HOW NATURAL AREAS FILTER WATER

Subject Area: Science, Natural Resources
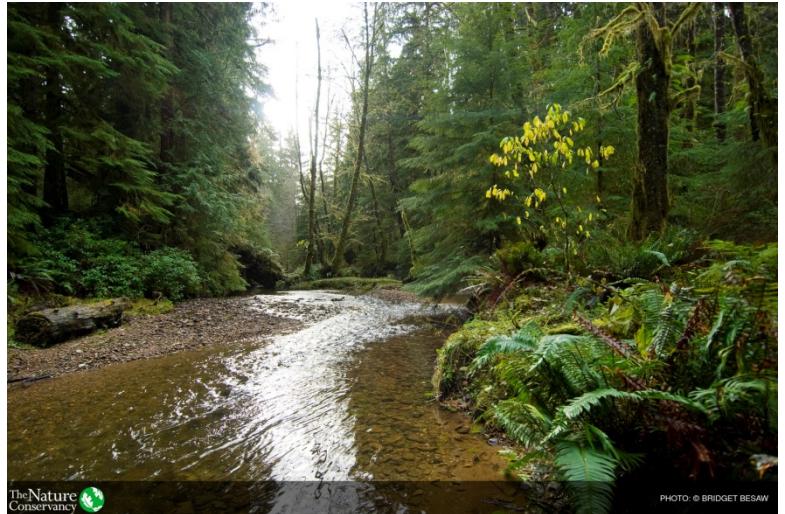
Grade Levels: 6th-8th grade

Time: Activity 1 – one to two 45 minute periods.
Activity 2 – two 45 minute periods.

Essential Question:

- How do paved areas impact the filtration of rainwater?

Purpose and Overview:

In this lesson, students learn the value of clean freshwater and the natural processes that ensure an adequate supply of usable freshwater. In activity 1, students learn about the importance of water quality for human health and agriculture. Students brainstorm the different ways that people use water, from household use to industry and agriculture. Statistics related to the quantity of water on the planet help students understand that water is a finite resource. Students relate their own activities to the water supply to put their own consumption in activities. Students then brainstorm various threats to the water supply. In activity 2, students conduct a hands-on activity that focuses on the role of natural areas as filters that produce clean water. Such natural filters are contrasted with impervious (paved) areas to compare the impact of development on the ability of nature to provide clean freshwater.

Theme:

Impervious areas increase pollution because runoff does not pass through nature's filtering systems.

Introduction:

Humans use an ever-greater proportion of available freshwater and activities like agriculture and industry can impact the water cycle. Pollutants like pesticides, fertilizers, and heavy metals can enter watersheds as a result of some agricultural practices and industrial activities. Contaminated water that enters a watershed can threaten all organisms that depend on water for survival.

Water contaminated with heavy metals or untreated sewage can have huge consequences for human health, especially in countries that lack adequate water treatment facilities. Contaminated water must be filtered for human consumption and the more contaminated the water is, the more costly it is to treat.

Nature works to filter and release water over time – for free! In this way, nature reduces the amount of artificial treatment needed to filter water and also contributes to prevention of flooding. In nature, water is filtered through layers of soil, sand, rock, and other natural materials like leaves. Surfaces where water can penetrate are called permeable surfaces. Impervious surfaces, like rooftops and paved roadways, are surfaces where water cannot penetrate. As impervious (or impenetrable) surfaces increase in urban areas, this leads to less natural water filtration. Impervious surfaces can contribute to pollution in urban watersheds because rainwater accumulates pollutants like car oil, fertilizers, detergents, and pesticides as it moves across them. These pollutants eventually end up contaminating the watershed.

