Lake Wingra Watershed

A New Management Approach

1999

Institute for Environmental Studies
Water Resources Management Workshop
University of Wisconsin-Madison

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A New Management Approach

Water Resources Management Workshop
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Institute for Environmental Studies
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Madison, Wisconsin 53706

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The Water Resources 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 and graduate students in the analysis of a contemporary water resources problem.

The conclusions and recommendations are those of the graduate student authors and do not necessarily reflect the official views or policies of any of the cooperating agencies or organizations, nor does the mention of any trade names, commercial products, or companies constitute endorsement or recommendation for use.

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"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature."
Henry David Thoreau, 1854, *Walden; or Life in the Woods*

Each year, graduate students of the University of Wisconsin-Madison Water Resources Management (WRM) program study a particular water resource problem or issue in significant depth. The purpose of the WRM Workshop is to provide an opportunity for graduate students to apply what they have learned over the course of their academic program, and to expose students to the interdisciplinary nature of water resource management. Graduate students explore biological, chemical, and physical characteristics of water systems as well as social, public policy, and regulatory issues associated with managing a water resource.

The 1999 WRM Workshop was conducted by eight graduate students of the Water Resources Management Program of the Institute for Environmental Studies (IES), University of Wisconsin-Madison. It was completed as partial fulfillment of their requirements for a Master of Science degree. This year, three students from different programs joined the multidisciplinary team. The group studied the Lake Wingra watershed in Madison, Wisconsin.

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Executive Summary

Introduction

As a small urban lake, Lake Wingra has been the focus of much recreation and research. But in spite of many efforts over the years, major water resource management issues still need to be addressed.

Located in the center of Madison, Wisconsin, the Lake Wingra watershed is heavily urbanized. Cultural eutrophication is the major problem for Lake Wingra today, as urban stormwater runoff carries nutrients, sediments, and other pollutants to the lake. Cultural eutrophication is evidenced by increased algae blooms, reduced water clarity, and degraded habitat for many species.

In recognition of the problems facing Lake Wingra, the Friends of Lake Wingra (FOLW) applied for and received funding from the Wisconsin DNR Lake Management Planning Grant program. The FOLW then contracted with the UW-Madison 1999 Water Resources Management (WRM) Workshop to address the ideas put forth in the grant proposal and to help further their mission: "to promote a healthy Lake Wingra through an active watershed community." The 1999 WRM Workshop work included, but was not limited to, the following:

- Synthesizing existing technical research
- Evaluating current watershed management practices
- Analyzing stakeholder coordination
- Designing an outreach strategy
- Proposing watershed management tools

The main goal of the WRM Workshop was to propose a set of tools for the protection and enhanced management of the Lake Wingra watershed.

Key Issues Facing the Lake Wingra Watershed

The following are some of the major issues facing the Lake Wingra watershed:

- Eutrophication and sedimentation from stormwater runoff
- Reduced spring flows and groundwater levels
- Degraded habitats
- Introduction of exotic plant and animal species
- Lack of stakeholder coordination and watershed-level management
- Lack of funding to effectively implement management strategies

A summary of past research and problems of Lake Wingra is detailed in *Chapter 2 - Synthesis of Technical Research*. Since most of these issues were linked to urban stormwater runoff, learning how to effectively manage stormwater became the primary focus.

Key Players in Lake and Watershed Management

The first step towards addressing stormwater management was to understand the existing stormwater management regulations. These are discussed in *Chapter 3 - Brief History of Management*. *Chapter 4* (*Lake and Watershed Management*) evaluates existing stormwater and in-lake management. This chapter also recommends enhanced management techniques and monitoring activities, and innovative strategies on both individual and municipal levels.

Stakeholder identification and involvement was analyzed alongside watershed management recommendations. Stakeholder and watershed resident information is found in *Chapter 5 - Stakeholders*, and *Appendix 6 - Lake Wingra Watershed Resident Survey*. These discussions recommend improved coordination of Lake Wingra watershed stakeholders and resource managers. Survey respondents expressed concerns for lake quality, and showed willingness to modify individual behavior to benefit Lake Wingra.

The WRM Workshop recommends actively involving Lake Wingra watershed residents in the management process, as individual actions greatly impact water quality. To improve stormwater runoff quality and quantity, watershed residents can modify lawncare, redirect roof downspouts from driveways, and improve yard waste management. The more ambitious residents could utilize rain barrels or install rain gardens (discussed in *Chapter 4 – Lake and Watershed Management*). Watershed residents can also be involved in monitoring activities.

Giving ownership to the watershed community will ensure that Lake Wingra is protected and improved. In response to this need, public outreach strategies and materials were recommended. The FOLW are especially interested in informing and involving their watershed community. Outreach strategies and materials are described in *Chapter 6 - Outreach Recommendations*.

Stormwater Utility Recommendations

While citizen involvement is key to watershed management success, consistent funding and an institutional structure for watershed-based management are also important factors. With this in mind, and with the consideration of the current politics surrounding stormwater management in Madison, the workshop investigated the possibility of a stormwater utility. Stormwater utilities (SWUs) provide a means for financing the capital and operating expenses needed for stormwater management. They have been described as "the most dependable and equitable approach available to local government to finance stormwater management" (Levin, 1997).

While many SWUs across the country are focusing simply on stormwater conveyance and flood protection, there are several that incorporate innovative management practices, educational programs, and public involvement activities. SWUs are discussed in detail in *Chapter 7 - Stormwater Utility*. Madison could maximize the effectiveness of a SWU by incorporating an advisory board with citizen representation, watershed coordinators, fee-reduction incentives for both residential and non-residential properties, and a small grants program for watershed education and restoration projects. A progressive SWU could effectively address the issues facing the Lake Wingra watershed.

Summary

The concepts presented in this document are applicable to the protection and enhancement of all the Madison lakes. Innovative approaches are recommended to deal with a major issue facing these water bodies – urban stormwater runoff. Effective management of urban stormwater runoff and other forms of non-point source pollution requires a coordinated approach, as well as active involvement of all those visiting, working, and living within that watershed.

Chapter 1

Introduction

The Ho Chunk, or Winnebago, Indians called Lake Wingra "Ki-chunk-och-hep-er-rah" meaning "the place where the turtle emerges" (Brown, 1915).

Lake Wingra, and its adjacent wetlands, prairies, and woods, are a unique and valuable asset for the people of Dane County. The area serves as an urban oasis for wildlife, boaters, swimmers, and fishermen. Lake Wingra's proximity to major research institutions has provided excellent opportunities for shallow lake research. However, in comparison to the deeper and clearer lakes of Madison, the shallow and marshy Lake Wingra has often gone unappreciated, and has been maligned throughout its history. In the mid-1800s, the lake was commonly referred to as "Dead Lake." One defender of Lake Wingra, Judge Levi B. Vilas, was provoked by this, and protested this name in an article in the *Madison Democrat* in 1869.

> "I protest here and now to the attempt in your issue of last evening to fasten the name of 'Dead Lake' upon that beautiful body of water upon the borders of our city known upon all the maps as Lake Wingra. It is one of the most healthy and beautiful lakes in our midst, and deserves no such name as you and your poetic contribution attempt to attach on it. It has none of the qualities of the Dead Sea, but on the contrary, is full of living fishes and surrounded and covered with winged fowls and singing birds from which it obtains its true and appropriate name. It takes its rise and origin from bubbling springs around its shores, and has a large flowing outlet by a connecting stream into the waters of Lake Monona. Then in the name of justice, truth, history, and propriety, let it always have its own true and beautiful name, 'Lake Wingra.' "

. . . the shallow and marshy Lake Wingra has often gone unappreciated, and has been maligned throughout its history.

Some people thought the lake was dying because marshy areas were expanding into the lake and springs were disappearing. Some thought the lake was sinking into the earth. But, as Judge Vilas pointed out, the lake was still very much alive. Moreover, the problems that Lake Wingra's detractors observed were due to their own actions. Farmers were turning up soil with their plowshares right up to the water's edge causing the solid banks to gradually wash away into the lake. This soil clogged the springs and filled in the lakeshore, providing shallow water for marsh vegetation. New housing developments and landfills filled in low-lying wet areas, eliminating springs and wetlands.

While agricultural runoff pollution was a major problem in 1869, the effects of urbanization have caused even greater changes to the lake ecosystem.

Lake Wingra faces similar problems today that are still caused by human activity. While agricultural runoff was a major problem in 1869, the effects of urbanization have caused even greater changes to the lake ecosystem. Vast areas of rooftops, roads, and sidewalks no longer allow rainwater to infiltrate the ground. As a result, rainwater enters the lake as surface-water runoff instead of recharging the groundwater aquifers that feed the lake's wetlands and springs. This has caused a fundamental shift in the lake's hydrology. Stormwater runoff carries high nutrient and sediment loads to the lake, which cause nuisance algae blooms, excessive macrophyte growth, degraded wetlands, and sediment buildup. As a result, much of the original flora and fauna have been replaced by exotic species. Flocks of canvasback ducks, and expansive beds of wild rice and celery are no longer found in Lake Wingra. Fens and sedge meadows along the lake's borders are threatened with elimination.

These problems demonstrate the immense challenges involved in improving Lake Wingra. However, meeting these challenges is essential. Besides the lake's recreational value, the Lake Wingra watershed supports abundant wildlife, natural springs, and cultural landmarks including the UW-Arboretum, Vilas Zoo, and Vilas and Wingra parks.

Preserving the resources of the Lake Wingra watershed will be challenging. Urban natural areas require unique stormwater management since they are often the end point for stormwater runoff. Once an area is fully developed, as the Lake Wingra watershed is, stormwater controls must fit into the preexisting infrastructure. Diverse stakeholder coordination, funding source development, and citizen participation are critical aspects that must be addressed and considered throughout the process of urban stormwater management. If these challenges are met, there is great potential for improvement in the Lake Wingra watershed.

Improvements in the Lake Wingra watershed will ultimately depend on public support.

Through the initiative of the Friends of Lake Wingra (FOLW), the 1999 Water Resources Management (WRM) Workshop was given support to help address these challenges. Our main objective was to research and develop tools that would better enable the FOLW to carry out its mission. We intended to provide watershed managers and citizen groups with tools and insights to manage the lake and its watershed. If our work is successful, the FOLW and other stakeholders will be equipped to develop an active watershed community committed to Lake Wingra.

Improvements in the Lake Wingra watershed will ultimately depend on public support. The watershed has potential to serve as a model for urban watershed management. People can indeed make a lake "dead" through their actions, but we can also learn from our mistakes and work to enable Lake Wingra to continue to be a refuge for living fishes, winged fowls, singing birds, and bubbling springs around its shores as Judge Vilas described in 1869. "Then in the name of justice, truth, history, and propriety, let it always have its own true and beautiful name, Lake Wingra."

Chapter 2

Synthesis of Technical Research

Introduction

The smallest of the five Madison lakes, Lake Wingra is part of the Yahara chain of lakes. It acts as a headwater area for Lake Monona, with a surface elevation approximately 1 meter higher than the surface of that water body (Baumann *et al.*, 1974). While the lake itself occupies 1.37 square kilometers, the total watershed drainage area (excluding the lake) is 14 square kilometers (**Figure 2-1**). Seventy-five percent of the watershed is urbanized, draining much of the southwestern portion of the city of Madison. The University of Wisconsin Arboretum occupies the remaining twenty-five percent of the watershed (Watson *et al.*, 1979). Some basic physical characteristics of the lake are shown in **Table 2-1**.

Table 2-1
Basic facts about Lake Wingra.

Lake area	1.37 square kilometers	339 acres
Average depth	2.7 meters	8.9 feet
Maximum depth	6.7 meters	22 feet
Shoreline length	5.9 kilometers	3.7 miles
Drainage area	14 square kilometers	3460 acres

Early records of the watershed include surveyor's notes from the original government land surveys, a sportsman's journal (Leopold, 1937), and amateur historical accounts. By the turn of the century, however, scientific attention was increasingly directed toward Lake Wingra and the surrounding area. Studies spearheaded by the UW-Madison accelerated during the early 1970s with the onset of the International Biological Program (IBP), and continue today with the Long Term Ecological Research (LTER) program. Currently, Lake Wingra is

part of the Yahara-Monona Priority Watershed Project, is assessed yearly by the Wisconsin Department of Natural Resources (WDNR) for fisheries, and is included in the Integrated Ecosystem Management (IEM) program for the Lower Rock River Basin.

This chapter is a synthesis of existing research on Lake Wingra and its watershed. It focuses on the period from 1974 to the present; Baumann *et al.* (1974) present a similar review of research from 1837-1973. However, some sections do deal with research before 1974 in order to present a clearer picture to the reader.

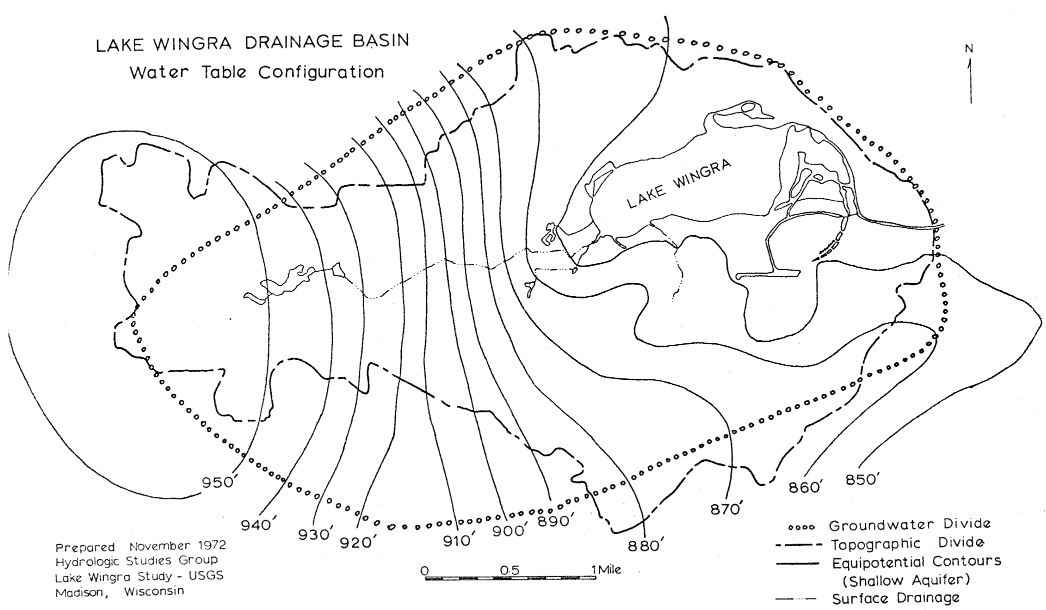
Hydrology

A significant amount of hydrologic research has been done within the Lake Wingra watershed. Among the most significant contributions have been the identification and definition of important components of water budgets, understanding how groundwater pumping affects the hydrology of a watershed, and how urbanization impacts watersheds with respect to their physical hydrology and water quality. These three major areas of research will be presented after a brief description of the physical character of the watershed.

Physical Setting

To understand the hydrology of the Lake Wingra watershed, it is important to consider its topography, soils, and bedrock geology. The topography of the region dictates the configuration of streams and lakes, influences the location of storm sewers, and controls groundwater flow. Infiltration of surface water is dependent on soils and bedrock geology, and the latter also affects groundwater flow and storage. **Figure 2-2** shows the surface and groundwater divides for the Lake Wingra watershed. It is evident that the two divides differ (Pennequin and Anderson, 1983).

Figure 2-2
Groundwater and surface water (topographic) watershed divides for Lake Wingra (after Pennequin and Anderson, 1983).



The topography of the Lake Wingra watershed, and the Madison area in general, has been significantly influenced by deposits from the last glaciation. The final phase of this glacial period, the late-Wisconsin stage, took place 13,000 to 15,000 years ago in this area (Mickelson, 1983). The maximum extent of the late-Wisconsin glacier is marked by the Johnstown Moraine only 10.5 kilometers southwest of Lake Wingra.

The topography of the Lake Wingra watershed, and the Madison area in general, has been significantly influenced by deposits from the last glaciation.

The general effect of glaciation on the Madison area was a lowering of relief. As large continental ice sheets move over a landscape, they scour material from uplands and ridges, and deposit the eroded debris (glacial till) in lowlands and valleys. The result is a landscape of moderate slopes and poorly developed drainage networks. The latter is manifest in the Madison area by the presence of a large number of wetlands and lakes, including Lake Wingra. The fact that Lake Wingra has few surface inputs is also indicative of a "young" drainage network. There is evidence to suggest that the Madison area had more relief before the Quaternary glaciations. For example, the bedrock surface of the glaciated area of Dane County has a deep valley in the Yahara Lowlands. However, that bedrock valley is now buried by glacial deposits (Mickelson, 1983).

Lake Wingra and its adjacent wetlands are underlain by lacustrine deposits that formed the bed of Glacial Lake Yahara, a large pro-glacial lake present during the retreat of the late-Wisconsin glacier (Mickelson and McCartney, 1979). This extensive lake once included what are today's Lakes Mendota, Monona, Waubesa, and Wingra, and at its maximum had a surface elevation approximately 3.5 meters higher than the present Lake Mendota (Mickelson, 1983). Other late-Wisconsin deposits in the Wingra watershed include ice-contact stratified deposits, drumlins, ground moraine, and end moraine (Mickelson and McCartney, 1979). A moraine named "Dead Lake Ridge," forming a half-mile-long ridge between Wingra Creek and Monona Bay, was quarried at the turn of the century for sand and gravel and completely removed by 1920 (Mollenhoff, 1982).

The late-Wisconsin glaciation also profoundly influenced the watershed's soils. The predominant upland soils in the watershed are Alfisols: nutrient rich, highly permeable silt-loams that are developed in loess and glacial till (Glocker and Patzer, 1978). The till in this area is very sandy as a result of glacial scour of Cambrian sandstones. The loess, or wind blown silt, was deposited over the till as glaciers retreated from the upper midwest. The primary source region for this silt was the broad floodplain of the upper Mississippi River. Tundra conditions prevailed during glacial retreat, and meltwater floods deposited silts and other sediments on an unvegetated floodplain surface. Prevailing westerly winds subsequently transported the silts and deposited them to the east of the upper Mississippi River. Consequently, loess thicknesses east of the river diminish from west to east, from a maximum of 10 - 12 meters in some localities of the western edge of Wisconsin to generally less than a meter in Dane County (Mickelson, 1983; Leigh and Knox, 1994).

The bedrock geology of the watershed is uniform, consisting of Ordovician dolomites and sandstone underlain by Cambrian sandstones and Pre-Cambrian basement rock. Two major groundwater reservoirs, or aquifers, reside in these sandstones and dolomites. A majority of the upper aquifer is formed in the Ordovician dolomites and sandstone, while the lower aquifer is formed completely within the Cambrian sandstones. The lower aquifer is the major water supply for municipal and industrial wells, while the upper aquifer primarily supplies domestic wells (Oakes *et al.*, 1975). Significantly, the upper aquifer is the source of springs in the Lake Wingra watershed.

Historical Changes to Watershed Uplands

Since European settlement, the uplands of the Lake Wingra watershed have experienced significant land cover changes that have had important hydrologic consequences (upland land cover changes are more fully discussed in *Historic Vegetation*, page 20). Most importantly, conversion of the original oak savanna vegetation cover to farmland, and ultimately to an urban landscape, has decreased the infiltration of rainwater into the soil. While there is no empirical data on presettlement infiltration rates in the Lake Wingra watershed, research by the U.S. Natural Resource Conservation Service (NRCS; formerly the Soil Conservation Service) has demonstrated that infiltration rates are significantly higher in forests and meadows than on farmlands (U.S. Soil Conservation Service, 1972; see also Knox, 1977; Knox and Hudson, 1995). Infiltration rates are lowest in urban areas with many impervious surfaces (Dunne and Leopold, 1978). As infiltration rates decrease, groundwater recharge also decreases and surface runoff increases.

Since European settlement, the uplands of the Lake Wingra watershed have experienced significant land cover changes that have had important hydrologic consequences.

During the second half of the nineteenth century when much land in the watershed was farmland, the increase in surface runoff likely contributed to increased rates of soil erosion and sedimentation (Knox and Hudson, 1995). While this is perhaps best documented in southwest Wisconsin's Driftless Area (Happ, 1944; Knox, 1977), it has also been reported in lower-relief, glaciated terrain similar to the Lake Wingra watershed (Beach, 1994).

In today's urban areas of the watershed, decreased infiltration and increased runoff pose additional problems. Urban runoff often transports contaminants from streets and other impervious surfaces directly into the lake via storm sewers. Furthermore, runoff from lawns in urban areas can be high in nutrients from fertilizer applications and pet waste, and may contain pesticides, herbicides, and insecticides. Water quality issues associated with urban runoff are more fully discussed *Lake Chemistry and Sediments*, page 11.

Historical Changes to the Lake and Wetlands

Lake Wingra itself has changed considerably since European settlement. Because no scientific investigations were done before the major changes to its physical characteristics, and because early accounts conflict, it is difficult to reconstruct Wingra's original hydrography (Baumann *et al.*, 1974). However, Baumann *et al.* (1974) have estimated that the original surface area of the lake was approximately 1.9 times greater than today. If marshes and wetlands are included, the area was about 3 times greater than present. The original lake surface elevation was estimated to be about 1.3 meters above Lake Monona.

The years between 1905 and 1925 brought the most significant physical changes to the lake through the building of dikes, draining and filling of wetlands, dredging, and the construction of a wooden lock and spillway dam at the outlet to Wingra Creek. The dam was built to maintain the lake at its original level, but in 1917 the failure of a dike that extended from the outlet to the south shore resulted in rapid drainage of the lake. Its level fell 1 meter and there was a major loss in surface area. In 1919, the dike was repaired and the present lock and spillway dam was built. However, the new dam only maintained a surface elevation of about 1 meter above that of Lake Monona, effecting a 0.3 meter loss (Baumann *et al.*, 1974).

At present, the dam built in 1919 at the eastern end of the lake is the only outlet. Surface runoff to the lake is primarily through storm sewers and ephemeral streams. The only perennial streams in the watershed that flow into the lake originate from springs on its western shore (Oakes *et al.*, 1975) (See **Figure 2-1**).

Previous Work

The most comprehensive work performed on the Lake Wingra watershed was done under the International Biological Program (IBP) conducted in the 1970s. Efforts included research on circulation, temperature, material transport and exchange (Elliot, 1976; Hoopes, 1971), evaporation and heat budget measurements (Stearns, 1971), and the development of hydrologic budgets (Novitzki and Holmstrom, 1979; Oakes *et al.*, 1975). The latter were the result of collaboration between IBP investigators and the United States Geological Survey (USGS) district office in Madison, Wisconsin.

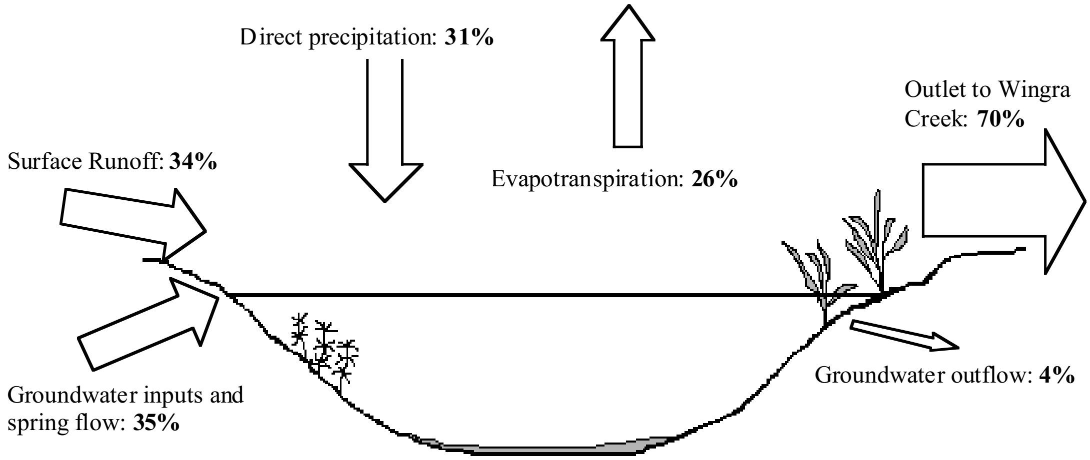
Water Budgets

The main objectives of the water budget studies were to identify and quantify the relative importance of significant hydrologic components such as groundwater inflow and outflow, surface water inflow and outflow, springflow, surface runoff, precipitation, and evaporation. Oakes *et al.* (1975) measured and estimated inputs and outputs to Lake Wingra over a one-year period (June 1972 to May 1973), while Novitzki and Holmstrom (1979) constructed a water budget using monthly and annual data collected over a 5 1/2-year period (January 1972 to September 1977). The Oakes *et al.* (1975) budget was used to validate a hydrologic transport model developed specifically for the Lake Wingra basin (Huff *et al.*, 1973; Watson *et al.*, 1979). Prentki *et al.* (1977) presented results of a water budget derived from that model.

Oakes *et al.* (1975) estimated that direct precipitation accounted for approximately 25% of all inflows to the lake. The rest of the inflow was nearly equally divided between surface runoff and groundwater inflow (including springflow). Outflow was estimated to be 10% groundwater, 15% evaporation from the lake surface, and 75% discharge at the lake outlet to Murphy Creek.

The results of Novitzki and Holmstrom (1979) were broadly similar to those of Oakes *et al.* (1975), especially considering the uncertainty in the estimation of some of the hydrologic components (i.e. evapotranspiration and groundwater flow). Their report indicated that the inflows to the lake were approximately the same for the three major sources: groundwater inflow at 35% (including springflow), direct precipitation at 31%, and surface runoff at 34%. Again the dominant outflow component was the outlet to Wingra Creek (70%), with evapotranspiration and groundwater outflow considerably less (26% and 4% respectively). **Figure 2-3** shows the 5 1/2-year average for each of the inflow and outflow components.

Figure 2-3
Water budget schematic for Lake Wingra (data source: Novitzki and Holmstrom, 1979).



Groundwater

One of the objectives of the groundwater studies in the Lake Wingra watershed was to understand the impacts of subsurface pumping on basin hydrology (McLeod, 1978). This was especially important considering that the City of Madison and surrounding municipalities draw their water from groundwater reservoirs. While it was generally understood that pumping would reduce water levels in the sandstone and upper aquifers, the rate of depletion and the impact on other important hydrologic components, such as the lake levels, springflow, and streamflow, was uncertain.

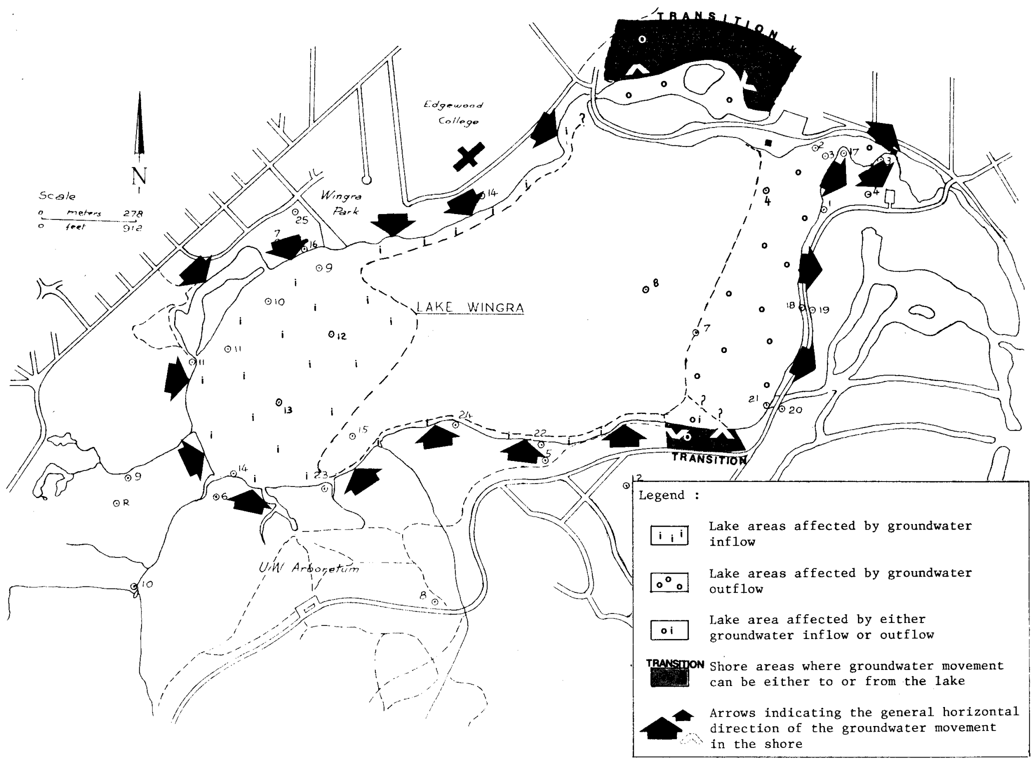
McLeod (1978) conducted an investigation of the water level declines in the Madison area. He discovered that the water level in a deep well that tapped into the Cambrian sandstone aquifer beneath downtown Madison had decreased from 1.5 meters above Lake Mendota's water level in 1882, to 21 meters below in 1975. Other deep wells on the east side of Madison showed similar reductions. Wells on the west side of Madison experienced smaller declines. Also, overall water levels in the upper aquifer had experienced drops of 3 to 6 meters when compared to prepumping conditions (McLeod, 1978). Recent regional modeling comparing modern and presettlement water table levels in both the upper and lower aquifers support McLeod's results (Dane County Regional Planning Commission, 1998).

The loss of groundwater from the upper aquifer could result in a smaller amount of water flowing to Lake Wingra through its springs. There is physical evidence to suggest that this has happened.

Similar to McLeod (1978), Oakes *et al.* (1975) felt that the significant drawdown of the lower aquifer by pumping caused increased recharge from the upper aquifer. The loss of groundwater from the upper aquifer could result in a smaller amount of water flowing to Lake Wingra through its springs. There is physical evidence to suggest that this has happened. Baumann *et al.* (1974) note the disappearance of at least 28 springs in the Lake Wingra watershed by the early 1970s. Moreover, in a description of 12 Lake Wingra springs by Brown in 1926, six of them were no longer in existence at the time of his writing. In the mid-1970s, Oakes *et al.* (1975) noted only eight springs. While the decrease in the number of springs is likely attributable to water table declines associated with groundwater pumping, the decrease in surface water infiltration and groundwater recharge associated with urbanization exacerbates the problem (Dane County Regional Planning Commission, 1998).

In 1983, Pennequin and Anderson constructed a comprehensive groundwater budget for the Lake Wingra watershed based on substantial amounts of field data. Their results confirmed a general west to east movement of groundwater in the basin (**Figure 2-4**), but the calculated magnitudes of both inflow and outflow were considerably lower than those estimated by Oakes *et al.* (1975), and Novitzki and Holmstrom (1979) (see *Water Budgets*, page 8). Pennequin and Anderson (1983) asserted that their figures for groundwater inflow and outflow were more accurate because the other researchers were forced to make questionable assumptions and use estimation techniques because of a lack of field data.

Figure 2-4
Groundwater flow for the Lake Wingra watershed (after Pennequin and Anderson, 1983).

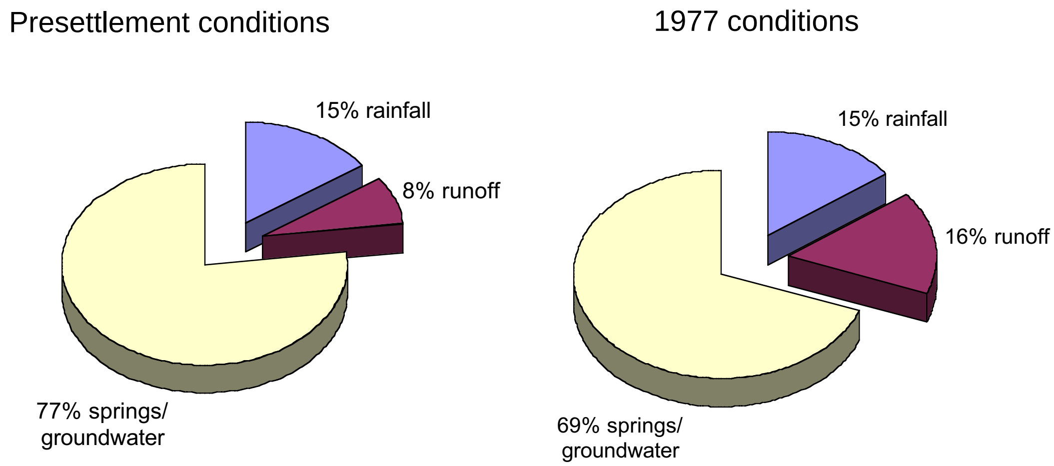


Stormwater

The impact of development on surface runoff in the Lake Wingra watershed was also an area of IBP research. Watson *et al.* (1979) estimated hydrologic and nutrient budgets for the Lake Wingra watershed based on 1977 urban conditions, and compared them with estimates for presettlement conditions. Estimates showed that surface runoff has increased since presettlement times, with accompanying decreases in spring and groundwater inputs (**Figure 2-5**).

It is apparent that the inputs for the modern water budgets presented by Novitzki and Holmstrom (1979), and Oakes *et al.* (1975) are considerably different from those reported by Watson *et al.* (1979). However, both the present and presettlement hydrologic budgets presented by Watson *et al.* (1979) were constructed primarily from model results, and the researchers noted in a later publication (1981) that the groundwater inflows were likely overestimated given the empirical data of Novitzki and Holmstrom (1979).

Figure 2-5
Relative importance of hydrologic inputs to Lake Wingra (after Watson *et al.*, 1979).



Nonetheless, their results show important changes in the relative importance of hydrologic inputs to Lake Wingra. Significantly, physical changes in the watershed since European settlement, for example the reduced number of springs flowing into the lake, support their characterization.

Significance of Hydrologic Research

Lake Wingra watershed hydrologic research made important contributions in understanding the watershed ecosystem. The identification and quantification of water budget components better characterized the modern hydrologic regime of this urbanized watershed (Oakes *et al.*, 1975; Novitzki and Holmstrom, 1979). Furthermore, the modeling work (Watson *et al.*, 1979) coupled with the groundwater pumping research (McLeod, 1978) helped identify the shift from a hydrologic system dominated by groundwater and springflow inputs to one where runoff inputs gained in relative importance. As the following sections illustrate, this shift has important implications for water quality and, in turn, the health of Lake Wingra watershed biota.

Lake Chemistry and Sediments

Lake Wingra is a naturally eutrophic lake, meaning that it has historically been high in nutrient levels. Some of the lake's major physical and chemical characteristics are shown in **Table 2-2**. Because Lake Wingra is shallow, it tends to stratify thermally and chemically only during periods of ice cover and remains well-mixed during the rest of the year (Murray, 1956; Goering and Neess, 1964). Dissolved oxygen (DO) is usually present throughout the water column

Table 2-2
Physical and chemical characteristics of Lake Wingra.

Ice cover duration	120 days
Water temperature (June 1 - August 31)	23 °C
pH (web data and Watson et al., 1979)	7.0 - 9.4
Secchi depth (June 1 - August 31)	0.7 meters
Total phosphorus	331 micrograms/liter
Total nitrogen	2000 micrograms/liter

Modified from http://limnosun.limnology.wisc.edu/map/madison_lake/wi_table.html and http://limnology.wisc.edu/lake_information/other_yahara_lakes/wingra.html during times of open water (Barber and Ensign, 1979), but is depleted at a rate of 0.18 milligrams of DO per liter per day during ice cover (Rast and Lee, 1977). Bannerman (1973) found that DO was close to zero at the bottom of the water column from the end of February until ice out.

Due to large populations of phytoplankton, there are seasonal variations in water clarity. Clarity is also affected by sediment input through runoff, and by physical mixing of the sediments.

Due to large populations of phytoplankton, there are seasonal variations in water clarity. Clarity is also affected by sediment input through runoff, and by physical mixing of the sediments. Maximum clarity occurs in late fall and winter (Goering and Neess, 1964). In 1970, the secchi depth, a measure of water clarity, averaged over the period from June 1 to August 31 was 0.85 meters (Rast and Lee, 1978). Currently, secchi depth averages 0.7 meters, indicating that clarity was greater in the past than at the present.

Lake Wingra's pH varies seasonally as well, ranging from 7.0 to 9.4 (**Table 2-2**). Alkalinity is at a maximum during winter, at approximately 195 mg/L, and then it decreases to approximately 115 mg/L as temperature and biological activity increase in the summer months (Rast and Lee, 1978; Richey *et al.*, 1978; Watson *et al.*, 1979).

Lake bottom sediments are predominantly gray marl, with approximately 54% carbonate content. The carbonate content increases towards the shorelines and the sediments here can be more accurately described as shell marl. Organic matter comprises 11.7 - 16.9 % of the sediment (Murray, 1956; Macgregor and Keeney, 1973), but some areas have thick accumulations of organic material, or muck (Noland, 1951). The measured sediment load in the 1970s was 2 mm/ year (Carpenter, personal communication). At this rate, Lake Wingra would take approximately 1000 years to completely fill in. Much of this sediment load is coming from external sources and will therefore be of a different composition than that described above.

Estimates of the average pH of the sediment range from 6.4 (Macgregor and Keeney, 1973) to 7.5 (Barber and Ensign, 1979). Sediment temperatures range from 4 degrees Celsius in February to 20 degrees Celsius in July. Sediment oxidation-reduction potential, or "redox," ranges from +50 to -150 millivolts, depending on the amount of dissolved oxygen present in the water (Macgregor *et al.*, 1973).

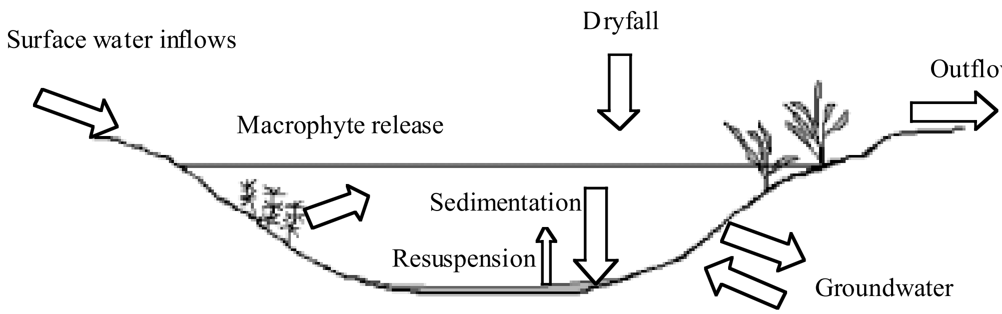
The main areas of research have focused on phosphorus, nitrogen, and carbon cycles. These are discussed in the next sections. More specifically, two main focal areas are 1) determining in-lake biological and inorganic influences on nutrient cycling and 2) determining sources of nutrient inputs and how relative contributions have changed through time. There seems to be a gap in published research through the mid-1980s. In keeping with the long recognized theme of impacts of urbanization and stormwater runoff, which is mentioned in articles as far back as the 1950s (Noland, 1951), most of the recent research focuses on stormwater runoff quality. A relatively small amount of work has also been conducted on trace metals and chloride. Currently, bi-weekly monitoring of some basic chemical parameters in Lake Wingra still occurs as part of the LTER program.

In-Lake Nutrient Cycling

Phosphorus

In Lake Wingra, phosphorus is a limiting nutrient for plant growth (Rast and Lee, 1977). The major sources of phosphorus in the lake are runoff from the watershed and dryfall from the atmosphere. Phosphorus is internally recycled in a variety of ways: through plant uptake, through the decomposition of plants and other lake organisms, through the breakdown of animal wastes, and through resuspension from the sediments (Armstrong *et al.*, 1971). Phosphorus exits the lake through lake outlets, the physical removal of fish and plants, and particle settling (see **Figure 2-6**). Overall, phosphorus inputs from external sources or recycling from the sediments can often greatly exceed losses (Bannerman, 1973).

Figure 2-6
Phosphorus cycle in shallow lakes.



Biological Influences on Phosphorus Cycling

Dissolved inorganic phosphorus is the form of phosphorus readily available to plants and algae. Rooted macrophytes absorb most of their phosphorus from the sediment, and algae take up phosphorus from the surrounding waters. Therefore, macrophytes and phytoplankton are not competing for nutrients (Loucks, 1981).

Macrophytes, however, can be a significant provider of dissolved inorganic phosphorus to the water. Smith and Adams (1986) and Carpenter *et al.* (1979) investigated the role of Eurasian water milfoil (*Myriophyllum spicatum*) in moving phosphorus between the bottom sediments and the water. Milfoil gets 70-100% of its phosphorus from the sediments (Loucks, 1981). Each square meter of milfoil removes 3 grams of phosphorus from the sediment per year, which is stored in the plant's shoots. Phosphorus does not leach from healthy milfoil shoots, but when the shoots decay, almost the entire amount that was removed from the sediments, 2.8 grams of phosphorus per square meter of milfoil per year, is released to the water.

Plants such as milfoil may increase phytoplankton growth by releasing phosphorus from the sediments (Smith and Adams, 1986). Phytoplankton respond to excess phosphorus supplies with nuisance blooms of blue-green algae.

Plants such as milfoil may increase phytoplankton growth by releasing phosphorus from the sediments (Smith and Adams, 1986). Phytoplankton respond to excess phosphorus supplies with nuisance blooms of blue-green algae. **Table 2-3** shows how very small amounts of available phosphorus can greatly influence the growth of algae.

Zooplankton also have a role in phosphorus cycling. For example, small zooplankton excrete more phosphorus per gram dry weight than do large zooplankton (Loucks, 1981). Therefore, changes in the lake ecosystem that affect zooplankton populations and size, in turn may affect phosphorus cycling in the system.

Table 2-3
Increases in algal growth as related to increases in phosphorus concentration.

Phosphorus concentration (mg P/L)	Algal growth (cells/ml x 10^{-3})
0	7
0.025	180
0.05	360
0.075	480
0.1	600

Modified from Fitzgerald et al., 1973.

Any in-lake manipulations that may alter macrophyte cover and/or predator-prey interactions can alter the predominant zooplankton size. Therefore, the most effective models of algal growth reduction will require a combination of reductions in phosphorus coming from external loading, control of macrophytes of the littoral zone, and reduction in zooplankton populations.

While the majority of the phosphorus cycle literature has focused on macrophytes, Hilsenhoff (1971), and Magnuson and Kitchell (1971) researched the role of aquatic insects and fish in the transfer of nutrients through and out of Lake Wingra (see *Invertebrates*, page 28).

Inorganic Influences on Phosphorus Cycling

Phosphorus cycling is also altered by changes in water chemistry, including changes in dissolved oxygen, and by physical movement of the sediments. Not much research was conducted in Lake Wingra after the 1970s, but these influences have been identified in other similar lakes.

The total quantity of phosphorus in the uppermost 1 cm of sediment often greatly exceeds that in the overlying water (Williams *et al.*, 1971). Most of this phosphorus exists as orthophosphate ions adhered to the surface of phosphorus-retaining components, such as iron and aluminum hydroxides. Since inorganic phosphorus is associated with iron oxides, the sorption of inorganic P is influenced by the presence of iron in the sediment, and by oxidation of Fe^{2+} ions. Low iron in the sediment increases phosphorus mobility by decreasing the amount of phosphorus held by sediment. High levels of dissolved oxygen inhibit the release of phosphorus, increasing the amount of P held by sediments (Armstrong *et al.*, 1971; Bannerman, 1973). Therefore, dissolved oxygen levels play an important role in the cycling of phosphorus, as anoxic sediments release phosphorus as much as 1000 times faster than oxygenated sediments (Horne and Goldman, 1994).

Other physical and chemical factors can affect the cycling of phosphorus. Sediment type affects phosphorus reactions: higher rates of cycling were found for calcareous sediments (Holdren, 1977). When concentrations of dissolved phosphorus are greater in the sediment interstitial water than in the lake water, phosphorus will move by diffusion into the lake water (Bannerman, 1973). Increasing temperatures and increasing pH also favor the movement of phosphorus into lake water (Holdren, 1977; Bannerman, 1973).

Physical turbulence caused by waves can stir up the sediments, releasing phosphorus. Bioturbation, the movement of sediment by living things (especially fish) is a main factor in enhancing phosphorus release. While the settling of these suspended sediments can actually remove phosphorus from the water, the phosphorus released during resuspension is still a major factor contributing to algae growth (see *Fish*, page 29).

Nitrogen

In Wisconsin lakes, nitrogen is not a limiting nutrient. Nitrogen is more readily available than phosphorus through lake processes such as biological fixation, mixing with the air, groundwater input, and internal recycling. The two main forms of nitrogen that plants can directly utilize are nitrate (NO_2^-) and ammonium (NH_4^+) ions.

Due to the fact that *Anabaena* sp. are not nitrogen limited an excess of available phosphorus in the water can lead to tremendous blooms of blue-green algae.

Nitrogen fixation is the process by which atmospheric nitrogen is converted to organic biomass by bacteria or blue-green algae. Goering and Neess (1964) found that *Anabaena* sp., a blue-green algae, was dominant in terms of rate of nitrogen fixation. The highest rates of nitrogen fixation occurred from mid-February though late-October, with the highest rate (14.85 micrograms of nitrogen per liter per hour) occurring in July. Due to the fact that *Anabaena* sp. are not nitrogen limited, an excess of available phosphorus in the water can lead to tremendous blooms of blue-green algae.

Bacteria within the top 10 centimeters of the sediment also play an important role in nitrogen cycling. Nitrification is the process of converting ammonium ions (NH_4^+) to nitrate ions (NO_3^-). Nitrification is often coupled with denitrification, the process by which nitrate ions are converted to nitrite ions (NO_2^-) and then to gaseous nitrogen (N_2) (Macgregor *et al.*, 1973). Nitrification by heterotrophs (organisms that are dependent on preformed organic carbon for growth) is dominant in the water column, and nitrification by autotrophs (organisms that can utilize inorganic carbon to produce organic matter) is dominant in the lake bottom sediments (Isirimah *et al.* 1976).

Ninety-seven percent of the total nitrogen in Lake Wingra is in the form of organic nitrogen in the sediment (Isirimah *et al.*, 1976). Given enough oxygen, bacteria can readily convert this organic nitrogen to ammonium ions, making it available to plants. In terms of available nitrogen, it was estimated that 50% is in the water, 20% in macrophytes, and 30% in the sediments, with significant daily interchange of nitrogen from the sediment to the water. Average nitrogen release rates were comparable to inputs, and so, even if controllable sources of N were eliminated, biomass N in the lake would not be significantly decreased (Isirimah *et al.*, 1976).

Phosphorus and iron are also important in controlling algae growth and therefore influence nitrogen fixation. Trace elements (e.g. Ca, B, Mo, and Co) can either enhance or limit nitrogen fixation (Goering and Neess, 1964).

Carbon

As an essential component of life, carbon is present in many forms in lakes. Most limnological studies have focused on carbon in the form of carbon dioxide in relation to respiration. Research on other forms of carbon in Lake Wingra has focused on methane and organic matter.

Of the 1600 - 1900 milliliters of dissolved gas that escapes from the lake surface each day, approximately 55% is methane, CH_4 (Barber and Ensign, 1979). The formation of methane is controlled by methanogenic bacteria, which are most prolific during the summer. Production of methane is greatest in the shallows, where most decomposing organic matter is found. Hard-water eutrophic lakes like Wingra have been found to produce ten to twenty times more methane than soft-water or oligotrophic lakes (Macgregor and Keeney, 1973).

