UPDATED FEB 2016 KEY

ES202 Lab 6: Fluvial Processes Lab Instructions *(updated Winter 2016)*

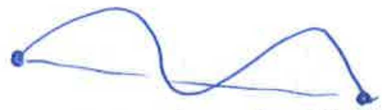
Uses AGI Lab Manual 10th Edition

PART 1. Thinking Questions. Using your lab book, complete the following exercises / answer the following questions:

1. Refer to p. 285, Fig. 11.1 and answer the following questions:
   a. Describe and sketch the difference between a meandering and braided river pattern.

MEANDERING   BRAIDED

   b. Write the equation for "sinuosity" and describe what it means in terms of calculated ratios.



$S = \frac{\text{TOTAL LENGTH}}{\text{STRAIGHT LINE DISTANCE}}$

   c. Draw a sketch of a meandering channel reach, identify zones of erosion and deposition, label important landforms.

CUT BANK - EROSION

DEPOSITION POINT BAR

   d. Compare and contrast the gradient of a meandering stream channel vs. braided? Are they the same, or different? How so?

Meandering – Low GRADIENT, SAND-MUD

BRAIDED – High GRADIENT, SAND-GRAVEL

2. Refer to p. 287, Fig. 11.2 and answer, match the following drainage patterns to geologic conditions:

D Dendritic	a. channels eroding rock fractures
C Radial	b. rivers flowing over folded rocks (anticlines and synclines)
E Annular	c. river erosion on stratovolcanoes
A Rectangular	d. leaf-like patterns formed on flay-lying or uniform rock material
G Centripetal	e. patterns associated with concentric circular channels
B Trellis	f. irregular streams, lakes, swamps and poorly drained areas
F Deranged	g. river channels that flow to a central low elevation

3. Refer to Strasburg Virginia map on p. 288, Fig. 11.3; and Fig. 11.6 on p. 292.
   a. Which direction is Passage Creek flowing (provide answer in azimuth degrees)

CONTOUR V POINTS UPSTREAM   FLOWS NORTH EAST, AZIMUTH AVG. ~ 50°

   b. Calculate the stream gradient of the unnamed tributary between points E and F. Answer in both ft/mi and dimensionless ratio of ft/ft; show all of your math work.

E-F Gradient 1000 ft / mi

E-F Gradient 0.19 ft/ft

$\frac{RISE}{RUN} = \frac{800 ft}{0.8 mi} = \frac{1000 ft}{mi}$

$\frac{1000 ft}{1 mi} \left(\frac{1 mi}{5280 ft}\right) = \frac{1000 ft}{5280 ft} =$

USE BAR SCALE → MAP IS ENLARGED → FRACTIONAL SCALE DOES NOT WORK

4. Examine Figure 14.7 on p. ~~265~~ 365, read the figure caption, and observe the landforms commonly found in arid to semi-arid (desert) landscape environments. Now examine the Ennis, MT topographic map on p. 291 Figure 11.5; answer the following questions.

   a. What prominent desert landform is "Lawton Ranch" located on (compared to Fig. 14.7)

      ALLUVIAL FAN

   b. What type of earth material likely forms the landscape immediately to the west of Lawton Ranch (bedrock? Regolith? Alluvial? Sand vs. gravel? Round or angular?)?

      SAND & GRAVEL, ROUNDED, ALLUVIUM, MOUNTAIN RIVER DEPOSITS

   c. What is the river channel pattern exemplified by the Madison River on the western edge of the map (meandering or braided?)

      BRAIDED

   d. What is the contour interval of the map?

      CI = 40 ft

PART 2. LAB ACTIVITIES. Refer to your lab manual exercises and work on the following problems.

Activity 11.2, p. 299, Part A, Questions 1 and 2 Stream Patterns See attach

Remember: gradient = elevation difference / distance along line of profile; Refer to Fig. 11.4 to see how to calculate gradient. *Procedure:* Calculate stream gradient (rise / run) in ft / mile. Find points A and B, where the contour lines cross and you can determine the elevation. The change in elevation (relief) is the difference between the two elevations. Then determine the length of the straight line segment between the two points using the bar scale.

