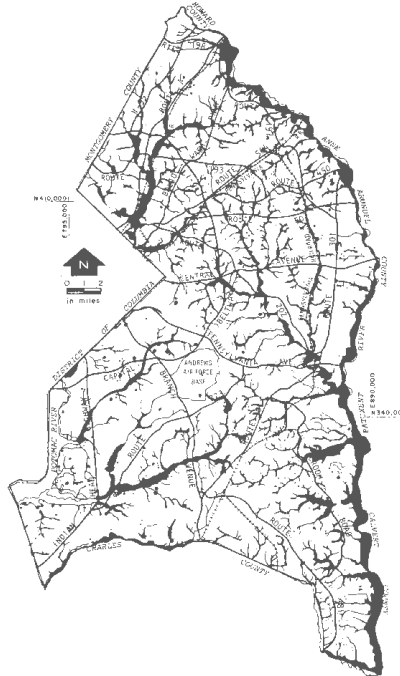


The Stream in Your Backyard: Water Quality, Hydrology, and Field Observations



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THE STREAM IN YOUR BACKYARD: WATER QUALITY

Let's start out by exploring some water quality issues and measurements in the classroom.

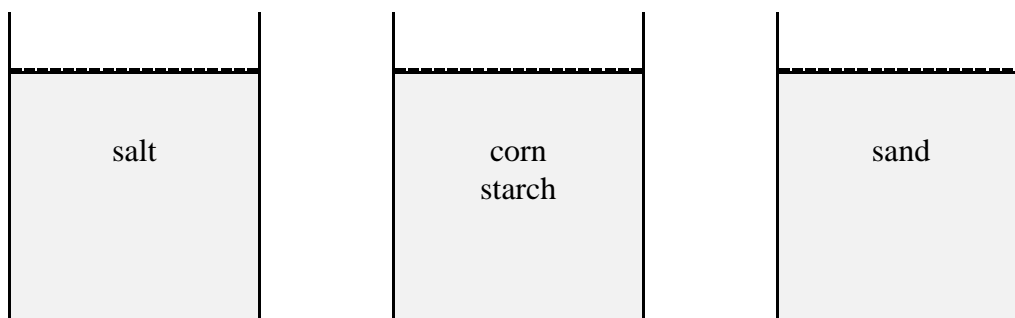
ACTIVITY 1- Let's Settle It: Dissolved or Suspended?

This activity distinguishes the difference between dissolved load and suspended load in stream water, and how particle size influences suspension.

Materials Needed:

- table salt (Kosher--pure, no additives)
- cornstarch
- sand
- 3 clear glass or plastic containers (same size)

In each container, add a spoon of salt, cornstarch, or sand. Fill to three-quarters with water, then mix. Make sure salt is totally dissolved.



Observe each container. Record what you see initially after mixing, at 30 minutes, and 24 hours later.

Collecting the dissolved load and suspended load from a stream is done by different techniques. The suspended load can be collected by filtration. Pour the sand/water mixture through a piece of cloth. Record your observation. Now pour the salt/water mixture through another piece of cloth. What happened?

Allow the salt/water mixture to sit in a warm place and evaporate (use a hotplate if one is available). What do you find when all the water is gone?

Allow students to feel the cornstarch and sand. What can you conclude about particle size and settling rate?

ACTIVITY 2- Is It Settled or Not?: Adsorption

This activity demonstrates the process of adsorption. **Adsorption** is the collection of a substance on the surface of fine particles. This is very important in the aquatic environment, as many dissolved substances can be adsorbed onto suspended sediment, especially clay particles. The suspended sediment can settle out and be buried, or adsorbed substances can be desorbed (removed from the surface, back into solution) due to a change in chemical environment, such as increased salinity, during transport of the suspended sediment. Adsorption changes the mode of transport of a substance.

Material Needed:

- food color (grocery store)
- activated charcoal (fish tank filter/pet supply store)
- clear plastic or glass jars with lids- 3
- acetone-based nail polish remover

On and off the particles!:

Place an equal volume of water into two jars. Add one drop of food color to each glass and stir. **The food color is the dissolved substance.**

To one of the jars of colored water add a spoonful of activated charcoal. **The charcoal is the suspended sediment.** Gently stir both jars of colored water. Cover with lids and allow both jars to sit undisturbed.

Record any differences or changes you observe when the charcoal is added.

After the charcoal has settled to the bottom, observe the water in the jar. The charcoal may take a while to settle. Why? Where is the food coloring?

Pour the water off and place the charcoal into a glass jar. Add a small volume of clear nail polish remover. What happens and why? Nail polish remover desorbs food coloring from the activated charcoal.

