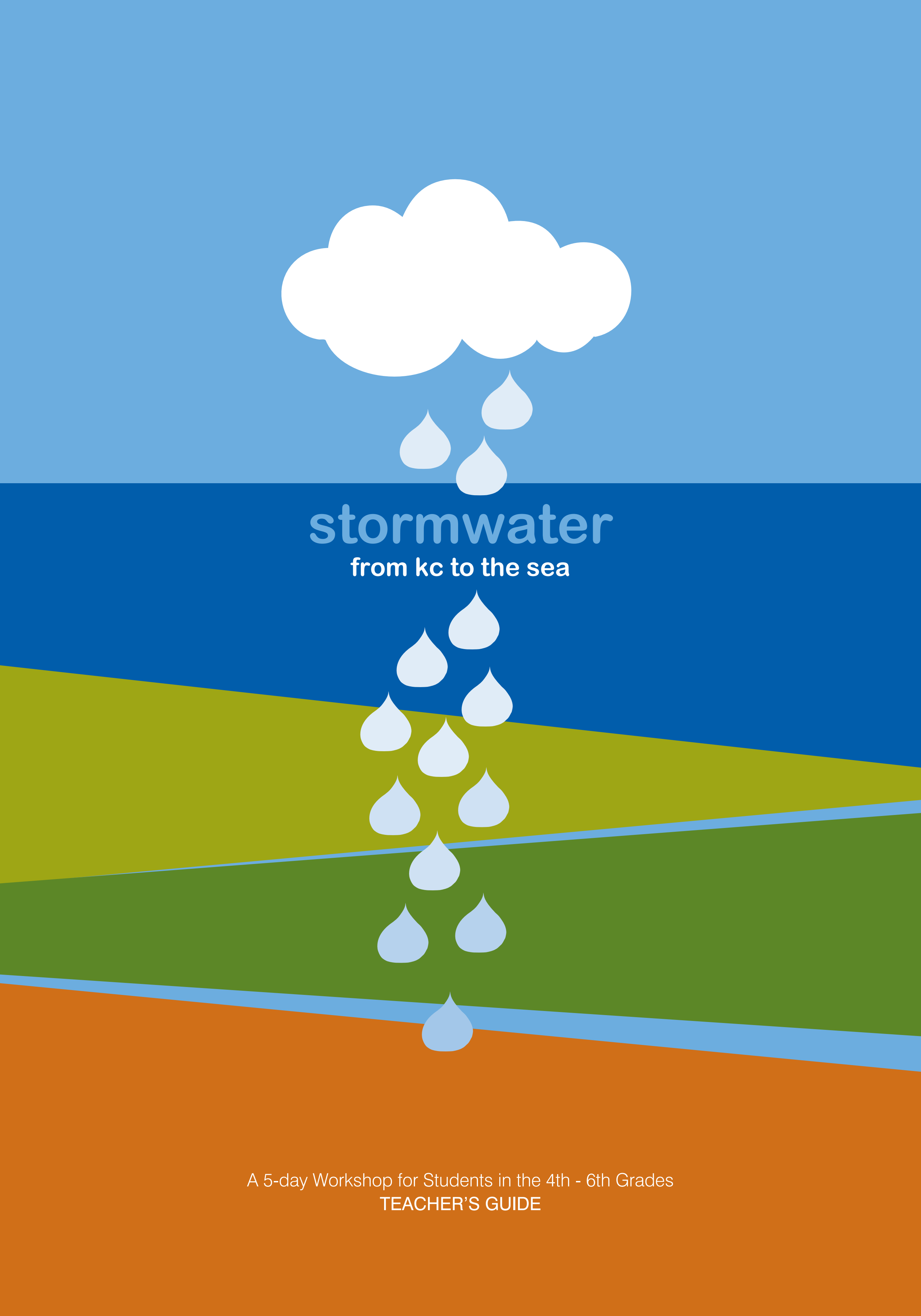


stormwater

from kc to the sea

A 5-day Workshop for Students in the 4th - 6th Grades

TEACHER'S GUIDE

contents

Introduction

The Water Services Department of Kansas City, Missouri believes good water quality is everybody's business. The agency is providing this curriculum for students, and ultimately their parents and the community, to become aware of one aspect of our City's water – the treatment of stormwater. This guide addresses that topic and is aligned with Common Core State Standards and New Generation Science Standards for students in the 4th and 5th grades. We see that 6th grade standards would be more advanced yet similar should 6th grade instructors wish to use this curriculum. Through five interactive and fun days, students will learn how precipitation moves through the watershed and how to measure rainfall amounts; they will learn to demonstrate how water becomes polluted and determine how best management practices (BMPs) improve the quality and quantity of our water; they will also locate current BMPs in their community, design the ideal street, and create a public service announcement, brochure or poster that persuades people to follow BMPs in their treatment of this valuable resource.

This knowledge will eventually be enhanced by a field trip to the Water Services Department at 4800 E. 63rd Street, where students will experience many of the practices put into action.

Lara Isch 816.513.0582

day one:

It's an Event!

Understanding Kansas City's rain and its journey through the watershed

Students will understand what the watershed is by quickly and visually "exploring" the slope of the school grounds and figuring out where water goes on the property. Using Kansas City's annual rainfall of 38.2 inches, they will discover how much water accumulates on impervious surfaces during events. They will judge whether measurements and computation of quantities seem reasonable – but they might be surprised. They will then "follow" the stormwater to the watershed, which will help them compare amounts/measurements. During this process, they will listen to one another and engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners.

SKILLS

Mathematics
Analytical
English Language Arts
Geography
Inquiry

50

TEACHING TIME IN MINS.

Materials Required

- Yardstick or tape measure
- Calculators
- Gallon bucket
- Topographical map of area

Learning Objectives

Students will be able to:

- Relate the type of landform/water body to the process by which it was formed
- Compare amounts/measurements
- Judge whether measurements and computation of quantities are reasonable
- Use quantitative and qualitative data as support for reasonable explanations
- Classify major bodies of surface water (e.g., rivers, lakes, oceans, glaciers) as fresh or salt water, flowing or stationary, large or small, solid or liquid, surface or groundwater
- Describe and trace the path of water as it cycles through the hydrosphere, geosphere, and atmosphere (i.e., the water cycle: evaporation, condensation, precipitation, surface runoff/ groundwater flow)
- Explain how major bodies of water are important natural resources for human activity(e.g., food, recreation, habitat, irrigation, solvent, transportation)
- Identify physical changes in common objects (e.g., rocks, minerals, wood, water, steel wool, plants) and describe the processes that caused the change (e.g., weathering, erosion, cutting, dissolving)
- Engage effectively in a range of collaborative discussions
- Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence.
- Demonstrate command of English conventions in speaking
- Determine the meaning of previously unknown words

Vocabulary

impervious, surface water, groundwater, aquifer, recharge, volume, runoff, Low Impact Development, stormwater, watershed, erosion, flowing, stationary

Background

A watershed is the land area from which water drains into a single body of water, such as a stream, river, or ocean. The two largest watersheds in the United States are the Pacific Ocean Watershed and the Atlantic Ocean Watershed, separated by the Continental Divide within the Rocky Mountains. A watershed can just be the water draining into a puddle in the back yard or a puddle in a parking lot, but small watersheds like this usually drain into larger ones.

For example, when it rains, all of the water from a small watershed may travel to a local creek. That creek will flow into a larger stream, like Brush Creek, which in turn collects water from other creeks to form an even larger one. Brush Creek flows into the Blue River, which then deposits water into the Missouri River. Finally, it ends up in the ocean.*

In the Kansas City region, all runoff eventually drains into the Missouri River, the world's 15th longest river. The Missouri River watershed drains one-sixth of the water in the United States, from the mountains of western Montana to its connection with the Mississippi River in St. Louis, MO. In downtown Kansas City, Kansas, the Kansas River flows into the Missouri River at Kaw Point. The Kansas River watershed (page 8) is part of the larger Missouri River Watershed and drains about one-third of the state of Kansas.

For additional resources, a good website is marc.org -- search watershed, and go to the link, Know Your Watershed. MARC is also willing to supply this as a booklet under Reports and Publications. For a map of area watersheds, go to another link on this site, Watersheds of the Kansas City Region.

*Much of the time, all this is happening underground where you can't even see it. It will be important for students to first realize that slope is important (and it might be slightly hard to see as well).

The Math

1 square yard is 36 in. x 36 in. = 1,296 square inches (L x W)
The amount of water in 1 square yard when 1 inch of rain falls: 36 in. x 36 in. x 1 in. = 1,296 cubic in. (L x W x H)
1 gallon = 231 cubic inches, so 1,296 cubic inches of water / 231 = 5.6 gallons of water
Therefore, when 1 inch of rain falls on 1 square yard of impervious surface (concrete, cement, asphalt or rooftops), 5.6 gallons of stormwater runoff is produced.
When discussing these numbers with students, the amount of stormwater runoff can be rounded to 5 gallons. This will allow the younger students to be able to do quick mental math when talking about the amount of runoff from parking lots, playgrounds, the school roof, etc.

