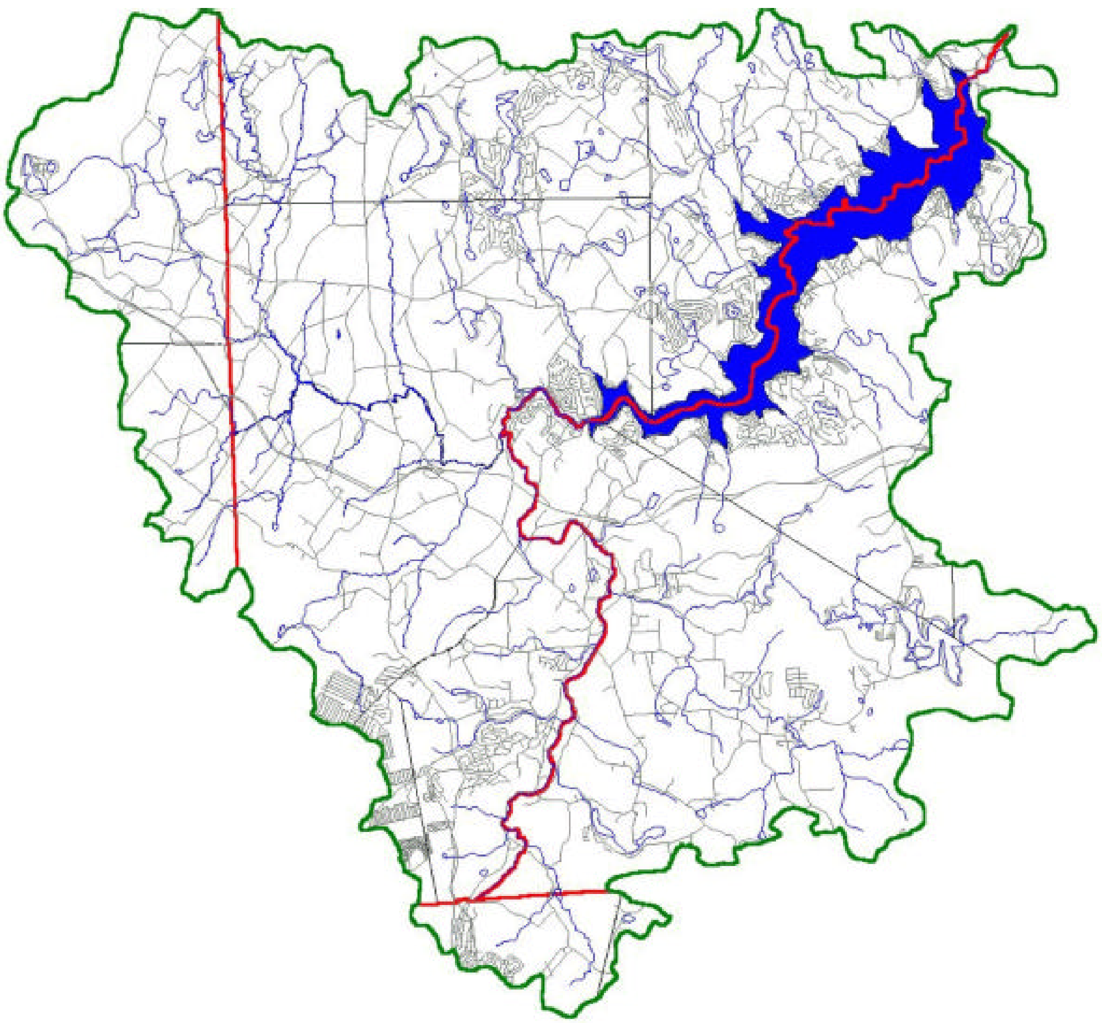
# •LAKE WALLENPAUPACK WATERSHED• LAKE AND WATERSHED MONITORING HANDBOOK



Lake Wallenpaupack Watershed Management District
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# Lake Wallenpaupack Watershed
# Lake and Watershed Monitoring Handbook:

July 2003

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# INTRODUCTION

## PURPOSE OF THIS HANDBOOK

This ***Lake and Watershed Monitoring Handbook*** has been written for the citizens of the Lake Wallenpaupack Watershed so that they may better understand the environment in which they live and so they may take an active role in preserving that environment. The purpose of this handbook is to prepare watershed residents for participation in the *LWWMD Volunteer Lake Monitoring Program*. With this handbook, residents can begin a volunteer monitoring program on their local lake, pond, and/or stream, coordinated through the Lake Wallenpaupack Watershed Management District.

## DOCUMENT ORGANIZATION

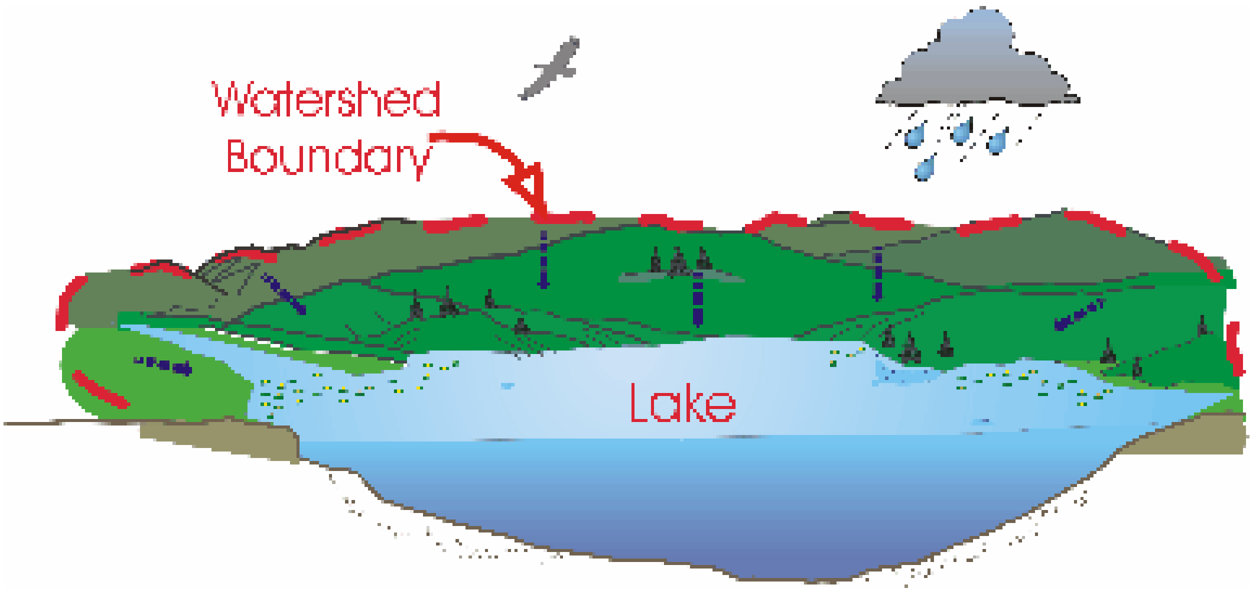
This handbook is broken into five major sections.

**Lake and Watershed Management** provides a brief introduction to understanding the watershed concept and the importance of lake and watershed management. This section discusses ways that human activities within a watershed can impact water quality and presents interesting facts about the Lake Wallenpaupack Watershed. **Lake Ecology** presents information on the important biological, chemical and physical properties of lakes. **Monitoring Programs** stresses the importance of a monitoring program for lake and watershed management and discusses the key elements of a monitoring program. **LWWMD Volunteer Lake Monitoring Program** presents the details of monitoring lakes and ponds within the Lake Wallenpaupack watershed. Topics include where, when, what and how to sample for the basic monitoring program, a step-by-step guide to sampling, and a brief discussion of additional parameters that may also be monitored by volunteers. Lastly, the **Appendices** include conversion tables, glossaries of lake and watershed terms and water quality parameters, detailed stream monitoring protocols, DO meter operational instructions, general references for additional information, and forms.

A number of documents were used in the preparation of this handbook. Complete references are provided within the appendix.

# LAKE AND WATERSHED MANAGEMENT

Lake and watershed management is a process for preserving or restoring acceptable water quality. It is accomplished by developing an understanding of key factors within a lake and its watershed, particularly those related to land use. Restoration is accomplished by following a plan of action to reduce or minimize those activities within a watershed that may negatively impact water quality. This section provides the basis for understanding the watershed concept and how human activities within a watershed can impact water quality. This section also provides some interesting facts and figures about the Lake Wallenpaupack watershed.




## THE WATERSHED CONCEPT

A watershed is the area of land that drains directly into a lake through rivers, streams, surface runoff, and groundwater flow. A watershed is best envisioned as a funnel with a glass at the bottom representing a lake. Anything that falls into the funnel will find its way into the glass. Likewise, water traveling through a watershed flows downstream to a lake. Along the way, that flowing water has picks up a material load, including dissolved elements and particulate matter, and transfers that load to the lake. Some of these materials are considered pollutants due to their potential to impair water quality. The types of things that impair water quality – including sediment, bacteria, and nutrients such as phosphorus and nitrogen – will be discussed in the **Ecology** section of the report. Here we will discuss how humans change a watershed and how those changes may affect water quality.

## THE WATERSHED AND YOU

We all live in a watershed. This handbook is intended for residents within the Lake Wallenpaupack watershed. There are numerous smaller lakes and ponds within the Lake Wallenpaupack watershed. Each of those individual lakes and ponds have their own watersheds

– a smaller portion of the Wallenpaupack watershed that drains directly to each particular lake or pond.

The land within a watershed has particular uses and cover types, referred to as land uses. Examples of land use include urban, residential, pasture, crops and forest. Depending on the type of land use, more or less sediment, nutrients and other pollutants will wash towards the lake when it rains. The land use in a watershed also affects the type of materials that will wash from those areas and potentially into the lake itself. One may expect oils and salts from roadways, sediments and fertilizers from farms and gardens, nutrients from on-site septic systems, and all kinds of materials in stormwater runoff. The permeability of the land use affects how much and how quickly water will travel. For example, rain falling on closely mowed grass and will travel faster and move more nutrients than if it were to fall onto a wooded area.

The amount of pollutants (nutrients and sediment) that can wash off a given area of land increases dramatically as land use is converted from forest to other land uses. Land uses in order from lowest to highest pollutant runoff are: forest ➜ residential ➜ urban ➜ agricultural.

## ABOUT THE LAKE WALLENPAUPACK WATERSHED

The Lake Wallenpaupack watershed was formed in 1926 when the power dam was constructed by Pennsylvania Power & Light to create Lake Wallenpaupack. The watershed is approximately 145,900 acres in size (228 square miles) and encompasses portions of 4 counties (Lackawanna, Monroe, Pike & Wayne) and 14 townships (Barrett, Blooming Grove, Coolbaugh, Dreher, Greene, Jefferson, Lake, Lehigh, Madison, Palmyra - Pike Co., Palmyra - Wayne Co., Paupack, Salem and Sterling). There are around 200 miles of streams and over 60 lakes and ponds within the Lake Wallenpaupack watershed. In the course of a year, on average, 40 inches of rain falls within the watershed and 15.5 billion cubic feet of water flows through the watershed (116 billion gallons).

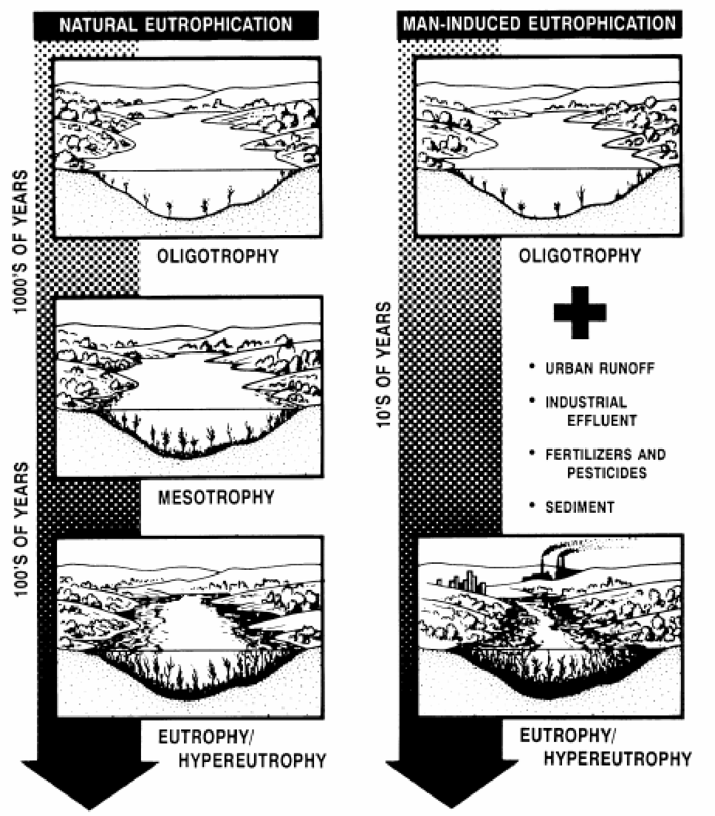
The main streams that drain into Lake Wallenpaupack include Wallenpaupack Creek, Ariel Creek, Purdy Creek and Mill Brook. Lake Wallenpaupack empties into the Lackawaxen River, a tributary of the Delaware River. The Delaware River flows past Philadelphia and into the Atlantic Ocean. In September 1979, Pike and Wayne counties and the townships in the Lake Wallenpaupack watershed formed the Lake Wallenpaupack Watershed Management District (LWWMD), a multi-governmental, nonprofit corporation that manages the Lake Wallenpaupack watershed and addresses water quality problems.

## LAKE ECOLOGY

The lake ecosystem is a complex interaction of biological, chemical and physical components. Biological components include plants and animals, both large and microscopic. Chemical components include nutrients and chemicals that affect the growth of plants. Physical components include the shape of the water body, water temperature and transparency.

