watershed stewardship curriculum

FOR SAN FRANCISCO SCHOOLS

Prepared for the

SFPUC Urban Watershed Management Program

By the

San Francisco Green Schoolyard Alliance

2009

watershed stewardship curriculum

FOR SAN FRANCISCO SCHOOLS

ACKNOWLEDGEMENTS

The Watershed Stewardship Curriculum Binder was funded by the SFPUC in fulfillment of a settlement of an enforcement action with the San Francisco Bay Regional Water Quality Control Board.

The following organizations provided valuable curriculum: The Watershed Project, San Francisco Recreation & Parks Youth Stewardship Program, and Project WET. Additional resources came from the University of Wisconsin, Madison Arboretum's Earth Partnership for Schools and The Groundwater Foundation.

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Miraloma Elementary School Outdoor Classroom, SFUSD

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INTRODUCTION

Lafayette Elementary School Rainwater Garden and Cistern, SFUSD

During the summer of 2009, the San Francisco Public Utilities Commission's (SFPUC) Urban Watershed Management Program funded the design and installation of five rainwater harvesting systems in San Francisco Unified School District. Four of the projects also included the installation of outdoor classrooms. Each project removed impervious surfaces from the schoolyard to make room for a garden and to let rainwater soak into the ground. Each site also incorporated native and edible plantings to be irrigated by the on-site rainwater harvesting system. The goal of the projects is to raise watershed awareness, green the city's public schools, and keep stormwater out of San Francisco's combined sewer system.

In order to ensure the new rainwater features at each school are used as an educational tool, the SFPUC allocated a portion of the funds for the San Francisco Green Schoolyard Alliance to create this curriculum binder to be used in the outdoor classroom. The lessons pertain to stormwater management, Best Management Practices (BMPs), pollution awareness and prevention, water conservation, and watershed awareness. All schools in San Francisco that replace schoolyard asphalt with permeable garden space and harvest rainwater for irrigation will find these lessons useful in connecting students to the stormwater management process as well as resource conservation. All the lessons in this binder can be adapted for kindergarten through 6th grade, and beyond.

Background Information

What is a watershed?

Each of us lives in a watershed. A watershed is the total land area and water bodies that drain into a single river, lake system, or in San Francisco's case, San Francisco Bay and the Pacific Ocean. Watersheds also include underground water features called groundwater aquifers.

Urban Runoff

Much of the rainfall in rural watersheds is absorbed into the porous soils (infiltration), is stored as groundwater, and flows back into streams through seeps and springs. Thus, in many rural areas, much of the rainfall does not enter streams all at once, which helps prevent flooding and erosion.

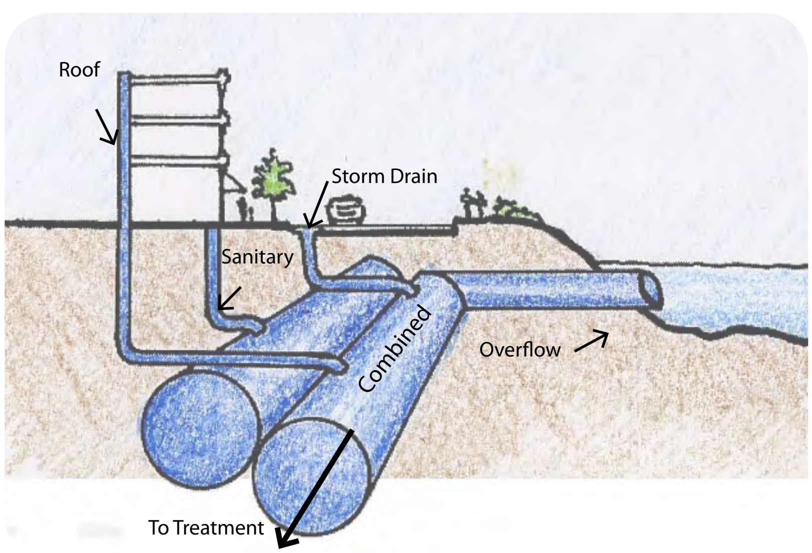
When areas are urbanized, much of the vegetation and top soil is replaced by impervious surfaces (where water can't be absorbed) such as roads, parking lots, and pavement. Rainfall that used to infiltrate into the ground is instead collected by catch basins and sewers.

In San Francisco, stormwater (water from rain storms) flows into one of the 23,000 catch basins located on every City block. Catch basins are the semi-circular, metal grates that you see at almost every street corner. They are the main entryway for stormwater and street runoff into our combined sewer system.

Catch Basin

Combined Sewers: Bringing wastewater and stormwater together

San Francisco is the only coastal city in California with a combined sewer system that collects and treats both wastewater and stormwater in the same network of pipes. That means the rain that runs off your roofs and streets gets treated at our plants just like the wastewater that goes down your drain every time you flush the toilet, take a shower, brush your teeth, do your laundry, or wash the dishes. Cleaning stormwater is just as important as cleaning wastewater because of the street pollutants that



wash into the sewer system. Imagine all the motor oil, pesticides, metals, and other street litter that you see on the street. They all go into the sewer system when it rains.

Together San Francisco's 1,000 mile-long combined sewer system and three treatment facilities help reduce pollution in the San Francisco Bay and Pacific Ocean. However, you still need to be careful about products that you dump down the drain or use in your garden. These same harsh chemicals can still possibly harm the environment and your family's health.

How can you protect San Francisco Bay?

Here are some things you, your school, and your family can do to prevent stormwater pollution:

At Home

- *Wash cars infrequently and use biodegradable soap when you do.*
- *Recycle used motor oil and anti-freeze at designated locations.*
- *Bring leftover toxic materials to a household hazardous waste collection site.*
- *Use water-based paints.*

At School

- *Start a recycling center for paper, glass, and cans.*
- *Always put trash in trash cans - never in the street!*
- *Ride your bike or the bus, or carpool with a friend.*
- *In the school garden, make it organic!*

Outdoors

- *Remind your parents not to apply fertilizer, herbicides, or pesticides.*
- *Use kitty litter to soak up spilled oil from your driveway. Sweep it up and throw it in the trash can.*
- *Pick up your pet's poop using a plastic bag or pooper scooper. Then, put the poop in the trash.*

SFPUC's Urban Watershed Management Program

Stormwater enters the combined sewer system through building roof drains or the thousands of catch basins along the street. Since most of San Francisco is paved over, the rainwater that falls from the skies usually ends up in our sewers.

This is a waste of a pretty clean water source. That's why the SFPUC has a Urban Watershed Management Program that develops green stormwater infrastructure policies and projects to reduce overloading of the sewer system with stormwater, use stormwater for non-drinking uses, and green the city.

What is rainwater harvesting?

Rainwater harvesting is the practice of collecting and using rainwater from impervious surfaces, such as roofs. It is an age-old technology that is growing in popularity as people look for ways to use water resources more wisely. Communities in ancient Rome were designed with individual cisterns and paved courtyards, which captured rainwater to augment supply from the city's aqueducts. Until recently, urban areas served by municipal water have tended to overlook rainwater as a water resource. San Francisco would like to change that by raising awareness about rainwater harvesting and promoting its use.

Your School

Your school is doing its part to reduce stormwater runoff in San Francisco. By removing a portion of asphalt on your schoolyard and by installing a rainwater harvesting cistern you are capturing water that would otherwise end up in the sewer. Additionally, you are conserving valuable resources by using your captured rainwater instead of drinking water to irrigate your school garden.

Learn more about stormwater runoff and wastewater treatment in San Francisco at www.sfwater.org

The Watersheds of San Francisco

Sources:
SF Public Utilities Commission, Urban Watershed Management Program:
http://sfwater.org/mc_main.cfm/MC_ID/14
Map: SFPUC
&
http://www.sacstormwater.org/KidsPage/WhatYouCanDo.html
http://www.epa.gov/owow/

LESSONS

WATER AS A RESOURCE

Starr King Elementary School Cistern, SFUSD

Rain Dance

Let's celebrate this essential life-giving element through creative movement.

From San Francisco Recreation & Parks Department, Youth Stewardship Program

OBJECTIVES
- Celebrate the rain as an important element of life
- Exercise the creative process through movement
- Have fun!

Grade Level	K-3rd
Time	10 minutes
Materials	None
Standards Met:	*Science* • Life Science *Visual & Performing Arts* • Artistic Perception • Creative Expression

Vocabulary:

Producer
Herbivore
Carnivore
Food chain
Ecosystem
Biotic
Abiotic

Key Concept:
- Rain is essential for life on Earth

BACKGROUND

Water is essential for life to exist on Earth. Plants cannot grow without it. And, without plants, no other life would exist, for they are at the bottom of the **food chain** and are our primary **producers** (in that they make their own food). Though rain may be an inconvenience to us at times, we should always appreciate and celebrate it for the life it supports and makes possible.

Usually the rain dance is performed just after a planting. Rain is extremely important to the survival of newly planted plants. The rain helps settle them into their new home as well as provides the nourishment they need at this vulnerable state.

Another appropriate time for a rain dance is before you plan to weed an area. It is often much easier to pull invasive plants shortly after a rain. Water softens the soil around a plant's roots and makes it much easier to remove from the Earth.

PROCEDURE:

1. Begin by organizing the students into a circle.
2. Discuss with your students what an **ecosystem** is. Brainstorm some living (**biotic**) and nonliving (**abiotic**) components of an ecosystem.
3. Engage them in a brief discussion about the importance of rain and water within an ecosystem. Talk about how abiotic factors such as water, temperature, and light can affect the number and types of organisms an ecosystem can support. Nonliving things can have a big effect on the survival of living things!
4. Tell the students that you are going to invite the rain by performing a rain dance.
5. Create a short chant. For example: "rain, rain, rain". Do a creative movement to accompany the chant. Demonstrate your dance for the students and then have them do it with you.
6. Then, invite the students to each create their own rain dance. Call on one student at a time, as they raise their hands, to share their rain dance with the class. Then, the whole class can do it with them.
7. When everyone who wants to has offered his/her rain dance, go back and see if the class can remember everybody's different movements.

DISCUSSION

Rain is necessary for the survival of many kinds of life on Earth. Without it plants (**producers**) could not grow. What would happen to the animals (**herbivores**) that depend on these plants for food? And how would this affect the other animals (**carnivores**) that eat the herbivores? Talk about how rain affects the **food chain** in a significant way.

EXTENSIONS

Another approach to Rain Dance might be to go around the circle and have each student create a movement that will be a part of one long rain dance. String the movements together as you go around the circle so they will know all the movements well by the end. Have the students do everyone's movement as one rain dance. Taking this a step further, you might break them into groups to perform for each other. Give them some time to arrange themselves and sort out how they want to present their version of the rain dance. Then, have them take turns performing while their friends sit and watch attentively.

Source:

San Francisco Recreation & Parks Department, Youth Stewardship Program
http://www.sfgov.org/site/recpark_index.asp?id=21196#Youth

Earth Ball Toss

What percentage of the Earth is land? What percentage is water?

From San Francisco Recreation & Parks Department, Youth Stewardship Program

OBJECTIVES
- Learn about the importance of water in all living things, including the Earth as a whole
- Do an experiment to discover about how much of the Earth's surface is covered by water
- Play an energizing warm-up activity

Grade Level	4th - 12th
Time	10-15 minutes
Materials	• Earth Ball • Score Sheet
Standards Met:	4th: 6d 5th: 3a, 3d, 3e, 6b, 6g 6th: 7c 7th: 7c 8th: 9a, 9b 9th-12th: I&E 1c

Vocabulary:
Aquifer
Groundwater
Reservoir

Key Concepts:
- Most of the Earth is made up of water

PROCEDURE:
1. Have the class stand in a circle. Discuss the centrality of water to all life on Earth. Ask the students to guess how much of the Earth's surface is covered by water. If they understand percentages, ask them to give you their guesses in percentage format. Record the most frequent guesses on the top of the score sheet.
2. Ask all the students to raise one hand. Throw the Earth ball to any student. After the student catches it, they should say their name and then announce whether their right thumb is touching water or land on the Earth ball.
3. Record the result on the score sheet by placing a tally in the appropriate column.

4. The student should then throw the ball to another student in the circle with his hand raised. (After each student has had a turn, they should lower their hand.) Continue throwing the Earth ball and tallying the results until every student in the class has participated and all hands are lowered.

* Depending on how much time is available, you may want to shorten the activity by merely using the Earth ball as a point of discussion. Show the Earth ball to the students and discuss the amount of water present on Earth instead of doing the whole activity. *

DISCUSSION

Add up the total number of thumbs that landed on water or on land. If the students are old enough, ask them to turn these numbers into percentages. If the result is not around 75% water, ask the class why they think the results are skewed. (Inaccurate Earth ball? Biased reporting?)

EXTENSIONS

Although 75% of the Earth is covered in water, most of that is saltwater. About 97% of the water on the Earth is saltwater while only 3% is freshwater. Discuss different sources of freshwater with your students. Explain that freshwater sources are found as either **groundwater** or surface water. Underneath San Francisco there is a network of **aquifers** which connect the areas remaining lakes. Where does San Francisco get its water from? You may want to have a map to show students how water from Hetch Hetchy **Reservoir** comes all the way to San Francisco for us to use!
Of the 3% of freshwater available on Earth, 2% is frozen in glaciers while less than 1% is available for us to use. Brainstorm with students ways in which we can help to conserve water.

Source:
San Francisco Recreation & Parks Department, Youth Stewardship Program
http://www.sfgov.org/site/recpark_index.asp?id=21196#Youth

Where does San Francisco's water come from?

San Francisco gets water from as far away as Hetch Hetchy Reservoir, approximately 150 miles east in Yosemite National Park.

Illustration by Kristin Maravilla, adapted from SFPUC original.

Our Water Planet

Students learn that freshwater is a precious resource.

From The Watershed Project

OBJECTIVES

- Estimate the ratio of freshwater to saltwater.
- Use a chart to compare types of water on Earth.
- Discuss the impacts of water as a limited resource.

Grade Level	K-12th
Time	30-40 minutes
Materials	• Globe • Relief Map of California • Chalkboard
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation *Math* • Number Sense • Statistics and Data Analysis • Mathematical Reasoning *Language Arts* • Reading • Listening and Speaking

Vocabulary:

Freshwater
Ice caps
Pollution
Saltwater

Key Concepts:

- Most of Earth's water is salt water.
- Freshwater is a limited resource.

BACKGROUND

Upon seeing Earth from space, many astronauts have been struck by the beauty and life of our planet and how watery our world is. Earth has been called the water planet, and with good reason; three-fourths of its surface is water. Most of the Earth's water is in the oceans, but it is also in flowing rivers, ponds, lakes, **ice caps**, and in the atmosphere as clouds.

Since water is so abundant on our planet, many people believe it is an unlimited resource that can be used and abused without consequence. Since a relatively small amount of **freshwater** is available to people, the importance of freshwater quality is clear. However, we are beginning to see that **pollution** and mining of our oceans are also threatening the health of the planet.

The various forms and relative quantities of Earth's water:
Saltwater 97%
Freshwater 3%

- 2.4% is frozen
- 0.597% is polluted, trapped in soil, or underground
- 0.003% is available for use by humans and animals

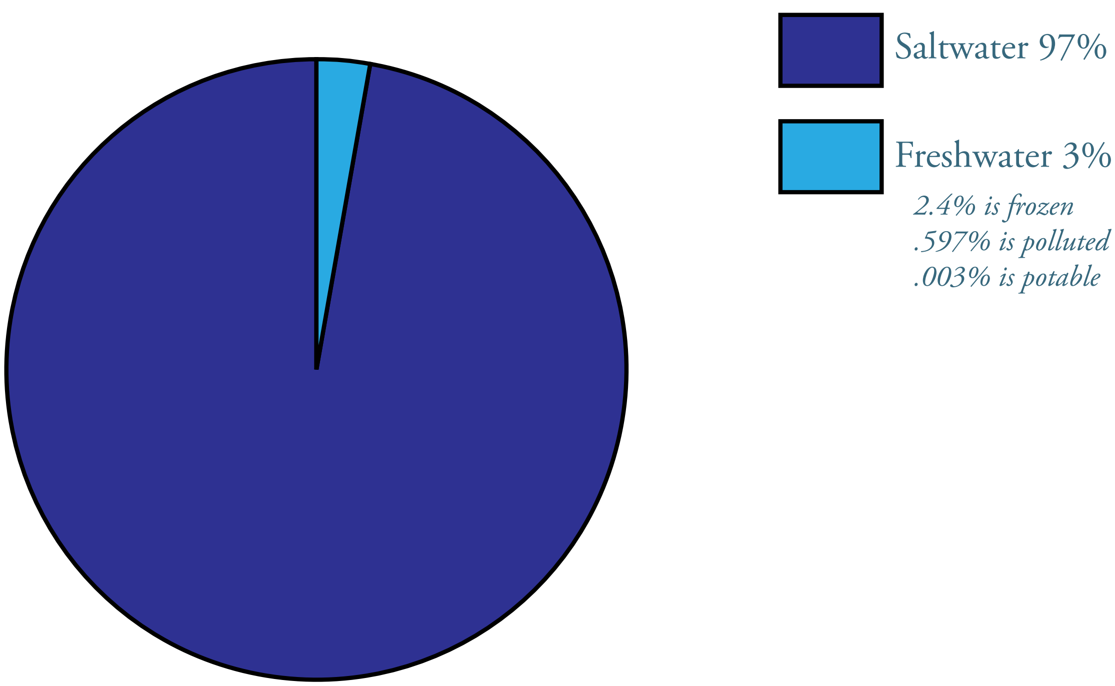
PROCEDURE

1. Have students jot down their answers to the following questions:
    - What is a natural place you enjoy that has water? (Can you locate it on the relief map of California?) It might be a place you only visited once, or a place you spend a lot of time. Wherever it is, it's a place you appreciate a lot.
    - What do you like to do there? Think about the sounds you hear there. Think about the things you see around you and the smells you smell.
    - What is the water in this place like? Is it refreshing? Relaxing? Fun? Rushing? Still?
    - How do you feel there?
2. Have a few students share their answers. Ask them to show where their water place would be on the California water map. Was anybody's water place not in California? Have students show on the globe where their place was.
3. Show students the globe and ask them whether they think Earth has more water or land on its surface. Have students guess how much of the Earth's surface is covered by water.
4. On the board, draw a circle pie chart that represents all the water on Earth (see sample diagram on next page).
    - Have students guess how much of the water is freshwater (not saltwater in the oceans). Fill in all but 3% of the circle. The unshaded area represents the amount of water that is freshwater.
    - Ask students how much water of the freshwater on Earth is non-frozen water. With your chalk, shade in all of the freshwater piece you drew in the previous step (3% of the total) except .6%. This represents the amount of freshwater that is not frozen.
    - Ask students how much of the remaining water on Earth is freshwater that is not polluted, trapped in soil, or too far below ground to be used. Fill in all but .003% of the circle. This represents the amount of freshwater that is available for use by humans and animals.
5. Have students represent this information in another format, such as a bar graph.

DISCUSSION

- What is the approximate ratio of water to land? What do you think it would be like if this ratio were reversed and there were more land than water?
- Where is most of the water found?
- Who do you think should make decisions about how oceans can be used?
- What would happen if one country pollutes the ocean water near its shore? How might this pollution affect other countries?
- Why do you think people sometimes call Earth the "water planet"? What does this say about Earth? What does this say about us?

