosity and meander, less stream length, and more defined riffle-pool sequence. Option B's channel slope is a moderate 0.003 (0.3%) and has a channel length of 2500 feet (Figure 5.16).

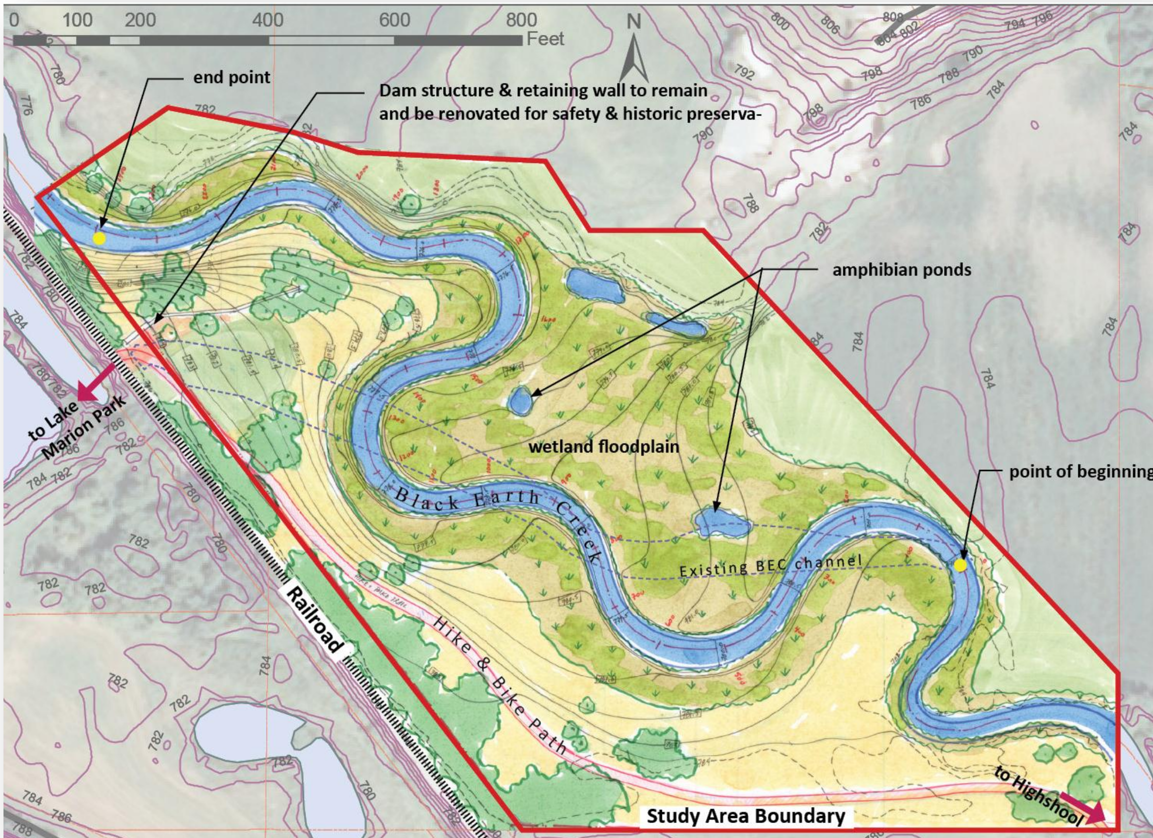

FIGURE 5.16 – FLOODPLAIN AND STREAM RESTORATION OPTION B. SOURCE: DANE COUNTY. AERIAL PHOTO (N_4308950_SE_16_1_20080829.TIF), CONTOURS (FLY DANE PARTNERSHIP, 2009). DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

According to stream restoration professionals, stream plan option B requires a coarser, gravelly bed material to create the defined riffle-pools. This material must be imported to the site. Stream plan option A does not require coarse bed material, but the banks may need to be armored to prevent channel-jumping and to protect against possible head-cuts during flood events. Where the stream has close meanders or runs in close proximity to floodplain scrapes, there is a higher chance of avulsion, which is where a channel creates a new channel and abandons the old. Strategies for mitigating head-cut and avulsion include bunkering the downstream slope with bioengineering, such as root wods and coarse woody debris, or building a floodplain levee on the upstream meander. Though the two options present conceptual plans for study, further engineering and modeling will be required to evaluate the plan geometries for bank shear stress and floodplain impacts.

Wetland Floodplain Restoration

Historic Public Land Survey records, NRCS soil maps, and buried wetland soils found beneath cultural soils in the floodplain indicate that the study area was historically a wetland. Furthermore, the property owner has a strong desire to restore significant wetlands along the stream. Therefore, in both stream realignment options, we recommend restoring a generous wetland floodplain in the wide area upstream of the dam between the railroad right-of-way and Mr. Wolf's farm fields.

Hydrology is perhaps the most critical factor in wetland restoration. Wetland plant communities require the moisture regime in the saturated soil zone. Other factors to consider in wetland restoration include the soil type, depth to groundwater, and frequency of floodplain inundation. At the East Branch Pecatonica River, restored floodplain elevations were determined by visually identifying the pre-settlement floodplain surface through a series of soil cores and transects. Accumulated sediments were then scraped and removed to restore the pre-settlement floodplain elevation (Booth, correspondence). A similar approach could be taken to restore the wetland floodplain in the study area.

Modeling of discharge stages and bankfull elevations provide another approach to determine floodplain surface elevation. A benchmark recognized in the stream restoration community is a bankfull recurrence interval of 1.5 years. However, a wetland floodplain typically experiences more frequent inundation. A floodplain inundation study along Black Earth Creek in Cross Plains, Wisconsin found that, under normal conditions, Black Earth Creek exceeded its bank elevations 10-20 times per year along a 0.55 mile study reach (Boyington, 2010). A recurrence interval from 0.06-0.14 years was recorded and found to be a higher frequency of inundation than reported at other sites. However, wetland restoration, especially along groundwater-fed Black Earth Creek may be dominated more by hydrogeology than stream discharge. Boyington concluded that very little of the total discharge actually flows across the floodplain (<1%) and that the "channel-floodplain interaction is less than commonly thought" (Boyington, 2010, i).

Similar to the East Branch Pecatonica River project, the excavated floodplain may be seeded with a wet-mesic sedge meadow mix. Wet sedge meadow species such as *Angelica atropurpurea L.* (great angelica), *Calamagrostis canadensis Michx. P. Beauv* (blue-joint grass), *Carex vulpinoidea Michx.* (fox sedge), *Impatiens capensis Meerb.* (orange jewelweed), *Scirpus atrovirens Willd.(*black bulrush), and *Carix hystericina Muhl. ex Willd.* (porcupine sedge) are already present in the existing floodplain in the oxbow area just northeast of the dam. During the sedge meadow establishment period, a management plan to control invasive species such as *Phalaris arundinacea L.* (reed canary grass) should be considered.

In addition, existing groundwater depressions in the landscape can be maintained, and others created, to provide critical habitat for amphibians. Providing habitat for "non-game" species should be a goal of the floodplain restoration. In addition to hibernacular structures for turtles and snakes, shallow scrapes in the floodplain and preservation of oxbows provide habitat for forage fish and amphibians. Shallow banks enable frogs and turtles to easily maneuver between land and water while wetland vegetation provides cover from predators as well as habitat for laying eggs. Additional structures such as rocks and fallen "basking" logs provide habitat for both thermal regulation and cover. A comprehensive guide to riparian restoration in the Driftless area can be found in Trout Unlimited's 2009 *Driftless Riparian Habitat Guide* (Hastings, 2009).

Preserving the Dam Structure

In both stream realignment options we recommend restoring the stream channel to the abandoned channel northeast of the dam, bypassing the dam structure, and leaving the dam structure in place. The dam is considered by the community to be a historic monument that played a critical role in the development of Mazomanie. By re-grading the earth around the dam and making minor modifications to the structure, the dam can not only be made safe, but also be commemorated and celebrated for its role in the town's history. In addition, a landscape plan and interpretive signage could be developed to enhance the dam's significance. Leaving the structure in place can save costs associated with removal and allows grant funding to be allocated towards other dam removal work, as permitted under the DNR's Dam Removal Grant.

The Larger Vision: Wolf Run Association Vision

The restoration in the study area is part of the larger vision of the Wolf Run Association, which is to create a public easement along the Black Earth Creek corridor. Mr. Wolf has been an active proponent for removing the dam and restoring the stream, wetland, and floodplain within his property. He is interested in dedicating roughly sixty acres of his private property along the creek for stream enhancement, wetland creation, and recreational amenities for the public such as nature observation, angling, canoeing, hike and bike trails and a public park. The plan is to connect the hike and bike trail to the regional trails system, including the Good Neighbor Trail. Connections from downtown Mazomanie and under Highway 14 will allow pedestrian passage to Lake Marion Park. This pedestrian passage could connect to the stream corridor at the dam location and head further south through DNR property to the high school (Figure 5.17). A linked trails system provides benefits to the community such as safe access and recreational opportunities.

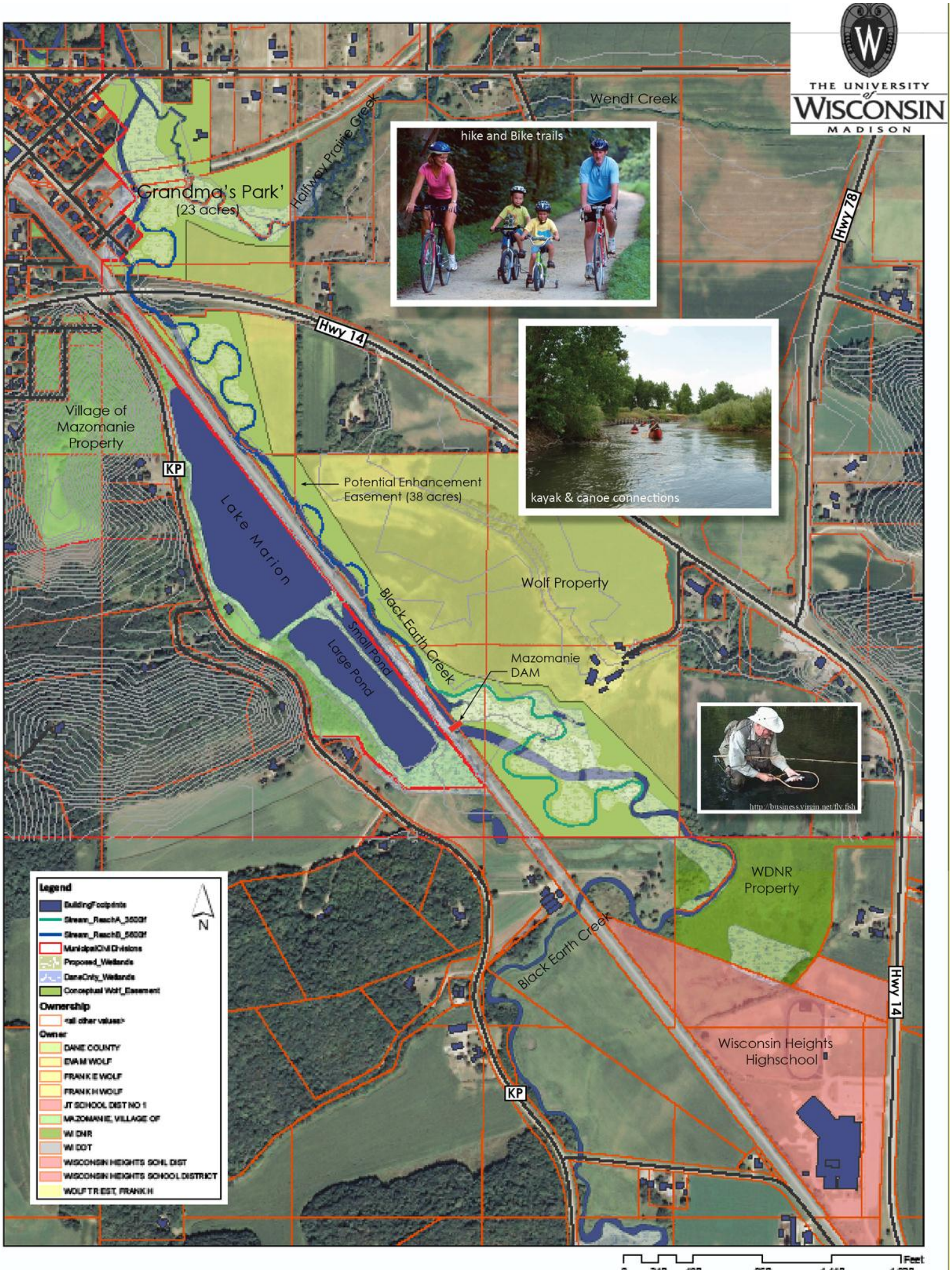

FIGURE 5.17 – MAP OF WOLF RUN ASSOCIATION CONCEPTUAL STREAM EASEMENT. SOURCE: DANE COUNTY. AERIAL PHOTO (N_4308950_SE_16_1_20080829.TIF), CONTOURS (FLY DANE PARTNERSHIP, 2009), BUILDING FOOTPRINTS 2008, ROAD CENTERLINES 2008, HYDROLINE & HYDROPOLY 2008, DANE COUNTY WETLANDS. CREATED BY 2010 WRM PRACTICUM.

CONCLUSION

The Mazomanie dam has had a detrimental impact on the natural function of the adjacent Black Earth Creek and the immediate upstream floodplain. Removing the function of the Mazomanie dam presents the opportunity to restore the adjacent Black Earth Creek and floodplain. Our assessment provides preliminary estimates of the floodplain sedimentation impacts associated with the dam as well as preliminary restoration design options to consider upon dam removal. Restoration of these natural systems will result in positive impacts to local biodiversity, flood control, and recreational opportunities and are consistent with the community's goal of enhancing this unique natural resource for future generations. The Village's decision to remove the dam opens up an opportunity to enhance the natural character of Mazomanie and sustain its independence and vibrancy of place for the future.

CHAPTER 6: ALTERNATIVES AND RECOMMENDATIONS

In the following chapter, the baseline information gathered by our group over the past year is used to identify the key issues that need to be addressed in order to maintain and enhance the Lake Marion area's natural conditions and recreational opportunities. We also identify feasible management alternatives to improve the limnic (open water), littoral (shoreline), park, and pond zones (Figure 6.1). These management alternatives address water quantity, water quality, the fishery, carp management, shoreline habitat, invasive plant management, goose management, recreational opportunities, and the southern ponds. The management alternatives listed in this section balance feasibility with a best fit for the current conditions and stakeholder preferences. A review of the alternatives shows that implementation of a single alternative may not improve an entire area; however, it will address the relevant issue and it could address multiple issues. On the other hand, while implementation of all the listed alternatives may not be an efficient use of resources, multiple alternatives could be required to completely address a single issue. Finally, while our recommendations represent what we as a group believe will be the best combination of actions for the enhancement of the Lake Marion area, it is up to the Village of Mazomanie to make all final decisions on what management strategies are actually implemented in Lake Marion and the surrounding area.

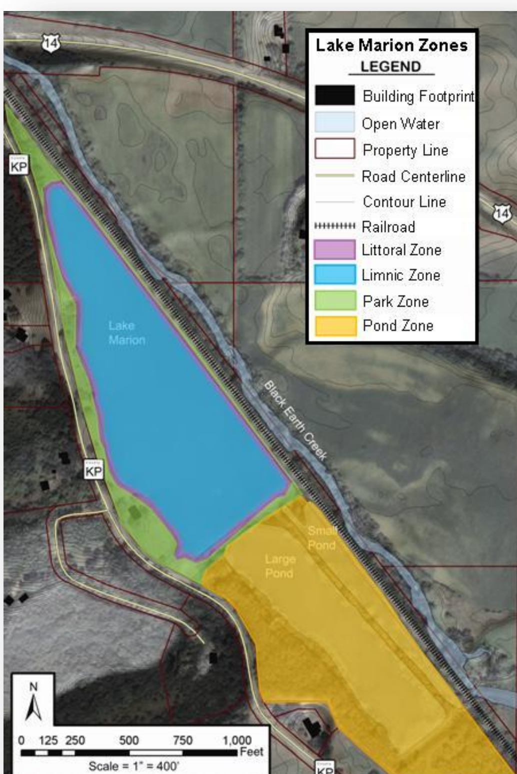

FIGURE 6.1 – LAKE MARION AREA ZONES: CONCEPTUAL ZONES OF FOCUS FOR MANAGEMENT ACTIVITIES IN THE LAKE MARION AREA. SOURCE: DANE COUNTY. BUILDING FOOTPRINTS 2009, OPEN WATER 2008, PARCELS 2009, ROAD CENTERLINES 2008, 2' CONTOURS 2009, AERIAL IMAGE 2008. CREATED BY 2010 WRM PRACTICUM.

Limnic Zone: Lake Marion

One of the main areas of concern for this project is the open water of Lake Marion, also known as the limnic zone. In order to maintain Lake Marion after the dam on Black Earth Creek is removed, there are three main issues to consider: ensuring adequate water quantity for the lake, improving the water quality, and improving the fishery. In this section we explore these three main issues and present recommended management alternatives.

Ensure Adequate Water Quantity

Once the dam is removed, an alternative water source will be needed to maintain Lake Marion's water levels. In this section we explore the use of groundwater as the most feasible water supply. We also explore the potential sources of power for the pump. As discussed in detail in Chapter 3, Water Supply and Quality, seepage from the lake is the dominant uncontrolled outflow. Therefore, the rate at which water seeps out of the lake is the minimum rate at which water will need to be supplied. Reducing seepage would reduce the cost of supplying water to the lake. Seepage reduction can be achieved in three ways: (1) sealing the lake with an impervious material; (2) constructing a lateral underground cut-off wall; and (3) physical compaction of the lake bed. The feasibility of each of these methods is discussed in this section.

The results of our investigation demonstrate that groundwater is the most feasible water supply. The water will need to be pumped from a well constructed within the Lake Marion area. The pump could potentially be powered by solar, wind, or electricity. The feasibility of each power source is discussed here. It is important to note that Jewell and Associates identified other alternative water supplies, including pumping or diverting water from Black Earth Creek; we recommend investigating these further to confirm that groundwater is the most feasible source.

Reduce Seepage

The effectiveness of the seepage reduction methods are determined by the hydrogeology and water level of Lake Marion. Approximately half of the seepage from Lake Marion occurs through the edges. The hydrogeology, and more specifically the soil immediately surrounding Lake Marion, determines where seepage rates are the greatest. The clay lining underneath the lake limits seepage through the bottom; whereas the relatively porous material found on the edges of the lake encourage seepage there. Higher water levels provide more area through which water can seep, which greatly increases the rate. At the highest water level during our lake shut-off experiment, the seepage rate was estimated to be approximately 460 gallons per minute (gpm). At the lowest water levels the seepage rate was estimated to be 100 gpm. Figure 6.2 demonstrates how seepage reduction management activities, such as sealing the edges with impervious material and reconfiguring the banks to a more gradual slope, could drastically reduce the seepage out of Lake Marion.

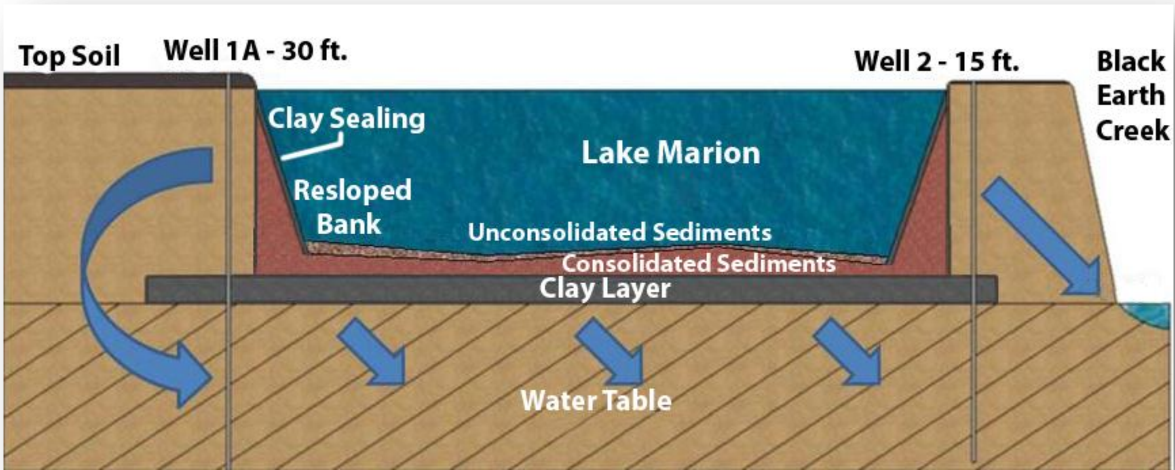

FIGURE 6.2 – SEEPAGE REDUCTION OPTIONS FOR LAKE MARION: THIS DIAGRAM ILLUSTRATES THAT THE GREATEST AMOUNT OF SEEPAGE OCCURS FROM THE EDGES (BLUE ARROWS) OF LAKE MARION. NOTICE THAT RECONFIGURING THE BANKS TO A MORE GRADUAL SLOPE AND SEALING THE PERIMETER WITH IMPERVIOUS MATERIAL (CLAY SEALING) CAN REDUCE SEEPAGE FROM THE EDGES OF THE LAKE.

Also, reducing the water level would reduce the bank surface area underwater, which would reduce the seepage rate even further.

SEALING

Sealing or lining involves adding a layer of impervious material to the lake's bottom and sides to reduce seepage. If dredging is performed, a sealant should be applied to reduce seepage from Lake Marion (see Chapter 6, Dredging). Several options exist for sealing the lake. One option is to re-line the edges of the lake to reduce horizontal seepage (Figure 6.2). The entire lakebed could also be sealed. This option would be more effective, but much more costly.

Bentonite, a type of clay, is commonly used to seal lakes because of its low permeability and non-toxicity. We identified two such products and compared the cost feasibility. One product, Pondseal, consists of bentonite clay particles wrapped around a limestone aggregate core that swells when hydrated to form a uniform, durable layer to prevent leaking. Application of this product on the perimeter of the lake would require a 3 to 1 reconfiguration of the edges for best results (Figure 6.2; also see Chapter 6, Bank Reconfiguration). Another product, known as Environmental Soil Sealant (ESS-13), contains compounds that work together to close pores by chemically and electrically re-aligning the clay particles within the existing lining of the lake. This product is both EPA compliant and non-toxic. Both products have been designed to be applied through standing water without drawing down lake levels. However, with ESS-13, the waterborne application method simply involves pumping or pouring approximately a gallon of product for every 2,000 gallons of water (rates will vary) and allowing it to settle out. ESS-13 waterborne application in Lake Marion was estimated to be $10,000 per acre. Over the entire 16 acres, the cost would amount to $160,000. To seal the lake perimeter alone, the estimated cost for applying Pondseal would be between $100,000 and $125,000.

CUT-OFF WALL

Another option for reducing seepage from Lake Marion would be to install a subsurface water flow barrier wall between Lake Marion and the railroad tracks. Due to elevation gradients, water is seeping from Lake Marion towards Black Earth Creek through the side next to the railroad (this was observed during the field work). In order to effectively evaluate this option, a detailed engineering design and cost estimate is required. If this option is of interest, we recommend an investigation into the feasibility of a cut-off wall for Lake Marion. Major considerations for this evaluation are:

- Cost for the engineering design.
- Materials procurement and construction.
- Materials and methods for effective installation.
- Accurate depth to groundwater and underlying clay layer.
- Confirmation of the presence and exact location of the suspected underlying clay layer.
- Length of cut-off wall necessary to effectively control underground water flow and water loss from Lake Marion.
- Regulatory permit and environmental conditions required for installation.
- The cost effectiveness of this option compared to other alternatives.

PHYSICAL COMPACTION

Another option for reducing lake seepage is lake drawdown and then physical compaction of the lake bottom by using heavy equipment. The compacted sediments would act as a lake sealant by reducing the sediment porosity. This option could be combined with reconfiguration of the lake edge with dredged material and then compaction of the reconfigured surface with heavy equipment. If this is done, it would be critical to avoid using the thin organic-rich material on the lake bottom. Material obtained from the dredging of deeper areas might be ideal as this material will be finer and have a high clay content. This combined option may be the most cost-effective seepage reduction option, especially if done in conjunction with lake dredging.

Water Supply Source

Source: Groundwater

Dam removal leaves Lake Marion without a water supply source. Water could be supplied from either local groundwater or Black Earth Creek. Although we did not conduct a formal assessment of Black Earth Creek as a water source, we did identify limiting factors. A creek source would require a permit for water withdrawal. The use of Black Earth Creek water would continue the eutrophic conditions that exist in the lake. If gravity flow is used, a long pipeline would be required. Such a pipeline would be subject to chronic sedimentation problems. Finally, pumping from a nearby location on the creek would be expensive, although less expensive than pumping groundwater since the elevation difference between Lake Marion and Black Earth Creek is less than the elevation difference between the lake and the groundwater well depth. For these reasons we focused our efforts on a groundwater source.

Our assessment found that low-nutrient regional groundwater is found at depths of 80 feet or greater. This depth is still considered part of the unconfined alluvial aquifer. As shown in Table 6.1 below, groundwater has lower TP concentrations compared to both the lake and the creek. Groundwater is also inherently free of total suspended solids (TSS) whereas the surface water source has high concentrations. Therefore, a groundwater source would not only reduce the phosphorus loading to the lake, but it would also reduce TSS and sediment loading, thus reducing external causes of turbidity. It is important to note that because of the depth of the source, the groundwater is low in dissolved oxygen (the recommended DO concentration for aquatic life is >5 mg/l). This issue can be solved through aeration of the water as it is pumped into the lake. Another positive consequence of a groundwater source is that it reduces the chance of introducing invasive species from Black Earth Creek into the system. For instance, curly leaf pondweed, an invasive aquatic plant, and a portion of the carp population were most likely introduced from the creek into the lake through the surface water source connection.

