Upper Elementary School Unit of Study

Teachers' Guide

WATER EDUCATION FOUNDATION

CAP CENTRAL ARIZONA PROJECT

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The Arizona Water Story:
An Upper Elementary School Unit of Study

Unit Overview

THE ARIZONA WATER STORY: AN UPPER ELEMENTARY SCHOOL UNIT OF STUDY

Teacher Introduction

This study unit is designed for use in grades 4–6. It may be particularly useful as a supplement to the study of Arizona as a state or as a supplement to a physical-science unit about natural resources. Every effort has been made to integrate many subject areas (geography, history, science, math, literacy and art) and to help students develop specific skills (critical thinking, organizing data, predicting, mapping and graphing).

The goals of this unit are to teach students:

- The importance of water as a natural resource
- How water relates to the state's geography
- The nature of the hydrologic water cycle
- The place of water in Arizona's history and its importance in Arizona's economy
- How water is used and transported around the state
- The importance of water conservation
- The importance of how water is managed

Materials Included in This Unit

- Lesson plans with worksheets
- DVD: Arizona Water Story

How to Use This Unit

Prioritizing for Time: These lessons can be taught individually or as a unit. Teachers can choose any part or the entire unit, as their time and interest allow. The entire unit can range from six to 14 days of instruction. Suggested times have been given for each lesson and each activity within the lesson so you can prioritize and plan according to your schedule.

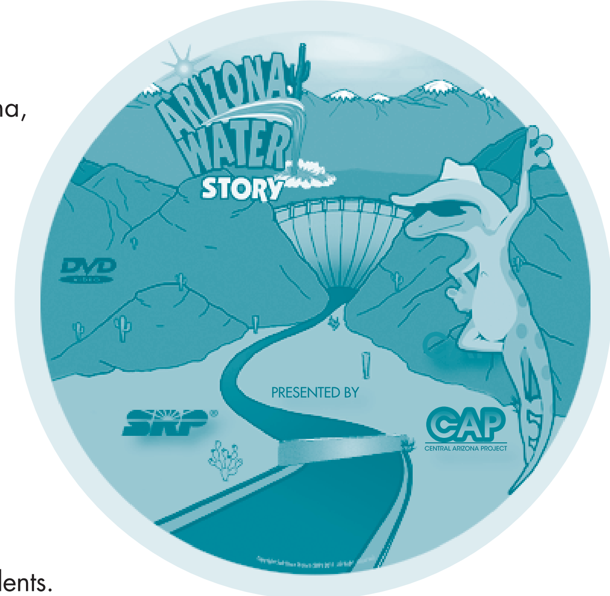
Arizona State Standards Correlation: The lessons and activities included in this guide have been correlated to Arizona state standards for fourth grade* and have also been prioritized for easy reference. "Standards Taught" indicates that the activities included in the lesson are specifically designed to meet the state-required competencies addressed by that particular performance objective. Standards listed as such are also evaluated at the end of the lesson. "Standards Addressed" indicates that those standards have a connection to the lesson and can be addressed if teachers so choose. However, at the end of the lesson, students will not be evaluated based on those performance objectives. *If you are not a fourth-grade teacher and would like a copy of the correlations for your grade level, visit www.srpnet.com/education.

Language and Literacy: Lessons that take a cross-curricular approach work well and engage all students in authentic learning situations. We also know that this is an essential approach for teaching English Language Learners (ELLs), a common reality in Arizona classrooms. Teachers can incorporate many language and literacy experiences into this unit of study. Examples of literacy connections you can make with your students are called out in "Literacy Links" boxes throughout the guide and have language-arts standards associated with them as well. Also, suggested language objectives and a vocabulary list accompany each lesson so teachers can integrate language instruction into the unit. Language objectives are aligned to state standards included in the Discrete Skills Inventory (DSI). There is a full teacher glossary located in the Appendix as well as a blank vocabulary journal page for students to make vocabulary entries throughout the unit if the teacher so desires.

Worksheets and Activities: Lessons are accompanied by graphic organizers and worksheets to enable students to better understand key concepts. All worksheets and maps may be duplicated. Answers to all worksheets can be found in the Appendix of this guide for easy grading.

Text Notations: Key concepts are **bolded** in the "Background Information" sections of each lesson for easy reference. In the "Procedures" sections, teachers' discussion comments are in blue type and possible student responses are (in parentheses).

Before You Begin the Unit: A few suggestions before you begin this unit of study are listed below.



- Set up a thematic bulletin board or word wall in your classroom complete with Arizona maps, pictures of various places in Arizona, and room for student work and vocabulary.

- Gather materials for the lessons and activities you choose to include. There is a supply shopping list for all necessary materials for teaching the unit located in the Appendix for easy reference as you are preparing.

- Learn about water! Attend an **Arizona Water Story** in-service training to learn about water concepts (find dates for in-services at **www.srpnet.com/education**).

  Then take time to read the Background Information of each lesson. The Background Information is designed for *you* as a teacher so that you are prepared to explain concepts to your students.

If you want to learn even more, there is a suggested reading list in the Appendix.

LESSON 1: WHAT WE KNOW ABOUT WATER

Estimated Time for Lesson
1 hour, 45 minutes

State Standards

Standards Taught
- S6C3PO1: Identify the sources of water within an environment (i.e., groundwater, surface water, atmospheric water and glaciers).
- S6C3PO2: Describe the distribution of water on the Earth's surface.

Standards Addressed
- S6C2PO3: Describe the role that water plays in the following processes that alter the Earth's surface: erosion, deposition and weathering.
- S6C2PO1: Identify causes of erosion.
- S1C1PO2: Formulate questions through observations.

Objectives

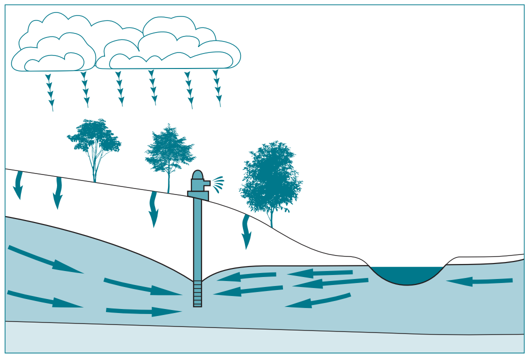
Content Objectives
- Students will be able to list sources of water on Earth and in the environment.
- Students will be able to model and explain the process of the hydrologic cycle.

Language Objective
Students will use new non-count noun vocabulary words (accumulation, evaporation, precipitation, runoff, erosion, surface water, groundwater, etc.) and transition words (next, then, after that, etc.) to explain the process of the water cycle and the sources of water in our environment in a descriptive paragraph (intransitive sentences).

Vocabulary
Accumulation: the buildup of water particles as they travel down a land area
Aquifer: an underground layer of permeable rock, sediment (usually sand or gravel) or soil that yields water
Condensation: the change in state of a gas to a liquid
Desert: a land area that receives less than 10 inches of rain annually
Erosion: the process through which the surface of the Earth is worn away by water, glaciers, wind, waves, etc.
Evaporation: the change in state of a liquid to a gas
Groundwater: water found underground in aquifers
Precipitation: any form of water, such as rain, snow, sleet or hail, that falls to the Earth's surface
Runoff: rainwater or snowmelt that flows over the surface of the ground (instead of infiltrating the soil)
Surface water: water found on the surface of land
Transpiration: the process of water evaporating from a plant (or living thing) into the atmosphere
Water cycle: the continual movement of water throughout our environment (through processes of evaporation, transpiration, precipitation, runoff, infiltration and accumulation)
Water vapor: water in the form of a gas

Background Information

Earth, appropriately nicknamed "The Blue Planet," is largely composed of water. Making up 71% of our Earth's surface, water is our most prevalent and yet most precious resource. We can think of the world's water as existing like a budget. Water is not added or removed from the environment; it simply changes states and locations. This constant movement throughout our environment is called the hydrologic cycle, or **water cycle**. The sources and locations of water on Earth are often referred to as the global water budget. Most of the world's water is stored in the oceans (97.5% in terms of the global water budget). This liquid form of water is constantly **evaporating** due to the heating power of the sun. The **water vapor** then travels upward toward the atmosphere and cools in the process (convection). Water found in the atmosphere accounts for only 0.01% of the total global water budget. As the water vapor cools, it transfers from its gaseous state back to its liquid state in a process called **condensation**. As condensation takes place in clouds and water droplets start to bond together, clouds get heavier, and when the air is cool enough, the water falls back to Earth as **precipitation** either in the form of rain or snow.



As water precipitates back to Earth, there are two main paths it could take to complete the cycle. The first path is to fall onto the earth and soak down into the ground. This "soaking in" process by the land is called infiltration. In essence, water infiltrates down through the soil to become **groundwater**. Groundwater exists in an aquifer, or underground layer of permeable rock, sediment (usually sand or gravel) or soil that yields water. **Aquifers** are like underground reservoirs for water. Groundwater can move slowly through the aquifer and can even discharge onto the surface as a spring. Water is constantly moving between states and locations. Designations like "groundwater" and "surface water" are simply human terms that describe the location of the water. In reality, water moves among the layers of the Earth and environment continuously.

When water precipitates faster than it can infiltrate into the ground, or the water table (top of the aquifer) is so high that the ground is saturated, then the second path is for the water to flow on the surface (called **runoff**). This runoff forms rivers and tributaries, which in turn form lakes, oceans and other sources of **surface water**. Surface water can be captured for a variety of biospheric and human uses. Water that is not captured then completes the cycle as it travels back to the ocean or other large bodies of water. Surface water and groundwater make up 2.4% of the global water budget and are the most common sources of freshwater for human use.

Procedures

Activity 1.1: Building Background for Unit

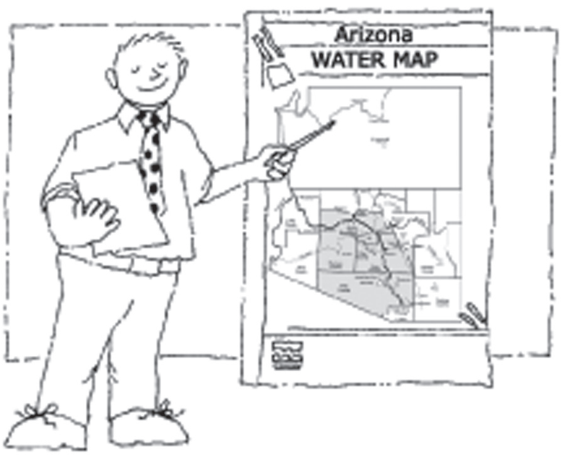
20 minutes

Materials

- Student copies of the water droplet worksheet
- Colored pencils

Teacher draws attention to the interactive bulletin board or word wall in the classroom about water.

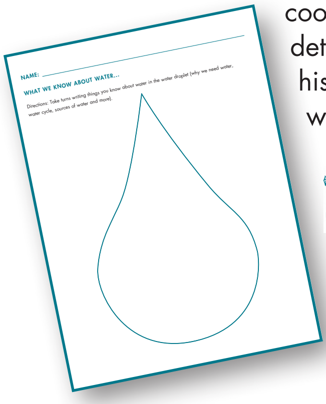
This year we will be learning a lot about Arizona. As we know, most of Arizona is **desert**, which means that a lot of places in Arizona get less than 10 inches of rain each year. But there are places in Arizona that are NOT desert and where it rains quite a bit. So the only way we are able to live here is by carefully using the limited available water. We will be studying water, including learning about the water cycle, our water sources on Earth and in Arizona, and how we can be good stewards of our water here in Arizona.



Teacher introduces the lesson of the day:

Today we will begin by calling to mind anything that we already know about water and listing things we want to learn about water. We will also learn about the water cycle.

Teacher hands out the water droplet worksheets to students (you may do this individually or in cooperative grouping). One suggestion for using



cooperative grouping is to use the Kagan strategy of "Say It, Write It, Pass It," which is detailed below. Each student on a team will need a different pencil color and will sign his/her name on the top of the paper in that color. This will enable the teacher to assess what individual students have written.

Before we learn anything, we will start by listing anything we already think we know about water. (Instruct student teams to perform the activity using the strategy "Say It, Write It, Pass It." Each student takes a turn and says one thing they know about water, then writes it on the paper and passes it to the next person.)

Review and debrief students' ideas as a class. Write key ideas on a poster for everyone to see.

Activity 1.2: Globe Toss – Water Sources on Earth
15 minutes

Materials

- Poster paper/ chart paper
- Inflatable globe

Show students the globe and ask them to identify it. Have students sit in a circle or go outside and stand in a circle for this activity.

Today we are going to play a game that will help us to learn about water. We are going to gently toss this globe around the circle. You should not toss it to someone right next to you, and you should only toss it to someone who hasn't had the globe yet. When it is tossed to you, catch it gently with all 10 fingers. Then, without moving your fingers, count how many fingers you have touching land and how many you have touching water (blue). We are going to record the scores for land and water on this chart.
Make a T-chart on the chart paper with land and water sections. Play the game and record the occurrences of land and water on the chart with tally marks.

Once everyone has had a chance to catch the globe, discuss your findings. If you toss the globe to enough students, the percentage should work out to about 70% water and 30% land (see Background Information for more details about the global water budget).
Lead a discussion with the students about the availability and sources of water on Earth. Some questions to lead their thinking include:

How much of our Earth is water?
(71%)

Can we use all of it?
(Only 1% of the world's water is usable freshwater that is not frozen in polar ice caps.)

Where can we find water on Earth?
(oceans, glaciers, ice caps, lakes, rivers, streams, etc.)

If it is most of our planet, why do we always hear about saving water and not wasting it?

What other questions do you have about the sources of water on Earth?
You may want to record additional questions the students have to return to at a later time.

Activity 1.3: Global Water Budget (Demonstration)
10 minutes

Materials

- Measuring cup or graduated cylinder
- 4 clear containers
- Eyedropper
- Dish
- Lamp

Ask the students:

How much of the water on Earth is available for drinking?

Fill a container with 1,000 ml of water.

97% of the water available on Earth is salt water. Only 3% is freshwater.

Pour 30 ml of water into second container. Label first container "salt water."

Almost 80% of the Earth's freshwater is frozen in the polar ice caps. That means only 20% is not frozen. What is 20% of 30?

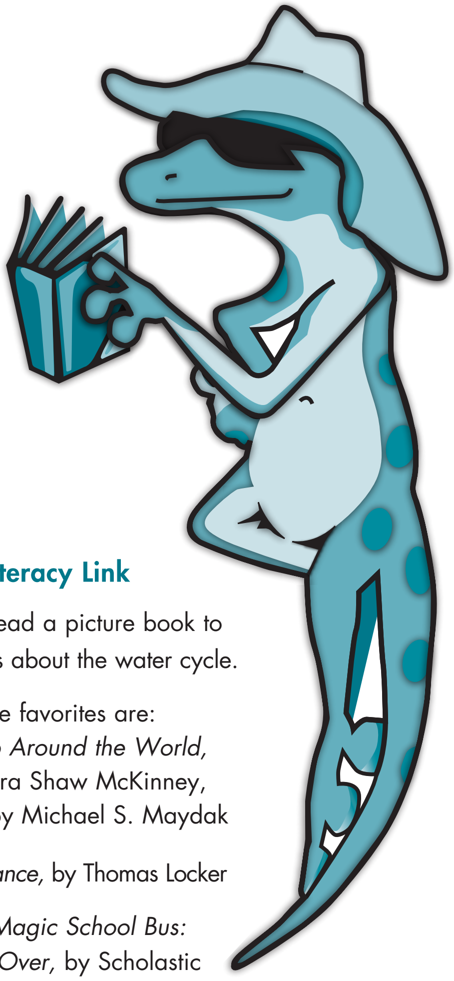
(.20 x 30 = 6) Pour 6 ml of water into third container. Label the 24 ml left in container No. 2 "frozen water in polar ice caps."

Where is the rest of the water found?

(lakes, streams, the atmosphere and underground)

Show the 6 ml remaining. Remove one drop of water using an eyedropper.

This one drop represents all the drinking water that is not in the atmosphere, too deep in underground aquifers or polluted. It is less than 1% of the total volume of water we started with.



Literacy Link

(RS1C6) Read a picture book to your students about the water cycle.

Some favorites are:

- *A Drop Around the World,* by Barbara Shaw McKinney, illustrated by Michael S. Maydak
- *Water Dance,* by Thomas Locker
- *The Magic School Bus: Wet All Over,* by Scholastic

Activity 1.4: The Water Cycle Model (The Hydrologic Cycle)
30–45 minutes

Materials

- Water-cycle vocabulary visuals
- Student copies of the Water Cycle Observation Sheet
- Small- to medium-size clear plastic bins, 1 per student group
- Sand and gravel in buckets (about 1 pound each for each group), each with a small shovel
- Pitchers of water for each team
- ¼ cup of salt for each team
- Large spoon for stirring
- Spray bottle filled with water for each team
- Clear plastic wrap

Engage

We have discussed the abundance of water on the planet but the limited availability of freshwater on Earth. We have even talked a little bit about where we can find water on Earth.

Review the sources they came up with in the previous discussion.

Today we are going to talk about the water cycle. What do you know about the movement of water in our environment?

Take student answers and ask follow-up questions to gauge their level of knowledge about the water cycle.

Today we are going to learn about that constant movement of water on Earth and through our atmosphere.

Exploration and Explanation – Water Cycle Model

Help students set up models of the water cycle in student teams. During each step, explain what that material represents in nature.

Each group receives a clear plastic bin. This bin is going to represent our environment. It's clear so that we can make observations throughout our work today.

Student teams place gravel and sand (sand on top) in half of their clear buckets about ¾ of the way up the side of the bin. There should be a slight slope of the sand and gravel.

What do you think the gravel and sand represent?

Give student teams the pitchers of water. Students add ¼ cup salt to the water and stir. They should pour the water in the other side of the clear bin about halfway up the side of the "mountain."

What does this water represent? Why did we add salt to our water? What questions do you have about the ocean? What do you observe happening as you pour the water in the bin? Where is the water? Is it just in that section?

Have students discuss their observations about the water seeping into the gravel.

The water fills in the gaps in the gravel. Underground, water fills in gaps in between rocks and even inside porous rocks. We call that underground lake an aquifer.

Point to the line where the water comes up to.

That line is called the **water table.** What questions do you have about where water exists in our environment?

Allow students time to observe, record their observations and ask questions. Pass out spray bottles filled with water. Instruct students to spray the mountain and record their observations. Students can even remove the tops and drizzle a little bit of water down the side of the mountain as well.

What do you think this spraying represents? Yes, rain! In the water cycle we call rain and snow **precipitation**. What did you observe as you sprayed the mountain?

Direct students to observe runoff and "streams/rivers" forming. If needed, prompt them to continue to spray the mountain until they see it.

Yes, when the precipitation collects together, this is called **accumulation**, and when it runs down the mountain, it is called **runoff**. What is the runoff doing to the land?

Direct students if needed to notice the erosion that occurs when the water carries the sand particles toward the "ocean."

What you are witnessing is **erosion**, when land particles get swept down with the precipitation runoff.

Pass out rolls of clear plastic wrap. Instruct students to stretch the clear plastic wrap over the top of the clear bins tightly (they may want to secure it with tape).

What do you think this clear wrap represents in our environment? Where can we find water in our atmosphere?

Discuss evaporation with students.

What do we need to make the whole cycle work? Yes, heat! So what should we do to give heat to our models?

Have students brainstorm ways that they could use heat to activate the water cycle in the bin. The easiest way is to simply take the bins outside into the sun.

Students take their models outside and leave them in the sun for at least 10 minutes.

*Optional: Have students place a small cup on top of their land (slightly buried so that it won't tip over). When students cover the model in plastic wrap, have them place a rock over the middle of the cup to slope the plastic wrap and thus collect the condensation into this cup. They will collect precipitation in this cup and can taste it later to show that it is pure (desalinated).

Have students return to their models and observe what is happening.

What do you observe happening in the water cycle? What happened to the water in the bottom of the bin? Do you think any water has left the system? How has the water changed? What questions do you have about the movement of water?

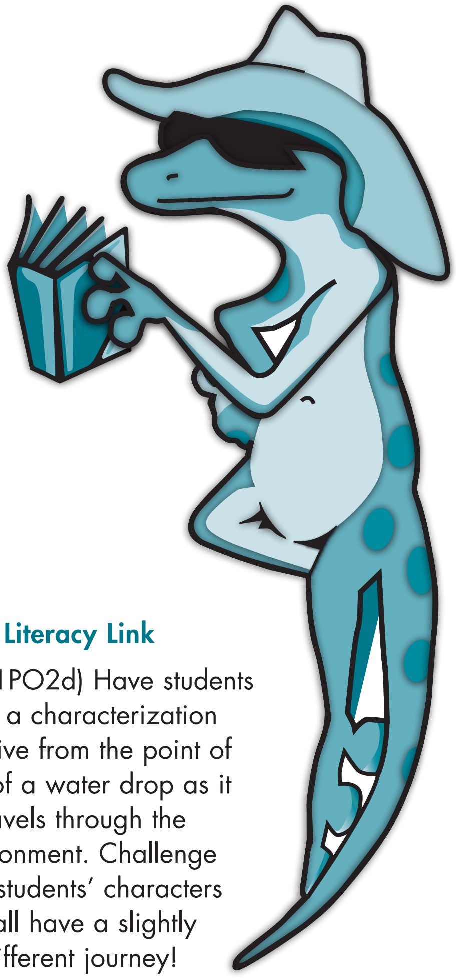
Discuss the global water budget.

There is a fixed amount of water on or in the earth. Water is never added to or removed from the system, but simply transferred from one state to another. For example, the water you drink will eventually be expelled or perspired and will go back into the atmosphere. Water is continually cycling through the system.

Some extension questions for follow-up include:

What do you predict would happen if we put a plant in the bin? Would it be safe to drink this water? How should we make this water safe to drink? What could we do if we lived on this land and we wanted water even when it wasn't raining?

Draw answers and more questions out of the discussion with the students. It may be helpful to have students record further questions they have to explore during the unit.



Literacy Link

(WS3C1PO2d) Have students write a characterization narrative from the point of view of a water drop as it travels through the environment. Challenge your students' characters to all have a slightly different journey!

> **Science Notebooking**
>
> These answers and drawings can also be placed in students' science notebooks for future reference.

Evaluation

15 minutes

S6C3PO1: Identify the sources of water within an environment (i.e., groundwater, surface water, atmospheric water and glaciers).

Assessment

Have students draw a picture of their water cycle models and label it using the vocabulary words. Proficiency is defined as labeling seven out of nine sources of water and stages of the water cycle correctly (groundwater, surface water, evaporation, condensation, precipitation, accumulation, runoff, transpiration, infiltration).

S6C3PO2: Describe the distribution of water on the Earth's surface.

Assessment

Have students write a sentence on their drawings underneath the label "surface water" about the distribution of water on Earth's surface. An example of an acceptable answer is, "Surface water can be in the form of oceans, rivers, lakes, swamps, ice caps and glaciers. Most of Earth's surface water is in the ocean (about 97%). A lot of the remaining water is locked in ice caps and glaciers. Usable freshwater is only about 1% of our Earth's water supply."