Streams transport their load in three ways:

1. in solution (dissolved ions or molecules)- **dissolved load**
2. in suspension (fine sand/silt/clay)- **suspended load**
3. along the bottom of the channel (sand/gravel)- **bed load**

8	dissolved load
water column	suspended load
9	bed load (movement along bottom)
bottom sediment	

The dissolved load of a stream is contributed by the following sources: rock weathering (breakdown of rock); industrial wastes; landfills; fertilizers (both agricultural and residential); wastewater (sewage) treatment plants, especially nitrogen and phosphorus (N/P) if no advanced treatment; and acid rain, especially nitrogen (as nitrate). The dissolved material can remain dissolved and be transported to the Chesapeake Bay or it can be adsorbed onto suspended particles then deposited when the stream flows into a larger body of water. Dissolved material, especially nutrients, can be removed by biological processes (in water column or on the bottom) and accumulate in organisms.

Suspended load is contributed by erosion of surrounding land (soil), especially with clearing for development and agriculture or stream banks (sediment), and by biologically produced material (usually minor source in streams). The fate of suspended load includes deposition which causes siltation problems in rivers or channels which may require dredging to remove sediment for shipping, especially in Baltimore Harbor. A number of colonial ports in Maryland where channels have been filled with sediment (siltation due mainly to agricultural land clearing) are given in the table below:

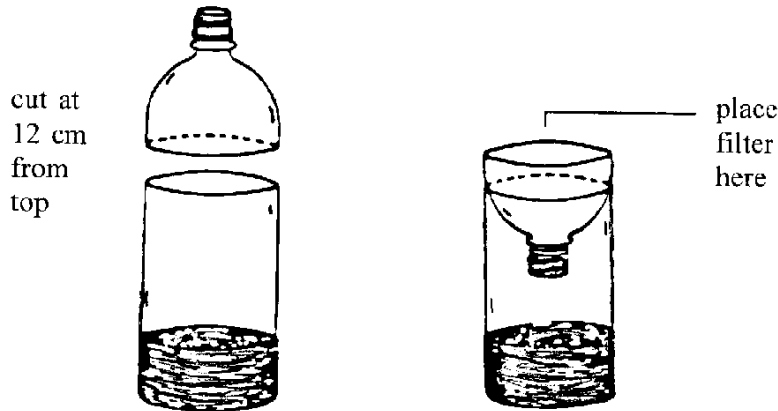
Town	River
Joppa Town	Gunpowder Falls
Elk Ridge Landing	Patapsco (Baltimore Harbor)
Bladensburg	Anacostia (Eastern Branch)
Upper Marlboro	Patuxent
Port Tobacco	Potomac

Measurement of Dissolved and Suspended Loads:

Suspended sediment is collected by filtration of a water sample. The filtered water can then be used to determine total dissolved solids (TDS). TDS is determined by evaporating the water and measuring the amount of residue remaining. Activity 4 will require a milligram balance for quantitative results.

ACTIVITY 3- Making Simple Apparatus for Determining Suspended Sediment and Total Dissolved Solids

Obtain a plastic 2-liter soda bottle and cut the top section off. Cut about 12 centimeters down from the cap.



Invert the top section (with the cap removed) and place it into the bottom section.

Place coffee filter (doubled) into the inverted top section. Push the filters into the funnel.

Collect a liter of stream water using a 1-liter soda bottle (mark the 1-liter level on the bottle before removing the soda).

Slowly pour water to wet the filter, especially the sides (so filter sticks to walls). Once wet, filter at a faster pace. After you have filtered a sample of stream water, you can measure the suspended solids from the sediment-covered filter paper and the total dissolved solids from the filtrate (filtered water in bottom section).

ACTIVITY 4- Making Stream Load Measurements

This activity determines the total dissolved solids content and suspended sediment content of a stream water sample. Both measurements can indicate the health of a stream. Too much suspended sediment can block sunlight and destroy plant life. Dissolved solids, especially when they consist of nitrates and phosphates, can produce high levels of nutrients leading to excessive algae growth.

Collect samples of water from a local stream (try to get samples before and soon after a storm event or at varying degrees of flow rate)

I. Determining Suspended Solids:

1. Pour a measured volume of water into a pre-massed coffee filter and allow water to drain through (collect filtrate for next part).
2. Allow the coffee filter with sediment to dry, then mass it.
3. Calculate the suspended sediment concentration:

mass of suspended sediment _____

volume of water poured through filter _____

mg sediment/ L (water) _____

II. Determining Total Dissolved Solids:

1. Place a measured volume of the filtered water (no suspended sediment) into a pre-massed evaporating dish. Heat to dryness (oven at 105°C or a hot plate set on low).
2. Allow dish to cool, then mass residue (salts).
3. Calculate the total dissolved solids (TDS) concentration:

mass of residue _____

volume of water _____

mg TDS/ L (water) _____

ACTIVITY 5- Neighborhood Lawn Fertilizer Survey

This activity considers the contribution of nutrients from fertilizer use by home owners through stormwater runoff to streams.