Earth's Water



EXTENSIONS

- If students want to prove the ratio of water to land, have them brainstorm a few ideas for using the materials to show if there is more water or more land. For example, using a map or a globe, students might trace outlines of land areas and see if they fit over water areas, or they might see how many graph paper squares fit on the globe's land areas and compare them with water areas. Divide students into pairs and encourage each pair to devise a plan for proving how much more water or land there is. After showing their plan to you, they can execute it.

- Have students study and discuss the tuna fishing controversy, in which people from various countries have protested the use of tuna fishing methods that also kill dolphins. Use the controversy as a basis for exploring such questions as: Who owns the oceans? Who owns ocean inhabitants? Who has the right to make decisions that affect the oceans and their inhabitants? What if countries have differing opinions about what to do in the oceans -who should decide?

Source:
The Watershed Project, Richmond California
http://www.thewatershedproject.org/
Adapted from "Water Planet/Land Planet," Water Wisdom: A Curriculum for Grades Four Through Eight, Alameda County Office of Education

How Wet is our Planet?

From The Groundwater Foundation

OBJECTIVE
To describe the amount and distribution of water in the Earth's oceans, rivers, lakes, groundwater, ice caps, and atmosphere.

Grade Level	3rd-12th
Time	20 minutes
Materials	• Large map of the world or 12" diameter globe (preferably one which depicts clouds) • Five-gallon container (aquarium or bucket) • Three clear containers (cups or jars). Label one "freshwater," the second "groundwater," and the third "rivers and lakes" • Tablespoon • Eye dropper • Blue food coloring (optional: use a few drops to tint water for improved visibility)
Standards Met:	*Math* • Number Sense • Measurement & Geometry *Science* • Earth Sciences • Investigation and Experimentation

Vocabulary:

Conservation
Desalinization
Freshwater
Groundwater
Hydrologic Cycle
Ice cap

Key Concepts:
- Freshwater is a very limited resource on Earth
- Water conservation is important for all of us

BACKGROUND
The Earth is also known as the "water planet," as approximately 75 percent of its surface is water. Water is found in rivers, ponds, lakes, oceans, **ice caps**, clouds, and as **groundwater**. All these forms of water are part of a dynamic and interrelated flow called the **hydrologic cycle**, in which each part of the cycle shares a portion of the total amount of water on the planet. Many people think water is a limitless resource, yet simple calculations demonstrate the fact that the amount of water on our planet is in fact limited. It is known that the Earth has the same amount of water now as it did when it was first created, therefore, the amount of water available to humans and wildlife depends largely on how its quality is maintained. Every person has the responsibility to **conserve** water, use it wisely, and protect its quality.

PROCEDURE

1. Fill the empty bucket or aquarium with five gallons of water, and ask the students to imagine that this is all the water on Earth including the water that is contained in the atmosphere, glaciers, ice caps, lakes, rivers, oceans and streams.
2. Next, have a volunteer take out 25 tablespoons of water from the bucket and place it in the large, clear jar labeled "freshwater." This represents all the freshwater on Earth (water contained in the atmosphere, icecaps, rivers, ponds, lakes, and groundwater). Now all the water in the bucket/aquarium represents all the salt water on Earth. Ask the students what the difference between salt and fresh water is (saltwater is not drinkable, fresh water is).
3. Next, have another volunteer take out 8 tablespoons from the freshwater supply and place it in the measuring cup labeled "groundwater." This represents all the groundwater on Earth. Discuss that groundwater is water that is located underground in the cracks and spaces within the soil. Ask them if they have ever dug a hole in their back yard to discover water underground, tell them that this is groundwater.
4. Finally, have a third volunteer take out one tenth of a tablespoon (or about 25 drops with an eye dropper) and pour it in a small glass labeled "rivers and lakes." This water represents all the water in rivers and lakes on Earth. Now we have removed the water contained in groundwater, rivers and lakes from the world's "freshwater" container, the "freshwater" container now represents all the water contained in the atmosphere (clouds, rain, snow) and all the water on the planet that is frozen (polar ice caps and glaciers). Ask the students if they think it would be easier to make a trip to Antarctica to chip away a chunk of ice, then melt it in order to get a drink. Ask them if they think it would be easy to collect a cloud or wait for it to rain in order to get a drink. Ask the students to compare the amount of drinkable water (the "groundwater" and "rivers and lakes" container) to the amount of undrinkable water (the bucket/aquarium of salt water and the "freshwater" container).

DISCUSSION

We all have a responsibility to protect water in all of its forms on Earth. Of immediate concern is the protection of our drinking water sources. The amount of freshwater on Earth represents a small percentage of the total water available. The freshwater in groundwater, rivers, and lakes is our primary source of drinking water. (It takes a massive amount of resources and energy to desalinize (remove the salt) water from the ocean for it to be drinkable.) Half of the citizens in the United States depend on groundwater as their source of drinking water; the remainder relies on surface water as their drinking water source. You may have been surprised to learn that groundwater and surface water make up such a small percentage of the Earth's total water supply. It becomes very apparent then how important it is to protect these water sources since they are available in a limited quantity and since our existence depends on them.

Source:
The Groundwater Foundation.
http://www.groundwater.org/kc/kc.html
Adapted from "Making Discoveries," published by The Groundwater Foundation.

WATERSHEDS

The Sunset watershed, flowing west to Ocean Beach

What is a Watershed?

What is a watershed? What is the path that water takes through the land?

From San Francisco Recreation & Parks Department, Youth Stewardship Program

OBJECTIVES
- Develop an understanding of what a watershed is
- Differentiate between bodies of water in a watershed
- Learn the stages of the water cycle
- Build team work skills

Grade Level	5th-12th
Time	60 minutes
Materials	• Watershed drawing • Water picture cards • Script
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation • 5^{th}- 3a-e • 6^{th}- 2 a-d, 5e

Vocabulary:
Watershed
Water Cycle

Key Concepts:
- Water moves around Earth via the water cycle
- Three key processes control the water cycle: evaporation, condensation, precipitation

BACKGROUND:
A **watershed** is the land area that drains into a body of water. The upper elevations of a watershed contain small creeks that flow downhill and grow into much larger bodies of water, such as rivers and lakes, and in San Francisco's case these eventually empty into the Pacific Ocean and San Francisco Bay.

PROCEDURE:
1. Have the students stand in a circle. Show them the watershed drawing and ask them to guess what a watershed is. See if they can identify different familiar bodies of water contained in the drawing. Discuss the difference between freshwater and saltwater sources in the drawing. How much of the total water on Earth is saltwater? (97%) How much is freshwater? (3%)

2. Define the word watershed and discuss its connection to the **water cycle**. Water can travel in many paths within a watershed. Can somebody give an example of how water may enter and move through a watershed (i.e. snow falls on a mountaintop, melts and flows down a river, enters an estuary and then the ocean, and then evaporates back up into the clouds).
3. Pass out the water picture cards. There should be one for each student. Going around the circle, have each student read his/her card aloud to the group.
4. Ask the group, "How does water initially get on land?" Hopefully they will answer "from rain" or "clouds." Ask the student holding the cloud card to be the beginning of the chain.
5. Continue to prompt the students with questions, following the movement of water through a watershed. The students should line themselves up in this same order. They will probably need a little bit of help, especially when it comes to tracing the water through human usage (reservoir, water treatment plant, pipes, etc.) *The students can create their own unique ordering, as long as it will work in reality.*
6. The chain of students will eventually form a complete circle, with the evaporation card beside the beginning cloud card.
7. Hand each student a cup. Explain that while you read a story about how water travels in a watershed, they will be passing water through their watershed from one cup to the next. Each student will pass the water only when you read the word on his/her neighbor's card.
8. Pour water into the cup of the student holding the cloud card. Read the script as the students pass the water through the watershed along with the story. You should emphasize the card words while you are reading the script so they know exactly when to pass the water.

DISCUSSION
Ask the students to define **watershed** once more. Ask what might happen if someone dumped pollution in the fresh mountain stream. Discuss how pollution may move throughout the water cycle. You can use acid rain as an example. Emphasize the key concepts of evaporation, condensation, and precipitation.

Discuss how the health of a watershed is determined by the entire system. How would water pollution affect the plants and animals that depend on water for survival? The *quality* and *quantity* of water available within an ecosystem determines the number and types of organisms that can survive there.

EXTENSIONS
Have the students trace the flow of water through their local watershed. For San Francisco students, they can trace their drinking water from Hetch Hetchy. Go back to the idea that there is a limited amount of freshwater available on Earth. How can we reduce the amount of pollution that enters our water? How can we conserve water?

SCRIPT

High up in the clear, blue sky clouds begin to form. The wind blows, and soon the sky is covered with clouds, making it dark and overcast. Up in the clouds tiny drops of water come together to make bigger drops (pour water into **CLOUD's** cup). When the drops get heavy, they fall from the clouds as **RAIN**, but because it is very, very cold outside, the rain comes down as **SNOW**. This snow is a form of **PRECIPITATION**. The snow falls down from the sky onto the high **MOUNTAINS**. In the spring, the snow slowly melts and goes down into the **SOIL**. **PLANTS** take up some of the water in the soil. The rest of the water collects underground before it bursts out of the land as tiny, bubbling **SPRINGS**. The little springs flow together to make **STREAMS** all over the mountain. The streams flow together into a big **RIVER.** The river comes down out of the mountain where the water is collected in a large **LAKE** or **RESERVOIR**. The reservoir holds the water until it is sent down into **WATER PIPES** all over the city of San Francisco. The water pipes bring the water to our homes where we use the water for many things. Some of that water goes down the drain into more **WATER PIPES** that go to the **WASTEWATER TREATMENT PLANT**. It is here that the water is cleaned and dumped back into the **BAY.** When it rains in San Francisco, water flows down into storm drains that carry more water into the Bay. Sometimes the water goes to the **OCEAN**. Out on the ocean, the sun has come out and **EVAPORATION** from the ocean takes place. The evaporated water rises to the sky and **CONDENSATION** occurs. This condensation creates more **CLOUDS**, thus completing the water cycle in this watershed.

You should have cards for each:

Cloud
Rain
Snow
Precipitation
Mountain
Soil
Plants
Spring
Stream
River
Lake
Reservoir
Water Pipes
Water Pipes
Wastewater Treatment Plant
Bay
Ocean
Evaporation
Condensation
Cloud

Modifications

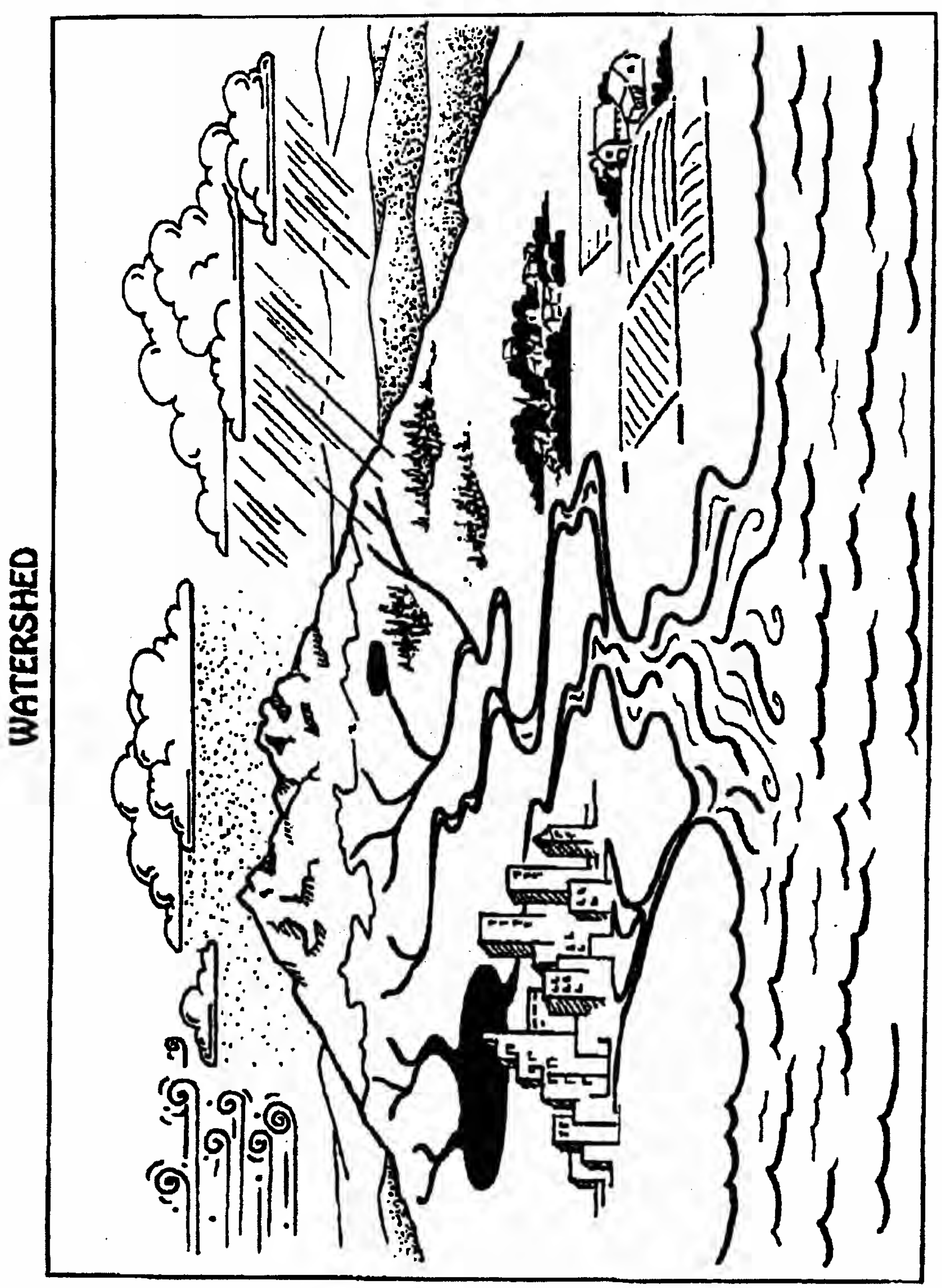
20 people – read as is
19 people – remove 2nd CLOUD
18 people – remove RAIN
17 people – remove PLANTS
16 people – remove LAKE
15 people – remove SOIL
14 people – remove PRECIPITATION
13 people – do sample script
12 people – sample script w/o LAKE
11 people – remove 2nd WATER PIPES
10 people – remove STREAMS

SAMPLE SCRIPT

High up in the clear, blue sky clouds begin to form. The wind blows, and soon the sky is covered with clouds, making it dark and overcast. Up in the clouds tiny drops of water come together to make bigger drops (pour water into **CLOUD's** cup). When the drops get heavy, they fall from the clouds as **RAIN**, but because it is very, very cold outside, the rain comes down as **SNOW**. This snow is a form of **PRECIPITATION**. The snow falls down from the sky onto the high **MOUNTAINS**. The snow slowly melts and goes down into the **SOIL**. **PLANTS** take up some of the water in the soil. The rest of the water collects underground before it bursts out of the land as tiny, bubbling **SPRINGS**. The little springs flow together to make **STREAMS** all over the mountain. The streams flow together into a big **RIVER.** The river comes down out of the mountain where the water is collected in a large **LAKE** or **RESERVOIR**. The reservoir holds the water until it is sent down into **WATER PIPES** all over the city of San Francisco. The water pipes bring the water to our homes where we use the water for many things. Some of that water goes down the drain into more **WATER PIPES** that go to the **WASTEWATER TREATMENT PLANT**. It is here that the water is cleaned and dumped back into the **BAY.** When it rains in San Francisco, water flows down into storm drains that carry more water into the Bay. Sometimes the water goes directly to the **OCEAN**.

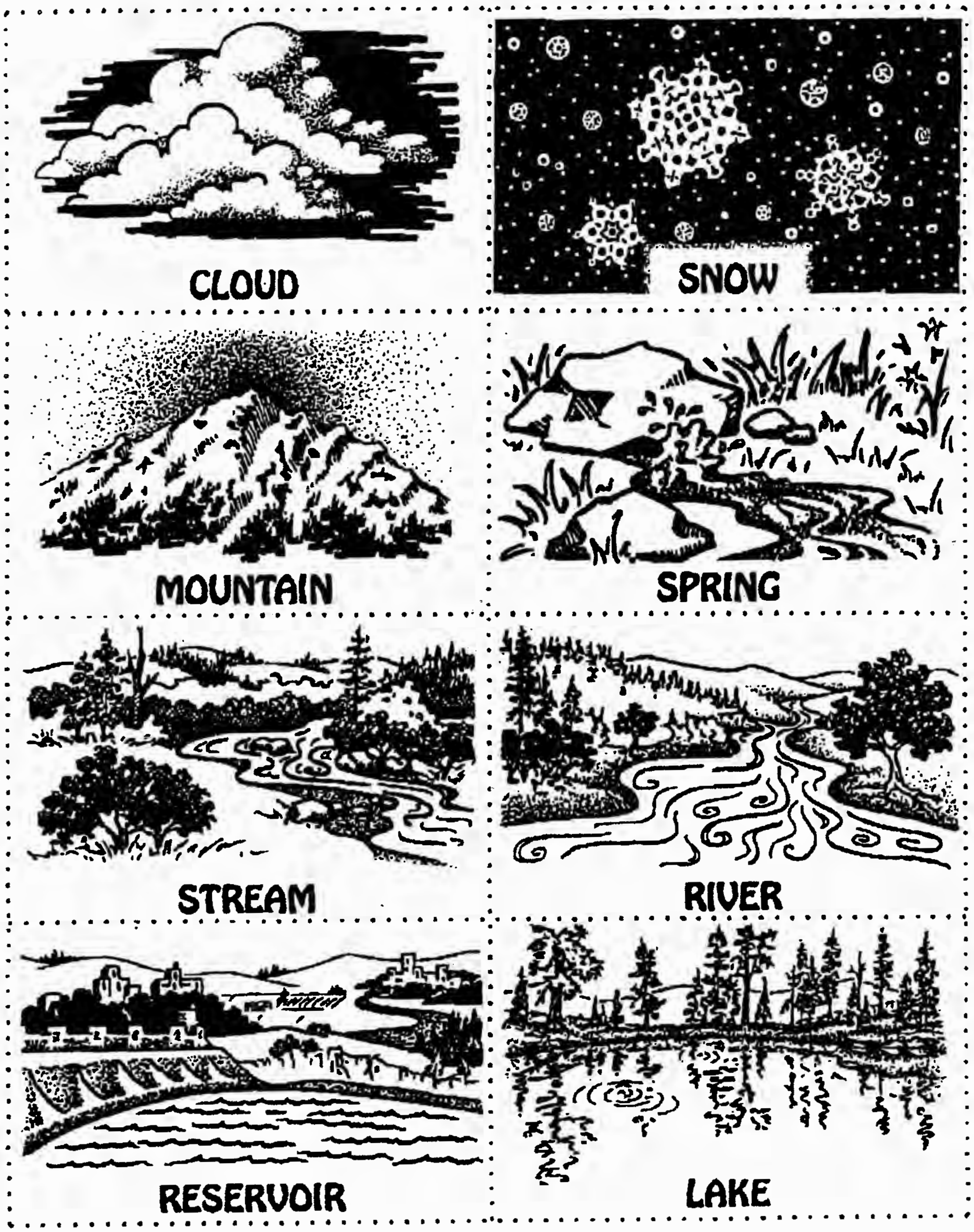
See following pages for watershed picture and sample cards.

