Streamer Inquiry

Activity 11.1

Name: ______________________ **Course/Section:** ______________ **Date:** __________

Have you ever stood beside a stream and wondered where the water comes from or where it goes? *Streamer* is a map-based database of stream maps and information that allows you to find out. It is a component of the U.S. National Atlas project, managed by the U.S. Geological Survey, that allows you to trace streams upstream to their sources or downstream to where they empty into larger streams or the ocean. To use *Streamer,* go to http://water.usgs.gov/streamer/web/ and click on the "Go to Map" button. Then follow the directions below.

A Where does the water come from?

1. Pick a community in the United States that you are interested in. What is the name of your community?

2. Locate your community on the *Streamer* map. You can use the zoom slider on the map to zoom in, use your mouse wheel to scroll in or out, or hold the shift key and drag a box around the area where your community is located. You can also type the location of the community (city, state) in the "Location Search" panel and then press "Enter/Return" on your keyboard to locate your community.

3. Choose the largest stream located in or near your community to study. Click on the "Trace Upstream" button and then click on a point on the stream to display in red all of the streams that supply water to that point on the stream.

4. Now click on the "Trace Report" button, and select "Detailed Report" to get a Stream Trace Detailed Report.

   (a) What stream did you study? Trace Origin Stream Name: ____________________
   (b) What are the elevation and coordinates of the point on the stream that you selected?
   Trace Origin Elevation (ft.): ____________ feet above sea level
   Trace Origin (latitude, longitude): ______________ ______________
   (c) Through how many communities does the stream flow before it gets to this point? Cities (count): _______
   (d) In how many named streams does the water flow to this point in the stream? Stream Names (count): ________
   (e) What is the total length of the stream(s) named in part **4d**? Total Length of Traced U.S. Streams (miles): __________
   (f) Close the Stream Trace Detailed Report (but *not* the map) by clicking on the small gray "x" of the right-hand tab labeled "Streamer Report" near the top of the browser window and proceed to part **B** below.

B Where does the water go?

1. Click on the "Trace Downstream" button. Then click on approximately the same point of the same stream that you studied in part **A** to display in red where the water goes after that point on the stream.

2. Click on the "Identify" button. Now when you click on any part of the red downstream trace of the water, it will identify the name of the stream at that point of the trace. List the names of all of the streams in the downstream trace of the water from upstream (the starting red point in your map) to where it enters the "Outlet Waterbody" at the downstream end of the red line on your map.

3. Click on the "Trace Report" button, and select "Detailed Report" to get a new Stream Trace Detailed Report.

   (a) In how many named streams does the water flow downstream from this point? Stream Names (count): ________
   (b) Through how many communities does the water flow downstream from this point? Cities (count): __________
   (c) What is the total length of the stream(s) named in part **3b**? Total Length of Traced U.S. Streams (mi.): __________
   (d) Into what "Outlet Waterbody" does the stream's water eventually empty? ______________________________
   (e) What is the name of the last community or feature that the stream passes through before it enters the "Outlet Waterbody"? ______________________________
   (f) Close the Stream Trace Detailed Report (but *not* the map), and proceed to part **C**.

C Your stream system.

1. Click on the "Trace Upstream" button again. Then click on the downstream end of the downstream trace that you identified in part **B**. It will be located near the place you identified in part **B3e**. This will display an entire stream drainage network from the smallest upland tributaries to the largest river (main stream or main river).

2. Comparing a tributary stream near the upstream headwaters of this river system with the main river near the mouth of the system,

   (a) Infer whether the upstream or downstream segment handles the most water in a given unit of time.

   ____

   (b) Infer whether the upstream or downstream segment has a greater channel width. ______________________

   (c) Infer which part of a stream system flows down a steeper slope: the upstream or downstream segment.

   ____

3. Click on the "Trace Report" button, and select "Detailed Report" to get a new *Streamer* Report. How many USGS stream gages are used to monitor this river system from source to its mouth, where it discharges to the outlet waterbody?

   ______

   This is a small indication of the continuing investment made by the people of the United States to understand and manage its surface-water resources and to protect people from flood hazards through the efforts of the U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and other federal, state, and local agencies.

D **REFLECT & DISCUSS** Why would a community located on or near a stream want to know where its stream water comes from, and what else might it want to know about the water?

E **REFLECT & DISCUSS** Why would a community located on or near a stream want to know where its stream water goes after passing the community?

Introduction to Stream Processes and Landscapes

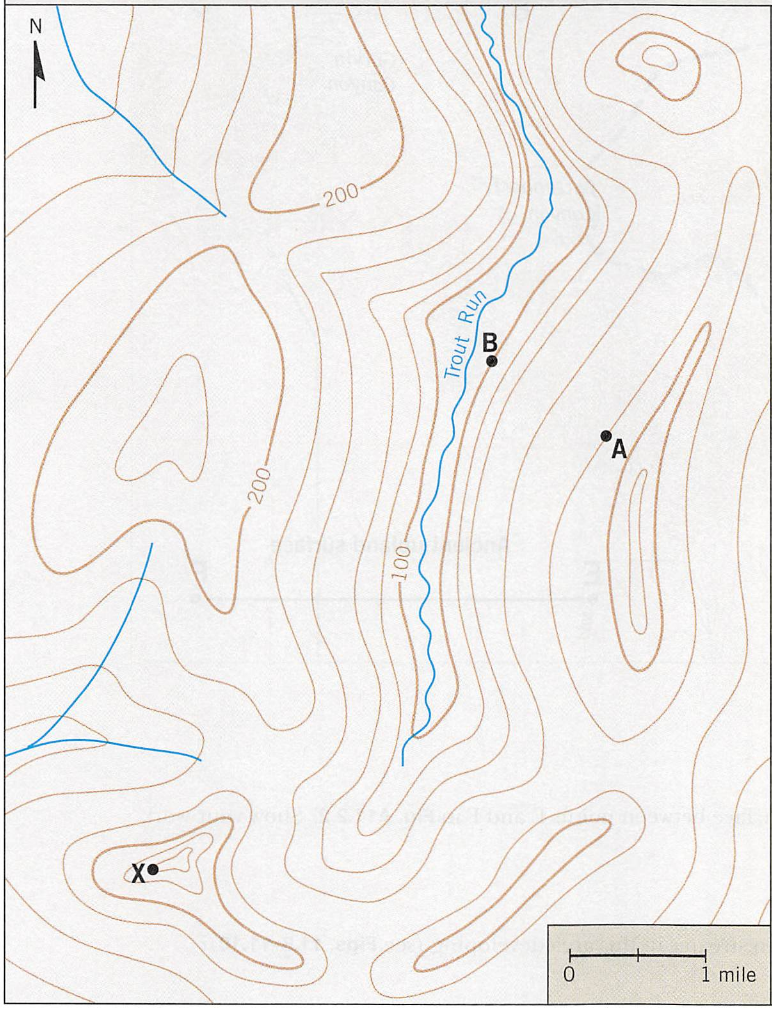
Activity 11.2

Name: ______________________ **Course/Section:** ______________ **Date:** __________

A Trout Run Drainage Basin:

1. Complete parts **a** through **h** in **Fig. A11.2.1**.

TOPOGRAPHIC MAP REVIEW FOR DRAINAGE BASIN MAPPING



a. This map is contoured in feet. The contour interval is: ____________ ft

b. The elevation of point X is: ____________ ft

c. The elevation of point B is: ____________ ft

d. The elevation of point A is: ____________ ft

e. The distance from A to B is: ____________ mi(s)

f. The gradient from A to B is: ____________ ft/mi

g. Lightly shade or color the area inside each closed contour that represents a hilltop, then draw a dashed line to indicate the drainage divide that surrounds Trout Run drainage basin.

h. Trout Run flows (drains down hill) in what direction? ____________

Figure A11.2.1

2. Imagine that heavy rain fell on a saturated landscape at location X in **Fig. A11.2.1**. Is it likely that runoff water would flow from X downhill into Trout Run? Explain your reasoning.

