Water Conservation

Exploring Water Use and How to Conserve It

Description

Students calculate their weekly water use and compare it to the average American. They explore three models of water conservation (land contouring, rooftop rainwater harvesting, and greywater recycling) while collecting quantitative data on the amount of water conserved.

Grade Level

5 – 12

Objectives

Students will:

- Evaluate and understand the application of water conservation methods
- Collect quantitative data on water conserved through models of water conservation techniques
- Understand their weekly water consumption
- Identify ways to reduce water consumption in their lives

Time

1 Hour

Common Core State Standards

English Language Arts Standards >> Speaking & Listening >> Grade 5
CCSS.ELA-LITERACY.SL.5.1.A: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.

English Language Arts Standards >> Science & Technical Subjects >> Grade 6-8
CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

English Language Arts Standards >> Science &Technical Subjects >> Grade 9-10
CCSS.ELA-LITERACY.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

English Language Arts Standards >> Science &Technical Subjects >> Grade 11-12
CCSS.ELA-LITERACY.RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Mathematics Standards >> Statistics & Probability >> Grade 6
CCSS.MATH.CONTENT.6.RP.A.3.C: Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

New Mexico State Science Standards

(Strand – Standard – Benchmark – Performance Standard)
5th Grade
1-1-1-1: Plan and conduct investigations, including formulating testable questions, making systematic observations, developing logical conclusions, and communicating findings.
1-1-1-3: Use graphic representations (e.g., charts, graphs, tables, labeled diagrams) to present data and produce explanations for investigations.
1-1-1-5: Communicate the steps and results of a scientific investigation.
1-1-3-1: Use appropriate units to make precise and varied measurements.
1-1-3-2: Use mathematical skills to analyze data.
2-2-1-4: Describe how human activity impacts the environment.
3-1-1-1: Describe the contributions of science to understanding local or current issues (e.g., watershed and community decisions regarding water use).

6th Grade
1-1-1-2: Examine the reasonableness of data supporting a proposed scientific explanation.
1-1-1-3: Justify predictions and conclusions based on data.

7th Grade
1-1-1-2: Use models to explain the relationships between variables being investigated.
1-1-3-2: Use mathematical expressions to represent data and observations collected in scientific investigations.
1-1-3-3: Select and use an appropriate model to examine a phenomenon.
2-1-2-1: Know how various forms of energy are transformed through organisms and ecosystems, including: effect of mankind's use of energy and other activities on living systems (e.g., global warming, water quality).

8th Grade
1-1-3-1: Use mathematical expressions and techniques to explain data and observations and to communicate findings (e.g., formulas and equations, significant figures, graphing, sampling, estimation, mean).
1-1-3-2: Create models to describe phenomena.

9th – 12th Grade
1-1-1-2: Design and conduct scientific investigations that include: testable hypotheses, controls and variables, methods to collect, analyze, and interpret data, results that address hypotheses being investigated, predictions based on results, re-evaluation of hypotheses and additional experimentation as necessary, error analysis.
1-1-1-4: Convey results of investigations using scientific concepts, methodologies, and expressions, including: scientific language and symbols, diagrams, charts, and other data displays, mathematical expressions and processes (e.g., mean, median, slope, proportionality, clear, logical, and concise communication, reasoned arguments).
2-2-1-4: Critically analyze how humans modify and change ecosystems (e.g., harvesting, pollution, population growth, technology).
2-3-2-12: Explain how the availability of ground water through aquifers can fluctuate based on multiple factors (i.e., rate of use, rate of replenishment, surface changes, and changes in temperature).
3-1-1-9: Describe how scientific knowledge helps decision makers with local, national, and global challenges (e.g., Waste Isolation Pilot Project [WIPP], mining, drought, population growth, alternative energy, climate change).

Next Generation Science Standards

5th Grade
5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Middle School
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

High School
HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Materials

- *Water Conservation* handout [1 per student]
- PowerPoint presentation
- Computer and projector*
- Station task cards [2 per station, 6 total]
- Land contouring station [materials for 2 stations]
    - Small cake pans [2]
    - Kinetic sand [2 – 2 lb. containers]
    - Small vial with 50 blue beads [2]
    - Ruler [2]
    - Cardboard pieces for flattening sand [2]
- Greywater recycling station [materials for 2 stations]
    - Clear marbles [200 total – 100 per station]
    - Square plastic containers for propping up PVC pipe system [16 – 8 per station]
    - PVC pipe system [2]
    - Container with cutout marked "Greywater Cistern" [2]
    - Container marked "Public Water Supply" [2]
- Rooftop Rainwater Harvesting station [materials for 2 stations]
    - Large clear bin [2]
    - Mini-crate [2]
    - Large binder clip [2]
    - Medium binder clip [2]
    - Square shaped Nalgene container (cistern) with cap [2]
    - Roof with attachments [2]
    - Large baking pan with holes punched through [2]