Activity 11.2, p. 302, Part D, Questions 1, 2, 3, 4 Montana Alluvial Fans See attach

Explanation: An alluvial fan is a fan-shaped deposit of sediment occurring where steep mountain rivers exit narrow canyons, and splay out onto broad open areas. Lawton Ranch is at the head of the fan, near the mountain river exit point (flowing east to west). Bear Creek on the southwestern part of the map flows along the "toe" of the fan, down gradient from Lawton Ranch. The entire alluvial fan is sloping from east to west, as shown by the contour patterns.

Activity 11.3, p. 304 Part A, B, C, D, E River Terraces and Incision in North Dakota See attach

Ideas for answering Questions: Discharge is the measure of volume of water that flows through a river channel (for e.g. measured in gallons per day). 12,000 years ago, the climate was dramatically different that it is today. It was the end of the last major glacial "ice age", particularly in the northern Midwest states (e.g. North Dakota)… glaciers were rapidly melting and retreating. Glacial ice covered Canada and the upper Midwest of the U.S. 20,000 years ago. Think about where the melt water would have been flowing 12,000 years ago, and compare to the climate and hydrologic conditions present in North Dakota today.

Activity 11.4 (p. 305) Rio Grande River Evolution See attach

Complete questions 11.2A through E, inclusive.

Concepts to Consider: think about current meander loops that are so tightly closed that they may cut themselves off via erosion). The questions ask you to compare the 1936 river shape to the 1992 shape; think of meandering, cutbank erosion, and point bar deposition. The goal is to see historic changes in the river position over about 60 years)

ACTIVITY 11.5 (p. 306) Niagara Falls Erosion Rates See attach

Complete questions 11.3 A through D, inclusive.

(*hint*: use the distance from the Escarpment to the present falls position as the distance of erosion over the past 11,000 years: Rate of erosion = erosion distance / time of erosion.

KEY

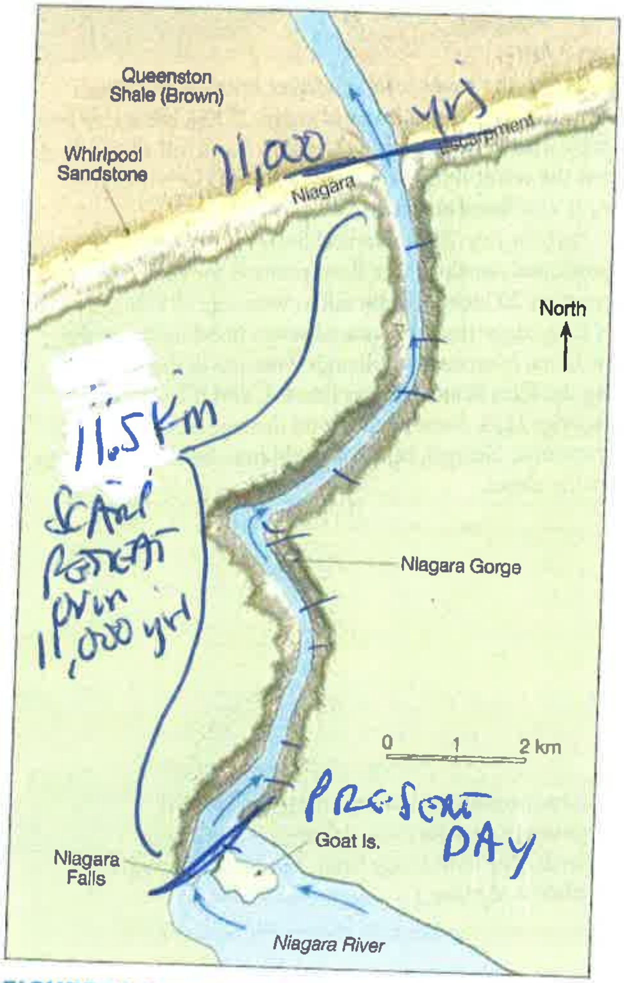


FIGURE 11.9 Geology of the Niagara Gorge Region. The Niagara River flows from Lake Erie north to Lake Ontario and forms the border between the United States and Canada. Niagara Falls is located on the Niagara River at the head of Niagara Gorge, about half way between the two lakes.