Objectives:
The student will…
Knowledge
- Identify the difference between natural areas and impervious surfaces.
- Describe the key indicators of water quality.
- Describe the key parts of the water cycle.
Comprehension
- Describe the volume of water on Earth in relation to Earth's total volume.
- Distinguish between different kinds of impervious surfaces.
- Explain the importance of water quality as it relates to water being a limited resource.
Application
- Compare differences in run-off volume and quality between natural areas and impervious surfaces.
- Characterize the different parts of the water cycle and how they are impacted by human activity.
Analysis
- Generalize about the impacts of water quality on human health.
- Calculate differences in run-off volume between natural areas and impervious surfaces.
Synthesis
- Contrast features of natural areas and impervious surfaces that lead to differences in runoff volume and water quality.
Evaluation
- Solve quantifiable problems related to run-off volume and water quality in natural areas and impervious surfaces.

Standards:

Next Generation Science Standards

Disciplinary Core Ideas

- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS4.D Biodiversity and Humans
- ESS3.C Human Impacts on Earth Systems

Crosscutting Concepts

- Cause and Effect
- Stability and Change

Science and Engineering Practices

- Asking Questions and Defining Problems
- Developing and Using Models
- Analyzing and Interpreting Data
- Constructing Explanations

Performance Expectations Middle School

- LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- ES3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- ES3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Common Core English and Language Arts Standards for Writing Grades 6-8

- CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- CCSS.ELA-LITERACY.WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
- CCSS.ELA-LITERACY.WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.
- CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- CCSS.ELA-LITERACY.WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- CCSS.ELA-LITERACY.WHST.6-8.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.

Vocabulary:

Finite: Limited, not endless

Impervious: Unable to pass through, as it relates to a surface or material

Pollution: Unwanted chemicals that impact water quality

Resource: *A limited quantity of useful substance or material*

Run-off: Water that drains into streams and rivers following rainfall

Watershed: An area of land where all the water that is under it, or drains off of it, flows to the same river, basin or sea.
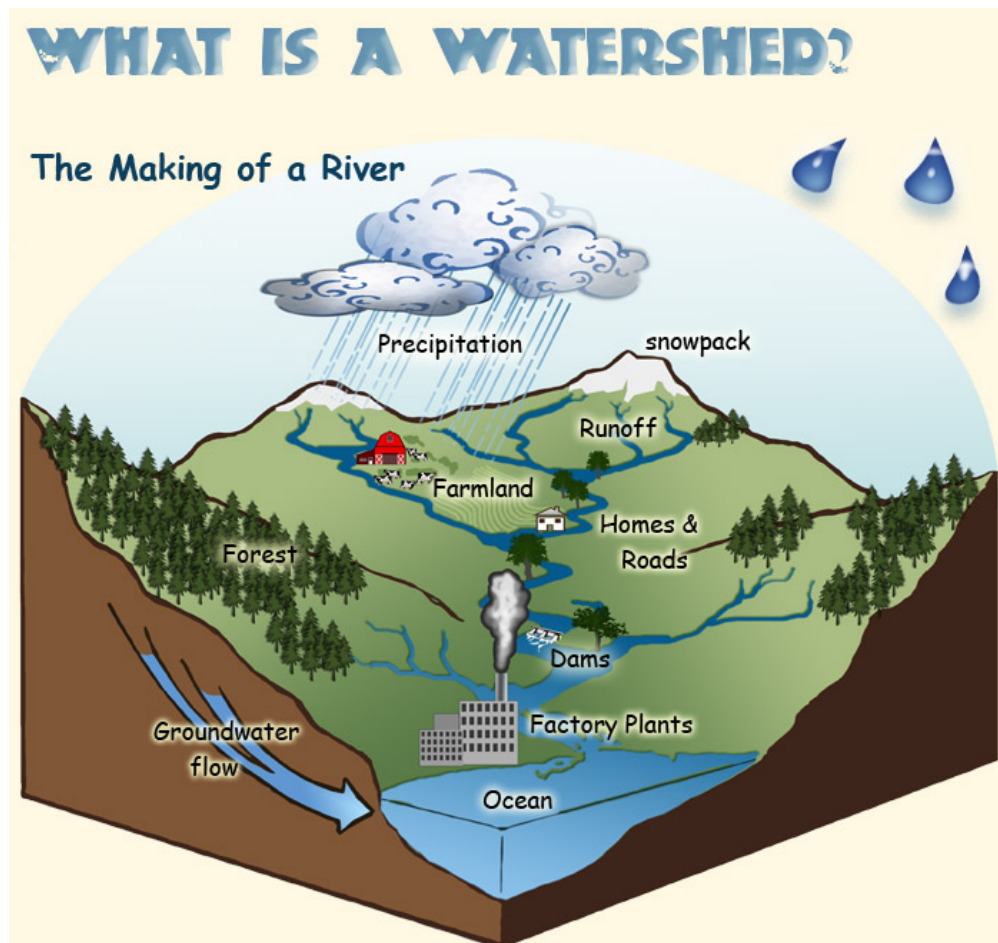

