1. LAKES

Contact: Tim Simonson, Tim Asplund
Last updated: 6-2008

Status: Currently in Place

This program has been in place since the late 1990's.

[Note: In addition to the baseline lake monitoring programs described here, there are also a few inland lake sites that have public drinking water intakes that are monitored according to the Safe Drinking Water Act. These include four sites on Lake Winnebago, and one site on Rainbow Lake. These surface water drinking intakes are monitored using the same protocols as described in the Public Drinking Water Well Monitoring section in Tier 3.]

Monitoring Objectives

Clean Water Act Objectives

- Determining water quality standards attainment
- Identifying potential impaired waters
- Identifying potential Outstanding or Exceptional Resource Waters
- Evaluating the effectiveness of management actions
- Establishing, reviewing and revising water quality standards

Fisheries Objectives

- Developing quantitative management objectives for waters
- Identifying populations not meeting objectives
- Compiling input for identifying problem causes
- Compiling input for developing management recommendations
- Analyzing general responses to management actions

Public Trust Doctrine Objectives

- Developing environmental goals or targets
- Monitoring impacts of permitting decisions at the overall lake scale
- Identification and delineation of Public Rights Features, including Sensitive Areas

Other Specific Objectives

Lakes monitoring is designed to achieve the following:

- A spatial and temporal inventory of the health and condition of statewide lake resources.
- A screening tool to initiate more in-depth field investigations of apparent water quality or fisheries problems.
- Standardized methods and data to evaluate statewide management activities.
- A context for comparing data collected among lakes and the capability to compare similar lakes.
- Effective surveillance for invasive species occurrence.
- A large data set on the state's lakes that can be used to prioritize project planning and individual lake assessments.
- Inferences on the condition of non-sampled lakes.
- Integration of existing Water Division monitoring programs.

Monitoring Design

Wisconsin has 15,081 lakes, covering about 1 million surface acres. About 13,000 lakes are less than 50 acres, while only about 2,000 are greater than 50 acres. The Lakes Monitoring Program focuses primarily on assessing the status of larger lakes (>100 acres) with public boat access (including large river impoundments). Sampling of smaller lakes without public access is included on a reduced scale, due to staff and funding limitations.

Clean Water Act Objectives

Wisconsin Citizen Lake Monitoring Network (CLMN) volunteers collect Secchi depth data on 670 lakes; chlorophyll-*a* and phosphorus data on 403 lakes, and dissolved oxygen on 244 lakes and temperature data on 377 lakes each year. At minimum, samples are collected once during spring overturn, and three times during the summer (June – Sept). Additional water quality data are collected from many lakes through lake planning and protection grants. Trophic status is determined from summer average field collected Secchi depth or chlorophyll-*a*, and is used for primary lake assessment. If available, field collected chlorophyll-*a* samples will be used preferentially over field collected Secchi depth. The monitored data are stored in WATERS.

Satellite photo spectral data are used to calculate water clarity values for approximately 8,000 lakes statewide. Satellite data collection is not possible on lakes less than five acres in size (49% of WI lakes) , lakes in which the Secchi depth is more than half of the maximum depth, or on stained lakes. At least two water clarity values, collected during the summer over a three year period, are averaged to determine a lake's trophic status.

Point-intercept (P-I) aquatic plant surveys are conducted annually on 40-50 lakes statewide on a stratified random basis. These surveys collect the data necessary to compute an Aquatic Macrophyte Community Index (AMCI). Separate from the Baseline Lakes Monitoring Program, DNR staff conduct P-I surveys on numerous lakes as part of ongoing aquatic plant management activities. During 2005 and 2006, 163 lakes between 10-1500 acres (mean area = 230 acres) were surveyed. From these data, reference conditions for AMCI values have been developed for different lake classifications. In the future, targeted lakes grouped by natural community will be selected each summer to further refine the reference AMCI metric values and add to the aquatic plant database.

In addition to the sampling design above, water quality monitoring (TSI indicators, plus other parameters (N-series, pH, alkalinity, color, conductivity) is conducted on 65 Long-Term Trend (LTT) lakes statewide to monitor long-term trends and provide regional reference conditions for each defined lake class. These lakes help to characterize within-lake and among-year variability in baseline water quality monitoring (see the Surface Water Quality section of the *Strategy* for details). A program is also proposed for monitoring pathogens (*E. coli*) at high-use inland beaches (see the Pathogen Monitoring on Inland Beaches section).