## WATER QUALITY PARAMETERS

### TROPHIC STATUS




Trophic state is a term used in limnology (the study of lakes) to describe the amount of algae and macrophytes (weeds) found in a lake. Oligotrophic lakes have few algae and macrophytes and appear clean and clear, while eutrophic lakes show an overabundance of growth and often have a pronounced green color due to algae. Mesotophic lakes have characteristics that fall in between oligotrophic and eutrophic lakes. Eutrophication is a natural process whereby lakes increase in trophic state over long periods of time. However, the process of eutrophication can be greatly accelerated by human activities (such as watershed development and sewage disposal) that introduce additional nutrients, organic matter and silt into the lake system. This cultural eutrophication can be reversed by controlling human inputs, but in many cases additional in-lake treatments are required in order to accelerate this rehabilitation process.

The Carlson (1977) Trophic State Index (TSI) is an extremely valuable tool for the evaluation of lakes. This index can be calculated using total phosphorus, chlorophyll a, and/or transparency (Secchi depth) data. The trophic state of a lake is best characterized using summer averages for each of these parameters. To calculate this index each seasonal average is logarithmically converted to a scale of relative trophic state ranging from 1 to 100. This index was constructed such that an increase in ten units represents a doubling in algal biomass. For example, a lake with a chlorophyll a TSI of 40 has twice as much algae as a lake with a TSI value of 30. Also, the index was designed so that under phosphorus limiting conditions, and where algae are the main factor affecting transparency, TSI values calculated from Secchi depth, total phosphorus and chlorophyll a data should be very similar.

The TSI can be used to classify lake trophic status. TSI values less than 40 are associated with oligotrophic (clean, clear water) conditions, TSI values of 40 to 50 are associated with mesotrophic conditions, while TSI values greater than 50 are associated with eutrophic (nutrient-rich) conditions.

## BIOLOGICAL COMPONENTS

### *CHLOROPHYLL A*

Chlorophyll a is the green photosynthetic pigment found in the cells of all algae. By taking a measured sample of lake water and extracting the chlorophyll a from the algae cells contained in that sample, monitors can get a good indication of the density of the algal population. The chlorophyll a concentration cannot be considered a precise measurement of algal density, however, because the amount of chlorophyll a found in living cells varies among algal species. Thus, two lakes can have identical densities of algae yet have significantly different concentrations of chlorophyll a because they are dominated by different species. Despite these drawbacks, the ease of sampling and relatively low cost of analysis makes chlorophyll a an attractive parameter for characterizing the algal density in lakes.

Chlorophyll a concentration is one of the three primary measurements used to classify lake water quality. Chlorophyll a concentrations less than 4 micrograms per liter (µg/L) are associated with oligotrophic conditions, while concentrations greater than 10 µg/L are associated with eutrophic conditions.

### *ALGAE*

Algae are photosynthetic plants that contain chlorophyll and have a simple reproductive structure but do not have tissues that differentiate into true roots, stems, or leaves. They do, however, grow in many forms. Some species are microscopic single cells; others grow as mass aggregates of cells (colonies) or in strands (filaments). Some even resemble plants growing on the lake bottom.

The algae are an important living component of lakes. They:

- convert inorganic material to organic matter through photosynthesis,
- oxygenate the water, also through photosynthesis,
- serve as the essential base of the food chain, and
- affect the amount of light that penetrates into the water column.

*Factors that Affect Algal Growth*

There are a number of environmental factors that influence algal growth. The major factors include:

- the amount of light that penetrates the water (determined by the intensity of sunlight, the amount of suspended material, and water color),
- the availability of nutrients for algal uptake (determined both by source and removal mechanisms),
- water temperature (regulated by climate, altitude, et cetera),
- the physical removal of algae by sinking or flushing through an outflow,
- grazing on the algal population by microscopic animals, fish, and other organisms,
- parasitism by bacteria, fungi, and other microorganisms, and
- competition pressure from other aquatic plants for nutrients and sunlight.

Of these factors, it is usually the supply of nutrients that will affect amount of algal growth in a lake the most. In most lakes, increasing the supply of nutrients (especially phosphorus) in the water will usually result in a larger algal population. However, it is a combination of environmental factors that determines the type and quantity of algae found in a lake. It is important to note that these factors are always in a state of flux. This is because a multitude of events, including the change of seasons, development in the watershed, and rainstorms constantly create "new environments" in a lake.

Environmental changes may or may not present optimal habitats for growth or even survival for any particular species of algae. Consequently, there is usually a succession of different species in a lake over the course of a year and from year to year.

*The Overgrowth of Algae*

Excessive growth of one or more species of algae is termed a bloom. Algal blooms, usually occurring in response to an increased supply of nutrients, are often a disturbing symptom of cultural eutrophication.

Blooms of algae can give the water an unpleasant taste or odor, reduce clarity, and color the lake a vivid green, brown, yellow, or even red, depending on the species. Filamentous and colonial algae are especially troublesome because they can mass together to form scums or mats on the lake surface. These mats can drift and clog water intakes, foul beaches, and ruin many recreational opportunities.

Blue-green algae are primitive, microscopic algae that grow in all sorts of environments, including streams and lakes. Certain species of these algae found in lakes and ponds may toxins that can damage livers in humans or kill pets and livestock.

### *AQUATIC PLANTS*

Aquatic plants have true roots, stems, and leaves. They, too, are a vital part of the biological community of a lake. Unfortunately, like algae, they can overpopulate and interfere with lake uses.

Aquatic plants can be grouped into four categories:

- *Emergent plants* are rooted and have stems or leaves that rise well above the water surface. They grow in shallow water or on the immediate shoreline where water lies just below the land surface.

- *Rooted floating-leaved plants* have leaves that rest on, or slightly above, the water surface. These plants, whose leaves are commonly called lily pads or "bonnets," have long stalks that connect them to the lake bottom.

- *Submergent plants* grow with all or most of their leaves and stems below the water surface. They may be rooted in the lake bottom or free-floating in the water. Most have long, thin, flexible stems that are supported by the water. Most submergents flower above the surface.

- Free-floating plants are found on the lake surface. Their root systems hang freely from the rest of the plant and are not connected to the lake bottom.

Through photosynthesis, aquatic plants convert inorganic material to organic matter and oxygenate the water. They provide food and cover for aquatic insects, crustaceans, snails, and fish. Aquatic plants are also a food source for many animals. In addition, waterfowl, muskrats, and other species use aquatic plants for homes and nests.

Aquatic plants are effective in breaking the force of waves and thus reduce shoreline erosion. Emergents serve to trap sediments, silt, and organic matter flowing off the watershed. Nutrients are also captured and utilized by aquatic plants, thus preventing them from reaching algae in the open portion of a lake.

#### *Factors that Affect Aquatic Plant Growth*

There are many factors that affect aquatic plant growth including:

- the amount of light that penetrates into the water,
- the availability of nutrients in the water (for free-floating plants) and in the bottom sediments (for rooted plants),
- water and air temperature,
- the depth, composition, and extent of the bottom sediment,
- wave action and/or currents, and

- competitive pressure from other aquatic plants for nutrients, sunlight, and growing space.

*The Overgrowth of Aquatic Plants*

Excessive growth of aquatic plants is unsightly and can severely limit recreation. Submergents and rooted floating-leaf plants hinder swimmers, tangle fishing lines, and wrap around boat propellers. Fragments of these plants can break off and wash up on beaches and clog water intakes.

For many species, fragmentation is also a form of reproduction. An overgrowth problem can quickly spread throughout a lake if boat propellers, harvesting operations, or other mechanical actions fragment the plants, allowing them to drift and settle in new areas of the lake.

Free-floating plants can collect in great numbers in bays and coves due to prevailing winds. Emergent plants can also be troublesome if they ruin lake views and make access to open water difficult. In addition, they create areas of quiet water where mosquitoes can reproduce.

### *BACTERIA AND WATER-BORN PATHOGENS*

Surface water can become contaminated with bacteria, *Giardia*, *Cryptosporidia, E. coli* and other pathogens. Coliform bacteria can be numerous in the natural environment, occurring naturally in soil, water, and the intestines of animals. Fecal coliform and fecal streptococcus bacteria are indicators of fecal pollution from warm-blooded animals. Sources of fecal coliform bacteria may be natural (beaver, deer, water fowl) or cultural (septic systems, livestock). *Giardia* is a microorganism common in surface waters. Ingestion of *Giardia* causes severe abdominal and digestive distress. *Cryptosporidia* and *E. coli* bacteria are contaminants often associated with animal or septic runoff. These also cause severe abdominal and digestive distress in humans. Certain strains of *E. coli* bacteria are known to be toxic to humans.

## CHEMICAL COMPONENTS

### *NUTRIENTS (PHOSPHORUS)*

Phosphorus is one of several essential nutrients that algae need to grow and reproduce. In many lakes, phosphorus is in short supply. Therefore, it often serves as a limiting factor for algal growth.

Phosphorus migrates to lake water from only a few natural sources. As a result, lakes located in pristine wilderness settings rarely have problems with algal blooms. Humans, on the other hand, use and dispose of phosphorus on a daily basis. This phosphorus is found in such common items as fertilizers, foods, and laundry detergents. Lakes with developed watersheds often receive a portion of this human-generated phosphorus through runoff, septic leachate, and other sources. This runoff fertilizes the water and can stimulate increased algal growth. Algae most readily consume a form of phosphorus known as orthophosphate, the simplest form of phosphorus found in natural waters. In fact, orthophosphate is so quickly taken up by a growing algal population that it often is found only in low concentrations in lakes.

Phosphorus is found in lakes in several forms other than orthophosphate. For example, when phosphorus is absorbed by algae, it becomes organically bound to a living cell. When the cell dies, the phosphorus is still bound to particles even as it settles to the lake bottom. Once the decomposer organisms break down the cell, the phosphorus can become attached to calcium, iron, aluminum, and other ions. Under anoxic conditions, chemical reactions can release phosphorus from the sediments to the overlying waters. Spring or fall overturn may then redistribute it back to the surface of the lake where it can be taken up by another algal cell.

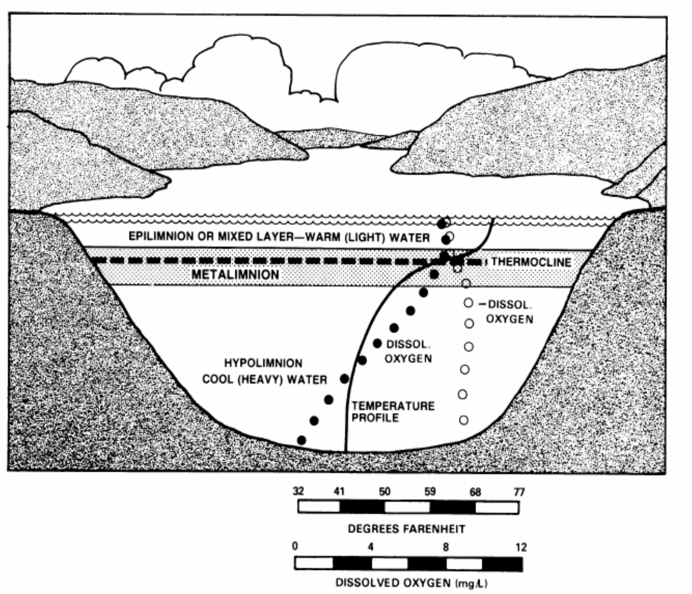
Phosphorus, therefore, is in a constant state of flux as environmental conditions change and plants and animals live, die, and decompose in the lake. Because the forms of phosphorus are constantly changing and recycling, it is generally most appropriate for citizen monitoring programs to measure all forms of phosphorus together. This one "umbrella" measurement is known as *total phosphorus* and is one of the three primary trophic state measurements used to classify lake water quality. Total phosphorus concentrations less than 10 micrograms per liter (µg/L) are associated with oligotrophic (clean, clear water) conditions while concentrations greater than 25 µg/L are associated with eutrophic (nutrient-rich) conditions.

## PHYSICAL COMPONENTS

### *DISSOLVED OXYGEN & TEMPERATURE*

Although oxygen is a chemical parameter, its presence in lakes and ponds is directly related to and therefore often discussed together with temperature. The amount of dissolved oxygen in the water is an important indicator of overall lake health. When oxygen is reduced, organisms are stressed. When oxygen is absent, all oxygen-breathing life forms must either move to an oxygenated zone or die.

Water temperature plays an important role in determining the amount of oxygen dissolved in water. Oxygen is more soluble in cold than warm water. Most lakes over 20 feet deep stratify during the summer into a warm, lighted upper layer (epilimnion) and a cold, dark lower layer (hypolimnion). Thus, the cold lower layer can potentially hold more oxygen than the warmer upper layer.




Usually these layers do not mix; thus, the bottom layer is cut off from atmospheric oxygen and oxygen-producing plants. Consequently, bottom oxygen can become depleted if there is an active population of decomposers in the bottom sediments. For these reasons, it is important to define the thermal layers in a lake when characterizing dissolved oxygen conditions.

There are also many chemical reactions that occur depending on whether or not oxygen is in the water. For example phosphorus can be released from bottom sediments when oxygen is reduced in the lower layer of a lake.

Dissolved oxygen conditions are best characterized by measuring the dissolved oxygen profile (measurements from the surface to the bottom at set intervals) and temperature profile (at the same intervals).

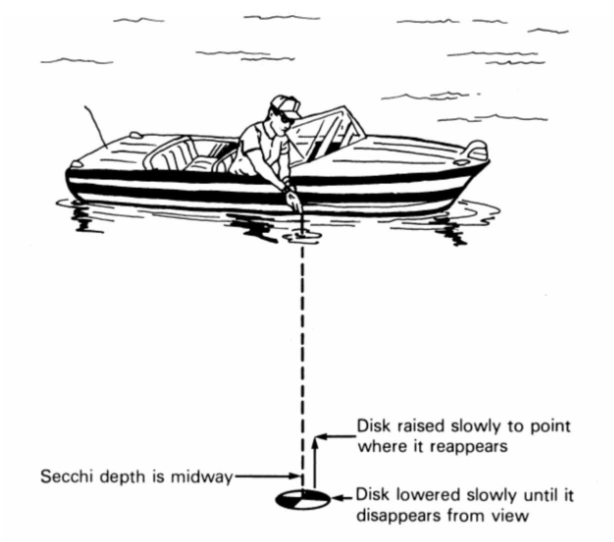
When characterizing the oxygen condition in a lake, it is important to know how oxygen concentrations differ from the surface to the bottom. In lakes that have a problem with low dissolved oxygen, it is not unusual to measure high dissolved oxygen levels at the surface during the day because algae in the photic zone are photosynthesizing and producing oxygen. At night, these same algae respire and consume oxygen.

