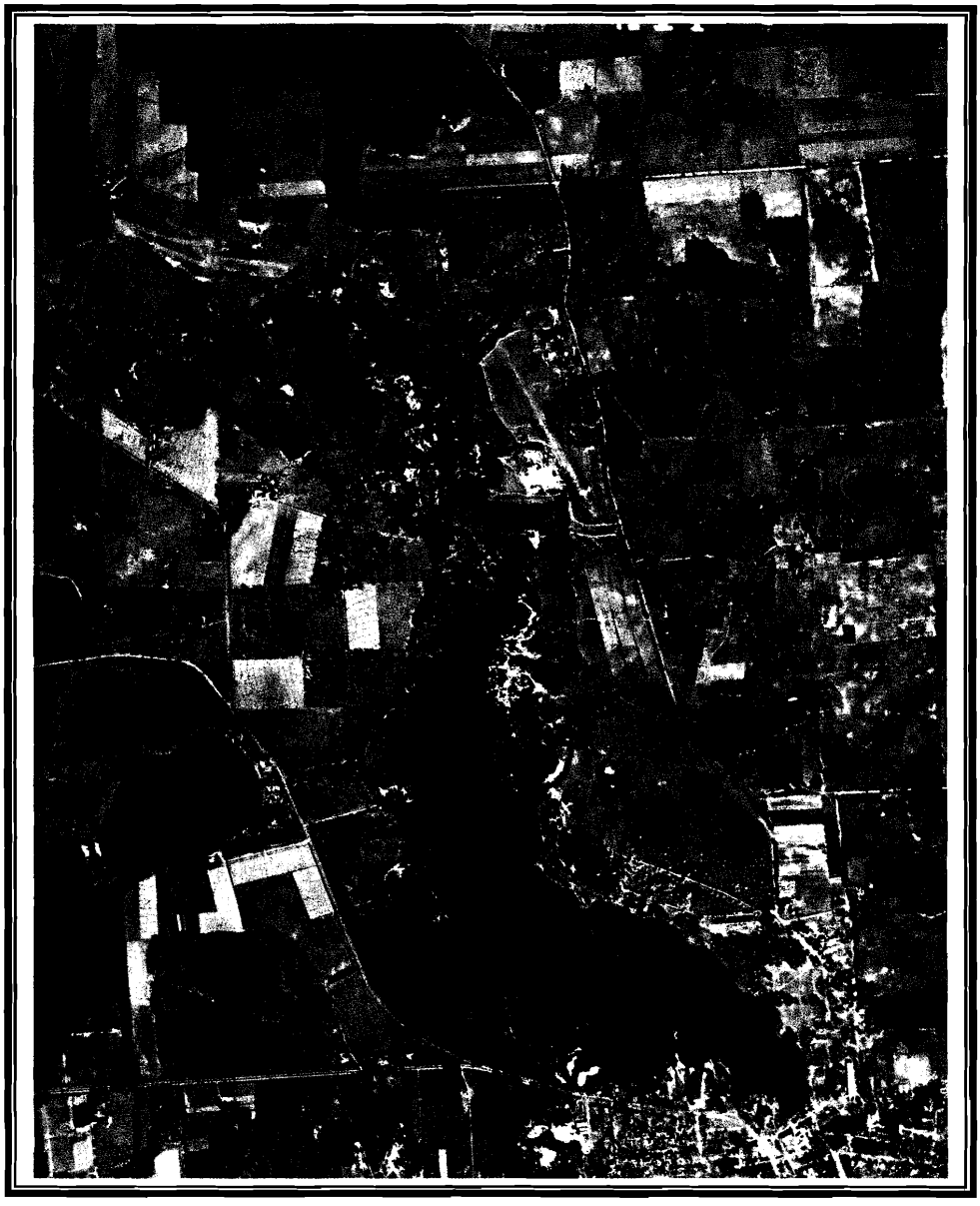
MONTELLO LAKE MANAGEMENT PLAN



LPL-689-00

MONTELLO LAKE MANAGEMENT PLAN

PROJECT LOCATION:
Montello Lake
Town of Montello
Marquette County, Wisconsin

MANAGEMENT UNIT:
Montello Lake Inland Protection & Rehabilitation District
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BOARD OF DIRECTORS (2001):
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PROJECT REFERENCE #: 4430

PLAN APPROVAL DATE: 3-25-02

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Date

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3-28-02
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CHAPTER 1: INTRODUCTION

1-1 BACKGROUND

Montello Lake is a 286-acre drainage lake located on the Montello River in Marquette County, Wisconsin. It is a shallow, meso-eutrophic impoundment with an abundance of aquatic vegetation that has resulted in various lake-use impairments. The lake is recognized as an important natural resource for the community, and is considered a regional asset of environmental, recreational and economic significance. Montello Lake is known and used primarily for fishing, peaceful relaxation, wildlife/scenic enjoyment and limited boating opportunities.

The Montello Lake Inland Protection and Rehabilitation District was formed in 1982 in response to resident concerns regarding issues such as nuisance rooted aquatic plant growth and unstable water levels. Later, in 1986, a Wisconsin Department of Natural Resources' assessment of Montello Lake confirmed popular sentiment by identifying excessive weed growth and fluctuating water levels as the lake's two most significant issues of concern. Since the formation of the Lake District, water-level stabilization has been addressed through cooperative agreements with North American Hydro, Inc.—operators of the Montello Dam. Management activities have since focused primarily on the control of excessive aquatic weed growth, using a combination of herbicide applications and mechanical weed harvesting, each with mixed results.

Today, the Lake District continues its efforts to improve fish and wildlife habitat while preserving the lake's recreational potential and facilitating unobstructed navigation to all non-restricted areas of the lake. Prolific weed growth, sediment accumulation and stunted panfish populations are a few of the major problems that are currently affecting the use and enjoyment of the resource. Although water quality conditions are shown to be fairly representative of similar lakes in central Wisconsin, non-point source pollution from a large, agriculturally dominated watershed continues to threaten the quality of Montello Lake.

1-2 GOALS & OBJECTIVES

To cost-effectively address the above challenges, the Lake District took appropriate action to develop a comprehensive lake management plan. This two-year planning effort was funded in part through a grant from the Wisconsin Department of Natural Resources. The Plan provides an important blueprint that will guide protection and rehabilitation efforts on Montello Lake for years to come.

Protecting the lake's valued attributes while affording reasonable, mixed-use recreation is no easy task. It is especially cumbersome due to conflicting public perceptions, lake-use priorities and management expectations. There is also the question of whether the resource is even realistically capable of supporting certain uses and desires. Proper planning helps ensure that management actions recognize this and do not inadvertently exacerbate an existing problem, or create entirely new problems. Without careful planning, money is too often thrown at "quick-fix" solutions without truly understanding all the potential impacts to the system. This is a common mistake that can prove very costly both financially and environmentally.

Prior to the development of this Plan, little guidance was available on such topics as aquatic plant control, fisheries and wildlife management, and non-point source pollution reduction. There was also a lack of guidance on how to deal with differing and ever changing public perceptions and expectations associated with Montello Lake and its management. Therefore, a comprehensive management plan was sought to provide interpretation, direction and a framework for decision-making with regard to these issue areas. A plan was also needed to objectively evaluate management options, establish realistic expectations, and lay out a course of action for resource protection and rehabilitation.

The Montello Lake Management Plan is meant to facilitate the protection and rehabilitation of Montello Lake by accurately identifying underlying problems, and offering holistic, watershed-scale management strategies to address these concerns. It is also meant to outline the potential risks and consequences associated with particular management actions. This is important since there is no silver bullet strategy that will produce equal benefits on every lake. Each lake is inherently unique, and each is likely to behave and respond in completely different ways. Therefore, every lake has its own set of problems and demands its own set of solutions. The lake-management plan is intended to help answer the following types of questions:

- What are the long-term goals and objectives?
- What are the problems, and whom do they affect?
- What are the management priorities?
- What management options can be used to address the identified problems?
- What are the potential benefits and drawbacks associated with each option?
- What is the most appropriate course of action?

The primary goal of the Montello Lake Management Plan is to propose appropriate strategies that will improve the deteriorating condition of the lake—which is largely attributed to the rapid and prolific growth of aquatic weeds. To increase the probability of success, recommendations are based on a combination of identified public priorities and a scientific diagnostic assessment of the ecosystem. Finally, preference is given to actions that support the long-term health and quality of the resource, rather than short-term solutions that are not likely to prove cost-effective over the long run.

1-3 PLAN DESIGN

The Montello Lake Management Plan is designed as a comprehensive information source and strategy document. It is intended as a flexible decision-making tool that can be used to effectively guide a variety of protection and improvement efforts on Montello Lake. Because no two lakes are exactly alike, this Plan is tailored specifically to Montello Lake's unique conditions and management challenges. For each particular issue of concern, every attempt was made to present multiple strategy options so the Lake District can pick and choose a course of action based on current needs and limitations.

This report builds upon the findings and conclusions of prior studies and planning efforts by (1) consolidating and summarizing relevant information, (2) re-evaluating proposed management recommendations, and (3) developing a one-source action plan based on the latest science and public consensus. As a plan, it should be considered a living document capable of evolving as resource conditions change or new information and technologies become available.

1-4 PROJECT DELIVERABLES

The following deliverables were produced as a result of this planning effort:

1. Description of existing physical, chemical and biological conditions
2. Water quality assessment of the lake based on existing data
3. Survey of public opinions and concerns regarding the lake and its management
4. Ranking and prioritization of lake-use preferences, values and perceived problems
5. Identification and analysis of significant problems interfering with the use and enjoyment of the lake
6. Analysis of past and ongoing management efforts
7. Cost-benefit review of applicable management strategies
8. Identification of remaining information needs
9. Discussion of major findings and recommendations
10. Proposed action strategy and implementation guidelines

1-5 METHODS

Lake managers that fail to plan appropriately are at risk of being reactionary and misguided in their decision-making. Without clearly articulated goals and objectives, it is possible for vocal interest groups to unduly influence the decision-making process by encouraging knee-jerk responses to complex issues. For instance, there may be pressure to take immediate action to resolve a perceived problem that is not adequately defined or understood. Acting upon such pressures to appease an interest group without understanding the nature, magnitude and complexity of the problem would be premature and irresponsible. Furthermore, grasping blindly at management strategies that are currently en vogue is sure to lead to less than desirable results over the long run, especially when strategy selection is not predicated on careful research and planning. The following is a description of the multi-phased approach that was employed to circumvent these potential pitfalls:

PHASE I: SOLICITATION OF PUBLIC PARTICIPATION & INPUT

The initial phase of the project involved notifying residents of the Montello Lake Inland Protection & Rehabilitation District and other key stakeholders about the goals and objectives of the project. Public meetings and written announcements were used to garner the understanding, support and participation of area residents and local officials who were likely to have an interest in contributing to the planning process. In addition, a comprehensive opinion survey was disseminated to all Lake District residents to evaluate public sentiment regarding the lake and its management. The survey was designed to gather in-depth feedback on existing conditions, lake-use preferences, perceived problems and management priorities. Survey responses were used in conjunction with the results of a 1998 opinion survey on aquatic plant control, as well as input received from various Lake District meetings, to assess public needs and priorities.

PHASE II: SUMMARIZATION AND ANALYSIS OF EXISTING INFORMATION

Phase II was to collect existing information on Montello Lake and its watershed. This information was primarily available through the Montello Lake Inland Protection & Rehabilitation District, Marquette County Land Conservation Department, Wisconsin Department of Natural Resources, and U.S. Geological Survey. Water quality data, resource assessment reports, an aquatic plant inventory, and prior studies were among the types of information sources used to characterize past and present conditions. A summary report was then prepared describing the various water quality parameters and landscape features that define the Montello Lake resource. This phase was used to highlight continuing information gaps, and guidance was subsequently provided for rectifying these data needs.

PHASE III: IDENTIFICATION OF PROBLEMS & MANAGEMENT PRIORITIES

Phase III involved an analysis of available data to identify both new and continuing problems that threaten the health and recreational attributes of the resource. A combination of public input and scientific information was used to rank problems and establish management priorities. Survey findings and technical analysis proved critical during this stage of the planning process. Every effort was made to use a holistic, watershed-based approach to pinpoint the root causes of particular issues of concern. This approach helped clarify distinctions between actual problems and their more obvious symptomatic responses.

PHASE IV: EVALUATION OF MANAGEMENT OPTIONS

Phase IV consisted of a review of available management options that, when implemented, would sufficiently address the problem at hand. Cost-benefit analyses were performed on a variety of options to highlight the pros and cons associated with each. Evaluation criteria included such factors as applicability, immediacy and longevity of effectiveness, estimated costs, and potential benefits and drawbacks. Management alternatives were also subjected to the public-priorities test. If a given strategy failed to satisfy at

least a majority of the public parameters set forth during the previous project phase, that strategy was dropped from further consideration. The purpose of this phase was to ultimately create a toolbox of management options from which the Lake District could select depending on current circumstances.

Phase V: Recommendation of Action Strategy

Phase V was to recommend a multiple-year course of action. Consideration was given to the relative significance of identified problems, lake-use preferences, management priorities, and future monitoring requirements. A basic timeline was developed to help guide the Lake District as it begins implementing any combination of suggested actions.

Phase VI: Communication of Key Findings and Conclusions

The sixth and final project phase is the communication of key findings, conclusions and recommendations to the public. Following the issuance of this planning document, the Lake District shall keep residents and key stakeholders informed of its progress through regular public meetings, press releases and informational mailings. Copies of the approved Montello Lake Management Plan shall also be submitted to the Wisconsin Department of Natural Resources, and made available for public review at local libraries and other repositories.

CHAPTER 2: EXISTING CONDITIONS

2-1 LOCATION

Montello Lake is an impounded section of the Montello River, located adjacent to the City of Montello and within the Town of Montello in Marquette County, Wisconsin (T15N, R10E, S5-8). Its adjoining watershed is defined as the upland land area that drains surface water to the lake. It is situated generally north and west of Montello Lake, and is part of the Upper Fox River Basin in the south-central part of the state. Most of the watershed is contained within Marquette County, with a small portion lying in neighboring Adams County. A location map is presented below as Figure 1.

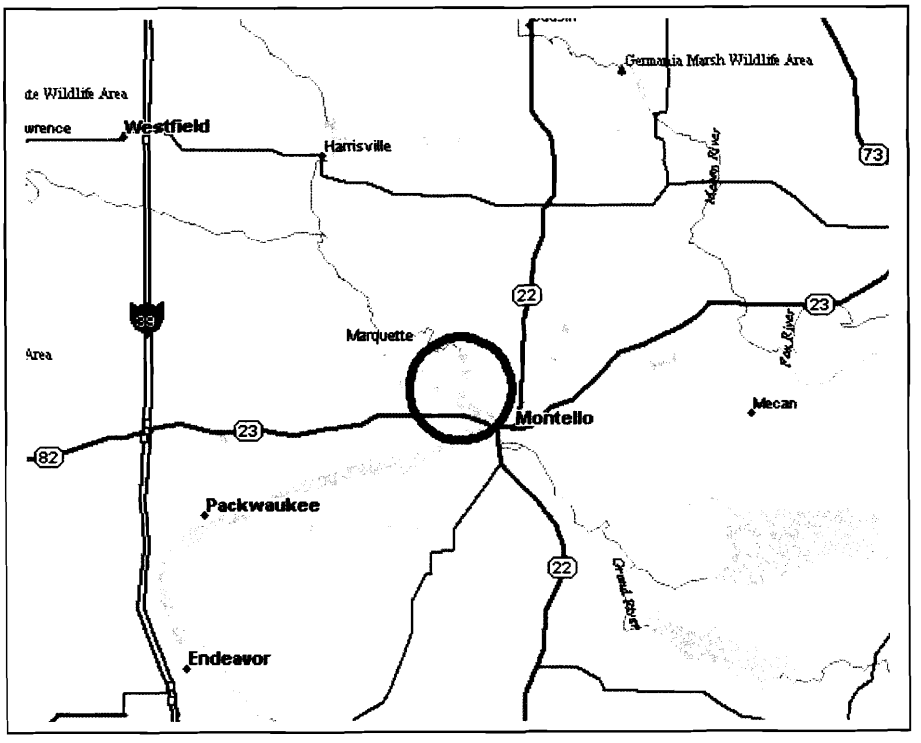


Figure 1: Location Map of Montello Lake

2-2 WATERSHED DESCRIPTION

DEFINITION

Water resource professionals often claim lakes are reflections of their watersheds. This is because the health and quality of a lake is directly linked to the condition of the land that drains surface water to the lake, also known as a watershed. A watershed is the total land area that is capable of shedding surface runoff to a particular water body. Its outermost boundary is defined by topographic high points on the adjoining landscape, and can be visualized as a giant bathtub with the lake situated where the drain is located. The watershed area is delineated from the lake's outlet and includes the surface area of the lake. The larger the watershed area, the more water it is able to collect and convey downstream as overland surface flow, also known as stormwater runoff. In the Montello Lake watershed, both surface water and regional groundwater flow generally in a southeast direction toward the lake.

Watershed-To-Lake Surface Area Ratio

Watershed-to-lake surface area ratios are used to estimate the level of influence the surrounding landscape has on water quality. As the size of the watershed increases in relation to the size of the lake, the greater the likelihood of pollutants entering the lake via stormwater runoff. This runoff is generated from snowmelt, precipitation and groundwater-derived discharge that does not evaporate or infiltrate into the soil. Instead, it collects on the landscape and is eventually funneled down gradient toward a receiving water body, transporting everything it can pick up and carry from the watershed to the lake. The actual amount of pollutants, sediment and other material delivered depends on watershed size, soil type, topographic relief, land-use practices, and runoff flow characteristics.

Montello Lake lies at the terminus of a large, 126.3-square-mile watershed that drains mostly farmland. The lake has a 0.45 square-mile surface area, which equates to a watershed-to-lake surface area ratio of just over 280:1. Lakes with ratios greater than 10:1 are shown to more commonly experience water quality problems when compared to lakes with smaller ratios. This is especially true in developed watersheds that are dominated by fertile, easily eroded soils, and where poor land-use practices produce excess runoff and erosion. Knowing the size of a particular watershed, as well as its defining topographic features, soil types and land uses will offer clues as to how much management effort will need to be focused in these critical upland areas.

Montello Lake is fortunate to exhibit relatively good water quality for having such a large watershed. However, the lake will continue to receive most of its water from stream discharge originating from an extensive watershed area. It is therefore important to properly manage land use on this adjoining landscape if the quality of Montello Lake is to be maintained. The Montello Lake/River Watershed is illustrated in Figure 2 below.

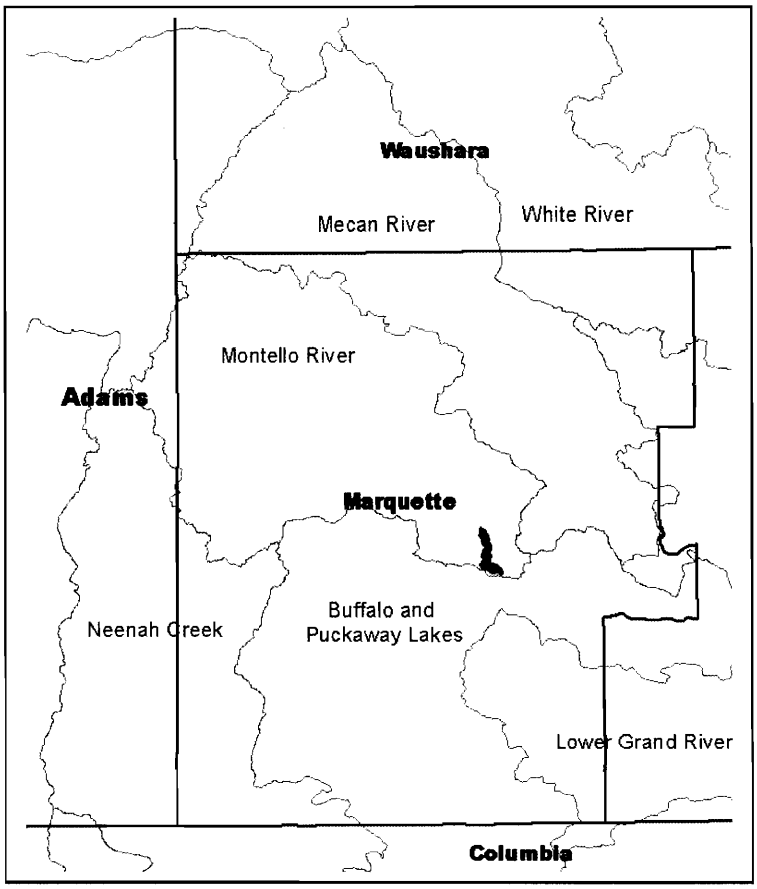


Figure 2: Montello Lake/River Watershed

Major Watershed Tributaries

Major tributaries include Tagatz and Caves Creek, Lawrence/Westfield Creek, Klawitter Creek and the Montello River. Most of these watershed tributaries are classified by the Wisconsin Department of Natural Resources as "outstanding" or "exceptional" in their upper reaches. Due to the effects of non-point source pollution, water quality begins to quickly degrade as you move downstream from the headwaters.

Tagatz Creek is 17 miles in length, of which 16 miles are classified as outstanding resource water. Caves Creek is slightly shorter at 12 miles, but its entire length is classified as exceptional. Both creeks are considered quality trout fishing streams, and eventually join Westfield Creek above Harrisville Millpond. This area is most impacted by erosion from cropland, construction sites, and stream banks.

Lawrence Creek begins in Adams County and is 4.4 miles long. The majority of the creek is classified as an exceptional and outstanding resource waters. The creek flows into Lawrence Lake where it turns into Westfield Creek. This area is most impacted by heavy agriculture and ditch systems.

All the above streams join at Harrisville to create the Montello River. It is 14 miles long with one main tributary, Klawitter Creek. The river ends at the City of Montello where it enters the Fox River. The entire length is considered a warm water sport fishery. Non-point source pollution problems impacting the Montello River include sedimentation and ditching problems (especially in the Klawitter Creek watershed), construction site erosion, and agricultural runoff (1999 Marquette County Land and Water Resource Management Plan).

Physical Setting

Diverse landscape features found within the Montello Lake Watershed were generally produced as a result of glaciations that occurred about 12,000 years ago. A thick mantle of glacial till, called a terminal moraine, covers the western portion of Marquette County, including major sections of the watershed. The terminal moraine consists of old glacial lakebeds that currently support marshland and scattered areas of red clay. A thinner mantle of glacial drift, called ground moraine, covers the remaining portions of the county and watershed. Underlying bedrock consists mostly of Upper Cambrian Sandstone, with limestone capping the hills in the northwester portion of Marquette County where the Montello Lake Watershed is located. Lake Montello and the city of Montello are underlain by Lower Proterozoic System granite and coeval rhyolite. The granite exists in the Montello area as well as other limited areas of Marquette and Waushara Counties.

Regional soils are generally sandy due to the underlying sandstone bedrock, and are classed as glacial and fluvial sands or sandy loams. Peat and muck soils, which support swamp forest and marsh vegetation, are found within the immediate Montello Lake area (1999 Marquette County Land and Water Resource Management Plan). Soil associations include: Plainfield-Gotham (loamy sand), Delton-Briggsville-Mundelein (silty clay & silty clay loam), and Houghton-Adrian (peat). Maps depicting regional topography/hydrography and soil types are included below as Figures 3 and 4, respectively.

