Unit IV. Field Investigation

This unit guides you through a water quality monitoring investigation of your local stream. You may choose to investigate one or all of the parameters in the following sections.

The sections for each parameter contain background information to help you understand and interpret your results. Specific field directions and data sheets are printed on separate pages to let you copy these easily to take with you when you sample.

Sections

1. General Stream Survey

The general stream survey helps you identify basic information about the site location, the sampling date and conditions, and any insights into activities in the area that might affect water quality.

2. Physical Properties

Physical measurements help you understand the movement of water through the stream and how the stream's watershed influences the flow and general functioning of the stream. These physical properties are especially important in evaluating the quality of fish habitat.

a. Stream Flow
b. Stream Shape
c. Physical Data Collection Sheet

3. Chemical Properties

Chemical measurements help us understand whether or not a stream's water is polluted. The sections also explain how the different pollutants affect our uses of the streams.

a. pH
b. Dissolved Oxygen
c. Nutrients
  Nitrogen (Nitrate and Ammonia)
  Phosphorus
d. Turbidity
e. Temperature

4. Biological Properties

The plants and animals found near and in a stream help us understand whether or not the stream is polluted, how changes in the watershed may be influencing the stream, and how the stream and its community is changing over time.

a. Macroinvertebrates
b. Riparian Vegetation

Each monitoring section contains the following information:

- Background information, including definitions, why we care about that measurement, and what might make it change over time.
- A simple overview of the monitoring method
- Masters for overheads
- Information to help you interpret your results
- Resources fur further investigation
- Directions for sampling in the field
- Data collection sheets

IV-1. General Stream Survey

A general stream survey is a good place to start you field investigation. It will provide some basic information on your stream, such as appearance and smell, that suggest a potential problem. Information on the stream's surroundings (land use) may provide clues to the source of a water quality problem. Other observations, such as weather and time, will help you interpret your water quality data when you return to the classroom and help you compare data collected on different dates.

Filling out the "General Stream Survey Data Sheet"

The following information and directions will help you understand the information requested in the General Stream Survey. NOTE: If you take separate sets of data (e.g., sample once in the morning and once in the afternoon) fill out a different data sheet for each set.

Site and Sampling Date Information

Stream – Name of stream.

Date – Include day, month and year.

Time of day – List the beginning and ending times (e.g., 10:30 am – 1:00 pm).

Watershed – The name of the major watershed in which your stream section is located (e.g. Spring Creek is in the Bear River Watershed).

School/group name – Self explanatory.

Teacher/leader – Self explanatory.

Group members – The name of group members with their monitoring roles in parentheses.

Location of stream section – The "stream section" runs from the furthest upstream sampling station to the furthest downstream sampling station. Be detailed in your description. Document the location as if you were describing it to someone who had never been there before. The following steps will help you determine and document a precise location.

1. Locate and mark your stream section on a 7.5' (1:24,000 scale) topographic map (available at sporting goods stores or from the U.S. Geological Survey on-line at **http://www.water.usgs.gov/**). You may want to include the latitude and longitude or UTM for your location.
2. Write directions to your stream section from a main access point or road. Include the county in which the stream is located.
3. Describe the stream section. Include the furthest upstream and downstream locations. For example, "The stream section begins at the downstream side of the bridge and runs 150 yards downstream to the cottonwood stand."
4. Include any other significant identifying landmarks or features.

Weather in past 24 hours – Choose all categories that apply to the weather over the past 24 hours. Past weather will affect volume of flow, turbidity, temperature, and other factors in your stream. If a weather event was an unusual one, your results may be unusual, too.

Weather now – Choose the one category that best represents the weather while you sampled.

Air temperature – Use the field thermometer to record the air temperature. Take the temperature in the shade.

Water and Watershed Information

Water appearance

Water appearance is often the most obvious water quality indicator that people notice. However, it is not a precise indicator of stream health and is best considered in combination with other data you will collect. Healthy streams may range from clear to brown. Unhealthy streams are often crystal clear. The following are common stream colors and possible causes.

Brown – Often results from decaying organic matter in the stream. Streams that drain wetlands may be stained a very dark brown.

Clear – Usually associated with healthy waters. However, clear waters may be polluted with colorless substances. Very clear water without any living organisms may indicate a severe pollution problem.

Multi-colored sheen – A heavy sheen may indicate floating oil from dumping or run-off from sewers, roads and parking areas. A light sheen may result from the natural breakdown of vegetation.

Foamy – If foam is fairly thin – less than 6 inches high – and grayish it may be the result of natural oils, soil particles and pollen. Heavy foam (more than 6 inches off the surface of the water) may be the result of detergents or animal waste runoff.

Milky – This color may indicate pulp or paper manufacturing discharge, a dairy operation or natural sediments.

Scummy – May result from floating algae or decaying plant material.

Muddy / Cloudy – May result from high amounts of sediment and indicate erosion upstream. Consider stream type and location, amount of sediment, recent storms, or seasonal events such as snowmelt.

Orange / Red – May indicate runoff from mines or oil wells; may result naturally from drainage through soils rich in iron or tannins.

Green – Slightly greenish water results from the presence of microscopic plants or algae and usually indicates healthy conditions. Deep green, or pea soup color, often results from an overabundance of algae (phytoplankton). Heavy nutrient loads from fertilizers (agriculture, golf courses, lawns), animal waste (feeding operations) and poor sewage treatment often promote heavy amounts of algae.

Other – What other colors do you see? Be specific.

Smell

Smell is another useful, but limited, tool that should be considered in combination with other indicators. Below are some common smells that result from both healthy and unhealthy waters.

Rotten egg – A sulphurous smell which often indicates sewage or animal waste pollution. Anaerobic (without oxygen) decomposition processes and minerals delivered from sulphur springs also give off this smell.

Musky – May indicate raw sewage, animal waste or heavy algal accumulation and decomposition.

Chlorine – May result from heavy chlorination of treated sewage.

Other – Smell another odor? Make a note.

Land Use Around the Sampling Site

Land uses around your stream and throughout your watershed can have both positive and negative effects on your water quality.

Factories – Industrial facilities and others may represent a direct, or point-source of pollution. Point source pollution can be sewage, chemicals or heated water.

Pavement – Paved surfaces and roof tops (malls, stores, parking lots) don't allow water to infiltrate into the soils. Pollutants on these surfaces (oil, antifreeze, sediment) often wash directly into streams.

Agriculture – Farm lands have the potential to deliver sediment, nutrients and pesticides to streams. Some irrigation practices in areas such as the Colorado River Basin wash salts from the soil and increase salinity levels in rivers and streams.

Logging – Silvicultural activity (logging) often increases runoff and sediment and nutrient supply to the stream.

Grazing – Overgrazing can potentially deliver organic matter and nitrates to the stream. Excessive grazing of the riparian zone may damage vegetation, causing increased erosion and loss of shading by woody plants.

Homes – Fertilizers and pesticides applied to lawns often find their way into local streams during rain storms. Faulty septic tanks may increase bacteria levels and nutrients in streams. Oil and household chemicals are other common impacts.

Mining – Various forms of mining may lower pH, increase heavy metal concentrations and sediment loads, and decrease streamflows.

Wildlands – Healthy, well-vegetated woodlands and fields stem the flow of nutrients and organic matter to streams.

Waste treatment plants – Plants that treat sewage and other polluted water often release water containing high concentrations of nutrients.

Unpaved roads and trails – Unpaved roads and associated road cuts and trails created by off-road vehicles can be significant sources of sediment to streams.

Stream modifications – This category includes dredging, damming, filling or channelizing through culverts.

General Stream Survey

Site and Sampling Date Information

Stream name________________________ Date _________________________

Time of Day __________________________ Watershed name___________________

School/group name ___________________ Teacher/leader ____________________

Group members ___________________________ ________________________________

___________________________ ___________________________

___________________________ ___________________________

Location of stream section ____

____

____

Weather in past 24 hours:
- storm (heavy rain)
- rain (steady rain)
- showers (intermittent rain)
- overcast
- clear/sunny

Weather now:
- storm (heavy rain)
- rain (steady rain)
- showers (intermittent rain)
- overcast
- clear/sunny

Air Temperature

____

degrees F
degrees C

Water and Watershed Information

Water appearance:
- clear
- brown
- multi-colored sheen
- foamy
- milky
- scummy
- muddy/cloudy
- orange/red
- green
- other ___________

Smell:
- rotten egg (sulphurous)
- musky
- chlorine
- other _____________

Land use around site:
- factories
- pavement
- agriculture
- logging
- grazing
- homes
- mining
- wildlands
- water treatment plant
- stream modifications
- unpaved roads/trails
- other _________

NOTES

____

Field Data Sheet

IV-2. Introduction to Physical Monitoring

Over the course of a year, the flow of a stream may vary from almost a trickle to a raging flood. These varying flows help to shape the stream's channel. Changes in physical characteristics can also occur over the length of your stream.

Investigate the many natural influences that account for changes in the physical characteristics of your stream. Then determine how these changes influence your stream's water chemistry and the plants and animals that live in and around your stream.

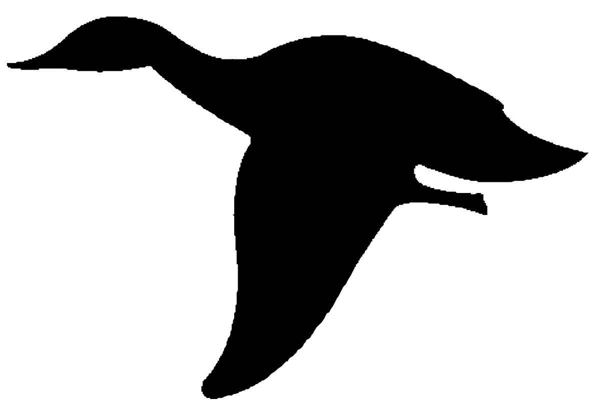
You can also combine your physical monitoring findings with what you have learned about watersheds and the water cycle to determine what influences humans are having on your stream.

This chapter helps you investigate the physical characteristics of your stream by providing background information and sampling directions for the following:

Sections

a. Stream Flow

b. Stream Structure



IV-2a. Stream flow

Key Terms

base flow	flood plain	storm runoff
channelized	intermittent	stream flow
climate	meandering	stream order
discharge	peak flow	volume
ephemeral	perennial	

What is stream flow?

Stream flow, or **discharge**, is the amount of water that flows past a specific point in a stream over a specific period of time. The two components of stream flow– **velocity** (how fast the water is moving) and **volume** (the amount of water in the stream) combine to determine the energy of the water. A water's energy greatly affects the shape of the stream as well as its biological and chemical characteristics.

Stream flow types
Streams which flow throughout the year are called **perennial streams**. Small streams, often those in the upper portions of a watershed, may be **intermittent** - they do not flow constantly throughout the year (usually only during the rainy season or spring runoff). In some areas of Utah, especially the drier regions, **ephemeral** streams are dry most of the year, flowing only for brief periods after extreme precipitation events.

What natural influences affect stream flow?

Climate

Weather patterns have the greatest influence on stream flow. Areas with higher precipitation produce streams with greater average volume. The Wasatch Range receives more precipitation than the desert areas of Utah and so its streams are more numerous and, on average, have higher flows.

Season

Stream flow varies throughout the year. Many rivers in Utah are fed by snow melt, and have their highest flows in the spring and early summer. Streams in southern Utah may also have very high flows in the fall due to "fall monsoons" in that region. A lower and more constant "base flow" occurs year round, fed primarily by water slowly draining into streams from the soils of the riparian areas and upper watershed.

Watershed

If all other factors, such as precipitation, are the same, stream volume will increase as the size of the watershed increases. This is why higher **stream orders**, which have larger watersheds, carry greater volumes of water.

Sinuosity

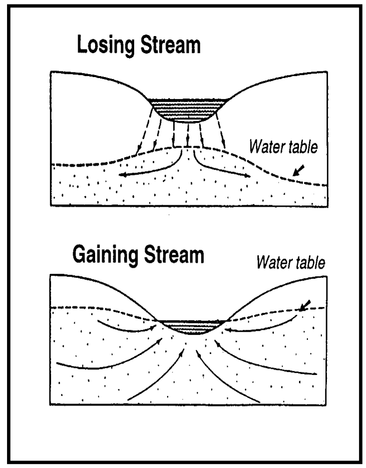
Most stream channels curve naturally, although some curve more than others. This curving pattern, called **meandering** , slows the water down and reduces its energy. **Channelized**, or straightened, streams have higher velocities and greater erosive power. Refer to section Stream Shape, section IV-2b, for more information.

Friction

Material in the stream – **substrate**, vegetation, and downed wood – create friction which decreases velocity. Larger substrate, such as cobbles and boulders, create more friction than fine-grained sediment such as mud and silt. Riparian vegetation decreases the velocity of flood waters.

> **? How do sinuosity, obstructions and friction combine to affect the velocity of a high mountain stream?** Small, high mountain streams are often filled with obstructions, such as boulders and trees, and have large rocky stream beds. These two factors combine to slow the water. However, these streams are usually steep and fairly straight, which produces high velocity. Since slope (or gravity) has the greatest influence on velocity, we find relatively fast water in high mountain streams.

Groundwater



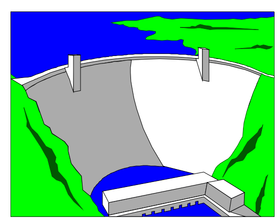
Groundwater will contribute to stream flow if the stream channel is lower than the **water table** (the top of the groundwater). See Figure 4, "Gaining Stream." During winter months, when precipitation is frozen, groundwater may be the only source of a stream's water.
If the stream channel site is above the water table, water will exit the channel and reduce stream flow as shown in Figure IV-1, "Losing Stream."

Vegetation

The roots and litter of riparian and upland vegetation intercept and slow surface runoff. This helps to regulate (spread out over time) the delivery of water to the stream. Without this regulating effect, stream flow will reach higher-than-normal levels during storms and increase erosion and threaten property. Upland vegetation also regulates water delivery to a stream.

What human influences affect stream flow?

Dams



In order to store water and produce hydroelectric power, dams often change the natural timing and patterns of downstream river flows. Dams release water gradually over time, which eliminates natural flood cycles.

The loss of flood cycles has many impacts on the floodplain below. Floods deposit sediments and nutrients back onto the floodplains and therefore help maintain healthy riparian areas. Floods create backwaters which are important habitat for young fish. Some trees require flooding before their seeds can begin to grow. Cottonwoods have become scarce in many riparian areas because flooding no longer occurs.

Channelization

The natural bends in a stream help to slow water down. When we channelize, or straighten, a stream we increase velocity and erosion of the stream banks. Channelization also reduces the diversity of habitats such as pools in a stream, necessary for fish and other aquatic life.

Land Use

Land use throughout the watershed can affect stream flow. Construction, logging, grazing, draining of wetlands and farming may alter water delivery to a stream. Urban development can have major impacts on stream flows. Impermeable surfaces, such as roads, parking lots and buildings, reduce the ability of water to soak back into the ground. Instead, the water runs off the land, causing increased flooding immediately after a storm or after snow melts. Summer flows, however, are often reduced because less water has soaked into the ground. Runoff over these "hard" surfaces also introduces more pollutants directly into the streams.

Why do we care about stream flow?

Water quality

Stream velocity and flow affects **turbidity** and **dissolved oxygen (D.O.)** concentrations.

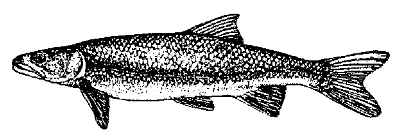
- High-velocity streams are more erosive and suspend sediments for a longer time, leading to greater turbidity.
- Turbulent, fast-moving streams are better aerated and therefore have higher concentrations of dissolved oxygen.
- Greater volume maintains cooler temperatures.

Aquatic life

Different stream flows create different habitats for aquatic organisms. Some organisms, such as the mayfly nymph, need highly oxygenated, swift flowing waters. Others, such as mosquito larvae, require still water. To protect the native species of a stream or river it is important to maintain natural stream flow levels.

The riparian zone

Overbank flow of water is essential for the health of the riparian zone. Without these flows riparian vegetation loses important supplies of water, nutrients and sediment.



Many fish require both high- and low-flow stages. The Colorado pike minnow, a giant (up to 5 ft.) minnow, native to the Colorado River system, requires floods to fill backwaters for spawning and low flows for other life processes. Dams, which smooth-out the variance of flow, have helped to place this fish on the Endangered Species list.

Humans

Control flooding

Although regular flooding occurs in natural streams, they can be costly and dangerous events for humans. Each year in the United States, about 100 people lose their lives to floods.

Hydrologists can predict the stream flow that will result from a storm of a specific size. They can then recommend if evacuation is necessary during a flood event and can recommend how far back from the river to build in the first place. Land use changes in the watershed change historic patterns of water flow and challenge our ability to predict the size and extent of major floods.

Water Storage

Most dams and reservoirs store water for industry, agriculture and cities. The amount and timing of stream flow determines how much water should be stored in the reservoirs. In Utah, peak stream flows occur in May and June while the highest demands for water occur in July and August. Spring runoff is stored and then released to meet water demands throughout the year.

Hydrologists predict annual stream flows which determine the amount of water reservoirs need to store. When the states of Utah, Wyoming, Nevada, Colorado, New Mexico, Arizona, and California divided up the water of the Colorado River in 1922 – The Colorado River Compact – hydrologists overestimated the annual flow of the river. Instead of the correct average annual flow of 13 to 15 million acre-feet, they estimated a flow of 17 million acre-feet; and, thereby allocated too much water to each state. Problems result when each state wants to use its entire allotment of water.

What's an acre-foot?
We measure large volumes of water, such as a stream's annual flow, in *acre-feet*. Water piled 1 foot high across a football field equals 1 acre-foot or 326,000 gallons. This is enough water to supply a family of five for one year!

How do we measure stream flow?

This section provides background information that will help you measure stream flow. It accompanies the "Stream flow Sampling Directions" (found at the end of this section), which provide step-by-step directions and a list of the time, persons and materials needed.

Preparation

1. Before sending students out, determine whether water depth is low enough for them to wade safely across the stream (water should not reach above the students' knees if it is flowing more than 1 foot per second). If it is not safe you have these options:
   a. Choose another site.
   b. Delay measuring until water levels drop.
   c. Obtain flows from another source. Accurate, up-to-the-hour information on stream flow for many larger streams is available from the U.S. Geological Survey – www.ga.water.usgs.gov
2. If you will be taking in-stream measurements in cold water or cool weather, be sure students have waders. Regardless of temperature be sure students have a change of clothing and are wearing close-toed shoes when wading.
3. Make sure your students practice and know the sampling procedures before entering the field. This will ensure a successful field experience. Use flags or markers to create a model stream in your schoolyard.

Measuring stream flow

To calculate stream flow you will need to determine average velocity (measured in feet per second – ft/s) and the average area of the cross-section of the stream (measured in square feet – ft^2). Multiply velocity and area to find stream flow. Stream flow is measured in cubic feet per second (cfs).

Stream flow = velocity (ft/sec) X area (ft^2)

= ft^3/sec (cfs)

Velocity

Velocity is determined by timing how long it takes an object (in our case a ping pong ball) to travel 50 feet along your stream section.

Measure Flood Height
See "Make Your Own Monitoring Equipment" for directions on how to make and operate a *crest gauge* – a tool for measuring the highest point to which flood waters rise.

Area
Volume is determined by measuring the cross-sectional area of the stream (width multiplied by average depth).

Accuracy
To increase accuracy take more measurements and average them. If you want to ensure the accuracy of your measurements or compare your sampling techniques to those of a professional, contact the U.S. Geological Survey (USGS) or the Utah Division of Water Quality (UDWQ). They can provide you with their data, explain differences in technology and methods, and may even join you in the field! Contact information is provided in the "Resources" Appendix.

How do we interpret our results?

Comparisons
Stream flow data allow you to compare your stream's discharge with other streams, with other seasons and with previous years. Table IV-1 provides historic stream flow data on some notable Utah rivers. Notice the tremendous variation in flow levels over time (e.g., the Colorado River has an average flow of ~16,000 cfs but has reached flows of as much as 105,000 cfs and as low as 2400 cfs). Also, notice that the Jordan River, which runs through Salt Lake City and is the most highly regulated river on the list, has the least amount of variation in annual flow. How does your stream compare.

Table IV-1. Historic stream flows in Utah rivers
[cubic feet per second]

	annual mean[1]	maximum[2]	minimum[3]
Bear	1790	14,770	47
Colorado	16,200	105,600	2400
Dolores	790	17,400	3
Duchesne	520	11,500	2
Fremont	90	1360	18
Green	6220	68,100	255
Jordan	140	450	-
Little Bear	100	1030	4
Logan	190	1740	5
Ogden	100	1390	4
Provo	280	6100	11
San Juan	2310	70,000	-
Virgin	200	22,800	22
Weber	500	1010	-

[1] derived from individual daily means
[2] highest recorded daily discharge
[3] lowest recorded daily discharge

[source: U.S. Geological Survey] Table IV - 1

How much water is in a cubic foot (cf)?
To picture 1 cf think of a milk crate (1′ x 1′ x 1′). Now, imagine that milk crate taking 1 second to flow by you – 1 cubic foot per second (cfs). The Colorado River, on a very high flow day, may send 70,000 or more of these milk crates by you every second!

Regulations
Minimum instream flow requirements are set by water management agencies to maintain enough water in a stream for fish or other aquatic wildlife populations. These requirements are usually set in areas where water withdrawals for irrigation, power, and municipal uses such as drinking water affect stream flow levels. Check with the Utah Division of Water Rights to see if any minimum flows have been established for your stream.

Water Quality
Stream flow data can help you interpret your chemical monitoring data. Graph your nutrient concentrations alongside your stream flow data. You may see higher concentrations during low flows because high flows may dilute chemical concentrations. However, during high flows the <u>total amount</u> of a chemical may actually increase (even though the concentration is lower). To check for this, multiply the chemical concentration by the regular flow and then by the high flow. Which total amount of nutrients is greater?

Also, check for relationships between stream flow and dissolved oxygen (DO). Low DO may coincide with low flows that leave the water stagnant. DO concentrations during turbulent high flows will probably elevate.

Hydrographs

If you have collected stream flow data on a regular basis (every hour, day, week), graph the data as a hydrograph. This will help you to see seasonal changes in your stream. Review the information on hydrographs from above for assistance.

Resources for further investigation

Colorado Basin River Forecast Center – Use an interactive mapping tool to find information on medium- and large-sized rivers across Utah and the nation. The site provides river conditions, including historical and real-time data on flow, weather conditions and forecasts, links to other hydrology sites and the opportunity to ask questions of experts. - www.cbrfc.gov

U.S. Geological Survey – Water Science for Schools – The USGS web site offers information on many aspects of water, along with pictures, data, maps, and an interactive center where you can give opinions and test your water knowledge. You can also link to USGS real-time flow data for rivers and streams in Utah. www.ga.water.usgs.gov/edu/

Utah Division of Water Resources (UDWR) – The UDWR implements water education and water conservation programs. They also maintain accurate and current water supply and land use data for each watershed in the state. Check out their Water Conservation Web Site to learn about water use in Utah, and how we can protect and conserve our clean water supplies. You can also request UDWR publications (e.g., Utah Water Facts Brochure). Contact: http://www.nr.state.ut.us/WTRRESC/water/Cons/cons.htm

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Stream Flow

Time – 45 minutes
Persons - 4
Materials:

- Measuring tape (at least 50 feet)
- 8 surveyor's flags
- stopwatch or watch with a second hand
- float (ping pong ball, bobber, orange)
- 2 sets of waders
- Physical Data Collection Sheet

STOP If your stream is too deep to wade into disregard the following directions. You can obtain accurate, up-to-the-hour data from the US Geological Survey – www.ga.water.usgs.gov

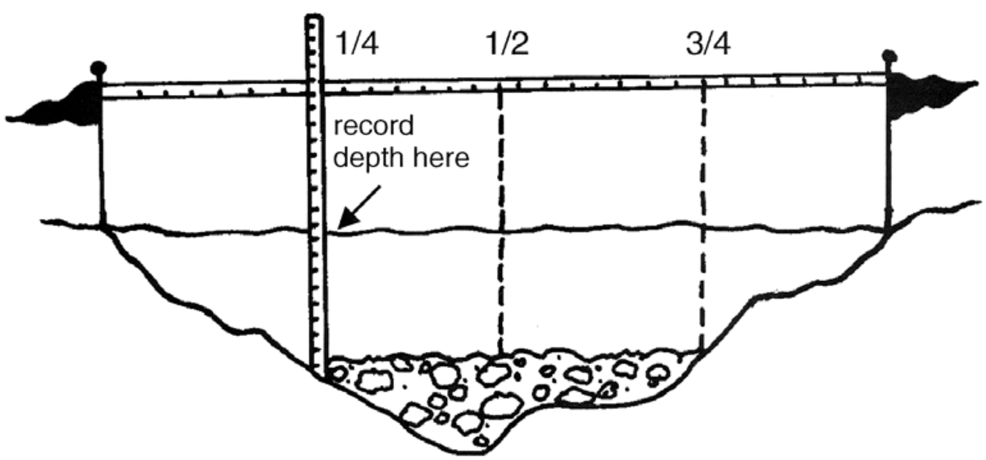
Step 1 - Measure length of stream section

1. Choose a fairly straight section of stream.
2. Use the tape measure to measure a 50 foot section. Place flags at both ends (next to the water's edge).
3. Record the length stream section as "50 feet" in Step 1 of the Physical Data Collection Sheet.

Step 2 - Measure cross-section area

a. Measure width of stream section (see Figure IV-2 for help)

1. Stretch a tape across the stream between two flags.
2. Record your width in Step 2a of the Data Collection Sheet <u>in inches</u>.
3. Keep holding the tape measure between the two flags. You will need it for the next step.



b. Measure average depth of stream section (see Figure IV-2 for help)

1. With the tape measure strung between the two zero ft flags, have a third person move one-fourth of the way across the width of the stream. To find this distance divide your width by 4. For example, if your stream is 20 feet, you would move 5 feet across.

