I Live to Sieve Stream Sediments

ADAPTED FROM: Harrelson, C.C., Rawlins, C.L., Potyondy, J.P., 1994. "Bed and Bank Material Characterization" in *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.*

GRADE LEVEL: Intermediate

DURATION: 2 consecutive days, 40 minutes each day

OBJECTIVES: Students will be able to classify streambed sediments according to their size. Students will learn about the changes in substrate within a stream.

VOCABULARY: chemical weathering, mechanical weathering, sediment, capacity, competence, suspended load, bed load, dissolved load, mature sediments, immature sediments, saltation, alluvium, point bars, natural levees, backswamps, wetlands.

RELATED MODULE RESOURCES:

- Sediment grain size charts
- Magnifying glasses
- Pebble Count Activity
- Measuring Turbidity with Filters Activity

MATERIALS (INCLUDED IN MODULE):

- Screen sieves
- Bottomless buckets

ADDITIONAL MATERIALS (NOT INCLUDED IN MODULE):

- Balances
- Buckets
- Shovels
- Incubator

ACADEMIC STANDARDS:

STEELS- 3.1 Life Science
6-8 Grade
3.1.6-8.K Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem

STEELS- 3.3 Earth and Space Science
6-8 Grade
3.3.6-8.E Construct an explanation based on evidence of how geoscience processes have changed Earth's surface at varying time and spatial scales.

9-12 Grade
3.3.9-12.H Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.

OVERVIEW: Students will investigate stream sediments and characterize sediment sizes. Students will compare the substrate from various locations within a stream or from different streams. Students will collect stream sediment samples and separate the samples into the various grain sizes using a sieve. Students will learn about the origin, transportation, and deposition of sediments.

BACKGROUND:

A Waterway's substrate is a very important component of a stream to study. **Substrate** refers to the mineral and organic substances on the bottom of the waterway channel. It is simply the rocks, sands, silt, muck, vegetation, twigs, and cement that may be found in our stream bottoms. A waterway's substrate influences aquatic life, water chemistry, and stream appearance and it can reveal a lot about what is happening in the stream.

Sediments make up the substrate. **Sediments** are composed of mineral material ranging from small bits of rock to tiny clay particles to big boulders and organic material such as dead leaves and twigs.

Sediments enter the water either from surrounding land surfaces and soil or from larger rocks. The weathering of rocks can create sediment. There are two types of weathering, **chemical weathering** and **mechanical weathering**. Chemical weathering occurs when water and rocks combine and the chemical makeup of a rock is altered. Mechanical weathering is the physical breakdown of rocks and can occur when water freezes in the cracks of rocks and breaks them apart. mechanical weathering also occurs when water erodes the surfaces of rocks.

Sediments range in size from boulder (> 256 mm in diameter) to very small silt and clay particles. sediments are usually classified by their size, but the sediment size classifications vary from source to source. Examples can be found at the end of this activity.

Sediments are transported and deposited, creating changes to the landscape. water is the most common transporter of sediments. When water flows over the landscape, it picks up sediments. Within a stream, sediments are on the move. the amount and type of sediments that a stream transports is determined by the stream's velocity and size, the composition and texture of the sediments, the stream's interaction with the surrounding land and land uses, and the characteristics of the bedrock through which the stream flow.

The maximum load of sediment that a stream can transport is its **capacity**. Capacity is expressed as the volume of sediment passing a given point on the stream back in a given amount of time. Capacity is proportionate to discharge: the more water flowing in the channel per second, the greater the volume of sediment that is transported in that time. The diameter of the largest particle that a stream can transport is the measure of a stream's **competence**. Streams transport sediment in different ways, depending on particle size.

The total volume of sediment carried by a stream is its **sediment load**. The sediment load consists of three components - dissolved load, suspended load, and bed load. Dissolved minerals from a stream's substrate and ions from groundwater entering a stream through the channel walls make up a stream's **dissolved load**.

BACKGROUND CONTINUED:

Typically streams carry only a about 120 ppm (parts per million- 120 ions per million water molecules). In streams that flow over particularly soluble minerals like halite or gypsum may contain over 1,000 ppm of dissolved ions. The **suspended load** of a stream contains tiny, solid grains (silt or clay size) that swirl along with the water without settling to the floor of the channel. The suspended load accounts for the bulk of sediment carried by a river. Large particles that bounce and roll along the stream bottom are known collectively as the **bed load**. Bed load movement involves a process known as **saltation**, when grains get knocked into the water column and follow a curved trajectory downstream and sink to the bed of the stream again. Here they may bump other grains into the water column and the process repeats.

