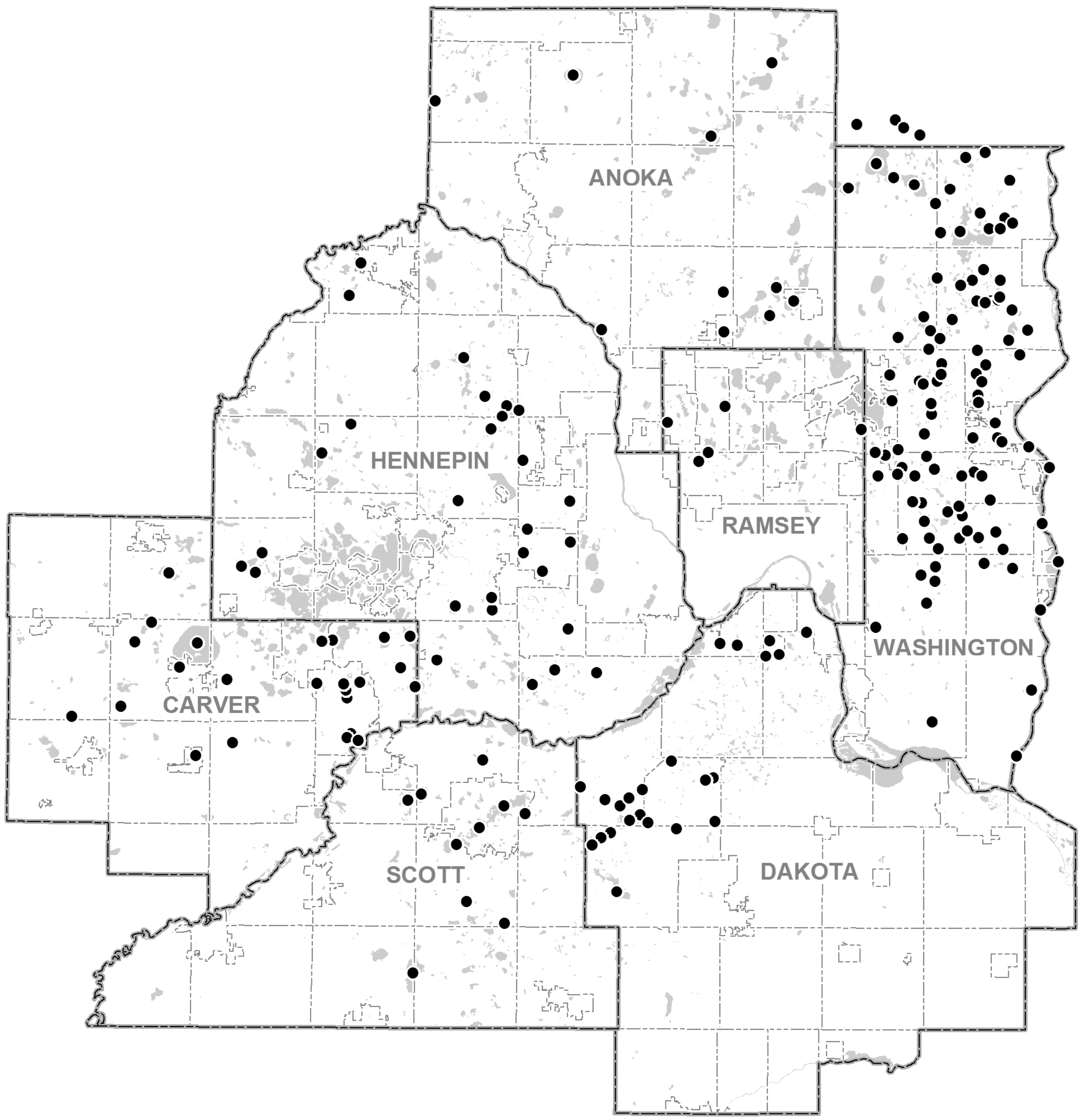
2009 Study of the Water Quality Of 194 Metropolitan Area Lakes



By
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December 2010

EXECUTIVE SUMMARY

This 2009 report is the latest in a continuing series of reports summarizing results of the annual lake monitoring program of the Metropolitan Council (METC) in the Twin Cities seven-county metropolitan area (TCMA). The METC has collected water quality data on area lakes since 1980. This report contains data from a total of 210 lake sites on 194 lakes monitored in 2009. This year's monitoring program included 6 lakes never before monitored by the Council.

To date, the METC's lake monitoring program (including monitoring by METC staff and volunteers) has provided an important tool for making informed lake management decisions. Data from our regional lake monitoring program are frequently used to determine possible trends in lake water quality, estimate expected ranges in water quality of unmonitored lakes, examine intra-and inter-regional differences, determine potential water quality impairments, and investigate the relationships between land use and water quality.

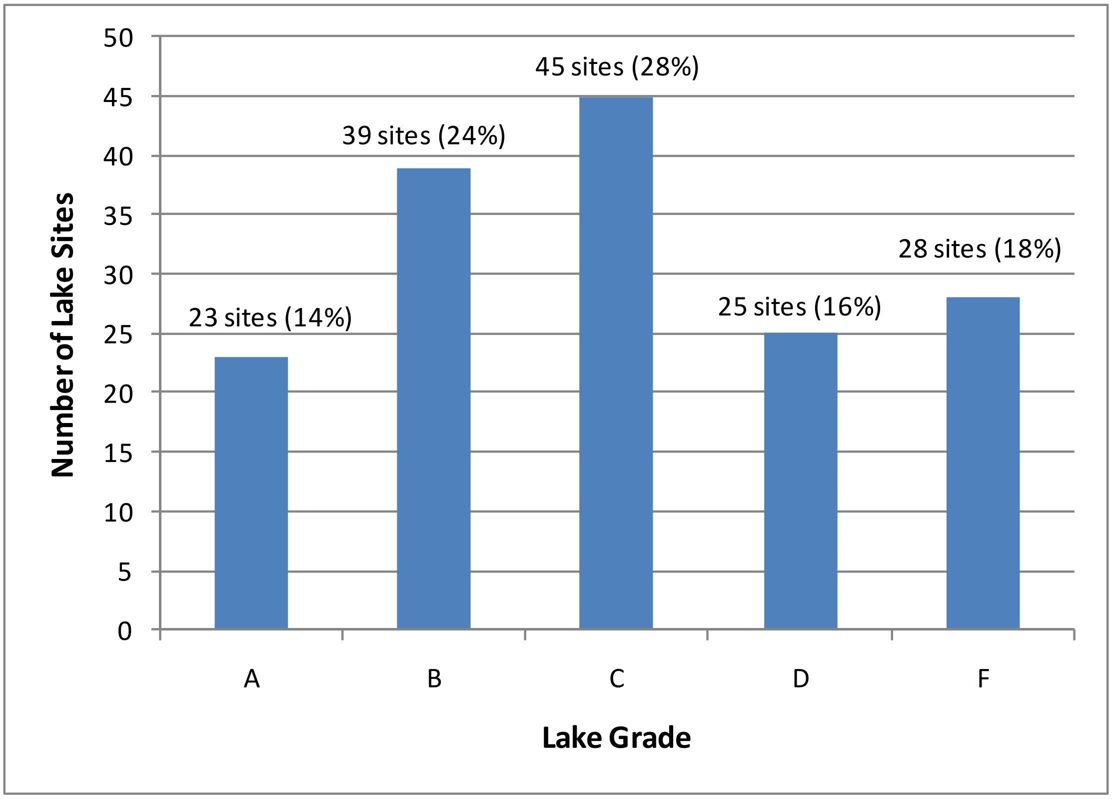
The objectives of this program are:

1. Provide lake water quality data to lake, watershed and water resource managers.
2. Advise managers of known or suspected threats to lake water quality.
3. Continue to compile a water quality database on the five area lakes that support a trout fishery.

The year 2009 marked the seventeenth year that the Citizen-Assisted Monitoring Program (CAMP) was used to increase our knowledge of the water quality of TCMA lakes. CAMP volunteers visited their assigned lake on a biweekly basis from mid April to mid October. The volunteers measured surface water temperature and water transparency, documented lake and weather conditions, and collected surface water samples. The samples were analyzed for total phosphorus, total Kjeldahl nitrogen, and chlorophyll-a by the METC's analytical laboratory located at the Metropolitan Wastewater Treatment Plant in St. Paul, MN. CAMP volunteers are sponsored by a local partner. In 2009, there were 29 sponsors who consisted of a mix of municipalities, watershed management organizations (WMOs), watershed districts (WDs), counties, and a basin water resources planning team.

Each lake was given a lake grade which was calculated on the basis of three parameters: total phosphorus, chlorophyll-a, and Secchi depth (water clarity). Not all lake sites received a lake grade because of an insufficient quantity of data during the summer-time period of May through September. The distribution of lake grades for all the lake sites monitored in 2009 is shown in the following figure.

The greatest percentage of the lake sites (28%) received a lake grade of C. The water quality of these lakes is considered average as compared to other lakes in the TCMA. There were more above-average lakes (38% A and B lake grades) compared to below average lakes (34% D and F lake grades).



