CHAPTER 9

BIG Idea

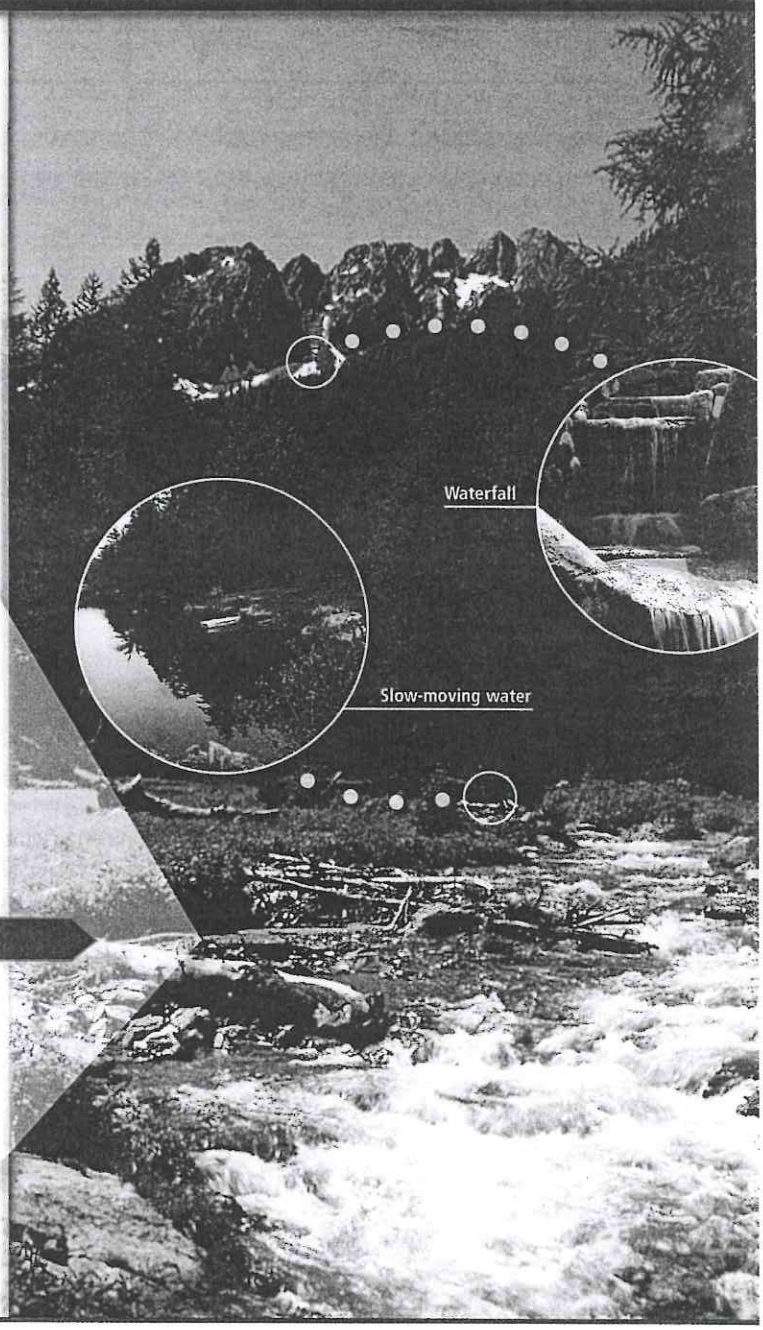
Surface Water Movement Ask students: What types of bodies of water constitute surface water? rivers, lakes, streams, ponds, seas Write their answers on the board. Ask students: From where does surface water come? rain, ice, snow, under the ground Write their answers on the board. Ask students: Where does surface water go? under the ground, into the ocean, evaporates into the sky Write their answers on the board.