Image credit: US Forest Service,
http://www.fs.fed.us/rm/boise/research/techtrans/projects/scienceforkids/watersheds.shtml

Materials:

Nature Works Everywhere videos supporting this lesson plan:
- *Nature Works – To Make Clean Water* overview video http://vimeo.com/77811268
- YouTube video where a 3rd grader shows a simple experiment of impervious versus natural surfaces (Activity 2) http://www.youtube.com/watch?v=Dw9p8jEB7m0
- Video of Conservancy scientist conducting Activity 2 – Water Filtration Experiment https://vimeo.com/137868819

Materials for Teacher:
- Computer with Internet connection, LCD projector, screen
- Activity 1
  - Two glasses of water and a teaspoon full of soil
  - Animation of water cycle https://illinois.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.watercycle/water-cycle-animation/
  - An orange and a sewing pin with a plastic ball head
  - Image of Earth's volume of water (to be projected) http://water.usgs.gov/edu/gallery/global-water-volume.html

Materials for each group of students (Activity 1):
- Brown modeling clay
- Blue modeling clay
- Ruler
- Calculator
- Measuring jug
- Two containers
- Blue and green food coloring (optional)
- Graduated measuring cylinder

Materials for each group of students (Activity 2):
- Copy of student handout for activity (located at the end of this lesson plan)
- 2 soda bottles with bottom removed
- 2 large jars about the same diameter as the soda bottles
- duct tape
- handful of horticultural moss (available from gardening stores)
- handful of dried leaves
- bag of river sand
- bag of gravel
- old newspaper
- old plastic cups
- garden soil
- bucket
- tap water
- vegetable oil
- 1 liter pouring jug
- timer with seconds
- ruler
- **Optional (for Elaborate)**
  - ruler
  - clear acetate sheet
  - narrow-point markers

Classroom Activities:

Activity 1: Humans and Water

Part 1: Engage

1. Ask students if they have ever shared a drink of water with a dinosaur. Well, not in real life! But in fact, the water we drink has been cycled over eons. So it's quite possible that a

few molecules in a glass of water were once imbibed by a dinosaur. View the *Nature Works – To Make Clean Water* overview video.

2. Present students with two glasses of water. One is filled with clean tap water. Another is filled with water to which a spoonful of garden soil is added. Ask students which they would prefer to drink. Ask students how many glasses of water they drink a day. Ask students how many different ways they use water.

3. Point out that water is the stuff of life. We can't live without it. It's essential for biological processes and for numerous industrial and agricultural activities. Explain that nature works to filter water and to release water over time and to thereby benefit people.

4. Have students brainstorm the different ways that people use water, from household use to industry and agriculture.

Part 2: Explore

1. Show students the animation of the water cycle - https://illinois.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.watercycle/water-cycle-animation/

2. Have students consider which part of the water cycle we use the most. Have students conclude that only a small part of the water cycle is available for human use (groundwater, stream, rain). Ask students why they think such a small percentage of Earth's water is drinkable.

3. Emphasize that humans use an ever-greater proportion of the available freshwater, and are therefore increasingly impacting the water cycle.

