Adopt-A-Stream

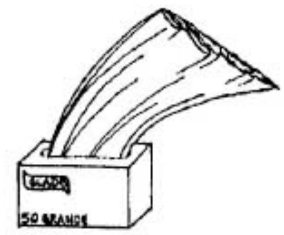
Written by:

Tina Laidlaw

Illustrations by:

Trich Jackson

PHYSICAL EVALUATION



Materials needed for the Physical Evaluation:

- Clipboard and Pencil
- Stream Evaluation Sheets
- Meter Stick
- Boots
- Bags to gather trash

To evaluate the stream's physical parameters, you will complete the back and front of the physical evaluation sheet. Emphasis is placed on a "sensory" assessment of stream water quality (i.e. the color of the water, the odor of the sediment) and identifying the local human activities which may influence stream water quality (i.e. local land use patterns). This evaluation is important because it can determine sources of pollution that enter the stream.

The specific stream attributes that you are required to evaluate are listed below. For each category, mark the answer on the evaluation sheet which best describes the observed stream condition at the site.

Water Quality:

Water quality can be evaluated with a variety of different techniques. Some techniques require equipment to analyze parameters. Other methods of analysis do not use equipment and instead involve documenting the color and odor of the stream. The following list is a brief description of basic stream parameters studied using the field sheets.

- **Weather Conditions:** Give a brief description of the climatic conditions during the sampling period. Include any recent climatic events, such as heavy rainfall. Even though the event may not have occurred during the sampling period, it can affect water flow and quality.

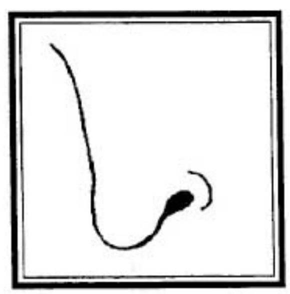
- **Stream Diagram:** Sketch a picture of the stream, making sure landuse patterns are highlighted since they may affect water quality.

- **Water Chemistry:** Record the value of each indicated water quality parameter.

- **Physical Characteristics:**
  Stream Width: Estimate the distance from shore to shore. Be sure to pick a point that is characteristic of the stream width at the sampling site.
  Pools and Rapids: Estimate the number of pools (deep, slow moving sections stream) and rapids (shallow, fast sections of the stream). Pools are important stream features since they provide habitat for fish. Rapids are often characterized by higher dissolved oxygen concentrations and can be areas of high biodiversity for aquatic insects. Determine the stream depth by measuring the distance from the water surface to the stream bottom.

Riffles are the shallow, fast-moving stream sections. Because of the wind aeration, riffles typically have higher dissolved oxygen concentrations. A riffle can be seen in the upper stream section. Pools tend to be deeper and slower moving. The lower section of this stream is more pool-like. Fish often reside in deeper pools. Each section supports a variety of organisms.

• **Water Parameters**

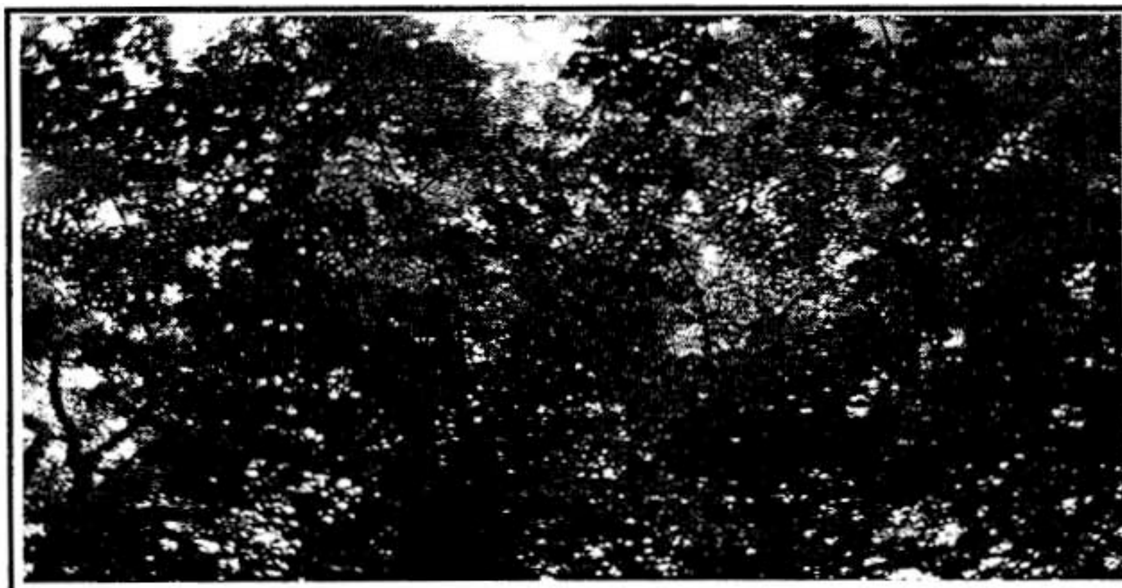


Water Color: Record the color of the water. Be sure to note if the color is peculiar (red, blue, etc.).

Substrate Color: Record the color that best describes the color of the stream substrate.

Sediment Odor: Disturb the sediment and record any odors described.

• **Canopy Cover**: Note the general proportion of open (no trees, stream receives direct sunlight) to shaded area (trees provide shading for the stream) which describes the amount of tree cover at the sampling site.



This picture shows a "closed canopy" above a stream. Note the reduced amount of sunlight penetrating through the leaves.

• **Organisms and Plants:**

Algae: Note the presence/absence of algae (a variety of aquatic photosynthetic organisms) in the stream or along the bank.

Aquatic Plants: Note the presence/absence and type of aquatic plants (also called macrophytes).

Fish: Note the presence/absence of fish in the stream.

Other Organisms: Note the presence of a variety of different organisms around the stream (i.e. birds, amphibians).

• **Predominant Land Use:** Observe the prevalent landuse type in the vicinity (noting other land uses in the area which, although not predominant, may potentially affect water quality).

Primary or Secondary Forest: Landuse dominated by forest.

Tacotal: Landuse characterized by patches of forest with young trees.

Pasture: Areas currently being used for cattle grazing or were previously grazed

Agriculture: Land under cultivation for crops, gardens, etc.

Residential: Areas with homes built close to the streambank.

Commercial: Grocery stores or shops near the stream.

Industrial: Factories located within the watershed.

• **Water Use**: Mark the ways in which humans use the stream. Changes in human uses of a particular water body can reflect water quality.

• **Human Impacts**:

Channelization: Indicate whether or not the sampling site is artificially channelized (straightened).

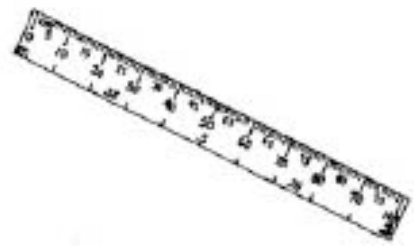
Barriers: Note whether there are any artificial or natural barriers immediately upstream or downstream of the sampling site

Trash: Record the presence/absence of any trash.

Note the amount of trash in or near your site. Then take a minute and pick it up to be disposed of properly.

HABITAT EVALUATIONS

<u>Materials needed for the Habitat Evaluation:</u>



- Clipbard and Pencil
- Stream Evaluation Sheets
- Meter Stick
- Boots
- Bags to gather trash

Like the Physical Evaluation, to evaluate the stream's habitat parameters you will complete a one-page sheet. The habitat evaluation consists of a series of seven parameters related to different stream characteristics that either directly or indirectly influence the quality of the stream habitat. An evaluation of habitat quality is critical to any assessment of ecological integrity of a river. A stream with excellent habitat quality provides organisms with a variety of locations for reproduction and refugia (logs, rocks, etc.) and food resources. A stream with poor habitat quality generally has fewer places for organisms to hide from predator or to find resources and therefore, has less ability to support a diversity of organisms.

To maintain data accuracy, it is preferable to have the same person(s) assess the habitat criteria for each site. To determine the stream rating, pick the category (excellent, good, fair, poor) that best describes the stream site. Within that category decide on the value that more specifically defines the observed conditions. The values are adjusted to emphasize the parameters which have the greatest influence on water quality. The sum is used for between site comparisons.

Habitat parameters pertinent to the assessment of habitat quality are separated into three principal categories: primary, secondary, and tertiary parameters.

- **Primary**: Instream parameters that have the greatest direct influence on the structure of the aquatic community.

- **Secondary**: Parameters that measure characteristics of the stream's <u>channel morphology</u> (the form or structure of the channel).

- **Tertiary**: Parameters that evaluate <u>riparian</u> habitat and bank structure.

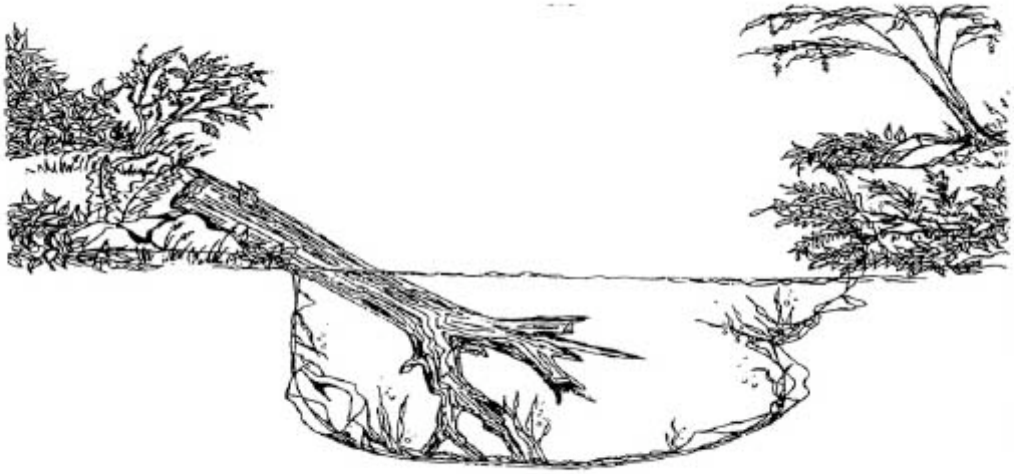
Generally, the primary parameters are evaluated within the first riffle/pool sequence, or the immediate sampling area. Secondary and tertiary parameters are evaluated over a larger stream area, primarily upstream where conditions will have the greatest impact on the community being studied.

Listed below are general explanations for each of the seven parameters used in the Habitat Evaluation.

PRIMARY PARAMETERS

The primary instream habitat characteristics consist of: substrate type and stability, availability of refugia, and migration/passage potential. These primary habitat parameters are given the highest rankings to reflect their degree of importance to biological communities.

• **Bottom Substrate**: This refers to the amount of habitat available to support aquatic organisms by providing locations for spawning (for fish) and refugia. A variety of substrate materials and habitat types are desirable. The presence of rock and gravel in flowing streams is generally considered excellent habitat. However, other forms of habitat may provide the niches required for community support. For example, logs, tree roots, submerged or emergent vegetation, undercut banks, etc. provide habitat for a variety of organisms, particularly fish.



This drawing shows a view of a stream with a varied bottom substrate. The log and plants provide habitat for different organisms.

• **Sediment Deposition**: The amount of sediment in the stream influences the habitat available for invertebrates and fishes. Human activities such as construction and erosion caused by deforestation lead to increased sedimentation in streams. The most desirable condition is to have less than 5% of the stream bottom covered with sediment.

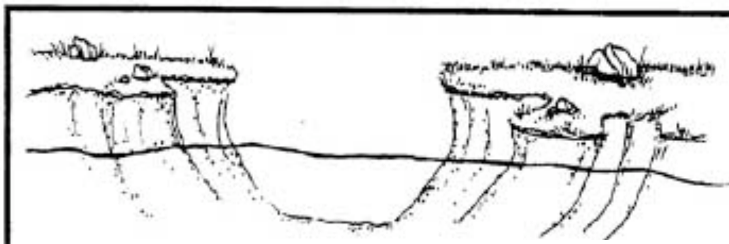
• **Presence of Pools and Rapids:** A greater variety of organisms can reside in a stream, with a range of velocities and depths. Pool areas, with slower-moving currents, provide shelter for fishes while shallow, faster riffle sections generally have higher dissolved oxygen concentrations and provide suitable habitat for filter feeding organisms. A stream with a combination of fast-shallow, fast-deep, slow-shallow, and slow-deep sections is considered the most desirable.

SECONDARY PARAMETERS

Secondary parameters evaluate the channel morphology. Channel morphology is determined by the flow regime of the stream, local geology, land surface form, soil, and human activities. The sediment movement along the channel and the sinuosity of the channel also affects habitat conditions.

The stream on the left has a natural, meandering pattern compared to the channelized stream on the right.

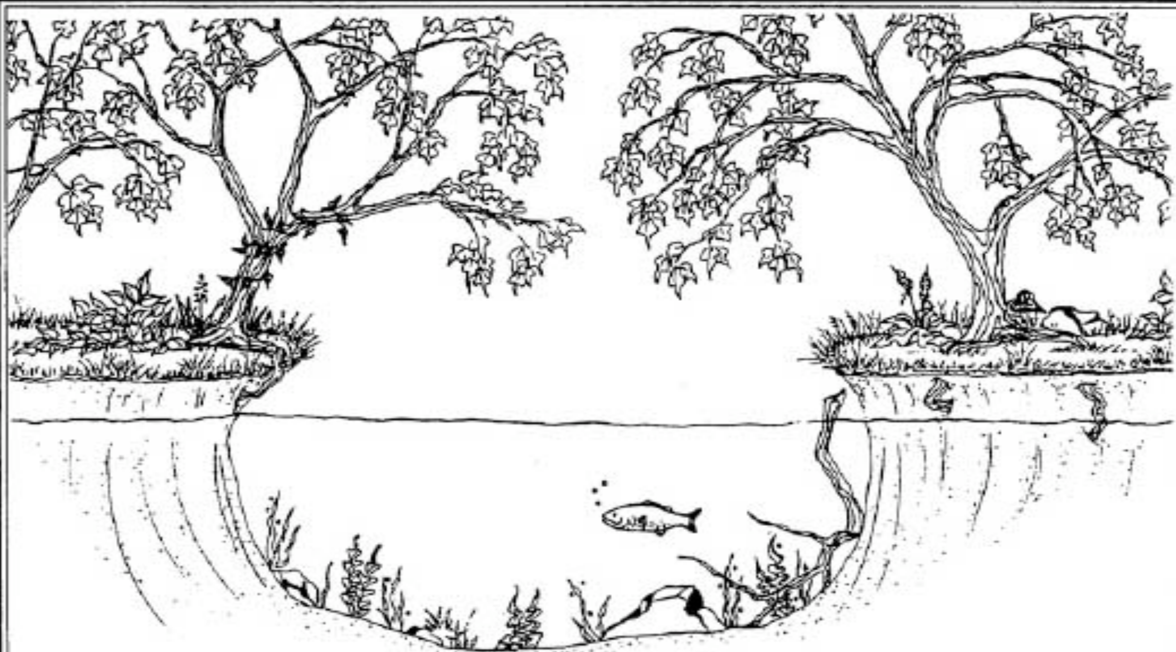
• **Channel Alteration**: The character of sediment deposits from upstream is an indication of the severity of watershed and bank erosion and of the stability of the stream system. The growth or appearance of sediment bars tends to increase in depth and length with continued watershed disturbance. Channelization (e.g., straightening, construction of concrete embankments) decreases stream sinuosity, thereby increasing stream velocity and the potential for scouring.



