MEANDER CURVE *(MODIFIED FOR ADEED)*

Overview:

Friction between water and stream banks causes water to move in a corkscrew fashion. This helical flow is called the water spiral. Gravity and the water spiral are responsible for erosion and deposition in streams.

Objectives:

The student will:
- correctly label the stream diagram;
- describe the connection between force and erosion and deposition; and
- create a data table and record meaningful data.

Targeted Alaska Grade Level Expectations:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[9] SD2.1 The student demonstrates an understanding of the forces that shape Earth by recognizing the dynamic interaction of erosion and deposition including human causes.

Math

[9] S&P-1 The student demonstrates an ability to classify and organize data by designing, collecting, organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers) using information from tables or graphs that display two sets of data or with technology.

Vocabulary:

braided - channels that meet and redivide

thalweg – the deepest continuous line along a valley or watercourse; derived from the German elements "thal," meaning valley, and "weg," meaning way

meandering - single channels with "S"-shaped channel patterns

water spiral – helical flow of water that moves in a corkscrew fashion

Materials:

- 1-quart clear plastic jar with lid (one per group)
- Sandblasting sand (2 ounces per group)
- Aquarium gravel (2 ounces per group)
- Water
- String, for use in measuring (approximately 10 inches per student)
- Centimeter ruler (one per student, or to share)
- Stopwatch or clock with second hand (one per group)
- OVERHEAD: "Rivers and Streams"
- TEACHER INFORMATION SHEET: "Water Dynamics"
- STUDENT WORKSHEET: "Meander Curve"
- STUDENT WORKSHEET: "Water Spiral Investigation"

Activity Preparation:

1. Place 2 ounces sandblasting sand and 2 ounces aquarium gravel inside each plastic jar. Fill each jar with water, leaving very little air space, and fasten lid.
2. Cut string into 8-10 inch lengths.

Activity Procedure:

Gear Up

Process Skills: observing, describing, and making generalizations

1. Show OVERHEAD: "Rivers and Streams." Ask students to describe the shared characteristics of the rivers. (curves and bends) Explain friction between water and stream banks causes water to move in a corkscrew fashion. This helical flow is called the water spiral. Gravity and the water spiral are responsible for erosion and deposition in streams.
2. As a class, discuss the following:
   a. Does water on both sides of the river move the same way?
   b. Is there more erosion on one side of the river?
   c. Is there more deposition on one side of the river?
   d. Does the width of a river affect water flow, erosion, or deposition?
   e. Does the amount of water in a river affect water flow, erosion, or deposition?

Explore

Process Skills: measuring, analyzing data, and investigating

3. Distribute the STUDENT WORKSHEET: "Meander Curve," pre-cut string, and a ruler to each student. Instruct students to measure the inside and outside of the bend of each curve on the worksheet from one line to the other.
4. Assist students in calculating the ratio of the outer distance to the inner distance; assuming the inner distance is 1. For example, if the inside curve measures at 6 inches and the outside curve measures at 9 inches, the ratio would be 1: 1.5, as shown below.

$$\frac{9}{6} \equiv \frac{x}{1}$$

$$6x \equiv 9$$

$$x \equiv 9 \div 6 \equiv 1.5$$

$$1{:}1.5$$

5. As a class, discuss the results. Which of the three bends will generate the most energetic water molecules? Explain water molecules try to stick together, just like a line of ice skaters, arm-in-arm, turning a corner. Ask students which skater will generate the most energy. (the one on the outside edge) Which section of the stream will generate the most energy? (the outside curve)

Generalize

Process Skills: inferring and describing

6. Divide students into groups of four and ask them to consider the following:
   a. What did they discover about the shape of bends and the size of the ratio?
   b. What does this mean?
   c. How does the width of a river affect the ratio?

Explore

Process Skills: investigating, observing, and communicating

7. Distribute a prepared jar to each group. Ask students to move the jar in various ways to demonstrate stream movement.

Generalize

Process Skills: inferring and describing

8. Ask groups to share with the class, answering the following questions:

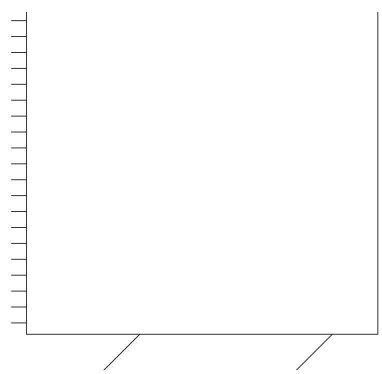
a. How did you move the jar to match the flow of water in a stream?
b. What did you discover using the jar?
c. What can you learn from the sand about water spirals and stream sediment?
d. What can you learn from the gravel about water spirals and stream sediment?

