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Rhode Island

Volunteer Monitoring

Water Quality Protocol Manual

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December 1992

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PREFACE

Volunteer monitoring is a growing new endeavor both in Rhode Island and around the country. Citizens concerned with water quality in their community are finding that good information on the status of local water quality and the causes of water quality degradation are often not available from scientific research projects or government surveys. Therefore this information is being collected by the citizens themselves.

This manual is designed to give new volunteer monitoring programs in Rhode Island an introduction to water quality sampling methods used successfully by volunteer groups. Much of the information contained in this manual was taken from Rhode Island's Watershed Watch, Salt Pond Watchers, and River Rescue methods manuals. Volunteer groups using this manual will need to adapt the methods described in the manual to suit their specific waters and their program's specific goals. It is often useful to develop detailed step-by-step instructions for volunteers to follow, and these will have to be created by each program coordinator. Some example instructions are included in Appendix A.

The Water Quality Protocol Manual is one of a series of manuals designed to assist volunteers in Rhode Island. A *Shoreline Survey Manual for Lakes, Rivers and Streams* , is available from the College of Resource Development, Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881. *Standardized Biological Monitoring Manual for Citizens' Volunteer Monitoring Groups in Rhode Island* written by Dr. Mark Gould at Roger Williams College is available from the Rhode Island Department of Environmental Management, 291 Promenade St., Providence, RI 02908. A litter survey and cleanup manual is available from the Coastal Resources Center, URI, Narragansett, RI 02882. The Environmental Protection Agency has also produced national volunteer monitoring guidance that can be obtained by writing the Volunteer Monitoring Coordinator, US EPA Office of Water, 401 M.St. SW, Washington, DC 20460.

This Water Quality Protocol Manual is intended to be a living document, growing and changing with the experience of citizen groups who have used it. Your comments are welcome and will be incorporated into later editions.

ACKNOWLEDGMENTS

The growth of volunteer monitoring in Rhode Island has been greatly facilitated by the Rhode Island Department of Environmental Management's Volunteer Monitoring Coordinators: Bob Ballou and Maureen Raposa. We appreciate all the work they have done to coördinate and promote volunteer monitoring in the state.

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INTRODUCTION

Why Monitor?

Water quality monitoring can be defined as repetitive measurements or observations of a waterbody, recorded over time for the purpose of determining changes in water conditions. Since natural systems are variable and ever changing, it is very difficult to detect water quality changes caused by pollution. In most cases, one or two years of data will not show trends in water quality and will not pinpoint sources of pollution. Monitoring is a long term effort. Carefully obtained, quality assured, objective citizen monitoring is very valuable for developing information about a waterbody's baseline conditions. These data can then be used to identify trends and changes in the system's water quality. Just like the wise, elderly sage, the monitoring data will provide a record of the past. The difference is that adequately quality controlled monitoring will provide an objective measure of the past, not the subjective information provided by human memories that are often clouded by impressions.

An Introduction to Lakes, Rivers and Estuaries

In order to plan a monitoring program for your selected waterbody, it is important to understand a few basic concepts of hydrology. The hydrology of a waterbody explains where the water in your lake, river or estuary comes from, and where it goes when it flows out of the waterbody. It also helps you to anticipate how pollutants introduced to the waterbody will be dispersed within the system.

Water is introduced to lakes, rivers and estuaries from rainfall on the watershed surrounding the waterbody and from groundwater. The watershed is the portion of the land area surrounding the waterbody that drains toward the waterbody. A watershed usually consists of a network of streams, intermittent drainage ways, ponds, wetlands, storm drains and man-made channels and the surrounding upland. At any point in the watershed, precipitation falling on the land surface will follow the slope, or topography, of the land area and collect in these natural and man-made drainage pathways. Some precipitation seeps into the ground where it moves through the soil. Water in soil can replenish groundwater aquifers, or can move laterally toward a nearby surface water feature. Pollution introduced to surface waters or goundwater anywhere in the watershed of a lake, river or estuary can potentially impact water quality. Therefore, any monitoring study should start with an understanding of the physical boundaries of the system's watershed.

Streams and rivers are the arteries of a watershed. Streams carry fresh water in defined channels from upland areas to the bottom of the watershed. The water in streams and rivers flows in one direction, and the volume of water carried by a river generally increases with movement down the watershed.* Pollution introduced to a river or stream will be carried downstream with the flow of the water. Pollutant concentrations will be decreased by dilution and degradation and can be increased by pollutant inputs from the air, land, tributaries or bottom sediments.

The water in rivers and streams is generally well mixed vertically (from top to bottom) and laterally (from side to side). However, water introduced to a river from a discharge or a tributary will need some time (in rivers, time is the same as distance downstream) to mix

* Some rivers can lose significant amounts of water to the ground, and actually have reduced flows with movement downstream. Irrigation and industrial water uses can also remove water from a stream or river.

with the stream's main flow. Stations selected to assess the impact of an input to a stream should be sited far enough downstream to allow complete mixing throughout the water column. Once the river is thoroughly mixed, monitoring samples taken from the surface at mid-stream are generally representative of the river at the selected station.

Lakes, ponds and reservoirs are standing bodies of fresh water. Lakes and ponds are naturally occurring waterbodies, with the water filling a depression in the earth's topography. Reservoirs are man-made lakes formed by the damming of a stream or river. Water in lakes comes from tributary streams and rivers, or from groundwater. Most lakes have defined outlets, although some lakes are free standing, at equilibrium with rainfall inputs and inflow and outflow to groundwater.

The water in lakes is usually not evenly mixed. Currents through the lake, wind patterns on the surface of the lake and sources of pollution from tributaries and near shore activities will affect the distribution of pollutants in a lake. Lakes also often display patterns of vertical stratification, or layering of the water. This layering occurs because of temperature differences and therefore density differences in water at various depths in the lake. Most lakes display seasonal stratification. During the spring and fall, water temperatures are uniform from top to bottom and circulation occurs throughout the entire lake. In the early summer, the sun warms the surface water, and this warmer, lighter water "floats" on top of the cooler, more dense deeper water. As the summer progresses and the temperature extremes grow, the top and bottom layers of most lakes become separate, distinct bodies of water with no opportunity for mixing between them. Oxygen levels can become depleted in the bottom layer. In the fall, the top waters cool, until they can again mix with the bottom water. This mixing is interrupted in the winter when the lake becomes ice covered.

Pollutants discharged to lakes will disperse into the water. Monitoring programs designed to assess pollutant dispersal will require a grid of stations emanating out from the point of discharge. Monitoring to assess the overall quality of a lake can often be performed at one or two sites in the main body (deepest portions) of the lake. Samples should be collected from both the surface and the deep water in lakes that are stratified. Reservoirs will often have complex shorelines and multiple basins. Monitoring programs should try to include all the major basins of the reservoir.

Estuaries are semi-enclosed bodies of water found between freshwater rivers and the saline ocean. Estuarine hydrology is more complex than that of rivers and lakes. Estuaries are subject to both freshwater flows and the tidal cycles of the ocean. Freshwater is less dense than saltwater, and it will float on top of the ocean water. This forms vertical water layers similar to those found in stratified lakes. The exact nature of the layering will depend on the relation between the freshwater flow and the tidal currents and the shape and size of the estuary.

Estuarine waters are influenced by tidal cycles. Pollutants discharged to an estuary will move up the estuary with the incoming tide and then back down the estuary with the outgoing tide. The net movement of the pollutants out of the estuary will be determined by the freshwater flow entering the estuary and the rate of dispersion of the pollutants in the estuarine waters. Monitoring programs in estuaries should be designed to evaluate conditions both above and below a suspected site of discharge.

Setting Goals

Before beginning any monitoring program, it is essential that the goals, objectives and uses of the collected data be carefully defined. **What** you choose to monitor, **where** you select monitoring sites and **when** you perform your monitoring study will be determined by the

goals and objectives of the project. The following questions should help with goal definition.

1. **Why** do you want to monitor? Why are you concerned about the waterbody?

2. **What do you plan to achieve?** When you are finished with your monitoring program, what will the outcomes be? What will you do with your collected data?

3. **What data do you need to collect to answer your questions?** Your monitoring program should be focused on the issues and questions you are trying to understand.

4. **Who are the data users and how will they be using the data?**

5. **How long will the program continue?** Is this a long term project or a more intensive, short term project?

6. **What time commitment can your volunteers contribute to the project?** How long can they spend monitoring each month? How frequently will they be asked to sample? Will they be asked to sample on a specific day, or will they be given a choice?

Site Selection

The goals and resources of a monitoring program will determine the choice of sampling stations. The following pointers will help as you narrow down your selection of sites:

1. Start small. If your program is just starting out, start with only a couple of stations that are easily within the reach of your volunteer work force and your available resources. This will allow you to work the bugs out of your sampling methodology. Try to find sites that will give you water quality information for a larger area of interest.

2. If you are concerned about a specific pollution problem, be sure to sample a background, "control" site upstream of the pollution problem as well as sites impacted by the pollution. In tidal rivers and marine areas, remember that water moves <u>up</u> as well as down the estuary with each tidal cycle. Your unimpacted site will need to be above the zone of influence of the pollution source. Three sites, one above the source, one near the source and one downstream of the source, should be sufficient to characterize most point source or localized nonpoint source problems. However, be aware that sites you select as "unimpacted" may have other sources of pollution affecting them. It is often wise to do a quick sampling study of your selected sites to be sure that they are representing the conditions you want.

3. Select stations that are safe and easy to reach. If potential sites are on private property, you **must** receive permission from the landowner. Trespassing is illegal.

Each type of waterbody requires unique considerations when planning your sampling study. Listed below are a few things to keep in mind:

1. **Rivers or streams** should be sampled from the main channel. It is often convenient to sample from bridge crossings. Always sample on the **upstream** side of the bridge to avoid runoff from the road surface. If you are sampling a single station on a river in order to assess the quality of the entire watershed, select a site near the river's mouth.

2. **Estuaries and marine waters** are strongly influenced by the tide, so be sure to note the tidal cycle on your data sheet. It is important to know if the tide is coming in (ebbing) or going out (flowing) and if it is near high or low tide. Monitoring programs designed to identify land based pollution in coastal area should sample on an outgoing tide, near low tide. This is the time of maximum impact. There is little dilution and the pollutants from the land have been pulled out into the coastal area.

3. **Lakes** should be sampled over the deepest section of the lake. For natural lakes, this is usually near the middle of the lake. In reservoirs, the deepest section is near the dam. Lakes with arms or bays should be sampled in the deepest section of each major arm.

Sampling Deep Waters

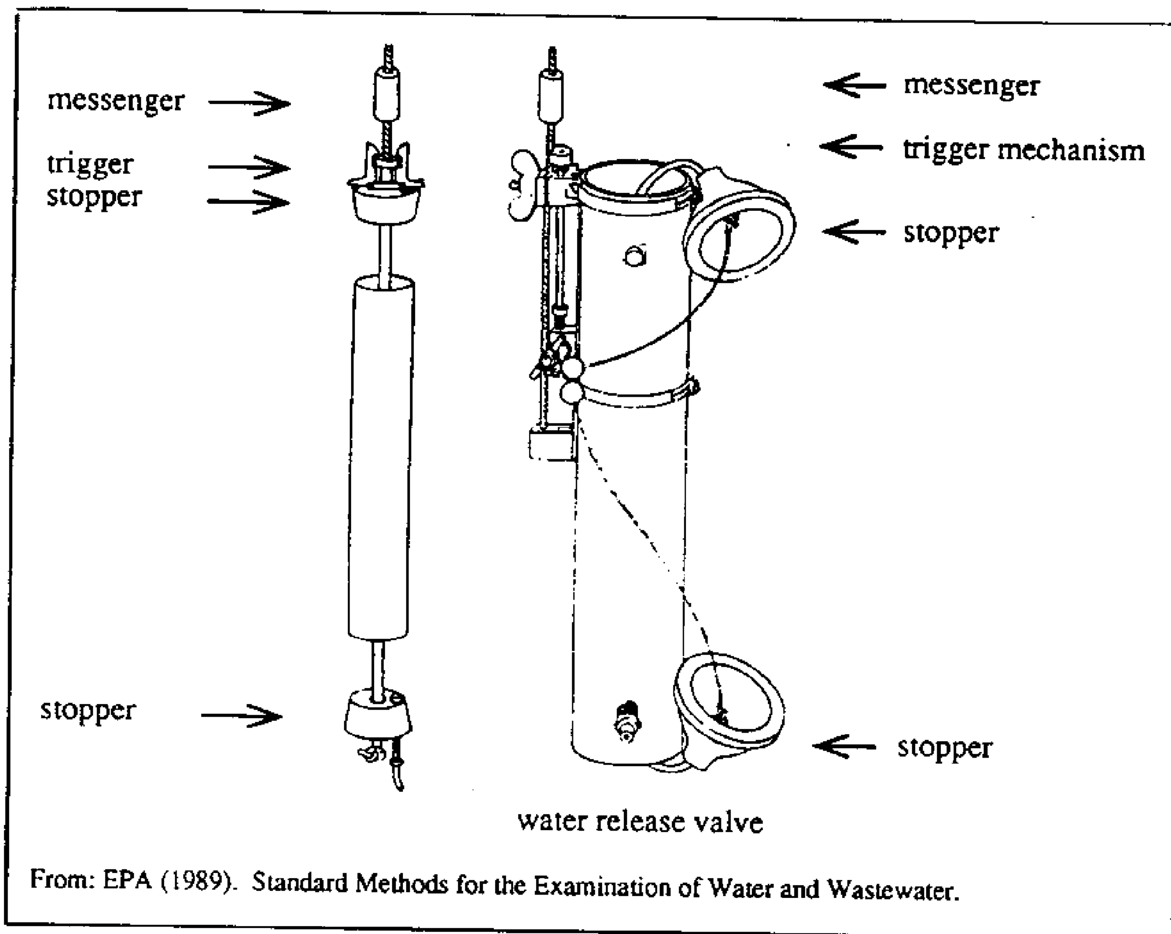
Flowing waters like rivers, streams and the upper portions of some estuaries are usually vertically and horizontally mixed. Samples collected from the surface of these waters is generally representative of the entire water column. However, lakes, estuaries, marine waters and large, slow moving rivers are not uniformly mixed and surface samples will not represent the entire water column. For these systems, it is often advisable to collect water samples from various depths in the water column.

Algae grow and reproduce in the photic zone of a lake, estuary or river. The photic zone is the upper portion of the water column where sunlight penetrates, allowing plants such as algae to photosynthesize. Monitoring projects designed to evaluate the growth of algae should collect samples from this photic zone, either as a point sample taken at a specific depth, or as an integrated sample from a range of depths in the photic zone.

Point sampling at depth is performed using a deep water sampling device such as a Van Dorn Sampler or a Kemmerer Sampler. Figure 1 shows a drawing of these two devices. They are cylindrical tubes with stoppers at both ends. On the boat, the sampler is opened and a triggering devise is set. The sampler is then lowered to the desired depth (using markings on the lowering line) and a weight, or messenger, is sent down the line. When the messenger reaches the sampler, it hits the trigger mechanism and the two stoppers snap shut. The water sample from the specified depth is trapped in the sampler. The sampler is brought on board the boat and the water is analyzed.

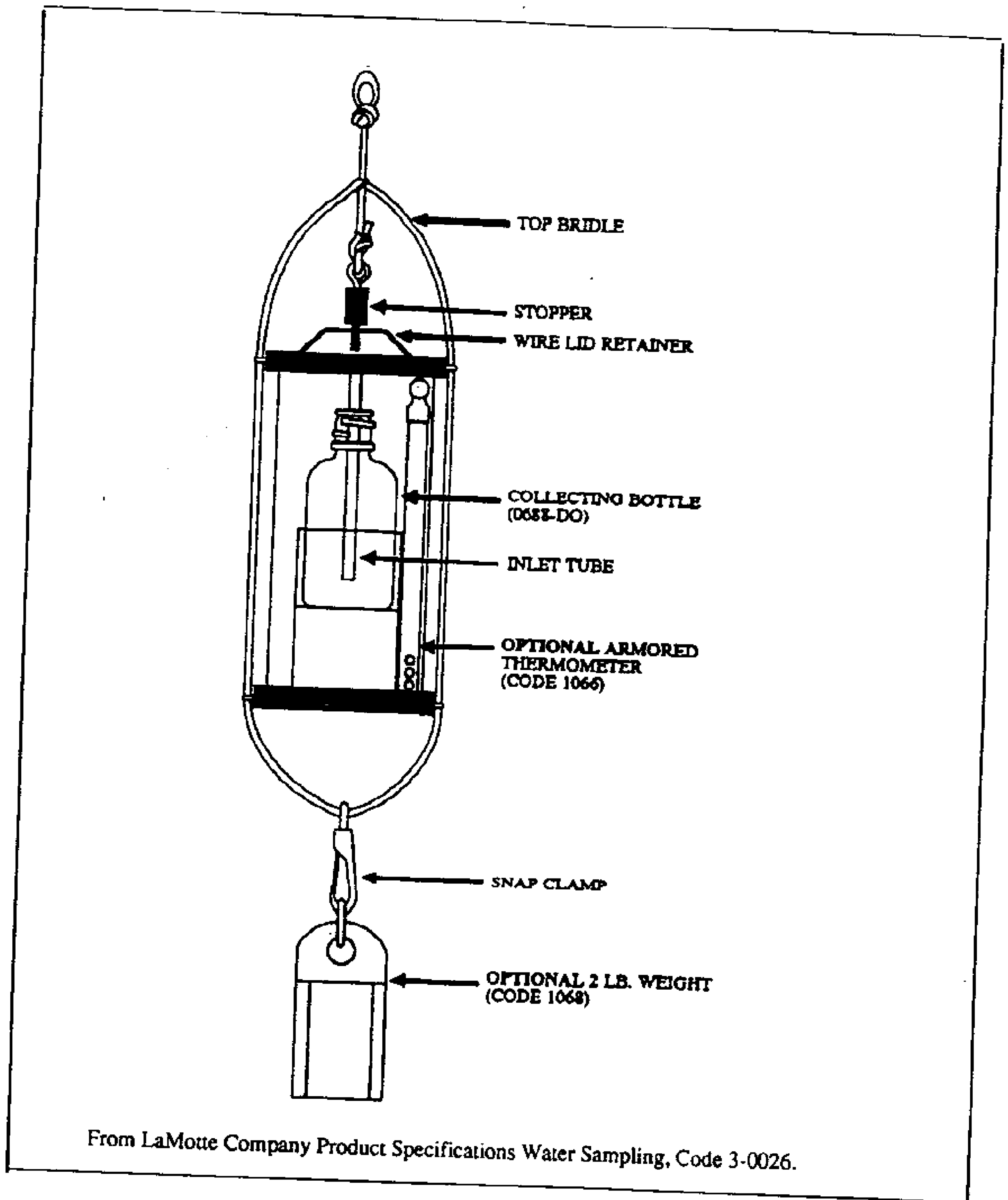
LaMotte and HACH sell remote sampling bottles that are similar in design to the Kemmerer and Van Dorn bottles. LaMotte also sells a sampler that is specifically designed for collecting dissolved oxygen samples at depth. Figure 2 shows this sampling devise.

Integrated sampling collects water from a range of depths. EPA (1991) recommends that volunteers try using a measured length of hose, weighted on one end as an integrated depth sampling devise. The unweighted end of the hose is held by the volunteer in the boat, and the weighted end is lowered into the lake. While the hose descends, it collects a vertical column of water. The surface end is then plugged and the weighted end of the hose is raised into the boat using a retrieving line. The hose can then be emptied into a bucket and samples drawn for analysis. Figure 3 illustrates this process.