This stream would be classified as "poor" for bank sustainability. Notice the eroded edges and lack of vegetations

TERTIARY PARAMETERS

Tertiary parameters assess the riparian zone and stream bank structure. Well-vegetated banks are generally stable regardless of bank undercutting. The ability of vegetation and other streambank materials to prevent erosion is an important determinant of the stability of the stream channel and instream habitat for aquatic organisms. Because tertiary parameters indirectly affect the instream habitat features, these parameters are weighted less than the primary or secondary parameters.



This drawing ranks as "excellent" for both back vegetative stability and vegetation type. Roots from plants and trees anchor the streambank while the trees also provide shade and leaf material (organic material) for the stream organisms.

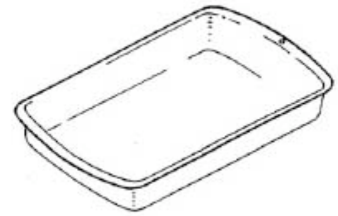
• **Bank Stability**: Bank stability is rated by observing any existing or potential detachment of soil from the upper and lower stream bank and its potential movement into the stream. Steeper banks are generally more subject to erosion and failure, and may not support stable vegetation.

• **Bank Vegetative Stability**: Bank soil is generally held in place by plant root systems. Protection from erosion may also be provided by boulder, cobble, or gravel material. An estimate of the density of bank vegetation (or proportion of boulder, cobble, or gravel material) covering the bank provides an indication of bank stability and potential instream sedimentation.

• **Bank Vegetation Type**: The type of dominant streambank vegetation gives an indication of bank stability, the quantity of organic material entering the stream, and the amount of shade to serve as refugia for fish and other animals.

BIOLOGICAL MONITORING

MATERIALS NEEDED FOR BIOLOGICAL MONITORING:



- D-frame nets (2)
- Forceps
- Magnifying Lenses
- Plastic Viewing Pans
- Macroinvertebrate Key

OPTIONAL:

- Vials and Alcohol

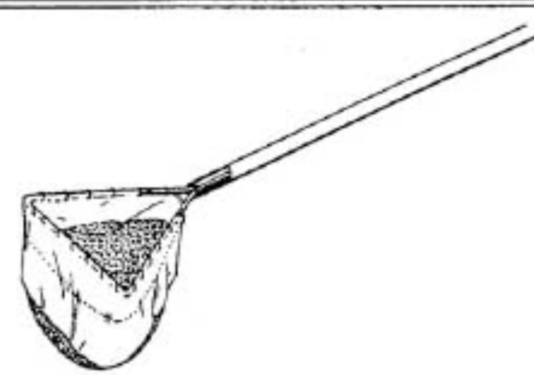
Biological monitoring refers to the sampling of aquatic macroinvertebrates (aquatic insects) to study the stream water quality. In temperate regions, the diversity and abundance of invertebrates and/or fish in a stream have been used to indicate water quality. Invertebrates are generally favored as biological indicators of water quality for several reasons:

1) Their lifespans are long enough to be affected by water quality conditions.
2) They are relatively immobile.
3) They tend to form distinct communities that are associated with particular physical and chemical conditions.
4) They are easy to collect.

However, many characteristics of Costa Rican aquatic invertebrates have not yet been studied and organisms' pollution tolerance or intolerance have not yet been determined. Therefore, for the purpose of our study, biological data is collected to increase awareness of the diversity of aquatic organisms living in the stream environment.

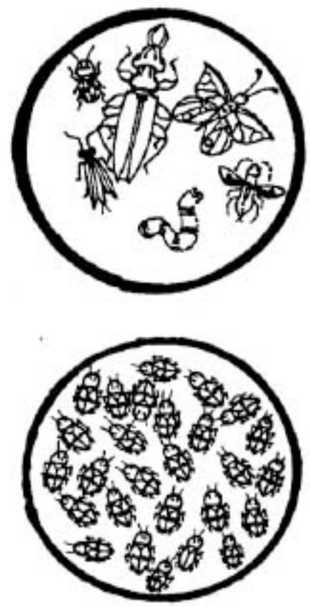
Biological data are recorded on Evaluation Sheet #3. Both diversity and abundance of aquatic macroinvertebrates as well as the abundance of algae (a variety of aquatic photosynthetic organisms), macrophytes (aquatic plants), and fish are assessed.

In evaluating stream water quality, the concept of diversity is often applied to indicate the health of an ecosystem. The number of different species (or “taxa”) of organisms is a better indicator of water quality than the total abundance of organisms. Several macroinvertebrate families are sensitive to environmental changes and their presence or absence can be a good indicator of the stream's condition. A large abundance of macroinvertebrates does not necessarily equate with good water quality since pollution tolerant species are often present in large numbers. Therefore, you should consider the overall macroinvertebrate community structure and how it changes over time.



D - Frame Net

Taxonomic identification of macroinvertebrates to family (i.e. Simuliidae) or genus can provide a more accurate evaluation of the stream's water quality but requires more extensive training. For our purposes, we will focus on identification to order and, when possible, to family. Simply looking at the different functional groups that are represented in a stream reach can reveal a great deal of information about the stream's condition. A functional group refers to groups of macroinvertebrates that serve particular roles in the aquatic ecosystem based on their feeding strategies. For example, the presence of caddisflies, (Order Trichoptera), that use fine silk nets to capture their prey indicates that sedimentation in their stream section is minimal. Otherwise, their nets would become clogged with debris and they would not be able to acquire food. An understanding of the natural history characteristics of the aquatic invertebrates can be a crucial link in assessing water quality.



High diversity, low abundance of organisms (top figure)
Versus high abundance, low diversity (bottom figure).

SAMPLING

Unlike the other study components which are evaluated monthly, macroinvertebrates should be sampled every 3 months. Collecting insects on a monthly basis could potentially reduce the population of invertebrates inhabiting a stream reach and would lead to confounding results. For example, if after several months of sampling the macroinvertebrate community structure changed, students would be unable to determine whether they had altered the population by oversampling the site or whether the change was induced by other factors such as pollution.

A D-frame net and a kick net are used to collect aquatic macroinvertebrates. Sample the riffles (fast-moving areas), pools, and streambanks. Using the kick net. sample the riffle area by having one, person hold the net while the second person stands in front of the net (figure at top of page). The person in front of the net kicks up the rocks and sediment (middle figure) and scrubs the rocks with his/her hands to remove any invertebrate (figure at bottom of page). The method is standardized by kicking for five minutes at different sites. The D-frame net is used to scoop up any insects living in the vegetation along the banks, logs, or deeper in the pools. These habitats arc particularly important to sample if the stream is characterized by more slow moving pool areas. Five scoops should be taken from

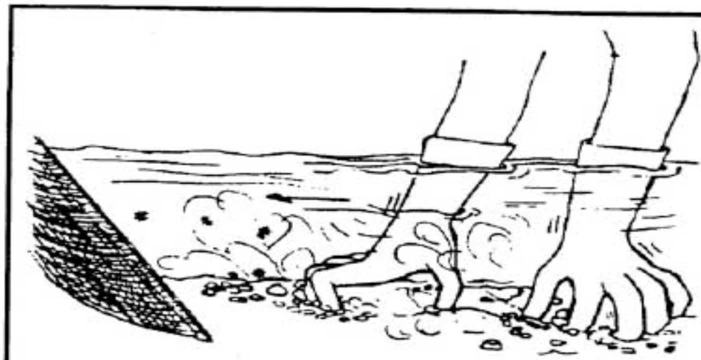
the vegetation, 2 from any snags, and 3 from the sandy-silty bottom. For muddy substrates, the motion goes against the current in a more forward direction along the bottom. Remember to rinse the bottom of the net through the water (not allowing the water to run over the top of the net) in order to rinse the fine silt from the net.

The contents of the net should then be placed into a plastic container to be picked through to collect all of the macroinvertebrates. Keep water in the pan to make it easier to see the organisms. If time is short, the contents of the net can be emptied into a plastic bag and then sifted through back at school.

Identify insects by order or family (when possible) using the macroinvertebrate key and the Guía de los Organismos Comunes de las Aguas Dulces de Costa Rica written by Carlos de la Rosa and Nicole Barbee. Record the order and the number of organisms found on Evaluation Sheet #3. Family names are also listed on the evaluation sheet and can be marked if known. This information can be used to detect changes in community composition and to identify which organisms are common to the stream. Presently there is not a guide to Costa Rican macroinvertebrates indicating which organisms, if present, reflect poor water quality or good water quality. However, the collection of macroinvertebrate data by the group can be used towards the development of an identification key.

Have one person hold the kick net, facing upstream.

Kick a 1 meter area in front of the net, dislodging organisms in the process.



Scrub rocks with fingers or place in tray and remove bugs.

ACKNOWLEDGEMENTS

This manual represents the efforts of many individuals through direct contributions to the manual or through the energy and support offered for the *Adopt-A-Stream* program. I would like to thank those individuals and organizations that helped to make this work posible.

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A Special Thanks to Dr. Cathy Pringue for her contributions to this manual and her dedication and enthusiasm for the *Adopt-A-Stream* program.

This manual can be divided into two sections. The first part serves as a tool for the *Adopt-A-Stream* program by providing students and teachers with program details. For teachers, this manual can be a useful teaching aid, showing them how to incorporate the program into their classrooms as a living laboratory. With the steps and suggestions presented here, you have the tools necessary to shape the program to your group's interests and develop your own unique monitoring program. The second part of the manual provides a case study of how *Adopt-A-Stream* has been applied in the classroom. This section was included to show you what kind of natural history information your group may want to collect and demonstrates how to initiate an *Adopt-A-Stream* propgram.

TABLE OF CONTENTS

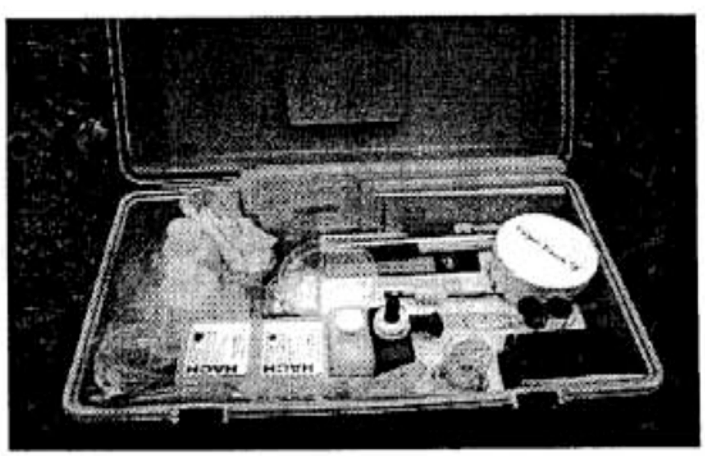
CHEMICAL TESTS

CHEMICAL
- Surface Water Test Kit (with refills of chemicals)
- Extra bottle to collect water
- Bucket with rope
- OPTIONAL:
    - Table
    - Timer

Chemical tests are used by aquatic ecologists to determine the condition of a stream at a given moment in time. When chemical analyses are used in conjunction with biological indicators, it is possible to obtain a more complete picture of the factors that influence the water quality of the aquatic system.

Guidelines for conducting chemical analyses and maintain sampling consistency include:

1) Sample at the same time of day for every month. Some chemical properties may differ depending on the time of day.
2) Take samples out in the center of the stream or river, away from the stream bank.
3) Rinse equipment (i.e. test tubes, etc.) with stream water several times before taking sample.
4) Remember that one mg/l (milligram per liter) =one ppm (part per million).
5) Remember: A concentration reading of 0 mg/l does not necessarily mean that the equipment does not work or that the chemical is absent from the stream. This measurement may indicate that the chemical is present in such a small quantity that it cannot be detected by the equipment.
6) Record the data in the chemical section of the Stream Evaluation Sheet #1.



Hach Surface Water Test Kit

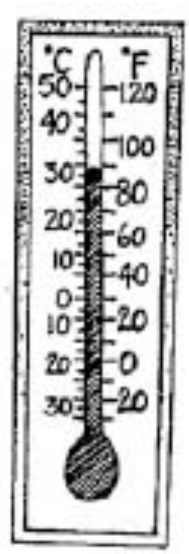
There are three tests that MUST be conducted at the stream site. These test are:
1) pH
2) Temperature
3) Dissolved oxygen.

Tests for nitrate, phosphate, ammonia, and chlorine can be run in the classroom with water collected from the stream. The following information highlights the chemical tests, the methods for conducting the analyses, and the techniques for evaluating the results.

TEMPERATURE

Temperature influences many aspects of an aquatic ecosystem and therefore, is a vital component to the survival of aquatic organisms (such as insects, fish, shrimp, etc.). Water temperature affects the photosynthetic rate of plants; the reproductive and feeding characteristics of aquatic organisms; and organisms' metabolic rates. Temperature also influences the saturation level for dissolved oxygen. Since gases dissolve more readily in cold water, high temperatures can reduce the amount of oxygen that is available to aquatic organisms.

<u>Measuring Temperature</u> (See Appendix 1A)



<u>Significant Levels of Temperature</u>

The absence of riparian vegetation or the extraction of woody debris often increases water temperature since the canopy is reduced, opening the stream to direct sunlight. Runoff from pavements and surrounding land can also increase stream temperature. Soil erosion contributes to increased water temperatures by increasing the amount of suspended solids in the water which absorb sunlight and heat the water.

High temperatures result in less dissolved oxygen in stagnant waters. The problem occurs when the organisms die and bacteria and fungi that decompose organic material use oxygen and reduce the already low quantity to oxygen contained in the system. This process is called <u>eutrophication</u>. Another indirect effect of warm temperatures is that fish and insects become vulnerable to disease and toxins.

pH

Water is comprised of hydrogen (H^+) and hydroxyl (OH^-) ions. The pH, or *potentia hydrogenii*, indicates the concentration of hydrogen ions in the water and is one of the most common tests used in water analyses. Stream pH regulates many chemical and physiological processes of an aquatic system. The pH scale ranges from 0 to 14. A value of "7" represents a neutral solution, a value of less than 7 indicates a more acidic solution, and a value greater than 7 represents a more basic solution. Battery acid has a pH of 0.5 compared to bleach which has a pH of 12.9.

<u>Measuring pH</u> (See Appendix 1B):

Remember that every one-unit change in pH represents a tenfold change in acidity. Therefore, a stream with a pH of 5 is one hundred times more acidic than one with a pH of 7.

<u>Significant Levels of pH</u>

Most aquatic organisms require a pH range between 5.6 to 8.5. Normal levels of stream pH also vary depending on the mineral inputs into the system. Low pH values may be a result of acid precipitation caused by emissions from automobiles, coal-fueled power plants, or volcanic activity. Water with an acidic pH can be detrimental to many aquatic organisms, especially affecting invertebrates and embryonic development in fish.