Lake Grades for the 2009 Monitoring Season

Since 1980, 355 TCMA lakes have been monitored through the METC's lake monitoring program. Since some of these lakes have multiple monitoring sites, a total of 390 lake sites have been monitored. The data from the METC's lake monitoring program are permanently stored in the U.S. EPA's national water quality data repository, called STORET (STOrage and RETrieval). Data for all METC lake monitoring sites can also be conveniently obtained via the METC's web-based Environmental Information Management System (EIMS), at: http://es.metc.state.mn.us/eims/. While the METC has done its best to enhance and expand the region's lake water quality database, it is apparent that one of the most economical and efficient methods to expand knowledge of our lakes has been with the assistance of volunteers and the cooperation and financial support of local partners via the CAMP.

The METC's lake monitoring program, especially the use of volunteer monitors through CAMP, has played a key role in the METC's recent efforts to use satellite imagery to assess annual lake water clarity for the entire region. The monitoring program provides direct field measurements that are used to calibrate mathematical models, which in turn are used to interpret the satellite images. The use of satellite technology provides a cost-effective way to extend the analysis of the region's lake water quality beyond just the lakes involved in the METC monitoring program. The satellite–based information can be used to detect how lake water clarity conditions have changed over time and space in relation to changes in land-use and land-cover conditions.

If you have questions pertaining to the lake data or descriptions contained in this report, inquiries about CAMP, or suggestions of lakes the METC should consider monitoring in the future, please contact Brian Johnson of the Metropolitan Council at (651) 602-8743 or brian.johnson@metc.state.mn.us.

ACKNOWLEDGMENTS

This report represents the coordinated efforts of many individuals. The author would like to acknowledge the following people for their technical and supportive contributions to the preparation of this report:

CAMP Volunteers and Local Partners

The enthusiastic participation of local sponsors and volunteers help make the CAMP successful. A list of sponsors and volunteers is shown in Appendix C. The following volunteers are given added appreciation for their multiple years of service:

17 years of service
Diane and Bob Coderre – Sunset Lake

16 years of service
Washington CD – multiple lakes

15 years of service
Bill Aamodt – Wilmes Lake
Carver Co. Env. Services – multiple lakes

14 years of service
City of Circle Pines – Golden Lake
John Ritter – Lake Alimagnet
Wargo Nature Center – George Watch

13 years of service
Anoka Co. Parks – multiple lakes

12 years of service
Glen Gramse – Keller Lake
Wally Shaver – Lac Lavon Lake

11 years of service
Lakeville – Valley and Lee lakes
John Ryski – Bavaria Lake
Westwood Nature Center – Westwood Lake

10 years of service
Dave Hanson – Sweeney Lake

9 years of service
Arnett Family – Crystal Lake
Gene Berwald – Pine Tree Lake
Kevin Bjork – Cloverdale Lake
Tom/Dorothy Goodwin – Orchard Lake
Wally Potter – Marion Lake
Rice Creek WD – Multiple
Terry Riley – Markgrafs Lake
Mike Depth – Tamarack Lake
Sly Family – Downs Lake
Bob Videen – Parkers Lake

8 years of service
Bonnie Juran – Klawitter Lake
Al Kettlekamp – Long Lake
Tom Sletta – Cates Lake

7 years of service
Walt Burris – Lower Prior Lake
Conservation League of Edina – Cornelia Lake
Bill Feely – Long Lake
Kellogg Family – Cobblecrest Lake
Kitty Francy-Payton – Long Lake

6 years service
David Bess – Wood Lake
Carolyn Dindorf – Magda Lake
David Florenzano – Riley Lake
Wayne Hubin – Swede Lake
Sue Morgan & Linda Scott – St. Joe Lake
Shelly Strohmaier – Lotus Lake
Chuck Taylor – Jane Lake
Gordan Warner – Mitchell Lake

5 years service
Carpenter Nature Center – St. Croix Lake (site 7)
Marvin Groth – Bass Lake
Roberta & Jim Harper – St. Croix Lake (site 2)
Arnie Johnson – Sunnybrook Lake
Jeff Keene – O'Connor Lake
Steven Lane – Cedar Island Lake
Sheryl & Rich Lindholm – St. Croix Lake (site 5)
Cecilia & Harry Martin – St. Croix Lake (site 3)
Rick Meierotto – St. Croix Lake (site 6)
Steve Pierson – Fish Lake

4 years service
Dick Bancroft – Sunfish Lake
David Bluhm – White Rock Lake
Terry Bouthilet – Lake Elmo
Bruce Cornwall – Twin Lake
Jerry Edberg – Cedar Lake
Marvin Groth – Bass Lake
Dave Johnson – Hornbean Lake
Scott Knudson – Lake Elmo
Minnesota DOT – Rest Area Pond
Dave Nimmer – Edith Lake
Martha Popp – Lost Lake
Bob Schumacher – Eagle Point Lake
Jim Serley – Echo Lake
Gregg Thompson – Bush Lake
Dan Wallace – Sunset Pond
Joe Williamson – McMahon Lake

<u>3 years service</u>
Dan Freeman – Twin Lake south
Lynne McMullen – Reitz Lake
Marty Ziermann – Rutz Lake
Robert Armstrong – Susan Lake
Jon Hafner & Don Jack – Bone Lake
Curt Sparks – Sylvan Lake
George & Pam Christ – Henry Lake
George Schneider – Rice Lake
Doug Hennes – Rogers Lake
Jon Moon/Heidie Dorfmeister – Cornelia Lake

<u>3 years service (continued)</u>
John Burton – Wing Lake
Gary Gerding – Karth Lake
Tam & Dick McGehee – Langton Lake
Jim & Tricia Hafner – Loch Ness
Voit Family – Dean Lake
Sandy & Mike Boyce – Lake O'Dowd
Randy Bjorklund – Seidl Lake
Jim Nayes – Horseshoe Lake

Metropolitan Council Staff

- The MCES Laboratory Services Section, for laboratory analysis of the lake samples.
- Craig Skone for support with data presentation and for developing all the graphics for this report.
- Jerry Saatzer for his assistance with preparation of CAMP equipment.

CONTENTS

INTRODUCTION

This 2009 report continues a series of annual lake reports from 1980 to present. Since 1980, 355 Twin Cities Metropolitan Area (TCMA) lakes have been monitored through the Metropolitan Council's (METC) lake monitoring program. Since some of these lakes have multiple monitoring sites, a total of 390 lake sites have been monitored. This report contains data from 210 lake sites on 194 lakes that were monitored in 2009, including 6 lakes and 11 lake sites that have not been previously monitored by the METC lake monitoring program. The list of lakes in the METC's monitoring database is shown in Appendix A. Refer to Appendix B for morphometry and other lake characteristic data.

METC lake monitoring data are available via:

- the METC's Environmental Information Management System (EIMS), at http://es.metc.state.mn.us/eims/,
- the Minnesota Pollution Control Agency's (MPCA) Environmental Data Access (EDA) system, at http://www.pca.state.mn.us/index.php/water/water-home.html,
- the STORET Data Warehouse, which is the U.S. EPA's national water quality data repository, at http://www.epa.gov/storet/dbtop.html.

The objectives of the METC lake monitoring program are:

1. Provide lake water quality data to lake, watershed and water resource managers.
2. Advise managers of known or suspected threats to lake water quality.
3. Continue to compile a water quality database on the five area lakes that support a trout fishery.

The long-term goal of the METC lake monitoring program is to provide a comprehensive database to enable cities, counties, watershed management organizations (WMOs), and watershed districts (WDs) to better manage TCMA lakes. The Council believes that without such comprehensive lake data, the foundation of lake and watershed management plans is weakened. While the METC has provided a commendable lake monitoring program, monitoring by other organizations is also encouraged (Osgood 1989a).

To date, the METC lake monitoring program has been an important tool for making informed lake management decisions. The majority of the lakes have been visited on a rotating schedule over the past 30 years, so as to develop an historical database to help lake and watershed managers in decision making. Data from the METC lake monitoring program are frequently used to determine possible trends in lake water quality, estimate expected ranges in water quality of unmonitored lakes, examine intra-and inter-regional differences, and investigate the relationships between land use and water quality. A comprehensive regional lake monitoring program should ensure adequate spatial and temporal representation of water quality. However, due to cost and logistical problems, ground-based monitoring programs usually sacrifice spatial coverage (fewer lakes) in favor of more frequent sampling.

As is the case throughout the United States, the majority of lakes in the TCMA suffer from this lack of water quality data. Area lakes and watershed managers need a broad, comprehensive water quality database for regulatory and decision-making purposes. Because of the lack of public funding and the high ratio of area lakes to monitoring staff, very little data exist for the majority of TCMA lakes, and local decision-makers are forced to make management decisions lacking adequate information.

The METC addressed this lack of adequate lake water quality data by initiating a citizen-assisted monitoring program (CAMP) in 1993. The purpose of the CAMP is to provide a more complete and improved water quality database for TCMA lakes. This database gives local decision makers a better idea of the water quality of their lakes, thereby assisting them in decision making on water quality issues. The METC's goal for the CAMP is to provide a means to gather as much information on TCMA lakes as is economically possible.