From: EPA (1989). Standard Methods for the Examination of Water and Wastewater.

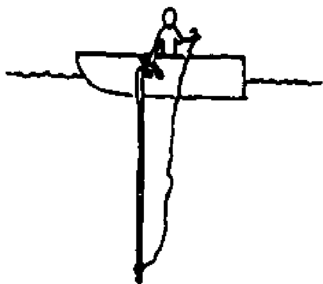
Figure 1. Kemmerer (left) and Van Dorn (right) samplers for collecting deep water samples.



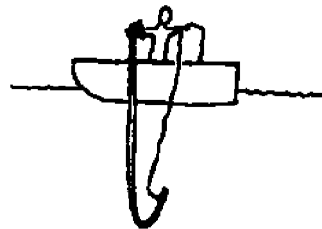
From LaMotte Company Product Specifications Water Sampling, Code 3-0026.

Figure 2. The LaMotte Water Sampling Bottle specifically designed to fill a LaMotte dissolved oxygen bottle at depth.

TAKING AN INTEGRATED SAMPLE



1. *Lower the weighted end of the hose, making sure the attached line is loose. When the hose is at the proper depth, crimp the hose closed at water level.*



2. *Maintain a firm grip to keep the hose crimped shut and pull up the weighted end of the hose with the open end of the hose facing upward.*

3. *Place the weighted end in the bucket, hold the crimped end high, and release the crimp.*

4. *Pass the hose through your raised hands until all the water from the hose empties into the bucket. Swirl the bucket to mix the sample water thoroughly.*

Adapted from:
The Vermont State Lay Monitoring Manual

From EPA (1991) Volunteer lake Monitoring: A Methods Manual.

Figure 3. Illustration of integrated depth sampling using a hose.

Quality Assurance and Quality Control

In order to generate data of known quality, it is important to develop an effective quality assurance and quality control program (QA/QC). Detailed instructions on completing a QA/QC plan can be found in several EPA reports[1] and in less detailed form in the EPA guidance documents[2] on volunteer monitoring. The following is a brief summary of the essential components of a quality assurance program.

First, program managers need to determine how the collected data is to be used, and what quality of information is needed to achieve these uses. This is done by developing data quality objectives. The objectives are defined by the data users, and they specify the uncertainty that can be tolerated for their specific purposes. The following areas of potential data uncertainty should be considered when developing data quality objectives:

1. **Accuracy**. The degree of agreement between the measured value and the true value. Accuracy is most affected by the equipment and the procedure used to measure a sample parameter.

2. **Precision**. A measurement of the ability to reproduce the measurement on the same sample (regardless of accuracy). Human error and individual differences in technique strongly influence precision.

3. **Representativeness**. The degree to which the collected data accurately and precisely represent the condition being measured. Representativeness is primarily influenced by site selection.

4. **Completeness**. A measure of the amount of valid data collected compared to the amount of data specified in the sampling plan. This is influenced by volunteer performance.

5. **Comparability**. A measure of the confidence with which one data set can be compared to another. Comparability is dependent on consistent training and sampling methods throughout a program.

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[1] U.S. Environmental Protection Agency. 1980. *Guidelines and Specifications for Preparing Quality Assurance Project Plans.* QAMS-005/80. Washington, DC.

_____. 1984. *The Development of Data Quality Objectives.* Washington, DC.

_____. 1984. *Guidelines for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring.* OWRS QA-1. Washington, DC.

_____. 1988. *Guide for Preparation of Quality Assurance Project Plans for the National Estuarine Program, Interim Final.* EPA 556-2-88-001. Office of Marine and Estuarine Protection, Washinton, DC.

[2] U.S. Environmental Protection Agency. 1991. *Volunteer Lake Monitoring: A Methods Manual.* EPA 440/4-91-002. Office of Wetlands, Oceans, and Watersheds, Washington, DC.

_____. 1990. *Volunteer Water Monitoring: A Guide for State Managers.* EPA 440/4-90-010. Office of Water Regualtions and Standards, Washington, DC.

Data quality objectives are also influenced by a project's budget. If all analyses cost the same, we might always choose the "Cadillac" measurement. But sophisticated analyses of parameters, which provide highly precise and accurate measurements, can be extremely expensive. You need to balance your data needs against your budgetary constraints. EPA recommends (and requires for EPA funded projects) that the quality assurance planning process culminate in preparation of a thorough Quality Assurance Project Plan. This plan should include the following 16 elements:

1. **Title Page.** This should include the names of the primary funding organizations for the project and the project coordinator.

2. **Table of Contents.**

3. **Project Description.** This should summarize the project's goals and objectives and experimental design.

4. **Project Organization and Responsibility.** Identify individuals responsible for overall QA/QC, sampling QC, analytical work and analytical QC, data processing, data review, and program reviews.

5. **QA Objectives.** For each parameter, list the QA objectives for precision, accuracy, representativeness, completeness and comparability. Table 1 shows a table summarizing QA Objectives for the Chesapeake Bay Citizen Monitoring Program.

6. **Sampling Procedures.**

7. **Sample Custody.** Include a discussion of how reagents and supplies are delivered to volunteers, sample preservation and holding times, sample storage, and handling of samples in the laboratory.

8. **Calibration Procedures and Frequency.** Include a discussion of standards or reference materials which will be used in the project's quality control program.
9. **Analytical Procedures.**

10. **Data Reduction, Validation, and Reporting.** This is your data management plan. It should include a copy of your data sheet, instructions for completing the sheet, data verification, data entry and data corrections.

11. **Internal Quality Control Checks.** This would include running duplicate samples, sending volunteers unknowns to check, and using two methods to test the same parameter.

12. **Performance and System Audits.** This is a periodic (annual) complete check of your programs quality control program, preferable performed by an outside expert.

13. **Preventative Maintenance.** This would include having back-up monitors to cover for sick days and vacations, replacing reagents, and retraining volunteers who are showing problems.

14. **Specific Routine Procedures Used To Assess Data Precision, Accuracy, and Completeness.** This would include equations to calculate precision and accuracy and the methods used to carry out any calibration and comparability studies.

15. **Corrective Action.** This includes the predetermined limits for data acceptability, and procedures for throwing out data.

16. **Quality Assurance Reports.** This would be a periodic report on the results of the QC audits and sessions, a discussion of QA problems and solutions, and a periodic assessment of data accuracy, precision and completeness.

Table 1. Precision and Accuracy Objectives.

PARAMETER	METHOD/RANGE	UNITS	SENSITIVITY*	PRECISION	ACCURACY	CALIBRATION
Temperature	Thermometer -5.0° to +45°	°C	0.5°C	±1.0	±0.5	with NBS Certified Thermometers
pH	Color Comparator Wide-Range Narrow-Range	Standard pH units	0.5 units 0.1	±0.6 ?**	±0.4 ±0.2	Orion Field pH Meter Beckman pH Meter
Salinity	Hydrometer	parts per thousand 0/00	0.1 0/00	±1.0	±0.82	Certified Salinity Hydrometer Set
Dissolved Oxygen	Micro Winkler Titration	mg/l	0.1 mg/l	±0.9	±0.3***	Standard Winkler & Y.S.I.. DO Meter
Limit of Visibility	Secchi Disk Depth	meters	0.05m	NA	NA	NA

*Determined by the increments measurable with the stated method reflecting estimation where allowed.
**Lack of sufficient data at present.
***Paired to analysis (α = 0.05, 3d.f.) of the standard deviation of the mean difference between 4 paired determinations

From EPA Volunteer Water Monitoring: A Guide for State Managers. EPA 440/4-90-010. Aug. 1990. Office of Water.

SAFETY FIRST!

General Precautions

1. Volunteers must attend training sessions before they can begin sampling. Contact URI (792-6224) for a schedule of training sessions.
2. Sample with a partner. This allows one person to do record observations while the other person is making them. Sampling with a buddy is a basic safety precaution and is more fun.
3. Observe boating safety rules and regulations. Basic boating safety will be covered during the training session.
4. Always bring life preservers and an anchor when you sample from your boat.
5. Be familiar with your instructions and procedures before going out in the field. Prepare bottle labels and filter apparatus at home before you go into the field.
6. Keep all equipment and reagent chemicals out of the way of small children. These chemicals are poison!
7. Call Poison Control if you have an accident or a suspected poisoning:

   In Rhode Island, call 277-5727
   In Massachusetts call 1-800-682-9211

8. Be careful when handling polluted water. Wear gloves if you wish, or wash your hands carefully (with full lather) after you are done.

Use Proper Analytical Technique

1. Avoid contact between reagent chemicals and skin, eyes, nose and mouth.
2. Use caps or stoppers, not your fingers while handling reagent chemicals.
3. Hold squeeze bottles upside down, not at an angle, when dispensing reagents.
4. Wipe up spills when they occur. In the field, wash spills with a bucket of water if they are on the ground.
5. Tightly close all reagent containers immediately after use.
6. Protect equipment and reagents from prolonged exposure to direct sunlight, and extreme temperatures.

CHEMICAL/PHYSICAL PARAMETERS

Water Clarity

(Analysis performed by volunteers) *Lakes, Estuaries*

Water clarity is affected by suspended particles in the water column and the angle of light striking the water. When there is a large amount of suspended material in the water, light penetration is reduced and it can be difficult to see the bottom.

Turbidity, or reduced water clarity, is often caused by phytoplankton (single-celled algae) or sediment in the water column. In the summer, warm temperatures, sunlight and nutrients promote the rapid growth of phytoplankton. Nutrient enriched waters often have reduced clarity in the summer due to excessive growths of phytoplankton. Silt-laden runoff after a heavy rain, stirring up of the bottom by wind- or boat-generated waves, and shoreline erosion all contribute to turbidity by increasing the sediment load of the water.

Excessive turbidity can have a harmful effect on life in lakes and estuaries. Rooted aquatic plants depend on light reaching to the bottom for photosynthesis and growth. Reduced light causes a "shading out" of these plants. In addition, large amounts of suspended matter can smother benthic habitats and clog the gills of fish and shellfish. Sediment can also make it difficult for fish who prey visually to find and capture food.

The Secchi disk is a convenient method for measuring light penetration below the water surface. The Secchi disk is a white and black disk which is weighted and attached in the center of a measured and marked rope. The weighted disk is lowered slowly straight down into the water from a boat or dock. The disk is lowered until it disappears from view and then slowly raised until it just reappears. This depth (the point where the marked line meets the water) is known as the "Secchi disk transparency." The less algae and silt in the water, the deeper the Secchi disk will be visible. Alternately, shallow readings will occur in turbid water with large amounts of suspended algae and silt.

Some regions of the State have natural dark water streams and lakes. The brown color of the water is caused by humic material (decaying vegetation) and is the natural, unpolluted condition of the water. Dark water lakes will often have a lower Secchi disk transparency than clear water lakes.

Measuring Water Clarity with a Secchi Disk

1. Take readings from a boat or off a dock.
2. Anchor the boat or have an assistant paddle to keep the boat in a fixed position to ensure that the Secchi disk is observed straight down, instead of at an angle.
3. Take readings directly on the station and at roughly the same time of day each time. It is preferable to sample between 10 AM and 2 PM to utilize the most direct sunlight.
4. To measure the Secchi transparency, lower the Secchi disk **on the shady side of the boat**, until it just goes out of sight. Note the depth where the disk disappears by reading the point where the line meets the water. If it is easier, you can mark the line with a clothespin or clamp. This is the **descending** Secchi depth. Lower the disk further and then bring it up, noting the depth on the line where the disk comes into view again. This is the **ascending** Secchi depth.

NOTE: Several programs recommend that volunteers use viewscopes to minimize glare on the water. Glare and wave action can greatly influence the apparent Secchi depth transparency. A viewscope is simply a tube, 2 to 3 feet long and about 4 inches in diameter, that is black on the inside and has a handle on one side. Instructions for making a viewscope are on page 15. Hold the viewscope vertically about 6 inches into the water and look through it to observe the disappearance and reappearance of the Secchi disk.

5. Record the ascending and descending Secchi depths on your field data sheet. Example field sheets are in Appendix B. Calculate the average Secchi depth.

6. If the disk is resting on the bottom and still visible, please note the bottom depth and the fact that the disk is on the bottom.

One Way to Make a Secchi Disk

1. Cut a disk 20 centimeters (8 inches) in diameter from a piece of plywood, metal, or plastic and paint it white with black quarter pie wedges.
2. Drill a hole in the center of the disk through which an eye bolt can be fitted.
3. Turn a nut onto the eye bolt.
4. Slip a lock washer and then a flat washer onto the bolt.
5. Slip the disk onto the bolt, white side toward the eye of the bolt.
6. Slip flat washer and weights onto the bolt. Weights need only be sufficient to counteract the buoyancy of the disk so that it will sink.
7. Slip a lock washer and nut onto the bolt and tighten it.
8. Attach one end of about 20 feet of cord to the eye bolt. The type of line used is very important. Avoid cotton clothesline because it stretches when wet. Nylon line is recommended.
9. From the top surface of the Secchi disk, measure regular intervals on the line (2 inches works well) and mark the increments on the cord with waterproof ink.

This is a design that has been successfully reproduced by many Volunteer monitors. It is not the only way to put together a Secchi disk. The most important criterion is that it is cut to an 8 inch diameter, painted black and white, and that the depth can be clearly and accurately read off the cord.

Making a Viewscope[3]

You will need:
4" diameter PVC pipe, black inside; 1 handle, 3-4 inches long; 4 screws and nuts

Cut a 2 - 3 foot section of 4" PVC pipe which is black on the inside. If you can't find pipe that is black, paint it yourself. If the pipe is shiny black, use sandpaper to rough up the interior. Attach handle about 6 inches from one end.

Programs that monitor in choppy waters may want to modify their viewscope by adding a plexiglass "window" at one end. This prevents water from coming up inside the tube and interfering with visibility.

You will need:
4.5 inch plexiglass disk; PVC coupling; silicone rubber sealant

Glue the plexiglass disk to the bottom of the tube, using silicone rubber sealant. Place a piece of PVC coupling over that end of the tube (like a collar) and seal with the silicone sealant. Drill two small (1/8") holes in the side of the collar so that air won't be trapped in the open end of the coupling when you put the viewscope into the water.

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[3] Instructions written by Jeff Schloss and included in **The Volunteer Monitor**, Fall 1991 issue.

Dissolved Oxygen
(Analysis performed by volunteers)

Aquatic organisms, like terrestrial plants and animals, depend on oxygen for their survival. Oxygen is dissolved in waters, and is measured as dissolved oxygen, or DO. Oxygen is added to water through mixing with the atmosphere (which is 21 percent oxygen by volume). Wind action and turbulence enhances the mixing of the water with the atmosphere. Oxygen is also added to waters by green plants when they **photosynthesize**. The **respiration** of green plants and other animals uses up dissolved oxygen. Oxygen is also removed from waters by bacteria which break down organic material such as dead plants and animals and pollutants.

Biological activity can significantly affect the concentration of oxygen in the water. Green plants and algae which photosynthesize give off oxygen during the day and can supersaturate shallow water with D.O. During the night, however, these same plants stop photosynthesizing and producing oxygen, but continue to respire, using up the oxygen dissolved in the water. Low oxygen levels can occur during the early morning hours in waters containing large numbers of green plants. Low levels can also occur during periods of low light such as prolonged cloudy spells. When plants die, oxygen is used up by bacteria breaking down the dead plant matter. Bacterial decay usually takes place at the bottom, and so large blooms of algae in the spring and summer, can also be responsible for consuming large amounts of oxygen from bottom waters.

The ability of water to dissolve oxygen is dependent on temperature. Colder water can hold more oxygen, so water always has higher levels of dissolved oxygen during the colder winter months. The temperature of the water also affects the way water mixes. Warm water is less dense than colder water. During the summer, the sun warms the surface waters of deep, slow flowing waterbodies such as lakes and estuaries. The surface water mass can become isolated from the bottom water by temperature induced differences in density. This is called stratification. In stratified lakes and estuaries, the surface water stays well aerated, but the bottom water is isolated from atmospheric reaeration, and decomposition of organic material can deplete its dissolved oxygen.

Dissolved oxygen levels vary from 0 mg/l, in severely polluted waters or deep waters of stratified lakes with large numbers of aquatic plants, to 14-18 mg/l in cold or supersaturated waters. Measurements outside of this range should be repeated to assure that the test is being done correctly.

D.O. can be measured with commercially available meters or with the Winkler (iodometric) method. Most volunteer groups rely on variations of the Winkler method sold in kits by LaMotte and HACH.

Table 2 shows the dissolved oxygen levels in milligrams per liter (Mg/L) which you would find in a sample at different temperatures under saturated conditions. It is important to note that salinity reduces the solubility of oxygen in water, and must be considered when sampling inland saline, estuarine and marine waters. Oxygen solubility declines exponentially with increases in salt content and is reduced by about 20 percent in normal salt water.

Table 2. Solubility of Dissolved Oxygen in Water

Temperature Degrees C	Solubility Mg/L (ppm)	Temperature Degrees C	Solubility Mg/L (ppm)
0	14.6	16	10.0
1	14.2	17	9.8
2	13.8	18	9.6
3	13.5	19	9.4
4	13.1	20	9.2
5	12.8	21	9.0
6	12.5	22	8.9
7	12.2	23	8.7
8	11.9	24	8.6
9	11.6	25	8.4
10	11.3	26	8.2
11	11.1	27	8.1
12	10.9	28	7.9
13	10.6	29	7.8
14	10.4	30	7.7
15	10.2		

Dissolved Oxygen Protocol using LaMotte test kits

Please read **all** the materials enclosed in your LaMotte kit **before** beginning!

SAFETY NOTE: Some of the chemicals used in this test are toxic and the final compound is an acid. Be careful with the procedure and observe warning labels on all chemical bottles.

Test Procedure (in field)

NOTE: To ensure quality of the chemicals, wrap the bottles in black electrical tape so that light does not enter bottle and degrade the reagents. Leave the chemical identification and safety information label visible.

1. Rinse sample bottle two (2) times with water to be sampled.
2. Tightly cap the mouth of the bottle, submerge the bottle six (6) inches underwater, remove the cap, tilt the bottle slightly and allow it to fill slowly.
3. Tap the sides of the submerged bottle to dislodge any air bubbles clinging to the inside of the bottle. Replace the cap while the bottle is still submerged.
4. Retrieve the bottle and examine it carefully to make sure that no air bubbles are trapped inside. Redo if air bubbles are present.
5. Repeat sampling procedure so that two separate D.O. samples are taken.

NOTE: Be careful not to introduce air into the sample while adding the reagents in Steps 6 and 7. Simply drop the reagents into the test sample, cap carefully, and mix thoroughly. Hold all dropper bottles vertically while dispensing the reagents.

6. Add eight (8) drops of manganous sulfate solution (#1) and then add eight (8) drops of alkaline potassium iodide solution (#2) to the sample. Hold the reagent dropper bottles vertically when adding drops of reagents to sample. These reagents are added in excess so the precise number of drops is not critical, i.e. if you add 9 or 10 drops you do **not** have to start over. However, it is necessary to add the manganous sulfate **first**. Cap the bottle and mix by inverting gently several times. The reaction causes a fluffy solid (called a precipitate) to form in the bottle. Allow the precipitate to settle below the shoulder of the bottle before proceeding.

7. Repeat procedure for second water sample.

8. Invert the bottle again, to mix precipitate and allow it to settle. (Let settle until the precipitate settles below the shoulder of the bottle).

