NATIONAL GEOGRAPHIC

lesson

Will There Be Enough Fresh Water?

How can we preserve supplies of fresh water for the future?

Content Created by

The Concord Consortium

Activity 1: Availability of Fresh Water | 45 mins

Directions

1. Engage students in thinking about how water is distributed on Earth.

Show the **Earth from Space** photograph. Tell students that most of Earth is covered with water. Show the **Diagram of Water Distribution on Earth**. (In media carousel; click the photograph images. Click the image and carousel down arrows to see the full image.) Ask:

- *How much of the water is available for us to use for things like drinking and crop irrigation—things that require fresh water?* (Less than 3% of the total water on Earth is fresh water.)
- *How does water cycle through Earth's systems?* (Water moves throughout Earth's systems through precipitation, runoff, and evaporation, among other processes.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. We see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to the NOAA National Weather Service. Ask them to input their zip codes into the "Local forecast by "City, St" or ZIP code" box in the top left (under "Home"), hit “Go”, scroll down to the bottom of the page, and click on the “Hourly Weather Graph”. This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dewpoint (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a “%”?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the

same as or lower than the dewpoint.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

Tell students that they will be asked questions about the certainty of their predictions and that they should think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen in Earth's climate system is a complicated process because there are many different interacting parts. Scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.) Ask:
- *What happens to the fox population when they've eaten most of the rabbits?* (The foxes will die of starvation as their food supply decreases.)
- *What happens to the amount of grass when the fox population is high?* (The amount of grass will increase because there are fewer rabbits to eat the grass.)
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they're sharing their food supply, the rabbits will decrease because they've got more predation, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Availability of Fresh Water interactive.

Provide students with the link to the Availability of Fresh Water interactive. Divide students into groups of two or three, with two being the ideal grouping to allow groups to share a computer workstation. Tell students they will be working through a series of pages of models and data with related questions. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 1 of the **Will There Be Enough Fresh Water?** lesson.

6. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on the following questions. Ask:

- *When water falls on the ground, what can happen to it?* (Water that falls on the ground can run off into streams or it can be absorbed into the ground. Students may also say that water can evaporate.)
- *Why is water considered a renewable resource?* (Water is considered a renewable resource because it cycles through the ground and atmosphere.)
- *What are some ways that humans have affected the quantity and quality of water supplies around the world?* (Humans have changed the surface, which has allowed less water to infiltrate the surface. They have pulled water out of very deep aquifers in desert areas. They have inadvertently contaminated some water supplies.)

Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

   - When water falls on the ground, what can happen to it?
   - Why is water considered a renewable resource?

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe the locations of fresh water on Earth
- explain why fresh water is considered a renewable resource
- describe how humans have affected freshwater supplies on Earth

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard G-1:**
Science as a human endeavor
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard F-4:**
Environmental quality
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
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Craft and Structure, RST.11-12.4
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Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1

ISTE Standards for Students (ISTE Standards*S)

• **Standard 3:**
Research and Information Fluency
• **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

• **Crosscutting Concept 1:**
Patterns
• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3:**
Scale, proportion, and quantity
• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 5:**
Using mathematics and computational thinking
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

Background & Vocabulary

Background Information

Water cycles through Earth's systems. It falls on Earth's surface as precipitation. The precipitation can evaporate back into the atmosphere, it can percolate into the ground, or it can run off into surface bodies of water. The composition of the layers of rock and sediment determine whether precipitation can percolate into the groundwater.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
condensation	*noun*	process by which water vapor becomes liquid.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
evaporation	*noun*	process by which liquid water becomes water vapor.
freshwater	*adjective*	having to do with a habitat or ecosystem of a lake, river, or spring.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
transpiration	*noun*	evaporation of water from plants.
water cycle	*noun*	movement of water between atmosphere, land, and ocean.

Partner

Funder

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Activity 2: Using Fresh Water | 45 mins

Directions

1. Engage students in thinking about how fresh water is used.

Tell students in this activity they will be taking a close look at how humans use water—both in direct and indirect ways. They will examine the relationship between freshwater distribution and populations, and they will analyze the costs and benefits of putting dams on rivers and streams. To begin, ask: *How do you use fresh water?* (Student answer will vary, but will include examples like the following: Fresh water is used for drinking, bathing, flushing toilets, and irrigating. Fresh water is also used in electricity production and manufacturing.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to the NOAA National Weather Service. Ask them to input their zip codes, hit “Go”, scroll down to the bottom of the page, and click on the “Hourly Weather Graph”. This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a “%”?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen

rather than perfect predictions.)

