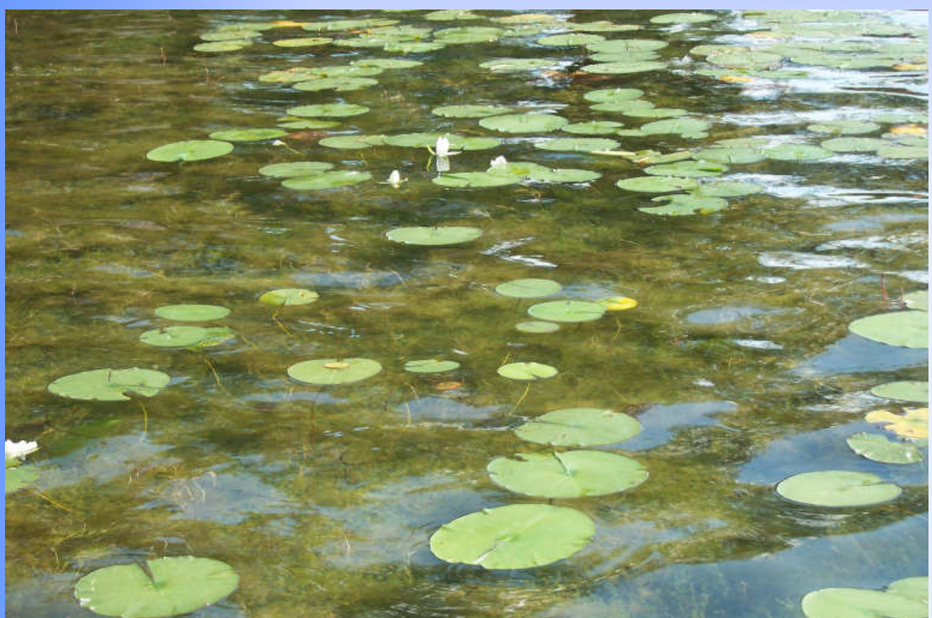
LAKE IMPROVEMENT STUDY
FOR
WALLED LAKE



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WALLED LAKE IMPROVEMENT STUDY

City of Novi & City of Walled Lake

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SECTION 1

REPORT SUMMARY

A. EXECUTIVE SUMMARY

On June 3, 2009, Spalding DeDecker Associates, Inc. and the Walled Lake Improvement Board entered into an agreement for the preparation of a Lake Improvement Study for Walled Lake. Exhibit A of this agreement specified a scope of services be performed with a Draft report to be provided September 16, 2009. This report, identified as the "Walled Lake Improvement Study", is for the purposes of improving the Lake under the Inland Lake Improvement Act (see Appendix A). The following summarizes the activities performed with this study:

Mapping – This task involved the preparation of a lake study map of the existing lake. This map was used to generate subsequent maps and figures such as; an approximate bottom contour map (bathymetric map), the approximate locations of springs, an aquatic plant inventory map, as well as several other references for Walled Lake.

The Walled Lake surface district map was developed by utilizing the Oakland County Geographic Information System parcel data and Institute of Fisheries Research Digital Water Atlas.

Computer generated contours were obtained from The Institute for Fisheries Research Lake Inventory digitized contours. The dataset, known as the Digital Water Atlas v1.0, developed under the Digital Water Atlas Project was incorporated with the City of Novi and City of Walled Lake GIS dataset and has been utilized to develop the Aquatic Vegetation Assessment Sites (AVAS) and lake contour maps. The Walled Lake "Bottom Contour Map", typically referred to as a bathymetric map or depth chart, has been included as Figure 2.6.

On August 3 and 5, 2009 Applied Science and Technology, Inc. (ASTI) performed an on-site aquatic plant survey by physical sampling and identification. Sampling was performed by identifying and collecting plant specimens within and along the shores of the Lake. A map was prepared to record the "Aquatic Plant Survey" and general concentrations of the plant species that are growing in Walled Lake. The aquatic plant survey and recommendations for weed treatment, which includes an analysis of the existing treatment program, are provided in Section 3.

Lake Bottom Analysis – Sediments were analyzed using probes, sonar, and visual observations along with lake bottom sediment substrate type obtained from the Michigan Department of Natural Resources Fisheries Division Institute for fisheries Research.

Lake Water Quality - The lake water quality was analyzed by collecting eight samples mid depth below the water's surface. Water sample locations have been specified in Figure 2.3. Samples were delivered to Brighton Analytical Laboratory for testing of:

- pH
- Nitrite + Nitrate - Nitrogen (NO_2+NO_3 - N)
- Ammonia Nitrogen (NH_3 - N)
- Total Kjeldahl Nitrogen (TKN)
- *Escherichia coli* (*E. coli*) bacteria
- Chlorophyll *a*

Temperature, dissolved oxygen, and specific conductance was determined by utilizing a with a hand-held multi probe system. Readings were taken two feet below the water's surface. Turbidity was analyzed by using a Secchi Disk Transparency. A theoretical nutrient budget was also calculated based on the characteristics of the Walled Lake watershed. Results and recommendations are covered in Section 2 of the report.

<u>Lake Assessment</u> - A component of lake improvement projects is the establishment of an assessment district methodology based on persons having record interest in the title to, right of ingress to, or reversionary right to a piece or parcel of land that would be affected by the permanent change in the bottomland of the Lake. Several assessment methodologies have been presented in Section 3 of the report.

B. PURPOSE OF STUDY

The purpose of this report is to present the findings of an Engineering Improvement Study for Walled Lake, make recommendations, and define the scope of a Lake Improvement Plan which will be in conformance with and will meet the requirements of the Inland Lake Improvement Act, Part 309 of Public Act No. 451, 1994, which replaced Act 345 of 1966.

A copy of the Inland Lake Improvement Act has been included in Appendix A of this report.

C. BACKGROUND

One of Michigan's greatest resources, in addition to being encompassed by the Great Lakes, is the abundance of fresh water inland lakes. The lands that abut these inland lakes typically have higher property values due to the unique characteristics that these lakes have to offer the residents.

As the inevitable development of a lake watershed occurs, a variety of environmental impacts may be experienced by the lake, causing concern to the residents that use and enjoy the lake that they live on. As problems inherently develop, mainly due to society's influence on the watershed, the lake residents will typically implement plans to mitigate the problems that they are experiencing on their lake.

As the lake watershed continues to develop, the residents will generally form a Lake Association to share common objectives. Whereas membership is optional in many of these associations, it is clearly recognized that not all of the lake residents or residents with lake privileges become active participants of the association.

As a result, from the inception of association activities, it is apparent that not all property owners may be interested in participating or pursuing the association's objectives. Starting out with 100% participation is usually not an initial concern to many of the association members because the initial cost for such start-up activities as annual cook-outs, fishing contests, minor park maintenance, etc., are relatively low. However, as the cost of such activities increase, or the nature of the activities change and their cost escalate, total participation may be needed in order to fund the continuation of the association's activities or the creation of new ones. It usually becomes apparent about this point in time that some of the residents are clearly benefiting in some form from the efforts of the active members of the associations.

Whereas it is difficult, if not impossible, to reach and maintain 100% active membership on a voluntary basis, there are few legal requirements that may require participation in an association, unless legally established by deed restrictions, covenants or some other binding means. It is for these reasons that the people of the State of Michigan through their elected representatives enacted the Inland Lake Improvement Act, Act 345 of 1966, which has subsequently been replaced by Part 309 of Public Act No. 451, 1994.

The Inland Lake Improvement Act contains provisions in Section 30902, (1), which enable people of the State of Michigan as follows:

"The local governing body of any local unit in which the whole or any part of the waters of any public inland lake is situated, upon its own motion or by petition of 2/3 of the freeholders owning lands abutting the lake, for the protection of the public health, welfare and safety and the conservation of the natural resources of this state, or to preserve property values around a lake, may provide for the improvement of a lake, or adjacent swampland, and may take steps necessary to remove and properly dispose of undesirable accumulated materials from the bottom of the lake or swamp by dredging, ditching, digging, or other related work."

With the provisions contained in the Inland Lake Improvement Act, lake associations throughout the State of Michigan have formed Inland Lake Improvement Boards for their lake that have the authority to create a Special Assessment District by which a special assessment can be levied to the property owners that abut the lake or have lake privileges for projects that are approved by the Lake Board during a Hearing of Practicability and Hearing of Assessment. Therefore, Lake Homeowner Associations through their Lake Improvement Boards have the means to require the 100% financial participation for activities that are initiated by the Lake Board.

This first meeting is typically referred to as the organizational Lake Board Meeting. During the first meeting, Lake Board members are acknowledged or elected by the Board Members, per the provisions of Section 30903 of the Inland Lake Improvement Act. A list of the Lake Improvement Board members for Walled Lake has been included as Exhibit I of this report. In conformance with Section 10 of the Inland Lake Improvement Act, the Lake Board proceeds in obtaining the services of a Registered Professional Engineer to prepare an Engineering Feasibility Report for Walled Lake.

A "Request for Professional Services" (RFP), dated March 20, 2009, was circulated to professional engineers and engineering firms within the State of Michigan by the Lake Board Secretary. A copy of the RFP is included in Appendix D of this report.

D. ENGINEERING FEASIBILITY STUDY REQUIREMENTS

As outlined in the Request for Professional Services for Walled Lake, the following items, while not all inclusive, were defined as basic criteria in preparing the Engineering Feasibility Study and were outlined as follows:

A. Analyze aquatic weed growth and make recommendations for removal and control. Prepare a map which shows the locations and types of aquatic vegetation, and approximate lake bottom contours. GIS data is available from the City of Novi or Oakland County Water Resource Commissioner's Office to the selected consultant.

B. Determine the lake water quality with respect to oxygen content and its relationship to fish population; determine possible adverse effects of stratification, and recommend whether aeration and/or other water conditioning is required.

C. Determine lake water quality using the following listed parameters and recommend appropriate action to improve water quality:

1. E. Coli
2. Ph
3. Oxygen concentration
4. Phosphorus concentration
5. Nitrogen concentration
6. Chlorophyll a concentration
7. Sechi disc Transparency
8. Theoretical nutrient budget

D. Evaluate the lake bottom sediments and associated nutrients, and their removal and appropriate disposal.

E. Investigate alternative methods of lake improvement other than weed control, aeration and dredging, if applicable.

F. Recommend methods to eliminate or reduce future sediment loading of Walled Lake. Determine extent of lake access rights for homes and condominiums on the lake and in proximity of.

G. Prepare estimates of costs for each of the above items, individually, with an analysis of effects of proposed assessments on the local units of government and interested landowners and residents.

H. Submit a schedule for completion based upon a Notice to Proceed.

The study was to be coordinated between the residents of Walled Lake, the City of Novi, the City of Walled Lake, the Oakland County Drain Commissioner's Office, and others, as may be required.

E. ENGINEERING SELECTION PROCESS

Subsequent to the RFP being circulated, eight lump sum bids were received by the Lake Board Secretary. A meeting was scheduled and held on May 13, 2009, which the Walled Lake Improvement Board voted to accept the proposal prepared by Spalding DeDecker Associates for the Lake Improvement Study.

On June 3, 2009 the Walled Lake Improvement Board and SDA entered into an agreement for the professional engineering services to perform an improvement study for Walled Lake. A copy of the agreement has been included in Appendix E.

F. LAKE CHARACTERISTICS

Walled Lake is located in sections 2 and 3 of the City of Novi and sections 34 and 35 of the City of Walled Lake, Oakland County, Michigan. The tributary watershed to Walled Lake is approximately 2,585 acres, which consist of a mix of residential, commercial, and undeveloped land uses (please see Figure 2.5). The surface area of Walled Lake is approximately 652 acres and its outlet is controlled with a lake level control structure, which is owned and operated by the Oakland County Water Resources Commissioner. The lake level control structure controls the lake elevation at the legally established normal summer elevation of 932.80 feet and winter level of 932.10 feet (NGVD 1929) and controls both Walled Lake and Shawood Lake, which is south of

Walled Lake and interconnected to Walled Lake with a shallow channel. Walled Lake has a perimeter of approximately 24,200 feet.

Walled Lake is classified as a “kettle” lake. As the name implies, these lakes are basically bowls or basins, where storm water runoff or ground water drain into. Kettle lakes do not typically have a direct source of water flowing into them, such as a creek, stream or river and were generally formed by glacial ice movements. Walled Lake is primarily spring fed and outlets to the headwaters of the Middle Branch Rouge River.

The maximum depth of Walled Lake is approximately 53 feet, located near the northeast section of the Lake. The average depth for the lake is approximately 12 feet.

Based upon the water surface elevation at the outlet weir of 932.80 feet the lake contains a volume of water of approximately 8,062 acre-feet.

Walled Lake currently has residential homes, condominium developments, commercial developments, and parks surrounding the perimeter of the lake. The commercial developments are generally concentrated on the north side of the lake and make up the downtown district of the City of Walled Lake.

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A. SAMPLING METHODS

Water Quality Analysis
The SDA/ASTI team sampled water quality at eight (8) locations in Walled Lake on August 3, 2009. Sampling locations were patterned after an analysis conducted in a study performed in 1999. The locations sampled represented six (6) near-shore, shallow water stations and two (2) deeper water locations, Stations 7 and 8, including the deep hole of the lake. Sampling stations are shown in Figures 2.1 and 2.2.

Grab samples were collected at each location at mid-depth using a Van Dorn horizontal sampling bottle, which allows water to flow through the sampler until reaching the desired depth. Samples were then collected using a messenger-activated release mechanism. Water samples collected in this fashion were transferred to bottles containing the appropriate preservatives, stored on ice at 4^{o} C, and delivered to Brighton Analytical Laboratory under established chain of custody procedures. Laboratory personnel confirmed that samples were received at the proper temperature and pH and laboratory control spike were confirmed to be within acceptable limits for precision and accuracy. Collected water samples were analyzed for the following parameters:

1. Total Phosphorus (TP)
2. Nitrite + Nitrate - Nitrogen (NO_2+NO_3 - N)
3. Ammonia Nitrogen (NH_3 - N)
4. Total Kjeldahl Nitrogen (TKN)
5. *Escherichia coli* (*E. coli*) bacteria
6. Chlorophyll-*a*

Additional water quality parameters were measured and recorded in the field with a hand-held Yellow Springs Incorporated (YSI) Model 556 MPS (Multi Probe System) meter. Water column transparency was measured using a Secchi disk. Field measurement parameters included:

7. Temperature
8. Dissolved Oxygen (DO)
9. Secchi Disk Transparency
10. Specific Conductance (Conductivity)
11. pH

Aquatic Vegetation Analysis
The species composition and densities of rooted aquatic plants in Walled Lake were assessed following the Michigan Department of Environmental Quality's (MDEQ) Procedures for Aquatic Vegetation Surveys. The shoreline and near shore areas of the lake were divided into 83 individual Aquatic Vegetation Assessment Sites (AVASs) each approximately 300 feet in length. The AVASs sampled and their numeric designations are shown in Figures 2.1 and 2.2.

Each AVAS was assessed by boat in a zigzag meander survey. Vegetation in each AVAS was sampled using a combination of visual observations and weighted rake tows. Rake tows consisted of a two-

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sided rake pitched from the boat in each cardinal direction and dragged along the lake bottom with collected plants inspected and identified on the boat deck. Each rooted aquatic plant species was recorded and the density of each species was recorded according to the following descriptors:

(A) = Found: one or two plants of a species found in an AVAS, equivalent to less than 2% of the total AVAS surface area.
(B) = Sparse: scattered distribution of a species in an AVAS, equivalent to between 2% and 20% of the total AVAS surface area.
(C) = Common: common distribution where the species is easily found in an AVAS, equivalent to between 21% and 60% of the total AVAS surface area.
(D) = Dense: dense distribution where the species is present in considerable quantities throughout an AVAS, equivalent to greater than 60% of the total AVAS surface area.

Lake-bottom sediments were also evaluated. The depths of soft, unconsolidated sediments were sampled using probes, sonar, and visual observations.

Sweet-Scented Water-Lily along Shoreline

B. RESULTS & DISCUSSION

Sampling and analytical results for water quality analyses conducted in Walled Lake are presented in Table 2.1. Samples collected in near-shore areas, Stations 1 through 6, were collected at mid-depth in water ranging from 2 to 5 feet deep. Stations 7 and 8 were sampled in deeper parts of the lake. Station 7 was sampled at mi-depth at a depth of 19 feet. Water quality samples at Station 8, the deep hole of the lake, were collected at a depth of 25 feet. Meter readings for Station 8 were

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collected at multiple depths throughout the water column. Graphs of these readings are presented as Figures 2.3 and 2.4.