Teacher Content Support

Wild and Scenic Rivers In 1968, Congress created the Wild and Scenic Rivers Act, which protects a number of rivers in the United States. Only one-quarter of 1 percent of the rivers in the United States are protected with this designation. Ask students: why might rivers need to be protected? Rivers might need to be protected from being diverted, being dammed, or being polluted.

CHAPTER 9

Surface Water



BIG Idea Surface water moves materials produced by weathering and shapes the surface of Earth.

9.1 Surface Water Movement
MAIN Idea Running water is an agent of erosion, carrying sediments in streams and rivers and depositing them downstream.

9.2 Stream Development
MAIN Idea Streams erode paths through sediment and rock, forming V-shaped stream valleys.

9.3 Lakes and Freshwater Wetlands
MAIN Idea As the amount of water changes and the amount of sediments increases, lakes can be transformed into wetlands and eventually into dry land.

GeoFacts

- The United States has approximately 5,600,000 km of rivers.
- The Missouri River is about 4087 km long, making it the longest river in North America.
- The Mississippi River Basin drains 41 percent of the United States.

Interactive *Chalkboard*

This DVD-ROM is an editable Microsoft® PowerPoint® presentation that includes:

- a premade presentation for every chapter
- additional diagnostic, formative, chapter, and Standardized Test Practice questions
- animations
- image bank
- Glencoe Earth Science Transparencies
- links to glencoe.com

ction 9.1

Focus

us Transparency

re presenting the lesson, pro- Section Focus Transparency id have students answer the mpanying questions. EL

IN Idea

ning Water Write the follow- erms on the board and ask nts to organize them in a ept map: *rain, slope, ocean, ilt, river, valley, sediments, stream, pond, flow.* Answers will

Teach

Identify Misconceptions

t students think clouds are le of water vapor.

over the Misconception

students what makes up ds.

nonstrate the Concept

students cloud droplets n when air becomes satu- d with water vapor and the r vapor condenses on small, l particles called condensa- nuclei, such as dust, pollen, lt. Tell students that these d drops are suspended in tmosphere, and when they ır in concentrations large gh to block out varying ees of sunlight, they can be gnized as a mass in them- s. The aggregate of droplets ferred to as a cloud. Hence, ds are composed of liquid s of water, not water vapor.

ess New Knowledge

students to answer the wing question: What are ds made of? Clouds are made liquid drops of water.

Section 9.1

Objectives

- **Describe** how surface water can move weathered materials.
- **Explain** how a stream carries its load.
- **Describe** how a floodplain develops.

Review Vocabulary

solution: a homogeneous mixture in which the component particles cannot be distinguished

New Vocabulary

runoff
watershed
divide
suspension
bed load
discharge
flood
floodplain

Surface Water Movement

MAIN Idea **Running water is an agent of erosion, carrying sediments in streams and rivers and depositing them downstream.**

Real-World Reading Link Have you ever noticed that sometimes a river is muddy but other times it is clear? In floods, rivers can carry greater amounts of materials, which makes them muddy. Under normal conditions, they often carry less sediment, which makes them clearer.

The Water Cycle

Earth's water supply is recycled in a continuous process called the water cycle, shown in **Figure 9.1.** Water molecules move continuously through the water cycle following many pathways: they evaporate from a body of water or the surface of Earth, condense into cloud droplets, fall as precipitation back to Earth's surface, and infiltrate the ground. As part of a continuous cycle, the water molecules eventually evaporate back to the atmosphere, form clouds, fall as precipitation, and the cycle repeats. Understanding the mechanics of the water cycle will help you understand the reasons for variations in the amount of water that is available throughout the world.

Often, a water molecule's pathway involves time spent within a living organism or as part of a snowfield, glacier, lake, or ocean. Although water molecules might follow a number of different pathways, the overall process is one of repeated evaporation and condensation powered by the Sun's energy.

Reading Check Explain What happens once water reaches Earth's surface?