2. At this one-quarter mark, *rest* your yard stick on the stream bottom (do not dig) and record the depth in Step 2b of the Physical Data Collection Sheet. Record depth in inches.

3. Move the same distance out along your tape measure (you will now be one-half way across the stream). Record the second depth measurement in Step 2b.

4. Record the depth at three-fourths of the way across the stream.

5. Add the three depths and divide by three to get an average depth for your stream section.

c. Calculate cross-section area
Fill-in the boxes in Step 2c – "Cross-section Area" – on the Physical Data Collection Sheet. Multiply the width times the depth. You now have cross sectional area in square inches. Divide that value by 144 for cross sectional area in square feet.

Step 3 – Measure velocity [see Figure IV-3 for help]

a. Calculate average travel time – the time it takes an object to travel your 50 foot section

1. Drop a floating object (ping pong ball) in the main channel upstream of your zero flag.
Start the stopwatch when the object passes the zero flag (the "starting line").

2. Yell to stop the clock when the object passes the 50 ft flag (the "finish line").

3. Collect the object and record the time on the data sheet.

4. Repeat steps 1-3 two more times. Throw out any tests where the float gets stuck in rocks or debris.

5. Add all three travel times and divide by 3 to get an average. Record on data sheet.

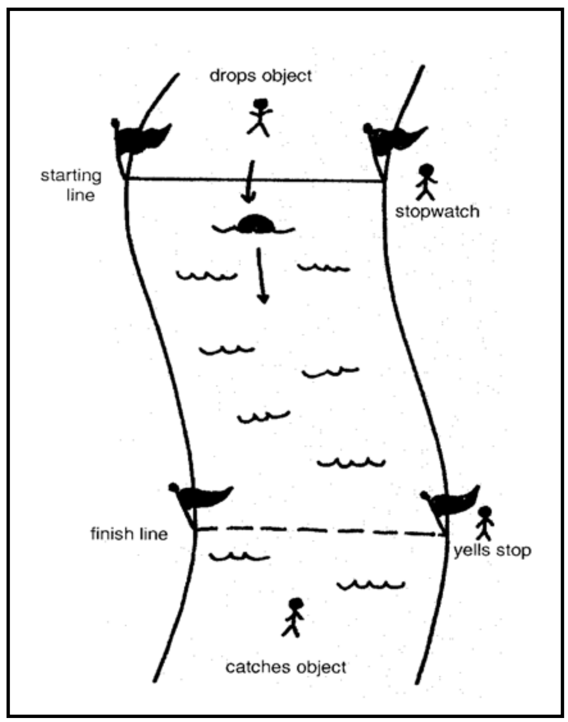


Illustration: Holly Broome-Hyer Figure IV-3

Calculate velocity
Divide stream section length by average travel time.

This will give you velocity in feet per second (feet/sec).

Step 4 – Calculate stream flow

Multiply the average cross-section area times the average velocity to determine stream flow for your section. Your flow will be in cubic feet per second.

IV-2b. Stream Shape

Key Terms

erosion	pool	sediment	thalweg
friction	riffle	sinuosity	
glide	run	substrate	

What is stream shape?

Have you ever wondered why your stream's channel (its physical structure) is shaped the way it is? Did you know that its shape continually changes? How do you think the stream channel affects water quality? If you understand general patterns of streams, their physical characteristics, and the natural and human influences that affect them, you will be able to answer these questions, and more!

Stream channel patterns

Channels follow one of three basic patterns based upon the stream's surrounding terrain. These patterns are described below and shown in Figure IV-2.

Meandering –A stream that **meanders** a lot (has a high degree of **sinuosity**) makes many, tight "S-turns." We often find meandering streams in valley bottoms with little slope. The Bear and Malad Rivers of northern Utah are meandering rivers.

Straight –Streams that run down steeper slopes may not meander much at all. Their fast waters erode downward until they are often confined by a deep, narrow channel of bedrock. Look for streams like this in Utah's Mountains.

Braided – Braided stream channels continually split and re-join. Loose **bed material** and sparse vegetation allow these channels to move great distances across flat, broad valley floors. Streams in glacier-carved valleys of the Uinta Mountain Range are home to many braided streams.

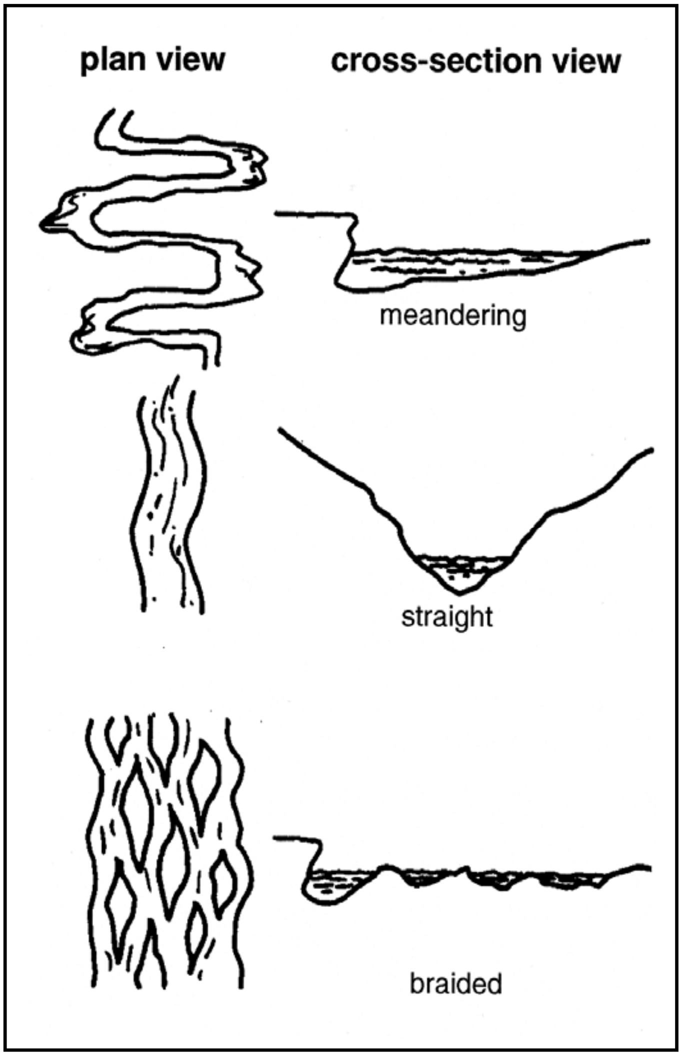


Figure IV-2. Different Stream Channel Shapes.
(Plan view is a view from above).

Erosion and Deposition

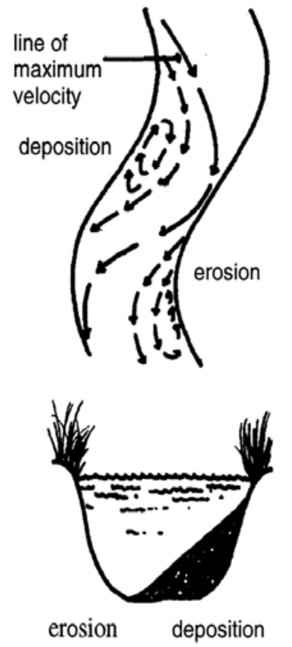
The processes of **erosion** and **deposition** cause stream channels to constantly change.

Erosion

Flowing water wears down or washes away soil and rock. We call this process erosion. Higher velocity waters are more **erosive** – they have more energy to pick up and move materials in the stream channel. Figure IV-3 shows us that most erosion in streams occurs on the outside of bends where velocity is fastest.

Deposition

When sediment is eroded from one area of a stream it must be deposited in another. Figure IV-3 shows that deposition occurs where water moves slowly, such as the inside of a bend.



Thalweg

Water, like all moving objects, wants to go in a straight line. Why then does it bounce across the channel as shown in this diagram? Well, water actually does move in straight line - it's the channel that bends. If we follow the **thalweg** - water's path of greatest velocity - we see that it travels in a straight line until it meets a bend. The thalweg then bounces off and heads straight for the next bank. This bouncing pattern slows the water down which decreases erosion.

Illustration: Holly Broome-Hyer

Figure IV-3. Thalweg of stream as seen from above, and resulting erosion and disposition patterns of stream sediments.

Physical characteristics of a stream channel

A stream contains riffles, runs and pools, illustrated in Figure IV-4. These different areas provide diverse habitats for fish and other aquatic life. The relative proportions of these different habitats in a stream are one way to determine how healthy the stream is.

Riffles –Water that moves over a shallow area of cobbles and gravel creates a **riffle**. These well-oxygenated, fast moving waters provide habitat for **macroinvertebrates** and spawning fish.

Runs – A **run**, or **glide**, is a length of a stream with smooth water and slow to medium velocity. Runs are good areas for fish to feed and travel.

Pools – A **pool** is a deep area of fairly still water which creates refuges for fish to hide in and to rest from the current. Pools provide unfrozen habitat for aquatic life during the winter and also act as natural pollution filters. Some pollutants, such as suspended solids, settle out of the water and down to the bottom of pools.

Obstructions –Objects in the channel, such as rocks and **large woody material** – fallen trees and limbs – create pools downstream. The turbulence they create mixes oxygen into the stream and the intricate spaces between tree trunks, limbs, and roots provide protection for fish.

Islands – Islands form as rocks in the channel snag sticks and leaves which then trap sediment. The trapped sediment supports hydrophilic, or water-loving, vegetation. An island soon develops and reduces turbidity. Islands also provide important habitat for fish, waterfowl and water dependent mammals, such as otters.

Side Channels – Every stream and river has a main stem – the primary path for water flow. Many streams also have side channels that enter and leave the main stem. These side channels are usually created by floods which scour paths outside the main stem. The steady water flows, rich riparian zones, and protective nature of side channels make great waterfowl nesting areas and fish nurseries.

Overhead and cross-section views of physical characteristics of a stream channel

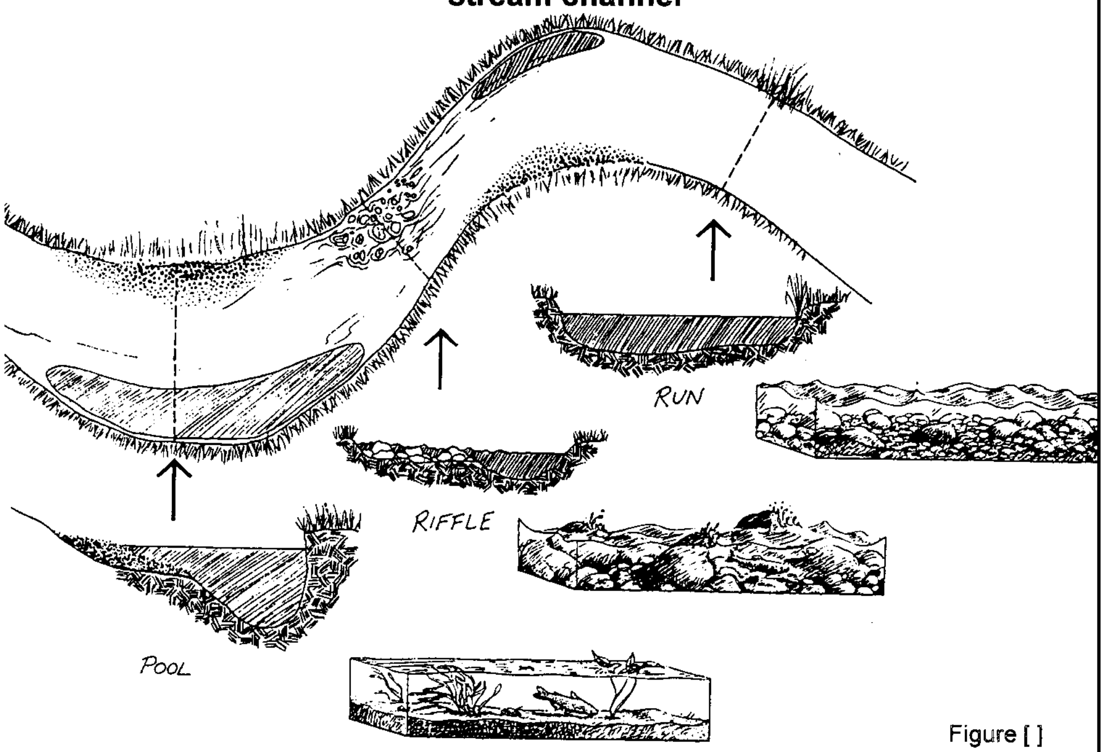


Figure [ ]

Figure IV-4

Source: Environmental Protection Agency: Volunteer Water Quality Monitoring: A Methods Manual

What natural influences affect stream shape?

The natural influences described below determine the shape of a stream and how often it changes. **Velocity** is a shaping force – it determines the power of water to erode areas of the stream channel. **Friction**, which is created by **substrate** (the material that makes up a stream channel) and **riparian** vegetation resist the erosional power of water.

Velocity

Faster water has more energy and is able to move more sediment of larger sizes. Once the sediment is suspended in water it acts like a sandblaster, further increasing the water's erosional power.

Friction

Water does not move smoothly down its channel. Anything that contacts water – the streambed, logs and sticks, and even wind – causes friction and slows the water down.

Substrate

Faster water moves larger substrate – the material that makes up a stream's channel. This is why we find boulders and cobbles in steep, high-velocity mountain streams; smaller particles, such as sand and silt, are carried away and deposited in low-gradient, slow-moving sections (Table IV-2). Why might you find boulders in a valley bottom stream? Think about changes in velocity that come with floods.

A stream's velocity also varies across the channel. As the fast, outside bend erodes the bank the inside bend builds up. This is why channels with small, easily-eroded substrate will move back and forth across their floodplains, like "a snake in a bed."

Table IV-2. Scientists divide stream substrate into different size categories shown below.
Hydrologists, scientists who study water and stream channels, divide substrate into six categories based on size.

<u>Bedrock</u> (solid rock)

<u>Boulder</u> >12" (anything larger than a volleyball)

<u>Cobble</u> 3–12" (golf ball to volleyball size)

<u>Gravel</u> 1/4–3" (pea size to golf ball size)

<u>Sand</u> <1/4" (smaller than a pea but large enough to be seen with the naked eye)

Riparian vegetation

The tough, tangled roots of **rushes**, **sedges**, **shrubs** and trees provide structure to streambanks. This reduces soil loss to the stream. Sticks and logs that fall in the water make the channel more complex. Vegetation also creates friction and decreases stream velocity.

The ability of water to suspend sediment depends on its velocity. To demonstrate this concept, place sediments of various sizes in a see-through container with a lid (clear 2-liter plastic bottles work well). Add water and swirl. All the particles will be suspended at first. But, as the velocity slows, the particles will begin to fall to the bottom in sequence (largest first). When you are finished you will have a visual example of the relationship between water's velocity and its ability to suspend and carry sediment.

What human influences affect stream shape?

Human activities can influence the bank structure of the stream, the amount of material that enters a stream, or the amount of water in a stream. Our actions can take affect anywhere in the watershed.

Upland impacts

Activities that affect the delivery of water and sediment to a stream affect stream shape. Development, logging, mining, grazing and even hiking or biking can destroy upland vegetation which in turn causes more water and sediment to drain directly into a stream, rather than soaking into the groundwater. Short bursts of high-volume water increase erosion and form deep, narrow channels. The increased sediment delivered to a stream may cover normally rocky channels with fine sediment and organic matter.

Riparian impacts

The roots of **rushes**, **sedges**, shrubs and trees provide structure to stream banks and reduce erosion. These well-vegetated banks are often steep or overhanging (many sandy riparian areas are exceptions). See picture a in Figure IV-5. Without the anchoring of riparian vegetation, the stream banks may erode and the channel may widen and become shallower, as shown in pictures b and c. The resulting channel shape increases water temperature which can decrease dissolved oxygen concentrations (see Section IV-3b on dissolved oxygen).

Figure IV-5. Changing channel shape resulting from loss of riparian vegetation

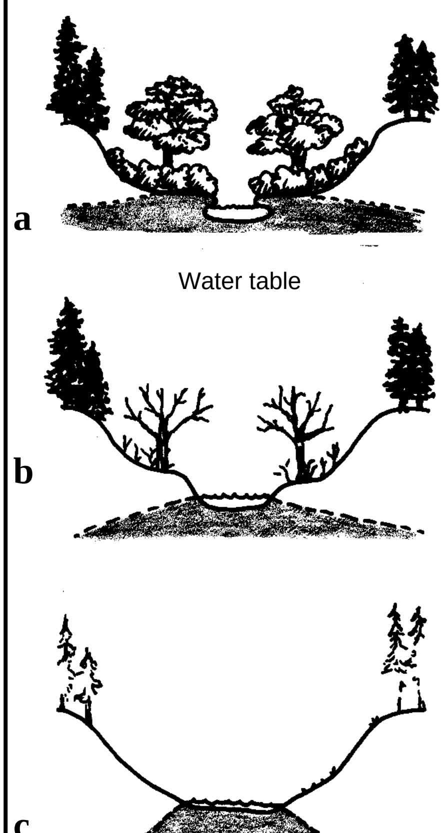


Illustration: Holly Broome-Hyer

Channel alterations

Many streams in urban and agricultural areas have been straightened, deepened or diverted into concrete channels, often for flood control purposes or to deliver water to other areas. These alterations:

- simplify the physical characteristics of the channel,
- reduce habitat for aquatic life
- increase water velocity and erosion.
- concrete channel beds increase water temperature which decreases dissolved oxygen concentrations.

Dams

Dams, by design, reduce downstream flooding. Without the high flows and increased sediment carried by a flooding river, backwaters and side channels can't form, beaches and riparian zones fail to receive essential supplies of sediment, and aquatic life suffers because nutrient-rich sediments remain trapped in the upstream reservoir.

Tamarisk

The banks of most streams and rivers in the Colorado River Watershed erode naturally. However, tamarisk – a widespread, non-native riparian plant – is changing this. Tamarisk's tough, tangled roots do a great job of anchoring the streambanks. This causes the water to erode the bottom of the channel (downcutting) instead of the sides. The resulting deep, narrow channels increase water velocity, decrease important overbank flooding and inhibit formation of side channels and backwaters. It also lowers the water table (see figure 5 above). Riparian and aquatic life suffers. Many scientists are now studying ways to remove this invasive species from our river banks.

Why do we care about stream shape?

Stream shape has a significant effect on water quality. Straightening of streams causes higher rates of erosion which in turn can have many impacts:

- Stream banks may slump, causing the loss of someone's property.
- Excess, unwanted sediments may be deposited downstream, on fish spawning beds and in macroinvertebrate habitat.
- Flood intensity downstream may increase.
- Turbidity (cloudiness of water) may also increase.

Stream shape affects water temperature, because deep, narrow channels aren't warmed as quickly by the sun. Aquatic habitat is also affected by stream shape, because streams with many different physical characteristics provide more habitat for aquatic communities.

Each stream has unique physical properties due to its location and the nature of the surrounding watershed. Some streams may be naturally sinuous and turbid; others may be straight and clear. However, if natural or human influences cause a stream's shape to change, water quality will likely change as well. When this happens, the aquatic life that has adapted to the old conditions may not be able to adjust to new ones. For example, some macroinvertebrates, such as caddisfly larvae, require small stones to build their protective cases. If silt and fine sediments, such as silt, cover the bottom, no building material is available for the caddisfly larva. The entire aquatic food chain may, in turn, be disrupted.

How do we monitor stream shape?

There are many aspects to stream shape and therefore, many ways to measure shape and changes in shape. The directions, provided at the end of this section, will help you to determine your stream's channel pattern, substrate and riffle/run/pool ratio.

- Channel pattern describes the general path the stream takes as it moves across the land (see Figure IV- 2).
- Substrate tells us what types of material make up the channel (see Figure IV-6).
- Riffle/run/pool ratio tells us what types of habitats are present in the stream, and which are the dominant habitats. (see Figure IV-4).

The Field Directions sheet, found at the end of this chapter, is designed to be laminated and carried in the field for use.

How do we interpret our results?

Just as we look at the chemistry and biology of a stream, we can also assess trends in channel pattern, substrate and riffle/run/pool ratios. These changes will tell us a lot about the current and future health of our stream.

We cannot say that a certain stream shape is necessarily "good" or "bad." Each stream has its own assemblage of physical characteristics. However, aquatic life that has adapted to the physical nature of a stream and the accompanying water quality may suffer if changes occur. This is why we monitor to establish long term trends in stream shape. Read below to find out how.

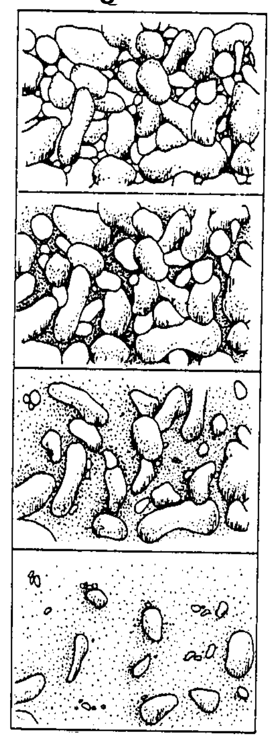
Channel Patterns

Straightening (channelizing) is a common change we see in channel pattern. The causes and effects are described earlier in this section. If you suspect your stream has been straightened, examine historic flow data (consult with the Utah Division of Water Resources or US Geological Survey) to see if abnormally high flows are resulting.

Channel Shape

Downcutting – heavy stream bottom erosion – is another common change we see in stream shape. Downcutting results from abnormally high flows that scour the channel away. It may also result from changes in the riparian zone such as tamarisk invasion, as previously discussed. Downcutting lowers the water table, leaving riparian communities "high and dry." High, steep banks and dead or dying riparian vegetation may be a clue that your stream is downcutting.

Figure IV-6. A rocky channel filling with silt



Source: Environmental Protection Agency: Volunteer Water Quality Monitoring: A Methods

Substrate

The dominant substrate in your stream may change naturally from larger to smaller particles (e.g. from gravel to silt) as the steepness of the stream (and therefore it's ability to carry large substrate) changes. Erosion in your watershed may also be sending too much sediment to your stream – refer to Figure IV-6. This may result from development of the watershed (logging, grazing or other activities). Consult your local Soil Conservation District office for information. Bank erosion from a lack of riparian vegetation can also fill a channel with fine sediment.

NOTE: A stream with one uniform substrate type will support fewer types of organisms than a stream with a wide variety of substrate types.

Riffle / run / pool ratio

If the ratio of riffles to runs to pools is fairly even, then the diversity of aquatic habitat is high and aquatic life will benefit. Abnormally high peak flows, often due to watershed impacts, will increase the number of runs and decrease overall structural diversity.

Resources for further investigation

<u>Stream Channel Reference Sites: An Illustrated Guide to Field Techniques</u> by the U.S. Forest Service. This manual provides an excellent introduction to basic physical sampling techniques, including cross-sections, longitudinal profiles, and pebble counts. Free copies are available from: Publications, USDA Forest Service, Rocky Mountain Station, 3825 E. Mulberry, Ft Collins, CO 80524, (970) 498-1719.

A View of the River by Luna Leopold. This classic book by America's most renowned hydrologist draws together all the pieces of river behavior. Although there are lots of charts and graphs, the material is presented in a very understandable fashion. Harvard University Press.

Water Science for Schools – This U.S. Geological Survey (USGS) web site offers information on many aspects of water, along with pictures, data, maps and an interactive center where you can give opinions and test your water knowledge. The site also offers real-time hydrologic data (e.g., stream flows). http://ga.water.usgs.gov/edu/

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Stream Shape

Stream channel pattern

Determine your stream's channel pattern with the help of the Physical Data Collection Sheet.

Time – 2 minutes
Persons - 1
Materials –
- Physical Data Collection Sheet

- Check the box next to the pattern that best describes the overall channel shape of your stream section.

- The fourth selection is an "unnatural" channel shape – it has been altered by humans. Include any altered channels, regardless of shape, in this category.

Substrate types

Determine the percentage of each type of substrate in your stream by doing a "pebble count." Follow the procedure below to perform a pebble count.

Time – 15 minutes
Persons – 3 (or more)
Materials –
- Physical Data Collection Sheet
- rulers

- To simplify calculating percentages, take exactly 50 samples. Two students can count pebbles (each one counts 25) while one student records data on shore.
- Record your totals on the Physical Data Collection Sheet.

Procedure

1. When instructed by the Recorder, have the Pebble Counters take one step into the stream towards the opposite bank.
2. After that step, reach down and touch the sediment at the tip of your toe. Important: do not look at the stream bottom while doing this, as this may bias your choice.
3. Pick up the sediment and measure the longest side with a ruler (in inches).
4. Tell the length to the Recorder. Make a mark next to the correct substrate size in column A of the Physical Data Collection Sheet. Refer to the "Substrate Sizes" table for help.
5. Repeat this until you reach the other shore. Then take 30 steps upstream and return back across the stream. Continue until 50 samples are recorded.
6. Calculate the percentage of each substrate type.
   1) Add up the marks for each row in column A. Write these totals in column B.
   2) Multiply the number in column B by "2" and record in column C. This will give you the

Substrate sizes

Bedrock (solid rock)

Boulder >12" (anything larger than a volleyball)

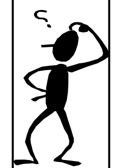
Cobble 3–12" (golf ball to volleyball size)

Gravel 1/4–3" (pea size to golf ball size)

*Sand <1/4" (smaller than a pea but large enough to be seen with the naked eye)

*Silt/clay (individual particles very hard to see with the naked eye)

* If having trouble determining the difference between silt and sand, pick up a handful of sediment. Silt will feel smooth, like mud. Sand will feel rough.



percent of each substrate type. For example, if you recorded 31 cobbles then, (31 X 2) = 62. This means that 62% of the substrate in your stream section are cobbles.

Riffle / run / pool ratio

The riffle/run/pool ratio is a measure of the kinds of habitat in your stream for fish, macroinvertebrates and other aquatic life.

