Catch the Rain!
Rainwater Harvesting
Activities 4-H_2O

A Guide for 4-H Leaders and Teachers

2011

Second Printing

Acknowledgments

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Photos not otherwise attributed taken by Alison Barrett

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Contents

Overview

Welcome to "Catch the Rain," a collection of hands-on, interactive activities designed to engage youth in understanding purposes, uses, applications, and designs of rainwater harvesting systems. Together the activities promote a culture of conservation through the development of rainwater harvesting demonstration and use projects, encouragement of community awareness and action, and optimally the reduction of groundwater and surface water use.

Collecting rainwater has been practiced throughout the world for thousands of years. There is a renewed and growing interest in rainwater harvesting in the United States as parts of the country experience periods of drought and municipalities work to manage stormwater. Where legally allowable,* rainwater harvesting offers people opportunities to conserve other water resources by using rainwater to water landscapes and gardens, flush toilets, and, with purification, for drinking, cooking, and washing.

The 33 activities in this publication are divided into seven categorical sections:

1. Water Cycle
2. Conservation
3. Watersheds and Aquifers
4. Rainwater Harvesting Basics
5. Passive Rainwater Harvesting
6. Active Rainwater Harvesting
7. Rainwater Harvesting Outreach

Sections 4 – 7 are on rainwater harvesting; sections 1 – 3 focus on general water concepts that provide a context for rainwater harvesting. Each activity stands on its own. However, the categories provide the option to focus on particular aspects of rainwater harvesting or use a progressive approach by moving from general to specific concepts. The activities can be customized to fit individual instructional programming.

Most activities use readily available materials and take an hour or less to complete. They have been created with youth in 5th through 8th grade as the focus age range but many activities can be adapted to those who are younger or older. The activities encourage an experiential learning style in which youth actively 1) participate in learning activities, 2) share their experiences, 3) discuss processes, 4) generalize concepts, and 5) apply what they learn to real-life situations and projects. The activities support learning objectives in science, technology, engineering, and math (STEM).

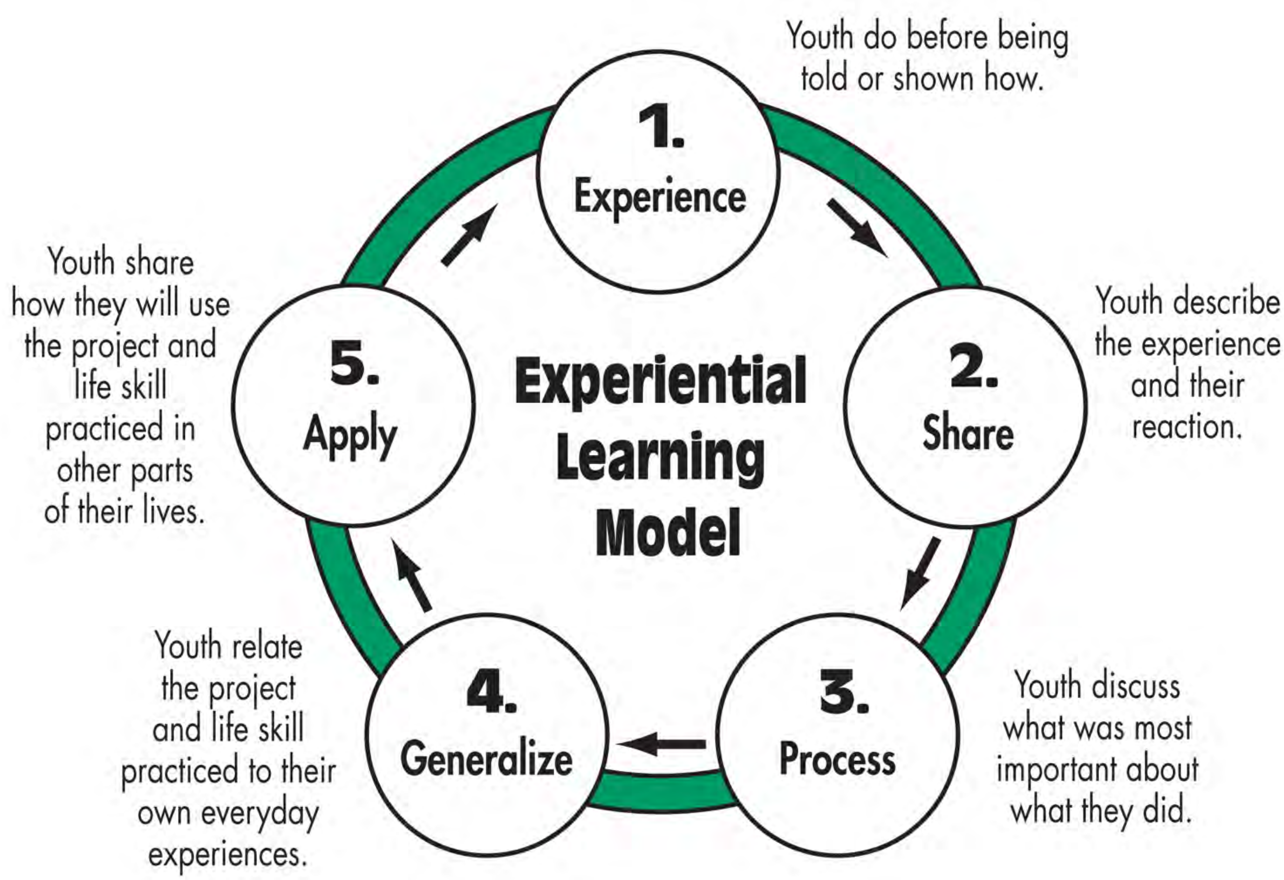
Enjoy "catching the rain" with youth!

* Check state laws before promoting rainwater harvesting practices as regulations on rainwater and stormwater collection vary.

Experiential Learning

The activities in this guide have been developed to actively engage youth in learning by doing. The experiential learning model empowers young people by letting them figure out concepts and processes for themselves. The format for the activities includes specific action steps that are described in sequence to provide support for leaders and teachers in guiding youth; however*, **the goal for teachers and leaders is to facilitate the activities so that participants take responsibility for their own learning and to encourage curiosity, exploration, questioning, discussion, and reflection***. Understanding the five stages of the experiential learning model can help leaders and teachers ask youth questions throughout the activities that encourage critical thinking, problem-solving, and reflection.

The diagram below briefly describes the five stages of the experiential learning model and behaviors to encourage in participants at each stage. The following page has a listing of questions that leaders and teachers can ask during each stage. The model and questions can be applied to all the activities in the guide.



Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals"

Suggested Inquiry Questions for Youth

Step 1 – Experience (Do)

- How is it working?
- What else might you try?
- What might make it easier?

Step 2 – Reflect (Share)

- What did you do?
- What happened?
- What was most difficult?
- What was most easy?

Step 3 – Process (What is important?)

- What went well?
- What problems or issues did you have?
- What experiences did you have?
- How did you feel when…?
- What suggestions do you have for the activity?

Step 4 – Generalize (So What?)

- How does this experience relate to other experiences you have had?
- How does this experience, information, or skill relate to real life?
- What did you learn about yourself through this activity?

Step 5 – Apply (Now What?)

- How can you use this experience, information, or skill in other situations?
- How will the issues raised by this activity be useful in the future?
- How will you act differently as a result of this activity?
- How can you share this experience, information, or skill with others?

The inquiry questions were adapted from *Heads On, Hands On: The Power of Experiential Learning Facilitator's Guide*, a training package developed by the 4-HCCS Design Team for Experiential Learning. It includes materials and a video or DVD to help educators in youth organizations make sense of experiential learning. Additional information and resources available at: http://www.4-hcurriculum.org/projects/learn/

Water Cycle

Lessons include: where water is found, amounts of water in different places on the planet, properties of water

Interactive, online activities on the water cycle:

- Interactive Water Cycle:
  http://www.epa.gov/safewater/kids/flash/flash_watercycle.html
- Water Cycle Quiz #1:
  http://earthguide.ucsd.edu/earthguide/diagrams/watercycle/watercycleq.html
- Water Cycle Quiz #2:
  http://www.livingclassrooms.org/slurrp/watercycle.html
- How Wet is our Planet? Lesson:
  http://www.groundwater.org/kc/activity6.html

Overview:

Youth gain an understanding of the limited amount of water available for every living thing on the planet to share, emphasizing the need to protect and conserve water now and in the future.

> ***Rainwater harvesting recognizes that water is limited and exemplifies the preservation of the earth's most precious resource.***

Materials:

- Globe or world map
- 1 gallon water container
- Blue food coloring (if desired) so that the water is more clearly visible
- 1 tablespoon measuring spoon
- 3 clear plastic cups
- Cotton ball
- Water dropper
- Water labels (included)
- Chalkboard or whiteboard
- Access to water

Activity Duration:

15 minutes

Preparation:

- Fill the gallon water container with water and add blue food coloring if desired.
- Cut out the water labels (consider laminating them for longevity, durability, and water resistance).
- Lay out all materials on a table visible to everyone.

Activity Steps:

1. Draw participants' attention to the materials on the table.
2. Show participants a globe or map of the world. Ask them how much of the surface of the earth is covered with water. Get responses. (The answer is approximately 72%.) Ask participants if we can use all the water in the world for drinking, cooking, cleaning, bathing, and all our other needs. Get responses. Ask, "How much of the water on the earth is available to people, animals, and plants?"
3. Hold up a gallon jug filled with water (blue food coloring will make it more visible). Explain to participants that a gallon container filled with water can be used as a model to look at water available on the earth. The full jug represents all the water on the earth.

4. Use the water dropper to take one drop of water out of the gallon. Put the drop onto the cotton ball, which represents the atmosphere (water in clouds). This is 1/1000 of 1% of the total. Label the cotton ball (atmosphere).
5. Show how much water is potentially available for human use by taking 7 tablespoons (3.2 oz.) out of the gallon of water and placing them in a plastic cup. The 7 tablespoons represent all the 2.5% of fresh water on the earth, while the remaining water in the jug (125 oz.) represents the 97.5% of salt water in the oceans. Label the gallon container (Oceans) and the plastic cup (Fresh Water).
6. Out of all the fresh water, 79% (5 tablespoons) is frozen in polar ice caps and glaciers. Take 5 tablespoons out of the cup labeled “Fresh Water” and place them in a second plastic cup. Label the cup (Glaciers/Ice Caps).
7. The remaining 2 tablespoons in the “Fresh Water“ cup represent groundwater and surface water on the planet. Use the water dropper to put 2 drops into a third cup to represent the amount found in lakes, rivers, and streams. Label the cup (Lakes and Rivers).
8. Cover the label “Fresh Water” with the label “Groundwater.”
9. Show the participants the two drops of water (the surface fresh water). This is all of the fresh water that is readily available to many people on the earth. In many parts of the American Southwest there is very little surface water. Many people rely exclusively on groundwater.
10. Hold up the cup representing groundwater. Explain to participants that this is the amount of groundwater that is available worldwide, not only in the Southwest. Groundwater is a resource that cannot be seen and must be pumped from the ground using wells. Groundwater is being removed in some areas faster than it is being replaced by rainfall.
11. Write the information in the table below on a chalkboard or whiteboard to emphasize the limited fresh water available.
12. Discuss how catching and storing rainwater can preserve limited groundwater and surface water resources.
13. Discuss ways that people can conserve water.

PERCENTAGES OF WATER ON EARTH

OCEANS		**97.5%**
FRESH WATER		**2.5%**
Distribution of the 2.5% of fresh water on Earth	Glaciers / Polar Ice Caps	79%
	Groundwater	20%
	Lakes, Rivers, Streams	1%
ATMOSPHERE		**.001%**

Source:

This activity was adapted with permission from Southern Rhode Island Conservation District's *Active Watershed Education Curriculum Guide*.
Southern Rhode Island Conservation District

Photocopy the pages with labels. Cut out the labels and fold them on the dotted lines to make table tents. Use the labels in demonstrating the water amounts in cups, jug, and cotton ball. (Consider using card stock and laminating the labels to make them sturdier and water resistant.)

Atmosphere	Glaciers/Ice Caps

Groundwater

Lakes and Rivers

Oceans

Fresh Water

Overview:

Youth practice water cycle vocabulary [illegible] ding a water cycle model.

> ***Rainwater harvesting is one way to direct precipitation that falls in an area toward a beneficial use.***

Materials:

- Water cycle cut outs (included)
- Masking tape
- Chalkboard or whiteboard
- Opaque bag (such as a canvas, paper, or plastic grocery sack)
- scissors

Activity Duration:

15 minutes

Preparation:

- Cut out the water cycle cut outs (consider laminating them for longevity).
- Put at least one of each of the cut outs into the opaque bag. (Add duplicates as needed so that the total number of cut outs equals the number of participants.)
- Designate a part of a chalkboard or whiteboard for the activity.
- Roll masking tape segments that will affix to the backs of the cut outs and have them available for the activity.

Activity Steps:

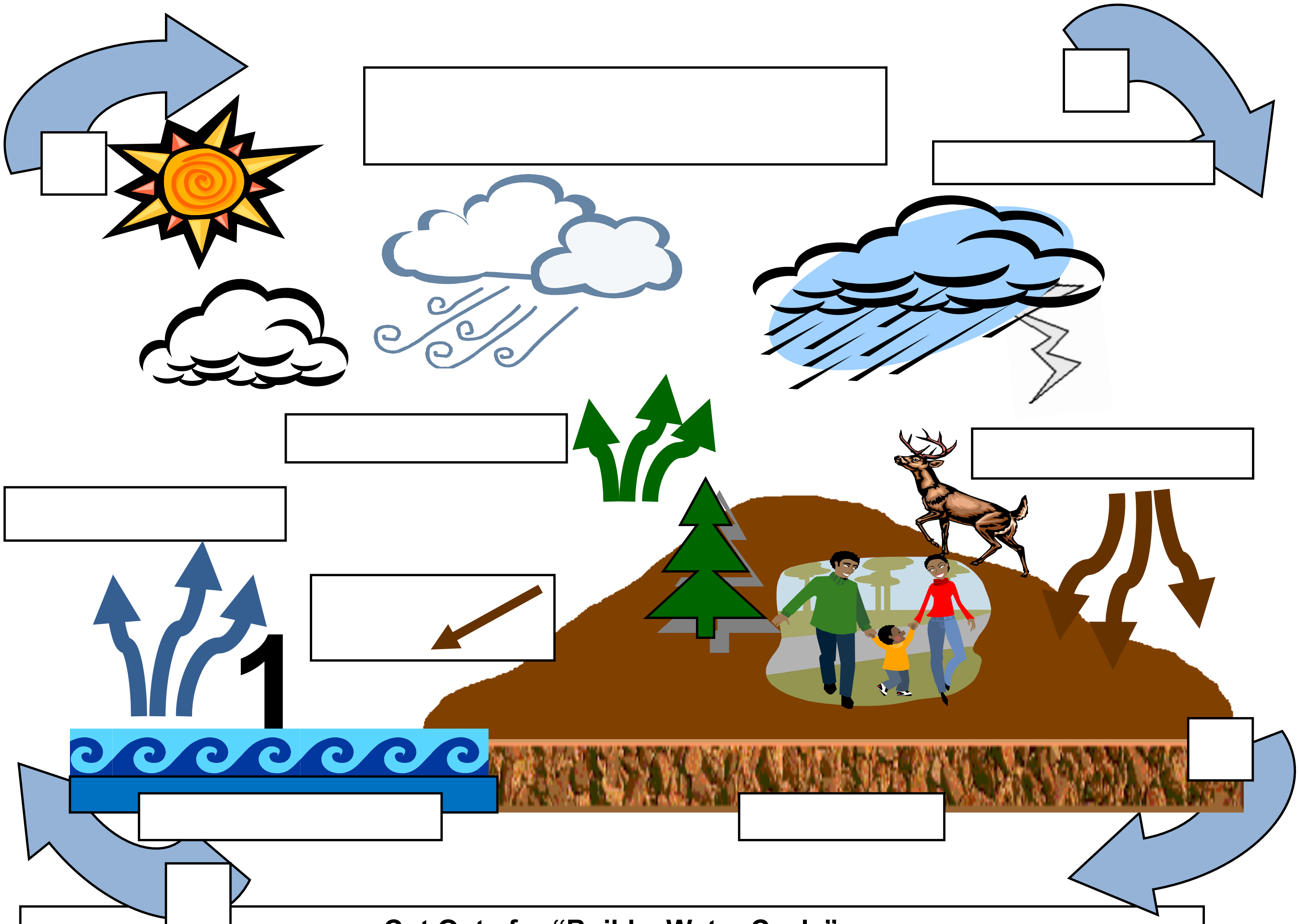
1. Ask participants if they like riding bicycles. Write the word on the board. Circle the "cycle" part of the word. Explain that a cycle means something that goes around in a circle like the wheel of a bicycle. Explain that everyone in the class is going to help build a model of a "water cycle," which will show how water moves around on the earth.
2. Move around the room, holding the opaque bag. Stop at each participant and ask him or her to reach into the bag without looking and pull out one of the papers inside.
3. Each participant will describe, one at a time, what is on the piece of paper and place it (with a segment of rolled masking tape) onto the board in the place where he or she thinks it should go. Others can make suggestions if the young person requests assistance.
4. As each participant places a cut out on the board, discuss that aspect of the water cycle.
5. When finished, the model on the board should look similar to the diagram example (included).

Note to Leaders and Teachers:

Enrich the activity by finding color images or photographs for each cut out. Youth can also create the cut outs as an art project prior to the activity. Consider using a memo whiteboard as a background and touch fasteners (such as Velcro©) to make a more permanent version.

Source:

The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
Willcox, AZ 85643-2790
(520) 384-3594
http://extension.arizona.edu/cochise



Cut Outs for "Build a Water Cycle"

1. mountain
2. aquifer
3. water/waves
4. word: evaporation
5. water vapor (upward blue arrows)
6. sun
7. white cloud
8. cloud with wind
9. cloud with rain
10. word: condensation
11. word: precipitation
12. lightning
13. trees
14. word: transpiration
15. deer
16. family
17. word: infiltration
18. word: runoff
19. title "Water Cycle"
20. transpiration (upward green arrows)
21. infiltration (downward blue arrows)
22. word: surface water
23. word: aquifer
24. arrow #1
25. arrow #2
26. arrow #3
27. arrow #4

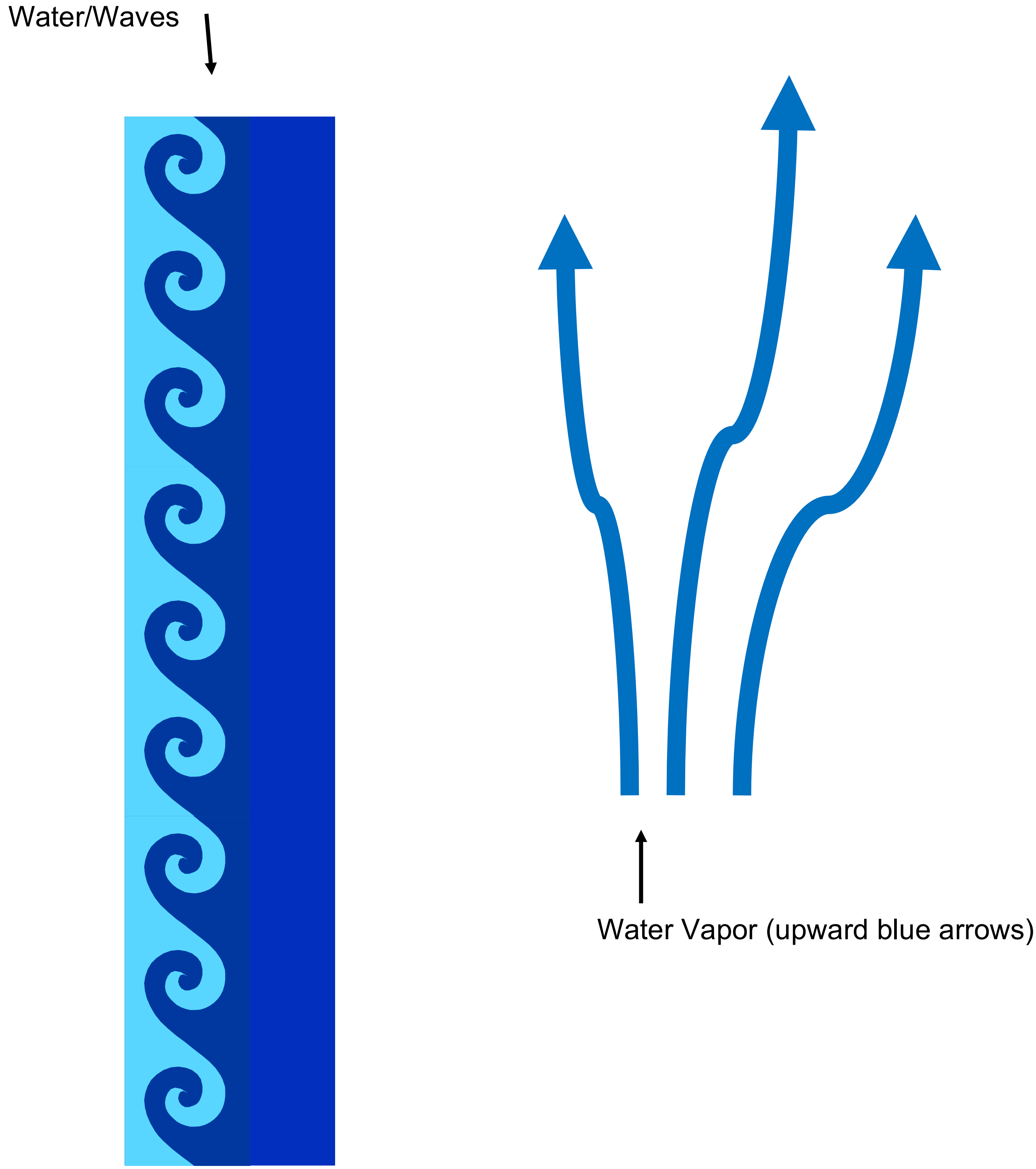
If more cut outs are needed to equal the number of youth, make two of any of the following until there are enough cut outs for all youth:

* lightning
* trees
* deer
* white cloud
* cloud with rain

Water Cycle Cut Outs

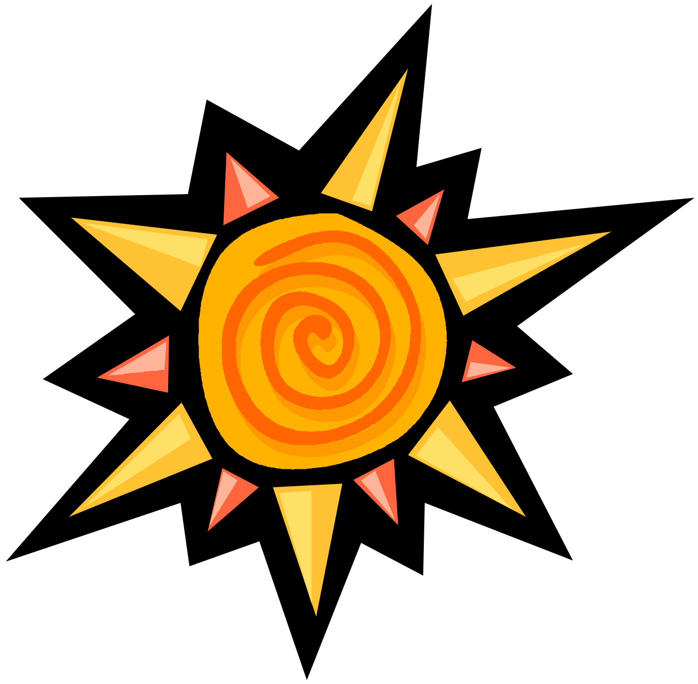
Mountain

Aquifer

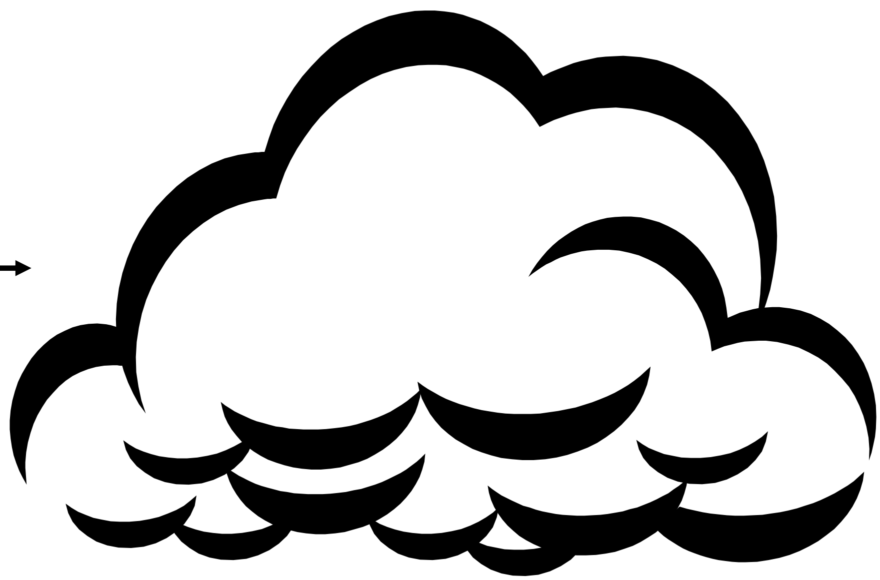


EVAPORATION

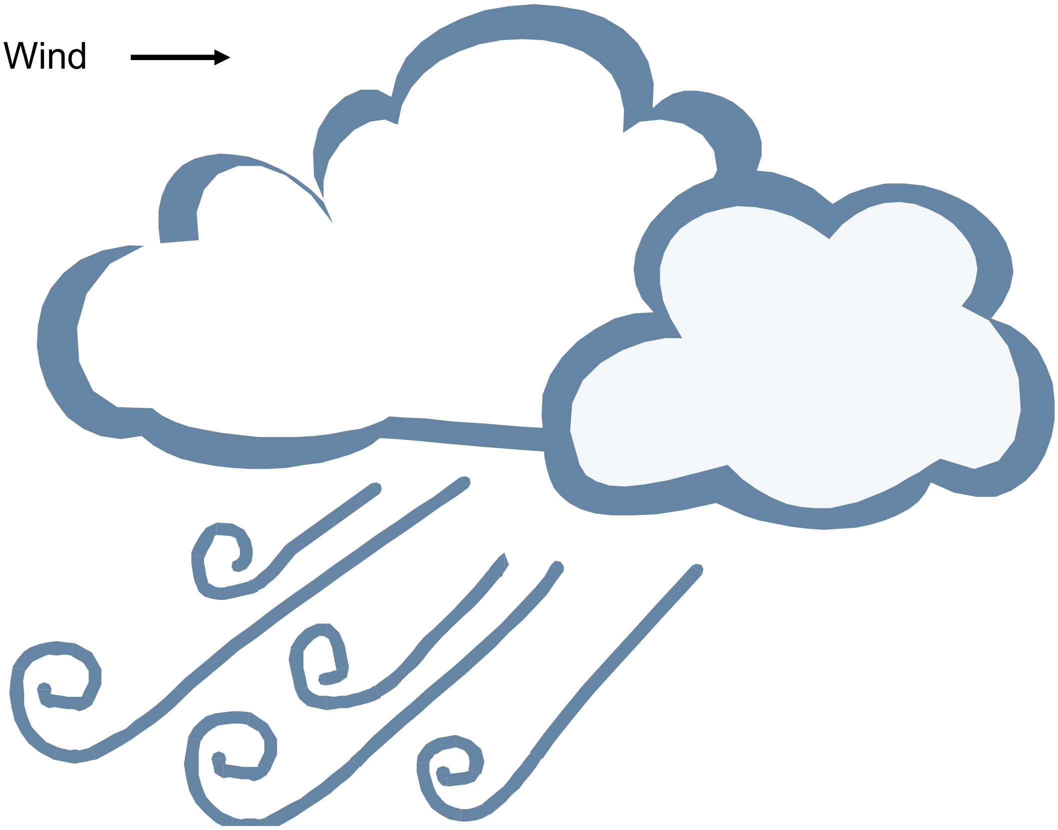
Sun →



White Cloud →



Cloud with Wind



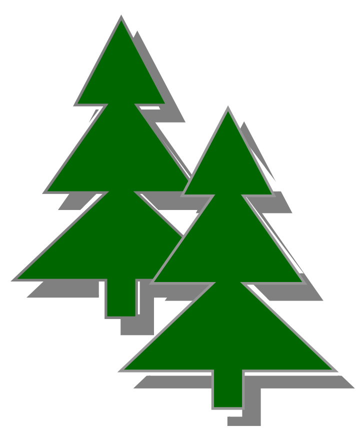
Family

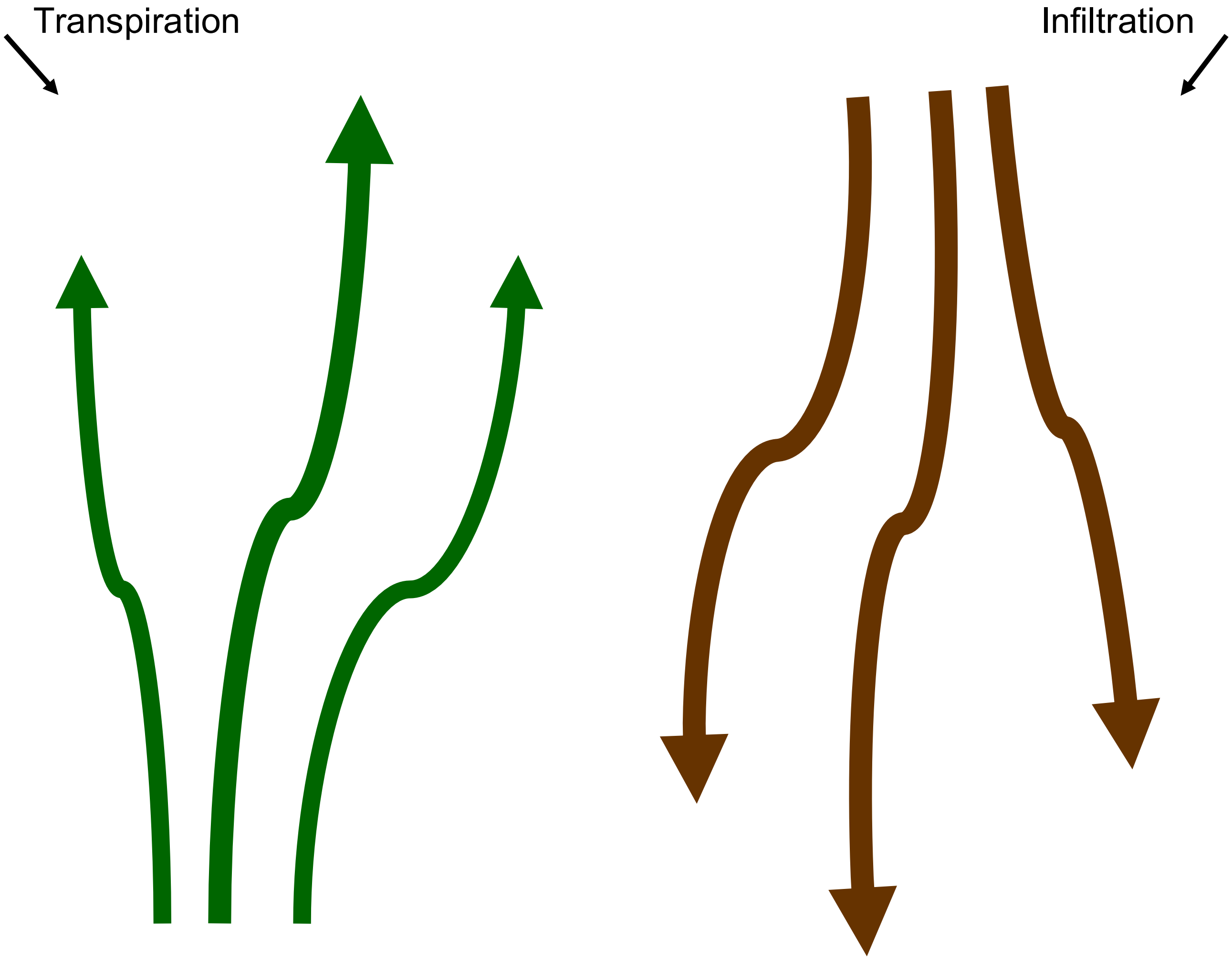
Deer

Cloud with → Rain

Lightning ↓

Trees ↓

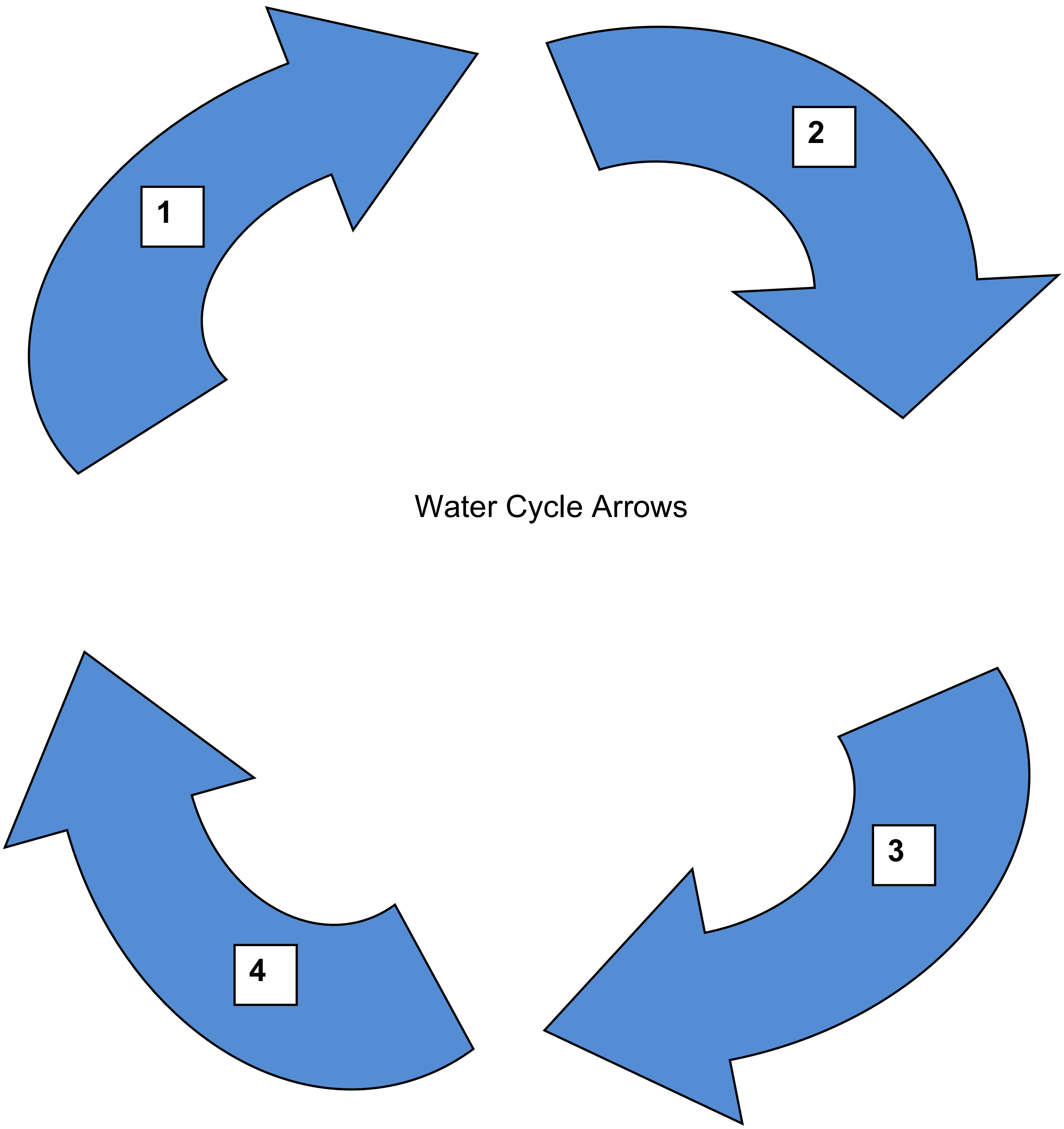




TRANSPIRATION

INFILTRATION

AQUIFER



Water Cycle Arrows

CONDENSATION

PRECIPITATION

SURFACE WATER

RUNOFF

THE WATER CYCLE
(HYDROLOGIC CYCLE)

Image courtesy of City of Tucson's *Stormwater Activity Book*

Overview:

Youth use common materials to demonstrate the water cycle processes of evaporation, condensation, precipitation, and transpiration.

Rainwater harvesting puts precipitation to beneficial use long after rain events have passed.

Materials:

- 3 sealable plastic bags
- ¼ cup of water
- ¼ cup of soil
- ½ cup of fresh leaves
- Masking tape
- Data sheet handout (2 pages)

Activity Duration:

15 minutes to fill and affix the bags; several hours for the experiment; 15 to 20 minutes to discuss results

Preparation:

Gather all the materials. There may be one or a number of demonstration models used.

Activity Steps:

1. Pour water into the first bag and soil into the second bag. Put the fresh leaves in the third bag.
2. Seal each bag completely.
3. Tape the three bags to a window that receives some sunlight.
4. Ask participants to predict what will happen and write their predictions on their data sheets.
5. Watch for a few minutes to see if anything happens.
6. Keep the bags on the window for several hours.
7. Ask participants what water cycle processes they see.
8. Participants can make and record observations over a longer time frame if desired.
9. Participants complete their data sheet handouts.
10. Discuss answers with youth.

Leader/Teacher Notes:

The processes of the water cycle demonstrated in this activity are evaporation, condensation, precipitation, and (in the bag with the leaves) transpiration. Each bag will show condensation on the sides of the bags in about a day. As the condensation builds up, the droplets will get larger and they will eventually run down the sides of the bag (precipitation). The leaves transpire water, the water in the soil evaporates, and water evaporates from the bag of water. The process continually repeats itself—a water cycle in a bag!"

Although subtle, the water cycle processes are readily observed in each bag. The observable processes are actually very similar in each bag – participants will likely not notice much of a difference between the bags. The point of including bags with soil and leaves is to demonstrate that both plants and the soil contain water and are a part of the water cycle.

There are several ways to add some variables to this experiment: teams of youth can collect soil from different places, collect different kinds of leaves, or place their bags in different locations.

Source:

Activity and materials adapted from *Stormwater in the Desert Teacher's Guide*, page 8.
Original activities can be found at: http://www.tucsonstormwater.com/teachers/

Activity courtesy of:
Stormwater Management Section
City of Tucson Department of Transportation
201 N. Stone Avenue, 6th Floor, North Wing
POB 27210, Tucson, Arizona 85726-7210
(520) 791-4371| (520) 791-5641 fax
http://dot.tucsonaz.gov/stormwater/

Water Cycle in a Bag Data Sheet

(Page 1)

Name: ___________________________________ Date: __________________________

Prepare your plastic bags according to instructions. It is best to put your bags in a location that receives some sun. What do you think will happen? Come up with a hypothesis and describe it below. Make observations (either during different times during one day or over the course of several days) and record your observations. After all observations have been made, answer questions 1 – 9.

Hypothesis: ____

Date	Observations

1. What processes of the water cycle did you observe in this activity?

2. What processes did you know occurred but didn't actually see happen?

3. Were there any visible differences between the three bags? Explain.

Water Cycle in a Bag Data Sheet
(Page 2)

Name: ____ Date: ______________________

4. What were the similarities between the bags?

5. Where is water held in the soil?

6. How does water escape from the leaves?

7. Was your hypothesis correct? Explain.

8. Why do you think this activity is called “Water Cycle in a Bag?”

9. Make a labeled drawing of your three bags.

Conservation

Lessons include: the importance of saving water and ways to make conservation a part of daily habits

Interactive, online activities on water conservation:

- How Much Water is Used? Activity:
  http://www.epa.gov/ogwdw/kids/flash/flash_matching.html
- Home Water Pledge:
  http://www.epa.gov/watersense/docs/drop_pledge508.pdf
- Home Water Savings:
  http://www.h2ouse.org/
- Water Audit Calculation Project:
  http://www.k12science.org/curriculum/drainproj/information.html

Overview:

Youth calculate the amount of water wasted by dripping faucets and analyze the benefits of fixing leaking fixtures.

> ***Rainwater harvesting is one way to save water. Keeping water from being wasted is just as important.***

Materials:

- Three 1-gallon jugs (such as recycled, plastic containers)
- 3 plastic tubs with at least a 1-gallon capacity, to place under the jugs
- Water
- Duct tape
- 3 colors of food coloring
- Copies of "Money Down the Drain" worksheet and "Answer Sheet" for each participant (included)
- Sample water bill
- Watches with second hands or stopwatches for each group (depending on the number of participants)
- One 1-cup measuring cup and two 2-cup measuring cups with mL measurements
- 3 calculators (optional)
- Faucet that can be set to drip slowly and continuously throughout the activity (optional but an important aspect of the activity)
- Tub that can contain 1 to 2 gallons of water from a dripping faucet (if doing the faucet leak portion of the activity)

Activity Duration:

30 – 50 minutes

Preparation:

- Put a small pinprick hole near the bottom of one of the 1-gallon jugs so that the flow rate is approximately 20 drops a minute; a slightly larger hole in the second jug so that the flow rate is 50 to 80 drops per minute; and a small nail hole in the third jug that produces a small but steady stream of water. (If the holes in the jugs are too small, they may take hours to empty.) In the case that a jug takes too long to actually empty, have that group skip question 5 on the worksheet.
- Cover each of the holes with duct tape.
- Fill the three jugs with water and add a different color of food coloring to each one, just before the activity begins.
- Shortly before beginning the activity begins, start a dripping leak from a faucet. Count the number of drops in one minute. Aim for a drip rate between 50 and 80 drops per minute. Place a tub under the faucet and record the time the "leak" started. (The water will continue to drip into the tub throughout the lesson.) Do not let the participants know about this part of the activity until the end.

