NOVA

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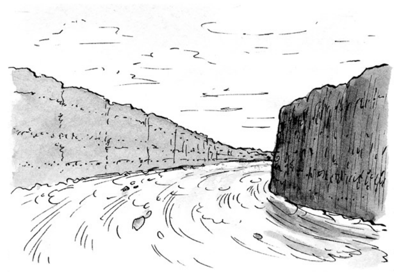
PBS

Mystery of the Megaflood

PROGRAM OVERVIEW



NOVA presents the story of the greatest flood ever found in the geologic record and the geologist who went against prevaiing theories to explain that the flood had occurred.

The program:

- reviews geologist J Harlen Bretz's radical theory—first proposed in 1923—that a massive flood formed some of the Pacific Northwest's unusual geologic features.
- presents the evidence collected by Bretz during his research, including the existence of the Channeled Scabland and the dry waterfalls, potholes, and erratics within the scablands.
- explains that, at the time, most scientists believed the Northwest's geological features were created through gradual erosive processes; the scientists followed the theory of uniformitarianism, which ruled out sudden catastrophic creations of landscapes.
- recounts the difficulty faced by Bretz as he worked to convince the scientific community of his theory.
- reports the key role of Joseph Thomas Pardee, the geologist who found evidence for an enormous body of glacial meltwater that could have provided the flood's source of water.
- describes how Pardee theorized that a lobe of the Cordilleran ice sheet dammed the Clark Fork River, forming an ice barrier that eventually walled off a lake described in size as "an inland sea."
- recreates what might have happened when the lake's water eventually breached the ice dam, allowing Glacial Lake Missoula to flood westward.
- reveals evidence indicating that the flood Bretz theorized may have been only one of many that repeatedly swept through the region.

BEFORE WATCHING

1 Have students locate Washington, Oregon, Idaho, and Montana on a U.S. map that displays landforms. What do they notice about the geological features of the four states? Have students follow the valley systems known as drainages. Do they link together? Do they lead in a particular direction? Then have students locate Missoula and the west flank of the Rocky Mountains and trace the drainages of this area.

2 Glaciers are often referred to as "rivers of ice." Ask students what they know about glaciers. Have students ever seen a glacier? In which regions of the world do students think they would be located? Where in the United States? How are they formed? Define glaciers for students and review some facts about them *(see Background on page 2 for more information)*.

AFTER WATCHING

1 J Harlen Bretz's theories were at first dismissed by his peers. Ask students to cite other scientists whose ideas were initially rejected. What were the obstacles that those scientists faced? How do they compare to the obstacles Bretz faced?

2 To help students understand more about Earth's ice ages, have them create a time line that includes the ice ages that occurred during **1)** the late Proterozoic (between about 800 and 600 million years ago), **2)** the Pennsylvanian and Permian (between about 350 and 250 million years ago), and **3)** the late Tertiary and Quaternary periods of the Cenozoic era (the past 4 million years). To give them additional context, have students include the age of dinosaurs and the ascent of humans on their time lines.

CLASSROOM ACTIVITY

Activity Summary

Students will use everyday items and speeds to describe the dimensions of a massive flood that occurred in the Pacific Northwest near the end of the last ice age.

Materials for Teacher

- meter stick
- yardstick

Materials for Each Team

- copy of the "How Big Is That?" student handout
- copy of "The Spokane Flood" student handout
- copy of the "Comparison Items List" student handout
- calculator
- access to print and Internet resources

Background

A glacier is a large mass of perennial ice that is formed when snowflakes pack down and recrystallize as solid ice. Although ice appears as a hard solid, glaciers flow slowly downslope under their own weight. Like a river, a glacier picks up and carries rock particles of all sizes. As the glacier moves, the particles are deposited and accumulated in mounds called moraines. In addition, glaciers can shrink and grow in response to climate changes. These changes occur over tens, hundreds, and even thousands of years.

Glaciers exist on all seven continents. About 10 percent of the world's land is covered with glaciers, most of which are found near the poles. One type of glacier is found only in polar regions of the world or at high altitudes. Called polar glaciers, these types of glaciers most often create icebergs, which are formed when a piece of glacier breaks off to float in the sea. Most U.S. glaciers are found in Alaska. The Bering Glacier in Alaska qualifies as North America's longest glacier, measuring 204 kilometers long.

LEARNING OBJECTIVES

Students will be able to:

- demonstrate how well-known items can serve as tools for nonstandard measurement.
- calculate length, width, height, and speed of different features related to the Spokane Flood.