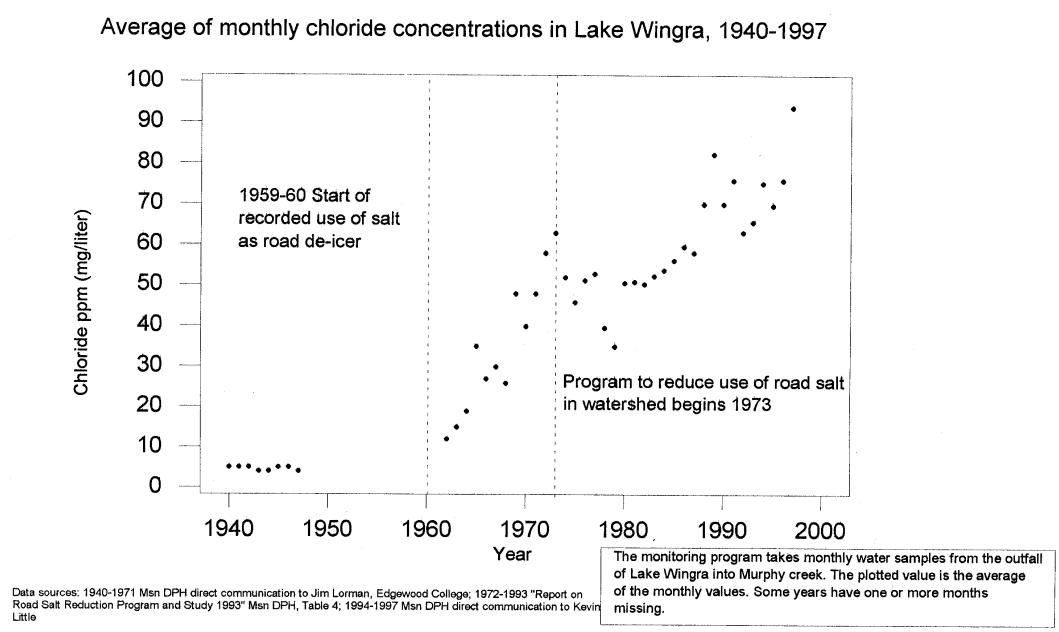
Organic matter is transported from the water column to the sediment by seston, the general term for all organic and inorganic suspended material. Fifty-five percent of the annual phytoplankton production, and 42% of the combined annual phytoplankton and macrophyte production, settles out of the water column as sediment. Seventy percent of this settling organic matter decomposes annually, so only a small percentage is involved in the long-term accumulation of bottom deposits (Gasith, 1976).

Chloride

While ionic chloride is necessary for photosynthesis (Horne and Goldman, 1994), its effect on biota in normal concentrations and in excess has not been researched in Lake Wingra.

Chloride data exists back to the 1940s for Lake Wingra (**Figure 2-7**). Chloride levels have been monitored as a part of Edgewood College's "GIS in Education" project in 1997. Samples were collected from stormwater runoff. The highest chloride concentrations averaged 302 ppm, measured during the spring snowmelt.

Figure 2-7
Chloride levels in Lake Wingra.



Before the 1950s, when Madison began road salting, chloride levels were below 10 ppm. Currently, levels often exceed 75 ppm, despite reductions in road salting (see *Chapter Three – History of Watershed Management* for a discussion on Madison's road salt reduction plan). Since chloride acts as a tracer for groundwater movement, its presence in spring water can provide a link between land use practices and water quality. Since groundwater moves slowly, this input of chloride may continue for years to come, reflecting past salting practices.

Chloride levels in Lake Wingra are higher than in both Lakes Mendota and Monona. Despite increased levels, chloride does not seem to be a problem in Lake Wingra. Plants and fish do not seem to be negatively affected by low levels of chloride, but its effect on other organisms, such as macroinvertebrates, is still undetermined. Williams *et al.* (1997) found some taxa of invertebrates that showed low tolerance to high chloride levels in springs in Ontario, Canada. Since concentrations are highest near stormwater outlets in the lake, chloride could become problematic in these areas as loading continues.

Trace Elements

Inputs of mercury to Madison lakes come from sewage, eroded soils due to deforestation and cultivation, urban runoff, atmospheric fallout, and groundwater. Dry deposition from coal plant emissions is the largest source of mercury. Syers *et al.* (1973) investigated mercury (Hg) levels in cores of Madison lakes. For Lake Wingra, the maximum accumulation was 0.19 ppm in the 0-5 cm surface layer. Mercury levels measured in the rest of the core were 0.06 ppm, which closely match concentrations in the soils around the lake. These levels are not high enough to warrant fish consumption advisories on Lake Wingra.

Trace metals, such as iron, manganese, lead and zinc, are found in highest concentrations near the storm sewer outlets of the western part of the lake, suggesting an anthropogenic source (Delfino *et al.*, 1978). Levels of these metals have been measured in relation to stormsewer flows (Prentki *et al.*, 1977), as discussed in the next section.

Nutrient and Sediment Inputs

The main sources of nutrient inputs to Lake Wingra include precipitation, atmospheric deposition, springflow, groundwater flow, and marsh drainage, as well as surface water drainage from residential areas, urban areas, the Arboretum, and storm sewers (Kluesener, 1972; Gasith, 1974; Rast and Lee, 1977; Delfino *et al.*, 1978). There have been occasional sewage overflows due to failures of sewage pumping stations, but otherwise there are no sewage or industrial discharges (Rast and Lee, 1977).

Lake Wingra is a naturally eutrophic lake, meaning that it has historically been high in nutrient levels. Eutrophication is the process of lake enrichment through increased nutrient (e.g. phosphorus, nitrate, and ammonia) loading. Eutrophication happens naturally in many shallow water bodies, but it can be accelerated by human inputs. Cultural eutrophication is defined as eutrophication caused by or increased by inputs of nutrients, sediments, and contaminants from human sources. Human inputs include sewage discharge, and excess fertilizer and eroded soil carried with stormwater runoff. Since Lake Wingra has no major point-source discharges (e.g. industrial effluent pipes), the main source of nutrients and sediments are from non-point sources (e.g. stormwater runoff).

Stormwater runoff is associated with both rural and urban watersheds. In rural watersheds, runoff can be reduced by agricultural practices such as minimal tilling and contour farming (Knox, 1977; Trimble and Lund, 1982). In urban watersheds, the situation with runoff is more difficult to control. With urbanization, the total amount of impervious surface increases. The hydrologic effects are twofold: stormwater volumes and stormwater magnitude at one point in time increase.

Because urbanization increases surface runoff, phosphorus loading is always expected to increase as land is developed (Watson *et al.*, 1979). Eighty to ninety percent of the total annual phosphorus load to Lake Wingra comes from surface runoff conveyed directly to the lake through the storm sewer system (Lee and Kluesener, 1971; Kluesener, 1972). If precipitation would instead infiltrate through the soil, much of this phosphorus would be retained by soils and plants. Because of increases in stormwater quantity, and associated increases in nutrients, metals, and other contaminants, the degree of urbanization is strongly correlated with the extent of damage to aquatic systems (Bannerman *et al.* 1996).

Several researchers have compared presettlement and postsettlement inputs of phosphorus and nitrogen to Lake Wingra. **Figures 2-8a and 2-8b** illustrate how urbanization has altered the hydrologic and nutrient budget for the lake.

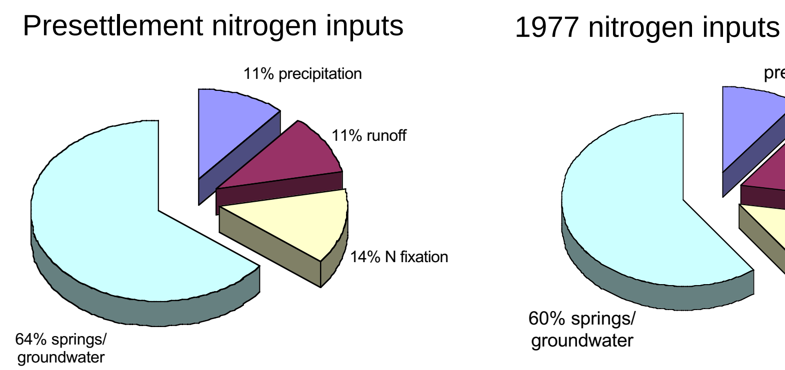


Figure 2-8a
Relative contribution of nitrogen, presettlement and postsettlement (after Watson *et al.*, 1979).

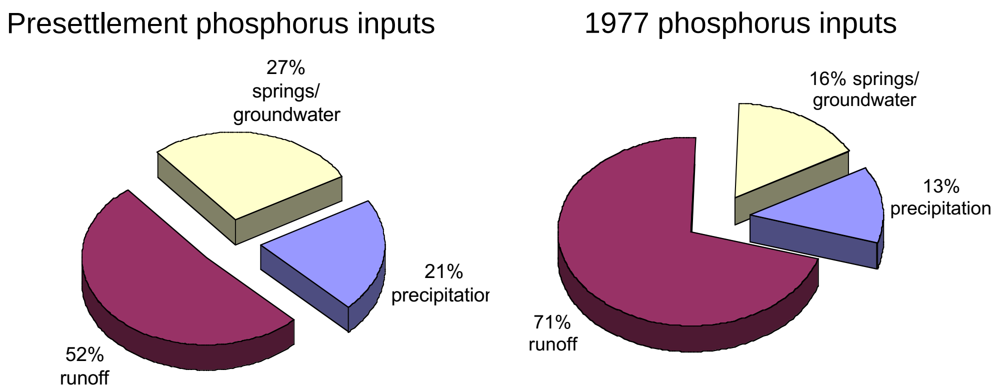


Figure 2-8b
Relative contribution of phosphorus, presettlement and postsettlement (after Watson *et al.*, 1979).

Perry *et al.* (1981) measured annual inputs and outputs of phosphorus to and from the marsh areas surrounding Lake Wingra. Ninety percent of the phosphorus entering the marsh was from residential runoff. Fourteen percent of the dissolved P and 82% of the particulate P were retained by the marsh. Higher amounts of soluble P discharged from the marsh to the lake during spring snowmelt and large runoff events. Earlier, Loucks *et al.* (1977) researched the retention capabilities of Wingra Marsh and estimated that only 8-10% of the dissolved reactive phosphorus was retained by that marsh.

Browman *et al.* (1979) researched phosphorus loading by urban stormwater runoff and measured both dissolved and particulate levels in the Manitou Way and Nakoma storm sewers of the Wingra basin in 1971-72. Levels of total dissolved phosphorus ranged from 0.10 to 2.11 mg phosphorus per liter and dissolved inorganic phosphorus comprised over 80% of the measured dissolved phosphorus. Levels of total particulate phosphorus ranged from 0.14 to 2.37 mg phosphorus per liter and most of the particulate phosphorus was in the form of organic phosphorus. Higher levels of both dissolved and particulate P occurred during leaf and fruit fall during the fall and spring respectively. Between 35-50% of the particulate P entering the lake comes from the first flush and high flow phases of runoff events and can remain suspended in the lake for several days, making it even more readily available for plant and algal uptake. Prentki *et al.* (1977) provided some very comprehensive data tables, much of which focused on nutrient and trace metal loads from individual storm sewers (See *Appendix 1a and b*).

A large amount of particulate carbon inputs (leaves, twigs, etc.) are washed into the lake instead of decomposing on land (Kluesener, 1972). More than one metric ton (dry weight) per year of these particulates enter Wingra via the Manitou Way storm sewer alone, which only represents 10% of the storm sewer inputs.

One stormwater retention basin in the Lake Wingra watershed, known as the Monroe Street basin, has been studied in detail (Waschbusch *et al.*, 1999). Runoff from lawns and streets contributed 80% of the total and dissolved phosphorus measured in stormwater runoff, with lawns contributing more than streets. Streets were found to be the largest source of suspended solids. The majority of the sediment mass of street dirt (75%) was in the >250 micrometer particle size. This size fraction contributed 50% of the total phosphorus mass. Another significant contribution of phosphorus comes from leaves and other vegetation, which contributed 30% of the total phosphorus mass in the >250 micrometer size fraction and 25% in all of the other particle sizes. *Appendix 1c* shows the relative loads of suspended solids, total phosphorus, and dissolved phosphorus from the different source areas in the Monroe Street basin.

Significance of Phosphorus Inputs

Increased phosphorus concentrations in the lake can lead to increases in the growth of phytoplankton, and submerged and emergent plants. Because of increased phytoplankton growth, water clarity will be diminished. Increases in primary productivity will also lead to increased biological oxygen demand (BOD), in turn creating dissolved oxygen (DO) deficiencies. While there is little evidence that low DO concentrations have led to fish kills in Lake Wingra, DO deficiencies do enhance the release of dissolved inorganic phosphorus from lake sediments. Increased dissolved inorganic phosphorus will contribute to further increases in primary productivity. Therefore, a positive feedback mechanism is in place so that increased phosphorus concentrations from surface inputs both directly and indirectly enhance plant growth.

Reducing phosphorus loads to the lake by diminishing the total amount of stormflow can help to improve lake water quality and reduce excessive plant growth.

Reducing phosphorus loads to the lake by diminishing the total amount of stormflow can help to improve lake water quality and reduce excessive plant growth. For example, it is estimated that nuisance algae blooms in Lake Mendota could be reduced from one in every two days to one in every five days through a 50% reduction in the phosphorus inputs to that water body (Waschbusch *et al.*, 1999). However, understanding the degree to which sediments can release and replenish dissolved inorganic phosphorus is equally important in trying to retard or reverse eutrophication (Bannerman, 1973). While significantly decreasing phosphorus loads to the lake will contribute to improving water quality, it is possible that phosphorus loads may remain high for years to come as a result of excessive amounts of dissolved inorganic phosphorus stored in lake sediments.

Vegetation

The majority of research on Lake Wingra and its vegetation was done in the 1970s and early 1980s. While much of the vegetation research concentrated on Eurasian water milfoil (*myriophyllum spicatum*), other in-lake aspects such as general macrophyte control (Carpenter and Adams, 1978; Nichols and Lathrop, 1994), phytoplankton (Koonce, 1972), and algae productivity and ecology received some attention (Jones, 1984; McCracken *et al*., 1974).

Historic Lake Wingra Vegetation

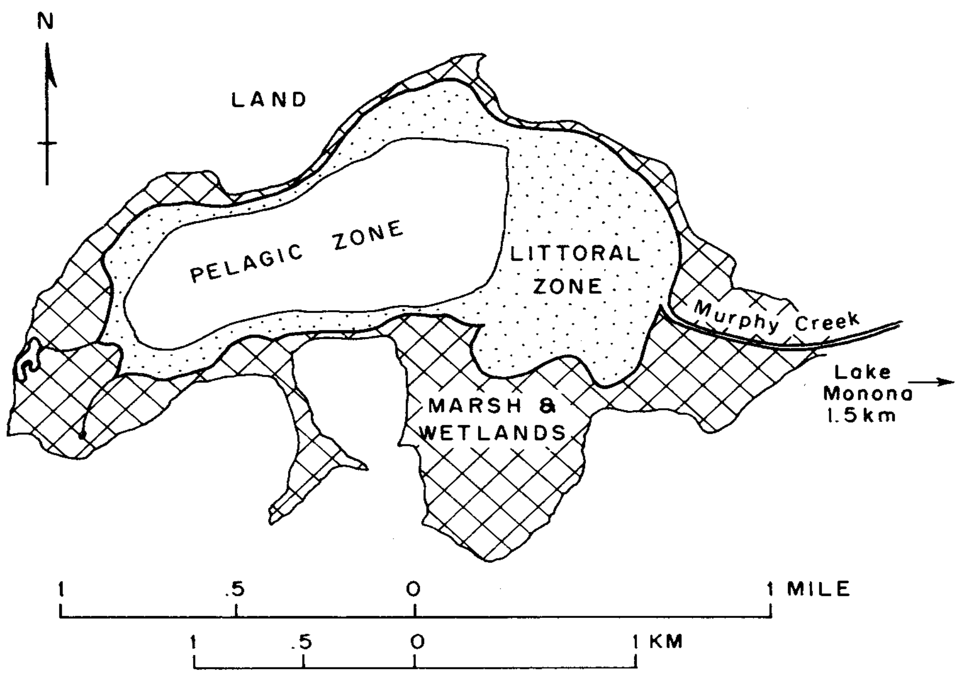
While the primary focus of this section is on vegetation in and immediately bordering Lake Wingra, it is important to point out broad scale changes to upland vegetation in the watershed. The original land surveyors noted that much of this area was oak savanna, or "oak opening," with widely spaced trees interspersed with prairie and other herbaceous vegetation (Ellarson, 1949). This type of vegetation cover was favored by the frequent occurrence of fire in the region (Curtis, 1971). Fires were started either by lightning strikes or set by local Native Americans as a means of flushing out game for hunting (Mollenhoff, 1982).

European settlement in the mid to late nineteenth century brought an end to the oak openings in the watershed as fires were regularly suppressed and the land was cleared for farming and grazing. During the late nineteenth and early twentieth centuries, there was increasing urbanization, and farms were often sold to developers for subdivisions (Mollenhoff, 1982). Now some of the only examples of oak openings and prairie vegetation in the watershed are restored communities found in the UW-Arboretum, where other examples of Wisconsin's native plant communities can also be found. Remaining patches of forest in the urbanized areas of the watershed are dominated by fire intolerant tree species like sugar maple and basswood. Honeysuckle and buckthorn, both exotic species, are common undergrowth.

The aquatic and wetland vegetation of the Lake Wingra basin has changed considerably since European settlement. In the last century it was known as "Dead Lake," partly because of its shallow and fertile character and because of the mistaken belief that it had no outlet (Brown, 1915). In the late 1800s, Lake Wingra and its surrounding wetlands covered three times its current area

(Baumann *et al.*, 1974) (**Figure 2-9**). As one resident reported, "The shores of the lake were shallow and one had to push a boat through a hundred yards or more of weeds and cattails before reaching open water" (Rowley, 1934). The vast area of surrounding wetlands supported a diverse group of plant communities, including prairie cord grass (*Spartina pectinata*) meadows, shallow marsh, sedge meadow, shrub carr, lowland forest, fen, and a stand of tamaracks with bog flora. Within the littoral fringe of Lake Wingra were cattails, bulrushes, wild rice, and dense growth of green algae (*Chara* sp.). In the deeper water a variety of small floating duckweeds (*Lemna* sp.), larger water lilies, and numerous submerged plants, especially wild celery (*Vallisneria americana*), were present. Numerous pondweeds (*Potamogeton* sp.), coontail (*Certophyllum demersum*), and other submerged plants were also abundant (Baumann *et al.* 1974).

Figure 2-9
Presettlement wetlands of Lake Wingra (after Baumann *et al.*, 1974). Note: Murphy Creek is now referred to as Wingra Creek.



Few early studies were done on Lake Wingra vegetation, and most focused on general descriptions of the vegetation (Birge, 1891; Juday, 1914; Cahn, 1915). Based on these historical reports, it can be seen that a much greater diversity of plant communities existed in the 1890s when compared to today (**Table 2-4**).

Much of the original littoral wetland fringe has been lost due to dredging, filling and changes in hydrology. Wetland communities further away from the lake have been changed by dredging and filling, lowered water tables, and increased surface water runoff.

Changes to Vegetation

Much of the original littoral wetland fringe has been lost due to dredging, filling and changes in hydrology. Wetland communities further away from the lake have been changed by dredging and filling, lowered water tables, and increased surface water runoff (Watson *et al*, 1979; Friedman, 1987). The subsequent alteration of soils, water level and water quality, and the invasion of exotic species have left very different plant communities than were present in the 1800s. Remaining wetland communities include shallow marsh, sedge meadows, degraded fens, shrub carr, southern wet forest, and wet meadows. **Figure 2-10** shows a generalized depiction of modern Lake Wingra vegetation.

Table 2-4
Changes to plant communities, a comparision between predevelopment and present day.

COMMUNITY OR PLANT ASSOCIATION*	ORIGINAL VEGETATION **	CURRENT STATUS ***
Submergent aquatic	Mixture of pondweeds, wild celery, coontail, and others	Mixture with Eurasian water milfoil and coontail most abundant
Emergent aquatic/ shallow marsh	Cattails, bulrushes, wild rice	Littoral fringe area reduced, similar species, wild rice is extirpated
Sedge meadow	Covered large areas near edge of lake	Decrease in area
Fens	Several present	Decrease in area, altered hydrology, loss of organic soil
Wet meadows	Probably uncommon	A disturbance community that may be more common now
Shrub carr	Common	Shrubby areas now common as shrubs invade fens and other wetlands
Tamarack stands	One area found in Gardner Marsh area, east of lake	No longer present. Peat in east marsh has diminished

** classification scheme after Eggers and Reed, 1997.*
*** after Baumann et al. (1974), Bedford et al., (1974) and Cahn, (1915)*
**** after Trebitz et al. (1993) and Bedford et al., (1974)*

While dredging and changes in water levels have caused great declines in littoral wetland area and diversity, increased surface water runoff and decreased groundwater flow may have had the greatest impact on the groundwater-dependent plant communities. These communities, including groundwater-fed wetlands such as fens and the bog flora associated with the tamarack stand, have suffered the greatest losses in both areal extent and species composition (Irwin, 1973; Friedman, 1987). The two existing fens are severely degraded because many of the springs have stopped flowing, and the tamarack stand with associated bog flora has been lost. **Tables 2-5 and 2-6** illustrate the changes in plant community area and species loss.

Table 2-5
Changes to plant species composition in Lake Wingra and surrounding wetlands: Extirpated species.

SCIENTIFIC NAME	COMMON NAME	HABITAT AREA
Brasenia schreberi	Water shield	Open water
Carex limosa	A sedge	Bogs
Epilobium tenuifolium	Narrow-leaf willow herb	Sedge meadow
Hippuris vulgaris	Mare's tail	Limestone springs
Ophioglossum vulgatum	Adder's tongue fern	Wet acid soil in forest or meadows
Pontederia cordata	Pickerelweed	Open water
Potamogeton amplifolius	A pondweed	Open water
Potamogeton freisii	A pondweed	Open water
Potamogeton praelongus	A pondweed	Open water
Sarracenia purpurea	Pitcher plant	Bogs
Triglochin maritima	Arrow grass	Limy sand beaches
Viola canina	Dog violet	Sand beaches
Zizania aquatica	Wild rice	Shallow marshes

In the lake, the diversity of native pondweeds (*Potamogeton* sp.), wild celery, and other submerged plants has been reduced by increased phosphorus loading, changes in water levels, and the introduction of exotic species. At least five open water species have been lost from the original vegetation (**Table 2-5**) (Bedford *et al.,* 1974; Baumann *et al.,* 1974). The rapid lowering of lake level in 1917 by a dike breach, followed by a rapid rise when the dike was

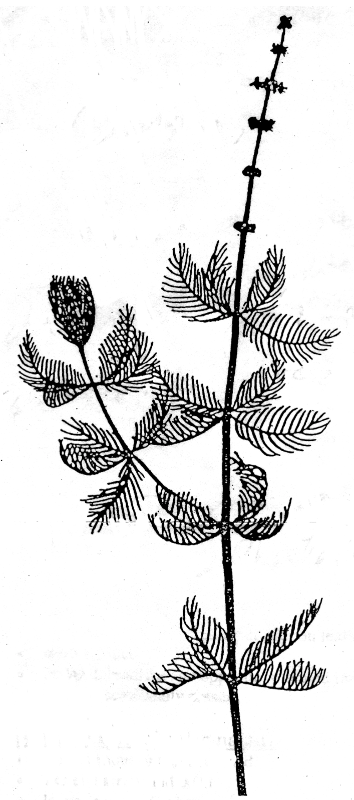
Table 2-6
Changes to plant species composition in Lake Wingra and surrounding wetlands: Introduced species.

SCIENTIFIC NAME	COMMON NAME	HABITAT AREA
Lonicera bella	Tatarian honeysuckle	Shrub carr, forest
Lythrum salicaria	Purple loosestrife	Shallow marsh
Myriophyllum spicatum	Eurasian milfoil	Open water
Nasturtium officinale	Water cress	Springs
Phalaris arundinacea	Reed canary grass	From shallow marsh to wet prairies
Rhamnus cathartica	Buckthorn	Upland forest
Rhamnus frangula	Glossy buckthorn	Shrub carr
Solanum dulcamara	Nightshade	Wet forest

(after Bedford et al. 1974 and Baumann et al. 1974)

repaired and a new outlet dam built in 1919, had deleterious effects on lake vegetation (Baumann *et al.*, 1974). Following this period, the introduction of carp nearly denuded the lake of vegetation (Baumann *et al.*, 1974). Sometime before 1960 the exotic Eurasian water milfoil was introduced and soon became the dominant submerged plant in the lake, accounting for 68% of plant frequency in a 1969 study (Nichols and Mori, 1971).

The peak of Eurasian water milfoil dominance coincided with the beginning of the International Biological Program (IBP) research at Lake Wingra. Understanding Eurasian water milfoil physiology, ecology, and control was a major concern, as its presence caused major ecological and aesthetic problems.



M. spicatum
Eurasian water milfoil

Eurasian water milfoil eventually declined in the 1970s for reasons not completely understood (Trebitz *et al.* 1993). In later decades, coontail increased dramatically and submerged plant diversity slightly increased. A hopeful sign was the reappearance of five aquatic species in the lake which had not been seen for years, including *Potamogeton illinoenis*, *Myriophyllum sibiricum* (a native milfoil), *Chara* sp., *Utricularia macrorhiza*, and *Vallisneria americana* (wild celery), a key food source for ducks (Trebitz, *et al.*, 1993).

While the IBP program greatly enhanced knowledge of vegetation within Lake Wingra, research on surrounding wetlands remains sparse. Wetland research to date consists of a few published papers (Cahn, 1915; Curtis, 1946; Bedford *et al.*, 1974) and four masters theses (Irwin 1973; Lovely, 1984; Friedman, 1987; Salli, 1965). Research topics were scattered in areas concerning natural history, shrub invasion of wetlands, and management. The most comprehensive study of the Lake Wingra wetlands is found in the Wetlands of Dane County (Bedford *et al.*, 1974). This study mapped existing wetland communities and described threats to wetland health. It also suggested possibilities for improving plant diversity.

The Future of Lake Wingra Vegetation

Lake Wingra has been much more heavily studied than many other Wisconsin lakes because of its proximity to major research institutions. However, there is still much to be understood about the vegetation of the area. Considering the historically large areas of wetland surrounding the lake and their importance for wildlife and plant diversity, research in this area has been minimal.

Two key players in future research may be the UW-Arboretum (for wetlands and upland communities) and the Long Term Ecological Research program in the UW Limnology department (in-lake studies). Historically, the Arboretum has concentrated on prairie and woodland studies. Nevertheless, interest in wetlands, such as Wingra Fen, is increasing. These two important institutions, along with other researchers, could collaborate to provide a more complete understanding of the entire continuum of plant communities in the Lake Wingra watershed.

Continuing Threats

While research helps us to understand Lake Wingra, knowledge alone is not enough to prevent further decline of its health and diversity. Many threats to plant health and obstacles to reestablishing native species still exist. These include in-lake problems such as turbidity, excess nutrients, and exotic species. Carp continue to cause problems by increasing turbidity and uprooting plants. Out of the lake, problems associated with urbanization that include increased nutrient levels, sedimentation, and decreased groundwater flows impair water quality. Species that require nutrient-poor conditions and organic soils (such as fens) are especially endangered. These groundwater dependent species have suffered from hydrologic and soil modifications, as evidenced by the loss of several spring and fen species in the area (Bedford *et al.*, 1974).

The rare plant communities around Lake Wingra, including the fens and spring-fed wetlands, are in need of better understanding and action to prevent further degradation and loss of species such as the state-threatened white lady slipper (*Cypripedium candidum* Wild). Other pressing problems that need further research include the control of exotic species, the effects of decreased groundwater discharge on fens and other wetlands, the requirements for re-establishing or increasing populations of wild celery, native pondweeds, and wild rice, and the effects of sedimentation on plant communities.

Invasion of exotic plant species poses serious threats to diversity in the Lake Wingra area.

Invasion of exotic plant species poses serious threats to diversity in the Lake Wingra area. Buckthorn (*Rhamnus* sp.) near the lake edge and in upland areas, reed canary grass (*Phalaris arundinacaea*) in sedge meadows and shallow marshes, and hybrid cattails (*Typha X glauca*) in shallow marshes all have large populations in or around Lake Wingra, and are serious problems (Zedler, personal communication). Sedge meadows, which used to be quite common in the area, have been reduced to a few stands and could lose much more area through invasion of reed canary grass and cattail hybrids on the sedge meadow-cattail marsh interface. A more recent invader, purple loosestrife (*Lythrum salicaria*), also looms as a threat to diversity. Recognizing the potential of this species to rapidly overwhelm shallow marsh areas, there have been some removal efforts already near the Edgewood College area, which supports a significant population (Hefty, personal communication).

The increased algal productivity caused by eutrophication also remains a serious problem, both ecologically and for recreational users of the lake. Blue-green algae or cyanobacteria, and green algae such as *Chara* sp., produce different types of algal blooms, but both may cause problems (for more detail on the relationship between eutrophication and algal blooms see *Lake Chemistry and Sediments*, page 11). Both types of algae can reach nuisance levels when growth conditions are ideal, developing mats associated with weedbeds in the case of *Chara* sp. and *Oedogenium* sp., or forming an unattractive green scum on the water's surface, which happens with planktonic blue-green algae (McCracken *et al.*, 1974; Olem and Flock, 1990).

When nutrient loading to shallow lakes increases, the biomass of aquatic macrophytes and algae will often increase to nuisance levels. However, control of weed beds and/or further eutrophication can lead to increased turbidity due to planktonic algal blooms. Eventually, this may lead to declines in aquatic macrophyte abundance and diversity due to shading by phytoplankton and periphyton (Scheffer, 1998). A model describing this switch in conditions, called the "Alternative States Model", describes this condition as "algal dominance" (Moss, 1998). While the factors controlling the relative abundance of macrophytes and algae are very complex, it is clear that "algal dominance" is undesirable on all accounts. Aquatic plant diversity has decreased in Lake Wingra over the years and excessive nutrient loading has been a major cause. A switch toward the algal dominated state would likely decrease plant diversity further. To decrease the extent and frequency of algal blooms, and provide conditions suitable for enhanced macrophyte diversity, improved stormwater management is needed.

Opportunities for Improvement

Lake Wingra cannot return to predevelopment conditions. However, opportunities exist to increase native populations and reintroduce certain key species. Decreases in runoff and turbidity accompanied by maintenance of, or increases in, groundwater flows are important for maintaining and/or improving plant diversity and habitat. If conditions were suitable, reintroducing wild rice and increasing populations of wild celery and native pondweeds could greatly enhance waterfowl diversity in the lake area. Opportunities for citizens to act are many, ranging from reducing runoff from residential yards to participating in the UW-Arboretum's volunteer restoration programs.

Invertebrates, Wildlife, and Fish

Historic Fauna in and around Lake Wingra

Lake Wingra and the surrounding area, particularly UW Arboretum lands, provide important habitat for waterfowl and other birds, reptiles, amphibians, deer, and small mammals. Considerable biological diversity has been documented in and around the lake. In one early study, more than 200 species of vertebrates were found in the springs area near the southwestern edge of Lake Wingra, including 14 mammal, 5 reptile, 9 amphibian, 16 fish, and 161 bird species (Cahn, 1915).

Anecdotal accounts and the name itself – Wingra, or 'Weengra,' which means "duck" in the Ho-Chunk, or Winnebago language – indicate that in times past, Lake Wingra supported large numbers of waterfowl.

Anecdotal accounts and the name itself – Wingra, or 'Weengra,' which means "duck" in the Ho-Chunk, or Winnebago language (Brown, 1915; Brown, 1926) – indicate that in times past, Lake Wingra supported large numbers of waterfowl. During the late 1800s, one avid sportsman, Walter Howard Chase, recorded bagging seventeen species of ducks from around Lake Wingra (See **Box 2-1**).

The Ho-Chunk Indians referred to the lake as Ki-chunk-och-hep-er-rah, or the "place where the turtle comes up" (Brown, 1915). Many turtles continue to inhabit Lake Wingra, including abundant painted turtles (*Chrysemys picta*) and snapping turtles (*Chelidra serpentina*). Soft shelled turtles (*Trionyx spinifera*),

Box 2-1

Historic waterfowl of Lake Wingra.

Lake Wingra has historically been rich in bird species. Many waterfowl, including ducks and geese, are still found in and around the lake. The loss of wetlands, the decline of native vegetation, and the destruction of feeding and nesting habitat, combined with increased human disturbance, have all contributed to the decline in the diversity and numbers of waterfowl.

Between 1873 and 1895, Walter Howard Chase recorded bagging seventeen species of ducks in and near Lake Wingra (Leopold, 1937). These are shown in the table below. Duck names were entered in Mr. Chase's hunting journal in the local vernacular (Journal Names), and Aldo Leopold (1937) provided some interpretation to more common names. Scientific names of the birds follow, along with the total number of ducks taken, and the percent of total birds. Note that four duck species, the lesser and greater scaup, the greenwing teal, and the mallard, make up sixty-eight percent of the recorded total.

JOURNAL NAMES	LEOPOLD'S IDENTIFICATION	SCIENTIFIC NAME	TOTAL NUMBER	PERCENT of TOTAL
Redhead		Aythya americana	52	4
Canvasback		Aythya valisineria	3	*
Bluebill	Possibly lesser scaup or ringneck	Aythya affinis / A. collaris	369	25
Scaup duck	Possibly Greater Scaup	Aythya marila	128	9
Whistler	American goldeneye	Bucephala clangula	16	*
Butterball	Bufflehead	Bucephala albeola	78	5
Ruddyduck		Oxyura jamaicensis	5	*
Mergansers	Undifferentiated mergansers	Lophodytes cucullatus, Mergus Merganser, M. serrator	5	*
Old-wives	Old squaws	Clanula hyemalis	13	1
Mallard		Anas platyrhynchos	190	13
Widgeon		Anas americana	24	2
Spoonbill		Anas clypeata	15	1
Greenwing teal	Including undifferentiated teals	Anas crecca	339	21
Bluewing Teal		Anas discors	55	5
Wood duck		Aix sponsa	161	11
Pintail		Anas acuta	44	3
Grayduck	Possibly gadwall	Anas strepera	3	*

** less than 1 percent of total ducks killed*

Habitat loss, overharvesting, and the introduction of exotic species have contributed to significant declines in native fauna.

and the largely terrestrial Blanding's turtles (*Emydoidea blandingii*) have also been reported in and around the lake (Noland, 1951).

Unfortunately, native wildlife populations have declined significantly since the time of European settlement. Habitat loss, overharvesting, and the introduction of exotic species have contributed to significant declines in native fauna.

In 1937, Aldo Leopold wrote, "It is common knowledge that Wingra is now spoiled as a duck lake, presumably by carp." The decline of waterfowl was certainly compounded by other changes, including increased human uses of the lake, and the disappearance of wild rice, a significant food source, which may have been precipitated by the carp stirring up bottom sediments and uprooting plants.

A number of animal species that once inhabited the Lake Wingra region have been extirpated, e.g. the buffalo (*Bison bison*) and bald eagle (*Haliaeetus leucocephalus*), or gone extinct, e.g. the passenger pigeon (*Ectopistes migratorius*). One early hunter recalled that, "[Passenger] pigeons were twice as plentiful as blackbirds and lots easier to kill" (Rowley, 1934). The ruffed grouse (*Bonasa umbellus*) disappeared from the Wingra woods shortly before the establishment of the UW Arboretum in the 1930s, and prairie chickens (*Tympanuchus cupido*) declined thereafter (Leopold, 1937).

Invertebrates

Invertebrate species are an extremely important part of an aquatic ecosystem. Many aquatic invertebrates, including insects, protozoans, rotifers, crustaceans, worms, snails and molluscs, consume algae, bacteria, rooted plants, and/or decaying materials. These organisms provide important links in food webs between producers or decomposers and the larger organisms that prey upon them. Aquatic invertebrates also recycle nutrients through their excretion, releasing nutrients (nitrogen and phosphorus) into the water column.

The diversity, abundance, and distribution of aquatic invertebrates is affected by a number of factors, including suitable habitat, available food, predation, dissolved oxygen availability, and water quality. Significant changes in the zooplankton and benthic invertebrate communities of Lake Wingra have occurred since Birge first surveyed communities of water fleas, or tiny crustaceans known as Cladocerans, in 1891. Only half of the nearly fifty water flea species present in 1891 were found in the early 1970s (Baumann *et al.*, 1974).

Tressler (1930) documented a rich benthic invertebrate community, including aquatic insects, water mites, molluscs, and crustaceans, dominated by the amphipod *Hyalella azteca*. Since the 1900s, the intensity of fish predation on aquatic invertebrates has increased, and may be partly responsible for the decreased diversity of zooplankton in general, and the functional extinction of the amphipod *Hyalella azteca* in Lake Wingra. Baumann *et al.* (1974) speculated that these changes have occurred since the mid-1950s.

"Intensive sampling in 1970-72 of the benthos and the fauna on littoral macrophytes revealed an invertebrate fauna dominated by small chironomids" (Baumann *et al.*, 1974). Chironomids, or true midges, whose larvae are also known as bloodworms, are generally not an indicator of good water quality.

The proliferation of chironomids may be due to their ability to tolerate low DO levels that likely exist in the bottom sediments of Lake Wingra.

The size of zooplankton in Lake Wingra is affected by size selective predation, where the fish prefer larger individuals of a prey species to the smaller ones. This can result in a zooplankton population with smaller individuals. Since the rate of phosphorus release is inversely related to animal size, size selective planktivory by bluegills results in an increase in phosphorus released per unit biomass of zooplankton (Bartell and Kitchell, 1978).

Fish

From open water fishing for muskies and panfishing from the shoreline, to winter ice fishing, this waterbody supports a range of year-round hook and line opportunities. Since fishing is a very popular activity at Lake Wingra, the dynamics of fish populations and their effects on the Lake Wingra ecosystem are socially significant.

Lake Wingra's fish community has changed considerably since European settlement. See **Box 2-2** for a listing of native fish found in Lake Wingra. A number of human-induced stresses have directly impacted the original assemblage of fish in Lake Wingra, including introductions of exotic species, stocking, fish rescue operations, seining, and fish removal efforts. These stresses have been compounded by major hydrologic changes, including construction of dams and dikes, dredging, wetland loss, and altered runoff associated with urbanization of the watershed.

A number of human-induced stresses have directly impacted the original assemblage of fish in Lake Wingra. . .

The abundance of any fish species fluctuates in inland lakes due to variable reproductive success (Churchill, 1976). In Lake Wingra, fish species such as the northern pike (*Esox lucius*) are limited due to the lack of suitable spawning habitat. For example, northern pike require shallow marshy areas to deposit their eggs; much of this habitat, like Gardner Marsh, has been isolated from the lake or filled in for parkland. Human actions have directly impacted many fish populations.

Records beginning in the late 1800s show that a number of fish species have been stocked, or otherwise been introduced into Lake Wingra (**Table 2-7**). Some of the stocked fish, often exotic species, have prospered in the lake, like the common carp (*Cyrpinus carpio*). Others have not fared so well, such as various trout species. As early as 1872, trout were stocked in the lake. Governor Washburn built stone-walled pools around Edgewood springs and stocked them with trout (Noland 1948, cited in Ross *et al.*, 1980; Brown, 1926).

During the 1930s and 1940s, flooding in the Mississippi River basin caused fish to be stranded in upland pools. Pools eventually dried out and consequently many fish were lost. Throughout the upper Mississippi basin, a common management practice was to rescue and transplant stranded fish to other waterbodies, including Lake Wingra. These fish rescue operations have had lasting impacts on the fish communities of Lake Wingra and many other waterbodies. It is estimated that between fish rescue operations and hatchery stocking, more than 20 species of fish were introduced into Lake Wingra (Baumann *et al.*, 1974; Foreman, 1999).

Table 2-7
History of fish stocking and removal at Lake Wingra.

1872	Trout stocked by Governor Washburn in stone walled pools around Edgewood springs (1)
1885 – 1897	Common carp introduced - 3,947 released into Yahara River System (2)
1900-03, 1905-09, 1912, 1916, 1921-22, 1928-30, 1940, 1943	Walleye stocked – 2,655,000 miscellaneous fish between 1900-1907, 5,528,050 fry between 1900-1930, and 7,000,000 fry in 1943 (1)
1908, 1910, 1911, 1913-14, 1916, 1930	'Black bass' stocked – fry and fingerlings (1)
1915, 1917, 1938-40	Perch stocked – eggs, fingerlings, and adults (1, 3)
1917, 1933, 1940, 1943	White bass stocked – fingerlings (1)
1922, 1940-42	Northern pike stocked – 846,198 fry (note – Baumann et al. 1974 cite 3,000,000 fry stocked in 1922, while Noland 1951 cites 300,000), fingerlings, and adults (1, 3) [see also 1950s]
1930, 1939, 1942, 1943, 1945	Bullhead stocked – undifferentiated species (1)
1930s – 1940s	Seining and removal of Carp and other rough fish, more than 58 tons of carp removed in 6 sein hauls, nearly 3 tons of longnose gar, and bowfin were removed (1)
1930s – 1940s	Fish Rescue Operations – The following species were likely stocked into Lake Wingra: white crappie, black crappie, bluegill, sunfish, yellow bass, white bass, pumpkinseed, yellow perch, bullheads, catfish, white sucker, spotted sucker, and northern redhorse (1, 3)
1934, 1936, 1937, 1940, 1941	Trout stocked, including brown, rainbow, and brook (1)
1937 – 1944	Largemouth bass stocked annually (1, 3)
1940	Suckers stocked - 6 adult suckers, including the white sucker (3)
1940, 1943	Walleye stocked - 7,000,000 fry in 1943 (1)
1940, 1945-48	Tiger muskie stocked – muskellunge x northern pike hybrids – 240 stocked in 1940 (1) [see also 1980s]
1950s	Northern pike was the only species stocked in the '50s (3)
1950s	Intensive seining and carp removal effectively reduces carp population (3)
1979 – 1984	Muskellunge (pure) and tiger muskie (hybrid) stocking – 215 muskie stocked in 1979 followed by at least 700 muskie (8-10") and 2,690 tiger muskie (4, 5)
1990 – 1999	Muskellunge stocked annually by WDNR - stocking rate lowered to 50 - 100 fingerlings per year over the past three years (5)

(1) - Noland, 1951
(2) - Frey, 1940, cited in Baumann et al., 1974
(3) - Baumann et al., 1974
(4) - Jaeger, 1985
(5) - Vogelsang, Personal Communication
NOTE – Records derived from WI Conservation Dept and WI Dept of Natural Resources planting records

The common carp (*Cyprinus carpio*), an exotic fish from Asia, was observed in Lake Wingra by the late 1890s (Baumann *et al.*, 1974). Although carp were stocked into other Madison lakes, where a commercial carp fishery existed for a period, no specific records were found of stocking carp into Lake Wingra. It is possible that carp made their way into Wingra from Lake Monona via Wingra Creek and Gardner Marsh. Wingra Creek, the outlet to Lake Wingra which flows to Lake Monona, provided a historic connection for fish movement between Lake Wingra and the Yahara River system, before Lake Wingra's outlet was dammed in 1919.

The introduction of the carp has caused considerable adverse impacts to waterbodies throughout North America, including Lake Wingra. By 1930, carp were the dominant fish in Lake Wingra. Trout were unsuccessfully stocked again during the 1930s-40s, in an effort to control carp through predation (Baumann *et al.*, 1974; Ross *et al.*, 1980).

During the next 20-25 years, the carp nearly denuded the lake of rooted vegetation.

During the next 20-25 years, the carp nearly denuded the lake of rooted vegetation (Arboretum Committee, cited in Ross *et al.*, 1980; Baumann *et al.*, 1974). Ross *et al.* (1980) reported that two alternatives were proposed, "poisoning the lake and then restocking, or seining." Seining and the removal of fish began in the mid 1930s, but it wasn't until the 1950s that intensive and effective seining efforts significantly reduced the carp population, so that there were few carp in Lake Wingra by the 1960s (Baumann, *et al.*, 1974).

Populations of pondweeds and other aquatic vegetation increased after carp numbers were diminished (Baumann *et al.*, 1974). The numbers of bluegills (*Lepomis macrochirus*) and other panfish also started to increase (Bartell and Kitchell, 1978; Baumann, 1974; WDNR 1999).

Overpopulation of panfish in Lake Wingra has created intense competition for food and habitat, which has resulted in stunted fish, i.e. fish smaller in size than would be found under normal conditions. Stunted panfish, specifically yellow bass (*Morone mississippiensis*), were observed in Lake Wingra immediately after carp removal. Body growth curves and weight-to-length ratios were found to be lower than average for bluegills compared to earlier growth curves for Lake Wingra before and during carp removal, and compared to other lakes in the region (Baumann *et al.*, 1974; Churchill, 1976).

During the 1970s, the dominant species were stunted bluegill and yellow bass (Baumann *et al.*, 1974; Churchill, 1976; WDNR 1999). Overall, fish (and invertebrate) populations were dense with a noted decline in northern pike and yellow perch (*Perca flavescens*) (Loucks *et al.*, 1977). A number of top predators, including longnose gar, bowfin, and walleye were rare, smallmouth bass were absent, and the most common predator was reportedly the largemouth bass (*Micropterus salmoides*) (Baumann *et al.*, 1974). Insufficient numbers of carp, northern pike, and largemouth bass were found to accurately estimate their populations during intensive studies in the early 1970s (Churchill, 1976).

A population of nearly one million adult bluegills was estimated during 1970, representing about two-thirds of the fish in Lake Wingra (Loucks *et al.*, 1977). Churchill (1976) found that about 75 % of the fish biomass was bluegill. Relatively small bluegills continued to dominate Lake Wingra's fish community into the 1980s. Increased bluegill size was reported shortly after several major changes in the Lake Wingra ecosystem that were observed during the late 1970s, including the disappearance of the yellow bass in 1977, the decline of Eurasian water milfoil beds which formerly ringed the shoreline, and the stocking of muskellunge (Jaeger, 1985).

Muskellunge (*Esox masquinongy*) have been stocked into Lake Wingra since 1979 (Jaeger, 1985), and yearly since 1991 (WDNR, 1999). Tiger muskie (*Esox lucius X E. masquinongy*), a sterile hybrid between the northern pike and muskellunge, had been stocked during the 1940s and 1980s. Muskie stocking serves the dual purpose of providing sport fishing opportunities and biomanipulation of the food web in an effort to control panfish numbers. By

Box 2-2

Native fish species of Lake Wingra.

No one knows for certain the exact assemblage of native fish that inhabited Lake Wingra before fish stocking and the arrival of exotic fish species. Even the experts disagree about whether certain fish species, including walleye and bigmouth buffalofish, lived in Lake Wingra before European settlement (Helm, 1958, cited in Baumann *et al*., 1974 and Noland, 1951). The following table summarizes early records of fish found living in Lake Wingra.

COMMON NAME	SCIENTIFIC NAME
Large Predators	
Largemouth bass [1, 2, 3] (also known as black bass)	*Micropterus salmoides*
Longnose gar [2, 3]	*Lepisosteus osseus*
Northern pike [2, 3] (also known as pickerel)	*Esox lucius*
Smallmouth bass [3] (also known as yellow bass)	*Micropterus dolomieu*
Medium Predators	
Black crappie [1, 2, 3]	*Poxomis nigromaculatus*
Bluegill [1, 2, 3]	*Lepomis macrochirus*
Pumpkinseed [2]	*Eupomotis gibbosus* Now – *Lepomis gibbosus*
Rock bass [2]	*Ambloplites rupestris*
Yellow perch [1, 2]	*Perca flavescens*
Rough fish	
Brown bullhead [2]	*Ameiurus nebulosus* Now – *Ictaluruus nebulosus*
Forage fish	
Banded killifish [2]	*Fundulus diaphanus menona*
Blackchin shiner [2]	*Notropis heterodon*
Blacknose shiner [2]	*Notropis cayuga*
Brook silverside [2]	*Labidesthes sicculus*
Brook stickle-back [2]	*Eucalia inconstans*
Central mud minnow [2]	*Umbra limi*
Johnny darter [2]	*Boleosoma nigrum* Now – *Etheostoma nigrum*

[1] Marshall & Gilbert, 1905, cited in Baumann et al. 1974
[2] Cahn, 1915, mentioned in study of Wingra Springs Region
[3] Rowley, 1934

controlling bluegill populations through predation, it is hoped that panfish growth will improve. Lake Wingra supports a very dense population of muskie (four fish per acre) only with stocking, because muskies have little or no reproductive success in the lake.