Activity Steps:

1. Explain to participants that when they turn on a faucet, the water comes through pipes from wells or reservoirs. Systems can develop leaks that can waste water and money. Sometimes leaks occur in pipes maintained by cities as they age. However, many leaks occur inside and outside houses, in kitchens and bathroom sinks, bathtubs and showers, toilets, and outdoor faucets and irrigation systems. Most household leaks are easy and inexpensive to fix. People just need to be aware of them.
2. Ask participants how much water can be wasted from a leaky fixture. It is more than one would think. A faucet that drips one drop per second (which is fairly common) will lose over 8 gallons of water per day which is over 3,000 gallons in a year. If a faucet leaks a small stream of water, over 25 gallons of water can be lost in a day. This is the amount of water needed to fill a typical bathtub. The cost of water is on the increase and leaks can raise a monthly water bill by $10.00 or more. Share information on the "estimated Water Loss through Leaky Fixtures" graph below.
3. Ask participants how they might know a leak exists (See it? Hear noise coming from the toilet?)
4. Explain to participants that this activity will help them see the amount of water wasted by leaks.
5. Divide youth into either three or six small groups (if there are six groups, double the sets of 1-gallon jugs filled with colored water, collection containers, and measuring cups).
6. Hand out the worksheets.
7. Arrange the jugs on the edges of level surfaces in different parts of the room where participants will have access to them and will be able to write on their worksheets.
8. Place collection containers beneath the jugs. Remove the duct tape and let the dripping begin.
9. Each group will work with one jug for the activity and will stay at that station. The youth will work together to complete the worksheets as they spend time at the stations.
10. After participants have completed their worksheets, have them replace the duct tape so that the jugs will not continue to drip.
11. Have youth share their data. Record the information on the answer sheet.
12. Call participants' attention to the faucet that has been "leaking" throughout the activity and ask them to notice the rate of the drip. Turn off the water and record the time the "leak" stopped.
13. Tell youth the time that the "leak" started (that was recorded at the start of the activity).
14. Participants determine the amount of time the leak was happening.
15. Express to participants the rate of the leak (number of drips per minute). Using data from the "Estimated Water Loss through Leaky Fixtures" graph, youth determine the amount of water the leak would waste in a day, month, and year.
16. Engage youth in a discussion about the amount of water wasted by the drips. Do they think the amount of water was significant? Was the loss more than they expected? Participants discuss reasons to identify and fix leaks quickly.

Estimated Water Loss through Leaky Fixtures

Drips per minute	Water wasted per day (gallons)	Water wasted per month (gallons)	Water wasted Per year (gallons)
5	0.75	22	263
10	1.5	43	526
20	2.9	86	1,051
30	4.3	130	1,577
40	5.8	173	2,103
50	7.2	216	2,628
60	8.6	259	3,154
70	10.1	302	3,679
80	11.5	346	4,205
90	13.0	389	4,731
100	14.4	432	5,256

Figures from the Environmental Protection Agency
http://www.epa.gov/WaterSense/docs/drop_guide508.pdf

Extension:

Photocopy and distribute the sample water bill. Discuss aspects of the bill, noting that water companies devise their own billing practices. Encourage youth to explore a family water bill and discuss with their families ways to save water and lower water costs.

Source:

Money Down the Drain Worksheet
(Page 1)

Name: ____ Date: ____________________

Instructions: Complete the information for your jug; then meet with the other groups to fill in the rest of the data. (For consistency, all measurements use the metric system.)

Observe water dripping from a jug and answer the following questions. Record your responses below. ***Skip question #1 if your jug has a small stream instead of drips.***

1. **How many drops fall in one minute?** (Use a 1-cup measuring cup to collect the drops. Count each drop. Take three readings and find the average.) Cover the hole with duct tape and replace the water in the jug. *Skip this question if your jug has a small stream of water.*

   Reading 1:______ drops Reading 2: _____ drops Reading 3: _____ drops

   Add the above readings and ÷ by 3 to find the average.

   Total drops divided by 3 = __________ average drops per minute

2. **How much water drips in one minute?** (Collect one minute's worth of water and measure the volume in a 2-cup measuring cup or in the plastic tub if your jug has a small stream of water.) Take three readings and find the average. Cover the hole with duct tape and replace the water in the jug.

   Reading 1:______ mL Reading 2: _____ mL Reading 3: _____ mL

   Add the above readings and ÷ by 3 to find the average.

   Total drops divided by 3 = __________ average mL per minute

3. **Estimate the length of time it will take for the jug to empty**: ____________ minutes (All groups answer this question and remaining questions.)

4. **Calculate the time it will take the jug to empty.**

   - One gallon of water equals 3,785 mL
   - 3,785 mL divided by the average amount of water collected in one minute = minutes for the jug to empty.

   3,785 mL divided by _________ mL per minute = __________ minutes for jug to empty.

Money Down the Drain Worksheet
(Page 2)

5. **Time how long it takes for the jug to actually empty.** (Note: reduced pressure as the water level goes down may cause some jugs to not empty completely. Do not shake or squeeze jug; stop timing after the last drop naturally falls): ________________ minutes

6. **How do the answers to 3, 4, and 5 compare to each other?** Write the reasons why they are similar or different (see note in number 5 for a hint).

7. **For this leaking faucet, how much water would be lost in one hour?** Use your calculation from question 2.

   Average amount of water collected in 1 minute __________ x 60 minutes =

   _______________ mL per hour

8. **How much water would be lost in one day?**

   mL per hour ____________ x 24 hours = _____________ mL per day

9. **How much water would be lost in one week?**

   mL per day ____________ x 7 days = _______________mL per week

10. **How much water would be lost in one month?**

    mL per week _____________ x 4 weeks = ___________ mL per month

11. **How much water would be lost in one year?**

    mL per month _____________ x 12 months = ___________ mL per year

12. **Many people have to pay for their water and leaks can be expensive. If water costs $0.01 per gallon, and the water leaking from your jug was coming from a real faucet, how much money would be wasted in one year?** Use your calculation from question 11.

    _______ mL per year divided by 3,785 = ________ x $0.01 = ________ (cost in dollars)

    Your answer to question 12 is the amount of money that could be saved if the leak were fixed right away!

Money Down the Drain Answer Sheet

Name: ______________________________ Date: ________________

Record answers to questions 1 and 2 in the table below.

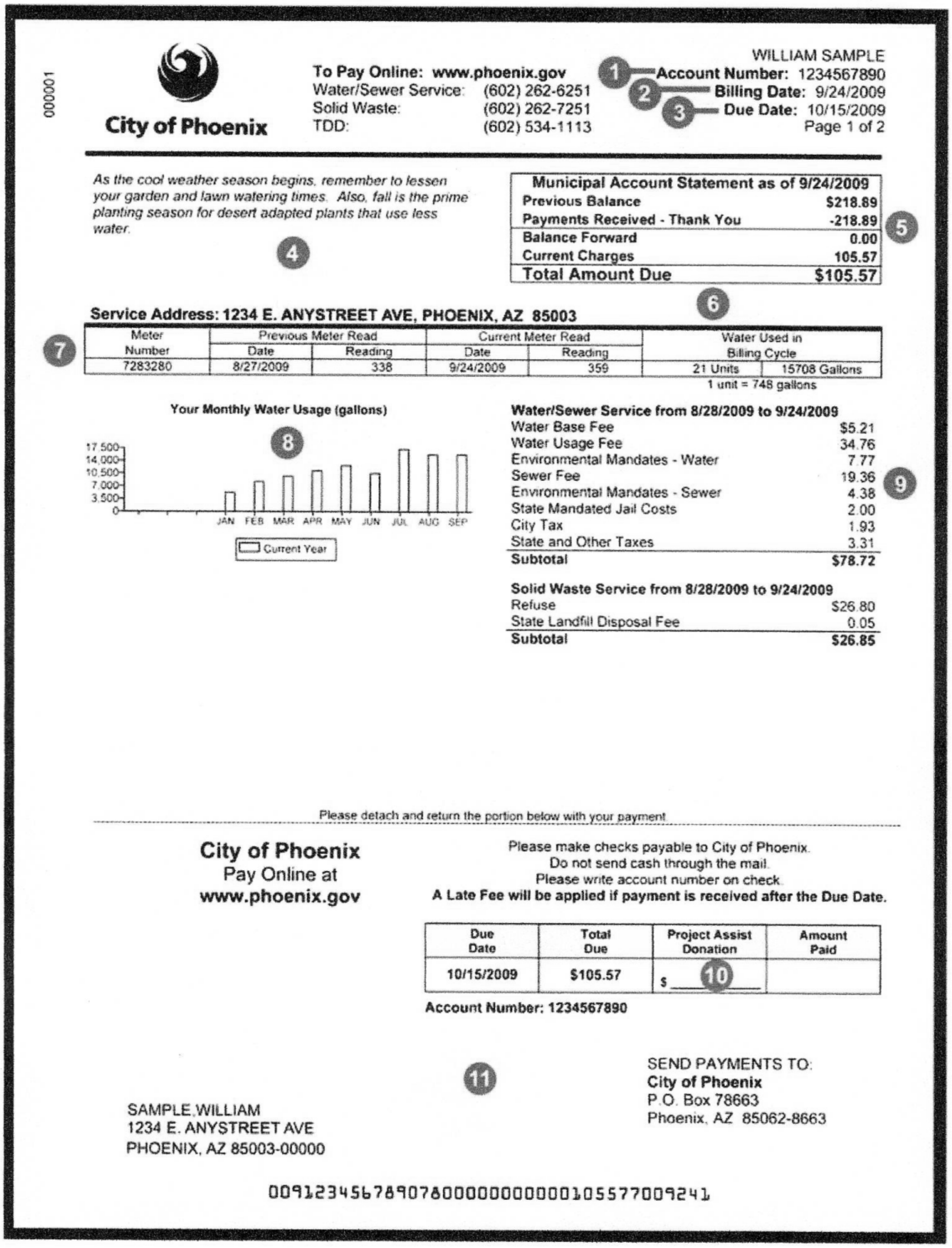
	1. Drops per minute			2. Volume of water (mL) collected in 1 minute		
	Jug #1	Jug #2	Jug #3	Jug #1	Jug #2	Jug #3
Reading #1						
Reading #2						
Reading #3						
Total						
Average (Total divided by 3)						

Record answers to questions 3 – 5 and 7 – 11 in the table below. Write the answer to question 6 in the space to the right or on another sheet of paper.

	Jug #1	Jug #2	Jug #3
3. estimate			
4. jug empty			
5. actual time			
7. mL/hour			
8. mL/day			
9. mL/week			
10. mL/month			
11. mL/year			
12. $/month			

6.

Sample Water Bill



000001

City of Phoenix

To Pay Online: www.phoenix.gov
Water/Sewer Service: (602) 262-6251
Solid Waste: (602) 262-7251
TDD: (602) 534-1113

WILLIAM SAMPLE
1 Account Number: 1234567890
2 Billing Date: 9/24/2009
3 Due Date: 10/15/2009
Page 1 of 2

As the cool weather season begins, remember to lessen your garden and lawn watering times. Also, fall is the prime planting season for desert adapted plants that use less water.

4

Municipal Account Statement as of 9/24/2009	
Previous Balance	$218.89
Payments Received - Thank You	-218.89
Balance Forward	0.00
Current Charges	105.57
Total Amount Due	$105.57

5

6

Service Address: 1234 E. ANYSTREET AVE, PHOENIX, AZ 85003

7

Meter Number	Previous Meter Read		Current Meter Read		Water Used in Billing Cycle	
	Date	Reading	Date	Reading		
7283280	8/27/2009	338	9/24/2009	359	21 Units	15708 Gallons

1 unit = 748 gallons

Your Monthly Water Usage (gallons)

8

17,500
14,000
10,500
7,000
3,500
0
JAN FEB MAR APR MAY JUN JUL AUG SEP
Current Year

Water/Sewer Service from 8/28/2009 to 9/24/2009	
Water Base Fee	$5.21
Water Usage Fee	34.76
Environmental Mandates - Water	7.77
Sewer Fee	19.36
Environmental Mandates - Sewer	4.38
State Mandated Jail Costs	2.00
City Tax	1.93
State and Other Taxes	3.31
Subtotal	$78.72

9

Solid Waste Service from 8/28/2009 to 9/24/2009	
Refuse	$26.80
State Landfill Disposal Fee	0.05
Subtotal	$26.85

Please detach and return the portion below with your payment

City of Phoenix
Pay Online at
www.phoenix.gov

Please make checks payable to City of Phoenix.
Do not send cash through the mail.
Please write account number on check.
A Late Fee will be applied if payment is received after the Due Date.

Due Date	Total Due	Project Assist Donation	Amount Paid
10/15/2009	$105.57	$ ____ 10	

Account Number: 1234567890

11

SEND PAYMENTS TO:
City of Phoenix
P.O. Box 78663
Phoenix, AZ 85062-8663

SAMPLE,WILLIAM
1234 E. ANYSTREET AVE
PHOENIX, AZ 85003-00000

0091234567890780000000000001055770092 41

1. Account Number

Overview:

Youth monitor their personal water use at home over a one-week period. They calculate their daily and weekly totals by the type of water use. The goal is for youth to gain a better understanding of the amount of water they use and to determine ways to reduce their water use.

Rainwater can preserve groundwater and reservoir supplies by reducing the amounts needed from those sources.

Materials:

- 1-gallon jug
- Water
- “Conservation Detective Activity Directions” for each participant, pair, or small group (included)
- “Water Use Chart” for each participant, pair, or small group (included)

Activity Duration:

15 minutes for directions; 7 days for the activity

Preparation:

- Fill the 1-gallon jug with water.
- Make photocopies of the “Conservation Detective Activity Directions” and “Water Use Chart.”

Activity Steps:

1. Explain to participants that it is easy to take water for granted and even waste it. Water pours out of our faucets as if it were endlessly available. Although natural systems continually recycle fresh water, the rate at which we use it is a problem. Sources of fresh water are dwindling in some areas and already scarce in others. Much of the water used in the Southwest comes from underground wells, reservoirs, rivers (such as the Colorado River), and streams. Water is replenished through rainfall and snowfall that either runs off the land into rivers or soaks into the ground as groundwater. The recharge process from precipitation percolating down into the ground may take a long time. In many areas, the rate at which groundwater is replenished cannot keep pace with the rate at which it is being used. Through the use of dams, reservoirs, and wells, people constantly try to increase the availability of fresh water. But if everyone made an effort to conserve water by making a few changes in their daily routines, huge amounts of water could be saved. For example, by installing high efficiency toilets, each person could save over 4,000 gallons of water a year! Fortunately, it is just as easy to conserve water as it is to waste it.
2. Show the youth an empty 1-gallon jug. Ask them to predict how many gallons of water they use at home each day. Hand out water use charts and ask the youth to monitor their water use at home for one week.
3. Using the “Water Use Chart,” participants record the ways in which they use water and the number of times they use the water in a particular way over the course of one week. In cases of

washing hands or taking showers, they will need to record the average length of time the water is running.

4. Encourage participants to involve their families in the water audit process.
5. Answer any questions that youth may have about the water audit activity. Explain that the participants will bring in their results after a week and the group will use math skills to analyze their data.
6. When youth bring in their completed sheets, a graph can be created to show the amounts of water used and saved by the participants and their families.
7. Discuss ways that individuals and communities can conserve water.

Source:

The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
Willcox, AZ 85643-2790
(520) 384-3594
http://extension.arizona.edu/cochise

Conservation Detective Activity Directions

In this activity you will use the chart on the other side of this sheet to record your personal water use at home for one week. After the chart has been completed, you will use addition and multiplication to determine the total amount of water that you typically use each day and each week. This activity will give you the opportunity to consider ways that you and your family can conserve water.

Directions:

On the other side of this sheet there is a chart to determine the amount of water that you use during typical activities at home.

1. Read the list of water use activities and keep the chart in a place that is easy to record the number of times you complete each activity.

2. Record the number of times or minutes each time you complete an activity such as washing your hands, brushing teeth, taking a shower or bath, flushing the toilet, or washing clothes or dishes.

3. At the end of each day, calculate the gallons used by category. Add them and list the total under, “Total Daily Gallons Used.” This figure will show you the amount of water that you used that day.

4. At the end of the week, add up the gallons in the “Total Weekly Gallons Used” row. This figure will show you the amount of water that you used that week for each activity. Then add the numbers in the “Total Weekly Gallons Used” column. To check this total, add the “Total Daily Gallons Used” for all 7 days. Both totals should be the same. **<u>This figure is your total estimated personal water use for the week</u>**.

5. If you multiply your “Total Weekly Gallons Used” by the number of family members living in your home, you will see approximately how much water your family would typically use per week.

6. If you multiply the “Total Weekly Gallons Used” total by 52, you will see how much water you *personally* would typically use in one year.

7. If you multiply your “Total Weekly Gallons Used” by the number of family members living in your home and then multiply this total by 52, you will see how much water *your family* would typically use in one year.

Water Use Chart

Name ___________________________ Date ________________

Total Water Use Per Day

Guess _____________ Actual ___________

Activity	Rate (Gallons/ Use) *	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total Weekly Gal. Used
Wash Hands (# of times multiplied by 1)	1 gallon per wash								
Brush Teeth (# of times multiplied by 1)	.5 gallon per brush								
Shower (minutes per day multiplied by 3)	2.5 gallons per minute								
Bath (# of times multiplied by 30)	30 gallons per bath								
Flush Toilet (# of times multiplied by 2)	1.6 gallons per flush								
Wash Clothes (# of loads multiplied by 35)	35 gallons per load								
Use Dishwasher (# of loads multiplied by 15)	15 gallons per load								
Total Daily Gallons Used									

Since 1994, the Environmental Protection Agency (EPA) standards: showerheads = 2.5 gallons per minute; toilets = 1.6 gallons per flush

Note: These rates and quantities may differ from your home fixtures.

Overview:

Youth discuss the importance of water conservation and make a personal commitment to use only the water they need and conserve it whenever possible.

> ***Rainwater harvesting can combine with conserving groundwater and surface water resources to have a powerful, positive impact in the world.***

Materials:

"Take the Pledge! Help Us Save Water!" handout

Activity Duration:

20 minutes

Preparation:

Photocopy a pledge sheet for each participant.

Activity Steps:

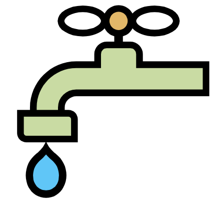
1. Ask youth how they use water in their daily lives.
2. Talk about ways that people waste water.
3. Discuss where water comes from.
4. Ask if participants are willing to make a commitment to save water whenever they can.
5. Hand out the pledge sheets to all youth.
6. Go over the list and discuss the amount of water people generally use.
7. If participants are willing to save water in the listed areas, they can put an "X" in the box.
8. Participants will add up the amounts potentially saved and sign at the bottom of the sheet.
9. Ask participants to post their pledge sheets where they will see them to remind them about the importance of saving water.

Source:

Adapted from the web site: http://20gallonchallenge.com/
San Diego Water Authority
4677 Overland Avenue
San Diego, CA 92123
(858) 522-6600
(858) 522-6568 Fax
www.sdcwa.org

Arizona Working Together to Conserve Water.

Take the Pledge! Help us save water!



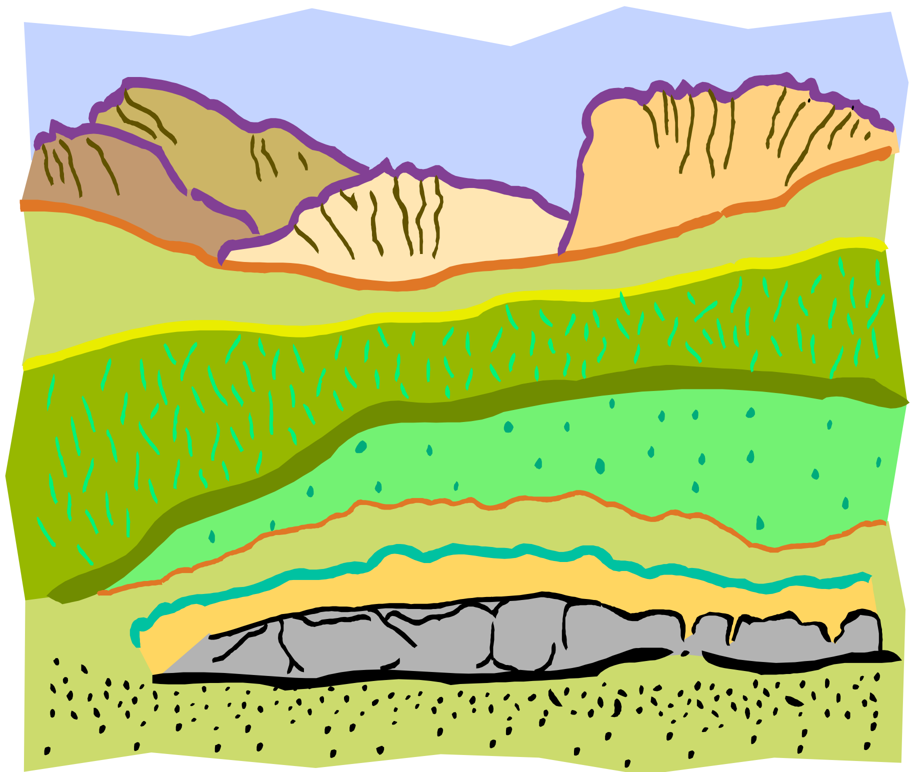
Put an (**x**) next to the things you know you
can do to save water around your home.

LAST NAME______________________ FIRST NAME__________________________

I promise to…	**Daily Savings**	**Yes! (x)**
1. Turn off the water while brushing my teeth (Twice daily)	1 gallon	
2. Not leave water running while rinsing the dishes (Twice daily)	5 gallons	
3. Shorten my showers by 2 minutes (Once daily)	5 gallons	
4. Fill the bathtub only half full while bathing (Once daily)	15 gallons	
5. Not use the toilet as a wastebasket (Once daily)	1.6 gallons	
6. Help my parents wash only full loads of clothes	15 gallons	
7. Help my parents fill the dishwasher before running it	2 gallons	
8. Remind my parents to fix a leaky faucet	15 gallons	
9. Remind my parents to fix a leaky toilet	30 gallons	
10. Use a broom instead of a hose to clean the driveway and sidewalks (Twice weekly)	22 gallons	
10. Turn off the hose while washing a car (10 minutes, once a week)	18 gallons	
12. Help put the cover on the pool to reduce evaporation	30 gallons	
TOTAL savings pledged	gallons	

Your Signature____

Watersheds and Aquifers



Lessons include: how water enters the ground, is stored there, is removed

Interactive, online activities on watersheds:

- Importance of Groundwater
  http://www.groundwater.org/kc/groundwater_animation.html
- Build your own Aquifer Activity
  http://www.epa.gov/ogwdw/kids/flash/flash_aquifer.html
- Take the Filter Challenge Activity
  http://www.groundwater.org/kc/activity7.html

Overview:

Youth define and demonstrate a wat shed, sir the h ds s node s.

> ***By holding water in their hands, participants can demonstrate rainwater capture.***

Materials:

Spray water bottle(s)

Activity Duration:

10 minutes

Activity Steps:

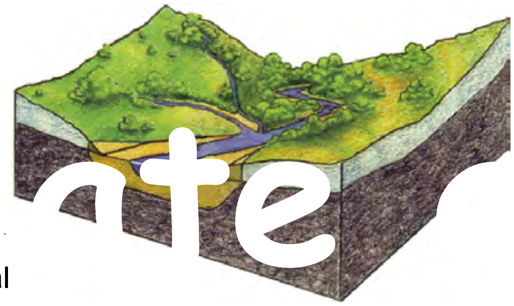
1. Ask if youth know what a watershed is.
2. If no one has the answer, ask if participants can explain what a shed is used for. (They will probably say something like sheds are used for storing things.)
3. Build on the storage concept and explain that a watershed is a land area that captures and contains water as it moves downhill from a ridgeline toward a valley's lowest point called a basin. Often at the bottom of a basin there is a stream or river.
4. Explain to participants that they are going to make a model of a watershed with their hands.
5. Have youth stand side by side in a line or circle.
6. Show youth how to place their hands together like a cup, with their little fingers touching.
7. Explain that the upper sides of their hands (toward their thumbs) represent hills or mountainsides; the lowest area (where their little fingers meet) represents a valley or basin.
8. Explain to participants that as you spray several sprays of water above their hands, the water will represent rain.
9. Ask participants to watch their hands as you spray the water over them, paying close attention to the direction the water is flowing.
10. Move down the line of youth or around the circle and spray four to five sprays into their hands. Ask participants to keep their hands in the cupped position and watch where the water ends up.
11. Ask youth the following questions:
    - Which way did the water run?
    - Where did the water go?
    - Is there water left in your hands?

- Did puddles form? If so, where?
- Did any water drain from your hand? If so, why?

12. Spray more water into participants' hands, asking them to watch again closely.
13. Explain again that the upper portions of their hands are the mountaintop areas. All the water that lands inside their cupped hands will move downward toward the place where their little fingers join. The creases and lines in their hands are like tributaries (smaller streams or washes that collect water and drain toward the bottom of the basin). In arid regions, channels (washes) can stay dry for most of the year. However, when there are storms, the water can run very fast, filling up washes, and causing dangers. It is very important to not play in washes and streambeds, especially when rain is falling anywhere in the area.

Source:

The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
Willcox, AZ 85643-2790
(520) 384-3594
http://extension.arizona.edu/cochise



Overview:

Youth create a three-dimensional model of a 'atershe define vocabulary, identify key geograp. ...at 'es, ... drainage patterns, and identify natural and human environmental impacts.

A watershed model can demonstrate runoff in action and the potential for collecting water in a landscape through passive rainwater harvesting methods.

Materials:

- 2 sheets of 8 ½" by 11" photocopy paper for each participant, pair, or small group
- Transparent tape
- Water soluble markers (not permanent) (1 each of red, blue, green, brown, black, purple, orange, yellow for each person, pair, or small group)
- Spray bottle filled with water
- "Arizona Watershed Map" (included)

Activity Duration:

45 minutes

Preparation:

- Collect all the necessary materials.
- Photocopy or bookmark the "Arizona Watershed Map."

Activity Steps:

1. Explain the basic concepts of a watershed. A watershed is the land that water flows across, through, or under on its way to a stream, river or lake, or closed basin. A watershed is like a natural bathtub that drains out at the lowest point.
2. Explain that the United States is divided into seven large regions. Arizona is a part of the Colorado River Basin and is divided into 84 major watersheds. There are many more sub-watersheds that are smaller drainage areas. Show participants the "Arizona Watershed" map" and explain that this activity will demonstrate aspects of watersheds.
3. Distribute all the materials for the activity.
4. Have participants crumple one of their two sheets of paper into a tight ball.
5. Have them carefully unfold the paper ball to expose the four corners of the sheet of paper. (Note: The paper should not be completely opened up and flattened. One side should bulge upward like a mountain. The "mountain" will become the summit of the model.)
6. Participants will carefully and gently pull the corners of the top sheet out slightly and fasten the edges to the bottom sheet of paper with transparent tape. The bottom sheet should extend

beyond the top sheet on all sides which will cause the top sheet to stand up like a mountain. (See examples).

7. Ask the participants what the top of a mountain is called. (Answer: summit or peak)
8. Ask youth the name of the sharper edges that connect the peaks. (Answer: ridgelines)
9. Help participants locate the summit(s) on their models. Using a blue marker, they will draw lines along the ridges.
10. Water moves downhill because of gravity. The ridges deflect water to one side or the other. Ask participants what the degree of slope has to do with water speed (velocity) and erosion.
11. Ask youth to define a low lying area between ridges. (Answer: valley) Help them to locate valley bottoms where water would flow when it would run off of the summit, ridges and slopes. Participants use green markers to outline valley areas.
12. Participants look at their models and identify distinct watersheds that are defined with blue and green markers. Have participants count how many watersheds they have on their model.
13. Have participants decide if there are any places on their model where they could have a farm. Using the brown marker, have them darken 2-3 areas (no bigger than a dime) that they might believe would be good for farming.
14. Have participants decide if they could have a town somewhere. Use black grids to designate town areas. Keep areas to no more than 1" X 1."
15. Use other colored markers to identify/describe/locate wastewater treatment plants, mines, landfills, and toxic waste sites.
16. Encourage participants to not overly clutter their models. Suggestions are for 2-3 mines, 1-2 landfills, 1-2 wastewater treatment plants, 2-3 farms/ranches, etc. A dime size colored dot can best represent a specific feature.

    Suggested marker colors:

    - Blue - Summit and ridges
    - Green - Valley
    - Brown - Farm/ranch
    - Black- Town
    - Orange - Waste water treatment plant
    - Yellow - Mine
    - Purple - Landfill
    - Red - Toxic waste site

17. Once the model is complete, ask the youth a few questions about their choices in placing the different sites where they did.
18. Take the models outside or to a place where water will not be damaging. Participants introduce a “monsoon” rain shower by spraying water over their models, using spray bottles at a distance of 9-12 inches. Ask participants to spray 5 sprays and watch what happens to their models. Have them spray 5 more sprays and watch. Have youth continue spraying water in 5-spray increments until there is some flooding. Ask participants to explain (in writing or out loud) the changes they see in their models after adding water.
19. Ask youth to locate areas where erosion, floods, runoff, and pollution have taken place. Ask what problems participants can identify (such as issues relating to blended colors). Ask participants follow-up questions and ask what they could have done to place their communities differently?

20. If space, weather, and time permit, the models can be air dried and used for follow-up observation and activities. Encourage youth to take the models home and explain a watershed to their families to increase awareness of watershed resources.

Follow Up Questions for Participants (To Answer in Writing or Aloud):

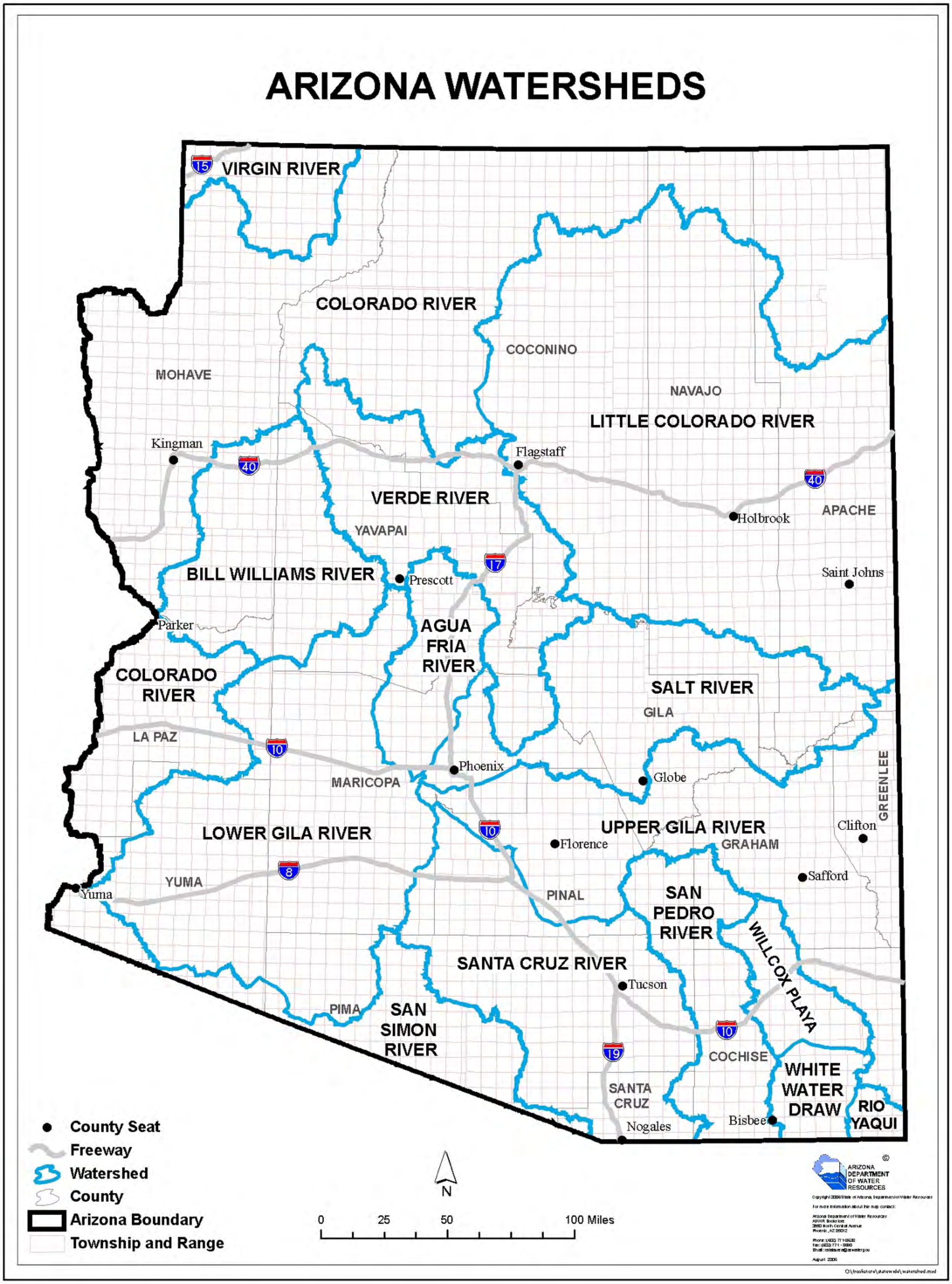
- How many watersheds are on your model?
- Where is the highest point on your model?
- Where is the lowest point on your model?
- What are the lowest areas called?
- Where are the ridges?
- Are some ridges steeper than others?
- Do the valleys vary a lot in size?
- Can upper valleys exist?
- Where would you most likely find towns and why?
- What are some benefits of being in a valley? (it is the most level area, good land for growing, more water available, etc.)
- What are some potentially negative aspects of being in a valley? (flooding, aquifer contamination, etc.)
- How can runoff water be contained or managed? (permeable surfaces, contouring landscapes to capture water, etc.)
- How can rainwater harvesting help watersheds?
- If you were to do this activity again, would you place your farms, towns, wastewater treatment plants, etc. differently?

Sources:

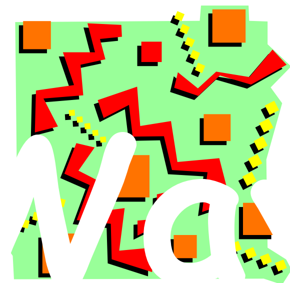
Adapted with permission from a lesson developed by Russ Raden, former Arizona Cooperative Extension staff member
The University of Arizona Cooperative Extension, Yavapai County
840 Rodeo Dr #C
Prescott, AZ 86305
(928) 445-6590
http://ag.arizona.edu/yavapai/

Arizona watershed map:
Arizona Department of Water Resources granted permission for inclusion
3550 N. Central Ave
Phoenix, AZ 85012
(602) 771-8500
www.azwater.gov/

Model before and after spraying



Watershed map courtesy of Arizona Department of Water Resources



Overview:

Youth role play the interaction between water molecules and different soil types including gravel, clay, and rock.

> ***Water moves through soil at different rates. Soil types influence water percolation rates important in passive rainwater harvesting.***

Materials:

- Open space in a classroom, gym, or outdoor grassy area
- Closed jar of gravel
- Closed jar of clay soil
- Several hand-sized rocks
- Clock or watch (optional)

Activity Duration:

20 minutes

Preparation:

- Gather all necessary materials.

Activity Steps:

1. Explain that gravel, clay, and rock are three different types of earth materials. Whereas water can travel with relative ease around individual particles of gravel, it is much more difficult for water to find its way around clay particles or large rock formations. In the case of clay, the particles are tiny and close together, and pore spaces are not interconnected well, so water cannot easily find its way through it to soak farther down into the earth. In the case of rocks, water must find a crack or hole, dissolve the rock, or simply go around the entire rock formation.
2. Pass around a rock and containers of gravel and clay. Ask youth to look for the spaces between the pieces of gravel and particles of clay and for cracks in the rock where water might be able to get through.
3. Divide the participants into groups: one group will represent water droplets that will move through the different earth materials; some youth will represent either gravel (which is loosely packed), clay (which is more dense), and rock (which is solid except for possible cracks). More youth should be in the clay group than in the gravel group. Even more should be in the rock group. Fewer sediment types may be used if there are not enough people.
4. "Gravel" youth stand beside each other in a row at the distance of their outstretched arms (but with their arms at their sides).
5. Behind the gravel group, "clay" youth stand side by side in a row with about one foot between them and with their arms at their sides.

6. Behind the clay group, “solid rock” youth stand side by side in a row with their arms linked and their shoulders close together. They may choose whether or not to put a “crack” in their formation by having two groups stand disconnected.
7. “Water droplet youth” try to move through the different sediment layers by walking slowly through the youth who are acting as earth materials. No sediment type youth may grab water droplet youth with their hands or trip them with their feet or legs.

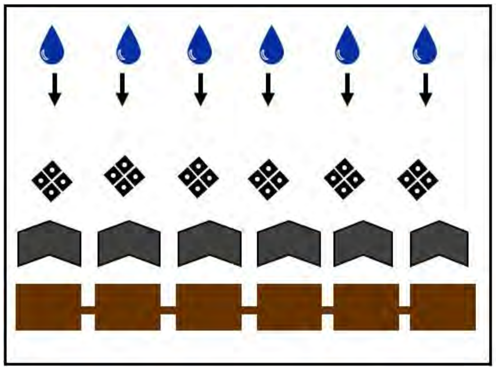


Diagram of activity layout

8. On the word “Start,” water droplets start walking slowly from one end of the game area toward the rows of “gravel,” “clay,” and “rock.” They try to make it through the various layers. (Optional: time how long it takes for the water droplets to get through.)
9. Conduct a second round and consider mixing the earth materials in different ways to show participants that underground areas can vary a lot in their composition which can affect groundwater in different areas.
10. Discuss the activity with the participants:
    - Did all the water droplets make it all the way through the layers?
    - What group was it easiest for the water droplets to move through? (Answer: gravel and possibly rock, if an opening—a crack—was created.) Why? (Gravel youth had spaces between them. Gravel is a collection of small rocks, with plenty of open spaces through which water can travel. The youth acting as rocks were barriers but the water youth could move through cracks or go around the rock formations.)
    - What group was the most difficult for the water droplets to travel through? (Answer: either clay or rock if no opening “crack” was created.) Clay particles pack very tightly together, and make it difficult for water to get through.
    - In what order do you find these layers under the ground? (Answer: In any order. The layers underground may be any grouping of the substances represented in the game and others, such as sand or humus (partially decomposed organic matter).
    - How can knowing the rate of percolation help in passive rainwater harvesting?
    - If someone wants to keep more rainwater on a landscape, which type of soil would be best for directing that water?

Source:

Activity adapted with permission from *Gee-Wow! Adventures in Water Education*
Activity: “Wiggling Water”
Access original activity online at: http://www.ecocenter.org/education/curriculum.php
Ecology Center
117 N. Division St.
Ann Arbor, MI 48104
(734) 761-3186
http://ecocenter.org/contact/contact.php

Overview:

Youth identify the geological components of a healthy aquifer by building an edible model, defining vocabulary, and observing changes that can take place that affect the world's water supply.

Most rainwater leaves the area where it falls instead of infiltrating into the soil and becoming part of the groundwater system. Rainwater harvesting can keep rainwater in an area for a longer period of time by enabling more rainwater to soak into the ground.

Materials:

For each participant, pair, or small group:

- 2 clear plastic cups
- Straw
- Spoon

General Material List:

- 1 clear plastic cup to use as a demonstration model
- 1 straw to use as a demonstration model
- 3 different kinds of fruit, cut into different sizes and placed in separate bowls (could include grapes, cantaloupe, honeydew melon, pineapple, apples, blueberries, strawberries, or other choices)
- Serving spoon for each fruit type
- Bottle of 100% white grape juice (or as much as needed for participants)
- 1 box of granola cereal
- Blue food coloring
- Small rocks to cover bottom of demonstration cup
- ¼ cup of gravel
- ¼ cup of sand
- 1 cup of water
- Plastic gloves for handling food (for those who will actually handle the food)
- Photocopy of aquifer handout (included)

Duration:

25 minutes

Preparation:

- Gather all necessary materials.
- Add food coloring to the bottle of white grape juice for greater visibility.
- Photocopy the needed number of aquifer handouts.

Activity Steps:

1. Ask participants to think about what they might find underground. (Youth might name rocks, worms, roots, etc.)
2. Ask participants to think about an orange. Explain that if one slices an orange in half, the inside looks very different than the surface. In the same way, the earth looks very different underneath the ground. This lesson is an exploration of what is below people's feet every day and how we "tap" into a hidden resource for many of our daily needs.
3. Distribute copies of the aquifer handout and explain to participants that there are different layers of different kinds of rock under the ground. Some of the layers can hold water. An area underground that can hold water is called an *aquifer*. In some places aquifers can be like small lakes, like in caves, but in most places, and throughout the arid Southwest, the water is held in cracks in rocks, clay layers, and in between gravel and sand particles.
4. Place small rocks in the bottom of the demonstration cup and ask youth if water could fill in the spaces around the rocks.
5. Add a layer of gravel to the cup and ask if water could fit in the spaces between the gravel. Note that the spaces are smaller.
6. Add a layer of sand to the cup and ask if water could fit in the spaces between the sand. Note that the spaces are even smaller.
7. Slowly add water to the cup—first just enough to wet the sand. Mention that the water is like rain, which, like snow, is a way that water gets down into the ground. Note that if there is not very much rain and the water only stays close to the surface, it will evaporate without being stored.
8. Slowly add more water to the cup so that it moves through the sand to the gravel layer. This is an area that could store water because it is further underground. However, the spaces are larger so water would move more quickly through the spaces.
9. Slowly add more water to the cup so that it fills the spaces between the rocks. Let the participants see the water in the spaces.
10. Explain to youth that the bottom of the cup is a confining layer—it is solid so the water is trapped and cannot soak further into the ground. Ask participants how water might get trapped underground (caught in cracks in large rock formations, caught in clay layers, etc.)
11. Have participants look at their aquifer handouts and define the terms. Mention that the diagram is a simplified picture. In reality, underground layers are rarely as even and clearly defined. In many places it would be as if the demonstration cup were shaken and then filled with water—a jumble of different materials all together.
12. Explain that much of the water used in many arid regions is groundwater—water stored in aquifers. Ask participants how that water could be removed.
13. After participants provide answers, place a straw into the cup, through the layers to the bottom. Explain that wells pull water from underground and bring it to people's houses through pipes. Sometimes that water is stored in storage tanks, especially in urban areas.
14. Slowly add more water until there is a layer of water on top of the sand. All the spaces have been filled. Explain that the area is saturated. Because all the spaces have filled up, there is nowhere for the water to go except to stay above ground. In lower places, this water becomes surface water in a river, pond, or lake.
15. Explain that participants are going to create their own aquifers that will become healthy treats.
16. Distribute two cups to each participant; one will be for the aquifer and the other for grape juice.
17. Go through the steps of creating "underground" layers, using fruit of different sizes. Participants should leave enough room at the top to add the yogurt and granola layers.
18. While participants are building their "aquifers," fill their second cups with grape juice.