Table 2.1. Walled Lake Water Quality Results

Parameter	Detection Limit	Sampling Stations 1	2	3	4	5	6	7	8	Average
Chlorophyll a	0.1 ug/l	1.0	2.1	1.0	1.7	0.7	0.7	1.7	1.4	1.3
Total Phosphorus (TP)	10 ug/l	ND	ND	ND	ND	ND	ND	ND	ND	---
Nitrite Nitrogen (NO_2)	0.1 ug/l	ND	ND	ND	ND	ND	ND	ND	ND	---
Nitrate Nitrogen (NO_3)	50 ug/l	ND	ND	ND	ND	ND	ND	ND	ND	---
Ammonia Nitrogen (NH_3)	10 ug/l	ND	ND	ND	ND	ND	ND	ND	ND	---
Total Kjeldahl Nitrogen (TKN)	0.1 ug/l	ND	ND	ND	ND	ND	ND	ND	ND	---
E. coli Bacteria	1 CFU/100 ml	10	4	15	5	155	4	4	10	25.9
Temperature (^oC)	---	23.76	23.78	22.04	23.00	21.96	22.35	22.68	22.11	22.36
Dissolved Oxygen (mg/l)	---	8.89	9.88	8.00	8.03	7.95	7.19	7.47	2.29	6.82
Dissolved Oxygen (% saturation)	---	105.5	117.3	92.2	91.5	90.9	81.9	91.1	26.3	79.0
Specific Conductance (uS/cm)	---	1016	1012	1017	1012	1015	1032	1037	1041	1026
pH	---	8.51	8.78	8.45	8.54	8.48	8.27	8.31	7.63	8.28

In-Field Physical Parameter Monitoring

Temperature

Temperature is one of the most important water quality variables. It affects the amount of dissolved oxygen (DO) that can be held in solution, the rates of various chemical transformations, and the metabolic rate and reproductive activities of aquatic organisms. Water generally holds less oxygen in solution with increased temperature, and higher temperatures increase metabolic activity in fish and invertebrates. This, in turn, increases their demand for DO. Fish and other aquatic organisms can therefore suffer metabolic stress at high temperatures.

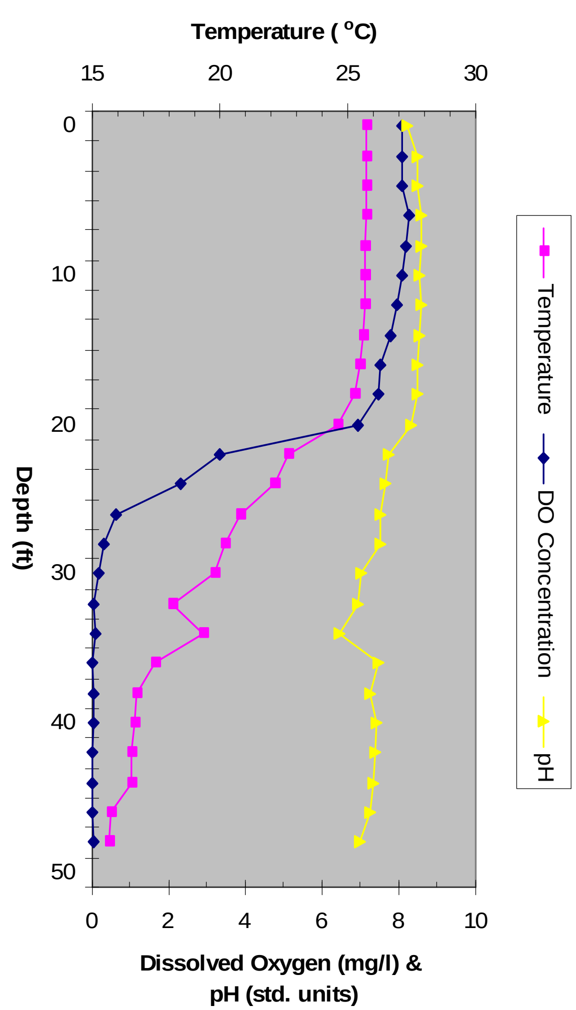

Figure 2.3. Temperature, pH & Dissolved Oxygen Profiles

Water temperature varies according to season, elevation, geographic location, and climate, and is influenced by the amount of shade provided by riparian vegetation, wind, and the relative contributions of groundwater, surface water runoff, and/or effluent.

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Temperature maxima for a variety of lake fish species are presented in Table 2.2. Based upon the late summer temperatures measured in this study it appears that Walled Lake is a cool-water lake able to support a variety of fish species. A number of fish species were incidentally observed during the water quality and vegetation assessments. These included largemouth (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieui*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*) and common carp (*Cyprinus carpio*). Discussions with lake residents indicated that Walled Lake exhibits a healthy smallmouth bass fishery. Smallmouth bass is a cool-water species and, from this sampling effort, water temperatures do not appear to limit the fishery.

Table 2.2. Temperature Limits for Local Fish Species[1]

Species	Max. Weekly Average Temp. for Growth (Juveniles)	Max. Temp. for Survival of Short Exposure (Juveniles)	Max. Weekly Average Temp. for Spawning	Max. Temp. for Embryo Incubation/Hatching
Bluegill	32°C	35°C	25°C	34°C
Common carp	---	---	21°C	33°C
Channel catfish	32°C	35°C	27°C	29°C
Largemouth bass	32°C	34°C	21°C	27°C
Smallmouth bass	29°C	---	17°C	23°C

The temperature profile collected in approximately 50 feet of water at Station 8 (Figures 2.3 and 2.4) indicates that Walled Lake does stratify during the summer months. Recorded temperatures declined from 25.30 °C at 18 feet in depth, which was not notably different than temperatures near the surface, to 22.69 at 22 feet in depth. Temperatures continued to steadily decline thereafter to 15.65 °C recorded at 48 feet. Although the temperature break at the thermocline appears modest (note the temperature scale in Figure 2.3 is exaggerated), it represents a significant change in dissolved oxygen levels (discussed below).

Dissolved Oxygen (DO)

Oxygen dissolved in water is necessary for life of both aquatic plants and animals. The amount of oxygen that can be held dissolved in water is generally temperature dependent, although saturation in excess of oxygen's equilibrium solubility (>100%) from photosynthesis or extreme turbulence is possible. Oxygen solubility increases with decreasing temperature (colder water generally holds more oxygen than warm water).

Besides temperature, the amount of DO in water is also dependent upon processes that consume, produce, and/or entrain oxygen. Oxygen is consumed through both plant and animal respiration and decomposition. Oxygen is added to the system from the atmosphere, by photosynthesis, and turbulence.

Plants produce oxygen during the daylight hours through photosynthesis. During the night, plants and bacteria continue to use

[1] FISRWG (10/1998). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.

oxygen for respiration while no photosynthesis is occurring. Thus, DO levels decrease at night, and are generally lowest just before dawn.

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Rule 64 of the Michigan Water Quality Standards (Part 4 of Act 451)[2] states that surface waters protected for warm water fish and aquatic life must contain a minimum of 5.0 mg/L DO. Prolonged exposure to low DO levels (less than 5 mg/L) may not directly kill organisms, but can increase their susceptibility to environmental stresses. Exposure to less than 30% saturation (less than 2 mg/L) for periods of one to four days may kill aquatic organisms unable to move to areas exhibiting higher concentrations.[3]

The DO profile presented in Figure 2.3 exhibits the differences in the upper, well-oxygenated, epilimnion of Walled Lake and the lower hypolimnion strata of the lake. Between approximately 20 and 22 feet in depth, DO at Station 8 dropped from 6.93 mg/l (83.5% saturation) to 3.33 mg/l (38.7% saturation). This represents a transition between areas containing enough DO sufficient for warm- and cool-water fish species and deeper waters lacking sufficient oxygen. Waters from a depth of 26 feet and below exhibit no or almost no oxygen.

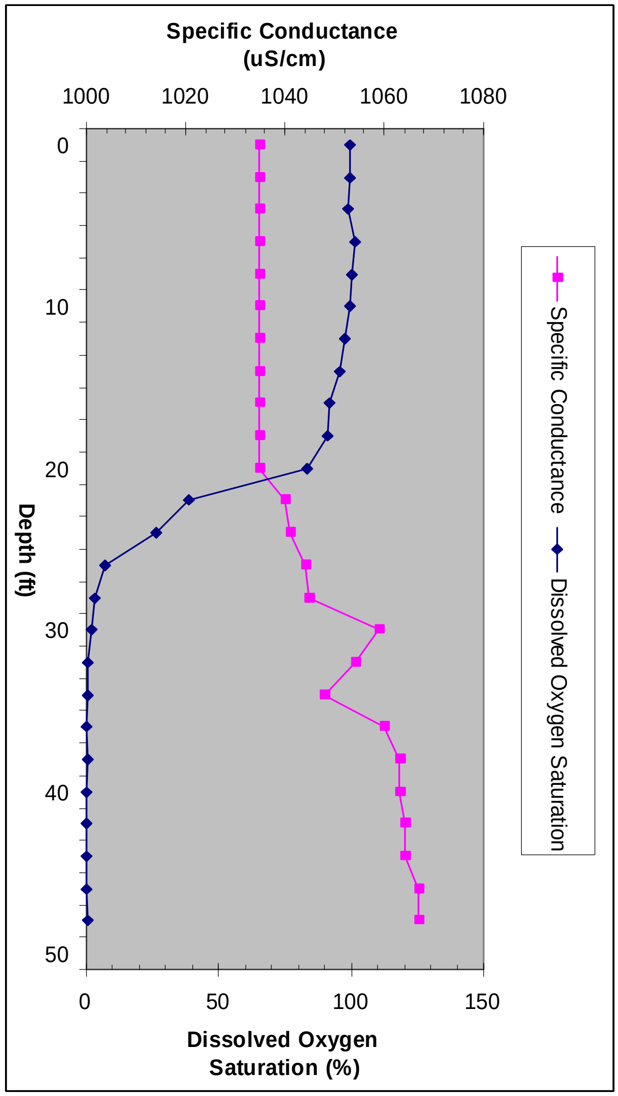

Figure 2.4. Dissolved Oxygen Saturation and Specific Conductance vs. Depth

Conductivity

Conductivity (specific conductance) is a measure of water's ability to conduct an electrical current and, as such, is an indirect measurement of the presence of inorganic dissolved solids such as carbonate, bicarbonate, chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge)

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[2] Michigan Department of Environmental Quality, Water Bureau, Water Resources Protection, Part 4. Water Quality Standards: http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=32301041&Dpt=EQ&RngHigh=

[3] http://www.deq.state.mi.us/documents/deq-swq-npdes-DissolvedOxygen.pdf

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or sodium, magnesium, potassium, calcium, iron, and aluminum cations (ions that carry a positive charge). Conductivity is affected by temperature: the warmer the water, the higher the conductivity. Because it is related to temperature, measurements of conductivity are generally standardized as conductivity at twenty-five degrees Celsius (25^{o} C).

Conductivity in streams and rivers is affected primarily by the geology of the watershed. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. Streams that run through areas with clay soils tend to have higher conductivity because of the presence of ionizing materials. Groundwater inflows can have the same effects depending on the bedrock they flow through.

Specific conductance values measured in Walled Lake are in keeping with waters in southeast Michigan. The profile for specific conductance at Station 8 exhibited a break at the same depth as curves for temperature and DO, but increase steadily below the thermocline.

Hydrogen Ion Concentration (pH)
The pH of water is a measurement of the concentration of hydrogen (H+) ions, on a scale ranging from 0 to 14. A pH of 7 is considered "neutral", indicating equal concentrations of H^+ and OH^- ions. Liquids or substances with pH measurements below 7 are considered acidic. Those with pH measurements above 7 are considered basic or alkaline. Every unit change in pH, indicates a ten-fold change in acidity or alkalinity. Natural waters generally exhibit pH values between 6.5 and 8.5 and Michigan's water quality standards require that surface waters be between 6 and 9 pH. Hydrogen ion concentrations vary naturally in relation to temperature and photosynthesis.

Similar to temperature and dissolved oxygen, the pH profile for Station 8 shifts to lower, more acidic, values below the thermocline. However, all pH values measured were circumneutral and within water quality standards.

Secchi Disk Transparency
Water clarity is assumed to be a product of the amount of zoo- and phytoplankton and suspended solids within the water column and, therefore, is also a product of, or related to, the amount of nutrients (particularly phosphorus) and chlorophyll-*a* within a lake.

All 6 of the shallow water sampling stations exhibited visibility to the bottom. Secchi disk transparency measured at Station 8 was 12 feet (3.66 m). This is 3 feet greater than the average Secchi disk depth of 9.0 feet reported in the 1999 study of Walled Lake.

Secchi disk transparency, along with chlorophyll-*a* and total phosphorus concentrations, are often used to determine the trophic status of lakes.

Oligotrophic lakes are low in nutrients, whereas eutrophic lakes are nutrient rich and highly productive. Mesotrophic lakes are those between these other ends of the spectrum. Secchi disk depths of 12 feet or greater are generally indicative of oligotrophic lakes. It should be noted that residents complained of algae blooms earlier in the season. Pictures taken June 24, 2009 showed that water clarity decreased rapidly within a few feet of the surface.

Limited transparency earlier this summer during algae bloom reported by residents

Laboratory Analysis

Phosphorus
Phosphorus and nitrogen are essential nutrients for plant growth. In Michigan waters, phosphorus is generally considered the limiting nutrient. This means that, because it is generally less available than other nutrients (relative to plant needs), the amount of available phosphorus generally determines the rate and amount of plant growth. Excessive phosphorus in aquatic systems can lead to excessive growth of algae and other aquatic plants, which can in turn deplete the available dissolved oxygen in the water. High nutrient concentrations and the resulting growth of nuisance plant levels can also inhibit recreation and enjoyment of lakes and streams. As such, phosphorus is a key water quality concern.

Phosphorus binds to soil particles, and is thereby delivered to streams and lakes with eroded soil. Phosphorus is also a chief component of lawn, garden, and agricultural fertilizers, detergents, fuels, and animal wastes. Phosphorus from these sources is carried in storm water runoff, and also enters rivers and lakes from failing septic tanks and from wastewater treatment plants.

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The U.S. EPA and the MDEQ consider TP concentrations higher than 0.05 mg/L to have the potential to cause eutrophic conditions (e.g., nuisance algae and plant growth, widely fluctuating DO concentrations, etc.) in lakes, ponds, and reservoirs.

All stations sampled on Walled Lake were found to have total phosphorus concentrations less than the 10 parts per billion (ppb = ug/l) laboratory detection limit. These low TP concentrations would generally indicate an oligotrophic lake system. A similar study conducted in 1999 found average TP concentrations in Walled Lake of 20 ppb, which would place the lake between oligotrophic and mesotrophic status.

Chlorophyll-a

Chlorophyll-a is the green pigment that is responsible for a plant's ability to convert sunlight into the chemical energy needed to fix CO_2 into carbohydrates. Measuring the concentration of chlorophyll-a is provides an estimate of algal biomass.

Chlorophyll-a concentrations ranged from a low of 0.7 ppb, at Stations 4 and 5, to a high value of 2.1 ppb measured at Station 2. Chlorophyll-a concentrations averaged 1.3 ppb. All chlorophyll-a concentrations measured fell within the range generally associated with oligotrophic lakes.

Nitrogen

Nitrogen is generally more available than phosphorus. Although nitrogen is abundant naturally in the environment, it is also introduced through sewage and fertilizers. Excess nitrogen can result in excessive aquatic plant growth, providing plant growth is not limited by concentrations of another nutrient (e.g., phosphorus) or trace constituent.

Nitrogen is found in a variety of forms. Those generally measured in water quality studies include ammonia, nitrate and nitrite, and organic nitrogen. Total Kjeldahl nitrogen is an analytical measure of ammonia plus organic nitrogen.

The sum of nitrite+nitrate (NO_2+NO_3) is a measure of total oxidized nitrogen. Nitrate dissolves readily in water, is stable over a wide range of environmental conditions, and is easily transported in groundwater and streams. Nitrite is an intermediate form and is quickly converted to nitrate by bacteria. Nitrite concentrations are hence generally very low or non-detectable.

Concentrations of all sampled forms of nitrite, nitrate, and total Kjeldahl nitrogen were below the analytical detection limits at all stations. Nitrite was below detection limits in the 1999 study as well. TKN, in the 1999 study, ranged 0.77 to 1.1 mg/l.

