Frost Depth

Overview:

In this lesson, students explore the active layer above permafrost and begin a long-term investigation of frost depth. (NOTE: This lesson requires a frost tube in your community. If one has not already been installed, a frost tube can be installed at your school by following the steps in the TEACHER INFORMATION SHEET: "Frost Tube Installation," included in this lesson. If possible, the frost tube should be installed in summer or early fall.)

Objectives:

The student will:

- make accurate measurements;
- explore the effects of freezing and thawing on various substances; and
- measure, record, and graph frost depth.

BSSD Standards Addressed:

Science

- SC 02.08 Records and collects data.
- SC 02.09 Accurately reads appropriate scientific instruments.
- SC 02.17.a The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by recognizing that temperature changes cause changes in phase.

GLEs Addressed:

Science

- [3-4] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [3] SA1.2 The student demonstrates an understanding of the processes of science by observing and describing the student's own world to answer simple questions.
- [4] SA1.2 The student demonstrates an understanding of the processes of science by observing, measuring, and collecting data from explorations and using this information to classify, predict, and communicate.
- [3] SB3.1 The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by recognizing that temperature changes cause changes in phases of substances (e.g., ice changing to liquid, water changing to water vapor, and vice versa).
- [4] SB3.1 The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by explaining that temperature changes cause changes in phases of substances (e.g., ice changing to liquid water and liquid water to water vapor).

Whole Picture:

The depth to which soil is frozen into permafrost varies based on local climate, soil and vegetation conditions. Frost tubes are important in the study of permafrost, allowing scientists to measure the extent of frost penetration and the thickness of the active layer, and to determine how the soil responds to seasonal variations in temperature and snowpack.

Frost tubes are a fairly recent development; previously, scientists had to undertake full-scale destructive excavations to study permafrost zones. The design is quite simple: a hollow plastic tube driven into a hole drilled in the soil past the line of permafrost. A thin plastic bag (flexible inner tube) is placed in the hollow outer tube and filled with water, and the line at which the water freezes is the level at which the ground is frozen. A coloring agent is often added to the water to make the freeze line clearly visible.

A frost tube measurement is accurate to within about a half-inch, and while it doesn't provide detailed information on temperature ranges, the tubes can be combined with temperature sensors that provide a temperature timeline for each location. The ease of frost tube fabrication, installation, and maintenance has allowed researchers to expand permafrost measurements across Alaska.

The equipment and materials needed to install a frost tube can easily be transported by snowmachine or light aircraft, giving scientists the ability to acquire new data on permafrost in remote Bush locations.

Materials:

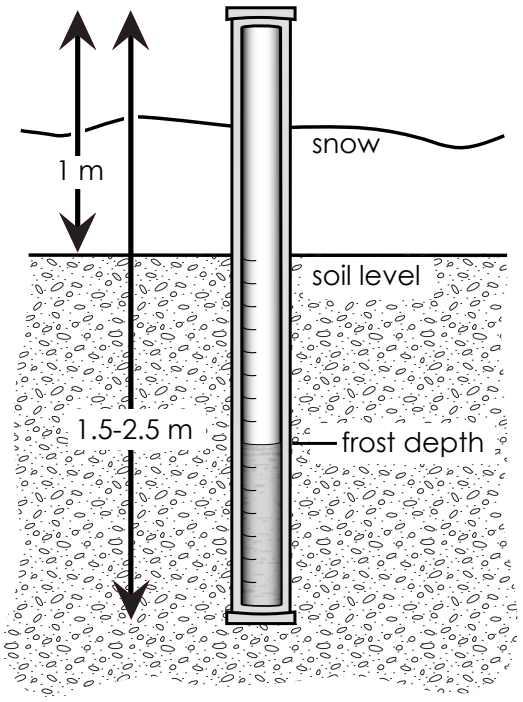
- OVERHEAD: "Permafrost Active Layer"
- TEACHER INFORMATION SHEET: "Frost Tube Installation"
- TEMPLATE: "Frost Tube Data"

Activity Preparation

Copy the TEMPLATE: "Frost Tube Data," so there is one per student. The template should be copied to make one double-sided page.

Activity Procedure:

1. Ask students what causes water to freeze. *(Cooling, low temperature, loss of heat.)*
2. Remind students that permafrost is frozen ground. Ask students if water in the permafrost is frozen. *(Yes.)*
3. Display OVERHEAD: "Permafrost Active Layer." Explain the top layer of ground above permafrost is called the "active layer." The active layer thaws during the summer and freezes during the winter, as opposed to the permafrost, which stays frozen *all* year.
4. Explain scientists put tubes of water in the ground to determine how far down the ground is frozen. Just as water will freeze if it is put in a freezer, water will freeze if it's surrounded by frozen soil.
5. Explain the frost tube is 2 meters or about 6½ feet deep. If the ground is frozen from the surface all the way down to 2 meters, then the water in the frost tube will be completely frozen. If the water in the frost tube is only frozen to 10 centimeters, the ground is only frozen down to 10 centimeters.
6. Take the class outside and demonstrate how to measure the frost depth by recording the depth of frozen water in the frost tube at your local school.