Today Lake Wingra is dominated by panfish and carp (WDNR, 1998b). The waterbody is managed by the WDNR as a warm water sport fishery. Muskellunge and largemouth bass are common, with fewer walleye (*Stizostedion vitreum*) and northern pike present in the lake (WDNR, 1995). Forage species include the golden shiner (*Notemigonus crysoleucas*), brook silverside (*Labidesthes sicculus*), brook stickleback (*Calea inconstans*), and minnows (*Notropis* sp.).

Current Threats to Fish, Wildlife, and Invertebrates

Threats to fish, wildlife, and invertebrates include increasing concentrations of contaminants and sediments from stormwater inflows, non-native species and continued development of watershed uplands.

Conclusions and Recommendations

In reviewing the scientific literature on Lake Wingra and its watershed, one of the most striking observations is the absence of research in the past fifteen years.

In reviewing the scientific literature on Lake Wingra and its watershed, one of the most striking observations is the absence of research in the past fifteen years. The majority of the work in both the physical and biological sciences was conducted in the 1970s as part of the International Biological Program (IBP). Many other studies published in the late 1970s and early 1980s including theses, dissertations, journal articles, and government reports, were also related to that effort. Though the IBP work and related studies substantially improved understanding of the lake and watershed, and successfully identified many of the major problems (see **Box 2-3**), follow-up studies investigating both physical and biological aspects of the watershed could help to identify modern trends and perhaps undiscovered threats.

Also evident in the existing literature is the lack of research focusing on mitigation or abatement of identified problems. A clear example is the change in the hydrologic regime that has played a central role in the health of watershed biota. Though it is amply recognized in the literature that the hydrologic shift from groundwater dominated inputs to runoff dominated inputs has negatively affected water quality and ecosystem health, few studies have examined how best to reduce runoff and increase groundwater recharge and springflow. One exception is the Dane County Regional Hydrologic Study (1998) that, through modeling, has identified ways to maintain future water table levels and perhaps even improve groundwater discharge on a regional basis.

Watershed specific research could extend this effort and identify specific local strategies for improving water quality. Research of this nature would be very useful to resource managers who have struggled thus far to effectively combat progressive water quality degradation, let alone see improvements. However, successful implementation of such strategies would depend upon the ongoing communication of research and monitoring results to watershed citizens, long-term public involvement, and cooperation among the various agencies and institutions responsible for lake research and management.

Box 2-3

Lake Wingra problem identification.

Lake Wingra watershed researchers have identified numerous problems that currently threaten water quality and the health of the watershed ecosystem. Many of these problems are interrelated and they require interdisciplinary solutions. The following summarizes issues identified in the synthesis of technical research.

◆ **Shift in Lake Wingra's water supply from groundwater to surface runoff**

Lake Wingra's watershed is 75% urbanized. With an increase in urbanization, impervious surface area increases. The effect of this is twofold: less water infiltrates into the ground, and instead runs off, and water moves faster through the landscape due to less resistance and interception. Other hydrologic problems include:

- Increase in groundwater pumping, without adequate recharge
- Increase in the quantity of stormwater runoff
- Increase in the "flashiness" of stormwater runoff

◆ **Increase in nutrient, sediment and contaminant inputs into Lake Wingra**

As stormwater flows through the watershed, it picks up nutrients from excess fertilizers and dead leaves, sediments from road sanding and debris, and contaminants, such as trace metals from roads. Stormwater is transported to Lake Wingra directly via storm sewers or indirectly via retention basins or settling ponds.

◆ **Long-term storage of phosphorous in lake sediments**

The long-term storage of phosphorus in Lake Wingra has been identified as a potential setback for watershed management. Over time, phosphorus has been accumulating in the sediments, and is being released gradually by physical turbulence and biochemical reactions.

◆ **Loss of species and species diversity**

The loss of species and their habitat in Lake Wingra, on its shorelines, and in its watershed has been well-documented in historical accounts. Continuing threats include:

- Habitat degradation
- Invasive/exotic species

Chapter 3

A Brief History of Management

Introduction

Lake Wingra has long been a focus of research and recreation. While people have lived along its shores for centuries, the last 150 years of urban development have resulted in pronounced impacts on the hydrology of the lake and its surrounding watershed. Baumann *et al*. (1973) detail the lake's development and research history from 1837 to 1973, but had little to say about the lake's management and the regulations that governed the lake and its watershed. Their report concludes: "An integrated whole ecosystem approach is essential in establishing ecologically sound management…As always, hindsight is better than foresight, which probably explains why the next chapter of this article is not yet written."

This 1999 WRM Workshop document is part of that next chapter. This particular chapter details the management efforts in the Lake Wingra watershed up to 1999, and explains the statutes and regulations in effect at this time. It also takes a look at expected changes in these regulations as projected by federal, state, and local plans. *Chapter 4* (*Lake and Watershed Management*) and *Chapter 5* (*Stakeholders*) of this report contain more details about the current Lake Wingra watershed management practices and organizations. The tables at the end of this chapter show a timeline of the major management and regulatory issues (**Table 3-1**) and list the current ordinances, along with the jurisdiction to which they apply (**Table 3-2**).

Early Efforts: Controlling Floods and Wetlands

When urban development began around Lake Wingra in the latter half of the 19th century, people were more concerned about the impact of water on land than the impact that land use activities had on water.

Most early efforts in watershed management focused on flood control. The Lake Wingra watershed is no exception. When urban development began around Lake Wingra in the latter half of the 19th century, people were more concerned about the impact of water on land than the impact that land use activities had on water. Although the worst storms have always caused floods, urbanization exacerbated the problem. As more land was paved, more storm-water runoff was generated, leading to more localized drainage problems.

Early flood control efforts included building dams and draining wetlands. In 1905 a dam was built at the outlet of Lake Wingra to control the lake's water level, protecting the surrounding communities from flooding. This dam is now owned by the city of Madison and has been modified over the years to include a lock and a V-notch weir. The lock allowed navigation to the other Yahara Lakes but has been inoperable for years. Structural issues exist, including cracks in the cement works of the dam and an unmanaged emergency spill-way (Sue Josheff, personal communication). At least two additional dams exist at inlets to Lake Wingra flowing from the Monroe Street detention pond.

Many areas in the Lake Wingra watershed, including Vilas Park and Gardner Marsh, were dredged and drained to create dry land in the early part of this century. Some of these projects were successful, while others continue to cause ecological and hydrological problems. For example, in the early 1920s some of the wetland areas on the lake's southeast side were drained for housing, an effort that was soon abandoned, leaving what is now known as the "Lost City." Residential areas to the southeast, in the town of Madison, continue to struggle with flooding.

Priority Shift: Water Quality Legislation

By the 1960s concern had shifted, both locally and nationally, to the negative impacts that urbanization was having on water quality (Leopold, 1968). Though Congress had enacted water quality legislation in 1948 through the Water Pollution Control Act, this only provided technical assistance and small grants to states that sought them out. The Federal Water Pollution Control Act of 1956 continued in this vein. The Water Quality Act of 1965 was notable because it required states to establish water quality goals for interstate waters. However, it was not until the Federal Water Pollution Control Act Amendments of 1972, known today as the Clean Water Act (CWA), that a comprehensive water pollution control law was developed. The CWA was amended in 1977 and 1987 (Kent *et al.*, 1995).

Development and implementation of the federal CWA is delegated to the states, provided they enact comparable legislation. Through the adoption of Wis. Stat. ch. 147, Wisconsin was granted authority to administer the federal program in 1974 (Kent *et al.*, 1995). The federal Environmental Protection Agency (EPA) retains supervisory jurisdiction over state programs and can terminate those that are not implemented in accordance with the CWA (Kent *et al.*, 1995). Significantly, states can adopt stricter regulations than those mandated by the EPA. The Wisconsin program is unique among states because it regulates discharges to groundwater (Wis. Admin. Code chs. NR 140 and 160).

The original CWA of 1972, aiming to protect surface water quality, established the National Pollution Discharge Elimination System (NPDES) program (Section 402), and wetland protection regulations (Section 404). In Wisconsin, the state implements NPDES through the Wisconsin Pollution Discharge Elimination System (WPDES) program.

Aside from the city of Madison's WPDES permit governing stormwater discharges (discussed below), no WPDES permits have been issued in the Wingra watershed. However, the city does regulate non-stormwater discharges to the storm sewer system (Madison General Ordinance Section 7-47). At least two leaking underground storage tank remediation projects exist in the Wingra watershed, which have the potential to discharge to the municipal storm sewer system—and eventually to Lake Wingra (Behm 1999).

Like almost all other states, Wisconsin has not sought Section 404 implementation authority. The EPA and the Army Corps of Engineers administer the wetland program jointly, with the Corps responsible for issuing permits (Kent *et al.*, 1995). However, Section 401 of the CWA provides for state certification of federally-issued 404 permits to ensure that they meet state water quality standards. If they do not, the state can effectively veto issuance of a permit. In Wisconsin, procedures and general standards governing certification of 404 permits can be found in Wis. Admin. Code chs. NR 299 and NR 103 (Kent *et al.*, 1995).

Section 404 regulates the discharge of dredged or fill material into navigable waters. "Navigable waters" are broadly defined to include wetlands. Therefore, any development or other activity that would involve the filling of wetlands in the Wingra watershed requires a permit. Significantly, Section 404 does not regulate wetland drainage (Kent *et al.*, 1995).

These regulations did little to improve water quality in urbanized areas like the Lake Wingra watershed where there are no industrial point sources.

The 1972 CWA established the NPDES to eliminate surface water pollution primarily by regulating point source discharges. Point source discharges emanate from identifiable sources; as such, most discharges regulated by the 1972 CWA were industrial and commercial effluents. These regulations did little to improve water quality in urbanized areas like the Lake Wingra watershed where there are no industrial point sources. In the Wingra watershed, pollutants including insecticides, herbicides, petroleum products, heavy metals, and fertilizers often accumulate in stormwater as it flows over road surfaces and lawns. Such non-point source pollution is untreated and enters Lake Wingra from municipal storm sewers designed to transport stormwater runoff.

The CWA was amended in 1977 to address stormwater and other non-point sources of pollution. Section 208 of these amendments gave authority to states to develop plans for water quality. Wisconsin designated counties as planning areas, requiring them to develop realistic and workable Section 208 plans for their region.

In 1987, the US Congress passed the Water Quality Act (WQA), which amended the NPDES regulations to include stormwater as a pollutant source to be monitored and, if necessary, treated. Again, implementation was delegated to the states. The Wisconsin Department of Natural Resources' (WDNR) WPDES program governs stormwater regulations. Madison’s WPDES permit was issued in 1995 and must be renewed in July 2000.

Recent Watershed, Water Quality, and Stormwater Management Plans

Recent stormwater regulations focus on coordinating different levels of government, local communities, and watershed level management. For example, the city of Madison’s WPDES stormwater permit is held jointly with the University of Wisconsin-Madison, as the UW Arboretum is within the Lake Wingra watershed. The EPA, WDNR, Dane County, city of Madison, town of Madison, UW-Madison, neighborhood associations, and watershed interest groups are establishing working relationships that facilitate watershed management. The plans described below are presented in order from national to local origin, but all affect the Wingra watershed.

Federal Clean Water Action Plan

The watershed approach is a fundamental aspect of the federal Clean Water Action Plan, established in 1998. The plan is sponsored by several government agencies and stresses that watershed management must be tailored to individual watersheds because of the differences between individual watersheds. It also stresses that watershed management must address the entire watershed because controlling non-point source pollution is more complex than regulating stormwater pipe discharges (http://www.cleanwater.gov/, 1999).

Wisconsin DNR Lower Rock River Basin Water Quality Plan, 1998

This water quality plan is updated every five years, most recently in 1998. It addresses the management of Lake Wingra, the Yahara River, and other water bodies within the Lower Rock River basin. Proposed management actions for Lake Wingra include:

- rerouting a major storm sewer outfall to flow through HoNeeUm pond in the Arboretum
- removing carp
- reintroducing wild rice
- reconnecting Gardner Marsh to Lake Wingra

The plan identifies the following problems in the Lake Wingra watershed:

- alterations of the lake and its wetlands
- introduction of exotic species (e.g. common carp and purple loosestrife)
- pollutants within urban stormwater (e.g. 75% higher sodium levels and 2 times higher chloride levels than those found in Lake Monona)

- nutrients, sediment, and contaminants attached to the incoming sediment
- decreases in groundwater levels due to both urban pumping and increasing impervious surfaces that limit stormwater infiltration

The plan references the WDNR Heritage Resources Database. This monitoring database indicates that Wingra fen is a water-dependent endangered community. It also identifies problems for Wingra Creek (classified as a warm water sport fishery), including:

- low base flow
- high urban stormwater runoff and sedimentation rates
- low dissolved oxygen levels causing occasional fish kills
- presence of heavy metals, DDT metabolites, and PCBs in creek sediment samples

Wisconsin DNR Integrated Ecosystem Management (IEM) Project

In 1997 the WDNR recognized Lake Wingra as an area that needed attention, identifying Wingra as a Lower Rock River Integrated Ecosystem Management (IEM) project. The project goals include:

- bringing partners together for cooperative water quality solutions
- promoting public involvement
- performing public outreach and education

Initial steps have resulted in general assessments of fisheries and dam safety. More information can be found at http://www.dnr.state.wi.us/org/gmu/sidebar/iem/ lowerrock/index.htm.

In response to the lake's designation as an IEM project, local citizens formed the group Friends of Lake Wingra (FOLW) in 1998 with the mission "to promote a healthy Lake Wingra through an active watershed community" (http://danenet.wicip.org/fowingra/, 1999). The FOLW have been active by holding community meetings, encouraging restoration and public education activities, acquiring funding through a DNR Lake Management Planning grant, and working with the University's Water Resources Management Workshop to further define their objectives.

Wisconsin DNR Yahara-Monona Priority Watershed Project

As part of the shift to watershed-level management, and as a response to Section 208 of the CWA, the Wisconsin legislature authorized the WDNR to develop the Priority Watershed Program. This program provides financial assistance to local governments, regional planning commissions, and drainage districts to implement non-point source pollution control projects (Kent *et al*., 1995). In 1992, the Yahara River and Lake Monona watersheds gained designation as a priority watershed project, with Lake Wingra included as a subwatershed of Lake Monona (Dane County RPC, 1992).

Water quality objectives for the Yahara-Monona Priority Watershed Project include the following (modified from Lorman *et al*., 1997):

- reduce non-point source pollution loads of phosphorus and sediment by 30-50%
- reduce pollutant loads of chloride and heavy metals
- identify sources and reduce levels of bacteria
- control purple loosestrife

- improve the effectiveness and increase the use of detention ponds
- pursue innovative management practices

The estimated total cost of the Yahara-Monona Priority Watershed Project is $21 million. Participation in the plan is voluntary, but helps communities comply with stormwater regulations that aim to protect water quality from stormwater runoff and soil erosion. The plan provides cost-sharing and public assistance for control of urban and rural non-point source pollution. In urban areas, like the Wingra watershed, the priority watershed project will pay for 70% of construction costs for stormwater quality practices, including wet detention basins, grass drainage systems, and infiltration basins. The project also pays up to 50% of land acquisition and storm sewer rerouting costs. Remaining costs are paid by the municipality or private landowner.

The Yahara-Monona Priority Watershed Project's recommendations for the Lake Wingra watershed include the following:

- The city of Madison and the town of Madison should pursue stormwater quality management plans and structural practices for critical land areas, with financial assistance provided by the priority watershed project for eligible practices.

- The city of Madison, the town of Madison, the University of Wisconsin, and Dane County should continue to emphasize judicious use of salt and sand. Priority should be given to the South Beltline Highway and Fish Hatchery Road. Alternatives to road salt and sand use should continue to be evaluated.

- The UW Arboretum should be encouraged to pursue wetland and shoreline restoration activities with public information and involvement initiatives.

The Dane County Regional Planning Commission (RPC) prepared the appraisal monitoring report (1990) and the priority watershed project plan (1992) for the Yahara-Monona Priority Watershed Project along with Dane County, municipalities in the watershed, and the 1990 UW-Madison Water Resources Management (WRM) workshop. This plan was prepared under the authority of the Wisconsin Non-point Source Water Pollution Abatement Program as described in Wisc. Stats. sec. 144.25 and Chapter NR 120 of the Wisconsin Administrative Code. The plan is an element of the Dane County Water Quality Plan (RPC, 1979) and the Lower Rock River Basin Water Quality Management Plan (WDNR, 1998).

Wisconsin DNR Non-point Source Redesign Program

In the fall of 1999, the WDNR's Bureau of Watershed Management (BWM) released a draft of the Non-point Source Redesign Program Initiative, which focuses primarily on agricultural areas. Although it specifies an urban stormwater management goal of 40% reduction in sediments, phosphorus, and heavy metals, any implementation of such standards in the Wingra watershed would still be implemented under the existing city of Madison / UW-Madison WPDES permit. The initiative also stresses the importance of education and outreach activities, and specifies several WDNR and UW-Extension programs that can and do assist communities in reaching stormwater management goals (http://www.dnr.state.wi.us/org/water/wm/nps/redesign/redesignplan).

Dane County

In Dane County, water quality plans began developing in the 1970s. In 1975, the Dane County Advisory Council for Lake Quality Improvement released an influential report which recommended urban watershed management actions such as improved street sweeping, catch basin maintenance, downspout "disconnection," and water quality monitoring (LQIAC, 1975). The report also recommended public outreach and lake management such as weed control, phosphorus reduction techniques, and wetland restoration.

In 1979, Dane County issued its first Water Quality Plan (RPC, 1979) with the goal of assuring that "all surface waters of Dane County will be suitable for the protection and propagation of fish…and wildlife, and provide for primary and secondary contact recreational activities," that is, to keep Dane County waters "fishable and swimmable."

Dane County is currently refining a stormwater management plan, and is working with the state and municipalities to ensure compatibility and consistency (Falk, 1998).

City of Madison

The city of Madison has taken several steps in the Wingra watershed to mitigate stormwater impacts on water quality. Most significantly was the construction of the Odana Hills Park retention pond in the 1950s, which holds pollutant-laden sediment and prevents it from entering Lake Wingra. Details on the current effectiveness and management issues of this and other ponds in the watershed are described below and on page 47, *Stormwater Treatment Ponds*.

One of the earliest non-point pollution concerns in Madison was the impact of road salt, which the city started using for road de-icing in 1959. The Madison Department of Public Health studied the effects of road salt on the city's surface waters in 1962, and determined that these effects were minimal. In 1973, the city began the study again as part of an effort to reduce the use of road salt in the Lake Wingra watershed by 50%. This reduction plan was extended to the rest of Madison in 1977. The Department of Public Health has produced an annual road-salt survey since that time. Lake Wingra has by far the highest chloride concentrations of any of the Madison lakes, and that level has risen an average of 15% since 1972 despite road-salt reductions. Public Health also reports significant rises in sodium and chloride levels in the city's groundwater (MPH, 1998).

The Madison Department of Public Health also monitors Lake Wingra water quality to determine the need for beach closures and other health advisories.

Future Challenges

Despite innovative management plans and progressive legislation, the conclusion of a 1980 study still holds true: “Governmental and environmental jurisdiction of the Lake Wingra watershed is a labyrinth of structure and regulation. There has been almost phenomenal growth in the number and kind of governmental tools available to deal with water quality issues, but there exists at present low priority rating for the drainage basin’s problems and a lack of integrated and comprehensive remedial action by the various governmental jurisdictions” (Ross *et al*., 1980). Tools and knowledge are available, but management coordination and a specific focus on Lake Wingra are lacking. Although the many management plans have made important recommendations, they have little authority and are limited by funding.

Perhaps the major change since the conclusions of Ross’ study may be an increase in the watershed’s “priority rating,” both within government agencies and among the general public. Although it may be inaccurate to claim a higher rating until more action is taken, the city of Madison is poised to take the next step by implementing what could be an innovative stormwater utility. The following sections of this report discuss the nature of such a utility, and the people and activities required to make it work effectively.

Table 3-1
Timeline of management and regulation changes.

	Statute / Activity	Description / Significance
1898	Wisconsin begins to regulate the discharge of sewage to the waters of the state.	
1948	Federal Water Pollution Control Act.	
1956	Federal Water Pollution Control Act.	
1950s	City of Madison builds Odana Hills Park detention pond.	
1965	Congress passes the Clean Water Act (CWA).	
1960s	Motorized boating banned on Lake Wingra.	Decreased noise, activity.
1972	Congress amends the Clean Water Act (CWA).	
1972	City of Madison adopts road salt reduction plan. City of Madison Public Health begins publishing an annual Road Salt Reduction Report.	Madison has reduced its salt use since 1972 and the county is encouraging other municipalities to do the same.
1973	Wisconsin enacts ch. 147 and revises ch. 144 to implement the 1972 CWA amendments.	Ch. 144 includes establishment of the “priority watershed” program. As of 1995 there were 78 such watershed projects in the state.
1975	Report of the Dane County Advisory Committee for Lake Quality Improvement: A Framework for Lake Management.	
1977	Congress amends the CWA establishing NPDES permit program.	The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the act.
1979	Dane County RPC Water Quality Plan.	
1980 or earlier	Aquatic weed harvesting responsibility changes from city to Dane County Public Works Lake Management.	Harvesting criteria based on visual observation and response to citizen complaints.
1985	Trolling boats allowed back on Lake Wingra on non-holiday weekdays.	
1987	Congress passes the Water Quality Act, which extends the Clean Water Act’s application to stormwater and establishes Phase 1 requirements.	Regulates municipalities over 100,000, construction sites over 5 acres, and industries.
1988	Dane County Lakes and Watershed Commission established.	
1989	Yahara-Monona Steering Committee Public Information and Education Subcommittee is established.	
1992	Yahara-Monona Priority Watershed Plan.	
1992-94	EPA’s NPDES stormwater Phase 1 takes effect.	
1994	Wisconsin begins WPDES permit process (NR216).	Implements EPA Stormwater Phase I.
1995	Madison Commission on the Environment: Stormwater Committee Report and Regulations, Steve Ventura and Nelson Eisman.	Recommendations focus on information and education, pollution prevention, and institutional coordination. Supports active role for Dane County Lakes and Watershed Commission and encourages county-wide standards. Recommends developing revenue source for major water quality improvements.
1995	Madison obtains 5-year WPDES permit.	WPDES Permit No. WI-S056416-1.
1995	Madison Stormwater Management Plan completed.	
1997	Yahara-Mendota Priority Watershed Plan approved.	
1998	Friends of Lake Wingra Established.	
1998	Dane County Board adopts ordinance requiring countywide construction site erosion control standards.	Enforced only in unincorporated areas, but legally apply within entire county.
1999, October	EPA’s NPDES stormwater Phase 2: Final signature.	Regulates municipalities between 10,000 and 100,000, “urbanized areas” with population density over 1,000 per sq. mile, and construction sites between 1 and 5 acres. Exempts industries who demonstrate no contact with stormwater.
2000, July	City of Madison WPDES renewal date.	As of 6-99, the renewal process and requirements are still being determined.
2000	Dane County will begin to enforce the construction site erosion control standards countywide, except where a municipality adopts and enforces the county standards.	

Table 3-2
Current (1999) regulations.

Category	Jurisdiction	Ordinance	Description
Boating	City of Madison	14.3	"Regulation of Boats": Adopts State laws 30.50–30.71.
Boating	City of Madison	14.30(6)	Speed limit in Murphy Creek and Henry Vilas Park Lagoon limited to "slow no-wake," and nighttime speeds limited to 15 mph for all city waters.
Boating	City of Madison	14.30(8)	"No motor boat races shall be approved for Lake Wingra."
Boating	City of Madison	14.30(9d)	Wingra boating restrictions.
Boating			Boating prohibited on weekends and holidays, except for those with physician's statement, and they are limited to slow no-wake, less than 5 mph.
Boating			At all other times, all boats are limited to slow no-wake, 5 mph.
Boating	City of Madison	14.32	Places Henry Vilas Park Locks under jurisdiction of city of Madison Board of Park Commissioners
Boating	Wisconsin	30.50 – 30.71	State boating and water safety laws
Erosion	City of Madison	Chapter 37	"Erosion and Stormwater Control": Details erosion control regulations for construction sites, but as of 1998 it includes the qualification that these regulations will not be more restrictive than the state's Uniform Dwelling Code. These regulations are adminstered primarily by the city engineer. Applies to sites 4,000 square feet or greater, or sites having at least a 12% grade, or sites having an impact on sensitive areas.
Erosion	City of Madison/Dane	37.08(2c)	"Sites not requiring a control plan as identified above shall submit the "Dane County Erosion Control Plan—Simplified Checklist" with the permit application."
Erosion	Dane	14.50-99	Erosion Control Regulations
Erosion	Dane	14.53	Regulations apply to sites 4,000 sq. ft. or greater, or sites having at least a 12% grade, or sites having an impact on sensitive areas.
Erosion	Dane	14.545	"Simplified Checklist" may be used for sites not greater than 20,000 sq. ft. and not over 6% grade.
Erosion	Dane	14.6	"One- and Two-Family Dwelling Erosion Control: Consistent with the Wisconsin Uniform Dwelling Code ("UDC").
Erosion	Dane	14.81	Penalties apply to sites 20,000 sq. ft. (a little under half an acre) and above.
Erosion	Wisconsin, Dept. of Commerce	Uniform Dwelling Code (UDC)	One- and Two- Family Dwelling Erosion Control. Supersedes local control; i.e., local standards cannot be stricter than UDC. Requirements are minimal and often enforced by building inspectors who may be unfamiliar with erosion control.
Miscellaneous	City of Madison	14.02	"Filling of Lakes and Rivers": $10-25 fine for dumping trash, dirt, etc. in lakes
Miscellaneous	City of Madison	14.03	"Filling of Lake Ends of Streets When Dock Line Established"
Miscellaneous	City of Madison	14.05	"Piers from Park Property on Lakeshores": $10-25 fines for unauthorized construction of piers or boat facilities on public property.
Stormwater	City of Madison	10.29	"Downspouts and Eaves of Buildings Not To Drain On Sidewalks"
Stormwater	Wisconsin State	283	This chapter, particularly sections 31-35, simply states that permits are required; all details are left to NR216 and related DNR ordinances.
Stormwater	City of Madison	35.03	"Public Stormwater System": Describes design standards for new construction stormwater management, based on amounts of pervious and impervious surface. Permits are required from the city engineer.
Swimming	City of Madison	Public Health Standards, 1999	Vilas Beach closes if fecal coliform reaches 1300 once or if the geometric mean is over 375. Fecal coliform is resampled if over 350 per 100 ml .
Swimming	City of Madison	14.30(7)	Marks "Vilas Park Beach Swimming Area" as a "bathing or swimming" area.

Chapter 4

Lake and Watershed Management

Introduction

Preceding sections of this report have presented the technical and ecological background, and management history of the Lake Wingra watershed. This section focuses on management practices in the watershed – those currently in place and those we recommend for implementation.

The majority of current watershed management practices focus either on aesthetic and recreational management of Lake Wingra, or on preventing flood damage from stormwater.

The majority of current watershed management practices focus either on aesthetic and recreational management of Lake Wingra, or on preventing flood damage from stormwater. While we recommend that these continue, we believe such efforts should also include progressive practices that improve the watershed's surface water quality, restore its groundwater resources, and protect its biotic communities. Such goals can only be accomplished with widespread support of the city of Madison, other government agencies, and the entire watershed community. Later chapters of this document discuss the details of how that support can be developed, organized, and sustained.

Management practices are designed to either solve or prevent problems. Although the Lake Wingra watershed contains some standard stormwater management structures, the watershed has many problems. Lake Wingra is small and eutrophic, and has been heavily impacted by decades of agricultural and urban development. These factors have contributed to sedimentation, nutrient loading, and altered biotic communities. Surrounding wetlands have been degraded or destroyed, and spring flows have decreased. Recreational opportunities are threatened by a fishery dependent upon stocking, carp that stir up bottom sediments, beach closures due to high fecal coliform levels, and aesthetic degradation due to smelly and unsightly algae and water plants.

Management practices in the watershed can be considered in two categories – practices that affect the lake directly, and those that address stormwater issues throughout the watershed. While implementing all practices is important, prioritizing between them is necessary, albeit complicated. For example, the algae blooms occurring in Lake Wingra are a result of high phosphorus levels. Phosphorus enters the lake in stormwater runoff from the watershed, and continues to cycle from the bottom sediments of the lake. The question is whether resources should be spent on reducing phosphorus levels in the lake, in stormwater, or in both. While reducing stormwater phosphorus inputs will reduce long-term algae blooms, short-term solutions such as weed harvesting on the lake may also be desirable. Therefore, many of the following lake and watershed management practices discussed in this chapter should occur in tandem.

This chapter first discusses stormwater and watershed management practices and then in-lake practices. The chapter concludes with an overview of monitoring activities within the Lake Wingra watershed and recommendations for expanding these activities.

Watershed and Stormwater Management

Stormwater can be managed in many different ways and on many different scales. The following section presents management practices that are most relevant to the Lake Wingra watershed, describing both current and recommended practices. These practices are summarized in **Table 4-1** and **Table 4-4**.

Stormwater management practices involve three areas: the storm sewer system, the treatment ponds, and the watershed land area.

The primary stormwater management practices in the Lake Wingra watershed consist of the storm sewer system and the treatment ponds to which part of that system is connected. The rest of the storm sewer system drains directly to the lake without treatment. Stormwater management practices involve three areas: the storm sewer system, the treatment ponds, and the watershed land area.

Table 4-1
Current stormwater management practices.

Practice	Description	Management Agency
Storm sewer catch basin cleaning	Biannually	City of Madison
Ponds	Several wet ponds, mostly in the Arboretum, and several dry ponds (Table 4-1)	UW-Arboretum, city of Madison, various private landowners.
Filters	Biobased filters enhance the effectiveness of stormwater ponds	UW-Arboretum—Monroe St. detention pond (Pond 5)
Wetlands	Wetlands around the lake can act to reduce nutrients and other contaminants in stormwater runoff (Lorman *et al*., 1997)	UW-Arboretum
Street sweeping	Eight to fifteen times per year	City of Madison

Storm Sewer System

The storm sewer system represents the most traditional form of stormwater management. The system conveys stormwater away from buildings and streets to avoid flooding and water damage. The primary management practice is regular cleaning and maintenance of the catch basins, which collect debris carried by stormwater. The city of Madison Public Works cleans these basins about every two years, but would like to do so more frequently if funding becomes available (Roger Goodwin, personal communication).

Stormwater Treatment Ponds

Storm sewers were constructed in the Lake Wingra watershed along with the present residential community. Treatment ponds were the next step taken in stormwater management. Simple conveyance typically increases downstream flooding, so detention ponds (dry ponds) have been created to detain runoff temporarily during storms. The water is then gradually released, avoiding a sudden downstream deluge. The Lake Wingra watershed has several dry detention ponds that also function as soccer fields, park areas, or even rooftops (for example, the city of Madison lists the Edgewood College Library rooftop as a detention pond).

While dry detention ponds alleviate flooding problems, they may not significantly improve stormwater quality. The next step in stormwater management is wet retention ponds, which retain water between storms and have a permanent pool of standing water at least four feet deep. Within the pond, stormwater is slowed and much of the sediment drops before the water flows into the lake.

Approximately 60% of the watershed's storm sewers convey runoff to wet retention ponds, which are among the most effective stormwater treatment methods available.

The Lake Wingra watershed contains eight major wet retention ponds: the Odana Hills Park pond, the Nakoma Golf Course pond, and six ponds in the UW-Arboretum. Approximately 60% of the watershed's storm sewers convey runoff to wet retention ponds, which are among the most effective stormwater treatment methods available (Schueler, 1987; Dedering, 1995). Each pond provides a single, discrete location for removing sediment, pollutants, and nutrients from runoff originating from a broad, diffuse area. The Lake Wingra watershed is fortunate to have large open areas such as the UW-Arboretum and the Odana Hills Park, which provide space for several ponds. **Table 4-2** provides drainage-area to pond-area ratios for each treatment pond. These ponds require careful management; effective ponds trap sediment, therefore requiring periodic dredging. As a pond fills with sediment, its water depth decreases. Once water depth is below four feet, the pond's efficiency to trap sediment decreases dramatically (Dedering, 1995). Currently, the Odana Hills Park pond and ponds 4 and 6 in the Arboretum need dredging.

The Odana pond is the only city-owned wet retention pond. It was built in the 1950s when the city Parks Department dredged a wetland area to create the pond. The pond (actually three connected ponds) has not been dredged since that time, although the city Department of Public Works has unsuccessfully requested funding from the city to do so for the past three years. The city Engineering Division estimates that once the pond is dredged, it may be 60 years or more before it needs to be dredged again. Much of the sediment currently in the pond originated from construction activity that occurred since the pond was originally built. Because the area drained by the pond is now completely developed, the major sources of sediment are automobiles, winter road sand, and atmospheric deposition (Fries, 1999).

The UW-Madison has recently contracted Strand and Associates of Madison to assess the effectiveness of the Arboretum's six stormwater treatment ponds. Our observations in 1999 indicated that between rainfall events, the water level in pond 6 decreases so much that an island about one-third the size of the pond forms in the middle, and the rest of the pond has a maximum depth of only two feet. Pond 6 is less than an acre in area, but treats stormwater from an area of about 576 acres, in addition to receiving all the stormwater from the Odana pond outlet (the Odana pond itself treats a larger area than pond 6). Because the Arboretum is UW property, maintaining these treatment ponds is the responsibility of the UW-Madison.

Table 4-2
Wingra watershed treatment ponds.

Pond Name	Pond Area (acres)	Drained Area (acres)	Drained-Area to Pond-Area Ratio
Pond 1 (Curtis Pond)	1.1	100.2	91
Pond 2 (Johannsen Pond)	0.96	102.8	107
Pond 3	1.25	332.6	266
Pond 4	0.6	283.26	472
Pond 5 (Monroe St. Pond)	2.0	319.88	160
Pond 6	0.86	576.1	670
Nakoma Golf Course Pond	0.23	242.18	1053
Odana Hills Park Pond	18.67	862.37	46

Filter Fabrics
Filter fabrics can be used at retention pond outlets to further remove organic contaminants and heavy metals. Such a filter is currently in use at pond 5 (Monroe Street retention pond) (Lorman, 1998).

Polyacrylamide
Polyacrylamide (PAM) gel blocks can be added to retention ponds to reduce turbidity, though none are currently used within the Wingra watershed. PAM is an organic polymer that has been found to reduce turbidity by flocculating suspended solids, thus aiding deposition. PAM has very low toxicity because its molecules are so large that they do not have the ability to penetrate biological membranes. PAM's molecular size is also the reason for its very low effective dosage rates – each PAM molecule has the ability to attach itself to many clay and fine silt particles at the same time. PAM has been widely used in agricultural and developing areas, and its flocculent capabilities provide a realistic option for improving the quality of stormwater entering Lake Wingra (www.wsdot.wa.gov/eesc/environmental/PAM.htm).

Underground Treatment Devices

A number of treatment devices have been developed that can be installed alongside or in line with storm sewer systems. These devices, similar to retention ponds, are underground within storm sewers. Although their capacity is too low to have the significant impact on flood control that ponds have, they have a similar impact on water quality and take up less space. Underground treatment devices usually treat water that is diverted from the main system, and are most appropriately used on small, highly impervious areas with high traffic density. These could be beneficial for a number of commercial and institutional sites in the Lake Wingra watershed.

Two types of these underground treatment systems, the popular Stormceptor® and the multi-chamber treatment train (MCTT) developed by Robert Pitt, were recently tested in the Madison area (Claytor, 1999). The test, although somewhat inconclusive, suggested that the MCTT was more effective but more expensive than the Stormceptor®.

Sand filters are another popular method of underground stormwater treatment. Like the above treatment tools they take up much less land surface than treatment ponds, but require frequent and regular maintenance to avoid clogging (Urbonas, 1999).

Non-point Source Management

Although the storm sewer system and ponds facilitate stormwater conveyance and its treatment at specific sites, they are best supported by additional efforts throughout the watershed. The following practices not only improve stormwater quality before it reaches the storm sewer system, but also decrease the overall quantity of water that reaches the sewer system in the first place.

Urbanization results in more runoff and less infiltration of stormwater: this is largely due to the paving over of natural areas. A major objective of a stormwater management program is to reverse these trends.

Diffuse Infiltration and Disconnection of Impervious Surfaces

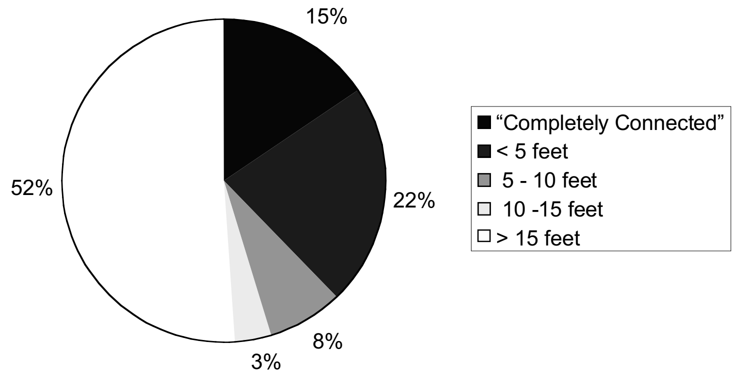
Urbanization results in more runoff and less infiltration of stormwater: this is largely due to the paving over of natural areas. A major objective of a stormwater management program is to reverse these trends. Increased infiltration can replenish Madison's groundwater reservoirs, perhaps increasing spring flows (page 66). Since impervious surfaces such as roofs and parking lots do not allow any water to infiltrate the soil, water must be directed to pervious surfaces such as lawns and grass swales. These pervious surfaces should be managed to maximize infiltration. Impervious surfaces are considered "connected" if they drain directly to the storm sewer system, and "disconnected" if they first drain over a pervious surface.

There are many methods of disconnecting impervious surfaces. These can be as simple as turning residential downspouts from driveways to lawns, or as complex as building rain gardens (described below), underground pumping stations, or infiltration basins. The dry detention ponds described on page 47 can function as infiltration basins if designed and maintained to do so.

An infiltration basin results in "concentrated infiltration" because it collects stormwater from a broad area and infiltrates it at a single location. In contrast, "diffuse infiltration" refers to the practice of many small-scale efforts throughout the watershed. For example, because rooftops contribute approximately 20% of the runoff in the Lake Wingra watershed (Bannerman, 1999), increasing this portion of diffuse infiltration can lessen the stormwater impact on the wet ponds and other concentrated treatment mechanisms.

An estimate of residential "connectedness" was conducted by the 1999 WRM Workshop and is shown in **Figure 4-1**. These results were compiled by ran-

Figure 4-1
Distribution of downspout disconnection distances.



domly selecting two residential blocks in each of the Lake Wingra sub-watersheds and estimating the distance from the front yard downspouts to the nearest impervious surface. The estimates were made from the street, rather than by direct measurement, so the results are qualitative. Low-density areas on the west side were much more disconnected than high-density areas near the lake. Direct connection may result in decreased groundwater recharge, a lower water table, and diminishing groundwater supplies. This, in turn, means diminished groundwater discharge to the lake as well as springs feeding the lake.

Defining "disconnectedness" is complex. Most stormwater estimates and models define an impervious area as either completely connected or completely disconnected, and make this determination based on a specified distance of pervious surface, such as 10 or 20 feet. Runoff is then calculated as if half of the impervious surface is impervious, and the other half is as pervious as an adjacent pervious area. In reality, however, the relationship is far more complex. If the degree of disconnection of an impervious surface is defined as the percentage of runoff that is infiltrated by an adjacent pervious surface, this degree will depend on many factors: the amount and intensity of rainfall, the soil and vegetation characteristics, the slope and angle to the sun of the pervious area, the level of soil moisture before it rains, and even the concentration and species of earthworms in the soil. Careful observation during a storm may provide more details about the degree of disconnection of a particular impervious area.

As a general stormwater management recommendation, property owners are encouraged to direct runoff from impervious surfaces over at least a 20-foot length of pervious area (Bannerman, 1999). When doing so, property owners should be careful to ensure that water does not collect near any buildings. Protecting building foundations is one reason for directing runoff to impervious surfaces, but careful planning can infiltrate the water without endangering property.

Bioretention and Rain Gardens
Bioretention combines disconnection and detention with managed vegetation. Some bioretention techniques, such as grass swales, are best suited to areas of new development and are therefore not applicable to the Lake Wingra watershed, but constructing rain gardens is an increasingly popular practice that is well-suited to this urbanized watershed.

With so much of the Lake Wingra watershed area taken up by residential housing and no land available for development, rain gardens are potentially an important tool for stormwater management and water quality protection.

Rain gardens are constructed to retain runoff, utilize nutrients, and increase infiltration. Rain garden soils also trap sediments and some heavy metals. These structures are built by creating a depression, sometimes partially filled with sand and gravel layers to encourage infiltration. Rain garden vegetation should be native to the area, and must be suited to both wet and dry conditions. The rain garden infiltrates the runoff into the ground and encourages evapotranspiration through the plants, dissipating most of the smaller storms (Moore, 1999). Although rain gardens eventually become saturated and therefore handle only the first part of a storm, this initial stormwater carries 90% of the pollutants found in stormwater (Schueler, 1999). Rain gardens can easily be incorporated into landscaping, are aesthetically pleasing, and on a scale as small as residential lots, require very little space. Rain gardens have been installed in parking lot medians and residential lawns (Schueler, 1999). The Lake Wingra watershed would be an excellent area for installing rain gardens. With so much land area taken up by residential housing, and no land available for development, rain gardens are potentially an important tool for stormwater management and water quality protection.

Golf Course Stormwater Management

Golf courses are conspicuous users of land in any watershed, primarily because of the amount of land they occupy. In the Lake Wingra watershed, approximately 330 acres are devoted to two 18-hole courses and one 9-hole course. The city of Madison owns and operates the 9-hole course (Glenway) and an 18-hole course (Odana Hills). The Nakoma Golf Club owns and operates the other 18-hole course.

When compared with natural land cover, golf courses may affect both runoff quality and quantity through fertilizer and pesticide use, and soil compaction. In the Lake Wingra watershed, they have an additional impact: all three of the courses in the watershed irrigate with groundwater. This is important considering recent research which indicates that groundwater pumping is a significant threat to baseflow quantities in the Madison area, and therefore threatens the water quality of our lakes and streams (Dane County RPC, 1998). Large groundwater withdrawals contribute to the shift from a lake system dominated by groundwater and springflow inputs to one dominated by runoff inputs.

The water usage and acres for the three Lake Wingra watershed golf courses are shown in **Table 4-3**. The usage varies from year to year based on rainfall amounts. The usage for the Odana Hills golf course has decreased significantly in recent years, indicating a change in irrigation management.

An example of alternative irrigation exists in Waunakee, Wisconsin, where the Meadows of Sixmile Creek Golf Course irrigates with stormwater.

An example of alternative irrigation exists in Waunakee, Wisconsin, where the Meadows of Sixmile Creek Golf Course irrigates with stormwater. The course has interconnected ponds that capture storm runoff, including some runoff generated by a nearby development. Only when the stormwater ponds dry up is groundwater used for irrigation (Potter, personal communication). While the groundwater withdrawals for the three Lake Wingra watershed golf courses are not excessive when compared with other institutional users, a cost-benefit analysis should be conducted to see whether or not retrofitting the watershed's golf courses for irrigation with stormwater is feasible.

Table 4-3
Golf course areas (acres) and water usage (million gallons).

	Nakoma*		Odana**		Glenway**	
Year	Land Area	Water Usage	Land Area	Water Usage	Land Area	Water Usage
	75		200		55	
1998				1.9		5.0
1997				1.6		0.6
1996				13.6		5.9
1995				18.2		6.0
1994				8.1		9.7
1993				13.5		
Average		6.0		9.5		5.4

Annual water usage is typically between the months of April and October
*Data sources: * Rowles, personal communication*
*** Madison Water Utility*

Special consideration should be given to retrofitting the Nakoma golf course for irrigation with stormwater. Though their water quantity usage is neither excessive nor different from the other courses in the watershed, both the type of well they use and their location may have direct impacts on the Lake Wingra watershed. While the city courses use municipal well water drawn from a deep aquifer, Nakoma's privately owned irrigation well (approximately 15 meters below the surface) draws from a shallow aquifer (Rowles, personal communication; see also page 5). The shallow, or upper, aquifer is the source of Lake Wingra's springs. Furthermore, the Nakoma well is near many of the springs that discharge into the western edge of the lake and is directly adjacent to Wingra fen, a sensitive wetland ecosystem dependent on spring discharge (see page 21). Research investigating changes in vegetation in Wingra fen indicates that hydrologic changes, specifically reductions in springflow, may be responsible for the above noted changes (Lovely, 1984). Further research should be conducted to examine possible links between Wingra fen degradation, hydrologic changes, and Nakoma's shallow well withdrawals.

Street Sweeping

Street sweeping is a very important stormwater management practice because much of the debris and sediment that reaches Lake Wingra first collects in the streets. About 90% of street debris gravitates to the curb (Waschbusch *et al.*, 1999). However, since performance monitoring conducted by the National Urban Runoff Program (NURP) in the early 1980s gave a pessimistic report, many professionals have lost confidence in the effectiveness of street sweeping. More recently, new vacuum-assisted sweepers have been developed that are showing more promise (Claytor, 1999).

The city of Madison has three older mechanical sweepers and one vacuum-assisted sweeper. The vacuum-assisted sweeper is used primarily in non-residential areas of the city because it can operate at 55 mph and is less maneuverable than the others. Although the vacuum-assisted sweeper is much better at collecting fine particles—a feature that is favorable for stormwater quality—it also clogs easily when encountering larger objects such as branches (Roger Goodwin, personal communication). For this reason, the mechanical sweepers are most often used in the Wingra watershed.

The city of Madison Streets Division sweeps the streets in the Wingra watershed from April to November every two to four weeks (Roger Goodwin, personal communication). Current parking ordinances do not require watershed residents to move their cars from the streets on sweeping days. Throughout the city, sweeping removes between 10 and 25 cubic yards of debris for every mile swept (about one-third of the total), with this amount varying with population density, traffic congestion, and parking restrictions (Interdepartmental Parking Team, 1996; Bannerman, personal communication).

Madison is considering the expansion of two of their programs, neither of which is currently active in the Wingra watershed. A 1995 pilot project that enforced parking restrictions on Madison's east side resulted in the removal of twice as much debris per mile swept, compared to other areas of the city. The city's Streets Division has indicated that this program, referred to as "high-intensity sweeping" will likely be expanded to the Wingra watershed if additional funding becomes available. The other program, called "special sweeping," involves temporary "post and tow" areas where there is usually such a high volume of parked cars that they cannot sweep otherwise. This is currently done once a year between Blair St. and Park St., with notices posted 48 hours in advance. The Streets Division would like to expand both the frequency and the area covered by this program to maybe three or four times a year in an area reaching towards West High and Vilas Park (Roger Goodwin, personal communication). For more discussion on Madison's street sweeping efforts, see page 75.

Road Salt Reduction

The city of Madison implemented a road salt reduction plan in 1972 to limit sodium and chloride inputs to the lakes. The city continues to carefully control when, where, and how much salt is applied while maintaining public safety standards. Heavy traffic routes, bus routes, and dangerous hills and curves receive a mixture of 90% sand and 10% salt, averaging 150 to 200 pounds per lane mile. Residential streets receive sand only (Roger Goodwin, personal communication).

The Dane County Highway Garage contracts with the Department of Transportation (DOT) to maintain the Beltline (along with other US highways in Dane County). Applications are primarily salt, though some sand is used in very cold weather (less than zero degrees Fahrenheit). For more discussion on Madison's road salting efforts, see page 75.

Lawn Runoff Management

Stormwater runoff from residential lawns and other open spaces (parks and schoolyards) throughout the watershed may be a major contributor of nutrients to Lake Wingra. Phosphorus in leaves, grass clippings, soil, and fertilizers contributes to the growth of algae and aquatic vegetation in the lake.

A large reduction in phosphorus loading will improve the water quality and reduce the frequency and size of algae blooms. This was shown during the drought of 1988 and 1989 when little stormwater runoff entered the Madison lakes. Over these years, the water quality noticeably improved and the number of algae blooms dropped off significantly (Roger Bannerman, personal communication, 1999).