Language Objective Evaluation

Have students explain the water cycle process, first orally to a partner, then in writing, using the vocabulary as well as transition words.

Lesson Closure

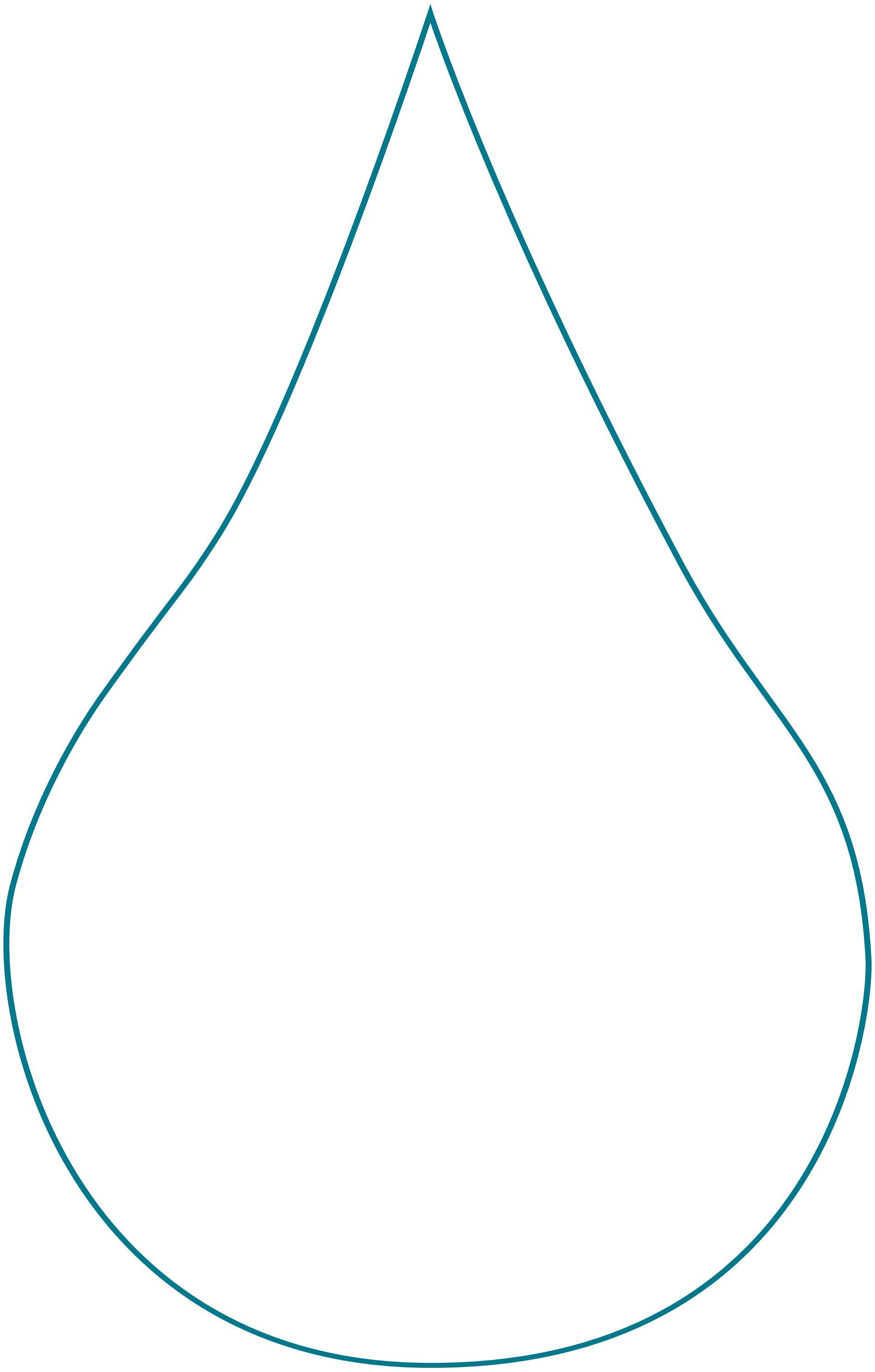
As a conclusion to the lesson, have the students discuss the following in pairs:

- Explain how water is distributed on the Earth's surface.
- Explain where water is located in our environment.
- Explain how water moves throughout the environment using new vocabulary words.

Name: ____________________

WHAT WE KNOW ABOUT WATER ...

Directions: Take turns writing things you know about water in the water droplet (why we need water, water cycle, sources of water and more).



Name: ______________________________

WATER CYCLE OBSERVATION SHEET

Directions: Follow your teacher's directions to create your model of the water cycle.
Record your observations on this sheet. Finally, draw a picture and label your water cycle model.

Step 1: Add gravel, sand and salt water to your bin.
Observe: What did you notice about the water in your model?
Did the water stay in the "ocean"?
Where do you observe water in your model?

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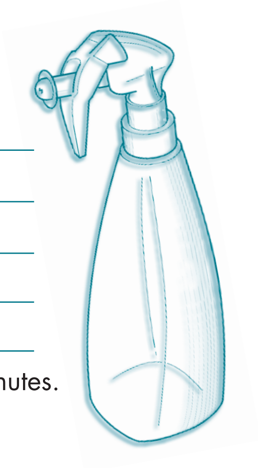

Step 2: Use the spray bottle to spray the sand on the top of the mountain.
Observe: What do you observe happening to the sand as you spray it?
What is happening to the water?

____
____
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____

Step 3: Place the plastic wrap over the top of the model and place in the sunlight for at least 10 minutes.
Observe: What do you see happening in your model?
Where do you observe the water now?

____
____
____
____
____

Draw: On the back of this page, draw a picture of your water cycle model. Label it using the following vocabulary words:

- Accumulation
- Condensation
- Erosion
- Evaporation
- Groundwater
- Precipitation
- Runoff
- Surface water

LESSON 2: ARIZONA'S GEOGRAPHY

Estimated Time for Lesson
2 hours, 30 minutes

State Standards

Standards Taught
- Social Studies – S4C1PO7: Locate physical and human features in Arizona using maps, illustrations or images: physical — Grand Canyon, Mogollon Rim, Colorado River, Gila River and Salt River; human — Phoenix, Yuma, Flagstaff, Tucson, Prescott, Hoover Dam and Roosevelt Dam.
- Social Studies – S4C1PO2: Interpret political and physical maps using the following map elements: title, compass rose, symbols, legend and scale.
- Social Studies – S4C1PO6: Describe characteristics of human and physical features: physical — river, lake, mountain, range, desert, valley, canyon, plateau and mesa; human — city, state and roads.
- Social Studies – S4C2PO3: Locate the landform regions of Arizona (plateau, mountain and desert) on a map.
- Social Studies – S4C2PO5: Describe how regions and places (e.g., Grand Canyon and Colorado River) have distinct characteristics.

Standards Addressed
- Social Studies – S4C1PO1: Use different types of maps to solve problems (e.g., historical maps).
- Science – S6C3PO1: Identify the sources of water within an environment.
- Science – S6C3PO2: Describe the distribution of water on the Earth's surface.
- Social Studies – S4C2PO1: Describe how the Southwest has distinct physical and cultural characteristics.
- Social Studies – S4C2PO4: Compare the landform regions of Arizona according to their physical features, plants and animals.
- Visual Arts – PO 202: Create an artwork that serves a function.

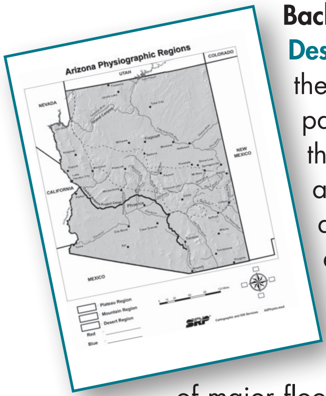
Objectives

Content Objectives
- Students will be able to identify and distinguish physical and human features on an Arizona map.
- Students will be able to identify and label the three regions of Arizona.
- Students will be able to describe the differences among the three regions of Arizona (animals, plants, places, rainfall levels and general characteristics).

Language Objective
Students will use descriptive adjectives, including comparatives and superlatives (dry/drier/driest), to describe the three regions of Arizona.

Vocabulary
Cardinal directions: the four main points of the compass (north, east, south and west)
Compass rose: a symbol on a map indicating direction (e.g., north, southwest)
Desert Region (Basin and Range): southernmost region in Arizona characterized by little rain and numerous mountain ranges separated by lower-elevation basins
Human features: the patterns that people make on the surface of the Earth, such as cities, roads, canals, farms and other ways people change the Earth
Legend: the map key that explains the meaning of map symbols
Mountain Region (Central Highlands): central region in Arizona characterized by mountainous terrain, higher elevation and relatively high levels of precipitation
Physical features: characteristics of a place that are part of the physical environment (e.g., mountains, deserts and bays)
Plateau Region (High Desert): northeastern region in Arizona characterized by relatively flat terrain but high elevation (See Background Information for further description.)
Relief map: a type of map that shows elevation and land features in three dimensions

Background Information



Desert Region: This region is also called the Basin and Range Region. It is located from the southern border of Arizona to the northwestern edge of the state. It encompasses parts of the Sonoran Desert, Mohave Desert and Mexican Highland. This region is where the majority of Arizona's population resides and includes cities such as Phoenix, Tucson and Yuma. The Central Arizona Project is a man-made river that stretches 336 miles across this region. This region is known for its hot, sun-baked, low-elevation basins. Dirt, dust and sand pave the desert floor. Dust storms and monsoons are seasonally common in this region. The climate in this region is very dry and seasonably warm. Due to the soil conditions in the area, when the region receives rain, very little water percolates the dry, cracked and pebble-paved ground at first, often having the effect of major flood events. About a week after a rain event in the spring season, wildflowers carpet the desert floor.

The saguaro cactus is a trademark of the region. You can also find the palo verde tree, mesquite, barrel cactus, prickly pear and agave. Animals in the region include coyotes, antelope jackrabbits, Gila monsters, javelina, mountain lions, black bears, Sonoran Desert toad, Costa's hummingbird, desert tortoise and the California myotis bat.

Mountain Region: The Mountain Region is also called the Central Highlands. This region is the transition zone between the basins and the Colorado Plateau. The Mountain Region consists of a chain of valleys and basins (Chino Valley, Verde Valley, Tonto Valley, San Carlos Basin, Safford Valley and Duncan Basin) formed by colliding tectonic plates. But much of the tall mountains that may have existed long ago have been worn down by weathering and erosion. This region receives more rain than the rest of the state, and during winter is snow-packed. Streams and small man-made lakes abound in the area. There is a rich mining history in the region, including mines in Jerome, Globe, Miami, Clifton, Kearny, Hayden, Morenci and Bisbee. The geologic landforms display a variety of colors, as seen in Sedona. Many of the plants found in the Mountain Region are similar to those found in the Plateau Region of Arizona. There are ponderosa pine forests mixed with oak and numerous areas of natural wildflowers. Elk, black bear, mountain lions and reintroduced Mexican gray wolves are some of the remarkable animals found in this region. You might also see the javelina, antelope and wild turkey.

Plateau Region: This region, also referred to as the Colorado Plateau, consists of a series of flat-topped plateaus 4,000 to 9,000 feet in elevation. The western boundary of the Plateau Region is the Grand Wash Cliffs along the Grand Wash Fault, and the southeastern edge is the Mogollon Rim. The hallmark of this region is the Grand Canyon, which thousands of tourists visit each year. However, the Plateau Region is also popular for lesser-known systems of deep and majestic canyons, weather-worn rock formations, vast untrammeled landscapes and unique life zones. The region is characterized mostly by high deserts, but mountainous areas pop out of the desert shrubbery like a forest island in the middle of a shrub sea. Within the mountainous regions of the plateau, you might see ponderosa pine, blue spruce, alpine fir, elm, cottonwood and aspen. However, the majority of the land in the Plateau Region is high desert containing yucca plants, various cactus plants and numerous shrubs, including high-desert sage. Some of the smaller flowers include Indian paintbrush, lupine and columbine. The Plateau Region of Arizona has a wide variety of animals ranging from the large black bear and great horned owl, two of the predators found in the region, to Arizona's most sought-after mule deer population. Some of the other animals include the ring-tailed cat, coyote, gray fox, badger, prairie dog, horned lizard, garter snake, bald eagle, collared lizard and even Townsend's big-eared bat.

Procedures

Activity 2.1: Geography Scavenger Hunt
45 minutes

Teacher draws attention to the map of Arizona hanging on the focus wall or bulletin board.

Today we are going to learn about the geography of Arizona. We will learn about physical and human features of our state as we play a scavenger-hunt game.

First, students will explore a map of Arizona through a map scavenger hunt. Pass out Arizona Physiographic Regions maps and Activity 2.1 Map Worksheets, "AZ Map Scavenger Hunt." Review the Arizona Physiographic Regions map before you begin. Then let students work in pairs or teams to read and follow the directions on the scavenger-hunt sheet. Facilitate students' questions as they explore the map and discover some of the unique features of Arizona. Monitor students for understanding, difficulties and progress. Ask questions to allow students to explore the map of Arizona. This time is about exploration, so encourage students to record questions they have about Arizona as they do the activity.

As students finish the scavenger hunt, pull the whole group together for a wrap-up. Review the map with the students, allowing students to come up to a class map and label where they found the geographical features.

Allow students time to ask questions about the map.

What questions do you have about Arizona now that you've done this activity? What are you curious about? What do you want to learn more about?

Record students' answers on chart paper or the whiteboard.

Materials

- Any Arizona map, or enlarged and laminated Arizona Physiographic Regions map, placed on focus wall or bulletin board
- Activity 2.1 Map Worksheet (1 per student pair or team)
- Arizona Physiographic Regions maps (1 per student)
- Colored pencils

Science Notebooking

Have students record questions they have about Arizona and about the map in their science notebooks while working. Afterward have students paste their maps into their science notebooks for later review.

Name: ______________________________

Arizona Physiographic Regions

☐ =	Plateau Region
☐ =	Mountain Region
☐ =	Desert Region
Red =	______________
Blue =	______________

SRP® Cartographic and GIS Services AZPhysio.mxd

Materials

- Maps from Activity 2.1
- Additional map copies (1 per student)
- Scissors
- 1 piece heavy cardboard (about 8-by-11 inches) per student (or use large shoebox lids)
- Toothpicks (17 per student)
- File-folder labels (17 per student)
- Colored pencils (red and blue)
- Salt dough in 3 colors (purple, green, yellow) *See salt dough preparation directions below.

Activity 2.2: Regions of Arizona
60–90 minutes

Introduce the activity to students.

We worked with a two-dimensional map in the first activity. Now we are going to work with a different type of map called a relief map. Relief maps show elevation levels or how high areas on a map are. Today we are going to make our own relief maps of Arizona!

We will be making the maps with a special kind of dough. We will also be labeling important and unique places in Arizona, so we will make labels and affix the labels to the map with toothpicks.

Have students get out their maps from Activity 2.1. Give each student their toothpicks and labels. Working with students, guide them to write the following physical features on labels in blue and attach them each to a toothpick: Grand Canyon, Mogollon Rim, Colorado River, Gila River, Salt River, Verde River, Plateau Region, Mountain Region and Desert Region.

Have students write the following human features on labels in red and attach each to a toothpick: Phoenix, Tucson, Prescott, Flagstaff, Yuma, Hoover Dam, Roosevelt Dam and Central Arizona Project.

Salt Dough Preparation
(for 25 students)

- 13 26-ounce packages of salt
- 2 bags all-purpose flour
- 1.25 gallons water
- Food coloring
- Purple = 4 drops blue, 10 drops red
- Green = 4 drops blue, 10 drops yellow
- Yellow = 15 drops yellow
- Gallon-size ziplock bags (at least 3)

Directions
(may want to do in parts)

In a bowl, mix equal parts salt and flour until thoroughly blended.

Add water a little at a time until the mixture reaches the consistency of dough (about half as much water as dry ingredients). Stir thoroughly. Be careful not to add too much water. Students can always add more if it is too thick. Dough that is too wet will not have the desired effect.

Separate the mixture into three parts (use large ziplock bags and mix one part purple, one green and one yellow until each color is well-blended).

Ask students to recall the three regions of Arizona (plateau, mountain and desert) using their maps from Activity 2.1. Have students say the words as they do hand motions for the three regions (plateau = flat hands stretched above head; mountain = fingertips together to form a mountain in front of face; desert = flat hands near waist).

Pass out blank Arizona maps. Have student trace the borders between the three regions of Arizona and label each region. Have students cut out the maps and glue them onto their piece of cardboard or shoebox top. Using shoebox tops is ideal because they provide a border around the map so dough does not run.

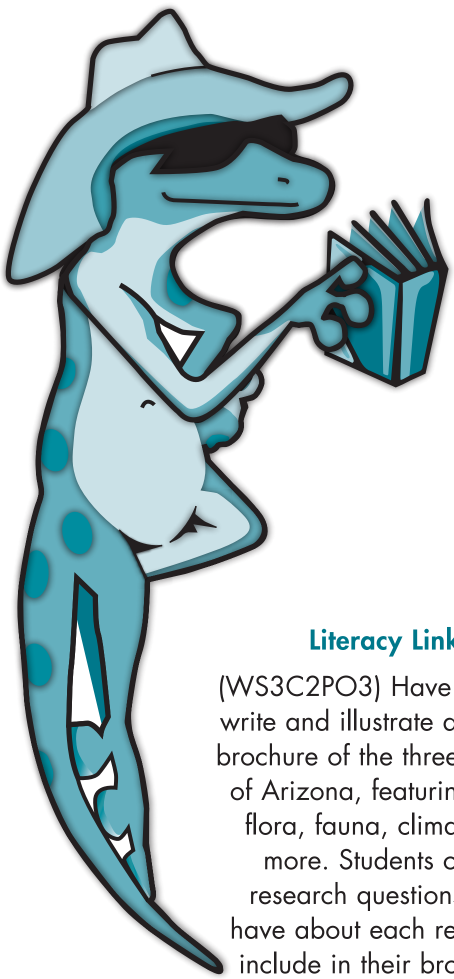
We are now going to make our map with salt dough. Each of the regions will be a different color. We'll make the Plateau Region out of purple dough first.

Give students each a large lump of purple salt dough. Have student make a high plateau in that region with the salt dough. As students are molding the Plateau Region, discuss the ecology and other characteristics of the region with the students. Background information about each region can be found in the Background Information section of this lesson. Record questions they have about the region on chart paper at the front of the room. After the lesson, allow students time to research those questions or discuss them.

After students mold the Plateau Region, have them carve the Colorado River and Grand Canyon in the dough. Have them stick the toothpicks that belong in that region into their topographic maps in the appropriate places. If dough is too runny, toothpicks will fall over. In that case, let maps dry for one day and try again.

Repeat this procedure for the Mountain (with green salt dough) and the Desert (yellow salt dough) regions of Arizona. Again discuss the ecology of the region as well as the physical and human features of each region as students work. It may be nice to show students pictures of animals and plants found in the region while they are shaping each region. Finally, have students place their toothpicks in the salt dough where they belong.

Allow salt dough maps to dry for at least one to two days. The wetter the dough, the longer they will take to dry.



Literacy Link

(WS3C2PO3) Have students write and illustrate a tourism brochure of the three regions of Arizona, featuring cities, flora, fauna, climate and more. Students could research questions they have about each region to include in their brochure.

Materials

- Arizona Physiographics Regions map (enlarged)
- Average precipitation in Arizona data table (on overhead or cut into pieces for groups)
- Blue, green, yellow and red sticky dots or overhead markers
- Graph paper for Math Connection activity

Precipitation amounts

- More than 20 inches = blue
- 12–20 inches = green
- 6–12 inches = yellow
- Less than 6 inches = red

Activity 2.3: Annual Rainfall Patterns and Analysis
30–45 minutes

Optional: You can do the activity in small groups or student pairs by copying the Arizona map and the precipitation data table back-to-back for each student and passing out colored pencils.

Make sure an enlarged map of Arizona is hung. Introduce the activity:

Now we are going to examine precipitation levels in the different regions of Arizona. We will be analyzing some data about the precipitation levels in various cities in Arizona.

Pass out the chart titled "Average Yearly Precipitation in Arizona." The students will use either colored sticky dots or water-soluble pens to mark the amount of rainfall of the listed locations from the chart on the map. Hand out the chart and then write the four color-coded categories on the board.

It is difficult to find patterns in an unorganized data list. If we can group the rainfall into ranges of amounts, we may be able to see a pattern of rainfall in Arizona.

You can assign locations to individuals or have them work in teams. An option is to give the students copies of the map in pairs and students label the cities on the map using the chart and colored pencils.

Have students decide which color dot to use for their city and stick on the class map. Once student teams have finished, review the map as a class and allow students to copy the colors on their own maps for each city. Have students give this map the title "Average Annual Precipitation."

x − + % =

Math Connection

Data Analysis Activity:

Pass out graph paper, and make a chart and graph titled "Amount of Precipitation in Different Arizona Geographic Regions." This can also be drawn on the board.

Desert	Mountain	Plateau

Ask each student or group to record the precipitation for their locations in the proper column on the chart. Have each student copy the figures and total each column. Then help students calculate the average precipitation for each area. Discuss why students need to average the totals. Next have students use different colors to make a bar graph.

Follow-up Discussion: Ask students to look at their maps and discuss their observations with their teams/partners.

What do you notice about this map? Do you observe any patterns in the average precipitation levels? Do you have any questions about precipitation in Arizona?

Tell students to record their observations on the back of their maps. Record all observations and questions as you discuss findings as a class. Encourage other students to answer questions posed by their classmates. The teacher should act as a facilitator in the discussion.

If students are having a hard time getting started, lead students to think about the following questions:

Where are the heaviest areas of precipitation (snow, sleet, hail or rain) in Arizona?
(in the mountains)

Which area has the lowest amount of rainfall?
(the southwestern corner of the state)

Look at your map from Activity 2.1. How does the amount of rainfall relate to the number of rivers in an area?
(The most rain and snow falls in the mountains, so there are more rivers that drain the watersheds in those areas)

Which has more rain and snow, the northeastern corner of Arizona or the central part of the state?
(the central part of the state, in the mountains)

When wind pushes clouds into mountains, they are forced upward where it is colder. Cold air cannot hold as much water as warm air. Soon the air is too cold to hold as much moisture as it had before, and the water condenses on dust particles and becomes rain. So where would you expect there to be more rain?
Point to locations on map.

Casa Grande or Flagstaff?
(Flagstaff)

Sedona or Tucson?
(Sedona)

Alpine or Phoenix?
(Alpine)

Evaluation

Social Studies – S4C1PO7: Locate physical and human features in Arizona using maps, illustrations or images: physical — Grand Canyon, Mogollon Rim, Colorado River, Gila River and Salt River; human — Phoenix, Yuma, Flagstaff, Tucson, Prescott, Hoover Dam and Roosevelt Dam.

Social Studies – S4C1PO2: Interpret political and physical maps using the following map elements: title, compass rose, symbols, legend and scale.

Social Studies – S4C2PO3: Locate the landform regions of Arizona (plateau, mountain, desert) on a map.

Performance Assessment: Collect students' Activity 2.1 maps and use the Activity 2.1 Map Rubric for scoring.