Source:
San Francisco Recreation & Parks Department, Youth Stewardship Program
http://www.sfgov.org/site/recpark_index.asp?id=21196#Youth
Adapted from Adopt-A-Watershed Program

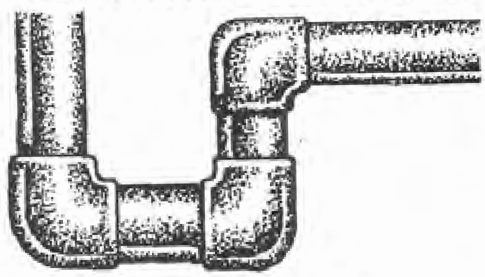


From the Adopt-a-Watershed Program.

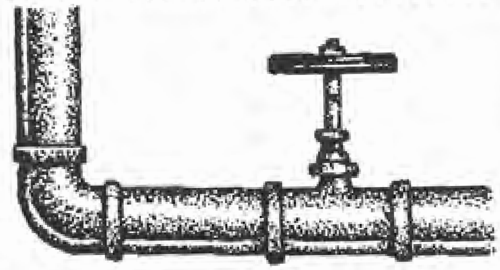
SAMPLE CARDS



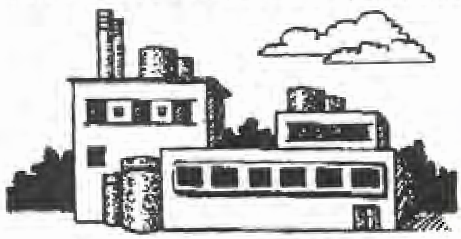
What Is a Watershed?



WATER PIPES



WATER PIPES



WASTEWATER TREATMENT PLANT

OCEAN

Branching Out

What is a watershed? How can we predict the flow of water through the city? Where does our school fit into this flow of water?

From Project WET International Foundation & The Council for Environmental Education; adapted by San Francisco Recreation & Parks Department, Youth Stewardship Program

OBJECTIVES:
- Construct a watershed
- Predict where water will flow in a watershed
- Describe drainage patterns in a watershed
- Locate their school in a watershed
- Learn about erosion and how it shapes the land

Grade Level	4th-12th
Time	60-90 minutes
Materials	• *Branching Patterns* sheet • Water • Spray bottles • Paper (thick butcher paper works well) • Pencils • Water-soluble blue marker • Permanent brown and green markers • *Model:* some rocks, thick white paper
Standards Met:	4^{th}- 5a, 5c 5^{th}- 3a, 3d, 3e 6^{th}- 2a, 2b, 7a 7^{th}- 7d 9^{th}-12^{th} CA Geology: 9c

Vocabulary:
Watershed
Erosion
Deposition

Key Concepts:
- Water flows downhill
- Watersheds drain a specific area that may contain any number of features, including Cities and schools.

BACKGROUND:
We all know something about the flow patterns of water. Children have watched water flowing down a street during a heavy rainstorm and may have asked: Where does all the water go? Viewing turbulent waters in a stream, students may have wondered: Where does all the water come from? Observing drainage patterns shows us how a **watershed** is both an *area* defined by the flow of water and the *process* of water moving through and over the land.

When the ground is saturated or impermeable to water during heavy rains or snowmelt, excess water flows over the surface of land as runoff. Eventually, this water collects in channels such as streams. The land area that drains water into the channels is called a watershed or drainage basin.

Watersheds are separated from each other by areas of higher elevation called ridgelines or divides. Near the divide of a watershed, water channels are narrow and can contain faster-moving water. At lower elevations, the slope of the land decreases, causing water to flow more slowly. As smaller streams merge together, the width of the channel increases. Eventually, water collects in a wide river that empties into a body of water, such as a lake or ocean.

From an aerial view, drainage patterns in watersheds resemble a network similar to the branching pattern of a tree. Tributaries, similar to twigs and small branches, flow into streams, the main branches of the tree. Streams eventually empty into a large river, comparable to the trunk. Like other branching patterns (e.g., road maps, veins in a leaf, the human nervous system), the drainage pattern consists of smaller channels merging into larger ones.

Watersheds are either closed or open systems. In closed systems, such as the Great Salt Lake in Utah, water collects at a low point that lacks an outlet. The only way water naturally leaves the system is through evaporation or infiltration into the ground. But most watersheds are open: water that collects in smaller drainage basins overflows into outlet rivers and eventually empties into the ocean and Bay.

PROCEDURE:
1. Discuss the percentage of land on Earth in comparison with water—only ¼ of the Earth is made up of land while ¾ of the Earth is covered in water! Most of the water found on Earth is saltwater (97%) while only a small percentage is freshwater (3%). Brainstorm sources of freshwater that can be found here on Earth.
2. Show students copies or an overhead of *Branching Patterns*. Look closely at the picture of the watershed drainage patterns. Define the term watershed. Make connections between this picture and the different sources of freshwater that you came up with in your class. How do lakes, rivers, streams, etc. fit into this picture of a watershed? Where might the watershed eventually drain out to?
3. Discuss what all the pictures have in common.
4. Instruct students to crumple up a piece of heavy paper in a ball. Then open it up and mold it into a flatter shape, leaving prominent ridges and bumps, which represent mountains. Support the "mountains" on the paper by placing rocks beneath them.
5. Have students sketch a bird's-eye view of their model. They should mark points of higher elevation with H's and low spots with L's. To identify possible ridgelines, connect the H's.

6. Ask students where on the model their school would fit in. (Is it a hilltop, canyon, or flat area?) They should mark this area with permanent marker.
7. With a water-soluble blue marker, have the students draw where on the model they want the water to be. They can draw in lakes, rivers and streams. With the green permanent marker, they should outline mountains and hilltops. With the brown permanent marker they should sketch towns.
8. Tell the students that the model will soon experience a rainstorm. Where do they think water will flow and collect in the model? Have them sketch their predictions on their bird's-eye view drawings.
9. Spray water over the model and note where it flows. Water may need to be sprayed several times to cause a continual flow. Assist students in identifying branching patterns as water from several channels merge into larger streams.
10. How do their predictions compare with the actual flow of water? Ask them to identify a watershed by noting where the water has collected in the model. Did lakes stay put or did they become rivers flowing downhill? Were towns well located or were they flooded?
11. Have students determine how different watersheds may be connected. Does all the water in the model eventually drain into one collection site? Does the model contain any closed watersheds? Can they get a picture of how their school fits into the watershed?
12. Compare their sketches and the actual drainage pattern with *Branching Patterns*. Discuss how all the networks involve smaller channels merging together and becoming larger.
13. Discuss the Hetch Hetchy **reservoir** and how water from Hetch Hetchy is brought to San Francisco for our use. How can we help conserve this limited source of freshwater?

You may want to modify this activity to cover the concepts of **erosion**, transportation, and **deposition**.

1. Make the model as described above. Then cover the model with sand.
2. Pour water down from one end of the model. Students should be able to see how the sand moves with the flow of water.
3. Discuss the terms erosion, transportation, and deposition. Can water change the shape of the land?
4. Make connections with this model and the formation of California's landscape.

EXTENSIONS:

- If the model were a real land area, do students think the drainage patterns would be the same thousands of years from now? Have students consider the effects of natural and human-introduced elements on the watershed (e.g., landslides, floods, erosion, evaporation, water consumption by plants and animals, runoff from streets and houses, dams, mining).
- Think about landscapes and human influences. How might pollution enter and travel through this watershed model?
- As in the game "Pin the Tail on the Donkey," blindfold students and have them randomly touch a point on a map of California. Have students explain likely routes water would flow to that area.

K-2 Option

Have children focus on how smaller streams merge into larger ones. Gather pruned branches and let students investigate how the main branches "branch out" into smaller ones. If branches are not available, students can make a branching system out of pipe cleaners.

Help students imagine a drop of water flowing down the twig to the larger branches and finally to the main branch. Students can paint or decorate the branch and name the rivers. Into what body of water might the large river (the main branch) flow?

Relate the branch to a river flowing near or through the community. What smaller channels might feed into this river? Where do students think the water in the river goes? Help them to imagine the water flowing into a larger river and finally to a lake or to the ocean.

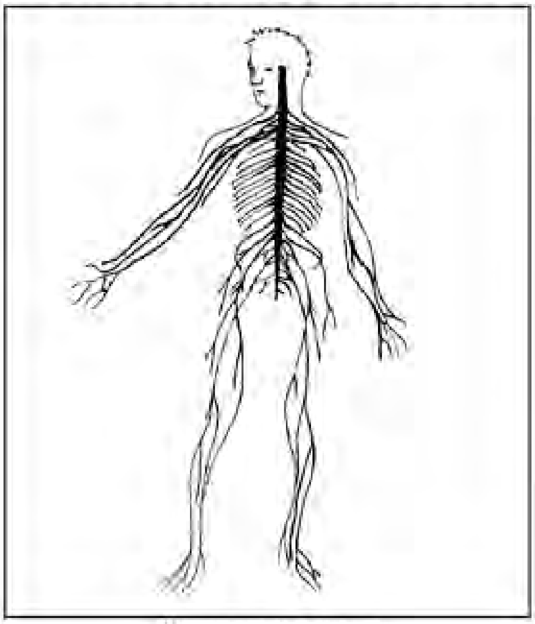
Lead them in the following hand motions to represent small rivers flowing into larger rivers. A simple song about rivers can accompany the motions.

A babbling brook (hold arm in front of body and wiggle fingers) flows into a small river (place both arms together and wave them in a serpentine motion). The water from smaller rivers goes into a large river (have students merge together in a column) and travels to the ocean or lake (students move to a place in the room designated as the sea or a lake and dance in the area like waves splashing about).

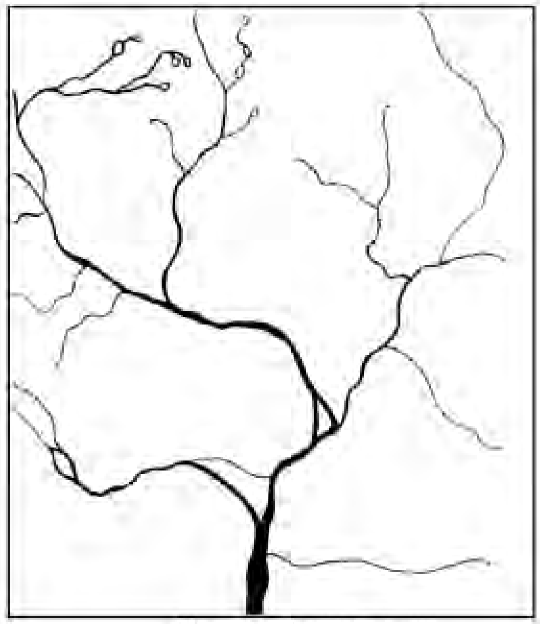
Sources:

San Francisco Recreation & Parks Department, Youth Stewardship Program: Adapted from "Branching Out!" Project Wet, Water Education for Teachers, Bozeman, MT.
http://www.sfgov.org/site/recpark_index.asp?id=21196#Youth
http://www.projectwet.org/

Branching Patterns

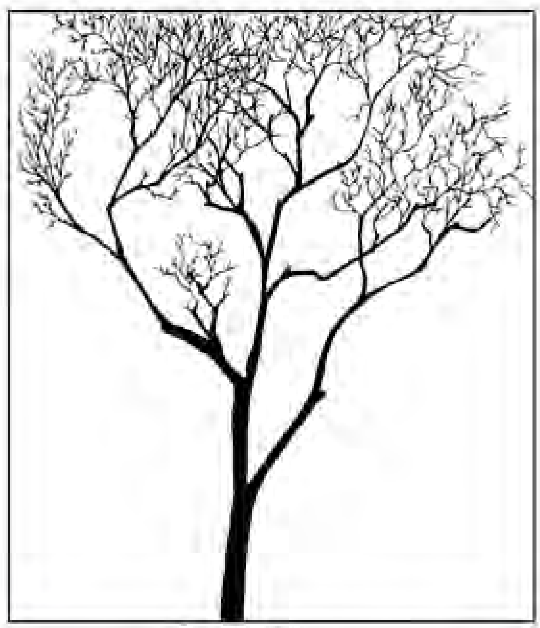


Human nervous system



Watershed drainage pattern

Road system



Tree in winter

Branching Out!

Aquifer in a Cup

From The Groundwater Foundation

OBJECTIVE

Groundwater is water that is found underground in the spaces and cracks between soil, sand, and gravel. Often hidden from view, in this activity you will "see" what groundwater looks like and learn some basic groundwater vocabulary.

Grade Level	2nd-12th
Time	30 minutes
Materials	• 2 clear cups • Sand, gravel, and aquarium rock • Pitcher of water
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation

Vocabulary:

Groundwater
Aquifer
Surface water
Contamination
Water table
Saturation zone
Infiltration,
Recharge
Porosity
Permeability

Key Concepts:

- Groundwater is an important source of freshwater
- Underground aquifers store groundwater
- Groundwater is recharged by infiltration

BACKGROUND

Groundwater is water that is found underground in the spaces and cracks between soil, sand, and gravel. Sounds easy, doesn't it? Amazingly, many people use groundwater but don't even know it. In fact, half of everyone in the United States drinks groundwater every day! Groundwater is used to irrigate crops which become food for tonight's dinner.

Where does groundwater come from? Groundwater comes from rain, snow, sleet, and hail that soaks into the ground. Gravity moves water down into the ground where it passes between particles of soil, sand, gravel, or rock (**infiltration**) until it reaches a depth where the ground is filled, or saturated, with water. The area that is filled with water is called the **saturation zone** and the top of this zone is called the **water table**. Makes sense, doesn't it? The top of the water is a table! The water table may be very near the ground's surface or it may be hundreds of feet below.

Think about this: have you ever dug a hole in sand next to an ocean or lake? What happens? As you're digging, you eventually reach water, right? That water is groundwater. The water in lakes, rivers, or oceans is called surface water...it's on the surface. Groundwater and surface water sometimes trade places. Groundwater can move through the ground and into a lake or stream. Water in a lake can soak down into the ground and become groundwater.

Groundwater is stored underground in between soil materials like gravel or sand. It's like the Earth is a big sponge holding all that water. Water can also move through rock formations like sandstone or through cracks in rocks.

An area that holds a lot of water, which can be pumped up with a well, is called an **aquifer**. Wells pump groundwater from the aquifer and then pipes deliver the water to cities, houses in the country, or to crops. In San Francisco, if you live on the western side of the City, you live on top of a giant groundwater basin.

Most groundwater is clean, but groundwater can become polluted, or **contaminated**. It can become polluted from leaky underground tanks that store gasoline, leaky landfills, or when people apply too much fertilizer or pesticides on their fields or lawns. When pollutants leak, spill, or are carelessly dumped on the ground they can move through the soil.

Because it is deep in the ground, groundwater pollution is generally difficult and expensive to clean up. Sometimes people have to find new places to dig a well because their own became contaminated.

PROCEDURE

1. Fill 2 cups with layers of sand and gravel to about 3/4 from the top of each cup. Remember that in nature, aquifers consist of layers of sand, gravel, and rock.
2. In one of the cups, pour water slowly into it. Watch how the water fills the spaces between the particles of sand and gravel. Does the water appear to move faster through the sand or faster through the gravel? Why?
3. Now continue to fill this cup with water to the top (above the top of the sand and gravel). Water that is located above ground, like rivers and lakes, is called surface water. Water below the ground's surface is called groundwater.
4. In the second cup, slowly pour water into the cup until the water line is about one inch below the top of the sand/gravel. Look closely at this line created by the water. This line is called the water table. Water below the water table is called the saturation zone.
5. Now pretend that your pitcher of water is a large rain cloud and pour some more water into your second aquifer until the water table is about one half an inch below the surface of the gravel. Your groundwater supply has just been **recharged**. This is what happens when it rains or snows and water infiltrates (or sinks) into the ground.

DISCUSSION

We have learned that groundwater is water that is found underground in the cracks and spaces in soil, sand, and gravel. We have learned that groundwater is stored in--and moves through--the layers of sand and gravel. This geologic formation of sand and gravel which stores groundwater is called an aquifer. Aquifers receive and store more water when they are recharged by rain and snow.

EXTENSIONS

Use liquid food coloring or powdered drink mix to represent a source of groundwater contamination. Sprinkle or pour the contamination on the surface of the gravel. Sprinkle water (to represent rain) on top of the gravel and contaminant. Observe and discuss what happens.

Source:

The Groundwater Gazette*, published by The Groundwater Foundation.*
http://www.groundwater.org/kc/kc.html

MAPPING & MEASUREMENT

Rainwater Cistern at Alvarado Elementary School, SFUSD

Map the Garden

From the San Francisco Green Schoolyard Alliance

OBJECTIVES
Maps can be used to see the relationships between elements in a specific area, such as where a school is located within a city. Students will map their school garden in relation to their school and schoolyard, labeling the directions and appropriate features.

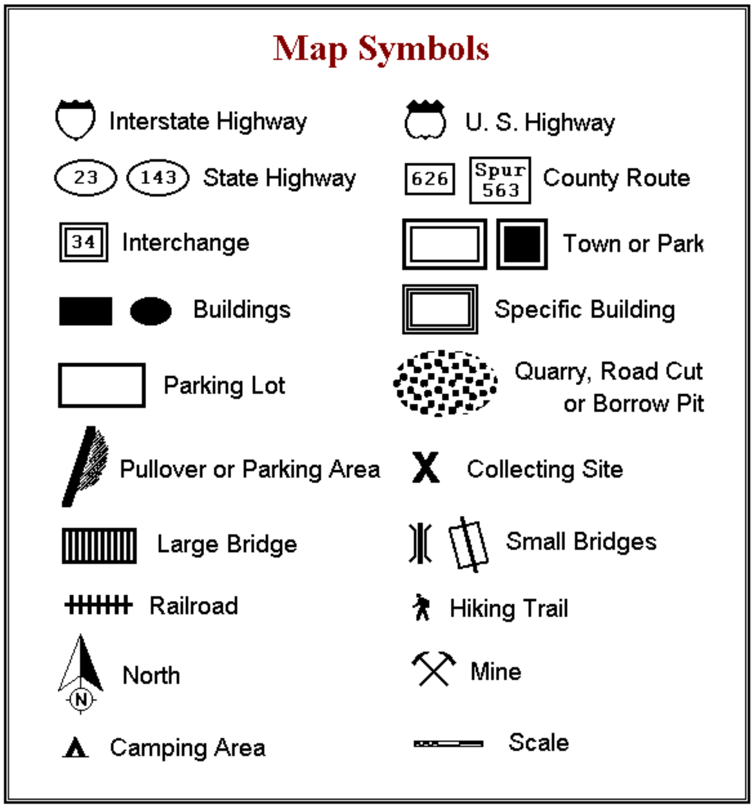
Grade Level	3rd-12th
Time	30-45 minutes
Materials	• Journals • Clipboards • Pencils and markers or colored pencils • Examples of maps: simple and to-scale • Compass
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation

Vocabulary:
Cartography
Geography
Key
Scale
Orientation

Key Concepts:
- Maps are useful in understanding spacial relationships between geographic features in an area
- Maps help show you where you are in the world
- Maps can guide you where you want to go
- Maps can help you analyse a place
- Maps can inspire you to think of new projects and where you could locate them on the schoolyard or at home

BACKGROUND
A map is visual representation of an area. They are often used to depict **geography** and help us see relationships between natural elements in that area, such as mountains, lakes, streams, oceans, bays, and built elements such as houses, streets, or schools. Understanding your local geography is important for getting a sense of your place on planet Earth.

Most maps have a **key** that defines what objects and features are illustrated, such as roads, trails, buildings, or bodies of water. The key also has a **scale**, which tells the reader of the map how to relate the distances on the page to actual distances on the ground. For instance, and scale of 1:100 ("one to



An example of a map "key."

one hundred") could mean that one inch of distance on the map equals 100 feet of distance on the ground. Lastly, a map has a direction symbol or compass that gives the map its correct **orientation**.