TABLE 6.1 – GROUNDWATER QUALITY: SUMMARY OF THE GROUNDWATER QUALITY RESULTS IN COMPARISON WITH SURFACE WATER QUALITY

	80ft groundwater well	Black Earth Creek (average)	Lake Marion (average)
Total Phosphorus (mg/l)	0.02	0.23	0.03
Dissolved Oxygen (mg/l)	0.6	7	8

Overall, an on-site groundwater well is the most feasible water supply option for Lake Marion. Once the well is constructed, the cost of maintenance will come from supplying power to the pump. The most cost effective approach would be to reduce the seepage rate and find a middle ground between socially desirable and cost-effective water levels. Once again, a more detailed study is required to determine the specific attributes, such as location and depth, of the new water supply well.

Supply Management (Energy)

The new water supply for Lake Marion will need to be pumped from the source, such as from a groundwater well. Pumping an average of 200 gallons of water per minute could require significant amounts of power, in the range of 5 to 20 kilowatt hours (kWh). We investigated various power sources, including the electrical grid, solar energy, and wind energy.

Connecting to the grid has several benefits. It requires the lowest upfront costs, namely extending the existing lines from the shelter to the pump's location. Of the options we investigated, grid power provides the most stable and consistent power source. In addition, setting it up would only slightly alter the lake's appearance since lines can be buried if needed. However, it requires purchasing power on an ongoing basis and is an ongoing cost with no payback. At the present electricity rates of $0.081/kWh, the potential monthly and cumulative costs are considerable.

FIGURE 6.3.1 – ENERGY SOURCE OPTION: ELECTRICAL GRID. SOURCE: WWW.APEXIN.DIA.IN/POWERHTML

FIGURE 6.3.2 – ENERGY SOURCE OPTION: WIND. SOURCE: HTTP://WWW.THECUTTINGEDGENEWS.COM/

There are advantages and disadvantages to the two renewable energy options as well. They are considerably more expensive to install and, since both solar and wind systems wear out over time, they will require replacement. Fortunately, ongoing costs to operate and maintain them are much lower than the ongoing costs for grid power. With current technology, both renewable energy systems require batteries that need maintenance, although advancements in renewable energy technology could reduce the need for batteries. Finally, solar and wind systems will change the lake's appearance in ways that some park users may not like.

There are many benefits to using solar and wind systems. They allow for a smaller carbon footprint than grid power. The systems can be purchased from local manufacturers and distributors, so money goes back into the local economy, and maintenance services are nearby. Renewable energy is also subsidized by governmental rebates, credits, and grants. In addition, excess electricity could be sold to the local power utility. This would reduce costs and add to the carbon-reducing benefits. Selling back to the grid would require an additional step of converting the energy from DC to AC, but creating such a hybrid system is a common practice.

FIGURE 6.3.3 – ENERGY SOURCE OPTION: SOLAR. SOURCE: HTTP://DEV.NSTA.ORG/EVWEBS/3368/IMAGES/ SOLARCELLSPANELSARRAYMONOCRYSTALINE.JPG

Solar panels require an open area free of shade, of which Lake Marion has an ample supply. Solar power generation is the greatest during the summer when the sun shines brightly and for many hours of the day. This is precisely when the lake loses the most water through evaporation. Thus solar power supply and demand correspond and the solar panels supply the most power when it is needed. Solar panel arrays are also highly durable. The average life of a panel is 25 years or longer. With no moving parts and a temperature range of -40 to 104 °F, the only maintenance they require is a quick wipe down to remove dust during particularly dry periods. According to recent estimates, a 1 kilowatt (kW) solar electric panel generates about 1200 kW of power per year and costs between $5,000 and $7,000 (Niels Wolter, personal correspondence, 2010).

Wind turbines are another renewable energy solution. Wisconsin has moderate wind resources that are greatest during the winter. An on-site wind assessment would determine if the area surrounding Lake Marion has enough wind to make wind power a viable option. With their moving parts, turbines require more maintenance than solar panels and can face damage due to icing. A warranty will cover such issues, but only over the duration of the warranty—typically five years. There is also the issue of adequate height for the turbine, which in the case of Lake Marion is approximated at 60 feet. Finally, wind turbines are not cheap. A 10 kW turbine that produces 6,750 kW per year could cost $56,000. A 100kW turbine that produces 140,000 kW per year could cost $550,000 to $750,000.

All three energy sources are potentially feasible at Lake Marion. The main differences between them are the initial investment, continued costs, funding opportunities, and aesthetic changes. These four points should be considered over the life of the lake.

Recommendations For Maintaining Adequate Water Quantity

Maintaining a water supply to Lake Marion is extremely important once the dam on Black Earth Creek is removed. This section has provided a detailed overview of many management alternatives for maintaining water quantity in Lake Marion. Based on our field studies, research, and consultations with experts, we recommend the following select list of management alternatives.

- Reconfigure the banks to a more gradual slope using appropriate (low organic matter and fine particle) dredged material.
- Physically compact the lake edges with heavy equipment.
- Seal the lake edges with impervious material.
- Identify an appropriate depth, location, and capacity for a groundwater well in order to use groundwater as the alternative water source for Lake Marion.
- Install a power pump that uses the electrical grid.

Water Quality Improvement

Improving water quality once the dam is removed will be crucial for maintaining Lake Marion's function as a fishery, natural area, and place of recreation. For that reason, the quality of the new water source will be important. Since phosphorus loading is the main cause of algae blooms and excessive plant growth in lakes, selecting a new water source that is low in phosphorus should be a priority. A reduction in internal and external phosphorus loading, from phosphorus-laden lake sediments and stormwater runoff from the watershed respectively, would also improve the water quality of Lake Marion. Decreasing the turbidity would increase water clarity and decrease phosphorus concentrations associated with suspended sediments. Increasing the dissolved oxygen concentrations would benefit the fishery. The following section addresses these issues in more detail.

Phosphorus Management

Dredging

Dredging, a technique used to remove sediment from the bottom of a lake, is a management technique aimed at reducing internal phosphorus loading within Lake Marion. Other positive consequences of dredging include deepening the lake and having the dredged material available to reconfigure the banks (see Chapter 6, Bank Reconfiguration). Dredging can be accomplished by hydraulic or mechanical methods. Hydraulic dredging is more common than mechanical dredging because mechanical dredging tends to be both more environmentally disruptive and more limited in application. If the phosphorus-laden sediment at the bottom of Lake Marion is to be removed, large-scale dredging, using one of the above methods, would be needed.

Lake Marion, similar to other shallow and eutrophic lakes, does not stratify thermally and is susceptible to continual or periodic nutrient input from bottom sediments (Stauffer & Lee, 1973). In the case of significantly nutrient-laden sediment, sediment removal may help reduce the rate of internal nutrient recycling, thus improving overall lake and water quality conditions (Cooke et al., 2005). Toxic substances, such as polychlorinated biphenyls (PCBs), are uncommon but could pose a serious problem if present. Toxic substances, which bind to fine sediment particles, are usually suspended in the water and take a significantly long time to re-settle to the bottom of the lake.

A positive consequence of dredging is deepening the lake. According to the bathymetry survey we conducted, the average depth of Lake Marion is about 5 feet at present. On average, there is about a half foot of soft sediment that could easily be removed from the lake bottom. In addition, more consolidated sediment could be removed in selected areas to create deep spots. Removing this sediment will eliminate a significant source of fine, re-suspendable sediment and phosphorus.

Deepening the lake will help increase the water volume and help prevent winter fishkill events by providing refuge for fish during the winter months. Some of the dredged sediment could be used to reconfigure the banks to form a more gradual slope (see Chapter 6, Bank Reconfiguration). The high phosphorus and organic content of some of this sediment might make it unsuitable for bank reconfiguration; therefore, careful consideration should be taken when reusing dredged material. For instance, material found at the deepest locations that contain low organic content and higher clay content would be beneficial when reconfiguring the banks.

Dredging has local and non-local negative impacts. Phosphorus release during dredging may cause temporary nutrient enrichment of the lake and potentially create algal blooms. Toxic substances, described earlier, also have the potential to become re-suspended during dredging activities. This is a problem for the lake ecosystem because aquatic organisms more easily ingest solids, and associated toxic substances, that are suspended in the water column rather than particles remaining at the bottom of the lake. In addition, the destruction of organisms at the bottom of the lake is a concern because two to three years may be required to reestablish these communities as a fish food source. However, in general, these local impacts are acceptable given the long-term benefits of sediment removal.

Sediment disposal requires major consideration before dredging. According to Section 404 of Public Law 92-500, The Clean Water Act, a federal permit is needed if the dredging or filling of any wetland area exceeds ten acres. The disposal area can become an environmental nuisance. Also, sediment transport and disposal requires a local dredge sediment containment site to allow water removal from the sediment, a process known as de-watering, to help reduce the costs associated with dredging.

Dredging costs depend on mobilization expenses, the volume and type of sediment to be removed, labor, and hauling/disposal expenses. If the containment/disposal site is in close vicinity to the dredging project, the cost of dredging can be significantly lower. For Lake Marion, there are two options that lower the dredging cost: using the dredged material to fill the ponds, or as fertilizer for crops if the phosphorus content is not too high. Dredging estimates for the soft sediment that is predominantly found in Lake Marion were obtained from two dredging companies. The costs ranged from 8 to 10 dollars per cubic yard if the sediments are disposed of nearby. During sediment depth analysis, we estimated the volume of soft sediment in Lake Marion at approximately 14,000 cubic yards. It is important to note that not all sediments need to be removed. Key locations within the lake could be chosen for deepening and sediment removal.

Prior to initiating a lake dredging project in Wisconsin, the WDNR requires an individual permit. This involves several steps. Chapter NR347 of the Wisconsin Statutes covers the dredging project requirements for sediment sampling and analysis, monitoring protocol, and disposal criteria. Three applications must be submitted in the permit process. The preliminary application encompasses the initial proposal. The WDNR should respond within 30 days to identify sampling requirements. Once the WDNR has responded and before implementing the plan, a Sampling and Analysis Plan should be submitted by the applicant. The NR347 guidance generally recommends that three sample cores be taken to determine the concentrations of various metals, nutrients, and inorganics and to determine the physical properties of the sediment. Consultation with a WDNR water management specialist is needed, especially to determine if the sediment may be used to fill the small pond or be applied to cropland. In summary, the associated benefits and concerns with dredging are as follows:

Benefits

- Removes phosphorus-laden sediments
- Removes contaminated sediments
- Deepens areas of the lake
- Low organic, high clay content material can be used to reconfigure the banks

Concerns

- Temporary re-suspension of sediments
- Potential re-suspension of toxic substances
- Locating a proper disposal area
- High costs
- Obtaining proper permits

In the case of Lake Marion, if external nutrient sources were also reduced, nutrient control through sediment removal could be significant. Overall, dredging is a feasible solution to reduce internal phosphorus loading if it is properly conducted and the required permits are obtained.

ALUM TREATMENT

One method of controlling algae blooms is using a chemical treatment for inactivation of phosphorus from the water column and lake bottom sediments. Aluminum sulfate, commonly known as alum, is a chemical that is widely used in the management of lakes and reservoirs to control phosphorus concentrations and increase water clarity. It is also used in the drinking water treatment industry to increase water clarity. Alum is popular because it has low toxicity to biota when applied with the proper precautions (Cooke et al., 2005). Alum can be applied using either a surface or underwater application. With surface treatment, the alum sinks down through the water column, forms aluminum hydroxide that clings to the particulate and soluble phosphorus in the water, and then precipitates out (changes from a dissolved to a solid form). Underwater application tends to be slower, more expensive, and less effective on phosphorus within the water column. With both application types, as the alum-phosphorus particles sink, it coats the sediment along the lake bottom, which prevents the future release of phosphorus. Thus the phosphorus in both the water column and the sediments become inactivated. This process quickly clarifies the water and could possibly show results within hours.

Prior to application of alum, there are a few important factors to consider. Alum treatment is sensitive to pH. Application of alum is optimal between pH of 6 to 8. At a pH less than 6, alum reacts with water to form products that are toxic to fish. During alum application, the pH should be monitored since pH reduction can occur during treatment. It is also important to be aware of wind conditions, especially in shallow lakes, that may disturb the formation of the alum-phosphorus particles. Underwater applications are generally recommended in situations where wind might be a hindering factor. Macrophyte (large aquatic plant) growth is not affected by alum treatment of water bodies but dense growth may interfere with the application. Some of these plants have also been known to release phosphorus. For effective alum application, it is recommended that the littoral zone, where macrophyte growth is abundant, be avoided. Once water clarity has improved with alum treatment, a shallow lake such as Lake Marion may experience an increase of macrophyte growth due to increased light penetration to the lake bottom (WDNR, 2003).

According to the WDNR, it is best to reduce the amount of phosphorus entering the lake before applying alum since the treatment does not interact with new phosphorus entering the system. Prior to adding alum, approval from the Wisconsin Lakes Department of the WDNR is required. The application process involves submitting a detailed plan for the alum treatment that includes dosage rates, when the treatment will be implemented, and what type of follow-up monitoring will be performed. For this type of treatment, unlike dredging, there may be potential lake implementation grants available. The cost of alum treatment greatly depends on the form of alum used (liquid or granular), the dose, and the area being treated. Estimates from 2003 show that costs range from $280 to $700 per acre (WDNR, 2003).

It may be feasible to use alum in Lake Marion if pH is within an acceptable range. Before treating with alum, the amount of phosphorus entering Lake Marion should be considered, especially if a new water source is established. Several studies have documented that alum treatment is more effective in stratified lakes as opposed to shallow lakes such as Lake Marion. Six of nine shallow lakes studied showed the phosphorus treatment to be effective on the average of 8 years (Cooke et al., 2005). Ultimately, alum treatment in Lake Marion may potentially reduce phosphorus release from bottom sediments, enhance the water clarity of the lake by reducing phosphorus in the water column, and reduce algae blooms.

STORMWATER RUNOFF CONTROL

Runoff from storm events has the potential to transport high concentrations of nutrients, sediments, and other chemicals. Lake Marion's watershed is relatively small (390 acres), therefore, stormwater runoff contributes only a small volume of water. Nonetheless, this small volume could potentially contain high concentrations of phosphorus and other chemicals from adjacent areas such as parking lots, roads, lawns and agricultural fields. Water quality samples, taken during storm events in the watershed, show total phosphorus (TP) concentrations from the agricultural area (1.3 mg/l) and nearby lawns (0.6 mg/l) were significantly greater than the average TP concentration in Lake Marion (0.03 mg/l). Although the most consistent and largest source of phosphorus is the lake's current water source (Black Earth Creek), stormwater is still a contributor to high phosphorus levels. Improvement of impervious surfaces and proper lawn care practices could reduce the external loading of phosphorus, sediments, and other chemicals to Lake Marion.

In general, impervious surfaces – materials that are not easily penetrated by water – cause more stormwater runoff and pollutant loads (phosphorus, sediments, and other chemicals) than any other type of land use. In the Lake Marion watershed, most impervious surfaces correspond to roads and parking areas. Most pollutants from these areas come from exhaust particles, fluid losses, drips, spills and mechanical wear and tear. When it rains, pollutant-laden stormwater flows directly into Lake Marion instead of being infiltrated into the soil. Impervious areas include compact dirt and gravel parking lots (0.23 acres) and Highway KP, which is an asphalt road that runs for 2,000 feet along the lake. Overall, approximately 1.6 acres are considered to be impervious near Lake Marion.

Street cleaning and reducing road salt use during the winter could reduce the total amount of pollutants that enter Lake Marion. Another step would be to improve parking lots for current areas and for future expansions. Current parking areas could be replaced with porous pavement, such as concrete grids or permeable asphalt. This would allow stormwater to infiltrate directly from the parking lot. This technique works well in low-intensity parking areas such as the ones at Lake Marion. In addition there are multiple benefits such as removal of pollutants by increasing infiltration of stormwater runoff and increasing groundwater recharge. However, this technique has relatively high construction costs and requires frequent maintenance to clean and replace the porous pavement when it gets clogged.

Stormwater could also be reduced by using runoff control structures such as bioretention ponds, grass swales, and vegetated filter strips. These structures capture stormwater, increase infiltration, reduce sedimentation, increase groundwater recharge, and reduce contaminant loads. In the case of Lake Marion where stormwater volume is small, such structures would not be necessary purely for stormwater control. However, if more impervious surfaces, such as parking lots or trails, are constructed in the future, these structures may need to be considered for stormwater control.

Park and residential lawn area make up 7 percent of Lake Marion's watershed; therefore, changing lawn care practices could decrease the amount of chemicals and nutrients going into Lake Marion. According to Chapter 94, Wisconsin Statutes, fertilizer that contains phosphorus cannot be applied to lawn or turf in Wisconsin unless the fertilizer application qualifies under certain exemptions. The intent of the law is to protect Wisconsin's water resources by reducing phosphorus runoff. A simple soil test could show how much nutrient (phosphorus and nitrogen) are contained in the soil and thus how much fertilizer is required to maintain the lawn (Minnesota Department of Agriculture). Unnecessary fertilizer application should be avoided in the Lake Marion watershed in order to reduce nutrient loading and the subsequent water quality issues.

Other chemicals such as herbicides and pesticides should be used as infrequently as possible to reduce the load into Lake Marion. Timing is also important when applying these chemicals and fertilizers. Application should not occur before or during rain events because the product is washed off into the lake instead of being absorbed by the lawn. Goose droppings can be a large source of phosphorus to water bodies; thus, reducing the goose population would also reduce phosphorus load to the lake (see Chapter 6, Goose Management). Plantings in bare soil areas could reduce the sediment load to the lake. Grass clippings are another source of phosphorus that can be easily reduced by spreading the clippings across the lawn or composting them instead of placing the clipping into gutters. Therefore, simple changes in lawn care practices along with reducing the goose population and the amount of bare soil could reduce the amount of pollutants entering Lake Marion.

DECREASE TURBIDITY

Turbidity, the amount of suspended solids present in the water column, is another major water quality concern. High turbidity decreases the amount of light in the water column and disrupts the biotic functions within the lake. Low light levels decrease the growth of plants that otherwise provide important habitat for many aquatic organisms. Also, fish that rely on sight are less able to find prey efficiently. There are two main causes of turbidity in Lake Marion: the feeding activities of carp and the transport of particles through wind and water flow. Management techniques for carp, the main cause of high turbidity levels in Lake Marion, are covered in the Fishery Improvement section of Chapter 3. Management alternatives for reducing wind and water transport of particles are discussed here.

Water transport of particles through stormwater runoff can be decreased by slowing water flows so that suspended particles settle out before reaching the water body. Since stormwater flow is low in this location, the current vegetation is sufficient in slowing the water flow. Decreasing wind deposition requires large areas of open space to be broken up by trees and shrubs of varying heights. Plants with broad tops are especially effective because their width decreases the speed of larger sections of wind. Trees with deep roots reduce the chance of collapse under high strain. Wind disturbance of a lake surface, especially in shallow lakes such as Lake Marion, can be a major cause of sediment re-suspension within the lake.

Allowing the current grasses to grow to their natural height will slow the water flow and decrease turbidity, but it will not provide a very diverse habitat. Native grasses, trees and bushes should be considered to increase the biodiversity of the area and provide wind and water flow mitigation services. There are many attractive native plants that could be used to produce a healthy ecosystem surrounding the lake and reduce turbidity in the process (See Appendix 12, Native Plant and Animal Species of Southern Wisconsin, and Messer, 2004). Implementation of a combination of these management alternatives (creating vegetated buffer strips and carp management) can drastically reduce turbidity in Lake Marion.

INCREASE DISSOLVED OXYGEN

AERATION

Dissolved oxygen (DO) levels are a result of many internal lake processes and play a very important role in the health of aquatic life. DO levels greater than 5 mg/l are recommended to sustain aquatic life (WDNR NR 102.04). Current DO levels in Lake Marion range from 3.5 mg/l to 10 mg/l (see Chapter 3, Dissolved Oxygen). These measurements were taken throughout the summer season. The lower DO readings in the early morning suggest that oxygen depletion is a problem within the lake. The higher DO levels during the day are due to high photosynthetic activity. The movement of water can also increase the DO levels; however, the movement of water entering the small pond from the creek is too low to promote re-aeration. In general the causes of low DO levels include shallow depth and decay of organic matter. Shallow depths cause the entire water body to warm and warmer water has less capacity to retain oxygen. On the other hand, shallow lakes are also more vertically mixed due to wind and wave action. Therefore the water may be warmer, but the actively mixed air-surface interface can add more DO to the system. Lake Marion also has a high nutrient level that produces algal blooms that contribute to organic matter that will later decompose, consume oxygen in the decomposition process, and lead to low DO levels.

Low DO levels (anoxic conditions) can lead to fishkills, which is where fish die due to a lack of oxygen. Fishkills are most common in the winter months when lakes freeze over. Anoxic conditions also allow the release of nutrients from the sediment at the bottom of the lake into the water column. Currently, there are no records of fishkills due to water quality issues in Lake Marion. The lack of ice formation due to the flow of warmer water from Black Earth Creek appears to reduce the likelihood of winter fishkills. However, when the dam is removed this flow will no longer exist. Therefore, because Lake Marion has relatively low DO levels, the lessening of water flow resulting from dam removal will present conditions that may result in fishkills in the future.

A solution to low DO levels is aeration – a process in which air is mixed with water in order to increase the concentration of oxygen in the water. Aerating a lake requires a mechanical aeration system that increases water contact with atmospheric oxygen. This technique is mostly used in small lakes and ponds. It works by pumping air into the lake water column, which allows absorption of oxygen from the atmosphere and, to a lesser degree, from air bubbles. However, the effectiveness of increasing DO by this method is variable. Winter fishkills may also be prevented by an aeration method that causes warmer water at the bottom of lake to mix with colder water near the surface. This circulation prevents oxygen depletion at the bottom of the lake which in turn decreases the release of phosphorus from sediments.

On the other hand, re-suspension of bottom sediments can occur through the physical action of the aeration system, and this would lead to increased turbidity. So, although anoxic conditions may prevent the release of nutrients into the water column, aeration has the potential to release nutrients. Finally, the purchase and installation of an aeration system can be expensive (ranging in the thousands of dollars).

A compressed air aeration system is the system best suited for Lake Marion (Figure 6.4). The compressed air aeration system will require a permanent structure onsite with an air compressor housed in a shelter on the lake shoreline. Air lines along the lake bottom to the deepest part of the lake would need to be installed. Optionally, an air diffuser could be added at the end of the air line. Air is then pumped from the compressor though the air line which causes air to bubble up from bottom of lake. This technique is effective in maximum depths of 10 ft. and mean depths of 6 ft. Lake Marion has a maximum depth of 7 ft. and a mean depth of 5 ft. approximately, so a compressed air aeration system may be appropriate. Maintenance for this system is also low. For Lake Marion, which is approximately 17 acres, one ¾ hp aeration unit would be needed. This would cost approximately $1,150 plus an additional $30 per month for electricity. These figures should be confirmed with a quote.

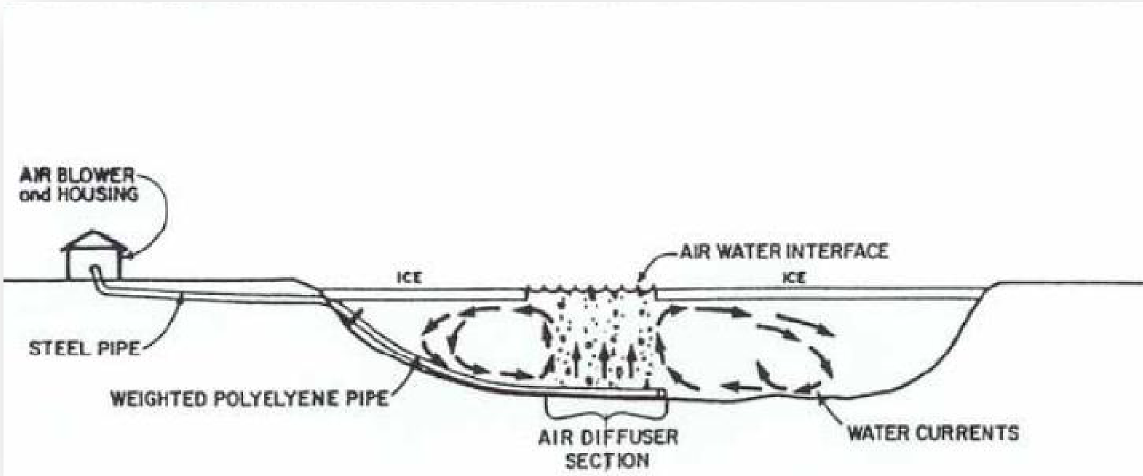

FIGURE 6.4 – A COMPRESSED AIR AERATION SYSTEM (CORNELIUS, 2006).

Another factor to consider when adding an aerator system is the legal requirement for a barricade around the open water during winter (Wisconsin Statute 167.26). An example barricade consists of fiberglass fence posts with PVC sponge net floats and rope passing through posts. Holes are drilled into the ice and fence posts plus net floats are placed in each hole to form the perimeter of the barricade.

There are many things to consider prior to installing an aerator within Lake Marion. Several WDNR permit applications may need to be submitted, including a permit for aeration of a public pond, a permit for a structure at the bottom of a lake, a permit for an open water barricade (Wisconsin Statute 167.26), and a water regulation permit for landowners. Since aerators are driven by electric motors, access to electricity is required. Again, aeration would help increase DO of the alternative water source as it is pumped into Lake Marion. It also prevents winter fishkills, improves lake water mixing, and decreases phosphorus release from sediments. A more in-depth engineering study is required to assess the feasibility of installing an aeration system in Lake Marion.

An alternative to in-lake aeration is aeration of the source water. If groundwater is used, which presented DO values less than 1 mg/l, a compressed air aeration system could be added at the outlet of the pumping system. The incoming water would be pumped and aerated and would discharge at the bottom of the lake through a pipe or water line.

RECOMMENDATIONS FOR WATER QUALITY IMPROVEMENT

Water quality improvement is necessary to the ecological diversity and recreational opportunities currently enjoyed at Lake Marion. Dam removal will alter the water quality of the lake and nearby ponds. The following is a select list of management actions that can be taken to maintain or improve upon water quality issues at Lake Marion. Our field studies, literature research, and consultations with experts led us to recommend the following list of the most feasible management alternatives:

For An Alternative Water Source

- Use groundwater as a water supply source because it has comparatively lower phosphorus and suspended sediment levels (see Chapter 6, Water Supply Source).