ACTIVITY 2.1 MAP RUBRIC		
☑	Labeled cardinal directions.	1 point
☑	Located the Grand Canyon.	1 point
☑	Located and labeled the Mogollon Rim.	2 points
☑	Located and traced Colorado, Gila, Verde and Salt rivers.	2 points
☑	Located Phoenix, Tucson, Prescott, Flagstaff and Yuma.	3 points
☑	Located and labeled Hoover Dam.	1 point
☑	Located and labeled Roosevelt Dam.	1 point
☑	Located the Central Arizona Project (CAP) Canal.	1 point
☑	Correctly colored and labeled the three regions of Arizona.	3 points
☑	Score:	15 points total

Social Studies – S4C1PO6: Describe characteristics of human and physical features: physical — river, lake, mountain, range, desert, valley, canyon, plateau and mesa; human — city, state and roads.

Social Studies – S4C2PO5: Describe how regions and places (e.g., Grand Canyon, Colorado River) have distinct characteristics.

Ticket Out Assessment

1. Students should correctly identify the definitions for human and physical features, and give three examples of each.

2. Students should write one correct sentence for each region describing the characteristics of that region (animals, cities, elevation, rainfall, plants, etc.).

Language Objective Evaluation

Students are expected to use descriptive adjectives and comparative adjectives (dry, drier, driest) in their descriptions of the three regions of Arizona.

Lesson Closure

As a conclusion to the lesson, have the students discuss their answers to the Ticket Out questionnaire.

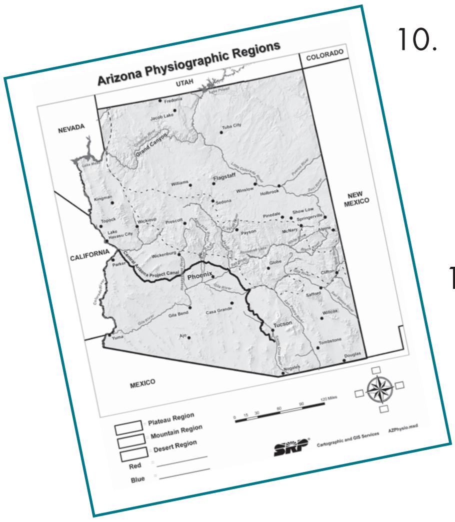
Student Activity 2.1 Map Worksheet

Name: ______________________________

AZ Map Scavenger Hunt

Find the following things on your Arizona Physiographic Regions worksheet:

1. Label all the cardinal directions on the compass rose, with north at the top.
2. With your blue colored pencil, draw this symbol next to the Grand Canyon. (Note: The entire cord of canyons along the Colorado River make up the Grand Canyon.)
3. Put your finger on Sedona. Now slowly move your finger southeast toward Show Low. Stop your finger when you are halfway between Sedona and Show Low. The ridge of mountains you see below your finger is called the Mogollon Rim. With your blue colored pencil, draw this symbol along the edge of mountains you see and label this as the "Mogollon Rim."
4. Trace the Colorado River, Gila River, Verde River and Salt River in blue. These are the major rivers of Arizona. Trace all the tributaries in blue as well.
5. Make a red star on Phoenix.
6. With your red colored pencil, circle the cities of Tucson, Prescott, Flagstaff and Yuma.
7. With your finger, start at the Grand Canyon and trace the Colorado River west to the large lake on the border of Arizona (where it meets Nevada). This is Lake Mead. Hoover Dam is on the southern edge of the lake. Draw this symbol with your red pencil and label it "Hoover Dam."
8. Find Roosevelt Lake along the Salt River. This is a reservoir for water storage held by Roosevelt Dam. Draw this symbol next to the dam with your red pencil and label it "Roosevelt Dam."
9. With your red pencil, color the Central Arizona Project Canal from the Colorado River to south of Tucson.



10. The two dotted lines going through the state show the boundaries of the three regions of Arizona. Lightly color the northeastern region purple and label it "Plateau Region." Lightly color the middle region stretching from the northwestern portion of the state to the southeastern portion green and label it "Mountain Region." Lightly color the southwestern portion of the state yellow and label it "Desert Region." Color the legend accordingly.
11. What do you notice about all of the things you labeled with blue pencil? What about all of the things you labeled with red pencil? What is the pattern? Discuss with your classmates and teacher, and fill in the map legend accordingly.

Activity 2.3 Information Chart

Average Yearly Precipitation in Arizona		
City	Average precipitation (inches)	Elevation (feet)
Ajo	8.40	1,736
Alpine	20.74	8,000
Casa Grande	8.39	1,405
Clifton	3.25	3,465
Douglas	14.20	4,020
Flagstaff	21.35	6,993
Fredonia	9.40	4,675
Gila Bend	6.13	737
Globe	15.90	3,540
Grand Canyon	15.68	6,965
Holbrook	8.45	5,061
Jacob Lake	20.69	7,920
Kingman	10.35	3,345
McNary	26.17	7,320
Nogales	16.57	3,800
Parker	4.79	425
Payson	21.48	4,910
Phoenix	7.95	1,117
Pinedale	18.31	6,500
Prescott	19.04	5,368
Safford	8.91	2,900
Sedona	18.05	4,223
Show Low	17.17	6,400
Springerville	11.94	6,964
Tombstone	13.84	4,610
Topock	4.80	450
Tuba City	6.50	5,936
Tucson	11.15	2,410
Wickenburg	11.23	2,070
Wikieup	9.73	2,125
Willcox	12.19	4,200
Williams	21.58	6,750
Winslow	7.79	4,880
Yuma	3.33	138

Sources: Western Regional Climate Center, http://www.wrcc.dri.edu/summary/climsmaz.html;
Vegetative Map — Agric. Experiment Station, University of Arizona, Tucson 85721; Bulletin A-45 (Map).

Lesson 2 Ticket Out Evaluation

Name: ______________________________

LESSON 2 TICKET OUT

1. Match the words with their definitions.

Human features	a characteristic of a place that comes from the physical environment
Physical features	the pattern that people make on the surface of the Earth

What are three examples of human features? ______________________________

What are three examples of physical features? ______________________________

2. Write a sentence describing the characteristics of each of the three regions in Arizona. Remember to use descriptive words.

Desert Region: ______________________________

____

Mountain Region: ______________________________

____

Plateau Region: ______________________________

____

Name: ______________________________

LESSON 2 TICKET OUT

1. Match the words with their definitions.

Human features	a characteristic of a place that comes from the physical environment
Physical features	the pattern that people make on the surface of the Earth

What are three examples of human features? ______________________________

What are three examples of physical features? ______________________________

2. Write a sentence describing the characteristics of each of the three regions in Arizona. Remember to use descriptive words.

Desert Region: ______________________________

____

Mountain Region: ______________________________

____

Plateau Region: ______________________________

____

LESSON 3: ARIZONA'S WATERSHEDS

Estimated Time for Lesson
1 hour, 30 minutes

State Standards

Standards Taught

- Science – S6C3PO1: Identify the sources of water within an environment.

Standards Addressed

- Social Studies – S4C1PO1: Use different types of maps to solve problems (e.g., historical maps).
- Social Studies – S4C1PO7: Locate physical and human features in Arizona using maps, illustrations or images.
- Social Studies – S4C1PO6: Describe characteristics of human and physical features.
- Social Studies – S4C6PO3: Use geography concepts and skills to find solutions for local, state or national problems.
- Science – S6C2PO3: Describe the role that water plays in the following processes that alter the Earth's surface features: erosion, deposition and weathering.
- Science – S3C1PO1: Describe how natural events and human activities have positive and negative impacts on environments.
- Science – S3C2PO2: Describe benefits and risks related to the use of technology (wells).
- Science – Strand 1: All inquiry process standards.

Objectives

Content Objective

- Students will be able to describe the sources of water within the environment.
- Students will be able to summarize how groundwater and surface water are interrelated.

Language Objective

Students will use key vocabulary (surface water, runoff, watershed/basin, groundwater, aquifer, overdraft, well) and complete sentences to answer questions orally and in writing about surface water and groundwater concepts.

Vocabulary

Aquifer: an underground layer of permeable rock, sediment (usually sand or gravel) or soil that yields water
Basin: synonymous with watershed — land draining into a river or lake
Groundwater: water found underground in aquifers
Overdraft: when more water is withdrawn from a well than is replenished through natural (rain) or unnatural (recharge) cycles
Porosity: the amount of space that exists between gravel, sand or soil particles below ground
Runoff: rainwater or snowmelt that flows over the surface of the ground (instead of infiltrating the soil)
Safe yield: the amount of water withdrawn from an aquifer through well pumping is less than the amount of water being replenished through natural (rain) or unnatural (recharge) causes
Surface water: water found on the surface of land
Watershed: the land area that drains into a particular low point (river, lake, ocean) — synonymous with basin
Well: a hole or shaft that is dug or drilled into the ground in order to obtain water (also can be for brine, petroleum or natural gas)

Background Information
As mentioned when discussing the water cycle, when an area receives precipitation, water that does not immediately evaporate back into the atmosphere travels in one of two ways: along the surface of the land or percolates into the ground. In this lesson, students explore both of those routes.

Surface Water
When it rains or snows on a mountain, runoff can travel down either side of the mountain. Thus rain falling on, say, the eastern side of a mountain will bond with other water droplets traveling in the same direction and all end up in one river. Rain falling on the western side of that same mountain will run off the other direction, bond with other droplets traveling the same way and end up in a different river, possibly hundreds of miles away. Drops of water that started out falling very closely end up very far apart due to gravity and the landscape of the area. The mountains that serve as these borders for water runoff make up the boundaries of each **watershed**. A watershed is defined as "a portion of land that all drains into the same water body (also called a drainage basin)" (Vigil, 2003). Watersheds are made up of all landforms, vegetation, organisms and water in the basin.

Groundwater
The second route for a water droplet to travel is to infiltrate down into the groundwater. Water seeps down into the spaces between rocks, gravel and sand. The **porosity**, or the amount of space that exists between gravel, sand or soil particles below ground, affects the rate at which water can infiltrate the soil and travel down into the aquifer. Water can travel between the spaces within gravel, soil and sand, or through fractured rock. As precipitation infiltrates the ground, gravity acts on the water droplet as it moves down to the lowest point it can reach. Eventually it will hit a layer of impermeable rock, like bedrock, and go no farther. Other water droplets will continue to fill the space between the grains above the bedrock and form an aquifer. Groundwater is constantly in motion (slow motion that is) as it moves through the aquifer under the force of gravity and can sometimes even appear on the surface again through springs.

Human Use of Groundwater
Humans use the water found in underground aquifers by pumping the water up from a well. Wells are constructed for either pumping or scientific-observation purposes. When a well is constructed for pumping purposes, a well casing with slots or perforations is installed in the well bore to screen large rocks, stones and sand. The water in the aquifer flows through the slots to fill the well casing. Water is pumped up using either a mechanical or an electrical pump. If necessary, the water can then be filtered and treated at water treatment sites to ensure its quality for drinking. Arizona has more than 100,000 wells being used to meet human needs. An **overdraft** occurs if the wells in an area withdraw more water than is replenished, either through natural cycles (rain) or artificial recharge (often through pumping water back into the ground). **Safe yield** is the term that indicates that overdraft is not occurring and thus no more water is being withdrawn than is being replenished. Groundwater managers are constantly monitoring these levels to ensure safe yield of aquifers in Arizona. If safe yield is not monitored, aquifers can be depleted over time.

Materials

- Any Arizona map, or enlarged and laminated Arizona Physiographic Regions map, placed on focus wall or bulletin board
- Heavy-grade white paper sheets
- Aluminum pie plates or other containers
- Water-soluble blue paint
- Measuring cups and water

Procedures
Activity 3.1: Watersheds and Runoff
30 minutes

Students should have their salt dough relief maps, annual precipitation maps from Lesson 2 and/or charts showing ranges of precipitation amounts with them for this discussion. Optional, but helpful, would be a United States Geological Survey (USGS) map or any other topographic or relief map that shows elevations (www.usgs.gov).

Lead a discussion with students to review the previous lesson:

Where in Arizona was the heaviest precipitation (rain and snowfall)?
(in the mountainous areas)

What happens to the rain or snow that falls in the mountains?
(It runs down into valleys and collects in low places.)

The drainage pattern of water running downhill out of mountains and into lower places is called a watershed. We are going to make a model of a watershed in the White Mountains.

Explore

Give each student a piece of white paper — the heavier the grade of paper, the better. Direct students to place their index finger in the middle of the paper and crumple the rest of the sheet around their finger and hand. This forms a rough model of a mountain, with the creases representing valleys on the sides of the mountain. Have the students place their mountain models in an aluminum pie plate and then place a drop of concentrated tempera, poster paint or other water-soluble paint on the top point or ridge of the "mountain." Have students pour 1 cup of water slowly onto the paint. Color will show the drainage pattern down the sides of the mountain.

The water in the small valleys coming down from the peak of the mountain drains into creeks, the creeks run together into larger creeks and the larger creeks eventually run together to form rivers. The area drained from the highest point or ridges down into a lower basin or series of valleys is called a watershed.

Using their salt dough maps, have students repeat the procedure with the tempera paint.

What do you notice about where the water drains? Why do you think this happens? What else do you observe?

Write observations on the board. Lead students to make generalizations about surface-water flow from their observations.

Explain

Ask one student to come up to the Arizona map and trace the path of the Salt River from the White Mountains (White River and Black River) down to Phoenix. Have another student find the Verde River and trace its path down out of the mountains south and west of Flagstaff to Phoenix. Ask another student to trace the path of the Colorado River across the northern part of the state down along the western border of Arizona.

Where are the large rivers in relation to the mountains?
(at the bases of the mountains)

Activity 3.2: Groundwater Model

60 minutes

Introduce the activity to students.

We have learned about surface water in creeks, rivers and lakes. Now we are going to learn about another place water is found — under the ground!

Engage/Explore

Fill a pint jar with clear marbles. These can be obtained at most hobby or florist supply shops. Have 2-cup measuring cup filled with colored water.

Is this jar full? Is there space in the jar for anything besides the marbles?
(Yes. Air spaces can be seen between the marbles.)

How much water do you think I can pour into this pint (2-cup) jar that is "filled" with marbles?

Students will guess. Put their guesses on the board. Pour the colored water into the jar of marbles. It will hold almost a cup of water.

Explain

The marbles are like dirt or sand particles. Water can fill up the spaces between the particles underground. We call this water groundwater.
A place under the surface of the ground where water is stored in the spaces between the dirt or sand or in the cracks in rocks is called an aquifer. If we filled the jar with gravel instead of marbles, would there be more space, less space or the same amount of space for water to be stored?

Materials
(for Activity 3.2 and additional activities included on student pages)

- Clear plastic glasses, 3 per group
- Clear plastic pop bottle with top cut off and inverted to form funnel, 3 per group
- Wire mesh or screen cut into squares (2-by-2 inches), 3 per group
- 1 liquid-soap dispenser pump per group
- Measuring cups
- Water
- Soil samples: sand, pea gravel, 50/50 mixture of sand and gravel
- Watch or clock
- Clear pint jar
- Clear marbles, enough to fill the jar
- Colored water — use food coloring

Expand

We will be doing an experiment to see what kind of soil can hold the most water. Water must be able to move through these pore spaces into a well if it is to be pumped to the surface for use. Does water travel through different soils at the same or different rates?

Follow the directions on the following student pages. Answers can be found in the appendix.

Literacy Link

(WS3C2PO2) Bring expository writing into this lesson by having students write an expository paragraph about the soil experiment they conducted. Students should write a topic sentence about what they did, supporting sentences about their findings and a concluding sentence about how what they observed relates to the real world.

Evaluation

Science – S6C3PO1: Identify the sources of water within an environment.

Assessment

Collect students' data sheets to assess data collection skills and participation in the activity. Write the following questions on the whiteboard or overhead. Have students discuss their answers with a partner and then record on a sheet of paper or science notebook.

- What is the path that a water droplet takes when it falls on a watershed?
- What type of soil held the most water? Why do you think that is?
- What type of soil did water move through quicker? Why do you think that is?
- In summary, where can you find water within our environment?

Science Notebooking

Have students write the answers to these questions in their science notebooks so they can revisit what they have learned later. Look for them to use the key vocabulary appropriately. You could also have them draw a diagram of a watershed (surface water) and aquifer (groundwater) in their notebooks.

Lesson Closure

As a conclusion to the lesson, have the students discuss the following items in pairs:

- Explain what a watershed is and how water travels over land.
- Explain what groundwater is and how we get water from the ground.
- Explain how surface water and groundwater are related.

Name: ______________________________

Lesson 3 Student Activity Page: Groundwater and Soil Types

Part 1: What kind of soil can hold the most water?

Directions

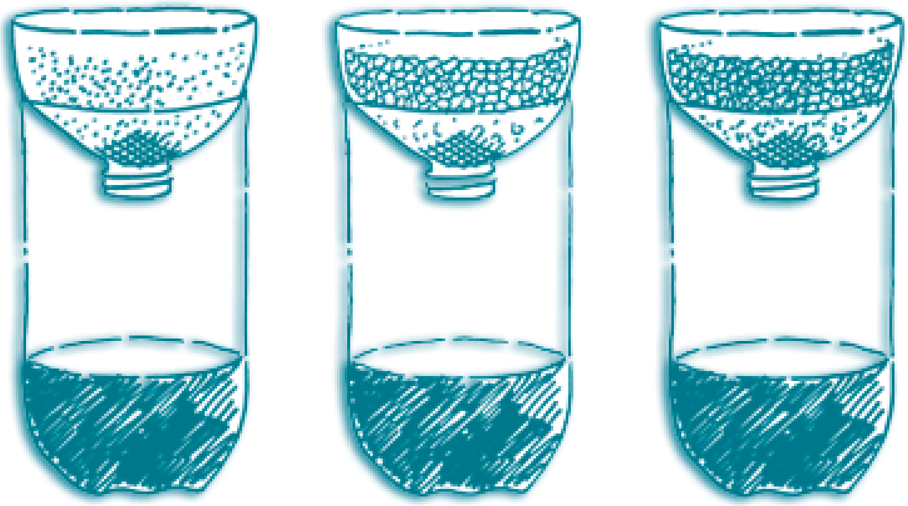
1. Fill one of your three cups with sand, one with gravel and one with a mixture of sand and gravel. Make sure the cups are filled level to the top, but not above.
2. Fill a measuring cup with water. Pour the water into the cup filled with sand until the water level comes to the top of the cup. How many ounces (or milliliters) of water went into the spaces between the sand particles? (Hint: Subtract how much is left in the cup from the total number of ounces or milliliters that you started with.) Record this amount in the chart.
3. Repeat with the cup of gravel and the cup of mixed sand and gravel. Record the amounts in the chart.

Data Table			
	Starting # of ounces of water	# of ounces of water left after fill	# of ounces of water stored in spaces between particles
Sand			
Gravel			
Mixture (S & G)			

Questions

1. Which soil type held the most water? ______________________________
2. Which held the least? ______________________________
3. Why do you think this type held the least amount of water? ______________________________

Name: ____________________



Part 2: Which type of soil will water travel through most easily?

Directions

1. Place cut-off tops of the plastic bottles upside down on bottom parts so they form funnels over the empty containers.
2. Place a square of wire screening over the hole in the funnel. Dump the sand from the first part of the experiment in the first funnel. Dump the gravel in the second funnel and the mixture into the third. Allow water to drain completely from each sample. Pour out.
3. Fill the measuring cup. Pour entire contents over soil sample (sand) in first funnel.
4. Time how long it takes before drips slow to one per second. Record in chart.
5. Repeat with other two samples. Record results.

Data Table	
Soil sample	# of seconds to drain
Sand	
Gravel	
Sand/gravel mixture	

Questions

1. Which soil sample drained the fastest?

   ____

2. Which soil sample drained the slowest?

   ____

3. Is the sample that held the most water the same as the soil type that drained the fastest?

   ____

Explain. ____________________

____

____

____

Name: ______________________________

Part 3: Aquifer Model With Well

Introduction

Beneath the surface of the earth — from a few feet to hundreds of feet down — water slowly seeps through the pores, cracks and fractures of rocks, and into the spaces between sand and gravel. When these spaces are filled or saturated with water, that water is called groundwater. In Arizona, most of the water that seeps into aquifers (recharge) comes from streams fed by mountain runoff and from water from the Central Arizona Project (CAP) that is spread on the ground. Arizona uses water from the Colorado River to recharge the aquifer by constructing basins where water floods, sits and, over time, seeps down into the ground. Recharge also occurs when crops and turf are irrigated and from storm water and municipal discharge of treated sewage.

Typically, aquifers in central and southern Arizona are made of sand and gravel and yield large amounts of groundwater. Northern Arizona aquifers are characterized by fractured rock; in many places, wells must be drilled to great depths and may yield little or no water.

To tap groundwater, a well must be drilled deep enough to penetrate the water table. When pumping occurs, the water table near the well drops. If more water is pumped from an aquifer than is recharged, overdraft occurs and the water table drops. In parts of Arizona, overdraft is a serious problem that has led to land settling and cracking (subsidence), lower well yields, water-quality problems, and the streams and rivers drying up. Water from the CAP can be used to help recharge aquifers (see www.cap-az.com/recharge). To reduce overdraft of groundwater resources, it is important for Arizonans to conserve water.

Directions

1. First, cover the bottom end of the liquid-soap dispenser with one of the wire mesh squares from previous activity and affix with a rubber band. Then, tape the liquid-soap dispenser pump to the side of a clear plastic glass, with the bottom of the pipe resting on the bottom of the glass. The opening of the pump should point outside the glass. This represents a well and pump. Fill the glass with sand. The sand is the aquifer, with spaces available to store water.
2. Pour water into cup to the top of the water level, which is called the water table, about halfway up the pipe of the well.
3. Pump water to the surface by pushing on the dispenser pump. Catch the water in another cup. When the aquifer is dry, pour the water you caught in the second cup back into the sand. This is called "recharge" because you are refilling the aquifer with water.

Questions

1. If you used the water you pumped up to irrigate crops, some of the water would percolate, or sink, back into the ground and recharge the aquifer, but some would be used by the plants and some would evaporate. What will happen to the water table in the aquifer? ______________________________
2. What are some other uses for groundwater that is pumped out of aquifers? ______________________________
3. Where else does water come from that recharges aquifers? ______________________________
4. What will happen to wells if there is no recharge of an aquifer? ______________________________
5. Then what would happen to plants, animals and humans? ______________________________

LESSON 4: ARIZONA WATER STORY VIDEO

Estimated Time for Lesson

1 hour

Video Run Time: Approximately 35 minutes

State Standards Addressed

Segment 1: The Water We Take for Granted

- Social Studies – S4C2PO1: Describe how the Southwest has distinct physical and cultural characteristics.
- Social Studies – S4C2PO3: Locate the landform regions of Arizona (plateau, mountain and desert).
- Social Studies – S4C2PO4: Compare the landform regions of Arizona according to their physical features, plants and animals.
- Social Studies – S4C2PO5: Describe how regions and places (e.g., the Grand Canyon and the Colorado River) have distinct characteristics.
- Science – S3C1: Describe how natural events and human activities impact environments.
- Science – S4C3: Describe uses, types and conservation of natural resources.
- Science – S3C1: Describe the interactions among human populations, natural hazards and the environment.