DISSOLVED OXYGEN

Like land animals, aquatic organisms require oxygen to survive. Dissolved oxygen is considered the most important environmental factor fur the survival, growth, and reproduction of aquatic organisms. Oxygen enters the water from the atmosphere or as a product of photosynthesis by planes, algae, and phytoplankton. Oxygen used by aquatic organisms is a gas and is not the oxygen part of the water molecule (H_2O). Water tenmeratwe, wind, and water velocity play important roles in determining the amount of oxygen that enters the aquatic system from the air. Oxygen dissolves better into cold water than it does with wanner waters. Wind aeration and turbulence can increase the distribution of oxygen throughout the system.

A teacher shows a student how to read a thermometer

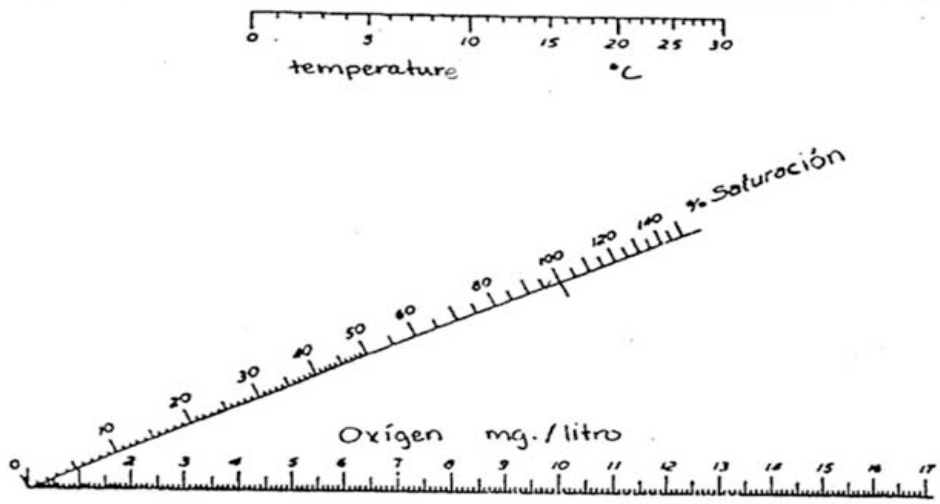
Living organisms tend to increase their metabolic activity in warm water, requiring more oxygen to support their metabolism. Critically low oxygen levels often occur during the warmer summer months. (See the temperature section for a more detailed explanation).

<u>Measuring Dissolved Oxygen</u> (See Appendix 1C)

<u>Significant Levels of Dissolved Oxygen</u>

The amount of oxygen required varies according 10 the species and the organism's stage of life. However, systems containing dissolved oxygen levels of less than 5 ppm cannot support a diversity of aquatic organisms. Most fish require levels of 5 to 6 ppm for growth and activity.

The dissolved oxygen level can be combined with the water temperature to evaluate the percent saturation. Percent saturation can be determined using the percent saturation chart. To determine the saturation level, draw a line connecting the temperature and the dissolved oxygen level. Record the value where the line passes through the percent saturation bar. That value represents the percent saturation. If the saturation level is greater than 90%, then the system is considered to contain an adequate supply of dissolved oxygen. However, saturation levels below 90% indicate the impacts of other influences, such as the input of plant, animal, or other organic waste which reduces the dissolved oxygen level. One reason for reduced dissolved oxygen levels may be attributed to the decomposition of algal blooms resulting from excess nutrient inputs.



To determine the percent saturation, draw a line between your results for water temperature and observed dissolved oxygen concentration. Record the number of where it crosses the middle line. That number is the percent saturation.

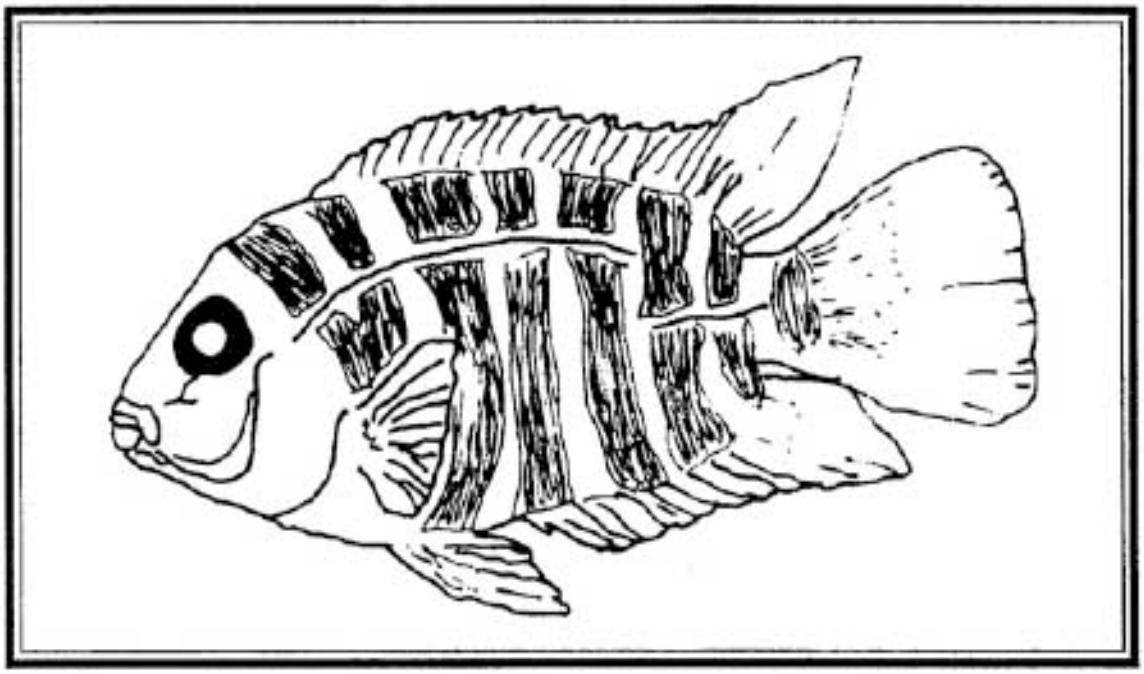
CHLORINE

Chlorine is used to treat drinking water supplies or swimming pools because it kills disease-causing microorganisms. When chlorine is applied to water it undergoes hydrolysis (the separation of compounds by taking up water elements) to form free chlorine. Free chlorine readily reacts with ammonia and certain nitrogenous compounds to form combined (total) chlorine. Wastewater that has been treated with chlorine at a sanitation facility primarily contains total chlorine.

<u>Measuring Chlorine</u> (See Appendix ID)

<u>Significant level of Chlorine</u>

Since drinking water and wastewater for most towns in Costa Rica are not treated, the normal level for both free and total chlorine is suppose to be 0 mg/l.



NUTRIENTS

Nitrogen (N) and phosphorus (P) are elements that are naturally present in aquatic systems and are required by plants and microorganisms for their growth and development, Plants require N and P in relatively large quantities; however, in general these two elements are scarce in the environment. However, certain bacteria and plants can convert inorganic compounds of N and Pinto organic compounds which other organisms can use.

These nutrients generally tend to occur in lower concentrations in the tropics than in temperate systems. Many scientists attribute these low concentrations in tropical systems to a lack of nutrient runoff from the surrounding nutrient poor soils. In addition, nutrients that are available get used up at a much faster rate due to warmer temperatures which increase organisms' metabolisms.

External sources of nitrogen and phosphorus can raise the nutrient concentrations in a stream. Some of these sources are: human and animal waste, decomposing organic matter, and fertilizer runoff. In the Sarapiqui region, high nutrient concentrations can also occur where "geothermal seeps" enter the stream. The *geothermal* inputs increase the ionic content and nutrient levels (particularly phosphorus) in a stream.

Nitrogen

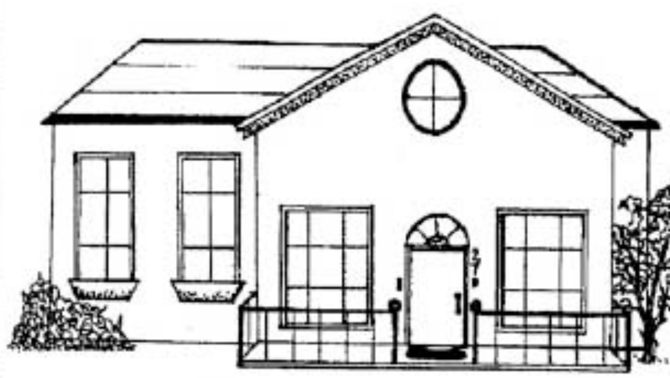
Despite the fact that nitrogen is very abundant in nature (approximately 78 to 80% of air is N), few organisms can use or "fix" nitrogen in its free form (except for some bacteria and blue-green algae, or Cyanobacteria). The rest of the organisms obtain nitrogen from compounds such as ammonium, (NH_4^+), nitrite $(N0_2)$, and nitrate. $(N0_3^-)$; these compounds can be created by electric reactions (like lightning), emitted by nitrogen fixers and decomposing organic matter. Nitrite is scarce in nature while nitrate is abundant. In our program, we will be focusing on nitrogen in the form of nitrate and ammonia.

Nitrogen in the form of ammonium (NH_4^+) is found in animal excrement and other wastes. It becomes nitrate, $(N0_3^-)$, through organic decomposition. Plants and algae can incorporate the nitrate into their cytoplasm (the liquid inside of a cell) and use the nitrogen to build proteins.

Measuring Nitrate (See Appendix 1E)

Significant Levels of Nitrate

High soil nitrification rates produce a high concentration of nitrate and because nitrate is very soluble, it is washed into streams and rivers attached to soil particles when it rains (Paaby-Hansen 1988). Even in an unimpacted lowland tropical stream in Costa Rica, a normal concentration may be between 0.050 - 0.100 mg/1. However, these high concentrations may still be too low to detect with colorimetric equipment.



Leaky septic tanks can cause elevated concentrations of nitrate in surface and groundwater.

Elevated nitrate concentrations may be seen when an area has recently been cleared for pasture and the soil nutrients arc being washed into the stream. Typically, after the land has been cleared for a period of tame, no detectable increase in nitrate levels will be seen since the soil layer which contained the nutrients has been removed. If the land is used for cattle grazing, nutrient levels may increase (Paaby, pers. com.).

Between anthropogenic sources of nitrate and nitrite, the most common are: the discharge of wastewater or untreated water, improperly functioning septic systems, runoff from animal operations (such as dairy farms, etc.) (de la Rosa 1994). The most important anthropogenic sources of nitrate and nitrite are: wastewater discharge, untreated wastewater, or septic systems that function improperly; and runoff from animal operations (such as dairies, agricultural fields, or other sites which receive high concentrations of fertilizers).

AMMONIA

Ammonia is produced in the excretions of aquatic organisms and is a result of the decomposition of fecal matter and the hydrolysis of urea. When plants or organisms die, bacteria break down the large protein molecules and form ammonia. Many plants, in order to form their organic compounds, prefer to use ammonia to nitrate because they consume less energy. An artificial source of ammonia is fertilizer. An important characteristic of ammonia is that it is highly water soluble.

<u>Measuring Ammonia</u> (See Appendix IF)

<u>Significant Levels of Ammonia</u>

Ammonia is normally present in low concentrations in aquatic systems. However, the addition of large amounts of decomposing material can raise the level of ammonia in the stream. Concentrations greater than -25 mg/l can affect the growth of fish and other organisms. Concentrations above 0.5 mg/l are considered lethal to the system (Adopt-A-Stream 1994).

PHOSPHORUS

Phosphorus is found in streams and rivers in the form of phosphates (HPO_4^{3}), orthophosphates, polyphosphates, and organically bound phosphates. Phosphorus is a nutrient that is essential for plant growth and for metabolic reactions in both plants and animals. Free phosphate is quickly used by algae and large aquatic plants or becomes bound to soil particles such as clay or aluminum and is unavailable for use except by plants rooted in the sediment. Therefore, phosphate is often viewed as the limiting factor for the growth of organisms in many aquatic systems.

In our study, we will be determining the concentration of orthophosphate. Orthophosphate is one of the most important forms of phosphorus because it is in a form that can easily be taken up by aquatic plants and phytoplankton. Natural inputs of orthophosphate occur through:

1) <u>Mineralization</u> (conversion to a mineral) of organic material through the erosion of rock particles,
2) Ash from forest fires, or
3) Fallout from volcano.

Man-made sources include fertilizers and phosphorus-containing detergents.

<u>Measuring Phosphates</u> (See Appendix 1G)

<u>Significant Levels of Phosphate</u>

Phosphate has been labeled the limiting factor in organisms' growth in aquatic systems and is typically found in low concentrations (less than 0.1 mg/l).

Heavy rainfall or the clearing of land for pasture can result in increased phosphate levels. As the soil erodes and washes into the stream it carries orthophosphates which are bound to the soil particles and increase the phosphate concentration. Construction activity that stirs up the bottom sediment, releasing phosphates that were previously trapped, can also increase phosphate levels. Anthropogenic elevation of phosphate concentrations can occur from human, animal, or industrial wastes.

High phosphate levels in the Sarapiqui area may also be linked to geothermal inputs. Geothermally-influenced streams can contain phosphorus levels that are significantly higher than levels in non-geothermal streams (Pringle 1991).

Excesses of free phosphorus in the water can cause "cultural eutrophication". Algal blooms occur in the water as a result of an increased level of phosphorus in the water (de la Rosa 1994). The problem arises when the phytoplankton and the plants die and start to decompose, reducing the amount of dissolved oxygen contained in the water.

A student conducting a chemical test for phosphate.

ANALYSIS

What to do with your data?

An important point to remember when conducting your monthly sampling is that one month of data is NOT sufficient to accurately assess the stream's water quality condition. Enough data must be collected to determine the "trends" in water quality and to identify the natural background levels of the chemical parameters. However, this statement should not provide an excuse for inactivity. You can start improving your stream's water quality today! Listed below are several ideas for ways to address water quality issues. Paramount for any activity or improvement is to recognize that the more people you educate about how the factors that impair water quality, the greater the potential for improved water quality.

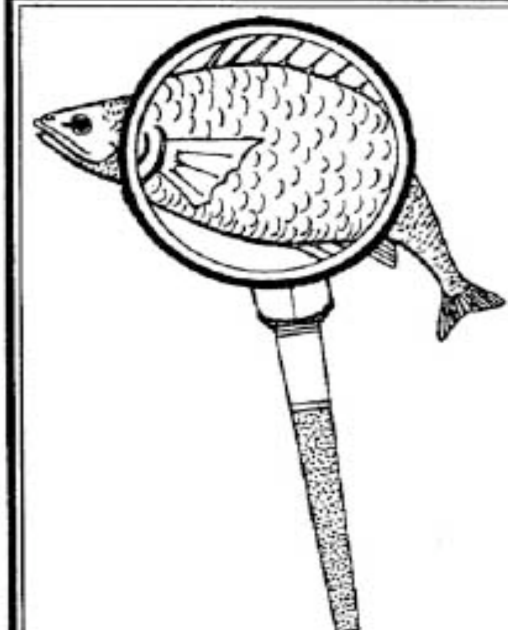
Use the data acquired from monthly sampling to take action! Reams of citizen data just sitting on a shelf to be analyzed does little to protect stream water quality. ACT ON IT!

