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.

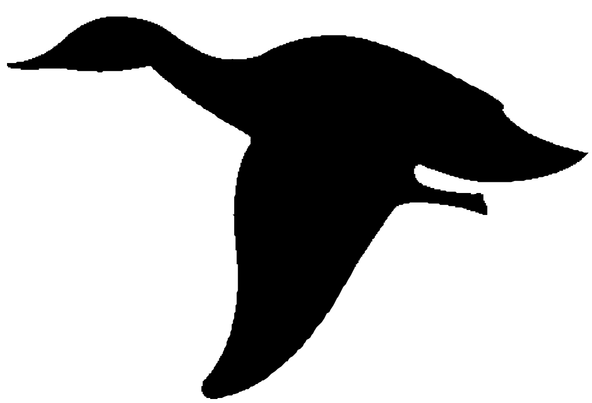
You can also combine your physical monitoring findings with what you have learned about watersheds and the water cycle to determine what influences humans are having on your stream.

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.

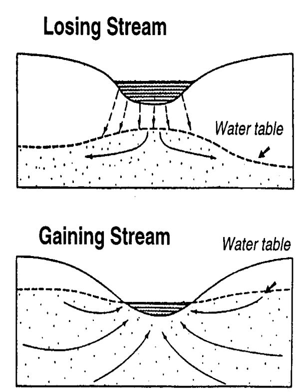
Friction

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."



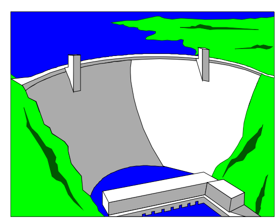
Vegetation

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.

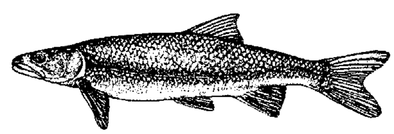
- High-velocity streams are more erosive and suspend sediments for a longer time, leading to greater turbidity.
- Turbulent, fast-moving streams are better aerated and therefore have higher concentrations of dissolved oxygen.
- Greater volume maintains cooler temperatures.

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)

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.

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.

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 total amount 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

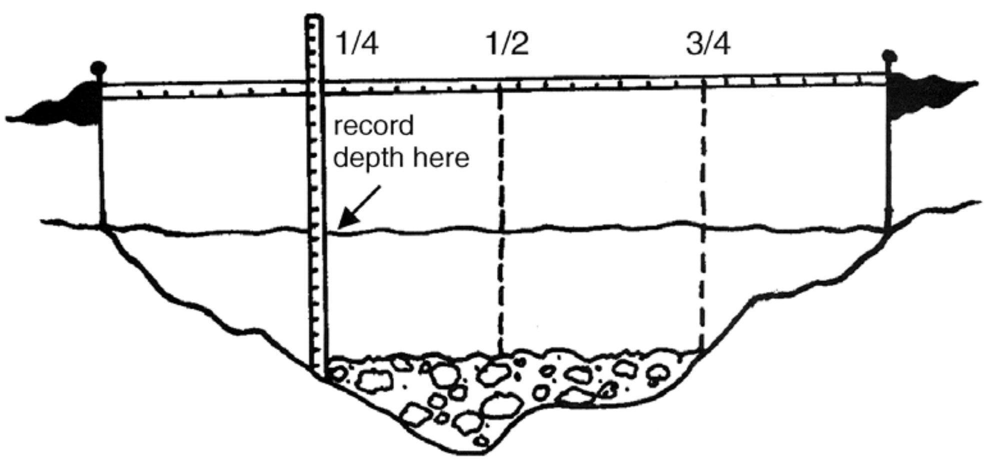
STOP If your stream is too deep to wade into disregard the following directions. You can obtain accurate, up-to-the-hour data from the US Geological Survey – www.ga.water.usgs.gov

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.