**If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.*

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.)
- *What happens to the fox population when they've eaten most of the rabbits? (The foxes will die of starvation as their food supply decreases.)*
- *What happens to the amount of grass when the fox population is high? (The amount of grass will increase because there are fewer rabbits to eat the grass.)*
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Have students launch the Using Fresh Water interactive.

Provide students with the link to the Using Fresh Water interactive. Divide students into groups of two or three, with two being the ideal grouping to allow groups to share a computer work station. Tell students that they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Tell students that this is Activity 2 of the **Will There Be Enough Fresh Water?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *Even if you live in an area where fresh water is plentiful, why do you have to be concerned about the freshwater supply?* (You should still be concerned about the freshwater supply because it can be contaminated by human actions. This would make the fresh water useless even if there was a lot of it.)
- *Are the benefits of dams worth the costs of dams?* (Answers will vary. Some of the benefits of dams are flood control, recreation, and electricity production. Some of the costs of dams are habitat disruption, sediment depletion of river deltas, and loss of surrounding land.)
- *What are some ways that humans have affected the quantity and quality of water supplies around the world?* (Humans have changed the surface, which has allowed less water to infiltrate the surface. They have pulled water out of very deep aquifers in desert areas. They have inadvertently contaminated some water supplies.)

Tip

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Tip

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Modification

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Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How are freshwater resources distributed on Earth?
- What are some direct and indirect uses of water?

2. Use the answer key to check students' answer on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe the relationship between freshwater distribution and populations
- list direct and indirect uses of fresh water
- describe some of the costs and benefits of putting dams on rivers and streams

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
    - Information, Media, and Technology Skills
        - Information, Communications, and Technology Literacy
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        - Critical Thinking and Problem Solving
- Critical Thinking Skills
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• **Science and Engineering Practice 7:**
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• **Science and Engineering Practice 8:**
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Preparation

Background & Vocabulary

Background Information

Freshwater resources are unevenly distributed on Earth's surface. This is due to climatic conditions (precipitation and temperature) and to geological conditions (the ability of water to percolate into the groundwater).

Water is used for many different purposes. Some uses are clear: water for drinking, bathing, and watering plants. Other uses are hidden: industrial processes, electricity production, manufacturing. The obvious uses are called “direct usage”; the hidden uses of water are called “indirect uses”.

As the human population has grown, water use for agricultural, industrial, and municipal uses has increased. Where there is a large amount of water available, there have been relatively few problems. But where water availability is limited, the increased water usage has led some communities to impose bans on unnecessary water use.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water

Vocabulary

Term	Part of Speech	Definition
agriculture	*noun*	the art and science of cultivating the land for growing crops (farming) or raising livestock (ranching).
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
dam	*noun*	structure built across a river or other waterway to control the flow of water.
freshwater	*adjective*	having to do with a habitat or ecosystem of a lake, river, or spring.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
municipal	*adjective*	having to do with local government.
per capita	*adjective*	for each individual.

Term	Part of Speech	Definition
population density	*noun*	the number of people living in a set area, such as a square mile.
reservoir	*noun*	natural or man-made lake.
runoff	*noun*	overflow of fluid from a farm or industrial factory.
systems-understanding	*noun*	process of comprehending and communicating complex, related sets of information and interactions.

Partner

Funder

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Activity 3: Groundwater Movement | 45 mins

Directions

1. Spark student discussion about how water moves.

Show the **Model 2: Sediment Columns.** Run the model, and let students observe how the water molecules move through the different sediments. Ask:

- *Why do you think water pools at the top of the black column while it flows through the pink column?* (Students might respond that the material of the black column has fewer holes through which the water can flow. The material in the pink column might be more loosely packed than the material in the black column. The spaces allow the water to flow down. If there are no spaces, then the water can't flow down as easily (or at all).)
- *What would happen if the water level reached the top of the black basin?* (If the water level reached the top of the black basin, it would spill over into the next column.)

Tell students that they will be investigating the characteristics of different rocks and sediments that let water flow through at different rates.

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to **NOAA National Weather Service**. Ask them to input their zip codes, hit “Go”, scroll down to the bottom of the page, and click on the “Hourly Weather Graph”. This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a “%”?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

  **If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.*

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty about their answer. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits.

Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.)
- *What happens to the fox population when they've eaten most of the rabbits?* (The foxes will die of starvation as their food supply decreases.)
- *What happens to the amount of grass when the fox population is high?* (The amount of grass will increase because there are fewer rabbits to eat the grass.)
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Go to **NOAA Weather Forecast Model**. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Groundwater Movement interactive

Provide students with the link to the Exploring Groundwater Movement interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer work stations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 3 of the **Will There Be Enough Fresh Water? lesson.**

6. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How can water move through rocks that look solid?* (Water moves through very small spaces. The rock can look solid even when it has many tiny spaces through which water can move.)
- *How does the shape and size of pore spaces affect the permeability of different sediments?* (More porous sediments have larger particles with large spaces between them. Sediments with smaller particles are less permeable because the particles pack closer together, leaving less space for water to move through.)
- *If a rock/sediment is porous, does that mean it is also permeable?* (A rock/sediment can be porous without being permeable. If the spaces do not connect to each other, water cannot move through the rock/sediment.)
- *What kind of rocks/sediments make a good aquifer?* (Rocks/Sediments that are very permeable make a good aquifer. This is because they allow quick flow of water, which means that you can get a good flow from the well as well as quick recharge from precipitation, assuming that the aquifer is unconfined.

Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students, or as a whole class activity. If using as a whole class activity, use an LCD projector or interactive whiteboard to project the activity.

Informal Assessment

1. Check students' comprehension by asking the following questions:

- How can water move through rocks that look solid?
- Why does sand have such a high flow rate compared to clay?
- If a rock is porous, does that mean it is also permeable?
- Is it better to use a confined aquifer or an unconfined aquifer for a water supply?

2. Use the answer key to check students' answers on embedded questions.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- explain the difference between porosity and permeability within the context of water movement
- explain how the permeability of a sediment affects water movement
- predict where water will accumulate based on topography and permeability
- predict the location of aquifers based on a given topography
- predict what types of rocks/sediments will form aquifers

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard D-1:**
Structure of the earth system
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-2:**
Structure and properties of matter
• **(9-12) Standard B-6:**
Interactions of energy and matter
• **(9-12) Standard D-1:**
Energy in the earth system
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard G-1:**
Science as a human endeavor
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3

ISTE Standards for Students (ISTE Standards*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 4**:
Systems and system models
• **Crosscutting Concept 5**:
Energy and matter: Flows, cycles, and conservation
• **Crosscutting Concept 6**:
Structure and function
• **Crosscutting Concept 7**:
Stability and change
• **Science and Engineering Practice 1**:
Asking questions and defining problems
• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 3**:
Planning and carrying out investigations
• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

Background & Vocabulary

Background Information

Water moves through Earth's geological layers. Its movement is controlled by the topography and the permeability of the layers. Sediments have different porosities and permeabilities. Porosity is a measure of how much space there is between sediment particles. Permeability is a measure of how connected the holes are. A sediment can be porous without being permeable if the pores do not connect to each other and to the outside.

Aquifers are layers of rock/sediment below Earth's surface that hold groundwater, preventing it from seeping further underground. When humans drill wells into the ground to extract water, they drill into aquifers. The flow of water out of an aquifer is dependent on the permeability of the rocks/sediments around it.

Aquifers come in two varieties: confined and unconfined. Confined aquifers are covered by an impermeable layer, preventing precipitation from refilling the aquifers. Unconfined aquifers are covered by permeable layers, allowing precipitation to refill them.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water
- Using Fresh Water

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
bedrock	*noun*	solid rock beneath the Earth's soil and sand.
clay	*noun*	type of sedimentary rock that is able to be shaped when wet.
confined aquifer	*noun*	layer of water-bearing rock between two layers of less permeable rock.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
freshwater	*noun*	water that is not salty.
gravel	*noun*	small stones or pebbles.
groundwater	*noun*	water found in an aquifer.

Term	Part of Speech	Definition
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
permeable	*adjective*	allowing liquid and gases to pass through.
pore	*noun*	tiny opening.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
porous	*adjective*	full of tiny holes, or able to be permeated by water.
pumice	*noun*	type of igneous rock with many pores.
recharge	*verb*	to renew or restore to a previous condition.
runoff	*noun*	overflow of fluid from a farm or industrial factory.
sand	*noun*	small, loose grains of disintegrated rocks.
silt	*noun*	small sediment particles.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
topography	*noun*	the shape of the surface features of an area.
unconfined aquifer	*noun*	layer of water-bearing rock covered by permeable rock.
water cycle	*noun*	movement of water between atmosphere, land, and ocean.