(continued on the next page)

* Not included in kit

Developed by the Asombro Institute for Science Education (www.asombro.org)

Materials (continued from previous page)

- Watering can [2]
- 500 ml beaker [2]
- ½ gallon jug of water, if water is not available in your classroom [2]*
- Bath towels [2]

- Calculators*

* Not included in kit

Background

Climate change, specifically higher average temperatures, is predicted to have multiple effects on New Mexico's water resources. Warmer temperatures result in reduced snowpack; snow will fall for a shorter season, and the snow that does fall will melt earlier in the spring. Warmer temperatures will also increase evaporation during the warmer seasons (spring and summer). This will lead to reduced soil moisture, which impacts plants and animals. Another predicted effect of warmer temperatures is more extreme weather events – both more frequent and intense droughts as well as more frequent floods.

While warmer temperatures are predicted for all parts of New Mexico, predictions about total amounts of precipitation vary for different regions of the state. A USDA compilation of 20 global climate models, comparing historic (1971-2000) to future (2040-2069) scenarios, show that most counties in New Mexico will see only modest changes in annual precipitation, although there will be changes in when the precipitation falls (https://swclimatehub.info/files/ClimateHubs_AnnualPrecipitation.pdf). However, counties in the northeastern corner of the state can expect precipitation decreases of 7 mm to 33 mm per year.

Changes in water resources in New Mexico will have profound impacts on the people and environments of this semi-arid state. For example, many state water decisions are constrained by the Rio Grande Compact, an agreement signed in 1938 by New Mexico, Colorado, and Texas which sets standards for the amount of water that New Mexico must deliver to Texas via the Rio Grande. As increasing temperatures reduce snowpack and alter the timing of streamflow, leading to more frequent and prolonged droughts, New Mexico's ability to honor the Rio Grande Compact while also providing sufficient water resources for New Mexicans will be challenged.

New Mexicans can contribute to preserving our state's precious water resources through both small and large actions. This activity introduces students to three old, but less well-known, water conservation techniques.

Tips for Entire Class Participation

- There are supplies to set up two identical stations for each of the three activities (six stations total). Divide students into six groups when it is time to rotate through the stations.
- When possible, we recommend setting up stations on tables where students can stand all around the set-up, rather than on a table or lab bench against a wall. This allows more students to have a good view and easy access to the station.

Preparation

1. Plan to divide students into six groups for the activity stations.
2. If no sinks are available in the classroom, fill ½ gallon jugs with water for the rooftop rainwater harvesting stations.
3. Set up two land contouring stations:
    a. Set out baking pans and evenly distribute two pounds of kinetic sand into each.

   b. Place one ruler, a jar of 50 beads, and one piece of cardboard near each station.
   c. Set out the station task card.
4. Set up two greywater recycling stations:
   a. Assemble a stack of five square plastic containers and a stack of three square plastic containers. Place both stacks upside down on the table.
   b. Place the PVC pipe system on top of the plastic containers. Adjust the materials so the stack of five plastic containers is under the PVC piece marked "Washing Machine" and the stack of three plastic containers is under the PVC piece marked "Bathroom Sink."
   c. Insert the unmarked end of the PVC pipe into the plastic container marked "Greywater Cistern."
   d. Place approximately 100 marbles in the plastic container marked "Public Water Supply."
   e. Set out the station task card.
5. Set up two rooftop rainwater harvesting stations:
   a. Spread out a towel at each station. Do all of the following on top of the towel.
   b. Empty contents of Water Conservation bins 2 of 3 and 3 of 3.
   c. Detach the lids from each bin.
   d. Place mini-crate with large and medium binder clips attached in the large bin.
   e. Place metal rooftop on top of the mini-crate. The wooden L-shape piece should hook onto the front edge of the crate with the back of the rooftop leaning against the binder clips.
   f. Attach cistern to the Velcro on the corner of the mini-crate. Adjust the front left corner of the rooftop so the opening in the gutters is over the top of the cistern.
   g. The crate, rooftop and cistern should be in place for the students to run their trial.
   h. Place the large baking pan with holes on top of the bin. You may need to compress or expand the pan slightly so that it rests on the edges of the bin.
   i. Place the watering can and 500 ml beaker near the station.
   j. Have ½ gallon jug of water filled and near bin (if no sink is nearby).
   k. Set out the station task card.
6. Prep computer, projector and PowerPoint presentation