Segment 2: Arizona Wasn't Always This Way

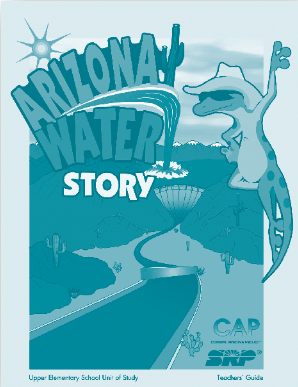
- Social Studies – S1C2PO1: Describe the legacy and cultures of prehistoric people in the Americas (development of agriculture).
- Social Studies – S1C2PO2: Describe the cultures and contributions of the Hohokam people (e.g., location, agriculture, housing, arts and trade networks).
- Social Studies – S1C5PO2: Describe the influence of American explorers and trappers on the development of the Southwest.
- Social Studies – S1C5PO3: Describe events that led to Arizona becoming a possession of the United States: the Mexican-American War, the Mexican Cession (Treaty of Guadalupe Hidalgo) and the Gadsden Purchase.
- Social Studies – S4C4PO1: Describe the factors that have contributed to the settlement, economic development and growth of major Arizona cities.
- Social Studies – S4C4PO2: Describe how Mexico and Arizona are connected by the movement of people, goods and ideas.
- Social Studies – S1C7PO1: Describe the economic development of Arizona: mining, ranching, farming and dams.
- Social Studies – S4C4PO5: Describe the major economic activities and land-use patterns (e.g., harvesting of natural resources) of regions studied.
- Science – S3C1: Describe how natural events and human activities impact environments.
- Science – S4C3: Describe uses, types and conservation of natural resources.
- Social Studies – S4C5PO1: Describe human dependence on the physical environment and natural resources to satisfy basic needs.
- Social Studies – S4C5PO2: Describe the impact of extreme natural events (e.g., floods and droughts) on human and physical environments.
- Social Studies – S4C5PO3: Describe the impact of human modifications (e.g., dams, irrigation and agriculture) on the physical environment and ecosystems.

Segment 3: What About Tomorrow?

- Science – S3C1: Describe how natural events and human activities impact environments.
- Science – S4C3: Describe uses, types and conservation of natural resources.
- Science – S3C1: Describe the interactions between human populations, natural hazards and the environment.
- Social Studies – S4C5PO1: Describe human dependence on the physical environment and natural resources to satisfy basic needs.
- Social Studies – S1C7PO1: Describe the economic development of Arizona: mining, ranching, farming and dams.
- Science – S3C2: Understand the impact of technology.
- Science – S4C3PO2: Differentiate renewable resources from nonrenewable resources.

Materials

- Arizona Water Story video



- Segment handouts (1 per student) *It is recommended that you blow up the handouts to 11-by-17 inches. This will allow more room for students to write, and handouts can also be made into a large brochure of facts about Arizona. Allow students to illustrate the other faces of the brochure.*

Objectives

Content Objectives

- Students will be able to describe the contributions of past people (Hohokam, American explorers, Mexican-Americans) on settlement and development of the land we now call Arizona.
- Students will be able to describe the process in which water is delivered to the Desert Region of Arizona.

Language Objective

Students will use complete sentences to describe how water plays a part in the history of Arizona.

Vocabulary

Desert: a land area that receives less than 10 inches of rain in a year
Drought: a long period of abnormally lower rainfall that creates a shortage of water
Erosion: how the earth is worn away by water, glaciers, wind and waves
Floods: when large amounts of water overflow the banks of rivers and streams
Groundwater: water that is pumped from deep underground, in between the rocks and sand
Plateau: a large area of high and fairly flat land
Prehistoric: the time before there were any written records
Surface water: water that flows over the surface of the land
Reservoir: a large natural or artificial lake used to store water until it's ready to be used
Renewable energy: energy produced with a source that is created over and over again by nature
Watershed: a land area that drains into a body of water

Procedures

Pass out the video guide to students. Read through the questions with the class before watching the video. You may want to pause the video periodically to allow students time to discuss and record their answers to the questions. At the end of each segment, review the questions with the students to reinforce their learning. To allow ample time for discussion, it is recommended that the segments be viewed on separate days.

Segment 1: The Water We Take for Granted
(run time: approx. 11 minutes)

Segment 2: Arizona Wasn't Always This Way
(run time: approx. 13 minutes)

Segment 3: What About Tomorrow?
(run time: approx. 11 minutes)

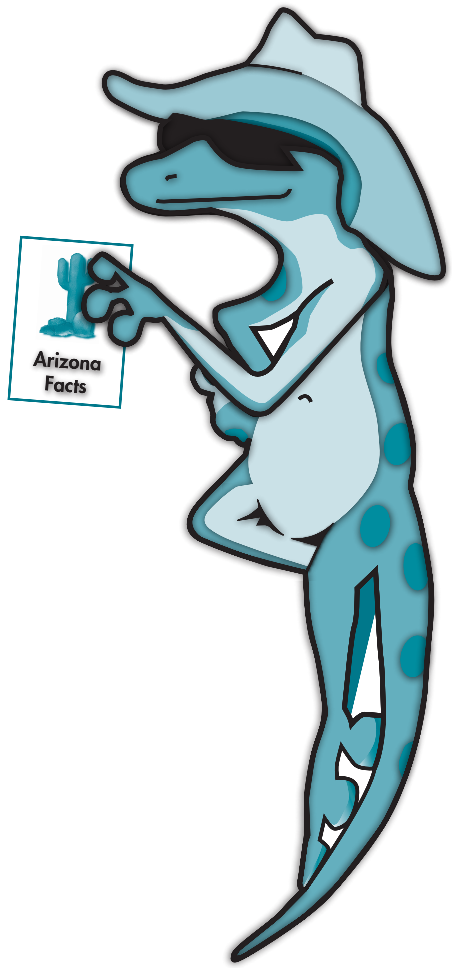
Evaluation

Have students complete the video guide worksheets, and discuss the answers as a class (answers can be found in the Appendix).

Lesson Closure

As a conclusion to the lesson, have the students discuss the following items in pairs:

- Explain why and how we are able to have water in the Desert Region of Arizona.
- Explain where we get our water from in (your town).



Arizona Water Story Video Script

Introduction

Arizona is a land of natural wonders, from the Grand Canyon carved by the mighty Colorado River, to the delicate and dry colors of the Painted Desert, to the dense, green forests of the White Mountains. But we tend to forget that much of the Arizona we know today, with its growing cities and productive farms, was once a dry and desolate wilderness. What changed the landscape? The availability of water. Water has shaped Arizona's history as well as its landscape.

Segment 1: The Water We Take for Granted

Cathy: Whew! That really hit the spot. But before I tell you what this glass of water has to do with why you're here, I'd like you to meet some of my friends.

Alex: Hi. My name is Alex.

Johnna: And I'm Johnna.

Taylor: I'm Taylor. This water is for my dog, Boxer.

Zoe: My name is Zoe, and I want my water good and cold when I'm ready for a drink.

Cathy: Here's one more friend. Meet Gilbert Gecko. It'll be his job to help us tell the story of water in Arizona.

Cathy: Now you all live here in Arizona, and what you have in common is that your grandparents and great-grandparents and great-great-grandparents played a role in making Arizona what it is today. They had a part in making sure you have all the water you need, when you need it. And Gilbert? He's from Arizona, too.

Cathy: Now here's a question for you. How many ways in a single day do you expect water to be there for you?

Taylor: Well, I wake up every morning and take a shower.

Alex: I have to brush my teeth twice a day.

Johnna: And I have to wash dishes after breakfast every morning.

Zoe: One of my jobs is to water the garden outside.

Cathy: Without this water, we'd be up a creek without a paddle, right?

Alex: Wait a minute. Without water, there wouldn't even be a creek.

Cathy: You're so right. And perhaps a creek is a good place for us to begin our story.

Cathy: First, remember that Arizona is located in the Southwestern part of the United States, along with California, Nevada, Utah, Colorado and New Mexico. And right in the middle of these states is a mighty river. Anyone know its name?

Johnna: Of course we do.

Kids together: It's the Colorado River.

Cathy: That's right. In fact, did you know that a raindrop that falls in Wyoming or Nevada could end up being drinking water for someone in Tucson?

Johnna: So, this glass might actually have water in it from some place in Wyoming?

Alex: And my glass could have water from Las Vegas?

Zoe: That's really neat.

Cathy: It is. All of these states are connected because we're all part of the Colorado River Watershed and because water is delivered from the Colorado River to some of our cities. In fact, all of the rivers in Arizona eventually drain into the Colorado River. These rivers are called tributaries.

Taylor: Does that include the Salt River and the Verde River?

Cathy: Yes. They're both tributaries of the Gila River, which is a tributary of the Colorado.

Alex: What about all the other rivers in Arizona?

Cathy: Good question. The Santa Cruz and San Pedro rivers are tributaries of the Gila River, too. And the Gila flows to the Colorado.

Zoe: So what you're saying is that finally all the rivers in Arizona are interconnected.

Cathy: And it all started with a creek.

Alex: Like Christopher Creek near Payson, where I go with my family ever year. Arizona sure has some beautiful places, doesn't it?

Johnna: Yes. There's the Grand Canyon. Last summer I hiked with some friends all the way down the canyon, and I stood right near the Colorado River.

Taylor: One time my parents took me to the Painted Desert, with its wild colors. I wanted to pick up a couple of the rocks and take them home to show my friends, but my parents said that it was against the rules so we wouldn't mess up the beautiful place.

Zoe: I like hiking in the woods in the White Mountains, especially when it's really hot in Phoenix.

Alex: And once, I visited the Organ Pipe National Monument in southern Arizona. Lots and lots of cactus.

Cathy: Each of these wondrous places represents one of the three different geographic regions of Arizona: the Plateau Region in the northern part of the state; the Mountain Region, which stretches from the northwest corner of the state diagonally across the middle; and the Southwestern Region of small mountains and desert valleys. What happens in each of these regions can help us understand where all the water we use comes from.

Cathy: Let's start way up in the northern part of Arizona. This region is called the Colorado Plateau.

Taylor: Look, there's the Painted Desert, where I went with my parents last summer.

Cathy: And those wild colors you mentioned are caused by minerals in the sandstone that make the pink and red and orange colors in the rocks.

Johnna: There are also some wonderful rock formations in this region.

Alex: They were made by erosion, probably over thousands of years.

Johnna: Oh, here's Gilbert – with a word. If Gilbert has it, it must be important. Erosion: how the earth is worn away by water, glaciers, wind and waves.

Zoe: I want to ask about another word. What exactly is a plateau?

Zoe: A plateau: a large area of high and fairly flat land. And if you drive some of the roads around Flagstaff, you will see a lot of pine trees and blue spruce and cottonwood.

Cathy: You'll also see trees like that around the southern end of the region.

Zoe: That's called the Mogollon Rim.

Taylor: The rim is really high. It's 5,000 to 7,000 feet above sea level.

Cathy: And because the Colorado Plateau is at a higher altitude than the southern deserts, the average temperature is lower and receives more precipitation. In fact, the winters can be very cold and snowy. Remember the snow, because we'll see later that the snow in the Plateau Region and the Mountain Region is an important part of the story about how water gets to us.

Cathy: The middle region of Arizona is really a series of mountain ranges.

Alex: I bet I can name them.

Cathy: OK, go ahead.

Alex: The mountain ranges include Hualapai, San Francisco, Juniper, Sierra Ancha, White, Gila and ... Oh nuts, I know there's one more.

Johnna: You forgot the Bradshaw mountain range.

Cathy: Right, and some of these peaks reach an elevation over 11,000 feet. There's more rain and snowfall in this region than anywhere else in Arizona. Some of the high regions receive as much as 30 inches a year. That rain and snowfall feeds Arizona's main rivers. Can you name them, too?

Zoe: The Verde River.

Alex: The Salt River

Johnna: The Agua Fria.

Taylor: And the Gila.

Cathy: Don't forget that all of these are connected to the Colorado River. As I said, when it rains, or when the snow melts, that water runs into the rivers, it drains the watershed, and brings water to the drier and lower valleys.

Johnna: Hold on. What's a watershed?

Cathy: I'll bet Gilbert knows.

Cathy: Watershed: a land area that drains into a body of water.

Alex: That means all the snow and rain in the mountain ranges around Flagstaff drains into the rivers and lakes, and that makes it possible for water to end up in cities like Phoenix or Tucson or Yuma.

Cathy: There are some beautiful and colorful places in this region, too. How many of you have been to Sedona?

Zoe: My dad calls it "red rock country."

Cathy: And if you drive from Sedona to Phoenix, you can actually begin to see the difference between the Mountain Region and the Southwestern Region.

Cathy: This part of Arizona is the Sonoran Desert.

Taylor: Gilbert's back again, which means he has a new word for us. Desert: a land area that receives less than 10 inches of rain in a year.

Cathy: Thanks, Gilbert. As I was saying, this part of Arizona is called the Sonoran Desert, and it's the region where the majority of Arizona's population lives, in cities such as Phoenix, Tucson and Yuma.

Johnna: But there are mountains in this region, too, right?

Cathy: And sometimes they're called "sky islands."

Alex: This time I can tell you their names: the Pinaleno range and the Santa Catalina and the Santa Rita.

Taylor: Wow. How do you know them so well?

Alex: Because, when I was a little kid living in Tucson, my grandpa and grandma would visit us from Nogales, and we'd take trips to see the mountains.

Cathy: OK. Now you guys live in this Southwestern Region. What is it most known for?

Johnna: It's dry.

Zoe: And it's hot.

Taylor: And summer lasts forever.

Cathy: Well, not exactly forever, but certainly from May to October. But the spring and fall seasons are perfect for growing a lot of different crops. And because southern Arizona is frost-free, it has a year-round growing season.

Johnna: Is that why Arizona has always been a good place to farm?

Cathy: Right. And what makes this possible? Think back to our discussion about rain and snow.

Taylor: You mean that this region is very dry.

Cathy: You bet it's dry. That's why it's called the Desert Region. You've all lived in Arizona long enough to know that it doesn't rain in Phoenix or Tucson a whole lot. In fact, the Desert Region doesn't get much surface water at all.

Alex: Hold it. What is surface water?

Cathy: Surface water: water that flows over the surface of the land. In other words, surface water is water that falls as snow or rain on the watershed – we call it precipitation – and then it collects in our rivers and lakes.

Zoe: So, the water we use at home comes from the canals that deliver surface water that originates in Arizona's watersheds.

Alex: I think I get it. Winter storms bring snow and rain to the mountains ...

Taylor: The snow melts ...

Johnna: The mountain streams carry the runoff down to creeks and the rivers ...

Cathy: And the rivers bring the water to the valleys and the desert.

Cathy: Our summer storms and monsoon season provide spectacular lightning shows and some great thundershowers, but that is not enough surface water to provide all the water we need.

Taylor: So, how do farms and people in cities like Tucson and Phoenix get more water? Where does it come from?

Cathy: Some of it comes from the ground and is called groundwater. That is water pumped from deep underground, in between the rocks and the sand.

Zoe: OK. So, the water I drink at home comes either from the surface water from the rivers around Arizona or from deep underground.

Alex: Yeah, but that doesn't explain how water actually gets to my house.

Cathy: To understand that, we need to move to the next chapter in our story about water in Arizona. That will include learning how water is delivered to us by the Salt River Project and the Central Arizona Project as well as about dams and reservoirs and canals – even about the Hohokam Indians. And about how, over many years, people, some of them may even have been your ancestors, who settled in this dry valley learned to adapt to their environment so they could farm and build cities and make this place their home.

Segment 2: Arizona Wasn't Always This Way

Alex: Whenever I turn on the faucet, I know I can get a drink of water.

Taylor: Or I can wash dishes.

Johnna: Or I can wash my dirty jeans.

Cathy: That happens every day of our lives. We believe we'll always have water when we need it. But imagine if you lived a thousand, or even a couple of hundred, years ago, especially in the deserts around Tucson or Phoenix.

Zoe: I bet it would have been much harder to find water in those days.

Cathy: Imagine that you lived in southern Arizona 1,500 years ago, about 450 A.D. You would have been a Hohokam Indian, and you would have spent a lot of your time digging ditches.

Alex: Digging ditches?

Taylor: It is hard to imagine what that would have been like.

Cathy: Actually, we would say all of this happened during prehistoric times.

Johnna: Let's get some help from Gilbert here. What does prehistoric mean?

Cathy: Prehistoric: the time before there were any written records. There were a lot of people living in what is now Arizona during prehistoric times. The Navajo and Hopi Indians lived in the Plateau Region near the Grand Canyon. The Anasazi people were in the Tonto Basin along the upper Salt River. And the Hohokam people lived along the lower Salt River near what is now Phoenix. Let's ask Gilbert to show us some drawings of the Hohokam in prehistoric times.

Cathy: This is what the Hohokam might have looked like. For about 1,000 years, these peaceful farmers made their home in central and southern Arizona, places where they had rivers and streams that ran for at least part of the year. Imagine that you are Hohokam.

Johnna: We built these irrigation ditches, or canals, to help make water flow from the streams to our farms.

Taylor: We used sticks, big rocks and even our hands to make the ditches.

Alex: And that made it possible for water to get to our fields so that we could grow the food we needed, such as corn and squash and beans.

Zoe: At one point, there were 100,000 of us living here in this desert, and we built at least 500 miles of canals to deliver water to our homes and farms.

Johnna: That's like if you could stretch out all the canals end to end, they would run all the way from Phoenix to Albuquerque.

Cathy: The Hohokam lived in Arizona for about 1,000 years, until the year 1450.

Johnna: And then they just sort of disappeared.

Taylor: No one knows for sure why.

Cathy: The best guess is that finally they couldn't survive the constant cycle of drought and flood that we still struggle with in Arizona. So, over time, they just slowly went away. It wasn't 'til 400 years later, when new settlers were moving West searching for gold, that they rediscovered the canals and thought it might be possible to use them again. Gilbert has a painting of Jack Swilling; he's the guy who gets most of the credit for beginning to rebuild the ancient Hohokam canals.

Johnna: So that's what Mr. Swilling looked like.

Cathy: Let's see if we can make you look like him, and you can tell us what he discovered.

Johnna: Yep, I came to this part of the country, I'd say it was about 1865 or 1866. I was a prospector and an explorer then. I was hoping to find gold. That's when I saw those old canals. I thought maybe I could make 'em work again. So, late in 1867, I got a few of my buddies together, and we formed the Swilling Irrigation and Canal Company. They named it after me. Our plan was to take water from the Salt River and move it through these canals so that we could grow crops and also sell hay and grain to the U.S. Cavalry at Fort McDowell. A small portion of the canal running through Phoenix was called the Town Ditch. I remember I was quite proud of myself.

Zoe: Wow, Mr. Swilling, you had a big impact on the future of Arizona.

Cathy: Around this same time, a government survey party came to the area and realized that a small community, calling itself "Phoenix," had appeared on the scene.

Taylor: Then, groups of farmers up and down the river began digging canals, even using some of the ancient Hohokam canals by cleaning them out and making them deeper.

Zoe: They used rocks and brush to build little dams so they could divert the water from the Salt River, forcing it to flow into the canals.

Cathy: Some of the famers formed private canal companies or associations. The men either worked on the canals and dams themselves or paid a fee for someone else to maintain them. The farmers also hired "zanjeros" to deliver water through the canal to their farms.

Alex: That is an amazing story. Just to think that all the canals near my house might go all the way back to Jack Swilling.

Cathy: And that's just around Phoenix. The people in the Santa Cruz Valley, where Tucson is now, faced similar water problems.

Taylor: Wasn't Tucson in Mexico at one time?

Johnna: I've been studying this for a report in school. I searched on my parents' computer about how Tucson came to be. It was the first place in Arizona settled by Spanish missionaries and soldiers. Those early settlers farmed and took care of their sheep and cattle.

Cathy: You may not have heard about the Treaty of Guadalupe Hidalgo, in 1848. That treaty ended the war. Mexico thought they had the territory, but that was only because someone made a huge mistake and said that the border between Mexico and the U.S. was on the Gila River, 80 miles north of Tucson.

Taylor: James Gadsden!

Alex: Who is James Gadsden?

Johnna: He's the guy – he must have had tons of money – well, he purchased all that land south of the Gila River for the United States gover nment, and it was then that Tucson finally became part of the U.S. It was called the Gadsden Purchase.

Cathy: In those days, most of Arizona's population lived in the central part of the state, around Phoenix and Tucson. Not many people lived in other parts of the state. By then, Tucson was becoming a city. But that didn't solve their water problem. Just like Phoenix, they still had to figure out how they could have a reliable source of water they needed for their farms and their lives.

Alex: It must have been tough being a farmer and living in the desert in those days.

Cathy: That's true. In the late 1800s, they faced the same problems that the ancient Indians had.

Johnna: Floods and drought.

Cathy: Gilbert, come and help us. We should be clear what we mean when we talk about floods and drought.

Alex: Floods: when large amounts of water overflow the banks of rivers and streams.

Johnna: Drought: a long period of abnormally lower rainfall that creates a shortage of water.

Zoe: In a year with heavy rain and snow in the mountains, the rivers were full of water so that farmers had more than enough water for their crops. Sometimes all that water washed away the small rock-and-brush dams in the river.

Taylor: But in the next year, they might have very little rain and not enough water.

Cathy: You're right; trying to be a farmer under those circumstances, or even trying to provide enough water for drinking, bathing and cleaning, was very difficult. And to make matters even more complicated, the population of Maricopa County grew by nearly 10,000 people. People just kept on moving to Arizona. All those people from the East and Midwest were looking for a warmer climate or the opportunity to start over in a different part of the country or because they heard it would be better for their health. All of those people needed water, too.

Johnna: It would have been a real challenge for them to make sure that they could have enough water they could count on.

Zoe: You said that one thing the Indians did was build diversion dams so they could control the distribution of water. They still did not have a way to collect and store the water running off the mountains.

Taylor: So, why couldn't those farmers just build a bigger dam that could hold even more water from the winter storms, and then let it flow into rivers and canals when the people needed it?

Cathy: They thought of that, too. In the 1890s, a private company was formed to construct what they called a "water storage dam," or reservoir. A reservoir is a large artificial or natural lake used to store water until it's ready to be used. But the people could never raise enough money to build the dam.

Alex: Don't you wonder why they just didn't give up?

Johnna: I would guess they almost did. But the more I learn how these people were determined to stick with it, the more I understand that quitting wasn't something they could ever do.

Cathy: That all changed in 1901, after Theodore Roosevelt became president of the United States. Now, who's been learning about him?

Zoe: I have.

Johnna: OK, Mr. President. Tell us how this all happened.

Zoe: When I became president, I had the chance to look out at the whole country, especially out West. And I realized something had to be done so that growing towns and cities would have enough water. I urged Congress to pass the National Reclamation Act, which they did in 1902. That act provided for government loans to actually reclaim the West with irrigation projects. There were several big projects that started throughout the United States. One, as you may know, was Hoover Dam on the Colorado River, and people started talking about how to deliver Colorado River water so that the seven states could share the river. But even before Hoover Dam, was the construction of a huge dam – named after me – Theodore Roosevelt Dam.