Taking Action: Follow these steps to effectively translate your data into action:

1. Look at the visual evaluation sheets and determine one potential source of pollution to the stream. Is there trash in the stream? Do you see a pipe which empties into the stream? Where does it come from? Is there oil on the surface of the water? Use this information to take immediate action. One of the best ways to start improving your stream's water quality is by organizing a stream cleanup. Spend a day picking up trash in the stream. Put a sign next to the stream stating that it is a study site and requesting that people not pollute it and instead help to protect it.

2. Record the data on a data sheet to compare monthly concentrations. Graph chemical concentrations by date. By entering the data for each collection date, fluctuations in chemical concentrations may become evident. What is the average range for dissolved oxygen? Nitrate? Determine the average concentration for each chemical parameter. Does the data contain any outlying data points? Could these points suggest inconsistencies in data collection? Review the data on a monthly basis and compare it to the previous month's data; this action can help to identify obvious stream contamination or problems in data collection.

Look at the section in the manual which discusses chemical analysis. Look at the ranges listed as "natural" ranges. Do the values for your stream site fall within this range? If not, what does the manual suggest that a high concentration may indicate? Based on this information, what other factors might be influencing the stream's water quality.



Act like a detective and try and find the reasons for problems in your stream.

3. Organize a water festival day for the town residents. Bring community leaders to the stream and tell them about your monitoring efforts. Hand out flyers that list ways the community can help improve local water quality.

4. Act like a private detective. This is your opportunity to deduce what sources of pollution are influencing the water quality in your stream. Once identified, try to think of a variety of solutions and then act to correct the problems.

5. Take the information and your understanding of your adopted stream to the community. Teach them about the organisms that live in the stream, what sources of pollution are impacting the stream, and what they can do to help. Involve other people. Get them to adopt other stream reaches.

6. Protecting streams is difficult work and can require additional help. Here are the names and numbers of some people who can help you in your quest for solutions and a better understanding of stream ecology:

CONTACTS

Orlando Vargas
La Selva Biological Station
Organization for Tropical Studies
Tel: 710-1515

Ministerio de Salud
Puerto Viejo de Sarapiquí
Tel: 766-6106

Dr. Carlos de la Rosa
FIREMA
Upala, Costa Rica
Tel: 470-0176

Dr. Pia Paaby
MeRida
Escazú, Costa Rica
Tel: 289-7672

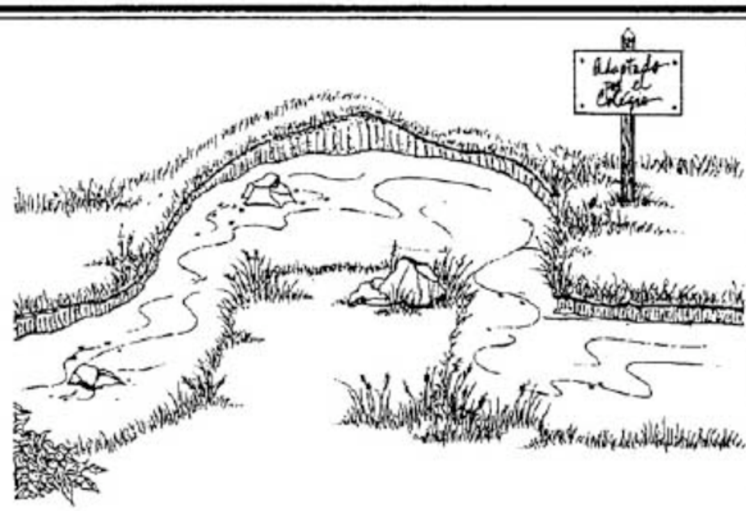
PROGRAM EXTENSIONS

Once *Adopt-A-Stream* has been started and the group has established a rapid and effective data collection system, there are many activities that can be added to the program. Use your imagination when creating new activities. *Adopt-A-Stream* is not limited to science related experiments and can he used to incorporate different disciplines.

Be creative! Keep the ideas flowing! Several ideas for supplemental activities are listed below. One example is to have the high school students write a play for the elementary schools which would describe a stream ecosystem and the importance of protecting our water resources. Another activity would be to write a newspaper article which describes the *Adopt-A-Stream* program. Focus on how stream monitoring can teach the community about water quality and ways that everyone can work to improve it.

SUPPLEMENTAL ACTIVITIES

- Spend a day picking up trash in and around the streambed.
- Conduct a watershed walk. Walk about 2 kilometers upstream and downstream of the study site to look at land uses in the watershed.
- Make a sign to let the community know that your group is monitoring a particular stream. Put information on the sign that encourages people not to pollute water resources.
- Post the stream data on a public bulletin board.
- Write an article describing the project for the bulletin board or local newspaper. Write a story describing a particular organism, or impact, that affects the stream water quality.
- Compare your stream to other streams in the area. Compare the water quality in your stream to the water quality in a forested stream, to a stream in the banana plantations, loan upstream section of the same stream, etc.



This sign shows the community that the stream is being studied.

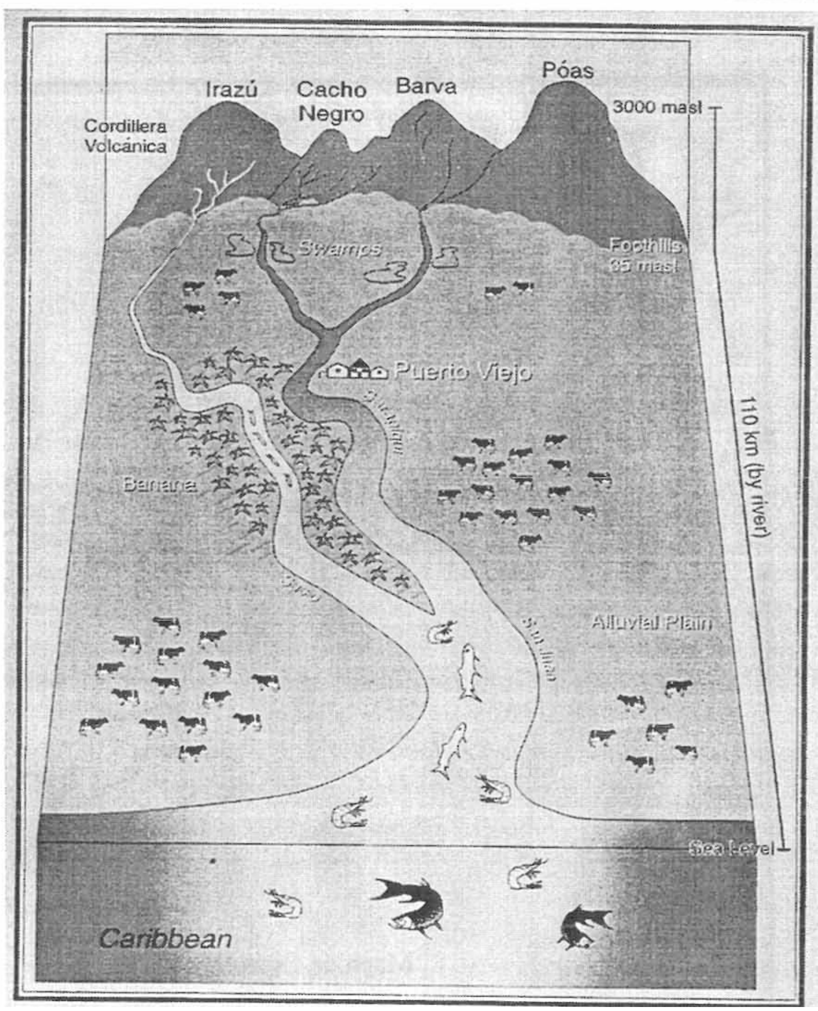
- Involve the local elementary schools. Have the high school participants teach the elementary school students how to conduct a visual survey of a stream near their school. Write a play for the elementary school students that focuses on water quality.
- Develop a brief information pamphlet highlighting your program and the information that you have learned.
- Design a book for children that highlights water quality issues.
- Discuss current issues in water quality by reading newspaper articles.

Map of the Country of Costa Rica

CASE STUDY: The Quebrada Grande in Puerto Viejo de Sarapiquí

Different regions of the world have unique ecological, geological, historical, and biological characteristics that shape their aquatic ecosystems. An understanding of the natural characteristics of a region's streams and rivers is required in order to distinguish between human and natural impacts on a stream or river.

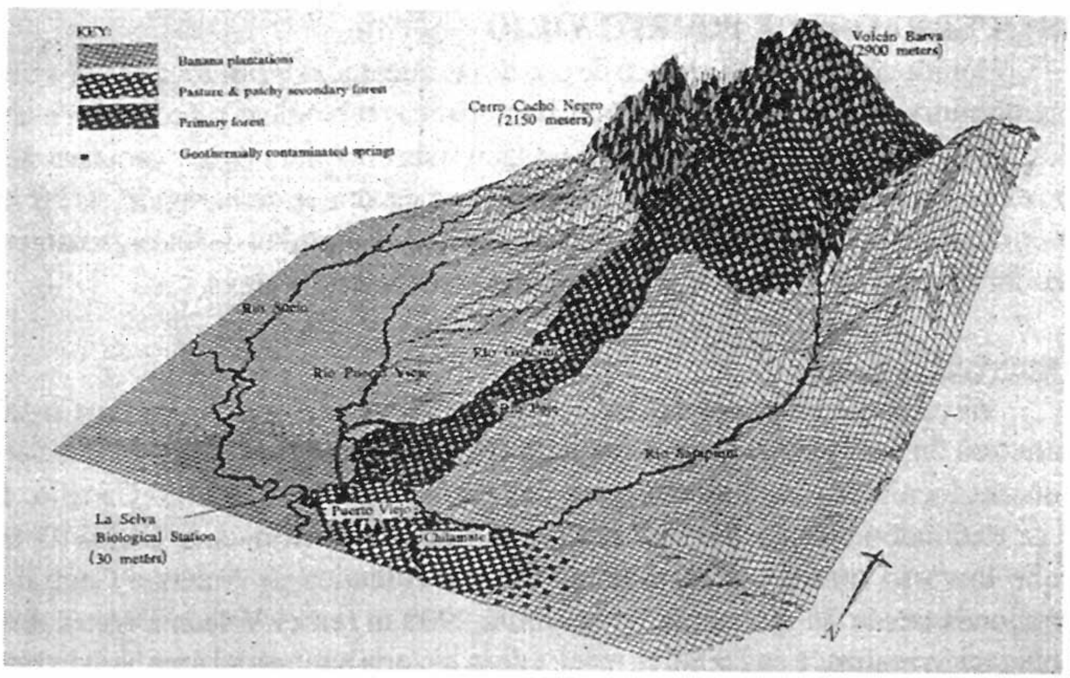
For the Sarapiqui region, this understanding has been acquired through years of research conducted by scientists at La Selva Biological Station and the University of Costa Rica and by information provided by local inhabitants. This section serves as an example of the *kind* of information that monitoring groups should obtain in order to determine the natural attributes of their local water resources. Sources for obtaining information of this nature can include: local inhabitants, government agencies such as AyA, research organizations working in the area, and studies conducted by the group.



This diagram shows the connections between Puerto Viejo and the Atlantic Coast and indicates how organisms migrate from the ocean back to freshwater.

HISTORY

The early development of the town of Puerto Viejo centered around the use of the Puerto Viejo River. Using the river for transportation, Puerto Viejo served as an important port in the trade route to the Caribbean. However, with the construction of roads to the area, the use of the river for transportation diminished. Instead, water resources became used for drinking water and recreation.



This map highlights Braulio Carrillo National Park and Puerto Viejo.
Residents obtain their drinking water from a geothermally-influenced spring inside the park boundaries.

Numerous factors have impacted the region's water quality. For example, in 1960, the majority of land in the Puerto Viejo watershed was forested. The existence of large expanses of intact forest within the watershed helped preserve the water quality of the streams and rivers by absorbing excess nutrients and reducing stream bank erosion. However, after 1970, accelerated deforestation began for fanning and to create banana plantations. This also resulted in a large influx of workers who came to the region to work on the plantations.

Changes in landuse patterns combined with a 352% increase in the local population (Vargas 1996) altered the characteristics of the watershed and impacted the water quality. The people living in Puerto Viejo had previously obtained drinking water from the Quebrada Grande (the streams that passes through town) and from springs located in the Quebrada Grande watershed. However, bacterial contamination from cattle made many springs, and rivers unsuitable for use as drinking water after 1991. The new water supply for the majority of people living in Puerto Viejo was a spring within Braulio Carrillo National Park. This spring is influenced by natural, geothermal inputs and is characterized by a high chemical content which gives the water a flavor which is distasteful to some but not harmful. It also leaves a dark residue on dishes. Residents are presently attempting to expand the water services to more households within the district and to find an alternative source of water.

The history of Puerto Viejo's drinking water supply shows how both natural and <u>anthropogenic</u> (human-induced) factors have impacted the capacity of local streams to be used as sources of drinking water.

STREAMS OF PUERTO VIEJO

Given the historical context of the human use of Puerto Viejo's water resources, we will now consider specific ecological characteristics of streams and rivers in the Sarapiqui region. To obtain a more complete picture of the area's aquatic resources we will examine: 1) general physical characteristics of the region; 2) geothermal properties of several La Selva streams; and 3) the diversity of organisms inhabiting streams such as fishes, invertebrates, crustaceans, and algae.

<u>Physical characteristics</u>

Several characteristics make the Puerto Viejo area unique to Costa Rica. Puerto Viejo is situated 4 kilometers from La Selva Biological Station (La Selva) which is located at the northern tip of Braulio Carrillo National Park. The corridor extending from La Selva to Braulio Carrillo is the LAST remaining tract of intact rainforest on the entire Atlantic slope of Central America which spans an elevational gradient of 35m (La Selva) to 2900m (Volcan Barva). Through research conducted at La Selva and the University of Costa Rica, much of the area's natural history has been intensively studied and documented (e.g. Pringle et al. 1984).

Most regions in Costa Rica experience distinctive wet and dry seasons. In contrast, Puerto Viejo receives an average of 4 meters of rainfall/year (Sanford et al. 1994) and is not considered to have an apparent "dry" season. The area around Puerto Viejo is classified as a 'tropical wet forest', which is the most species-rich life zone according to the Holdridge classification system. This designation refers to a system of classifying ecoregions based on temperature and the type of vegetation (Holdridge A. 1971).