Sediment load is material mixing and moving with the flowing water, making the water muddy. The fine material will eventually settle in the water because of its density and weight, but it can be lifted again from the bottom into the water column during disturbances (high flow rates, dredging, boating, swimming, and water withdrawals for industry or municipalities). when the motion of the water slows or stops, suspended solids settle out of the water in a process called **sedimentation**. The smallest, lightest soil particles stay suspended in the water the longest, and the largest, heaviest settle first. Slow moving or still area in a waterway allows for sedimentation to occur. Pools will have more fine sediment settling than in a riffle areas. The mid-channel of a creek (larger substrate size) is usually faster flowing and has large substrate size) is usually faster flowing and has larger substrate size as compared to closer to the shore. In fast water, the small particles do not have a chance to settle out or do not remain at the bottom. High velocity waters erode and transport large boulders, but they also transport small particles, flat clay particles and mica flakes. Higher velocities are sometime required to move clay and silt particles because electrical forces on their surfaces cause them to cling to the streambed. Once in the streamflow the fine clay particles remain suspended and are transported long distances.

Substrate changes from headwaters to the mouth of the stream. At the headwaters of a stream the sediment grains are very **immature**. The grains are poorly sorted; they vary in size from large boulders to silt size grains and the grains have sharp, jagged edges. **Mature sediments** have a well rounded shape, very fine particle size (1/16-1/8 mm), and the sediments are well-sorted (uniform size of sediments). A stream sorts the particles it carries by depositing them in order of size, the heaviest are deposited first and the lighter sediments are carried downstream to the mouth of the stream. The further particles travel the more mature and better sorted they become. *(Refer to the grain size sorting charts included in the module for grain sizes, sorting and shape comparisons.)*

Deposited steam sediments are described collectively as **alluvium.** During normal flow a stream with large amount of coarse bed load sediment often deposits some of its load in its channel as mid-channel bars.

BACKGROUND CONTINUED:

As sand and gravel accumulates the stream flows around the channel bars and the stream becomes braided. The bars become more resistant to erosion as vegetation begins to grow on them. In-channel deposits may also be in the form of **point bars**, where sediments from the outside banks of meandering streams are deposited on the inner banks. Point bars are where meandering streams drop their heaviest particles.

When a stream's channel is unable to contain the water flowing through it, the water overflows onto the surrounding floodplain. Floodplains catch large volumes of sediment from floodwaters because the velocity of the water is decreased and the sediments settle out. **Natural levees** are ridges of coarser sediment deposited on both banks of a stream during successive flooding. Natural levees grow higher from sediment accumulation from each flood and tend to be the highest points on a floodplain. **Backswamps** are the portion of the floodplain near the river where deposits of fine silts and clays settle from standing waters following a flood. If a floodplain has surface depressions water may remain at the surface as **wetlands.**

Excessive erosion, transport and deposition of sediment in surface waters is a major problem in the United States. The 1996 National Water Quality Inventory (Section 305(b) Report to Congress) indicates sediments are ranked as a leading cause of water quality impairment of assessed rivers and lakes. Human disturbances of land (deforested, plowed, and constructed on) can increase erosion levels, increasing the sediment load faster than ecosystems can adjust. Heavy rain storms and sudden snow melts can increase soil and sediment **erosion,** the process of wearing away the earth's surface into the stream. Moving water moves soil, and the stronger the water flow, the more soil it moves.

Excessive deposition of sediments can pose hazards to fish and benthic macroinvertebrates communities by disrupting habitats, degrading spawning habitats, and reducing the flow of oxygen through gravel beds. High concentrations of suspended sediment can adversely affect aquatic species that filter and ingest water. Poor land-use practices increases the amount of sediments that find their way into streams. Areas undergoing intense development create large quantities of sediments. These sediments are then eroded away through surface runoff, severely impacting water quality, fish and wildlife and ecological habitats as they are carried to streams and lakes. Increased sedimentation can also cause streams and rivers to flood. Sedimentation in the stream bed narrows the stream channel also decreasing the amount of water the stream can transport. When heavy rains fall, the stream is unable to contain the water and the stream floods the surrounding area.

BACKGROUND CONTINUED:

References

Chernicoff, Stanley, 1995. Geology. New York, NY: Worth Publishers.