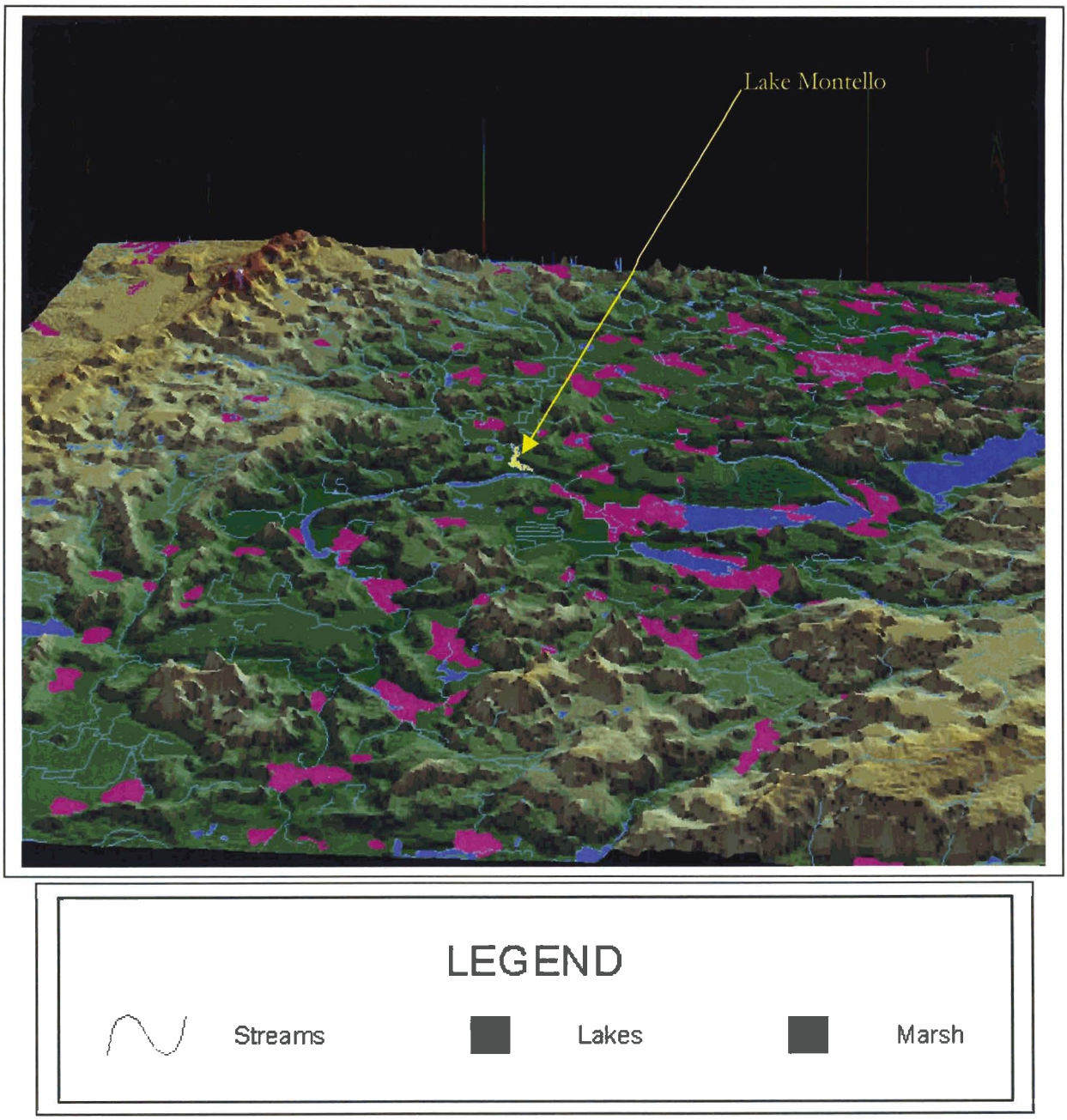
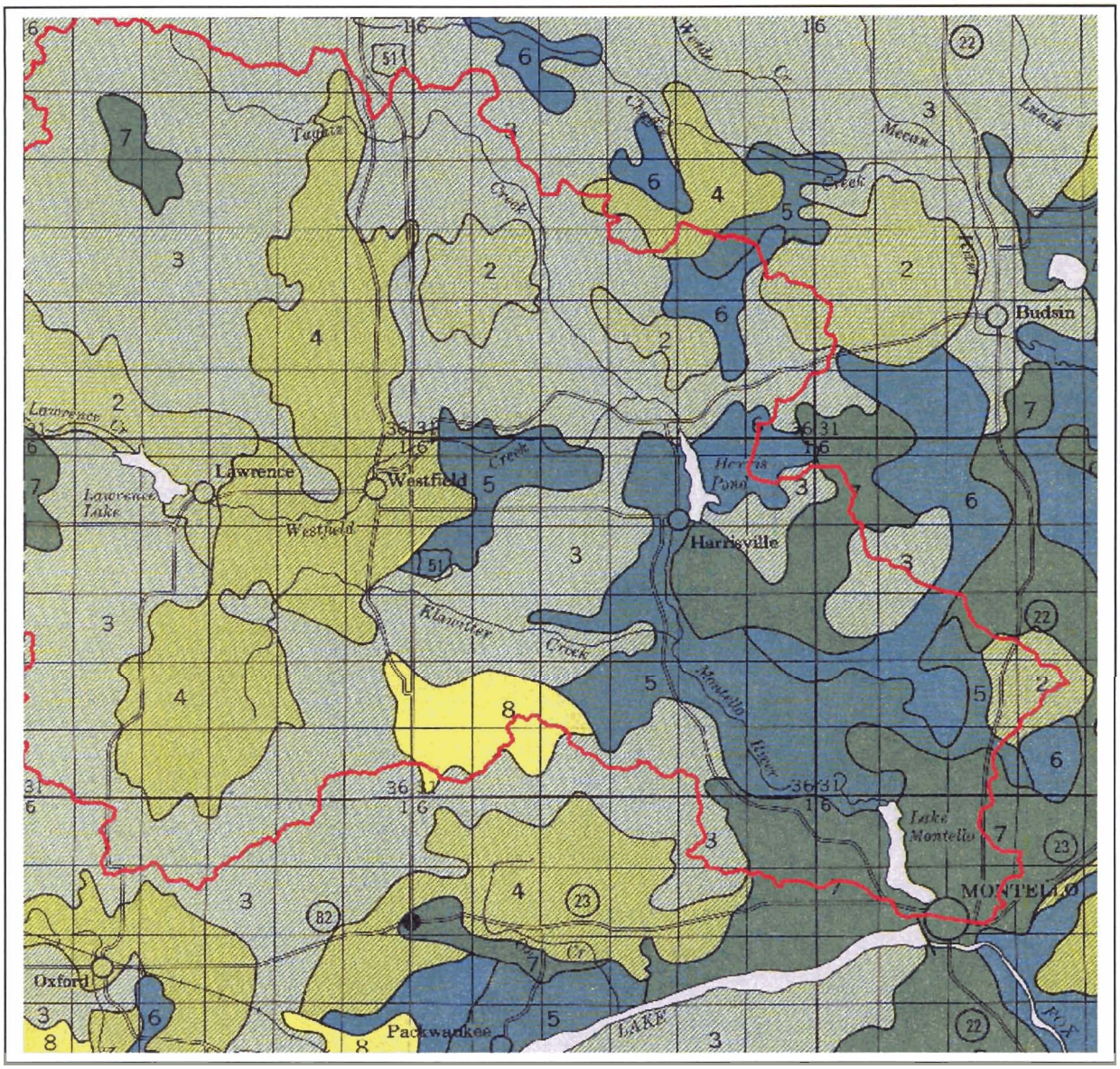


Figure 3: Regional Topographic and Hydrologic Features



Numerical Code	Soil Type
1	Lapeer-Pardeeville-Metea association: Deep, well –drained, moderately permeable and moderately rapidly permeable soils that have a sandy clay loam, sandy loam, and loamy sand subsoil over loamy glacial till
2	Gotham-Mecan association: Deep, will-drained, moderately rapidly permeable and rapidly permeable soils that have a sandy loam and loamy fine sand subsoil over loamy glacial till and sandy outwash.
3	Plainfiled-Gotham association: Deep, excessively drained and well-drained, very rapidly permeable and rapidly permeable soils that have a sand substratum or a loamy fine sand subsoil over sandy outwash
4	Delton-Briggsville-Mundelein association: Deep, well-drained and somewhat poorly drained, slowly permeable and moderately slowly permeable soils that have a silty clay and silty clay loam subsoil over lake-laid silt, clay, or sand
5	Grandby-Tedrow-Moundville association: Deep, poorly drained, somewhat poorly drained, and moderately well drained, rapidly permeable soils that have a loamy fine sand subsoil over sandy outwash
6	Houghton-Adrian association: Deep, very poorly drained, moderately rapidly permeable soils that have an organic subsoil over organic material or sand
7	Oshtemo-Gotham association: Deep, well-drained, moderately rapidly permeable and rapidly permeable soils that have a sandy loam and loamy fine sand subsoil over sandy outwash
8	Mecan-Metea association: Deep, well-drained, moderately permeable and moderately rapidly permeable soils that have a sandy loam and sandy clay loam subsoil over loamy glacial till

Figure 4: Regional Soil Types

Watershed Land Use/Cover

Agriculture, forestland and developed areas are the primary land uses in the Montello watershed. Westfield, Harrisville, and a portion of the City of Montello are the only municipalities located in the watershed. A breakdown of general land use/cover types by area is presented in Table 1 below. An accompanying land-use map is illustrated as Figure 5.

Table 1: Watershed land use/cover by acreage.

General Land Use/Cover	Type	Watershed Area (Acres)
Urban/Developed	High Intensity	238.63
	Low Intensity	429.22
Agriculture	Other Agriculture	1354.38
	Corn	9248.03
	Other Row Crops	8040.21
	Forage Crops	8040.21
	Cranberry Bog	1.11
Grassland	Grassland	14873.04
Forest	Jack Pine	506.61
	Red Pine	506.61
	Mixed/Other Coniferous	491.94
	Oak	19114.09
	Mixed/Other Broad Leafed	2637.37
	Mixed/Deciduous/Coniferous	6292.19
Water	Open Water	1554.98
Wetland	Emergent/Wet Meadow	1554.98
	Broad Leafed Deciduous	2256.19
	Broad Leafed Deciduous	3516.05
	Coniferous	2337.58
	Barren	142.78
	Shrubland	183.25
		83319.45

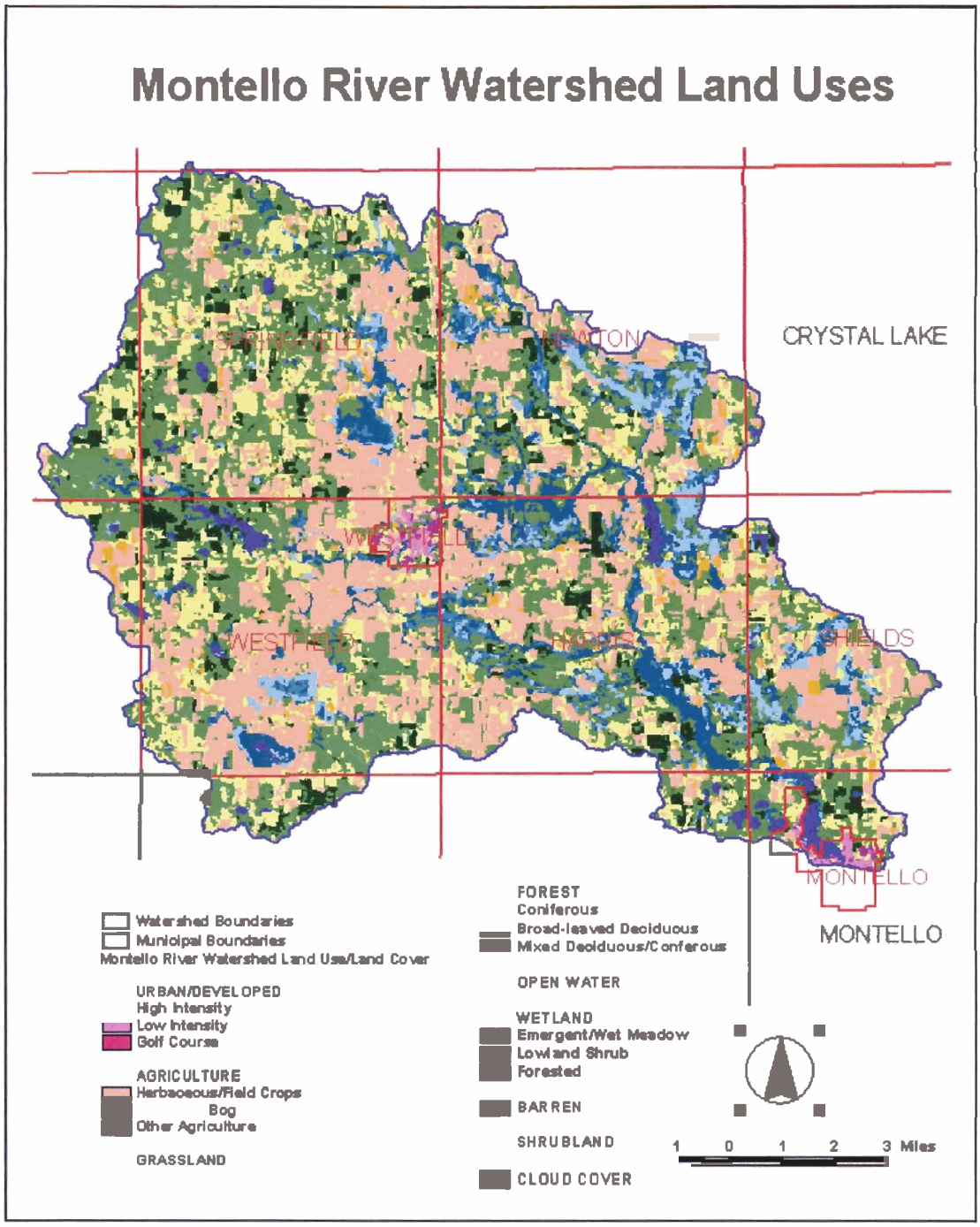


Figure 5: Watershed Land Use/Cover

2-3 LAKE DESCRIPTION

Overview

Montello Lake is a 286-acre, artificially impounded drainage lake on the Montello River with mean and maximum depths of five and 15 feet, respectively. The lake receives most of its surface water from an extensive, agriculturally dominated watershed. Shallow water depths in conjunction with high nutrient inputs from the surrounding watershed have resulted in an upper mesotrophic to eutrophic system. Montello Lake currently balances good water clarity with an abundance of aquatic vegetation, and supports a healthy warm-water sport fishery consisting of northern pike, largemouth bass, crappie and a variety of panfish. In terms of recreation, it is mostly used for fishing, peaceful relaxation, observing local wildlife, enjoying the natural scenery, and boating.

Mechanical harvesting is used to maintain limited open water areas for recreational purposes. Vegetation is cleared predominantly within a boating channel located along the old channel bed. Designated protected areas are located at the northeast and southwest sections of the lake. A 1994 aquatic plant inventory showed that these areas support high quality plant communities and wildlife habitat. There is also a designated fish refuge area just north of the dam, at the southeast corner of the lake. A map of Montello Lake is illustrated as Figure 6 below.

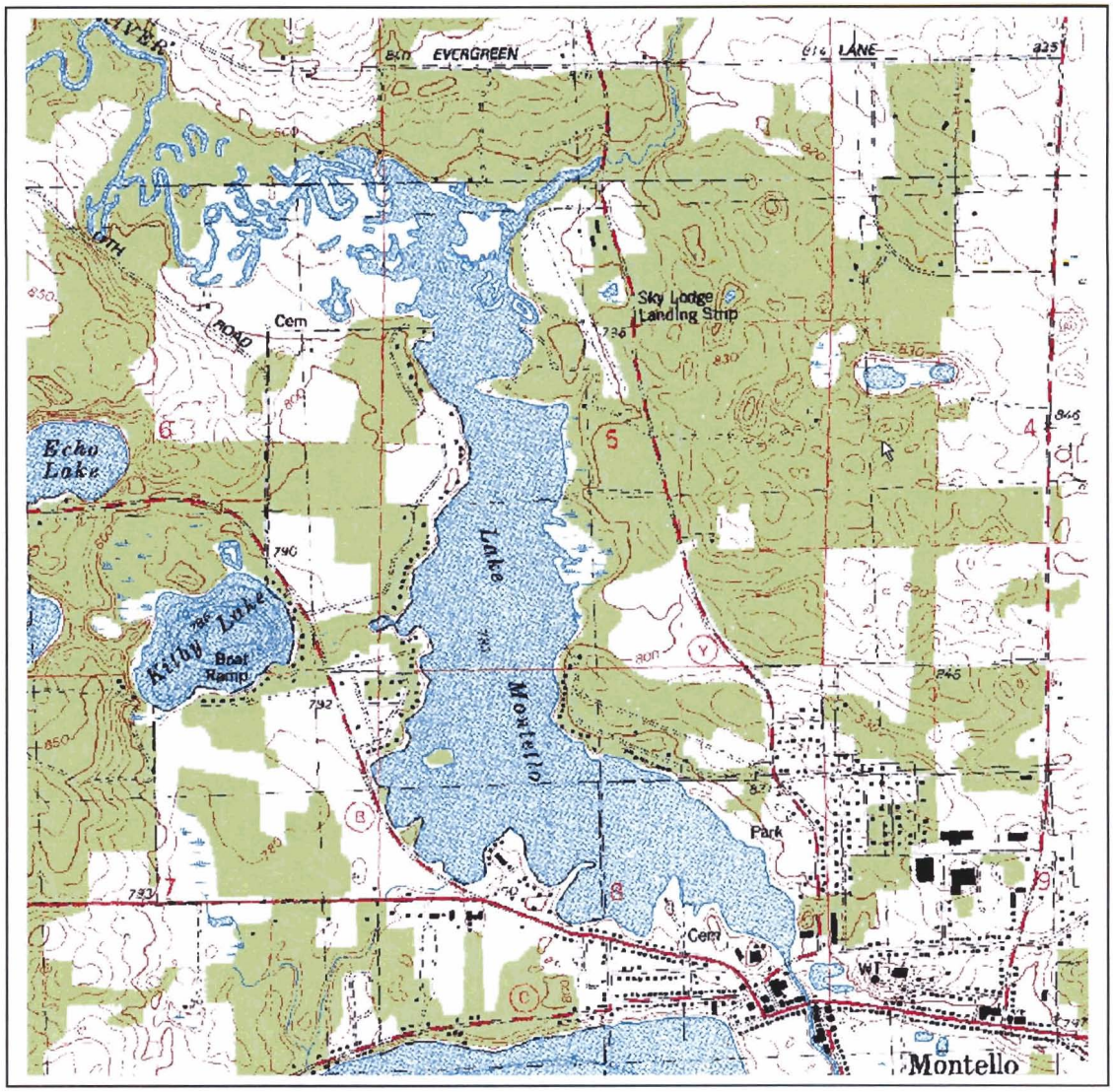


Figure 6: Montello Lake Map

Lake Type

Lakes may be classified according to their primary source of water, and how that water enters and leaves the water body. Drainage lakes, like Montello Lake, receive most of their water from the watershed in the form of stream drainage. These lakes have a prominent inlet and outlet that serve to move water through the system. Montello Lake has one major inlet and outlet, the Montello River, which enters at its northwest corner and exits through a hydroelectric dam at its southeast corner, eventually feeding into the Fox River. There is also one minor, unnamed inlet on the northeast side of the lake. Drainage lakes are referred to as artificial lakes, impoundments or flowages when a dam is responsible for at least one-half of their maximum depth—as is the case with Montello Lake.

Knowledge of lake types is important when attempting to identify and address various water quality and quantity problems. By examining the different sources and quality of water that recharge a lake, water resource professionals are better able to pinpoint the root causes of water quality impairments. For example, if stream discharge provides the major source of water, nutrient levels are often high and water exchange takes place more rapidly. These lake types have the most variable water quality, depending on the amount of runoff and human activity in the watershed. Conversely, if groundwater is the major water source, the lake is usually well buffered against acid rain, contains low to moderate amounts of nutrients, and has fairly slow

water exchange rates. This includes all groundwater drainage lakes and some seepage lakes. Local septic systems or groundwater contamination could cause water quality problems in these lake systems.

Morphometric Characteristics

Lake morphometry (or bathymetry) describes a lake's physical dimensions. Montello Lake's physical characteristics include lake volume (1,676 acre-feet of water), surface area (286 acres), shoreline length (6.5 miles), mean depth (5 feet) and maximum depth (15 feet). It has a gradually sloping bottom, with the deepest point occurring along the thread of the old river channel near the lake's center. Only 5-10% of the lake consists of water depths exceeding 10 feet. It is 1.9 miles long and 0.6 mile wide, and consequently has a short fetch. Fetch describes the maximum distance across a lake that would be subjected to the effects of prevailing winds. Montello Lake's physical dimensions suggest that it is relatively sheltered from wind-induced processes.

Surface area, maximum and mean water depths, basin shape, shoreline length, water volume, and other physical measurements can offer many clues as to how a lake should appear and function in a natural state. For example, a lake's morphometry will dictate how well its water column is able to mix and self-aerate. The extent to which the water mixes affects the lake's water quality and ability to support a diversity of aquatic life. The complete mixing of a lake's water column is called "turnover." While shallow lakes tend to continuously mix or turn over throughout the year due to wind and wave action, deeper lakes turn over less frequently—typically as a result of seasonal temperature changes or large storm events. This is because deeper lakes undergo a process known as thermal stratification. A bathymetric map illustrating the configuration of the lake basin is presented as Figure 7 below.

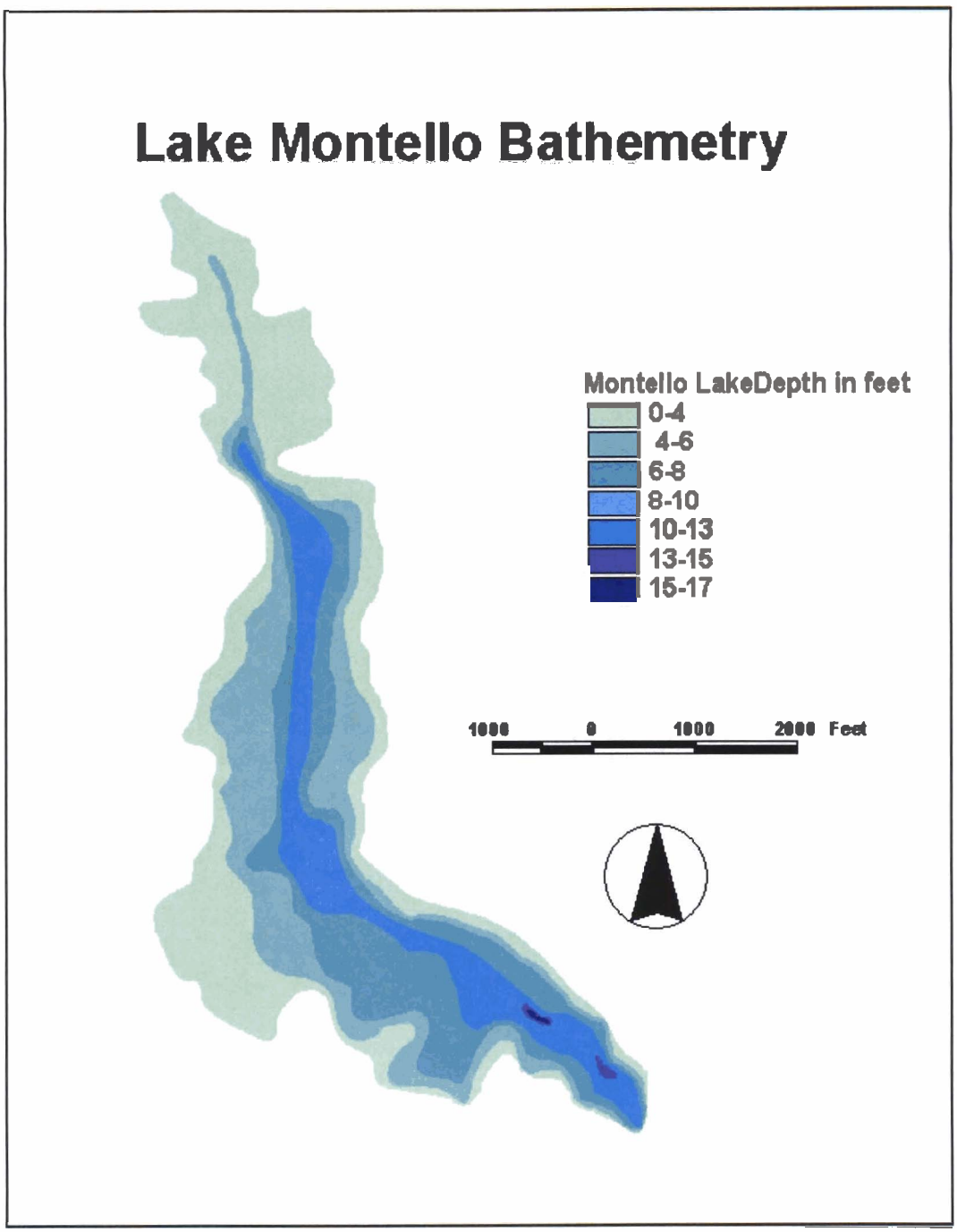


Figure 7: Montello Lake Bathymetry

Thermal Stratification

Thermal stratification occurs in deep lakes during stable weather conditions when the water column forms horizontal water layers of varying temperatures and densities. As air temperatures rise in the spring, a temperature-density "barrier" begins to form in deeper water bodies between the warmer, lighter surface water that is heated by solar energy and the underlying denser, colder water. This barrier is marked by a sharp temperature gradient called the thermocline. The zone where the thermocline occurs is known as the metalimnion. It separates the warmer, less dense, upper zone of water called the epilimnion, from the cooler, more dense, lower zone called the hypolimnion. Summer stratification generally occurs in lakes where depths are greater than 20 feet. However, depending on their shape, small lakes can stratify even if they are less than

20 feet deep. Montello Lake, for instance, routinely exhibits weak thermal stratification in its deepest points during mid-summer. In larger lakes, the wind may continuously mix the water to a depth of 30 feet or more.

Lakes may also undergo a second stratification period during the winter months. Because water density peaks at 39°F, winter stratification develops with a temperature difference of only 7°F between the top and bottom (32°F right below the ice versus 39°F on the lake bottom). This explains why ice floats and forms at the water's surface. The ice layer at the surface helps maintain stratification by preventing wind from mixing the water column. The ice also helps insulate the water beneath it, which prevents deeper lakes from freezing solid.