For Internal Phosphorus Loading

- Dredge to remove unconsolidated, phosphorus-laden sediments from the lake.
- Apply alum, a chemical treatment, to inactivate the phosphorus-laden sediments.

For External Phosphorus Loading – Stormwater Runoff

- Improve impervious surfaces to increase infiltration of stormwater runoff and reduce transport of phosphorus, sediments, and other contaminants into the lake.
- Improve lawn care practices to reduce fertilizer use.
- Reduce mowed areas along the shoreline.

Reducing Turbidity

- Remove carp (see Chapter 6, Carp Management).
- Create vegetated buffers by discontinuing mowing near shoreline and supplement with plantings of native vegetation.

For Maintaining Adequate Dissolved Oxygen Levels

- Depending on the DO concentration of the new water source, installation of an aeration system may be necessary to prevent winter fishkills. If the new water source is from a groundwater well, water could be aerated at the source, therefore eliminating the need for a complete in-lake aeration system.

Fishery Improvement

Lake Marion's fishery is of the utmost importance to the community, as illustrated by the results from multiple community meeting surveys. A majority (57%) of community surveys indicate that stakeholders are interested or very interested in fishing at Lake Marion (Appendix 4, Question 2). Additionally, a majority (54%) of community surveys indicate that stakeholders are not satisfied with the quality of fishing at Lake Marion (Appendix 4, Question 5). Issues and associated management techniques concerning the fishery are discussed here and include improving the physical habitat, managing the carp population, increasing fish diversity through stocking, and increasing plant diversity through management of the invasive plant known as curly leaf pondweed.

Physical Habitat Improvement

Improving specific physical structures of Lake Marion can create opportunities for greater fish growth and reproduction. There are several methods of shaping the physical environment to make Lake Marion more suitable for fish. First, reconfiguration of the banks to a more gradual slope can create more fish habitat by increasing the shallow area. This alternative is discussed in greater detail in the Bank Reconfiguration section of Chapter 6. Second, addition of woody debris and underwater structures may provide more habitat and protection for fish. Additional structures increase the amount of available hiding places for young fish while they grow and mature into desirable, reproductive adults. Lastly, dredging, aeration, and water quality improvement together can make the habitat more suitable for fish and are discussed in greater detail in the Water Quality Improvement section.

Carp Management

Carp were stocked into Lake Marion in 1893. During this time, carp were stocked throughout much of United States because they were viewed as a potentially important food and sport fish. Today, carp are considered a major contributor to degraded and impaired waters. The high turbidity seen at Lake Marion today is most likely due to the activities of carp. Lake Marion's history shows that carp removal was performed twice on a large scale to maintain the quality of the fishery. The first removal was in 1939 by the State Conservation Commission. A total of 2 to 3 tons of carp were removed from Lake Marion. The second removal was in the late 1980s by the Wisconsin River Sportsmen's Club. Approximately 95% of the carp were removed using pick-up trucks and nets during a lake drawdown event.

Figure 6.5 – Common Carp (*Cyprinus carpio*). Source: Photo by John Lyons; from http://wiscfish.org/fishid/

- Carp are primarily bottom (benthic) feeders and can damage aquatic ecosystems in many ways. Carp cause damage by uprooting submerged aquatic macrophytes and by disturbing bottom sediments. The impact of carp in Lake Marion can summarized as follows:
- Overabundant carp deplete lake-bottom food that is needed by game fishes such as bluegills, crappies, largemouth bass, and other species living in Lake Marion.
- The rooting activities of carp increase water turbidity, thus blocking light for photosynthesis and eliminating submerged macrophytes. As a result of decreased photosynthesis, dissolved oxygen levels may also be depleted.
- The elimination of submerged plants not only reduces habitat for small fishes and spawning areas for adults, it also reduces habitat for important fish prey items as well.

Because carp alter their aquatic habitat to the detriment of other fish species, and because they can quickly outgrow predation, human efforts are often needed for effective carp management. There are two commonly-used methods for eliminating a current population: water level drawdown and rotenone application during peak spawning time. Before implementing either of these methods, proper permits and approvals from the WDNR must be obtained. Permits from WDNR are needed for drawdown of the water level. An Environmental Impact Assessment (EIA) and permits are needed before using rotenone. A temporary suspension in fishing is also needed if rotenone is used.

FIGURE 6.6 – CARP SPAWNING IN THE SHALLOWS OF LAKE MARION IN THE SPRING OF 2010.

Water level drawdown is an effective, inexpensive, and widely recognized reservoir fishery management method. Every spring, female carp expel their eggs and fertilization occurs. The eggs either attach themselves to submerged grasses, weeds, and roots, or drift into shallow areas. Drawdown can be used to manage a carp population by lowering the water level at spawning time in the spring. When water is withdrawn, eggs are exposed and juvenile fish are stranded in pools. Also, the eggs can be removed with nets following drawdown. This method is intended to primarily eliminate carp eggs to prevent newly born carp, however exposed juvenile and adult carp can also be removed during this process. A few benefits of the drawdown technique are that: (1) water clarity will be improved by decreasing the number of newly born carp and limiting the current population by hand removing existing carp; (2) it is among the least expensive lake management techniques. One constraint of this technique is that drawdown may only kill the eggs. Mature female fish have a high reproductive capacity and can lay up to 2 million eggs during each spawning event. Therefore, intensive hand removal of existing carp would also have to occur to remove the current population. Typically this technique is used in combination with other water quality improvement techniques such as dredging and sealing of the lakebed.

In ponds and small reservoirs (less than 300 acres), a common approach to restoring a desirable fish community is complete carp eradication with rotenone. This management option is available to Lake Marion since it has an area of 17 acres. Rotenone is a natural fish toxicant that kills fish by inhibiting their oxygen use. Rotenone is non-persistent so there is no accumulation in the water, soil, plants or animals. The breakdown process is very rapid; it breaks down into carbon dioxide and water. Rotenone affects all species of fish and is especially effective on carp. It should be dispersed carefully to ensure lethal concentrations to all carp in the system. Sometimes, water level drawdown is needed to lower the cost of rotenone use before carp eradication. Also, to remove large numbers of carp with minimal cost and effort, it is important to select good rotenone dispersing spots. In the spring, carp like to congregate in areas that are relatively warm; this makes them good dispersal spots. Rotenone application has proven to be more effective than traditional methods of eliminating carp in a system. Traditional methods of capturing carp, such as using nets, can miss many individuals. Rotenone, when applied properly, can successfully eliminate carp from a system. Also, the use of rotenone in combination with a drawdown can be cost-effective.

It is important to note that a single, quick-fix solution is unlikely to reduce carp population. An integrated approach using several techniques is much more likely to succeed. Before any actions are taken it is necessary to be aware of relevant laws and permitting. Other ecosystem reconstruction methods should be taken to ensure successful carp control, such as planting aquatic macrophytes and stocking native fish. In the case of Lake Marion, there is a source population of carp in Black Earth Creek. Dam removal eliminates this connection. Therefore, a combination of carp management techniques and dam removal could potentially eliminate most of, if not the entire, carp population resulting in dramatic increases in water and habitat quality.

A Carp Management Success Story

Lake Wingra, located in Madison, WI, is a shallow, eutrophic lake similar to Lake Marion. In the summer of 2005, a 2.5 acre carp exclosure study was initiated by lake managers in conjunction with the North Temperate Lakes – Long Term Ecological Research program. First, all carp were removed and new carp were prevented from entering the exclosure (Figure 6.7). During the three years of the experiment, the ecological and physical effects of carp exclusion were, literally, clearly seen. Due to the increase in water quality, macrophyte growth increased because aquatic plants could grow in deeper waters. The effects of carp exclusion were most clearly seen in the summer months when blue-green algae blooms plagued the lake, but were not seen in the exclosure. Once the exclosure study was completed, carp were removed from the entire lake and there was a dramatic increase in water clarity and quality (Friends of Lake Wingra, 2009).

Figure 6.7 – Carp Exclusion in Lake Wingra: The 2.5 acre, square exclosure can be seen in the center of this photograph. A large algae bloom combined with carp activity causes the water outside the exclosure to look green and cloudy. Water clarity is high in the exclosure. The bottom of the lake is seen easily from above because of carp removal from the area. Source: Friends of Lake Wingra, 2009.

Stock With Preferable Fish

The current fish population provides adequate fishing opportunities but, according to the community surveys, the stakeholders would like to see improvements made on the current opportunities. One method of improving the fishery would be to stock Lake Marion with preferable game fish. According to the WDNR, the number and size of fish stocked are based on the size of the water body and the management goal for that water body. Factors such as growth rate, mortality, habitat, and the amount of natural reproduction are used to determine the number and types of fish stocked (WDNR, 2009). Before stocking activities can take place at Lake Marion, a fish stocking permit application must be submitted to your local WNDR fish biologist, as required under Chapter 29.736 of the Wisconsin State Statutes. In general, stocking of native fish species would not only enhance the recreational aspects of the fishery, it would also improve the biodiversity within Lake Marion.

Aquatic Plant Improvement: Invasive Species Management (Curly Leaf Pondweed)

Curly leaf pondweed (*Potamogeton cripsus*) is an aquatic invasive plant that can limit the diversity of a lake's aquatic plant community. It is tolerant of turbidity and is frequently associated with degraded water quality (Nichols, 1999). This species becomes an issue in Lake Marion in the early season when the invasive plant quickly reaches the surface. This surface matting can hinder the recreation use of Lake Marion and degrade aesthetic quality. For instance, in the image below, a man is seen removing large quantities of curly leaf pondweed from Lake Marion in preparation for a RC boat racing event in the summer of 2010 (Figure 6.9). In addition, shading can cause increases in water temperature, exacerbate algal growth, and reduce native plant growth. Early summer decomposition of this plant can also increase internal nutrient loading in the lake.

Figure 6.8 - Curly Leaf Pondweed (*Potamogeton cripsus*) Source: Photo by Elizabeth J. Czarapata; WDNR, 2008.

FIGURE 6.9 - REMOVAL OF CURLY LEAF PONDWEED FROM LAKE MARION.

The curly leaf pondweed population in Lake Marion could be managed in the following ways:

WATER LEVEL DRAW DOWN

- A draw down extending for a period of 12-16 months would reduce the viability of turions (a specialized overwintering bud) and prevent turions from re-sprouting once water levels are returned.

HERBICIDE TREATMENT

- Requires a lake management plan and permitting from the WDNR.
- Effective if done in early spring, shortly after the ice melts.
- Needs to be repeated for at least a period of three years to reduce the turion population.
- Requires consultation with a professional company that specializes in aquatic herbicide treatments.

HAND PULLING

- Low cost but requires a significant amount of physical labor.
- Needs to be repeated as necessary.

The poor water quality, mainly turbidity, of Lake Marion is inhibiting native plant growth and encouraging the proliferation of curly leaf pondweed. Based on the aquatic plant surveys completed this year, this species is dispersed in low densities throughout Lake Marion. If the water quality of Lake Marion is improved, curly leaf pondweed has the potential to become highly aggressive and establish in high densities throughout Lake Marion. If no action is taken to improve the water quality of Lake Marion, it is recommended that no management actions take place to control this species. On the other hand, if actions are taken to improve water quality and dam removal eliminates the source population from Black Earth Creek, then a combination of management techniques have the potential to reduce or eliminate, the curly leaf pondweed population.

Recommendations For Fishery Improvement

The fishery is an important recreational opportunity that is valued by the stakeholders. Dam removal threatens the integrity of the fishery because of the potential impact on water quality. On the other hand, dam removal also provides an opportunity to control the invasive aquatic plant curly leaf pond weed and the carp population because the source population of both will be cut off. Based on our field studies, literature research, and consultations with experts, we recommend the following management alternatives for maintaining and improving Lake Marion's fishery:

- Add woody debris and structure to improve fish habitat.
- Dredge to deepen specific locations to increase fish habitat diversity.
- Eliminate the carp population through water level drawn down, treatment of the remaining pools with rotenone, and net removal of individual carp.
- Stock with preferable fish species.
- Manage curly leaf pondweed if the population becomes excessive.

Littoral Zone

The edges of Lake Marion, also known as the littoral zone, are an important habitat area for both aquatic and terrestrial wildlife. Improvement of the littoral zone could improve the overall biological diversity and the natural beauty of the area.

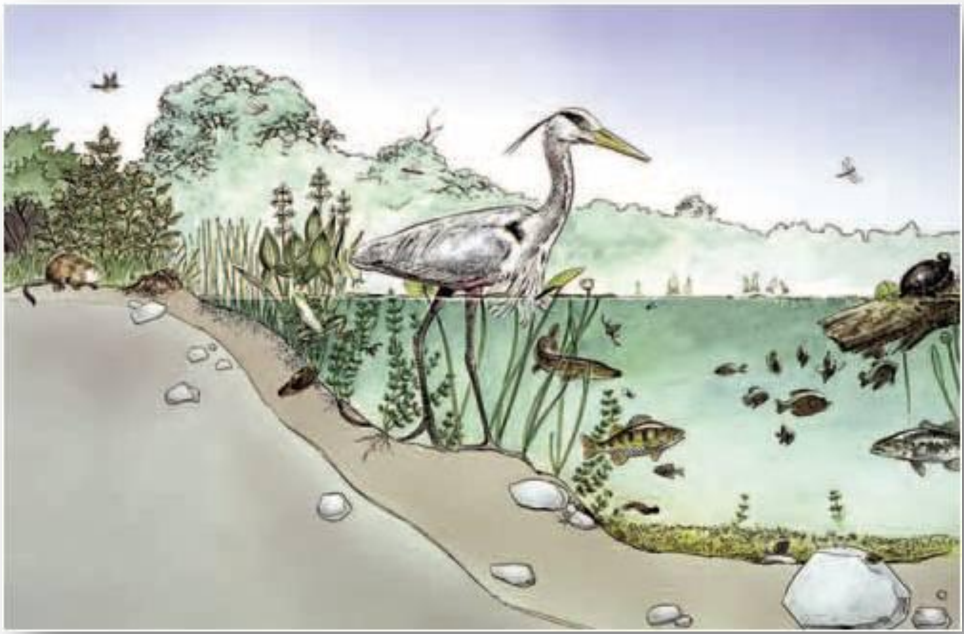

FIGURE 6.10 – ASPECTS OF LITTORAL ZONE DIVERSITY. SOURCE: ILLUSTRATION BY CAROL WATKINS; FRIENDS OF LAKE WINGRA, 2009.

Reconfiguration of the lake's banks would improve the habitat for fish, macroinvertebrates, amphibians, reptiles, and birds. Management of invasive plant species, such as reed canary grass, would allow the growth of more native species. Management alternatives for improving these aspects of the littoral zone are discussed here.

BANK RECONFIGURATION

The littoral zone is home to a diversity of aquatic life and is a particularly valuable habitat for fish. In addition this area is rich in submerged and emergent macrophytes that provide shade, protection and food for insects, fish, shorebirds, waterfowl, and amphibians. This near shore vegetation protects water quality and reduces turbidity by anchoring lake bottom sediments and trapping sediment flowing from the shoreline. The aquatic plants also use nutrients that may otherwise lead to nuisance algal blooms. Eighty percent of the Wisconsin's threatened and endangered species use the littoral zone for some portion of their life stages.

The littoral zone of Lake Marion is limited. The littoral zone provides very little habitat for aquatic life because most of the banks are steep, mowed to the edge, and do not have shoreline woody structure (Figures 6.11 and 6.12). These steep banks are poor habitat for amphibians and aquatic insects. For fish, Lake Marion provides very little in terms of shallow vegetative spawning area and the cobble habitat is covered in a layer of unconsolidated sediment. This makes it difficult for fish to spawn successfully. In addition these steep banks are susceptible to erosion that could cause sediment and nutrient loads into the lake. Only the northern edge of Lake Marion has a gradual slope that provides a refuge where a diverse assemblage of aquatic life has the potential to thrive. However, sediments begin to cover any fish spawning grounds early in the year and, by mid-summer the northern edge is covered with algae that shade out any other vegetation. Reconfiguring the banks to a more gradual slope along Lake Marion will not only provide easier access to the lake for fishing but, more importantly, would provide necessary habitat to support aquatic life. Bank reconfiguration will also increase the bottom littoral area and create a greater opportunity for a variety of species to live.

FIGURE 6.11 – STEEP AND ERODING BANKS OF LAKE MARION.

If the banks are reconfigured, slopes less than 10% are recommended. As mentioned in the Dredging section, material low in organic matter and high in clay content can be used to reconfigure the banks. Special attention will have to be given to the shoreline along the railroad side. Because of the railroad right away, reconfiguring the banks would require an extension of the current lake edge into Lake Marion rather than back towards the railroad. Any activities that take place under the ordinary high water mark (OHWM) require WDNR input and possibly a permit. The region along the railroad is narrow so the necessary buffer width may need to be reduced and the slope aspect will be very important. We recommend the WDNR's technical and mandated guidelines for work under the OHWM and an engineer approved plan to determine the proper bank reconfiguration.

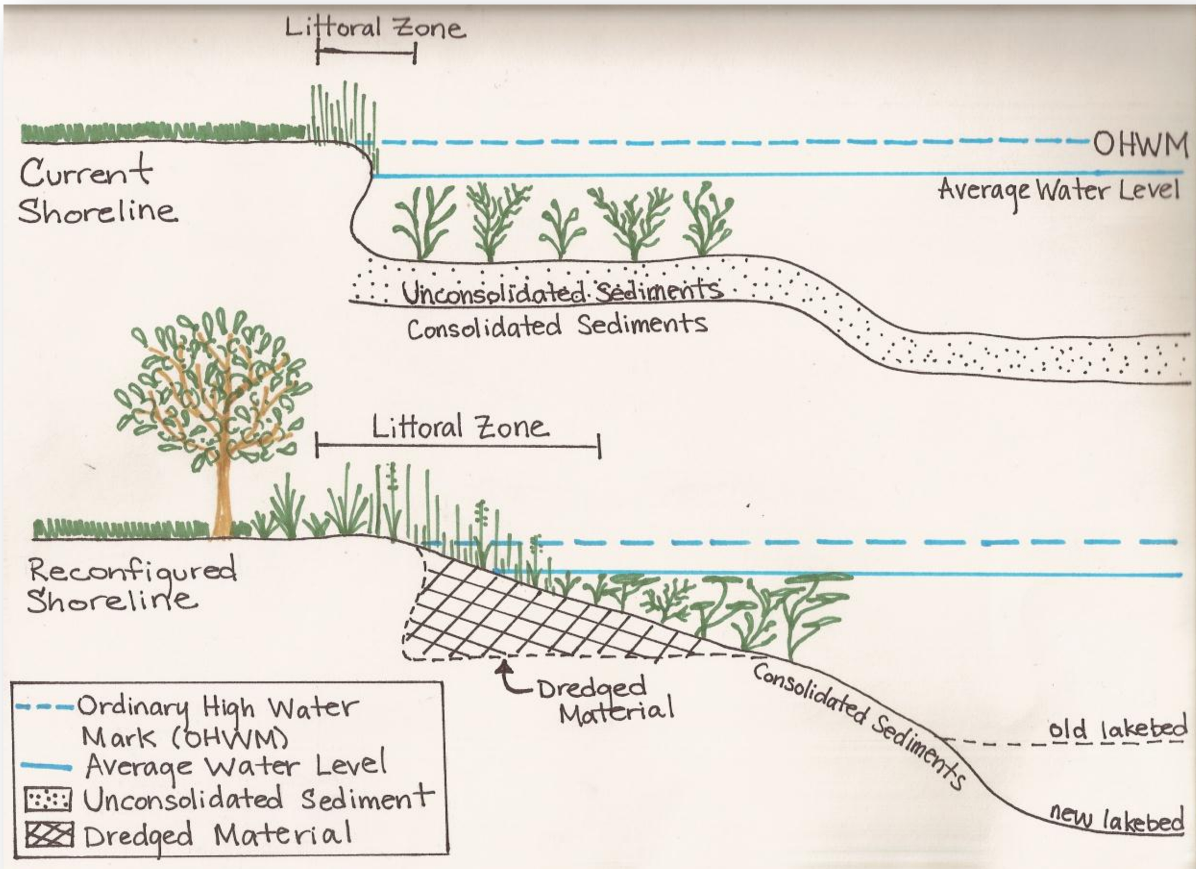

FIGURE 6.12 – BANK RECONFIGURATION:
CURRENT CONDITIONS OF LAKE MARION'S LITTORAL ZONE. BANKS ARE STEEP AND ERODING. THE PARK AREA IS MOWED CLOSE TO THE EDGES AND ANY VEGETATION ABOVE WATER IS MOSTLY THE INVASIVE PLANT REED CANARY GRASS. THE POTENTIAL FOR MACROPHYTE GROWTH IS LOW DUE TO HIGH TURBIDITY AND LACK OF SHALLOW WATER AREAS. OVERALL, THE CURRENT CONDITIONS PROVIDE A SMALL AREA OF LOW DIVERSITY HABITAT.
RESTORED CONDITIONS OF LAKE MARION'S LITTORAL ZONE. BANKS ARE RECONFIGURED TO A MORE GRADUAL SLOPE USING APPROPRIATE DREDGED MATERIAL FROM DEEPER LOCATIONS WITHIN THE LAKE. SEDIMENTS ARE COMPACTED USING HEAVY EQUIPMENT. NATIVE VEGETATION IS PLANTED IN THE WATER AS WELL AS ALONG THE SHORELINE. THESE ACTIVITIES GREATLY EXTEND THE AREA AND INCREASE THE HABITAT AND SPECIES DIVERSITY OF THE LITTORAL ZONE.

Bank reconfiguration and stabilization will only be as successful if done in conjunction with the establishment of shoreline and aquatic plants. Shoreline plants may be established from seed or from small nursery pots. Recruitment of native aquatic vegetation may occur. However, it may be very possible that aquatic native vegetation will have to be re-introduced into the lake. Additionally, the State of Wisconsin currently requires a 35 foot natural or buffer zone along any navigable water body. This is to protect aquatic life and provide a buffer to prevent excessive nutrients and pollutants from entering the lake. To protect the future water quality of Lake Marion, a minimum of 35 feet should be left in a natural buffer, with only access paths to the lake maintained (Figure 6.13).

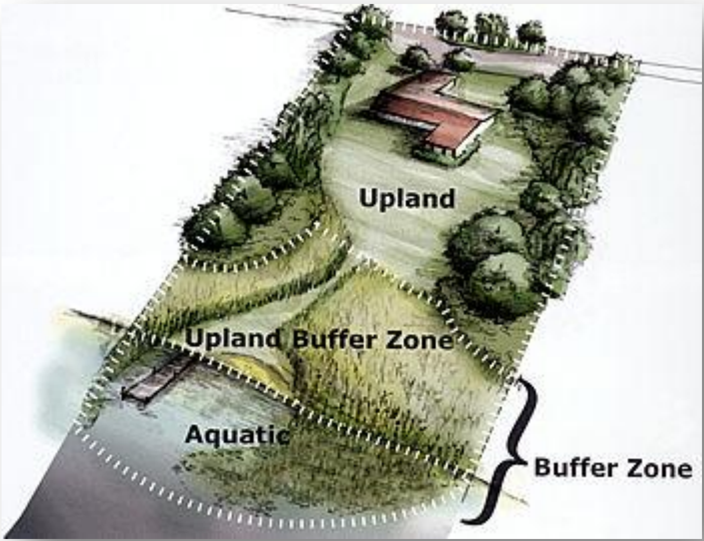

FIGURE 6.13 – WHAT IS A BUFFER ZONE? GROWTH OF NATIVE VEGETATION ACTS AS A BUFFER FOR THE LAKE AGAINST INPUTS OF POLLUTANTS, SEDIMENTS, AND NUTRIENTS. PATHS WITHIN THE BUFFERS ALLOW ACCESS TO THE WATER'S EDGE FOR RECREATIONAL ACTIVITIES SUCH AS FISHING. SOURCE: MINNESOTA SHORELAND MANAGEMENT RESOURCE GUIDE, MINNESOTA SEA GRANT, 2011.

INVASIVE PLANT MANAGEMENT (REED CANARY GRASS)

Reed canary grass (*Phalaris arundinacea*) is an aggressive invasive species that thrives in wetlands and on shorelines. As discussed in the terrestrial vegetation section, reed canary grass (RCG) is currently the dominate species on the Lake Marion shoreline, creating an almost monoculture habitat (Figure 6.14).

FIGURE 6.14 – REED CANARY GRASS (*PHALARIS ARUNDINACEA*). SOURCE: PHOTO BY STEPHEN SOLHEIM; HTTP://DNR.WI.GOV/INVASIVES/PHOTOS/INDEX.ASP?MODE=PHOTOVIEW&RECID=525&SPEC=88

A native plant assemblage has a much higher capacity to support a diverse and healthy wildlife community compared to that of an RCG monoculture. The following RCG management techniques have the potential to improve the buffering capacity of the shoreline vegetation as well as improve wildlife habitat along Lake Marion's shoreline. It is important to be aware that many of these techniques require permitting from the WDNR before implementation. For further advice and permits be sure to check with a local WDNR representative before taking action.

FIGURE 6.15 – REED CANARY GRASS AT LAKE MARION: LISA FENG SAMPLES FOR MACROINVERTEBRATES IN A SEA OF REED CANARY GRASS ALONG THE SOUTHERN END OF THE LARGE POND.

Reed canary grass management techniques aim at reducing the population as much as possible – because complete eradication of any invasive is nearly impossible – while at the same time limiting the damage to other plants and wildlife. Reed canary grass management techniques require the removal/destruction of the plant's rhizomes (roots) and the seeds that remain in the soil (seed bank). The following biological, chemical, and physical techniques can be used to manage RCG on Lake Marion's shoreline:

- Tree and shrub planting: In areas where herbaceous plants are unable to become established among the RCG, tree and shrub planting is a good option. This technique does not eradicate RCG. Rather, the woody plants shade the RCG and slow its spread and growth while adding structure to the plant community.

- Chemical treatment: A grass specific herbicide – for example glyphosate or Dalapon – may be used to suppress the growth of RCG. The grass specific herbicide damages RCG but allows many other herbaceous (non-grasses) native plants to grow. However, caution should always be used when applying herbicides around standing water in order to prevent run-off into and pollution of the nearby water body.