Hauer, F.R., and G. Lamberti, 1996. Methods in Stream Ecology. San Diego, CA: Academic Press.

Marshak, Stephen, 2001. Earth: Portrait of a Planet. New York, NY: W.W. Norton & Company, Inc.

Morisawa, Marie, 1968. Streams: Their Dynamics and Morphology. New York, NY: McGraw-Hill Book Company.

PROCEDURE:

Teacher Preparation:

1. Students will be collecting substrate sediments in this activity. You will need to determine from where students will be collecting substrate. option are listed below. Choose the collection area option/s/ that best suits your stream and learning objectives.

   Collection Area Options

   A. Shoreline & Middle of the Stream
   B. Riffle Zone & Pool
   C. Upstream & Downstream
   D. Two Different Streams

2. Be sure the stream is safe for students to enter. Do not have them enter the stream if it is flowing faster than normal; currents can be misleading, powerful, and cause students to lose balance. Water should not be entered in the winter (late November- mid March), even if students are wearing hip waders, because of the threat of hypothermia. Warn students to be careful not to slip or fall on rocks in the creek.

3. Once you have chosen the areas of the stream you would like to investigate you will need to choose one of the following substrate collection methods that best suits the collection site and how scientific you want this activity to be. The methods vary from basic collection to more quantitative methods. Procedure for these methods are in the Student Experiment/ Activity section.

PROCEDURE CONTINUED:

Teacher Preparation Continued:

a.) Shovel Method- Students will use shovels or hand towels and buckets to collect a sample from the stream bottom. This method works best in shallow water (<24 inches deep) but can be done in deeper water. This method is a very basic collection of a sample and the least scientific because it is difficult to replicate procedures and very small sediments will have a tendency to wash away when digging.

b.) Milk jug scooping method- Students will use milk jugs with the bottoms removed to scoop down into the sediment and collect a sample. One milk jug with cap per group will need to be collected for your class. This procedure can be replicated and can be somewhat quantitative if specific scoop technique is uniformly performed. This method works best in shallow water (<24 inches deep). To make a milk jug scoop, collect ½ gallon milk jugs (keep the cap). Using a utility knife, cut the *bottom* 2 inches off the jog creating a “scoop” with a handle (jug handle).

c.) Bottomless bucket method- Using a bottomless bucket, students will push the “cylinder” into the stream-bed and scoop out the sediments with hand shovels and collect them in a bucket. This method can be done in either fast or slow water, but water depth may be limited to the height of the bucket. This method is more scientific and provides more quantitative results because find sediments are contained within the bucket (are not washed away) and there is a fixed area of substrate being studied.

d.) Dredges or Grabs method- These devices have spring-loaded jaws that close on the bottom flaps that close on the top to completely enclose a special area of sediment and overlying water. Dredge and grabs can be inserted into the streambed with a long handle or lowered from a boat or bridge on a cable through the water. With care, a dredge can collect a sediment core without losing fine surficial materials.

e.) There are other scientific collection methods/ equipment to collect substrate samples that you will unlikely use with students. The Helley-Smith pressure differential sampler is a handheld sampler commonly used for bedload measurements. The DH-48 depth-integrating sampler is a handheld sampler that measures the changes in suspended sediment concentrations that occur with depth. When frequent sampling is required or when multiple samples are required, pumping samplers are used. The pumping samplers are self-contained units that can gold all samples taken in a single holding unit or place each sample into a separate container. The fine meshed Surber sampler is an empty square frame with a net connected to it. Sediments can be collected from within the frame into a bucket and suspended fine sediments drift downstream into the net.

PROCEDURE CONTINUED:

Teacher Preparation Continued:

4. Divide students into groups based on the collection equipment availability and based on different areas you want them to collect from. Each group of students will collect one sediment sample. The class can later share and compare the data collected from the various locations.

5. After the samples have been collected, students will use sieves. There are two ways to sieve.
   a.) Dry Sieving Method (preferred method) is performed in the classroom after sediment samples dry. This is a more quantitative method of investigating sediment samples because you can measure the mass or volume of various sediment types/sizes.

   b.) Wet Sieving Method can be completed streamside or outside the school with wet sediment samples. It is more difficult and messy to sieve this way and once the sediment sizes are separated, it is more difficult to quantify results. But it is still useful for a visual method of comparing sediment samples.