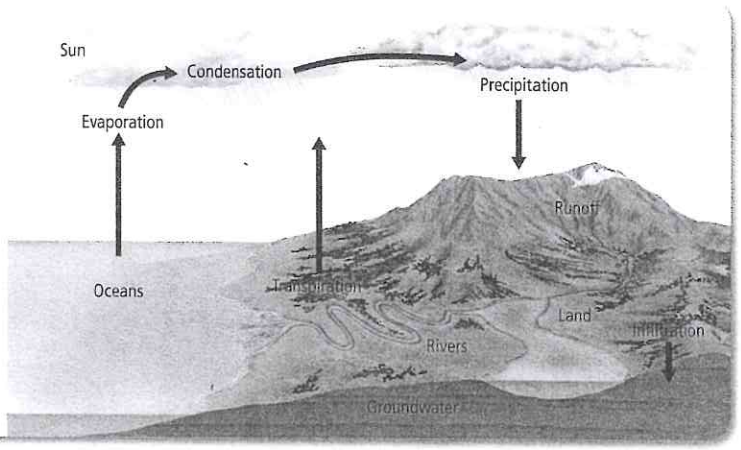


Figure 9.1 The water cycle, also referred to as the hydrologic cycle, is a never-ending, natural circulation of water through Earth's systems. **Identify** *the driving force for the water cycle.*

Concepts In Motion
Interactive Figure To see an animation of the water cycle, visit glencoe.com.

Reading Check Water can infiltrate or run off when it reaches the surface.

Caption Question Fig. 9.1 The driving force of the water cycle is the Sun.

Concepts In Motion
Interactive Figure Students can see an animation of the water cycle at glencoe.com.

Earth Science Journal

Local Brooks and Streams Ask students to locate local brooks or streams near their homes and to describe them in their Earth science journals, including where students think they start and where they end. Then encourage students to consult maps of their area to discover the routes of the local brooks and describe the actual routes in their Earth science journals. OL

Runoff

Water flowing downslope along Earth's surface is called **runoff.** Runoff might reach a stream, river, or lake, it might evaporate, or it might accumulate as puddles in small depressions and infiltrate the ground. During and after heavy rains, you can observe these processes in your yard or local park. Water that infiltrates Earth's surface becomes groundwater.

A number of conditions determine whether water on Earth's surface will infiltrate the ground or become runoff. For water to enter the ground, there must be large enough pores or spaces in the soil and rock to accommodate the water's volume, as in the loose soil illustrated in **Figure 9.2.** If the pores already contain water, the newly fallen precipitation will either remain in puddles on top of the ground or, if the area has a slope, run downhill. Water standing on the surface of Earth eventually evaporates, flows away, or slowly enters the groundwater.

Soil composition The physical and chemical composition of soil affects its water-holding capacity. Soil consists of decayed organic matter, called humus, and minerals. Humus creates pores in the soil, thereby increasing a soil's ability to retain water. The minerals in soil have different particle sizes, which are classified as sand, silt, or clay. As you learned in Chapter 7, the percentages of particles of each size vary from soil to soil. Soil with a high percentage of coarse particles, such as sand, has relatively large pores between its particles that allow water to enter and pass through the soil quickly. In contrast, soil with a high percentage of fine particles, such as clay, clumps together and has few or no spaces between the particles. Small pores restrict both the amount of water that can enter the ground and the ease of movement of water through the soil.

Rate of precipitation Light, gentle precipitation can infiltrate dry ground. However, the rate of precipitation might temporarily exceed the rate of infiltration. For example, during heavy precipitation, water falls too quickly to infiltrate the ground and becomes runoff. Thus, a gentle, long-lasting rainfall is more beneficial to plants and causes less erosion by runoff than a torrential downpour. If you have a garden, remember that more water will enter the ground if you water your plants slowly and gently.

VOCABULARY

ACADEMIC VOCABULARY

Accommodate
to hold without crowding or inconvenience
The teacher said she could accommodate three more students in her classroom.