- Burning: Burning invaded areas will stress RCG and decrease the biomass. Additionally the heat will stimulate seed bank growth and decrease the available nitrogen in the soil. Burning is most effective in late spring when RCG is active but many of the native species are still dormant.

- Altering the hydrology: Increasing water levels may prevent seed germination as well as kill the rhizomes because RCG relies on a particular amount of moisture in the soil to thrive.

- Excavation: Removing the soil that currently holds RCG would also remove the seed bank and rhizomes, preventing further growth. Excavation of soil could be done if the banks of Lake Marion are reconfigured.

Reducing the abundance of reed canary grass will improve the shoreline along Lake Marion. RCG management will diversify the vegetation, improve the buffering capacity of the shoreline, and lead to improved water quality. Planting native wildflowers, grasses, legumes, and sedges will aid in the diversification of the vegetation in the Lake Marion area (see Appendix 12). Ultimately, diversification of vegetation through RCG management and native plantings will improve the habitat available to wildlife.

Improve Amphibian/Reptile Habitat

Lake Marion has the potential to provide quality habitat for both fish and wildlife. However reptile and amphibian habitat is often overlooked when developing habitat restoration plans. There are simple additions that can be included to help enhance the habitat for a greater range of species (see Appendix 12). Many of the recommended additions will also enhance the habitat for fish and birds. Before beginning any project it is important to understand the species and local habitat. The booklet, *Wisconsin's Wildlife Action Plan*, would be good place to start to learn more about the specifics (http://dnr.wi.gov/org/land/er/wwap/). In addition, the WDNR and NRCS have a staff devoted to understanding the biology and habitat of reptiles and amphibians. Finally, contact your local WDNR representative to confirm all permits have been acquired before the project is started. The following options for amphibian and reptile habitat improvement are feasible for Lake Marion's littoral zone:

- Woody debris and cover objects: Addition of woody debris or structure along the shoreline increases the area for basking, shelter from predators and the mid-day sun, and provides habitat for prey.
- Basking logs and rocks: Adding structures 3-4 feet from shore will provide an area for sunning that has limited access by predators.
- Grass plantings: Areas of grasses and forbs along the buffer will provide foraging habitat.
- Hibernacula: Adding a structure that provides overwintering habitat for species that hibernate.
- Brush bundles: Hanging branches in the water will allow silt to accumulate and provide habitat for turtles. Water snakes also benefit from the overhanging branches.
- Ephemeral ponds: Temporary side ponds that are only occasionally filled by snow melt or rain are important spring breeding locations. They are too small to support fish so predation is not much of a concern.

Any one or a combination of these options has the potential to improve the habitat for amphibians and reptiles and therefore increase the overall biodiversity of the Lake Marion area.

Recommendations For Enhancing Lake Marion's Littoral Zone

The littoral zone is an important area for sustaining ecological diversity at Lake Marion. Simple steps such as planting native vegetation can improve the structural and biological diversity of the littoral zone (See Appendix 12 for a list of native plants). More difficult decisions, such as where to reconfigure the banks to a more gradual slope, depend on the extent of restoration activities taken up by the Village as well as economic constraints. The following management alternatives are based on our field studies, literature research, and consultations with experts:

- Reconfigure the banks to a more gradual slope – using fine-particle dredged material (Figure 6.12). Not all banks need be reconfigured, just enough to provide a diverse, stable habitat for littoral zone organisms.

- Manage the invasive plant reed canary grass.
- Improve biodiversity with native shoreline plantings.

PARK ZONE

FIGURE 6.16 – OPEN PARK SPACE AT LAKE MARION.

The Lake Marion park zone provides an important area for wildlife as well as recreationists. The topics explored in the section below include management of the goose population, improving wildlife habitat, and enhancing recreational opportunities within the park area. Goose management is a major concern because the current population leaves a large volume of droppings in the area. This impedes the recreational use and aesthetic enjoyment of the area. Enhancing wildlife habitat in the park zone will help maintain the natural beauty and biodiversity presently enjoyed at Lake Marion. Stakeholders have expressed their enjoyment of bird-watching in the park; therefore, improving habitat for birds and other wildlife should be part of this effort. The recreational and open space opportunities at Lake Marion are extremely important to the stakeholders. In this section, we explore both active and passive recreational opportunities such as trails, piers, and remote-controlled (RC) boating. We also address stakeholder concerns about the railroad easement and parking locations. Finally, we explore many new activities that could be developed for the community, including community gardens, installation of educational signs, and involvement in the restoration process.

GOOSE MANAGEMENT

The Lake Marion park area attracts Canadian geese (*Branta canadensis maxima*) because of its large open lawn areas and easy access to water from the shoreline. The droppings left behind by the geese are the community's most common complaint because the large quantity of droppings degrades the park's aesthetics. Droppings can also lead to E. coli breakouts and the spread of avian diseases within species and to other waterfowl species. Nutrient loading into the lake is another concern. Geese, when nesting or caring for young are also known to be aggressive and can attack pets, children, and adults. The publication, Managing Canadian Geese in Urban Environments (Smith et al.,1999) provides a comprehensive list of techniques for managing urban goose populations. The Migratory Bird Treaty Act of 1918 makes it illegal to harvest waterfowl or other migratory birds such as Canadian geese except by permit or during the hunting season. Therefore, before any of the following techniques can be implemented, local, state, or federal permits may be required. The majority of these techniques have the potential to mitigate the observed Lake Marion goose problem.

Urban Canadian geese populations can be managed using a combination of the following techniques: habitat modification, discontinuance of public feeding, and hazing or scaring. Habitat modification aims at making the site unfavorable for large populations of geese to nest and congregate. General habitat modifications include: placement of walking paths near the shore, placement of open fields away from the water, removal of nesting structures, and elimination of shoreline, islands, and peninsulas. These general modifications permanently reduce nesting and congregating habitat, but they have at a relatively high startup cost.

FIGURE 6.17 – GEESE AT LAKE MARION: (A) THE NORTHEAST SIDE OF LAKE MARION ALONG THE RAILROAD IS PRIME GOOSE HABITAT. THE LARGE, OPEN LAWN AREAS PROVIDE FOOD (NEWLY SPROUTING GRASSES) AND MOWING TO THE EDGE PROVIDES EASY ACCESS TO THE WATER. (B) GEESE ON LAKE MARION IN THE SUMMER OF 2010.

Another habitat modification technique is to build barriers between the shore and water. Geese require a clear view of their surroundings, as well as easy access to water, in order to establish nests. Fences, vegetative barriers, and rock barriers block these views, prevent easy access to water, and can permanently and immediately reduce or eliminate the nuisance flock. Barriers will not be successful if the geese can move to a nearby area that is not barricaded or if they land directly on the lake.

Lawn management practices provide another habitat modification technique. Geese prefer large, well fertilized lawn areas with short newly sprouting grasses for feeding. Lake Marion, with large areas of open, mowed lawn areas, provides this habitat. Reduction or elimination of mowing, reduction of fertilizer use, reduction in lawn area in the park, and/or planting unpalatable vegetation will eliminate this favorable habitat. While planting unpalatable vegetation has high startup costs and a large reduction in mowed areas may not be favorable to the public, a balance between natural vegetation and mowed areas could easily be found. Reducing mowing and fertilizer use are inexpensive changes that can immediately reduce or eliminate feeding and congregating problems.

Feeding of geese by the public encourages congregation at the site and may make the geese more aggressive towards humans. Discontinuance of public feeding will reduce congregation, potentially reduce aggressiveness of geese towards humans, and have a low overall cost. However, it may be difficult to implement this technique without public acceptance and compliance.

Another set of techniques involves hazing or scaring the geese away from the site. This can be done by installing noise-makers or simulating a threatening situation, such as the presence of a predator, in order to keep the geese from congregating and nesting at the site. Noise makers range from air horns and mimicked distress calls to propane cannons and pyrotechnics. Strobe lights and “eye-spot” balloon kites that mimic predatory eyes at night can deter geese from nesting nearby. Other simulations of threat include reflective mylar tape, scarecrows, trained dogs, swans, falcons, radio-controlled aircrafts, vehicles, and boats. These techniques can immediately reduce or eliminate the nuisance flock from the site. On the other hand, these techniques detract from human enjoyment as well as impair other wildlife’s use of the site. Most of these hazing or scaring techniques usually require permits from local authorities, must be implemented before the nuisance flock arrives, and require a high level of maintenance. In addition, geese may become habituated to the devises, rendering them ineffective at scaring away the nuisance flock.

Services for many of these techniques are provided by a variety of companies. A limited list of company contacts is provided in the publication, *Management of*

Canadian Geese in Urban Environments (Smith et al., 1999). Other local providers can be found in the yellow pages or through area pest control firms.

While the Canadian goose management techniques listed above have the potential to reduce nesting and congregating goose populations at Lake Marion, they do not reduce the current population's numbers through lethal means. Instead they prevent geese from congregating and reproducing at the site. A reduction in nesting geese today leads to fewer resident geese in the future. Since Canadian geese are migratory birds, flocks may frequent the site on their migratory route but not use the site as a permanent place of congregation. Some of the techniques listed, such as simulation of a threat, can also apply to management of migratory flocks. It is essential to follow a few key guidelines in order to develop a successful goose management plan (Smith et al., 1999). First, the management plan should use a combination of techniques. Second, timing of implementation is critical for the technique to be successful. Third, public and neighbor relations are important to success. Fourth, implementers should be aware of relevant laws and ordinances at the local, state, and federal levels. Finally, most management plans work on reducing the number of geese to a level that all stakeholders can tolerate because it is rarely desirable or possible to eliminate all geese at a site. By following these guidelines, the right combination of Canadian goose management techniques will reduce the goose population and improve the enjoyment of the park by both humans and wildlife.

Wildlife Habitat Enhancement

In order to enhance the wildlife habitat surrounding Lake Marion, the following principle habitat characteristics must be met: food, water, shelter, protection, function, diversity, and seasonality.

***Food*:** Birds and mammals have unique food requirements. Some species are specialists, requiring specific types of food, whereas other species are generalists and can survive on a wide variety of food types. Food for birds and mammals can be in the form of berries, nuts, grasses and insects.

***Water*:** All life requires water. Depending on the species, water requirements will vary. Lake Marion, the two ponds, and Black Earth Creek provide a water source for a variety of wildlife.

***Shelter/Protection*:** Shelter provides protection during inclement weather and from predation. This protection is especially important during the breeding season when wildlife are nesting and raising young. Also, shelter provides a place for wildlife to rest and sleep. Some species of birds are ground nesters that require tall grasses and forbs while other species nest in trees and shrubs. Standing dead trees provide critical habitat for species that require cavities to nest, such as wood ducks.

FIGURE 6.18 – SHELTER: A WOOD DUCK TAKES SHELTER IN A HOLLOW TREE. SOURCE: HTTP://BBNE.ORG/IMAGES/BASICS10.JPG

SEASONALITY: It is important that during the winter months there are areas that provide shelter and wind protection for species that are year round inhabitants including otters, muskrats and a variety of song birds. Evergreen trees and shrubs keep their needles year round and are excellent protection from winter elements.

FIGURE 6.19 – SEASONALITY: A CHICKADEE TAKES SHELTER IN AN EVERGREEN TREE DURING HARSH WINTER WEATHER. SOURCE: HTTP://NETREASURES.COM/SONG%20BIRDS/CHICKADEES/CHICKADEE(2).JPG

There is potential to enhance the wildlife habitat around the Lake Marion park by providing wildlife with the few key characteristics stated above. All of these characteristics can be incorporated into the area by planting and restoring the native plant community. There are a variety of benefits to using native plants over nursery stock to promote wildlife and wildlife habitat. Native plants are adapted to seasonal changes and are less sensitive to winter kill. In addition they are generally more tolerant to diseases and insects and require little to no maintenance.

Diversifying the native plant community will provide a variety of habitats and allow for a variety of wildlife species to live. The three types of diversity that are important to consider include plant diversity, structural diversity and vertical diversity. Plant diversity includes providing a wide array of forbs, grasses, trees, and shrubs. Structural diversity includes providing standing and fallen trees for cavity nesting and amphibian habitat. Structure also includes augmenting the park with bird boxes and brush piles. Bird boxes will provide nesting habitat and brush piles provide cover. Vertical diversity takes into account species living underground, at the ground level, and those that live in treetops.

Native plant communities vary throughout Wisconsin, so the geographic region does matter. Native species should be selected based on the Lake Marion geographic region. In addition, specific site location will matter. Sites that are dry will support different plant communities then sites that are wet. There are a variety of nurseries and consulting companies that specialize in native plants and restoration. A professional or someone who is experienced in the native vegetation of Wisconsin and is familiar with the eco-regions and microhabitats that are present at Lake Marion could help create a specific planting and restoration plan.

Recreation And Open Space Enhancement

The Lake Marion area is an important place of recreation for Mazomanie and the surrounding communities. There are a multitude of recreational and open space enhancement opportunities for the Lake Marion area. Below we discuss topics such as stakeholder concerns, active recreation, passive recreation, quiet contemplation areas, and community involvement opportunities. Concerns expressed by the stakeholders include: the railroad easement, parking, and other recreational additions to the area. Active recreational uses include: trails, piers, picnic areas, dog park enhancement, and remote controlled boat racing. Opportunities for community-based and educational activities such as community gardens, interpretive signage, and volunteer work are also presented here. By understanding the background and management alternatives associated with these topics, there is a vast amount of activities that have the potential to enhance the recreational and open space areas at Lake Marion.

Stakeholder Concerns

Railroad Easement

Lake Marion lies adjacent to a railroad easement. The easement is owned by the Wisconsin and Southern Railroad Company (WSOR) and extends thirty feet to either side of the center line of the railroad tracks. This could impact restoration or enhancement activities depending on their proximity to the railroad and the intensity of the activity. For instance, the extent to which physical alterations can be made to the lake's banks (See Chapter 6, Bank Reconfiguration) depends on their proximity to the railroad easement. The size of the vegetation planted near the easement cannot impede the railroad. Vegetation would have to be compatible with the herbicides sprayed by the WSOR. Trail management near the easement could be inhibited. A property line survey and identification should be completed before any management activities are implemented along the northeastern edge of Lake Marion. Agreements, permits, and approvals from the Village of Mazomanie, WSOR, and the Wisconsin Department of Transportation should be granted before proceeding with any management alternatives in this area.

FIGURE 6.20 – RAILROAD ALONG LAKE MARION.

PARKING

Stakeholders have expressed the need for an increase in parking areas. There are a few areas along County Road KP that could be converted to parking. Specific areas for expanding parking are presented in the Mapping Workshop section of Chapter 2. Before new parking areas are constructed, the potential impact on water quality should influence the type of material used and the size of the parking area (see Chapter 6, Stormwater Runoff Control).

FIGURE 6.21 – PARKING: CURRENT PARKING AMENITIES AT LAKE MARION ARE SPARSE AND COULD BE EXPANDED TO RESEMBLE THE PHOTOGRAPH HERE.

POTENTIAL ADDITION OF OTHER RECREATIONAL OPPORTUNITIES

Playground

Stakeholders have expressed an interest in utilizing Lake Marion for community-based recreational purposes. Open ended responses during the first meeting showed that stakeholders have some interest in developing a playground at Lake Marion. On the other hand, a survey conducted at the second community meeting indicated that stakeholders want to keep Lake Marion as natural and pristine as possible. They were not interested in developing a playground at Lake Marion that would negatively impact on the natural experience. Given this interest, instead of constructing a playground, the open space and lawn areas should be maintained for passive recreation such as picnics, Frisbee, soccer, kickball, and so on (see Chapter 6, Passive Recreation). These areas should be located along the southwestern edge of Lake Marion adjacent to the pavilion and/or fishing pier and Highway KP (see Chapter 6, Pond Zone Enhancement). This area is easily accessible and is the most frequented area at Lake Marion.

Beach

If implemented, the management alternatives recommended in this report could drastically improve the water quality in Lake Marion. This may allow some opportunity for swimming and other water activities. These activities could be enhanced through the addition of a beach to improve water access. Nevertheless, survey results show that a majority of participants are against having a beach for swimming or sunbathing. As Lake Marion's primary uses are as a fishery (see Chapter 6, Fishery Improvement) and for more passive recreational activities, the development of a beach is not supported. In addition there is an existing beach for Mazomanie on the Wisconsin River and permits would be required to legally construct a beach.

Active Recreation

Trails and Open Spaces

Currently there is no trail system at Lake Marion. Instead, large mowed areas of lawn are used for pedestrian traffic. Stakeholders have expressed interest in connecting regional trail systems and local destinations through a local trail network. There is also interest in developing a trail in the woodland area near the ponds. In addition, stakeholders have expressed disapproval of paved paths and use of trails by motorized vehicles. There are several benefits to constructing a more developed trail system around Lake Marion. Excessive amounts of goose droppings are known to impede the aesthetics and pedestrian use of the open lawn areas. Developed trails would decrease the goose habitat, be easy to maintain and clean, and provide developed areas for pedestrian use. Trails at Lake Marion could connect to local trail systems and connect downtown Mazomanie to the Wisconsin Heights High School (WHHS). Eventually this trail system could connect to established trails in Middleton and Sauk City, WI and to other regional and state-wide trail systems.

There are both positive and negative consequences of trail development in this area. A more developed trail system would reduce the labor and cost of mowing large open areas throughout the park. The reduction in large open areas would also reduce goose habitat and thus reduce the presence of excessive goose droppings (see Chapter 6, Goose Management). Reducing mowed areas also increases natural vegetation, which adds to the natural beauty of the park. On the other hand, the more developed the trail system becomes, the more users it will attract. An increase in pedestrian and bike traffic may disturb wildlife or may not be favorable to certain users. A more developed trail system requires more impervious surfaces, which could lead to an increase in stormwater runoff and associated nutrients into the lake. Vegetated buffer strips could mitigate these effects (See Chapter 6, Phosphorus Management).

FIGURE 6.22 – POTENTIAL TRAILS: TRAILS COULD BE MAINTAINED AT LAKE MARION SIMILAR TO THE ONE SHOWN IN THIS PHOTOGRAPH. NATIVE VEGETATION GROWS ALONG THE BORDER AND THE TRAILS THEMSELVES ARE MOWED TO MAINTAIN PATHS THROUGHOUT THE PARK.

There are several different alternatives for a trail system at Lake Marion. The Village could:

- Leave Lake Marion without a trail system and continue using large patches of lawn and mowed areas for pedestrian traffic.
- Use native plantings and mowed areas to delineate a trail system around Lake Marion.
- Develop a trail system using stone, fine gravel, and sand in the park area and wooden boardwalks in sensitive areas such as the wetlands and woodlands near the ponds.
- Use permeable paver/asphalt/concrete technology to develop trails around Lake Marion.
- Use conventional asphalt/concrete materials to develop trails around Lake Marion.

These alternatives can be combined in many ways in order to balance stakeholder preferences with financial feasibility in the development of a trail system at Lake Marion.

Piers

Piers provide better access to water for fishing, bird watching, handicap access and enjoying nature. Piers also provide shade and structure for fish species. There are three types of piers: cantilevered piers, floating piers, and posted piers. Cantilevered piers extend out over the edge of the water, but are anchored to the shore with a counterweight footing. Posted piers have posts that are placed along the shore or in the water for support. Floating piers use a floatation device to float the pier on the water's surface. The pier that currently exists at Lake Marion is an example of a cantilevered pier. Each type of pier offers its own benefits for recreational use and impacts the lake in different ways.

The cantilevered and floating structures change very little of the land within the lake. Yet, depending upon the size of the pier, they can require a fair amount of modification to the shoreline. Piers that use posts for stability can typically extend further out into the water and provide better access. However, posted piers can be difficult to install and a permit to dig into the bottom of the lake is required. According to the survey and mapping exercise, some participants were interested in placing additional piers at Lake Marion. A pier placed along the southeast side of Lake Marion can provide better access to those areas where people spend the most time fishing. Other piers placed in the ponds could provide areas for wildlife observation and fishing. The type of pier and its location at Lake Marion should be considered, along with stakeholder preferences, before implementing this alternative.

Dog Park

Lake Marion is classified as a dog recreation area that, allows off leash dogs on park grounds. The stakeholders have conflicting desires concerning the level of access dogs should have if and when the park sees any recreational or restoration improvements. The dog park area and level of access could be either expanded or reduced depending on the extent of recreational enhancement of the park.

The current dog park area could be expanded by constructing dog friendly facilities and improving water quality. Dog bag clean up stations are one way to improve the park's dog amenities. Stations could be constructed throughout the park area. Trash cans are already present, but the park could provide plastic bags for disposing waste. If either or both of the ponds are filled, a fenced-in recreational area could be constructed there. Finally, while the current water quality of the lake is not good enough for dogs to swim, as shown by cases of rashes and ear infections reported by the local vet, efforts to improve water quality could improve swimming opportunities (see Chapter 6, Water Quality Improvement). Depending on the type and extent of management activities performed at the lake after dam removal, reducing dog access may be necessary. Reduction of the current dog park area could be done by making the park area an on-leash facility only.

Expansion of dog park areas would improve the overall appeal of Lake Marion as a recreational area. Lake Marion is known by many residents in and outside of Mazomanie for its dog friendliness. However, ultimately, dog park conditions should balance stakeholder preferences, economic feasibility, and the extent of restoration activities.

Kayak/Canoe Launch

A kayak or canoe launch is a place where users of Lake Marion and Black Earth Creek can easily launch or load their boats. These areas typically include some type of launch structure or ramp that extends into the water. The launch area should be designed to permit easy access to the water and reduce the distance that a kayak or canoe must be carried. This would make it safer and more convenient to boat at Lake Marion.

A launch area could be located adjacent to the existing parking area to the south of the pavilion. This location seems to be more suitable for a boat launch because of the drainage swale. The swale could potentially be modified and expanded to include a boat launching area that is more accessible from the parking lot. Also, a boat launch could be located at the existing pier and parking area to the north of the pavilion.

Canoe access to Black Earth Creek would require the canoe/kayak users to carry their boats to a creek launching area. Once the dam is removed, a maintained pathway across the railroad tracks could be created. The bank of the stream could be cleared and a launching structure could be built to provide easier boat access to the creek. However, certain permissions, approvals, and permits must be negotiated and acquired from the railroad before any trail development to cross the railroad occurs.

Remote Controlled Boat Races

Lake Marion is a prime location for remote-controlled (RC) boat racing. A RC boat racing club has built a racing platform, with storage areas for their equipment, using the southwest portion of Lake Marion for racing. Stakeholders have expressed a significant interest in maintaining or improving the RC boat racing opportunities. The existing racing platform should be maintained as is or improved to better suit the needs of the RC boat club. The RC boat club has indicated that the conditions at Lake Marion are not optimal for these boat races. Aquatic plant growth and shallow water has recently become a problem. The club removes a considerable amount of aquatic plants with a cutter and can only run the boats in a small portion of the lake. Management techniques could be used to control the aquatic plants, which are most likely the invasive species curly leaf pondweed (see Chapter 6, Aquatic Plant Improvement). Dredging (see Chapter 6, Dredging) could also be used to improve the RC boat racing opportunities. Site-specific dredging could deepen an area to improve its use for boat racing when water levels become low.

Since the RC boat club has been using Lake Marion for their boat racing events, they should continue to be allowed to operate in their designated area. The club membership should continue their efforts to maintain this area and contribute to the overall maintenance of this specific area for this purpose.

FIGURE 6.23 – RC BOAT RACING PAVILION AT LAKE MARION.

PASSIVE RECREATION

QUIET CONTEMPLATION AREAS

Quiet contemplation areas are located in more scenic locations than most other passive recreation areas and provide minimal disturbance from traffic and road noise. Quiet contemplation areas are typically used to relax, meditate, enjoy nature, read, picnic, or observe wildlife. They are meant to accommodate individuals or smaller groups of people. These areas usually have minimal development and only include a few site features such as a bench, or stones for seating, and natural plantings.

Lake Marion's current quiet contemplation areas are minimal. Existing structures are located along Highway KP, which is noisy and intrusive for the types of activities which take place in contemplation areas. The existing sites are more conducive to larger groups or other less meditative activities. New smaller structures and site features could be placed around Lake Marion to encourage reflection and contemplation of the area's natural beauty.

It would be best to locate quiet contemplation areas away from areas that are typically busier and have more unnatural noise. For example, benches could be located on the berm areas of the smaller ponds closer to the Black Earth Creek to be more isolated from the road and other activities. A small picnic shelter could be built closer to the smaller ponds for small informal family gatherings.

Passive Recreation Area

A passive recreation area is an undeveloped space or environmentally sensitive area that requires minimal development, yet is still maintained for recreational purposes. Examples of this are an open field, a lawn area, or an un-programmed pavilion space. Passive recreation areas are typically larger than the quiet contemplation areas and can accommodate larger groups of people.

Activities which would take place at these types of areas include picnics, social gatherings, nature observation, photography, and some informal sports activities such as 'pick-up' games of soccer, football, or Frisbee. Passive recreation areas can include features such as trails, picnic tables, or benches. Oftentimes, shrubs, trees and other plantings are used to develop a sense of enclosure and add some informality to the space.

There are several areas at Lake Marion which are already used as passive recreation areas. Some improvements could maximize the use and enjoyment of these areas. For example, picnic tables could be placed around trees to add shade. Benches could be located around Lake Marion and the other ponds to provide areas for relaxation and bird watching. More shrubs and trees could be planted along the road adjacent to the pavilion to provide a buffer from County Road KP. Trails could connect parking areas to passive recreation areas and provide better accessibility for those who wish to enjoy Lake Marion's natural beauty.

Community Involvement

Community Gardens

Stakeholders have expressed an interest in utilizing the Lake Marion area for community-based and educational purposes. Land area around Lake Marion is limited, but could potentially support a small community gardening plot. A larger community garden area could be created if one or both of the ponds are filled. Given a large enough area, the space could even be used for Community Supported Agriculture (CSA). CSAs are small farms which are run through contributions from local community members who then receive produce from the farm throughout the growing season.

Figure 6.24 – Example of a Community Garden.