6. After the students have completed their data sheets, they will need to share their data with the other groups.

Student Experiment or Activity:

Safety Precautions

Only enter the waterway if the teacher gives permission and the stream conditions are deemed to be safe.

1. Students will be entering a stream and collecting a sediment sample according to the method chosen by the instructor. Each group will collect one sample, unless told otherwise. The teacher should let each group know where exactly in the waterway samples will be obtained from. The data collected will be shared and compared with the other groups.

2. The following are several collection methods and instructions for each. Follow the instructions for the method chosen by the instructor.

   a.) Shovel Method- Carefully wade into the stream downstream from the sample collection site, this way sediments will not be disturbed prior to collection. Using a shovel or hand trowel and plastic bucket, scoop a sample from the bottom of the stream. Carefully lift the shovel and sediment out of the stream and place into bucket. Bring the substrate sample to shore.

PROCEDURE CONTINUED:

Student Experiment or Activity:

b.) Milk jug scoop- Carefully wade into the stream downstream from the sample stream collection site, this way sediments will not be disturbed prior to collection. Holding the jug by the handle, scoop down into the streambed and then lift the jug out of the water. The teacher may have more specific specifications for the scoop procedure (ie. how long / far to drag scoop into the jug). Pour the sample into a bucket. Bring the substrate sample to shore.

c.) Bottomless Bucket method - Enter the stream downstream from the sample collection site, this way sediments will not be disturbed prior to collection. One group member will push the bottomless bucket straight down into the sediment and hold it on place. Twist the bottomless bucket in a circular motion to reach a depth of at least 4-6 cm. The top of the bottomless bucket should not be under the surface of the water. Using the hand shovels or some other scooping tool, other members should scoop the sediment out of the bottomless bucket and place into a plastic different bucket (with bottom) held by another member. All sediment should carefully be removed from a depth of 4-6 cm (or as deep as the bottomless bucket was inserted in the substrate). Bring the substrate sample to shore.

d.) Dredge or Grab method - Follow the teachers instructions for this method.

3. Once samples have been collected, the sediments will be separated according to their grain size using a sieve. The teacher will have chosen a method of sieving for the class. The instructions are listed below.

Dry Sieving Method - to be completed in the classroom

A. Take the sample back to the classroom. Notice the very fine sediments making the water in the sample bucket cloudy. Let the water inside the bucket settle overnight. the next day, carefully drain as much of the water out of the bucket as possible, but try not to dump out too much of the fine sediments from the bucket.

B. It is time to dry the sediment sample. The teacher will decide whether the sample will be spread out in some type of tray and allowed to air dry for a few days or if the sample will be dried in an incubator or oven.

C. After the sediment samples have dried, the weight of the entire sediment sample should be obtained and recorded on the data sheet. Factor in and deduct the weight of the tray or container holding the sediments.

PROCEDURE CONTINUED:

Student Experiment or Activity Continued:

D. Next, obtain the screen sieves, arranging them with the largest screen/mesh size on top, proportionally decreasing in screen/mesh size to the closed-bottom container. For example:

1st Sieve - #5 mesh (largest)
2nd Sieve - #10 mesh
3rd Sieve - # 35 mesh
4th Sieve - #60 mesh
5th Sieve - #120 mesh
6th Sieve - #230 mesh (smallest)
Bottom pan (no mesh)

E. Place the sediment in the upper most sieve, cover it, and lightly shake it using a back and forth motion. The particles should fall through the various mesh screens, being sorted by their size. You may need to check the various sieves to make sure none are getting clogged by particles, not allowing smaller particles to pass through to lower sieves.

F. After the sediments are sorted. Carefully remove each sediment size from each sieve, removing all particles from the screens. Now weigh each sediment size separately. Record the weight but don't forget to factor in and deduct the weight of the container folding the sediments obtained and recorded.

G. On the data sheet, the masses of each particle size can be converted to a percentage by dividing the previously recorded total mass into the mass of each individual particle size.

H. Follow clean up procedures provided by the teacher.

Wet Sieving Method - to be completed streamside or outside

A. The screen sieves should be arranged with the largest screen size on top, proportionately decreasing in screen size to the smallest mesh sieve. Do not place the bottom pan on the sieve.

B. One group member will hold the sieve above an empty bucket gently shaking the sieve in a back and forth motion while another group member carefully pours a portion of the sediment sample into the top of the sieve. Some of the cloudy water being collected in the bucket may need to be poured back through the sieve to assist with the sorting.