> **Time** – 15 minutes
> **Persons** – 3
> **Materials** –
> - Physical Data Collection Sheet

Notes

- Use Figure 6 below to help you correctly identify *pools*, *riffles* and *runs*. Practice identifying in the field before sampling.

- The "Riffle/Run/Pool Procedure" can be done at the same time as the "Substrate Sampling Procedure." Record both measurements each time you take a step across the stream.

Procedure

1. Walk along the edge of your stream, using even paces. Stop after each step and look across the stream. Determine whether the stream is a riffle, pool or run at this point in the river. Note: If there are several habitat types, choose the most common type.
2. Mark the correct habitat type in column A on the Pool/Run/Riffle chart on the Physical Data Collection Sheet.
3. Continue for exactly 50 paces (this simplifies calculating the percentage).
4. Add your marks for each row in column B.
5. Multiply the number in Column B by 2 to find the percentage of pools, runs and riffles in the stream. For example, if you sampled 31 riffles then 31 X 2 = 62. This tells you that 62% of your stream section consists of riffles.

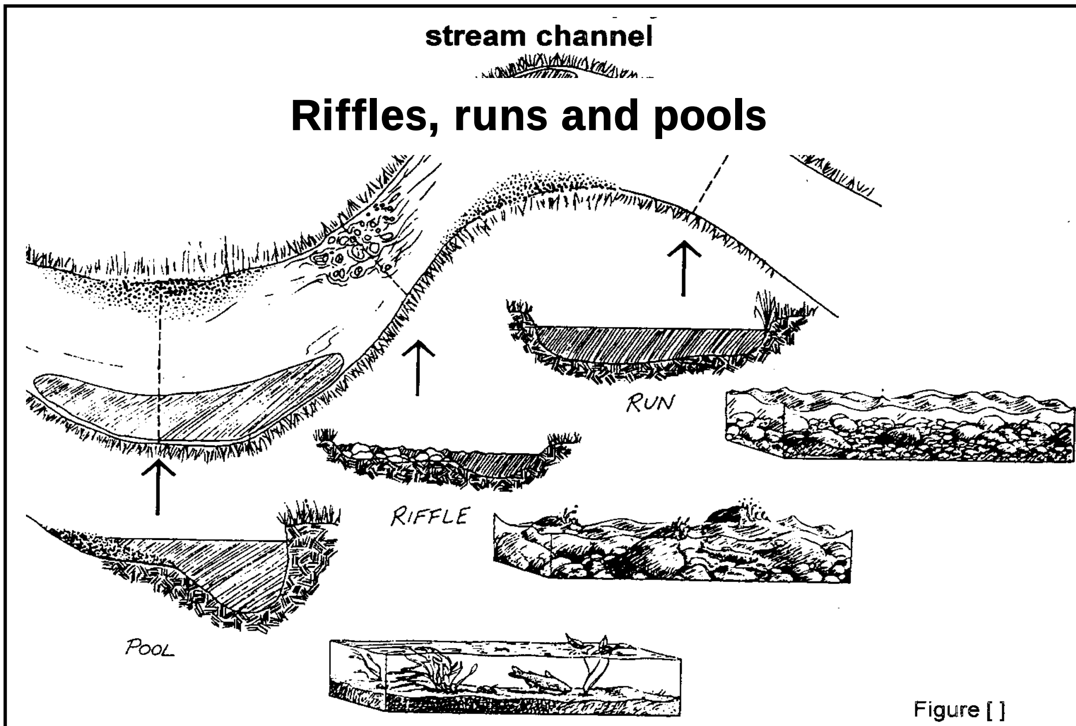


Figure [ ]

Date:__________________ Recorder:____________________________

Streamflow

Step 1 - length of stream section [ ] feet

Step 2 - cross-section area (width x depth)

a) width ________ (inches)

G **b) depth** **1.** __________ (inches)

2. __________ (inches)

+ 3. __________ (inches)

= __________ (inches)

÷ 3 = ________ (inches)

C) cross section area

________ **width** (inches)

X ________ **depth** (inches)

= ________ (square inches) **÷ 144**

= [ ] **cross section area** (square feet)

Step 3 – velocity

a) travel times

1. __________ (sec)

2. __________ (sec)

+ 3. __________ (sec)

= __________ (sec)

÷ 3 = _________ **average travel time** (sec)

b) velocity

_____________ length (feet)

÷ _____________ average travel time (sec)

= [ ] **velocity** (feet/sec)

Step 4 – stream flow

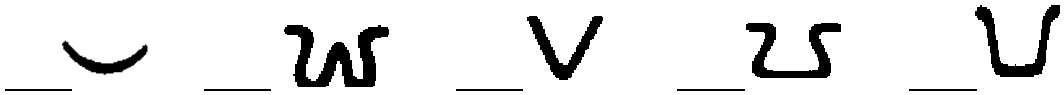
__________ **cross section area (square feet)**

X ____________ **velocity (feet/sec)**

= [ ] **stream flow ($feet^3$/sec)**

Stream Shape

Channel Pattern



Substrate Type

Substrate type	A. Record each observation	B. Total number of observations	C. Percent substrate type (column B x 2)
Silt (individual particles very hard to see with the naked eye)			
Sand 1/4” (smaller than a pea but large enough to be seen with the naked eye)			
Gravel ¼” – 3” (pea size to golf ball size)			
Cobble 3” – 12” (golf ball to volleyball size)			
Boulder >12” (anything larger than a volleyball)			
Bedrock (solid rock)			

Riffle / Run / Pool Ratio

Feature	A. Number of observations	B. Total number of observations	C. Percent feature type (column B x 2)
Riffle			
Run			
Pool			

IV-3. Introduction to Chemical Monitoring

Most substances in nature are "soluble" in water – water dissolves them. Consequently, streams with "pure" water (free of impurities) do not occur in nature. The amounts and types of impurities in the stream, whether they are natural or human-introduced, determine its chemical composition.

By monitoring the chemical composition we can show, quantitatively, changes in water quality. These changes may indicate disturbances in the watershed affecting the stream community.

This unit explains:
- the meaning of different types of chemical tests;
- how to perform the chemical tests; and
- how to interpret the results of those tests.

In this section, you will find information and sampling instructions for the following:

a. pH
b. Dissolved oxygen
c. Nutrients
   Nitrogen (nitrate and ammonia)
   Phosphorus
d. Turbidity
e. Temperature

A note on "detection limits"

Tests for chemicals in water have limitations. Below a certain concentration, a test cannot give you an accurate measurement of a chemical. We call this threshold the **detection limit**. A detection limit is listed for each chemical test method in the *Utah Stream Team* manual. For example, the detection limit for phosphate is .02 mg/L.

The values of most water quality tests (excluding temperature and turbidity) are determined by color change. If you cannot detect a color change in a test, report your result as "less than the detection limit," not "0." For example, if you get no color change when you do a phosphate test, report the results as "<0.02 mg/L."

NOTE: Your actual detection limit may vary from the one listed in the directions depending upon how careful you were in performing the test and how well you can distinguish different colors.

PPM's and PPB's ?
In the Chemical Properties Unit you will sometimes see chemical concentrations described as ppm (parts per million) and ppb (parts per billion). These terms indicate the amount of chemical relative to the amount of material in which the chemical is contained (usually, water). A part per million equals one milligram per liter (mg/L). A part per billion equals one milligram per 1000 liters. Visit "A Drop in the Bucket," in the Water Pollution section, for more information on these units.

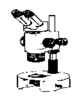
IV-3a. pH

Key terms
acidic basic neutral
alkaline buffer

What is pH?

The pH of water is a measurement of how **acidic** or how **basic** the water is. We measure pH on a scale of 0 to 14. Distilled water, which has no impurities, is **neutral.** It has a pH of 7.

Many substances dissolve in water. Sometimes when substances dissolve, they produce charged molecules called ions. Acidic water contains extra hydrogen ions (H^+). Acidic water has pH values between 0 and 7, zero being the most acidic. Basic, or alkaline, water contains extra hydroxyl ions (OH^-). Basic water has pH values between 7 and 14, 14 being the most basic. You might expect rainwater to be neutral. In fact, it is somewhat acidic with a pH of 5 to 6. This is due to the formation of carbonic acid as rain interacts with CO_2.



The pH scale is logarithmic – each unit change (e.g., from 7 to 6) in pH represents a 10-fold change in the acidity of the water. Water with a pH value of 6 is ten times more acidic than water with a pH value of 7. Water with a pH value of 9 is a 100-times more basic than water with a pH value of 7. The Richter Scale, which measures earth quakes, is another well-known logarithmic scale.

Look at the pH table below. Notice that substances that are highly acidic or basic, such as battery acid and lye, are toxic to most organisms. Refer back to this chart when you interpret your pH sample values.

Table IV-3. The pH Scale

	Common substances	pH	Biological effects
	Stomach acid	1	
	Lemon juice		
		2	
	Vinegar	3	
ACIDIC			All fish die
	Soft drinks	4	
	Tomatoes		Caddis and may flies die
	Carrots	5	
	Normal rain		Salmon eggs and **alevin** die
		6	Bass and trout begin to die
	Milk		Snails and tadpoles begin to die
		7	
	Human blood		Optimum for most fish
	Egg whites	8	
	Baking soda	9	
			All fish die
BASIC		10	
	Ammonia		
		11	
	Bleach	12	
	Lye	13	
		14	

What natural influences cause the pH of our streams to change?

Watershed effects

- Certain dissolved minerals, such as calcium carbonate, can combine with the extra hydrogen or hydroxyl ions that alter water's pH. When these minerals are present, the pH of the water doesn't change as much when acids or bases are added to the water. We call this buffered water. Many soils in our part of the west contain these minerals. When precipitation percolates these soils the minerals dissolve and the buffering quality is passed along to the water. Some watersheds contain primarily rocks with few of these buffering minerals. These watersheds, therefore, will produce poorly buffered water and any additional acid will change the pH of these waters.

> Limestone rock contains minerals which buffer streams. This type of rock is found throughout central and northern Utah. How do you think this might affect the pH values of our streams? If you found low pH values (high acidity) would you want to investigate further?

- If you have pine or fir forests in your watershed, you may see a lower pH value for your stream. The decomposing needles of these trees add to the acidity of soils and also influence the acidity of nearby streams.

- Water that enters your stream from the water table has had a chance to percolate through soil. If the soil is buffered, and if ground water is your stream's main source, then pH may be somewhat higher (7-8).

Seasonal effects

- When precipitation falls through the air, it dissolves gases such as carbon dioxide, and forms a weak acid. Natural, unpolluted rain and snow is slightly acidic – it has a pH between five and six. When snow melts rapidly it may not **percolate** through the soil before reaching the stream: soil minerals can't buffer it. At these times, the stream water may also be slightly acidic.

- During autumn, decomposing leaves and needles in the stream may increase the acidity of the water.

Daily effects

- When aquatic plants convert sunlight to energy during photosynthesis, they remove carbon dioxide from the water. This can raise the pH of your stream. Since photosynthetic activity occurs in sunlight expect the highest pH in your stream to occur in the early afternoon. Lowest pH levels will occur just before sunrise.

What human influences cause the pH of our streams to change?

- Polluted precipitation, also known as "acid rain," increases the acidity of waters near many industrial or large urban areas. The main contributors to acid rain are sulfuric acid (produced by coal burning industries) and nitric acid (produced by automobile engines). In Utah our buffering soils help to decrease the effects of acid rain.

- Dumping industrial pollutants directly into waters – also known as **point source pollution** – can have intense and immediate effects.

- Mining may expose rocks to rain water and produce acidic runoff. Mining drainage can therefore introduce acids into streams, and if the stream is poorly buffered the pH may quickly reach toxic levels.

Why do we care about the pH of our streams?

Animals and plants

Most aquatic animals and plants have adapted to life in water with a specific pH and may suffer from even a slight change.

- Even moderately acidic waters (low pH) may reduce the hatching success of fish eggs, irritate fish and aquatic insect gills and damage membranes.
- Water with extremely high or low pH is deadly. A pH below 4 will kill most fish and very few animals can tolerate waters with a pH below 3.
- Amphibians are particularly vulnerable, probably because their skin is so sensitive to pollutants. Some scientists believe the recent drop in amphibian numbers around the world is due to low pH levels caused by acid rain.

Other chemicals in the water

- A change in the pH of water can alter the behavior of other chemicals in the water. The altered water chemistry may affect aquatic plants and animals. For example, ammonia is harmless to fish in water that is not acidic. But, as pH increases ammonia becomes toxic.

- A lower pH will cause heavy metals such as cadmium, lead and chromium to dissolve more easily. Many heavy metals become toxic when dissolved in water.

How do we sample pH?

We measure pH using colored indicator strips which are dipped in the water. The colors on the strips react with the water and change. The color change is compared to a chart to determine the water's pH. The test requires one student and takes 5 to 10 minutes. If the strip cannot be dipped into the water safely, collect water with a bucket hung from a bridge or deck and then sample. The pH of the collected water may change, so sample immediately.

How do we interpret our results?

Natural pH levels vary between 6.5 and 8.5, depending on the surrounding soil and vegetation.
If your pH value falls out of this range ask your group these questions.

- Did we perform the test correctly? Re-read the pH directions to ensure you sampled properly.
- Is it summer time? Water containing many aquatic plants may have raised pH values on summer afternoons because of the plant photosynthesis.
- Does our watershed contain a lot of granite-like rock, dense conifer forests or acidic soil? If so, you are likely to have relatively acidic waters.
- Does our stream have a lot of snow melt in it? Remember, snow melt will lower pH values.

If you answered "no" to these questions then take a look at your watershed. Are there land use practices that might be affecting the pH of your stream? Refer to the "Human Influences" section for possible sources of abnormal pH.

> The allowable range of pH is 6.5 to 9.0 in the State of Utah.

Resources for further investigation

ChemTeam – This web site provides information in all standard topics for students in high school chemistry. You'll find a special section on acids, bases and pH. Contact: www.dbhs.wvusd.k12.ca.us/ChemTeamIndex.html

Miami Museum of Science – The pH Factor – This web site introduces pH at the grade- and middle-school level, with fun lesson plans for teachers. Contact: www.miamisci.org/ph/

Project Aquatic Wild Education Activity Guide - Project Aquatic Wild is an interdisciplinary conservation and environmental education program emphasizing aquatic wildlife and the natural and human forces that affect them. You will find several hands-on classroom and field activities that focus on pH. Contact: Project Wild, 707 Conservation Lane, Suite 305, Gaithersburg, MD 20878, (301) 527-8900 (p), (301) 527-8912 (f), email: info@projectwild.org, web: www.projectwild.org

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pH

Time – 2 minutes
Persons – 1
Materials
- pH strips

Step 1
Dip one strip of indicator paper in to the stream and pull out.

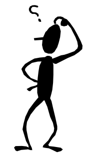
Step 2
Wait 1 minute.

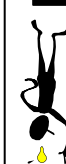
Step 3
Compare the color of the litmus paper to the pH color key on the pH box.

Step 4
Record the number associated with the correct color match on the Chemical Properties Field Data Sheet.

Remember: Take pH readings directly in the stream. If this cannot be done safely, collect water in a bucket and take the pH reading of this water immediately.


The allowable range of pH is 6.5 to 9.0 in the State of Utah.





IV-3b. Dissolved oxygen

Key Terms
dissolved oxygen percent saturation respiration
eutrophication photosynthesis

What is dissolved oxygen?

Did you ever wonder how the bugs and fish in the water breath? We may look at the bubbles of oxygen in the water and think we have our answer. But the oxygen that makes aquatic life possible does not form bubbles, nor is it the oxygen that is part of the H_2O water molecule. It is a separate O_2 molecule that is **dissolved** in the water and invisible to our eyes.

The oxygen concentration of most healthy streams is between 6 and 12 oxygen molecules per one million water molecules. By comparison, the atmosphere maintains a ratio of about one oxygen molecule out of five!

How does it get in the water?

Oxygen dissolves in water in two ways.
1) Atmospheric oxygen mixes into the stream in areas of turbulence, such as **riffles**.
2) Aquatic plants release oxygen into the water during **photosynthesis**.

What natural influences cause dissolved oxygen concentrations to change?

Elevation

The amount of oxygen in the atmosphere drops as elevation increases. Since streams get much of their oxygen from the atmosphere, they too, will have less oxygen at higher elevations.

Temperature

The maximum amount of oxygen that can be dissolved in water is called its saturation concentration. The saturation concentration decreases as water temperature increases. The following chart (Figure IV-7) shows the relationship between water temperature and dissolved oxygen concentrations at sea level. At higher elevations, the entire line would be shifted down (less oxygen can dissolve at higher elevations).

The dissolved oxygen concentration for your stream will vary throughout the year as temperatures rise and fall. As ponds and standing water heat up and cool down on a daily basis, dissolved oxygen concentrations may also change throughout the day.

Open a can of *warm* soda - what happens? You probably end up with a face full of foam, and the soda tastes flat. What happens when you open a *cold* soda? Your face stays dry and the soda tastes carbonated. The carbonation, or bubbles, in the soda comes from gas dissolved in the liquid. Cold soda holds more gas than warm soda – just like your stream.

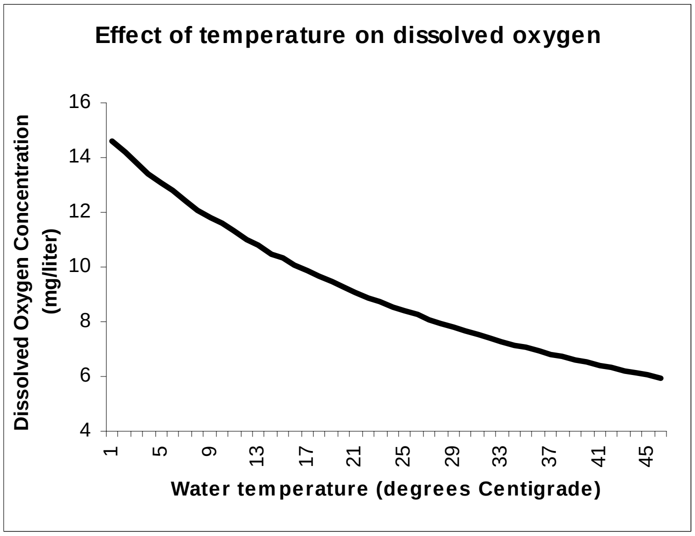


Figure IV-7. The effect of temperature on dissolved oxygen – note that warmer water can hold less oxygen

Saltiness

Salty water holds less oxygen than fresh water. However, the water must be very salty – as salty as ocean water – for the oxygen level to be affected. Do you think the Great Salt Lake can hold as much dissolved oxygen as a clear mountain stream?

Turbulence

We already know that one way for oxygen to enter a stream is through the mixing of air and water in turbulent areas. If your stream has rapids or riffles, how do you think the dissolved oxygen concentration will be affected? If you said that it increases it, you're right.

More mixing creates more opportunity for oxygen to enter the stream. In fact, if your stream is very turbulent, it may become *supersaturated* – the dissolved oxygen concentration rises above the saturation level.

In contrast, the deep portion of lakes or reservoirs may be so isolated from the atmosphere that the oxygen concentration drops to zero. Lakes that freeze over in the winter are also isolated from the atmosphere and may lose all their oxygen. Do you think aquatic life must adapt differently to a turbulent stream than a deep lake bottom?

Aquatic Life

Animals living in water use oxygen just as you and I do. Bacteria also use oxygen when they decompose material. This is why we see dissolved oxygen levels drop in a water body that contains a lot of dead, decomposing material.

Vegetation

Aquatic plants release oxygen as part of the photosynthetic process. As photosynthesis speeds up and slows down with daily changes in sunlight, the amount of oxygen in the water changes, too. Plants also use oxygen during **respiration**. Streams with a lot of aquatic vegetation see wide daily fluctuations in dissolved oxygen levels.

Riparian vegetation along the banks of a stream affects dissolved oxygen concentrations indirectly. By shading the stream, vegetation maintains lower temperatures, allowing the water to hold more oxygen.

What time of day would you expect to find low DO levels in your stream? Photosynthesis cannot occur without sunlight. When the sun goes down, and photosynthesis stops, plants quit producing oxygen. The plants and animals in the water, however, continue to use oxygen all night long. Because of this, oxygen levels in your stream drop through the night and reach their lowest point just before the sun rises.

What human influences cause dissolved oxygen concentrations to change?

Introduction of organic waste

Microorganisms, such as bacteria, decompose organic waste. Organic waste is anything that was once part of a plant or animal, such as leaves and manure. Microorganisms use up oxygen in the decomposition process. If there is a lot of organic waste in the stream, then the microorganisms multiply and use more oxygen than can be replaced in the stream.

Organic wastes may come from a variety of sources:

- untreated sewage
- runoff from dairies, feedlots and other agricultural operations
- lawn clippings, top soil and other materials from around our homes

Land uses

Land uses throughout the watershed can increase the temperature of streams and introduce excess organic material. Both impacts result in lower-than-normal DO concentrations.

Land use impacts include:

- Destruction of riparian areas from development or overgrazing. Loss of riparian vegetation decreases shading and increases water temperature.
- Land clearing activities such as construction or logging may send excess amounts of organic material into streams.

Why do we care about dissolved oxygen?

Animals

All aquatic (and terrestrial) animals need oxygen.

- A change in oxygen concentration may affect the composition of aquatic communities. Many macroinvertebrate species depend on oxygen-rich water. Without sufficient oxygen they may disappear, disrupting the food chain.
- Many fish require a specific range of oxygen concentrations. “Warmwater” fish, such as carp and bass, can usually live with lower oxygen concentrations than “coldwater” fish, such as trout. See Table IV-4.

How do some aquatic animals survive without much oxygen?
Some of them use *hemoglobin*.
The job of hemoglobin, besides turning your blood red, is to carry oxygen. Animals with a lot of hemoglobin can use more of the oxygen that is in the water around them – a handy trick if you’re living at the bottom of a lake. You might find some of these critters in your sample. Look for red-colored **macroinvertebrates**, such as fly larvae and Daphnia (water fleas).

Minimum Oxygen Concentrations Required for Common Fish		
	Minimum Summer Concentration (mg/liter)	Minimum Winter Concentration (mg/liter)
Pike	6.0	3.1
Black Bass	5.5	4.7
Black Crappie	5.5	1.5
Yellow Perch	4.2	4.7
Sunfish	4.2	1.4
Black Bullhead	3.3	1.1

Table IV-4. Minimum oxygen requirements for common fish

Chemicals

Oxygen concentration affects the behavior of other chemicals in the water.

- In the presence of oxygen some metals such such as cadmium solidify and sink out of the water. Without oxygen, these solids may dissolve again into the water. The dissolved forms of many of these metals are poisonous to animals.
- Nutrients change with oxygen as well. Nitrogen forms shift, and phosphorus will solidify and sink in oxygen-rich waters. Without oxygen, the phosphorus dissolves back into the water, and may overfertilize the lake.

How do we sample DO?

During this test stream water is mixed with chemicals in a small ampoule, which then change color depending on the amount of oxygen present in the water. The darker blue, the more oxygen in the sample. The entire test takes about 5 minutes.

The concentrations may change after the water sample is collected, so measure the dissolved oxygen immediately after the water sample is taken.

> The dissolved oxygen concentration may not be the same in all parts of your stream. Deep, still waters often have more dissolved oxygen near their surface than at the bottom. Note the location of your sample (e.g. riffle, top of pooled-up area) to help you interpret your results.

How do we interpret our results?

Do you meet the Utah State criteria?

The State of Utah has set minimum dissolved oxygen concentrations to protect fish and other aquatic animals. These minimum concentrations vary according to the natural temperature of the stream. Check with the Utah Division of Water Quality (contact information in the "Resources" Appendix) to determine if your stream is a "coldwater fishery" or "warmwater fishery."

> The minimum concentration for:
> Streams which Utah protects for coldwater fish: 6.5 mg/liter
> Streams which Utah protects for warmwater fish: 5.5 mg/liter
> NOTE: Values are for a 30-day average, to account for daily and weekly fluctuations.

Resources for further investigation

Streamkeepers Field Guide: Watershed Inventory and Stream Monitoring Methods by Tom Murdoch, Martha Cheo, and Kate O'Laughlin (2nd Edition). Section on understanding watersheds, conducting field inventories, water quality monitoring programs, keys to plant and animal life, methods of analyzing and presenting your data and how to effect changes in attitude and policy. The manual is adaptable for use by students ages 12-adult. The companion video also available. Contact: The Adopt-A-Stream Foundation at the Northwest Stream Center, 600-128th Street SE Everett, WA 98208-6353 (425)316-8592; Fax: 425-3381423; Email: aasf@streamkeeper.org; www.streamkeepers.org

"The Volunteer Monitor: The National Newsletter of Volunteer Water Quality Monitoring." This bi-annual EPA publication addresses all aspects of water quality monitoring, including those specific to school and youth groups. The Spring 1997 edition (vol. 9, no. 1) addresses DO and DO sampling. Back issues are available on the internet. Contact: www.epa.gov/volunteer/spring97

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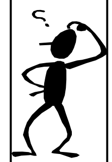
Dissolved Oxygen

- **This test detects dissolved oxygen concentrations of 0 to 12 mg/L (ppm)**

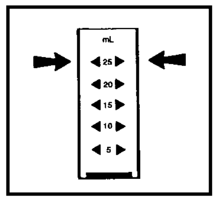
- Collecting and handling of the water should be done with as little shaking as possible. Shaking may cause oxygen from the air to dissolve into the water sample and produce a inaccurate measurement.

Time - 3 minutes
Persons - 1
Materials -
- CHEMets DO Sampling Kits

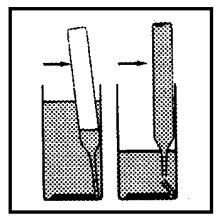
Sunlight can damage the ampoules in your DO kit. Keep them shaded at all times.



Step 1
1. Pre-rinse collection bottle with stream water.
2. Fill the sample cup to the 25 mL mark with your sample.



