Management Plan Report

Lake Manuka
Management Plan Report

Prepared for:
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November 2006

Project No: 59250101

ProgressiveAE

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Introduction

PROJECT BACKGROUND

Lake Manuka is located in Sections 25 35, and 36 of Hayes Township in Otsego County (T.30N, R.4W; Figure 1). In September of 2005, Progressive AE was retained by the Lake Manuka Association to conduct a lake improvement feasibility study. The objective of the study was to develop and define a comprehensive lake management plan for Lake Manuka. The purpose of this report is to discuss study findings, recommendations, and conclusions.

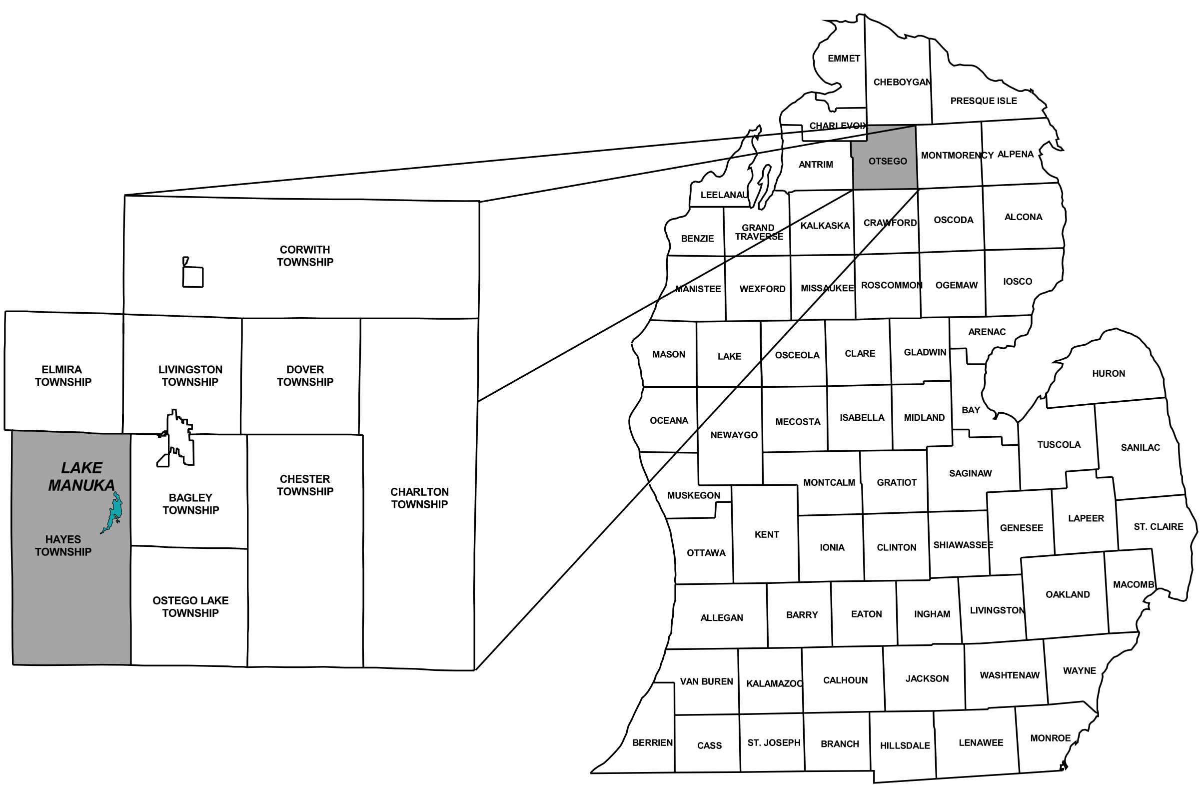


Figure 1. Project location map.

LAKE AND WATERSHED CHARACTERISTICS

A summary of the physical characteristics of Lake Manuka and its watershed is provided in Table 1. Lake Manuka has a surface area of 167 acres, a maximum depth of 27 feet, and a mean or average depth of 5.2 feet. A map depicting approximate depth contours in Lake Manuka is shown in Figure 2. Lake Manuka contains about 868 acre-feet of water, a volume which equates to about 283 million gallons. The lake has a shoreline 5.25 miles long and a shoreline development factor of 2.9. The shoreline development factor indicates the degree of irregularity in the shape of the shoreline. That is, compared to a perfectly round lake with the same surface area as Lake Manuka (i.e., 167 acres), the shoreline of Lake Manuka is nearly 3 times longer because of its irregular shape. Currently, approximately 118 seasonal and year-round homes border the lake.

TABLE 1
LAKE MANUKA
PHYSICAL CHARACTERISTICS[1]

Lake Surface Area	167 acres
Maximum Depth	27 feet
Mean Depth	5.2 feet
Lake Volume	868 acre feet
Shoreline Length	5.25 miles
Shoreline Development Factor	2.9
Watershed Area	2,179 acres
Lake Area: Watershed Area	1:13

[1] Shoreline length, lake elevation, watershed and lake areas were determined by examining a United States Geological Survey topographic maps of the Lake Manuka area. Lake volume, maximum and mean depths were derived from a depth contour map of Lake Manuka (Michigan Conservation Department 1953). An aerial photograph of the study area was utilized to delineate watershed land use types (MapTech, 1994).

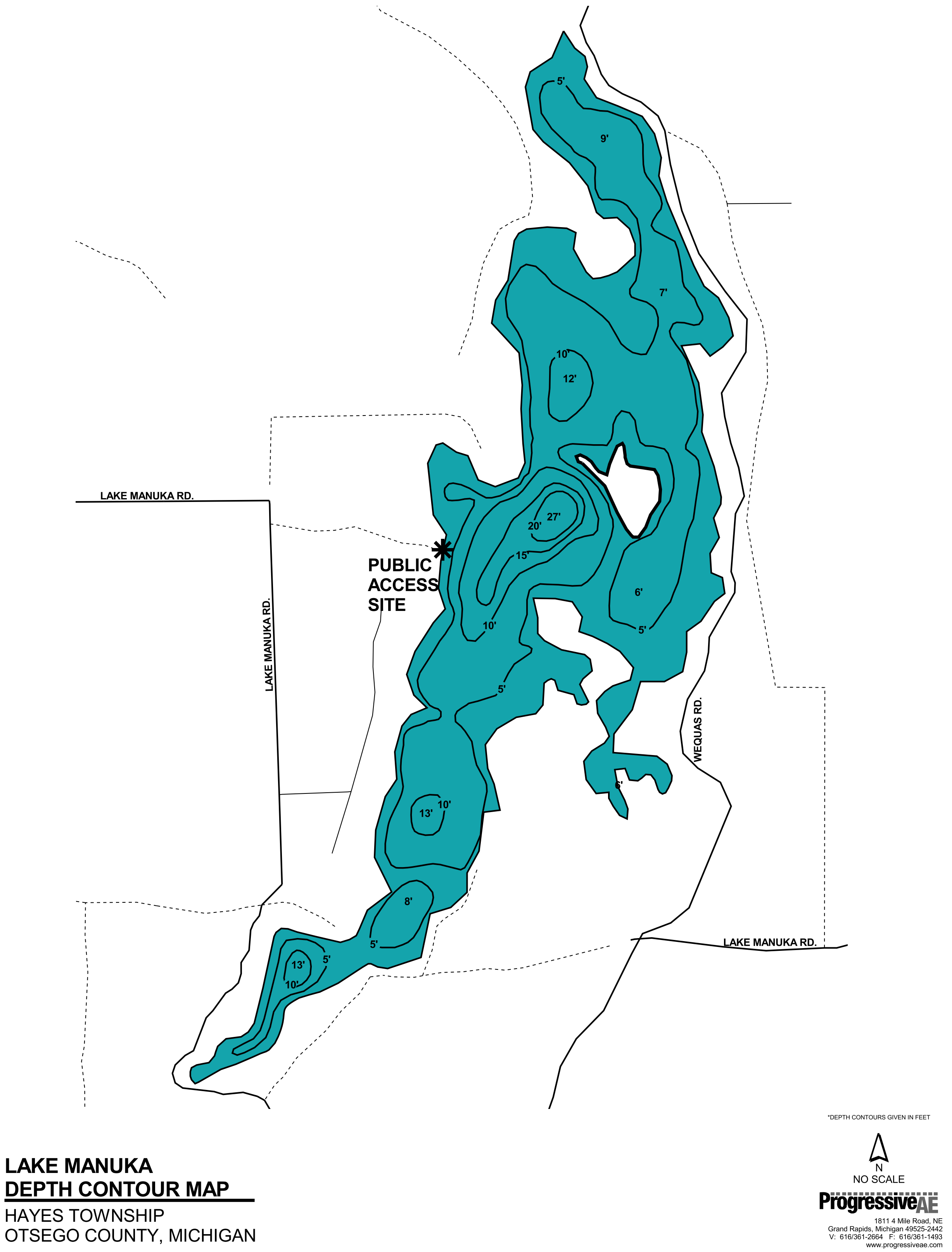


Figure 2. Lake Manuka depth contour map.

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Lake Manuka watershed encompasses 2,179 acres (Figure 3). The majority of the watershed is forested, although much of the shoreland abutting the lake consists of residential development interspersed with several small wetlands. General land cover in the Lake Manuka watershed is depicted in Figure 4. Soil mapping contained in the Soil Survey of Otsego County, Michigan prepared by the U.S. Department of Agriculture Natural Resources Conservation Service indicates that that soils in the Lake Manuka watershed are predominately sandy and well drained.

From a regional perspective, Lake Manuka is located in a drainage divide between several large river systems. The Au Sable River drains the land south and east of Lake Manuka, the Manistee River flows to the west, and several small river systems convey water to the north. During high water periods, Lake Manuka receives drainage from Lake Wequas to the north. However, Lake Manuka is essentially a closed-basin lake that lacks surface tributaries or an outlet. The level of Lake Manuka is sustained primarily via groundwater and by direct precipitation on the lake surface. In recent years, below-normal precipitation has caused Lake Manuka to drop below its normal level.

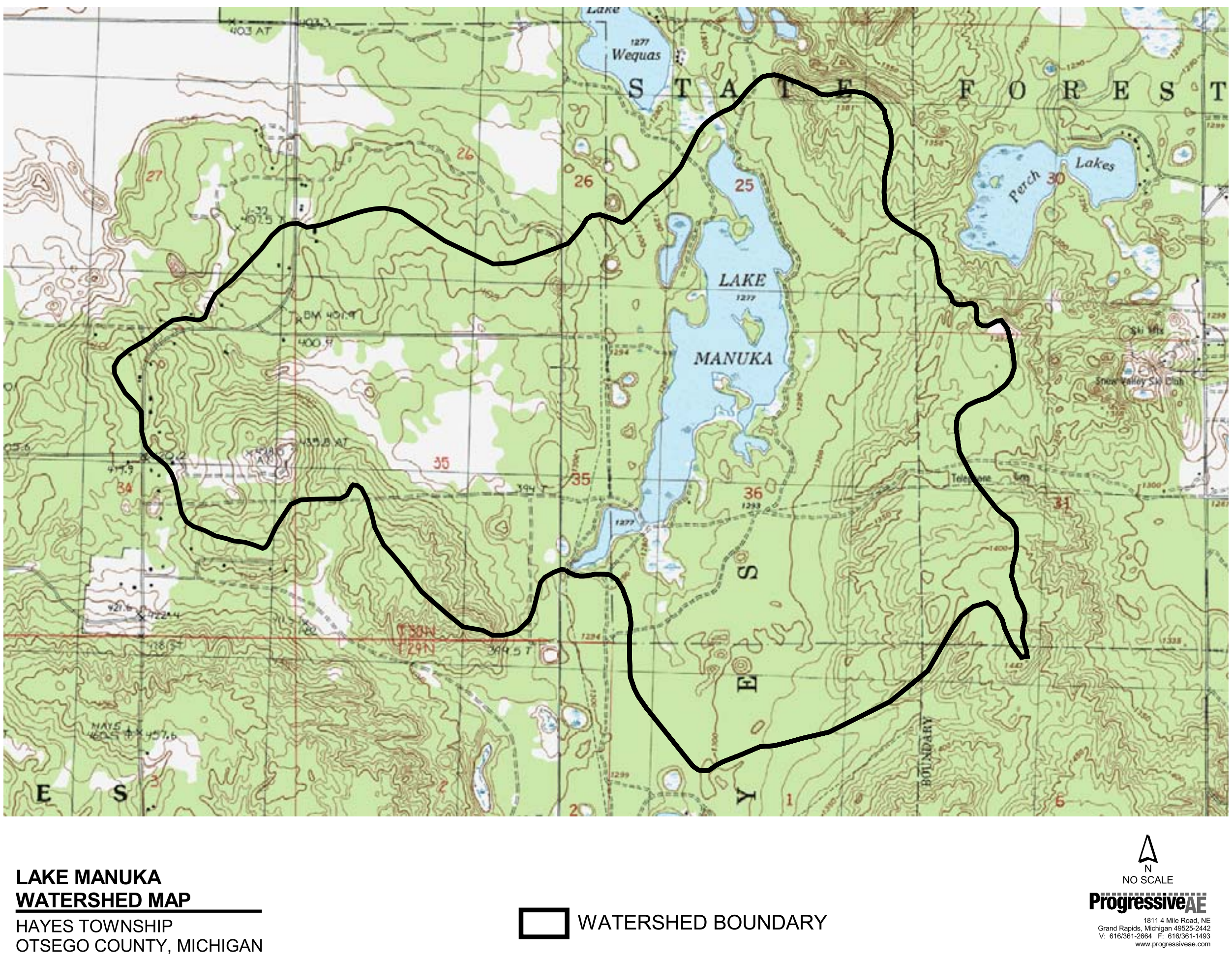


Figure 3. Watershed map.