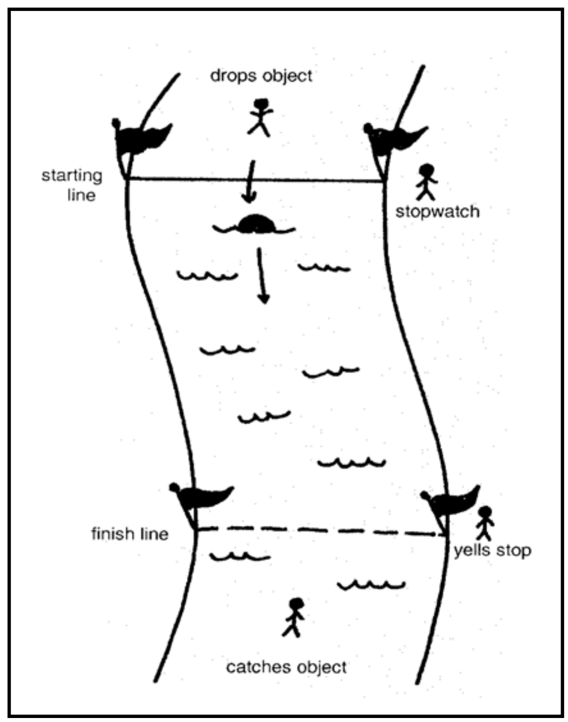


Illustration: Holly Broome-Hyer Figure IV-3

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.

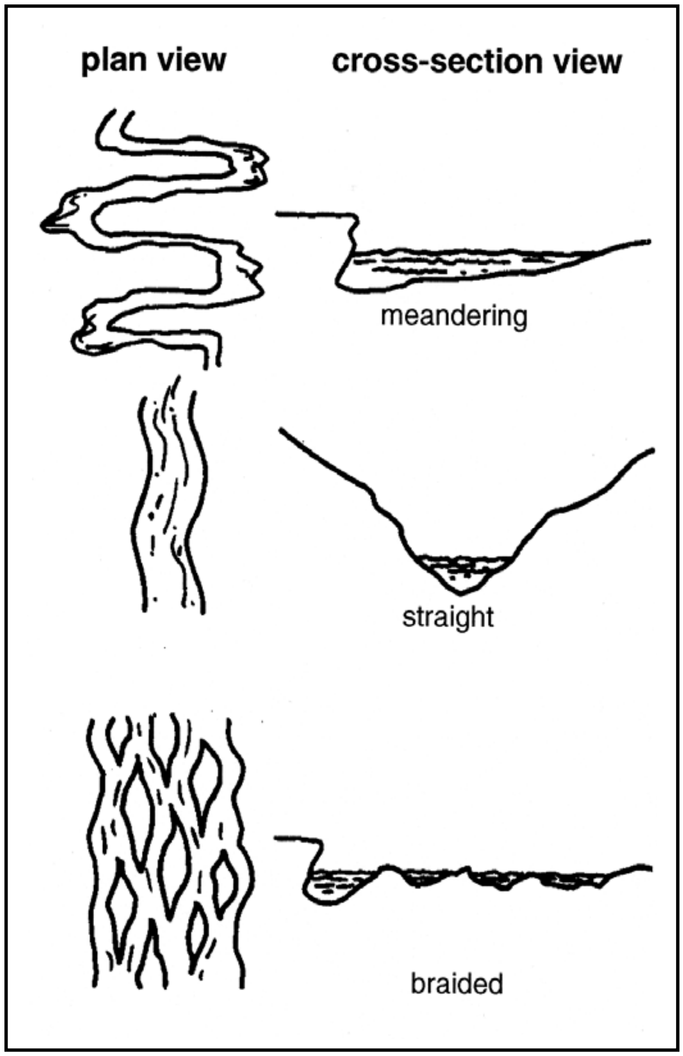


Figure IV-2. Different Stream Channel Shapes. (Plan view is a view from above).

Erosion and Deposition

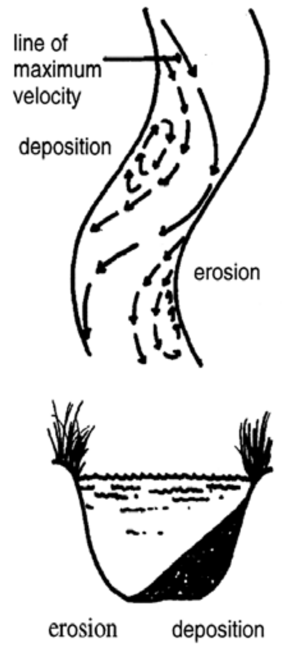
The processes of **erosion** and **deposition** cause stream channels to constantly change.