C. Be careful not to overflow the sieve with water. The water will begin to accumulate in the lower pans of the sieve. If water begins to seep through the cracks between the pans, carefully take apart the pans and unclog the screen of fine particles by gently swirling the water with your finger or scraping the screen. Be sure to keep the sieve pan directly over the next pan of the sieve. Repeat this process, carefully adding a portion of your sample at a time.

PROCEDURE CONTINUED:

D. Once the sample has been sieved take apart the pans and make visual observations of each pan’s sediments.

E. Follow the clean up procedures of the teacher.

DISCUSSION:

How does substrate change from the headwaters of a stream to the mouth? *See background information.*

Where in a stream might you find smaller sediments to have settled out? *See background information.* Where any of your sediment sample for this activity from these types of areas? Were the sediments from these locations different than other areas in the waterway?

How does the velocity of a stream determine the deposition of sediments? *See background information.*

What else may affect the downstream trend of change in grain size? *Parent material of the sediments, bedrock of the stream and surrounding area, addition of sediments from tributaries, land use disturbances, soil erosion, excessive high, fast water or flooding.*

Why do scientists study a stream’s substrate? What are some things that the substrate can reveal about what is happening in a waterway? *See background information.*

How does too much sediment in a stream affect the aquatic life? *See background information.*

If the amount of smaller sediments in a stream stretch of moderately flowing water is increasing over a number of years, what be happening to the waterway? What might be causing this to occur?

EVALUATION:

- Correctly completed data sheets.
- Correctly conducted sieving methods.
- Accurately completed graphs of sediment sizes.

EXTENSIONS & MODIFICATIONS:

- Examine and identify the types of rocks and/or materials in the sediment sample.
- If you completed the Setting Sediments activity, you could sieve the Sedimentation that you constructed and compare the sediments to your stream sample.
- Collect the cloudy water (with fine clays and silts) from this activity and conduct the activity "Measuring Turbidity with Filters" to determine the weight of the clay and silt.

NOTES (Please leave suggestions you have for Teachers using this activity in the future):

TABLE 3.3 The classification of mineral substrates by particle size, according to the Wentworth Scale (After Cummins, 1962; Minshall, 1984)

Size Category	*Particle Diameter (range in mm)*
Boulder	>256
Cobble	
Large	128–256
Small	64–128
Pebble	
Large	32–64
Small	16–32
Gravel	
Coarse	8–16
Medium	4–8
Fine	2–4
Sand	
Very coarse	1–2
Coarse	0.5–1
Medium	0.25–0.5
Fine	0.125–0.25
Very fine	0.063–0.125
Silt	<0.063

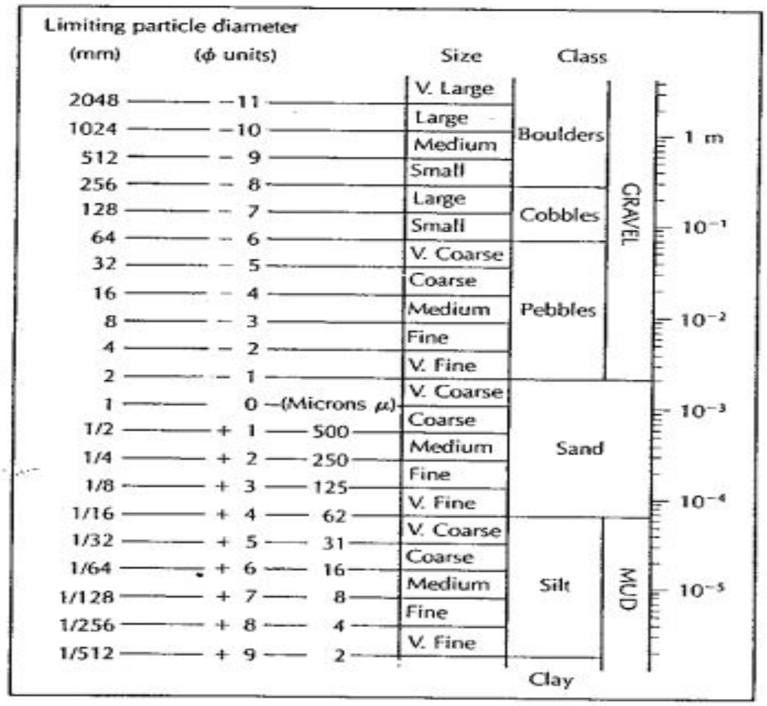


FIGURE 4.3 Standard sizes of sediments with limiting particle diameters and the φ scale of sediment size, in which φ is equal to $\log_2 s$ (the particle diameter). Source: G. M. Friedman and J. E. Sanders, *Principles of Sedimentology* (New York: John Wiley, 1978). Used with permission.