Ammonia

Ammonia, a form of nitrogen, occurs naturally in groundwater and surface waters, is the preferred form of nitrogen for aquatic plant uptake and growth, and is the least stable form of nitrogen in water. It is easily transformed to nitrate in oxygenated waters or to nitrogen gas in water low in oxygen. Ammonia takes the forms of the ammonium ion (NH4+) and dissolved un-ionized ammonia gas (NH3). Total ammonia nitrogen (NH3-N) is the sum of these two forms. The ammonium ion is considered nontoxic and generally comprises most of total ammonia. NH3 is much more toxic to aquatic organisms than the ammonium ion (NH4+).[4] The relative balance of these two forms is dependent upon both pH and temperature. Increases in pH push the balance toward aqueous NH3. At pH < 8.75, NH4+ predominates. The two forms are in approximately equal proportions at a pH of 9.24, and aqueous NH3 predominates at pH >9.75. Michigan's Rule 57 Aquatic Maximum Value for un-ionized ammonia (NH3) in warm water systems is 0.210 mg/L and the Final Chronic Value is 0.053 mg/L.

Concentrations of all sampled forms of nitrogen, including ammonia, were below the analytical detection limits at all stations.

Bacteria (Pathogens)

Bacteria are simple, single-celled organisms that can reproduce rapidly by binary fission. While over 60 genera of bacteria are naturally present in waters of the U.S., certain types of bacteria can increase as a result of human use of a watershed and may indicate sources of water pollution.[5]

Most bacteria are harmless; however, some have the potential to cause illness or disease in humans. These are referred to as *pathogens*. Examples of waterborne diseases caused by bacteria include cholera, dysentery, shigellosis and typhoid fever. Minor gastro-intestinal discomfort is probably the most common ailment associated with water-borne bacteria; however, pathogens that cause only minor discomfort to some may cause serious illness or even death in other individuals, particularly the young and elderly or those with compromised immune systems.[6,7]

Of particular interest or concern is a sub-group called coliform bacteria, typically found in the digestive systems of warm-blooded animals. Coliform bacteria include total coliforms, fecal coliforms, and the group *Escherichia coli* (*E. coli*). Each of these indicates the presence of fecal waste in surface waters.[8] The fecal-coliform bacteria group was formerly the preferred indicator for potential water quality concerns; however, recent advances in the use and analysis of indicator bacteria have

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[4] City of Boulder, BASIN Project, http://bcn.boulder.co.us/basin/data/NUTRIENTS/info/NO3+NO2.html

[5] Gregory, M.B. and E.A. Frick. 2000. Fecal-coliform bacteria concentrations in streams of the Chattahoochee River National Recreation Area, Metropolitan Atlanta, Georgia, May-October 1994 and 1995. U.S. Geological Survey Water Resources Investigation Report 00-4139, August 2000.

[6] Ibid

[7] Schueler, T.R. 1999. Microbes and Urban Watersheds II. Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 1-12.

[8] Ibid

shown that *E. coli* are more reliable for predicting the presence of disease-causing organisms.[9]

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Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451)[10] limits the concentration of microorganisms in surface waters of the state. Waters of the state which are protected for total body contact recreation must meet limits of 130 *E. coli* per 100 milliliters (mL) of water as a 30-day average and 300 *E. coli* per 100 mL of water at any time. The limit for waters of the state which are protected for partial body contact recreation is 1000 *E. coli* per 100 ml water during any one sampling event.

Bacteria from human sources can enter waters through either point or nonpoint sources of contamination. Point sources are those that are readily identifiable and typically discharge water through a system of pipes (e.g., an industrial or wastewater discharge). Point source discharges can also include "illicit" connections to storm drainage systems, wherein wastewater that would normally require treatment prior to discharge is instead routed through storm drains without treatment. Nonpoint sources are diffuse, with contamination entering waters through overland runoff or seepage through the soil. Fecal coliform and *E. coli* concentrations in urban storm water frequently exceed water quality standards by a factor of 35 to 75.[11] Failed septic systems in residential or rural areas can contribute bacteria to surface water and groundwater. Other sources include combined sewer overflows, sanitary sewer overflows, dumping of wastewater, and animal wastes from livestock, pets, wildlife and waterfowl. Domestic dogs and cats were found to be the primary source of fecal coliforms in urban watersheds near Puget Sound in Washington State.[12]

Measured *E. coli* bacteria concentrations in Walled Lake, during this study, ranged from a low of 4 colonies per 100 ml at Stations 2, 6, and 7, and a high of 155 cfu/100 ml at Station 5. Although the value measured at Station 5, exceeds the 130 cfu/100 ml standard for the geometric mean of several sampling events, it does not exceed the single event standard of 300 cfu/100ml. The geometric daily mean of all stations was 9.64 cfu/100ml during this investigation.

Bacteria concentrations measured during this investigation, at the locations described above, were generally very low. Bacteria concentrations may frequently be higher, however, in shoreline areas

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[9] Gregory, M.B. and E.A. Frick. 2000. Fecal-coliform bacteria concentrations in streams of the Chattahoochee River National Recreation Area, Metropolitan Atlanta, Georgia, May-October 1994 and 1995. U.S. Geological Survey Water Resources Investigation Report 00-4139, August 2000.

[10] Michigan Department of Environmental Quality, Water Bureau, Water Resources Protection, Part 4. Water Quality Standards: http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=32301041&Dpt=EQ&RngHigh=

[11] Schueler, T.R. 1999. Microbes and Urban Watersheds II. Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 1-12.

[12] Trial W. et. al. 1993., cited in Schueler, T.R. 1999. Microbes and Urban Watersheds II. Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 1-12.

due to wind and wave action or localized inputs. Such was the case at the E.V. Mercer City Beach in Walled Lake.

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WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

Samples collected the same day by the Oakland County Health Department at the E.V. Mercer City Beach exceeded state water quality standards and the beach was closed from July 14 to August 18, 2009, a period of 35 days. Daily means for Health Department sampling at Mercer beach, during the summer of 2009, have ranged from a low of 7 cfu/100 ml to a high of 1,695 cfu/100 ml.

Analysis of sampling records from 2003 through 2009 indicate that this extended period of beach closure is unusual and that the number of water quality exceedances this summer has been greater than during previous years. During that period of record daily means in excess of 300 cfu/100 ml occurred zero (0) times in 2004 and 2008, once in 2003, 2005, and 2007, and three (3) times in 2006. In contrast, there have been seven (7) such exceedances in 2009.

Review of Health Department sampling records and rainfall data from the National Atmospheric & Oceanic Administration (NOAA) do not indicate a strong correlation between bacteria and stormwater runoff, although there is a storm drain that enters the lake at the beach. Personnel from the Walled Lake Department of Public Works have attributed the problem, primarily, to higher than normal waterfowl concentrations exacerbated by residents and visitors feeding the geese and swans.[13]

Theoretical Nutrient Budget

Consider the relative importance and contributions of point sources and non-point sources to the lake. The watershed to lake surface area ratio is also important. The ratio can indicate whether point or non-point sources are likely to dominate water quality. This ratio is quite simple to calculate: Lake area ratio equals the watershed area divided by lake area (computed in acres). If the watershed is small, local point sources and septic tank drainage are probably quite important. As the watershed to lake surface ratio increases, these sources might still be important, but nonpoint sources also must be considered.

Point sources which had been perceived to contribute to the majority of water quality problems, had masked nonpoint source pollution problems. Once point sources were subjected to corrective actions, the importance of nonpoint sources became apparent. Only by stepping away from the narrow viewpoint (that point sources caused nearly all water quality problems) were water quality specialists able to see the lake and watershed as an integrated system being affected by diverse sources of influences.

By approaching the management of lakes from a broader perspective water specialists found that in many systems, nonpoint sources were equal to or greater than point source contributions and, in general,

[13] Spinal Column article, August 18, 2009. http://www.spinalcolumnonline.com/1editorialbody.lasso?-response=%2f1editorialbody.lasso&-token.folder=2009-08-19&-token.story=70537.113117&-token.disearea=3&-nothing&-token.disearea=1

nonpoint sources were major contributors of sediment organic matter and nutrients to a lake. Although the nutrient concentration in runoff waters or the amount of nutrients absorbed to the sediments are generally not as great as the nutrient concentrations in a point source, the total load (concentration times flow) can be substantial and far exceed point source contributions. The Nutrient Budget describes the amount of nutrients which flow into a lake, generally source of origin, how much accumulates in the water or on the bottom and how much flows out. This will in part determine the excessive plant growth in a lake.

Phosphorous is the key parameter in Nutrient Budget calculations, this is because it has been identified as the major nutrient contributing to plant growth. The aquatic plants need more phosphorous than what naturally occurs in lakes. Phosphorous is also the one nutrient that man is able to control through good lake management practices. Nitrogen is generally not considered a controllable source as it occurs naturally in lakes in sufficient quantities for the aquatic plants.

Walled Lake Theoretical Nutrient Budget - The following assumptions were made in calculating the nutrient budget for Walled Lake:

- All residents are on public sanitary sewer
- Volume of lake remains constant
- Average residency is three persons per household
- Phosphorous is the limiting nutrient

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WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

Walled Lake Data

Volume Calculated	8,062 Acre-feet 351,180,720 ft^3 (43,560 ft^2/acre x 8,062 acre-feet) as provided by Institute for Fisheries Research 21,922 million pounds (79,935,660 gallons x 8.345 LB/gallon)
Tributary Drainage Area Measured	2,585 acres (See Figure 2.5 Walled Lake Watershed)
Flow in/out of Lake	Negligible flow in or out of lake Evaporation Average for SE Michigan = 33.88 in./year Precipitation Average for SE Michigan = 29.13 in./year Spring fed groundwater will make up the difference to maintain average lake level water surface elevation of 932.80 (NGVD) (From Summary Evaporation in Michigan by Fred V. Nurnberger, December 1989)
Phosphorous Concentration	Below 10 ppb detection limit (from analytical testing)
Average Daily Water Use (per capita)	45.6 Gallons (EPA, 1980)
Wastewater mean Phosphorous Concentration (Domestic Septic)	23 mg/L (EPA, 1980)
Septic Sludge mean Phosphorous Concentration	232 mg/L (EPA, 1980)
% of Residences	85% Residences that Fertilize
Stormwater Runoff Phosphorous Concentration	0.39 LB/acre/year (Controlling Urban Runoff, July 1987)

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WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

Walled Lake Calculations

1. Lawn Fertilizers

Surveys from previous studies indicate that nearly 100% of homeowners use fertilizers for their lawns, gardens, shrubs and flowers at least once a year. A 100% application of fertilizer for all residents in the watershed may be too conservative of an estimate for fertilizer usage. Also, the availability of phosphorous free fertilizer is becoming more common. Therefore an estimated 85% of residents utilizing fertilizer will be assumed. Fertilizer management considers the proper time to spread a fertilizer and the proper amount to optimize plant growth with minimal impact on the lake. For lawns the common application rate for fertilizers is .39 pounds of phosphorous per acre per year. Assuming that half of each lot is lawn and lots are approximately one acre in size, therefore approximately ½ acre worth of fertilizer is applied to 85 percent of the lots.

<u>Assumptions</u>
1,300 acres residential lots and condominium developments
Half of each lot is lawn (87.5 acres)
.39 pounds of phosphorous fertilizer per acre per year
85% of residents fertilize at least once per year

Pounds phosphorous from fertilizers = 1,300 acres x .39 LB/acre x 85%
= 430 LB phosphorous/year

Assuming that 75% of the phosphorous is absorbed into the lawns, gardens, and wetland areas, this means that approximately 107 pounds of phosphorous is captured by surface runoff and discharged into Walled Lake due to fertilization of lawns and gardens.

2. Septic Tanks

All lots adjacent to Walled Lake are connected to the public sewerage system. Therefore, Walled Lake is not subject to phosphorous contributions from on site disposal systems.

3. Discharge and Retention of Phosphorous

The volume of Walled Lake is approximately 79,935,660 gallons, and using the phosphorous from the water sampling of 0.00 mg/L, the amount of phosphorous in Walled Lake is as follows:

8,062 acre-feet (9,944,519,00 L)
0.00 mg/L phosphorous dissolved in lake water from analytical results
2.205 x 10^{-6} LB/mg conversion factor

Pounds of phosphorous in Walled Lake

= 9,944,519,000 x 0.00 x 2.205 x 10^{-6}
= 0 pounds

The estimate of phosphorous contributions from the watershed suggests that laboratory results would detect phosphorous in the lake. The abundant presence of zebra mussels may be the contributing factor to the low phosphorous levels due to the zebra mussels' ability to filter nutrients from the water. The zebra mussels may improve water clarity but can adversely effect the phytoplankton population, which serves as food for native aquatic species.

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WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

Aquatic Plant Assessment

A summary of the species and densities for each AVAS is presented in Table 2.3. Non-native (adventive) species are identified with their scientific names in all capital letters. Twenty-five (25) species of floating-leaved, emergent or submergent rooted aquatic plants were identified in the Walled Lake vegetation survey. Individual AVASs exhibited from one (1) to thirteen (13) species of rooted aquatic plants. Seven (7) species were found in 25% or more of the individual AVASs and these are noted in bold text.

Areas of the lake exhibiting moderate and dense, versus very few plants or sparse plant densities, are shown in Figure 2.6. With the exception of one area at the north end of the lake near AVAS 53, which now exhibits lower plant densities, the distribution and characterization of plant densities around the lake appear to have changed little since the 1999 study.

Large sections of shoreline exhibit relatively little aquatic vegetation. The section of the near shore area between AVAS 53 and 77 is one notable area that exhibits very little vegetation, with generally less than 5% of the total surface area covered. A number of AVASs exhibited very little vegetation (e.g., 5-10% coverage) in close to shore with greater plant coverage (e.g., 25-35% or greater) in water 5 to 16 feet in depth. Frequently these differences appear to coincide with substrate type. The sandy soils near the shoreline appear to support much less plant growth than areas of silty or marl bottom in deeper water.

Walled Lake does exhibit extensive areas of both Eurasian (*Myriophyllum spicatum*) and native water-milfoils and these tend to be densest in these same deeper areas away from shore at the depths described above. A 2001 aquatic vegetation survey was provided by William Kraus, of Aquatic Management Services, Inc., a lakeshore resident. That study did not differentiate between Eurasian and native milfoils, but included a map of high milfoil densities. That map has been recreated here in Figures 2.7 and 2.8, showing the distribution of milfoils relative to areas mapped as having a marl substrate and relative to depth. In general, although extensive beds of the invasive Eurasion water-milfoil were observed, rake tows in these areas showed that they still exhibit a diversity of native species interspersed with the invasive species.

There area few areas where these, or the dense mats of chara and naiad, fouled the prop of the boat during the plant survey, but this occurred infrequently and was not experienced as a factor limiting

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WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

recreational use of the lake. Boating access seemed to be limited in more areas by shallow water depths than by plant growth. Aquatic herbicides are not applied extensively in Walled Lake. Review of MDEQ records indicate that two areas; near the Bayside Sports Bar and Grille at the north end of the lake and the area owned by the Shoreline Condominium Association received permits to apply herbicides in 2009. Lake residents verbally noted a 3rd location; near the Harbor Cove Subdivision.

Sediments

Assessment of bottom sediments in Walled Lake did not indicate the need for dredging. Depths of the lake's deep holes appear to have changed little since the lake bottom bathymetry was mapped by the Department of Conservation in the 1940s. Walled Lake's shoreline and near shore areas exhibit extensive areas of sand.

A review of the 2009 Michigan Family Fish Consumption Guide as produced by the Michigan Department of Community Health (MDCH) indicated that sampled fish populations showed levels of PCBs and Mercury. The presence of these contaminants in the fish suggests that they may reside within the sediments and may provide challenges for their removal and disposal.

The sampled fish were Carp and Northern Pike. These fish may have been selected as the indicator fish to measure the contaminants because Carp are bottom dwellers and Northern Pike are top water feeders. The advisory for Walled Lake was developed from data collected in 1988. Discussions with the MDCH and Michigan Department of Natural Resources (MDNR) indicated that they would expect PCB levels to have dropped over time but believe it is more difficult to predict mercury levels due to their continued use. The data for Walled Lake has not been updated since 1988 due to the lack of secure public boat access for the MDNR. If the Walled Lake Improvement Board wished to have the fish advisory updated for Walled Lake, the Michigan Department of Environmental Quality (MDEQ) would accept fish samples for testing. Typically 10 legal sized fish are collected per year for a two year period. The MDCH would update the fish advisory from the MDEQ test results. A copy of the 2009 Michigan Family Fish Consumption Guide has been included in Appendix L.

