Soil Soakers

Topic: What is a Watershed?	**Time Frame:** 110 minutes chunked to fit class schedule

Brief Description:
Students test different soil types, moss, and peat wetlands to compare drainage, porosity, and water retention. Students learn that soil porosity and water retention determine water storage capacity of the particular material within the watershed. They summarize their results in a bar graph and rank the "ground" in different types of places in terms of relative capacity to retain and store water. Students also consider what happens when soils become waterlogged and runoff may result in erosion.

Performance Expectations:
Students who demonstrate an understanding can develop a model and use it to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **(5-ESS2-1)**

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models: Develop a model using an example to describe a scientific principle.	**ESS2.A: Earth Materials and Systems** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes.	**Systems and System Models:** A system can be described in terms of its components and their interactions.

Common Core State Standards for ELA:

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

Common Core State Standards for Mathematics:

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Alaska State Science Content Standards:

D1 Concepts of Earth Science
SD2 Students develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth.
[4] SD2.1 observe models of how wind, water, and ice shape and reshape the Earth's surface by eroding rock and soil (L)

Anchorage School District SEL Standards:

1D. Student has a sense of personal responsibility.
2C. Student uses effective decision-making skills.
3B. Student demonstrates consideration for others and a desire to positively contribute to the community.
4A. Student uses positive communication and social skills to interact effectively with others.

Teacher Background Information:
Different types of soils can contain considerable amounts of water and can store or filter this water over a long period of time. Water can infiltrate soils, and will keep doing so until the soil is saturated, which means the rate at which water can be transmitted in and out of all of the pores or spaces between soil

particles has been exceeded. To understand this, think about a dry sponge. Sponges are made of permeable material, which allows them to be used to absorb water. The sponge (like soil) keeps on absorbing water until it reaches its capacity or saturation point, at which time, water will begin to drip out.

Water moves more quickly through soils with relatively large particles and more pore space, such as sand. A good analogy would be to think about filling a jar with marbles and pouring water through the marbles. It would flow through them quickly.

Water moves more slowly through soils with smaller particles and less pore space, like silt and clay. Think about taking a something like play-doh and trying to get water to flow through it. The clay has very little pore space and water just sits on top of it. When there is greater pore space, the soil is very permeable. When there is little pore space, the soil is impermeable.

Peat mosses have a large capability of absorbing water while they are alive and continue to absorb water even after they have died. In contrast to other non-living soil materials that have pore spaces around the particles, peat moss holds water inside the living and dead plant cells. The mosses decay very slowly so may be many feet deep in areas like a bog that retains water, usually because they are underlain by an impermeable soil layer. Bogs, marshes and other types of wetlands are permanent features in Southcentral Alaska because they are all underlain by an impermeable layer, often clay.

In permafrost areas, it's a permanently-frozen soil layer that underlies wet tundra habitats and is impermeable to water flow. Water pools on top during the summer season, or drains a short distance through the area that thaws each year, creating wetlands.

Silica gel is one of the substances that can be used in this activity. This is a processed version of the silica found naturally in soils, which provides an example of a material that has a capacity to retain large amounts of water as result of a very small pore sizes and an affinity for water molecules. This property makes it an excellent desiccant in situations where moisture is undesirable. It can "pull" water out of the atmosphere.

This activity also connects the process of erosion - the movement of soil by water and gravity - to runoff of precipitation that exceeds the limits of the porosity of different soil materials. (A number of variables affect erosion rates, including the angle of slope in downhill movement of water, the amount of vegetation and the volume of water flow.) An extension activity in the 4th grade kit provides a model that demonstrates that a ground cover like grass will slow and filter runoff on steep hillsides and thus reduce the rate of erosion.

Possible Learner Misconceptions and Instructional Clarifications:

Learner Misconception: "Soil" refers to one type of material.
Instructional Clarification: Soil is the several different types of materials or combinations of materials with different properties that affect the rate of water flow through the watershed.

Learner Misconception: Students may not understand that water moves "downstream" in watersheds.
Instructional Clarification: The topography causes water to moves downhill and gravity causes water to move downward into soils where it may be stored before being released into surface waters or retained in wetlands.

Learner Misconception: Students may expect a clear boundary between the hydrosphere and the geosphere.
Instructional Clarification: The hydrosphere can be held between particles in the geosphere or be present in a layer of groundwater above an impermeable soil layer, like clay. During erosion events, particles of the geosphere can end up being carried in the hydrosphere until they are deposited.

Prior Student Knowledge:
In the Water, Water, Everywhere and Water Expedition Learning Experiences, students learn that the geosphere is one of the spheres of the Earth system where groundwater is stored and released to the hydrosphere.