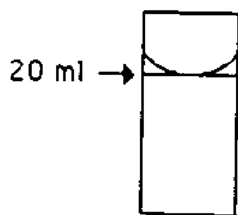
9. Using the 1 gram measuring spoon, add one (1) level measuring spoon of sulfamic powder to the sampling bottle. The sulfamic acid crystals are added in excess so the amount is not critical. You can spill a few grains and do not have to start over. Or add 8 drops of the sulfuric acid solution, depending on which kit you have.

10. Cap the bottle and invert the bottle several times to mix, until both the reagent and precipitate have dissolved. The sample is now fixed. A **clear** yellow to brownish-orange color will develop, depending on the oxygen content of the sample. (The more orange the sample, the higher the oxygen content). If a few grains of acid do not go into solution and all the precipitate is dissolved, you may continue the titration. You may at times find that organic material or sediment in the water do not dissolve either. This will not effect the tests results.

NOTE: At this point you can stop and complete the titration at home, within 8 hours of sample collection.

Titration

1. Fill the titration bottle to the 20 ml etched line with the "fixed" sample and cap the titration bottle. The amount of sample (20 ml) to be titrated is **CRITICAL**. Measure carefully. The bottom of the meniscus should rest on top of the white line on the titration bottle. (A meniscus is a curved upper surface of a liquid column that is concave when the containing walls are wetted by the liquid).



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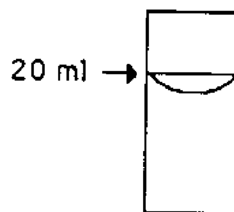

not correct

2. Depress plunger of titrator syringe to expel air. Insert titrator syringe into plastic fitting of the sodium thiosulfate solution. To fill the syringe invert the bottle and slowly withdraw the plunger until the bottom of the plunger is opposite the zero mark on the scale.

NOTE: A small air bubble may appear in the syringe barrel. Expel the bubble by partially filling the barrel and pumping the titration solution (sodium thiosulfate), back into the inverted reagent container. Repeat this pumping action until the bubble disappears. Turn the bottle right-side up and remove the syringe.

3. Dry off the outside of the titrator syringe making sure no liquid is pulled out of the titrator tip when drying off the outside drops. Insert titrator into the center hole of the titration bottle cap. Add one drop at a time to sample. The plunger is very sensitive, so press gently—it is very easy to overshoot. Swirl sample between each addition to knock any partial drops off the titrator syringe tip and to mix sample. Continue to add thiosulfate until the color of the sample is a faint yellow.

NOTE: The accuracy of the titration is extremely important since the amount of titrant added is equal to the amount of oxygen dissolved in the water. Be sure that all water is removed (shake the syringe and plunger) before filling the syringe with the titrant, sodium thiosulfate solution. Make sure there are no air bubbles in the syringe. When the amount of D.O. is above 10 mg/l, you will have to refill the syringe. For accurate results, refill to 0 mark and continue titration. Read the test results from the second syringe and add it to the 10 mg from the first syringe.

4. When the color is a faint yellow, remove titrator along with the cap. Be careful not to disturb the titrator plunger, the sample is not completely titrated yet. Using the plastic eye dropper, add 8 drops of starch solution to the sample, which will cause a color change (to blue).

   If the color of the fixed sample (after the sulfamic powder has been added), is already a faint yellow add the starch solution right away. A faint yellow color means there is very little oxygen present in the sample. You will only need to add a small amount of titrating solution to determine the oxygen concentration.

5. Continue titrating and swirling the sample until the blue color just disappears. The first complete disappearance of blue color is the endpoint. Do this against a pure white background (a piece of white paper works nicely) so that you can see the color change from light blue to clear.

6. Where the plunger tip meets the titrator scale on the syringe, read the test result in mg/L (same as ppm {parts per million}) dissolved oxygen.

7. Complete two (2) titrations, one from each water sample, and write down the numbers. If the difference between the two titrations is greater than 0.6 mg/L then do a third titration of either of the sample bottles. Record all three values and average the two closer values.

8. Pour the sample on the grass (if in the field) or down the sink drain with the tap water running to dilute it.

9. Rinse the sample bottle and titrator bottle in distilled water (or tap water if distilled is not available) and store for next sampling.

Temperature

(Analysis performed by volunteers)

Although temperature may be one of the easiest measurements to perform, it is probably one of the most important parameters to be considered. It dramatically affects the rates of chemical and biochemical reactions in the water. Many biological, physical, and chemical processes are temperature dependent. Among the most common of these are the solubility of compounds in water, cycles of reproduction and maturation of organisms living in the water, and rates of chemical reactions.

Temperature is reported in degrees Celsius (centigrade). To convert Fahrenheit to Celsius:

$$(^\circ F) = (1.8 * {}^\circ C) + 32 \qquad \text{or} \qquad (^\circ C) = (^\circ F - 32)/1.8$$

Typically, the temperature in Rhode Island waters ranges from just below freezing in the winter (- 1 - 10 °C) to as much as 28 - 29 ° C in summer.

Measuring Water Temperature

1. Keep the mercury filled tip of the thermometer suspended about 6 inches (10 centimeters) below the water surface for at least two minutes. You may have the thermometer hung by a string while you go on to other sampling. If sampling from a bucket, keep the bucket in the shade while measuring the temperature. Direct sunlight will warm the water rapidly.

2. Read the thermometer while it is still suspended just below the surface of the water. Any wind or direct sunlight on the thermometer once it is in the air will change the reading rapidly and give you an incorrect measurement.

3. Record the value on your field data sheet. (Example data sheets are found in Appendix B).

Salinity
(Analysis performed by volunteers)

Salinity is a measure of total dissolved salts in a volume of water and is commonly expressed in parts per thousand (ppt) or number of grams salt dissolved in 1000 grams (roughly one liter) of water. Under natural conditions, salinity ranges from 0 ppt for freshwater to an average of 35 ppt in ocean water.

Levels of salinity in Rhode Island estuaries vary according to the time of year, and proximity to influxes of fresh or sea water. Stations near the mouth of the bay or inlet are more saline than stations located near stream outflows. Salinity decreases in the spring when rainfall, groundwater, and melting snow cause increases in freshwater inflows. When freshwater inputs are reduced, salinity levels rise. Since fresh water is less dense than salt water, it may form a lens floating on the surface of the estuary, and may actually be visible. More often, this stratification is only evident when measuring the salinity of deeper water.

Measuring Salinity

Salinity can be measured with a meter. However, meters are expensive, and salinity can also be estimated using a variety of other methods.

Calculating from chloride concentration. The salinity of a water sample can be calculated from the chloride concentration of the samples. Chloride can be determined by a laboratory, or can be estimated using a test kit. Express the chloride concentration as grams/l (parts per thousand, ppt), and calculate the salinity using the equation:

$$\text{Salinity (ppt)} = (1.805 * \text{chloride concentration (ppt)}) + 0.03$$

Using a hydrometer. Salinity can be estimated by measuring the specific gravity of a water sample with a hydrometer. Hydrometers can be purchased from many scientific supply companies.

1. Fill a 500 ml graduated cylinder to the 500 ml mark with the water to be tested. Fill a bucket with the water you are testing.

2. Measure the temperature of the water sample in the cylinder. Leave the thermometer in the graduated cylinder for 2 minutes. Record the temperature to the nearest 0.5 degree C. If possible, place the hydrometer in the bucket of sample water while measuring the temperature. The purpose is to have the hydrometer as close to the temperature of the water in the cylinder.

3. Before removing the thermometer, use it to stir the water sample to break up density layers in the cylinder. Then remove the thermometer and immediately place the hydrometer from the bucket into the cylinder slowly without letting the hydrometer crash to the bottom of the cylinder. If the cylinder is glass, it is easy to break the hydrometer.

4. Read the density on the hydrometer by carefully reading the meniscus (the bottom of the curve that forms by the water). Record the specific gravity to the fourth decimal place by referring to the figure "Reading the Hydrometer."

NOTE: The hydrometer should be free floating with no friction with the sides of the cylinder. There should be no air bubbles on the surface of the hydrometer.

5. Look on the shoulder of your hydrometer for information on the scaling basis of your instrument. If your hydrometer is graduated on a 60 °/60 °F basis, subtract 0.0010 from your initial reading. If it is scaled on a 15°/4° C basis, skip this step.

6. Find the correction factor for temperature from Table 1, "Values for Converting Hydrometer Readings at Certain Temperatures to Density 15 Degrees C." This is a large, 4 page table. Find the recorded density in the vertical column and then go across to the recorded temperature on the horizontal axis. Find the correction factor and record it as 0.00_ _. For example, 25 would be recorded as 0.0025. Single digit factors, such as 3, would be recorded as 0.0003.

7. If the correction factor is positive (+), add it to the recorded density. If the correction factor is negative (-), subtract it from the recorded density. The result is the density corrected to 15 degrees C.

8. To determine the salinity, locate the corrected density value on Table II, "Corresponding Densities and Salinities" and read off the salinity. Record the salinity on the data sheet.

Hydrometer Work Sheet		
Water Temperature	____________	°C
Density	1. ____________	g/cc
Correction for 60°/60°F scaling	-0.0010	
Corrected Density (subtract)	1. ____________	g/cc
Correction from table	0.00 ___ ___	
Corrected Density	1. ____________	g/cc
Salinity from table	____________	ppt

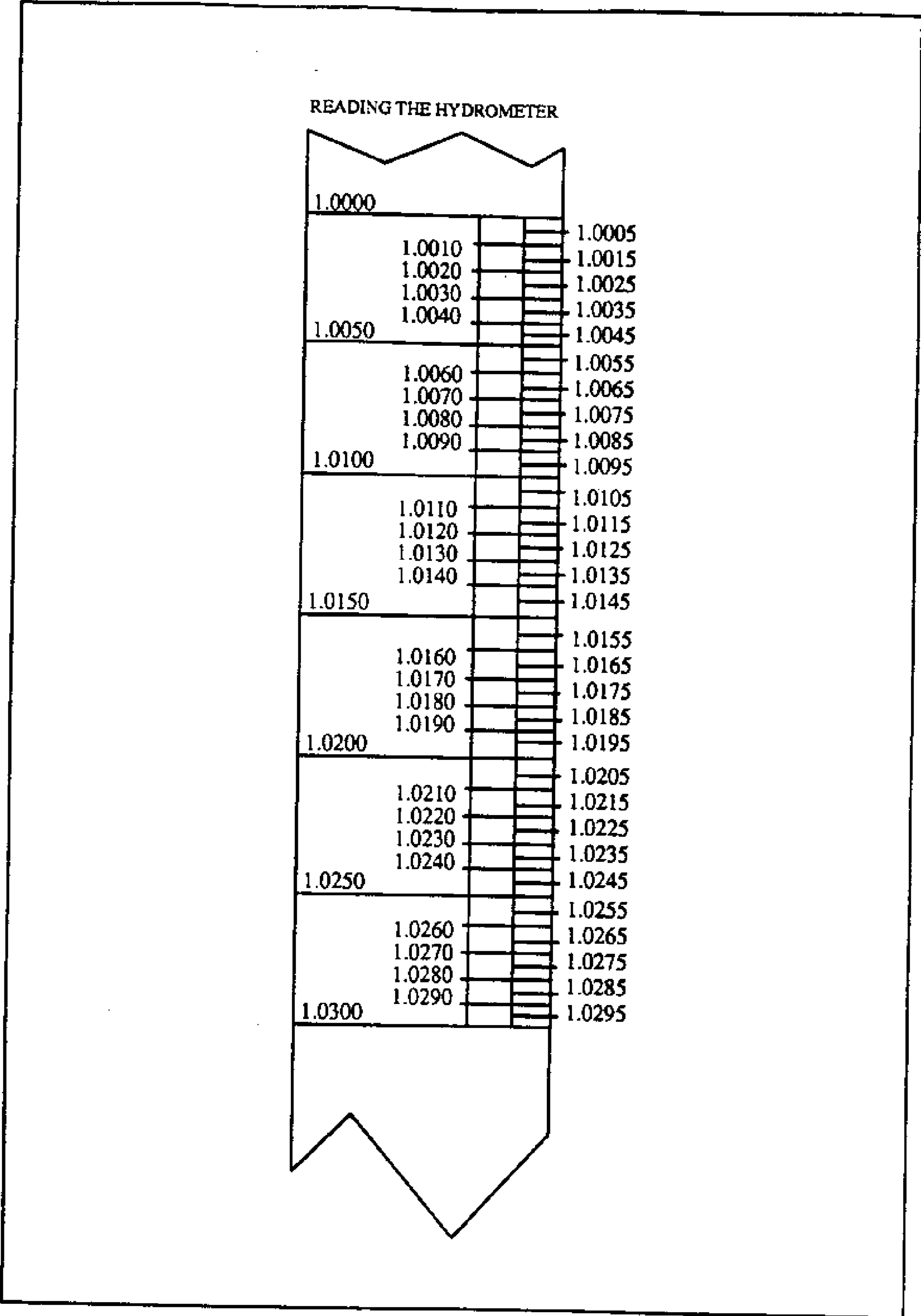

Figure 4. Chart for reading a hydrometer.

Table 3. Values for converting hydrometer readings at certain temperatures to density at 15°C.

Observed Reading	Temperature of Water in Jar, C											
	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	18.5	19.0	19.5	20.0
0.9960												
0.9970												
0.9980							3	4	5	6	7	8
0.9990	−4	−3	−2	−1	0	1	3	4	5	6	7	8
1.0000	−4	−3	−2	−1	0	1	3	4	5	6	7	8
1.0010	−4	−3	−2	−1	0	1	3	4	5	6	7	8
1.0020	−4	−3	−2	−1	0	1	3	4	5	6	7	8
1.0030	−4	−3	−2	−1	0	1	3	4	5	6	7	8
1.0040	−5	−4	−3	−1	0	2	3	5	6	6	7	8
1.0050	−5	−4	−3	−1	0	2	3	5	6	7	8	9
1.0060	−5	−4	−3	−1	0	2	3	5	6	7	8	9
1.0070	−5	−4	−3	−2	0	2	3	5	6	7	8	9
1.0080	−5	−4	−3	−2	0	2	3	5	6	7	8	9
1.0090	−5	−4	−3	−2	0	2	3	5	6	7	8	9
1.0100	−5	−4	−3	−2	0	2	3	5	6	7	8	9
1.0110	−5	−4	−3	−2	0	2	3	5	6	7	8	9
1.0120	−6	−4	−3	−2	0	2	3	5	6	7	8	9
1.0130	−6	−4	−3	−2	0	2	4	5	6	7	8	10
1.0140	−6	−4	−3	−2	0	2	4	5	6	8	9	10
1.0150	−6	−4	−3	−2	0	2	4	5	6	8	9	10
1.0160	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0170	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0180	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0190	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0200	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0210	−6	−5	−3	−2	0	2	4	6	7	8	9	10
1.0220	−7	−5	−3	−2	0	2	4	6	7	8	9	11
1.0230	−7	−5	−4	−2	0	2	4	6	7	8	9	11
1.0240	−7	−5	−4	−2	0	2	4	6	7	8	10	11
1.0250	−7	−5	−4	−2	0	2	4	6	7	8	10	11
1.0260	−7	−5	−4	−2	0	2	4	6	7	9	10	11
1.0270	−7	−5	−4	−2	0	2	4	6	7	9	10	11
1.0280	−7	−6	−4	−2	0	2	4	6	8	9	10	11
1.0290	−7	−6	−4	−2	0	2	4	6	8	9	10	11
1.0300	−7	−6	−4	−2	0	2	4	6	8	9	10	12
1.0310	−8	−6	−4	−2	0	2	4					

Table 3. (Continued)

Observed Reading	Temperature of Water in Jar, C −2.0	−1.0	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.9960													
0.9970													
0.9980													
0.9990	−1	−2	−3	−4	−5	−5	−6	−6	−6	−6	−6	−5	−5
1.0000	−2	−3	−4	−5	−5	−6	−6	−6	−6	−6	−6	−5	−5
1.0010	−3	−4	−4	−5	−6	−6	−6	−7	−7	−6	−6	−6	−5
1.0020	−3	−4	−5	−6	−6	−7	−7	−7	−7	−7	−6	−6	−5
1.0030	−4	−5	−6	−6	−7	−7	−7	−7	−7	−7	−6	−6	−5
1.0040	−4	−5	−6	−7	−7	−7	−8	−8	−7	−7	−7	−6	−6
1.0050	−5	−6	−6	−7	−8	−8	−8	−8	−8	−7	−7	−6	−6
1.0060	−6	−6	−7	−8	−8	−8	−8	−8	−8	−8	−7	−6	−6
1.0070	−6	−7	−8	−8	−8	−8	−8	−8	−8	−8	−7	−7	−6
1.0080	−7	−8	−8	−9	−9	−9	−9	−9	−8	−8	−7	−7	−6
1.0090	−7	−8	−9	−9	−9	−9	−9	−9	−9	−8	−8	−7	−6
1.0100	−8	−9	−9	−10	−10	−10	−10	−9	−9	−8	−8	−7	−6
1.0110	−9	−9	−10	−10	−10	−10	−10	−10	−9	−9	−8	−7	−6
1.0120	−9	−10	−10	−10	−10	−10	−10	−10	−10	−9	−8	−7	−7
1.0130	−10	−10	−11	−11	−11	−11	−11	−10	−10	−9	−8	−8	−7
1.0140	−10	−11	−11	−11	−11	−11	−11	−11	−10	−10	−9	−8	−7
1.0150	−11	−11	−12	−12	−12	−12	−11	−11	−10	−10	−9	−8	−7
1.0160	−12	−12	−12	−12	−12	−12	−12	−11	−11	−10	−9	−8	−7
1.0170	−12	−12	−12	−13	−13	−12	−12	−12	−11	−10	−9	−8	−7
1.0180	−13	−13	−13	−13	−13	−13	−12	−12	−11	−10	−9	−8	−7
1.0190	−13	−13	−14	−14	−13	−13	−13	−12	−12	−11	−10	−9	−8
1.0200	−14	−14	−14	−14	−14	−13	−13	−12	−12	−11	−10	−9	−8
1.0210	−14	−14	−14	−14	−14	−14	−13	−13	−12	−11	−10	−9	−8
1.0220	−15	−15	−15	−15	−15	−14	−14	−13	−12	−11	−10	−9	−8
1.0230	−15	−15	−15	−15	−15	−15	−14	−13	−12	−12	−10	−9	−8
1.0240	−16	−16	−16	−16	−15	−15	−14	−14	−13	−12	−11	−10	−8
1.0250	−16	−16	−16	−16	−16	−15	−15	−14	−13	−12	−11	−10	−8
1.0260	−17	−17	−17	−16	−16	−16	−15	−14	−13	−12	−11	−10	−8
1.0270	−18	−17	−17	−17	−17	−16	−15	−14	−14	−12	−11	−10	−9
1.0280	−18	−18	−18	−17	−17	−16	−16	−15	−14	−13	−11	−10	−9
1.0290	−19	−18	−18	−18	−17	−17	−16	−15	−14	−13	−12	−10	−9
1.0300	−19	−19	−19	−18	−18	−17	−16	−15	−14	−13	−12	−10	−9
1.0310	−20	−19	−19	−19	−18	−17	−16	−16	−15	−13	−12	−10	−9

- Add tabular values to the last decimal of observed reading. For example, as observed reading of 1.0000 at 10.0 C is converted to 1.0000 + (-0.0005) or 0.9995 at 15 C.