7. Frost depth should be measured on the same day at the same time each week, ideally within one hour of solar noon. To measure, remove the cap on the CPVC pipe and raise the flexible inner tube.
8. Ask for a student volunteer to note the depth where the water is frozen (frozen water in inner tubing is clear; unfrozen water will have the color of whatever food coloring you added in the frost tube), and count the number of centimeters down from the soil surface that freezing extends.
9. Return the inner tube to the outer CPVC pipe and record the measurement. Return to the classroom, and distribute the TEMPLATE: "Frost Tube Data" graphic organizer. Instruct students to fold along the dotted lines so that the graph is on the inside. Assist students in decorating their graphic organizer (drawing the active layer and ground surface, etc.) and graphing their first set of data. Encourage students to define the active layer and permafrost on their graphic organizer.

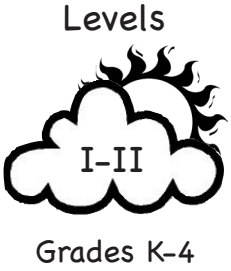
Extension Idea: Snow forms when tiny drops of water freeze in the air. On a cold, dry day, carry a cup of almost boiling hot water outside. With a large motion, throw the water (not the cup) as high in the air as possible. Be sure to aim your throw away from any students. The water will turn into snow and fall to the ground. Repeat this several times for students. ([3-4] SB3.1)

Answers:

There is no worksheet associated with this lesson. Student's graphic organizers should demonstrate an understanding of the active layer, permafrost, and basic graphing skills.

Frost Tube Installation

Teacher Information Sheet



Materials:

- Soil auger or post digger (12 millimeter diameter)
- 12 millimeter CPVC Pipe (up to 4 meters*)
- 10 millimeter O.D. tubing (up to 4 meters*)
- Ground cover, cap, or other material to keep water and cold air out
- Food coloring
- Funnel
- Black waterproof marker
- Meter stick with centimeter markings
- CPVC pipe glue
- Lighter

* See Procedure Step 2.

Procedure:

1. Find a location that is undisturbed and contains loose soil. Check with the appropriate authority to verify it is safe to dig at the selected site. If possible, obtain a GPS reading of the location for future reference.
2. If possible, measure the depth of the active layer by using a steel stick to probe the ground at the end of summer. The length of the outer pipe/tube and flexible inner tubing should be this length with an additional 1 meter (above the surface).
3. Attach the CPVC cap to the bottom end of the CPVC pipe using the CPVC glue.
4. Seal one end of the flexible inner tubing, using a lighter to melt the plastic. Use caution and do this in a well-ventilated area. Do not touch the hot plastic. Allow the melted end to dry fully to form a seal.
5. Using a funnel, fill the flexible tube with water and food coloring until the water is 15 centimeters from the top.
6. Seal the top end of the tube in the same manner as in step 6.
7. Place the tubing into the CPVC tube so that it extends to the bottom.
8. Use a soil auger or post digger to dig the hole into which the frost tube will be placed. Save the removed soil for step 10.
9. Place the frost tube (flexible inner tubing and outside tube) into the hole.
10. Mix the removed soil with a little water and then use this paste to fill in any gap between the frost tube and the surrounding soil. If possible, try to place the different kinds of soil back into the gap in the order in which they were removed. Gently work the soil into the gap with a stick, trying to eliminate any air pockets.
11. Note how far the ground level is from the top of the CPVC outer tube. Raise the flexible inner tube and mark that place with a permanent marker on the outside of the tube. Using the meter stick as a guide, continue to mark each centimeter below that line until you get to the bottom. Indicate every 10 centimeters with consecutive numbers next to each mark. Return the flexible tube to the installed CPVC tube and leave until measurement day.
12. Cover the top of the outside tube with a CPVC cap (Do Not Glue) to minimize the chance of cold air or water getting down into the space between the flexible tube and the CPVC tube.

