GEORGIA

*A*dopt-A-Stream

Department of Natural Resources
Environmental Protection Division
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Macroinvertebrate & Chemical Stream Monitoring

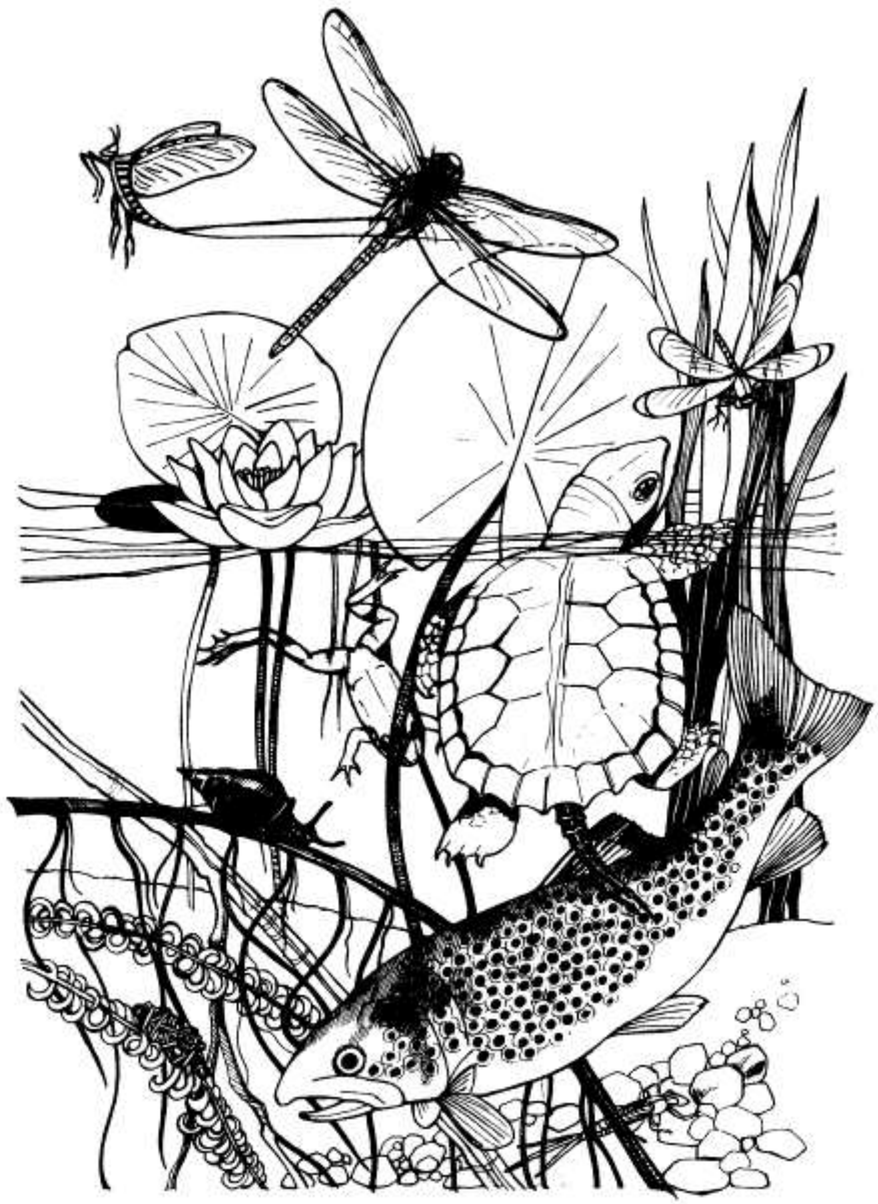

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TABLE OF CONTENTS

Acknowledgements

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Special Contributions:
Georgia Environmental Protection Division, Georgia Adopt-A-Stream Advisory Board, Georgia Adopt-A-Stream Community Coordinators

Writers/Editors
Georgia Adopt-A-Stream staff

Advice and some of the material in this manual was taken from the following documents:

Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003
Hach Company
LaMotte Company
EPA Rapid Bioassessment Protocols
EPD Rapid Bioassessment Protocols
Save Our Streams, Izaak Walton League of America

Resources Available from Georgia Adopt-A-Stream

- Organization and technical support
- Website at www.GeorgiaAdoptAStream.org
- Online water quality data clearing house
- *Getting To Know Your Watershed* manual & workshop✳
- *Visual Stream Survey* manual & workshop ✳
- *Macroinvertebrate and Chemical Stream Monitoring* manual & workshop ✳
- *Bacterial Monitoring* manual & workshop
- *Amphibian Monitoring* manual & workshop
- *Adopt-A-Wetland* manual & workshop for freshwater wetlands
- *Coastal Georgia Adopt-A-Wetland* manual & workshop
- *Adopt-A-Lake* manual & workshop
- *Adopt-A-Stream Educator's Guide* & workshop
- *Rivers Alive 'Guide to Organizing and Conducting a Cleanup'*
- *'Life at The Water's Edge'* brochure on protecting, preserving and restoring local waterways
- *Georgia Adopt-A-Stream: It All Begins With You* video
- Train – The – Trainer workshops
- 'You Are The Solution To Water Pollution' posters and brochures
- Quarterly newsletters (available also in e-newsletter format)
- Confluence, our annual volunteer conference and award ceremony

✳ **Available in Spanish**

Getting Started with Georgia Adopt-A-Stream

Georgia Adopt-A-Stream (AAS) is a statewide volunteer water quality monitoring program. AAS is housed in the NonPoint Source Program in the Watershed Protection Branch of the Georgia Environmental Protection Division (EPD) and is funded by a United States Environmental Protection Agency (U.S. EPA) Section 319(h) Grant. Georgia Adopt-A-Stream encourages individuals and communities to monitor and/or improve sections of streams, wetlands, lakes or estuaries. Manuals, training and technical support are provided through Georgia EPD and more than 60 established Community Adopt-A-Stream organizers. Adopt-A-Stream Community Programs organize monitoring groups in their watershed, county or city. These local programs are funded by counties, cities and nonprofit organizations and use the Georgia Adopt-A-Stream model, manuals and workshops to promote nonpoint source pollution education and data collection in their area.

The goals of Georgia Adopt-A-Stream are easy to remember by thinking about the word "**ADOPT**".

Awareness: Increase public awareness of the State's nonpoint source pollution and water quality issues

Data: Collect baseline water quality data

Observations: Encourage volunteers to take observations of their adopted site and surrounding environment

Partnerships: Encourage partnerships between citizens and their local government

Tools and Training: Provide citizens with the tools and training to evaluate and protect their local waterways

Awareness

Georgia Adopt-A-Stream has been tasked with the goal of increasing public awareness of the State's nonpoint source pollution and water quality issues. We accomplish this through workshops, outreach materials such as newsletters, manuals and brochures, as well as our annual volunteer conference and by presenting at community events. We encourage our volunteers to also foster this goal, by building awareness within their own communities.

Data

Georgia Adopt-A-Stream houses an online clearinghouse for volunteer water quality data for the State of Georgia. This water quality data is publicly accessible on our website at www.GeorgiaAdoptAStream.org and can be viewed at the city, county and watershed level to help citizens better understand the health of their local waterways. Volunteer monitoring data is used to educate the public and help local, state and federal agencies make informed decisions and to identify water quality impairments.

Observations
Careful observations of our waterways can lead to success in protecting and improving its conditions. In addition to the data found on the datasheets, you may notice other details that are important to record when visiting your adopted site. Stay aware of baseline conditions so if anything changes in future visits, you will be able to tell and can act accordingly.

Partnerships
Adopt-A-Stream encourages new groups to inform their local government about their activities and to create partnerships with local schools, businesses, watershed organizations and government agencies. These partnerships can enhance your program by providing support for your group through data interpretation, advice on restoration techniques, remediation, sponsorships and volunteer recruitment. We cannot emphasize enough the importance of beneficial partnerships to any volunteer monitoring group. If you need help establishing partnerships, we encourage you to contact your local coordinator/trainer or the AAS state office.

Tools and Training
The Adopt-A-Stream program offers many levels of involvement including training, certification and monitoring. Some of our monitoring programs require the volunteer to obtain Quality Assurance/Quality Control certification (QA/QC), which is accomplished by attending a workshop and passing the QA/QC test. This certification allows the volunteer to enter data into the database. Our non-QA/QC programs offer a training workshop and manuals, but certification is not required. Manuals and support materials are provided for each monitoring type to guide volunteers through the monitoring process. To find out more about different levels of involvement, visit our website: http://georgiaadoptastream.org.

Adopt-A-Stream Certifications and Monitoring Programs
For Freshwater and Coastal Waterways

Watershed Assessments (Y)	Visual Monitoring (Q)
Macroinvertebrate Monitoring (Q)*	Amphibian Monitoring (bi-monthly)
Chemical Monitoring (M)*	Bacterial Monitoring (M)*
Freshwater Wetland Monitoring (Q)	Coastal Monitoring (M)*
Lake Monitoring (M)	Rivers Alive (annually)
Trainer Certification*	Adopt-A-Stream in the Classroom

*=QA/QC programs M=Monthly Sampling Q=Quarterly Sampling Y=Yearly Sampling

Currently, Adopt-A-Stream has thousands of active volunteers who monitor over 500 sites and our quarterly newsletter has over 8,000 subscribers. We invite you to join us to help protect Georgia's water resources.

Water Quality in Georgia

As outlined in Water Quality in Georgia, 2010-2011, Chapter 1, Executive Summary (Georgia Environmental Protection Division, Department of Natural Resources)

Georgia is one of the fastest growing states in the nation. Between 2000 and 2010, Georgia gained 1.5 million new residents, ranking 4th nationally. The increasing population places considerable demands on Georgia's ground and surface water resources in terms of water supply, water quality, and in the assimilative capacity of rivers to receive wastewaters from industrial and municipal discharges. To address these demands, the General Assembly and Governor Perdue in February 2008 approved the implementation of the Comprehensive State-wide Water Management Plan in Georgia. The regional water plans are not themselves an end. The plans present solutions identified by a cross-section of regional leaders, drawing on regional knowledge and priorities. The plans are based on consistent, statewide forecasts of needs and reflect the best available information on the capacities of Georgia's waters. More about these plans can be found at: http://epd.georgia.gov/georgia-305b303d-list-documents.

The pollution impact on Georgia streams has radically shifted over the last several decades. Streams are no longer dominated by untreated or partially treated sewage discharges which resulted in little or no oxygen and little or no aquatic life. The sewage is now treated, oxygen levels have returned and fish have followed. However, another source of pollution is now affecting Georgia streams. That source is referred to as nonpoint and consists of mud, litter, bacteria, pesticides, fertilizers, metals, oils, detergents and a variety of other pollutants being washed into rivers and lakes by stormwater. Even stormwater runoff itself, if rate and volume is unmitigated, can be extremely detrimental to aquatic habitat and hydrologic systems. Nonpoint source pollution, although somewhat less dramatic than raw sewage, must be reduced and controlled to fully protect Georgia's streams. Structural and nonstructural techniques such as green infrastructure, pollution prevention and best management practices must be significantly expanded to minimize nonpoint source pollution. These include both watershed protection through planning, zoning, buffer zones, and appropriate building densities as well as increased use of stormwater structural practices, low impact development, street cleaning and perhaps eventual limitations on pesticide and fertilizer usage.