Have students survey their neighborhood. Draw a map of the area showing the properties and streets. Consider the following questions in the survey:

1. Do you apply lawn fertilizers or any other chemical?
2. If so, how often and at what times of the year?
3. Ask if the property owners knows where any of their yard runoff drains.
4. Find the nearest stormwater drain to each property.
5. Can you find the nearest stream where the stormwater from your neighborhood drains? Trace the general path of stormwater on your map. Remember that water flows downhill!!!
6. Many communities have their storm drains labeled with "DO NOT DUMP CHESAPEAKE BAY DRAINAGE." Why? Where is all the excess lawn fertilizer going?
7. Some new housing developments have their stormwater runoff drain into stormwater collection ponds which then drain into a stream. If so, what color is the pond water? See the next section for explanation.

Water Quality- from Eye-Ball to Chemical Tests:

The health of a stream can be determined by a number of methods that judge water quality.

1. The eye-ball as a monitoring tool.

A number of simple observations can be made by just looking at the color and clarity of stream or pond water. The observations are listed below and an explanation follows.

ACTIVITY 6- Water Quality Monitoring Using Your Eye-ball

Make the following observations:

Measurement	Observation
clarity/turbidity (cloudiness) Can you see the bottom? clearly?	
color of water	
smell? (use your nose!!!!)	
surface sheen?	
any organisms visible?	

Have students monitor different streams in your area. Make regular observations, especially after storm events. Is there any new development occurring in the stream watershed?

Turbidity is the amount of suspended material in the water column. As turbidity increases the following occurs:

- ! cloudiness of the water increases;
- ! the clarity of the water decreases;
- ! the amount of light penetration for photosynthesis decreases.

Turbidity is caused by sediment (mainly clay-sized particles), which is supplied by soil erosion of the surrounding land and/or bank erosion of floodplain sediments, and/or algae which live in the water. Since streams transport more suspended sediments during high flow events, turbidity increases dramatically.

Some causes of different colors of streams and ponds are given in the table below. A sheen is the color of the surface.

Colors of Streams and Ponds

Color	Possible Cause
cloudy brown	sediment or soil
cloudy green	algae
multicolored sheen (rainbow)	oil
green sheen- almost metallic	bacteria
yellow sheen in spring	pollen
dull chocolate brown sheen	decaying vegetation

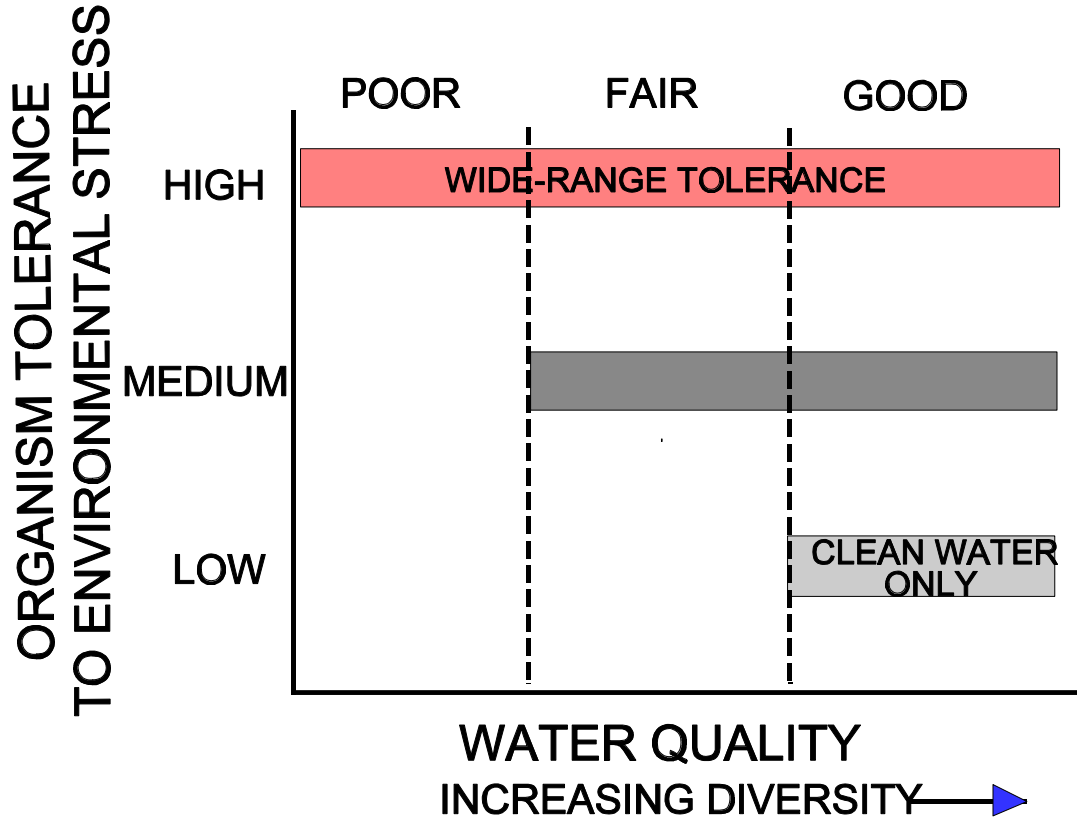
Organisms, especially the macroinvertebrates living in the sediment, can actually be used to determine the overall health of a stream. Fish are usually a good sign of a healthy stream.