Experiment
Process Skills: hypothesizing, collecting data, analyzing data, and making generalizations
9. Explain that groups will complete an investigation with their jar to quantify the ability of water to erode and move sediment. Distribute the STUDENT WORKSHEET: "Water Spiral Investigation" and a stopwatch. Guide groups through the investigation procedure as necessary, instructing students to stop after the Analysis of Data section.

Interpret
Process Skills: inferring and describing
10. Create a table of class data and record the averages for each speed. Calculate the class average for each speed.

Teacher Note: Mean, median, and mode can all be calculated and the advantages and disadvantages of each can be discussed.

11. As a class, or individually, ask students to create a bar graph of the class data. Make sure to label the graph and provide a key. It may look something like this.



12. Discuss Results

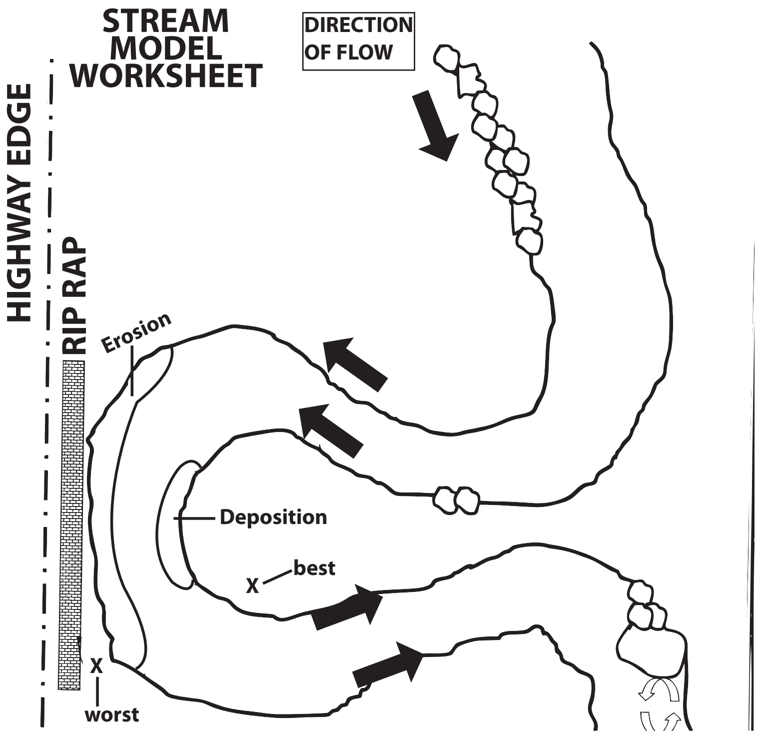
Apply
Process Skills: predicting and communicating
13. Ask students to complete the reaminder of their STUDENT WORKSHEET.

Answers:

STUDENT WORKSHEET: "Meander Curve"
Answers will vary.

STUDENT WORKSHEET: "Water Sprial Investigation"
1A. Answers will vary.
1B. Answers will vary.
2A. B. gravel
2B. Answers will vary, but should indicate that the faster the bottle moved the more energy was produced. The gravel moved the most in the bottle that spun the fastest.
3. B. outer bend
4. A. inner bend

5. B. outer bend
6. A. inner bend
7. A. See illustration below.
   B. See illustration below.



C. Answers will vary, but should resemble the following placement on the diagram above. Explanations should be related to the location of erosion and deposition on the stream.

Rubric:

Objective	GLE	Below Proficient	Proficient	Above Proficient
The student correctly labels the stream diagram.	[9] SD2.1	The student labels the stream diagram with 5 or more errors.	The student labels the stream diagram with 3-4 errors.	The student labels the stream diagram with 2 or fewer errors.
The student describes the connection between force and erosion and deposition.	[9] SA1.1	The student does not describe the connection between the force of the spiraling water and erosion and deposition in a river.	The student describes the connection between the force of the spiraling water and erosion and deposition in a river.	The student describes the connection between the force of the spiraling water and erosion and deposition in a river and can apply it to rivers they have observed.
The student creates a data table and records meaningful data.	[9] S&P-1	The student creates a data table and records data with 3 or more errors.	The student creates a data table and records data with 2 errors.	The student creates a data table and records data with one or less error.

