COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer
Lakes Monitoring Program

ANNUAL SUMMARY REPORT

1999

a partnership for michigan's lakes

Michigan Lake & Stream Associations, Inc.
Michigan Department of Environmental Quality
Michigan's Citizen Volunteers

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INTRODUCTION

Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide tremendous aesthetic and recreational value for the people of Michigan and neighboring states. A great Michigan summer pastime is going to a cottage on an inland lake to fish, water-ski, swim, and relax.

As more and more people use the lakes and surrounding watersheds, the potential for pollution problems and use impairment increases dramatically. Although many of Michigan's inland lakes have a tremendous capacity to accommodate the burden of man's activities in the short term, continuing stress on the lakes and lake watersheds over time will ultimately lead to adverse water quality impacts.

Reliable information, including water quality data, levels of use, and use impairment are essential for determining the health of a lake and for developing a management plan to protect the lake. As the users and primary beneficiaries of Michigan's lake resources, citizens must take an active role in obtaining this information and managing their lakes.

Michigan's abundant water resources...

..includes over 11,000 inland lakes.

The Cooperative Lakes Monitoring Program (CLMP) is a partnership between the Land and Water Management Division of the Michigan Department of Environmental Quality (DEQ) and the Michigan Lake and Stream Associations, Inc. (ML&SA). The primary purpose of this cooperative program is to help citizen volunteers monitor indicators of water quality in their lake and document changes in lake quality over time. The CLMP provides sampling methods, training, workshops, technical support, quality control, and laboratory assistance for volunteers to monitor their lake for the basic indicators of lake productivity.

THE SELF-HELP LEGACY

Originally known as the Self-Help Program, the CLMP continues a long time tradition of citizen volunteer monitoring on Michigan's inland lakes. Michigan has maintained a volunteer lake monitoring program since 1974 which makes it the second oldest volunteer monitoring program for lakes in the nation. The original program was designed for lake property owners to monitor water quality by measuring water clarity with a Secchi disk. In 1992, the DEQ Land and Water Management Division (then part of the Department of Natural Resources) and the ML&SA entered into a cooperative

"working together to protect lakes"

Michigan Department of
Environmental Quality

John Engler, Governor
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agreement to expand the basic program. An advanced Self-Help program was initiated in 1993 that included a monitoring component for the plant nutrient phosphorus. In 1994, a side-by-side sampling component was added to the program to assure the quality of the data being collected.

The CLMP continues the "self-help" legacy by providing Michigan's citizens an opportunity to participate in environmental management and learn more about their lakes. Currently, the CLMP supports monitoring components for basic indicators of primary productivity in lakes, including: Secchi disk transparency, total phosphorus, chlorophyll *a*, and aquatic plants.

The CLMP is a cost-effective process for the DEQ to increase the baseline data available for Michigan's inland lakes as well as to establish a continuous data record for determining water quality trends in lakes. The CLMP continues the DEQ/citizen volunteer partnership critical to lake management in Michigan.

LAKE QUALITY

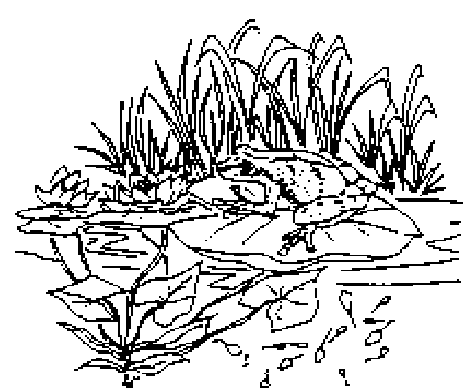
Lake quality is influenced by many factors such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of lake chemistry and

CLMP Goals

- provide baseline information and document trends in water quality for individual lakes.
- educate lake residents, users, and interested citizens in the collection of water quality data, lake ecology, and lake management practices.
- build a constituency of citizens to practice sound lake management at the local level and to build public support for lake quality protection.
- provide a cost-effective process for the DEQ to increase baseline data for lakes state-wide.

CLMP Measurements

- Secchi disk transparency
- spring total phosphorus
- summer total phosphorus
- chlorophyll *a*
- aquatic plants



biology. The health of a lake is determined by its water quality.

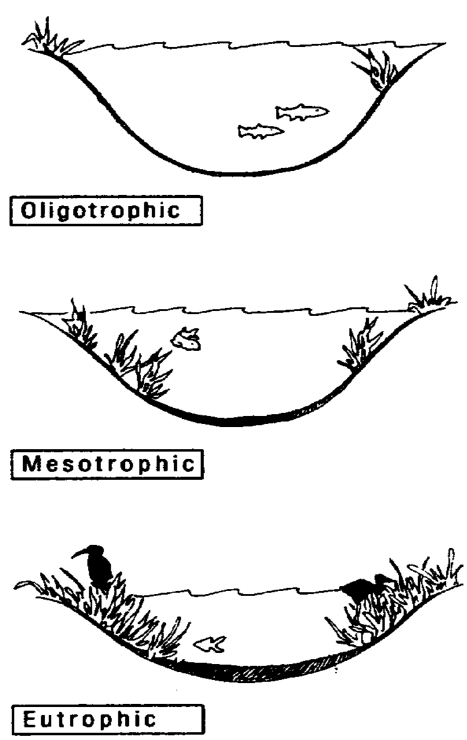
Problems most commonly cited by lake residents, such as excessive weed growth, algal blooms and mucky bottom sediments, are caused by water quality factors that lead to increased lake fertility or productivity. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

Plant *nutrients* are a major factor that cause increased productivity in lakes. In Michigan, *phosphorus* is the nutrient most responsible for plant and algae growth (*primary productivity*) in inland lakes.

The CLMP is designed to specifically monitor changes in lake productivity. The current program enlists citizen volunteers to monitor water clarity and the algal plant pigment chlorophyll *a* throughout the summer months and total phosphorus is measured during the spring and late summer. These parameters are indicators of primary productivity and, if measured over many years, these data may document changes, or trends, in the lake's productivity.

CLASSIFYING LAKES

A lake's ability to support plant and animal life defines its level of productivity, or *trophic state.* Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved oxygen* in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, high productive *eutrophic* lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two classifications



(Source: Hamlin Lake Improvement Board)

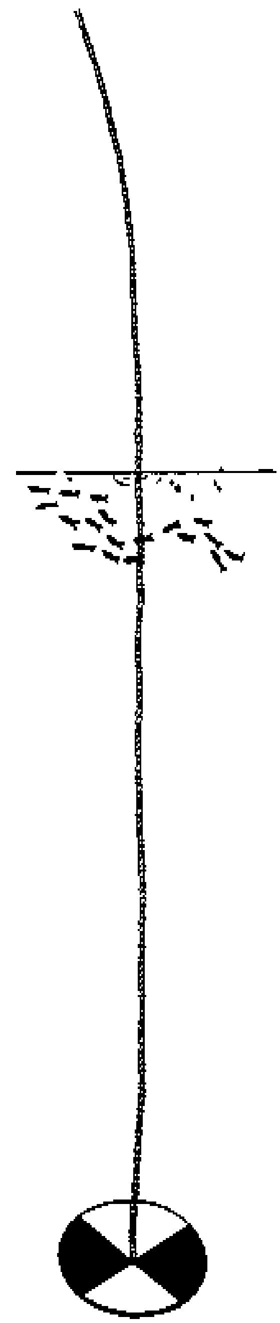
are called *mesotrophic* lakes. Lakes that exhibit extremely high productivity such as nuisance algae and weed growth are called *hypereutrophic* lakes.