C. CONCLUSIONS AND RECOMMENDATIONS

Nutrients & Plant Growth

Water quality sampling conducted in August 2009 resulted in both phosphorus and nitrogen below standard laboratory detection limits, indicating that Walled Lake is low in nutrients. Likewise, Secchi disk transparency and low chlorophyll-*a* concentrations are in keeping with a lake somewhere between an oligotrophic and mesotrophic state. Yet the dense housing surrounding most of the lake and the presence of several storm water outfalls to the lake would seem to indicate that the lake should be relatively nutrient-rich.

Rooted plant growth is more closely linked to phosphorus or other nutrient levels with the bottom sediments, and hence are not as dependent upon water-borne nutrient concentrations as phytoplankton. Yet the lush plant growth exhibited between 5 and 16 or more feet in depth would seem to indicate a system with greater nutrient inputs than revealed by the water quality sampling and analysis conducted in this study.

Researchers did note an abundance of zebra mussels on the surface of plants, rocks, and docks throughout the lake. It may be that this adventive species is creating conditions of high water clarity and low levels of phytoplankton that would seem to indicate a nutrient-poor lake system.

Although Eurasian water-milfoil is prevalent within Walled Lake, we experienced little negative affect upon boat access and residents report a good fishery. Because areas exhibiting dense invasive milfoil also exhibit diverse native plant assemblages widespread chemical treatment is not recommended to reduce milfoil levels. Instead, selective localized treatment is recommended. If additional treatments are desired, Table 2.3 and Figure 2.6 should be used to identify areas and prioritize needs.

Dissolved Oxygen

Although areas of the lake below 22 feet in depth exhibit low dissolved oxygen, extensive areas of the lake are shallower than this depth, are well-oxygenated, and seem to provide adequate fish habitat. Areas of low oxygen at greater depths do not seem to adversely impact the native fishery. Because of this it does not appear that adding mechanical aeration to the hypolimnion is necessary. This recommendation, or lack of a recommendation, is based upon discussions with lake residents regarding the fishing. Additional water profile sampling during the winter months, to determine if similar winter stratification occurs, along with observations regarding the presence of absence of winter fish kills may be warranted to determine if the fishery is negatively impacted by low dissolved oxygen at depth.

E.coli Bacteria

Escherichia coli bacteria in water quality samples collected during this study were low, but this followed on the heels of the closing of the E.V. Mercer City Beach in Walled Lake. Novi's beach at the south end of the lake did not experience the same problems. Educational programs, as well as signage, discouraging the feeding of waterfowl are recommended for implementation throughout the lake basin. Programs aimed at physically excluding waterfowl from shoreline areas are also encouraged. These may include the destruction of swan and goose nests in the spring, a goose relocation program, and the use of border collies to scare geese and swans from the area. They may also include programs that train and/or provide incentives to homeowners to convert shoreline areas from turf grass to high growing native vegetation to discourage waterfowl grazing.

D. BOTTOM CONTOUR MAPPING

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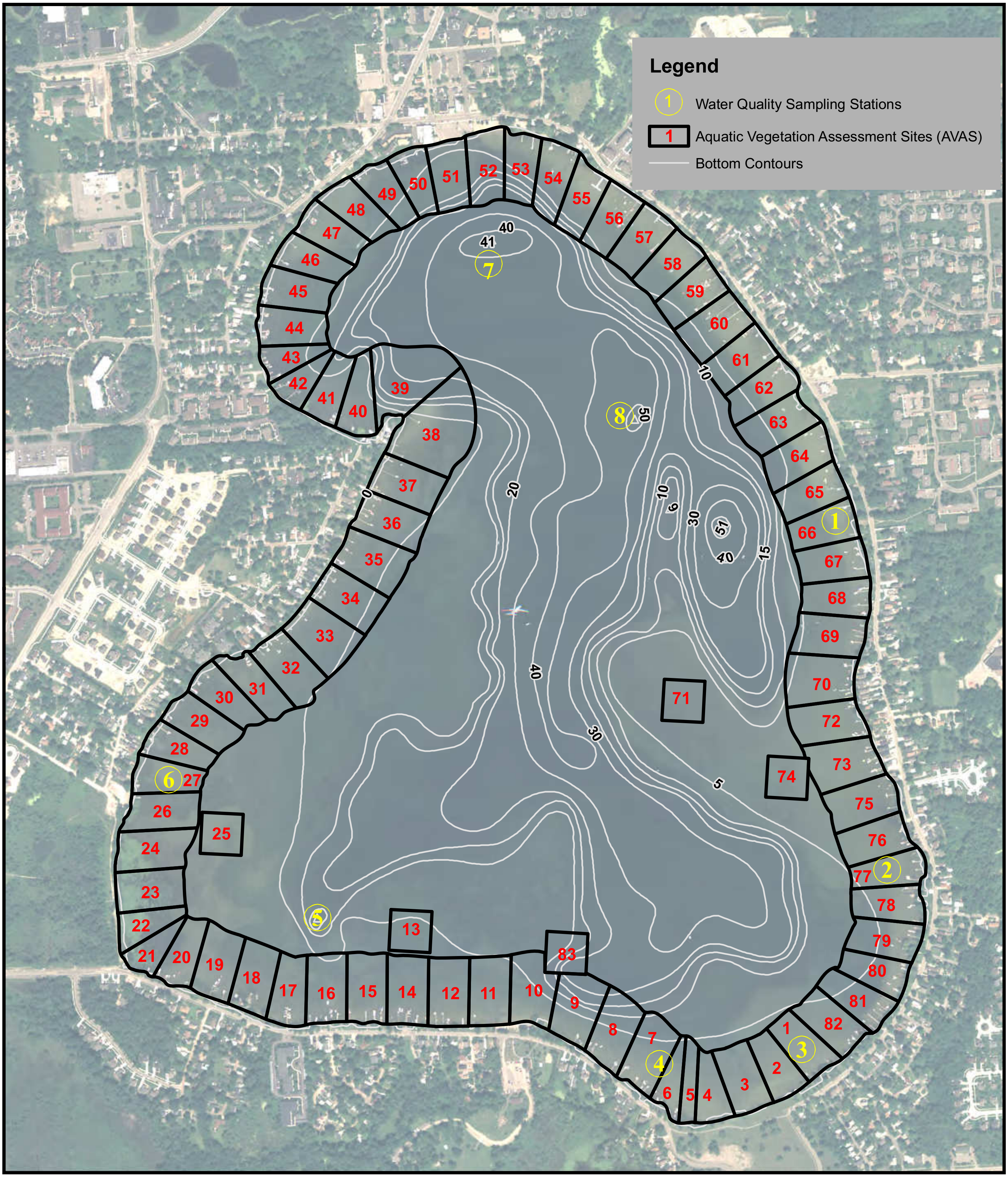
WATER QUALITY AND LAKE VEGETATION ASSESSMENTS/ BOTTOM CONTOUR MAPPING

The Institute for Fisheries Research Lake Inventory digitized contours has been utilized for the approximate lake bottom contours. The dataset, known as the Digital Water Atlas v1.0, developed under the Digital Water Atlas Project has been incorporated with the City of Novi and City of Walled Lake GIS dataset. The Walled Lake "Bottom Contour Map", typically referred to as a hydrographic map or depth chart, has been included as Figure 2.9.

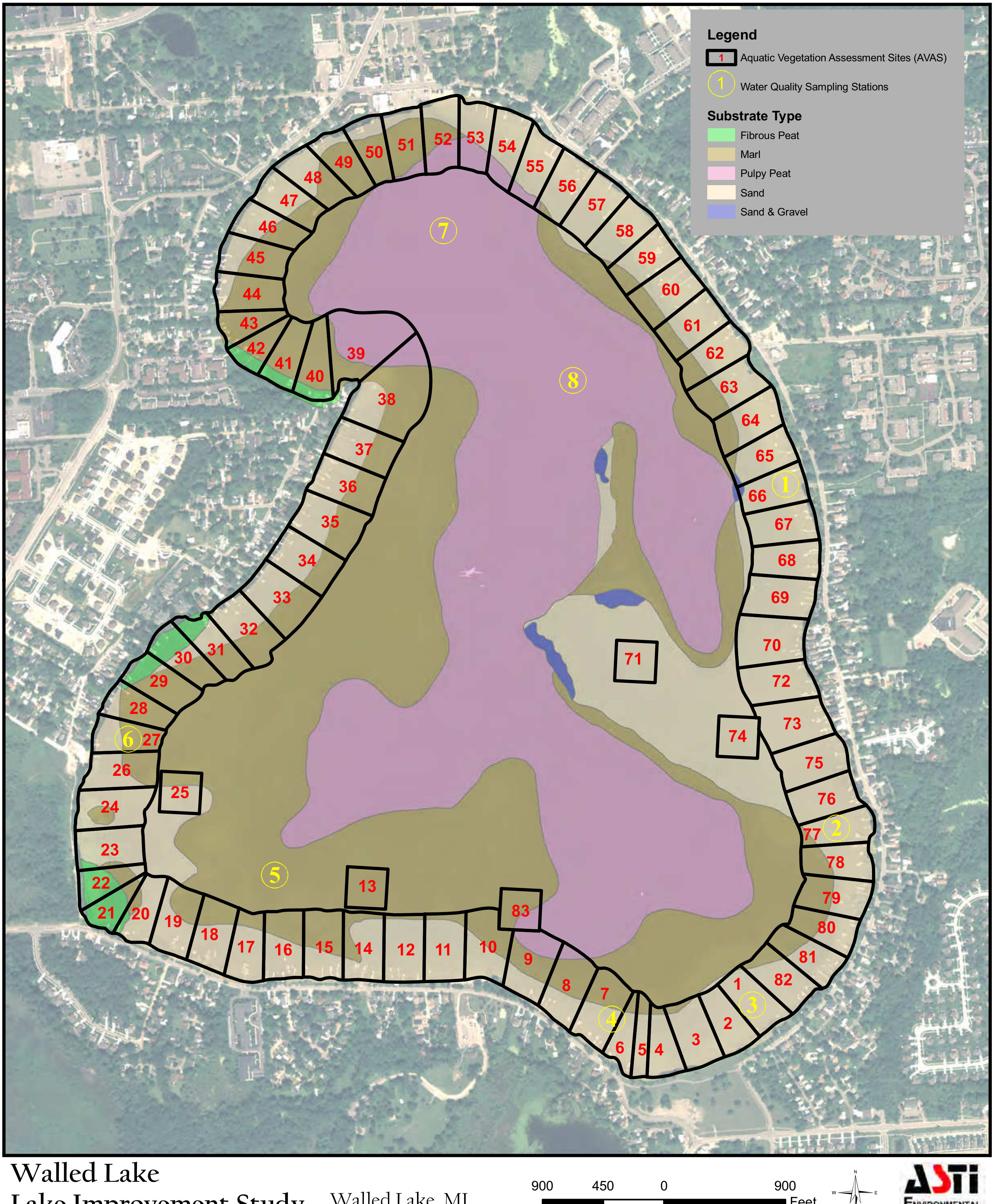


Walled Lake
Lake Improvement Study

Walled Lake, MI

Created for: Walled Lake Improvement Board
Created by: AGS, August 17, 2009, ASTI Project 7048