Another issue of importance is the reduction of toxic substances in rivers, lakes, sediment and fish tissue. This is extremely important in protecting both human health and aquatic life. The sources are widespread. The most effective method to reduce releases of toxic substances into rivers is pollution prevention, which consists primarily of eliminating or reducing the use of toxic materials or at least reducing the exposure of toxic materials to drinking water, wastewater and stormwater. It is very expensive and difficult to reduce low concentrations of toxic substances in wastewaters by treatment technologies. It is virtually impossible to treat large quantities of stormwater and reduce toxic substances. Therefore, toxic substances must be controlled at the source.

Nutrients also serve a very important role in our environment. They provide the essential building blocks necessary for growth and development of healthy aquatic ecosystems. However, if not properly managed, nutrients in excessive amounts can have detrimental effects on human health and the environment, creating such water quality problems as excessive growth of macrophytes and phytoplankton, harmful algal blooms, dissolved oxygen depletion, and an imbalance of flora and fauna. In Georgia, site specific nutrient criteria have been adopted for several major lakes and their tributaries. Some of these lakes are currently listed for chlorophyll a, which is the primary biological indicator in lakes for nutrient over-enrichment. TMDLs, based on watershed modeling, have been completed or are in development to address the nutrient issues for these lakes. Currently, the Georgia EPD is in the process of collecting the necessary data and information for use in developing nutrient standards for rivers, streams and other waterbodies in Georgia. Determining the relationship of nutrient levels and biological response is necessary in order to develop appropriate nutrient criteria.

It is clear that local governments and industries, even with well-funded efforts, cannot fully address the challenges of toxic substances and nonpoint source pollution control. Citizens must individually and collectively be part of the solution to these challenges. The main focus is to achieve full public acceptance of the fact that what we do on the land has a direct impact on water quality. Adding more pavement and other impervious surfaces, littering, driving cars which drip oils and antifreeze, applying fertilizers and other activities and behaviors all contribute to toxic and nonpoint source pollution. If streams and lakes are to be pollutant free, then some of the everyday human practices must be modified. The Georgia EPD will be emphasizing public involvement; not only in decision making but also in direct programs of stream improvement. The first steps are education and Adopt-A-Stream programs.

Water Resources Atlas

State Population (2012 estimate)	9,383,941
State Surface Area	58,910 square miles
Number of Major River Basins	14
Number of Perennial River Miles	44,056 miles
Number of Intermittent River Miles	23,906 miles
Number of Ditches and Canals	603 miles
Total River Miles	70,150 miles
Number of Lakes Over 500 Acres	48
Acres of Lakes Over 500 Acres	265,365 acres
Number of Lakes Under 500 Acres	11,765
Acres of Lakes Under 500 Acres	160,017 acres
Total Number of Lakes & Reservoirs, Ponds	11,813
Total Acreage of Lakes, Reservoirs, Ponds	425,382 acres
Square Miles of Estuaries	854 square miles
Miles of Coastline	100
Acres of Freshwater Wetlands	4,500,000 acres
Acres of Tidal Wetlands	384,000 acres

Water Quality in Georgia, 2010-2011, Chapter 3, Water Quality Monitoring and Assessment **(Georgia Environmental Protection Division, Department of Natural Resources)**

Introduction

MACROINVERTEBRATE & CHEMICAL STREAM MONITORING

Welcome to Georgia Adopt-A-Stream; *Macroinvertebrate and Chemical Stream Monitoring*. This manual is intended for Adopt-A-Stream monitoring groups who have already registered with the program and are eager to take their monitoring activities to the next level. This manual describes methods for evaluating the physical, chemical, and biological parameters of your adopted stream or river.

Getting to Know Your Watershed focuses on map assessments and a watershed survey as evaluation tools. *Visual Stream Monitoring* introduces a diversity of low-cost, hands-on methods for analyzing the physical health of your adopted stream.

Different levels of involvement offer different levels of activity. At the most basic level, volunteers register with Georgia Adopt-A-Stream, conduct a watershed assessment and perform visual surveys of their adopted stream. Optional participation includes chemical, macroinvertebrate and bacterial monitoring, and/or a habitat enhancement project.

- Watershed Assessment — Once a year
- Visual Monitoring — 4 times a year (quarterly)
- Macroinvertebrate Monitoring — 4 times a year (quarterly)
- Physical/Chemical Monitoring — 12 times a year (monthly)
- Bacterial Monitoring — 12 times a year (monthly)
- Habitat Enhancement — One time project

Macroinvertebrate and chemical monitoring requires training. Training workshops are available through the Adopt-A-Stream State office as well as through our more than 60 local Adopt-A-Stream programs. Training includes an overview of the program, monitoring techniques and quality assurance tests.

These activities **help protect water quality and streams** because:

- Regular monitoring provides specific information about the health of your local stream.
- Both long-term trends and immediate changes in water quality can be documented.
- Macroinvertebrate monitoring will detect changes in water quality and habitat and provides an indication of overall stream health.
- Chemical monitoring, however, provides specific information about water quality parameters that are important to aquatic life – such as dissolved oxygen and pH.
- Habitat enhancement projects improve streambanks and/or the streambed. Habitat enhancement projects may stop a streambank from eroding, and therefore decrease the amount of sediment entering a stream or improve an in-stream habitat for fish to feed, hide and lay eggs.

Quality Assurance Certification

Georgia Adopt-A-Stream's monitoring program is aligned with the protocols set forth in our Quality Assurance Project Plan (QAPP) that has been submitted to and approved by the United States Environmental Protection Agency (US EPA). This plan is the core of our monitoring program and it is essential that volunteer monitors follow these protocols to ensure the collection of credible data. Volunteers who wish to ensure that their data is of the highest quality, can become quality assurance quality control (QA/QC) certified. Quality assurance quality control certification is part of every chemical and macroinvertebrate training workshop. Data collected under a QA/QC plan can be entered into the Adopt-A-Stream database and is often used by local and state agencies to assess water quality conditions. To become a QA/QC volunteer, the following conditions must be met.

Macroinvertebrate Certification

Volunteers must:

1. Attend a QA/QC macroinvertebrate monitoring workshop.
2. Demonstrate the ability to collect a macroinvertebrate sample.
3. Identify, with 90% accuracy, no less than 20 macroinvertebrates and correctly calculate the water quality index.
4. Pass the written test with a score of at least 80%.
5. Re-certify annually in order to submit QA/QC data.

Chemical Certification

Volunteers must:

1. Attend a QA/QC chemical monitoring workshop.
2. Demonstrate testing methods that achieve results within duplicate precision of those obtained by a certified Adopt-A-Stream trainer.
3. Pass the written test with a score of at least 80%.
4. Volunteers must replace test kit reagents as they expire or become contaminated.
5. Re-certify annually in order to submit QA/QC data.

Trainer Certification

Georgia Adopt-A-Stream has a trainer program for our chemical, macroinvertebrate, and bacterial monitoring programs.

Criteria for new trainers:

- Attend a macroinvertebrate (6-hours), chemical (5-hours), or bacterial (4-hours) Train-The-Trainer workshop and pass field and written tests. To attend a TTT workshop, one must have current QA/QC certification in the training of interest, have working knowledge of biology, chemistry, microbiology or a related field, and commit to conducting two workshops within a year. Train-The-Trainer workshops cover what it means to be a trainer, how to conduct a workshop, and how to work with volunteers.
- After attending the TTT workshop, a new trainer must do two co-trainings with another trainer who has been approved by the State Office. These co-trainings count towards the two workshops that a trainer commits to do within a year.

Safety and Health Checklist

Your safety and health are of number-one importance to Georgia Adopt-A-Stream. There are several important things to remember when you are monitoring your adopted stream, river, lake or wetland. If you follow these "rules of monitoring" you will have a fun, enjoyable and accident-free experience.

Before visiting your site:

- Develop a site emergency plan: (i.e. site location, nearest medical center, nearest phone, medical conditions of team members and their emergency contact, etc.).
- Check weather reports. Stop monitoring if a storm occurs while you are monitoring.
- Determine if you have safe, legal access to your site.

Rules to monitor by:

- Your adopted site should be wadeable or accessible by a bridge. Do not monitor waters that are deeper.
- If at any time you feel uncomfortable about the condition of the waterbody or your surroundings, stop monitoring and leave the site.
- Monitor during base flow conditions. Do not monitor if the waterbody is at flood stage. Fast moving water is very dangerous. Never wade in swift or high water.
- Never cross private property without the permission of the landowner.
- Always bring your 'Who to Call List' found on the Adopt-A-Stream website.
- If you are sampling from a bridge, be wary of passing traffic. Never lean over bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds. If walking under a bridge, watch for objects knocked off the road from overhead.
- Look out for broken glass, poison ivy, snakes and biting/stinging insects.
- Never drink the water. Always wash or sanitize hands after monitoring.
- Do not monitor if the water body is posted as unsafe for body contact.
- Carry a first aid kit with you.
- Adopt-A-Stream recommends that you monitor with another person.
- Wear gloves while monitoring.

If you observe any of the following at your sampling station STOP and refer to your 'Who to Call List' for the course of action.

- STOP! If you observe closed or leaking drums near or in the water.
- STOP! If you observe a large quantity of dead fish or other organisms.
- STOP! If you observe a pipe discharging odd looking/smelling substance into the water.

Monitoring in areas with high fecal coliform levels:

The following conditions warrant concern for high fecal coliform levels; occurrence of heavy rain in the past 24 hours, muddy water, a leaking sewer line and/or the presence of a large number of animals in the water. If monitoring in these conditions please take the following precautions:

- If you have open or incompletely healed wounds, avoid any contact with water.
- Avoid swimming or other high contact activities for at least 24 hours after heavy rains, or if water is obviously muddy.
- Avoid stirring or disturbing sediment. There are higher survival rates of bacteria and potentially other pathogens in sediment.
- Avoid swimming or other high contact activities areas where fecal droppings from wildlife are obvious, large numbers of wildlife are present (ducks, geese), or domestic or companion animals are observed in the waterway or on shore (cows, dogs, etc.).
- Anyone with a compromised immune system should avoid any primary contact activities in waters that have elevated levels of fecal bacteria.
- Avoid contact with water for at least a week if recovering from gastrointestinal illness, especially children.

Health Safety Contacts:

Georgia Department of Public Health
404-657-2700
http://dph.georgia.gov/contact-dph

Centers for Disease Control
1-800-232-4636
http://www.cdc.gov

Chapter 1

MACROINVERTEBRATE MONITORING

- Macroinvertebrate Monitoring
- Why Monitor for Macroinvertebrates?
- Determining Stream Type and Sampling Location
- Begin Sampling For: Rocky Bottom Streams
- Begin Sampling For: Muddy Bottom Streams
- Calculate Your Results

Macroinvertebrate monitoring involves identifying and counting macroinvertebrates. The purpose of macroinvertebrate monitoring is to quickly assess both **water quality and habitat**. The abundance and diversity of macroinvertebrates found is an indication of overall stream quality. Macroinvertebrates are organisms that lack a backbone and can be seen with the naked eye, including aquatic insects, crustaceans, worms, and mollusks. The organisms that are being sampled for are benthic macroinvertebrates meaning that they live in the substrate, or bottom of a waterbody. Macros live in various stream habitats and derive their oxygen from water. They are used as indicators of stream quality. These organisms are impacted by all the stresses that occur in a stream environment, both man-made and naturally occurring.