2. Macroinvertebrates- the large invertebrates that live in the bottom sediment.

See Stream-Walking in SIMBY pp. 22-32. This is a modified version of an activity produced by Save Our Streams. You will make the collection equipment and collect, identify, and determine water quality from the organisms found in the bottom sediment.

See figure below for the general interpretation based on the tolerance to environmental conditions using macroinvertebrates in bottom sediments (gravel).

**JUDGING WATER QUALITY USING
MACROINVERTEBRATE ORGANISMS
IN BOTTOM SEDIMENTS.**



3. Chemical Tests-

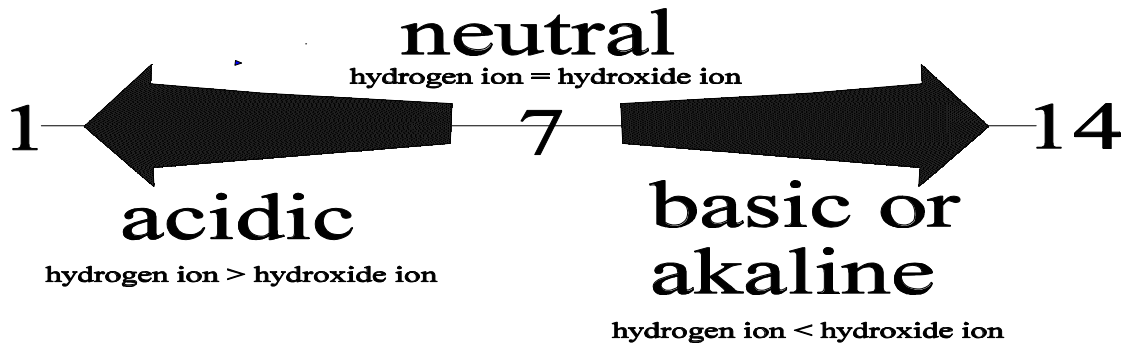
The easiest to use and least expensive test kits are available from LaMotte Company. Buy direct (its cheaper) not through another company!

If you want to put together your own kits follow the procedures given in Standard Methods for the Examination of Water and Wastewater available in most large libraries.

Water Quality Parameters:

1. pH- a measure of acidity or amount of hydrogen ion

A scale of 1 to 14 is commonly used:



Some common pH of solutions:

! normal rain	5.5-6.5	(due to dissolved carbon dioxide- CO ₂)
! acid rain	< 5	(due to dissolved sulfur dioxide, SO ₂ , and oxides of nitrogen, NO and NO ₂)
! freshwater streams	< 7	
! seawater	8.1	
! mean of Adirondack lakes in 1930s	6.6	
! mean of Adirondack lakes in 1975	4.8	
! lowest rain	1.5	Wheeling, VA
! mean of fogs in Vermont's Green Mtns.	3.5	
! lowest fog	1.6	California

Bass and trout begin to die at pH of 5.8.

Pike, perch, suckers begin to die at pH of 5.3. (fish eggs die)

All fish dead at pH of 4.5

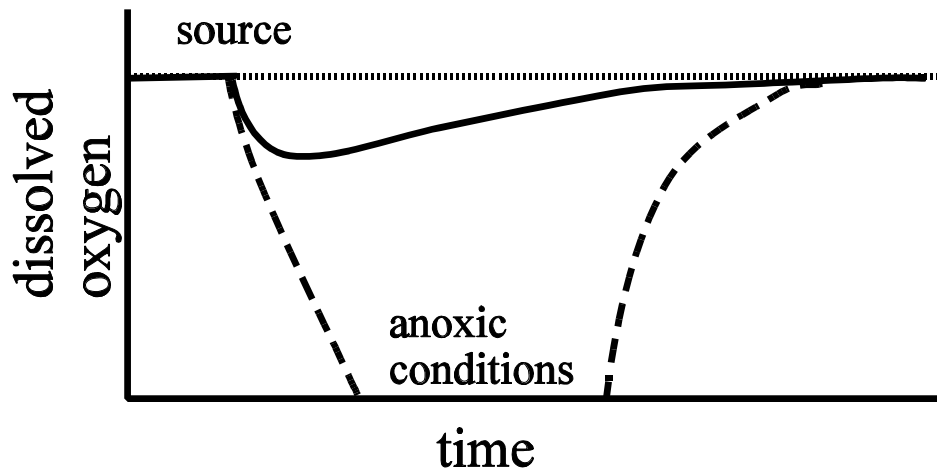
2. Dissolved Oxygen (DO)- amount of oxygen gas, O_2 , dissolved in water

DO decreases as temperature increases (gases are more soluble in cold water)

salinity (salt content) causes DO levels to decrease

organic wastes (raw sewage, industrial waste) lower dissolved oxygen by reacting with it

The graph above illustrates an oxygen sag curve, which shows oxygen demand for waste or source of pollution.