EUTROPHICATION

The gradual increase of lake productivity from oligotrophy to eutrophy is called lake aging or *eutrophication*. Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the lake basin with accumulated sediments, silt and muck. Human activities can greatly speed up this process by dramatically increasing nutrient, soil, or organic matter input to the lake. This human influenced, accelerated lake aging process is known as *cultural eutrophication*. A primary objective of most lake management plans is to slow down cultural eutrophication by reducing the input of nutrients and sediments to the lake.

MEASURING EUTROPHICATION

Measuring a lake's water quality and eutrophication is not an easy task. Lakes are a complex ecosystem made up of physical, chemical and biological components in a constant state of action and interaction.



As on land, plant growth in lakes is not constant throughout the summer months. Some species mature early in the season, die back, and are replaced by other species in a regular succession.

While overall population levels often reach a maximum in mid-summer, this pattern may be influenced or altered by numerous temporal factors such as temperature, rainfall, and aquatic animals. For the same reasons lakes are different from week to week, lake water quality can fluctuate from year to year.

Given these factors, observers of lake water quality must train themselves to recognize the difference between short-term, normal population fluctuations and long-term changes in lake productivity (eutrophication). Many years of reliable data collected on a consistent and regular basis are required to separate true long term changes in lake productivity from seasonal and annual fluctuations.

Important Measures of Eutrophication

Nutrients are the leading cause of eutrophication. Nitrogen and *phosphorus* both stimulate plant growth. Both are measured from samples of water and reported in units of ug/l (micrograms per liter), or ppb (parts per billion). *Phosphorus* is the most important nutrient, and is often used directly as a measure of eutrophication.

Plants are the primary users of nutrients. *Chlorophyll a* is a component of the cells of most plants, and can be used to measure the concentration of small plants in the water, such as algae. *Chlorophyll a* is measured from samples of water and reported in units of ug/l. Macrophytes are aquatic plants with stems and leaves. The location of different species of plants can be mapped, and the density can be measured in pounds of plants per acre of lake.

Transparency or the clarity of water is measured using a device known as a *Secchi disk*. This is an eight inch diameter target painted black and white in alternate quadrants. The disk is attached to a marked line, or measuring tape, and lowered from a boat into the lake. The distance into the water column the disk can be seen is the transparency, measured in feet or meters. A short distance of visibility means that there are suspended particles or algae cells in the water, an indication of nutrient enrichment.

Dissolved Oxygen (DO) which is oxygen dissolved in the water, is necessary to sustain fish populations. Fish such as trout require more DO than warm water species. Eutrophic lakes occasionally have levels of DO below the minimum for fish to survive, and fish kills can result.

Sediments can be measured to determine how fast material is depositing on the bottom. This may indicate watershed erosion, or large die-off of aquatic plants.

Fish can be sampled using nets. In an oligotrophic lake there are likely to be cold water species such as trout. A sample of warm water fish such as sunfish, bass, bullheads, and carp is more typical of a eutrophic lake.

Temperature affects the growth of plants, the release of nutrients, and the mixing of layers of water in the lake. Temperature measurements can determine if mixing occurs, moving nutrients and algal cells from the bottom up into the lake.

LAKE PRODUCTIVITY INDEX

The general lake classification scheme described above is convenient but somewhat misleading in that it places all lakes into a few distinct trophic categories. In reality, lake water quality is a continuum progressing from very good to very poor conditions. A more precise method of describing the productivity of a lake is to use a numerical index which can be calculated directly from water quality data. A variety of indexes are available with Carlson's (1977) *Trophic State Index*, or TSI, being the most widely used.

Carlson's TSI was developed to compare lake data on water clarity, as measured by a Secchi disk, chlorophyll *a* and total phosphorus. These parameters are good indirect measures of a lake's productivity. The TSI expresses lake productivity on a continuous numerical scale from 0 to 100 with increasing numbers indicating more eutrophic conditions. The zero point on the TSI scale was set to correlate with a Secchi transparency of 64 meters (210 feet).

Carlson developed mathematical relationships for calculating the TSI from measurements of Secchi depth transparency, chlorophyll *a*, and total phosphorus in lakes during the summer season. The

Carlson's TSI Equations

$$TSI_{SD} = 60 - 33.2 \log_{10} SD$$

$$TSI_{TP} = 4.2 + 33.2 \log_{10} TP$$

$$TSI_{CHL} = 30.6 + 22.6 \log_{10} CHL$$

where,
SD = Secchi depth transparency (m)
TP = total phosphorus concentration (ug/l)
CHL = chlorophyll *a* concentration (ug/l)

computed TSI values for an individual lake can be used to compare with other lakes, to evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

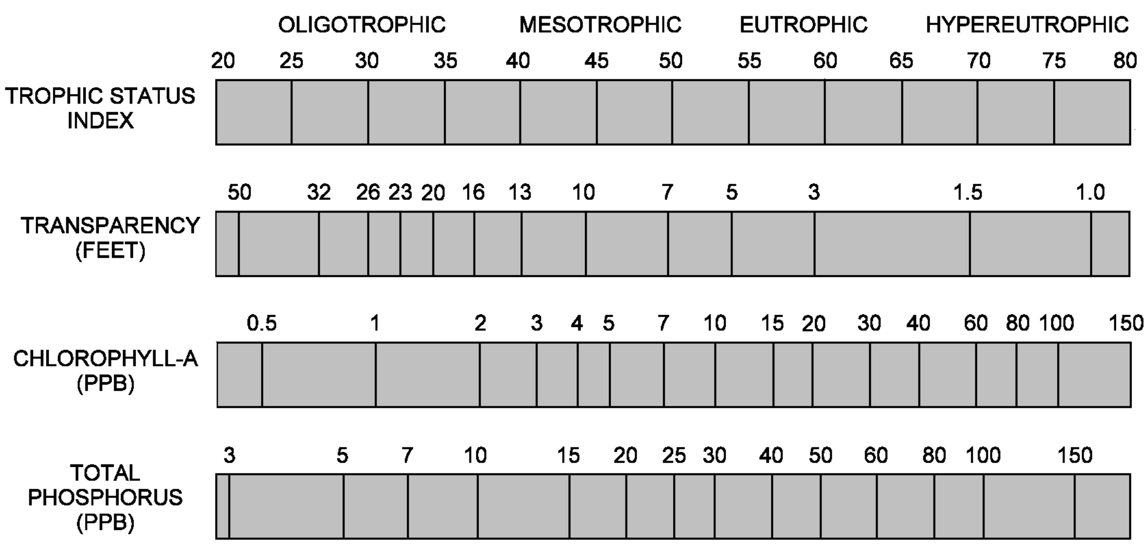
For those preferring to use the general lake classification scheme, the TSI values which correspond approximately with the trophic state terms are illustrated in the figure below. However, the dividing lines between these categories are somewhat arbitrary since lake water quality is a continuum and there is no broad agreement among lake scientists as to the precise point of change between each of these classifications.