Aquatic macroinvertebrates are good indicators of stream quality because:

- They are affected by the physical, chemical and biological conditions of the stream.
- They are not very mobile. They can't escape pollution and, therefore, will show effects of short- and long-term pollution events.
- They are relatively long lived – the life cycles of some sensitive macroinvertebrates range from one to several years.
- They are an important part of the food web, representing a broad range of trophic levels.
- They are abundant in most streams. Some 1st and 2nd order streams may lack fish, but they generally have macroinvertebrates.
- They are a food source for many recreationally and commercially important fish.
- They are relatively easy to collect, view, and identify with inexpensive materials.

Macroinvertebrates are present during all kinds of stream conditions from drought to floods. Macroinvertebrates are adaptable to extremes of water flow. Some may burrow when it is raining and flow increases. However, heavy rain in areas with a high percentage of impervious surface (most urban areas) can cause flash floods and carry macroinvertebrates downstream.

Populations of macroinvertebrates may differ in north and south Georgia. For example, since the Adopt-A-Stream macroinvertebrate index is based on dissolved oxygen, the "sensitive" organisms that require a lot of oxygen, such as the stonefly, may not be found in warm, slow-moving streams in south Georgia. That does not mean that the stream has bad water quality or habitat, just that streams in north and south Georgia support different populations of macros. If you are monitoring in south or coastal Georgia, it is important for you to conduct monitoring each season for several years. Doing this will help you recognize biological trends in your stream so that you can determine which changes are natural and which may be induced by human impact.

Populations of macroinvertebrates may vary from headwater streams to the river mouth. For more information, please review "The River Continuum Concept" in the *Visual Stream Survey* manual.

Seasonal cycles can also affect the number and kinds of macroinvertebrates collected. Organisms such as immature stoneflies and mayflies will gain weight and size primarily during the fall and winter. During the spring and summer they may reach maturity and begin to metamorphose into their adult (non-aquatic) stage. Therefore, the presence of aquatic macroinvertebrates will tend to be more evident during winter and spring just before metamorphosis. After adults emerge, females lay eggs near or in the water. Soon after, the larvae and nymphs hatch and begin to grow, feeding on leaf litter, detritus and other organic matter that might be present. For more information on macroinvertebrates and their life cycles, please turn to "Background on Aquatic Insects" in the Appendix.

If conditions are unsafe for any reason, including high water or slippery rocks, **DO NOT SAMPLE**.

Why Monitor for Macroinvertebrates?

The basic principle behind the study of macroinvertebrates is that some species are more sensitive to pollution than others. Therefore, if a stream site is inhabited by organisms that can tolerate pollution, and the pollution-sensitive organisms are missing, a pollution problem is likely.

For example, stonefly nymphs, which are very sensitive to most pollutants, cannot survive if a stream's dissolved oxygen falls below a certain level. If a biosurvey shows that no stoneflies are present in a stream that used to support them, a hypothesis might be that dissolved oxygen has fallen to a point that keeps stoneflies from reproducing or has killed them outright.

This brings up both the advantage and disadvantage of the biosurvey. The advantage of the biosurvey is it tells us very clearly when the stream ecosystem is impaired, or "sick," due to pollution or habitat loss. It is not difficult to realize that a stream full of many kinds of crawling and swimming "critters" is healthier than one without much life. Different macros occupy different ecological niches within the aquatic environment, so diversity of species generally means a healthy, balanced ecosystem. The disadvantage of the biosurvey, on the other hand, is it cannot definitively tell us why certain types of creatures are present or absent.

In this case, the absence of stoneflies might indeed be due to low dissolved oxygen. But is the stream under-oxygenated because it flows too sluggishly, or because pollutants in the stream are damaging water quality by using up the oxygen? The absence of stoneflies might also be due to other pollutants discharged by factories or run off from farmland, water temperatures that are too high, habitat degradation such as excess sand or silt on the stream bottom has ruined stonefly sheltering areas, or other conditions. Thus a biosurvey should be accompanied by an assessment of *habitat and water quality* conditions in order to help explain biosurvey results.

Determining Stream Type and Sampling Location

Find a sampling location in your stream. This location should be within your stream reach, which you should have determined during your visual survey. Sample the same stretch of stream each time, to ensure consistency. Sample every three months, approximately once each season (spring, summer, fall and winter).

Macroinvertebrates can be found in many kinds of habitats—places like riffles (where shallow water flows quickly over rocks), packs of leaves, roots hanging into the water, old wood or logs, or the streambed. Based on the types of habitats that characterize your stream, determine if you have a **muddy bottom or rocky bottom stream.** Follow the directions that correspond with your stream type.

- **Rocky bottom streams** are generally found in north Georgia and the Piedmont Region. However, there are exceptions—some south Georgia streams possess rocky bottom characteristics. Rocky bottom streams are characterized by fast-moving water flowing over and between large rocks and boulders, interspersed with longer, smooth sections where the water forms pools.
- **Muddy bottom streams** include most south Georgia streams and many streams found in urban environments, which have been degraded by the introduction of sediment. In muddy bottom streams the pool/riffle system is replaced by slow moving water with little or no disturbances. The substrate is generally composed of fine silt, sand or coarse gravel.

Equipment List:

- Aquatic Macroinvertebrate Field Guide for Georgia's Streams (found on the AAS website)
- Macroinvertebrate Data Form (found on the AAS website)
- D-Frame and/ or Kick Seine Nets
- Spoons, forceps, hand lenses, petri dishes, sorting pans, ice trays, bucket(s), small pieces of screening
- Pitcher or jug for rinsing out macros from nets into sorting pans
- Clear container or Whirl-pak® bag for the visual observations
- Pens/pencils
- Clipboard
- Trash bag to pick up litter
- The 'Who to Call List' (found on the AAS website)
- First Aid Kit
- Waders, boots, or old tennis shoes

Optional:

- Rubber gloves for rubbing rocks
- Bucket with screen bottom (for muddy bottom sampling)

The Appendix provides information on how to make a kick seine net.
A list of places to purchase equipment is located on the AAS website.

Begin Sampling for: Rocky Bottom Streams

In the “rocky bottom” method, you will sample two different habitats—**riffles** and **leaf packs**. The rocky bottom method requires a minimum of two volunteers; one to hold the kick seine and one to “work” the sample area.

First, identify three different riffle areas. Collect macroinvertebrates in all three riffles with a kick seine, sampling a 2 x 2 foot area (the kick seines are usually 3 x 3 feet). Look for an area where the water is 3 to 12 inches deep. Place the kick seine downstream and firmly wedge the seine into the streambed, weighting the bottom edge with rocks. Gently rub any loose debris off rocks and sticks so that you catch everything in the seine. When you have "washed off" all the rocks in a 2 x 2 foot area, kick the streambed with your feet. Push rocks around; shuffle your feet so that you really kick up the streambed. Now gently lift the seine, being careful not to lose any of the macroinvertebrates you have caught. Take the seine to an area where you can look it over or wash the contents into a bucket.

Now look for decayed (old, dead) packs of leaves next to rocks, logs or on the streambed. Leaf packs may be found throughout your designated stream reach, in the riffle or pool systems. Add 4 handfuls of decayed leaves to your sample. The total area of stream you will sample is 16 square feet.

In summary, collect:

- 3 kick seine samples of substrate from the riffle area (4 square feet each)
- 4 handfuls of organic matter or leaf packs (1 square foot each)

Substrate: Riffles

Riffle areas constitute shallow areas of a stream or river with a fast-moving current bubbling over rocks. The water in riffle areas is highly oxygenated and provides excellent habitat, shelter, and food for a variety of macroinvertebrates.

Organic Matter: Leaf packs

This includes decomposing vegetation (leaves and twigs) that is submerged in the water. Leaf packs serve as a food source for organisms and provide shelter from predators.

Dragon Fly Adult

Begin Sampling for: Muddy Bottom Streams

In this method you will sample three different habitats, using a D-frame (or dip) net. The habitats are **vegetated margins, woody debris with organic matter,** and **sand/rock/gravel streambed** (or substrate). Each scoop involves a quick forward motion of one foot, thus covering a sample area of one square foot. With this method you will sample the stream a total of 14 times or 14 square feet. To maintain consistency, collect the following numbers of scoops from each habitat each time you sample:

- 7 scoops from vegetated margins (1 square foot each)
- 4 scoops of organic matter (woody debris, 1 square foot each)
- 3 scoops of substrate from sand/rock/gravel or coarsest area of the streambed (1 square foot each)

Each time you sample you should sweep the mesh bottom of the D-frame net back and forth through the water (not allowing water to run over the top of the net) to rinse fine silt from the net. This will prevent a large amount of sediment and silt from collecting in the pan and clouding your sample.

As you collect your scoops, place the contents of the net into a bucket. Separate the samples collected from the streambed and vegetated margin or woody debris samples. Keep water in the bucket to keep the organisms alive. Note descriptions below of each muddy bottom habitat and collection tips:

Vegetated margins
This habitat is the area along the bank and the edge of the waterbody consisting of overhanging bank vegetation, plants living along the shoreline, and submerged root mats. Vegetated margins may be home to a diverse assemblage of dragonflies, damselflies, and other organisms. Move the dip-net quickly in a bottom-to-surface motion (scooping towards the stream bank), jabbing at the bank to loosen organisms. Each scoop of the net should cover one foot of submerged (under water) area.

Organic Matter: Woody debris
Woody debris consists of dead or living trees, roots, limbs, sticks, leaf packs, cypress knees, and other submerged organic matter. It is a very important habitat in slow moving streams and rivers. The wood helps trap organic particles that serve as a food source for the organisms and provides shelter from predators such as fish.

To collect woody debris, approach the area from downstream and hold the net under the section of wood you wish to sample, such as a submerged log. Rub the surface of the log for a total surface area of one square foot. It is also good to dislodge some of the bark as organisms may be hiding underneath. You can also collect sticks, leaf litter, and rub roots attached to submerged logs. Be sure to thoroughly examine any small sticks you collect before discarding them. There may be caddisflies, stoneflies, and midges attached to the bark.