3. Total Dissolved Solids (TDS)

total amount of dissolved ions (salts such as sodium chloride from seawater, calcium chloride from de-icing) and organic molecules in a water sample

determined by evaporation of water after suspended solids are removed

determined by conductivity measurements since most dissolved solids are ions (relationship used to convert to TDS)

as TDS increases, so does conductivity

4. Suspended Solids

total amount of sediment (silt/clay or mud) carried in suspension in a water sample

the amount of suspended sediment increases as stream flow velocity increases-during major storms or floods

determined by filtration

5. Turbidity (cloudiness)

the reduction of transparency of water due to the scattering and absorbing effect of light by suspended particles

turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms

measurement by comparison to standard solution of known turbidity or depth of light penetration using a Secchi disk

6. Nitrate (NO_3^-)

an important nutrient for microorganisms in streams with sewage or animal waste being the major source

fertilizers from farmland may also be a source

contributed by acid rain from airshed

7. Phosphate (PO_4^{-3})

an important nutrient for microorganisms in streams with sewage or animal waste being the major source

fertilizers from farmland may also be a source

phosphate rock can be a source (not in this area)

The table below gives typical levels of some major water quality parameters.

Significant Levels of Water Quality Parameters

Parameter	Level	Comments
dissolved oxygen	1-2 mg/L	will not support fish
	<3 mg/L	stressful to most aquatic organisms
	5-6 mg/L	usually required for growth and activity
nitrate (as NO_3^- -N)	<1 mg/L	unpolluted water
	>10 mg/L	unsafe for drinking water
phosphate	>0.03 mg/L	contributes to increased plant growth (natural eutrophication)
	>0.1 mg/L	cultural eutrophication
turbidity	Secchi depth >1 m	favors SAV growth
	high values	can damage gills and interfere with ability of fish to find food
pH	6.5-8.2	optimal for most organisms
total dissolved solids (TDS)	<10 mg/L	rainwater
	<500 mg/L	municipal water systems
	100-2000 mg/L	rivers
	35,000 mg/L	seawater

From: The Monitor's Handbook, LaMotte Co. (1992)

THE STREAM IN YOUR BACKYARD: FIELD HYDROLOGY

After a big storm, what do you notice about your local stream? Think about color and level of water.

Let's explore some characteristics of streams and their channels, the flowing water, and the health of streams.

Channel Dynamics:

Walk along a section of the stream and make the following observations:

Notice the shape of the stream channels as you walk along the stream. Is it straight or curved? Make a simple drawing.

What direction is the water flowing? How did you tell?

Is the water depth constant or does it change along the channel? Note any deeper water areas on your drawing above.

What type of sediment occupies the majority of the channel bottom? Use the sediment names given in the table below.

Sediment	Particle Size	"Look and Feel"
gravel	> 2 mm	good size
sand	0.063-2 mm	gritty/can see grains
mud	< 0.063 mm	slippery/little grit/can't see grains

Do you find other types of sediment in certain places? Note where you find them.

Where do you think the sediments came from?

What is the purpose of the black silt fencing found around construction sites?

Find an area with a good bend in the channel of the stream. This is called a **meander bend**.

Where does erosion appear to be occurring? What evidence led you to this?

Where does deposition appear to be occurring? What evidence led you to this?

Where is the deepest water in the channel of the meander?

Compare this to a straight section of stream channel.

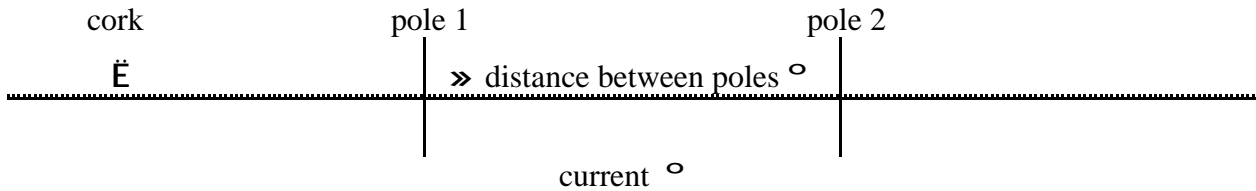
Can you find any man-made structures to prevent erosion along the stream?

When do you think most stream erosion occurs?

Stream Velocity:

Now let's measure the velocity or speed of the water flowing in the channel.

In a straight section of the stream, place the two poles a known distance apart.



Distance (in meters) between poles: _____

Release a cork at a point slightly upstream from pole 1.

Measure the time it takes for the cork to travel between pole 1 and pole 2. Repeat two more times. Record the data in the table below.

Trial	Time (seconds)
1	
2	
3	

Calculate the average time: _____

Calculate the velocity by using the following formula:

$$\text{velocity} = \frac{\text{distance}}{\text{average time}}$$

The stream velocity determined today is _____.