For many lakes in Michigan, Carlson's TSI equations can be used to roughly predict values of one variable from measurements of another in the surface water of the lake during the summer season as shown in the figure below.

Lake scientists have also developed relationships to predict summer productivity indicators from water quality variables measured during lake turnover in the spring. One such relationship was developed by Dillon and Rigler (1974) which predicts mean (average) summer chlorophyll *a* from spring total phosphorus measurements.

These relationships must be used carefully when predicting water quality variables and productivity.

CARLSON'S TROPHIC STATE INDEX



(Source: Minnesota Pollution Control Agency)

CLMP RESULTS

Secchi Disk Transparency

Citizen volunteers measure Secchi disk transparency from late spring to the end of the summer. Ideally, eighteen weekly measurements are made from mid May through mid September. As a minimum, eight equally spaced measurements from the end of May to the beginning of September are accepted to provide a good summer transparency mean (average) for the lake. Frequent transparency measurements are necessary throughout the growing season since algal species composition in lakes can change significantly during the spring and summer months, which can dramatically affect overall water clarity.

A summary of the transparency data collected by the lake volunteers during 1999 is included in Appendix 1. The number of measurements, or readings, made between mid May and mid September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. For those lakes with eight or more evenly spaced readings over this time period, the mean, median, standard deviation and Carlson TSI_{SD} values were calculated and listed.

The mean, or average, is simply the sum of the measurements divided by the number of measurements. The median is the middle value when the set of measurements is ordered from lowest to highest value. The standard deviation is a common statistical determination of the dispersion, or variability, in a set of data.

The data range and standard deviation gives an indication of seasonal variability in transparency in the lake. Lakes with highly variable Secchi disk readings need to be sampled frequently to provide a representative mean summer transparency value. Few measurements and inconsistent sampling periods for these lakes will result in unreliable data for annual comparisons.

The TSI_{SD} values were calculated using Carlson's equations (see page seven) and the mean summer transparency values. (Note: the mean transparency value is converted from feet to meters for the TSI_{SD} calculation) The graphical relationship on page eight can be used to relate the TSI_{SD} value to the general trophic status classification for the lake (i.e. oligotrophic, mesotrophic, eutrophic) as well as to provide a rough estimate of summer chlorophyll *a* and total phosphorus levels in the lake. If the transparency measurements are made properly and consistently year after year the annual TSI_{SD} values can be compared to evaluate changes, or trends, in trophic status of the lake over time.

During 1999, Secchi disk transparency data were reported for 141 lakes (201 basins). Over 2600 transparency measurements were reported which ranged from 2 to 61 feet. For the lakes with eight or more equally spaced readings between mid-May and mid-September, the overall mean, or average, Secchi disk transparency was 12 feet. The Carlson TSI_{SD} values ranged from 27 to 57 for these lakes with a mean value of 42. A Carlson TSI value of 42 is generally indicative of a good quality mesotrophic lake (see page 8).

Total Phosphorus

Phosphorus is one of several essential nutrients that algae need to grow and reproduce. For most lakes in Michigan, phosphorus is the most important nutrient, the limiting factor, for algae growth. The total amount of phosphorus in the water is typically used to predict the level of productivity in a lake. An increase in phosphorus over time is a measure of nutrient enrichment in a lake.

The CLMP volunteers monitor for total phosphorus during spring overturn, when the lake is generally well mixed from top to bottom, and during late summer, when the lake is at maximum temperature stratification from the surface to the bottom. Spring overturn is an opportune time of the year to sample just the surface of a lake to obtain a representative sample for estimating the total amount of phosphorus in the lake. A surface sample collected during late summer represents only the upper water layer of the lake, the epilimnion, where most algal productivity occurs. The late summer total phosphorus results, along with the Secchi disk transparency and chlorophyll measurements, are used to determine the trophic status of the lake. The spring overturn total phosphorus data, collected year after year, are useful for evaluating nutrient enrichment in the lake.

Total phosphorus results for the 1999 CLMP are included in Appendix 2. The spring total phosphorus data are listed first, followed by the late summer data. The TSI_{TP} values were calculated using Carlson's equations (see page seven) and the late summer total phosphorus data. Results from replicate and side-by-side sampling are also provided. Approximately 10% of the replicate samples collected by the volunteers were analyzed as part of the data quality control process for the CLMP. Also, the DEQ participated in side-by-side sampling on approximately 10% of the enrolled lakes.

During 1999, samples for total phosphorus measurements were collected on 103 lakes (108 basins). The spring overturn total phosphorus results ranged from <5 to 70 ug/l with a mean (average) of 16.4 ug/l. The late summer total phosphorus results ranged from 5 to 61 ug/l with 14.1 ug/l as the mean. The Carlson TSI_{TP} values ranged from 27 to 61 for these lakes with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a good quality mesotrophic lake (see page 8).

Chlorophyll *a*

Chlorophyll is the green photosynthetic pigment in the cells of plants. The relative amount of algae in a lake can be estimated by measuring the chlorophyll *a* concentration in the water. As an algal productivity indicator, chlorophyll *a* is often used to determine the trophic status of a lake.

Chlorophyll monitoring was added to the CLMP in 1998 and expanded in 1999. Chlorophyll samples were collected on 62 lakes in 1999. For each lake, the volunteers collected and processed five sets of chlorophyll *a* samples, one set per month from May through September.

Results from the chlorophyll monitoring study are included in Appendix 3. Results for each monthly sampling event are listed as well as the mean, median, and standard deviation of the monthly data for each lake. The TSI_{CHL} values were calculated using Carlson's equations (see page seven) and the median summer chlorophyll values. Results from the replicate and side-by-side sampling are also provided. Side-by-side and replicate samples were collected and analyzed for nearly half of the lakes.

Over 350 chlorophyll samples were collected and processed in 1999. The chlorophyll *a* levels in these lakes ranged from <1 to 82 ug/l over the five-month sampling period. The overall mean (average) was 5.3 ug/l and the median was 4 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 58 with a mean value of 43. A Carlson TSI value of 43 is generally indicative of a good quality mesotrophic lake (see page 8).