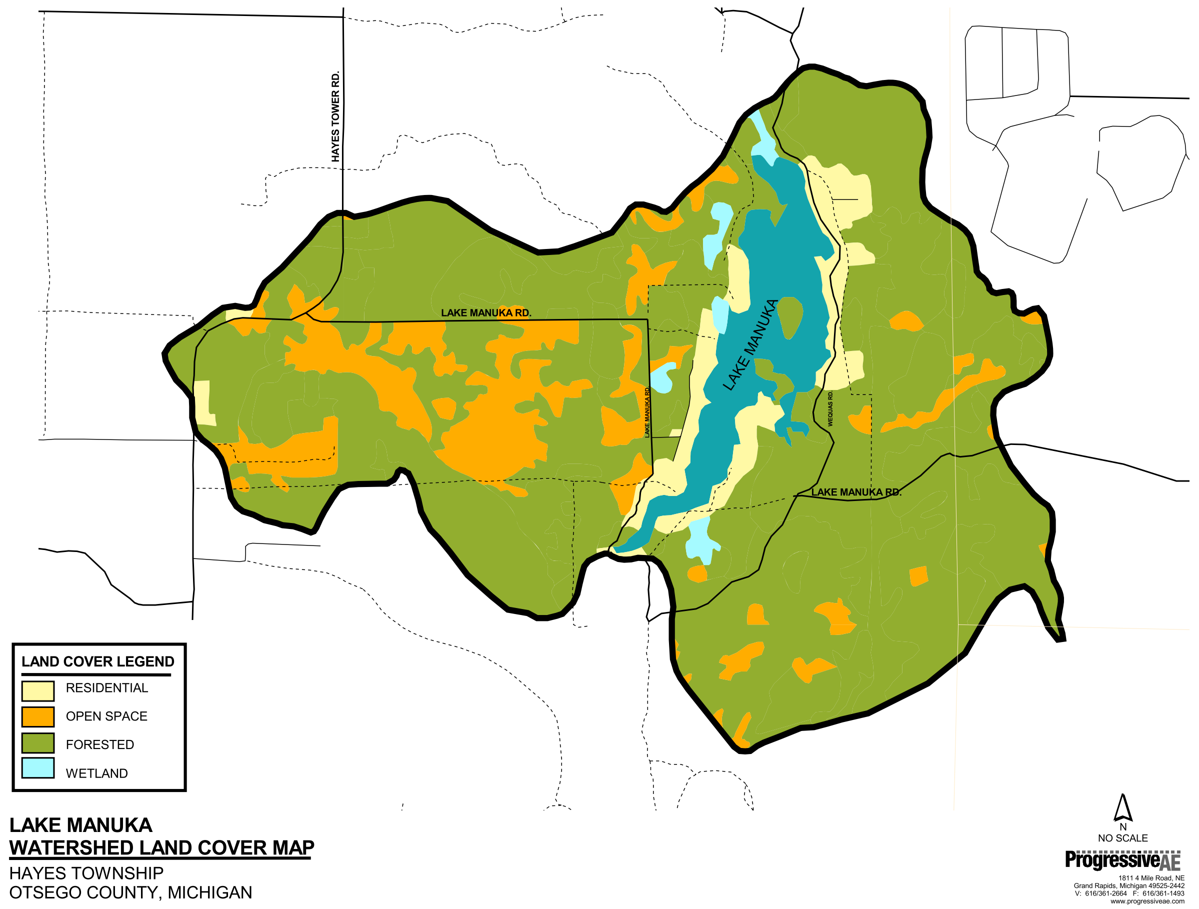


Figure 4. Watershed land use map.

Lake Water Quality

INTRODUCTION

Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact of drainage from the surrounding watershed.

Lakes are commonly classified as **oligotrophic, mesotrophic, or eutrophic**. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

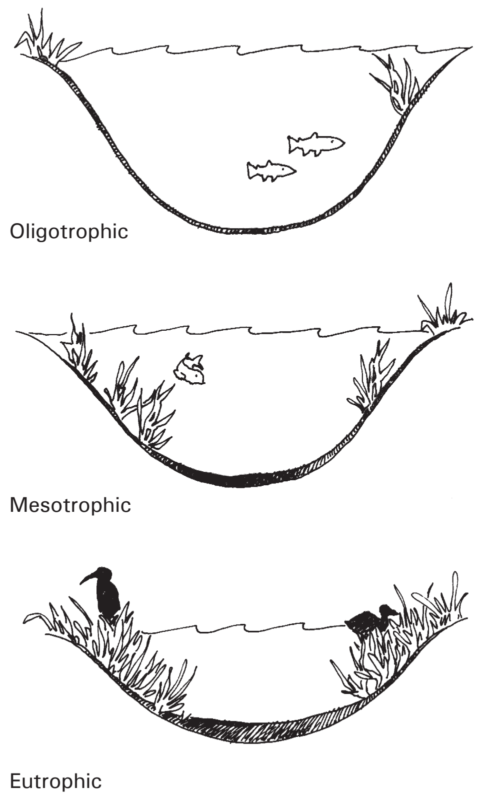


Figure 5. Lake classification.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The aging process in lakes is called "eutrophication" and may take anywhere from a few hundred to several thousand years, generally depending on the size of the lake and its watershed. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as "cultural eutrophication." The problem of cultural eutrophication can be managed by identifying sources of sediment and nutrient loading (i.e., inputs) to the lake and developing strategies to halt or slow the inputs. Thus, in developing a management plan, it is necessary to determine the limnological (i.e., the physical, chemical, and biological) condition of the lake and the physical characteristics of the watershed as well.

Key parameters used to evaluate the limnological condition of a lake include temperature, dissolved oxygen, total phosphorus, chlorophyll-a, and Secchi transparency. A brief description of these water quality measurements is provided as an introduction for the reader. Particular attention should be given to the interrelationship of these water quality measurements.

TEMPERATURE

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as "spring turnover" because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the "thermocline." The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as "fall turnover." As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are 15 - 30 feet deep may stratify and destratify with storm events several times during the year.

DISSOLVED OXYGEN

An important factor influencing lake water quality is the quantity of dissolved oxygen in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

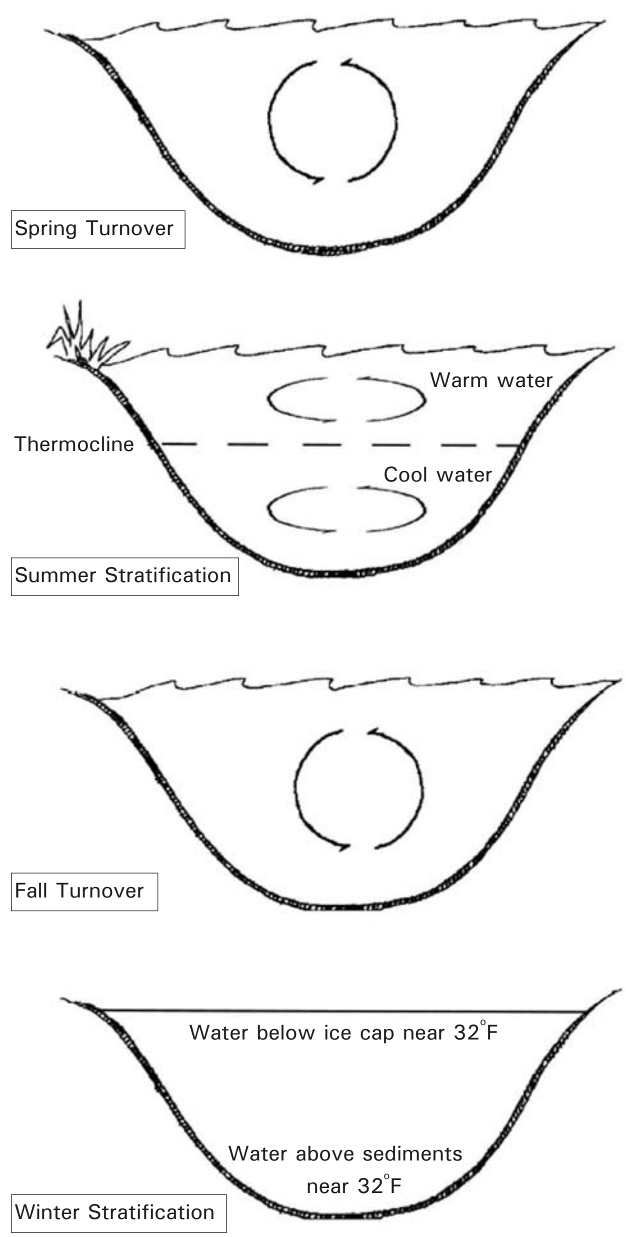


Figure 6. Seasonal thermal stratification cycles.

PHOSPHORUS

The quantity of phosphorus present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, lake sediments act as a phosphorus trap, retaining phosphorus and, thus, making it unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus will be released from the sediments and may be available to promote aquatic plant growth. In some lakes, the internal release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input).

By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 µg/L (micrograms per liter, or parts per billion) are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.

CHLOROPHYLL-*a*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-a concentration greater than 6 µg/L is considered characteristic of a eutrophic condition.

SECCHI TRANSPARENCY

A Secchi disk is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line. The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of approximately twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

LAKE CLASSIFICATION CRITERIA

Ordinarily, as phosphorus inputs (both internal and external) to a lake increase, the amount of algae will also increase. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria developed by the Michigan Department of Natural Resources is shown in Table 2.

TABLE 2
LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (µg/L)[1]	Chlorophyll-*a* (µg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

[1] µg/L = micrograms per liter = parts per billion.

FECAL COLIFORM BACTERIA

A primary consideration in evaluating the suitability of a lake to support swimming and other water-based recreational activities is the level of bacteria in the water. Escherichia coli (E. coli) is a bacteria commonly associated with fecal contamination. The current State of Michigan public health standard for total body contact recreation (e.g., swimming) for a single sampling event requires that the number of E. coli bacteria not exceed 300 per 100 milliliters of water.

SAMPLING METHODS

Water quality sampling was conducted in the fall of 2005 and spring of 2006 at three locations in Lake Manuka (Figure 7). Temperature was measured using a YSI Model 550A probe. Samples were collected from just below the surface to the lake bottom with a Kemmerer bottle to be analyzed for dissolved oxygen, pH, total alkalinity, and total phosphorus. Dissolved oxygen samples were fixed in the field and then transported to Progressive AE for analysis using the modified Winkler method (Standard Methods procedure 4500-O C). pH was measured in the field using a Hach pH Pal. Total alkalinity and total phosphorus samples were placed on ice and transported to Progressive AE and to Prein and Newhof[1], respectively, for analysis. Total alkalinity was titrated at Progressive AE using Standard Methods procedure 2320.B, and total phosphorus was analyzed at Prein and Newhof using Standard Methods procedure 4500-P E. In addition to the depth-interval samples at each deep basin, Secchi transparency was measured and composite chlorophyll-a samples were collected from the surface to a depth equal to twice the Secchi transparency. Chlorophyll-*a* samples were analyzed by Prein and Newhof using Standard Methods procedure 10200H.

In August of 2006, 10 samples were collected from near-shore areas around the lake to determine E-coli bacteria levels (Figure 7).

[1] Prein and Newhoff, 3260 Evergreen Drive, NE, Grand Rapids, MI 49525.