Now let's do some observations regarding velocities around a meander bend in the stream. Release two corks at the same time, one on the inside of the bend and one on the outside.

Which cork traveled the greater distance in a specific amount of time? Can you explain why?

Can you relate this to the erosion and deposition patterns seen earlier?

Now find a straight section of the channel where it becomes restricted (wide to narrow).

What do you observe about the velocity of the water?

What type of sediment do you find in the wide channel? in the narrow channel? Explain.

Can you find any deep pools along the channel? How does the water's velocity compare to the shallow parts of the channel? What type of sediment is in the bottom of the pools? Explain.

Stream Health:

Every stream in Prince George's County is part of the Chesapeake Bay watershed. The water in your backyard stream eventually flows into the Chesapeake Bay.

With a county map, can you trace the path the water takes from your stream to the Bay?

Can you find any evidence of pollution by man in the stream? List any evidence found.

Can you find any stormwater outflows (pipes)? They deliver water collected on streets and parking lots to the stream.

As more housing developments, shopping centers, and office complexes are built, new streets and more parking lots are also constructed. What happens to all the stormwater collected from these new areas? Where did the water go before all these items were constructed?

Never dispose of waste motor oil or antifreeze into a storm drain. Why?

The overall health of the stream can be determined from some simple water quality measurements. Make the following observations:

Measurement	Observation
clarity/turbidity (cloudiness) Can you see the bottom? clearly?	
color of water	
smell?	
surface sheen?	
any organisms visible?	

For small streams the largest source of nutrients for the photosynthetic organisms, such as algae, is leaf litter (decaying vegetation). Can you find any? Where did you look?

After being in the stream for parts of this activity, did you notice any change in water clarity? What happened? What does a storm do to water clarity? Why?

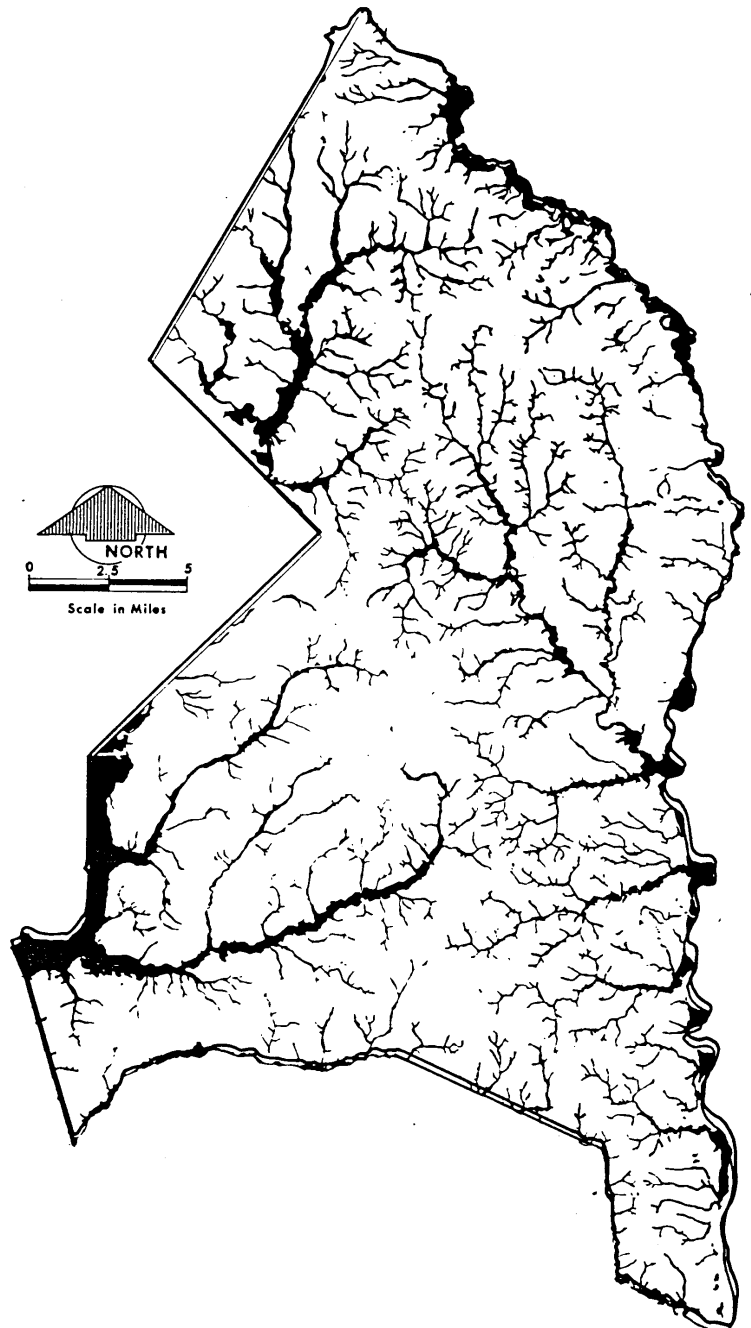
If turbidity is very high in a stream, can algae that grow on the stream bottom survive? Why or why not?