. . . the majority of phosphorus in stormwater runoff originated from residential neighborhood lawns (Waschbusch *et al.*, 1999).

During the summers of 1994 and 1995, a study by the WDNR and the US Geological Survey (USGS) concluded that the majority of phosphorus in stormwater runoff originated from residential neighborhood lawns (Waschbusch, *et al*, 1999). Officials then hypothesized that more phosphorus may be coming from regularly fertilized lawns. The WRM Workshop tested this hypothesis in the spring and summer of 1999. Preliminary results of this study can be found in *Appendix 3*. The WDNR and the USGS intend to continue this study into the year 2000. If these studies verify that phosphorus-containing fertilizers are contributing to lake problems, the use of such fertilizers could be restricted. This has been done in Plymouth, Minnesota, after a similar study found a significant contribution of phosphorus from fertilized lawns. Plymouth's regulations have special allowances in cases where phosphorus levels in the soil are especially low (Barton, 1995). In the Lake Wingra watershed, most soils have enough naturally occurring phosphorus that no additional applications of phosphorus fertilizer are needed for healthy lawn growth.

Yard waste such as grass clippings and leaves also contributes to phosphorus found in stormwater runoff. The city of Madison, along with the Dane County Public Works Department, collects and composts yard waste. Residents are requested to place their leaves on the grass-covered terrace next to the curb rather than in the street to prevent the leaves from being washed into the storm sewer.

Living Machines

Living machines can be used to treat stormwater and can provide excellent educational and research opportunities. Living machines remove nutrients and sediment from stormwater at the "end of the pipe" through physical and biological processes. Living machines hold water as treatment ponds do, but they also provide intensive treatment by removing nutrients and sediment through vegetation and biofilters.

Researchers at Edgewood College have proposed construction of a living machine at the northwestern edge of Lake Wingra (Lorman, 1998). A small-scale experimental living machine was constructed at Edgewood College to determine stormwater treatment effectiveness. This 250-gallon capacity system was designed to remove sediments, chloride, and phosphorus. Although the system was successful at removing some types of contaminants, phosphorus removal was not as successful: To decrease phosphorus levels to half their original concentration, forty days of stormwater retention time was required (Lorman, 1998).

A full-scale living machine would consist of a series of treatment cells located downstream from storm sewer outfalls. The cells would use constructed wetlands and fiber filters to remove nutrients, salt, hydrocarbons, heavy metals, and solids from stormwater. The cells would also serve to detain some stormwater at high flows. One of the proposed treatment sites is located in a depression at Edgewood College that is currently acting as a *de facto* detention pond. The living machine would consist of the following components:

1) *Native wetland vegetation* would be established in the upper part of the depression. Vegetation would decrease water velocity, increase infiltration, and remove nutrients and sediments.
2) A *wet pond or constructed wetland* would serve as a small-scale test site for research on wet pond and wetland management practices.
3) *Biofilters*, consisting of plant and soil material, would be placed in wooden frames and would serve as filtration barriers between two or three existing cells.
4) An *outlet control structure* would be built. After this point, some of the effluent water would be diverted from the treatment cells to an *indoor living machine*, providing more research opportunities.
5) A *natural wetland* on the shores of Lake Wingra would provide final stormwater filtration, but would be minimally impacted by the prefiltered water.

The main benefits of living machines may be the opportunities they present for research and public education.

The main benefits of living machines may be the opportunities they present for research and public education (Lorman, 1998). These treatment sites would demonstrate to students and the public the importance of stormwater treatment and the role of alternative stormwater management practices. Removal rates of contaminants, solids, and nutrients could be measured by comparing inflow and outflow concentrations. Modifications to the living machine system could then be made to increase efficiency based on the analysis of the data and the need for testing specific stormwater management practices.

The main disadvantage to living machines may be the large areas needed to construct systems big enough to remove significant amounts of nutrients and contaminants. Therefore, the cost of using living machines for large-scale stormwater treatment would be prohibitive at this point (Lorman, 1998). However, the UW-Arboretum, which owns roughly half of the Lake Wingra shoreline and contains many stormwater outfalls, may be an ideal location for constructing living machines as education and research tools. If living machines turn out to be successful at removing nutrients and contaminants, elements of this stormwater management tool could be incorporated into existing practices to improve their efficiency.

Modeling and Analysis of Stormwater Characteristics

The city of Madison has used the Source Loading and Management Model (SLAMM) to estimate the contribution of runoff and pollutants from land areas. The city calculated these contributions for most of the 39 subwatersheds in the Lake Wingra watershed to compare potential stormwater runoff issues between different areas of the watershed. Because the data is based on general citywide land-use data and is currently inconclusive, the evaluation of this data is located in *Appendix 4* of this report. While the results are interesting and the summary is useful, more research is required to ensure reliability.

Table 4-4
Recommendations for stormwater management.

Recommendation	Advantages	Disadvantages
Odana Pond should be dredged; the Arboretum ponds 6 and 4 (plus others) should be dredged and perhaps expanded.	Higher treatment effectiveness of ponds.	Expensive.
Wetlands should be protected and not used as storage for polluted stormwater.	Protects wetlands.	Underutilizes an effective runoff treatment tool.
Street sweeping efforts should be intensified through enforced parking restrictions, slower sweeping operators, and the purchase of high-efficiency sweepers.	Increases removal of pollutants and nutrients from road surfaces.	Parking inconvenience for residents; expensive.
Storm sewer catch basin cleanings should be performed on a regular schedule, more frequently than present plans call for.	Keeps storm sewers clean.	Expensive.
Underground treatment devices (stormceptors, sand filters, multichamber treatment train) may be appropriate for some private property owners to install.	Convenient treatment for small, highly pervious sites.	Expensive.
Disconnection of impervious surfaces should be encouraged, to increase infiltration of stormwater throughout the watershed.	Deals with stormwater at its source; is much less expensive than technical engineering solutions.	Requires ongoing public outreach and education.
Bioretention of stormwater via rain gardens and other vegetation should be encouraged.	Same as above.	Same as above.
Ongoing research and monitoring programs should be supported. Current research projects include the UW-Wisconsin diffuse infiltration research, the WDNR/USGS phosphorus-in-fertilizer research, and the Edgewood College experimental stormwater system.	Develops new understanding and management methods regarding stormwater.	Expensive.

In-Lake Management

Introduction

While stormwater management practices are critical tools for improving the water quality of Lake Wingra, in-lake restoration efforts may also be necessary. In-lake restoration practices can combat the nutrient loading caused over the last century by urban development, or cultural eutrophication. In-lake practices such as biomanipulation and native plant restoration can improve biotic communities and habitat in ways that stormwater management cannot.

The accumulation of nutrients in the bottom sediments of Lake Wingra shows the need for in-lake management. Even if external nutrient inputs to the lake are significantly reduced, nutrient storage in lake sediments may keep loads high for years (Steve Carpenter, personal communication). For example, sediments in Lake Wingra store large amounts of dissolved inorganic phosphorus, a nutrient responsible for excessive macrophyte growth and nuisance algae blooms. Bannerman (1973) felt that understanding the degree to which sediments can release and replenish dissolved inorganic phosphorus is very important in trying to slow or reverse eutrophication. Lake Wingra sediments also store large amounts of organic nitrogen. Release of this nitrogen via bacteria and plants can keep nitrogen levels high even if other nitrogen sources are eliminated (Isirimah *et al*., 1976). Furthermore, though high sediment loads associated with urban runoff may be reduced, sediment already accreted would need removal if original depths were to be restored.

The management practices presented below are divided into two categories: methods of controlling nutrients and sediments, and methods to manage biotic communities. Summaries of current and recommended in-lake management practices can be found in **Table 4-5** and **Table 4-6**.

Table 4-5
Summary of current in-lake management practices.

Practice	Description	Agency
Fish stocking	Muskellunge fingerlings stocked yearly	WDNR Bureau of Fisheries, Management and Habitat Protection
Plant harvesting	Limited harvest of aquatic plants in selected areas	Dane County Department of Public Works
Wetland management	Exotic plant removal and native plantings	UW-Arboretum, city of Madison Parks
Boating regulations	Limited use of power boats to no wake and 5 mph, weekdays only	City of Madison
Water control structures	Dam and weir at downstream outlet of lake	Dane County Public Works

In-Lake Control of Nutrients and Sediment

Dredging

In lakes such as Wingra, where bottom sediments hold phosphorus and cycle it into the water column, dredging can significantly reduce lake phosphorus levels and thereby retard eutrophication. Dredging may also be used to restore lake depths where intensive sedimentation has occurred, especially at areas of public use.

The main advantage that dredging has over other techniques is that it does not introduce foreign substances into the lake. However, sediment removal is very expensive and often ineffective as phosphorus continues to be released from remaining sediment. Another disadvantage is that the extracted sediments are a waste product requiring costly disposal and possibly further treatment. The greatest disadvantage of dredging is the ecological disturbance of aquatic systems.

Alum Treatment

Phosphorus can also be controlled through precipitation and inactivation of phosphorus. Aluminum salts, usually aluminum sulfate (alum) or sodium aluminate, are the most commonly used chemicals. Aluminum salts remove phosphorus from the water column by reacting with phosphorus to form an aluminum hydroxide precipitate. The precipitate, or "floc", settles to the bottom, seals the bottom sediments with up to 1-2 inches of floc, and ultimately retards release of phosphorus from those sediments. The floc layer continues to remove phosphorus from the water column for as long as five to ten years, but may be inadequate as a long-term solution if low doses of alum are applied (Olem, 1990).

Alum treatment was used with mixed success in many ponds during the 1970s as part of the WDNR Inland Lake Renewal and Management Demonstration Project. Generally phosphorus concentrations and blue-green algae blooms were reduced for at least one to two years. However, in some lakes little reduction in phosphorus concentrations in the water column occurred, and other lake concentrations returned to pretreatment levels after a few years (Dunst *et al*., 1974).

The feasibility of alum treatment depends on several factors, including the depth and volume of the lake, the pH buffering capacity of the lake (alum precipitation is sensitive to pH), and the relative contributions of internal and external phosphorus loads (Olem, 1990). Although the pH buffering capacity of Lake Wingra is high enough for this technique, it is probably too shallow and has too high a proportion of externally derived phosphorus for the treatment to be effective in the long term. There are also public health safety issues to consider when deciding on the feasibility of alum treatments, as long-term effects of aluminum on human health are unknown.

Biotic Community Management

Fish Stocking

The WDNR stocks Lake Wingra with muskellunge (*Esox masquinongy*) for sport fishing. "Muskies" are both a popular sport fish and an important predator that help control other fish species, particularly panfish. Panfish, such as bluegill, are also a popular sport fish, but the population decline of their native predator, the northern pike, resulted in a large population of stunted fish. Muskies take this previous predator's role, restoring panfish to larger sizes (Jaeger, 1985). Panfish size also has a direct effect on nutrient cycling in shallow lakes since the smaller the panfish are, the more nutrients they cycle. Therefore, increasing panfish size is one of the necessary aspects of in-lake nutrient controls (Steve Carpenter, 1999, personal communication).

Because muskies are not native to the lake, they have to be continually stocked. This expensive practice could be eliminated if northern pike populations were revived, but doing so would be even more costly because it would require large-scale restoration of wetland spawning grounds. The implications of a possible wetland restoration are discussed in the next section.

Although other predator fish, such as northern pike and tiger muskellunge (a hybrid cross of northern pike and muskellunge), were released into Lake Wingra from the 1930s to the 1980s, stocking of the pure muskellunge has had the most success. Lake Wingra supports an extremely high population of muskellunge (four per acre) which makes for an excellent sport fishery.

Wetland Management

The wetlands surrounding Lake Wingra are among the watershed's most unique and valued features – and may be the most endangered. Dropping groundwater levels, nutrient- and sediment-laden stormwater, and exotic species such as glossy buckthorn, purple loosestrife, and reed canary grass, threaten the wetlands. The wetlands have lost their wild rice and wild celery populations, and no longer provide adequate habitat for migrating canvasback ducks and spawning northern pike.

. . .wetland water levels are the same as the lake, and they share nutrients and contaminants with the lake. Therefore, anything done in the lake will have a direct effect on the wetlands, and vice versa.

The wetland discussion is included here among the in-lake management practices because most of the wetlands are hydrologically connected to Lake Wingra. As a result, wetland water levels are the same as the lake, and they share nutrients and contaminants with the lake. Therefore, anything done in the lake will have a direct effect on the wetlands, and vice versa.

Current wetland management consists primarily of exotic species control and stormwater management via detention ponds. The Arboretum directs efforts to remove purple loosestrife, buckthorn, and reed canary grass, and is also concerned with controlling the spread of hybrid cattails. The city of Madison recently classified purple loosestrife as a noxious weed, requiring its removal from all parks, open spaces, and residential lots.

Wetland areas have also been used as stormwater treatment areas, either as locations for constructed stormwater retention ponds or as recipients of direct runoff. Because some of the retention ponds in the Arboretum are filling in with sediment, overflow into adjacent wetlands has created concerns over degradation of these resources.

The largest wetland that is not connected to Lake Wingra is Gardner Marsh, located along the southeast side. The UW-Arboretum's McCaffery Drive follows a man-made berm that isolated the marsh from the lake. Gardner Marsh now flows into Wingra Creek, downstream from Lake Wingra.

The reconnection of Gardner Marsh to Lake Wingra, and the accompanying disconnection of the marsh from Wingra Creek, has been a controversial management question. Reconnection would provide northern pike their required wetland-spawning habitat, and therefore would remove fish stocking needs. If the marsh were reconnected, its water levels would increase to its previous levels before the berm was built, which would inhibit woody species invasion (Salli, 1965; Friedman, 1987; see also page 21 of this report). The reconnection of Gardner Marsh is thought by some to be appropriate for Lake Wingra, due to the strong fishing presence on the lake, and the consistency with arboretum efforts to restore historic wetlands.

However, there are many drawbacks to reconnection. Gardner Marsh is connected to Lake Monona via Wingra Creek. Reconnection would connect Lake Wingra to the downstream chain of lakes, increasing the chances for exotic species, like zebra mussels, to invade Lake Wingra. Secondly, reconnection would require extensive berming to protect nearby homes from flooding, and costly construction of water outlets under McCaffery Drive. Thirdly, if the marsh were reconnected, Lake Wingra's water level would fall as the water drained out through Gardner Marsh to Wingra Creek. The connection would essentially negate the head of water created by the dam, allowing water to pass through at a lower elevation, dropping the water level to the elevation of the culverts that connect Lake Wingra to the marsh. This drop in lake water levels would drastically alter the present "lake" character of Lake Wingra. This drop could be prevented, but only via expensive berm construction along Wingra Creek. Finally, Gardner Marsh currently receives stormwater runoff from the southeast corner of the watershed and may hold a large supply of nutrients and sediment. If the marsh were reconnected, it could serve as a nutrient source to the lake, aggravating eutrophication problems (Q. Carpenter, 1999).

Water Control Structures

The dam and outlet structure at the northeast end of Lake Wingra maintains a lake level that is several feet higher than would naturally occur. No active water level manipulation currently takes place at this outlet structure. However, due to alterations to the presettlement hydrology, the lake is still about one foot lower than it was in the 1800s (Baumann *et al*., 1974). No changes to the Lake Wingra outlet structure are planned or recommended.

Native Aquatic Vegetation Restoration

Restoring native aquatic vegetation in Lake Wingra would reduce sediment suspension, possibly reduce algae growth, and increase the overall biodiversity of the lake. A reduction of suspended sediment would result from plant roots binding the sediments in place on the lake bottom. Aquatic plants also help to break up wave action and would thus reduce wave strength near the sediments, decreasing the amount of sediment suspension. Aquatic plants contribute to reducing algae growth not only by binding sediments, but also through competing for nutrient resources.

Restoring native aquatic vegetation in Lake Wingra would reduce sediment suspension, possibly reduce algae growth, and increase the overall biodiversity of the lake.

Native aquatic vegetation would also increase the diversity of plant communities in Lake Wingra and its wetlands. Exotic plants often tend to be invasive and choke out most native species. This allows a single disease to destroy a large part of a plant community. Also, dominance by a few species decreases suitable habitat for native fish and wildlife.

The reintroduction of native vegetation is appropriate for Lake Wingra. The UW-Arboretum and Edgewood College are positioned to facilitate research on restoring native plant communities. Wild rice, wild celery, and pickerelweed have been suggested as potential restoration species (Lorman, 1998; S. Carpen-

The restoration of wild rice and wild celery, in addition to the increase of other native aquatic plants, would help improve fish and duck habitat and the lake ecosystem as a whole.

ter, 1999). The restoration of wild rice and wild celery, in addition to the increase of other native aquatic plants, would help improve fish and duck habitat and the lake ecosystem as a whole.

Aquatic Plant Harvesting

Aquatic plant harvesting is intended to remove nuisance rooted aquatic plant growth like Eurasian water milfoil. Harvesting can keep surface waters open for navigation and recreation. Mechanical harvesting of rooted aquatic plants often results in a good deal of plant debris left behind, even though this practice removes a good deal of the plant biomass. While harvesting is effective for short-term control, the machines are costly and the technique is not a permanent solution to excessive macrophyte growth. More importantly, if plant harvesting were done to an extreme, the removal of macrophytes could lead to a turbid algae-dominated state due to the loss of nutrient competition between algae and aquatic plants (Scheffer, 1998). Because of this, harvesting is best reserved for areas of heavy public use or extremely dense Eurasian water milfoil growth. Since this exotic plant can regenerate from plant fragments, mechanical harvesting should be accompanied by plant debris collection. This entails raking, pumping, and sectioning off harvest areas with booms until plant debris is removed.

Harvesting aquatic plants has an additional in-lake restoration benefit that should be considered. Removing plant biomass, which contains large amounts of nutrients, reduces the release of large amounts of nutrients into the lake that would otherwise be released during plant decomposition.

Algae Control Using Straw Bales

A new method of controlling algae, developed by the Center for Aquatic Plant Management, involves the application of barley straw to water (ACR, 1997). The straw bales are placed near the surface of the water, preferably in a net or cage. When barley straw is placed in water, its decomposition inhibits algae growth. As barley straw decomposes, lignins from its cell walls are released. If the water has sufficient dissolved oxygen, lignins are oxidized to humic acids. Humic acids occur naturally in many water bodies: it has been shown that sunlight causes humic acids to form hydrogen peroxide, and that low levels of peroxide inhibit algae growth. Peroxides are very reactive molecules and will last in water only for a short time. However, while humic acids are present, peroxides will be continuously generated with sufficient sunlight. The slow and uneven decomposition rate of barley straw ensures the presence of humic acids.

In the still water found in Lake Wingra, bales should not be used, as they are too tightly packed and would not allow adequate water movement through the straw. It would be preferable to apply barley straw in a loose form retained in some form of netting or cage. Also, several applications of small amounts of straw would be preferable rather than one larger application. This method works best if barley straw is held near the surface where water movement is the greatest. In order to ensure that there are no areas within the water body unaffected by the straw, it is necessary to calculate how much straw is needed, how many nets should be employed, and how far apart each net should be. Although barley straw could be applied at any time of year, it is much more effective if applied just before algae growth takes place.

There are several considerations that affect the performance of this algae control method. First, oxygenated conditions are needed. Usually there is adequate dissolved oxygen to ensure that humic acids are produced. However, if barley straw is applied in large compact masses such as bales, or to very sheltered and isolated areas of water, there will be insufficient water movement through the straw, and the water will become progressively anaerobic. Secondly, waters turbid with suspended mud will need more straw because mud quickly inactivates the chemical produced.

The use of barley straw for algae control has been tested in a wide range of situations and in many countries throughout the world. This method has proved to be very successful in most situations, with no known undesirable side effects. In addition, barley straw has been found to provide good habitat for invertebrates. As with most methods that decrease algae growth, water clarity increases, submerged aquatic plant growth increases, and fish populations increase.

The use of straw would be a very inexpensive and environmentally acceptable way of controlling algae in Lake Wingra.

The use of straw would be a very inexpensive and environmentally acceptable way of controlling algae in Lake Wingra. Potential conflicts could include a dissatisfaction with increased plant growth, or interference with boating and fishing activities. Hopefully barley straw could be placed as unobtrusively as possible while still achieving maximum effectiveness.

Table 4-6
Summary of recommended in-lake management.

Recommendation	Advantages	Disadvantages
Dredging: should only be used if phosphorus loading from the watershed is reduced to acceptable levels	Removes built-up sediments	Costly; disturbs ecological systems; inconvenient for lake users
Alum Treatment: should only be used if phosphorus loading from the watershed is reduced to acceptable levels	Removes nutrients from the water column	Costly; may have health risks; may be a short-term solution
Muskellunge Stocking: should continue unless native northern pike populations can be restored	Maintains popular fishery; predatory fish control panfish population	Costly; ongoing
Plant Harvesting: should continue, especially in areas of heavy public use and areas with dense milfoil growth	Removes problem aquatic plants; removes plant- bound nutrients	Costly; ongoing
Native Aquatic Plant Restoration: should expand research and demonstration plots on aquatic plant restoration; small pilot projects could be expanded as species are found to have a good chance of success	Holds sediments; reduces algae growth; increases biodiversity	Costly
Wetland Management: should concentrate on reducing stormwater runoff impacts, increasing groundwater flows, and continuing exotic plant control	Preserves plant biodiversity and animal habitat	Costly
Boat Wash: should be constructed, particularly if zebra mussels reach the Madison lakes	Prevents zebra mussel invasion	Costly

Boat Regulations and Zebra Mussels

Lake Wingra is currently a favorite Madison area for non-motorized watercraft sports, including canoeing, kayaking, sailing, and windsurfing. Because of the lake's importance as a natural area and research site, limitations have been placed on motorized boats. These restrictions include no weekend or holiday boating, no-wake and 5 mph limits at all other times, and no motor boat races (City Ordinance 14.30(8) and (9d)). Speed limits in Wingra Creek and Henry Vilas Lagoon are limited to 5 mph. The city has control over boat regulation, and may enforce state boating and water safety laws (Wis. Stats. ch. 30.50-30.71).

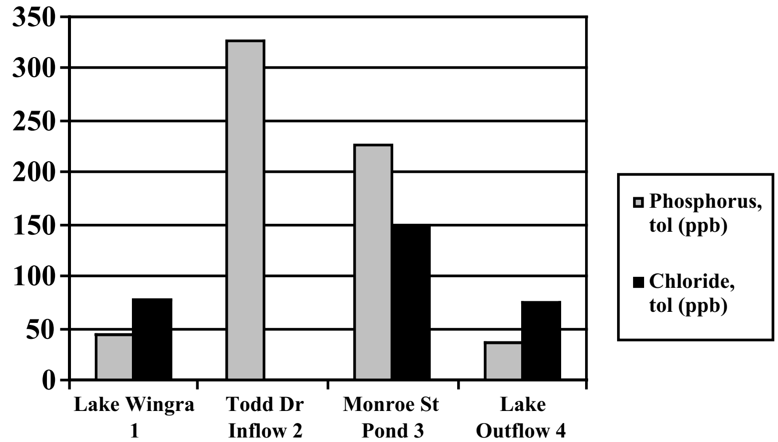
Regulation regarding boat washing may be necessary to prevent zebra mussel invasion into Lake Wingra. Zebra mussels are an exotic species introduced to the Great Lakes via European shipping boats, and are now transported between inland lakes on recreational boats and trailers. Zebra mussels are a nuisance since they attach to hard surfaces, including stormwater outfall pipes, boats, and other native shellfish. There is only one boat launch site on Lake Wingra, and so the installation of a boat wash site there would reduce the chance of zebra mussel introduction. Spraying down boats and trailers is an effective method of removing the zebra mussel veliger larvae. This process would also remind boat owners to examine their boats and trailers for exotic plants or animals that may be attached to motors or around trailer supports. The city of Madison would most likely be responsible for the construction and maintenance of a boat wash site.

Monitoring for Management Purposes

Monitoring water resources is an essential part of watershed management that measures changes in watershed conditions and water quality. Identifying trends through long-term monitoring is critical to good lake planning and decision-making. It confirms progress toward stated objectives, and reveals problems that require attention. This section will describe surface water monitoring activities currently occurring within the Lake Wingra watershed, and will suggest areas where both professionals and community volunteers could do additional monitoring. **Table 4-7** at the end of this section summarizes our recommendations for monitoring efforts within the Lake Wingra watershed.

It is important to note that concentrations of nutrients and other contaminants change as water moves through the watershed. Therefore, trends can be observed not only by long-term monitoring at a single point, but also by monitoring many points along a flow path. This is reflected in the varying contaminant concentrations at different points within the Lake Wingra watershed. For example, **Figure 4-2** shows phosphorus and chloride concentrations of Lake Wingra, of a stormwater treatment pond, of stormwater inflow into Lake Wingra, and of water just downstream of the lake outflow point.

Figure 4-2
Average concentrations of total phosphorus and chloride in Lake Wingra, stormwater inflows, and the lake outflow.



1 - Water quality data collected during 1996 (UW-Madison LTER)
2 - Stormwater quality data collected between 1993 and 1994 (USGS, 1997)
3 - Stormwater quality data collected between 1987 and 1988 (USGS, 1993)
4 - Water quality data collected between 1990 and 1999 (Madison Department of Public Health)

Lake Wingra Monitoring

Monitoring data for Lake Wingra itself, which considers chemical, physical, and biological parameters, is collected by the UW-Madison Long-Term Ecological Research (LTER) project (http:\\www.limnology.wisc.edu). Since 1996, water chemistry data has been collected on a regular schedule. Zooplankton, phytoplankton, and fish communities are also sampled. In 1999, sampling began for zebra mussels. The WDNR is also involved in collecting monitoring data, conducting fish population samples, and performing a limited amount of testing for mercury levels in fish tissue. The Vilas Beach area is regularly monitored for bacteria levels by the city of Madison Public Health Department.

Phosphorus is often the limiting nutrient for both plant and algae growth in northern temperate lakes. Phosphorus stimulates algae growth rates until 'algae blooms' are observed. The US Environmental Protection Agency (USEPA) states that total phosphorus should not exceed 25 parts per billion (ppb) within lakes and reservoirs (USEPA, 1986). Recent water samples collected from the surface of Lake Wingra have an average total phosphorus concentration of 43 ppb.

Excessive amounts of chloride can affect the survival, growth, and reproduction of freshwater aquatic life. Steadily increasing levels of chlorides have been documented in each of the Madison lakes. This situation has been especially dramatic for Lake Wingra, where chloride concentrations are presently more than twice as high as in Lake Mendota. This may have more to do with the fact that Lake Wingra is a shallow lake, than a direct reflection of land use differences between each watershed. The present concentration of chloride in surface water samples from Lake Wingra has an average of 76 parts per million (ppm), well above historic levels of 5 ppm measured in 1940. The chloride levels in Lake Wingra, although higher than they have been in the past, may not be an issue for this lake ecosystem. Freshwater fish are continuously regulating against osmotic pressure differences, and therefore higher salt concentrations in their surroundings help keep their body salt concentrations higher than their surroundings. Unless aquatic plant communities in Lake Wingra are found to be affected by changes in salt concentrations, these salt levels are probably not as pressing an issue as others facing the Lake Wingra watershed (Bill Foreman, 1999, personal communication).

Vilas Beach has been closed a number of times during the past several years due to high levels of bacteria, presumably from pet waste entering the lake in stormwater runoff.

The primary reason for beach closures in the Madison area lakes is high bacteria levels. For recreational swimming, the USEPA recommends a maximum level of 235 per 100 ml for the bacteria *Escherichia coli* (USEPA, 1986). Vilas Beach has been closed a number of times during the past several years due to high levels of bacteria, presumably from pet waste entering the lake in stormwater runoff. Also, during 1999, Olin Beach on Lake Monona was closed due to an overflow of animal waste from the Vilas County Zoo into the storm sewer system, resulting in bacteria levels ranging up to 2800 per 100 ml of *E. coli* and 3500 per 100 ml of total fecal coliforms in Wingra Creek (DPH, 1999).

Inflowing Surface Water Monitoring

Several small first-order streams enter Lake Wingra. These streams originate as springs and seeps, and some combine with overland stormwater flow. Although there are no point source discharges within the watershed, twelve storm sewer outfalls discharge to the lake; these collect non-point source pollution from the Lake Wingra watershed.

Past studies of both treated and untreated stormwater flowing into Lake Wingra from the Monroe Street retention pond and the Todd Drive sampling station have been performed by the USGS. Monitoring results are discussed below.

Monroe Street Retention Pond

Monitoring was conducted by the USGS at the inlet and two outlets of the Monroe Street retention pond between February 1987 and April 1988, to determine the effectiveness of urban stormwater runoff treatment (House *et al*., 1993). Renewed monitoring was conducted at the pond inlet between March 1992 and December 1994 to estimate storm loads entering the retention pond (Owens *et al*., 1997). While large variations in stormwater quality occur, this retention basin has been shown to be relatively effective at treating stormwater runoff entering Lake Wingra. Efficiencies varied considerably for different constituents. The median decrease in event mean concentrations (EMC) for total phosphorus was found to be 43%; the total load decreased 58%. For suspended solids, the total load decrease and median decrease in EMC was 88%. Chloride levels were higher at the outflow than at the inflow, indicating that this pond is a source of chloride to Lake Wingra. There was also a 93% decrease in total lead.

Todd Drive Station

Untreated stormwater runoff monitoring was conducted at Todd Drive near the Arboretum and the Beltline (USGS Station No. 05429073) between May 1993 and November 1994. Storm loads were computed for a number of constituents, including nutrients, ions, bacteria, and organic and inorganic contaminants. The subwatershed draining to this monitoring station consists of highway, commercial, and multifamily residential areas (Waschbusch, 1996). Average concentrations of total phosphorus and other contaminants are generally higher in untreated stormwater flowing into Lake Wingra. Samples of untreated stormwater collected from the Todd Drive station had an average total phosphorus concentration of 328 ppb. Fecal coliform bacteria levels of up to 3200 per 100 ml of water were found in the stormwater.

Wingra Creek Monitoring

Water quality at the outlet weir of Lake Wingra is periodically monitored by the city of Madison Public Health Department for certain nutrients and ions, namely chloride. The outlet weir flows into Wingra Creek, which was sampled periodically in 1989 and 1990 by the USGS. Heavy metals, PCBs, and DDT metabolites have been detected in the bottom sediments of Wingra Creek (WDNR, 1998).

Some surface water also flows out of Lake Wingra in an engineered bypass system. Passing under the Vilas County Zoo, this flow combines with stormwater from the zoo and empties into Wingra Creek through a storm sewer outfall located just below the Lake Wingra outlet. During heavy rainfall this bypass system becomes a combined sewer, as the zoo waste system overflows into the storm water sewer system. As discussed previously, elevated bacteria levels in water flowing from this bypass system have been responsible for beach closures downstream.

Springflow Monitoring

Springflow monitoring gauges the success of attempts to increase groundwater levels. If serious efforts are made in the watershed to reduce groundwater pumping and increase infiltration of snowmelt and rainfall, then springflows should be monitored over a long-term basis to measure magnitudes and rates of improvement.

Of the stream gauging methods available to monitor Lake Wingra's springs, many are not feasible because of funding limitations, political barriers, or physical constraints. For example, most of the springs lack confined channels so some traditional stream gauging methods are not possible. Also, it would be costly to employ professionals to take regular current meter measurements for calculating discharge. Though trained citizen volunteers could take current meter measurements on a regular basis, the error involved in the measurements can be considerable, even when taken by professionals (Herschey, 1995). This is especially the case for narrow, shallow streams like those flowing from the springs near Lake Wingra.

Considering the limitations for directly gauging the springs, an indirect method for gauging springflow and groundwater inputs was investigated for Lake Wingra. This method compared two watershed basins with similar climates, and assumed that the land in the basin being used as the index reference point was not changing (in this case, the Black Earth Creek watershed). The method also assumed that all discharge from the downstream end of the basin under study (that is, at the Lake Wingra outlet) during baseflow periods, represents water displaced by groundwater and springflow inputs. The method hypothesized that the two watershed basins would experience contemporaneous baseflow periods. See Potter (1999, in press) for a more detailed description of this method of analysis.

The Lake Wingra outlet was gauged by the USGS from 1970 to 1777 so baseflow periods for the lake outlet to Wingra Creek could be compared, or "indexed," to the same periods in the nearby Black Earth Creek basin. If the assumptions of the indexing method are met, and the two gauges exhibit a strong statistical relationship during baseflow periods, then it is possible to indirectly gauge springflow and groundwater inputs to Lake Wingra by resuming gauging of the lake outlet. If there is no change in the statistical relationship between the two gauges over long periods, this indicates that baseflow into the lake is not changing. Changes in the statistical relationship would be evidence of decreases or increases in baseflow to Lake Wingra.

There was not a strong relationship between the baseflow periods for the Black Earth Creek watershed and the Lake Wingra watershed outlet between the years 1970 and 1977. This was likely because many of the assumptions for the method were not met. For example, changes in lake storage may have invalidated the assumption that during baseflow periods all outputs are equal to the inputs of springs and groundwater. Also, ice conditions may have affected gauging measurements. Finally, the measurement accuracy of excessively low flows at the outlet is suspect.

There is, however, the possibility of gauging one spring that does have a relatively confined flow. This spring flows through the UW-Arboretum oak savanna restoration project, a well-traveled natural area adjacent to Monroe Street. The most accurate way of gauging the spring would involve building a weir control structure. Though construction of a permanent structure on this spring may be unpopular for aesthetic reasons, alternative removable structures could be developed to use a few times a year. If the Lake Wingra watershed community makes efforts to improve groundwater recharge and decrease groundwater pumping in the watershed, accurately gauging this spring would enable evaluation of such efforts.

Citizen Monitoring

Though monitoring some areas, such as springs, requires professional expertise, citizen monitoring of surface water inflows and outflows can be an effective way of involving neighborhoods. One program that coordinates citizen monitoring is Water Action Volunteers, a cooperative effort of the UW-Extension and the WDNR. To ensure consistency in measurements, volunteers are required to participate in a training course to learn proper sampling techniques, and must commit to a certain number of data collection sessions. Citizen monitoring covers chemical, physical and biological data. Regular and ongoing sampling could provide valuable assistance to professional monitoring programs. Drawing on citizen volunteer efforts is an effective way to increase monitoring capabilities. More importantly, involving individuals and groups in ongoing monitoring activities will educate the community about Lake Wingra watershed issues and solutions.

Table 4-7
Recommendations for monitoring efforts.

Recommendation	Advantage
Sampling and analytical methods should be uniform for water quality monitoring at inflows, in Lake Wingra itself, and at outflows. Data collection should be regularly scheduled and coordinated with other monitoring activities.	Ensures consistency, maximizes efficiency.
One or more stormwater monitoring stations should be professionally maintained within the Lake Wingra watershed. The city of Madison should provide funds to resume monitoring at the Monroe Street retention basin. The estimated operation cost range is between $15,000 and $20,000 per year (Dave Owens, personal communication, 1999). Long-term monitoring should be conducted throughout the Lake Wingra watershed in order to determine trends; it is difficult to correctly interpret data covering less than a decade.	Identifying trends through long-term monitoring is critical to good lake planning and decision-making.
Cooperation, data sharing, and timely communication between data collection entities should be a priority. Annual summaries of water quality data should be prepared and disseminated.	Assists planning and decision making.
The city of Madison Public Health Department should continue to monitor the bypass sewer system flowing from the Vilas County Zoo, and determine an acceptable alternative to the combined sewer.	Provides the needed information to ensure public health.
Monitoring for fecal coliforms specific to cats and dogs should be conducted in Lake Wingra. If pet waste is found to contribute to fecal coliform counts, monitoring data would support the implementation of a pet waste pick-up program.	Provides the needed information to ensure public health.
WDNR fish tissue mercury testing should be continued on an on-going basis, not only to determine fish advisories for Lake Wingra, but also to better understand atmospheric deposition.	Protects public health, aids important research.
Surface water and groundwater pesticide sampling should be conducted downstream of the Lake Wingra watershed golf courses.	A potential impact could be identified and addressed.
Selective sampling should be performed downstream of non-stormwater discharges to the storm sewer system to determine other possible sources of contaminants entering Lake Wingra.	A potential impact could be identified and addressed.
Sampling should be performed on the Wingra Creek sediments to determine whether heavy metal and other contaminant presence is due to present inflows.	A potential impact could be identified and addressed.
Despite complications, springflow monitoring should occur.	Effectiveness of infiltration enhancing practices can be evaluated.
The development of long-term citizen monitoring programs should be further pursued.	Reduces the cost of many of the above recommendations, enhances citizen awareness.

Conclusion and Recommendations

Selecting appropriate management tools for the Lake Wingra watershed depends upon stakeholder goals for the lake. Recreation, restoration, and research interests need to be considered. As this and following chapters stress, management activities throughout the watershed need to be integrated – stormwater management practices need to be implemented alongside in-lake restoration and monitoring activities.

Tables 4-4, **4-6**, and **4-7** summarize our recommendations for stormwater management, in-lake restoration, and monitoring practices respectively. These activities can be divided into three categories and are summarized below:

practices that need immediate attention, practices for which foundations can be laid now, and practices which can be implemented once additional outreach has been conducted and/or additional funding becomes available.

Current stormwater management practices such as storm sewer system maintenance, street sweeping, and road salt reduction programs should be continued. Stormwater treatment ponds need immediate dredging to improve their effectiveness, in particular, the Odana Hills treatment pond and UW-Arboretum ponds 4 and 6. There should be continued support of research occurring in the Lake Wingra watershed (e.g. Edgewood College's research on living machines). Other important research is also being conducted at the UW-Madison, the USGS, and the WDNR on the significance of diffuse infiltration, the impact of phosphorus fertilizers, and the impact of stormwater on wetland vegetation. Synthesis of research and ongoing monitoring data should and can begin now.

Plans for additional management practices, and increased coordination, research, and education should begin as soon as possible.

Plans for additional management practices, and increased coordination, research, and education should begin as soon as possible. Examples of what could be done include the following: The UW-Madison is currently conducting treatment pond assessments. Once these are complete, routine maintenance plans should be developed. With increased coordination between the management entities, uniform standards for road salt and sand application could be developed to maximize lake protection. Based on the research findings on the impact of stormwater on wetland vegetation, plans for wetland protection can begin to be drafted. Many of the in-lake recommendations, for example those regarding fisheries and native plant restoration, will depend on defined goals for Lake Wingra. Education on the pros and cons of various in-lake management options would help citizens and managers develop workable and acceptable plans. Other education topics should include diffuse infiltration, bioretention, zebra mussel invasion, and watershed monitoring. Educating individuals about what they can do to enhance lake quality will have ongoing returns.

With additional funds, and an active education and outreach program in place, many of the above mentioned activities can be implemented and expanded. Enhancement of existing management practices could include, for example, a more aggressive street sweeping program. Additional stormwater and in-lake treatment practices, such as PAM, living machines, or alum could be applied. Plans to protect and restore the wetland and fishery could be implemented. A boat wash may protect Lake Wingra from zebra mussel invasion. Lastly, the recommended monitoring coordination and expansions could occur. Costs could be reduced through the development of volunteer monitoring opportunities.

In summary, creative approaches need to be brought to bear on the management of the Lake Wingra watershed. The following chapters of this document address the public outreach, stakeholder coordination, and administrative and funding aspects that will be needed to effectively implement management practices in the Lake Wingra watershed.

Chapter 5

Stakeholders

Introduction

Comprehensive watershed management not only entails consideration of natural resources, but also the people with interest in those resources. These are the stakeholders; the people whose activities and ideas in some way impact these resources, and whose interests are affected by how that resource is managed. Stakeholder interests range from government level managers and researchers, to business owners, to citizens who live in the watershed, and to lake users. Stakeholder involvement and support is critical to the success of any resource management program.

The goals of our stakeholder analysis included:

1) identifying Lake Wingra watershed stakeholders
2) defining the agencies and organizations whose work directly affects the watershed
3) describing, where applicable, how the work of these entities is coordinated
4) highlighting community-based activity and opinion
5) analyzing the current state of coordination among managing entities
6) determining the extent of communication between managing entities and the public

The information discussed in this chapter was gathered through conducting a series of phone interviews. The questions asked of each stakeholder are listed below.

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

Because of the lengthy list of identified stakeholders, we were unable to contact each one. In addition, stakeholders did not necessarily answer all of the above questions. We focused our attention on contacting government level managers and organizations, because the support by these entities will provide authority, political support, and expertise to any proposed management plan. To reach citizen stakeholders, we conducted a survey of the watershed residents. The opinions reflected in the survey results are based on respondents only and are assumed to be representative of the community stakeholders, in this case the residents of the Lake Wingra watershed. A contact table of the Lake Wingra watershed stakeholders can be found in *Appendix 5*. This table also supplies stakeholder function and contact information.

The *Current Management and Research* section provides a narrative description of the work of government level managers and organizations (relevant work of private institutions was also included), how that work either directly or indirectly influences Lake Wingra and its watershed, and cases where the various entities work together. It is organized by topic so that all of the key contacts for an issue can be readily identified. While the names of the current contact people are provided where possible, the job titles are also provided so that this information will continue to be a useful reference in the future.

The *Citizen Involvement* section discusses the Lake Wingra watershed resident survey results (for more discussion, see *Appendix 6*, and outlines current community involvement in the watershed. The *Analysis* section describes the findings of our research, lists gaps and overlaps in watershed management activities, and provides recommendations for improvement. Recommendations are described only briefly, as the primary means for implementation are described in the context of a stormwater utility, described in *Chapter 7*.

Current Management and Research Activities in the Lake Wingra Watershed

Runoff and Erosion Control

Stormwater runoff from the Lake Wingra watershed is one of the main problems influencing Lake Wingra.

Stormwater runoff from the Lake Wingra watershed is one of the main problems influencing Lake Wingra. The challenge of managing this form of non-point source pollution is reflected in the myriad of people whose work in some way deals with runoff and erosion control. While the scope of most work on this problem is at the state or county level, it is still relevant to the Lake Wingra watershed.

Research and Planning

The Bureau of Fisheries Management and Habitat Protection (BFMHP) and the Bureau of Watershed Management (BWM) in the Wisconsin Department of Natural Resources (WDNR) are involved with runoff and erosion control issues.

Roger Bannerman is the current non-point source monitoring specialist for the BFMHP. Bannerman deals with watershed plans, focuses on non-point pollution, and has done extensive research on stormwater runoff. He has given many presentations to neighborhood groups and schools, was involved in the "Urban Runoff Run," and helped produce a video, "In Current Repair," dealing with Madison lake issues. He communicates with the Dane County Regional Planning Commission, Madison city staff, Madison City Council, and neighborhood groups.

BFMHP's non-point evaluation monitoring specialist is currently Mike Miller. He conducts statewide research on stream monitoring techniques and the use of invertebrates and fish as indicator species. Miller is also involved in education and outreach. While not specifically focused on Lake Wingra and its watershed, some of his research and outreach deals with the effects of land use on aquatic habitats.

In the BWM, there is a subset of staff working solely on runoff management issues. In June 1999, the runoff management practices staff released the Non-Point Source Redesign Program, a statewide initiative to meet strict runoff standards both in rural and urban areas. The program's stormwater management component has a 20% pollution load reduction goal for established urban areas like the Lake Wingra watershed. The BWM education coordinator and webmaster, currently Carol Holden, accepted public comment on the redesign efforts. A full copy of the report can be accessed at www.WDNR.state.wi.us/org/water/wm/index.htm. The Non-Point Source Redesign Program must be passed by the Wisconsin State Legislature, which could happen as early as fall of 1999. Within urban areas, the program may be implemented via local ordinances by many agencies. Agencies working together may include Dane County Land Conservation, Wisconsin Department of Commerce, Wisconsin Department of Transportation, WDNR, and the city of Madison.

While the Department of Agriculture, Trade, and Consumer Protection (DATCP) has had little involvement with urban stormwater management issues to date, it has been involved with writing priority watershed plans along with the WDNR and the county Land Conservation Department. DATCP has no current direct involvement with Lake Wingra, but was involved with the Yahara Lakes Priority Watershed Plan several years ago (Lynn Hess, personal communication).

The current county land conservationist for the Dane County Land Conservation office is Kevin Connors. The goal of this office is to "provide conservation planning assistance and technical service in the area of soil and water conservation to landowners, land users, and decision makers of Dane County, Wisconsin" (www.co.dane.wi.us/landconservation). The Dane County Land Conservation office does not have an active presence in the Lake Wingra area because neither new construction nor agriculture is occurring within the watershed. There is, however, a small amount of redevelopment and infilling occurring.

The Wisconsin district office of the Water Resources Division of the United States Geological Survey (USGS) has done stormwater sampling in detention basins in the Lake Wingra watershed to evaluate their effectiveness. Dave Owens and Robert Waschbusch are current contacts. While the USGS serves the whole state, Lake Wingra has been a high priority because it is near the USGS office. Owens and Waschbusch have worked in collaboration with Roger Bannerman. USGS hydrologist Todd Stuntabeck has also been involved with UW-Madison research projects on phosphorus and lawn runoff (see *Appendix 3*). In the future, the USGS Wisconsin district would like to continue research on nutrient and sediment loads, best management practices (BMPs), evaluation of current practices, and "end-of-pipe" treatment options. Cost sharing may be available for these types of projects.

The Dane County Executive Office has a county lakes volunteer coordinator who works to educate the community about lake and watershed issues. The current coordinator is Danielle Dresden. She was involved with a Lake Wingra project in the mid-90s that demonstrated runoff and nutrient issues of residential lawns. Dresden's concurrent position is as the public officer for the Yahara-Monona priority watershed.

Engineering, Inspection, and Permitting

The current city building plan examiner, Mike Van Erem, helped develop the city of Madison's original erosion control ordinance. The supervisor for building permits and inspections on construction site erosion is currently Harry Sulzer. Madison's Department of Engineering generally drafts the plans, and staff from City Permits and Inspection enforce them. Questions about undeveloped tracts should be directed toward city engineering.

The WDNR Bureau of Watershed Management (BWM) is involved with construction site erosion control and stormwater permitting. These are Wisconsin Pollution Discharge Elimination System (WPDES) permits. Contacts for these activities are the water resources engineer for BWM runoff management practices (currently Jim Bertolacini) and the water resources engineer for BWM permits process and facilities management (currently Bruce Moore). BWM inspection and permitting activities do not presently occur in the Lake Wingra watershed since there is little to no new development.

City of Madison engineering is also involved with stormwater management, and attempts to do as much as possible to treat stormwater prior to its discharge into Madison lakes.

City of Madison engineering is also involved with stormwater management, and attempts to do as much as possible to treat stormwater prior to its discharge into Madison lakes. City Engineering does not consider the lakes as treatment systems, but as resources to be protected. As Lake Wingra and the other Madison lakes are waters of the state, and the city of Madison is only one of the municipal areas draining to them, city engineering is a partner with the state and other municipalities. While the city views all of its discharges to the lakes with similar priorities, it may appear at times that some take precedence over others due to priority watershed funding (Greg Fries, personal communication). The city is mandated by the WDNR to meet watershed goals for runoff, and has done so through the use of the following management practices. For further discussion of these, see *Chapter 4.*

Stormwater Treatment Ponds

Runoff management from Highway 12/18 (the Beltline) is the joint responsibility of the Dane County Highway Garage, the Department of Transportation (DOT), the UW-Arboretum, and the WDNR. The county has built two detention ponds within the UW-Arboretum, north of the highway. The Arboretum director, currently Greg Armstrong, said that the Curtis and Johanssen detention ponds were built at the same time by the DOT, although an outside contractor or the county may have done the actual construction. Dane County Highway Garage staff supervisor, Steve Haag, understands that detention pond maintenance is the responsibility of the WDNR. Currently, however, there has been no maintenance of the detention ponds.