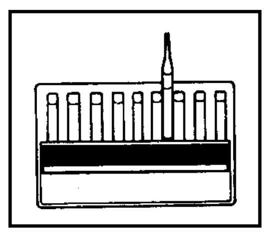
Step 2
1. Place the CHEMet ampoule in the sample cup.
2. Snap the tip by pressing the ampoule against the side of the cup.
3. The ampoule will fill, leaving a small bubble that will help you mix the contents of the ampoule.



Step 3
1. Mix the contents of the ampoule by turning it up and down several times, allowing the bubble to travel from end to end each time.
2. Wipe all liquid from the outside of the ampoule.

Step 4
1. Wait **2 minutes** for color development.

Step 5
1. With the sun (or another light source) shining on the comporator – rack of colored tubes – from directly above, place the dissolved oxygen ampoule between the color standards for viewing. It is important that the ampoule be compared by placing it on both sides of the color standard tube before deciding that it is darker, lighter or equal to the color standard.
2. Record the concentration of the best color match.



In Utah:
The minimum concentration for coldwater fish is 6.5 mg/L
The minimum concentration for warmwater fish is 5.5 mg/L.

IV-3c. Nutrients

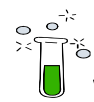
This section describes how to measure the concentrations of several **nutrients** in your stream – nitrogen (nitrate and ammonia) and phosphorus (phosphate). Nutrients are chemicals that are essential for plant growth. We add nutrients when we fertilize our gardens and fields. In the same way, adding nutrients to water fertilizes water-dwelling plants.

Unlike some of the common chemicals in water, such as calcium or sodium, nutrients usually occur at very low concentrations relative to plant demands. Nutrient concentrations may change dramatically throughout the year as growing plants remove them from the water and dying plants release them back into the water.

Nutrient Limitation

Typically, plants in water will continue to grow until something they need (sunlight, carbon dioxide or oxygen, nutrients) runs out. Adding more of this limiting factor to the water test tube will often stimulate more plant growth.

In most streams and lakes, phosphorus or nitrogen limits plant growth. Adding more of the limiting nutrient, in fact, can stimulate too much plant growth, which starts a chain of events that may eventually deplete oxygen from the water and kill fish and other aquatic animals. For this reason, nutrients are considered a leading cause of water quality impairment in Utah.



What limits plantgrowth?

Collect some water from a local pond or lake. Pour the water into two clear jars and place in a lighted area (such as a window sill). Add a few grains of house plant fertilizer to one jar. After a week, compare the color of the two jars. Is the "fertilized" jar greener? Was your water body nutrient limited?

What is a plant?

Not all plants in water are visible. Tiny microscopic plants, called algae, may float freely in lakes, reservoirs or big rivers. Although you cannot see these individual plants with you eyes, they can become so abundant that the water turns green. Other types of microscopic algae form slimy coverings on rocks in streams.

Larger plants also grow in water. These attach to the stream or lake bottom and look similar to plants on land, with a stem and leaves.

Nitrogen (nitrate, ammonia)

Key terms		
ammonia	nitrite	toxicity
detritus	nitrogen	
nitrate	nitrogen fixation	

What is nitrogen?

Nitrogen is used in building proteins and is an essential nutrient for plant and animal growth. In fact, 5 percent of the dry weight of living cells is composed of nitrogen! Nitrogen is found in a variety of forms throughout our environment and changes forms readily. The nitrogen cycle on the next page demonstrates how many different paths nitrogen may follow around our earth.

To simplify things, we can combine all of these forms of nitrogen into two groups: organic and inorganic.

Organic nitrogen

Organic forms of nitrogen include all the nitrogen that is part of living plants or animals, animal waste, and the remains of living things, such as dead leaves. Nitrogen that is bound up in organic forms cannot be used by plants but must first be broken down to simpler, inorganic forms.

Inorganic nitrogen

Inorganic forms of nitrogen can be taken up directly by plants and bacteria, or are easily changed to a form that is usable. We measure several forms of inorganic nitrogen when we test for water quality, because of the impacts resulting from the fertilization of water plants.

Nitrogen gas (N_2) Most of the inorganic nitrogen on earth exists in the form of **nitrogen gas (N_2)**, which comprises 79 percent of our atmosphere. Some simple forms of one-celled plants can also use nitrogen gas for their needs in a process called **nitrogen fixation**.

Nitrate (NO_3) Nitrate is the most common form of inorganic nitrogen in unpolluted waters. It can be used directly by aquatic plants, so nitrate concentrations in natural surface waters may change considerably throughout a year. Because nitrate is so soluble, it moves readily into groundwater, where concentrations can be much higher than in surface waters.

Ammonia (NH_3) Ammonia is formed when organic nitrogen is broken down by bacteria. Plants prefer to use ammonia over nitrate, but it is typically less abundant in natural waters. It is found at high concentrations only when dissolved oxygen concentrations are very low or when the water is polluted.

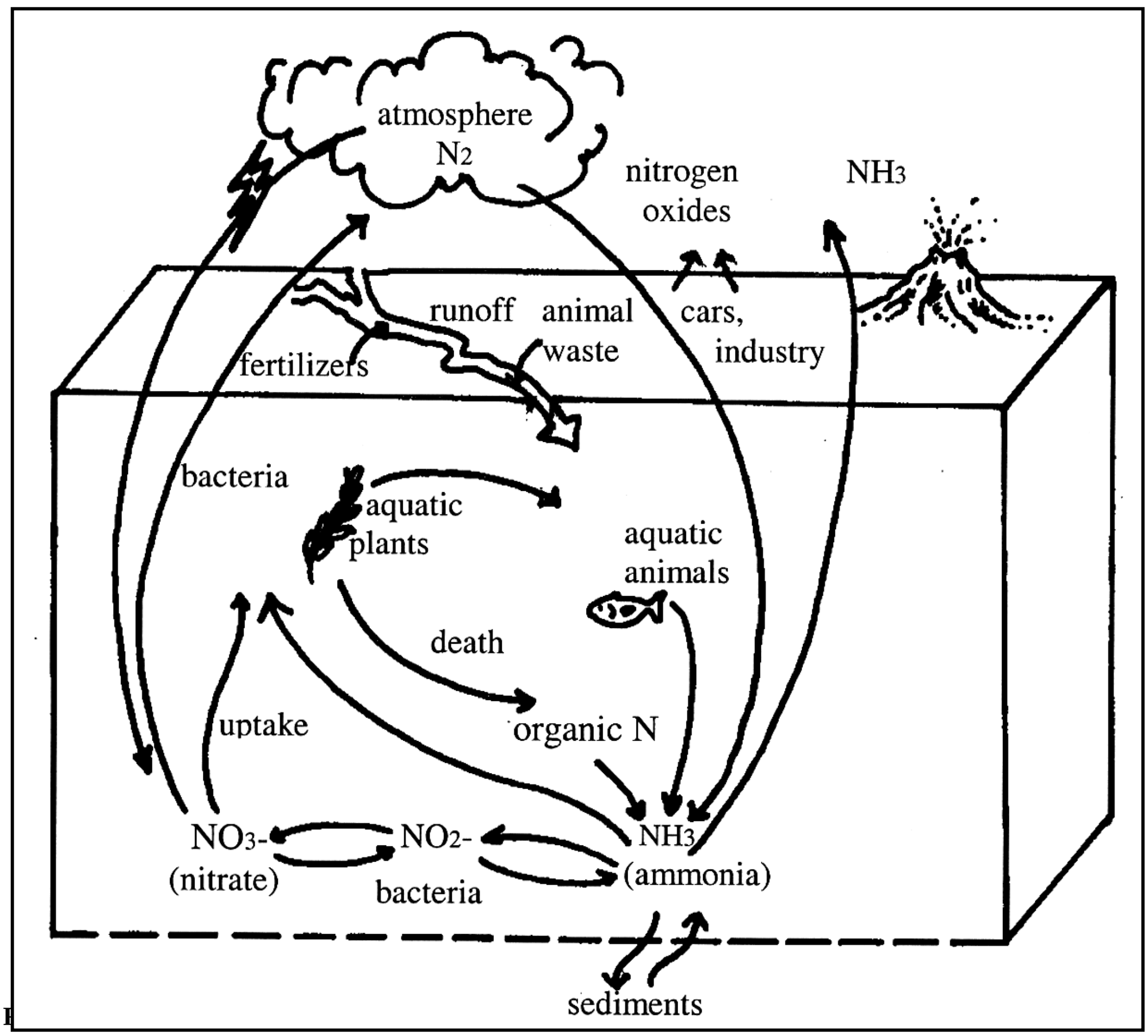
Nitrite (NO_2) Bacteria turn ammonia into nitrite but usually transform it again to nitrate very rapidly. Because of this, nitrite is not usually found at measurable concentrations. If nitrite is present at concentrations above 0.02 mg/liter, it usually indicates polluted waters.

Blue-green algae can use nitrogen gas directly for their nitrogen needs. We say they "fix" nitrogen and convert it to an organic form. While this is a handy trick if there's no other nitrogen in the water, it requires a lot of energy that the algae could use in other ways.

What is the Nitrogen Cycle?

The **nitrogen cycle** (Figure IV-8) shows the many ways nitrogen moves around our earth. Bacteria play a big role in breaking down organic nitrogen into inorganic forms, and in transforming one type of inorganic nitrogen into another. Plants use the inorganic nitrogen in soil and water and transform it into organic forms. It is then passed on to animals when the plants are eaten. **Detritus** (dead and decaying plant and animal material) becomes part of soils or lake and ocean sediments. Nitrogen from the land returns to streams and lakes in surface runoff.

Nitrogen gas is the most abundant gas in our atmosphere. It can be used by some simple plants, but also may be changed to nitrate by lightening! Although ammonia is usually dissolved in water, it may also enter the atmosphere as a gas. Other types of nitrogen gases are created by automobile engines. These may dissolve in rainwater and produce acid rain.



F

water to living organisms.

What natural influences cause nitrogen concentrations in your stream to change?

Seasonal changes

Concentrations of nitrogen change naturally in streams throughout the season. In Utah, concentrations are often highest during the spring when snow melts, because runoff from the land brings nutrients from lawns, farms, and other areas.

In fall and winter, the main source of water in many streams in Utah is groundwater, which often has naturally high concentrations of nitrate.

Plant uptake

Concentrations of nitrate and ammonia may be very low during periods of rapid aquatic plant growth, because the plants are taking as much as is available. During fall and winter, when plants quit growing and die, much of this nitrogen is released back into the water and concentrations generally increase.

What human influences cause nitrogen concentrations in your stream to change?

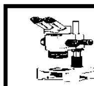
Land uses in your watershed

Inorganic nitrogen is extremely soluble. This means that it is easily carried in surface water and also travels easily through soils and groundwater. This allows human introductions of nitrogen to have wide-ranging effects.

Common human-influenced sources of inorganic nitrogen include:

- fertilizers, animal manure
- malfunctioning septic systems
- discharge from sewage facilities and acid precipitation.

Some of these sources also introduce organic nitrogen to our waters, which are eventually transformed into ammonia and nitrate.



We usually don't think of acid rain as a source of nitrogen to our watersheds. This can happen, however, when nitric acid is formed as a by-product of the combustion in cars and other engines. Nitric acid falls to the ground as rain and snow. In some areas this is becoming a significant source of nitrogen in streams.

Why do we care about nitrogen?

Excessive plant growth

When we over-fertilize our waters with nitrogen, we can cause heavy plant growth. Sometimes these plants grow on stream and river bottoms. More often, the problem occurs in the lakes and reservoirs that the streams enter. Too much nitrogen can cause floating scum or “blooms” of microscopic algae in lakes and reservoirs.

Over fertilization of water can cause various problems:

- Excessive plant growth can decrease the aesthetic value of water bodies by making the water cloudy or causing unsightly and smelly mats of decaying plants on the shore.
- When plants die in the water, bacteria go to work decomposing the dead material. This uses oxygen. If there is too much plant material in the water, the bacteria multiply and use up all the oxygen.

- In extremely high concentrations, some simple bacteria called blue green algae form neurotoxins that can kill actually kill animals drinking from the water.

Health concerns

Some forms of inorganic nitrogen are poisonous to humans or to aquatic organisms.

- Concentrations of nitrate in drinking water greater than 10 mg/liter can be harmful to young babies.
- Nitrite can be toxic to fish, such as rainbow trout, at concentrations of about 4 mg/liter.
- Ammonia may be toxic to fish and aquatic invertebrates at very low concentrations. Ammonia can affect fish at very low concentrations, especially when the water is somewhat basic (high pH) and at temperatures above 20 degrees C.

What does toxic mean?
Scientists need to identify the concentration of pollutants that will harm animals that live in our streams and lakes. Laboratory experiments called "toxicity tests" are often the way we determine these concentrations. These experiments expose fish to different concentrations of a pollutant and determine what effect the pollutants have.

Pollutant concentrations that cause fish to die within a few hours are called "short term toxicity concentrations." Sometimes, the fish survive but just don't grow or reproduce. The concentrations that produce these results are called "long term toxicity concentrations."

How do we sample nitrate and ammonia?

Both nitrate and ammonia tests are color tests, where the amount of color change is proportional to the amount of pollutant being measured.

If you wish, you can collect water samples and save them for up to two days before actually conducting the tests. If you do this, keep the water in sealed plastic jars in a dark cool place (a cooler with ice or a refrigerator).

Step-by-step directions are found at the end of this section.

STOP Both these tests use very small quantities of poisonous chemicals. Be careful that students never use their mouths to open reagent packets, and that they use plastic gloves or wash their hands well after running the test.

How do we interpret our results?

Nitrate

- Usually nitrate concentrations in natural streams and rivers are less than 2 to 3 mg/liter.
- If the stream or river is used as a source of drinking water, Utah has set a standard of 10 mg/liter.
- For waters used for other purposes, such as fisheries, recreation, or irrigation, the state lists a "pollution indicator" concentration. This is not an enforceable standard, but is a benchmark the state uses to indicate possible water quality problems. When these concentrations are found, the state conducts additional studies to find the source.

In Utah:

The maximum concentration of nitrate allowed in drinking water is 10 mg/liter.

The State of Utah considers nitrate concentrations of 4 mg/liter to be an indicator of pollution problems.

Ammonia

The toxicity of ammonia to fish and other aquatic life is affected by the pH of the water, by the temperature of the water, and by how long the fish are exposed to the ammonia in the water.

pH effects

The common form of the ammonia molecule has one nitrogen and three hydrogen atoms (NH_3). This form is toxic to fish at very low concentrations. In somewhat acidic water, however, a fourth hydrogen atom attaches to ammonia, creating the ammonium ion (NH_4^+). Ammonium is much less toxic to fish. Therefore, we need to know the pH of water to know how toxic the ammonia concentration really is.

Temperature effects

At temperatures above room temperature (about 20 degrees C), both forms of ammonia become more toxic to fish.

Exposure times

Most fish can handle higher concentrations of ammonia for short periods of time (hours or less) than over longer periods of days and weeks.

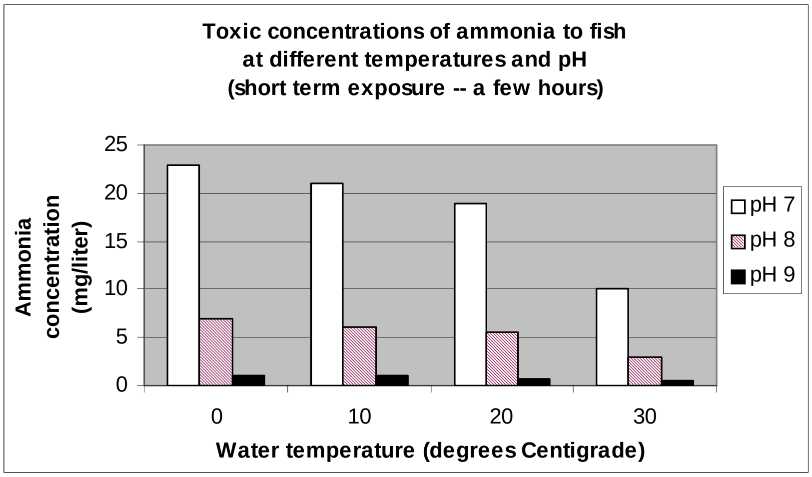


Figure IV-9

Figure IV-9 The effect of temperature and pH on ammonia toxicity to fish (short term exposure, just a few hours).

- Notice how ammonia becomes much more toxic as the water's pH increases from 7 to 9. For example, at water temperatures of 10 degrees C, the toxic concentration at pH 7 is 21 mg/liter, but at pH 9, the toxic concentration is 1 mg/liter.

- A change from pH 7 to pH 9 could occur within a single day in some streams.

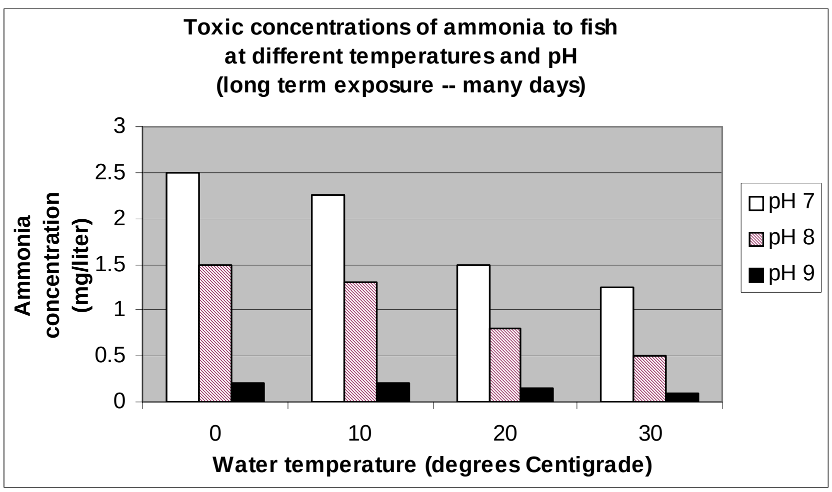


Figure IV-10

Figure IV-10 The effect of temperature and pH on ammonia toxicity fish (long term exposure, many days).

- Compare this graph with the one above. Notice that at the same pH and temperature, much lower concentrations affect fish exposed for long periods of time.

- Notice how the toxic concentration of ammonia degrees as the temperature increases. For example, at a pH of 7, the toxic concentration is 2.5 mg/liter at 0 degrees C, but at 30 degrees C the toxic concentration is 1.2 mg/liter. Luckily, temperatures this high are not often found in natural streams.

Resources for further investigation

"The Volunteer Monitor: The National Newsletter of Volunteer Water Quality Monitoring." This bi-annual EPA publication addresses all aspects of water quality monitoring, including those specific to school and youth groups. You'll find plenty of useful information on nitrogen and nitrogen sampling. Back issues are available on the internet. www.epa.gov/volunteer/spring97

Water Pollution - This web site covers most major water pollution concepts in detail. You'll find an entire section on nitrogen and how to measure it. Information is presented at a middle- to high school level. http://www.geocities.com/RainForest/5161/lab3.htm

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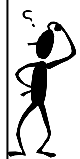
Nitrate

- **This test detects Nitrate at concentrations of 0.1 to 5 mg/L (ppm)**
- **The range for this test is 0 to 5 mg/L (ppm)**

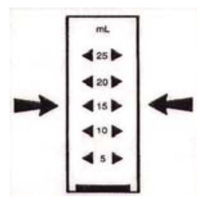
Time – 15 minutes
Persons - 1
Materials -
- CHEMets Nitrate Sampling Kits

Sunlight can damage the ampoules in your Nitrogen kit. Keep them shaded at all times.



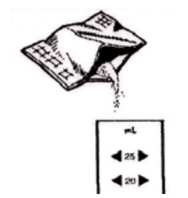
Step 1

1. Pre-rinse collection bottle with stream water.
2. Fill the sample cup to the 15 mL mark with your sample.



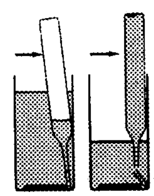
Step 2

1. Empty the contents of one Cadmium Foil Packet into the sample cup. Use caution when handling the Cadmium Packet. Tear it carefully or open with scissors. Do NOT use teeth.
2. Cap the sample cup and shake it vigorously for exactly **3 minutes**.
3. Allow the sample to sit undisturbed for **30 seconds**.



Step 3

1. Place the ampoule in the sample cup.
2. Snap the tip by pressing the ampoule against the side of the cup. The ampoule will fill leaving a small bubble to help mixing.



Step 4

1. Mix the contents of the ampoule by turning it up and down several times, allowing the bubble to travel from end to end each time.
2. Wipe all liquid from the outside of the ampoule.

Step 5

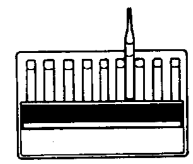
1. Wait **10 minutes** for color development.

Step 6

1. Use the appropriate comparator to determine the level of nitrate-nitrogen in the sample. For low range, use the tube comparator. For high range use the rack comparator.

   a. Tube Comparator – Place the ampoule, flat end down into the center tube of the low range comparator. Direct the top comparator

up to the sun or another bright light source while viewing from the bottom. Rotate the comparator until the color standard below the ampoule shows the closest match.



b. Rack Comparator – Hold the rack horizontal while standing underneath a bright light source. Place the ampoule between the color standards moving it from right to left along the comparator rack until the best color match is found.

Step 7

1. Record the number of the best match on the comparator on your Chemical Properties Field Data Sheet. This is your nitrate-nitrogen concentration in mg/liter (ppm).

In Utah:

The maximum concentration of nitrate allowed in drinking water is 10 mg/liter.

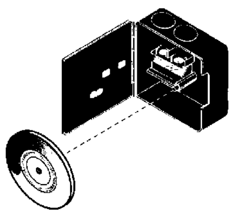
The State of Utah considers nitrate concentrations of 4 mg/liter to be an indicator of pollution problems.

Ammonia

NOTE: These directions are for concentrations less than 3 mg/liter. More detailed instructions can be found in the kit

Time – 5 minutes
Persons - 1
Materials
- Hach ammonia sampling kit

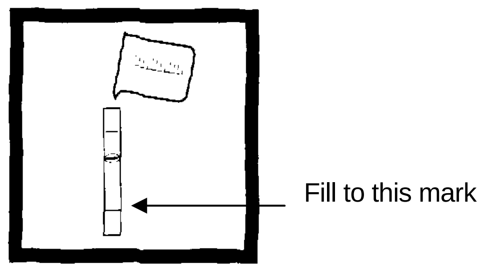
Detection limit = 0.10 mg/liter



Step 1 - assemble color viewer

Add color wheel to color comparator.

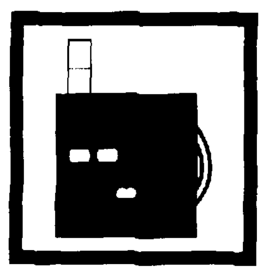
Step 2 – place blank in viewer



1. Pre-rinse two tubes with sample water

2. Fill one tube to the 5 ml mark with sample water

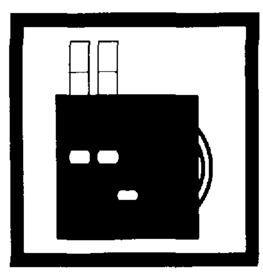
3. Place the tube in the top, left opening of the viewer. This will be your blank to control for natural water color or turbidity.



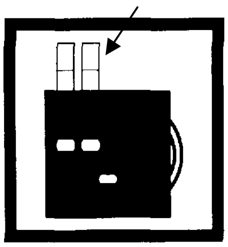
Step 3 – prepare the sample

1. Add three drops of Nessler Reagent to one tube
2. Swirl to mix.

NOTE: Wait at least 1 minute but not more than 5 minutes before proceeding to Step 4

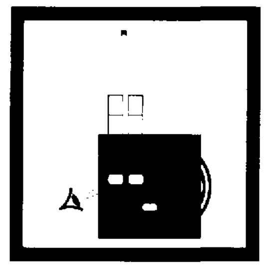


Step 4 - read concentration



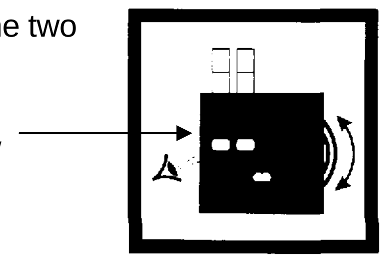
1. Place the tube with the reagent in the top
right opening of the viewer.

2. Hold the viewer so that your light source (sun, lamp) is behind the viewing window.



3. Rotate the color disc until the color matches in the two openings. Read the number in the scale window.

Scale window



Step 5 – Record your results

The number in the scale window is the ammonia-nitrogen concentration (mg/liter NH3-N) of your sample. Record this on your Chemical Properties Field Data Sheet.

In Utah:
The maximum allowable concentration of a ammonia depends on the pH and temperature of the water.

ease refer to the Utah Stream Team manual for more information.

Phosphorus

Key Terms
decomposition | particulate phosphorus | total phosphorus
orthophosphate | phosphorus

What is phosphorus?

Phosphorus is an important plant nutrient. Phosphorus occurs in many different forms in the environment, much like nitrogen. Unlike nitrogen, however, phosphorus cycles through the environment more slowly. Most of the phosphorus is found in rocks and minerals. We can divide the phosphorus in the environment into two major groups:

- organic and inorganic
- particulate and dissolved

Organic phosphorus includes all the phosphorus found in living plants or animals, their dead remains and their waste. **Dissolved** (soluble) forms of organic phosphorus are often organic molecules released when plants and animals decay. These molecules must be broken down by microorganisms before they can be used again by plants.

Inorganic phosphorus includes several forms. Most of the phosphorus on Earth is found in minerals, rocks and soil. The soluble form of inorganic phosphorus, called **orthophosphate** (PO_4^{-3}), is the form that we will sample. Plants can use this molecule easily, but it is often very scarce in waters. For this reason, phosphorus often limits plant growth in streams and lakes.

One reason orthophosphate is scarce is that it easily attaches to tiny sediment particles and then settles out of the water. This is why orthophosphate does not move quickly through soils and into groundwater (like nitrate).