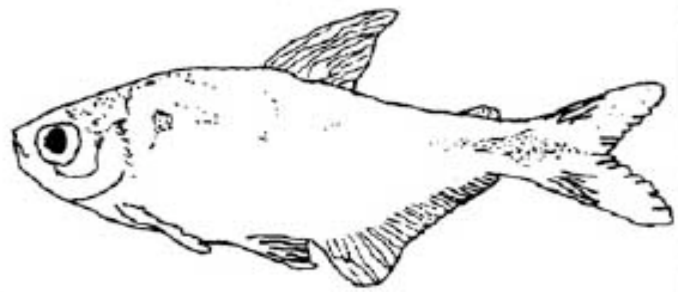
<u>Geothermally-influenced streams</u>

The term geothermal typically connotes images of hot bubbling waters, such as the Tabacon Hot Springs located near Volcan Arenal. Geothermally-influenced waterbodies in the Sarapiqui region are not hot in temperature and possess a different (chemical) composition compared to other geothermal streams found near Volcan Arenal or at higher elevations near Volcan Barva. In 1991, Dr. Cathy Pringle determined that even lowland streams at La Selva were influenced by the underlying volcanic activity of Volcan Barva. Although Volcan Barva is dormant, hot vapors emitted from lava deep in the earth rise through fissures and are absorbed into waters that bubble up as acid springs at the top of the volcano (Rio Azufre near Vara Blanca). The acid water then flows underground down to the base of Volcan Barva where it emerges as alkaline springs (such as the Guacimo springs which are Puerto Viejo's source of potable water) (Pringle 1991).

These geothermal inputs into the streams result in high concentrations of phosphorus, chloride, magnesium, and sulfate (Pringle et al. 1993). These high levels of phosphorus accelerate leaf decomposition and permit the growth of dense algal masses where there is sufficient light. Decomposing leaves and algae in streams are an important food source for shrimps and fishes and other animals.

Stream organisms

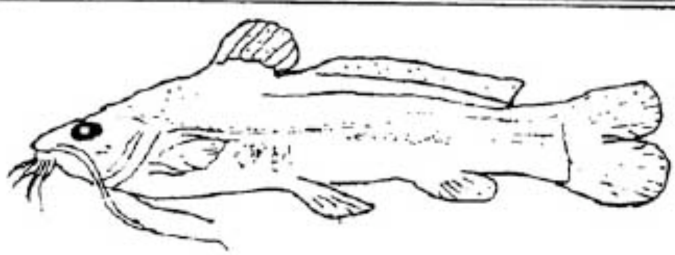
Primary organisms of tropical aquatic foodwebs form part of a tightly interwoven foodweb. These primary organisms include: fishes, shrimps, and aquatic invertebrates which act as the intermediate link between the top predators (e.g. crocodiles, caimans) and primary producers (e.g. algae, plants).



Brycon guatemalensis

Fishes

Forty-three taxa of fishes have been documented at La Selva (Bussing 1994). Although tropical areas in South America have a much higher fish species diversity (>3,000 species), this is considered to be a very diverse fish community for Central America (Bussing 1994). Several of the most common fish species are described below. Machacas, *Brycon guatemalensis*, are notorious for their large size and frugivorous (fruit-eating) feeding habits. However, smaller class sizes of *Brycon* have been observed to feed primarily on aquatic and terrestrial insects and then switch to feed on fruit and leaves when they are older and larger in size. Their vertically positioned eyes help them to track the descent of fruit or other plants as they fall into the stream.



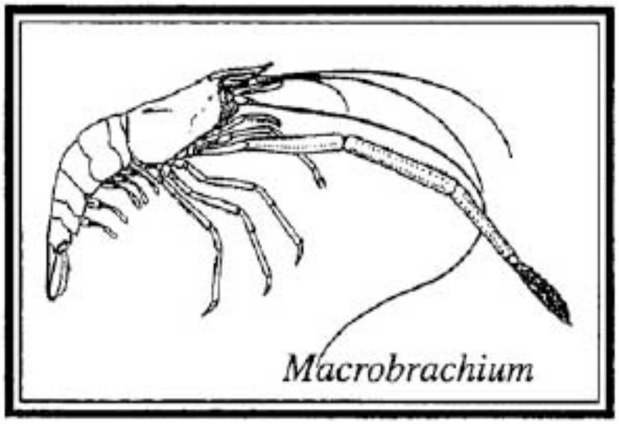
Barbudo: Rhamdia guatemalensis

Feeding on other components of the foodchain are *Poecilia gillii* which are specialists feeding on microscopic plants or diatoms. Bobos, *Joturus pichardi*, are another common fish that are highly prized as a food source in Puerto Viejo and other communities in Costa Rica. Bobos are herbivorous fishes (plant eating) that prefer faster moving waters where they graze on algae.

The Sabalo real, *Tarpon atlanticus*, is a large marine fish that looks prehistoric. Like the bobo, it has been harvested extensively and is becoming rarer. It migrates seasonally from freshwater to the ocean and back. Sabalos can grow to lengths of over 1 meter with the largest recorded at 2.4 meters. Sabalos feed on other fish species.

Shrimps

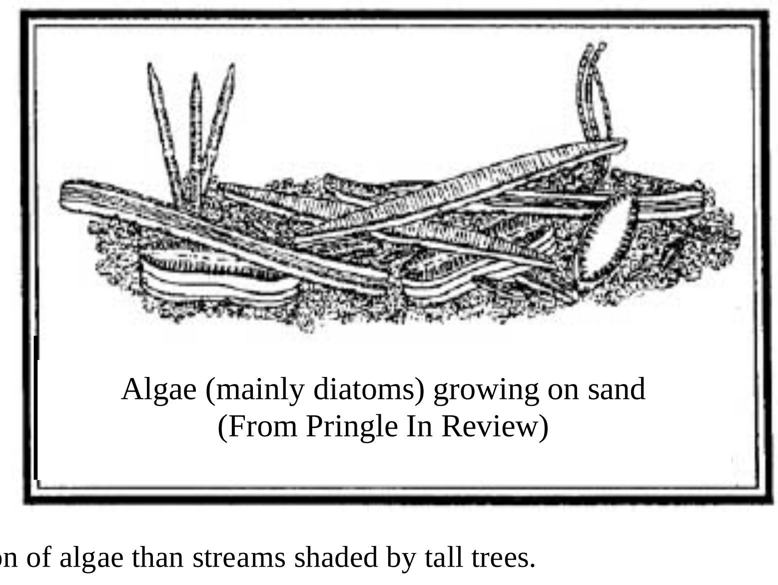
Shrimps also play a dominant role in tropical stream foodwebs. Shrimps inhabiting lowland streams are nocturnal (active at night) as a strategy to avoid being eaten by predaceous fishes which are active during the day. If you take a night walk down to the banks of the Rio Grande or Rio Puerto Viejo, you can see the red eyes of the shrimps with your flashlight. The theory that shrimps are active at night to avoid fish predation is supported by the fact that in mid-elevations of Braulio Carrillo National Park, where fishes are less abundant, shrimps are active during the daytime.



Macrobrachium and *Atya* are two shrimp genera whose larvae migrate out to the Atlantic Ocean where they spend part of the early part of their life. They then migrate all the way back upstream into stream headwaters where they live as adults. The reason for this migration is that larval shrimps require brackish (salty) water to develop into larger shrimps. This means that the shrimp that you see in your streams have already traveled all the way down the Sarapiqui River into the Rio San Juan and into the estuary at the mouth of the river where it empties into the ocean. Shrimps are very long-lived invertebrates and it is believed that their lifespans can exceed 10 years. Shrimps feed on a variety of resources, from algae and decaying leaves, to fishes and they play a very important role in the food chain. Otters eat shrimps almost exclusively!

Algae

Looking at a close-up picture of a diatom (a type of algae), one can notice that these slimy mats are actually comprised of individual organisms. Algae are aquatic one-celled or many celled plants that carry out photosynthesis. The mount of algae in a given stream depends on the stream nutrient levels and the amount of light entering the water. Streams where riparian zones have been cleared for pasture are more likely to have a more dense concentration of algae than streams shaded by tall trees.

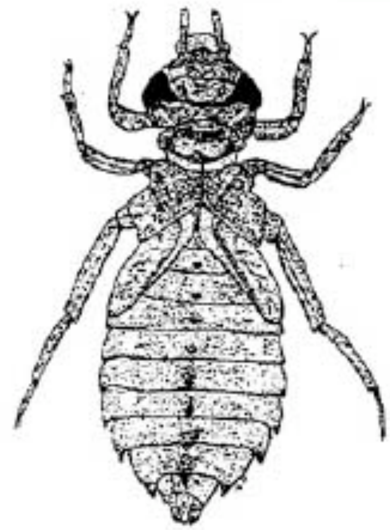


Algae (mainly diatoms) growing on sand
(From Pringle In Review)

Macroinvertebrates

Many of the insects found in Puerto Viejo and La Selva streams can be found in streams throughout Costa Rica. Dragonflies, mayflies, caddisflies, and blackflies are examples of some of the more abundant insect orders found in the Quebrada Grande as well throughout the country.

Dragonflies and damselflies are in the order Odonata. These insects spend their developmental stage in the water before molting to become the winged adults that we frequently see flying near lakes and streams. Dragonflies are more common in slow moving, pool-like waters and are likely to be collected when students sample along the vegetated banks of the Quebrada Grande with a D-frame net. Some dragonflies found in the tropics even live in bromeliads or tree holes (Matt and Cummins 1984). Odonates are characterized by their amazing mouth, called a labium. The labium is extremely useful in capturing the insect's prey (odonates are predators). When a dragonfly nymph spots something it wants to eat, it quickly extends its labium, which is cuplike in shape and is lined with teeth, grasps its prey, then retracts the labium and devours the prey. Another interesting feature of dragonflies is how they respire (breathe). The oxygen enters and leaves in the water which passes through their anus. This exchange of water can result in a jet-propulsion effect, surging the insect forward when the water is expelled.



Odonata: Dragonfly
Drawing by Alonso Ramirez

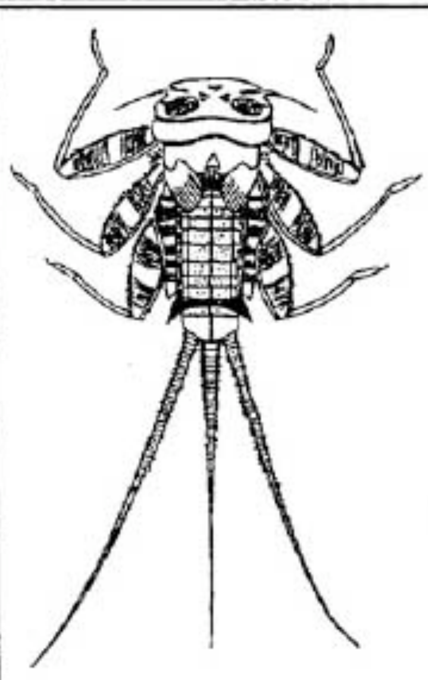
Mayflies, (Order Ephemeroptera) can be found in a variety of habitats but are most commonly located in stream riffle areas. Ephemeroptera refers to their ephemeral, or short, adult life spans. Studies of Ephemeroptera revealed that some species emerge as adults for a few hours during the night and then are dead by morning. Sometimes large numbers of adult ephemeropterans will hatch at the same time, producing a mass of adult mayflies above a stream or crawling onto streamside roads. Compared to odonate adults that live for a four-month period of time, and feed and reproduce as adults, adult ephemeropterans primary activity is to reproduce and then they die. Life spans of nymphal ephemeropterans vary depending on the temperature with warmer temperatures generally shortening the life span. Most mayfly nymphs feed by collecting food (such as detritus or algae that filters downstream) or by scraping algae, detritus, or animal material off substrate (Merritt and Cummins 1984). Other species of mayflies are adapted to burrowing or filtering food and possess modified leg parts which are covered in hair.

Caddisflies, or Trichopterans, with their diverse feeding behaviors and protective case-like structures, have been able to exploit most types of aquatic habitats. The order the more well-known groups being case or net building caddisflies. Caddisflies will construct "houses" built out of pieces of leaves or small pebbles which vary in shape and structure depending on the environment that they live in. One species of caddisfly lives in the streambank and builds a tube-like casing out of minute sand grains. In the "house", the caddisfly has a net which it uses to filter the water and trap particles for food. Other caddisflies construct larger "houses" out of rocks or sticks and live on the top of rocks or along the substrate. The cases provide protection to the insect by helping to <u>camouflage</u> the organism from predators and by serving as a strong outer shell of defense. Free-flowing nets without the case housing are also used by some caddisflies to trap debris.

Mosquitoes, black flies, and chironomids are in the order Diptera and can be found in a variety of habitats ranging from pristine streams to sess pools. Black flies, family Simuliidae, are vectors of disease which transmit such illnesses as River Blindness. Black flies are usually found in large clusters of organisms and can survive in very nutrient rich waters. Black flies adhere their posterior end to submerged rocks or other substrate with a silky "glue" produced by the larva. Simuliids also possess fans which they use to capture detritus floating in the water column.

Hydropsyche caddisfly
Drawing by Alonso Ramirez

Typically, aquatic insects found in tropical streams are smaller in size than the same species found in a temperate streams. Reasons for this size difference may include: 1) smaller body size as an adaptation against predation by fish; or 2) increased water temperatures which cause shorter life cycles and smaller body sizes.



Ephemeroptera: Mayfly

Otters and Caimans

Otters, *Lutra longicaudis*, and caimans, represent two top <u>predators</u> in the foodweb of a Sarapiqui stream. Both feed on a variety of the stream organisms mentioned in previous sections. Otters have been intensively hunted but are occasionally seen in the Puerto Viejo and Sarapiqui Rivers at La Selva. While the species of caiman found in the Sarapiqui region is very abundant throughout the new world tropics (Janzen 1983), its populations are very low in Sarapiqui due to hunting. As the human population of Sarapiqui gets larger and larger, hunting pressure on caimans is greater and it is now very rare to see a large caiman in the river.

Otters are one of the few carnivores that do not consume large quantities of fruit (Janzen 1983), instead feeding on crustaceans, such as shrimps, and fishes. They live in a terrestrial burrow on the stream bank, in contrast to caimans which build a nest on the above-ground stream bank from grass, leaves, and soil. Caimans primarily eat aquatic insects but will also feed on fishes and other amphibians.

Each organism described above, from fish to algae, plays an important role in determining stream dynamics. A change in one part of the food chain affects other links in the chain. For example, if a streambank was cleared for cattle grazing and all of the trees were removed, the fruit and leaves that had previously been deposited into the stream would be lost. The loss of their primary food source would probably result in a decrease in the number of *Brycon guatemalensis* living in that stream section. Each component of the stream food web is linked to the others and something which alters one component has the potential to modify all of them. We will now consider some factors which may induce changes to the stream ecosystem.

POTENTIAL LOCAL SOURCES OF POLLUTION

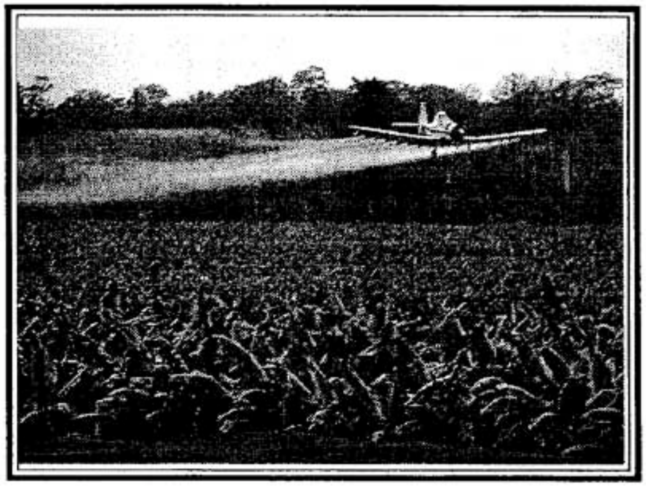
Understanding the local ecological and geormorphological stream characteristics helps us to determine the pollution sources impacting the stream's water quality. Water quality, in this sense, is evaluated by its ability to sustain aquatic organisms and maintain the ecological integrity of the stream ecosystem. Potential sources of pollution affecting local water quality include: 1) trash being dumped in the water; 2) runoff from cattle grazing; 3) bananas plantations with no stream buffer zone; 4) wastewater from houses being emptied into streams; or 5) gravel extracted from rivers to create roads.