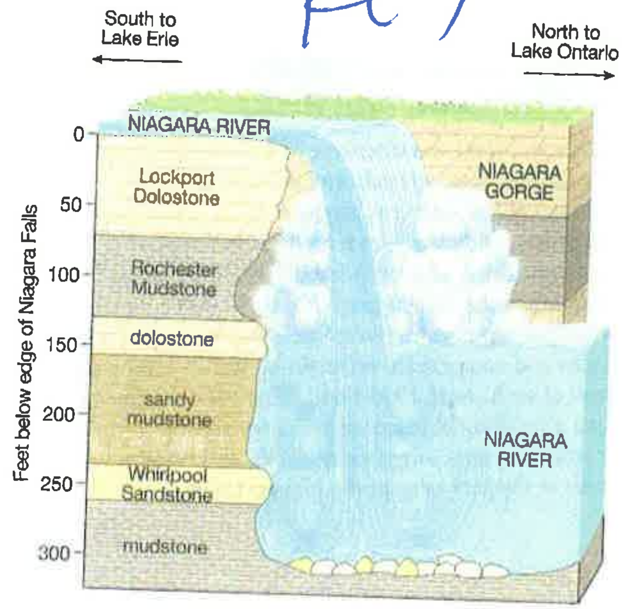


FIGURE 11.10 Cross Section of Niagara Falls. Niagara Falls exists because the named rock units beneath the falls vary in their hardness (resistance to erosion). As the hard dolostone caprock is undercut by erosion of the softer mudstone beneath it, pieces of the caprock break off and the falls moves upstream.

Mass Wastage at Niagara Falls

Mass wastage is the downslope movement of Earth materials such as soil, rock, and other debris. It is common along steep slopes, such as those created where rivers cut into the land. Some mass wastage occurs along the steep slopes of the river valleys. However, mass wastage can also occur in the bed of the river itself, as it does at Niagara Falls.

The Niagara River flows from Lake Erie to Lake Ontario (FIGURE 11.9). The gorge of the Niagara presents good evidence of the erosion of a caprock falls, Niagara Falls (FIGURE 11.10).

ACTIVITY 11.6 Flood Hazard Mapping, Assessment, and Risk

THINK About It How do geologists determine the risk of flooding along rivers and streams?

OBJECTIVE Construct a flood magnitude/frequency graph, map floods, and flood hazard zones, and assess flood hazards along the Flint River, Georgia.