The temperature and density of the water column will be fairly consistent from top to bottom in both the early spring and late fall. The uniform water density allows the lake to mix completely, replenishing the bottom water with dissolved oxygen and recycling nutrients up to the surface. This destratification process is called spring and fall turnover. Algae blooms often proceed turnover events in stratified, eutrophic lakes when nutrients are suddenly infused into the upper photic zone of the lake.

It is important to note that lakes experiencing strong thermal stratification are frequently subject to oxygen depletion in the hypolimnion. As algae, plant debris and other organic material fall into the hypolimnion to decay, oxygen becomes depleted to the extent that anaerobic conditions may develop. A strong sulfur odor is frequently associated with such waters. This oxygen deficiency can stress a cool water fishery, and may cause the mobilization of phosphorus from nutrient-rich bottom sediment into the overlying water. During turnover, the fertile bottom water is then mixed throughout the water column, creating a situation that favors nuisance algae blooms. Although Montello Lake may become weakly stratified during the mid-summer period, it remains fairly well mixed on a year-round basis. Consequently, the lake does not form an extensive hypolimnetic zone, nor does it significantly suffer from the effects of oxygen depletion caused by strong thermal gradients.

Retention Time/Flushing Rate

The average length of time water remains in a lake is called the retention time, or hydraulic residence time. It is primarily determined by lake size, water source, and watershed size. Rapid water exchange (flushing) rates allow nutrients to be flushed out of the lake quickly. Such lakes respond best to management practices that decrease nutrient input. Drainage systems and impoundments, like Montello Lake, fit this category. Conversely, longer retention times occur in seepage lakes with no surface outlets. Nutrients that accumulate over a number of years in lakes with long retention times can be recycled annually with spring and fall mixing. Thus, the effects of watershed protection may not be apparent for a number of years. Nevertheless, lakes with long retention times tend to have the best water quality since they are usually deeper with smaller watersheds.

Trophic State

Eutrophication is a term used to define the aging process of a lake, and describes the primary productivity response of a lake to nutrient enrichment. Water bodies that receive excessive amounts of nutrients, such as phosphorus and nitrogen, are most likely to become eutrophic systems. Once in the lake, these excess nutrients increase fertility levels and contribute to murky water conditions, algae blooms or nuisance weed growth—the symptoms of eutrophication.

A lake's trophic state describes its degree of eutrophication or level of primary productivity. Lakes can be classified as either oligotrophic, mesotrophic or eutrophic. Oligotrophic lakes are generally clear, deep and free of weeds or algae blooms. They are low in nutrients and are not capable of supporting large fish populations. Eutrophic lakes have poor water clarity, are high in nutrients, and support a large biomass of aquatic plants and animals. They are usually either weedy or subject to frequent algae blooms, or both. Although capable of supporting large fish populations, these lakes are also susceptible to oxygen depletion. Devoid of oxygen in late summer, their hypolimnions become intolerable to cold-water fishes and cause

phosphorous cycling from bottom sediments. Large rough fish populations (e.g. carp) are commonly found in eutrophic lakes. Mesotrophic lakes lie between the oligotrophic and eutrophic stages. It is important to recognize that a natural aging process occurs in all lakes that cause them to become shallower and increasingly eutrophic over time. However, human activity can accelerate the eutrophication process by allowing greater quantities of nutrients to enter the lake.

Trophic state is determined by correlating three water quality parameters--phosphorus concentration, chlorophyll *a* concentration and water transparency values. The trophic state of Montello Lake is meso-eutrophic, indicating that it fluctuates between a mesotrophic and eutrophic condition. The trophic state of Wisconsin lakes based on chlorophyll a, Secchi depth, and total phosphorus values is presented in Table 2 below.

Table 2: Trophic classification of Wisconsin lakes based on total phosphorus, chlorophyll a, and Secchi depth values.

(Adapted from Lillie and Mason, 1983.)

Trophic Level	Trophic State Index	Total Phosphorus (mg/l)	Chlorophyll *a* (ug/l)	Secchi Depth (meters)
Eutrophic				
----------	----------50----------	--------0.017----------	----------7.4----------	----------2.0----------
Mesotrophic				
----------	----------40----------	--------0.005----------	----------2.0----------	----------4.0----------
Oligotrophic				

Limiting Nutrient

Phosphorus (P) and nitrogen (N) are the two nutrients that most directly influence plant and algae growth; the extent of which depends on the relative abundance and availability of each nutrient. These nutrients usually enter lakes in the form of polluted runoff that may contain sediment, manure, pet waste, chemical fertilizers, and organic debris, among other materials. The erosion of stream banks, construction sites, shorelines and farmland all contribute sediment and nutrients to downstream lakes. Failing septic systems on smaller, heavily developed lakes with small flushing rates can also contribute significantly to nutrient-loading problems. Septic contributions are not considered a significant problem on Montello Lake.

Plants need both phosphorus and nitrogen to grow. However, phosphorus minimization is generally the focus of lake-management programs because it is (1) most frequently the limiting nutrient that controls the rate of algae growth, and (2) it is easiest to manipulate since the element has no gaseous component in its biogeochemical cycle. N:P ratios are used to determine which nutrient most "limits" or controls algae productivity by comparing the relative availability of each nutrient within the water column. A limiting nutrient is an element that is critical to the growth of primary producers, but is found in short supply relative to other required elements found in a particular water body. Because the essential nutrient is in short supply, it effectively limits the amount of primary productivity the lake is capable of supporting. A N:P ratio greater than 15:1 near the water surface may generally be considered phosphorus limiting; a ratio from 10:1 to 15:1 indicates a transition situation; and a ratio less than 10:1 usually indicates nitrogen limitation. Lakes with intermediate ratios could be limited from time to time by either element, but by reducing phosphorus availability, phosphorus could be made the limiting factor.

N:P ratios were computed for Montello Lake by the U.S. Geological Survey during the 1995-96 monitoring period. Values ranged from 128:1 in 1995, to 95:1 in 1996. Therefore, phosphorus is the limiting nutrient for algae growth in Montello Lake. This is not surprising since phosphorus is the key nutrient affecting the amount of algae and weed growth in the vast majority of Wisconsin's lakes. Note that the Marquette County Land and Water Conservation Department is currently surveying the watershed to identify major non-point source pollution loading hot spots. Their findings will help determine external phosphorus

sources to Montello Lake. The completion of this type of study, known as a phosphorus budget, was recently recommended by the WDNR in its Upper Fox River Basin Report.

The lake bottom may also be a significant source of phosphorus. Phosphorus is commonly released from nutrient-rich bottom sediment as a result of physical disturbance, high pH levels, and/or anoxic conditions. This phosphorus may cause noxious algae blooms, especially when it is mixed throughout the water column during the summer growing season. Knowledge of the phosphorus content of sediment in various locations along the lakebed is useful in identifying potential "hot spots" that are most likely to contribute the largest amounts of nutrients to the lake. This information can be used to determine whether management techniques such as dredging and alum treatments will effectively correct a potential in-lake, nutrient-recycling problem. Sediment cores are generally taken at certain locations in a lake to better characterize the depth and distribution of nutrient-rich bottom sediments. Sediment core information has not been collected for Montello Lake as of the date of this report.

In addition, total phosphorus concentrations at the top and bottom of the water column can be compared. These measurements can suggest whether phosphorus is actually collecting in the anoxic hypolimnion from sediment releases during the summer stratification period. Because Montello Lake is so shallow, phosphorus release due to stratification-induced anoxia is not a serious concern. This is confirmed by prior water quality testing performed by the U.S. Geological Survey.

When phosphorus concentrations exceed 0.025 mg/l at the time of spring turnover in natural lakes and impoundments, these water bodies may occasionally experience excess growth of algae or other aquatic plants. In hard water lakes where limestone is dissolved in the water, marl (calcium carbonate) precipitates and falls to the bottom. These marl formations absorb phosphorus, reducing its overall concentration as well as algae growth. Hard water lakes often have clear water, but may be weedy since rooted aquatic plants can still get phosphorus from the sediments.

Phytoplankton (Algae)

Phytoplankton, more commonly known as algae, describes free-floating, microscopic plant life. Algae are the primary producers that form the base of the aquatic food chain. The amount of sunlight and nutrients that are available in a lake, among other factors, will dictate algae abundance. In eutrophic lakes, high nutrient fertility can cause nuisance algae blooms that make the water appear very green and murky. Blue green algae (cyanobacteria) are even known to produce a floating green scum thick enough to shade out aquatic plants. High concentrations of wind-blown algae may accumulate on shorelines where they die and decompose, causing noxious odors, unsightly conditions and oxygen depletion.

Controlling nuisance algae populations in lakes is a difficult undertaking. Because algae are microscopic plants that are free-floating and even free-swimming in the water column, managing the whole lake rather than just the problem areas is usually necessary. Since algae populations are caused by high nutrient concentrations, attempting to eliminate algae by attacking it directly with algacides (chemical herbicides) is a short-term solution that may become a costly management approach over the long run. The best way to manage excessive algae is to both reduce the flow of nutrients into the lake, and control the availability of nutrients that are already contained within the lake.

Chlorophyll *a*, the green pigment found in all photosynthesizing organisms, is commonly used as an indicator of algae biomass. Chlorophyll *a* values for Montello Lake during the summer months are generally indicative of a mesotrophic, or moderately productive ecosystem.

Water Clarity

Water transparency measurements are taken with a device known as a Secchi disc, which is used to evaluate the clarity of a lake's water column. A Secchi disc is an eight-inch-diameter, black-and-white patterned plate that is lowered into the water until it reaches a depth at which it is no longer visible from the

water surface. The recorded depth can be compared to values from other lakes and used as an indicator of overall water clarity.

Generally, sunlight can penetrate to a depth equal to 1.7 times the Secchi depth. The depth to which light is able to penetrate, defined as the photic zone, roughly coincides with the depth where there is enough oxygen to support fish and other aquatic life. Transparency may be affected by factors such as turbidity (suspended sediment and particulate matter), watercolor, and free-floating algae cells. Secchi depth measurements are often used in conjunction with chlorophyll *a* and total phosphorus concentrations to determine a lake's trophic state and overall water quality condition.

Secchi measurements taken on Montello Lake typically range from 1.6 to 2.6 meters. These measurements are indicative of a relatively transparent water column in comparison to similar lakes. Abundant rooted plant growth and a lack of sediment re-suspension from boating activity are believed to contribute to the above average water clarity.

Water Quality Index

Lillie and Mason (1983) classified all Wisconsin lakes using a random data set collected in the months of July and August. The water-quality index that was developed is based on surface total-phosphorus and chlorophyll *a* concentrations and Secchi depths. Applying the water-quality index to Montello Lake revealed that the measured surface total-phosphorus concentrations were generally indicative of "fair" to "poor" water quality, while Secchi transparency and chlorophyll *a* concentrations were generally indicative of "good" water quality. Table 3 shows the total phosphorus, chlorophyll *a* and Secchi depth ranges that correspond with each water quality ranking. Typical value ranges for Montello Lake's 1995-96 monitoring period are highlighted in gray. Table 4 shows the relative condition and percent distribution of central Wisconsin lakes that exhibit various total phosphorus, chlorophyll *a* and Secchi depth ranges. Once again, typical value ranges for Montello Lake's 1995-96 monitoring period are highlighted in gray.

Table 3: Water quality index for Wisconsin lakes based on total phosphorus, chlorophyll a and Secchi depth values.

(Adapted from Lillie and Mason, 1983)

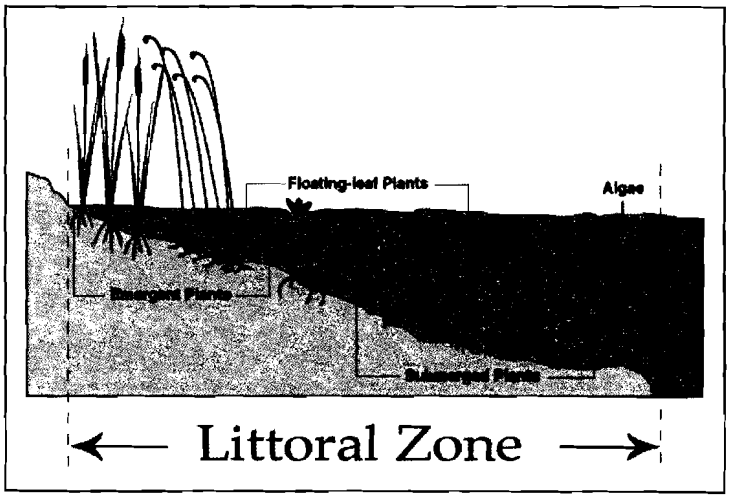
Water Quality Index	Total Phosphorus (mg/l)	Chlorophyll a ([g/l)	Secchi Depth (meters)
Excellent	<0.001	<1	>6.0
Very good	0.001-0.010	1-5	3.0-6.0
Good	0.010-0.030	5-10	2.0-3.0
Fair	0.030-0.050	10-15	1.5-2.0
Poor	0.050-0.150	15-30	1.0-1.5
Very poor	>0.150	>30	<1.0

Table 4: Relative condition and percent distribution of central Wisconsin lakes within various parameter ranges.

Parameter	Relative Condition	% distribution of central WI lakes within parameter ranges
Total-phosphorus (mg/L)		
<0.010	Best condition	32
0.010-0.020	▼	39
0.020-0.030	▼	9
0.030-0.050	▼	12
0.050-0.100	▼	7
>0.100	Worst condition	2
Chlorophyll a (ug/L)		
0-5	Best condition	35
5-10	▼	44
10-15	▼	9
15-30	Worst condition	12
Secchi depth (feet)		
>19.7	Best condition	5
9.8-19.7	▼	21
6.6-9.8	▼	39
3.3-6.6	▼	29
<3.3	Worst condition	5

LITTORAL ZONE

The relative abundance, distribution and types of rooted aquatic plants (macrophytes), fish, and other aquatic organisms provide an excellent indicator of lake quality. This is why the shallow, biologically rich areas on a lake are so important. These areas represent the lake's littoral zone. The depth at which sunlight is able to penetrate the water column in quantities necessary to promote photosynthesis determines the extent of the littoral zone. Like a rainforest, it is where you will find the greatest biological diversity.



The littoral zone's counterpart is the deep, open water pelagic zone. Uniformly shallow lakes like Montello will usually have insignificant pelagic zones when compared to their vast littoral areas. However, deeper lakes that have extensive, irregular shorelines with lots of small bays and narrow channels may also support large littoral zones. Macrophytic vegetation dominates both these types of systems, especially under conditions of good water clarity and nutrient-rich bottom sediments. Montello Lake's littoral zone supports a diversity of flora and fauna, and it occupies most of the lake's total surface area. As a result, the lake has natural limitations that will preclude any lake uses that require large areas of deep, open water.

Aquatic Plant Community

A diversity of native aquatic vegetation is the foundation of a healthy and balanced lake ecosystem. Such a situation is ideal for maintaining good water quality and wildlife habitat conditions. Plants provide nutrient buffers, stabilize bottom sediment, oxygenate the water during photosynthesis, provide shelter and spawning habitats for fish, act as refuges for zooplankton (algae consumers), and serve as food sources for wildlife. Aquatic plant growth is limited by factors such as sunlight availability and sediment type.

Degraded lakes are disturbed ecosystems characterized by too much or too little aquatic vegetation that is usually dominated by non-native, invasive "weeds." An absence of vegetation usually leads to poor water quality and a loss of fish and wildlife habitat. This situation favors an increase in algae growth and a reduction in water clarity. A different set of problems occurs when non-native aquatic weeds become overly abundant. This situation reduces native plant diversity, impedes certain recreational functions of the lake, stunts fish growth, and can cause dramatic fluctuations in dissolved oxygen levels. The decomposition of plant material is also shown to release nutrients that were previously tied up in the living plant tissues. Isolated areas in a lake where either native plant growth is sparse or a nuisance weed condition exists are excellent indicators of localized disturbances. Disturbances can be in the form of pollution, sedimentation, motorboat damage, or the chemical eradication or over harvesting of plant beds.

Examples of beneficial native plants include water lilies, bulrushes and pondweeds. Eurasian watermilfoil and curly-leaf pondweed, on the other hand, are nuisance species that are not native to Wisconsin. Under the right conditions, these exotic invaders will out-compete native plants and form monotypic stands of dense vegetation. Such prolific growth can eventually reduce biological diversity and restrict recreational use of the water. This is the case of Montello Lake where an overabundance of aquatic vegetation restricts recreational access to open water areas and results in stunted panfish populations.

Refer to the 1994 Montello Lake Plant Management Plan for more information describing Montello Lake's aquatic plant community. The Lake District should consider performing a follow-up plant inventory to determine how conditions have changed since 1994.

Fisheries

A 1979 DNR fishery survey revealed "good natural reproduction as evidenced by strong numbers of young-of-year largemouth bass, bluegill, black crappies, and pumpkinseeds." The survey also found good growth rates on northern pike; average growth rates for largemouth bass; slow-growing panfish; and the absence of a carp problem.

Montello Lake currently has good largemouth bass, northern pike and panfish populations. The presence of relatively undisturbed, natural shorelines and extensive wetland areas enhance the spawning and nursery habit for game fish. Shoreland wetlands and abundant aquatic plant growth also provide refuge and cover while maintaining good water quality conditions. There is a diversity of aquatic plants that are valued as food sources for wildlife. Quiet wetland areas and dead trees provide excellent habitat for both fish and wildlife (1994 Montello Lake Plant Management Plan).

Unfortunately, overly dense plant growth is preventing predator fish from grazing on smaller fish. This situation leads to the overpopulation and stunting of panfish populations. Protecting high-quality plant communities while controlling the spread of non-native species will benefit the fishery as a whole. Other improvement strategies include harvest restrictions, creation of edge habitat in weed-choked locations, maintaining good water clarity, and protecting wetlands and natural shorelines.

Dissolved Oxygen & Temperature

Dissolved oxygen is one of the most critical factors affecting lake ecosystems, and is essential to all aquatic organisms that require aerobic conditions to survive. The solubility of oxygen is dictated by water

temperature. Basically, the colder the water temperature, the more oxygen it is able to hold in solution. Dissolved oxygen is also more abundant in water that is well mixed and in greater contact with the atmosphere. Areas in a lake that support photosynthesis will further enhance dissolved oxygen levels during daylight hours. This helps explain why oxygen levels fluctuate throughout the water column depending on variables such as time of day, water depth, clarity and temperature. When dissolved oxygen concentrations become depleted, the survival of fish and other oxygen-dependent aquatic life becomes compromised. The water quality standard for oxygen in "warm water" lakes like Montello is 5.0 mg/l, which is the minimum amount of oxygen needed for most fish to survive and grow.

As discussed earlier, the amount of oxygen present within the hypolimnion of deeper lakes plays an important role in the mobilization of nutrients from the bottom sediments into the surrounding water column. Phosphorus can be chemically converted into a more soluble state and released from bottom sediments when the overlying water becomes devoid of oxygen, or anoxic. These anoxic conditions commonly occur within the hypolimnions of deeper, eutrophic lakes where the rate of decomposition and bacterial respiration exceeds the rate of photosynthesis and natural aeration. For instance, as thermal stratification isolates the hypolimnion from the atmosphere, the surface supply of oxygen from the atmosphere is sealed off. The remaining dissolved oxygen is often rapidly consumed when respiration rates increase due to excessive decomposition of organic material that settles to the bottom. As anoxia develops, phosphorus contained in the sediments chemically converts into a more soluble state, migrating from the sediments to the surrounding water. When the lake eventually destratifies (mixes), any nutrients that were released from the bottom sediments are transported throughout the water column where they become available for algae growth. It should be noted that anoxic conditions are also capable of developing in weedy, shallow lakes, especially during non-daylight hours when bacterial and microbial respiration is likely to exceed photosynthesis.

Vertical profiles of water temperature and dissolved oxygen in Montello Lake exhibit no abnormalities and are sufficient to support a diversity of aquatic life. Complete water column mixing occurs both in the spring and fall, and very weak thermal stratification develops during the summer months. Oxygen deficiencies were measured near the lake bottom during periods of stratification.

Acidification

pH measures the concentration of hydrogen ions in a lake. Lower pH waters have more hydrogen ions and are more acidic than higher pH waters. A pH of 0 indicates that a particular water sample is highly acidic, while a pH of 14 suggests a highly basic sample (7 is considered neutral). Every 1.0 unit change in pH represents a tenfold change in hydrogen ion concentration. Therefore, a lake with a pH of 6 is ten times more acidic than a lake with a pH of 7.

Low pH is shown to increase the solubility of certain metals that can become toxic in higher concentrations, such as aluminum, zinc and mercury. It is also harmful to the survivability of fish and other aquatic organisms. In Wisconsin, pH ranges from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes). Lakes having good fish populations and productivity generally have a pH between 6.7 and 8.2. Lower pH lakes are often found in the northern part of the state where acid rain has a greater impact on surface waters due to the limited buffering capacity of regional soil types. Natural, unpolluted rainfall is relatively acidic, and typically has a pH of between 5 and 6. However, rainfall varies from a pH of 4.4 in southeastern Wisconsin to nearly 5.0 in northwestern Wisconsin. Fortunately, naturally acidic precipitation is usually neutralized as it is exposed to acid-buffering carbonates in the environment.

The amount of dissolved carbon dioxide in a lake, which is influenced by photosynthesis and respiration processes, generally affects pH levels. For instance, as carbon dioxide levels increase, pH will correspondingly decrease, and vice versa. 1995-96 water chemistry data indicate that the pH of Montello Lake generally ranges from about 7.1 to 8.4. These values are common for lakes in this part Wisconsin, pose no problems for aquatic life, and indicate that the system is well buffered from acidification. Acidity effects on different fish species are presented in Table 5 below.

Table 5: Effects of acidity on fish.

(Adapted from Olszyk, 1980)

Water pH	Effects
6.5	Walleye spawning inhibited
5.8	Lake trout spawning inhibited
5.5	Smallmouth bass disappear
5.2	Walleye, burbot, lake trout disappear
5.0	Spawning inhibited in many fish
4.7	Northern pike, white sucker, brown bullhead, pumpkinseed sunfish, rock bass disappear
4.5	Perch spawning inhibited
3.5	Perch disappear
3.0	Toxic to al fish

Alkalinity & Hardness

A lake's hardness and alkalinity are each affected by the types of minerals found within the watershed's soils. Hardness and alkalinity increase the more the lake water comes into contact with minerals containing bicarbonate and carbonate compounds. These compounds are usually found with two hardness ions: calcium and magnesium. If a lake receives groundwater from aquifers containing limestone minerals such as calcite and dolomite, hardness and alkalinity will be high. High levels of hardness (>150 mg/l) and alkalinity can cause marl (calcium carbonate) to precipitate out of the water. Hard water lakes like Montello Lake tend to be more productive and support larger quantities of fish and aquatic plants than soft water lakes. They are also usually located in watersheds with fertile soils that add phosphorus to the lake. As a balancing mechanism, however, phosphorus precipitates with marl, thereby controlling algae blooms. If the soils are sandy and composed of quartz or other insoluble minerals, or if direct rainfall is a major source of lake water, hardness and alkalinity will be low. Lakes with low amounts of alkalinity are more susceptible to acidification by acid rain and are generally unproductive.

Montello Lake has high alkalinity and "low" sensitivity to acid rain due to its significant buffering capacity. Table 6 shows relative hardness levels for lakes with varying concentrations of calcium carbonate (CaCO3). Table 7 shows relative sensitivity levels of lakes to acid rain based on alkalinity values.

Table 6: Categorization of hardness by mg/L of calcium carbonate (CaCo3).

Level of Hardness	Total Hardness as mg/l CaCO3
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very Hard	>180

Table 7: Sensitivity of lakes to acid rain based on alkalinity values.

(Adapted from Taylor, 1984)

Sensitivity to Acid Rain	Alkalinity (ppm CaCO3)	Alkalinity (ueq/l CaCO3)
High	0-2	0-39
Moderate	2-10	40-199
Low	10-25	200-499
Nonsensitive	>25	>500

CHAPTER NOTE:
A summary of the lake and watershed's physical, chemical, biological & demographic characteristics is included in Table 8 below.

Table 8: Summary of physical, chemical and biological characteristics.