Cartography is the art of creating maps. Today, each student will become a cartographer by making a map of the garden in relation to their schoolyard.

PROCEDURE

Begin by asking your students what a map is and what it can be used for. Discuss what a bird might see flying over the garden (a bird's-eye view). Draw it on the board. This is a *rough* map, not exact, but it illustrates the general relationships between features around you. What direction is north? South? East? West? What streets border our school and garden? Lable these elements on the map. Discuss what a map "key" is and show them an example, such as the one above. Show the students the examples of maps that you have, from simple maps to more complex, to-scale maps.

Give each student their garden journal, along with a clipboard to write on. Tell them that they are now cartographers and will be making a map of the school garden. They will also need to show where the garden is in relation to the rest of the school. Ask them to include a key on their own maps, along with a compass indicating the correct orientation. Students may use colored pencils or markers to enhance their map details: beds, cistern, fences, hoses, seating, entry way, shed, etc.

When they have finished a rough map of their school garden and schoolyard, have each student pair up with another student to share and discuss their map and its details.

DISCUSSION

- What streets boarder our garden or school?
- What direction is north? South? East? West?
- What features does our garden contain?
- Where do we enter and exit the garden?

EXTENSIONS

1. What if you had to use your map to find your way around the schoolyard or in the garden? With your partner, ask him or her to find a certain feature that is represented on your map, using your map as a guide.
2. If you could add a new feature to your garden or schoolyard, where would it be located? Ask students to think about what they would add and where it could go (i.e. new beds, a cistern, compost, etc.), placing it on the map.

See the following lesson for more work with maps and using maps to identify features and location.

Sources:
The San Francisco Green Schoolyard Alliance, Rachel Pringle, 2009. www.sfgreenschools.org
Map symbols courtesy of New Jersey Department of Environmental Protection
http://www.state.nj.us/dep/seeds/sect6.htm

What Direction Does Your Water Flow?

From the San Francisco Green Schoolyard Alliance

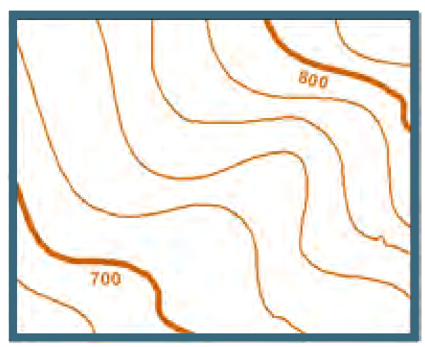
OBJECTIVES
Students will identify what watershed their school or home is in and in what direction water flows during a storm. They will become familiar with maps, map reading, and topography.

Grade Level	3rd-12th
Time	30 minutes
Materials	• Creek & Watershed Map of San Francisco
Standards Met:	*Science* • Earth Sciences • Physical Sciences • Investigation and Experimentation

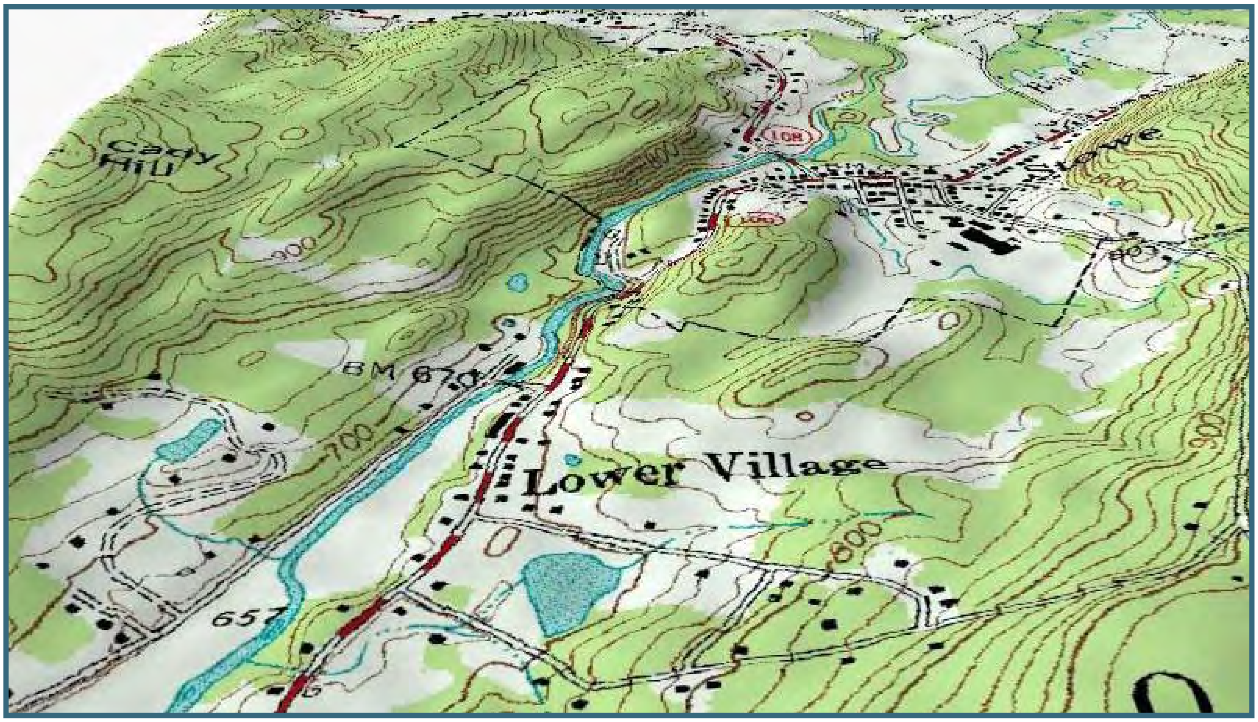
Vocabulary:
Contour lines
Topographic map
Relief
Terrain

Key Concepts:
- Everyone lives in a watershed, including you and your school
- All the water in a watershed flows downhill and eventually ends up in one body of water

BACKGROUND
As is mentioned in the lesson "Map the Garden," maps are a visual representation of an area. A **topographic map** consists of an accurate representation of both cultural and natural features on the ground, including elevation differences, or **relief**, represented by **contour lines**. (Contour lines connect points that have the same elevation. If you walk along a contour line, you neither ascend nor descend. But, if you walk across contours, you will either gain or lose elevation depending on your direction of travel.) Specifically, a topographic map can show how tall a mountain is and how low a valley is -what the **terrain** (the third or vertical dimension of land surface) is like in an area: hilly, flat, mountainous, etc. San Francisco is characterized by hills which are part of the Coast Mountain Range that stretches from southern California into Canada and further north.



We learned in "What is a Watershed" that a watershed is the land area that drains into a body of water. The upper elevations of a watershed contain small creeks that flow downhill and grow into much larger bodies of water, such as rivers and lakes. There are eight major watersheds in San Francisco: Channel, Islais Creek, Lake Merced, North Shore, Richmond, Sunnydale, Sunset, and Yosemite. Each of these watersheds either drains into San Francisco Bay or the Pacific Ocean.



A topographic map shows the relief (or terrain, such as hills and valleys) in a particular area. Also shown are towns, buildings, waterways, and roads.

PROCEDURE

Unfold the Creek & Watershed Map of San Francisco (or another topographic map of the city) and lay it out on a flat surface where everyone can gather around to see it. Ask the students what they notice about the map. How have the cartographers depicted different features? How did they define features, objects, and themes? Point out the different watersheds. Ask the class what watershed their school is in? Can they tell? How?

DISCUSSION

Is this map a topographic map? Can the students tell where the high points are? The low points? Can they determine, approximately, how high (elevation) their school site is by looking at the contour lines? What elevation is the ocean? *All points of elevation begin at "sea level," which is zero.* Ask the students in what direction does water flow? Up or down? Why? *Gravity.* In a watershed, where does all the water flow? *Downhill.* In your school's watershed, if there were no sewer, where would all the water flow? Find it on the map. *Much of the water in SF flows into the combined sewer and is treated and then released into the Bay or Pacific Ocean. However, some water in SF still does flow downhill, outside of the sewer system and flows into the Bay or Pacific Ocean on its own.*

Sources:

The San Francisco Green Schoolyard Alliance, Rachel Pringle, 2009. www.sfgreenschools.org
Example topo map from: http://en.wikipedia.org/wiki/File:Topographic-Relief-perspective-sample.jpg
Example contours from: http://raider.muc.edu/~mcnaugma/Topographic%20Maps/contour.htm

Calculating Rainwater Runoff

OBJECTIVE

Students will determine how many gallons of rainwater fall on the roof that is linked to their cistern. They will also estimate how much water their school uses to flush toilets and determine how many cisterns they would need to meet this demand and if their school's larger roof could capture this water.

Grade Level	4th-12th
Time	30-45 minutes
Materials	• Length of string or rope for measuring (50 or 100 ft.) • Rainfall chart from Resources section for reference
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation *Math* • Measurement and Geometry • Statistics and Data Analysis • Mathematical Reasoning

Vocabulary:

Annual
Cistern
Volume
Storage Capacity

Key Concepts:

- A lot of water can be captured from roofs during storm events
- We use a lot of water just to accomplish basic tasks such as flushing a toilet; we could rainwater to accomplish these tasks.

BACKGROUND

The average **annual** rainfall in the Bay Area is about 20 inches, or 1.7 feet of rain. This means that if it rains on a hard, **impermeable** surface like a roof or pavement, and there are no drains to take the water away, then there would be 1.7 feet of water covering that area over the course of the rainy season. In non-urban areas, where much of the ground is **permeable**, rainwater is absorbed, recharges groundwater aquifers, or flows into creeks and rivers that empty into a bay or ocean.

Think of nearly two feet of water covering your school or home! That is a lot of water. In San Francisco, this water instead goes into storm drains and enters our combined sewer system to be treated before it enters San Francisco Bay or the Pacific Ocean. What if we could capture some of the water that falls during a rain storm and use it to water our garden or flush the toilets at school or in our homes?

The great news is that your school *is* harvesting rainwater! Your school has a **cistern** that holds water that is collected off of a roof. Your cistern doesn't collect ALL of the rainwater that falls on your school, only a part of it. But this may be enough to water your garden during dry periods. Any water that we do not take from the tap is water that can stay in rivers, lakes, and streams. (San Francisco gets its water from the Hetch Hetchy Reservoir that is fed by the Tuolumne River in Yosemite National Park. See the graphic on page 11.)

How much water is collected, annually, by your cistern? To calculate the annual **volume** of water that falls on the roof that you are capturing water off of, multiply the area of that roof by the annual rainfall (20 inches or 1.7 ft.).

PROCEDURE

1. Measure the area of your roof

To determine the area of the roof you can roughly measure the length and the width of the building below the roof by marking these lengths with a string that is 100 or 50 feet. Measure these two lengths and multiply them to find the rough area of the roof.

Area = Length x Width

Example: If your building measures 100 ft. long by 30 ft. wide, then:

100 ft. x 30 ft. = 3000 ft^2

2. Calculate volume of runoff generated by rainfall

The annual volume of water that falls on the roof is the product of the area of your roof multiplied by the annual rainfall.

Area of Roof (ft^2) x Depth of Annual Rainfall (ft.) = Cubic ft.. (ft^3)

______ ft^2 x _______ ft. = ______ ft^3

3. Convert cubic feet to gallons (if you choose)

Once you have estimated your annual captured volume, convert your cubic feet to gallons. To do this, multiply your number of cubic feet by 7.5 = to get number of gallons.

______ Cubic feet X 7.5 = ______ Gallons

DISCUSSION

1. How many gallons of rainwater fall on your roof annually?
2. Does your cistern have the capacity to hold all of this water?
3. Where would overflow go?
4. How do you use the water after it's been captured?

EXTENSIONS

What if you and your classmates wanted your school to use rainwater to flush toilets and water the gardens at school? How many gallons of rainwater would you need? How many cisterns would you need to store enough water to meet these water demands at your school?

To calculate the annual volume of water that falls on your school, follow the procedure above. If your school is oddly shaped, break the footprint down into separate rectangles and squares, and add up the areas that you calculated.

- Find out how many students are at your school
- Determine the area of garden space that needs watering
- Determine the size/capacity of your current cistern

Refer to the tables below to calculate the amount of water needed to flush the toilets in your school and irrigate a garden planted with native plants (which use less water).

Number of Students x 1,998 Gallons Annually = _________ Gallons Annually

(Area of Garden / 100 ft^2) x 1,000 Gallons = _________ Gallons Annually for watering.

Add these annual water demands together to determine the total annual water needs at your school for toilets and irrigation. To find out how many cisterns are required to capture and store this much water, divide your school's water need (that you just figured out) by the capacity of your current cistern.

Example: 200,000 Gallons (annual need) / 1000 Gallon Cistern = 200 cisterns!

Water Use:	**Annual Demand (Gallons)**
Irrigation (100 ft^2 of drought tolerant planting or "native garden")	1,000
Flushing **Toilets**: 3 low flow flushes per day per student x 3.7 gallons/flush x the number days at school (180)	1,998

Typical Sizes for Rain Barrels & Cisterns:	**Storage Capacity (Gallons)**
Rain Barrels	60
Cisterns	1000+

EXTENSION DISCUSSION

1. About how much water does your school use each year to flush toilets or water the garden?
2. Does this surprise you?
3. How many people are in your family?
4. How large are your total toilet flushing needs?
5. How many rain barrels would you need at home?

Sources:
Techbridge curriculum, SFPUC. Adapted by The San Francisco Green Schoolyard Alliance, 2009

Graphing Change Over Time with a Rain Gauge

OBJECTIVES
Students will observe, measure (using a rain gauge), record, and graph the change in rainfall over a period of time.

Grade Level	3rd-12th
Time	15 minutes
Materials	• Rain gauge • Pole or wooden stake • Large graph or grid paper • Thick black permanent marker • Blue permanent marker • Ruler
Standards Met:	*Science* • Earth Sciences • Investigation and Experimentation *Math* • Measurement and Geometry • Statistics and Data Analysis • Mathematical Reasoning

Vocabulary:
Precipitation
Meteorology
Graduated cylinder

Key Concepts:
- Rain can be measured using an instrument called a rain gauge
- Graphing change over time can illustrate trends in how little or much rain has fallen in a season

BACKGROUND
A rain gauge helps us determine how much liquid **precipitation** (rain) fell during a particular storm event. There are many types of rain gauges, but the simplest kind often consists of a **graduated cylinder** with a funnel at the top. Rain is collected in the cylinder and the water level is measured after the storm. **Meteorologists** keep careful records of rainfall over a period of time in order to compare trends and patterns in the weather. In California, the amount of precipitation has steadily decreased over

Garden Rain Gauge

the last few years, creating drought conditions throughout the state. Drought causes many problems for farmers, citizens, wildlife, and fisheries alike.

Note: Rain gauges, like most meteorological instruments, should be placed far enough away from structures and trees to ensure that any effects caused are minimized.

PROCEDURE

Set up your rain gauge in the garden or schoolyard, away from any buildings or overhangs. You may need to attach the gauge to a pole or wooden stake to secure it in the ground. Create your graph, in front of the class, by highlighting the X and Y axes on your grid paper with the black permanent marker. Explain how the X axis is where we'll record "Time" and the Y axis is where we'll record "Inches of Rain." Label the axes appropriately. Choose one student each class to check the gauge and report what the level is. Record the measurement on the graph with a dot using your blue permanent market. Repeat this procedure throughout the rainy season and connect the dots using a ruler.

DISCUSSION

1. What does the line that you've created in blue marker represent? *Change in rainfall over time.*
2. How much rain fell over the entire wet season?
3. How does this compare to previous years? Do you notice any trends or patterns? *You can look up this data on the internet.*
4. What do the peaks, or highest points, on the graph represent? *Storm events.*
5. What do the valleys represent? *Dry periods.*

EXTENSIONS

Research the last ten years of weather data in California for rainfall, snow pack, and reservoir level and compare them to this year's rainfall data that you collected as a class. California has been experiencing a drought for the past few years. Does the weather data confirm this? Does the data that you collected confirm this? If not, why is this? *Localized weather, only one collection point.*

What does a drought mean for us as citizens? What does this mean for farmers and their crops or livestock? What does this mean for wildlife and fisheries? What can we do to conserve the water that we use?

Refer to the "Monthly Rainfall Averages for San Francisco" chart on page 87.

Sources:

The San Francisco Green Schoolyard Alliance, Rachel Pringle, 2009
www.sfgreenschools.org

POLLUTION AWARENESS & PREVENTION

Cover crops like these fava beans provide nutrients to the soil without the use of synthetic fertilizers.

Pollution Soup

Using a jar of water to represent the watershed, students add materials to demonstrate of the impact of urban runoff and nonpoint source pollution.

Adapted by The Watershed Project

OBJECTIVE
Students will demonstrate how our activities cause urban runoff pollution and impact water quality in creeks, the San Francisco Bay, and the Pacific Ocean; describe how the combined actions of all of us have a cumulative effect.

Grade Level	K-12th
Time	45 minutes
Materials	• Large, clear container filled with clean water • Small containers to hold "pollutants" (yogurt containers work well) • Materials to put into containers (see Preparing for the Activity, below)
Standards Met:	*Science* • Physical Science • Earth Science • Investigation and Experimentation • Life Science • Ecology • Evolution • California Geology *Language Arts* • Reading • Listening and Speaking • Writing

Vocabulary:
Point Source Pollution
Nonpoint Source Pollution
Pesticides
Herbicides

Key Concept:
- Nonpoint source pollution is caused by the combined actions of individuals who misuse or improperly dispose of common home and garden products

BACKGROUND
Our actions at school and home can cause environmental damage to our creeks, the San Francisco Bay, and the Pacific Ocean. To keep our watersheds, the ocean, and the Bay healthy, we first need to learn about the effects of our actions, and then how we can change our behaviors.

Many people assume that most of our water pollution is caused by large industries and agriculture. This type of pollution can be traced back to one particular source so it is called **point source pollution**. But the most damaging source of water pollution is actually the combined actions of individuals who misuse, dump, or discard hazardous household substances around their homes, gardens, and city streets. We call this **nonpoint source pollution** because it is hard to trace the pollution back to just one place.

Rubber dust from tires, antifreeze, oil, insecticides, **pesticides**, **herbicides**, household chemicals, fertilizers, and paint are all substances that become pollutants when they are washed off our yards, streets, and parking lots. This polluted water flows into the gutter, disappears down storm drains, flows into creeks, and eventually runs untreated into the San Francisco Bay and Delta.

PROCEDURE
Label each container, and fill each with the corresponding materials:

- **Earth:** dirt and rocks
- **Nature:** leaves and twigs
- **Trash:** various wrappers, cigarette butts, etc.
- **Old Car Owner:** molasses or syrup to represent car oil
- **New Car Owner:** liquid soap and water
- **Just Your Average Car Owner:** metal (penny) and rubber (rubber band)
- **Homeowner:** paint
- **Pet Owners:** Tootsie Roll or chocolate covered raisins to represent pet waste
- **Gardeners:** water and green food coloring to represent fertilizer
- **Industrial Waste:** soy sauce and water (use hot water if possible) to represent industrial discharges

Place the watershed jar where everyone can see it.

