STORMWATER IN THE DESERT

A Middle School Activity Book

Hey Teens!

Water is such an important resource, especially in the desert. We are just beginning to understand how to control, protect, and make better use of stormwater in our communities!

The Maricopa and Pinal Counties, the Arizona Department of Transportation, and more than twenty Central Arizona towns and cities have joined together to bring ***STORMWATER IN THE DESERT*** to teens just like you. The Central Arizona region, in the Sonoran Desert, includes the Phoenix metro area and the surrounding suburban and agricultural communities in the Valley.

Arizona STormwater Outreach for Regional Municipalities (or AZSTORM, for short) needs your help educating adults about stormwater here in the desert. You CAN make a difference! Middle school students have the math, science, writing, and computer skills to understand the complexities and concerns about stormwater. In ***STORMWATER IN THE DESERT***, you'll learn about and practice science concepts with the weather cycle, land topography, watersheds, stormwater, pollution, flood safety, and other topics. You can construct your own watershed, test a collection of surfaces, and try your hand at cleaning up polluted water! Also, venture into cyberspace with interactive stormwater games, exercises and links to useful websites.

Why is it important for us to understand stormwater in the desert? Our systems aren't perfect, and there is still great potential to improve how we plan and develop desert landscapes to more efficiently and safely direct our stormwater. As the future stewards of Central Arizona, you can acquire the tools to understand how your daily decisions impact our watershed, and encourage your parents to make positive changes. In fact, you can check out our water harvesting story to see creative ways you might store rainwater at home and school.

You can share us with your family and friends at www.azstorm.org.

Enjoy your new book! Remember…only rain in the storm drain!

Your AZ STORM Group!

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Stormwater in the Desert?

If you live in Central Arizona, you live in the desert. Specifically, your home is the Sonoran Desert. Like most deserts, it receives very little rainfall. However, Central Arizona cities like Phoenix, Chandler, Scottsdale, Tempe, Avondale, Fountain Hills, and other neighboring towns and cities receive around eight inches of rain each year, making the Sonoran Desert one of the wettest deserts in the world.

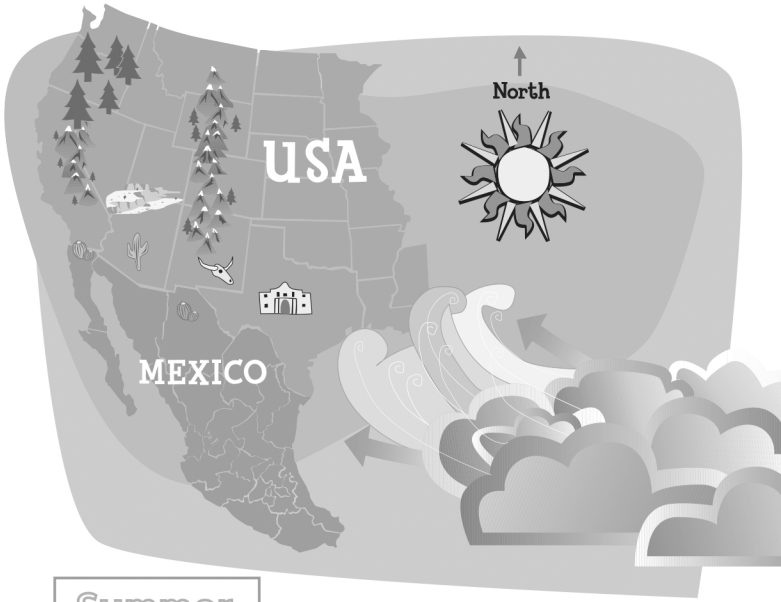
The Sonoran Desert has two distinct rainy seasons - one in the winter and one in the summer.

In the winter, our storms originate mostly in the northern Pacific Ocean. Winds carry these storms across the country from west to east. Rainfall from these storms is typically gentle, widespread, and may last for several days. Our summer storms are quite different. In the summer, the wind direction changes and carries moisture from the Gulf of Mexico and Gulf of California northward towards Arizona. Our hot summer temperatures cause this moisture to rise into the atmosphere where condensation forms clouds and generates thunderstorms. These storms can be intense. They are generated quickly and can move swiftly over the city, dumping large amounts of rainwater in a short period of time. Lightning and thunder often accompany these storms. We call our summer storms "monsoons" because they are caused by a seasonal change in wind direction.

A rainstorm in the desert is exciting! The air is filled with fragrant desert smells. Animals emerge from underground hiding places, and the normally dry, desert washes run with water. Once rain hits the ground and begins to flow, it is called stormwater.

(continued)

Winter



Summer

The stormwater flows over the desert and either seeps into the ground or is channeled into small washes. All around Phoenix and Central Arizona, the desert is patterned with washes, like the branches of a tree. Small washes flow into larger and larger washes. Because they drain a large area of land, these washes can fill quickly - sometimes in a matter of seconds. We call this rapidly rising water a ''flash flood.'' Eventually, the washes empty into one of the larger watercourses such as the Salt River, Gila River, and Agua Fria River.

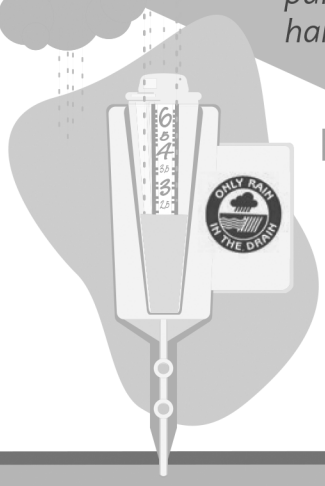
Rain in the desert is a valuable resource but is also a challenge.

In natural desert areas, stormwater follows these natural watercourses. However, houses, buildings and parking lots in Phoenix and its surrounding cities, with a connecting grid of streets, were built over the Sonoran Desert landscape and natural drainageways. While some of the natural drainage patterns still exist to convey stormwater, many are paved over with streets and parking lots. Although flooding is nothing new in these areas, the stormwater now lands on and flows over miles of pavement and acres of buildings. There is more stormwater runoff from these paved surfaces and less open ground for the water to seep in. Also, stormwater travels faster over concrete and asphalt than it does in the natural drainage systems.

Managing stormwater in Central Arizona is important to reduce flooding, keep people safe, maintain clean water, and to reduce soil erosion. The cities have built a system of streets, washes, channels, dry basins and stormdrains to manage stormwater and direct it to major watercourses such as the Salt, Gila, or Agua Fria Rivers. Because our stormwater drains from small washes to these larger watercourses, keeping stormwater clean is also important. The next time it rains, consider how the rain affects you. Do you want to go outside and play in the raindrops and puddles? Can you smell the desert plants? What happens to the streets in your neighborhood? Do you live near any washes that flow when it rains? Where does your stormwater go?

TRY THIS

Measuring Rainfall: *A rain gauge is a great way to measure and monitor the amount of rainfall you receive at your home or school. Rain gauges are inexpensive and can be purchased at your local hardware store.*



Rain Gauge

Get Online

• Go To: www.tucsonstormwater.com

Visit the City of Tucson's stormwater education online activity site. Click on ''Storm Maps'' and follow the instructions to see real weather maps depicting Arizona's winter and summer storm patterns.

• Also, visit the ''STORM: Only Rain in the Stormdrain'' website at **http://www.azstorm.org/faqs/storm-sewer-system**. Tons of cool facts and FAQs about stormwater!

ACTIVITY

Know Your Weather

How well do you know where you live and where your weather comes from?

Show what you know on the map below.

1) Draw arrows across the map to indicate the origin and wind direction of winter storms. Label these arrows "winter storms."

2) Draw arrows across the map to indicate the origin and wind direction of summer storms. Label these arrows "summer storms."

3) Fill in the blanks on the map using the labels from the box to the right.

North	Pacific Ocean
South	Mexico
East	Gulf of Mexico
West	Arizona
Phoenix	Gulf of California

Get Online

Go To: http://www.noaa.gov

Click on "Find Your Local Weather" and enter "Phoenix". Select "Phoenix, Arizona", and then "GO." Check out the current weather in Phoenix. On this web page, you can view the latest radar and satellite images, get local weather news and information, and learn more about the climate in Phoenix. This is Phoenix's local web page of the National Weather Service Forecast Office. The National Weather Service (NWS) is part of the National Oceanic and Atmospheric Administration (NOAA), and is the primary source of weather data, forecasts and warnings for the United States. Scroll around on the Home page to explore different climates around Arizona and United States, ocean sustainability, satellite information, and more!

Directions:

Look at each word in the list to the right, and write words that describe winter storms under the "Winter Storm Words" column. Write words that describe summer storms under the "Summer Storm Words" column. Some words might describe both. What other words describe our storms? There is space for you to add some words of your own!

Words to describe Central Arizona's rainstorms:

cool; flash flood; monsoon; drizzle; torrential; puddles; sudden; overcast; downpour; deluge, cloudburst; sprinkle; gentle; cold; misty; showers; thunder; intense; pouring; lightning; windy; thunderhead; violent; humid; prolonged; brief

Our winter rainstorms look, feel, and sound quite different from our summer rainstorms.