TABLE 4.2 Engineering grain-size classification

Name	Size Range (mm)	Example
Boulder	>305	Basketball
Cobbles	76–305	Grapefruit
Coarse gravel	19–76	Lemon
Fine gravel	4.75–19	Pea
Coarse sand	2–4.75	Water softener salt
Medium sand	0.42–2	Table salt
Fine sand	0.075–0.42	Powdered sugar
Fines	<0.075	Talcum powder

Various Sediment Size Classifications

Sediment	Description
Boulder	Formed from mechanical weathering of rock. 15.24cm – several meters in diameter
Gravel	Formed from mechanical weathering of rock. 0.32cm – 15.24cm in diameter
Sand	Formed from mechanical weathering of rock. Ranges in size from 1/8mm – 2.0mm
Silt	Formed from chemical weathering of rock. Grains stick together when wet and form mud. Pieces float in moving water, making water cloudy. Ranges in size from < 1/16mm – 1/8mm.
Clay	Formed from chemical weathering of rock. Individual pieces are not visible. They are more than ten times smaller than silt pieces. When dry, clay is powder. The pieces stick together when wet and form mud. Pieces float in moving water, making water cloudy.
Plant Remains	Made of pieces of plant roots, stems, leaves, fruits, and flowers. Pieces may have many sizes and are usually dark brown or black. Pieces float in moving water. Thick layers form muck.
Animal Remains	Made of seashells, tiny skeletons, and teeth.
Salts	Formed from the evaporation of seawater.

Adapted from SEDIMENTATOR™ Copyright 1996 Janeval Toys, Inc.