Community gardens can take a considerable amount of room and access to be successful. Access to water hydrants and tool storage areas would also be a necessity. Also, community members, a local organization, or a class from Wisconsin Heights High School (WHHS) would be needed to maintain the gardens during the growing season. A considerable amount of support would be needed from those interested in pursuing this alternative. Local, regional, and state-wide grants exist that support every shape and size of community garden or CSA initiative. A community garden plan for the Lake Marion area could be implemented in the following ways:

- Construct a limited community garden in the existing land area at Lake Marion for community members and adjacent landowners. The garden should be located somewhere easily accessible to the parking areas.

- If one or both the ponds are filled, the increased land area would allow for a larger community garden. Dredged soil would be a suitable fill for the ponds, if they are used for gardening, because of the high nutrient content of the sediment. A driveway to the garden area would provide vehicle access. The driveway could be closed with a gate when not in use. Water access could be made available using a ground water well. A tool shed could be built to house materials and tools.

- If both ponds are filled and the interest in the community and at the WHHS exists, the space could be used for CSA. The CSA could utilize help from the WHHS and local organizations to provide a rich community and educational experience for those involved.

Depending upon the restoration and management plans for the Lake Marion area, any one of these solutions may be implemented. The key would be to start small and garner support for community gardening in the area. The garden area could grow over time, with the approval of the Village of Mazomanie. Key elements for a successful garden would be local support and obtaining state/county-wide grants for community gardens. Trail development (Chapter 6, Trails and Open Spaces) and prairie restoration could also be incorporated into the creation of a community garden. Trail systems and prairie restorations adjacent to the community garden would allow for more access and educational opportunities.

Interpretive Signage

Interpretive signage could provide educational opportunities at Lake Marion. The rich history of the area is documented in the downtown area, but there are no interpretive signs currently located at Lake Marion. Information pertaining to the historical significance of the lake and the surrounding region could be posted at key locations throughout the park. Educational signage could also inform users of the natural characteristics of the lake system. A couple options exist for the content of the educational signs at the park:

- Develop signs similar to that of downtown Mazomanie to showcase the rich history of Lake Marion.

- Develop educational signs to inform users of the concepts of watershed management and other water quality issues present at Lake Marion and in the Black Earth Creek watershed. Native plant and animal species could be showcased to inform users of the biodiversity present at Lake Marion.

FIGURE 6.25 – INTERPRETIVE SIGNAGE: EXAMPLE OF AN EDUCATIONAL SIGN PLACED ALONG A WALKWAY IN A NATURAL AREA.

Posting signs at the park would be a good opportunity to inform users of Lake Marion's unique historical significance and natural conditions. Water and habitat quality, watershed management, and other environmental issues could be featured to educate the public on the broad concepts illustrated by the Lake Marion area.

RESTORATION AND ENHANCEMENT ACTIVITIES

Local organizations or clubs, adjacent landowners, and users of Lake Marion could organize to complete volunteer work at Lake Marion. This labor could consist of planting native vegetation, invasive species removal, shoreline restoration, and trail construction. For instance, in 2001 shoreline restoration activates began on degraded shoreline segments along the edges of Lake Phalen in Minnesota. Restoration activities, such as shoreline and wetland plantings of native vegetation, were performed by city employees, volunteer citizens, and a nearby elementary school. Most of the grants available for completing work at Lake Marion would require some type of matching figure. If used properly, donated or in-kind labor services could be used as the required matching amount. Additionally, these work days could become social functions and educational opportunities for the community. There already exist several local organizations and clubs that perform maintenance at Lake Marion – including the Friends of Lake Marion and the Wisconsin River Sportsmen's Club – which may be interesting in organizing or sponsoring such events. Creek clean up days are already coordinated by the Black Earth Creek Watershed Association with the help of local landowners. These volunteer work days could be expanded to include areas around Lake Marion once work associated with dam removal begins. Volunteer work is not only rewarding, it can make an extensive restoration project more economically feasible.

FIGURE 6.26 – VOLUNTEER ACTIVITIES: CITIZEN VOLUNTEERS PULL WEEDS ALONG THE SHORELINE OF LAKE GEORGE IN MINNESOTA AFTER PLANTING NATIVE VEGETATION A FEW WEEKS EARLIER. SOURCE: MINNESOTA NATURAL RESOURCES CONSERVATION SERVICE, 2003.

Recommendations For The Park Zone

There are specific actions the Village of Mazomanie can take to manage the goose population and diversify wildlife.

- Manage goose population.
- Create a natural buffer zone by planting native vegetation.
- Reduce mowed areas.
- Create signs to discourage public feeding of geese.
- Diversify wildlife.
- Diversify vegetation by planting native vegetation.
- Create structures (e.g. bird boxes) for shelter.

On the other hand, actions taken to improve recreational opportunities in the Lake Marion park are more flexible and depend on stakeholder wants and needs. Some actions will be more costly than others (e.g. piers) whereas some may actually reduce maintenance costs (e.g. reduce mowing) and some fall somewhere in between. However, we do recommend that restoration activities be performed to some extent by volunteers in order to reduce costs as well as provide an opportunity for community education and togetherness. The Village should continue to facilitate discussions in collaborative and creative ways in order to determine the best management actions for improving the recreational and open space opportunities for Lake Marion.

Pond Zone Enhancement

The southern portion of Lake Marion park presents the largest planning opportunity when the dam is removed. Historically, Lake Marion comprised the entire area of the park, including and extending past the area now occupied by the two southern ponds. Lake Marion was divided into three water bodies in the 1950's when the DNR attempted to create a fish hatchery. Although the fish hatchery was short-lived, the ponds have remained intact as separate water bodies. Since then the ponds have served as retention ponds for Black Earth Creek water, allowing sediments to settle before reaching Lake Marion. This section explores the community's vision for the ponds and three scenarios if the Village decides reclaim some park space by filling in the small pond.

Currently the small pond is shallow – approximately one foot in depth - and filled with a layer of unconsolidated sediments that settled out of the Black Earth Creek diverted water. The small pond is highly turbid and has very little aquatic plant life. It is also hypereutrophic. During the summer, warm temperatures create an optimum environment for extensive algal growth and low oxygen levels. During the Spring of 2010, extensive carp spawning was observed. This activity degrades the habitat further by re-suspending phosphorus-laden sediments and thus reducing light levels.

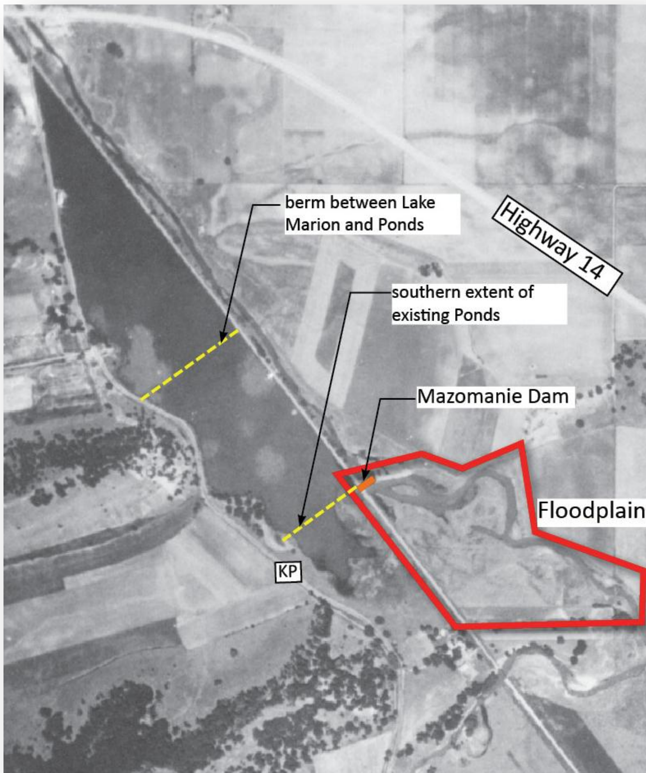

FIGURE 6.27 – 1937 AERIAL PHOTO OF LAKE MARION.

As water moves from the small pond to the large pond, water quality improves slightly. The total dissolved phosphorus (TDP) and total phosphorus (TP) levels decrease slightly. Depth also increases, with an average depth of 2 feet, and a maximum depth of 3.3 feet at the northern corner (See Chapter 3, Results and Conclusions). Similar to the small pond, it also acts as a retention pond for sediments from Black Earth Creek. From the sediment evaluation (Hydrology and Water Quality Section), we have calculated that the large pond currently has an accumulated volume of 8,500 cubic yards of unconsolidated sediment. Due to the high concentration of found in the water, the pond is considered eutrophic. The large pond is hydraulically connected to Lake Marion through a culvert under the earthen berm that separates the two. Historical data indicates that a clay liner exists under the ponds, but we have no independent verification. Although seepage tests were not performed for the large and small pond in the scope of our study, it is highly likely that side and bottom seepage occur. It is important to note that without the water supply from Black Earth Creek, the small and large pond will dry out relatively quickly, on the order of hours to days. An alternative water supply will be required to maintain the ponds if the community desires to preserve them. Therefore, exploring options that either reduce seepage from the existing ponds or remove them completely should be considered.

The Community's Vision

A theme reiterated by the community was the value of the southern ponds area for its natural aesthetics and wildlife habitat. Community members expressed the desire to preserve this side of the park for natural wildlife habitat, quiet contemplation, passive recreation and "connection with nature." During the design charette in the summer 2010, community members were asked to brainstorm ideas for the pond area if the dam was removed. The community generated many creative and diverse ideas such as preserving the ponds, restoring an oak savannah landscape, creating community garden space, creating a wetland park, and/or filling the ponds for open space. All of these ideas represent possibilities. In the end, the fate of these ponds and the park rests on the community's long-term vision and how much they want to invest in the space.

The planning scenarios presented below offer a range of opportunities for improving and enhancing the pond area of the park. The plan option solutions were derived directly from concepts and visions expressed by the community both during the summer planning workshop held June 17, 2010 and other community participation events. The solutions are assessed using the results of the field studies conducted by our group. The three scenarios represent a spectrum of ideas (from wet to dry) and are meant to inspire ideas for park planning. Drawings and written descriptions are provided to illustrate the elements and character of the design. We strongly encourage the community to continue crafting their vision for the space in a collaborative and participatory manner.

Fill The Small Pond To Reclaim Park Space

In each planning scenario we recommend filling the small pond to create a more meaningful and usable park space along the railroad corridor. Through social surveys, it was determined that the small pond does not provide much value to the community. In order to maintain and enhance the natural character of the park, this area could be restored to an oak savannah ecosystem, a landscape that is evident in historical aerial photographs. This type of prairie landscape requires less mowing than a traditional lawn and discourages geese from gathering. It, however, does need to be maintained periodically with seasonal mowing and controlled burns. A portion of the area could also be dedicated to usable open space such as community gardens, family picnicking and a new pavilion structure.

A rough calculation of the volume to fill the small pond was derived using an average water depth of one foot, an average water surface to bank height of 1.25

feet, and a pond sediment compaction of 0.5 feet. With an area of 1.5 acres, the rough fill volume is 6,700 cubic yards. Excavation of the adjacent floodplain and/or dredged fill excavation from the large pond may provide the source of fill material required to fill the small pond (see Chapter 5, Stream and Floodplain Restoration Options).

Filling wetlands requires a permit from the WDNR, a measure that was established to protect the state's many vulnerable and natural wetlands. However, since the small pond is an artificial wetland which would dry out without a water diversion, its classification is questionable. The community should discuss the intent of filling the small pond in terms of the larger picture of wetland creation and enhancement within the Lake Marion and the Black Earth Creek floodplain.

SCENARIO A: WATER GARDEN

The Water Garden scenario celebrates preserving water as a major park element in the southern portion of Lake Marion Park. In this scenario, the large pond would be preserved and enhanced. Dredging can be utilized to create variation in depth across what is now a consistently shallow pond. Unconsolidated sediments on the bottom of the pond can be dredged and the material can be pumped to fill the small pond, or to create wetland shelves and in-lake islands. Visually connecting the large pond to Lake Marion can be achieved by removing part of the dyke which currently separates them. A picnic / fishing island could be created in the center to maintain pedestrian access and provide more usable park space. The small vertical gradient between the water levels of the large pond and Lake Marion can be maintained or increased by creating a cascade or stream, providing a form of aeration to Lake Marion, as well as being an attractive park feature.

The Water Garden scenario requires providing a water supply in addition to what is required to maintain Lake Marion's volume. Water supply for the Water Garden and Lake Marion can be from the same water source, pump and infrastructure. The pump house should be strategically located where it is most feasible in terms of groundwater location and quality and efficiency of underground piping and electrical infrastructure. Designs should explore utilizing the pump house as an opportunity for a multi-purpose park structure. Although seepage tests were conducted for Lake Marion, the WRM scope of work in the summer of 2010 did not include an in-depth study of the small and large pond. Assessment of this scheme would involve further investigation of the presence and integrity of the large pond's clay lining, seepage, and a schematic design for the proposed lake bathymetry to calculate supply water volumes.

FIGURE 6.28 – SCENARIO A: WATER GARDEN. DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

SCENARIO B: WETLAND PARK

The Wetland Park scenario explores the community's desire to create wetlands in the pond area. The design explores a yin-yang type scenario, where the large pond is excavated at the northern end to create emergent wetlands, and then filled on the southern end to create an upland park space. The two areas could be connected by a wet prairie swale to allow for storm water infiltration, groundwater recharge, and habitat diversity. The upland park can be designed as a natural picnicking area, or community garden space.

The premise of the plan is to eliminate the large pond as a standing water feature and take advantage of the sunken character of the site to create a natural, groundwater-fed, wetland landscape. However, the WRM group learned from groundwater wells installed during the summer at Lake Marion that groundwater in Lake Marion Park is roughly nine feet below the park's land surface. That means that groundwater is beneath both Lake Marion and the southern ponds. Therefore, to create an emergent wetland in this area would require excavating a 10 foot or deeper hole in the landscape. This is quite a considerable grade change and may not be the most desirable, safe, or cost-effective park feature. If a wetland landscape is desired, artificial pumping would most likely be required to maintain safe and attractive land surface relationships.

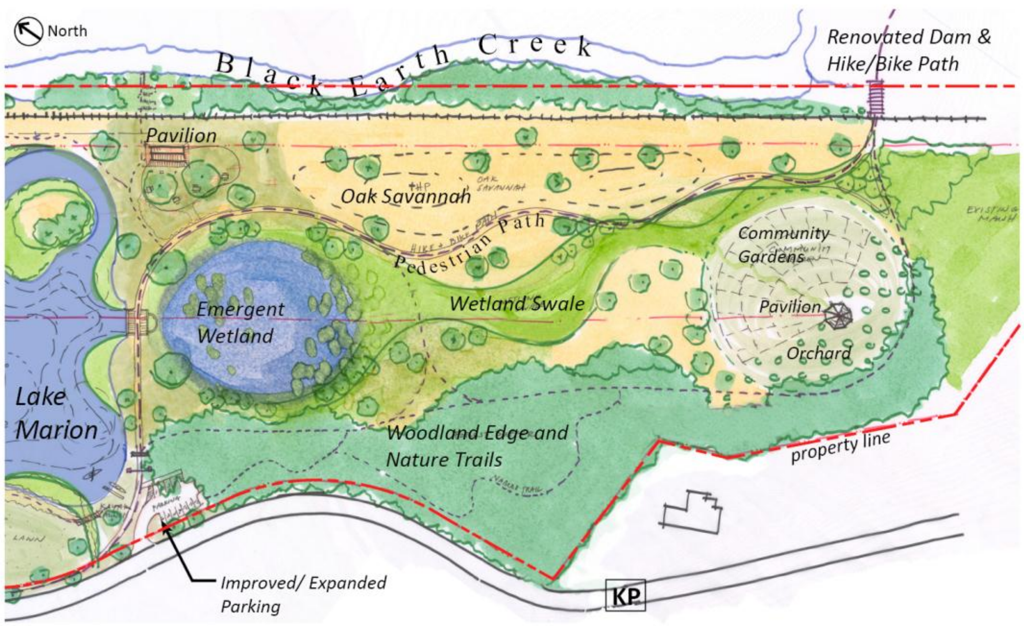

FIGURE 6.29 – SCENARIO B: WETLAND PARK. DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

SCENARIO C: SUNKEN OPEN SPACE

The final planning scenario explores creating usable upland park space, while celebrating the history of the ponds. Instead of completely filling the large pond, it may be interesting to leave a historical trace of its presence by only partially filling its area. Grade changes would provide opportunities to create edges and define 'rooms' in the landscape. The existing dyke between the large and small pond could be reused to create a grass terrace down to a multi-purpose lawn space that would be used as playing fields and event space in warm weather and flooded for ice skating in the winter. A more formal approach is to plant the edges of the open space with canopy trees to provide a shaded promenade and space for relaxation and observation. This formal landscape can feather into a more natural, forested landscape on the edges. The flat area of open space can be graded so that it drains to the south and into a natural wetland area. The existing marsh south of the large pond could be extended further north, which would enhance infiltration and groundwater recharge to the shallow aquifer, as well as expanding wildlife habitat and nature observation opportunities.

To achieve this scenario a significant volume of fill material is required. Based on rough estimates of the large pond, roughly 70,900 cubic yards of soil is needed to fill the entire pond area. Therefore, filling roughly half of the pond would require 35,500 cubic yards of soil. Approximately 48,400 cubic yards of sediment may be available if the Black Earth Creek floodplain is excavated during stream and floodplain restoration efforts associated with the dam removal. In order to use this sediment, the timing of these projects should be coordinated. The Village should collaborate with the WDNR and the Wolf Run Association to determine the best way to leverage resources between the two projects.

FIGURE 6.30 – SCENARIO C: SUNKEN OPEN SPACE. DRAWN BY LAUREN BROWN – 2010 WRM PRACTICUM.

Recommendations for the Pond Zone

The southern pond area comprises a sizable portion of Lake Marion Park. Now that the decision to remove the dam is certain, planning for this area should be given importance equal to preserving Lake Marion. The Village should begin to pursue grant opportunities for funding further design and construction. The Village should also leverage resources related to dam removal and stream/floodplain restoration, as well as consider phasing improvements in the ponds area. The schemes above are meant to provide inspiration and a jumping-off point for further design. It is our hope that the community continues to work together to develop a cohesive vision for Lake Marion Park.

Management Alternatives Conclusions and Recommendations

After over a year of field studies, interaction with stakeholders, and consultations with experts, we are able to provide the previously described management alternatives. Along with the extensive list of management alternatives, we have compiled a short list of recommended management actions at the conclusion of each section. A summary of the recommendations can be found in Table 6.2. As mentioned at the beginning of the chapter, notice that some actions are a solution to multiple issues - e.g. carp management can enhance water quality and improve the fishery. On the other hand, multiple actions are sometimes required to solve one issue - e.g. reducing seepage from the lake by reconfiguring the banks and sealing the bottom of the lake. Applying the recommended management alternatives could potentially result in the illustration in Figure 6.31. Our recommendations try to provide a balance between economic limitations, stakeholder preferences, and scientific feasibility in order to help the Village of Mazomanie make management decisions for Lake Marion and the surrounding area.

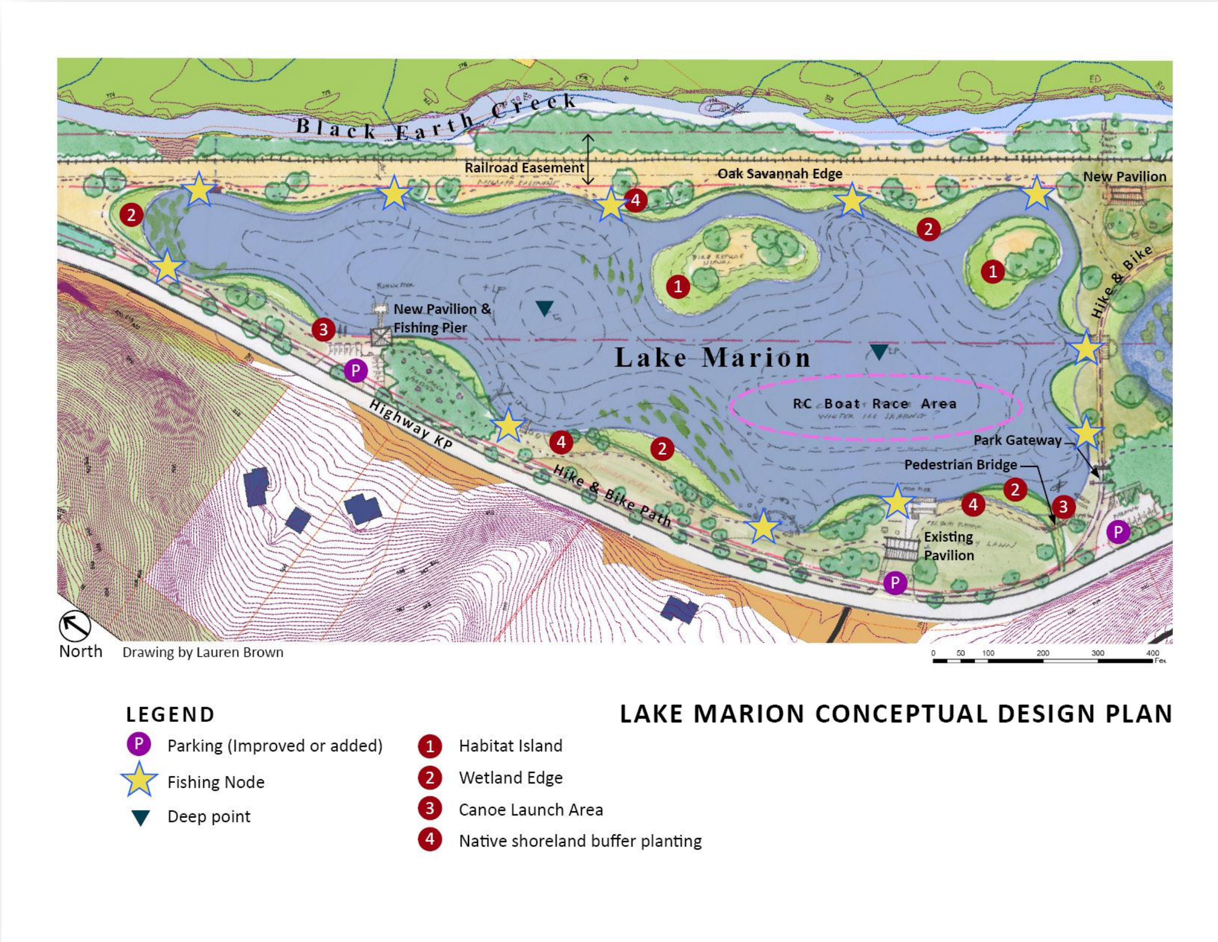

Figure 6.31 – Lake Marion Conceptual Design Plan: There are a multitude of activities that could improve the Lake Marion area's habitat and recreational opportunities and implementation of the recommended management alternatives could have multiple outcomes. Illustrated here is one outcome that may arise from implementation of a wide range of management activities. Drawn by Lauren Brown – 2010 WRM Practicum.

Table 6.2 – Management Recommendations for Maintaining and Enhancing the Lake Marion Area.

Implementation of Recommended Management Alternatives — ACTIONS	RESULTS: decreases seepage	decreases total phosphorus	decreases total suspended solids	increases water clarity	increases dissolved oxygen	improves fish habitat & fishery	improves biodiversity	improves fishing opportunities	improves natural aesthetics	improves recreational opportunities	increases community involvement
reconfigure the banks	x					x	x				
physically compact edges of lake	x										
seal lake edges with impervious material	x										
obtain new water source (groundwater)		x	x	x							
dredge		x				x	x				
apply alum		x									
install aeration system					x	x					
improve impervious surfaces		x	x	x	x						
improve lawn care practices		x	x	x	x						
add woody debris and structure in shallow areas						x	x	x			
remove carp			x	x		x	x	x			
stock with preferable fish species							x	x		x	
manage aquatic curly leaf pondweed						x	x			x	
reduce mowed areas		x	x				x		x	x	
create vegetated buffers along shoreline using native plants							x		x	x	
manage reed canary grass							x		x		
manage goose population		x							x	x	
create signs to discourage feeding of geese									x	x	x
create shelter for preferable bird species							x			x	x
add fishing pier(s)								x		x	
implement community volunteer restoration										x	x
add recreational structures (e.g. picnic tables/pavilion)										x	x
install interpretive signage										x	x

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GLOSSARY

Aeration: The process by which air is circulated through, mixed with, or dissolved in a liquid or substance

Anoxic: State of depleted oxygen.

Anthropogenic: Caused or produced by humans.

Aquifer: Any geological formation containing or conducting groundwater

Avulsion: Rapid abandonment of a river channel and the formation of a new river channel.

Bank-full discharge: Height in which a stream overflows its banks; associated with a momentary maximum flow which, on the average, has an occurrence interval of 1.5 years as determined using a flood frequency analysis.

Bathymetry: Depth profile of the bottom of a lake.

Benthic zone: The bottom of a lake.

Bentonite: A type of clay.

Biomass: Mass (quantity) of living biological organisms.

Chlorophyll a: Pigment, vital for photosynthesis, found in plants and algae. It is used as a measure of algae biomass in water.

Conductivity: Measure of the water's ability to conduct an electric current. It is greatly influenced by the geology of the area and is an indirect measure of dissolved inorganic ions, such as nitrates and phosphates.

Culvert: A pipe through which water is diverted.

Dissolved oxygen (DO): Gaseous oxygen dissolved in the water. It is an important indicator of water quality, especially with regards to aquatic life.

Eutrophic: Excessive nutrients in, or over fertilization of, lakes; causes algal blooms.

Eutrophication: Accumulation of nutrients in a water body; causes algal blooms.

Evaporation: Water, from soils or open surface water such as lakes and rivers, that changes from liquid to atmospheric water vapor. It is considered an outflow (or water loss) in the water balance.

Fibric: Organic soil material that contains virtually all organic matter; allows for identification of plant forms.

Flocculation (floc): Clump of particles that form as a result of a chemical reaction.

Floodplain: Level area near a river channel; constructed by the river in the present climate and overflowed during moderate flow events.

Groundwater: Water beneath the ground surface or subsurface of the earth. The source of water in wells and springs.

Head-cut: The initiation of channel incision at a nick point as the stream channel bed elevation adjusts to a natural or a human-induced disturbance.

Herbaceous: Leafy plant without woody stems.