Table 3. (Continued)

Observed Reading	Temperature of Water in Jar, C											
	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0	25.5	26.0
0.9960											19	20
0.9970			10	11	12	14	15	16	17	18	19	20
0.9980	9	10	11	12	13	14	15	16	17	18	19	21
0.9990	9	10	11	12	13	14	15	16	17	18	20	21
1.0000	9	10	11	12	13	14	15	16	17	19	20	21
1.0010	9	10	11	12	13	14	15	17	18	19	20	21
1.0020	9	10	11	12.	13	14	16	17	18	19	20	22
1.0030	9	10	11	12	13	15	16	17	18	19	21	22
1.0040	9	10	11	12	14	15	16	17	18	20	21	22
1.0050	10	11	12	13	14	15	16	17	19	20	21	22
1.0060	10	11	12	13	14	15	16	18	19	20	21	23
1.0070	10	11	12	13	14	15	17	18	19	20	21	23
1.0080	10	11	12	13	14	16	17	18	19	20	22	23
1.0090	10	11	12	13	15	16	17	18	19	21	22	23
1.0100	10	11	12	14	15	16	17	18	20	21	22	24
1.0110	10	12	13	14	15	16	17	19	20	21	22	24
1.0120	10	12	13	14	15	16	18	19	20	21	23	24
1.0130	11	12	13	14	15	16	18	19	20	22	23	24
1.0140	11	12	13	14	15	17	18	19	20	22	23	24
1.0150	11	12	13	14	16	17	18	20	21	22	23	25
1.0160	11	12	13	14	16	17	18	20	21	22	24	25
1.0170	11	12	13	15	16	17	18	20	21	22	24	25
1.0180	11	12	14	15	16	17	19	20	21	23	24	25
1.0190	11	12	14	15	16	18	19	20	21	23	24	26
1.0200	11	13	14	15	16	18	19	20	22	23	24	26
1.0210	12	13	14	15	17	18	19	21	22	23	25	26
1.0220	12	13	14	15	17	18	19	21	22	23	25	26
1.0230	12	13	14	16	17	18	20	21	22	24	25	26
1.0240	12	13	14	16	17	18	20	21	22	24	25	27
1.0250	12	13	15	16	17	18	20	21	23	24	25	27
1.0260	12	13	15	16	17	19	20	22	23	24	26	27
1.0270	12	14	15	16	17	19	20	22	23	24	26	27
1.0280	12	14	15	16	18	19	20	22	23	25	26	28
1.0290	13	14	15	16	18	19	21	22	23			
1.0300	13	14	15	16	18							
1.0310												

Table 3. (Continued)

Observed Reading	Temperature of Water in Jar, C 27.0	27.5	28.0	28.5	29.0	29.5	30.0	30.5	31.0	31.5	32.0	32.5	33.0
0.9960	23	24	25	27	28	29	31	32	34	35	37	38	40
0.9970	23	24	26	27	28	30	31	33	34	36	37	39	40
0.9980	23	25	26	27	29	30	31	33	34	36	38	39	41
0.9990	24	25	26	28	29	30	32	33	35	36	38	39	41
1.0000	24	25	26	28	29	31	32	34	35	37	38	40	41
1.0010	24	25	27	28	30	31	32	34	35	37	39	40	42
1.0020	24	26	27	28	30	31	33	34	36	37	39	41	42
1.0030	25	26	27	29	30	32	33	35	36	38	39	41	42
1.0040	25	26	28	29	30	32	33	35	36	38	40	41	43
1.0050	25	26	28	29	31	32	34	35	37	38	40	42	43
1.0060	25	27	28	30	31	32	34	36	37	39	40	42	44
1.0070	26	27	28	30	31	33	34	36	38	39	41	42	44
1.0080	26	27	29	30	32	33	35	36	38	39	41	43	44
1.0090	26	28	29	30	32	33	35	36	38	40	41	43	45
1.0100	26	28	29	31	32	34	35	37	38	40	42	43	45
1.0110	27	28	30	31	32	34	36	37	39	40	42	44	45
1.0120	27	28	30	31	33	34	36	37	39	41	42	44	46
1.0130	27	29	30	32	33	35	36	38	39	41	43	44	46
1.0140	27	29	30	32	33	35	36	38	40	41	43	45	46
1.0150	28	29	31	32	34	35	37	38	40	42	43	45	47
1.0160	28	29	31	32	34	35	37	39	40	42	44	45	47
1.0170	28	30	31	33	34	36	37	39	40	42	44	46	47
1.0180	28	30	31	33	34	36	38	39	41	42	44	46	48
1.0190	29	30	32	33	35	36	38	39	41	43	44	46	48
1.0200	29	30	32	33	35	37	38	40	41	43	45	47	48
1.0210	29	31	32	34	35	37	38	40	42	43	45	47	49
1.0220	29	31	32	34	36	37	39	40	42	44	45	47	49
1.0230	30	31	33	34	36	37	39	41	42	44	46	47	49
1.0240	30	31	33	34	36	37	39	41	42	44	46	48	49
1.0250	30	31	33	35	36	38	39	41	43	44	46	48	50
1.0260	30	32	33	35	37	38	40	41	43	45	46	48	50
1.0270	30	32	34	35	37	38	40						
1.0280	31	32											
1.0290													
1.0300													
1.0310													

Source: Zerbe W.B. and C.B. Taylor. 1953. Sea Water Temperature and Density Reduction Tables. U.S. Dep. Commerce Spec. Publ. No. 298, Washington, D.C.

Table 4. Converting density measured with the hydrometer to salinity.

Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity
0.9991	0.0	1.0046	7.1	1.0101	14.2	1.0156	21.4	1.0211	28.6	1.0266	35.8
.9992	.0	1.0047	7.2	1.0102	14.4	1.0157	21.6	1.0212	28.8	1.0267	35.9
.9993	.1	1.0048	7.3	1.0103	14.5	1.0158	21.7	1.0213	28.9	1.0268	36.0
.9994	.3	1.0049	7.5	1.0104	14.6	1.0159	21.8	1.0214	29.0	1.0269	36.2
.9995	.4	1.0050	7.6	1.0105	14.8	1.0160	22.0	1.0215	29.1	1.0270	36.3
.9996	.5	1.0051	7.7	1.0106	14.9	1.0161	22.1	1.0216	29.3	1.0271	36.4
.9997	.7	1.0052	7.9	1.0107	15.0	1.0162	22.2	1.0217	29.4	1.0272	36.6
.9998	.8	1.0053	8.0	1.0108	15.2	1.0163	22.4	1.0218	29.5	1.0273	36.7
.9999	.9	1.0054	8.1	1.0109	15.3	1.0164	22.5	1.0219	29.7	1.0274	36.8
1.0000	1.1	1.0055	8.2	1.0110	15.4	1.0165	22.6	1.0220	29.8	1.0275	37.0
1.0001	1.2	1.0056	8.4	1.0111	15.6	1.0166	22.7	1.0221	29.9	1.0276	37.1
1.0002	1.3	1.0057	8.5	1.0112	15.7	1.0167	22.9	1.0222	30.0	1.0277	37.2
1.0003	1.4	1.0058	8.6	1.0113	15.8	1.0168	23.0	1.0223	30.2	1.0278	37.3
1.0004	1.6	1.0059	8.8	1.0114	16.0	1.0169	23.1	1.0224	30.3	1.0279	37.5
1.0005	1.7	1.0060	8.9	1.0115	16.1	1.0170	23.3	1.0225	30.4	1.0280	37.6
1.0006	1.8	1.0061	9.0	1.0116	16.2	1.0171	23.4	1.0225	30.6	1.0281	37.7
1.0007	2.0	1.0062	9.2	1.0117	16.3	1.0172	23.5	1.0227	30.7	1.0282	37.9
1.0008	2.1	1.0063	9.3	1.0118	16.5	1.0173	23.7	1.0228	30.8	1.0283	38.0
1.0009	2.2	1.0064	9.4	1.0119	16.6	1.0174	23.8	1.0229	31.0	1.0284	38.1
1.0010	2.4	1.0065	9.6	1.0120	16.7	1.0175	23.9	1.0230	31.1	1.0285	38.2
1.0011	2.5	1.0066	9.7	1.0121	16.9	1.0176	24.0	1.0231	31.2	1.0286	38.4
1.0012	2.6	1.0067	9.8	1.0122	17.0	1.0177	24.2	1.0232	31.4	1.0287	38.5
1.0013	2.8	1.0068	9.9	1.0123	17.1	1.0178	24.3	1.0233	31.5	1.0288	38.6
1.0014	2.9	1.0069	10.1	1.0124	17.3	1.0179	24.4	1.0234	31.6	1.0289	38.8
1.0015	3.0	1.0070	10.2	1.0125	17.4	1.0180	24.6	1.0235	31.8	1.0290	38.9
1.0016	3.2	1.0071	10.3	1.0126	17.5	1.0181	24.7	1.0236	31.9	1.0291	39.0
1.0017	3.3	1.0072	10.5	1.0127	17.6	1.0182	24.8	1.0237	32.0	1.0292	39.2
1.0018	3.4	1.0073	10.6	1.0128	17.8	1.0183	25.0	1.0238	32.1	1.0293	39.3
1.0019	3.5	1.0074	10.7	1.0129	17.9	1.0184	25.1	1.0239	32.3	1.0294	39.4
1.0020	3.7	1.0075	10.8	1.0130	18.0	1.0185	25.2	1.0240	32.4	1.0295	39.5
1.0021	3.8	1.0076	11.0	1.0131	18.2	1.0186	25.4	1.0241	32.5	1.0296	39.7
1.0022	3.9	1.0077	11.1	1.0132	18.3	1.0187	25.5	1.0242	32.7	1.0297	39.8
1.0023	4.1	1.0078	11.2	1.0133	18.4	1.0188	25.6	1.0243	32.8	1.0298	39.9
1.0024	4.2	1.0079	11.4	1.0134	18.6	1.0189	25.8	1.0244	32.9	1.0299	40.1
1.0025	4.3	1.0080	11.5	1.0135	18.7	1.0190	25.9	1.0245	33.0	1.0300	40.2
1.0026	4.5	1.0081	11.6	1.0136	18.8	1.0191	26.0	1.0246	33.2	1.0301	40.3
1.0027	4.6	1.0082	11.8	1.0137	19.0	1.0192	26.1	1.0247	33.3	1.0302	40.4
1.0028	4.7	1.0083	11.9	1.0138	19.1	1.0193	26.3	1.0248	33.4	1.0303	40.5
1.0029	4.8	1.0084	12.0	1.0139	19.2	1.0194	26.4	1.0249	33.6	1.0304	40.7
1.0030	5.0	1.0085	12.2	1.0140	19.4	1.0195	26.5	1.0250	33.7	1.0305	40.8
1.0031	5.1	1.0086	12.3	1.0141	19.5	1.0196	26.7	1.0251	33.8	1.0306	41.0
1.0032	5.2	1.0087	12.4	1.0142	19.6	1.0197	26.8	1.0252	34.0	1.0307	41.1
1.0033	5.4	1.0088	12.6	1.0143	19.7	1.0198	26.9	1.0253	34.1	1.0308	41.2
1.0034	5.5	1.0089	12.7	1.0144	19.9	1.0199	27.1	1.0254	34.2	1.0309	41.4
1.0035	5.6	1.0090	12.8	1.0145	20.0	1.0200	27.2	1.0255	34.4	1.0310	41.5
1.0036	5.8	1.0091	12.9	1.0146	20.1	1.0201	27.3	1.0256	34.5	1.0311	41.6
1.0037	5.9	1.0092	13.1	1.0147	20.3	1.0202	27.4	1.0257	34.6	1.0312	41.8
1.0038	6.0	1.0093	13.2	1.0148	20.4	1.0203	27.6	1.0258	34.7	1.0313	41.9
1.0039	6.2	1.0094	13.3	1.0149	20.5	1.0204	27.7	1.0259	34.9	1.0314	42.0
1.0040	6.3	1.0095	13.5	1.0150	20.6	1.0205	27.8	1.0260	35.0	1.0315	42.1
1.0041	6.4	1.0096	13.6	1.0151	20.8	1.0206	28.0	1.0261	35.1	1.0316	42.3
1.0042	6.6	1.0097	13.7	1.0152	20.9	1.0207	28.1	1.0262	35.3	1.0317	42.4
1.0043	6.7	1.0098	13.9	1.0153	21.0	1.0208	28.2	1.0263	35.4	1.0318	42.5
1.0044	6.8	1.0099	14.0	1.0154	21.2	1.0209	28.4	1.0264	35.5	1.0319	42.7
1.0045	7.0	1.0100	14.1	1.0155	21.3	1.0210	28.5	1.0265	35.6	1.0320	42.8

Source: G.M. Manufacturing Company, New York, New York.

Conductivity

Rivers, Lakes

(Analysis performed by volunteers)

Conductivity describes the ability of an aqueous solution to carry an electrical current. The conductivity depends on the presence of ions (salts) in the water and the water temperature. Conductivity varies depending on the natural chemistry of the water, but pollution also affects conductivity.

Sodium and chloride, the salts found in table salt, are the most common ions found in natural waters. Sodium and chloride can have subtle effects on water quality, including induced stratification, heavy metal release, and long-term effects on organisms. The most common sources of sodium and chloride to a freshwater body are sewage disposal systems, road salting, and even rain in areas close to the ocean. Salt piles, if unprotected, may result in locally high concentrations of sodium and chloride in runoff and surface waters.

Salts are not reactive in water, and can be excellent markers for pollution. A well mixed stream, should have a uniform conductivity across its width. Measurement of conductivity at several points across a bridge can be used to assess whether the stream is well mixed. A sudden increase in conductivity often indicates a pollution source, and should be investigated.

Measuring Conductivity

Conductivity can only be measured with a meter. Purchase a meter that measures salinity, conductivity and temperature. **Each meter will come with specific instructions for calibrating and using the instrument.** Please read these instructions and follow them carefully.

Velocity and Volume
(Analysis performed by volunteers)

Water quality is affected by the volume of water carried by a stream, river or lake. Large, swiftly flowing rivers can receive discharges of pollution and be little affected, while small streams and ponds have less capacity to dilute and degrade the wastes.

Water volume is affected by weather patterns, increasing during rainstorms and decreasing during dry periods. It also changes during different seasons of the year, decreasing during the summer when evaporation rates are high and shoreline vegetation is actively growing and removing water from the ground. August and September are usually the months of lowest flow for most streams and rivers in the northeast. Agricultural irrigation in a watershed can seriously deplete water flow, as can water withdrawals for industrial purposes. Dams used for electric power generation, particularly facilities designed to produce power during periods of peak need, often block the flow of a river, and release it within a short time period.

The velocity of water in a stream or river increases as the volume of water carried by the river increases. The velocity determines the kinds of organisms that can live in a portion of stream. Organisms in rocky, fast flowing areas are different than organisms found in deep pools. The water velocity also affects the amount of silt and sediment carried by a river. Sediment introduced to quiet slow flowing rivers will settle to the bottom. Fast moving streams and rivers keep sediment suspended in the water column. High velocity streams are well aerated, and will have a higher dissolved oxygen concentration than sluggish streams.

Measuring Stream Velocity

You will need:

100 foot measuring tape
4 stakes
heavy string or clothesline (long enough to go across your stream twice)
apple or orange
watch with a second hand or a stop watch

1. Select a uniform section of stream that is 100 feet in length
2. Place stakes on each side of the stream at the beginning of the 100 foot section and at the end of the section.
3. Stretch pieces of line across the stream at the stakes.
4. Toss the apple or orange into midstream at the water upstream starting line. Measure the time it takes it to travel between the start and finish lines. Record the time on the table below.
5. Repeat the time trial 2 more times and record the results in the table.
6. Average the time.

TRIALS	TIME (SECONDS)
1.	
2.	
3.	
AVERAGE	

7. Calculate the velocity of the stream (in feet per second) by dividing 100 feet by the average time from the table.

Average velocity (fps) = (100 feet)/(______ average seconds)

= ______________ feet per second

Measuring Discharge (flow volume in cubic feet per second)

Discharge is the volume of water passing a point over a given time period. To calculate the discharge, you multiply the flow times the cross sectional area of the stream.

Measuring Cross Sectional Area

You will need:

- at least two people
- measuring tape, or rope marked in one-foot increments
- yardstick
- graph paper, and clipboard
- pencil
- hip boots
- Table for calculating area (copy of Table 5)

1. Stretch tape measure or calibrated rope across the stream.

2. Walk along the line and measure the **depth** of the water in inches at one foot intervals across the stream. Have your buddy on shore record these measurements in the table.

3. Make measurements every foot across the entire stream transect. On shore, convert your **depth in inches to depth in feet** (divide by 12). Record the answer in Table 5.

4. **Average the depth** for each 1 foot section (This can be confusing. See the example calculations for clarification).

5. Calculate the area for each 1 foot section

   AREA = average depth (from 4 above) x width
   = average depth x 1 foot
   = average depth

6. **Sum** the individual areas for the total cross sectional area of your stream.

Calculating Stream Discharge

Multiply your cross sectional area (square feet) times the average stream velocity measured in the beginning of the exercise.

Cross sectional area (square feet)	x	**Velocity** (feet per second)	=	**Discharge** (cubic feet per second)

For example, if the average flow measured with the oranges was 0.5 feet per second, the discharge would be:

13.6 square feet x 0.5 feet per second = 6.8 cubic feet per second

Measuring Water Level

Water level can be measured by installing a staff gauge, or calibrated stick, in the stream or lake. The level of water on the stick will indicate the relative flow at that point. Staff gauges can be calibrated by measuring the discharge at a variety of stream levels and constructing a relationship between depth and discharge. Stage/discharge relationships are best developed with professional help and mechanical flow meters.

Table 5. Use this table in the field to measure your stream's cross-sectional area.

WIDTH MARK	DEPTH (inches)	DEPTH (feet)	AVERAGE DEPTH (ft)	AREA (square feet)
0 (shore)	0			
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
SUM				

EXAMPLE: How to calculate your stream's cross sectional area

WIDTH MARK	DEPTH (inches)	DEPTH (feet)	AVERAGE DEPTH (ft)	AREA (square feet)
0 (shore)	0			
1	3	.25	(0+.25)/2=.125	.125*1=.125
2	10	.83	(.25+.83)/2=.54	.54
3	18	1.5	(.8+1.5)/2=1.2	1.17
4	25	2.08	(1.5+2.08)/2=1.79	1.79
5	30	2.5	(2.08+2.5)/2=2.29	2.29
6	20	1.67	(2.5+1.67)/2=2.09	2.09
7	20	1.67	(1.67+1.67)/2=1.67	1.67
8	15	1.25	(1.67+1.25)/2=1.46	1.46
9	10	.83	(1.25+.83)/2=1.04	1.04
10	8	.67	(.83+.67)/2=.75	.75
11	4	.33	(.67+.33)/2=.5	.5
12	0 (shore)	0	(.33+0)/2=.165	.165
13				
SUM				13.59 = 13.6

Rainfall

(Analysis performed by volunteers)

All Watersheds

In order to understand the quality of a waterbody, it is also essential to understand the system's hydrology. Where does the water in your lake, river, estuary come from? Where does it go? How is it influenced by ground water? Rainfall monitoring allows you to estimate how much of the water in your watershed is introduced directly by rainfall and indirectly by runoff.

Rainfall can also be a significant source of pollution to your waterbody. Rainfall runs off the land, carrying with it pollutants from yards, farms, roads, roofs and parking lots. These pollutants end up in your local waterways. Stormwater runoff can contain significant concentrations of coliform bacteria, nitrogen and phosphorus, pesticides, and automobile oils and gas.