Structures in streams, such as fallen logs, boulders, roots, and artificial objects, provide habitat diversity and help meet the needs of fish and other animals living in streams. To understand how these structures function, the basics of stream hydraulics need to be understood.

The principal forces acting on water in a stream channel are gravity and friction. Gravity propels water downstream. Friction, between the water, streambed, and banks, resists water flow.

Water velocity is influenced by:

- steepness of slope;
- size of substrate materials;
- type and amount of riparian area and stream vegetations;
- shapes, depth, and frequency of pools and riffles;
- stream form; and
- obstructions.

As velocity increases, these factors provide more resistance to flow. This causes eddies, chutes, and waterfalls that can dislodge and move objects downstream.

There are three basic stream forms:

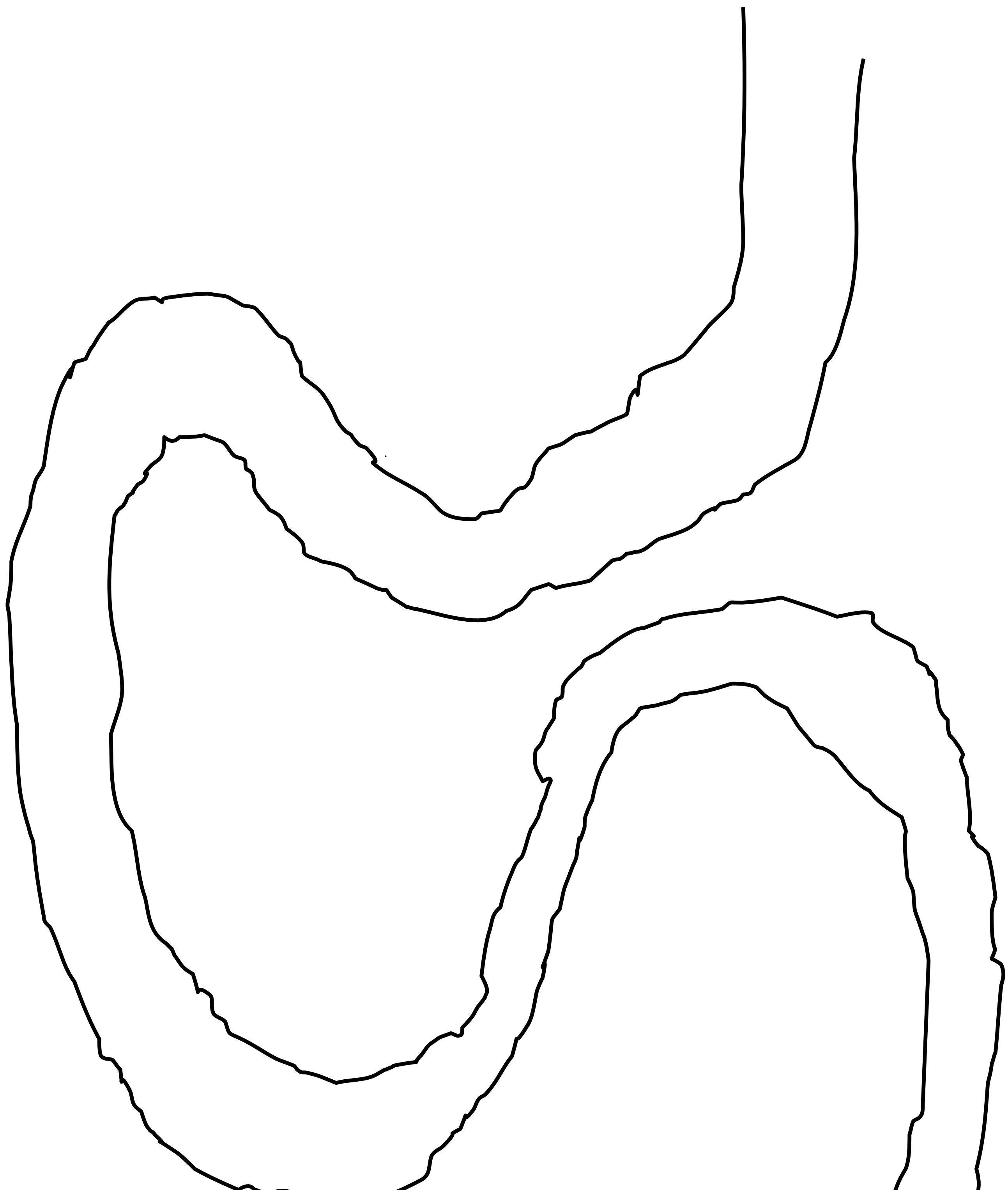
1. Straight – relatively straight or non-bending channels (found on steep slopes)
2. Braided – channels that meet and redivide (usually found on snow melt streams that have dramatically variable flow levels)
3. Meandering – single channels with "S"-shaped channel patterns (most mature streams)