PHYSICAL DESCRIPTION (LAKE)	
Origin of lake:	Artificial impoundment of Montello River
Lake type:	Drainage lake (one major inlet and regulated outlet)
Surface area:	286 acres (0.45 square miles)
Shoreline length:	6.5 miles
Mean depth:	5 feet
Maximum depth:	15 feet
Volume:	1,676 acre-feet
Primary water source:	Stream drainage
Relative flushing rate:	Rapid
Thermal stratification:	Polymictic (weak stratification w/ multiple mixing events)
Summer anoxia:	Minor
Shoreline development factor:	2.7 (circle=1; number increases as shore irregularity increases)
PHYSICAL DESCRIPTION (WATERSHED)	
Watershed area:	126.3 square miles
Watershed-to-lake surface area ratio:	280:1
Dominant land use:	Agriculture
Wetland acreage:	9,991 acres
Major soil types:	Plainfield-Gotham Loamy Sand; Delton-Briggsville-Mundelein Silty Clay, Silty Clay Loam; Houghton-Adrian, Peat
Topography:	Gently rolling to flat
Length of inlet tributaries:	99.5 miles
Public lake access:	Boat ramp, park and beach
CHEMICAL & BIOLOGICAL DESCRIPTION	
Nitrogen to phosphorus ratio:	95:1 (1996 data)
Limiting nutrient:	Phosphorus
Trophic status:	Meso-eutrophic
Water quality indices (1996):	Total phosphorus ("Fair"); chlorophyll *a* ("Good"); Secchi transparency ("Good")
Nutrient sensitivity:	Low
Alkalinity & hardness:	Moderate to high
Acidification sensitivity:	Low
Winter fish kill sensitivity:	Low
Major sport fisheries:	Largemouth bass, northern pike, crappie, panfish
Total aquatic plant species:	19 (1994 survey)

CHAPTER 3: PUBLIC PRIORITIES & NEEDS ASSESSMENT

3-1 INTRODUCTION

Actively involving the public is important in facilitating the identification and prioritization of desired lake uses and problems. In addition, public involvement helps educate users about the lake ecosystem, their role in contributing to certain problems, and the actions they can take to eliminate or reduce the severity of these problems. Greater understanding and awareness of problems will generally lead to increased cooperation in their solution and thus a greater likelihood of program success.

We recognize that lakes cannot be all things, to all people, at all times, and that lake uses often conflict and must be separated. Therefore, desired lake uses and values must be prioritized based on considerations such as level of lake resident support, and the feasibility of attainment given the natural limitations of the aquatic environment. Prioritizing is commonly used to resolve mutually exclusive recreational desires and management goals. It also reduces the likelihood that any random interest group would be able to unduly influence the decision-making process by making false claims of "need" or "resident support."

Public opinions pertaining to lake-use preferences and perceived problems were evaluated using feedback from the following surveys and public meetings:

- 1998 survey of lake property owners regarding aquatic plant management (Appendix A)
- Public input from August, 2000 meeting of the Montello Inland Lake Protection & Rehabilitation District
- 2000 survey of lake district residents (Appendix B)

The purpose of these surveys and meetings was to determine people's general feelings regarding the lake, their impression of the overall management policies, and whether there were any suggestions regarding new policies or ideas for improving the lake.

3-2 PUBLIC SURVEY RESULTS

In the summer of 2000, a survey was developed and distributed to all property owners within the Montello Lake Inland Protection & Rehabilitation District. The purpose of the effort was to engage public participation in the lake planning process by soliciting the opinions and concerns of Lake District residents regarding the lake and its management. Responses were used to help prioritize and rank desired lake uses, and to identify the problems jeopardizing the health and recreational value of the resource. Ultimately, 71 of 256 surveys were completed and returned for analysis, representing response rate of 28%. The response rate exceeded expectations, and may be indicative of a prevalent interest to protect and enhance this valued resource. Results from the 2000 survey are presented below. Whenever appropriate, comparisons are made to the 1998 survey to identify trends and changed perceptions.

DEMOGRAPHICS

The vast majority of Lake District respondents are year-round residents (70%) that own residential property in the immediate vicinity of Montello Lake, either on the lake or within a one-quarter mile radius. Property ownership timeframes were highly variable but fairly evenly distributed, ranging from less than a few years to over 30 years. The top reasons for owning property on or near the lake were for the enjoyment of a peaceful/tranquil setting and the availability of recreational diversions. Although a small percentage of survey respondents claim never to spend time on the lake, most spend time on Montello Lake during the warmer months.

User Preferences

Lakefront residents most frequently describe their immediate lake frontage as consisting of a mowed lawn that leads to a pier at the water's edge. Stabilizing rocks or some form of retaining wall are commonly used for erosion control. A slight majority of respondents are of the opinion that chemical lawn treatments are either never or rarely appropriate near the lake. The most popular types of watercraft used on Montello Lake include (in descending order): small paddleboats, motorboats with engines of less than 25 horsepower, canoes/kayaks, and pontoon boats. Powerboats, sailboats and personal watercraft are currently uncommon, most likely due to limiting characteristics of the lake (e.g. small and shallow water body with abundant plant growth).

Survey respondents generally feel that clear water is the most important quality associated with Montello Lake. High rankings were also given to moderate levels of aquatic plant growth, sandy bottoms, and the presence of fish and wildlife. Recreational activities of choice include fishing, enjoying the peaceful atmosphere, and observing wildlife, respectively. Of those who fish, 44% indicate that they practice "catch-and-release" on a consistent basis when fishing for species other than panfish. In order of preference, anglers enjoy pursuing largemouth bass, bluegill/sunfish, perch, northern pike and crappie. Other popular recreational pursuits consist of appreciating scenic lake views and boating. A vast majority of respondents (90%) feel Montello Lake offers adequate public access.

Opinions on Existing Conditions

When asked how various conditions have changed over time, five factors are perceived to have worsened to the greatest degree over time. These factors include aquatic weed growth, silt accumulation, algae growth, aquatic habitat and fish size, respectively. The aquatic plant growth in Montello Lake is considered excessive by 90% of survey respondents. Another 94% believe there are areas on the lake where aquatic plant growth becomes especially problematic, but referenced locations were highly variable. The main problems associated with the over-abundance of vegetation related to restricted navigation and lack of shore fishing access. Most people (84%) do not feel the current weed control program is effectively controlling nuisance plant growth.

Overall, respondents describe Montello Lake's water clarity as generally clear during the summer months. Water clarity is perceived to be at its worst following heavy rainfall. Few people believe heavy motorboat traffic or fluctuating water levels contribute to water clarity problems on the lake. As far as the angling community is concerned, most rank the quality of fishing as "fair" in terms of fish size, and "good" in terms of fish numbers.

Lake-use conflicts do not currently appear to represent a significant concern for Montello Lake. A strong majority of respondents (59%) do not feel there are any types of behavior, recreational activities or lake uses that seriously jeopardize the health and safety of the lake. Of the 29% that disagreed with this assessment, many pointed to large horsepower motorboats, personal watercraft, fertilizer runoff, and inappropriate weed cutting as the biggest issues of concern. Almost three-quarters of the respondents believe the lake is sufficiently regulated, and that there is an adequate law enforcement presence.

Perceived Problems

Survey respondents overwhelmingly consider nuisance weed and algae growth as the two conditions that most negatively impact their use and enjoyment of Montello Lake. A much smaller number of people consider small fish size and poor water clarity as the problematic conditions of greatest concern. Top factors that are perceived to contribute to these types of problems include farmland erosion, fertilizer runoff, leaking septic systems, and inappropriate management efforts, respectively.

MANAGEMENT OPINIONS

Most people appear to be of the opinion that current management efforts are ineffective at controlling excessive weed growth, algae and silt accumulation. Although the popular belief is that the mechanical harvester cannot keep up with the rate of plant growth, opinions vary as to what type of strategy would be most appropriate. It is interesting to note that the 1998 survey revealed that 68% of the respondents favored more weed control near the shorelines and less time spent in the main channel, but were generally against the idea of purchasing a smaller weed cutter for these near-shore areas (58%). Instead, the 1998 survey also showed that an overwhelming majority (70%) preferred exploring the feasibility of a draw down to control plant growth.

There does not seem to be much concern with recreational or behavioral conflicts at this time. In fact, as mentioned earlier, most people feel the lake is adequately regulated and is not in need of a greater law enforcement presence. A majority of survey respondents (58%) also do not feel a need for expanding slow-no-wake times and/or locations to promote safety and protect sensitive habitat areas.

Respondents generally appear quite satisfied with the lake's above-average water clarity conditions, above average fishing opportunities, abundant wildlife habitat, stable water levels, and tranquil setting. Many people are also cognizant and appreciative of the Lake District's continued efforts to improve the quality of life on and around Montello Lake. A majority of survey respondents (60%) feel they are adequately informed of lake-management decisions, and that they have a voice in decision-making matters regarding the management of the lake (51%). This appears to be an improvement over the 1998 opinion survey, which showed that 73% of the respondents did not feel they received "sufficient and timely information on the condition of the lake from the Lake District." The best way for the Lake District to communicate with its members is through newsletters, special mailers and public meetings, respectively.

3-3 MANAGEMENT IMPLICATIONS

According to the results of public opinion surveys, management strategies should be selected that meet as many of the following criteria as possible:

1. Controls excessive aquatic weed growth, especially in near-shore areas, while maintaining moderate growth for habitat and water quality protection.
2. Controls the accumulation of silt and detritus that leads to a mucky lake bottom.
3. Protects conditions that favor a healthy fishery and resident wildlife population.
4. Favors increase in fish size.
5. Protects or improves existing water clarity conditions.
6. Preserves the existing peace and tranquility found on the lake.
7. Limits the need for additional regulation and enforcement.
8. Maintains existing water-level stability.

Aside from satisfying the public criteria test to the greatest extent possible, strategy selection will also be based on the availability of supporting scientific evidence. This two-tiered approach will help keep popular opinion from disproportionately influencing management decisions. Management actions driven solely by public sentiment are often not the most prudent choices. They frequently involve rash decisions that are predicated on misdiagnosed problems and an incomplete understanding of all the possible side effects.

CHAPTER NOTE:
Refer to Appendix B for a copy of the questionnaire and a graphical presentation of the 2000 survey results.

CHAPTER 4: PROBLEM ANALYSIS

4-1 INTRODUCTION

Many factors can negatively influence the health and quality of a lake. Irresponsible shoreline and watershed development, wetland drainage, habitat destruction, and lake-use pressures are just some of the factors that might contribute to any number of problems and recreational impairments. Each of these activities is capable of upsetting the stability of a balanced ecosystem and producing a variety of undesirable consequences. Separating the root cause of a particular problem from its more observable symptoms is the key to a successful lake management program.

To illustrate, consider the fact that Montello Lake is plagued with excessive aquatic plant growth. Because nuisance plant growth can prevent lake users from fully enjoying the resource, it is tempting to mistakenly characterize it as the true "problem" in this situation. In actuality, however, the abundant plant production is more likely the "symptom" of a much larger problem called eutrophication. It is also most likely the natural by-product of a shallow lake. In other words, the real problems are excessive nutrient enrichment from the adjoining watershed that favors abundant and prolific plant growth, and our own misguided perceptions as to what the lake should look like.

Employing symptomatic solutions that attack the nuisance plant growth directly rather than controlling the root cause or source of the problem is a recipe for failure over the long run. Common mistakes such as these often prove costly, especially if management strategies are prematurely and incorrectly chosen that do not appropriately address the real issue at hand. It is also important to determine if the concerns identified can realistically be alleviated through lake-management efforts.

The following section discusses the three major factors contributing to real and perceived problems on Montello Lake. These factors include:

1. The public's perceptions and expectations conflict with the natural limitations of a shallow, meso-eutrophic ecosystem.

2. The lake is receiving high nutrient inputs from upstream watershed sources.

3. The Lake District's current aquatic plant management program is inadequate given the rate and extent of plant growth.

4-2 PUBLIC PERCEPTION ISSUE

Montello Lake is naturally going to support abundant rooted aquatic plant growth. Shallow water depths, good water clarity and fertile bottom substrates provide the ideal conditions that favor this biological response. Residents and lake users must recognize and accept this fact. Expectations of transforming the lake into a deep, weed-free, and clear blue water body are probably not very realistic. Neither is it realistic to expect the lake to easily support activities such as water skiing, sailing or Jet Skiing that require large open water areas.

Public understanding and acceptance of the lake's natural limitations is the first step in dealing with perceived lake-use impairments. This is best achieved through an ongoing information and education campaign. Newsletters, press releases, public meetings, and educational brochures are all effective methods for elevating awareness and dispelling popular myths and misconceptions. An educated public is also more likely to voluntarily comply with rules and regulations that may be in place for lake-protection purposes.

4-3 NON-POINT SOURCE POLLUTION

Cultural eutrophication caused by non-point source pollution is arguably the most significant problem affecting Montello Lake today. Eutrophic waters are those that are severely impacted by nutrient enrichment and excessive productivity. Surface waters located within larger watersheds that are urbanized, intensively farmed, or face strong development pressures are at the highest risk of exhibiting eutrophication problems. Symptoms include nuisance algae blooms, excessive weed growth, poor water clarity and/or mucky lake bottoms. Eutrophication problems are caused by external phosphorus loading from the watershed, and/or internal phosphorus recycling from the lake itself. Identifying the relative nutrient contributions from each source is usually necessary before the right management strategy can be formulated to control this problem.

EXTERNAL NUTRIENT LOADING

External nutrient loading is the influx of eroded soil, fertilizers, polluted runoff, organic debris and other material from the surrounding watershed to the receiving water body. This material is delivered to the lake primarily as stormwater runoff, and may contain large amounts of phosphorus and other nutrients that fuel algae blooms and weed growth. Unregulated construction sites, poor farming practices, irresponsible fertilizer applications, loss of upstream wetlands, vegetative clear-cutting, and eroding shorelines and drainage ditches are just some of the more common factors that can increase nutrient inputs to the lake. This is especially true in the absence of proper measures that are designed to limit stormwater runoff and control soil erosion.

Water bodies with large watershed-to-lake surface area ratios (>10:1) are much more likely to experience water quality problems due to nutrient loading from the adjacent landscape. Since Montello Lake has a ratio of approximately 280:1, activities occurring in the watershed will always have a great influence on water quality and the level of primary productivity. Consequently, external loading is believed to be responsible for the vast majority of nutrient inputs to Montello Lake.

Protecting and managing the watershed is paramount to maintaining the health and quality of Montello Lake. Erosion-control measures known as Best Management Practices (BMPs) are used to control the sources of external nutrient loading. BMPs include grassed waterways, vegetative buffers, reduced tillage, field stripcropping, contour cropping, nutrient management, shoreline erosion control, and wetland restoration. The sources of external nutrient loading should be addressed before any in-lake management techniques are implemented. If not, in-lake management efforts will not be as effective over the long run, especially if external nutrient loading is significant.

INTERNAL NUTRIENT RECYCLING

Internal nutrient loading, also called in-lake phosphorus recycling, occurs when nutrients are released from the lake bottom or by the life cycles of aquatic plants and organisms. This process is usually more significant in lakes with smaller watersheds and longer hydraulic retention times. Hydraulic retention describes the length of time a given volume of water remains in the lake before it is able to be replenished by new water entering the system. When this timeframe is short, in-lake nutrient recycling is less likely to account for a significant proportion of the total nutrient loading to the lake. Montello Lake has a short hydraulic retention time, and therefore is not as prone to internal nutrient recycling problems. Furthermore, since Montello Lake remains fairly well mixed, it is not very susceptible to internal phosphorus release caused by hypolimnetic oxygen deficiency.

However, the anoxic hypolimnion is not the only area known to cause large-scale, in-lake phosphorus releases. The shallow, littoral zone of many lakes is also shown to contribute to internal phosphorus recycling as a result of anoxia, sediment disturbance and elevated pH. Anoxic conditions may develop in shallower areas during non-daylight hours when respiration exceeds photosynthesis, causing

phosphorus to be released from near shore areas. Also, sediment disturbance from wind and wave action and motor boating activity may re-suspend bottom sediment that is rich in phosphorus, increasing nutrient availability in the water column. Finally, pH levels may increase as carbon dioxide concentrations are depleted during photosynthesis. These high pH conditions are shown to be a mechanism for phosphorus release due to complex biochemical processes. These processes are not well studied on Montello Lake, so it is unknown how much they contribute to overall nutrient loading.

Developing a phosphorus budget is usually recommended to more accurately identify the actual sources of internal nutrient loading, especially before an expensive management technique is considered which may not target the actual problem area. Options to control internal nutrient loading include phosphorus precipitation and inactivation (alum treatments), hypolimnetic withdrawal, artificial circulation, hypolimnetic aeration, sediment removal (dredging), and dilution/flushing techniques. Each of these options is described in detail in the following chapter. Although in-lake nutrient recycling does occur on a very limited basis in Montello Lake, its relative significance is believed to be minimal. Existing information suggests that it is not currently an issue of concern, especially when compared to external nutrient loading.

Management Considerations

The most obvious symptoms of eutrophication are nuisance plant and algae growth. Therefore, a great deal of time and effort is spent managing these biological consequences of a eutrophic water body. Even if all major nutrient sources are being addressed, plant and algae production could continue to represent an ongoing problem. This may be the case for Montello Lake. Therefore, combining nutrient-reduction strategies with more symptomatic-oriented solutions is probably both unavoidable and appropriate. For aquatic plant control, options include mechanical and manual harvesting, plant screens (sediment barriers), water level manipulation (drawdowns), dredging, and chemical treatment (herbicides). Algae control techniques include biomanipulation as a top-down approach, nutrient reduction as a bottom-up approach, and chemical treatment (algacides). Each of these options is described and evaluated in the following chapter.

Montello Lake is an ecosystem with two alternative stable states of equilibrium—algae dominated or rooted aquatic plant dominated. Algae and aquatic plant abundance represent two ecological variables that are inextricably linked. This relationship makes it difficult if not impossible to manipulate one variable without dramatically affecting the other variable. For example, reducing or eliminating algae growth will result in improved water clarity, enhancing sunlight penetration through the water column and, thus, plant growth. Conversely, eliminating plant growth will free up nutrients and create conditions favorable for increased algae growth. The elimination of aquatic vegetation removes the lake's ability to stabilize its own bottom sediment and assimilate the nutrients that fuel algal blooms. It also reduces the amount of structural habitat used by algae-consuming zooplankton. As you can see, it is very easy to trade one problem for another if special precautions are not taken.

Controlling aquatic plant growth is the major objective of this lake management plan. However, because there are numerous benefits associated with a healthy and diverse native plant community, aquatic plant control should only target specific species in especially problematic, high-use areas. A majority of the desired lake uses and values will be supported if a reduction in nuisance weed growth is achieved strictly to facilitate public navigation and create edge habitat for the benefit of the fishery. In general, the Lake District is advised to enact programs that control nuisance "weeds" while maintaining a diversity of native plant species.

4-4 INADEQUATE WEED-CONTROL PROGRAM

Records provided by the Lake District indicate that widespread cutting and chemical control of nuisance plant growth started as early as 20 years ago on Montello Lake. Cutting and herbicide treatments were accomplished by private contract until the Lake District implemented its own mechanical harvesting program in 1983. A large weed harvester and associated equipment were purchased with cost-share assistance from a Waterways Commission Grant. The main objective of the program was to keep the center of the lake navigable for fishing and water sports. About 12 years later the Lake District upgraded to a newer, more efficient weed harvester. Currently, mechanical harvesting is about a 70-hour/week operation throughout the summer growing season. This includes 12-hour cutting shifts Monday through Friday, and 10 hours on Saturday involving a shoreline weed pick up service. Harvesting consumes an operating budget of $16,000-18,000 each year.

Mechanical harvesting is a very appropriate plant-control strategy for Montello Lake. An evaluation of the benefits and drawbacks of harvesting is presented in the next chapter. Unfortunately, input from residents and lake users suggest that the current mechanical harvesting efforts are inadequate. Recommendations found in the 1994 Montello Lake Plant Management Plan confirm these findings, as does the extremely long and consistent operating hours. Even though the program appears well organized and targeted at appropriate locations, it cannot hope to keep pace with the rapid and prolific rate of plant growth.

Despite the efficiency problem, harvesting should continue given that the lake is well suited for this management technique. In addition, the Lake District has already purchased most of the necessary capital equipment and developed an operating program. These initial efforts are arguably the most costly and difficult tasks associated with mechanical harvesting. To resolve its continuing plant-control problems, the Lake District may wish to enhance its existing program by investing in additional equipment, or supplementing it with other plant-reduction strategies. These recommendations are discussed and evaluated in greater detail beginning in Chapter 5.

CHAPTER 5: REVIEW OF MANAGEMENT OPTIONS

5-1 INTRODUCTION

This chapter provides an overview of strategies that are commonly used to manage: (1) recreational conflict, (2) external pollutant sources, (3) internal nutrient recycling, and (4) the biological symptoms of eutrophication. The management techniques discussed below may or may not be appropriate for Montello Lake. Techniques and strategies that are found to be applicable to Montello Lake generally receive more in-depth analysis and evaluation. The purpose of this chapter is to mainly provide additional information on popular lake-improvement methods for future reference and possible consideration. A recommended action strategy employing many of these management strategies is presented in Chapter 6.

5-2 RECREATIONAL CONFLICT RESOLUTION

Many problems arise when conflicting recreational uses compete for time and space on the lake. Since lakes cannot be all things to all people, certain sacrifices and compromises must be made to support a mixed-use recreational environment. The first logical step is to determine what types of activities a particular lake is even capable of supporting. For instance, a very small, shallow and weedy lake like Montello might be more appropriate for fishing and paddle boating versus power boating and water skiing. Conversely, a larger and deeper lake might be better suited for more aggressive activities that require larger, deeper areas. The next step is to then determine how the majority of lake residents prefer to enjoy the lake, and how these priorities may be jeopardized due to the current condition or use of the resource. The following are a couple common methods for managing lake uses to resolve recreational conflicts.

EDUCATION

Educating the public is the first and perhaps most important step in resolving recreational conflicts. This can be achieved through an information and education campaign that might include newsletters, public meetings, press releases, radio spots, Web sites, fact sheets, brochures and lake fairs. Explaining the actions that individuals can take to protect the lake and share it with others is often very conducive to increasing awareness and changing bad behavior. Problems can frequently be avoided simply by teaching lake-use etiquette and sharing common sense approaches to sharing a finite resource. An educated public is also more likely to accept greater levels of personal responsibility and accountability for its actions.

Applicability: YES
Recommended: YES
Public education programs are both applicable and recommended for Montello Lake. Educational efforts should increase the public's understanding and acceptance of management programs, lake rules and regulations.

Longevity of Effectiveness: To ensure long-term effectiveness, an educational program should be considered an ongoing activity. Constant reminders are often needed to hammer home points and keep up with demographic changes.

Estimated Costs: There is usually only minimal cost (in terms of donated time) associated with public meetings and the submittal of press releases to the local media. Educational materials such as newsletters and informational flyers require more preparation time, and involve copying and mailing costs.

Potential Benefits:

- Increased awareness and understanding of issues and management programs
- Greater appreciation and acceptance of lake rules and regulations
- Behavioral improvements as people recognize the consequences of their actions

Potential Drawbacks:

- Inability to control whether people take the time to digest the information
- Time commitment and certain level of expertise required to produce educational materials
- Costs associated with production and dissemination

TIME & SPACE ZONING

A lake can be zoned in a manner that best supports conflicting, mutually exclusive interests. Conflicts occur when two different recreation types attempt to occupy the same general locations at the same time. When this happens, more aggressive recreation types (e.g. power boating & Jet Skiing) are usually able to displace passive recreation types (e.g. canoeing, fishing and swimming). Conflicts may also arise between different activities that fall within the same recreational classification. For example, although fishing and swimming are each considered passive forms of recreation, they also require their own space and unique conditions. Anglers may prefer a quiet, undisturbed area with an abundance of aquatic plants and bottom structure. Swimmers, on the other hand, may demand sandy bottoms, no aquatic vegetation, and an area free of fishing boats and dangerous hooks. Time and space zoning can help manage different lake activities to minimize conflict.

Time and space zoning can also be used to facilitate the protection and management of ecologically sensitive areas that are not compatible with certain lake uses. For example, underwater turbulence produced by personal watercraft and motorboats is frequently strong enough to disturb plant beds and bottom sediments in shallow water. This constant scouring of the lake bottom is detrimental to sensitive aquatic habitat, re-suspends phosphorus-rich sediment, and encourages the spread of undesirable plant species. Since eliminating boats or banning certain horsepower engines may not be feasible on many lakes, it might be appropriate to restrict certain activities to specified locations on the lake that are best suited for that lake use. Passive recreational uses such as fishing and canoeing might be permitted in the shallow, weedy areas, while more aggressive activities like water skiing and jet skiing might be directed to deeper, open water areas.

Applicability: YES
Recommended: NO
This strategy is applicable but not currently necessary for Montello Lake. Public opinion surveys suggest that lake-use conflicts are not currently a major issue of concern. However, this situation may change over time as more people use the lake, or as new forms of recreational watercraft are popularized.

Longevity of Effectiveness: This particular strategy would remain in effect for as long as the time/space zoning regulation is in place.

Estimated Costs: Costs would be associated with education, violation monitoring and enforcement. The erection of informational signage, as well as the installation and removal of special buoys are potential cost considerations. Buoy systems typically cost about $100 each.