The METC lake monitoring program, especially the use of volunteer monitors through the CAMP, has played a key role in the METC's recent efforts to use satellite images to assess annual lake water clarity for the entire TCMA. The monitoring program provides the "ground-based" measurements used to calibrate mathematical models, which in turn are used to interpret the satellite images. The use of satellite technology provides a cost-effective way to extend the analysis of the TCMA's lake water quality from just the lakes involved in our ground-based programs to all the lakes in the region. Over time, the satellite–based information can be used to detect how lake trophic conditions (especially water clarity) have changed over time and space in relation to changes in land-use and land-cover conditions.

METC STAFF MONITORING PROGRAM

METHODS

Metropolitan Council staff monitored 11 lake sites on 10 TCMA lakes during 2009 (Figure 1). The lake sites generally were located over the deepest spot of the lake basin or sub-basin (Figures 2 and 3). A hand-held Global Positioning System (GPS) receiver was used to determine the coordinates of a lake site, and to aid in relocating lake sites during subsequent monitoring events. Time, water surface and weather conditions, water depth, and water transparency were recorded on a field data sheet. Water transparency was measured using a 20 cm black-and-white Secchi disk. Temperature, dissolved oxygen (DO), pH, specific conductivity, turbidity, and oxidation reduction potential (Redox) were measured at one-meter intervals throughout the water column. These parameters were measured using a YSI 6920 multi-parameter sonde that was connected to a YSI 650 data logger.

The sonde probes for DO and pH were calibrated before each field trip. These probes were also calibrated again the same day after returning from the field, to check for calibration drift. The conductivity probe was calibrated on a weekly schedule. The turbidity and Redox probes were calibrated on a monthly schedule.

Water was collected from the lake surface (0-2 m) using a two-meter PVC pipe with a two-liter capacity. Three such samples were mixed in an 8-liter plastic jug. Subsurface samples were collected using a 2-liter Van Dorn sampler. All water samples were transported on ice in a dark cooler and processed and preserved within 12 hours of collection.

The surface and subsurface samples were analyzed for the standard parameters as shown in Table 1. Chlorophyll was not analyzed in the subsurface samples. The analytical methods for each parameter also are shown in Table 1. Samples that were analyzed for total dissolved phosphorus (TDP) were filtered through a 0.45 μm membrane filter and then analyzed for TP. All chemical analyses were performed at the Metropolitan Council Environmental Services - Environmental Quality Assurance Department (MCES-EQA) laboratory.

The chlorophyll analysis results are reported by the laboratory according to two different equations: the trichromatic equation and the monochromatic equation. The trichromatic equation gives the following chlorophyll parameters:

- chlorophyll-a (CLA),
- chlorophyll-b,
- chlorophyll-c.

The monochromatic equation gives the following parameters:

- chlorophyll-a corrected for pheophytin,
- pheophytin-a.

The chlorophyll data in this annual report are reported as trichromatic CLA. However all the analytical results from the trichromatic and monochromatic equations can be accessed via the monitoring data databases as provided in the Introduction section.