<u>Measuring Rain Volume with a Rain Gauge</u>

1. Rain gauges can be purchased at a local hardware store.
2. You need a large open area away from trees, buildings, etc.
3. Place rain gauge approximately three times as far away as the height of the buildings or trees. This means if your house is 30 feet high, you should place the gauge 90 feet from the house.
4. Try to place gauge as close to your waterbody as you can while remembering to keep the right distance from trees and houses.
5. Make daily observations of the water level in the rain gauge. Empty the gauge after each reading.

pH
(Analysis performed by volunteers or laboratory)

The pH is a measure of the hydrogen ion concentration of a solution. The pH scale runs from 0 to 14, with 7 being neutral. From pH 7 to 0, the solution becomes increasingly acidic, and from pH 7 to 14, the solution is increasingly basic. The pH scale is logarithmic, so each change in 1 pH unit represents a 10 fold change in pH. Lemon juice is acidic with a pH of about 2, while ammonia is basic with a pH of about 11. The pH of natural waters is affected by the geology of the watershed. Waters flowing through granite will be acidic, while waters flowing through limestone will have a higher pH. The pH of most waters is between 6.5 and 9.0.

Automobile exhaust and coal-fired power plants emit nitrogen oxides and sulfer oxides which are converted to nitric acid and sulfuric acid in the atmosphere. These acids fall to earth as "acid rain". Waters that flow through limestone can neutralize the acidic rainfall and the pH is not affected by the precipitation, but the pH of other waters can be lowered dramatically by acidic precipitation. At pH values less than 4.5, the water becomes unsuitable for most organisms. Acidified lakes are often crystal clear. Nothing can live in them.

Water pH can be measured with a pH meter, with pH paper and with a variety of test kits. If carrying samples back to the lab for measurement, be careful to fill the entire sample bottle with water, leaving no air space. Make the measurement as soon as possible after collection. pH is affected by the sample temperature, so always record the temperature with the pH.

Hardness *Rivers, Lakes*

(Analysis performed by volunteers or laboratory)

Water hardness was originally understood to be a measure of the capacity of the water to precipitate soap. Soap is precipitated by the calcium and magnesium ions present in the water, so hardness is defined as the sum of the calcium and magnesium concentrations in the water sample.

The toxicity of metals in water to aquatic organisms varies with the hardness. In general, metals are more toxic in soft waters (waters with little hardness) than they are in hard waters. Unfortunately, waters in Rhode Island tend to be soft.

Hardness can be calculated from the concentration of calcium and magnesium in the water.

$$\textbf{Hardness (mg CaCO3/L)} = 2.497\ [\text{Ca, mg/L}] + 4.118\ [\text{Mg, mg/L}]$$

Hardness can also be measured by titrating a sample with EDTA. EDTA will react with the calcium and magnesium and remove the ions from the solution. A dye is added to the solution before titrating. With calcium and magnesium in solution, the dye is wine red. Once the ions are removed, the dye turns blue. The hardness can be calculated from the amount of EDTA needed to titrate the water sample.

Test kits are available that measure water hardness using the EDTA titration.

Nitrogen and Phosphorus *Rivers, Lakes, Estuaries, Marine Waters*
(Analysis performed by laboratory)

Nitrogen and phosphorus are the major components of most commercial lawn and garden fertilizers. These chemicals are essential for the growth of plants, and in situations where the plant's other needs are satisfied, added nitrogen and phosphorus will stimulate plant growth. Aquatic plants such as weeds and phytoplankton also require nitrogen and phosphorus. When excess amounts of these chemicals are introduced to the water, plant growth is stimulated. Excess phytoplankton and algae can choke the system, slowing the velocity of the water and destroying the aesthetic appeal of the waterbody. Dead plants and algae fall to the bottom of the river, lake or estuary and decompose. The decomposition process uses up oxygen, and can deplete a waterbody of oxygen that is needed by fish and other aquatic organisms. Turbidity caused by living plankton in the water column also diminishes light available to aquatic grasses which are an important food source and habitat for waterfowl and fishes.

Nitrogen and phosphorus enter aquatic systems from a variety of sources. Rain runoff carries nutrients to waters. Runoff from forested lands generally contributes the least nitrogen and phosphorus, while runoff from agricultural lands contribute significant amounts. Septic tanks leach nutrients into groundwater, where it can affect nearby surface water systems. Wastewater from sewage treatment plants introduces significant levels of nutrients to waters since conventional secondary treatment plants are not designed to remove either nitrogen or phosphorus from the waste.

Nutrient Sampling Procedure

A variety of companies sell test kits for nitrogen and phosphorus. The kits will not detect low levels of nutrients and are suitable for screening studies or for studies of highly polluted areas. A laboratory analysis is necessary for most studies of natural waters. Contact a local water analysis laboratory for information on the cost of nutrient analyses and their level of detection. The laboratory will provide information on the type of sampling containers to use and a recommended sampling procedure.

Metals *Rivers, Lakes, Estuaries, Marine Waters*
(Analysis performed by laboratory)

Although trace concentrations of heavy metals are present in all natural water, pollution from direct sewage discharges and rainfall runoff can introduce toxic levels of metals to aquatic systems. In urban and industrialized areas, metals can be major pollutants affecting aquatic life. The Environmental Protection Agency has analyzed the toxicity of metals to a variety of aquatic organisms. Toxic substances affect organisms in two general ways. High levels of chemicals will kill organisms immediately. EPA has established "acute" criteria designed to protect aquatic organisms from short term exposures to high concentration of pollutants. Chemicals can also have long term effects, where the toxicity develops after the organism has been exposed for some time to a lower concentration. EPA has developed "chronic" criteria to protect organisms from these long term, low level exposures. Criteria developed by EPA are expressed in terms of the hardness of the water. It is therefore important to measure the water's hardness when monitoring for metals.

When collecting water samples for metals analyses, be sure that the water does not contact metal surfaces. If you use a collecting bucket, be sure that the bucket is plastic and remove the metal handle. Bottles need to be very clean. It is best use bottles supplied by the lab doing the metals analysis.

Private laboratories charge about $15.00 for each metal sample analyzed. You may be able to work out a better arrangement if the lab director is sympathetic to your cause. Test kits for metals analyses are available, but most are not sensitive in the ug/L ranges typical of natural waters.

Eelgrass Wasting Disease

Estuaries

Eelgrass wasting disease was responsible for virtually eliminating eelgrass from coastal waters throughout the North Atlantic in the 1930's. By the 1960's eelgrass populations had largely been restored, but in the past decade, the characteristic symptoms of eelgrass wasting disease have again developed and are spreading.

Infection of wasting disease is characterized by dark, decaying lesions on both young and old eelgrass blades. The infection of wasting disease takes place in two stages: 1) the initial infection and development of the lesions; and 2) mass mortality of eelgrass. The current infection has spread throughout New England, but dieoffs have been restricted to localized areas.

Eelgrass wasting disease has been traced to a slime mold-type pathogenic protist called *Labarinthula*. This microorganism evidently flourishes in high saline waters. Eelgrass growing in low salinity waters seems to be less susceptible to infection.

Mass mortality of eelgrass in the 1930's was associated with loss of productivity in estuarine and coastal waters. The eelgrass loss had a devastating effect on migratory waterfowl and commercial fisheries habitat. Some locations were permanently altered, and eelgrass never returned.

Not all eelgrass decline is due to wasting disease. Disappearance of eelgrass in estuaries in both North American and Europe has been attributed to pollution of coastal waters. Eelgrass can also be killed by shading of the bottom by dense surface plankton blooms associated with eutrophic waters. If surface algae is dense enough, it can prevent light from reaching the eelgrass plants causing them to die back. The combined effects of wasting disease and pollution could devastate eelgrass populations.

Eelgrass Wasting Disease Protocol

The purpose of the wasting index method is to have an easy and quick way to determine the amount of disease on an eelgrass shoot. This procedure should be followed in the area around each station (provided that there is eelgrass present) once each growing season.

Steps

1. Collect 10 plants from an eelgrass bed at or near your regular sampling station. Each plant is called a shoot. As you collect each shoot, pull them up by the roots to make sure you have gotten the whole plant. If the eelgrass bed is large, take shoots randomly around the whole bed; if the bed is a very small clump with few shoots, scale down the number of shoots taken to minimize impact to the plant community. Make a note of how far off and in what direction the eelgrass bed is in relation to your regular sampling station.

2. Information from each shoot is entered in a new box on the data sheet for each sampling site and date.

3. Enter the date the plants were collected under "Date," the location and site the plants were collected under "Location/Site," and the person collecting and recording information under "Person."

4. Select and number a plant. Enter the number on the data sheet under "Shoot #."
5. Measure the width of the base of the shoot in millimeters and enter under "Width."
6. Measure the height of the sheath in centimeters and enter under "SH."
7. Number the leaves of each shoot from youngest to oldest. The youngest shoot will be the newest looking, the shortest whole leaf and the one growing furthest into the stem. The number does not usually exceed 6.
8. Measure the length of each leaf in centimeters and enter under "Length."
9. Estimate the percentage of disease cover on each leaf. To estimate cover, look at the whole leaf from the top of the sheath to the leaf tip and refer to the "Wasting Index Key" on the next page. The Key shows wasting disease covering 0, 1, 10, 20, 50, and 100 percent of the leaf. Estimate where the leaf you are looking at stands on this scale. Interpolate coverage that falls between the percents illustrated on the scale. Enter the percentage of disease on each leaf under "Index."
10. Enter anything that seems abnormal, that has changed, or that seems to be worthy noting under "Comments."

Monitoring of eelgrass wasting disease involves harvesting leaves from several plants in an area and estimating the percent cover of dark, decaying tissue on each leaf.

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WASTING INDEX METHOD

Introduction: The purpose of the wasting index method is to have an easy and quantitative way to determine the amount of disease on an eelgrass shoot.

A. Enter the date the plants were collected under "Date," the location and site the plants were collected at under "Site," and the person collecting the eelgrass and measuring the disease under "Person."

B. Select a terminal, vegetative shoot and number it. Enter the number on the data sheet under "Shoot #."

C. Measure the shoot width in millimeters (e.g. 3.2) and enter under "Width."

D. Measure the height of the youngest visible sheath (this is the bundle sheath which usually encloses the youngest two to three leaves) from the youngest root node (the first set of roots) in centimeters (e.g. 14.7) and enter under "Sheath."

E. Number the leaves of each shoot from youngest to oldest.

F. Measure length of each leaf from the youngest root node to the tip in centimeters (e.g. 54.9) and enter under "Length." If the tip is broken, measure to break and write "BT" next to measurement.

G. Enter percentage of disease on the leaf under "Index." To estimate the percentage of disease on a leaf look at the entire leaf from the top of the sheath to the tip, then refer to the "Wasting Index Key." On this key is drawn the amount of disease for 0, 1, 10, 20, 40, and 80 percent. Estimate where the leaf you are looking at stands on this sheet. You should estimate if it appears to have a percentage of disease between the numbers on the key (e.g. 3% or 65%).

H. Enter anything that seems abnormal or worthy noting under "Comments."

EELGRASS WASTING INDEX DATA ANALYSIS															
Date		Site			Person										
Shoot#	Width (mm)	Sheath (cm)	Leaf #1 Length	Index %	Leaf #2 Length	Index %	Leaf #3 Length	Index %	Leaf #4 Length	Index %	Leaf #5 Length	Index %	Leaf #6 Length	Index %	Comments
1															
2															
3															
4															
5															
6															
7															
8															

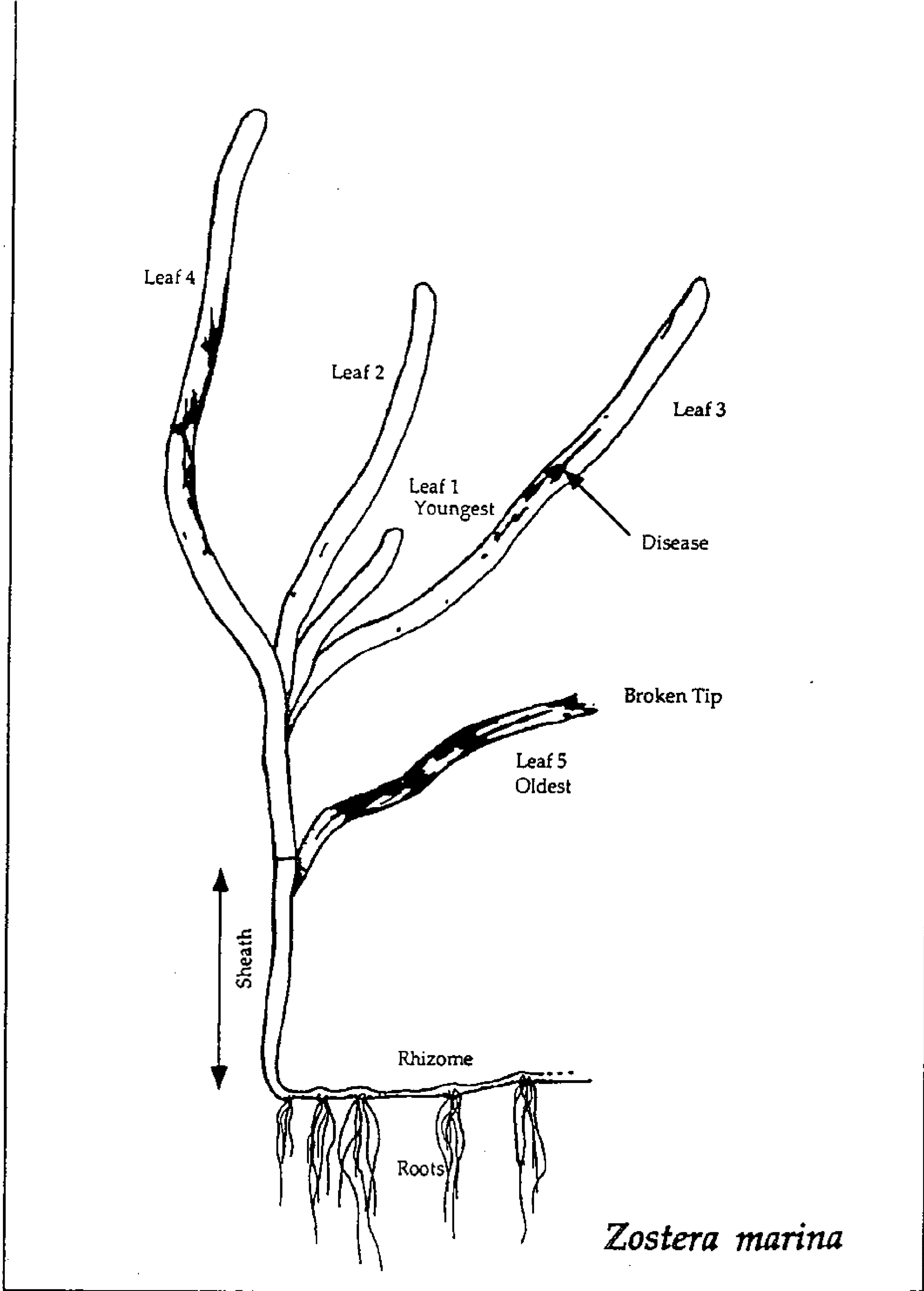


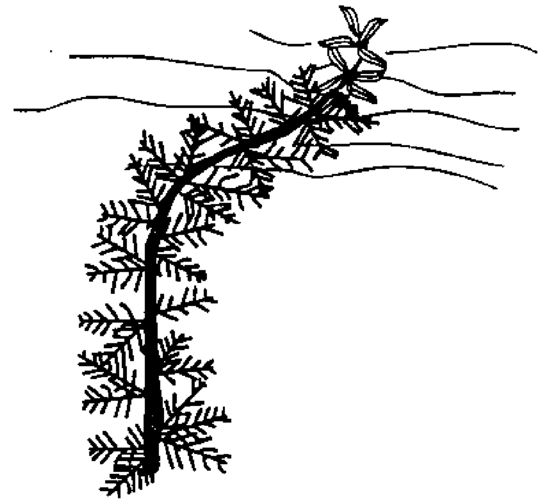
Figure 5. Diagram of eelgrass plant showing diseased portions.

Monitoring Nuisance Aquatic Plants in Freshwater Lakes

This section focuses in on a common problem that faces many lakes and ponds in the Northeast as well as other regions around the United States—the problem of invasive rooted aquatic plants.

All aquatic plant growth should not be considered detrimental to the lake's ecosystem. In most cases rooted aquatic plants, submergent and emergent plants are advantageous to the health of a lake. The problem arises when growth of one or two species competes and successfully eliminates other species of aquatic plants destroying the plant diversity of the lake's littoral zone. By eliminating competing species, these invasive rooted plants can grow at uncontrolled rates in just the right conditions. The overgrowth of rooted aquatic vegetation becomes nuisance and eventually begins to impair the quality, uses and appearance of the lake.

These aggressive rooted aquatic plants are in fact exotic plants from other countries that were brought here to local surface waters. It is through their high tolerance to varied lake conditions that enables their domination over native aquatic species. One example of an exotic plant species that plagues the waters of New England is Eurasian watermilfoil. Vermont's Department of Environmental Conservation developed a citizens volunteer monitoring program called the Milfoil Watchers Program to train volunteers on the proper identification of Eurasian Milfoil.



Watermilfoil

Other invasive rooted aquatic plant species are water hyacinth, coontail and pondweeds. In the EPA's Volunteer Lake Monitoring: a Methods Manual, the monitoring program is designed to train citizen volunteers on methods of:

- mapping the distribution of rooted aquatic plants;
- determine the relative density of rooted plant species along a transect line running perpendicular from the shore in selected areas; and
- collect specimens for professional identification.

The EPA's lake manual begins its discussion on developing a lake aquatic plant monitoring program with sampling considerations and methods on how to sample and inventory the selected plant species of interest. The purpose of monitoring your lake is to provide early prevention of exotic aquatic plant overgrowths and protect the health of your lake. Sample consideration of a lake monitoring program should focus on the proper identification of the nuisance plant species to determine the correct management techniques to control or eliminate the invasive plant species. Other considerations involve determining sampling site locations, frequencies of sampling and methods of mapping growth patterns and density.

A host of single-celled algae, known as phytoplankton, inhabit most waters. Phytoplankton populations depend on a number of environmental factors such as light, temperature, salinity, and nutrient loadings and can therefore serve as indicators of water conditions.

The chlorophyll filtration test provides an index to the amount (biomass) of phytoplankton that are present in a volume of water. Chlorophyll *a*, the chemical compound actually measured in the test, plays a crucial role in photosynthesis and is therefore present in some amount in all living phytoplankton. Chlorophyll *a* is measured by passing a known volume of water through a fine filter. The filter is wrapped in foil to protect it from light and frozen until it can be read. To be analyzed, each filter is placed in acetone to extract the chlorophyll, which is measured by using a fluorometer. When chlorophyll is struck by a beam of ultraviolet light, it emits red light; the intensity varies with the chlorophyll concentration in the original water sample.

Phytoplankton occur in "patches" in natural waters. Water quality monitors will find that phytoplankton abundance varies from station to station and from season to season. When two samples are taken only a meter apart, sometimes one may have twice as much phytoplankton as the other. The sources of this patchiness are not well understood; turbulence is known to be one factor, but patchiness is seen in calm water as well. Three replicate chlorophyll samples should be collected from each station to reduce the influence of random variation due to patchiness.

Chlorophyll Protocol

The laboratory analyzing the chlorophyll samples will recommend a sampling procedure. The following method is used successfully by several RI monitoring programs.