Procedure

First, go through the water cycle on the back page of the students' Day One handout (See also Figure 5, Page 11). You may want to do a 5 minute group exercise where each team summarizes this process in their own words. Ask them what happens if there is not enough rain or snow.

Then, take a brief tour of the school grounds and have students look for the general slope of the ground. Have them discuss what they think generally happens to water when it hits the various locations of the school grounds. Rain that falls on planted areas (pervious surfaces) will most likely soak in. Tell them that this "infiltration" ends up traveling through the soil very slowly. This water will come back to the surface downslope to help replenish streams, lakes, ponds, wetlands, etc. Walk around the school property to locate a storm drain. Ask the students what materials are used when constructing parking lots, streets, and sidewalks. Explain that when water falls on concrete, cement, and asphalt (impervious surfaces), most of the water will run off into storm drains. In many cases, storm drains carry rain water through underground pipes directly to the nearest creek, stream, or river. This reduces the risk of flooding on streets and parking lots. Have them locate downspouts and see if they are routed to pervious or impervious surfaces.

Take students to a pervious area of the school yard and have them make 1 square yard on the ground using 4 yard sticks. Have a student pour 1 gallon of water onto the ground inside the square and ask them to make observations about what happens to the water. Put several drops of food coloring, representing pollution, on the ground inside the square and pour another gallon of water on top of the food coloring. Ask students to share their observations about what happens to the food coloring. Most will soak into the ground.

Take students to an impervious area of the school parking lot and have them mark off the same 1 square yard area. (This demonstration works best on a sloped area.) Have a student pour 1 gallon of water onto the ground inside the square and ask them to make observations about what happens to the water. Put several drops of food coloring on the ground inside the square and pour another gallon of water on top of the food coloring. Ask students to share their observations about what happens to the food coloring and how this compares with the previous demonstration on a pervious area. Ask students where they think pollution found on impervious surfaces goes when it rains.

Remind them that thinking about watersheds helps remind us that our actions can impact — for better or for worse — all of the streams and rivers in our region.

Discussion Questions

1. What do we mean by water cycle?
2. What is the role of the land on water movement?
3. How did the slope of the surface impact where the water flowed?
4. Is the water around here salt or fresh water? Where do you find salt water?
5. Is the water flowing or stationary? How do you know?
6. Why is the Missouri River so important to us? Use specific reasons.
7. What does erosion mean? Do you see any examples of erosion here?
8. What is the difference between pervious and impervious?
9. Are there any examples of pervious pavement at our school?
10. Are there some places where the water could be better directed?
11. What would happen if your area had fluids like oil from cars?
12. If you selected an area with vegetation, what happened to the water when it landed?
13. From which surface would you rather drink the water?
14. How many gallons would fall during each rain event on the square yard?

Additional Math Activity:

1 inch of rain falling on 1 square yard of impervious surface produces approximately 5 gallons of stormwater runoff. 1 parking space in a parking lot is approximately 20 square yards. Approximately how many gallons of runoff are produced when 1 inch of rain falls in 1 parking space?

(20 square yards x 5 gallons of water - 100 gallons of runoff from EACH parking space)

Have students count the number of parking spaces in the school parking lot and multiply that number by 100. Students can quickly calculate the total amount of stormwater runoff coming off the parking spaces in the school lot when 1 inch of rain falls.

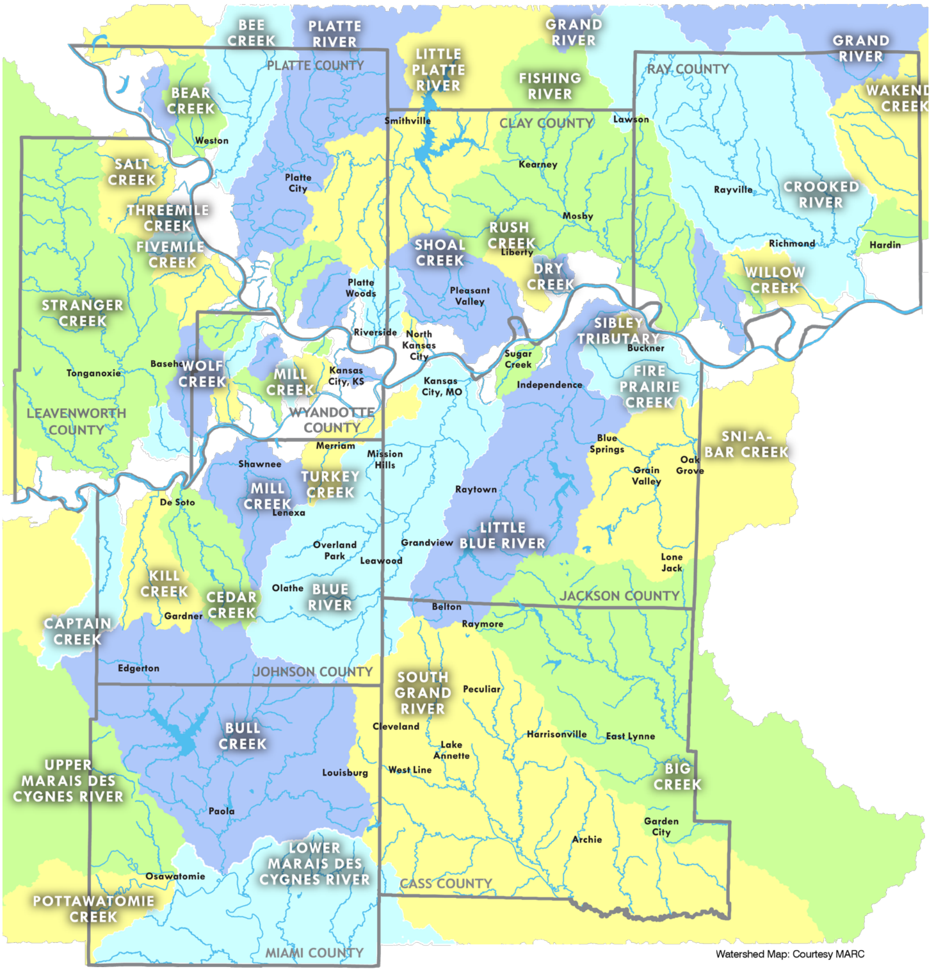


FIGURE 1

Kansas City Area Watershed Map

This map illustrates the region's larger watersheds. Captain Creek, Kill Creek, Stranger Creek and Cedar Creek are some of the larger streams emptying into the Kansas River. Others, like the Platte River, Fishing Creek and Crooked River flow directly into the Missouri River.

An interactive watershed map can be found at: *http://www.marc2.org/watershed/*. Students can click on their watershed and discover what pollutants are impacting it and activities in place to help improve water quality.

FIGURE 2

Impervious v. Pervious Pavements

Photograph on the left shows a section through a typical impervious pavement. The section on the right shows a pervious pavement that is designed to allow percolation or infiltration of stormwater through the surface into the soil below where the water is naturally filtered and pollutants are removed.

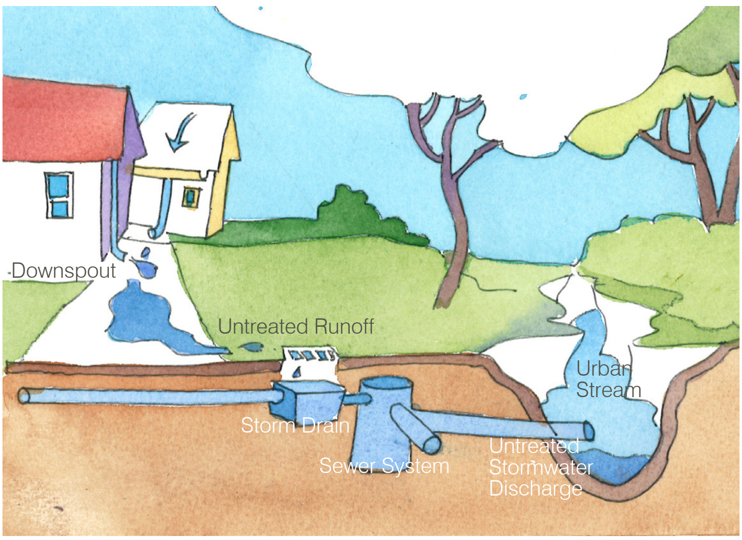


FIGURE 3

Urban Watershed

Additional Activity

Go to *http://www.google.com/earth/explore/products/earthview.html* and download the Google Earth Plug-in. Then you can put in your school's address, double clicking to let students get an idea of how much pavement is surrounding their school.