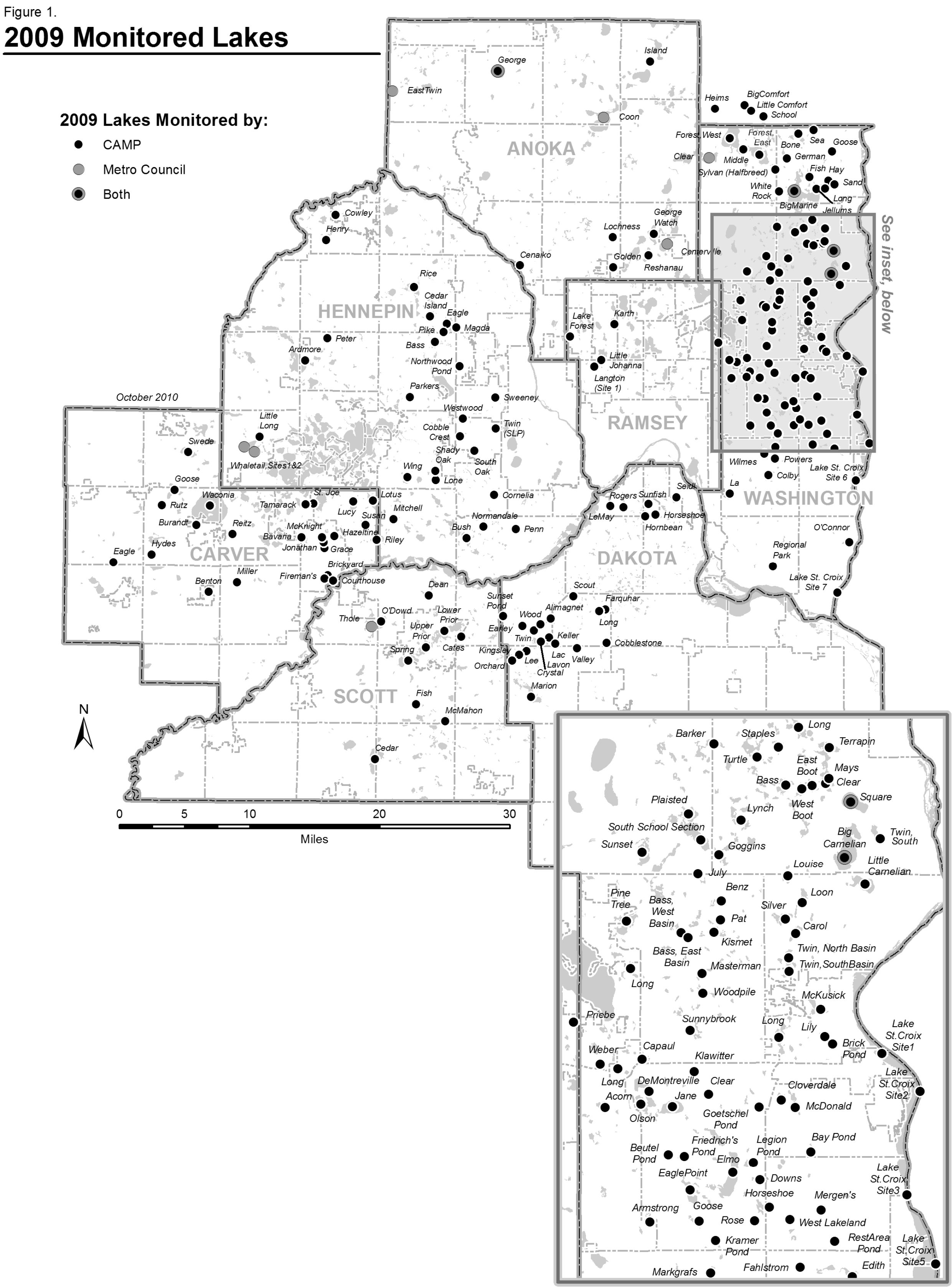


Figure 1. 2009 Monitored Lakes

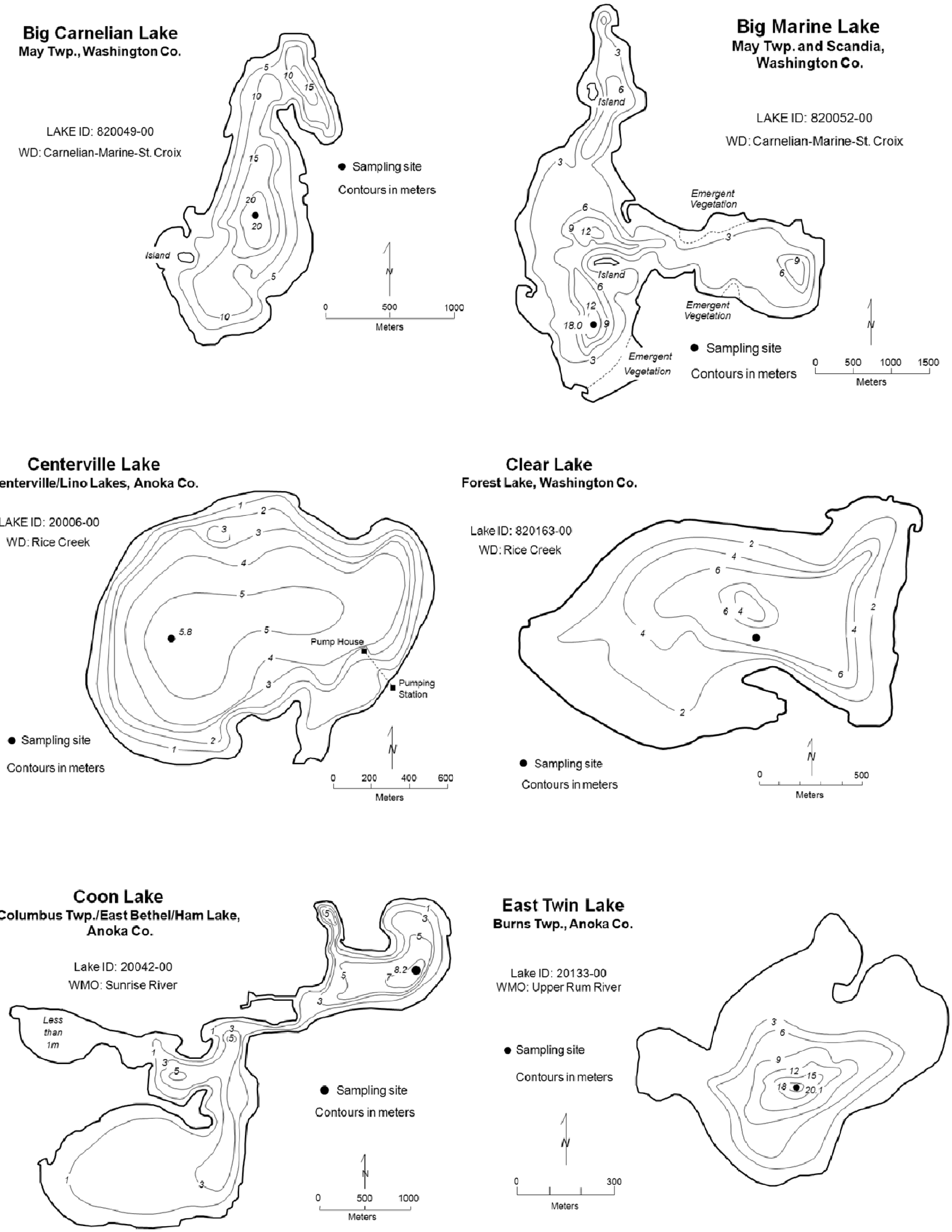
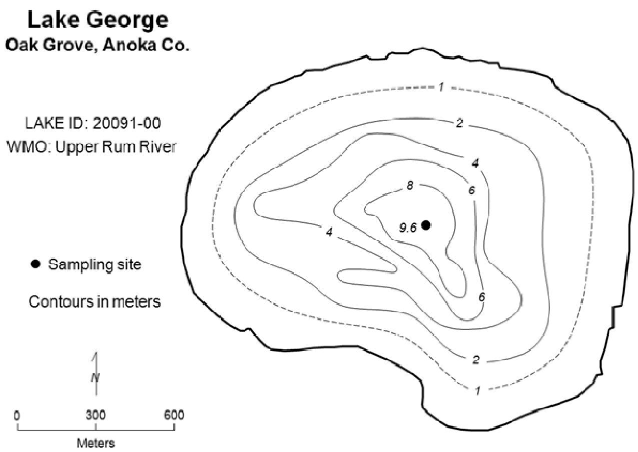
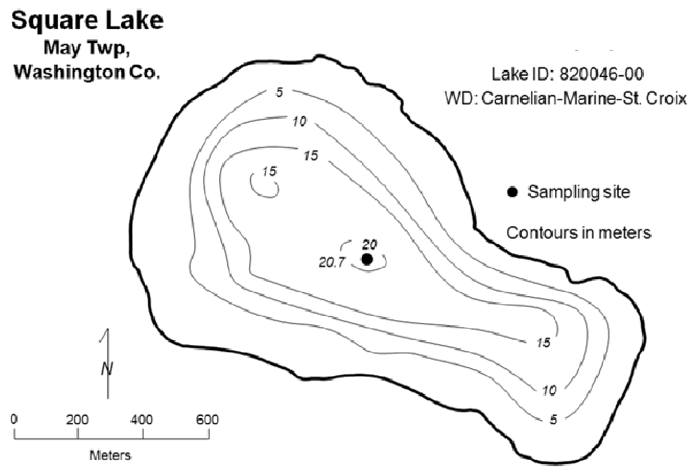
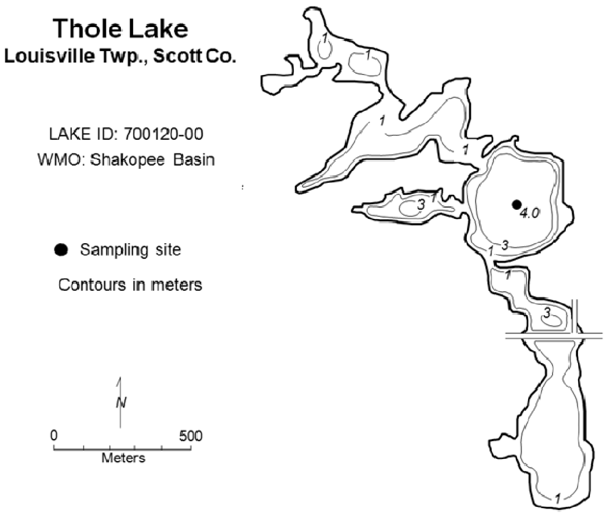
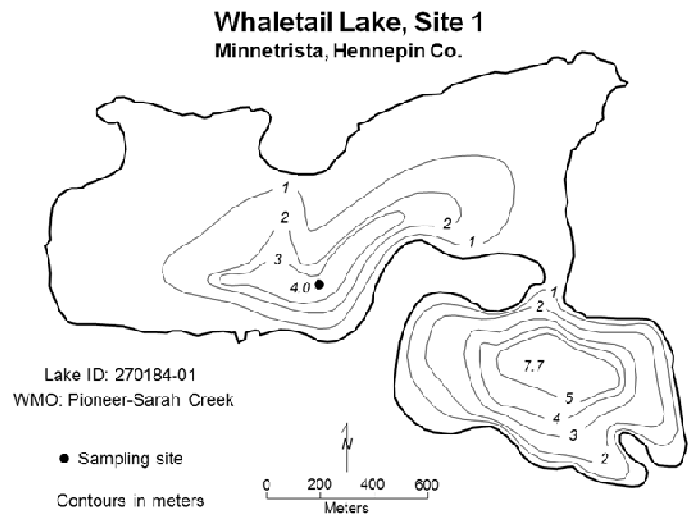


Figure 2. METC Staff Monitored Lakes (Big Carnelian – East Twin)









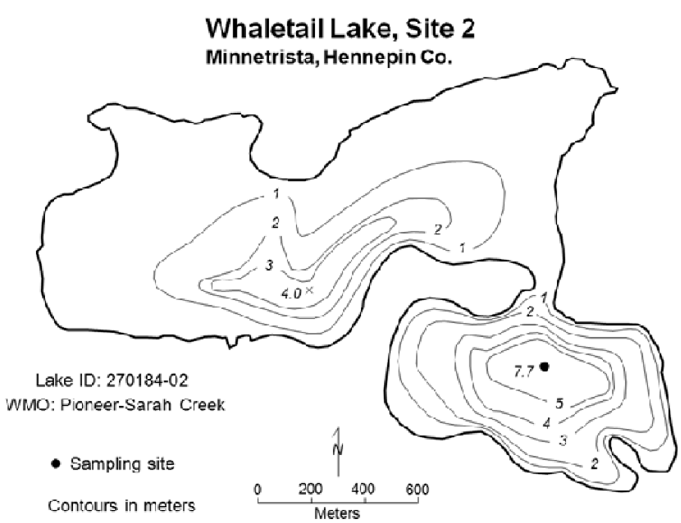


Figure 3. METC Staff Monitored Lakes (George – Whaletail)

Table 1
Summary of Analytical Methods

Standard Parameters	**Analytical Method**
Total Phosphorus (TP)	U.S. EPA Method 365.4
Total Kjeldahl Nitrogen (TKN)	U.S. EPA Method 351.2, Rev. 2.0
Chlorophyll	ASTM Method D3731-87
Chloride	Method 4500-Cl- E , (APHA 1998)
Hardness	Standard Methods for the Examination of Water and Wastewater, Method 2340 C, Online Edition
Sulfate	U.S. EPA Method 300.0
Optional Parameters	
Ortho-phosphate	4500-P E Ascorbic Acid Method, (APHA 1998)
Iron, total	U.S. EPA, Method 200.8, Revision 5.4, 1994 as modified

RESULTS

Table 2 shows select monitoring data for the METC staff monitored lakes. All of the monitoring data are available via the METC's Environmental Information Management System (EIMS) at http://es.metc.state.mn.us/eims/. The monitoring data was also sent to the MPCA for inclusion in their Environmental Data Access system.

Any questions about the 2009 METC lake monitoring data should be directed to Brian Johnson at (651) 602-8743 or brian.johnson@metc.state.mn.us.