A stream will naturally meander whenever possible. In large streams, a line of maximum velocity, called the thalweg, wanders back and forth across the channel in response to streambed configuration. Thalwegs are generally found near the center of a water column because of friction with the streambed and surface tension.

Water Spiral
Friction between water and streambanks causes water to move in a corkscrew fashion down the channel. This corkscrew, or helical flow, is called a water spiral. As changes occur in the stream channel (straight or curved, high or low gradient, or as a result of structures), the water spiral will change.

A water spiral slows and becomes smaller as it moves through the inside of a curve in a stream channel. As velocity decreases, suspended material carried by the current drops out of the flow and settles along the bend. This change in velocity forms gravel bars and deposits.

A water spiral enlarges and accelerates as it moves around the outside of a curve or obstruction, such as a boulder. The force of the water is dispersed over a larger area. Thus, increased velocity creates pools during high flows. These pools provide excellent feeding and rearing habitat for fish during low flow periods.



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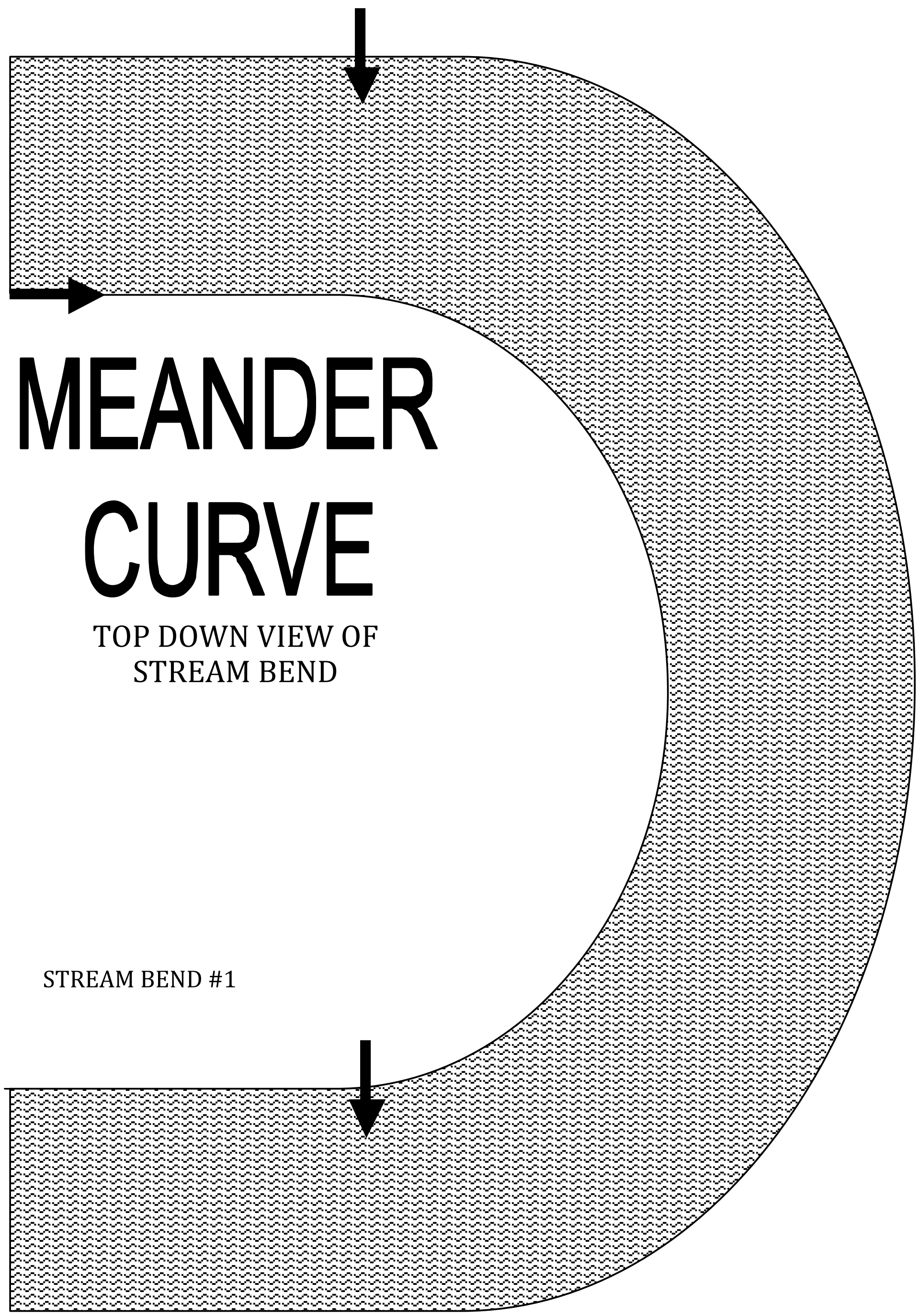
MEANDER CURVE