> Phosphorus is common in minerals found throughout Utah and surrounding areas. In fact, deposits of phosphorus are mined in nearby Wyoming and Idaho. This mineral form of phosphorus enters streams mainly through erosion. Phosphorus contained in rocks and sediments cannot be immediately used by aquatic plants. It may take many years for the dissolved orthophosphate molecule (the form plants can use) to develop.

What natural influences cause phosphorus concentrations in your stream to change?

Phosphorus concentrations can change dramatically throughout the year. When flows are high, such as during spring runoff or after a big summer storm, sediment concentrations can be quite high in the stream. Since phosphorus attaches to sediment it, too, may be quite concentrated in the water.

How much do plants use?

Concentrations of orthophosphate are usually low throughout the year. During periods of rapid plant growth, plants remove all the orthophosphate they can find. During these times, the concentration might be so low it can't be measured by chemical tests.

During fall and winter, when plants quit growing and die, some of this orthophosphate is released back into the water. However, because orthophosphate tends to attach to little particles of plant and soil materials, the measurable amounts of orthophosphate may be low even during these seasons.

What human influences cause phosphorus concentrations in your stream to change?

Land uses in the watershed

Activities that cause erosion in the watershed may result in particulate organic and inorganic phosphorus entering the stream:

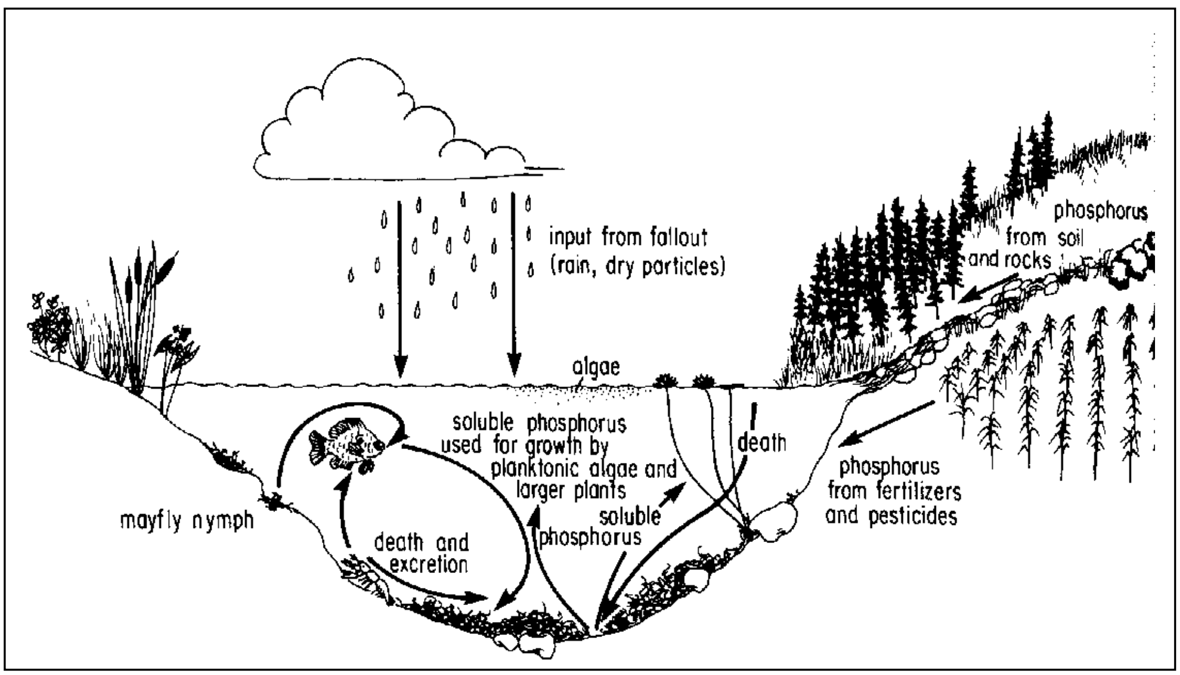
- logging or building activities
- overgrazing in riparian areas
- activities which remove the riparian plants and buffer strips around our streams reduce the ability of these areas to filter out sediments and keep them from entering the streams.

Runoff from the land can also introduce orthophosphate into a stream:

- fertilizers may run off lawns and agricultural fields during snow melt, rainstorms or heavy irrigating;
- poorly functioning septic tanks release phosphorus into groundwater;
- wastewater treatment facilities from our towns often introduce large amounts of dissolved phosphorus into our streams and rivers.

Figure IV-11. The Phosphorus Cycle—note how phosphorus enters the water from land or atmosphere and the cycles between living organisms and decayed material.

Figure IV-11 The Phosphorus Cycle



Why do we care about phosphorus?

Excessive plant growth

Concentrations of orthophosphorus are often very low in our waterbodies. Phosphorus is often the nutrient that limits how much plant growth occurs in a stream, lake or reservoir. Adding a small amount of phosphorus, therefore, may cause excess plant growth.

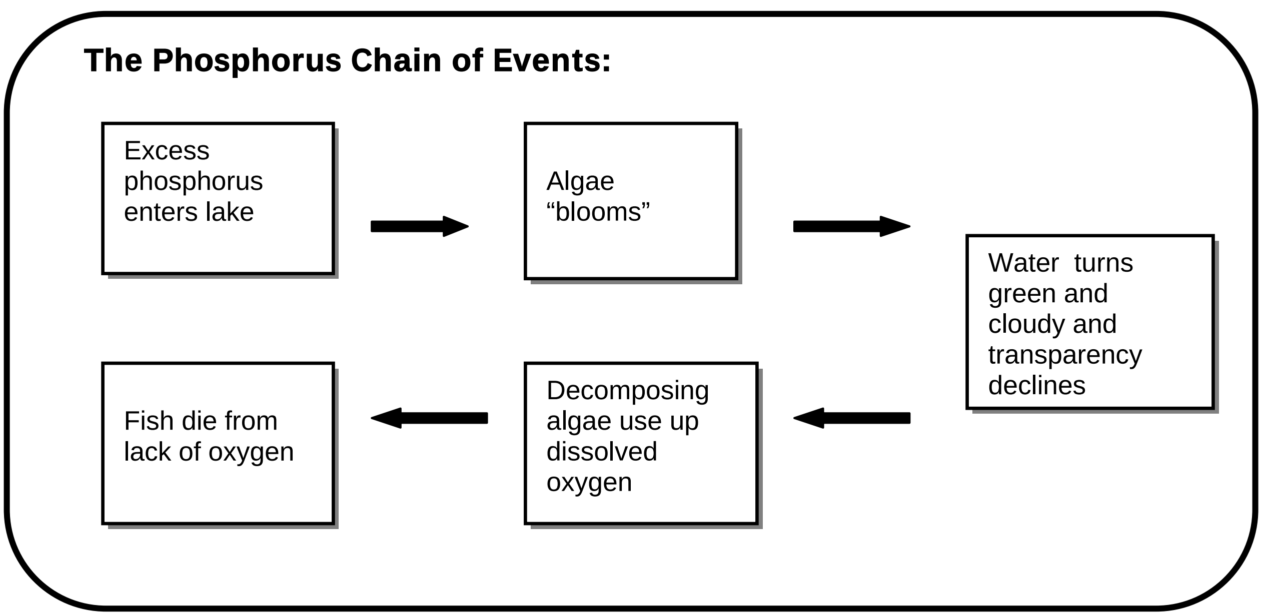
Sometimes these plants are large and grow from the lake bottoms in shallow areas. Sometimes, the plants that grow are microscopic algae.

Heavy plant growth caused by over fertilization of water can cause various problems (Figure IV-12):

- Large attached plants in shallow areas of lakes entangle boaters and swimmers. When the plants die, huge mats of decaying plants create odor and aesthetic problems.
- “Blooms” of algae make the water cloudy and unsightly.
- When the plants in lakes and reservoirs die, more oxygen may be used in the **decomposition** process than can be replaced. During winter, an entire lake may freeze and lose all its dissolved oxygen. If this happens, all the fish and other aquatic life will die.
- Certain types of microscopic algae can be toxic if they reach very high concentrations. Animals, such as dogs or livestock, that drink from these toxic water bodies can become sick or even die.

> We may not realize we have a phosphorus problem until we look at the lakes and reservoirs fed by our streams and rivers. Too much phosphorus can cause huge amounts of plant growth in lakes and reservoirs, while, at the same time, the contributing streams are relatively free of plants.

Figure IV-12. The Indirect Effect of Phosphorus on Fish. This chain of events leads from too much phosphorus in a lab to fish kills from lack of oxygen.



How do we sample phosphorus?

[Step-by-step sampling directions can be found at the end of this section.]
Utah Stream Team field tests measure the orthophosphate in water (the dissolved, inorganic form of phosphorus). This is a color test, where the amount of color change is proportional to the amount of pollutant being measured. The chemicals added to our sample cause the water to change blue if orthophosphate is present. The darker the blue, the more orthophosphate present. A color wheel is used to determine the concentration in the water.

If you wish, you can collect water samples and save them for up to two days before actually conducting the tests. If you do this, keep the water in sealed plastic jars in a dark cool place (a cooler with ice or a refrigerator).

How do we interpret our results?

Phosphorus is considered a pollution indicator. It is not toxic, and its negative impacts come from the series of events that result from over-fertilizing a water body.

> The State of Utah considers a total phosphorus concentration of 0.05 mg/liter in a stream or river to be an indicator of pollution problems. A concentration of 0.025 mg/liter in lakes is considered a potential problem.

How much is 0.050 mg/liter? It is equivalent to 50 phosphorus atoms for every *billion* water molecules! Because orthophosphate is usually a very small percentage of the total phosphorus, the concentrations of actual plant fertilizer in water are even lower.

Resources for further investigation

Environmental Protection Agency's Volunteer Stream Monitoring: A Methods Manual - This 210-page manual takes the reader through an introduction to streams and watersheds then proceeds to offer in-depth, step-by-step approaches to monitoring a variety of water quality components. You will find helpful background information on stream temperature. For a free copy of the manual, contact Alice Mayio at USEPA (4503F), 401 M St. SW, Washington, DC 20460; 202/260-7018; mayio.alice@epamail.epa.gov. Also available on the web: www.epa.gov/owow/monitoring/vol.html.

Kentucky Water Watch – This Kentucky Water Watch web site, administered by the State of Kentucky Natural Resource and Environmental Protection Cabinet, offers background information on all major water quality parameters, including phosphorus. You'll also find lots of other useful information to support classroom and field monitoring.
www.state.ky.us/nrepc/water/wwhomepg.htm

Water Conservation and Nonpoint Source Pollution – This activity book features hands-on, minds-on activities for younger ages. Several activities specifically address temperature concepts (in both indoor and outdoor settings). Contact: Your local County Cooperative Extension Service – or – Utah State University Extension, 1500 N 800 E, ASTE Dept, Utah State University, Logan, UT 84322-2300, (435) 797-3389. extension.usu.edu/natres/wq/

Phosphorus (phosphate)

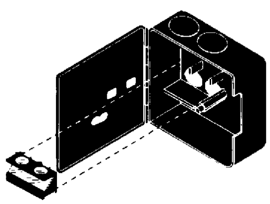
NOTE: These directions are for concentrations less than 0.3 mg/liter PO_4 - P. More detailed instructions can be found in the kit.

Detection limit = 0.01 mg / liter

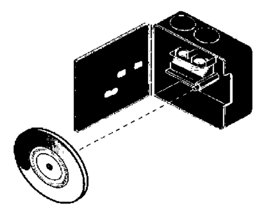
Time – 5 minutes
Persons – 1
Materials
- Hach phosphorus sampling kit

Step 1 - assemble color viewer

1. Add Long Path Viewing Adaptor.



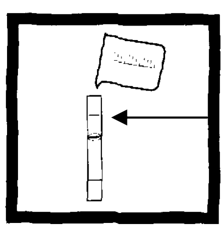
2. Add color wheel.



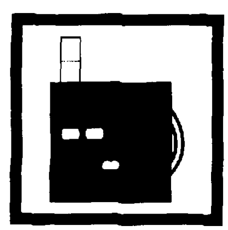
Step 2 - pour the blank

1. Pre-rinse 1 test tube with stream water and fill to top mark with sample water.

2. Place this tube in the left top opening of the viewer. This is your blank.



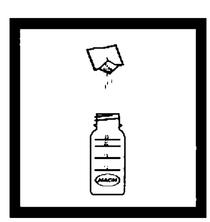
Fill to this mark



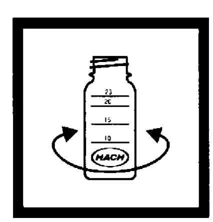
Step 3 – develop color

1. Fill square bottle to the 20 ml mark with stream water.

2. Add contents of Phosphorus Reagent packet into bottle.



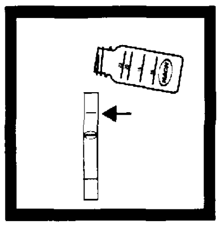
3. Swirl until the powder is dissolved.



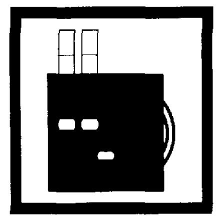
NOTE: Wait at least 8 minutes but not more than 10 minutes before proceeding to Step 4.

Step 4 - read the color (concentration)

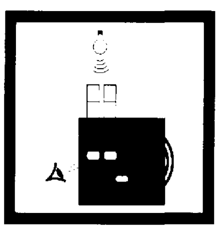
1. Fill 2nd tube to the top mark with prepared sample from Step 3.



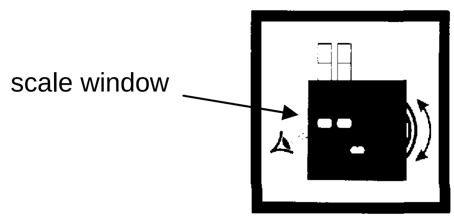
2. Place in top right opening of viewer.



3. Hold the viewer so that the top of the tube points toward a light source.



4. Rotate the color disc until the color matches in the two openings. Read the # in the scale window.



Step 5 – Calculate and record your results

Divide the number in the scale window by 150.

This is the phosphate-phosphorus concentration (mg / liter of (PO_4^{3-} -P) .

> The State of Utah considers a total phosphorus concentration of 0.05 mg/liter in a stream or river to be an indicator of pollution problems. A concentration of 0.025 mg/liter in lakes is considered a potential problem.

IV-3d. Turbidity

Key terms

nephelometric turbity units (NTUs)
turbidity
Secchi disk
turbidity tube
suspended solids

What is turbidity?

If you've ever visited the Colorado River you were probably able to see only about 30 centimeters (~1 ft) beneath the water's surface. On the other hand, if you visit some lakes in Alaska, you will see 30 meters (100 ft) below the surface! The amount of material suspended in the water – soil (sediment), microorganisms, pollution – affects how deeply light can penetrate. We call this material **suspended solids**. The Colorado River has more suspended solids in it than the Alaskan lakes and so light cannot penetrate as deeply. The degree to which light penetration is blocked by suspended solids is called **turbidity.**

Turbidity tells us how much material is suspended in the water. Common types of suspended solids include small pieces of soil, plant material, industrial waste, and microorganisms. Any natural or artificial process that places suspended matter in water causes turbidity.

What natural influences cause the turbidity of our stream to change?

- The types of material that form the stream channel affect the turbidity of the water. For example, if a stream channel runs through hard basalt bedrock, less erosion will occur than if the channel is composed mainly of loose soil.

- Smaller streams carry sediments eroded from the surrounding area, and from their banks and streambeds. Larger rivers, which generally are wider, slower and more exposed to the sun, may contain many microscopic plants, which also increase turbidity.

- Seasonal weather patterns will alter turbidity. Both spring snow melt and rain increase runoff, which generally increases turbidity.

- Plant root systems, both in the riparian zone and throughout the watershed, help keep soil out of the stream which reduces turbidity. Dramatic natural events, such as forest fires, floods or wind storms, may destroy plants, resulting in erosion.

Many large rivers in Southern and Western Utah are naturally very turbid. The loose, sandy soils add a lot of sediment to the stream. What other factors cause our large rivers, such as the Green and San Juan, to be so turbid? Look at the "Natural Influences" section for help with your answer.

What human influences cause the turbidity of our stream to change?

- Bank stabilization helps reduce erosion and turbidity. We can improve bank stability by maintaining healthy riparian vegetation or installing reinforcements such as wire wrap or boulders.

- In pools and slower moving, larger rivers, activities that introduce nutrients (plant food) to a stream will increase microscopic algae production and increase turbidity.

- Any activity that increases erosion in a stream will increase turbidity (e.g. road building, development and overgrazing in riparian zones and dredging or deepening channels).

Why do we care about turbidity?

If a stream's turbidity increases beyond natural levels, it loses its ability to support life that has adapted to those levels.

- Suspended solids prevent sunlight from reaching aquatic plants that grow on the stream bottom. Without light, photosynthesis cannot take place, which may reduce the concentration of dissolved oxygen in the water. Dissolved oxygen is necessary for the survival of fish and other aquatic life.
- Turbidity can raise the surface water temperatures of ponds and lakes because suspended sediment absorbs heat.
- Turbidity makes it difficult for fish to see their prey. Heavy loads of suspended solids can also clog fish gills and filter-feeding devices of aquatic **macroinvertebrates**.
- As solid matter settles, it may cover and harm bottom-dwelling plants and animals and spawning beds. Fish, such as trout, which lay eggs in **redds** are particularly vulnerable to sediments in the stream.
- All streams have a natural level of turbidity. While some forms of aquatic life need clear water to survive, other aquatic species are adapted to and thrive in high turbidity. The Colorado River is very turbid, yet its waters hold abundant life.

How do we sample turbidity?

We measure turbidity of streams with a **turbidity tube**. Fill the tube with stream water, then release the water until you can see the black and white disk at the bottom. The depth in the tube to this point is recorded. The test takes about 5 minutes.

For ponds, wetlands or lakes, a **Secchi disk** is usually used. This black and white disk is lowered into the water until it is no longer visible and that depth is recorded.

How do we interpret our results?

To compare our results with state standards, we need to convert the distance measured with the turbidity tube to standard turbidity units. Because turbidity is usually measured with an instrument called a nephelometer, the turbidity unit is a **NTUs** (Nephelometric Turbidity Units). The higher the turbidity (NTUs) the greater the amount of scattered light, or the cloudier the appearance. Use the conversion chart on the back of the field directions.

Standards for NTUs in Utah (Utah's Standard is for an *increase* in turbidity over natural levels. This increase may apply to one site over time or from one site to another at the same time).

In Utah:

- An *increase* of more than 10 NTUs over natural levels is considered unacceptable for:

  Aesthetics | Warmwater fisheries | Coldwater fisheries
  Drinking water | Non-game aquatic life

- An *increase* of more than 15 NTUs over natural levels is considered unacceptable for:

  Water-oriented wildlife

Check with the Utah Division of Water Quality for an established natural level of turbidity for your water body. If no level has been established, you can create a benchmark and then monitor for increases or decreases over time. Be sure to note natural conditions or events that may affect your measurements at the time of sampling, such as spring melt or recent heavy precipitation.

Resources for further investigation

"The Volunteer Monitor: The National Newsletter of Volunteer Water Quality Monitoring." This bi-annual EPA publication addresses all aspects of water quality monitoring, including those specific to school and youth groups. You'll find plenty of useful information on turbidity and turbidity sampling. Back issues are available on the internet. www.epa.gov/volunteer/spring97

Water Conservation and Nonpoint Source Pollution – This activity book features hands-on, minds-on activities for younger ages. Several activities specifically address temperature concepts (in both indoor and outdoor settings). Contact: Your local County Cooperative Extension Office – or – Utah State University Extension, 1500 N 800 E, ASTE Dept, Utah State University, Logan, UT 84322-2300, (435) 797-3389. extension.usu.edu/natres/wq/index/htm.

Water Pollution - This web site covers most major water pollution concepts in detail. You'll find an entire section on nitrogen and how to measure it. Information is presented at a middle- to high school level. http://www.geocities.com/RainForest/5161/lab3.htm

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Turbidity

Detection limit = 6 NTU

Time – 2 minutes
Persons - 1
Materials –
- Turbidity tube

Step 1 – collect your sample

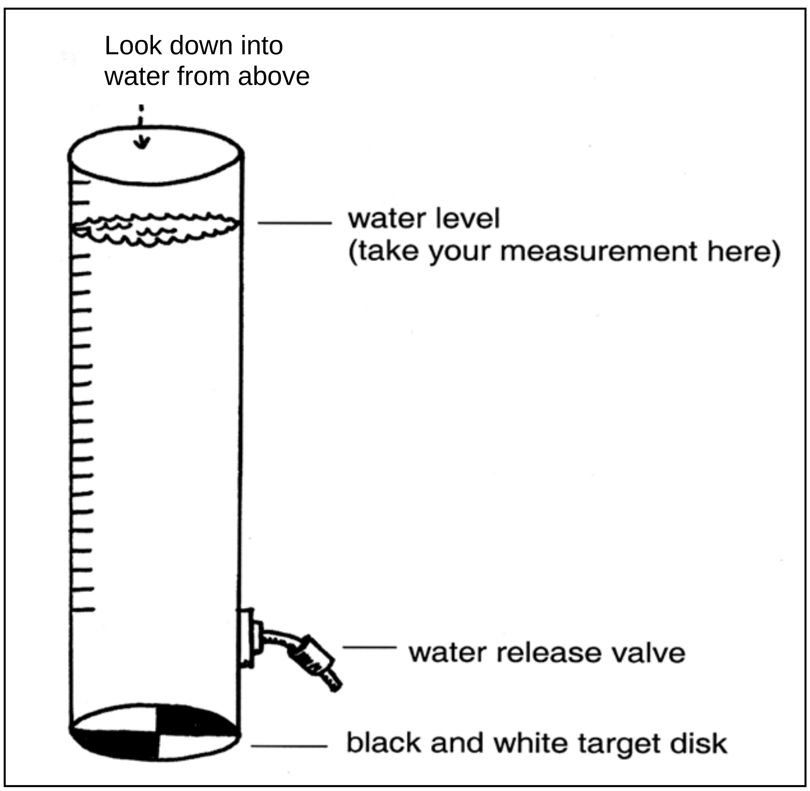
1. Dip the tube into the water at your sampling site and fill to the top. Be careful to sample flowing water and not the stream bottom.

Step 2 – Take your measurement (see figure below for help)

1. Take your filled turbidity tube to a shaded spot. If there is no shade around, use your body to block the sun from shining on the tube.
2. With your hand over the opening, shake the tube vigorously. This will help to re-suspend any sediment that has settled to the bottom.
3. Look down through the tube toward the target disk on the bottom of the tube.
   - If the disk is visible, record the water level in centimeters (cm).
   - If the disk is not visible, slowly release water from the release valve, until the disk becomes visible. Record the water level in centimeters (cm) on the Chemical Data Collection Sheet.

Step 3 – Convert from centimeters (cm) to turbidty units (NTU's)

1. Match your turbidity measurement in centimeters to the corresponding NTUs using the conversion chart on the back of this page. Record on the Data Collection Sheet.



Turbidity Conversion Chart

Distance from bottom of tube (cm)	NTU's
< 6.25	> 240
6.25 to 7	240
7 to 8	185
8 to 9.5	150
9.5 to 10.5	120
10.5 to 12	100
12 to 13.75	90
13.75 to 16.25	65
16.25 to 18.75	50
18.75 to 21.25	40
21.25 to 23.75	35
23.75 to 26.25	30
26.25 to 28.75	27
28.75 to 31.25	24
31.25 to 33.75	21
33.75 to 36.25	19
36.25 to 38.75	17
38.75 to 41.25	15
41.25 to 43.75	14
43.75 to 46.25	13
46.25 to 48.75	12
48.75 to 51.25	11
51.25 to 53.75	10
53.75 to 57.5	9
57.5 to 60	8
Over the top	6

- Utah standards state that an **increase** of more than 10 NTUs is unacceptable for most waters.
- This increase can be over natural levels or from one location to another nearby downstream location.

IV-3e. Temperature

Key terms

temperature	Centigrade
Fahrenheit	Celsius
warmwater fish	coldwater fish

What is temperature?

Have you ever put your hand in mountain stream in the spring? How about a big lake or reservoir in late summer? Why were the **temperatures** so different? Why does it matter to water quality? Read below and find out.

The temperature of water is a measure of how much heat energy the water contains. Temperature can be measured on many different scales. In the U.S. we usually use the Fahrenheit scale. On the Fahrenheit scale, water freezes at 32 degrees and boils at 212 degrees. Scientists usually use the Centigrade (or Celsius) scale. Water freezes at 0 degrees C and boils at 100 degrees C.

Table IV-5. Comparison of Celsius and Fahrenheit Temperature Scales.

Temperature Scales		
Celsius	**Fahrenheit**	
100	**212**	Boiling point of water at sea level
90	194	
80	176	
70	158	
60	140	
50	122	
40	**104**	38°C (98.6 °F) – average human body temperature
30	86	
20	**68**	Average room temperature
10	50	
0	**32**	Melting (freezing) point of ice (water) at sea level
-10	14	
-20	-4	
-30	-22	
-40	-40	
-50	**-58**	-50°C (-59°F) – 2nd lowest recorded temperature in continental U.S. (near Logan, UT)
-60	-76	
-70	-94	
-80	-112	
-90	**-130**	-67°C (-89°F) – lowest recorded temperature - Antarctica, July, 1983
-100	-148	

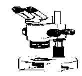
Converting Fahrenheit to Celsius	Converting Celsius to Fahrenheit
°C = (5/9) x (°F-32)	°F = [(9/5) x °C] + 32

What natural influences cause temperature to change?

Your stream heats up from direct sunlight and from heat in the surrounding land and air. Water is different than almost any other substance on earth. It takes a lot more heat energy to increase the temperature of water than it does to increase the temperature of the surrounding land and air. Thus, water heats up and cools off more slowly than air or land. Water temperatures vary by:

Geographic area

The temperature of streams reflects the surrounding climate. Streams in warm climates generally stay warm throughout the year while streams in colder climates tend to change more throughout the year.