Partner

Funder

This material is based upon work supported by the National Science Foundation under

Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in

this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Activity 4: Groundwater and Surface Water | 45 mins

Directions

1. Engage students in thinking about how water moves through sediments.

Tell students that much of their water comes from groundwater and that water moves from the ground to the surface. Ask:

- *Why does water move through gravel more quickly than it moves through clay?* (Gravel is more permeable than clay.)
- *Would it be easier to get water out of sand or out of gravel?* (It would be easier to get water out of gravel because the pore spaces are larger. The water will move more quickly through larger pore spaces.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to **NOAA National Weather Service**. Ask them to input their zip codes, hit “Go”, scroll down to the bottom of the page, and click on the “Hourly Weather Graph”. This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a “%”?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

  *If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.)
- *What happens to the fox population when they've eaten most of the rabbits?* (The foxes will die of starvation as their food supply decreases.)
- *What happens to the amount of grass when the fox population is high?* (The amount of grass will increase because there are fewer rabbits to eat the grass.)
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Go to **NOAA Weather Forecast Model**. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Groundwater and Surface Water interactive.

Provide students with the link to the Groundwater and Surface Water interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer workstations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 4 of the **Will There Be Enough Fresh Water?** lesson.

6. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How does the water table affect the relative amount of water in surface bodies and underground?* (When the water table is high, meaning the soil is saturated, water will move [or stay] above ground and surface bodies of water will expand. When the water table is low, water will move from the surface downward toward the ground.)
- *What are the effects on a stream of removing too much water from the ground?* (If too much water is removed from the ground, the stream can dry up. The water table can be lowered below the level of the stream.)
- *How can humans better manage their use of limited water supplies?* (Humans can conserve water. They can use the wastewater to recharge the water supplies.)
- *Are rivers an endless supply of fresh water?* (Rivers are not an endless supply of fresh water. They can be run dry if the water table goes too low. This can happen when people withdraw too much water from the river and/or from the groundwater that supplies the river. Even though the rivers still receive precipitation, they can be depleted if the water table isn't high enough.)

Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students, or as a whole class activity. If using as a whole class activity, use an LCD projector or interactive whiteboard to project the activity.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- How does water move between groundwater and surface water when the water table is high?
- What can humans do to keep water flowing in streams?

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe how water moves between the ground and surface water bodies depending on the level of the water table
- describe the effects on a stream of withdrawing too much water

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
    - Information, Media, and Technology Skills
        - Information, Communications, and Technology Literacy
    - Learning and Innovation Skills
        - Critical Thinking and Problem Solving
- 21st Century Themes
    - Global Awareness
- Critical Thinking Skills
    - Analyzing
    - Evaluating
    - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard D-1:**
Structure of the earth system
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-6:**
Interactions of energy and matter
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1

ISTE Standards for Students (ISTE Standards*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3**:
Scale, proportion, and quantity
• **Crosscutting Concept 4**:
Systems and system models
• **Crosscutting Concept 5**:
Energy and matter: Flows, cycles, and conservation
• **Crosscutting Concept 6**:
Structure and function
• **Crosscutting Concept 7**:
Stability and change
• **Science and Engineering Practice 1**:
Asking questions and defining problems
• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 3**:
Planning and carrying out investigations
• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 5**:
Using mathematics and computational thinking
• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

Background & Vocabulary

Background Information

Water moves between the groundwater and surface bodies of water. Gaining streams gain water from the groundwater. Losing streams lose their water to the groundwater. The level of the water table determines which way water will move between the groundwater and surface. Humans can alter the water table by withdrawing water from the groundwater with wells.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water
- Groundwater Movement
- Using Fresh Water

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
confined aquifer	*noun*	layer of water-bearing rock between two layers of less permeable rock.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
freshwater	*noun*	water that is not salty.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
permeable	*adjective*	allowing liquid and gases to pass through.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
porous	*adjective*	full of tiny holes, or able to be permeated by water.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
recharge	*verb*	to renew or restore to a previous condition.

Term	Part of Speech	Definition
runoff	*noun*	overflow of fluid from a farm or industrial factory.
stream	*noun*	body of flowing water.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
topography	*noun*	the shape of the surface features of an area.
unconfined aquifer	*noun*	layer of water-bearing rock covered by permeable rock.
water cycle	*noun*	movement of water between atmosphere, land, and ocean.
water table	*noun*	underground area where the Earth's surface is saturated with water. Also called water level.

Partner

Funder

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Activity 5: Using Groundwater Wisely | 45 mins

Directions

1. Engage students in thinking about how water cycles through the ground.

Tell students that much of their water comes from groundwater and that water moves from the ground to the surface. Show the **Urban Water Cycle** diagram. Ask:

- *When precipitation falls, how does it move into and through the ground?* (When precipitation falls on the ground, it can run down the surface (runoff) or it can move into the ground. Water moves through the ground because sediments are permeable. If the sediments are very permeable, the water can penetrate deep into the ground, but if they are less permeable, the water will not be able to flow very deep into the ground.)