Directions: For each river bend below and on the following pages, measure the inside curve and the outside curve from one line to the other using a string and meter stick. Then, calculate the ratio of the outside curve to the inside curve. Be sure to label your units.

	Bend 1	Bend 2	Bend 3
Inside Curve			
Outside Curve			
Radio of Outside to Inside Curve			



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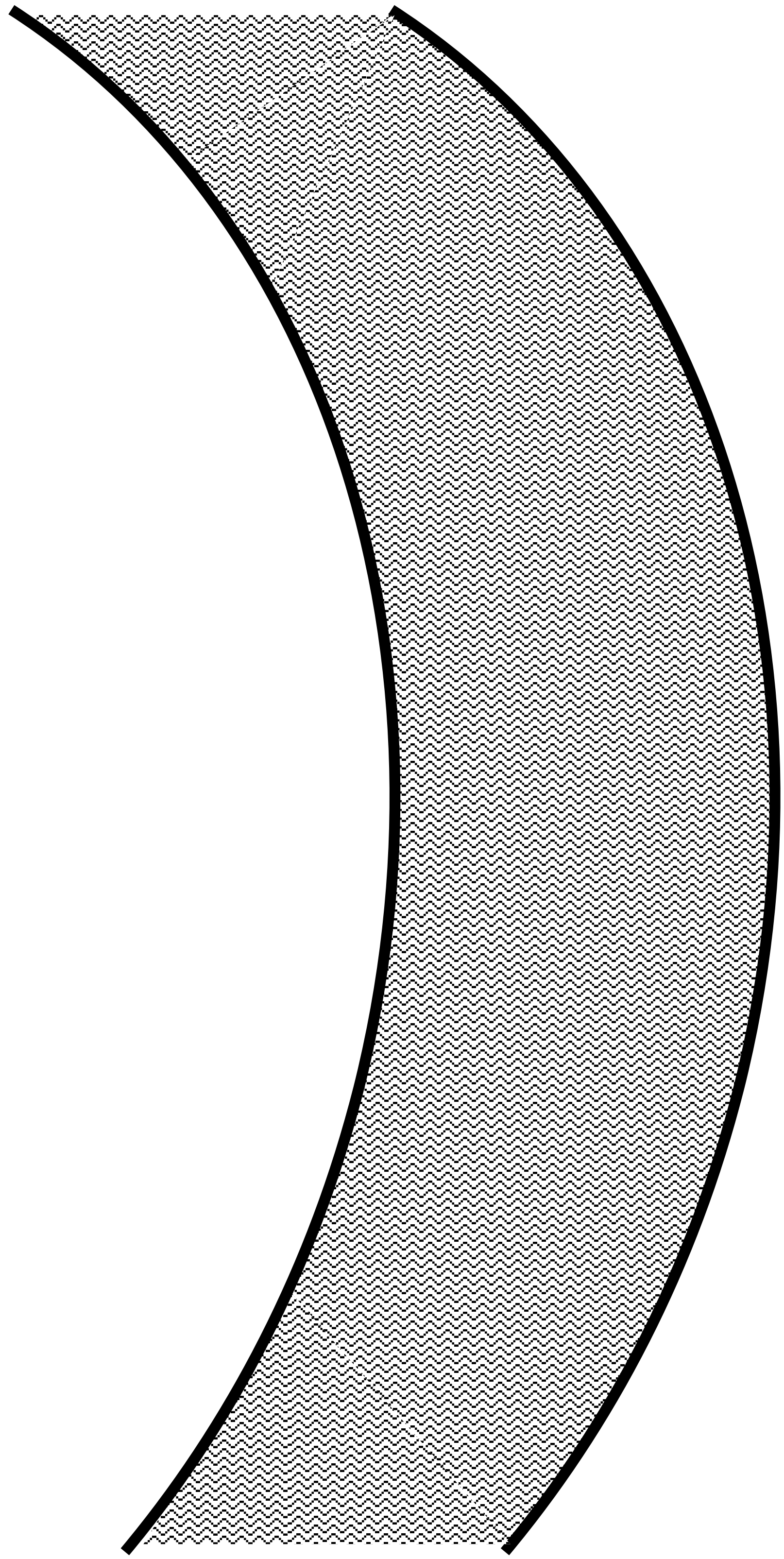
MEANDER CURVE