The water in a stream is constantly mixing. Therefore, its temperature usually remains the same at all depths. However, if the water is moving very slowly, or pools-up in an area, you may find different temperatures at different depths. Lakes and reservoirs often change dramatically in temperature from the surface to the bottom.

Seasons

Water temperature changes as the air temperature changes throughout the seasons. Your water body may freeze at the surface in the winter but be very warm during the summer.

Source of the water

Streams fed by snow melt will be very cold in the early spring and summer. Streams fed by cold water springs may remain cool all year long. Hot water springs may keep sections of a stream warm throughout the year.

Channel shape

Because stream water heats up from the sun and from contact with the warmer earth, a narrow, deep stream will be cooler than a wide, shallow stream, if all other factors are equal.

Riparian shading

A stream that receives a lot of shading from riparian vegetation will stay cooler than a stream that is more exposed to the sun.

What human influences cause temperature to change?

- When the shade provided by riparian vegetation is removed, streams heat up faster.
- If activities cause a stream channel to become shallower and wider, the stream will heat up faster. Deep, narrow channels remain cooler. Removing riparian vegetation may also lead to a wider and shallower channel which leads to increased temperatures.
- The material on the stream bottom and banks affects water temperature. A stream that travels through a concrete channel absorbs more heat than a stream travelling through a plant-filled meadow.
- Industries (such as power plants) may discharge warm water into a stream.

Because cold water is heavier than warm, it sinks below warm water in lakes. You may feel this when you swim in a lake and dive below the warm surface water into COLD deeper water. A funny thing happens to very cold water, however. At about 4 degrees C (39 degrees F), fresh water becomes as heavy as it will get. As it continues to cool it starts to get lighter again. When water freezes, it is much lighter than liquid water (ice floats, right?). Therefore, in a frozen lake, the water is coldest at the top (0 degrees C), and warmest at the bottom (4 degrees C). In a summer lake, the water is warmest on the top and coldest at the bottom.

Why do we care about temperature?

- Water temperature greatly affects aquatic organisms. Most aquatic organisms – **macroinvertebrates**, fish, amphibians – are "cold-blooded." Their metabolism speeds up and slows down with the animal's surrounding temperature. Each organism has adapted to survive best at a given range of temperatures. If the temperature changes too drastically, their metabolism will not function as well, decreasing their ability to survive and reproduce.
- The optimal temperature is not the same for all aquatic organisms. For example, trout do best at temperatures below 22°C while carp may do fine in temperatures as high as 28°C. We divide fish into coldwater fish (fish who require fairly cool temperatures) and warmwater fish (fish who can survive warmer water temperatures).
- Warmer water holds less dissolved oxygen than cold water. Aquatic organisms may have trouble getting enough oxygen at very warm temperatures. For example, 11 mg/liter of dissolved oxygen can dissolve in 10°C water, while water at 30°C can dissolve only 7.5 mg/liter.

How do we sample temperature?

Detailed sampling directions are included at the end of this section.
When measuring temperature with a field thermometer, we usually measure only the surface temperature of the water body. To measure the temperature of deep pools, attach your thermometer to a pole or stick, or attach a string and a weight to it.

If you cannot reach moving water safely from the shore, attach a string to the thermometer and lower it from the bank or a bridge into the water.

Be aware that the temperature below the surface may be different, especially if the water is still (turbulent water mixes and keeps temperature more uniform).

How do we interpret our results?

Does it meet Utah State criteria?

You can determine an appropriate stream temperature by looking at temperature criteria for fish. The State of Utah has established maximum water temperatures for both warm and cold water fisheries. Check with the Utah Division of Water Quality to determine the designation for your particular stream (in "Resources" Appendix).

The maximum temperature allowed for warm water fisheries and aquatic wildlife is 27° C (81° F).

The maximum temperature allowed for cold water fisheries and aquatic wildlife is 20° C (68° F).

Does it protect desirable fish species?

For fish, there are two kinds of limiting temperatures – they can survive exposure to warmer temperatures for short periods (hours) but require cooler temperatures over longer periods of exposure. This may also vary according to the time of year and the life cycle stage of the fish species. Reproductive stages (egg incubation and embryo development) are the most sensitive stages. See Table IV-6 for the maximum temperatures for several common fish species.

Table IV-6

Maximum temperatures for typical coldwater and warmwater fish			
Species	Maximum average temperature for young fish to grow **(long term exposure) 1**	Maximum temperature for fish to survive **(short term exposure) 2**	Maximum average temperature for successful incubation and hatching of eggs **(long term exposure) 1**
Brook Trout	19ºC (66ºF)	24ºC (75ºF)	9ºC (48ºF)
Rainbow Trout	19ºC (66ºF)	24ºC (75ºF)	9ºC (48ºF)
Smallmouth Bass	29ºC (84ºF)	---	17ºC (63ºF)
Largemouth Bass	32ºC (90ºF)	34ºC (93ºF)	21ºC (70ºF)
Bluegill	32ºC (90ºF)	35ºC (95ºF)	25ºC (77ºF)
Channel Catfish	32ºC (90ºF)	35ºC (95ºF)	27ºC (81ºF)

[1] This is based on maximum temperatures averaged over at least a week.
[2] This is based on maximum temperatures averaged over a few hours.

Source: Volunteer Stream Monitoring: A Methods Manual

Resources for further investigation

Environmental Protection Agency's Volunteer Stream Monitoring: A Methods Manual - This 210-page manual takes the reader through an introduction to streams and watersheds then proceeds to offer in-depth, step-by-step approaches to monitoring a variety of water quality components. You will find helpful background information on stream temperature. For a free copy of the manual, contact Alice Mayio at USEPA (4503F), 401 M St. SW, Washington, DC 20460; 202/260-7018; mayio.alice@epamail.epa.gov. Also available on the web: www.epa.gov/owow/monitoring/vol.html.

Kentucky Water Watch – This Kentucky Water Watch web site, administered by the State of Kentucky Natural Resource and Environmental Protection Cabinet, offers background information on all major water quality parameters, including temperature. You'll also find lots of other useful information to support classroom and field monitoring. www.state.ky.us/nrepc/water/wwhomepg.htm

Water Conservation and Nonpoint Source Pollution – This activity book features hands-on, minds-on activities for younger ages. Several activities specifically address temperature concepts (in both indoor and outdoor settings). Contact: Your local County Cooperative Extension Office – or – Utah State University Extension, 1500 N 800 E, ASTE Dept, Utah State University, Logan, UT 84322-2300, 435/797-3389. extension.usu.edu/natres/wq/

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Environmental Protection Agency. Volunteer Stream Monitoring: A Methods Manual (EPA 841-B-97-003). Office of Water. Washington, DC, 1997.

Moore, J.A., and J.R. Miner. “Stream Temperatures: Some Basic Considerations.” Oregon State University Extension Service, 1997.

Morton, Stephen D. Water Pollution: Causes and Cures. Mimir Publishers, Inc. Madison, WI, 1976.

Temperature

Time – 2 minutes
Persons – 1
Materials –
- Thermometer

Step 1

1. Dip the thermometer into a moving part of the stream or river.

2. Wait for the temperature to stop changing (at least 1 minute).

Step 2

1. Read the temperature and record on the data sheet. Be sure to record your temperature in degrees Celsius.

2. Use the equations below to convert between degrees Celsius to degrees Fahrenheit.

Converting Fahrenheit to Celsius: $°C = (5/9) \times (°F - 32)$

Converting Celsius to Fahrenheit: $°F = [(9/5) \times °C] + 32$

The maximum temperature allowed for warm water water fisheries and aquatic wildlife is 27° C (81° F).

The maximum temperature allowed for cold water fisheries and aquatic wildlife is 20° C (68° F).

Date:____________________ Recorder:___________________

Your Results	Compare your results to Utah's requirements
Water Temperature ______ ºF (or) ______ ºC	The maximum temperature for: • warmwater fisheries is 27° C (81° F) • coldwater fisheries is 20° C (68° F).
pH (Value of the color match) _________________	The allowable range for most waters in Utah is 6.5 to 9.0
Dissolved Oxygen (Value of the color match) _____________ mg / liter	The minimum concentration for: • warmwater fisheries is 5.5 mg/liter • coldwater fisheries is 6.5 mg/liter.
Nitrate (Value of the color match) _____________ mg / liter Nitrate-nitrogen	The maximum concentration for drinking water is 10 mg/liter. The concentration which indicates a possible pollution problem for streams and rivers is 4 mg/liter.
Ammonia (Value of the color match) _____________ mg / liter Ammonia-nitrogen	The maximum allowable concentration depends on the water's pH and temperature. Please check the Ammonia section in the manual.
Phosphate (Divide value of the color match by 150) _____________ mg / liter Phosphate-phosphorus	The concentration which indicates a possible pollution problem: • in streams and rivers is .05 mg/liter • in lakes is .025 mg/liter
Turbidity (Use chart to convert target distance to NTUs) ________________ NTUs	The maximum *increase* over natural levels in most streams and rivers is 10 NTUs.

Chemical Properties Field Data Sheet

IV-4. Introduction to Biological Monitoring

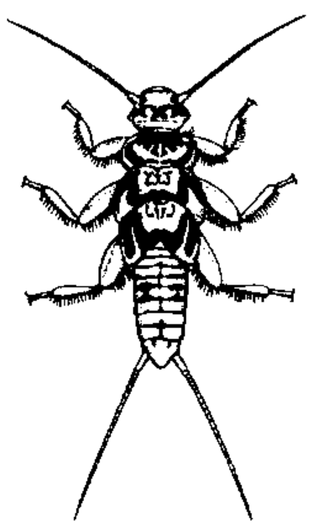
How would you know if a barrel of chemicals spilled into your stream? If you hadn't seen it spill you would have to sample the water for its effects. Chemical data would tell you a lot about the water at the particular time you sampled. But, if the barrel spilled a week ago, the chemicals might have flushed through without you knowing. Luckily, we can examine the biological components of a stream to gain information on the history of our stream's water quality. Since the plants, insects and other critters of the stream live in that environment all the time, they can tell us a lot about what has happened to the water in days, weeks, or years past. If we don't find the amounts or types of aquatic insects that are supposed to be there, then we know something is wrong and we can investigate further. It can be said that chemical monitoring provides a snap shot of water quality while biological monitoring provides a video. In this manner, the two complement each other well.

This chapter will help students examine biological components of a stream from both a classroom and field setting. A variety of sampling techniques are outlined for each biological parameter. Identification keys will help you collect your data and information provided at the end of each chapter will help you interpret your results.

Sections included:

a. Macroinvertebrates

b. Riparian Vegetation



Source: Tennessee Valley Authority

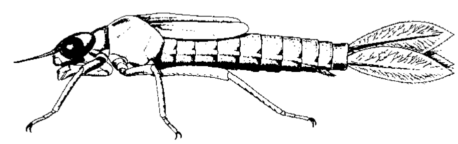
V-4a. Macroinvertebrates

Key Terms

Collectors	functional feeding groups	nymphs	shredders
dichotomous key	larvae	piercers	substrate
engulfers	macroinvertebrates	predators	Water Quality Rating Index
EPT Value	metamorphosis	scrapers	species

What is a macroinvertebrate?

The tiny animals that live in streams are called aquatic **macroinvertebrates**. These macroinvertebrates include many types of insects as well as other animals such as worms, molluscs and tiny crustaceans.

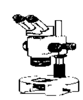


1

Where do we find them?

Most of the macroinvertebrates you will sample make their home in the rocks, leaves and sediment of stream beds. These organisms have many special adaptations that allow them to live in demanding environments. When you sample from riffles and fast-moving areas, look closely for features that help the animals hold on in the current, such as hooked feet, suction cups, and flat bodies. Animals that live deep in the mud may have adaptations for a low oxygen environment. For example, some are red because of hemoglobin in their tissues.

Figure IV-13, "Macroinvertebrates In Your Stream," illustrates some of the areas in a stream where macroinvertebrates live. Consider the unique environmental conditions of each area and how macroinvertebrates might deal with those conditions.



The name says it all. "Macro" means large (or large enough to be seen with the naked eye). "Invertebrate" means lacking an inside skeleton, like we have. Instead, they have an exoskeleton – a protective, supportive case on the outside of the body.

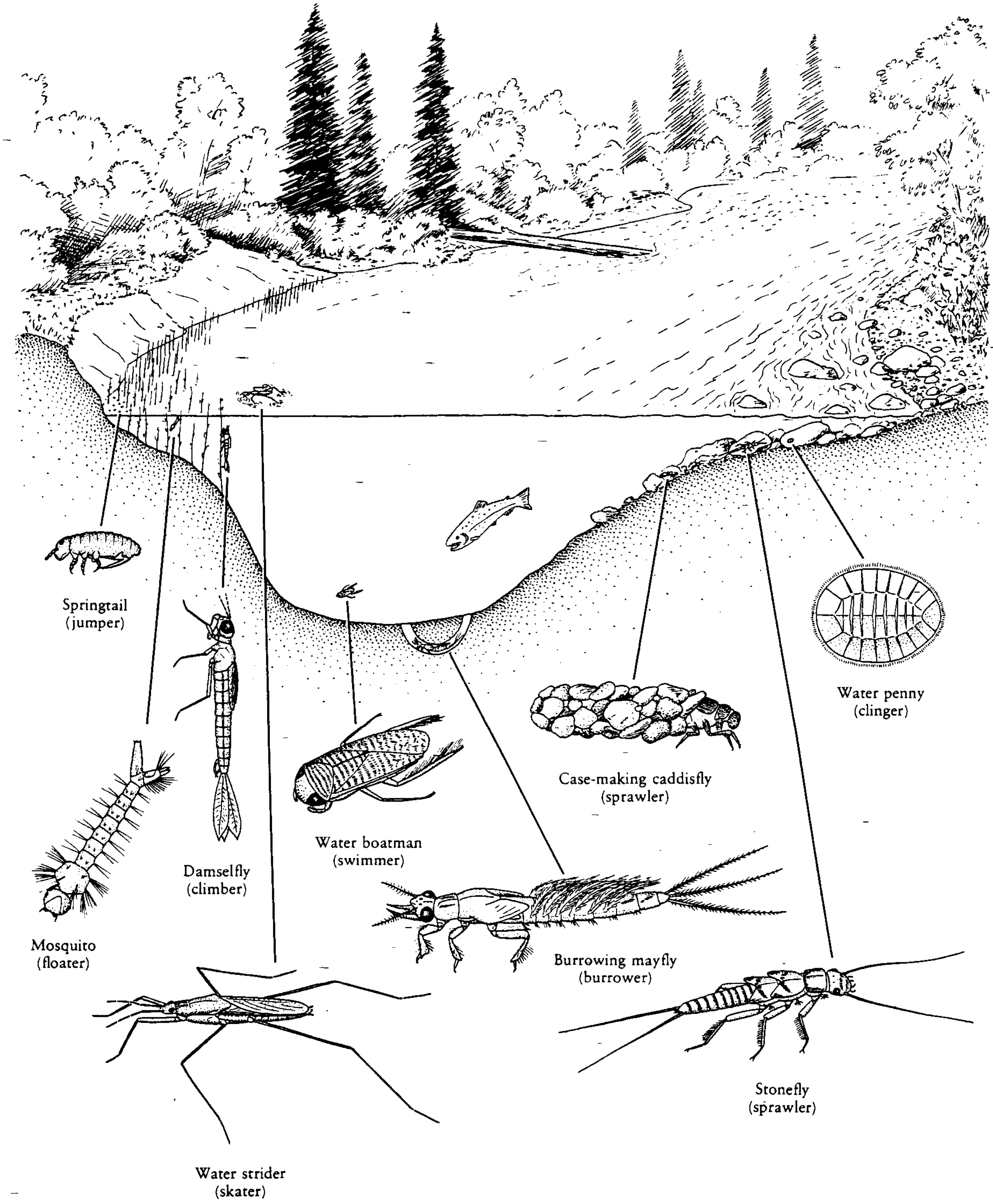
Do they spend their whole life in water?

Some macroinvertebrates complete their lives in a few weeks; others may live for several years. Usually, just the immature phases of insects' lives (**larvae** and **nymphs**) are spent in the water but some insects, such as water boatmen and backswimmers, spend their whole lives in the water. Most non-insect macroinvertebrates, such as amphipods (scuds), gastropods (snails) and bivalves (clams and mussels) spend their entire life in the water. Some mussels have been found to live for 100 years!

Young their whole life

Some mayflies live as nymphs for 2-3 years in water. But, when they hatch into adults, they have just 24 hours left. In that time they must find a partner, mate and lay their eggs before they die. They don't even have time to eat.

Figure IV-13 Common macroinvertebrates found in your stream

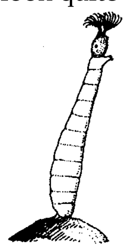


Provonsha in McCafferty, Aquatic Entomology, 1998: Jones and Bartlett Publishers, Sudbury, MA. www.jg[ub.com. Reprinted with permission

Do they change as they grow?

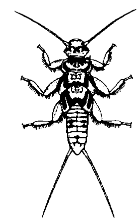
All aquatic macroinvertebrates start life as eggs. Some animals, such as water beetles and leeches, don't change much as they grow – they only get bigger, much as humans do. Some insects, however, may change (**metamorphose**) quite dramatically as they grow. After hatching, the insect may go through several stages before reaching adulthood. Depending upon the species, it may go through a larval stage, a nymph stage or both (see Figure IV-14).

Larvae do not show wing buds and usually look quite different than adults.



blackfly larva

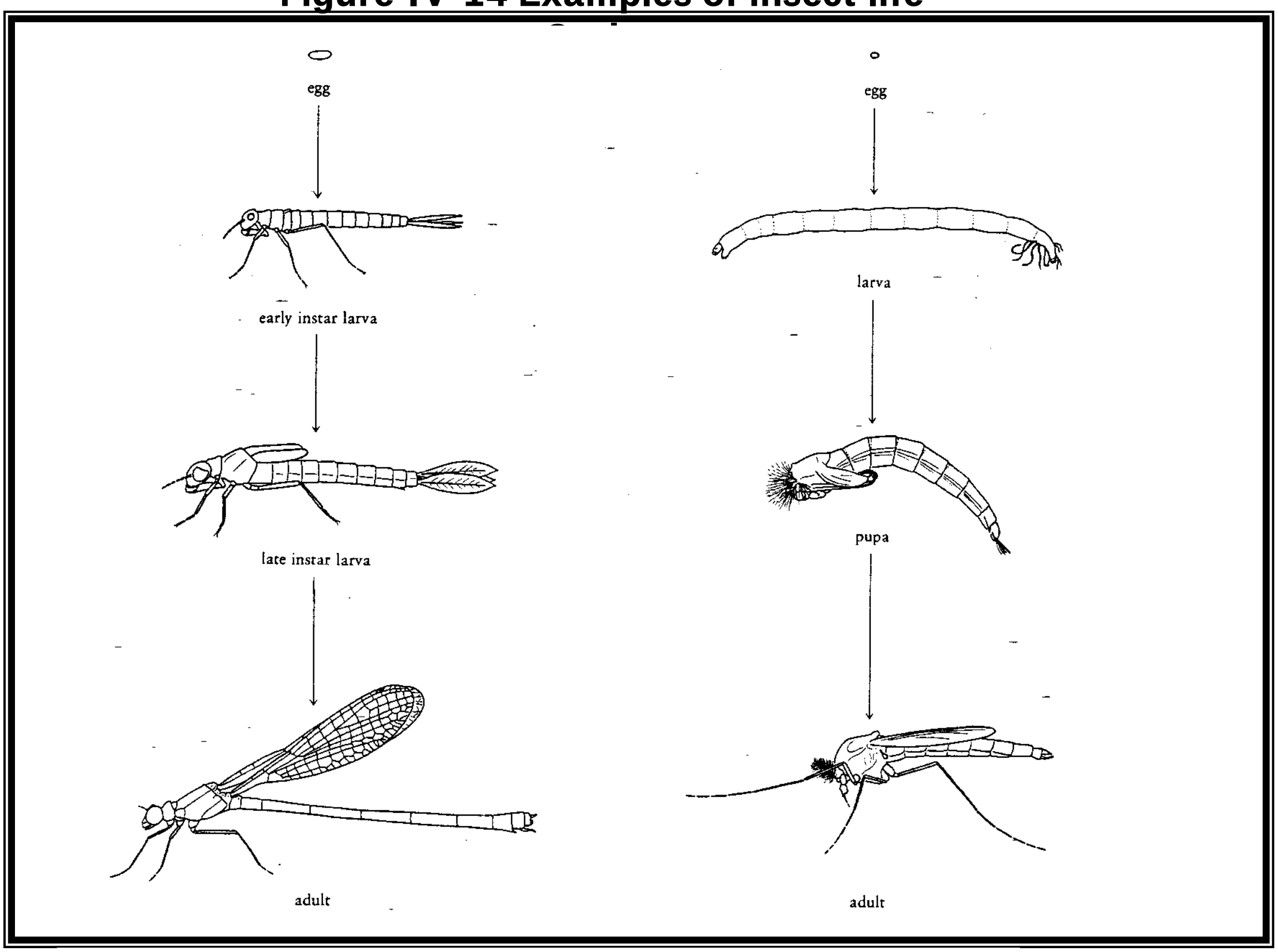
Nymphs usually resemble adults, but are smaller and have no wings.



stonefly nymph

Source: Tennessee Valley Authority (TVA)

Figure IV-14 Examples of insect life



Provonsha in McCafferty, Aquatic Entomology, 1998: Jones and Bartlett Publishers, Sudbury, MA. www.jg[ub.com. Reprinted with permission

What natural influences cause macroinvertebrate populations to change?

Seasons

Macroinvertebrate populations change through the year. You will find different types of macroinvertebrates during different seasons. The life histories of these invertebrates is tied to food availability. For example, **scrapers** (macroinvertebrates that eat microscopic plants called algae from the surfaces of rocks and leaves) are most abundant during the summer when algae production is highest. In general, the greatest diversity of organisms is found in autumn because there is a lot of organic matter such as fallen leaves in the stream.

Dissolved Oxygen

Aquatic macroinvertebrates breathe oxygen that is dissolved in the water. Immature stages of species such as stonefly nymphs, mayfly nymphs, and water pennies (beetle larvae) require high levels of dissolved oxygen. Look for the fluttering gills on the abdomen (sides) of mayfly nymphs. If dissolved oxygen is low, even for a short while, these insects may not survive.

Substrate

The **substrate** in your stream will greatly influence what macroinvertebrates are present. Expect to find the greatest variety and abundance of species in rocky or gravelly substrate. Because of the abundance of fine food particles, you can find many **collectors** (macroinvertebrates that eat tiny food particles from the water or stream bottom) in slow, murky waters with sandy or muddy bottoms.

What human influences cause macroinvertebrate populations to change?

Nutrient enrichment

Nutrient enrichment in a stream or lake may result from introductions of human sewage, manure or fertilizer. These substances can enter the water directly or be delivered by runoff from the surrounding watershed. Added nutrients may greatly accelerate the growth of algae and other plants. When these plants die, decomposition by microorganisms can use up much of the dissolved oxygen in the water, which is harmful to the macroinvertebrates.

pH

Acid precipitation, runoff from mining activities and dumping of industrial pollutants can lower pH. Low pH can weaken shells and exoskeletons, disrupt egg laying and reduce food availability. A pH below 4.5 will kill many macroinvertebrates in a short time. Water boatmen are one of the most resistant, surviving at a pH as low as 4.0.

Stream bank vegetation

Removal of vegetation in the riparian area eliminates important insect breeding grounds. It also deprives many types of macroinvertebrates of an important food source. These **shredders** feed on fallen sticks and leaves.

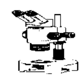
Why do we care about macroinvertebrates?

The types and abundance of macroinvertebrates in your stream are important to know for two reasons:

1) They are indicators of water quality.
   - Different macroinvertebrates tolerate different types of stream conditions. Depending on what we find, we can make predictions about water quality.
2) They are an important part of aquatic and terrestrial food chains.
   - Each macroinvertebrate plays a role, or function, in a stream. These roles are combined into "Functional Feeding Groups," such as shredders, collectors, scrapers and predators.

Pollution tolerance levels

Sometimes it's easy to tell if a stream is in trouble. Strange colors and dead fish are indicators of poor water quality. But, biologists need to know about water quality problems long before they reach such a severe point. Some of their most effective partners in detecting declining trends in water quality are macroinvertebrates because they respond so rapidly to changes in water quality.



Chemical samples provide a "snapshot" of the water quality at a particular moment. Macroinvertebrates provide a "video." Because they remain in the same area over a long period of time they enable biologists to assess both recent and more historic water quality.

To evaluate the health and productivity of a stream, biologists look at the types of species that live there. Different species have different tolerances to pollution. If many pollution-intolerant species, such as stonefly and caddisfly nymphs, are present then the water quality is probably quite good. Although the presence of certain species indicates good water quality, the absence of these species does <u>not</u> necessarily indicate bad water quality. Other factors besides pollution may account for their absence. For example, they may have metamorphosed (changed) into adults and flown away.

We can classify macroinvertebrates into three groups based on pollution tolerance.

Group 1 - *Sensitive or Intolerant Species*
Organisms that are easily killed, impaired or driven off by bad water quality: these include stonefly, dobsonfly and mayfly nymphs, caddisfly larvae, water pennies and snails.

Group 2 - *Somewhat Tolerant Species*
Organisms that have the ability to live under varying conditions. You may find them in good or poor quality water. These organisms include amphipods, scuds, beetle and cranefly larvae, crayfish and dragonfly nymphs.

Group 3 - *Tolerant Species*
Organisms capable of withstanding poor water quality: these include leeches, snails, aquatic worms, midge larvae and sowbugs.