4. Have students consider a glass of water and what makes that water fit to drink. Have students make a list of factors that contribute to water quality. Have them first brainstorm factors, and then research online. The list should include how those factors might be measured. Here are some of the most important:

Factor affecting water quality	Ways to measure	Units
Dissolved oxygen (DO)	Chemical assay, DO probe	mg/L
Nitrate	Chemical assay, nitrate electrode	mg/L
Phosphate	Indicator test strip	parts per million
Biochemical oxygen demand (BOD)	Biochemical assay	mg O_2 consumed per liter/L
Pesticides	Chemical assay	mg/L
Metals	Chemical assay	mg/L
pH	pH indicator, pH probe	pH
Temperature	Thermometer, temperature sensor	Degrees Celsius
Turbidity	Secchi disk, nephelometer	NTUs

5. Given the various factors that affect water quality, and the animation of the water cycle, have students brainstorm various threats to water quality.

6. Challenge students to create a concept map of what governs water quality.

7. Ensure that students understand that run-off is an important part of the water cycle, and is therefore a potential source of pollution.

8. Stick a pin (with the little colored balls at the end, preferably blue) into an orange and pass around. This is about the volume of water on Earth compared with its total volume.

Math Extension (optional):

9. Water is a *finite* resource. Have students consider the volume of Earth relative to the volume of all Earth's water.
   i. 1.1×10^{12} cubic kilometers/1.4×10^{9} cubic kilometers $= 773$
   ii.   That is, Earth's volume is about 773 times the volume of all its water.

10. Have students use the modeling clay to construct two spheres. One sphere represents Earth. The other sphere represents the volume of water on Earth.

11. Challenge more advanced students to derive the <u>diameter</u> of the spheres from the equation $V = (4\pi r^3)/3$ (For lower grade students explain that the diameter is derived from the volume and skip to Step 12.)
   i. $V = (4\pi r^3)/3$
   ii. $3V = 4\pi r^3$
   iii. $(3V/4) = \pi r^3$
   iv. $(3V/4)/\pi = r^3$
   v. $\sqrt[3]{\dfrac{\frac{3V}{4}}{\pi}} = r$
   vi. $2r = D$

12. Have students scale the diameter of the spheres of Earth and its comparative volume of water to create the two spheres from the available materials. Using the comparative volumes:
   i.   If Earth's volume $= 773$, its radius, $r_E = 5.69$ and its diameter, $D_E = 11.38$
   ii.   Therefore water volume $= 1$ and $r_W = 0.62$ and $D_W = 1.24$.

13. To build a scale model where the volume of Earth's water is represented by a ball of blue clay 1 cm in diameter, Earth would be represented by a ball of brown clay about 9 cm across.

14. When their models are complete show students the computer-generated image of the Earth compared with the volume of water.

15. Explain that the small clear sphere is the volume of *all* of Earth's surface water relative to Earth itself.

16. Of even this small amount most water is unavailable for human use. Have students consider how much water in the sphere is available for humans. They might think half or a quarter. But more than 95% is in the oceans. Of the 2.5% of the freshwater almost three-quarters is inaccessible, locked up in ice-caps or deep underground aquifers. Therefore less than a hundredth (< 1%) of the little water sphere is available for human use. Have students try to pinch off a hundredth of the sphere of clay that represents water volume.

17. That is why water quality is so important. Even though water seems abundant, it is a relatively scarce resource. Moreover easily contaminated or wasted. As human population increases, demand on that tiny amount of freshwater increases.

18. Challenge students to measure an amount of water to represent all of Earth's water. They then use a graduated cylinder to measure out an amount of water (colored green) to represent the amount of water available for human use (colored blue). Add the blue water to the green water. The amount of (blue) water available for human use does not change the color of the green water.