Fisheries Objectives

Fisheries assessments are conducted on 1,222 lakes with fisheries of local, regional, or statewide importance and adequate public access. Most (>60%) are 100 acres or larger. All lakes are designated as one of the following:

1) "High Profile" lakes (lakes sampled most intensively on a relatively short rotation of about 4 years; generally lakes > 1,000 acres).

2) "Public Access" lakes (lakes sampled less intensively on a somewhat longer rotation of about 8 years – generally lakes between 100 and 1,000 acres);

3) "Minor Fishery" lakes (lakes of relatively low importance that are sampled on a much longer rotation of about 10 years).

Lake fisheries assessments are designed to meet the following objectives for each lake sampled:

- Estimate the abundance, size- and age-structure of adult walleyes on "high profile" and treaty lakes;
- Estimate the relative abundance and size structure of other selected gamefish, panfish and selected non-game fishes; and
- Estimate the relative abundance of young of the year and yearling walleye and muskellunge on lakes with natural reproduction or potential for natural reproduction.
- Visually screen for the occurrence of diseases in wild fish populations.

The first objective is met by conducting mark/recapture surveys during, and shortly after, peak walleye spawning activity. Gamefish are captured predominately with fyke nets during the marking phase. Recapture sampling is done via electrofishing with a boom shocker shortly after the marking period. The second objective is met by estimating CPE of selected gamefish and panfish during late spring, primarily by electrofishing with a boom shocker. The third objective is determined from CPE estimates conducted via fall electrofishing.

The actual lakes sampled each year are randomly selected from within each designation, with some minor modifications to the schedule permissible based on logistical considerations.

About 150 lakes are sampled each year:

Designation	Default Size (acres)	Default Rotation	Actual Rotation (years)	Number of Lakes	Average Size (acres)	Sampled/ year
"High Profile"	>1000	4	1 to 5	118	2,240	22
"Public Access"	100-1000	8	6 to 8	465	250	67
"Minor Fishery"	50 to 100[2]	10	9 to 12	623	121	37
Total				1,222	496	150

At this time, little emphasis is placed on sampling non-game fish species (except common carp). However, efforts are made to develop a complete list of fish species encountered, along with an approximate count, including invasive fish species.

Public Trust Doctrine Objectives

The Critical Habitat Designation program seeks to identify and delineate Public Rights Features (NR 1.06), Sensitive Areas (NR 107) and Resource Protection Areas. About 40 lakes are sampled each year, and are prioritized based on resource quality, existing information, and future threats to the resource. These areas are afforded additional protection via permitting programs by state and local units of government under Chapter 30, Wis. Statutes. The program also provides advice to local units of government on resources protection. The primary Public Rights Features that are delineated and monitored include woody habitat, submerged, emergent, and floating leaf vegetation, and substrate. Delineations also include bank features, navigation corridors and natural scenic beauty.

Core and Supplemental Water Quality Indicators

The following metrics will be sampled in lakes to monitor the attainment of the listed designated uses.

Table 2. Metrics for Baseline Lakes sampling.

Designated Use Supported	Metrics Sampled for Lakes
Fish & Aquatic Life	TSI (trophic status index) AMCI (aquatic macrophytes community index) Gamefish Population Dynamics
Public Health & Welfare	Contaminants in fish tissue – mercury & PCBs (selected sites) Pathogen Indicators

Trophic Status Index (TSI): Satellite imagery is used to determine water clarity for the vast majority of lakes simultaneously on a regular basis. Trophic status indices will be computed from regression models. Citizen Lake Monitoring Network volunteers calibrate images by completing Secchi disk transparency measurements for a sub-sample of all lake classes on the same days as satellite photos are taken. Reference values for TSI scores are estimated from sediment cores. Sediment cores allow a comparison of historical (pre-settlement) and recent water quality data in order to place modern day water clarity measurements in context and indicate changes in algal concentrations over time. Diatoms are a type of algae containing siliceous cell walls that fossilize in lake sediments. Diatom taxa are known to prefer narrow ranges of water quality and therefore the fossilized diatom community from the bottom of the core can be used to infer historical phosphorus concentrations or Secchi depth values. These inferred concentrations can then be converted to TSI values using the Carlson equations and used as reference values. This approach will not work for impoundments or raised wetland lakes. Since these lakes are artificial, pre-settlement conditions do not exist. Individual lakes are compared to expectations derived for each lake class based on the sediment core data set to determine lake health. Volunteers also assess pH and dissolved oxygen and temperature profiles during the period of peak summer stratification on a sub-sample of lakes. Trends in Secchi depth, phosphorus, and chlorophyll *a* are determined on a fixed set of approximately 150 lakes monitored by volunteers.