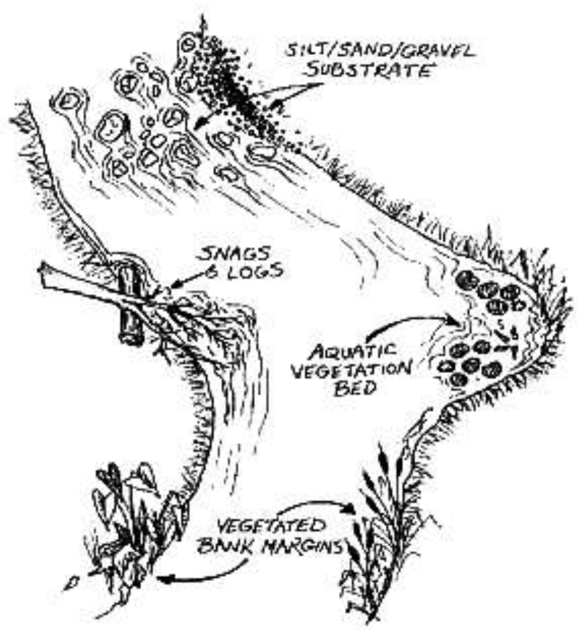
Substrate: Sand/rock/gravel or coarsest area of the streambed

In slow moving streams, the substrate is generally composed of only sand or mud because the velocity of the water is not fast enough to transport large rocks. Sample the coarsest area of the streambed—gravel or sand may be all you can find. Sometimes, you may find a gravel bar located at a bend in the river. The streambed can be sampled by moving the net forward (upstream) with a jabbing motion to dislodge the first few inches of gravel, sand, or rocks. You may want to gently wash the gravel in your screen bottom bucket and then discard gravel in the water.

If you have large rocks (greater than two inches in diameter) you should also kick the substrate upstream of the net to dislodge any burrowing organisms. Remember to disturb only one square foot of upstream sample area.

Elutriation

Some substrate samples are composed almost entirely of fine silt and mud. To separate aquatic organisms, place the sample in a bucket with water and stir. Pour off water into the D-frame net and repeat 3 times. Any macroinvertebrates present will separate from the collected mud and be caught in the net. Before dumping remaining substrate, inspect bucket for snails or mollusks. This process is called elutriation.



Calculate Your Results

Place your macroinvertebrates in a white sorting pan or plastic tray. Separate creatures that look similar into groups. Use the Adopt-A-Stream's *Macroinvertebrate Field Guide For Georgia's Streams* to classify the types and numbers of each kind of insect. As you sort through your collection, remember each stream will have different types and numbers of macroinvertebrates. Calculate the score for your stream using the index on the Macroinvertebrate Data Form. Use the table below to interpret your results.

If you find:	**You may have:**
Variety of macroinvertebrates, lots of each kind	Healthy stream
Little variety, with many of each kind	Water enriched with organic matter
A variety of macroinvertebrates, but a few of each kind, or **NO** macroinvertebrates, but the stream appears clean	Toxic pollution
Few macroinvertebrates and the streambed is covered with sediment	Poor habitat from sedimentation

Chapter 2

PHYSICAL/CHEMICAL MONITORING

- Physical/Chemical Monitoring
- Why Are Physical/Chemical Tests Important?
- Temperature
- pH
- Dissolved Oxygen
- Conductivity
- Salinity
- Water Clarity
- Settleable Solids
- Nutrients
- Nitrates
- Phosphorus
- Alkalinity

Physical/Chemical testing allows information to be gathered about **specific water quality characteristics**. A variety of water quality tests can be run on fresh water – including temperature, dissolved oxygen, pH, settleable solids, water clarity, phosphorus, nitrogen, chlorine, total dissolved solids, fecal coliform and many others. In addition to basic visual observations and weather information, Adopt-A-Stream recommends monitoring these core parameters:

- Temperature
- pH
- Dissolved Oxygen
- Conductivity (Stream and Lake)
- Salinity (Coastal)
- Water Clarity (Coastal and Lake)

Phosphorus, nitrogen, alkalinity, and setteable solids monitoring may be added to your list as interest and equipment allows.

If you choose to conduct chemical testing as an activity, plan on sampling regularly – at least once a month at the same time and the same location. Regular monitoring helps ensure your information can be compared over time. Water quality and environmental conditions can change throughout the day, so monitoring at approximately the same time of day is important. Also, chemical testing during or immediately after a rain may produce very different results than during dry conditions. Therefore, it is very important to record weather conditions. If conditions are unsafe for any reason, including high water or slippery rocks, **DO NOT SAMPLE**.

Equipment List:

- Chemical testing kit for appropriate parameters & instructions
- Conductivity Meter & Calibration Solution (Stream and Lake monitoring)
- Refractometer & Calibration Solution/Distilled Water (Coastal monitoring)
- Secchi Disk (Lake and Coastal monitoring)
- Waste jug (old milk jug labeled as 'Waste' will work)
- Rubber gloves & safety glasses
- Physical/Chemical Data Form (found on the AAS website)
- Bucket with rope (if sampling from a bridge or in deeper water)
- Clear container or Whirl-pak® bag for the visual observations
- Pen/pencil
- Clipboard
- Trash bag to pick up litter
- The 'Who to Call List' (found on the AAS website)
- First Aid Kit
- Waders, boots, or old tennis shoes

A list of places to purchase equipment is located on the AAS website.

Detailed instructions for each chemical test are found on the Adopt-A-Stream website; however, a few recommendations are listed below.

1. Measure air and water temperature in the shade. Avoid direct sunlight.
2. Rinse glass tubes or containers twice with stream water before running a test.
3. Collect water for tests in a well-mixed area of flowing water, one foot below surface. If water is less than one foot deep, collect approximately one-third of the way below surface. Collect samples at stream base flow.
4. Read values on plastic titrators (small syringe with green plunger) on the liquid side of the disc around the plunger tip. If you are using a glass syringes, read values at the plungers tip.
5. For dissolved oxygen and pH, run two tests. If the tests are not within duplicate precision of each other, run another test to ensure accuracy.

Safety Notes: Read all instructions before you begin and note all precautions. Keep all equipment and chemicals out of the reach of small children. In the event of an accident or suspected poisoning, immediately call the Poison Control Center (listed on the inside cover of most telephone books). Avoid contact between chemicals and skin, eyes, nose, or mouth. Wear safety goggles or glasses and rubber gloves when handling chemicals. After use, tightly close all chemical containers. Be careful not to switch caps.

Why Are Physical/Chemical Tests Important?

This section describes some chemical and physical tests you can conduct and why they are important. Physical/Chemical testing should be conducted at least once a month because this type of monitoring measures the exact sample of water taken, which can vary weekly, daily or even hourly. A shallow water monitoring kit (temperature, pH, and dissolved oxygen tests in waterproof monitoring case) and conductivity meter costs approximately $350 or approximately $200 to purchase these tests individually. Replacement chemicals are inexpensive and will need to be replaced as they expire or if they become contaminated. Additional parameters include total alkalinity, ortho-phosphate, conductivity, and nitrate. Some groups may wish to work with a certified laboratory to sample for chlorophyll A.

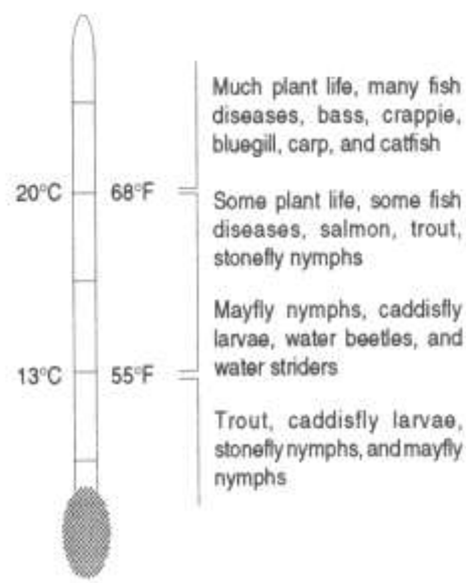
Further information for evaluating your test results can be found in the *Getting to Know Your Watershed* manual.

Temperature

Water temperature is one factor in determining which species may or may not be present in the system. Temperature affects feeding, respiration, and the metabolism of aquatic organisms. A week or two of high temperatures may make a stream unsuitable for sensitive aquatic organisms, even though temperatures are within tolerable levels throughout the rest of the year. Not only do different species have different requirements, optimum habitat temperatures may change for each stage of life. Fish larvae and eggs usually have narrower temperature requirements than adult fish.

Measuring Temperature

A thermometer protected by a plastic or metal case should be used to measure temperature in the field. Temperature is recorded in degrees Celsius. First, measure air temperature by placing the dry thermometer in the shade until it stabilizes. Record the temperature of the air before measuring water temperature. To measure water temperature, submerge the thermometer in a sample of water large enough that it will not be affected by the temperature of the thermometer itself, or hold it directly in the stream.



State Standards
Water temperatures should be less than 32.2°C (90°F) to meet Georgia state standards.

Significant Levels
Temperature preferences among species vary widely, but all species can tolerate slow, seasonal changes better than rapid changes. Thermal stress and shock can occur when water temperatures change more than 1 to 2 degrees Celsius in 24 hours.

Many biological processes are affected by water temperature. Temperature differences between surface and bottom waters help produce the vertical water currents, which move nutrients and oxygen throughout the water column.

What Measured Levels May Indicate
Water temperature may be increased by discharges of water used for cooling purposes (by industrial or utility plants) or by runoff from heated surfaces such as roads, roofs and parking lots. Cold underground water sources, snow melt, and the shade provided by overhanging vegetation can lower water temperatures.

pH

The pH test is one of the most common analyses in water testing. An indication of the sample's acidity, pH is actually a measurement of the activity of hydrogen ions in the sample. pH measurements are on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acids and those above 7.0 considered bases.

The pH scale is logarithmic, so every one-unit change in pH actually represents a ten-fold change in acidity. In other words, pH 6 is ten times more acidic than pH 7; pH 5 is one hundred times more acidic than pH 7.

Measuring pH
pH is measured by adding a reagent to a sample of water which dyes the sample based on its pH level. The color of the water sample is then matched to a color comparator to determine the pH level. Take two samples for duplicate precision. The two samples must be within ±0.25. If the tests are not within duplicate precision of each other, run another test until two are within that range.

State Standards
pH levels should fall between 6.0 and 8.5 to meet Georgia state standards.

Significant Levels
A range of pH 6.5 to pH 8.2 is optimal for most aquatic organisms. Rapidly growing algae or submerged aquatic vegetation remove carbon dioxide (CO_2) from the water during photosynthesis. This can result in a significant increase in pH levels, so the water becomes more basic. Low or high pH can affect egg hatching, kill sources of food for fish and insects, or make water uninhabitable for any aquatic life. In

Georgia, mountain and piedmont streams will have pH ranges of 6.0 to 8.0. Black water streams of coastal and south Georgia will naturally have more acidic conditions, with pH values as low as 3.5. In coastal waters, normal pH levels fall within state standards and increase (becomes more basic) with increasing salinity. In other regions of Georgia, pH readings outside of the acceptable levels may be the result of mine drainage, atmospheric deposition or industrial point discharges.

pH values of some common substances:

pH	
0.5	battery acid
2.0	lemon juice
5.9	rainwater
7.0	distilled water
8.0	salt water
11.2	ammonia
12.9	bleach

Dissolved Oxygen (DO)

Like land organisms, aquatic animals need oxygen to live. Fish, invertebrates, plants, and aerobic bacteria all require oxygen for respiration. Dissolved oxygen is measured in parts per million (ppm) or milligrams per liter (mg/L).

Sources of Dissolved Oxygen

Oxygen dissolves readily into water from the atmosphere at the surface until the water is "saturated". Once dissolved in water, the oxygen diffuses very slowly, and distribution depends on the movement of aerated water by turbulence and currents caused by wind, water flow and thermal upwelling. Aquatic plants, algae and phytoplankton produce oxygen during photosynthesis.