19. After discussing their fruit layers, participants slowly pour a little bit of grape juice into their cups and watch how it begins to move through the top layer(s).
20. Participants keep adding grape juice slowly until the level reaches just below their top layer. Have them look at the way the liquid filled in the spaces.
21. Remind them that the base of the cup is a confining layer but mention that confining layers can be much closer to the surface. (For example, there is a layer of hard subsoil encrusted with calcium-carbonate, called *caliche*, which can be found close to the surface in arid regions).
22. On top of the fruit layers, participants next add a layer of vanilla yogurt to represent soil. This layer is just below the surface. Water infiltrates into the soil where it is used by plants but most of the water evaporates rather than soaking in and becoming part of the groundwater system.
23. Participants add a top layer of granola which represents topsoil. This is the layer people walk on. It is the most susceptible to evaporation and erosion.
24. Distribute straws.
25. Participants "pump" "groundwater" by sucking grape juice through their straws. They should do this process slowly so that they can see the "water level" drop. As the liquid moves out of the spaces, participants may see shifts and compression occur in the layers and the yogurt may ooze down into the spaces.
26. Ask youth what might happen if all the "water" is pulled from their aquifers.
27. Ask youth to imagine what might happen if they were to pour a lot of grape juice onto their aquifers. Get responses (runoff or flooding, for example). Participants can imagine this scenario because the yogurt is not solid and if participants were to really pour the grape juice, it would liquefy the yogurt and might be less appealing to eat later; however, some youth might want to try it.
28. To demonstrate the recharging of an aquifer, participants can pour more grape juice on top of their aquifers and watch the time it takes for the liquid to move through the layers. Explain that most water that falls on a landscape during a rain event evaporates instead of soaking into the ground. Groundwater is a limited resource.
29. Participants suck the grape juice out again, depleting the aquifer.
30. Explain to youth that just like the food in their models is healthy, it is critical to keep aquifers healthy. Passive rainwater harvesting can help more water recharge the aquifer.
31. Distribute spoons so that participants can eat their healthy aquifers. Review vocabulary terms and concepts.

Sources:

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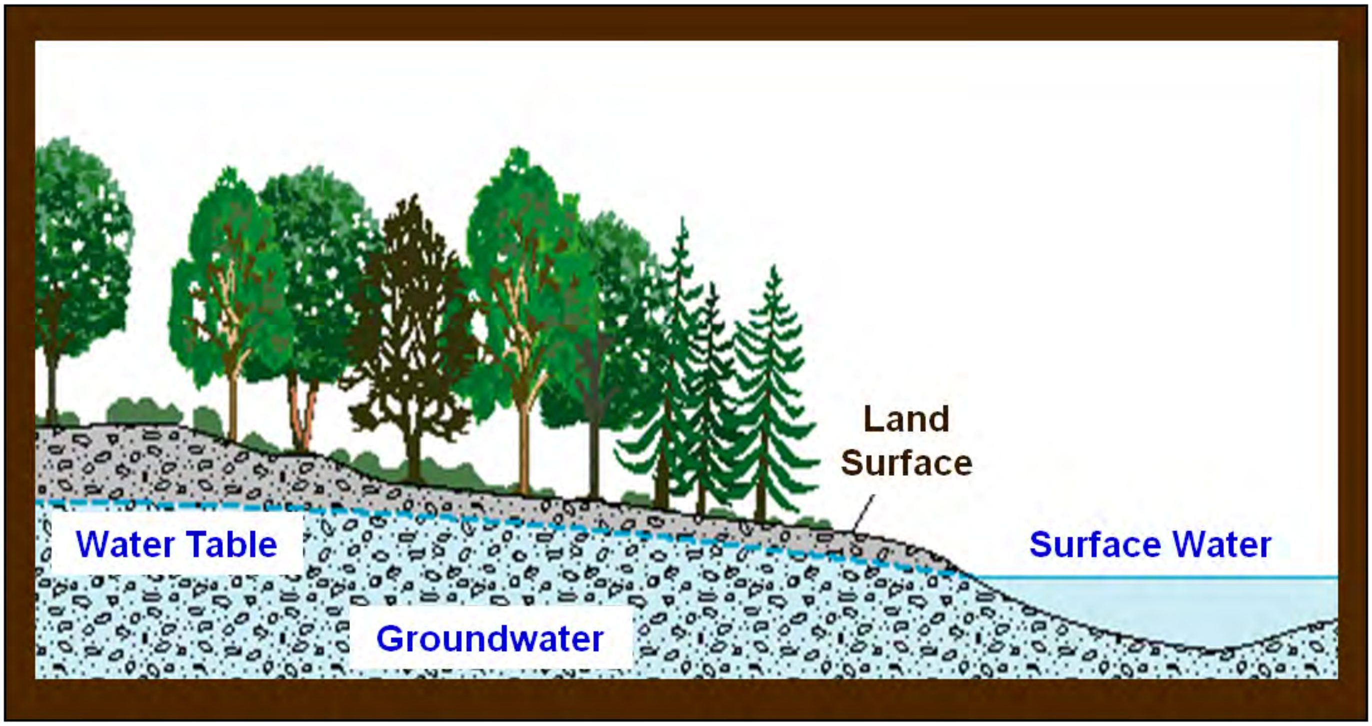
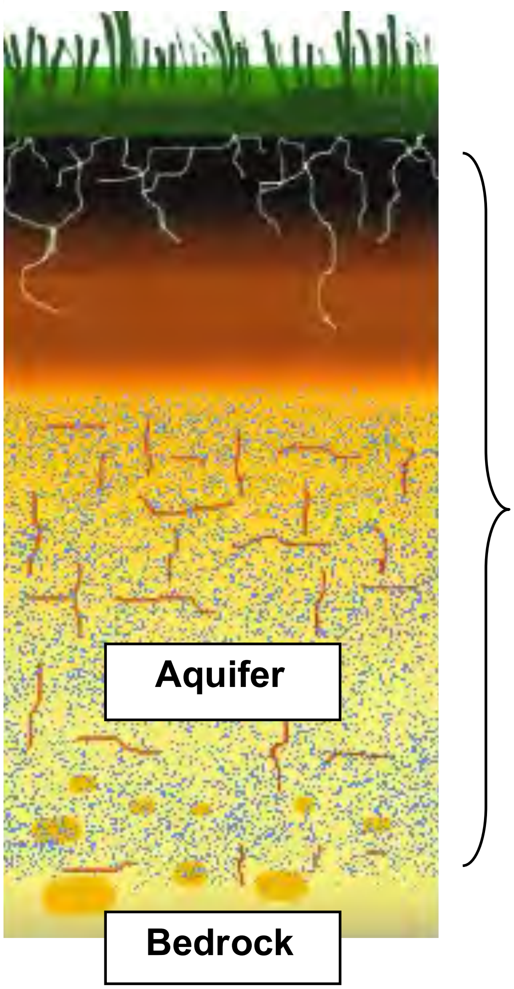
http://extension.arizona.edu/cochise

Diagram of surface water and groundwater adapted from U.S Geological Survey (USGS)
USGS web site: http://www.usgs.gov/
Diagram: http://ga.water.usgs.gov/edu/pictures/gwaquiferflow.gif
Diagram of soil layers adapted from Riverina Environmental Education Centre
Riverina Environmental Education Centre web site: http://www.reec.nsw.edu.au/
Diagram: http://www.reec.nsw.edu.au/k6/image/so3g.gif

Aquifer Handout



Groundwater fills the spaces between soil particles and fractured rock underground.



Underground layers of clay, sand, gravel, and rock that can store water.

Aquifer model before adding water.

Aquifer model after adding water.

Rainwater Harvesting Basics

Lessons include: general introduction, definitions, practical applications for rainwater

Interactive, online activities on rainwater harvesting purposes and uses:

- Cooperative Rainfall Monitoring Network:
  http://www.rainlog.org
- Rainwater Harvesting Simulation
  http://www.tucsonstormwater.com/ (Click on "water harvesting")
- Water Purification Activity:
  http://www.epa.gov/safewater/kids/pdfs/activity_grades_4-8_waterpurification.pdf

Overview:

Youth read about lizards that live in arid gions a d ar na ura rainwater harvesters and then create pa r models em nst ute ways that these fascinating creatures capture water to drink.

Photograph courtesy of Tom Wood

Horned lizards are perfect animal mascots for rainwater harvesting.

Materials:

- Article from *Highlights for Children Magazine*, "The Mystery of the Wet Lizards" (included)
- Photocopy of lizard drawings for each participant, pair, or small group
- Foam or plastic dessert-sized plate for each participant, pair, or small group
- Scissors
- Spray bottles
- Paper towel
- Clear bowl or cup of water
- Blue food coloring (optional)
- "Water Mascot Name List" handout (optional for activity extension)

Activity Duration:

1 hour

Preparation:

- Gather all materials.
- Photocopy the handout of lizard drawings (on regular paper, not card stock).
- Photocopy the handout of water words (if desired).

Activity Steps:

1. Briefly explain that rainwater harvesting consists of rain being captured from a surface and used (and possibly stored) for a particular purpose.
2. Ask participants if they can think of any animals that catch water with parts of their bodies other than their mouths. (They can think and offer ideas.)
3. Explain that one animal that lives in the Southwest catches rainwater with its back—the Texas horned lizard. Another lizard, the Australian thorny devil, also catches rainwater. In addition, it defies gravity by moving water upward on its body through capillary action, the way that plants draw up water through their roots.
4. Explain to participants that horned lizards are amazing creatures who can serve as mascots for people wanting to capture and conserve water. This activity highlights a scientist whose life

work is to investigate the behavior of horned lizards. He has discovered some fascinating behaviors.

5. Read or have participants read (aloud or in small groups) the story of two horned lizards. One is the Texas horned lizard that flexes its back to allow water to collect and move between its scales and toward its mouth. The other lizard is the Australian Thorny Devil that also drinks water that has fallen on its back. In addition, it uses capillary action to move water up between its scales to its mouth.

6. Youth discuss the article and ways that scientists learn by observing animal behavior.
7. Youth cut out the drawing of the Texas horned lizard (or they can create their own versions; the drawings need to have an overhead perspective).
8. They next fold their Texas horned lizard in half from the head to the tail, with the illustrated side folded in (see photo).
9. Participants open their folded figure; the lizard's back will be concave.

10. Participants fold the legs down and the feet up on the dotted lines so that the figure can stand upright.
11. Next, youth stand their Texas horned lizard cut out on a plastic or foam plate.
12. Participants spray their figures five times with spray bottles and notice that water has collected in the depression on each lizard's back. (If participants overspray their lizards, their figures will collapse.)
13. Ask if participants can direct water toward the horned lizard's mouth by adjusting the folds on the figure.
14. Youth discuss their observations.
15. Youth set the Texas horned lizard aside.
16. Participants next cut out the drawing of the Australian thorny devil (or they can create their own versions; the drawings need to have an overhead perspective).
17. Participants fold the legs down and the feet up on the dotted lines so that the figure can stand upright.
18. Participants spray a thin layer of water on their plates.
19. They place their Australian thorny devil cut out onto the plate and watch what happens. (The lizard will begin to sink down into the water and the paper will darken where the paper absorbed the water.)
20. Ask youth why the figure collapsed and sank down in the water. Get responses. (Water moves upward through the Australian thorny devils' legs through capillary action. The weight of the water exceeds the paper's support capability.)
21. Explain capillary action to youth. Demonstrate how a paper towel absorbs water when just one corner is dipped in water (add blue food coloring to the water for emphasis if desired).

22. Remind students that the article mentioned that the Australian thorny devil also lies down in damp sand to bring water up onto its back and down to its mouth through capillary action. This is an effective adaptation to an arid region where standing water is rare.
23. Participants can lift their figures out of the water and feel how limp they have become because the water has moved up through fibers of the paper.

24. Explain that capillary action is also the way plants move water up through their roots and the way nutrients get into people's blood from the digestive system.

Extension:

- Have participants consider choosing a horned lizard as a rainwater harvesting mascot. Ask participants what lessons horned lizards can teach people (such as capturing rainwater, using rainwater to provide survival needs, adapting to a dry environment, using very little water, etc.).
- Explain to participants that there are many water oriented words that can be chosen as mascot names.
- Brainstorm water words that participants know that might be good names for a horned lizard serving as a "rainwater harvesting awareness" mascot.
- Distribute copies of the "Mascot Name Water Words" sheet and go over vocabulary words and meanings. This is an opportunity to introduce youth to unusual vocabulary terms having to do with water that they otherwise might not encounter.
- Participants can determine a way to choose a name for their water harvesting mascot. (They can vote on one name for a group or pick individual names.)

Sources:

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It can be found at:
http://highlightskids.com/Science/Stories/SS1006_wetLizards.asp

There is a National Geographic YouTube video (a minute and a half in length) that shows an Australian thorny devil drinking water. It can be found at:
http://www.youtube.com/watch?v=JoduGti4G_k&NR=1

The Mystery of the Wet Lizards

By Charline Profiri and Wade C. Sherbrooke, Ph.D.
Photos by Wade C. Sherbrooke, Ph.D.
Illustrated by Gary R. Phillips

Why do they stand like that . . . and in the rain?
One rainy afternoon in Arizona, Wade Sherbrooke saw a strange sight. Outside, in a wire cage, his two Texas horned lizards were standing in an unusual way.

A Texas horned lizard standing in its rain-drinking posture. This magnified view shows a channel between two scales. Water in the channel will stick to the sides and move along the channel.

"Both lizards stood with their legs extended and spread far apart," he says. "Their backs arched up, and their tails and heads pointed down. They were slowly and rhythmically opening and closing their jaws, ever so slightly."

He thought the lizards might be drinking rainwater that collected on their wide backs and flowed to their mouths. He got this idea from reading about another lizard, the Australian thorny devil.

The thorny devil can be placed in a bowl with only its underside touching a shallow pool of water in the bottom. Then water creeps up the lizard's skin and across its surface. (See "How Water Flows Up" below.) When the water reaches the head, the lizard opens and closes its jaws as it drinks. Scientists thought that thorny devils drank this way during rainstorms, but no one had seen them do it.

"Did I just see horned lizards drinking in a similar way?" Wade wondered. He set out to answer that question.

Experiments with Lizards
First, he wet his lizards with a lawn sprinkler. He recalls, "My lizards watched me, and never took up the body stance or moved their jaws. They seemed too concerned to move, probably considering me a predator."

Next, Wade dripped harmless colored water from a syringe onto the lizards' backs. "The dark blue water spread through the channels between their scales to form a lace-like pattern," he says. "As the water moved outward and up to cover each lizard's head, the lizards began opening and closing their mouths, swallowing the water."

Off to Australia
Did the Australian thorny devil drink in a similar way? No one had reported seeing a thorny devil drinking, except in a bowl. Wade wondered how they drank in their desert habitat. He traveled to Australia to try to find thorny devils and rain at the same time. Amazingly, in nine weeks, he found both three times.

"An Australian biologist and I drove to a remote location in the southwestern part of the continent," he recalls. "We soon located ten thorny devils. To find them again after release, we taped a thread bobbin to their tails and tied the free end to a shrub. As the lizards walked away, they left a thread trail."

An Australian thorny devil with a thread bobbin attached to its tail.

The scientists checked up on the lizards daily. When rain fell, Wade stooped and crawled through vegetation, following thread trails. His reward was the sight of thorny devils standing in the rain. None of these lizards had the rain-harvesting posture that Wade had observed in horned lizards. But they did open and close their mouths slightly to drink.

After a light rain, Wade found each thorny devil again. Next to some of the lizards, he saw smooth, circular areas of sand where the lizards had rubbed their bellies.

"What a surprise!" he says. "By rubbing their bellies in the damp sand, they used the channels between their scales to pull water from the sand onto their skin."

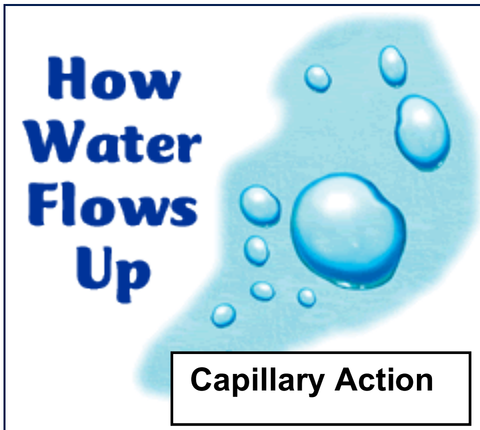
Were Horned Lizards Drinking?

Back in the United States, Wade tested to see if horned lizards really were drinking the rainwater that flowed across their backs.

He built an experimental box for releasing drops of water onto the reptiles. He weighed the lizards before and after dripping water on them. The amount of weight they gained depended on how fast the drops fell and the number of times they opened and closed their jaws. This result showed that the animals really were drinking.

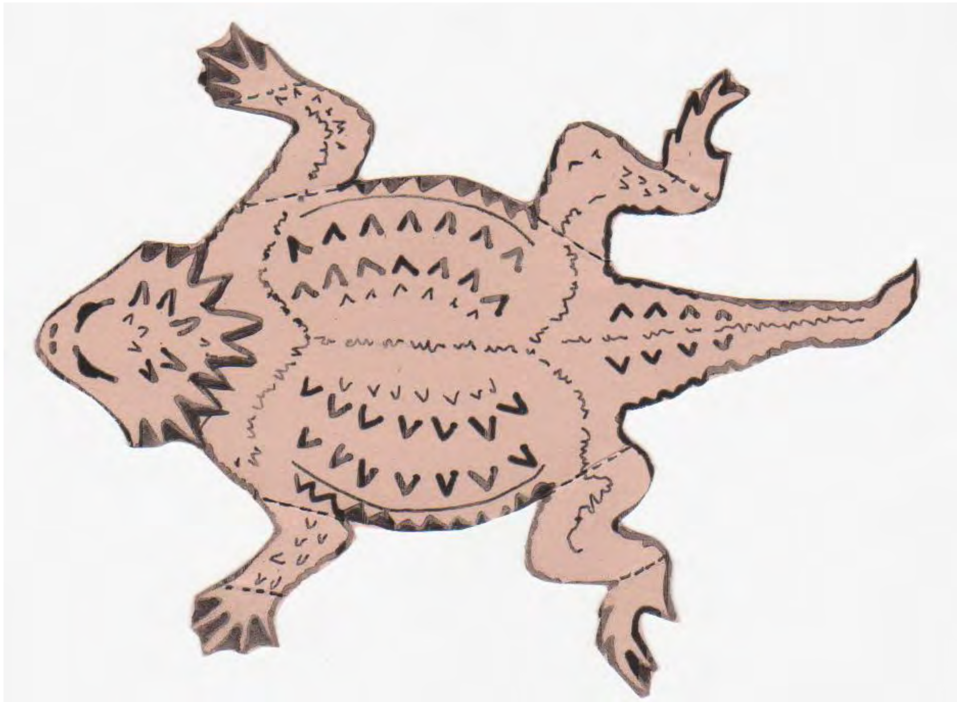
Observing two horned lizards in his yard led Wade Sherbrooke to discover how some lizards harvest water from rare desert rainfall. Proving his idea took years and helped him earn a doctoral degree in the science of reptiles (such as lizards) and amphibians (such as frogs and salamanders).

He says, "When I see a horned lizard standing in the rain, I'm now convinced that it uses its back and scales to harvest water. I hope you are, too."



Gravity makes water flow down. But in narrow spaces, water can go in any direction—across a horned lizard's back or even up the side of a thorny lizard. Water is made up of tiny units called molecules. Water molecules act like magnets, sticking to one another and to some surfaces. Water can rise through a narrow channel as molecules at the top stick to the channel surface and pull other molecules up from below. To see this effect, touch the tip of a narrow tube, such as a straw from a boxed juice drink, to the surface of some water. The water will rise into the straw.

Directions: Cut on the solid lines and fold on the dotted lines.



Texas horned lizard to use in water capture demonstration

Australian thorny devil to use in capillary action demonstration

Drawings by Beverly Rutter

Water Mascot Name List

A horned lizard makes a great mascot for rainwater harvesting since it captures rainwater for drinking. Read over the list of lesser-known water words and choose a name for your water mascot.

Acequia	Irrigation ditch
Agua	The word for "water" in Spanish Also the largest known toad species, native to Central America and valuable destroyer of insect pests
Arroyo	Small, steep-sided watercourse or gulch with a nearly flat floor: usually dry except after heavy rains
Cascade	Waterfall descending over a steep, rocky surface
Charco	Water hole, pool, or puddle
Coulee	Deep ravine or gulch, usually dry, formed by running water
Chuck	Canadian slang term meaning any body of water
Cienega	Swamp or marsh, especially one formed and fed by springs
Cove	Small indentation or recess in the shoreline of a sea, lake, or river
Dale	Valley, especially one that is broad
Delta	A nearly flat plain of alluvial deposit between diverging branches of the mouth of a river
Draw	Dry bed of a stream
Eddy	A current at variance with the main current in a stream of liquid or gas, especially one having a whirling motion
Ford	Place where a river or other body of water is shallow enough to be crossed by wading
Gully	Small valley or ravine originally worn away by running water and serving as a drainage way after prolonged heavy rains
Guzzle	To drink greedily, frequently, or plentifully
Hook	Curved arm of land jutting into the water
Jolla	Small boat carried on a larger boat to take passengers ashore
Laguna	Bay, inlet, or other narrow or shallow body of water
Marsh	Tract of low wet land, generally characterized by a growth of grasses, sedges, cattails, and rushes

Water Mascot Name List (Page 2)

Meander	Curve in a winding river
Oasis	Fertile or green spot in a desert or wasteland, made so by the presence of water
Olla	A pot, especially an earthen pot for holding water
Playa	A nearly level area at the bottom of an undrained desert basin, sometimes temporarily covered with water
Riffle	Rocky shoal or sandbar lying just below the surface of a waterway
Rill	Small rivulet or brook
Ripple	Small waves or undulations, as water agitated by a breeze
Runnel	Narrow channel or course, as for water
Seep	To pass, flow, or ooze gradually through a porous substance
Shoal	Place where a sea, river, or other body of water is shallow; a sandbar
Strait	Narrow passage of water connecting two large bodies of water
Swale	Shallow trough-like depression that carries water mainly during rainstorms or snow melts
Tank	Large receptacle, container, or structure for holding a liquid or gas
Vega	Open tract of ground; a plain, especially one which is moist and fertile
Zanja	Long narrow hollow dug in the ground especially one to drain water from a field or road

Overview:

Youth brainstorm reasons to catch rainwater and different ways to use rainwater.

> ***Passive and active rainwater harvesting systems can be implemented in a variety of ways for beneficial uses, both inside and outside a home or business.***

Materials:

- Chalkboard or whiteboard
- 2” x 2” sticky notes (enough for each participant to have two)
- Pencil or pen for each participant

Activity Duration:

20 to 30 minutes, depending on group size

Preparation:

- Gather all necessary materials.
- Choose a location where participants can see the chalkboard or whiteboard.

Activity Steps:

1. Provide participants with a definition of rainwater harvesting (the process of collecting and storing rainwater for beneficial use).
2. Ask participants if any of them have seen rainwater harvesting in action. If so, explain to them that you will ask them to share what they know later in the activity.
3. Hand out pencils or pens and two sticky notes to each participant.
4. Ask participants to think about and write down on each sticky note one way that people could use collected rainwater. They can consider ways that individuals, schools, businesses, and communities could use rainwater as well as both inside and outdoor uses.
5. Give time for participants to consider ideas and write them down.
6. When participants finish, they post their sticky notes on the chalkboard or whiteboard.
7. When all have posted their ideas, read the information on all the sticky notes (even if there is repetition).
8. After hearing all the ideas, participants suggest categories for the ideas (home vs. commercial use for example).
9. Youth who are familiar with rainwater harvesting can share their stories and information during this process. Add new ideas that emerge through discussion to the chalkboard.
10. Using the categories on the board, discuss with youth some ways that rainwater harvesting can realistically be incorporated by individuals and communities into homes, businesses, and landscapes. (Many people think of *active* rainwater harvesting only. This activity offers the opportunity to discuss *passive* rainwater harvesting methods too.) (See glossary for “active” and “passive” rainwater harvesting definitions.)

11. Help youth gain a deeper understanding of rainwater harvesting possibilities by expanding on their ideas.
12. Write up a list of rainwater harvesting possibilities to which to refer while doing other rainwater harvesting activities.

Source:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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Overview:

Youth use readily available materials to build a simple rain gauge to measure rainfall.

Knowing the amount of rain that has fallen enables people to calculate the potential for rainwater collection.

Materials:

- Ruler sheet (included)
- Plastic, wide-mouth jar with wide, flat base (suggested size: 1 quart)
- Clear, waterproof tape
- Scissors

Activity Duration:

20 minutes

Preparation:

- Gather needed materials. Encourage participants to use recycled jars (plastic peanut butter jars work well).
- Make enough photocopies of the ruler sheet for everyone to have a ruler (each sheet has 5 ruler cut outs).

Activity Steps:

1. Participants cut out a ruler from the paper ruler sheet.
2. Participants hold the ruler vertically against the side of their jars to determine an appropriate length for the ruler (at least six inches).
3. Participants cut their rulers to the size that will fit on the side of their jars.
4. Participants cover their rulers completely with waterproof tape.
5. Using more waterproof tape, participants tape their rulers vertically to the inside of their jars, making sure that the edge of each ruler beginning with "0" is aligned with the base of their jars.
6. When it is going to rain, youth put their rain gauges outside in an open area where rain can fall freely into their jars (not under trees or near buildings).
7. After the rain event, youth place their rain gauges on a level surface and measure the amount of rainfall in inches and centimeters.
8. Ask youth how knowing the quantity of rain that falls in an area can help people design rainwater harvesting systems.
9. See the activity, "Rain Tracking" for a process to record rainfall over time.

Extension:

Participants can research how to make a more accurate rain gauge and construct one like the official United States Weather Bureau version.

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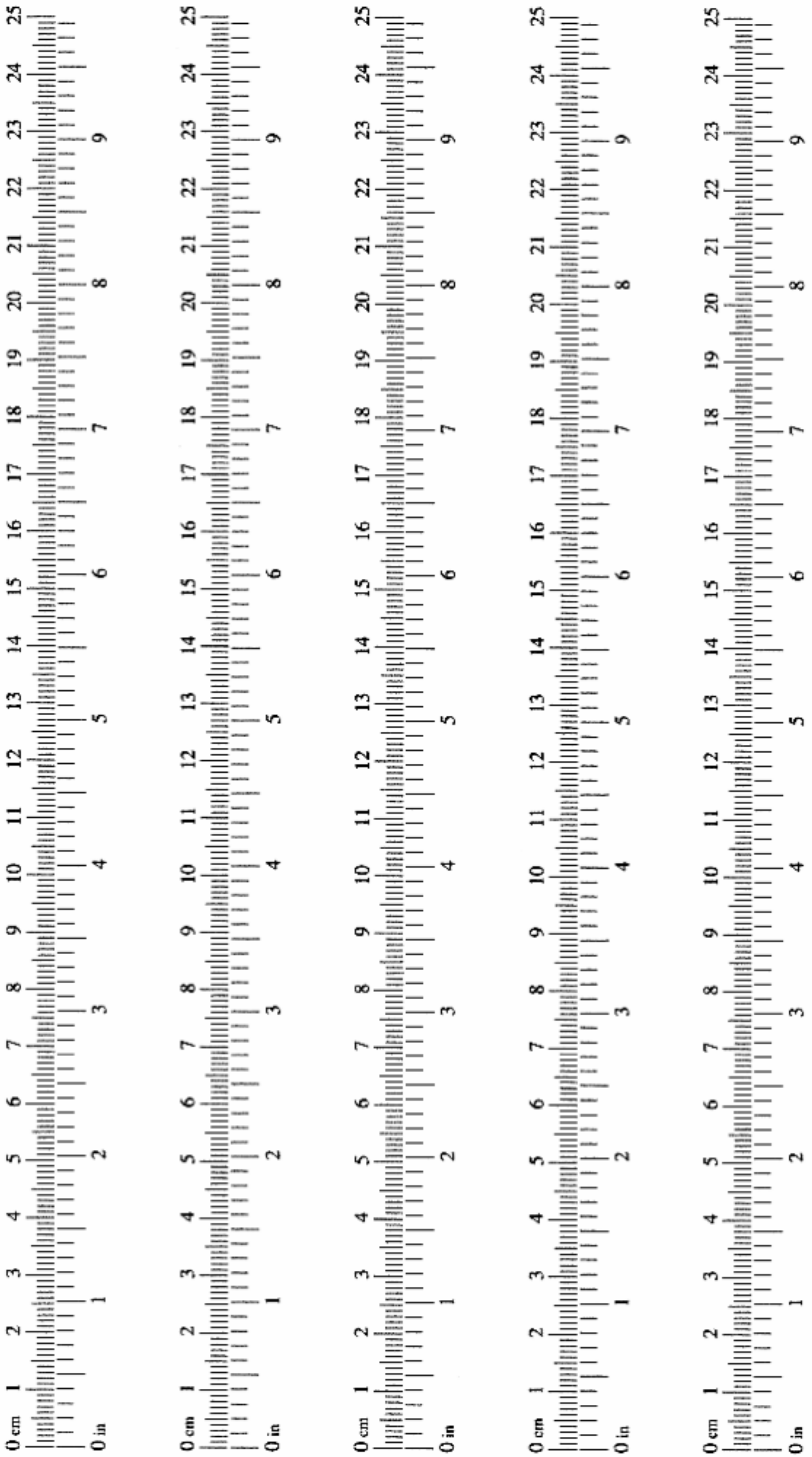
A ruler template can be found at:

http://vendian.org/mncharity/dir3/paper_rulers/



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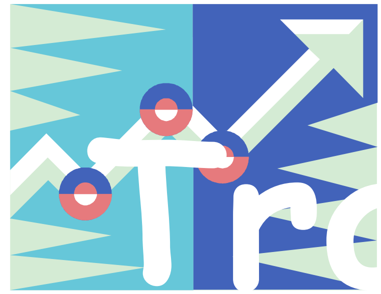


Overview:

Youth monitor rainfall throughout the year, using the data to determine the amount of water that can be collected through water harvesting.

> ***Keeping track of rainfall and using rainfall statistics enable people to understand the rainfall rhythms in their area and plan the size and uses of their rainwater harvesting systems.***

Materials:

- Rain gauge
- Rainfall Data Sheet (included)

Activity Duration:

Ongoing throughout the year

Activity Steps:

1. Place a rain gauge outside on a level surface, away from any overhanging eaves or trees. The gauge may be placed either on the ground or on a stand to elevate the gauge above the ground.
2. Leave the rain gauge outside when there is a chance of rain.
3. Make a copy of the Rainfall Data Sheet (2 pages) and post it where participants may record daily rainfall data. If there is no rain, a "0" should be entered.
4. Following a rain event, ask youth how tracking rainfall patterns can help people design rainwater harvesting systems.

Note: Since many parts of the Southwest receive so little rain, participants will not need to go outside to check the rain gauge except following rain events. When it does rain, rainfall data should be measured and recorded as soon after the rain event as possible to minimize evaporation. After recording rainfall, the rain gauge can be emptied in preparation for the next recording.

Source:

Activity and materials adapted from *Stormwater in the Desert Teacher's Guide*, page 4.
Original activities can be found at: http://www.tucsonstormwater.com/teachers/

Activity courtesy of:
Stormwater Management Section
City of Tucson Department of Transportation
201 N. Stone Avenue, 6th Floor, North Wing
POB 27210, Tucson, Arizona 85726-7210
(520) 791-4371| (520) 791-5641 fax (http://dot.tucsonaz.gov/stormwater/)

Rainfall Data Sheet
(Page 1)

Year ______________ Location of Rain Gauge __________________________________

Name/Group/Class ____________________________________

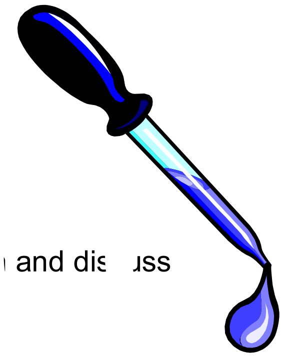
Day of Month	Amount of Rain in Inches						
	Jan	Feb	Mar	Apr	May	Jun	Notes

Rainfall Data Sheet
(Page 2)

Year ______________ Location of Rain Gauge __________________________________

Name/Group/Class ____________________________________

Day of Month	Amount of Rain in Inches						
	Jul	Aug	Sep	Oct	Nov	Dec	Notes



Overview:

Youth make a solution of food coloring with a concentration of one part per million and discuss clean water standards.

Substances dissolved in water can be present in very tiny amounts that are not visible to the eye. In order for rainwater to be used as potable (drinking) water, contaminants must be reduced to amounts approved by the Environmental Protection Agency, often in parts per million or even parts per billion.

Materials:

- Permanent marker
- "One in a Million" background information sheet
- 1 clear cup of water (for demonstration purposes)

For each participant, pair, or group:

- One 9-ounce, clear cup, filled halfway with water
- One empty, 9-ounce, clear cup
- Six 2-ounce cups or ½ of the bottom portion of a Styrofoam egg carton
- 2 water droppers*
- Bottle of blue or red food coloring
- "What Does One in a Million Look Like?" handout (included)
- "One in a Million" background information handout (included)
- Pencil

** If a "dropper" style of food coloring bottle is used, participants will only need one water dropper each.*

Activity Duration:

30 minutes

Preparation:

- Review the background information sheet.
- Gather all materials.
- Cut the bottom portion of an egg carton in half lengthwise (to make a strip of six "cups") or prepare six 2-ounce cups for each participant, pair, or group.

Activity Steps:

1. Ask participants if they think about the cleanliness of their water when they turn on a faucet at their houses. Get responses. (Explain that city water systems have strict rules that keep water safe.) Ask participants if they have been to rivers or lakes and if they feel the water would be safe to drink right from the source. Get responses. Ask participants if they can always drink water that looks completely clear. Get responses. Discuss contaminates that are too small to see (background information is included).
2. Explain that many people around the world use rainwater for drinking water. In order for it to be "potable" (safe for drinking), people must filter and disinfect it. Ask what contaminants might get into a rainwater harvesting container? Get responses.
3. Explain that youth are going to participate in an activity that will demonstrate how contaminants are measured. The U.S. Environmental Protection Agency has standards for the amounts of contaminants allowed in drinking water. Many of the contaminants are measured in parts per million. This activity will demonstrate what one part in a million looks like.

4. Distribute to each participant, pair, or group, six cups (or one egg carton strip), one 9-ounce cup filled halfway with water, one empty cup (for cleaning a water dropper), two water droppers (or one if using a "dropper" style food coloring bottle), and the two handouts.
5. Participants place their six cups (or strip of egg carton) in a line in front of them. If desired, they can label their cups 1 through 6 with their pencils. Their 9-ounce cups can be placed nearby.
6. Following the instructions on the "What Does One in a Million Look Like?" handout, participants place 1 drop of food coloring into Cup 1. Using a clean water dropper, participants add 9 drops of water to the cup. Ask youth, "How many colored drops did you add to the cup? How many drops are in the cup all together?"
7. Instruct participants to collect 1 drop of the mixture from Cup 1 and place it in Cup 2. Using a clean water dropper, youth add 9 drops of water to Cup 2. (Youth may need to rinse their droppers with tap water and squirt the excess into the empty cup.)
8. Participants will repeat the procedure, using 1 drop from the previous cup until all 6 cups are filled.
9. When participants have completed making their solutions, have them observe the colors of the solutions in the different cups. Ask, "What happened to the color of the water in the different samples?" "In which sample does the color seem to disappear?" "Do you think that Cup 6 contains no food coloring?" Get responses.
10. Participants look at the fractions represented in the "What Does One in a Million Look Like?" handout. Have youth note that the concentration in Cup 6 is one part in one million. Each of the cups has a solution that is 10 times more diluted than the solution in the preceding cup. Ask, "Is there another way that we could make a mixture that has one part in 1 million?" (One way is to add 1 drop of food coloring to 999,999 drops of water! Another would be to add one drop of food coloring to a fill bathtub of water—this would be an approximation.)
11. Hold up one of the cups of tap water. Ask, "What about this water? Could it also have tiny amounts of other things in it? What might those tiny things be?" (Possible answers could

include minerals, microorganisms, or chemicals.) Ask if all the things that cannot be seen in water are harmful? Get responses. Help youth understand that almost no water, except in a laboratory, is completely pure. There are minerals that can be very healthy in water. On the other hand, point out that some pollutants can be harmful to human beings in very tiny amounts, often measurable in parts per million or parts per billion (for example, heavy metals like lead and mercury, pesticides and some industrial chemicals). Mention that certain city, county, state and federal agencies test drinking water for potentially harmful chemicals. Ask youth why testing might be important?

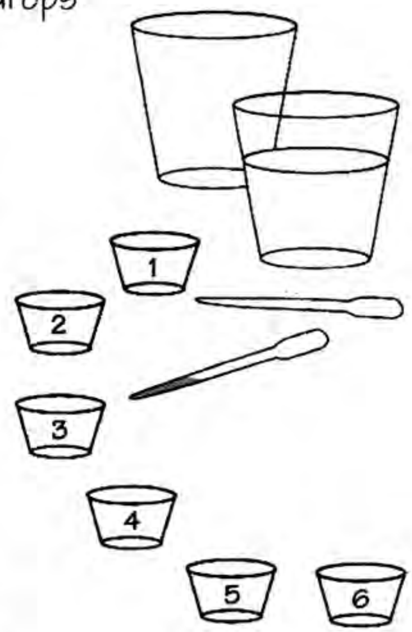
Source:

Activity adapted from *My World: Water Teacher's Guide*
Activity: "What is a One Part in a Million Solution?

http://www.k8science.org/resources/files/Water_7_OnePPM.pdf

For more information, contact:
Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, TX 77030
(713) 798-8200
(713) 798-8244
www.BioEdOnline.org
www.CCITonline.org/ceo

What Does One in a Million Look Like?



1. Add one drop of food coloring to Cup 1. Now add nine drops of water to Cup 1.

   How many drops of food coloring does Cup 1 have? ________

   How many drops does Cup 1 have in all? ________

   The amount of food coloring in Cup 1 is: 1 drop in 10.

2. Take one drop from Cup 1 and put it in Cup 2. Add nine drops of water.

   How many drops does Cup 2 have in all? ________

   The amount of food coloring in Cup 2 is: 1 drop in 100.

3. Continue adding 1 drop from the previous cup and 9 drops of water to each new cup until all six cups have 10 drops each. Then finish the chart. (Hint: look for a pattern in the amount of food coloring that ends up in each cup.)

Cup Number	Total Drops in Cup	Amount of Coloring
1	10	1 drop in 10
2	10	1 drop in 100
3	______	1 drop in 1,000
4	______	1 drop in ________
5	______	1 drop in ________
6	______	1 drop in ________

One in a Million" Background Information Sheet

All the water on Earth ultimately forms part of a single, immense system, Oceans, wetlands, streams, lakes, and underground water supplies are all linked through drainage patterns in watersheds and through the endless cycling of water on our planet. Because water sources are connected, pollutants travel from one part of the system to another and, eventually, can affect very distant ecosystems and populations (human and wildlife).

Water can look clean and clear and still contain many different types of chemical and biological materials. Most of these are harmless---especially in tiny quantities. In fact, even water that comes from crystal clear wilderness sources, or water that is sold in stores as "natural" spring water, contains dissolved minerals and other substances.

Some types of water contaminants are harmful to human health even in very small amounts. The concentration of many of these substances usually is measured in parts per million or even in parts per billion. The Environmental Protection Agency (EPA) sets limits for the amounts of potentially harmful chemicals in drinking water sources.

Water pollutants can be divided into several major categories, all of which impact human health and well-being.

Nutrients. These can come from chemical sources (fertilizers or detergents) or can be biological in origin (sewage or manure). Nutrients usually are carried into water sources by rainwater. They cause excessive growth of water plants and algae, which can clog navigable waterways and use up oxygen (needed by other organisms such as fish) when they decompose. These changes cause the decline of important lakes and wetlands, and can affect drinking water quality as well. In groundwater, fertilizers can make water from wells unsafe to drink.

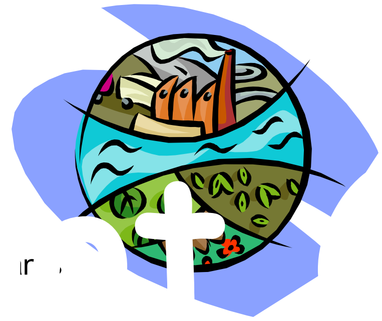
Soil and sand from plowed fields, construction sites, logging sites, urban lands and areas being strip-mined. These sediments make lakes, wetlands and streams more shallow, affecting the use of waterways for transportation and decreasing the quality of habitats for wildlife. Washed-off soil also can be a source of excess nutrients.

Disease-causing organisms. Bacteria, viruses and single-celled parasites can enter water supplies from inadequately treated sewage, storm water drainage, septic systems, livestock pens, and boats that dump human wastes. These organisms cause diseases such as dysentery and typhoid, as well as skin and respiratory illnesses.

Metals (such as mercury and lead) and toxic chemicals (such as those found in pesticides, herbicides, cleaning solvents, plastics and petroleum derivatives). These substances can be poisonous to humans as well as to wildlife. Metals and many manufactured chemicals persist in the environment. They build up in the bodies of fish and other animals, and can find their way into groundwater, making it unsafe to drink.

Heat. Warm water discharged from power plants (where water is used for cooling) can drastically alter aquatic ecosystems. Changes in water temperature can affect the quantity of oxygen in the water and can make some organisms more susceptible to disease, parasites and toxic chemicals.

Most sources of water pollution are spread over large areas. Water from rain and irrigation collects pollutants as it washes over the land or sinks into the soil. This type of pollution, which is not attributable to a single location, generally is referred to as **non-point source pollution**. It is much more difficult to monitor and to control than **point source pollution** –which is pollution that is discharged at a single place (such as from a factory, a single water treatment plant or a chemical spill).



Overview:

Youth experiment with different substances to determine the effects of pollution carried by stormwater and discuss ways to reduce stormwater pollution.

> ***Passive rainwater harvesting slows the flow of water across a landscape and allows more water to soak into the soil. Active rainwater harvesting collects and holds rainwater in a container. Both processes help to reduce the potentially negative effects of uncontrolled stormwater.***

Materials:

- Instruction sheet for each participant, pair, or small group (included)
- Data sheet for each participant or small group (included)
- Water
- Large cookie sheet for each participant, pair, or small group
- Plastic tub wide enough to fit the short end of a cookie sheet for each participant, pair, or small group (15 quart storage containers available at variety stores work well)
- Water dropper for each participant, pair, or small group
- Plastic cup(s) to fill water dropper(s)
- Spray bottle for each participant, pair, or small group
- Collection of “pollutants” (which might include powdered drink mix or cocoa, pancake syrup or honey, cooking oil, salt, glitter, confetti, etc.)
- Pencils for recording data
- Roll(s) of paper towels for drying cookie sheets
- Table or other level surface large enough for cookie sheets

Activity Duration:

45 minutes

Preparation:

- Determine whether the activity will be done as individuals, in pairs, or in small groups.
- Make enough photocopies of the instruction sheet and data sheet for each participant, pair, or small group.
- Prepare all materials.