Hydrogeology: Study of groundwater in the soil and rocks near the surface of the land.

Hydrologic system: The spatial region of a closed water cycle. It can range from a small scale, such as a lake or reservoir, to a large scale, such as a watershed.

Hyper-eutrophic: Extremely eutrophic.

Impervious material/surface: A material/surface that eliminates water infiltration and natural groundwater recharge

Invasive Species: Non-native species that typically overcrowd native species and are an economic and environmental nuisance.

Littoral zone: Area of a lake habitat where sunlight penetrates to the bottom. This zone is usually located around the periphery of the lake.

Macroinvertebrate: An animal that has no backbone and is visible to the unaided eye (approximately 0.5 mm or larger).

Macrophyte: A plant large enough to be visible to the unaided eye.

Nitrate (NO3): A form of inorganic nitrogen that can be used by aquatic plants. Concentrations in groundwater above 10 mg/l can be harmful if ingested, especially by infants and expectant mothers.

Nitrite (NO2): A form of inorganic nitrogen that can quickly convert into nitrate.

Nutrient loading: Addition of nutrients (e.g. phosphorus) to a system in greater amounts than would occur naturally.

Nymph: Immature form of some invertebrate insects.

Oligotrophic: Water having a low concentration of nutrients; these lakes are characteristically clear and have low fertility/photosynthetic activity.

Permeability: A measure of the ability of a porous material (e.g. soil) to allow fluids to pass through it.

pH: A measure of the acidity of a liquid.

Phosphate: Ion of phosphorus plus oxygen. It is used as indirect measure of phosphorus in water.

Photosynthetic activity: Plants performing the synthesis of complex organic materials, using sunlight as the source of energy.

Phytoplankton: Small, photosynthetic aquatic organisms (e.g. algae).

Precipitation: Water that falls on the earth's surface as rain and snow. It is considered an inflow (or water gain) in the water balance.

Rotenone: Odorless chemical used as a broad-spectrum insecticide and pesticide. It kills fish by inhibiting their oxygen use.

Seepage: Downward entry of water from a lake to the soil, to become groundwater. It is considered an outflow (or water loss) .

Soil core: A cylindrical-shaped soil sample obtained by hand-auguring or drilling. It is used to identify soil layers, soil texture, and other soil characteristics.

Soluble iron: Iron dissolved in water. Considered an aesthetic contaminant for drinking water where more than 0.3 mg/l can result in odor, metallic taste, and a red, brown, or yellow tinting.

Stage: Elevation of a water body's surface.

Streamflow: Water flowing in a channel, stream, or river. Depending on its direction, it can be considered an inflow or outflow in the water balance.

Suspended sediments: Particulate matter that is suspended in or carried by the water column, It is a good indicator of the water's turbidity.

Swale: a place of low elevation where water from storm events occasionally flow.

Taxa: A grouping of organisms that are evolutionarily related and have characters in common which differentiate them from other groupings.

Terrace: An abandoned floodplain.

Terrestrial: Of or relating to the land as opposed to the water.

Total dissolved phosphorus (TDP): phosphorus dissolved in water, a state which makes it readily available for aquatic plants.

Total phosphorus (TP): Concentration of all phosphorus types (dissolved or particulate) in water or sediment. In Wisconsin lakes, phosphorus levels are the key determinant of aquatic plant growth.

Turbidity: Measure of water clarity that expresses the degree to which light is scattered off particles in water; turbid water gives water a cloudy/hazy appearance.

Turion: Overwintering bud produced by certain water plants.

Unconsolidated sediments: Loose sediments at the bottom of a lake or reservoir.

Water balance: A method of mathematically accounting for water flows in a hydrologic system, based on the conservation of mass equation. It can be applied to time periods that vary from minutes to decades.

Water column: Conceptual area of water between the surface and bottom of a water body

Water table: Usually, the elevation where the groundwater surface is located.

Watershed: An area that contributes all its surface runoff to a stream, delineated topographically.

Winterkill / fishkill: Death of fish due to low oxygen conditions, usually occurring during the winter months.

APPENDIX 1: STAKEHOLDER INPUT

STAKEHOLDER PARTNERSHIPS

Local governments and organizations have been an integral part of sustaining Lake Marion and the Black Earth Creek corridor. The following groups have been involved with the project and have had representatives present at our meetings and events. Some of the groups are pursuing partnerships to coordinate funding opportunities and restoration activities in the Lake Marion area. Below is a brief description of each organization, its role in the surrounding area, and current contact information.

BLACK EARTH CREEK WATERSHED ASSOCIATION

The Black Earth Creek Watershed Association (BECWA) is a community-based non-profit organization founded in the early 1980s. It focuses on protecting and enhancing the Black Earth Creek Watershed. The organization promotes awareness of the watershed and its natural resources, monitors areas of concern, collects information, facilitates the coordination of public and private entities, and sponsors mediation of significant conflicts within the watershed. BECWA's goals are:

> *To protect, conserve, support, and advocate for the wise long-term management of the physical, biological, environmental, cultural, and historical resources that constitute the heritage and future assets of the Black Earth Creek Watershed; To foster and encourage citizen and locally-based stewardship among the many members of the watershed community; To provide a forum for civil and informed discussion of issues and problems in the watershed.*

BECWA is a proponent for restoration activities that take place along the Black Earth Creek and within its watershed. The organization supports and advocates for funding initiatives undertaken by other organizations in the region. It provides a public forum to showcase and allow discussion of such initiatives. BECWA also promotes studies to pursue creek restoration and improvement activities taking place in the Mazomanie area along this section of the Black Earth Creek corridor.

Black Earth Creek Watershed Association Contact Information:
Mailing Address: 4296 County Road P; Cross Plains, WI 53528
Phone Number: 608-320-3243
Email Address: becwa_coordinator@yahoo.com

Friends of Lake Marion

The Friends of Lake Marion (FOLM) is a loose organization of residents and neighbors in the Lake Marion area. It was formed around 1990 to assist the Village of Mazomanie and coordinate efforts with other groups interested in maintaining and preserving the natural beauty and wildlife habitat. Their objective is to enhance the limited recreational use of the area for Northwest Dane County residents and visitors to our area.

Over the years FOLM has engaged in a wide range of activities including raising funds for additions to the Lake Marion park area, park and County Road KP cleanup, installing trash receptacles around the park and providing trash removal. The group also added park amenities such as benches and bird houses and has helped clean up significant portions of the park area. FOLM is committed to continue working to assist in making and keeping the Lake Marion area a place where a balance between human recreational use and the lives of the natural inhabitants can be preserved.

Friends of Lake Marion Contact Information:
Contact Person: Dennis Schafer
Phone Number: 608-795-4365
Email Address: dkschafer@centurytel.net
Contact Person: Jim Craney
Phone Number: 608-795-4484
Email Address: craneys@charter.net

Good Neighbor Committee

The Good Neighbor Committee (GNC) was formed in 2007 by a group of elected officials, community representatives, and interested community members. Townships and villages included in the GNC include the Villages of Black Earth, Mazomanie, and Cross Plains; the Towns of Berry, Black Earth, Cross Plains, Middleton, Mazomanie, Springfield, and Vermont, and the City of Middleton. Meetings are also attended regularly by members of the Ice Age Trail Foundation, the University of Wisconsin Extension Office, and state government liaisons and staff members. The main goal of the organization is to promote intergovernmental cooperation on matters of mutual interest through communication and information sharing.

The GNC is pursuing the development of the multi-use Good Neighbor Trail to provide recreation and alternative transportation opportunities for residents of the communities along HWY 14. It would span a 13 mile long, 4 mile wide corridor along HWY 14 to connect the City of Middleton to the Village of Mazomanie and highlight natural resources in the area. It would also connect to existing trails and link communities to schools to maximize use by a variety of user groups. The GNC is currently facilitating the trail planning process and coordinating funding opportunities with Dane County and a local design firm.

Good Neighbor Committee Contact Information
Contact Person: Jim Bricker
Phone Number: 608-848-5060
Email: corridor-14-trails@googlegroups.com
Website: http://groups.google.com/group/corridor-14-trails

Town of Mazomanie

The Town of Mazomanie is located along the Wisconsin River in northwestern Dane County, Wisconsin. The Town is about 30 miles west of Madison, the state capital. The Black Earth Creek runs through portions of the town. A town resident has donated an easement for a trail between the Village of Mazomanie and Wisconsin Heights High School. The proposed multi-use trail would be used to encourage safe, off road access for students to go to the school; serve as a destination for bird watchers, prairie enthusiasts and sportsmen; and, in the future, become a link in an expanded trail system that runs from Madison to Devil's Lake State Park.

To this end, an NGO 501C3 association (the Wolf Run Association) was formed to move the proposed project forward. The Town of Mazomanie donated $500 for a feasibility study in 2010 and has committed $10,000 towards the completion of the project over the next several years.

Town of Mazomanie Contact Information:
Contact Person: Maria Van Cleve, Clerk
Phone Number: 608-795-2920
Contact Person: Fred Wolf, Chairman
Phone Number: 608-767-2668
Mailing Address: Town of Mazomanie, 711 West Hudson, Mazomanie, WI 53560
Website: www.townofmazomanie.org
Email Address: twnmazo@gmail.com

Trout Unlimited

The Southern Wisconsin Chapter of Trout Unlimited (SWCTU) was founded in 1969. Since then it has grown to over 650 members. The chapter and its members have become strong and respected advocates for the cold water resources in the region. The mission of the organization is conservation, protection, and improvement of trout and salmon habitat. The Chapter is affiliated with the

Wisconsin State Council of Trout Unlimited and with the national organization of Trout Unlimited.

The SWCTU and national field staff working in the Driftless Area Restoration Area have supported and participated in the working group that has developed and promoted the Lake Marion and Black Earth Creek restoration project. Members have helped the community partnership prepare an application for project funding from the Dane County Partners for Recreation and Conservation grant program. County funds would be used to preserve and enhance Lake Marion, restore portions of Black Earth Creek, and construct a link in a regional recreational trail system. The Chapter has added its pledge of funding support to those of the village and town, and the state Department of Natural Resources. Trout Unlimited is committed to providing labor and seeking future funding as it continues to participate in restoration and maintenance of Black Earth Creek in the project area.

Trout Unlimited Contact Information:
Mailing Address: SWTU; P.O. Box 14352; Madison, WI 53708
Email Address: Admin@SWTU.org
Website: http://www.swtu.org/index.html

Wisconsin River Sportsmen's Club

The Wisconsin River Sportsmen's Club (WRSC) is a not-for-profit organization located on the Wisconsin River. The organization is dedicated to the conservation of wildlife habitat and the preservation of natural areas in the Mazomanie area. In 1973, the WRSC worked closely with the Wisconsin Department of Natural Resources to obtain the property where Lake Marion is located. At the time the club had the idea to enhance the lake as a fishery for youth and senior citizens, which remains their goal to this day. When the property was acquired, the lake bed had been dry for several years. The club was instrumental in restoring water to the lake and stocking it with fish. As stewards of Lake Marion, club members have played key roles in maintaining the lake. It has since been converted to a community park. The club has added a handicapped accessible fishing pier and a pavilion and hosts community activities at the lake to better the fishery and promote fishing for children.

Over the years, the Wisconsin River Sportsmen's Club has maintained and restored Lake Marion and the surrounding park. Club members have donated their time and effort to a number of park features, ranging from the picnic pavilion to fish habitat projects. The organization plans to continue its activities at Lake Marion. They worked closely with the WRSC to organize events, increase community participation, and gather information about the lake.

Wisconsin River Sportsmen's Club Contact Information:
Contact Person: Bob Pailing
Mailing Address: 10041 County Trunk Y, Mazomanie, Wisconsin 53560
Email Address: wrsclub@hotmail.com
Website: http://www.wrsclub.org

Wolf Run Association

The Wolf Run Association (WRA) is a non-profit organization that is interested in the preservation, protection, and improvement of Lake Marion and the lower Black Earth Creek. The organization's goals include the preservation and improvement of the Lake Marion and Black Earth Creek area, educating the public about water resources, and developing a local and regional trail system. The WRA seeks to maintain Lake Marion and the lower Black Earth Creek watershed as areas for multi-use recreational activities and for protecting the ecosystem of the watershed. Through this effort, the organization will encourage and provide leadership to promote Mazomanie as a focal point for recreational use of the lower Black Earth Creek.

The WRA also provides a collective forum for all levels of government, watershed and recreational organizations, and individual enthusiasts to discuss and promote the use and protection of the lower Black Earth Creek. The organization will encourage community growth and economic development while promoting the aesthetic value within the area. The organization seeks to acquire donations of land, easements, grants, and other charitable donations to fulfill these goals. It has already accepted land and easement donations from the Wolf Family to undertake the restoration of the Black Earth Creek adjacent to Lake Marion and develop a nature preserve and recreation area next to the Village of Mazomanie. It has also acquired a River Planning Grant to undertake planning initiatives along the Black Earth Creek. We worked closely with the WRA to organize events, increase community participation, and gather information about Lake Marion.

Wolf Run Association Contact Information:
Contact Person: Scott Stokes
Mailing Address: 106 Brodhead St., Mazomanie, WI 53560
Phone Number: 608-795-4574
Email Address: sstokes@chorus.net

Village Of Mazomanie

The Village of Mazomanie (VoM) acquired Lake Marion after the Wisconsin Department of Natural Resources (DNR) abandoned its development of a fish hatchery. The VoM also owns the Black Earth Creek dam and the water rights that provide Lake Marion its source of water from the creek. It is currently exploring ways to keep Lake Marion a recreational and wildlife habitat area for the residents of Mazomanie and surrounding communities.

The Village has currently accepted the Dam Removal Grant provided by the DNR and is moving forward with plans to remove the Black Earth Creek dam with the help of a local engineering firm. The VoM has also partnered with a few organizations in the area to apply for funding that would help pay for improvements around the Lake Marion area and supply an alternative water resource for the lake. It will continue to oversee decisions made about Lake Marion and the maintenance of the lake area. We worked with Mazomanie to organize community meetings and coordinate field work taking place at Lake Marion.

Village of Mazomanie Contact Information:
Mailing Address: Village of Mazomanie, 133 Crescent Street, PO Box 26, Mazomanie, WI 53560
Phone Number: (608) 795-2100
Email Address: sdietzen@villageofmazomanie.com
Website: http://www.villageofmazomanie.com

APPENDIX 2:
Standardized Interview Questions

GENERAL QUESTIONS:

1. What do you know about Lake Marion's history?
2. How have you observed Lake Marion being used? How do you see it being used in the future? What are the current main uses of Lake Marion?
3. What is important about Lake Marion? What is important about Black Earth Creek? What is important about the dam on Black Earth Creek?
4. If you could change the area around Lake Marion, how would you do it?
5. What organizations and/or community members do you see as having a major role in the development of the future of Lake Marion?

ORGANIZATION ADDENDUM:

1. How does your organization use Lake Marion?
2. Does your organization address issues concerning Lake Marion? If so, what issues are addressed and how?

APPENDIX 3:

PERSONAL REFLECTION

Question 1: Reflect on your past experiences with the Lake Marion park space. What are your fondest or most memorable experiences at the Lake? If you are new to the community and have not developed experiences, can you share a fond experience from another lake?

Responses	Category	Sub-Category
"My oldest son's wedding was held at Lake Marion."	Personal Value	Family
"Watching my youngest son going fishing for the first time."	Personal Value	Family
"Both of my kid's senior pictures were taken at the lake."	Personal Value	Family
"DNR had drained the lake. …..'s cows had escaped and at dawn came thundering through our yard across the road, through the lake, the creek, and home to be milked."	Personal Value	Events
"Taking my grandchildren to fish last summer."	Personal Value	Family
"Hockey with my sons."	Personal Value	Family
"Grandfather, grandchildren on lake."	Personal Value	Family
"Picnicking at Lake Marion as a child."	Personal Value	Family
"….'s truck went through the ice one winter."	Personal Value	
"Fog coming off the lake in the early fall mornings."	Personal Value	Beauty/Naturalness
"Views of Lake Marion from the Bluff."	Personal Value	Beauty/Naturalness
"Daughter caught first fish at lake."	Personal Value	Family
"Gives Mazomanie its unique character: Water, flowing, rushing, trickling. No place like it."	Personal Value	Beauty/Naturalness
"The end of the annual depot-to-depot run as it goes past Lake Marion."	Personal Value	Events

"Enjoying seeing people enjoying the wonderful area."	Personal Value	Beauty/Naturalness
"Walking around the lake(s) on a nice summer day with my family and our puppies."	Personal Value	Family
"Ice skating with my kids."	Personal Value	Family
"Walking and relaxing in a beautiful setting."	Personal Value	Beauty/Naturalness
"Family walks in the park."	Personal Value	Family
"Fishing when a kid."	Personal Value	Family
"I like seeing the geese at the Lake. Last summer when Hwy 14 was being worked on and people took Hwy KP and the traffic was backed up for a long way, I think people really noticed the Lake and had fun watching the geese. P.S. I don't get out of the car much so the goose poop doesn't bother me."	Personal Value	Beauty/Naturalness
"I have no personal experience, but was extremely interested as a newcomer to research the history of the 1855 dam, the new DNR Dam, the 'lake's' usage, etc."	Personal Value	Events
"The day the circus train stopped."	Personal Value	Events
"Discovery of the dam."	Personal Value	Events
"My most memorable experience involving 'Lake' Marion was tonight, learning it is an artificial impoundment, and not a lake at all, which means that it has local cultural importance, but not importance as a natural resource."	Personal Value	Events
"Goose poop around the lake/park."	Health/Cleanliness	Geese
"Daughter stopped cold in her tracks: 'Dad I can't go any more, there's poop (goose poop).'"	Health/Cleanliness	Geese
"Walking around the lake trying to avoid the bird poop."	Health/Cleanliness	Geese
"Spending <u>three years</u> cleaning out brush after we moved in. The first two without a chainsaw!"	Health/Cleanliness	Vegetation

"I like seeing the geese at the Lake. Last summer when Hwy 14 was being worked on and people took Hwy KP and the traffic was backed up for a long way, I think people really noticed the Lake and had fun watching the geese. P.S. I don't get out of the car much so the goose poop doesn't bother me."	Wildlife/Habitat	Wildlife
"Watching the loons when they passed through."	Wildlife/Habitat	Wildlife
"Finding 5 White Egrets at dusk."	Wildlife/Habitat	Wildlife
"Observing geese no's growing from the first family with 6 goslings to migrating flocks of up to 700 – seems to have stabilized at 500 by time lake freezes."	Wildlife/Habitat	Wildlife
"Wildlife – lives of the geese and ducks. Bald Eagle on the ground 50' away. Snowy Egrets and rare warbler sightings."	Wildlife/Habitat	Wildlife
"Geese fly over house."	Wildlife/Habitat	Wildlife
"Watching my youngest son going fishing for the first time."	Recreation	Fishing
"I like seeing the geese at the Lake. Last summer when Hwy 14 was being worked on and people took Hwy KP and the traffic was backed up for a long way, I think people really noticed the Lake and had fun watching the geese. P.S. I don't get out of the car much so the goose poop doesn't bother me."	Recreation	Wildlife Observation
"Access point to the trout stream."	Recreation	Fishing
"Dog Park – teaching a dog to swim."	Recreation	Dog Park
"Fishing when a kid."	Recreation	Fishing
"Family walks in the park."	Recreation	Walking/Jogging
"Walking and relaxing in a beautiful setting."	Recreation	Walking/Jogging
"Ice skating parties at night with a large bonfire on the island in the middle."	Recreation	Ice Skating
"Walking around the lake trying to avoid the bird poop."	Recreation	Walking/Jogging
"Walks around the lake."	Recreation	Walking/Jogging

"Ice skating with my kids."	Recreation	Ice Skating
"Walking around the lake(s) on a nice summer day with my family and our puppies."	Recreation	Walking/Jogging
"Walking around the lake(s) on a nice summer day with my family and our puppies."	Recreation	Dog Park
"Walking the dogs."	Recreation	Dog Park
"Enjoying seeing people enjoying the wonderful area."	Recreation	Aesthetics
"The end of the annual depot-to-depot run as it goes past Lake Marion."	Recreation	Walking/Jogging
"Walking around the lake with my dog."	Recreation	Walking/Jogging
"Walking around the lake with my dog."	Recreation	Dog Park
"Catching bluegills in the large pond with…."	Recreation	Fishing
"Daughter caught first fish at lake."	Recreation	Fishing
"Walking dog around the lake."	Recreation	Walking/Jogging
"Walking dog around the lake."	Recreation	Dog Park
"Geese fly over house."	Recreation	Wildlife Observation
"Time fishing at Lake Marion."	Recreation	Fishing
"Taking my grandchildren to fish last summer."	Recreation	Fishing
"Ice skating."	Recreation	Ice Skating
"Ice Skating."	Recreation	Ice Skating
"Hockey with my sons."	Recreation	Ice Skating
"Walking, running."	Recreation	Walking/Jogging
"Walking out from the village."	Recreation	Walking/Jogging
"Jogging around the lake and between the ponds."	Recreation	Walking/Jogging
"Finding 5 White Egrets at dusk."	Recreation	Wildlife Observation
"Watching the loons when they passed through."	Recreation	Wildlife Observation
"Observing geese no's growing from the first family with 6 goslings to migrating flocks of up to 700 – seems to have stabilized at 500 by time lake freezes."	Recreation	Wildlife Observation
"CC Skiing between the ponds."	Recreation	Skiing
"Cross-country skiing around the lake."	Recreation	Skiing

"Fog coming off the lake in the early fall mornings."	Recreation	Aesthetics
"Views of Lake Marion from the Bluff."	Recreation	Aesthetics

Question 2: What are your hopes and desires for the future of Lake Marion? How would you like to enjoy this resource in the future?

Responses	Category	Sub-Category
"Reduced in size to find its natural size from groundwater into the lake with more rec. area around."	Personal Value	Sustainability
"Scale down Lake Marion in size and maintenance expenses based on natural recharge sustainable levels."	Personal Value	Sustainability
"Scale down Lake Marion in size and maintenance expenses based on natural recharge sustainable levels."	Personal Value	Financial
"Make 'the lake' as self-sustaining as possible."	Personal Value	Sustainability
"More public awareness of the beauty of the area."	Personal Value	Beauty/Naturalness
"A continuation for the area of being Western Dane Co.'s Hidden Treasure."	Personal Value	Beauty/Naturalness
"Retain the 'natural', not too commercial."	Personal Value	Beauty/Naturalness
"For family fun."	Personal Value	Family
"Productive fishery accessible to all young, old, handicapped."	Personal Value	Accessibility
"Improve pier for handicap fishing."	Personal Value	Accessibility
"In response to local sentiment, I hope the lake can be maintained at a minimum cost to taxpayers."	Personal Value	Financial
"Create a recreational area for various users so as many taxpayers benefit as possible."	Personal Value	Financial
"To keep Lake Marion for people to use."	Personal Value	Keep the Lake
"A reasonable compromise by DNR and village to retain the lake."	Personal Value	Keep the Lake

"Need to keep the lake no matter what. It would be nice to keep the dam, too, but if we can't, we need to figure out how to keep it."	Personal Value	Keep the Lake
"Get rid of goose poop!!"	Health/Cleanliness	Geese
"Cleaner lake for swimming."	Health/Cleanliness	Water Quality
"Improve water quality."	Health/Cleanliness	Water Quality
"Dredge the 'Large Pond' and clean up the fallen trees around it!!!!!"	Health/Cleanliness	Vegetation
"Keep the lake… More different kinds of fish put in --- Repair the dam.	Wildlife/Habitat	Fish
"Have more area of habitat for wildlife."	Wildlife/Habitat	Wildlife (Non-Fish)
"Surrounded by wetlands and natural areas for birds and small mammals."	Wildlife/Habitat	Wildlife (Non-Fish)
"Retain combination of picnic areas and wildlife areas."	Wildlife/Habitat	Wildlife (Non-Fish)
"also a place for wildlife, birds, etc. to meet and raise their young."	Wildlife/Habitat	Wildlife (Non-Fish)
"Wetland and creek restoration."	Wildlife/Habitat	Restoration
"RR (Wis. & Southern) doesn't spread ballast (stone) out from the track. (Aesthetics, allow village mowers to cut grass close to tracks.)."	Wildlife/Habitat	Vegetation
"More grass instead of crabgrass!!!!! More trees around by the tracks."	Wildlife/Habitat	Vegetation
"Reduced in size to find its natural size from groundwater into the lake with more rec. area around."	Recreation	Recreation Area
"I would like to see Lake Marion and the park stay the way it is, as a recreational area."	Recreation	Recreation Area
"Retain area as a community park."	Recreation	Recreation Area
"Area around it should be planned for multi-use recreational purposes."	Recreation	Recreation Area
"Create a recreational area for various users so as many taxpayers benefit as possible."	Recreation	Recreation Area
"Maintain as an area recreation facility."	Recreation	Recreation Area
"Link park to trail, if it does come to fruition."	Recreation	Trail

“Bike path.”	Recreation	Trail
“Walking area”	Recreation	Trail
“Connection by foot from village, bluffs, and lake.”	Recreation	Trail
“Bike path.”	Recreation	Trail
“Better access by foot from village.”	Recreation	Trail
“Bike trail to high school and Black Earth.”	Recreation	Trail
“Hopes = Bike trail (somewhere in the area to schools, B.E., etc.) Level land between lake and RR track.”	Recreation	Trail
“Hope it would include a ‘swimming beach’.”	Recreation	Swimming
“Cleaner lake for swimming.”	Recreation	Swimming
“Canoe access to WI River.”	Recreation	Boat Access
“Hope it would be a ‘navigable’ lake – or have an area to launch kayaks, canoes, and rubber boats.”	Recreation	Boat Access
“A place for anyone to fish.”	Recreation	Fishing
“Productive fishery accessible to all young, old, handicapped.”	Recreation	Fishing
“Improve pier for handicap fishing.”	Recreation	Fishing
“Fishing area for kids in the community.”	Recreation	Fishing
“Keep the lake… More different kinds of fish put in --- Repair the dam.	Recreation	Fishing
“Continued dog friendly area.”	Recreation	Dog park
“Safe environment for humans and pets (dogs).”	Recreation	Dog park
“A kind of quiet place for walking.”	Recreation	Quiet Contemplation
“Quiet Areas for contemplation.”	Recreation	Quiet Contemplation
“Camping.”	Recreation	Camping
“For family fun.”	Recreation	Recreation Area
“Retain combination of picnic areas and wildlife areas.”	Recreation	Picnicking
“A place to ice skate.”	Recreation	Ice Skating