Dissolved Oxygen Capacity of Water

The dissolved oxygen capacity of water is limited by the temperature and salinity of the water and by the atmospheric pressure, which corresponds with altitude. These factors determine the highest amount of oxygen that is able to dissolve in the water.

As water temperature changes, the highest potential dissolved oxygen level changes.

> Lower temperature = Higher potential dissolved oxygen level
> Higher temperature = Lower potential dissolved oxygen level

- At 0 degrees Celsius the saturation point for dissolved oxygen is 14.6 ppm
- At 32 degrees Celsius the saturation point for dissolved oxygen is 7.6 ppm

The temperature effect is compounded by the fact that living organisms increase their activity in warm water, requiring more oxygen to support their metabolisms. Critically low oxygen levels often occur during the warmer summer months when capacity decreases and oxygen demand increases. This is often caused by respiring algae or decaying organic material.

Measuring Dissolved Oxygen

Dissolved oxygen is measured using the Winkler titration method. A sample bottle is filled completely so that no air is present in the sample. Reagents are added to produce a 'fixed' solution – the dissolved oxygen content cannot be influenced by external sources or changes. This fixed solution is then titrated until it reaches the 'endpoint' where the color of the solution changes to clear. The level of the remaining liquid in the direct-read titrator corresponds to the dissolved oxygen level in the sample. Take two samples for duplicate precision. The two samples must be within ±0.6 ppm or mg/L. If the tests are not within duplicate precision of each other, run another test until two are within that range.

State Standards

Dissolved oxygen levels must average 5mg/L and no less than 4mg/L to meet Georgia state standards.

Significant Levels

The amount of oxygen required by an aquatic organism varies according to species and stage of life. DO levels below 3 ppm are stressful to most aquatic organisms. DO levels below 2 or 1 ppm will not support fish; levels of 5 to 6 ppm are usually required for growth and activity. Fish and invertebrates that can move will leave areas with low dissolved oxygen and move to higher level areas.

What Measured Levels May Indicate

A low dissolved oxygen level indicates a demand on the oxygen in the system. Pollutants, including inadequately treated sewage or decaying natural organic material, can cause such a demand. Organic materials accumulate in bottom sediments and support microorganisms (including bacteria), which consume oxygen as they break down the materials. Some wastes and pollutants produce direct chemical demands on any oxygen in the water. In ponds or impoundments, dense populations of active fish can deplete dissolved oxygen levels. In areas of dense algae, DO levels may drop at night or during cloudy weather due to the net consumption of dissolved oxygen by aquatic plant respiration.

High dissolved oxygen levels can be found where stream turbulence or choppy conditions increase natural aeration by increasing the water surface area and trapping air under cascading water. On sunny days, high dissolved oxygen levels occur in areas of dense algae or submerged aquatic vegetation due to photosynthesis. In these areas, the lowest DO levels occur just before sunrise each morning and highest levels just after noon.

Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity levels indicate the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius. Conductivity is measured in microsiemens per centimeter (µs/cm).

Conductivity in natural systems is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock such as in north Georgia tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water.

Measuring Conductivity

Conductivity is measured with a parameter-specific probe that must be calibrated with a known conductivity standard within 24 hours prior to each monitoring event. A single measurement is recorded for conductivity.

State Standards

There are no regulated levels of conductivity in Georgia.

Significant Levels

Distilled water has conductivity in the range of 0.5 to 3 µs/cm. The conductivity of rivers in Georgia generally ranges from 0 to 1500 µs/cm. Studies of inland fresh waters indicate that streams supporting mixed fisheries have a range between 50 and 500 µs/cm. Some north Georgia streams may have natural background levels well below 50 µs/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can be as high as 10,000 µs/cm.

What Measured Levels May Indicate

Discharges to streams can change the conductivity depending on their composition. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity. Conductivity can also fluctuate from baseline levels because of mining operations, agriculture, and urban runoff. Documented changes in conductivity readings warrant further investigation.

Salinity

Salinity refers to the concentration of dissolved salts in seawater. More specifically, salinity is the number of grams of dissolved salts in a kilogram of seawater, thus the units of salinity are parts per thousand (ppt). The salinity of average ocean water is 35 ppt. Aquatic plants and organisms are sensitive to changes in salinity.

Coastal Conditions
Coastal and inshore waters such as estuaries, tidal rivers and marsh creeks generally have lower salinity values. These inshore areas also have highly variable salinity conditions. As the tide comes in or rises, seawater is pushed further inshore or inland, and the salinity at a particular location might increase within hours. Similarly, as the tide goes out, the seawater moves seaward and thus the salinity may decrease.

Salinity is a very important feature and parameter of coastal aquatic habitats. Not only does salinity affect the biological community, but it also affects the density of the water itself. The resulting water density has an effect on, and may be the cause of water flow and transport (both speed and even direction). In fact, typical inshore water circulation includes less dense, less salty water moving downstream along the surface while denser, saltier water is actually moving inshore/upstream along the bottom.

In coastal aquatic habitats, it is thus very important to know and record the salinity at any monitoring site. Salinity is one of the most basic chemical parameters for characterizing a coastal aquatic habitat.

Estuary Monitoring
Estuaries are partially enclosed bodies of water where seawater and freshwater (e.g. from a river) mix. With variations in river inflow (due to rainfall, melting, freshwater removal for industries, agriculture, etc.) and the constant tidal action moving seawater in and out, estuaries are water bodies of temporally and spatially variable salinity. Organisms that live in estuaries must be able to withstand variable salinity conditions. Adaptations include escaping/moving to more favorable conditions, closing up until more favorable conditions return, burrowing/digging into the bottom, using internal water balance metabolic processes such as producing more or less urine, drinking more or less water, or spending more energy to conserve or get rid of excess water and salts. Georgia estuarine animals such as oysters, blue crabs, shrimp, and mullet are capable of surviving in and dealing with the variable salinity conditions of coastal rivers, sounds, and salt marshes.

Measuring Conductivity
Salinity is most commonly determined by using a salinity refractometer, a hand held device that measures the refraction or bending of light passing through a solution to determine the strength or concentration of that solution. The refractometer should be calibrated within 24 hours prior to each monitoring event. Take two samples for duplicate precision. The two samples must be within ±1.0ppt. If the tests are not within duplicate precision of each other, run another test until two are within that range.

State Standards
There are no regulated levels of salinity in Georgia.

What Measures Measured Levels May Indicate

If high salinity readings are found in upstream rivers and estuaries, which traditionally have lower salinity readings, freshwater flow may be reduced. This in turn will impact the coastal aquatic habitat.

Water Clarity

Water clarity refers to the transparency or clearness of the water. It is affected by the amount of suspended particles in the water column and algae growth. Suspended particles can lower water clarity which can limit the amount of sunlight available for photosynthesis, damage the gills of fish and macroinvertebrates, suffocate fish and oysters, and disturb filter feeding organisms.

Measuring Water Clarity

The Secchi disk (pronounced sec'-key) is used to measure the clarity of the water. The disk is named after Pietro Angelo Secchi, a papal scientific adviser and head of the Roman Observatory in the 1860s. Secchi lowered a white plate on a rope into the Mediterranean to determine the depth at which he could no longer see it as a relative measure of water clarity.

Modern Secchi disks are weighted metal disks. The face of the disc is divided into quarters and painted black and white for contrast. The disk is lowered into the water to the point at which the disk can no longer be seen – this depth is then called the Secchi depth. Secchi depths can then be compared to track changes and compare differences in water clarity within and between bodies of water. Take two Secchi disk depth readings for duplicate precision. The two samples must be within ±10cm. If the tests are not within duplicate precision of each other, run another test until two are within that range.

State Standards

There are no regulated levels of water clarity or Secchi depth in Georgia.

What Measured Levels May Indicate

Water clarity can be affected by natural influences such as wind, rainfall, tidal stage, and algae growth. Human influences can cause changes in water clarity. Nutrient additions, development, boating or dredging activities could cause the clarity of a waterbody to decrease.

Settleable Solids

The settleable solids test is an easy, quantitative method to measure sediment and other particles found in surface water. A measurement of settleable solids is not the same as a turbidity reading. Turbidity levels are measured by taking into account all particles suspended in the water column, including small, colloidal sized particles, like clay. A settleable solids test only measures those particles large enough to settle out within a given period of time.

Excessive solids in water can block sunlight and clog fish and macroinvertebrate gills. Sediment that settles on the streambed can smother habitat for fish and other aquatic life. Sediment can also carry harmful substances such as bacteria, metals, and excess nutrients.

Measuring Settleable Solids
An Imhoff cone (a plastic or glass 1 liter cone) is filled with one liter of sample water, stirred, and allowed to settle for 45 minutes. Solids will settle in the bottom of the cone and are then measured as a volume of the total, in millimeters per liter. This measurement is a reproducible analogue for turbidity.

State Standards
There are no regulated levels of settleable solids in Georgia.

What Measured Levels May Indicate
Land-disturbing activities contribute to elevated levels of settleable solids in Georgia's streams, rivers, lakes and wetlands. Possible sources include cropland, pasture, livestock operations, forestry activities, construction, roads, and mining operations. Sediment in streams functions much like sandpaper, scouring stream banks, leading to streambank failure, and ultimately causing further erosion.

Nutrients

The addition of nitrogen, phosphorus and other nutrients to a body of water may lead to increased plant growth, ultimately resulting in algae blooms. Over time, living and dead plant material builds up and, combined with sediments, fills in lakes and reservoirs. This is a naturally occurring process called **eutrophication**. However, when excess nutrients and sediment are added as a result of human activity, the speed of this natural process is increased significantly.

> Eutrophic – a body of water with excess nutrients, sediment and organic matter, which often causes water quality problems.

Plants, especially algae, are very efficient users of nitrogen and phosphorus. By the time an algae bloom is observed, the nutrients may no longer be measurable but may continue to impact the ecosystem. By sampling upstream from areas of algae blooms, the source of excess nutrients may be identified. Algae blooms will usually be found in lakes and reservoirs. If excessive algae are found in streams, the nutrient content is probably very high. The macroinvertebrate population will reflect a high input of nutrients, meaning you may find little variety of macroinvertebrates but many of one or two kinds.

High flow rates in streams may prevent the establishment of floating aquatic plants and algae despite the presence of high levels of nutrients. As the summer progresses and flow rates drop, once rapidly flowing streams can become choked with algae. Wide, slow moving and tidal areas downstream may exhibit algae blooms weeks earlier.

Sources of Nutrients
Nitrogen and phosphorus enter water from human and animal waste, decomposing organic matter and fertilizer runoff. Phosphates are also found in some industrial effluents, detergent wastewater from homes, and natural deposits.

Nitrates

Nitrogen occurs in natural waters as ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), and organically bound nitrogen. Through a process called nitrification, bacteria convert ammonium to nitrites, which are quickly converted into nitrates. Ammonia test results are expressed as “ammonia as nitrogen”. Nitrate test results are expressed as "nitrate nitrogen" (NO_3-N), meaning "nitrogen that was in the form of nitrate." Some test kits and literature express levels only as nitrate (NO_3). Both expressions refer to the same chemical and concentrations, but use different units of measure:

Nitrate Nitrogen ppm x 4.4 = Nitrate ppm

Significant Levels

Unpolluted waters generally have a nitrate-nitrogen level below 1 ppm. Nitrate-nitrogen levels above 10 ppm (44 ppm nitrate) are considered unsafe for drinking water.