Activity Steps:

1. Ask participants to think about what happens to the rain during a storm—where does it go? Ask if anyone has been out in a storm and seen water running down the street or across the landscape or perhaps flooding an area. Get responses.

2. Explain that water running off a surface is called "runoff." When it rains, water is not the only substance that runs off—the water collects all kinds of materials from trash, to oil on the streets, to other pollutants. Ask participants to think about what happens to those pollutants.
3. Explain the activity to participants and distribute the instruction and data sheets and all materials except for the "pollutants."
4. Display and introduce the "pollutants" and ask students what each might represent (cooking oil could be motor oil, for example). Get responses.
5. Provide directions on the amounts of the "pollutants" to use, based on their information and data sheets. Explain that the "pollutants" will be placed on the cookie sheets when the sheets are flat. The sheets can then be placed with the short end in the plastic containers at the inclines listed on the instruction sheet. The containers will catch the "runoff."
6. Before each experimental round, participants write their predictions on their data sheets.
7. Participants conduct four rounds of tests to note what happens to the different "pollutant" substances in different runoff situations. They will test two different incline positions (higher and lower) and two different water amounts (lesser and greater). The lower incline level should be in a position that is just enough for the water to flow. The higher incline level should be close to 45 degrees (or about twice as high as the first position). The lesser amount of sprayed water should be just enough to drip down the incline. The greater amount of water should be multiple sprays from a spray bottle.
8. Participants note their observations and answer the questions on their data sheets. (Ultimately, youth should be noting which "pollutants" are more easily picked up and carried by the water, which pollutants dissolve in the water, what happens when more water is added, and what happens when the incline is increased.)
9. Ask participants to look at the bottom of the container where the "runoff" collected and give responses.
10. Wrap up the activity using the data sheet questions as a guide to a class discussion. Ask participants to share rainwater harvesting ideas on keeping pollutants from getting "carried away."

Source:

Activity and materials adapted from *Stormwater in the Desert Teacher's Guide*, page 25.
Original activities can be found at: http://www.tucsonstormwater.com/teachers/

Activity courtesy of:
Stormwater Management Section
City of Tucson Department of Transportation
201 N. Stone Avenue, 6th Floor, North Wing
POB 27210, Tucson, Arizona 85726-7210
(520) 791-4371| (520) 791-5641 fax
http://dot.tucsonaz.gov/stormwater/

Let's Not Get Carried Away
Instruction Sheet

Name__________________________________ Date _________________

In these experiments, you will conduct four rounds of tests to observe what happens to different "pollutant" substances in different runoff situations. You will test the following:

- Two different incline positions
  - The "lower" incline level should be in a position that is tilted just enough for the water to flow.
  - The "higher" incline level should be close to 45 degrees (or about twice as high as the first position).

- Two different water amounts
  - The lesser water amount should be just enough to flow down the incline.
  - The greater water amount should be a steady stream of water.

Procedure for each round:

1. Choose and list your "pollutants" in the appropriate table on the data sheet and write your predictions.

2. Hold the cookie sheet surface flat. (*Note: If the pollutant is placed on the surface in an inclined position, it may run off before the water reaches it*.)

3. Place your chosen "pollutants" on the cookie sheet one at a time (or, if testing more than one at a time, place them some distance away from each other so that they won't mix), slightly down slope from where the water will be added.

4. Slowly tilt the surface to your selected incline level.

5. As soon as the surface is tilted, the selected water amount should either be dropped from a water dropper (for the lesser amount) or slowly sprayed from a spray bottle (for the greater amount).

6. Record your observations in the appropriate table.

7. Clean the cookie sheet surface between each test.

Let's Not Get Carried Away
Data Sheet (Page 1)

Name ________________________________ Date ________________

Round 1 – Lower incline and lesser amount of water

"Pollutant" (substance being tested)	Predictions	Observations

Round 2 – Higher incline and lesser amount of water

"Pollutant" (substance being tested)	Predictions	Observations

Round 3 – Lower incline and greater amount of water

"Pollutant" (substance being tested)	Predictions	Observations

Let's Not Get Carried Away
Data Sheet (Page 2)

Name ___________________________________ Date __________________

Round 4 – Higher incline and greater amount of water

"Pollutant" (substance being tested)	Predictions	Observations

Questions:

1. What kinds of substances are more easily carried by water?

2. Describe what happens to your substances when the surface incline is increased.

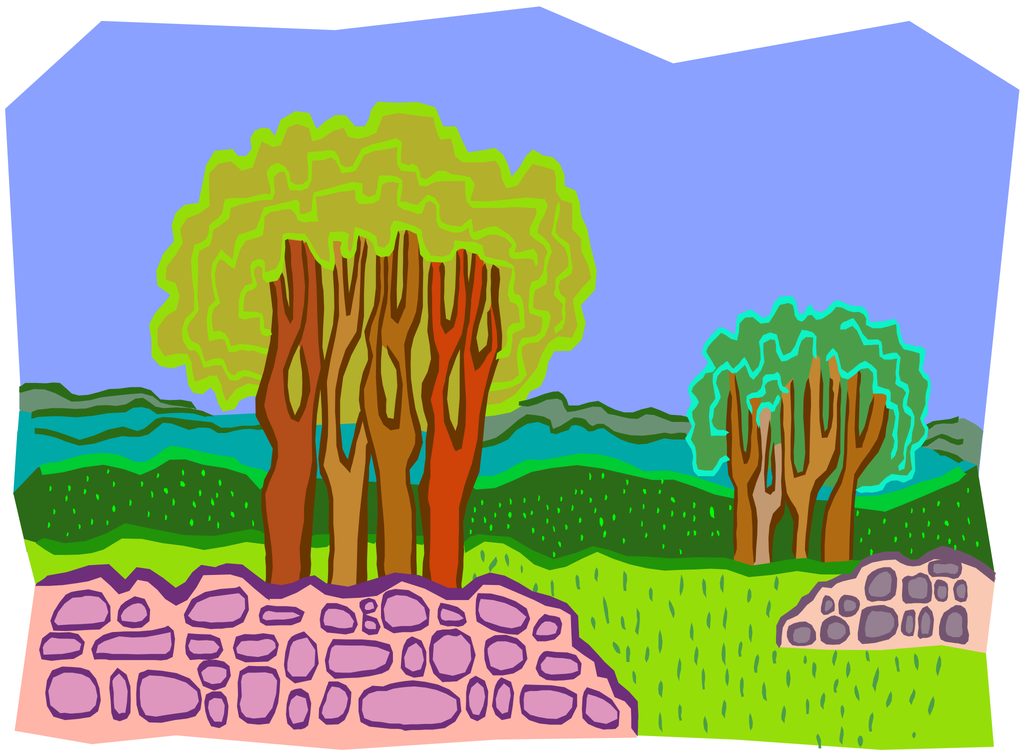
3. Describe what happens to your substances when more water is added.

4. Describe what happens to your substances when both the surface incline and the amount of water are increased.

5. What real-life pollutants might be represented by the "pollutants" you used in your experiments?

6. What has this experiment taught you about the way stormwater runoff picks up and carries pollutants?

Passive Rainwater Harvesting



Lessons include: how rainwater moves when it lands on a surface and where it goes, contouring landscapes for catchment and retention

Interactive, online activities on passive rainwater harvesting:

- Water Filtration Activity:
  http://www.groundwater.org/kc/activity7.html
- Wastewater Treatment:
  http://www.epa.gov/ogwdw/kids/flash/flash_filtration.html
- Non-Point Source Pollution Activity:
  http://www.epa.gov/safewater/kids/pdfs/activity_grades_4-8_nonpoint_pollution.pdf

Overview:

Youth experiment with different materials to dete[illegible] they allow water to soak in.

Image courtesy of City of Tucson's Stormwater Activity Book

Different soil types allow water to soak in or run off.

Materials:

- Variety of materials to test, which might include:
  - Cookie sheet
  - Cutting board
  - Cardboard
  - Outdoor carpet
  - Washcloth
  - Sponge
  - Paper towel
- Water droppers (enough for participants, pairs, or small groups)
- Water in cups for filling water droppers
- Photocopies of the "Soak or Splash? Data Sheets"

Activity Duration:

30 minutes

Preparation:

- Gather together materials or have participants bring materials of their choice.
- Make photocopies of the "Soak or Splash? Data Sheets."

Activity Steps:

1. Ask participants what causes liquids to either soak into a material or remain on top.
2. Define the terms, "pervious" and "impervious" (see glossary).
3. Distribute the "Soak or Splash? Data Sheets" and explain that participants are going to test different materials to determine if they are pervious or impervious.
4. Give participants time to test different surfaces and record their data. Encourage creativity as to the types of surfaces they test. They should always release the drops from the same height above the various surfaces.
5. Participants answer the questions at the bottom of their data sheets when they are finished with their experiments.
6. Use the data sheet questions to guide a wrap up discussion of the experiment.
7. Ask participants what this experiment shows about the way rainwater moves over different surfaces.

Extension:

This activity follows the same processes as the "Soak or Splash" activity except that the drops are made with juice colored with food coloring (for visibility) onto different snack foods. This experiment also illustrates the concepts of pervious and impervious surfaces. The activity enables youth to test their predictions and eat the results!

Extension Materials:

- Variety of snacks to test, which might include:
    - Bread
    - Fruit roll-ups
    - Real fruit choices (with and without peels)
    - Crackers
- Water droppers (enough for individuals, pairs, or small groups)
- 100% white grape juice in cups for filling water droppers
- Blue food coloring
- Photocopies of the "Food Trials Data Sheets" for individual participants

Source:

Activity and materials adapted from *Stormwater in the Desert Teacher's Guide*, page 19.
Original activities can be found at: http://www.tucsonstormwater.com/teachers/

Activity courtesy of:
Stormwater Management Section
City of Tucson Department of Transportation
201 N. Stone Avenue, 6th Floor, North Wing
POB 27210, Tucson, Arizona 85726-7210
(520) 791-4371| (520) 791-5641 fax
http://dot.tucsonaz.gov/stormwater/

Soak or Splash?
Data Sheet (Page 1)

Name______________________________________ Date_________________________

In this activity you will drop water on different surfaces to see if it soaks in or splashes. Make and test your predictions to determine what will happen on different surfaces. Complete the table below as you conduct the experiments. Then answer the questions.

1. Complete the table below:

Type of surface	Prediction: Will your drop soak or splash?	What happened when you dropped water on the surface?	Would you describe this surface as pervious or impervious?

2. Describe the surfaces on which water tends to splash:

Soak or Splash?
Data Sheet (Page 2)

Name____ Date_______________________

3. Describe the surfaces which tend to soak up water:

4. Which surfaces soak up water, those that are impervious or pervious?

5. What has this experiment taught you about the way rainwater moves over different surfaces?

Extension Activity
Food Trials
Data Sheet (Page 1)

Name____ Date_______________________

In this activity you will drop a colored beverage on different food surfaces to see if it soaks in or splashes. Make and test your predictions as to what will happen on different surfaces. Test at least one fruit, dropping the beverage on the skin (peel) in one test and on the flesh of the fruit in another test. Complete the table below as you conduct the experiments. Then answer the questions at the bottom and back of this page. Finally, you can eat the results!

1. Complete the table below:

Type of food surface	Prediction: Will your drop soak or splash?	What happened when you dropped water on this food surface?	Would you describe this food surface as pervious or impervious?

2. Describe the food surfaces on which drops tend to splash.

3. Describe the food surfaces which tend to soak up liquid.

Extension Activity
Food Trials
Data Sheet (Page 2)

Name____ Date______________________

4. What happened when you dropped your beverage on the peel of the fruit?

5. What happened when you dropped your beverage on the flesh of the fruit?

6. Which is more pervious, a fruit with its peel on or off?

7. What does this experiment tell you about the role of peel on a fruit?

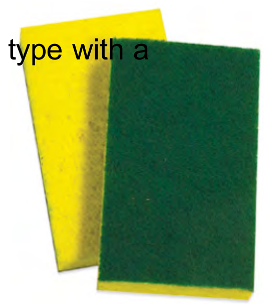
8. What has this experiment taught you about the way rainwater moves over different surfaces?

Overview:

Youth explore passive rainwater harvesting techniques that can be used to capture water in a landscape.

Passive rainwater harvesting involves shaping a landscape so that water moves through it more slowly and has a better opportunity to soak into the ground, thus benefiting plants and groundwater.

Materials:



- One 8” by 8” square aluminum cake pan for each pair or small group of participants
- Spray bottle for each pair or small group
- Water
- Two 6” by 3 ½ “ scour pad sponges for each pair or small group (look for the type with a green side to represent grass)
- 1-cup measuring cup for each pair or small group
- Bowls for collecting “runoff” water
- Plastic wrap for covering sponges
- 6” by 3” mosaic tile strip on open-weave, adhesive backing for each pair or small group (see included photo)
- “Water Lost/Water Saved” handout (included)
- Two berm and swale photographs (included)

Activity Duration:

30 minutes

Preparation:

- Make photocopies of the berm and swale photographs or bookmark them to show participants.
- Make photocopies for participants of the “Water Lost/Water Saved” worksheet.
- Purchase and prepare participant materials.

Activity Steps:

1. Ask participants if they have ever been in a rainstorm in a place where a lot of the area is covered with concrete or asphalt (city roads, parking lots, buildings with cement courtyards, etc.) Ask where the water goes. Get responses.
2. Explain that areas around buildings, including houses, are designed to move water away as quickly as possible to keep the buildings from flooding. In natural, unpaved areas, rain has a better opportunity to soak into the ground and move more slowly across a landscape. Where there is pavement, water can move very quickly and collect in areas that can cause damage or injury. Cities have stormwater systems that move water from buildings to streets and into gutters or washes as quickly as possible. Most water that falls on a city landscape is lost to that landscape.

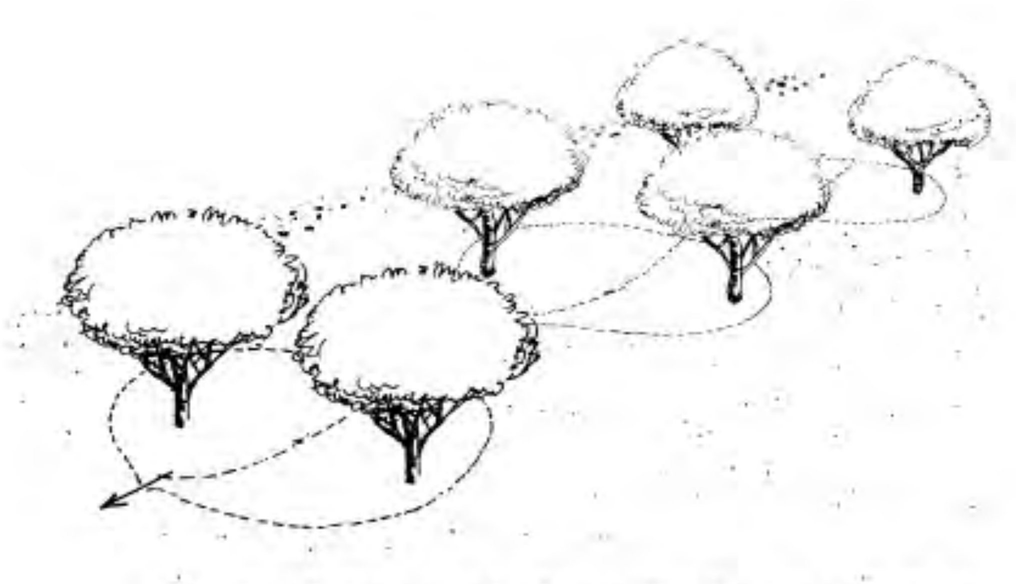
3. Explain that participants will explore ways to keep water in a landscape as a welcome and appreciated addition.
4. Distribute the aluminum pans, spray bottles filled with water, and worksheets to pairs or small groups. Turn a pan upside down and demonstrate bending the lip up on all sides to form a gutter. Explain that the bottom of the pan is an impervious surface; water will either collect on the surface (if it is level) or run off downhill (if there is a slope).
5. Participants spray the bottoms of their pans until water spills over the edge(s) and begins to collect in the gutter. Participants carefully pour the water into collection bowls. Explain that, just as they dumped their water into bowls, cities either "dump" their stormwater into systems of pipes that carry water (and whatever is in the water) to waste treatment plants or the water (and whatever is in the water) runs into nearby washes, streams, and rivers.
6. Next, participants bend one corner of their pans so that there is a spout and place that end into their measuring cups. They create a slight downward slope toward the spout and spray the pan bottom 50 times (the number of times is important for consistent measuring). They record their findings on the worksheet.
7. For the next activity, show participants a sponge. The green side represents unpaved areas (soil with or without turf). Explain that soil is like a sponge in its ability to absorb and hold water.
8. Participants place two sponges side by side on the upside down pan, spray the two sponges with a total of 50 sprays, and squeeze the water from both sponges into the measuring cup. They record their findings on the worksheet.

9. Participants compare and discuss the water lost or saved.
10. Ask participants to think about the processes for covering landscapes. Soil can be muddy or get washed away when it rains and raise dust when it is windy. People like level places to walk so they build paved sidewalks, driveways, and patios. Sometimes the materials people choose do not allow water to soak in (like cement) or do allow water to soak in (like brick in sand or loose flagstone pavers).
11. Explain that materials that do not allow water to soak in are considered "impervious" and materials that do allow water to soak in are considered "pervious" (see glossary).
12. Participants wrap one of their sponges in plastic wrap (this mimics covering the soil with an impervious material such as a concrete sidewalk or putting a plastic weed barrier under a landscaped area). They place a mosaic tile strip onto the top of the other sponge (this mimics covering the soil with a permeable pavement material such as concrete paving tiles).
13. Participants then place the two sponges side by side on the upside down pan. One participant slightly tilts the pan and holds it with the spout over the measuring cup and another participant sprays the two sponges with a total of 50 sprays. They record their findings on the worksheet.

14. Show participants the photographs of berms and swales. Explain that "berms" are mounds of soil that have been put in place to keep water in. Water flows from the higher places to the lower places which are called "swales." The low places collect and hold the water, allowing it to soak into the ground instead of running off the property.
15. Ask participants to notice how plants are planted. Show them a muffin tin, held upside down. Explain that many people plant on mounds (berms). Ask why planting this way might be a problem. Get responses. Spray water onto the upside down tin so participants can watch the water run between the "berms."

16. Turn the muffin tin over and explain that passive rainwater harvesting encourages planting in depressions in the soil (swales) that can collect water. Spray water over the tin so participants can see that the water moves into the cups.
17. Ask youth to describe ways to create landscapes that collect water (see diagram below for one idea).
18. As a wrap-up, ask participants to notice surfaces around town and look for ways that people incorporate pervious surfaces to hold onto more water.

Example of landscape design to collect rainwater in the landscape



Series of planted water harvesting basins on a slope.

Drawing courtesy of Patricia Waterfall

Sources:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
Willcox, AZ 85643-2790
(520) 384-3594
http://extension.arizona.edu/cochise

Creative inspiration from Brad Lancaster
Author of *Rainwater Harvesting for Drylands, Volumes 1 and 2*
Rainsource Press, 2008
www.HarvestingRainwater.com
Activities for teachers can be found at:
http://www.harvestingrainwater.com/rainwater-harvesting-inforesources/water-harvesting-curriculum/

Drawing can be found in *Harvesting Rainwater for Landscape Use*, by Patricia Waterfall
Available from http://ag.arizona.edu/pubs/water/az1052/harvest.html

Water Lost/Water Saved Worksheet

Name ____ Date ______________________

Activity 1:

- Use an 8” by 8” disposable, aluminum cake pan. Turn it upside down and bend the lip on all sides upward to form a gutter. Bend one corner downward to make a spout. Then rest the spout over a 1-cup measuring cup so that water will flow into the cup.
- Next, tilt the pan slightly to create a downward slope toward the cup and spray the surface of the pan 50 times.

Amount of water in the cup: _________________ (Water lost to runoff)

Activity 2:

- Place two sponges side by side on the upside down pan.
- Spray the two sponges with a total of 50 sprays.
- Squeeze the water from both sponges into the measuring cup.

Amount of water in the cup: _________________ (Water saved through infiltration)

Activity 3:

- Wrap one of the sponges in plastic wrap (this mimics an impervious surface like concrete).
- Put a mosaic tile strip onto the top of the other sponge (this mimics a pervious, paved surface).
- Place the two sponges side by side on the upside down pan.
- One participant slightly tilts the pan and holds it with the spout over the measuring cup.
- Another participant sprays the two sponges with a total of 50 sprays.
- Measure the amount of water in the cup (from runoff).

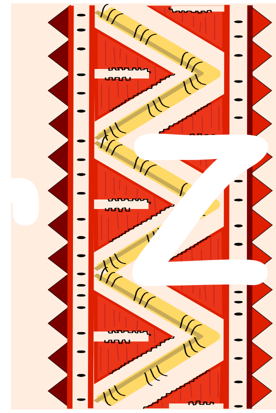
Amount of water in the cup from runoff: _________________ (Water lost)

- Empty the water from the measuring cup.
- Squeeze the water from the sponge with the tiles into the measuring cup.
- Measure the amount of water in the cup.

Amount of water in the cup from the sponge: ______________ (Water saved)

Berms and Swales

Berms and Swales



Overview:

Youth team up to create race courses ere e wi in eam wa r mov s the slowest through a designed layout.

Sculpting a landscape through passive rainwater harvesting holds water that would otherwise run off.

Materials:

- Water
- 2 large cookie sheets (of the same size)
- 2 large spray bottles
- 2 identical, plastic tubs wide enough to fit the short end of a cookie sheet (15 quart storage containers available at variety stores work well)
- 1 package of 12 ounce, classic modeling clay (available at variety stores); each team will use ½ of the package
- Roll(s) of paper towels for drying cookie sheets
- Location for disposing collected water
- Table or other level surface large enough for the two plastic tubs, located in an area where participants can gather to watch the race(s)

Activity Duration:

30 minutes

Preparation:

- Consider the number of participants and how to divide them into two groups (2 to 4 in a group is optimal; if there are more than 8 participants, consider doubling the materials and having concurrent races).
- Gather and prepare materials.

Activity Steps:

1. Explain that participants are going to work together to devise a system where water moves over a sloped landscape in the slowest way possible.
2. Hold up a cookie sheet with its back side facing up and tilted at a steep angle. Spray water onto the top part of the cookie sheet so that participants can see the water running unencumbered down the sheet.
3. Participants watch the way the water moves and make comments.
4. Next, lean the cookie sheet backward against the side of the tub (the slope will be less severe). Spray water onto the top part again.
5. Participants watch the way the water moves and compare the speed of the flow with the previous demonstration.
6. Explain that what participants are witnessing is "sheet runoff" (just think of cookie sheets). The speed of the runoff depends on the slope of the landscape. Sheet runoff can be very fast and damaging to the landscape by causing erosion. When there is sheet runoff, the water also

leaves the area very quickly without having time to soak into the ground to benefit plants in the area.

7. Dry the cookie sheet.
8. Explain that the goal is for participants in teams to use clay to devise a course on a cookie sheet that will slow the water the most. The race course will be the length of the back side of the cookie sheet. The cookie sheets of competing teams will be placed in separate plastic tubs so that they lean against the side (in order for the angle to be the same for both teams).
9. Explain that Arizona surface water laws do not allow people to dam water so participants cannot place clay in strips that go all the way across their cookie sheets. However, people can use clay in many creative ways to channel and slow the flow of water. Participants will have a set time to devise their course, using some or all of their clay. Give participants 5 to 10 minutes, depending on their progress. They should choose one member to be the sprayer and another to be a spokesperson. At least two participants can hold the sides of each tub so that the weight of the cookie sheet does not cause it to tip over.
10. Divide the group into teams and give each group a cookie sheet and ½ of the clay from the 12-ounce package.

11. Teams move to different places in the room to devise their courses.
12. Allow participants to devise their own courses but encourage them to pay attention to the edges of their cookie sheets, especially in the upper region, and use clay to keep water from running off the edges and immediately going to the bottom of the tub.
13. When the activity time is up, the teams bring their cookie sheets to a table or level surface and place the tubs side by side, facing the same direction. Two to three tubs work best. If there are more teams, have different rounds.
14. The spokesperson for each team explains the reasons for developing the course in the way their team did and describes how their course will effectively slow the water. Participants at this point may hypothesize about which course will slow the water most effectively.
15. Participants place their cookie sheets in their tubs while the teams gather around. At least one participant on each team will hold the side of the team's tub to keep it from tipping over backward (if they hold their cookie sheet it can jiggle and affect the water flow).
16. Participants designated to spray the water will stand facing their cookie sheets so they can spray the tops of their sheets effectively. Consider having participants spray their competitor's cookie sheet to promote fairness.

17. Give each team a spray bottle.
18. Participants should give their spray bottles several "test" sprays in a different direction than the cookie sheets to assure a good flow of water. A wide-angle flow best resembles rain.
19. When the leader calls out to start, the participants, at the same time, spray five sprays at the tops of their cookie sheets.
20. Participants stop to watch the direction(s) the water has run and where it has collected.
21. Instruct participants to keep spraying in sets of five sprays until one team's water reaches the bottom of the sheet.
22. Everyone watches the water to determine the moment that one team's water runs off the base of the sheet. The team whose water takes the longest to reach the bottom of the cookie sheet has the more effective design because the "landscape" was able to hold the water for the longest time.

23. Lead a discussion on the participants' designs, the direction(s) the water moved, and which designs were most effective.
    - Possible questions to ask:
        - What was your design strategy?
        - How did you decide on your design?
        - How many sprays did it take for the water to reach the base of the sheet?
        - What direction(s) did the water actually move down the sheet?
        - Did the direction(s) the water moved surprise you? Explain why or why not.
        - If you did the Zig Zag Race again, how would you change your design?

24. Show participants a muffin tin, held upside down. Explain that many people plant on mounds (called "berms"). Ask why planting this way might be a problem. Get responses. Spray water onto the upside down tin so participants can watch the water run between the "berms."
25. Turn the muffin tin over and explain that passive rainwater harvesting encourages planting in depressions in the soil (called "swales") that can collect water. Spray water over the tin so participants can see that the water moves into the cups.
26. Ask participants what techniques could be used in actual landscapes to hold water there longer.
27. Youth may opt to redesign their "landscapes" to try to make them more effective at holding water.

Extension:

Distribute grape stems as "trees" and ask youth to use the clay to "plant" the "trees" in the best locations in their bermed landscapes. This added activity gives participants the opportunity to explore "best practices" such as planting a tree in a raised area in the middle of a swale (called "doughnut planting") to keep water from collecting around a tree's base or planting a tree on the uphill side of a berm to allow water to soak in where the roots can best take up water.

Example of a "doughnut planting"

Source:

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Overview:

Youth explore ways that rocks can influ the mov t of wa learn song about the water cycle and conservation and rit r on ervation song raps, or poems to highlight rainwater harvesting concepts.

> ***Three effective assists for passive rainwater harvesting include rock ripraps, gabions, and French Drains.***

Materials:

- Photograph of rock riprap (included)
- Photograph of a gabion (included)
- One-cup measuring cup(s) (the number will depend on the number of participants; several can share)
- Cookie sheet(s) (the number will depend on the number of participants; several can share)
- Small funnel(s)
- Access to water
- Blue food coloring (optional)
- Stapler
- Ruler
- Scissors
- Guitar, piano, or keyboard for group leader (optional)
- Rhythm instruments for participants (optional) (could include wood blocks or dowels, bells, etc.)
- Chalkboard or whiteboard for brainstorming song ideas

For each participant:

- Three 9-ounce plastic cups
- A piece of vinyl screening (7” by 5”) or 1 leg of hosiery (knee highs work well and one pair will serve two participants)
- Soil to fill two 9-ounce plastic cups
- Handful (approximately 1/3 cup) of fine gravel or craft pebbles
- Song sheets (included)
- Paper and pencil

Activity Duration:

45 minutes to 1 hour

Preparation:

- Photocopy song sheets.
- Photocopy or bookmark photographs.
- Purchase and prepare materials.

Activity Steps:

1. Ask participants if they know what "rock riprap" is. (See glossary.) (This is not a very common term and many participants will probably think of types of music.) Get responses.
2. Explain that rock riprap is rock or other material used to protect waterways, including washes and streambeds, from erosion.
3. Explain that the activity will give participants a chance to explore the use of rocks to both slow the flow of water (through a landscape) and speed up the flow of water's access to plant roots, depending on the way the rocks are used.
4. Participants will keep the term "rock riprap" in mind because one part of the activity returns to the idea of rock and rap music and participants will have a chance to write some lyrics relating to water.

Part I – Slow the Water

1. Pass around or show participants photographs of rock riprap and a gabion. Riprap is composed of loose rock and a gabion encases rocks in wire cages to hold the rocks in place. If gabions are located along the sides of waterways, they help prevent erosion. If they are built across a wash or streambed they slow down the flow of water during storms which also reduces erosion along the banks. In slowing the water during a rain event, gabions enable more water to soak into the ground to benefit plant and replenish groundwater. Riprap and gabions are ways that rocks can be used in passive rainwater harvesting.
2. Distribute cookie sheet(s), measuring cup(s) with ¾ to 1 cup of water (add blue food coloring if desired), and a handful of gravel or craft rock to each participant.
3. Demonstrate water "sheeting" across a landscape by slightly lifting one end of a cookie sheet and pouring water slowly onto the top portion of the cookie sheet.
4. Next, with several participants sharing a cookie sheet, youth arrange their gravel or craft rock so that it forms two parallel lines (to represent the sides of a wash), with some rock forming at least one riprap across.
5. A participant slightly lifts one end of each cookie sheet while another youth slowly pours the water through the "wash." Participants compare the speed of the water (while water does move through the rocks, the speed is considerably slower than it was when it was unimpeded).
6. Pour off the water, leaving the gravel on the cookie sheet(s).
7. Distribute to each youth, pair, or small group, a piece of vinyl screening (7" by 5") or 1 leg of hosiery. Explain that when rocks are wrapped in wire to hold them in place, the structure is called a "gabion." A gabion is used in the same way that rock riprap is used but it is often stronger and more stable and it can be designed and shaped in ways to solve specific issues of erosion and runoff.
8. Explain that participants will make models of gabions by putting gravel in hosiery or a mesh "sack." If youth use hosiery, they will use scissors to cut the hose at the ankle and place a small handful of gravel inside. They will then tie a knot at the end, as close to the gravel as possible, and cut off any excess hosiery. To make a "sack" out of vinyl mesh, youth will roll a piece of vinyl screening,

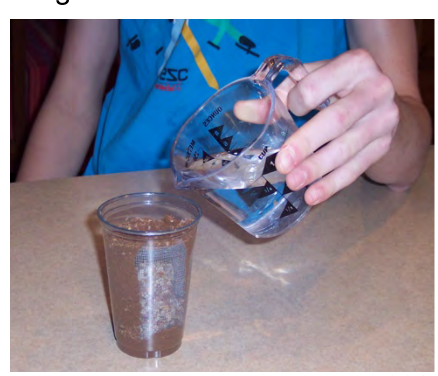
Vinyl screening "gabion"

fold over one end and staple it closed, and place a small handful of gravel inside. Participants then staple the other end closed. (See photo example.)

9. Participants again form two parallel lines of gravel on their cookie sheet(s). This time they place at least one "gabion" across the channel. If they choose to use more than one gabion, the participants may stack them or line them side by side; they can determine the design. Again, participants pour water down the channel. They compare the amount of water slowing to that of the rock riprap.
10. Explain that the participants have just seen how rocks can slow water. Next, participants will see how rock used in passive rainwater harvesting can speed the flow of water; they are going to make a model of a "French Drain."
11. Participants hold onto their "gabions" which will become "French Drains" in the next part of the activity.

Part II –Speed up the Water

1. Explain that sometimes people want to move water quickly through parts of their landscapes. For this purpose, they can use a "French Drain," which is a system by which a ditch is dug and filled with gravel and rocks; water flows more quickly into them than into the surrounding soil. One place that people do not want water to collect is right up against buildings because over time the water can cause damage to walls and weaken foundations. Moving water away from a building quickly is one use of a French Drain. A downspout can direct water to a rock filled channel which can move water to another part of a landscape. The water moves through the rock much faster than it moves through soil because the spaces in between the rocks are larger. Another use for a French Drain is to enhance tree watering. In the Southwest, the soil gets very dry and hard and there is often a layer of rock underground, called "caliche." The majority of shrub and tree roots are found within the top three feet of the surface. However, water from light rains does not penetrate the soil deeply enough to water plants. French Drains (either gravel and rock placed in ditches around trees or rock contained in permeable fabric or wire) can move water quickly down to a plant's root depth, even during short rain events.
2. Explain that in this activity participants will explore the way French Drains work.
3. Distribute to each youth, pair, or small group, three 9-ounce plastic cups.
4. Hold up a "gabion" from Part I and announce that it is now a "French Drain." The gravel in the mesh represents smaller rock since the rocks used to make a French Drain are usually smaller than those used in gabions.
5. Participants place their gravel-filled hosiery or mesh sacks inside one of their empty cups in an upright position against the side of their cups.
6. They fill their cups containing their "French Drains" with soil and fill one of the other 9-ounce cups with soil alone.
7. Participants fill the third cup with water.
8. Using their cup containing soil alone, youth slowly pour just enough water over the top of the soil to wet the surface. They watch as the water infiltrates the soil and note the depth where the water stops.
9. Next, youth experiment with the cup that contains the "French Drain." While they watch the side of their cup, they slowly pour just enough water over the top of the soil to wet the surface. They watch as the water infiltrates the soil. If the water does not reach the bottom of the cup, participants can add a little more water until they see water along the bottom of the cup. They should see that the soil at the bottom of the cup is wet as is the upper portion of the cup. However, the middle layer of soil opposite the "French Drain" is dry
10. After observing, ask youth to describe what they are seeing and ask if a French Drain could be useful for watering plants or moving water away from a building.



11. As a wrap up, ask participants to think of locations that could benefit from riprap, gabions, and French Drains.
12. Try Part I and Part II with different sized soil and rock particles.

Part III – Rock and Rap Music

1. Explain to participants that since the term, “rock riprap” may cause people to think of rock and rap music, this part of the activity involves songs, chants, and raps about water. Participants will have a chance to compose their own music.
2. Distribute the song sheets and (if being used) the rhythm instruments.
3. Choose from some of the songs/chants or teach all of them, depending on the time available.
4. After learning the songs, note that, with perhaps the exception of the “Itsy, Bitsy Spider” song, the water songs have to do with the water cycle or conservation. There are not many songs about rainwater harvesting. This activity will help youth fill that gap by creating songs, chants, or raps having to do with rainwater harvesting.
5. Using a chalkboard or whiteboard, participants brainstorm vocabulary words and concepts that have to do with rainwater harvesting.
6. Provide some tips on rhythm and rhyme and some guidelines for the songs (such as including at least three facts about water harvesting) and let the youth work alone or in pairs or groups to come up with their own rainwater harvesting music.

Extension:

Consider putting together a rainwater harvesting songbook and/or having a performance at a rainwater harvesting demonstration or celebration.

Source:

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Rock Riprap

Photograph courtesy of Cado Daily

Gabion

Water Songs/Raps/Chants

Waterdrop Rock Rap

By Cado Daily

Water is precious, just like gold
It falls from clouds and it's very, very old.
We can get it from a river or a stream or a lake
It comes as rain and it tastes pretty great.

Save a drop (snap fingers or clap) save a lot (snap fingers or clap).
Do the Waterdrop Rock.
(Snap fingers or clap 3 times)

We use water every day,
We use it for cleaning and drinking and play.
We use it for food, for cars and plants
Animals use it, including the ants!

Save a drop (snap fingers or clap), save a lot (snap fingers or clap).
Do the Waterdrop Rock (snap fingers or clap 3 times)

Inside the bathroom we brush and flush,
We use water, but not too much!
When taking a shower, sing a short song,
Get yourself clean- and don't be long!

Wash a full load, either dishes or clothes
And don't forget to turn off the hose!
Fix a drip and be hip—
We all save water with these tips!

Save a drop (snap fingers or clap), save a lot (snap fingers or clap).
Do the Waterdrop Rock. Do the Waterdrop Rock. Yeah!

Itsy, Bitsy Spider
Key of C
(Guitar Chords Included)

```
         C                         G               C
The itsy, bitsy spider went up the water spout          (walk index fingers and thumbs of both
                                                         hands upward in front of body)
                                  G                    C
Down came the rain and washed the spider out            (swish hands in front of body)
                              G                 C
Out came the sun and dried up all the rain              (make a circle with arms above head)
                                       G               C
And the itsy, bitsy spider went up the spout again      (walk index fingers and thumbs of
                                                         both hands upward in front of body)
```

Water Cycle Song (To the tune of "She'll be Comin' 'Round the Mountain)
Key of C
(Guitar Chords Included)

```
          C
Water travels in a circle, yes it does (move arms in a circular motion in front of body)
                                  G
Water travels in a circle, yes it does (move arms in a circular motion in front of body)
         C
It goes up as evaporation (raise arms up)
           F
Forms clouds of condensation (make a circle with arms above head)
        G
Falls down as precipitation (move arms slowly down in front of body while wiggling fingers)
         C
Yes it does
```

Water Cycle Song (to the tune of "Clementine")
Key of C
(Guitar Chords Included)

```
C
Evaporation

Condensation
                             G
Precipitation falls to the ground—

Accumulation
         C
Water Cycle
        G              C
In a circle it goes around
```

Conservation Song (To the tune of "I've Been Working on the Railroad")
Key of C
(Guitar Chords Included)

C
I've been saving lots of water
F C
all the livelong day,

I've been saving lots of water
D7 G
that will help in every way.

G7 C
Can't you see me turn the faucet?
F C
so it won't drip drop,
F C
I've been saving lots of water,
G C
and I'll never stop!

Save it in the yard,
F
save it in the house,
G C
save it in the bathroom, too,

Save it in the sink,
F
save it in the shower,
G C
I know what to do!

Overview:

Youth create two tools to measur[illegible] slo[illegible] nd [illegible] se[illegible] the [illegible] an [illegible] sca[illegible] e t[illegible] determine the direction that water v[illegible] ura[illegible] or[illegible] r to [illegible] esig[illegible] a [illegible] e water harvesting system.

> ***Assessing a site's characteristics, including slope and contour, helps to effectively shape the land for rainwater collection.***

Materials:

- "Git Along Little Dogies" song sheet handouts (included) for all individuals, pairs, or small groups
- "Appendix 2: Bunyip Water Levels and A-Frame Levels" handout (included)
- Bunyip materials:
  - 2 five-foot to six-foot tall, straight stakes
  - 30 feet or more of 5/8-inch diameter clear vinyl tubing, available in the plumbing section of hardware stores
  - 3 feet of wire or string
  - Yardstick, meter stick, or tape measure
  - Permanent ink marker
  - 2 to 3 gallons of water
  - Funnel
  - 2 corks and 2 strings (optional)
- A-Frame level materials
  - 3 straight poles, pipes, sticks (or 2 straight poles and a level)
  - Rope, cordage, nails, or screws to securely fasten the poles, pipes, or sticks
  - 4 feet of string and a weight (stone, horseshoe, etc.) to tie to one end of the string (not necessary if a level is used as the horizontal piece)
  - Marker, knife, or paint

Activity Duration:

- Introduction and cowboy song: 25 minutes
- Building and using bunyips and A-Frame levels are extended projects that may involve several sessions to build the tools and learn to use them.

Preparation:

- Read through the activity in its entirety to determine the aspects that fit best with the participants, location, and timeframe available.
- Purchase and gather all necessary materials.
- Make photocopies of the "Git Along Little Dogies" song sheet handout.
- Make photocopies of "Appendix 2: Bunyip Water Levels and A-Frame Levels" handout for individuals, pairs, or groups.

Activity Steps:

1. Ask participants to think about the job of a cowboy. Explain that they spend a lot of time on the trail, moving cattle to and from fertile grazing areas and then to market, driving them often hundreds of miles. Out on the trail cowboys can encounter many problems. Many of the days are long and monotonous, broken up by periods of stress if the cattle stampede or in past generations, if they were attacked by outlaws. Singing is a popular pastime to make the long days easier. Cowboys often carry instruments that are portable such as guitars, fiddles, and harmonicas and sit around the campfire at night, playing instruments, making up songs, and telling stories. To hear a cowboy, J. Frank Dobie, tell the story, "Cattle just naturally love music, and many a herd that went up the trail snored to the tune of some cowpuncher's fiddle." Cowboys sing to the cattle to keep them calm. The wranglers who have the job of watching the cattle overnight circle the herd, checking for signs of danger while singing restful songs (and helping the cowboys stay awake).
2. Distribute the "Git Along Little Dogies" song sheets to participants and teach them a cowboy song. There are songbooks available with music and guitar chords; the melodies of many songs are available on the Internet. Consider locating a recorded version performed by a Western band to play for participants.
3. Explain that just as cowboys herded cattle, singing songs with signature words like, "Whoop-ee-ti-yi-o," people today can "herd" water where they want it to go by recognizing its natural flow and contouring the land to better channel the water to move in a particular direction.
4. Explain that recognizing the natural flow of water in a landscape involves understanding the slope of the land. Two tools that can be used to determine slope in a landscape are a "bunyip" and an A-Frame level.
5. Define "bunyip" (see glossary) and guide participants through the process of constructing and using a bunyip and/or an A-Frame level, following the directions in the "Appendix 2: Bunyip Water Levels and A-Frame Levels" handout.

Sources:

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"Appendix 2: Bunyip Water Levels and A-Frame Levels"
From *Rainwater Harvesting for Drylands and Beyond: Volume 2 Water-Harvesting Earthworks*, pages 339-347
Author: Brad Lancaster
Rainsource Press, 2008
www.HarvestingRainwater.com
Used with permission, May 2009

Cowboy Quotation:
Glen Seber, *The Duncan Banner*
http://www.texhoma.net/~glencbr/p501.html
http://www2.sas.com/proceedings/sugi26/p232-26.pdf
Accessed May 23, 2009

Git Along Little Dogies Song Sheet

Key of C

(Guitar Chords Included)

C F G7 C F G7 C
As I was walking one morning for pleasure, I spied a cow-puncher a-strollin' along.
F G7 C
His hat was throwed back and his spurs were a-jinglin',
F G7 C
And as he approached he was singin' this song: CHORUS

CHORUS

C7 F
Yippee-ti-yi-yo, git along little dogies,
C7 F C
It's your misfortune and none of my own.
C G7 C
Yippee-ti-yi-yo, git along little dogies,
F G7 C
You know that Wyoming will be your new home.

It's early in spring that we round up the dogies,
We mark them and brand them and bob off their tales.
We round up our horses, load up the chuck wagon,
And then throw the dogies out onto the trail.