Materials:

Soil Sample grid (See diagram below)
500 mL (≈2 cups) potting soil (one cup will be used to make the permafrost)
250 mL (≈1 cup) gravel (groups rotating through this station can use the same material over and over)
250 mL (≈1 cup) sand (groups rotating through this station can use the same material over and over)
250 mL (≈1 cup) sphagnum moss (several cups are included in the kit so groups can rotate through this station)
250 mL (≈1 cup) peat moss (several cups are included in the kit so groups can rotate through this station)

OPTIONAL:
250 mL (≈1 cup) silica gel (groups rotating through this station can use the same material over and over)
250 mL (≈1 cup) glacial silt/dry clay or local soil (groups rotating through this station can use the same material over and over)
map of impermeable surfaces in local watersheds

For each station:

Bowl
Water collection container
Measuring device (cup or graduated cylinder)
Cheesecloth
Stopwatch
Strainer
Funnel

Teacher Preparation:
1. The day before the class, make permafrost by placing 1 cup (250 mL) of potting soil in a bowl. Add enough water until the soil is wet, but not muddy, and place the bowl in a freezer overnight. Remove the "permafrost" from the bowl shortly before class.
2. Print out a soil sample grid for each table. (ENGAGE)
3. Create and print out a data table (see below) as needed to differentiate instruction for your students. Other students may create their own data table directly in their science notebooks.

Soil Soaker Data Table

Soil Type	Volume of Soil (mL) A	Volume of Water Poured (mL) B	Volume of Water in bowl (mL) C	Volume of Water held by Soil (mL) D = B-C	% Water Held by soil E = D/B x 100
Example: compost	Example: 250 mL	Example: 500 mL	Example: 230 mL	Example: 270 mL	Example: 54%
Gravel					
Sand					
Soil from schoolyard					
Permafrost					
Sphagnum					
Peat moss					

4. Provide a piece of graph paper to each student and have them glue it into their science notebook.
5. Set up six stations around the room. At each station, place:
   - A bowl with 250 mL (≈ 1 cup) of **one** of the following: permafrost, potting soil, gravel, sand, sphagnum moss, peat moss,(**optional**- silica gel).
   - If available, set up an additional station with soil collected from outside the building and/or glacial silt/clay.
   - Strainer
   - cheesecloth (~ 1 square foot, enough to line the strainer)
   - Water collection container
   - timing device-stopwatch
   - Measuring device (cup with mL measurements or 250-mL graduated cylinder)
   - funnel

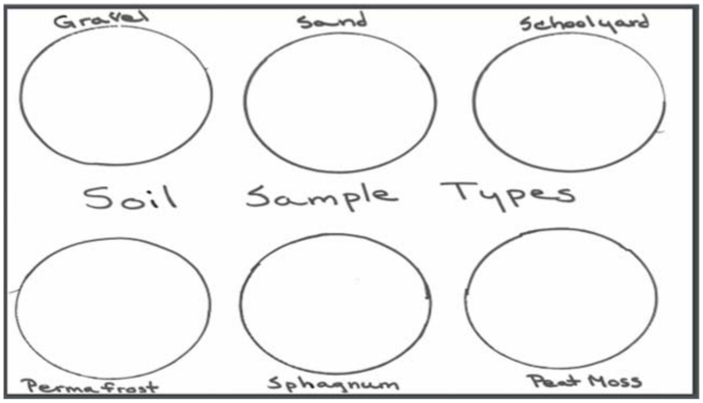
Vocabulary:

slope: ground that has a natural incline [lean; bend]; as the side of a hill
water holding capacity: the amount of soil moisture or water content held in the soil after excess water has drained away
waterlogged: so filled or flooded with water as to be heavy or unmanageable
wetland: a low-lying area of land that is saturated with moisture, especially when regarded as the natural habitat of wildlife; marshes, swamps, and bogs are examples of wetlands
porosity: the condition of being porous [having many pores or other small spaces that can hold a gas or liquid or allow it to pass through]
permeable: capable of being passed through or permeated, especially by liquids or gases
impermeable: relating to a material through which substances, such as liquids or gases, cannot pass

ENGAGE: (20 minutes)

1. **Say:** ***People all over the world dig it dirt, plant crops, move soil for building construction, and make playing fields and roadways, but what really is soil? Turn and discuss with your table group about what you think soil is.***
   a. Teacher circulates among the groups and probes students to
      i. hypothesize if water can go through soil and if so how water moves through soil.
      ii. clarify that "soil" could be composed of different types of materials

2. Once students have a working idea about soil and soil types, show students different types of materials that are all considered soils. Scoop out a small sample of each soil type onto a Soil Sample grid (shown below) on each table. Allow students to examine the soil types. Provide a sheet for each table and have students make a similar graphic in their science notebook to record their predictions.



3. **Ask:** ***Predict what would happen if you were to pour water onto these different soils, what will the water do? Will it stay on top? Seep through? Run through the soil fast/slow?*** Encourage students to justify their reasoning to each other.

4. Students may share ideas with a partner or with table groups. Then everyone should record their predictions in their individual science notebooks.

5. Encourage each table of students to write down at least one question their group has about how water retention in soils might be important in terms of where different habitats are located in the watershed.

EXPLORE: (30 minutes)

1. Model for students: how to build a "soaker tester" by placing cheesecloth inside the strainer that will possibly drain into the bowl.