What Measured Levels May Indicate

Levels of nitrate-nitrogen above 1 ppm may indicate a sewage overflow. High levels may also indicate the presence of fertilizers and animal waste. High levels of ammonia nitrogen generally indicate a more immediate source of pollutants.

Phosphorus

Phosphorus occurs in natural waters in the form of phosphates, orthophosphates, polyphosphates and organically bound phosphates. Simple phosphate test kits measure reactive phosphorus (primarily orthophosphate), which is the form of phosphate applied as fertilizer to agricultural and residential lands.

Organically bound phosphates in water come from plant and animal matter and wastes. Organically bound phosphates and polyphosphates cannot be measured directly. They must first be broken down and then an orthophosphate test is performed to measure total phosphorus. Results are expressed as phosphate (PO_4).

Significant Levels

Total phosphorus levels higher than 0.03 ppm contribute to increased plant growth (eutrophic conditions), which will lead to oxygen depletion. Total phosphorus levels above 0.1 ppm may stimulate plant growth sufficiently to surpass natural eutrophication rates.

What Measured Levels May Indicate

Levels in excess of 0.1 ppm indicate a potential human source such as industrial soaps, sewage, fertilizers, disturbance of soil, animal waste, or industrial effluent.

Alkalinity

Alkalinity of water is its acid-neutralizing capacity. It is the sum of all the bases found in a sample, including carbonate, bicarbonate, and hydroxide content. The alkalinity, and therefore buffering capacity, of natural waters will vary with local soils.

Significant Levels

The higher the alkalinity, the better the capacity to buffer the fluctuation of pH in water. To protect aquatic life it should be at least 20 mg/L.

What Measured Levels May Indicate

Alkalinity levels should not fluctuate much unless a severe industrial problem has occurred upstream.

Appendix

- Resources Available on the Adopt-A-Stream Website
- How to Make A Kick Seine
- Background on Aquatic Insects
- Habitat Enhancement
- Glossary of Stream Related Terms

Resources Available on the Adopt-A-Stream Website

www.GeorgiaAdoptAStream.org

- Chemical Data Form
- Macroinvertebrate Data Form
- Field Directions for Core Tests of Chemical Monitoring
- Aquatic Macroinvertebrate Field Guide for Georgia's Streams
- Chemical Monitoring Training Presentation
- Macroinvertebrate Monitoring Training Presentation
- Chemical and Macroinvertebrate Equipment Purchasing Information

How to Make A Kick Seine

For collecting macroinvertebrates
(Courtesy of the Tennessee Valley Authority)

Materials:

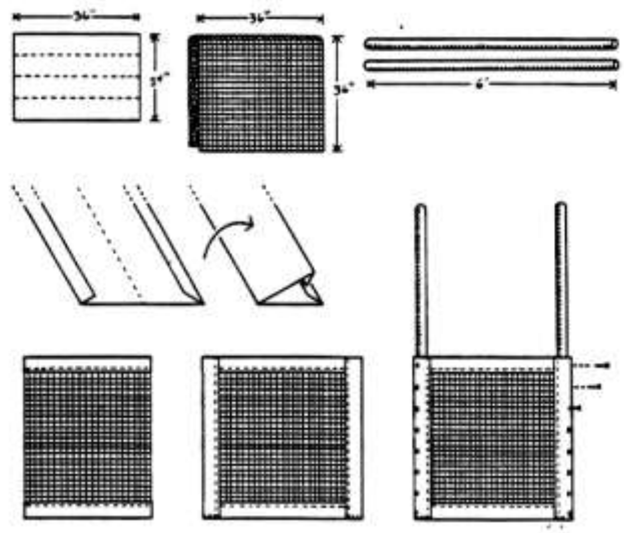
- 3 foot by 3 foot piece of nylon or metal window screening
- 4 strips of heavy canvas (6 inches by 36 inches)
- 2 broom handles or wooden dowels (5 or 6 feet long)
- finishing nails
- thread
- sewing machine
- hammer
- iron and ironing board

Procedure:

1. Fold edges of canvas strips under, 1/2 inch, and press with iron.
2. Sew 2 strips at top and bottom and then use other 2 strips to make casings for broom handles or dowels on left and right sides. Sew bottom of casings shut.
3. Insert broom handles or dowels into casings and nail into place with finishing nails.

Speed method:

1. Lay 3 foot by 3 foot piece of screening over broom handles.
2. Staple or nail screen to broom handles.



Background on Aquatic Insects

To understand and identify aquatic insects, one must start with how all animals are classified. The most general category is first, with the species level being the most specific. Volunteers will learn to identify aquatic insects to the order level. A stonefly is classified as an example.

Kingdom	Animal (all animals)
Phylum	Arthropoda (all animals with exoskeletons)
Class	Insecta (all insects)
Order	Plecoptera (all stoneflies)
Family	Perlidae (Perlid stoneflies)
Genus	*Acroneuria*
Species	*Acroneuria lycorias* (Golden Stonefly)

Life Stages of Insects

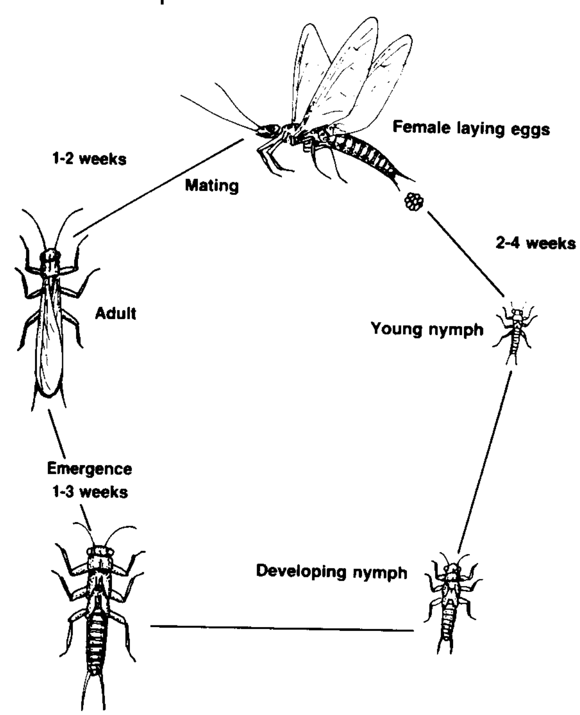
Identifying insects is complicated because of the different stages they pass through during their development. The changes from the egg stage to the adult are often dramatic. The incredible change of a caterpillar into a butterfly is well known; most aquatic insects experience similar changes. The process of changing form during the life cycle is called metamorphosis, of which three types are possible: ametabolous, incomplete, and complete.

Ametabolous Metamorphosis

This type of metamorphosis means "without change" and refers to the lack of change between the immature and adult stages. It's found in only a few very primitive orders of insects that have no wings as adults. Some species are semiaquatic.

Incomplete Metamorphosis

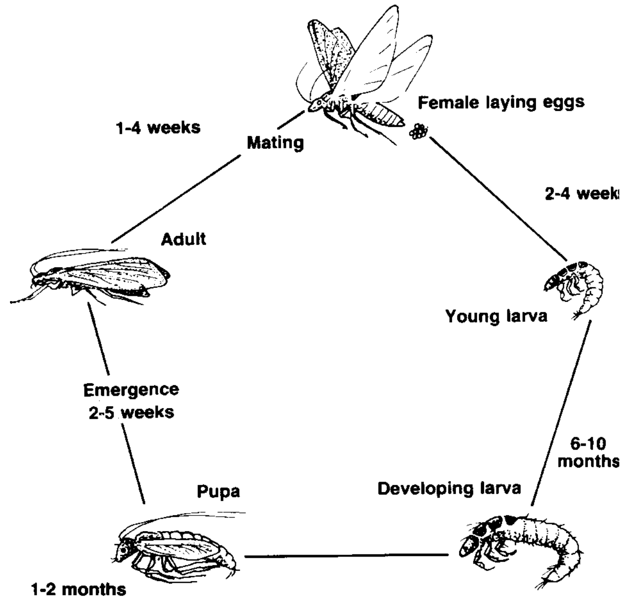
Insects with incomplete metamorphosis pass through three distinct stages: egg, nymph, and adult. The time required to complete each stage varies widely, with the greatest amount of time usually spent in the nymphal stage. In most cases, the entire cycle requires one year to complete, although this also varies with different species. Nymphs often look similar to their adult stage. As nymphs mature, the adult wings begin developing in stiff pouch-like structures on the thorax called wing pads. This is an obvious and unique characteristic of insects with incomplete metamorphosis. The wing pads on fully mature nymphs will be quite dark, almost black, in color. The orders of aquatic insects with incomplete metamorphosis include:



- Mayflies (Order Ephemeroptera)
- Dragonflies and Damselflies (Order Odonata)
- Stoneflies (Order Plecoptera)
- Water Bugs (Order Hemiptera)

Complete Metamorphosis

Insects with complete metamorphosis pass through four distinct stages: egg, larva, pupa, and adult. The addition of the pupal stage separates insects with complete metamorphosis from those with incomplete metamorphosis. While the length of time needed to complete each stage again varies widely, the entire cycle usually takes one year. Most of the cycle is generally spent in the larval stage. Unlike nymphs, larvae bear little resemblance to the adults and show no development of wing pads. It is during the pupal stage that the wing pads and other adult features develop. The orders of aquatic insects include:



- Dobsonflies and Alderflies (Order Megaloptera)
- Caddisflies (Order Trichoptera)
- Aquatic Moths (Order Lepidoptera)
- Aquatic Flies (Order Diptera)
- Aquatic Beetles (Order Coleoptera)

Growth And Development

The growth of insects occurs in a series of stages called **instars**. The exoskeleton of insects must be periodically shed in order for growth to continue. The process of shedding the old exoskeleton is called **molting**. When the old exoskeleton is cast aside, a new, slightly larger one is present underneath. The old empty exoskeleton is often referred to as a **shuck**. Except for mayflies, molting stops once the insect reaches the winged adult stage. Most insects molt five or six times during their development. Mayflies, stoneflies, dragonflies, and damselflies, however, may molt 15-30 times before reaching their adult stage.

Recognizing the insect's stage and degree of development can help anglers determine what insect to imitate. Mature nymphs and larvae often become more active in the water as they move to emergence or pupation sites. This increased activity makes them more available to fish and thus makes them more important to imitate. Looking for and imitating the most mature insects will normally produce the best fishing.

One of the most vulnerable periods in the insect's life cycle is during emergence from the immature to the adult stage. At the time of emergence, mature nymphs or pupae typically crawl out of the water or swim to the water's surface. Those that emerge in the surface film must break through the surface tension, which can take from several seconds to over a minute. Thus, during emergence the shelter of the lake or stream bottom no longer protects insects. Fish readily take advantage of the insects' vulnerability and often feed selectively on emerging nymphs or pupae. The angler who recognizes this activity will find fish fast by imitating the shape and action of the natural prey.