Cathy: That happened because farmers and landowners in that territory, the ones who wouldn't give up, formed an association called the Salt River Valley Water Users' Association, so they could pledge their land in order to get a government loan. Now we call the group SRP. After that, things really got going.

Taylor: The government hired stonemasons to cut huge blocks of stone out of the nearby mountains to build the dam.

Johnna: The equipment and supplies they needed were hauled by mule-driven wagons on the Apache Trail.

Cathy: The trail itself was built by Apache and other Native American workers. It's a trail that connected the end of the railroad near Mesa to the Theodore Roosevelt Dam site.

Alex: You know, if it weren't for the Hohokam and the Apache, we might not even be here now.

Zoe: Yes, and though those workers faced many challenges – hot summers, cold winters and a flood in 1905 that almost destroyed their work – they didn't give up, and the dam was finally completed in 1911. I was so happy, that I attended the dedication celebration myself. In fact, there is a photo of me standing on the dam with all the people who helped make it happen.

Zoe: The building of the dam gave new hope to the people who lived near it. The Salt River Valley Water Users' Association and the federal government worked together to widen the old canals and build new ones. They also built ditches – we call them laterals now. They delivered water from the canals to the farmers' fields and orchards.

Alex: That's how they operated. Workers would open the canals by using hand cranks.

Taylor: Those workers were called "zanjeros."

Alex: Hey, I remember you using that word before.

Taylor: Yeah, it comes from the Spanish word for ditches: zanjo.

Zoe: The zanjeros kept track of how much water the farmers used, and then the farmers were charged for the water.

Johnna: For 50 years, teams of horses were used to clean the canals to keep them free from moss and weeds. Now SRP and CAP use algae-eating fish to keep their canals clean.

Cathy: You know how you often see joggers on the banks of the canals now? Well in those early days, thanks to the trees lining them, the banks of the canals were also a place people came for a relaxing stroll or a family picnic.

Alex: OK. But that was then. What about now?

Cathy: Now there are several dams on the Verde and Salt rivers. And one on the Aqua Fria. Two canal systems, operated by SRP and CAP, deliver water from these reservoirs to our homes.

Taylor: And one of the canals is practically next door to our house.

Zoe: We know that the dams and rivers and canals tell us a lot about how water gets delivered to us today.

Cathy: And it all got started years and years ago with the Hohokam.

Alex: We lived for many years in what you now call Arizona.

Johnna: We dug ditches …

Taylor: … so we could divert the water from rivers and streams …

Zoe: … to grow our food.

Johnna: I was lucky, I guess. I was exploring and prospecting for gold when I first arrived here. I found some of those ancient canals. As more and more people moved West needing more and more water to live on, we figured out how to rebuild some of those canals and connect them to the rivers. We even built some of the first dams.

Zoe: I'm glad I was the president at the beginning of the 20th century. I was able to help the Western part of the country grow, thanks partly to Theodore Roosevelt Dam, so we could store water in the reservoir behind the dam and then release it into the Salt River and then into the canals around Phoenix.

Cathy: That's the then, which takes us to the now – to today and the story of how we have built dams to store water and canals to deliver it to cities and how without CAP – the Central Arizona Project – life in southern Arizona would be much different than it is now. That story will tell us how when we turn on a faucet, we will have water.

Taylor: And how we still can't take water for granted.

Segment 3: What About Tomorrow?

Johnna: I love being here at the lake with my friends.

Taylor: Isn't it amazing though to think that the water we're swimming in will actually become the water that we drink? But how does this water get to our houses?

Alex: And once we drink it, is it all gone? To make sure we have enough to drink, how do we get more water into the reservoir?

Zoe: Wouldn't it be neat if we could recycle water like we recycle bottles and cans?

Johnna: I've heard about something like that.

Cathy: Have you also heard about scientists who are trying out technology that would make it possible to clean the salt out of ocean water so we can use it, too?

Taylor: Wow. So, I guess the really important question is, how do we make sure that there will be water here for the future so that kids can come and swim in the lake and have plenty of water to drink?

Zoe: Yeah, what about tomorrow?

Cathy: What about tomorrow? To answer that question, we need to understand how reliable water is delivered to our homes and businesses now. It's a story that began with building dams and canals. Remember when we talked about the geography of Arizona? Most of the rainfall in Arizona happens in the Mountain Region. And we are a part of a larger watershed, the Colorado River Basin. As water travels down the mountainous watersheds into rivers, we can use surface water. However, we need to store it so that we can use it when we need it.

Alex: That's why we need dams.

Cathy: You got that right. Let's go back to 1911.

Johnna: That's when Theodore Roosevelt Dam was completed.

Taylor: And that made it possible for the water in eastern Arizona's mountains and rivers to flow into the reservoir behind the dam, creating Theodore Roosevelt Lake.

Cathy: Theodore Roosevelt Lake is the largest reservoir in Arizona, but …

Alex: Let me guess – it's not enough water.

Cathy: Well, let's do some math. Theodore Roosevelt Lake can store more than 1 million acre-feet of water.

Johnna: Good grief. How much is that, and what's an acre-foot?

Alex: I'll bet Gilbert knows!

Alex: An acre-foot is around 326,000 gallons of water.

Taylor: And that's just about how much water it takes to flood a football field to the depth of 1 foot.

Zoe: And that's about how much water two families use in a year.

Johnna: Wow. So, that means between our four families, we use nearly 652,000 gallons a year!

Zoe: No wonder that's not enough water for the people in central Arizona. So, what did they do?

Taylor: I bet they had to build more dams.

Cathy: Locally, people saw that there was a need to build more reservoirs for water supply in the Valley. In the 1920s, SRP developed a plan to construct additional dams on the Salt River.

Zoe: Let's see. On the Salt River, that includes Mormon Flat Dam, Horse Mesa Dam and Stewart Mountain Dam.

Johnna: And the dams and reservoirs on the Verde River include Bartlett Dam and Bartlett Lake as well as Horseshoe Dam and Horseshoe Lake.

Taylor: Are dams only used for storing water?

Cathy: No. These dams also had hydropower capabilities for generating electricity. Water falling through a dam can spin a turbine, which spins a generator.

Alex: This generates electricity.

Johnna: We learned about electricity in our class this year. We learned that using water to make energy is a clean way to make energy, so it's called renewable energy.

Taylor: Renewable energy is energy produced with a source that is created over and over again by nature. So that means water is recycled over and over again by nature.

Alex: Yeah. Through the water cycle.

Taylor: Now I get it.

Cathy: So SRP and CAP use water flowing through dams to create electricity for homes, farms and businesses. What else can we use these lakes for?

Alex: We love to go fishing.

Johnna: Boating.

Taylor: Bird watching. We almost always see the great blue heron at Saguaro Lake.

Zoe: And eagles, too.

Cathy: The reservoirs have a lot of different uses: storing water, providing renewable energy and recreation. But that's only part of the delivery equation.

Alex: You mean it's still not enough water?

Cathy: No, not necessarily. But remember, part of the problem during both prehistoric and historic times was that the water supply wasn't reliable. Early citizens of Arizona knew they needed to be careful with their water supply to make sure there was a wide variety of sources of water for Arizonans to use.

Johnna: So they began to build canals. Canals brought surface water to treatment plants and eventually to homes.

Cathy: Right! We'll talk more about that later. Let me tell you the story of a very important canal that was built.

Taylor: You mean the Central Arizona Project.

Cathy: Right! The CAP. Statewide, people began discussing how to bring Arizona's portion of the Colorado River water to cities that needed it in southern Arizona. Remember how we started our conversation talking about the Colorado River? Seven states share that river, and in Arizona, we pump it to central and southern Arizona so it can be used where there is very little rainfall and lots of people. The Central Arizona Project, or CAP, took 20 years to construct and was completed in 1993.

Alex: The other day in school, we looked at a map of what the CAP looks like.

Johnna: The canal begins on Bill Williams River near Lake Havasu. This is very close to the Arizona-California border.

Taylor: And get this: The canal is 335 miles long, running east and then south, ending just below Tucson.

Cathy: In fact, the CAP is the largest river in Arizona, although a man-made one, and provides more than 1.5 million acre-feet of Colorado River water each year to Maricopa, Pima and Pinal counties.

Alex: Are there dams along the CAP route?

Taylor: We were just near one last weekend. We were on our boat on Lake Pleasant. That's the water storage reservoir on the Aqua Fria River behind the New Waddell Dam. It's a 15½-square-mile lake.

Cathy: Yes, CAP uses the dams to store water and make renewable energy. CAP pumps water into Lake Pleasant during the spring and releases water in the summer, when it is hotter and people use more water. Because of this, each year the elevation of the lake might change by 75 feet as water is stored and then used depending on the time of year. CAP uses the renewable energy from the dams and other sources to power their pumps along the canal and move renewable Colorado River water to homes.

Alex: Why is it called renewable water?

Cathy: It's renewable because rain and snow fall each year, refilling the lakes along the Colorado River. Sometimes the amount of water available is more than we can actually use, so some of the water is recharged underground to be used in the future.

Zoe: So, CAP delivers the water to recharge the aquifers under the ground.

Taylor: Now that's mind-boggling. How do they do that?

Cathy: The recharge process floods a site, letting the water drain down through the soil. Recharge helps to replace depleted underground water supplies. CAP operates half a dozen recharge projects that can hold millions of gallons of water every year.

Johnna: Between CAP and SRP, who uses all this water?

Cathy: CAP water is used by cities that treat the water for drinking; farmers to water their crops; Native American communities; and as we just said, it is also used to recharge depleted aquifers and replenish groundwater supplies.

Alex: And that's one way CAP helps care about water for tomorrow.

Cathy: Let's recap what we know about how water makes its way to your houses.

Johnna: Water falls as rain or snow on our watersheds …

Zoe: … and travels through tributaries like the Salt and Verde rivers and through larger rivers like the Colorado.

Taylor: In the past, engineers built dams to store the water along the rivers so we could use it when we need it …

Alex: … and then they built canals to deliver it long distances from rivers to our cities and towns.

Alex: In the Phoenix area, water is released from the dams into the Salt and Verde rivers.

Johnna: It is delivered through about 1,300 miles of canals, laterals and ditches. My granddad, who is 80, says he remembers the time when there were a lot more farms around here than there are now. He says the cities kept getting bigger and bigger.

Cathy: That's why SRP now delivers the majority of its water to homes and businesses in the metropolitan Phoenix area.

Taylor: It does? But there aren't any canals that bring water to my house.

Zoe: You're right. Remember the water treatment plant we visited on a field trip this year?

Alex: Yes. SRP delivers water to the city water treatment plants.

Cathy: They filter the water to remove dirt and algae, and disinfect it to remove naturally occurring bacteria.

Johnna: Then the cities move the water through pipes to my house and yours, and to our schools and businesses.

Taylor: So that's what my parents are paying for when they send a check with the water bill every month.

Zoe: Now that means we will always have enough water and that we can use as much of it as we want whenever we want.

Other kids (in unison): Oh no we can't.

Zoe: Why not?

Johnna: Well, for one thing, we live in a desert, so water is precious. There really isn't any more water for us in Arizona than there was when the Hohokam first settled here.

Cathy: Sometimes even less. Arizona still has periods of drought, when water is much less available, especially in the years we don't have much rainfall and there isn't much snow in the mountains.

Alex: So, we will always have to assume that our water supply is limited because we live in a desert. We can't just do whatever we want with it.

Taylor: What can we do to help make sure we have water here when we need it?

Cathy: Let's brainstorm this. What ways can we all help save water?

Alex: Well, I could take shorter showers.

Zoe: I have to remember not to leave the water running the whole time while I'm brushing my teeth.

Johnna: I can remind my dad or mom to put in a new rubber seal – they call it a washer – when the faucet is dripping. I'm sure a dripping faucet can waste tons of water.

Zoe: It would be harder work, but I could use a broom to clean our driveway when it's my turn, instead of a garden hose.

Alex: You know what I'd like to do? Invent a whole new water-saving dog bath.

Johnna: And I'll work with scientists who want to clean salt out of the ocean water.

Taylor: Maybe I'll become an engineer working to develop a canal from the ocean straight to Arizona to deliver clean water.

Cathy: Well, that's a beginning. Water is a precious resource in Arizona. No matter where we live, we are all connected through water. We all need to be good stewards of our water supply and think about using water more wisely – just like those who came before us used water wisely and planned for the future. I believe you and your families, working together, could find a lot more ways to save water so that we have plenty for the future.

Note to teacher: Enlarge to 11-by-17 size for student use.

Arizona Water Story Video Guide

Segment 1: The Water We Take for Granted

Read these questions before you view the video. Look and listen for the answers while you are watching the video.

1. What is one way the characters in the video use water? ____________

2. What region of the U.S. is Arizona located in? ____________

3. What river connects all the states in our region and Wyoming? ____________

4. All the rivers in Arizona are ____________ .

5. Write the names of the three regions of Arizona into the blanks in the table below.

6. Describe the characteristics of the three regions in the table below.

____________	____________	____________

7. Which region receives the most rainfall? ____________

   Why do you think that is? ____________

Segment 2: Arizona Wasn't Always This Way

Read these questions before you view the video. Look and listen for the answers while you are watching the video.

1. What is the name we give to the Native Americans who lived in central Arizona during prehistoric times? ____________

2. Describe the contributions of the Hohokam people. ____________

3. Who was Jack Swilling? What was his contribution to the development of what is now Arizona? ____________

4. Describe how Tucson became part of the U.S. ____________

5. Why was it hard to control the water in this area in the 1800s? ____________

6. What did the farmers in the area want to do to control the flow of water to their farms and homes? ____________

7. Describe what President Theodore Roosevelt did to help the problem. ____________

8. What was SRP's first purpose? How did it solve the problem of controlling the water? ____________

9. Describe how Roosevelt Dam was built. ____________

Segment 3: What About Tomorrow?

Read these questions before you view the video. Look and listen for the answers while you are watching the video.

1. A large amount of water is typically measured in acre-foot quantities. How much is an acre-foot? ____________

2. Why did we need to build more dams in the 20th century? ____________

3. Dams are used as storage reservoirs. What can they also be used for? ____________

4. What is the longest man-made river (canal) in Arizona? ____________

5. Describe how CAP "recharges" water into the ground. ____________

6. Describe how water gets from the watershed to your home. ____________

7. Name ways you can conserve water at home. ____________

LESSON 5: WE ALL NEED WATER, BUT SUPPLY IS LIMITED

Estimated Time for Lesson

45 minutes

State Standards

Standards Taught

- Social Studies – S3C3PO1: Describe the responsibilities of state government (e.g., making laws, enforcing laws and collecting taxes).
- Social Studies – S3C3PO2: Describe the responsibilities of the local government (e.g., determining land use, enforcing laws and overlapping responsibilities with state government).

Standards Addressed

- Social Studies – S4C1PO1: Use different types of maps to solve problems (e.g., historical maps).
- Science – S3C1PO1: Describe how natural events and human activities have positive and negative impacts on environments.
- Science – S3C2PO2: Describe benefits and risks related to the use of technology (dams and wells).
- Science – S6C3PO1: Identify the sources of water within an environment.

Objectives

Content Objective

Students will be able to analyze water-rights policies in Arizona by simulating and discussing important water-rights issues.

Language Objective

Students will use complex sentences to defend their positions in discussions of water-rights issues. Students will use key vocabulary to discuss water-rights issues.

Vocabulary

Allocate/allocation: a system of dividing a lot or resource, in this case water, among the various people who lay claim to it
Beneficial use: a recognized positive use made of the water in a river, lake, groundwater aquifer or other water body, including domestic, industrial and agricultural water supplies; fish and wildlife resources; power generation; contact recreation; aesthetic enjoyment; and others
Benefit: something that is advantageous or good
Compliance: cooperation, in this case following the law
Cost: the price paid to acquire, produce, accomplish or maintain anything (can be monetary, environmental, economical, social, etc.)
Law: the body of such rules concerned with a particular subject, in this case water
Local government: government at the city level, including the city council and the mayor as the highest executive (county government can fit into the term "local government" as well)
Priority: the right to take precedence in obtaining certain supplies, services, facilities, etc., especially during a shortage
Responsibility: an obligation upon one to do the right thing or what is expected of them
Right: a claim or title to something, in this case water
State government: government at the state level, including all three branches of government and the governor as the highest executive

Background Information

In a desert, water is not a renewable resource. And, as you now know, the water we use in Arizona must come from all over the state, so many people need and therefore must use our precious water resources. If water runs in a creek by your house, are you able to use it? Do you have the right to drink that water or does it already belong to someone else? What would you need to know in order to determine the answers to these questions? These questions of regulating the amount of water each "user" can use, called allocation of Arizona's water resources, are the focus of this lesson. The focus is also on students participating in the critical thinking, communication and problem solving needed to examine this critical issue in Arizona.

Regulation of Water Rights and Allocation

Water rights in Arizona are regulated based on whether or not the water is surface water or groundwater. This can get confusing because of the constant movement of water. Groundwater can become surface water through springs, surface water can infiltrate to become groundwater, etc. This relationship between surface water and groundwater can make for a lot of gray area in water laws. Based on the designation of water, it is subject to different sets of laws and regulations.

Surface-Water Rights

Surface water is defined as water that flows in streams, rivers, canyons, canals or in definite underground channels (just under the surface of the stream). Arizona state laws regarding surface-water allocation follow the Doctrine of Prior Appropriation sometimes referred to as "first in time, first in right." This simply means that the first person who puts the water to use has the right to use it before anyone else who comes later. Imagine your students coming in from recess and all standing in line for the drinking fountain. If you used the Doctrine of Prior Appropriation to determine who got to drink from the fountain first, you would have to start with the first student to ever take a drink from the fountain (since they were the first person to put the fountain to "beneficial use" in your classroom). This analogy is used in the lesson activity as well.

More Background About the Doctrine of Prior Appropriation

The Doctrine of Prior Appropriation arose out of mining practices during the gold-rush days of the 1800s. The miners constructed diversion canals to bring water to their sluicing areas. Therefore they did not have to own the land near that water in order to use it. The Phoenix metropolitan area and most associated areas have water rights through SRP, which has a senior water right because of the farmers who put the Salt and Verde rivers' water to use long ago.

However, there is another set of rules that governs surface-water rights. Surface-water rights are also regulated under the Arizona Surface Water Code of 1919 (now known as the Public Water Code). This law states that, in general, any person must apply for and obtain a permit in order to use surface water. The water must be put to a beneficial use in order to obtain a permit. Beneficial uses could include domestic (watering lawns, etc.), municipal (city use), irrigation, livestock watering, recreation, wildlife (including fish), storage and mining.

To illustrate what this means, let's return to the analogy of assigning students places in line for the drinking fountain. If you used both the Doctrine of Prior Appropriation and the Public Water Code to determine who got to drink from the fountain first, you would have to start with the first student to ever take a drink from the fountain (since they were the first person to put the fountain to "beneficial use" in your classroom).

Groundwater Rights

One can think of groundwater like a bank account. Just as you cannot withdraw more money from your bank account than you have deposited, we cannot withdraw more water than goes into the supply (either through precipitation or recharge). This balance is called **safe yield**. Because we monitor the amount of water that is being withdrawn (via a well and pump) and we have the capability to measure rainfall and snowpack as well as recharge amounts, we can monitor these bank-account-like transactions. When more water is withdrawn than is supplied, it is called **overdraft**.

In 1980, Arizona passed the Arizona Ground Water Management Code, the goal of which was to prevent and regulate the overdraft of aquifers in Arizona. The Arizona Department of Water Resources (ADWR) was charged with monitoring these water transactions. To make the job a bit easier, it divided the state into more-manageable pieces, called Active Management Areas (AMAs). The AMA boundaries usually follow the boundaries of the large aquifers in the state. Permits must be issued by the ADWR and by each AMA before water is allowed to be withdrawn. As with surface water, the amount that any one right-holder can withdraw is subject to adjudication and determining how much water is needed for beneficial use on the property.

The Law of the River

The Colorado River is managed and operated under numerous compacts, federal laws, court decisions and decrees, contracts and regulatory guidelines collectively known as the "Law of the River." This collection of documents apportions the water and regulates the use and management of the Colorado River among the seven basin states (Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming) and Mexico.

For more information and for specific laws that make up the Law of the River, go to **www.cap-az.com/about-cap/lawoftheriver**.

Procedures

Activity 5.1: Whose Water Is This Anyway?

Engage

Conduct a discussion and simulation with the class to understand the basics of water rights in Arizona.

Imagine that you are all lined up for the drinking fountain after recess. You have to be patient while you wait, but you know you'll get your drink when it's your turn. What is a fair way for everyone to get a drink?

Allow students to talk in pairs about a fair solution for everyone to get a drink.

Now imagine if the drinking fountain ran out of water, or better yet imagine that we only have this much water.

Hold up the pitcher that says "surface water."

How would that change your attitude? Would you act differently in line? Would you be upset if the person in front of you wasted the water?

How would you feel if someone cut you in line? How would you determine a solution to these problems?

Allow students to discuss these issues. Break students into pairs or teams. Have them discuss how they would solve the problem. Have them think of a drinking-water policy for the classroom. Allow students to share their ideas, and record them on a class chart. If needed, prompt students by asking leading questions like:

Who gets the first drink? How much water do you think each person should get? Are there acceptable uses for the water other than drinking?

Materials

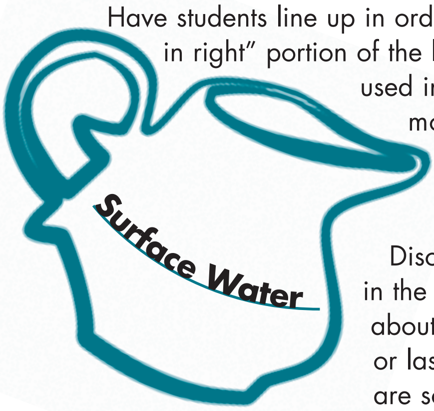
- Cups of various sizes
- 2 pitchers full of water (1 labeled "surface water" and 1 labeled "groundwater")
- 1 empty pitcher labeled "precipitation"
- 1 5-gallon bucket (empty)
- Whiteboard or chart paper and marker

Explore/Explain

Simulate the concepts as you explain the basics of water rights. First show students the pitcher of water that is labeled "surface water" and explain to them that the water in the pitcher is going to simulate the surface water we have available in Arizona to use.

How should we determine the order in which people should line up for a drink of the water?
Allow students to pose ideas.

Just like you don't like it when someone cuts in front of you in line at the drinking fountain, no one likes to be cut in front of when getting the water they need for their daily use. If someone tries to skip in front of you in line, you say, "Hey I was here first!" Each person has to wait his/her turn. Arizona's law is sort of like that. The people who were here first get the first "drink," or allocation, from the rivers. So to simulate that, I will start with the oldest student in our class since that student has been on Earth the longest.



Have students line up in order by birth date (oldest to youngest). This simulates the "first in time, first in right" portion of the law. While this procedure is slightly different from the analogy used in the Background Information portion of the lesson, this type of lineup is more realistic for the typical classroom setting (rather than trying to remember the order in which students came into the room on the first day of school).

Discuss their feelings about this policy as a class. Ask people at various places in the line how they feel about being in that place. Encourage students to think about how they would feel if they were first or second in line, middle of the line or last. Emphasize to students that this is why water rights and disputes are so important and difficult.