B **Figure A11.2.2** is a portion of the Lake Scott 7.5-minute quadrangle, Kansas, that is centered around latitude 38.7°N, longitude 100.95°W. This area is an ancient upland surface that slopes gently eastward from an elevation of about 5500 feet along the Rocky Mountains to about 2000 feet above sea level in western Kansas. Streams in western Kansas drain eastward and cut channels into the ancient upland surface. Small tributary streams merge to form larger streams that eventually flow into the Mississippi River.

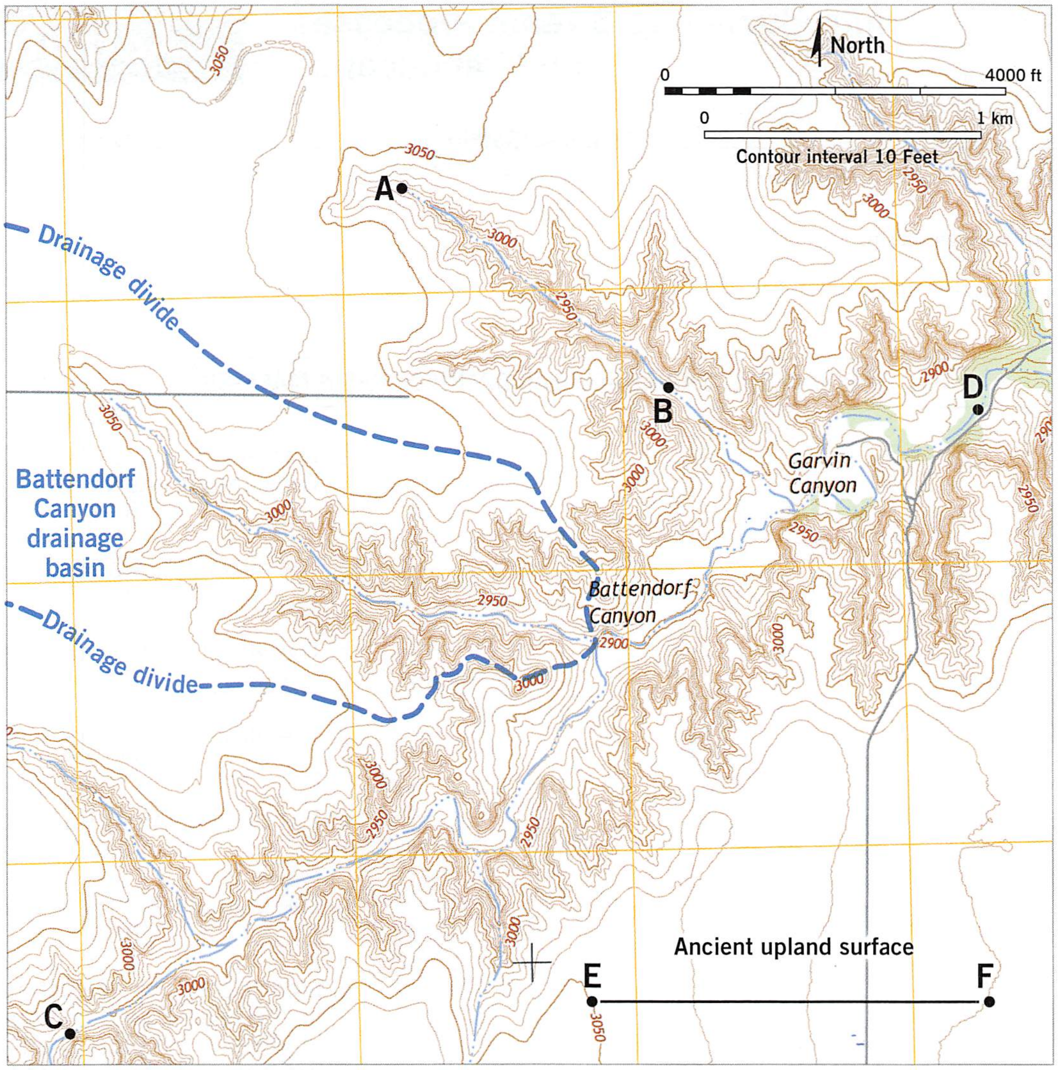


Figure A11.2.2

1. What is the gradient of the ancient upland surface between points E and F in **Fig. A11.2.2**? Show your work.

2. What type of drainage pattern are the modern streams in this area developing (see **Figs. 11.8–11.10**)?

3. Notice in **Fig. A11.2.2** that small tributaries merge to form larger streams. We will consider the intermittent stream in Garvin Canyon to be a first-order stream because it has no significant tributaries (refer to **Fig. 11.7**). What is the gradient and sinuosity, from A to B on **Fig. A11.2.2**, of the first order stream in Garvin Canyon? Refer to **Figs. 11.3** and **11.4** for help measuring gradient and sinuosity. Show your calculations. You will graph these data later in the activity.

   Gradient: ____________ft./mi. Sinuosity: ____________

4. Notice how the drainage divide of the stream in Battendorf Canyon is defined by a blue dashed curve in **Fig. A11.2.2**. Draw a similar curve, as exactly as you can, to show the boundary of the Garvin Canyon drainage basin. Points A and B are in Garvin Canyon. Refer to **Fig. 11.5** for help in deciding how to draw the drainage divide. Draw the divide.

5. What is the gradient and sinuosity of the stream that flows between points C and D (**Fig. A11.2.2**), and what is the stream order? (Refer to **Figs. 11.3** and **11.4** for help measuring gradient and sinuosity.) Show your calculations. You will graph these data later in the activity.

Gradient: ____________ft./mi. Sinuosity: ____________ Stream order: ____________

____

____

6. **REFLECT & DISCUSS** By some accounts, the Mississippi River is a 10th-order stream. Based on your answers to the parts **3** and **5** above, what do you think happens to the *gradient* of streams as they increase in order?

7. **REFLECT & DISCUSS** What do you think happens to the *discharge* of streams as they increase in order?

C Examine the enlarged part of the Strasburg, Virginia, quadrangle map in **Fig. A11.2.3**, which is centered near latitude 38.92°N, longitude 78.34°W.