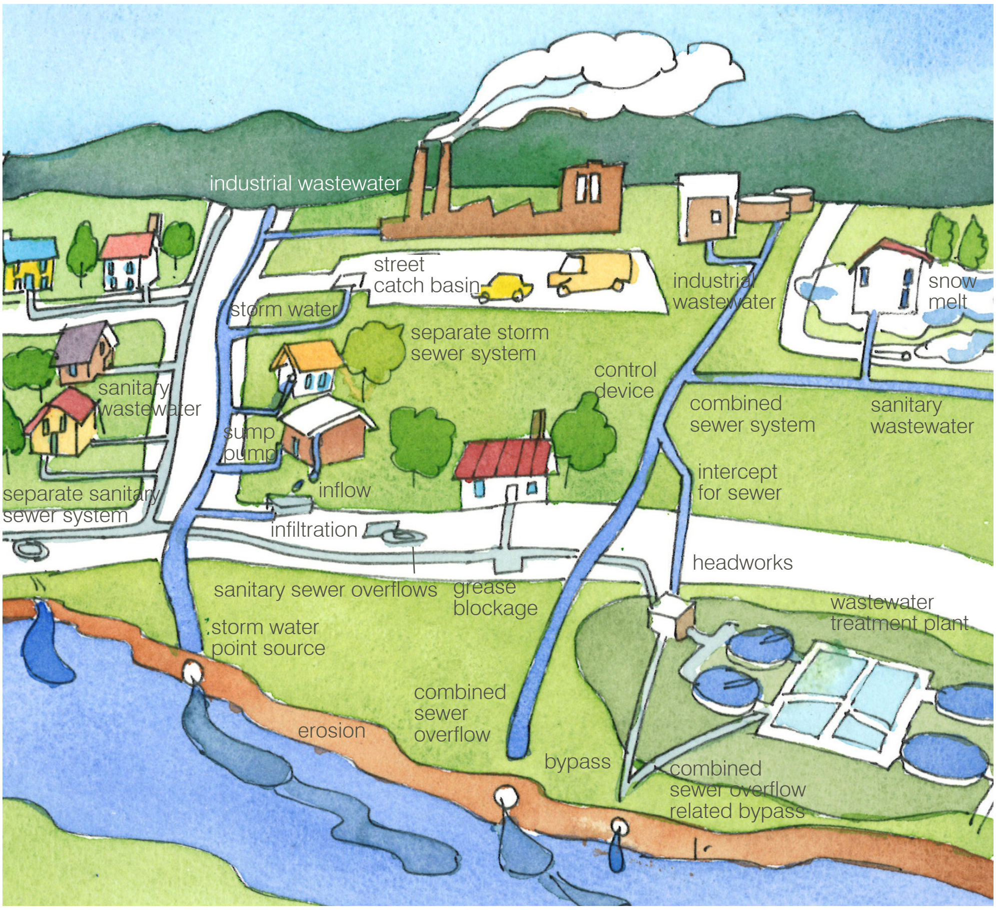


FIGURE 4

Urban Wet Weather Flows

There are two types of sewer systems in Kansas City. Figure 4 and Figures 7 and 8 on page 24-25 display where certain pollutants originate.

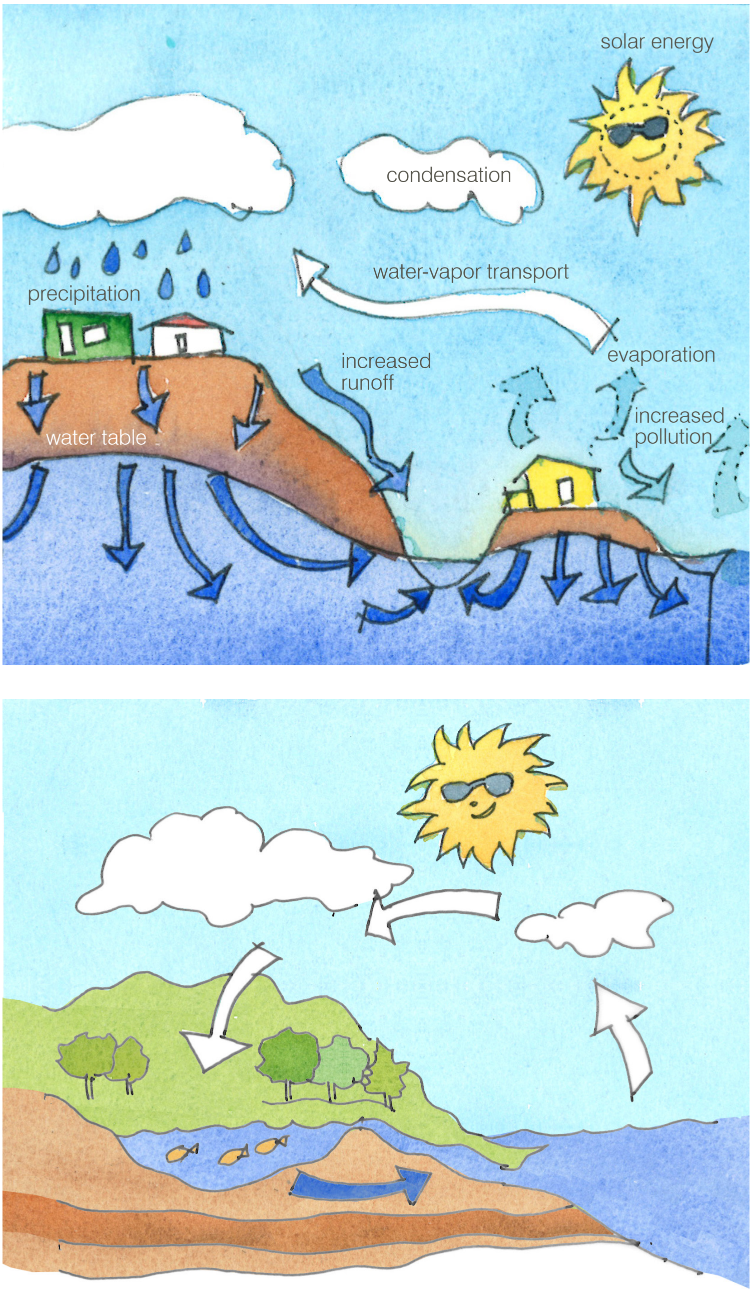


FIGURE 5

The Water Cycle

Water falls from the sky to the earth in different forms: rain, snow sleet, and hail. Some of the water soaks into the ground and becomes ground water. The rest, even if it soaks into the ground, flows into streams, lakes, rivers, and oceans. The sun's heat changes some of the water into a gas called water vapor. This process is called evaporation. The vapor rises into the sky and forms a cloud. Clouds are made of trillions of water droplets. The droplets are tiny and light enough to float. When the cloud droplets get cold enough to freeze or very large, they fall out of the cloud and melt on the way down to Earth as rain. If the air is too cold on the way down, the drops of water will stay frozen and fall as sleet, hail, or snow.

day two:

Dangerous Travel

Hitchhiking with H_20 (nonpoint source pollution)

Students will learn to understand the idea of water as a solvent, to understand water pollution from a short demonstration, and then learn about the sources of point and nonpoint pollution through a video, discussion, or a short activity. Using point and nonpoint source flashcards, students can engage in collaborative discussions to come to a group consensus.

SKILLS

Predicting and Estimating
Inquiry
English Language Arts
Analysis

50

TEACHING TIME IN MINS.

Materials Required

- Large clear jar with lid and another container to hold the liquid when you pour it out.
- A spoonful of salt, dirt, and vegetable oil and a handful of shredded paper, leaves, or pieces of styrofoam. You may choose to add other items to this lesson. (When you "clean up," be sure not to pour the solids down the sink!)
- 4 sets of colored 5 x 5 cards provided; each set labeled with the "Scenarios" on page 15

Learning Objectives

Students will be able to:

- Identify water as a solvent that dissolves materials but also can let them float or settle
- Distinguish between the components in a mixture/solution
- Identify the ways humans affect the erosion and deposition of Earth's materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings)
- Describe how human needs and activities (e.g., irrigation, damming of rivers, waste management, sources of drinking water) have affected the quantity and quality of major bodies of fresh water
- Analyze the ways humans affect the erosion and deposition of soil and rock materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings, building or removal of dams)
- Describe the effect of human activities (e.g., landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water
- Engage effectively in a range of collaborative discussions
- Summarize information presented in diverse media and formats
- Demonstrate command of standard English grammar and usage when writing or speaking
- Determine the meaning of previously unknown words

Vocabulary

solvent, dissolve, fertilizer, herbicide, septic system, environment, ecosystem, biotic, abiotic, soluble, insoluble, nonpoint pollution

Background

Understanding the properties of (rain) water is important for your students so that they realize how we inadvertently pollute our own water sources. Pollution entering a water body can be classified into two categories. Point source pollution enters a stream (river or other body of water) from a well-defined location, such as a pipe leading directly into a creek or river, which is called an outfall pipe. This source can be traced back to its origination, and the producer of the pollution can be notified so that the problem can be corrected.

Nonpoint source pollution is much more difficult to combat because it involves any pollutant that enters the stream by way of surface runoff. The pollutant might originate anywhere in the watershed, near the stream, or miles away. Nonpoint source pollutants are often substances that are not inherently toxic, but if collected in enough concentration, they can be detrimental to the ecosystem. Nitrates, phosphates (both needed for plant growth and key ingredients in fertilizers), and soil sediment are examples of these. Typical nonpoint source pollutants include herbicides and insecticides, oil, grease, and toxic chemicals; sediment from improperly managed construction sites; eroding stream banks; bacteria and nutrients from livestock, pet wastes, and faulty septic systems. Sediments are the primary source of pollution. They can carry a variety of water-quality contaminants including nutrients, bacteria, metals, organic matter and a variety of potentially toxic organic chemicals. Erosion of surface and stream channel soils has led to increased levels of sediments transported by area streams.

