Stream Gradient

Adapted from: An original Creek Connections activity.
Creek Connections, Box E, Allegheny College, Meadville, Pennsylvania, 16335

Grade Level: Intermediate to Advanced

Duration: One class period or more depending on the length of the stream used

Setting: Classroom

Summary: Students use map wheels, topographic maps, and graphing skills to determine stream gradient.

Objectives: Students will be able to use a map wheel and the contour lines on a topographic map to graph the stream gradient of a waterway.

Vocabulary:
Stream gradient, headwaters, mouth, elevation, contour lines, contour interval, index and intermediate contour lines, riffles, sedimentation

Related Module Resources:
- Activities: Stream Length and Stream Order

Materials (Included in Module):
- Map wheels, topographic maps, blank graphs, calculators, removable tape
- Data Sheet: Stream Gradient
- Stream Gradient Graphs and associated topographic maps:

Meadville Quad [20 Laminated 11x17" maps]
-Bennyhoof Creek (headwaters to mouth)
-French Creek (Saegertown to Meadville)

Cambridge Springs NE Quad
[20 Laminated 11x17" maps]
-Trout Run (headwaters to edge of map—see reverse side of graph for exact tributary used)

Townville Quad [8 Laminated full quads]
-Temple Run (headwaters to Mackey Run—see reverse side of graph for exact tributary used)

- Stream Gradient Graphs (not all necessary maps included in module)
  -French Creek (headwaters to mouth) (laminated 11x17" and unlaminated full Meadville quads included)
  -Sugar Creek (headwaters to mouth) (Townville laminated full quads included)

Additional Materials (NOT Included in Module):
- Clymer, NY, Wattsburg, Union City, Waterford, Millers Station, Cambridge Springs, Blooming Valley, Geneva, Cochranton, New Lebanon, Utica, & Franklin Quads for French Creek gradient
- Centerville, Sugar Lake, Dempseytown, Titusville South, Franklin, & Utica Quads for Sugar Creek gradient

ACADEMIC STANDARDS:

ECOLOGY & ENVIRONMENT

10th Grade
4.1.10.A. Describe changes that occur from a stream's origin to its final outflow.
- Describe changes by tracing a specific river's origin back to its headwaters including its major tributaries.

4.1.10.B. Explain the relationship among landforms, vegetation and the amount and speed of water.
- Describe how topography influences streams.

12th Grade
4.1.12.A. Categorize stream order in a watershed.
- Compare and contrast the physical differences found in the stream continuum from headwater to mouth.

GEOGRAPHY

6th Grade
7.1.6.A. Describe geographic tools and their uses.
- Geographical representations to display spatial information: topography
- Basic spatial elements for depicting the patterns of physical and human features: point, line, area, location, distance, scale

7.2.6.A. Describe the physical characteristics of places and regions.
- Components of Earth's physical systems (e.g., relief and elevation (topography))
- Comparisons of the physical characteristics of different places and regions (e.g., topography)

BACKGROUND:

A watershed is the total land area that drains into a particular waterway. Watersheds can consist of chains or networks of streams of different sizes and lengths. Streams gradient also differs among waterways. **Stream gradient** is the vertical drop of a waterway per unit distance. Another way to think of stream gradient is as the rate of descent of a waterway. Geologists usually express stream gradient in feet per mile or meters per kilometer.

In general, streams have steeper gradients near the **headwaters** (beginning or origin of the waterway) and level out as they approach the **mouth** (end) of the waterway. Therefore, first and second order streams, tumbling from mountain springs and wooded hillsides, typically have steeper stream gradients than slowly meandering, deep, wide, fifth and sixth order streams.

A stream section that has a steep gradient behaves differently and has different characteristics than a stream section with a gradual gradient. Flow rates of waterway sections with steep gradients are greater than flow rates for waterway sections with more gradual gradients. Waterway sections with steep gradients also generally have more **riffles** that occur at a greater frequency than would be seen in waterway sections with more gradual gradients. Riffles are shallow, rapid areas of waterways, commonly in straight sections between bends. Because of the greater flow rates and greater incline of waterway sections with steep gradients, the potential for soil erosion is greater in these waterways than in waterway sections with more gradual gradients. Soil is more easily eroded from streambanks in waterway sections with steep gradients. However, because of the steep inclination of these waterway sections and fast flow rates, the eroded soil seldom settles to the bottom. Thus the potential for **sedimentation** is generally greater in waterway sections with gradual gradients than waterway sections with steep gradients because water is flowing more slowly, allowing debris to settle out. Sedimentation is the filling in of waterways with soil, sand, and silt particles resulting from soil erosion. Finally, waterway sections with steep gradients generally support different forms of aquatic life than those with more gradual gradients. Shredders such as cranefly larvae, case-building caddisfly larvae, scuds, and aquatic sowbugs are more common in waterway sections with steep gradients whereas collectors such as blackfly larvae, mussels, worms, and net-spinning caddisfly larvae are more common in waterway sections with more gradual gradients.