Preparation (at home)

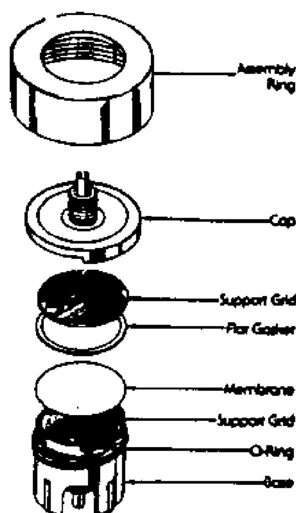
It is advisable to take 3 chlorophyll samples since the results can be highly variable.

1. Take a square of aluminum foil and fold it into a pocket, about 2 inches across. Make three pockets. The filter will be placed in the pocket after the water sample has been filtered.

2. Label foil packet s #1, #2, and #3.

3. Load the chlorophyll filter heads: The diagram below shows how to load a Swin-Lok Holder. The Fisher Gelman Type AE Membrane Filter Holder is just as good and is handled slightly differently.

Label filter heads #1, # 2 and #3



Expanded view of Swin-Lok Holder

a. Unscrew assembly ring and remove cap.

b. Make sure the O-ring (black ring) is properly seated in the base by pressing O-ring into molded groove with fingers.

c. Using forceps, carefully place a filter on top of the base grid. **The "gridded," distinctly waffled side of the filter is to be down, flat against the supporting grid**—be sure filter completely covers the O-ring. Wet the filter with four drops of magnesium carbonate (1 gr $MgCO3$ diluted to 100 ml).

d. Place flat gasket (gray or red ring) over filter. Be sure gasket is carefully centered on the filter and O-ring.

e. Mate the cap and base so the tabs interlock. Its important that the gasket does not get caught between the cap and base—the filter head will leak if it does.

f. Screw assembly ring tightly onto base. Attach filter holder to syringe and force air through filter to remove excess magnesium carbonate from filter.

Field Sampling Procedure (on station)

a. Attach tubing to syringe and draw 20 ml of water into the syringe. Push this water back and forth, then discard.

NOTE: **DO NOT** draw water through filter, it will rupture the filter.

b. **Slowly** pull back plunger and completely fill syringe.

c. Remove tubing. Hold syringe upright (Pointed end up) tap large bubbles to top—depress plunger slowly and force the bubbles out of the syringe.

d. Once bubbles are removed push plunger to the 50 ml mark, if you overshoot, re-do (Volume is very important).

e. Attach a loaded filter head to syringe. Apply slow steady pressure to plunger to force sample water through the filter.

NOTE: If water is very green, filter only 25 ml of water. A larger volume will clog the filter. Be sure to mark the filter clearly with the reduced volume. The volume of water sampled is essential to accurately determine the chlorophyll content.

f. Remove filter head. Draw back plunger of syringe and fill with approximately 20 mls of air. Reattach the filter head to the syringe and slowly depress the plunger, forcing air through the sample filter. This helps reduce excess water on the filter. Remove filter head, store upright and **protect from the light in field box.**

g. Replace tubing, repeat process two more times.

Sample Processing and Storage (at home)

a. Carefully unscrew the filter and remove the top from the base.

b. With forceps (use 2) grip the edges of the filter and fold it evenly in half so the green side of filter folds in and you get a neat semi-circle. Use the edge of the base to keep the filter from sliding off the base. Remove filter from base and place in tin foil. Place filter from the filter assembly labeled "3" into the foil packet labeled "3."

c. Put chlorophyll packet labeled with tape and waterproof ink, in a baggie and store it in the freezer.

NOTE: DO NOT write on the foil packet once the filter is in it. The foil can rip and the filters get contaminated, use label tape.

Microbiological examinations are performed on water samples to assess the degree of contamination with human wastes. Water can contain many types of bacteria, most are benign, but some bacteria cause disease. These disease causing bacteria, or pathogens, enter the water through leachate from failed septic systems, direct discharges of sewage, malfunctioning sewage treatment plants, leaking sewers, and sanitary landfills.

It is very difficult and expensive to identify specific pathogenic organisms in water samples. Therefore, tests for detection and enumeration of **indicator organisms,** rather than the pathogens themselves, are used. The coliform group of bacteria is currently the principal indicator group used. Coliform bacteria are present in human and animal waste, they survive both in fresh and salt water, living longer than most pathogenic organisms, they do not easily reproduce in the receiving waters, and they are easy to measure. In most cases, elevated coliform populations are suggestive of significant contamination by excrement of warm-blooded animals.

The total coliform test identifies any lactose fermenting, gram negative, non spore-forming rod bacteria. The total coliform group includes many species that are naturally found in soils and vegetation-laden waters. Fecal coliform bacteria are the component of the total coliform population that grow successfully at "body" temperature, or 44.5°C. Because fecal coliform bacteria originate in the gut of all warm-blooded animals, the fecal coliform measurement is not a completely precise test for human fecal pollution. There is no specific test to differentiate the proportion of fecal coliforms contributed by human sewage from those coming from the wastes of other warm-blooded animals like waterfowl, livestock, and family pets. Therefore, shoreline surveys and other investigations of potential sources are critical to the interpretation of bacterial data.

There are two standard methods for the detection and enumeration of coliform bacteria. The **membrane filter technique (MF)** involves direct plating of the coliform bacteria. The **multiple tube fermentation technique (MPN)** involves the examination of replicate tubes and dilutions of the sample water. The results are reported as the Most Probable Number (MPN) of organisms present.

The membrane filter technique is highly reproducible, and is preferred by many volunteer groups. Compared to the MPN method, the MF method is easier for volunteers to perform, is less expensive and yields results quicker. However, there are limitations to the MF method[4]. Turbidity caused by algae, sediment, or solids in wastewater may clog the filter and not allow sufficient sample to be analyzed. Also, low coliform estimates may be caused by the presence of high numbers of non-coliform bacteria, other organisms such as molds or fungi, and toxic substances.

In Rhode Island, the Rhode Island Department of Health and the federal F.D.A. use the MPN method for examining shellfish waters. Median bacterial concentrations should not exceed the following levels for safe shellfishing and swimming in Rhode Island tidal waters:

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[4] APHA, AWWA, WPCF, *Standard Methods for the Examination of Water and Wastewater Seventeenth Edition.* 1989

	TOTAL COLIFORM mean MPN/100 mL	FECAL COLIFORM mean MPN/100 mL
SHELLFISHING	70	15
RECREATION (swimming)	700	50

Rhode Island DEM has the authority to close an area for shellfishing where the median total coliform levels consistently exceed acceptable levels (15 MPN/100 ml). DEM can also **recommend** to towns that a swimming area be closed when levels exceed 50/100 mL.

In fresh waters classified for drinking water supply and swimming, the median bacterial level should not exceed:

	TOTAL COLIFORM mean MPN/100 mL	FECAL COLIFORM mean MPN/100 mL
DRINKING WATER (A)	100	20
SWIMMING (B)	1000	200

Sampling Protocol

It is essential to maintain a sterile environment when performing bacterial monitoring. All sample collection bottles must be sterile. You can autoclave sample bottles to sterilize them, or purchase sterile bottles from a scientific supply company. Bacteria are everywhere, in the air, in the water, on our skin, and on the outside of the sample bottles, so it is important to avoid getting anything in the sample bottle, on the mouth of the bottle, or inside the lid except the water sample you want to test. Water samples should be taken at an arm's depth, not from the water surface. You should not using any pump or other water collection device unless it has been carefully sterilized.

Supplies

Sample Jars (sterile, should hold at least 150 mL)

Dowel or Stick (for taking water sample 2 feet below surface, or for extending the reach of the bottle if sampling from the shore)

Ice (for storing samples in the field. Bacteria samples can only be held for 6 hours before analysis.)

Field Procedures

DO NOT OPEN THE BOTTLE UNTIL YOU ARE READY TO SAMPLE

1. If sampling from the shore, put the bottle onto the stick. If sampling from a boat, roll up your sleeve on the arm you will be sampling with, as close to your shoulder as possible.

2. Take the lid off the sample bottle. Be careful not to touch the inside of the lid or the rim of the bottle. Hold the lid in one hand. Do not put the lid down on the ground or the seat of your boat.

3. **If sampling from the shore:** Sample in water deep enough to prevent contamination from the bottom. (As a rule of thumb, the water should be at least 3 feet deep). Plunge the bottle, neck downward, below the surface of the water. Turn the bottle until the neck points slightly upward and the mouth is directed toward the current. If there is no current, create a current artificially by pushing the bottle forward horizontally in a direction away from your body.

   If sampling from a boat: If there is a current, sample from the upstream side of the boat. With the opening straight down, put the bottle straight down into the water as far as you can reach. Turn the bottle away from you, scoop it forward and up out of the water. Do this in one sweeping motion. Make sure you sample forward and away from you so that there is no chance that you contaminate the sample with bacteria from your skin.

4. Place the lid back on the bottle. Leave ample air space in the bottle (at least 1 inch) to facilitate mixing by shaking before examination.

5. Place the bottle in an ice chest. Bacteria samples must be iced or refrigerated at a temperature of 1 to 4°C during transit to the laboratory. Make sure the sample bottles are **not** totally immersed in water during transit or storage.

6. Samples should be analyzed within 6 hours of sampling and can be held for no longer than 24 hours.

7. Note on field data sheets the presence of any water fowl, swans, geese and their distance from the station.

8. Note on field data sheets any rain fall within the last 48 hours prior to sampling.

NOTE: Things to look out for when selecting a sampling site for bacteria.

> **Do not** Stir up the bottom with oar, prop or sampling stick
> **Avoid** algae mats or debris on water surface
> **Stay away from** oil slicks or scum
> **Do not sample** water fowl or other bird droppings
> **Avoid** prop wash (move station location if necessary)

Analysis

Professional laboratories will test water samples for a fee. If you chose to use their services, most labs will also provide you with the sample bottles. Some volunteer programs have successfully worked out cooperative arrangements with local private laboratories or sewage treatment plant labs. If you can get a chemist or technician at a lab interested in your project, they may volunteer time to run your samples for free or for a nominal fee.

If you are interested in running your own samples, methods for the membrane filter technique and the MPN method can be found in **Standard Methods for the Examination of Water and Wastewater, 17th Edition,** 1989, APHA, AWWA, WPCF. Order from the publications office, American Public Health Association, 1015 15th St., N.W., Washington, DC., 20005.

Volunteer monitoring groups around the country have also developed adaptations of the **Standard Methods** analyses. Method manuals can be obtained from:

The University of Maine Cooperative Extension, 375 Main St., Rockland, ME 04841. They will have a detailed training manual and video on coliform analyses available in the fall of 1992.

GREEN Project, School of Natural Resources, University of Michigan, Ann Arbor, MI 48109-1115 (William Stapp 313-764-1410)

Kits can also be purchased from various scientific supply companies. The following is a partial list of the kits available. We do not endorse the use of any specific kit, and have not conducted studies to evaluate the reliability of each kit.

HACH Company (800-227-4224) makes kits for MPN and MF bacterial testing. They also have a COLIQUIK test for E. coli and total coliform screening.

Millipore Corporation (617-275-9200) has a kit for detecting coliforms.

RCR Scientific (219-533-3351) sells the **redigel** ColiChrome tests for detecting E. coli and total coliforms.

GLOSSARY

Anoxia. A condition of no oxygen in the water. Often occurs near the bottom of eutrophic, stratified lakes in summer; under ice in winter.

Algae. Green plants that occur as microscopic forms suspended in water (phytoplankton), and as unicellular or filamentous forms attached to rocks and other substrates. About 15,000 species of freshwater algae are known.

Algal bloom. A sudden increase in the abundance of suspended (planktonic) algae, especially at or near the water surface, producing a green scum or a "pea-soup" appearance.

Biomass. The weight of biological matter.

Brown water lakes. Lakes which are naturally rich in humic (organic) materials derived from plants, giving the water a "tea" color; "stained" lakes.

Chlorophyll. Green pigments found in plants which are necessary for photosynthesis; may be utilized as an indicator of algal population levels.

Cultural eutrophication. The accelerated enrichment of waters due to the activities of man, such that they support a higher amount of plant and animal matter than they would naturally.

Discharge. Outflow, the flow of a stream, canal, or aquifer.

Ecosystem. A community of plants and animals interacting within the physical and chemical environment.

Effluent. Any treated or untreated liquid waste that flows from an waste treatment facility.

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

Erosion. The wearing away of land surface by wind and water.

Eutrophic. A term used to describe very productive or enriched lakes. These lakes tend to exhibit some or all of the following characteristics: an abundance of rooted plants; turbidity due to high algal populations; loss of oxygen in bottom waters during the summer months; rapid accumulation of soft bottom sediments; and abundant fish, which may include stunted and/or rough species in the most fertile lakes.

Eutrophication. A gradual increase in the productivity of a lake ecosystem due to enrichment with plant nutrients, leading to changes in the biological community as well as physical and chemical changes. This is a natural process, but can be greatly accelerated by man (see cultural eutrophication).

Evaporation. The process by which water is changed from a liquid to a gas or vapor.

Flushing rate. The number of times that the total volume of water in a lake is replaced in a year by inflowing streams, groundwater, precipitation, and overland runoff.

Food chain. The dependence of one type of life on another, each in turn eating or absorbing the next organism in the chain. Grass is eaten by a cow, cow is eaten by man. This food chain involves grass, cow, man.

Habitat. The place where a plant or animal lives, which has all of the conditions necessary to support its life and reproduction.

Hydrology. The science of the behavior of water in the atmosphere, on surface of the earth, and underground.

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

Infiltration. The flow of a fluid into a substance through pores or small openings. The common use of the word is to denote the flow of water into soil material.

Leaching. The removal in solution of the more soluble minerals by percolating waters.

Mainstem. The main channel of a river, stream or estuary.

Mesotrophic. A term used to describe lakes which are moderately productive. These lakes tend to exhibit some or all of the following characteristics: moderate growth of rooted plants and algae; some loss of oxygen from bottom waters during the summer months; some sediment accumulation; relatively good fish production of cool or warm water species, such as walleye, perch, bass, pike, and panfish. The majority of lakes are placed in this category.

Metalimnion. The layer of rapidly changing temperature and density which separates the hypolimnion from the epilimnion.

Nitrogen. An element necessary for the growth of the aquatic plants; may be found in several forms, including nitrates, nitrites, and ammonia.

Nutrient. Any of a group of elements necessary for growth. Although over 15 elements have been identified as necessary for growth of aquatic plants, most are readily available in natural waters. Supplies of phosphorus or nitrogen may be depleted, however, thus limiting plant growth in surface waters.

Oligotrophic. A term used to describe a relatively unproductive lake or one poorly supplied with plant nutrients. Because of low biological production, these lakes tend one poorly supplied with plant nutrients. Because of low biological production, these lakes tend to exhibit some or all of the following characteristics: clear waters; limited growth of algae or rooted plants; bottom waters well supplied with oxygen throughout the year; low rate of sediment accumulation; low fish production, but often of desirable species, such as trout, walleye, or perch.

Plankton. The community of micro-organisms, consisting of plants (phytoplankton) and animals (zooplankton) inhabiting open-water regions of lakes and rivers.

Phosphorus. An element necessary for the growth of aquatic plants. It is naturally present in low concentrations, and lack of phosphorus often limits plant growth.

Thus the addition of phosphorus can affect water quality by increasing the production of algae and rooted plants.

Producers. Green plants that manufacture their own food through photosynthesis.

Productivity. The amount or mass of living things which can be supported by an ecosystem (e.g., a lake) over a specified period of time.

Photosynthesis. Conversion of water and carbon dioxide in the presence of sunlight to carbohydrates.

Residence Time. The average time required to completely renew a lake's water volume is called the hydraulic residence time. Short residence times are ten days or less, long residence times are greater than one hundred days.

Secchi disk. A simple device widely used to measure the transparency or clarity of water, consisting of a metal or plastic plate, usually 8" in diameter, painted black and white, on a calibrated line.

Secchi depth transparency. The depth at which a Secchi disk disappears from view when lowered into the water. A measure of water clarity.

Sediment. Solid material including both soil particles and organic matter which is suspended in the water and gradually deposited in the bottom of a lake.

Standard deviation. A statistical term used to describe the amount of variation in a set of data; 68% of all measurements are expected to fall within plus- or minus-one standard deviation from the mean (average).

Thermocline. A horizontal plane of water across the lake through the point of greatest temperature change. It is within the metalimnion.

Tributary. A stream or river that flows into a larger stream, river or lake.

Trophic state. The level of productivity in a lake, or degree of eutrophication; generally described as eutrophic (very productive).

Trophic State Index (TSI). A numerical scale used to classify lakes according to productivity (the amount of living material supported by the lake). The TSI value (0-100) is calculated directly from Secchi depth transparency, phosphorus concentration, or chlorophyll a concentration.

Turbid. Cloudy, not clear.

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

REFERENCES

Adopt a Stream. 1992. *Chemical Characteristics Monitoring, A Stream Team Monitoring Project.* Boston, MA: Massachusetts Adopt a Stream, Riverways Program.

American Public Health Association. 1989. *Standard Methods for the Examination of Water and Wastewater. 17th ed.* Baltimore: American Public Health Association, American Water Works Association, Water Pollution Control Federation.

Delta Laboratories, Inc. 1987. *Adopt-A-Stream Teacher's Handbook.* Webster, NY: Printed Creations.

Dexter, B.L. and R.B. Harris. 1992. *Water Quality Monitoring, A Guide for Concerned Citizens.* Long Island Sound Task force.

Ellett, K.K. 1986. *Citizen Monitoring Manual.* Baltimore, MD: Citizens Program for the Chesapeake Bay, Inc.

Green, L. T. 1990. *Rhode Island Watershed Watch Monitoring Procedures.* College of Resource Development, University of Rhode Island.

Kerr, M. 1992. River Rescue Water Quality Testing Field Procedures Manual. Narragansett, RI: URI Coastal Resources Center.

LaMotte Company Staff. 1992. *The Monitor's Handbook.* Chestertown, MD: LaMotte Company.

Lee, V., D. Avery, E. Martin, N. Wetherell. 1991. *Salt Pond Watchers Protocol #1, Field Sampling Manual.* Narragansett, RI: URI Coastal Resources Center.

Mitchell, M.K. and W.B. Stapp. 1988. *Field Manual for Water Quality Monitoring, An Environmental Education Program for Schools, 3rd ed.* Dexter, MI: Thomas-Shore, Inc.

Tennessee Valley Authority. 1992. *Teacher-Student Water Quality Monitoring Network, Fall Workshop Teacher Guide.* TVA, Norris, TN.

U.S. Environmental Protection Agency. 1991. *Volunteer Lake Monitoring: A Methods Manual.* EPA 440/4-91-002, Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 1990. *Volunteer Water Monitoring: A Guide for State Managers.* Washington, D.C.: U.S. EPA Office of Water Regulations and Standards, Assessment and Watershed Protection Division, Washington, DC.

Suggested Literature and Other Sources of Information

Cooke, G.D., Welch, E.B., Peterson, S.A. and Newroth, P.R. 1986. *Lake and Reservoir Restoration*. Butterworth Publ. Stoneham, MA.

Ellett, K. January, 1988. *An Introduction to Water Quality Monitoring Using Volunteers - A Handbook for Coordinators*. Citizens Program for the Chesapeake Bay, Inc. Baltimore, MD.

Green, L. April, 1990. *Rhode Island Watershed Watch Monitoring Procedures*. The University of Rhode Island, Department of Natural Resources Science, RI Cooperative Extension.

Illinois Department of Energy and Natural Resources. August, 1990. *Citizens Steam Monitoring - Manual for Illinois*.

Joubert, L. and A. Gold. June, 1990. *Rhode Island Watershed Watch - Shoreline Survey Manual for Lakes, Rivers and Streams*. The University of Rhode Island, Department of Natural Resources, RI Cooperative Extension.