TABLE 2

Select Field and Analytical Data for METC Staff Monitored Lakes 2009

LAKE NAME	DATE	Secchi Depth (m)	CLA (ug/L)	TEMP (deg C)		DO (mg/L)		TKN (mg/L)		TP (ug/L)		TDP (ug/L)		Chloride (mg/L)	
				surface	bottom	surface	bottom	surface	bottom	surface	bottom	surface	bottom	surface	bottom
Big Carnelian Lake	5/22/2009	4.7		17.2	6.8	9.92	0.18								
	5/28/2009	5.7	2.5	17.1	6.8	10.19	0.20	0.43	1.10	15	158	< 10	20	12	13
	7/23/2009	6.3	1.6	23.4	7.5	9.71	0.06	0.41	2.00	7	657	3	453	13	13
	8/5/2009	6.5	3.3	22.6	7.7	10.12	0.09	0.42	2.20	8	588	< 3	400	12	13
Big Marine Lake	5/28/2009	4.1	3.1	17.8	15.9	9.64	9.13	0.43	0.51	13	22	< 10	< 10	13	13
	7/17/2009	3.0	5.2	20.6	15.7	8.95	0.12	0.49	0.61	12	35	6	20	13	13
Clear Lake	6/22/2009	1.2		25.3	15.9	8.68	0.48	1.20	1.40	42	36	6	6	86	85
	7/17/2009	1.0	17	20.3	19.5	7.69	7.98	1.60	1.50	37	41	22	18	92	92
Centerville Lake	6/22/2009	2.4		23.9	17.4	8.97	0.91	1.10	0.87	39	40	33	25	37	37
	7/17/2009	1.4	22	20.9	20.9	8.04	7.97	1.20	1.20	52	47	11	12	40	
Coon Lake	6/25/2009	1.2	16	26.0	15.6	8.10	0.47	1.10	1.10	40	37	< 10	< 10	14	14
	7/28/2009	0.8	40	22.8	18.7	11.67	0.11	1.60	1.70	47	44	8	9	14	14
East Twin Lake	6/11/2009	5.2		18.1	4.1	11.43	0.16	0.88	1.80	21	275		71	11	13
	6/25/2009	3.3	5.5	26.9	4.3	8.53	0.28	0.93	2.10	30	314	15	133	11	13
	7/20/2009	3.7	4.4	21.0	4.4	9.45	0.07	0.93	2.10	22	305	10	176	12	13
George Lake	6/25/2009	3.6	4.4	26.3	16.0	8.38	1.29	0.70	0.62	20	28			15	15
	7/20/2009	2.4	8.3	20.5	17.9	9.44	2.40	0.83	0.87	25	33	< 10	< 10	16	15
Square Lake	7/23/2009	5.9	2.3	22.3	6.1	10.59	0.08	0.37	1.20	7	69	3	6	8	9
	8/27/2009	6.7	3.0	23.2	6.4	10.36	0.11	0.38	1.00	10	88	5	10	8	8
Thole Lake	7/24/2009	0.4	180	22.9	20.2	14.46	0.16	2.50	1.90	91	97	20	26	48	47
	8/6/2009	0.5	110	25.3	21.7	11.92	0.32	3.00	2.00	166	106	22	28	51	49
Whaletail Lake (site 1)	6/30/2009	0.4	78	20.8	20.7	8.67	8.75	3.20	3.10	194	198	8	9	18	18
	7/22/2009	0.3	70	22.3	20.0	12.24	8.60	3.20	3.60	119	150	13	9	19	18
	8/6/2009	0.4	60	24.2	22.0	13.10	5.90	2.60	2.90	87	105	6	10	19	19
Whaletail Lake (site 2)	6/30/2009	0.7	31	21.4	15.1	6.89	0.26	3.70	2.50	122	106	12	25	17	17
	7/22/2009	0.9	54	22.3	14.7	11.79	0.09	1.80	5.30	72	397	< 10	44	17	17
	8/6/2009	1.0	28	23.4	16.4	10.37	0.26	1.70	4.40	44	160	8	60	17	17

CITIZEN-ASSISTED MONITORING PROGRAM (CAMP)

CAMP OVERVIEW

The year 2009 marked the seventeenth year of the CAMP since the program began in 1993. The CAMP monitored 203 lake-sites on 189 lakes in 2009, including 5 lakes and 11 lake-sites that have not been previously monitored by the METC (Figure 1). The CAMP is jointly funded by the METC and local sponsors such as WDs, WMOs, counties, and cities.

The main purpose of the CAMP is to provide lake and watershed managers with water quality data that will not only support them in properly managing water resources, but also provide much needed historical data to help document water quality changes and trends. Previous volunteer monitoring programs conducted throughout the United States have shown that, with proper equipment and instructions, volunteers can be trained to produce credible water quality data. Because most of the volunteers live near the lakes they are monitoring, they are very interested in determining any trends and/or changes in local water quality (Nichols 1992). An additional benefit of the monitoring program is the volunteer's increased awareness of the lake's condition and workings throughout the summer, which may foster grass-roots initiatives to protect lakes and promote support for lake management.

Prior to the inception of the CAMP in 1993, The METC conducted a pilot study in 1991 to assure that the data collection methods used by citizen volunteers would be credible. Results of the pilot study showed that the volunteer monitoring methods, as used in the CAMP, yielded results comparable to monitoring methods used by METC staff (Hartsoe and Osgood 1991).

CAMP volunteers collect surface water samples that are analyzed for total phosphorus (TP), total Kjeldahl nitrogen (TKN), and chlorophyll-a (CLA). In addition, they measure surface water temperature and water transparency, and record user perceptions. Some lakes are monitored for dissolved oxygen. Most lakes are visited biweekly from April through October (fourteen sampling dates) and are sampled at the lake's deepest open-water location. In 2009, quite a few of the lakes were not monitored on each of the desired 14 sampling weeks. The reasons for the missed sampling dates varied. However, the majority of the lakes, even with the missed sampling dates, were sampled adequately and often enough to provide an annual overview of the water quality of each lake. Water samples were submitted to METC staff and then analyzed at the MCES-EQA laboratory in St. Paul, MN.

ACKNOWLEDGMENTS

The successful performance of the 2009 CAMP would not have been possible without the greatly appreciated work performed by volunteer monitors, and the support of the organizations that enrolled lakes in the program. The enrolling organizations, which included 13 cities, 11 watershed management organizations and watershed districts, 3 counties, 1 conservation district, and 1 basin planning team, were involved in volunteer recruitment, training, and occasional follow up on the progress of their volunteer lake monitors. Without this help, the program would not have been as successful.

Those deserving the greatest appreciation are the volunteers themselves. Their efforts have made this program successful. A list of the 2009 CAMP volunteers is shown in Appendix C. The METC and the local sponsors thank them for their sustained efforts, including their quality work.

CAMP METHODS

Recruiting Volunteers

Active recruitment of lakes and interested volunteers for the CAMP began in the winter months prior to the monitoring season. Potential sponsors were solicited for their list of lakes that they wished to enroll in the CAMP. The sponsors were encouraged to recruit volunteers for each lake they enrolled in the program. If there were problems finding willing volunteers, the METC assisted with the search; however, the belief was that the supervising organization would benefit in the long run by having direct contact with the volunteers it recruited. This contact would hopefully open a two-way communication line between concerned citizens and the local partners.

Training Volunteers

Volunteer training was conducted by METC staff at various locations throughout the TCMA. Volunteer training was scheduled between early March and early April. At each training session, volunteers were given a handbook describing the program, outlining basics in the biology and ecology of lake systems, and containing detailed written instructions for the lake monitoring and data form completion procedures (Anhorn 2003a).

At each training session, volunteers received the necessary equipment for lake monitoring. This equipment was purchased by the sponsor through the METC, and then loaned to the volunteers. At the end of the monitoring season, equipment was returned to the sponsor for use in future years. Each lake's volunteer received:

- Chlorophyll hand pump, flask, and filters
- Digital thermometer
- Map of lake with sampling site(s)
- Field data sheets
- Sample jug
- Sample vials, Petri dishes, and labels
- Secchi disk
- Aluminum foil
- Tweezers (forceps)

During the training session, volunteers were given a brief description of limnology and lake ecology as described in their handbook, instructed on proper lake monitoring procedures, and shown how each piece of sampling equipment works. After this discussion, the volunteers received a package containing the equipment, and the proper use of each piece of equipment was again described and practiced. Finally, the volunteers were asked to sign a waiver of liability stating that they were not an employee of either the METC or the local partner enrolling the lake in the program.

Monitoring Methods

Volunteers were instructed to monitor their designated lake site(s) on a biweekly basis from mid-April to mid-October, including 14 possible sampling periods. The monitoring methods are detailed in the following paragraphs.

First, during pre-arranged sampling weeks, volunteers located and anchored their boat at pre-determined monitoring locations (typically the deep open-water area of the lake). Once at the monitoring location, lake and meteorological conditions were recorded on a field data sheet (Figure 4). The form also provides space to record natural and cultural observations which may have influenced what was happening in the lake (e.g. heavy rains prior to monitoring, application of herbicide), and includes an area to document general perceptions of the lake's physical condition and suitability for recreation.

Next, the volunteers took a water transparency reading by lowering a Secchi disk on the shaded side of the boat to the point at which it disappeared. The point where the disk reappears is the Secchi transparency depth that was recorded on the observation form.

The next lake monitoring step involved the collection of the surface water sample. A surface water sample was collected in a clean one-gallon plastic jug. To begin, the volunteer pre-rinsed the jug three times with lake water. After rinsing, the jug was filled by submerging it upside down to forearm depth and turning it upright while still submerged. Immediately after filling the sample jug, the volunteer obtained the water temperature and poured-off aliquots for analytical analysis. The collection methods for each parameter are given as follows:

- **Temperature**. Surface water temperature was measured in the volunteer's sampling jug using a digital thermometer that is readable to 0.1°C. The temperature was measured immediately following sample collection. Special care was taken to keep the sample out of direct sunlight in order to minimize temperature change.