Winter Storm Words

Summer Storm Words

TRY THIS

Remembering Rain

On a separate sheet of paper, describe a rainstorm you remember. You might write in the form of a short story, poem or news report. Be creative with your description. Try to remember details of the storm and use descriptive words to portray the event.

The Water Cycle

The water cycle is the continual circulation of water from the earth to the atmosphere and back. This cycle occurs through specific processes and patterns based on the properties of water. Water can exist as either a solid, liquid or gas. In the water cycle, solid water exists as ice and snow. Lakes, rivers, oceans and rain are water's liquid form in the cycle. Water vapor is water in its gaseous form and, although you can't see it, is present in the air around us. Through such processes as evaporation, condensation, precipitation, and runoff, water is constantly moving from one form to another and from one location to another.

Evaporation is the process in which liquid water rises from the earth in the form of a vapor. Plants release water vapor, too, through their own process called transpiration. Evaporation is greater in warm, dry climates such as Central Arizona's than in a warm, moist climate like a tropical rainforest.

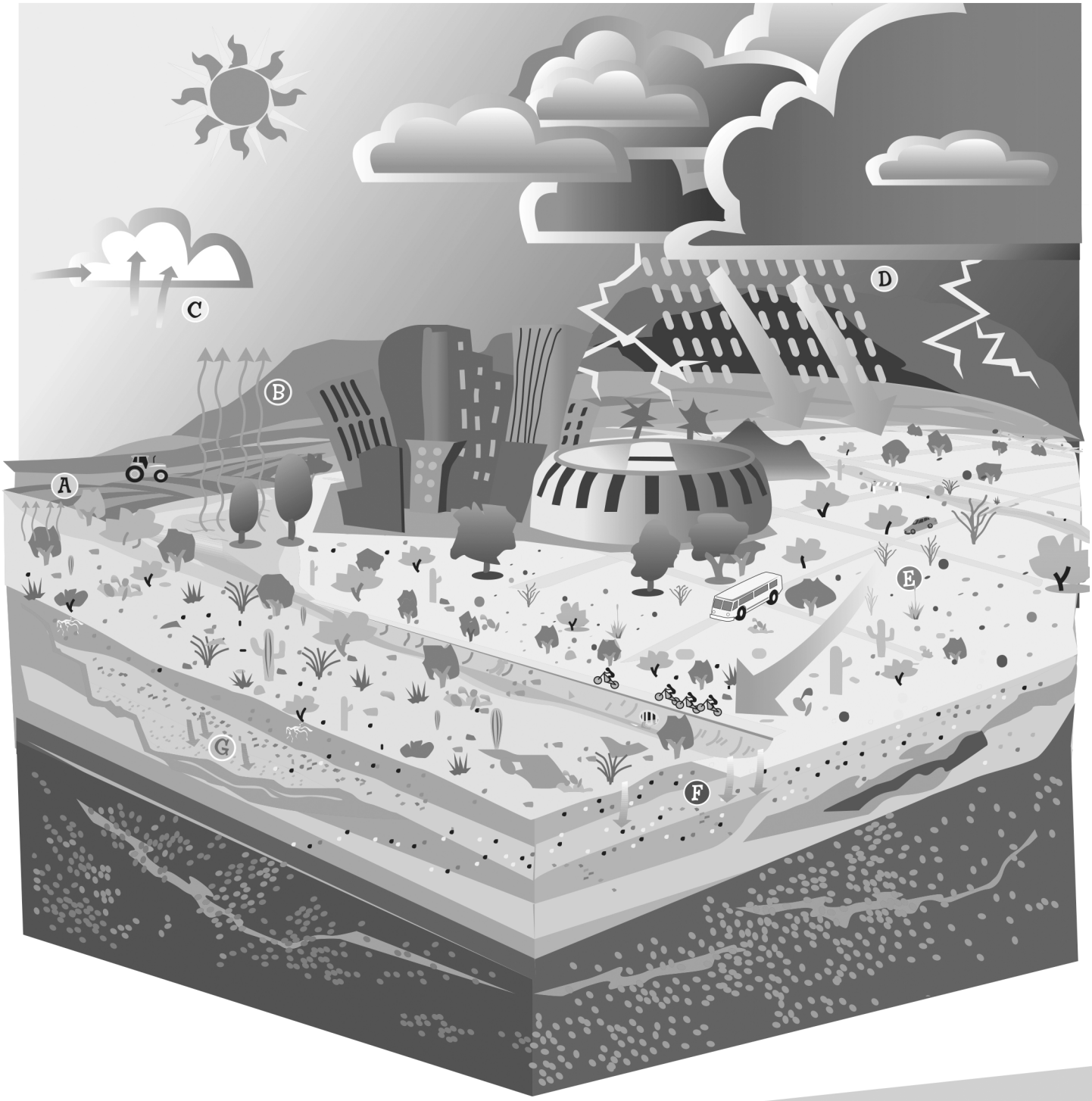
Once in the atmosphere, evaporated water vapor rises and may condense to liquid droplets, forming clouds. Summer monsoons in our desert cities provide a great opportunity to watch the buildup of clouds through condensation. Once clouds contain enough moisture, droplets collect into larger raindrops and become heavy - and then it begins to rain! Water falling from the atmosphere in the form of rain, snow, sleet or hail is called precipitation. In Central Arizona, our precipitation usually happens as winter or summer rains. Because of our warm climate, we rarely experience precipitation in its solid form of icy hail or snow. However, in the northern, mountainous regions around Prescott and Flagstaff, as well as to the south atop Mount Lemmon near Tucson, climates are colder and snow falls almost every winter.

ACTIVITY

Test Your Water Cycle Knowledge

Directions: To the right are some definitions which describe water cycle processes. Find the correct word for each definition, reading ahead or referring to the glossary if necessary. Next, identify which letter in the diagram is depicting each word. Write the letter in the space provided.

Water Cycle Definitions

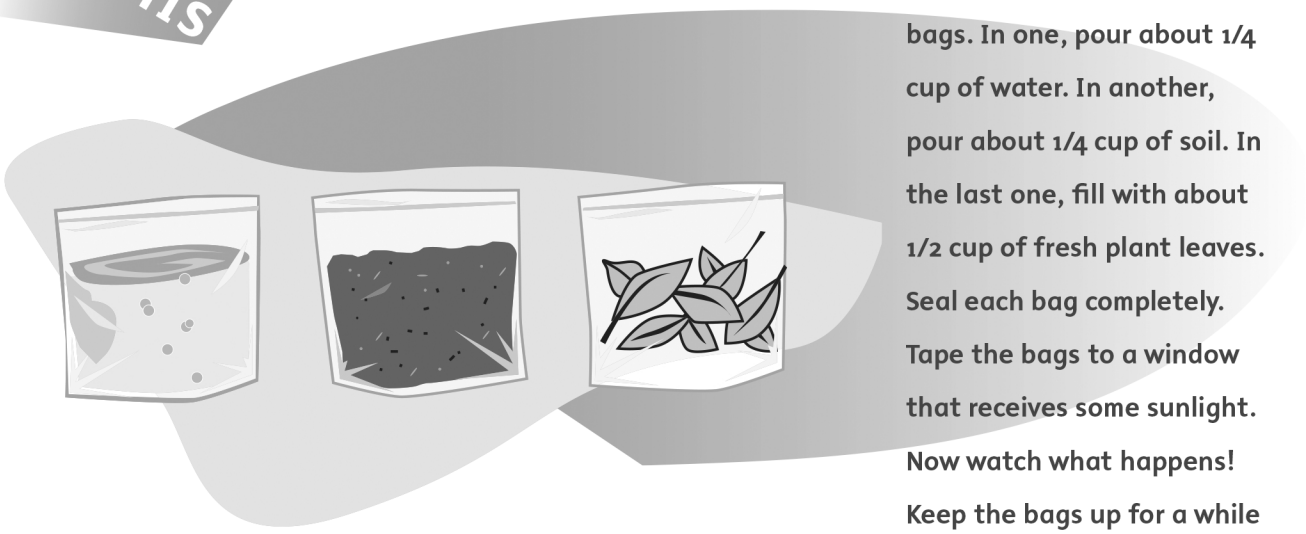


	Correct Word	Letter
1. The process of a vapor becoming liquid (the formation of clouds).		
2. The movement of water through the soil surface into the soil.		
3. The process in which water vapor is released from plants into the atmosphere.		
4. Rainwater that hits the ground and flows over the earth's surface.		
5. Water falling from the atmosphere in the form of rain, snow, sleet or hail.		
6. The process of liquid water becoming a vapor.		
7. The movement of water through the soil to the water table.		