Organic trash can reduce the oxygen levels in a stream.

<u>TRASH</u>

Trash comes in many different forms and can have a negative impact on water quality. Trash can enter a stream or river when people directly throw their trash into the river. What many people fail to realize is that when they drop their trash on the road, it will most likely get washed into the stream when it rains.

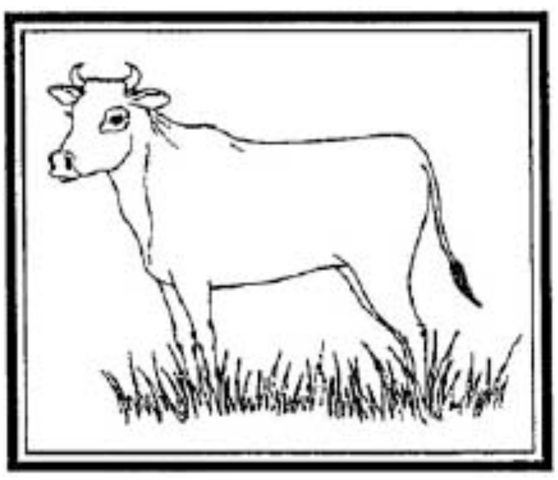
Organic trash, such as animal carcasses or decomposing fruit, can result in an increase in bacterial concentrations in the water. Inorganic trash, such as drink cans, plastic bags, or pieces of clothing, may remain in the stream for years without decomposing. Fish or turtles may think that the trash is food and try to eat it. For example, sea turtles often die when they ingest plastic bags that have been washed into the ocean from streams and rivers.
Some trash also contains toxins that are released into the water and kill the organisms living in the stream.



SOLUTIONS: Resolving this problem may be as simple as having a trash pickup day where students cleanup the stream site and surrounding area. Posting notices near the stream encouraging people not to throw trash into the stream can also be effective. Starting a recycling program in the town can provide an alternative method for disposing of trash.

<u>AGRICULTURE</u>

The predominant agricultural crop in the Puerto Viejo district is bananas, followed by palmito and pineapple. Large-scale agriculture poses several threats to water quality particularly when crops are planted up to the edge of the river, leaving no riparian buffer strip. Soil erosion increases due to the lack of a buffer strip and fertilizers and pesticides that are applied to crops runoff into the river, instead of infiltrating into the soil. Streams are channelized to provide sufficient irrigation for crops and drainage ditches are dug to prevent crop infection from fungi. These activities drastically modify the basic geomorphological characteristics of the streams which in turn impacts the aquatic ecosystem by: 1) impacting the kind of organisms that inhabit the stream; 2) increasing water velocity within the stream; and 3) increasing streambank erosion. Alteration of the land in development of banana plantations is often so extreme that streams and rivers are actually removed from the landscape. Rows of bananas and drainage ditches replace what used to be forested stream watersheds.

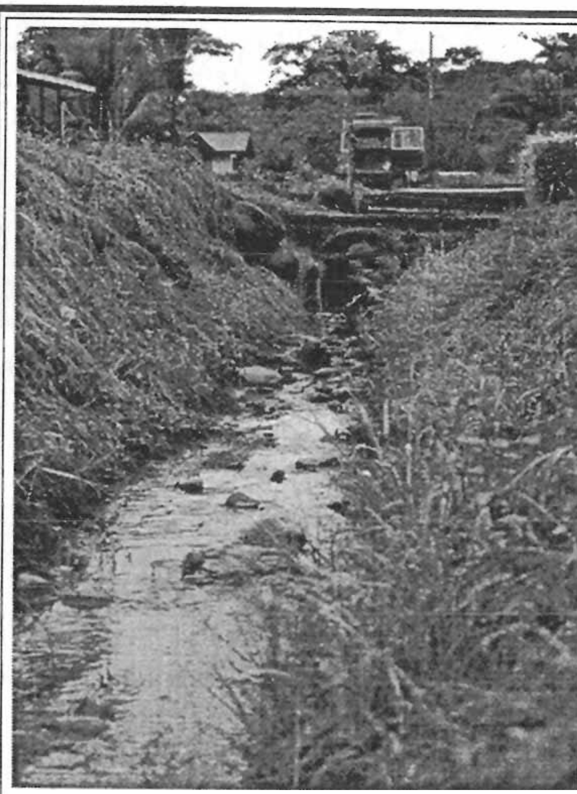


SOLUTIONS: Retaining a buffer strip of trees between the stream and the crops can significantly improve water quality. New programs, such as ECO-OK, work with the banana plantations to design more "environmentally friendly" methods of crop production. An initial step is the restoration of buffer strips along riverbanks and a move towards using fewer pesticides. Students can get involved by planting and tending trees in the stream riparian zone.

CATTLE GRAZING

A large percentage of the land in the Puerto Viejo area is used for cattle grazing. Land is cleared for the cattle and, frequently, the trees are removed from the land up to the edge of the stream or river. This removal of trees from the riparian zone impacts water quality since trees are not present to trap soil particles and to absorb excess nutrients. As a result of increased soil erosion and runoff, streams tend to be more turbid and have higher sediment loads. Disease-causing fecal coliform and leptospirosis populations tend to be higher in the streams influenced by grazing since cattle comes to the stream to drink and their feces is washed into the river. Also, bank instability increases when cattle come to a stream to drink and compact the soil.

SOLUTIONS: A forested buffer strip" of even 50m can significantly reduce the impact of cattle grazing on streams. Providing cattle with a trough to drink from instead allowing them stream access can also help to reduce impacts on water quality.



Ditches channel the greywater from houses into nearby streams and rivers in Puerto Viejo.

GREYWATER

Most cities and towns in Costa Rica lack the facilities to treat their sewage wastewater, much less treat "greywater" (water that comes from sinks, showers, etc.). This water is funneled into canals which flow openly through the streets until they are emptied into a stream or river. However, greywater is generally high in phosphorus and other nutrients as a result of phosphorus contained in soap and other detergents. The addition of greywater to a stream increases the nutrient loading in the stream and can cause algal blooms. Observations of the canals reveal the tendency towards excessive algal growth (picture).

SOLUTIONS: Greywater pipes could be filtered through a vegetated buffer strip instead of directly emptying the contents into a stream. This strip would help to absorb most of the excess nutrients into the soil as the greywater infiltrates into the soil before reaching the stream or water table.

EXTRACTION OF MATERIALS

Extraction of materials from the river is a more recent problem impacting river ecosystems. Boulders and cobble are removed from the river using heavy machinery and are used to construct new roads or improve old ones. This technique of removal and the quantity being removed alter the channel and reduce the sinuosity of the river. When materials are extracted from a river, the amount of available instream habitat declines, with resulting changes in the types of organisms that can survive in that reach of the river. Also, the, extensive gravel mining in large rivers such as the Puerto Viejo and Sarapiqui which has occurred intensively over the last decade can result in upstream channel deterioration (Hartfield 1993). For example, removal of gravel and sand from the streambed can initiate extensive erosion throughout the stream system upstream because of the increase in channel slope. The increased current ve1ocity associated with the increased channel slope results in erosion along the affected reach which becomes concentrated at the upstream end and moves upstream.

Students' study site on the Quebrada Grande

Biologists are just now understanding the biological consequences of this erosion. Gravel mining in the United States, particular1y in southeastern rivers, has caused severe bank erosion, channel widening, depth reduction and the loss of many aquatic organisms (e.g., fishes and mussels) and their habitats. One of the reasons for our poor understanding of the consequences of gravel mining on upstream conditions is the delay between cause and effect: channel erosion often occurs during flood stages and changes resulting from gravel mining are incorrectly attributed to local erosion from natural causes.

SOLUTIONS: The best solution is to decrease extraction of gravel directly from the river and its flood plain and to find another source of gravel for road building materials that will not damage the river so severely and decrease extraction activities in the river. Lower impact extraction techniques could be utilized instead of operating with large backhoe machinery.

PUERTO VIEJO's *ADOPT-A-STREAM*

A class of fourth-year agroecology students at the Puerto Viejo high school became involved in the *Adopt-A-Stream* program in March 1995. Their program was administered by the educational staff of La Selva Biological Station that provided technical and logistical support to the program.

Students participated in two training workshops-- one which covered the techniques for the chemical tests and a second workshop where they learned how to identify aquatic macroinvertebrates.

Students learn to identify macroinvertebrates

After being trained, students began monthly sampling at their site on a stream close to the high school. The stream, called the Quebrada Grande, runs through pastureland before passing directly behind the town of Puerto Viejo. Each month, the group collected information on the physical, habitat, and chemical conditions of the stream. Quarterly they conducted a biological assessment. The results were recorded on the data sheets and then given to La Selva where they were stored.

The group acquired data for an entire school-year period ending in November 1995. The group now has enough data to begin examining it to determine long-term trends.

After becoming familiar with the sampling methodology, the Puerto Viejo group expanded to sample additional sites. They monitored an upstream site on the Quebrada Grande before the stream passed through the town. A less impacted, more pristine stream was sampled at La Selva Biological Station. This stream was geothermally-influenced but served as a "reference" site for the group.

In December 1995, the students monitored a more degraded stream in the town of Rio Frio. Analysis showed higher nutrient levels and obvious signs of pollution (i.e. trash, wastewater discharge pipes). Based on their results, La Selva's educational staff is trying to initiate an *Adopt-A-Stream* program in the Rio Frio high school. Activities such as the two just mentioned helped maintain student enthusiasm for the program.

The Puerto Viejo *Adopt-A-Stream* program has been successful in encouraging students to become interested in aquatic ecology and in raising their awareness of how human activities impact water quality. Based on these achievements, in January 1996 the La Selva Advisory Committee recommended that the Organization for Tropical Studies continue its involvement with *Adopt-A-Stream* and pursue long-term funding for the program.

Puerto Viejo's *Adopte-A-Stream* program demonstrates the ability of citizens to protect natural resources when they are included as part of the solution.

GLOSSARY

algae: a variety of aquatic photosynthetic organisms

anthropogenic: human-induced

aquatic ecology: the study of streams and rivers and the organisms that live in them; the interrelationships between organisms and their environment

aquatic macroinvertebrate: aquatic insects, mollusks, and crustaceans

camouflage: the ability to blend into the background environment through coloration patterns, body form, etc.

channelization: straightening of a stream

channel morphology: the form and structure of a stream or river

cytoplasm: the liquid inside a cell

diatom: a type of algae

decomposition: the breaking down of dead organisms by bacteria and fungi

ecosystem: relatively self-contained ecological system defined by the types of organisms found in it and their interactions

eutrophication: excessive enrichment of a stream, river, etc. with nutrients, resulting in the growth of organisms and depletion of oxygen

frugivorous: fruit eating

geothermal: of volcanic origin

hatch: mass emergence of aquatic insects

hydrolysis: the separation of compounds by taking up water

macrophytes: aquatic plants

mineralization: conversion to a mineral

niche: an organism's role in the ecosystem, including its habitat and its effect on other organisms and its environment

nitrification: the change in nitrogen forms to nitrate by bacteria and fungi *non-point source pollution*: pollution that comes from a diffuse source

nutrient: any substance used or required by an organism as food

organic material: material derived from a living organism

photosynthesis: the use of light energy (by plants) and chlorophyll to synthesize carbohydrates which are used for energy

point source pollution: pollution that originates from a clearly identifiable source (i.e. factory)

pool: deep, slow-moving section of a stream

predator: any organism that catches or kills other organisms for food

riffle: fast-moving, shallow section of the stream

riparian: the area of vegetation directly beside the stream and extending back approximately 50 meters; this area serves as a buffer zone for the stream

sinuous: with curves

solute: chemical

substrate: stream bottom

taxon: any defined unit (e.g. species, genus) in the classification of living organisms

turbid: cloudy; low clarity or visibility

watershed: the area of land from which runoff drains to a specific point

watershed walk: a walk upstream and downstream of the study site to evaluate the landuses within the watershed

Why do you want to adopt a stream?

Where do you get your drinking water? Do you remember the last time you went swimming in a local stream or river? Only twenty years ago many people used the water from nearby streams as their drinking water supply. However, now many of our streams are used as dumping grounds for trash. Rivers are contaminated by wastes from factories. Soapy water from households is fed directly into streams. The quality of our waterways is rapidly deteriorating. To protect them requires immediate action and a commitment to improving their water quality. Humans have polluted streams and rivers for decades. Now is our opportunity to turn the tide and help promote the conservation and protection of our streams and rivers!

What does it mean to “adopt a stream”?

Adopting a stream involves the same responsibilities as taking care of a puppy or your younger sibling. When you adopt a stream you are taking on the responsibility of “caring" for a stream and trying to protect the stream's health. A time commitment is required to learn to recognize the "needs" and condition of the stream and to help maintain its water quality. When you adopt a stream, you agree to monitor that stream for at least one year and then, if necessary, you can transfer the care of the stream to another responsible group.

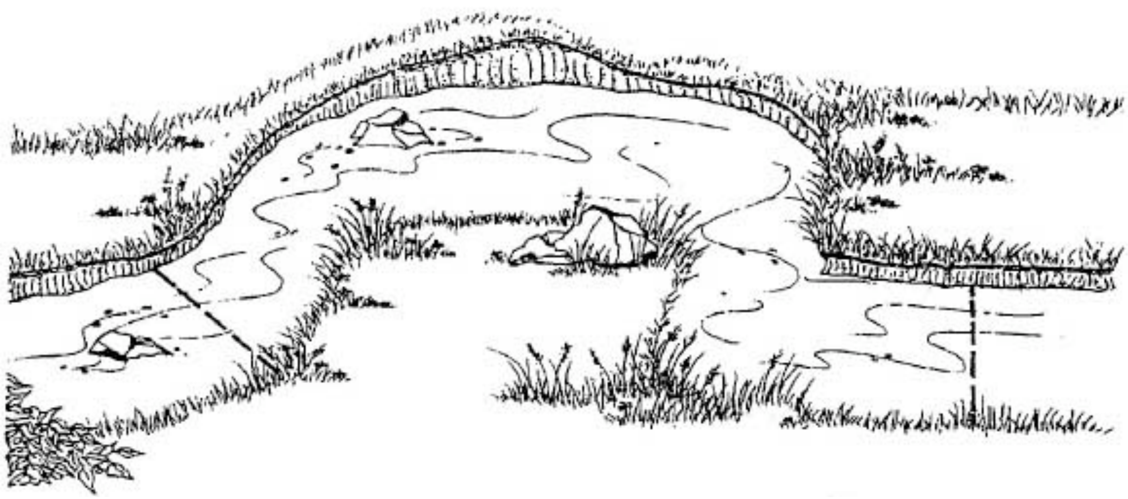
The more time you spend at the stream, the more information you learn about the organisms that live within it and what is needed to improve its water quality. You can also serve as a "stream doctor," helping to identify the sources of pollution entering the stream. Then it is your task to help address and resolve these problems which impact the stream.