Kopec, J. and S. Lewis. _______. *Stream Quality Monitoring: A Citizen Action Program*. Ohio Department of Natural Resources, Division of Natural Areas & Preserves, Scenic Rivers Program.

Massachusetts Adopt-a-Stream Program. March, 1992. *Chemical Characteristic monitoring, A Stream Team Monitoring Project*. Riverways Program Massachusetts Fisheries, Wildlife and Environmental Law Enforcement, Boston, MA.

Meeker, S., Reid, A., Schloss, J., Hayden, A. February, 1992. *Great Bay Watch A Citizen Water Monitoring Program Manual*. University of New Hampshire/U Maine Sea Grant Program, Durham, NH.

Mitchell, M. and W.B. Stapp. 1990. *Field Manual for Water Quality Monitoring - An Environmental Education Program for Schools*. Thomson-Shore, Inc. Dexter, Michigan.

National Conference on Enhancing the States' Lake Management Programs, Integrating Stormwater & Local Nonpoint Source Issue. January, 1991. U.S. Environmental Protection Agency and National American Lake Management Society. Washington, DC.

New Hampshire Fish and Game Department and University of New Hampshire. 1991. *Stream Study and Water Quality Assessment Curriculum*. NH Dept. of Fish & Game, Public Affairs Division, Concord, NH.

New York Department of Environmental Conservation & Federation of Lake Association, Inc. 1990. *Diet for a Small Lake: A New Yorkers Guide to Lake Management*. Albany, New York.

Olem, H. and G. Flock, eds. August, 1990. *The Lake and Reservoir Restoration Guidance Manual*. 2nd ed. EPA 440/4-9--006. Prep. N. Am. Lake Management Society for U.S. Environmental Protection Agency, Office Water, Washington, DC.

Protocol Manual for Salt Pond Watchers. May, 1991. Rhode Island Sea Grant, Coastal Resources Center, University of Rhode Island, Technical Report #12.

Rhode Island Department of Environmental Management. April, 1990. *An Assessment of Nonpoint Sources of Pollution to RI's Waters,* State of the States' Water - Report to Congress.

Rhode Island Department of Environmental Management. February, 1977. *Fisheries Investigation & Management in Rhode Island's Lakes and Ponds.* Fisheries Report #3. Division of Fisheries and Wildlife.

Rhode Island Department of Environmental Management. April, 1989. *Rhode Island Nonpoint Source Management Plan.* Office of Environmental Coordination, Providence, RI.

Rhode Island Department of Environmental Management. September, 1976. *Rhode Island Lakes & Ponds - Fisheries Inventory.* Fisheries Report #2. Division of Fish and Wildlife, Providence, RI.

Rhode Island Department of Environmental Management. August, 1992. *State of the States' Water - Report to Congress - PL92-500, 305b.* Division of Water Resources, Providence, RI.

Rhode Island Department of Health. April, 1970. *Rhode Island Lakes & Ponds.* State of Rhode Island Water Resources Board. Providence, RI.

Standard Methods for the Examination of Water and Wastewater. 16th ed. 1985. Am. Pub. Health Ass., Am Water Works Ass., and Water Pollution control Federation 1985. American Public Health Association. Washington, DC.

Synder, Hank. 1991. *The Delaware Riverkeeper Network: Volunteer Manual.* Lambertville, NJ.

U.S. Environmental Protection Agency. April, 1985. *Coastal Marina Assessment Handbook.* EPA 904/6-85-132. Region 4, Georgia.

U.S. Environmental Protection Agency. 1980. *Guidelines and Specification for Preparing Quality Assurance Project Plans.* QAMS - 005/80. Washington, DC.

U.S. Environmental Protection Agency. April, 1990. Rhode Island Sea Grant Program, University of Rhode Island. *National Directory of Citizen Volunteer Environmental Monitoring Programs.* EPA 440/9-90-004. Office Water, Washington, DC.

U.S. Environmental Protection Agency. August, 1989. *Saving Bays and Estuaries - A Primer For Establishing and Managing Estuary Projects,* EPA/503/8-9-001. Office of Marine and Estuarine.

U.S. Environmental Protection Agency. July, 1986. *Septic Systems & Groundwater Protection, An Executive Guide.* Office of Groundwater Protection, Washington, DC.

U.S. Environmental Protection Agency. December, 1991. *Volunteer Lake Monitoring: A Methods Manual.* EPA 440/4-91-002. Office of Water, Washington, DC.

U.S. Environmental Protection Agency. August 1990. *Volunteer Water Monitoring: A Guide for State Managers.* EPA 440/4-90-010. Office Water, Washington, DC.

APPENDIX A

Example Instructions for Volunteer Field Work
(From: Rhode Island Watershed Watch)

DEEP PONDS: **Weekly and Biweekly Monitoring**

This section summarizes the monitoring procedures used. Detailed descriptions of each procedures can be found in Section III, Specific Monitoring Methods. Items and steps preceded with and asterisk (*) are for **biweekly monitoring only**.

1. Before going out on the water **go over this checklist** to make sure you have everything you need. Have all testing items set out on-shore and inside to test your samples as soon as you come off the water.

   On the water:

   life preservers
   anchor
   map of pond with landmarks noted
   pencil and notepad
   secchi disk, line, 2 clothespins
   view tube
   * thermometer
   * water sample and lines
   * white plastic bottle
   * clear glass dissolved oxygen bottle with stopper
   * insulated cooler bag

   On shore:

   * chlorophyll filtration apparatus
     syringe
     2 round plastic filter holders
     2 small filter circles
     forceps
     squeeze bottle containing magnesium carbonate
     1 large filter circles, torn in half
     2 aluminum foil squares
     labeling tape and pen
   * dissolved oxygen kit

2. Proceed to your location, anchor your boat.

3. Make your first set of **secchi depth transparency** measurements.

*4. **Rinse** the water sampler with surface water.

*5. Close the lid on the sampler and plug top with stopper. Do not put the glass bottle inside.

*6. Lower **sampler to 1 meter depth**, pull out the stopper, wait about 1 minute, then pull the sampler rapidly to the surface.

*7. Rinse white plastic bottle with a little of the 1 meter water, then pour remaining contents of sample into the bottle.

*8. Put **thermometer** in white plastic bottle, cap bottle, place out of direct light.

9. Make second set of **secchi depth transparency** measurements.

*10. **Record temperature** of 1 meter water.

*11. Place glass **dissolved oxygen bottle into sampler**. Secure lid on top making sure that inlet tube extends into bottle.

*12. Lower **sampler to 5 meter depth**, pull out stopper. Raise sampler after 1 minute and restopper, leaving glass bottle inside. Store sampler out of sunlight, but not in cooler.

13. **Check depth to bottom** with your secchi disk. Return to shore.

*14. Once on shore remove glass bottle from sampler and **immediately** perform the first three steps of the dissolved oxygen analysis.

*15. Measure and record **temperature of 5 meter water** remaining in sampler. Complete dissolved oxygen analysis.

*16. Perform the chlorophyll filtration **twice** on 1 meter water sample, remembering to properly label your filters before freezing them.

*17. Rinse all apparatus with tap water, air dry on a paper towel.

18. **Fill out and mail in postcard weekly**.

DEEP PONDS: Triseason Water Sampling

1. Before going out on the water go over this checklist to make sure you have everything you need. Have all testing items set out on-shore and inside to test your samples as soon as you come off the water.

   On the water:

   life preservers
   anchor
   map of pond with landmarks and sampling site noted
   secchi disk, line, 2 clothespins
   view tube
   water sampler and lines
   bacterial monitoring bottle (labeled "autoclaved")
   2 white plastic bottles, labeled "shallow" and "deep"
   2 brown glass bottles, labeled "unfiltered-shallow" and "unfiltered-deep"
   2 clear glass dissolved oxygen bottles with stoppers, labeled "shallow" and "deep"
   thermometer
   insulated cooler bag

   On shore:

   chlorophyll filtration apparatus
   - syringe
   - 2 round plastic filter holders
   - 4 small filter circles
   - 2 large filter circles, torn in half
   - tweezers or large safety pin
   - squeeze bottle containing magnesium carbonate
   - 4 aluminum foil squares
   - labeling tape
   - 2 brown bottles labeled "filtered-shallow" and "filtered-deep"

   dissolved oxygen test kit

2. Proceed to your sampling location, **anchor** your boat.

3. Make your first set of **secchi depth transparency** measurements.

4. Perform **bacterial monitoring** in water at arm's depth, removing "autoclaved" label just before sampling. Do not touch inside of bottle or lid. Do not put lid on boat seat. Do not use any water sampling device. Recap bottle immediately after sampling and place in cooler.

5. **Rinse** your water sampler with surface water.

6. Close the lid on the sampler and plug top with stopper. Do not put glass dissolved oxygen bottle inside.

7. Lower the sampler to 1 meter depth, pull out the stopper, wait about 1 minute, then pull the sampler rapidly to the surface.

8. Rinse the "shallow" white plastic and brown bottles with some of the 1 meter water.

9. Repeat steps 6-7 to **fill (with 1 meter** water) the "shallow" white plastic bottle and the "unfiltered-shallow" brown bottle.

10. Measure the **temperature** of the 1 meter water in the plastic bottle. Place bottle in cooler bag.

11. Put a clear glass **dissolved oxygen bottle in sampler.** Secure lid and stopper, making sure that inlet tube extends into bottle. Lower to 1 meter, pull; out stopper to obtain sample for dissolved oxygen. After 1 minute raise sampler. Remove lid of sampler and cap glass bottle **while in sampler**. Remove glass bottle and place in cooler bag.

12. Make second set of **secchi depth transparency** measurements.

13. Repeat steps 6-10 **sampling at 5 meters**. Make sure the plastic and brown glass bottles filled are labelled "deep." Check the **temperature of the 5 meter water.**

14. Place "deep" **(five meter)** clear glass **dissolved oxygen** bottle into sampler. Secure lid on tap, making sure that the inlet tube extends into the bottle.

15. Lower the sample to 5 meter depth, pull out stopper. After 1 minute raise sampler. **Do not open sampler to remove glass bottle.**

16. Check **depth to pond bottom** with your secchi disk.

17. Once on-shore, remove the glass bottle from the sampler and perform the first three steps of **dissolved oxygen analysis** immediately on it **and** on the sample in the glass bottle labeled "shallow."

18. While waiting for the D.O. flocculant to settle, **out of direct sunlight** perform the chlorophyll filtration **twice** on shallow and deep water samples, taking care to properly label the filters before freezing them. Remember to **save the filtered water** in the brown glass bottles so labelled, as well as the water remaining in the white plastic bottles.

19. **Finish the dissolved oxygen analyses**, flush chemicals down the drain with plenty of water. Rinse all apparatus with tap water; air dry on a paper towel.

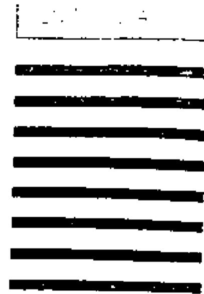
20. Bring WW postcard, water samples and frozen filters to URI.

APPENDIX B

Example Data Sheets

BUSINESS REPLY MAIL
FIRST CLASS MAIL PERMIT NO 1 WAKEFIELD, RI 02879

POSTAGE WILL BE PAID BY ADDRESSEE



ATTN: Linda Taylor Green
RI Watershed Watch
The University of Rhode Island
P.O. Box 800
Kingston, RI 02881-9900

LOCATION:
CODE #:
DATE MONITORED: (mo/day/yr)

MONITORS:

TIME: (military)

(circle best descriptions)

LIGHT:	1=Distinct shadows,	2=no shadows,	3=Very Overcast	
WIND: 0=Calm,	1=Light,	2=Gentle,	3=Moderate,	4=Strong
RAIN W/IN 48 HR:	1=None,	2=Light,	3=Moderate,	4=Heavy

SECCHI DEPTH (measure 4X) _______ , _______ , _______ , _______ meters
BOTTOM DEPTH ______ m, SECCHI VISIBLE ON BOTTOM: yes or no

WATER TEMPERATURE _______ , _______ , _______ Degrees C
AT WHAT DEPTH ? _______ , _______ , _______ meters
DISSOLVED OXYGEN: _______ , _______ , _______ mg/l

CHLOROPHYLL SAMPLES FILTERED/FROZEN: yes or no (circle one)

STATE OF TIDE: EBB____ FLOOD____ HIGH____ LOW____ N/A____

SALINITY: water temp ______ deg. C, at what depth? ______ m
Density 1. _ _ _ _ g/cc
Correction + or - 0 _ _ _ _
Corrected Density 1. _ _ _ _
Salinity ________ ppt

SECCHI MONITORING
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
VOLUNTEER LAKE MONITORING PROGRAM

(Please print, using ink pen)

Lake Name ______________________ County: ______________________

Volunteer's Name(s) ______________________

Volunteer's Address (if new or changed) ______________________

Date: ______________________ Telephone: ______________________

Directions: Anchor boat at sampling site. Record time in blank for that site. Measure total depth and record to closes[t] foot in blank for that site. Measure Secchi disc depth: lower disc until it disappears and note depth; raise until ap[pears] again and note depth. Average the two and record to the nearest inch in the blank for that site. Repeat for other site[s]. *conversion table from feet to inches is provided on the back of this form.)*

COLUMN 1	COLUMN 2 Place number recorded in blank and circle appropriate time units.	COLUMN 3 FOR AGENCY USE ONLY
SITE #1		STATION CODE S C , , 1-14
Time	______ AM or PM (Circle AM or PM)	YR. MO. DAY 15-20; HR. MIN. 21-25; DEPTH OF SAMPLE 0 0 0 1 , 26
Total Depth	______ feet (to closest 1/2 foot)	Total Depth (feet) P 7 2 0 2 5 , , 31-43
Secchi Disc Depth	______ inches (to closest inch)	Secchi (inches) P 7 7 , , 44-53
SITE #2		STATION CODE S C , , 1-14
Time	______ AM or PM (Circle AM or PM)	YR. MO. DAY 15-20; HR. MIN. 21-25; DEPTH OF SAMPLE 0 0 0 1 , 26
Total Depth	______ feet (to closest 1/2 foot)	Total Depth (feet) P 7 2 0 2 5 , , 31-43
Secchi Disc Depth	______ inches (to closest inch)	Secchi (inches) P 7 7 , , 44-53
SITE #3		STATION CODE S C , , 1-14
Time	______ AM or PM (Circle AM or PM)	YR. MO. DAY 15-20; HR. MIN. 21-25; DEPTH OF SAMPLE 0 0 0 1 , 2[6]
Total Depth	______ feet (to closest 1/2 foot)	Total Depth (feet) P 7 2 0 2 5 , , 31-43
Secchi Disc Depth	______ inches (to closest inch)	Secchi (inches) P 7 7 , , 44-53

IL 532 0941
DWPC 368 Rev. 04 84

This Agency is authorized to request this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1004(b). Disclosure of this information is voluntary. This form has been approved by the Forms Management Center.

FIE
ILLINOIS ENVIRO
VOLUNTEER L

To be completed each date a Secchi disc reading is made. Please print, using ink pen)

Lake Name ______________________ County ______________________

Volunteer's Name(s) ______________________

Date ______________________

DIRECTIONS. Please place number(s) in blanks which best describe lake conditions at the time sampled. On page 2, record [illegible] for each s[illegible] the lake. NOTE OBSERVATIONS FOR COLOR, SEDIMENT, ALGAE, AND WEEDS AT SAMPLE SITE AS YOU ARE LOOKING DOWN INTO [illegible] WATER AT THE SECCHI DISC. On page 3, record observations for lake as a whole.

	Site 1	Site 2	Site 3
A. **Color.** The apparent color of the water is:	____	____	____

1. clear
2. light green
3. moderately green
4. very green
5. pea soup
6. greenish-brown (more green than brown)
7. brownish-green (more brown than green)
8. light brown
9. moderately brown
10. very brown
11. milky chocolate
12. tan
13. yellowish
14. grayish
15. other (specify)

	Site 1	Site 2	Site 3
B. **Sediment.** The amount of suspended sediment in the water is:	____	____	____

1. none/minimal
2. slight
3. moderate
4. substantial

	Site 1	Site 2	Site 3
C. **Algae.** The amount of suspended algae in the water is:	____	____	____

1. none/minimal
2. slight
3. moderate
4. substantial

	Site 1	Site 2	Site 3
D. **Weeds at Sample Site.** The amount of submergent or floating aquatic weeds at the sample site is:	____	____	____

1. none/minimal
2. slight
3. moderate
4. substantial

	Site 1	Site 2	Si[illegible]
E. **Weeds Near Shore.** The amount of aquatic weeds in shoreline areas near the sample site is:	____	____	____

1. none/minimal
2. slight
3. moderate
4. substantial

F. **Other Substances.** The following substances are present:

1. none
2. dead fish
3. garbage
4. leaves, debris
5. oil films
6. "grass clippings" algae
7. algal mats
8. algal colonies
9. filamentous algae
10. duckweed
11. clumps of sediment
12. waterfowl
13. other (specify)

AT SAMPLE SITE:

Site 1	Site 2	Si[illegible]
____	____	____

SHORELINE AREA[illegible]

Site 1	Site 2	Si[illegible]
____	____	____

	Site 1	Site 2	Si[illegible]
G. **Odor.** The odor of the water is:	____	____	____

1. no odor
2. fishy
3. musty
4. rotten egg
5. septic
6. other (specify)

H. Previous Week's Weather:

During the past 7 days, which days had measurable rainfall and what amount?

Days Prior to Sampling	Amount of Rainfall	(Place appropriate # in blank) Rainfall ranges
7	________	0. no rain
6	________	1. trace (0 - 0.1 in.)
5	________	2. light (0.11 - 0.5 in)
4	________	3. moderate (0.51 - 1.0 in.)
3	________	4. heavy (1.1 - 2.0 in.)
2	________	5. very heavy (more than 2 in)
1	________	
today (since midnight)	________	

Weather conditions since last sampling period (wind, cloud cover, temperature, rainfall, etc.) particularly noting any unusual conditions.

____

____

____

____

____

I. Current Weather

Cloud Cover over Lake is: ____________

1. clear
2. hazy
3. few clouds
4. many clouds
5. overcast

Waves are: ____________

1. calm
2. ripple waves
3. small waves
4. moderate waves
5. white caps

Air Temperature at Lake is: ____________

1. cold (less than 40°)
2. cool (41°-60°)
3. warm (61°-80°)
4. hot (81°-90°)
5. very hot (over 90°)

Wind Speed at Lake is: ____________

1. calm
2. breezy
3. strong
4. gusty

Wind Direction at Lake is: ____________

1. north
2. south
3. east
4. west

J. Water Level of Lake: (use code)

1. above normal
2. normal or full
3. below normal

If lake is not at normal level, specify # inches ____ above or ____ below normal

K. Recreational Usage

Recreational usage at time sampled (circle all applicable uses)

1. none
2. fishing
3. swimming
4. power boating
5. waterskiing
6. row boating or canoeing
7. sailing
8. waterfowl hunting
9. camping
10. picnicking
11. other (specify)

L. Lake/Watershed Management

Chemicals or other lake/watershed management techniques u[sed] since last sampling

Date ______________________________

Type, extent, and amount of treatment____

____

____

____

____

Reason for treatment ____________________

____

____

____

M. IMPORTANT! Please provide any additional comments or obser[va]tions on current lake quality, changes observed since last samp[ling] date, pumpage into reservoir, etc.