1. Ask students if this were a body of water near their home, would they consider swimming in it? Fishing from it? Drinking it?
2. Brainstorm a list of substances that are considered pollution. Have students discuss which of these materials might contain substances that are harmful to the environment. Ask students to think about how these substances might get into the watershed.
3. Hand out the various containers to students. Explain that they will be adding some possible pollutants to their watershed.
4. Call students up, having them describe what is in their container before emptying the contents into the "watershed."
5. Discuss each pollutant added (see information below--answers to the questions are in italics) With older students, copy the information below and let students ask and answer the questions:

- **Earth:** Imagine that there is a heavy rainstorm. Sand, dirt, and pebbles wash from construction sites and into the street and then the storm drain. This material ends up in the creeks. Would they still swim, fish or drink from this water? How might all the debris impact the stream? *Sediment in the water can impact the food chain by decreasing the amount of light available to aquatic plants, increasing the surface temperature of the stream, smothering fish and fish eggs, or may contain contaminants.*

- **Nature:** Leaves and other natural debris can get into our storm drains. How might these natural materials pollute our watershed? *Paved streets and parking lots don't allow organic matter to decompose into soil, and it concentrates in our waterways. Too much debris can block fish migrations, impede water flow, and consume oxygen as it decomposes -reducing oxygen available for aquatic life.*

- **Trash:** How might litter end up in the creeks that we cannot even see? How does this impact the health of the creeks? *Litter from far away washes into creeks and the Bay via the storm drain system. Plastics, aluminum, and other human trash does not degrade easily, or contains materials toxic to aquatic life.* Would students still swim, fish or drink from this water?

- **Old Car Owner:** What types of hazardous substances might come from cars? *Copper and asbestos from brakes, rubber from tires, motor oil, are just a few of the by-products of an automobile-based society. One gallon of motor oil can contaminate 250,000 gallons of water. Motor oil contains hydrocarbons and metals which endanger the health of humans and wildlife; oil creates a film on the surface of water that can smother aquatic animals and coats the feathers of birds—keeping them from flying and affecting their ability to stay warm and dry. Antifreeze contains ethylene glycol, which is poisonous.*

- **New Car Owner:** If you had a brand new car, with nice shiny paint, what would you do to take care of it? What goes down the drain with the water? Where does this water go? Why is washing something in the driveway different from washing in the kitchen sink? *Soaps, cleaners, and dirt that go down the drains in your home pass through the water treatment plant before they are flushed out to sea. However, if you wash your car in the driveway or the street, the cleaners sometimes enter our creeks and Bay, untreated. Phosphates, detergents, and cleaning agents can cause rapid growth of algae, or kill aquatic life outright.*

- **Just Your Average Car Owner:** What was in this container? What do a penny and a rubber band represent? *Vehicles may be the single greatest contributor to urban runoff pollution. They are a major source of copper, lead, cadmium and chromium—all which are toxic to either humans, aquatic life, or both. Brake pads and tires wear directly onto roads, where the metals and other contaminants can be transported very efficiently into the stormwater system, and ultimately creeks.*

- **Homeowner:** What does it look like the container is filled with? What activities of a homeowner might cause pollution? *This canister is filled with paint. The solvents used in paint are toxic and flammable. The pigments may contain heavy metals, and many paints contain fungicides to inhibit mold growth. When leftover paint is poured down the storm drain, or brushes and rollers are cleaned outside, our watershed may become polluted.*

- **Pet Owners:** How does pet waste get into the watershed? What impact can pet or human waste have? *Pet owners who don't pick up after their pets allow waste and the bacteria and parasites it carries to enter the watershed. Fecal coliform and E. coli bacteria make waters unsafe for swimming and drinking.*

- **Gardeners:** How many products can you think of that we apply to our gardens and landscaping? Even if they are applied to the plants, how might they end up as runoff into our creeks? *Pesticides, herbicides, fertilizers, and weed killers are just of few of the products commonly used by gardeners that contain hazardous chemicals. Many of these products are washed into our storm drains and on to creeks and the Bay by over-watering or rain water. Many of the ingredients in pesticides and herbicides are toxic to aquatic life. The nutrients in fertilizers can cause algae blooms, which when it dies allows bacteria to feed upon it and in turn use up the oxygen in the water, suffocating aquatic life.*

- **Industrial Waste:** How is the waste from industry different from the waste from our homes? *While there is more regulation of industrial pollution than home pollution, some industries illegally dump toxic waste or discharge hot water into rivers or the Bay. Industrial toxins are as bad—if not worse than—the toxins in our homes; temperature changes from hot water can kill aquatic life.*

6. Let the watershed jar sit for all to see. Discuss the lessons that can be learned from this demonstration. Explain that environmental scientists think in terms of point source, and nonpoint source pollution. Nonpoint source pollution does not come from a single, identifiable point, place, pipe, etc. -but is rather the accumulation from a variety of sources. All but one of the sources above are generally considered nonpoint source pollution, or urban runoff in this case (agricultural runoff is another source of nonpoint source pollution). Can you figure out which one is usually a type of **point source pollution**? *Industrial Waste. While you can make the argument that each thing by itself is a point source of pollution, all are flushed from many locations into creeks and the Bay through the storm drain system and collectively are nonpoint source pollutants.*
7. For **younger students**, draw a picture of a healthy watershed. For **older students**, write about urban runoff pollution in our community. Allow students to choose a creative writing or essay format.

DISCUSSION

- Describe this watershed. Would this water be safe to drink? To swim in? For wildlife?
- How can these pollutants get into creeks and the Bay?
- Who is responsible for polluting the water?
- Which of the causes of pollution did you know about? Which ones didn't you know about?
- Were any of the causes of pollution things you or your family might do?
- Who should be responsible for cleaning up the water?
- What can individuals do to lessen the problem of nonpoint source pollution?

EXTENSIONS

- Provide students with a variety of 'clean-up' materials (coffee filters, scoops, fish nets, spoons, wire mesh, cheesecloth, funnels, paper towels, gravel, charcoal, etc.) and ask them to try and filter out the impurities in the water.
- Walk around your school and look for storm drains and pollution.
- Take a field trip to a local creek and to look for storm drain out flow pipes, and other sources of pollution. Make a visual survey of the health of the creek.
- Take a field trip to the local sewage treatment plant such as the Oceanside or Southeast Treatment Plant.
- Do further research on each of the examples of pollution problems used in this activity, and report back to class.

Source:
The Watershed Project, Richmond California
http://www.thewatershedproject.org/
Adapted from "Who Dirtied Boston Harbor," Down the Drain, Massachusetts Water Resources Authority.

Mapping Nonpoint Source Pollution

We cannot track some pollution back to its source, so how can we try to stop it?

From San Francisco Recreation & Parks Department, Youth Stewardship Program

OBJECTIVES
- Learn how the health of a watershed is adversely affected by nonpoint source pollution
- Identify sources of nonpoint source pollution in a watershed
- Exercise map and compass skills (optional)

Grade Level	4th-12th
Time	30-45 minutes
Materials	• Map of watershed or blank paper • Binoculars, pencils • Compass (optional)
Standards Met:	5^{th}- 3a-e 6^{th}-5e 9^{th}-12^{th} CA Geology: 9c

Vocabulary:
Groundwater
Surface water
Effluent
Watershed
Nonpoint source pollution

Key Concepts:
- Nonpoint source pollution is cumulative
- Change in individual behaviors can have a big impact on keeping pollutants out of the watershed

BACKGROUND
Seventy-five percent of the Earth's surface is covered by water. Similarly, water makes up over 80% of our body weight. All organisms need water in order to survive. Water supports all food webs and the microscopic plant life responsible for Earth's oxygen.

Although 75% of the Earth is covered in water, most of that is saltwater. About 97% of the water on the Earth is saltwater while only 3% is fresh water. There are two main sources of fresh water: groundwater and surface water.

Groundwater is found within cracks and porous rock formations underground. It can be pumped to the surface through wells, may flow to the surface as a spring, or seep underground into streams, ponds, wetlands, or rivers.

Streams, lakes, and ponds are examples of **surface water**, which originates from groundwater, rain, melted snow, surface runoff from surrounding land, and **effluent**—water returned to the environment after it has been used by people.

Although we are surrounded by water here in San Francisco, most of that water is saltwater. The fresh water we use in our homes comes all the way from Hetch Hetchy—a reservoir in the Sierras near Yosemite! The few sources of freshwater we have in San Francisco are very precious and are vital to the survival of the animals living in the city. The amount of freshwater available within an ecosystem is one important factor that determines the number and types of organisms it can support.

Water Quality and Pollution:
A **watershed** is the land area that drains into a body of water. The upper elevations of a watershed contain small creeks that flow downhill and grow into much larger bodies of water, such as rivers, lakes and eventually into the ocean. Water quality is affected by how the surrounding watershed is used. When water is polluted through human use, it can negatively impact an entire ecosystem. There are many human pollutants that reach our watershed. Some examples are: chemical and nutrient runoff from agriculture and home gardening, household cleaners that get into our drainage system, street and parking lot runoff, and acid rain from air pollutants.

We tend to think of water pollution as being caused by industrial waste or overflows of untreated sewage from sewage treatment plants caused by flooding, and indeed this can be the case. However, another major source of water pollution is caused by the combined effect of pollutants that are dumped by individuals around the home and garden. Since this type of pollution cannot usually be traced back to its source, it is called **nonpoint source pollution**.

Many items at home (motor oil, paint, cleaning products, fertilizers, pesticides, etc.) contain powerful substances that can cause pollution if they are not recycled or disposed of properly. If these products are carelessly washed into neighborhood streets and gutters, or soak into the ground from lawn watering, they can eventually reach waterways and cause environmental damage. Storm drains are not connected to the sewer system, but instead drain directly into waterways. Anything other than water that is dumped into a gutter or storm drain can eventually pollute a stream, river, estuary, the San Francisco Bay, or the Pacific Ocean.

Nonpoint source pollution, often caused by the improper disposal of pollutants around the home, can damage life in waterways long after and far from where it was released!

PROCEDURE

1. Discuss the information above with the students. Talk about the importance of freshwater sources in their watershed. Why are they important? Who depends on them? What happens if they get polluted?

2. Have students hypothesize sources of nonpoint source pollution near their school or home. Here you may want to discuss acid rain and how it is formed. This is a great way to demonstrate the water cycle and to talk about how pollution in the air can affect our water.
3. Hand out a pencil and blank map of the school's watershed to each student. If a map is not available, you can use plain pieces of paper. The students can draw their own maps!
4. Divide the class into groups of 3 or so students. Give each group a pair of binoculars. Tell them their jobs are to identify probable sources of nonpoint source pollution that are possibly affecting their school's watershed. (Examples include: pesticide and fertilizer runoff from golf courses or nearby houses, oil and auto fluid runoff from a parking lot, trash dumped by boaters into waterways, overflowing trash cans in the neighborhood, etc.)
5. Ask the students to draw and label these nonpoint source pollutants on their map. If the class is advanced enough, the students can create a key and use symbols to represent different types of pollution. Every student in a group needs to draw and label his/her own map, even though the group is working together to identify the pollutants. The groups should not venture out of sight of the leaders.
6. Optional: The groups can find the bearing to the nonpoint source pollutants using compasses.

DISCUSSION

Call all of the groups together and have them sit in a large semicircle. Each group, one at a time, should stand in front of the semicircle and describe two interesting pollutants it found.

Discuss how many of these nonpoint source pollutants can be easily avoided. Some ways to reduce our contributions to nonpoint source pollution: recycling used motor oil, not dumping paint in storm drains, not using pesticides or fertilizers, not over watering the lawn, etc.

EXTENSIONS

The students can develop a plan for curbing the release of some of these pollutants that eventually reach their watershed. This could mean educating the neighborhood through an article in the local paper, creating signs to post in the neighborhood, reporting their findings to their school or park council, or doing further research on the effects of pollutants on native plant and animal life.

In addition to reducing the amount of pollutants we put in our water, it is also important to help conserve water. Discuss with students the limited amount of freshwater we have on the Earth. Brainstorm ways in which we can help to conserve water.

Sources:
San Francisco Recreation & Parks Department, Youth Stewardship Program; "Don't Let Your Pollution Leave Home: Exploring Nonpoint Source Pollution," Freshwater Guardians, *California Aquatic Science Education Consortium*
http://www.sfgov.org/site/recpark_index.asp?id=21196#Youth

Friend, Foe, or Escargot?

Integrated Pest Management (IPM) Activity: Students identify and learn about garden pests and beneficial insects.

From The Watershed Project

OBJECTIVES
- Identify common insects
- Learn about insect biology
- Classify organisms as beneficial or not

Grade Level	K-12th
Time	60 minutes
Materials	• Friends & Foes identification sheets (per groups or child) • Hand lenses (optional) • Friends & Foes Background Information (per group or child) • Garden reference books with information on garden pests and beneficial insects
Standards Met:	*Science* • Life Science • Earth Science • Genetics • Ecology *Math* • Number sense • Statistics and Probability • Algebra *Language Arts* • Reading • Writing • Listening and Speaking

Vocabulary:
Integrated Pest Management
Beneficial Insects
Biological Control

Key Concepts:
- Insects are important organisms in our ecosystem
- Some insects are pests and some are beneficial to have in the garden
- Integrated Pest Management is a pest control strategy that requires careful observation
- IPM focuses on keeping pest populations in check, not eliminating them

BACKGROUND

A garden is a complex ecosystem teeming with life. While a few of the animals and insects that live in a garden can cause damage to the plants, most of the creatures we find in the garden are essential to the health of the plants.

Insects are the most common creatures we see in the garden, and very few of them are pests. It is estimated that of the nearly one million insect species we have identified, less than one percent are pests. Insects have been on Earth for over 400 million years and play an important role in the garden. Many insects are pollinators that are essential for the production of fruit, vegetables, and flowers. Some insects are parasites or predators that prey on garden pests. Insects are an essential link in many food chains, providing food for other insects, birds, and animals. Many insects provide us with foods and household materials like silk, honey, and wax.

Insects are not the only important creatures that live in the garden. Spiders, members of the arachnid family, provide an important **biological control** as they catch and eat a variety of garden pests. They differ from insects in the amount of body segments (2) and legs (8). Spiders live all over the globe, and in one acre of land there may be as many as 50,000 spiders! Earthworms are also essential to the health of garden soil. They digest organic matter and excrete it in castings that provide important nutrients to plants. Earthworms also help improve the texture of soil as they tunnel through the ground. Other animals, like birds, bats, snakes, lizards, toads, frogs, and salamanders eat large numbers of insect pests.

Being able to identify the insects and animals living in a garden and understanding the predator-prey relationships between these organisms is essential in developing a safe plan to control or manage pests. Using chemical pesticides at the first sign of pest damage can often cause more problems than it solves. Pesticides do not target a specific pest—they also kill the beneficial organisms in a garden. By killing off **beneficial insects**, insects that were never a problem may now become a pest. What's more, pests can become resistant to these chemicals and can pass their resistance on to new generations. Pesticides are designed to kill biological organisms, so they pose a health risk to people and pets as well. Toxic chemicals used in a garden can remain active in the soil for many years, and they can wash into our storm drain system where they enter our creeks, Bay, and ocean and harm aquatic life. Disposing of these chemicals is also a problem -some pesticides poured down household drains are not removed at the sewage treatment plant and can enter our waterways untreated.

In an IPM program, the goal is not to wipe out all garden pests, but to keep these populations at low levels so that the amount of damage to garden plants is acceptable. Keeping some pests in the garden ensures that you will also have a healthy population of the beneficial insects that prey on them. In this activity, students learn about Integrated Pest Management techniques as they inventory the animals and insects that live in the garden, identify the roles these creatures play in the garden ecosystem, and monitor the garden for damage done by pests.

PROCEDURE

1. Brainstorm a list of the insects and animals that might be found in a garden.

2. Which of the organisms on their list might be considered a pest? Discuss what is meant by the word "pest". What are some pests around your home and garden? Is a pest always harmful? Ask students if any of them have mice, rats, snakes, or rabbits as pets. *Some people consider these animals to be pests while others consider them pets. Some insects may be pests in one stage of their life cycle while they are beneficial in another stage. (For example the tomato hornworm eats the leaves on tomato plants, but the adult moth acts as a pollinator.)*

3. Look at pictures of common garden insects. Ask students if they can always tell if an insect or animal is a pest just by the way it looks. *Some larval forms of beneficial insects look like hideous monsters, but they can eat huge numbers of garden pests. Some people think spiders and bats are scary, but they are important controls of insect pests.*

4. Hold up some examples of leaves that show insect damage. Ask students if they can identify the pest that caused the damage. Can you tell if it was a sucking or chewing pest? How can you find out which pest caused the damage? Why might it be important to know exactly which insect or animal was the pest?

In the Garden

5. Divide the students into pairs and give each pair the Garden Friends and Garden Foes identification sheets, and hand lens (optional). Have students explore the garden to create an inventory of the insects and animals they find living there. They should list and/or draw any insects, signs of insect damage, or evidence of other animals visiting the garden (chewed leaves, feathers, old spider webs, tracks).

6. Have each team share its results with the rest of the class and create a class list of the organisms that use the garden. Which of these are considered pests, and which are considered beneficial?

In the Classroom

7. Assign each pair of students one of the insects from the Friends and Foes card, or one they found in the garden to research. They can use the background information included with this activity, garden reference books, and the Internet to find out more about their insect or animal. Is it harmful or beneficial? What is its role in the garden ecosystem? What types of adaptations allow it to survive in the garden habitat? What is its life cycle? If it is a pest, what types of non-toxic controls can be used to control it? If it is a beneficial organism, what pest does it help to control? Have students share their findings with the class.

8. Introduce and discuss the ideas and techniques used in an IPM approach that would allow students to solve pest problems in the garden, without causing harm to themselves or the environment:

- **Plan the garden carefully.** Choose plants adapted to your climate and area, and choose species that are least prone to damage. Planting a diverse mix of vegetables and flowers will help maintain a balance of pests and predators. Choose "companion" plants that help to repel pests, and rotate crops each year.

- **Keep plants healthy.** Strong plants are less susceptible to pest damage, so be sure to give your plants the water, light, and nutrients they need to keep from being stressed and weak.

- **Identify the specific pest.** Be sure you know which pest is actually causing the damage and learn about its life cycle and its predators.

- **Accept a certain amount of damage.** Don't assume a pest will become a problem. Some amount of damage should be acceptable—wait to see if the amount of damage becomes a real problem.

- **Start with the least-toxic or intrusive controls**. Some methods of control include hand-picking pests, protecting plants with barriers like floating row covers or collars, setting out traps, introducing beneficial insects or pathogens, and mixing up liquid soap and water to spray the plants.

DISCUSSION

- How can you use the relationships between pests and beneficials to keep the garden healthy?
- What insect or animal was the most numerous in your garden? Why would this organism be so numerous?
- Where did you find the most organisms in the garden? What type of habitat did they seem to prefer?
- Did you find more garden friends or garden foes? Why do you think?
- Did you find evidence of insect damage on the garden plants? What kind of evidence? Could you identify the pest that was feeding on the plants? Is it always easy to determine what has been eating your plants?
- What would happen if there were no insects living in your garden? What would life be like if there were no insects alive on Earth?
- How much do people's attitudes towards insects and animals play a part in the types of controls they use in the garden?
- Compare and contrast the benefits and costs of using pesticides or controlling pests with beneficial insects.

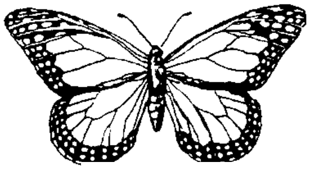
EXTENSIONS

1. Create an IPM plan that would apply to the pests and problems in your garden.
2. Create a flyer or brochure with a sketch and brief description of the most common beneficial insects in the garden and why they are important. Be sure to include a description of IPM techniques. Take copies of the flyer home and distribute them at local garden centers and libraries.