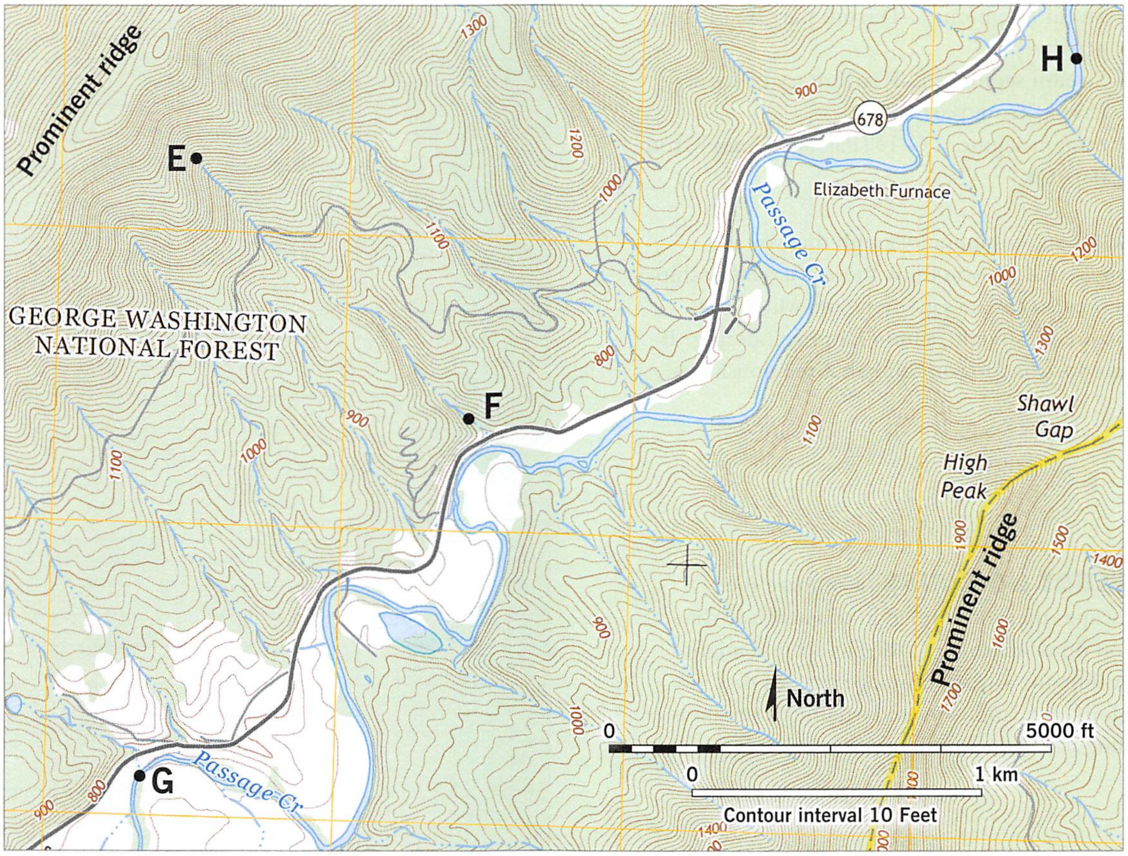


Figure A11.2.3

1. What drainage pattern is developed in this area, taking note that this map area is between two prominent, nearly parallel ridges? Refer to **Fig. 11.8** for help. Explain your reasoning.

2. In **Fig. A11.2.3**, what is the gradient and sinuosity of the small stream, from E to F? (Refer to **Figs. 11.3** and **11.4** for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

Gradient: ____________ft./mi. Sinuosity: ____________

3. In **Fig. A11.2.3**, what is the gradient and sinuosity of Passage Creek from G to H? (Refer to **Figs. 11.3** and **11.4** for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

   Gradient: ___________ft./mi.
   Sinuosity: ___________

D We will use semi-logarithmic graph paper (**Fig. A11.2.4**) to investigate whether there might be a relationship between gradient and sinuosity.

1. Plot points for the following streams, and draw a best-fit line through the points:
   - Stream segment A–B (Garvin Canyon stream) from part **B4** of this activity.
   - Stream segment C–D from part **B5** of this activity.
   - Stream segment E–F (tributary of Passage Creek) from part **C2**.
   - Stream segment G–H (Passage Creek) from part **C3**.

2. Based on the summary graph that you just completed, do you think there is a relationship between a stream's gradient and whether its channel is straight, sinuous, or meandering? If you do, what do you think that relationship is?

E **REFLECT & DISCUSS** Compare the landscapes that you studied in this activity. What do you think are some of the factors that might determine the kind of drainage pattern that develops on a landscape and whether a stream is eroding its channel or depositing sediment?

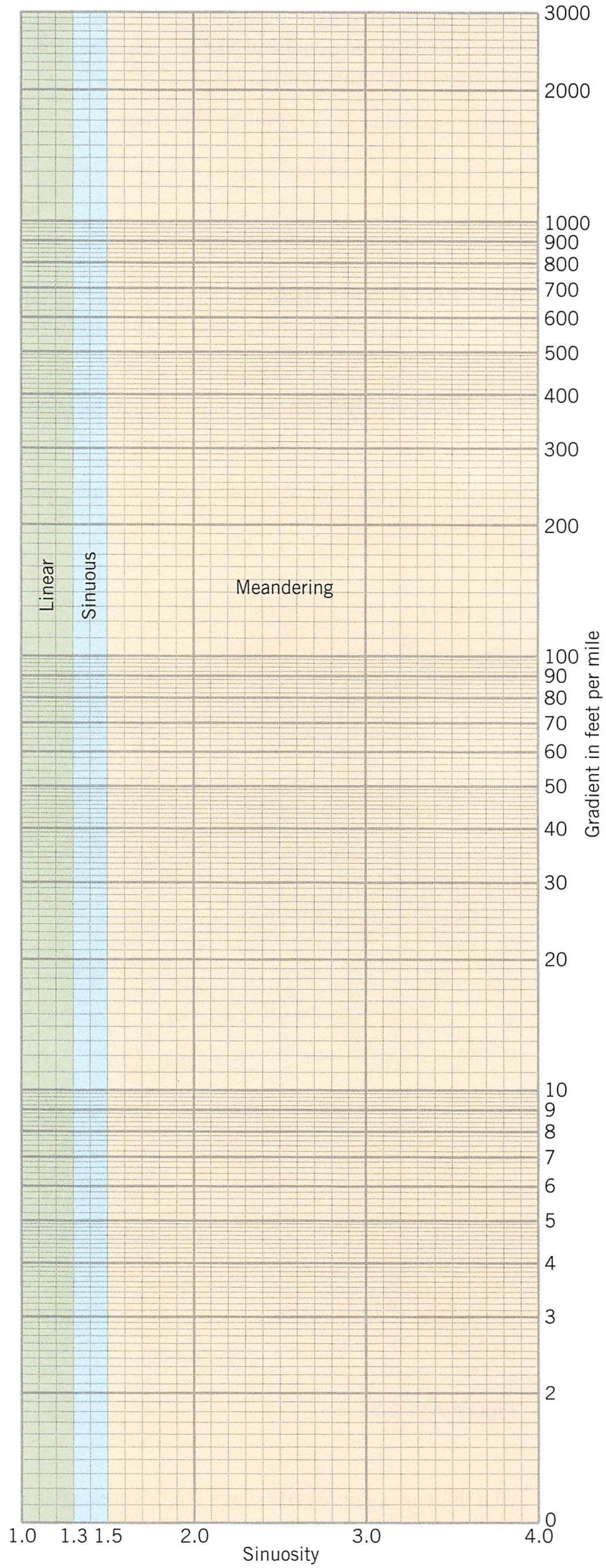


Figure A11.2.4

A Mountain Stream

Activity 11.3

Name: ____________________ **Course/Section:** ____________ **Date:** ________

Refer to the portion of the Ennis, Montana, 15-minute quadrangle in **Fig. 11.2**.

A What types of stream channel (shown in **Figs. 11.11–11.13**) are present on:

1. The streams in the mountains along the east side of this map?
2. The Cedar Creek Alluvial Fan?
3. The valley of the Madison River (northwestern portion of **Fig. 11.2**)?

B **Figure A11.3.1** is an expanded portion of **Fig. 11.2**, centered near latitude 45.31°N, longitude 111.59°W. **Fig. A11.3.1** includes a gridded rectangular area called a *profile box* that we will use to plot the profile of Cedar Creek as it flows from the