Teaching Guide

Introduction: Are You a Water Wizard? (~15 minutes)

1. Use the first three slides in the Powerpoint presentation to guide students through a comparison of their own weekly water use and the weekly water use of an average American.
2. Slide 1: Water Conservation – New Mexico Climate Champions
3. Slide 2: Are you a water wizard? Tell students that they will be calculating the amount of water they use in a week by filling in the Water Use Table on page 1 of the handout.
   a. First, have students estimate the number of times per week that they do each of the activities listed.
   b. Remind students that this is meant to give them a general idea of their water use. If students do not know exact numbers for each week, encourage them to make an estimate.
   c. After students have estimates for the number of times they do each activity, they multiply these numbers by the gallons of water each activity uses. Students will need calculators for this activity.
   d. You can do the first activity (bath) together. For example, if you take an average of two baths per week, you place the number "2" in the "Number of Times Per Week" column. Then, you multiply this by the Water Use (gallons) of 35 gallons per bath to come up with 70 gallons of Total Weekly Use for baths. Enter 70 in the final column of the Water Use Table in the Bath row. If students don't ever take baths, this row would show 0 gallons.
   e. Students then add the total weekly water use for each activity to determine how much water they use in a week.

f. Discuss students' results as a class. Were they surprised by their water use? Which activity used more or less water than expected?

4. Slide 3: The average American uses 700 gallons of water per week. Ask students to share how their water consumption compares to the average American.

Procedures: Activity Stations (~30 minutes)

1. Slide 4: Explain to students that they will explore three different methods of water conservation by moving through three stations: land contouring, rooftop rainwater harvesting, and greywater recycling. Students will have 7 minutes at each station to interact with the model and to complete the section of the handout that corresponds with that station. Help students recognize that many proposed methods of water conservation are not new technologies, but rather a reintroduction of historic principles in water conservation. All of the methods introduced in this activity were practiced before the development of modern irrigation technologies.
2. Slide 5: Land contouring is the creation of basins that collect and absorb runoff from rooftops, sidewalks, and streets. Terraced fields and other land-forming techniques have been used throughout wet and dry areas of Asia, North and South America, Africa and Europe for generations. Perhaps one of the most commonly known methods of land forming is terracing, when sloped land has flat platforms, resembling steps, cut into it. These are used for reducing soil runoff and capturing water and are used widely when planting rice. Other methods of land forming were used in New Mexico before modern irrigation technology was developed. For example, the Zuni created waffle gardens, ground-level beds with berms of earth built around them to capture and hold water. With multiple beds, the land resembles the shape of a waffle.
3. Slide 6: Students will model the collection of rain through land contouring by observing how water gathers in specific places due to intentional shaping of the land. In this model, the kinetic sand represents the land, the beads represent water, and the tilt of the pan represents a hillside that water flows down. Emphasize to students that there is a task card at each station that gives step-by-step instructions for completing each station. Here are the instructions from the task card:

> 1) Turn to page 2 on your handout.
> 2) Flatten kinetic sand. Use cardboard to smooth out surface.
> 3) Place 50 beads representing water on top of the sand, as seen in Image 1. Fifty beads are already counted for you.
> 4) Have one student hold the ruler vertically next to the end of the pan with the beads.
> 5) Slowly lift the end of the baking pan with the beads until the top edge of the pan is 6 inches in the air. Hold for 10 seconds.
> 6) Slowly set pan back on table.
> 7) Count the beads that land at the bottom of the pan and record in the table under question 1.
> 8) Put beads back into jar and place lid on jar.
> 9) Look at images of Berm 'n' Basin (Image 2) and Boomerang Berms (Image 3) and choose one type of land contouring to test. Circle your choice in question 1.
> 10) Form kinetic sand to model your chosen land contour. Use cardboard to smooth out other bumps in surface.
> 11) Repeat steps 3 – 8.
> 12) Put sand back into pile in the center of pan.
> 13) Respond to question 2 on your handout.

4. Slide 7: Rooftop rainwater harvesting is a method of collecting the rainwater that falls on a rooftop by draining it into a barrel or cistern to store for later use. Collecting and storing rainwater goes as far back as the first human settlements in India in the Indus Valley. Evidence of rainwater harvesting systems has been found in writings as well as reservoirs, wells and other small structures to hold water. An impressive example of an underground cistern is in Istanbul,

Turkey. The Basilica Cistern can hold more than 20 million gallons of water. While this cistern was fed from spring water, it is an example of the lengths people went to historically to store water. Rooftop rainwater harvesting is beginning to take hold all over the world in light of climate change. It's even taking place right here in New Mexico. For example, the Asombro Institute for Science Education installed a 500-gallon rainwater harvesting tank at their Chihuahuan Desert Nature Park in Las Cruces. Water that falls on the roof of the storage building drains into a gutter system that directs the water into the storage tank. The water can later be used to water plants, mix concrete, and for other uses.