? *What would the following species distributions suggest to you?*

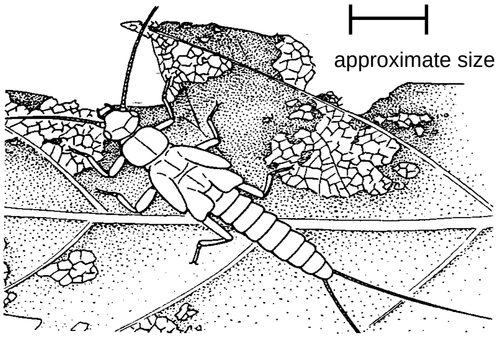
- A community with many species from Group 1, some from Group 2 and a few from Group 3. – Indicates good water quality.
- A community with no species from Group 1, a few from Group 2 and a lot from Group 3. – May indicate poor water quality but we can't be sure (better do some chemical and physical monitoring, too)

Functional Feeding Groups

Macroinvertebrates are a critical link in the food webs of streams and riparian areas. They graze on algae that grows in the stream, they help break down leaves and sticks that fall in the water, they are an important food source for fish and much more.

One way to study and classify macroinvertebrates is to look at their role in the food web. Biologists categorize their food web roles into 4 groups - the **Functional Feeding Groups** (Figure IV-15):

approximate size



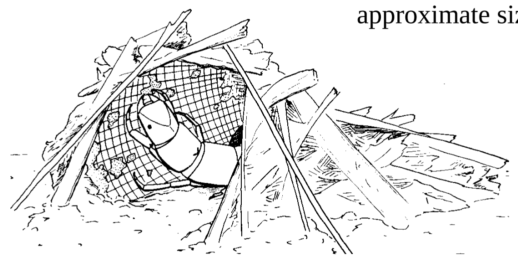
Shredder (stonefly nymph)
Provonsha in McCafferty, 1998

1) **Shredders** feed by biting or cutting on leaves and wood that has fallen into the stream. The shredding action is an initial step in the decomposition process. The shredded particles become food for smaller macroinvertebrates and microscopic decomposers. Shredders, such as stonefly, cranefly and mayfly larvae and nymphs, are found mainly in small, upper stream reaches that receive large amounts of leaves and wood from the riparian zone.

2) **Collectors**, which feed on particles 1 mm or less in size, further the decomposition process. They feed on fragments of shredded organic material or feces cast-off by shredders as well as on algae and bacteria. To get their meal, collectors often use a variety of specialized methods.

- Some, such as the blackfly larvae, spread out fan-like mucous-covered body parts to trap particles that float by.
- Others, such as this caddisfly nymph, spin webs to filter their food from the water.
- Some species of caddisfly larvae are picky. They spin webs of different mesh sizes to collect specific-sized particles.

approximate size



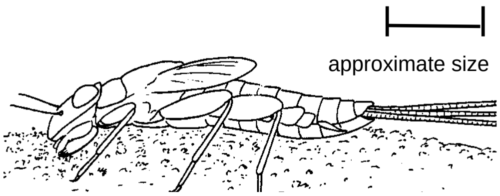
Collector (caddisfly nymph)
Provonsha in McCafferty, 1998

Collectors are abundant in medium and large stream sections. These sections are slower and contain a lot of small (less than 1 mm in diameter) pieces of leaves and wood.

? *Would you expect to find a lot of collectors in a stream if there were no shredders?*
No. Without shredders, collectors would not have enough small food particles to eat.

1) **Scrapers** harvest material that adheres to rocks, such as algae and bacteria. Scrapers need to stay close to the rock surface to feed. Special adaptations, such as flat bodies and suction disks, allow them to do this. Scrapers, which include certain mayfly and caddisfly larvae, and water pennies, are found mainly in

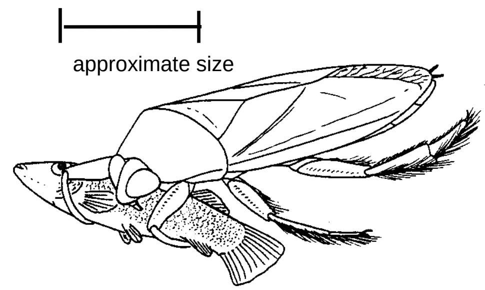
middle-sized stream sections. These stream sections receive greater sunlight which increases the abundance of algae – a major food source for scrapers.



Scraper (mayfly nymph)
Provonsha in McCafferty, 1998

? *What time of year would you expect to find a lot of scrapers and grazers in your stream?*
Summer and fall, when the most sunlight reaches the stream and algae production highest.

4) Fish, birds and reptiles all prey on macroinvertebrates, as do other macroinvertebrates. We call these **predators**. Just like shredders, collectors, and grazers, predators have unique mechanisms for obtaining a meal. Odonates (dragonflies and damselflies) often bury themselves in the sand with only their eyes protruding and wait to spring their retractable mouthparts at unsuspecting prey. Some predators, such as predacious stoneflies, are more active and pursue their prey.



Predator (water boatman)
Provonsha in McCafferty, 1998

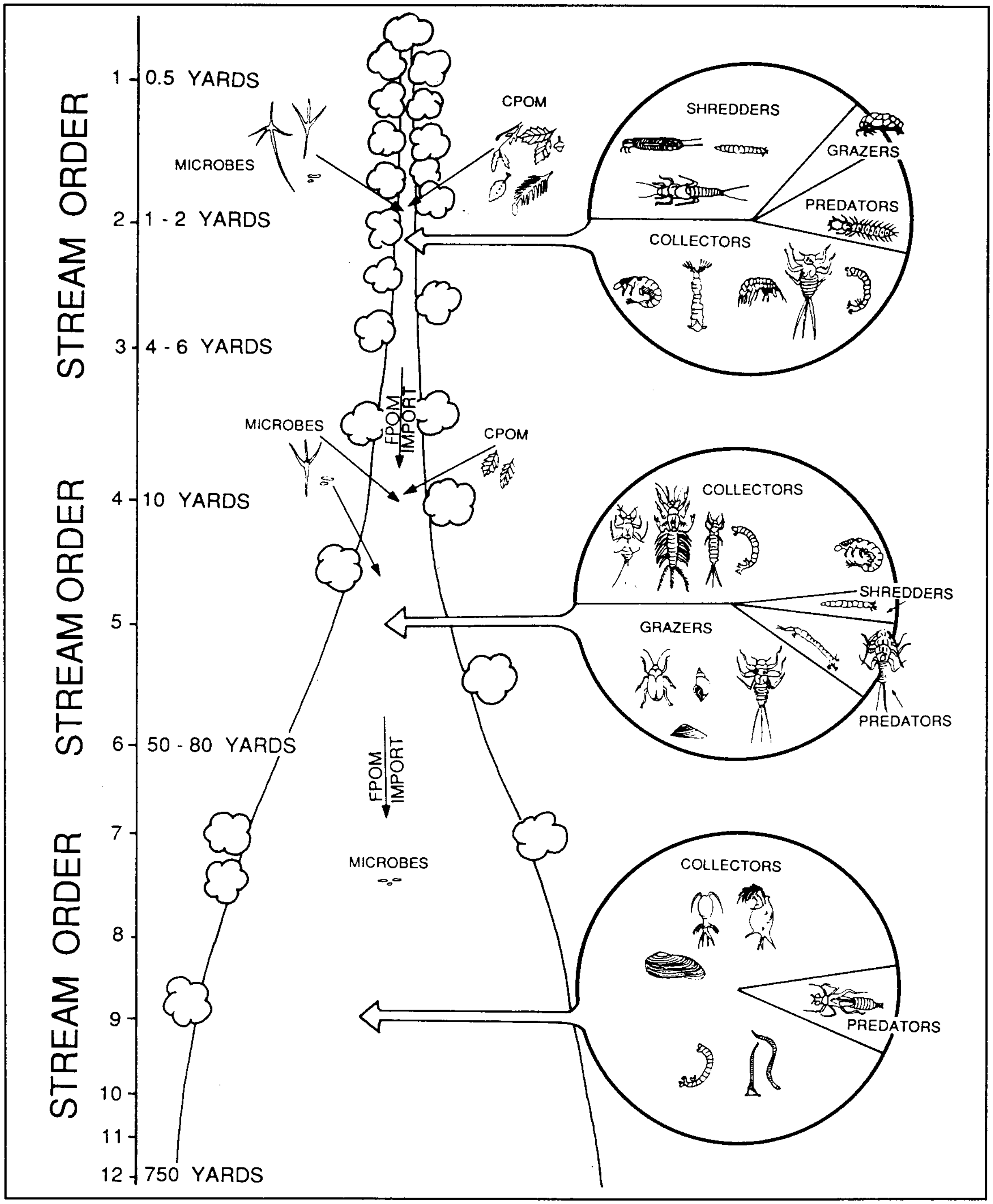
We classify predators into two groups.

- **Engulfers** swallow their prey whole.
- **Piercers** inject a mouth part into their prey and suck out the body fluids. This giant water bug is an example of a piercing predator.

? *Would you expect to find predators in areas without shredders,collectors and grazers?* No. Predators depend upon them for food.

? Look for different “Functional Feeding Groups” in Figure IV-17. Consider how the size and location of the stream section affects the type of food available and how the available food affects the location of the different functional feeding groups.

Figure IV-15. **Functional Feeding Groups** Note how the types of macroinvertebrates change in a stream as the stream gets larger.



Source: Ken Cummins, "From Headwater Streams to Rivers," *The American Biology Teacher*.

CPOM (coarse particular organic matter) – plant material (leaves, needles and wood)
FPOM (fine particulate organic matter) – feces and tiny bits of plant materials

How do we sample macroinvertebrates?

The *Utah Stream Team* provides a standard method for collecting macroinvertebrates. This method is detailed in the Field Directions at the end of the chapter. Once you have collected your sample, you may want to simply observe the animals. If you want to use the sample to evaluate water quality, calculate one of the indexes described below.

When do we sample?
Anytime is a good time to look at bugs. Fall is an especially good time to sample since many macro-invertebrates will be large and more easily studied. Also, lower stream levels in the fall make sampling easier and safer.

Making Observations:

Many groups choose to simply collect and look at their macroinvertebrates without quantifying them. Encourage your students to use the hand lenses to look at the animals closely. This is easiest if they to transfer individual animals into the small petri dishes with a little water.

- Investigate the insect body parts. The head, abdomen and thorax are easy to see, and the students can count the legs on insects compared to other animals they find. Students can investigate the different types of mouth parts and the large eyes some of these insect have.
- Consider how the animals breath. Mayflies have distinctive gills on their abdomen, stoneflies have gills under their legs, damselflies have gills on plates at the end of their thorax. Try to see what they do when they need more oxygen. For example, stoneflies do "push ups" to pass more water over their gills.
- Watch for animal behavior. Look for differences in how they move and watch how they interact with other animals. Look for evidence of predation. Encourage your students to think about how these animals experience their world, how they see, or how they might detect chemical signals in the water.
- Have students draw the animals. Some are beautiful while others resemble monsters.

Quantifying Samples

Two methods are provided for quantifying (indexing) your sample: 1) the **EPT Value** and 2) the **Water Quality Rating Index**. If you wish to quantify and interpret your results using either of these two indexes, read the next section before you start to sample. A Data Collection Sheet is included for each of these indexes.

EPT Value

This biotic index is one way to interpret water quality in your stream using the types and amounts of macroinvertebrates you collect. The EPT value – **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**ricoptera (caddisflies) – is a sum of the total number of "species" of these three orders in the sample. These insect groups contain many species that cannot tolerate poor water quality. Generally, the more EPT species you find, the better your water quality. The **EPT Value** is simpler than the Water Quality Rating Index and will take the least amount of time to conduct (about 1 hour for a trained group of three students).

Water Quality Rating Index

The Water Quality Rating Index requires more extensive identification of different types and more time to conduct (about 2 – 3 hours). However, it will provide a more accurate assessment of your water quality. The Water Quality Rating Index operates in a similar manner as the EPT. Species are collected and identified – the more pollution-intolerant individuals collected, the higher the value and the better the water quality rating. With this index, however, <u>all</u> the different types of organisms in your sample must be identified and totaled. Note that this can be difficult for younger students, especially when very small organisms are present. Intolerant and Somewhat Tolerant species have higher values than Tolerant species.

What is a "species"?

Species is a term used by scientists to identify groups of animals that are uniquely different from other groups. If animals can potentially reproduce with each other, they are in the same species.

In this section we use this term somewhat loosely. In the *Utah Stream Team*, "species" refers to animals that are related but have enough different physical characteristics that they can be easily divided into separate groups. For example, caddisflies have different body widths and shapes, different gill sizes and make different kinds of cases. For our purposes, we consider these different caddisflies to be different "species."

How do we interpret our results?

Pollution tolerance indexes provide a relatively quick means for assessing stream quality and help students to understand pollution tolerance ranges for organisms. However, they need to be considered along with physical and chemical data in order to provide a comprehensive picture of water quality.

EPT Value

Compare your calculated EPT Value with the water quality ratings below. If your stream does not score well, refer back to the "Natural and Human Influences" sections in this chapter as well as your physical and chemical data to help you determine why. You may want to share your rating with a local aquatic biologist (consult the UT Division of Wildlife Resources or UT Division of Water Quality) to help you interpret it.

EPT Value:

[]	>10	not affected (excellent water quality)	[]	2 – 5	moderately affected (fair water quality)
[]	6 – 10	slightly affected (good water quality)	[]	< 2	severely affected (poor water quality)

Water Quality Rating Index

Compare your calculated Water Quality Rating Index with the water quality ratings listed below. If your stream does not score well, refer back to the "Natural and Human Influences" sections in this chapter as well as your physical and chemical data to help you determine why. You may want to share your rating with a local aquatic biologist (consult the UT Division of Wildlife Resources or UT Division of Water Quality) who can help you interpret it.

Water Quality Rating Index

[]	Excellent (> 79)	[]	Fair (40-59)
[]	Good (60-79)	[]	Poor (< 40)

Resources for Further Investigation

Guide to Macroinvertebrate Sampling - The River Watch Network's guide offers a user-friendly picture key, methodology and various indices such as the Percent Composition of Major Groups, the Modified Family Biotic Index, and Organism Density per Sample (these indices are excellent opportunities to weave math into your monitoring program). The manual is available for $5 from RWN, 153 State St., Montpelier, VT 05602.

Monitor's Guide to Aquatic Macroinvertebrates by Kellogg, L.L. 1994. 60 pages. A pocket-sized guide including a key (with some important fly families), descriptions of major invertebrate groups, sampling protocols for both rocky bottoms and muddy bottoms, and sample data sheets with excellent illustrations. Contact: Save Our Streams, Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878; (800)BUG-IWLA. $5.

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Macroinvertebrate Sampling

Time – 40 minutes
Persons – 2
Materials -

- 1 kick net
- 1 plastic pan
- transfer pipettes
- plastic4 petri dishes
- magnifying glasses
- dichtomous key

OPTIONAL

- paint brushes (for transferring)
- 5 gal plastic bucket (for decanting)
- waders (for sampling in cold or deep water)

Step 1 - Choose your sample site

- Select sampling reaches that are safe and easily accessed by everyone in your group. A riffle will offer the best variety of organisms.
- You may also want to collect samples from other habitats such as pools, aquatic vegetation and stream margins. Compare the different results you obtain from these areas and discuss why (think about Functional Feeding Groups, different flows, or available oxygen).

Step 2 – Collect your sample.

Note: Follow these directions if you are sampling in *flowing* water.

1. Wade into the stream and place your net so the mouth of the net is perpendicular to and facing the flow of water.
2. Stand upstream of the net and disturb the stream bottom with your feet and hands.
3. Carefully pick up and rub stones directly in front of the net to remove attached animals. The stream bottom material and organisms will be carried by the current into the net. If the rocks are lodged in the stream bottom, rub them vigorously, concentrating your effort on any cracks or indentations.
4. After removing all large stones, disturb the sand and gravel to a depth of about 3 inches by raking and stirring with your hands.
5. Continue this process until you can see no additional animals or organic matter being washed into the net.

Note: Follow these directions if you are sampling in *pools or highly-vegetated* areas.

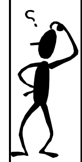
1. Scoop material from the stream bottom.
2. Push and pull the net through aquatic vegetation.
3. Hand pick organisms from sticks and other structures.

Step 3 – Empty your sample

1. Hold your sampling net over a plastic pan and use a bucket of stream water to wash the material into the pan.
2. If your sample contains a lot of rocks or debris, stir the sample in the pan to suspend the animals, then pour the suspended material back into your net. Rinse the debris from the pan, then wash the animals in the net back into the pan.

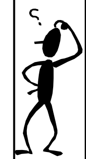
Step 4 – Sort out the bugs

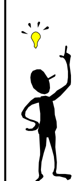
1. Use plastic transfer pipettes, small paint brushes or your fingers to remove bugs from pans. For easier observation, place the animals into smaller water-filled containers (plastic ice cube trays or petri dishes work well).
2. Use the keys provided in this section to identify the bugs.



Macroinvertebrate Indices

Time – 60+ minutes
Persons – 3 or more
Materials -
- Macroinvertebrate sample
- 1 plastic pan
- transfer pipettes
- plastic petri dishes or ice cube trays
- magnifying glasses
- ruler for subsampling
- dichotomous key
- Macroinvertebrate Index Data sheet





Subsample to simplify EPT Value or Water Quality Rating Index

To calculate either index, you need to sort approximately 100 animals. It is very difficult to "randomly" select animals from a large sample, because we tend to choose the most obvious, largest or most active animals. This will bias the results. Subsampling gives you a representative selection from your larger sample.

1. Place entire macroinvertebrate sample into flat plastic pan.
2. Pour off most of the water from the pan, so material and animals are no longer floating. Distribute material evenly on the bottom of the pan.
3. Distribute material evenly on bottom of pan. Take a ruler and divide the material in the pan in half. Remove one half of the material from the pan.
4. Redistribute the material again over the bottom of the pan and divide this material again with a ruler.
5. Continue this process until you have a sample with about 100 total organisms.
6. Add some stream water back into the pan for easier sorting.

EPT Value

1. Find all the mayflies, stoneflies and caddisflies in your subsample using the identification key.
2. Separate these into as many distinct species by looking for differences in body shape, color and markings. Place all members of each species into separate containers.
3. Count the total number of species of mayflies, stoneflies and caddisflies. This total is the EPT Value.

Remember: A separate "species" in this case refers to animals that are related (e.g. all mayflies) but have enough different physical characteristics that they can be easily divided into separate groups.

Water Quality Rating Index

1. Separate each different type of macroinvertebrate in your subsample into a different container.
2. Use the identification key to identify each different type. Look at the body shape, color and markings.
3. Separate these different types into pollution tolerance categories, using picture guides on data sheet.
4. Multiply the number in each category by the pollution sensitive weighting found on the data sheet.
5. Sum the number of animals in each category and the weighted values for each category. Add up the total number of animals, and the total weighted values.
6. Divide the total weighted values by the total number of animals. This will give you the Water Quality Rating Index.

	EPT Value	Water Quality Rating Index
Time –	45 minutes	60 minutes
Persons –	3+	3+

Materials (needed for either sampling method)

- 1 plastic pan
- 4 plastic petri dishes
- 4 transfer pipettes
- 1 kick net
- 4 magnifying glasses
- dichotomous keys
- 1 pair waders (for cold and/or deep water)

EPT VALUE

Aquatic invertebrate Group	**Number of different "species" found**
MAYFLIES	
STONEFLIES	
CADDISFLIES	
TOTAL	

Total "species" equals EPT Value

[ ] >10 not affected (excellent water quality)

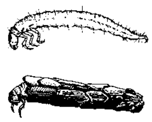
[ ] 6 – 10 slightly affected (good water quality)

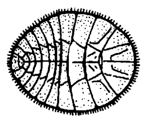
[ ] 2 – 5 moderately affected (fair water quality)

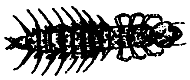
[ ] < 2 severely affected (poor water quality)

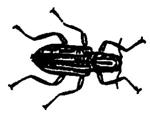
Water Quality Rating Index
(Circle each category found)

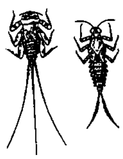
Group 1: Pollution Sensitive


Caddisfly larva


Water penny


Dobsonfly larva adult


Riffle Beetle


Mayfly nymph

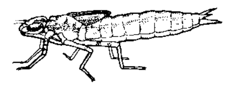

Gilled Snail

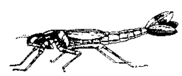
Group 3: Fairly Tolerant

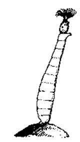

Scud


Clams, Mussels

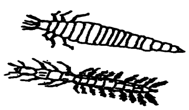

Crayfish nymph

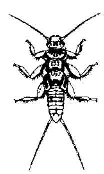

Dragonfly

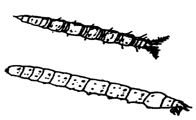

Damselfly nymph


Blackfly larva

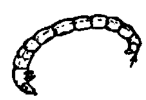
Group 2: Slightly Tolerant

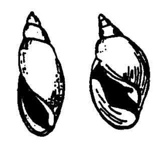

Beetle larva

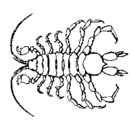

Stonefly nymph

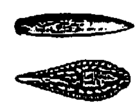

Cranefly larva

Group 4: Very Tolerant


Midge larva


Pouch (left hand) Snail


Sowbug


Leech

Total # categories of Pollution Sensitive Group 1	________	X	100	=	____________
Total # categories of Slightly Tolerant Group 2	________	X	80	=	____________
Total # categories in Fairly Tolerant Group 3	________	X	60	=	____________
Total # categories in Very Tolerant Group 4	________	X	30	=	____________

COLUMN TOTALS _________ (a) ____________ (b)

Divide (b) by (a) ___________ / ___________ = Water Quality Rating Index _______________

Water Quality Rating Value:

[ ] > 79 Excellent [ ] 60-79 Good [ ] 40-59 Fair [ ] < 40 Poor

IV-4b. The Riparian Zone

Key Terms		
aquatic zone	greenline	sedges
emergents	groundwater recharge	shrubs
forbs	niches	swale
floodplain	ocular tube	uplands zone
grasses	rushes	water table

What is the Riparian Zone?

The riparian zone is the green ribbon of life alongside a stream. This ribbon is a mixture of vegetation types, which varies greatly from place to place. Riparian vegetation along a desert stream may be small and sparse while the vegetation along a mountain stream may be tall and lush.

The riparian zone is critical to the health of every stream and its surrounding environment. It connects the **uplands zone** to the **aquatic zone**, controlling the flow of water, sediment, nutrients, and organisms between the two. Without a proper functioning riparian zone, the other zones suffer. Riparian zone functions are discussed (Figure IV-16) in detail below.

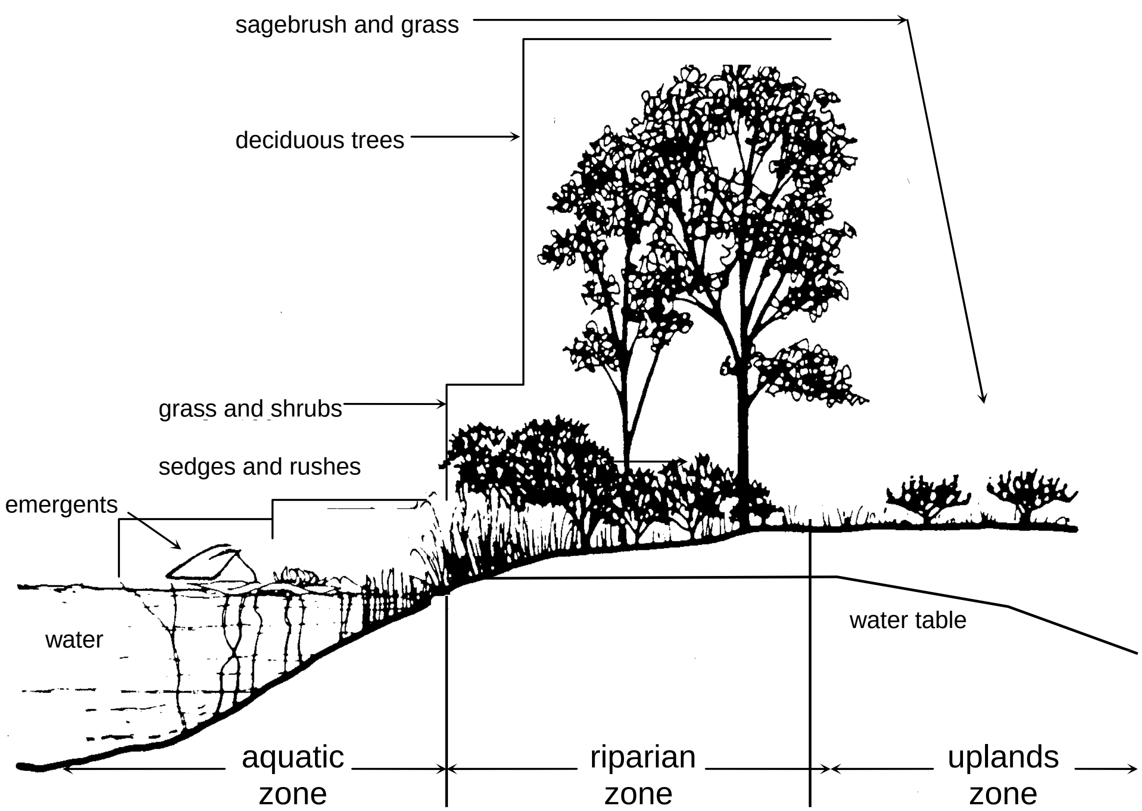


Figure IV-16. The Riparian Zone Connects the Stream (Aquatic Zone) to the Upper Part of the Watershed (Uplands Zones)

Adapted from "The Riparian Zone," Utah Riparian Management Coalition

1) Is the riparian zone wetter than the uplands zone?

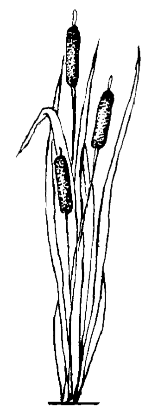
- Yes, because it receives regular flooding and is closer to the **water table**.