Aquatic Macrophyte Community Index (AMCI): Native aquatic plant communities are recognized as a vital and necessary component of healthy aquatic ecosystems. Diverse and stable plant communities offer habitat for aquatic invertebrate and fish species and attenuate wave action, which minimizes shoreline erosion. Aquatic plants inhabit the littoral zone, the lake area most closely connected with direct anthropogenic habitat modification, and therefore are a good indicator of disturbance. Many recent studies in Wisconsin and Minnesota have shown that aquatic plant communities have been reduced in areas of shoreland development and have been altered by eutrophication.

For these reasons, the characteristics of the aquatic plant community are excellent indicators of in-lake, riparian, and watershed health for lakes. This metric is used primarily on small lakes, and is assessed once during the summer. Aquatic plants are also a lake biotic community that can be measured using standard, repeatable methods to estimate change over time and/or space. An aquatic macrophyte community index (AMCI) for Wisconsin has been developed by Nichols et. al. (2000) and has been shown to illustrate disturbance. The AMCI is a multi-metric parameter that combines:

- maximum depth of plant growth,
- aerial coverage of plants,
- species richness and diversity, and
- relative area covered by submersed plant species, sensitive plant species and exotic plant species.

Gamefish Population Dynamics: The relative abundance of all fish species sampled, as well as recruitment, population size-structure, and age and growth is determined for targeted gamefish populations. Gamefish sampling is conducted primarily during the spring using boat electrofishing. Spring fyke netting is also used to target walleye, muskellunge and panfish in specific circumstances. Fall electrofishing is used to sample young-of-year walleye and muskellunge in lakes with natural reproduction of these species. An approximate count of each species collected is also recorded at each sampling station, including invasive fish species. Temperature and conductivity are recorded when electrofishing occurs.

Contaminants: Selected lakes are screened for mercury and polychlorinated biphenyls (PCBs) in the fish tissue.

Pathogen Indicators: *E. coli* is an indicator of the presence of fecal matter in water and is used as a tool to help protect humans from waterborne exposure to dangerous pathogens associated with feces. *E. coli* may be sampled at select high-use beaches. See the section on Pathogen Monitoring on Inland Beaches for more details.

Quality Assurance

The WDNR has a quality management plan (QMP) and an Evaluation System Manual Code (MC 9314.1) in place that establishes processes and protocols that the state's monitoring program must meet. The QMP is currently under revision, and quality assurance processes may be added or modified as needed.

Standard monitoring protocols are distributed to all staff participating in monitoring. Protocols and data sheets are also accessible at any time on our network and web-based database. Training of field staff for consistency in data collection and recording is critical to the success of the monitoring program. Training in taxonomy, deployment of field gear, and general program implementation is periodically made available to all staff. A layer of quality assurance to maximize data integrity through a data screening process is built into the statewide database. All monitoring protocols employed, at a minimum, meet the Department's data standards as developed by the Aquatic and Terrestrial Resources Inventory (ATRI) Team. The State Lab of Hygiene, a certified laboratory with approved quality assurance procedures, completes most water quality analyses.

Data Management

An internet-based electronic data storage system following state geo-locational standards is used to manage fish and habitat data (http://infotrek.er.usgs.gov/wdnr_bio/). Water quality data are managed in the SWIMS database. Contaminant data are managed on a client-server system and are available upon request.

Data Analysis/Assessment

See Assessment Methodology report. Probability-based sub-sampling of core indicators from all waterbody classes within the geographical scale of interest will allow inferences to be made for all waters within the area on a basin, ecoregional, or statewide scale. Attainment of standards for lakes is determined relative to the baseline condition for the core indicators in Tier 1. Baseline condition is set by lake-type within a lake classification framework. Lakes with any metric falling below the designated level are flagged as "non-attainment" lakes. These lakes are prioritized based on the degree extent of non-attainment and more intensive sampling, under Tier 2, is completed in priority order.

Reporting

Lake status is reported in the 305(b) Report (future integrated 303(d)/305(b) Report). Biennial administrative reports are produced describing the work accomplishments of the monitoring program. Reports on the health and condition of waterbodies and their fisheries are also produced.