Street Sweeping

The city of Madison Streets and Sanitation Division is charged with street sweeping. Roger Goodwin (city street superintendent, Streets and Sanitation Division) is the main contact for street information. This division has responsibility for street maintenance and repairs, sweeping, snow and ice removal, and leaf collection. Streets in the Lake Wingra watershed are swept after leaf collection, according to the city's goal of keeping leaf nutrients out of area lakes. The city of Madison's stormwater permit from the EPA includes street sweeping as a management plan for remediating the effects of stormwater runoff. The effectiveness of street sweeping depends on the thoroughness of the operator, as slow speeds and sweeping close to the curb are more effective. Materials swept up vary according to season: leaf debris in the fall, sand in the spring, and grit and heavy metals for the rest of the season. General data on heavy metals in swept material is available.

The Lake Monona watershed has a high-intensity street sweeping program: the Clean Streets, Clean Lakes program. This high-intensity sweeping began as a pilot program a few years ago through a WDNR urban watershed funding program, and was implemented through the persistence of city Ald. Bert Zipperer in the 6th district.

Road Salting

The city of Madison Streets and Sanitation Division is responsible for salting streets within the city, and the Dane County Highway Garage is responsible for roads with different municipalities on either side. For example, the county salts Fish Hatchery Road because the city and the town of Madison are on either side of the road. The city of Madison has implemented a road salt reduction plan with the goal to apply as little salt as possible to its streets in order to reduce salt loading to area lakes. This means, for example, that the only streets salted in residential areas are main transportation and bus routes. The Lake Wingra watershed has even less salt applied to its roads, due to the lake's designation as a research area. The city's operations analyst (currently Maryanne Hose) has tonnage data for the amount of salt applied citywide per year by the city of Madison Streets and Sanitation Division.

The city of Madison has implemented a road salt reduction plan with the goal to apply as little salt as possible to its streets in order to reduce salt loading to area lakes.

The Dane County Highway Garage contracts with the Department of Transportation (DOT) to maintain the Beltline (along with other US highways in Dane County). DOT hydrogeologist Bob Pearson is the current contact for Beltline salting issues. For further detail on both city and county salting practices, see page 53.

Yard Waste Composting

The city of Madison Streets and Sanitation Division's west side office collects yard waste in the Lake Wingra watershed, with some involvement from Dane County Public Works. State recycling laws ban yard waste from landfills, and city of Madison ordinances enforce curbside pickup compliance. Collection occurs three times in the fall and twice in the spring. Approximately 11,400 tons per year of yard waste are collected citywide from curbside pickup, the bulk of this being fall leaves.

In addition to curbside collection, there are drop-off sites for grass clippings and other garden debris. Approximately 6200 tons are brought to drop-off sites. This, and the collected yard waste, are composted by Dane County Public Works. Compost tonnage has increased over the years, perhaps due both to the growth of the urban forest, and increased public awareness and compliance.

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The city of Madison's recycling coordinator is currently George Dreckmann. The coordinator's outreach includes advertising leaf collection days, and educating the public on the benefits of leaf collection for water quality. Mindy Habecker of the UW-Extension provides citizens with home composting information, alternative lawn-care methods, and related water quality information. Many Madison residents do their own on-site composting and mulching.

In-Lake Management and Research

Much of the in-lake work relevant to Lake Wingra is currently being done by three bureaus of the WDNR: the Bureau of Fisheries Management and Habitat Protection (BFMHP), the Bureau of Watershed Management (BWM), and the Bureau of Integrated Science Services (ISS). Bureau directors, such as the BFMHP's director Mike Staggs, informed us that the responsibility for the management of Lake Wingra is vested with the South Central region WDNR staff. However, the bureau directors deal with policy issues and budget decisions that affect how the regional staff develop management plans and activities. The WDNR has assigned basin team leaders as supervisors for programs in various state basins. Lake Wingra is a part of the Lower Rock River Basin and Ken Johnson is the current Lower Rock River Basin team leader. The five main program areas that Johnson coordinates include water resources, water regulations, fisheries, water supply, and watershed management. He is active in the formation of local watershed-based organizations, and believes that external partners are critical to successful management. To further develop partnerships and obtain public input, the WDNR has assigned a UW-Extension staff member, currently Susanne Wade.

Fisheries Biology

The BFMHP fisheries biologist for the Lower Rock River General Management Unit (GMU) is currently Mike Vogelsang. Vogelsang's work involves fisheries issues, and fish stocking and surveys for all of the Madison lakes. He has no specific focus on Lake Wingra. The BFMHP fisheries expert, Scott Stewart, is currently working on habitat restoration projects in Token Creek and Black Earth Creek. Stewart also has been involved with fish stocking and surveys in Lake Wingra.

Shallow Lakes Management

The BFMHP fisheries policy ecologist, Paul Cunningham, is responsible for shallow lake management, provides technical leadership for shallow lake restoration projects, and reviews restoration proposals. Cunningham helps administer the Lakescaping for Wildlife and Water Quality fund and the Nongame Wildlife Planning fund. He also participates in the education and training of other WDNR staff. To date, none of these funds have been used on Lake Wingra, although it is a potential funding candidate. The BFMHP is supportive of small lakes and watersheds.

The BFMHP lake management analyst is currently Jim Leverance. His work includes managing aquatic plants and issuing permits for herbicide applications near shorelines, as well as monitoring Lake Wingra for zebra mussels. Leverance has worked as a lakes program coordinator for the Wisconsin Lakes Partnership (see section on *Current Opportunities for Public Participation in Wingra Watershed*), and worked with the Friends of Lake Wingra to get funding under the WDNR Lake Management Planning Grant program. Future efforts for Leverance may involve working with the Dane County Lakes and Watershed Commission on various related issues.

Aquatic Plant Harvesting

Within the Lake Wingra watershed, Dane County Public Works (Ken Koscik, supervisor) is involved in aquatic plant harvesting. After "Take a Stake in the Lakes" events, Dane County Public Works picks up weeds collected during these cleanup efforts. Currently, Joe Yager is in charge of aquatic weed harvesting for Lake Wingra and other county lakes. Yager communicates with Stan Nicols and Steve Carpenter of the UW-Madison to avoid interference with in-lake aquatic plant research. Since Lake Wingra is a research lake, it has a limited harvesting policy. Aquatic plants are presently harvested from Lake Wingra for sailing and rowing events, and from public beaches and the boat launch area. See page 61 for further information on aquatic plant harvesting as a management tool.

Research
The University of Wisconsin's Long-Term Ecological Research (LTER) project has a WDNR site manager, currently Dick Lathrop, for the southern lakes portion of this project. Lake Wingra is one of the LTER lakes.

Jim Lorman has conducted significant collaborative research on integrated ecosystem management for Lake Wingra and on stormwater management at Edgewood College. For more details on this research see Lorman *et al*., 1997, Lorman, 1998, and page 54 of this report on *Living Machines*. Furthermore, both faculty and students at Edgewood College are involved with projects involving aquatic plants, GIS mapping of sediments and vegetation, purple loosestrife, water quality, and chloride levels.

Commissions and Councils

The commissions and councils described below are involved with planning and management water resources, regional issues, general environmental issues, and parks and zoos. They serve as advisors to governmental agencies, and some have regulatory and enforcement authority.

Dane County Lakes and Watershed Commission
The watershed management coordinator for the Dane County Lakes and Watershed Commission is currently Sue Jones. The commission works on countywide policies and ordinances that will protect lakes and other water bodies. The commission's work includes securing direct funding for watershed projects, fostering partnerships within watersheds, implementing policy, enforcing regulations, and educating and informing the public on watershed issues.

Dane County Regional Planning Commission
The Dane County Regional Planning Commission (RPC) considers urban development impacts on the environment and evaluates issues of urban growth, especially sewer issues. The RPC has little legal authority, but makes substantial comments on plans and proposals, and does have authority over sewer extensions. As such, the RPC determines the growth boundary of each municipality. RPC authority is delegated by the WDNR and is specific to Dane County (Mike Kakuska, personal communication). Once an urban service area boundary is established, as in the Lake Wingra watershed, the RPC does not have jurisdiction. However, since the RPC is concerned with lakes and waterways, it provides staff assistance and information as a water quality planning agency for the county (for example, Dane County Regional Groundwater Protection Plan). Furthermore, the RPC has an archive of water quality data and analyses, as well as a collection of stormwater plans from all of the different jurisdictions.

Madison Metropolitan Sewerage District (MMSD)
The Madison Metropolitan Sewerage District (MMSD) collects and treats wastewater for the Madison area. The MMSD has statutory authority to implement a stormwater utility, and has met several times with the WDNR to coordinate stormwater permit efforts under the Wisconsin Pollution Discharge Elimination System (WPDES) (Jim Nemke, personal communication). WPDES staff member Steve Fix is working on this effort. Fix also reviews urban sewer service amendments as proposed by the RPC (see previous section).

The MMSD is involved with several watershed organizations, including the Upper Sugar River watershed advisory group, the Rock River partnership, and the Rock River Basin forum. It has a water quality committee developing effluent trading. In this instance, effluent trading involves allowing higher-than-usual point source discharges (treated wastewater) if non-point pollution sources within the same watershed system are eliminated or treated. The Rock River is a pilot watershed (one of three in Wisconsin) for effluent trading.

City Commission on the Environment
The city Commission on the Environment advises the mayor and the City Council on policies and ordinances that affect the environment. The Lake Wingra watershed has high priority for the commission because it is almost completely within the city and is almost completely urban. About three years ago the commission established stormwater management recommendations, which included advice from UW-Madison Professor Steve Ventura to investigate a stormwater utility.

County Level Commissions and Councils
Other county commissions and councils include the Dane County Environmental Council, the Parks Commission, and the Henry Vilas Zoo Commission. Of these, the Dane County Environmental Council is involved with projects most relevant to Lake Wingra. Ed Brick is the current chair. The council has a small grants program ($200-$1000) to fund projects that promote environmental education, conservation, and restoration.

Parks and Open Spaces

Madison City Parks Division
The Madison Parks Division manages the 200+ parks in the city of Madison. City parks in the Lake Wingra watershed include Glenwood Children's Park, Westmorland Park, Wingra Park, and Vilas Park. Dane County runs the zoo within Vilas Park. No chemical applications are allowed on park lawns, except for some fertilizers and pesticides applied to the soccer and football fields. Because of its high use, Vilas Park is a relatively high priority: the Parks Division mows lawns, picks up garbage, regrades public skating areas on the lagoons, and pumps water from the lagoons to the top of the ice skating rinks. Time and money permitting, the Parks Division would like to improve the shelters and roads at Vilas to improve the congestion from bike and car traffic (Si Widstrand, personal communication).

The city of Madison parks outreach coordinator, currently Laura Prindle, focuses on volunteer park cleanup coordination. Oftentimes neighborhood groups coordinate cleanups, and Prindle simply provides bags and gloves. For more extensive projects, neighborhood groups may receive staff support. Parks in the Wingra watershed have had trash cleanups and some purple loosestrife removal.

The city has a parks and open space plan that is updated every five years. The city Parks Division also regulates lakes and waterways within Madison, and as such, controls access to Lake Wingra via the boat landing and boat restrictions.

The conservation supervisor for the city Parks Division, currently Russ Hefty, supervises the city's 14 conservation areas and ski trails, some of which are in the Lake Wingra watershed. Work done at the Edna Taylor Conservation Area as part of the 1995 Monona Priority Watershed Program exemplifies the type of projects Hefty is involved with. Due to gravel roads and the absence of a storm sewer system, sediment was filling in parts of the conservation area's marsh. The marsh was excavated, ponds were designed after natural oxbows, and 20,000 emergent and submergent aquatic plants were planted. This restoration project made an innovative retention facility that provides wildlife habitat and recreational opportunities. The restoration work was done in conjunction with trail revision and geoblock installation (concrete connected with cable and filled with gravel), which provided improved infiltration and prevented trail erosion.

Hefty has also encouraged Edgewood College to remove its purple loosestrife because the city wants to keep it out of parks and greenways. The City Council recently amended an ordinance to make purple loosestrife a noxious weed. When the city Parks Division hears that someone has purple loosestrife on his or her property, a notice is sent with an information packet and a removal date. This can be legally enforced, but the need has not arisen in over 200 removal notices.

Dane County Parks Department

The Dane County Parks Department is not involved in management within the Lake Wingra watershed because it owns no land in the watershed. Dane County Public Works is involved with managing the water levels in the Madison lakes, but does not do so in Lake Wingra since it has a free-flowing weir. However, management and restoration plans that the department has been involved with can serve as useful examples for the Lake Wingra watershed, such as the Nine-Springs E-way plan. The department acquires and protects land, and works on wetland and upland restoration. Upland buffer areas are being considered in Fitchburg, and the Parks Department is changing the Nine-Springs E-way plan to include these buffers either through a parks and open space plan or through legislative amendments. **Box 5-1** contains more information on E-ways. Dane County Parks Department contacts are the staff planner (Jim Mueller) and the natural areas manager (Wayne Pauly).

University of Wisconsin-Arboretum

The greatest environmental problem faced by the UW-Arboretum, due to being within a developed urban area, is stormwater runoff.

The director of the UW-Arboretum, currently Greg Armstrong, said that of all the environmental problems faced by the UW-Arboretum due to being within a developed urban area, the greatest is stormwater runoff. Other related issues include reduced infiltration, decreased spring flow, and degraded native communities such as the wetlands and Wingra fen. Because of the UW-Arboretum's quality resources and the issues it faces, it is an ideal place for doing research and training on watershed management. The major focus of the Arboretum is restoration. Armstrong said that this means not only trying to restore ecological communities, but also restoring relationships between these and human communities. The UW-Arboretum works closely with the WDNR, Edgewood College, and the UW-Madison. Community involvement takes place in the form of volunteer restoration activities and educational programs and tours.

Box 5-1

The E-way and Lake Wingra.

Part of the original E-way plan developed in the 1960s and 1970s included not only natural resource areas, but also a loop that would run through the city of Madison to link these with education and cultural resources. Phil Lewis, the founder of the original plan and professor emeritus at UW-Madison, laid out the E-way because he was interested in how to protect, among other things, special landforms. He created an open space plan for Wisconsin that was funded by $50 million in revenue from Governor Gaylord Nelson's one cent sales tax on cigarettes. Lewis' focus was to protect three areas that were deemed 'cherished areas' in a public survey: waterways, wetlands, and steep hills of more than 15% grade. Lewis' programs proposed corridors composed of those three environments for the entire state. More than 30,000 acres per year have been purchased during the 10-year program. For Madison, Lewis made recommendations for a corridor near the State Capitol and the UW-Madison campus. The Madison E-way contains both urban and wilderness areas, following a route which includes Lake Wingra. To educate the community about the cultural and environmental resources along the E-way, Lewis established the Friends of Dane County Parks. This group is currently raising funds to form a Heritage Center. The goals of the center will be to provide education on natural and cultural patterns, protect environmental corridors, help identify exceptional vegetation and farm lands, and form guidelines for growth and development. Lewis is now working on determining buffers needed to protect E-ways from stormwater runoff. He recently authored the book, "Tomorrow by Design - A Regional Design Process for Sustainability." For more information, see the E-way website at http://www.geocities.com/~vicsite/Eway/home.htm.

Public and Environmental Health

Both Dane County and the city of Madison have departments of health. Since the Lake Wingra watershed is within the city of Madison, the city Public Health Department is responsible for food, water, and airborne health hazards within the watershed. Health departments regulate beaches, swimming pools, sanitary and storm sewers, restaurants, and grocery stores.

While temperature and bacteria are the main reasons for beach closures, on rare occasions turbid water or algal blooms have provided reason for closure.

Mary Ellen Testen is the current contact regarding beach closures. The Public Health Department regulates 13 beaches, of which Vilas is by far the most popular. Vilas Beach is monitored twice a week for physical and bacteriological parameters. While temperature and bacteria are the main reasons for beach closures, on rare occasions turbid water or algal blooms have provided reason for closure. The Public Health Department has long-term data on how urban runoff has been affecting Lake Wingra; monitoring of chloride, phosphorus, nitrate, and heavy metal levels has occurred since the 1940s.

The public health epidemiologist for the Public Health Department, currently Rob Savage, organizes and coordinates the investigations of suspected disease outbreaks in the Madison lakes. Savage also conducts technical background research on the health effects of what is found in these investigations. One of Savage's top priorities is investigating possible outbreaks of gastroenteritis at the Vilas Beach.

The chief of research on environmental contaminants for the WDNR Bureau of Integrated Science Systems (ISS) is currently Doug Knauer. He coordinates his work with the city Public Health Department. The chief of environmental virology for the Wisconsin State Lab of Hygiene is currently David Battigelli. Also working in conjunction with the city Public Health Department, Battigelli has done testing at the Vilas Park beach for enteric (intestinal) viruses using gene probe methods. While these methods do not determine whether viruses are infectious, they do provide useful information on how water quality is influenced by fecal contaminants. Battigelli has submitted a proposal to apply other biotechnological approaches to track pollutants in recreational waters: he mentioned that Lake Wingra would be an ideal location for one of the research sites.

Citizen Involvement in the Wingra Watershed

Organizational Activities

City of Madison Department of Planning and Development

The city of Madison Department of Planning and Development publishes "A Guide to Madison's Neighborhood Associations," which provides useful information on neighborhood features, facilities, and housing. It also details neighborhood association meetings, events, and newsletter information. Gretchen Patey works for the department and is involved with neighborhood planning; she meets with neighborhood steering committees, sends newsletters to neighborhood association presidents, and organizes both local and national conferences.

Madison neighborhoods can put together 'neighborhood plans.' These are drafted by neighborhood steering committees, whose members are appointed by the mayor and approved by the City Council. Steering committees meet for up to a year to talk about what they want to protect and change – housing, transportation, parks, and community facilities – and then they publish a neighborhood plan. Limited funds are available through Community Development Block Grants to implement these plans; neighborhood steering committees must often come up with other ways to fund their plans. Madison Parks Division has provided matching funds for past projects.

Dane County Education and Outreach Coordinators

The Dane County lakes volunteer coordinator, Danielle Dresden, also works with the Dudgeon-Monroe Neighborhood Association. She is the public officer for the Yahara-Monona priority watershed, and provides public outreach information on lake improvements to help citizen groups make informed decisions. Dresden's activities include fostering neighborhood association contacts, distributing runoff and yard care information, coordinating public events, and advertising backyard compost sales.

The Dane County parks volunteer coordinator, currently Louise Goldstein, organizes the annual Take-A-Stake-In-The-Lakes event by distributing press releases and mailings to neighborhood associations, recreation user groups, non-profits, and return volunteers. Take-A-Stake-In-The-Lakes activities include cleanups as well as informational and recreational opportunities. The cleanup of Lake Wingra is organized and run by the Dudgeon-Monroe Neighborhood Association.

Dane County's Clean Sweep program targets homeowners and small businesses, encouraging them to wisely dispose of household hazardous wastes such as waste oil, paints, aerosols, organic solvents, pesticides, and poisons. State recycling laws ban these materials from landfills. Drop-off centers include the Dane County Highway Garage, golf courses, and city gas stations. The recycling section of the Dane County webpage (www.co.dane.wi.us) has detailed information, as does the Clean Sweep hotline (294-5366). Clean Sweep is run jointly by the city of Madison and Dane County Public Works. The Dane County Public Works recycling manager, John Reindal, has tonnage data. He works closely with the Dane County landfill engineer, currently Al Czecholinski, who focuses on reducing the waste stream entering the Dane County landfill.

University of Wisconsin-Extension - Education and Outreach
UW-Extension's Environmental Resources Center established a Basin Education Program in 1998 to help meet the new management goals of the WDNR, the Natural Resources Conservation Service (NRCS), and the Dane County Land and Conservation Department. Basin educators assess local needs, facilitate the development of citizen teams that serve as external partners to the WDNR, and develop basin-wide education strategies. Suzanne Wade is the current Rock River Basin educator. (See page 76 for more WDNR extension activities.)

Mindy Habecker of the UW-Extension provides citizens with home composting information, alternative lawn-care methods, and related water quality information. (See page 76 for more of her activities.)

Lake Wingra Watershed City Alderpersons
The current city of Madison alderpersons for the Lake Wingra watershed are Matt Sloan and Ken Golden. Their main activities are to legislate and pass laws that are supported by their constituents. Sloan has worked with the head city engineer (Larry Nelson) on stormwater runoff to Wingra Creek. Plans include cleaning up the creek, dredging it, and making it a canoe area. Sloan also works with the City Commission on the Environment (see page 78). Ken Golden has worked on a pilot street sweeping project and detention pond proposals. He is an advocate for both the Monroe Street Business Association and the Dudgeon-Monroe Neighborhood Association.

Friends of Lake Wingra
The Friends of Lake Wingra (FOLW) is a diverse group of citizens, watershed residents, and representatives from the WDNR, Edgewood College, UW-Madison, and other agencies that have gathered in response to the designation of Lake Wingra as an Integrated Ecosystem Management (IEM) Project by the WDNR. FOLW members share a common desire to understand the current status of Lake Wingra, and to work together to understand the issues and choices that will define its future. The vision of the FOLW is to promote a healthy Lake Wingra through an active watershed community.

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Neighborhood Associations
A list of neighborhood associations in the Wingra watershed, their current presidents, newsletter editors, and contact information is provided in the table in *Appendix 5*. Neighborhood associations are important for community orga-

nization. Several activities involving Lake Wingra have been organized by these organizations, such as the Lake Wingra cleanups organized by the Dudgeon-Monroe Neighborhood Association.

Lake Wingra Watershed Residents

Residents of the Lake Wingra watershed ultimately have the most influence on the success of watershed management.

Residents of the Lake Wingra watershed ultimately have the most influence on the success of watershed management. Our survey of Lake Wingra watershed residents, included in *Appendix 6*, gauged resident opinions on many watershed issues. Based on over 300 responses, residents are concerned about water quality and pollution issues. For example, 82% of respondents perceive that Lake Wingra has environmental or pollution problems.

The watershed resident survey also indicated that many respondents would be willing to take personal action to improve water quality. From a list of activities ranging from cleaning up dog waste to attending public meetings on protecting water quality, more than twice as many residents said they would be willing to partake in every activity listed than would not.

See *Appendix 6* for a complete analysis of the watershed resident survey. The survey results indicate strong public support and willingness to assist in water quality and watershed improvements. Opportunities for public participation are described in a subsequent section.

Educational Institutions

There are several public and private educational institutions located within the Lake Wingra watershed. Public schools include Randall Elementary, Franklin Elementary, Aldo Leopold Elementary, Midvale Elementary, Velma Hamilton Middle School, Wright Middle School, and Madison West High School. Don Vincent, a biology teacher at Madison West, is interested in using Lake Wingra and its watershed as a teaching resource. The Madison Metropolitan School Community Recreation Association conducts summer programs on and around Lake Wingra. Private schools located within the Lake Wingra watershed are Blessed Sacrament School, Edgewood Grade School, Edgewood High School, and Edgewood College.

Current Opportunities for Public Participation in the Lake Wingra Watershed

Public participation opportunities in the Lake Wingra watershed are numerous and fall into three categories: 1) planning and program review (public comment), 2) volunteer opportunities (assisting in monitoring or cleanups), and 3) outreach (informational documents and websites). The following are ways citizens can become involved.

Planning and Program Review

- **Fisheries (WDNR):** Mike Vogelsang emphasized the importance of public involvement in WDNR fisheries programs. He noted that people can attend fish and game hearings to vote on proposed fish management plans, held annually during the second week in April. Approximately 300-400 people usually attend these meetings. Fishing groups and clubs are important stakeholders in the watershed, particularly the muskie anglers.
- **Shallow Lakes Management (WDNR):** Paul Cunningham stated that public involvement in shallow lakes management is very important, and that some level of public participation is always included in project design

and review. The extent of participation depends on the scale of the proposal and interest in the issue.

- **Wisconsin Lakes Partnership (WDNR):** Jim Leverance was instrumental in the partnership between the WDNR and Edgewood College, which led to the eventual formation of the FOLW. He stated that there are roles and participation opportunities for anyone who wants to be involved through volunteering or providing comments on issues related to lakes and their watersheds. The WDNR supports and encourages partnerships statewide.
- **Lower Rock River Basin (WDNR)**: Ken Johnson said that before new regulations are implemented within the Rock River Basin, there is opportunity for public comment. He was a key player in organizing the FOLW and was actively involved in creating other similar organizations (for example, the Pheasant Branch and Token Creek citizen groups).
- **Lakes and Watersheds Commission (Dane County):** Sue Jones stated that community input influences the focus of the Lakes and Watersheds Commission. Citizen support for ordinances and citizen lobbying of the county board in support of lake issues are high priorities for the commission.
- **Stormwater/Storm Sewers (City of Madison):** Greg Fries of the Engineering Department stated that as project opportunities present themselves, the city holds public meetings with stakeholders and neighborhood residents. The city takes comments and suggestions from non-profit groups just as they do from businesses, and their plans are often extensively modified based on public comment.
- **Planning and Construction (Madison Metropolitan Sewerage District):** MMSD planning and construction processes include public hearings and meetings. Public input is ongoing for projects such as the Lower Rock River Basin project (conducted in conjunction with the WDNR).
- **Commission on the Environment (City of Madison)**: The commission is made up of citizen representatives who give project recommendations to City Council. The mayor appoints members based on prior experience and activities.
- **Construction Site Erosion (City of Madison)**: Harry Sulzer at the Building Inspection Department can be contacted with questions or complaints on construction site erosion within the city.
- **Beach Closings (City of Madison):** The Public Health Department intake nursing staff can be contacted with questions or concerns about water quality and health at Lake Wingra's beaches.
- **Parks (Dane County):** Public feedback is a large part of long-range planning for Dane County open space and parks.
- **Parks (City of Madison):** The City of Madison Parks Commission gets citizen feedback on park and open-space plans. For individual park information contact the department.
- **Wetland Permitting (US Army Corps of Engineers):** Public involvement plays a central role in deciding which permits will be issued. The Army Corps always puts out public notices, and depending on the project, has public hearings.
- **City of Madison:** The alderpersons for the Lake Wingra watershed, currently Ken Golden and Matt Sloan, encourage public comment on all issues involving the city, such as parks, storm sewers, beaches, street sweeping, and public health.

Volunteer Opportunities

- **Water Quality Sampling (US Geological Survey):** The USGS has had success with volunteer monitoring in some basins. However, volunteer programs are limited because of logistical difficulties, such as the need for sampling during a rainstorm in the middle of the night.
- **Take-A-Stake-In-The-Lakes (Dane County):** As the Dane County parks volunteer coordinator, Louise Goldstein organizes this event. She garners citizen participation via press releases and mailings to neighborhood associations, recreation user groups, non-profits, and return volunteers. Events incorporate lake cleanup and public education on lakes and watersheds. For the last several years, the Dudgeon-Monroe Neighborhood Association has organized this event for Lake Wingra.
- **Fish Sampling (University of Wisconsin Long-Term Ecological Research)**: According to Dick Lathrop, community volunteers are often involved in fish sampling for the Lake Wingra LTER studies.
- **Park Cleanups (City of Madison)**: The Madison Parks Division works with neighborhood associations, volunteer groups, and other non-profits on park cleanups. For example, the Dudgeon-Monroe Neighborhood Association has done tree clearing, plantings, and reseeding for erosion control in Madison parks. The division has not been involved in planning for these projects, but has worked with volunteers to remove collected trash and to provide supplies.
- **UW –Arboretum**: The Arboretum holds frequent volunteer work days for restoration and other projects within the Lake Wingra watershed. Calendars of events can be found on their website, http://wiscinfo.doit.wisc.edu/arboretum/

Outreach Resources

The following outreach activities and resources were identified during our interview process. For information on additional outreach opportunities, as well as a discussion of the importance of outreach, see *Chapter 6 – Outreach Recommendations* .

- **Stormwater Runoff (WDNR):** Roger Bannerman has given many presentations on stormwater runoff to neighborhood groups and schools. He was also involved in the "Urban Runoff Run" and the production of a video titled “In Current Repair,” dealing with Madison lakes issues. The WDNR has brochures and other information about stormwater.
- **Purple Loosestrife (WDNR):** The Bureau of Endangered Resources has pamphlets on purple loosestrife and its removal.
- **Lakes and Watersheds Commission (Dane County):** The commission produces public information brochures on non-point lawn pollution.
- **Water Quality Data (Dane County):** The Regional Planning Commission provides public access to their documents. They also have water quality files, water quality plans on subject areas (groundwater, surface water), and reports for the Monona priority watershed projects.
- **Dane County Lakes (Dane County):** Danielle Dresden, the public officer for the Yahara-Monona priority watershed, provides public outreach information on lake improvements to help citizen groups make informed decisions. Dresden’s work focuses on improving water quality and the natural environment, distributing runoff and yard care information, setting up public events, and advertising backyard compost sales.

- **Parks (Dane County)** The care of the E-ways is associated with the Friends of Dane County Parks; their Heritage Center and website promote environmental awareness.
- **Parks (City of Madison)**: Madison Parks Division produces a newsletter on parks; individuals or citizen groups can submit articles for publication.
- **Beach Closings and Public Health (City of Madison):** The city Public Health Department has brochures and will field questions via telephone.
- **Neighborhood Associations (City of Madison):** The city of Madison has a website with information on its neighborhood associations, with maps and contact numbers.
- **Monitoring Data (US Geological Survey):** The water resources section of the USGS has a website with current fact sheets and data from monitoring activities in the area.
- **Wetland Restoration (US Fish and Wildlife Service):** The USFWS has publications on restoring shallow emergent wetlands, information on their Partners for Wildlife program, and wetland restoration grant information.
- **UW-Arboretum:** The Arboretum has a calendar of events that includes volunteer activities and speakers.
- **Friends of Lake Wingra:** The FOLW have a website address with current watershed issues, events, and contact numbers.

Stakeholder Analysis

Current Stakeholders

We have identified the major stakeholders in the Lake Wingra watershed. The stakeholders described in this chapter fall into two main categories: the decision-makers (managers and policymakers) and those who are impacted by, or may influence, the decision-makers' activities.

The city of Madison is the governmental unit with the most vested interest in the Lake Wingra watershed.

The city of Madison is the governmental unit with the most vested interest in the Lake Wingra watershed. The mayor, Common Council, and alderpersons all have strong policy influence on watershed activities. The city of Madison Engineering Department plays the key role regarding technical controls of stormwater runoff. The city departments of Public Works, Parks, and Public Health also play important roles in planning, research, management, and regulating usage of the lake.

Dane County, particularly through its Lakes and Watershed Commission, Regional Planning Commission, and Land Conservation Department, has significant influence on watershed management through its land use policies. County programs are geared towards countywide policies and tend not to focus on any one lake. Similarly, state level organizations frequently have a statewide focus, although the WDNR South Central regional office deals with issues specific to the region. The bureaus of Watershed Management, and Fisheries Management and Habitat play a management role in the Lake Wingra watershed.

Federal agencies do not have direct roles in the management of the Lake Wingra watershed, although federal regulations do determine wetland and pollutant regulations (the US Army Corps of Engineers and the US Environmental Protection Agency, respectively). For further discussion of federal regulations, see *Chapter 3 – A Brief History of Management*.

Non-governmental stakeholders are those who are impacted by, or have influence on, decisions that are made. These include neighborhood associations, environmental groups, recreational users, schools and universities, businesses, and residents of the watershed. These stakeholders are important because of the input and influence they may have on watershed management: they will be personally influenced by results of management activities in the Lake Wingra watershed. Among these, the Friends of Lake Wingra (FOLW) is one of the most active citizen groups dealing directly with Lake Wingra issues. UW-Madison and Edgewood College play vital roles in local research and public education regarding lake and watershed issues.

Management Gaps and Overlaps: Recommendations

Through identifying and interviewing stakeholders in the Lake Wingra watershed, we have identified 'gaps and overlaps' in management and outreach activities. The following discussion recommends how government agencies may better coordinate their activities, and work together for effective Lake Wingra watershed management.

Management 'overlaps' revealed even more 'gaps'.

We identified few 'overlaps' in the current management of the Lake Wingra watershed. This may be due to the division of management responsibilities between agencies. However, there are areas of overlap in data collection, outreach and education publications, and road salt and sand application. However, these few management 'overlaps' revealed even more 'gaps.'

Although the following programs gather similar data, they do not appear to coordinate or combine their collected information. USGS, UW-Madison LTER, WDNR, and the Madison Public Health Department collect lake and stormwater quality data. WDNR and UW-Madison LTER conduct fish survey programs. Efforts to coordinate monitoring efforts between each of these entities may lead to combined information synthesis, and may possibly lead to joint input for policymaking. In particular, staff from the city Public Health Department should be regularly conferring with other monitoring agency staff to work together on public health risks.

Outreach materials are created and disseminated by UW-Extension, WDNR, and the Dane County Lakes and Watershed Commission. However, coordination of outreach material production is not apparent. This may be due to each entity having different outreach and planning goals, and therefore not consulting with each other. Communication between each could involve 'checking in' with other staff members who produce outreach materials; this would help ensure less audience and message overlap, and may also lead to collaborative efforts of outreach material production.

Road salt and sand are applied to different areas of the watershed by the city of Madison, the city of Fitchburg, and Dane County. Dane County and the WDNR are currently working on new standards for salt and sand application, in particular for Highway 12/18. The city of Madison currently has a road salt reduction plan, and may serve as a model for other jurisdictions concerned about the effects of road salt on watershed health. Related to sand application are street sweeping efforts. The Lake Monona watershed street sweeping program – Clean Streets, Clean Lakes – would be an excellent model to implement in the Lake Wingra watershed. Municipalities, Dane County, and the WDNR need to work together to coordinate their application standards for road salt and sand, and support in-lake monitoring by research institutions so that standards can be modified to maximize lake quality.

. . . watershed-level management is vital for lake quality improvements.

There is currently no single agency responsible for managing the entire Lake Wingra watershed. This was the most important management 'gap' we identified, due to the fact that watershed-level management is vital for lake quality improvements. Although there are many agencies working within the watershed, management activities are divided so that no single agency is responsible for the whole watershed. There are divisions of different levels of government (city, county, state, and federal), different issues (stormwater versus lake management), and different locations (lakes versus uplands). For example, one agency or unit may deal with detention ponds while completely separate groups work with fisheries management, exotic plant control, or lawn runoff. The lack of management at the watershed level stems not only from the division of management responsibilities, but also because of a lack of funding for watershed-level approaches. Without one organization or staff position funded specifically for watershed management, divided management activity may fail to bring Lake Wingra to desired quality.

One method for improved management would be to create a watershed-level management position. This staff person could facilitate stakeholder communication, coordinate watershed activities, and act as a 'clearinghouse' for watershed and lake quality concerns. Perhaps most importantly, this position could have a voice in watershed policy decision-making, and could ensure that input from Lake Wingra watershed stakeholders was incorporated. If watershed-level management positions existed citywide for the Madison area lakes and their watersheds, communication between these watershed managers would be essential. Watershed-level management positions would be a possibility if Madison implemented a stormwater utility; for more discussion, see *Chapter 7 – Stormwater Utility*.

There are currently three staff positions that could be better coordinated to enhance watershed-level management. The Dane County Executive's Office has two positions, a lakes volunteer coordinator and a watershed management coordinator, and Dane County has a parks volunteer coordinator. These three positions have excellent outreach opportunities; coordinating their work with watershed-level management would be very important. Each educates the community about lake and watershed issues, and actively cultivates partnerships with citizen groups. Their work also includes organizing volunteers to clean up lakes, securing funding for watershed projects, and implementing watershed policy.

Involving the public in management is essential for the long-term success of watershed management plans (Born *et al.*, 1998).

Another identified management 'gap' was a need for more public involvement in management and policy decisions affecting the watershed. Involving the public in management is essential for the long-term success of watershed management plans (Born *et al*., 1998). This point was emphasized repeatedly by resource managers in our stakeholder interviews. Without grassroots

If citizens have opportunities to participate in management activities and policy decisions, they will be more likely to take a vested interest in the watershed and support government management plans.

backing, projects may fail in the long term. Currently, there are several avenues for the public to voice their opinion and even vote on management decisions, such as at the fish and game hearings held by the WDNR in the second week of April (Mike Vogelsang, personal communication). However, private citizens generally lack direct power to determine how the watershed is managed. City alderpersons are a direct link for the public to influence city of Madison watershed policies, and should therefore be kept current on watershed developments. If citizens have opportunities to participate in management activities and policy decisions, they will be more likely to take a vested interest in the watershed and support government management plans.

Groups or individuals may weaken the authority or political support of decision-makers, especially if these stakeholders have not been included from the start. Although we did not identify any specific groups who were openly opposed to current watershed management plans, there are many organizations that could limit the success of watershed management. Plans or regulations calling for individuals to modify their behavior have potential to be controversial issues. Public input in decision-making is critical, therefore, in the management of the Lake Wingra watershed.

Chapter 7 – Stormwater Utility suggests methods to increase public input and support, including suggestions for a small grants program. What Lake Wingra will look like in the future is ultimately up to the public; therefore, a system for public feedback and comment needs to be established. This process would necessitate much ongoing outreach and education. For more discussion on outreach methods, see *Chapter 6 – Outreach Recommendations*.

For effective watershed management, stakeholder efforts need to be coordinated.

Lack of stakeholder coordination was another 'gap' we observed in the management of the Lake Wingra watershed. At present, management responsibilities are unclear, and information is scattered. Improved coordination is needed between managers and stakeholders to prevent overlaps or conflicts. Also, great efforts should be made by citizen groups to keep communication between each other clear and open so that they do not replicate efforts. For example, the Dudgeon-Monroe Neighborhood Association coordinates a Lake Wingra cleanup, through the annual Take-a-Stake-in-the-Lakes event. It may be effective to combine this group's enthusiasm, interest, and organization with the FOLW vision and efforts.

The UW-Arboretum owns over half of the Lake Wingra shoreline, and six of the seven major treatment ponds in the basin are within its property. The UW-Arboretum is the main natural area within the Lake Wingra watershed, and is impacted by stormwater runoff. Coordinated management and communication is therefore needed to integrate stormwater runoff management with the protection of the UW-Arboretum natural areas. Edgewood College owns lakefront property and is doing stormwater treatment research that may be helpful to the WDNR and other watershed managers (see page 54). The Edgewood College campus is growing, and this means that it will need to work with government agencies to carefully manage the watershed impacts of its building construction, impervious parking lots, and road salting. The other major landowners in the Lake Wingra watershed are Madison Parks Division and the Vilas County Zoo. These entities should work closely with watershed managers: for example, agencies such as the USGS research the effects of lawn runoff research, and the city Public Health Department is interested in bacterial loading from pet waste and zoo animal sewage. The stormwater utility described in *Chapter 7* provides a means for coordinating the above stakeholders. However, without a utility that funds watershed management, strong efforts to improve coordination will be even more necessary for Lake Wingra watershed management.

Conclusion

Although relevant management plans and recommendations have been made in the past, the management 'gaps' discussed above are hindering the management of the Lake Wingra watershed. Throughout the process of investigating current stakeholders, it became clear to us that there are limiting factors for watershed management. These limiting factors are the need for watershed-level management institutional and funding frameworks, and the need for improved stakeholder coordination and public outreach. Stakeholder coordination and public outreach would be best provided by a watershed-level manager, while a stormwater utility could establish an institution for watershed-level management as well as provide a steady funding source. The final chapter of this report outlines a stormwater utility framework for the city of Madison.

Chapter 6

Outreach Recommendations

Introduction

Outreach is critical to the successful implementation of other watershed management tools. Without community involvement, support, or even knowledge of water quality issues facing Lake Wingra, little can be accomplished. Community residents are some of the most important stakeholders in the watershed, yet they are the most difficult to reach.

Resource management issues often revolve around the challenges of changing individual behavior. The discussion in this chapter focuses on the premise that awareness building and education are key for cultivating behavior changes. Once interest in watershed issues is sparked and momentum develops, groups of individuals can begin to work together on problem solving.

In researching effective outreach strategies, Water Resources Management (WRM) students spoke with several education and outreach specialists, and reviewed written materials on effective public outreach. This chapter is a synthesis of findings and recommendations, and includes both outreach materials and strategies for their effective use. The Friends of Lake Wingra (FOLW) were provided with an expanded outreach notebook which included the material in this chapter as well as detailed outreach possibilities, materials, contacts, and resources.

Outreach activities and their importance have been discussed briefly in *Chapter 5 – Stakeholders.*

Foundations for Outreach

One of the most important components of a successful outreach campaign is a strong organizational structure. Based on recommendations from diverse sources, there are seven distinct but overlapping components necessary for effective outreach.

1. Clear Vision, Goals, and Objectives

As stated by the EPA, a clear vision helps watershed groups to understand, relate to, and support protection and restoration efforts. When framed well, they can also help the general public, elected officials, business, the press, and community leaders to understand watershed issues (EPA, 1997).

The FOLW have begun to envision a plan for outreach in the Lake Wingra watershed. Their mission statement, "To promote a healthy Lake Wingra through an active watershed community," acknowledges the importance of working with the community to develop a clear and inclusive vision of what Lake Wingra could and should be.

Goals and objectives also should be developed for each aspect of the overall vision. These form the foundation for developing programs for action. Goals state the desired results of outreach activities, while objectives state the methods of attaining these goals. Clear goals and objectives include a measure of the expected outcome, supply guidance for planning, and provide the basis for developing strategies and specific tasks (Beech and Dake, 1992). Goals and objectives should be consistent with the overall vision and mission statement. Outreach goals and objectives for the Friends of Lake Wingra are discussed further on page 95 and following, and in **Figures 6-1** and **6-2.**

2. Leadership and Initiative

Strong leadership was identified as being a key component of an effective watershed organization in a survey of Dane County watershed organizations (Born *et al*., 1998). Not only do leaders organize, garner funds, and take action, but they motivate others to be involved and encourage leadership within the organization (Born *et al*., 1998). For community education plans to be effective, someone needs to take responsibility for managing or leading the process, such as an outreach coordinator.

3. Funding and Resources

Consistent and adequate funding is essential for a successful watershed organization. Even more foundational are resources such as outreach materials, experts, contacts, and the support of the watershed community. The outreach notebook given to the FOLW provides links to many of these resources.

4. Relationships

Watershed work is about relationships (EPA, 1997). Networking among organizations provides support and enables groups to learn from each other through the sharing of ideas and resources (Born *et al*., 1998). Sharing planning time, energy, and funding can lead to greater successes for all involved. Relationships between groups and individuals strengthen individual and community knowledge bases.

As relationships develop between interested community members, these people become personally involved in the work of the organization. Relationships build an organization's foundation, and keep its momentum going. Perhaps even more significantly, relationships build consensus and trust, which are vital for an organization to take on new and long-term challenges.

5. Planning

A plan is essential; the most important aspects of any plan are its scale, timeline and evaluation (see page 99). Outreach plans should be broken down into manageable activities, and should consider available time, personnel, and resources. Plans should be revisited and evaluated on a regular basis.

6. Action-Based Education

Education and involvement drive action (EPA, 1997). Environmental education resources emphasize the process of learning. Awareness leads to understanding, understanding leads to interest, interest leads to action, and action leads to commitment. An effective outreach program must address all of these attitude levels, and encourage each step. Community education activities should be active and interesting. Examples include involving citizens in gathering data, encouraging service projects, and rewarding local initiatives (see **Box 6-1**).

Community participation models stress the involvement continuum of "know, care, and do." To keep interested people involved, relationship building must be combined with result-based action. As people become involved, they gain more knowledge on issues and become committed to activities and relationships within the group. Once people are personally committed, they will become committed to the issues that captured their interest in the first place. Lower the barriers to participation, and give people activities that show immediate results.

7. Membership

Diverse membership, member commitment, and achievement recognition are essential to effective watershed organizations. It is important to target the diverse communities that make up the Lake Wingra watershed when planning outreach strategies, and to invite diverse audiences to join the FOLW. Utilizing member strengths and recognizing successes will be ongoing challenges for leaders, but in the long run these will strengthen both the FOLW and its outreach mission.

Goals and Objectives for Outreach

Mission of the Friends of Lake Wingra (FOLW)

To promote a healthy Lake Wingra through an active watershed community.

"The best plans have clear visions, goals, and action items" (EPA, 1997).

In *Top 10 Watershed Lessons Learned* (1997), the EPA defines visions as general statements of where a group or effort wants to go and what it will accomplish over a given time span. Visions can motivate individuals to take action and can help people focus their efforts on specific goals.

Box 6-1

Community education: models that work.

A successful community education program uses one or more of the following to complement a local process:

1. Personal Action
Individuals or small groups can assess and evaluate personal practices that affect environmental quality.

2. Community Service Projects
These activities respond to citizen interest by providing an opportunity to learn about environmental management through active involvement.

3. Community Environmental Monitoring
Environmental monitoring provides citizens with a hands-on opportunity to learn how environmental management decisions are made. Data is often, but not always, compiled and analyzed by natural resource or pollution prevention specialists.

4. Community Vision Planning
This process develops community vision and sets goals to address environmental, economic, and social interests. Goals are then linked to specific measures chosen by the community to indicate progress. A community identifies its goals and measures of success based on its own history and sense of identity. Once relevant goals and indicators have been chosen, community groups can make plans to meet priority goals.

5. Community Participatory Research
Participatory research involves local people summarizing their experience and knowledge about environmental management, selecting target conservation behaviors, and carrying these through.

6. Group Activities for Taking Responsibility for Impacts
Businesses, organizations, and community councils can take the lead. Individual groups can analyze their own activities and determine their own plan of action. Groups can act on their own but are more effective if their actions provide leadership in the community.

7. Community Recognition
Public recognition of successful results is a great education method.

8. Advocacy Activities
The boundary between advocacy and education is sometimes blurred. In the process of advocating environmental policy or management choices, group members often gather, summarize, and interpret information about a specific environmental issue and its relationship to the community. Not only do group members educate themselves, they often educate their community.

Modified from Elaine Andrews, UW Cooperative Education, April 1999
Adapted from "An EPA/ USDA Partnership to Support Community-based Education, Discussion Paper," 1999

Goals refer to components of the overall vision or effort. Goals are usually developed for different functional areas of a vision or mission, such as outreach, political involvement or group organization. These goals are usually somewhat general, but they should include the very essence of the program's purpose.

In contrast to goals, objectives should be specific about what will be done. They narrow down the very broad vision of the goal to something that can be accomplished through organizational resources (Beech and Dake, 1992). Objectives can be made more specific by including a single outcome and a date of completion for tasks.

Everyone in the organization should have input into goals and objectives, or at least buy into the ideas before they can be successfully implemented (Beech and Dake, 1992). Involvement from the beginning gives community members ownership and responsibility. With this principle in mind, goals and objectives should be periodically re-evaluated for purpose and relevance.

In the 1999 WRM Workshop planning for outreach, we referred to preliminary goals and objectives as defined by the FOLW for their purposes. All products were created with these and the FOLW vision in mind. Future planning and evaluation should consider these goals and objectives, and include re-evaluation.

Figure 6-1 and **Figure 6-2** are preliminary goals and objectives developed by the FOLW for their outreach program.

Figure 6-1

Friends Of Lake Wingra Preliminary Outreach Goals
Increase citizen awareness of the Lake Wingra watershed's ecological, economic, and cultural attributes.
Enhance citizen ability to understand, evaluate, and support policies and practices that protect and enhance the water and habitat quality and quantity in and around Lake Wingra.
Support citizen involvement, especially of students, in accessing and interpreting existing information and conducting new research and special projects.
Support the development of community resources and events to build a "sense of place" around Lake Wingra and its watershed.
Connect outreach for the Lake Wingra watershed to outreach work throughout the Madison lakes and Rock River basins.

Figure 6-2

Friends Of Lake Wingra Preliminary Outreach Objectives
Learning objectives:
Understand what a watershed is, and understand the significance of the Lake Wingra watershed.
Identify what affects water and habitat quality and quantity in Lake Wingra.
Identify practices that individuals can apply and practices that require collective action in the community to improve water and habitat quality and quantity in Lake Wingra.
Action objectives:
Support citizen activities that increase the individual implementation of water quality practices, and provide support to groups to implement practices that require collective actions.
Recognize and celebrate success as a means to attract more attention to, and involvement in, the Lake Wingra watershed.

Outreach Planning

Short- and long-term planning is essential for any outreach campaign. Planning should be a group process, and should be consistent with the goals, objectives, and other foundations for outreach. Brainstorming and evaluation are critical elements of planning.

Based on discussion with the Friends of Lake Wingra, the following are general planning recommendations specific to this organization. These planning components should be established for each general objective, product, or project.