Procedure

There are two different, short activities in this lesson. One is a teacher led activity about the characteristics of water and the other is a student-focused activity about point and non-point source pollution.

1: The teacher led activity is about water and its properties when various ingredients are added to it. A large, clear jar with a lid is the best option because you can shake it and show your students the results. Fill the jar with warm water so items can dissolve easily. Explain to students that when rain hits the ground, it carries pollution into rivers and streams. Pollution can interact with water in several ways. Ask the students what most cities use on the streets and roads in the winter when it snows. Ask them what they think happens to the salt when it enters a waterway.

Have a student add a spoonful of salt to the water in the jar, replace the lid, and shake (or stir with a spoon) until the salt dissolves. Explain to the students that some types of pollution break down in water (salt, fertilizers, pesticides, and some chemicals) and, therefore, cannot be seen.

Next, have a student add a spoonful of dirt to the water, replace the lid, and shake. Set the jar on a table and let students observe how the dirt swirls around in the water and then settles to the bottom. Tell them that this kind of pollution (dirt, animal waste, leaves, and grass clippings) can be seen when it first enters the water, but when flowing water slows down, these things sink to the bottom. Once this pollution sinks to the bottom, it is called sediment. Explain that sediment becomes a pollutant in waterways when too much is washed in from erosion areas such as stream banks and construction sites, or when it contains toxic chemicals.

Have a student add a spoonful of oil to the water and let them observe how it disperses (spreads out) and floats on the top. Tell students that oil floats because it is less dense than the water. Explain that just two drops of oil can contaminate a gallon of water and that the water will be contaminated indefinitely (or until the oil is removed). Tell them that this kind of pollution (liquid toxins, oil and soap) can cause contamination long distances from where it enters the water.

Have a student drop a handful of shredded paper and/or pieces of styrofoam into the jar and let them observe how these objects float. Explain to them that this kind of pollution

(paper, plastic, and styrofoam) can be carried downstream in creeks, rivers, and streams. Floating pollution is easily seen which makes it easier to remove from the water.
You can easily extend this activity to include dish soap, brown play-dough to represent animal waste, food coloring, etc.

2: Begin this activity by explaining point and nonpoint source pollution to the students. Make sure to include the definition of point and nonpoint listed in the glossary of this guide. Take four sets of the 5 x 5 Point/Nonpoint Source cards provided. Break the students up into four teams and give them each a set of cards. The cards are pre-labeled with team names representing some of Kansas City's waterways. Have a discussion with your students, using the questions on page 19, to get them thinking about stormwater pollution.

Have the teams designate a pile for point source and a pile for nonpoint source pollution flash cards. Allow the students to decide as a team which cards go in each pile. Once all teams have completed the exercise, go through each scenario as a class.

If there are scenarios that teams disagree on, have each team defend their answers based on the concepts learned in the lesson.
It is more important that the students come to a consensus on each card than it is for the answers to match the answer key on Page 18 of this guide.

Conclude with the teams listing what they can do to prevent pollution. Ask students on each team to collaborate and come up with one complete sentence which summarizes what they have learned. Point out that if they were writing this sentence, it could serve as either a main topic sentence or a concluding sentence.

Note to Teacher: The DVD in your materials box contains a word file titled "Lesson 2 Clickable List of Videos" that contains links to several short videos from YouTube. These videos cover topics such as the water cycle, watersheds, stormwater runoff, point and non-point source pollution, and pollution prevention. You may want students to view one or more of these videos in class or on their own.

Scenarios for the Point/Nonpoint Source cards provided

Point Source Pollution

- Loose soil at a construction site
- Fishermen have created their own path to the river
- A chemical plant has a pipe coming from it and is dumping a liquid into the river
- Warm water enters a stream from an electric power plant
- A sewage treatment plant overflows during a storm
- An oil tanker spills oil into the ocean
- Acidic water seeps from a coal mine
- A big train derails on a bridge and insect spray spills into the creek
- Your friend has a septic tank, and there are wet spots in his yard all the time

Nonpoint Source Pollution

- Your dad changes your engine oil and pours it into a drain in the garage
- A farmer's field is fertilized
- Oil is running off your driveway into the side yard
- Weed killer is sprayed on the front lawn
- When you walk your dog, you don't clean up after he poops
- You have an outdoor cat that never comes into the house
- Oil runs off a parking lot
- Your neighbor dumps some old weed killer behind his fence
- You throw away some half full paint cans
- There's a car crash on the highway and oil and gas spill onto the road
- Manure from a farmer's field mixes with rainwater and washes into the stream
- You see your neighbor fertilizing his yard right before a big rain storm is in the forecast
- Your mom says the sledding hill used to be much steeper and that big flat place at the bottom was shorter
- You always wash your car in your driveway

Discussion Questions

1. Do you have any manholes or storm drains in your neighborhood?
2. Have you ever washed your car at home? Where does that water go?
3. Is there water after a storm in puddles somewhere near where you live? Or a large parking lot? Where does that water go after a rainstorm or snow storm?
4. What can people do to reduce nonpoint pollution?
5. Why should we try to reduce nonpoint pollution?

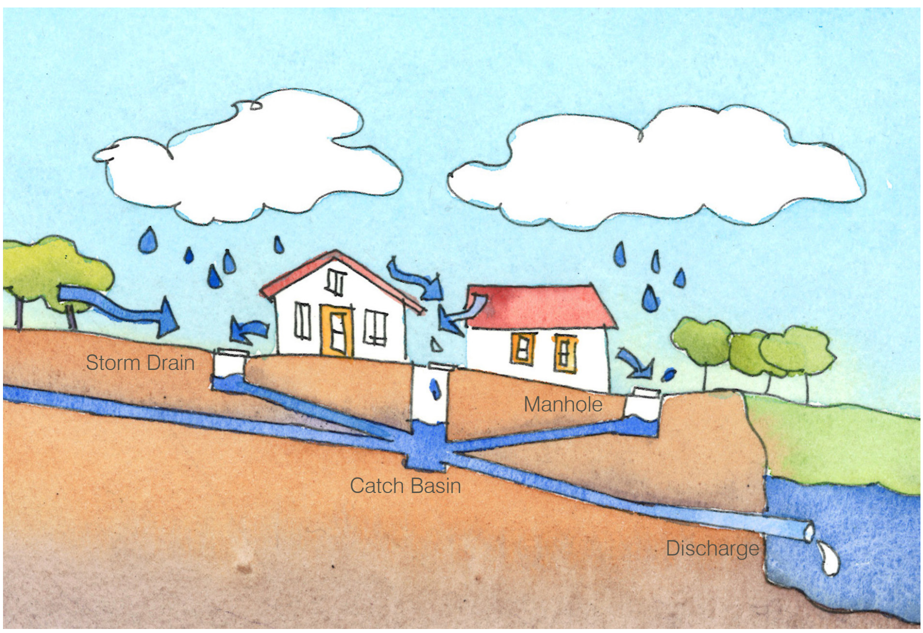


FIGURE 6
Nonpoint source pollution gets into water supply

Use the Lake of the Ozarks or Brush Creek as examples. There are some newspaper articles that demonstrate the effects of nonpoint pollution.

day three:

Cleaning Up Our (Water) Act

How to manage stormwater - Best Management Practices

Students will study BMPs and play a game (BMP Bingo!) to recognize what improvements or best management practices already exist in their neighborhoods. They will write a paragraph on the topic of BMPs.

SKILLS

Geography (elementary map making)
Inquiry
Problem Solving
English Language Arts

50
Teaching Time in mins.

Materials Required

- Possible topographical map (from Day 2) of school and grounds
- BMP Bingo cards
- You may want students to work in teams of two if they:
  a) live near each other or
  b) you use the school
- Possible prizes to make the game more fun

If possible walking the school grounds is the better option, and you should find a stormwater drain before you take the students out so you can be sure to point it out to them

Learning Objectives

Students will be able to:

- Formulate testable questions & hypotheses
- Describe the effect of human activities (e.g., landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water
- Analyze the ways humans affect the erosion and deposition of soil and rock materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings, building or removal of dams)
- Describe possible solutions to potentially harmful environmental changes within an ecosystem
- Write a paragraph on the topic of BMPs in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes
- Speak clearly at an understandable pace
- Demonstrate command of the conventions of standard English grammar and usage
- Determine the meaning of previously unknown words

Background

Managing stormwater runoff is often considered the job of the local government, a subdivision developer, or possibly a homeowners' association. Certainly, good planning and implementation by any or all of these entities is important to a successful community stormwater management plan. However, it is also important that individual homeowners understand their role in stormwater management and their impact on the larger community.