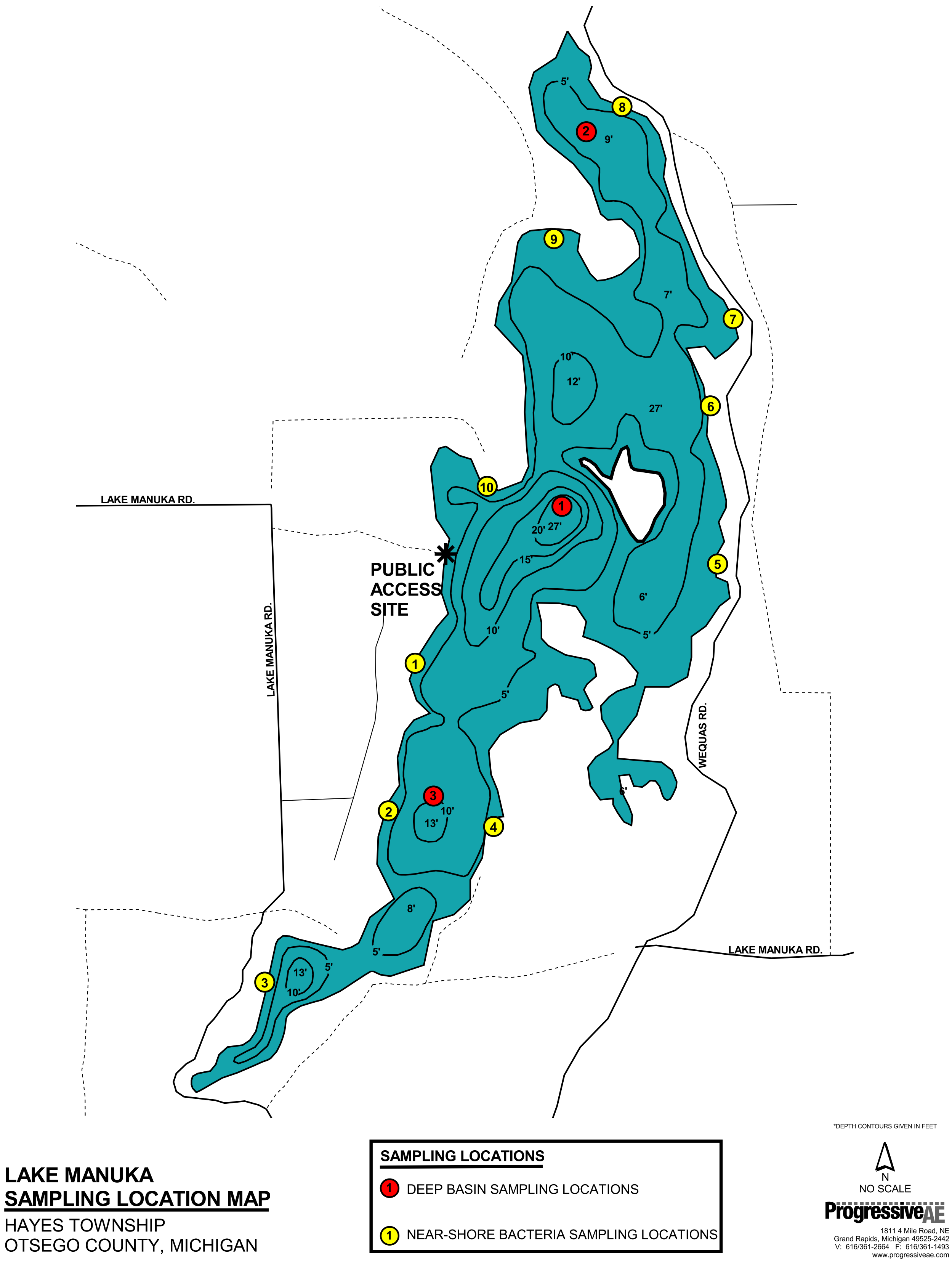


Figure 7. Sampling location map.

RESULTS AND DISCUSSION

Deep basin water quality data for Lake Manuka is provided in Table 3. During the period of sampling, Lake Manuka did not exhibit strong thermal stratification and water temperatures were nearly uniform surface to bottom at the shallower sampling locations (i.e., Sites 2 and 3). At Site 1, deep water temperature and dissolved oxygen levels were slightly depressed. However, dissolved oxygen levels were sufficient at all depths to sustain a warm-water fishery.

Phosphorus is the nutrient that most often stimulates excessive growth of aquatic plants and algae, leading to a variety of problems collectively known as eutrophication. Phosphorus levels measured in Lake Manuka during the September sampling period were above the eutrophic threshold concentration of 20 parts per billion, but phosphorus levels in the lake were relatively low during the spring sampling period.

pH is a measure of the amount of acid or base in water. The pH scale ranges from 0 (acidic) to 14 (alkaline or basic) with neutrality at 7. The pH of lakes generally ranges between 6 and 9 (Wetzel 1983). Most organisms tolerate only very narrow ranges in pH; and, therefore, large amounts of alkalinity (see discussion of alkalinity, below) are needed as natural buffers to changes in pH.

Alkalinity is the measure of the pH-buffering capacity of water in that it is the quantitative capacity of water to neutralize an acid. Lakes that have high alkalinity (over 100 mg/L as calcium carbonate) are able to sustain large inputs of acid with little change in pH. Addition of acid can occur naturally (e.g., during bacterial decomposition of organic material in the sediments; during natural diffusion of carbon dioxide into the surface waters) or because of pollution (acid deposition, both wet and dry fall). The ability of the lake to maintain a stable pH is crucial to the survival of its aquatic inhabitants. The major source of calcium carbonate in most lakes is from soils in the watershed. The low alkalinity measured in Lake Manuka indicates that the soils in the watershed contain little calcium carbonate. In some instances, calcium carbonate will bind with phosphorus and make it unavailable for aquatic plant growth. The low alkalinity measured in Lake Manuka indicates that the lake has little natural ability to buffer phosphorus inputs. Thus, the lake is sensitive to phosphorus loading.

Surface water data for Lake Manuka are presented in Table 4. During the period of sampling, Secchi transparency readings ranged from 8 to 10 feet. At the shallower sampling sites (i.e., Sites 2 and 3), the Secchi disk could be seen on the lake bottom. These data indicate that water transparency is relatively good and sufficient to permit aquatic plants to colonize much of the lake bottom. Chlorophyll-*a* levels in the water column ranged from 1 to 4 parts per billion, a level below the eutrophic threshold concentration of 6 parts per billion. These data indicate that algae growth in the water column was minimal during the period of sampling.

Bacteria levels in the lake ranged from less than 1 to 13 (Table 5). These values are well below the standard for safe swimming and other lake uses. No evidence of septic contamination was detected during the August sampling period.

Based on the data collected and presented herein, Lake Manuka would be classified as mesotrophic in that it exhibits slightly elevated phosphorus levels, bottom water oxygen declines, moderate transparency, and algae growth. Data collected during the course of study is generally consistent with historical water quality data for Lake Manuka (Appendix A).

TABLE 3
LAKE MANUKA
DEEP BASIN WATER QUALITY DATA

Sample Location	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L as $CaCO_3$)[4]
			September 22, 2005			
1	1	67	8.0	21	7.8	9
1	10	67	7.9	19	7.9	9
1	20	64	4.2	34	7.2	10
2	1	67	7.8	21	7.2	8
2	6	66	7.2	33	7.3	9
3	1	67	7.6	12	7.9	9
3	8	67	7.5	19	7.9	9
			April 26, 2006			
1	1	55	13	5	8.1	11
1	10	54	12	5	8.3	12
1	20	48	9	<5	8.2	10
2	1	49	9	7	8.3	12
2	6	46	8	6	8.5	5

[1] mg/L = milligrams per liter = parts per million.
[2] µg/L = micrograms per liter = parts per billion.
[3] S.U. = standard units.
[4] mg/L $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE 4
LAKE MANUKA
SURFACE WATER QUALITY DATA

Date	Sample Location	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[1]
September 22, 2005	1	8.0	1
September 22, 2005	2	7.0 (Bottom)	1
September 22, 2005	3	7.5	3
April 26, 2006	1	10	4
April 26, 2006	2	6.9 (Bottom)	2
April 26, 2006	3	9.9 (Bottom)	3

TABLE 5
LAKE MANUKA
BACTERIOLOGICAL DATA

Date	Site No.	E. Coli Bacteria/100mL[2]
August 14, 2006	1	1
August 14, 2006	2	3
August 14, 2006	3	3
August 14, 2006	4	<1
August 14, 2006	5	10
August 14, 2006	6	1
August 14, 2006	7	4
August 14, 2006	8	13
August 14, 2006	9	2
August 14, 2006	10	1

[1] µg/L = micrograms per liter = parts per billion.
[2] mL = milliliters.

Aquatic Plants

The distribution and abundance of aquatic plants are dependent on several variables, including light penetration, bottom type, temperature, water levels, and the availability of plant nutrients. The relatively low water levels in Lake Manuka in recent years have likely increased the abundance of vegetation in the lake.

The term "aquatic plants" includes both the algae and the larger aquatic plants or macrophytes. The macrophytes can be categorized into four groups: the emergent, the floating-leaved, the submersed, and the free-floating.

In developing an effective aquatic plant control program, the type and distribution of nuisance plant growth must be evaluated so that a balanced, environmentally sound control strategy can be determined. Aquatic plant surveys of Manuka Lake were conducted on September 22, 2005 and August 14, 2006. Plant types observed during the surveys are listed in Table 6. The most common species observed in Lake Manuka during the surveys were water shield (*Brasenia*), bulrush (*Scirpus*), and water lily (*Nymphaea*).

TABLE 6
LAKE MANUKA
AQUATIC PLANTS

Common Name	Scientific Name	Group	Occurrence
Water Shield	*Brasenia schreberi*	Floating-Leaved	Common to Dense
Hardstem Bulrush	*Scirpus acutus*	Emergent	Common to Dense
White Water Lily	*Nymphea odorata*	Floating-Leaved	Common to Dense
Submersed Bulrush	*Scirpus subterminalis*	Submersed	Common
Ribbon Leaf Pondweed	*Potamogeton epihydrus*	Submersed	Common
Seven-Angle Pipewort	*Eriocaulon setangulare*	Emergent	Sparse
Brittle Wort	*Nitella sp.*	Submersed Macro-Algae	Sparse
Slender Watermilfoil	*Myriophyllum tenellum*	Submersed	Sparse
Yellow Water Lily	*Nuphar sp.*	Floating-Leaved	Sparse
Alga Pondweed	*Potamogeton confervoides*	Submersed	Sparse
Bladderwort	*Utricularia sp.*	Submersed	Sparse
Pickerelweed	*Pontederia cordata*	Emergent	Found
Floating-Leaf Pondweed	*Potamogeton natans*	Submersed	Found

Lake Improvement Alternatives

INTRODUCTION

In recent years, below normal precipitation has caused Lake Manuka to drop below its normal level. Currently, shallow water conditions in portions of the lake inhibit navigation and full recreational use of the lake. This section of the report includes a discussion of alternatives that may be employed to improve conditions in Lake Manuka.

AQUATIC PLANT CONTROL

Although an overabundance of undesirable plants can limit recreational use and enjoyment of a lake, it is important to realize that aquatic plants are a vital component of aquatic ecosystems. They produce oxygen during photosynthesis, provide food and habitat for fish and other organisms, and help stabilize shoreline and bottom sediments.

The objective of a sound aquatic plant control program is to remove plants only from problem areas where nuisance growth is occurring. Under no circumstance should an attempt be made to remove all plants from the lake.

Mechanical harvesting (i.e., plant cutting and removal) and chemical herbicide treatments are methods commonly employed to control aquatic plant growth. For large-scale aquatic plant control, harvesting may be advantageous over herbicide treatments since plants removed from the lake will not sink to the lake bottom and add to the buildup of organic sediments. In addition, some nutrients contained within the plant tissues are removed with the harvested plants. With the use of herbicides, treated plants die back and decompose on the lake bottom while bacteria consume dissolved oxygen reserves in the decomposition process. Since the plants are not removed from the lake, sediment buildup on the lake bottom continues, often creating a bottom substrate ideal for future aquatic plant growth.

It should be noted however that attempts to control certain plant types by harvesting alone may not prove entirely effective. This is especially true with Eurasian milfoil (Myriophyllum spicatum) due to the fact that this plant may proliferate and spread via vegetative propagation (small pieces break off, take root, and grow) if the plant is cut (Figure 8). Eurasian milfoil is especially problematic in that it often becomes established early in the growing season and can grow at greater depths than most plants. Eurasian milfoil often forms a thick canopy at the lake surface that can degrade fish habitat and seriously hinder recreational activity (Figure 9). Once introduced into a lake system, Eurasian milfoil may out-compete and displace more desirable plants and become the dominant species. When Eurasian milfoil is present, it may be possible to control the growth and spread of the plant by treating the lake with a species-selective systemic herbicide. Fortunately, Eurasian milfoil has not infested Lake Manuka.

In Michigan, Act 368 of 1978 (the Public Health Code) requires that a permit be acquired from the Department of Environmental Quality before any herbicides are applied to inland lakes. The permit will include a list herbicides that are approved for use in the lake, respective dose rates, use restrictions, and will show specific areas in the lake where treatments are allowed.