Target Audience

Target audiences are groups that have common characteristics, such as education levels, attitudes, behaviors, or needs. They should be broken down into specific groups, so that they can be targeted with specific messages and strategies (Beech and Dake, 1992). Here are a few possible target audiences:

"In a sense, the target audience is the consumer of your message and program." (Beech and Dake, 1992)

1. **Homeowners of the Lake Wingra watershed**
   These include homeowners involved in the Dudgeon-Monroe Neighborhood Association, homeowners who live within a half-mile radius of Lake Wingra, and homeowners on the far side of the watershed who may not realize they are part of the Wingra watershed.

2. **Recreational users of Lake Wingra and its watershed**
   These include people who swim, boat, and fish in Lake Wingra, as well as those who hike and enjoy the natural areas and parks surrounding the lake.

3. Civic groups
These include neighborhood associations, church groups, scout troops, business associations, and schools.

Specific Objectives

Specific objectives for each product should be developed. Objectives can be theoretically broken down into two categories: learning (or product) objectives, and action (or process) objectives. Learning objectives are lessons we want the audience to learn; their success can be measured through tests of knowledge. Action objectives are practices we want the audience to do; these are not easily quantifiable.

Messages

What messages should the Friends of Lake Wingra convey? Messages should be specifically defined for different goals of FOLW outreach efforts. Some of these messages should lead to action. Action messages should specifically target activities that involve minimal time, energy, money, and materials. In short, activities should be easily accomplished by the average citizen (EPA/USDA, 1998).

Messages should be useful and relevant, and use concrete and vivid language. To effectively communicate to the target audiences, messages should also be used repeatedly, in a variety of formats and media channels.

The following are a few general messages that have been used in some of the WRM outreach materials prepared for the Friends of Lake Wingra:

1. Lake Wingra is a valuable natural area.
2. The Lake Wingra watershed is mostly urban residential.
3. Lake Wingra is being threatened by non-point source pollution from its watershed.
4. Individuals and the community can protect Lake Wingra by disconnecting home rain gutters from impervious surfaces, avoiding overfertilization of lawns, and getting involved in lake restoration efforts.

Media Formats and Channels

Media format refers to the type of outreach material produced, such as newsletter articles, signs, slide shows, or bike maps. Media channels are the channels of distribution for outreach materials, such as presentations at civic group meetings, or delivery of maps to local bike shops. The best media formats and channels for your materials depend on the message, target audience, and resources available (Beech and Dake, 1992). Examples of suggested media formats and channels can be found in the outreach notebook given to the FOLW.

Evaluation

Evaluation is an essential tool for any education or outreach. It shows you where you've been, and points you in the right direction.

When you evaluate a program, you systematically collect information about how the program operates, and the effects it may (or may not) be having on the actions of target audiences (Shepard, 1997).

Evaluation is as critical as the goals and objectives of your program. You should begin formulating your evaluation when the program begins; it is part of the planning process. Without evaluation, you will be wasting precious time and money (Beech and Dake, 1992).

Collecting data is a major part of any evaluation, but keep in mind that method follows purpose.

Before going into the details of evaluating, look at the big picture of evaluation. Collecting data is a major part of any evaluation, but keep in mind that *method follows purpose* (Taylor-Powell and Steele, 1996). To begin, use this four-question checklist:

1. *What are you evaluating?*
   What are the goals and objectives your program is trying to achieve?
2. *Why are you evaluating?*
   What are you trying to find out? Information about refining the program? Evidence of behavior change? Accountability within your program? Keep in mind that every detail will not need to be evaluated.
3. *What are you going to do with the information?*
   Who is going to use this information? Whose needs will it serve?
4. *What kind of evaluation would then be most appropriate?*
   Method follows purpose.

The following moves through steps in evaluation, continually revisiting these four questions. We will address these concepts in a way relevant to the Friends of Lake Wingra and their mission statement.

Purpose of Evaluation

An evaluation effort can have one or more specific purposes (Shepard, 1997). For the FOLW, evaluation could discover whether audience needs are being met, look for evidence of behavior change, or understand the costs and benefits of the current outreach program. As the FOLW outreach program develops, the purposes of evaluation in light of their outreach goals and objectives should be developed. One of the reasons for creating quantifiable objectives is for the purpose of evaluation.

Qualities of the program to be evaluated should be specifically identified. These may include effectiveness (achievement of desired outcomes), efficiency (outcomes compared to costs), equity (access and value for all), appropriateness (fit of program with situation), relevance (critical problem or need addressed), and utility (usefulness for users) (Shepard, 1997).

Beech and Dake (1992) describe a hierarchy of steps in the outreach process, based on *Bennett's Hierarchy of Evidence for Program Evaluation*. These seven steps increase in complexity and difficulty in terms of quantification and evaluation. A more in-depth discussion is found in the outreach notebook given to the FOLW.

1. Inputs
2. Activities
3. Target Audience Involvement
4. Reactions
5. KASA change (Knowledge, Attitudes, Skills, Aspirations)
6. Changes in Behavior
7. End Results

Internal and External Constraints
Many factors can influence how an evaluation will be conducted, and these should be identified early on. Constraints can affect the stage of the program in which the evaluation occurs, as well as the techniques possible for the evaluation (Beech and Dake, 1992).

The focus of the evaluation process should be on finding the most effective method of evaluation.

The two major constraints for most programs are the time and energy of the evaluators. This may limit the extent and depth of evaluation, but should not be a discouraging factor. Instead, the focus of the evaluation process should be on finding the most effective method of evaluation.

Evaluation Techniques
Evaluations can be done at the beginning, middle, or end of a program. Effectiveness depends on the purpose of the evaluation and the constraints for the evaluator. Four basic types of evaluation are presented below. Since they are to be used at different points in the outreach program, they have different purposes.

1. *Formative or Developmental Evaluation: before the program begins*
   A formative evaluation serves to test materials and ideas, and to understand target audiences before a project is started. It provides information during the program planning phase. Often this is a more non-formal type of evaluation, involving discussion, review, and step-by-step feedback.

2. *Process Evaluation: during program activities*
   Using process evaluation, activities can be monitored through participation and feedback throughout the course of the outreach program. Examples of process evaluations include informal discussion with participants, monitoring the number of participants or monitoring the number of requests for more information.

3. *Program Monitoring / Outcome Evaluation: immediately after activities*
   Short-term results can be measured using outcome evaluation (Beech and Dake, 1992). Program monitoring usually occurs after activities as follow up, and can be very effective at getting audience response. Questionnaires or surveys can be used to learn changes in participant knowledge, attitudes, skills, or behaviors.

4. *Impact Evaluation: long after activities*
   Impact evaluation is intended to discover long-term results of an outreach program. Impact evaluations can be very difficult to do, often requiring a pretest and post-test design to compare "before and after" circumstances of knowledge, attitudes, skills, and behaviors.

Collecting Evidence
By turning objectives into questions, you can decide upon the types of evidence that are available (Beech and Dake, 1992). Evidence can include changes in knowledge, beliefs, attitudes, or behaviors. Evaluations can include hard data (numerical) or soft data (observation based) that may or may not truly reflect the attitudes or opinions of the target audience. Evaluations are best if they are based upon valid information that represents the target audiences, but often this can be difficult and time consuming. Again, revisit the idea of con-

straints and effectiveness – find evaluation techniques that will answer your questions. Remember: method follows purpose.

There are many resources for evaluation techniques. Some can be found in the document source list, or through agencies such as local extension offices. In choosing a method of evaluation, think about the advantages and disadvantages of different methods, or consider combining methods to reveal different aspects of the outreach program (Taylor-Powell and Steele, 1996). Some basic methods for collecting evaluation information include expert or peer review, questionnaires, case studies, observation, surveys, and interviews.

FOLW Evaluation
Several components of the outreach program suggested for the FOLW can be evaluated. For each of the outreach materials provided by the 1999 WRM Workshop students, an evaluation summary is included; these are intended to be examples of product or material evaluation, not evaluations of the entire FOLW outreach program. The entire program itself, as well as the status of the FOLW in the public eye, could be evaluated using very different methods for different purposes and points in time.

For example, one of the preliminary outreach objectives of the FOLW is to help watershed residents identify what affects water and habitat quality and quantity in Lake Wingra. This objective can be evaluated from the perspective of watershed residents through asking whether people can identify water quality problems. This question can be answered and evaluated using a survey (as done for the 1999 WRM Workshop; see *Appendix 6),* doing informal interviews with visitors to a FOLW booth, or asking questions of an audience before giving an informative presentation on Lake Wingra.

Outreach Materials

The following outreach materials were specifically prepared for the Friends of Lake Wingra. In addition to the creation of these materials, strategies for their use, distribution, and improvement were developed. A general timeline for each describes the strategy steps as phases in the outreach process. **Box 6-2** shows a visual flowchart timeline.

Phase 1: implemented as soon as possible or within the next 6 months
Phase 2: implemented within the next 12 months
Phase 3: implemented over a longer timespan, as determined necessary by the FOLW

Slide Presentation

This slide show was developed for general audiences to spark interest and encourage involvement in both the Lake Wingra watershed and the Friends of Lake Wingra. It visually and orally describes Lake Wingra and its surroundings, defines the watershed concept, identifies problems in the watershed affecting water quality and quantity, and identifies individual solutions to Lake Wingra problems. The slide show's flexible format allows for changes in message, topics, and use.

Box 6-2

Flowchart of outreach material strategies.

This flowchart shows the phases for each of the outreach materials developed for the FOLW. Phases in the usage of outreach materials include expanded use, evaluation, revision, and connection to other outreach activities.

Outreach Materials	Phase 1	Phase 2	Phase 3
Presentation	• FOLW members should become well acquainted with the presentation • Give 6-10 presentations a year	• Use the presentation to boost membership in FOLW • Change topics to include new FOLW activities and current issues	• Evaluate impact of presentation • Modify presentation to meet new goals and address specific issues
Website	• Determine FOLW web contact person • Advertise web address on materials, listserver, newsletters	• Encourage more links both to and from related websites • Update website	• Explore guest book and bulletin board options • Review website for expansion and maintenance
Bike Map	• Distribute to local bike shops, and at events and FOLW presentations	• Lead bike tours • Modify map as needed; link to other bike trails	• Evaluate usage and interest • Modify map; link to other bike trails • Expand distribution
Stories	• Integrate stories into outreach materials • Share stories at FOLW meetings, events	• Use stories for new outreach materials and newsletter articles • Story hour, storytelling	• Continue to collect more stories • Consider collecting stories into a booklet

Phase 1: Members of FOLW should see and be familiar with the messages of the presentation. Some members should learn to give the presentation. The FOLW should give 6-10 presentations per year to neighborhood, church, and civic groups.
Phase 2: Use the presentation to encourage membership in FOLW. The ending can include FOLW activities or current issues. Change topics to include new activities and current issues.
Phase 3: Evaluate impact of presentation. Modify presentation to meet new goals and address specific issues.

Webpage

This website was designed to provide information on Lake Wingra and area water quality practices, and to provide links to existing information on watersheds and water quality. It could easily be appended to include recent information, and could announce FOLW and watershed events. The FOLW webpage address is http://danenet.wicip.org/fowingra/.

Phase 1: Transfer web files to FOLW website and determine a contact person. Use the web address on outreach materials, neighborhood association newsletters, and event fliers. Advertise on FOLW listserver.
Phase 2: Encourage more links both to and from other related websites. Update the website to include more calendars and current events to encourage people to visit regularly.
Phase 3: Explore the possibility of using a guest book or bulletin board to monitor usage and get feedback. Review the website for maintenance and expansion.

Bicycle Tour

This bicycle map was created to encourage the exploration of the Lake Wingra watershed. Stops are labeled and described with stories and observations, and the brochure format includes an explanation of the watershed concept. The map can be distributed both in bicycle shops and at FOLW events.

Phase 1: Distribute to local bike shops, at FOLW presentations, and at watershed events like Jazz in the Park.
Phase 2: Lead bike tours.
Phase 3: Explore expansion of distribution through business sponsors. Evaluate usage and interest; modify map as needed. Connect watershed bike routes to surrounding bicycle trails.

Stories

This short collection of stories about Lake Wingra is intended to be a resource for outreach. The stories can be incorporated into newsletter articles, presentations, or storytelling events. They serve as a means of sparking interest in the history of Lake Wingra and its watershed.

Phase 1: Collect stories on Lake Wingra. Integrate stories with other materials, such as the presentation and website. Share stories at FOLW meetings and events.
Phase 2: Story hour presentation of Lake Wingra stories at local libraries, bookstores, and events. Use stories for new outreach materials and newsletter articles.

Phase 3: Consider collecting stories into a booklet for distribution. Continue story collection.

Checklist for Outreach

As an outreach program is implemented, the FOLW will need to continue to re-evaluate all of the steps in the planning process. These steps are listed below as a checklist, to ensure that the outreach program meets their needs.

____	1	Are the FOLW vision, outreach goals, and objectives consistent with the FOLW mission statement?
____	2	Is a structure set up for the re-evaluation of goals and objectives?
____	3	Has the FOLW identified an outreach coordinator? Responsibilities include keeping track of outreach materials, and coordinating the members involved in updating the webpage and giving presentations.
____	4	Are there adequate outreach materials and supplies?
____	5	Is the funding adequate to support and increase outreach activities?
____	6	Have relevant potential relationships been identified, contacted, and involved in outreach events and activities?
____	7	Has there been communication and sharing of materials with local organizations?
____	8	Is there diverse representation within outreach audiences and FOLW?
____	9	Have under-represented watershed stakeholders been identified and involved?
____	10	Have outreach endeavors used creative approaches?
____	11	Have planned outreach activities actively involved participants?
____	12	Are a variety of media channels and formats being utilized in outreach?
____	13	Have follow-up activities been implemented for outreach events?
____	14	Does the current outreach program need to be evaluated and updated?

Lessons Learned by Outreach Experts

The following list is a compilation of lessons from outreach experts of diverse fields (see document source list). These have been chosen due to their repeated discussion in the outreach literature and in interviews with outreach professionals. The lessons are organized into a potential timeline for outreach priorities.

1. Relate objectives and activities to each other, and to long-term vision.
2. Communicate concrete and clear messages.
3. Build watershed recognition through regular events and activities.
4. Link outreach events to other established events.
5. Be flexible with time, energy, and message. Tailor your focus to audience and objectives.
6. Provide opportunities for feedback and evaluation.
7. Build community by allowing time for discussion, socializing, networking, and working on hands-on projects.
8. Become a part of the community. Develop FOLW recognition and cultivate diverse membership.
9. Recognize and celebrate successes.

The Future of Outreach

Outreach is an integral aspect of watershed management.

As the Friends of Lake Wingra develop new initiatives, their outreach program will also need to be adapted. Issues such as the city's proposal of a stormwater utility will need to be addressed in outreach material, as well as issues related to stormwater management and water quality advocacy. New messages and objectives will depend on decisions made by the Friends of Lake Wingra based on their vision for Lake Wingra and their members' stance on political issues. No matter what the FOLW goals and objectives become in the future, outreach must be incorporated into all FOLW activities. Outreach is an integral aspect of watershed management.

Chapter 7

A Stormwater Utility for Madison

Introduction

Preceding chapters of this report have included recommendations for improving water quality, and for improving watershed management, education, and citizen involvement. The successful implementation of these recommendations depends on consistent funding and a watershed-oriented institutional framework that provides coordinated management. Though various watershed management programs have been tried in the state of Wisconsin, they have their limitations. The Priority Watershed Program, administered by the WDNR, provides opportunities for comprehensive watershed management. However, the number of participating watersheds is limited, as is the duration of funding for any given watershed. Lake management districts can provide a long-term source of funding for lake management, but participation is limited to riparian landowners.

The city of Madison is currently considering a new mechanism for funding water quality improvement initiatives: a stormwater utility. If this consistent source of funding is coupled with well-coordinated watershed management and integrated citizen input, education, and outreach, then Madison will have a strong vehicle for protecting and improving its area lakes. This chapter provides an overview of the stormwater utility concept, gives examples of existing stormwater utilities and the types of programs they fund, and includes recommendations for a progressive, watershed-oriented stormwater utility for Madison.

Background

What is a Stormwater Utility?

Stormwater utilities (SWUs) are methods of financing the capital and operating expenses needed for stormwater management.

Stormwater utilities (SWUs) are methods of financing the capital and operating expenses needed for stormwater management. They have been described as "the most dependable and equitable approach available to local government to finance stormwater management" (Levin, 1997). In areas with decreasing public works budgets, they are becoming the primary funding mechanism for stormwater management programs. SWUs are similar to electric or water utilities, collecting fees based on the amount of service provided. SWU fees usually fund the planning and development, engineering, administration, operation and maintenance, enforcement, and capital improvements associated with stormwater management (John Ferris, personal communication).

SWU fees are usually proportional to the amount of stormwater runoff produced by a property. Therefore fees for individual homes with lawns are usually much less than for commercial lots with large parking areas. Fee structures are based on "equivalent residential units" (ERUs), which represent average impervious areas for all residential units in an area. Non-residential units are charged for the number of ERUs that equal their impervious area. For example, while a home would be charged for one ERU, a typical drug store with a parking lot might be charged for 15 ERUs (John Ferris, personal communication).

Common billing methods include adding the SWU fee to an existing utility bill or to property tax bills, or creating a new and separate billing system. SWU fees are usually the responsibility of the property owner, but in some cases responsibility lies with the resident. Streets, highways, rail corridors, public parks, and undeveloped lands are usually exempt from SWU fees. An exception is the Orlando, Florida, SWU, which charges all users a minimum base charge in addition to the ERU charge for managing the runoff contributed by the city's streets. Most residential SWU fees are in the range of $1 - $5 a month, with 50% in the $2 - $4 range. Local governments can decide whether or not to provide credits for properties that reduce their stormwater impact (Levin, 1997).

How Common are Stormwater Utilities?

Black & Veatch, an environmental engineering firm that helps municipalities establish SWUs, conducted a survey of 97 SWUs from 20 different states (Levin, 1997). The engineering firm Camp, Dresser, & Mckee has worked on the development of over 80 utilities and has implemented more than 60 SWU programs nationwide. The number of utilities is continually growing as communities face the significant costs associated with stormwater management. More specifically, the growth is occurring in communities that are regulated under the EPA National Pollution Discharge Elimination System (NPDES), specifically under their stormwater permitting program. This includes all communities with a population greater than 100,000, as well as many smaller communities. Reasons for SWU formation include legal requirements to implement stormwater management plans, and the need to address flood control, water pollution, property damage, streambank erosion, and habitat destruction issues (Levin, 1997).

What Do Stormwater Utilities Do?

Consistently, existing stormwater utilities fund and implement the programs needed to achieve mandated stormwater quality standards. However, as **Table 7-1** indicates, SWUs are taking on a range of programs and activities. There is much variation among utilities in terms of what management practices they use to achieve stormwater runoff standards, and whether they define additional programs, such as education and community involvement, as part of their functions.

Table 7-1
Activities commonly financed by SWUs (modified from Levin, 1997).

Stormwater Program/Activity	% of SWUs
Street sweeping	85
Public education	80
Erosion/sediment control	78
Stormwater quality management	71
Household toxin collection	67
Illegal discharge detection	59
Storm drain stenciling	58
Commercial/industrial regulation	45

Figure 7-1 is a schematic continuum of some utilities across the country. We categorized programs as "least progressive" if their only function was to fund the capital improvement projects needed to achieve mandated stormwater quality standards. Slightly more progressive utilities, such as Hollywood, Florida, focus on achieving stormwater quality standards, but also incorporate more innovative management practices such as naturescaping and natural infiltration. The "most progressive" utilities combine innovative management practices with comprehensive education programs. Components of the Orlando, Florida, and the Bellevue, Washington, SWUs are discussed below, and a full description of the functions of all of the utilities represented in **Figure 7-1** can be found in *Appendix 6*.

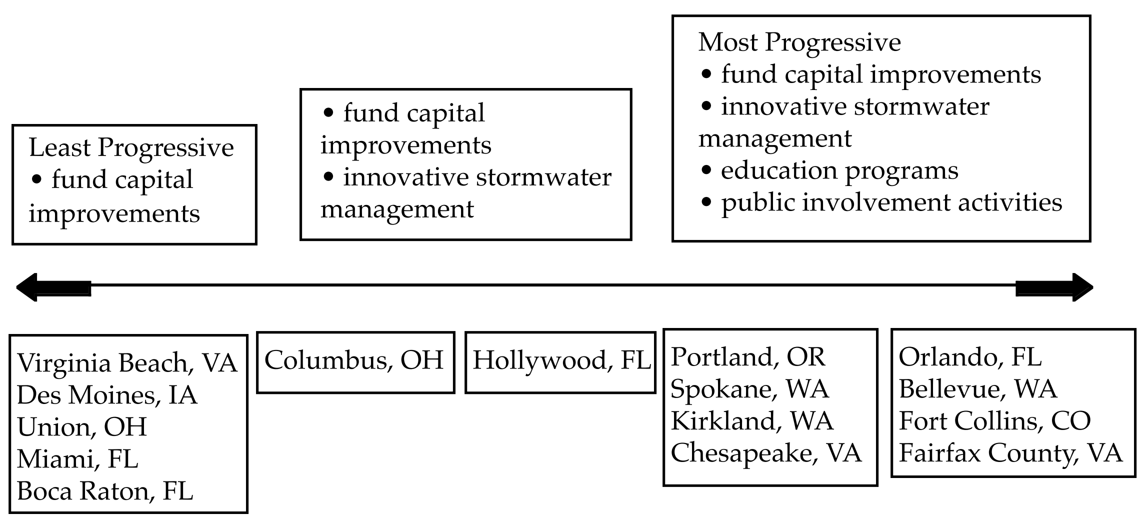


Figure 7-1
Continuum of SWUs based on the programs and activities they support.

In addition to complying with applicable regulations, the Orlando, Florida, SWU also lists lake management, education, and outreach among its responsibilities. Its SWU Bureau ensures compliance with the city SWU code, collects and maintains the data necessary to monitor lake quality, inspects private stormwater retention/detention facilities, and is involved with the enforcement of municipal codes dealing with illegal discharge of polluting substances to surface water and groundwater. The SWU Bureau also acts as a liaison to citizens by providing them access to lake water quality data, answering inquiries and complaints, and conducting public awareness and education programs. It supports the Florida LAKEWATCH program, a citizen participation program that trains volunteers to collect samples on a monthly basis. The SWU Bureau purchases needed sampling equipment, trains volunteers, and assists with the storage and transport of the samples to the lab. Further, the SWU Bureau has an active public awareness program to help inform residents of how to reduce pollutant loadings. The program includes writing articles for neighborhood association newsletters, giving presentations at neighborhood meetings and schools, presenting displays at weekend activities, and working with volunteer groups to post "No dumping, drains to lake" signs.

The Bellevue, Washington, SWU provides assistance for residents who want to enhance streams near their homes and conducts educational programs such as "Stream Teams" and "Business Partners for Clean Water." The SWU in Fort Collins, Colorado, co-sponsors youth education programs with the Northern Colorado Conservancy District, has a team of three speakers who visit elementary schools, and provides outdoor demonstrations and educational publications.

Fairfax County, Virginia, recommended that its SWU should retrain all county officials and administrators who have stormwater management responsibilities; fund non-profit initiatives to reforest, restore, conserve, and protect upstream reaches and buffer areas; promote the protection and expansion of public parkland and private conservation greenspace; and increase vegetation and forest restoration around stormwater facilities. Fairfax County also holds a general conference and public workshop about progressive on-site stormwater practices as alternatives to conventional engineering solutions.

How are Stormwater Utilities Structured?

Most stormwater utilities are operated by or within a municipality's department of public works. Sometimes the department of finance is involved with the billing (Levin, 1997). Only a handful of utilities currently have boards that serve either in an advisory or a decision-making role. The list below provides some examples of SWU administrative structure, and discusses the makeup of existing boards.

- **Ft. Collins, Colorado:** Under the direction of the City Council, a utilities general manager reports to the city manager. A citizen advisory board, the Water Board, advises the City Council on issues affecting the utility. The Water Board consists of 11 volunteer members broadly concerned with water, wastewater, and stormwater policy issues. Diverse backgrounds and interests characterize the board members, who currently include

representatives from construction, engineering, economics, political science, law, business, and consumer and environmental concerns.
http://www.ci.fort-collins.co.us/utilities/water/stormwater/index.html

- **Orlando, Florida:** The SWU Bureau is part of the city Public Works Department. There are nine members of the bureau: the bureau chief, an administrative assistant, two engineering assistants, three environmental specialists, a construction inspector, and a lake enhancement coordinator.
http://cityinter.ci.orlando.fl.us/departments/

- **Spokane County, Washington:** The SWU is housed within the county Public Works Department. The Board of County Commissioners established the SWU after extensive public participation and education, as part of the development and planning process. Public participation was made possible through the creation of the Citizens Committee on Stormwater Management.
http://web.spokanecounty.org/utilities/stormwtr/index.htm

- **Lebanon, Indiana:** The Stormwater Management Board is part of the Lebanon Utilities Board. It consists of three members, each of whom are appointed by the mayor to 3-year terms.
http://www.lebanon-utilities.com/storm.htm

- **Columbus, Ohio:** The Stormwater Management Section of the Division of Sewerage and Drainage (DOSD) of the Department of Public Works runs the SWU. SWU staff work closely with the DOSD Sewer Systems Engineering Section.
http://utilities.ci.columbus.oh.us/sewrpt.html

- **Kirkland, Washington:** Kirkland has not yet implemented its stormwater utility, but its Department of Public Works plans to hire a stormwater engineer and expand its maintenance and operation staff to handle the increased workload.
http://www.ci.kirkland.wa.us/about/

- **Union, Ohio:** The SWU is part of the city Water and Sewer Department and was established by the City Council.
http://www.union.oh.us/watersew.htm

- **Hollywood, Florida; Bellevue, Washington; Boca Raton, Florida; Cocoa, Florida; and Chesapeake, Virginia:** The SWUs for each of these cities are part of the Department of Public Works or the Department of Public Utilities.
http://www.hollywoodfl.org/pub-util/hlwd-pub.htm
http://www.ci.bellevue.wa.us
http://www.ci.boca-raton.fl.us/utility/storm.htm
http://www.chesapeake.va.us/services/depart/

Stormwater Utility Trends and Lessons

The main goals of the Black & Veatch survey (see page 108) were to identify current trends in SWUs and to assimilate the lessons that established utilities have learned. **Table 7-2** summarizes the trends identified by the survey.

The three important lessons highlighted by the survey analysis are as follows:

1. Comprehensive planning is critical. Before SWU fees are established, there is a need to identify where funds will go and what level of service will be provided. Goals of the SWU and the steps needed to achieve these should be clearly defined.

2. Public involvement is essential both before and after the implementation of a SWU. To gain public acceptance and support, it is important to identify the problems the SWU intends to address, and make those issues relevant to the community. Most utilities view public involvement as important to financing and rate determination, policy definition, service level recommendation, and as litigation protection.

3. User fees alone are not adequate to address all stormwater management needs, and should therefore be coupled with other funding methods. These methods include setting up general funds with money from a government agency, or via assessments for structural improvements (John Ferris, personal communication). Camp, Dresser, & Mckee further stresses that the most critical element in any comprehensive stormwater management program is the ability to generate sufficient funds to meet water quality and infrastructure needs.

Table 7-2
Trends in SWUs (modified from Levin, 1997).

Trend in SWU	% of SWUs
Meets most, or at least most urgent, needs	82
Covers both capital costs, and operation and maintenance costs	81
Billed on a monthly basis	74
Property owner is responsible for user fee payment	65
View public information/education to be essential to success	61
View public information/education to be unnecessary	1
Devote >2% of operating budget to public education	57
Charge between $2 and $4 a month	57
Credits given if private detention/retention practices exist	57
Use impervious cover as basis for user fees	55
Is less than 5 years old	55
Water is shut off and/or property put in lien for non-payment of user fees	54
User fee included in water or other utility bill	35
Revised user fees in the last year (89% of these revisions were fee increases)	35
User fees were legally challenged (user fees were sustained in 60% of these challenges)	16
Major runoff problems created by unusually heavy rain and/or floods	11
Revenues adequate for all needs	11

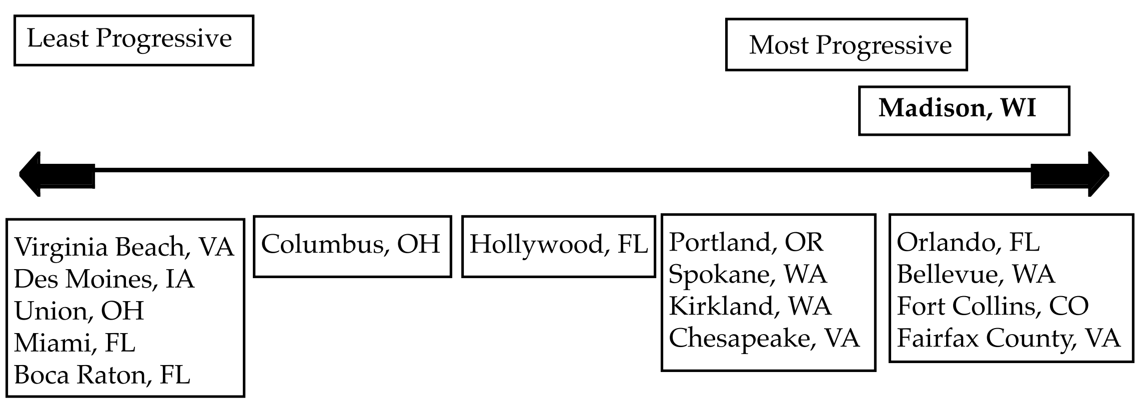
A Stormwater Utility for Madison

The city of Madison is currently considering the development of a SWU as a means to raise the funds needed to protect the area's water resources. Like many other cities, the utility plans are also being influenced by the additional sampling and monitoring requirements stipulated in their Wisconsin Pollution Discharge and Elimination System (WPDES) permit, which implements recent EPA regulations. Madison has had a WPDES stormwater permit since 1995 and will renew it in 2000. The city of Madison Engineering Division estimates the cost of meeting the new requirements to be as much as $100,000 a year.

Because the structure and function of Madison's SWU have not yet been defined, a unique opportunity exists to design and implement a progressive watershed management program. A Madison SWU should improve upon existing practices, and promote innovative strategies for managing stormwater. For example, in the Lake Wingra watershed, a SWU would provide the money and coordination needed to properly maintain detention ponds and establish a more aggressive street sweeping program, as recommended in *Chapter 4*. As discussed on page 109, the most progressive SWUs go beyond simply complying with current stormwater permits: Madison could surpass many other SWUs (**Figure 7-2**). In addition to coordinating education and public involvement, Madison's SWU could include individual incentives for reducing quantity and improving quality of runoff, offer a small grants program to fund local watershed research and projects, coordinate data gathering and accessibility, and establish a structure for significant community input and involvement. In supporting such initiatives, Madison's SWU would increase public participation opportunities and fill a current watershed-level management gap (see page 82).

A Madison SWU should improve upon existing practices, and promote innovative strategies for managing stormwater.

Figure 7-2
Potential continuum of stormwater utilities.



Incentives can be given to property owners whose management practices reduce the amount and improve the quality of runoff from their property.

Incentives for Progressive Stormwater Management Practices

Many communities have incorporated fee reduction incentives for non-residential areas into their SWU plans. Although it is important that SWU fees be charged to treat the runoff that will inevitably be produced, incentives are a crucial part of any progressive stormwater management program. Incentives can be given to property owners whose management practices reduce the amount and improve the quality of runoff from their property (see page 49). For example, owners whose practices increase the infiltration of precipitation into the soil on their property can effectively treat stormwater runoff at its source. We recommend that Madison encourage these types of practices through incorporating incentives into its SWU fee structure. Further, to encourage maximum lake protection, these incentives should not only be offered to non-residential areas, but to residential areas as well.

Non-Residential Incentives

Most commonly, fee reductions are given to larger properties such as apartment complexes, schools, and businesses. For example, businesses in Orlando, Florida, qualify for a fee reduction if they are in compliance with the Orlando Urban Stormwater Management Manual. A business with 15 ERUs would have its annual fee reduced from $990 to $574.20 for incorporating outlined practices. In Chesapeake, Virginia, a privately-owned and operated business may reduce its stormwater utility fees by up to 40% through the use of a stormwater management facility such as a detention pond. Reductions of 20% are given for meeting the required standards for pollutants or for reducing runoff to predevelopment levels.

In most cities, the property owner must demonstrate that implemented practices are reducing the quantity and/or improving the quality of stormwater runoff. In order to qualify for a fee reduction, an application must be completed and signed by a qualified individual such as an engineer or land surveyor. While site inspections by a SWU inspector will still occur, this eliminates the need for the utility to verify each application.

Residential Incentives

Reducing the SWU fee for properties that have incorporated detention or infiltration-enhancing practices encourages homeowners to use innovative techniques.

It is more difficult to offer a SWU fee reduction to single family homes simply because there are so many. However, for the same reason, it is imperative that incentives are given at this level. Residential lots produce a significant percentage of urban runoff, yet are completely unregulated. Practices implemented at the residential level have the potential to dramatically improve the quality of stormwater and decrease the volume of runoff entering the lakes. Reducing the SWU fee for properties that have incorporated detention or infiltration-enhancing practices encourages homeowners to use innovative techniques. Outreach activities could be used to teach these practices to homeowners, and the participation in one of these approved activities could qualify the homeowner for a small fee reduction.

One example of an infiltration-enhancing practice that homeowners can construct is a rain garden (see page 50). In addition, since the fee reduction might not offset the short-term cost of implementing some of the conventional management practices, less expensive stormwater management practices would also qualify for fee reductions. For example, slight modifications in downspout placement can greatly increase infiltration and could therefore be encouraged with SWU fee reductions.

Fee reductions for residential properties could be administered similar to non-residential properties. An application including questions about the use of runoff-reducing techniques, such as directing downspouts towards a pervious surface, installing rain gardens and/or detention ponds, and using cisterns for collecting rainwater, could be completed and sent to the SWU. A problem with this method is the expense of checking the accuracy of the application. A single inspector could not check all the homes in the city, and hiring multiple inspectors may not fit within the budget of the SWU. Requiring individual homeowners to hire either a stormwater engineer or other qualified individual to inspect and sign-off on their property may be asking too much of the homeowner. With an average monthly charge of five dollars, even a substantial fee reduction may not be worth the trouble. One possible solution to these problems is to have random inspections of homes paying reduced fees. It could be feasible to use the non-residential inspector to randomly inspect residential properties.

Small Grants Program

A small grants program could provide another way to support community involvement and enhance communication between the SWU administration and citizen groups such as the Friends of Lake Wingra (FOLW). Under this program, some of the funds generated by the SWU could be awarded to citizen organizations that propose projects related to water quality, aquatic habitat improvement, or public education and involvement.

Providing funding for citizen organizations is already a set precedent in Madison communities. The WDNR has a Lake Planning Grant program that has provided funds to local watershed organizations. Also, the US Community Development Block Grant (CDBG) program, created in 1974, helps cities and states meet the needs of their low- and moderate-income residents by providing better housing and a suitable living environment, and by expanding economic opportunities. Examples of CDBG grant recipients in Madison include neighborhood centers, community gardens, and affordable housing projects.

Watershed management grants have also been given to local organizations in other parts of the country. For example, the Rouge River Watershed project in Michigan has distributed more than 40 grants, totaling $5 million. Local communities have used these grants to demonstrate innovative ways to control stormwater and non-point source pollution, encouraging approaches such as streambank stabilization and erosion controls, source controls, detention basin enhancements, grassy swales on highways to collect runoff, and wetland creation and restoration.

Information Gathering and Accessibility

As discussed in *Chapter 2 –Synthesis of Technical Research, Chapter 4 – Lake and Watershed Management*, and *Chapter 5 – Stakeholders*, not only is additional long-term monitoring and research needed, but existing data and research needs to be more accessible. Long-term monitoring of spring flows, for example, could be achieved if the SWU would support a volunteer citizen-monitoring program similar to Orlando's LAKEWATCH program (page 109). Further, the SWU could serve as a data clearinghouse. A water resources management professional should be employed for gathering and maintaining the data sets available for each watershed in their jurisdiction. These data sets should be made readily available for watershed management efforts and research.

Recommended Structure for a Madison Stormwater Utility
A Madison SWU would most likely be housed within the engineering section of the city Department of Public Works (see page 117). As discussed on page 112, public involvement is critical before, during, and after the implementation of a SWU. There are several options for incorporating public input, including direct representation on a governing board, representation through a watershed coordinator who serves as a liaison between the governing body and the community, implementation of a watershed council, or some combination of these (Griffin, 1999).

We recommend a Madison SWU be guided by a board with a strong citizen voice, which enables and encourages citizens to better participate in the management of their watersheds.

We recommend a Madison SWU be guided by a board with a strong citizen voice, which enables and encourages citizens to better participate in the management of their watersheds. Active citizen participation will also help the SWU be flexible and responsive to community interests. To further ensure the involvement of the watershed community, a watershed coordinator should serve as a liaison between the SWU board and watershed stakeholders, and promote outreach and education programs.

Stormwater Utility Board
Existing SWU boards vary in terms of their goals, effectiveness, leadership, stakeholder composition, involvement in "real" decision making, types of participation allowed, financing, efficiency, and decision-making procedures (Griffin, 1999). The above components will need to be considered when defining the membership and function of a Madison SWU board.

Ideally, a multi-interest board would bring the needed diversity to the decision-making process, and limit biases of particular projects over others.

The Madison Metropolitan Sewerage District (MMSD) board provides a local model of how diverse interests can be represented. The MMSD board has five members appointed by the county executive and approved by the County Board. The appointed board members must reside within the district served by the MMSD. The board votes only on policy issues, and on decisions and responsibilities that are required by state statutes. They are not involved with day-to-day "in-house" issues. The board members include a retired UW-Extension professor of governmental affairs, a city of Fitchburg planner (also on the Regional Planning Commission), a retired UW-Madison professor of civil and environmental engineering, a Sierra Club legislative issues representative, and an attorney (also the County Board supervisor).

Stormwater Utility Board Membership
Based on the composition of similar utility boards, including the MMSD board, we suggest that the Madison SWU board consist of approximately 10 appointed individuals. They should all reside within the watershed boundaries of the managed area, and each subwatershed should have weighted representation, perhaps by population. Individuals with expertise in stormwater management, shallow-lakes management, outreach, planning, and law would be particularly helpful as board members. Community representa-

tives from watershed organizations, business associations, lake user groups, and neighborhood associations should also be appointed to the board. Some of the individuals with expertise in water resources may work for government agencies; they should only be allowed to serve on the board as private citizens, not as representatives of the agencies they work for. Ideally, a multi-interest board would bring the needed diversity to the decision-making process, and limit biases of particular projects over others.

Stormwater Utility Board Function

While SWU staff would run the day-to-day operations of the SWU, the board would guide direction by making funding and policy decisions. As exemplified by other SWUs across the country, generated revenues can be used for much more than engineering approaches to treating stormwater. Once the administrative and operating costs were determined, the board would decide how the remaining funds would be used (e.g. outreach and education programs). Further, the board could advise the SWU staff on the level of community support for in-lake and watershed management practices.

Watershed Coordinator

While we are suggesting that there be significant community representation on the SWU board, there is still the need for a liaison between the SWU and the public. A watershed coordinator would identify the interests of watershed residents and bring them to the SWU board for their consideration. The coordinator would also be responsible for the planning and implementation of education and outreach programs. A key component of education programs could be demonstrating practices that would qualify individuals for the residential fee-reduction incentives discussed above.

For effective management, several coordinators, for example one for each of the major watersheds that Madison incorporates, may be needed for the Madison SWU. In order to be knowledgeable about different stakeholders, management practices, and watershed features, coordinators must work at a small enough scale for meaningful interaction with the watershed community.

Political Process of Stormwater Utility Implementation

While the city of Madison is currently exploring the possibility of implementing a SWU, the exact nature of the legislation and infrastructure needed has not been determined. Dane County has also considered a revenue-generating utility for stormwater management, but there are no immediate plans to develop one. For more details on the current status of municipal, county, and state stormwater plans and how they affect the Lake Wingra watershed, see *Chapter 3 – A Brief History of Management*.

The development of the SWU plan will most likely follow these steps:

1. The city of Madison Engineering Division of the Department of Public Works is currently developing a fee structure based on impervious area

calculations for the entire city. According to this plan, non-residential property owners would be charged a fee based on the amount of impervious area on their property. Residential property owners would be charged a standard ERU fee (see page 108); there may be multiple residential categories for different housing densities. The city Engineering Division plans to complete this assessment by the spring of 2000.

2. When the Department of Public Works completes its assessment and recommendations, it will notify the city of Madison Common Council, who will begin circulation and discussion of the proposed SWU plan. Individual alderpersons often sponsor plans, but in this case the Council as a whole will probably sponsor it.

3. The Common Council will probably spend very little time on the plan at this time, but will send it to various groups for public review, including the Board of Estimates, the Council on the Environment, and the Department of Public Works.

4. There will most likely be an additional period of public hearings because the proposed legislation would involve instituting citywide fees. A citywide referendum is not currently planned, however, and would not be required to pass SWU legislation.

5. After the hearings, Public Works will again present the SWU plan to the Common Council, including any changes based on the hearings. The Council will vote on whether or not to implement the SWU. Wisc. Stat. Sec. 66.072, which authorizes municipalities to form SWU districts, stipulates that a three-fourths vote of all members of Madison's Common Council is required to establish the district (Prey *et al*., 1995).

6. The Madison SWU could take one of the following structures:
   a) Report to the Public Service Commission, which requires a SWU board of directors. Both the Madison Water Utility and the Madison Metropolitan Sewerage District report to this commission.
   b) Report to the city Common Council through Public Works. The Madison Sanitary Utility reports to the Council. A board is neither prohibited nor required.
   c) Report to the city Common Council through Public Works and have a board of directors and/or an advisory committee.

The city of Madison is currently working on developing the fee structures, and by December 2000 plans to move to the assessment and recommendation phase (step 2). Presentations of SWU recommendations have been made to the Council on the Environment by both the city Engineering Division and members of the 1999 WRM Workshop.

We recommend that a Madison SWU report to the city Common Council, have a board of directors, and empower the public by having an advisory board with citizen representation.

As of August 1999, the city had not determined which management structure would be the most appropriate. Greg Freis of the city Engineering Division felt that reporting to the Common Council instead of the Public Service Commission would keep the utility closer to the public voice, as citizens have direct access to alderpersons. While the idea of reporting to a board has not been considered by the Engineering Division, no objections were voiced during recent conversations with their staff (August 1999).

We recommend that a Madison SWU report to the city Common Council, have a board of directors, and empower the public by having an advisory board with citizen representation.

Conclusion

If the city of Madison designed a SWU to incorporate the components discussed in this chapter, it would have an excellent watershed-based management tool. **Box 7-1** contains a summary of management recommendations for the Lake Wingra watershed that were mentioned throughout this document. All of these could be addressed and implemented through the funding, coordination, and programming of a stormwater utility.

As outlined in *Chapter 4 – Lake and Watershed Management*, there is a need for improving upon standard stormwater management practices such as detention ponds and street sweeping. A Madison SWU could coordinate detention pond inspections and maintenance, and provide the needed funding to promote more comprehensive street sweeping programs. There are also significant opportunities for improving stormwater quality and quantity through more innovative and less expensive management practices. A SWU fee-reduction incentive program would promote these practices such as rain gardens and 'disconnecting' residential roof downspouts.

Box 7-1

Management recommendations for the Lake Wingra watershed.

Stormwater Management Practices

- Stormwater treatment pond maintenance
- Wetland protection
- Street sweeping program expansion
- Diffuse infiltration implementation
- Innovative management practices

Research

- Comprehensive long-term monitoring
- In-lake restoration and management
- Further research areas
- Impact of groundwater pumping on water levels, springs, and fens
- Habitat restoration
- Wetland protection

Stakeholder Coordination

- Implement watershed-level management
- Improve communication between watershed stakeholders
- Increase public participation opportunities
- Improve data accessibility, communication, and coordination

Education and Outreach

- Incorporate into every program

The synthesis of technical research conducted in the Lake Wingra watershed highlighted several areas where additional monitoring and further research would be beneficial. A SWU and/or a watershed coordinator would provide the needed support to sustain a volunteer monitoring program. Volunteer monitoring would be less expensive, and would provide an excellent way to educate and involve the community. A small grants program supported by a SWU could prioritize funding for proposals involving research and restoration of identified key areas – that is, wetland, shoreland, and habitat restoration.

There is presently a diverse array of management agencies involved in the Lake Wingra watershed (see *Chapter 5 – Stakeholders*). A Madison SWU could serve as the entity performing and coordinating watershed-level management. A SWU board would ensure that the utility would not conflict with the current management structure. The board could work closely with several agencies, in particular the Dane County Lakes and Watersheds Commission and the WDNR Non-Point Program. The proposed Madison SWU could fund projects involving many agencies outside of the city Department of Public Works, therefore coordination of many agencies will be imperative. The overall goal of a SWU would be to achieve integrated watershed management, and to succeed in protecting the area lakes.

Both *Chapter 5* and *Chapter 6* (*Stakeholders* and *Outreach Recommendations* respectively) of this document highlight the need for increased public participation opportunities. In addition to providing a consistent source of funds for outreach and education programs, Madison's utility could go further to empower citizens by giving them decision-making authority as board members. Further, watershed coordinators can ensure that public interests are taken into account. Much of this document on the Lake Wingra watershed – the synthesis of technical research, the stakeholder analysis, and the outreach strategy – would assist a watershed coordinator, and serve as models for the other Madison watersheds.

We challenge Madison to deal with stormwater in a progressive and forward-thinking manner through the implementation of its own SWU.

Funding is a major roadblock to many of our recommended solutions, but is an issue a SWU would address. There are, however, many things that can be accomplished even without increased stormwater management budgets. These include improving communication among resource managers, incorporating citizen input into management decisions, and soliciting the volunteer support of local watershed organizations to educate individuals on how they can protect our lakes against stormwater runoff.

In summary, the concepts presented throughout this document, while focused on the Lake Wingra watershed, have the ultimate goal of protecting and enhancing the Madison lakes. We recommend innovative approaches for dealing with the main issue facing these water bodies – stormwater runoff. Effective management of stormwater runoff and other forms of non-point source pollution requires a coordinated approach, and the involvement of all those living and working within that watershed.

We encourage resource regulators and managers to accept the challenges involved with holistic approaches to resource management. We challenge Madison to deal with stormwater in a progressive and forward-thinking manner through the implementation of its own stormwater utility.

Appendix 1

Stormwater Data

A. Concentrations (mg/l) of stormwater constituents from storm sewer and creeks entering Lake Wingra.

	Manitou Way	Nakoma Road	Glenway Street	Knicker-bocker St.	Van Buren Street	Marshland Creek
Calcium	11	9.4	8.5	7.4	8.6	65
Magnesium	3.7	3.4	2.6	2.2	3.1	6.8
Sodium	7.8	7.3	5.4	2.6	6.0	95
Potassium	3.1	2.7	2.4	3.5	4.5	3.1
Bicarbonate	46	40	35	28	38	136
Carbonate	0	0	0	0	0	0
Sulfate	11	9.0	10	9.2	11	15
Chloride	9.2	6.8	3.9	2.0	5.8	190
Fluoride	0.1	0.1	0.1	0.1	0.1	0.5
Nitrate	2.7	4.4	3.4	3.4	3.1	0.2
Dissolved Solids	77	70	52	46	71	463

Modified from Prentki et al. (1977)

B. Average annual loads (kg/yr) of forms of nitrogen and phosphorus from various sources into Lake Wingra.

	Nakoma storm sewer	Other storm sewers	Marshland Creek	Springs	Groundwater	Wetfall	Dryfall
DIP	200	160	130	43	44	17	0
DOP	32	26	20	0	0	0	0
Particulate P	220	150	120	39	0	23	95
Total P	450	330	260	82	44	41	95
DIN	800	450	480	8600	9700	1000	0
DON	910	520	520	0	0	0	0
TON	2600	1500	1500	0	0	370	1000
Particulate N	1700	980	980	0	0	370	5900
Total N	3400	1900	2000	8600	9700	1400	1900

Other storm sewers = Manitou, Knickerbocker, and Mallat
Modified from Prentki et al. (1977)

C. Concentrations of suspended solids, total phosphorus, and dissolved phosphorus at the Monroe Basin.

	Lawns	Feeder Street	Collector Street	Arterial Street	Parking Lots	Pitched Roofs	Flat Roofs
suspended solids (mg/l)	75	60	46	64	44	18	20
total P (mg/L)	0.99	0.31	0.16	0.17	0.09	0.06	0.12
dissolved P (mg/L)	0.61	0.14	0.04	0.03	0.02	0.02	0.02

All values shown are the medians of the sample data.
Modified from Waschbusch et al., 1999.

