Lesson: Land's Wonders and Worries: Operation Stormwater

*Arlington Echo works to continuously improve our lessons. This lesson may be modified over the course of the school year.

Environmental Literacy Question: How have humans affected the Chesapeake Bay and its watershed?

Topic/Essential Question: How do weathering and erosion change the Earth? How can we prevent erosion?

Unit/Lesson Sequence: This lesson is one of two in the "Land's Wonders and Worries" module based at Arlington Echo Outdoor Education Center.

Content Standards:

- **Environmental Literacy**
  5.A.1. Analyze the effects on human activities on earth's natural processes
  1.A.5.f. Make recommendations supported by data to help address or resolve the issue.
  8.F.1.b. Identify actions that can be taken as individuals and those that require the involvement of other people, organizations and government.
- **Social Studies**
  3.D.1.b Geography Describe ways and reasons people in Maryland and the U.S. modify the natural environment and the consequences of modifications.
- **Science**
  6.4.B.1. Recognize and describe that people in Maryland depend on, change, and are affected by the environment.
  2.4.A.2.b. Cite evidence to show that erosion shapes and reshapes the earth's surface as it moves from one location to another.
- **Math**
  Common Core 3.MD Geographic measurement: understand concepts of area and relate area to multiplication and to addition.

Length of Lesson:

Overnight Program: 60 minutes
Day Program: 45 minutes

Student Learning Outcome: The students will investigate the Arlington Echo surfaces pictured on the map and evaluate their effectiveness in infiltrating rain water.

Knowledge of the Learner:

- Prerequisite knowledge, skills and processes: When rain hits impervious surfaces, it runs off into storm drains. Students should be able to listen to instruction and follow directions.
- Student needs, interests, previous learning: These will be identified in the pre-assessment.
- Conceptual difficulties: All students should be able to differentiate between some of the surfaces but some group discussion may be required to find all the stormwater controls. Students may work in pairs or small groups to identify and label these.
- Differentiation: Students are in 4th grade with a diversity of backgrounds and skill levels.

Knowledge of the Content

At the beginning of the lesson, students work with the activity leader to create a thinking map of their knowledge. This creates a base on which they can root their findings. The activity leader can refer back to the map at the end of the lesson to reinforce the students' findings. Students will work in pairs or small teams to find ways to control stormwater. They may discuss their findings along the way to improve understanding and encourage cooperation. Students will use their knowledge of stormwater controls to investigate the area and evaluate the effectiveness of stormwater controls at Arlington Echo.

- **Vocabulary:**

Stormwater	Watershed	Runoff	Pervious
Impervious	Erosion	Rainscape	Green Roof
Rain Barrel	Bioretention Area	Infiltration	Sandstone
Pervious Concrete	Swale		

- **Resources:**

Clipboards	Small buckets	Blue and red wet erase markers
1 large bucket of water	Thinking map poster	Measuring cups
Easel	Green roof sample	Dry erase marker
Roofing tile sample	2 large metal cans	Laminated Maps

- **Supplements:**
  A: Background for Activity leader: Information on Stormwater
  B: Operation Stormwater Thinking Map
  C: Operation Stormwater Investigative Map
  D: Operation Stormwater Key Terms
  E: Watershed Model

Lesson setup:

1. Fill large bucket by the boat house with water from the rain barrel (or from spout on the side of the maintenance building if the rain barrel is empty), students will use this to fill their blue buckets.
2. Set out the blue buckets about halfway filled with water and place a measuring cup inside each (1 per every 2 students).
3. Pair the clip boards with wet erase markers and laminated maps on the picnic table (1 per 2 students).
4. Set up easel with Thinking Map Poster, thin marker, and wipe cloth by the picnic tables.
5. Place the two large cans in two different areas: one in a grassy area of the field and one in the forest.
6. Refer to **Supplement A** for background information on stormwater prior to the lesson.

Instructional Delivery

Pre-Assessment:

1. Have students sit at the picnic tables facing the easel and thinking map poster.
2. Ask students to define stormwater and discuss responses to create a definition *(stormwater is precipitation from any major storm event).*
3. Continue by asking students if anyone knows what a watershed is *(a watershed is the area of land where all the rivers and streams flow across and into a large body of water;* ex: we are in the

Chesapeake Bay watershed)! *Remind them of the watershed dance and game they played with AE staff during the module introduction.