- **Total Phosphorus (TP) and Total Kjeldahl Nitrogen (TKN)**. Duplicate samples were decanted from the volunteer's jug in the field into their respective triple pre-rinsed, pre-labeled 50 milliliter (ml) vials. These samples were then placed in the cooler, taken home, and stored in the freezer until they were picked up and delivered to the laboratory for analysis.

- **Chlorophyll**. Chlorophyll samples from the volunteer's jug were filtered in the field *(out of direct sunlight)* using a field filtration apparatus (called a filter holder) and a hand pump. Water from the sampling jug was measured using a graduated cylinder, and then poured into the reservoir of the filter holder. The reservoir holds approximately 250 ml. By squeezing the handle of the pump, the sample water was forced through a 1 micrometer (µm) glass-fiber filter, and the suspended planktonic algae were trapped on the filter. The filtered water was then returned to the lake. If possible, this process was repeated until a total of 1,000 ml of sample water was allowed to pass through the filter. However, if the water sample contained much suspended material, and the filter became clogged without allowing more water to pass through, the amount of water that did pass through the filter was recorded on the field data sheet and sample label. The filter was then removed from the filter holder with a tweezers, and placed in a Petri dish. The Petri dish was then labeled, wrapped in aluminum foil to keep the sample in the dark, and frozen until pick-up and delivery to the laboratory for analysis.

The frozen samples were picked up within approximately 30-90 days by METC staff and delivered to the MCES laboratory for analysis. For some CAMP lakes, sub-surface samples were also collected for analysis of TP, TKN, chloride, orthophosphate, and/or total iron. These sub-surface samples were usually collected near the bottom of the lake using a Van Dorn sampler. Vertical profiles of dissolved oxygen and temperature measurements were also obtained on some lakes.

CITIZEN-ASSISTED MONITORING PROGRAM

Lake Name: ______________________ Site #: ________

DNR ID#: _______________

Sampling Date: _________________ Time: ___________ (military time)
(Use this same time on the sample labels.)

Name(s) of Volunteer(s):

_________________________________ Quantity of samples collected: Nutrient: _____ CLA: _____

____

SECCHI DISK DEPTH: ____________meters

SURFACE TEMPERATURE: _________°C

VOLUME OF FILTERED LAKE WATER (CLA): _______________ml

GENERAL OBSERVATIONS
(Circle the one best choice)

*** Water Color**

Clear Yellow
Green Gray
Brown Blue-Green
Comment:

*** Odor of Water**

None Rotten Egg-like
Fishy Septic-like
Musty Other: ________
Comment:

*** Wind Conditions**

Calm Breezy Strong

Wind is coming from the:

North South East West

*** Water Surface**

Calm Moderate Waves
Ripple Whitecaps
Small Waves
Comment:

*** Cloud Cover**

0% 75%
25% 100%
50%

*** Lake Level**

Above Normal
Normal
Below Normal
Staff Gage Reading ________

*** Amount of Aquatic Plants**

None Moderate
Minimal Substantial
Slight

*** Air Temperature (°F)**

< 40 81-90
41-60 > 90
61-80

***Unusual Conditions in the past week:**
(storms, high winds, temp. extremes):

*** Physical Condition**

Crystal Clear (1)
Some Algae Present (2)
Definite Algae Present (3)
High Algal Color (4)
Severe Bloom (Odor, Scum) (5)

*** Suitability for Recreation**

Beautiful (1)
Minor Aesthetic Problem (2)
Swimming Slightly Impaired (3)
No Swimming / Boating OK (4)
No Aesthetics Possible (5)

Figure 4. CAMP Field Data Sheet

Laboratory Analytical Methods

The chemical analyses of CAMP water samples were performed at the MCES-EQA laboratory, according to the methods shown in Table 1. Chlorophyll samples collected by the CAMP volunteers were not preserved with magnesium carbonate ($MgCO_3$), which is a change in the method provided in Table 1. Samples that were analyzed for TDP were filtered through a 0.45 µm membrane filter and then analyzed for TP.

Data Management

The field data from the volunteers' sampling forms and the analytical results from the MCES laboratory were entered into the Council's Environmental Information Management System (EIMS). EIMS is a system for providing timely and reliable information for environmental planning and decision-making. The Council's EIMS can be accessed via the internet at http://es.metc.state.mn.us/eims/. This data handling system served three purposes:

1. Check-in of forms and tracking of volunteer participation.
2. Entry of nutrient, Secchi, and user perception data into a database for statistical, graphical, and tabular outputs.
3. Storage of the CAMP data in the Metropolitan Council's EIMS, as well as in the U.S. Environmental Protection Agency's (U.S. EPA) national water quality data bank, STORET.

If there were questions concerning the data and lake observations, METC staff contacted the volunteer. The METC maintained contact with most volunteers throughout the season by telephone, in person during sample pick-up, or through their sponsor's CAMP coordinator.

Quality Assurance

CAMP employs a quality assurance (QA) program which includes quality control (QC) activities. The purpose of the QA program is to assure that CAMP produces and reports scientifically credible water quality data. The MCES laboratory follows its own internal QA program, which employs an extensive internal and external check and balance system to ensure credible data. Documentation of their QA program and QC procedures can be obtained from the laboratory.

The CAMP QA program has several components. One important component is training, which ensures that the volunteers are familiar with the CAMP monitoring methods prior to their first monitoring season. The training also ensures that the same monitoring methods are used by all the volunteers. Another component is that the volunteers' samples are checked by METC staff prior to submitting the samples to the MCES laboratory. The samples are checked for legible and correct labeling and sample integrity (e.g. cracked vials, missing caps, torn filters, etc.). Samples with poor integrity are discarded to avoid producing potentially erroneous data.

QC monitoring is another important component of the CAMP QA program. The purposes of QC monitoring are:

- To verify that the monitoring methods are producing reproducible data.
- To verify the monitoring performance of the volunteers with respect to professional staff.

A METC staff member performs QC monitoring throughout the monitoring season by visiting a volunteer's lake site during a scheduled monitoring week, but not necessarily on the same day as the volunteer's visit. The METC staff member monitors the lake site using the same methods and identical type of equipment as the volunteer. After the QC samples are collected, they are handled, stored, and submitted to the laboratory in the same manner as the volunteers' samples. Occasionally, an METC staff member accompanies a volunteer in the field during the monitoring season as a check on their monitoring methods. This latter method is used less commonly than the former method. Accompanying a volunteer in the field is usually prompted by noting potential problems during the sample checking process, or if the volunteer expresses that they need further assistance or explanation.

If a problem is discovered during the course of the sample checking or QC monitoring processes, the volunteer is contacted to discuss the cause of the problem. If needed, a METC staff member visits with the volunteer to observe his/her monitoring activities, in an effort to help identify the cause of the problem. Once the cause is identified, the volunteer is given instructions on how to correct the situation. If the problem resulted in erroneous data, then the data are censored and excluded from the database.

The CAMP sample data are reviewed after receipt from the MCES laboratory. The data are reviewed for outliers and other inconsistencies. Data that are determined to be suspect are flagged as such in the database. Data determined to be erroneous are censored and excluded from the database.

The 2009 CAMP QC data are provided in Appendix D. The results of the 2009 QC monitoring indicate good agreement between data from samples and measurements collected by METC staff versus those collected by the volunteer. Figures 5, 6, and 7 show the QC data for TP, CLA, and Secchi depth, respectively. The linear regression for each parameter shows close agreement to a 1:1 relationship between data collected by METC staff versus data collected by the volunteers. The R^2 values for TP and CLA were >0.90, which indicates that most of the variability between the volunteer- and METC staff-collected data can be explained by a linear relationship. The 0.85 R^2 value for the Secchi depth QC data indicates that the linear relationship is not as strong as those for the other two parameters, but is still robust, nonetheless. Considering that METC staff typically collect QC samples on a different day and time than the volunteer (although during the same week), it should be expected that there will be variation between the METC staff- and volunteer-collected data.