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 <u>hydrophilic</u>, 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

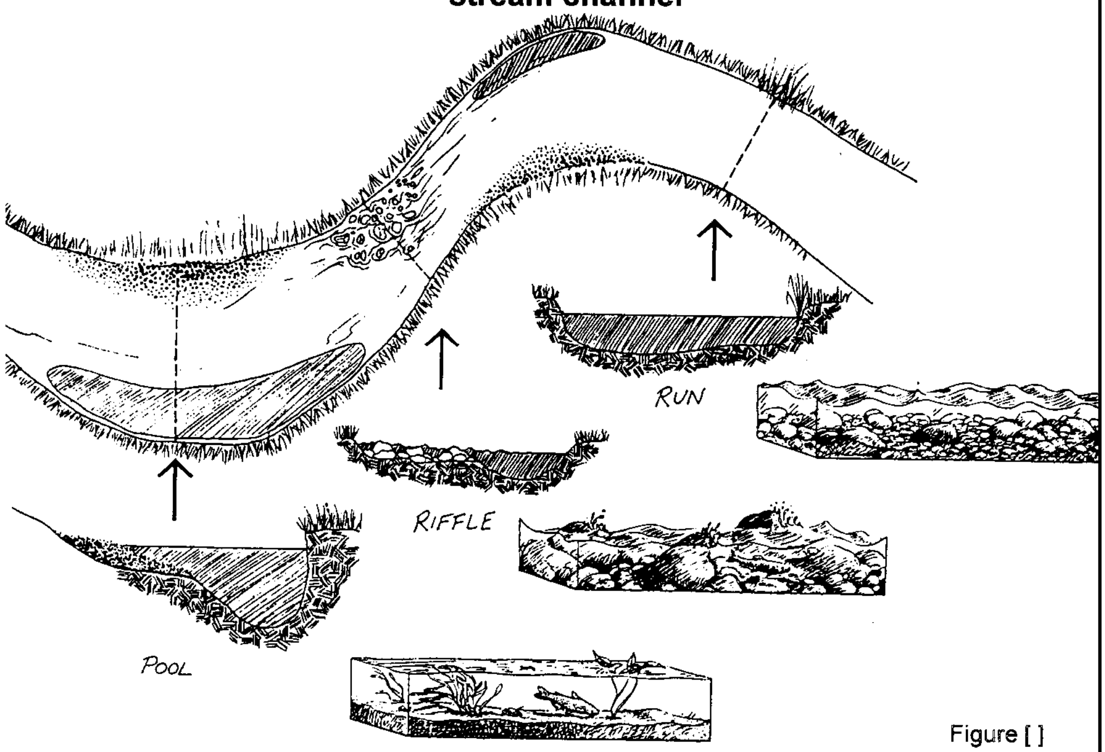


Figure [ ]

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.

Bedrock (solid rock)

Boulder >12" (anything larger than a volleyball)

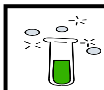
Cobble 3–12" (golf ball to volleyball size)

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)

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

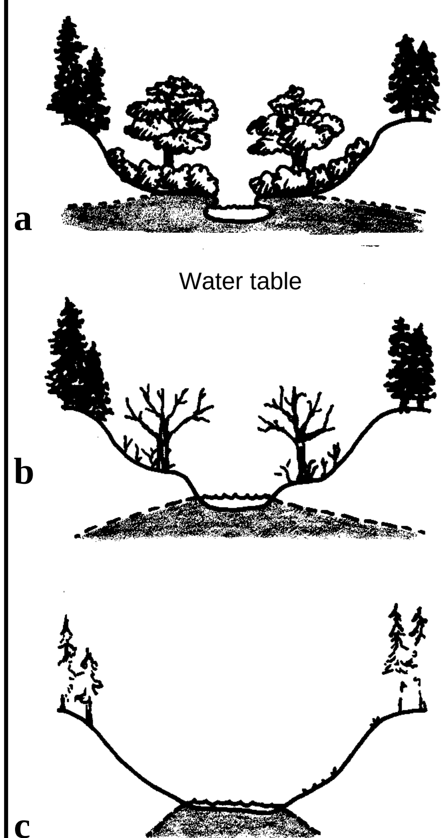


Illustration: Holly Broome-Hyer

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.