Figure 2.1 - Vegetation Sampling Areas



Walled Lake
Lake Improvement Study

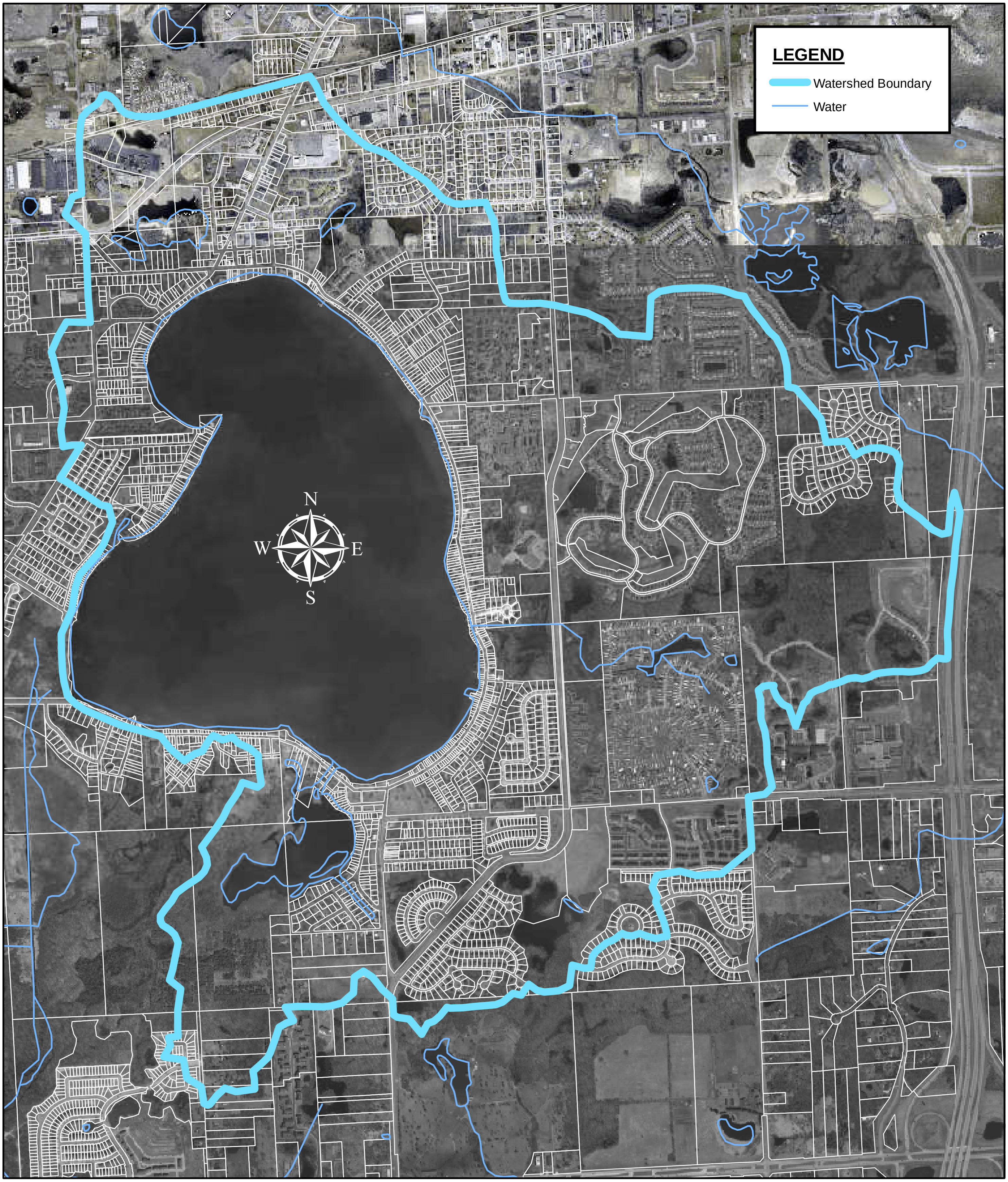
Walled Lake, MI

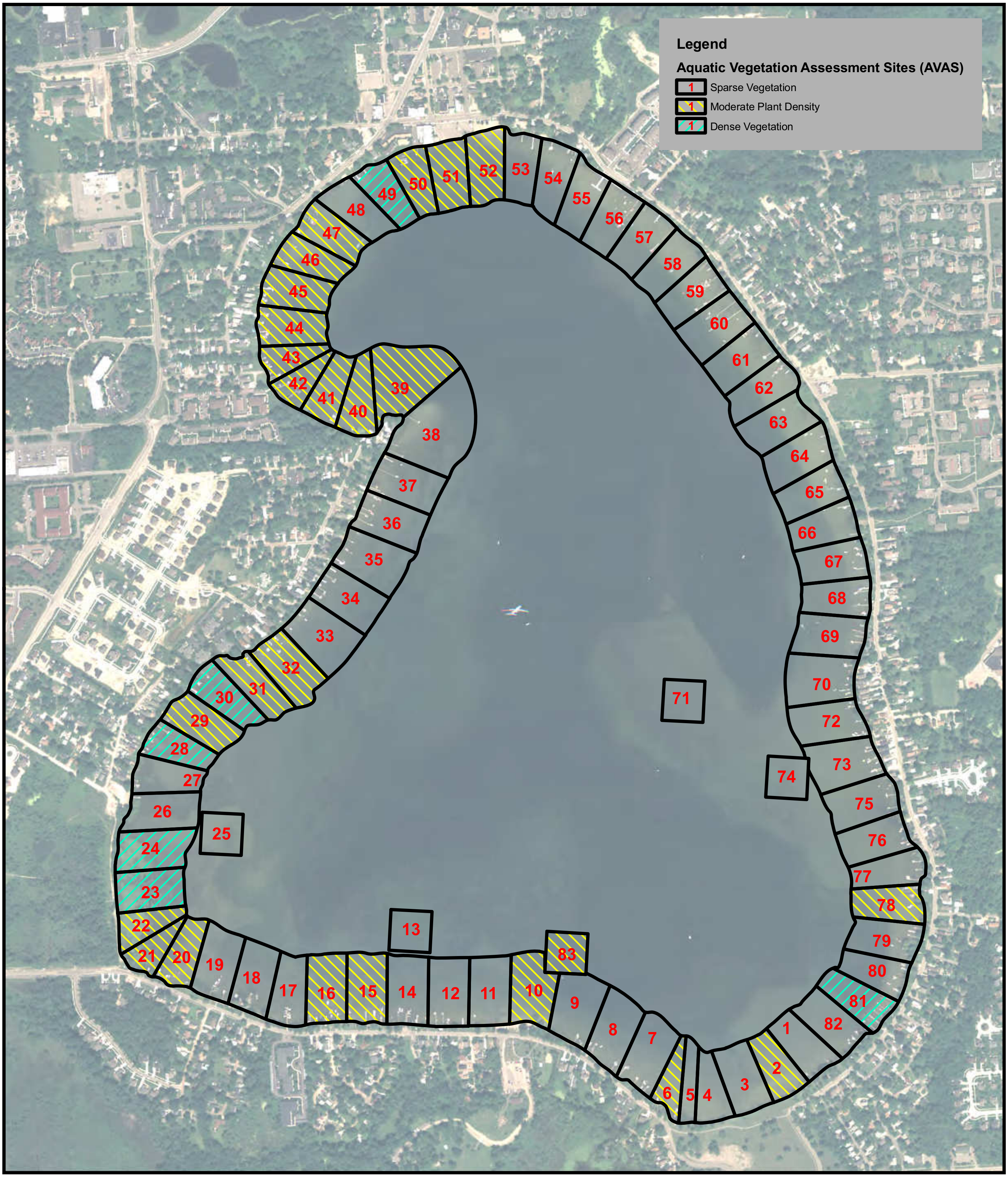
ASTI Environmental

Created for: Walled Lake Improvement Board
Created by: AGS, August 17, 2009, ASTI Project 7048

Figure 2.2 - Substrate Types

FIGURE 2.5 WALLED LAKE WATERSHED BOUNDARY





Walled Lake
Lake Improvement Study

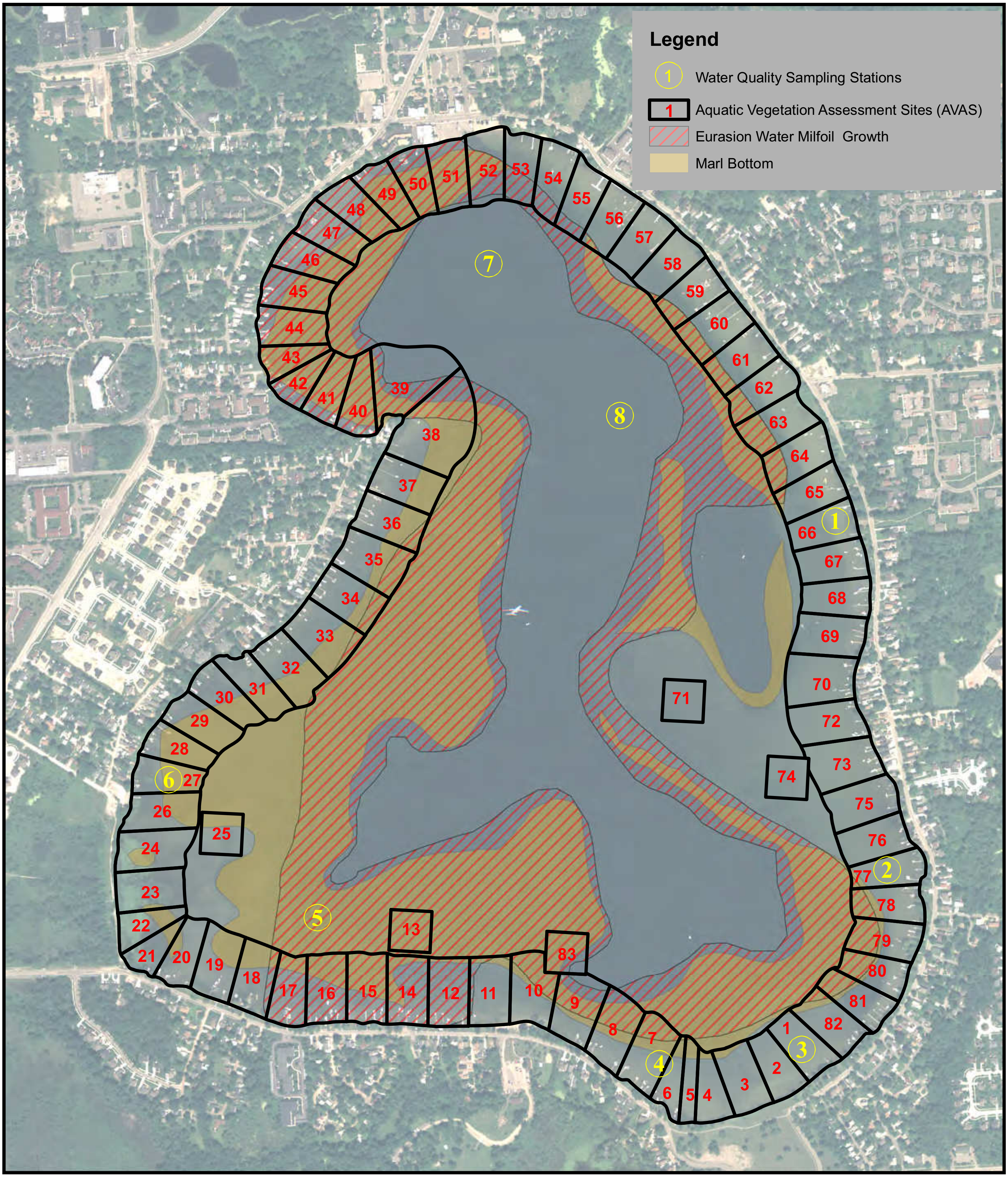
Walled Lake, MI

900 450 0 900 Feet

ASTI ENVIRONMENTAL

Created for: Walled Lake Improvement Board
Created by: AGS, August 17, 2009, ASTI Project 7048

Figure 2.6 - Plant Density by AVAS



Walled Lake
Lake Improvement Study

Walled Lake, MI

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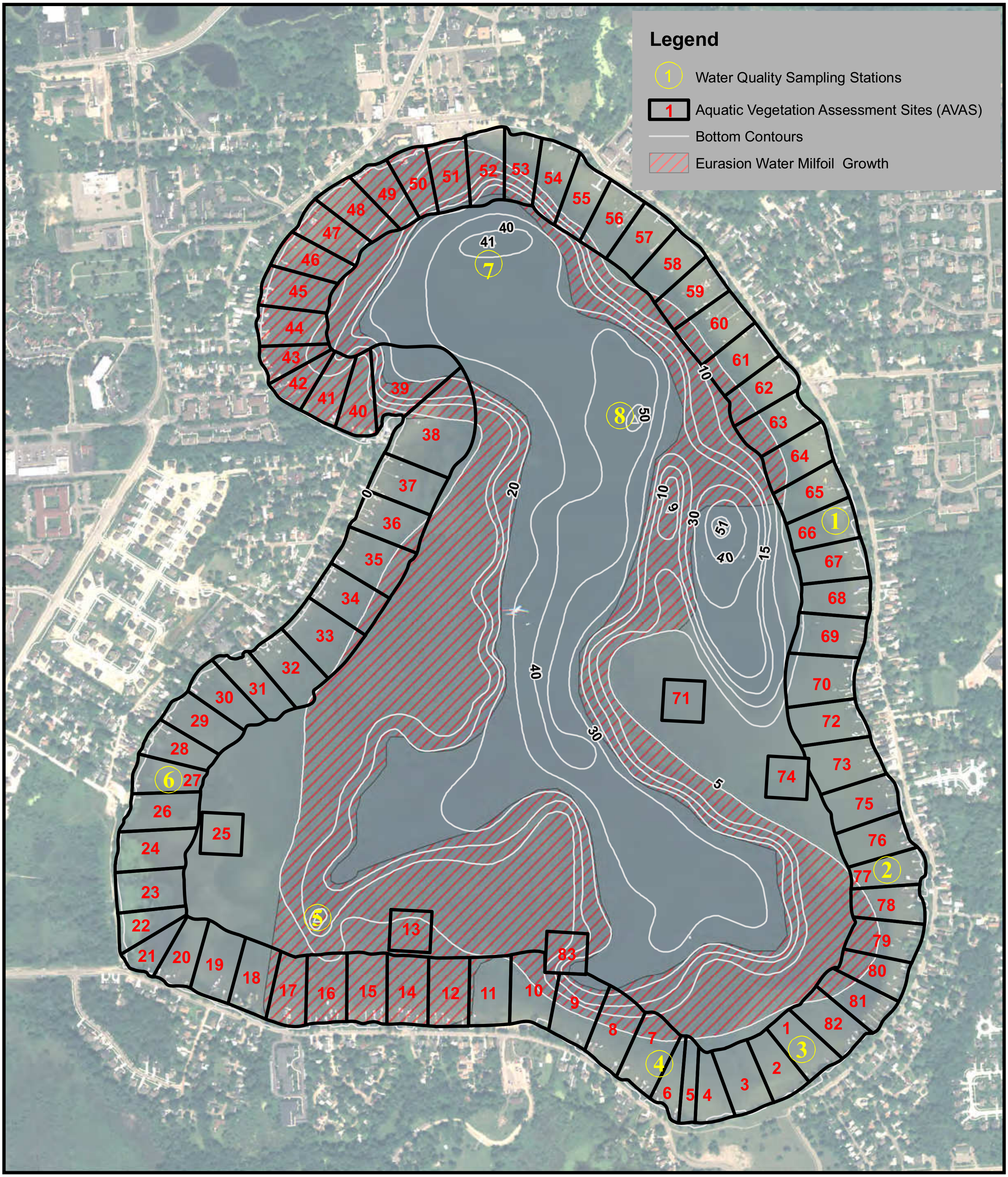
Figure 2.7 - Milfoil Concentration Relative to Substrate



Walled Lake
Lake Improvement Study

Walled Lake, MI

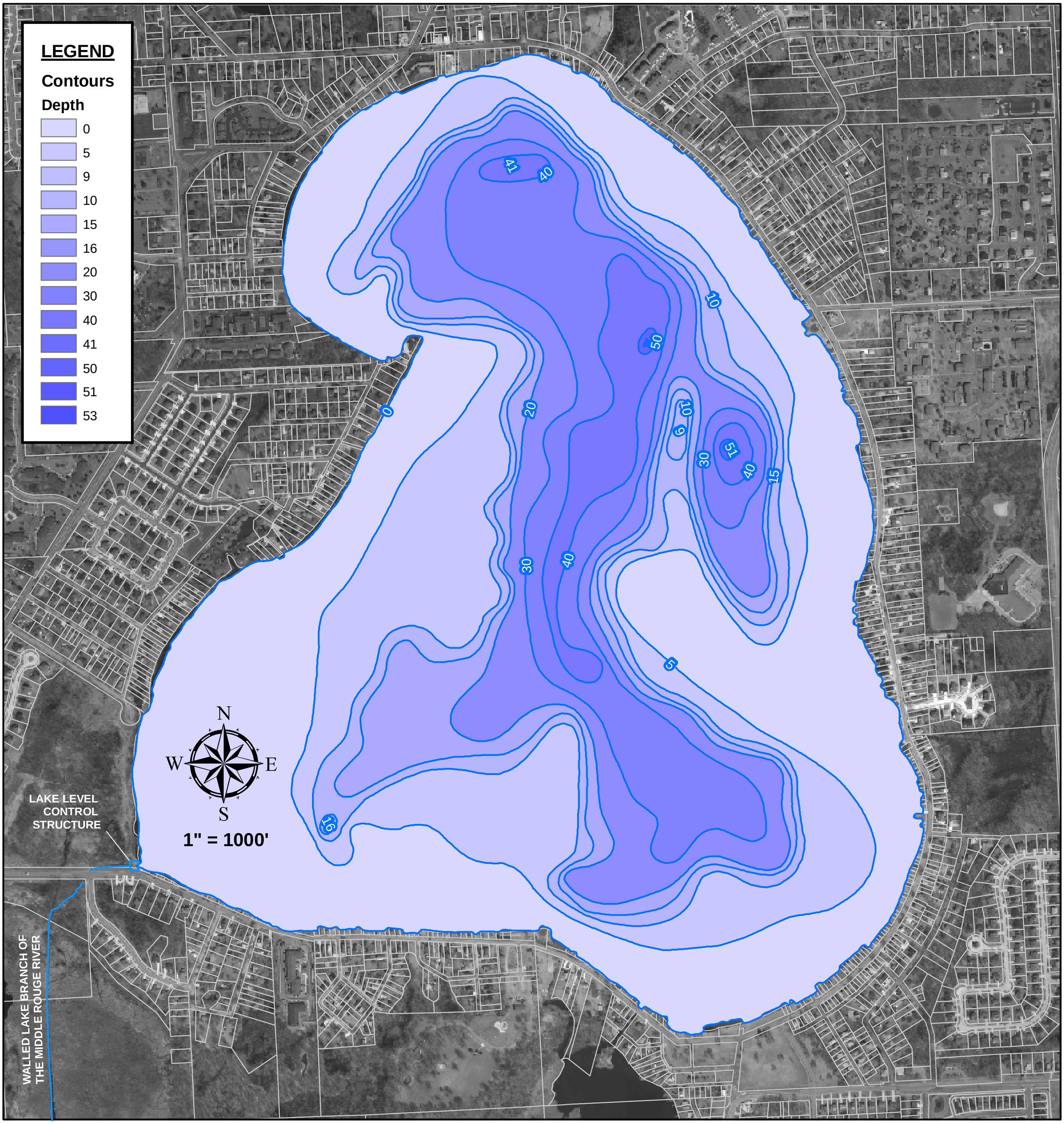
900 450 0 900 Feet

ASTI ENVIRONMENTAL

Created for: Walled Lake Improvement Board
Created by: AGS, August 17, 2009, ASTI Project 7048

Figure 2.8 - Milfoil Concentration Relative to Depth

Figure 2.9 WALLED LAKE BOTTOM CONTOUR MAP



Water Surface Area: 652 Acres
Water Volume: 8,062 Acre-Feet

Note: Water depth information obtained from Digital Water Atlas of Michigan, State of Michigan: Michigan Department of Natural Resources Fisheries Division Institute for Fisheries Research. August 2004.

SECTION 3

LAKE ASSESSMENT

A. INTRODUCTION

One of the objectives of a Lake Board is to develop a special assessment district to identify persons having record interest in the title to, right of ingress to, or reversionary right to a piece or parcel of land that would be affected by the permanent change in the bottomland of the Lake. Parcels of land and local units, which benefit by the improvements of the lake, must be included in the assessment. The assessment district serves as the mechanism to fund lake improvement projects.

Various assessment methodologies may be employed to establish an assessment district. Following are options, which are intended to assist in the development of the assessment district.

Option A – Assess Riparian Properties
Assessing only riparian properties represents the most straightforward method of developing an assessment district. This method may involve assessing properties equally, by land area, or lake frontage. Common Access parcels, such as private parks or boat launches operated by a local association, condominium developments, and apartment complexes would then be responsible for allocating the cost amongst the persons having access rights to those parcels and ultimately the Lake improvements. Walled Lake contains 101 Walled Lake parcels and 275 Novi parcels for a total of 376 riparian land parcels. A map of the riparian land parcels is shown in figure 3.1.

Option B – Benefit Units
Developing benefit units requires identifying and assessing all properties or units that have legal access rights to the Lake and weighting the assessment according to a benefit unit factor. This may include condominium units, apartment complexes, and subdivision lots with deeded access to a common riparian parcel. This method is more labor intensive in that it requires obtaining deeds and or association documents to identify access rights to such parcels. Once these parcels and their access rights are identified a benefit use factor is assigned, which serves to weight the assessment of the parcel based on the access rights. Table 3.1 provides an example of possible assessment groups and benefit use factors.