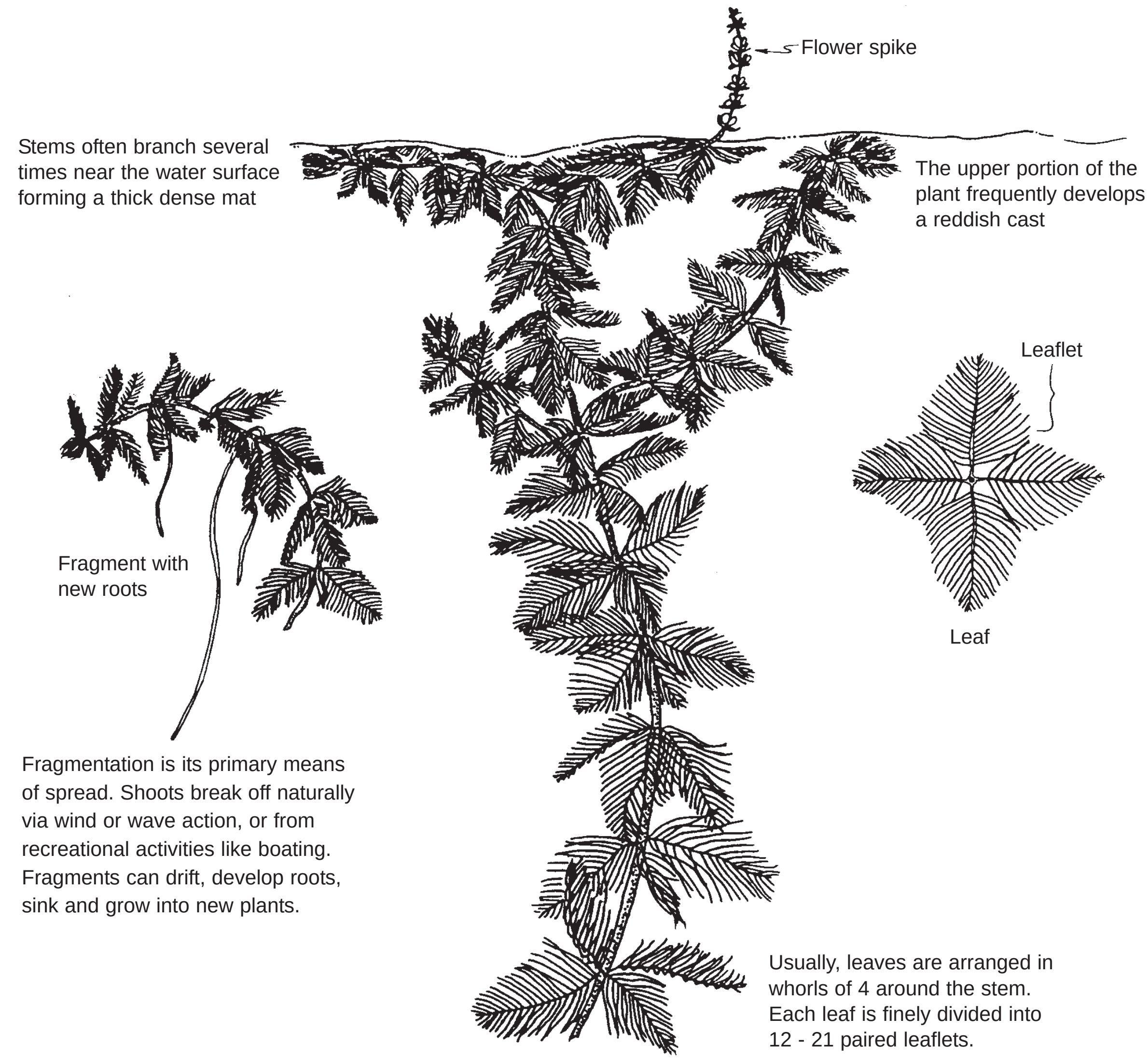


Figure 9. Eurasian milfoil canopy.

Figure 9. Eurasian milfoil canopy.

Currently, approximately 25 acres of Lake Manuka contain nuisance plant growth. The primary nuisance species is water shield (Figure 10). It is recommended that about 25 acres of Lake Manuka be harvested on an annual basis over a five-year period to remove nuisance plant growth. To maximize biomass removal, harvesting would be most effective if conducted during the period of peak growth (mid to late July). Harvesting equipment (Figure 11) is generally operated parallel to the shore in water depths greater than about 2 feet. Harvesting work is proposed to be conducted under the direction of the lake association's consultant. The consultant would be responsible for preparing bid documents and contract extensions for the plant control program, conducting surveys of the

Figure 10. Lake Manuka water shield.

Figure 11. Mechanical harvesting.

lake to determine the scope of work to be performed by the plant control contractor, and performing follow-up inspections to ensure work is performed in a satisfactory manner. The consultant would maintain a written record of the date, scope, and cost of plant control activities and would report to the association regarding the performance of the plant control contractor.

The consultant would also be responsible for conducting a vegetation survey each year to map the type and distribution of aquatic plants throughout the lake. If, as the result of the survey, invasive exotic species such as Eurasian milfoil are detected, appropriate corrective action could be taken. An estimate of probable costs to implement an aquatic plant harvesting program on Lake Manuka is presented in Table 7.

TABLE 7
LAKE MANUKA MECHANICAL HARVESTING
ESTIMATE OF PROBABLE COSTS

Mechanical Harvesting (25 acres @$300 per acre)	$7,500
Administration, Oversight, and Vegetation Surveys	$4,500
Total	**$12,000**

DREDGING

Currently, shallow water conditions in portions of Lake Manuka inhibit navigation and full recreational use of the lake. Dredging is a lake management alternative that is often considered to improve navigability. There are two major dredging methods: Drag-line and hydraulic (Figures 12 and 13). Drag-line dredging involves excavation using a crane, backhoe, or similar equipment. The crane is placed on shore or on a floating barge and excavates material with its "clamshell" or bucket. Excavated material is placed in an interim location to drain or "dewater" the dredged material, or, if a location is available nearby, dredge spoils can be placed directly in the final disposal location. Drag-line dredging is limited to areas that are within reach of the crane arm. With hydraulic dredging, excavated material is pumped in a slurry through a floating pipeline to the point of disposal. Most large-scale lake dredging projects are conducted with a hydraulic dredge. Hydraulic dredging can be limited by underwater obstructions such as stumps, logs, rocks, etc.

Figure 12. Drag-line (backhoe) dredging.

Figure 13. Hydraulic dredging.

Figure 14. Dredged sediment disposal cell.

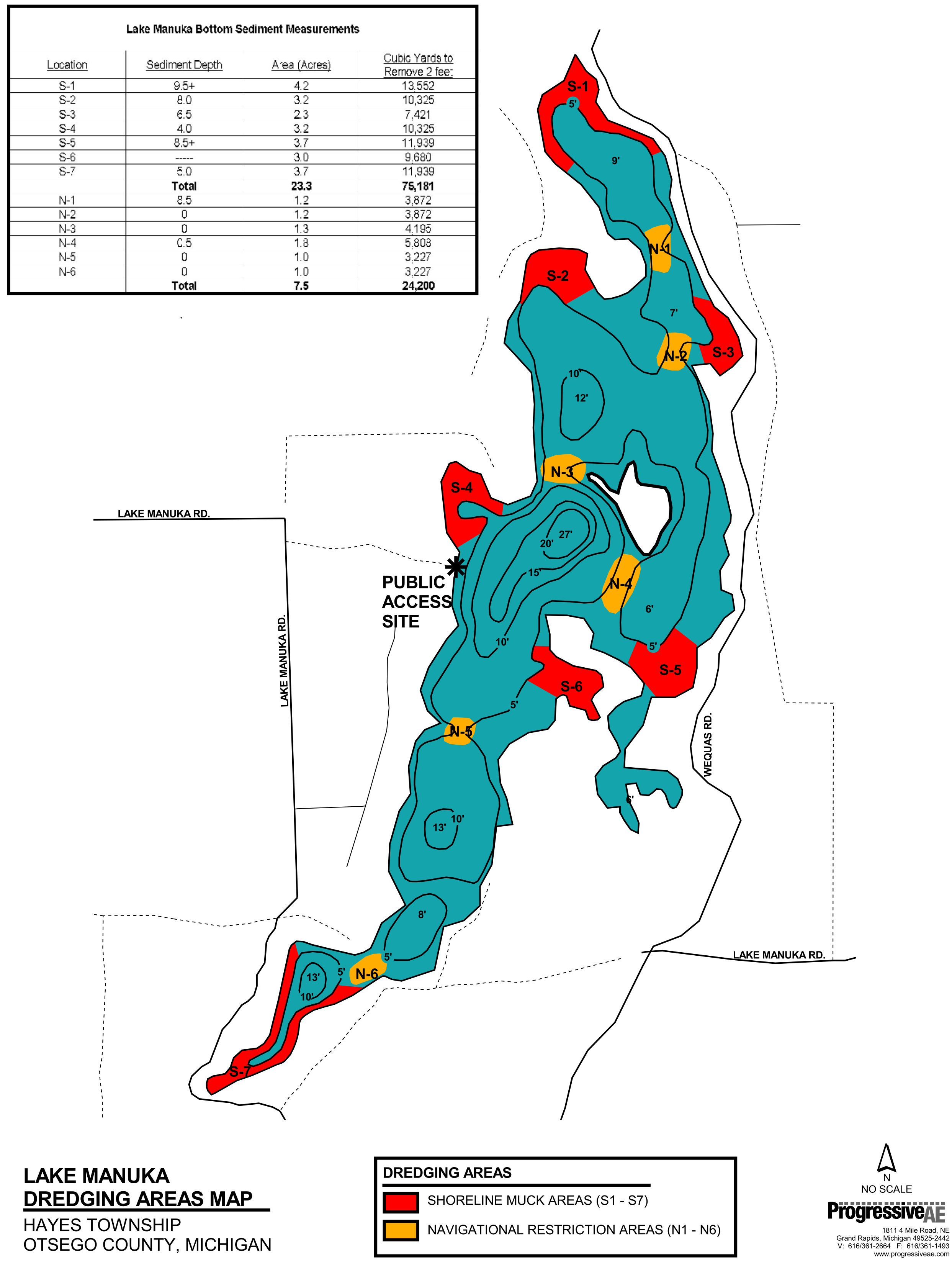
A primary consideration in a lake dredging project is identifying a suitable location (or locations) for the placement of dredged material. When a hydraulic dredge is used, disposal sites are usually constructed by excavating an area and creating an earthen dike to contain the dredged slurry (Figure 14). Given the flocculent nature of the organic sediments found in most lakes and the extended time frame for dredged material to dewater and consolidate, the disposal cell must be adequately sized to accommodate the amount of dredged material produced. The disposal cell should be designed to maximize the settling of solids while allowing excess water to drain off. After dredged materials have been deposited and sufficiently drained and dried, the disposal area may be graded and seeded. Another disposal alternative for hydraulic dredging is pumping to sealed, permeable, geotextile tubes which are filled with dredged materials and allowed to dewater by percolation through the geotextile fabric walls (Figure 15). The drier sediments are retained inside the tube.

Figure 15. Geotextile tubes.

Pursuant to provisions of Part 301 of P.A. 451 of 1994, the Natural Resource and Environmental Protection Act, a permit must be acquired from the Michigan Department of Environmental Quality (MDEQ) before a dredging project can be initiated. Permit conditions will generally require that the dredge disposal site be located in an upland location and that steps be taken during the dredging operation to prevent excessive sediment transport to adjacent areas. Dredge spoils are not typically allowed to be placed in wetland areas. MDEQ has recently developed testing procedures for sediments proposed for dredging that require non-sandy sediments to be tested for certain heavy metals, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PNAs). If sediment proposed for dredging is found to be contaminated, the MDEQ may require special disposal requirements or, in extreme cases, that sediments be placed in a licensed landfill. These requirements can substantially increase the cost of a dredging project.

To evaluate the amount of sediment buildup in Lake Manuka, a survey of the lake bottom was conducted in which measurements of water and sediment depth were taken at various locations throughout the lake. Two dredging scenarios were evaluated. Alternative 1 would involve dredging near-shore muck areas, and Alternative 2 would involve dredging shallow, off-shore areas that pose significant navigational difficulties (Figure 16). Sediment thickness was much greater in the near-shore areas where muck depths ranged from 4 feet to greater than 9.5 feet. In the off-shore areas, the lake bottom was primarily sand and with little soft sediment accumulation (with the exception of Site N-1; Figure 16). Dredging 2 feet of sediment from the near-shore muck areas in Lake Manuka (Alternative 1) would require removal of approximately 75,181 cubic yards of sediment, while removing 2 feet of sediment from the off-shore areas (Alternative 2) would require dredging approximately 24,200 cubic yards of sediment.

As previously discussed, a major consideration in any dredging project is locating a suitable site for the disposal of dredged materials. Ideally, a relatively flat, upland site large enough to accommodate the volume of dredged material can be found in close proximity to the lake. Land located immediately north of Lake Manuka appears to be potentially suitable for the placement of dredged material. For dredging Alternative 1, it is estimated that approximately 15 acres of land would be required for dredge material disposal, while approximately 5 acres of land would be required for dredged materials under Alternative 2.