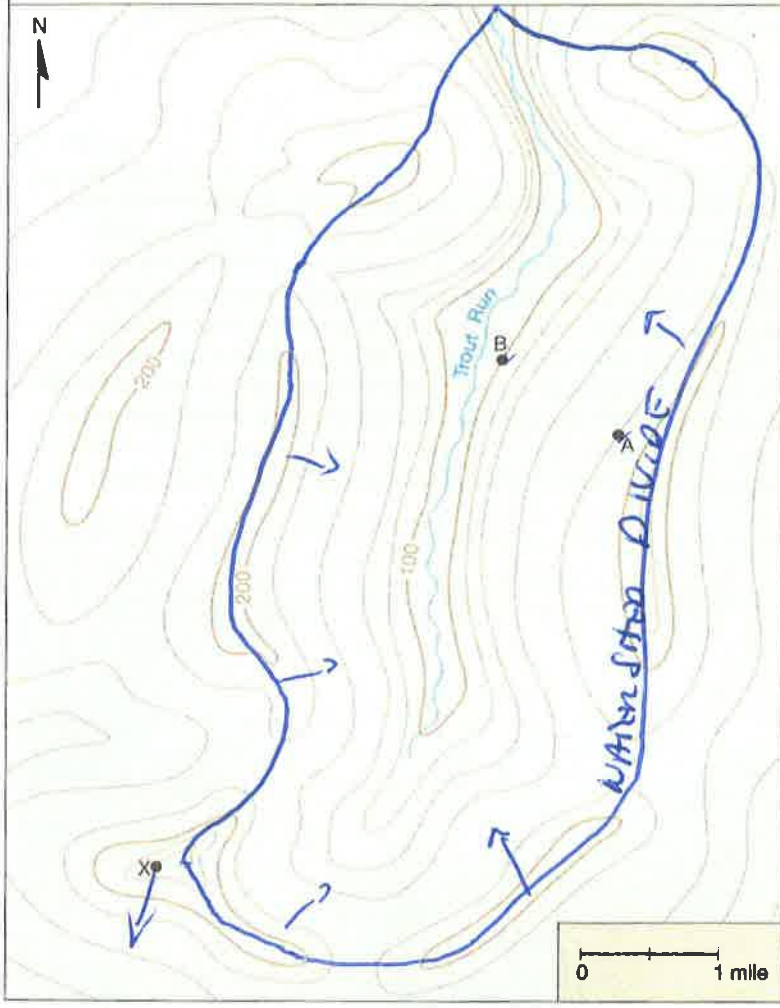
PROCEDURES

1. **Before you begin**, read Flood Hazard Mapping, Assessment, and Risks below. Also, this is **what you will need**:
   - ___ calculator
   - ___ Activity 11.6 Worksheets (pp. 307–310) and pencil with eraser
2. **Then follow your instructor's directions** for completing the worksheet.

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

A. Trout Run Drainage Basin: **1.** Complete items **a** through **h** below.

TOPOGRAPHIC MAP REVIEW FOR DRAINAGE BASIN MAPPING



a. This map is contoured in feet. The contour interval is: 20 feet.

b. The elevation of point X is: 240 feet.

c. The elevation of point B is: 100 feet.

d. The elevation of point A is: 180 feet.

e. The distance from A to B is: 1.0 mile(s).

f. The gradient from A to B is: 180-100ft / 1 mi = 80 feet per mile.

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?
TO NORTH

2. Imagine that drums of oil were emptied (illegally) at location **X** above. Is it likely that the oil would wash downhill into Trout Run? Explain your reasoning.

NO — OUTSIDE OF DRAINAGE DIVIDE WILL FLOW TO SOUTH

B. Refer to the topographic map of the Lake Scott quadrangle, Kansas (**FIGURE 11.4**). This area is located within the Great Plains physiographic province and the Mississippi River Drainage Basin. The Great Plains is a relatively flat grassland that extends from the Rocky Mountains to the Interior Lowlands of North America. It is an ancient upland surface that tilts eastward from an elevation of about 5500 feet along its western boundary with the Rocky Mountains to about 2000 feet above sea level in western Kansas. The upland is the top of a wedge of sediment that was weathered and carried eastward from the Rocky Mountains by a braided stream system that existed from Late Cretaceous to Pliocene time (65–2.6 Ma). Modern streams in western Kansas drain eastward across the Great Plains and cut channels into the ancient upland surface. Tiny modern tributaries merge to form larger streams that eventually flow into the Mississippi River. You can view this in *Streamer*: go to **http://nationalatlas.gov/streamer/Streamer/welcome.html** and click on the "Go to Map" panel. Then click on the "Trace Downstream" tab, zoom in to any stream in western Kansas (KS), and click on the stream. The red line will show how the stream is part of a stream drainage system the flows east across Kansas, on the ancient upland surface.

4. What is the gradient (ft/mi) and sinuosity, from A to B on FIGURE 11.4, of the first order stream in Garvin Canyon? (Refer to FIGURES 11.1 and 11.6 for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

Gradient: ____________ ft/mi Sinuosity: ____________

5. What is the stream order of the stream that occurs in Timber Canyon (FIGURE 11.4), and what is its gradient (ft/mi) and sinuosity from C to D? (Refer to FIGURES 11.1 and 11.6 for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

Stream order: ________________

Gradient: ____________ ft/mi Sinuosity: ____________

Skip

6. The Mississippi River is a tenth order stream. Based on your answers to the two questions above, state what happens to the gradient of streams as they increase in order.