However, the most important part of "adopting" a stream is to have fun! Tell other people about what is happening in your stream. Get the community involved in your activities!

How do you adopt a stream?

The first step in the adoption process is to organize a group that is interested in studying a stream. Groups vary in numbers of volunteers and in the backgrounds of individual participants. Monitoring teams can range from high school students to a soccer team or a group of interested citizens. Each volunteer must recognize the responsibilities associated with adopting a stream and make a commitment to the program.

Find a stream that your group wants to study and pick a fifty-meter section to serve as the study site. If you have to walk through private property to reach the study site be sure to obtain the owner's permission.



The dotted lines delineate the 50 meter stream section being studied

What do you do once you have adopted a stream?

Now that you have adopted a stream, how do you begin the process of "'becoming acquainted" with it? This manual describes activities and studies that you can use to get to know your stream. It contains explanations of terms and concepts related to aquatic ecology (the study of streams and rivers and the organisms that live in them) and highlights general characteristics of streams and rivers. Tools and techniques for studying a stream are also included to get you started on your analysis of the stream's water quality. Information is provided to help you interpret the "health" of your stream with the data that you obtain. Take this information and ACT on it! Have a stream cleanup day! Involve your neighbors! Teach them that we must all act together to protect our water resources!

LET'S GET STARTED!!!

Getting to know your stream

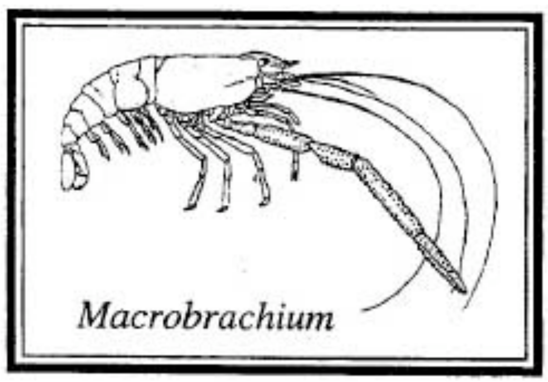
Before beginning your stream study, decide the amount of time, money, and resources that your group is willing to invest. If money is a constraint, you may want to focus on completing a monthly habitat evaluation and an assessment of the stream's physical parameters. If you have access to a chemical kit or are collaborating with the local ministry of health, you may want to collect chemical data on your stream. Sampling regimes vary but the four recommended study components include:

1) Physical Evaluation
2) Habitat Evaluation
3) Chemical Analysis
4) Biological Monitoring

Details of how to complete each component as well as methods for interpreting the data are provided in this manual.

What four aspects of the stream are we monitoring and why?

1/2. Physical and habitat evaluation: You will begin each study by evaluating the physical and habitat components of the stream. These two evaluations can be conducted without purchasing costly equipment and can help identify stream pollutants. Physical and habitat evaluations combined with a watershed walk (a walk up and downstream of the study site to evaluate land uses within the watershed) are some of the most important first steps in determining what pollutants are entering a stream.



3. Aquatic bugs: Biological indicators, such as aquatic insects can reveal brief ecological stresses that influence the water quality of the stream and that may otherwise not be detected. Compared to chemical tests, biological monitoring can reveal events which may have occurred several days or even weeks prior to sampling. Stream pollution is determined by looking at the number and type of aquatic insects living in the stream. Alack of certain insect groups suggests that an external factor is impacting the stream's water quality.

4. Stream chemistry: Chemical analyses indicate stream water quality at a particular point in time. Stream chemistry data can provide supporting information about pollutants identified with the habitat evaluation. However, with chemical tests it is easy to miss impacts that have already passed through the system. For example, if a pesticide washes into a stream, the only way to detect its presence with chemical tests is to sample the stream during that instant. If you sample the next day or even two hours later, chemical analysis may suggest that the stream is healthy and unimpaired.

Chemical and biological monitoring requires the purchase of equipment and a greater time commitment. These components can be added to the program later. Each component of the study combines to paint a more complete picture of what is occurring within the stream environment.

The data obtained from all four elements is used to evaluate the stream's water quality.

Goals of *Adopt-A-Stream*:

Adopt-A-Stream is designed to
1) Initiate and maintain a volunteer monitoring program for a minimum of 2 to 3 years;
2) Teach students, teachers, and citizens about the basic principles of aquatic ecology;
3) Stimulate an interest in studying and protecting local streams and rivers;
4) Use the data collected to evaluate the stream's water quality patterns;
5) Take action to rehabilitate or protect the stream's water quality; and
6) Make the learning experience fun!

Some important aquatic terms and concepts

To accurately determine the sources of pollution impacting stream water quality you must consider the stream's watershed. A watershed is an area of land from which runoff (water from rain, and springs) drains to a specific point such as a stream, river, lake, or other body of water. Since water runs downhill, the slope and terrain of the land influences the characteristics of the watershed. You can use a topographic map to determine the watershed area of a particular stream and then verify the watershed size on site. Locate the stream on the topographic map and then find the topographic line representing the ridge or highest point situated closest to the stream. This ridge marks the watershed boundary. Rain falling on one side of the ridge would flow into the stream while water falling on the other side would flow into another watershed. These smaller watersheds, such as the watershed of the Quebrada Grande, can feed into larger watersheds. This series of watersheds feeding into one another is known as a drainage basin. For example, the watershed of the Quebrada Grande is just one watershed within the drainage basin of the Río Sarapiquí.

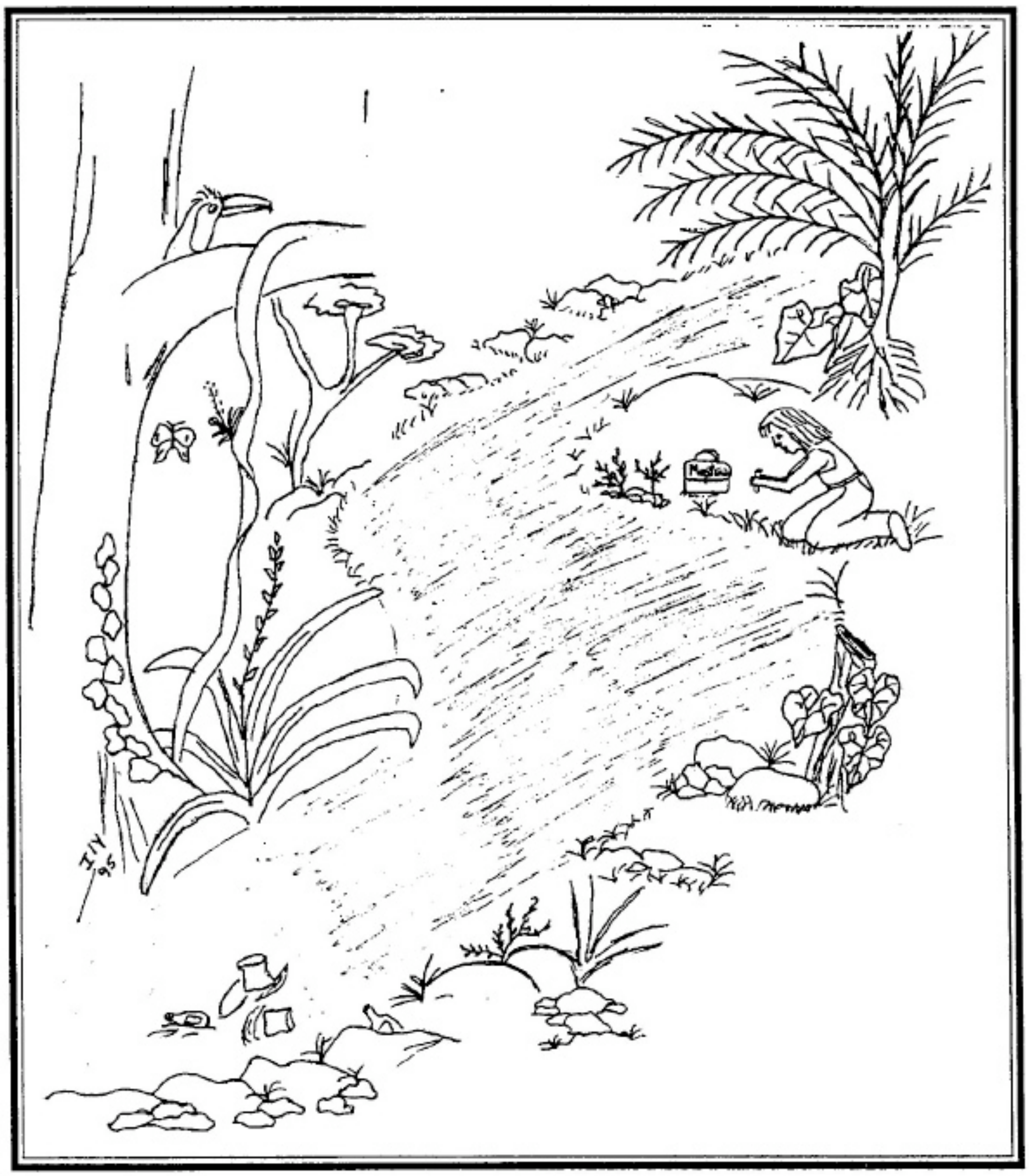
Within the watershed, you may find different sources of pollution that enter the stream. Point source pollutants are pollutants that originate from a clearly identifiable source, such as discharge from a factory. Non-point source pollutants are pollutants that come from a diffuse source. An example of non-point source pollution is runoff from pastures containing pesticides, fertilizers, or manure. Walking one or two kilometers up and downstream of your site can help locate potential point and non-point pollution sources. Landuse patterns can be marked on a topographical map to create a quick, handy watershed reference.

What equipment do we need to monitor our stream?

Before heading out to sample your stream, make sure that you are prepared with all the equipment that you need to complete your study. The materials required for each component are listed at the beginning of the section which describes the individual study components.

Safety of the monitors should always be considered when sampling the stream. The following list provides several recommended safety precautions:

- Visit the stream site with another person. Never go alone.
- When collecting water samples, avoid touching your mouth or eyes and remember to wash your hands after samples are taken. If the stream is polluted, wear gloves.
- Be aware of traffic. If sampling from a bridge, make sure that the cars have enough room to go around you. Also watch for rocks which may fall off the bridge when cars pass overhead.



APPENDIX 1A:

TEMPERATURE

Water Temperature:

1. Put the thermometer in the water without letting it touch the bottom of the stream or the bucket.

2. Let the thermometer sit 2 to 3 minutes. After sufficient time has passed, record the temperature.

Air Temperature

3. Remove the thermometer from the water and place it in the shade in order to record the air temperature.

4. Let the thermometer stabilize for 2 to 3 minutes. Read the thermometer in the shade and record the temperature.

APPENDIX 1B:

pH

1. Slide the on/off switch to on. The switch is located on top of the Pocket Pal.

2. Remove protective cap from the bottom.

3. Immerse the bottom of the Pocket Pal 2.5-8.9 cm into the sample.

4. Using the Pocket Pal, gently stir the sample for several seconds. After stirring and when the digital display stabilizes, read the pH value.

5. Rinse the bottom of the Pocket Pal and replace the protective cap.

NOTES:

- Before using the Pocket Pal and for periodic calibration, prepare a pH 7.0 buffer solution. Use the Pocket Pal to read pH. If necessary, adjust with a small screwdriver through the hole in the back to a 7.0 reading.
- Place several drops of water in the protective cap to prevent the glass bulb from drying out.

APPENDIX 1G:

CHLORINE

Free Chlorine:

1. Fill the viewing tube to the 5-mL mark with sample.

2. Place this tube in the left top opening of the color comparator.

3. Fill the other viewing tube to the 5-mL mark with sample.

4. Add the contents of a DPD Free Chlorine Reagent Powder Pillow. Swirl to mix.

5. Place this tube in the right top opening of the color comparator.

6. Hold comparator up to a light source or against a. white piece of paper. Rotate the color disc until the color matches in the two openings.

7. Within 1 minute, read the mg/L free chlorine through the scale window.

Total Chlorine:

1. Fill the viewing tube to the 5-mL mark with sample.

2. Place this tube in the left top opening of the color comparator.

3. Fill another viewing tube to the 5-mL mark with sample.

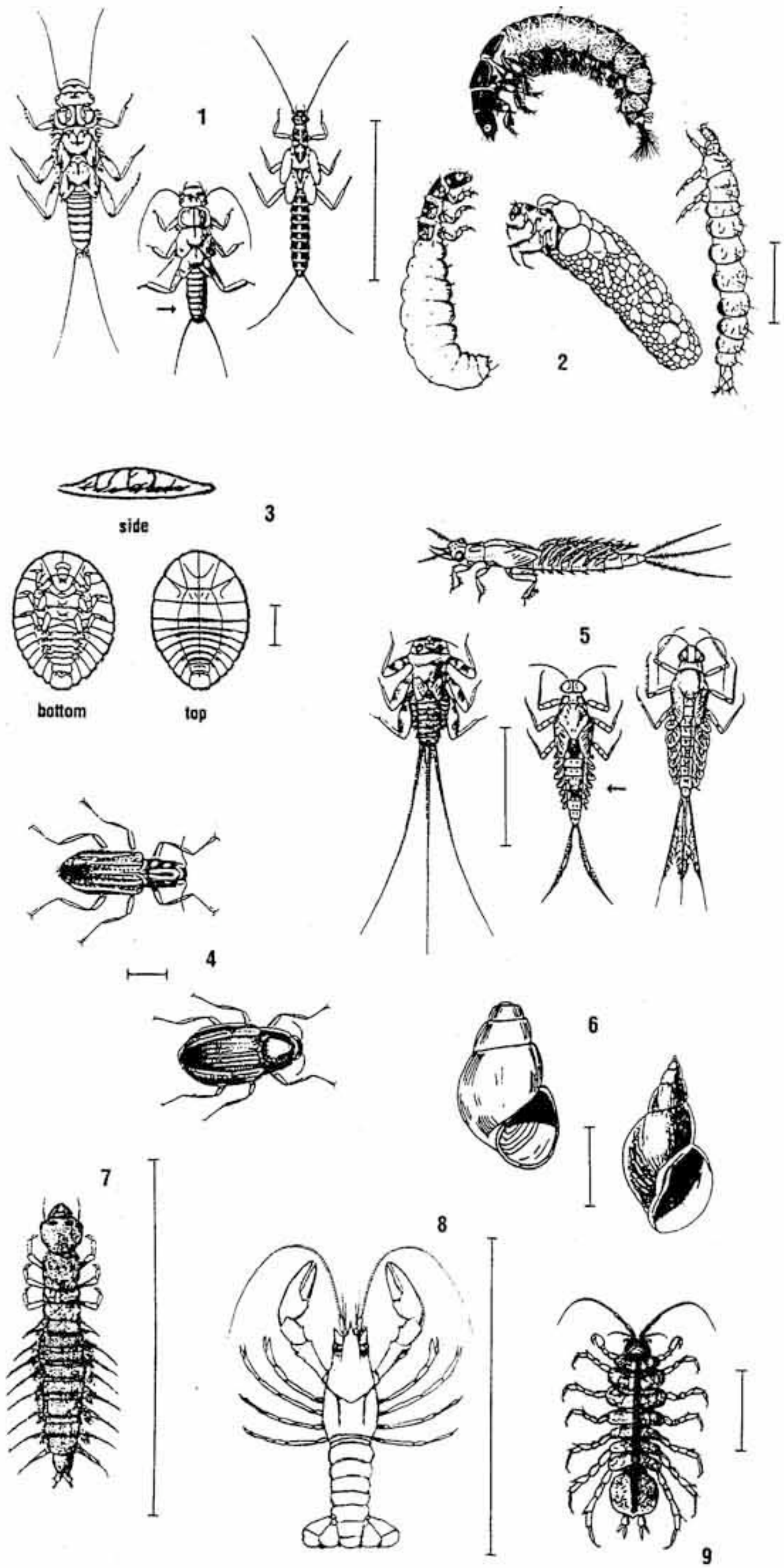
4. Add the contents of a DPD Total Chlorine Reagent Powder Pillow. Swirl to mix.