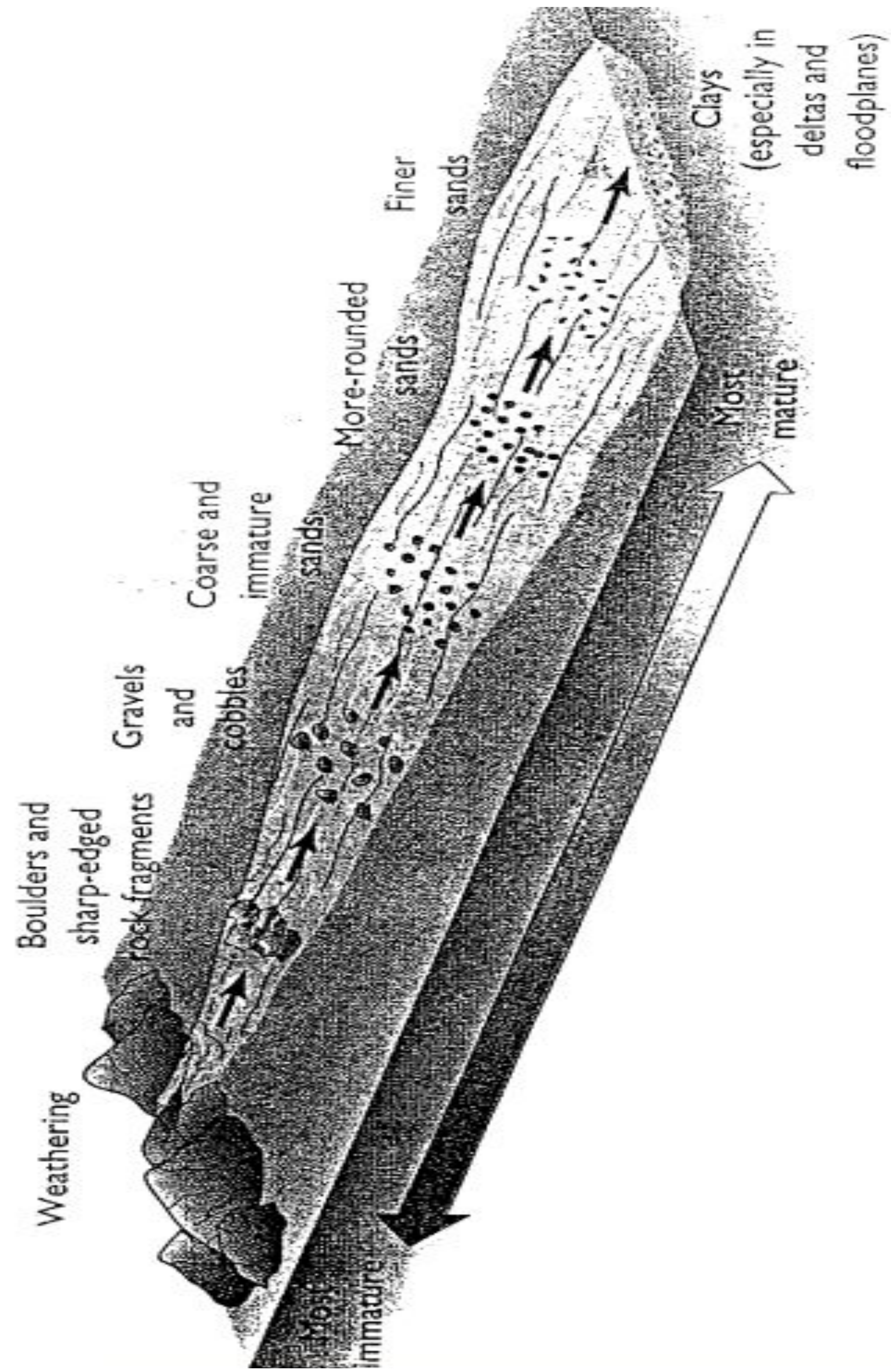
TABLE 7.5

Particle Size Classification of Clastic Sediments and Sedimentary Rocks

SEDIMENT		PARTICLE SIZE	ROCK
COARSE			
Gravel	Boulder		
		256 mm	
	Cobble		Conglomerate
		64 mm	
	Pebble		
		2 mm	
	Sand		Sandstone
		0.062 mm	
Mud	Silt		Siltstone
		0.0039 mm	
	Clay		Mudstone (blocky fracture) Shale (breaks along bedding)
FINE			

Understanding EARTH, 1993.

Gradation of River Sediment Maturity



In this example, maturity increases from the headwaters toward downstream.

Peters, Kristen E., and Davis, Larry E. Geology From Experience: Hands-On Labs and Problems in Physical Geology, 1st Ed. New York: NY, 2001.

Data Sheet: I Live to Sieve

Name: ________________________________ **Date:** __________

Sediment Sample Identification: ____

Location of Sediment Sample: ____

Visual Description of Sediment Sample: ___________________________________

Sieve Information	Correlating Sediment Size	Weight of EMPTY Sieve/Container	Weight of Sieve/Container and Sediment together	Weight of Sediment	Percentage (divide the total weight into the individual size weights from column #5)
1st sieve #5 mesh	Coarse Gravel or larger				%
2nd sieve #10 mesh	Fine Gravel				%
3rd sieve #35 mesh	Very Coarse Sand				%
4th sieve #60 mesh	Coarse Sand				%
5th sieve #120 mesh	Medium Sand				%
6th sieve #230 mesh	Fine Sand				%
Bottom Pan	Silt and Clay				%
			Total Weight	=	**100%**

Pie Chart for Results:

Data Sheet: I Live to Sieve

SUMMARY of Sediment Sample Size Composition

Sediment Sample Identification/ Location	% of coarse gravel or larger (#5 sieve)	% of fine gravel (#10 sieve)	% of very coarse sand (#35 sieve)	% of coarse sand (#60 sieve)	% of medium sand (#120 sieve)	% of fine sand (#230 sieve)	% silt and clay

Other Notes:

Worksheet: I Live to Sieve

Name____________________________________ Class______________

1. Which of the sediment samples contains the greatest amount of coarse particles?

2. Why does this occur?

3. What range of particle sizes seems to dominate your sample?

4. Is there a way to separate the silt from the clay?

5. How are the other stream site samples different from the sample collected by your group? Why are the samples different?

Worksheet: I Live to Sieve

6. How are the other stream site samples similar to the sample collected by your group?

7. What influences the composition of the streambed substrate? Does the location of the stream influence the substrate?

8. Does the sediment sample your group collected give you any clues to the geologic history of the stream?

9. What does the sediment sample you collected tell you about your stream? (maturity of sediments, deposition patterns within the stream, effects on aquatic life)