7. What do you think happens to the discharge of streams as they increase in order, and what effect do you think this would have on the relative number of fish living in each stream order within a basin?

C. Examine the enlarged part of the Strasburg, Virginia, quadrangle map in FIGURE 11.3.

1. What drainage pattern is developed in this area, and what does it suggest about the attitude of bedrock layers in this area? Explain your reasoning. (*Hint:* Refer to FIGURE 11.2 and notice the stream pattern in relation to ridges and valleys.)

2. What is the gradient (ft/mi) and sinuosity of the small stream, from E to F? (Refer to FIGURES 11.1 and 11.6 for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

Gradient: ____________ ft/mi Sinuosity: ____________

3. What is the gradient (ft/mi) and sinuosity of Passage Creek from G to H? (Refer to FIGURES 11.1 and 11.6 for help measuring gradient and sinuosity.) Show your calculations. You will graph this data later in the activity.

Gradient: ____________ ft/mi Sinuosity: ____________

D. Refer to the Ennis Montana 15' quadrangle in **FIGURE 11.5**. Some rivers are subject to large floods, either seasonal or periodic. In mountains, this flooding is due to snow melt. In drylands, it is caused by thunderstorms. During such times, rivers transport exceptionally large volumes of sediment. This causes characteristic features, two of which are braided channels and alluvial fans. Both features are relatively common in arid mountainous regions, such as the Ennis, Montana, area in **FIGURE 11.5**. (Both features also can occur wherever conditions are right, even at construction sites!)

1. What main stream channel types (shown in **FIGURE 11.1B**) are present on:

   a. the streams in the forested southeastern corner of this map?

   DENDRITIC / CONVERGENT

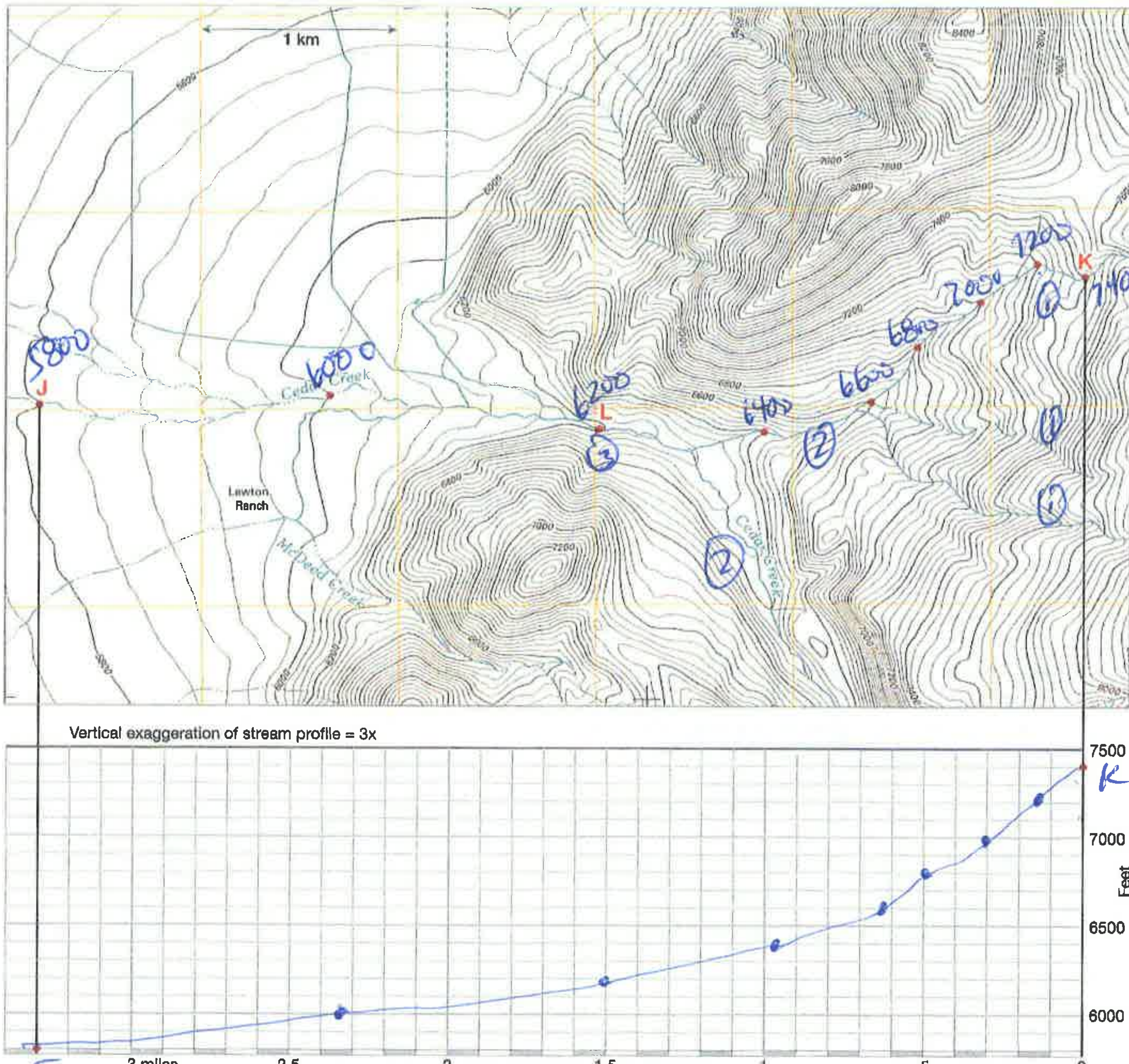
   b. the Cedar Creek Alluvial Fan?