Part 3: Explain

1. Have students list the key parts of the water cycle.

2. Have students create a list of reasons *why* water quality is important. Reasons include:
    a. Clean water is necessary for human health
    b. Various industries including agriculture and manufacturing require clean water
    c. Animals and plants depend on relatively clean water
    d. Contaminated water can kill aquatic life
    e. Contaminated water must be filtered, increasing the cost of water

Part 4: Extend

1. Have students consider consequences of water pollution and wastage. They can list the impacts on human health of water contaminated with heavy metals (e.g., mercury or lead poisoning) or untreated sewage (e.g., typhoid, cholera, etc.).

2. Have students research incidents where contaminated water resulted in sickness or even death. (For example, the 2008 United States salmonellosis outbreak was traced to contaminated irrigation water used on peppers. In 1999, contaminated water at the Washington County Fair in Easton, New York resulted in 71 hospitalizations and two deaths.)

Part 5: Evaluate

Have students self-evaluate their concept maps: were a wide variety of topics featured, were the connections appropriately relevant, and were groupings logical? Specific questions (for lower middle school provide the numbers in parentheses):

1. If the total amount of water on Earth is 1,386,000,000 cubic kilometers, and the total volume of freshwater is 49,000,000 cubic kilometers, what percent of Earth's water is freshwater?

2. Using the information in Question 1, calculate the approximate fraction of the world's total surface freshwater available for human use if the volume of unavailable freshwater (locked up in ice caps and deep groundwater) is 48,400,000 cubic kilometers.

Scoring key for evaluation
1. Amount of non-freshwater (oceans) = 1,386,000,000 − 49,000,000 = 1,337,000,000 cubic kilometers.

   Percent of freshwater (49,000,000 ÷ 1,386,000,000) × 100 = **3.53%**

2. Total volume of freshwater = 49,000,000 cubic kilometers.

   Volume unavailable water = 48,400,000 cubic kilometers.

   Percent water unavailable = (48,400,000 cubic kilometers ÷ 49,000,000 cubic kilometers) × 100 = 98.77 %

   Percent available for human use = 100 − 98.77 = 1.23%

   That is only about a **hundredth** of the freshwater on Earth that is available for human use.

Additional Resources and Further Reading:

- The Water Cycle: Oceans
  http://water.usgs.gov/edu/watercycleoceans.html

- The World's Water - Percentages
  http://water.usgs.gov/edu/earthwherewater.html

- pH – Water Properties
  http://water.usgs.gov/edu/phdiagram.html

- *E. coli* Information
  http://water.epa.gov/drink/contaminants/basicinformation/ecoli.cfm

Activity 2: Water Filtration – Natural Surfaces versus Impervious Surfaces

Materials for Teacher
- Computer with Internet connection, projector, screen
- Photocopy student handout for activity (located at the end of this lesson plan)
- YouTube video where a 3rd grader shows a simple experiment of impervious versus natural surfaces (Activity 2) http://www.youtube.com/watch?v=Dw9p8jEB7m0
- Video of Conservancy scientist conducting Activity 2 – Water Filtration Experiment https://vimeo.com/137868819

Materials for each group of students
- 2 soda bottles with bottom removed
- 2 large jars about the same diameter as the soda bottles
- duct tape
- handful of horticultural moss (available from gardening stores)
- handful of dried leaves
- bag of river sand
- bag of gravel
- several pieces of concrete
- old newspaper
- old plastic cups

- garden soil
- bucket
- tap water
- vegetable oil
- 1 liter pouring jug
- timer with seconds
- ruler
- **Optional (for Elaborate)**
  - ruler
  - clear acetate sheet
 - narrow-point markers

Part 1: Engage

1. Ask students how often they walk on the bare ground each day. Have students discuss how often they walk on bare ground compared to concrete, floors, parking lots or other surfaced areas.

2. Have students discuss how much of the area around them is paved. A lot? A little? Have students look at a Google Map around their town to see how much area is paved. Have students categorize the different kinds of impervious surfaces such as parking lots, roads, driveways and roofs.