When rainwater hits the ground, it becomes stormwater runoff, flowing downhill toward washes and rivers. Some stormwater seeps into the ground by infiltration. This water may evaporate from the soil surface, be absorbed by the roots of plants, or percolate deeper through the soil to the water table. The water table is where soil pores, or tiny spaces in between particles, are completely filled with water. All of this water moving through the soil is part of the water cycle. In many Central Arizona cities, wells are used to pump water from the ground for us to drink, use in our houses, water our plants, and fill our swimming pools. From the earth's surface, water continues to move through the never-ending water cycle of evaporation, condensation, precipitation, and stormwater runoff.

TRY THIS

Water Cycle in a Bag!



Want to see the water cycle happening? You will need 3 separate, sealable, plastic bags. In one, pour about 1/4 cup of water. In another, pour about 1/4 cup of soil. In the last one, fill with about 1/2 cup of fresh plant leaves. Seal each bag completely. Tape the bags to a window that receives some sunlight. Now watch what happens! Keep the bags up for a while and note the changes. What water cycle processes do you see? Are the processes different with each bag?

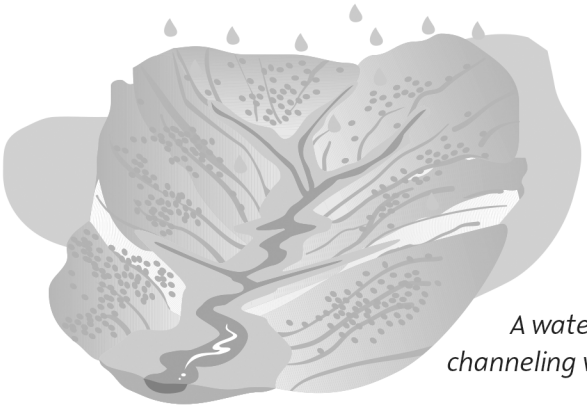
Get Online

Go To: http://ga.water.usgs.gov/edu/watercycle.html

Visit the U.S. Geological Survey's site that depicts the water cycle. Check out information on various topics by clicking on the features of their comprehensive diagram of the water cycle.

Know Your Watershed

Wherever you live, you are in a watershed. A watershed is an area of elevated land that sheds water and directs its flow downhill to a common watercourse, such as a river. The roof of a house is like a watershed because it directs the water that falls on its sloped sides. The peak of the roof divides the flow so that water is diverted in different directions. In nature, ridges and crests of higher ground along hills and mountains act like the peak of a roof. Ridges act like a funnel, directing the water down into the narrower parts of the canyons. These ridges form a ridgeline, or boundary, of a watershed.

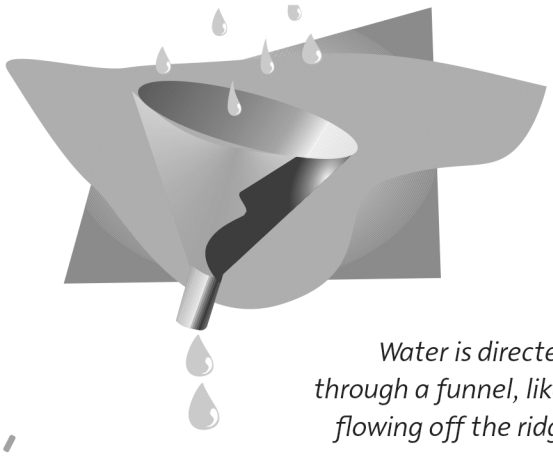


A watershed channeling water.

Watersheds exist on different scales. Big rivers like the Colorado River and Mississippi River collect their water from large, multi-state regions of the country and carry it to the oceans. Central Arizona is part of a watershed named the Salt River Basin, to the northeast of Phoenix. As the winter snowpack on the mountaintops within the Salt River Basin begins to melt, the water flows downward to the Black River and White River, the two main tributaries that converge to feed the Salt River. Around 160 miles downstream and to the west - and through several dams along the way - the Salt River reaches Phoenix. Its water is then diverted into canals that direct it to the cities surrounding Phoenix for residents' water needs. Central Arizona cities shed their stormwater runoff primarily to the Salt River. Eventually, the Salt River feeds into the Gila River (southwest of the cities) and then empties into the Gulf of California.

The Salt River Basin drains an area of around 5,980 square miles - that's a huge area! It includes the forested slopes of the Colorado Plateau, the western slopes of the White Mountains, the northern slopes of the Gila Mountains, and all of the land in between. It is bordered by several other larger watersheds, which can be made up of numerous smaller watersheds.

Watersheds channel our stormwater runoff and can also serve as a community's water supply source. Some of the stormwater runoff in our major rivers can also seep into coarse sand and gravel to recharge our groundwater supply. Watersheds are important (continued)



Water is directed as it runs through a funnel, like rainwater flowing off the ridges of a hill.

because conditions that affect the land surface in a watershed may have an impact on both the quality and quantity of water flowing from that watershed or seeping into the ground along the way. The surface of the ground over which the stormwater flows determines how fast the water will flow, whether or not it will soak in, what kind of debris and pollutants the stormwater might pick up, and the health of the environment downstream. Because water is scarce in the desert, it makes sense to be aware of and take care of our watersheds.

TRY THIS

Build a Watershed

To build a watershed, you'll need to find a sheet of heavy paper (cardstock is a good option) to first build a mountain. Crumple the paper into a ball, then unfold and form into the shape of a mountain. Your mountain should be around 3-5 inches high and as realistic as possible with ridges and valleys. Set your mountain on a cookie sheet or heavy foil pan. Next, fill a spray bottle with water and set aside. Using a tube of tempera paint, squeeze paint along the ridgeline (the very top) of your mountain. Now, make it rain! Spray "rain" from the water bottle as evenly as possible atop your mountain. Note the paths your rain takes as it runs off the mountain.

- Can you see how your mountain "sheds" water?
- Where is the water flowing? Along the high or low points on the slope?
- How many watersheds did you create?
- Can you outline each specific watershed by following the ridgelines around it?

Here's a Challenge: Group several paper mountains together, each with different heights and shapes. Connect with tape to form valleys.

Make it rain again.

Can you form a river?