Potential Benefits:

- Separation of conflicting lake uses
- Improved safety and enjoyment by competing recreational types
- Means of balancing the protection of ecologically sensitive areas with recreational demands

Potential Drawbacks:

- Adds another layer of regulation to the lake
- Requires additional time and resources for implementation and enforcement
- Installation of special buoys may detract from the lake's aesthetic appeal
- Certain types of recreation may become more restricted following lake zoning

5-3 CONTROL OF EXTERNAL POLLUTANT LOADING

External pollutant loading is that which is derived from the watershed, and includes both point and non-point sources. Point sources are the easiest to identify and control since they are typically associated with industrial processes that directly discharge waste product. Non-point sources describe just about everything else that could possibly be washed into the lake, making them much more difficult to manage. The activities that take place throughout the surrounding watershed essentially dictate both the quality and quantity of water that eventually enters the lake. Therefore, watershed management attempts to minimize the amount of stormwater runoff and soil erosion taking place on the landscape. The methods used to accomplish this goal—short of dictating where and what type of development can occur—are called Best Management Practices, or BMPs. A list of some popular BMPs is presented below.

• Contour farming	• No-till planting
• Strip-cropping	• Wetland restoration
• Grassed waterways	• Stormwater detention/diversion
• Nutrient (fertilizer) management	• Construction site silt fencing
• Riparian buffer strips	• Steam bank stabilization

Applicability: YES
Recommended: YES
The use of watershed BMPs to control stormwater runoff and soil erosion is both applicable and recommended for Montello Lake. Due to the large number and diversity of BMPs, a more complete cost-benefit analysis was not performed as part of this report. Refer to the next chapter for more detailed recommendations and implementation guidance.

5-4 CONTROL OF INTERNAL NUTRIENT RECYCLING

ALUM TREATMENTS

A chemical compound known as aluminum sulfate (alum) is widely used in deep eutrophic lakes to remove phosphorus from the water column and retard its release from anoxic lake sediments. Alum is considered nontoxic and effective at lowering phosphorus levels of certain types of lakes, thereby controlling the nutrient that encourages algae growth. On contact with water, alum forms an aluminum hydroxide precipitate known as floc. Aluminum hydroxide reacts with phosphorus to form an aluminum phosphate compound that is insoluble in water under most conditions, depriving algae of this critical nutrient. As the floc settles, inorganic phosphorus and phosphorus-containing particulate matter is removed from the water column. When applied in sufficient quantities, the floc may form a lasting chemical barrier that retards phosphorus release at the sediment-water interface as anoxic conditions develop in the hypolimnion.

Hypolimnetic alum treatments do not address phosphorus that may be released from the shallow, littoral areas as a result of elevated pH, sediment disturbance and/or anoxia during non-daylight hours. Some lakes may be good candidates for this procedure, however, especially if external nutrient loading is brought under control and high internal phosphorus releases are shown to occur within the anoxic hypolimnion of the lake. When implemented correctly, this technique can provide an effective, nontoxic and long-term approach to algae control by reducing concentrations of the limiting nutrient that usually drives algae growth. However, it should be noted that increased plant growth often occurs due to improved water clarity

conditions following an alum treatment. Although alum treatments can increase a lake's acidity, toxicity problems from lowered pH are unlikely in lakes with high alkalinity and buffering capacity.

Applicability: NO
Montello Lake is not a good candidate for this procedure. The lake is not of sufficient depth, nor does existing evidence suggest a serious problem with hypolimnetic phosphorus release.

Artificial Circulation

The purpose of this management technique is to destratify and mix the water column of a lake by injecting compressed air near the lake bottom. If sufficiently powered, rising air bubbles will induce lake-wide mixing, eliminating thermal gradients within the water column while aerating portions of the lake that were previously devoid of oxygen. Artificial circulation is used to prevent an anoxic hypolimnion from forming near the bottom of deeper lakes, thereby preventing the release of phosphorus from the bottom sediments. Circulation pumps are usually operated continuously throughout the summer stratification period so that aerobic conditions are always maintained. Improper use of this technique could harm an established cool-water fishery, or mix nutrient-rich water throughout the water column, exacerbating an existing algae problem.

Applicability: NO
Artificial circulation is not appropriate for Montello Lake. The lake's shallow water depths already keep it fairly well mixed, and severe algae blooms have not been shown to be a problem.

Hypolimnetic Aeration

This management technique uses an airlift device to bring nutrient-rich and oxygen-poor water from the hypolimnion of deeper lakes to the surface where it can be aerated without thermally destratifying the lake. Hypolimnetic aeration attempts to reduce the extent of an anoxic hypolimnion that forms near the bottom of deeper, eutrophic lakes. As a result, a smaller portion of the lake bottom is allowed to become oxygen deficient and capable of releasing phosphorus into the water. Because the lake is not allowed to destratify, a cool-water fishery can be adequately protected. Aerators need a large hypolimnion to work properly, and are most effective in deep lakes. As with artificial circulation, improper use of this technique may circulate nutrient-rich water. A poorly designed aeration system may also destratify a lake, or keep sediment and organic matter in suspension for longer periods of time.

Applicability: NO
Hypolimnetic aeration would not be applicable for a shallow water body like Montello Lake. Montello Lake exhibits very weak thermal stratification, and does not consequently have serious dissolved oxygen problems related to an extensive hypolimnion---one of the main requirements for this particular management strategy.

Hypolimnetic Withdrawal

Hypolimnetic withdrawal addresses phosphorus releases that occur within the deep, anoxic zone by removing nutrient-rich, hypolimnetic water before it mixes with the entire water column. The principal purpose of this technique is to change the depth at which water leaves the lake, from the surface to the deep hypolimnion, so that higher nutrient-content water is discharged from the lake. Hypolimnetic withdrawal is accomplished by installing a tube along the lake bottom from the deepest point to the outlet. The tube acts as a siphon, removing nutrient-rich water from the hypolimnion and discharging it at the outlet.

The technique requires a sufficient water exchange rate to replenish the amount of water that needs to be discharged. Hypolimnetic withdrawal should only be implemented during the summer stratification period when anoxic conditions develop in the hypolimnion. If not used appropriately, it may produce thermal instability and destratification that could introduce nutrient-rich, anoxic water to the lake's epilimnion. There may also be negative impacts downstream caused by the discharge of poor quality water.

There are few documented case histories regarding this procedure. The technique is most applicable to stratified lakes and small reservoirs in which anaerobic hypolimnia restrict fish habitat and promote the release of phosphorus from the sediments.

Applicability: NO
Hypolimnetic withdrawal would not be applicable for a shallow water body like Montello Lake. Montello Lake exhibits very weak thermal stratification, and does not consequently have serious dissolved oxygen problems related to an extensive hypolimnion---one of the main requirements for this particular management strategy.

Dilution & Flushing

Dilution and flushing is a management technique that uses large quantities of nutrient-poor water from an upstream source to dilute nutrient concentrations in the lake and flush out algae cells. Lakes with low initial flushing rates, or hydraulic retention times, are poor candidates because in-lake phosphorus concentrations could increase unless the dilution water is essentially devoid of phosphorus. Flushing rates of 10-15% of the lake volume per day are believed to be sufficient in most cases.

Applicability: NO
Montello is not a good candidate for this management approach for two reasons. First, a large, upstream source of nutrient-poor water has not been identified. Second, the lake does not have a serious alage problem, nor would such action provide relief from nuisance plant growth. Aquatic plants are able to derive most of their nutrient requirements from the bottom substrate, rather than from the surrounding water column.

Sediment Removal (Dredging)

This management alternative may be used to address phosphorus releases that occur in the shallow, littoral areas of a lake. However, dredging is more frequently employed to deepen a lake, or remove aquatic plants (discussed under Section 5-3). If sediments are the source of internal nutrient loading, and the bulk of nutrients are located in the top 1-1.5 feet of a sediment core, then removal of that layer by dredging may provide the most reliable and permanent solution. If bottom sediment is rich in nutrients below that depth, then dredging would only expose more sediment with the same high nutrient content, providing little or no expected decrease in internal loading. This technique will also have limited effectiveness if external sediment loading is not controlled prior to implementation. Dredging may be very effective if small, accessible areas have sediment that is high in phosphorus. Lakes most suitable for dredging have shallow depths, low sedimentation rates, organically rich sediments, long hydraulic retention times, and the potential for extensive use following dredging.

Sediment must be analyzed to determine how difficult it will be to dredge the material and its appropriateness for land disposal. Selective "spot" dredging is less expensive and is not as detrimental to aquatic plant and animal habitat, biodiversity, various recreational uses, and aesthetics. One strategy is to breach a dam, if available, in order to draw down the lake and expose near shore sediment that can then be removed by earth-moving equipment. This may be the simplest and most cost-effective method, even though mechanical and hydraulic dredging are much more common approaches to sediment removal. Dredging is an extremely expensive and involved process. It requires identifying the source of sediment; evaluating sediment cores (thickness, distribution, grain size, organic content, contaminant analysis, nutrient analysis); determining the volume of sediment to be removed; evaluating potential environmental impacts; securing a large de-watering and disposal site; and obtaining the appropriate local, state and federal permits.

Applicability: NO
This strategy is not recommended for Montello Lake for in-lake nutrient control purposes. It would be most applicable as a plant control technique, and to facilitate navigation (see Section 5-5 below).

5-5 CONTROL OF EUTROPHICATION SYMPTOMS

MECHANICAL WEED HARVESTING

When excessive weed growth becomes a problem, mechanical harvesting can be used to cut and remove the upper portion of rooted aquatic plants that grow close to the water's surface. Unlike herbicide applications that leave plants in the lake to decompose, mechanical harvesters are designed to physically remove plant material from the water. This prevents decaying plant matter from depleting dissolved oxygen levels and releasing nutrients that could culminate in further plant and algae growth. Harvesters can also clear an area of vegetation without the post-treatment waiting period associated with herbicides, and without significant danger to non-target species when controlled by a trained operator.

The typical harvester is a highly maneuverable, low-draft barge designed with one horizontal and two vertical cutting bars, a conveyor to remove cut plants to a storage unit on the machine, and another conveyor to unload plants onto shore. Harvesters vary in size and storage capacity from about 200 cubic feet of cut vegetation to 800 cubic feet. Cutting rates range from about 0.2 to 0.6 acres per hour, depending on machine size. Harvesting works best in open, unobstructed areas of the lake where the water is three to six feet deep. A selective harvesting approach, rather than clear cutting, is recommended to avoid causing serious habitat disturbance. Mechanical harvesting is most effective when used to: (1) open navigation lanes to access open water areas; (2) control nuisance vegetation in high-intensity recreational user zones; and (3) create edge habitat for fish in weed-choked fishing areas. Most harvesting operations are successful in producing at least temporary relief from nuisance plants by removing organic matter and associated nutrients without the addition of potentially deleterious substances.

Applicability: YES
Recommended: YES
Montello Lake is a prime candidate for an ongoing weed-harvesting program to control nuisance plant growth, especially since the Lake District already possesses most of the necessary equipment. However, to keep up with the prolific rate of growth, consideration should be given to the purchase of a transport barge, second shore conveyor, and/or second harvester. Multiple off-loading sites along the shoreline might also help. This strategy is discussed further in Chapter 7: Plant Management Guidance.

Longevity of Effectiveness: This strategy allows only temporary relief of nuisance aquatic weeds. Harvesting is most effective when it is repeated multiple times during each growing season. Research indicates that there is often a carry-over effect from season to season where less growth occurs in subsequent years following multiple harvests.

Estimated Costs: A high capital outlay for equipment is required, and may be energy- and labor-intensive and thus expensive. However, it is usually somewhat less expensive than herbicide treatments over the long run. Expenditures for a particular project will vary depending on machine cost and reliability, operator wages, fuel, insurance, equipment storage, and the amount of down time. Operating costs can be quite variable, but generally average around several thousand dollars per year with labor comprising from 20-65% of the total operating costs.

Potential Benefits:

- Removes nuisance plant material and associated nutrients from the lake
- Provides temporary but immediate relief from nuisance aquatic plants
- Could encourage positive shifts in species composition by reducing competition from aggressive species
- Reduces the thick vegetative cover that causes stunting of panfish
- Avoids the use of potentially harmful chemicals
- Allows specific areas and plant beds to be targeted for control
- Permits most recreational use of the water to continue during operations

- Poses little danger to non-target organisms (except when inadvertently removed with the cut plants)
- Harvested plants may be used as a nutrient-rich soil conditioner or fertilizer

Potential Drawbacks:
- Controls relatively small areas per unit of treatment time
- Harvesting can be over-used, destroying critical aquatic habitat
- Could contribute to vegetative fragmentation and spread of nuisance, non-native species
- Could encourage unfavorable shifts in species composition by promoting opportunistic species
- Could damage valuable, native plant species
- There is the potential to inadvertently harvest small game fish along with the plant material
- Operating depths may be limited
- Requires regular cutting during each growing season for effective control
- Excessive plant growth may continue in extremely shallow areas where larger harvesters cannot gain access

Manual Weed Harvesting

Manual harvesting of aquatic weeds can also be used to control plant growth in smaller, more confined areas. This technique is usually the simplest, most species-selective method for small, shallow water areas. However, it is also the most labor-intensive method. Plants should be pulled from the sediment by the base so the root systems are removed in their entirety. The frequency and practicality of continued hand harvesting depend on the availability of labor, the re-growth or re-introduction potential of the vegetation, and the level of control desired.

Manual harvesting techniques include dragging, raking, cutting and pulling. Dragging is an inexpensive method that involves pulling "draglines" through weed beds. Draglines are constructed of rope, wire or chains that can be placed into the water from either shore or boat, and then pulled in manually or towed. They are often used in water that is greater than six feet deep, but are not effective at removing root systems. Raking can be done in shallow water with a long-handled steel garden rake or pitchfork. The root systems of certain plant species will be removed, while others will remain in place. Hand-held weed cutters are specially designed rakes or cutters that are manually thrown out into the lake and slowly retrieved. While rakes can remove the entire root systems, cutters usually leave root systems to regenerate. Hand pulling is the most labor-intensive method, but it is also the most effective and species-specific.

Applicability: YES
Recommended: CONDITIONALLY
Manual harvesting of nuisance aquatic vegetation is an applicable control strategy for Montello Lake. However, this technique is too time and labor intensive to be considered cost-effective on a lake-wide basis. Manual harvesting is more appropriate for individual lakefront property owners who need to clear small areas around piers and boatlifts.

Longevity of Effectiveness: This strategy is effective for immediate relief of nuisance vegetation, but is relatively short lived and requires repeated effort.

Estimated Costs: Costs are associated with labor time and the purchase of rakes or other personal harvesting devices.

Potential Benefits:
- Localized, species-specific control of nuisance vegetation
- Strategy can be performed in areas that are inaccessible to mechanical weed harvesters
- Does not involve the use of potentially harmful chemical heribicides
- Plant material is removed from the lake

Potential Drawbacks:

- Very labor intensive and slow
- Lake-wide application of this strategy is not feasible
- Requires educating lakefront property owners in the identification of "good" versus "bad" plants

Aquatic Plant Screens (Sediment Covers)

Aquatic plant screens are synthetic barriers typically constructed of fiberglass mesh or polyvinyl fabric that are placed on the lake bottom in near-shore areas. The purpose of the screens is to smother existing vegetation, inhibit light penetration and prevent new plants from rooting. The most effective covers are opaque, durable, negatively buoyant, vented and gas-permeable. Plastic sheets of polyethylene, polypropylene, fiberglass or nylon are all used as aquatic plant screens. Gravel, sand and clay are also used as sediment covers, although these materials are less effective plant barriers.

Installation requires securely anchoring the screens to the substrate in the spring before plants begin growing. This is often difficult to accomplish over heavy plant growth, in soft sediment, and on steep slopes. Aquatic plant screens work well in small, flat, shallow areas or where other methods are not feasible. These barriers will need to be periodically removed and cleaned as sediment deposits on the screen surface. They should be removed every 1-3 years in the fall for cleaning. The barriers do not effectively control algae or free-floating plants. Effectiveness is highly correlated with application techniques and type of material used.

Applicability: YES
Recommended: CONDITIONALLY
Applicability to Montello Lake is restricted to small, flat, shallow areas with firm substrates and where recreation is unreasonably impacted by nuisance plant growth. Suitable locations may include community swimming beaches and public piers that are inaccessible to mechanical harvesters.

Longevity of Effectiveness: Strategy effectiveness depends on the quality of the materials and installation methods used. At a minimum, plant screens should be removed and cleaned every one to two years to prevent sediment build-up and re-rooting.

Estimated Costs: The more effective synthetic materials are very expensive, running at least several thousand dollars per acre of coverage. Installation is also very labor intensive, which will drive up costs.

Potential Benefits:

- Causes little negative impact to the lake
- Use is confined to small, site-specific areas
- Sediment covers can be installed in areas that will not be disrupted by boat traffic or harvesters
- No toxic chemicals are used

Potential Drawbacks:

- Materials are expensive to purchase
- Plant screens are difficult to apply over large areas, over obstructions, in deeper water, and on slopes
- May be difficult to secure to the bottom, especially if gases are trapped beneath the covers
- Plant screens may be difficult to remove or relocate, and may tear during installation
- Some materials do not last more than a few seasons, and are degraded by sunlight
- A permit may be required before installation can take place
- Benthic invertebrates may be eliminated in treatment areas

Water Level Manipulation (Draw down)

Altering the water levels in lakes is sometimes used to manage nuisance weed growth that may occur in shallower areas. This is accomplished by either significantly raising or lowering water levels, usually by regulating an outlet-control structure. Recreational use of the water is often severely restricted during implementation, especially if a draw down is performed.

Raising water levels will essentially drown out certain plant species by limiting sunlight availability through increased water depths. This strategy is often not feasible as previously dry, lowland areas would be subjected to flooding and increased shoreline erosion. It also requires a significant amount of extra freeboard on a dam to retain sufficient quantities of water. Alternatively, lake level drawdowns are used to expose near-shore sediments to prolonged freezing and drying. Some rooted plant species are permanently damaged by these conditions and the entire plant is killed if exposed to freezing for two to four weeks. Other species, however, are either unaffected or enhanced. Sediment compaction and oxidation is a secondary benefit that can increase near-shore water depths.

This management technique is best suited for reservoirs or water bodies that have a suitable outlet control structure and a steady water flow that will refill the lake or reservoir by the summer. On smaller water bodies where a draw down is performed, the reduced volume of water and dissolved oxygen can cause fish kills. Similar to artificially raising water levels, a draw down may damage banks and shorelines, and fish spawning grounds may be adversely affected. A winter draw down should be conducted to control vegetation through freezing and scouring, as opposed to a summer draw down that will usually encourage plant growth. To be most effective, complete freezing and desiccation are required, and freezing operations should be alternated every two years with no draw down so that resistant species do not become firmly established.

Applicability: YES
Recommended: YES
Water level manipulation as a plant-control strategy is applicable and recommended for Montello Lake. The lake has a suitable outlet-control structure, and has adequate inflow/outflow characteristics to support such an effort. Furthermore, the lake has extensive shallow areas that could benefit from the effects of a water-level draw down. This strategy is discussed further in Chapter 7: Plant Management Guidance.

Longevity of Effectiveness: Effectively controls certain plant species for 1-3 years. This strategy must be repeated every few years to maintain control of nuisance plant growth in near-shore areas.

Estimated Costs: Costs are usually minimal, and mostly associated with lost recreational use of the lake during the period of draw down. However, this technique could prove prohibitively expensive if compensation must be provided for lost hydroelectric revenues.

Potential Benefits:

- Inexpensive if compensation does not need to be provided to dam operators
- Effective at controlling several nuisance plant species in shallow, near-shore areas
- Control lasts up to two years
- Strategy may stimulate the growth of a more desirable and beneficial plant community
- Sediment oxidation and compaction may deepen near-shore areas
- Allows better access for improvements to shore structures (e.g. docks, boat landings, etc.)
- Reduces potential for shoreline damage caused by winter ice
- Facilitates greater flood storage capacity in the spring
- Minimizes lost recreational use of the water when performed over the off-season
- Lower temperatures slow the biological decomposition processes that creates odors
- Increases the feasibility of a limited dredging project during the draw down period

Potential Drawbacks:

- Expensive if compensation must be provided for lost hydroelectric revenues
- Must be repeated every few years to maintain plant control and re-compact sediments
- Some variability inherent in which species are susceptible to control
- Restricts recreational use of the lake during period of draw down
- Requires certain weather conditions for adequate freezing and desiccation
- Groundwater inflow points or moisture-retaining sediments will reduce effectiveness
- Temporarily reduces aquatic habitat used by fish and wildlife
- Increases likelihood of a winter fishkill from oxygen depletion in remaining pool
- Concentrates fish and increases risk of over harvesting by anglers
- Possible algae blooms after re-flooding due to sediment nutrient release and reduction of plants
- Temporarily reduces diversity and abundance of benthic invertebrates
- Disrupts waterfowl feeding and roosting patterns
- Short-term increase in turbidity and odors from rotting organic matter

Plant Removal by Dredging

Dredging involves the physical removal of sediment and associated rooted plants. In extreme cases of overgrown aquatic vegetation, conventional or specially adapted dredging machines may be used to remove vegetation and underlying sediments. The resulting depth increase, if sufficient, will reduce or eliminate the potential for rooted vegetation to become re-established by inhibiting light penetration. However, this effective depth would have to exceed 10-15 feet in Lake Montello. Dredging operations are expensive to implement, and the disposal of sediments can be difficult if a nearby disposal site is not available. This strategy will be a short-lived treatment method unless sediment is removed entirely from the lake's photic (light-penetrating) zone. Spot dredging to create boat channels or deepen high-use areas is a cheaper compromise to dredging an entire lakebed.

Applicability: YES
Recommended: CONDITIONALLY
This strategy would be applicable to Montello Lake as a plant control technique, and to facilitate navigation. Sediment removal would be most appropriate to deepen high-traffic areas that are restricted by excessive weed growth and sediment accumulation. Dredging would be most cost-effective if performed following a water-level draw down.

Longevity of Effectiveness: Long-term effectiveness is likely if external sediment loading is adequately addressed beforehand, and all nutrient-rich sediment is removed beyond the photic zone. Dredging may need to be repeated depending on sedimentation rates.

Estimated Costs: Sediment removal is currently an extremely expensive management strategy. Costs are highly variable, depending upon site conditions, access, nature of the dredge material, disposal method, monitoring and other factors. It is not uncommon for lake-dredging efforts to end up being multi-million dollar projects. Partial funding through the Waterways Commission is possible only when dredging is used for navigational and public access purposes.

Potential Benefits:

- Deepens the lake and may improve navigation
- Removes plant material and associated sediment from the lake
- Removes the nutrient-rich material that contributes to in-lake nutrient recycling

Potential Drawbacks:

- Represents a very massive and expensive undertaking
- Causes temporary increase in turbidity due to re-suspension of sediment
- Damages or destroys fish spawning habitat
- Destroys benthic (bottom-dwelling) organisms that represent an important component of the food chain
- Releases heavy metals and other contaminants within the sediment (if present)
- Releases anaerobic gases such as ammonia and hydrogen sulfide, which can threaten aquatic life
- Requires a large, suitable land area near the lake for sediment de-watering and disposal purposes

Chemical Control (Herbicides)

Aquatic herbicides are often used in problematic areas to aggressively control small pockets of nuisance, pioneer species before they can spread throughout the lake. Preferred treatment areas are small, confined and absent of high quality native species. Herbicides can be either broad spectrum or fairly species-specific. Contact and systemic herbicides are both available and commonly employed, but each leaves plants in the water to decay. Application rates and frequencies depend upon physical conditions (e.g. wave action, currents, dilution, water temperature, etc.). Plants differ considerably in their susceptibility to chemical treatment. Chemical treatment should be viewed as a last resort when other methods fail or prove infeasible. This treatment method may limit certain water uses, and chemical drift can potentially damage or destroy desirable plant beds.

The herbicide 2, 4-D (2,4-dichlorophenoxyacetic acid) is one of the most common and most effective chemicals used to systemically control Eurasian watermilfoil. This particular herbicide has been shown in certain situations to shift community composition from watermilfoil and coontail, to beneficial pondweeds and wild celery. Proper timing of herbicide applications is extremely important for both effective control and to avoid other potential problems. Timing involves knowing water temperatures and waiting until vigorous plant growth is present, but not waiting until plants are fully grown which would result in large amounts of weeds decomposing and robbing the water of oxygen.

Although herbicides do not address the source or underlying cause of the problem, it may be the only option available for short-term relief if nutrient sources cannot be addressed. It is recommended that this management technique be implemented only if other strategies are determined to be infeasible due to costs or other considerations. If necessary, herbicides should be targeted to small areas to control isolated stands of exotic, invasive plant species.

Applicability: YES
Recommended: CONDITIONALLY
This strategy may be appropriate for Montello Lake under certain conditions. First, due to the considerable extent of nuisance weed growth, applications would only be cost-effective if performed within limited areas. If necessary, applications can be targeted to small, isolated pockets of nuisance weed growth that cannot be controlled using mechanical harvesting methods.

Longevity of Effectiveness: Chemical control is a temporary control strategy, and must be repeated on a fairly regular basis.

Estimated Costs: Costs depend on the size of the area being treated and the type of chemical used. Regular, lake-wide applications would be expensive and are not recommended.