Now lead a discussion about the approved uses of water in this situation.
Let's suppose I start with the oldest person in class, and that person fills a cup up to drink but does so carelessly and spills some. Should that be allowed? What if the person wanted to drink some of it and pour the rest out? How about if the person drank some of it and then used the rest to shower or water a plant? What activities will you allow people to use the water for?
Listen to student discussion about which uses they will permit. Write these answers on chart paper or a whiteboard.

Show students the different sizes of cups they have to choose from. Say to students:
These cups are going to represent how much water each of you gets to use. Notice that they are different sizes. When it is your turn, come up and choose the size of cup you will need, as long as you are using it all for one or more of the approved uses.

Point to class chart of approved uses. Allow students (in line order) to choose the size of cup they would like, and have them explain to the class how they plan to use it. Continue with this process from the "surface water" pitcher.

Ask students what they think should be done for the remaining students so that everyone can get the water they need. Prompt students, if needed, to use the "groundwater" pitcher.
We can use the groundwater to fill your cups, but there is a law about groundwater that we have to know before we do it. The law is that we cannot pour more water out of the bucket (or aquifer) than we put back in. To monitor this balance, we will measure the water table. The water table is the top level of water in an underground aquifer.

Mark a line with a washable marker on the side of the pitcher right at the water line and label it "water table."

If we use water so the water table falls below that point, we have to replace it somehow. How could that water be replaced?

Prompt students to recall the water cycle and that when it rains or snow, some of the water infiltrates back into the ground.

Yes, the groundwater may be replaced with precipitation.

Pour the water in the same way as for the "surface water" pitcher in the beginning of the simulation, requiring students to tell you what they will use the water for. Continue the simulation until everyone gets water or, more likely, the water runs out.

We are out of water for the year, and our underground aquifer is low. What will need to happen next year for us to replenish our groundwater supply? (rain) Let's simulate the next year now and see what issues we run into.

Have students "use" their water by pouring it into a 5-gallon bucket.

Before we begin again, we need to consider annual precipitation like we studied in Lesson 2.

Fill the empty pitcher labeled "precipitation" with water.

As it rains on Arizona's watersheds, the water has two paths it can take. What are those two paths?

(flow along the surface into rivers or infiltrate into the ground) When students identify those paths, pour "precipitation" from the pitcher into the "surface water" and "groundwater" pitchers. Be sure to fill the "groundwater" pitcher back up to the water-table line and remind students that we cannot use more water than is replenished. Pour the rest of the water into the pitcher labeled "surface water."

What do you notice about the water levels now?

(less available surface water)

Have students make predictions about what will happen during the new "cycle." Have students also brainstorm ways we can prepare in years of higher levels of precipitation for years with smaller levels of precipitation (conservation, capture and storage of precipitation in reservoirs).

The issues you all thought about are the same ones officials at both local and state government levels in Arizona debate. We all need water, but the supply is limited. Therefore we must be good stewards of this precious resource.

Extend

Allow students to research their questions more in depth and present their findings to the class. Water-rights information can easily be found through the Arizona Department of Wat Resources and the Arizona Department of Environmental Quality Web sites. This is also a great place to begin the discussion about how humans impact their environment, and the costs and benefits associated with controlling and regulating water in our environment. One option is to have students present the costs and benefits of a particular law or regulation from various points of view.

Evaluation

Social Studies – S3C3PO1: Describe the responsibilities of state government (e.g., making laws, enforcing laws and collecting taxes).

Social Studies – S3C3PO2: Describe the responsibilities of the local government (e.g., determining land use, enforcing laws and overlapping responsibilities with state government).

Assessment

Have students write a summary and reflection in their science notebooks or as a "quick write" to the teacher, addressing the following questions. Write on whiteboard or overhead projector.

- Summarize the laws for how surface water and groundwater are allocated in Arizona.
- What are the acceptable uses for water? Are there some that we listed that you don't think should be included as an acceptable use?
- Who or what else uses water in Arizona that didn't have a cup? How do you think we should plan for those users?
- What questions do you have about how the laws work in Arizona to monitor these water rights?

Lesson Closure

Allow students time to discuss their written answers to the questions above.

LESSON 6: MY WATER USAGE – HOW CAN WE USE WATER WISELY?

Estimated Time for Lesson
3 hours (suggested to be done on multiple days)

State Standards

Standards Taught
- Science – S4C3PO1: Describe ways various resources (e.g., water) are utilized to meet the needs of a population.
- Science – S6C2PO6: Analyze evidence that indicates life and environmental conditions have changed (e.g., tree rings).
- Science – S4C3PO3: Analyze the effect that limited resources may have on the environment.
- Science – S4C3PO4: Describe ways in which resources can be conserved.

Standards Addressed
- Science – S4C1PO1: Compare structures in plants that serve different functions in growth and survival.
- Science – S3C1PO1: Describe how natural events and human activities have positive and negative impacts on the environment.

Objectives

Content Objectives
- Students will be able to analyze their own (and their families') water usage at home.
- Students will be able to describe the types and benefits of water-saving devices they can use at home.
- Students will be able to analyze evidence from tree rings to study Arizona's climate for the past 700 years.
- Students will be able to draw conclusions from tree-ring evidence about the future water needs of our community.
- Students will be able to describe recommendations for ways in which water can be conserved for future sustainability.

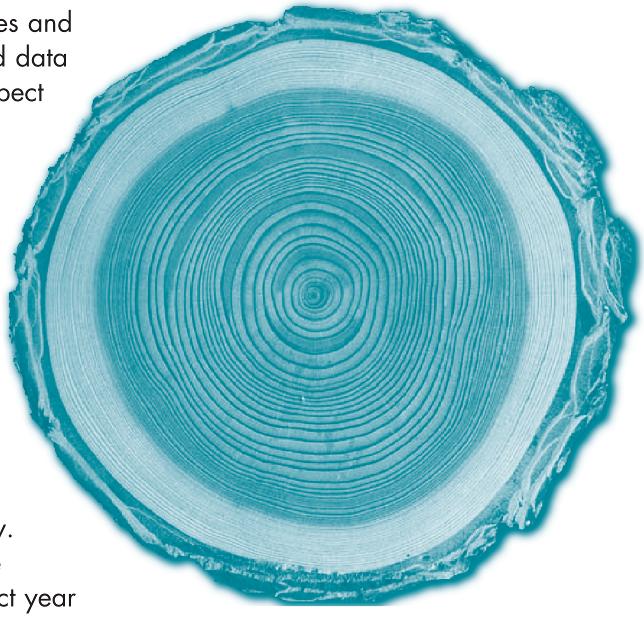
Language Objective
Students will write a paragraph about their home water usage using complex sentences, including one habitual past sentence (e.g., "We used to run the faucet while we brushed our teeth,") and one simple present sentence (e.g., "but now we turn off the faucet.") to describe their home water use in the past and present.

Vocabulary
Benefit: something that is advantageous or good
Conserve: save or use wisely
Tree ring: a layer of wood cells produced by a tree in one year, usually consisting of an earlywood ring plus a latewood ring
Water-saving device: something made for the specific purpose of conserving water
Watershed manager: a person who controls and manipulates resources, in this case water, in a particular land area

Background Information

Tree-Ring Study

SRP and CAP both deliver water for the people who live in Arizona and therefore need to carefully measure and capture each drop so that none is wasted and the water can be used for the benefit of the people who live here. Thus both companies measure the streamflow of their rivers and collect data they can analyze to predict future supplies and plan accordingly. Within the past 100 years, we have gathered data from streamflows, so we have a pretty good idea of what to expect for the coming years.



However, when planning for future needs, we need to look beyond the next 100 years, which means we need to look back more than 100 years. Thus scientists have had to look beyond streamflow to other means of collecting information about the climate in the past — trees!

Did you know that trees carry a long, historical story in their trunks? Scientists are able to study cut sections of a tree to provide them with valuable information, such as determining the age of the tree and how fast it grew during certain time periods. This historical study of trees is called dendrochronology. Dendrochronology (dendron = tree, chronos = time, logos = the science of) is the science that uses tree rings, dated to their exact year of formation, to analyze temporal and spatial patterns of processes in the physical and cultural sciences. A **tree ring** is a layer of wood cells produced by a tree in one year, usually consisting of thin-walled cells formed early in the growing season (called earlywood and is lighter in color) and thicker-walled cells produced later in the growing season (called latewood and is darker in color). The beginning of earlywood formation and the end of the latewood formation form one annual ring, which usually extends around the circumference of the tree.

Scientists are even able to study the cut sections of tree trunks to determine what the climatic conditions were like during this time. Such study is called dendroclimatology and can examine present climate as well as reconstruct past climate. In fact, that is just what the University of Arizona's Laboratory of Tree Ring Research (UA LTRR) did. UA LTRR conducted a study of the trees on the Salt and Verde watersheds to tell us a little bit more about the historical climate of the area. This data can be used to educate us about the area's past and also to plan for the future.

The LTRR Study

Scientists from UA and SRP were able to go up into the watershed region and collect data from trees in the areas where we get our water. This enabled them to gather data from the past 700 years. The scientists could look at the width of the tree ring and use a formula to determine the approximate rainfall for that year. From that analysis, scientists found that 1996 was the second-lowest predicted rainfall value since 1330. Additionally, 2002 was the driest year since 1330, and some trees didn't even have a ring for 2002, which means there was no growth in the tree for that year. The conclusion that both of the driest years since 1330 were in our very recent history worried watershed managers like SRP. This gives even more importance to our planning and conservation efforts.

From that LTRR data, the scientists were also able to conclude that there were dry periods that lasted up to 30 years. Yet even within a 30-year dry period, there were wet years. They found that there was never a period greater than five years when we didn't have some sort of wet event (heavy rain or snow). Thus from a watershed management planning standpoint, within a dry period of time (or dry cycle), if you can capture the water, you'd have enough to last you until the next wet event. Thus we should have a secure supply of water for years to come, as long as we are monitoring, conserving and planning accordingly.

Materials

- Copies of Student Data Chart (2 per student)
- Chart paper
- Markers
- Graph paper (optional)

Literacy Link

(WS2C4PO3) Using old magazines, allow students to find and cut out pictures of activities or devices that use water. Have students glue the pictures into a collage and write a sentence under each one explaining how the activity or device uses water.

Procedures

Activity 6.1: Personal Water Conservation
30–60 minutes

Engage/Explore

Ask students to list all the ways water is used in their homes. Write these on the board. Ask students which activities they think use the most water.

Pass out water-use chart and graph pages.
Now you are going to be water detectives. Use this list to keep track of how much water is used in your home for one day. Each time one of the activities happens, put a tally mark next to it. It is hard to know everything that goes on at home, but try to be as accurate as you can.
It may be more helpful to allow students to conduct their home-water-use audit over an entire week so they have enough data to show trends.

When the students come in with their lists, have them multiply the number of marks by the number of gallons for that activity and list the total. Use a calculator to total the number of gallons for each activity for the whole class and the class total for all activities.
Have students list these class totals on their charts.

Ask students to suggest ways water could be saved at home. List all suggestions on the board. (Examples: Turn off the faucet when you brush your teeth. Turn off the shower when you soap. Only wash full loads in the dishwasher and washing machine.) Ask students to copy the water-saving suggestions onto their own pieces of paper or into their science notebooks and take them home to talk over with their families.

Pass out a new water-use chart. The students now keep a record of a day or week (same period of time as first audit) with the family more water-conscious. Total the individual usage and the class usage as before. Now direct the students to graph the class water-use totals for each activity. Use graph paper and set up each axis as shown in the diagram below the chart. Have students decide how to number the left axis. Use two colors to represent the two days. Tell them not to forget to include a key.

Activity 6.2: Water Savings All Around Us
30 minutes

Engage

Refer and remind students of their learning in Activity 6.1. Discuss with a partner:

What are some of the ways that we determined we could save water in our daily lives?

Review ideas as a class.

Introduce the Lesson

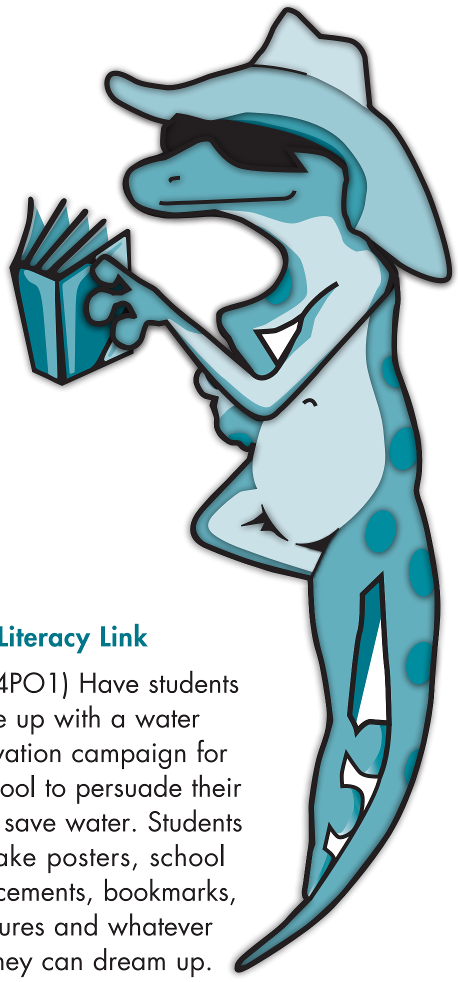
In the last activity, we learned about how we can change our behavior to save water. Now we are going to learn about some devices used to save water around our homes.

Explore

Pass out the Water-Saving Devices Matching Game cards. Have students work in pairs or groups to match each picture of a water-saving device to what it is used for. It is helpful to have some examples for students to pass around. Some of these devices can be purchased cheaply at a hardware store.

Explain

Use the Water-Saving Devices PowerPoint to review the answers to the matching game and to explain the uses of the devices. You can find the PowerPoint presentation in Appendix F and in the Supplementary PowerPoint folder on the CD-ROM.



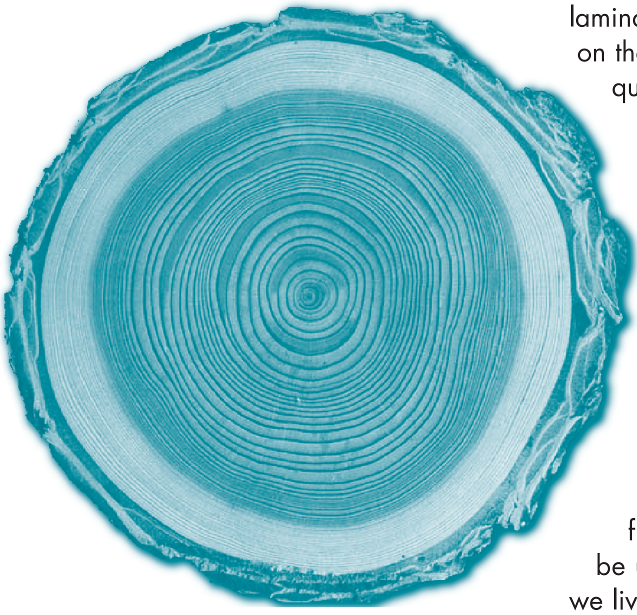
Literacy Link

(WS3C4PO1) Have students come up with a water conservation campaign for their school to persuade their peers to save water. Students can make posters, school announcements, bookmarks, brochures and whatever else they can dream up.

Materials

- Laminated tree-ring photographs*
- Student data sheets
- Chart paper
- Markers

(*found in Appendix F and in the Supplementary PowerPoint folder on the CD-ROM)



Activity 6.3: Water in the Desert – Past – Tree-Ring Inquiry
60 minutes

Engage

If possible, give students samples of tree-ring cores to observe; otherwise post a photograph on a projector for students to observe. Prompt students to use their observational skills and record their observations in a science notebook or on a piece of paper. Then have them brainstorm with a partner or group what they could be and what information they could give scientists. Write ideas on the board or chart paper.

Explore

Explain to students what a tree ring is using the samples or one of the photographs (review Sample A as an example). Count the number of rings and the diameter for each sample and record on the Tree-Ring Data Sheet (could do in groups with laminated copies of the photographs or as a class on the overhead). Graph the results and use questions found on worksheet to lead a discussion and make generalizations about what tree rings are used for.

Explain/Extend

Use the Tree-Ring PowerPoint to explain the tree-ring study conducted by the UA LTRR (see Background Information section for details). You can find the PowerPoint presentation in Appendix F and in the Supplementary PowerPoint folder on the CD-ROM. Use prompts at the end of the PowerPoint for students to make predictions of future water supplies and how tree rings can be used to help manage the watershed in which we live.

Activity 6.4: Water in the Desert – Future – Problem-Based Learning
45 minutes

Procedures

Give student groups the situation cards and have them read the situation aloud:

> "You have been asked to form a Water Conservation Advisory Committee to advise the city council and watershed managers in planning for the future use of the water that falls on our watershed.
>
> 1. Use your knowledge of the past in looking at tree rings from Activity 6.3 and predictions about future water supplies to help you know how much water you may have to work with.
> 2. Use your knowledge from Activity 6.1 to help give you an idea of how much water is needed for daily use (demand). It may be helpful to look up the population of your city and the other cities in your watershed to calculate the total amount of water that is needed.
> 3. Use what you have learned about water-saving devices from Activity 6.2 as well as any other information from this unit to make your recommendations to the city council and watershed managers.
>
> You will make a poster giving (1) your predictions about the future water supply in your town, (2) your predictions about how much water will be needed (the demand) in your town in the future and (3) your recommendations to meet the water needs of the community. Good luck, Water Conservation Advisory Committee!"

Monitor and provide feedback as students complete the project. Have students share their presentations with the class when finished.

Materials

- Chart paper (1 per group)
- Markers
- Situation Cards

Evaluation

Science – S4C3PO1: Describe ways resources (e.g., water) are utilized to meet the needs of a population.

Science – S4C3PO4: Describe ways in which resources can be conserved.

Assessment

Students will write a paragraph in their science notebooks or on sheets of paper describing their water use before and after the lesson.

Science – S6C2PO6: Analyze evidence that indicates life and environmental conditions have changed (e.g., tree rings).

Science – S4C3PO3: Analyze the effect that limited resources may have on the environment.

Assessment

Students' worksheets and presentations — see Appendix for possible answers.

x − + % =

Math Connection

(MS2C2PO2) Have students make a graph showing their predictions about the future water supply in Arizona using precipitation data from the past. Then have students make a graph showing their predictions about the future population of Arizona. For data tables you can use, go to www.srpnet.com/education and click on "Arizona Water Story."

Language Objective Assessment

Students will write a paragraph about their home water usage using complex sentences, including one habitual past sentence (e.g., "We used to run the faucet while we brushed our teeth,") and one simple present sentence (e.g., "but now we turn off the faucet.") to describe their home water use in the past and present.

Lesson Closure

As a conclusion to the lesson, have the students discuss the following in pairs:

- Explain how you are going to save water at home (either by changing your behavior or installing some of the devices you learned about).
- Explain what we learned from the tree-ring research and why it is important.

Literacy Link

(WS2C3PO1; WS3C3PO2) Students can write a persuasive letter to the city council about water conservation recommendations for changes that should be made in order to ensure a water supply for the future population of Arizona.

Name: ____________________

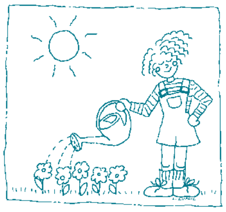
Lesson 6 Student Data Chart

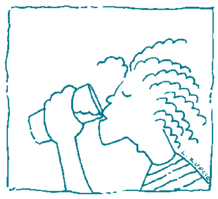
How Much Water Do We Use?

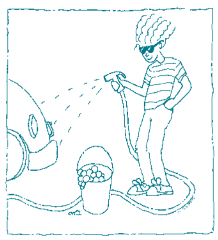
Directions

You are going to do a family water audit. Use this data table to record your family's water usage at home. Every time someone does one of the activities listed in the chart, place a tally in the third column. At the end of your water audit time period, fill in the columns by doing the necessary calculations. Be prepared to share this information with your class.

Activity	Gallons of water per use (approx.)	Number of uses in one day/week	Family total (# of uses × gallons)	Class totals (family totals × # of students)	Rank of most to least water use
5-min. shower	20 (old) 12 (new) 8 (low-flow)				
Water yard	180				
Wash dishes	13 (by hand) 8 (by machine)				
Wash clothes	35				
Wash car	50				
Brush teeth	2 (water running)				
Cleaning and cooking food	5 (water running)				
Drinking	½				
Flush toilet	4 (standard) 1.6 (low-flow)				
Toilet or faucet leak	60				
Totals					

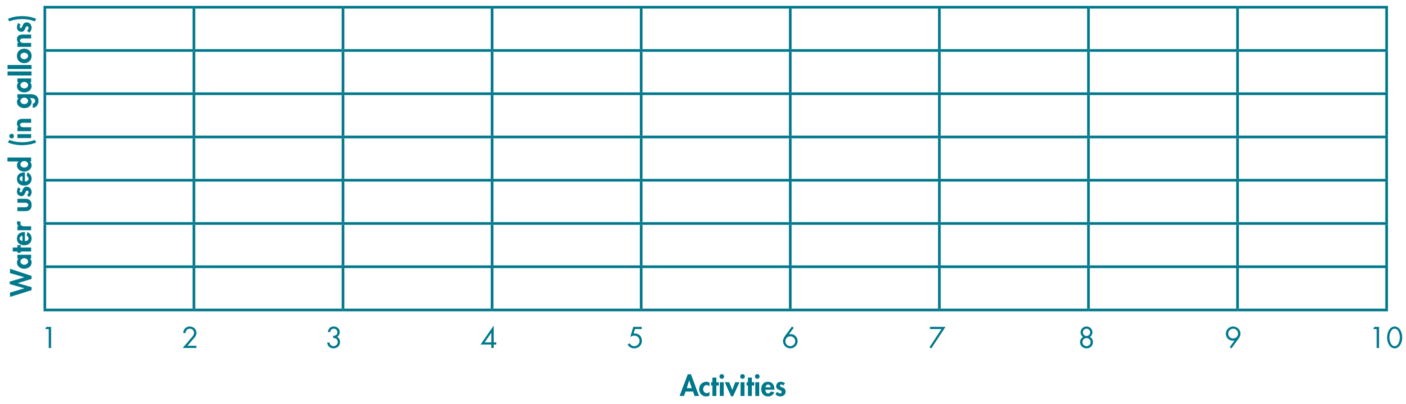






Lesson 6 Graph Worksheet

Water Conservation at Home



Questions

1. Which activities used the most water?

2. How do you use the graph to determine how much water was saved the second day by using the conservation suggestions?

3. Which conservation suggestion saved the most water?

4. List two ways water can be conserved in your bathroom.

5. List two ways water can be conserved in the kitchen and laundry room.

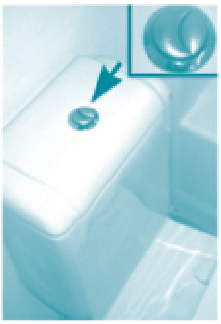
6. Water can be saved outside your home, too. The following are water-wasting activities. Describe a way to do these jobs differently so you can conserve water. (You might want to get help from your parents.)

   a. Cleaning the driveway with a hose:

   b. Planting your yard with grass and water-loving plants:

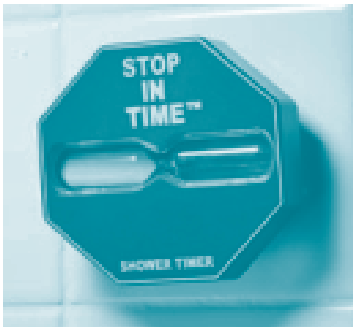
   c. Watering your yard with a sprinkler:

WATER-SAVING DEVICES MATCHING GAME



Dual-Flush Toilet

Toilet Tab



Shower Timer

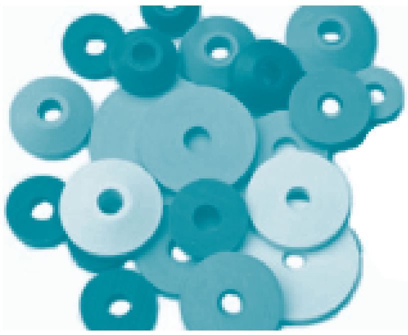
This type of toilet flushes half a flush if you press the No.1 button (liquid only) and a full flush if you press the No. 2 button.