Adult insects often rest on the water's surface after emerging from the nymphal or pupal shuck. Then, after mating, most aquatic insects return to the water to lay their eggs. Insects resting or laying eggs on the surface provide fish with many easy meals.

Source: An Angler's Guide to Aquatic Insects and their Imitations, Hafele and Roederer, 1987.

Habitat Enhancement

(from Protecting Community Streams: A Guidebook for Local Governments in Georgia, Atlanta Regional Commission, 1994)

Stream habitat enhancement projects directly improve the health of streams by improving the adjacent (riparian) area, stream bank, or streambed habitat. All three of these areas function together to make up a stream ecosystem.

Stream habitat enhancement projects can be complicated. Check with your local Natural Resources Conservation Service, Cooperative Extension Service, the Fish and Wildlife Service, or a private consultant to be sure your efforts will yield the results you seek. Also, a Corps of Engineers permit may be needed before any material is placed in a stream or adjacent wetlands. Small projects are usually exempt. Call the Corps' office for more information on Georgia streams, 678-422-2721 (North Georgia) and 229-430-8566 (South Georgia).

Stream habitat enhancement projects may occur on private property with permission of landowners or on public property in cooperation with the local or State agency responsible for property management. Habitat enhancement projects involve three major activities:

- riparian reforestation
- streambank stabilization
- streambed restoration

Riparian Reforestation

The contribution of trees and woody understory vegetation to the maintenance of stream health cannot be overstated. Streamside forested areas not only provide habitat, shade, and forage for both aquatic and land-based species, but their ability to filter pollutants and rainfall provides a buffer – a last line of defense – from watershed runoff. Restoring streamside areas is one of the most cost-effective steps a community or Adopt-A-Stream program can take to protect stream health. The objective should be to replicate or mimic the natural ecosystem as much as possible; therefore, a mix of young and older native plant and tree species are preferred. Follow these steps to conduct a riparian reforestation project:

1. Evaluate current water quality conditions – take "before" pictures and/or conduct physical/chemical, macroinvertebrate, bacterial or visual assessments.
2. Choose a site(s) that needs additional vegetation to protect water quality from stormwater runoff.
3. Purchase a variety of plants that will tolerate wet conditions.
4. Plant trees, shrubs and grasses in the area immediately adjacent to your stream. Plant enough so that the vegetation will actually protect the stream – filter pollutants from stormwater, stop sediment from entering water, etc.
5. Water after planting and as needed.
6. Check each week for four to six weeks to ensure that plants are healthy.
7. Once plants are well established, evaluate water quality improvement – take "after" photograph and/or compare with initial water quality tests.

Streambank Stabilization

If you have an eroding or collapsing streambank, you need to first determine the cause of the problem. Streambank erosion occurs for a number of reasons, including increased stream velocity, obstacles in the stream, floating debris, wave action, and direct rainfall. Streambank failure occurs when a large section of streambank collapses into the stream channel. Among the causes of streambank failure are downcutting of the streambed and undercutting of the bank, increased load on the top of the bank, and internal pressure from uneven water absorption.

Selection of an appropriate bank stabilization method requires careful analysis of each site. No single method is appropriate in all situations. Technical advice will often be needed. Consult the Soil and Water Conservation Commission's "Guidelines for Streambank Restoration".

One technique to stabilize streambanks is called "soil bioengineering", which involves using vegetation as the structural control to stabilize banks. Plantings of woody vegetation, such as willows (either as individual live cuttings or in bundles of cuttings), grow into a dense network of protective vegetation. See Figures 1 and 2. The vegetation's root structure provides resistance to the sliding and shear displacement forces involved in slope erosion.

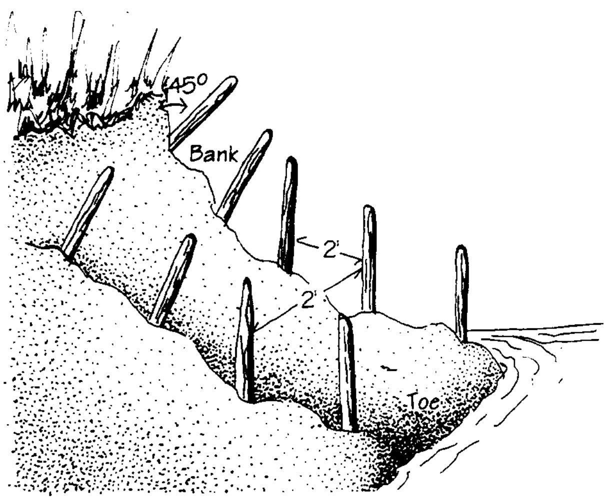


Figure 1 - Willow plantings

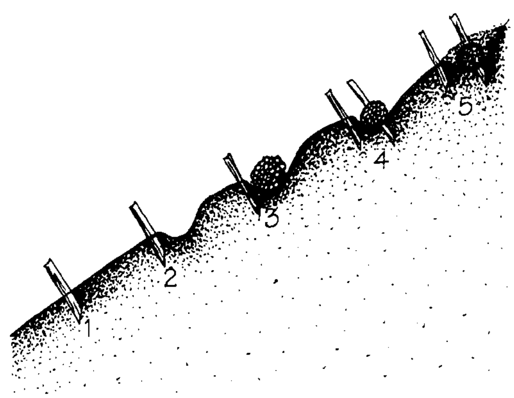


Figure 2

In some cases, a solely vegetative approach may be all that is needed. In others, conditions such as excessive stream velocities or poor soil conditions may require a combination of vegetative and structural elements (such as stone walls or bulkheads). See figure 3

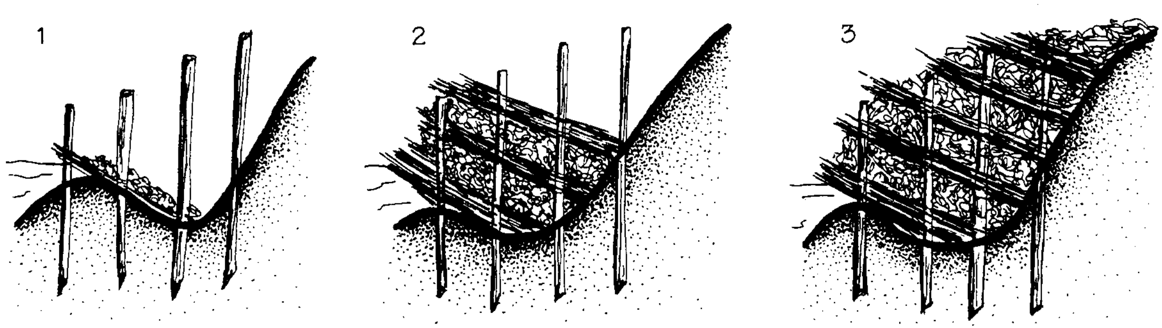


Figure 3

Streambed Restoration

Prior to any streambed restoration, upstream conditions should be assessed. Without corrective measures or retrofitting upstream, stormwater flows could quickly destroy any streambed restoration work. If the stream is in equilibrium, or if appropriate corrective measures are in place, streambed restoration can recreate the habitat conditions needed to support aquatic life. Several goals may be accomplished when restoring a streambed, including:

- Replacement of pools and riffles (in north Georgia and Piedmont areas)
- Velocity control
- Restoration of the stream gradient and normal flow channel
- Removal of major stream obstructions
- Restoration of suitable channel patterns such as:
    - Meandering – repetitive bends
    - Irregular – more or less straight
    - Braided – stream separates and rejoins around islands
- Restoration of substrate (removal of sediment and replacement with gravel and cobbles, as appropriate)

Some of these techniques permit the stream water flows to work to restore healthier streambed conditions; others require excavation and physical realignment of the stream channel. Three basic techniques include deflectors, in-stream boulders and drop structures.

Deflectors can easily be constructed from common, local materials such as cobbles, boulders and logs and are adaptable to a variety of conditions and stream sizes. They are sited in the channel with the intent of deflecting the current into a narrower channel. Deflectors can use the streamflow for a variety of purposes, including deepening channels, developing downstream pools, enhancing pool/riffle ratios and assisting in the restoration of meander patterns with channeled reaches. There are several deflector designs. Figure 4 (left) shows a simple double "wing deflector" that consists of rock structures on each bank deflecting the streamflow to a central channel. Single deflectors along one bank are also used as shown in Figure 4 (center). Deflectors can be offset on opposite banks of a stream to imitate meanders, as shown in Figure 4 (right). (Pennsylvania DER, 1986).

A third type of deflector is the V-type, which is placed in the middle of the channel with the point of the "V" pointing upstream deflecting water towards both banks. This type of deflector helps re-establish riffles and pools downstream. An underpass deflector is a log placed across a small stream several inches off the bottom. Water is deflected under the log, which helps remove sediment deposits and restore pools. (Gore, Ed. 1985) (Kumble, 1990).

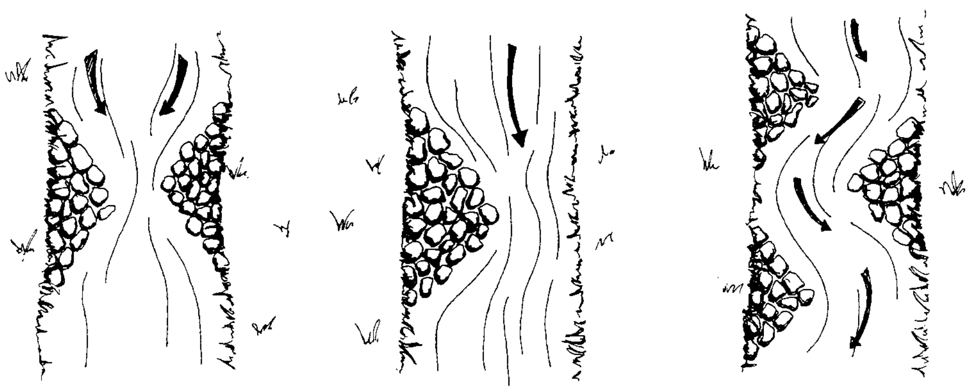
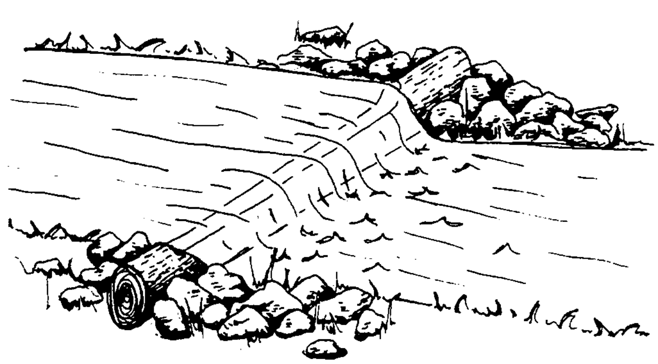


Figure 4 – wing deflector (left), single deflector (center) and double deflector (right)

Drop structures include a number of variations such as weirs, check dams, sills and plunges. They can serve a variety of functions in streambed restoration depending upon their design, including: slowing stream flow; deepening existing pools; and creating new pools upstream and downstream. Structures with notches can be used to control heavy stormwater flows and can help re-establish deep pools immediately downstream. Drop structures can be made of concrete, logs or boulders. Log or boulder structures can be used to replicate small falls or rapids. Single log dams across a streambed are simple and effective in restoring plunge pools (figure 5). The K-dam is a variant of the single log dam, so named by adding downstream bracing. In some areas, especially headwater areas, reintroducing beavers has been effective in restoring the habitat. Their dams function as drop structures in headwaters and on small streams.