- *What effects have humans had on the natural movement of water?* (Humans have made a lot of the surface impermeable with buildings and pavement. The water cannot easily enter the ground through paved surfaces because they are impermeable.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to the **NOAA National Weather Service**. Ask them to input their zip codes, hit "Go", scroll down to the bottom of the page, and click on the "Hourly Weather Graph". This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a "%"?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

  **If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.*

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population? (It will increase because there is an ample food supply.)*
- *What happens to the fox population when they've eaten most of the rabbits? (The foxes will die of starvation as their food supply decreases.)*
- *What happens to the amount of grass when the fox population is high? (The amount of grass will increase because there are fewer rabbits to eat the grass.)*
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Go to the **NOAA Weather Forecast Model**. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Using Groundwater Wisely interactive.

Provide students with the link to the Using Groundwater Wisely interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer workstations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 5 of the **Will There Be Enough Fresh Water?** lesson.

6. **Discuss the issues.**

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *What happens to rainwater when it rains in a city?* (The rain runs off impermeable surfaces into basins or rivers.)
- *How does that differ from when it rains in a non-urban area?* (In a non-urban area, the water can penetrate the ground because it is not covered by impermeable surfaces. The water in non-urban areas can recharge aquifers.)
- *How can humans better manage their use of limited water supplies?* (Humans can use water sparingly for necessary purposes. They can use the wastewater to recharge aquifers so that the wells don't run dry.)

Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them to respond to the following question.

- Which area's aquifer is more likely to be recharged by precipitation: an urban area or a rural area? Explain your answer.

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe how human developments have changed the natural water cycle
- describe how wastewater can be used to recharge an aquifer

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-directed learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
    - Information, Media, and Technology Skills
        - Information, Communications, and Technology Literacy
    - Learning and Innovation Skills
        - Critical Thinking and Problem Solving
- Critical Thinking Skills
    - Analyzing
    - Applying
    - Evaluating
    - Understanding

National Standards, Principles, and Practices

National Science Education Standards

- **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
- **(5-8) Standard A-2:**
Understandings about scientific inquiry
- **(5-8) Standard B-1:**
Properties and changes of properties in matter
- **(5-8) Standard G-2:**
Nature of science
- **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
- **(9-12) Standard A-2:**
Understandings about scientific inquiry
- **(9-12) Standard B-6:**
Interactions of energy and matter
- **(9-12) Standard F-6:**
Science and technology in local, national, and global challenges
- **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4

Next Generation Science Standards

- **Science and Engineering Practice 1:**

Asking questions and defining problems
• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 3**:
Planning and carrying out investigations
• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

Background & Vocabulary

Background Information

Human development has affected the natural water cycle in many ways. One way is in the urbanization of the landscape with more impermeable surfaces that do not allow water to infiltrate the groundwater. Another way is in extracting water from aquifers at a rate greater than the natural recharge rate.

Increasingly, water has been transferred from one aquifer to another as water is piped into urban areas from rural areas. This can deplete the aquifers in two regions, as water that falls into the urban area is unable to penetrate the impermeable surfaces.

Septic systems allow for local recharge of the aquifers. Water that is removed from local wells is returned as it leaches out of the septic system's leaching fields. By contrast, urban wastewater treatment plants often dump the treated water into streams, rivers, or the ocean. This water does not recharge the local aquifer or the aquifer from which it came. The wastewater can be discharged into holding pools where it can percolate through the soil and eventually reach a local aquifer.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water
- Groundwater and Surface Water
- Groundwater Movement
- Using Fresh Water

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
confined aquifer	*noun*	layer of water-bearing rock between two layers of less permeable rock.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
freshwater	*noun*	water that is not salty.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
permeable	*adjective*	allowing liquid and gases to pass through.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
porous	*adjective*	full of tiny holes, or able to be permeated by water.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
recharge	*verb*	to renew or restore to a previous condition.
runoff	*noun*	overflow of fluid from a farm or industrial factory.
stream	*noun*	body of flowing water.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
topography	*noun*	the shape of the surface features of an area.
unconfined aquifer	*noun*	layer of water-bearing rock covered by permeable rock.
urbanization	*noun*	process in which there is an increase in the number of people living and working in a city or metropolitan area.
water cycle	*noun*	movement of water between atmosphere, land, and ocean.

Term	Part of Speech	Definition
water infiltration	*noun*	process by which water on the ground surface or atmosphere enters the soil.
water table	*noun*	underground area where the Earth's surface is saturated with water. Also called water level.

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