The TSI_{CHL}, TSI_{SD}, and TSI_{TP} values for the individual lakes can be compared to provide useful information about the factors controlling the overall trophic status in these lakes (Carlson and Simpson, 1996). For lakes where phosphorus is the limiting factor for algae growth, all three TSI values should be nearly equal. However, this may not always be the case. For example, the TSI_{SD} may be significantly larger than the TSI_{TP} and TSI_{CHL} values for lakes that precipitate calcium carbonate, or marl, during the summer. The marl particles in the water column would scatter light and reduce transparency in these lakes, which would increase the TSI_{SD}. Also, phosphorus may adsorb to the marl and become unavailable for algae growth which would reduce the TSI_{CHL}. For lakes where zooplankton grazing or some factor other than phosphorus limits algal biomass, the TSI_{TP} may be significantly larger than the TSI_{SD} and TSI_{CHL}.

Data from the CLMP provide citizens with basic information on their lakes which can be used as indicators of the lake's productivity. If measured over many years, these data may be useful in documenting changes and trends in water quality.

Although CLMP data provide very useful water quality information, anyone who is involved in making decisions on lake management will want to assemble more information on a lake's condition. The DEQ and ML&SA may be able to help you obtain additional information on your lake.

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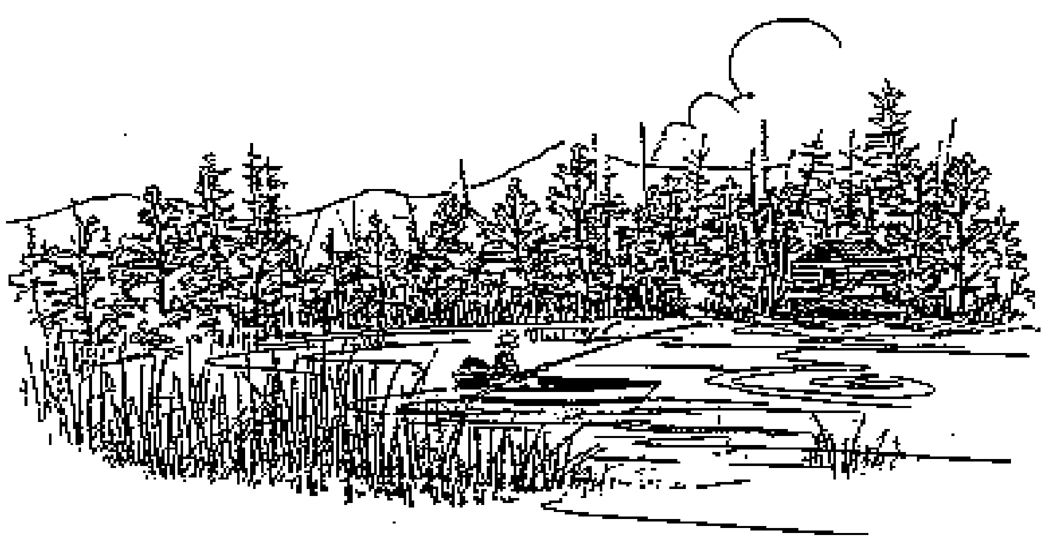

ACKNOWLEDGEMENTS

Ralph Bednarz of the Inland Lakes and Wetlands Unit, Michigan Department of Environmental Quality, prepared this report. Brian Carley compiled the transparency data. Ralph Bednarz, along with Donald Winne and Pearl Bonnell of Michigan Lake and Stream Associations, Inc coordinate the CLMP.

Thank you to the dedicated volunteers who have made the CLMP one of the nations most successful citizen volunteer lakes monitoring programs. Special thank you is extended to Niles Kevern and Joe Landis for their help in building the chlorophyll sampling and filtering equipment and to Ralph Vogel for constructing the Secchi disks for the CLMP.

APPENDIXES

Appendix 1

1999 Secchi Disk Transparency Results

Appendix 2

1999 Total Phosphorus Results

Appendix 3

1999 Chlorophyll Results

APPENDIX 1
1999 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Arbutus 1	Grand Traverse	11	10.0	13.5	12.8	13.0	1.03	40
Arbutus 2	Grand Traverse	11	14.0	23.0	18.5	17.0	3.17	35
Arbutus 3	Grand Traverse	11	16.0	25.0	19.2	18.0	3.27	34
Arbutus 4	Grand Traverse	11	15.5	24.0	18.5	17.0	3.00	35
Arbutus 5	Grand Traverse	11	12.0	18.4	15.4	15.0	1.58	38
Arnold	Clare	17	14.0	27.0	18.6	17.0	3.81	35
Avalon	Montmorency	6	18.0	35.0				
Baldwin	Montcalm	17	9.0	20.0	12.4	12.0	2.79	41
Baldwin 1	Cass	10	7.4	14.0	9.9	8.4	2.62	44
Baldwin 2	Cass	10	6.2	12.6	9.7	9.9	2.40	44
Baldwin 3	Cass	10	6.4	15.0	9.9	8.9	3.06	44
Baldwin 4	Cass	10	6.8	13.6	9.3	8.6	2.37	45
Bankson	Van Buren	13	11.0	15.0	13.0	13.0	1.12	40
Barlow	Barry	12	10.0	19.0	13.6	13.0	2.31	40
Baseline	Livingston	10	8.5	21.0	13.9	13.5	3.82	39
Bass	Kent	18	6.0	12.5	9.2	9.5	2.06	45
Bear	Manistee	8	7.0	12.0	9.6	9.5	1.90	45
Bear 1	Kalkaska	13	21.5	38.0	30.1	28.0	5.63	28
Bear 2	Kalkaska	13	23.0	37.0	30.0	29.0	4.90	28
Beaver	Alpena	17	8.6	15.3	10.7	10.1	1.72	43
Big Bradford	Otsego	17	13.0	19.0	15.9	16.0	1.85	37
Big Pine Island	Kent	18	5.0	12.0	7.8	7.0	2.01	47
Big Platte	Benzie	18	8.0	21.0	12.4	11.5	3.69	41
Big Pleasant	St. Joseph	14	12.0	16.0	13.6	13.5	0.94	40
Bills	Newaygo	15	8.0	13.0	9.9	10.0	1.94	44
Birch	Cass	18	11.0	30.0	15.5	13.0	6.21	38
Blue	Mason	13	29.5	36.0	32.5	32.5	2.18	27
Blue 1	Mecosta	18	10.0	20.5	14.6	14.0	3.02	38
Blue 2	Mecosta	18	10.0	23.0	15.2	14.0	4.00	38
Burkhart	Washtenaw	18	12.1	18.0	14.8	14.3	2.10	38
Byram 1	Genesee	18	8.0	20.0	14.2	14.0	4.14	39
Byram 2	Genesee	18	8.0	21.0	14.1	14.0	4.34	39
Byram 3	Genesee	18	8.0	20.0	13.6	13.5	4.38	40
Campau	Kent	9	6.0	10.0	8.1	8.0	1.54	47
Cedar	Van Buren	18	9.5	20.0	15.3	15.8	2.94	38
Chain	Iosco	13	8.0	15.0	10.5	10.0	1.98	43
Christiana	Cass	18	3.5	10.5	5.8	4.8	2.29	52