   STRAIGHT / DIVERGENT

   c. the valley of the Madison River (northwestern portion of **FIGURE 11.5**)?

   BRAIDED

2. Notice on **FIGURE 11.5** and the portion of that map enlarged below that Cedar Creek is the source of water that transports sediment onto Cedar Creek Alluvial Fan. Below, complete profile J-K of Cedar Creek by plotting and connecting the nine red elevation points (notice how points J and K have already been plotted).



(Courtesy of USGS)

deposited from Cedar Creek."

4. Observe Cedar Creek on the map in part D2.

   a. What is its stream order classification at point L?

   ORDER (3)

   b. What happens to that stream's gradient and order downstream, as it enters the alluvial fan, and how does this contribute to the formation of the alluvial fan?

   - GRADIENT DECREASES
   - ORDER INCREASES
   - FLOW SPREADS OUT DEPOSIT

E. On the semi-logarithmic graph paper provided at right, you can determine if a stream is linear, sinuous, or meandering by plotting a point based on the stream's gradient and sinuosity.

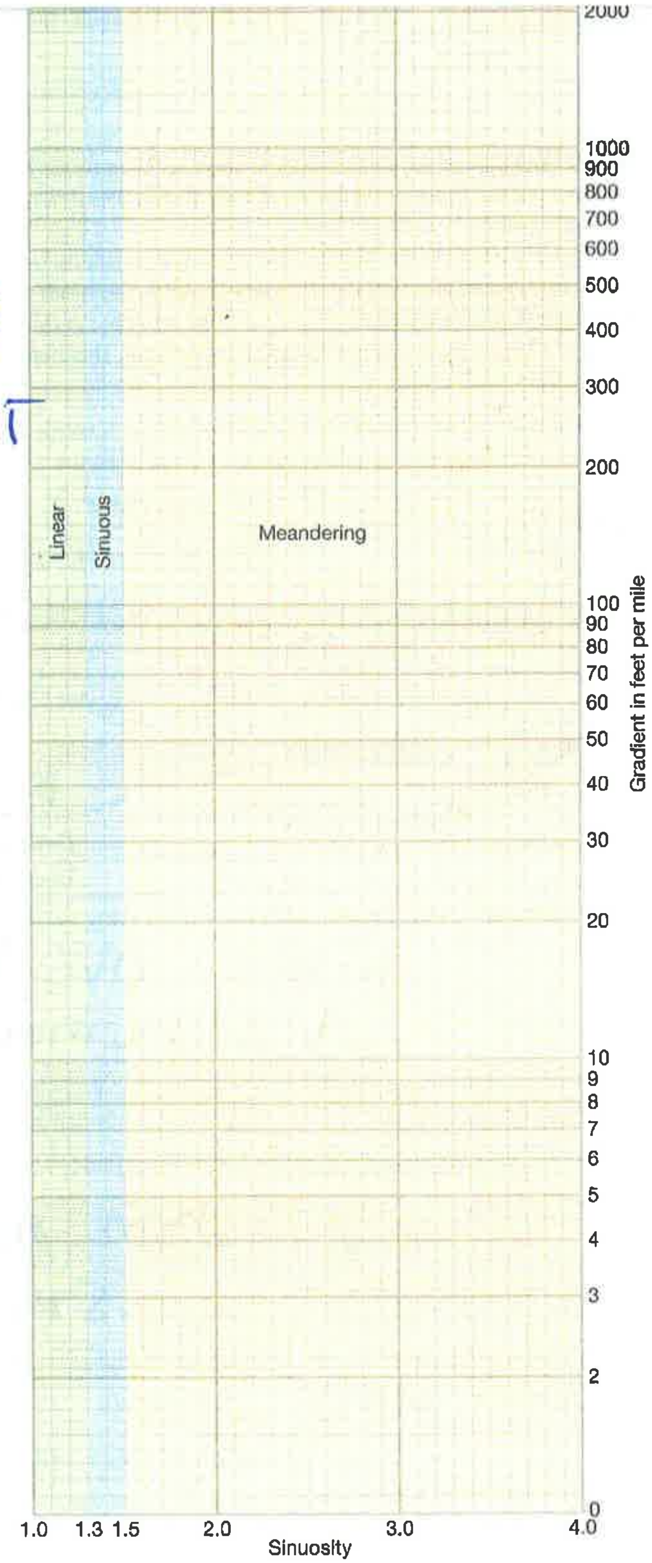
1. Plot points for the following streams, and draw a best-fit line through the points:

   - Stream segment A-B (Garvin Canyon stream) from part B4 of this activity
   - Stream segment C-D (Timber Canyon stream) 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, is there a relationship between a stream's gradient and whether its channel is straight, sinuous, or meandering? If yes, then what is that relationship?