Figure 5



Boulder placement is a third in-channel treatment that can assist streambed restoration. Boulders can be used to reduce velocity, restore pools and riffles, restore meanders, provide cover and protect eroded banks by deflecting flow. Boulders can be placed randomly or in a pattern. Placing them in a "V" pointed upstream produces eddies that replicate riffles as well as restores downstream pools (Figure 6). Combined with placement of cobbles and gravel, boulder placement can also help restore the stream substrate.

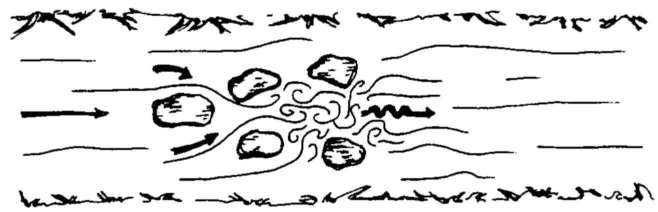


Figure 6

Excavation and fill may also be necessary to restore the stream gradient, the normal flow channel and the stream channel pattern, including meanders and braids, where appropriate. Channel pattern restoration should be combined with streambank restoration and re-vegetation.

Streams that have been severely degraded by large amounts of sediment or heavy stormwater flows may require greater restoration work. Sediment may have to be removed mechanically and replaced with gravel and cobbles to replicate the original streambed. Major debris accumulation that is obstructing flows may also need removal.

Additional references:

- Guidelines for Streambank Restoration. Georgia Soil and Water Conservation Commission. 1994.
- A Georgia Guide to Controlling EROSION with Vegetation. Georgia Soil and Water Conservation Commission. 1994.
- Protecting Community Streams: A Guidebook for Local Governments in Georgia. Atlanta Regional Commission. 1994.
- Gore, James A., editor. The Restoration of Rivers and Streams. 1985.
- Barnett, John L. Stream Restoration Along the Greenways in Boulder, Colorado. 1991.
- Commonwealth of Pennsylvania, Department of Environmental Resources. A Streambank Stabilization and Management Guide for Pennsylvania Landowners. 1986.

Glossary of Stream Related Terms

Accuracy – a measure of how close repeated trials are to the desired target.

Acid rain – rain with a pH of less than 5.6; results from atmospheric moisture mixing with sulfur and nitrogen oxides emitted from burning fossil fuels; causes damage to buildings, car finishes, crops, forests, and aquatic life.

Acidity – a measure of the number of free hydrogen ions (H+) in a solution that can chemically react with other substances.

Algae – simple plants which do not grow true roots, stems, or leaves and live mainly in water, providing a base for the food chain.

Algal bloom – a heavy growth of algae in and on a body of water as a result of high nitrate and phosphate concentrations from farm fertilizers and detergents.

Alkalinity – a measure of the negative ions available to react and neutralize free hydrogen ions. Some of most common of these include hydroxide (OH), sulfate (SO_4), phosphate (PO_4), bicarbonate (HCO_3) and carbonate (CO_3)

Ambient – pertaining to the current environmental condition.

Assemblage – the set of related organisms that represent a portion of a biological community (e.g., benthic macroinvertebrates).

Benthic – pertaining to the bottom (bed) of a water body.

Best management practices - an engineered structure or management activity, or combination of these, that eliminates or reduces an adverse environmental effect of pollutants.

Biochemical oxygen demand (BOD) – the amount of oxygen consumed by microorganisms as they decompose organic materials in water.

Biological criteria – numerical values or narrative descriptions that depict the biological integrity of aquatic communities in that state. May be listed in State water quality standards.

Channel - the section of the stream that contains the main flow.

Channelization - the straightening of a stream; this is often a result of human activity.

Chemical constituents - chemical components that are part of a whole.

Clear cutting – felling and removing all trees in a forest area.

Cobble stone –Stones 2-10 inches in diameter, among which aquatic insects are commonly found.

Combined sewer overflow (CSO) - sewer systems in which sanitary waste and stormwater are combined in heavy rains; this is especially common in older cities. The discharge from CSOs is typically untreated.

Community - the whole of the plant and animal population inhabiting a given area.

Culvert – a man-made closed passageway (such as a pipe) under roadways and embankments, which drains surface water and diverts the natural flow.

Designated uses – state-established desirable uses that waters should support, such as fishing, swimming, and aquatic life. Listed in State water quality standards.

Dissolved oxygen (DO) – oxygen dissolved in water and available for living organisms to use for respiration.

Distilled water – water that has had most of its impurities removed.

Dredge – to remove sediments from the stream bed to deepen or widen the channel.

Effluent – an out-flowing branch of a main stream or lake; waste material (i.e. liquid industrial refuse, sewage) discharged into the environment.

Ecoregion – geographic areas that are distinguished from others by ecological characteristics such as climate, soils, geology, and vegetation.

Embeddedness – the degree to which rocks in the streambed are surrounded by sediment.

Emergent plants – plants rooted underwater, but with their tops extending above the water.

Erosion – the wearing away of land by wind or water.

Eutrophication – the natural and artificial addition of nutrients to a waterbody, which may lead to depleted oxygen concentrations. Eutrophication is a natural process that is frequently accelerated and intensified by human activities.

Floating plants – plants that grow free-floating, rather than being attached to the stream bed.

Flocculent (floc) – a mass of particles that form into a clump as a result of a chemical reaction.

Glide/run – section of a stream with a relatively high velocity and with little or no turbulence on the surface of the water.

Fish kill – the sudden death of fish due to the introduction of pollutants or the reduction of dissolved oxygen concentration in a water body.

Floodplain – a low area of land surrounding streams or rivers which holds the overflow of water during a flood.

Flow – the direction of movement of a stream or river.

Groundwater – a supply of fresh water under the earth's surface which forms a natural reservoir.

Headwaters – the origins of a stream.

Hypoxia – depletion of dissolved oxygen in an aquatic system.

Impairment – degradation.

Impoundment – a body of water contained by a barrier, such as a dam.

Land uses – activities that take place on the land, such as construction, farming, or tree clearing.

Leaching – the process in which material in the soil (such as nutrients, pesticides, chemicals) are washed into lower layers of soil or are dissolved and carried away by water.

Macroinvertebrate – organisms that lack a backbone and can be seen with the naked eye.

Nonpoint source pollution – pollution that cannot be traced to a specific point, but rather from many individual places (e.g., urban and agricultural runoff).

NPDES – National Pollutant Discharge Elimination System, a national program in which pollution dischargers such as factories and sewage treatment plants are given permits to discharge. These permits contain limits on the pollutants they are allowed to discharge.

Nutrient – substance which is necessary for growth of all living things (i.e. phosphorous, nitrogen and carbon).

Orthophosphate – inorganic phosphorus dissolved in water.

Outfall - the pipe through which industrial facilities and wastewater treatment plants discharge their effluent (wastewater) into a waterbody.

Permeable – porous; having openings through which liquid or gaseous substances can penetrate.

Pesticide – a chemical that kills insects and rodents. Pesticides can poison aquatic life when they reach surface waters through runoff.

pH – a numerical measure of the hydrogen ion concentration used to indicate the alkalinity or acidity of a substance. Measured on a scale of 1.0 (acidic) to 14.0 (basic); 7.0 is neutral.

Phosphorus – a nutrient that is essential for plants and animals.

Photosynthesis – the chemical reaction in plants that utilizes light energy from the sun to convert water and carbon dioxide into simple sugars. This reaction is facilitated by chlorophyll.

Point source pollution – a type of pollution that can be tracked down to a specific source such as a factory discharge pipe.

Pollutant – something that makes land, water or air dirty and unhealthful.

Pool – deeper portion of a stream where water flows more slowly than in neighboring, shallower portions.

Precision – a measure of how close the results of repeated trials are to each other.

Protocol – defined procedure.

Reagent – a substance or chemical used to indicate the presence of a chemical or to induce a chemical reaction to determine the chemical characteristics of a solution.

Riffle – a shallow area of a stream or river with a fast-moving current bubbling over rocks.

Riparian – of or pertaining to the banks of a body of water.

Riparian zone – the vegetated area on each bank of a body of water.

Riprap – rocks used on an embankment to protect against bank erosion.

Runoff – water, including rain and snow, which is not absorbed into the ground but instead flows across the land and eventually runs into streams and rivers. Runoff can pick up pollutants from the air and land, carrying them into the stream.

Saturated – inundated; filled to the point of capacity or beyond.

Sediment – soil, sand, and materials washed from land into waterways. Other pollutants may attach to sediment and be carried into the stream.

Sedimentation – when soil particles (sediment) settle to the bottom of a waterway.

Septic tank – a domestic wastewater treatment system into which wastes are piped directly from the home; bacteria decompose the organic waste, sludge settles to the bottom of the tank, and the treated effluent flows out into the ground through drainage pipes.

Sheen – the glimmering effect that oil has on water as light is reflected more sharply off the surface.

Silviculture – forestry and the commercial farming of trees.

Slumping – sections of soil on a streambank that have come loose and slipped into the stream.

Stagnation – when there is little water movement and pollutants are trapped in the same area for a long period of time.

Submergent plants – plants that live and grow fully submerged under the water.

Substrate – refers to a surface. This includes the material comprising the stream bed or the surfaces to which plants or animals may attach or upon which they live.

Surface water – precipitation which does not soak into the ground or return to the atmosphere by evaporation or transpiration and is stored in streams, lakes, wetlands, and reservoirs.

Taxon (plural taxa) – a level of classification within a scientific system that categorizes living organisms based on their physical characteristics.

Taxonomic key – a quick reference guide used to identify organisms. They are available in varying degrees of complexity and detail.

Tolerance – the ability to withstand a particular condition, e.g., pollution-tolerant indicates the ability to live in polluted waters.

Toxic substances – poisonous matter (either chemical or natural) which causes sickness, disease and/or death to plants or animals.

Tributaries – a body of water that drains into another, typically larger, body of water.

Turbidity – murkiness or cloudiness of water, indicating the presence of some suspended sediments, dissolved solids, natural or man-made chemicals, algae, etc.

Undercutting – a type of erosion which occurs when fine soils are swept away by the action of the stream, especially around curves. The result is an unstable overhanging bank.

Water cycle – the cycle of the earth's water supply from the atmosphere to the earth and back which includes precipitation, transpiration, evaporation, runoff, infiltration, and storage in water bodies and groundwater.

Water quality criteria – maximum concentrations of pollutants that are acceptable, if those waters are to meet water quality standards. Listed in State water quality standards.

Water quality standards – written goals for State waters, established by each State and approved by EPA.

Watershed – land area from which water drains to a particular water body.

Water table – the upper level of groundwater.

Waterway – a natural or man-made route for water to run through (such as a river, stream, creek, or channel).

Wetland – an area of land that is regularly wet or flooded, such as a marsh or swamp.