Stream Hydrology

Streams are the major erosional force altering the surface of the Earth and are also the major transporting agent for moving sediment. Erosion increases with increasing stream velocity or flow such as during storms or flood events. Clay and silt (mud) are transported as suspended load while sand and gravel (only at very high velocity) are transported as bed load (move along the bottom by either skipping/hopping or rolling/sliding).

In Prince George's County, all stream drainage flows into the Patuxent or Potomac Rivers which then flow into the Chesapeake Bay. A flood plain map of the major streams and their tributaries shows the drainage to either the Patuxent River to the east or the Potomac River to the west. The topographic high that separates them is called the **drainage divide**.

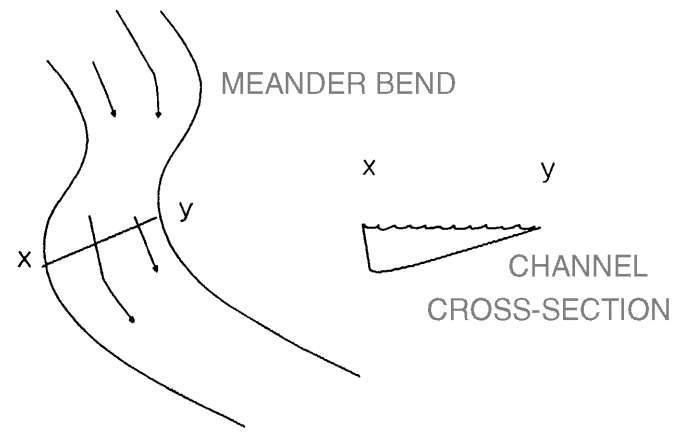
The **floodplain** is the relatively flat area adjacent to the stream, where flood waters run over and deposit sediment. Most streams in the County are meandering streams, they wind back and forth across the flood plain.



Floodplain Map of Prince George's County showing drainage to Patuxent and Potomac Watersheds

Can you locate the drainage divide?

The figure below illustrates the characteristics of a meandering stream.



1. Flow velocity is greatest on the outside of a meander bend (longer arrow)
2. EROSION occurs on the outside (deeper water) of a meander bend, cuts stream bank at point x
3. DEPOSITION occurs on the inside (shallow water) of a meander bend, slightly offshore from point y (in the water)

Here are some aspects of stormwater management. With increasing development in PG County, more and more stormwater is directed into streams. The land developed is covered by buildings, parking lots, and roads, which all decrease the ability of stormwater to infiltrate the ground (soaked up by soil). This increased runoff carries numerous materials into streams and is the cause of flash flooding in streams (rapid volume increases).

In new housing developments and business parks, it is common to find a lake constructed near by. These are **stormwater holding ponds**. They collect the stormwater quickly, allow it to infiltrate while in the pond, and slowly deliver it to a stream. The ponds are an attempt to reduce flash flooding and the amount of suspended sediment delivered to streams. You will notice most of these ponds are cloudy and brown due to the large amount of suspended sediment in the water.

Stormwater is an increasing source of contamination to streams. Remember what goes down a storm drain flows into the Chesapeake Bay. Think about all the excess, overapplied lawn chemicals and where they go!

More about this when we cover urban streams later.

Extension Activity- Stream Scavenger Hunt

The objective of this exercise is identification and observation. You will need marker flags (different colors for each group) to mark the features found along the stream. Hit the stream and start looking. Mark your items with a flag as found.

List of possible items:

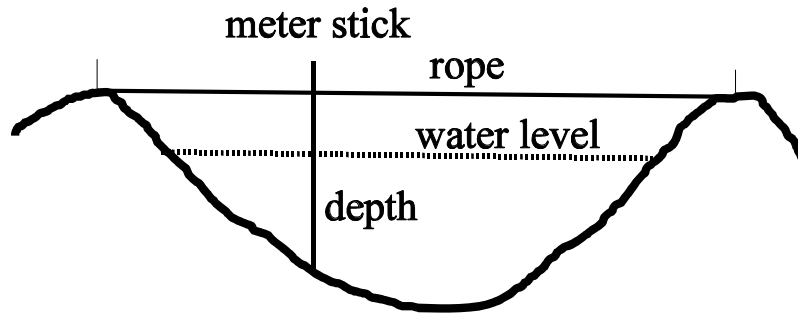
gravel	sand
mud	erosional feature (undercut bank)
ripple marks	man-made structures (for erosion control)
algae	fish (hard to mark!)
macroinvertebrates (in sediments)	deep water
shallow water	tributary to main stream
fossils	trash

THE STREAM IN YOUR BACKYARD: ADVANCED FIELD HYDROLOGY

Stream discharge is the volume of water passing a point per unit of time, typical metric units are cubic meters per second. Two basic measurements in a stream are required to determine the discharge: stream velocity (from page 16) and the cross-sectional area of the stream channel. Find a relatively straight section of stream channel to perform the following measurements.