Appendix 2

Lake Wingra Watershed Spatial Data Repositories

Aerial Photos

The best way to locate traditional stereoscopic aerial photos for the Lake Wingra watershed is through the State Cartographer's Office (SCO) website at http://feature.geography.wisc.edu/sco/sco.html. The SCO website has a catalog of aerial photos for the state of Wisconsin that includes the year and season of the flight, scale, area covered, format (black and white, color infrared), and location. Many of these photos are available at the Arthur Robinson Map Library in 310 Science Hall at the University of Wisconsin–Madison. However, some are held at other government agencies (Department of Transportation, Earth Resources Observation Systems Data Center) and private firms. The SCO has contact information for all sources of aerial photos listed in their website catalog.

Orthophotos

Aerial photo imagery is usually distorted because of the relief of the terrain being photographed and/or the perspective projection of the camera. This distortion is manifested in a varying scale throughout the image. Orthophotos are digitally corrected aerial photos that re-establish a uniform scale and, therefore, are more readily useable for measurement and spatial analysis. They are particularly useful when developing a GIS database for an area.

Since orthophotos are expensive to produce, coverage of many areas may be limited or nonexistent. Fortunately, a few orthophoto data sets are available for the Lake Wingra watershed from 1992, 1995, and 1997. Respectively, the agencies maintaining these data sets are the EROS Data Center (http://edcwww.cr.usgs.gov/webglis), the Dane County Land Information Office (http://216.56.2.131/lio/lio_home_page.htm), and the city of Madison Engineering Department. The Land Information and Computer Graphics Facility (LICGF) at the UW-Madison also has access to several of these orthophoto data sets (http://rat.lic.wisc.edu/).

GIS data

Geographic Information System (GIS) data sets are generated for various purposes by public agencies, private firms, and individuals. There is no central repository for data sets pertinent to watershed management; therefore, searching out and acquiring these data can be time consuming.

The Land Information and Computer Graphics Facility at the UW-Madison has compiled GIS data sets relevant to Lake Wingra watershed management; these are maintained at Edgewood College. Other GIS data sets may, however, be useful to Lake Wingra watershed residents. The following are entities that maintain, distribute, or provide procurement information on GIS data.

- University of Wisconsin, LICGF
  Math Heinzel, wheinzel@facstaff.wisc.edu
  http://rat.lic.wisc.edu/
- Dane County Regional Planning Commission
  http://www.co.dane.wi.us/rpc/rpc.htm
- City of Madison, Engineering Department
  Jeff Dux, 266-4751
- City of Madison, Planning and Development
  Pete Olson, 267-1150
- Edgewood College
  Jim Lorman, lorman@edgewood.edu

Satellite Imagery

Many agencies provide satellite imagery for use in environmental monitoring and resource management. However, Landsat (USA) and SPOT (France) images are the most common. There are a large number of images available of the Lake Wingra watershed, and a variety of image types (e.g. multispectral and color infrared). Therefore, searching for the proper image for an application can be time consuming. The State Cartographer's Office webpage (http://feature.geography.wisc.edu/sco/sco.html) offers a number of excellent links to sites where images can be found and ordered through public agencies and private firms. Also, the US Geological Survey Earth Resources Observation Systems data center's website (http://edcwww.cr.usgs.gov/) is useful for obtaining the commonly used Landsat images.

Maps

The US Public Land Survey produced the earliest maps of the Wingra watershed in the early 1830s. These maps and their surveyors' notes are available at the Wisconsin State Historical Society in Madison through their state archives office. The Historical Society also has Lake Wingra watershed maps of topography, hydrography, original vegetation, and streets from the 19th and 20th centuries.

Another excellent source for maps of the Lake Wingra watershed is the Robinson Map Library at the UW-Madison in Science Hall. They have a complete collection of USGS topographic maps covering the Wingra watershed beginning in 1887.

Appendix 3

Phosphorus Study

Introduction

Stormwater runoff and associated contaminants come from a variety of urban sources, including driveways, streets, and roofs. All of these sources are potential targets for volume reduction and pollution control efforts. Lawns are no exception, comprising approximately 65% of Madison's urban area (Washbusch *et.al*., 1995). While often acting as a buffer between impervious contaminated surfaces and our lakes and streams, lawns can also act as a source of contamination. A US Geological Survey (USGS) study found a significantly higher concentration of phosphorus in lawn runoff than in runoff from driveways, streets, rooftops, and other sources (Wascbusch *et. al*., 1995).

Although lawns produce less runoff per square foot than streets and rooftops, they still contribute about 20% of the total runoff in the Wingra watershed (Washbusch *et al*., 1995). Phosphorus loading into lakes is dependent on concentration of phosphorus and volume of water. Lawns may not be the largest contributors of phosphorus to Lake Wingra, but they do contribute a sizeable portion of the total phosphorus load.

The WDNR, the USGS, and the graduate students of the Water Resources Management Workshop studied the extent to which residential lawns are a source of the phosphorus found in stormwater runoff. This study examines the difference in phosphorus levels between fertilized and non-fertilized lawns.

Project Description

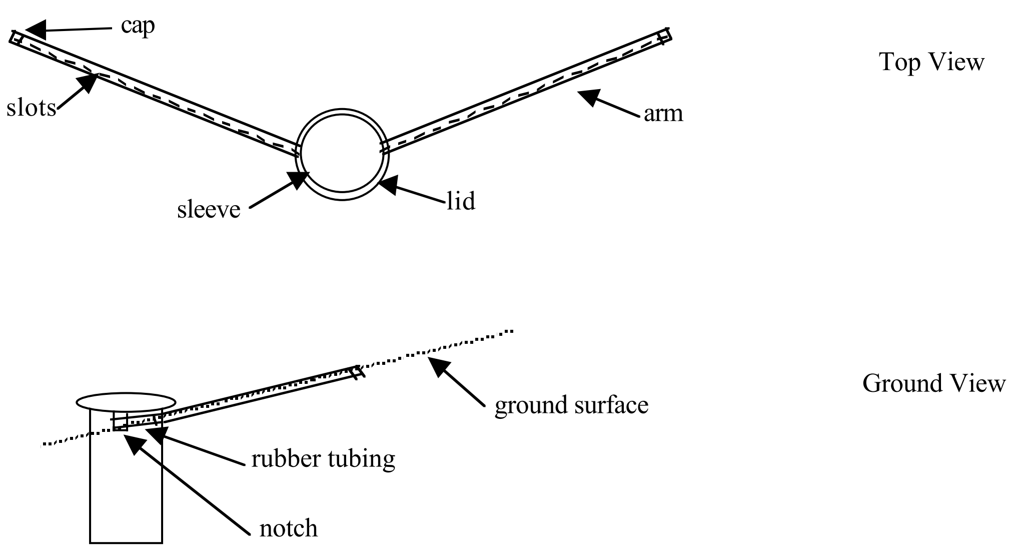
Thirty lawns in the Lake Wingra watershed were selected for runoff analysis. The purpose was to determine whether fertilized lawns produced higher concentrations of phosphorus than unfertilized lawns. Half of the lawns had been fertilized at least twice the previous year, and at least once at the start of the study period (May through September of 1999). The owners of these lawns planned on fertilizing at least once more during the study period. The other half of the lawns had not been fertilized within the past year, and owners had no plans for fertilizing during the study period.

The lawns were selected based on size and uniformity of slope, tree canopy, and location of downspouts. Steep lawns produce more runoff than flat lawns. Although no precise measure of slope was taken, lawns selected were neither completely flat nor steep. Lawns with variable slopes, or "bumpy" lawns, make installation of the sampler arms difficult (see **Figure A3-1**) and can allow runoff to bypass the samplers, so lawns used were relatively uniform in gradient. Excessive tree canopy intercepts rain, therefore producing less runoff over a given area; when possible, treeless lawns were used. Downspouts directed into the study area contribute runoff from rooftops, and so all downspouts were directed away from samplers.

Samplers were installed in each lawn, and various tests were run for quality control purposes. Distilled water swirled in the bottles left in the samplers for five days showed phosphorus levels between 0.04 and 0.15 mg/L. Results could have been skewed by the presence of bugs, or leaf and grass debris, which would yield higher phosphorus levels. These numbers are one to two orders of magnitude smaller than actual levels of phosphorus found in the runoff samples. Distilled water was also run through sampler arms that had been in the lawns for five days. Sampler arms had higher phosphorus levels than the empty bottles, but still at least an order of magnitude smaller than levels found in the runoff. Again, the presence of insects, or leaf and grass debris could have caused variations. The distilled water and the non-phosphorus soap were also tested for phosphorus, and showed negligible levels.

Based on these analyses we developed a protocol regarding the amount of time bottles and arms could be in the field before being replaced or cleaned. Bottles were replaced 48 hours before an expected rainfall event. Arms were cleaned no more than four days before an expected rainfall event. In addition, samples were removed from the field within 18 hours of the cessation of a rainfall event; after 18 hours, chemical and biological processes will affect the phosphorus concentrations in the sample.

Figure A3-1
Lawn samplers (not to scale).



The Wisconsin State Laboratory of Hygiene requires at least 30 ml to analyze for total phosphorus. The samplers often had less than 30 ml after an event. In such cases samples from different lawns were combined in equal amounts to produce samples of sufficient volume. While combining samples does not affect the calculation of mean phosphorus concentrations, it does make it difficult to estimate the lawn-to-lawn variability in phosphorus concentrations. As a result, we were not able to conduct statistical tests of significance. Results are reported as mean phosphorus concentrations for fertilized and unfertilized lawns for each of four storm events. Dissolved reactive phosphorus was analyzed when possible, and is also reported as mean phosphorus concentrations for fertilized and unfertilized lawns for each of the storm events.

Results

The results of the study can be seen in **Figures A3-2** and **A3-3**. These figures show the concentrations of total and dissolved phosphorus from fertilized and unfertilized lawns. The graphs suggest that there were higher concentrations of phosphorus in runoff from unfertilized lawns for each of the storm events.

Figure A3-2
Mean total phosphorus concentrations.

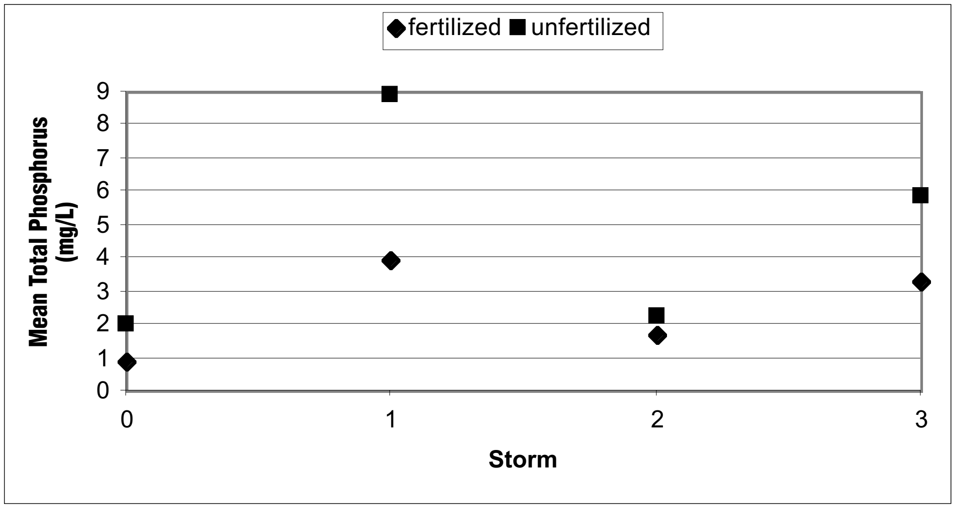
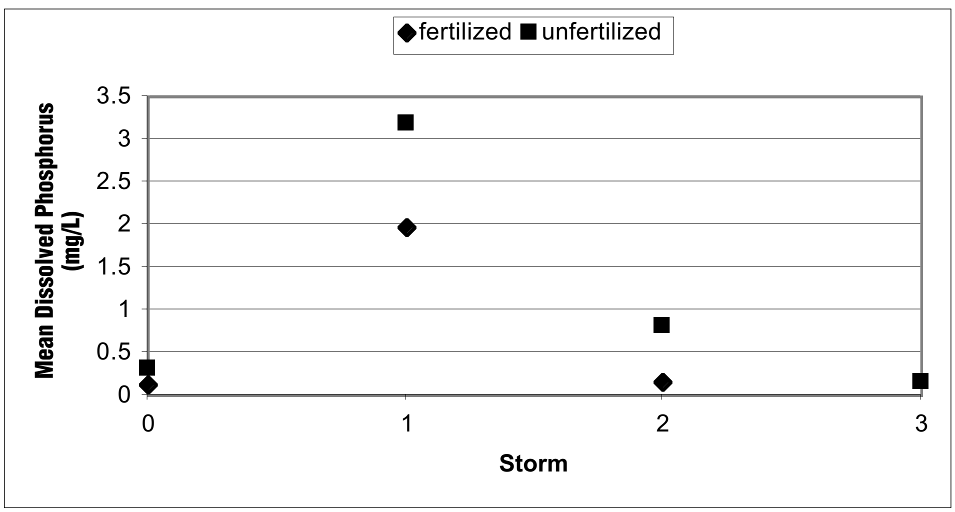


Figure A3-3
Mean dissolved phosphorus concentrations.



Discussion

Due to the large number of combined samples, no tests of significance were performed on the study data. However, based on the graphs in **Figures A3-2** and **A3-3**, it would appear that unfertilized lawns produce greater concentrations of phosphorus in their runoff than do fertilized lawns. It may seem unlikely that regular applications of granular or liquid phosphorus fertilizer would result in smaller concentrations of phosphorus in the runoff. However, lawns are fertilized to make their grass healthier and thicker. It is not unreasonable to expect that infiltration rates would be higher in healthier lawns, thereby allowing soluble fertilizer to be transported to the plant roots, and hence not be available for overland transport in runoff. Less healthy lawns may have lower infiltration rates and higher runoff rates, which could result in transporting loose soil particles containing phosphorus.

Conclusion

In future lawn studies, there are several steps that can be taken to ensure that collected data can be statistically analyzed. The most important step is to analyze samples from each lawn separately to preserve lawn variability. Two research design changes would help to ensure this by enabling the collection of a larger sample volume: sampler design and irrigation.

New sampler designs, when placed in proximity to a sampler of the old design, have proved to be much more effective in collecting runoff. Events of only a few tenths of an inch produced samples in the new design, while the old design remained dry. This new design consists of larger arms with larger slots, a completely enclosed drainage area, and bentonite clay seals for the bottom of the arms.

Irrigating study lawns would also ensure a large enough sample size. Although irrigating would eliminate the natural variability of storms, it could mimic the watering that residential lawns often receive. Knowing the volume of water irrigated would enable the researcher to determine the relationship between runoff and infiltration. In addition, a phosphorus load could be calculated, which is much more valuable than simply knowing the phosphorus concentration.

It is the intent of the WDNR and the USGS to continue this study into the spring and summer of 2000. With the above-mentioned changes in place, a more useful data set will be collected. Recommendations regarding the application of phosphorus-based fertilizers to urban residential lawns can be made at that time.

Appendix 4

SLAMM Data

The Source Loading and Management Model (SLAMM) has been used to estimate the contribution of runoff and pollutants from land areas. The city of Madison has calculated these contributions for most of the 39 subwatersheds in the Lake Wingra watershed, allowing comparisons between different areas of the watershed. Although more research and testing are required to ensure reliability, the following preliminary summary of SLAMM results are provided for reference.

SLAMM data are based on land use types. For example, commercial areas are known to produce more runoff than low-density residential area due to a higher percentage of impervious surfaces, such as parking lots and rooftops. High-density residential areas produce more runoff for the same reason, but may produce less phosphorus than low-density residential areas because sediment, leaves, and fertilizer from lawns contribute more phosphorus than rooftops and driveways.

The city of Madison SLAMM analyses utilize broad, citywide land use categories – therefore caution must be used when viewing and evaluating the data. For example, **Table A4-1** provides a comparison of a USGS analysis of the Monroe Street retention basin (UW-Arboretum pond 5) and a city of Madison analysis of outfall 192 in subwatershed 2. While the watershed area and land use type draining to both pond 5 and outfall 192 are roughly equivalent, there are fairly large differences in the particulate solids results. This can be explained by the fact that the USGS analysis utilized more detailed land use categories specific to the Wingra watershed. Therefore, the USGS results are probably more representative of the Wingra watershed and they exemplify the difference that more detailed land use categorizations can make. The data in **Table A4-1** can hopefully serve as calibration tools while viewing the city of Madison SLAMM estimates, which are provided in the remaining tables and figures of this appendix.

Table A4-1.
SLAMM results for the Monroe Street retention basin watershed (Judy Wierl, personal communication) and for Storm Sewer Outfall 192 watershed in subwatershed WI-02 (Greg Freis, personal communication).

Measurement	USGS	City of Madison
Area of Watershed (acres)	232.2	.53
Total Precipitation (inches)	33.54	30.36
Rainfall April 1 - October 31 (inches)	25.01	26.75
Runoff (inches)	11	9.51
Runoff / Rainfall (inches)	0.440	0.356
Particulate Solids (lbs./year)	33,265	41,662
Part. Solids (lbs./acre/inch of rainfall /year)	5.7	7.4
Part. Solids (lbs./acre/inch of runoff /year)	13.0	20.7

**Note that the two studies use precipitation data from different years (1994 and 1981 respectively).*

Figures A4-1 through **A4-4** summarize the city of Madison SLAMM data, dividing the Lake Wingra watershed into 8 subwatersheds. **Table A4-2** following the figures presents data from the smaller 39 subwatersheds, showing which of the 39 contribute the most of various pollutants (A map showing the subwatersheds of the Wingra watershed will be made available in UW-Madison's Institute for Environmental Studies library). The city of Madison does not have data for subwatershed 6 because it is completely within the town of Madison and the UW-Arboretum. All of the runoff from subwatershed 6 flows to Wingra Creek (some via Gardner Marsh), and therefore has no direct impact on Lake Wingra.

The data summary presented here is not intended as a guide for watershed management decisions, but as a summary of preliminary SLAMM results. Further work with SLAMM modeling may eventually allow watershed managers to identify areas of the Lake Wingra watershed that contribute pollutants most heavily. This information could then be used to make informed decisions regarding which management practices would be most appropriate for which areas.

Figure A4-1
Wingra sub-basins (1-8) runoff proportions (based on city of Madison SLAMM data).

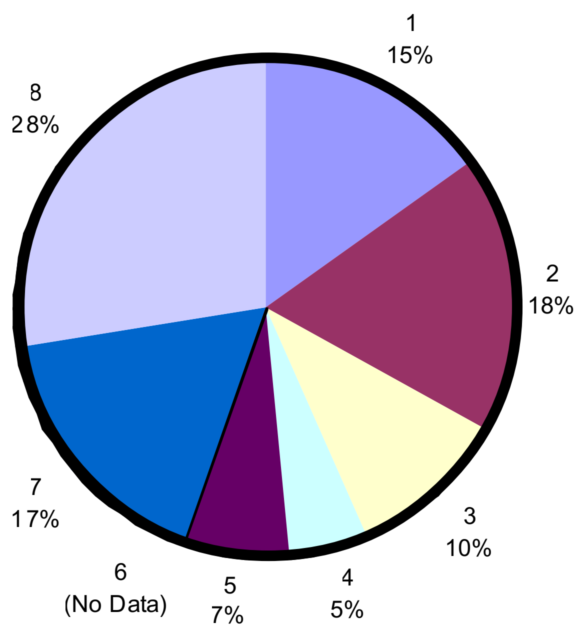


Figure A4-2

Wingra sub-basin areas and runoff.

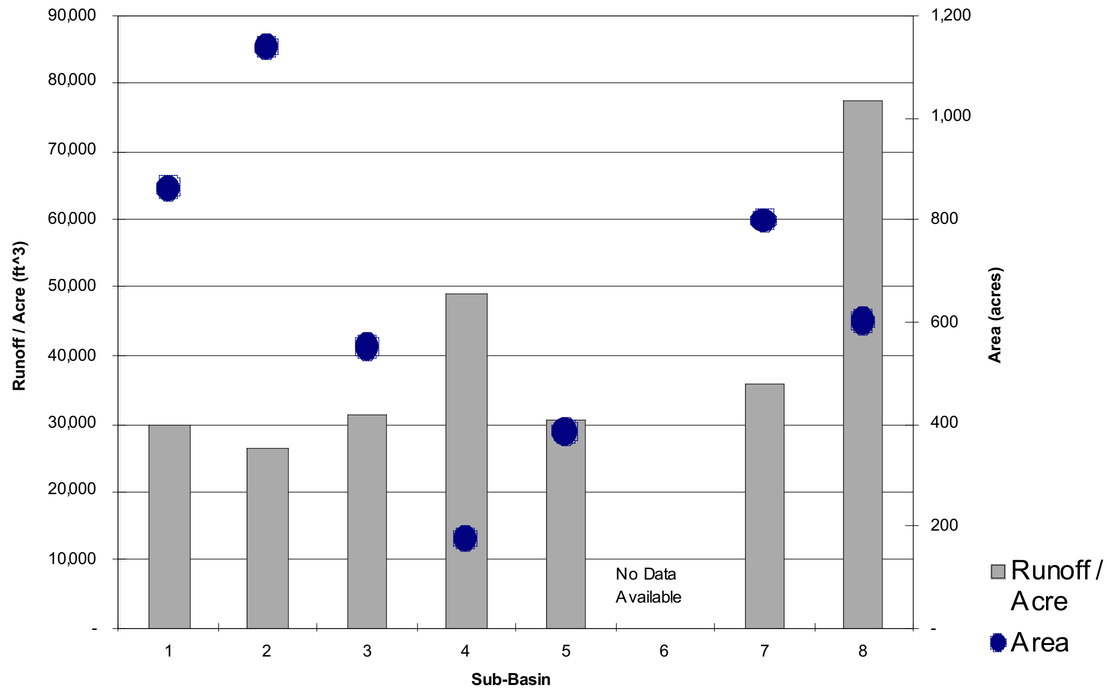


Figure A4-3

Wingra sub-basins: pounds per year of Cu, Zn, and P per Acre.

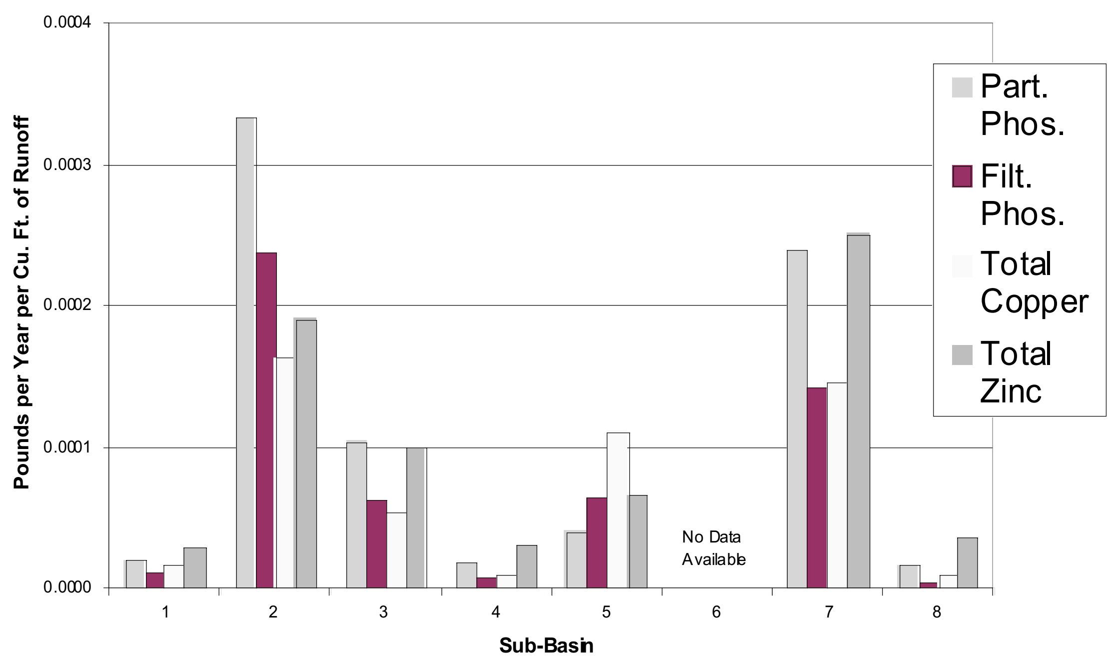


Figure A4-4
Wingra sub-basins: solids pounds per year per acre.

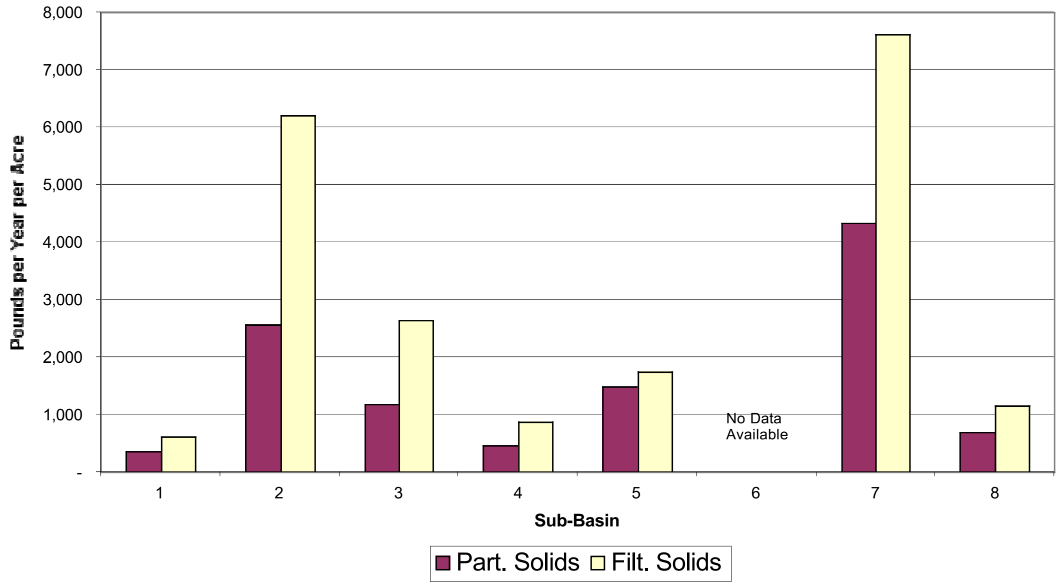


Table A4-2
Top ten storm sewer outfalls in several categories.

Outfall	Area (Acres)	Outfall	RUNOFF (FT^3)	Outfall	Runoff / Acre
195	600.45	195	46,609,397	222	83,010
206	374.8	186	15,791,284	195	77,624
365	330.07	365	12,066,453	232	75,046
186	273.36	219	8,630,361	306	69,273
179	220.52	230	8,477,586	198	68,169
192	211.53	196	5,869,204	226	64,602
199	208.35	184	5,595,244	307	59,369
188	187.45	185	5,037,613	186	57,767
219	174.88	225	4,075,189	230	51,873
230	163.43	306	3,986,648	185	51,636

Total Pounds per Year							
Outfall	*Part. Solids*	*Outfall*	*Filt. Solids*	*Outfall*	*Part. Phos.*	*Outfall*	*Filt. Phos.*
195	418,036	195	690,166	195	790	195	226
186	146,307	186	257,176	186	287	365	111
365	124,895	365	240,931	365	249	198	110
230	86,188	219	152,945	219	169	230	100
219	82,223	230	128,860	230	143	186	98
196	61,908	179	118,233	196	113	192	77
184	55,936	192	113,607	184	110	179	76
199	52,188	188	110,788	188	106	188	76
185	51,923	196	103,903	192	103	219	73
179	48,980	184	97,907	179	101	182	62

Pounds per Acre per Year							
Outfall	Part. Solids	Outfall	Filt. Solids	Outfall	Part. Phos.	Outfall	Filt. Phos.
222	829	195	1,149	222	1.381	198	2.5094
198	775	222	1,141	195	1.316	183	0.7007
180	733	232	1,106	232	1.281	230	0.6132
195	696	306	1,002	306	1.129	189	0.4865
306	685	226	944	226	1.077	306	0.4865
232	685	186	941	186	1.049	324	0.4742
226	600	307	903	307	1.043	220	0.4242
307	560	219	875	184	0.972	184	0.4240
186	535	184	865	219	0.967	194	0.4214
185	532	185	844	230	0.874	190	0.4207

Pounds per Cubic Foot of Runoff per Year							
Outfall	*Part. Solids*	*Outfall*	*Filt. Solids*	*Outfall*	*Part. Phos.*	*Outfall*	*Filt. Phos.*
180	0.019	191	0.043	228	4.06E-05	198	3.68E-05
199	0.018	221	0.025	221	4.06E-05	191	3.10E-05
179	0.016	228	0.039	191	4.06E-05	228	3.10E-05
192	0.015	194	0.041	194	4.06E-05	221	3.10E-05
182	0.014	190	0.041	190	4.04E-05	194	3.10E-05
228	0.014	192	0.043	182	3.77E-05	190	3.09E-05
221	0.014	182	0.043	193	3.76E-05	193	2.79E-05
194	0.014	193	0.043	187	3.74E-05	182	2.77E-05
191	0.014	187	0.043	192	3.69E-05	192	2.77E-05
190	0.014	179	0.043	188	3.30E-05	187	2.75E-05

Appendix 5

Stakeholder Contact Table

Organization	Title / Function / Job Description	Contact Person As of August 1999	Contact Information As of August 1999 (area code is 608 unless noted)	Notes
CITY GOVERNMENT LEVEL				
City of Madison Elected Officials	Mayor	Sue Baumann	266-4611 sbauman@ci.madison.wi.us	Sets policy, appoints ad hoc committees. Plays key role in determining policies that influence the Lake Wingra watershed.
"	Common Council (Alders)	City Clerk	266-4071	Alders serve as key communicators of citizen concerns to common council.
"	Alder	Ken Golden	238-4370	Has worked on stormwater issues for many years. Works with the Monroe Street Business Association.
"	Alder- 13th District	Matt Sloan	250-6664	New alder, interested in stormwater issues.
"	Alder – 6th District	Judy Olson	266-4071, extension 35	Bert Zipperer, a previous 6th district alder, helped implement the high-intensity street sweeping pilot project.
City of Madison Commission on the Environment	Commission Member	Steve Ventura	262-6416	Advises city and mayor on environmental policy. Has suggested that the city look into a stormwater utility.
"	Commission Chair	Dennis McGilligan	271-0820	Commission advises common council and mayor on environmental issues.
City of Madison Planning and Development	Neighborhood Planning	Gretchen Patey	261-9980	Works with neighborhood associations. Julie Stroick is also a good contact.
City of Madison Building Permit Office	City Building Plan Examiner	Mike VanErem	266-4559	Does building inspections. Does not work directly on watershed issues.
"	Building Inspection	Harry Sulzer	266-4568	Addresses construction site erosion. This is not a major concern in Wingra watershed since little construction is occurring at this time.
City of Madison Public Health Department	Public Health Advisor	Mary Ellen Testen	294-5356 metesten@ci.madison.wi.us	Regulates beach closings. Monitors Lake Wingra water quality advisories. Is the key public health contact.
"	Intake Nurse		266-4821	Answers questions about lake water quality and public health at beaches.
"	Epidemiologist	Rob Savage	294-5314	Interprets water quality results for public health, particularly for swimming advisories and beach closings.
City of Madison Parks Department	Front office		266-4711	Provides general information on parks. Parks Division manages beaches and boat landings.
"	Parks Planner	Si Widstrand	266-4714	Parks Dept. manages 200+ parks in city, including Vilas and Wingra. Widstrand is interested in Wingra watershed issues
"	Park Maintenance	John Sundby	267-8804	Supervises park maintenance (lawns, buildings).
"	Parks Outreach Coordinator	Laura Prindle	266-5949	Coordinates volunteer groups and neighborhood associations doing park cleanups.
"	Conservation Supervisor	Russ Hefty	267-4918	Involved in innovative stormwater issues in other watersheds. Has worked on purple loosestrife control in Vilas and Wingra parks.

City of Madison Public Works Department	Stormwater Engineer	Greg Fries	267-1199 gfries@ci.madison.wi.us	Actively involved on projects in the Lake Wingra watershed.
"	Head City Engineer	Larry Nelson	266-4751	City Engineering Division provides technical solutions for stormwater management. Nelson makes high-level policy decisions regarding stormwater controls.
"	City Engineer	Mike Dailey	266-4058 mdailey@ci.madison.wi.us	Does work on stormwater engineering. Has stormwater drainage map layers.
City of Madison Streets and Sanitation	Street sweeping	Roger Goodwin	266-4680	Interested in high-efficiency street sweeping.
"	Director of Operations	Maryanne Hose	266-4681	Has street sweeping and road salting information and tonnage.
City of Madison Recycling	Recycling Coordinator	George Dreckmann	267-3626	Works on pollutant disposal issues. Coordinates leaf pickup & oil recycling programs.
City of Fitchburg	Stormwater	Kevin Wonder	270-4262	None of Fitchburg's stormsewer system is within the Lake Wingra watershed.
Town of Madison	Public Works	Front Office	257-0251	Town of Madison's stormwater system drains to Wingra Creek only, downstream of Lake Wingra.
COUNTY GOVERNMENT LEVEL				
Dane County Sheriff's Office	Public Safety: lakes and recreation	Sgt Ron Bolam	284-6878	Is not involved on Lake Wingra.
Dane County Parks Department	Park Planner	Jim Mueller	246-3893	Works on parks outside of the city of Madison. Worked on stormwater issues for the Nine- Springs E-Way.
"	Volunteer Coordinator	Louise Goldstein	246-5366	Coordinates the "Take-A-Stake-in-the-Lakes" volunteer lake cleanup program. Works closely with the Dudgeon-Monroe Neighborhood Association for the Lake Wingra cleanup.
Dane County Public Health Department	Public Health Director	Jim Clark	242-6515	Works outside of city of Madison, in Dane County.
Dane County Public Works	Aquatic Weed Harvesting	Joe Yaeger	246-3897	Harvests aquatic plants for sporting events, as well as from Lake Wingra's beaches and boat launches.
"	Public Works Supervisor	Ken Koscik	266-4592	Controls lake levels. Does not work on Lake Wingra, as its outflow has a free-flowing weir.
"	Solid Waste Engineer	Al Czecholinski	266-4139	Runs the Clean Sweep and yard waste composting programs jointly with the city of Madison. Promotes recycling programs.
Dane County Land Conservation	Land Conservationist	Kevin Connors	224-3730	Works on erosion control for new building developments. Is very active in soil and watershed issues, but not in the Lake Wingra watershed.
Dane County Highway Garage	Head Supervisor	Steve Haag	266-4012	Maintains winter road safety for the Beltline highway; this requires road salting. The Highway Garage constructed detention ponds in the UW-Arboretum.
Dane County Lakes and Watershed Commission	Volunteer Coordinator	Danielle Dresden	224-3735	Does watershed outreach and works as the public officer for the Yahara-Mendota Priority project.
"	L&W Coordinator	Sue Jones	267-0118	Works on countywide policies to protect water resources. Is a key outreach and policy contact.

Dane County Regional Planning Commission	Planner	Mike Kakuska	266-9111	Works on gathering and analyzing county lake and groundwater data. Is involved in watershed management.
Madison Metropolitan Sewerage District	Head Wastewater Engineer	Jim Nemke	222-1201, extension 253	Has much watershed management experience. Is the primary contact for MMSD issues. Has not been involved with Lake Wingra watershed stormwater runoff.
STATE GOVERNMENT LEVEL				
Wisconsin Department of Natural Resources (WDNR)				
Bureau of Watershed Management	Education Coordinator	Carol Holden	266-0140	Works for the Runoff Management Program and is involved with the Non-Point Source Redesign Program. www.WDNR.state.wi.us/org/water/wm/index.htm
"	Permitting Staff	Steve Fix	275-3280 fixs@dnr.state.wi.us	Reviews urban sewer service area expansions. Coordinates projects with MMSD and Dane County RPC.
"	Environmental Engineer	Bruce Moore	275-3205 mooreb@dnr.state.wi.us	Works on construction site erosion control and detention ponds. Has little Lake Wingra involvement.
"	Permitting Staff	Jim Bertolacini	275-3271	Works on WPDES stormwater permits.
"	Hydrologic Engineer	John Panuska	267-7513 panus@dnr.state.wi.us	Develops hydrologic models for stormwater management; not presently working on the Lake Wingra watershed.
Bureau of Fisheries Management and Habitat Protection	Fisheries Biologist	Mike Vogelsang	273-5946	Works on fisheries management (fish stocking, creel surveys) in the Monona watershed.
"	Fisheries Biologist	Scott Stewart	275-5967 stewar@dnr.state.wi.us	Works on fisheries management (fish stocking, creel surveys) on Token Creek and Black Earth Creek.
"	Lakes Program Coordinator	Jim Leverance	275-3329 leverj@dnr.state.wi.us	Is an aquatic plant and shoreline expert; works on restoration and public education. Is a FOLW member.
"	Lower Rock River Basin Team Leader	Ken Johnson	275-3243 johnsk@dnr.state.wi.us	Works on Rock River Basin watershed and runoff issues.
"	Hydrologic Engineer	Roger Bannerman	266-9278 banner@dnr.state.wi.us	Is involved with research and policy making regarding stormwater runoff in the Lake Wingra watershed.
"	Stream Ecologist	Mike Miller	267-2753 millema@dnr.state.wi.us	Works on stream monitoring techniques. Is involved in public education, especially through citizen stream monitoring.
"	Bureau Director	Mike Staggs	267-0796 staggm@dnr.state.wi.us	Works on fisheries policies that influence Lake Wingra's management, fish stocking, and research.
"	Shallow Lakes Manager	Paul Cunningham	267-7502 cunnip@dnr.state.wi.us	Is involved in shallow lake restoration; reviews restoration proposals.
Bureau of Integrated Science Services Research Center, Monona	LTER Southern Lakes Site Manager, UW-Madison Staff	Dick Lathrop	221-6327 rlathrop@facstaff.wisc.edu lathrr@dnr.state.wi.us	Oversees sampling, data analysis, and LTER research plans for Lake Wingra.
"	Chief of Research on Environmental Contaminants	Doug Knauer	221-6354 knaued@dnr.state.wi.us	Does public health research relevant to Lake Wingra.
Bureau of Endangered Resources		Patricia Manthy	266-0822 manthp@dnr.state.wi.us	Does work on endangered species policy. Currently no involvement in the Lake Wingra watershed.

Wisconsin Department of Transportation (DOT)				
	Hydrogeologist	Bob Pearson	266-7980	Works on highway runoff issues. Interested in Lake Wingra watershed issues, especially regarding Hwy 12/18 road salting.
Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP)				
Land and Water Resource Bureau	Land and Water Conservationist	Lynn Hess	224-4606	Helps with writing priority watershed plans, works with County Land Conservation offices and the WDNR.
UW-EXTENSION				
Environmental Resources Center	Community Resource Development Agent	Mindy Habecker	262-0020 224-3718	Works on public education and outreach, regarding alternative lawn care and home composting. Is also an associate professor for the UW-Madison.
" "	Upper and Lower Rock River Basin Educator	Suzanne Wade	(920) 674-8972, Jefferson WI	Works with WDNR, NRCS and Dane County Land and Conservation to meet management goals in the Rock River Basin.
" "	Assistant Director for WGNHS	Ron Hennings	263-7395 rghennin@facstaff.wisc.edu	Works with the Wisconsin Geological and Natural History Survey; is academic staff for the UW-Madison.
FEDERAL GOVERNMENT LEVEL				
US Geological Survey, Water Resources Department	Environmental Studies	Dave Owens	827-6255	Does research on mitigating Lake Wingra watershed stormwater runoff, especially on the Monroe Street detention pond. USGS also has remote sensing data from NASA.
US Army Corps of Engineers	CWA Wetland Permitting	St. Paul, MN Office	(651) 290-5201 www.usace.mil/	Regulates and permits new developments in wetlands. Is not currently working in the Lake Wingra watershed.
US Department of Transportation, Highway Department	Highway Salting and Maintenance	Main Office	264-5215	Contracts highway salting and maintenance to Dane County, therefore does not directly deal with Lake Wingra watershed stormwater runoff.
EPA Region 5 Office, Watershed and Non-Point Source Pollution Branch, Chicago IL	Branch Chief	Kevin Pierard	(312) 886-4448	EPA offices have regulatory power over pollution discharges. This branch works on watersheds, specifically non-point source pollution. Does not work specifically in the Lake Wingra watershed.
"	Environmental Protection Specialist	Don Roberts	(312) 886-1765	Works on the Clean Lakes program.
"	Environmental Engineer	Peter Swensen	(312) 886-0236	Works on regional stormwater issues; involved in the NPDES permitting process.
"	Environmental Scientist	Steve Jann	(312) 886-2446	Works on water quality permitting; gives technical support.
US Fish and Wildlife Service, Madison Office	Wetland Restoration	Art Kitchen	221-1206	F&WS restores wetlands through a small grants program. Does not work specifically in the Lake Wingra watershed.

NEIGHBORHOOD ASSOCIATIONS

For a list of additional neighborhood association contacts, see www.ci.madison.wi.us/planning/nrbrorg.html.

Arbor Hills	President	Paul Didier	didiep@mailbag.com	
Bay Creek	Editor	Kirk Elliot	255-5646	
Brittingham-Vilas	President	Gail Martinelli		
Burr Oaks	President	Brad Boyle	251-4520	
Dudgeon-Munroe	President	James Beal	jbeal@engr.wisc.edu	Coordinates Lake Wingra Take-a-Stake-in-the-Lakes cleanup.
" "	Wingra Chair	Jane Riley	murriley@aol.com	Coordinates Lake Wingra Take-a-Stake-in-the-Lakes cleanup.
Greenbush	President	Andy Heidt	258-9727 aheidt@idis.com	
" "	Editor	Madeline Para	255-4529	
Greentree	President	Jody Sherman	274-2205	
" "	Editor	Steve Allison	271-6836 steve@a2enterprises.com	
Meadwood	President	Daniel Kelly	274-6009 dkelly1060@aol.com	
Midvale Heights	President	Ron Rotter	rfrotter@aol.com	
Orchard Ridge	President	Jim Ring	278-0026	
" "	Editor	Ann Schultz		
Radio Park	President	Howard Erlanger	233-7878	
Regent	President	Ron Rosner	238-1828	
" "	Editor	Erika Kluetemeier	238-6209	
Sunset Village	President	Kelly Kohlstruk	232-1476 kohlstru@rayovac.com	
Vilas	President	Barb Sanford	255-1508	
" "	Editor	Medora Ebersole	256-7186	
Westmorland	Contact	Margaret Rasmussen	233-7143	
" "	Editor	Amy Mitchell	231-3069	
Town of Madison	President	Michelle Roberts	255-9247	
Dunn's Marsh	President	Scott Sauer	273-0904	

ENVIRONMENTAL GROUPS

Madison Audubon Society		Harry Read	255-2473	222 S. Hamilton, Madison, WI 53703
Wisconsin Wetlands Association	Executive Director	Charlie Luthin	250-9971	222 S. Hamilton, Madison, WI 53703
Citizens for a Better Environment	Senior Policy Analyst	Rob Kennedy	251-2804 (414) 271-2803, Milwaukee WI	Provides land-use advice on local issues. 511 S. Baldwin St., Madison, WI 53703
Wisconsin Environmental Decade	Program Director	Keith Reopelle	251-7020	122 State St., Madison, WI 53703
The Nature Conservancy (TNC)	Director	Mary Jean Huston	251-8140	633 W. Main St., Madison, WI 53703
Sierra Club - Great Lakes Chapter, Midwest Office	Senior Regional Representative	Bret Hulsey	251-0565	Midwest office has a national and regional focus. Hulsey works on urban sprawl issues. 222 S. Hamilton, Madison, WI 53703
Sierra Club - John Muir Chapter, State Office	Watershed Management Expert	Caryl Terrell	256-0565	State office works with state legislature; oversees local groups.
Sierra Club - Four Lakes Chapter	Volunteer	Al Matano	238-3045	Local focus only - all volunteer.
Friends of Lake Wingra (FOLW)	Volunteer	Jim Lorman	lorman@edgewood.edu	Citizen group promoting a healthy Lake Wingra through an active watershed community. http://danenet.wicip.org/fowinga/
Trust for Public Land	Midwest Regional Office		(612) 338-8467, Minneapolis, MN	Protect open-space land.
Ice Age Park & Trail Foundation	Volunteer Work Party Leader	Gary Werner	249-7870	Build and maintain the Ice Age Trail throughout Wisconsin.
Token Creek Watershed Association	Resource Manager	Sarah Van Tiem	846-3854	Work for the protection and restoration of the Token Creek watershed and its trout populations.
Token Creek Watershed Association	Board Chairman	Tom Culver		
Dane County Natural Heritage Foundation	Executive Director	Danielle Wood	danielle@dcnhf.org	633 W. Main St., Madison, WI 53703
Dane County Natural Heritage Foundation		Sarah Van Tiem	258-9797	633 W. Main St., Madison, WI 53703
1000 Friends of Wisconsin	Executive Director	Dave Cieslewicz	259-1000	Work on development issues, particularly urban sprawl. 16 N. Carroll St., Madison, WI 53705
Friends of Dane County Parks	UW-Madison Professor Emeritus, Park Commissioner	Phil Lewis	238-7219	Founded the Wisconsin E-ways. The present Madison E-way plan would incorporate Lake Wingra as a 'jewel on the necklace'.
Lake Associations		Ron Hennings	241-9510	Lake property owners associations that work on lake quality and regulatory issues.
WisPIRG	UW-Madison Office		251-1918	The Wisconsin Public Interest Research Group is a campus-based student organization that works on environmental advocacy issues.

EcoTeams	Dane County Executive Assistant	Topf Wells	266-4114	EcoTeams are small groups of citizens who work together on environmental neighborhood outreach. Wells has worked to start several EcoTeam groups in the Madison area.
RECREATION GROUPS AND BUSINESSES				
Carl's Paddling			284-0300	
Flying Fish Sail Boards			251-4500	
Isthmus Sailboards			849-4991	
Rutabaga		Gordon Sussmann		
Yahara Fishing Club	President	Jeff Paffenroth	849-7165	Promotes and protects fishing rights and responsibilities.
Mad City Paddlers	Information Line	Don and Amy Hynek	455-2001	Supports paddling sports.
4 Lakes Bassmasters	President	Steve Hauge	245-1040	Bass-fishing enthusiasts; sponsor fishing tournaments, including the annual Madison Fishing Expo.
Muskies, Inc. - Capital City Chapter	President	Bill Wood	798-2155	Muskie conservation and sport fishing group. PO Box 8862, Madison, WI 53708
SCHOOLS AND RESEARCH INSTITUTIONS				
Edgewood College	Assistant Professor of Biology	Francie Rowe	663-6923	Does research on and monitoring of purple loosestrife near the Edgewood College campus.
Edgewood College	Professor of Biology	Jim Lorman	lorman@edgewood.edu	Is a member of the FOLW. In addition to university-level biology teaching and research, is involved with K-12 watershed education and outreach.
UW Arboretum	Director	Greg Armstrong	262-2748	Is an advocate of watershed issues.
UW Arboretum		Bill Jordan	263-7888	Is a member of the FOLW.
UW Center for Limnology	Professor	Steve Carpenter	srcarpen@facstaff.wisc.edu	Does lake ecosystems and watershed research.
"	Professor	Jim Kitchell	kitchell@macc.wisc.edu	Does lake ecosystems and fish ecology research.
"	Professor	Stan Nichols	sanichol@facstaff.wisc.edu	Does lake ecosystems and aquatic plant research.
"	Professor	John Magnuson	jmagnuson@macc.wisc.edu	Is involved with research and monitoring on Lake Wingra.
UW-Madison Faculty and Staff with interest in the Lake Wingra watershed	Civil & Envir Engineering	Ken Potter	kwpotter@facstaff.wisc.edu	Is involved with the arboretum and local communities in stormwater and infiltration issues. Has been the advisor for the WRM Practicum; is on the WRM Board.
" "	Soil Science	Steve Ventura	sventura@facstaff.wisc.edu	Works with LCGIF; is active in the Lake Wingra watershed. Is a member of the City Commission for the Environment.