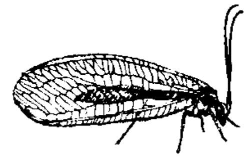
3. Create a garden habitat mural. Include both garden friends and garden foes and show where they might be found in the garden. Use string to show connections between predators and prey.
4. Visit the garden at regular intervals and chart what insects you find.
5. There are many plants that attract beneficial insects. For example, goldenrod has been found to attract more than 75 species of beneficials! Research these plants and include them in your garden.
6. Choose one organism you found in the garden and write a story about its life from that animal's or insect's point of view. What is your life like in the garden? What do you eat? How do you find your food? What are the dangers of living in the garden?
7. Set up an experiment to determine the food preferences of garden pests. Collect several different leaf samples of approximately the same size from the garden and place them in a large jar or petri dish. Introduce a pest from the garden and observe it for 24 hours to determine which food it prefers. (Be sure the insect is kept out of direct sunlight and has an adequate air supply.) Repeat this experiment with different insects. Can this information help you plan a pest management program in your garden?
8. Research what your garden site was like 200 years ago. What plants and animals might have been living there? Would pests have been a problem?

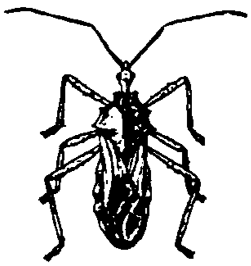
Source:
The Watershed Project, Richmond California
http://www.thewatershedproject.org/

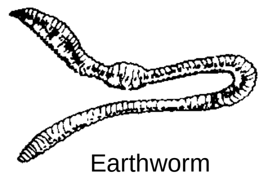
Garden Friends


Butterfly


Hover Fly


Lacewing


Assassin Bug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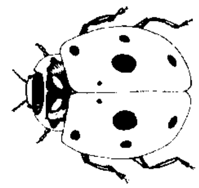
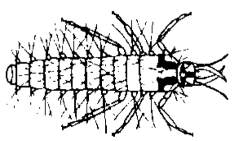
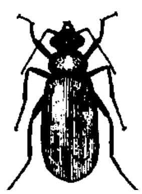

Ladybug

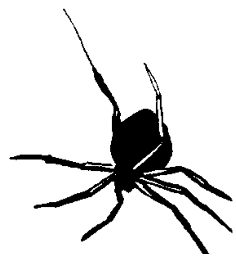

Lacewing Larva


Honeybee

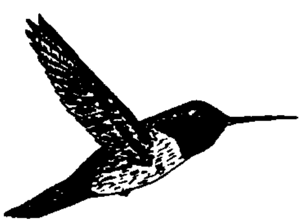

Ladybug Larva


Wasp


Ground Beetle


Spider


Frog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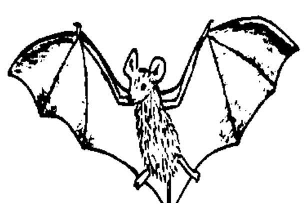
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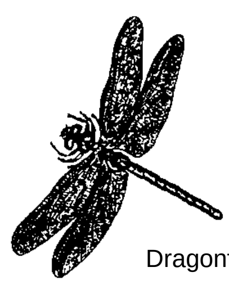
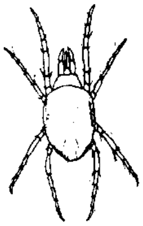

Dragonfly

Garden Foes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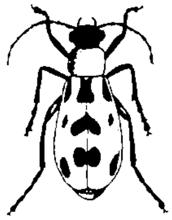
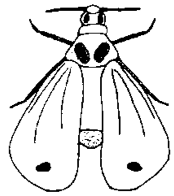

Cucumber Beetle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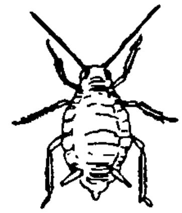
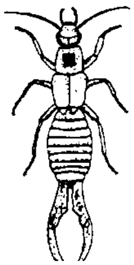

Aphid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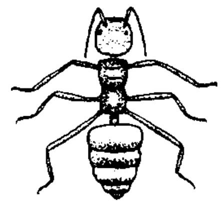
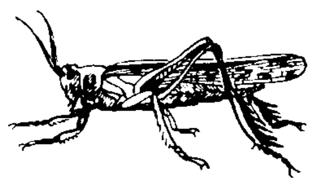
Scale


Ant


Harlequin Bug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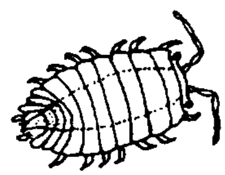
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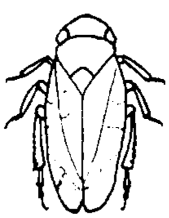
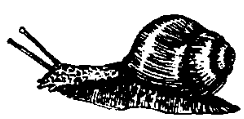

Spittlebug


Snail


Tomato Hornworm

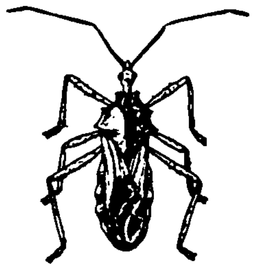

Gopher


Slug


Sow Bug

Garden Friends and Garden Foes
Background Information

Garden Friends

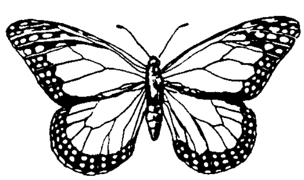


Assassin Bugs

Assassin bugs earn their name because they are such deadly hunters. They feed on many insects including leafhoppers, tomato hornworms, flies, and caterpillars. When you see them feeding they may look like they are kissing another insect, but they are actually using their long, curved beak to inject a paralyzing venom into their prey before they eat it. When you see these bugs in the garden, watch them carefully but don't pick them up—they may bite you!

Bats

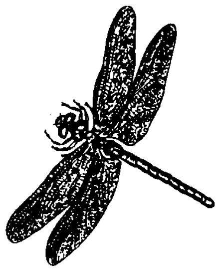
Many people are afraid of bats and think that they are dirty, bloodthirsty animals. Bats are actually clean, shy animals that consume huge numbers of insect pests and help to pollinate plants. Bats hunt at night and eat many insects, including moths, leafhoppers, and mosquitoes. A single brown bat can eat up to 600 mosquitoes in one hour! Bats play an essential role in dispersing seeds of plants and in pollinating many flowering and food plants like avocados, bananas, mangoes, dates, and figs. Bat droppings, called *guano*, provide plants with an excellent fertilizer.



Butterflies

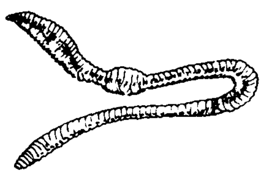
Butterflies and moths pollinate more plants than any other insect except bees! Butterflies have chemical sensors on their feet allowing them to "taste" the flowers they walk on. They sip the sweet nectar at the base of flowers through a tube-like mouth called a *proboscis.* Butterflies pick up pollen on their bodies as they feed on the nectar and carry the pollen with them from flower to flower. The pollen fertilizes the flowers, allowing it to produce fruit and seed.

Dragonflies



Dragonflies are fierce predators and eat many garden insects including flies and mosquitoes. The legs of the adult dragonfly hang down to form a basket. Dragonflies catch insects in this basket and eat them as they fly. They can fly at speeds up to 75 miles an hour. Newly hatched dragonflies are called *nymphs*, and they live in water. The nymphs are also predators of other insects, and one nymph can eat as many as 60 mosquito larvae in ten minutes.

Earthworms

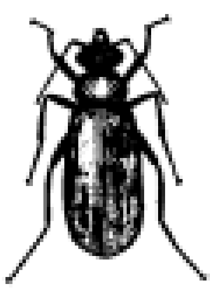


Earthworms are not insects; they belong to a group of animals called *Annelida*. Earthworms are essential to the health of your garden soil. They eat and digest dead organic material in the soil and excrete it in droppings, called *castings* that are rich in the minerals and nutrients that plants need to grow. Earthworms can eat their weight in decaying plant material every day. As earthworms tunnel through the ground, they help to break up the soil, permitting air and water to penetrate. Earthworms also provide an important source of food for birds and other animals that live in the garden.

Frogs and Toads

Frogs and toads love to eat insects. They have fast tongues and can eat between 10,000 and 20,000 insects per year! Amphibians, such as toads, frogs, and salamanders, and many reptiles, such as lizards and snakes, will eat slugs, flies, grubs, cutworms, grasshoppers, and many other insect pests in your garden.

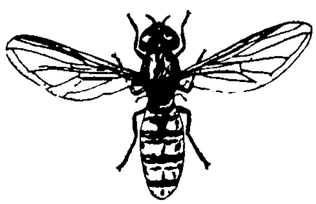
Ground Beetles



There are over 1,200 different species of ground beetles in North America. Ground beetles are predators that eat caterpillars and other soft-bodied insects like slugs, snails, cutworms, and maggots. They prefer to live in dark places, and you will often find them under boards, stones, and logs. Some beetles give off a stinky odor when frightened. Beetles can live for two to three years.

Honeybees

Honeybees are hard workers and our most important pollinators. Honeybees gather pollen and nectar from flowers, and as they fly from flower to flower they pollinate the plants. Bees also produce honey and wax. A bee must make 60,000 nectar-collecting trips to produce one teaspoon of honey! Honeybees can sting, but they do so only when they have been threatened or to protect their nests.

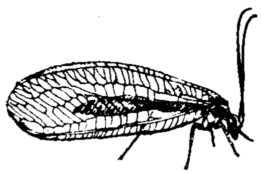


Hover Flies

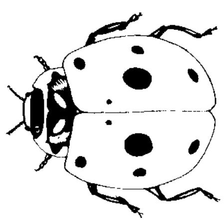
There are many different species of flies that help to pollinate flowers and keep insect pests under control. **Hover flies** have yellow-and-black or white-and-black stripes and resemble bees. They do not sting, and if you look closely, you will notice they only have one pair of wings. Hover fly adults are important pollinators and are sometimes called flowerflies because they feed on nectar. Their larvae, called maggots, are fat, worm-like creatures that eat large amounts of aphids. **Robber flies** have hairy, bearded faces and are predators that eat beetles, flies, and grasshoppers. **Tachinid flies** look like huge houseflies but you can identify them by the many coarse hairs that cover their bodies. The adults pollinate flowers and eat caterpillars, beetles, and borers. The females lay their eggs on the bodies of insect pests, and when the eggs hatch, the larvae eat the insect host.

Hummingbirds

Hummingbirds are important pollinators and predators of insects. They eat more than one half their weight in food everyday. Hummingbirds are attracted to colorful flowers that produce a lot of nectar. They have long bills and tongues that can extend out into the flowers to help them sip the nectar. In a single day a hummingbird might visit 1,500 flowers! Hummingbirds also need to eat insects for protein, and they feed insects to their young. There are 342 species of hummingbirds in the world and 15 species are found here in North America.

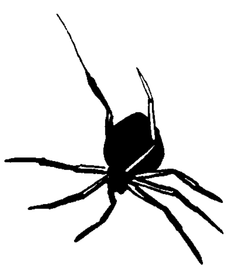


Lacewings are delicate, bright green insects that fly through the garden at night looking for nectar and insects. Most adult lacewings feed mainly on nectar from flowers. When lacewings first hatch from an egg, the larvae are small, brown, oval-shaped creatures covered with tufts of stiff hair. These larvae are hungry predators that use curved jaws, called mandible, to grab and suck the juices out of their prey. They prefer to eat soft-bodied insects, especially aphids and are such ferocious hunters they have been nicknamed "the aphid lion".



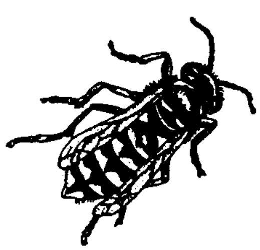
Ladybugs

There are many different species of ladybugs, and most of them are fierce hunters of garden pests like aphids, mealybugs, and scale. Both the adult ladybugs and their young feed on insects. They especially like to eat aphids and will often lay their eggs near aphid colonies. Ladybug larvae are tiny, black and orange creatures less than a half inch long, and one larva can eat up to 500 aphids a day! Adult Lady bugs can e at 3 0 to 40 aphids a day.



Spiders

There are more than 34,000 different species of spiders, and they are some of the most important insect catchers in the world. Although they have terrible eyesight, spiders use their clever hunting skills to catch their prey. Once they catch an insect, spiders sink their fangs into their prey and inject them with paralyzing venom. Then they feed on the juicy insides of their prey. Spiders are also an important source of food for other garden animals like birds and frogs.

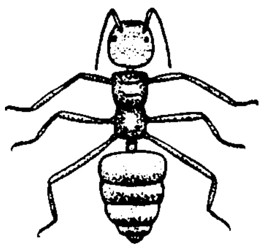


Wasps

There are more than 3,300 different species of wasps in North America. Wasps are considered to be beneficial insects because they eat insect pests. The young of some wasps are parasites—adult wasps lay their eggs on or inside other insects, and when the eggs hatch, the young wasps eat their insect host. Some species of wasps are used in greenhouses to control whiteflies. Yellow jackets are one type of wasp that can sometimes become a pest, but they also help us by pollinating flowers and keeping insect pests like caterpillars under control.

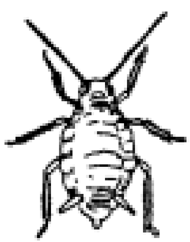
Garden Foes

Ants



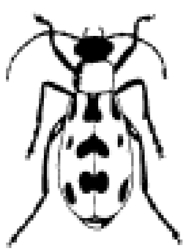
Ants can be a friend or foe in the garden. When they tunnel to make their homes underground, they help to break up and improve the structure of the soil. They also feed on termites. However, ants like to eat the sweet "honeydew" that aphids secrete. Ants will actually herd the aphids together, protect them, and "milk" them. By protecting aphids, they are protecting a garden pest! Ants live together in communities called *colonies.* There are more ants than there are any other creature on earth. Ants can live about eight years and can lift up to 50 times their own weight.

Aphids



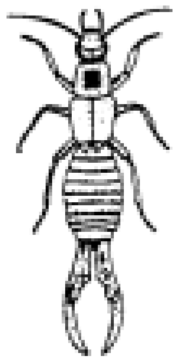
Aphids are tiny, pear-shaped, soft-bodied insects that suck the juices out of plants. One unusual thing about aphids is that they give birth to live young instead of laying eggs like most other insects. One female aphid can have 100 babies at a time, so aphid colonies can grow rapidly. Aphids vary in size, but most are 1/16 to 1/18 inches long. There are many different colors of aphids, including green, brown, yellow, pink, and black. There are both winged and non-winged species. Aphids produce a sweet, sticky substance called *honeydew* which ants love to eat. This honeydew can coat plants and become a place where a black mold grows.

Cucumber Beetles



Cucumber beetles feed on the leaves of many garden plants including melons, corn, tomatoes, squash, and beans. There are many different types of cucumber beetles. The most common ones are small yellow-and-black striped beetles. Spotted cucumber beetles are larger and prefer to feed on corn. In addition to eating plants, cucumber beetles cause many problems in the garden because they can carry and spread diseases that infect your garden plants.

Earwigs

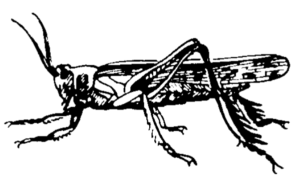


There are 18 different species of earwigs found throughout North America. These insects are easily identified by the large pinchers on the end of their bodies. Earwigs are both helpful and harmful in the garden. They eat insect pests like aphids and other insect larvae, and as scavengers they help to break down dead organic materials. But they also like to eat the leaves of your plants and can do quite a bit of damage. Earwigs live in dark, dry places and come out into the garden to eat at night. Because earwigs like to hide in dark places, people once incorrectly believed that they would hide inside people's ears—that is how they got the name *earwig*.

Gophers

Not all the pests that live in the garden are insects. Many mammals, like gophers, moles, squirrels, and deer, can become major garden pests. There are 33 different species of gophers, but the most common garden species is the pocket gopher, which was named for the pouches or pockets it has inside its cheeks for storing food. Gophers tunnel through the garden leaving fan-shaped mounds where they emerge. They like to nibble on the roots of plants but will often pull the entire plant under the ground and eat it!

Grasshoppers

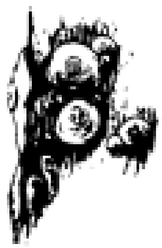


Grasshoppers are not particular about what they eat and can do a lot of damage to any garden. Grasshoppers eat during the day and use their strong jaws, called *mandibles*, to chew up leaves and stems. Grasshoppers "sing" by rubbing their forelegs together to attract a mate. Grasshoppers provide an important source of food for birds, reptiles, mammals, and other insects like beetles. Some cultures around the world eat grasshoppers as a tasty snack!

Harlequin Bugs

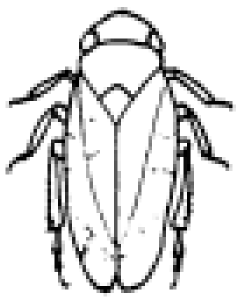
Harlequin bugs have distinctive orange-and-black markings on their backs and are about an inch long. These insects puncture the leaves and stems of plants to suck out the juices. Harlequin bugs love to eat plants in the cabbage family, but they will also feed on beans, squash, and tomatoes. They are related to stink bugs and can release a foul odor when they are disturbed.

Scale



Scale insects cling to the stems and twigs of plants where they suck the juices out of the plant. They are related to aphids, but they have a waxy, shell-like covering that helps to protect and camouflage them. They usually live in clusters or small groups. Many species of scale produce a sweet, sticky substance called *honeydew,* which can stick to plants and attract molds.

Spittlebugs



If you find a wet glob of what looks like spit on garden plants, you are actually looking at the hiding place of an insect called a *spittlebug.* Spittlebugs are small, hopping insects that are green or brown in color. Young spittlebugs produce a spit-like substance that allows them to hide and also keeps them from drying out. Spittlebugs pierce plant stems and leaves and suck out the juices. They can stunt the growth of plants or kill the entire plant. Some people think that spittlebugs look like tiny frogs, so they are sometimes nicknamed *froghoppers.*

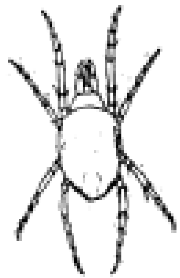
Sow Bugs and Pill Bugs

Sow bugs and pill bugs are not really insects; they are crustaceans and are related to crabs and crayfish. They have hard bodies divided into many segments and ten pairs of legs. Sow bugs and pill bugs are both harmful and helpful in the garden. They act as scavengers and help to break down dead organic material, which enriches the soil. But they will also feed on young seedlings and tender fruits like strawberries. Sow bugs and pill bugs live in dark, damp places and you will often find them in compost piles and worm bins. Sow bugs are flatter then pill bugs and only pill bugs roll up into a ball when they are disturbed. Sow bugs breathe though gill-like structures so they need to live in damp places. You will sometimes find both gray and dark blue sow bugs. They are the same species but the blue one carries a harmless worm called a nematode which gives it its bluish color.

Slugs and Snails

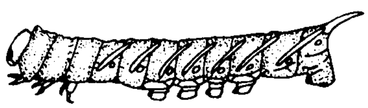
Slugs and snails leave a familiar, slimy trail wherever they travel in the garden. They are one of the worst garden pests here in California. Both snails and slugs are mollusks, but only snails carry a shell on their back. Snails and slugs feed on decaying organic matter, young seedlings, leaves, and low-growing fruits like strawberries. They travel on one, muscular foot and leave behind some slimy mucus which dries into a shiny trail. Snails and slugs hide during the day and come out to feed at night. They love damp weather and will sometimes come out to feed on wet, overcast days. Their eggs look like tiny clusters of pearls in the soil.