   SKIP

F. **REFLECT & DISCUSS** Compare the four landscapes that you studied in this activity. What factors determine the kind of drainage pattern that develops on a landscape and whether a stream is eroding bedrock or depositing sediment?



ACTIVITY 11.3 Escarpments and Stream Terraces

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

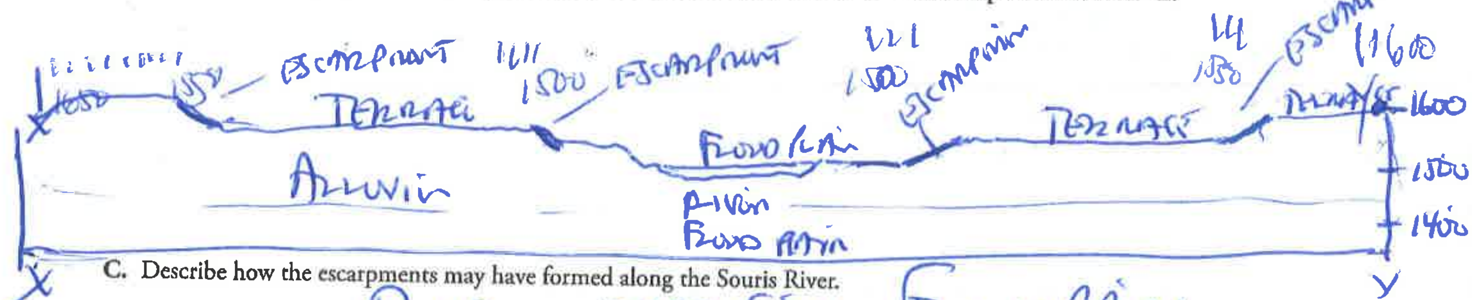
Associated with many streams are escarpments and terraces. Escarpments are long cliffs or steep narrow slopes that separate one relatively level part of the landscape from another. Terraces are long, narrow or broad, level surfaces bounded on one or both sides by an escarpment. Stream terraces parallel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

Refer to part of the the Voltaire, North Dakota quadrangle (orthoimage with topographic contours) in **FIGURE 11.7**. Glaciers (composed of a mixture of ice, gravel, sand, and mud) were present in this region at the end of the Pleistocene Ice Age. When the glaciers melted about 11,000–12,000 years ago, a thick layer of sand and gravel was deposited on top of the bedrock, and streams began forming from the glacial meltwater. Therefore, streams have been eroding and shaping this landscape for about 11,000–12,000 years.