APPENDIX 4: SURVEY

Question 1

Where are you a resident?		
Village of Mazomanie	14	58.33%
Town of Mazomanie	3	12.50%
Black Earth	2	8.33%
Town of Vermont	1	4.17%
Cross Plains	1	4.17%
Blue Mounds	1	4.17%
Merrimac, WI	1	4.17%
Areana, WI	1	4.17%

Question 2

What do you use Lake Marion for?		
Fishing	12	19.05%
Walking	9	14.29%
Relaxation	9	14.29%
Picnics	5	7.94%
Watching Wildlife	5	7.94%
Family Gatherings	5	7.94%
Dog Swimming	4	6.35%
Recreation	3	4.76%
Photography	3	4.76%
Cross Country Skiing	2	3.17%
RC Boats	2	3.17%
Canoeing	1	1.59%
Club Events	1	1.59%
Ice Skating	1	1.59%
Fire Department Drills	1	1.59%

Question 3

How often do you use Lake Marion?	A) Never	B) A few times per year	C) A few times per season	D) A few times per month	E) A few times per week	F) Every day
	0	10	1	7	2	2
	0%	45%	4%	31%	9%	9%

Question 4

How much of this time is spent at the two smaller ponds?	A) None of the time	B) Less than half the time	C) Half the time	D) More than half the time	E) All of the time
	7	**10**	**5**	**1**	**1**
	31%	**45%**	**22%**	**4%**	**4%**

Question 5

	Not Satisfied		Somewhat Satisfied	Satisfied	Very Satisfied	**Total Responses**
Are you satisfied with…	**1**	**2**	**3**	**4**	**5**	
…water quality at Lake Marion?	**4**	**6**	**12**	**2**	**0**	**24**
	17%	**25%**	**50%**	**8%**	**0%**	
…the current depth at Lake Marion?	**5**	**1**	**13**	**3**	**2**	**24**
	21%	**4%**	**54%**	**13%**	**8%**	
…the quality of fishing at Lake Marion?	**4**	**3**	**10**	**3**	**0**	**20**
	20%	**15%**	**50%**	**15%**	**0%**	

Question 6

	Strongly Oppose		Neutral		Strongly Support	**Total Responses**
Would you support…	**1**	**2**	**3**	**4**	**5**	
…removal of BEC dam if Lake Marion could be sustained?	**1**	**2**	**6**	**4**	**9**	**22**
	5%	**9%**	**27%**	**18%**	**41%**	
…limiting the number of geese at Lake Marion?	**1**	**2**	**4**	**7**	**9**	**23**
	4%	**9%**	**17%**	**30%**	**39%**	
…modifying the shoreline to allow access for swimming & sunbathing?	**9**	**2**	**3**	**6**	**4**	**24**
	38%	**8%**	**13%**	**25%**	**17%**	
…playground equipment being added around Lake Marion?	**5**	**0**	**7**	**8**	**4**	**24**
	21%	**0%**	**29%**	**33%**	**17%**	
…converting some lawn area to more natural areas around Lake Marion?	**0**	**4**	**6**	**7**	**7**	**24**
	0%	**17%**	**25%**	**29%**	**29%**	

APPENDIX 5:

PHOTO PREFERENCE QUESTIONNAIRE

PHOTO 1:

Likes

"Multiple use resource, no motorboats"

"Boats-yes, Swimming-yes"

"Sail boats-okay"

"Beach, swimming access, sand"

Dislikes

"We have a pool for swimming"

"Green water"

"Pond is too small for boats and beach"

"No beach, please"

"Too developed"

"I do not believe a beach is a good idea here"

"No swimming, Mazomanie has a pool"

"Mixed use of swimmers and motorcraft"

PHOTO 2:

Likes

"Extended pier out into lake"

"We have a handicap pier"

"Large trees by beach, natural looking, minimal signage"

Dislikes

"Disagree with boating and swimming on lake"

"No Piers"

"Pond is too small for boats and beach"

"No beach, please"

"Too developed"

"No beaches"

"No swimming"

PHOTO 3:

Likes

"Lighted pier"

"Good idea for fishing"

"Much better"

"Handicap access to pier"

"Maintain and expand existing pier"

"Nice fishing pier"

"Dock and seating area inviting and natural"

Dislikes

"Sea gulls"

"Telephone poles, housing development in back"

"Houses, power lines, too many lights, too many sea gulls"

"No piers"

PHOTO 4:

Likes

"Informational signage"

"Assuming this provides history, this is good"

"Good, Natural"

"Naturalized shoreline, bench, sign"

"An informational sign with the history on it would be good"

"Nice"

"Educational signs, colorful, but natural setting, bench"

Dislikes

"Excessive weeds in water"

"Mowed grass right down to the water line"

"Green algae/scum on lake"

PHOTO 5:

Likes

"Benches, picnic areas, garbage cans available"

"Lots of trees"

"Nice picnic spot"

"Picnic tables and benches, green grass, native trees"

"Nice views"

"Beautiful pastoral area"

Dislikes

"Need a couple of more tables"

"No boats"

"Motorized boats"

PHOTO 6:

Likes

"Playground equipment good idea"

"Multi-use for kids"

"Yes"

"Limited playground equipment is a good idea"

"Playground is a nice idea"

"Playground is okay"

"Welcoming and pretty"

Dislikes

"No playground, too many in the area not being used now"

"Playground is too close to the Lake"

"Not really a good spot for this"

"Not this kind of park area"

Photo 7:

Likes

"Walkways are good"

"Picnic tables are good"

Dislikes

"Don't like power lines"

"Power lines, too much concrete, no buffer area around water"

"Aerated lake/pond"

"Way too much pavement"

"No pavement"

"Utility lines, too much cement, water spout"

"Not enough shoreline weeds"

"Rather keep it more rural"

"Sidewalk too urban, power lines, fountain"

PHOTO 8:

Likes	Dislikes
"Natural area good idea"	"Residential areas bordering the water"
"Buffer area around water's edge"	"No pavement, please"
"I like the walkway"	"No sidewalks, please"
"Path, natural shoreline"	"Concrete sidewalk"
"Trails would be a good idea, natural buffer looks good"	
"This looks okay"	
"Tall grasses, trees"	

APPENDIX 6: WATER BALANCE METHOD AND RESULTS

METHOD

A water balance method of estimating flows in a hydrologic system is based on the conservation of mass concept. When evaluating long periods of time (like years), net flows in and out of a system balance each other out and it is assumed that there is no overall change in the system's total volume or water storage (ΔS). The basic water balance equation is:

$$\text{Flows In} - \text{Flows Out} = \Delta S = 0$$

The parameters that are considered as flows in a system are precipitation (P), incoming streamflow (Qi), and incoming groundwater flow (Gi). The parameters that are considered as flows out are evaporation (E), outgoing streamflow (Qo), and outgoing groundwater flow (Go), also known as seepage. Replacing these parameters, the water balance equation is:

$$(P + Qi + Gi) - (E + Qo + Go) = \Delta S$$

In order to evaluate the amount of water that would be needed to maintain Lake Marion in the event of dam removal, we established a modified equation of the basic water balance. Currently, Lake Marion is fed by water from Black Earth Creek through a dam diversion. The lake discharges water back into Black Earth Creek through the outlet weir located in its northern corner. From a hydrologic aspect, these flows would be considered Qi and Qo, respectively. For modeling purposes, we "shut off" the flow coming into Lake Marion from Black Earth Creek to evaluate how much water would be needed from another water supply source. We also "shut off" Lake Marion's discharge through the weir to minimize this water loss, and consequently the water requirement. Therefore, the modified equation does not include streamflows. As Lake Marion is a losing lake, we established Gi to be zero. Based on these assumptions, Lake Marion's water balance equation is:

$$P - E - Go = \Delta S$$

We constructed an Excel spreadsheet model that uses historical meteorological information and is based on the water balance equation. We used the longest period of records available for the precipitation and evaporation: January 1948 to February 2008. Daily precipitation is historical data from the National Oceanic and Atmospheric Administration (NOAA) weather station at Prairie du Sac, WI, which is approximately 9 miles south of Lake Marion. Daily evaporation was calculated through the Lamoureux equation using NCEP/NCAR Reanalysis 1 data (relative humidity, wind speed and short-wave radiation) and NOAA data (temperature). Seepage was based on the second preliminary lake shut-off experiment (March to April 2010) and was assumed constant for the whole modeling period. It is important to note that we evaluated only Lake Marion as the hydrologic system.

Results

When comparing the annual averages and total sums of the three water balance parameters, precipitation and evaporation are very similar and practically balance each other out. On the other hand, seepage represents the largest outflow value and is therefore considered the determining factor for Lake Marion's water requirement. When the dam is removed, the future water supply would need to compensate for this loss in order to maintain Lake Marion.

Table A6.1 - Water Balance Results.

Parameter	Daily Average in/day	Daily Maximum in/day	Daily Minimum in/day	Annual Average in/year	Total Sum in/period
Precipitation	0.08	9.27	0	30.6	1,844
Evaporation	0.07	0.23	0	24.1	1,452
Seepage*	0.56	-	-	205.3	12,361

*Constant throughout modeling period.

APPENDIX 7:
LAKE SHUT-OFF EXPERIMENT AND SEEPAGE METER METHODS AND RESULTS

I. LAKE SHUT-OFF EXPERIMENTS

EQUIPMENT

Plywood boards
Metal rulers
Rope for gate handles
PVC pipe for depth gauges
Zip ties
Sledge hammer
Hand saw
Foam
Duct tape
Sand bags
Water resistant spray paint
Wooden wedges
Waders

METHODS

Scott Stokes and John Wick of the Village of Mazomanie conducted two preliminary lake shut-off experiments, in the Fall of 2009 and the Spring of 2010, to calculate approximate seepage rates in the Lake Marion system. In both cases, the culverts between Black Earth Creek and the Small Pond, the Small Pond and Lake Marion, the Large Pond and Lake Marion, and the weir outlet of Lake Marion were blocked using plywood boards (Figure A7.1).

The first preliminary experiment was conducted from October 22nd to October 27th, 2009. The culverts were blocked on October 22nd, and remained shut until October 27th, which is when the plywood at the culvert between the Small Pond and Lake Marion slipped due to a reduction in water pressure. At the end of the experiment, a ruler was used to measure the water level decrease in the corresponding culverts for the three water bodies. During the experiment, no water motion was observed on the lakeside of the blocked culverts, which indicates little or no passing water.

The second preliminary experiment was conducted from March 29th to April 2nd, 2010. A ruler was used to measure the decrease in water level in Lake Marion at the end of the experiment. The south end of the Large Pond and the Small Pond were dry at the time of the experiment and therefore no measurements were taken in these bodies of water.

The results of the preliminary experiments helped design the subsequent lake shut-off experiment, which was conducted from September 27th to October 15th, 2010. This experiment also blocked the culverts between Black Earth Creek and the Small Pond, the Small Pond and Lake Marion, the Large Pond and Lake Marion, and the weir outlet of Lake Marion. Plywood boards were cut to size, waterproofed with spray paint, and the bottoms and sides of the boards were lined with foam to create a better seal. Rope handles were attached to assist with placement and removal. The boards were inserted to prevent water flow through the culverts. Wooden wedges were hammered in alongside the boards to compress the foam and create the best seal possible (Figure A7.1).

The change in water level was measured using depth gauges (Figure A7.2) made of metal rulers tied to PVC pipes. Depth gauges were firmly placed in the bodies of water in the Small Pond, the Large Pond, and at each end of Lake Marion. The individual water levels were recorded daily for all bodies of water throughout the experiment.

FIGURE A7.1 - PHOTO OF BOARDS BLOCKING A CULVERT.

FIGURE A7.2 - PHOTO OF DEPTH GAUGE.

Results

Preliminary Lake Shut-Off Experiment

Table A7.1 - Preliminary Lake Shut-Off Experiment Seepage Rates

	Estimated Seepage Rates	
Body of Water	in/day	gal/min
First Preliminary Experiment - October, 2009		
Small Pond	0.64	21.8
Large Pond	1.00	140.3
Lake Marion	0.36	111.4
Second Preliminary Experiment - March/April, 2010		
Lake Marion	0.56	173.3

WRM Lake Shut-Off Experiment

The raw depth gauge data (Table A7.3) was converted into flow measurements of gallons per minute (gpm) in a 3-step process.

Table A7.2 - Depth gauge measurements from Lake Marion, the Small Pond, and the Large Pond, from September 27th to October 15th, 2011

	Day	Time	Gauge 1 – Small Pond (in)	Gauge 2 - S. Lake Marion (in)	Gauge 3 – Big Pond (in)	Gauge 4 - N. Lake Marion (in)	Exit flow time (sec)	Exit flow rate (gal/sec)	Rain (in)
Monday 27	0	17	12.75	18	12	20	5.92	0.8446	0
Tuesday 28	1	9	11.4375	17.125	10.6875	18.4375	6.87	0.7278	0
Wednesday 29	2	18	10.0625	15.4375	9.25	17.75	9.42	0.5308	0
Thursday 30	3	18.5	9.3125	14.3125	8.75	16.25	9.6625	0.5175	0
Friday 1	4	17	8.375	13.4375	7.6875	15.625	11.54	0.4333	0
Saturday 2	5	13.5	7.625	12.625	7	15	12.0967	0.4133	0
Sunday 3	6	13.5	6.8125	11.8125	6.3125	13.9375	11.72	0.4266	0
Monday 4	7	14	6.1875	11.125	5.9375	13.375	12.4667	0.4011	0
Wednesday 6	9	18	5	9.9375	4.875	12.1875	12.26	0.4078	0
Friday 8	11	13.5	4.0625	9.4375	4.0625	11.375	12.6033	0.3967	0
Sunday 10	13	18	3.25	8.25	3.0625	10.4375	12.7433	0.3924	0
Friday 15	18	9	0.9375	6.0625	0.5	8.25	12.7433	0.3924	0
Total Change			**11.5625**	**11.0625**	**10.1875**	**10.1875**	**10.625**		

We calculated the drop in the water level by subtracting the current day's water level from the previous day's water level, adjusting for the time the measurements were taken. Total rainfall was then subtracted from the calculated water level drop. This gave us a seepage rate of inches/day for each water body (Table A7.3).

TABLE A7.3 - BENTHIC SEEPAGE FROM SEEPAGE METERS.

Seepage Rate (in/day)	Gauge 1 – Small Pond	Gauge 2 – S. Lake Marion	Gauge 3 – Large Pond	Gauge 4 – N. Lake Marion	Lake Marion Average
Monday 27	N/A	N/A	N/A	N/A	N/A
Tuesday 28	1.968	1.3128	1.968	2.3448	1.8288
Wednesday 29	1.0008	1.2264	1.0464	0.4992	0.864
Thursday 30	0.7344	1.1016	0.4896	1.4688	1.2864
Friday 1	1.0008	0.9336	1.1328	0.6672	0.7992
Saturday 2	0.8784	0.9504	0.804	0.732	0.8424
Sunday 3	0.8136	0.8136	0.6864	1.0632	0.9384
Monday 4	0.612	0.6744	0.3672	0.552	0.612
Wednesday 6	0.5472	0.5472	0.4896	0.5472	0.5472
Friday 8	0.5184	0.276	0.4488	0.4488	0.3624
Sunday 10	0.372	0.5424	0.456	0.4296	0.4848
Friday 15	0.4992	0.4728	0.5544	0.4728	0.4728
Average	**0.6984**	**0.7536**	**0.648**	**0.6888**	**0.72**

The inches/day seepage rate was multiplying by the area of the water body (A7.4) to calculate a volume over time (acre-inch/day) and then converted to gallons per minute (gmp) (Table A7.5).

TABLE A7.4 - AREA OF LAKE MARION, THE LARGE POND, AND THE SMALL POND.

Water Body	Area (acres)
Lake Marion	16.14
Large Pond	7.44
Small Pond	1.81

Table A7.5 - Unadjusted seepage rates in gpm.

Seepage Rate (gpm)	Gauge 1 – Small Pond	Gauge 2 – S. Lake Marion	Gauge 3 – Large Pond	Gauge 4 – N. Lake Marion	Lake Marion Average
Monday 27	N/A	N/A	N/A	N/A	N/A
Tuesday 28	66.6363	396.1361	273.9083	707.3859	551.761
Wednesday 29	33.847	370.413	145.45	150.909	260.661
Thursday 30	24.8672	332.6158	68.1443	443.4877	388.0517
Friday 1	33.847	281.6968	157.6784	201.212	241.4544
Saturday 2	29.7193	287.0952	111.9811	220.8424	253.9688
Sunday 3	27.5007	245.2271	95.6505	320.6816	282.9544
Monday 4	20.7227	203.2652	51.1082	166.3079	184.7865
Wednesday 6	18.5508	165.4195	68.2262	165.4195	165.4195
Friday 8	17.5071	83.2601	62.3677	135.2977	109.2789
Sunday 10	12.5717	163.8441	63.6014	129.3506	146.5973
Friday 15	16.9235	142.7518	77.0844	142.7518	142.7518
Average	**23.6057**	**227.5588**	**90.1294**	**207.626**	**217.5924**

During the experiment, water flowed out of Lake Marion through the weir due to water pressure and inadequate sealing of the blocking boards. The outflow rate was measured using a 5-gallon bucket and calculated using the volumetric method (Table A7.6). The outflow values were subtracted from the daily gpm seepage rates to account for this additional water loss. Additionally, after October 3rd, excess water flowed from Black Earth Creek into the Small Pond due to an increased deterioration of the culvert seal. This inflow rate was also measured using volumetric method and assumed to be constant at 0.18 gpm. The inflow value was added to the seepage rates after October 3rd. The resulting seepage rates are adjusted to the outflows and inflows observed during the lake shut-off experiment (Table A7.8).

Table A7.6: Outflow measured from Lake Marion's weir.

	Outflow rate (gpm)
Monday 27	50.676
Tuesday 28	43.668
Wednesday 29	31.848
Thursday 30	31.05
Friday 1	25.998
Saturday 2	24.798
Sunday 3	25.596
Monday 4	24.066
Wednesday 6	24.468
Friday 8	23.802
Sunday 10	23.544
Friday 15	23.544

TABLE A7.7 - FINAL ADJUSTED SEEPAGE RATES IN GPM.

Adjusted Seepage Rate (gpm)	Small Pond	Large Pond	Lake Marion
Monday 27	N/A	N/A	N/A
Tuesday 28	66.63628	273.9083	508.0929
Wednesday 29	33.847	145.452	228.8139
Thursday 30	24.86718	68.14433	357.0038
Friday 1	33.847	157.6784	215.4579
Saturday 2	29.71932	111.9811	229.1686
Sunday 3	27.6832	95.6505	257.3571
Monday 4	20.9051	51.10824	160.7224
Wednesday 6	18.7333	68.22623	140.9497
Friday 8	17.6896	62.36772	85.4757
Sunday 10	12.7542	63.60137	123.0556
Friday 15	17.106	77.08443	119.21

The seepage rate for each body of water was not static; they changed over time. By plotting the adjusted seepage rates, we observe a decrease in seepage rate with a decrease in water level. The resulting best fit regression lines:

Small Pond: y=53.274e-0.124x, R^2: 0.76

Large Pond: y=182.39e-0.115x, R^2: 0.45

Lake Marion: y=461.87e-0.14x, R^2: 0.74

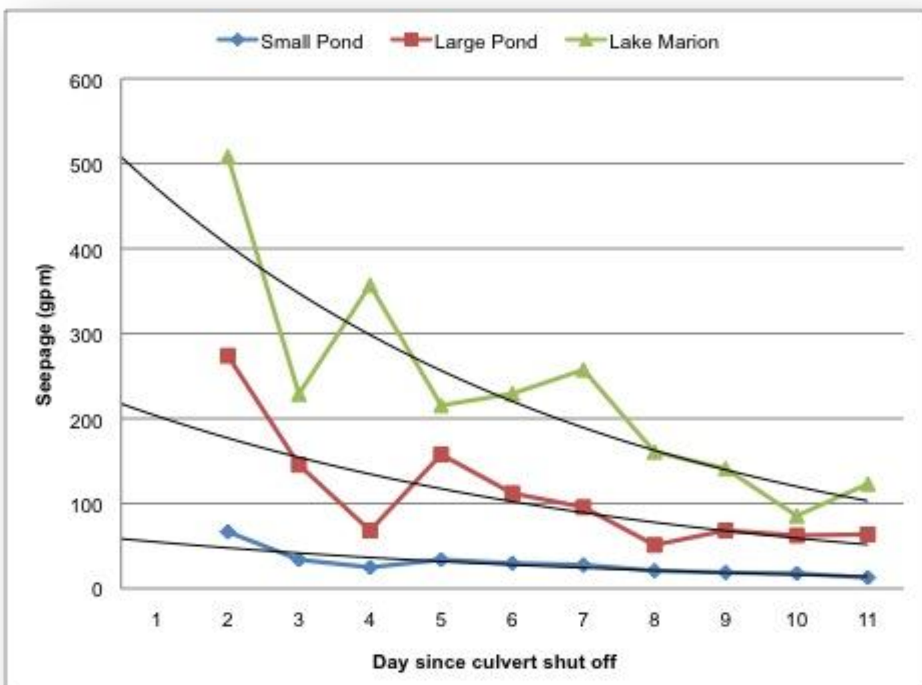


FIGURE A7.3 - LAKE SHUT-OFF EXPERIMENT SEEPAGE RATES.

II. Seepage Meters

Equipment

Seepage meter
Waders
Plastic bags (2 Liter)
Rubber bands
Rubber stopper
Sledge hammer
Wooden plank (4' x 2')
Stop watch

Methods

Seepage meters were used to measure point seepage rates at 32 locations in the southern and eastern edges of Lake Marion (Figure A7.1). The seepage meters (Figure A7.2) were hammered into the side wall or lake bottom of Lake Marion using a sledge hammer. A plank of wood was placed across the seepage meter in order to protect it from damage. The seepage meter was hammered into the bank until no holes or gaps could be felt anywhere along its edge. Once installed, a plastic bag was filled with 1 liter of lake water. The plastic bag was then double bagged and placed around a rubber stopper with a tube in the middle. Multiple rubber bands were used to hold the bags in place. Air was forced out of the plastic bags until only water remained. The stopper was then quickly placed into the seepage meter and timed for 30 minutes. After the 30 minutes elapsed, the stopper and bag were removed from the seepage meter and the water remaining in the bag was measured and recorded. This process was repeated in each location in order to get two consecutive readings and assure accuracy.

RESULTS

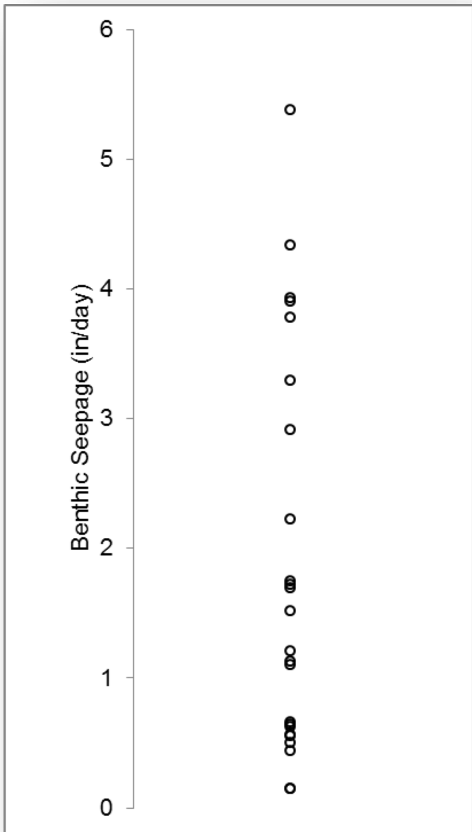


FIGURE A7.4 – BENTHIC SEEPAGE FROM SEEPAGE METERS.

APPENDIX 8: HYDROGEOLOGY METHODS AND RESULTS

I. GROUNDWATER MONITORING WELLS

Jim Rauman and Jason Smith of the Wisconsin Water Sciences Center at the US Geological Survey used a Geoprobe to install four groundwater monitoring wells on August 12th, 2010 (Figure A8.1 and Table A8.1).

TABLE A8.1 - GROUNDWATER MONITORING WELLS.

Well ID	UTM Coordinates* East	UTM Coordinates* North	Location	Well Depth (ft.)
1A	273603.702	4783064.272	Southwest side of Lake Marion, about 15 ft. south of observation deck and 5 ft. from edge of lake	30
1B	273604.219	4783063.426	1 ft. north of well 1A	12
2	273766.318	4783149.680	Northeast side of Lake Marion, about 5 ft. from dead tree, and 5 ft. from edge of lake	15
3	273507.104	4783518.246	Northeast side of Lake Marion, next to weir	15

* Datum: NAD 1983

WELL 1A

Well Depth: 30 ft.
Specifications:

- 1 inch SCH 40 PVC
- 30 ft. riser
- 1 ft. screen, 0.01 slot size
- Natural caving at 12 ft.
- ¼ inch bentonite pellets (BARIOD) to surface
- Flush mounted

Well 1B

Well Depth: 12 ft.
Specifications:

- 1 inch SCH 40 PVC
- 2.5 ft. screen, 0.01 slot size
- Natural caving at 10 ft.
- Sand fill to 3 ft.
- ¼ inch bentonite pellets (BARIOD) to surface
- Flush mounted

Well 2

Well Depth: 15 ft.
Specifications:

- 1 inch SCH 40 PVC
- 5 ft. screen, 0.01 slot size
- Natural caving at 14 ft.
- Sand fill to 8 ft.
- ¼ inch betonite pellets (BARIOD) to surface
- Flush mounted

Well 3

Well Depth: 15 ft.
Specifications:

- 1 inch SCH 40 PVC
- 5 ft. screen, 0.01 slot size
- Natural caving at 14 ft.
- Sand fill to 8 ft.
- ¼ inch betonite pellets (BARIOD) to surface
- Flush mounted

II. Groundwater Monitoring Well Core Logs

Figure A8.1 - Photo of cores.