Near the bottom, however, there may be low or no oxygen because decomposers are absorbing it while breaking down the "rain" of organic matter (dead algae cells, zooplankton, fish) falling from above.

A profile of oxygen measurements taken from top to bottom may provide insight on the relative populations of oxygen-producing plants and bottom-dwelling decomposers.

### *SECCHI DISK TRANSPARENCY*

The Secchi disk is a standard piece of equipment for lake scientists. It is simply a weighted circular disk 20 centimeters (about eight inches) in diameter with four alternating black and white sections painted on the surface. The disk is attached to a measured line that is marked off in meters (subdivided by tenths of meter).




The Secchi disk is used to measure how deep a person can see into the water. It is lowered into the lake by the measured line until the observer loses sight of it. The disk is then raised until it reappears. The depth of the water where the disk vanishes and reappears is the Secchi disk transparency. In extremely clear lakes, disk readings greater than 10 meters can be measured. On the other hand, lakes affected by large amounts of algal growth, suspended sediments, or other conditions often have readings of less than one-half meter. In some shallow lakes, it is impossible to get a Secchi disk reading because the disk hits the bottom before vanishing from sight. This means the true Secchi disk reading is greater than the depth of the lake in that particular location.

Secchi disk transparency is affected by a number of factors. Inside the lake, water transparency can be reduced by microscopic organisms other than algae, natural or unnatural dissolved materials that color or stain the water; and sediments. Factors outside the lake can also affect a Secchi disk reading. These outside factors can include the observer's eyesight and other sources of human error, the angle of the sun (time of day), latitude, season of the year, weather conditions (cloud cover, rain), and water surface conditions (waves, sun glare, surface scum).

Secchi disk transparency is one of the three primary measurements used to classify lake water quality. Transparencies greater than 4 meters are associated with oligotrophic conditions, while transparencies less than 2 meters are associated with eutrophic conditions.

# VOLUNTEER MONITORING PROGRAMS

## INTRODUCTION

Volunteer monitoring programs are an increasingly popular way to gather environmental data for several reasons. First, collecting large amounts of information over wide areas can be cost-prohibitive. Volunteer monitors reduce that cost by performing the field work themselves rather than hiring a scientist to collect the data. Also, volunteer monitoring programs provide a means to educate and involve the local property owners and community members. The information gained is useful both to the volunteer with an interest in his or her own water body and to the scientist trying to evaluate regional trends. And it has been proven that volunteer monitoring programs provide valid data for tracking water quality trends over time.

### WHY MONITOR?

Monitoring a lake or pond on a regular basis and from year to year provides two important pieces of information. One is a baseline of water quality – how is the health of a particular lake during a given year or a general assessment of the water quality of a particular lake. The second important information is a water quality trend – how is the water in a particular lake changing from year to year and over time. Baseline and long-term trend data are important because they allow lake scientists to detect changes in water quality before problems get out of hand. These data also provide a measure of reference if something happens that dramatically alters the lake, such as a sudden pollution event.

Volunteers in the LWWMD Volunteer Lake Monitoring Program will learn how to gather valuable information about their particular water body, such as information about its water quality health and water quality trends. Volunteers will also be helping to provide information that will be useful to other lakes in the Lake Wallenpaupack watershed. The Lake Wallenpaupack Watershed Management District has been working hard for many years to protect water quality within Lake Wallenpaupack, and this program extends that protection to the individual lakes and ponds in the watershed as well. The data gathered by volunteer monitors can be shared among the participants so that everyone can see how their lake or pond compares with other regional water bodies. More importantly, information gained by this volunteer monitoring program may help direct funding towards local projects that improve water quality, including agricultural and residential Best Management Practices and streambank restoration and protection projects.

### SAFETY CONSIDERATIONS FOR SAMPLING LAKES

The following are some basic common sense safety rules. At the site:

- Always monitor with at least one partner. Teams of three or four people are best. Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.

- Develop a safety plan. Find out the location and telephone number of the nearest telephone and write it down. Locate the nearest medical center and write down directions on how to get between the center and your site(s) so that you can direct emergency personnel. Have each member of the sampling team complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, epilepsy, etc.

- Have a first aid kit handy. Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings). It is best if at least one team member has first aid/CPR training.

- Listen to weather reports. Never go sampling if severe weather is predicted or if a storm occurs while at the site.

- If you drive, park in a safe location. Be sure your car doesn't pose a hazard to other drivers and that you don't block traffic.

- Put your wallet and keys in a safe place, such as a watertight bag you keep in a pouch strapped to your waist. Without proper precautions, wallet and keys might end up at the bottom of the lake or downstream.

- Never cross private property without the permission of the landowner. Better yet, sample only at public access points such as public parks or a boat access. Take along a card identifying you as a volunteer monitor.

- Confirm that you are at the proper site location by checking maps, site descriptions, or directions.

- Watch for irate dogs, farm animals, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps. Know what to do if you get bitten or stung.

- Watch for poison ivy, poison oak, sumac, and other types of vegetation in your area that can cause rashes and irritation.

- Never drink the water from a lake. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap.

- Do not monitor a lake if posted as unsafe for body contact. If the water appears to be severely polluted, contact the LWWMD.

- Do not walk on unstable lake or stream banks. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb shoreline vegetation as little as possible.

- If at any time you feel uncomfortable about the condition of the lake or your surroundings, stop monitoring and leave the site at once. Your safety is more important than the data!

When using chemicals (total phosphorus sample bottle contains small quantity of concentrated sulphuric acid as a preservative):

- Keep all equipment and chemicals away from small children. Many of the chemicals used in monitoring are poisonous. Tape the phone number of the local poison control center to your sampling kit.

- Avoid contact between chemical reagents and skin, eye, nose, and mouth. Never use your fingers to stopper a sample bottle (e.g., when you are shaking a solution). Wear safety goggles when performing any chemical test or handling preservatives.

- Know chemical cleanup and disposal procedures. Wipe up all spills when they occur. Return all unused chemicals to your program coordinator for safe disposal. Close all containers tightly after use. Do not switch caps.

## QUALITY ASSURANCE & QUALITY CONTROL

One of the most difficult issues facing volunteer environmental monitoring programs today is data credibility. Potential data users are often skeptical about volunteer data -- they may have doubts about the goals and objectives of the project, about how volunteers were trained, about how samples were collected, handled and stored, or about how data were analyzed and reports written. A key tool in breaking down this barrier of skepticism is the quality assurance and quality control program.

Quality assurance (QA) refers to the overall management system that includes the organization, planning, data collection, quality control, documentation, evaluation, and reporting activities in a monitoring program. QA provides the information needed to ascertain the quality of the data and whether it meets the requirements of the program. QA ensures that the data will meet defined standards of quality with a stated level of confidence.

Quality control (QC) refers to the routine technical activities whose purpose is, essentially, error control. Since errors can occur in either the field, the laboratory or in the office, QC must be part of each of these functions.

Together, QA and QC help you produce data of known quality and enhance the credibility of the monitoring program. The elements of QA and QC have been built into the LWWMD Volunteer Monitoring Program.

# THE LWWMD VOLUNTEER LAKE MONITORING PROGRAM

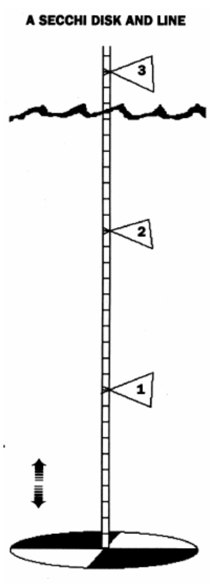
## THE LAKE MONITORING PROGRAM

The lake monitoring program has been designed to provide information for determining existing water quality conditions and tracking water quality over time. The basic parameters, described in detail in the previous section, are chlorophyll a, total phosphorus, transparency, dissolved oxygen and temperature.

Prior to sampling, the necessary equipment and sample containers should be picked up by the volunteers at the District Office. A training session will be conducted to familiarize the volunteers with equipment operation. During this training session, each volunteer group will be provided with information about the monitoring program and instructions on sampling protocol. In addition, this handbook serves as a written reference about the volunteer monitoring program.

### INTRODUCTION TO SAMPLING EQUIPMENT

There are several pieces of equipment that you will need in order to study your lake. These include a Secchi disk for measuring transparency, a vertical water sampler, and a dissolved oxygen/temperature meter. This equipment, along with all necessary sample bottles, will be available by reservation from the LWWMD Office. The equipment is described here. Its use is presented in detail in the Step by Step Procedures section.




The Secchi disk is a weighted circular disk 20 centimeters in diameter (about eight inches) with four alternating black and white sections painted on the surface. The disk is attached to a measured line that is marked off in meters (subdivided by tenths of meter) and is used to measure how deep a person can see into the water.

A horizontal water sampler, such as the Van Dorn sampler shown here, is a device used to collect samples at a specific depth. The device consists of a marked line used to lower the sampler to a specific depth, a weighted messenger used to trip the sampler closed, and the sampler itself. The sampler consists of a water chamber, and end seals that remain open while lowering and close when triggered by the messenger.

A dissolved oxygen and temperature meter ("D.O. meter") is used to measure water temperature and the concentration of oxygen dissolved in water at any depth in a lake or pond. The instrument consists of the meter itself and a submersible probe connected to a cable. The meter has an analog or digital readout panel, along with dials to calibrate the meter and switch between reading temperature and dissolved oxygen. The probe consists of a depth-compensating membrane, a temperature thermistor, and an oxygen sensor. Once calibrated, the probe can be lowered to any depth where levels of temperature and dissolved oxygen can be measured.

### WHERE TO SAMPLE

#### *LAKE LOCATION*

A lake and its water quality are not uniform from shore to shore or from surface to bottom. Lake morphometry, exposure to winds, incoming streams, watershed development, and human activity can greatly influence the algal conditions found at any one location in the lake. In most cases, a site over the deepest section of the lake best represents average conditions. In natural lakes that are circular in shape, the deepest section is usually near the middle. In reservoirs, the deepest section is usually near the dam. Sample site selection must be consistent within the LWWMD Volunteer Lake Monitoring Program in order to get results worthy of lake-to-lake comparison. Therefore, the deepest part of the lake has been chosen as the location for sampling.

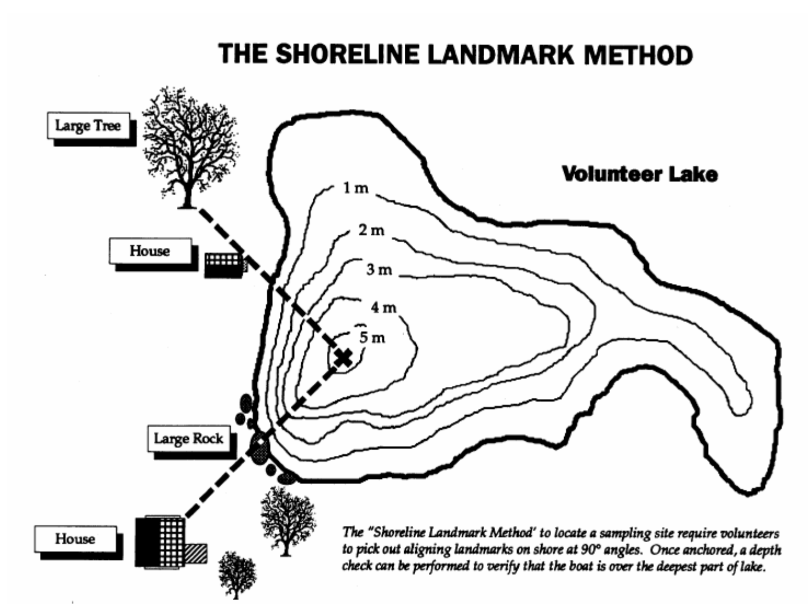
The LWWMD Volunteer Lake Monitoring Program coordinator will assist in identifying the proper sampling site location in each volunteer lake. Once identified, the site should be clearly marked on a lake map and located by boat by cruising to the general location and verifying the depth using the anchor rope, a weighted calibrated sounding line, or an electric "fish-finder" apparatus that indicates bottom depth.

Volunteers should use one of the following methods to return consistently to the same sampling site location: locate the site by using landmarks visible on the shore; or by setting a permanent marker buoy at the sampling location.

*Shoreline Landmark Method*

Once securely anchored at the site, the volunteer should pick out two permanent landmarks on shore (a dwelling, tall tree, large rocks) that align one behind the other. This alignment forms an imaginary bearing line through the objects to the site.

Then, at about a 90 degree angle, two more aligning landmarks should be identified. These landmarks then form a second bearing line to the sampling site. Volunteers should



*The "Shoreline Landmark Method' to locate a sampling site require volunteers to pick out aligning landmarks on shore at 90° angles. Once anchored, a depth check can be performed to verify that the boat is over the deepest part of lake.*

mark these landmarks and bearing lines on their lake map for future reference. They should also practice finding the site location with the program manager.

*Marker Buoy Method*

If the lake is small and protected from strong winds and waves, a marker buoy may be the simplest way to designate a sample site location. In many public lakes, however, it is illegal to set out buoys without proper permits. The rules and regulations regarding buoys should be checked before any placement.

There is a risk that winds, waves, and/or lake users will move a marker buoy. Thus, volunteers should also be trained to verify that the buoy is in the proper location using the shoreline landmark method before starting the sampling procedure. This training will be useful if the buoy is lost or needs to be repositioned.