A. The modern floodplain of the Souris River can be identified by its lush, dark green vegetation and blue meandering river. What other meandering stream features named in Figure 11.1C do you recognize in this image?

MEANDERING CUT BANKS CUT OFFS
POINT BARS OXBOW LAKES

B. On the basis of the image and topographic contours, make a sketch, below, of a cross section of the landscape from **X** to **Y**. Label the north and south sides of your sketch, and label terraces with a "T" and escarpments with an "E."



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

RIVER INCISION, FLOODPLAIN ABANDONMENT, TERRACE DEVELOPMENT

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

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

VEGETATION AREA / MAP
~0.5 mi WIDE FLOODPLAIN

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

MORE WATER DUE TO GLACIER MELT
12,000 years AGO

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.

ACTIVITY 11.4 Meander Evolution on the Rio Grande

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

Refer to **FIGURE 11.8** showing the meandering Rio Grande, the river that forms the national border between Mexico and the United States. 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 **FIGURE 11.8**, and then proceed to the questions below.

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?

CUT BANKS HAVE ERODED OUTWARD, BENDS EXTENDING

B. Study locations **H** and **I.**

1. In what country were **H** and **I** located in 1936? USA
2. In what country were **H** and **I** located in 1992? MEXICO

> THE RIVER IS MEANDERING - BORDER IS CENTER OF RIVER

3. Explain a process that probably caused locations **H** and **I** to change from meanders to oxbow lakes.

MEANDER LOOP CUT OFF

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

CUT OFF + STRAIGHTEN = OXBOW LAKE FORMATION

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

OXBOW LAKES - OLD MEANDER LOOPS

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.

A ~ 200m
B ~ 180m
C ~ 180m
D ~ 210 m
E ~ 200m
F ~ 300m
G ~ 250m

AVG ~ $\frac{2020}{7}$ = 288m/yr

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.

ACTIVITY **11.5 Mass Wastage at Niagara Falls**

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

A. Geologic evidence indicates that the Niagara River began to cut its gorge (Niagara Gorge) about 11,000 years ago as the Laurentide Ice Sheet retreated from the area. The ice started at the Niagara Escarpment shown in **FIGURE 11.9** and receded (melted back) north to form the basin of Lake Ontario. The Niagara Gorge started at the Niagara Escarpment and retreated south to its present location. Based on this geochronology and the length of Niagara Gorge, calculate the average rate of falls retreat in cm/year. Show your calculations.

$$\frac{11.5\text{ km}\left(\frac{1000\text{ m}}{\text{km}}\right)\left(\frac{100\text{ cm}}{\text{m}}\right)}{11{,}000\text{ years}} = \frac{105\text{ cm}}{\text{yr}}$$ retreat Avr

B. Name as many factors as you can that could cause the falls to retreat at a faster rate.

BEDROCK RESISTANCE TO EROSION
SHALE = SOFT / FAST
SANDSTONE = HARD / SLOW
DOLOSTONE = HARD / SLOW

C. Name as many factors as you can that could cause the falls to retreat more slowly.

BEDROCK RESISTANCE

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

$$35\text{ km}\left(\frac{11{,}000\text{ years}}{11.5\text{ km}}\right) = 33{,}478\text{ years}$$

WILL ERODE INTO LAKE ERIE

E. **REFLECT & DISCUSS** Look at the cross section of Niagara Falls in **FIGURE 11.10**. Describe how the process that formed the falls could have begun. (Hint: Use your knowledge of stream erosion and the effects of stream gradient.)