Recently, more community stormwater plans have incorporated the concept of "no net loss" of water from the site. This policy involves keeping and using the rain that falls onto a site as much as possible, rather than simply collecting the rain and sending it off site as stormwater discharge. One basic starting point for such a plan is for homeowners to reduce runoff from their individual lots. Many simple yet effective methods can be used to help reduce individual runoff.

Vocabulary

alternative pavers, bioretention, constructed wetlands, extended detention, dry swale, dry well, filter strips (grassed), grassy swale, green parking, green roof, infiltration basins, infiltration trenches, native vegetation, pervious pavement systems, phased construction, rain barrels, rain garden, riparian buffer, sand and organic filters, stormwater planter, topsoil stockpiling, tree establishment, tree preservation, vegetated channel/ swale, wet pond, wet swales, wetlands preservation

"We All Live Downstream"

Before considering some methods, or best management practices (BMPs), to reduce runoff, it is important to understand why runoff is a concern. No matter where a person lives, they live in a watershed. As your students have already seen, a watershed is simply an area of land that drains to a specific point of water, whether it is a lake, stream, river, or ocean. We've talked about local watersheds that eventually drain into the Mississippi River, which also has many other areas that drain into it, covering several states and millions of acres. All watersheds are interrelated since smaller ones feed into the larger ones that ultimately drain into the ocean.

Activities in the smaller watersheds ultimately impact the larger watersheds. Although too few of us think about it, our individual actions affect everyone "downstream" in the watershed. And, the fact of the matter is that we all live downstream from someone else. (Ask the students again what watershed they live in.)

What Is Stormwater Runoff?

Stormwater runoff is the rain and melting snow that flows off streets, rooftops, lawns, parking lots, open fields, and any other exposed area. The runoff carries with it whatever can be dislodged from the various sites, such as salt, soil, leaves, pesticides, fertilizers, oil, gasoline, and any other materials present on the surface. These materials are washed off a wide geographic area rather than originating from one point. That makes preventing contamination more important as well as more difficult, especially in the areas of Kansas City that have combined storm and sanitary sewer systems.

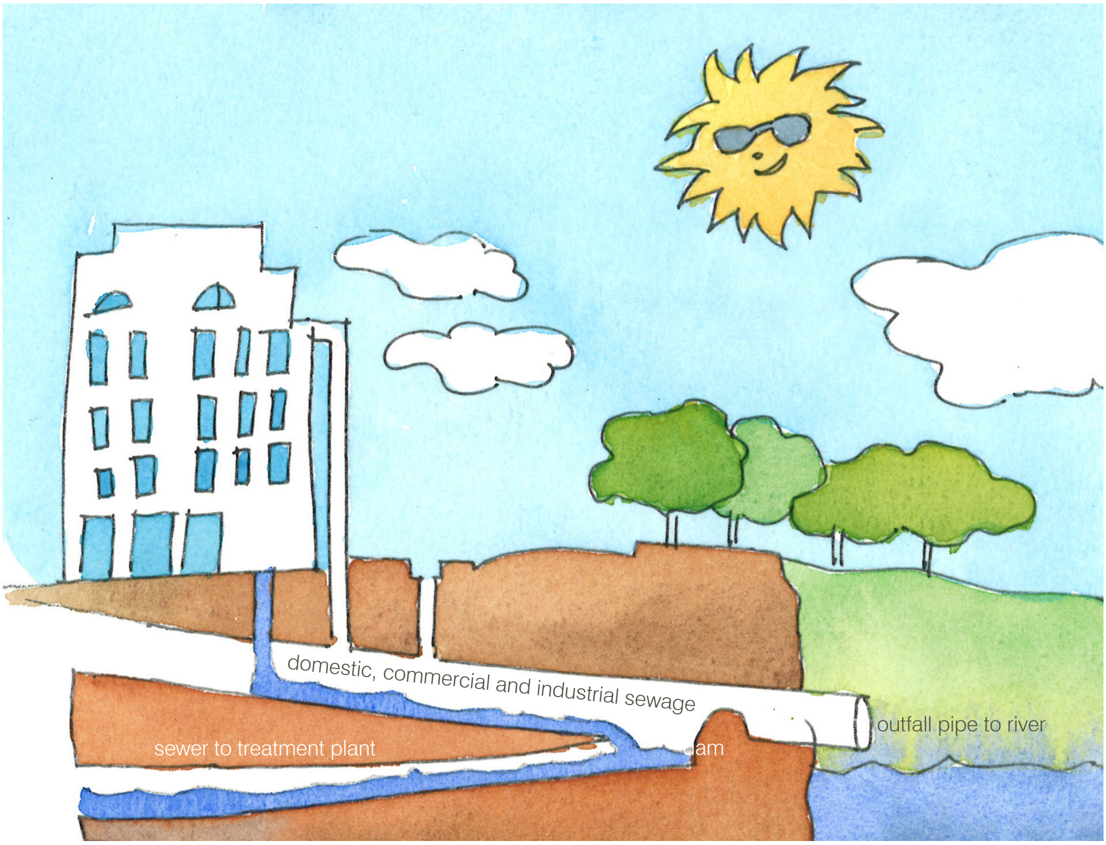
Stormwater runoff can affect the quantity and quality of water that must be handled somewhere downstream. Excess runoff can contribute to flooding. Contaminated runoff can damage water, making it unfit for human consumption and wildlife habitat. Both situations can be costly to correct. Prevention is more effective and efficient.

As land is developed, much of the surface is paved or roofed, creating more runoff potential. Usually, storm sewers are used to carry the resulting runoff to nearby waterways. The water from developed areas often contains contaminants. Even on lawns or other open areas, water that is not absorbed can run off into the street or parking lot and then into the storm sewers.

Storm sewers are a system of underground pipes that have surface drains or inlets designed to gather stormwater. Many people think that storm-sewer water is treated in a sewage treatment plant just like water from sanitary sewers. But in most communities, that is not the case. Stormwater usually receives no treatment before entering local waterways. In Kansas City, during a severe rain or run off event, both sewage and stormwater can go directly into the nearest waterway, for instance, Brush Creek, the Blue River, or the Missouri River.

While your students don't need the details of how our combined sewer system works, which is over 100 years old and used in many cities in the country, it obviously creates some problems during heavy water events. Some communities are incorporating more natural drainage systems and increased on-site water infiltration to help reduce the quantity of runoff and improve water quality. Also, the increased use of conservation design for housing developments helps reduce stormwater runoff by incorporating more open space.

Dry Weather



FIGURES 7 & 8:
It works like this in combined sewer system areas in Kansas City!

Wet Weather


downspout
storm drain
mixed sewage and stormwater
outfall pipe to river
sewer to treatment plant

Procedure

There are two sets of power point presentations available on your DVD. These files are labeled *Lesson 3 BMP Bingo Game 1 and 2.* There are 29 pictures of various BMPs in a different order in each Power Point with an answer key at the end for your use. Ask your students what kind of markers would be best to use for the game (recyclable or edible markers work well). Small prizes would make this more fun. Go through all the slides if possible, even if several students have already reached Bingo! If you play "blackout bingo", all students should win.

<u>Teachers Note</u>: If your school or an area near your school has examples of BMPs you can take the students outside to "survey" those BMPs (depending on location and safety). They can also look around at possible BMPs in their neighborhood or places they visit (the zoo has a green roof). First, help students identify BMPs by playing BMP Bingo!.

Day-to-Day BMPs

Many of these best management practices may seem rather simple or small, but the cumulative effect throughout an entire watershed can significantly contribute to improved stormwater management.

- Avoid overuse of pesticides and fertilizers—use only the amount needed and apply only when necessary.
- Apply fertilizer and pesticides only onto target areas. Don't spread fertilizer onto paved surfaces that drain to the storm sewer.
- Follow recommended watering practices. Avoid excess watering and don't sprinkle water onto paved or other areas that drain into the storm sewer.
- Avoid compacting yard and garden soils because compaction impedes water infiltration.
- Avoid unnecessary pesticide, fertilizer, or water use by using plants adapted to the local area.
- Clean up hazardous material spills properly and don't wash waste into the storm sewer.
- Store oil, gasoline, antifreeze, and other automotive products properly. Keep these substances tightly sealed and avoid leaky containers.
- Clean up oil or other vehicle fluid drippings. Do not store used vehicle parts on areas that drain to the storm sewer.
- Wash vehicles at a commercial car wash or on a non-paved surface to avoid drainage to the storm sewer.
- Avoid allowing pet waste to be dumped or washed into the storm sewer. Properly bury or flush the waste down a toilet into the sanitary sewer system for treatment. Reduce or avoid areas of concentrated pet waste.
- Mulch grass clippings and leave these on the lawn for natural fertility or use the clippings for composting.
- Keep grass clippings and leaves from washing into the storm sewer.
- Drain downspouts onto grassy areas. Collect water from downspouts for use around the home.
- Do not discharge sump-pump water onto paved surfaces that drain to the storm sewer.
- Mulch and seed bare soil as soon as possible to prevent the soil from eroding into the storm sewer.