STREAM BEND #2

STREAM BEND #3

NAME: ______________________________

WATER SPIRAL INVESTIGATION

Materials:

- Marker
- Centimeter ruler
- Stopwatch or clock with second hand
- Prepared stream jar

Procedure:

1. Using a marker, mark lines at 1-centimer intervals along the side of the jar. These will be used as a scale to read how high sediment is lifted in the water column by the circular movement of the container.
2. There are four group roles: jar spinner, timer, sand observer, and gravel observer.
   A. The jar spinner should move the jar, counting the number of turns, while the timer counts aloud for 15 seconds using a stopwatch or clock. The member moving the bottle should try to sustain a constant rate of motion.
   B. As soon as the 15 seconds are counted, the jar spinner should stop spinning the jar. The sand and gravel observers should note the height of the sand or gravel and count how long it takes the sand or gravel to drop out of the water column.
   C. Practice moving the jar as quickly as possible until the group feels confident of the procedure.
3. Rotate the jar at a constant fast rate for 15 seconds. Stop immediately. Observe the height of the sand or gravel. Count how long it takes for all the sand or gravel to drop out of the water column. Record the data in the data table or the following page. Repeat until at least three trials have been completed. Average the results and record in the data table.
4. Repeat step 3 at a medium rate of speed.
5. Repeat step 3 at a slow rate of speed.
6. Observe the bottle at rest. Note observations below the data table in 1B.

Data:

1.

Speed	# of turns per 15 seconds	height of sand in centimeters	# of seconds in suspension	# of seconds gravel was in suspension
Fast Trial 1				
Fast Trial 2				
Fast Trial 3				
Fast Average				
Medium Trial 1				
Medium Trial 2				
Medium Trial 3				
Medium Average				
Slow Trial 1				
Slow Trial 2				
Slow Trial 3				
Slow Average				

1B. Bottle at rest: ____

NAME: ____________________________

WATER SPIRAL INVESTIGATION

Analysis of Data:

2A. Did it take more energy to raise the sand or the gravel?

A. sand

B. gravel

2B. Explain your reasoning.

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Further Questions:

3. Where in a stream bend will there be enough energy to raise gravel into temporary suspension?

A. inner bend

B. outer bend

4. Where in a stream bend will there be enough energy in the water to raise sand into temporary suspension?

A. inner bend

B. outer bend

5. Where will maximum erosion be in a stream bend?

A. inner bend

B. outer bend

6. Where will minimum erosion be in a stream bend?

A. inner bend

B. outer bend

7. Complete the following steps to label the diagram below.

A. Using larger arrows to represent stronger current and smaller arrows to represent weaker current, label three points on the bend of the diagram below: the start of the bend, the maximum bend, and the end of the bend.

B. Label the parts of the bend where erosion will occur and where deposition will occur.

C. Using an "X" to represent or symbolize a house, mark an "X" at two separate locations near the stream: one "X" showing the best or ideal location for a resident and the other "X" showing the riskiest location. Label each "X" as either "best or "riskiest." Explain your reasoning for choosing those locations.