Lake Manuka Bottom Sediment Measurements

Location	Sediment Depth	Area (Acres)	Cubic Yards to Remove 2 feet
S-1	9.5+	4.2	13,552
S-2	8.0	3.2	10,325
S-3	6.5	2.3	7,421
S-4	4.0	3.2	10,325
S-5	8.5+	3.7	11,939
S-6	-----	3.0	9,680
S-7	5.0	3.7	11,939
	Total	**23.3**	**75,181**
N-1	8.5	1.2	3,872
N-2	0	1.2	3,872
N-3	0	1.3	4,195
N-4	0.5	1.8	5,808
N-5	0	1.0	3,227
N-6	0	1.0	3,227
	Total	**7.5**	**24,200**

Figure 16. Lake Manuka dredging areas map.

Estimates of probable construction costs for dredging Alternatives 1 and 2 for Lake Manuka are presented in Table 8.

TABLE 8
LAKE MANUKA DREDGING
ESTIMATE OF PROBABLE CONSTRUCTION COSTS

Near-Shore Muck Areas (Alternative No. 1)	
Dredging, Disposal, and Site Restoration (75,181 cubic yards @ $22/yard	$1,654,000
Engineering, Permitting, Legal, and Contingencies (15% of Construction)	$ 248,100
Total	**$1,902,100**
Navigation Restriction Areas (Alternative No. 2)	
Dredging, Disposal, and Site Restoration (24,200 cubic yards @ $20/yard	$484,000
Engineering, Permitting, Legal, and Contingencies (15% of Construction)	$96,800
Total	**$580,800**

LAKE LEVEL AUGMENTATION

Below-normal precipitation in recent years has resulted in a significant decline in the level of Lake Manuka. A review of precipitation data compiled by Michigan State University indicates annual mean precipitation in the Grayling area in the 30-year time frame between 1971 and 2000 was 33.4 inches while mean annual precipitation in the 10-year time frame between 1996 and 2005 was only 29.9 inches. Thus, in the last decade, net precipitation in the Grayling areas was about 35 inches below the 30-year norm. An analysis of precipitation data for the Gaylord area indicates a precipitation deficit of about 12 inches over the past decade. Lake Manuka has no tributary inflows and the lake's level is sustained largely by groundwater and by direct precipitation on the lake surface. Thus, during periods of below-normal precipitation, the level of Lake Manuka can decline dramatically. Currently, Lake Manuka appears to be about 2 feet below its ordinary high water level (Figure 17). In gently sloping shoreland areas, broad expanses of lake bottomlands are exposed.

Figure 17. Lake Manuka ordinary high water mark.

One method that could be employed to help stabilize the level of Lake Manuka would be the construction of a lake augmentation well that would pump groundwater into the lake. However, there are several factors that must be considered when evaluating the feasibility and cost of an augmentation well system. First, to avoid recirculating water from the same aquifer that feeds the lake, an augmentation well would need to draw from a deep, confined aquifer that is physically separated from the lake. Second, a determination would need to be made of the capacity of the aquifer to sustain the desired augmentation-pumping rate without depleting the aquifer or nearby wells. Another variable to be investigated would be the amount of water that may potentially seep out of Lake Manuka through its basin walls once the lake level is raised. This volume of water would increase once the lake is artificially maintained at a level greater than the existing groundwater level. The force of gravity (called head pressure) would likely increase the seepage rate from the lake and thus require additional production volume from the augmentation well to sustain the desired lake level. Before artificially raising the lake level, an evaluation would need to be made to ensure sufficient freeboard capacity exists in the lake to prevent flooding of low-lying properties during large storm events. (Freeboard capacity refers to the distance between the level of the water and low-lying structures around the lake.) Finally, the construction of an augmentation well would require a permit from the Michigan Department of Environmental Quality (MDEQ) in accordance with Part 301 (Inland Lakes and Streams) of the Natural Resource and Environmental Protection Act, PA 451 of 1994. A permit may also be required from the MDEQ under provisions of PA 33 of 2006 and from the Otsego County Health Department in accordance with the Michigan Public Health Code, Part 127 of PA 368 of 1978. Recent guidance from the DEQ regarding lake level augmentation projects is included in Appendix B.

Though a detailed hydrogeological study was beyond the scope of this study, general information on subsurface conditions for the Lake Manuka area was acquired from existing well log data. Well logs indicate a static water level in close proximity to the lake of between 7 and 12 feet below grade. Some of the well logs indicated a potential clay confining layer at about 50 feet deep.

To evaluate the potential for seepage from Lake Manuka, information on area soil types was obtained from the Soil Survey of Otsego County, Michigan prepared by the U.S. Department of Agriculture Natural Resources Conservation Service The soil survey identifies the soils around Lake Manuka as predominately Rubicon sand and Deford-AuGres-Croswell complex (Figure 18). In addition to identifying and describing individual soil types, the soil survey also identifies certain engineering properties of the soils. The predominant soil types around Lake Manuka are rated "severe" for limitations on ponds, embankments, and aquifer-fed excavated ponds. The Soil Survey identifies seepage as being the primary cause of the severe rating. Thus, if an augmentation well were to be constructed for Lake Manuka it would need to produce a substantial volume of water just to keep up with the expected seepage from the lake and evaporative losses. Attempting to artificially raise the level of Lake Manuka with an augmentation well would require that the regional water table be raised as well.

Given that Lake Manuka is a closed-basin lake that has no outlet, consideration would need to be given to what level the lake would be raised. A detailed topographical survey and hydraulic analysis would need to be performed to ensure sufficient freeboard capacity existed in the lake to prevent flooding of near-shore structures and septic systems during large storm events.

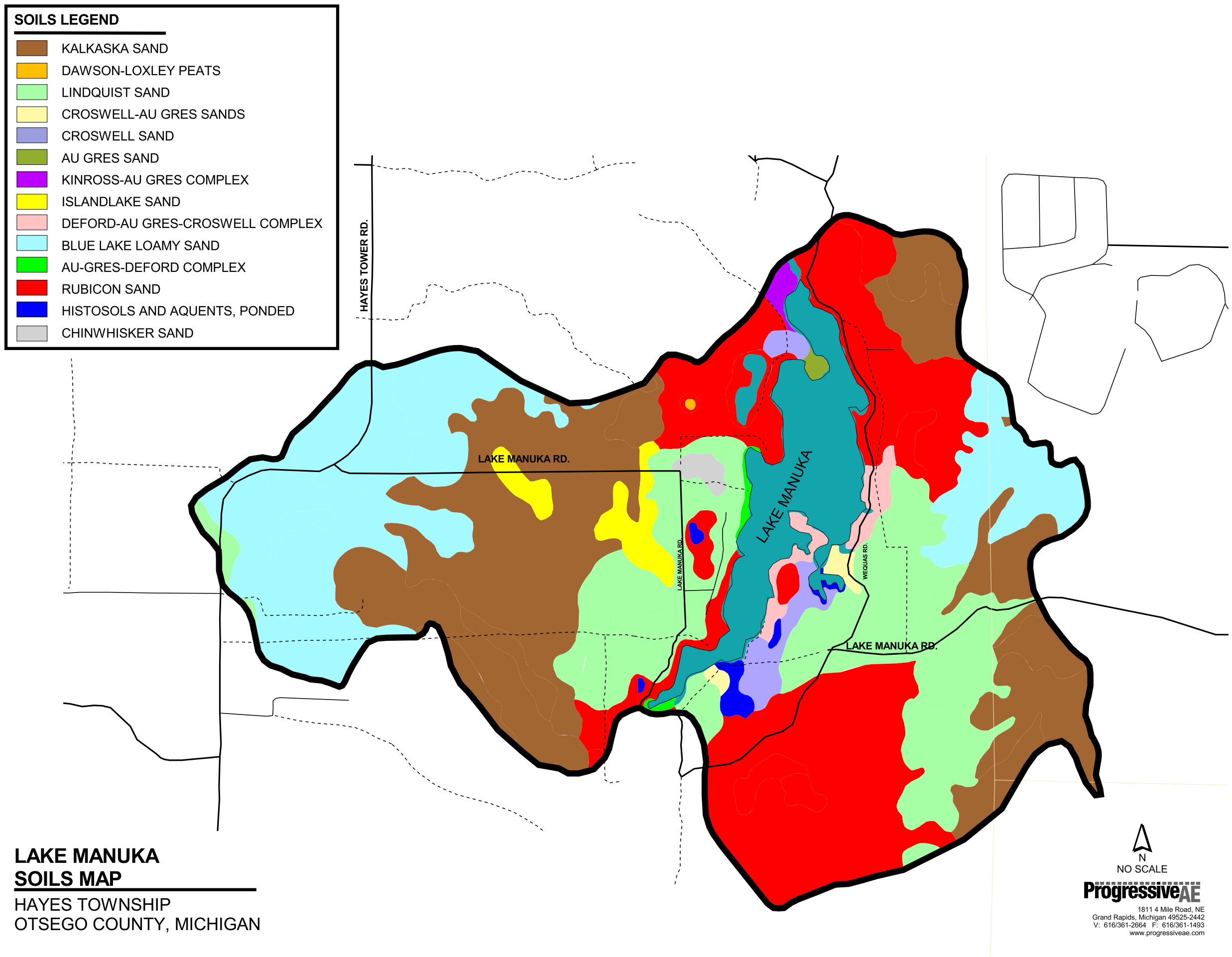


Figure 18. Lake Manuka soils map.

Factors influencing the cost of an augmentation well include pump size, well depth, and proximity to the lake. An augmentation well would need to be sufficiently isolated from the lake and area residential wells to minimize the potential of recirculating lake water or impacting nearby wells. Assuming a minimum pumping rate of 1,500 gallons per minute (gpm), a 200-foot well depth, and a 0.5-mile isolation distance, a preliminary estimate of probable construction costs for an augmentation well system would be $190,000. In addition, annual operation and maintenance costs would likely range between $8,000 to $10,000 depending on the rate and duration of pumping in any given year.

Given the probable cost and low likelihood of success, an augmentation well for Lake Manuka is not recommended. The level of Lake Manuka will likely recover once more normal precipitation patterns persist.

WATERSHED MANAGEMENT

Currently, much of the Lake Manuka watershed is forested and the soils in the watershed are highly permeable. Thus, there is little runoff to the lake from the undeveloped portions of the watershed. However, in the developed shoreland areas around the lake, vegetative cover has been replaced by homes, driveways, roads and other impervious surfaces that increase runoff to the lake. Often, runoff water contains high concentrations of fertilizer, oil and gas residue and other potential pollutants. The homes around Lake Manuka are served by on-site septic systems. At present, most of the homes are seasonal. However, as more homes are converted from seasonal to year-round use the limited capacity of area soils to bind phosphorus will be exceeded. Once this occurs, phosphorus will slowly leach to the lake where it can stimulate excessive aquatic plant growth and accelerate the natural lake aging or eutrophication process.

Sampling conducted during the course of study indicates that phosphorus levels in Lake Manuka at times exceed the eutrophic threshold concentration. Also, due to its low alkaline waters, Lake Manuka is very sensitive to phosphorus inputs. Therefore, to preserve and protect the quality of Lake Manuka over the long term, specific guidelines on watershed management practices should be distributed to all lake residents. The guidelines should include information on lakeside landscaping, septic system maintenance, and practices to minimize the impact of shoreland development on lake water quality. Watershed management should be conducted in concert with any in-lake improvements.

Recommended Management Plan

Below-normal precipitation in recent years has resulted in a significant decline in the level of Lake Manuka. Currently, the lake appears to be about 2 feet below its ordinary high water level. In gently sloping shoreland areas, broad expanses of lake bottomlands are exposed. Shallow water conditions in portions of Lake Manuka are inhibiting navigation and full recreational use of the lake. The relatively low water levels in recent years have likely increased the abundance of aquatic vegetation as well.

Phosphorus is the nutrient that most often stimulates excessive growth of aquatic plants and algae, leading to a variety of problems collectively known as eutrophication. Sampling conducted during the course of study indicates that phosphorus levels in Lake Manuka at times exceed the eutrophic threshold concentration. Also, due to its low alkaline waters, Lake Manuka is very sensitive to phosphorus inputs. Watershed management should be conducted in concert with any in-lake improvement alternatives.

In light of these considerations, the management plan for Lake Manuka is proposed to include the following:

1. Aquatic Plant Control: An aquatic plant control program consisting of mechanical harvesting approximately 25 acres of nuisance plant growth on an annual basis for a five-year period. Harvesting work is proposed to be conducted under the direction of the lake association's consultant. The consultant would be responsible for preparing bid documents and contract extensions for the plant control program, conducting surveys of the lake to determine the scope of work to be performed by the plant control contractor, and performing follow-up inspections to ensure work is performed in a satisfactory manner. The consultant would maintain a written record of the date, scope, and cost of plant control activities and would report to the association regarding the performance of the plant control contractor. The consultant would also be responsible for conducting a vegetation survey each year to map the type and distribution of aquatic plants throughout the lake. If, as the result of the survey, invasive exotic species such as Eurasian milfoil are detected, appropriate corrective action could be taken.
2. Hydraulic Dredging: Consideration should be given to dredging portions of Lake Manuka to improve navigability. Two dredging scenarios were evaluated. Alternative 1 would involve dredging near-shore muck areas, and Alternative 2 would involve dredging shallow, off-shore areas that pose significant navigational difficulties.
3. Watershed Management: A program to disseminate guidelines to all lake residents that include information on lakeside landscaping, septic system maintenance, and practices to minimize the impact of shoreland development on lake water quality.