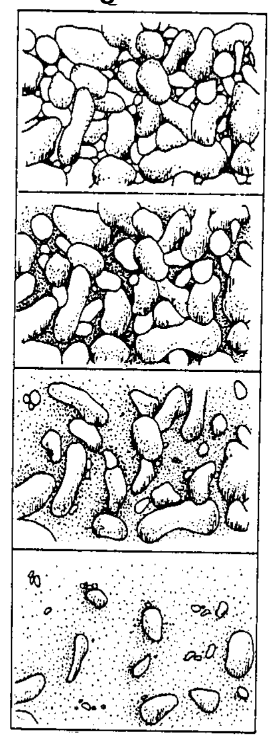
Channel Patterns

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

Stream Channel Reference Sites: An Illustrated Guide to Field Techniques 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.

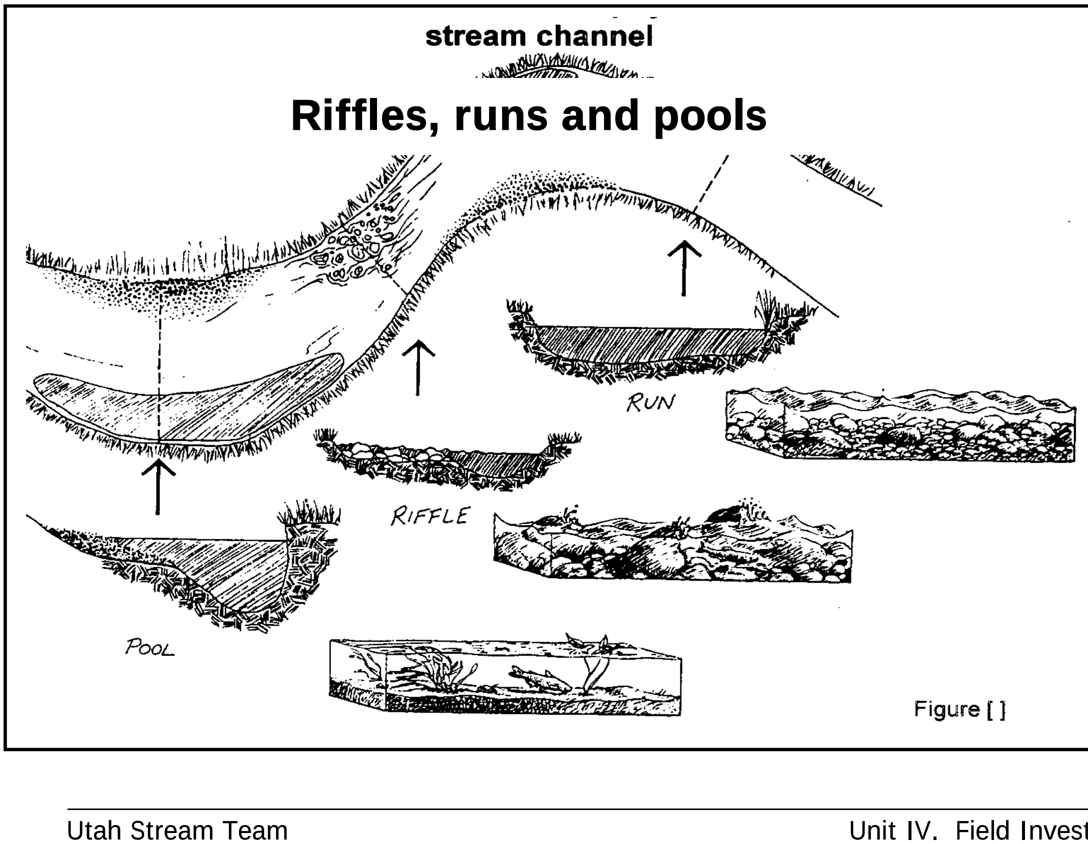


Figure [ ]

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)**

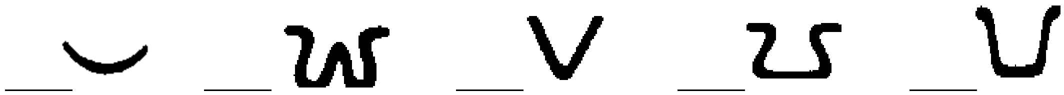
x ____________ **velocity (feet/sec)**

= [ ] **stream flow (feet³/sec)**

Physical Properties Field Data Sheet page 1 of 2

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			