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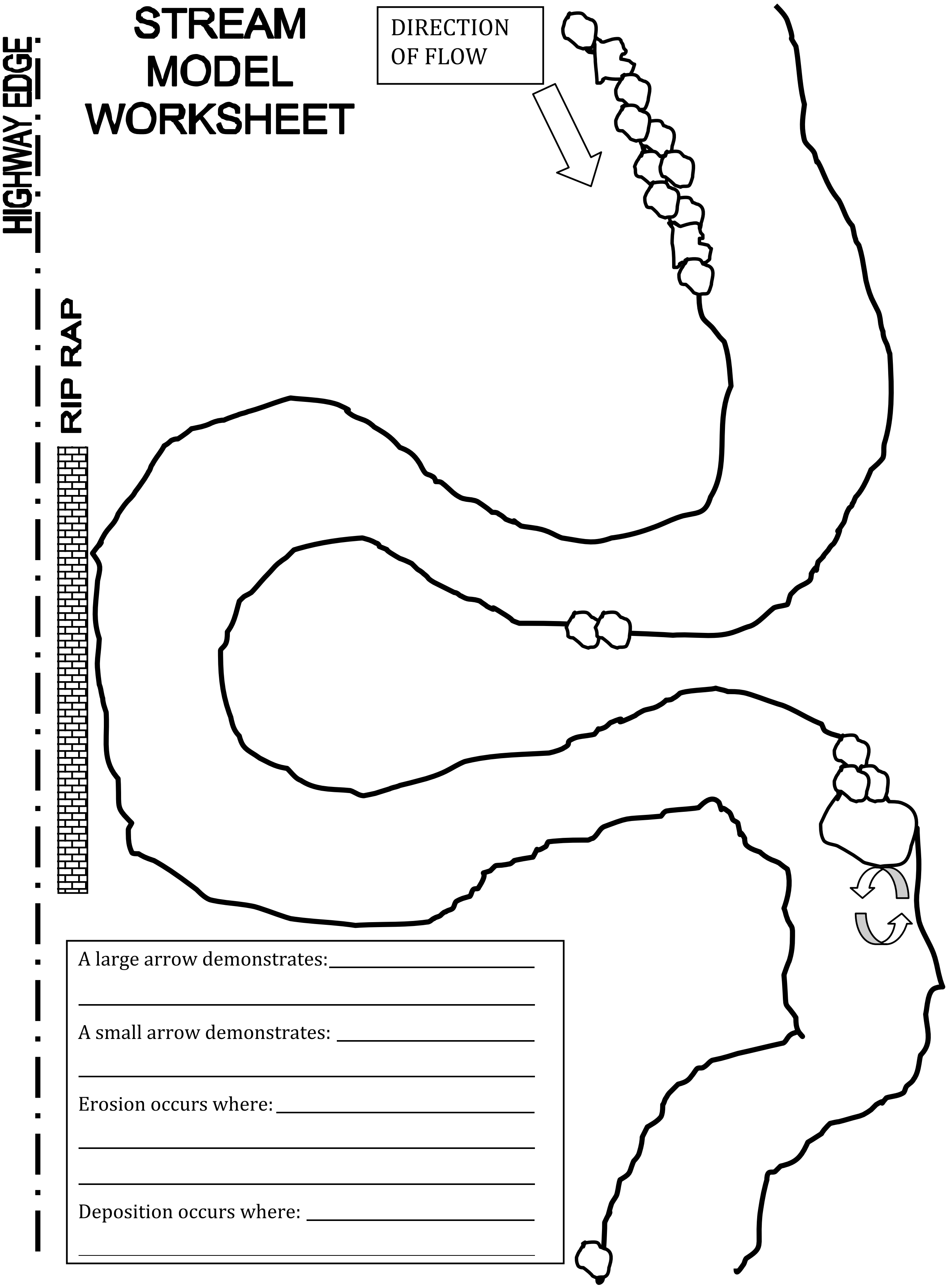
NAME: ______________________________

WATER SPIRAL INVESTIGATION

STREAM MODEL WORKSHEET



A large arrow demonstrates: ______________________________

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A small arrow demonstrates: ______________________________

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Erosion occurs where: ______________________________

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Deposition occurs where: ______________________________

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