CHORUS

It's whooping and yelling and drivin' the dogies,
And oh how I wish you would only go on!
It's whooping and punching, go on, little dogies,
You know that Wyoming will be your new home.

CHORUS

Appendix 2

Bunyip Water Levels and A-Frame Levels

SIMPLE TOOLS FOR MEASURING SLOPE AND DETERMINING THE PLACEMENT OF WATER-HARVESTING EARTHWORKS

Professionals typically use transits or surveyor's levels to measure slope and define how they want to shape the land. These tools work well, but they are expensive and require training to use. Here are two effective and inexpensive alternatives you can make—a "*bunyip*" *water level* and an *A-frame level.*

THE "BUNYIP" WATER LEVEL

The "bunyip" (fig. A2.1), as this water level is called in Australia, is a simple tool that enables you to find a land "contour" (a level line on the landscape), determine elevation differences between two points, and determine the slope of the land.

You can use this tool to mark the locations for contour berms, slopes of diversion swales, end points of boomerang berms, depths of basins, and appropriate locations for overflow routes.

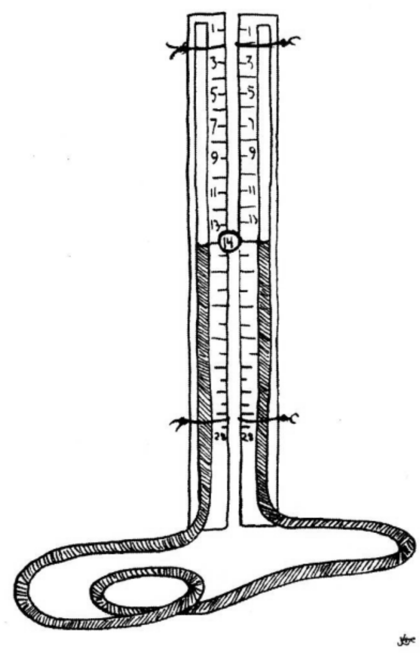


Fig. A2.1. Bunyip water level

A bunyip consists of a long clear vinyl tube, with each end attached to a tall stake that is marked in inches or centimeters. When the two stakes stand vertically, the tube becomes "U" shaped. Water is then carefully poured into the tube so no air bubbles are entrained in the water. The bunyip works on the principle that still, standing water is level across its entire surface, as you would find on a calm lake. A bunyip is basically a lake in a tube.

The tube is filled with enough water so the surface of the water reaches about halfway up each vertically held stake. If the stakes are standing right next to each other on level ground, the water level will be the same in both ends of the tube, and the measurement reading on each stake will be the same. If one stake is raised onto a small dirt mound while the other stays where it was, the water level will stay straight across, but the measurement readings on the stakes will be different, reflecting the elevation difference of the land

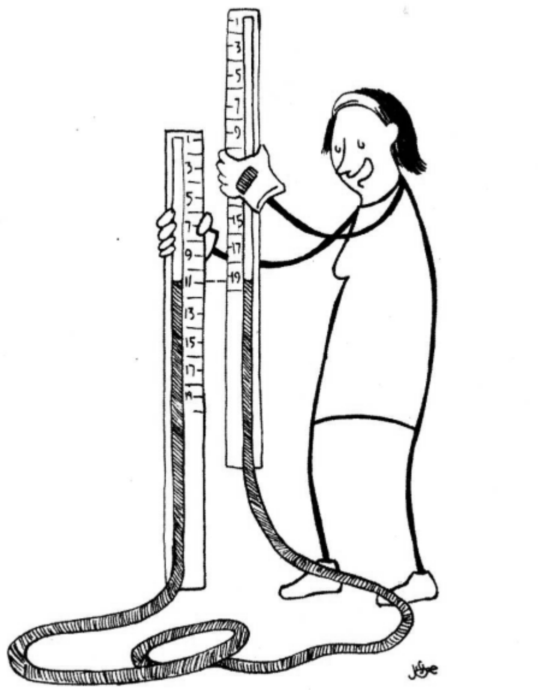


Fig. A2.2. Testing the bunyip level; the water is level.

the stakes are standing on. It takes two people to use a bunyip water level—one to hold each stake. Bunyips are easy to make using the materials and instructions below.

WHAT YOU NEED TO MAKE A BUNYIP

- Two 5- to 6-foot (1.5- to 1.8-m) tall, straight stakes
- 30 feet (9.1m) or more of 5/8-inch (16-mm) diameter clear vinyl tubing, available in the plumbing section of most hardware stores
- 3 feet (90 cm) of wire or string to bind the tubing to the stakes
- Yard (meter) stick or tape measure
- Permanent ink marker
- 2 to 3 gallons (9 liters) of water
- Funnel to pour water into the tubing

• Optional: 2 corks and 2 strings. Corks are used to plug the tube ends when moving the water level around, then removed during use. Wine bottle corks can be whittled down to fit the tubing. Tie one end of a string to the top of the bunyip stake and the other end to a cork so you don't lose the corks.

HOW YOU MAKE A BUNYIP

Lay the stakes beside one another on the ground with the bottom ends even. Measure 5 feet (1.5 m) up from the bottom of each stake and mark this point. These marks should be level with one another since the bottom ends of the stakes are even. Starting from the upper mark of each stake, use the measuring tape or yard stick and permanent marker to mark each inch (or centimeter) going down for 30 inches (or 75 cm). Check the accuracy of the marks by standing the stakes next to each other on level ground to confirm they line up. Starting with zero at the top, number the marks from top to bottom on each stake so the numbers also correspond.

Bind the tubing near the top of each stake using wire or string. Lash it tight enough to hold the tubing in place, but not so tight that it significantly pinches the tubing. Pull the tubing straight down along the stake and lash it in the middle, then near the bottom of the stake.

Fill the tubes with water in one of two ways:

Method 1: *Pour the water in.* With both stakes in an upright position, carefully pour water into one end of the tube until water overflows the tube. Any air bubbles that become entrained in the tubing will prevent accurate water level measurements. Remove air bubbles from the tube (see box A2.1 for instructions), and add more water until the desired water level is attained.

Method 2: *Siphon the water in.* Lay one stake on the ground. Set the other stake upright against a table that has a bucket of water standing on it. Release the upper tubing from the upright stake and stick the end of the tubing in the bucket of water. Wash the end of the tubing of the stake laying on the ground, then suck on the end of the tubing to initiate water siphoning. Air bubbles typically do not get entrained in siphoned water running from the bucket into the tubing.

With the air bubbles removed, hold the stakes upright next to one another on level ground. Check that the level of water is about halfway up the stakes. Drain or add water as needed to get water to the right level. Water should move freely up and down in the

Box A2.1. Getting Rid of Air Bubbles in Bunyip Tubing

To ensure accurate water level measurements, enlist a friend to help you remove air bubbles in tubing. First, pour water into bunyip tubing. Next have your friend stand on a spot several feet higher than surrounding land and hold the two bunyip stakes upright next to each other. Then stretch the intervening tubing out along the ground. Where the tubing "folds" back on itself (the bottom of the "U"), pick up both parts of the tubing 2 feet (0.75 m) from the bottom of the "U," using one hand. Make sure the tubing is not pinched anywhere. The bottom of the "U" will hang down forcing any air bubbles in that length of tubing to rise toward your raised hand. Now slowly slide your hand up the tubing, always keeping the bubble-free section of tubing lower than the tubing in your hand. Tap the tubing with your free hand to help free any bubbles sticking to the side. When your hand gets to the stakes, drop your hand slightly or lift the stakes slightly so the collected air bubbles can escape out the open ends of the tubing (fig. A2.3).

You may need to add more water in the tubing to fill the space the bubbles occupied. After you've put more water in, check for bubbles again.

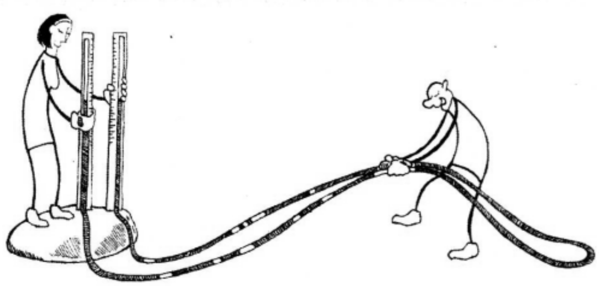


Fig. A2.3. Removing air bubbles from tubing

tubing when you move the stakes. If water does not move, check the tubing for kinks, remove the kinks, and verify that water moves correctly. Once the water becomes calm after moving the tubes, check that the water level lines up in both tubes, and that the measurement reading is the same on both stakes. If the water levels are not at the same height when the stakes are standing next to each other on level ground, check again for air bubbles or a kink in the tubing. If the measurement reading is not the same, check for mismarked stakes.

Now your bunyip is ready to use. While carrying it around, use the corks or your thumbs to plug the tubing to keep water from sloshing too much in the tubing. Remove corks or thumbs when you are reading water level measurements. During a long project, it's a good idea to periodically set stakes on level ground next to each other to verify no new bubbles or kinks have formed.

USING YOUR BUNYIP—TWO HYPOTHETICAL EXAMPLES

Marking a level line for a contour berm

Al and Bonnie want to mark a level contour line on their land where they plan to dig a contour berm later that day. They get out their bunyip water level and Bonnie holds the two stakes upright as Al fills the tubing with water and gets rid of air bubbles. The water is about halfway up their stakes and is level, so they are ready to start.

To refamiliarize themselves with the water level, Bonnie holds one of the stakes a few inches higher than the other. When the water stops moving, the water in the higher stake reads "19" while the lower stake reads "11" (fig. A2.2), so they are reminded that the stake that reads the higher number is also higher in the landscape than the other stake.

As they walk to where they want to begin measuring the contour line, they each hold a stake with their thumb over the open end of the tube to keep water from spilling out. Bonnie sets the bottom end of her stake down where they want to begin the berm. Al walks 5 to 20 feet (1.5 m to 6 m) along what he thinks is the contour line (20 feet if the land is relatively flat, closer if the land is more undulating). Al puts his stake down in a spot he feels is on the same contour line as Bonnie's stake. Standing in these positions, they each gently tap the top of their end of the tube with their thumb to stop the water sloshing around within the tubing. When the water is still, and they've removed their thumbs from the end of the tubing, they tell each other what water level measurement they have. Bonnie reads 13 while Al reads 17.

"I have the higher number, so my stake is higher than yours," says Al. "So I'll move my stake downslope

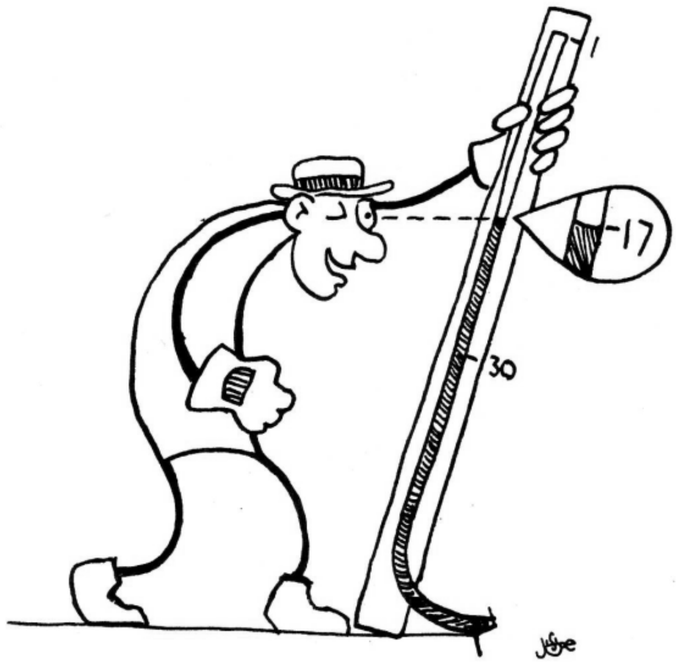


Fig. A2.4A. A non-vertical bunyip stake will give a lower, incorrect reading

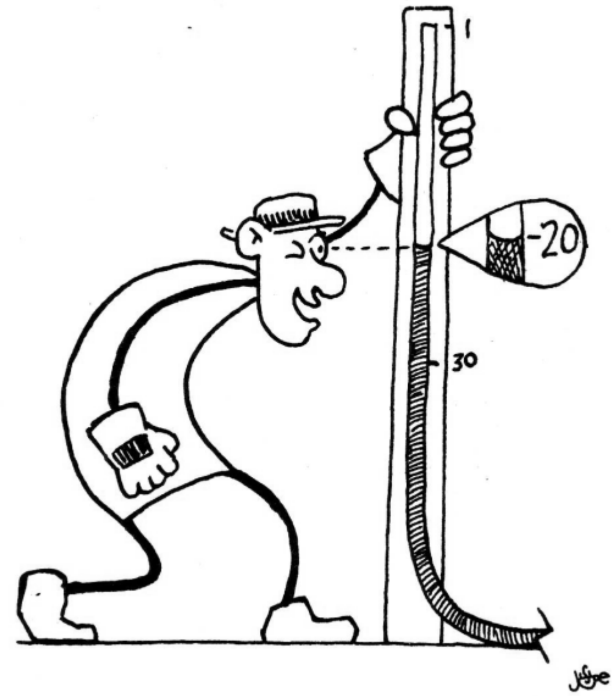


Fig. A2.4B. The bunyip stake must be vertical for a correct reading

a bit. You stay where you are since you're in the spot where we want to begin the berm." After moving his stake several times, Al and Bonnie each read 15 on their stakes, so they are now at the same elevation. They scuff a line in the dirt connecting Bonnie's point to Al's. With that done, Al keeps his stake in place and puts his thumb on the top of the tubing. Bonnie plugs her end of the tubing and walks her stake beyond Al ("leapfrogging him") to a point she thinks is level with his stake (fig. A2.5).

As Al and Bonnie find a series of points on the same land contour, they continue to connect the dots by scuffing the contour line into the dirt. They could have marked the contour line with wooden stakes or other markers, but since they planned to dig a berm 'n basin along the contour line right after lunch, scuffing is sufficient. They keep going until they reach the full length chosen for the contour berm. If they had encountered a landform that presented a natural barrier, they would have stopped there instead.

With the contour line marked, they prop the bunyip water level against a tree to keep water from running out of the tubing, call some friends, and dig a contour berm along the line they just marked

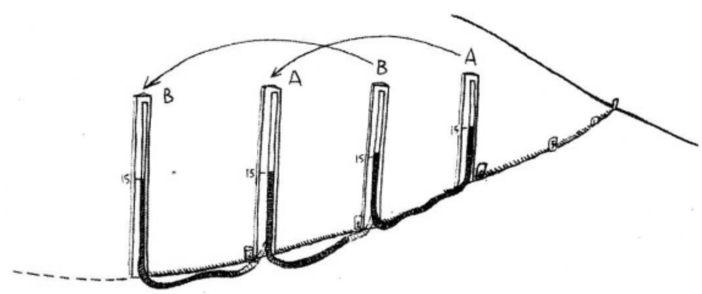


Fig. A2.5. Leapfrogging the bunyip to mark a level contour line on the land. Here the contour line is marked both by scuffing a line in the dirt and with stakes.

(see chapter 2 on Berm n' Basins for more information about construction). By four o'clock that afternoon, the contour berm is complete.

Using a bunyip to determine a difference in elevation and measure slope

In the middle of a record-breaking drought, friends of Bonnie and Al decide to make use of the

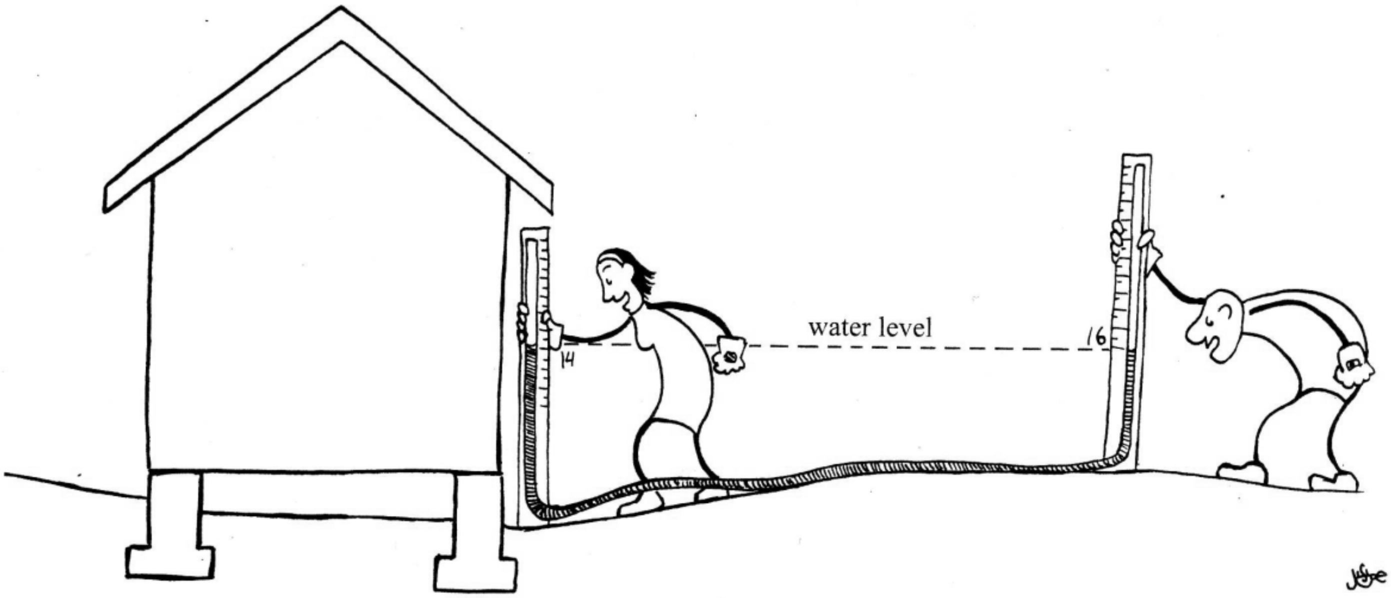


Fig. A2.6. Bunyip shows land slopes toward house.

rain that does eventually fall by putting in a water-harvesting basin in front of their house. To make sure they don't dig into and damage underground utility lines they call their free local utility-marking service (this is called Blue Stake where I live in Tucson) to have buried lines marked between the public right-of-way and the meters. Then they hire a private utility-marking service to continue marking buried lines from the utility meters to the house. Once all utility lines are marked, they ask Bonnie and Al to bring their bunyip over and help them figure out the direction water naturally drains around their new home.

Bonnie and Al look at the relatively flat lot and try to eyeball the way water would flow, then get out their bunyip water level to see if they are right. "OK," says Bonnie, "I'm putting my stake by the house." Al places his stake 10 feet (3 m) away from the house at a point he thinks is directly downhill from Bonnie. When the water stops moving within the tubing, Al and Bonnie tell each other the water level readings they have (fig. A2.6).

"I've got 14," says Bonnie. "My stake reads 16," says Al, "and with our bunyip that means you are a full two inches lower than me, so water will drain toward this house…which is bad news!"

Al, Bonnie, and their friends decide to dig a shallow basin about 15 feet (4.5 m) from the house to intercept rainwater, and to move the soil from the basin to the house foundation to deflect rainwater away from the house. They dig out a level-bottomed basin 6 feet (1.8 m) wide and 8 feet (2.4 m) long, and put most of the fill dirt next to the house, making sure the dirt is at least 6 inches (15 cm) below the top of the foundation's stem wall (as recommended by local building codes to keep termites and/or soil moisture from entering the home). They rake the area between the newly dug basin and the house so the grade slopes away from the house and into the basin. Then they use the bunyip water level to check their work. Bonnie again stands by the house and Al places his stake about halfway between the house and the basin on the new slope they created.

"My stake reads 16," announces Bonnie.

"And I read 14, so we did reverse the slope and water will now drain away from the house," cheers Al. "Bonnie, stay up against the house while I move my stake to the bottom of the basin to see how much deeper it is than the soil by the house."

Al moves to the bottom of the basin and reads 6 on his stake (fig. A2.7).

"I've got 24" exclaims Bonnie. "Subtract your 6 from my 24 and that tells me you are 18 inches lower than me. We did a good bit of digging!"

"This basin will catch a lot of rainwater! Let's make sure when it fills up, any surplus water will overflow away from the house," says Al.

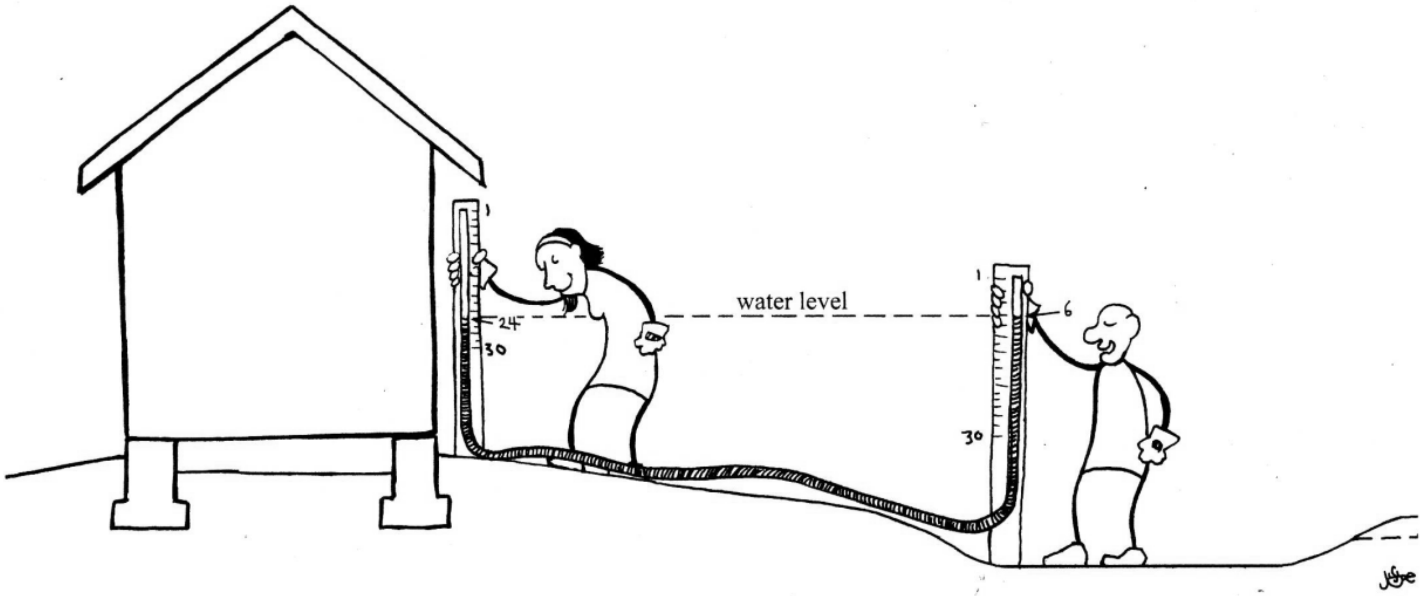


Fig. A2.7. Using a bunyip to measure how much lower the bottom of the basin is than the area near the house, confirming that the slope now drains away from the house

They take land surface readings all around the edge of the basin using their bunyip water level. They learn from the readings that if water flows out the lowest point around the edge of the basin, it will drain water toward the neighbor's house. To change this, they pick up the shovels and alter the dirt level of the basin's rim slightly so the lowest point on the basin's edge will now direct overflow into another basin on site.

Checking their work with the bunyip as they go along, they dig several more basins, this time located in the public right-of-way (public land located between their property line and the street). These basins will harvest even more rainwater and will receive overflow from the basin they dug in front of the house. So this series of basins will direct overflow water all the way from the house to the street. The edges, bottoms, and general slope of the basins are checked using the bunyip one last time.

The basins were constructed so that while the overflow spillways that move water from one basin to the next are at the same elevation, that elevation is well below the soil level abutting the house. This way the house will stay high and dry. The elevations of the level bottoms of the basins varied, but were all lower than their respective overflow spillways, so some water will be retained in each basin. The depth between a basin's overflow spillway and the bottom of the basin determines the storage capacity of the basin.

Bonnie and Al's friends are delighted with their new water-harvesting basins. After taking a break, they plant the basins. Hardy native trees go in along the street in the public right-of-way basins. The basin in front of the house is planted with a drylands-adapted peach tree to provide fruit for future pies. Along with it, they plant a wolfberry, a chuparosa, and native flowers that produce native foods and medicinals and attract hummingbirds. This basin will receive direct rainfall, harvested runoff, and greywater from the home.

Bonnie and Al's friends are so inspired, a week later they dig several more basins near their house. A vegetable garden goes into the basin south of the house where it will receive winter sunlight. A native mesquite tree is planted in a basin west of the house to fix nitrogen in the soil and screen the vegetable garden from harsh summer-afternoon sun. Once all the basins are dug, planted, and well-mulched, Bonnie and Al's friends dance together to entice the rain (fig. A2.8).

For more information see chapter 5 on infiltration basins, chapter 11 on vegetation, and chapter 4 in volume 1 on integrated design.

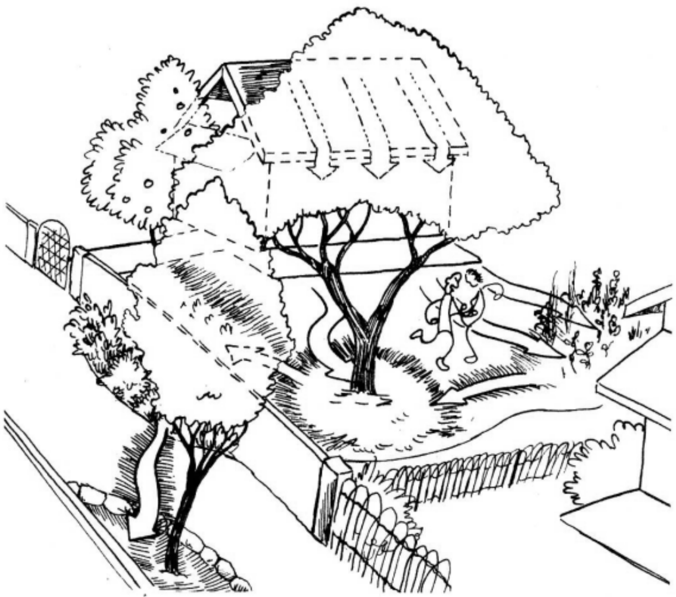


Fig. A2.8. Celebrating completion of a water harvesting landscape

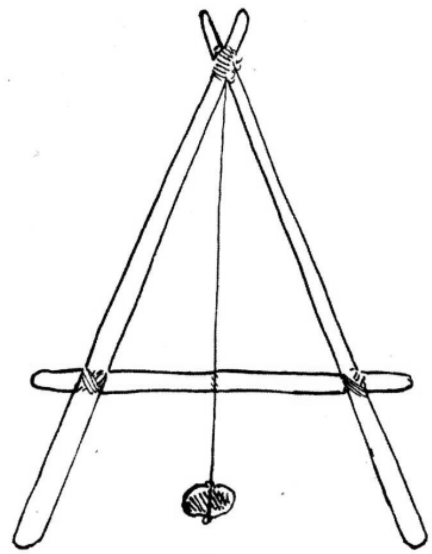


Fig. A2.9. A-frame level

THE A-FRAME LEVEL

The A-frame level (fig. A2.9) is even simpler to construct than the bunyip water level. No tubing or water is needed, and you can use it all by yourself. An A-frame level can be used to find a contour line on the landscape, but unlike the bunyip, you cannot measure the elevation differences between two points at different levels, nor can you measure the slope of the land. It does come in very handy for marking the line on which to construct contour berms and for checking to see if the two ends of a boomerang berm are level.

The A-frame level is made of three poles or sticks tied or fastened together to form a capital "A" (thus the name). A weighted string is hung from the top of the "A" like a plumb bob. When both "feet" of the "A" are level with one another the weighted string will hang alongside a center line marked on the horizontal stick of the A-frame. If the two feet are not level with one another, the string will hang to one side or the other of the center mark, depending on which foot of the A-frame is lower.

WHAT YOU NEED TO MAKE AN A-FRAME LEVEL

- 3 straight poles, pipes, sticks, or something similar. They must be long enough so that the top of the "A" is about as tall as you are and the feet of the "A" are at least 3 feet (0.9 m) apart. The feet can be closer together, but the narrower the "A" the longer it will take to mark a level contour line on a slope.

- Rope, cordage, nails, or screws to securely fasten the poles, pipes or sticks together at 3 points

- A piece of string about 4 feet (1.2 m) long and a weight of some sort (stone, horseshoe, etc.) to tie to one end of the string

- Marker, knife, or paint

HOW YOU MAKE AN A-FRAME LEVEL

Lay your three stakes, poles, or sticks on the ground in the form of a capital "A." Tie or screw the three stakes together in the three points where they touch. This is a great opportunity to live out your Boy Scout or Girl Scout knot-tying fantasies with clove hitches and lashing! Make sure all bindings are tight so

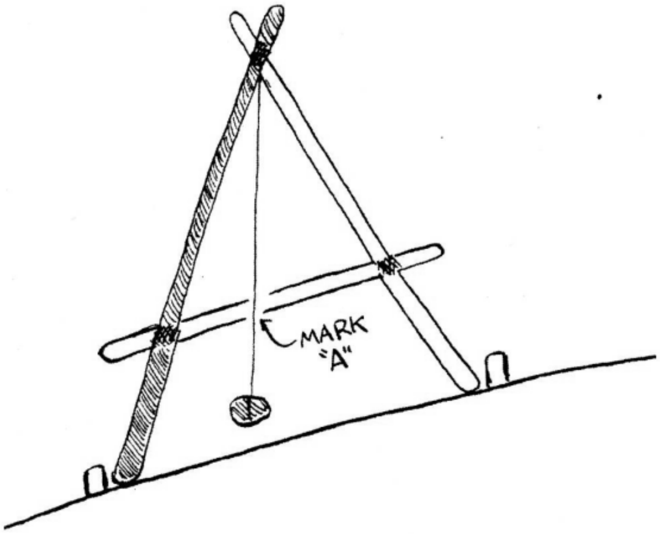


Fig. A2.10. Calibrating the A-frame, step one

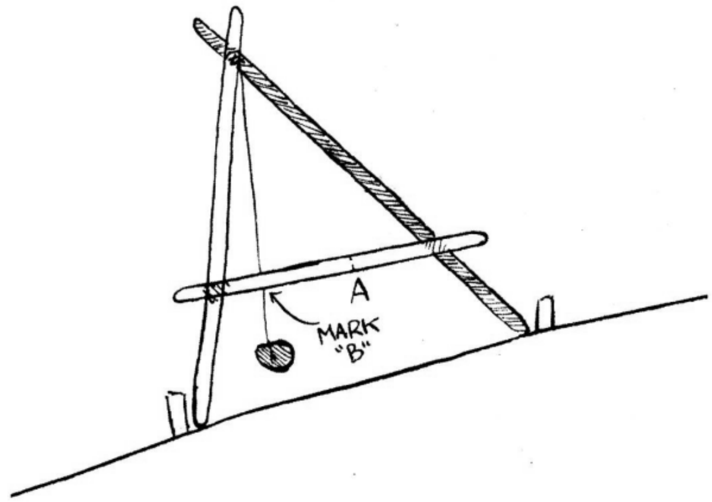


Fig. A2.11. Calibrating the A-frame, step two

that your A-frame level won't come apart and the joints don't loosen, as that would result in inaccurate readings.

Once bound, set the A-frame upright and tie one end of the string to the top of the "A." Tie the weight to the other end of the string. The heavier the weight, the less likely it will get blown around on a windy day. The weighted end of the string should hang below the cross stake (the stake parallel with the ground). To make the center mark on the cross stake, place the feet of the upright A-frame on a section of unlevel ground, so one foot of the A-frame is a little higher than the other. When the weighted string comes to rest in a spot alongside the cross stake of the A-frame, lightly mark that spot (fig. A2.10).

Now, mark the two points where the A-frame is standing on the ground. Lift the A-frame, rotate it, then set it back down with the "feet" switching places. When the weighted string again comes to rest alongside the cross stake, lightly mark that spot (fig. A2.11).

Now you have two marked spots on the cross stake. Permanently mark the midpoint between these two spots on the cross stake (fig A2.12).

From now on when the weighted string comes to rest alongside this permanent mark you will know the two feet of the A-frame are standing on two points level with one another.

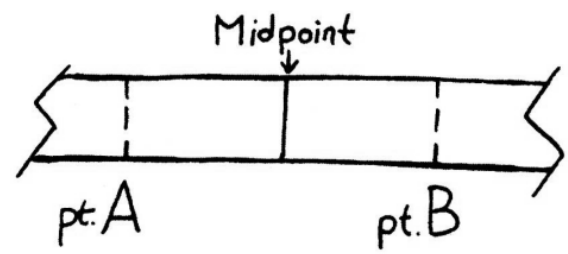


Fig. A2.12. Calibrating the A-frame, final step

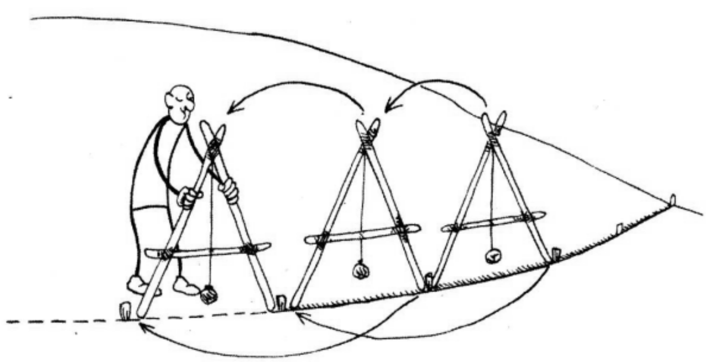


Fig. A2.13. Using an A-frame level, finding and marking a level contour line

Your A-frame will read accurately as long as it does not loosen up and change shape. You can quickly test it by going through the steps just described. If the heavy mark is still at the midpoint when you test it on level ground, then your A-frame will read correctly. If the mark is not at the midpoint, retighten the joints and make a new midpoint mark.

HOW TO USE AN A-FRAME LEVEL

Go to a spot where you want to mark a level contour line across the landscape. Place the A-frame upright with its "feet" on what you think is level ground, and see where the weighted string comes to rest along the cross bar. If the string comes to rest alongside the permanent mark, the feet of the A-frame are on a level line. Now mark a straight line in the dirt from one foot of the A-frame to the other. Rotate the A-frame 180° with one foot left standing on the end of the line you just marked and the other foot moved to a new spot you think will be level with the first (fig. A2.13). If the weighted string comes to rest to either side of the permanent mark, the A-frame is not on a level line. Move the newly placed foot slightly up or down the slope until it rests on a spot that is level with the other foot. Again, mark this straight line in the dirt. Continue finding and marking the level contour line by rotating and stepping the A-frame across the landscape. Repeat this process until you have marked the contour line length needed for your project.

AN A-FRAME VARIATION FOR WINDY SITES

On very windy days the weighted string of the A-frame will blow around. A variation used by Chris Meuli on his windblown New Mexico land was built by lashing a line-level tool to the horizontal cross stake of the A-frame instead of using a weighted string. If you construct this type of A-frame, you'll need a line level, a *straight* cross stake, and a level place to build the device. With both feet of the "A" on level ground, secure the cross brace so the line level's bubble is right in the middle of the cross brace reading "level."

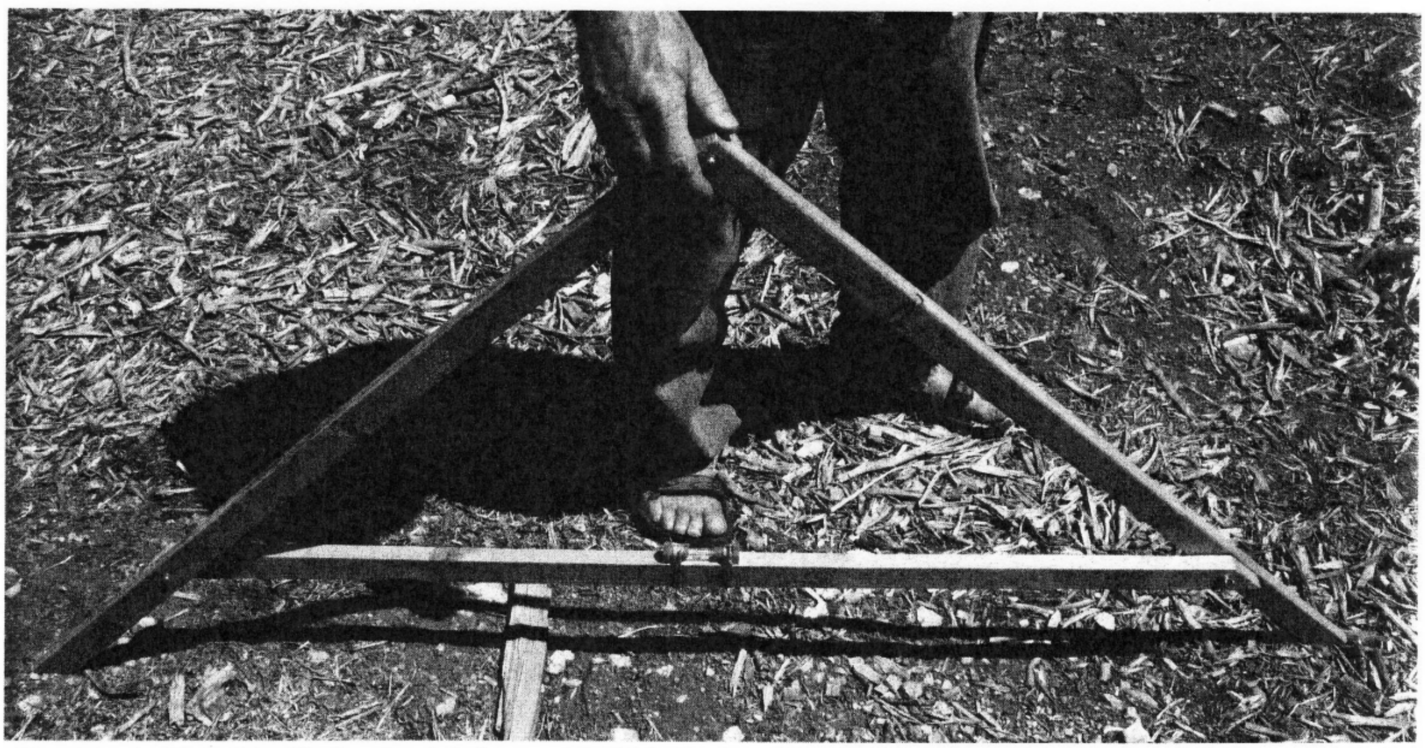
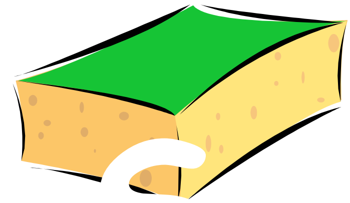


Fig. A2.14. Chris Meuli's line-level A-frame. A bubble level tool is lashed to horizontal bar below Chris' toes. Chris bolts his A-frame together with wing nuts so he can disassemble and fold it up for easy storage. His A-frame is only as tall as his waist, which allows him to use the tool under the branches of trees.



Overview:

Youth experiment to determine if a spor e's cap :ity ,old /a r is u cie' to grow plant

> ***Soil with sponge-like characteristics readily absorbs water.***

Materials:

For individuals, pairs, or small groups:

- Sponge
- Plastic or foam plate
- Small spray bottle
- Grass seed (there are many varieties to choose from—rye grows quickly)

General materials:

- Permanent markers for writing names on plates
- Water
- Plastic wrap
- Table or counter near a window or natural light location

Activity Duration:

25 minutes for the initial activity; one to two weeks to completion

Preparation:

Gather all materials.

Activity Steps:

1. Ask participants to describe what plants need to grow and what role soil plays in a plant's development. Get responses.
2. Explain that soil is a natural sponge. When rain or snow falls onto the ground, some of it soaks down between the spaces between rock, gravel, sand, and silt. Plants are able to access the moisture through their roots through a process called, "capillary action." Water is important for many seeds in their germination process.
3. This activity will enable participants to determine if seeds can germinate on an actual sponge, even without nutrients contained in soil.
4. Distribute a sponge and plate to each individual, pair, or small group. Have the participants write their names on the rim of their plates. Youth closely observe their sponges—feel their texture, try to bend them (not so hard that they break), and look at the small openings throughout them.
5. Participants put their sponges on the plates and slowly spray water several times over the top of their sponges. Have participants watch the color of the sponges get darker as the water soaks into them.
6. Participants pick up their sponges and look along the sides; they should see some parts that are wet and other parts that are still dry. They can feel the change in texture from hard to soft.

much rain is falling, the dryness and compactness of the ground, etc.

Mention that when it rains, the water soaks into the ground at different rates, depending on how much rain is falling, the dryness and compactness of the ground, etc.

7. Participants continue to spray water onto their sponges until they are completely saturated. Explain the term, "saturation" (see glossary.) Explain that the ground soaks up the water because the water seeps into spaces and cracks. Have them press down in the center of the sponge and look at the pool of water made by the depression. Explain that when the ground is saturated with water, the water reaches the surface of the ground in low areas that are known as ponds, lakes, or rivers.

8. Once their sponges are completely saturated, participants (or leaders) gently shake grass seeds over the top of their sponges. Using their index fingers, participants push the seeds gently down into the sponge so that the seeds get wet.
9. Participants "rain" on their seeds by gently spraying enough water over the top that the grass seeds turn a bit darker in color and there is a thin layer of water surrounding the sponge (just enough water to slightly cover the base of the plate; if there is too much water, the seeds can mold).

10. Place the plates on a table or countertop near a window. Check the sponges every day and add water to the plates as needed to keep the sponges wet (do not pour water over the sponges because the seeds will wash off). If the sponges dry out too quickly, participants can cover them with plastic wrap. Periodically leave the seeds uncovered so they do not mold.

Extensions:

The grass will grow without additional nutrients for several weeks. Participants can experiment to see if all the grass begins to die at the same time. Some may want to trim their grass with scissors to see if cutting has an effect on growth. They can also add soil to their sponges to determine if additional nutrients extend the life of the grass.

Source:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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Overview:
Youth create a model of a cac us th t d str te daptatic to low-water environments throu ab y t st e nv ter for c periods.

In creating attractive landscapes, rainwater harvesting can provide sufficient water between rain events if low-water use plants, like cacti, are used.