Discussion Questions

1. **What is a BMP?**
   Explain why it is important.
2. **What are some BMPs that you and your family could do at home?**
3. **What could farmers do as best management practices?**
4. **If there is a shopping center in your neighborhood, describe a BMP that could be designed to help capture excess stormwater from this area.**

Additional Resources

http://www.floridayards.org/professional/Stormwater-bmpmanual.pdf
http://dnr.mo.gov/pubs/pub2446.pdf

There is a PBS special," Liquid Assets" at *http://liquidassets.psu.edu.* It is a 90 minute documentary which tells the story of essential infrastructure systems: water, wastewater, and stormwater. It is available for sale for $24.95 at *http://liquid.assets.media.psu.edu/moreInfo_8015DVD.htm*l. It is aimed at adults but the language is not complex.

There are two pertinent excerpts from this film available on line: There is a 4 minute video about water conservation specifically in Las Vegas at *http://www.teachersdomain.org/resource/psu08-liq.sci.sustainable/*

The second one is *http://www.teachersdomain.org/resource/psu08-liq.sci.sustainable/*. This video segment describes the process by which water contaminated with raw sewage can be purified to be clean enough for rivers and seas, or even drinking. Wastewater treatment systems are covered.

day four:

Those Traveling Stormwater Teams

“Building” Clean Water Projects

After an interactive vocabulary review that serves to explain BMPs again, students will “design” their own BMP project for their neighborhood, showing both the way it is now and what it could look like in the future once a BMP is implemented. All their samples will be coordinated into a long visual “quilt” so that they can see the difference individual actions can make, predict the consequences of their actions, and explain their rationale for their improvement.

SKILLS

Analysis
Evaluation
Comparison
English Language Arts

50
TEACHING TIME IN MINS.

Materials Required

- Old Town, New Town “quilting” sheets of paper
- Students’ photos, drawings, or other pictures
- Tape
- Paste

Learning Objectives

Students will be able to:

- Formulate testable questions and explanations (hypotheses)
- Conduct a fair test to answer a question
- Judge whether measurements and computation of quantities are reasonable
- Use quantitative and qualitative data as support for reasonable explanations
- Use current data as support for observed patterns and relationships, and to make predictions to be tested
- Evaluate the reasonableness of an explanation (conclusion)
- Communicate simple procedures and results of investigations and explanations through drawings (or photographs)
- Identify a question that was asked, or could be asked, or a problem that needed to be solved when given a brief scenario (fiction or nonfiction of individuals solving everyday problems or learning through discovery)
- Use data as support for observed patterns and relationships, and to make predictions to be tested
- Describe beneficial and harmful activities of organisms, including humans (e.g., deforestation, overpopulation, water and air pollution, global warming, restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources), and explain how these activities affect organisms within an ecosystem
- Describe possible solutions to potentially harmful environmental changes within an ecosystem
- Describe the effect of human activities (e.g., landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water
- Analyze the ways humans affect the erosion and deposition of soil and rock materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings, building or removal of dams)
- In all activities that involve describing, speak clearly at an understandable pace and demonstrate command of the conventions of standard English grammar and usage

Vocabulary

Today would be a good day to review all words that are part of Best Management Practices and the other words under the Vocabulary section.

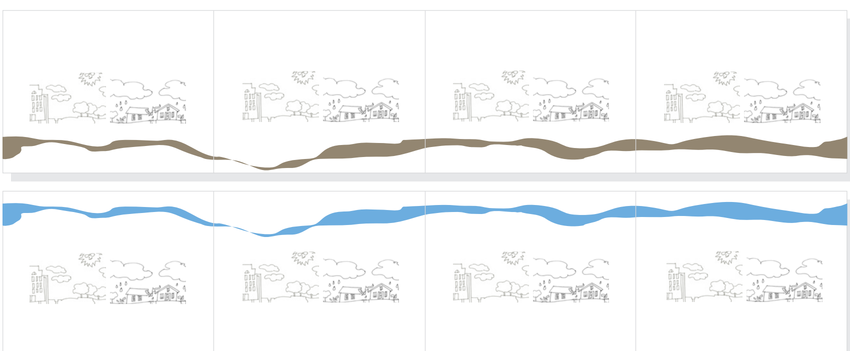
Background

Best Management Practices have already been discussed with the students. There is an excellent website from the EPA that you might find very helpful: *http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.*

This site includes a helpful glossary. Ask students what words they've seen that they do not understand and do either a "call-out" vocabulary lesson or have everyone stand up and do a vocabulary "bee" where they give the definition of a word you select. If they cannot give the definition, they sit down and the next person gets the chance to answer it.

Process

After a discussion about BMPs and using the two sheets in their work book labeled Old Town and New Town, students will either draw a picture, take a photo and print it, or find a picture on the Internet, to show something they have seen in their neighborhood or school vicinity that demonstrates either a polluting action, potential pollution, or non-green technique. Have them make sure the brown line runs on the bottom of their picture but do not tell them yet that represents the nearest river or stream watershed. On their second sheet, with now the blue "stream" running on the top (again, do not tell them), have them draw, photograph or somehow illustrate what the corrective "fix" would be for the same condition they have demonstrated in Old Town. Line up some desks and have students put both sides together with the river being the connector. Have each of them "present" their Old Town vs. New Town solution.



Old Town / New Town

Discussion Questions

1. What is an ecosystem?
2. What will happen if we make no changes to the things you saw that were not a best management decision or practice?
3. Why do you think people don't pay much attention to water and the path of stormwater?
4. Once we have all the BMPs in New Town set up, what will the river be like?
5. In New Town, what might be expected for our ecosystem? How could you prove you would have a better habitat for animals, fish, etc.?

day five:

Walking the Talk

Getting the message to KC

Students will develop videos (YouTube) or brochures (to include in the water bill) or posters (to put up in their school or area wide) to educate the public on BMPs.

This is the culmination of the week's activities and the lesson the students will probably be most excited about. Now is the time they must convey what they thought was the most significant in learning about water and its importance. They also must think about how to change people's behavior though communication and persuasion.

SKILLS

Analysis
Research
Graphic Arts
English Language Arts

50
Teaching Time in mins.

Materials Required

- Computer use
- Printer and Paper
- Digital Video Camera (optional)

Learning Objectives

Students will be able to:

- Develop a topic with facts, definitions, concrete details, quotations, or other information and examples
- Draw evidence from informational texts to support analysis, reflection, and research
- Introduce a topic clearly and group related information ; include formatting, illustrations, and multimedia when useful to aiding comprehension
- Write or present informative/explanatory text to examine a topic and convey ideas and information clearly.
- Integrate information from several texts or formats on the same topic in order to write or speak about the subject knowledgeably.
- Use precise language and domain-specific vocabulary to explain the topic.
- With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others
- Engage effectively in a range of collaborative discussions
- Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes
- Speak clearly in an organized manner at an understandable pace

Vocabulary

You may want them to review the total vocabulary list and ask if there are any words they still do not understand. Since they might be doing additional research, be prepared to help them look up any terminology not covered.

Background

Students are aware of advertising of all kinds: TV, Internet, billboards, magazines, but they may not have thought about its basic purpose, which is to persuade. You might talk a few minutes about persuasion and tell them some important techniques – discussing the difference between written and verbal, but pointing out some (all?) are true for both. These might include:

Know what your goal is. Is it simply to inform or are you actually trying to accomplish something? Always focus on the end result. Your purpose is to make someone think something or make someone do something. Everything you do should have the intention of reaching that goal.

Not only must you know the "what" behind your argument, you should be clear about the "why." Support your persuasive argument with as much solid and relevant information as possible to demonstrate accurate support.

Relate to your audience (whether it be one or many). Consider your audience and try to identify what you know about them and then appeal to that. Figure out what objections your audience might have and how you can counter them in your presentation or material – without stating those objections. You may search for the benefits your audience will experience from your idea and use them to counter their objections.

Elaborate on what you said earlier. You must repeat what you said for the audience to remember it, but say it differently.

Use strong and descriptive words – make every word mean something. Some words ring bells like "good," "evil," "freedom," "liberty," "right," "wrong," etc. But be sparing in your use of those words.

Stay away from too many statistics. The more facts and figures you use, the more you will bore people and the more likely it is that they will disagree with you.

If doing a presentation, be confident and compelling, leaving the "Uhs" and "Ums" and "likes" out. Practice making your argument before hand, don't fidget and be articulate. That way, you can seem relaxed and confident – someone worthy of being believed.

Procedure

After demonstrating both videos and flyers/ brochures to students, and dividing class into teams of 4-6 students, have them answer one key question to get them started: If you wanted Kansas Citians to understand the importance of water and how to improve its quality, what would you tell them? This becomes their purpose (and central idea to whatever they do), and it is used as their guiding principle to determine what they want to say. They also should determine who their audience is: is it adults, kids their own age, manufacturing executives, who?

Now they know what they want to say and who they want to read about it or see/hear it. Each group should develop their own purpose and audience and be able to tell that to you before they start their work. In their groups, after about 10 minutes, have each of them write down their purpose and audience individually and then have them compare their answers to their team members before they decide which is the best way to do that. This will help them all align to a common goal. They will have to discuss that because their choice of video, poster, or pamphlet will have to be one best suited to their intended audience.