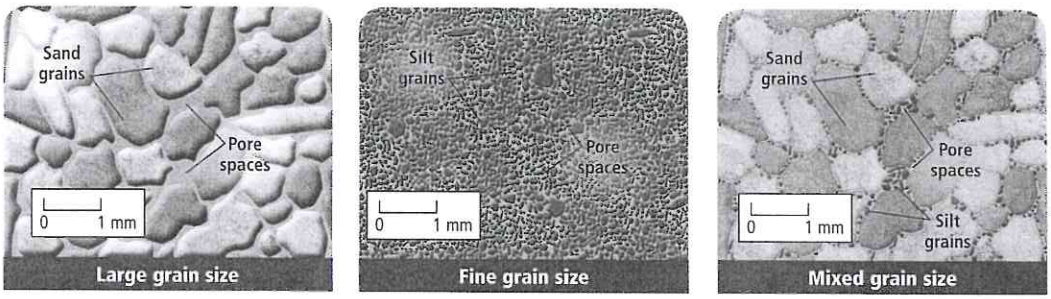


Figure 9.2 Soil that has open surface pores allows water to infiltrate. The particle size that makes up a soil helps determine the pore space of the soil

Demo

Model Infiltration Pack soil into a large, clear container. Fill another clear container loosely with soil. Sprinkle equal amounts of water into both containers of soil. Ask students to note which container of soil allows the most water to penetrate. The loosely packed soil allows more water to penetrate because it has spaces available for the water. The packed soil has few or no spaces for the water to enter.

Teacher Content Suppo

Runoff Runoff that consolida in long, narrow depressions pr duces channel or stream flows. Runoff that flows downslope i generally broad sheets is called overland flow. There are differe types of overland flows. When runoff flows over smooth surfaces in continuous, thin sheet it is called sheet flow. Runoff th flows over steep slopes of bare soil or less resistant bedrock flows in long, slender channels called shoestring rills.

Tie to Previous Knowled

Water and Temperature Ask students what they notice wher a glass of ice water sits on a tab during the summer. The glass seer sweat and water appears around the glas Explain to students what happe to the glass is part of the water cycle. The cooled container of water cools the air around it an causes water vapor in the air to condense on the outside of the glass of ice water. OL

Interpret the Photo

Infiltration Tell students to study **Figure 9.2.** Ask students: Which soil type will allow mor water to infiltrate? large grains Which soil type will allow the least amount of water to infiltr fine grains

ɜ Science Terms

ɜam and River The words *ɯm* and *river* can be used rchangeably in Earth science he most part. Although the d *river* generally indicates a e stream, water moves in the e manner in both small and e bodies of moving water. As sult, the word *stream* is com-ıly used to refer to moving ies of water of various sizes.

llaborative Learning

ɜam Systems Have groups tudents develop and make clay dels of landscapes that show a am system, the system's water-d, and at least one divide. Ask ı group to develop questions ut its watershed model at spe-: areas noted on the model.

COOP LEARN

Identify Misconceptions

ıdents often underestimate ɜ power of moving water.

ıcover the Misconception
k students if moving water ses a threat to human lives.

ɜmonstrate the Concept
ıdents who have experienced ɜ force of the moving water ıociated with waves along ocean shore might need to be ninded of the strength of the ce they felt at the time. ıdents might not relate these ɔeriences to the danger of ving through a flooded street to the possibility of being ept away by floodwater, which ı rise quickly. Point out that ves breaking against the ɔres of a lake during a storm t only poses a threat to mans, but also can damage or stroy infrastructure.