"	Arboretum / Botany	Joy Zedler	jbzedler@facstaff.wisc.edu	Is a wetlands restoration expert, specifically regarding monitoring and research. Is on the WRM Board.
"	Urban and Regional Planning	Steve Born	smborn@facstaff.wisc.edu	Is active in watershed organizing, policy, and planning. Is on the WRM Board.
"	Soil Science	Fred Madison	fredmad@facstaff.wisc.edu	Works in soil conservation outreach and education. Is the current chair of the WRM Board.
"	Wildlife Ecology	Bob Ray	raray@facstaff.wisc.edu	Has expertise in public participation and outreach.
"	Water Chemistry	Dave Armstrong	armstrong@engr.wisc.edu	Works in water chemistry. Is on the WRM Board.
"	Hydrogeology	Jean Bahr	jmbahr@geology.wisc.edu	Works on groundwater modeling. Is on the WRM Board.
"	Landscape Architecture	Evelyn Howell	eahowell@facstaff.wisc.edu	Works on prairie restoration.
"	Biological Systems Engineering	Jim Peterson	jopeters@facstaff.wisc.edu	
"	Center for Biology Education	Robert Bohanan	rbohanan@facstaff.wisc.edu	Coordinates biology education for Madison and Southern Wisconsin elementary, middle, and high-school students.
WI State Lab of Hygiene	Microbiologist	Jon Standridge	jhs@mail.sih.wisc.edu	
UW-Madison, Institute for Environmental Studies (IES)	Student Services Coordinator	Barbara Bornes	263-4373, 262-9206 blbornes@facstaff.wisc.edu	The Water Resources Management (WRM) program is housed within IES. The website address for the WRM program is http://www.ies.wisc.edu/research/wrm99/Webpage/wingra.htm.
Madison West High School	Biology Teacher	Don Vincent	231-1331	Is interested in Lake Wingra and its watershed.
LOCAL BUSINESSES				
Monroe Street Business Association	President	Orange Scroeder	255-8211	Association of over 40 businesses in the Monroe Street area.
Orange Tree Imports	Owner	Orange Scroeder	255-8211	1721 Monroe St.
Harlan Sprague Dawley			277-2000	2826 Latham Dr.
Waste Management Incorporated			273-2500	Knickerbocker Place
St. Mary's Hospital			251-6100	707 S. Mills St.
Ken Kopp's Fine Foods			257-3594	1864 Monroe St.
Madison Newspapers, Inc.			252-8000	Is a part of the Clean Sweep program. 1313 Fish Hatchery Rd.
Steinhafels Shopping Center			288-5000	2164 W. Beltline Hwy
Kayser Ford			271-6000	2303 W. Beltline Hwy

Westgate Shopping Mall	Polacheck Property Management		288-1100	160 Westgate Mall
Arbor House Bed & Breakfast	Owners	John & Kathy Imes	238-2981	3402 Monroe St.
Nakoma Golf Course	Private ownership		238-3141	4145 Country Club Rd.
Glenway Golf Course	Municipality owned	Ray Shane	266-4737	3747 Speedway Rd.
Odana Golf Course	Municipality owned		266-4724	4635 Odana Rd.

Appendix 6

Lake Wingra Watershed Resident Survey

Introduction

In order to maintain and restore the quality of the Lake Wingra watershed, residents must take an active role. Getting residents involved in restoration, protection, and monitoring activities is an important step in connecting people to the watershed. A 'Resident Survey for the Lake Wingra Watershed' was conducted during August 1999. The survey was limited to 17 questions, and was designed to take an average of 20 minutes to complete. Two thousand surveys and return envelopes were mailed to households within the watershed. A random sample of homeowner addresses within the watershed was generated from a database maintained by Survey Sampling, Inc. of Fairfield, Connecticut. Census tracts and block groups were used to define the watershed area. Of the 2,000 surveys that were distributed, 370 surveys were completed and returned – a response rate of 18.5 %. This indicates a high level of concern for Lake Wingra among watershed residents.

The survey measured a variety of community attitudes towards Lake Wingra and attempted to gauge the connections that exist between the residents and the watershed they live in. The survey addressed three main topics:

- How do residents use the watershed?
- How do residents view the quality of the environment in the Lake Wingra watershed?
- What are residents willing to do to improve the quality of the natural environment?

This appendix presents the following information:

- Respondent background and watershed demographics
- Overview of responses to individual questions
- Discussion of results and recommendations for outreach and education opportunities
- A sample survey
- Tabular summary of question responses
- Population Detail Report

Respondent Background and Watershed Demographics

There were 32,915 persons age 15 years and over who lived in the Lake Wingra watershed in 1990; this number is now thought to exceed 33,000 (1990 U.S. Census information). There are 17,306 children present in one quarter of the Lake Wingra watershed households (see *Population Detail Report*). A survey conducted in 1978 estimated 1,670,000 non-resident visits to Lake Wingra, the UW-Arboretum, and Vilas Park/Beach/Zoo each year (Ross *et al*., 1980).

For this survey, 207 respondents were male and 147 were female. More than 90% of the respondents were over 30 years of age. 48% of the respondents reported having advanced degrees, and 35% reported having a college degree. 25% of the watershed population actually have graduate or professional degrees, and 27% have college degrees (see *Population Detail Report*).

Overview of responses to individual questions:

Question 1: Using the map provided as reference, in which zone is your residence located?

- 32 % from Zone 1 - western portion of the watershed, furthest from Lake Wingra
- 48% from Zone 2 - north of Lake Wingra
- 19% from Zone 3 - south of Lake Wingra

Question 2: Before beginning this survey, did you know that your home is in the watershed of Lake Wingra?

- 52% did not know
- 9% from Zone 1 did not know
- 40% from Zone 2 did not know

Question 3: How long have you lived within the watershed?

- 30% have lived there greater than twenty years
- 23% have lived there between 11 and 20 years
- 16% have lived there between 7 and 10 years
- 13% have lived there between 4 and 6 years
- 18% have lived there three years or less

TOPIC 1: HOW DO RESIDENTS USE THE LAKE WINGRA WATERSHED?

Question 4: People use Lake Wingra and the surrounding areas for a variety of recreational activities. How often do you participate in the activities listed?

a. Visit Lake Wingra or its shoreline

- 48% visit several times per year
- 23% visit several times a month
- 16% visit several times a week or every day
- 13% never do this

b. Drive through the watershed

- 49% do this every day

c. Go to Westgate Mall

- 56% go several times each year
- 31% go several times a month
- 9% go several times a week or every day

d. Walk, run, or hike within the watershed

- 20% do this several times a year
- 18% do this several times a month
- 49% do this several times per week or every day
- 15% never do this

e. Observe birds and/or wildlife within the watershed
- 36% do this several times a year
- 11% do this several times a month
- 17% do this several times a week or every day
- 36% never do this

f. Visit the UW-Arboretum
- 61% visit several times a year
- 18% visit several times a month
- 9% visit several times a week
- 11% never do this

g. Shop on Monroe Street
- 46% shop several times a year
- 24% shop several times a month
- 17% shop several times a week or every day
- 14% never do this

h. Visit Vilas County Zoo
- 71% visit several times a year
- 10% visit several times a month
- 19% never do this

i. Bike in the watershed
- 23% do this several times a year
- 15% do this several times a month
- 20% do this several times a week or every day
- 41% never do this

j. Play and relax at a park or natural area
- 47% do this several times a year
- 18% do this several times a month
- 7% do this several times a week
- 27% never do this

k. Participate in sporting events (team sports, races, rides)
- 20% do this several times a year
- 9% do this several times a month
- 68% never do this

l. Golf in the watershed (Nakoma, Glenway, and Odana Hills courses)
- 19% do this several times a year
- 8% do this several times a month or week
- 73% never do this

m. Swim or wade in Lake Wingra
- 20% do this several times a year
- 76% never do this

n. Fish at Lake Wingra
- 14% do this several times a year
- 83% never do this

o. Boat, sail, or canoe on Lake Wingra
- 30% do this several times a year
- 6% do this several times a month or week
- 64% never do this

p. Participate in winter sports (skating, skiing)
- 33% do this several times a year
- 12% do this several times a month or week
- 56% never do this

Questions 5 & 6: Looking at the map of the watershed boundaries, do you have one place that you enjoy more than any other place or event in the watershed, not including your home?
Please briefly describe your favorite place, and why it is so special to you.

Place
- 18% UW-Arboretum
- 6% Vilas County Zoo
- 6% Vilas Park
- 6% Wingra Park
- 5% Lake Wingra
- others included Duck Pond, Knickerbocker Park, and eateries (Ex. Michael's Frozen Custard)
- family and personal enjoyment were cited most often, as reasons why these are special places

Event/Activity
- 11% walking
- 9% participating in sports (running, skiing, biking, soccer)
- 8% Jazz in the Park
- others included Edgefest

TOPIC 2: HOW DO RESIDENTS VIEW THE QUALITY OF THE ENVIRONMENT IN THE LAKE WINGRA WATERSHED?

Question 7: Do you feel that living near Lake Wingra improves your quality of life?
- 87% yes

Question 8: How do you rate Lake Wingra and its watershed as a recreational area?
- 18% outstanding
- 52% good
- 17% average
- 4% poor

Question 9: How do you rate Lake Wingra and its watershed as a natural area, with respect to plants, animals and ecosystems?
- 20% outstanding
- 52% good
- 16% average
- 3% poor

Question 10: How do you rate the current water quality of Lake Wingra?
- 1% outstanding
- 10% good
- 32% average
- 38% poor

Question 11: In the time you have lived in the watershed, do you think that the water quality in Lake Wingra has…?
- 8% improved somewhat
- 46% stayed the same
- 41% worsened
- 5% greatly worsened

Question 12: Do you feel that there are any major environmental or pollution problems in Lake Wingra?
- 82% yes

Question 13: Listed below are some existing and potential problems that affect Lake Wingra. What do you feel is the magnitude of each problem?
- Large Problems:
  -algae and lake weeds
  -fertilizer and/or pesticide use on lawns and gardens
  -stormwater runoff from streets and buildings

- Medium Problems:
  -smell of lake water
  -water clarity
  -decrease in spring flows
  -sand and salt from streets
  -handling of leaves, grass, and yard waste
  -beach closings; lake not swimmable

- Small Problems
  -overfishing
  -park maintenance

- Do not know
  -presence of exotic species (ex. carp, Eurasian water milfoil)
  -future invasions of exotic species (ex. zebra mussels)
  -overfishing
  -decrease in spring flows

- Other
  -zoo runoff and waste management
  -fertilizers and pesticides

TOPIC 3: WHAT ARE RESIDENTS WILLING TO DO TO IMPROVE THE QUALITY OF THE NATURAL ENVIRONMENT?

Question 14: Below are some things that individuals can do to reduce the amount of pollutants entering local water bodies, such as Lake Wingra. Circle the answer that best applies to you.

a. Rake leaves away from the street and curb
- 68% already do this
- 16% were willing to do this
- 3% were not willing to do this

b. Use lawn fertilizer not containing phosphorus
- 31% already do this
- 33% were willing to do this
- 3% were not willing to do this

c. Perform soil tests of lawn and garden soils before deciding to apply fertilizers
- 8% already do this
- 45% were willing to do this
- 10% were not willing to do this

d. Stop using chemical fertilizers
- 29% already do this
- 29% were willing to do this
- 18% were not willing to do this

e. Stop using pesticides, including herbicides, fungicides, rodenticides and insecticides
- 31% already do this
- 25% were willing to do this
- 21% were not willing to do this

f. Clean up dog waste promptly
- 31% already do this
- 6% were willing to do this
- 1% were not willing to do this

g. Attend a public meeting on how to protect water quality
- 3% already do this
- 68% were willing to do this
- 23% were not willing to do this

h. Modify roof gutters & downspouts on your home to divert rain away from driveways, sidewalks and roads
- 41% already do this
- 31% were willing to do this
- 8% were not willing to do this

Question 15: If you had questions regarding Lake Wingra, such as water quality, soil testing or stormwater, who do you feel would be the best source to answer your questions?
- 62% watershed project staff
- 54% county conservationist
- 48% extension agent
- 46% environmental organization
- 22% local professor or teacher
- 16% neighbors
- 8% lawn care or landscaping company

- 5% lawn and garden club
- 5% hardware or gardening store
- 2% fishing club
- Other responses included the WDNR, city officials, and neighborhood associations

Question 16: In what formats do you prefer information to be provided for you?

- 71% fact sheets
- 70% newsletters
- 59% brochures
- 21% radio
- 18% neighborhood demonstrations
- 14% workshops
- 12% meetings
- 9% community activities
- 9% video tapes
- 8% letters
- 4% home visits
- 3% phone calls

Discussion and Recommendations

Presuming that survey results represent the views of residents of the Lake Wingra watershed, some statements can be made concerning resident perceptions of Lake Wingra and the management of its watershed. The further away from the lake people live, the less likely they were to know that they lived in the watershed. Fifty-one percent of the respondents did not know that they live in the watershed. This indicates that public outreach and education should focus on raising awareness and sense of place, so that residents are informed that their activities have direct impacts on Lake Wingra.

Many of the survey respondents were long-term residents of the watershed, who may have concomitant long-term interest in the quality of Lake Wingra. Opportunities for outreach and education may be most effectively directed toward these long-term residents. The fact that neighbors were named as a source for learning about water quality practices indicates that communication between groups of neighbors, via neighborhood associations or ecoteams, could be a successful outreach method.

Distributing information is a key aspect of changing behaviors in household practices, such as modifying gutters, using fertilizer without phosphorus, and keeping leaves from streets and sidewalks. To make the information more effective, efforts should be focused on places, events, and activities that draw large and steady numbers of watershed residents. Survey results showed that these places and events included the UW-Arboretum, Wingra Park, Vilas County Zoo, Monroe Street businesses, and events like Jazz in the Park and EdgeFest. Activities could be organized that incorporate both education and preferred activities – for example, running, skiing, biking, and bird watching. Since many respondents preferred to receive information in written format, brochures, letters, and fact sheets could be distributed at commonly frequented places and events. Outreach experts feel that to create an effective education program, activities should be accompanied by written documents giving additional and practical information.

In 1970, the Institute of Environmental Studies at UW-Madison conducted a Lake Wingra watershed resident survey that looked at similar activities as were listed in our survey. Results from the 1970 survey indicated that 55% of respondents swam in Lake Wingra at least once a year (Ross, 1980); today, only 24% of the respondents do. Comparing the 1970 survey to ours showed that fishing and boating have stayed relatively the same: our survey reported 36% and 17%, and the 1970 survey reported 31% and 21%, respectively.

More than seventy-five percent of the survey respondents never swim in Lake Wingra. Overall, swimming at Madison area beaches has been on the decline for a number of years, with some beaches receiving less than one-half the usage as compared to the 1980s. The low percentage of in-lake users may be partially explained by the responses to watershed and water quality. Although respondents viewed Lake Wingra and its watershed areas as important aspects of their lives, they viewed the water quality of Lake Wingra as average to poor, having generally stayed the same or worsened over time. Respondents identified several large problems, including algae, weeds, fertilizer and pesticide use, and street runoff. These survey results show that Lake Wingra watershed residents are aware of the causes of lake water quality problems.

A majority of residents feel that there are pollution problems in the watershed linked to individual behavior (for example, fertilizer and pesticide use). When asked if residents would be willing to change their behavior, a majority responded that they had already done so or were willing to, if applicable to them. Support for changing behaviors is already evident in the community, which is an integral part of developing an effective outreach program.

Conclusion

The nearly 20% response rate to this survey may reflect tremendous interest and potential to protect, maintain, and restore water quality in the Lake Wingra watershed. One aspect of the survey was to gather information about resident activities, views, and interests in order to develop effective outreach and education. Public interest, concern, and participation in the watershed are qualities that residents of the Lake Wingra watershed have demonstrated they posses, along with a willingness to change current household practices. Outreach and education efforts should work from this foundation.

Survey respondents indicated that the Lake Wingra watershed is important to their lives – it is a valued natural and recreational area to live in. However, like many urban lakes, Lake Wingra water quality has degraded and will continue to degrade because of pollution sources within its watershed. Lake Wingra watershed residents have indicated that they realize this, and have shown their willingness to support attempts to improve water quality in and around Lake Wingra.

Resident Survey for the Lake Wingra Watershed

Dear Resident:

Thank you for your time! This is a survey intended for residents of the Lake Wingra watershed. Please take a moment to read and fill out the survey. This survey is being conducted by the University of Wisconsin- Madison Water Resources Management program. This survey is part of a larger study of the Lake Wingra watershed. All of the land in this watershed drains into Lake Wingra.

In this survey, we are investigating how residents use Lake Wingra and its surrounding watershed, and how residents feel about water quality and land use issues. By completing this survey, you will help us understand how residents are involved in the watershed, and how watershed managers can best assist them.

Before you begin, we want to assure you that **all of the information that you provide is confidential**. No information will be released that would specifically identify you or your household. Your participation is voluntary and very much appreciated.

A map of the watershed is provided, with the boundary of the drainage area marked, and zones identified. Feel free to refer to it (or any other map) while you are filling out the survey. Please complete all 3 sides of the survey. **Enclose the completed survey and this letter (with your signature of consent) in the envelope provided by August 2nd, 1999.**

1. Using the map provided as reference, in which zone is your residence located? _______

2. Before beginning this survey, did you know that your home is in the watershed of Lake Wingra? YES NO

3. How long have you lived within the watershed? ______ years

4. People use Lake Wingra and the surrounding areas for a variety of recreational activities. We'd like to know if you do. Circle how often you participate in each of the activities listed below.

Recreational activities	Every day	Several times a week	Several times a month	Several times a year	Never
a. Visit Lake Wingra or its shoreline	1	2	3	4	5
b. Drive through the watershed	1	2	3	4	5
c. Go to Westgate Mall	1	2	3	4	5
d. Walk, run, hike within the watershed	1	2	3	4	5
e. Observe birds and/or wildlife	1	2	3	4	5
f. Visit the UW-Arboretum	1	2	3	4	5
g. Shop on Monroe Street	1	2	3	4	5
h. Visit Vilas County Zoo	1	2	3	4	5
i. Bike in the watershed	1	2	3	4	5
j. Play and relax at a park or natural area	1	2	3	4	5
k. Participate in sporting events (team sports, races, rides)	1	2	3	4	5
l. Golf in the watershed (Odana Hills, Nakoma, Glenway)	1	2	3	4	5
m. Swim or wade in Lake Wingra	1	2	3	4	5
n. Fish at Lake Wingra	1	2	3	4	5
o. Boat, sail, canoe on Lake Wingra	1	2	3	4	5
p. Participate in winter sports (skating, skiing)	1	2	3	4	5

List any other recreational activities that you do in the Lake Wingra Watershed:

____

Questions 5 and 6: Looking at the map of the watershed boundaries, do you have **one place**, such as a park, restaurant, lakeshore, store, church, tree, or Indian mound, **and one event**, such as a celebration, a festival or an Arboretum activity, that you enjoy more than any other place or event in the watershed, not including your home?

Please briefly describe what your favorite place and event is, and why it is so special to you.

5. Place: ____

6. Event: ____

Questions 7 – 12: For each question, circle the best option.

7. Do you feel that living near Lake Wingra improves your quality of life?
YES NO

8. How do you rate Lake Wingra and its watershed as a recreational area?
OUTSTANDING GOOD AVERAGE POOR DON'T KNOW

9. How do you rate Lake Wingra and its watershed as a natural area, with respect to plants, animals and ecosystems?
OUTSTANDING GOOD AVERAGE POOR DON'T KNOW

10. How do you rate the current water quality of Lake Wingra?
OUTSTANDING GOOD AVERAGE POOR DON'T KNOW

11. In the time you have lived in the watershed, do you think that the water quality in Lake Wingra has…?

GREATLY IMPROVED	IMPROVED SOMEWHAT	STAYED THE SAME	WORSENED	GREATLY WORSENED

12. Do you feel that there are any major environmental or pollution problems in Lake Wingra? YES NO

13. Listed below are some existing and potential problems that affect Lake Wingra. On a scale from 1 to 5, rate each problem by circling the number that you feel best describes the magnitude of the problem.

Problems	Large problem	Somewhat a problem	Small problem	Not a problem	Don't know
a. Too much algae	1	2	3	4	5
b. Smell of lake water	1	2	3	4	5
c. Clarity of lake water	1	2	3	4	5
d. Too many weeds	1	2	3	4	5
e. Spring flow decreases	1	2	3	4	5
f. Fertilizer and/or pesticide use on lawns and gardens	1	2	3	4	5
g. Stormwater runoff from streets and buildings	1	2	3	4	5
h. Over-fishing	1	2	3	4	5
i. Sand and salt from streets	1	2	3	4	5
j. Park maintenance	1	2	3	4	5
k. Exotic species (ex. carp, Eurasian water milfoil)	1	2	3	4	5
l. Exotic species that could invade in the future (ex. zebra mussels)	1	2	3	4	5
m. Handling of leaves, grass, and yard waste	1	2	3	4	5
n. Beach closings/ lake not swimmable	1	2	3	4	5

List or describe any other problems or threats to Lake Wingra:

____

14. Below are some things that individuals can do to reduce the amount of pollutants entering local water bodies, such as Lake Wingra. Circle the answer that best applies to you.

	Already do this	Willing to do this	Not willing to do this	Not applicable
a. Rake leaves away from the street and curbs	1	2	3	4
b. Use a lawn fertilizer that does not contain phosphorus	1	2	3	4
c. Perform soil testing of lawn and garden soils before deciding to apply fertilizers	1	2	3	4
d. Stop using chemical fertilizers	1	2	3	4
e. Stop using pesticides, including herbicides, fungicides, rodenticides, and insecticides	1	2	3	4
f. Clean up dog waste promptly	1	2	3	4
g. Attend a public meeting on how to protect water quality	1	2	3	4
h. Modify roof gutters & downspouts on your home to divert rain away from driveways, sidewalks, and roads *	1	2	3	4

** modifying roof gutters and downspouts to divert stormwater runoff can reduce the total amount of runoff entering lakes and streams, through increasing infiltration. This can increase recharge of ground-water, and increase spring flows.*

15. If you had questions regarding Lake Wingra, such as water quality, soil testing or stormwater, who do you feel would be the best source to answer your questions? Check all that apply.

_____ Extension agent
_____ Landscape contractor
_____ Local professor or teacher
_____ Fishing club
_____ Environmental organization
_____ Watershed project staff
_____ County conservationist
_____ Neighbors
_____ Hardware or gardening store
_____ Lawn and garden club
_____ Lawn care company
_____ Other: ________________

16. In what formats do you prefer information to be provided for you? Check all that apply.

_____ Fact sheets _____ Brochures _____ Newsletters
_____ Workshops _____ Meetings _____ Personal letters
_____ Community activities _____ Video tapes _____ Visits to my home
_____ Phone calls _____ Neighborhood demonstrations _____ Radio

PERSONAL INFORMATION

This information will remain confidential, and will be used for statistical purposes only

Gender: FEMALE MALE

Age: LESS THAN 20 20-30 31-40 41-50 51-60 60 +

Education background: K-12 HIGH SCHOOL DEGREE SOME COLLEGE COLLEGE DEGREE ADVANCED DEGREE

Approximate annual household income: <$15,000 $15,000-$24,999 $25,000-39,999 $40,000-59,999 $60,000-89,999 $90,000-129,999 $130,000 +

TABULAR SUMMARY OF RESPONSES for the RESIDENT SURVEY FOR THE LAKE WINGRA WATERSHED:

The following tables summarize the responses to individual questions that were answered by the 370 respondents to this survey. The entries under the 'subtotal' column reflect the number of persons that responded to that particular question, followed by the percentage of the total that responded to the question. Some questions were not answered on every survey.

Question 1: Using the map provided as reference, in which zone is your residence located?

Response	**Zone 1**	**Zone 2**	**Zone 3**	Subtotal
# of Responses	114	171	68	353
Percentage Response	32.29	48.44	19.26	95.41

Question 2: Before beginning this survey, did you know that your home is in the watershed of Lake Wingra?

Response	**Yes**	**No**	Subtotal
# of Responses	171	182	353
Percentage Response	48.44	51.56	95.41

Question 3: How long have you lived within the watershed?

Response	**0-3**	**4-6**	**7-10**	**11-20**	**>20**	Subtotal
# of Responses	63	46	58	82	107	356
Percentage Response	17.70	12.92	16.29	23.03	30.06	96.22

Question 4: People use Lake Wingra and the surrounding areas for a variety of recreational activities. We'd like to know if you do. Circle how often you participate in each of the activities listed below.

a. Visit Lake Wingra or its shoreline

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	10	49	81	174	46	360
Percentage Response	2.78	13.61	22.50	48.33	12.78	97.30

b. Drive through the watershed

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	175	59	38	73	14	359
Percentage Response	48.75	16.43	10.58	20.33	3.90	97.03

c. Go to Westgate Mall

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	7	24	111	202	16	360
Percentage Response	1.94	6.67	30.83	56.11	4.44	97.30

d. Walk, run, or hike within the watershed

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	79	96	65	72	53	365
Percentage Response	21.64	26.30	17.81	19.73	14.52	98.65

e. Observe birds or wildlife

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	27	35	40	132	130	364
Percentage Response	7.42	9.62	10.99	36.26	35.71	98.38

f. Visit the UW-Arboretum

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	1	32	66	222	41	362
Percentage Response	0.28	8.84	18.23	61.33	11.33	97.84

g. Shop on Monroe Street

Response	**Every day**	**Several times a week**	**Several times a month**	**Several times a year**	**Never**	Subtotal
# of Responses	11	48	87	167	49	362
Percentage Response	3.04	13.26	24.03	46.13	13.54	97.84

h. Visit Vilas Zoo

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	0	6	33	256	68	363
Percentage Response	0	1.65	9.09	70.52	18.73	98.11

i. Bike in the watershed

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	31	42	54	85	151	363
Percentage Response	8.54	11.57	14.88	23.42	41.6	98.11

j. Play and relax at a park or natural areas

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	1	25	67	173	99	365
Percentage Response	0.27	6.85	18.36	47.40	27.12	98.65

k. Participate in sporting events (team sports, races, and rides)

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	2	9	32	74	244	361
Percentage Response	0.55	2.49	8.86	20.50	67.59	97.57

l. Golf in the watershed: Odana Hills, Nakoma, Glenway courses

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	1	6	22	71	267	367
Percentage Response	0.27	1.63	5.99	19.35	72.75	99.19

m. Swim or wade in Lake Wingra

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	0	3	13	71	277	364
Percentage Response	0	0.82	3.57	19.51	76.10	98.38

n. **Fish at Lake Wingra**

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	0	4	4	53	305	366
Percentage Response	0	1.09	1.09	14.48	83.33	98.92

o. Boat, sail, or canoe on Lake Wingra

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	0	6	16	108	234	364
Percentage Response	0	1.65	4.4	29.67	64.29	98.38

p. Participate in winter sports (skating, skiing)

Response	Every day	Several times a week	Several times a month	Several times a year	Never	Subtotal
# of Responses	0	10	31	120	203	364
Percentage Response	0	2.75	8.52	32.97	55.77	98.38

Questions 5 and 6: Looking at the map of the watershed boundaries, do you have one place, such as a park, restaurant, lakeshore, store, church, tree, or Indian mound, and one event, such as a celebration, a festival, or an Arboretum activity, that you enjoy more than any other place or event in the watershed, not including your home? Please briefly describe what your favorite place and event is, and why it is so special to you.

Place

Response	Arboretum	Zoo	Vilas Park	Wingra Park	Lake Wingra
# of Responses	67	23	22	21	16

Event/Activity

Response	Walking	Sports	Jazz in the Park
# of Responses	19	16	14

Question 7: Do you feel that living near Lake Wingra improves your quality of life?

Response	Yes	No	Subtotal
# of Responses	312	48	360
Percentage Response	86.67	13.33	97.30

Question 8: How do you rate Lake Wingra and its watershed as a recreational area?

Response	Outstanding	Good	Average	Poor	Don't Know	Subtotal
# of Responses	66	190	63	14	32	365
Percentage Response	18.08	52.05	17.26	3.84	8.77	98.65

Question 9: How do you rate Lake Wingra and its watershed as a natural area, with respect to plants, animals and ecosystems?

Response	Outstanding	Good	Average	Poor	Don't Know	Subtotal
# of Responses	74	188	60	12	31	365
Percentage Response	20.27	51.51	16.44	3.29	8.49	98.65

Question 10: How do you rate the current water quality of Lake Wingra?

Response	Outstanding	Good	Average	Poor	Don't Know	Subtotal
# of Responses	2	36	119	139	71	367
Percentage Response	0.54	9.81	32.43	37.87	19.35	99.19

Question 11: In the time you have lived in the watershed, do you think that the water quality in Lake Wingra has… ?

Response	Greatly Improved	Improved somewhat	Stayed the Same	Worsened	Greatly Worsened	Subtotal
# of Responses	1	27	151	136	15	330
Percentage Response	0.30	8.18	45.76	41.21	4.55	89.19

Question 12: Do you feel that there are any major environmental or pollution problems in Lake Wingra?

Response	Yes	No	Subtotal
# of Responses	263	56	319
Percentage Response	82.45	17.55	86.22

Question 13: Listed below are some existing and potential problems that affect Lake Wingra. On a scale from 1 to 5, rate each problem, by circling the number that you feel best describes the magnitude of the problem.

The following provide the criteria for categorizing 'potential problems' responses for Question 13:

- *"Large problems" if more than 40% of the respondents felt that it was a 'large problem,' and the combined percentage of 'large problem' and 'somewhat a problem' was greater than 70%.*
- *"Medium problems" were those that were considered to be a 'large problem' by more than 10% of the respondents, and the combined percentage of 'large problem' plus 'somewhat a problem' was near 50%.*
- *"Small problems" were those potential problems that were considered to be a large problem by less than 10% of the respondents, and near 50% of responses were 'small problem' or 'not a problem.'*
- *"Don't knows" were those potential problems that had greater than 50% of the respondents answering 'don't know.'*

a. Too much algae

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	165	125	19	2	50	361
Percentage Response	45.71	34.63	5.26	0.55	13.85	97.57

b. Smell of lake water

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	46	134	86	37	54	357
Percentage Response	12.89	37.54	24.09	10.36	15.13	96.49

c. Clarity of lake water

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	110	142	43	11	45	351
Percentage Response	31.34	40.46	12.25	3.13	12.82	94.86

d. Too many weeds

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	152	121	32	8	48	361
Percentage Response	42.11	33.52	8.86	2.22	13.30	97.57

e. Spring flow decreases

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	46	65	33	10	193	347
Percentage Response	13.26	18.73	9.51	2.88	55.62	93.78

f. Fertilizer and/or pesticide use on lawns

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	179	81	24	5	72	361
Percentage Response	49.58	22.44	6.65	1.39	19.94	97.57

g. Stormwater runoff from streets and buildings

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	149	107	27	9	68	360
Percentage Response	41.39	29.72	7.50	2.50	18.89	97.30

h. Over-fishing

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	10	24	44	87	189	354
Percentage Response	2.82	6.78	12.43	24.58	53.39	95.68

i. Sand and salt from streets

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	104	115	46	13	83	361
Percentage Response	28.81	31.86	12.74	3.60	22.99	97.57

j. Park maintenance

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	8	24	79	151	92	354
Percentage Response	2.26	6.78	22.32	42.66	25.99	95.68

k. Non-native species (carp, Eurasian water milfoil)

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	52	65	34	16	190	357
Percentage Response	14.57	18.21	9.52	4.48	53.22	96.49

l. Non-native species that could invade in the future (ex. Zebra mussels)

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	104	115	46	13	83	361
Percentage Response	28.81	31.86	12.74	3.60	22.99	97.57

m. Handling of leave, grass, yard waste

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	45	78	35	14	183	355
Percentage Response	12.68	21.97	9.86	3.94	51.55	95.95

n. Beach closings/ lake not swimmable

Response	Large Problem	Somewhat a Problem	Small Problem	Not a Problem	Don't Know	Subtotal
# of Responses	96	122	56	14	71	359
Percentage Response	26.74	33.98	15.60	3.90	19.78	97.03

o. Other responses to potential environmental pollution problems

Response	Zoo runoff	Fertilizer and pesticides on lawns and golf courses
# of Responses	18	7

Question 14: Below are some things that individuals can do to reduce the amount of pollutants entering local water bodies, such as Lake Wingra. Circle the answer that best applies to you.

a. Rake leaves away from the street and curbs

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	241	58	10	45	354
Percentage Response	68.08	16.38	2.82	12.71	95.68

b. Use a lawn fertilizer that does not contain phosphorus

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	111	119	12	115	357
Percentage Response	31.09	33.33	3.36	32.21	96.49

c. Perform soil testing of lawn and garden soils before deciding to apply fertilizers

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	29	155	35	126	345
Percentage Response	8.41	44.93	10.14	36.52	93.24

d. Stop using chemical fertilizers

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	104	104	64	81	353
Percentage Response	29.46	29.46	18.13	22.95	95.41

e. Stop using pesticides, including herbicides, fungicides, rodenticides, and insecticides

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	107	88	72	81	348
Percentage Response	30.75	25.29	20.69	23.28	94.05

f. Clean up dog waste promptly

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	111	20	4	224	359
Percentage Response	30.92	5.57	1.11	62.40	97.03

g. Attend a public meeting on how to protect water quality

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	9	229	77	24	339
Percentage Response	2.65	67.55	22.71	7.08	91.62

h. Modify roof gutters & downspouts on your home to divert rain away from driveways, sidewalks, and roads

Response	Already do this	Willing to do this	Not Willing to do this	Not Applicable	Subtotal
# of Responses	146	109	30	70	355
Percentage Response	41.13	30.70	8.45	19.72	95.95

Question 15: If you had questions regarding Lake Wingra, such as water quality, soil testing or stormwater, who do you feel would be the best source to answer your questions? Check all that apply.

Source of Information	# of Responses	Percent of Total
Extension Agent	179	48.38
Neighbors	58	15.68
Fishing club	7	1.89
Lawn care company	14	3.78
County conservationist	200	54.05
Local professor or teacher	82	22.16
Lawn and garden club	20	5.41
Watershed project staff	231	62.43
Landscape contractor	20	5.41
Hardware or gardening store	17	4.59
Environmental organization	169	45.68

Other

Response	WDNR	City Official	Neighborhood Association
# of Responses	13	8	5

Question 16: In what formats do you prefer information to be provided for you? Check all that apply.

Source of Information	# of Responses	Percent of Total	Subtotal
Fact sheets	263	71.08	370
Workshops	52	14.05	370
Community activities	34	9.19	370
Phone calls	10	2.70	370
Brochures	218	58.92	370
Meetings	43	11.62	370
Video tapes	33	8.92	370
Neighborhood demonstrations	66	17.84	370
Newsletters	260	70.27	370
Personal letters	30	8.11	370
Visits to my home	14	3.78	370
Radio	77	20.81	370

Question 17: Personal Information

a. Gender

Response	Female	Male	Subtotal
# of Responses	147	207	354
Percentage Response	41.53	58.47	95.68

b. Age (years)

Response	# of Responses	Percentage Response	Subtotal
<20	0	0	361
20-30	32	8.86	361
31-40	63	17.45	361
41-50	108	29.92	361
51-60	61	16.90	361
>60	97	26.87	361

c. Education background

Response	# of Responses	Percentage Response	Subtotal
K-12	2	0.56	358
High School Diploma	18	5.03	358
Some College	40	11.17	358
College Degree	127	35.47	358
Advanced Degree	171	47.77	358

d. Approximate annual household income

Response	# of Responses	Percentage Response	Subtotal
<$15,000	13	4.06	320
$15,000-24,999	30	9.38	320
$25,000-39,999	48	15.00	320
$40,000-59,999	71	22.19	320
$60,000-89,000	87	27.19	320
$90,000-129,000	48	15.00	320
$130,000 +	23	7.19	320

Population Detail Report

Wisconsin Block Group
Water Resources
Scan/US, Inc.
10/04/99

1998 Estimates

Households by Race/Ethnicity

Total Households	17,306
White	15,626
Black	1,040
Asian/Pacific Islander	580
American Indian/Eskimo/Aleut	60
Hispanic Households	332

Educational Attainment (age 25+)

No High School Diploma	1,334
High School Graduate	4,150
Some College	7,618
College Degree	7,562
Graduate/Professional Degree	7,048

Group Quarters Population

Total	671

Marital Status (age 15+)	Male	Female
Population 15+	15,419	17,496
Single	5,745	5,858
Married	7,884	7,667
Separated	160	265
Widowed	369	1,656
Divorced	1,261	2,050

Size of Households	Total	%
1 Person	5,324	30.8%
2 Persons	6,591	38.1%
3 Persons	2,527	14.6%
4 Persons	1,892	10.9%
5 Persons	691	4.0%
6+ Persons	281	1.6%

Households with Vehicles Available

0 Vehicles	1,447
1 Vehicle	7,600
2 Vehicles	6,368
3+ Vehicles	1,891
Vehicles Available	26,550
Average Vehicles per Household	1.53

Households by Type

Family	9,523
Married Couple Families	7,491
Non-Family	7,783
1 Person	5,324
Male Householder	1,995
Female Householder	3,329

Total Age of Householder

	Total	%
<25	1,404	8.1%
25-34	4,370	25.3%
35-44	3,702	21.4%
45-54	2,469	14.3%
55-64	1,669	9.6%
65-74	1,765	10.2%
75+	1,927	11.1%

Presence of Children in Households

	Total	%
No Children	12,987	75.0%
With Children	4,319	25.0%

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Appendix 7

Examples of U.S. Stormwater Utilities

- **Bellevue, Washington:** The SWU operates and maintains the city's drainage system including 11 regional flood control sites and 250 small neighborhood detention sites. Many detention sites are wetlands while others are innovative sites that can serve as parks or athletic fields during dry weather. The SWU also offers the following services: 24-hour emergency response, advice on drainage around homes, residential lot connections, water quality compliance to meet state and federal requirements, assistance for residents who want to enhance streams near their homes, private system maintenance inspections, and educational programs such as "Stream Teams" and "Business Partners for Clean Water."
http://www.ci.bellevue.wa.us

- **Fort Collins, Colorado:** The SWU maintains drainage facilities, addresses stormwater quality, reviews new developments for compliance with criteria, constructs capital projects, and engages in floodplain management and basin-wide drainage planning. The SWU also co-sponsors youth education programs with the Northern Colorado Conservancy District, has a team of three speakers who visit elementary schools, and provides outdoor demonstrations and educational publications.
http://www.ci.fort-collins.co.us/utilities/water/stormwater/index.html

- **Orlando, Florida:** The SWU collects and maintains the data necessary to support the quality of area lakes, and to comply with applicable regulations. The SWU lists lake management as one of their responsibilities. Further, it monitors and insures compliance with the city SWU code, which seeks to "improve public health, safety, and welfare by providing for the safe and efficient capture and conveyance of stormwater runoff and the correction of stormwater problems;" inspects private stormwater treatment facilities; and is involved with the enforcement of municipal codes dealing with the illicit discharge of polluting substances to the city's surface and groundwater. The SWU acts as a liaison to citizens for lake water quality data by answering inquiries and complaints, and by conducting public awareness and education programs. It supports the Florida LAKEWATCH program, a citizen participation program that trains volunteers to collect samples on a monthly basis. The SWU Bureau purchases needed sampling equipment, trains volunteers, and assists with the storage and transport of the samples to the lab. Further, the SWU has an active public awareness program to help inform residents of how to reduce pollutant loads. This program includes writing for neighborhood association newsletters, giving presentations at neighborhood meetings and schools, presenting displays at weekend activities, and working with volunteers to post "No dumping, drains to lake" signs .

http://cityinter.ci.orlando.fl.us/departments/public_works/swu/index.html

- **Chesapeake, Virginia:** The SWU raises revenue to support state and federally mandated programs that require the city to regulate stormwater. Services include maintaining pipes and ditches, analyzing stormwater runoff pollutants, dredging lakes and other pollution reduction projects, inspecting construction site sediment and erosion controls, inspecting illegal connections into the storm drain system, running public information programs for citizen awareness of pollution prevention, and coordinating volunteer litter removal programs.
http://www.chesapeake.va.us/services/depart/pub-wrks/strmwtr/credit.html

- **Kirkland, Washington:** The goals of the SWU are to reduce the quantity of silt washed into lakes and streams, minimize local flooding, provide funds for minor capital improvement projects, and establish a stormwater education program for schools and businesses.
http://www.ci.kirkland.wa.us/about/cityupdates/cuw98/stormwtr.htm

- **Spokane County, Washington:** The SWU ensures that stormwater systems are planned, developed, and maintained to prevent flooding, protect water quality, and preserve natural stormwater systems. The SWU also provides leadership and a focus for community efforts working towards stormwater management. In addition, the SWU manages flood plains and works to ensure that construction and maintenance projects minimize both short- and long-term environmental harm.
http://web.spokanecounty.org/utilities/stormwtr/index.htm

- **Fairfax County, Virginia:** In addition to funding traditional capital improvements, and operation and maintenance costs, the SWU funds intensive retraining of all county officials and employees with stormwater management responsibilities. The SWU also funds non-profit initiatives to reforest, restore, conserve, and protect upstream and buffer areas. The SWU further promotes the protection and expansion of public parkland and conservation of private open spaces, and restores vegetation around stormwater facilities. The SWU holds a general conference and public workshop about civil engineering alternatives – advanced, progressive, on-site stormwater practices and bioengineering.
http://www.geocities.com/rainforest/5663/storm.html

- **Portland, Oregon:** While Portland does not have a SWU, it does have a stormwater management plan. This plan has integrated non-conventional partnerships with diverse entities to improve water quality through activities and structures on properties. The city has found these partnerships and local initiatives to be viable alternatives to regional structural facilities, providing opportunities to incorporate innovative techniques into future projects.
Hottenroth *et al.*, 1999.

- **Columbus, Ohio:** The SWU coordinates work, such as floodwall construction projects, with the US Army Corps of Engineers . The SWU manages NPDES permitting and funds capital projects. It has implemented 30% of its proposed neighborhood capital improvement plans, a computerized flood warning system, an enhanced SWU administrative database for more accurate billing, a citywide stormwater plan, and an erosion and sediment control program.
http://utilities.ci.columbus.oh.us/sewrpt.html

- **Hollywood, Florida:** The SWU maintains a storm and surface water management system that includes various inlets, piping systems, manholes, channels, ditches, drainage easements, retention and detention basins, infiltration facilities, and natural waterways. All of these elements provide for the collection, storage, treatment, and conveyance of stormwater, and provide services and benefits to all property within the city.
http://www.hollywoodfl.org/pub-util/hlwd-pub.htm

- **Boca Raton, Florida:** The SWU provides an economically feasible stormwater management program to improve flood protection and improve the quality of stormwater runoff. It meets state water policy requirements and USEPA NPDES permit conditions.
http://www.ci.boca-raton.fl.us/utility/storm.htm

- **Miami, Florida:** The SWU funds capital improvement projects and deals with the maintenance and administration of stormwater collection systems, including sewer cleaning and inspection. It is responsible for the NPDES permitting process.
http://www.cdm.com/svcs/wateres/strmwat1.htm

- **Virginia Beach, Virginia; Des Moines, Iowa; Lebanon, Indiana; and Union, Ohio:** These SWUs mainly fund capital improvement projects that let them meet their stormwater management plan goals and NPDES permit requirements.
http://www.cdm.com/svcs/wateres/strmwat1.htm; http://www.lebanon-utilities.com/storm.htm; and http://www.union.oh.us/watersew.htm

Appendix 8

Stormwater Utility White Paper

A Stormwater Utility for Madison

Madison's lakes need our help. Water quality problems include algae blooms, high bacterial counts and the associated beach closings, reduced biological diversity, and increased sedimentation. Surprisingly, these water quality problems are caused by "non-point" sources like our city's stormwater runoff.

Why Does Madison Need a Stormwater Utility?

During rainstorm and snowmelt events, untreated runoff from our roofs, driveways, lawns, and streets carries nutrients, sediments, and contaminants straight to the lake. Concentrations of these pollutants contribute to the degradation of lake ecosystems. Street sweeping, retention ponds, and curbside leaf pick-up are not effective enough to protect the lake from runoff pollution. Necessary improvements to maintain or increase effectiveness can be very expensive.

A stormwater utility can help Madison, as it has helped hundreds of other communities in the USA, to raise funds specifically for improving stormwater management practices.

What is a Stormwater Utility?

A stormwater utility is a special purpose organization that uses the financial ability and authority necessary to carry out its mission. Like an electric or water utility, it collects fees for services provided. The fees collected by a stormwater utility fund storm sewer maintenance, street sweeping, retention ponds for filtering out sediments, and other projects to control stormwater runoff. Fees are proportional to the amount of runoff produced by the property; hence fees for homes are much less than for larger buildings with large impervious surfaces such as parking lots. A stormwater utility's revenues, such as fees collected for storm sewer use, must be spent on improving stormwater management.

What Kind of Stormwater Utility Should Madison Have?

The city of Madison is currently considering the implementation of a stormwater utility. Stormwater management plans also continue to develop at the county, state, and federal levels. While these levels of government are coordinating their planning with each other, citizen roles need to be defined. Madison has a history of progressive environmental legislation, and should demand the best possible use of its stormwater utility including the following components.

1. Governance Structure with Community Involvement
A Madison stormwater utility should receive input from a board that includes community representatives from watershed organizations, business associations, lake user groups, and/or neighborhood associations. Considering Madison's active citizens, it is appropriate that stormwater solutions include neighborhood participation to help improve water quality. A board with a strong citizen voice would enable citizens to better participate in the management of their watersheds. Citizen participation will also help the utility be flexible and responsive to community interests. The board should also include representatives with expertise in stormwater management, shallow lakes management, outreach, planning, and law. With this kind of board membership, a broad set of interests would be represented in decisions. To further ensure the involvement of the watershed neighborhood, a watershed coordinator could serve as a liaison between the board and citizens, and promote education and outreach.

2. Innovative Solutions
A Madison stormwater utility should promote a wide range of innovative strategies for managing stormwater. These should include infiltration practices that reduce the quantity of runoff, treatment practices that improve stormwater quality, and in-lake practices that enhance our lakes and streams. In addition to standard construction and maintenance costs, funds generated by the utility could be used to implement innovative stormwater management practices, fund a small grants program for community-based watershed management projects, and conduct public education, outreach, and demonstration projects.

3. Incentives for Individual Solutions
Stormwater utilities often provide incentives to businesses for management practices that decrease the quantity and improve the quality of stormwater runoff. These could be extended to homeowners as well. For example, houses that direct downspouts to lawns, instead of driveways and other impervious surfaces, generate less runoff because the runoff infiltrates into the soil instead of running directly into the street. On a larger scale, businesses and developments can minimize impacts with retention ponds, constructed wetlands, and less impervious surface areas. Encouraging these and other solutions with a reduction in fees has been successful for stormwater utilities elsewhere.

Summary
Based on lessons learned from other watershed management plans, efforts to protect and enhance resources are ultimately limited by a lack of consistent funding and a lack of community involvement and interest necessary for long-term support. Designing a stormwater utility for Madison with opportunities for community participation, and funds set aside for innovative watershed improvements, would decrease these limitations.

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