Create your own watershed with paper

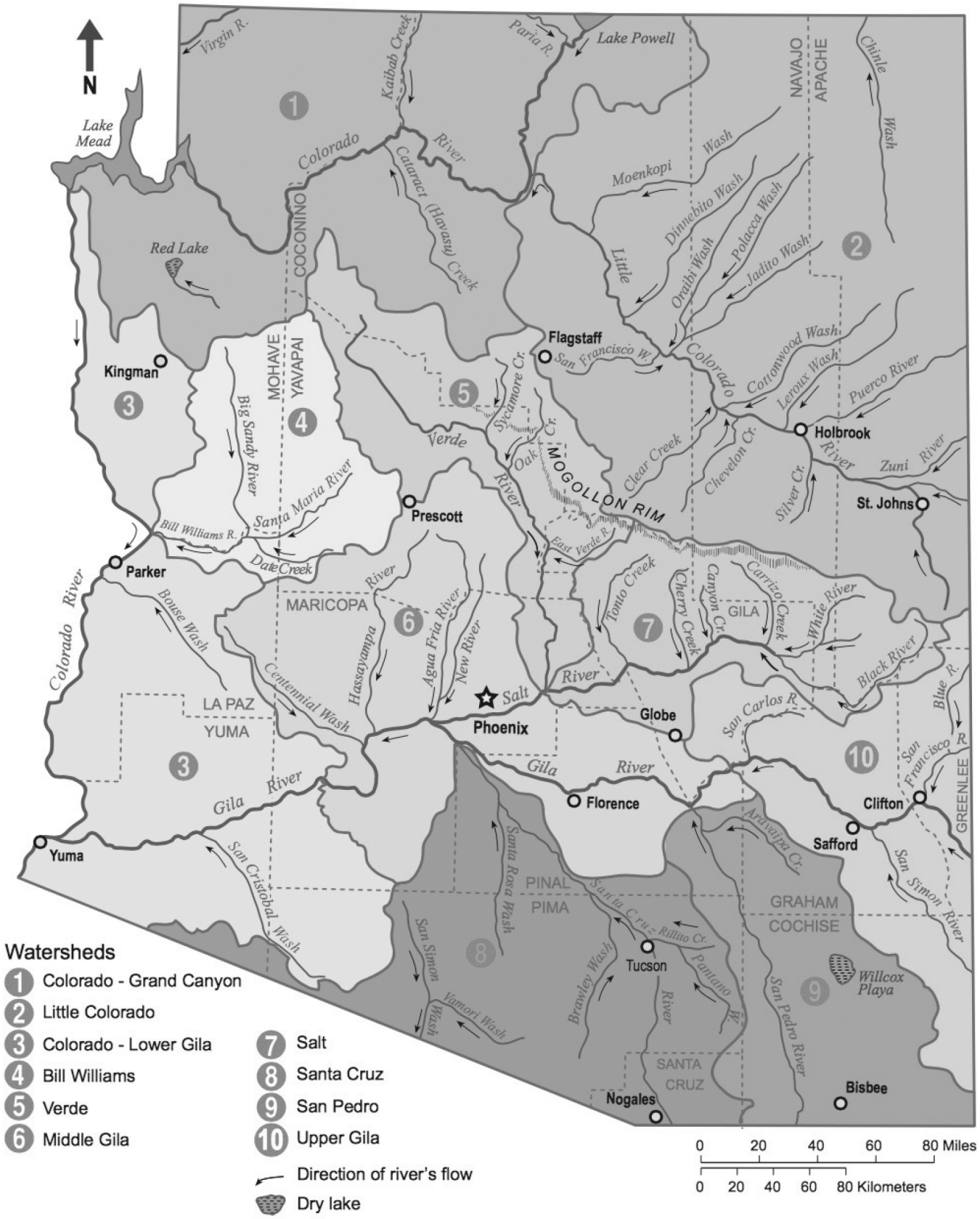
Get Online

• Go To: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=maps

Visit the University of Arizona's "Arizona NEMO" water education site. This page lists maps of the watersheds for the different counties in Arizona. For Phoenix, click on "Maricopa County Watershed Map", then select "large jpg". Locate the different cities in and around Maricopa County. How many watersheds are found within Maricopa County? Do you see any mountain ranges that you might recognize? Here's another challenge: You can also check out watershed maps for other counties in Arizona. Can you find the Grand Canyon's watershed?

GOING FURTHER: Explore Arizona NEMO! Click on the categories at left to learn about watershed mapping, stormwater, groundwater, and other cool water facts!

Arizona's Watersheds



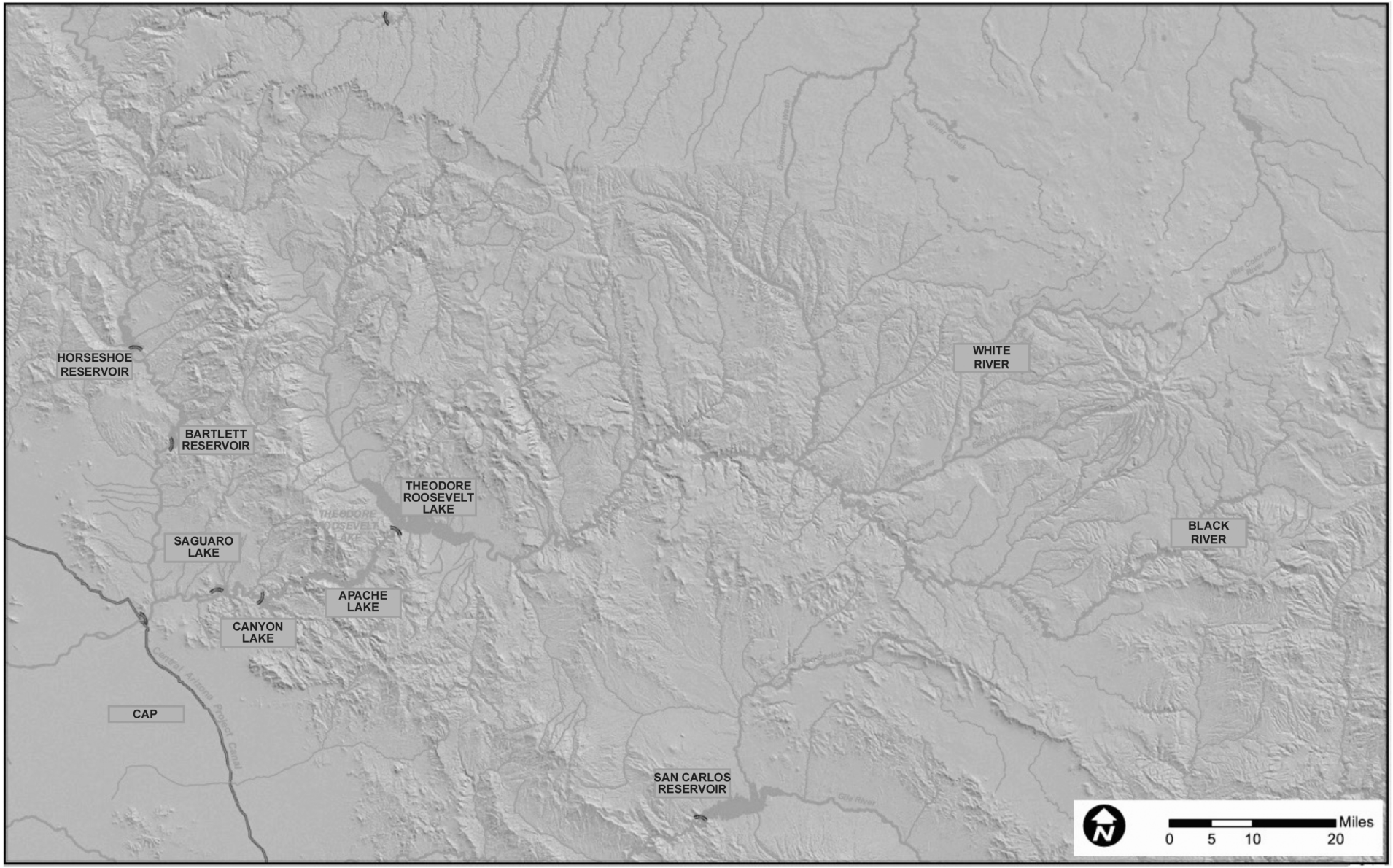
Watersheds

1. Colorado - Grand Canyon
2. Little Colorado
3. Colorado - Lower Gila
4. Bill Williams
5. Verde
6. Middle Gila
7. Salt
8. Santa Cruz
9. San Pedro
10. Upper Gila

Direction of river's flow

Dry lake

Courtesy of Salt River Project



Courtesy of Salt River Project

Mapping the Salt River Basin Watershed

Locating the Watershed That Supplies Phoenix

How Do You Map a Watershed?

Gather the following colored pencils: red, green, blue, orange, and purple. Use the map above to trace the waters in the steps below.

1. Locate Theodore Roosevelt Lake and notice the dam on its southwest side. Trace the main part of the Salt River below (southwest of) the dam in red. This is the path water takes into Phoenix.

2. On the Lake's eastern edge, you'll see the Salt River feeding into it. Trace the Salt River northeast to where it begins (where the White River and Black River converge near the right edge of the map) in red.

3. What are main tributaries? A river's main tributaries are small streams or rivers that converge with and flow into a larger stream or main river, such as the Salt River. The Salt River's main tributaries "feed" directly into the Salt River. Now, trace all of the Salt River's main tributaries in green.

4. Trace the secondary (smaller) tributaries in blue that branch off the main tributaries (already in green). All of the rivers connected to the Salt River should now be colored showing the extent of the Salt River Basin Watershed.

5. Using the orange pencil, draw a dot at the end of each main and secondary tributary (already in green or blue).

Time To Predict!

Look over your tracings and dots. Which way is the Salt River flowing? Can you predict the boundaries of your watershed? What elevation of land do the orange dots represent? Which way is downhill?

6. To define your watershed, connect the dots! Starting at the Central Arizona Project Canal (CAP) southwest of Theodore Roosevelt Lake and moving clockwise, use the purple pencil to draw lines and connect the orange dots. Keep going until you circle back to the CAP.

AMAZING WORK! You've now mapped the Salt River Basin watershed! The orange dots represent the highest mountain ridges where tributaries begin. Water from rain and snowfall then flow downhill through these tributaries to the Salt River, which then flows southwest to be diverted in Phoenix.

Watersheds: Expand Your Thinking

Using the Arizona watersheds map on page 11 and your mapped Salt River Basin watershed, think about the following questions. You may have to do some online research!

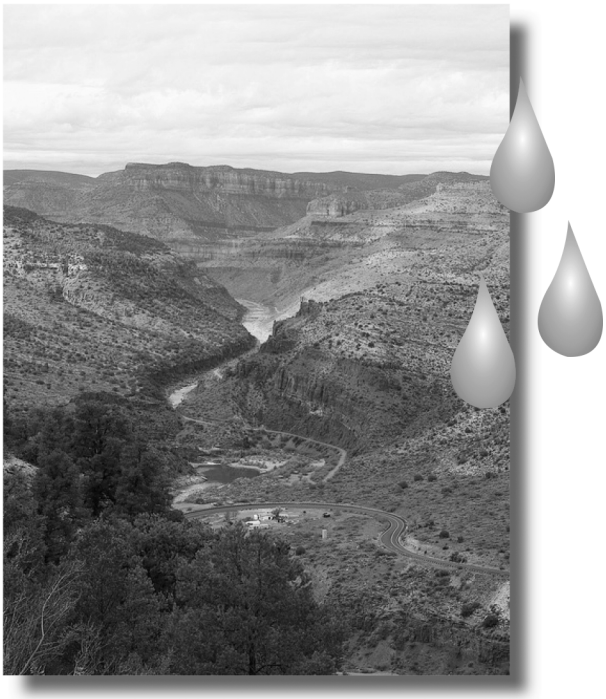
1. What are the neighboring watersheds that border the Salt River Basin watershed? Use the map on page 11 as a resource.