ɜsess New Knowledge
k students to describe the reats posed by moving water

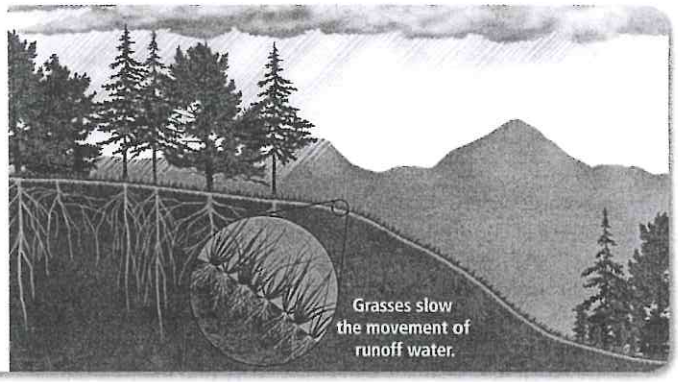


Figure 9.3 Vegetation can slow the rate of runoff of surface water. Raindrops are slowed when they strike the leaves of trees or blades of grass, and they trickle down slowly.

Vegetation Soils that contain grasses or other vegetation allow more water to enter the ground than do soils with no vegetation. Precipitation falling on vegetation slowly flows down leaves and branches and eventually drops gently to the ground, where the plants' root systems help maintain the pore space needed to hold water, as shown in **Figure 9.3.** In contrast, precipitation falls with far more force onto barren land. In such areas, soil particles clump together and form dense aggregates with little space between them. The force of falling rain can then push the soil clumps together, thereby closing pores and allowing less water to enter.

Slope The slope of a land area plays a significant role in determining the ability of water to enter the ground. Water from precipitation falling on slopes flows to areas of lower elevation. The steeper the slope, the faster the water flows. There is also greater potential for erosion on steep slopes. In areas with steep slopes, much of the precipitation is carried away as runoff.

Stream Systems

Precipitation that does not enter the ground usually runs off the surface quickly. Some surface water flows in thin sheets and eventually collects in small channels, which are the physical areas where streams flow. As the amount of runoff increases, the channels widen, deepen, and become longer. Although these small channels often dry up after precipitation stops, the channels fill with water each time it rains and become larger and longer.

Tributaries All streams flow downslope to lower elevations. However, the path of a stream can vary considerably, depending on the slope and the type of material through which the stream flows. Some streams flow into lakes, while others flow directly into the ocean. Rivers that flow into other streams are called tributaries. For example, as shown in **Figure 9.4,** the Missouri River is a tributary of the Mississippi River.

Differentiated Instruction

Below Level Prepare several cardboard boxes with approximately 15 cm of various types of soil in each. You could use packed clay, sand, topsoil, and gravel. Have students slowly pour 40 mL of water into each box and place the boxes on separate cookie sheets. Have students check the bottoms of the boxes at one-minute intervals for signs that moisture has begun to leak through. Have students discuss their observations.

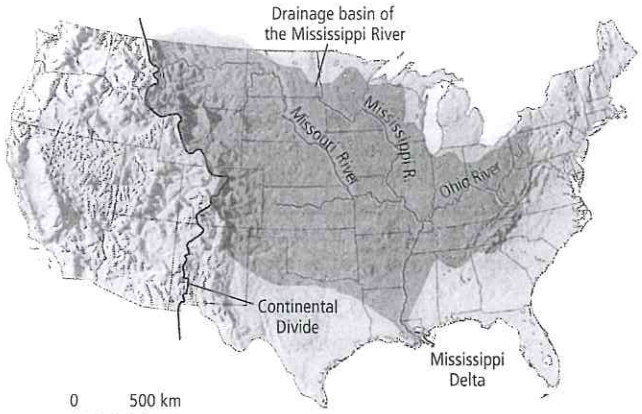


Figure 9.4 The watershed of the Mississippi River includes many stream systems, including the Mississippi, Missouri and Ohio Rivers. The Continental Divide marks the western boundary of the watershed.
Identify *what portion of the continental United States eventually drains into the Mississippi River.*

Watersheds and divides All of the land area whose water drains into a stream system is called the system's **watershed.** Watersheds can be relatively small or extremely large in area. A **divide** is a high land area that separates one watershed from another. In a watershed, the water flows away from the divide, as this is the high point of the watershed.