____

____

____

____

RETURN TO: Kathleen Ellett
c/o Chesapeake Bay Program
410 Severn Ave. Suite 110
Annapolis, Md 21403

CITIZENS PROGRAM FOR THE CHESAPEAKE BAY
CITIZEN MONITORING PROGRAM
DATA COLLECTION FORM

PATUXENT RIVER

Collection Date: ____________________

Time of Day: ____________________

Monitor Name: ____________________ Monitor Number: ________

Site Name: ____________________ Site Number: ________

Air Temperature: ____________________ C

Secchi Depth: ____________________ m

Water Depth: ____________________ m

Water Temperature: ____________________ C
(In bucket)

Hydrometer Reading: ____________________ Salinity: ________ 0/00

____

Water Temperature: ____________________ C
(In hydrometer jar)

pH: ____________________ SU (Standard Units)

Dissolved Oxygen: Test 1: ______ Test 2: _____ Average: ______mg/l (ppm)

Water Surface: (Circle one)
1 Calm 2 Ripple 3 Waves 4 White Caps

Weather: (Circle one)
1 Cloudless 2 Partly Cloudy 3 Overcast 4 Fog/Haze
5 Drizzle 6 Intermittent Rain 7 Rain 8 Snow

Rainfall: ________ mm (Weekly accumulation, enter '0' if no rainfall)

Other: (Circle ones that apply)
1 Sea Nettles 2 Dead Fish 3 Dead Crabs 4 SAV
5 Oil Slick 6 Ice 7 Debris 8 Erosion
9 Foam 10 Bubbles 11 Odors

Water Color: (Circle one and describe) Normal Abnormal

Comments: (Observations about your site)

Signature: ____________________ Date: ____________________

RHODE ISLAND POND WATCHER FIELD DATA SHEET, 1989 -1990

(Please fill out a data sheet for <u>each</u> station, fill it out on the pond, it is OK if it is messy).

NAME ________________ POND ________________ STATION __________

DATE ________________ TIME ________________

TYPE OF SAMPLE (Please check if sampled)

BACTERIA _____ CHLOROPHYLL A _____ NUTRIENTS _____ D.O.______

STATION AREA DESCRIPTION (Please fill in appropriate information)

I. PHYSICAL CHARACTERISTICS

1. Water Temperature (^{o}C) ________
2. Secchi Disc Depth a.__________ (in rope units) b.___________ meters
3. Depth to Bottom a.__________ (in rope units) b.___________ meters
4. Dissolved Oxygen: Test 1:_______ Test 2:_______ Average:______mg/l (ppm)

II. WEATHER AND TIDE (within last 24 hours)

1. a. Cloudless b. Partly Cloudy c. Overcast d. Fog/Haze e. Drizzle f. Showers g. Downpour h. Snow
2. Wind: _________ miles per hour from ___________direction
4. Tide or pond level: low medium high

III. POND CONDITIONS

1. Pond surface calm ripple waves white caps
2. Sea grass (condition): clean green fouled brownish

IV. POND & SHORELINE ACTIVITY

1. Swans, waterfowl at station prior to arrival

Distance	0ft	5ft	10ft	25ft	50ft
Number	___	___	___	___	___

2. Fishing	lots	some	none
3. Motor boating	lots	some	none
4. Shoreline construction	lots	some	none
5. Road runoff or discharges observed	Yes		No

V. OTHER

Please use back of page for more comments if needed.

APPENDIX C

Several companies sell kits that can be used for testing water samples. Some companies are listed below.

Company	Products
LaMotte Chemical Products Co. P.O. Box 329 Chestertown, MD 21620 1-800-344-3100	Chemical test kits for field and lab
HACH Company P.O. Box 389 Loveland, CO 80539 1-800-227-4224	Chemical test kits for field and lab
Fisher Scientific 461 Riverside Ave. PO Box 379 Medford, MA 02155 (617) 391-6110	Scientific Instruments and chemicals
Thomas Scientific 99 High Hill Rd. PO Box 99 Swedesboro, NJ 08085-0099 1-800-345-2100	Scientific instruments and chemicals
Millipore Corporation 80 Ashby Rd. Bedford, MA 01730 (800)-225-1380	Specialize in bacterial testing

APPENDIX D

UNITS OF MEASUREMENT

Acre (ac). An acre is equal to 43,560 square feet, approximately 0.4 hectare.

Centimeter (cm). One one-hundredth of a meter, equivalent approximately to two-fifths of an inch.

Concentration. The ratio of the amount of one substance in another substance. For example, in seawater, the amount of chloride dissolved in water is approximately 18,000 milligrams per liter.

Gram (g). One one-thousandth of a kilogram.

Hectare (ha). Metric measurement for area equivalent to 10,000 square meters or approximately 2.5 acres.

Kilogram (kg). The base unit for mass in the metric system; 1000 grams or approximately 2.2 pounds.

Liter (L). A unit of metric measurement for volume; roughly equivalent to 1 quart or 0.25 gallon.

Mass. In common usage, mass is used synonymously with weight; the common English unit for mass is pounds (lb) while the metric system uses the kilogram (kg).

Meter (m). The basic metric unit for length; equivalent to approximately 3.25 feet.

Metric System. An international system of scientific measurements based on multiples of 10.

Microgram (ug). One one-millionth of a gram, one one-thousandth of a milligram.

Micrograms per Liter (ug/L). An expression for concentration usually in reference to a liquid, roughly equivalent to parts per billion.

Milligram (mg). One one-thousandth of a gram.

Milligrams per Liter (mg/L). An expression for concentration, usually in reference to a liquid, roughly equivalent to parts per million.

Millimeter (mm). One one-thousandth of a meter; 1 inch equals approximately 25 mm.

COMMON CONVERSIONS

Length

inch	=	25.4 millimeters
foot	=	0.3048 meters
mile	=	1.609 kilometers

Area

sq. foot	=	0.09290 square meters
acre	=	0.001563 square miles
hectare	=	10,000 sq. meters
hectare	=	2.471 acres

Discharge (flow rate, volume/time)

cubic ft/sec	=	0.6463 million gal/day
cubic ft/sec	=	448.8 gallons/min
cubic ft/sec	=	28.32 liters/sec

Volume

US gallon	=	231.0 cubic inches
US gallon	=	3.785 liters
cubic foot	=	0.02832 cubic meters
acre-foot	=	43560 cubic feet

Velocity

foot/sec	=	86400 foot/day
foot/sec	=	0.6818 mile/hr
mile/hr	=	1.609 kilometer/hr

Mass

pound	=	0.4536 kilogram
kilogram	=	0.06852 slug
metric ton	=	1000 kilogram

APPENDIX E

Rhode Island and Massachusetts Water Classifications

Class	Rhode Island	Massachusetts
A	Drinking Water Supply	Drinking Water Supply Fish and Wildlife Habitat Suitable for Primary and Secondary Recreation
B	Public Water Supply with Appropriate Treatment Agricultural Uses Bathing, Other Primary Contact Recreational Activities Fish and Wildlife Habitat	Public Water Supply with Appropriate Treatment Agricultural Uses Primary and Secondary Contact Recreation Fish and Wildlife Habitat Industrial Cooling and Process
C	Boating and Other Secondary Contact Recreational Activities Fish and Wildlife Habitat Industrial Processes and Cooling	Secondary Contact Recreation Fish and Wildlife Habitat Irrigation Industrial Cooling and Process
SA	Shellfish Harvesting for Direct Human Consumption Bathing and Primary Contact Recreation Fish and Wildlife Habitat	Shellfish Harvesting for Direct Human Consumption Primary and Secondary Contact Recreation Fish and Wildlife Habitat
SB	Shellfish Harvesting for Human Consumption After Depuration Bathing and Primary Contact Recreation Fish and Wildlife Habitat	Shellfish Harvest for Human Consumption after Depuration Primary and Secondary Contact Recreation Fish and Wildlife Habitat
SC	Boating and Other Secondary Contact Recreation Fish and Wildlife Habitat Industrial Cooling Good Aesthetic Value	Secondary Contact Recreation Fish and Wildlife Habitat Industrial Process and Cooling

Rhode Island and Massachusetts Water Quality Standards

Class A

Parameter	Rhode Island	Massachusetts
Dissolved Oxygen	75% saturation, 16 hrs/day Not < 5 mg/l at any time	Not < 6.0 mg/l nor < 75% saturation due to discharge; site specific criteria can be developed for background levels
Temperature	No temperature increase other than natural	Not >68 ° F in cold water fisheries or > 83 ° F in warm water fisheries. No changes that will impair uses assigned to this Class
pH	As naturally occurs	6.5 - 8.3 SU, not more than 0.5 units outside background range
Fecal Coliform	Not > 20/100 ml, nor shall 10 % > 200/100 ml	Not > 20 organisms/100 ml, nor shall 10 % > 100/100 ml
Solids	None allowed	None allowed that impair use Discharge shall not raise background levels > 3 mg/l
Color/Turbidity	None other than natural. Turbidity < 5NTU over bkgrd (<50 NTU) or less than 10 % increase (>50 NTU)	None that will impair use Color not > 15 color units unless naturally higher, rise in turbidity over background not > 5 NTU
Oil and Grease	None allowed	None allowed
Taste and Odor	None other than natural.	None other than natural

Class B

Parameter	Rhode Island	Massachusetts
Dissolved Oxygen	75% saturation, 16 hrs/day. Not < 5 mg/l at any time	Cold water: Not < 6.0 mg/l , nor < 75% saturation; Warm water: not < 5.0 mg/l nor < 60% saturation due to discharge; site specific criteria allowed
Temperature	Only increases than will not impair uses allowed	Cold water: Not >68° F, no more than 3°F rise Warm water: Not > 83° F, no more than 5°F rise. No changes that will impair uses assigned to this Class
pH	6.5 - 8.0, or as naturally occurs	6.5 - 8.3 SU, not more than 0.5 units outside bkgrd
Fecal Coliform	Not > 200/100 ml, nor shall 20 % > 500/100 ml	Not > 200 organisms/100 ml, nor shall 10% > 400/100 ml
Solids	None allowed.	None allowed that impair use, discharge shall not raise bkgrd > 3 mg/L
Color/Turbidity	None that would impair use. Turbidity: < 10 NTU over bkgrd (< 50 NTU), or < 20% increase (>50 NTU)	None that will impair use. Color: Discharge may not increase color more than 10% nor exceed 50 color units. Turbidity: discharge may not increase bkgrd more than 5 NTU (<50 NTU) or than 10% (>50 NTU). Max. increase above bkgrd < 25 NTU
Oil and Grease	None allowed	No oils, grease and petrochemicals that produce a visible film, impart an oily taste to the water or an oily or undesirable taste to edible portions of aquatic life, or deleterious to aquatic life
Taste and Odor	None that would impair use or taint edible portions of fish	None that are aesthetically objectionable, would impair uses or taint edible aquatic life

Class C

Parameter	Rhode Island	Massachusetts
Dissolved Oxygen	Not < 5 mg/l	Not <5 mg/L for 16 hrs., never < 3 mg/L. Site specific criteria allowed
Temperature	Increases allowed that will not impair uses and not promote growth of unfavorable biota	Not > 85° F, no more than 5°F rise. No changes that will impair uses assigned to this Class
pH	6.0 - 8.5 SU	6.5 - 9 SU, not more than 1.0 unit outside bkgrd
Fecal Coliform	Not applicable	Not > 1000 organisms/100 ml, nor shall 10 % > 2000/100 ml
Solids	Only allowed if discharged with properly treated sewage	None allowed that impair use, conc. < 80 mg/L
Color/Turbidity	None that will impair use. Turbidity < 10 NTU over bkgrd (<50 NTU), or < 20 % increase (>50 NTU)	None that will impair use, or are aesthetically objectionable
Oil and Grease	Only allowed if discharged with properly treated sewage	No oils, grease and petrochemicals that produce a visible film, impart an oily taste to the water or an oily or undesirable taste to edible portions of aquatic life, or deleterious to aquatic life
Taste and Odor	None that would impair uses or taint edible portions of fish	None that are aesthetically objectionable, would impair uses or taint edible aquatic life

Class SA

Parameters	Rhode Island	Massachusetts
Dissolved Oxygen	Not <6.0 mg/l at any time	Not <6.0 mg/l nor <75% saturation due to discharge; site specific for background levels
Temperature	Not >28.3°C nor a rise of >0.9°C June–Sept, and not >2.2°C Oct–June	Not >29.4°C nor >26.7°C daily mean; rise not >0.8°C; will not impair use; Sec 316(a) Fed Act for thermal discharge criteria
pH	6.8 - 8.5 s.u.	6.5 - 8.5 s.u.; not >0.2 s.u. of variability
Fecal Coliform	Not >15 MPN/100 ml and not >10% of samples to exceed 50 MPN/100 ml	Not >14 MPN/100 ml and not >10% of samples exceed 43 MPN/100 ml for shellfishing; Not >200 MPN/100 ml and not >10% of samples exceed 400 MPN/100 ml for no shellfishing
Solids	None allowable that impair use	Not impair use or aesthetics or benthic biota or chemical composition of the bottom
Color/Turbidity	None allowable that impair use	None allowable that impair use
Taste/Odor	None allowable	None other than of natural origin
Oil/Grease/ Chemicals	None harmful to human, animal, or aquatic life; which impairs fish/shellfish propogation; which impairs use	Free of oil, grease, petrochemicals

Class SB

Parameters	Rhode Island	Massachusetts
Dissolved Oxygen	Not <5.0 mg/1 at any time	Not <5.0 mg/1 nor <60% saturation due to discharge; site specific for background levels
Temperature	Not >28.3°C nor a rise of >0.9°C June–Sept, and not >2.2°C Oct–June	Not >29.4°C nor >26.7°C daily mean; rise not >0.8°C Jul–Sept nor <2.2°C Oct–June; will not impair use; Sec 316(a) Fed Act for thermal discharge criteria
pH	6.8 - 8.5 s.u.	6.5 - 8.5 s.u. and not >0.2 s.u. of variability
Fecal Coliform	Not >50 MPN/100 ml and not >10% of samples to exceed 500 MPN/100 ml	Restricted shellfishing (depuration) not >88 MPN/100 ml and >10% of samples to exceed 260 MPN/100 ml; No shellfishing (closed) not >200 MPN/100 ml and not >10% of samples exceed 400 MPN/100 ml
Solids	None allowable	None that would impair use or aesthetics or chemical composition of bottom; not >25 mg/l nor >10 mg/l rise due to discharge
Color/Turbidity	None that would impair uses	None that would impair use or aesthetics
Taste/Odor	None that would impair uses.	None that would be aesthetically objectionable or impair use or flavor edible aquatic life
Oil/Grease/ Chemicals	None harmful to human, animal, or aquatic life; which impairs fish/shellfish propogation; which impairs use	Free of oils, grease and petrochemical that a visible film on the water; impart oily taste to water or aquatic life; coat banks or bottom or toxic to aquatic life

Class SC

Parameters	Rhode Island	Massachusetts
Dissolved Oxygen	Not <5.0 mg/l for 16 hours of any 24 hour period; not <4.0 mg/l at any time	Not <5.0 mg/l for 16 hours of any 24 hour period; not <4.0 mg/l at any time; not <50% saturation due to discharge; site specific for background levels
Temperature	Not >28.3°C nor a rise of >0.9°C June–Sept, and not >2.2°C Oct–June	Not >29.4°C or rise >2.8°C; will not impair use, diversity, migration, reproduction, or growth of aquatic organisms. Sec 316(a) Fed Act for thermal discharge criteria
pH	6.5 - 8.5 s.u.	6.5 - 9.0 s.u. and not >0.5 s.u. of variability
Fecal Coliform	None that impair use	Not >1000/100 ml for the geometric mean of samples and >10% of samples to exceed 2000/100 ml
Solids	None except that amount resulting from waste treatment facility providing appropriate treatment	Not impair use, aesthetics, benthic biota, or chemical composition of the bottom; not >80 mg/l
Color/Turbidity	None that would impair use	None that would impair use or are aesthetically objectional
Taste/Odor	None that would impair use or flavor edible fish or shellfish	None that would be objectionable or impair uses or flavor edible aquatic life
Oil/Grease/ Chemicals	None harmful to human, animal, or aquatic life; which impairs fish/shellfish propogation; which impairs use	Free of oil, grease, petrochemicals that give oily film or oily taste to aquatic life, coats the banks or bottom, or are toxic to aquatic life

APPENDIX F

Fact Sheets Available from URI

Rhode Island Sea Grant Fact Sheets

The one-page fact sheets provide information on different estuary and marine systems, oceanography and Rhode Island river systems. To order the RI Sea Grant fact sheets, just mail in your list of fact sheets needed with the quantities of each outlined on your list. **The cost is 25 cents per fact sheet plus a $1.00 postage and handling fee.** The mailing address is Rhode Island Sea Grant Information Office, University of Rhode Island, Narragansett Bay Campus, Narragansett, Rhode Island 02882-1197.

Fact Sheet #	Subject
P185	Haddock
P186	Flounder
P187	Scallop
P188	Atlantic Cod
P189	Atlantic Mackerel
P597	Barnacle
P605	Horseshoe Crab, Understand Him, He's an Old Timer
P606	Waves
P615	Red Crab
P637	Phytoplankton
P645	Beaufort Wind Force Scale
P651	Zooplankton
P800	Old Sea Sayings
P833	The Role of Grass Shrimp in a Tidal Ecosystem
P858	Abyss
P886	Sea Farming
P915	What is Oceanography?
P923	Beach Processing in Southern Rhode Island
P927	Tunicates: Animals with a Coat
P931	Brine Shrimp
P932	Boating Security Tips
P934	Eelgrass
P954	Sounds in the Sea
P955	Salt: In the Oceans and in Humans
P956	Fish Schooling
P976	Sand
P995	Tidepools
P996	The Trumpet Worm
P1066	The American Lobster
P1099	Rid Tide in the Northeast
P1123	Quahog
P1175	The Blackstone River
P1187	The Pawtuxet River
P1188	The Moshassuck River
P1189	The Woonasquatucket River

Water Quality Related Fact Sheets (cont'd)

The University of Rhode Island, College of Resource Development, Department of Natural Resources Science has fact sheets available through the Cooperative Extension Educational Center. Copies can be requested by calling (401) 792-2900.

Sheet No.	Subject
88-1	Homeowners Guide to Managing Your Lawn to Protect Water Quality
88-2	Maintaining Your Septic System
88-3	Household Hazardous Waste
88-7	Defining Your Watershed
88-8	Pollution Concerns
88-9	Eutrophication
88-10	Lake Classification
88-11	Measuring Water Clarity
88-12	Dissolved Oxygen
89-1	What is a Watershed?
89-2	Watershed Watch
90-3	Drinking Water Wells
90-4	Home Water Testing
90-5	Questions to Ask When Purchasing Water Treatment Systems
90-6	Bacteria in Drinking Water
90-7	Fluoride in Drinking Water
90-8	Iron and Manganese in Drinking Water
90-9	Lead in Drinking Water
90-10	Nitrates in Drinking Water
90-11	Pesticides and Other Organics in Drinking Water
90-12	pH of Drinking Water
90-13	Radon in Water
90-14	Sodium Chloride in Drinking Water
90-15	Activated Carbon Treatment of Drinking Water Supplies
90-16	Distillation Treatment of Drinking Water Supplies
90-17	Ion Exchange (Water Softening)
90-18	Microfiltration Treatment of Drinking Water Supplies
90-20	What is a Watershed?
90-21	Outlining Watershed Boundaries
90-22	Water Testing Brochure
90-23	GIS Geographic Information Systems of Rhode Island
90-24	Pesticide Use and Groundwater Protection
91-1	Pawcatuck Watershed Project
91-2	Water Conservation In and Around Your Home
92-1	Bacterial Monitoring of Surface Waters