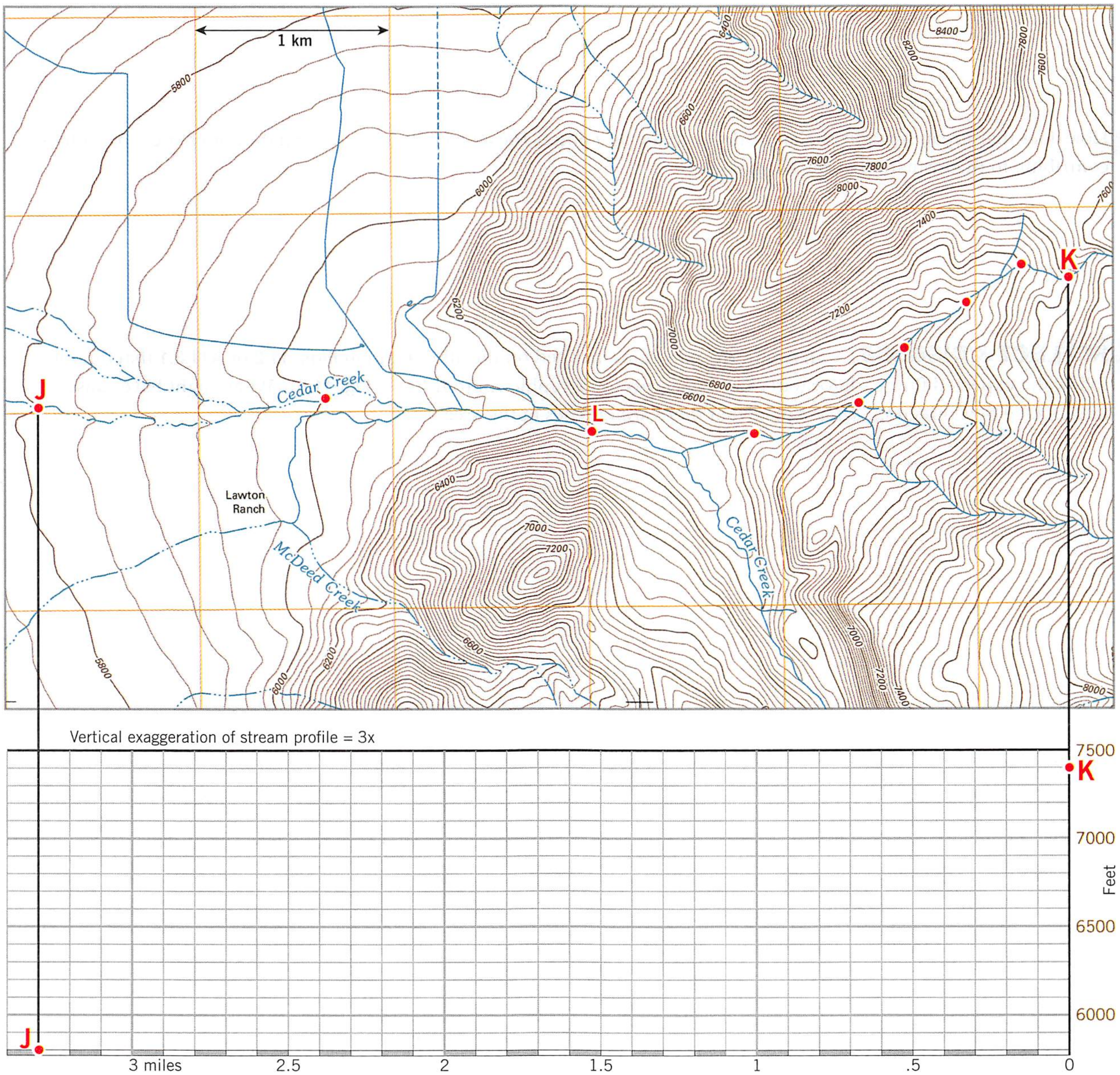


Figure A11.3.1

mountains onto the alluvial fan. The horizontal axis is east–west distance along Cedar Creek, in miles, and the vertical axis is elevation, in feet. Complete the profile from point J to point K along Cedar Creek by plotting and connecting the nine red elevation points. Points J and K have already been plotted in the profile box as examples.

C On the profile you constructed in part **B**, identify and label the parts of the profile that represent (1) where the channel is eroded into bedrock and (2) where the channel is established on sediment that was deposited by Cedar Creek.

D What is the average gradient of Cedar Creek

1. from point K to point L? Gradient: ___________ft./mi.

2. from point L to point J? Gradient: ___________ft./mi.

E How does that stream's gradient change downstream as it enters the alluvial fan, and how might this change in gradient contribute to the formation of the alluvial fan?

F **REFLECT & DISCUSS** Can you find any streams mapped on the alluvial fan in **Figs. 11.2** or **A11.3.1** that do not follow the expected flow path for water moving across topographic contour lines (**Fig. 11.5**)? What might have caused this unexpected flow direction? *Hint*: Notice that there are ranches in the area.

Escarpments and Stream Terraces

Activity 11.4

Name: ______________________ **Course/Section:** ______________ **Date:** __________

Escarpments and terraces are found along many stream valleys. Escarpments are long cliffs or steep narrow slopes that separate one relatively level part of the landscape from another. Terraces are long, narrow, or broad almost-level surfaces bounded on one or both sides by an escarpment. Stream terraces parallel the stream. The difference in elevation between two terraces can range from centimeters to tens of meters.

The 7.5-minute quadrangle map of Voltaire, North Dakota, includes part of the course of the Souris River (Fig. A11.4.1). Part of a large continental ice sheet extended south and west from the Hudson Bay area of eastern Canada during the Pleistocene Ice Age, covering this area. As the ice sheet melted and became smaller, meltwater streams flowed where the ice had been, transporting and depositing vast amounts of sediment. Streams have been forming and modifying this landscape since the ice retreated, about 11,000–12,000 years ago.

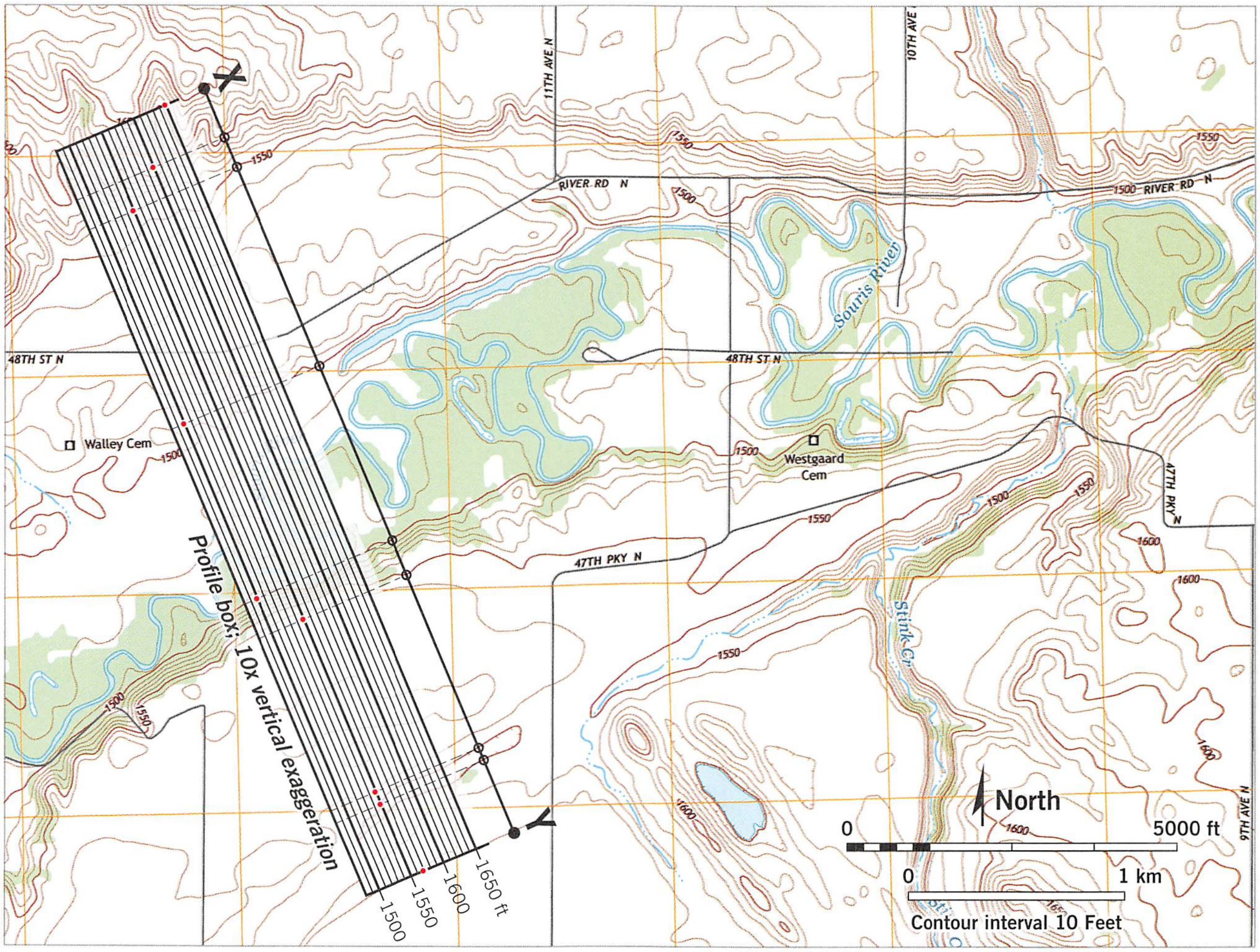


Figure A11.4.1

A The modern floodplain of the Souris River near latitude 48.11°N, longitude 100.81°W can be identified by the flat area on both sides of the active stream channel. What other meandering stream features named in **Fig. 11.13** do you recognize in this image?