Engage:

***Overnight only: Watershed Model**

Demonstrate the Chesapeake Bay watershed using the model. Refer to **Supplement E.**

Day Program Continue below

1. Have students sit at the picnic tables facing the easel and thinking map poster.
2. Ask students to define stormwater and discuss responses to create a definition *(stormwater is precipitation from any major storm event).*
3. Continue by asking students if anyone knows what a watershed is *(a watershed is the area of land where all the rivers and streams flow across and into a large body of water;* ex: we are in the Chesapeake Bay watershed)! *Remind them of the watershed dance and game they played with AE staff during the module introduction.
4. In this activity, the students will be looking at the movement of stormwater across different surfaces in a watershed. Explain that water runs over 2 main types of surfaces in a watershed: PERVIOUS and IMPERVIOUS.
5. Ask students for a definition or guess of what pervious and/or impervious means. If the students do not have any guesses, tell them the definition for pervious (*a surface that absorbs water)* and ask them to use that to come up with a definition of impervious (*a surface that does not absorb water).* Write both definitions on the thinking map **(Supplement B)**.
6. Complete the thinking map as a group, asking the students to make educated guesses about which surfaces are PERVIOUS and IMPERVIOUS. It is important to write down what the students say, whether or not it is the correct answer. The map will be revisited at the end of the lesson and corrected if needed. If the students have trouble coming up with surfaces, give them one or two examples for each type of surface to generate ideas **(examples in Supplement B)**.
7. Ask students which type of surface (pervious or impervious) is better for protecting the health of the Chesapeake Bay and discuss their answers to reach a consensus within the group.
    a. *Pervious is better because it slows down and soaks up water to control stormwater runoff. Stormwater runoff can carry pollutants into the Bay and can cause erosion and flooding.*

Explore:

Impervious surface mapping:

1. Divide the students into groups of 2-3. Tell the students that they will work with their pair or small group to investigate the pervious and impervious surfaces.
2. Pass out an Operation Stormwater laminated map **(Supplement C)** to each pair or small group. Point out that the map is gridded, and explain that the group will investigate the surfaces labeled on the map to find out whether they are pervious or impervious. Have students mark the "Surface Type" key boxes—red for impervious, blue for pervious using the wet erase markers. Each group needs one clipboard and map, 1 blue and 1 red wet erase marker, a bucket and a measuring cup.
3. Using the compass rose on the road next to the boat house, help the students orient themselves to the directions on their map.
4. Direct students to test the various surfaces labelled on the map using one of the two variations below:
   Variation A:

- As a whole group, guide the students on a tour around the various test sites.
- At each site, ask the students to make a prediction as to whether the surface is pervious or impervious **(Supplement D)**.
- Let the students know that they are acting as scientists! They should fill the measuring cup halfway and then pour water onto the surfaces to determine if they are pervious or impervious.
- Explain what the site is, what is happening to water as it flows through or over the surface, and how it controls or does not control stormwater flow.
- Remind students to mark the feature on their map as pink for impervious or blue for pervious.

Variation B: **This variation requires students to work independently with their pair or small group to self-navigate and investigate surfaces. If you do not feel confident that the students will succeed without activity leader guidance, do not choose this variation.*

- Briefly walk the students to the various test sites and explain what they are (green roof, rain garden, bio-retention area, etc.) **(Supplement D)**
- In pairs or groups, students will disperse to investigate the surfaces pictured on the map using the blue buckets and measuring cups. Let the students know that they are acting as scientists! They should fill the measuring cup half way and then pour water onto surfaces to see if they are pervious or impervious.
- Remind students to mark their findings on their maps (blue for pervious, pink for impervious).
- Chaperones and the lesson activity leader should walk between groups to help orient students and answer questions as they test different sites, pointing out various infiltration practices.
- Ask students and chaperones to return to the picnic tables by the boat house approximately 10 minutes before the lesson is set to end to allow time for the infiltration measuring and assessment.

Explain:

Bring student together to discuss their findings.

1. Ask students "How could you tell if a surface was impervious or pervious?" *Water will soak into a pervious surface and will pool on top of an impervious surface.*
2. "Did you notice more pervious or impervious surfaces here at Arlington Echo?" "Were pervious surfaces only planted areas?" *Many pervious surface are gardens or planted areas. Some pervious surfaces are made of rocks or concrete that allows water to soak in.*
3. "Do you think that some of these pervious surfaces are better at soaking up water than others?"

Elaborate:

*****For **Variation A** this will take place after the bio-retention area when students pass the can in the field across from the dining hall; for **Variation B** this will take place after small groups or pairs have tested surfaces on their own.

1. Gather the students around the large can in the field by the dining hall.
2. Define Infiltration *(the passing of water into and through the soil).* Invite students to hypothesize the rates of infiltration at the field as compared to the forest.
3. Ask a volunteer to pour 1/2 cup water into the field can and have students count aloud to see how many seconds it takes for the water to completely soak into the ground.

4. After testing the field, lead students to the large can in the forest.
5. Remind students how long it took the water to soak into the field—ask students if it they think water will soak into the forest faster or slower than the field.
6. Ask a different volunteer to pour the same amount of water (1/2 cup) into the forest can and again have students count aloud to see how long it takes for the water to completely soak in.
7. Ask students to compare the infiltration rates and discuss their implications.
    a. *The forest can will drain much faster because the soil is not compacted and the land cover is trees, roots and leaves—this means that a forest is more effective at managing stormwater, especially in a heavy rainfall, even though both surfaces are pervious.*

Evaluate:

1. Have students return to the picnic tables to complete checking off their maps (marking pervious and impervious surfaces) and discuss their findings.
    - Have the students count the blue (pervious) and pink (impervious) boxes on their maps and write the totals. They should write a simple ratio of this number.
2. Use the following questions to assess the students' knowledge and lead the discussion:
    - Which location allowed water to drain quicker, the field or the forest?
    - Why? (What do the infiltration rates indicate?)
    - How many blue blocks did they count? How many blocks were colored pink?
    - How do the blue-colored stormwater controls help to infiltrate water?
    - Which color do we want to see more of, blue or pink?
    - What are some things that we could do as Chesapeake Stewards to have more pervious surfaces, or to help slow down and soak in rain water runoff?
    - Can any rainscaping projects be done to create more pervious surfaces around your school or home?
3. Re-examine the thinking map of pervious/impervious and make changes as needed.