STANDARDS CONNECTION

The "How Big Is That?" activity aligns with the following Principles and Standards for School Mathematics (see **standards.nctm.org/document/index.htm**).

GRADES 3–5
Mathematics Standard
Measurement

GRADES 6–8
Mathematics Standard
Measurement

Video is required for this activity.

Classroom Activity Author
Developed by James Sammons and WGBH Educational Outreach staff. Sammons has taught middle and high school science for 30 years. His teaching practices have been recognized by the National Science Teachers Association, the Soil Conservation Service, and the National Association of Geoscience Teachers.

CLASSROOM ACTIVITY (CONT.)

Procedure

Part I

1. Large dimensions can be difficult to grasp. Often large dimensions are more comprehensible when likened to well-known objects. Students in this activity will develop ways to represent the dimensions associated with a massive flood event that took place sometime between 16,000 and 12,000 years ago in what is now Washington State.
2. The measurements in this activity are represented in meters. To help students understand the difference between standard and International System of Units (SI) measurements, hold up the meter stick and yardstick together. How do they differ in length? How many meter sticks would reach the ceiling? How many yardsticks? (Teachers who would like to do the activity in standard units can have students convert the measurements to standard prior to doing the activity.)
3. Next, ask students which distances are easier to imagine:
   - 275 meters or almost three football fields?
   - 4,725 kilometers or the distance between New York and San Francisco?

   Most students would choose the second measurement in both examples because those dimensions are more easily visualized than the large numerical measurement.
4. Organize the class into teams and provide each team with copies of the student handouts. Review with students the activity instructions listed on the "How Big Is That?" handout. Discuss with students why it can be helpful to use nonstandard forms of measurement to describe something. *(It may be easier to communicate the meaning of a standard measurement through comparison with commonly known objects.)* When should nonstandard forms of measurement be used? *(Nonstandard forms of measurement can be useful when communicating large measurements to a non-scientific audience.)* When are nonstandard forms of measurement less useful? *(Nonstandard forms of measurement are generally estimates and do not provide the mathematical accuracy that science often requires.)*
5. First have students categorize the Comparison Items List into the following five categories: length, height/depth, area, volume, and speed. Then have students read "The Spokane Flood" description and highlight each of the measurements within it. Divide up the measurements in the reading among teams *(see Activity Answer on page 5 for a list of measurements that appear in the story).* Make sure that the same set of measurements is assigned to more than one team.

CLASSROOM ACTIVITY (CONT.)

6 Have each team choose items from the Comparison Items List to represent the team's assigned measurements. Have teams perform the calculations necessary to create new representations of the measurement in the reading into items they have chosen from the Comparison Items List.

7 Help students with calculations as necessary. Converting length, height/depth, and speed are simple proportions—so many of these equal so many of those. Students may need assistance converting area and volume, however. For example, although there are 3 feet in a yard, there are 9 cubic feet in a cubic yard (3 feet • 3 feet • 3 feet = 9 feet^3).Students may benefit from a brief refresher about finding area and volume:

$a = l \cdot w$

$v = l \cdot w \cdot h$

8 After each team uses the items from the Comparison Items List to create a new representation of its assigned measurements, have teams that have done the same measurements from the reading pair off to check their results and discuss their choices.

9 Ask all teams to report their equivalent measurements. Discuss and work out any discrepancies in differing results.

Part II

1 Hold a class discussion about other comparison items that might be good to use to bring meaning to the large flood measurements. Record these on the board. Assign teams items from the newly created class comparison items list.

2 Have teams use print and Internet resources to find the measurements for the new comparison items they have been assigned. Then have students convert their original assigned measurements from the reading to the new comparison items they have researched.

3 When all teams have finished, have each team report its representations using the new comparison items list created by the class. Record unusual or controversial representations on the board. Once all teams have reported, have a class discussion about the results. Which ones are most comprehensible? Why? What are some common features of good analogies?

4 As an extension, have students research the measurements of the seven wonders of the ancient world and develop ways to represent them in more comprehensible terms.

ACTIVITY ANSWER

Analogies can be useful to give meaning to large quantities. How Much Is a Million?, by David M. Schwartz, is a children's book that explores this technique. "A billion kids would make a tower that would stand up past the Moon," is one example from the book. Here are how some of the items from the Comparison Items List relate to the dimensions in the flood story.