Table 3.1 Benefit Use Factor Examples

Group #	Access Rights	Benefit Use Factor	Unit
1	Riparian Property Owners (Lake Front Parcels)	1	Per Lot
2	Condominium Developments with Marina/Boat Launch	0.6	Per Condo Unit
3	Condominium Developments with Developed Park Area	0.5	Per Condo Unit
4	Condominium Developments with Undeveloped Lake Frontage	0.4	Per Condo Unit
5	Apartment Complexes	0.4	Per Apartment Unit
6	Parcels with Deeded Lake access through developed park/common area.	0.6	Per Unit
7	Parcels with Deeded Lake access through undeveloped park/common area.	0.3	Per Unit

The basis of the benefit use factors are as follows:

Group 1- Riparian Property Owners (Lake Front Parcels)
These lots have the greatest benefit due to the accessibility to the Lake. These lots have full use of the lake including but not limited to docks, boats, swimming, fishing, and an unrestricted view of the Lake.

Group 2 - Condominium Developments with Marina/Boat Launch
These condominium developments have direct frontage on Walled Lake and may have docks available for the residents and/or a boat launch. The assessment would be per condominium unit.

Group 3 - Condominium Developments with Developed Park Area
These condominium developments have direct frontage on Walled Lake with a developed park area or beach adjacent to the Lake. The assessment would be per condominium unit.

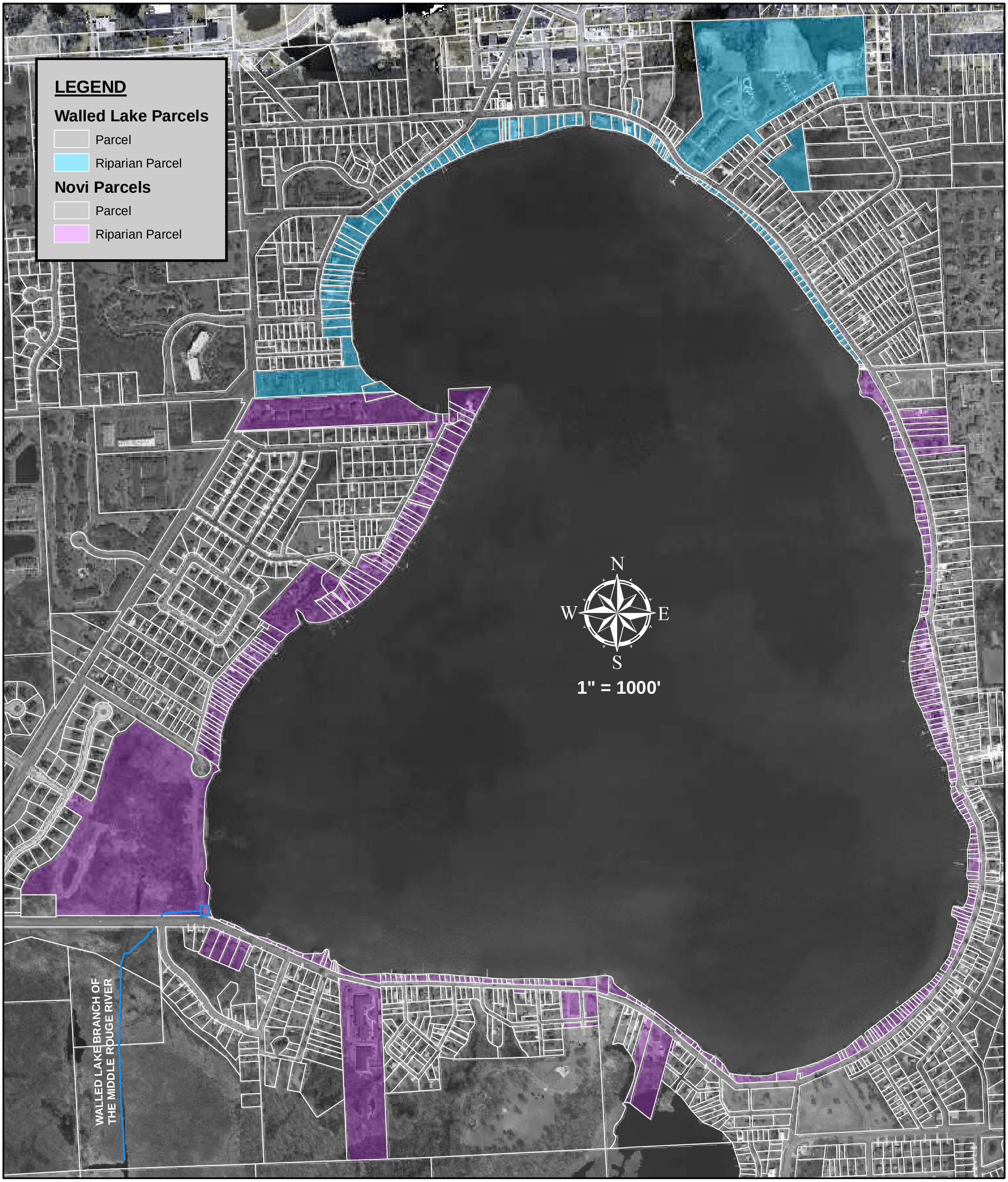
Group 4 - Condominium Developments with Undeveloped Lake Frontage
These condominium developments have access to Walled Lake and have an undeveloped common area adjacent to the Lake. The assessment would be per condominium unit.

Group 5 - Apartment Complexes
These apartment complexes have access to Walled Lake through a common area. Assessment would be per number of units.

Group 6 – Parcels with Deeded Lake Access through Developed Park/ Common Area
These parcels have access rights to a common parcel that has been developed as a park or beach area. Access rights are granted through deeds and restrictions or subdivision association by-laws.

Group 7 – Parcels with Deeded Lake Access through Undeveloped Park/ Common Area
These parcels have access rights to a common parcel that has a park area that has not been developed beyond walking trails or board walks through undeveloped natural vegetation. Access rights are granted through deeds and restrictions or subdivision association by-laws.

FIGURE 3.1 RIPARIAN PARCELS



SECTION 4

LAKE MANAGEMENT ALTERNATIVES

A. INTRODUCTION

Lake management goals should include efforts to maintain a proper balance of plants within the lake while retaining recreational and other desired uses. A Management Program is recommended to include two phases: long-term management and short-term management.

Short-term management of macrophytes through cutting or herbicides has been practiced for many years in Michigan and throughout the country. Long-term control methods are not as well developed, in part because the physiology and environmental factors controlling growth of aquatic plants are still not fully researched or understood.

The managing of aquatic plants does not involve complete eradication of plant species, but maintains a balance which while allowing recreational uses, retains the critical functions of providing food and cover for fish, waterfowl, and other aquatic life.

B. LONG-TERM MANAGEMENT (NUTRIENT CONTROL)

Typically an effective aquatic plant management program must give proper attention to the nutrients that enter the lake. Aquatic plants require nutrients for their growth and regeneration, and the presence of these plants in significant quantities is a symptom of high nutrient levels. Long-term management of macrophytes attempts to limit the movement of nutrients off the watershed and into lakes thereby limiting the abundance of the aquatic plants. Walled Lake’s watershed is characteristic of residential properties, a golf course, wetlands, and a commercial district. It is expected that large levels of nutrients would be present in Walled Lake under these conditions. As discussed previously Walled Lake’s nutrient levels were determined to be very low. Though current levels are low it is still important to maintain Best Management Practices for nutrient control to ensure the future overall health of Walled Lake and the surrounding watershed.

Sources of nutrients are either natural or a result of man's activities (cultural). Natural nutrient sources will enter a lake even without man's presence, and typically contribute low amounts of nutrients to a water body. Nutrient sources which are man-made typically have large volumes and concentrations of nutrients which can act to accelerate the eutrophication of the lake through increased plant growth.

Natural nutrient sources can include runoff from forests, meadows, and wetlands; direct precipitation on the lake surface; sedimentation from erosion; wildlife wastes; deposition of leaves, pollen, and dust; groundwater influxes; nitrogen fixation by plants; and sediment recycling.

Cultural nutrient sources include urban storm water runoff; septic tank discharges; construction activity runoff; wetland drainage for agricultural use; agricultural runoff; industrial and domestic wastewater; runoff from managed lawn areas; and atmospheric fall-out of wind-borne fertilizers from land and industry.

It is valuable to determine which nutrients are entering the lake from natural or cultural sources and in what quantities. It is then possible to adjust activities around the lake to attempt to reduce nutrient introduction. Extensive studies are typically required to make such assessments.

Long-term management techniques include proper land use, wise consumer use of commercial products, treatment of inflowing waters high in nutrients, diversions of waters high in nutrients, municipal and industrial wastewater treatment. Each of these techniques is discussed in the following text.

Proper Land Use
Watershed planning and proper land use are important factors in watershed quality. The State's Soil Erosion and Sedimentation Control Act is a critical tool to limit the movement of sediments into surface waters during earth moving and grading activities. Many communities are enacting additional local ordinances to regulate land uses.

Some examples of wise land use practices are listed below. These practices can aid in reducing the movement of nutrients into lakes from their watersheds.

1. Advocate sediment control from earth moving and grading activities.

2. Preserve wetlands and watercourses as no development areas.

3. Promote greenbelts or vegetative buffer strips around the lakeshore or streambanks.

4. Limit or restrict fertilizer use within the lake’s watershed. Use slow release nitrogen and zero phosphorous fertilizers.

5. Promote pre-treatment of storm water prior to its entering the lake, through the utilization of storm water manhole sumps (catch basins), water quality basins and best management practices.

6. Preventing leaf litter from entering the lake, by promoting community collection and disposal of leaves in lakefront areas. Discourage the burning of yard waste.

7. Require routine inspection and maintenance of catch basins in city storm sewer systems. Install oil/gas separators in existing storm sewer systems discharging to lake.

8. Restrict or prohibit development in areas with high groundwater levels or soils with poor nutrient trapping capabilities.

9. Require an environmental impact statement for developments with the potential to degrade water quality.

Wise Consumer Use of Commercial Products
Several detergents and fertilizers among other commercial products can contain significant levels of nitrogen and phosphorus which can ultimately end up in natural waters. Nutrient loading can be reduced by restricting or reducing the use of these products, or by substituting low nutrient products. High phosphate detergents in Michigan have been banned.

A low nutrient fertilizer can be used if the soil does not require phosphorus. This can be determined through soil testing by an Oakland County - Cooperative Extension Agent or by obtaining a soil test kit from the local Michigan State University Extension Office.

Diversions of Waters High in Nutrients
Diversions of waters involves re-routing high nutrient water away from a lake. While this method often involves municipal wastewater, it can be utilized for any waters with high nutrient levels. This method can result in an increase in water quality when implemented. Diversions however are not considered to be proper land management as they only transfer problems to communities downstream.

Diversions of storm water discharges through grassed swales, water quality basins, or other Low Impact Development (LID) methods are recommended best management practices.

Treatment of Inflowing Waters High in Nutrients
Some situations may require that inflowing water be treated to reduce nutrient levels prior to entering the lake. Streams may carry substantial nutrients from storm water runoff. Chemically or physically treating the inflowing water may be more feasible than attempting to control the diverse nutrient sources contributing to the streams.

Municipal and Industrial Wastewater Treatment
While most communities do not have problems with municipal wastewater discharges, when they are present, they can contribute significant amounts of nutrients for plant growth. Diversions of this water or land disposal are possible alternatives to eliminate this nutrient source.

Industrial wastewater varies greatly in quality. Any known contributors must be considered in the lake management program. A pre-treatment program may be established with many industries in order to limit or reduce the amount of nutrients being discharged from their operations.

C. SHORT-TERM MANAGEMENT (AQUATIC PLANTS)

As noted in the previous section, lake management activities are practiced in the short-term as well. The short term is often periods of 2-5 years for most lake programs that are in the beginning stages of development. During these first years, the goals and objectives are developed, as well the plans for financing the proposed projects to be undertaken by the lake residents.

There are a variety of short-term management techniques that can be implemented on a lake. The lake residents will want to see quick results and get the most for each dollar that has been contributed or assessed for a particular project. ***It is wise and highly recommended that a Lake Board carefully plan their proposed projects. Any proposed project should be based upon realistic goals and objectives.***

Several methods of short-term management activities are summarized in the following discussions.

BIOLOGICAL CONTROL - Biological control of aquatic vegetation is presently the least understood and utilized of the techniques for managing aquatic plant species. A typical biological control program would include the introduction of an organism which would compete with, prey upon, inhibit the growth of, cause disease in or parasitize a plant species which is inhibiting the use of a lake.

The introduction of Grass Carp is an example of a biological control. Triploid grass carp, an exotic species from central Asia, have been introduced into lakes in 31 states. They are sterile and, therefore, cannot reproduce. Unfortunately, grass carp are selective feeders; the weed they like to eat the least is milfoil, which is one of the largest weed problems that develop and proliferate in Michigan lakes.

Act No. 286 of the Public Acts of 1929, and Act No. 196 of the Public Acts of 1958 state that the introduction and release of exotic, foreign or non-native insects, fish or other animals into Michigan without specific authorization is strictly forbidden.

ENVIRONMENTAL MANIPULATION - The objective of environmental manipulation is to alter one or more physical or chemical factors critical to plant reproduction and growth. This goal of this practice is to make the environment less suitable or desirable for plant species to proliferate. This type of management technique can vary in relative economic and environmental practicability for a specific lake. It should be noted that once a lake environment has been altered from its current state, other challenging circumstances affecting enjoyment of the lake may develop. If this management technique is chosen, it is wise to alter one thing at a time and observe the resulting changes and reactions that occur as a result of implementation.

Most of these activities require a permit from the Department of Environmental Quality and some cases the U.S. Army Corps of Engineers.

Several methods of environmental manipulation such as dredging, aeration, nutrient inactivation, draw-down, dilution or displacement, shading, covering of bottom sediments and intensive use and periodic manual cleaning of shoreline areas are discussed below.

Dredging

Dredging is the process of removing material from the bottom of lakes in order to remove soft mucky sediments that may be rich in nutrients that enhance nuisance plant growth. It is also typically the goal to dredge the lake to a depth where natural sunlight cannot penetrate, therefore discouraging plant growth.

Advantages of dredging programs are that they remove bottom sediments of the lake and deepen the lake, temporarily removing nuisance aquatic plants and reducing the growth of new plants.

The disadvantages of dredging operations are that they cause a temporary increase in the silt suspended in the water, which may smother bottom-living organisms and animals when it settles. A fish restocking program may also be a necessary part of these projects, if implemented.

A key disadvantage to this management technique is the relative cost. Associated with cost is the location of the disposal site that is necessary for such an operation. The farther the disposal site, the higher the cost. If a disposal site is not located contiguous to the body of water being dredged, the cost of transporting dredged material can become prohibitive.

State MDEQ permits are required for a dredging operation. Part of the permit process would be that an approved site for the deposition of the dredged material be included.

The actual cost of dredging a lake is dependent on several factors. A key factor is the relative amount of material that is to be dredged. It is also difficult to benefit from economy of scale for these operations, unless the amount of material is a minimum of 20,000 to 25,000 cubic yards. Most dredging companies that perform this type of work will only submit a bid if the dredging job is large enough. Figure 5.1, illustrates a hydraulic dredger which is a typical piece of equipment used to perform this work.

Aeration

Hypolimnetic Aeration is the introduction of air into the water to increase the dissolved oxygen concentration. This procedure is most often implemented in lakes where the deep water is devoid of oxygen. By adding oxygen to the deep water, the release of nutrients from the sediments may be reduced. In many instances following aeration, a decrease in nuisance algal populations and a shift to more favorable species is observed.

There are possible detrimental effects to cold water species if the warm surface waters are mixed with cool bottom waters; however, there are methods of aerating only the deeper waters. The aerator may also increase the turbidity of the water by re-suspension of the bottom sediments. Figure 4.2, illustrates a typical aeration system that would be used on a lake.