3. Have students brainstorm what happens to rain that runs off roads and parking lots. Most of this water does not water plants or natural areas, but is transported in drains along with chemicals and trash that pollute streams, rivers, lakes, and the ocean. Have students consider the kinds of chemicals that end up in streams from run-off. Oil and gasoline residue from parking lots are washed into streams and rivers.

4. Have students consider how impervious surfaces reduce water supply. Water is transported along gutters and drains instead of seeping into the ground. As it seeps, water is filtered naturally, ensuring aquifers are replenished with clean freshwater. Explain that nature works to reduce the amount of artificial treatment needed to filter water and also contributes to prevention of flooding, thereby benefiting humans.

5. If you don't have time to conduct the activity, you can show students the video of a Conservancy scientist conducting the experiment and use this as the basis for a discussion about impervious surfaces versus natural surfaces. The video can be found here: https://vimeo.com/137868819.

Part 2: Explore

1. Students will use a model to compare water that is filtered through a natural system versus water that runs off from an impervious surface.

2. Have students construct two funnels with the soda bottles as shown in the diagram. Invert one of the soda bottles to make a funnel and use the duct tape to secure the soda bottles to the large jars.

3. Have students mix together a handful or so each of the garden soil, sand, gravel, leaves and moss. The quantities are not important, but try to keep the amounts of each material about equal. Keep aside a small handful of moss. Place the small handful of moss in the neck of the funnel. Add the mixture to the funnel. Ensure the material is packed firmly but not too tightly. This funnel represents soil through which water filters in natural areas.

Materials

Tape

4. In the other funnel, students place the pieces of concrete, to the same volume as the soil-filled funnel. Loosely crumple the old newspaper into various sized pieces and crush the plastic cups. Add the newspaper and plastic cups into the funnel. This funnel represents areas across which water drains in paved areas. The newspaper and cups represent trash which may collect in the drains of paved areas.

5. Students mix together a small amount of the garden soil with 2 liters of water and add two cups of the vegetable oil.

6. Have students add 1 liter of this mixture to the pouring jug.

7. Have students pour the mixture into the soil-filled funnel. Have students record how long it takes for the water to drain through and their observations. Also have students measure the height of the oil layer that rises to the top of the water once it has filtered through.

8. Repeat the above step for the funnel filled with pieces of concrete.

9. You can extend this activity by having students change the order of layers and/or types of materials in the natural surfaces set-up to determine which natural surfaces make the best filter.

Part 3: Explain
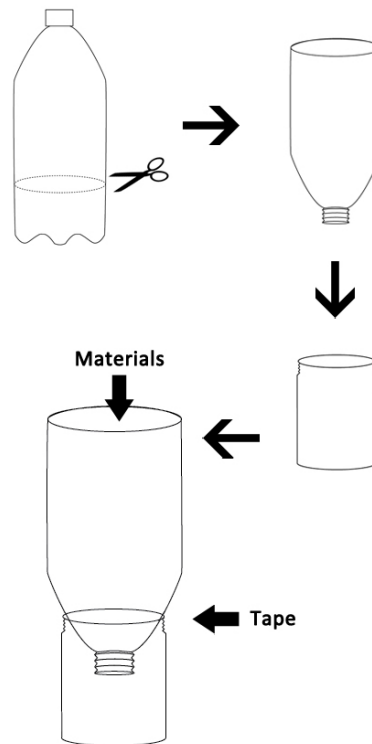
1. Have students describe and discuss their observations. Ask students to consider the differences between the two funnels. They will observe that the water drains a lot faster through the concrete-filled funnel. They will also observe that the height of the oil layer is higher in the concrete funnel.

2. Have students explain why the water from the impervious surface bottle is dirtier than that from the soil-packed bottle. (Impervious surfaces cannot drain water. Hence water drains much faster.)

3. Share the definition of a watershed – an area of land where all the water that is under it, or drains off of it, flows to the same river, basin or sea. Have students describe the consequences for a watershed. For example, during a dry spell water will remain in streams and rivers that are drained naturally because the water takes longer to move through soil. When rain is heavy, floods are more likely in areas with impervious surfaces because most of the water drains rapidly into gutters and then into rivers.