Since group work often proceeds at different paces, this project part of the curriculum should be explained at the very beginning of the lesson so students can begin thinking of what they may want to do as well as be taking notes as they go along. You also should have an additional activity planned for groups who finish rapidly. Another class period may be necessary for a finished product and for them to present their work. Each group should convey their purpose and audience, and why they chose their method of presentation. Have the class then discuss each of the projects, emphasizing the objectives above. There are some sample videos from YouTube for students to use (on CD).

There are some sample videos from YouTube for students, both on the DVD. Encourage your students to find additional sources.

- "Woman in Glasses" *http://www.youtube.com/watch?v=s1H5m0S-sdQ&NR=1&feature=fvwp* – Not a student presentation but some good easy tips on giving a presentation – aimed at business but not so advanced. Conviction is misspelled at the end – which could be a talking point. Also the comment about using humor – is this really to be recommended? 1:35 minutes
- "Kids Consortium" *http://www.youtube.com/watch?v=c05md_BBXWU* Not a student presentation, but a total presentation with a viewpoint. Ask your students why this video was made, who was to be the audience, and what they took away from it. 3:08 minutes.
- "Operation Breakthrough" *http://www.youtube.com/watch?v=SUuwOkQbkhQ* These students were told to make a video to instruct other kids about how to behave at Operation Breakthrough. Operation Breakthrough is an inner city family care center with a large after-school program. Ask students if this would be effective if they were entering the center for the first time. You might want to show them only the first few minutes, then go to the last 2 or so, which brings home another lesson that it may take several tries to get your presentation right – whether it's a video, a poster, or a pamphlet. 6:00 minutes.

Examples of BMPs may be found at *http://water.epa.gov/polwaste/nps/ex-bmps.cfm.* and *http://www.montgomeryconservation.org/toursites.htm* is another good site for students to research BMPs.

Discussion Questions

1. Where will you get your information for your project? How do you know it is correct?
2. How do you divide up the research for your project?
3. What research did you use?
4. How will you check your work?
5. Who will be the presenters to explain how you did your work?
6. Why did you choose this person or people to be your presenters?
7. Is there anything different from your presenter you would have done?
8. What did you learn from this part of this project?
9. On your entire project, what would you do differently if you were to do it again?

vocabulary

alternative pavers
Permeable surfaces that can be used for driveways, parking lots, and walkways in place of asphalt and concrete. From a stormwater perspective, this is important because alternative pavers can replace impervious surfaces, creating less stormwater runoff. The two broad categories of alternative pavers are paving blocks and other surfaces, including gravel, cobbles, wood, mulch, brick, and natural stone.

anaerobic
Applying to metabolism in the cells of the body, or to micro-organisms, this means functioning without oxygen.

aquifer
An underground bed or layer of permeable rock, sediment, or soil that yields water.

berm
A mound or wall of earth.

check dam
A barrier for preventing the flow of water or of loose solid materials (soil).

combined sewer systems (CSS)
Sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. The wastewater is then transported to a sewage treatment plant where it is treated and discharged to a water body.

combined sewer overflows (CSO)
Occur during periods of heavy rainfall or snowmelt, when the wastewater volume in a combined sewer system exceeds the capacity of the sewer system or treatment plant. During and overflow, excess wastewater discharges directly to nearby streams, rivers, or other water bodies.

constructed wetlands
Structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. This kind of wetland is among the most effective stormwater practices in terms of pollutant removal, and they also offer aesthetic value.

disconnected rooftop areas
Rooftops designed so that drainage can occur to pervious areas beneath. It is interesting to know that in general, the pitch of the roof is proportional to the amount of precipitation. Houses in areas of low rainfall frequently have roofs of low pitch while those in areas of high rainfall and snow, have steep roofs.

dissolve
To cause to pass into solution: dissolve salt in water; to reduce (solid matter) to liquid form; melt; to cause to disappear or vanish; dispel; To break into component parts; disintegrate - to become reduced to components, fragments, or particles; to lose cohesion or unity; in physics & chemistry, to decompose, decay, or undergo a nuclear transformation.

dry swale

A shallow, gently sloping channel with broad, vegetated side slopes that remains dry during periods of no rainfall. Soil and water runoff are caught in the swale which becomes a fertile area. Gradual infiltration of water and nutrients and the dead roots of plants growing in the swale, slowly improve soil structure down-slope.

dry well

An underground structure that disposes of unwanted water, most commonly stormwater runoff, by dissipating it into the ground, where it merges with the local groundwater. Water flows through it under the influence of gravity. A dry well receives water from one or more entry pipes or channels at its top and discharges the same water through a number of small exit openings in the side(s) and bottom of the structure. Simple dry wells consist of a pit filled with gravel, riprap, rubble, or other debris. A more advanced dry well defines a large interior storage volume by a reinforced concrete cylinder with perforated sides and bottom.

ecosystem

A complex set of relationships among living resources, habitats and residents of a region.

evaporation

The process by which a liquid changes into a gas.

environment

The circumstances, objects or conditions by which one is surrounded.

erosion

When soil is carried over the surface of the earth by water or the wearing away of land by the action of natural forces.

extended detention

Extended detention wet ponds maintain a permanent pool of water typically equal to a portion of stormwater runoff after a storm. They effectively reduce downstream peak flows and remove pollutants via settling of solids, plant uptake of nutrients, and bacterial decomposition of organics and pesticides.

fertilizer

A substance (such as manure or a chemical mixture) used to make soil more fertile – rich in material needed to sustain plant growth:

filter strips (grassed)

Strips of ground that separate impermeable areas and are often grassed in or planted.

green parking

Parking areas that use one or more stormwater management strategies in their design. Examples include porous paving to reduce surface runoff, swales between rows of parking spaces, and/or planting large canopy trees to shade, cool and filter the air in parking areas.

Parking areas are a leading contributor to stormwater runoff. The information in the following paragraphs, taken from *http://www.greenlaws.lsu.edu/Seminar_Notes.htm* explain why in more detail.

Eighty to ninety percent of the demand for parking is met with surface parking lots. Some have estimated that surface parking often utilizes two or three times the amount of floor space used in commercial buildings. A ten thousand square foot commercial office building is likely to consume twelve thousand square feet of parking (1 space for every 250 square feet). That would be enough ground space to store forty (40) parked vehicles.

The supermarket on the corner that has one hundred and fifty thousand (150,000) square feet under roof, would require seven hundred and fifty (750) parking spaces consuming two hundred twenty-five thousand (225,000) square feet (1 space for every 200 square feet) or approximately five (5) acres of land.

A regional shopping mall of two (2) million square feet of retail space would require parking for sixty-six hundred cars taking up almost fifty acres of land (1 space per 300 square feet). That is a lot of land; those are a lot of cars.

Obviously, the more intense the land use, the more cars need to be stored and more land that must be set aside for car storage. In the past it was common practice to just cover the fifty acres with concrete or asphalt. The parking lot was one vast expanse of concrete that became a tremendous solar collector and covered an area large enough to drain five million gallons of water in a twenty-four hour rainstorm. At the rate of 0.15 cfs/acre per day, five million gallons of runoff, is a lot of water to drain.

green roof

A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. (The use of “green” refers to “environmentally friendly” and does not refer to roofs that are merely colored green, as with green roof tiles or roof shingles.)

groundwater

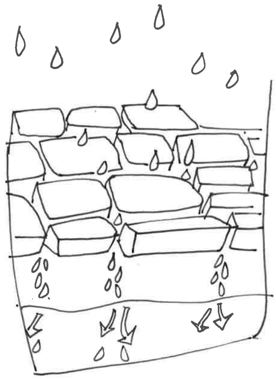
Water that occurs below the surface of the Earth, where it occupies spaces in soils or geologic strata. Most groundwater comes from precipitation, which gradually percolates into the Earth. Typically, 10 % to 20% of precipitation eventually enters aquifers.

herbicide

A chemical substance used to destroy or inhibit the growth of plants, especially weeds.

impervious

Incapable of being penetrated; normal pavement is an impervious surface that sheds



Pervious Pavement

rainfall and associated surface pollutants, forcing the water to run off paved surfaces directly into nearby storm drains and then into streams and lakes.

infiltration basins
An open-surface storage area for water having no outlet other than an emergency spillway.

infiltration trenches
Also called a percolation trench, this is a type of best management practice (BMP) that is used to manage stormwater runoff, prevent flooding and downstream erosion, and improve water quality in an adjacent river, stream, lake, or bay. It is a shallow excavated trench filled with gravel or crushed stone that is designed to infiltrate stormwater though permeable soils into the groundwater aquifer.

insoluble
A substance that cannot be dissolved.

low impact development (LID)
A term used in the United States to describe a land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.

native vegetation
The natural, indigenous, plants and flowers of a region.

nonpoint (source) pollution
Pollution that enters water bodies from various areas. One cannot detect or point out where it is coming from.

pervious pavement
Pavement designed to allow percolation or infiltration of stormwater through the surface into the soil below where the water is naturally filtered and pollutants are removed.

pesticide
A substance or mixture of substances intended for preventing, destroying, or repelling insects.

phased construction
The construction of a site or building in defined stages, typically to interfere as little as possible with the already established portions of the project.

point source pollution
Pollution that enters into water bodies from a specific source. Most point source pollution comes through a pipe. Point source pollution is pollution that allows you to “point out” where it is coming from.

precipitation
A deposit on the earth of hail, mist, rain, sleet or snow; also the amount of water deposited

rain barrels
A rainwater tank (sometimes called rain barrels in North America or a water butt in the UK) that is used to collect and store rain water runoff, typically from rooftops via rain gutters. Rainwater tanks are devices for collecting and maintaining harvested rain. Rainwater tanks are installed to make use of rain water for later use, reduce water use for economic or environmental reasons, and aid self-sufficiency. Stored water may be used for watering gardens, agriculture, flushing toilets, in washing machines, washing cars, and also for drinking, especially when other water supplies are unavailable, expensive, or of poor quality, and that adequate care is taken that the water is not contaminated or the water is adequately filtered.