### ***SAMPLE DEPTH***

The LWWMD Volunteer Lake Monitoring Program uses a composite sample for tracking water quality. A composite sample is collected by combining equal parts of water samples collected with a horizontal water sampler at equal depths throughout the photic zone (twice the Secchi depth). A composite provides a fairly consistent sample for comparison over time and between lakes. Instructions for collecting a composite sample will be provided in the **STEP BY STEP PROCEDURE FOR SAMPLING A LAKE OR POND** section below.

### **WHEN TO SAMPLE**

Ideally, lakes and ponds in the LWWMD Volunteer Lake Monitoring Program should be sampled once per month between May and September. Volunteers should try to schedule their lake sampling at around the same time each month, so that each sampling trip is more or less one month apart. Sampling at the end of one month and the beginning of the next does not provide representative information for each month.

Ideally, samples should be collected on a sunny day with little wind. However, partly cloudy days or even mostly cloudy days would be preferable over windy days. Sampling under choppy conditions is dangerous and some of the readings, particularly Secchi disk transparency, are difficult to obtain accurately when the water surface is agitated. More information about when to sample will be discussed during the training session.

Samples must be collected between 10 AM and 3 PM since transparency readings become inaccurate when the sun is low on the horizon. Volunteers should complete all of the sample collection on the same trip out, so that the various measured parameters are comparable.

Volunteers must coordinate sampling days with the LWWMD Volunteer Lake Monitoring Program coordinator to make sure someone will be available to take the samples to the laboratory within 48 hours of sampling.

## STEP BY STEP PROCEDURE FOR SAMPLING A LAKE OR POND

### STEP 1 - SCHEDULE SAMPLING DATE

The LWWMD Volunteer Lake Monitoring Program coordinator will schedule sampling dates with volunteers. For quality control purposes, the water samples must be delivered to the laboratory within 48 hours of sampling, so careful planning with the LWWMD Volunteer Lake Monitoring Program coordinator is very important. Since there are only two sets of sampling equipment, it is highly recommended that volunteers plan ahead for sampling in order to make sure the equipment is available when they need it. In general, volunteers should conduct sampling between 10 a.m. and 3 p.m., and return the equipment as soon as possible after use so that it is available for other groups. Volunteers must understand, however, that there is flexibility in both the day and time, especially in consideration of weather conditions.

Common sense and good judgment should dictate when it is appropriate to sample. Both acceptable and unacceptable weather conditions will be defined during the training session. Under no circumstances should volunteers be on the water during rain or electrical storms, high winds (white caps), or other unsafe conditions. Check the current and forecasted weather and decide if the conditions allow for safe sampling. Confirm this decision after personally inspecting lake conditions prior to launching the boat and beginning the sampling trip.

### STEP 2 - BOATING SAFETY EQUIPMENT CHECK

Before leaving shore, confirm that all required safety equipment is on board. Boating safety is a subject that needs to be taken seriously, as lake monitoring requires a great deal of moving around the boat and leaning over the edge while working with equipment.

Wear a life preserver (Type I, II, or III personal flotation device) at all times. Confirm that the following boating safety equipment is on board the sampling boat:

- A personal flotation device for each person that is Coast Guard-approved, readily available, and the proper size
- First aid kit
- Other equipment that may be required by State and local boating laws

### STEP 3 - SAMPLING EQUIPMENT CHECK

Pick up the following gear from the LWWMD office:

? Field sampling data sheet
? LWWMD Volunteer Lake Monitoring protocol sheet
? Horizontal water sampler
? Secchi disk with measured line and clothespin
? Dissolved oxygen meter

- ? One 1- L opaque chlorophyll a laboratory bottle
- ? One 1-L clear total phosphorus laboratory bottle (with preservative)
- ? Pair of vinyl or latex gloves and safety glasses
- ? Cooler with ice packs (make sure ice packs are frozen prior to sampling date)
- ? Clean bucket

Before leaving shore, confirm all the needed sampling equipment is on board the sampling boat. The following sampling equipment and supplies should also be included:

- ? Anchor (with a measured line if a depth check is required). Two anchors are helpful on windy days, one off the bow and the other off the stern
- ? Clipboard and pencils
- ? Map of lake with sampling site and landmarks marked
- ? Depth meter or weighted sounding line

Turn on the DO meter just before leaving shore to allow the instrument time to warm up before sampling. Complete the bottle labels prior to leaving the shore. Using a pencil or permanent marker (do not use a felt-tip marker or ballpoint pen to write on the labels; it may wash off if the bottle gets wet), write the following information on each of the sample bottles:

- Parameter to be analyzed (chlorophyll a or total phosphorus)
- Date sample was collected
- Time sample was collected
- Name of the sample lake
- Name of lake association or owner

### STEP 4 - ANCHOR AT SAMPLE SITE AND DOCUMENT BASIC CONDITIONS

Locate the sample site on the water. Whether or not a marking buoy is used, verify the position using the shoreline landmark method (see previous section). Once the site is located, anchor the boat. Repositioning the anchor once it is dropped is discouraged, especially in shallow lakes, because it can stir up sediments from the lake bottom. Increasing sediment turbidity may alter the data collected at the site. After anchoring, volunteers should allow the boat position to become stable.

Record observations about the lake and weather conditions on the field sampling data sheet. Record the lake and sampling location names, the date, the time of sampling, and the names of volunteers doing the sampling. Record weather and water condition observations. Record any other factors or conditions that make the sampling trip unusual or may potentially influence results. For example, report any chemical, mechanical, or biological control of algae or rooted aquatic plants, recent storms, visible floating algae, or particularly cloudy or “soupy” water that may indicate an algae bloom.

Using an electronic depth meter, measure the depth of the site and record it on the sampling form. It is important to know the depth because the oxygen probe must not be allowed to come in contact with the lake bottom. Alternatively a sounding weight with calibrated line can be used to measure the depth at the sampling location. For this method, lower the sounding weight all the way to the bottom of the lake, and mark the line with the clothespin at water level. Haul the sounding weight back up and record the level of the clothespin as the water depth. If a depth meter or sounding weight with calibrated line is not available, the Secchi disk can be used in the same manner. Take care not to stir up the bottom sediments during depth measurement; if this happens, all of the rest of the sampling should take place on the opposite side of the boat from where the depth was measured.

### STEP 5 - MEASURE TEMPERATURE AND DISSOLVED OXYGEN PROFILE

Complete instructions for warming up and calibrating the dissolved oxygen meter are included in the DO Meter Operation Instructions in the Appendix. The DO meter should be allowed to warm up for approximately 5 minutes before use.

Once the meter is properly warmed up and calibrated, begin measuring the dissolved oxygen and temperature profile. Lower the probe into the lake, just below the surface. Allow the probe to adjust (wait until meter readings stabilize), then record the dissolved oxygen and temperature values on your field sheet as the "0" depth, representing the surface values. Lower the probe to one meter in depth beneath the surface and take the next set of readings. Continue to collect readings at one-meter intervals until the probe is approximately one-half meter above the bottom. If the lake is less than five meters deep at the sampling location, you should use half-meter intervals, rather than one meter intervals.

### STEP 6 - MEASURE SECCHI DISK DEPTH

The Secchi disk is used to measure the depth that a person can see into the water (transparency). A Secchi disk reading is a personal measurement; it involves only two pieces of equipment, the Secchi disk and the person's eyesight. It is preferable to have the same individual take the reading at the lake sampling location throughout the entire sampling season in order to eliminate bias due to differences in eyesight.

The line attached to the Secchi disk is marked in meters, with large black markings representing 1 meter intervals, small black marking representing 1/10 meter intervals, and large red markings representing each 5 meter interval. Readings should be measured to the nearest one-tenth meter.

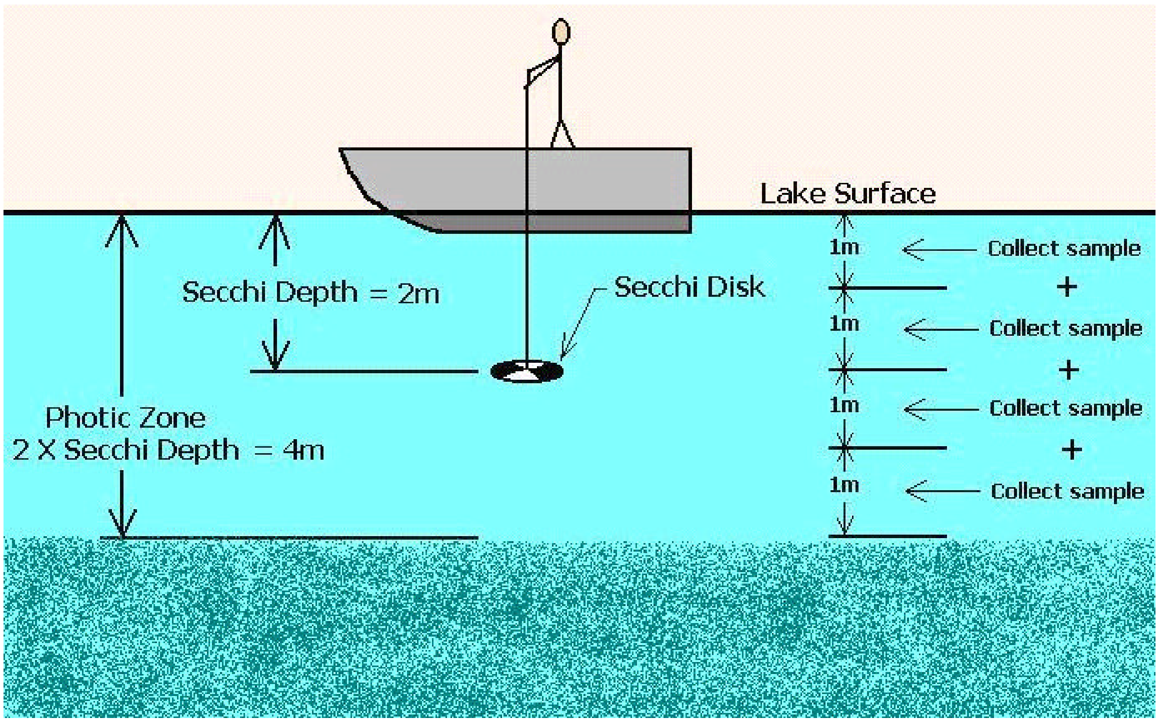
Check to make sure that the Secchi disk is securely attached to the calibrated line. Lean over the sunny side of the boat and lower the Secchi disk into the water, using your hand or arm to block the glare. Do not wear sunglasses of any kind while taking the reading. Continue to lower the disk until it just disappears from view. Lower the disk another half meter and then slowly raise the disc until it just reappears. Continue to move the disk up and down until the exact vanishing/reappearing point is found. Attach a clothespin to the calibrated line at the point where the line enters the water. This is the point at which the measurement will be read. Slowly pull the disk out of the water and record the measurement based on the location of the clothespin on the calibrated line.

This procedure can be repeated as a quality control check; an average of the two readings should be recorded on the sampling form.

### STEP 7 - COLLECT SAMPLE FOR CHLOROPHYLL A

Rinse out the bucket with lake water by swirling several inches around in the bucket, also repeating three times. Check to make sure that the water sampler is securely attached to the measured line, which is marked in meters like the DO meter line. Prepare the sampler for collection by setting the top latch into place (turn notch to latch onto post), pulling open each end and attaching stopper cords to the trigger mechanism. Determine the depth at which the composite water sample will be taken; four separate water samples will be taken from equally-spaced sampling points throughout the photic zone. The photic zone is a vertical area of twice the Secchi disk depth. Divide the photic zone into four equal areas. A water sample will be taken at the midpoint of each of the four areas. Use the following graphic as an example:

Example Secchi depth: 2.1 meters




Make sure the sampler remains open all the way down to the sampling depth. Hold the line out away from the boat and release the messenger, allowing it to slide down the line to close the sampler. When the messenger hits the catch on the sampler, the catch releases the two end covers. The two covers snap around and seal off the ends. You will feel a gentle tug on the line when the sampler closes. Gently haul the sampler to the surface and empty the contents into the bucket. Reset the sampler and repeat the sampling procedure to collect a sample at the other three depths.

You will fill all of the sample containers while on the boat. Immediately after collecting the lake water in the bucket, use the 1 L chlorophyll a bottle to mix the water in the bucket. Rinse the chlorophyll a sample bottle (opaque bottle) with lake water by dipping it into the bucket, allowing it to fill with an inch or so of water, closing the cap tightly, and shaking vigorously. Empty the bottle and then rinse it two more times. Do not rinse the total phosphorus bottle as it contains acid preservative. After rinsing the chlorophyll a bottle, fill it with the water from the bucket and cap it tightly. Place the bottle into the cooler away from sunlight. At this point, you can empty the bucket.

### STEP 8 - COLLECT SAMPLE FOR TOTAL PHOSPHORUS

Prepare the sampler for collection again by setting the top latch into place, pulling open each end and attaching stopper cords to the trigger mechanism. Lower the sampler to a depth of ½ meter using the measured line, and release the messenger. Haul the sampler up onto the boat, keeping it closed.

Caution must be used when filling the phosphorus bottle. The phosphorus sample can be easily contaminated if the inside of the cap is touched or debris blows into the bottle. Leave the cap on the phosphorus bottle until ready to pour the sample water into it. The phosphorus sample bottle contains a small amount of acid that preserves the sample during transport to the laboratory. This acid must be treated cautiously because it can burn skin or clothing if spilled or mishandled (see safety instructions in the previous section). Volunteers should wear clean vinyl gloves, not smoke, and be careful not to breathe the vapors from the opened bottle. Accidental spills should be flushed very thoroughly with water.

Wearing vinyl gloves, open the stopcock valve on the sampler tubing and carefully fill the 250 mL total phosphorus bottle. **Do not overfill the bottle** as this can cause the preservative to leak out. It is sometimes easier to have one volunteer hold the sampler and another volunteer hold the bottle, but both should wear gloves. Place the cap back on the total phosphorus bottle and place it in the cooler.