The use of aeration through air injection (diffuser) systems, introduces oxygen by causing the water in the hypolimnion (cold bottom water layer) to rise, pulling this water into the epilimnion (warm, surface water layer). When the colder, hypolimnetic water reaches the lake surface; it flows across the surface and eventually sinks, mixing with the warmer epilimnetic water. If the system is adequately powered and enough air is injected, this process continues and the metalimnion (transition zone between the epilimnion and hypolimnion) is broken down. Eventually, the entire lake becomes of nearly equal temperature with oxygen distributed throughout. The majority of oxygenation occurs through the water's contact with the atmosphere; relatively little oxygen increase occurs through direct diffusion from the bubbles. This method is more effective in deeper lakes due to the stratification of the lake temperature. For shallow lakes, it is less likely that complete circulation would result in any of the above mentioned benefits. This is because algae are less likely to become light-limited in shallow lakes, nor would water chemistry changes be as pronounced. It should be noted that very shallow lakes (4 feet or less) can be aerated by wind at the water's surface.

Other systems are available that may be applicable to non-stratified (shallow) lakes to enhance the water's oxygen content. Such systems include surface spray such as a fountain, impeller-aspirator systems, and pump-and-cascade systems.

Bacterial Augmentation

The introduction of microbes has been successfully used to break down organic matter and control algae and weed populations in lakes. The bacteria will break down organic material and muck at the bottom of the lake. Additionally, the microbes can compete for nutrients with the algae before the alga has a chance to feed. The microbes require oxygen, which makes it ideal for shallow lakes and use in conjunction with an aeration system.

State MDEQ permits are required for use of bacterial augmentation products. An MDEQ list of acceptable Michigan bacterial augmentation products is provided in Appendix J.

Nutrient Inactivation

Nutrient inactivation is the application of a chemical to a lake that binds with and immobilizes the nutrients necessary for plant growth. After the nutrients have been immobilized, the nutrients settle to the lake bottom. The chemical substance used in such a management program is usually a metal ion such as: iron, aluminum or calcium. The process of the immobilized nutrients settling may also reduce the suspended solids and decrease the turbidity and color, in addition to inactivating nutrients.

Nutrient inactivation has been useful for algae control, but has had little effect on the growth of aquatic plants. This technique may also have an adverse effect on a lake's biology by covering the bottom sediments and fish food sources with settling material.

This management technique is expensive.

Draw Down

Draw-down or artificial lake water level control is one method of controlling certain types of aquatic vegetation. This technique requires that the water level of a lake be lowered for a period of time that will allow exposure of shallow water areas, such as lake shorelines to air. This process dries out exposed plant life and kills them.

In Michigan this process is used effectively during the winter months. The lake levels are usually lowered approximately 6 to 12 inches for a period of at least two months. In the process of the weeds being eradicated from the shoreline, the residents also are given the opportunity to perform lake shore cleanup activities and maintenance. This management technique is only recommended on lakes that have drawdown facilities, and that are known to have a watershed of significant size that will allow the spring runoff to fill the lake back up to the desired lake level.

Many submergent macrophytes such as milfoil are controlled by this procedure; but, unfortunately, some emergent macrophytes actually benefit from it. This method also does not control algae. Figure 5.4, lists the reaction that several plant species have to lake level draw-downs.

Dilution or Displacement

Dilution or displacement of low quality water with water or higher quality may lessen the proliferation of nuisance aquatic plant growth. However, a supply of higher quality replacement water must be available, as well as an acceptable means of disposing of lower quality lake water.

The impact on the downstream receiving waters must be accounted for prior to implementing such a lake management technique. Due to the limited area of contributing watershed area for most lakes in the State of Michigan, this technique is not generally recommended.

Shading

For prolong periods of 4 weeks or greater, shading has been effective in reducing certain submergent aquatic plants by limiting the amount of light necessary for plants to grow. Light reduction using two methods of shading have been practiced, consisting of dyes and floating plastic sheeting. The dye shading technique has been effective for submergent macrophytes and limited control has been observed for emergent macrophytes. The floating plastic shade has been more effective in small ponds and adjacent to dock areas and swimming areas. The wave action and currents of larger lakes generally limit the use of floating shades to small ponds.

Covering of Bottom Sediments

The covering of bottom sediments is accomplished with a sheeting material such as black plastic and/or a particulate material, such as sand, clay or fly ash. These materials are generally considered inert. This is effective in two ways: the sheeting prevents the exchange of nutrients from the sediments to the overlying water, and it can retard the establishment of rooted aquatic plants. If sheeting is chosen as a management technique, the sheeting must be porous so as to allow lake bottom gases to escape. This will prevent the sheeting material from floating to the surface. It is generally not recommended that placement of bottom covering be made over known or suspected ground water springs that may be feeding a lake.

Disadvantages of covering are that the bottom-dwelling animals are usually killed when the sediment is covered. The control method is generally viewed as a temporary measure since aquatic plants gradually re-colonize over the cover.

Intensive use and Periodic Manual Clearing of Shoreline

This practice can prove to be an effective means of aquatic plant control in small beach areas. The rooted plants must produce sufficient food in their leaves to maintain their root systems. Frequent cutting of the plants leaves, or their destruction by wading and swimming, will eventually lead to the death of the plant's root system, by which aquatic plants generally spread. This technique is particularly effective with emergent vegetation, and water lilies. Similar to weeding a garden, this process must be repeated on an as needed basis and the aquatic plants must be eliminated before they can become established and spread of large unmanageable areas.

Mechanical Weed Harvesting

Mechanical weed harvesting employs the cutting and removal of aquatic plants from selected areas of a lake; generally away form the lake shorelines. This procedure is similar to mowing a lawn. Figure 5.5, illustrates a typical mechanical weed harvesting operation. The weeds are cut and removed from the water by a series of conveyors. When the plants are cut the majority of them float to the top and must be removed and taken off-site. The plants make good compost for farmers. In removing the cut material from the lake, water quality occasionally improves somewhat if the amount of nutrients removed in plant material is greater than the amount of nutrients entering the lake from the watershed.

Advantages of mechanical weed harvesting are that herbicides are typically not added in the same area of harvesting operations. There also is no waiting period after mechanical weed harvesting has been implemented, so recreational uses can be immediately restored. A large organic load is removed when the cut plants are removed from the lake.

Some disadvantages of mechanical weed harvesting are that the harvester cuts everything in its path, including desirable aquatic plant species. Most weed harvesters cannot operate in shallow areas, such as lake shorelines, small bays or near docks. During the process of removing the cut vegetation, fish and other invertebrates may also be removed. The fragments of certain plants may actually promote additional growth. The cutting equipment rental and removal equipment rental is quite expensive. Also, weed harvesting is not effective for the removal of planktonic and filamentous algae.
The cost of mechanical harvesting will vary with the accessibility of the lake, and the type of equipment that can be put on the lake.

Herbicide Use
Herbicides are an effective method of managing aquatic plant and algae growth. There are a number of herbicides available which offer varying degrees of action time, persistence, cost, selectivity and safety.

Advantages of herbicides are that there is a degree of selectivity, meaning that noxious plants can be eliminated, while desirable plants can still be preserved. Most modern herbicides have a very low toxicity to humans or fish, if any. The application of herbicides early in the year kills the plants before they reach maximum growth; and there is less vegetation to decompose on the bottom. Systemic herbicides kill plants from the root, not leaving any fragments to continue growing. Herbicides give immediate results and the costs are generally limited to paying for the application of the herbicide.

Disadvantages of herbicides are that they are prone to wind or current action and may concentrate near a lake shoreline. They may also affect private wells located near the lake. The Department of Environmental Quality imposes limits on recreational activities on a lake for a period of 24 to 72 hours after application, depending upon the herbicide that is applied. The decomposition of plants settling to the bottom may deplete the dissolved oxygen level in the water, causing a fish kill. A permit must be obtained prior to application of chemical herbicides, by a state licensed applicator.

It is important with herbicide use that they are properly used in every way, as noted on their labels. Improper use can result in harm to humans or wildlife.

D. CURRENT WALLED LAKE MANAGEMENT PRACTICES

Herbicide Treatment

The Bayside Sports Bar and Grille and Shoreline Condominium Association currently have permits to apply herbicides. It is understood that the herbicide treatments are limited to the areas adjacent to those properties, which are located near the north and northwest corners of the Lake.

Weir Outlet Control

The Walled Lake water elevation is currently controlled by an Oakland County lake level control structure located near the southwest corner of the Lake. The Lake is maintained at a legally established Lake level. During the dry warmer summer months it is common for the water level of Walled Lake to be below the legal limit and no outflow will be experienced. Because Walled Lake does not have an inletting river or stream and is fed by groundwater and storm water runoff, the lake level will remain at or below the weir during these dry times until adequate rainfall is received to raise the Lake elevation. A theoretical surface water budget has been prepared to better understand hydrologic process and outlet control function of Walled Lake.

SECTION 4

LAKE MANAGEMENT ALTERNATIVES

FIGURE 4.1 Hydraulic Dredging Equipment

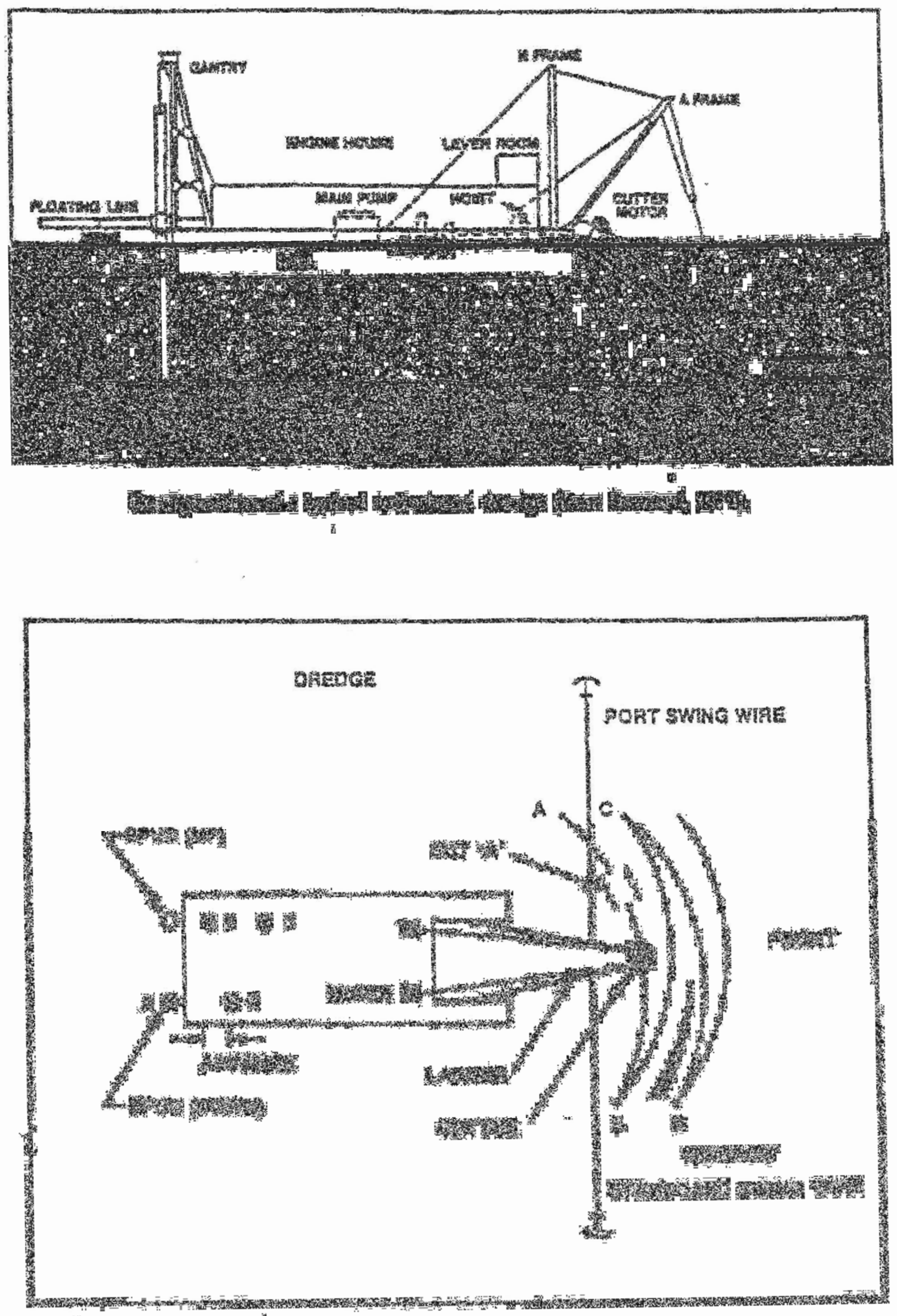


FIGURE 4.2 Lake Aeration System

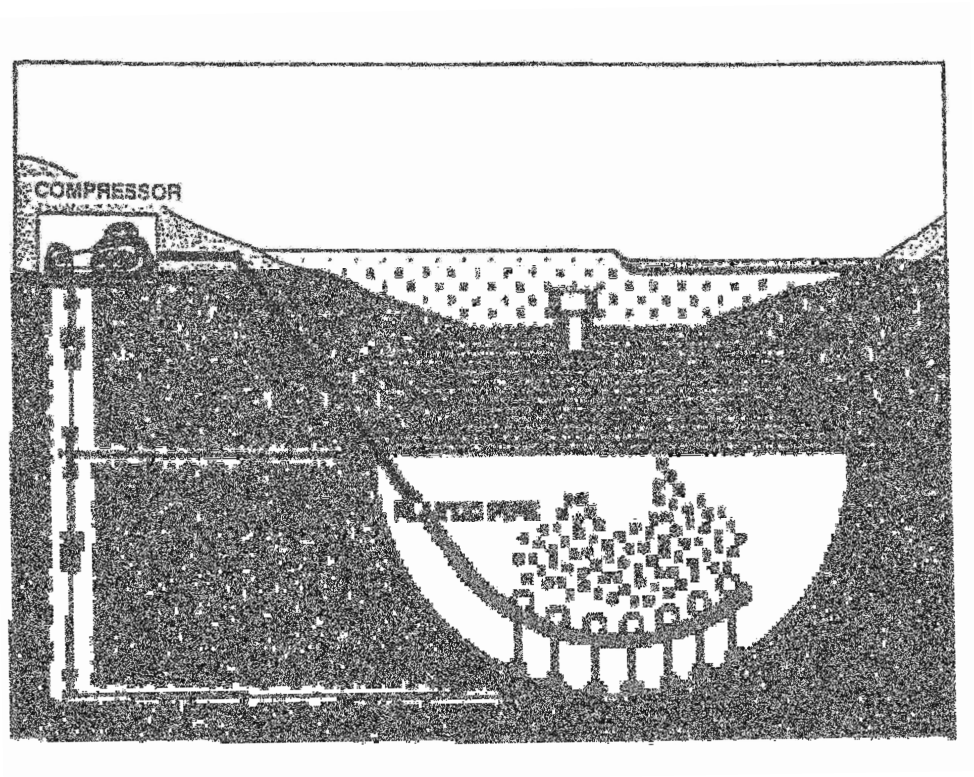


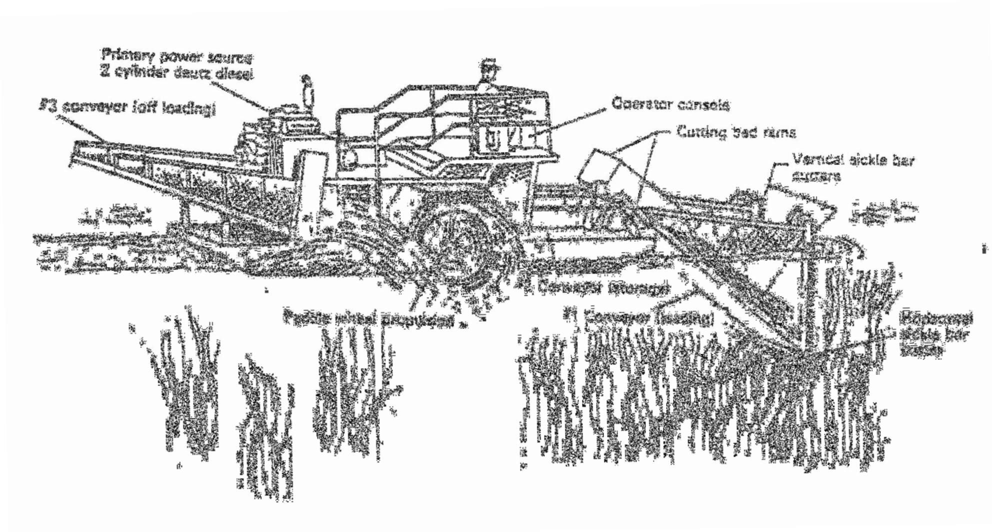
FIGURE 4.3 Lake Draw-Down Effects on Plant Species

Decrease
Coontail *(Ceratophyllum demersum)*
Brazilian elodea *(Elodea = Egeria densa)*
Milfoil *(Myriophyllum spp.)*
Southern naiad *(Najas guadalupensis)*
Yellow Water Lily *(Nuphar spp.)*
Water Lily *(Nymphaea odorata)*
Robbin's Pondweed *(Potamogeton robbinsii)*

Increase
Alligator Weed *(Alternanthera philoxeroides)*
Hydrilla *(Hydrilla verticillata)*
Bushy Pondweed *(Najas flexilis)*

Variable
Water Hyacinth *(Eichhornia crassipes)*
Common Elodea *(Elodea canadensis)*
Cattail *(Typha latifolia)*

Figure 4.4 Mechanical Weed Harvesting



SECTION 5

LAKE IMPROVEMENT RECOMMENDATIONS

A. GOALS AND OBJECTIVES DISCUSSION

The research performed with this study bears out the fact that Walled Lake functions as a thriving, viable water body. As with any viable lake, an ecological balance must be maintained in order for the lake to survive. The resources utilized behind the research performed have been varied but all necessary to accurately assess Walled Lake's current condition and improvements to the lake that are necessary in order for it to survive and thrive.