Flood Dimension	New Representation	Comparison Item
Glacier		
height: 762 m	twice as high as	the Empire State Building (381 m)
Lake Missoula		
depth: 610 m	almost twice as deep as the height of	the Eiffel Tower (321 m)
area: 7,770 sq km	slightly larger than the area of	Delaware (6,447 sq km)
volume: 2,084 cu km	more than four times larger than	Lake Erie (483 cu km)
Flood		
length traveled: 842 km	more than twice the distance from	New York City to Washington D.C. (386 km)
area covered: 41,440 sq km	almost half the area of	Maine (91,700 sq km)
height at tallest: (170 m)	almost one and a half times the height of	the Washington Monument 244 m
maximum flow rate: 40 cu km/hr	more than 350 times the flow rate of	the 1993 Mississippi River flood, peak flow rate (0.11 cu km/hr)
Grand Coulee Canyon		
length: 80 km	almost twice the distance of	a standard marathon race (42.2 km)
width: 10 km	almost four times the length of	San Francisco's Golden Gate Bridge (2.7 km)
height: 274 m	more than one and a half times as high as	the Washington Monument (170 m)
Dry Falls		
height: 107 m	a stack of about 11	two-story houses (each 10 m)
width: 4.8 km	about six times wider than	Niagara Falls (Horseshoe Falls only) (792 m)
Camas Prairie Hills		
height: 11 m	as high as	a common utility pole (11 m)
width between hills: up to 152 m	wider than six lengthwise	tennis courts (23.8 m)
area: 16 sq km	about half the size of	Chicago's O'Hare Airport (28.3 sq km)
flood velocity : through 85 km/hr	almost two and a half times faster than	a world-class sprinter (36.9 km/hr)
Wallula Gap		
daily amount through: 167 cu km	almost 65 times more than the	1993 Mississippi Flood, peak flow rate (0.11 cu km/hr)

LINKS AND BOOKS

Links

NOVA—Mystery of the Megaflood
www.pbs.org/nova/megaflood
Read what one geologist has to say about megafloods, discover what Glacial Lake Missoula was like before it burst, use an interactive map to explore the scablands, and test your hunches about the earthly forces that made eight super structures.

A Brief Introduction to the Ice Age Floods
www.iceagefloodsinstitute.org/floods.html
Provides information on how the Pacific Northwest ice floods occurred and how scientists came to understand what happened, as well as links to additional resources.

Books

The Channeled Scablands of Eastern Washington
by Paul L. Weis and William L. Newman.
Eastern Washington Press, 1989.
Looks at J Harlen Bretz's theory that the scablands were formed by a giant flood, and Bretz's eventual vindication after years of disbelief by fellow geologists.

Glacial Lake Missoula and Its Humongous Floods
by David D. Alt.
Mountain Press, 2001.
Describes Glacial Lake Missoula and traces the periodic floods' routes across northern Idaho, the Columbia Plateau, and down the Columbia River to the Pacific Ocean.

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How Big Is That?

Sometime between 16,000 and 12,000 years ago, a massive flood in the Pacific Northwest carved out major landforms across much of Washington State and part of northern Oregon. The flood covered almost 42,000 square kilometers and at its crest stood 244 meters high. But how far and high is that? In this activity you will look at different ways to understand these measurements.

Procedure

Part I

1 Prepare a five-column table by writing the following measurement categories at the top of each column:
- length (meters/kilometers)
- height/depth (meters/kilometers)
- area (square meters/kilometers)
- volume (cubic meters/kilometers)
- speed (kilometers per hour)

2 Carefully review the items on your “Comparison Items List” handout. Complete the table by writing each item on its own row under the column heading to which it best belongs.

3 Read the description about the Ice Age flood provided on your handout called “The Spokane Flood.” Highlight any dimensions that fit any of the measurement categories listed in your table.

4 After you have highlighted all the dimensions in the reading, your teacher will assign some of these measurements to your team to compare to the size of other items.

5 Convert the measurements assigned to your team so that they are more meaningful. Select an item from the comparison item table you prepared in step 1. Perform the calculations necessary to make your new measurement representative of the measurement in the description about the flood.