These tablets can be used to determine if you have a leak in your toilet or not. Simply place a tablet it in the tank of the toilet, wait 10–20 minutes and check if there is blue water in the toilet bowl. If there is, you have a leak and are wasting water without intending to. Checking for leaks and fixing them quickly can save hundreds of gallons of water per year.

This five-minute timer is placed in your shower and helps you pace your shower so that you don't spend longer than five minutes running the water. Just twist it when you get in and the sand starts to run to the opposite end of the timer. When it runs out … you get out!

Lady Bug

Faucet Aerator



Rubber Washers

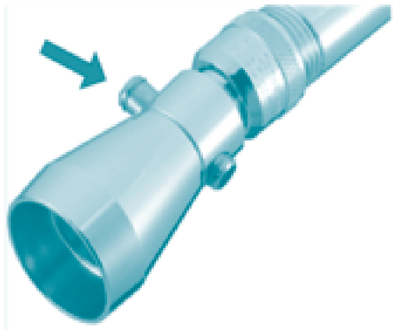
Do you let the water run while it's getting hot? This "Lady Bug" is installed between your showerhead and the pipe that connects it to the water source, and helps to reduce the amount of water lost by shutting the shower off when the water is warm. Then when you are ready to get in, you pull the cord to turn the shower back on.

This little device is like a screen the water has to pass through to come out of the faucet. It helps save water because it decreases the flow rate of water (less water flows through the faucet in a given time period) while it increases the pressure of the faucet (so you don't feel like you need to use as much). It costs less than $1 at any hardware store, so it's a cheap and easy way to save water.

Like you learned about with toilets, leaks can waste a lot of water. If you see a faucet dripping, that means the rubber washer needs to be replaced. This is another cheap and easy repair that can save a lot of water and money.

Lawn Hose Sprayer

This device saves water in the same way the faucet aerator does. It funnels water from the hose through narrow nozzles, decreasing the amount of water used while increasing the pressure, so we don't need to use as much.



Showerhead With Pause Button

This specially designed showerhead has a button that turns the water on and off, so you can turn the water off while shampooing your hair or washing your body, and then turn it on again to rinse off.

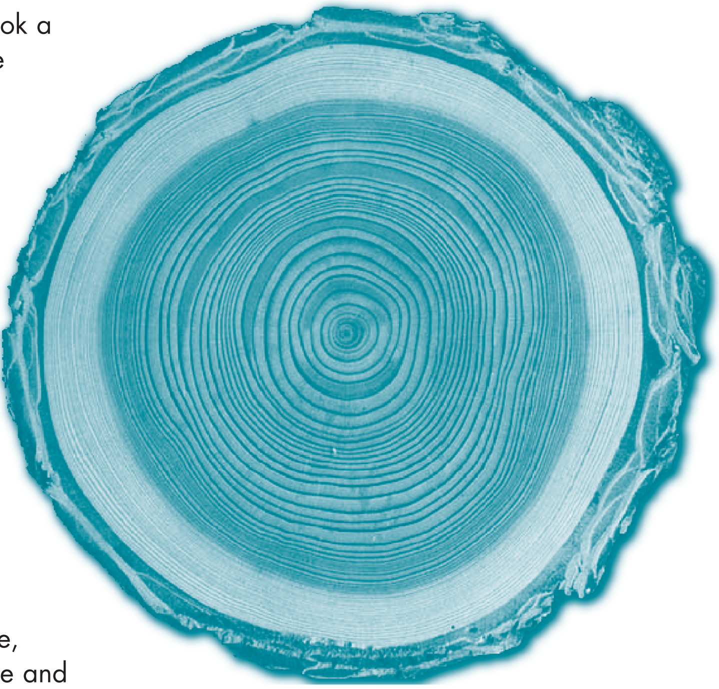
Tree-Ring Data Sheet

Name: ______________________________

Is there a pattern between the size of a tree trunk (its diameter) and its age (number of rings)?

Background Information

When you look at a cross section of a tree, you will see a pattern of rings. Each ring is a layer of wood that took a season to grow. This is usually one year. But the tree does not grow at the same speed all year. In our climate, it grows very quickly in spring and summer, slowly in the autumn and not at all in the winter. The light ring is larger because it is the spring and summer growth; the dark ring is the slow autumn growth.



When you look at the rings, one year is a light and a dark ring together. To find the age of the tree when it was cut down, just count the dark rings. The oldest ring is the small one in the middle and the youngest is the last ring just below the bark (flaky layer on the outside). So how old is this tree?

Measuring

Now that you know how to find out the age of a tree, we can try to see if there is a pattern between its age and the size of the trunk. For this you will need photos of tree sections and a table to record results.

Your teacher will give you the photos, and on each one you will see a tape measure so you can find out the diameter of the section in centimeters. Then all you need to do is count the rings to find out the age of each tree. Put your results in a table; your teacher may give you a table to fill in.

Recording Your Results

Here is a table that you could use with the 12 photos. The first section, which is the smallest, has been recorded for you.

Sample letter	Diameter of the tree (in cm)	Age of the tree (number of rings)
a	7	8

Drawing a Graph

You will see a pattern better if you draw a graph using your results. Use graph paper to draw a graph with an X and a Y axis. On the horizontal, or X, axis, put the diameter of the tree in (cm). The scale will need to go from 0 to 40. On the vertical, or Y, axis, put the age (number of rings). The scale will need to go from 0 to 50. Plot your 12 answers from the table.

The Pattern

1. Is there a pattern on your graph? Describe what you see.
   What happens to the size of the tree as it gets older?

____

____

____

2. What can you infer from this exploration about what tree rings are used for?

____

____

____

3. Are all the tree rings the same size?

____

____

____

4. Why do you think some tree rings are thin while others are thick?

____

____

____

Activity 6.4 Situation Cards

You have been asked to form a "Water Conservation Advisory Committee" to advise the city council and watershed managers in planning for the future use of the water that falls on our watershed.

1. Use your knowledge of the past in looking at tree rings from Activity 6.3 and predictions about future water supplies to help you know how much water you may have to work with.

2. Use your knowledge from Activity 6.1 to help give you an idea of how much water is needed for daily use (demand). It may be helpful to look up the population of your city and the other cities in your watershed to calculate the total amount of water that is needed.

3. Use what you have learned about water-saving devices from Activity 6.2 as well as any other information from this unit to make your recommendations to the city council and watershed managers.

You will make a poster giving (1) your predictions about the future water supply in your town, (2) your predictions about how much water will be needed (the demand) in your town in the future and (3) your recommendations to meet the water needs of the community. Good luck, Water Conservation Advisory Committee!

Activity 6.4 Situation Cards

You have been asked to form a "Water Conservation Advisory Committee" to advise the city council and watershed managers in planning for the future use of the water that falls on our watershed.

1. Use your knowledge of the past in looking at tree rings from Activity 6.3 and predictions about future water supplies to help you know how much water you may have to work with.

2. Use your knowledge from Activity 6.1 to help give you an idea of how much water is needed for daily use (demand). It may be helpful to look up the population of your city and the other cities in your watershed to calculate the total amount of water that is needed.

3. Use what you have learned about water-saving devices from Activity 6.2 as well as any other information from this unit to make your recommendations to the city council and watershed managers.

You will make a poster giving (1) your predictions about the future water supply in your town, (2) your predictions about how much water will be needed (the demand) in your town in the future and (3) your recommendations to meet the water needs of the community. Good luck, Water Conservation Advisory Committee!

APPENDIX A: UNIT SUPPLY LIST

You will need the following materials to do the activities in this unit. We suggest you ask students and parents to bring in some of the items from home. Many hardware, grocery or discount stores also donate items like these for use in schools. You may also be able to find grant funding in your area. The supply list below includes materials (other than worksheet copies) for about 25 students grouped into teams of five. Individual materials lists are also included for each activity.

Art Supplies
- ☐ Colored pencils
- ☐ Markers
- ☐ Chart paper
- ☐ Scissors
- ☐ Blue, green, yellow and red sticky dots or overhead markers
- ☐ Graph paper
- ☐ 25 sheets heavy-grade white paper
- ☐ Water-soluble blue paint
- ☐ 450 (approx.) file-folder labels
- ☐ Clear marbles, enough to fill a jar

Kitchen or Household Items
- ☐ 5 measuring cups or graduated cylinders
- ☐ 5 clear containers (large enough for 1,000 ml water)
- ☐ Eyedropper
- ☐ Ice cube
- ☐ Dish
- ☐ Lamp
- ☐ 5 small- to medium-size clear plastic bins
- ☐ 5 pitchers of water, 1 gallon each
- ☐ 14 packages (26 ounces) salt
- ☐ 5 bags (5 pounds) all-purpose flour
- ☐ Food coloring
- ☐ 5 large spoons for stirring
- ☐ 5 spray bottles
- ☐ 1 roll cellophane
- ☐ 450 (approx.) toothpicks
- ☐ 25 large shoebox lids or heavy cardboard
- ☐ 5 aluminum pie plates or other containers
- ☐ Tablecloths or newspaper for 5 tables
- ☐ 15 clear plastic glasses, 3 per group
- ☐ 15 clear plastic pop bottles, 3 per group
- ☐ 5 liquid-soap dispenser pumps
- ☐ Clear pint jar
- ☐ Cups of various sizes

Hardware Items
- ☐ 10 pounds pea gravel
- ☐ 5 pounds sand
- ☐ Small shovel
- ☐ ½ yard wire mesh or screen
- ☐ 5-gallon bucket

Teaching Supplies
- ☐ Inflatable globe (1)
- ☐ Copies of blackline masters as indicated throughout unit

APPENDIX B: GLOSSARY OF TERMS

Accumulation: the buildup of water particles as they travel down a land area

Allocate/allocation: a system of dividing a lot or resource, in this case water, among the various people who lay claim to it

Aquifer: an underground layer of permeable rock, sediment (usually sand or gravel) or soil that yields water

Basin: synonymous with watershed

Beneficial use: a recognized positive use made of the water in a river, lake, groundwater aquifer or other water body, including domestic, industrial and agricultural water supplies; fish and wildlife resources; power generation; contact recreation; aesthetic enjoyment; and others

Benefit: something that is advantageous or good

Cardinal directions: the four main points of the compass (north, east, south and west)

Compass rose: a symbol on a map indicating direction (e.g., north or southwest)

Compliance: cooperation, in this case following the law

Condensation: the change in state of a gas to a liquid

Conserve: save or use wisely

Cost: the price paid to acquire, produce, accomplish or maintain anything (can be monetary, environmental, economical, social, etc.)

Desert Region (Basin and Range): southernmost region of Arizona, characterized by little rain and low elevation

Desert: a land area that receives less than 10 inches of rain annually

Drought: a long period of abnormally lower rainfall that creates a shortage of water

Erosion: the process through which the surface of the Earth is worn away by water, glaciers, wind, waves, etc.

Evaporation: the change in state of a liquid to a gas

Floods: when large amounts of water overflow the banks of rivers and streams

Groundwater: water found underground in aquifers

Human features: the patterns that people make on the surface of the Earth, such as cities, roads, canals, farms and other ways people change the Earth

Law: the body of such rules concerned with a particular subject, in this case water

Legend: the map key that explains the meaning of map symbols

Local government: government at the city level, including city council and the mayor as the highest executive (county government can fit into the term "local government" as well)

Mountain Region (Central Highlands): central region of Arizona, characterized by mountainous terrain, higher elevation and high levels of precipitation

Overdraft: when more water is withdrawn from a well than is replenished through natural (rain) or unnatural (recharge) cycles

Physical features: characteristics of a place that are part of the physical environment (e.g., mountains, deserts and bays)

Plateau Region (High Desert): northeastern region of Arizona, characterized by relatively flat terrain but high elevation (see Background Information for further description)

Porosity: the amount of space that exists between gravel, sand or soil particles below ground

Precipitation: any form of water, such as rain, snow, sleet or hail, that falls to the Earth's surface

Prehistoric: the time before there were any written records

Priority: the right to take precedence in obtaining certain supplies, services, facilities, etc., especially during a shortage

Relief map: a type of map that shows elevation and land features in three dimensions

Renewable energy: energy produced with a source that is created over and over again by nature

Reservoir: a large natural or artificial lake that is used to store water until it is ready to be used

Responsibility: an obligation upon one to do the right thing or what is expected of them

Right: claim or title to something, in this case water

Runoff: rainwater or snowmelt that flows over the surface of the ground (instead of infiltrating the soil)

Safe yield: the amount of water withdrawn from an aquifer through well pumping, less than the amount of water being replenished through natural (rain) or unnatural (recharge) causes

State government: government at the state level, including all three branches of government and the governor as the highest executive

Surface water: water found on the surface of land

Transpiration: the process of water evaporating from a plant (or living thing) into the atmosphere

Tree ring: a layer of wood cells produced by a tree in one year, usually consisting of an earlywood ring plus a latewood ring

Water cycle: the continual movement of water throughout our environment (through processes of evaporation, transpiration, precipitation, runoff, infiltration and accumulation)

Water-saving device: something made for the specific purpose of conserving water

Water vapor: water in the form of a gas

Watershed: a land area that drains to a body of water (river, lake, reservoir, etc.) often named for that body of water (e.g., Salt River Watershed)

Watershed manager: a person who controls and manipulates resources, in this case water, in a particular land area

APPENDIX C: STUDENT VOCABULARY PAGE

Word: ____________________

Picture

Definition: ____________________

Word: ____________________

Picture

Definition: ____________________

Word: ____________________

Picture

Definition: ____________________

Word: ____________________

Picture

Definition: ____________________

APPENDIX D: UNIT ANSWER KEY

Lesson 1

Activity 1.1 Worksheet – What We Know About Water

Answers vary.

Activity 1.4 Worksheet – Water Cycle Observation Sheet

Step 1 – Students should observe water infiltrating into the sand and gravel and creating one line (level) on the side of the bin. This line is called the water table. It's important for students to notice that if they let the water infiltrate long enough, the line becomes even across both the "ocean" and the "mountain" portions of their models.

Step 2 – Students should notice that the more they spray, the water, or "rain," begins to collect together, forming streams and rivers down the "mountain" and back to the "ocean," or low point. This simulates the action of water falling on a watershed (land area that drains water to a low point). The "ocean" in this model could be a lake or reservoir as well. Students should also notice that some of the sand will fall into the water, simulating erosion.

Step 3 – Students should notice condensation on the cellophane "atmosphere" of their model. This allows students to draw conclusions about the water evaporating from the "ocean" and condensing into "clouds" on the cellophane.

Step 4 – Student visual representations may vary but should accurately portray the actions of water in the environment. Diagrams should also include the following labels: accumulation, evaporation, precipitation, runoff, erosion, surface water and groundwater.

Lesson 2
Activity 2.1 – Map Rubric

ACTIVITY 2.1 MAP RUBRIC		
☑	Labeled cardinal directions.	1 point
☑	Located the Grand Canyon.	1 point
☑	Located and labeled the Mogollon Rim.	2 points
☑	Located and traced Colorado, Gila, Verde and Salt rivers.	2 points
☑	Located Phoenix, Tucson, Prescott, Flagstaff and Yuma.	3 points
☑	Located and labeled Hoover Dam.	1 point
☑	Located and labeled Roosevelt Dam.	1 point
☑	Located the Central Arizona Project (CAP) Canal.	1 point
☑	Correctly colored and labeled the three regions of Arizona.	3 points
☑	Score:	15 points total

Activity 2.2 and 2.3 – Ticket Out Assessment

1. Students should correctly identify the definitions of human and physical features, and give three examples of each.

2. Students should write one correct sentence for each region describing the characteristics of that region (animals, cities, elevation, rainfall, plants, etc.).

Lesson 3

Activity 3.2 – Groundwater

Part 1

1. Gravel and sand will hold similar amounts; may differ depending on how uniform gravel-particle sizes are.

2. Mixture holds the least.

3. Mixture holds the least because the sand fills in the spaces between the gravel particles.

Part 2

1. Gravel will drain most quickly.

2. Sand or mixture will drain most slowly.

3. No, sand and gravel held similar amounts, but gravel drains more quickly because spaces are larger. (Water molecules have less surface area of soil particles to adhere to.)

Part 3

1. The water table will go down.

2. Water can be used in homes for cleaning, bathing, drinking, cooking and watering yards, as well as for industry.

3. Rain can percolate into the ground to recharge aquifers. Water from rivers running out of the mountains can sink into the ground and recharge aquifers.

4. If there is no recharge, wells will eventually go dry.

5. Would have to find another source of water, move out of area or die.

Lesson 4

Arizona Water Story Video Guide

Segment 1: The Water We Take for Granted

1. Take a shower; brush teeth; wash dishes; water garden

2. Southwestern region of U.S.

3. Colorado River

4. Connected; tributaries of the Colorado River

5. and 6.

Colorado Plateau Region	Mountain Region	Desert Region
Sandstone Painted Desert Grand Canyon Rock formations Flagstaff Pine trees Blue Spruce Cottonwood Mogollon Rim Snowy winters	Mountain ranges Mogollon Rim Much more snow and rainfall Verde, Salt, Gila and Aqua Fria rivers drain watersheds in this region Sedona	Hot and dry Sonoran Desert Less than 10 inches of rain Saguaro cactus Agave Coyotes Phoenix "Sky islands" of mountains Tucson Nogales Summer May to October Frost-free year-round growing season A good place to farm Not much surface water; use of groundwater

7. Mountain Region due to higher elevation

Segment 2: Arizona Wasn't Always This Way

1. Hohokam

2. Development of agriculture, canal system

3. Jack Swilling was a prospector and explorer who saw a need for a canal system and used the early Hohokam canals to divert Salt River water to ditches for growing crops.

4. Mexican-American War, Treaty of Guadalupe-Hidalgo, Gadsden Purchase

5. Periods of flood and drought made water sources inconsistent.

6. Farmers decided they needed a storage reservoir and needed to build a dam but did not have enough money.

7. Theodore Roosevelt passed the National Reclamaition Act which provided people with government loans to build dams.

8. SRP was first responsible for building Theodore Roosevelt Dam which made water flow constant and consistent for the farmers in Phoenix.

9. SRP used stone from nearby mountains to construct the dam, which was completed in 1911. The Apache Trail was constructed for the project.

Segment 3: What About Tomorrow

1. An acre-foot is equivalent to an acre (or a football field sized area) filled to the depth of one foot (about 326,000 gallons) and is typically the amount of water used by two families in a year.

2. Built more dams to make more storage reservoirs along the Salt and Verde Rivers.

3. generating electricity through hydropower; recreation

4. The CAP Canal stretching from the Bill Williams River near Lake Havasu to just below Tucson.

5. Water is stored underground to be pumped up later when we need it.

6. Precipitation falls on the watersheds in the Mountain Region, water travels via tributaries to the storage reservoirs around the stat, water is released into canals like those in Phoenix and the CAP, the water is delivered to water treatments plants, and then finally delivered by the cities to homes.

7. Answers will vary.

Lesson 5

We All Need Water, But Supply Is Limited

Evaluation: Student's written answers should include the following responses.

1. In Arizona, the law says that the person who was here first gets to choose how much surface water he/she needs as long as the person is using that water for one of the approved activities (called beneficial uses). After the surface water has been allocated, remaining users can use groundwater, as long as they stay within "safe yield," or in other words, using less than is being replaced with precipitation and recharge.

2. In Arizona, beneficial uses are defined as domestic (watering lawns, etc.), municipal (city use), irrigation, stock watering, recreation, wildlife (including fish), storage and mining.

3. Plants, animals, etc.; answers will vary.

4. Answers will vary.

Lesson 6

Water Conservation at Home Graph Worksheet

1. Answers will vary.

2. Subtract the lower (lesser) amount on the graph from the upper (larger) amount.

3. Answers will vary.

4. Save water in the bathroom by turning off the faucet while you brush your teeth, using toilet-tank displacement bags (toilet tummy), checking for leaks in pipes and fixtures, using low-flow showerheads and taking shorter showers.

5. Save water in the kitchen and laundry room by only running washing machines with full loads, rinsing dishes in a basin rather than letting water run in sink, checking for leaks, putting a container of water in the refrigerator for cool drinking water rather than letting the tap run and insulating hot-water pipes to reduce time spent waiting for hot water.

    a. Use a broom instead of a hose to clean driveways, sidewalks and patios.

    b. Plant gardens with drought-tolerant or native plants, and reduce the size of your lawn. Use mulch to hold in moisture.

    c. Use drip irrigation where possible. Use a rain gauge to determine the minimum amount of water necessary to keep your yard healthy. Get help from your local water district or nursery to plan a water-wise yard.

APPENDIX E: SUPPLEMENTARY RESOURCES AND READINGS

Suggested Reading Lists

The following resources will help you and your students learn more about the concepts addressed within these pages.