2. Looking at your mapped watershed, can you tell which directions are at higher and lower elevations? Is Theodore Roosevelt Lake higher or lower than the east end of the watershed?

3. Another water source for Central Arizona is the Central Arizona Project Canal (CAP). Where is the water source for the CAP? Which direction does the water in this canal flow?

4. Why is the amount of snowfall in the winter time essential for our water supply year-round?

5. What are some environmental benefits (upsides) and costs (downsides) of water retention, such as dams and man-made lakes?



6. Considering the watershed as being a major source of water for Central Arizona, explain how a pollutant would affect locations along the watershed.

7. How are watershed health, water cleanliness, and the 3R's (Reduce/Reuse/Recycle) related?

Stormwater Cross Word Search

Directions: Using the crossword clues and glossary, complete the crossword puzzle within the word search. When you have filled in all the letters on the puzzle, search for the words from the word search list. Look closely - some may be spelled backwards!

C	J	B	Y	1					G	U	L	F	O	F	C	A	L	I	F	O	R	N	I	A
S	P	D	D		G	P	O	O	P	J	R	S	V	O	K	R	R	D	W	Q	B	J	G	O
A	A	2				K	D	X	3	U	D	D	L	E	S	W	E	P	T	A	W	A	Y	G
S	C	R	H		J	R	W	B		T	4	U	M	M	E	R	M	V	W	O	H	G	Q	K
C	I	Q	M	5			6								S	Z	I	W	I	P	N	C	W	J
E	F	Q	A		A	I		B		S		S	B	K	E	H	C	E	G	R	D	K	Q	G
R	I	Q	B		C	N		D		W		B	7	L	O	W	R	G	A	V	T	K	A	T
D	C	8	W		H	G		C		B		K		R	W	Q	O	D	Z	M	O	L	Q	R
C	O		W		E	A		V		K		E		H	D	D	B	D	W	9	L	A	A	E
W	C		S		M	U		S	10						11							N	L	S
L	E		L		I	G		T		K		B		G		A	S	Y	N		T	D	W	E
E	A		E		C	E		W	S	V		A		W		I	I	U	J		S	S	T	D
C	N		N	Q	A	D	E	D	D	G		T		G		N	N	W	Q		D	C	J	N
C	Y		N	T	L	M	I	B	C	F		E		A		A	S	B	I		V	A	X	A
V	C		A	R	S	U	S	G	K	H		L		I		G	T	L	S		W	P	12	R
A	S		H	W	Q	W	Q	X	S	B		F		J		E	Y	13	K	T	R	E		O
14													C	F		W	R		I	N	M	R		N
H	E	J	L	S	W	N	R	Q	F	L		T	B	N		S	L		P	E	O	Q		O
O	T	W	R	D	F	T	G	S	U	R		A	C	E	15									
E	T	W	T	U	H	E	D	C	S	T	G	Q	K	L		T	C		S	D	S	R		A
N	U	16															E		D	Q	T	G		K
I	G	A	G	U	L	F	O	F	M	E	X	I	C	O	R	Y	W		A	H	U	L		U
X	D	S	F	17																	R	Y		I
F	E	H	T	N	K	W	S	A	G	T	W	Q	C	B	P	I	R		Y	T	E	N	L	G

Word Search List

RAIN
FLOW
PHOENIX
WASH
PACIFIC OCEAN
SONORAN DESERT
SALT RIVER
SUMMER
WINTER
GULF OF CALIFORNIA
GULF OF MEXICO
SURFACE
PUDDLE
LANDSCAPE
LIQUID
GALLON
RAIN GAUGE
CHANNEL
SWEPT AWAY
MOISTURE
DRAINAGE
DRIP
DOG POOP
CHEMICALS
TRASH
GUTTERS
MICROBASINS

Crossword Clues

Crossword Clues

Across

1. A white or gray mass in the sky that is made of many very small drops of water
2. Continual movement of air over the earth from high to low pressure
5. The process of liquid water becoming a vapor
10. The process in which water vapor is released from plants into the atmosphere
14 Water falling from the atmosphere in the form of rain, snow, sleet or hail
15. Not allowing water or other liquids to pass through a surface
16. Collecting and putting rainwater or stormwater to beneficial use
17. An estimated proportion of rainfall that becomes stormwater runoff

Down

1. The process of water vapor becoming a liquid (the formation of clouds)
3. The movement of water through the soil to the water table
4. Rainwater that hits the ground and flows over the earth's surface
6. Allowing the passage of water or other liquids through a surface
7. Rapidly rising water in a wash or river that is usually caused by heavy rainfall
8. The continual sequence of water passing from vapor in the atmosphere to precipitation upon land or water surfaces and ultimately back into the atmosphere as a result of evaporation and transpiration
9. A seasonal pattern of wind and rainfall
11. The movement of water through the soil surface into the soil
12. Any substance in air, water, or soil that may be harmful to the health of humans or other living things, or that may harm the environment
13. An area of land that sheds water and directs it downhill to a particular watercourse or point

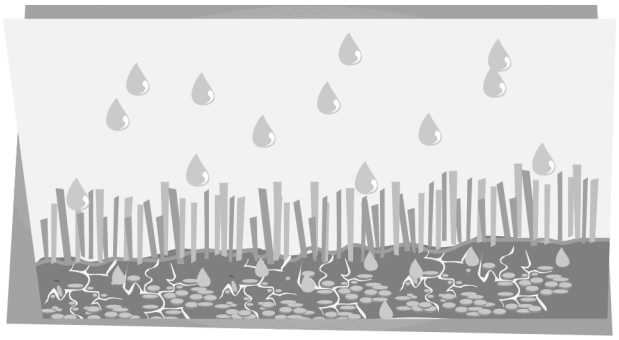
When Water Comes to Town – What Happens?

When it rains, stormwater either seeps into the ground or flows away depending on the kind of surface upon which it lands. Water infiltrates pervious ground surfaces such as grass lawns, sand, gravel and other soils. Areas with this type of covering are porous and act similar to a sponge to soak up much of the rainwater that lands on them. Impervious surfaces, such as concrete, asphalt pavement, metal, and rock don't allow water to penetrate, and stormwater flows off of them.

Rainwater that hits the ground and flows away is called stormwater runoff. When it rains, there is more stormwater runoff from impervious surfaces than from pervious ones. But, even pervious surfaces cannot absorb all the water that falls during a rainstorm. When soil pores become filled with water, the rest of the rain that falls on the ground runs off.

Runoff from pervious surfaces happens slower because of absorption, surface roughness, and vegetation. Runoff is faster from impervious surfaces because they prevent infiltration, provide a smooth surface for flow, and move water directly downhill.

In natural desert areas, rainwater usually falls on ground surfaces that are somewhat pervious. Much of the stormwater that soaks into the ground nourishes desert plants. Stormwater runoff flows to natural drainages that convey stormwater to larger washes and eventually to rivers.



Water soaks into pervious surfaces.

Water runs off impervious surfaces.

When it rains in Central Arizona, on what kind of surface is the rainwater most likely to fall - pervious or impervious? Rainwater that falls in cities usually lands on impervious surfaces such as streets, parking lots, and rooftops. The amount of stormwater runoff can be large enough to cause flooding. In most cities, including Phoenix, streets, stormdrains, and washes are used to convey stormwater runoff away from areas where it might damage property or make travel difficult. However, as cities continues to grow, more and more impervious surfaces are built and the amount of stormwater runoff increases. An important job of our city governments is managing our stormwater runoff to prevent flooding.

There are many things we can do to reduce stormwater runoff. We have control over the kinds of surfaces we install around our homes! Instead of paving driveways and patios, we can use alternative, pervious surfaces such as gravel, crushed stone, or open paving blocks. We can also build small channels to direct stormwater to our plants. We can even harvest (collect and store) stormwater for future use. Everyone can help reduce the amount of stormwater runoff!

Microbasins capture runoff and allow water to seep into the soil.

ACTIVITY

Calculating Runoff

You can calculate the amount of runoff from a particular place if you know three things (variables):

- The surface area of the place receiving rain
- The amount of rainfall (in gallons per square foot)
- The runoff coefficient for the type of surface

The formula for figuring out how much runoff will come from a particular area is:

$$V = A \times R \times Cw$$

Where:

V = runoff volume

A = area

R = rainfall amount (in gallons per square foot)

Cw = runoff coefficient

Note: To convert inches of rainfall to gallons per square foot, multiply the amount in inches by 0.623 (gal/ft^2) /inch.

Average Rainfall for PHOENIX AND SURROUNDING CITIES IN CENTRAL ARIZONA

Month	Inches
January	0.91
February	0.91
March	0.98
April	0.28
May	0.12
June	0.4
July	1.06
August	0.98
September	0.63
October	0.59
November	0.67
December	0.87
Total	**8.4**

What is the Runoff Coefficient?