### STEP 9 - RETURN EQUIPMENT, SAMPLES AND FIELD DATA SHEETS

Return to shore and unload the sampling equipment and supplies. Turn off the DO meter. Make a final check at the lake to ensure that all sampling equipment has been collected, that the sample data sheets have been completely filled out, and that the bottles are properly labeled. Return all equipment, samples, and field data sheets to the LWWMD office. Place the water samples in the designated area at the LWWMD office, making sure the volunteer coordinator knows they have been delivered. The original field data sheet must be signed by the volunteer coordinator, who will deliver it along with the laboratory bottles to the laboratory. Volunteers should make a photocopy of the field data sheet if they desire to keep one for their records. **Volunteers must fill out the chain-of-custody information at the bottom of the field sheet for quality control purposes** (collected by and relinquished by).

All water samples should be placed in a refrigerator if they cannot be delivered to the LWWMD office within several hours of sampling. All samples must be delivered to the laboratory (not just the LWWMD office!) within 48 hours of sampling. Therefore, all sampling must be closely coordinated with the LWWMD Volunteer Lake Monitoring Program coordinator to ensure that the samples are handled properly and delivered to the laboratory in a timely manner. Samples should never be delivered to the LWWMD office without notifying the coordinator.

### STEP 10 – LABORATORY ANALYSIS AND RESULTS

The LWWMD volunteer coordinator will deliver the water samples to the F. X. Browne, Inc. analytical laboratory within 48 hours of sampling. Each volunteer lake will receive one free total phosphorus and one free chlorophyll a sample analysis. Results will be sent to the LWWMD, who will send a short report to the volunteer association. Please make sure that the LWWMD has a contact name and address for this purpose. Further analyses and more detailed sample reports can be provided for a nominal charge.

Lake data from all the participating lakes will be compiled, with permission, and posted on the LWWMD website for sharing purposes. This will allow volunteers to see how their lake compares to other local lakes. This data will also assist the LWWMD in furthering its goal of protecting and preserving water quality within the Lake Wallenpaupack watershed, and may provide valuable information for future funding applications targeting watershed BMPs.

## ADDITIONAL MONITORING PARAMETERS

This section covers some additional water quality parameters not measured as part of the LWWMD Volunteer Lake Monitoring Program. These parameters may be of interest to certain associations depending upon specific problems occurring in their lakes and ponds.

### ACIDITY STATUS

The acidity status of a lake can be determined by measuring pH and alkalinity. The pH level is a measure of acidity that is related to the number of unattached hydrogen ions in the water. Alkalinity (or acid neutralizing capacity) is a measure of the water's buffering capacity, the ability of a lake to absorb or withstand acidic inputs.

The pH is reported in standard units on a logarithmic scale that ranges from one to fourteen. Seven is neutral, lower numbers are more acid, and higher numbers are more basic. In general, pH values between 6.0 and 8.0 are considered optimal for the maintenance of a healthy lake ecosystem. Many species of fish and amphibians have difficulty with growth and reproduction when pH levels fall below 5.5 standard units. Lake acidification status can be assessed from pH as follows:

| | |
|---|---|
| pH less than 5.0 | Critical (impaired) |
| pH between 5.0 and 6.0 | Endangered (threatened) |
| pH greater than 6.0 | Satisfactory (acceptable) |

Alkalinity is reported as a concentration in milligrams per liter (mg/L) or microequivelents per liter (µeq/L). In the northeast, most lakes have low alkalinities, which means they are sensitive to the effects of acidic precipitation. This is a particular concern during the spring when large amounts of low pH snowmelt runs into lakes with little or no contact with the soil's natural buffering agents. Typical summer concentrations of alkalinity in northeastern lakes are around 10 mg/L (200 µeq/L).
Lake acidification status can be assessed from alkalinity as follows:

| | |
|---|---|
| Alkalinity less than 0 mg/L | acidified |
| Alkalinity between 0 and 2 mg/L | extremely sensitive |
| Alkalinity between 2 and 10 mg/L | moderately sensitive |
| Alkalinity between 10 and 25 mg/L | low sensitivity |
| Alkalinity greater than 25 mg/L | not sensitive |

Alkalinity and pH can be tested by collecting a water quality sample from the deep part of the lake and submitting it to a laboratory for analysis.

### NITROGEN

Nitrogen concentrations in a lake can have a pronounced effect on water quality, most importantly with respect to algae and aquatic plant populations. Either phosphorus or nitrogen can be the "limiting" nutrient required for algal growth in a lake. Measuring the ratio of total nitrogen to total phosphorus concentrations in a lake can determine which nutrient is most affecting algal growth.

The common inorganic forms of nitrogen in lake water are nitrate ($NO_3^-$), nitrite ($NO_2^-$), and ammonia ($NH_3$). The form of inorganic nitrogen present depends largely on dissolved oxygen concentrations. Nitrate is the form usually found in surface waters, while ammonia is only stable under anaerobic (low oxygen) conditions. The presence of high levels of nitrates in a lake indicates possible sewage or manure pollution. Total Kjeldahl nitrogen (TKN) is an indicator of the presence of organic nitrogen. Total nitrogen is calculated by summing the nitrate-nitrite, ammonia, and organic nitrogen fractions together.

The various nitrogen parameters are sampled by collecting a water quality sample from the deep part of the lake and submitting it to a laboratory for analysis.

### ALGAE

The LWWMD Volunteer Lake Monitoring Program measures information about algae by measuring Secchi disk transparency and chlorophyll a concentrations. However, specific information on the types of algae present can also be important to understand, particularly in a lake that has problems with algae blooms.

Algae samples can be collected from anywhere in a lake or pond using a plankton net, either by lowering the net in deep water or tossing the net our from shore or boat in shallow water. During algae blooms, mats of algae may wash up near shore. A sample from these mats can be scooped directly into a bottle. Laboratories use a microscope to identity the species present.

Ideally, phytoplankton samples should be collected at the same time as the other lake water quality samples. As with other water quality parameters, samples collected once per month throughout the summer provide the best information about the lake's algae population. However, if time and funds allow for only one sample per year, it should be collected during late July or August, which is typically the most problematic time for algae blooms.

### AQUATIC PLANTS

Eutrophic lakes usually contain an abundance of aquatic plants. While aquatic plants can provide good fish habitat, excessive aquatic plants can cause problems by tangling boat propellers and making it difficult to swim or enjoy recreational opportunities in the lake. By monitoring aquatic plants in a lake, volunteers can track changes in vegetative location and density. In lakes with excessive amounts of aquatic plants, these maps can be useful for planning the application of aquatic plant control methods, such as harvesting.

Even in lakes with very few aquatic plants, it is a good idea to perform a plant survey periodically in order to maintain a historical record of plant colonization. This is particularly important in lakes with public access, since such lakes are more likely to see the introduction of invasive non-native plant species such as Eurasian watermilfoil, hydrilla, or water chestnut. These invasive species spread very rapidly and can be difficult to eradicate once well established. Early detection methods, such as plant surveys, are the best means of preventing invasive aquatic plants from taking over a lake.

Volunteers usually perform an annual or biannual aquatic plant survey by traveling along the edge of the lake in a canoe or small boat and mapping the distribution of plant species in the lake. Transects can also be used to estimate the density of aquatic plants in a selected area. In order to participate in aquatic plant monitoring, volunteers need to educate themselves about how to identify the aquatic plant species typically found in their lake. When volunteers encounter plants they are unfamiliar with, they collect specimens for professional identification. Aquatic plant surveys should be performed in mid-July to mid-August, when aquatic plants have reached full maturity but have not yet begun to senesce. The monitoring should be performed at approximately the same time each year to ensure proper consistency.

### BACTERIA

Bacteria and other disease-causing organisms in water that people swim in or drink from can cause serious human health problems. Sources of water-borne pathogens include sewage, runoff from animal or wildfowl areas, and even swimmers themselves. Public health officials usually monitor bathing beaches for the presence of one or more indicator organisms as part of a regular sampling program. Volunteer lake monitors may wish to perform periodic bacteria monitoring when a public beach is not present to make sure their lake is safe for swimming.

The relative abundance of an indicator organism found in a water sample serves as a warning for the likely presence of other, more dangerous pathogens in the water. The indicator organisms most often used to indicate sanitary conditions at bathing beaches are fecal coliform bacteria, enterococcus bacteria, and E. coli.

Fecal coliforms are the part of the coliform group that are derived from the feces of warm-blooded animals. The fecal test differentiates between coliforms of fecal origin and those from other sources. Enterococcus are a subset of the fecal coliform group. Like fecal coliforms, they, too, indicate fecal contamination by warm-blooded animals. They are useful because they are found only in certain animals. Examination of the ratio of fecal coliform to enterococcus can, therefore, indicate whether the bacterial pollution is from humans or animals. E. coli is also a species of fecal coliform bacteria that has been linked to numerous food born illness outbreaks in the United States. A number of other bacteria in combination comprise the fecal coliform group. In other words E. coli is not a direct substitute for fecal coliform.

Volunteers wishing to conduct bacteria monitoring should first contact their local heath department to determine the local regulations. Most public health officials recommend weekly testing of swimming beach areas, but in the absence of a public beach, the frequency of testing is up to the volunteer. Sampling should occur at one or more sampling sites in water three to four feet deep. The number of sites needed will vary with the length and configuration of the shoreline. A general rule of thumb is to sample one site for every 300 linear feet of shoreline.

Samples are collected by dunking a sterilized sampling bottle prepared by the laboratory into the water at approximately elbow depth, and filling it using an upward sweeping motion. Samples must be delivered to the sampling laboratory within six hours of collection; therefore, careful coordination and advance planning is necessary if this type of testing is desired.

Sometimes, lakeshore owners have problems with contaminated wells from failing septic systems and shallow groundwater. It may be useful for a volunteer association to organize a well testing day, where they travel to different houses around the lake and collect samples from various homeowners who are interested in having their water tested. If the lake water bacteria testing is performed on the same day, it can save costs, and potentially provide insight into the source(s) of the bacteria, while providing valuable information to the lakeshore homeowners.

### SEDIMENTATION

Sedimentation problems occur in a lake when erosion is taking place in the watershed. Surface runoff washes sand and silt into the lake where it settles to the bottom and creates shallow areas that interfere with lake use and enjoyment. In addition, sediments often carry significant amounts of nutrients that can fertilize rooted aquatic plants and algae.

Volunteers can characterize the build-up of sediments by measuring water depth and the depth of unconsolidated (soft bottom) sediments in key areas (mouths of tributary streams or near an eroding shoreline). In this manner, a historical record of sedimentation can be developed. To measure sediment, volunteers set up a transect line and measure sediment thickness at specified intervals along it.

Some of the silt and organic matter that enters a lake does not settle to the lake bottom. Instead it remains suspended in the water. These suspended solids decrease water transparency and can affect the suitability of the lake habitat for some species. The LWWMD Volunteer Lake Monitoring Program measures suspended solids indirectly by measuring the transparency of the lake water with a Secchi disk. However, if a more precise measurement of total suspended solids is desired, volunteers can collect a separate water sample for laboratory analysis of this parameter.

### VOLUNTEER STREAM MONITORING

Stream ecology differs from lake ecology in that the stream ecosystem is dominated by the influence of flowing water. Moving water affects the chemical, physical and biological processes in many ways. Water moving through the watershed picks up solid materials and dissolved chemicals and moves these downstream. These solid and dissolved materials, particularly sediments and nutrients, can act as pollutants within the stream itself. Impacts within small streams are not always easily observed, since the moving water carries many of the pollutants on downstream. These pollutants eventually reach pools within the stream or a downstream lake or pond, where the problems they cause become more severe.

Many of the water quality parameters that are important in streams are the same ones that are important in lakes. Stream water quality parameters should generally be collected with the same frequency as lake samples, unless otherwise noted. If stream sampling is being conducted in conjunction with lake monitoring, stream samples should be collected on the same day that lake samples are collected.

It is very important to make note of the weather conditions during stream sampling. Recent rainfall can have a significant affect on stream water quality. In general, volunteers should not sample the stream within a 24-hour period after a large rain event, unless they are specifically trying to document stormflow conditions. Sampling during a rain event can provide valuable information about the effects of stormwater runoff on the stream water quality; however, it is important to document the condition of the stream during “dry” (baseflow) conditions.

The following sections cover those parameters that are unique to streams. More detailed information about stream monitoring parameter protocols and instructions for stream monitoring are included in the Appendix.

#### *MACROINVERTEBRATES*

Macroinvertebrates are aquatic insects, crustaceans, worms, and insect larvae that live within a stream and form a key component of the ecosystem. Macroinvertebrates feed on microscopic plants and animals. Since certain species of macroinvertebrates require clean water while others can survive even in severely polluted streams, the presence and absence of specific species of macroinvertebrates provides a good indicator of stream water quality.

Macroinvertebrates are collected by using a kick-net to disturb the bottom of a stream and collect insects and other organisms that are resting on the rocks and in the detritus at the bottom of the stream. The organisms are then identified and counted using a microscope and taxonomic keys. Calculations are performed to determine whether the sample of macroinvertebrates collected represents species intolerant of pollution, or tolerant of polluted waters.

Usually, volunteer macroinvertebrate monitoring is performed once per year, late enough in the spring that most of the larvae have emerged but not so late in the fall that the macroinvertebrates have begun to disappear. Care must be taken to sample at exactly the same time and place each year to ensure that any year-to-year differences are not due to sampling bias. Changes in water quality are less rapidly detected using macroinvertebrates as an indicator of stream health than other chemical or physical parameters, but overall macroinvertebrate monitoring can be a very accurate measurement of water quality. It is especially useful when viewed in conjunction with other water quality and habitat assessment parameters.

#### *HABITAT ASSESSMENTS AND WATERSHED SURVEYS*

Visual assessments of a stream and its watershed can provide valuable information about problems such as pollution sources, stream blockages, eroded streambanks, land use changes, and overall water quality. Watershed surveys are performed by walking or driving through the watershed and making note of any problem areas observed on a map. Habitat assessments are usually performed at a specific stream site where macroinvertebrate and/or chemical samples are also collected. A habitat assessment is very simple to perform, and involves observing specific aspects about a stream site, such as vegetative cover, presence of riffles, streambank integrity, or water flow, and recording them on a specialized form. Habitat assessments need only be conducted once per year, or whenever other monitoring, such as macroinvertebrate sampling, is being done.