Potential Benefits:

- Temporary and relatively fast relief of nuisance aquatic weed growth
- Offers some selectivity so certain specie types can be targeted
- Chemical applications are not very labor intensive
- Provides longer control when compared to mechanical harvesting

Potential Drawbacks:

- Provides only temporary relief of nuisance aquatic plant growth
- Fails to remove plant material and associated nutrients from the lake
- Decreases in dissolved oxygen levels due to decomposition of plant matter
- Some nuisance species may be unaffected by the herbicides
- Aggressive, pioneer species can re-colonize treated areas
- Could produce more frequent and severe algae blooms
- Toxicity issues are poorly understood
- Herbicides produce no restorative benefit, show no carryover of effectiveness to the following season, and may require several applications per year

Chemical Conrol (Algacides)

Algacides are chemical agents that are applied to the water to control algae growth. These chemicals are usually applied in liquid form at the lake's surface, killing algae cells on contact through selective toxicity. Although this technique does not address the source or underlying cause of the algae problem, it may be the only option available for short-term relief if nutrient sources cannot be addressed. Algacides are generally applied in small ponds, and may be appropriate when other strategies are infeasible due to costs or other considerations. Before using algacides, it is important to understand all the risks that are associated with a particular chemical. Considerations include toxicity to non-target aquatic life, chemical persistence in the environment, and indirect impacts to dissolved oxygen levels.

Applicability: QUESTIONABLE
Recommended: NO
Algacides are probably not applicable and are not recommended for use on Montello Lake, mainly because nuisance algae blooms are not considered a significant problem. Drawbacks of using this strategy to control algae in Montello Lake include the following:

- Chemical applications may be toxic to non-target aquatic life
- Oxygen depletion may occur from the rapid die-off and subsequent decomposition of algae
- Blue-green algae are known to become increasingly tolerant to algacides
- Chemicals residues may accumulate in the sediment
- Must be repeated on a regular basis, and may be expensive over the long run

Biomanipulation for Algae Control

Biomanipulation attempts to alter the food web (usually through fish management and stocking programs) to create a less favorable environment for algae, thereby improving water quality conditions. It is a top-down management strategy that may be used to compliment bottom-up management strategies that manipulate nutrient inputs. Biomanipulation is based on a theory known as the Trophic Cascade Hypothesis. Simply stated, top predators such as large game fish can ultimately control the abundance and productivity of lower trophic levels, such as algae, which in turn can affect water clarity and nutrient recycling. The Trophic Cascade Hypothesis predicts that a large number of piscivorous (fish-eating) fish will consume large numbers of smaller, planktivorous (plankton-eating) fish, resulting in a decline in the abundance of planktivores. Lower numbers of planktivores will consequently consume fewer zooplankton (algae consumers), allowing

for the development of a large zooplankton population. Large numbers of zooplankton will then consume large numbers of algae, reducing algae abundance and increasing water clarity.

Biomanipulation may be accomplished by directly enhancing the success of piscivores (e.g. walleye, bass, northern pike, etc.) through stocking programs, angler harvest restrictions, and/or habitat improvements. Another option is to reduce the number of planktivores (e.g. perch, bluegill, sunfish, etc.) within a lake through selective fish removal programs and habitat manipulations. Fewer planktivores translates into a higher survival rate for algae-grazing zooplankton. Reducing planktivore populations has the added benefit of freeing up food resources for small piscivores that could otherwise get out-competed during early life stages. Creating habitat conditions that are more favorable to zooplankton will further enhance the effects of biomanipulation. For example, oxygenating the hypoliminion will allow for greater vertical migration of zooplankton within the water column, increasing their ability to avoid capture by planktivores. Aquatic plant beds can also be protected to provide structural refuge for zooplankton.

Applicability: QUESTIONABLE
Recommended: CONDITIONALLY
Biomanipulation should only be used in conjunction with other strategies if a significant, long-term improvement is going to be achieved. Full implementation of a biomanipulation project, which prohibits the harvesting of game fish, may be unpopular since fishing is identified as a top priority lake use.

Longevity of Effectiveness: If the sources of excess nutrients to the lake are fully addressed, biomanipulation can have a lasting and sustained effect. The success of this technique relies heavily on the continued health and viability of the sport fishery (e.g. walleye, largemouth bass and northern pike).

Estimated Costs: Costs are relatively low, and are associated with fish stocking (currently State-funded) and habitat enhancement efforts. Habitat enhancement may involve using the mechanical harvester to control Eurasian watermilfoil. Costs are also associated with information and education programs that encourage anglers to practice catch-and-release.

Potential Benefits:
- Harnesses the natural power of the food web to keep algae production in check
- May provide a fairly self-sustaining control mechanism
- Does not involve the use of potentially harmful chemicals or expensive equipment
- Improves the sport fishery

Potential Drawbacks:
- Can be very difficult to effectively manipulate the food web
- Requires angler participation to prevent the over-harvest of sport fishes
- Must usually be used in conjunction with other strategies (e.g. nutrient reduction) to produce observable changes

5-6 COST-COMPARISON SUMMARY (AQUATIC PLANT CONTROL)

Cost-comparison summaries of plant-control strategies applicable to Montello Lake are presented below. Only those strategies that could feasibly be applied on a lake-wide scale were evaluated. Estimated cost breakdowns are based on verbal quotes received from several Wisconsin-based contractors.

Plant-control Option	Cost Breakdown
Dredging	Equipment mobilization charge: $5,000 Excavate spoil site: $2/cubic yard to move dirt Road crossings: $1,500/crossing Sediment removal: $12/cubic yard (hydraulic); $2.50/cubic yard (mechanical) Other minor costs: Lab analysis of sediment and permit fees (Notes: Dredging may need to be repeated on an infrequent basis, depending on sedimentation rate. Cost-share assistance is generally not available unless for purposes of public access.)
Herbicides	Chemicals: $350-450/acre Application: $700 for first five acres, $50/acre thereafter Other minor costs: Permit fees (Notes: Herbicide applications must be repeated on a frequent and consistent basis, depending on rate of re-growth. Cost-share assistance is generally not available.)
Mechanical Harvesting	Mechanical harvester: $100,000 (new) Harvester trailer: $10,000 (new) Shore conveyor: $15,000 (new) Dump truck: $50,000 (new) Operating costs: $16,000-18,000/year (wages, insurance, storage, repair costs, etc.) (Notes: Mechanical harvesting must be repeated on a frequent and consistent basis, depending on rate of re-growth. Cost-share assistance is available for the purchase of equipment.)
Winter Draw down	Compensation to hydro-plant: $3,750 per month when drawdown exceeds 3 feet Economic cost from lost recreational use: Undetermined (Notes: Winter drawdowns must generally be repeated every few years, depending on near-shore re-growth rates. Cost-share assistance is typically not available.)

CHAPTER 6: OVERVIEW OF RECOMMENDED ACTIONS

6-1 INTRODUCTION

Selecting an appropriate course of action requires an understanding of all the potential limitations, tradeoffs and consequences associated with each available management option. Regardless of the management strategy chosen, it should be recognized that permanent and observable changes in the overall condition of a lake are rarely if ever accomplished over night. Lakes can be very slow to respond, especially if they are already severely impacted or degraded. The following questions should always be answered prior to selecting and implementing a potentially costly management program.

- What is the problem, and what are its underlying causes?
- Which interest groups does the problem affect and how?
- Is it economically, ecologically and publicly feasible to address the underlying causes of the problem?
- What management strategies are available that can remedy the situation?
- Do these strategies address the cause of the problem, or do they attack the symptoms?
- What are the potential drawbacks and side-affects associated with each strategy?
- How immediate are the results?
- How long does the strategy remain effective once implemented?
- Will the strategy in any way restrict the use of the water?
- Are any special permits or approvals needed prior to implementation?
- What are the short and long-term costs and benefits compared to other available options?

Questions such as these will need to be answered before the right strategy can be selected and implemented successfully. It is a good rule of thumb to first protect what you have before attempting to rehabilitate what has been lost. This is because protection is almost always more effective and less expensive than rehabilitation. Critical sites that function to maintain the health and quality of the resource should be protected. The faster these sites are identified, the faster they can be preserved and properly managed for the benefit of the lake. Critical sites include high-quality aquatic plant beds, wetlands and undisturbed shorelines and stream banks. These areas act as natural water quality buffers and provide ideal habitat conditions for a diversity of wildlife, among other benefits. Once a critical site is identified, there are a number of ways to ensure long-term protection. Conservation easements, purchase of development rights, property acquisitions, and special zoning restrictions can all be used effectively, depending on the situation.

6-2 STRATEGY SELECTION METHODOLOGY

Management techniques were selected only after careful consideration was given to potential ecological and recreational impacts, estimated cost of implementation, longevity of effectiveness, and overall potential for success. In most cases, strategies that address the root causes of problems were favored over symptomatic solutions. Although many symptom-oriented techniques enjoy faster results and lower initial costs, the benefit-to-cost ratio usually decreases over time as the underlying problem is left unresolved. Efforts were also made to avoid lake-protection strategies that would serve only to add unnecessary or duplicative layers of regulation.

In selecting viable management strategies, it was recognized that Montello Lake is influenced by a number of complex physical, chemical and biological components. These components are extremely dynamic and affect the lake's responsiveness to management efforts. Because the lake is a highly interactive system, it is impossible to alter one characteristic, such as rooted plant growth, without affecting some other aspect, such as algae growth or the clarity of the water. The selection of management options was based on high priority lake uses and problems identified through a combination of public input and the evaluation of available scientific data.

6-3 OVERVIEW OF RECOMMENDED STRATEGIES

- Conduct a public information and education campaign.

  Ongoing communication with residents and key stakeholders increases the public's awareness and understanding of lake-improvement programs. Education is vitally important if the Lake District hopes to build support and cooperation as it works to manage the lake. Newsletters, special mailers and public meetings are the preferred means of sharing information and providing access to the decision-making process. At a minimum, quarterly newsletters and regular public meetings are recommended.

  Implementation Timeline: Immediate and ongoing

- Perform a detailed watershed inventory to identify critical sites that either mitigate or contribute to non-point source pollution.

  Non-point source pollution is one of the most significant threats to the long-term health and quality of Montello Lake. A watershed inventory is needed to evaluate current land uses, and to pinpoint potential problem areas that require Best Management Practices. Problem areas might include wastewater discharge points, poorly managed barnyards, eroding farm fields and construction sites, unstable stream banks, drainage ditches, etc. Areas requiring special protections would consist of wetlands, natural shorelines and other high quality landscape features. A DNR Lake Planning Grant and other funding sources can be used to cost-share these types of studies.

  Implementation Timeline: Immediate

- Maintain a diversity of native plant species, and selectively control nuisance weed growth to facilitate reasonable public access and navigation.

  Residents and lake users need to recognize that Montello Lake has intrinsic limitations. Because it is a shallow impoundment, the lake will continue to support abundant rooted plant growth. Ensuring a healthy plant community is the best way to protect the quality of the lake. A diversity of native plant species provides essential fish and wildlife habitat. It is also the best defense against poor water clarity, algae blooms, and foreign invaders like Eurasian watermilfoil.

  Unfortunately, Montello Lake suffers from too much of a good thing. Although plants provide numerous benefits, their rapid and prolific growth has led to various lake-use impairments. Aggressive, non-native species ("weeds") are especially problematic. If left unchecked, these exotics can form vast monocultures that are less valuable as habitat, more susceptible to disease and more likely to turn into a recreational nuisance. Control efforts would be most effective if targeted along major navigational routes and public access points.

  Implementation Timeline: Immediate and ongoing

- Perform a six-month winter draw down on an as needed basis to control nuisance weed growth in near-shore areas.

  Montello Lake is an excellent candidate for a draw down. As a shallow impoundment of the Montello River, it continues to struggle with excessive plant growth, especially in near-shore areas. The problem is only compounded when this plant material eventually decomposes and accumulates as silt on the lake bottom. By breaching the Montello Dam, water levels could be periodically lowered for the purpose of near-shore plant control and sediment oxidation/compaction. This strategy would have to be performed on a recurring basis every few years to maintain desired results.

The biggest question is whether this particular strategy would be financially feasible after compensating for lost hydroelectric revenue. Other considerations include the possibility of sediment phosphorus release and associated algae blooms, and the short-term impact to the fishery. This strategy is evaluated in detail in the next chapter.

Implementation Timeline: Mid-September to mid-March every few years (depending on rate of re-growth)

- Use mechanical harvesting to maintain navigability and water flow in main channel, and to create edge habitat in weed-choked areas. Purchase additional equipment to improve efficiency.

  Mechanical harvesting is recommended over herbicide treatments as a lake-wide control strategy. To increase the efficiency and effectiveness of the program, harvesting should be selective and targeted to specific areas. In particular, harvesting should be used to clear the main navigational channel and public access points. It can also be used to create fish-cruising lanes for the purpose of establishing edge habitat in excessively weed-choked areas. Harvesting should not take place in less than three feet of water, or in designated protected areas that support high-quality vegetation or sensitive habitats.

  It is also suggested that the Lake District apply for a Waterways Commission Grant to help pay for additional harvesting equipment. A second harvester, a transport barge, and/or an additional shore conveyor and off-loading site would dramatically increase the efficiency of the current cutting program. This strategy is evaluated in detail in the next chapter.

  Implementation Timeline: Ongoing

- Conduct regular water quality and biological monitoring.

  Basic water quality testing should be performed on a seasonal and annual basis. Recommended sampling parameters include temperature and dissolved oxygen profiles, total phosphorus, pH, lake stage, Secchi depth and chlorophyll *a*. Sampling locations and methods should follow the procedures established by the U.S. Geological Survey during its recent monitoring of Montello Lake. Volunteer monitors could be employed to reduce costs.

  Regular aquatic plant inventories and fishery surveys are also recommended. Aquatic plant inventories and fishery surveys should be performed regularly to (1) gauge the effectiveness of management programs, (2) track changes over time, and (3) diagnose potential problems before they become serious.

  Implementation Timeline: Ongoing

CHAPTER 7: PLANT MANAGEMENT GUIDANCE

7-1 INTRODUCTION

It is important to recognize that aquatic plants form the foundation of a healthy lake ecosystem by protecting water quality and producing oxygen. A diversity of aquatic plants are effective at filtering pollutants, absorbing nutrients, stabilizing the lake bottom, as well as providing food, spawning habitat and structural refuge for aquatic life. Unfortunately, the aquatic plant communities found in disturbed, eutrophic lakes have frequently undergone significant degradation. "Disturbances" such as shallow-water motor boat traffic, non-point source pollution, sedimentation, and aggressive plant eradication efforts only accelerate the degradation process. The result is a gradual decline in plant diversity as the lake is taken over by non-native, nuisance plant species. Because these weedy species have few competitors and are tolerant to eutrophic conditions, they tend to grow to nuisance proportions to the detriment of native, beneficial species. This in turn detracts from the recreational enjoyment of the lake, and justifies the use of appropriately targeted plant-control methods.

This chapter discusses the two primary plant-control methods that are recommended for implementation by the Montello Lake Inland Protection & Rehabilitation District. The Lake District is encouraged to improve upon its existing mechanical weed-harvesting program, and consider complementing this program with a periodic winter draw down of six-month duration.

7-2 WINTER DRAWDOWN

Strategy Overview

A draw down is the temporary lowering of the lake's water level for a specified time period. Lake-level draw down and the subsequent exposure of sediments to prolonged freezing and drying is a means of aquatic weed control in very shallow, near-shore areas. It is commonly employed on shallow impoundments where water levels are easily manipulated by a control dam at the outlet. Exposure and de-watering of the lake bottom may also deepen certain areas through sediment oxidation and compaction. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the draw down.

By exposing sediment to prolonged freezing and drying, some rooted plant species are permanently damaged as a result of this technique. The entire plant, including roots and perhaps seeds, is usually killed if consistently exposed to freezing for two to four weeks. Water level draw down is an effective method for at least the short-term control (1-2 years) of susceptible aquatic plants, and can be accomplished without the introduction of chemicals or need for expensive machinery. However, this technique is species-specific and requires careful identification of the target plants beforehand to avoid the rapid establishment of resistant species. There is also the risk of accelerated, short-term phosphorus release from the bottom sediment following re-flooding.

Implementation Guidelines

A winter draw down should be conducted to control nuisance plant growth through freezing and desiccation, rather than a summer draw down that will usually encourage plant growth. The effectiveness of a winter draw down is dependent upon a deep frost and complete de-watering of the sediments. These conditions may not occur under heavy snow cover or during milder winters.

The recommended winter draw down timeframe for Montello Lake is a minimum six-month period. Water levels should be lowered gradually to their maximum extent by around mid-September, and complete refilling should be achieved by about the end of March. This timeframe successfully avoids the majority of

the peak summer boating season. It also limits disruption to fish spawning and wildlife nesting. A disadvantage is the increased potential for a fish winterkill, due either to an oxygen deficit or to a whole lake freeze. Afterwards, the lake should refill quickly with water from snowmelt and spring rainstorms. It is important to keep in mind that some species of aquatic plants will not be affected by a draw down, and others will actually increase in abundance. Therefore, drawdowns should be alternated at least every couple of years with no draw down so that resistant species do not become firmly established.

In most cases, implementing a draw down is relatively inexpensive since most costs are associated with restricted recreational use of the lake while water levels are low. Montello Lake may not be as fortunate if it must compensate for lost hydroelectric revenues incurred during a given draw down period. The Lake District may need to identify a funding source and/or work out a special arrangement with the hydroelectric company before selecting the winter draw down method as a long-term control strategy.

An Environmental Assessment (EA) must be completed prior to the implementation of a winter draw down. The Wisconsin Department of Natural Resources has already expressed interest in completing the EA. A pre- and post-draw down monitoring plan should also be prepared. Water quality and biological monitoring (e.g. aquatic plant inventories) are necessary to gauge the impacts of this type of management program.

Potential Impacts

This section provides some additional discussion on how a winter draw down might affect different plant species and in-lake nutrient recycling. Note that a complete list of potential benefits and drawbacks associated with a winter draw down was presented earlier in Chapter 5: Review of Management Options. Please refer back to Section 5-5 for a review of the many possible impacts and considerations related to water level manipulations.

The impact of a winter draw down on the aquatic plant community is somewhat variable. A list of plant species and their typical response to a winter draw down is presented in Table 9 below. Those species that were found in Montello Lake during the 1994 plant inventory are denoted with a star. An updated aquatic plant inventory of Montello Lake is strongly recommended prior to implementation of a draw down. Inventories are commonly used to evaluate the plant community and estimate the effects of a winter draw down.

Table 9: Responses of common aquatic plants to winter draw down.

(Adapted from Nichols, S.A., 1974)

Control by draw down	
Swamp milkweed	*Asclepias incarnata*
Watershield	*Brasenia schreberi*
Coontail*	*Certaophyllum demersum*
Spike Rush	*Eleocharis acicularis*
Milfoil*	*Myriophyllum* spp.
Yellow water lily*	*Nuphar* spp.
White water lily*	*Nymphaea* spp.
Pickerelweed	*Pontedieria cordata*
Large-leaf pondweed	*Potamogeton amplifolius*
Robbin's pondweed	*P. robbinsi*
Marsh cinquefoil	*Potentilla palustris*
Stiff wapato	*Sagittaria heterophylla*
Bladderwort	*Uticularia* spp.

Little Control by draw down	
Sweet flag	*Acorus calamus*
Waterweed	*Anacharis*
Watershield	*Brasenia schreberi*
Coontail*	*Ceratophylium demersum*
Spike rush	*Eleocharis acicularis*
Duckweed*	*Lemna* spp.
NA	*Potamogeton epihydrus*
Floating-leaf pondweed	*Potamogeton natans*
Richardson's pondweed*	*Potamogeton richardsonii*
Flat-stemmed pondweed*	*Potamogeton zosteriformes*
Water crowfoot	*Ranunculus tricophyllus*
Arrowhead	*Sagittaria latifolia*
Three square bulrush	*Scirpus americanus*
NA	*Sparaganium chlorocarpum*
Big duckweed*	*Spirodela polyrhiza*
Cattail	*Typha latifolia*
Bladderwort	*Utricularia vulgaris*
Wild celery*	*Vallisneria americana*
Increase with draw down	
Sweet flag	*Acorus calamus*
Manna grass	*Glyceria borealis*
Cut-grass	*Leersia oryzoides*
Bur marigold	*Megalodonta beckii*
Naiad*	*Najas flexilis*
Marsh smartweed	*Polygonum coccineum*
Floating-leaf pondweed	*Potamogeton natans*
NA	*Potamogeton diversifolium*
NA	*Potamogeton epihydrous*
Leafy pondweed	*Potamogeton foliosus*
Variable pondweed	*Potomogeton gramineus*
Richardson's pondweed*	*Potamogeton richardsonii*
Sand-bar willow	*Salix interior*
Softstem bulrush	*Scirpus validus*
Water parsnip	*Sium suave*
Cattail	*Typha latifolia*

* = found during 1994 aquatic plant inventory of Montello Lake

According to Ms. Deb Konkel, an Aquatic Plant Specialist with the DNR's West-Central Regional Office, drawdowns generally favor emergent plants due to improved seed germination. She believes that wild rice would also benefit, as long as the lake was stabilized before May or June. Wild rice develops through a floating leaf stage before it sends up its emergent. Ms. Konkel explains that if the water level rises through this stage, the plants could be lifted out of the substrate.

It is questionable whether drawdowns actually promote or discourage the in-lake recycling of nutrients that might cause algae blooms. There is some evidence suggesting that drawdowns compact sediments and minimize the exchange of plant nutrients such as phosphorous into the overlying water over the long run. During the period of draw down, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation rate of the surface layer of the sediments, draw down may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent zone. This zone, located at the sediment-water interface, plays an important role in the exchange of nutrients and re-suspension of sediments into the overlying water column.

However, recent findings now show that an initial release of nutrients could be anticipated upon re-flooding of the exposed lakebed. This initial release of nutrients may contribute to a late spring or early summer algae bloom, especially if these nutrients are not flushed out of the lake or diluted by in-flowing waters.

Maps depicting the extent of impact based on arbitrary four-foot and eight-foot drawdowns are presented as Figure 8 below. A draw down of at least several feet is recommended for Montello Lake.

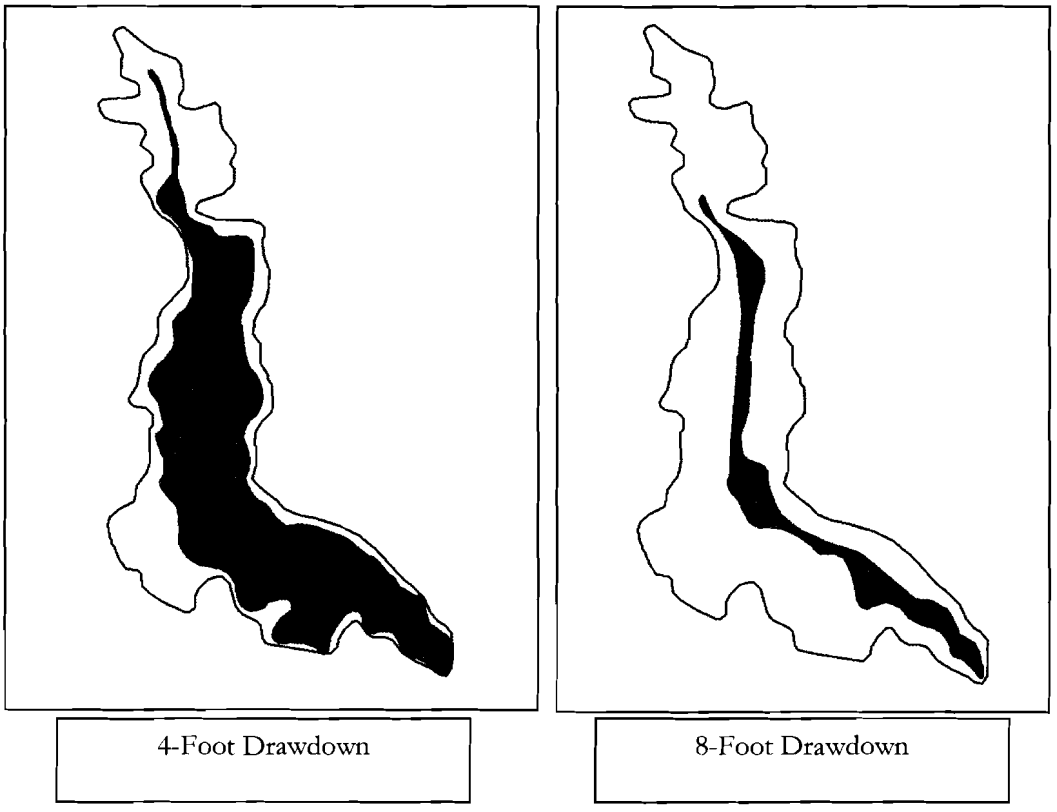


Figure 8: Area of Impact Based on 4-ft & 8-ft Drawdowns

Estimated Compensatory Costs

The Montello dam currently operates at a hydraulic head of 16.5 feet, meaning the lake level above the dam is 16.5 feet higher than the river level below the dam. This hydraulic head is capable of producing a maximum of 190 kilowatts of hydroelectric power. Average output is 114 kilowatts of power, which is produced 24 hours per day on a continuous basis. At this rate, the plant produces almost one million kilowatt hours of electrical energy per year. The plant uses 78,600 gallons of water per minute at maximum output.