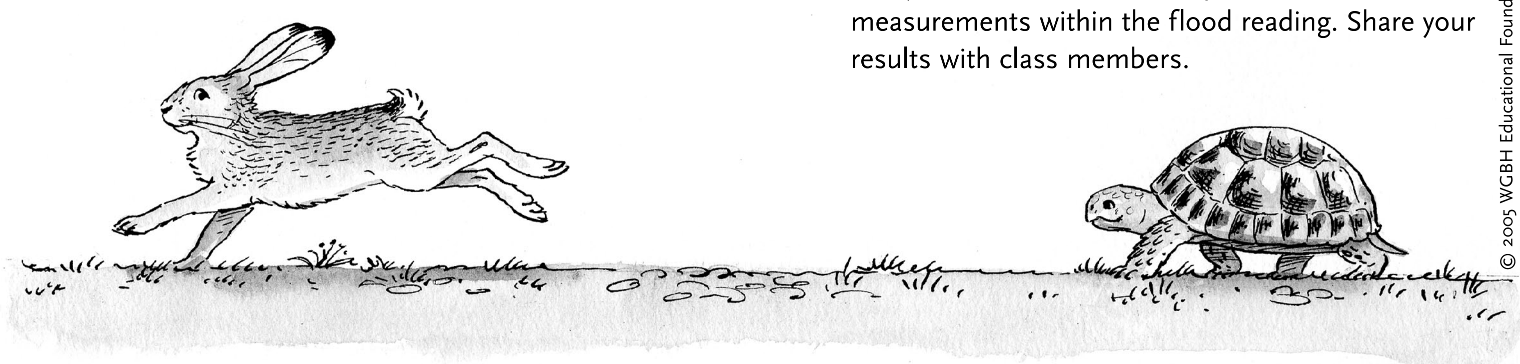
6 For each assigned measurement, record the comparison item you chose and describe why you think the new measurement is more meaningful than the original.

7 When you are done with your calculations, compare your results with another team that was working with the same measurement set as yours. Work with other team members to prepare an explanation of both teams’ thinking about items for which you chose different new measurements. Report your results to the class.

Part II

1 Your teacher will help your class develop a list of new comparison items that you can use to represent the measurements found in the flood description reading.

2 Use print and Internet resources to research the measurements of the class comparison items so that you can calculate new representations of the measurements within the flood reading. Share your results with class members.



The Spokane Flood

During one of the most recent ice ages about 17,000 years ago, ice sheets thousands of feet thick covered what is now southern British Columbia. A lobe from the Cordilleran ice sheet crept into the Idaho panhandle and blocked the Clark Fork River with an ice dam more than 762 meters high. Water melting from the glacier further to the north backed up behind the ice dam, forming Glacial Lake Missoula. At the ice dam, the lake reached a depth of 610 meters and covered nearly 7,770 square kilometers of western Montana. It contained 2,084 cubic kilometers of water.

The climate warmed. The weakening ice dam base reached a point where it could no longer resist the increasing water pressure behind it. Catastrophically, the ice dam ruptured and the greatest flood in recorded geological history began. Water rushed from the ice dam westward at 40 cubic kilometers per hour. Upon reaching a plateau in eastern Washington, the water spread, carving out the Channeled Scabland. One of the features it created there is the present-day Grand Coulee canyon, an 80-kilometer long trench up to 10 kilometers wide with steep walls of basalt up to 274 meters high.