Project Implementation and Financing

In order to finance the recommended improvements, it is recommended that consideration be given to establishing a special assessment district for Lake Manuka. Under Michigan law, there are two statutes commonly used to finance lake improvement projects: Part 309 (Inland Lake Improvements) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994 and the Township Special Assessment Act, PA 188 of 1954 (Appendix C). Under Part 309, a lake improvement board would be established to coordinate the project. For Lake Manuka, the lake improvement board would be composed of the county drain commissioner, a county commissioner, two representatives of Hayes township, and a lake resident representative. Under Act 188, the lake improvement project would be coordinated by the Hayes Township Board. With respect to process, both Part 309 and Act 188 are similar. Both statutes provide for the establishment of a special assessment district to finance lake improvements, and both statutes require a public hearing on 1) the necessity (or practicability) of the project, and 2) a public hearing on the special assessment roll. Under these statutes, projects are generally initiated by formal petition of lake residents.

A special assessment district for Lake Manuka is proposed to include all properties that border the lake and back lots that have deeded or dedicated lake access. It is recommended that assessment be apportioned as follows:

- Waterfront Developed - 1 unit
- Waterfront Undeveloped - 0.5 unit
- Back Lot Developed - 0.5 unit
- Back Lot Undeveloped - 0.25 unit

Based on these criteria, there are approximately 150 assessment units within the proposed special assessment district for Lake Manuka. A breakdown of probable costs for the recommended lake improvements based on these criteria is presented in Table 9.

TABLE 9
LAKE MANUKA IMPROVEMENTS
ESTIMATE OF PROBABLE COSTS

Improvement	Cost	Annual Cost	Unit Cost
Dredging Alternative No. 1 (Muck Areas)	$1,902,100	$246,000	$1,640[1]
Dredging Alternative No. 2 (Navigation Areas)	$580,800	$75,200	$500[1]
Mechanical Harvesting	$60,000	$12,000	$80[2]

[1] Assumes dredging project would be financed over 10 years at 5 percent interest.
[2] Annual cost of mechanical harvesting over a 5-year period.

Appendix A
Historical Water Quality Data

MANUKA LAKE WATER QUALITY DATA
(Summer 1980)

Date	Station	Secchi (m)	Depth (m)	T (°C)	D.O. (probe)	D.O. (wink.)	% sat. O_2	pH (field)	pH (lab)	Acidity ppm P.P.	Sp. Cond. umohs	Hard. ppm	Alkalinity ppm $CaCO_3$	Color Hach	Turb. FTU
/12/80	1	1.5	1	15.7	9.8	2.2	102	7.8	5.9	20	25	20	10		
	1		3.5	15.3											
	1		5.5	14.3	14.2	2.7	87	7.6	6.0	10	30	10	8		
	1		8	13.0	0.2	2.7	2	6.9	5.9	15	35	15	7		
	2	1.5	1	16.2	10.0	2.4	105	8.5	6.1	10	30	10	0		
	2		2	15.2	9.6	2.6	99	8.8	3.8	10	95	10	5		
/17/80	1		1					7.7	7.8	5	40		9		
	1		5					7.7	8.1	0	45		10		
	1		9					7.5	7.5	0	40		11		
	2		2					7.2	3.8	25	110		0		
	2		5					7.9	8.4	0	40		13		
	3		1					7.4	7.9	0	40		10		
	3		3					7.4	8.4	0	50		12		
/23/80	W-1	.5	0.5					7.6	7.5	0	125	40	59	20	5
	W-1a	2	2					7.9	7.7	0	95	40	44	20	5
	W-2	2	0.3					8.4	7.4	0	80	50	32	10	5
	W-3	2	1					8.4	8.1	0	70	45	30	10	0
	W-3	2	2					8.5	8.0	5	65	50	28	20	0

Date	Station	Depth (m)	Iron ppm	K ppm	Mg ppm	Ca ppm	NO_2+NO_3 ppm	NH_3 ppm	Na ppm	PO_4 ppm	P-Total ppm	Si ppm	Chlor. *a* ppb	Phaeo ppb	Cl ppm
/12/80	1	1			<.8	2.9	≤.005	≤.003		<.001	.013	≤.005			
	1	3.5	--	--	--	--	--	--	--	--	--	--	0.9	1.3	
	1	5.5			<.8	2.9	≤.005	< .003		≤.001	.010	0.1			
	1	8			<.8	3.5	≤.005	.008		≤.001	.013	≤.005			
	2	1			<.8	2.9	≤.005	< .003		≤.001	.016	≤.005			
	2	2			<.8	2.9	≤.005	.016		.011	.010	≤.005			
/17/80	1	1		.30	<.8	4.8	≤.010	.010	.23	≤.001	.007	≤.005			.77
	1	5		.30	<.8	8.2	≤.010	.020	.26	≤.001	.010	≤.005			.87
	1	9		.25	<.8	4.0	≤.010	.010	.18	≤.001	.010	≤.005			.72
	2	2		.30	<.8	5.8	≤.010	.115	.26	.004	.009	≤.005			.87
	2	5		.30	<.8	2.9	≤.010	.001	.20	≤.001	.010	≤.005			.57
	3	1		.25	<.8	5.8	≤.010	.110	.42	≤.001	.016	≤.005			1.08
	3	3		.30	<.8	6.4	≤.010	.015	.20	≤.001	.010	≤.005			.72
/23/80	W-1	0.5		.48	1.6	19.3	.007	.012	.64	≤.001	.014	0.9	27.9	37.5	2.95
	W-1a	2		.35	1.4	15.0	≤.002	.010	.48	≤.001	.017	0.3	4.4	1.9	2.21
	W-2	0.3		.35	<.8	10.8	.007	< .002	.29	.001	.006	0.1	3.6	0.8	1.02
	W-3	1		.40	<.8	8.7	.007	.005	.42	≤.001	.007	0.1	3.3	1.5	1.43
	W-3	2		.35	<.8	8.7	.005	.003	.37	≤.001	.012	0.1	3.0	1.7	1.38

MANUKA LAKE WATER QUALITY DATA (Summer 1980) continued

Date	Station	Secchi (m)	Depth (m)	T (°C)	D.O. (probe)	D.O. (wink.)	% sat. O_2	pH (Field)	pH (lab)	Acidity ppm P.P.	Sp. Cond. µmohs	Hard. ppm	Alkalinity ppm $CaCO_3$	Color Hach	Turb. FTU
7/8/80	1	1.5	1	21.5	9.0	4.2	106	6.7	6.0	20	25	15	7	20	15
	1		2	21.5	8.8		103	6.7	6.5	10	25	10	7	15	10
	1		2	21.5	8.8				3.6	45	125	15	0	10	5
	1		3	21.0	8.6		99	6.7	3.5	35	150	10	0	20	10
	1		3.5	20.0	5.2		59	6.6	6.0	10	25	15	5	20	10
	1		4.0	19.0	3.1	2.9	34	6.4	5.9	10	25	10	9	15	15
	1		4.5	17.5	0.9		8	6.3	5.8	10	25	10	9	20	20
	1		5	16.5	0.1		1	6.1	5.9	5	25	10	8	20	15
	1		6	14.5	0.1		1	6.1	5.7	20	30	15	9	20	15
	1		7	12.5	0.1		1	6.1	5.9	10	35	10	10	20	10
	1		7	11.5	0.1	0.4	1	6.1	5.8	5	40	10	12	30	10
	3	1.5	1	22	9.6		112	7.0	6.0	20	30	10	6	15	15
	3		2	21.5	9.3		109	6.9	5.8	10	25	10	7	20	15
	3		2.5	20.5	7.7		102	6.9	6.0	10	25	10	6	15	10

	Station	Depth (m)	Iron ppm	SO_4 ppm	Mg ppm	Ca ppm	NO_2+NO_3 ppm	NH_3 ppm	N·org ppm	PO_4 ppm	P·Total ppm	Si ppm	Chlor. *a* ppb	Phaeo ppb	Cl ppm
7/8/80	1	1		6.2	<.8	3.1	<.002	<.002		.005		<.001	5.1	1.9	1.1
	1	2		16.8	<.8	2.6	<.002	<.010		.006	<.013				
	1	2		15.2	<.8	2.9	<.002	<.002		.003	.010				
	1	3		25.4	<.8	2.3	<.002	.006		.005	.009	<.001			1.1
	1	3.5		9.2	<.8	2.9	<.002	<.002		.005	.009	<.001	2.6	1.6	1.1
	1	4.0		8.8	<.8	2.6	<.002	<.002		.003	.011	<.001			1.1
	1	4.5		6.4	<.8	2.6	<.002	.003		.004	.013	<.001	10.2	9.4	1.1
	1	5		7.9	<.8	2.6	<.002	<.002		.003	.017	.2	23.5	18.7	1.3
	1	6		7.1	<.8	2.6	<.002	.020		.005	.009	.5	3.6	7.1	1.2
	1	7		7.2	<.8		<.002	.034		.003	.009	.2			1.2
	1	7		6.2	<.8	3.1	<.002	.424		.003	.010	<.001			1.1
	3	1		9.0	<.8	2.6	<.002	<.002		.004	.010	.1	5.0	2.8	1.1
	3	2		7.9	<.8	2.6	<.002	<.002		.008	.011	<.001	7.0	6.8	1.1
	3	2.5		6.6	<.8	2.6	<.002	<.002		.005	.011	<.001	16.5	5.2	1.2

MANUKA LAKE WATER QUALITY DATA (Summer 1980) continued

Date	Station	Secchi (m)	Depth (m)	T (°C)	D.O. (probe)	D.O. (wink.)	% sat. O_2	pH (field)	pH (lab)	Acidity ppm P.P.	Sp. Cond. umohs	Hard. ppm	Alkalinity ppm $CaCO_3$	Color Hach	Turb. FTU
8/5/80	1	2.0	1	22.5	8.4	8.5	99	6.5	6.6	5	35	20	7	5	20
	1		4a	21	4.0	1.6	46	6.2	4.9	5	30	15	9	10	20
	1		4b						6.3	5	30	15	7	20	20
	1		5	17.5	0.2	1.1	20	5.6	6.0	5	30	15	8	10	0
	1		7	12.5	0.1	0	1	5.7	5.9	0	45	10	22	40	30
	3	1.0	1	22.2	8.4	7.2	99	6.3	6.5	10	30	10	10	0	0
	3		2	21.7	8.3		97	6.9	6.6	5	30	10	8	0	0
	3		2.5	21	3.0	8.1	3	6.4	6.5	5	30	10	8	0	15

	Station	Depth (m)	Iron ppm	SO_4 ppm	Mg ppm	Ca ppm	NO_2+NO_3 ppm	NH_3 ppm	N·org ppm	PO_4 ppm	P·Total ppm	Si ppm	Chlor. *a* ppb	Phaeo ppb	Cl ppm
8/5/80	1	1			.23	3.0	<.030	.028		<.003	<.013		5.2	2.0	--
	1	4a			.20-	3.3	<.030	.028		.004	<.013	<.05	5.9	2.2	<1.28
	1	4b			.23	3.2	<.030	.033		.005	<.013	<.05	9.2	3.0	<1.28
	1	5			.23	3.3	<.030	.030		.004	<.013		5.0	2.9	--
	1	7			.84	3.9	<.030	1.00		.006	.020	.10	29.0	7.2	<1.28
	3	1			.23	3.0	<.030	.033		<.003	<.013		5.4	3.1	--
	3	2			.23	2.9	<.030	.028		.004	<.013	<.05	4.7	2.0	<1.28
	3	3			.23	3.3	<.030	.030		.004	<.013	<.05	19.7	26.7	<1.28

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		

State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W

Hydrologic Unit Code (HUC): 04070007

Station Type Indicator Description: Surface Water

Legacy STORET Station Type: /TYPA/AMBNT/LAKE

Start Date:	04-24-1990	Start Time:	1415
End Date:		End Time:	0
Sample Depth:	0 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	14.00		D
00077	TRANSPARENCY, SECCHI DISC (INCHES)	168.00		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	23.00		D
00300	OXYGEN, DISSOLVED MG/L	11.40		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	109.615	$	D
00400	PH (STANDARD UNITS)	8.20		D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.132		D
00612	AMMONIA, UNIONZED (MG/L AS N)	0.0050904	$	D
00619	AMMONIA, UNIONIZED (CALC FR TEMP-PH-NH4) (MG/L	0.00618936	$	D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.67		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.065		D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.008		D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36 MAJ BASIN: LAKE HURON MIN BASIN: AU SABLE RIVER 0723		