Programmatic Evaluation

The Baseline Monitoring Program operates within the framework of the Water Division biennial workplan. The Water Division Monitoring Team meets annually to review the protocol, strategy, and products of the sampling program to ensure that it is meeting the needs of resource managers. Any changes to the protocol or strategy are recommended to the Water Division Monitoring Team. Reviews of workplan performance are completed periodically to evaluate job completion.

General Support and Infrastructure Planning

Staff & Training –Along with fisheries program staff, Integrated Science Services (ISS) supports several baseline components of lakes sampling; ISS staff also serve on the Lakes Baseline Monitoring sub-team. Volunteer monitors provide a significant amount of data to support this program.
Laboratory resources – No State Lab of Hygiene funds are allocated for Baseline Lakes monitoring. Some Basic Agreement funds are allocated for the Long Term Trends Lakes program.
Funding – This program is funded under Sport Fish Restoration at approximately $230,000 annually. Total estimated support, including permanent salaries, fringe benefits, and other indirect costs is approximately $600,000 annually. Support for Long-Term Trend Lakes is also provided through the Basic Agreement with the State Lab of Hygiene (see the Surface Water Quality section for details).

Program Gaps

One problem with the current Wisconsin aquatic plant data collection is the lack of representative data from reference lakes in both the Nichols et. al. (2000) data set and the current DNR baseline monitoring data. Approximately 100 of the 163 lakes for which we have collected DNR data are lakes with Eurasian water-milfoil, an exotic plant species that could represent a poor condition, not an excellent condition. However, until more aquatic plant data are available, these values will be used. These data are stored at the Science Operations Center. Currently there are no data with which to set a threshold for small lakes, spring ponds or impounded flowing waters.

- **Invasive Species Inventory:** There is a need to develop a comprehensive invasive species sampling program.
- **Satellite limitations:** needs to be supported (staff and resources)
- **Better integration of CLMN and strategic planning.** CLMN lakes are self-chosen. We need to start recruiting volunteers from geographic areas or lake natural communities that are underrepresented.
- **Shoreline Assessments:** The National Lake Survey conducted in 2007 included an instrument for assessing shoreline health and quantifying human disturbance. In the future, this tool may be refined for WI lakes and incorporated into baseline monitoring.
- **Blue Green Algae:** There is a need to develop criteria for the use of Blue Green Algae as a pathogen indicator.
- **Critical Habitat Designations:** There is a need to support this program with consistent staff and resources. This multidisciplinary program needs to be assigned to a specific bureau in order to receive specific administrative support.

CITIZEN LAKE MONITORING NETWORK

Contact: Jennifer Filbert
Last updated: 10-2007

Status: Currently in Place

This network has been in place since 1986.

Monitoring Objectives

Clean Water Act Objectives

- Establishing, reviewing and revising water quality standards
- Determining water quality standards attainment
- Identifying impaired waters
- Identifying causes and sources of water quality impairments
- Supporting the implementation of water management programs
- Supporting the evaluation of program effectiveness

The Citizen Lake Monitoring Network, coordinated by the Department of Natural Resources and the University of Wisconsin-Extension in cooperation with Wisconsin Association of Lakes and lake groups, assesses the chemical, physical, and biological quality of selected Wisconsin lakes statewide. The overall goal of Citizen Lake Monitoring is to train and equip a network of citizen volunteers who provide useful information for the ongoing protection of Wisconsin's lakes. The objectives of the Network are:

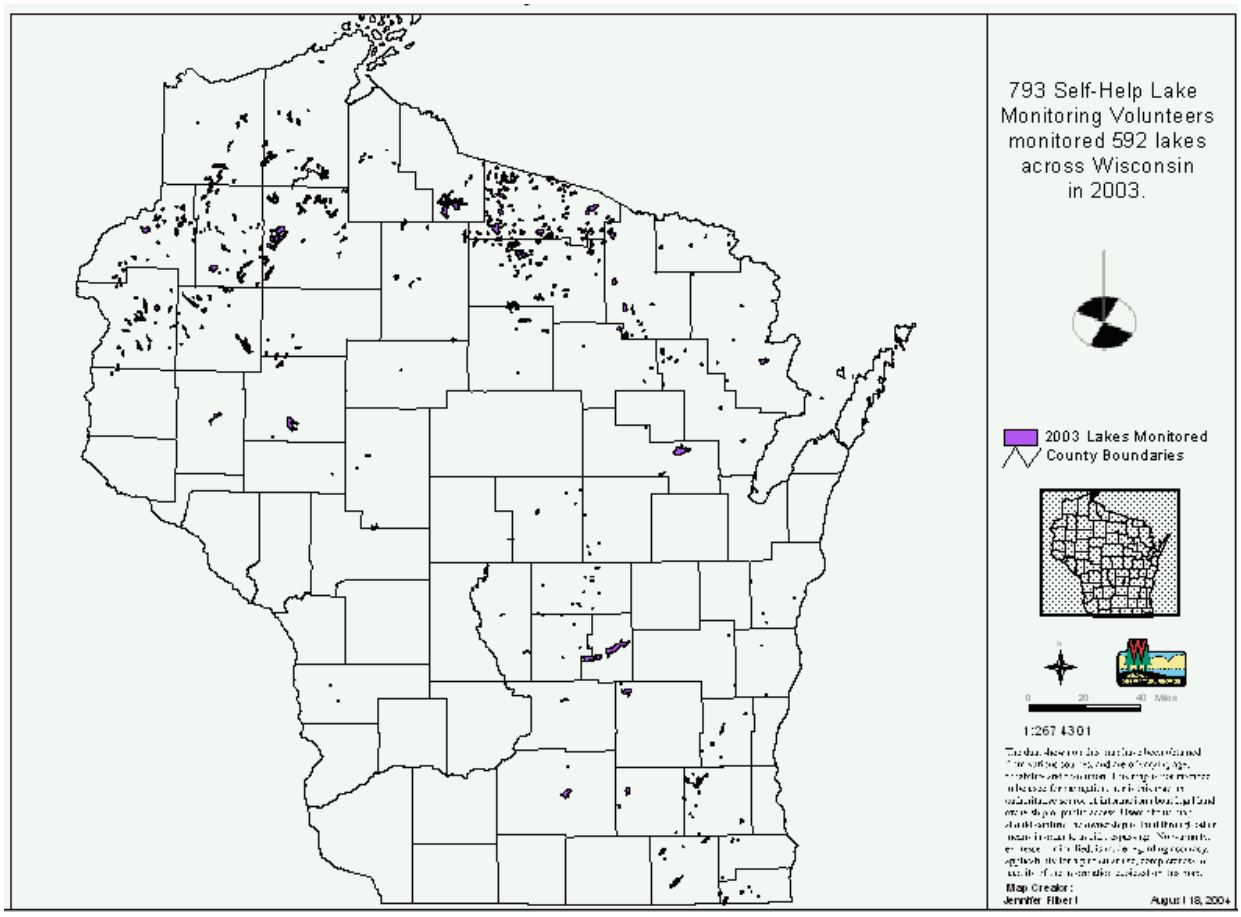
- Quality / Accessible data
- Shared / Useful results
- Educated and informed citizen lake monitors (lakes and issues)
- Greater number and frequency of lakes monitored
- Enhanced participation in statewide network
- Quality and sufficient staff support
- Reduced administrative overhead (state, community & citizen)
- To engage others in support of network
- Tie-in to lake research and national monitoring
- Recognize and appreciate citizen involvement

Monitoring Design

Volunteers monitor over 600 lakes throughout Wisconsin (Figure 1). Generally, the volunteer expresses interest in monitoring a particular lake they live on or visit frequently. Citizen Lake Monitoring sites sometimes overlap with those sites chosen for baseline monitoring, but primarily the citizen-monitored sites provide a large body of additional sites beyond those sampled through the baseline program. Baseline staff and Citizen Lake Monitoring staff coordinate at the beginning of each sampling season to remove redundancy in sampling.

The Citizen Lake Monitoring Network provides equipment and training to the volunteer. In the past this has usually been done one-on-one by region staff. In the future, training will be more commonly done through group training sessions or short courses offered at local technical colleges. The network provides each volunteer with a photographed step-by-step instruction manual.

Figure 1. Lakes monitored by Citizen Lake Monitoring volunteers in 2003.



Core and Supplemental Water Quality Indicators

- Most volunteers begin their involvement as a water clarity monitor, using a secchi disc. Water clarity monitoring is usually conducted every other week from approximately April/May to October.
- After a year of secchi monitoring, some volunteers choose to monitor D.O., temperature, total phosphorus and chlorophyll *a*. Additional training and equipment is provided at this point. Temperature and dissolved oxygen are measured using a variety of field equipment. Total phosphorus and chlorophyll *a* are measured through the volunteers collecting water samples in the field and sending them to the State Lab of Hygiene for analysis.
- Some volunteers also monitor aquatic plants, and some monitor invasive species, including purple loosestrife, zebra mussels, curly leaf pondweed and eurasian watermilfoil.