Notes for inclement weather:
Arlington Echo encourages keeping students outdoors whenever possible—even in the rain.
If it is raining or cold the group might meet inside the Boathouse or West Cabin to get some protection from the weather during the pre-assessment and then move outside for the activity. In the case of severe weather, (thunder, extreme cold, etc.), the alternative lesson: Watershed Model, will be taught in the Boathouse or West Cabin unless directed otherwise by the Arlington Echo Staff. The materials and lesson will be provided at that time.

Notes for Clean up
Please organize and return the lesson folder, poster and materials into the Boathouse. Remember to inform the Arlington Echo Staff if you need assistance or if any materials are damaged or missing.

Supplement A

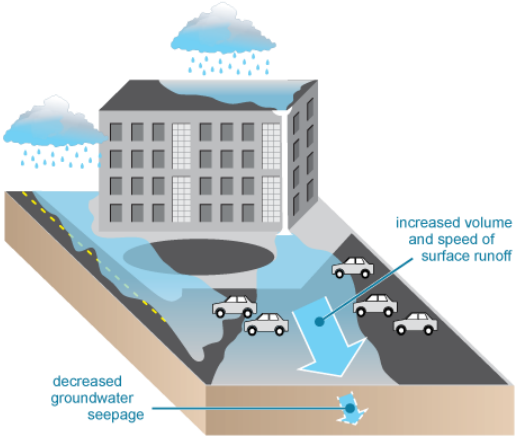
Information on Stormwater

Stormwater is one of the biggest environmental problems in the Chesapeake Bay watershed. Nature provides many systems that control stormwater. These systems include pervious surfaces like forests, meadows, and gardens that allow water to soak into the ground. Wetland areas such as bogs, wet meadows, ponds, and marshes play an exceptionally important role in stormwater control as they retain and infiltrate much more water than dry areas. The most effective approach to controlling stormwater is to catch it and have it soak into the ground as early as possible (*Slow it down, soak it in!)*. It is much easier to control stormwater at the source than it is downstream. Unfortunately, many natural wetlands and other pervious surfaces are filled in and paved over for shopping malls, apartment complexes, and other impervious features that do not control stormwater as effectively.

The more we build on the land, the more impervious surfaces we create. Impervious surfaces do not allow water to infiltrate into the ground or only allow it to infiltrate very slowly. Anything paved or compacted may be considered impervious. Some lawns can even be considered impervious due to tight compaction of the soil and the very short root structure of grass! With more impervious surfaces, less water is able to infiltrate into the ground. This displaced water runs over and erodes the land, carrying pollutants and sediment to the rivers and streams that feed the Bay. Increased stormwater can flood the streams that were once ecologically balanced and place them under tremendous stress. The stressed streams become deep gullies that encourage even more erosion during storm events.

We can mimic natural features to control stormwater in developed urban areas using a landscaping method known as “Rainscaping”. Rainscapes capture and slow stormwater so that it may infiltrate into the ground more effectively. Some examples of rainscapes include: green roofs, rain barrels, swales, pervious pavement, rain gardens, and human-made bogs, ponds, and other bio-retention areas. All of these human-made systems slow stormwater so it can infiltrate into the ground even in high-traffic areas. Schools and residences can have a big impact on the health of our waterways and the Bay by installing rainscapes to trap and manage stormwater on their site.

Impervious surfaces



Impervious ‘hard’ surfaces (roofs, roads, large areas of pavement, and asphalt parking lots) increase the volume and speed of stormwater runoff. This swift surge of water erodes streambeds, reduces groundwater infiltration, and delivers many pollutants and sediment to downstream waters.

Pervious surfaces

Pervious ‘soft’ surfaces (green roofs, rain gardens, grass paver parking lots, and infiltration trenches) decrease volume and speed of stormwater runoff. The slowed water seeps into the ground, recharges the water table, and filters out many pollutants and sediment before they arrive in downstream waters.

Conceptual diagram illustrating impervious and pervious surfaces. Impervious surfaces are hard and increase stormwater runoff, causing pollutant and sediment delivery in downstream waters. Pervious surfaces are soft and decrease stromwater runoff, which filters out pollutants and sediments before they arrive in downstream waters.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Chesapeake and Atlantic Coastal Bays Trust Fund, 2013. Stormwater Management: Reducing Water Quantity and Improving Water Quality. IAN press, newsletter publication.