5. Slide 8: Students explore a model rooftop rainwater harvesting system. In the model, the large bin represents the property, the crate represents the house, the rooftop represents the roof of the house, the baking pan with holes represents the storm cloud, and the water represents precipitation. Here are the instructions from the task card:

> 1) Turn to page 2 on your handout.
> 2) Make a prediction in question 1.
> 3) Measure 500 mL of water and pour into the watering can.
> 4) Slowly pour the contents of the watering can into the pan. Distribute the water evenly. Watch as the water flows off the roof into the cistern.
> 5) Once the rain has stopped, remove the pan, tighten the cap on the cistern and remove the cistern from bin.
> 6) Measure water that was collected in the cistern using the beaker, and record your results in question 2.
> 7) Calculate the percentage of total rainwater harvested in the cistern, and record this value in the table in question 2.
> 8) Empty the contents of the beaker. Place the cistern (cap removed) against crate, place the roof on the crate, and place the pan on top of the bin.
> 9) Respond to questions 3 and 4 on your handout.

6. Slide 9: Greywater is water from bathtubs, showers, bathroom sinks, and washing machines that can be captured and saved for later use. These sources are considered greywater because while they may look "dirty," they are considered safe for irrigation and a few other uses. Greywater is different from wastewater, or blackwater, which comes from toilets and kitchen sources. Greywater is typically reused on site for landscape irrigation. Use of non-toxic, low sodium soap and personal care products is required to protect vegetation when using greywater for irrigation. Other uses for greywater include: agriculture, public parks, golf course irrigation, cooling water for power plants and oil refineries, toilet flushing, dust control, and construction activities. Tuscon, Arizona, is an excellent example of a community working together to meet water needs through greywater recycling. All new single family and duplex residential dwellings must include an outlet pipe on washing machine hookups to allow separate discharge of greywater. All new single family residential dwellings must include drains for showers and bathtubs that are connected to allow for future installation of greywater systems.
7. Slide 10: Students explore a model of a greywater recycling system that could operate in their homes. Each student acts as a family member completing activities that create greywater. As each group member completes greywater activities, they will remove marbles from the public water supply and send them down the chutes to greywater storage. Each marble represents 5 gallons of water. Students will reference the table they complete in question 1 to determine how many marbles to roll down the chutes to the greywater cistern. Here are the instructions from the task card (next page):

1) Turn to page 3 in your handout.
2) Complete table in question 1 to determine how many marbles to roll for each activity.
   - 1 marble = 5 gallons of water
3) Each person in your group chooses one of the activities listed in the table on your handout and rolls the correct number of marbles for that activity.
   - Two people may choose the same activity.
4) Count the number of marbles that ended up in the greywater cistern after each person has rolled, and answer question 2 on your handout.
5) Multiply the total number of marbles by 5 and determine how many gallons of greywater could be recycled. Answer question 3 on your handout.
6) Empty marbles from greywater cistern into the public water supply container.

8. Slide 11: Put up this activity station slide while students are moving through stations.

Results and Conclusions (~5 to 15 minutes)

1. Go through the results of each station with students. The amount of time you spend on this discussion can depend on the amount of time you have left in the class period. Have students report on the results from their group and compare results with other groups.
2. Ask students how each of these water conservation practices we modeled today could help people adapt to the impacts of climate change (increased temperatures and resulting decreases in water availability). Ask students to answer question 1 on the Conclusions section on page 3 of their handout.
3. Discuss challenges that could arise when using each of these water conservation practices.
4. Have students look back at the Water Use Table they completed on page 1 of their handout and think about the three activity stations. Ask students to think of at least two ways they can personally change their own habits to conserve water. Write these ideas on question 2 on the Conclusions section on page 3 of the handout.
5. Slide 12: Go over some of the tips for water conservation on this slide. Compare this list with the ideas students wrote on question 2.

Extension

1. Have students go back to their "Water Conservation: Are You a Water Wizard?" handout. The first five activities on this list (the ones shaded grey) are activities that produce greywater that could be recycled and used again. Have students calculate how much greywater they personally produce. Ask them to think about ways this water could be used around their homes.