Each tributary in a stream system has its own watershed and divides, but they are all part of the larger stream system to which the tributary belongs. The watershed of the Mississippi River, shown in **Figure 9.4,** is the largest in North America.

Reading Check **Describe** what a divide is and what role it plays in a watershed.

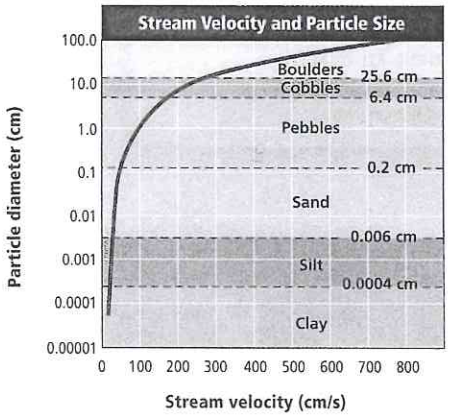
PROBLEM-SOLVING LAB

Interpret the Graph

How do sediments move in a stream? The critical velocity of water determines the size of particles that can be moved. The higher the stream velocity, the larger the particles that can be transported.

Think Critically

1. **Identify** at what velocity flowing water would pick up a pebble.
2. **Identify** at what range of velocities flowing water would carry a pebble.
3. **Infer** which object would not fall into the same size range as a pebble: an egg, a baseball, a golf ball, a table tennis ball, a volleyball, and a pea. How would you test your conclusions?



Reading Check A divide is a h area of land that separates one wa shed from another.

Caption Question Fig. 9.4 Roughly a third of the continental Unite States eventually drains into the Mississi

PROBLEM-SOLVING L

Purpose Students will determ how different-sized sediments move in a stream.

Process Skills Make and use graphs, observe and infer

Teaching Strategies

- Ask students whether they h ever dropped something int stream and had it carried aw by the stream. Have student share their experiences.
- Review with students the fu tion of the x-axis and the y-a on the graph.

Think Critically

1. at 50 cm/s
2. from 50 to 120 cm/s
3. Baseball and volleyball; measure the c to see if they fall between 0.2 and 6.4

Model

Watersheds Have students w in groups of four to make a m of a watershed. This can be do using a stream table or a large with a mound of dirt placed a one end. Have students sprink water from a hose or watering over the mass of dirt and allov the water to form rills and gul Larger streams will naturally f with tributaries and meanders The erosional and depositiona features of stream action will a be evident in the student mod

BL EL

cept Development

am Load What is carried as am load depends on many rs. One factor is the land over h the water is moving. If the : is moving over soluble mate- t will pick up minerals more r than it would if it were flow- ver less-soluble material. The erature of the water also ts how much material can be lved in it. Warmer water usu- an dissolve more material Earth's surface than colder r can. The temperature of the r can also affect the amount ses that can remain in solu- In general, colder water can more gases than warmer r. The types and numbers ants and animals living in the r can also affect what materi- oth gases and particulates, arried in the stream's load.

cussion

am Load Ask students why ndwater adds most of a stream's olved load, while runoff adds a small amount. Groundwater, eneral, moves over and through s for a longer period of time runoff moves over Earth's sur- As a result, groundwater has e opportunity to come in con- with the minerals in rocks and olve them. Runoff, on the other d, not only spends less time ing over Earth's surface, but it might not flow directly on the s themselves but might instead over vegetation. OL

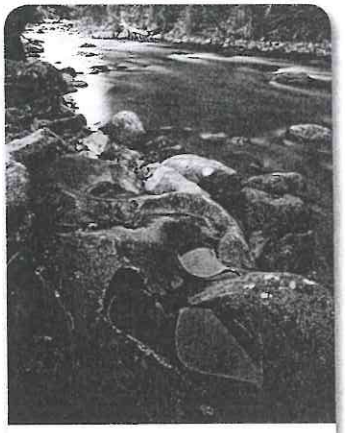


Figure 9.5 Particles rub, scrape, and grind against one another in a streambed, which can create potholes.