TABLE A8.2 - CORE LOGS.

Core Interval	Depth (in)	Observation
Well 1A		
0 - 5 ft.	0 – 5	No core
	5 – 12	Top soil, mostly silt with some clays, velvety, with vegetation and roots
	12 – 57	Old Lake Marion dredged sediments, clay silt, dry, mottled, dark brown and orange colored
5 – 10 ft.	0 – 6	No core
	6 – 23	Old Lake Marion dredged sediments, clay silt, dry, dark brown colored
	23 – 30	Old Lake Marion dredged sediments, clay silt, dry, dark gray colored
	30 – 43	Old Lake Marion dredged sediments, clay silt, dark brown colored, more moisture than upper section (6-30 in)
	43 – 56	Clay lining, very compacted, dry, medium gray colored
	56 – 58	Fine to medium grain sand, moderately sorted, saturated, dark, more reduced conditions
10 – 15 ft.	0 - 23	No core
	23 – 44	Coarse sand, rounded to sub-rounded cobbles (top 2 inches), areas with finer sand and less cobbles, very saturated
	44 – 58	Fine to medium grain sand, some pebbles, moderately sorted, very saturated, less gray sand, more oxidized
15 – 20 ft.	0 – 25	No core
	25 – 34	Very poorly sorted from fine sand to large cobbles (1 inch), big lithic fragments, saturated
	34 – 42	Fine to medium grain sand, poorly sorted, lithic fragments, round to sub-rounded, fining upward sequence, saturated
	42 – 52	Fine to medium grain sand with some pebbles, saturated
	52 – 58	Medium to coarse grain sand with some pebbles, saturated
20 – 25 ft.	0 – 15	No core
	15 – 17	Poorly sorted sand to small cobbles, rounded to sub-rounded, saturated
	17 – 27	Poorly sorted sand with lithic fragments, fining upwards sequence, 1 inch cobbles at bottom, saturated
	27 – 40	Coarser sand, more lithic cobbles, sub-angular to sub-rounded, saturated
	40 – 46	Fine grain sand, moderately to well sorted with coarse lithic sand, saturated
	46 – 53	Poorly sorted gravel with fine sand, mostly lithic, saturated
	53 – 57	Well sorted, fine silty sand, light tan color, saturated
25 – 30 ft.	0 – 37	No core
	37 – 54	Medium to coarse sand, poorly sorted with lithic pebbles, sub-angular to sub-rounded, saturated
	54 – 58	Coarse sand and pebbles, saturated
	58 – 60	Fine sand, very light tan color, saturated

TABLE A8.2 - CORE LOGS (CONTINUED).

Core Interval	Depth (in)	Observation
Well 1B: no cores taken		
Well 2		
0 – 5 ft.	0 – 60	Old Lake Marion dredged sediments, clay silt, dark brown, clay silt, dry
5 – 10 ft.	0 – 10	No core
	10 – 42	Old Lake Marion dredged sediments, clay silt, mottled in some sections, wet root at 28 inches
	42 – 54	Clay lining, dense clay
	54 – 56	Orange sand and big cobbles, dry
	56 – 58	Sand and gravel, saturated
10 – 15 ft.	-	No core was taken
Well 3		
0 – 5 ft.	0 – 23	No core
	23 - 60	Old Lake Marion dredged sediments, clay silt, dry
5 – 10 ft.	0 – 14	No core
	14 – 18	Old Lake Marion dredged sediments, clay silt, dry
	18 – 23	Silty sand, dark gray, very saturated, perched water table
	23 – 34	Medium to coarse sand, mottled, saturated
	34 – 43	Sand and angular cobbles, dry, weather bedrock
	43 - 58	Yellow sand, very oxidized, dry
10 – 15 ft.	0 - 28	No core
	28 – 37	Yellow sand, very oxidized, dry
	37 – 53	Yellow sand with cobbles (1 inch), saturated
	53 – 58	Silty clay gravel, white/gray

III. CLAY LINING

From the soil cores, we measured the depth and width of the clay lining deposited by the Wisconsin Department of Natural Resources. The lining is about one foot thick and extends across the majority of Lake Marion. On the west side of the lake, the clay lining is eight feet below the surface. On the southeast side of the lake, the clay lining is approximately 7.7 feet below the surface. On the northeast side of the lake, the clay lining does not exist. The elevation of the clay lining is nearly level throughout its spatial extent. The missing clay lining at the northeast end of the lake is a likely source of high rates of seepage, especially since the groundwater and lake water flow towards this end of the lake.

TABLE A8.3 - CLAY LINING ELEVATION.

Well	Width of Clay Lining (feet)	Depth Below Surface of Clay Lining (feet)	Clay Lining Elevation (ft.)
1A	1.08	8.08	90.64
2	1.00	7.67	91.23
3	Not Present	Not Present	Not Present

Elevation data is relative. A temporary benchmark was created using a random elevation value of 100 feet and all elevation values are relative to the benchmark. The temporary benchmark was located between wells 2 and 3 along the railroad tracks.

IV. WATER TABLE

Water table depths were measured at the groundwater monitoring wells using an electric tape. The water table around Lake Marion is located approximately 8.9 feet below the surface on the west side of the lake, approximately 9.5 feet below the surface on the southeast side of the lake, and approximately 12.4 feet below the surface on the northeast side of the lake (Table A8.4). By subtracting these values from the ground surface elevation, the water table elevation at each well was calculated. The groundwater elevation is highest on the west side of the lake, lower on the east, and lowest at the northeast end of Lake Marion. Groundwater flows towards the lowest elevations; therefore, groundwater is flowing towards the northeast end of Lake Marion where it then continues to Black Earth Creek.

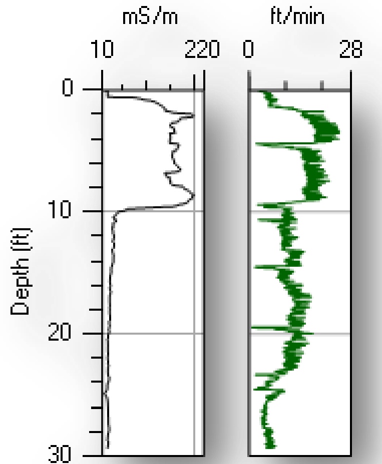
TABLE A8.4 - WATER TABLE ELEVATIONS.

Well	Depth Below Surface to Water Table (feet)	Water Table Elevation (feet)
1A	8.96	89.76
1B	8.92	89.83
2	9.51	89.39
3	12.40	86.60

Elevation data is relative. A temporary benchmark was created using a random elevation value of 100 feet and all elevation values are relative to the benchmark. The temporary benchmark was located between wells 2 and 3 along the railroad tracks.

V. Soil Conductivity Profile

Figure A8.2 - Soil Conductivity Graph.



A soil conductivity profile was taken in well 1A to obtain information on the characteristics of soils around Lake Marion. The left plot (black) is electrical conductivity, in units of micro-Siemens per meter. The right plot (green) is the rate at which the probe moved through the ground, in feet per minute.

Three distinct regions are observed in the conductivity graph (left plot), representing three distinct types of sediment. At the top, there is about ten feet of old dredged lake sediments. Conductivity in this region is high because of the high concentration of clay within the sediment matrix. Clay contains various cations, which are good conductors of electricity. The variations in conductivity in this section could be due to moisture differences and/or clay particles that have been transported downwards. Around a depth of eight feet the conductivity increases; this is likely due to the presence of the clay lining, which is made of pure clay. Conductivity becomes very low at depths lower than ten feet due to the non-conductive sand that was deposited by Black Earth Creek when it flowed through the Lake Marion area and to the non-conductive sand and gravel which was deposited by glacial meltwater.

The right plot, which shows the rate at which the probe moved through the ground, is used as a measure of penetration resistance. The faster the probe moves through the ground, the less the resistance. The higher values in the top ten feet, approximately, are likely due to the predominance of silt- and clay-sized particles with little to no large pieces of pebble or gravel for the probe to drill through. The large increase in penetration resistance around five feet is unclear but could be due to the presence of a rock or plant roots. Penetration resistance increases slightly a second time at approximately eight feet. This increase is likely due to the presence of the pure clay layer. Penetration resistance continues to increase from approximately a depth of ten feet and downwards. This increase is likely due to the presence of sand and gravel; the presence of gravel increases with depth and this translates to an increase in resistance to penetration.

Appendix 9: Surface Water Quality Methods and Results

Equipment

- Cooler
- Ice
- Permanent markers
- Large plastic liner bag for cooler
- 250 ml bottle per site for TP
- 2 quart bottles per site for TSS and chlorophyll a
- 60 ml bottle per site for TDP
- 1 test request form for each sampling site
- 50 ml syringe per 60 ml bottle
- 0.45 µm capsule filter per 60 ml bottle
- Vial of 1:3 sulfuric acid (H2SO4) per 250 ml bottle
- Vial of 0.5 ml 12.5% H2SO4 per 60 ml bottle
- CHEMetrics K-7501 (0 -1 mg/l range) dissolved oxygen kit
- CHEMetrics K-7512 (1 – 12 mg/l range) dissolved oxygen kit
- Secchi disk

Methods

TP, TDP, TSS, and Chlorophyll a

Prior to collecting water samples, each sampling bottle was labeled with the site name and number, the type of sample being collected, and if the sample was preserved or field filtered. All samples were collected by dipping the corresponding bottle directly into the water, rinsing the bottle with water three times, and then filling the bottle.

For TSS and chlorophyll a, quarter bottles were filled and capped immediately after collection. For total phosphorus (TP), the 250 mL bottle was used and a vial of 1:3 sulfuric acid was added to preserve the sample. For total dissolved phosphorus (TDP), approximately 50 mL of water was filtered using a 0.45 µm filter and syringe, and then poured into the 60 mL bottle. A vial of sulfuric acid was added to the sample.

A test request form was filled out for each sampling site. The form indicated the samples taken, which samples were preserved, and which samples were field filtered. The cooler was lined with a liner bag and filled with ice. The individually bagged samples were placed in the cooler. Samples were taken to the State Lab of Hygiene within 24 hours of collection.

Dissolved Oxygen

For DO measurements, CHEMestrics chemical kits were used. A 0 – 1 mg/l kit was used for low-end DO concentration, while a 1 – 12 mg/l was used for higher DO concentrations. These chemical kits have an accuracy of +/- 0.025 mg/l and 1 mg/l respectively. A water sample was taken, and the corresponding ampoule was used, following the kit's instructions. The color of the ampoule was compared against the comparators and the measurement was recorded.

WATER CLARITY

Water clarity was measured visually using a Secchi disk. Two readings were taken in the deeper parts of Lake Marion by two different observers and then averaged. The Secchi disk was lowered into the water by unraveling its measuring tape. At the point where the Secchi disk was no longer visible in the water, a measurement was taken on the tape at the surface of the water and recorded in meters.

Results

Table A9.1 - Surface Water Quality Results.

Sampling Site	Sample Date	Parameter					TSI		WQ Index for WI Lakes
		TDP mg/l	TP mg/l	TSS mg/l	Chlorophyll mg/L	DO mg/l			
LM1	10/23/09	0.251	0.379	47	-	-	89.8	Hypereutrophic	Very poor
	10/30/09	0.346	0.610	98	-	-	96.6	Hypereutrophic	Very poor
	11/06/09	0.044	0.086	27	-	-	68.4	Eutrophic	Poor
	11/13/09	0.033	0.046	4	-	-	59.4	Eutrophic	Fair
	06/29/10	0.104	0.079	10	-	6	67.2	Eutrophic	Poor
	07/07/10	0.049	0.067	10	-	10	64.8	Eutrophic	Poor
	07/15/10	0.054	0.065	3	-	9	64.4	Eutrophic	Poor
	07/23/10	0.421	0.539	52	-	4	94.8	Hypereutrophic	Very poor
LM2	10/23/09	0.251	0.424	51	-	-	91.4	Hypereutrophic	Very poor
	10/30/09	0.348	0.586	91	-	-	96.1	Hypereutrophic	Very poor
	11/06/09	0.044	0.073	29	-	-	66.0	Eutrophic	Poor
	11/13/09	0.034	0.065	21	-	-	64.3	Eutrophic	Poor
	06/29/10	0.094	0.120	-	-	7	73.2	Hypereutrophic	Poor
	07/07/10	0.053	0.071	8	-	10	65.5	Eutrophic	Poor
	07/15/10	0.058	0.073	7	-	10	66.0	Eutrophic	Poor
	07/23/10	0.432	0.516	43	5.67	3	94.2	Hypereutrophic	Very poor
LM3	10/23/09	0.020	0.067	49	-	-	64.8	Eutrophic	Poor
	10/30/09	0.036	0.071	24	-	-	65.6	Eutrophic	Poor
	11/06/09	0.027	0.067	28	-	-	64.8	Eutrophic	Poor
	11/13/09	0.017	0.162	289	-	-	77.5	Hypereutrophic	Very poor
	06/29/10	-	0.076	61	-	8	66.6	Eutrophic	Poor
	07/07/10	0.022	0.051	12	-	8	61.0	Eutrophic	Fair
	07/15/10	0.022	0.045	8	-	12	58.9	Eutrophic	Fair
	07/23/10	0.031	0.072	20	8.17	4.5	65.8	Eutrophic	Poor
LM4	10/23/09	0.007	0.026	11	-	-	51.1	Eutrophic	Good
	10/30/09	0.012	0.039	7	-	-	57.0	Eutrophic	Good
	11/06/09	0.016	0.045	19	-	-	59.0	Eutrophic	Fair
	11/13/09	0.010	0.033	15	-	-	54.6	Eutrophic	Good
	06/29/10	0.026	0.033	6	-	9	54.6	Eutrophic	Good
	07/07/10	0.014	0.027	2	-	7	51.8	Eutrophic	Good
	07/15/10	0.016	0.033	7	-	10	54.7	Eutrophic	Good
	07/23/10	0.016	0.030	4	3.51	6	53.2	Eutrophic	Good
LM5	07/22/10	0.272	0.607	216	-	,4 - 5	96.6	Hypereutrophic	Very poor
LM6	07/23/10	0.030	0.079	21	-	-	67.2	Eutrophic	Poor
LM7	09/01/10	0.965	1.290	44	-	-	107.4	Hypereutrophic	Very poor

Surface Water Quality Stations

LM1 Black Earth Creek, upstream dam, at inlet to Small Pond

LM2 Small Pond, at inlet to Big Pond

LM3 Big Pond, at inlet to Lake Marion

LM4 Lake Marion, at outlet, near weir

LM5 Lake Marion watershed drain, neighbor's lawn

LM6 QA/QC, field duplicate of LM3 on 07/23/10, "outlet"

LM7 Lake Marion watershed drain, SW crop field

Analysis performed by the State Lab of Hygiene

ND: not detected. TDP and TP: <0.005. TSS: <2.

(yellow highlight) TDP>TP

APPENDIX 10: TROPHIC STATE INDICES

The Trophic State Index (TSI), developed by R.E. Carlson (1997), was used to classify the trophic state of the surface water bodies. It establishes trophic state values based on TP, chlorophyll a and/or Secchi disk readings:

TSI = 14.42 ln (TP in µg/l) + 4.15
9.81 ln (chlorophyll a in µg/l) + 30.6
60 - 14.41 ln (Secchi disk readings in meters)

TABLE A10.1 - TSI CLASSIFICATION.

TSI Classification	TSI Value	Description
Oligotrophic	<30	Clear water and oxygen throughout the year in hypolimnion.
	30 - 40	Shallow lakes become anoxic in hypolimnion in summer.
Mesotrophic	40 - 50	Water moderately clear with increased probability of anoxia in hypolimnion in summer.
Eutrophic	50 - 60	Lower boundary eutrophic, decreased transparency, anoxic hypolimnion in summer, and macrophyte problems.
	60 - 70	Dominance of blue-green algae, possibility of algal scums, and macrophyte problems.
Hypereutrophic	70 - 80	Heavy algal blooms possible in summer, dense macrophyte beds, with limit to light penetration.
	>80	Algal scums, summer fish kills, few macrophytes, and dominance of rough fish.

The Water Quality Index (WQI) of Wisconsin Lakes (Lillie & Mason, 1983), adapted by the Wisconsin Department of Natural Resources, was used to determine the water quality of the water bodies relative to other Wisconsin lakes. The WQI ranks water bodies from very poor to excellent, depending on TP concentration.

Table A10.2 - WQI Classification.

WQI Classification	TP mg/l
Very poor	> 0.15
Poor	0.15 0.14 0.13 0.12 0.11 0.10 0.09 0.08 0.07 0.06
Fair	0.05 0.04
Good	0.03 0.02
Very good	0.01
Excellent	0.001

APPENDIX 11: BATHYMETRY AND SEDIMENT SAMPLING METHODS AND RESULTS

EQUIPMENT

Bathymetry PVC rod
Sediment cup
GPS
Row boat

METHODS

To sample the unconsolidated sediment depth of Lake Marion and the Large Pond, a 50 m x 50 m grid was placed over Lake Marion and a 30 m x 60 m grid was placed over the Large Pond, both using ScribbleMaps Pro. Each square of the grid was given a designated letter and the longitude and latitude of the center of the square was recorded. These values were then transferred into a GPS unit that was used to locate each sampling site in the field.

A bathymetry rod was used to record the depth of water to the top of the sediments and the depth of the unconsolidated sediment. The rod was constructed from a 10 ft. length of 1" PVC piping, a 6" square piece of ¼" plywood, a 1' PVC cap, and 2 1" PVC screw-on connecting pieces. The board was screwed into the cap, which was in turn placed on one end of the rod to provide a flat surface for measuring the water depth (over the unconsolidated sediment). The length of the rod was scored at the centimeter marks from both ends, with each tenth mark labeled to enable easy depth measurement.

A rowboat was used to move to the location of each sampling point. At each sampling point, the bathymetry rod was lowered into the water with its broad side down. Once the rod reached the top of the unconsolidated sediments, a depth reading was recorded. The bathymetry rod was then removed from the water and re-inserted narrow side down. Once it reached the depth where the unconsolidated sediments ended and the hard consolidated sediments began, the depth was recorded. This process was repeated for the 33 points on Lake Marion and the 18 on the Large Pond.

To collect information on the nutrient content of the sediment, samples were collected from the 6 deepest points in Lake Marion and the 3 deepest points in the Large Pond. At these depths, the sediment cup was attached to the bathymetry rod and lowered to the bottom of the water body to enable collection of the unconsolidated sediment. Each sample was filtered to remove excess water, stored in a 250 mL container, and then placed in a cooler with ice. The samples were sent to the State Lab of Hygiene for TP analysis.

By subtracting the unconsolidated sediment depth from the consolidated sediment depth, the depth of sediment was determined for each sampling point. Using mapping software, this data was plotted to show the amounts of unconsolidated sediment throughout Lake Marion and the Large Pond. Using the same mapping technique for the consolidated sediment depth, a bathymetry map of Lake Marion was created.

Results

Table A11.1 - Lake Marion Bathymetry and Sediment Results.

Sediment Grid	Coordinates Lat	Long	Water Depth ft.	Sediment Depth ft.	Volume cy	TP Concentration mg/kg
A	43.167	-89.783	5.2	0.8	726	745
B	43.167	-89.784	5.3	0.4	395	
C	43.166	-89.784	4.9	0.5	437	
D	43.166	-89.785	2.3	0.1	44	
E	43.167	-89.784	5.4	0.5	458	
F	43.167	-89.784	4.8	0.1	98	
G	43.167	-89.785	5.2	0.2	229	
H	43.167	-89.785	4.4	0.7	271	580
I	43.168	-89.784	5.4	0.3	294	
J	43.167	-89.784	5.2	0.2	196	
K	43.167	-89.785	5.3	0.4	392	
L	43.167	-89.785	5.3	0.3	161	
M	43.168	-89.784	5.6	0.3	294	
N	43.168	-89.785	5.7	0.3	294	
O	43.168	-89.785	5.8	0.2	229	
P	43.167	-89.786	4.9	0.3	195	
Q	43.168	-89.785	5.6	0.4	360	
R	43.168	-89.785	6.0	0.3	294	
S	43.168	-89.786	5.9	0.1	131	
T	43.168	-89.786	5.2	0.4	90	
U	43.169	-89.785	6.1	0.2	229	
V	43.168	-89.786	6.1	1.4	1406	532
W	43.168	-89.786	5.3	0.0	26	
X	43.169	-89.785	6.1	0.4	425	
Y	43.169	-89.786	6.3	0.6	621	
Z	43.169	-89.786	5.1	0.3	146	
AA	43.170	-89.786	6.5	2.7	2649	559
BB	43.169	-89.786	6.2	2.0	1504	526
CC	43.170	-89.786	6.5	0.4	392	
DD	43.170	-89.787	2.5	0.5	257	
EE	43.170	-89.787	6.9	0.7	719	617
FF	43.170	-89.787	1.9	0.2	38	
GG	43.171	-89.787	6.3	0.5	268	
Total					**14,270**	

TABLE A11.2 - LARGE POND BATHYMETRY AND SEDIMENT RESULTS.

Sediment Grid	Coordinates		Water Depth	Sediment Depth	Volume	TP Concentration
	Lat	Long	ft.	ft.	cy	mg/kg
A	43.166	-89.783	3.1	1.6	832	
B	43.166	-89.783	3.3	1.0	747	576
C	43.166	-89.784	2.0	1.6	744	
D	43.166	-89.783	3.1	1.0	723	
E	43.166	-89.783	3.0	0.7	494	
F	43.166	-89.783	2.5	0.6	367	
G	43.166	-89.782	2.3	0.2	94	
H	43.165	-89.782	2.8	0.6	424	560
I	43.165	-89.783	2.6	0.8	468	
J	43.165	-89.782	2.3	1.1	603	
K	43.165	-89.782	2.2	0.4	283	
L	43.165	-89.782	1.9	0.7	345	
M	43.165	-89.781	1.4	1.7	720	
N	43.165	-89.781	1.5	0.5	353	
O	43.164	-89.782	1.6	0.5	357	
P	43.164	-89.780	1.3	0.8	119	
Q	43.164	-89.781	1.5	0.7	452	582
R	43.164	-89.781	1.2	0.6	398	
Total					**8,522**	

Appendix 12: Native Plant and Animal Species of Southern Wisconsin

When implementing any restoration plan, it is important to know the plants and animals that are native to the region. There are many advantages to planting native vegetation and creating habitats in which native animals can live. For instance, native species are more adapted to the region's climate; therefore less maintenance is needed once a community is established. We recommend referring to the document, *Wisconsin Native Plant Sources and Restoration Consultants: Seeds & Plants for Prairies, Woodlands, Wetlands, and Shorelands,* for further information. Below are lists of plant and amphibian/reptile species that are native to the Lake Marion area. Efforts to enhance the native plant community at Lake Marion will ultimately increase habitat for native animal species as well as increase the overall biodiversity and natural beauty of the area.

Native Plants

Wildflowers
Acorus calamus - Sweet Flag
Allium cernuum - Nodding Onion
Asclepias incarnate - Marsh Milkweed
Aster laevis- Smooth Blue Aster
Aster puniceus- Red-stemmed Aster
Aster novae-angliae - New England Aster
Coreopsis palmate - Prairie Coreopsis
Eupatorium maculatum - Spotted Joe Pye Weed
Eupatorium perfoliatum - Boneset
Helenium autumnale - Sneezeweed
Helianthus grosseserratus - Saw-tooth Sunflower
Heliopsis helianthoides - Early Sunflower
Iris virginica Shrevei - Blue Flag Iris
Lycopus americanus - Water Horehound
Monarda fistulosa - Wild Bergamot
Physostegia virginiana - Obedient Plant
Pycnanthemum virginianum - Mountain Mint
Ratibida pinnata - Yellow Coneflower
Rudbeckia hirta - Black-eyed Susan
Rudbeckia laciniata - Wild Golden Glow
Sagittaria latifolia - Arrowhead
Silphium laciniatum - Compass Plant
Silphium perfoliatum - Cupplant
Solidago graminifolia - Grass-leaved Goldenrod
Solidago riddellii - Riddell's Goldenrod
Thalictrum dasycarpum - Purple Meadow Rue
Vernonia fasciculate - Ironweed
Zizia aurea - Golden Alexanders

Legumes
Baptisia leucantha - Wild White Indigo
Cassia hebecarpa - Wild Senna

Grasses
Andropogon gerardii - Big Bluestem
Bromus ciliatus - Fringed Brome
Calamagrostis Canadensis - Blue Joint Grass

Elymus Canadensis - Canada Wild Rye
Elymus virginicus - Virginia Wild Rye
Glyceria Canadensis - Rattlesnake Grass
Glyceria grandis - Reed Manna Grass
Leersia oryzoides - Rice Cutgrass
Panicum virgatum - Switch Grass
Schizachyrium scoparium - Little Bluestem
Sorghastrum nutans - Indian Grass
Spartina pectinata - Prairie Cord Grass

Sedges
Carex bebbii - Bebb's Sedge
Carex bicknellii - Copper-shouldered Oval Sedge
Carex comosa - Bristly Sedge
Carex hystericina - Porcupine Sedge
Carex stipata - Common Fox Sedge
Carex stricta -Tussock Sedge
Carex vulpinoidea - Brown Fox Sedge
Juncus torreyi - Torrey's Rush
Scirpus atrovirens - Dark-green Bullrush
Scirpus cyperinus - Wool Grass
Scirpus validus - Soft-stem Bullrush

Reptiles and Amphibians

Salamanders
Blue-spotted salamander
Central newt
Common mudpuppy
Eastern tiger salamander
Four-toed salamander

Frogs
American bullfrog
Boreal chorus frog
Cope's gray treefrog
Eastern American toad
Eastern cricket frog
Gray treefrog
Northern green frog
Northern leopard frog
Pickerel frog
Spring peeper
Wood frog

Snakes
Bullsnake
Common gartersnake
Common watersnake
Dekay's brownsnake
Eastern hog-nosed snake
Eastern milksnake
Gray ratsnake
North American racer
Northern red-bellied snake
Prairie ring-necked snake
Timber rattlesnake
Western foxsnake

Turtles
Blanding's turtle
Painted turtle
Snapping turtle
Spiny softshell turtle
Wood Turtle