APPENDIX 1
1999 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson TSI$_{SD}$ (transparency)
		Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	
Clear	Jackson	18	9.0	16.0	12.0	12.0	2.19	41
Clear 1	St. Joseph	6	13.0	16.5				
Clifford 1	Montcalm	15	10.0	22.0	14.7	14.0	3.81	38
Clifford 2	Montcalm	15	11.0	22.0	14.5	12.0	3.93	39
Coldwater	Branch	14	3.5	16.5	9.3	8.3	3.99	45
Cordley	Livingston	6	10.0	14.0				
Corey	St. Joseph	18	7.5	18.5	13.0	13.0	2.92	40
Cowan	Kent	17	3.5	10.0	7.0	8.0	2.25	49
Crockery	Ottawa	16	3.0	7.6	4.5	4.0	1.34	55
Crooked 1	Clare	12	10.3	16.8	11.4	10.8	1.78	42
Crooked 2	Clare	11	10.3	16.7	11.6	11.0	1.79	42
Crooked (Big)	Van Buren	17	14.8	24.3	18.2	18.0	2.77	35
Crooked (Little)	Van Buren	10	13.8	20.5	16.7	16.5	1.68	36
Crystal	Benzie	3	15.0	20.0				
Cub	Kalkaska	15	10.0	23.0	19.2	20.0	3.17	35
Dewey	Cass	18	5.0	7.0	6.0	6.0	0.58	51
Diamond	Cass	18	6.0	14.0	9.5	8.5	2.73	45
Doc & Tom	Clare	15	7.0	12.0	9.3	9.0	1.28	45
Donnell	Cass	12	5.0	13.0	9.4	10.0	2.66	45
Duck 1	Grand Traverse	17	8.0	13.0	10.4	11.0	1.58	43
Duck 2	Grand Traverse	17	8.0	13.0	10.4	11.0	1.58	43
Eagle	Allegan	16	10.4	18.4	14.7	15.4	2.74	38
East Twin	Montmorency	7	9.0	21.0				
Emerald	Newaygo	17	6.0	19.0	13.4	14.0	3.95	40
Evans	Lenawee	18	10.0	17.5	13.4	13.5	2.16	40
Fair	Barry	15	8.1	11.1	9.5	9.7	0.85	45
Fenton	Genesee	5	13.7	14.2				
Fish	Van Buren	11	6.0	11.0	9.0	9.2	1.65	45
Ford	Mason	17	7.3	19.4	13.4	13.5	3.16	40
Forest	Oakland	17	5.0	15.0	9.8	9.0	2.78	44
George 1	Clare	17	6.0	15.0	10.4	10.5	2.32	43
George 2	Clare	13	6.0	15.0	10.6	10.5	2.63	43
George 3	Clare	17	6.0	17.5	10.9	11.0	2.83	43
Gill/Gut	Livingston	11	9.0	11.0	10.2	10.5	0.64	44
Glen (Big)	Leelanau	12	11.0	21.0	15.9	16.0	3.23	37
Hackert	Mason	12	10.0	19.0	14.2	14.0	2.76	39
Hamburg	Livingston	18	8.5	29.5	13.6	13.5	4.86	40

APPENDIX 1

1999 COOPERATIVE LAKES MONITORING PROGRAM

SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson TSI$_{SD}$ (transparency)
		Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	
Hamilton	Dickinson	15	9.5	14.5	11.5	11.0	1.64	42
Hamlin 1	Mason	6	8.0	15.5				
Hamlin 2	Mason	6	15.5	20.0				
Harper	Lake	14	9.1	16.5	12.1	11.1	2.31	41
Hawk	Oakland	17	4.5	12.0	7.2	6.5	2.00	49
Higgins 1	Roscommon	4	19.0	27.0				
Higgins 2	Roscommon	9	17.0	37.0	25.6	27.0	6.82	30
Horsehead	Mecosta	15	9.5	13.5	10.6	10.0	1.26	43
Hubbard	Alcona	17	8.5	31.0	20.2	19.5	7.21	34
Hunter's 1	Alcona	10	20.0	27.0	23.0	22.9	1.93	32
Hunter's 2	Alcona	10	14.0	22.0	18.1	18.7	2.36	35
Hutchins	Allegan	10	4.5	10.7	7.3	6.9	2.31	49
Indian	Montcalm	17	6.5	16.0	10.4	10.0	3.12	43
Indiana	Cass	17	7.5	21.0	13.4	12.5	4.45	40
Jeptha (Upper)	Van Buren	18	8.2	14.8	11.5	11.9	2.17	42
Juno	Cass	18	3.5	8.0	5.4	5.3	1.69	53
Keeler 1	Van Buren	18	9.5	13.0	11.6	12.0	1.27	42
Kettle	Kent	7	9.0	16.0				
Kirkwood	Oakland	18	2.3	5.6	4.1	4.1	1.02	57
Klinger	St. Joseph	17	8.0	19.0	12.8	12.0	3.01	40
Lake Ann	Benzie	7	11.7	15.8				
Lake Margrethe 1	Crawford	18	10.0	20.0	13.7	13.0	3.65	39
Lake Margrethe 2	Crawford	18	10.0	22.0	13.9	12.0	3.62	39
Lake Margrethe 3	Crawford	18	10.0	23.0	14.0	12.5	4.03	39
Lake Margrethe 4	Crawford	18	9.0	20.0	12.9	12.0	3.57	40
Lake Nepessing	Lapeer	12	5.6	19.1	11.1	11.4	4.57	42
Lake of the Woods	Van Buren	14	7.3	11.9	9.2	8.4	1.75	45
Lancelot 1	Gladwin	4	3.3	9.0				
Lancelot 2	Gladwin	4	3.2	8.0				
Lancelot 3	Gladwin	4	4.7	7.0				
Lancer 1	Gladwin	3	8.0	9.0				
Lancer 2	Gladwin	3	8.0	9.0				
Lancer 3	Gladwin	3	4.0	7.5				
Lancer 4	Gladwin	3	4.0	4.0				
Lancer 5	Gladwin	3	3.0	6.0				
Lansing	Ingham	18	5.3	8.8	6.0	5.8	0.79	51
Leelanau (North)	Leelanau	15	9.0	19.0	11.9	10.0	3.07	41