4. Have students explain how their experiment models real systems. (The vegetable oil represents the oil and gasoline deposits left by vehicles in parking lots or driveways. Hence water that runs off impervious surfaces contains more toxic chemicals that need to be treated. If untreated, the chemicals in this water end up in the food chain.)

5. Have students quantify the difference between water filtered by soil compared with water runoff from impervious surfaces. What is the difference in time for water to filter compared with runoff?

6. Have students calculate the volume of oil that is filtered by soil compared with water runoff from impervious surfaces. To do this they can use the formula for measuring the volume of a cylinder, where the volume of the oil is the height of the layer times the area of the circle formed by the interior of the jar. If the height of the oil layer in the jars is too small to measure accurately, simply pour the oil into a narrower diameter measuring cylinder. (Ensure students understand how to measure levels of fluids in a cylinder, accounting for the meniscus.)

Part 4: Elaborate

1. Have students consider the proportion of runoff from a parking lot compared with a grassy meadow. About 95 percent of rain falling on a parking lot ends up directly in drains and gutters. Only about 5 percent of rain falling on a meadow drains off the field. In terms of development, areas differ considerably in the proportions that are impervious. In a residential zone, the impervious area may range from 20% to nearly 50%. The differences are determined largely by the layout of streets and parking, and sizes of lots compared with houses.

2. Time allowing, more advanced students can engage in an exercise to quantify and compare the amounts of vegetative cover versus impervious surface.

3. Have students find their school, residence or other suitable location on Google Maps. Switch to Satellite view. Use the zoom tools until the area of interest covers an area about

7 x 10 inches on the screen. Take a screen shot of the area. Using a color printer, print out the screen shot. You should now have an image of the area.

4. Using the marker, students draw a 1cm grid on the acetate sheet.

5. Lay the acetate sheet over the satellite photo image. Count squares accordingly, categorizing surfaces depicted in each one as "soil" or "impervious." If a square includes both surfaces, record the surface that occupies the larger part of the square. If it's hard to tell which surface occupies the larger part of the square, record that square in both categories.

6. Count the number of squares in each category and derive the proportion of total area covered with impervious surface. Have students discuss their findings in context of the impact of impervious surfaces. (See article *The Importance of Imperviousness*)

7. Have students recall from the overview video how they can help reduce runoff in their own backyard.

Part 5: Evaluate

Have students self-evaluate on how well they performed the experiment and recorded their observations. Specific question:

1. In residential zone A, scientists measured the impervious area to be 23%. In residential zone B, the impervious area was found to be 45%. In both these zones, 95% of the rainfall drains into gutters in the impervious areas. In the natural areas, about 10% of the rainfall drains. If both zones receive one centimeter of rainfall per hour for 24 hours, what is the total volume of rain that drains from one hectare in each residential zone? (Assume that 1 cm of rain on 1 hectare = 10,000 liters.)

Scoring key for evaluation
Problem is worked out as follows:
- Calculate the total amount of rainfall

    Total amount of rainfall: $1 \times 24 = 24$ centimeters.

    Total amount of rainfall on 1 hectare: $24 \times 10,000 = 240,000$ liters

- Calculate amount draining from Zone A

    Amount draining from zone A impervious areas: 95% (240,000 × 23%) = 95% × 55,000 = 52,250

    Amount draining from zone A natural areas: 10% (240,000 × 77%) = 10% × 184,800 = 18,480

    Total amount draining from **Zone A**: 52,250 + 18,480 = **70,730 liters**

- Calculate amount draining from Zone B

  Amount draining from zone B impervious areas: 95% (240,000 × 45%) = 95% × 108,800 = 103,360

  Amount draining from zone B natural areas: 10% (240,000 × 55%) = 10% × 132,000 = 13,200