One can determine stream gradient by determining the elevation of and distance between various points along a waterway using a topographic map and a map wheel. **Elevation** is the height above sea level and it is represented by brown **contour** lines on topographic maps. The distance between contour lines is referred to as the **contour interval** and is specified on the topographic map. Dark brown contour lines labeled with their elevation are called **index contour lines**. Light brown contour lines between index contour lines are referred to as **intermediate contour lines**.

Map measurer wheels are commonly used to determine distances on topographic maps. The distance between two points on the map is measured in map wheel units (typically inches or centimeters) and then converted to actual distance units (miles or centimeters) based on the scale of the topographic map. Refer to the activity, “Stream Length” for more information on using map wheels to measure distances.

Reading elevations using contour lines and measuring distance using a map measure wheel and the map scale, you can combine this information to determine the stream gradient. The stream gradient is shown using a line graph.

OVERVIEW:

Students use topographic map contour lines and map wheels to determine the elevation and distance between points along a waterway. They then use their graphing skills to plot a graph of stream gradient, or stream elevation as a function of distance.

PROCEDURE:

Teacher Preparation:

1. If not done so already, you should conduct or at least discuss the "Watershed Topography" Activity and the "Stream Length" Activity.

2. Select the stream(s) whose gradient(s) your students will determine.

3. Locate the appropriate topographic maps in the module and lay them out around the classroom on flat surfaces. You may want to secure the maps to the flat surfaces using permanent tape if the map is laminated or <u>removable</u> tape if the map is unlaminated.

4. Make copies of the Stream Gradient Data Sheet and Graph for your students.

5. Distribute data sheets, graphs, and map wheels at the map stations around the classroom.

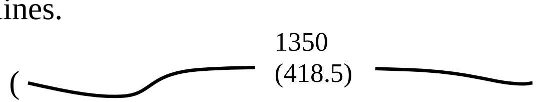
Student Activity:

1. Discuss stream gradient and how it is determined using contour lines and concept of scale and distance on topographic maps.

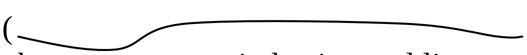
2. On a topographic map, locate the mouth and headwaters of the stream whose gradient is to be determined. Mentally trace the stream from mouth to headwaters, noting the course of the stream and the contour lines it crosses.

3. Starting at the mouth of the stream again, note and write down significant points that the stream crosses moving from mouth to headwaters such as contour lines, bridges, roads, etc. on your Data Sheet under "Description of Point." To make it easier, you might want to include some darker brown index contour lines as significant points.

4. Now go back and determine the approximate elevation of each of the significant points noted above and write these elevations next to the corresponding points under "Elevation (feet)". You will determine the elevations based on contour lines that cross the waterway. Sometimes the "points" you have chosen will be a) right next to an index contour interval line; b) right next to an intermediate contour line; c) or somewhere between contour lines.

   a) Index contour interval line (

)
   It is simple for the contour index interval lines—simply record the index contour interval line label (1350 ft. or 418.5 m).

   b) Intermediate contour lines ()
   For intermediate contour lines between contour index interval lines, consult the bottom of the topographic map for the contour interval. This is the distance between contour lines. Use the index contour lines as points of reference and either add or

subtract feet in multiples of the contour interval to determine the elevation of the contour line you seek.

c) Somewhere between two contour lines.
This is a little trickier. If a significant point falls between two contour lines, you know that the elevation must be between the elevations of those two lines (ex. 1350 ft. (418.5 m) and 1340 ft. (408.4 m)). You will have to estimate the elevation of the significant point by its proximity to one of those contour lines. For instance, if it is exactly halfway between the two contour lines, then the elevation can be estimated to be 1345 ft. (410 m).