Quality Assurance

The Citizen Lake Monitoring Network does not currently have an official Quality Assurance Project Plan (QAPP). However, one will be developed in the coming years.

Data Management

Volunteers report data through either 1) the SWIMS database using a personal user ID and password; or 2) the Secchi touch-tone telephone line. Other data are regularly transferred from the State Lab of Hygiene into the SWIMS. Citizen data are fed nightly into the Waterbody Assessment Display and Reporting System (WATERS), to populate information on the trophic state of lakes for use in waterbody assessment.

Data Analysis/Assessment

Citizen Lake Monitoring data has been used for:

National Information and Statewide Reporting

Water Quality Reports to Congress: Citizen generated information is used every two years to report trends in Wisconsin lakes and to identify needs to the federal government.

Great American Secchi Dip-in: Citizen data are collected and analyzed with other data collected nationally to report lake clarity.

Lake and Basin Assessment and Planning

Numerous lake diagnostic and feasibility studies: Citizen data are used for before and after documentation, as well as to show severity of water quality problems and to set restoration goals. Examples include Delavan Lake, Fox Lake, Bass Lake, Big Green Lake, and Devils Lake.

Annual condition reports to individual lake groups and media: Citizen data are summarized and presented annually by volunteers to lake organizations and to the local media to show water quality trends.

Watershed and Basin Plan preparation: Citizen lake data are summarized in tables and used to express lake water quality conditions and trends. This information is used to set priorities for lake protection, restoration, and funding.

Requests to Wisconsin Legislature

Request for a phosphorus water quality standard: Citizen data was used to show trophic status of WI lakes to demonstrate the need to limit the phosphorus being discharged from wastewater treatment facilities and to support a ban on phosphate detergents in WI. This legislation was later passed.

Request for Aquatic Invasive Species Funding and Legislative Language: Volunteer data was utilized to help prepare statewide lists and maps of new invasions of zebra mussels and Eurasian Water milfoil in support of the department's request for funding and policy. We were successful in gaining $300,000 per year for watercraft inspection, invasive species education, monitoring and biological control of purple loosestrife; and strong legislation prohibiting the launching of watercraft with aquatic plants or zebra mussels attached.

Satellite Research

The University of Wisconsin's Environmental Remote Sensing Center (ERSC) and the Citizen Lake Monitoring Network have been partners in Remote Sensing research since 2000. ERSC is using satellite images in conjunction with citizen data to develop a set of algorithms to predict basic water quality parameters from LANDSAT data. Collecting sufficient lake data on the variables of interest on dates concurrent with satellite overpass dates would be impossible without volunteer involvement.

Long Term Ecological Trends of Northern Temperate Lakes--Kathy Webster, Ph.D. UW-Madison:

This research used 11+ years of citizen data from a set of 50 Wisconsin Long Term Trend Lakes. The data was analyzed to look for trends in individual lakes over the 11-year period. In this research, only four lakes showed long-term trends in two or more water quality variables (chlorophyll *a*, total phosphorus, or Secchi depth). However, significant inter-annual variation was observed.

Reporting

At the close of each season (data must be turned in by November 1), Annual Reports are prepared on each lake and are sent to each volunteer. The Annual Reports are available on the Citizen Lake Monitoring website. Every several years statewide and regional summary reports are also prepared and made available on the web. Citizen data also contribute significantly to the biennial integrated 303(d)/305(b) report statistics on trophic state. Currently, the Department uses Citizen Lake Monitoring data for initial screening when identifying waters to add to the 303(d) list. Also, a nightly program calculates trophic state index scores and supplies that information to the WATERS database for use in assessments.

Programmatic Evaluation

Periodically staff from Central office and the regions who are involved with the Citizen Lake Monitoring Network meet to discuss their protocols and the manuals.

General Support and Infrastructure Planning

The Citizen Lake Monitoring Network is funded through contracts in lieu of individual lake grants. Several WDNR central office staff and staff in each WDNR region contribute time to this program regularly in addition to other duties. The budget is approximately $87,000/year.

References

Citizen Lake Monitoring Network Website: http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/