Materials:

For each participant, pair, or group:

- Small, foam plate
- 5 ½ inch by 3 inch sponge (green in color if possible)
- 6 inch long piece of ¼ inch, braided, nylon rope
- 2 sponge pieces, each approximately 1 ¼ inches wide (from 5 ½ inch by 3 inch sponges cut in fourths) (green or blue in color if possible)
- Rubber band
- Two, 7 ½ inch long pieces of 14-gauge or 16-gauge wire (copper works well)
- 12 inch, round, green balloon
- 4 to 6 round, wood toothpicks
- 1 red-topped, round, wood, cocktail toothpick
- 1 yellow-topped, round, wood, cocktail toothpick

General Materials:

- Scissors
- Bag of aquarium gravel (natural colors)
- 1 cup measuring cup (depending on the number of participants, several may be needed)
- 1 gallon jug of water (or access to faucet)
- Lighter (adult only)
- Pliers or wire cutter (adult only)

Activity Duration:

20 minutes

Preparation:

- Collect all the necessary materials.
- Cut braided, nylon rope into 6 inch long pieces for participants.
- Unbraid 3 inches of the nylon rope and following safety measures (adult only), use a lighter to seal the still braided end of each piece of rope as well as the place where the unbraided section meets the braided section.
- Cut into fourths the number of sponges needed for each participant, pair, or group to have two pieces of sponge.

- Cut enough wire into 7 ½ inch lengths for each participant, pair, or group to have two pieces. Bend each piece of wire so that it makes a "U" shape with the two sides the same length (see the photo in the "Activity Steps" section).
- Cut the end off of each balloon at the point where the balloon begins to taper inward (see photo).

Activity Steps:

1. Explain that landscaping is the largest water user on many residential properties in the southwestern United States, sometimes making up over 50% of overall use. The vast majority of water used is groundwater or reservoir water, treated to a drinking water standard, which is expensive and of unnecessarily high quality.
2. Ask youth how landscapes might be designed to use less water. Get responses. (Encourage discussion of rainwater harvesting, use of gray water, and the planting of native and drought tolerant plants.)
3. Emphasize the use of low water plants in a landscape. Explain that while there are many plant choices that include trees, shrubs, succulents, vines, and flowers, one kind of plant that is especially well adapted to low water environments is a cactus. A cactus is a succulent that has groups of spines called *areoles*. A succulent is a plant that can store water like a rainwater harvesting tank, so it can stay alive without getting any rain for a long period of time, sometimes over a year or more.
4. Explain that youth will create models of a cactus to demonstrate the many ways a cactus conserves water.
5. Distribute the materials to each participant, pair, or group.
6. As youth create their cactus models, ask them questions about the components and what they represent for a real cactus. Youth can build their models first with discussion to follow or discussion can take place throughout the activity.
7. A suggested order for putting model components together, including what they represent in a cactus.
    a. Using scissors, make a hole in the center of the 5 ½ inch by 3 inch sponge.
    b. Take the braided, nylon rope and pull it through the hole to the place where the unbraided section begins. *The unbraided rope represents roots and the braided section represents a stem for the water to move up through the cactus. Water is needed for any plant to grow.*
    c. Place the sponge on the foam plate with the "roots" splaying out in all directions under the "soil." *Cacti typically have shallow roots which enable them to capture water from small amounts of rain. Their root systems are very efficient.*
    d. Take the two sponge pieces, place them back to back on either side of the braided, nylon rope, and use the rubber band around the middle of the sponges to hold them upright. *The sponges represent the spongy material inside the cactus that stores water for dry periods. The nylon rope represents the stem, which moves water and dissolved solids up through the cactus. There, water and watery products and solutions are processed and stored. They're exactly where they're needed the most.*
    e. Place the two, 7 ½ inch long pieces of wire over the sponges at perpendicular angles, and push the ends into the sponge to secure the "cactus." *The wires represent ribs*

which support the cactus and allow the plant to expand in size during rains and to shrink during dry spells for water retention. Ribs also provide shade to parts of the cactus.

f. Cover the upright sponges completely with the balloon. *The balloon represents the cactus' skin. It is tough, waxy, outer covering that prevents water loss. Its green color enables photosynthesis to take place. The rounded shape of the cactus allows complete contact with the ground. This makes it easy for its modified leaves in the form of spines to direct any available, precious moisture (dew, fog, or rainfall) to the ground, which is so close that little is lost to evaporation. The moisture quickly gets below ground, to be taken in by the plant's roots. A cactus can store water for long periods of time.*

g. Poke four to six toothpicks through the balloon and into the sponges. *The toothpicks represent spines. The spines protect the plant from having bites taken out of it by animals, which would dry it out. The spines also provide some shade for the cactus since cacti do not have leaves.*

h. Poke the red-topped toothpick and yellow-topped toothpick into the top of the "cactus." *The toothpicks represent flowers, which will be replaced with fruit. The fruit contains seeds which will grow new cacti. The fruits provide food for animals.*

i. If desired, youth can sprinkle aquarium gravel over the top of the sponge being used as "soil." *The gravel represents topsoil, which in arid regions can be hard packed, encouraging more runoff than the ability to soak in.*

8. Review parts of a cactus and ask youth if they have any questions. (Their questions can inspire discussion and offer follow-up research opportunities.)
9. Ask youth to feel their cacti and the sponge being used as their model's base.
10. Ask participants what happens to cacti during rain events. Get responses. Ask them what might happen if water were added to their models. Get responses.
11. Youth fill the 1 cup measuring cup with water and slowly pour approximately ¼ of a cup of water over the top of their "soil" sponges. Participants can add more water slowly until the sponge is saturated and there is a small pool of water on the plate. (Note: a spray bottle can be used instead of a measuring cup to better simulate rain, but the process of saturating the sponge will take much longer.)
12. Ask participants what changes they notice in the color and texture of the sponge base and, in feeling their cacti, what changes they notice. Get responses. (In approximately five minutes, the sponges inside the balloon will be saturated.) Explain that cacti take in water through their roots and stem like their models did.
13. Ask participants the possible benefits and possible disadvantages in using cacti in a landscape.
14. Explain that there are many drought tolerant plants in addition to cacti that can be combined to create beautiful landscapes that use little or no supplemental water. Low water use landscapes are called *xeriscapes*. If additional water is needed, rainwater harvesting can be used instead of precious groundwater or water from reservoirs.

Alternate Activity:

Youth can make "dry" models using a piece of Styrofoam, painted brown, as a base.

Source:

Adapted activity courtesy of:
Tucson Cactus and Succulent Society
P. O. Box 64759
Tucson, AZ 85728-4759
www.TucsonCactus.org

Overview:

Youth explore the water saving benefits of a traditional farming method used by the Zuni Nation and still practiced today. Youth investigate how a waffle structure holds water and plant their own waffle gardens.

> ***Traditional People relied on rainfall for crop irrigation. A Zuni waffle garden is a method used to capture rainwater.***

Materials:

- Waffle ingredients (see included recipe)*
- Clear Karo syrup
- Waffle recipe card handout with Zuni waffle garden photograph (included)
- Waffle iron
- Plates and forks for all participants
- Zuni waffle garden article (included)
- Biodegradable “waffle” seed starter trays in sets of at least six (enough to have a set for all participants, pairs, or small groups)
- A variety of herbs or vegetables that grow well from seeds. If participants are going to take their starter trays home, consider herbs such as basil, chives, and thyme as they can be transplanted into larger pots. If participants are going to transplant their starts into a garden, consider vegetables that will grow in the timeframe of the project (see the “Ten Steps to a Successful Vegetable Garden” handout in the “Water Harvest” activity for ideas). Consider using low water use varieties.
- Plastic spoons for planting
- Potting soil
- Water (to water soil)
- If a variety of seeds will be planted in the each starter tray, craft sticks and waterproof markers for labeling each seed type
- Plant Logs (for one and multiple plants) (included)

*Frozen waffles or a waffle mix can be used in place of the recipe

Activity Duration:

- Activity overview and background: 15 minutes
- Making waffles: 30 – 40 minutes
- Planting seeds: 20 minutes

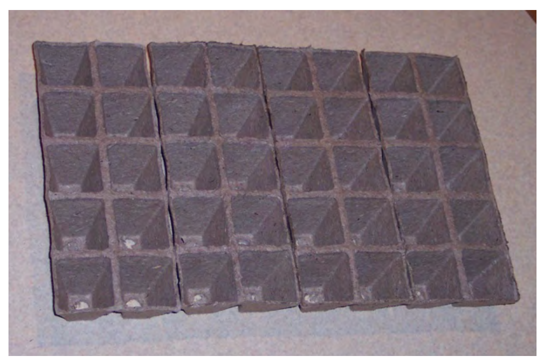
Preparation:

- Gather all materials.
- Make photocopies of the waffle recipe card for individuals, pairs, or small groups.

Activity Steps:

Part I – Making Waffles

1. Ask participants to think about waffles they have eaten and how delicious they are. Ask, "What defines a waffle?" Get responses. (The batter is similar to pancakes; the shape is definitive.) Ask participants if they have ever heard of a waffle garden. Get responses.
2. Explain that in this activity participants will make waffles and use them (as well as eating them) as a model for a type of gardening that is over one thousand years old and is still used effectively today.
3. Distribute the waffle recipe cards to participants and ask them to look at the photograph. Explain that this is a picture of a Zuni waffle garden. Explain that the Zuni People have lived in the American Southwest for thousands of years. Living in an arid region, the Zuni developed ways to farm without using very much water since they had to rely, for the most part, on rainwater for their crops. One style of growing crops that enabled them to have kitchen gardens close to their homes was waffle gardening which involved creating a grid pattern made up of two foot square, sunken beds, surrounded by ground-level berms which were several inches high.
4. Let participants know that this activity will explore the structure of waffles and a waffle garden's ability to capture and hold water.
5. Using the cooking materials and recipe cards, make waffles (following directions and safety guidelines).
6. When the waffles are on the participants' plates, ask them to slowly pour some clear Karo syrup over the waffles and watch what happens. (A little Karo syrup is enough to demonstrate the effect if consumption of corn syrup is an issue.) Ask youth where the liquid goes (it settles into the depressions). What would happen to rain if it fell on ground that was made into a waffle formation?
7. Have participants tilt their plates slightly to see what happens to the liquid (some waffle gardens were built on hillsides; the berms and swales helped to contain the water). Get responses.
8. Explain that just like the Karo syrup stayed in the depressions in the waffles, the rain in the Zuni waffle gardens remained in the depressions so that the plants (primarily corn, bean, and squash) could get the greatest benefit from rainwater.
9. Explain that waffle gardening is still used today. Using the article, "Zuni Teens Build an Edible Schoolyard," highlight the youth leadership process in wanting more nutritious food from the school cafeteria and the creative ways that the youth combined their traditional farming methods with modern techniques to improve their lives and the lives of others.
10. Explain to participants that after they finish eating, they will make their own miniature waffle gardens.



Part 2 – Planting Seeds

1. Distribute the planting materials to participants.
2. Youth plant their seeds in potting soil.
3. If a variety of seeds are planted in each starter tray, participants can write the name of each seed type on a craft stick with a waterproof marker and place it in the appropriate section.
4. Discuss the look of participants' starter trays. Ask what would happen if the waffle garden were on a slope. Participants can tilt their trays slightly. Ask how the berms could be formed to keep the most water in the depressions.
5. Participants water their seeds regularly, keeping the soil moist but not soggy.
6. Participants may wish to experiment with the quantity of water needed for their plants to

grow. They can keep a log of their watering schedule and make observations regarding the amount of water certain plants require.

7. When the plants have gotten large enough to transplant they can be moved to larger pots or planted in a garden where observation and experimentation can continue to take place.
8. Consider creating a larger waffle garden for the plants to grow in.
9. If the plants produce, celebrate the harvest.

Sources:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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http://extension.arizona.edu/cochise

Online article, “Zuni Teens Build an Edible Schoolyard,” used with permission from:
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http://www.whatkidscando.org/featurestories/2007/it_makes_me_feel/index.html

Traditional Zuni waffle garden, circa 1950

Photograph from online article, “Zuni Teens Build an Edible Schoolyard,” www.whatkidscando.org

Waffle Recipe

Ingredients:
1 cup all-purpose flour
1 cup whole wheat flour
2 tablespoons sugar
1 tablespoon baking powder
1/4 teaspoon salt
2 large eggs (or egg substitute)
2 tablespoons butter, melted
2 tablespoons canola oil
1-1/2 to 2 cups 2% milk

Directions:
Place the flour, sugar and baking powder in a medium bowl and whisk with a wire whisk to combine well. Add the eggs, butter, oil and 1-1/2 cups of the milk; beat with the whisk until smooth. Add more milk as needed to thin the batter just to a pouring consistency, being careful to keep it thick. Heat a waffle iron and bake according to manufacturer’s directions. Serve immediately.
Notes: The batter may be made the night before, covered and refrigerated. Add a little more milk before baking if it has become too thick. Waffles freeze very well. Just bake them a little lighter than usual, let them cool on a wire rack, wrap individual portions in waxed paper and place in a freezer bag. To heat, just toast the waffle in the toaster oven until lightly browned.

Modified from: http://teriskitchen.com/breads/waffles-c.html

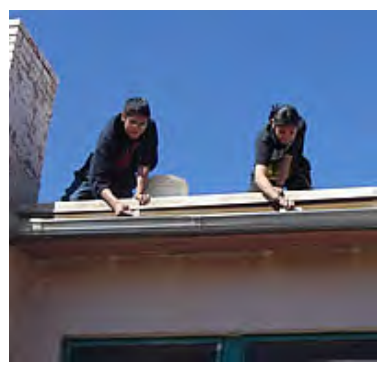
Zuni Teens Build an Edible Schoolyard

By Abe Louise Young, with students of Twin Buttes High School

Zuni waffle garden, circa 1950 **Zuni greenhouse project, 2007**

ZUNI, NM—Alexander Jamon, 17, and his science teacher were sitting around one day when Alex started talking about vegetarianism—so he and teacher Alicia Fitzpatrick hopped on the Internet together and bought a copy of *Diet for a Small Planet* for 79 cents. After reading the book, Alex felt inspired—and then incensed. Lunch at his high school offered no fresh fruits or vegetables, and no vegetarian options. All students at Twin Buttes qualify for free or reduced lunch, so everyone eats at the cafeteria. Alex checked with other students and found that almost everyone felt less than thrilled about what was on their plate at lunchtime. “Traditionally, Zuni food has a special quality,” Alex says. “There are no preservatives in it and it is all done organically”—a far cry from a frozen pizza in a Styrofoam box. Together, the students started voicing concerns about nutrition.

Rather than dwelling on the problem, however, they decided to invent a solution. That spontaneous act launched the student body into an adventure in sustainable agriculture. Five months later, they’ve won grants, demolished an abandoned building, developed their own agriculture management curriculum, designed a plan to combine traditional Zuni waffle gardening with modern greenhouse methods, built a greenhouse, and won a promise that their fresh produce may be sold in the community grocery store—the produce they don’t eat in the school cafeteria, that is.



In this small pueblo of sun-drenched earth and bright blue skies, two hours west of Albuquerque by car, the Zuni Greenhouse Project is transforming Twin Buttes High School and the lives of its students.

Outdoor learning laboratory allows research in action

At a far corner of the school, students climb a ladder to investigate the gutters that will funnel rain into a catchment system made of rusty barrels. They plan to harvest rainwater from the school roof, because a drought has plagued the area for several years. Zunis have long practiced water conservation strategies—and the ancient waffle garden pattern in use throughout the area holds moisture near the plants’ roots. The sunken garden is divided into squares that look just like a waffle, with plants where the syrup would pool.

In the center of the yard, the "Alternative to Expulsion" teacher looks on while a group of girls takes turns wielding a heavy sledgehammer, banging steel piling into the gravel foundation. "I like using the level and laying down gravel," a soft-spoken girl named Farrah says. Two tattooed boys carry the curved pipes that will form the spine of the greenhouse across the dirt, casting long, thin shadows.

"Greenhouse is important to me because we as students built it and got the money to get the Greenhouse," Justin says. "It is important to me to keep it going and maintain it so other people who go to school there can have a good house and maintain it. It's nothing I've never done before so building it and maintaining it, it's something exciting."

"I believe that a school and a community shouldn't be separate entities. They are the same. I believe it is the responsibility of the educator to explore and learn about the community, to have the critical conversations necessary to learn what resources are available there to enhance the curriculum that you are using or developing."—**Alicia Fitzpatrick, Educator**

Richelle, 17, says, "The Greenhouse is important to me because many people in the pueblo doubt Twin Buttes High School because it's an alternative school. They consider it like a drop-out school, and I think we're making a big change with the community and the school. That's important." Alex agrees: "I always hear students say that they're embarrassed to go to school at Twin Buttes. Now I think people look at it and feel proud."

The Greenhouse Project has mobilized the school with an energy of purpose that seems unique to action research. Alicia Fitzpatrick watches all the buzzing activity contentedly: This method is her pedagogical passion. "The students are totally designing their entire units. They have complete decision-making and voice. They choose their topics, determine their objectives, and decide how they're going to study and reach those objectives. I'm just allowing them the space. It's radical to see what they can do when they are allowed to," Fitzpatrick says.

In the science classroom, students—unabashedly artistic—design a logo and Website for the project. Younger students are talking about building beds to grow flowers outside of the school's front door.

The careful work of using a level and a line requires frequent measurement, and a group of students gathers around the paper plans that came with the greenhouse, deciphering its diagrams and shorthand. "It seems we work better in small groups—less than five," someone says out loud, and other people nod. Mathematics, chemistry, biology, writing, the science of nutrition, bookkeeping, and business basics….it all comes together.

Unlike most other school garden programs, which invite young people into a garden environment, at Twin Buttes the students themselves are creating the garden from the ground up. "It was really surprising when we realized that in order to have a fresh salad bar everyday, we'd need to have a growing area the size of a couple of football fields," Alex Jamon muses, smiling. "So you know, you have to do your math, and start small."

School as family: connecting school and community

Planting and growing food are not news in Zuni—to the contrary, they are the very basis of the Zuni culture. Agriculture is intertwined with art, religion, language, and all of the stories of the people. Yet since the 1940s, people on the reservation have grown their own food less and less. Slowly but noticeably, livelihoods changed, and a diabetes epidemic began. And so, this Greenhouse Project is about more than food. On a deeper level, the students at Twin Buttes are pioneering in Native America: They're moving to reclaim their native lifeways and integrate them into the public education system.

Twin Buttes students have decided to do traditional ceremonies in their garden and greenhouse. For some students, doing so will honor their ancestors—and protect both the reputation of the project and the health of their harvest, by not angering or saddening those ancestors.

Student Chris Watsa, 18, is happy that his classmates will follow the traditional steps of thanking the earth and sun, offering blessings and prayer. Chris tends a waffle garden with his girlfriend Elaine in her family's front yard. Elaine, 15, loves taking care of their garden: "Your plant is like your baby. We say to the plants, grow, grow, we want you to grow!" The intimate, caring relationship that Zunis have with plants is often described in terms of parent and child. Chris explains in detail:

"When you first put in a seed, you have to watch it because a dog or something might come along and dig it up and that's it. You have to wake up in the morning, offer cornmeal to the sun, then water the garden, and in the day as it gets bigger, there are more problems to watch for. There will be weeds around it. There will be things you don't want in your garden. That's like watching your child and you don't want none of the stuff that's going on in other kids' minds to get in it. So you take that out, and as it starts getting big, it needs water, it needs loving, so you have to make walls to protect it and let it know that it's loved. And when it gets big, you watch it grow. As you watch it, you get older, and that's like you becoming an elder. You see and you look and you see an ear of corn start coming out. You see another one. When it comes out to ripe corn, you know, that's your child. You know what I mean? You've got to take that, cherish it, value it, no matter what, no matter if it came out late or if it came out early, you always have to cherish it."

The idea of family in the school garden isn't just symbolic—several students at Twin Buttes have children already. Taking staff into account, the school has several generations of families under its roof. Health Assistant Noreen Boone's daughter Adonica and son-in-law Ross attend Twin Buttes High School and are teen parents. Boone spoke on the subject:

"My son-in-law, Ross, is participating in that Greenhouse and he's really into it. Ross was also wondering how to go about buying him a small greenhouse. Kaya, their daughter, was thin, they took her up and she was low on iron. They said, "How can we get the iron to go up?" I said with food like meats, eggs, fresh green vegetables.

So he wants to grow at home. It's helping them eat more like vegetables, too, because they never used to. So it's helping both in health and parenting."

When word about the project got out into the community, elders began saving seeds. A community member called and offered peach trees; another family offered part of their land by a lake for planting. If a harvest comes, Halona Plaza—the store at the center of the Pueblo—will dedicate a special space to selling the students' crops. The director of the A:Shiwi A:wan Heritage Museum, Jim Enote, is teaching workshops for the students, so that they understand the communal and ritual aspects of Zuni planting.

Planting faith for the future

A harvest doesn't come automatically or all at once—and in Zuni, it is taboo to talk of a harvest as if it is a sure thing. "If we are lucky enough to have a harvest," is how students preface their plans to market herbs and vegetables.

Harvest of food or not, the young people are harvesting an unforgettable educational experience. They're documenting their learning process with photography, journals, and video, and have been asked to present at three conferences over the course of the summer and next school year.

Student Garren Tsethlikai says, "If we're lucky and blessed with a harvest, how cool would it be to market Greenhouse tours to the tourists at the Arts & Crafts Center? And then on the walls of the adobe house, laminate pictures of the traditional vegetables that we're going to grow with the Zuni word and the English word?"

A worn bilingual poster on the school wall advises, *Hon yumola a:ho'ik'yanna*: Be honest and trustworthy to one another. *Hon i:yansatdena:wa:* We will help one another. *Don dehwan illaba:* It is your turn. *Hom dehwah ukna:we:* It is my turn.

It is the young people's turn in Zuni, in more ways than one.

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3-Week Plant Log

One Plant

Name ____________________________________

Plant ____________________________________

Date	Height	Observations

3-Week Plant Log

Multiple Plants

List the name of each plant. Record plant development including height and health over the course of three weeks.

Name ______________________________

Plant ______________________________

Date	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6

Overview:

Youth experiment with different w … n … ec … of … ants … and … eter … wh … plants grow best in an arid environment.

> ***Plants grow well in nitrogen-rich rainwater. Growing vegetables is an effective way to use stored rainwater.***

Materials:

For individuals, pairs, or small groups:

- At least four plastic or Styrofoam cups to use as planting pots
- Potting soil
- Plastic spoons
- 1 cup measuring cup (several can be shared between participants)
- Laundry pen for marking cups with seed type (several can be shared between participants)
- Pinto bean seeds and tepary bean seeds (a drought-tolerant, pole bean variety available through online resources)
- "Tepary: The Bean that Laughs at Drought" handout (included)
- Recommended: garden plot for continued growth
- "Ten Steps to a Successful Vegetable Garden" handout (included)

Activity Duration:

This is a longer-term activity. Introduction and initial planting will take approximately 45 minutes. Ongoing experimentation, care and observation will take several weeks. If the plants will be planted in a garden plot for harvesting, the activity will take approximately two to three months (actual time to harvest will vary with plant type).

Preparation:

- Gather all materials.
- Using an ice pick or knife, cut small holes in the bottom of all the cups being used as planting pots.
- Review "Ten Steps to a Successful Vegetable Garden" handout if new to gardening vegetables and planning to grow the plants in a garden plot.

Activity Steps:

1. The term, "harvest," means the process of gathering in a crop. The term, "water harvesting," refers to gathering up and holding a quantity of water for later use. This activity combines the two meanings of the word, "harvest." One of the ways that harvested rainwater can be used is to grow vegetables that can be harvested in the future.
2. Explain that rainwater helps plants grow because it flushes out harmful salts from the soil. However, rainwater is not always available, even when storage tanks are being used because in arid regions there can be long periods of dry weather. For this reason, people who want to grow

vegetables in areas with low rainfall can improve their chances of successful crops by planting low water use varieties.

3. This activity will give participants the chance to experiment with different water needs of two varieties of a common vegetable—beans. Ask participants if they have eaten pinto beans (the type commonly used to make refried beans and baked beans). Get responses.
4. Show participants what pinto beans look like.
5. Ask participants if they have eaten tepary beans. Get responses.
6. Show participants what tepary beans look like and how they compare with pinto beans.
7. Using the article, "Tepary: The Bean that Laughs at Drought" as a guide, share information about the low water use requirements of tepary beans versus pinto beans.
8. Explain that participants will explore different water needs of the two types of beans.
9. Distribute the planting materials and seeds.
10. Participants plant at least two pinto bean seeds and two tepary bean seeds, each in a separate, labeled cup.
11. Following the seed packet directions, participants water all the seeds in the recommended way for germination, recording the dates and amounts of water.
12. Participants design logs for recording their watering schedules and tracking their plants' progress.
13. Participants set up the same watering schedule for one pinto bean plant and one tepary bean plant and a watering schedule that uses much less water for the other pinto bean plant and tepary bean plant (choosing to vary either the amount of water or frequency of watering). If a set of plants (one of each type) begins to suffer, the participant(s) can change the watering schedule as long as the same change is made to both plants in the set.
14. Participants record and analyze the growth data and compare water needs with the type of bean plant.
15. If different participants have set up schedules that are different from each other, results between participants can be compared.
16. After a couple of weeks, participants may wish to transplant their successful plants. If there is a garden plot available, participants can plant their beans. If the plants produce beans, consider some of the recipes in the "Tepary: The Bean that Laughs at Drought" handout.
17. Ask participants what conclusions they can draw from their experiment.

Extension:

Using the "Ten Steps to a Successful Vegetable Garden" handout, participants may wish to plant different vegetables. They may want to research drought-tolerant varieties of other vegetables and experiment with them.

Sources:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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Online article, “Tepary: The Bean that Laughs at Drought,” is reprinted with permission by MOTHER EARTH NEWS, the Original Guide to Living Wisely.
www.MotherEarthNews.com
The article is found at: http://www.motherearthnews.com/print-article.aspx?id=69068

“Ten Steps to a Successful Vegetable Garden,” written by Norman F. Oebker, Vegetable Specialist, Emeritus and Robert E. Call, Horticulture Agent, The University of Arizona College of Agriculture and Life Sciences, is available online at: http://ag.arizona.edu/pubs/garden/az1435.pdf

TEPARY: THE BEAN THAT LAUGHS AT DROUGHT

By Sharman Russell

With the summer sun baking your garden soil, you might want to try cultivating . . .

Most modern gardeners have likely never heard of the tepary bean. *[EDITOR'S NOTE:* Indeed, even a search through *MOM's* seldom stumped editorial reference library couldn't provide much information on the legume.] The truth is, however, that this little-known *plant-Phaseolus acutifolius--is* among North America's oldest agricultural crops: The naturally heat-, drought-, and pest-resistant bean has been identified in strata that are at least 8,000 years old! It served as a staple food for generations of prehistoric native Americans, and-by 1701-was the principal crop raised at the mission Nuestra Senora de los Dolores in New Mexico. In fact, it was there that (according to one legend) the bean got the name by which we know it today . . . because, when the arriving Spanish asked a group of Papagos what they were planting, the Indians responded, "T pawi, " meaning simply, "It's a bean."

However, while the original residents of the Southwest have long taken advantage of the tepary's hardiness (the Papagos and Pimas, among other tribes, still raise the bean), it enjoyed little respect from the Spanish-who believed it to be a degenerate version of their own favored legume, P. vulgaris-and is all but unknown to today's commercial and backyard growers. There are a number of good reasons to *change this* policy of neglect. For one, the tepary has produced yields of up to 700 pounds per acre without irrigation . . . whereas most conventional dry beans won't even survive in arid areas without supplemental watering. (And when both crops are irrigated, the t pawi's yields can equal or exceed the national average of 1,400 pounds per acre for the more popular legumes.) With water shortages and summer rationings occurring all too often over the past few years, the tepary could prove to be an excellent choice for many southwestern gardeners . . . and perhaps for folks in other regions, as well.

TEPARY CULTURE... BOWL AND ARROYO

Phaseolus a cutifolius is traditionally a two season bean, with the first planting being made in early spring and another in midsummer. (The Pimas sowed their teparies when the mesquite bushes leafed out and again when the saguaro was harvested.) The seeds some sources are listed at the end of this article-should be planted two inches deep, eyes down, and two to three inches apart . . . with each row one and one half to two feet from its neighbor. (Folks who plant by the moon generally agree that the second lunar quarter is the prime bean sowing time.)

It's best to cultivate your tepary patch regularly, to keep down weed competition, at least until the blooms appear. Note, too, that these are pole beans, which will require some sort of support (a wire or string fence would be a good choice). And, though teparies will grow under very arid conditions, they'll generally produce *better-as noted* above-when watered. The legumes have a reputation for adaptability, however, so, to find the optimum amount for your location, you might want to vary the waterings given to different clusters of plants in your first crop and note the results.

If you're in the mood for experimentation, you could try to duplicate the early Native Americans' method of cultivation. Using a digging stick, such farmers would sow three to five seeds, three inches deep, in hills spaced six to eight feet apart. The Papagos often planted their teparies at the mouths of arroyos, waiting till after those gullies had been flooded with the early summer rains. These areas are usually moister than the open desert, and they're also rich in the nutrients and trace minerals washed down by the seasonal torrents.

Regardless of which growing method you choose, though, you should know that teparies aren't eaten green. Let them dry on the vine, and harvest the small kernels when they're orange brown. Papago women traditionally shelled the beans by beating the pods with sticks. The harvesters would then parch the kernels over live coals to destroy any insect eggs that might be present. (You can accomplish the same thing by simply placing the beans, on a shallow baking pan, in a 180° oven for 15 minutes . . . or by freezing them for at least an hour.)

BEAN CUISINE

Of course, no plant will find much favor among gardeners unless its productivity is matched-or exceeded-by its popularity at the dinner table. And the tepary performs well on both counts. Its flavor is sweet and delicate, and the legume lends itself well to almost any recipe in which more common beans are specified.

Before cooking, let your teparies soak in cold water for at least 12 hours. After that time, the beans will have swollen to about twice their dried size, and will be ready to be incorporated into your favorite dishes. (They may, however, require more cooking time than do some other bean varieties.) The following recipes have always received an enthusiastic reception around my house. I hope they'll provide you with a worthwhile "beginner's course" in tepary cuisine.

REFRIED BEANS

Boil some soaked beans-the amount will depend upon the number of servings desired until they're quite soft, then mash them into a paste. Flavor the dish, to taste, with your favorite seasonings . . . minced garlic, diced chilies, sautéed onions, cilantro (fresh green coriander, also known as Chinese parsley), cumin, oregano, and salt are commonly used. Finally, fry the teparies in vegetable oil or lard until they're very hot and have lost most of their moisture … then serve them, as a complete meal, with tortillas, cheese, and hot sauce. A serving of refried beans can also be used as a side dish to accompany other main course Mexican recipes.

TEPARY SOUP

1 large onion 2 cloves of garlic 1/2 pound of salt pork crushed red pepper (to taste) 3 quarts of water 6 cups of dried beans, soaked overnight and drained 1 cup of chopped celery 1 cup of grated carrots salt and pepper

First, chop the onion and mince or press the garlic cloves .... then combine them with the salt pork, a judicious amount of red pepper, and the 3 quarts of water. Bring the mix to a boil and let it simmer for an hour (or until the meat is tender). Now, remove the pork, dice it, and return it to the stock, along with the soaked teparies. After another 2 to 3 hours of gentle boiling, the beans should be tender. At that point you can toss in your celery and carrots, and when the soup has cooked slowly for 30 minutes more-add salt and pepper to taste . . . and serve the hearty meal. The recipe should feed a dozen people!

ZUNI STEW

This meal is simplicity itself. To prepare it, just add cubes of wild or domestic meat to a pot of soaked teparies (still in their water), and boil the stew until the meat *and* beans are tender. We like to season the dish with coriander, salt, and chili powder . . . and occasionally add corn kernels or diced squash early in the cooking process-to create a *thicker* stew.

IT'S A LONG WAY TO TEPARY. . .

I know of only two sources of tepary (also referred to as *tepari)* seeds. They can be ordered--for 80d per packet (about 200 seeds), plus $1.00 shipping and handling-from Plants of the Southwest, Dept. TMEN, 1570 Pacheco Street, Santa Fe, New Mexico 87501 . . . or, at 802 (postpaid) for a similar sized packet, from Redwood City Seed Company, Dept. TMEN, P.O. Box 361, Redwood City, California 94046.

TRIAL AND ARID?

Summer's heat is coming into full swing, and thirsty gardens are demanding more and more water. But with shortages occurring throughout the country-and perhaps rationing measures being taken in your own community-chances are you're beginning to feel just a bit guilty about the amount of the precious liquid your plot requires. Now would be a good time to put in your own experimental tepary patch ... and watch those beans grow *high,* even when the soil *is dry.*

ARIZONA COOPERATIVE
EXTENSION

THE UNIVERSITY OF ARIZONA.
College of Agriculture and Life Sciences

College of Agriculture and Life Sciences

AZ1435

11/08

Ten Steps to a Successful Vegetable Garden

Gardening with vegetables can be fun and provide delicious and highly nutritious fresh food. Watching and working with plants can add a new dimension of enjoyment to life and bring an awareness of the wonderful world of nature in the backyard. The marvels of nature will have special personal meaning when nurturing a small seed into a colorful productive plant with your own hands. These accomplishments can be obtained regardless of the size of garden. A few plants or a large plot will give rewarding experiences for both young and old.The path to a successful vegetable garden is not difficult or long. Ten carefully taken steps will produce many enjoyable moments and an abundant harvest of fresh vegetables during much of the year.

Select a good location

Step 1

Choose an area with plenty of morning sunlight and some afternoon shade. Most vegetables, especially fruiting types, do best with six to eight hours of full sun exposure. Leafy and root vegetables will tolerate partial shade. Don't plant gardens under or near trees or large shrubs—their roots will rob fertility and water from vegetables. Don't plant vegetables in the narrow shaded space between houses and walls.

A loose, fertile, level, well-drained soil is best. If possible, avoid heavy clays and very sandy soils. If caliche is present it must be dug out and removed. Avoid areas that are crusted with alkali salts or infested with Bermudagrass, nutgrass or Johnson grass.

A synthetic soil, self prepared or purchased, can be used in raised beds or containters (pots, tubs, boxes) if good soil is not available. Where the space is limited, container gardening can be practiced. A convenient water supply for irrigating is necessary.

Plan your garden layout

Step 2

Planning ahead will help avoid problems and make your garden a complement to your landscape. First, sketch a plan of the intended planting area for vegetables. Write down the size of the area or location of containers. This is the beginning of a gardening notebook or journal.

- Decide on the vegetable species wanted. Select those that your household likes, that are adapted to your climate and practical for the location. If space is a problem, plant those that utilize space efficiently like bush varieties or bush beans, beets, broccoli, cabbage, carrots, leaf lettuce, onions, radishes, Swiss chard, tomatoes, and turnips.
- Mark on the plan where the vegetables will be planted, making sure to leave room for growing space between plants. Also, list the planting date for each vegetable. Arrange plantings according to harvest periods and growth characteristics. Plant vegetables adjacent to each other which will be harvested about the same time. Avoid having taller plants shade younger and smaller vegetables. Use vertical space by trellising climbing crops.

Grow recommended varieties

Step 3

Gardening success can be greatly influenced by the varieties you use. Select from recommended lists and from those know to do well locally. It is a good idea to try one or two new varieties each year. Plant them next to old favorites for comparison. Keep a notebook or journal from year to year to note what varieties perform best. For mini-gardens, try bush or dwarf varieties and the more colorful ones. Seed catalogues will be a big help in finding these. Look for All-American Selection Award winners. (www.all-americaselections.org/)

Step 4

Obtain good seed, plants, equipment and supplies

Before planting, find a reputable source for seed and other garden supplies. Seed catalogs can be a big help, but be sure the varieties are locally adapted. Buy new seed since some seeds over a year old will not germinate (sprout) well. Some seeds can be saved and are best placed in jars or in plastic bags and stored in a freezer.

Vegetable transplants can be purchased at garden stores, nurseries and greenhouses. Insist on recommended varieties. Select plants that are healthy, stocky, medium-sized, with vigorous roots and that are pest free. Avoid plants that are wilted, yellow, spindly, too large or have spots on the leaves, brown lesions on the stems or knots/galls on the roots. Obtain plants in containers (pots, 6 or 8 packs, bands or boxes) when possible so that the root systems are intact. Transplants should not be disturbed any more than necessary and should be "hardened-off." Transplants can be started at home if desired.

Have all equipment and tools clean and in good condition before working the soil. A hoe, spade, garden rake, trowel, measuring stick and planting line are essential. A hand cultivator and seed drill reduce work in larger gardens. Hoses and sprinklers convenient for watering are also needed. Other needed supplies are fertilizers and mulching materials.

Study pest control recommendations to determine what may be needed after positively identifying the pest. It is important to have a quick source of materials for pest control if needed. A good sprayer or duster to control garden pests should be available for use. Care should be taken in handling, applying and storing all chemicals. **Always follow the pesticide label instructions; it is a legal document!**

Step 5

Prepare and care for the soil properly

Soil provides nutrients and water for plants. If these materials are limited or if the soil is compact or hard and crusty when dry, and water-soaked and sticky when wet, plants will not grow and develop properly. To maintain and improve soil conditions, mix organic matter and fertilizers into the soil before planting, and prepare and cultivate the soil when dry or slightly moist (never when wet).

Organic matter makes the soil loose (friable) and easy to work. It improves nutrient and water-holding capacity, drainage and aeration. Well rotted manure, compost, and leaf mulch are commonly used organic materials. Composted manure is easy to use and is relatively free of weed seeds. Apply a layer of organic matter 2 to 3 inches thick on the garden area about 1 to 2 months before planting. Work it into the top 10-12 inches of soil. A thorough watering of soil at this time helps leach harmful salts from the root zone. If poultry manures are used, apply them at half rate.

A fertilizer should be added containing both nitrogen and phosphorus and be applied before planting. These nutrients will benefit most garden crops. Although soils vary in fertility, a typical fertilizer application would be 1 to 2 lbs. (1 to 2 cups) of 16-20-0 (ammonium phosphate) per 100 $ft.^2$ spread evenly over the soil. Also, 3 to 5 lb. of soil sulfur/100 $ft.^2$ may be added if water drainage is poor. All these materials should be plowed, roto-tilled or spaded into the top 10 to 12 inches of soil shortly before planting.

In preparing the seedbed, do not work the soil when it is too wet. Wait for it to dry sufficiently so it crumbles in your hands. Level the area by raking. Then make raised beds if using furrow irrigation (*See Figure A*). Top dress planted area with a three inch layer of organic mulch after seedlings emerge or after transplanting (*See Step 8*).

When growing vegetables in close quarters or where good soil is not available, an artificial soil can be used. If the soil doesn't drain well consider using raised beds filled with ½ garden soil and ½ artificial soil mix, coarse sand, perlite or vermiculite. (*see Figure B*).

During the growing season fertilizers may be needed. Applying bands of fertilizer, usually only nitrogen, is called "side-dressing." Apply ½ lb./100 feet of row of 21-0-0 or equivalent fertilizer, three inches deep and about four inches to the side of the plants. Alternatively, spread nitrogen fertilizer on the soil surface about 4 inches from the plant and water it in. However, too much fertilizer too close to the plant may injure plant roots. Examples of side-dressing timing are: tomatoes—after the first clusters of tomatoes form; sweet corn—when plants are "knee high" and again when they tassel; cucumbers, melons and squash when they begin to produce runners.

Step 6

Plant your vegetables properly

Most vegetables are started from seed or transplants. Seed can be sown directly into the garden soil, while transplants are started elsewhere and later planted into the garden. Harvest can be obtained sooner with transplants; however, it is more expensive and certain plants do not transplant well. Generally, beans, beets, carrots, cucumbers, lettuce, muskmelons, onions, peas, pumpkin, radish, spinach, squash, sweet corn and watermelon are started in

Step 6

the garden from seed. Vegetables like asparagus, broccoli, cabbage, cauliflower, eggplant, peppers, sweet potatoes and tomatoes are generally transplanted, but care needs to be taken to minimize root drying and injury.

A few simple rules need to be followed in seeding:

- Mark out straight rows to make the garden attractive and to make cultivation, insect control and harvesting easier. To mark a row, drive two stakes into the ground at each end of the garden and draw a string tightly between them. Shallow furrows, suitable for small seed, can be made by drawing a hoe handle along the line indicated by the string. For deeper furrows, use the corner of the hoe blade. Use correct spacing between rows.
- Space seeds properly in the row. The number of seeds to sow per foot or hill (more than one seed/hole) is suggested on seed packages or in reference materials. Space the seeds uniformly. Sometimes small seeds can be handled better if they are mixed with dry, pulverized soil or sand and then spread. To aid in spacing seed, spread on one layer of toilet paper placed on the soil. The contrast of the white toilet paper will aid in seeing seed spacing.
- Plant at the proper depth. A general rule to follow is to place the seed at a depth about four times the diameter of the seed. Cover small seeds such as carrots and lettuce with no more than ¼ to ½ inch of soil. Place large seeds such as corn, beans and peas 1 to 2 inches deep. In sandy soils plant seed somewhat deeper.
- Cover seeds and firm the soil over them by gently tamping the soil by hand or the flat back of a hoe. This prevents rain or sprinkler water from washing away the seeds.
- Irrigate by sprinkling the soil surface lightly. When using furrow irrigation, hold water until moisture moves across seed row. Seeds need moisture to germinate. Water often enough to prevent crusting and drying around the seed. After plants emerge, water less often but deeper.
- Thin plants to the desired number as soon as possible. Remove weaker plants. Scissors can aid in thinning by cutting out young plants. Do not wait too long before thinning or injury will result from crowding and disturbing the remaining plants.

When transplanting follow these directions:

- Transplant on a cloudy day or in the evening.
- Handle plants with care. About an hour before transplanting thoroughly water plants and soil in the containers (pots, bands, flats). Carefully remove plants from their containers, disturbing the roots as little as possible. Try to keep the "soil ball" around the roots. Keep roots moist at all times when they are out of the soil. If roots are "pot bound" tease them out before planting.
- Dig a hole large enough so that the transplanted plant sits slightly deeper than it grew in the container.
- Use a starter solution to get plants off to a faster start. Starter fertilizer is a soluble fertilizer high in phosphorous like 10-52-17 or 10-50-10 mixture. Mix fertilizer with water following the label directions (about 2 tablespoons per gallon of water). After plants are set in the soil, pour about 1 cup of solution around the roots of each plant. When peat or fiber pots are set in the soil add enough water to soften pot. Also, break off any excessive pot material so it is below the garden soil level to prevent water wicking. Remove any plastic or wooden bands from around roots.
- Cover the roots with soil and firm the soil around the plant.
- Protect plants for a few days from sun, wind or cold if necessary.