B On the basis of the image and topographic contours, make a profile of the landscape from X to Y in the profile box provided in **Fig. A11.4.1**. Red circles mark several points along that profile that have already been plotted for you. Label terraces with a T and escarpments with an E.

C Describe how the escarpments might have formed along the Souris River.

D On your sketch, label the modern floodplain of the Souris River and record its width along line X–Y.

E What was the maximum width of the Souris River floodplain in the past (measured along line X–Y), and how can you tell?

F Give one possible reason why the Souris River floodplain was wider in the past.

G **REFLECT & DISCUSS** Notice along line X–Y that the terrace on the south side of the Souris River is 30–40 feet higher than the terrace on the north side of the river. Suggest how these two different levels of terraces may have formed and which one is older based on your hypothesis.

Meander Evolution on the Rio Grande

Name: ______________________ **Course/Section:** ______________________ **Date:** ______________

The Rio Grande River forms part of the national border between Mexico and the United States (**Fig. A11.5.1**). Notice that the position of the river changed in many places between 1936 (red line and leaders by lettered features) and 1992 (blue water bodies and leaders by lettered features). Study the meander terms provided in **Figs. 11.13** and **A11.5.1**, and then proceed to the questions on the next page.

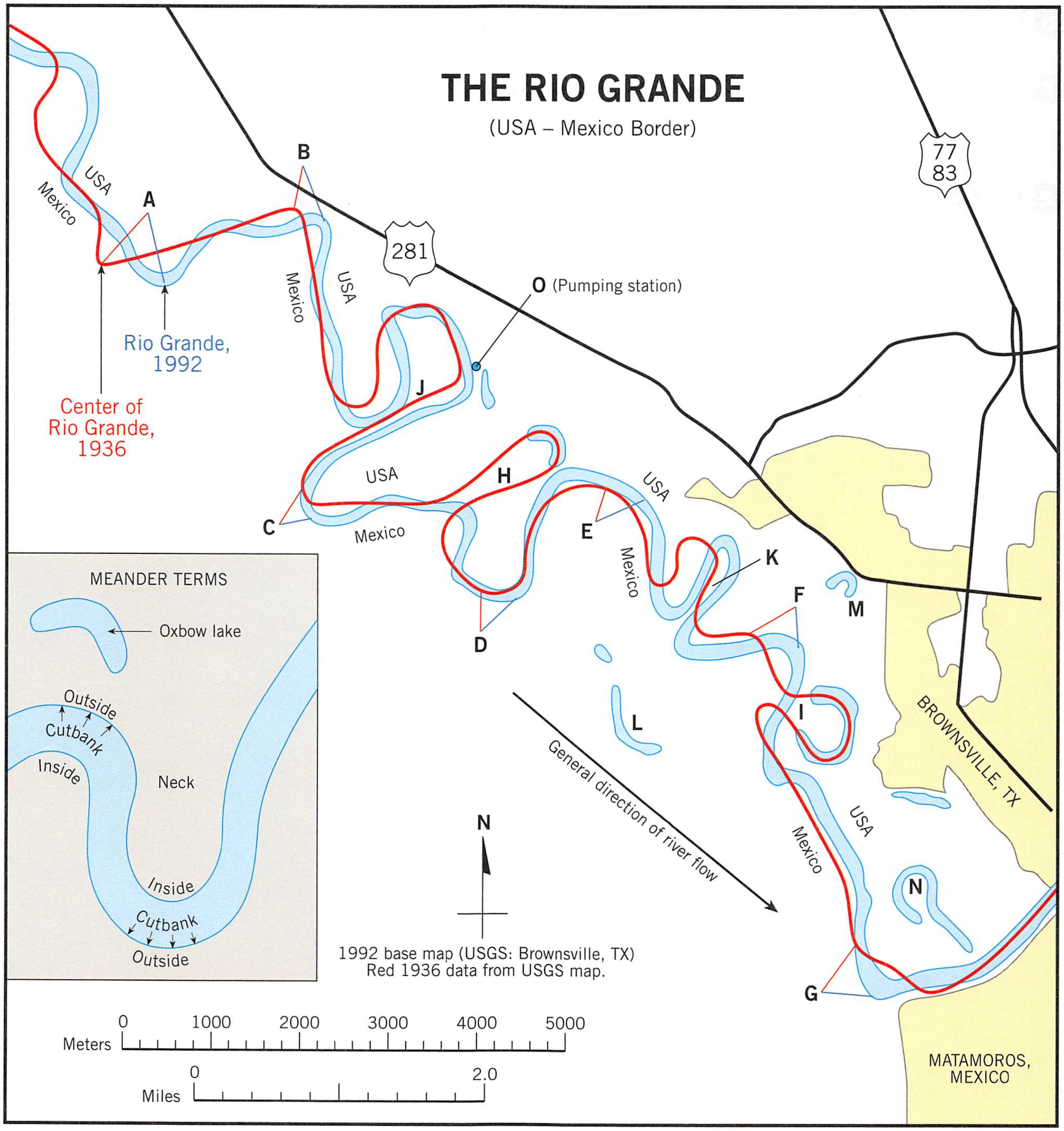


Figure A11.5.1

A Study the meander cutbanks labeled A through G. The red leader from each letter points to the cutbank's location in 1936. The blue leader from each letter points to the cutbank's location in 1992. In what two general directions (relative to the meander, relative to the direction of river flow) have these cutbanks moved?

B Study locations H and I.

1. In what country were H and I located in 1936?
2. In what country were H and I located in 1992?
3. Explain a process that probably caused locations H and I to change from meanders to oxbow lakes.

C Based on your answer in part **B3**, predict how the river might change in the future at locations J and K.

D What are features L, M, and N, and what do they indicate about the historical path of the Rio Grande?

E What is the average rate at which meanders like A through G migrated here (in meters per year) from 1936 to 1992? Explain your reasoning and calculations.

F **REFLECT & DISCUSS** Explain in steps how a meander evolves from the earliest stage of its history as a broad, slightly sinuous meander to the stage when an oxbow lake forms.

Retreat of Niagara Falls

Activity 11.6

Name: ______________________ **Course/Section:** ______________ **Date:** __________

The Niagara River flows north from Lake Erie to Lake Ontario and forms part of the border between the United States and Canada. Over this straight-line distance of approximately 43 km, the river drops approximately 100 m in elevation to Lake Ontario. Just over half of that total drop in elevation occurs at Niagara Falls, where the river flows over a hard dolostone caprock called the Lockport Formation (**Fig. A11.6.1**). A series of soft shales and harder dolostone beds are below the hard caprock. As the water tumbles over the edge, its turbulence is a potent agent of erosion that removes rock from the weaker formations and undercuts the stronger Lockport dolostone caprock. Blocks of the caprock break off, and the edge that marks the top of Niagara Falls migrates upstream (south), eroded block by block.