  Total amount draining from **Zone B**: 103,360 + 13,200= **116,560 liters**

Additional Resources and Further Reading:

- The Importance of Imperviousness
  https://www.ci.milpitas.ca.gov/_pdfs/cwp_site_planning/ch2.pdf

- The Need to Reduce Impervious Cover to Prevent Flooding and Protect Water Quality
 http://www.dem.ri.gov/programs/bpoladm/suswshed/pdfs/imperv.pdf

Activity 2: Natural Materials versus Impervious Surfaces

Materials:

- 2 soda bottles with bottom removed
- 2 large jars about the same diameter as the soda bottles
- duct tape
- handful of horticultural moss (available from gardening stores)
- handful of dried leaves
- bag of river sand
- bag of gravel
- several pieces of concrete

- old newspaper
- old plastic cups
- garden soil
- bucket
- tap water
- vegetable oil
- 1 liter pouring jug
- timer with seconds
- ruler

Procedure:

1. Construct two funnels with the soda bottles as shown in the diagram to the right. Invert one of the soda bottles to make a funnel and use the duct tape to secure the soda bottles to the large jars.

2. Mix together a handful or so each of the garden soil, sand, gravel, leaves and moss. The quantities are not important, but try to keep the amounts of each material about equal. Keep aside a small handful of moss.

3. Place the small handful of moss in the neck of the funnel. Add the mixture to the funnel. Ensure the material is packed firmly but not too tightly. **This funnel represents the soil through which water filters in natural areas.**

4. In the other funnel, place the pieces of concrete, to the same volume as the soil-filled funnel. Loosely crumple the old newspaper into various sized pieces and crush the plastic cups. Add the newspaper and plastic cups into the funnel. This funnel represents areas across which water drains in paved areas. The newspaper and cups represent trash which may collect in the drains of paved areas.

5. Mix together a small amount of the garden soil with 2 liters of water and add two cups of the vegetable oil.

Materials

Tape
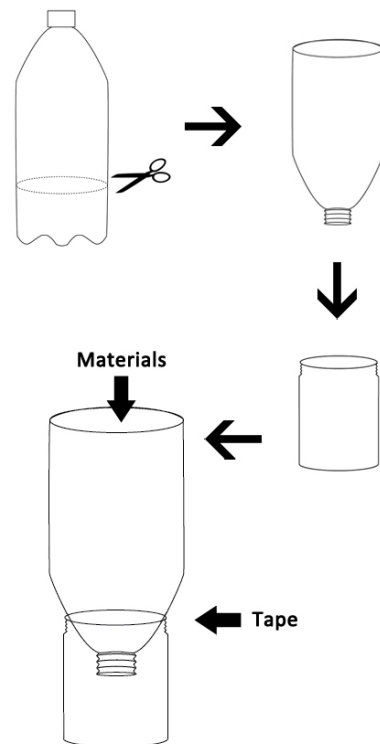
6. Add **1 liter** of this mixture to the pouring jug.

7. Pour the mixture into the soil-filled funnel. Record how long it takes for the water to drain through and your observations. Measure the height of the oil layer that rises to the top of the water once it has filtered through.

8. Repeat the above step for funnel filled with pieces of concrete.

Observations and Discussion:

1. Describe and discuss your observations. Consider the differences between the two funnels.

2. Explain why the water from the impervious surface bottle is dirtier than that from the soil-packed bottle.

3. Describe how these different surfaces might impact a watershed in rainy and dry conditions.

4. Explain how the experiment models real systems.

5. Quantify the difference between water filtered by soil compared with water runoff from impervious surfaces. What is the difference in time for water to filter compared with runoff?

6. Calculate the volume of oil that is filtered by soil compared with water runoff from impervious surfaces.

   a. *(To do this you can use the formula for measuring the volume of a cylinder, where the volume of the oil is the height of the layer times the area of the circle formed by the interior of the jar. If the height of the oil layer in the jars is too small to measure accurately, simply pour the oil into a narrower diameter measuring cylinder.)*