State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W

Hydrologic Unit Code (HUC): 04070007

Station Type Indicator Description: Surface Water

Legacy STORET Station Type: /TYPA/AMBNT/LAKE

Start Date:	04-24-1990	Start Time:	1417
End Date:		End Time:	0
Sample Depth:	15 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	7.40		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	24.00		D
00300	OXYGEN, DISSOLVED MG/L	11.40		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	93.4426	$	D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.154		D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.71		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.061		D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.009		D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	04-24-1990	Start Time:	1419
End Date:		End Time:	0
Sample Depth:	22 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	6.20		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	25.00		D
00300	OXYGEN, DISSOLVED MG/L	10.60		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	84.80	$	D
00400	PH (STANDARD UNITS)	8.30		D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.21		D
00612	AMMONIA, UNIONZED (MG/L AS N)	0.0056021	$	D
00619	AMMONIA, UNIONIZED (CALC FR TEMP-PH-NH4) (MG/L	0.00681154	$	D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.73		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.058		D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.01		D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	**21MICH**	Organization Name:	**MICHIGAN DEPT ENV QUALTY**
Station ID:	**690130**	Station Alias:	**AC00163**
Station Name:	**LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36**		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State: **Michigan**		County:	**Otsego**
Latitude: **44deg. 57min. 34sec. N**		Longitude:	**84deg. 44min. 22sec. W**
Hydrologic Unit Code (HUC):	**04070007**		
Station Type Indicator Description:	**Surface Water**		
Legacy STORET Station Type:	**/TYPA/AMBNT/LAKE**		

Start Date:	**04-24-1990**	Start Time:	**1421**
End Date:	**04-24-1990**	End Time:	**1422**
Sample Depth:	**20 feet**	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:	**Spatial Composite/Vertically Integrated**		

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
32209	**CHLOROPHYLL A UG/L FLUOROMETRIC CORRECTED**	**3.00**		**D**

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1334
End Date:		End Time:	0
Sample Depth:	0 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	20.80		D
00077	TRANSPARENCY, SECCHI DISC (INCHES)	108.00		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	24.00		D
00300	OXYGEN, DISSOLVED MG/L	8.00		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	88.8898	$	D
00400	PH (STANDARD UNITS)	7.60		D
00410	ALKALINITY, TOTAL (MG/L AS CACO3)	10.00		D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	-0.002	T	D
00612	AMMONIA, UNIONZED (MG/L AS N)	-0.0000328839	$	D
00619	AMMONIA, UNIONIZED (CALC FR TEMP-PH-NH4) (MG/L	-0.0000399832	$	D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.74		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.001	T	D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.012		D
00916	CALCIUM, TOTAL (MG/L AS CA)	2.70		D
00927	MAGNESIUM, TOTAL (MG/L AS MG)	1.00	K	D
00929	SODIUM, TOTAL (MG/L AS NA)	1.00	K	D
00937	POTASSIUM, TOTAL MG/L AS K)	0.13		D
00940	CHLORIDE,TOTAL IN WATER MG/L	1.00	K	D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36 MAJ BASIN: LAKE HURON MIN BASIN: AU SABLE RIVER 0723		
State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1334
End Date:		End Time:	0
Sample Depth:	0 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00945	SULFATE, TOTAL (MG/L AS SO4)	4.00		D
46570	HARDNESS, CA MG CALCULATED (MG/L AS CACO3)	10.8599	$	D

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1336
End Date:		End Time:	0
Sample Depth:	10 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	19.90		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	25.00		D
00300	OXYGEN, DISSOLVED MG/L	8.70		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	94.5661	$	D
00400	PH (STANDARD UNITS)	7.60		D
00410	ALKALINITY, TOTAL (MG/L AS CACO3)	13.00		D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	0.001	W	D
00612	AMMONIA, UNIONZED (MG/L AS N)	0.0000154133	$	D
00619	AMMONIA, UNIONIZED (CALC FR TEMP-PH-NH4) (MG/L	0.0000187409	$	D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.76		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.001	T	D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.013		D
00916	CALCIUM, TOTAL (MG/L AS CA)	2.60		D
00927	MAGNESIUM, TOTAL (MG/L AS MG)	1.00	K	D
00929	SODIUM, TOTAL (MG/L AS NA)	1.00	K	D
00937	POTASSIUM, TOTAL MG/L AS K)	0.13		D
00940	CHLORIDE,TOTAL IN WATER MG/L	1.00	K	D
00945	SULFATE, TOTAL (MG/L AS SO4)	4.00		D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State:	Michigan	County:	Otsego
Latitude:	44deg. 57min. 34sec. N	Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1336
End Date:		End Time:	0
Sample Depth:	10 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
46570	HARDNESS, CA MG CALCULATED (MG/L AS CACO3)	10.6102	$	D

Start Date:	08-22-1990	Start Time:	1338
End Date:		End Time:	0
Sample Depth:	15 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	19.90		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	25.00		D
00300	OXYGEN, DISSOLVED MG/L	8.20		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	89.1304	$	D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State: Michigan		County:	Otsego
Latitude: 44deg. 57min. 34sec. N		Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1340
End Date:		End Time:	0
Sample Depth:	20 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	19.70		D
00094	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	26.00		D
00300	OXYGEN, DISSOLVED MG/L	8.60		D
00301	OXYGEN, DISSOLVED, PERCENT OF SATURATION	93.4792	$	D
00400	PH (STANDARD UNITS)	7.60		D
00410	ALKALINITY, TOTAL (MG/L AS CACO3)	8.00		D
00610	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	-0.001	T	D
00612	AMMONIA, UNIONZED (MG/L AS N)	-0.0000151926	$	D
00619	AMMONIA, UNIONIZED (CALC FR TEMP-PH-NH4) (MG/L	-0.0000184726	$	D
00625	NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	0.68		D
00630	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.001	W	D
00665	PHOSPHORUS, TOTAL (MG/L AS P)	0.013		D
00916	CALCIUM, TOTAL (MG/L AS CA)	2.70		D
00927	MAGNESIUM, TOTAL (MG/L AS MG)	1.00	K	D
00929	SODIUM, TOTAL (MG/L AS NA)	1.00	K	D
00937	POTASSIUM, TOTAL MG/L AS K)	0.13		D
00940	CHLORIDE,TOTAL IN WATER MG/L	1.00	K	D
00945	SULFATE, TOTAL (MG/L AS SO4)	4.00		D

Date Created: Jan 11, 2006

STORET LDC - Detailed Data Report

Organization Code:	21MICH	Organization Name:	MICHIGAN DEPT ENV QUALTY
Station ID:	690130	Station Alias:	AC00163
Station Name:	LAKE MANUKA IN CENTRAL BASIN; HAYES TWP., SEC.36		
	MAJ BASIN: LAKE HURON		
	MIN BASIN: AU SABLE RIVER 0723		
State: Michigan		County:	Otsego
Latitude: 44deg. 57min. 34sec. N		Longitude:	84deg. 44min. 22sec. W
Hydrologic Unit Code (HUC):	04070007		
Station Type Indicator Description:	Surface Water		
Legacy STORET Station Type:	/TYPA/AMBNT/LAKE		

Start Date:	08-22-1990	Start Time:	1340
End Date:		End Time:	0
Sample Depth:	20 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:			

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
46570	HARDNESS, CA MG CALCULATED (MG/L AS CACO3)	10.8599	$	D

Start Date:	08-22-1990	Start Time:	1342
End Date:	08-22-1990	End Time:	1343
Sample Depth:	18 feet	Effluent Monitoring Code:	
UMK:		Replicate Number:	
Composite Method Code:		Pipe ID:	
Composite/Grab Number:			
Primary/Secondary Activity Category:	Spatial Composite/Vertically Integrated		

Parameter Code	Parameter Long Name	Result Value	Remark Code	Composite Statistic Code
32209	CHLOROPHYLL A UG/L FLUOROMETRIC CORRECTED	9.00		D

Date Created: Jan 11, 2006

Appendix B

Michigan Department of Environmental Quality Draft Staff Guidance Lake Level Augmentation Projects

Staff Guidance
Lake Level Augmentation Projects
July 7, 2006
(DRAFT)

Background

A lake augmentation project seeks to supplement the existing water in a lake by pumping water from another surface water source or by extracting groundwater, via a well or a series of wells, and pumping it into the lake for the purpose of increasing its water level or maintaining a water level higher than what would typically result under natural circumstances.

Water levels in inland lakes fluctuate in a natural process that is influenced by a combination of factors, including groundwater input, precipitation, snow melt, rates of evaporation, and water use in the watershed. In some instances, lakeshore property owners desire to maintain lakes at a static level for a variety of purposes, including maintaining favorable boating conditions, avoiding the perceived aesthetic impacts of seasonally low or high levels, or reducing shoreline changes (i.e., vegetation growth or ice shove) that naturally occur in fluctuating lake systems.

Natural fluctuation of water levels in lakes contributes significantly to ecosystem health. Shorelines and their associated plant and animal communities are established based upon the natural cycle of fluctuating water levels. Lake augmentation activities that restrict the amplitude of the natural fluctuation constrict the dynamic transition zone between the land and water that provides high quality habitat for fish, reptiles, amphibians, and birds.

Natural fluctuations encourage an increased number of plant species by naturally controlling the establishment of monotypic stands of highly competitive plants such as cattail or purple loosestrife. Because many aquatic plants germinate best on moist soils or in very shallow water, temporary low water periods offer species an opportunity to establish in recently exposed areas even though they thrive as adults in completely flooded areas.

Stabilization of water levels on inland lakes reduces the biological diversity of wetlands on lakes (above and below the Ordinary High Water Mark). Maintaining levels at the high end of the natural fluctuation affects the survivorship of many plants and may accelerate shoreline erosion by reducing the extent of aquatic vegetation that serves to buffer the impacts of wind and wave action. Maintaining levels at the low end of the natural fluctuation can foster the growth of certain invasive species such as purple loosestrife and phragmites.

Regulatory Considerations

Section 30102 (d) of Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act (NREPA) requires a permit to "create, enlarge, or diminish an inland lake or stream." Historically, the DEQ has interpreted Section 30102 (d) to include only those activities that involve the placement, manipulation, operation, or removal of fill or structures to increase or decrease water levels in a lake, stream, or impoundment. This interpretation was promulgated as rule R281.811 (1)(e).

However, the recent circuit court decision in *Michigan Citizens for Water Conservation v. Nestle Waters of North America* (*Nestle*) and the State of Michigan's amicus brief in the *Nestle* appeal, have stated that this interpretation is overly restrictive and inconsistent with the unambiguous statutory language.

After review and discussion with the Department of the Attorney General, the DEQ has determined that lake augmentation activities on any lake, including lakes where a legal lake level has been established pursuant to Part 307, require permits pursuant to Part 301. Furthermore, flooding a wetland for recreation or other purposes is a use of the wetland under Section 30304 (c) and requires authorization under Part 303. In reviewing projects that involve multiple statutes, all applicable criteria must be evaluated.

There is a perceived conflict between Part 307 (Inland Lake Levels) and Parts 301 and Part 303. Although it is clear that lake augmentation is regulated by Parts 301 and 303, Section 8 of Part 307 authorizes delegated authorities to install augmentation wells. Specifically, 324.30708 (3) states:

> "For the purpose of maintaining the normal level, a delegated authority may drill wells or pump water from another source to supply an inland lake with additional water, may lower the level of the lake by pumping water from the lake, and may purchase power to operate pumps, wells, or other devices installed as part of a normal level project."

However, it is clear in Section 23 of Part 307 that this authority is constrained by the requirements of other applicable statutes. Specifically, 324.30723 states:

> "This part does not abrogate the requirements of other state statutes."

Therefore, proper permits must be obtained from the DEQ prior to initiation of lake level augmentation activities.

Furthermore, permits are required for all augmentation well or pump projects that include any other activities typically regulated under statute, such as placement of riprap or structures on the bottomland, dredging, or filling bottomland, or dredging, filling, or constructing a use in a regulated wetland adjacent to the lake. In addition, permits may be required under other parts or statutes for regulated activities, including but not limited to floodplains, soil erosion and sedimentation control, or endangered species.

In addition, staff should inform anyone inquiring about installation of augmentation well(s) that the well(s) may be regulated under the following authorities:

- Part 127, of the Public Health Code, 1978 PA 368, Section 12701(1) (d)
  Augmentation wells meet the definition of a "well" under the statute; therefore, a well construction permit may be required by the county health departments. However, neither the DEQ nor county health departments can require a hydrogeologic assessment under Part 127 prior to permitting the project. The DEQ strongly recommends that such an assessment be done to determine potential impacts on drinking water wells.