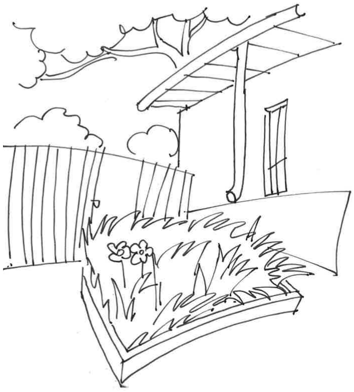
rain garden
A planted depression that allows rainwater runoff from impervious urban areas like roofs, driveways, walkways, and compacted lawn areas the opportunity to be absorbed. This reduces rain runoff by allowing stormwater to soak into the ground (as opposed to flowing into storm drains and surface waters, which causes erosion, water pollution, flooding, and diminished groundwater). Rain gardens can cut down on the amount of pollution reaching creeks and streams.

recharge
The process by which water moves downward from surface water to groundwater

riparian or riparian buffer
The part of the watershed immediately adjacent to the stream channel. Plant communities along the river margins are called riparian vegetation, characterized by hydrophilic plants. Riparian zones are significant in ecology, environmental management, and civil engineering because of their role in soil conservation, their biodiversity, and the influence they have on aquatic ecosystems. Riparian zones occur in many forms including grassland, woodland, wetland or even non-vegetative. In some regions the terms riparian woodland, riparian forest, riparian buffer zone, or riparian strip are used to characterize a riparian zone. The word “riparian” is derived from Latin ripa, meaning river bank.

runoff
Stormwater or surface runoff is the rain and melting snow that flows off streets, rooftops, lawns, parking lots, open fields, and any other exposed areas. The runoff carries with it whatever can be dislodged from the various sites, such as salt, soil, leaves, pesticides, fertilizers, oil, gasoline, and any other materials present on the surface.

sediment
Soil and other materials like grass clippings that ends up



stormwater planter

in streams, rivers, and other water bodies. Sediment is soil that is no longer in the right place. Sediment becomes a problem in the streams, rivers, and oceans because it is not supposed to be there. It cannot be used to grow food or forests because it is floating around in the water and sinking to the bottom. A lot of sediment enters water bodies after heavy rainstorms, especially when loose soil is left exposed to the rain.

sand and organic filters
Usually two-chambered stormwater treatment practices; the first chamber is for settling, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and the finer particles and other pollutants are removed as stormwater flows through filtering media.

separate sewer systems (SSS)
Sewers where one pipe system carries domestic sewage and industrial waste and a separate pipe system collects stormwater runoff. These pipes are not interconnected like in a combined system and the stormwater runoff discharges directly to a water body without passing through a treatment plant.

solvent
Liquid, solid, or gas that dissolves another solid, liquid, or gaseous solute, resulting in a solution.

soluble
A substance that is able to be dissolved. In chemistry, a solution is a homogeneous mixture composed of two or more substances. In such a mixture, a solute is dissolved in another substance, known as a solvent.

septic system
A sewage-disposal tank in which a continuous flow of waste material is decomposed by anaerobic bacteria.

septic tank
The key component of a septic system. It is a small scale sewage treatment system common in areas with no connection to main sewage pipes provided by local governments or private corporations.

stormwater
Water that originates from a storm event. Stormwater discharges are generated by runoff from land and impervious areas such as paved streets, parking lots and building rooftops during rainfall and snow events. If often contain pollutants in quantities that could adversely affect water quality.

stormwater planter
A small, contained vegetated area that collects and treats stormwater using bioretention. Bioretention systems collect and filter stormwater through layers of mulch, soil and plant root systems where pollutants such as bacteria, nitrogen,

phosphorus, heavy metals, oil and grease are retained, degraded and absorbed.

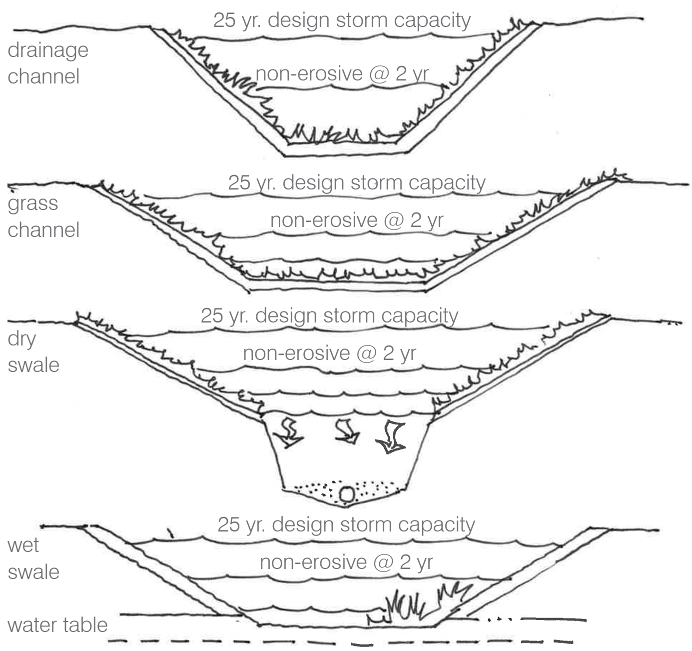
surface water
Water collecting on the ground or in a stream, river, lake, wetland, or ocean; it is related to water collecting as groundwater or atmospheric water. Surface water is naturally replenished by precipitation and naturally lost through discharge to evaporation and sub-surface seepage into the groundwater. Although there are other sources of groundwater, such as connate water and magmatic water, precipitation is the major one and groundwater originated in this way is called meteoric water.

swale, (wet swale)
A low tract of land, especially when moist or marshy; a long, narrow, usually shallow trough between ridges on a beach, running parallel to the coastline; a shallow trough-like depression that carries water mainly during rainstorms or snow melts.

topsoil stockpiling
Topsoil is the top layer of native soil; soil that is usually better for plant growth than what is beneath it. The term is often also used to describe good soil sold at nurseries and garden supply stores. When it is stockpiled, this topsoil is put into piles and conserved for later use on the site. The key to successful topsoil stockpiling is stabilizing the stockpiles immediately. The two more common methods are seeding or placing plastic sheeting on the stockpile to protect it from rainfall. If a stockpile will be uncovered for the winter, other erosion control measures such as mulching may be needed.

vegetated channel (swale)
Traditionally, swale designs were simple drainage and grassed channels that primarily served to transport stormwater runoff away from roadways and rights-of-way and provided inconsistent water quality treatment. Today, designers emphasizing water quality management are shifting from the drainage/grassed channel design concepts to carefully engineered dry/wet vegetated swale designs. Generally there are dry swales, which provide water quality benefits by facilitating stormwater infiltration, and wet swales, which use residence time and natural growth to treat stormwater prior to discharge to a downstream surface water body.

volume
The volume of any solid, liquid, gas, plasma, or vacuum is how much three-dimensional space it occupies, often quantified numerically. One-dimensional figures (such as lines) and two-dimensional shapes (such as squares) are assigned zero volume in the three-



swales

commonly presented in units such as cubic meters, cubic centimeters, liters, or milliliters

water cycle
The continuous process in which water travels in a sequence from the air through condensation to the earth as precipitation and back to the atmosphere by evaporation.

water pollution
The contamination of a water source; usually by humans.

wet pond
A stormwater retention impoundment created by either constructing an embankment or excavating a pit that retains a permanent pool of water. They improve water quality by allowing pollutants and nutrients present in stormwater runoff to settle out or be taken up by biological activity occurring in the pond.

watershed
An area of land that drains downslope to the lowest point. The water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers, which become progressively larger as the water moves on downstream, eventually reaching an estuary and the ocean. Other terms used interchangeably with watershed include drainage basin or catchment basin.

wetland
An area where the water level remains near or above the ground surface for most of the year. Marshes and swamps are examples of wetlands. Wetlands are usually found in a landscape's low spots where water naturally pools and the water table is high. Most wetlands also contain soils that drain slowly, which further retains the water.

wetland

Author
Project Explore, Inc.

Book Design & Illustrations
BNIM

Updates
Kansas Ciity Water Services