Spider Mites



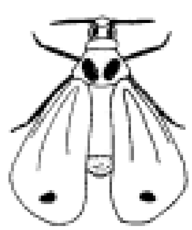
Spider mites are so tiny they look like small dots moving across the leaves of garden plants. Mites are only about 1/50 of an inch long and have eight legs. You will find them on flowers, vegetables, shrubs, fruit trees, and houseplants. You may not see the mites, but you may notice leaves that have small yellow speckles, look like they are bleached, or are covered with fine webbing. Many other species of mites will feed on spider mites to keep their populations down. Research on mites has shown that they will actually reproduce faster when exposed to certain pesticides!

Tomato Hornworms



Tomato hornworms are huge caterpillars whose beautiful green and black markings provide them with camouflage that makes them hard to find on a tomato plant. With their fierce-looking horns these caterpillars look dangerous but they do not harm people. You can often find these caterpillars by looking for their tiny black droppings on the leaves of tomato plants. Tomato hornworms can be a friend or foe of the garden. They are the larval form of a beautiful moth called the sphinx moth, which helps to pollinate flowers. But the caterpillar can do a great deal together can eat all of the leaves off a plant!

Whiteflies



Whiteflies are very tiny insects that can do a lot of damage in the garden and to your houseplants. They are relatives of aphids and scale and are only 1/12 of an inch long. Whiteflies are named for the white powder that covers their two pairs of wings. Whiteflies tend to gather in large groups, and when they are disturbed, you will see a white cloud of insects fluttering around the plant. Here in California they are mainly a problem in greenhouses and on citrus trees. Both adults and larvae suck the juices out of a plant and tend to hide underneath the leaves. Adult whiteflies excrete a sticky substance called *honeydew*, which can stick on the plant and promote diseases such as a mold called *sooty black fungus.*

Source: The Watershed Project, Richmond, CA. Kids in Gardens Education Program. (Illustrations were reprinted with permission from *Dead Snails Leave No Trails*, Loren Nancarrow and Janet Hogan Taylor, Ten Speed Press; and *The Bug Book*, Barbara Pleasant, Storey Communications, Inc.)

RAIN GARDENS & NATIVE PLANTS

Eriogonum fasciculatum, California Buckwheat. Photo by Barbara Eisenstein.

Water You Wearing?

In this activity, a student volunteer will be dressed up with different objects to demonstrate how plants adapt to dry conditions. This is a fun, creative activity that comically presents concepts of plant adaptation.

From The Watershed Project

OBJECTIVES

- Observe and describe appearance of native plants
- Discuss the physical adaptations of native plants.
- Summarize what has been discussed.

Grade Level	K-12th
Time	30 minutes
Materials	• See list of suggested materials in the list provided below
Standards Met:	*Science* • Life Science • Earth Science • Genetics • Ecology • Evolution *Language Arts* • Listening and Speaking

Vocabulary:
Native plant
Drought
Adaptation
Tap root
Transpiration

Resources: see Resources for a list of California native plants and a rainfall graph for the Bay Area

Key Concept:

- Native plants have adapted features over time that allow them to survive in their environment

BACKGROUND

The Bay Area is characterized by a Mediterranean climate, with long dry summers and wet winters with mild temperatures. The majority of the annual rainfall in this region occurs between November and April, and averages only about 20 inches per year. The remaining months are relatively dry. Furthermore, California occasionally experiences **drought** conditions, extended periods of time with very little rainfall.

Native plants are adapted to these conditions, which is one of the reasons they are particularly suited for local gardens. They require less water to survive during the summer months than many exotic plants that originated in wetter climates.

Investigating local wild areas will make apparent how California native plants have evolved to survive with almost no irrigation for half the year. These **adaptations** include:

- **Small, narrow leaves:** Small leaves require less water and have less surface area from which to lose water through **transpiration**.
- **Light colored leaves:** Grey or light green leaves reflect sunlight, rather than absorbing it the way dark green leaves do.
- **Thick waxy leaves:** A waxy coating on leaves helps the plant maintain its moisture.
- **Deep root systems:** Long **tap roots** or deep root systems mean that a plant can reach down for water that is further below the surface.
- **Aromatic leaves:** Many drought resistant plants contain aromatic oils which help the plant retain moisture.
- **Hairy leaves:** A layer of hair or fuzz on the surface of leaves catches moisture from dew or fog.

PROCEDURE

1. Ask students if they know what a drought is. Explain that California is prone to long periods with no rain, and that the rainy season in the Bay Area only lasts from November to April. Why is it important to not take long showers or water the lawn so much that it runs off on the pavement?
2. Have students think about how plants get water during the summer months when there is no water. How can plants survive if it does not rain for 4 or 5 months at a time?
3. Ask for a volunteer to help with this activity. Tell the students that this volunteer is going to pretend to be a drought tolerant plant.
4. Have students give some suggestions for how plants might adapt to low water conditions. If students are having trouble finding the answers, prompt them with questions such as:
    - What color clothes would you want to wear to stay cool? Think about a hot day, do you wear black or white?
    - How would you try to keep the moisture inside your body?

(For more prompts, see the adaptations listed in background section.)

5. As students guess correctly, dress the student volunteer up with objects that represent these adaptations. The more the student dresses up, the sillier he or she will look. This activity can be done using a wide variety of materials and is open to creative adaptation. One way to do this is to take a large white t-shirt and cover it with strips of Velcro. Then the objects that represent adaptations can be placed on the t-shirt. The following list can help you dress your student as a native plant.

Plant Adaptation	Suggested Costume Materials
Hairy leaves	Costume gloves covered with hair such as bear paws, a coat or sweater that is very fuzzy, felt strips attached with Velcro.
Deep root system	Attach a long piece of hose to the student to represent a tap root, use a long pair of pants that will act to extend the length of the student's legs, or attach long pieces of string to a pair of shoes and have the student wear the shoes.
Waxy leaves	Small candles can be attached to the student or held in his/her hands, or rubber gloves which trap water inside as hands sweat.
Narrow leaves	Self-adhesive acrylic fingernail tips
Light colored leaves	A white shirt or lab coat, grey or light green felt or construction paper strips.
Aromatic leaves	Have student hold an oil can, or put a few drops of an essential oil such as rosemary or lavender on the student.

6. After all of the adaptations have been identified, have the student hand the objects back to you one by one and ask the class to explain again what the different items represent.

DISCUSSION

- How long can plants live without any water at all? What are some signs that plants in the garden need watering?
- What are some characteristics of plants that are adapted to wet conditions?
- What are some common native drought-tolerant plants? *See Resources section!*

EXTENSIONS

- Have students research drought tolerant plants and design a garden using these plants. What are the different features and characteristics of a water-wise garden?
- Show examples of native plants and ask students to identify how they are adapted to the climate. Compare examples of plants that need a lot of water with those that are water-conserving.

Source:
The Watershed Project, Richmond California
http://www.thewatershedproject.org/

Bimodal Botany Bouquet

A warm-up activity to introduce students to rain garden plant species and encourage their observational, organizational, and taxonomic skills.

From: Earth Partnership for Schools, University of Wisconsin –Madison Arboretum

OBJECTIVES

- Use their observational skills
- Learn how plants differ structurally from one another
- Learn the scientific naming system for plants
- Appreciate unique characteristics of native rain garden plants

Grade Level	1st-12th
Time	30-45 minutes
Materials	• Sample plant specimens representative of the native rain gardens you have planted (or plan to plant) on your school grounds.
Standards Met:	*Science* • Life Science • Earth Science • Ecology • Investigation and Experimentation *Language Arts* • Writing • Listening and Speaking

Vocabulary:
Bimodal
Binomial nomenclature
Rain garden

Key Concepts:

- Native plants are adapted to the environment in which they evolved
- Latin names help us classify and distinguish organisims

BACKGROUND

Rain Garden Plants Are Unique

Plants suitable for **rain gardens** are adapted to both wet and dry soil conditions. California native plants are adapted to survive a rainy season and a dry season. Plants growing in a rain garden will not survive if they cannot withstand these extremes. After a rainfall, plants are inundated with water. During times of no or little rainfall, plants are without water. This characteristic of being able to withstand opposite conditions is called "**bimodal**." Native plants used in rain gardens have long, deep-growing roots that are able to direct water downward through channels in the soil, which moves water quickly. They also take in water along their entire root system and transpire (release) it through their leaves into the atmosphere. These long roots also help the plants reach available moisture during the driest times, therefore not requiring special irrigation. Rain garden plants are unique and perfectly suited for the job of taking rainwater out of the combined sewer system.

Plant Names are Unique

There are a variety of languages spoken around the world. In North America, you can find Hmong, and French to Spanish, German, and indigenous languages such as Cayuga and Oneida.

Scientific names are basically another language system, which uses Latin as the root source. Latin, which is often a combination of Latin and Greek, was historically the language used by educated people and is the reason why Latin was chosen to give scientific names to plants and animals.

For a long time scientists were confronted with the challenge that one plant or animal species could have many different names, depending on what language was spoken. This challenge created all sorts of language barriers when scientists from different parts of the world wanted to talk about their research. In 1758, a Swedish biologist, Carl Linnaeus, decided everyone should use the same name to describe a given species and proposed a universal naming system, now known as "**binomial nomenclature**" (bi = two, nomen = name, calo = call, so it translates as "two-name name-calling"). This naming system gives each species a surname and a personal name, just like people in North America have. If you are called Pat Jones then Jones is your surname, and Pat is your personal name. Scientists call the equivalent of a person's last name the "genus" or "generic name." The genus always has a capital letter as the first letter. The equivalent of a person's first name is called the "specific name" and is written entirely in lower case letters. Unlike people's names in North America, the generic name comes first and the personal (specific) name is second in this binomial system. For example, the Latin name for the tree species, Red Maple, is *Acer rubrum*. *Acer* is the Genus name. There are at least another dozen different maples found in North America that have the same genus name. This is just like you and your siblings, all of whom have the same last name. The species name *rubrum* is similar to your first name and tells you it is a red maple.

These Latin names have other meanings, too. For instance, "*rubrum*" means "red" in Latin, and red is generally the color red maple leaves turn in the fall season. Sometimes the scientific name is based on people's names, such as *Heuchera richardsonii*; *Heuchera* after Johann Heinrich von Heuchera, an early German medical botanist, and *richardsonii* after Sir John Richardson, a 19th century North American explorer. Some plants are given a name based on where the plant was first discovered, such as *Elymus virginicus*. *Virginicus* refers to the state of Virginia. (Common names can vary widely for a specific plant; they can be influenced by local culture, history, or other factors. We use latin names to address specific plants by their true species and variety.)

The following activity will help students understand the scientific naming process and familiarize them with the diversity and unique attributes of rain garden species they plant on their school grounds. Students will learn the variety of patterns and shapes of plant parts. The next step can be applying names to what they observe in terms of plant structure (reference the list at the end of this binder as well as any California native plant field guide).

In addition to acquainting students with rain garden species and their names, this activity is a good introductory activity to a plant unit and/or can be used as an "ice-breaker" among a group of students who do not know each other well. Likewise, this activity can sharpen participants' observation skills and build upon their creativity as they learn more about plant structure and diversity.

PROCEDURE

1. Prepare a bouquet of plant species, representing a rain garden. The number of sample plants will depend on the size of the group and should be approximately a third to a quarter of the number in the group. For example, a group of 30 students will break into 6 groups of five, which will require five samples from 6 different plant species.
2. Have the bouquet well mixed and pass out one plant to each person.
3. Ask those who know names of the plants being passed out not to share that information until the end of the activity.
4. Allow group members to find others who have the same plant, and then form a small group. If participants do not know one another, ask them to introduce themselves to the other group members.
5. Ask groups to come up with a creative description of the plant based on their close observations that would help others identify that plant.
6. Next, ask them to come up with a creative name for their plant (their own "common name").
7. Request representative(s) from each group to present their plant's name and description.
8. Once a small group has shared their creative name and related plant description, ask the entire group if they know the common and scientific names of the plant. If the name is unknown, share common and Latin names and a further description (especially ecological and human uses) of each plant.

DISCUSSION

Ask group members why they think there are scientific names for plants—then review the history of why plants have scientific and common names. Have students visit the library to further research the plants used during this activity, the related habitat preferences, and the human uses for the plants.

Conclude with a discussion of why these particular native plants are perfectly suited for infiltrating water in rain gardens and the characteristics that make them suitable.

EXTENSIONS

- Collect weed plant samples that appear in the native rain garden that need to be identified and removed.
- Write a story that describes a plant and its characteristics and explains the related adaptations to wet/dry conditions and its ability to infiltrate and filter stormwater.
- Create a phenology calendar, journal, or computer database that describes your plant observations throughout the year.

(Note* Phenology: One of the best known and most dramatic sequences in a rain garden involves flowers blooming during the spring, summer and fall. This sequential or phenological change is striking and attractive to pollinating insects such as butterflies.)

- Develop a Web page on the plant species from this activity using photos, drawings, and life history information.

FOLLOW UP

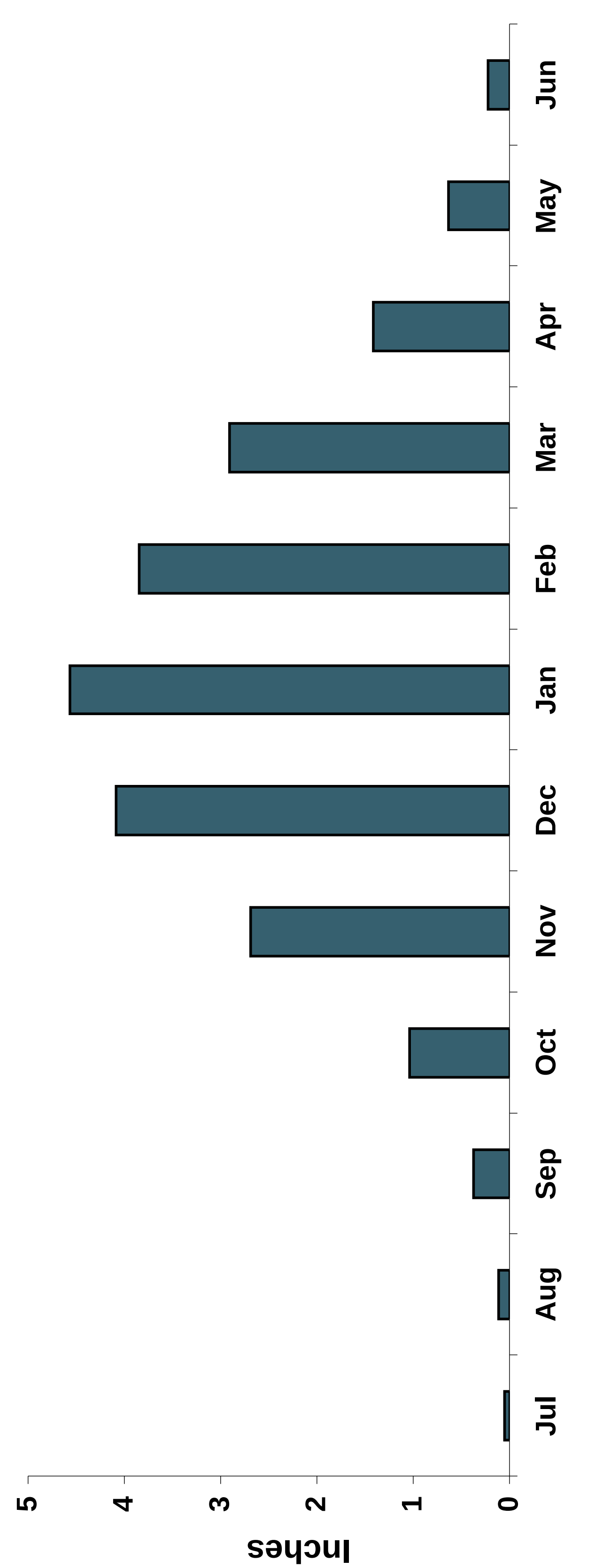
- Name (common and scientific name) and describe at least two plant species.
- Write a short story describing the plant species used in this activity, the human uses of the plant (e.g. medicinal uses), and the root words of the plant's scientific name.
- Create a mobile with drawings illustrating various plants and their unique physical characteristics. Include the scientific and common names on the mobile.
- Describe the adaptations and beneficial and unique characteristics of plants used in rain gardens.

***Source*:**
Earth Partnership for Schools, University of Wisconsin –Madison Arboretum
http://uwarboretum.org/eps/research_act_classroom/rain_garden_curriculum.php

RESOURCES

Cisterns at Miraloma Elementary School, SFUSD

Monthly Rainfall Averages for San Francisco



Rainwater Curriculum Vocabulary

Adapted from Earth Partnership for Schools, University of Wisconsin-Madison Arboretum & myfairlakes.com

Abiotic: Of or characterized by the absence of life or living organisms.

Adaptation: Any alteration in the structure or function of an organism or any of its parts that results from natural selection and by which the organism becomes better fitted to survive and multiply in its environment.

Algae: They are simple single-celled, multi-celled or colonial, aquatic plants that contain the green pigment chlorophyll. They grow by absorbing nutrients (nitrogen and phosphorus) from the water or sediments. They add oxygen to the water during the process of photosynthesis and represent the basic component of the aquatic food chain.

Algae Blooms: Refers to the harmful and excessive growths of algae generally caused by excessive nutrients in the water. This often results in scum forming on the water surface and it is associated with a foul odor. These blooms can be potentially harmful to fish, wildlife and humans in extreme situations.

Allocate: The share or portion given.

Annual: Occuring yearly.

Aquifer: Underground porous rock or sediment that holds groundwater.

Base flow: The low water level in a perennial stream; that portion of a stream flow derived from groundwater.

Beneficial Insects: Any of a number of species of insects that perform valued services like pollination and pest control.

Best Management Practices: Methods determined by land and water managers to describe land use measures designed to reduce or eliminate nonpoint source pollution.

Bimodal: Having or providing two modes, methods, systems, etc.

Binomial nomenclature: A system of nomenclature in which each species is given a unique name that consists of a generic and a specific term.

Bioaccumulation: The progressive build-up of a substance or pollutant that collects in the animal's tissue resulting from repeated exposures. Animals farther up the food chain have higher concentrations, because each level acquires the build-up of the previous level. An example would be that the big fish eating the little fish would equal all the build-up that the little fish acquired from the many, slightly polluted algae it ate.

Biological control: The control of pests by interference with their ecological status, as by introducing a natural enemy or a pathogen into the environment

Biotic: Pertaining to life.

Carnivore: Meat eating or an animal that eats flesh.

Cartography: The creation of maps.

Cistern: A reservoir, tank, or container for storing or holding water or other liquid.

Condensation: The process by which a gas turns into a liquid.

Conservation: The protection, preservation, management, or restoration of wildlife and of natural resources such as forests, soil, and water.

Contour lines: A line joining points of equal elevation on a surface.

Deposition: The state of being deposited or precipitated: *deposition of soil at the mouth of a river*.

Desalinization: To de-salt

Dissolved Oxygen (DO): The dissolved oxygen content is an indication of the status of the water with respect to the balance between oxygen-consuming and oxygen-producing processes. Fish and other desirable clean water biota require relatively high dissolved oxygen levels at all times.

Drought: A period of dry weather, esp. a long one that is injurious to crops.