2) How do riparian plants and trees affect the stream?

- Riparian vegetation contributes shade, food and shelter for aquatic organisms. The riparian zone is also home to many animals that move between land and water, such as insects, amphibians and waterfowl.
- Riparian vegetation and litter reduces erosion and regulates the overland flow of water to the stream (uplands vegetation serves this function, too).
- The riparian zone acts as a natural sponge, soaking up water as it runs off the land, and slowly releasing that water back into the stream.

3) How does the variety of species differ between each zone?

- The riparian zone generally has a greater variety of species than the other zones. It is also denser and more structurally complex (plants have a greater variety of shapes and heights).
- Some plants, such as **sedges** and **rushes** are not found in most areas of the upland zone because they require a lot of water.
- Other plants, such as sagebrush, are not found in the aquatic zone because they cannot tolerate a wet environment.
- **Emergents** which are found only in the aquatic zone grow up through the water and expose their leaves at the surface. Submerged and floating vegetation are also found in the aquatic zone.



Cattail

Utah riparian areas

- Riparian zones constitute less than 3% of Utah's land area. However, 75% of the 360 bird species found in Utah depend on riparian zones for some part of their life cycle.
- The cottonwood/willow forest is a type of riparian zone common in Utah. The cottonwoods form a tall canopy and the willows create a thick understory. A variety of birds and other animals fill the niches created by this complex structure.
- Many other riparian vegetation types can be found in the varied landscapes of Utah. Look for saltgrass and cattail in western salt marshes; alkali bullrush and coyote willow in the sagebrush country; and even subalpine fir and Engleman spruce in high mountain areas.

> The western cottonwood willow forest, an exclusively riparian forest type, is the most threatened of the 106 forest types found in North America.

What natural influences affect riparian zones?

Water supply

Water supply is the major factor that regulates the growth of riparian vegetation. Flood waters transport nutrients, sediment and new seeds from upstream. Floods also strip away larger, established vegetation and allow new seedlings to establish.

Unlike floods, groundwater offers a steady source of water for the stream and riparian zone. In fact, it may be the only source of water for a stream in winter when precipitation is frozen (groundwater remains at a relatively constant 50 degrees). The closer you get to the stream, the closer the water table (the top of the groundwater) is to the surface of the soil. Groundwater comes to the surface at the edge of a stream.

Soils
The type of soil in the riparian zone influences the amount of water and nutrients available. Organic-rich soil holds water and provides abundant nutrients to plants, with out releasing these nutrients to the water. We can expect to find denser vegetation in these soils than in a gravely soil with little water-holding capacity and few nutrients.

Topography
The shape of the land affects the location and abundance of plants in the riparian zone. See figure IV-17 to find out how.

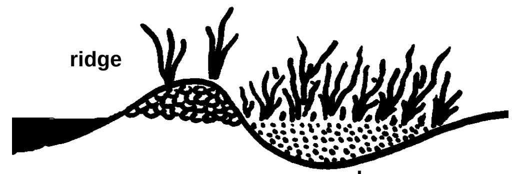


Figure IV-17. The shape of the land near a stream affects the plants which grow there.

The gravelly composition of this ridge allows fine sediment and organic matter to filter through and collect in the swale. These materials, which have high water-holding capacities, keep the swale wetter than the ridge; even though it is further from the stream. Notice the thicker vegetation that results. Why else might we find thicker vegetation in the swale? Think about access to the *water table*.

Climate
Riparian zones in different climates have different appearances. In the deserts of southern Utah riparian zones are "green oases" in sparse, dry surroundings. In the mountains, where precipitation is more abundant, the upland vegetation remains relatively lush. It is usually less structurally and visually different than the riparian vegetation.

What human influences affect riparian zones?
Humans, just like animals, are attracted to riparian zones. Unfortunately, many of our activities can have a negative influence on the riparian zone and reduce its value both for the ecosystem and ourselves. Through respect and good planning we can help to avoid many of these problems.

Road building
Riparian zones, which tend to be flatter than the surrounding land, are attractive routes for road builders. Roads, however, may cause accelerated erosion, introduce oil and other pollutants to the stream, cut off subsurface water flow to the stream and threaten wildlife.

Farming
Farmers often clear riparian zones to increase the amount of available farmland. However, without the stabilizing effect of riparian vegetation, the banks of a field may erode during floods. Farmland is lost where the erosion occurs and sedimentation increases downstream. More and more farmers now maintain the health of their riparian areas to ensure long-term sustainability of their land.

Grazing
Just like other animals, cattle are attracted to cool, lush riparian zones. If managed correctly – herded or fenced out after a short time – cattle can be part of a healthy riparian zone. However, mismanagement, or overgrazing of the riparian zone can cause changes in the types of vegetation and the amount of cover and forage, increase erosion, and introduce increased amounts of nutrients and fecal coliform bacteria to the stream through manure.

Development
The aesthetic value of riparian zones makes them prime targets for housing and commercial development. However, construction often removes vegetation and alters the stream banks and may even result in concrete lined banks. These changes can increase the intensity of floods, increase the direct input of pollutants to water, and decrease wildlife.

Logging
Logging operations today realize the importance of healthy riparian zones and rarely log them. However, logging roads continue to be built through these zones, creating the same problems that all roads do. When we strip away upland vegetation, we allow too much water to flow down into the stream at one time, which can lead to bank erosion, deep and narrow channels and shrunken riparian zones. Along with the increased water flow may come increased loads of sediment.

Dams
Dams reduce downstream flooding. While this serves the people who live downstream in the **floodplain** it degrades riparian zones. Natural flood cycles are critical to healthy riparian zones. Floods bring essential supplies of water, nutrients and sediment. They also help to create backwaters that serve as critical fish nurseries.

Why do we care about riparian zones?
Well-functioning riparian zones are critical to a healthy watershed. Plants and animals depend on their unique, diverse and productive habitats. Humans, as well, depend on riparian zones; they provide the following services.

Erosion control
The tough, tangled roots of sedges, shrubs and trees provide structure to streambanks and reduce soil loss to the stream.

Filters
As surface runoff flows through the riparian zone to the stream, vegetation traps much of the sediment it carries which reduces turbidity levels in the stream. Riparian vegetation also pulls nutrients out of the soil before they can reach the stream.

Groundwater recharge
Riparian zones supply water to underground reservoirs. We call this process **groundwater recharge**. Well-vegetated areas trap the overland flow of water, allowing it to infiltrate the soil and percolate downward. Underground stores provide the primary and sometimes only source of water for streams during dry periods. Without this supply, the aquatic ecosystem would collapse. Recharge is equally crucial for humans who depend on groundwater for drinking and other purposes.

Flood control
Riparian zones serve as reservoirs for flood waters. The vegetation and soil absorb overbank flow then releases it over time. This decreases the amount and energy of water flowing through the stream at any one time. People who live in floodplains benefit from the regulating effect of healthy upstream riparian zones.

Wildlife
Riparian zones concentrate water and nutrients from the stream and the surrounding uplands. In response, the vegetation grows dense and structurally complex – it takes on a variety of shapes and sizes. This greater complexity translates into more **niches** for organisms to fill.

- The diversity and production of riparian zones surpass all other terrestrial (land) ecosystem types.
- Riparian zones in the Southwestern United States have a higher breeding diversity of birds than all other western habitats combined.
- Aquatic organisms are just as dependent upon riparian zones for their survival. The leaves, sticks and bark that fall into the water may provide up to 99% of the energy for organisms in a small headwater stream (the other 1% comes from **photosynthesis**).

Southwestern willow flycatcher

The southwestern willow flycatcher breeds throughout southern Utah (and elsewhere). It migrates up from Central America and Mexico in mid-May and nests mainly in the understory of cottonwood/willow riparian forests. As these types of riparian zones have been lost or changed, the 6-inch, green and yellow insectivore has decreased in number. In fact, so many have disappeared that in 1995 it was placed on the endangered species list. The southwestern willow flycatcher had historically been found in Utah along Kanab Creek and the Virgin, Colorado and San Juan rivers. However, only three sightings have been confirmed in the last five years.

How can you help the southwestern willow flycatcher and other birds that depend on riparian zones? Contact your local Fish and Wildlife Department to learn more about these birds. Ask if there are riparian zone restoration projects you and your class can participate in.

How do we sample the riparian zone?

This section provides three ways to monitor the riparian zone:

1) Greenline Transects,
2) Ground Cover Transects and
3) Canopy Cover Transects.

Each activity measures a different characteristic of the riparian zone.

NOTE: Step-by-step “Sampling Directions” can be found at the end of this section along with the “Riparian Zone Data Collection Sheet.”

Greenline transects

The **greenline** consists of the first plants you encounter as you move away from the water (see Figure IV-18). The greenline may at times closely parallel the stream and at other times it may head a considerable distance away from the stream.

- The greenline gives us a measurement of bank stability, which is the ability of banks to withstand erosion. We determine stability by calculating the percent composition of five different vegetation types along the banks. These are: 1) grasses, 2) forbs, 3) sedges and rushes, 4) shrubs and trees, and 5) bare ground (see Figure IV-19) for help identifying different vegetation types). Each vegetation type has a different ability to stabilize the bank, due primarily to the depth and density of their roots or whether they are annuals (die back after one year) or perennials (survive through the winter). Stability ratings are found on the “Riparian Zone Data Collection Sheet.”

- Before sampling work with your students to correctly identify the different vegetation types and to locate the greenline. This can easily be done in your schoolyard in an area where vegetation meets bare soil. The more practice students have before they visit the stream site the more successful they will be.

- The greenline will take two students 30 minutes to complete if they are familiar with the different vegetation types.

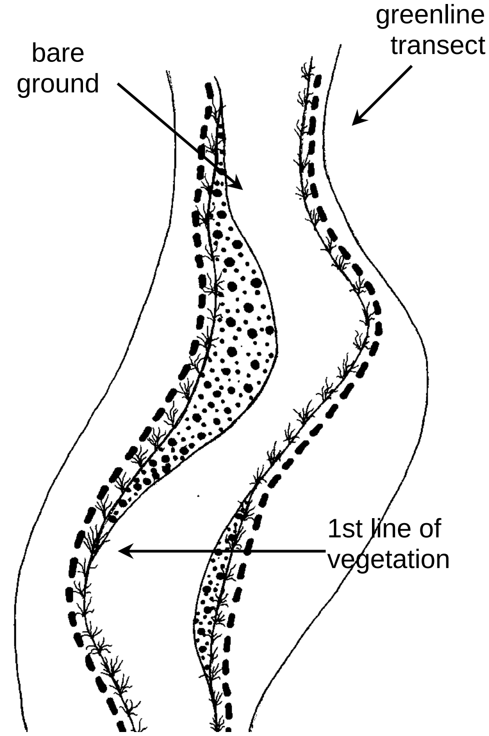
Canopy cover transects

- The canopy cover transect measures the percentage of overhead area covered by leaves or branches. This tells us the amount of shading the stream receives.

- The canopy cover transect runs along the greenline transect and can be measured at the same time. The canopy cover transect will take two students 15 minutes to complete.

- Students can simply look up to determine whether the overhead space is covered or they can use an **ocular tube** for a more precise measurement. One student looks through the tube, pointing it straight up. A second student tells him/her when the tube is vertical, at which time, the observation is made ("covered" or "open"). To make an occular tube refer to the appendix "Make Your Own Monitoring Equipment."

Figure IV-18. The Greenline transect (line of vegetation nearest the stream) as seen from below



Ground cover transects

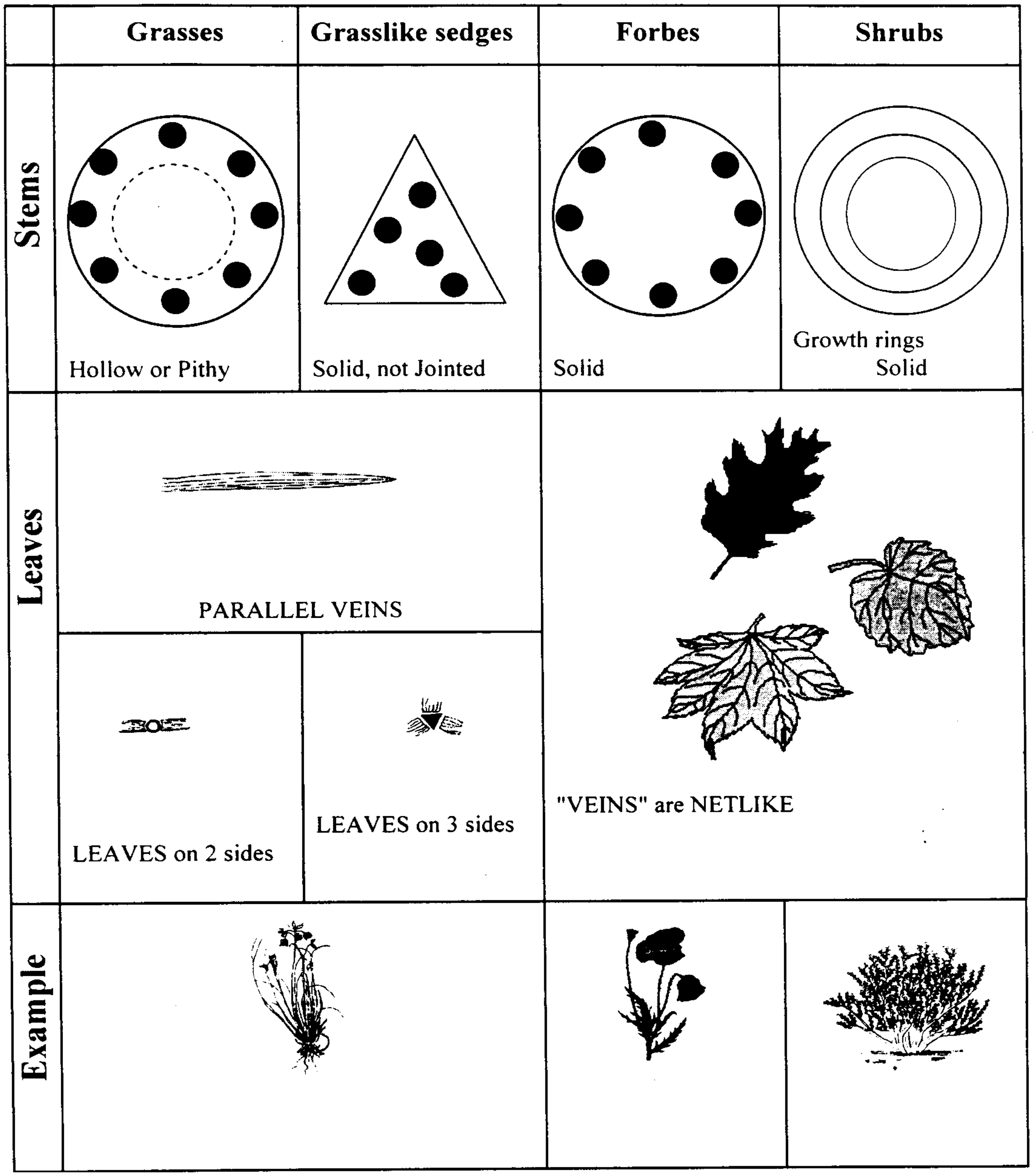
- Measuring ground cover tells us how well the riparian zone prevents erosion and filters runoff before it enters the stream.

- Riparian ground cover transects are set up perpendicular to the greenline. They begin at the stream's edge and extend approximately 30 feet away from the stream. Generally, five transects are run per stream stretch.

- Students count paces to measure the ground cover transect. Along each transect students will record four possible categories: 1) live vegetation; 2) litter (dead plant or tree material); 3) rock; and 4) bare ground. These different cover types provide varying degrees of protection from erosion. The cover type found at each sampling point should be tallied on the data sheet.

- One ground cover transect will take two students 10 minutes to complete (60 minutes to complete all five).

Figure IV-19 Different types of vegetation. Note the differences in stems and leaves.



Grasses – These have hollow stems that are jointed and leaves with parallel veins.
The leaves come off the stem in opposite directions.
Grasslikes sedges – These resemble grasses but they have solid, triangular stems with no joints. The leaves have parallel veins but they come off the stem in three directions. This group also includes rushes which have round, hollow stems with very small or no leaves.
Forbs – These generally have broad leaves with net-like veins. The stems are solid or spongy and they die back to the ground every year.
Shrubs and trees – These have woody stems that remain alive all year. The leaves tend to have net-like veins. Rarely do shrubs grow taller than 13 feet. Trees are similar to shrubs in that they generally have a single woody stem but they grow taller than 13 feet.

How do we interpret our results?

- When interpreting your transect data, remember that a considerable amount of natural variability exists within and between different riparian zones. Not all riparian zones have naturally abundant plant/tree growth. Simply because your study area does not have 100% canopy or ground cover does not necessarily mean that it is unhealthy or that it was impacted by humans.

- To use your transect data to accurately assess riparian zone health you must establish long-term trends. Regular and continual sampling will show if changes are occurring over time. Consult with local land owners, local land management personnel or historic photos to determine past conditions.

Greenline
The higher the greenline score, the better the riparian zone can control erosion and stabilize the bank.

Canopy cover
The greater the percentage of overhead cover, the more shading your stream receives. Shading helps lower water temperature. Overhead material also adds organic matter to the stream which is an important food source for aquatic **macroinvertebrates**.

Ground cover
The materials that comprise riparian zones naturally vary according to their individual watersheds. Riparian zones in the Uinta Mountains may be primarily rock, while lower lying areas may be completely vegetated. As a general rule, though, a healthy riparian zone will be covered by a mixture of litter, rock and vegetation (many desert streams, which have very sandy banks, are an exception). A mixture of cover types is ideal because each provides a different service. Vegetation functions well as a filter and also buffers against erosion. Rock does little to filter erosion but acts as an excellent buffer against erosion. Litter serves both functions.

Resources for further investigation

River Corridors and Wetlands Restoration – Consult this web site if you want to involve your group in a riparian restoration project. It contains information on restoration projects, proposals, ideas, and contacts.
www.epa.gov/owow/wetlands/restore

Enviroscape: Riparian Kit – This plastic waterflow model offers an accompanying activity guide that focuses on the Riparian Zone. Contact : Your local [county] Cooperative Extension Service – or – Utah State University Extension, 1500 N 800 E, ASTE Dept, Utah State University, Logan, UT 84322-2300, (435) 797-3389. www.ext.usu.edu/natres/wq/index.htm. See the "Resources" appendix for ordering information.

Rocky Mountain Flower Finder : A Guide to Wildflowers Found Below Tree Line in the Rocky Mountains by Janet L. Wingate. Publishers - Berkeley : Nature Study Guild, ©1990.
This field guide will help students identify common grasses, plants, shrubs and flowers in Utah. More importantly, it provides easy-to-understand techniques for identifying plant families. This is an excellent guide for student field trips.

Rocky Mountain Tree Finder : A Pocket Manual for Identifying Rocky Mountain Trees by Tom Watts. Publishers – Berkeley: Nature Study Guild, ©1972. This made-for-students field guide makes an excellent compliment to the Rocky Mountain Flower Finder.

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Riparian Zone

Greenline

Time – 30 minutes
Persons – 2
Materials –
- Flagging
- Tape measure
- Riparian Zone Data Collection Sheet
- Plant guide (optional)

NOTE: The "greenline transect" can be done at the same time as the "canopy cover transect." To save time have your directions and data sheets ready for both.

1. Measure a 100 ft stretch along your stream. Place a flag near the water at the beginning and end points.

2. Standing at the first flag, look toward the water. Note the vegetation type that is closest to the water and record it in row (1) of the data sheet.

3. Take one pace toward the other flag and stop. A pace is a normal stride you would take while walking. Look toward the water and record the vegetation type closest to the water.

4. Repeat these steps until you reach the other flag.

5. Add up the total number of steps you took and record in row (2).

6. Sum up all the observations and record in row (3)

7. For each vegetation category, divide the number in row (2) by the number in row (3), multiply by 100 and record in row (4). This will give you the percentage of the greenline that is made up of that vegetation category. For example, if you took 50 steps and found grass at 20 of them then 40% of your greenline consists of grasses.

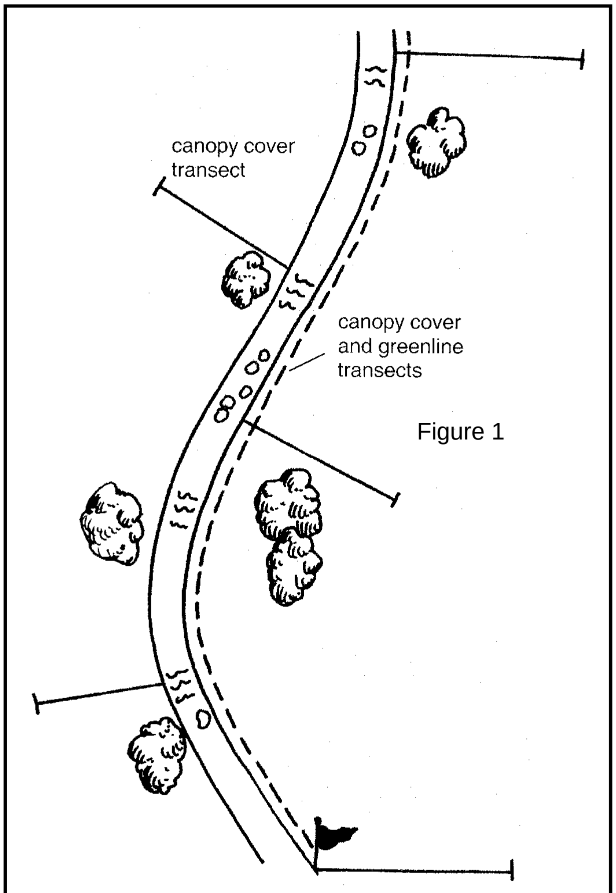
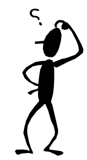


Figure 1

8. For each vegetation category, multiply the number in row (4) by the factor in row (5) and record in row (6). This will give you the "site score" for each vegetation category. Because sedges and rushes have the strongest roots and prevent erosion the best they receive the highest factor - "9." Bare ground doesn't prevent erosion so it receives the lowest factor – "1."

9. Add the individual site scores in row (6) together to get the "total site score" for that stretch of stream.



Canopy Cover

Time – 30 minutes
Persons – 2
Materials –
- ocular tube
- measuring tape
- Riparian Zone Data Collection Sheet

Note: At each point where you record greenline data you will also record canopy cover data.

1. Point the ocular tube straight up in the air (90 degree angle) and look through it with one eye. Your partner who is recording data can help you adjust the tube until it is as straight as possible.
2. Tell the recorder whether the "X" at the end of the tube points at sky (a "miss") or a part of a tree or bush (a "hit"). Record this on your "canopy cover data chart."
3. Repeat these steps for the rest of the greenline.
4. Add up the total hits and misses and record in the second row.
5. Add the two scores recorded in row 2. This will tell you the "total number of steps" you took along the transect (the greenline). Record this total in row 3.
6. Divide the number of "hits" in row 2 by the total observations in row 3 and multiply by 100. This will give you the percent canopy cover for the transect.

Ground Cover

Time – 35 minutes
Persons – 2
Materials –
- Measuring tape
- Riparian Zone Data Collection Sheet

Note: Riparian ground cover transects start at the stream edge and extend 15 paces away from the stream, into the riparian vegetation. A pace is a normal stride you would take while walking.

1. You will collect data along five separate transects in your stream stretch, spaced out at approximately equal distances along your stream reach. If possible, you should run two transects on one side of the stream and three on the other to get a better picture of the total riparian zone. Refer to the figure on page 1 of these instructions for help locating these transects.
2. Starting at the stream's edge take one pace away from the stream. Touch your finger to the ground at the tip of your front foot.
3. Note the ground cover type that your finger touches. The categories are: bare ground, live vegetation, litter (dead vegetation or sticks) or rock. Record the type with a slash in the appropriate box on the "ground cover data chart." Note that each column on the data chart is for a separate transect.
4. Repeat steps 2 – 3 for 15 paces. Then move on to the second transect. Repeat.
5. When you've finished with all five transects, add the totals for each row or cover type. Record your totals for each ground cover category in the category total column. In the next column, divide the categoy total by 75 (your total number of steps) and multiply by 100. This will give you a percentage of ground cover for each type in the riparian zone. To check your math, add up your percentages for each ground cover type. They should total 100%.

* The percentage of each ground cover type provides a measure of ground cover that can be compared to other sites or to compare changes over time (between different years or seasons). As a general rule, though, a healthy riparian zone will be covered by a mixture of litter, rock and vegetation. An important exception to this are desert streams, which have very sandy banks.

Greenline

	Vegetation Categories				
	Deep Rooted Plants		Shallow Rooted Plants		
	Sedges and Rushes	Shrubs and Trees	Grasses	Forbes	Bare Ground
Row 1: Record each observation as a slash mark in the appropriate box.					
Row 2: Total # of observations for each category					
Row 3: Total number of observations for the entire greenline (sum of all observations in Row 2):					
Row 4: % of each category (divide row 2 values by total in row 3. Multiply by 100)					
Row 5: Multiply each value in row 4 by this factor.	X 9	X 8	X 6	X 3	X 1
Row 6: Site score for each category					

Total Site Score (add up all site scores in Row 6)**:**____________________

The higher your score the stronger your plant roots are and the more your stream banks will resist erosion.

Notes:

Canopy cover

	"Miss" (Open sky)	"Hit" (Vegetation)
At each step along green line, record with a slash whether you see a "miss" (open sky) or a "hit" (vegetation) in your ocular tube.		
Total # of slash marks for each category		
Total number of observations		
% Canopy cover: Divide total "hits" by total observations and multiply by 100		

The more "covered" area you have the more shading your stream receives (this keeps the water cool and provides food for aquatic organisms).

Ground cover

	Transects Perpendicular to the Greenline						
	1	2	3	4	5	Category Total	**Percent of each category** (divide category total by 75 and multiply by 100)
Live vegetation							
Litter							
Rocks							
Bare ground							