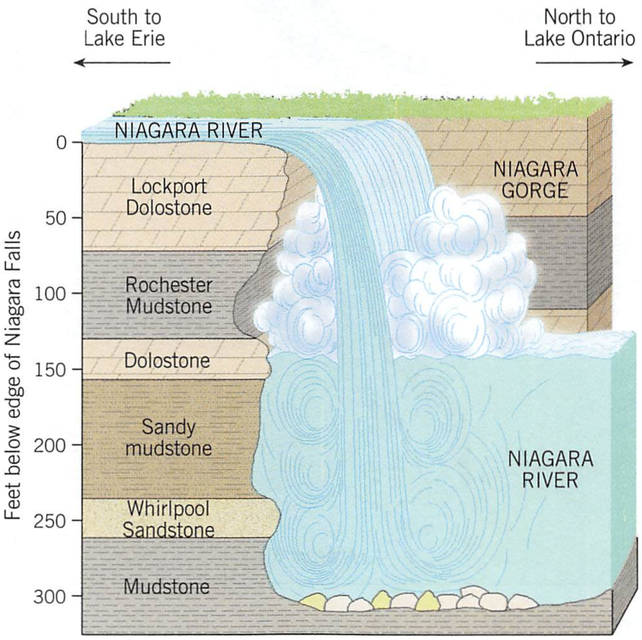


Figure A11.6.1

Today, Niagara Falls is located about halfway between the two lakes at the head of Niagara Gorge (**Fig. A11.6.2**). Geologic evidence indicates that the Niagara River became the primary outlet river for the upper Great Lakes into the Ontario Basin about 11,000 years ago, as an enormous continental ice sheet retreated north out of the area. At that time, the Niagara River cascaded over the edge of the Lockport Formation at the Niagara Escarpment near Lewistown, New York, and Queenston, Canada, near 43.16°N, 79.05W. Since that time, retreat of the waterfall has resulted in the excavation of Niagara Gorge downstream (north) of the falls.

A About how long is the Niagara Gorge today? To measure the approximate length of the Niagara Gorge, manipulate a piece of string so that it follows the centerline of the Niagara Gorge as mapped in **Fig. A11.6.2**. Mark the beginning and end of the gorge on the string. Then pull the string straight and measure the distance between the two marked points to give you the map distance along the channel in the gorge. Then compare that map distance with the bar scale on the map, and calculate the true length of the gorge using proportions. Approximate length of Niagara Gorge: ~ _____ km.

B Based on this geochronology and the length of Niagara Gorge as shown in **Fig. A11.6.2**, calculate the average rate at which Niagara Falls has migrated southward along the Niagara River course in cm/year. Show your calculations. Rate of retreat: ~ _____ cm/year.

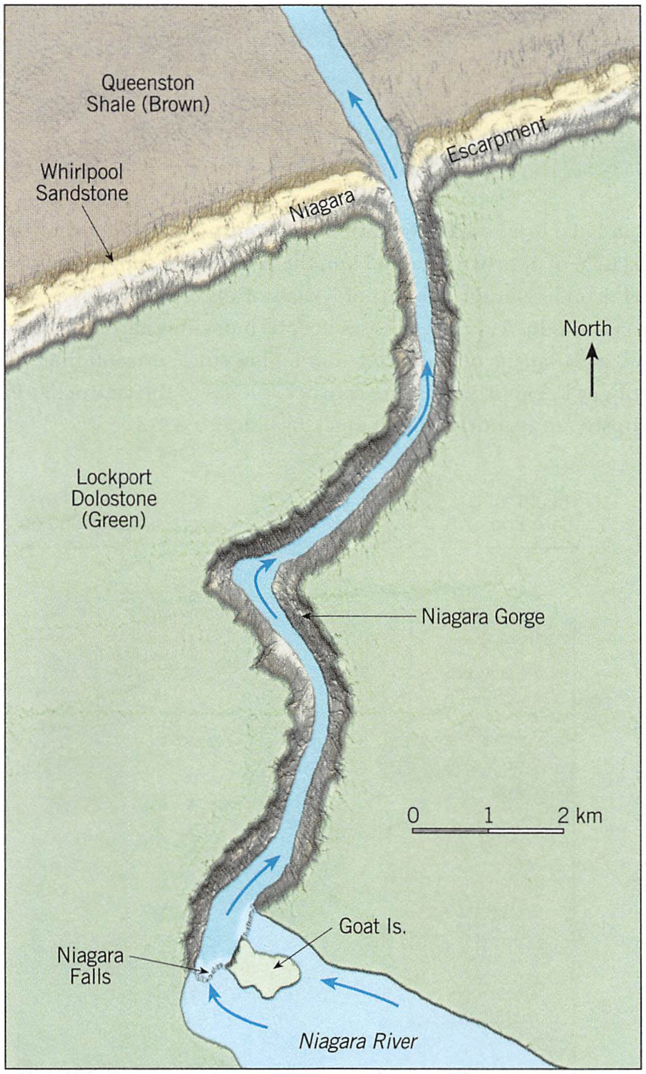


Figure A11.6.2

C Name as many factors as you can that could cause Niagara Falls to retreat at a faster rate.

D Name as many factors as you can that could cause Niagara Falls to retreat more slowly.

E Niagara Falls is about 35 km north of Lake Erie, and it is retreating southward. If the falls were to continue its retreat at the average rate calculated in part **A**, then how many years from now would the falls reach Lake Erie? ____________ years.

F **REFLECT & DISCUSS** Look at the cross-section of Niagara Falls in **Fig. A11.6.1**. Describe how the process that formed the falls could have begun. (*Hint*: Use your knowledge of stream erosion and the effects of stream gradient.)

Flood Hazard Mapping, Assessment, and Risk

Activity 11.7

Name: ______________________ **Course/Section:** ______________________ **Date:** ____________

A On the portion of the 7.5-minute topographic map of Montezuma, Georgia (**Fig. A11.7.1**), locate the gaging station on Flint River in the middle of the map. The center of the map is near latitude 32.30°N, longitude 84.05°W. The elevation from which the gage measures changes in river level—the **gage datum**—is at an elevation of 255.83 feet above sea level, and the height of the river relative to this datum is called the **gage height** or **stage**. The river is considered to be at flood stage when the gage height is 20 feet above the gage datum, or an elevation of 275.83 feet. A flood in July 1994 established a record gage height of 34.11 feet, or 289.94 feet above sea level. This corresponds to the 290-foot contour line on the map. Trace the 290-foot contour line on both sides of the Flint River and label the area within these contours where the land is lower than 290 feet, "1994 Flood Hazard Zone."