Mr. Scott Klabunde, North American Hydro Operations Manager, claims the dam is capable of allowing a maximum water level draw down of 11 feet. According to Mr. Klabunde, the configuration of the dams power generating equipment limits power generation when water levels are lowered. Lowering the water level of Montello Lake greater than three feet would eliminate power generation.

Mr. Klabunde indicated that under North American Hydro's 2001 price structure, $3,750 in revenue would be lost each month that the water level was lowered greater than three feet. Therefore, costs are

estimated at around $22,500, assuming a six-month winter draw down scenario where water levels are lowered at least three feet.

7-2 MECHANICAL WEED HARVESTING

Strategy Overview

Mechanical weed harvesting uses specially designed machinery to cut, collect and remove nuisance plant material from the lake. Standard equipment includes a mechanical weed harvester, harvester trailer, dump truck, transport barge, and shore conveyor. The harvester cuts the tops of plants growing within several feet of the water surface. Harvested plant material is collected onto a conveyor system and temporarily stored on the harvester. The plant debris can then be off-loaded onto a transport barge, or taken directly to an off-loading site along the shoreline. A shore conveyor is used to move plant material from the transport barge or harvester into an awaiting dump truck for later land disposal.

A harvesting program is used to trim and remove near-surface vegetation on a recurring basis throughout the summer growing period. Although this technique provides immediate relief of nuisance plant growth, it must be repeated frequently during the operating season to maintain this relief. Trained operators and maintenance workers are needed to ensure the effectiveness of the program. Mechanical harvesting should not be performed in less than three-foot water depths, around piers and rafts, within designated protected areas, or where underwater obstructions could damage the equipment.

Implementation Guidance

For implementation guidance, refer to the Montello Lake Plant Management Plan completed by Aron & Associates in 1994. A summary of the recommendations outlined in the Plan is presented in a bulleted format below.

- Use mechanical harvesting to maintain reasonable public access and navigation.
- Selectively target weed-choked public access points and main navigational channels.
- Focus efforts on nuisance weed beds dominated by non-native species (e.g. Eurasian milfoil).
- Harvest Eurasian milfoil canopies to allow light penetration to underlying native plants.
- Avoid operating in designated sensitive areas or in locations that harbor a diversity of native, beneficial plant species (e.g. a variety of pondweeds).
- Do not use clear-cutting techniques as a means of controlling plant growth.
- Clear paths through excessively dense stands of vegetation to create edge habitat for game fish.
- Do not operate in very shallow water depths where sediment disturbance might occur.
- Leave at least one foot of plant material remaining to stabilize the lake bottom.
- Make every effort to reduce the amount of floating plant debris, especially Eurasian milfoil fragments.
- Cut to a depth of five to six feet in deeper water areas that require harvesting.
- Avoid harvesting during the spring spawning season.
- Operate in a slow, methodical manner to increase cutting effectiveness and prevent the capture of small fish and wildlife.
- Do not harvest near natural shorelines in designated sensitive areas except to provide direct access to piers.
- Maintain off-loading sites in a clean, debris-free manner.
- Provide adequate operator training to ensure the effectiveness of the program.
- Perform preventative maintenance on all harvesting equipment, and operate in a safe manner.
- Keep comprehensive and detailed operational records (e.g. harvest locations, dominant plant species, number of loads, hours worked, equipment repairs, etc.).
- Consider the purchase of a second weed harvester to increase operating efficiency.

- Investigate the feasibility of storing all harvesting equipment at an indoor facility.
- Consider the establishment of an additional off-loading site.

Potential Impacts

Note that a complete list of potential benefits and drawbacks associated with mechanical weed harvesting was presented earlier in Chapter 5: Review of Management Options. Please refer back to Section 5-5 for a review of the many possible impacts and considerations related to mechanical harvesting.

Estimated Operational Costs

Estimated operational costs are also discussed in Chapter 5: Review of Management Options. Please refer back to Section 5-6 for a cost breakdown and comparative analysis among various plant-control strategies. Additional cost information can be found in the 1994 Montello Lake Plant Management Plan. These costs may need to be adjusted upward to account for inflation.

CHAPTER 8: SUMMARY

Montello Lake should continue to be managed as a shallow, aquatic plant dominated resource. A diversity of native plants is an essential component of a healthy aquatic ecosystem, and is needed for wildlife habitat and water quality protection. Abundant vegetation is also a natural by-product of a shallow, clear and fertile water body like Montello Lake. Attempts to change the lake into something different would be ecologically disruptive and cost prohibitive at best. It would also risk shifting the lake into an alternate, less desirable state of equilibrium in which algae and high turbidity replace rooted plant growth and clear water conditions. Therefore, it is imperative that people recognize the lake's natural limitations, and adjust their lake-use and management expectations accordingly. Overcoming public misconceptions about the resource is the first step in implementing a successful management program. The Lake District is encouraged to use a combination of quarterly newsletters, regular public meetings, press releases, informational brochures and direct mailers (among other strategies) to increase the awareness and educational level of the general lake community.

Unfortunately, Montello Lake does appear to be suffering from too much of a good thing. It also struggles with the rapid and prolific growth of non-native, nuisance plant species like Eurasian water milfoil. Current lake-use impairments are primarily attributed to this nuisance weed growth, which also contributes to excessive silt accumulation and a stunted panfish population. The biggest challenge is to address these recreational impairments in a cost-effective and priority-driven manner, and without inadvertently causing other problems. To do this, public opinion surveys were combined with sound, scientific analysis to help select the most appropriate management options. Recommended management strategies were those that best satisfied as many of the following criteria as possible:

- Controls nuisance weed growth to facilitate reasonable public access and lake use.
- Protects ecologically sensitive areas, and maintains a diversity of native plant species for habitat and water quality protection.
- Addresses the accumulation of silt that leads to a mucky lake bottom.
- Promotes conditions that sustain a healthy fishery and diverse wildlife population.
- Protects or improves existing water clarity.
- Maintains the lake's peace and tranquility.
- Avoids the need for additional regulation and enforcement.
- Reduces the likelihood of (unplanned) water level fluctuations.

To achieve these objectives, a combination of lake-improvement strategies is recommended. First, management efforts should begin in the watershed by addressing the root cause of most problems—namely non-point sources of pollution. These pollutants may consist of sediment, manure, chemical fertilizers and herbicides, heavy metals, organic debris and various other materials. They are delivered to the lake predominantly in the form of stormwater runoff. A detailed watershed inventory is needed to assist the Lake District in evaluating current land uses, and identifying potential pollutant-loading hot spots. These hot spots might consist of industrial discharge locations, active construction sites, eroding farmland, unstable stream banks or drainage ditches, and inappropriate or unplanned development. A watershed inventory is also useful in locating critical areas that serve to protect the health and quality of Montello Lake. Critical sites can include wetlands, natural shorelines and other landscape features that warrant special protections. Once all these sites are identified, a number of Best Management Practices can be used to minimize the amount of polluted runoff that ultimately reaches the lake.

In-lake management options are also warranted, and should be implemented in conjunction with watershed protection efforts. Recommended management options include the use of regular mechanical weed harvesting and occasional winter drawdowns. Both harvesting and winter drawdowns require long-term commitments if they are to be used as effective plant-control methods. They represent symptomatic solutions, and offer more immediate, albeit temporary, relief of nuisance weeds.

Harvesting should be performed in accordance with the instructions outlined in the 1994 Montello Lake Plant Management Plan. However, this Plan is based on information from an aquatic plant inventory that is now several years old. Since plant communities can change dramatically over time, an updated aquatic plant inventory is needed so the harvesting program can be adjusted accordingly. The Lake District is also encouraged to purchase supplementary harvesting equipment to improve overall cutting efficiency. Existing operations have proven inadequate given the rate and extent of nuisance weed growth. The purchase of a second harvester could speed up the cutting process significantly, and would greatly enhance the overall effectiveness of the program. Other options include securing a transport barge, or establishing multiple off-loading sites. Harvesting should be used strictly to (1) clear main navigation routes, (2) provide relief of nuisance weed growth around public access points, and (3) enhance edge habitat conditions in severely weed-choked areas. Operating in shallow water, around physical obstructions, or within ecologically sensitive areas is strongly discouraged.

A six-month, winter drawdown may be considered every few years to maintain weed control in shallow, near-share locations. This strategy may also offer a secondary benefit of limited sediment compaction. To be effective, water levels must be lowered enough to completely de-water and expose targeted areas of the lake bottom. A pre and post-monitoring program is needed to evaluate the affect of the drawdown on water quality, aquatic plants, fisheries and wildlife. The Wisconsin Department of Natural Resources requires the completion of an Environmental Assessment (EA) prior to implementation. Special consideration should be given to the following risks: (1) the potential for increased phosphorus release from the bottom sediment and its affect on algae growth; (2) the impact of reduced water levels on the fisheries; and (3) the long-term affect on wild rice beds. In addition, Lake District would need to determine how it is going to compensate American Hydro, Inc. for lost revenues during the drawdown period. If a funding source cannot be identified, this particular strategy may prove too cost prohibitive.

The Montello Lake Inland Protection & Rehabilitation District is to be commended for its ongoing efforts to protect and improve the resource. Montello Lake continues its status as both a recreational and economic asset, despite the threats of non-point source pollution and abundant weed growth. Through careful planning and a commitment to the lake's long-term ecological health, the Lake District is well on its way to implementing a successful management program that can benefit all its users.

APPENDIX A

RESULTS OF 1998 AQUATIC PLANT MANAGEMENT OPINION SURVEY

MONTELLO LAKE DISTRICT
Aug. 31, 1998

Results of Survey

Residents of the Montello Lake District:

At the September (1997) annual meeting a motion was made and passed to survey all lake property owners regarding management of the weeds on Montello Lake.

The lake management committee has tabulated the results of the lake survey, which included responses from both lake and back lot property owners. The results are as follows:

Y	N		
56%	34%	1.	Are you in favor of the weed barriers like those from last summer?
45%	55%	2.	Are you in favor of more cutting time spent to keep the middle of the lake open?
68%	32%	3.	Are you in favor of more cutting of the shoreline?
42%	58%	4.	Would you be in favor of purchasing a new smaller cutter to do shoreline removal, cutting, and cleanup?
36%	64%	5.	Would you be willing to go along with an increase in lake fees, should it be necessary, for purchasing a new smaller weed cutter?

The present balance for the weed harvester and related equipment is approximately $16,000.00. At an interest rate of 5.75% our loan will be paid off in 2000.

69%	31%	6.	Are you in favor of a continued Saturday pickup?
70%	30%	7.	Would you like more information on the cost, advantages, and disadvantages of a drawdown?
43%	57%	8.	Would you like to see the weed harvester and equipment stored in a pole barn during winter months to extend machinery life?
64%	36%	9.	Would you like to see more cutting and cleanup in the early part of the summer?
20%	80%	10.	Would you like to see less cutting during the summer months?
34%	66%	11.	Would you like to see more cutting and cleanup during the fall or the later season?
46%	54%	12.	Would you like to see less cutting in the fall, no cleanup, and taking the cutter out on Labor Day?
25%	75%	13.	Would you be willing to personally pay students to remove weeds at a current minimum wage rates from your own property?
24%	76%	14.	Would you be willing to hire/pay students to pick-up weeds?
89%	11%	15.	Should the Lake District work more closely with appropriate governmental bodies to control lake weeds?
36%	64%	16.	Would you be willing to work on the weed committee this year or sometime in the future?
27%	73%	17.	Do you feel that you receive sufficient and timely information on the condition of the lake from the Lake District?
71%	29%	18.	After the survey results are published, are you willing to go along with the majority consensus?
on back		19.	How much time do you spend per week or month removing shoreline weeds for pick-up? 1 hour weekly___: 3 hours weekly___; 5 hours weekly___: once a month___; as needed___; never___.

OVER

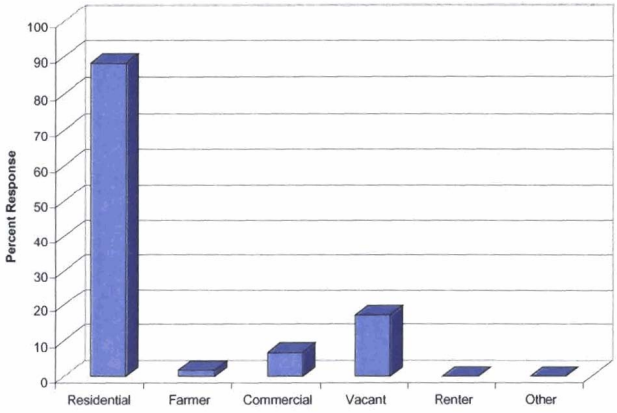
APPENDIX B

RESULTS OF 2000 LAKE DISTRICT RESIDENT OPINION SURVEY

RESULTS

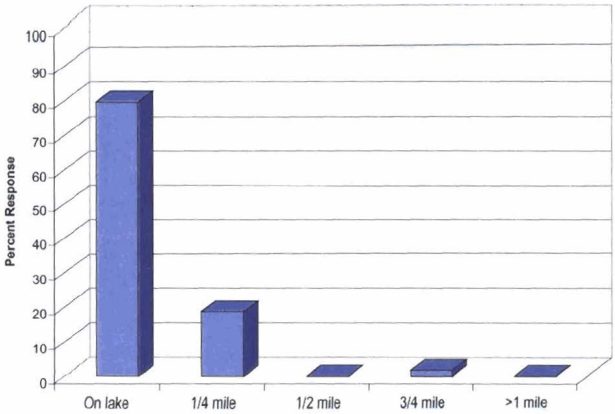
2000 SURVEY OF MONTELLO LAKE MANAGEMENT DISTRICT RESIDENTS

1. What type of property owner are you?

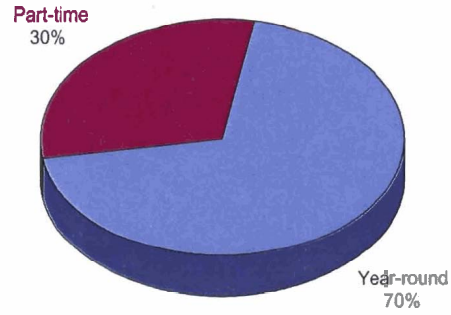


2. Are you a tax-paying resident of the Montello Lake Management District?

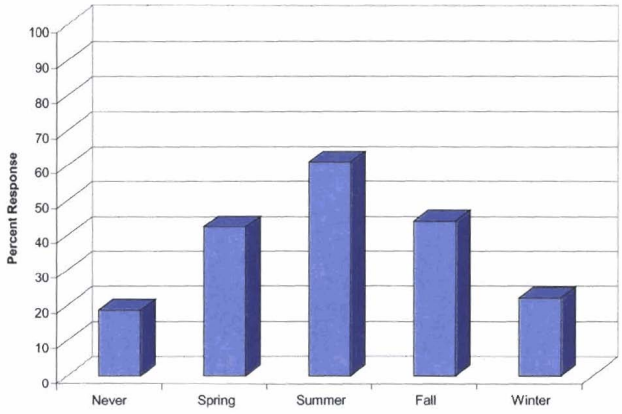
3. Approximately what distance from the lake is your property located?



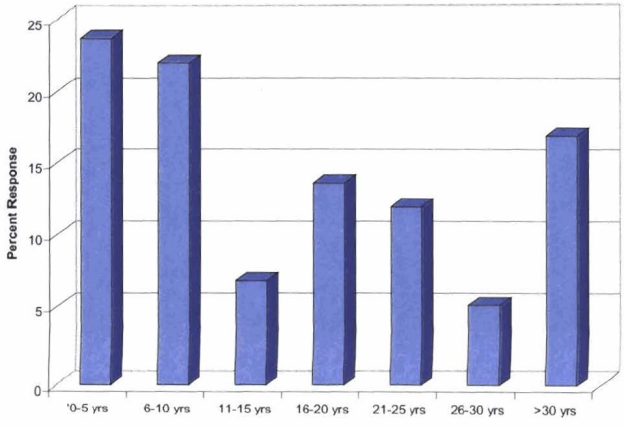
4. What is your residency status?



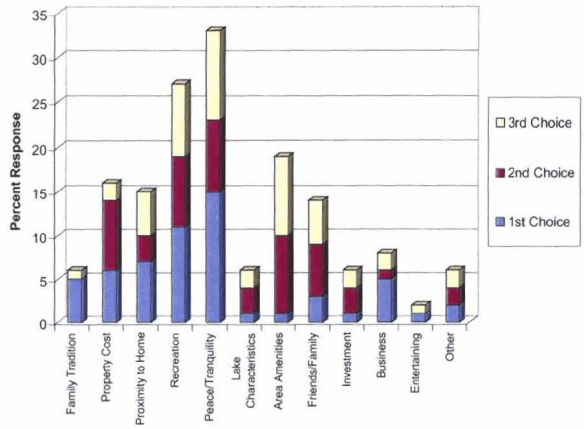
5. When do you most often spend time on Montello Lake?



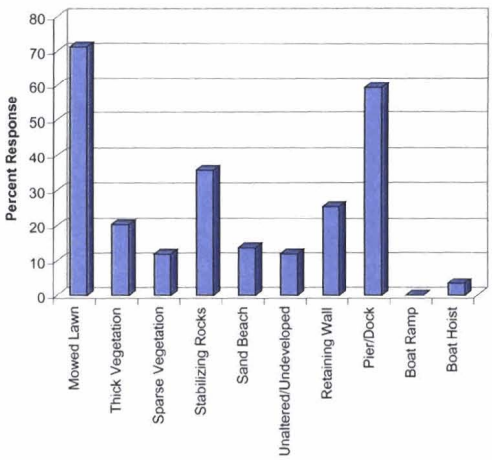
6. How many years have you owned property in the Montello Lake Management District?



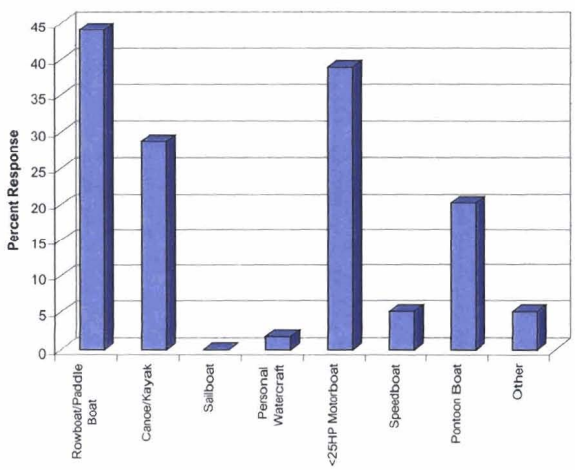
7. What are the top three reasons you chose to own property on or near Montello Lake?



8. If you own lakefront property, which of the following describes your lake frontage within 25 feet of the water's edge?



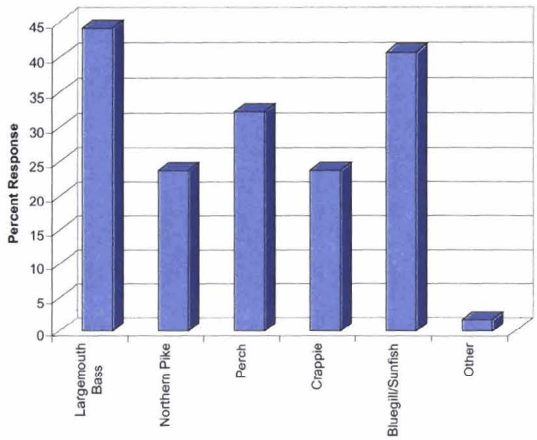
9. What types of watercraft do you routinely use on Montello Lake?



Other: Fishing boat

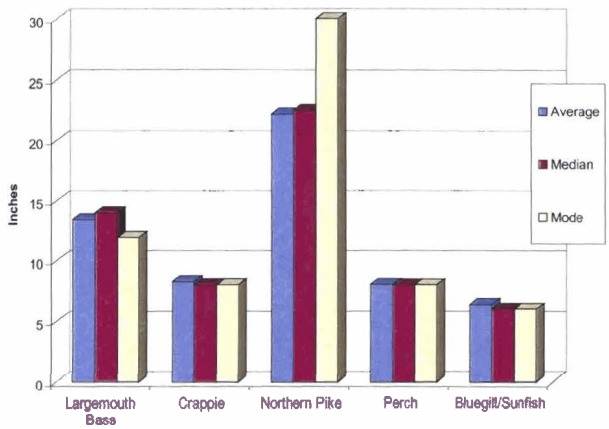
<u>If an angler, please answer the following questions:</u>

10A. Rank the following fish species that you prefer to catch on Montello Lake.

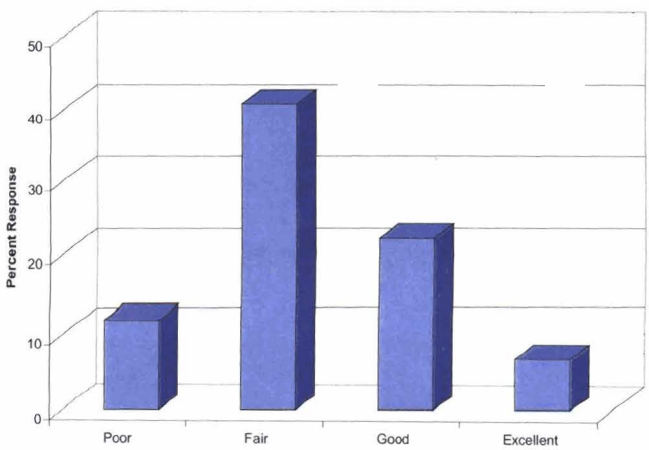


Other: Walleye, rock bass, small mouth bass, catfish

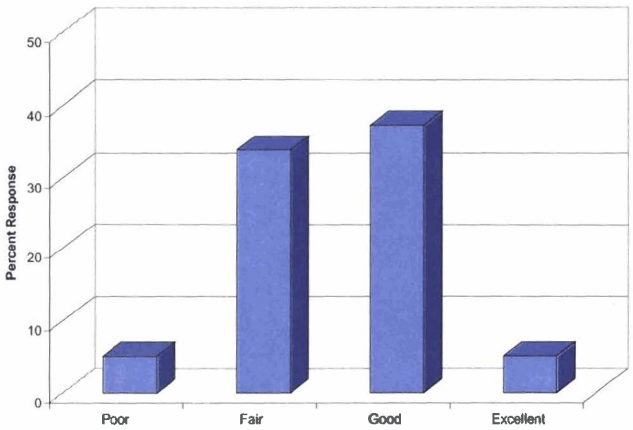
10B. What is the average size of each type of fish that can be caught on Montello Lake?



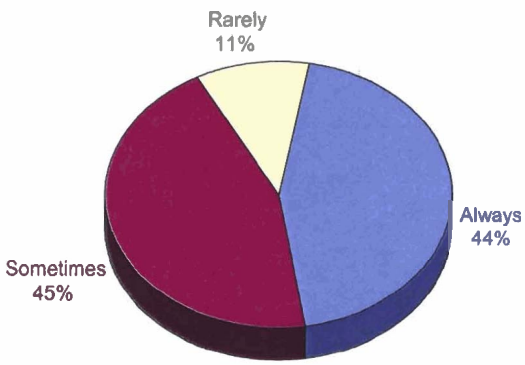
10C. How would you rate the quality of fishing on Montello Lake in terms of fish SIZE?



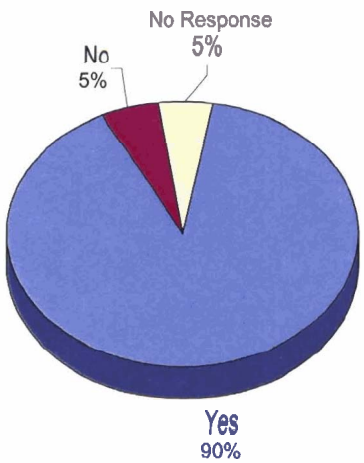
10D. How would you rate the quality of fishing on Montello Lake in terms of fish NUMBERS?



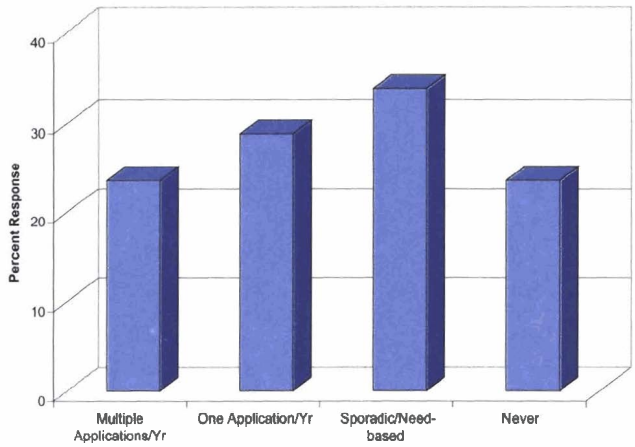
10E. Do you voluntarily practice "catch-n-release" when fishing for species other than panfish?