The amount of water that will run off a particular surface differs depending on the surface. Pervious surfaces soak up rainwater. Impervious surfaces shed rainwater. To take this effect into consideration when calculating runoff volumes, a runoff coefficient (Cw) is used. The runoff coefficient tells us what proportion of the rainfall will run off from a specific surface. A higher runoff coefficient represents a less pervious and more "slick" surface. Some runoff coefficients are listed below:

soccer field: Cw = 0.17 (This relatively low runoff coefficient indicates a fairly pervious surface which will allow a lot of infiltration.)

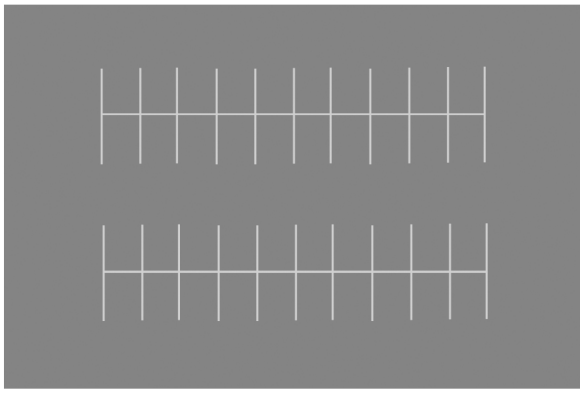
asphalt: Cw = 0.9 (These relatively high runoff coefficients indicate very impervious surfaces which will shed 90% of the water.)

gravel: Cw = 0.65 (Bare ground usually has a mid-range value.)

rooftop: Cw = 0.9

Directions: The diagram below represents an **asphalt parking lot** at your school. How much water runs off of this area during the month of June in an average year?

Scale 1''= 30'



1. Use a ruler to measure sides of the space in the diagram.

Length = _____inches

Width = _____inches

2. Calculate actual size using the scale provided.

Length = _____feet

Width = _____feet

3. Calculate surface area of the space (A) using the formula A= L x W. (Remember your units!)

_____ = _____ x _____
area length width

A = _____ ft^2

4. Use the rainfall table to determine the rainfall amount in inches.

June rainfall = _____inches

5. Convert the rainfall amount (R) from inches to gallons per square foot (gal/ ft^2)/inch.

_____inches x 0.623 (gal/ ft^2)/inch = _____gal/ft^2

R = _____ gal/ft^2

6. Select runoff coefficient (Cw) for this surface.

Cw = _____

7. Use the formula V = A x R x Cw to calculate the volume (V) of runoff.

_____ = _____ x _____ x _____
V A R Cw

V = _____ gal

8. Now suppose this same space is a **soccer field**. Repeat the steps above to calculate the amount of runoff (V) from this area during the month of **June** in an average year.

_____ = _____ x _____ x _____
V A R Cw

V = _____ gal

9. Which variable do you have to change and why?

_____

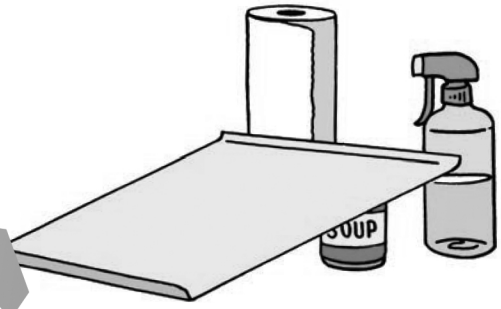
10. Is there more runoff from a soccer field or a parking lot?

_____

Get Online

Go To: http://water.usgs.gov/edu/activity-howmuchrain.html

Experiment with the USGS Water Science School's rainfall calculator and find out how many gallons of rainwater can fall where you live! Enter the size of your property and inches of rain and be amazed! You can also test a football field, your neighborhood park, or your entire city. That's a lot of stormwater! Afterwards, scroll to the left menu bar and click on "How much water does a dripping faucet waste?" Make a prediction, plug in the numbers, and see how close your prediction was!



TRY THIS

Raindrop Races

On which surface will drops flow the fastest? Test pervious and impervious surfaces using a cookie sheet, a soup can, a paper towel, tape, and a spray bottle filled with water. Prop your cookie sheet on your can so it is resting at an angle. On one side, lightly tape a paper towel to the cookie sheet. The cookie sheet will act as a city landscape with hard, impervious surfaces like sidewalks and streets, and the paper towel will represent pervious surfaces such as soil. Get a friend and make predictions - on which side will the water flow the fastest and how long will it take for the raindrops to reach the bottom of the cookie sheet? Race your drops and find out! Start your rainfall by evenly spraying water onto the top of the cookie sheet, counting the sprays. What happened to the rainwater? Which type of surface allows faster flow of the rain? What was your number of sprays before the rainwater reached the bottom of the cookie sheet on the impervious side? Pervious side? How do you explain the differences? *(Adapted from Maricopa County Environmental Services and STORM's* ***We All Live In a Watershed*** *activity.)*

Extension – Twinkie Trials

How pervious is snack food? Get some colored Kool-Aid or juice and try dropping drops onto a Twinkie, piece of bread, banana slice, marshmallow, cracker, piece of cheese, and a fruit roll-up. On which of these will the drops soak in the fastest? Will a drop run off of any of these? Make your predictions and test your theories. Choose other snack foods. Have fun eating your test results!

ACTIVITY

Central Arizona Homes- Pervious and Impervious Surfaces

The scene below shows a typical Central Arizona home. What do you think will happen to rainwater when it lands on this house and yard? In the list of surfaces, write whether you think the surface is pervious (soaks up water) or impervious (sheds water). After you complete the list, choose 3 surfaces you have identified as impervious and write what might be done to create a pervious alternative. Your goal should be to install pervious surfaces that will help the water infiltrate and reduce runoff.

Surface	Pervious or Impervious
parking area	
grassy play area	
sidewalk	
soccer field	
basketball court	
rooftop	
desert landscape	
driveway	
patio	
street	

Changes you can make so this yard soaks up more rainwater:

Surface	Changes that can be made
1)	
2)	
3)	

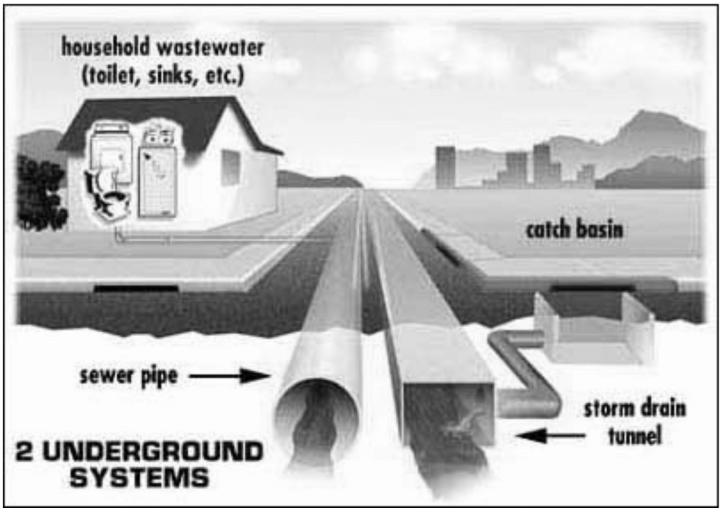
When Water Comes to Town

Where does it go?

Central Arizona cities have two types of drainage systems: wastewater and stormwater.

The wastewater system, or ''sewer system'', carries household wastewater (from sinks, showers, and toilets) through underground pipes to a treatment plant, where it is cleaned to standards that protect public health. Once treated, this ''reclaimed'' water can be reused to irrigate landscaping at schools, parks, and golf courses. Reusing our wastewater helps save our valuable drinking water.

Our stormwater system includes gutters, streets, and a network of underground storm drains, culverts, and washes that channel untreated rainwater into rivers, washes, and basins. All of these features ultimately direct stormwater to the Salt River, Agua Fria River, and Gila River. Stormwater is not sent to a treatment plant as our wastewater is - it goes directly from our streets and storm drains to our washes and rivers.



Without stormwater management, Central Arizona cities would experience serious flooding with almost every rainfall. Buildings, parking lots, and many other impervious surfaces make it impossible for runoff to soak in and cause water to run off faster. Because of so many impervious surfaces and without proper drainage, there would be standing water on most streets and transportation would be difficult. Standing water can also result in more mosquitoes and other unhealthy problems.