#### *BACTERIA AND WATER-BORN PATHOGENS.*

As in lakes and ponds, streams can easily become contaminated with bacteria and other pathogens. Principle sources of these pollutants include farm animals and septic systems. Water samples are collected by hand in a pre-sterilized bottle from a deep portion of the stream in the same way that lake bacteria samples are collected. Stream bacteria samples must be delivered to the analytical laboratory within six hours. Bacteria samples should be collected at multiple stream sites when contamination is suspected, in order to document the location of the contamination.

#### *ACIDITY STATUS*

The acidity status of a stream – pH and alkalinity – is similar to lakes and ponds. Low pH which is detrimental to aquatic life can be caused by acidic precipitation and acid mine drainage.

Excessively high pH can also be a problem to aquatic life and can sometimes be caused by discharges from industrial plants and wastewater facilities. Samples are collected by hand from a deep part of the stream and delivered to the analytical laboratory for analysis.

### *NUTRIENTS (PHOSPHORUS AND NITROGEN)*

Excessive levels of nutrients in streams can cause many of the same problems as in lakes – an overabundance of plants and algae that degrades the ecosystem. Typical nutrients that are monitored in streams include phosphorus (dissolved phosphorus and total phosphorus) and nitrogen (nitrates and ammonia). Nitrates from land sources end up in rivers and streams more quickly than other nutrients like phosphorus. This is because they dissolve in water more readily than phosphates, which have an attraction for soil particles. As a result, nitrates serve as a better indicator of the possibility of a source of sewage or manure pollution during dry weather. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. However, even very low concentrations of phosphorus can have a dramatic impact on streams. Phosphorus is readily washed into streams during storm events since it tends to be associated with soil and particulate matter.

By monitoring the stream at multiple sampling sites, the source of any nutrient contamination can sometimes be pinpointed. Nutrient water quality samples are usually collected in prepared laboratory bottles by hand from a deep part of the stream and delivered to the analytical laboratory for analysis.

### *FLOW*

Water flow is the most significant factor that affects the stream ecosystem. Flowing water moves material through the system and regulates where plants and animals can live. Fast-flowing water can erode stream banks and move sand and silt from stream bottoms downstream to lakes and ponds. Moving water also aerates the stream, introducing oxygen and helping to break up pollutants. Slow water can become stagnant and, if polluted, may suffer from many of the same problems that plague polluted lakes and ponds. These include algae blooms and loss of oxygen. Large, swiftly flowing rivers can receive pollution discharges and be affected very little, whereas small streams have less capacity to dilute and treat wastes.

Stream flow, or discharge, is the volume of water that moves over a designated point during a fixed period of time. It is often expressed as cubic feet per second ($ft^3$/sec). The flow of a stream is directly related to the amount of water moving off the watershed into the stream channel. It is affected by weather, increasing during rainstorms and decreasing during dry periods, and also by the watershed's land use.

Stream flow is measured in several steps. First, select a stretch of stream that has moving water (no slow-moving pools). It is usually easiest to choose a segment near a bridge or road for easiest access and safety. Next, calculate the cross-sectional area of the stream by measuring the stream depth across the width of the stream at even increments. Third, measure the velocity of the water moving through the chosen stretch. This can be accomplished by using a flow meter, or by floating a ball or orange down the stream and calculating velocity based on how long it takes the object to float down a measured length of stream (say 20 feet). Finally, stream flow is calculated by using the following equation:

$$Flow = ALC / T$$

Where:

- A = Average cross-sectional area of the stream (stream width multiplied by average water depth).
- L = Length of the stream reach measured (usually 20 ft.)
- C = A coefficient or correction factor (0.8 for rocky-bottom streams or 0.9 for muddy-bottom streams). This allows you to correct for the fact that water at the surface travels faster than near the stream bottom due to resistance from gravel, cobble, etc. Multiplying the surface velocity by a correction coefficient decreases the value and gives a better measure of the stream's overall velocity.
- T = Time, in seconds, for the float to travel the length of L

### *SUSPENDED SOLIDS (TURBIDITY, TOTAL SUSPENDED SOLIDS)*

Turbidity is a measure of water clarity, or how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, microbes, and other substances. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold water. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates.

Turbidity is not a measurement of the amount of total suspended solids present or the rate of sedimentation of a steam since it measures only the amount of light that is scattered by suspended particles. Measurement of total suspended solids is a more direct measure of the amount of material suspended and dissolved in water. Total suspended solids (TSS) include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. Higher concentrations of suspended solids can serve as carriers of toxics, which readily cling to suspended particles.

Turbidity and TSS can be useful as indicators of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity and TSS often increases sharply during a rainfall, especially in developed watersheds that have relatively high proportions of impervious surfaces. Therefore, regular monitoring of these parameters can help detect trends that might indicate increasing erosion in developing watersheds.

Turbidity is generally measured by using a turbidity meter. However, volunteer programs usually prefer to take samples to a lab for analysis. TSS can only be measured by laboratory analysis; therefore, a water sample is necessary. Water samples are collected from the deep part of the stream and submitted to a laboratory for analysis.

### *SAFETY CONSIDERATIONS FOR SAMPLING STREAMS*

The following are some basic common sense safety rules. At the site:

- Always monitor with at least one partner. Teams of three or four people are best. Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.

- Develop a safety plan. Find out the location and telephone number of the nearest telephone and write it down. Locate the nearest medical center and write down directions on how to get between the center and your site(s) so that you can direct emergency personnel. Have each member of the sampling team complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, epilepsy, etc.

- Have a first aid kit handy. Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings). It is best if at least one team member has first aid/CPR training.

- Listen to weather reports. Never go sampling if severe weather is predicted or if a storm occurs while at the site.

- Never wade in swift or high water. Do not monitor if the stream is at flood stage.

- If you drive, park in a safe location. Be sure your car doesn't pose a hazard to other drivers and that you don't block traffic.

- Put your wallet and keys in a safe place, such as a watertight bag you keep in a pouch strapped to your waist. Without proper precautions, wallet and keys might end up at the bottom of the lake or downstream.

- Never cross private property without the permission of the landowner. Better yet, sample only at public access points such as bridge or road crossings or public parks. Take along a card identifying you as a volunteer monitor.

- Watch for irate dogs, farm animals, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps. Know what to do if you get bitten or stung.

- Watch for poison ivy, poison oak, sumac, and other types of vegetation in your area that can cause rashes and irritation.

- Never drink the water from a lake or stream. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap.

- Do not monitor a lake or stream if posted as unsafe for body contact. If the water appears to be severely polluted, contact the LWWMD.

- Do not walk on unstable lake or stream banks. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb shoreline vegetation as little as possible.

- Be very careful when walking in the stream itself. Rocky-bottom streams can be very slippery and can contain deep pools; muddy-bottom streams might also prove treacherous in areas where mud, silt, or sand have accumulated in sink holes. If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck. Your partner(s) should wait on dry land ready to assist you if you fall. Do not attempt to cross streams that are swift and above the knee in depth. Wear waders and rubber gloves in streams suspected of having significant pollution problems.

- If you are sampling from a bridge, be wary of passing traffic. Never lean over bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds.

- If at any time you feel uncomfortable about the condition of the stream or your surroundings, stop monitoring and leave the site at once. Your safety is more important than the data!

# APPENDICES

# CONVERSION CHARTS

| Conversion of Feet to Meters | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Feet** | **Meters** | **Feet** | **Meters** | **Feet** | **Meters** | **Feet** | **Meters** |
| **1** | 0.30 | **26** | 7.92 | **51** | 15.54 | **76** | 23.16 |
| **2** | 0.61 | **27** | 8.23 | **52** | 15.85 | **77** | 23.47 |
| **3** | 0.91 | **28** | 8.53 | **53** | 16.15 | **78** | 23.77 |
| **4** | 1.22 | **29** | 8.84 | **54** | 16.46 | **79** | 24.08 |
| **5** | 1.52 | **30** | 9.14 | **55** | 16.76 | **80** | 24.38 |
| **6** | 1.83 | **31** | 9.45 | **56** | 17.07 | **81** | 24.69 |
| **7** | 2.13 | **32** | 9.75 | **57** | 17.37 | **82** | 24.99 |
| **8** | 2.44 | **33** | 10.06 | **58** | 17.68 | **83** | 25.30 |
| **9** | 2.74 | **34** | 10.36 | **59** | 17.98 | **84** | 25.60 |
| **10** | 3.05 | **35** | 10.67 | **60** | 18.29 | **85** | 25.91 |
| **11** | 3.35 | **36** | 10.97 | **61** | 18.59 | **86** | 26.21 |
| **12** | 3.66 | **37** | 11.28 | **62** | 18.90 | **87** | 26.52 |
| **13** | 3.96 | **38** | 11.58 | **63** | 19.20 | **88** | 26.82 |
| **14** | 4.27 | **39** | 11.89 | **64** | 19.51 | **89** | 27.13 |
| **15** | 4.57 | **40** | 12.19 | **65** | 19.81 | **90** | 27.43 |
| **16** | 4.88 | **41** | 12.50 | **66** | 20.12 | **91** | 27.74 |
| **17** | 5.18 | **42** | 12.80 | **67** | 20.42 | **92** | 28.04 |
| **18** | 5.49 | **43** | 13.11 | **68** | 20.73 | **93** | 28.35 |
| **19** | 5.79 | **44** | 13.41 | **69** | 21.03 | **94** | 28.65 |
| **20** | 6.10 | **45** | 13.72 | **70** | 21.34 | **95** | 28.96 |
| **21** | 6.40 | **46** | 14.02 | **71** | 21.64 | **96** | 29.26 |
| **22** | 6.71 | **47** | 14.33 | **72** | 21.95 | **97** | 29.57 |
| **23** | 7.01 | **48** | 14.63 | **73** | 22.25 | **98** | 29.87 |
| **24** | 7.32 | **49** | 14.94 | **74** | 22.56 | **99** | 30.18 |
| **25** | 7.62 | **50** | 15.24 | **75** | 22.86 | **100** | 30.48 |

| Conversion of Meters to Feet | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Meters** | **Feet** | **Meters** | **Feet** | **Meters** | **Feet** | **Meters** | **Feet** |
| **1.0** | 3.28 | **9.0** | 29.53 | **17.0** | 55.77 | **25.0** | 82.02 |
| **1.2** | 3.94 | **9.2** | 30.18 | **17.2** | 56.43 | **25.2** | 82.68 |
| **1.4** | 4.59 | **9.4** | 30.84 | **17.4** | 57.09 | **25.4** | 83.33 |
| **1.6** | 5.25 | **9.6** | 31.50 | **17.6** | 57.74 | **25.6** | 83.99 |
| **1.8** | 5.91 | **9.8** | 32.15 | **17.8** | 58.40 | **25.8** | 84.65 |
| **2.0** | 6.56 | **10.0** | 32.81 | **18.0** | 59.06 | **26.0** | 85.30 |
| **2.2** | 7.22 | **10.2** | 33.46 | **18.2** | 59.71 | **26.2** | 85.96 |
| **2.4** | 7.87 | **10.4** | 34.12 | **18.4** | 60.37 | **26.4** | 86.61 |
| **2.6** | 8.53 | **10.6** | 34.78 | **18.6** | 61.02 | **26.6** | 87.27 |
| **2.8** | 9.19 | **10.8** | 35.43 | **18.8** | 61.68 | **26.8** | 87.93 |
| **3.0** | 9.84 | **11.0** | 36.09 | **19.0** | 62.34 | **27.0** | 88.58 |
| **3.2** | 10.50 | **11.2** | 36.75 | **19.2** | 62.99 | **27.2** | 89.24 |
| **3.4** | 11.15 | **11.4** | 37.40 | **19.4** | 63.65 | **27.4** | 89.90 |
| **3.6** | 11.81 | **11.6** | 38.06 | **19.6** | 64.30 | **27.6** | 90.55 |
| **3.8** | 12.47 | **11.8** | 38.71 | **19.8** | 64.96 | **27.8** | 91.21 |
| **4.0** | 13.12 | **12.0** | 39.37 | **20.0** | 65.62 | **28.0** | 91.86 |
| **4.2** | 13.78 | **12.2** | 40.03 | **20.2** | 66.27 | **28.2** | 92.52 |
| **4.4** | 14.44 | **12.4** | 40.68 | **20.4** | 66.93 | **28.4** | 93.18 |
| **4.6** | 15.09 | **12.6** | 41.34 | **20.6** | 67.59 | **28.6** | 93.83 |
| **4.8** | 15.75 | **12.8** | 41.99 | **20.8** | 68.24 | **28.8** | 94.49 |
| **5.0** | 16.40 | **13.0** | 42.65 | **21.0** | 68.90 | **29.0** | 95.14 |
| **5.2** | 17.06 | **13.2** | 43.31 | **21.2** | 69.55 | **29.2** | 95.80 |
| **5.4** | 17.72 | **13.4** | 43.96 | **21.4** | 70.21 | **29.4** | 96.46 |
| **5.6** | 18.37 | **13.6** | 44.62 | **21.6** | 70.87 | **29.6** | 97.11 |
| **5.8** | 19.03 | **13.8** | 45.28 | **21.8** | 71.52 | **29.8** | 97.77 |
| **6.0** | 19.69 | **14.0** | 45.93 | **22.0** | 72.18 | **30.0** | 98.43 |
| **6.2** | 20.34 | **14.2** | 46.59 | **22.2** | 72.83 | **30.2** | 99.08 |
| **6.4** | 21.00 | **14.4** | 47.24 | **22.4** | 73.49 | **30.4** | 99.74 |
| **6.6** | 21.65 | **14.6** | 47.90 | **22.6** | 74.15 | **30.6** | 100.39 |
| **6.8** | 22.31 | **14.8** | 48.56 | **22.8** | 74.80 | **30.8** | 101.05 |