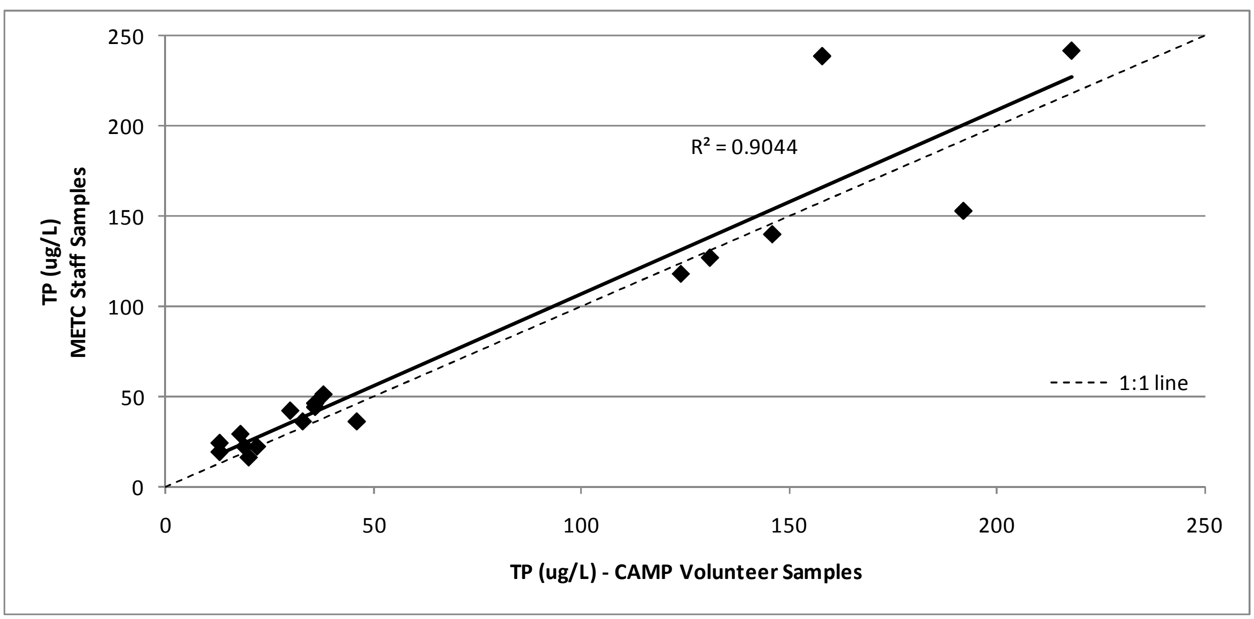


Figure 5. Total Phosphorus Quality Control Data 2009

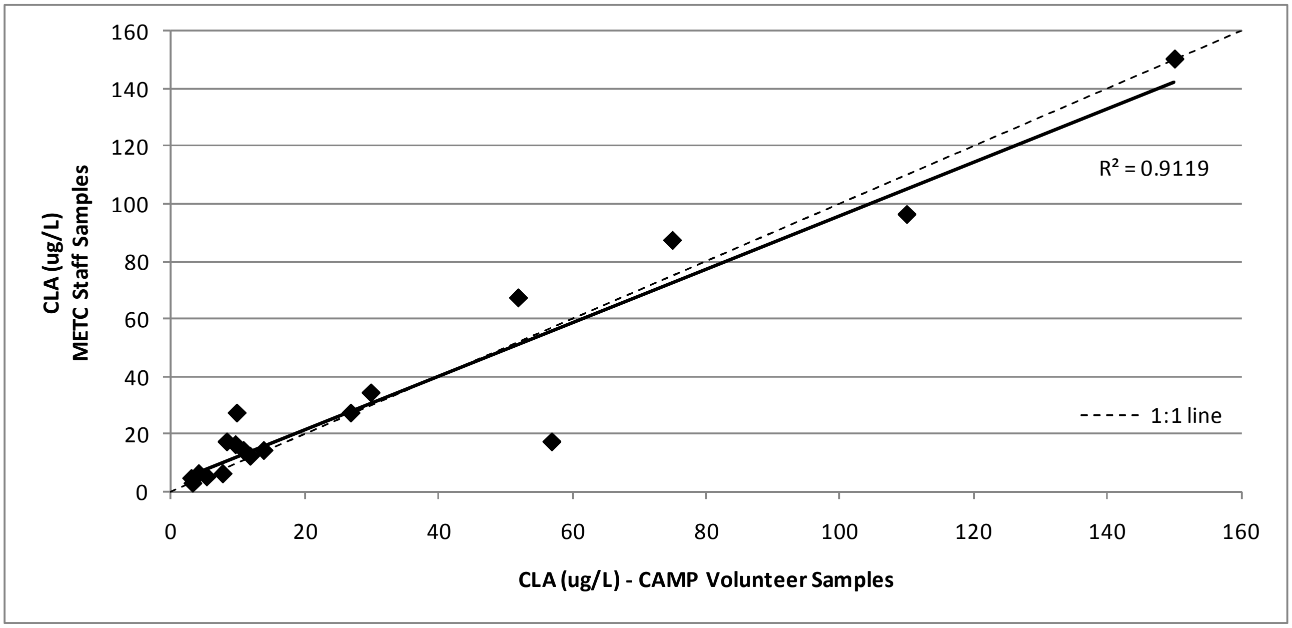


Figure 6. Chlorophyll-a Quality Control Data 2009

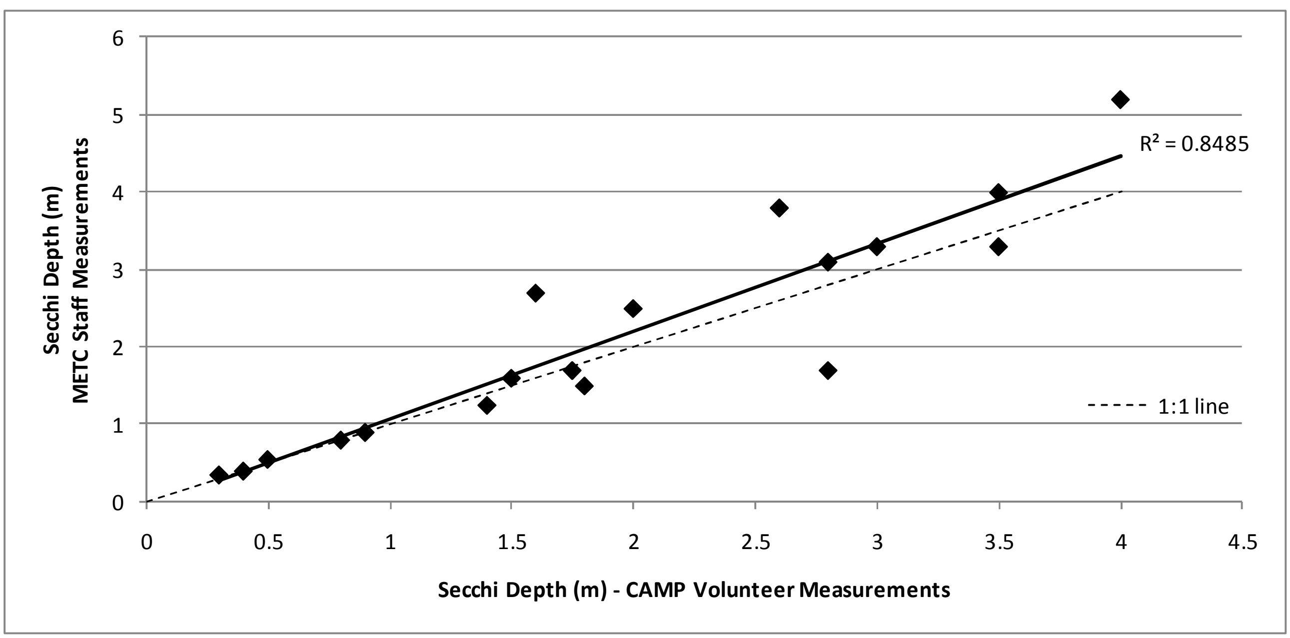


Figure 7. Secchi Depth Quality Control Data 2009

LAKE QUALITY REPORT CARD

The Metropolitan Council, following its 1989 lake survey (Osgood 1989b), developed the lake quality report card. The idea is simply that lake water quality characteristics can be ranked by comparing measured values to those of other Metro Area lakes. In this way, technical information, which in the past had required professional analysis, can more easily be used by a less technical audience to visualize the water quality of their lake relative to other TCMA lakes. The lake grading curve (Table 3) represents percentile ranges for three water quality indicators: the summertime (May - September) average values for total phosphorus, chlorophyll-a, and Secchi depth. These percentiles use ranked data from 120 lakes that were monitored from 1980 – 1988:

Table 3. Lake Grading Curve

GRADE	PERCENTILE	TP (µg/l)	CLA (µg/l)	Secchi (m)
A	< 10	< 23	< 10	> 3.0
B	10-30	23-32	10-20	2.2-3.0
C	30-70	32-68	20-48	1.2-2.2
D	70-90	68-152	48-77	0.7-1.2
F	> 90	> 152	> 77	< 0.7

The three variables used in the grading system (TP, CLA, Secchi depth) give an indication of the trophic status of the lake (Carlson 1977, Osgood 1982). The trophic status is the condition of the biological productivity of the lake ecosystem. The trophic status is strongly related to open-water nuisance-aspects of a lake (e.g. algal blooms, excess vegetation growth, poor water clarity), which can indicate accelerated aging (cultural eutrophication). For example, lake phosphorus concentration has been related to increased algal abundance, increased frequency of algal blooms, and to the increased abundance of blue-green algae (Osgood 1988). Chlorophyll-a, which is a pigment in plants (including algae) essential in the photosynthesis process, is used to estimate the algal abundance of a lake. Secchi depth relates to the appearance of a lake (generally the fewer algae, the better the transparency of a lake). TKN concentration was not included in the grading process because most lake nuisances in the area are related to the phosphorus concentration of the lake (Osgood 1988).

These water quality grades, however, only characterize the open-water quality of lakes. Other nuisances, such as the abundance of aquatic macrophytes, are not indicated in these grades.