In addition to research detailed in prior sections, discussions with the Walled Lake Board identified overall goals and objectives for lake improvement. These included:

- Reduction in aquatic weed growth
- Reduce/eliminate closing of E.V. Mercer Beach due to high E.coli levels

The primary objective for this section of our report is to summarize deficiencies within the Lake and provide practical and economical lake improvement recommendations given the stated goals and objectives of the Lake Board. As with most Lake Improvement Boards, funding for construction improvements is limited. Therefore, a thoughtful approach to remediate the identified lake problems is necessary. Our recommendations are therefore categorized into Short Term and Long Term Lake Management plans.

Short Term Improvements constitute those activities which can be performed with minimal cost and construction impacts to the Lake. These improvements require little if any design or regulatory effort (permits, approvals, etc.). These improvements are intended to be implemented on a yearly basis for the most part.

Long Term Improvements include those activities which will typically require more expense and longer construction timing and which may pose complicated access issues to the lake. The lead time necessary to raise funding for these types of improvements can extend well beyond 1 year. For these reasons we consider Long Term Improvements to be those implemented for year 3 and beyond of the Lake Management Plan.

The Lake Management Plan (Short and Long Term Improvements) timing and costs should constitute the basis behind a Lake Area Special Assessment District for Walled Lake.

Our research on Walled Lake has found that the following conditions exist:

- Low Nutrient Levels

- Greater weed growths in depth of 5 to 16 feet in depth and silty and marly bottom substrates

- Abundant Zebra Mussels, which is an invasive specie

Our Lake Management recommendations include detailed descriptions of the treatment, estimated costs to implement, and the initial frequency recommended for the treatment. Finally, implementation options and procedures for the management plans are outlined.

B. LAKE MANAGEMENT PLAN

OVERVIEW - Discussion with the Walled Lake Board indicates that the majority of residents of Walled Lake would like to eradicate or reduce the growth of aquatic weeds in Walled Lake. Short term recommended actions include:

Herbicide Treatment Program - We recommend that an herbicide treatment program be implemented annually. Applications may have to be performed two to three times annually as needed.

The MDEQ Water Bureau has produced a table containing information about the herbicides permitted for aquatic plant and algae control in Michigan (see Appendix I). Considering the August 3rd and 5th vegetation survey results, it appears that an annual application of herbicides may be needed at Walled Lake to control early and mid season growth of Eurasian water-milfoil.

It is important to note that complete eradication of all aquatic plants in a lake is not the objective of an herbicide treatment program. Most plants play a very important role as part of the ecological health of a lake system. Therefore, the purpose of an aquatic plant management program is to manage the growth and proliferation of aquatic nuisance plants from only selected areas. The areas that are to be managed should be based upon those parcels that have existing homes and those areas that need to be cleared for access to the lake.

It is recommended that a product such as 2,4-D, Fluridone, or Diquat Dibromide be used to control the Eurasian Water Milfoil in the areas identified as densely populated. It is estimated that the densely populated encompasses 30 acres of the Lake. The application should be performed in the spring (mid-May), while the Milfoil is still relatively small and won't leave as much decaying plant matter on the bottom of the lake. Approximately 30 days, after the initial application, a second application should be applied as needed to follow up and to control any remaining Milfoil growth. The process will probably have to be applied on an annual basis but the overall treatment area may decrease based on the effectiveness of the previous year's application, thereby resulting in a reduction of yearly management costs.

The use of contact herbicides should be avoided when using 2,4-D to control the growth of Eurasian Milfoil. The main reason for this concern is that 2,4-D acts as a systemic control method, whereas contact herbicides may kill the tops of the plants and interfere with the systemic action of 2,4-D.

Please refer to Figure 2.6, 2.7 and 2.8 which illustrates the Aquatic Plant densities for Walled Lake, based upon the August 3, 2009, plant survey. The licensed herbicide applicator should conduct a pretreatment survey with a representative as designated by the Lake Board, in order to confirm the general limits of the plant growth and finalize the treatment plans.

In addition to recommended herbicide treatment modifications an annual aquatic plant survey should be performed, at least for the first three treatment seasons, in order that a plant response can be observed and recorded. These observations will allow the herbicide treatment program to be further modified as needed and may provide an early indication as to the success of the program. A state licensed herbicide applicator can perform this task once the program begins, and can include these observations along with the permit application to the MDEQ.

ESTIMATED COST:

Aquatic Herbicide Treatment Program (Milfoil) – Initial Application

$375/Acre x 30 Acres	$11,250
Permit Fee	$ 1,500
	$12,750

Aquatic Herbicide Treatment Program (Milfoil) – Follow Up Application

$375/Acre x 10 Acres	$ 3,750
Project Total (Annual Cost)	**$16,500**

APPLICATION FREQUENCY - Annually

Mechanical Weed Harvesting – The implementation of a mechanical weed harvesting program would assist in providing aquatic weed control near the top 5 to 6 feet of the lake. This method would not eradicate the invasive plants, such as Eurasian Milfoil, but would have a similar effect as mowing a lawn. It is anticipated that it would be necessary to have a minimum of two subsequent follow up harvestings to manage the aquatic weeds due to regrowth. The level and speed of regrowth will be affected by climatic conditions and can vary from year to year. It should be noted that if the harvesting operation distributes fragmented pieces of Eurasian Milfoil that the Lake may experience new growth from the fragments. Careful selection of the harvester should be made to address this issue.

It is recommended that a weed harvesting program is implemented to control excessive weed growth for areas that are not treated by the herbicide program. It is estimated that this area encompasses 120 acres. The initial harvesting program should be conducted two times annually to further evaluate the aquatic weeds response and should be conducted in June and July.

ESTIMATED COST:

Mechanical Weed Harvesting (Approximately 120 acres)

$325.00/Acre x 120 Acres	$39,000

Assume 2 times per year

Project Total (Annual Cost)	**$78,000**

FREQUENCY – Annually

Waterfowl Management Program - We recommend that a waterfowl management program be implemented annually to assist in controlling E.coli levels within Walled Lake. A spring and summer program may need to be implemented.

A waterfowl management program is permitted through the Michigan Department of Natural Resources (MDNR). Currently there is not a permit fee but it is anticipated that a fee of approximately $200 will be required in the future. A waterfowl management company can assist in controlling waterfowl populations. These practices typically include a spring time swan and goose nest removal. These activities can be performed by residents according to the MDNR parameters and permit.

A follow up goose round up may be required during the summer. (Swans are not controlled in this manner.) The geese are collected during the summer before the young geese are able to fly and when the adult geese have lost their flight feathers. Geese are relocated to swamps, ponds, and lakes throughout Michigan as directed by the MDNR.

This program is recommended on an annual basis but may be re-evaluated annually upon the effectiveness of the waterfowl removal in preceding years.

A waterfowl management program will reduce the E.coli level contributions from waterfowl, though they may not be the only source of E.coli contributions to the lake. Existing programs, as required through the National Pollutant Discharge Elimination Program, are in effect that require Municipalities to identify and correct sources of E.coli from illicit connections.

ESTIMATED COST:

Spring Nest Removal

Permit Fee	$ 200
Contractor Appearance Fee (for Geese)	$ 100
Contractor Appearance Fee (for Swans)	$ 200
$30/nest x 10 nests	$ 300
	$ 800

Summer Goose Round Up

Appearance Fee	$ 100
100 geese	$1,100
Project Total (Annual Cost)	**$2,000**

Self-Help Program - The MDEQ has developed a program that has been entitled the Cooperative Lakes Monitoring Program http://www.michigan.gov/deq/1,1607,7-135-3313_3686_3731-14766--,00.html. It is recommended that the Lake Improvement Board for Walled Lake, begin such a program on the lake. The data that is collected by the residents of Walled Lake will assist in developing a historical data, by which future projects may be based upon. Several of the items that can be included in such a program are: Secchi disks observations, lake level water observations, temperature, pH, and dissolved oxygen levels, among others. Self imposed restrictions may also be developed that will benefit the lake water quality such as: limited use of phosphorus based fertilizers, encourage the raking of leaves adjacent to shoreline (to prevent the leaves from being blown into the lake), restricted yard waste burning, irrigation schedules and the development of neighborhood environmental awareness programs. A vegetative buffer zone, or lake-scaping program, should also be considered as a Best Management Practice (BMP).

These programs also offer the most important aspect that can be available to any organization that share common goals, and that is networking. The association will be able to make contact with other associations and lake improvement boards that have already implemented some of the programs and projects that the residents may be in the process of considering, such as the Michigan Lake and Stream Association.

ESTIMATED COST – Costs to develop this program can vary. If performed by residents, it is recommended that a budget of $2,000 be established for year 1 and $500 for subsequent years.

FREQUENCY – Year 1, updated annually.

SECTION 5

LAKE IMPROVEMENT RECOMMENDATIONS

C. BUDGETS AND FINANCING OPTIONS

The budgets that are developed below are to be used for estimating purposes only. As one begins the process of planning, designing, construction and maintenance phases of projects involving lakes, a word of advice would be to proceed, prudently.

If the projects are to be financed for a period of several years, then interest cost would need to be accounted for and added to the cost shown below.

Lake Management Budget

	Year 1	
A.	Herbicide Treatment (40 acres)	$ 16,500
B.	Mechanical Weed Harvesting (120 acres)	$ 78,000
C.	Waterfowl Management Program	$ 2,000
D.	Self Help Program (year 1)	$ 2,000
E.	Lake Improvement Study	$ 16,115
F.	Administrative/Legal Fees	$ 20,000
G.	Lake Management Fees	$ 1,500
	Year 1 Total	**$ 136,115**

	Subsequent Years	
A.	Herbicide Treatment (20 acres)	$ 9,000
B.	Mechanical Weed Harvesting (120 acres)	$ 78,000
D.	Waterfowl Management Program	$ 2,000
D.	Self Help Program (year 1)	$ 500
E.	Administrative/Legal Fees	$ 10,000
F.	Lake Management Fees	$ 1,500
	Subsequent Year Annual	**$101,000**

D. IMPLEMENTATION

Since it is unknown how the Walled Lake Improvement Board will develop the special assessment district (SAD), at the time of writing of this report, a cost distribution per riparian parcel will be used to assist in planning purposes. If the cost is distributed equally amongst the riparian parcels each parcel would be assessed approximately $375 for year 1 and $275 for subsequent years.

In order to implement any one of the above outlined projects, the Lake Improvement Board will need to take the following actions:

1. Adopt a project or program and its initial estimated budget.

2. Set a date for the Hearing of Practicability. During this meeting, the Lake Improvement Board for Walled Lake approves the proposed improvement projects and their associated estimated budgets.

3. Set a date for the Assessment Hearing. During this meeting, the Board approves the assessment formula, and the associated Assessment Roll. Once approved, the roll is forwarded to the City Clerk with authorization to spread the approved assessments.

4. Contract Documents are usually prepared next. The contract documents generally include the plans and specifications for the approved project.

5. A bid opening date is set and the project is then advertised.

6. The bids received are opened and the bids are evaluated.

7. The project is awarded.

8. The project begins.

Items 1 - 8, listed above are but a simple summary of all of the tasks and events that generally need to take place when proceeding with project associated with lake improvements.

When the project implementation process has been completed for a particular project or program, the above noted items will generally need to be repeated on an annual basis.

F. CLOSING REMARKS

The SDA Project Team would like to thank the Walled Lake Improvement Board for haven given us the opportunity to prepare this report.

Walled Lake is a beautiful Lake. The fact that its residents have made a commitment to take the initial steps to preserve the lake and its water quality is a clear indication that Walled Lake is in good hands. We wish you all the best of times.

EXHIBIT I

Walled Lake Board Member List

David Galloway, Riparian Owner Representative (Chairperson)

Brian Coburn, PE, City of Novi Representative (Secretary/Treasurer)

William Burke, City of Walled Lake Representative

Karen Warren, PE, Oakland County Water Resource Commissioner's Representative

Jeff Potter, Oakland County Board of Commissioner's Representative

EXHIBIT II

Project Team Members

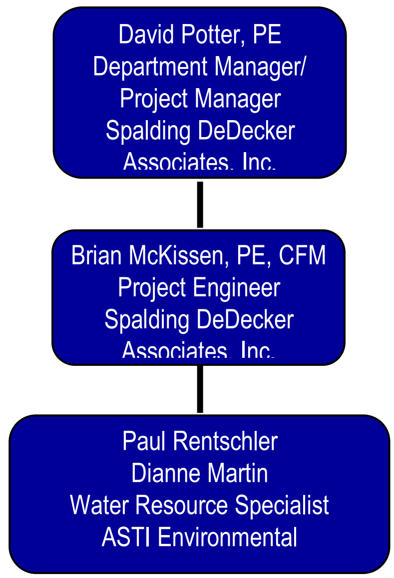


EXHIBIT III

Project Schedule

Action	Completion Date
Aquatic Weed Analysis	August 3 and 5, 2009
Water Quality Analysis	August 3 and 5, 2009
Sediment Analysis	August 3 and 5, 2009
Prepare Cost Estimates	September 1, 2009
Draft Report	September 16, 2009
Final Report	December 1, 2009

SECTION 7

REFERENCES

Breck, J.E., and L.S. Kraft. Digital Water Atlas of Michigan. State of Michigan: Michigan Department of Natural Resources Fisheries Division Institute for Fisheries Research. August 2004.

Brzozowski, Carol. "A Breath of Fresh Air." Water Efficiency, May/June 2007: pgs 10-15.

"Evaporation." *Geotechnical, Rock and Water Resource Library*. 2002-2004 Arizona Board of Regents http://www.grow.arizona.edu/Grow--GrowResources.php?ResourceId=208.

Fassett, Norman C., 1985. A Manual of Aquatic Plants University of Wisconsin Press, Madison, WI, 385 pp.

Hoddle, Mark S. "Quagga & Zebra Mussels", (Center for Invasive Species Research), Available: http://cisr.ucr.edu/quagga_zebra_mussels.html (Accessed: 2009, September).

Hudson, Holly and Kirschner, Bob, "Lake Aeration and Circulation", Lake Notes, Illinois EPA, November 1997.

Lake Feasibility Study for Eagle Lake, Spalding DeDecker Associates, Inc., Waterford, MI, August 16, 2007.

Lake Feasibility Study for Kellogg Lake, JCK & Associates, Inc. Novi, Mi, September 13, 1996.

U.S. EPA, "Water Quality Criteria", 1972, EPA R3-72-033, U.S. Environmental Protection Agency, Washington, D.C., 1973.

"Michigan Statewide Data Examples." *Introductory Land & Water Learning Module.* January 20, 1997 Institute of Water Research, Michigan State University http://www.iwr.msu.edu/edmodule/data/mprecan.html

Pullman, G. Douglas, 1992. Aquatic Vegetation Management Guidance Manual The Midwest Plant Management Society, Swartz Creek, MI, 39 pp.

Schmidt, James C. (editor), 1990. How to Identify and Control Water Weeds and Algae Applied Biochemists, Inc., Milwaukee, WI, 108 pp.

"U.S. Fish and Wildlife Service National Wetlands Inventory" (2009, July 27), (U.S. Fish and Wildlife Service Conserving the Nature of America), Available:http://www.fws.gov/wetlands/Data/Mapper.html (Accessed: 2009, August 7).

Westerdahl, H. E. and Kurt D. Getsinger (editors), 1988. Aquatic Plant Identification and Herbicide Use U.S. Army Corps of Engineers, Washington D.C. 104 pp.