- Part 31, Water Resources Protection, of the NREPA (NPDES)
  A National Pollutant Discharge Elimination System (NPDES) permit may be required from the DEQ's Water Bureau depending on the depth and location of the well. If the well is being drilled into an aquifer deeper than the lake or into a potentially contaminated aquifer, water quality testing may be required to determine if an NPDES permit is necessary for the proposed discharge to the lake. Additionally, a NPDES permit may be required for surface water to surface water transfers when the receiving water quality would be degraded by this action. The Water Bureau will establish internal guidelines to clarify this issue. Responsible parties should be referred to the Surface Water Permits Section for further information (517-373-8088).

  With any projects of these types, initial pumping from the well may contain high concentrations of suspended solids. This initial pumping should not be directed to surface waters. Additionally, proper measures should be taken to prevent potential scouring by the discharge flow.

- Part 31, Water Resources Protection, of the NREPA (Floodplain Regulatory Authority) and the Land Division Act (formerly the Subdivision Control Act), Act No. 288, Public Acts of 1967 as amended, Sections 116 and 117.
  Depending on the size of the proposed augmentation, the project may alter floodplain elevations in the immediate vicinity. Any potential impacts to floodplains should be reviewed by a floodplain engineer. In addition, a recorded plat should be amended for lake augmentation projects which raise the elevation of an established floodplain affecting a subdivision under the Land Division Act

- 2003 PA 177, Groundwater Dispute
  Most augmentation wells are subject to dispute resolution under Act 177 because they are capable of pumping over 70 gallons per minute. If a well is found to interfere with drinking water wells in the area, the Water Bureau can order that the well stop pumping.

- 2006, PA 33 and the Water Regulatory Package of 2006
  Depending on the size of the withdrawal proposed to service the augmentation project, it may be regulated under a new law passed in February, 2006. Withdrawals over 100,000 gallons per day (averaged over a 90-day period) are required to report to the DEQ. Permits are required for proposed withdrawals greater than 2 million gallons per day from groundwater or inland wetlands, lakes, or streams (averaged over a 90-day period), or greater than 5 million gallons per day from the Great Lakes (averaged over a 90-day period).

Information Required from Applicants In order to Evaluate Permit Applications
Lake augmentation projects are akin to projects that seek to increase lake levels through the establishment of a legal lake level pursuant to Part 307. In order to fully evaluate proposed lake augmentation projects, information typically provided in Parts 301 and 303 applications as well as Part 307 proceedings is necessary.

In order for an application to be considered administratively complete in addition to information typically required in Part 301 and 303 applications the following information should be submitted by the applicant:

- Written authorization (permission) of a minimum of 2/3 of the owners of lands abutting the lake.
- Historic lake level records including high and low lake levels, the ordinary high-water mark, and seasonal and annual fluctuations based on historic lake level records, aerial photographs, DEQ OHWM determinations, and other relevant sources.
- The lake level regime that the project proposes to achieve, including high and low levels, as well as seasonal and annual fluctuations.
- An assessment of potential effects on shallow water and shoreline habitat, including changes in type and area of wetlands that may result from the project.
- The amount (in gallons per day) and timing (daily/weekly/seasonally) of pumping (with annual totals) that is proposed in order to achieve this water level regime.
- A hydrologic analysis in accordance with Land and Water Management Division's (LWMD's) General Guidelines for Hydrogeological Investigations. This analysis should include the ability of the water source to sustain the withdrawal and the likely impacts to wetlands in the area (including surface or subsurface drainage), as well as the extent of flooding of the lake, associated wetlands, and downstream areas. A water budget and aquifer pump test should be included in the analysis.
- Potential impacts to downstream flow.
- The location relative to the proposed lake level, of septic tanks, drain fields, seawalls, docks, or other structures that may be impacted by increased water levels.
- Analysis of impacts to riparian property owners.
- The applicant must also provide names, e-mail addresses, and permanent mailing addresses of all affected property owners.

Staff should determine if the information provided is adequate, and require additional or updated information if necessary.

For projects that propose lake augmentation on lakes for which a Part 307 legal lake level has been set, much of this information will have already been prepared as part of the court proceedings and will be relevant to the LWMD decision-making process. The applicant should provide this information. However, depending on when the legal lake level was established, staff may determine that the information gathered for the Part 307 process needs to be supplemented or updated.

Because augmentation projects may impact all riparian property owners, staff must review the possible effects to all impacted properties. Particular attention should be given to the adverse natural resource impacts caused by the proposed increase in water levels.

Appendix C
Project Finance Information

LAKE BOARD ACT AMENDED

By
Tony Groves, Water Resources Director, Progressive AE

This is the first of a two-part article about lake boards. The first article discusses recent amendments to the lake board act and the second article will explore the pros and cons of organizing a lake project under an existing township board versus establishing a lake board.

In the final moments of the 2003-2004 Legislative Session, several changes were made to the act that governs lake boards in Michigan. Part 309 (Inland Lake Improvements) of the Natural Resources and Environmental Protection Act provides for the establishment of lake boards and special assessment districts to finance lake improvement projects. Since 1966, this act has been used extensively to organize and finance a variety of lake projects. Currently, there are over 100 active lake boards in Michigan. The recent amendments change the membership of a lake board (Section 30903), project costs (Section 30927), and provide a formal mechanism for dissolving a lake board (Section 30929).

SECTION 30903

Section 30903 of the act defines the composition of a lake board and requires that a lake board consist of all the following:

- A member of the county board of commissioners appointed by the chairperson of the county board of each county affected by the lake improvement project.
- A representative of each local unit of government (other than the county) affected by the project appointed by the legislative body of the local unit. However, if there is only 1 local unit of government involved, 2 representatives of that local unit shall be appointed to the board.
- The county drain commissioner or his or her designee.
- A property owner, appointed by the lake board, who owns land abutting the lake.

Under the amendments, a representative from the Michigan Department of Environmental Quality (MDEQ) will no longer sit on the board. However, many lake projects will require the issuance of a permit from the MDEQ so the department will still provide regulatory review of proposed projects. Amendments to this section also require that once established, a lake board must now elect a treasurer, in addition to a chairperson and secretary.

SECTION 30927

Section 30927 deals with the computation of project costs and requires the lake board to make a computation of all costs associated with the project including preliminary engineering, contract work, inspections, publication of notices, legal expenses, administrative costs, permit fees, and contingent expenses. Amendments to this section require that a lake board shall not expend money unless it has adopted an annual budget.

SECTION 30929

Section 30929 was added to the act to provide a mechanism for dissolving a lake board. Prior to this amendment, Part 309 was silent on this issue. Section 30929 provides for a lake board to be dissolved if all the following conditions are met:

- The governing body of each local unit of government in which all or part of the lake is located holds a public hearing on the proposed dissolution, determines that the lake board is no longer necessary for the improvement of the lake because the reasons for establishing the lake board no longer exist, and approves the dissolution of the lake board.
- All outstanding indebtedness and expenses of the lake board are paid in full.
- Any excess funds of the lake board are refunded based on the last approved assessment roll. However, if the amount of excess funds is a minimal amount, the excess funds shall be distributed to the local units involved with the project apportioned in accordance with last approved special assessment roll.
- The lake board determines that it is no longer necessary for the improvement of the lake, because the reasons for its establishment no longer exist, and adopts an order approving its dissolution.

To ensure compliance with the recent amendments to Part 309, existing lake boards should appoint a treasurer. Also, if there is only one local unit of government involved with the project, request that the legislative body of the governmental unit appoint a second representative to serve on the lake board. Finally, if a lake board has not formally adopted an annual budget for expenditures, it should do so.

Financing Your Lake Project: Lake Boards vs. Township Boards

By Tony Groves, Water Resources Director, Progressive AE

This is the second part of a two-part article about financing alternatives for lake projects. The first article, which appeared in the February 2005 issue of the Michigan Riparian, examined recent amendments to the Lake Board Act. This article discusses the pros and cons of organizing a lake project by establishing a lake board versus using an existing township board.

Part 309 (Inland Lake Improvements) of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended, provides for the establishment of lake boards and special assessment districts to finance lake improvement projects. Since 1966, this act has been used extensively to finance a variety of lake projects. Currently, there are over 100 active lake boards in Michigan.

The Township Special Assessment Act, PA 188 of 1954 was amended in 1994 to provide a mechanism to finance lake improvement projects. However, with Act 188, projects are organized under an existing township board.

With respect to process, both Part 309 and Act 188 are similar (Table 1). Both statutes provide for the establishment of a special assessment district to finance lake improvements, and both statutes require a public hearing on 1) the necessity (or practicability) of the project, and 2) a public hearing on the special assessment roll.

Some practical things that should be considered in establishing a special assessment district include:

<u>The Petition</u>: If a project is proposed to be initiated via petition, the petition should clearly state that "a special assessment district will be established and that special assessments will be levied to finance the desired lake improvements." Space should be provided on the petition for property owners to both sign and print their names. If property is owned jointly, all freeholders should sign the petition. Prior to circulation, the local unit(s) of government involved with the project should review the petition to ensure petition language is acceptable.

<u>Developing the "Plan"</u>: An independent study should be conducted to evaluate the feasibility of lake improvement alternatives and to determine the proposed scope and cost of the project. The preparation of a lake improvement plan is important. You want to make sure that the thousands of dollars that may be invested in a lake project are being spent on improvements that are both environmentally sound and cost effective.

<u>Special Assessments</u>: When establishing a special assessment district for a lake project, care should be taken to ensure the district only includes those properties that directly benefit from the proposed improvement. Typically, this will include all lake front properties and back lots with deeded or dedicated lake access. To avoid legal challenges, assessment should be levied in a fair, consistent, and equitable manner. All similarly situated properties should be assessed the same. Often, a simple assessment apportionment scheme (where, for example, lakefront parcels are assessed one unit of benefit and back lots with access one-half unit of benefit) is easier to defend (and explain) than a more complex assessment methodology.

With respect to procedure, neither statute is superior over the other. However, there are some instances where one act may be preferred over the other. For example, if a lake is located entirely within one township and the township is willing to undertake the project, then Act 188 may be a more expedient way to proceed. If, on the other hand, a lake is located in several townships or political jurisdictions, then Part 309 may be more desirable. (In a situation where a lake is in several townships, each township involved would need to undertake separate assessment proceedings which could be both time-consuming and cumbersome. In addition, no single entity would be administering the project). Another practical consideration with Act 188 is that township boards often have full agendas and address a myriad of issues at their meetings. (If you have ever sat through a township board meeting, you can attest to this fact.). Often, they have precious little time available to discuss and address lake issues and concerns. By contrast, a lake board is formed to address only the lake in question and thus, focuses only on lake issues.

This article provided an overview of the procedures that must be followed in organizing a project under Part 309 or Act 188. In organizing a lake improvement project, it is important that statutory hearing and notice procedures be followed closely. Lake projects can be time-consuming enough without having a project challenged and prolonged due to a procedural flaw. To help ensure proper steps and procedures are followed, lake residents who are considering pursuing the establishment of a special assessment district for their lake should seek professional assistance or legal counsel before embarking on the process.

Table 1 - An Overview of Part 309 and Act 188 Procedures

Part 309 (Inland Lake Improvements) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994

- Projects are administered by a lake board that is comprised of a lakefront property owner, a representative of each local governmental unit (if there is only one local unit of government involved, 2 representatives of that local unit are appointed to the lake board), a county commissioner, and the county drain commissioner or his or her designee. (Note that local units of government can appoint lake residents as their representative(s) if they so choose.)
- Projects are initiated by motion of the local unit(s) of government or by petition of 2/3 of freeholders abutting the lake.
- Pursuant to the Act, projects can be implemented that provide the following benefit(s): The elimination of pollution and elimination of flood damage, elimination of water conditions which jeopardize the public health or safety; increase of the value or use of lands and property arising from improving a lake or lakes as a result of the lake project, and the improvement or development of a lake for conservation of fish and wildlife and the use, improvement or development of a lake for fishing, wildlife, boating, swimming or any other recreational, agricultural, or conservation uses.
- Lake board retains an engineer to conduct lake improvement feasibility study, and to determine the scope and estimated cost of project and probable assessments.
- Public hearings are required on the practicability of the project and special assessment roll.

Township Special Assessment Act, P.A. 188 of 1954, as amended

- Projects are administered by the township board.
- For lake improvements, projects can be initiated by motion of the township board or by petition of land owners constituting more than 50% of the land area in the special assessment district.
- Under this Act, assessments can be levied for the eradication or control of aquatic weeds and plants, the construction, improvement, and maintenance of a lake including, but not limited to, dredging, and the construction, improvement, and maintenance of dams and other structures which retain the waters of the state for recreational purposes. (Note that under Act 188, a lake, pond, river, or stream under the jurisdiction of the county drain commissioner cannot be improved without written permission of the drain commissioner.)
- Plans are prepared describing the improvement and estimated costs.
- Public hearings required on the necessity of the project and the special assessment roll.

References

Wetzel, R.G. 1983. Limnology. 2nd edition. Saunders College Publishing, Philadelphia, Pennsylvania.