APPENDIX 1
1999 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson TSI_{SD} (transparency)
		Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	
Leelanau (South)	Leelanau	14	5.5	13.5	9.9	10.3	2.56	44
Leisure	Shiawassee	15	9.4	20.2	13.9	13.8	3.32	39
Lily	Clare	18	8.0	13.5	10.9	10.0	2.05	43
Little Bradford	Otsego	9	17.0	19.0	17.7	18.0	0.71	36
Little Paw Paw 1	Berrien	16	5.0	8.0	6.3	6.5	0.79	51
Little Paw Paw 2	Berrien	16	5.3	7.8	6.4	6.3	0.77	50
Little Paw Paw 3	Berrien	16	5.3	7.8	6.2	6.1	0.71	51
Little Twin	Cass	14	6.8	14.6	11.9	12.5	2.46	41
Londo 1	Iosco	6	7.0	9.0				
Londo 2	Iosco	6	6.0	9.0				
Londo 3	Iosco	6	8.0	9.0				
Londo 4	Iosco	6	7.0	10.0				
Long	Branch	12	2.5	8.0	5.0	5.0	1.51	54
Long	Grand Traverse	18	17.0	61.0	31.8	28.5	13.03	27
Long	Iosco	16	8.0	16.0	11.0	10.5	2.07	43
Louise	Dickinson	15	9.5	13.0	11.6	11.5	1.10	42
Mary	Dickinson	15	8.5	14.0	11.4	11.5	1.54	42
McGilvery 1	Gladwin	5	8.0	10.5				
McGilvery 2	Gladwin	5	7.0	11.0				
McGilvery 3	Gladwin	5	7.0	10.0				
Mecosta	Mecosta	15	10.0	23.0	13.4	11.0	4.71	40
Mill	Van Buren	15	10.0	23.5	13.1	11.0	3.92	40
Minor	Allegan	14	7.0	16.5	12.2	13.0	3.56	41
Moon	Gogebic	15	14.0	32.0	19.7	18.0	5.59	34
Nevins	Montcalm	18	8.0	18.0	11.8	11.0	3.29	41
North 1	Alcona	18	9.0	22.0	17.1	18.0	3.65	36
North 2	Alcona	18	10.0	22.0	16.6	17.0	3.01	37
Oneida 1	Livingston	18	8.1	16.1	10.6	10.3	1.75	43
Oneida 2	Livingston	18	7.7	16.7	10.8	10.1	2.20	43
Ore	Livingston	17	4.0	13.0	6.6	6.0	2.37	50
Oxbow	Oakland	6	10.6	12.3				
Painter	Cass	18	3.0	8.5	5.9	6.0	1.65	52
Paw Paw 1	Berrien	16	2.6	9.3	6.2	6.3	2.24	51
Paw Paw 2	Berrien	16	2.4	9.6	6.0	6.1	2.28	51
Paw Paw 3	Berrien	16	2.5	9.2	5.9	5.6	2.18	52
Payne	Barry	9	8.0	20.0	11.6	10.0	4.05	42
Pentwater 1	Oceana	6	4.3	7.0				

APPENDIX 1
1999 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson TSI$_{SD}$ (transparency)
		Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	
Pentwater 2	Oceana	6	4.8	7.3				
Pentwater 3	Oceana	6	4.5	7.5				
Pentwater 4	Oceana	6	4.5	8.2				
Pleasant 1	Washtenaw	6	8.9	9.8				
Pleasant 2	Washtenaw	6	8.2	9.8				
Pleasant 3	Washtenaw	6	8.3	10.5				
Pleasant 1	Wexford	8	4.8	7.0	6.2	6.6	0.88	51
Pleasant 2	Wexford	5	9.5	10.0				
Puterbaugh 1	Cass	15	7.3	18.3	10.9	10.0	3.49	43
Puterbaugh 2	Cass	15	7.3	19.3	11.3	10.5	3.53	42
Puterbaugh 3	Cass	11	7.3	12.8	9.8	10.3	1.83	44
Robinson	Newaygo	16	6.0	11.0	8.4	9.0	1.50	46
Round	Kent	11	10.0	24.0	15.7	13.0	5.76	37
Round 1	Mecosta	18	10.0	14.0	11.4	11.0	1.04	42
Round 2	Mecosta	18	10.0	14.0	11.4	11.0	1.04	42
Sage 1	Ogemaw	17	10.0	14.5	12.5	12.0	1.39	41
Sage 2	Ogemaw	9	14.2	17.3	15.1	14.7	1.06	38
Sanford	Benzie	14	11.0	20.0	14.8	13.0	3.12	38
Sapphire	Missaukee	16	8.0	9.5	8.5	8.5	0.46	46
School Section 1	Mecosta	18	11.6	13.8	12.9	12.9	0.72	40
School Section 2	Mecosta	18	11.7	14.1	12.9	12.9	0.67	40
School Section 3	Mecosta	18	11.8	13.9	12.9	12.8	0.64	40
Secord 1	Gladwin	9	6.3	12.0	9.0	9.0	1.74	45
Secord 2	Gladwin	9	4.5	8.0	6.7	7.0	1.48	50
Secord 3	Gladwin	9	4.0	6.0	5.1	5.0	0.93	54
Selkirk	Allegan	11	5.4	13.7	9.4	8.7	2.72	45
Shan-gri-la 1	Livingston	18	3.6	6.1	5.4	5.7	0.70	53
Shan-gri-la 2	Livingston	17	3.1	9.5	6.6	6.0	1.95	50
Sherwood	Oakland	17	3.5	8.0	5.7	5.5	1.62	52
Shingle	Clare	15	9.0	16.0	12.0	12.0	2.14	41
Silver 1	Genesee	8	4.5	10.5	7.8	7.8	2.09	47
Silver 2	Genesee	8	4.3	11.3	8.2	8.5	2.47	47
Silver 3	Genesee	8	5.0	11.3	8.4	8.5	2.00	46
Spider 1	Grand Traverse	16	11.0	29.0	17.6	14.0	6.47	36
Spider 2	Grand Traverse	17	11.5	28.0	17.0	15.0	5.54	36
Spider 3	Grand Traverse	17	11.0	23.0	15.3	14.0	3.93	38
Stone Ledge	Wexford	18	7.0	12.0	10.2	10.0	1.40	44

APPENDIX 1

1999 COOPERATIVE LAKES MONITORING PROGRAM

SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson TSI$_{SD}$ (transparency)
		Number of Readings	Range Min.	Range Max.	Mean	Median	Standard Deviation	
Strawberry 1	Livingston	14	4.0	8.9	6.1	6.0	1.74	51
Strawberry 2	Livingston	4	4.2	10.4				
Sylvan	Newaygo	17	5.0	12.0	7.5	7.0	2.00	48
Tamarack	Livingston	18	8.0	14.0	9.3	8.5	1.86	45
Taylor	Oakland	18	13.0	18.0	15.6	16.0	1.69	38
Twin Lakes North	Cass	17	12.0	17.0	14.6	15.0	1.62	38
Van Etten	Iosco	18	3.0	11.0	4.7	3.8	2.20	55
Vaughn	Alcona	9	8.5	16.5	12.1	12.3	2.57	41
Viking	Otsego	18	2.0	10.0	5.6	5.0	2.01	52
Vineyard	Jackson	18	4.5	24.0	11.8	9.0	7.32	41
West Twin	Montmorency	14	7.1	12.0	10.0	10.3	1.61	44
White 1	Oakland	18	12.0	13.5	12.5	12.5	0.52	41
White 2	Oakland	18	11.6	14.0	12.6	12.5	0.74	41
White 3	Oakland	18	13.5	15.0	14.0	14.0	0.53	39
Windover 2	Clare	13	14.0	28.0	18.5	18.0	3.71	35
Windover 3	Clare	13	14.0	32.0	19.5	18.0	5.13	34
Wolf	Lake	12	10.0	12.0	11.0	11.0	0.62	43
Woods	Kalamazoo	13	8.0	14.0	11.4	12.0	1.97	42
Zukey	Livingston	9	6.0	10.0	8.1	8.0	1.36	47