Ecosystem: All of the interacting systems and organisms in association with their interrelated physical and chemical environment.

Effluent: Something that flows out or forth; outflow; effluence.

Erosion: The process by which the surface of the Earth is worn away by the action of water, glaciers, winds, waves, etc.

Eutrophication: The process by which lakes and streams are enriched by nutrients (nitrogen and phosphorus), which leads to excessive plant growth or algae blooms.

Evaporation: A physical change where a liquid turns into a vapor or gas.

Evapotranspiration: A process in which water dissipates into the atmosphere by evaporation from moist soil and plant transpiration.

Fecal Coliform Bacteria: These are found in the intestinal tracts of warm-blooded animals. Just like *E. coli*, they are used as microbiological indicators that determine the safety of the water for drinking or swimming. They originate from many sources that include bird droppings, pet waste, livestock waste, failing septic systems, stormwater runoff, and sanitary and combined sewer overflows.

Food Chain: This is the transfer of food energy from successive levels of organisms. An example of this would be algae being eaten by invertebrates, which in turn are eaten by small fish, which are the eaten by larger fish, which are eventually eaten by people.

Function: The purpose or benefit provided by a specific stage/aspect of a process.

Graduated cylinder: A container for liquid marked with a graded scale.

Geography: The science dealing with the areal differentiation of the earth's surface, as shown in the character, arrangement, and interrelations over the world of such elements as climate, elevation, soil, vegetation, population, land use, industries, or states.

Groundwater: Water that infiltrates into the ground and renews/recharges underground aquifers.

Habitat: The given physical characteristics define a particular habitat, whether it is trees for shading fish or deep pools that fish can escape to during a drought. The combination of these different aspects set different habitats apart from each other.

Headwaters: The source of a stream or river.

Herbicides: A substance or preparation for killing plants, esp. weeds.

Herbivore: Plant eating.

Hydrologic cycle: A circulation of water from a water body to the atmosphere, to the land, back to open water either above or below ground, or directly back into the atmosphere. This is also known as the water cycle.

Ice cap: An extensive dome-shaped or platelike perennial cover of ice and snow that spreads out from a center and covers a large area, especially of land.

Impervious: Not capable of being penetrated or non-permeable. An example would be roads and parking lots that prevent runoff from being absorbed into the soil.

Impoundment: To accumulate and store in a reservoir.

Infrastructure: The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and waterways.

Infiltration: The movement of water through the soil.

Integrated Pest Management: An ecological approach to pest management that combines understanding the causes of pest outbreaks, manipulating the crop ecosystem for pest control, and monitoring pest populations and their life cycles to determine if and when the use of pesticides is indicated. Abbreviation: IPM

Key: A systematic explanation of abbreviations, symbols, etc.

Landscape: This is defined by the various characteristics, whether natural or man-made, that create the geological features that distinguish one part of the Earth's surface from another part. An example would be hills, fields, forest, and water.

Land use: This describes the dominant types of human activities which are prevalent in the dominant geographic area where they occur. An example would be cropland, forest, pasture land, suburban and urban developments.

Mainstem: The principal watercourse or stream formed by the smaller contributing tributaries that flow into it.

Meteorology: The science dealing with the atmosphere and its phenomena, including weather and climate.

Native plant: A plant off indigenous origin, a plant that evolved in its particular environment.

Natural Resource: A material source of wealth, such as timber, fresh water, or a mineral deposit, that occurs in a natural state and has economic value.

Nitrogen: This is one of several nutrients needed by all plants and animals. This is the key component of proteins, and as plants/animals live and die they release many nitrogen compounds into their surrounding environment.

Nonpoint Source Pollution: This comes from diffuse, undefined sources; it is usually associated with land uses like urban development and agriculture. This kind of pollution and the stormwater runoff it occurs in is considered the most threatening to the nation's water quality.

Orientation: one's position in relation to true north, to points on the compass, or to a specific place or object.

Pathogens: An agent that causes disease, especially a living microorganism such as a bacteria or fungus.

Pervious: Able to be penetrated or permeable. This is a surface that allows rainwater to be absorbed into the soil. An example would be lawn or grasslands.

Pesticides: A chemical preparation for destroying plant, fungal, or animal pests.

Phenology: The science dealing with the influence of climate on the recurrence of such annual phenomena of animal and plant life as budding and bird migrations.

Phosphorus: This is one of the major nutrients required for plant nutrition. Excess concentrations can lead to rapid algae or plant growth causing the condition of accelerated aging of waters or eutrophication. It can enter waterways through many sources which include domestic/industrial wastewater discharge, agriculture, and fertilization of urban and suburban areas.

Point Source Pollution: Water pollution from an identifiable point or source of pollution such as a pipe or drainage ditch, and the pollutant and its source is known.

Pollution: The destruction or contamination of a natural resource usually by harmful substances entering the environment.

Porosity: The state or quality of being porous (permeable by water, air; full of pores).

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

Producer: An organism, as a plant, that is able to produce its own food from inorganic substances.

Recharge: The processes by which ground water is absorbed into the zone of saturation.

Relief: The differences in elevation and slope between the higher and lower parts of the land surface of a given area.

Reservoir: A natural or artificial place where water is collected and stored for use, esp. water for supplying a community, irrigating land, furnishing power, etc.

Riparian: The banks or edges of a natural course of water.

Runoff: Rainwater that flows over the land because the ground and vegetation cannot absorb it.

Sediment: Solid fragments of material (inorganic or organic) that come from the weathering of rock and are carried by wind, water, or ice, especially those which settle to the bottom of water.

Saturation zone: A subsurface zone in which all the pores or the material are filled with groundwater.

Scale: A graduated line, as on a map, representing proportionate size.

Sedimentation: The process of depositing or forming sediment.

Storage capacity: The total amount a container can hold.

Storm sewers: They collect stormwater runoff from streets and yards then deliver that water to a river, lake or local watershed every time it rains or the snow melts.

Surface water: Water collecting on the ground or in a stream, river, lake, wetland, or ocean.

Stormwater runoff: The overflow of surface water due to a heavy rain or snowstorm.

Tap root: A main root descending downward from the radicle and giving off small lateral roots.

Temperature: This is important to aquatic organisms, because it affects the ability of oxygen to dissolve and the toxicity of various substances found in the water. This also influences the rate of biochemical processes, metabolism, respiration and reproduction of aquatic organisms.

Terrain: The surface features of an area of land.

Topography: The arrangement of the surface of the landscape including hills, valleys, and the positions of natural and man-made features.

Topographical map: A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines.

Transpiration: A process where water moves up a plant and out of its leaves as water vapor, and into the atmosphere.

Tributary: A stream that contributes its water to another stream or body of water.

Turbidity: This is suspended particles found in water and it is measured by a particle's ability to scatter sunlight. Excessive turbidity can clog the gills of fish and mussels, and can cover the bottom habitats of invertebrates and fish spawning areas.

Volume: The amount of space occuipied by a three-dimensional object, expressed in cubic units.

Watershed: The entire land area draining into a specific body of water. Watersheds are divided by ridges of high land. This can also be called a Drainage Basin or Water Basin.

Water table: The planar, underground surface beneath which Earth materials, as soil or rock, are saturated with water.

Water users: Anyone who uses water. The various categories of users include domestic, public, industrial, commercial, agriculture, energy production, mining, recreation, fish and wildlife, and navigation.

What Is a Water Cycle?

Water moves around the Earth in a cycle as it changes from a solid, to a liquid, to a gas over and over again. These changes are all part of the water cycle, which is also known as the hydrologic cycle (see figure). More specifically, water evaporates from the ocean and fresh water bodies, such as rivers and lakes, into the atmosphere. The water vapor condenses into water droplets as clouds. As the droplets grow larger, they precipitate and fall to the Earth as liquid rain or frozen sleet and snow. Once the water falls to the Earth, some of it will flow downhill on the surface of the land as runoff to rivers, lakes, and ponds. Small streams flow into large streams which flow into rivers that eventually flow to the ocean. Some water soaks (infiltrates) into the ground through the soil and rocks. If the water infiltrates deeply, it may become ground water or may flow under the ground and return to the surface of the ground in rivers and lakes or springs. Some of the water is taken up by plants through roots, stems, and leaves. Through the process of transpiration, water inside the leaves moves into the air as vapor. These six revolving processes make up the hydrologic cycle:

1) Evaporation from surface water

2) Condensation into clouds

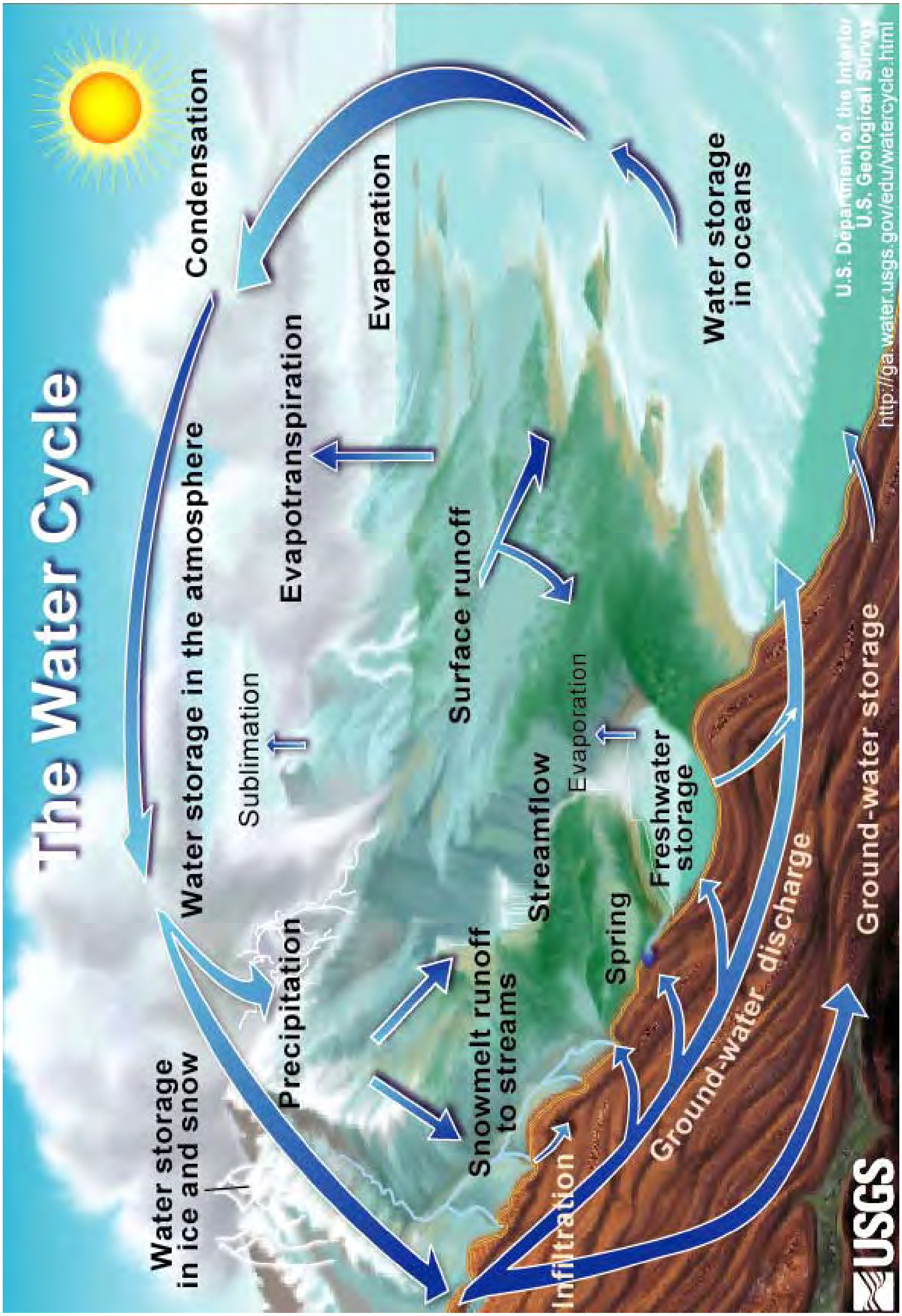
3) Precipitation as rain, snow, sleet or fog

4) Infiltration into the soil

5) Water flow over the surface or in the ground

6) Transpiration from plants

Source:
http://www.danewaters.com/pdf/stormWaterCurriculum.pdf


The Water Cycle
Water storage in the atmosphere
Condensation
Sublimation
Evapotranspiration
Evaporation
Water storage in ice and snow
Precipitation
Snowmelt runoff to streams
Surface runoff
Streamflow
Evaporation
Freshwater storage
Spring
Infiltration
Ground-water discharge
Ground-water storage
Water storage in oceans
USGS
U.S. Department of the Interior
U.S. Geological Survey
http://ga.water.usgs.gov/edu/watercycle.html

California Native Plants for the School Garden

Latin name *Common name

Achillea sp. * Yarrow
Aquilegia formosa * Crimson Columbine
Arctostaphylos densiflora * Vine Hill Manzanita
Asclepias sp. * Milkweed
Armeria maritima * Thrift or Sea Pink
Ceanothus * California Lilac
Cercis occidentalis * Western Redbud
Clarkia sp. * Clarkia
Clematis ligusticifolia * Creek Clematis
Collinsia heterophylla * Chinese Houses
Cornus nuttallii * Mountain Dogwood
Erigeron sp. * Daisy
Eriogonum sp. * Buckwheat
Eschscholzia californica * California Poppy
Festuca californica * California Fescue
Garrya eliptica * Coast Tassel Bush
Heuchera 'firefly' * Coral Bells
Heteromeles arbutifolia * Toyon
Iris douglasiana * Douglas Iris
Juncaceae * Rush (aquatic plant)
Lupinus sp. * Lupine
Mimulus sp. * Monkey Flower
Quercus sp. * Oak
Rhamnus californicus * Coffee Berry
Ribes speciosum * Fuchsia Flowered Currant
Romneya coulteri * Matilija Poppy
Salvia apiana * White Sage
Salvia sp. * Sage
Sambucus mexicana * Mexican Elderberry
Sisyrinchium bellum * Blue Eyed Grass
Triteleia laxa * Ithuriel's Spear
Zauschneria californica (Epilobium)

Bay Area Native Plant Nurseries

California Native Plant Society (CNPS):
Native Here Nursery
101 Golf Coarse Drive
Tilden Regional Park
Berkeley, CA 94708
(510) 549-0211
www.ebcnps.org/nativehere.html

Bay Natives
375 Alabama Street, #440
San Francisco, CA 94110
Phone: (415) 287-6755
Fax: (415) 285-2240
www.baynatives.com

Berkeley Horticultural Nursery
1310 McGee Avenue
Berkeley, CA 94703
(510) 526-4704
www.berkeleyhort.com

California Flora Nursery
P.O. Box 3
Somers & D Streets
Fulton, CA 95439
(707) 528-8813
www.calfloranursery.com

The Center for Social and Environmental Stewardship Native Plant Nursery
9619 Old Redwood Highway
Windsor, CA 95492
(707) 838-6641
www.crpinc.org

Larner Seeds
P.O. Box 407
Bolinas, CA 94924
www.larnerseeds.com

Mostly Natives Nursery
27235 Hwy One
P.O. Box 258
Tomales, CA 94971
(707) 878-2009
www.mostlynatives.com

North Coast Native Nursery
P.O. Box 744
Petaluma, CA 94953
(707) 769-1213
www.northcoastnativenursery.com

O'Donnell's Fairfax Nursery
1700 Sir Francis Drake Boulevard
Fairfax, CA 94930
(415) 453-0372

Pacific Coast Seed
533 Hawthorne Place
Livermore, CA 94551
(925) 373-4417
www.pcseed.com

Sonoma Horticultural Nursery
3970 Azalea Avenue
Sebastopol, CA 95472
(707) 823-6832
www.sonomahort.com

The Watershed Nursery
155 Tamalpais Road
Berkeley, CA 94708
(510) 548-4714
www.thewatershednursery.com

Yerba Buena Nursery
19500 Skyline Boulevard
Woodside, CA 94062
(650) 851-1668
www.yerbabuenanursery.com

Additional Resources

Adopt a Watershed:
http://www.adopt-a-watershed.org/index.php/home

Bay Friendly Gardening –from StopWaste.org:
http://www.bayfriendly.org

BOOK: *Rainwater Harvesting for Drylands (Vol. 1): Guiding Principles to Welcome Rain into Your Life and Landscape*, by Brad Lancaster. ISBN-13: 978-0977246410

Clean Rivers Education Program –Portland, Oregon:
http://www.portlandonline.com/bes/index.cfm?c=41186

EPA Adopt a Watershed:
http://www.epa.gov/adopt/

EPA Greenscapes:
http://www.epa.gov/epawaste/conserve/rrr/greenscapes/owners.htm

EPA Nonpoint Source Pollution –Kids Page:
http://www.epa.gov/owow/nps/kids/

EPA Office of Water, for Kids –Education Links:
http://www.epa.gov/water/kids/watered2.html

EPA Ten Things to Steward your Watershed:
http://www.epa.gov/adopt/Earthday/

EPA Toolkit:
http://www.epa.gov/adopt/#toolkit

EPA Top Rated Watershed Curricula:
http://www.epa.gov/adopt/resources/toprelated.html

EPA Watersheds:
http://www.epa.gov/owow/watershed/

H2O Conserve Education Resources:
http://www.h2oconserve.org/?page_id=51

Harvest H2O.com
http://www.harvesth2o.com/resources.shtml

Massachusetts Water Resources Authority -Water Curriculum:
http://www.mwra.state.ma.us/02org/html/sticurriculum.htm

New Jersey Department of Environmental Protection:
http://www.state.nj.us/dep/seeds/sect6.htm

Project WET:
http://projectwet.org/

Rain Garden Curriculum:
http://uwarboretum.org/eps/research_act_classroom/rain_garden_curriculum.php

www.rainwaterharvesting.org

San Francisco Bay:
http://sfbay.wr.usgs.gov/

San Francisco Bay Area Graphic Creek & Watershed Finder:
http://www.museumca.org/creeks/wb-resc.html

Save the Bay:
http://www.savesfbay.org

Stormwater Center:
http://www.stormwatercenter.net/

Stormwater Curriculum:
http://www.danewaters.com/private/curriculum.aspx

The Groundwater Foundation:
http://www.groundwater.org/

The Rainwater Observer –a blog with many great resources:
http://www.rainwatercollecting.com/blog/

The Watershed Project:
http://www.thewatershedproject.org/
&
http://www.thewatershedproject.org/explore.html

USGS Water Science for Schools:
http://ga.water.usgs.gov/edu/
&
http://ga.water.usgs.gov/edu/sc2.html

The San Francisco Green Schoolyard Alliance
135 Van Ness Ave., Room 408
San Francisco, CA 94102
www.sfgreenschools.org

The San Francisco Green Schoolyard Alliance serves children and families of San Francisco by promoting and supporting green schoolyards. We provide resources, training, and advocacy to school communities to help them create and sustain outdoor learning environments.

SFPUC Urban Watershed Management Program
1145 Market St.
San Francisco, CA 94103
http://stormwater.sfwater.org/

The San Francisco Public Utilities Commission (SFPUC) is the agency charged with managing San Francisco's wastewater system, which collects both sanitary flows and stormwater runoff. The SFPUC is working to improve the system's stormwater drainage performance and its wastewater treatment efficiency. The SFPUC Stormwater Program aims to comply with regulatory requirements, maximize sewer system performance, engage community members in its work, improve watershed function, enhance the environmental quality of San Francisco's neighborhoods, and protect the water quality of the San Francisco Bay and Pacific Ocean.