5. Let stand for 3 minutes but not more than 6 minutes.

6. Place this tube in the right top opening of the color comparator.

7. Hold the comparator up to a light source or against a white piece of paper. Rotate the color disc until the color matches in the two openings. Read the mg/L total chlorine through the scale window.

APPENDIX



Bar lines indicate relative size

Stream Insects & Crustaceans

GROUP ONE TAXA

Pollution sensitive organisms found in good quality water.

1 *Stonefly: Order Plecoptera.* 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 *Caddisfly: Order Trichoptera.* Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on lower half.

3 *Water Penny: Order Coleoptera.* 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs on the other side. Immature beetle.

4 *Riffle Beetle: Order Coleoptera.* 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 *Mayfly: Order Ephemeroptera.* 1/4" - 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 *Gilled Snail: Class Gastropoda.* Shell opening covered by thin plate called operculum. Shell usually opens on right.

7 *Dobsonfly (Hellgrammite): Family Corydalidae.* 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and 2 pairs of hooks at back end.

GROUP TWO TAXA

Somewhat pollution tolerant organisms can be in good or fair quality water.

8 *Crayfish: Order Decapoda.* Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 *Sowbug: Order Isopoda.* 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Save Our Streams

Izaak Walton League of America
1401 Wilson Blvd. Level B
Arlington, VA 22209

ADOPTE UNA QUEBRADA

EVALUACION DE HABITATS

PARAMETRO	Excelente	Buena	Regular	Pobre
1. Substrato del fondo/espacio disponible	Más del 50% piedras, grava, palos sumergidos, riberas socavadas u otros habitats. 10 9	30-50% piedras, grava, u otro habitat estable. 8 7 6	10-30% piedras, grava, u otro habitat estable; poca disponibilidad de habitat. 5 4 3	Menos del 10% piedra, grava u otro habitat estable; falta de habitat es obvio. 2 1 0
2. Deposición de sedimento	Poco o no depósitos de sedimento. Menos del 5% del substrato cubierto con sedimento. 10 9	Algunos depósitos de sedimento, principalmente en pozas. 5% al 30% del substrato cubierto con sedimento. 8 7 6	Deposición moderada de sedimento. 30% al 50% del substrato cubierto con sedimento. 5 4 3	Fuertes depósitos de sedimento. Más del 50% del substrato cubierto con sedimento. 2 1 0
3. Presencia de pozas y rápidos	Rápido-llano, rápido-hondo, lento-llano, lento-hondo (presentes las cuatro) 10 9	Solo tres categorías presentes (si faltan rápidos la nota es más baja) 8 7 6	Solo dos de las cuatro categorías presentes (si faltan rápidos o intermedios, la nota es más baja) 5 4 3	Basicamente una sola categoría de velocidad/profundidad (por lo general pozas solamente) 2 1 0
4. Alteración del canal	Poco o no alargamiento de islas o barras de arena y/o no canalización 10 9	Algunos nuevos aumentos en la formación de barras de arena, la mayoría por grava gruesa y/o algo de canalización presente 8 7 6	Deposición moderada de nueva grava y arena gruesa en barras, de arena nuevas y viejas; pozas parcialmente llenas de limo y/o terraplentes en ambos lados 5 4 3	Fuertes depósitos de materia fina; aumento en la formación de barras; mayoría de las pozas llenas de limo y/o canalización extensiva 2 1 0

EVALUACION DE HABITATS, Continuación

5. Estabilidad del banco u orilla	Estable. No hay evidencia de erosión o fallas en las orillas. 10 9	Moderadamente estable. Erosión infrecuente; erosión solamente en algunas áreas. 8 7 6	Moderadamente inestable. Tamaño y frecuencia de zonas de erosión moderadas. Orillas hasta de un 60% en algunos bancos. 5 4 3	Inestable. Muchas áreas erosionadas. Evidencia de erosión en 60 al 100% de las orillas. 2 1 0
6. Estabilidad vegativa del banco	Más del 80% de la superficie de la orilla del río cubierta de vegetación o de rocas grandes. 10 9	Del 50 al 79% de las orillas cubiertas por vegetación, grava o material inorgánico más grande. 8 7 6	Del 25 al 49% de las orillas cubiertas por vegetación, grava o material inorgánico más grande. 5 4 3	Menos del 25% de las orillas cubiertas por vegetación, grava o material inorgánico más grande. 2 1 0
7. Cubierta vegetal de las orillas	Vegetación dominante es arbustos. 10 9	Vegetación dominante es árboles. 8 7 6	Vegetación dominante es gramíneas o zacates. 5 4 3	Mas del 50% de las orillas del rio sin vegetación y el material dominante es suelo, piedras, minas, o alcantarillas. 2 1 0
Total de todas las columnas	________	________	________	________
SUMA DE TODOS ________				

Adopte Una Quebrada


Macrobrachium

Evaluación Física (Continuación)

PARAMETROS FISICOS

Cubierta de Dosel

- ☐ Abierto (0-25% de la quebrada en la sombra)
- ☐ Poco Abierto (25-50% en la sombra)
- ☐ Medianamente Cubierto (50-75% cubierto)
- ☐ Totalmente Cubierto (75-100% cubierto)

ORGANISMOS Y PLANTAS

Algas
- ☐ Ausentes
- ☐ Pocas
- ☐ Muchas

Plantas Acuáticas
- ☐ Flotantes
- ☐ Emergentes
- ☐ Sumergidas

Peces
- ☐ Ausentes
- ☐ Pocos
- ☐ Muchos

Otros Organismos
- ☐ Anfibios
- ☐ Reptiles
- ☐ Mamíferos
- ☐ Aves
- ☐ Insectos

USO DE LA TIERRA

1. Bosque
   - ☐ Bosque
   - ☐ Tacotal
   - ☐ Charral
2. Agricultura
   - ☐ Potrero/ pastos
   - ☐ Agricultura
   - ☐ Otro
3. Areas Urbanizadas
   - ☐ Residencial
   - ☐ Comercial
   - ☐ Industrial
4. Explotación maderera ☐
5. Construción ☐
6. Otro ______________

USO DEL AGUA

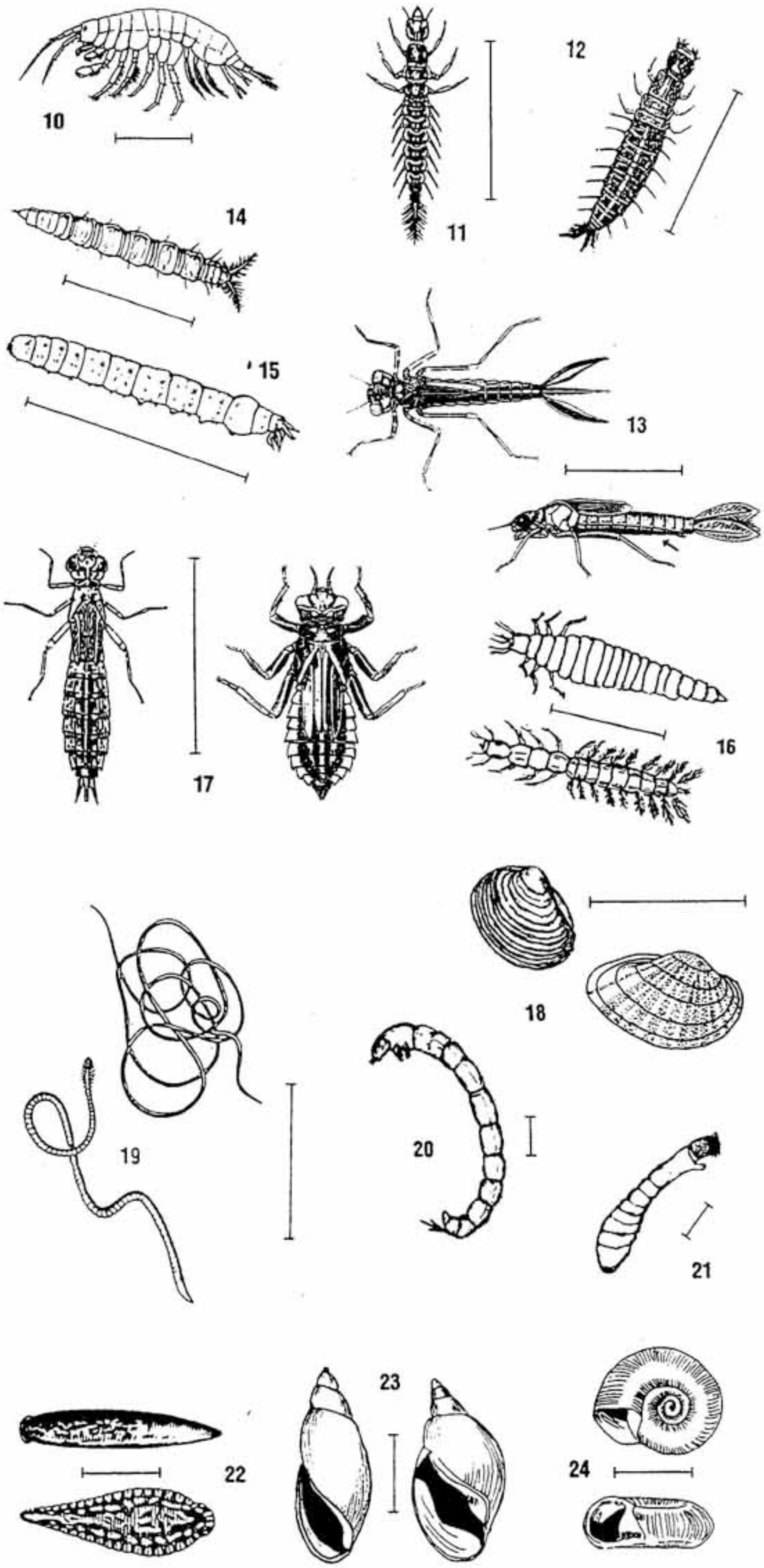
1. Consumo Humano ☐
2. Abastecimiento Industrial ☐
3. Abastecimiento Agrícola
   - ☐ Irrigación
   - ☐ Agua para ganado
4. Recreación
   - ☐ Nadar
   - ☐ Pescar
   - ☐ Otro ______________
5. Desechos
   Presencia de tubos de desagües
   Si ☐ No ☐
   Vienen de: ☐ Finca
   ☐ Fábrica
   ☐ Otro ______________
6. Presencia de Fuentes de Contaminación No Localizadas
   Si ☐ No ☐

IMPACTOS HUMANOS

Alteración del Canal
- ☐ Dragado
- ☐ Canalización
- ☐ Otro ______________

Barreras
- ☐ Represa
- ☐ Puente
- ☐ Isla
- ☐ Catarata
- ☐ Palos sumergidos
- ☐ Otro ______________

Basura
- ☐ Ausente
- ☐ Poca
- ☐ Mucha



Bar lines indicate relative size

GROUP TWO TAXA continued

10 *Scud: Order Amphipoda.* 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 *Alderfly larva: Family Sialidae.* 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 *Fishfly larva: Family Corydalidae.* Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 *Damselfly: Suborder Zygoptera.* 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

14 *Watersnipe Fly Larva: Family Athericidae (Atherix).* 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 *Crane Fly: Suborder Nematocera.* 1/3" -2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 *Beetle Larva: Order Coleoptera.* 1/4" 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 *Dragon Fly: Suborder Anisoptera.* 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 *Clam: Class Bivalvia.*

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

19 *Aquatic Worm: Class Oligochaeta.* 1/4" - 2", can be very tiny; thin worm- like body.

20 *Midge Fly Larva: Suborder Nematocera.* Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 *Blackfly Larva: Family Simulidae.* Up to 1/4", one end of body wider. Black head, suction pad on end.

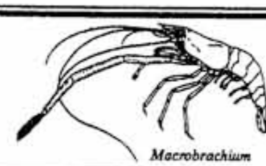
22 *Leech: Order Hirudinea.* 1/4" - 2", brown, slimy body, ends with suction pads.

23 *Pouch Snail and Pond Snails: Class Gastropoda.* No operculum. Breathe air. Shell usually opens on left.

24 *Other snails: Class Gastropoda.* No operculum. Breathe air. Snail shell coils in one plane.

Adopte una Quebrada

Evaluación Física


Macrobrachium

Nombre de la Quebrada ____________ Localidad ____________

Recolectores ____________ Fecha ____________

Condiciones Climáticas

- ☐ Claro
- ☐ Nublado
- ☐ Lluvioso
- ☐ Otro ________

Tipo de Muestra

- ☐ Física
- ☐ Química
- ☐ Biológica
- ☐ Coliformes
- ☐ Otro ________

Fotos Tomados

Nº de Rollo ________

Nº de Foto ________

PRUEBAS QUIMICAS

Temperatura (agua)____________ (°C)
Temperatura (aire) ____________ (°C)
pH ____________
Oxígeno Disuelto 1)______ 2) ______ (mg/l)
Otro ____________

Nutrientes:
Nitrato ____________ (mg/l)
Fosfato ____________ (mg/l)
Amoníaco ____________ (mg/l)
Cloro ____________ (mg/l)

ESQUEMA DE LA QUEBRADA

CARACTERISTICAS FISICAS

Ancho de la Quebrada ____________

Nº de Pozas ______ Profundidad ________

Nº de Rápidos ______ Profundidad ________

PARAMETROS DEL AGUA

Color del Agua

- ☐ Clara
- ☐ Café
- ☐ Negra
- ☐ Gris
- ☐ Verde
- ☐ Sucia
- ☐ Aceitosa
- ☐ Lechosa
- ☐ Espumosa
- ☐ Otro ________

Color del Substrato

- ☐ Anaranjado/rojo
- ☐ Amarillo
- ☐ Negro
- ☐ Café
- ☐ Gris
- ☐ Ninguno
- ☐ Otro ________

Olor del Sedimento

- ☐ Normal
- ☐ Aguas Negras
- ☐ Petróleo
- ☐ Químicos
- ☐ Anaeróbico
- ☐ Cloro
- ☐ Ninguno
- ☐ Otro ________

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