APPENDIX 2

1999 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOSPHOROUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring -Overturn (Volunteer)	(DEQ)	Late - Summer (Volunteer)	(DEQ)	Carlson TSI_{TP} (summer TP)
Arbutus	Gr. Traverse	8		8		34
Arnold	Clare	4 T		9		36
Avalon	Montmorency	7		5		27
Baldwin	Cass	12				
Baldwin	Montcalm	19		14		42
Barlow	Barry	13		7	9	32
				(6)		
Baseline	Livingston	20		*		
Bass	Kent	18		22		49
Bass	Livingston	*				
Bear	Kalkaska	4 T		5		27
Big Bear	Otsego	10		9	10	36
Big Bradford	Otsego	15		8		34
		(14)				
Big Crooked	Van Buren	12		10		37
Big Pine Island	Kent	20		16		44
Birch	Cass	10		8		34
Blue	Mason	18		9		36
Blue	Mecosta	10		8		34
Burkhart	Washtenaw	14		8		34
Cedar	Van Buren	11		11		39
Chain	Iosco	14		10		37
Chemung	Livingston	14	15	12		40
		(16)				
Christiana	Cass	14	15	16		44
		(16)				
Clear	Jackson	10		10		37
				(14)		
Clear	St. Joseph	*				
Clifford 1	Montcalm	15		12		40
Clifford 2	Montcalm			12		40
Cordley	Livingston	13		8		34
Corey	St. Joseph	12		10		37

APPENDIX 2
1999 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHOROUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring -Overturn (Volunteer)	Spring -Overturn (DEQ)	Late - Summer (Volunteer)	Late - Summer (DEQ)	Carlson TSI TP (summer TP)
Cowan	Kent	40		26		51
		(38)				
Crockery	Ottawa	70				
		(66)				
Crystal	Benzie	11		11		39
Cub	Kalkaska	3 T		9		36
Diamond	Cass	10		7		32
Donnell	Cass	11				
		(9)				
Duck	Grand Traverse	10				
E. Twin	Montmorency	13	11	11		39
East	Kalkaska	*				
Evans	Lenawee	14	12	11		39
		(12)				
Fair	Barry	11		11		39
				(12)		
Fenton	Genesee	11		14		42
Fish	Van Buren	10		21		48
Gallagher	Livingston	*				
Gill	Livingston	25		16		44
Gulliver	Schoolcraft	*				
Hackert	Mason	13		13		41
Hamburg	Livingston	15		10		37
		(24)				
Hamilton	Dickinson	29		22		49
				(15)		
Hamlin (Upper)	Mason	19		*		
Hamlin (Lower)	Mason	8		*		
Harper	Lake	11		9		36
Higgins	Roscommon	7		6		30
		(7)				
Horsehead	Mecosta	13		6		30
Hubbard	Alcona	12		10		37

APPENDIX 2
1999 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHOROUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring -Overturn (Volunteer)	(DEQ)	Late - Summer (Volunteer)	(DEQ)	Carlson TSI TP (summer TP)
Hunter's	Alcona	22		11	14	39
Hutchins	Allegan	16		*		
Jeptha (Upper)	Van Buren	20				
Juno	Cass	20	24	20		47
Keeler	Van Buren	13		11		39
Klinger	St. Joeseph	8		7		32
Lake George 2	Clare	17		14		42
Lake George 3	Clare	10		15		43
Lakeville	Oakland	14				
		(12)				
Lancelot	Gladwin	17	18	47		60
Lancer	Gladwin	13	14	21		48
		(12)	(14)			
Lansing	Ingham	23	27	17	15	45
				(17)		
Lily	Clare	14		19		47
		(14)		(18)		
Little Crooked	Van Buren	10		14		42
Little Paw Paw	Berrien	27		24		50
Long	Gr. Traverse	4 T		11		39
Long	Iosco	23		9		36
Long	Washtenaw	*		14		42
Louise	Dickinson	18		10		37
		(18)				
Mary	Dickinson	19		13		41
McGilvery	Gladwin	24		16		44
Mecosta	Mecosta	9		10		37
Meadow	Oakland	*		*		
Missaukee	Missaukee	10				
Moon	Gogebic	11		8		34
Nepessing	Lapeer	17		32	38	54
		(14)		(30)		
N. Twin	Cass	9		11		39

APPENDIX 2

1999 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHOROUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring -Overturn (Volunteer)	Spring -Overturn (DEQ)	Late - Summer (Volunteer)	Late - Summer (DEQ)	Carlson TSI_{TP} (summer TP)
Nevins	Montcalm	17		*		
Oneida	Livingston	12		10		37
Ore	Livingston	17		17		45
Oxbow	Oakland	20		11		39
Oxford	Oakland	*				
Painter	Cass	22	23	40		57
Paw Paw 1	Berrien	22		14		42
Paw Paw 2	Berrien	35		24		50
Paw Paw 3	Berrien	41		17		45
Pentwater	Oceana	18		21		48
Pleasant	Wexford	10				
Robinson	Newaygo	30		21		48
				(20)		
Round	Kent	19		17		45
Round	Mecosta	16		14		42
S. Twin	Cass	10		8		34
Sanford	Benzie	11		9		36
				(8)		
Sapphire	Missaukee	*		13		41
School Section 1	Mecosta	12		8		34
School Section 3	Mecosta	11		7		32
Secord	Gladwin	15		11		39
Shangrila	Livingston	17		11		39
Shingle	Clare	14		17		45
Spider	Gr. Traverse	8		9		36
Stone Ledge	Wexford	19		14		42
Strawberry	Livingston	21		*		
Tamarack	Livingston	22		22		49
				(17)		
Taylor	Oakland	16		14		42
				(13)		
Van Etten	Iosco	25		51		61

APPENDIX 2

1999 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOSPHOROUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring -Overturn (Volunteer)	(DEQ)	Late - Summer (Volunteer)	(DEQ)	Carlson TSI$_{TP}$ (summer TP)
Vaughn	Alcona	24		14	13	42
					(14)	
Viking	Otsego	21		24	27	50
				(24)		
Vineyard	Jackson	12	8			
			(8)			
West Londo	Iosco	15		17	14	45
				(15)		
W. Twin	Montmorency	14	15	11		39
White	Oakland	12		18		46
Winans	Livingston	17		*		
Windover	Clare	12		12		40
Woods	Kalamazoo	25		19		47
Zukey	Livingston	10		6		30

* no lake sample received, or sample turned in to late to process
T value reported is less than criteria of detection (5 ug/l)
( ) values in parenthesis are replicate sample results for QA/QC program