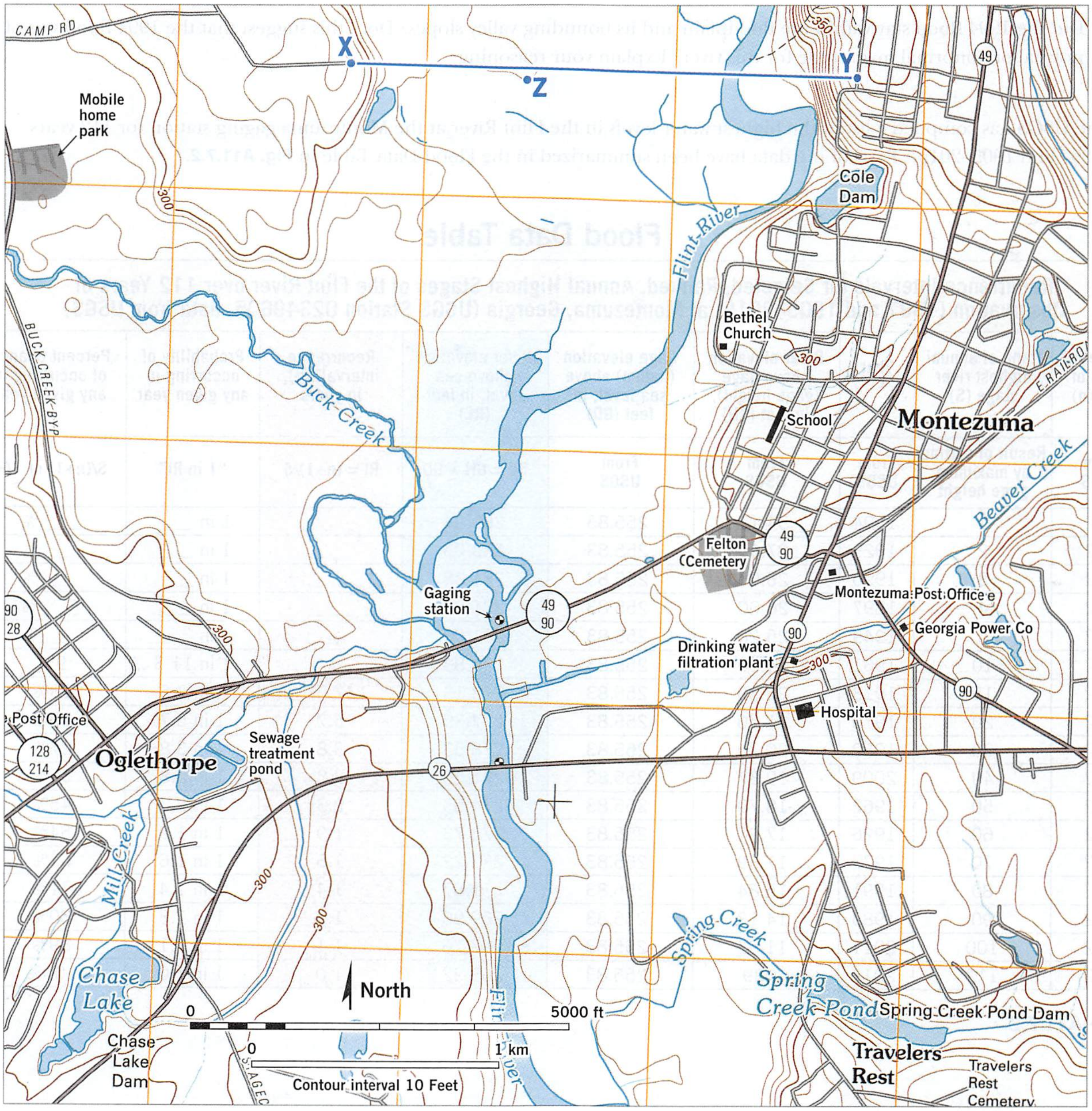


Figure A11.7.1

B Name two essential public utilities or facilities that were submerged by the flood, and infer the possible impact that flooding those facilities might have had on the environment and on quality of life in Montezuma, Oglethorpe, or downstream communities after the flood.

C Notice line X–Y near the top center part of **Fig. A11.7.1**.

1. The map shows the Flint River at its normal stage. What is the width of the Flint River at its normal stage along line X–Y? ____________ ft.

2. What was the width of the river along this line when it was at maximum flood stage (290 feet) during the July 1994 flood? ____________ ft.

D Notice the floodplain of the Flint River along line X–Y on the map in **Fig. A11.7.1**. The floodplain is the relatively flat, marshy land between the river and the steep escarpments that develop by erosion during floods.

1. What is the elevation of the floodplain at point Z near line X–Y, expressed in feet above sea level? ____________ ft.

2. How deep was the water that covered that floodplain at point Z during the 1994 flood? ____________ ft.

3. How did you derive your answer?

4. Did the 1994 flood stay within the floodplain and its bounding valley slopes? Does this suggest that the 1994 flood was of normal or abnormal magnitude for this river? Explain your reasoning.

E The USGS has compiled a list of the highest water levels in the Flint River at the Montezuma gaging station for 112 years (1897 and 1905–2015). Parts of the data have been summarized in the Flood Data Table in **Fig. A11.7.2**.

Flood Data Table

Recurrence Intervals for Selected, Ranked, Annual Highest Stages of the Flint River over 112 Years of Observation (1897 and 1905–2015) at Montezuma, Georgia (USGS Station 02349605, data from USGS)

Number of years of data (n)	Rank of annual highest river stage (S)	Year	River elevation above gage (gage height), in feet (GH)	Gage elevation (datum) above sea level, in feet (GD)	River elevation above sea level, in feet (RE)	Recurrence interval (RI), in years	Probability of occurring in any given year	Percent chance of occurring in any given year
From USGS	Result of sorting by maximum gage height	From USGS	From USGS	From USGS	RE = GH + GD	RI = (n+1)/S	"1 in RI"	S/(n+1) or 1/RI
112	1	1994	34.11	255.83	289.94	____	1 in ____	____%
112	2	1929	27.40	255.83	283.23	____	1 in ____	____%
112	3	1990	26.05	255.83	281.88	____	1 in ____	____%
112	4	1897	26.00	255.83	281.83	____	1 in ____	____%
112	5	1949	25.20	255.83	281.03	____	1 in ____	____%
112	10	1961	24.00	255.83	279.83	11.3	1 in 11.3	9%
112	15	1913	22.30	255.83	278.13	7.5	1 in 7.5	13%
112	20	1978	21.56	255.83	277.39	5.7	1 in 5.7	18%
112	30	1952	20.70	255.83	276.53	3.8	1 in 3.8	27%
112	40	2009	19.37	255.83	275.20	2.8	1 in 2.8	36%
112	50	1962	18.70	255.83	274.53	2.3	1 in 2.3	45%
112	60	1926	17.90	255.83	273.73	1.9	1 in 1.9	54%
112	70	1977	17.39	255.83	273.22	1.6	1 in 1.6	63%
112	80	1991	15.84	255.83	271.67	1.4	1 in 1.4	71%
112	90	1986	14.13	255.83	269.96	1.3	1 in 1.3	80%
112	100	2011	11.93	255.83	267.76	1.1	1 in 1.1	89%
112	112	2012	7.39	255.83	263.22	1.0	1 in 1.0	100%

Figure A11.7.2

1. The annual maximum elevations of the Flint River were ranked in magnitude from S = 1 (the highest annual river level ever recorded—the 1994 flood) to S = 112 (the lowest annual maximum elevation). Data for 17 of these ranked years are provided in the Flood Data Table and can be used to calculate recurrence interval for each magnitude (rank, S). The **recurrence interval** (or **return period**) is the average number of years between occurrences of a flood of a given rank (S) or greater. The recurrence interval for a flood of a given rank can be calculated as: $RI = (n + 1)/S$. Calculate the recurrence interval, probability of occurring in any given year ("1 in RI"), and percentage chance of occurring in any given year (1/RI) for ranks 1–5, and write them in the table.

2. Notice that a recurrence interval of 5.0 means that there is a one-in-five probability (or 20% chance) that an event of that magnitude will occur in any given year. This is known as a *5-year flood.* What is the probability that a *100-year flood* will occur in any given year?

3. Plot (as carefully as you can) points on the flood magnitude/frequency graph (**Fig. A11.7.3**) for all 17 ranks of annual high river stage in the Flood Data Table. Use the vertical axis (blue) to plot the "river elevation above sea level" listed in the blue column of the Flood Data Table (**Fig. A11.7.2**) and the horizontal axis (pink) to plot the "recurrence interval" listed in the pink column. Then use a pencil and ruler to draw a line through the set of points so that approximately as many points are above the line as are below the line. Extend the line to the left and right edges of the graph.