Books to Read With Students

A Journey Into a River
Ages 8–12
Rebecca L. Johnson and Phillis V. Saroff
A study of the animals that make their home in a river. Reveals how rivers are homes to many creatures, from the smallest of tadpoles to a sleek, swimming otter.
ISBN 1575055953

The Magic School Bus at the Waterworks
Ages 6–9
Joanna Cole and Bruce Degen
ISBN 0590403605

One Well: The Story of Water on Earth
Ages 8–13
Rochelle Strauss and Rosemary Woods
This beautifully illustrated book uses real data to describe the dependence of all living things on water. Sends the message that everyone can and should help to conserve water for our global future.
ISBN 1553379543

The Rainstick, a Fable
Sandra Chisholm Robinson
Ages 6–10
Colorful illustrations depict the travels of a young boy on his quest for rain. Includes directions for how to make a rainstick and the cultural significance a rainstick holds.
ISBN 1560442840

River of Words: Images and Poetry in Praise of Water
Ages 8–12
Pamela Michael, Robert Hass and Thacher Hurd
A heartening collection of children's art and poetry about water.
ISBN 1890771651

A River Ran Wild
Ages 8–12
Lynne Cherry
A true story about the Nashua River, from pristine to polluted and eventually restored.
ISBN 0-329-04462-1

River Song: With the Banana Slug String Band
Ages 3–7
Steve Van Zandt
Outdoor educator, poet and musician Steve Van Zandt celebrates rivers as a source of wonder and joy. Comes with Banana Slug String Band music CD.
ISBN 1584690941

Song of the Water Boatman
Ages 6–11
Joyce Sidman and Beckie Prange
Invites a closer look at pond and wetland life through a unique combination of science, poetry and art.
ISBN 0618135472

Water Dance
Ages 9–12
Thomas Locker
Outstanding Science Trade Book for Children Award
Follow the planet's most precious resource — water — on its daily journey as it dances through our world.
ISBN 0152163964

The Water Hole
Ages 4–9
Graeme Base
An ingenious fusion of counting, puzzle, story and art book with a strong environmental message: Animals come together to drink from a disappearing watering hole.
ISBN 0810945681

More Background Information for the Teacher

Clean Water
Kenneth Vigil
This book gives a wonderfully simple explanation of basic hydrology.
ISBN 0870714988

Arizona Conserve Water: Educators' Guide
Project WET
ISBN 188863149X

Earth Book for Kids: Activities to Help Heal the Environment
Ages 9–12
Linda Schwartz
ISBN 0881601950

Last Child in the Woods: Saving Our Children From Nature-Deficit Disorder
Richard Louv
This book speaks to the ever-increasing disconnect children have with the environment and offers positive scenarios to support the concepts proposed by the author. A must-read for educators and parents alike!
ISBN 1565125223

Keepers of the Animals: Native American Stories and Wildlife Activities for Children
Michael J. Caduto and Joseph Bruchac
ISBN 1555913857

Learning From the Land: Teaching Ecology Through Stories and Activities
Ages 8–14
Brian Ellis
Activities that focus on writing, mapmaking, storytelling, observation and discussion, encouraging educators to take their students into the outdoor classroom to pursue the spirit and science of ecology.
ISBN 1563085631

Making a Bigger Splash
The Groundwater Foundation
Field-tested ideas perfect for developing water education programs.

Making Ripples: How to Organize a School Water Festival
The Groundwater Foundation
Step-by-step planning and implementing guide for a school water festival, games, activities and tips from those who have already done it and lived to tell the tale.

River Wild: An Activity Guide to North American Rivers
Ages 7–11
Nancy F. Costaldo
An activity guide to teach kids about the formation of rivers, the water cycle and the variety of habitats for all major rivers that flow through North America.
ISBN 1556525850

Water: The Fate of Our Most Precious Resource
Marq de Villiers
An informative book, this is a comprehensive analysis of Earth's most precious resource and the source of all life: water. Of interest to teachers, water professionals and students.
ISBN 0618127445

Web sites

www.srpnet.com

www.centralarizonaproject.com

www.groundwater.org
Groundwater Foundation: This site gives great background information and even has a "Kids Corner" with activities and lessons you can do with your students to expand on groundwater concepts.

www.riverreborn.org
Documents the restoration of Arizona's Fossil Creek.

www.watershed.nau.edu/fossilcreekproject
Information about the Fossil Creek watershed and riparian restoration project.

www.bellmuseum.org/distancelearning/watershed/watershed2.html
Interactive game and information about how different decisions affect the quality of water.

http://extension.usu.edu/waterquality
The Stream Side Science Curriculum is a set of 11 water-related activities and lesson plans correlated directly to the ninth-grade Earth Systems Science Core (Utah).

www.sahra.arizona.edu
Comprehensive list of Arizona/Southwestern water news, educational resources, programs and more.

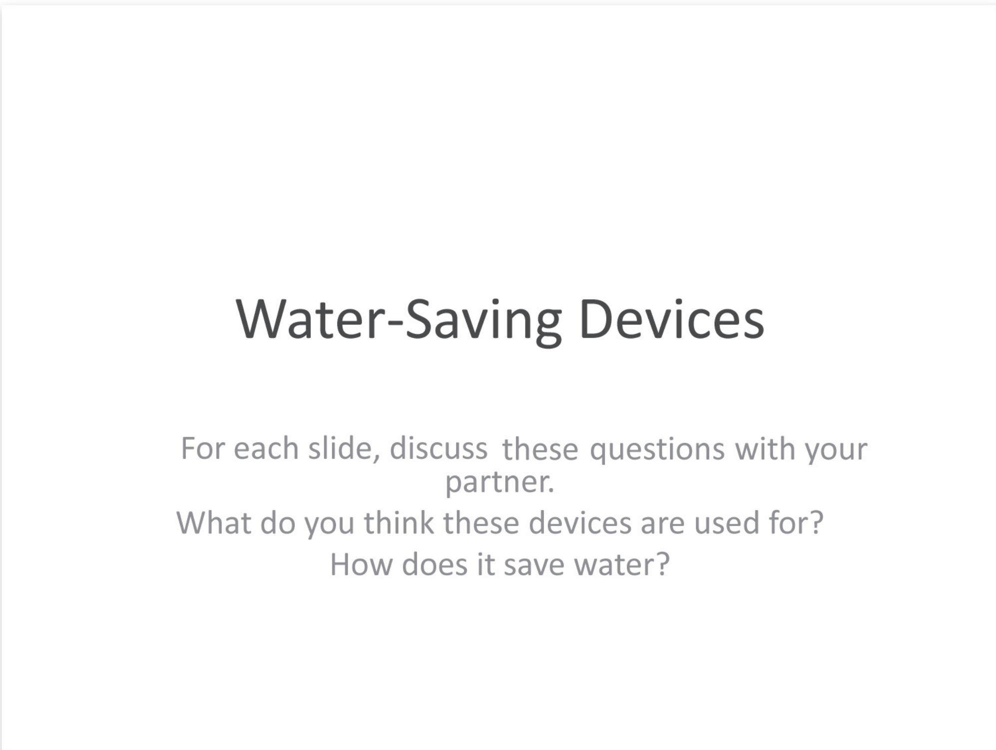
www.srpnet.com/about/history/legacy.aspx
SRP history, services and current operations.

http://water.usgs.gov/waterwatch
Click on "Arizona" in pull-down option.

APPENDIX F: SUPPLEMENTARY POWERPOINT PRESENTATIONS
WATER-SAVING DEVICES POWERPOINT

This PowerPoint presentation walks students through the answers to the Water-Saving Devices Matching Game.You can use the presentation with an interactive whiteboard or a regular LCD projector. Have students check their answers as you go through the slides. Use each slide to discuss the following questions with students:

- What do you think this device is used for?
- How does it save water?



Dual Flush Toilet

This type of toilet flushes half a flush if you press the #1 button (liquid only) and a full flush if you press the #2 button .

Toilet Tabs

These tablets can be used to determine if you have a leak in your toilet or not. Simply place it in the tank of the toilet, wait 10–20 minutes and check if there is any blue color to the water in the toilet bowl. If there is, you have a leak and are wasting water without intending to. Checking for leaks and fixing them quickly can save hundreds of gallons of water per year.

Shower Timer

This 5 minute timer is placed in your shower and helps you to pace your shower so that you don't spend longer than 5 minutes running the water. Just twist it when you get in and the sand starts to run to the opposite end of the timer. When it runs out … you get out.

Lady Bug

Do you let the water run when it's getting hot? This "Lady Bug" is installed in between your shower head and the pipe that connects it to the water source, and helps to reduce the amount of water lost by shutting the shower off when the water is warm. Then, when you are ready to get in, you pull the cord to turn the shower back on.

Faucet Aerator

This little device is like a little screen that the water has to pass through to come out of the faucet. It helps save water because it decreases the rate of the flow of water (less water flows through the faucet in a given time period) while it also increases the pressure of the faucet (so you don't feel like you need to use as much). These can be found inexpensively at any hardware store, so they are a cheap and easy way to save water.

Rubber Washers for Faucet Repairs

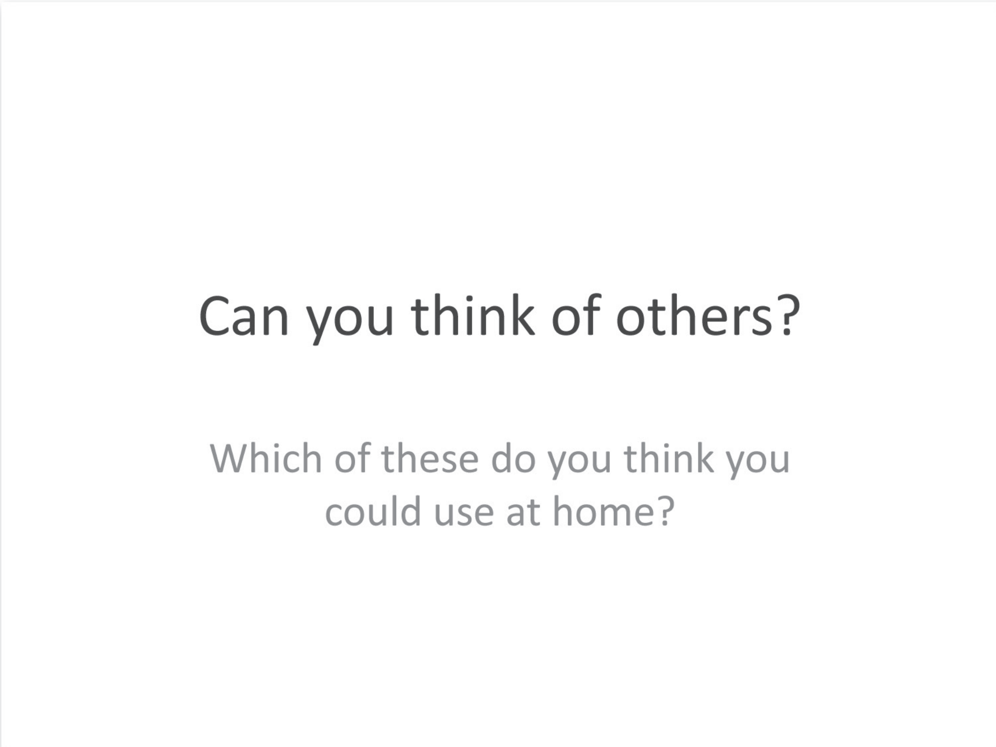
Like you learned about with toilets, leaks can waste a lot of water! If you see a faucet dripping, that means the rubber washer needs to be replaced. These are another cheap and easy repair, and can save a lot of water and money.

Lawn Hose Sprayer

This device saves water in the same way the faucet aerator does. It funnels water from the hose through narrow nozzles so it decreases the amount of water used while increasing the pressure so we don't need to use as much.

Shower Head with Pause Button

This specially designed shower head has a button that turns the water on and off, so you can turn the water off while shampooing your hair or washing your body, and then turn it on just to rinse off.



Technology Link

This is a natural way to model using instructional technology for your students. If you have time, allow students to take digital pictures of their water-saving behaviors at home and use them to create a PowerPoint presentation. Students can present their water-saving-behavior presentations to the class or to another class in the school to teach them about water conservation.

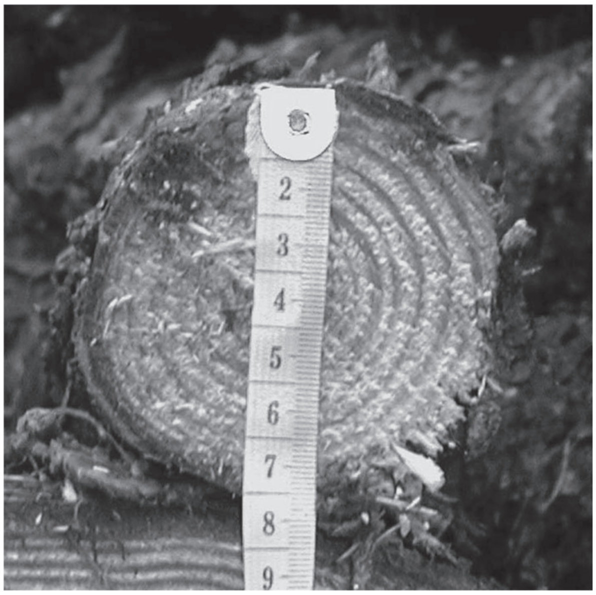
SUPPLEMENTARY POWERPOINT PRESENTATIONS
TREE-RING PHOTOGRAPHS POWERPOINT

This presentation can be printed and laminated for student groups to use and analyze, or you can project the images onto the screen for the entire classroom to see. It is recommended to analyze the first photograph, Sample A, together as a class to show the earlywood and latewood, and also to model for students how they will need to count the rings.

Tree-Ring Photographs

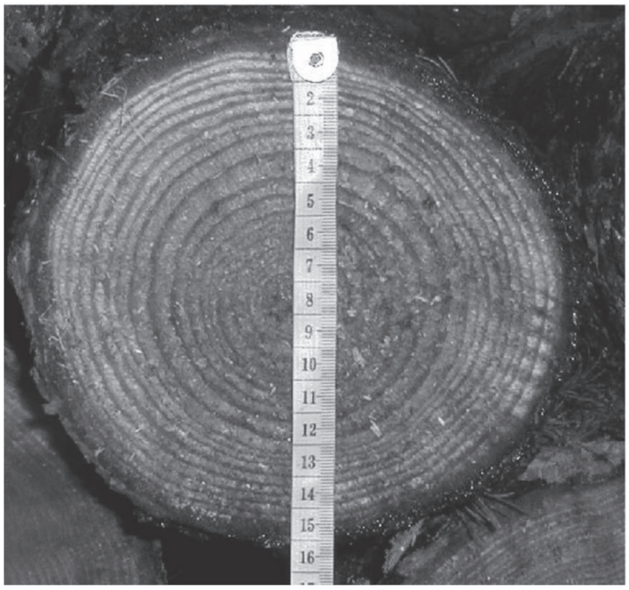
Print and Laminate

Sample A

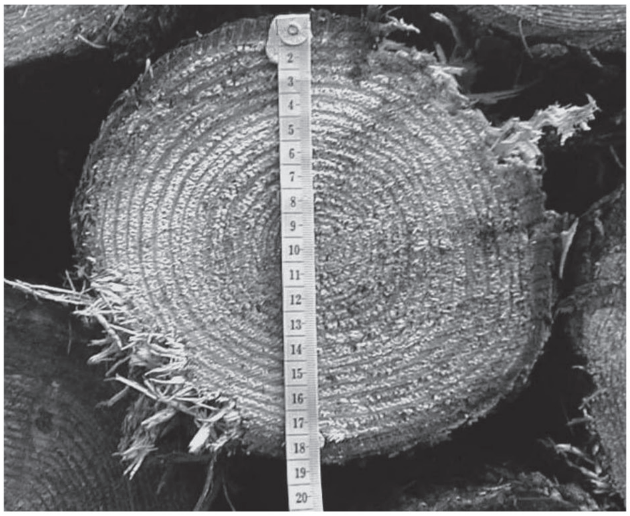


Sample B

Sample C

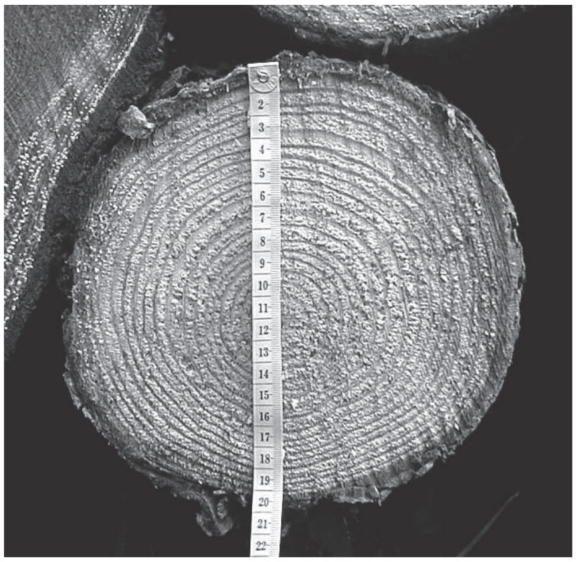


Sample D



Sample E

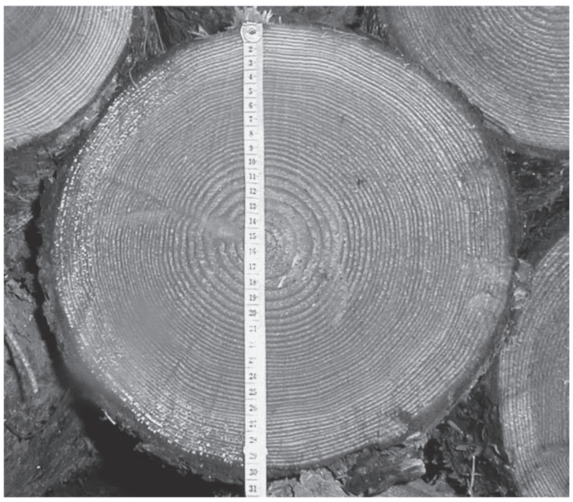
Sample F



Sample G

Sample H

Sample I



Sample J

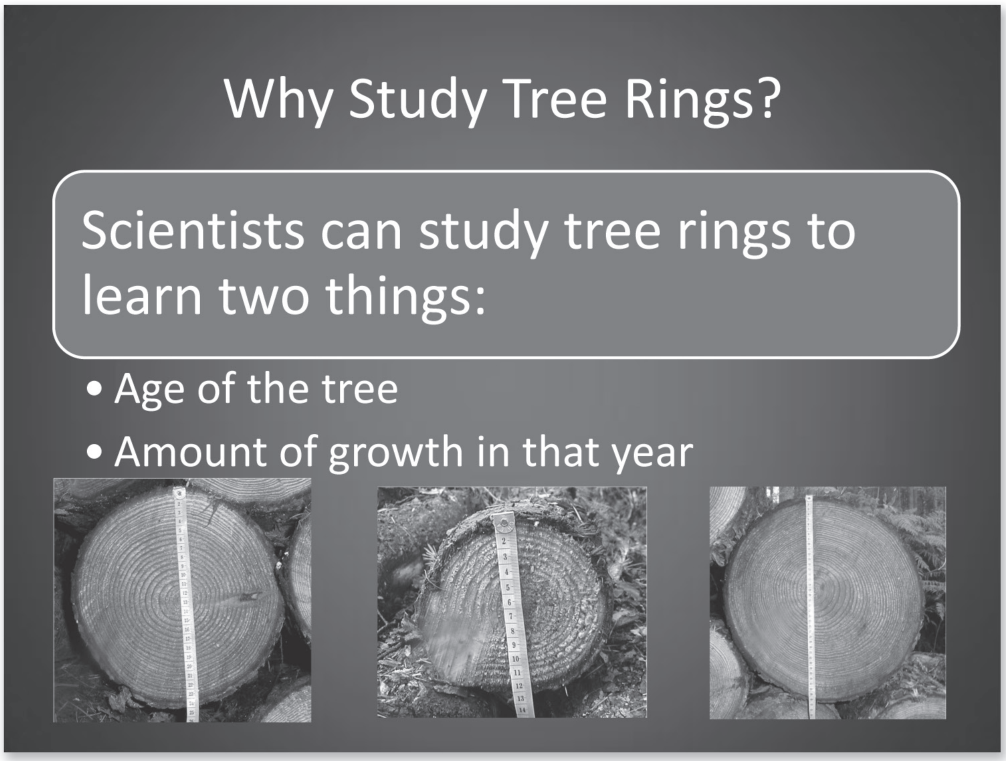
Sample K

Sample L

SUPPLEMENTARY POWERPOINT PRESENTATIONS

TREE-RING RESEARCH STUDY POWERPOINT

This presentation can be printed and laminated for student groups to use and analyze, or you can project the images onto the screen for the entire classroom to see. It is recommended to analyze the first photograph, Sample A, together as a class to show the earlywood and latewood, and also to model for students how they will need to count the rings.



But why do we care how much a tree grew in a year?

We can find out many things by studying how much a tree grew in a particular year… but ***you*** try to figure it out!

- What does a tree need to grow?
  - Water, Sunlight
- What do you think makes a tree grow more in one year over another year?
  - More water!!
- How would a tree get more water one year than in another year?
  - More rain and snow that year!!

We Study Trees to Learn About Water!

We can study the size of the tree rings to learn about how much water there was in that year!

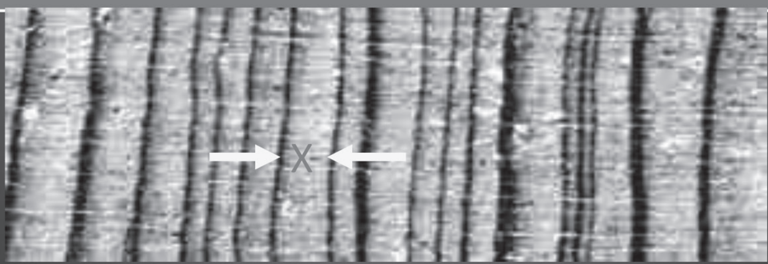
Then we can analyze patterns of rainfall (precipitation) over time!

Here's How it's Done:

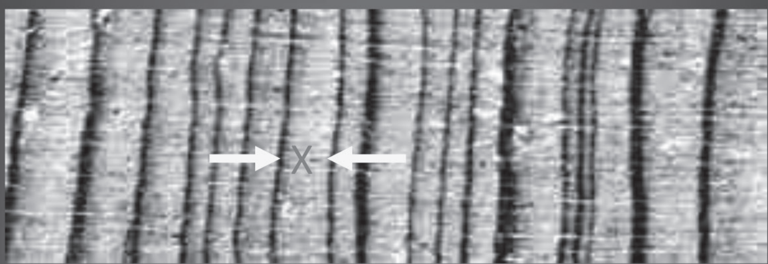
A tree ring is a layer of wood cells produced by a tree in one year, consisting of two layers:

- *earlywood* formed early in the growing season and is lighter in color
- *latewood* produced later in the growing season and is darker in color.

Earlywood + latewood = one annual tree ring



Check it out again…



Notice that some layers are thicker, and some are thinner?

Why?

- The thicker layers were years when the tree got more water which means there was more rain/snow that year!

The University of Arizona Study

Scientists at the University of Arizona Laboratory of Tree Ring Research analyzed tree rings in trees from the Salt and Verde watershed areas.

They were able to study tree cores that dated back to 1330!!

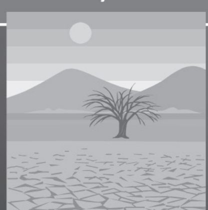
They did this to give SRP information about the two watersheds that we use in Phoenix.

The data the scientists gathered helps SRP plan for the future!

What did they learn?

Scientists found that 1996 and 2002 were the driest years we have ever seen (since 1330) in the area.

In fact, 2002 was SO dry, that some trees didn't even have a ring for that year! This means the trees didn't grow at all that year because it was so dry!




But…there was good news too!
They also found that even in periods of drought, there were years that the Salt and Verde basins got larger volumes of rain and snow.
So that means that as long as we capture and store water during wet years, we should have enough to last us during dry years.


Think about it…
Even if we may have enough water since we save it in reservoirs, can we waste it?
Remember, the driest years in the last 700 years were 1996 and 2001 (VERY RECENT!)
What would happen if that trend continues and we see more dry years?
WE MUST CONSERVE!!