APPENDIX 3
1999 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYL RESULTS

Lake	County	Chlorophyll *a* (ug/l) Sampling Event May	June	July	Aug.	Sept.	Mean	Median	Standard Deviation	Carlson TSI_{CHL} (chlorophyll)
Arbutus	Grand Traverse	3	*	3	3	2	2.8	3	0.50	41
Arnold	Clare	<1	1	2	1	<1	1.0	1	0.61	31
Avalon	Montmorency	<1	<1	2	<1	4	1.5	<1	1.54	<31
Baldwin	Montcalm	2	3	5	7	6	4.6	5	2.07	46
		(<1)								
Barlow	Barry	1	4	2	3	2	2.8	3	0.96	40
						(4),[4]				
Bass	Kent	4	6	6	3	2	4.2	4	1.79	44
Big Bear	Otsego	*	*	*	*	1				
						(2),[2]				
Big Bradford	Otsego	4	2	2	3	2	2.6	2	0.89	37
		(6)								
Big Crooked	Van Buren	4	2	3	4	4	3.3	4	0.96	43
Big Pine Island	Kent	6	13	13	12	12	12.5	13	0.58	55
				(10)						
Birch	Cass	2	5	1	3	4	3.3	4	1.71	43
				(2), [1,(1)]						
Blue	Mecosta	<1	3	4	4	3	2.9	3	1.43	41
Burkhart	Washtenaw	5	4	3	7	5	4.8	5	1.48	46
				(4)						
Cedar	Van Buren	1	5	3	7	5	4.5	5	2.52	46
					(8)					
Chemung	Livingston	*	*	*	*	*				
		[3]								
Christiana	Cass	5	8	4	8	6	6.2	6	1.79	48
				(3),[2]						
Corey	St. Joseph	4	3	2	3	3	3.0	3	0.71	41
Cowan	Kent	1	7	25	49	16	19.6	16	18.78	58
					(52), [49]					
Crystal	Benzie	<1	<1	<1	<1	<1	<1	<1		<31
Diamond	Cass	2	<1	5	4	4	3.1	4	1.82	44

APPENDIX 3
1999 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYL RESULTS

Lake	County	Chlorophyll *a* (ug/l) Sampling Event May	June	July	Aug.	Sept.	Mean	Median	Standard Deviation	Carlson TSI_{CHL} (chlorophyll)
			(<1)							
East Twin	Montmorency	2	3	2	5	1	2.6	2	1.52	37
Evans	Lenawee	1	5	7	4	3	4.0	4	2.24	44
			(5)							
Fair	Barry	8	4	5	3	4	5.0	5	2.16	45
						(4)				
Fenton	Genesee	<1	<1	3	<1	1	1.1	<1	1.08	<31
Fish	Van Buren	13	5	12	11	13	10.8	12	3.35	55
			(7)							
Hackert	Mason	3	3	4	*	*				
Harper	Lake	2	6	4	2	3	3.4	3	1.67	41
Higgins	Roscommon	1	<1	<1	<1	<1	<1	<1	0.25	<31
			(<1)							
Horsehead	Mecosta	2	*	*	4	5				
Hubbard	Alcona	<1	<1	3	2	2	1.6	2	1.08	37
Juno	Cass	9	8	6	10	10	8.6	9	1.67	52
				(7),[4]						
Klinger	St. Joseph	1	1	2	3	2	1.8	2	0.96	35
		(<1)								
Lake George	Clare	<1	4	4	4	6	3.7	4	1.99	44
Lancelot	Gladwin	*	7	2	1	19	7.3	5	8.26	45
					(2)					
Lancer	Gladwin	*	2	2	5	6	3.8	4	2.06	43
Lansing	Ingham	4	3	4	5	4	4.0	4	0.71	44
						(5),[5]				
Lily	Clare	3	6	1	3	1	3.3	3	2.06	41
				(3)						
Little Crooked	Van Buren	7	4	4	7	6	6.0	7	1.41	49
					(11)					
Long	Iosco	8	5	6	8	7	6.8	7	1.30	50
Long	Washtenaw	*	*	*	*	*				
McGilvery	Gladwin	1	6	8	3	7	5.0	6	2.92	48
			(9),							

APPENDIX 3
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[9]

Lake	County	Chlorophyll *a* (ug/l) Sampling Event May	June	July	Aug.	Sept.	Mean	Median	Standard Deviation	Carlson TSI_{CHL} (chlorophyll)
Mecosta	Mecosta	1	3	4	5	3	3.2	3	1.48	41
Meadow	Oakland	*	*	*	*	*				
Moon	Gogebic	2	2	3	3	3	2.6	3	0.55	41
				(4)						
Nepessing	Lapeer	*	*	*	*	15				
						(14), [11]				
Nevins	Montcalm	1	4	4	1	*	2.5	3	1.73	40
					(<1), [2]					
Oxbow	Oakland	1	1	1	<1	2	1.1	1	0.55	31
		(3)				(2)				
Oxford	Oakland	*	*	*	*	*				
Painter	Cass	4	4	82	21	17	25.6	17	32.44	58
				(58), [80]						
Paw Paw	Berrien	*	*	*	*	*				
Pentwater	Oceana	9	5	13	16	18	12.2	13	5.26	56
Robinson	Newaygo	15	6	10	6	14	10.2	10	4.27	53
					(6)					
Round	Kent	<1	4	13	8	4	5.9	4	4.77	44
			(5)							
Round	Mecosta	2	<1	5	7	5	3.9	5	2.61	46
					(6)					
Sapphire	Missaukee	*	2	7	5	3	4.3	4	2.22	44
School Section	Mecosta	2	<1	4	3	4	2.7	3	1.48	41
Secord	Gladwin	1	<1	3	29	28	12.3	3	14.82	41
Shingle	Clare	1	4	5	5	24	7.8	5	9.20	46
Spider	Grand Traverse	<1	1	6	4	5	3.3	4	2.44	44
		(<1)								
Stone Ledge	Wexford	9	2	4	6	2	4.6	4	2.97	44
Twin (North)	Cass	4	<1	1	2	<1	1.6	1	1.47	31
Twin (South)	Cass	2	<1	<1	2	<1	1.1	<1	0.82	<31
Van Etten	Iosco	6	5	32	25	4	14.4	6	13.13	48

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Lake	County	Chlorophyll *a* (ug/l) Sampling Event May	June	July	Aug.	Sept.	Mean	Median	Standard Deviation	Carlson TSI_{CHL} (chlorophyll)
Viking	Otsego	3	20	16	18	11	13.6	16	6.80	58
					(20)	[13]				
West Twin	Montmorency	3	6	4	3	3	3.8	3	1.30	41
			(5)							
White	Oakland	*	*	*	*	*				
Windover	Clare	2	2	4	2	2	2.4	2	0.89	37
						(2)				
Woods	Kalamazoo	2	4	7	7	18	7.6	7	6.19	50

* no sample received, sample turned in to late to process, or sample contaminated
T value reported is less than criteria of detection (1 ug/l)
( ) values in parenthesis are replicate sample results for QA/QC program
[ ] values in brackets are DEQ side-by-side sample results for QA/QC program