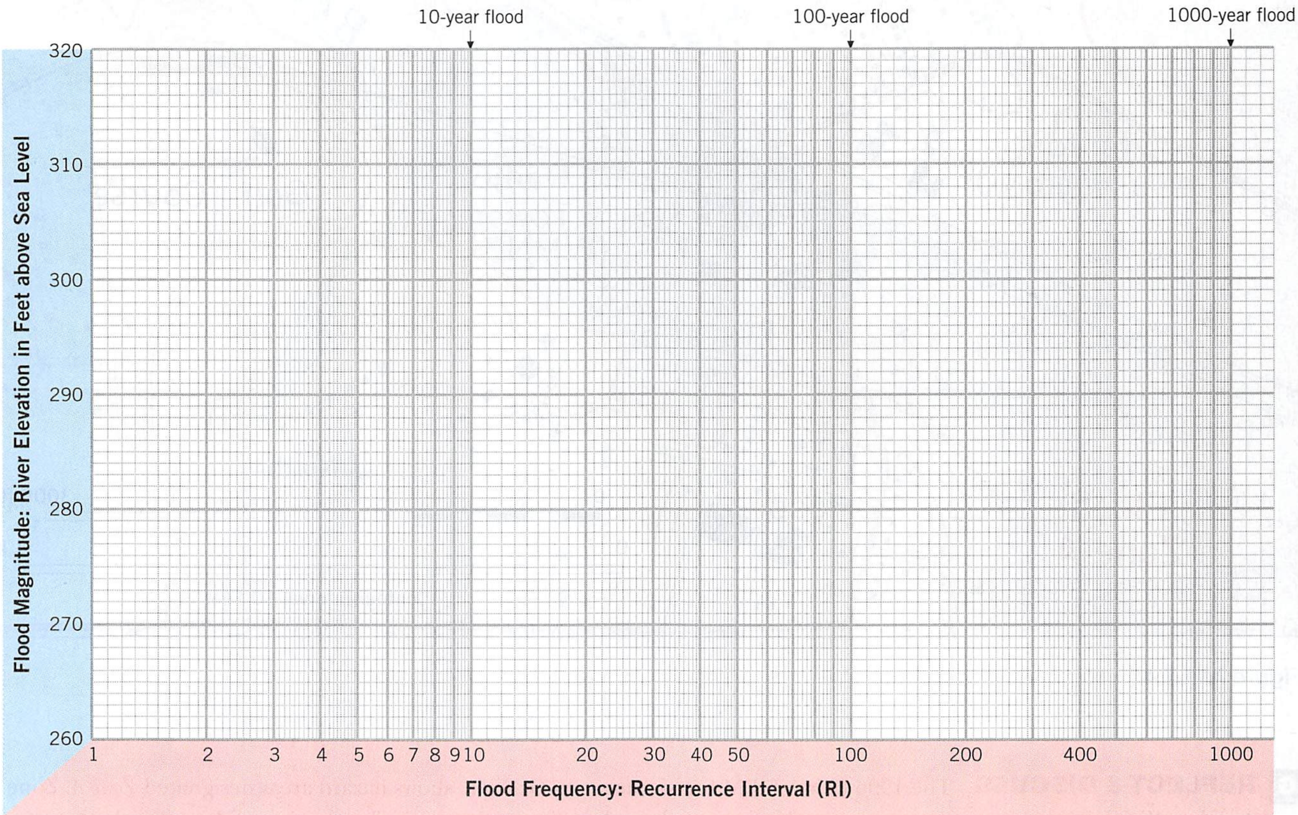


Figure A11.7.3

4. Your completed flood magnitude/frequency graph can now be used to estimate the probability of future floods of a given magnitude and frequency. A 10-year flood on the Flint River is the point where the line in your graph crosses the vertical line that corresponds to a flood frequency of 10 years. What is the probability that a future 10-year flood will occur in any given year, and what will be its magnitude expressed in river elevation in feet above sea level?
Probability: 1 in. ____________ Magnitude of 10-year flood: ____________ ft.

5. What is the probability for any given year that a flood on the Flint River at Montezuma, Georgia, will reach an elevation of 275 feet above sea level? Probability: 1 in. ____________

F The hazard areas on a Flood Insurance Rate Map are defined using a *base flood elevation* (BFE)—the computed elevation to which floodwater is estimated to rise during a *base flood.* The regulatory-standard base flood elevation is the 100-year flood elevation. Based on your graph, what is your interpretation of the BFE for Montezuma, Georgia? ____________ ft. above sea level.

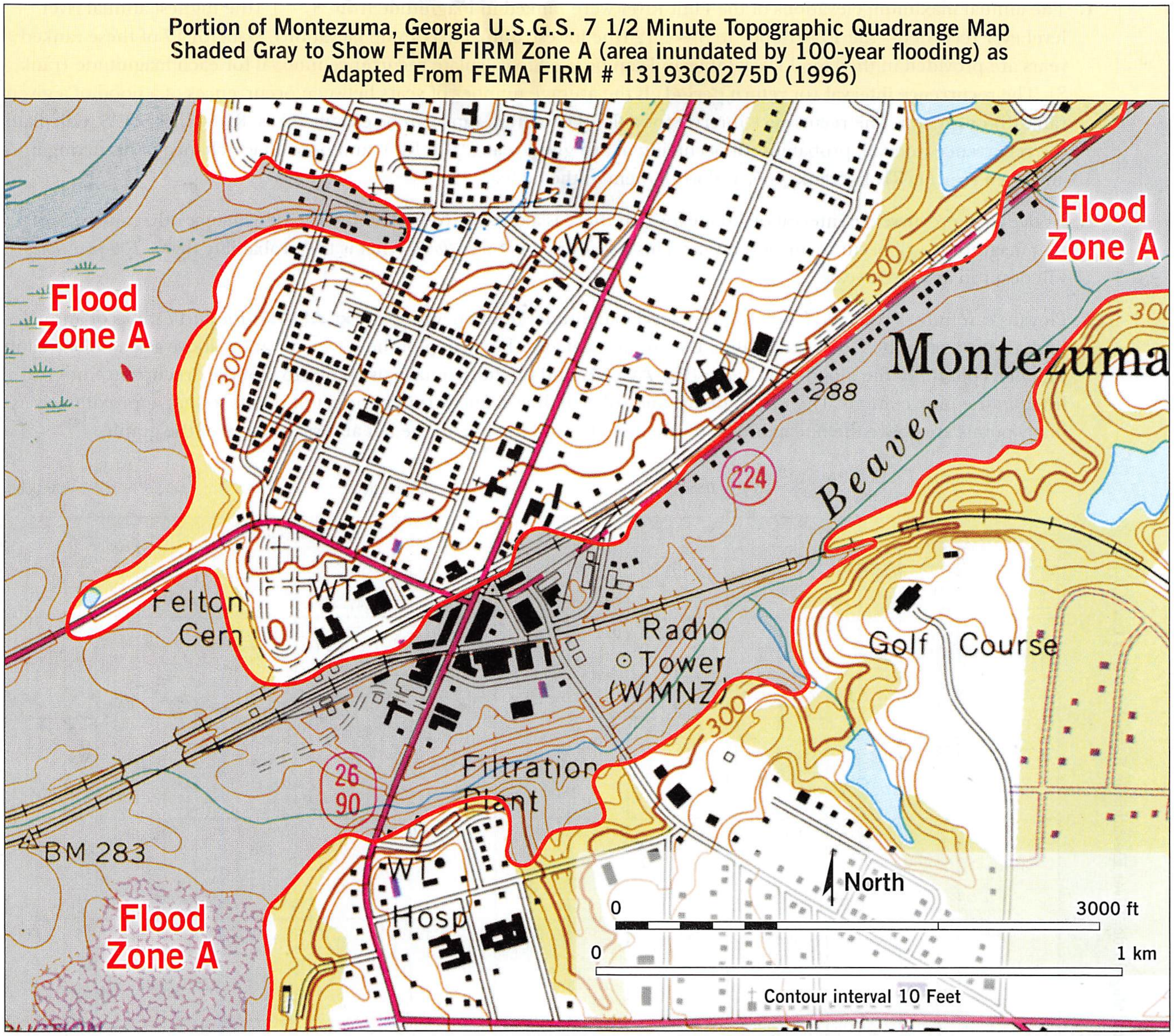


Figure A11.7.4

G **REFLECT & DISCUSS** The 1996 FEMA FIRM for Montezuma, Georgia, shows hazard areas designated *Zone A*. Zone A is the official designation for areas expected to be inundated by 100-year flooding. The location of Zone A is the gray area bounded by the red curve on **Fig. A11.7.4**. The analysis you completed in part **F** of this activity allows you to estimate the BFE corresponding to 100-year flooding at Montezuma, Georgia, based on approximately two decades more data than was available when the 1996 FIRM map was developed. Using the topographic contours as a guide, trace your estimate of the 100-year base flood elevation on **Fig. A11.7.4**, using a pen or pencil that will make your tracing legible. How does your work compare with the red line on the 1996 FEMA FIRM map?