Determination of the Stream Profile:

1. Place a rope (marked in 0.25 meters) across the channel at or near the water's surface.



2. Using a meter stick measure the depth from the surface of the water to the bottom. Make depth measurements every 0.25 m across the stream.
3. Using graph paper plot the profile. The y-axis will be distance across in meters. The x-axis will be depth in centimeters for small streams (plot down, negative direction). Your profile should look like the water in the channel as shown in the figure above.
4. Estimate the cross-sectional area (A) of the water flowing in the channel. Since most cross-sections will be irregular, approximate the area by one of the following methods:
 - a. Area can be approximated by mass (need a milligram balance). Cut a known area (scaled the same as the profile) out of the graph paper, determine its mass. Cut the stream profile out, determine its mass.

$$\frac{\text{area known}}{\text{mass known}} = \frac{\text{area profile}}{\text{mass profile}}$$

- b. Estimate the area by counting small squares on the graph paper. Remember to multiply by the actual area of a block based on the scale set on the plot.
- c. Divide the stream profile into measurable rectangles and triangles, calculate their areas, and add together.

- d. Average your depth data for the entire profile and simplify the cross-section as one rectangle. Show the average depth as a straight line on the profile to see how it approximates the total area.

Calculation of Discharge or Flow Rate:

Discharge (m^3/s) is calculated by multiplying the velocity (m/s) by the cross-sectional area (m^2).

$$\text{Discharge} = Q = A \times v$$

The velocity from page 16 is the surface velocity. The average velocity of the stream is slightly lower than the surface velocity.

$$v_{\text{average}} = 0.85v_{\text{surface}}$$

Discharge of the stream today is _____ m^3/sec .

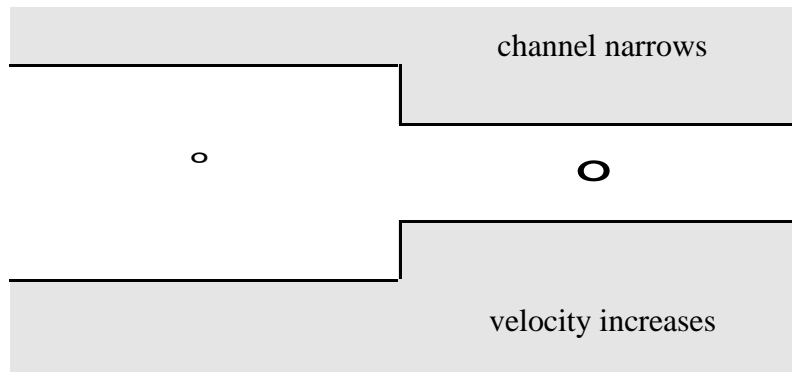
Why Doesn't the Water Pile Up?

Walk along a straight section of stream channel, what do you notice about the velocity of the water in the channel? Is the water constantly moving at the same velocity? Sketch the view (cross-section or aerial) of the channel.

The velocity of water will change as the channel morphology (shape) changes. The amount of water passing any point in the channel must always be the same or the water level would rise or drop. Mathematically this can be stated:

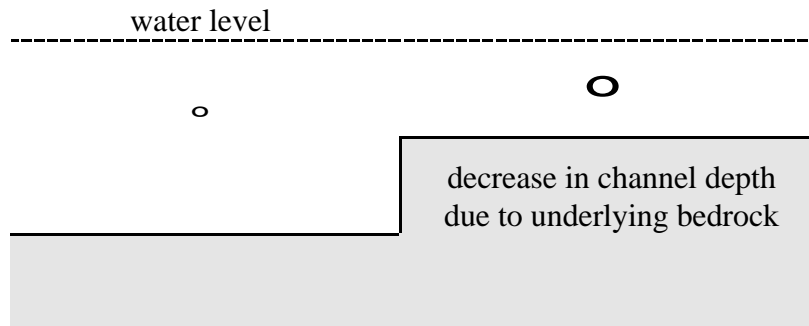
$$Q_1 = Q_2 \quad \text{or} \quad A_1v_1 = A_2v_2$$

Channel width narrows without depth changing (aerial view):



The increased velocity (larger arrow) in the narrow channel will cause erosion especially of fine sediment and possibly deepening of the channel. Only coarse sediment will occupy the narrow channel.

Channel depth changes without channel width changing (side view):



The velocity increases (larger arrow) as the water flows in the shallow area. An area of rapids form on large streams, while in small streams this is called a riffle.

In both cases illustrated above, the same stream discharge, volume of water per second (m^3/sec), must pass through the narrow (shallow) and wide (deep) sections of the stream. Discharge (Q) is determined by cross-sectional area (A) of the channel times the flow velocity (v). Thus if the channel cross-sectional area decreases (increases), the velocity must increase (decrease).