The percentile curve can be used to assign individual grades for TP, CLA and Secchi depth to the monitored lakes. For example, a lake having a mean summertime Secchi depth of 1.7 m would receive a "C" grade for Secchi depth. A grade of C is considered average for TCMA lakes. Lakes were also assigned a single, overall grade, called a lake grade. Lake grades were determined by averaging the individual parameter grades. A lake grade generally corresponds to descriptive rankings and recreational-use conditions of the lake. Lakes receiving an "A" grade (upper 10 percentile) can be deemed as having full recreational use capability. A lake receiving a B lake grade is considered to have very good water quality and some recreational use impairment. Lakes receiving a "C" lake grade are considered to have average water quality but are recreationally impaired. A "D" grade lake translates to a very poor ranking with severely impaired recreational use. Lakes receiving an F lake grade have extremely poor water quality with little to no possible recreational use.

In 2000, the percentiles determined from the 1980-1988 water quality database of 120 lakes were compared to calculated percentiles from a more current and expanded 1980-1999 water quality database of 230 lakes. It was found that the percentiles from the expanded database were very similar to those determined from the 1980-1988 database. For this reason, and in an attempt to maintain consistency, the original 1980-1988 percentiles continued to be used for lake quality grading purposes (Anhorn 2003b).

2009 LAKE GRADES

Each lake monitoring site was given a lake grade if there were sufficient data to calculate the grade. At least 5 monitoring events are required to calculate a lake grade, and these 5 events must occur during the May-September (summer) period. Some lakes were not monitored sufficiently, so they did not receive a lake grade. The distribution of lake grades for lake sites monitored in 2009 is shown in Figure 8.

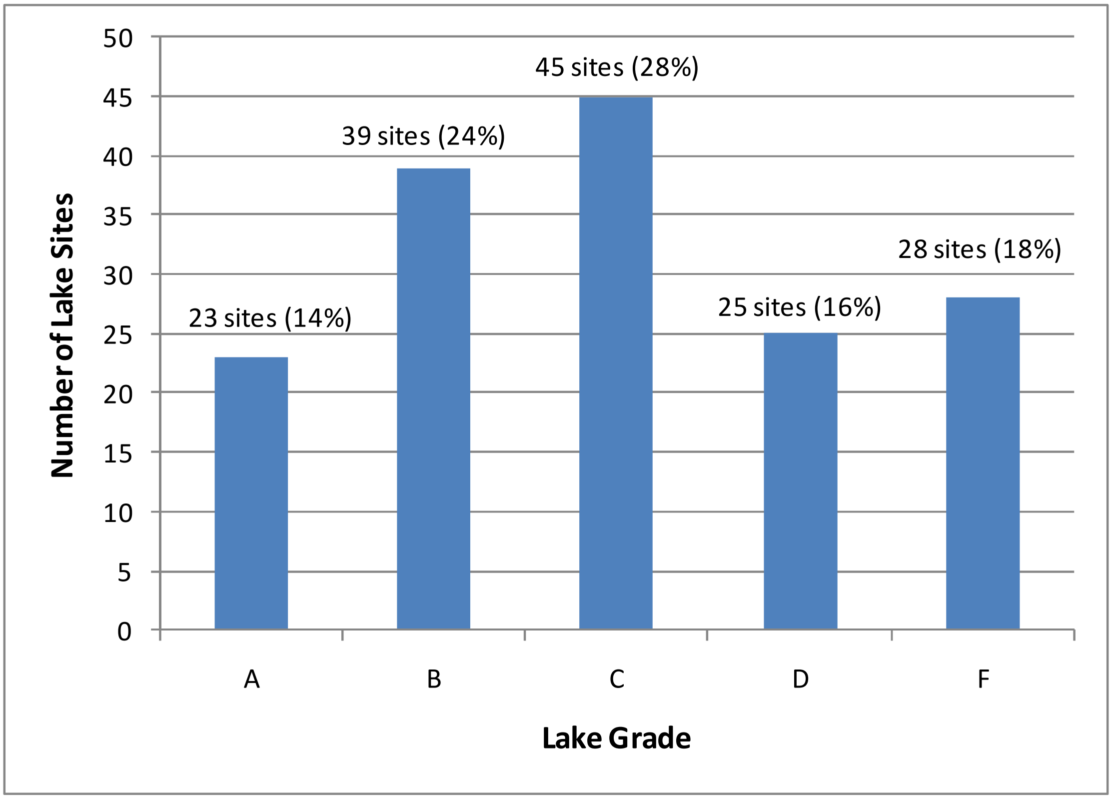


Figure 8. Distribution of 2009 Lake Grades

The greatest percentage of the lake sites (28%) received a lake grade of C. The water quality of these lakes is considered average as compared to other lakes in the TCMA. More lakes were above average (38% A and B lakes) than below average (34% D and F lakes).

A summary of the best ten and worst ten lakes with respect to the three water quality indicators is shown in Table 4. All of the best ten and worst ten lakes received A and F grades, respectively. The best ten and worst ten lakes include only those lakes that are equal to or greater than 35 acres in surface area.

Table 4. Summary of the Best Ten and Worst Ten Lakes
METC Lake Monitoring Program 2009
(for lakes greater than or equal to 35 acres)

	Lake Name	DNR ID #	Location	Summer-time Average Secchi (m)	Summer-time Average CLA (ug/L)	Summer-time Average TP (ug/L)	Lake Grade
Best Ten	Clear Lake	82004500	May Twp.	6.1	3.2	16	A
	Mays Lake	82003300	May Twp.	5.8	2.8	18	A
	Sylvan Lake	82008000	Forest Lake	5.0	2.7	15	A
	Long Lake	82011800	Pine Springs	4.8	2.6	9.4	A
	Twin Lake south	82004800	May Twp.	4.8	4.3	20	A
	Jane Lake	82010400	Lake Elmo	4.5	3.8	14	A
	Little Long Lake	27017901	Minnetrista	4.4	3.1	16	A
	Elmo Lake	82010600	Lake Elmo	4.0	2.8	17	A
	Shady Oak Lake	27008902	Minnetonka	4.0	3.3	15	A
	Lac Lavon Lake	19044600	Apple Valley	3.8	4.0	13	A
Worst Ten	Henry Lake	27017500	Hassan Twp.	0.4	81	245	F
	Goose Lake	10008900	Waconia Twp.	0.4	106	104	F
	Long Lake	19002200	Apple Valley	0.4	114	216	F
	Swede Lake	10009500	Watertown Twp.	0.4	159	392	F
	Downs Lake	82011000	Lake Elmo	0.3	75	206	F
	Cedar Island Lake	27011900	Maple Grove	0.3	130	343	F
	Goose Lake	82011301	Lake Elmo	0.3	196	300	F
	Hazeltine Lake	10001400	Chaska	0.3	287	277	F
	Benton Lake	10006900	Cologne	0.2	94	196	F
	Lynch Lake	82004200	May Twp.	0.2	543	518	F

Similar to past years, there is no distinct pattern as to where lakes with specific water quality were located. The lakes with below average lake grades (D's and F's) were not area specific. They were located in all of the seven TCMA counties. Common similarities between the majority of lakes with D and F grades are their size and mean depth. These lakes are generally shallow with small surface areas. Shallow lakes typically do not stratify during the summer months, allowing the potential release of phosphorus from sediments to mix through the water column and become available for plant growth during the summer season. Also, smaller lakes generally have higher watershed-to-lake ratios. Smaller lakes with high watershed-to-lake ratios have a more difficult time handling larger pollutant loads than larger lakes in watersheds of similar size and land-use.

Similarly, the lake sites with above-average grades (A's and B's) were not area specific. They were located in six of the seven TCMA counties. Common characteristics of the above-average lakes were deeper maximum and mean depths, development of a thermocline, and small contributing watersheds relative to the lake's surface area.

The MPCA has released its draft 2010 Minnesota Impaired Waters Inventory. The draft 2010 inventory indicates that 77 of the 194 lakes monitored in 2009 by the METC are listed as impaired. Seventy three lakes are listed as impaired for not meeting recreational use, and 8 lakes are listed as impaired for not meeting aquatic consumption use. Some lakes have multiple impairments. The impairments for aquatic recreational use were caused by excess phosphorus and enhanced eutrophication, as measured by the presence of too much algae (chlorophyll-a) and reduced water clarity (Secchi depth). The aquatic consumption impairments were driven by contaminants in fish tissue, such as mercury, polychlorinated biphenyls (PCB), and/or perfluorooctane sulfonate (PFOS). To learn more about the impaired lakes listings and potential next steps, refer to MPCA's webpage: http://www.pca.state.mn.us/water/tmdl/index.html.

If there are questions pertaining to the lake data or descriptions contained in this report, inquiries about CAMP, or suggestions of lakes that the METC should consider monitoring in the future, please contact Brian Johnson of the Metropolitan Council at (651) 602-8743 or brian.johnson@metc.state.mn.us.

MONITORING RESULTS FOR CAMP LAKES 2009

The water quality of each CAMP lake is discussed in the following section. Each lake report includes a written section describing the lake's water quality condition and a lake information sheet. Each information sheet includes 2009 water quality data, shown in tables and figures, and the water quality grades from 1980 through 2009.

If you notice any errors in the lake's data or physical information, or are aware of any additional or missing information, please contact Brian Johnson of the Metropolitan Council at (651) 602-8743 or brian.johnson@metc.state.mn.us.