Irrigate with care

Step 7

Irrigation is necessary for all garden crops in Arizona because of limited and uncertain rainfall. Water enough to keep the soil moist (not wet) in the root zone of the plant throughout the growing season. Excessive fluctuations of soil moisture adversely affect plant growth and quality. Regular applications of water need to be made to prevent the soil from becoming too dry (*see Figure C*).

Proper watering can be accomplished by observing the plant and soil. Do not allow the plant to become stressed, wilted or slow-growing. On the other hand, too much water, especially on heavy soils, will exclude air from the root zone, resulting in poor growth. When the soil becomes crumbly upon squeezing, it's time to irrigate. Moisture is needed around the seed for sprouting. Frequent watering will be needed to keep the soil adequately moist and prevent crusting of the surface. A three inch layer of organic mulch will help prevent evaporation. Do not place mulch on top of seedlings or transplants, but around them.

As the plant grows, the watering period should be longer, allowing deeper penetration through the root zone. Determine the moisture depth with a spade or by probing with a stick, trowel or iron rod. Most vegetables are shallow-rooted and use water from the upper 12 to 24 inches of soil.

Frequency of watering depends on many things. A large plant needs more water than a small plant. A shallow-rooted vegetable (cabbage, onion, lettuce, corn)

Step 7

needs to be irrigated more often than a deep-rooted vegetable (asparagus, tomato, watermelon). Coarse textured soils (sandy loams) need to be irrigated more often than fine-textured (clay or silt loams). Plants need to be watered more often during hot periods than cool periods. In an average situation during warm weather, a good soaking of the soil every 5 to 7 days should give satisfactory results with established plants.

The following irrigation methods are commonly used: furrow, sprinkler, soaker hoses and drip (trickle). The furrow method delivers water alongside the plant row. Water should be kept in the furrow long enough for moisture to completely infiltrate the soil of the root zone. Garden sprinklers apply water on both plants and soil and should not be used if the water is salty. Drip or trickle emitter systems and soaker hoses apply water through a hose which lies beside the crop row. All four methods have a place in Arizona gardens. Traditionally, a raised bed with two rows is used with furrow irrigation, while a flat bed with no furrows is normally used with the other methods. If a watering method moistens the plant foliage, irrigate in the morning so plants have time to dry during the day. This will lessen disease problems. Night time watering encourages disease growth.

Plants growing in containers should be watched more closely for water needs because the roots are more crowded and temperatures of root media are more extreme. Keep soil moist but do not over-water. Make holes on the side and/or the bottom of the container for drainage and air.

Mulch & cultivate to control weeds

Step 8

Weeds compete with vegetables for water, nutrients and light. Weeds often harbor insects and diseases. Two important ways to keep down the weeds in and around your garden are mulching and cultivation. If proper attention is given to this problem early much time and effort can be saved. Small weeds are easier to control than large ones. When weeds get started they can cause many headaches and backaches, and retard plant growth.

Mulching is covering the soil around your vegetables with a protective material. Besides controlling weeds, the mulch will conserve moisture, regulate the soil temperature and keep the vegetables cleaner. With mulch very little cultivation is needed. Mulch materials include leaves, straw, sawdust, wood chips, cardboard, newspaper, shredded paper, old carpet, and paper and plastic sheeting. On established plantings, materials are spread around the plants. With paper or plastic sheeting the material is rolled out on the prepared seedbed and anchored on the edges with soil. Seeds and transplants are planted through holes at the desired spacings. Water can be applied from the side through furrow irrigation or by a trickle/drip tube or soaker hose under the mulch.

Cultivate with a sharp hoe or cultivator just as the weeds begin to sprout. Scrape and loosen the total soil surface around the plants without going too deep, which would cut or damage shallow roots of the vegetable plants. Cultivation will also help aerate the soil and can be used to mix a side-dressing of nitrogen fertilizer into the soil.

Chemical herbicides for weed control are not generally recommended for use in home gardens.

Be prepared for pests and problems

Step 9

Problems of the garden can be minimized by being prepared for them. Learn about the insects and diseases that commonly occur in the area and learn control methods. Whenever possible select disease resistant varieties. Soil problems can be reduced if the steps mentioned earlier are followed; however, crop injury from salt can appear if proper management has not been followed. High temperature and shallow watering often cause problems especially when plantings are made too late in the spring or too early in the fall. Also, as temperatures increase more pest problems will occur; be prepared for them. Learn as much as possible from books, bulletins and professionals. Experience is the best teacher on how to handle these problems. Recording treatments in a gardening notebook will be helpful in the future when they occur again.

Harvest at peak quality

Step 10

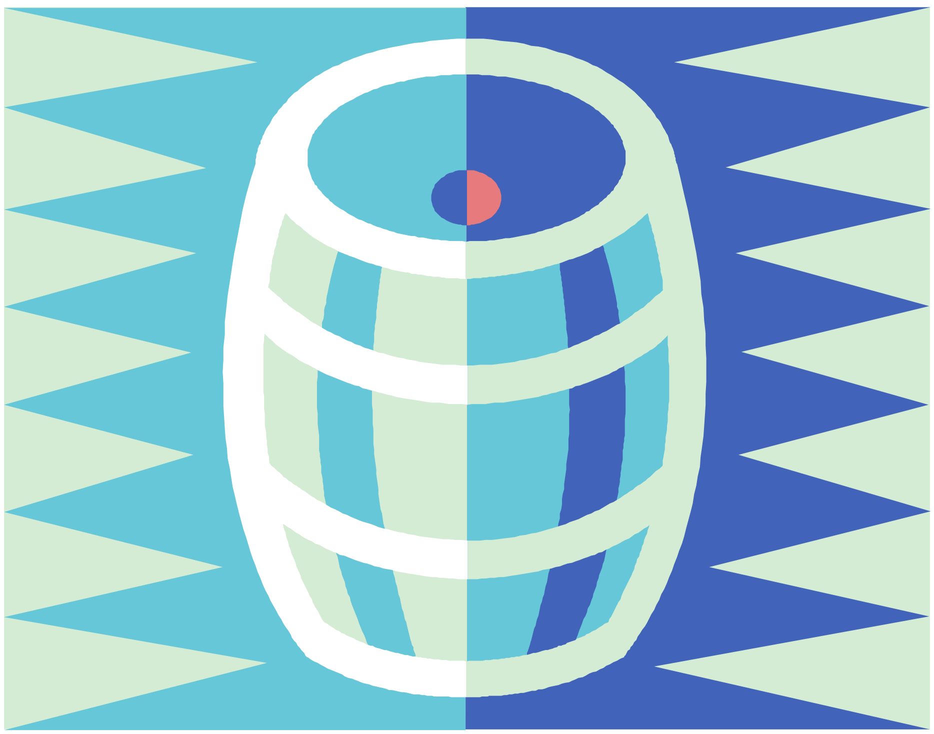
The job is not done until top quality vegetables are harvested from the garden. When the "fruits" of your labor are tasted, then it will be worth all the effort.

Most vegetables are at peak quality for only a short period of time and should be harvested. Learn to tell the proper time to harvest each crop. Immature vegetables will not improve after harvest and over-mature vegetables will be tough and lack the desired taste and texture.

To maintain quality after harvest, handle vegetables carefully. Cool and store vegetables like asparagus, broccoli, leafy crops, peas and sweet corn below 40° F.; tomatoes, peppers, cucumbers and eggplant around 55° F. Remove "field heat" as soon as possible by placing them in the shade or a refridgerator, unless they are eaten immediately.

Garden vegetables offer you a variety of experiences and flavors throughout the year. Enjoy them both.

Active Rainwater Harvesting



Lessons include: collecting and storing water in containers

Interactive, online activities on active rainwater harvesting:

- Rainwater Harvesting Simulation
  http://www.tucsonstormwater.com/ (Click on "water harvesting")
- Online Water Harvesting Capacity Calculator:
  http://www.grow.arizona.edu/Grow--GrowResources.php?ResourceId=174#

Overview:

Youth form teams to move water from one point to another as a way to understand the energy and time required to physically transport water by hand. Participants gain an appreciation of the ease of water access through modern technology and the need to conserve water.

Rainwater harvesting offers people who must otherwise haul water from a distance, more flexibility with their time and new opportunities to improve their lives.

Materials:

- Four 1-gallon buckets (plastic or metal)
- Four 1-gallon plastic jugs with lids removed
- 2 large plastic or metal funnels
- 2 plastic pylons, baseball bases, or other objects for use as turnaround indicators
- Watch or stopwatch
- Photos of people hauling water (included)
- Outside area with a race length of 100 feet (race distance may be shortened, based on participant age and ability)

Activity Duration:

30 minutes

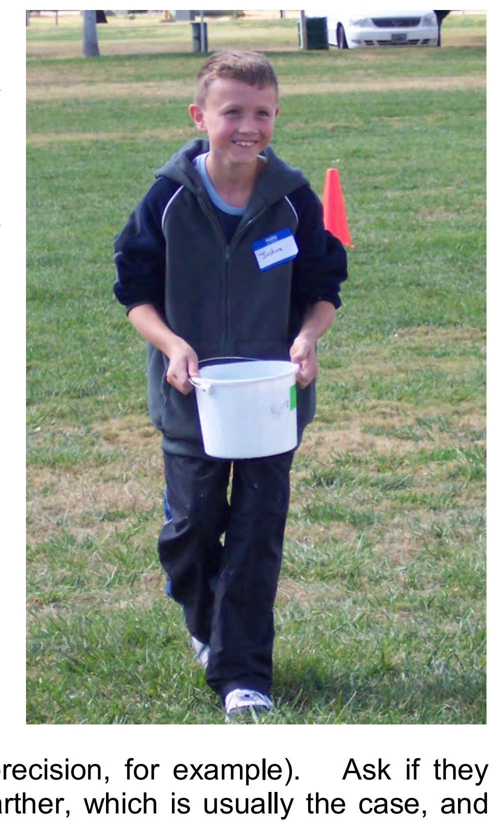
Preparation:

- Select an outdoor site for the water hauling portion of the activity.
- Measure the distance and place the objects being used as the starting and turnaround points for a race length.
- Fill the four 1-gallon jugs with water.
- Prepare activity materials.
- Make photocopies or bookmark the water hauling photographs.

Activity Steps:

1. Ask participants the following questions and get their responses:
   - How do you get the water you need for drinking and other uses?
   - Is it hard for you to get enough of the water you need?
   - Have you ever been without water or known anyone who did not have water available for a period of time?
   - Have you ever had to carry water from a distance or know anyone who has done so?

2. Explain that participants are going to do an activity that will help them appreciate the water that easily flows from their faucets and realize that many people around the world still have to haul water to provide for their basic needs.
3. Show participants a photo of a woman carrying water as pioneers did in the past. Explain that as settlers moved west, they often had to carry water for their houses from rivers or lakes. Participants may not know that many people around the world today still haul water. There are approximately 2.6 billion people globally who lack safe water to drink. Just one flush of a toilet in the United States uses more water than most Africans have to perform an entire day's washing, cleaning, cooking, and drinking.
4. Explain that hauling water, sometimes daily from great distances, is a chore that is most often done by women and children. When children have to spend a large part of their day carrying water for their families, they do not have time for school or play activities.
5. Show participants the photos of children carrying water. Ask them about the different ages of the children and ask them to note all the different kinds and sizes of containers being used. Ask them to think about the ways their lives would be different if they had to spend several hours each day carrying water from place to place. Get responses.
6. Explain that they are going to participate in a water hauling activity that has to do with both speed and precision.
7. Show youth a bucket and a plastic milk jug. Explain that each container can hold one gallon of water. Ask how much one gallon of water weighs and get responses. (Answer: 8.34 pounds). Ask participants which container they would rather carry and why. Get responses.
8. Explain that participants are going to take turns carrying over 16 pounds of water from place to place in different containers.
9. Go to the outdoor site and divide participants into two teams. Show them the starting line and the turnaround point. Divide the group into two teams.
10. Explain that a member of each team will carry two jugs full of water to the turnaround point and back as quickly as possible. When the first participant on each team returns to the starting point, he or she will pour the water from the jug into a bucket. The next participant on each team will carry the water using the bucket out and back. When that individual returns, he or she will use a funnel (and probably the help of other team members) to pour the water from the bucket into the gallon container. Participants will continue hauling the water in alternating containers until all have participated.



11. Using a watch or stopwatch, time the water hauling activity and ask participants to keep track of the number of gallons that have been transported (imagining that each person is hauling additional water).
12. After the activity, pour all the remaining water into the milk jugs and have the two teams compare the amounts of water to determine the "winning" team (the team that has the most water conserved).
13. Ask participants the differences they found in carrying the water in open buckets versus the milk jugs with smaller openings (they had to balance speed with precision, for example). Ask if they would feel tired if they had to carry the water a lot farther, which is usually the case, and return several times for more. Explain the time the activity took and ask how giving that amount of time daily to hauling water would affect their lifestyles.

14. Ask the participants how many gallons were hauled. Using the "Average Daily Water Uses" table, share the amounts of water typically used for daily activities and ask participants to think about the number of trips for water that would be required for those activities.

Average Daily Water Uses	
Flushing toilets	1.6 gallons per flush
Taking a shower	2.5 gallons per minute
Taking a bath	20 gallons
Washing dishes (dishwasher)	5 gallons per load
Doing laundry	27 gallons per wash
Washing hands	½ gallon
Brushing teeth	½ gallon

Data from *Handbook of Water Use and Conservation*, by Amy Vickers, 2001

15. Ask participants if they can think of ways that people who have to carry water might not have to carry water from such long distances. Get responses.
16. Facilitate a discussion about rainwater harvesting and ways that having tanks to store water closer to people's homes could be beneficial (less time during the day spent carrying water so more time for school or work activities that could help a family's income, potentially cleaner water, ability to measure amounts and make plans for use based on rainfall expectations, etc.)
17. Explain that information compiled in 2006 by the United Nations Environment Programme (UNEP) stated that "rainwater has the potential to solve most of Africa's water shortages." A pilot program for rainwater harvesting in Kenya has "helped women and children a lot….women used to walk up to 10 km every day in search of water, leaving their school-going children unattended….women now [have] more time to engage in other economic activities."

Sources:

Adapted by Alison Barrett, Former Instructional Specialist, Sr.
The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
Willcox, AZ 85643-2790
(520) 384-3594
http://extension.arizona.edu/cochise

Article on rainwater harvesting benefits in Africa:
http://www.alertnet.org/thenews/newsdesk/IRIN/1410f656176e7d9e33a2971057baa6fb.htm
Information accessed 07/25/09

Average Daily Water Uses Chart:
Vickers, Amy. 2001. *Handbook of water use and conservation*. Amherst, MA: WaterPlow Press.

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Girls in Ethiopia courtesy of:
Magnus Franklin and can be found at: http: http://www.flickr.com/photos/adjourned/3069327644/

Boys in India courtesy of:
MRFINK and can be found at: http://www.flickr.com/photos/mrfink/3271952766/

Children in Sierra Leone courtesy of:
Adam Cohn and can be found at: http://www.flickr.com/photos/adamcohn/3306247074/

Pioneer women and children spent a lot of their time carrying water.

Photograph courtesy of Cyndi Wilkins

Girls carrying water in Ethiopia

Photograph courtesy of Magnus Franklin at http://www.flickr.com/photos/adjourned/3069327644/

Boys carrying water in India

Photograph courtesy of MRFINK and can be found at: http://www.flickr.com/photos/mrfink/3271952766/

Children carrying water in Sierra Leone

Photograph courtesy of Adam Cohn and can be found at: http://www.flickr.com/photos/adamcohn/3306247074/

Overview:

Youth create a model to demonstrate a simple active rainwater harvesting system and highlight key components.

The practice of capturing and storing rainwater in containers has been used around the world throughout history.

Materials:

- Rainwater harvesting tank photograph (included)
- Copy of house template (included)
- Cellophane tape or glue stick
- Packing tape
- Scissors
- Hole punch
- Spray bottle
- Permanent markers in various colors, crayons, or colored pencils for decorating the houses
- Card stock sheets (enough for each participant)
- Flexible straw for each participant
- Small plastic container for each participant to use as a rain barrel. Soy sauce containers work well (check with a local Asian market for purchase or donation) as do emptied and rinsed mini bubble containers available at party stores.

Activity Duration:

45 minutes to one hour

Preparation:

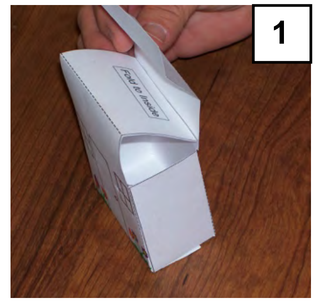
- Gather all necessary materials. This activity can be done individually, in pairs, or in small groups.
- Photocopy the house template onto card stock for the number of participants, pairs, or groups.
- Photocopy or bookmark the rainwater harvesting tank photograph.

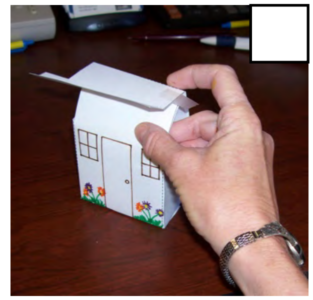
Activity Steps:

Part I – Building the Model

1. Show youth the photograph of a rainwater harvesting tank and explain that rain that falls onto a hard surface, such as a roof or parking lot, can be directed into tanks and stored for later use. Participants will make models of an active rainwater harvesting system and learn vocabulary of different system components.
2. Distribute the materials to participants.
3. Youth cut out the house template and fold it along the dotted lines. If they do not want the fold lines to show, they can fold their houses so that the printed lines are to the inside.

4. If students wish to decorate their houses, they can decorate the section that has “Fold to Inside” on it. If students use markers for their decorating, permanent markers will not run when their models get wet. It is easier to decorate the houses before they have been folded.
5. Participants fold their houses on the lines and secure their base and sides with tape or glue stick.
6. Youth fold the roof that says “Fold to Inside” to the opposite, inside of the box so that the peak of the roof is at the top of the house (see photo #1).
7. They then fold the roof section that has no wording over the top of other roof and secure the open sides with tape (see photo #2).
8. Using packing tape, participants cut strips and cover the underside of the roof and the entire top of the roof (so the roof will not get soggy when water is sprayed on it).
9. Participants make a “gutter” by folding the edge of the roof line up at an angle along the dotted line (it may be resistant due to its tape covering) and tape the upward end to the side of the roof to form the end of the gutter.
10. Youth take the container being used for the rain barrel and if it has a thin plastic top, they punch a hole in it, using a standard hole punch. They then place the lid on the container. A container without a lid will work as well.
11. Participants cut the top of a straw (the end that is closest to the flexible portion) so that the top section is approximately 1½” long.
12. Youth snip a ½” horizontal slice along the 1 ½” end of the straw (this piece will slide onto the open end of the gutter).
13. Participants cut the other end of the straw to a length that when the straw is flexed, it extends into the “rain barrel” container, just above the base. If a container with a lid is being used, participants can place the lid on the container first and insert the straw to determine the best length. There should be a decline in angle of the gutter so that water will flow into the container.
14. Encourage students to experiment with different design models.
15. The finished model will resemble photo #3.

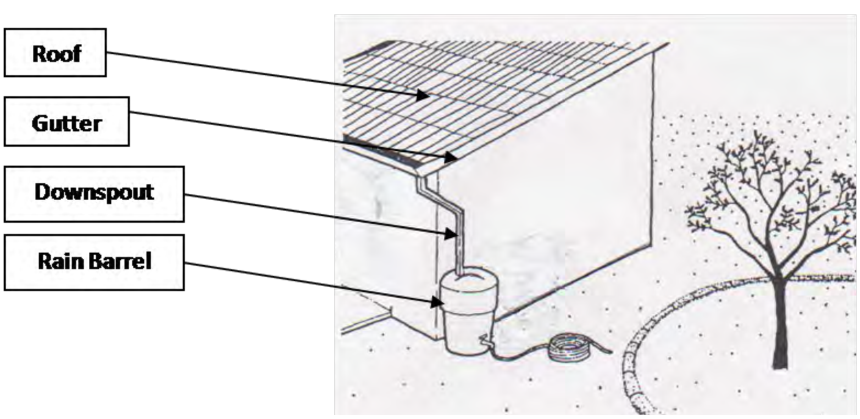




Note: The “Catch the Rain!” activity can also be done using ½ pint milk cartons with folded card stock or folded index cards for the roof instead of using the house template.

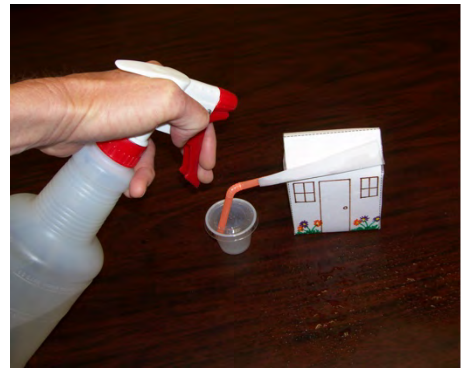
Part II – Demonstrating the Model

1. Participants place their models in a location where the surrounding area can get wet.
2. Ask youth to identify the parts of their systems (see diagram below).



Drawing from *Harvesting Rainwater for Landscape Use*, by Patricia H. Waterfall

3. Using a spray bottle, participants spray water in a mist (like rain) over their roofs and watch what happens to the water. Ask where the water goes.
4. If the water runs into the container, the design has been successful. If the water does not go into the container, encourage participants to spray additional water to determine the reason(s), make adjustments to their designs, and try again.



Extension:

Place the "house" on a sponge or paper towel to demonstrate that rainwater can be captured in both tanks and the landscape.

Source:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
The University of Arizona Cooperative Extension, Cochise County
450 S. Haskell Avenue
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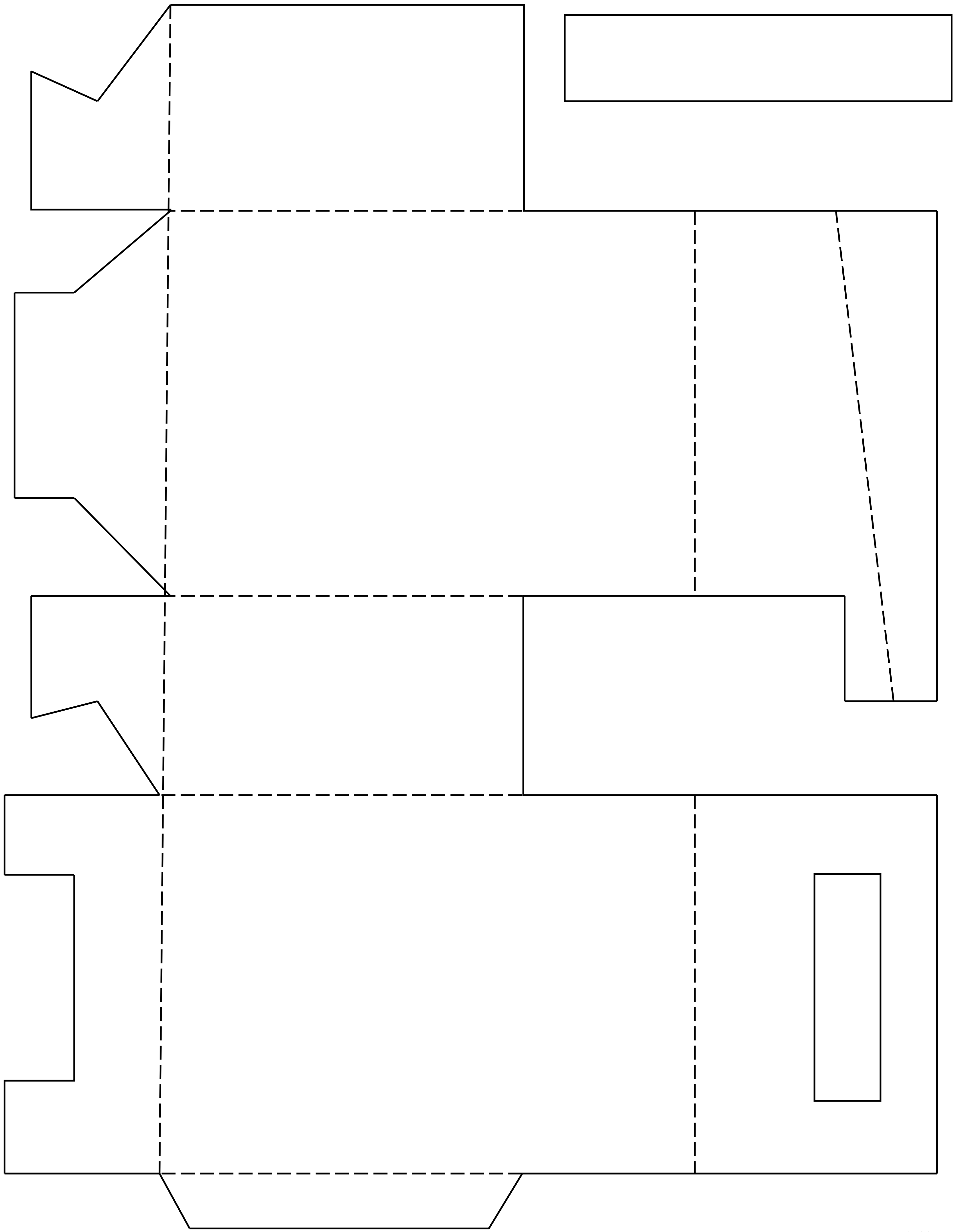

Rainwater Harvesting Tank

Overview:

Youth use games and either a cistern model r actual ster. ider y c oner s, vocabulary, and processes for active rainwate vest g ns.

> ***Active rainwater collection systems can be comprised of a few simple and inexpensive components.***

Materials:

- 2 rainwater harvesting component photograph card sheets (included)
- 2 rainwater harvesting component description sheets (included)
- Photograph of a rainwater harvesting tank (included)
- Diagram of an active rainwater harvesting system (included)
- Card stock paper (2 sheets will make one set of flash cards; 4 sheets will make a memory game)
- Scissors
- Colorful, self-adhesive shelf liner paper (such as Contact paper) (optional)
- Access to a photocopy machine or computer and printer
- Directions for building a cistern connections model (included)
- Materials for constructing a cistern connections model (see included instruction sheet) or an actual water harvesting tank and system
- Water if using a cistern model

Activity Duration:

- Memory game – 30 minutes
- Flash card game – 30 minutes
- Cistern components activity – 30 minutes

Preparation:

- Determine whether participants will quiz each other with flash cards or play the memory game.
  - For the flash cards:
    - Use two sheets of card stock paper to make one set.
    - Photocopy both rainwater harvesting component photograph card sheets.
    - Photocopy the matching description sheets onto the reverse sides of the photograph card sheets.
    - Cut apart the doubled sided flash cards. Laminate the cards if desired.
    - Make enough sets for pairs of participants.
  - For the memory game:
    - Use four sheets of card stock paper to make one set.
    - Make two photocopies of each rainwater component photograph sheet. Do not photocopy the component description sheets.

    - Cover the blank side of the two sheets with self-adhesive shelf liner paper (optional).
    - Cut apart the photo cards (there should be two of each photo). Laminate the cards if desired.
    - Make enough sets for groups of up to four participants.
- If you plan to make a rainwater harvesting cistern model, purchase and prepare materials.
    - Make one photocopy of the rainwater harvesting component photograph card sheets with their descriptions on the reverse sides.
    - Laminate the cards if desired.
- Photocopy or bookmark the rainwater harvesting tank photograph.

Activity Steps:

Part I: Flash Cards and Memory Game

1. Ask participants if they have seen rain barrels or other water catchment systems in action. Get responses.
2. Show participants the diagram of an active rainwater harvesting system and help youth identify key components.
3. Explain that the youth will participate in an activity that will teach them about the different components of an active rainwater system.
4. Flash Cards:
    - Divide participants into pairs and distribute one set of flash cards for each pair. Participants quiz each other by having one person show the other the photograph side of a card and the other guessing the name and purpose of the component.
    - Participants can also work together to lay the cards out onto a surface in a way that "builds a system" and describe the way the components fit together.
5. Memory Game:
    - Divide participants into pairs or groups of up to four and distribute one set of memory game cards. Youth shuffle them face down on a surface and make a grid of six rows horizontally and six rows vertically. Participants take turns turning over two cards at a time. When they find two matching cards, they remove the cards from the game and keep them. The individual with the most pairs wins.
    - To add to the learning, make a photocopy of the rainwater harvesting component description sheets and participants can explain the purpose of each component as matches are made.

Part 2: Tour an active system or build an active rainwater harvesting cistern model

1. If participants have access to a functioning, active rainwater harvesting system, give them a "tour" while describing each component's function and the way it contributes to the overall system. The flash cards can be used to prepare participants before the tour or as a quiz afterward.

    If there is no access to an active rain barrel, participants can put together a model of the main components (see preparation section and the directions for building a cistern connections model).
2. Rainwater harvesting cistern model activity:
    - Show participants a small rain barrel (a 16-gallon size works well). Explain that they will be constructing a model of an active rainwater harvesting system.
    - Distribute the rainwater harvesting component photograph cards with descriptions to participants.
    - Take each component out of the barrel. As each component is removed, the participant with the matching card tells the name of the component and its purpose.
    - Distribute the components to participants that do not have photograph cards.
    - Place the rain barrel in an open area where all participants have access to it and can watch the way the components fit together (a circle works well).

- Build the model from the ground up. While each participant puts his or her component onto the system, the youth with the matching card can describe the component and its purpose.
    - Order of components and building process:
        - Fill the watering can with water and set it aside
        - On the rain barrel, point out the faucet drain
        - Point out the overflow outlet
        - Place the PVC threaded couplings in the faucet drain and overflow outlet
        - Put the faucet in the threaded coupling in the faucet drain
        - Place the screen into the barrel lid
        - Show the completed rain barrel
        - Place the downspout in the screen
        - Connect the gutter-downspout connector with end cap to the downspout
        - Connect the gutter to the gutter-downspout connector
        - Place the gutter end cap onto the end of the gutter
        - Two participants hold the roof at an angle at the edge of the gutter
        - A participant uses the watering can to pour water over the roof so that the water runs down the gutter, into the downspout, and into the rain barrel
        - Participants can take turns making it "rain" while others watch the water move through the system
        - Remove all the components that are above the barrel (roof, gutter, gutter-downspout connector, and downspout) and set them aside
        - Discuss ways that rainwater can be used
        - Place the rain barrel on an elevated surface (such as a storage crate)
        - Fill the barrel with two to three gallons of water (using a bucket, hose, or watering can)
        - Hook the hose onto the faucet
        - Discuss ways to put rainwater to use and the use of gravity to move water
        - If in a suitable area, turn on the faucet and watch the water come out
        - A participant can extend the hose toward some plants while another person turns on the faucet
        - Demonstrate what happens if the end of the hose is lifted above the level of the water in the barrel
        - Discuss the benefits, drawbacks, and alternatives for a gravity-flow system
        - Draw participants' attention to the hose nozzle—while the pressure will probably not be enough to use it with the hose, it is an important conservation tip to always use a nozzle on a hose
    - As a wrap up, review vocabulary for components and discuss the processes and benefits of rainwater harvesting.

Sources:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
The University of Arizona Cooperative Extension, Cochise County
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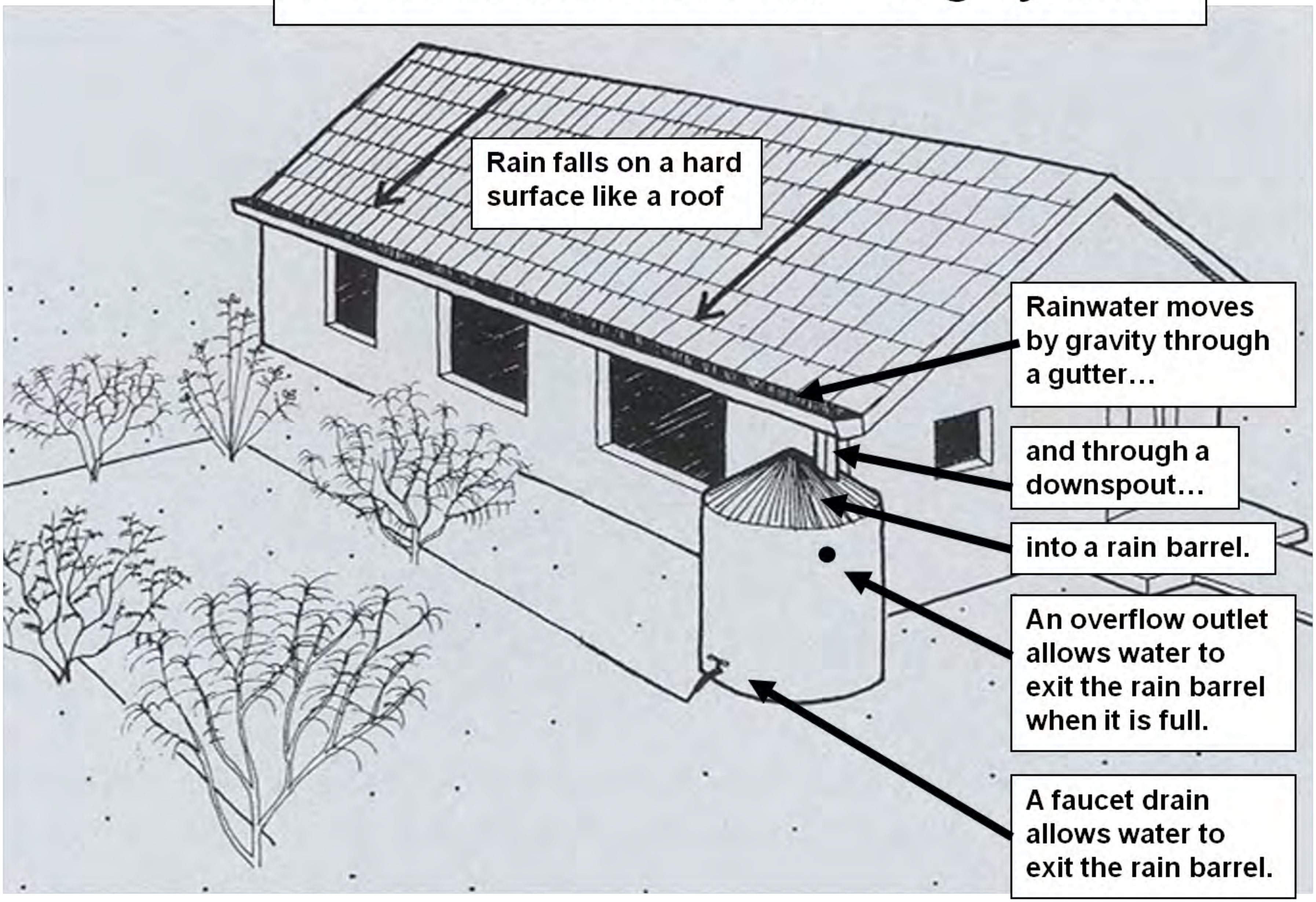
http://extension.arizona.edu/cochise

Flickr.com photograph of the roof for a flash card/ Memory Game card used with permission to share, copy, distribute, and transmit. It is for noncommercial, educational use only with no derivative works. Courtesy of Paul Blakeman and found at: http://www.flickr.com/photos/paul_blakeman/2832983311/

Active Rainwater Harvesting System



Drawing courtesy of Patricia Waterfall

For flash cards, make two-sided photocopies—one side with a rainwater harvesting component photograph sheet and the other side with the matching rainwater harvesting component description sheet. This is photograph sheet #1 which will match up to description sheet #1. Do the same for the #2 sheets. Cut apart and quiz. For a memory game, photocopy two copies of the photograph pages onto card stock paper (not including descriptions), cut apart, mix up, and lay out in a 6 card by 6 card grid.

This is description sheet #1.

C w t

A hole in the upper par

r re

w t ro

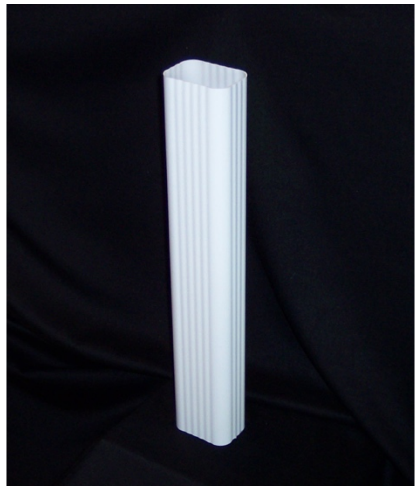
ba ne ul

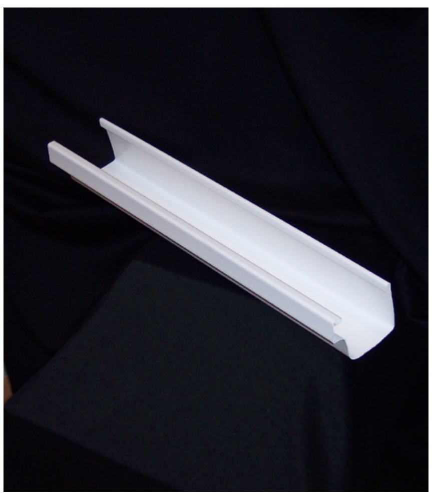
water. Attaching a fau

w o

ct p

This is photograph sheet #2.





This is description sheet #2.

Gutt Dc ou

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assists in the transition

Directions for a Building a Cistern Connections Model

Materials:

- 16-gallon, plastic barrel, preferably with handles for ease of transport (available at many feed stores)
- 30” wide by 20” long piece of pliable, plastic roofing material (purchase one sheet, usually 8’ by 2’, and cut)
- 21” long piece of plastic gutter (purchase a 10’ long gutter and cut)
- 18” to 20” long piece of plastic downspout (purchase a 10’ long downspout and cut)
- Gutter-downspout connector or flexible downspout
- Pair of gutter end caps
- Two PVC threaded couplings (one ½” for the faucet at the base of the barrel; the other is usually larger for the overflow drain at the top of the barrel)
- ½” faucet
- Wire mesh sink strainer (available at variety and hardware stores)
- Length of hose (15’ hoses can be purchased or shorter lengths can be made from discarded hoses)
- Plastic or metal milk or storage crate for elevating rain barrel
- Watering can that sprinkles water
- Nozzle (optional but useful in emphasizing water conservation when watering)
- Drill with ¾” drill bit (for making the faucet drain) and an appropriate sized, larger drill bit (for making the overflow drain)
- Jigsaw or other means for making an opening in the lid of the rain barrel
- Saw for cutting roofing material, gutter, and downspout
- Access to water for the demonstration

Steps:

1. Use a drill and ¾” drill bit to put a ½” hole approximately 2 inches from the bottom of the rain barrel for the faucet.
2. Use a drill and an appropriately sized drill bit to put a hole approximately 1 inch below the lid to the side of the faucet drain for the overflow outlet.
3. Screw a ½” faucet into the faucet drain and secure it by screwing a ½” coupling to it on the inside of the barrel.
4. Screw a threaded coupling into the overflow outlet.
5. Using a jigsaw or other means, cut a hole in the rain barrel lid to accommodate a wire mesh strainer (available at variety stores) and the downspout. Use the wire mesh strainer as a guide to determine the size of the hole to drill in the lid.
6. Using a saw, cut the downspout and gutter pieces to the recommended lengths and so that they will fit into the rain barrel for storage.
7. Cut a 2” to 3” piece of gutter and attach an end cap to it. (This will allow the end cap to hook into the gutter-downspout connection.)
8. Put the other end cap onto the end of the 21” long piece of gutter.
9. Cut a 30” by 20” piece of plastic roofing material and remove any loose plastic from the edges.
10. Keep all the model’s components in the rain barrel for storage and transport (all pieces should fit with the exception perhaps of the watering can which can be stored in the storage crate).

Overview:

Youth use math to determine the amount of rain that can be captured from a roof.

The amount of water that can be captured from a roof surprises most people.

Materials:

For each participant, pair, or small group:

- Recycled ½ gallon milk or juice carton
- 8 ½" by 11" sheet of card stock paper
- Ruler
- "How Much Rain Can You Catch?" handout (included)
- Pencil

Activity Duration:

25 minutes

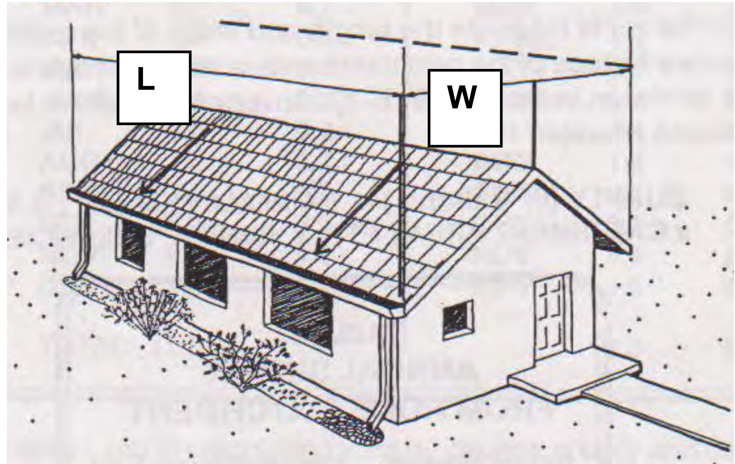
Preparation:

- Collect or encourage participants to bring in recycled ½ gallon cartons.
- Purchase card stock paper and any other necessary materials.
- Photocopy "How Much Rain Can You Catch?" handout.
- Go through the steps of measuring the amount of rain that can be collected from the paper roof so the process is familiar.

Activity Steps:

1. Review components of an active rainwater system. Explain that in designing and building a rainwater harvesting system, one of the steps is to use math to calculate the amount of roof runoff (the number of gallons of water) that can be collected from a roof. Knowing the potential for rainwater collection helps in planning for the water's usage.
2. Show participants a ½ gallon carton and a sheet of cardstock paper. Explain that they will go through a step by step process to determine the amount of rain a surface like a roof can catch and collect.
3. Distribute the cartons, cardstock paper, rulers, pencils, and the "How Much Rain Can You Catch?" handout.
4. Explain that to determine the amount of rainwater a roof will capture, participants will first measure the surface area that is receiving the rain. This may be a different measurement than they think.
5. Have participants fold their card stock paper in half, width-wise, and place the paper over the tops of their cartons as roofs.

6. Ask participants to imagine that it is raining and to envision the way that water would fall on the roof. Using the model as an example, demonstrate measuring the roof collection area. Participants measure the length of the roof; with a pitch roof, the width will be the distance between the eaves. (See drawing on the next page as an example.)
7. Work through the handout with the participants, explaining each equation for determining the amount of water that could be collected.
8. Participants use their models and the handout to calculate how much rainwater they could "catch" from their "roofs."
9. Discuss different kinds of surfaces and their collection capacity (a grass soccer field versus a paved parking lot for example). Ask youth what kinds of surfaces would work best for active rainwater collection. Get responses.