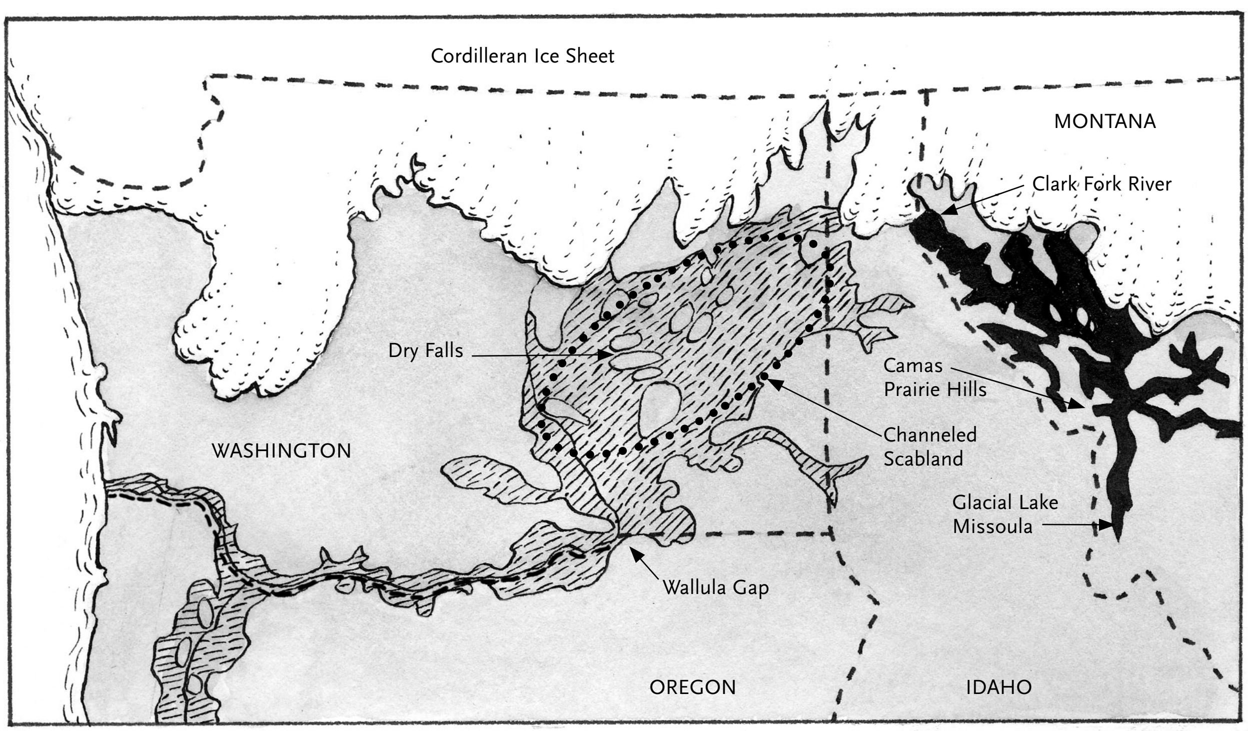
Rushing water also created present-day Dry Falls, 5.6 kilometers wide with a drop of more than 122 meters. At its height, the flood was 244 meters high. It formed the Camas Prairie's rolling hills, each up to 11 meters high and spaced 152 meters apart, covering an area of 16 square kilometers. The water tore across the Camas Prairie at the rate of 85 kilometers per hour.

By the time it traveled through the narrow Wallula Gap, it was flowing at 167 cubic kilometers per day. By the time the torrent reached the Pacific Ocean, it had traveled 966 kilometers and left its mark across 41,440 square kilometers of land. As incredible as this seems, the scientist who first theorized this flood, J Harlen Bretz, believed it occurred many times as the glacier moved down and reformed the ice dam after each breakthrough by lake waters.

Sources

Cataclysms of the Columbia
by John Eliot Allen and Marjorie Burns. Timber Press, 1986.

The Channeled Scablands of Eastern Washington
by Paul L. Weis and William L. Newman. Eastern Washington Press, 1989.



Comparison Items List

1980 Mount St. Helens initial debris surge = 500 kilometers/hour

1993 Mississippi River flood, peak flow rate = .11 cu kilometers/hour

Chicago's O'Hare Airport = 28.3 square kilometers

Delaware = 6,447 square kilometers

Eiffel Tower = 321 meters

Empire State building = 381 meters

Football field (not including end zones) = 4,504 square meters

Goodyear blimp = 5,740 cubic meters

Highest posted Interstate limit (Texas, 2005) = 129 kilometers/hour

HMS *Titanic* = 232,000 cubic meters (tanker equivalent)

Lake Erie = 483 cubic kilometers

Lake Superior = 12,230 cubic kilometers

Maine = 91,700 square kilometers

Marathon race, standard = 42.2 kilometers

Minimum hurricane = 121 kilometers/hour

Mississippi River daily output = 1.4 cubic kilometers

Mississippi River, northern Minnesota to New Orleans = 3,705 kilometers

Mount Everest = 8,850 meters high

New York City to Washington, D.C. = 386 kilometers

Niagara Falls (Horseshoe Falls only) = 792 meters wide

Niagara Falls (Horseshoe Falls only) = 51 meters high

Ohio = 116,500 square kilometers

Peak of a two-story house = 10 meters high

Rhode Island = 2,707 square kilometers

San Francisco's Golden Gate Bridge, shore to shore = 2.7 kilometers

Semi-truck trailer (15 meters) = 102 cubic meters

Space shuttle shortly after entering atmosphere = 28,200 kilometers/hour

Tennis court, between base lines = 23.8 meters

Texas = 713,300 square kilometers

World-class sprinter, hundred meter dash (Asafal Powell, 2005) = 36.9 kilometers/hour

Utility pole, common = 11 meters high

Washington Monument = 170 meters high