Get Online

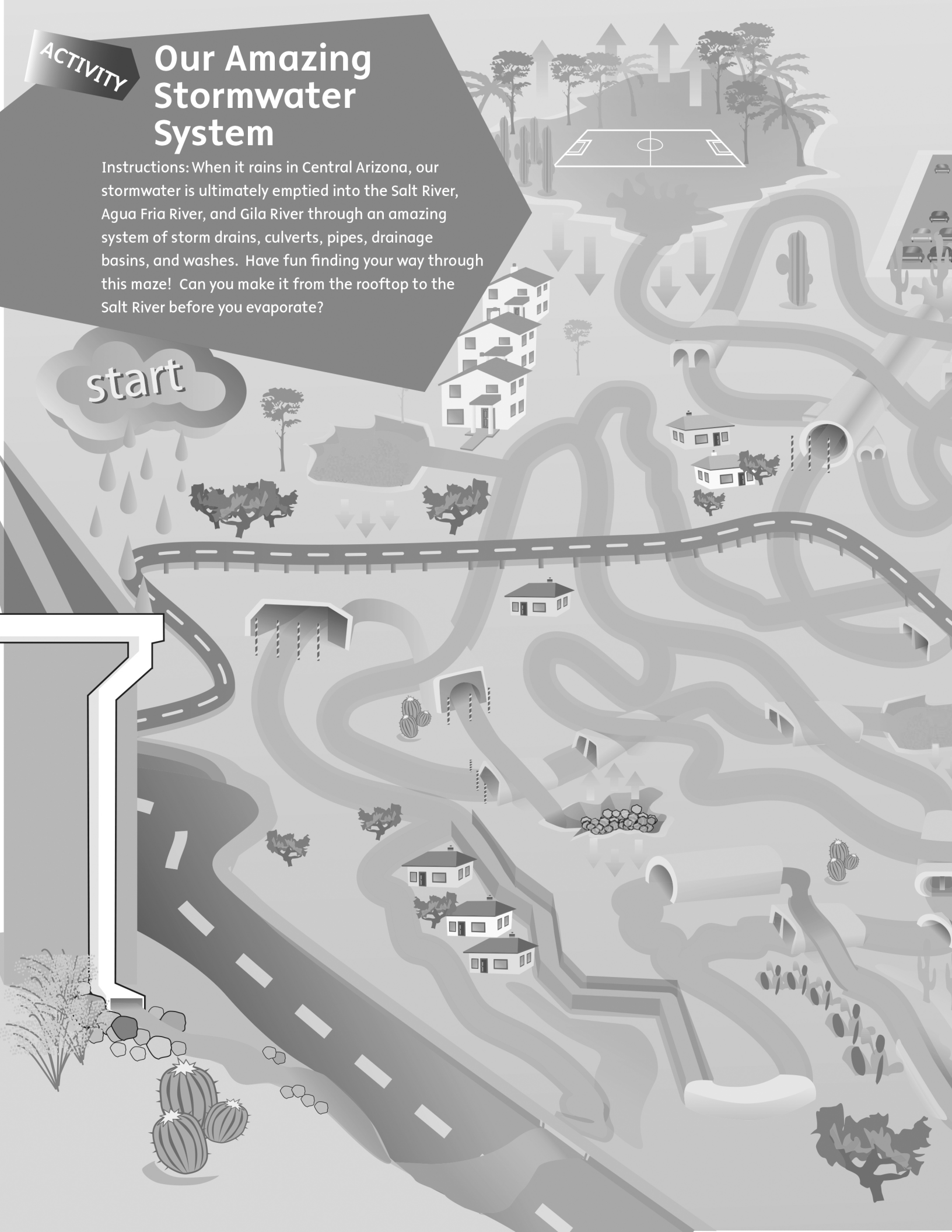
Go To: https://www.phoenix.gov/waterservices/envservices/stormwater-program/interactive

The City of Phoenix offers a cool interactive stormwater site! Click on ''Let's Get Started!'', and then choose ''Residential''. Read more about the sanitary sewer and storm drain systems by clicking on the raindrops above the manhole and storm drain. Other raindrops will tell you more easy ways to keep our stormwater clean.

ACTIVITY

Our Amazing Stormwater System

Instructions: When it rains in Central Arizona, our stormwater is ultimately emptied into the Salt River, Agua Fria River, and Gila River through an amazing system of storm drains, culverts, pipes, drainage basins, and washes. Have fun finding your way through this maze! Can you make it from the rooftop to the Salt River before you evaporate?



finish

Keep Our Stormwater Clean!

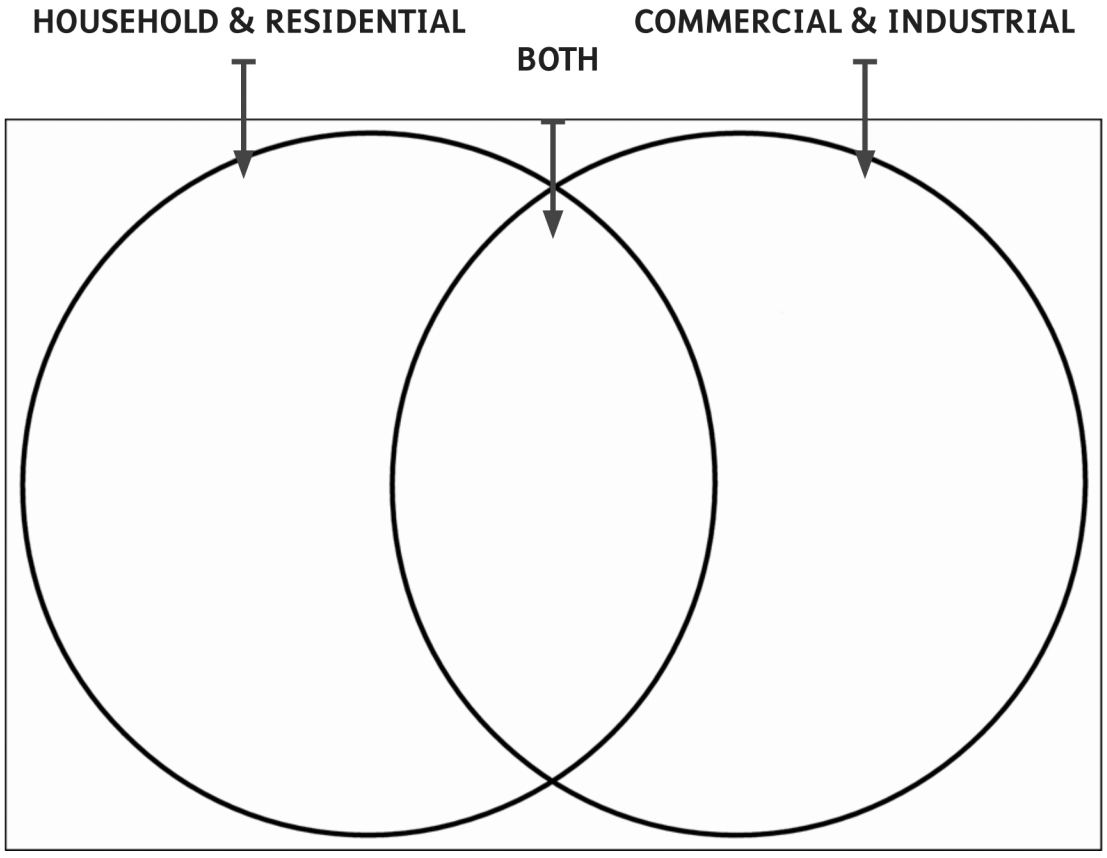
Central Arizona's stormwater management system effectively channels stormwater to our washes and rivers. Along the way, stormwater travels over streets, yards, driveways, sidewalks, parks, and parking lots. Stormwater also runs off commercial and industrial properties including construction sites, gas stations, auto shops, factories, stables, skate parks, movie theaters, and shopping malls.

ACTIVITY

Pollutant Identification Exercise

Below is a list of pollutants found in stormwater when pollution is not prevented. Try your hand at categorizing them in the Venn Diagram according to their source: Household & Residential, Commercial & Industrial, or both. Some of these could be tricky!

motor oil
trash
plant clippings
pesticides
detergents
weed killer
dog poop
plant fertilizer
construction debris
antifreeze
cleansers and cleaning fluids
paints
chemical solvents
scrap metals
gasoline



Get Online

Go to the Environmental Protection Agency's website at **https://watersgeo.epa.gov/mywaterway/** to find out what types of pollutants are found in your city's main waterway. Click on "Choose A Location" and type in your city and state. Then, choose a waterway listed (such as the Salt River), and check out pollutants that have been found in the river's water! You can plug in other cities or locations around the U.S.

What happens to these pollutants? They are untreated, and wash away by stormwater into our washes and rivers! Most chemicals and trash carried away by stormwater are not natural to our desert environment and not only are these pollutants unsightly, but some of them can be toxic, even in small amounts.

Consider tadpoles who hatch and swim in the temporary pools of stormwater. Doves and quail drink from puddles after a rain, and rabbits nibble on plants that grow in and around our washes. Bats soar in the evening, feeding on insects hatched in pools of stormwater. What would happen if stormwater brought pollutants like motor oil, battery acid, or pesticides into these parts of the environment? Gross! Can you imagine being one of these creatures and swimming in all the stuff that's on our streets? And pollution not only affects our natural washes and rivers, but can seep into the water we use every day - including our drinking water! Where do the pollutants come from? Leaky cars, animal poop, household chemicals, yard clippings, tree branches, and even our trash contribute to stormwater pollution if not properly handled. Factories, power plants, and businesses that generate large amounts of chemical and waste pollution are required by law to use controls to prevent pollution. Here's the cool thing - YOU CAN HELP, TOO! What we do around our homes, at school, at work, and in our communities can improve stormwater quality and protect the environment.