Drawing to demonstrate measurements for roof runoff capacity courtesy of Patricia Waterfall

Extensions:

- Youth can determine the collection area of their houses and research the average rainfall where they live to determine their capacity for rainwater collection.
- Families can be encouraged to build their own rainwater harvesting systems.

Leader/Teacher Note:

The calculations for determining the amount of rain that can be collected from a roof in this activity do not include a runoff coefficient which is the average percentage of rainwater that runs off a type of surface. The calculation is determined by the permeability of the surface. As an example, a roof with a runoff coefficient of 0.95 would indicate that 95% of the rain that falls on that roof will run off. As an extension activity, participants can add a runoff coefficient to their calculations.

Sources:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
The University of Arizona Cooperative Extension, Cochise County
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Rainwater harvesting drawing courtesy of *Harvesting Rainwater for Landscape Use*, by Patricia Waterfall, Extension Agent, University of Arizona Cooperative Extension/Low 4 Program, Second Edition, August 2004.
Publication may accessed at: http://ag.arizona.edu/pubs/water/az1052/harvest.html

How Much Rain Can You Catch?
(Page 1)

Name ____ Date _________________

Directions: Calculating the collection of rainwater from an impermeable surface involves several steps that take into consideration the surface area of the roof, the amount of predicted rainfall, and a multiplier to convert the inches of rain per square foot of roof into gallons. Follow the steps to find out the amount of rain you can catch.

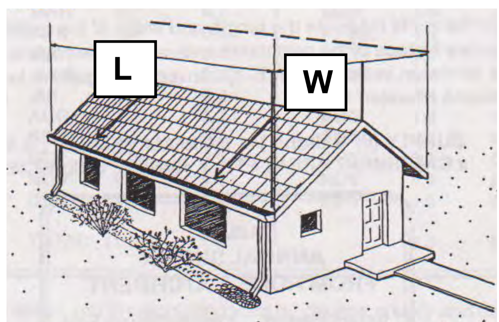
1. Determine your roof's collection area. For this activity, ¼" = 1 foot.

   With the card stock "roof" on the carton, use a ruler to measure its length (L) in inches. _____________

   Since ¼" = 1 foot, multiply the number of inches by 4 to get "ft": _____________"ft"

   Measure the width (W) of the "roof" at the eaves in inches (see diagram below) _____________

Safety Note: When measuring a real house roof's collection area, measure from the ground the area the roof covers. You do not have to go up onto the roof.



Since ¼" = 1 foot, multiply the number of inches by 4 to get "ft": _____________"ft"

Multiply the length x the width of the collection area: _____________"ft^2"

2. The next step is to multiply the square footage (ft^2) by an amount of rainfall in inches. Rainfall varies by location and month. Use the graph on the next page to choose a rainfall amount.

   Month _____________ City _________________ Rainfall (in inches) ___________

   Multiply ft^2 above __________ by rainfall above ____________ = _______________
   Volume of water in inches of rain per square foot

How Much Rain Can You Catch?
(Page 2)

Name ____ Date ________________

Average Monthly Rainfall in Arizona Cities (in inches over a 30-year period)			
Month	Flagstaff	Phoenix	Tucson
Jan.	2.2	0.8	1.0
Feb.	2.6	0.8	0.9
March	2.6	1.1	0.8
April	1.3	0.3	0.3
May	0.8	0.2	0.2
June	0.4	1.0	0.2
July	2.4	1.0	2.1
Aug.	2.9	0.9	2.3
Sept.	2.1	0.6	1.5
Oct.	1.9	0.8	1.2
Nov.	1.9	0.7	0.7
Dec.	1.8	0.9	1.0

http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmpcp.txt

3. The final step is to multiply the volume of water in inches of rain per square foot (the answer to question 2) by 0.623, called a "multiplier." The number 0.623 is the "conversion coefficient," which converts the inches of rain per square foot of roof into gallons.*

Volume of water (page 1) ______________ x 0.623 = ______________ gallons of water that could be harvested

4. List three ways that people can use rainwater.

____

____

____

* Where does the number 0.623 come from?

It is the number of gallons there are in 1 square foot, 1 inch deep.

Overview:

Youth determine the amount of water being stored in a rainwater storage tank and calculate the number of drops used for a particular purpose.

Collecting rainwater can conserve other water resources.

Materials:

- An existing rainwater harvesting tank or demonstration model
- Hose attached to the tank that is a least as long as the tank is tall
- String to go around the circumference of the tank
- Tape measure or yard stick
- Masking tape
- Ladder for leader if tank is taller than a person
- A 1-gallon jug for each individual, pair, or small group
- Watch or stopwatch
- "Count Drops Saved" worksheet for round and rectangular tanks (included)
- Pencils for participants

Activity Duration:

- Part I – 25 minutes – Determining storage capacity
- Part II – 25 minutes – Determining volume of water in a tank
- Part III – 40 minutes – Calculating water used (counting drops saved)

Preparation:

- Determine the height, circumference (if the base is round); the area (if the base is rectangular), and capacity of a rainwater harvesting tank or demonstration model (see Part I worksheet for instructions).
- Photocopy the "Count Drops Saved" worksheet for participants.
- Collect enough 1-gallon jugs (recycled plastic milk jugs) for the number participating.

Activity Steps:

Explain that a major benefit of harvesting and using rainwater instead of tap water is that it saves water would otherwise need to be pumped from under the ground or from rivers or reservoirs. There are several activities that can be done to determine the amount of water being stored that can be used for different purposes. By using rainwater, other water resources can be conserved.

Part I – Determining the Storage Capacity of a Rainwater Harvesting Tank

1. Bring participants to a location with a rainwater harvesting tank or demonstration model and ask them if they can think of ways to measure the amount of water that can be stored in the tank (determine the tank's capacity). Get responses.

2. Participants wrap a string around the rainwater harvesting tank. Cut or mark the string where the ends meet.
3. Mark off a set measurement length with masking tape (such as one yard or meter) on a level surface.
4. Participants use the measurement tape to determine (in feet) the length of the string that had wrapped around the tank.
5. Distribute the “Count Drops Saved” worksheet. Participants determine the capacity of the tank by completing Part I on the worksheet.

Part II – Determining the Volume of Water Inside a Rainwater Harvesting Tank

1. In view of a rainwater harvesting tank or demonstration model, ask youth if they can think of ways to determine the amount of water in the tank (volume). Get responses.
2. Explain that since the participants know the capacity of the tank, they can figure out the amount of water in the tank if they know the height of the water.
3. One simple way to estimate the height of the water is to feel the side of the tank. Participants start at the bottom of the tank and move their hands up the side until the temperature feels different. The line where the temperature changes is the level of the water. (Participants can do this activity if the water level is within reach. Otherwise the group leader can determine the level.) Sometimes the exact height is difficult to determine exactly, but the activity works as an estimate.
4. Explain that a more accurate way to determine the water level is to make use of the fact that water finds its own level.
5. Participants hold a hose that is connected to a rainwater harvesting tank up against the side of the tank so that the nozzle end is pointing upward.
6. Have a participant turn on the faucet for the tank so that water slowly comes out. The youth moves the hose up or down the side of the tank until water begins to come out of the hose. The height of the hose shows the water level in the tank. (Depending on the height of the tank, a leader may need to use a ladder to conduct this part of the activity.)
7. A participant measures the height of the water in feet from the bottom of the tank to the point where water is just starting to come out of the hose.
8. Participants determine the amount of water in the tank by completing Part II on the worksheet.

Part III – Counting Drops Saved

1. Explain to youth that by determining the amount of water in the tank, they can know the amount of water used for a certain purpose. Rainwater can potentially save water from other sources (such as groundwater, a reservoir, or river) that would otherwise have been used for that purpose.
2. Explain to participants that the simplest way to measure the water is to fill up 1-gallon water jugs, use the water for a purpose (such as watering plants), and then count the number of gallons used.
3. Participants take turns filling up their jugs (being careful not to spill any drops) and using the water; each gallon is counted and tallied and the total is determined and listed in Part III of the worksheet.

4. Discuss the benefits and disadvantages to using gallon jugs for measuring water used. Ask participants if they can think of any other ways that water coming out of the tank can be measured. Get responses.
5. Another way to measure the amount of rainwater used (thus saving other water resources) is to determine the amount of water that comes out of the tank in one minute.
6. Use a watch or stopwatch and 1-gallon jugs to time and measure the amount of water that leaves the tank in one minute. Participants then multiply that amount by the number of minutes the water from the tank is used. The total can be listed in Part III of the worksheet.

Extensions:

- Youth can determine the number of *actual* drops saved in using rainwater instead of other water resources. Use the following information to convert gallons to drops:
    - There are approximately 3785 drops in one gallon (there are approximately 24 drops per mL)
    - Participants multiply the amount of rainwater used by 3785 to see that drops really do count (and add up)
- Youth research ways to increase water pressure for rainwater harvesting tanks.

Source:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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Drops Count Worksheet for a Round Tank
Page 1

Name ____ Date ______________________

<u>Part I – Determine the Storage Capacity of a Rainwater Harvesting Tank.</u>
There are approximately 7.5 gallons per cubic foot.

π or "Pi" = 3.14

1. Measure the circumference (length around the outside) in feet using a string or tape measure.

________________ Ft

2. Measure the height of the tank.

_________________Ft

3. Use the circumference data to determine the radius.

$$r = \frac{C}{2\pi}$$

Radius ______________

4. Use the formula for volume of a cylinder to determine the capacity of the rainwater harvesting tank.

$$V = \pi r^2 h$$

Volume ______________ Ft^3

5. Determine tank's capacity in gallons by multiplying volume by 7.5.

______________Gal

<u>Part II – Determine the Volume of Water Already in a Rainwater Harvesting Tank.</u>

6. Measure the circumference of the tank (length around the outside) in feet using a string or tape measure (or use the circumference calculated in Part I).

_______________ Ft

7. Measure the height of the water in the tank (hose activity).

_______________Ft

8. Use the circumference data to determine the radius.

$$r = \frac{C}{2\pi}$$

Radius ______________

Drops Count Worksheet for a Round Tank
Page 2

Name ____ Date _______________________

9. Use the formula for volume of a cylinder to determine the capacity of the rainwater harvesting tank.

$$V = \pi r^2 h$$

Volume ______________ Ft^3

10. Determine tank's capacity in gallons by multiplying volume by 7.5.

______________Gal

Part III – Counting Drops Saved.

11. Number of 1-gallon jugs of water used for a purpose (= total gallons that have saved other water resources):

____________________Gal

12. Amount of water removed from the tank in 1 minute: ________________Gal in 1 minute

13. Multiply the amount of water removed in 1 minute by the number of minutes used (= total gallons that have saved other water resources):

______________Gal Saved

Drops Count Worksheet for a Rectangular Tank

Name ____ Date ______________________

Part I – Determine the Storage Capacity of a Rainwater Harvesting Tank.
There are approximately 7.5 gallons per cubic foot.

1. Find the area of the floor of the tank: Multiply the length (in feet) x width (in feet).

Area = Length _______ X Width ________(ft) = ___________Ft^2

2. Measure the height of the tank. Height_____________Ft

3. Multiply area x height to determine volume. Volume____________Ft^3

4. Determine tank's capacity in gallons by multiplying volume by 7.5. _______________ Gal

Part II – Determine the Volume of Water Already in a Rainwater Harvesting Tank.

5. Find the area of the tank: Multiply the length (in feet) x width (in feet) (or use the area calculated in Part I).

Area = Length _______ X Width ________(ft) = ___________Ft^2

6. Measure the height of the water in the tank (hose activity). Height_____________Ft

7. Multiply area x height to determine volume. Volume____________Ft^3

8. Determine tank's capacity in gallons by multiplying volume by 7.5. _______________ Gal

Part III – Counting Drops Saved.

9. Number of 1-gallon jugs of water used for a purpose (= total gallons that have saved other water resources): _____________________Gal

10. Amount of water removed from the tank in 1 minute: _________________Gal in 1 minute

11. Multiply the amount of water removed in 1 minute by the number of minutes used (= total gallons that have saved other water resources): _____________________Gal Saved

Overview:

Youth use their creativity to design and decorat vat harve ing ink models to demonstrate that storage containers n be at active a we as functional.

Rainwater harvesting tanks can be a palette for artistic expression.

Materials:

- Template photocopied on white card stock paper for each participant (template included)
- 1 sheet of white card stock paper cut in half (so the size is 8 ½ inches by 5 ½ inches) for each participant
- Pencils for design drafts
- 1 bendable straw for each participant
- Variety of art media (which may include watercolor and acrylic paints, colored pencils, crayons, etc.) for final draft
- Cellophane tape
- Access to a computer and the Internet for artistic tank review
- Painted rainwater harvesting tank photograph (included)

Activity Duration:

Timeframe is variable. Introduction and preliminary drawing drafts – 30 minutes to 1 hour. This is an activity that could become a longer-lasting project.

Preparation:

- Gather art supplies and other materials.
- Photocopy the template on white card stock paper for each participant.
- Cut a piece of white card stock paper into two 8 ½ by 5" pieces for each participant (so that each participant will have a "design draft" and a "final draft").
- Prepare computer(s) for research.
- Make a photocopy of the painted rainwater harvesting tank photograph or bookmark the page to share with participants.

Activity Steps:

1. Ask participants if they have seen rainwater harvesting tanks. Ask them to describe what they look like? Get responses. Show them the photo of a painted rainwater harvesting tank.
2. Explain that one factor that people consider in putting in rainwater harvesting systems is the attractiveness of the containers. Many people want their tanks to blend into their home or business design. A rain barrel can be a palette for creativity. This is an activity that will give youth the opportunity to design artistic rain barrels.
3. Show participants examples of artistic tanks online. Two recommended web sites are:
   - City of Lenexa, Kansas, Rain to Recreation's "Rainscapes" educational campaign that sponsors an annual rain barrel art contest. View a slide show of current year tanks at: http://www.raintorecreation.org/rain_barrels_gallery.html

- City of Lincoln, Nebraska's Artistic Rain Barrel Program at: http://www.lincoln.ne.gov/city/pworks/watrshed/educate/barrel/artist/2009/index.htm

4. Distribute photocopies of the template, two pieces of 8 ½ inch by 5 ½ inch card stock paper, and a straw to each participant.
5. Hold up one of the half sheets in a "landscape" orientation and explain that youth will use paper to create artistic designs for rainwater harvesting tank models.
6. Explain and demonstrate that after completing their designs, participants will roll their sheets and tape the ends together. When the rolled sheets are placed upright, they resemble cylindrical "tanks."
7. Discuss ideas for designs and give participants the opportunity to brainstorm ideas (some individuals may have very definite ideas for their designs but others may need help thinking of ideas).
8. While there are no design "rules," participants should avoid using others' creations (including existing cartoon characters, product logos) or any designs that depict risky behaviors such as drinking, smoking, drug use, or gang activity, or could be considered offensive.
9. Encourage participants to use one of their half sheets to create "design drafts" and then create final drafts. Encourage youth to use the mid section of the piece of paper as the center for the design so that when the ends are taped together, the design is in the most visible position.
10. In addition to decorating the tank model, youth can decorate the house on their templates.
11. Youth fold their templates along the dotted line and stand the part with the house so it is upright.
12. Participants tape their tank models to the base and upright parts of the paper (see example).
13. Participants insert a straw into the tank model and tape it at an angle to the "gutter" on the template to represent a downspout.
14. Participants "showcase" their artistic "tanks" and explain their design concept.

Extensions:

- Participants find a location to display their rainwater harvesting tank models (such as a library, school, or other public building) and provide informational write-ups on the purposes and benefits of rainwater harvesting.
- Designs can be posted to a web site and offered as design templates for personal and/or community rainwater harvesting tanks.
- As an alternative to using the template, youth can use recycled soda cans. They can decorate their half sheets, wrap the paper around their cans, and tape the ends of the sheets together.

Source:

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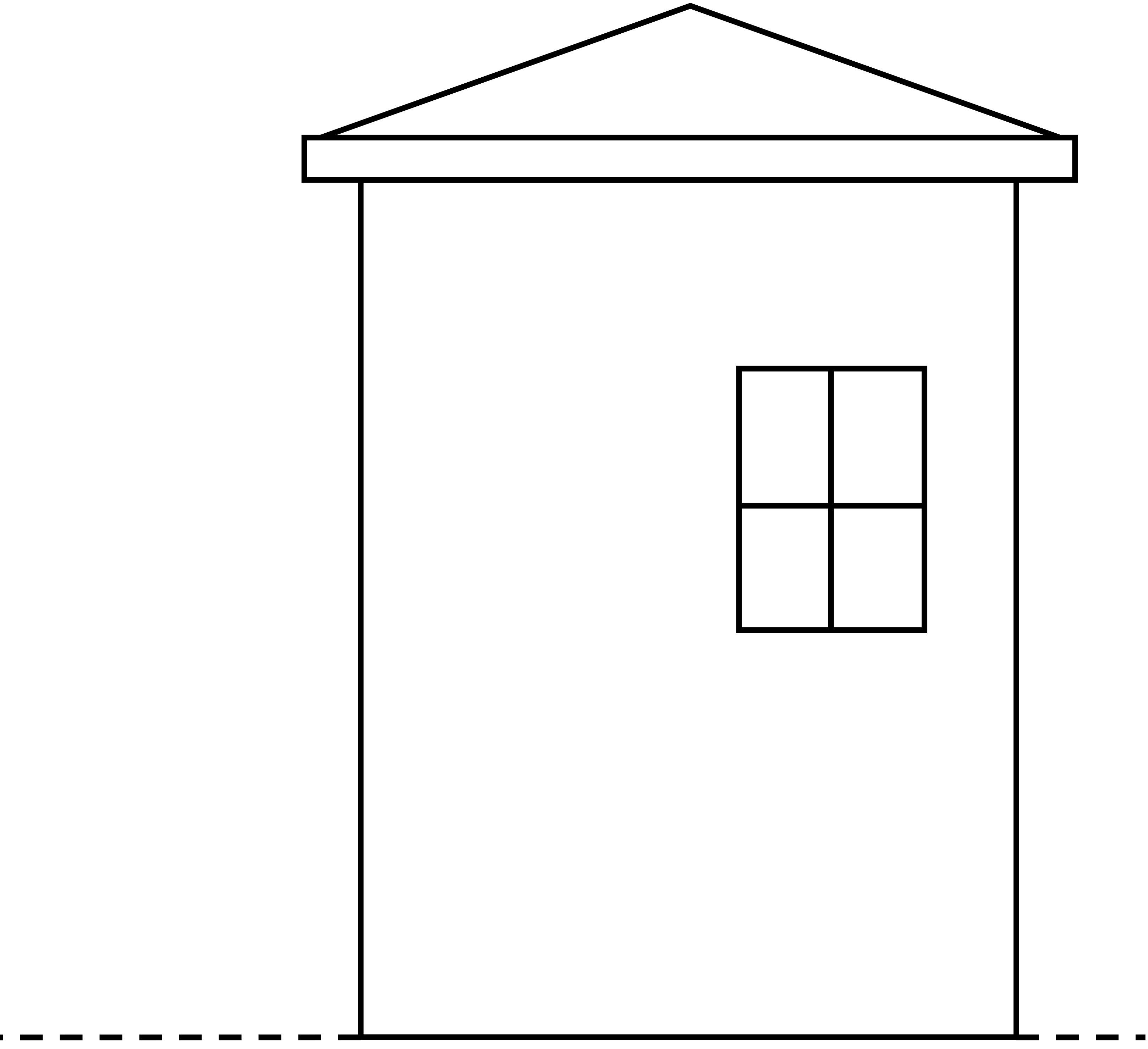

Artistic rainwater harvesting tank located at The University of Arizona South, Sierra Vista, Arizona

Rainwater Harvesting Outreach

Lessons include: educating and contributing to the community

Web sites for community outreach:

- Community Service Project Activity:
  http://www.groundwater.org/ta/serviceproject.html
- Give Water a Hand Action Guide:
  http://www.uwex.edu/erc/gwah/
- Web site resources for community service:
  http://www.epa.gov/teachers/community-svc-projects.htm
- 4-H_2O Online – A Community for Youth to learn about Water in their Communities
  http://www.4-h.org/youth-development-programs/4-h-science-programs/environmental-science-alternative-energy/4h2online/4h2online.html

Overview:

Youth show what they know about rainwater harvesting by developing educational signs to explain systems to the public.

Signs can educate the public by explaining processes and encouraging people to develop their own rainwater harvesting systems.

Materials:

- "Sign Design Elements" handout (included)
- Pencils for participants to take notes on the site and system
- Photographs of educational signs (included)
- Paper and art materials for sketches of sign designs
- Computer with software capable of creating design files (may be a basic program such as Microsoft Word or PowerPoint or more complex design oriented programs such as Microsoft Publisher or Adobe Illustrator or InDesign) (optional)
- Computer projector and screen for PowerPoint demonstration (optional)

Activity Duration:

This is a longer-term activity which could take place over the course of weeks or months. It is also a culmination activity best conducted after participants have a substantial knowledge base and practical experience with rainwater harvesting systems.

- Tour and review of a rainwater system – 30 minutes to one hour
- Design process workshop with PowerPoint or "Sign Design Elements" handout – 45 minutes to one hour
- Youth sign design process, production, and installation – timeframe varies widely

Preparation:

- Investigate rainwater harvesting sites with access to the public that could be potential locations for educational signs.
- Gain approval from appropriate entities to develop signage for a specific location.
- Have or develop in-depth knowledge about the size, capacity, material, design, construction method, components, flow rate, and use of the rainwater harvesting system.
- Research municipal or county codes on installing signs at the desired location.
- Investigate sign company options to determine printing costs.
- Secure funding to print and install a sign.
- Based on costs and funds available, determine the sign size and building materials to use.
- Determine youth transportation needs to a rainwater harvesting site.
- Photocopy the "Sign Design Elements" handout for participants, pairs, or small groups.
- Photocopy or bookmark the educational sign examples.

Activity Steps:

The process will take place over time rather than in one session.

1. Explain to participants that a rainwater harvesting site has been chosen to become a demonstration model for the community, school, etc. (based on its location) and that they will participate in creating an educational sign to share information about rainwater harvesting principles and practices.
2. Tour the rainwater harvesting site with youth. Participants take notes while discussing the system's size, capacity, material, design, construction method, components, flow rate, and use.
3. Show participants the photograph of rainwater harvesting tanks at Biosphere 2, north of Tucson, Arizona. Explain that the sign highlights the system's purpose and processes in order to teach visitors. Explain that demonstration sites, museums, historic and community sites, nature trails, and other locations use educational signs to share information so that people can enhance their knowledge and appreciation.
4. In a classroom setting, participants work in groups to research rainwater harvesting processes, components, and uses to determine the information to include on their sign layouts. Signs may also include specific information about the site location and the specific rainwater harvesting system's processes and purpose.
5. Discuss design elements with participants. There are six **elements of design** that make up what people see visually. They are tools that can be used in limitless ways to create meaning and impact. They are:
   - Line
   - Shape
   - Forms
   - Space
   - Color
   - Texture

   There are also **principles of design** which organize the design elements. There are limitless ways to combine them to enhance a message. They are:
   - Balance
   - Emphasis
   - Movement
   - Pattern
   - Repetition
   - Proportion
   - Rhythm, variety, and unity

6. Distribute the "Sign Design Elements" handout and discuss the elements. Using the photos of the educational signs, point out different elements that are evident on the examples.
7. If there is a computer and projector available, create an interactive PowerPoint presentation with slides like those on the "Sign Design Elements" handout. Participants contribute to the presentation as a way to explore the meaning of different elements and principles of design. (For example, display a blank slide and explain that one design element is a line. As participants describe different kinds of lines, use the "AutoShapes" tool in PowerPoint to draw a variety of lines on the slide. Label the slide with the word, "Line," and open another blank slide. This slide might address the element, "shape." Participants suggest different shapes and they are inserted and labeled on the slide.) The PowerPoint presentation can be an interactive brainstorming and learning tool. The examples of educational signs can be scanned into the PowerPoint presentation ahead of time and the different elements and principles of design can be addressed in the examples by toggling back and forth between the examples and the element descriptions.

8. Participants use their "Sign Design Elements" handouts as a guide as they experiment with layout ideas and create sign design drafts, aiming to incorporate design elements and principles in their signs.
9. Participants analyze the drafts and choose a final design for the actual sign.
10. Participants gain design approval from all necessary entities.
11. Depending on youths' ages, some may take a leadership role in researching the sign production process and developing fundraising events.
12. Select a sign making company and follow-up with the company throughout the sign making process.
13. Plan a "grand opening" celebration once the sign has been installed. Encourage the media to cover the event so the community can gain awareness about rainwater harvesting and youth community outreach efforts.

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Rainwater Harvesting Tank
Exhibit at Biosphere 2, Oracle, Arizona

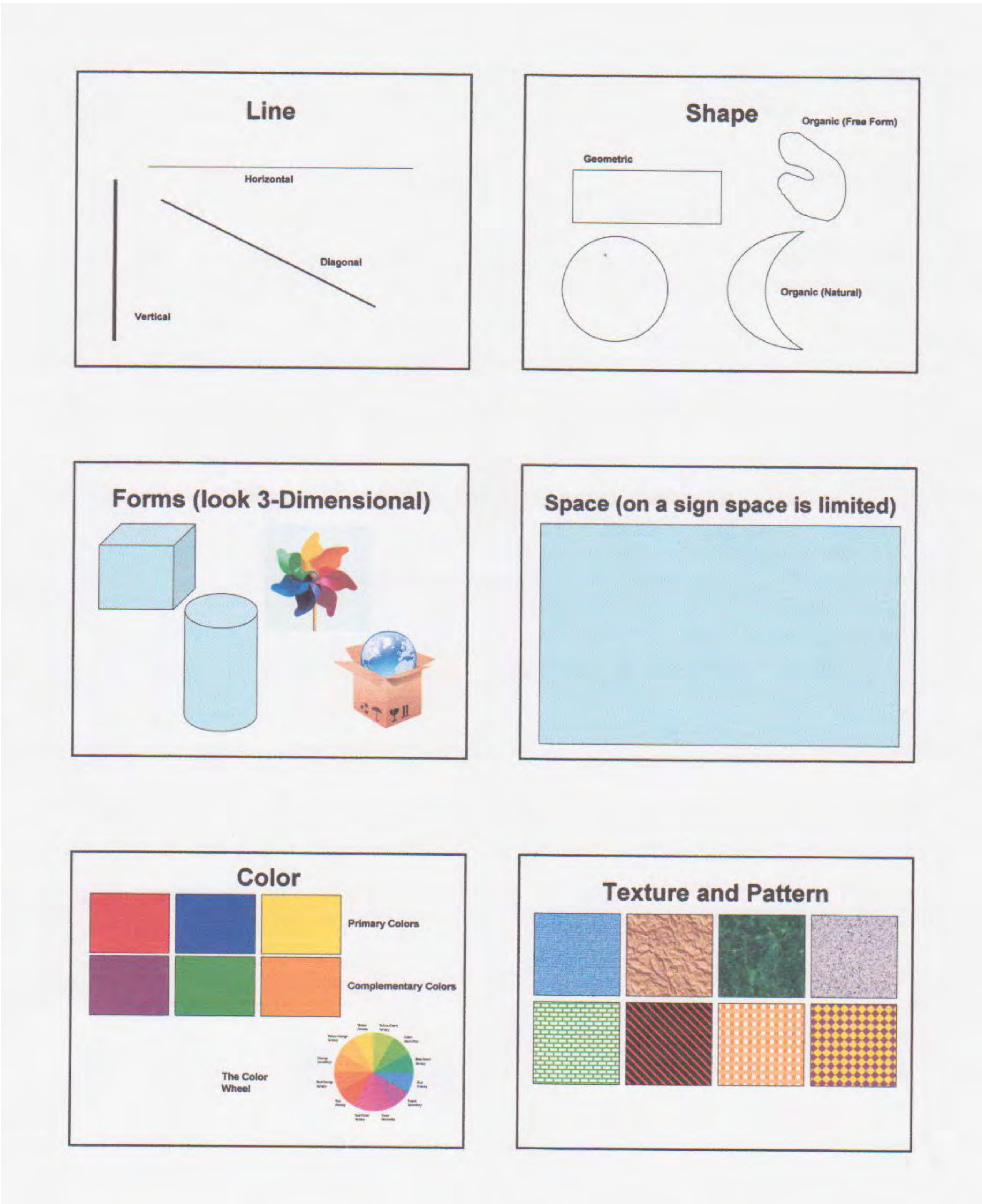
Photograph courtesy of Matt Adamson

Educational Sign at Biosphere 2
Oracle, Arizona

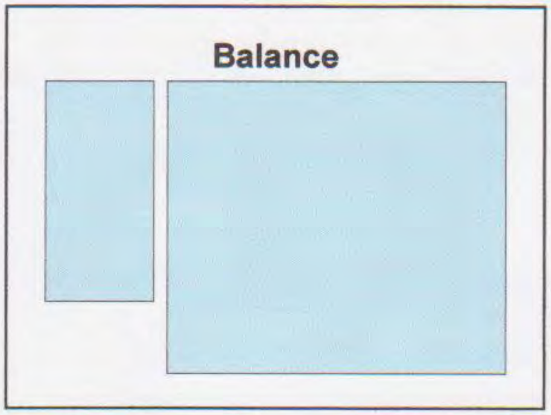
Photograph courtesy of Matt Adamson

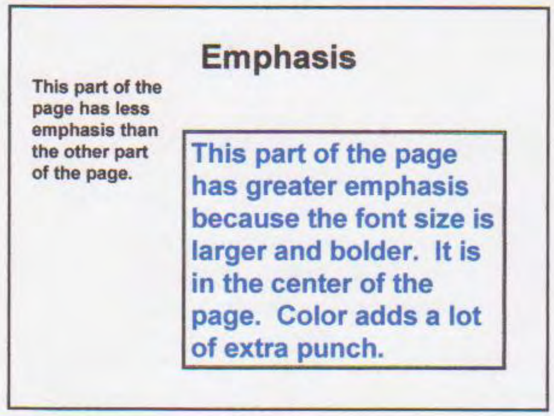
Educational Sign at Cochise College, Sierra Vista, Arizona

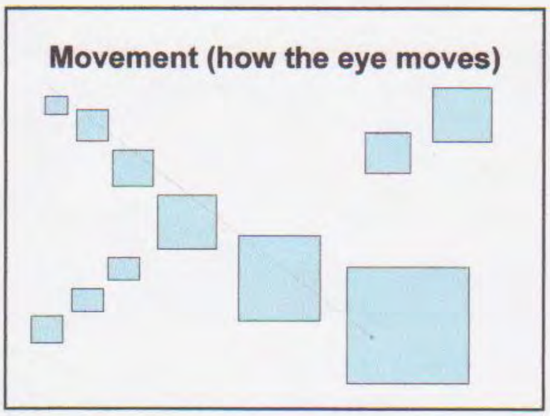
Sign Design Elements
(Page 1)

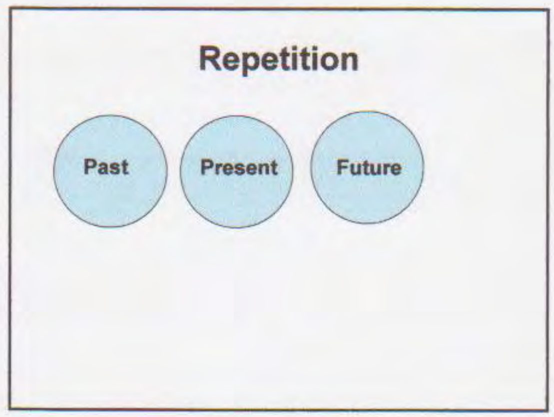


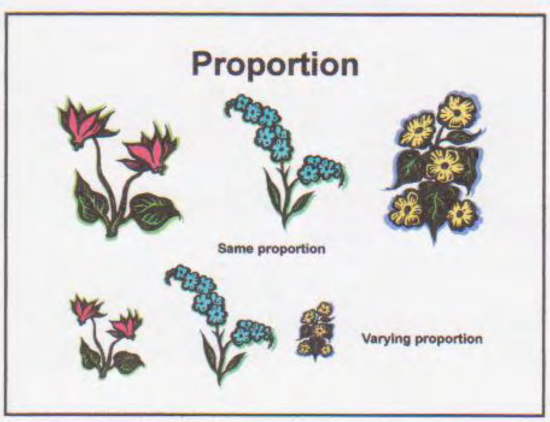
Sign Design Elements
(Page 2)

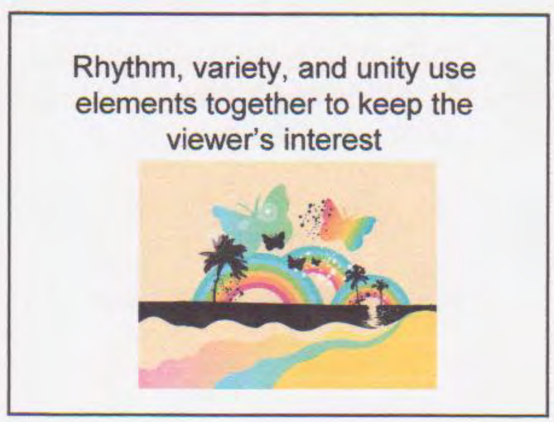


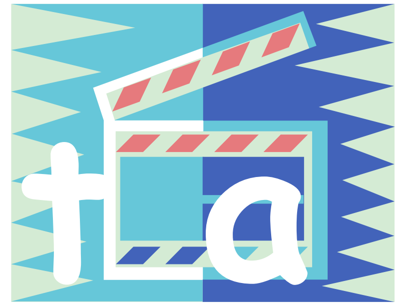












Overview:

Youth share rainwater harvesting c(cepts an p jects , plan ng, producing, editing, and showing ..ona. v eos th.. exp.. rainwater harvesting processes.

Creating a movie can bring rainwater harvesting to life by sharing information that can encourage increased interest and participation in rainwater harvesting processes and systems.

Materials:

- Web-based Terrapod curriculum found at: http://www.4-h.org/curriculum/filmaking
- Computer with Internet access and projector for presenting online Terrapod tutorials or order the DVD of tutorials at the web site listed above
- Minimum video-making supplies for small groups to include:
  - Video camera with capability for file download onto a computer (USB cord or card reader compatible with the computer)
  - Computer
  - Computer program: Windows Movie Maker. Most computers have this program installed. If not, there is a free download at www.microsoft.com/windowssxp/downloads/updates/moviemaker2.msp
  - Free computer download: Any Video Converter at: www.any-video-converter.com/products
  - Full sized tripod
- Parental release form (The University of Arizona Cooperative Extension form included)

Activity Duration:

This is a project that may take place over time either in a concentrated workshop format of several days or an ongoing program that may take place in regular, shorter-duration sessions over the course of several weeks.

Preparation:

- Watch the 11-module, video making tutorials online or on DVD.
- Review the video resources found online.
- If possible, go through the steps of making a short film to better understand the processes and software/hardware issues, options, and limitations.
- Determine the timeframe and format for guiding participants through the Terrapod process (a workshop format over the course of several days or a longer-term project over the course of several weeks).
- Photocopy parent release forms and have all participants return them before starting the videotaping process.

Activity Steps:

1. Introduce Terrapod to participants and explain that it is a program that helps young people explore science, engineering, and technology through the art of film-making. Youth will learn filmmaking skills while making short films about rainwater harvesting. They can also become a part of a web-based social networking community to share filmmaking ideas and techniques and upload approved films to share them with friends and family.
2. Stress the importance of returning the release forms that grant permission to participate in the filmmaking activities.
3. Participants watch the beginning tutorials online or on DVD. The tutorials describe the video making process and video camera functions.
4. Once participants have a basic understanding of the process, divide the participants into small groups (3 to a group works well).
5. Equip each "film crew" with a digital camera and tripod and briefly explain aspects of its use. Answer any questions participants may have.
6. Ask participants to go out and make a 2-3 minute film about a topic of their choice.
7. After a set period of time (30 minutes is a suggested timeframe), the participants reassemble and the movies are previewed (without any editing at this point). Comments are provided about positive aspects of film techniques, story lines, and other components.
8. Participants move through the video making process by watching each appropriate tutorial prior to completing each step. The tutorials explain all the processes in sequence including filming, downloading, editing, and uploading footage. (There are many resources on the Terrapod web site including free downloads of music and images.)
9. After the participants complete their videos, they come together to show their films, discuss them, and celebrate their success.
10. Consider assisting the youth in planning and organizing an event to show the films to family and friends.
11. The videos can be part of a community education and outreach project (see the activity, "Rainwater Harvesting Junior Docents" for ideas).

Sources:

For tutorials and more information:

National 4-H Council Terrapod tutorials:
http://projects.4-hcurriculum.org/curriculum/filmmaking/

Montana State University Terrapod tutorials:
http://www.terrapodcast.com/

4-H Youth Create Water Science Videos

PHOTO/VIDEO/AUDIO CONSENT AND RELEASE FORM
University of Arizona Cooperative Extension

ARIZONA COOPERATIVE EXTENSION
THE UNIVERSITY OF ARIZONA • COLLEGE OF AGRICULTURE AND LIFE SCIENCES

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I have read this release before signing below, and I fully understand the contents, meaning, and impact of this release. I understand that I am free to address any specific questions regarding this release by submitting those questions in writing prior to signing, and I agree that my failure to do so will be interpreted as a free and knowledgeable acceptance of the terms of this release.

____

Signature of Subject (if age 18 or older) Date

____

Address (please print) City State Zip Code

____

Area Code and Phone Number

____

Parent or Legal Guardian (if subject is under 18) Date

____

Address (please print) City State Zip Code

____

Area Code and Phone Number

If subject is under 18 years old, a parent or legal guardian must write the minor's name as the subject and grant permission by signing on the appropriate line.

Overview:

Youth plan an educational presentation or project to educate people about the processes and benefits of rainwater harvesting. This is a culminating activity, bringing together youths' knowledge and skills about rainwater harvesting.

> ***Service activities build youth leadership skills and strengthen communities.***

Materials:

- Whiteboard, chalkboard, or flip chart for collecting brainstorming ideas
- Rainwater harvesting tank(s) in the community
- Computer with presentation software such as Microsoft PowerPoint
- Access to digital cameras and/or video cameras (optional but useful if this activity will be combined with "Make a Movie")

Activity Duration:

This is an activity that will take place over the course of weeks or months.

Preparation:

Research online and print resources for guiding youth through community outreach projects (see web sites listed on the title page for this section for ideas on projects and processes).

Suggested Projects:

1. Organize a rainwater harvesting community exposition at a school or community center to highlight rainwater harvesting concepts. Youth can set up demonstrations to show components, processes, and applications for rainwater harvesting.
2. Schedule a rainwater harvesting demonstration day. Determine a rainwater harvesting site where, at a certain time, the public can view a rainwater harvesting system. Youth can explain how the system works and discuss benefits of rainwater harvesting.
3. Sponsor a community rainwater harvesting contest (see resources for the "Artistic Tanks" activity for ideas).
4. Landscape a school or community site using passive and/or active rainwater harvesting methods to reduce water runoff.

Source:

Developed by Alison Barrett, Former Instructional Specialist, Sr.
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Active Rainwater Harvesting – The process of collecting and storing rainwater in tanks or other containers for later use.

Aquifer – Any geological formation containing or conducting groundwater.

Berm – Mound of earth formed to control the flow of water.

Bunyip – Water-level tool for finding a landscape's contour, determining differences in elevation, and determining slope.

Cistern – Storage tank or underground reservoir for rainwater.

Condensation – Process of a vapor becoming liquid (the formation of clouds).

Contaminant – Impure, hazardous substance.

Downspout – Vertical pipe that drains stormwater downward from the gutters.

Drought tolerant – Ability of a plant to survive with little water.

Erosion – Process by which the surface of the earth is worn away by the action of water, glaciers, winds, waves.

Evaporation – Process of liquid water becoming a vapor.

Filter – Porous material through which a liquid or gas can pass through.

Flash Flood – Sudden and destructive rush of water down a narrow gully or over a sloping surface, caused by heavy rainfall.

French Drain – Gravel-filled hole or trench placed so that stormwater can seep in.

Gabion – Wire cage filled with rocks used to stabilize stream banks.

Gradient – The degree to which something inclines; a slope.

Gravity Flow – The use of gravity as opposed to a pump to move a liquid such as water.

Groundwater – Water that occupies the pores and crevices of rock and soil beneath the earth's surface.

Gutter – Channel along a roof's edge to catch and direct stormwater.

Hydrology – Science dealing with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.

Impervious – A material that does not allow water or other liquids to pass through.

Infiltration – Movement of water through the soil surface into the soil.

Monsoon - Seasonal pattern of wind and rainfall.

Mulch – Covering of material such as bark, wood chips, or gravel on top of the soil.

Nonpoint Source Pollution – Contamination of a body of water from a number of sources and locations.

Passive Rainwater Harvesting – Water collected and held in the soil.

Percolation – The movement of water through the soil to the water table.

Permeability – The ability of water or other liquids to pass through a surface.

Pervious – Material that allows the passage of water through it.

Pervious Pavement – Driveways, walkways and patios made with gravel, crushed stone, open paving blocks, or special porous concrete to allow water infiltration.

Point Source Pollution - Single, identifiable, localized source of contamination.

Pollutant – Any substance in air, water, or soil that may be harmful to the health of humans or other living things or may harm the environment.

Potable – Liquids considered safe for drinking.

Precipitation (in meteorology) – Water falling from the atmosphere as rain, snow, sleet, hail, or other form.

Rain Barrel – Container used to collect and store rainwater.

Rainwater Harvesting – Process of collecting and storing rainwater or stormwater for beneficial use.

Recharge – Process by which groundwater is absorbed into the zone of saturation.

Ridge – Long and narrow upper edge, angle, or crest of something, such as along the top of a mountain.

Rock Riprap – Blanket of graded rock placed on a shaped streambank surface which provides structural slope protection to slow or stop erosion.

Runoff – Something that drains or flows off, as with rain that flows off the land.

Runoff Coefficient – Estimated proportion of rainfall that becomes water runoff.

Saturation – Process or state that occurs when one substance is filled so full of another substance that no more can be added.

Soil – Composed of gravel, sand, silt, clay, organic matter, gases, and liquid.

Stormwater Runoff – Rainwater that hits the ground and flows over the earth's surface.

Surface Water – Water that collects on the ground or in a stream, river, lake, wetland, or ocean.

Swale – Shallow trough between two areas of higher ground.

Transpiration – Process in which water vapor is released from plants into the atmosphere.

Valley – Extensive, more or less flat, relatively low region between higher surfaces.

Wastewater – Discarded water.

Water Vapor – Water in a gaseous state.

Watershed – Area of land that sheds water and directs it downhill to a particular watercourse or point.

Xeriscape – Environmental design of land using various methods to minimize the need for supplemental water use.

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