## Conversion of Temperature in °C to °F

| °C | °F | °C | °F | °C | °F | °C | °F |
|---|---|---|---|---|---|---|---|
| **0.0** | 32.0 | **7.0** | 44.6 | **14.0** | 57.2 | **21.0** | 69.8 |
| **0.5** | 32.9 | **7.5** | 45.5 | **14.5** | 58.1 | **21.5** | 70.7 |
| **1.0** | 33.8 | **8.0** | 46.4 | **15.0** | 59.0 | **22.0** | 71.6 |
| **1.5** | 34.7 | **8.5** | 47.3 | **15.5** | 59.9 | **22.5** | 72.5 |
| **2.0** | 35.6 | **9.0** | 48.2 | **16.0** | 60.8 | **23.0** | 73.4 |
| **2.5** | 36.5 | **9.5** | 49.1 | **16.5** | 61.7 | **23.5** | 74.3 |
| **3.0** | 37.4 | **10.0** | 50.0 | **17.0** | 62.6 | **24.0** | 75.2 |
| **3.5** | 38.3 | **10.5** | 50.9 | **17.5** | 63.5 | **24.5** | 76.1 |
| **4.0** | 39.2 | **11.0** | 51.8 | **18.0** | 64.4 | **25.0** | 77.0 |
| **4.5** | 40.1 | **11.5** | 52.7 | **18.5** | 65.3 | **25.5** | 77.9 |
| **5.0** | 41.0 | **12.0** | 53.6 | **19.0** | 66.2 | **26.0** | 78.8 |
| **5.5** | 41.9 | **12.5** | 54.5 | **19.5** | 67.1 | **26.5** | 79.7 |
| **6.0** | 42.8 | **13.0** | 55.4 | **20.0** | 68.0 | **27.0** | 80.6 |
| **6.5** | 43.7 | **13.5** | 56.3 | **20.5** | 68.9 | **27.5** | 81.5 |

## Conversion of Temperature in °F to °C

| °F | °C | °F | °C | °F | °C | °F | °C | °F | °C |
|---|---|---|---|---|---|---|---|---|---|
| **32.0** | 0.0 | **43.0** | 6.1 | **54.0** | 12.2 | **65.0** | 18.3 | **76.0** | 24.4 |
| **32.5** | 0.3 | **43.5** | 6.4 | **54.5** | 12.5 | **65.5** | 18.6 | **76.5** | 24.7 |
| **33.0** | 0.6 | **44.0** | 6.7 | **55.0** | 12.8 | **66.0** | 18.9 | **77.0** | 25.0 |
| **33.5** | 0.8 | **44.5** | 6.9 | **55.5** | 13.1 | **66.5** | 19.2 | **77.5** | 25.3 |
| **34.0** | 1.1 | **45.0** | 7.2 | **56.0** | 13.3 | **67.0** | 19.4 | **78.0** | 25.6 |
| **34.5** | 1.4 | **45.5** | 7.5 | **56.5** | 13.6 | **67.5** | 19.7 | **78.5** | 25.8 |
| **35.0** | 1.7 | **46.0** | 7.8 | **57.0** | 13.9 | **68.0** | 20.0 | **79.0** | 26.1 |
| **35.5** | 1.9 | **46.5** | 8.1 | **57.5** | 14.2 | **68.5** | 20.3 | **79.5** | 26.4 |
| **36.0** | 2.2 | **47.0** | 8.3 | **58.0** | 14.4 | **69.0** | 20.6 | **80.0** | 26.7 |
| **36.5** | 2.5 | **47.5** | 8.6 | **58.5** | 14.7 | **69.5** | 20.8 | **80.5** | 26.9 |
| **37.0** | 2.8 | **48.0** | 8.9 | **59.0** | 15.0 | **70.0** | 21.1 | **81.0** | 27.2 |
| **37.5** | 3.1 | **48.5** | 9.2 | **59.5** | 15.3 | **70.5** | 21.4 | **81.5** | 27.5 |
| **38.0** | 3.3 | **49.0** | 9.4 | **60.0** | 15.6 | **71.0** | 21.7 | **82.0** | 27.8 |
| **38.5** | 3.6 | **49.5** | 9.7 | **60.5** | 15.8 | **71.5** | 21.9 | **82.5** | 28.1 |
| **39.0** | 3.9 | **50.0** | 10.0 | **61.0** | 16.1 | **72.0** | 22.2 | **83.0** | 28.3 |
| **39.5** | 4.2 | **50.5** | 10.3 | **61.5** | 16.4 | **72.5** | 22.5 | **83.5** | 28.6 |
| **40.0** | 4.4 | **51.0** | 10.6 | **62.0** | 16.7 | **73.0** | 22.8 | **84.0** | 28.9 |
| **40.5** | 4.7 | **51.5** | 10.8 | **62.5** | 16.9 | **73.5** | 23.1 | **84.5** | 29.2 |
| **41.0** | 5.0 | **52.0** | 11.1 | **63.0** | 17.2 | **74.0** | 23.3 | **85.0** | 29.4 |
| **41.5** | 5.3 | **52.5** | 11.4 | **63.5** | 17.5 | **74.5** | 23.6 | **85.5** | 29.7 |
| **42.0** | 5.6 | **53.0** | 11.7 | **64.0** | 17.8 | **75.0** | 23.9 | **86.0** | 30.0 |
| **42.5** | 5.8 | **53.5** | 11.9 | **64.5** | 18.1 | **75.5** | 24.2 | **86.5** | 30.3 |

# Glossary of Lake and Watershed Terms

# GLOSSARY OF LAKE AND WATERSHED TERMS

**Acid neutralizing capacity (ANC)**: the equivalent capacity of a solution to neutralize strong acids. The components of ANC include weak bases (carbonate species, dissociated organic acids, alumino-hydroxides, borates, and silicates) and strong bases (primarily, OH-). In the National Surface Water Survey, as well as in most other recent studies of acid-base chemistry of surface waters, ANC was measured by the Gran titration procedure.

**Acidic deposition**: transfer of acids and acidifying compounds from the atmosphere to terrestrial and aquatic environments via rain, snow, sleet, hail, cloud droplets, particles, and gas exchange.

**Adsorption**: The adhesion of one substance to the surface of another: clays, for example, can adsorb phosphorus and organic molecules

**Aerobic**: Describes life or processes that require the presence of molecular oxygen.

**Algae**: Small aquatic plants that occur as single cells, colonies, or filaments. Planktonic algae float freely in the open water. Filamentous algae form long threads and are often seen as mats on the surface in shallow areas of the lake.

**Alkalinity**: (see *acid neutralizing capacity*).

**Allochthonous**: Materials (e.g., organic matter and sediment) that enter a lake from atmosphere or drainage basin (see *autochthonous*).

**Anaerobic**: Describes processes that occur in the absence of molecular oxygen.

**Anoxia**: A condition of no oxygen in the water. Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

**Anoxic**: "Without oxygen." (see *anoxia*).

**Autochthonous**: Materials produced within a lake e.g., autochthonous organic matter from plankton versus allochthonous organic matter from terrestrial vegetation.

**Bathymetric map**: A map showing the bottom contours and depth of a lake; can be used to calculate lake volume.

**Benthic**: Macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate. Also referred to as *benthos*.

**Biochemical oxygen demand (BOD)**: The rate of oxygen consumption by organisms during the decomposition (respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

**Biomass**: The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

**Biota**: All plant and animal species occurring in a specified area.

**Chemical oxygen demand (COD)**: Non-biological uptake of molecular oxygen by organic and inorganic compounds in water.

**Chlorophyll**: A green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide and water to sugar (photosynthesis). Sugar is then converted to starch, proteins, fats and other organic molecules.

**Chlorophyll** a: A type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.

**Cluster development**: Placement of housing and other buildings of a development in groups to provide larger areas of open space

**Consumers**: Animals that cannot produce their own food through photosynthesis and must consume plants or animals for energy (see *producers*).

adapted from: *The Lake and Reservoir Restoration Guidance Manual* (US EPA 1990)

**Decomposition**: The transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

**Delphi**: A technique that solicits potential solutions to a problem situation from a group of experts and then asks the experts to rank the full list of alternatives.

**Density flows**: A flow of water of one density (determined by temperature or salinity) over or under water of another density (e.g. flow of cold river water under warm reservoir surface water).

**Detritus**: Non-living dissolved and particulate organic material from the metabolic activities and deaths of terrestrial and aquatic organisms.

**Drainage basin**: Land area from which water flows into a stream or lake (see *watershed*).

**Drainage lakes**: Lakes having a defined surface inlet and outlet.

**Ecology**: Scientific study of relationships between organisms and their environment: also defined as the study of the structure and function of nature.

**Ecosystem**: A system of interrelated organisms and their physical-chemical environment. In limnology, the ecosystem is usually considered to include the lake and its watershed.

**Effluent**: Liquid wastes from sewage treatment, septic systems or industrial sources that are released to a surface water.

**Environment**: Collectively, the surrounding conditions, influences and living and inert matter that affect a particular organism or biological community.

**Epilimnion**: Uppermost, warmest, well-mixed layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline.

**Erosion**: Breakdown and movement of land surface which is often intensified by human disturbances.

**Eutrophic**: From Greek for well-nourished; describes a lake of high photosynthetic activity and low transparency.

**Eutrophication**: The process of physical, chemical, and biological changes associated with nutrients, organic matter, silt enrichment, and sedimentation of a lake or reservoir. If the process is accelerated by man-made influences it is termed cultural eutrophication.

**Fall overturn**: The autumn mixing, top to bottom, of lake water caused by cooling and wind-derived energy.

**Fecal coliform test**: Most common test for the presence of fecal material from warm-blooded animals. Fecal coliforms are measured because of convenience; they are not necessarily harmful but indicate the potential presence of other disease-causing organisms.

**Floodplain**: Land adjacent to lakes or rivers that is covered as water levels rise and overflow the normal water channels.

**Flushing rate**: The rate at which water enters and leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water.

**Flux**: The rate at which a measurable amount of a material flows past a designated point in a given amount of time.

**Food chain**: The general progression of feeding levels from primary producers, to herbivores, to planktivores, to the larger predators.

**Food web**: The complex of feeding interactions existing among the lake's organisms.

**Forage fish**: Fish, including a variety of panfish and minnows, that are prey for game fish.

**Groundwater**: Water found beneath the soil surface; saturates the stratum at which it is located; often connected to lakes.

**Hard water**: Water with relatively high levels of dissolved minerals such as calcium, iron, and magnesium.

**Hydrographic map**: A map showing the location of areas or objects within a lake.

adapted from: *The Lake and Reservoir Restoration Guidance Manual* (US EPA 1990)

**Hydrologic cycle**: The circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Runoff, surface water, groundwater, and water infiltrated in soils are all part of the hydrologic cycle.

**Hypolimnion**: Lower, cooler layer of a lake during summertime thermal stratification.

**Hypoxia**: A condition of low oxygen in the water (< 2.0 mg/L). Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

**Influent**: A tributary stream.

**Internal nutrient cycling**: Transformation of nutrients such as nitrogen or phosphorus from biological to inorganic forms through decomposition, occurring within the lake itself. Also refers to the release of sediment-bound nutrients into the overlying water that typically occurs within the anoxic hypolimnion of stratified, mesotrophic and eutrophic lakes.

**Isothermal**: The same temperature throughout the water column of a lake.

**Lake**: A considerable inland body of standing water, either naturally formed or manmade.

**Lake district**: A special purpose unit of government with authority to manage a lake(s) and with financial powers to raise funds through mill levy, user charge, special assessment, bonding, and borrowing. May or may not have police power to inspect septic systems, regulate surface water use, or zone land.

**Lake management**: The practice of keeping lake quality in a state such that attainable uses can be achieved and maintained.

**Lake protection**: The act of preventing degradation or deterioration of attainable lake uses.

**Lake restoration**: The act of bringing a lake back to its attainable uses.

**Lentic**: Relating to standing water (versus lotic, running water).

**Limnologist**: One who studies limnology.

**Limnology**: Scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes. Also termed freshwater ecology.

**Littoral zone**: That portion of a waterbody extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

**Loading**: The total amount of material (sediment, nutrients, oxygen-demanding material) brought into the lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time (often annually).

**Macroinvertebrates**: Aquatic insects, worms, clams, snails, and other animals visible without the aid of a microscope, that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

**Macrophytes**: Rooted and floating aquatic plants, commonly referred to as waterweeds. These plants may flower and bear seed. Some forms, such as duckweed and coontail (*Ceratophyllum*), are free-floating forms without roots in the sediment.

**Mandatory property owners association**: Organization of property owners in a subdivision or development with membership and annual fee required by covenants on the property deed. The association will often enforce deed restrictions on members' property and may have common facilities such as bathhouse, clubhouse, golf course, etc.

**Marginal zone**: Area where land and water meet at the perimeter of a lake. Includes plant species, insects and animals that thrive in this narrow, specialized ecological system.

**Mesotrophic**: Describes a lake of moderate plant productivity and transparency; a trophic state between oligotrophic and eutrophic.

**Metalimnion**: Layer of rapid temperature and density change in a thermally stratified lake. Resistance to mixing is high in this region.

**Morphometry**: Relating to a lake's physical structure (e.g., depth, shoreline length).

adapted from: *The Lake and Reservoir Restoration Guidance Manual* (US EPA 1990)

**Nekton**: Large aquatic organisms whose mobility is not determined by water movement -- for example, fish and amphibians.

**Nominal group process**: A process of soliciting concerns/issues/ideas from members of a group and ranking the resulting list to ascertain group priorities. Designed to neutralize dominant personalities.

**Nutrient**: An element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

**Nutrient budget**: Quantitative assessment of nutrients (e.g., nitrogen or phosphorus) moving into, being retained in, and moving out of an ecosystem; commonly constructed for phosphorus because of its tendency to control lake trophic state.

**Nutrient cycling**: The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

**Oligotrophic**: "Poorly nourished," from the Greek. Describes a lake of low plant productivity and high transparency.

**Ooze**: Lake bottom accumulation of inorganic sediments and the partially decomposed remains of algae, weeds, fish, and aquatic insects. Sometimes called muck (see *sediment*).