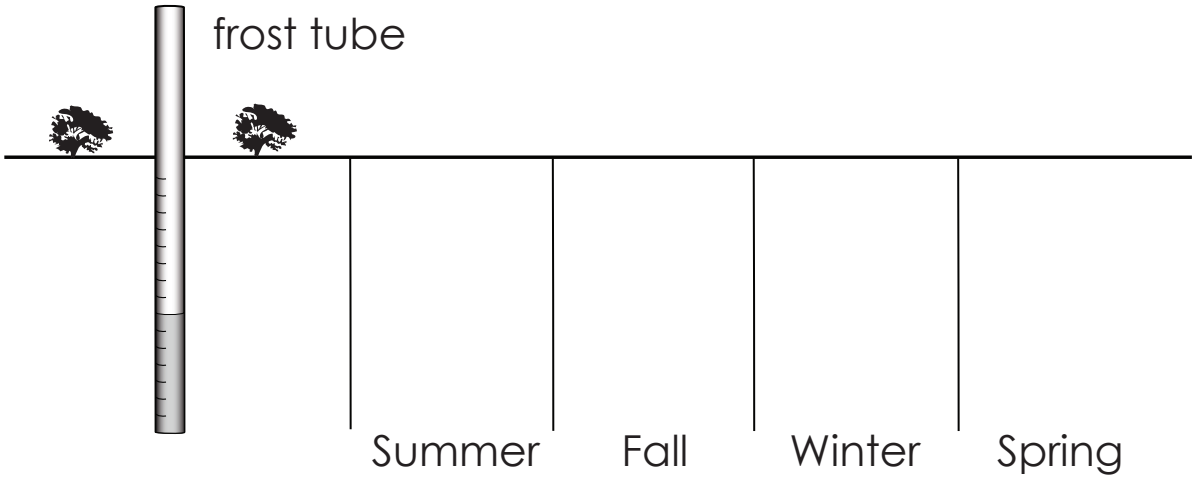
PERMAFROST

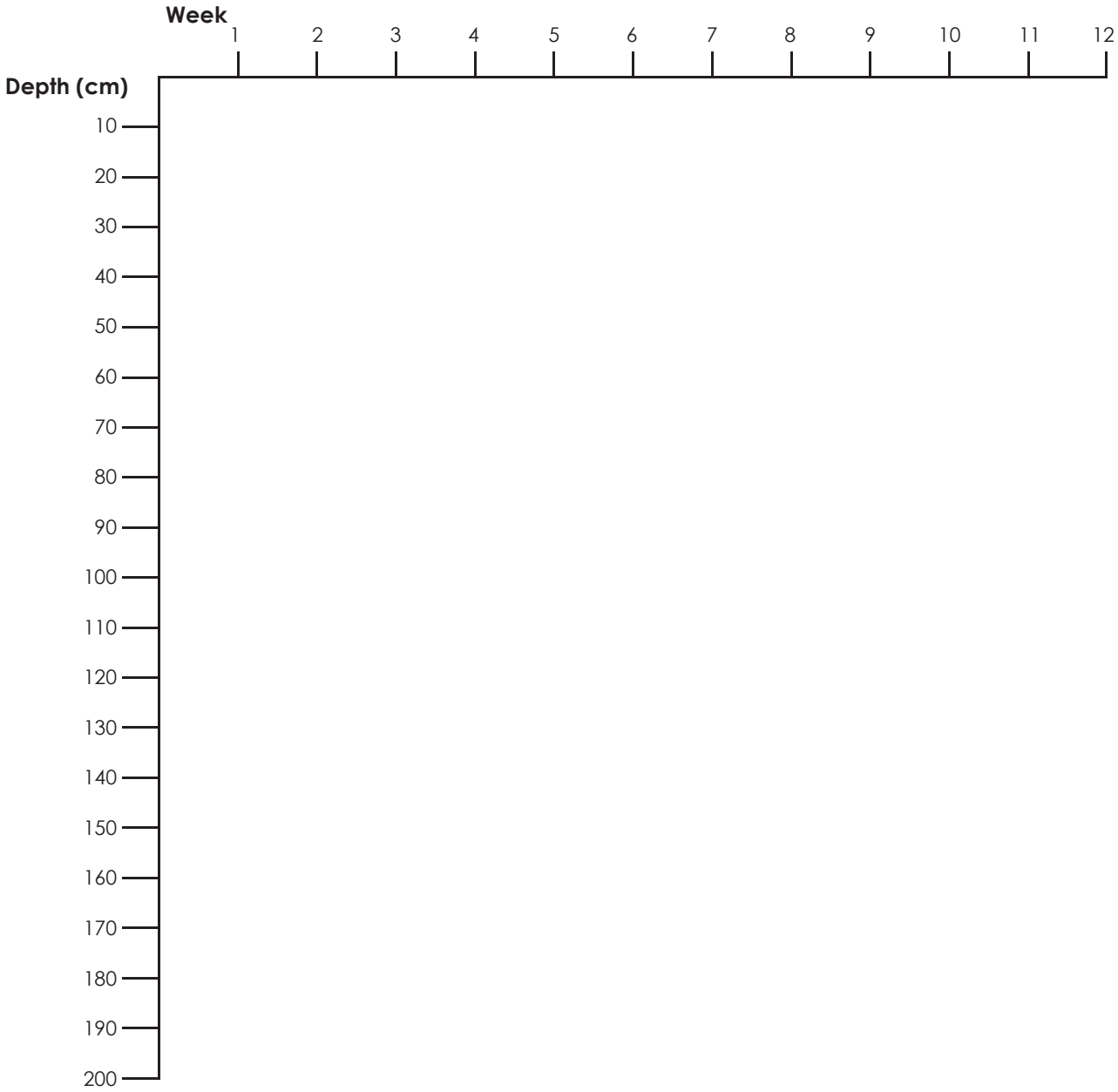
FROST TUBE DATA

Name: ______________________________

School: _____________________________

ACTIVE LAYER


frost tube
Summer
Fall
Winter
Spring


Week
1
2
3
4
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6
7
8
9
10
11
12
Depth (cm)
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30
40
50
60
70
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90
100
110
120
130
140
150
160
170
180
190
200

Permafrost Active Layer
Overhead