2. Divide the class into six groups.

3. Before students test each soil type, students compare their predictions about the relative water-holding capacity of each soil they test and explain, discuss, and write down the reasons for their predictions.

4. Each group of students will go to one of the stations and place 250 mL of soil in the soaker tester, slowly pour 250 mL of water through the soil, then wait three minutes. After three minutes, students remove the strainer and measure the amount of water in the bowl using the graduated cylinder and a funnel.

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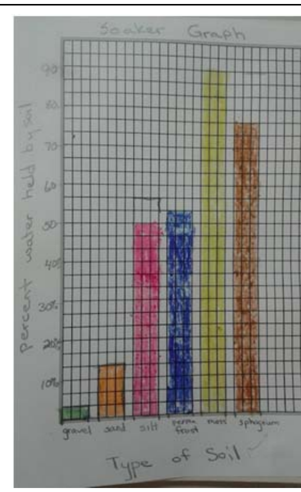
Sand					
Soil from schoolyard					
Permafrost					
Sphagnum					
Peat moss					

5. Students record the volume of water that was in the bowl on the data sheet and subtract that volume from 250 mL to determine the total amount of water that was retained in the soil. Students may then determine the percentage of water the soil type held. The data sheet will guide the students through the process.

6. Students should dispose of the water in the graduated cylinder, rinse and wring out the cheesecloth, and move to another station. Time permitting, each group repeats the experiment for at the six stations.

EXPLAIN: (30 minutes)



1. Students analyze their data and compile the information into a bar graph, in their science notebook, that shows the percentage of water retained in each of the soil types they tested. Note: If groups did not get to all six stations, have students use a large class data table for additional data points.

2. Using the data tables and the graphs, have table groups of students discuss their results and make claims based on evidence about soil porosity vs soil's ability to retain water.
   a. As student tables are critically analyzing their finds, circulate among table groups asking probing questions such as:
      i. Did their results surprise them?
      ii. Compare each group's data. If there are differences, what do they think could account for them? Note: the repetitions will have different quantitative outcomes because some water will be retained every time the experiment is conducted on the same soil, but the pattern should be the same.

ELABORATE: (20 minutes)
Class Discussion:
Pose the question: *Based on their evidence, what types of soils would you expect to find:*

In the wettest parts of a watershed?
On stream bottoms?
In the bottom of ponds or lakes?
In bogs or marshes?
On ridges?
Since the mosses held the most water, how do they function in wet places? (They **absorb** water and temporarily store it.)
How might high water retention in some places in the watershed affect the rate of water flow through the watershed? (It may prevent flooding by releasing water to the surface gradually over time. Some water many trickle through the soil and add to the groundwater supply that can be drawn up in wells.)
What part of these models best represents the geosphere?
What part of these models best represents the hydrosphere?
What part of these models best represents the biosphere?
How are the models similar to the world around us? How are they different? What can we learn from the models?

Pose the questions to small groups as you circulate around the room:

What happens when soil can no longer absorb any more water and it keeps raining?
Which of the different soil types you experimented with would expect might begin to erode and move downhill with the runoff or be washed away in a flood?
What might affect how much erosion happens?
How might this interaction of the geosphere and the hydrosphere eventually affect the biosphere?

Discuss with students why there are laws to protect wetlands from being developed in ways that greatly reduce wetlands storage capacity. If available, use a map showing the impermeable surfaces in local areas as a result of development. Students look at the map and discuss how these impermeable surfaces may change the flow of water in local watersheds.

<u>Cultural and Local Connections</u>
Extension: Design the Perfect Water Container
Ask the students to look at a collection of water containers and/or the photographs of traditional containers in their local Alaska Native culture as a design problem that has been solved in a variety of ways. Have students group the containers in different ways (e.g., size, material, age) and explain the logic of their groupings.

As a class, develop a rubric for evaluating containers. Examples of criteria might be: permeabiity to water, weight, cost, available materials, durability, compactness, strength. Students might decide that some factors are more important than others, and so weight them more. After the rubric has been determined, students can evaluate the various containers and decide on the best.

They can then use the same criteria to work in groups to design the perfect water container and discuss the extent to which each design fits the criteria.

Extension adapted from Immiuġnik: Finding Winter Water unit, North Slope Borough School District

EVALUATE:(30 minutes)
1. Students first describe a way the geosphere, biosphere, and hydrosphere interact.
2. Then they apply what they learned in a different context where they must think about situations where people have needed materials that are not porous and permeable to solve design problems

(e.g., using clay and other substances to make water containers; or sand and gravel mixed with soil to make it drain better.

3. Either working individually or with a partner, students make a poster showing the interactions of two spheres and how the properties of an Earth material provides a good solution to a problem.

Credit: Adapted from “Soil Soakers” in *Alaska’s Ecology Teacher’s Guide*, Alaska Department of Fish and Game by Alaska Sea Grant and the Anchorage School District STEM Department for the Anchorage School District 4th Grade Interdependence STEM Kit.