Stream Load

The material that a stream carries is known as stream load. Stream load is carried in three ways.

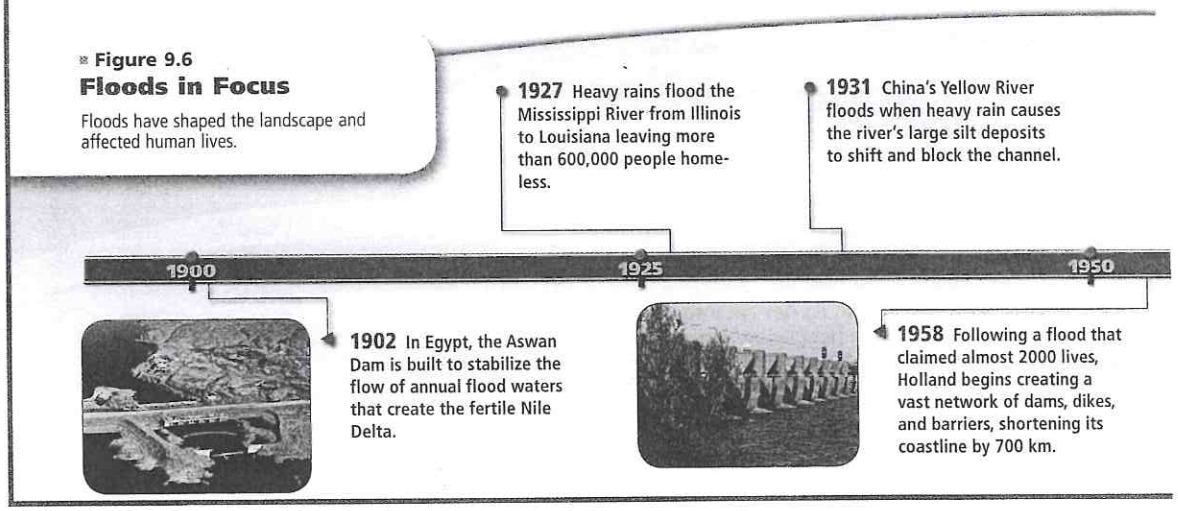
Materials in suspension **Suspension** is the method of transport for all particles small enough to be held up by the turbulence of a stream's moving water. Particles such as silt, clay, and sand are part of a stream's suspended load. The amount of material in suspension varies with the volume and velocity of the stream water. Rapidly moving water carries larger particles in suspension than slowly moving water.

Bed load Sediment that is too large or heavy to be held up by turbulent water is transported by streams in another manner. A stream's **bed load** consists of sand, pebbles, and cobbles that the stream's water can roll or push along the bed of the stream. The faster the water moves, the larger the particles it can carry. As the particles move, they rub against one another or the solid rock of the streambed, which can erode the surface of the streambed, as shown in **Figure 9.5.**

Materials in solution Solution is the method of transport for materials that are dissolved in a stream's water. When water runs through or over rocks with soluble minerals, it dissolves small amounts of the minerals and carries them away in the solution. Groundwater adds the majority of the dissolved load to streams. The amount of dissolved material that water carries is often expressed in parts per million (ppm). For example, a measurement of 10 ppm means that there are 10 parts of dissolved material for every 1 million parts of water. The total concentration of materials in solution in streams averages 115–120 ppm, although some streams carry as little dissolved material as 10 ppm. Values greater than 10,000 ppm have been observed for streams draining desert basins.

Figure 9.6
Floods in Focus

Floods have shaped the landscape and affected human lives.



Demo

Bed Load Run water over a mound of soil and have students observe the bed load with a magnifying lens. Ask them to describe how the sediment particles are moving. They should observe that the rounder sediments roll and the flatter sediments slide in the water. The smaller sediments might be suspended in the water, while the heavier sediments will roll along the bottom. BL