**Ordinary high water mark**: Physical demarcation line, indicating the highest point that water level reaches and maintains for some time. Line is visible on rocks, or shoreline, and by the location of certain types of vegetation.

**Organic matter**: Molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

**Paleolimnology**: The study of the fossil record within lake sediments.

**Pathogen**: A microorganism capable of producing disease. They are of great concern to human health relative to drinking water and swimming beaches.

**Pelagic zone**: This is the open area of a lake, from the edge of the littoral zone to the center of the lake.

**Perched**: A condition where the lake water is isolated from the groundwater table by impermeable material such as clay.

**pH**: A measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic, and most life forms can not survive at pH of 4.0 or lower.

**Photic zone**: The lighted region of a lake where photosynthesis takes place. Extends down to a depth where plant growth and respiration are balanced by the amount of light available.

**Phytoplankton**: Microscopic algae and microbes that float freely in open water of lakes and oceans.

**Plankton**: Microscopic plants, microbes and animals floating or swimmng freely about in lakes and oceans.

**Primary productivity**: The rate at which algae and macrophytes fix or convert light, water and carbon dioxide to sugar in plant cells (through photosynthesis). Commonly measured as milligrams of carbon per square meter per hour.

**Primary producers**: Green plants that manufacture their own food through photosynthesis.

**Profundal zone**: Area of lake water and sediment occurring on the lake bottom below the depth of light penetration.

**Reservoir**: A manmade lake where water is collected and kept in quantity for a variety of uses, including flood control, water supply, recreation and hydroelectric power.

**Residence time**: Commonly called the hydraulic residence time -- the amount of time required to completely replace the lake's current volume of water with an equal volume of new water.

**Respiration**: Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

adapted from: *The Lake and Reservoir Restoration Guidance Manual* (US EPA 1990)

**Secchi depth**: A measure of transparency of water obtained by lowering a black and white, or all white, disk (Secchi disk, 20 cm in diameter) into water until it is no longer visible. Measured in units of meters or feet.

**Sediment**: Bottom material in a lake that has been deposited after the formation of a lake basin. It originates from remains of aquatic organisms, chemical precipitation of dissolved minerals, and erosion of surrounding lands (see *ooze* and *detritus*).

**Seepage lakes**: Lakes having either an inlet or outlet (but not both) and generally obtaining their water from groundwater and rain or snow.

**Soil retention capacity**: The ability of a given soil type to adsorb substances such as phosphorus, thus retarding their movement to the water.

**Stratification**: Layering of water caused by differences in water density. Thermal stratification is typical of most deep lakes during summer. Chemical stratification can also occur.

**Swimmers itch**: A rash caused by penetration into the skin of the immature stage (cercaria) of a flatworm (not easily controlled due to complex life cycle). A shower or alcohol rubdown should minimize penetration.

**Thermal stratification**: Lake stratification caused by temperature-created differences in water density.

**Thermocline**: A horizontal plane across a lake at the depth of the most rapid vertical change in temperature and density in a stratified lake (see *metalimnion*.).

**Topographic map**: A map showing the elevation of the landscape at specified contour intervals (typically 10 or 20 foot intervals, may be expressed in feet or meters). Can be used to delineate the watershed.

**Trophic state**: The degree of eutrophication of a lake. Transparency, chlorophyll a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can be used to assess state.

**Voluntary lake property owners association**: Organization of property owners in an area around a lake that members join at their option.

**Water column**: Water in the lake between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize lake water.

**Water table**: The upper surface of groundwater; below this point, the soil is saturated with water.

**Watershed**: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

**Zooplankton**: Microscopic animals that float or swim freely in lake water, graze on detritus particles, bacteria, and algae, and may be consumed by fish.

adapted from: *The Lake and Reservoir Restoration Guidance Manual* (US EPA 1990)

# GLOSSARY OF WATER QUALITY PARAMETERS

**pH**: The pH level is a measure of acidity (concentration of hydrogen ions in water), reported in standard units on a logarithmic scale that ranges from one to fourteen. On the pH scale, seven is neutral, lower numbers are more acid, and higher numbers are more basic. In general, pH values between 6.0 and 8.0 are considered optimal for the maintenance of a healthy lake ecosystem. Many species of fish and amphibians have difficulty with growth and reproduction when pH levels fall below 5.5 standard units. Lake acidification status can be assessed from pH as follows:

| | |
|---|---|
| less than 5.0 | Critical (impaired) |
| between 5.0 and 6.0 | Endangered (threatened) |
| greater than 6.0 | Satisfactory (acceptable) |

**Alkalinity**: Alkalinity (or acid neutralizing capacity) is a measure of the water's buffering capacity, the ability of a lake to absorb or withstand acidic inputs. In the northeast, most lakes have low alkalinities, which means they are sensitive to the effects of acidic precipitation. This is a particular concern during the spring when large amounts of low pH snowmelt runs into lakes with little or no contact with the soil's natural buffering agents. Alkalinity is reported in milligrams per liter (mg/L) or microequivelents per liter (µeq/L). Typical summer concentrations of alkalinity in northeastern lakes are around 10 mg/L (200 µeq/L). Lake acidification status can be assessed from alkalinity as follows:

| | |
|---|---|
| less than 0 mg/L | acidified |
| between 0 and 2 mg/L | extremely sensitive |
| between 2 and 10 mg/L | moderately sensitive |
| between 10 and 25 mg/L | low sensitivity |
| greater than 25 mg/L | not sensitive |

**Conductivity**: Conductivity is a measure of the ability of water to conduct electric current, which is related to the amount of dissolved ions within the water. Higher conductivity values are indicative of pollution by road salt or septic systems and more eutrophic conditions in a lake. Conductivities may be naturally high in water that drains from bogs and marshes. Clean, clear-water lakes in our region typically have conductivities of around 10 - 30 micro-mhos per centimeter (µmhos/cm), and eutrophic lakes have conductivities near 100 µmhos/cm.

**Color**: The color of water is affected by both dissolved (e.g., metallic ions, organic acids) and suspended (e.g., silt and plant pigments) materials. The degree of coloration is assessed by comparing the samples to standardized chloroplatinate solutions. The measurement of color is usually used in lake classification to describe the degree to which the water body is stained due to the accumulation of organic acids. Dystrophic lakes (heavily stained - with a tea-like appearance) are common in this part of the country and often have a tea-like appearance. They are usually found in areas with poorly drained soils and large amounts of coniferous vegetation (i.e. pines). Color can be used as a possible index of organic acid content since higher amounts of total organic carbon (TOC) are usually found in colored waters. The importance of TOC is that it can complex (bond with or tie up) aluminum in water, thus mitigating toxicity to fish.

**Phosphorus**: Phosphorus is one of the three main nutrients of life, along with nitrogen and carbon. In the northeast, phosphorus is the nutrient that most often controls productivity of lake systems. Total phosphorus is a measure of all forms of phosphorus, both organic and inorganic. Total phosphorus concentrations are directly related to the trophic condition (water quality status) of a lake. Excessive amounts of phosphorus lead to algae blooms and loss of oxygen in lakes. Epilimnetic (surface water) total phosphorus concentrations less than 10 micrograms per liter (µg/L) are associated with oligotrophic (clean, clear water) conditions and concentrations greater than 25 µg/L are associated with eutrophic (nutrient-rich) conditions.

**Chlorophyll a**: Chlorophyll a is the green pigment in plants used for photosynthesis, and measuring it provides information on the amount of algae (microscopic plants) in lakes. Chlorophyll a concentrations can also be used to classify lake trophic state. Chlorophyll a concentrations less than 2 micrograms per liter (µg/L) are associated with oligotrophic conditions, while concentrations greater than 8 µg/L are associated with eutrophic conditions.

**Transparency**: Transparency is a measure of water clarity in lakes and ponds. It is determined by lowering a 20 cm black and white disk (Secchi disk) into a lake to the depth where it is no longer visible from the surface. Since algae are the main determinant of water clarity in non-stained lakes that lack excessive amounts of inorganic turbidity (suspended silt), transparency is used as an indicator of lake trophic state. Transparencies greater than 4.6 meters (15.1 feet) are associated with oligotrophic conditions, while transparencies less than 2 meters (6.6 feet) are associated with eutrophic conditions (DEC & FOLA 1990).

**Calcium**: Calcium is one of the buffering materials that occurs naturally. It is often in short supply in Adirondack lakes and ponds, making these bodies of water susceptible to acidification by acid precipitation. A measure of the amount of calcium in a lake provides additional information on the buffering capacity of that lake, and can assist in determining the timing and dosage for acid mitigation (liming) activities. Adirondack lakes containing less than 2.5 mg/L of calcium are considered to be sensitive to acidification.

**Calcite Saturation Index**: The calcite saturation index (CSI) is another method to determine the sensitivity of a lake to acidification. Higher CSI values indicate increasing sensitivity to acid inputs. CSI is calculated using the following formula:

CSI = - log SUB 10 Ca OVER 40000 - log SUB 10 Alkalinity OVER 50000 - pH + 2

Lake acidification status can be assessed from CSI as follows:

no calculation possible due to negative alkalinity (nc)
 extremely vulnerable/acidified
greater than 4
 very vulnerable to acid deposition
between 3 and 4
 moderately vulnerable to acid deposition
less than 3
 low vulnerability to acid deposition

**Nitrate**: Nitrogen is one of the three main nutrients of life, along with phosphorus and carbon. Nitrate is an inorganic form of nitrogen that occurs naturally. It is a component of atmospheric pollution and elevated concentrations in lakes and ponds may be associated with acidification. Elevated concentrations of nitrate may also be indicative of wastewater pollution.

**Chloride**: Chloride is an anion that occurs naturally in surface waters, though typically in low concentrations. Background concentrations of chloride in Adirondack lakes is less than 1 mg/L. The primary sources of additional chloride in Adirondack lakes are road salt (winter road deicing) and wastewater (septic systems). Increasing concentrations of chloride can alter the distribution and abundance of aquatic plant and animal species. As chloride concentration increases in a lake, the actual number of species present (biodiversity) is reduced. Seawater has a chloride concentration of 19,000 mg/L (35% salinity). Roughly half of all freshwater species are eliminated at chloride concentrations of approximately 1400 mg/L (2.5 % salinity) and all freshwater species are eliminated at around 5,400 mg/L (10% salinity). Even our most salt impacted waters have chloride concentrations of less than 100 mg/L (0.2 % salinity).

**Aluminum**: Aluminum is one of the most abundant elements found in the earth's crust. Acid rainwater leaches the aluminum from the soils, where it then may flow into nearby streams and lakes. If a lake becomes acidified, aluminum can also be leached from the sediments in the bottom of the lake. Low concentrations of aluminum can be toxic to fish in acidified water bodies, depending on the type of aluminum available, the pH, and the amount of dissolved organic carbon available to bind inorganic aluminum. Values are reported as mg/L of total dissolved aluminum.

**Temperature and Dissolved Oxygen**: The amount and distribution of dissolved oxygen in a lake ecosystem can affect the health of aquatic organisms and nutrient cycles. For normal growth and reproduction, adult warm water fish (i.e. bass and pike) require oxygen concentrations of at least 5.0 milligrams per liter (mg/L), and adult cold water fish (i.e. trout and salmon) require at least 6.5 mg/L of dissolved oxygen (US EPA 1986). Lakes receive most of their oxygen from the atmosphere through gas exchange at the surface. In deeper lakes that stratify, the cold bottom water (hypolimnion) is isolated from the oxygen entering the upper water (epilimnion). If the lake sediments are rich in organic matter, bacterial decomposition uses up the oxygen in the bottom waters and the hypolimnion becomes anoxic (without oxygen). If this occurs, cold water fish habitat is lost, and phosphorus within the sediments may be released into the overlying water.

# STREAM MONITORING PROTOCOLS

# DO METER OPERATING INSTRUCTIONS

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# Volunteer Monitoring Internet Resources

**Fortunately for the volunteer monitor, in this day and age there are many excellent resources for volunteer monitoring methods and interpretation available on the Internet. Listed below is just a small sample of some of the best sites to start out with. Most of the sites below include links to other reference materials.**

EPA Volunteer Monitoring Program http://www.epa.gov/owow/monitoring/vol.html
This site provides information and methods manuals for volunteer stream, lake, estuary, and wetland monitoring.

National Association of Lake Managers http://www.nalms.org/resource/lnkagenc/links.htm
This site has links to lake-related sites listed by state.

Izaac Walton League Save Our Streams Program http://www.iwla.org/sos/
This site provides information about volunteer stream monitoring methods and links to other programs.

EPA Biological Indicators http://www.epa.gov/bioindicators/html/invertebrate.html
This site provides information about how to use macroinvertebrates as indicators of stream health, and has excellent links to other biological monitoring keys.

New York Dept of Environmental Conservation Macroinvertebrate Key http://www.dec.state.ny.us/website/dow/stream/index.htm
This is an excellent site for basic macroinvertebrate identification. It has photographs to the family level for mayflies, stoneflies, and caddisflies.

Pennsylvania Citizens Volunteer Monitoring Program http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/cvmp/cvmp_hdbook.htm
This site provides a technical handbook for community-based monitoring in Pennsylvania.

Ohio State Measuring Watershed Quality http://tycho.cfm.ohio-state.edu/whyimp.html
This site provides instructions on quantifying the chemical and biological data that you may collect. It also provides a good resource for performing and interpreting the Qualitative Habitat Evaluation Index.

Hoosier Riverwatch Volunteer Stream Monitoring Program http://www.in.gov/dnr/soilcons/riverwatch/vsm/manual.html. This site has an excellent manual and set of printable data sheets for different stream monitoring parameters. It pertains to a specific program, but serves as a good model.

Volunteer Monitoring Groups On-Line http://www.state.ky.us/nrepc/water/vm.htm This site has many links to various volunteer monitoring groups on the federal, state, and local level.

# FORMS

# LWWMD Volunteer Lake Monitoring Workshop Notes