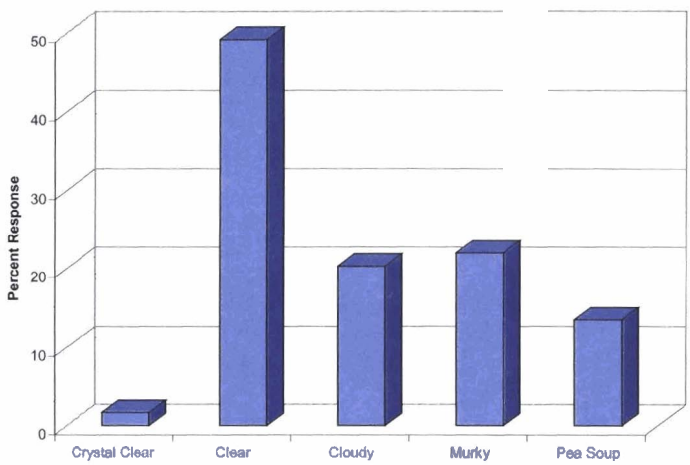
11. Do you feel that Montello Lake has adequate public access?



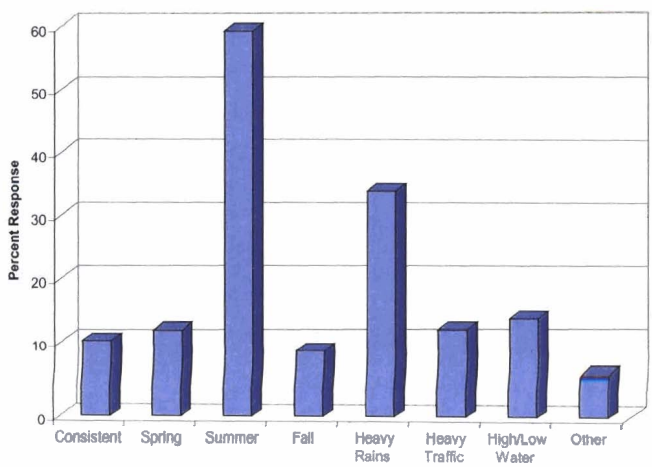
12. What is your opinion regarding the use of fertilizer and/or weed killer to maintain lawns around Montello Lake?



13. Overall, how would you describe the water clarity during the summer months?

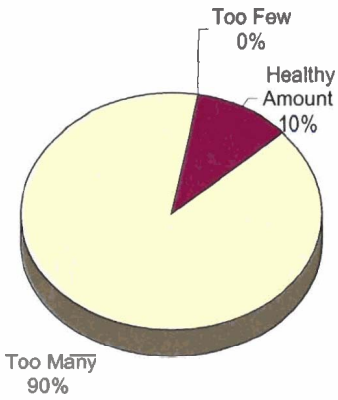


14. When is water clarity at its worst?

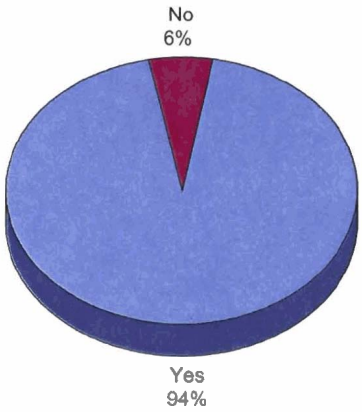


Other: During weed harvesting

15. Overall, how would you describe Montello Lake's aquatic plant growth?

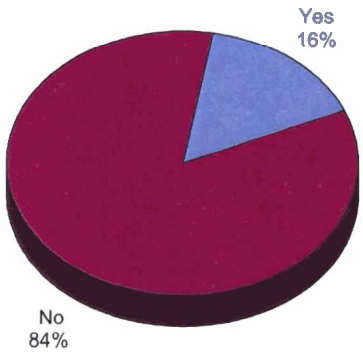


16. Are there areas on the lake where aquatic plant growth becomes especially problematic?



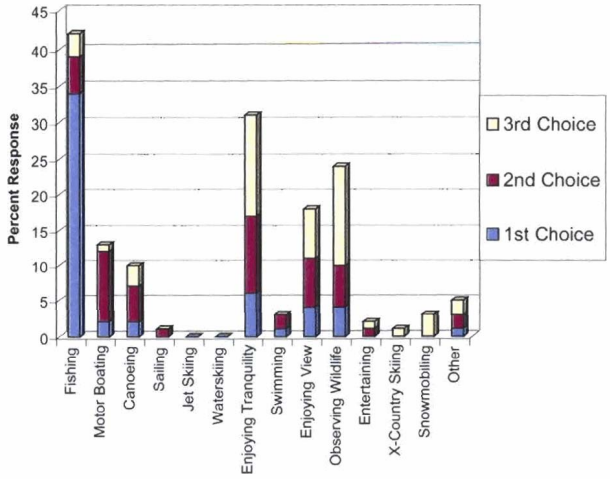
Locations: Whole lake (responses widely varied)
Problems: Navigation & fishing from shore

17. Do you feel the current weed control program is effectively controlling nuisance plant growth?

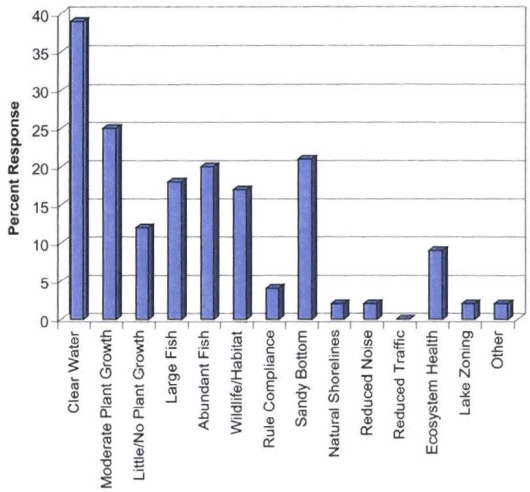


Most frequent responses: Harvester can't keep up with growth and targets only specific areas—need a better plan! Floating plant debris is a problem.

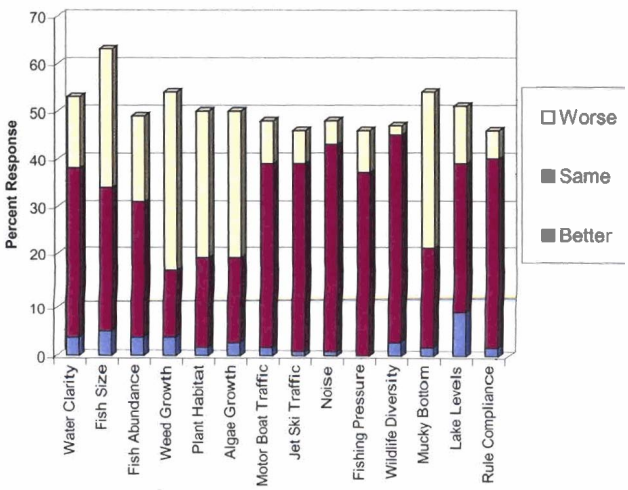
18. What activities do you and the members of your household most enjoy while recreating on Montello Lake?



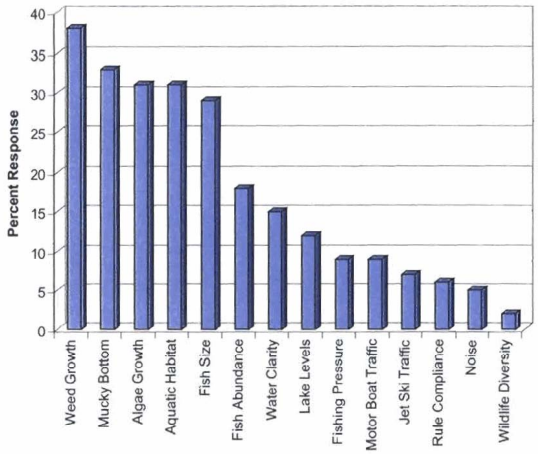
19. Rank the following lake qualities according to their level of importance to you.



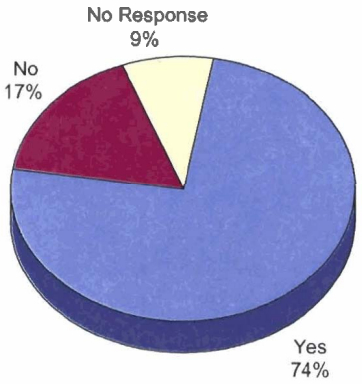
20. How have the following changed since you've lived on or near Montello Lake?



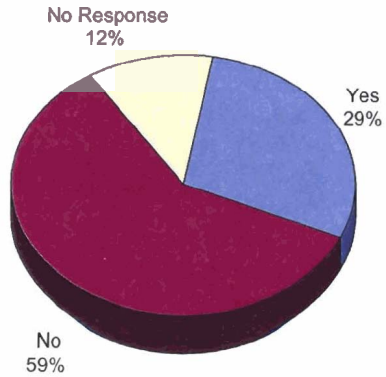
20b. The following graph illustrates on a relative basis what people feel has gotten worse over time.



21. Do you feel there is an adequate law enforcement presence on Montello Lake?

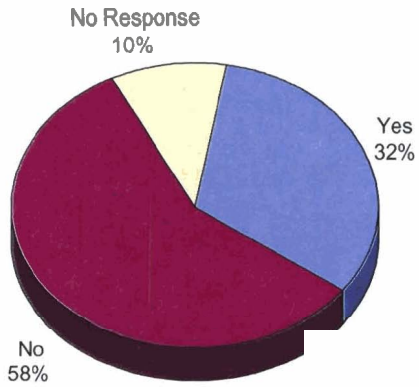


22. Are there any types of behavior, recreational activities or lake uses that you feel seriously jeopardize the health and safety of Montello Lake?

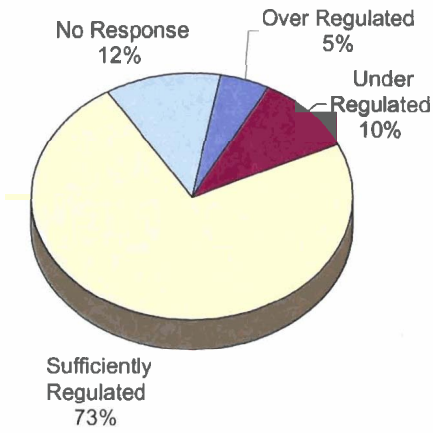


Yes: Large horsepower motor boats; jet skis; fertilizer runoff; upstream livestock operations; weed cutting

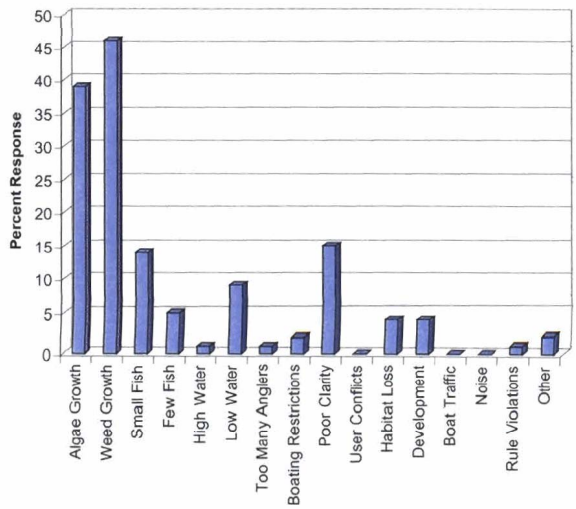
23. Would you be in favor of expanding "slow-no-wake" times and/or locations to promote safety and protect sensitive habitat areas on Montello Lake?



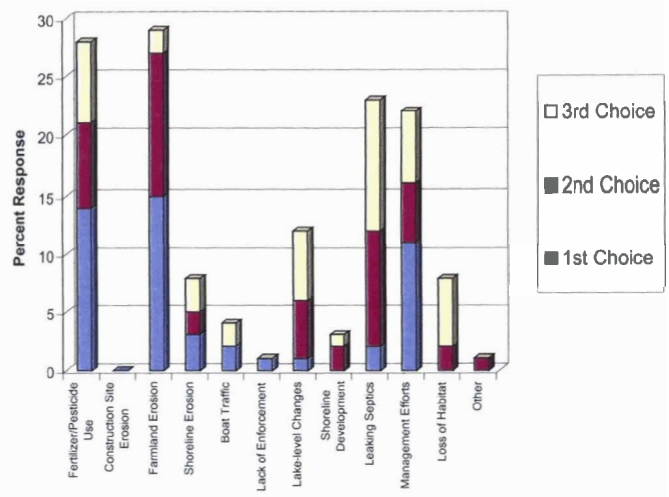
24. What is your opinion regarding lake-use regulations on Montello Lake in general?



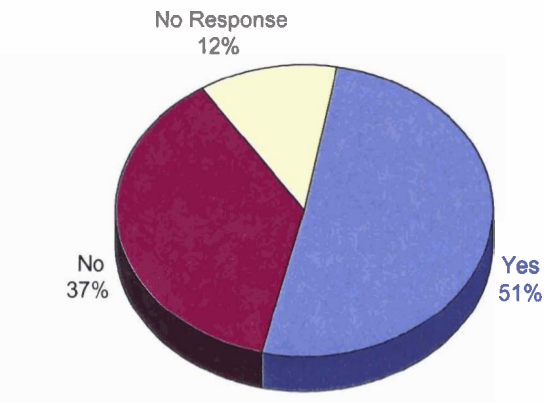
25. Rank the following according to the degree each condition negatively impacts your use or enjoyment of Montello Lake.



26. What do you feel are the top three factors that contribute to problems on Montello Lake?

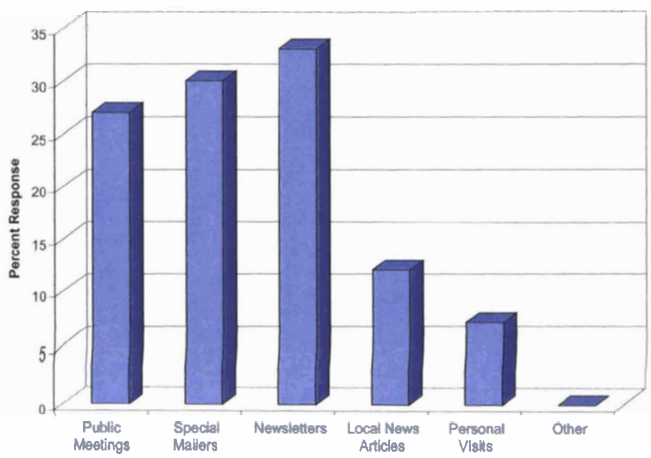


27. Do you feel you have a voice in decision-making matters regarding the management of Montello Lake?

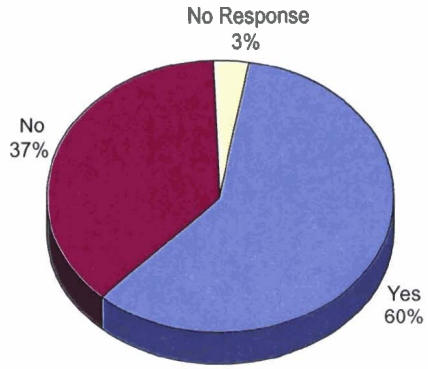


No: Can't make it to meetings; Board does not listen to my concerns and does whatever it wants

28. What is the best way for the lake district to communicate with its residents?



29. Do you feel that you are adequately informed of lake-management decisions?



No: Send more newsletters & special mailers; Board needs to ask for and listen to resident opinions

30. What do you think is the most negative aspect about Montello Lake or its management?

Most frequent responses:

- Nuisance weed growth
- Ineffective weed-control strategies
- Harvester does not cut certain parts of the lake
- Algae and muck
- Agricultural runoff & non-point pollution

31. What do you think is the most positive aspect about Montello Lake or its management?

Most frequent responses:

- Good fishing & water clarity
- Weed control
- Efforts of the lake management district
- Lake is quiet and peaceful
- Wildlife habitat
- More consistent water levels

32. Do you have other concerns or questions that were not addressed in this survey?

Responses:

- Focus should be on upstream runoff
- Mechanical harvesting is not adequate
- Would not support drawdown (2)
- Would support drawdown (3)
- Accumulation of silt is biggest problem (2)
- Would support dredging
- Would not support chemical use
- County board supports farming interests over water quality
- Thank you for asking our opinions

RESIDENT SURVEY
MONTELLO LAKE MANAGEMENT DISTRICT

ATTENTION: *The Montello Lake Management District would like your feedback to the following questions. Your comments and opinions are very important to us, and will form the basis of developing a Comprehensive Lake Management Plan for Montello Lake. The Plan will be used to guide the implementation of lake-protection and improvement strategies over at least the next several years. Please answer all the questions to the best of your ability. Completed surveys should be returned to Ramaker & Associates, Inc. no later than* **August 18, 2000**. *To send, simply re-fold so the return address at the end of the survey is clearly visible, tape shut (please do not staple), and mail before the deadline. Thank you in advance for your input!*

1. What type of property owner are you? (Check all that apply.)
   ___ Residential Homeowner ___Farmer ___ Commercial Business ___ Vacant Landowner ___ Renter ___ Other

2. Are you a tax-paying resident of the Montello Lake Management District?
   ___ Yes ___ No

3. Approximately what distance from the lake is your property located?
   ___ On the water ___ ¼ mile ___ ½ mile ___ ¾ mile ___ 1+ miles

4. Which of the following best describes your residency status?
   ___Year-round/Permanent ___Seasonal/Part-time

5. When do you most often spend time recreating on Montello Lake?
   ___Never ___Spring (Mar – May) ___Summer (Jun – Aug) ___Fall (Sept – Nov) ___Winter (Dec – Feb)

6. How many years have you owned property in the Montello Lake District?
   ___0-5 years ___ 6-10 years ___11-15 years ___16-20 years ___ 21-25 years ___26-30 years ___30+ years

7. List the top three reasons why you chose to own property on or near Montello Lake? (List the letters of your top three choices.)

A.	Family inheritance/tradition	G.	Area amenities (small town atmosphere, etc.)
B.	Cost of property	H.	Location of friends or family
C.	Proximity to primary residence	I.	Real estate investment
D.	Recreational opportunities	J.	Business purposes
E.	Peace/tranquility	K.	Entertaining
F.	Type & quality of lake	L.	Other (Specify)_____

   1st ___ 2nd ___ 3rd ___

8. If you own lakefront property, which of the following describes your lake frontage within 25 feet of the water's edge? (Check all that apply.)
   ___Mowed lawn ___ Thick vegetation ___Sparse vegetation ___Stabilizing rocks ___ Sand beach ___Unaltered/undeveloped
   ___Retaining wall ___Pier/dock ___ Private boat ramp ___ Boat hoist

9. What types of watercraft do you routinely use on Montello Lake? (Check all that apply.)
   ___ Rowboat/Paddle boat ___ Canoe/Kayak ___ Sailboat ___ Personal watercraft ___ Motor boat under 25HP
   ___ Speed boat ___ Pontoon boat ___Other (Specify)_____

10. If you are an angler, please answer the following questions.
    A) Rank the following fish species that you prefer to catch on Montello Lake? (Rank 1-6: 1 = most important and 6 = least important)
       ___Largemouth Bass ___Northern pike ___Perch
       ___Crappie ___Bluegill/Sunfish ___Other (Specify)_____

    B) What is the average size of each type of fish that can be caught on Montello Lake?

Largemouth Bass:	___ inches	Perch:	___ inches
Crappie:	___ inches	Bluegill/Sunfish:	___ inches
Northern Pike:	___ inches	Other (_____):	___ inches

C) How would you rate the quality of fishing on Montello Lake in terms of fish SIZE?
___ Poor ___ Fair ___ Good ___ Excellent

D) How would you rate the quality of fishing on Montello Lake in terms of fish NUMBERS?
___ Poor ___ Fair ___ Good ___ Excellent

E) Do you voluntarily practice "catch-and-release" when fishing for species other than panfish?
___ Always ___ Sometimes ___ Rarely

11. Do you feel Montello Lake has more than adequate public access? If not, what type of access is most needed?
___ Yes ___ No (type most needed:_____)

12. What is your opinion regarding the use of fertilizers and/or weed killer to maintain lawns around Montello Lake? (Check all that apply.)
___Two or more applications needed per year
___One application needed per year
___ Needed only on a sporadic basis depending on soil and plant growth conditions
___ Not needed or not justified due to perceived health/environmental effects

13. Overall, how would you describe the water clarity in Montello Lake during the summer months?
___Crystal clear ___Clear ___Cloudy ___Murky ___Pea soup

14. When is water clarity at its worse? (Check all that apply.)
___Consistently bad ___After heavy rains
___Spring ___After heavy motor boat & jet ski traffic
___Summer ___During abnormally high/low lake levels
___Fall ___Other (Specify)_____

15. Overall, how would you describe Montello Lake's aquatic plant growth?
___ Too few plants ___ Healthy amount of plant growth ___ Too many plants

16. Are there areas on the lake where aquatic plant growth becomes especially problematic? If yes, please specify the location and nature of problem.
___Yes (Location:_____ Nature of Problem:_____)
___No

17. Do you feel the current weed management program is effectively controlling nuisance plant growth? If not, please explain.
___Yes ___No
_____
_____

18. What activities do you and the members of your household most enjoy while recreating on Montello Lake? (List the letters of your top three choices.)

A.	Fishing	H.	Swimming/Snorkling
B.	Motor boating	I.	Enjoying the view
C.	Canoeing/Paddle boating	J.	Observing wildlife
D.	Sailing/Wind surfing	K.	Entertaining
E.	Jet skiing	L.	Cross-country skiing
F.	Water skiing	M.	Snowmobiling
G.	Enjoying peace & tranquility	N.	Other (Specify)_____

1st____ 2nd____ 3rd____

19. Rank the following according to their level of importance to you. (Rank 1-14: 1 = most important, 14 = least important)

___ Clear water	___ Sandy bottom
___ Moderate amount of aquatic plant growth	___ Natural, well-vegetated shorelines
___ Little or no aquatic plant growth	___ Reduced noise
___ Large fish	___ Reduced traffic & congestion
___ Abundant fish	___ Overall ecosystem health
___ Presence of wildlife/habitat	___ Greater separation of conflicting lake uses
___ Rule compliance	___ Other (Specify)_____

20. How have the following changed since you've lived on or near Montello Lake?

	BETTER	SAME	WORSE
Water clarity:	___	___	___
Fish size:	___	___	___
Fish abundance:	___	___	___
Nuisance "weed" growth:	___	___	___
Aquatic plant habitat:	___	___	___
Algae growth:	___	___	___
Motor boat traffic:	___	___	___
Personal watercraft traffic:	___	___	___
Noise:	___	___	___
Fishing pressure:	___	___	___
Wildlife diversity:	___	___	___
Muckiness of lake bottom:	___	___	___
Lake-level fluctuations:	___	___	___
Rule compliance/enforcement:	___	___	___

21. Do you feel that there is an adequate law enforcement presence on Montello Lake?
___ Yes ___ No

22. Are there any types of behavior, recreational activities or lake uses that you believe are seriously jeopardizing the health and safety of the lake? If yes, please explain.
___Yes ___No
_____
_____

23. Would you be in favor of expanding "slow-no-wake" times and/or locations to promote safety and protect sensitive habitat areas on Montello Lake? Please explain.
___ Yes ___ No
_____
_____

24. What is your opinion regarding lake-use regulations on Montello Lake in general?
___ Over regulated ___ Under regulated ___ Sufficiently regulated

25. Rank the following according to the degree each condition negatively impacts your use or enjoyment of Montello Lake? (Rank 1-16: 1 = biggest problem, 16 = smallest problem)

___Nuisance algae growth
___Excessive weed growth
___Small fish size
___Small fish quantity
___Lake-level too high
___Lake-level too low
___Too many fishermen
___Too many boating restrictions
___Poor water clarity
___Passive vs. active recreational conflicts
___Loss of wildlife habitat (e.g. shoreland & aquatic vegetation)
___Shoreline development
___Boat traffic/congestion
___Noise
___Lack of rule compliance/enforcement
___Other (Specify)_____

26. What do you feel are the top three factors that contribute to problems on Montello Lake? (List the letters of your top three choices)

A. Fertilizer/pesticide use
B. Construction site erosion & runoff
C. Farm field erosion & runoff
D. Shoreline and stream bank erosion
E. Motor boat & jet ski traffic
F. Inadequate law enforcement
G. Lake-level fluctuations
H. Shoreline development pressures
I. Leaking septic fields
J. Inappropriate lake management efforts
K. Wetland & wildlife habitat destruction
J. Other (Specify)_____

1st___ 2nd___ 3rd___

27. Do you feel that you have a voice in decision-making matters regarding the management of Montello Lake? If not, please explain why you think this is the case.
___ Yes ___ No
_____
_____