5. Next, set the map measurer wheel to zero (actually 36 inches (91.4 cm)), align the map wheel at the mouth of the stream, and wheel it so the dial moves positive (counterclockwise) to determine the distance (in inches on the map wheel) between the mouth and your first significant point. Stop and without bumping/moving the little wheel on the map measurer wheel, record this distance under "Distance from Mouth (inches on map wheel)" next to the corresponding "Description of Point" and "Elevation." Refer to the "Stream Length" activity for more detailed map wheel instructions.

6. Without moving the map wheel dial or resetting it, replace the map wheel on the significant point and measure the distance between it and the next significant point upstream (in the direction of the headwaters and away from the mouth) by rolling the map wheel upstream. Record this distance under "Distance from Mouth (inches on map wheel)" next to the corresponding "Description of Point" and "Elevation."

7. Repeat step 5 and 6 for the rest of your significant points. If some of the significant points are too close together to reveal a different distance from the previous significant point downstream, just move on to the next significant point and put a dash under "Distance from Mouth" for the significant point whose distance was too close to determine.

8. Once finished, now convert the distances from the stream mouth from map wheel inches to miles using the information provided on the data sheet (1 inch (2.54 cm) = .3788 mile (0.61 km) or 1 mile (0.61 km) = 2.64 inches (6.7 cm)). Note - these are for 1:24,000 scale maps only. *Teachers: You may want to have your students determine this conversion factor by using a ruler and the topographic map scale.*

9. Next, use the blank graph provided or a computer-graphing program to plot your data on an XY graph.

10. Also determine the average gradient for the entire stream length on the data sheet.
    Total elevation change (feet) ÷ Total distance (mile)

DISCUSSION:

What is stream gradient? *See background.*

Why is stream gradient a useful thing to know about a waterway? *See background.*

How is stream gradient related to stream order? *See background.*

Does the stream gradient you plotted show the typical steep slope near the headwaters and flattening out near the mouth of the waterway? *Answers will vary. If the stream is long enough, it probably will show this relationship. Streams only a few miles long may not.*

What were the most useful significant points you used to determine stream gradient? *Answers will vary.*

Is it possible to accurately determine the exact elevation of a point that falls between two contour lines by using a topographic map? *No! In fact, when asked to determine the elevation of a point that falls between two contour lines, it is best to say that the elevation is between the two contour line values and leave it at that. Elevation does not necessarily decrease on a consistent slope between two contour lines so it is often inaccurate to estimate the elevation. However, for a stream gradient exercise, it is sometimes necessary to estimate the elevation of such points.*

Trace the stream from mouth to headwaters and describe changes (topographic/physical/land use) that occur along the way. *Answers will vary.*

How does the topography of the area surrounding the stream affect the stream itself? *Answers will vary. For example, if the surrounding area is rugged and steep, the stream gradient is likely to be steeper than in areas that are predominately plains or flat land. As described in the background section, portions of waterways with steep gradients have different characteristics than waterway sections with more gradual gradients.*

EVALUATION:

- Define stream gradient.
- Discussion questions above.
- Correctly filled out data sheet.
- Accurately plot the stream gradient graph.
- Correctly plot the stream gradient of a "mystery waterway."

EXTENSIONS AND MODIFICATIONS:

- Use a topographic map of your area to determine the stream gradient of waterways in your watershed.
- For larger streams, you may need to use a larger scale map such as a county map (1:50,000 scale), but you will need to have students calculate how much 1 inch (2.54 cm) equals on this map. *1 inch (2.54 cm) = .7891 mile (1.27 km)*
  1 mile (1.61 km)= 1.267 inches (3.22 cm).

- Test the hypothesis that lower order streams have steeper stream gradients by graphing the stream gradient of several waterways of different stream order and comparing the graphs.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

DATA SHEET: STREAM GRADIENT

Name____Date_____________

Stream Name: ____

MOUTH

Description of Point *(e.g., at entry of Watery Creek tributary, at Curvy Road bridge, at 2500 feet contour line)*	**Elevation** *(feet)*	**Distance from mouth** *(inches on map wheel)*	**Distance from mouth (miles)** = *Distance from mouth (inches on map wheel)* / *1 inch = .3788 mile 2.64 inches = 1 mile.*

HEADWATERS

Determine the average gradient for the entire stream length.

Total elevation change (feet) ÷ Total distance (mile) = ____________________