It's not difficult to prevent stormwater pollution. To begin with, reducing stormwater runoff by installing pervious surfaces or rainwater harvesting systems can make a huge difference. We can help our families control the materials that pollute stormwater. We can tell others about the issue.

Can You Reverse Pollution?

ACTIVITY

Ready to try your hand at reversing pollution? Grab the following items at home: plastic bucket or dishpan filled with clean water, wooden spoon, household trash items (such as paper, plastic wrap, banana peel, pencil shavings, aluminum foil, styrofoam, etc.), vegetable or motor oil, handful of flour, soil or dirt, tongs, strainer, and other needed tools. BE SURE TO ASK A PARENT BEFORE DOING THIS EXPERIMENT - IT CAN GET MESSY! One by one, "dump" the trash items, oil, and dirt into the clean bucket of water. These items represent trash, toxic chemicals, and sediments that are found in our stormwater runoff. Swirl around with a long spoon and let sit for a few minutes. Now, use kitchen tongs, strainers, and other gadgets to "clean" up and return the water to its original clean and clear state. Can you do it? What's your conclusion? How does this relate to stormwater pollution on a large scale?

TRY THIS

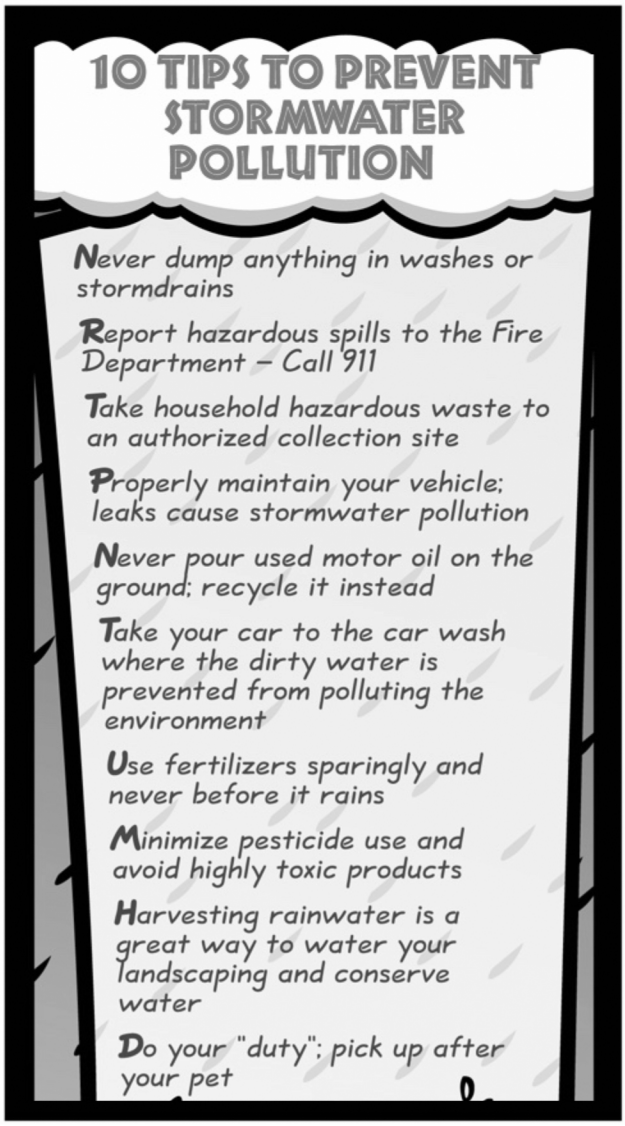
Get Proactive in Preventing Pollution!

Act it! Get a group of friends together and record a PSAV (Public Service Announcement Video) using your Smartphone or video camera. What ideas about stormwater and pollution can you share with your class or community? Research, brainstorm, and get dramatic! Share with your teacher and neighbors, or post on social media (make sure its okay with your friends).

Create it! Explore around your school campus or neighborhood and collect trash, being careful to avoid sharp glass or dangerous items. Design a poster with a catchy slogan about preventing pollution, and glue the trash to the poster. Display in your school, neighborhood center, or local coffee shop.

Adopt it! Consider adopting care for a street in your community through the Adopt-A-Street program. Adopt-A-Street allows organizations, businesses and individuals to help maintain and beautify Phoenix streets by volunteering to remove trash and debris four times per year. In recognition of the cleanup efforts, the City will customize and install signs crediting participants for their commitment to the program and community. Visit the City of Phoenix website at **https://www.phoenix.gov/streets/neighborhood-matters/adopt-a-street-program.** The City of Tempe has a cool video about adopting; go to **http://bit.ly/25k41QG** (web address is case sensitive) video and check it out. Neighboring cities also offer street and park cleanup programs. Visit your city's website to adopt!

Design it! Use your imagination to design the most eco-friendly and minimally pollutive home as possible. Using graph paper, draw out a home for a family of four and consider the following aspects: How big would the rooms be? Would the house be heated and cooled? How much direct sunlight would enter the house? How high would the ceilings be? What materials would the house be built of? How could



family members reduce their waste and reuse and recycle more? How could water be conserved? What types of landscaping and tree shade would there be? How would you design and implement pervious and impervious surfaces for safe and efficient stormwater runoff? Feel free to research online! Share your creation!

Pitch it! Create an incentive program for residents of your community or students at your school for reducing pollution. What types of things would encourage people to reduce trash and chemical pollution and promote a cleaner environment? Write a proposal to your state government or school principal and see what happens!

ACTIVITY

Jumbled Pollutants

Unscramble the words to reveal some pollutants that can be transported by stormwater to our washes. Then unscramble the circled letters to discover the secret message below.

ILO _ _ _

SREEGA _ _ _ _ _ _

NATIP _ _ _ _ _

ODG OPOP _ _ _ _ _ _ _ _ _

DICESSETIP _ _ _ _ _ _ _ _ _ _

PARSY SNAC _ _ _ _ _ _ _ _ _

ARC TREESTAIB _ _ _ _ _ _ _ _ _ _ _ _

ARNID LERACEN _ _ _ _ _ _ _ _ _ _ _

SLEDOHUHO TESSAW _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Secret Message:

_ _!

Get Online

Log on for cool stormwater videos and links from Central Arizona Cities!

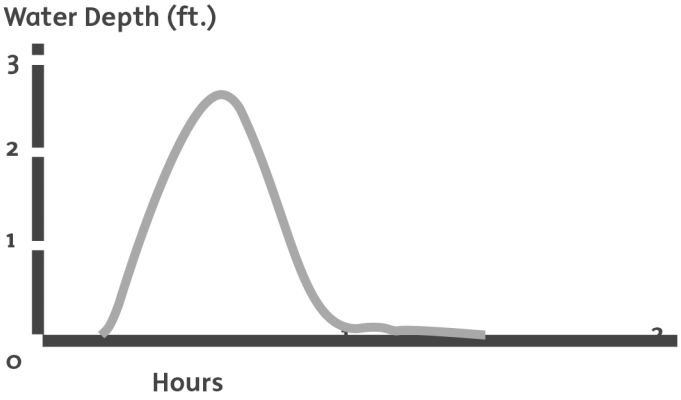
- City of Chandler offers an informative video about stormwater pollution at **http://www.chandleraz.gov/default.aspx?pageid=646**
- Read a real water quality report from the Town of Queen Creek at **http://www.queencreek.org/home/showdocument?id=18515**
- Review what YOU can do to help prevent stormwater pollution at Avondale's website at **http://www.avondale.org/index.aspx?NID=2578**
- Multiple cities and groups have teamed to create "Tap Into Quality", a site devoted entirely to water supplies and quality. Visit **http://www.tapintoquality.com/your-water/your-water-lifecycle** to view a pictorial "flowchart" of the water cycle and where water ends up after we use it.

Safe From the Storm?

In Phoenix and its neighboring cities, washes and riverbeds are usually dry. Out-of-town visitors are often suprised to see our dry rivers, but most of us desert dwellers know that those dry washes and river beds can quickly become raging torrents! Flooding in the desert is hard to imagine if you've never experienced it.

During a storm, heavy rains can quickly fill washes with swift-flowing water. The water can rise rapidly and without warning. The flow can be sudden and brief (which we call a flash flood) or can last for days and even weeks. Anytime a wash or river is flowing, it should be avoided. It is not safe to drive a vehicle through a flowing wash, and it is unsafe to play anywhere near flowing washes. Flash floods can occur many miles away from a storm. If you are under a National Weather Service Flash Flood Warning, you are in danger - even though it may not be raining where you are!

When heavy rains occur in the Central Arizona desert cities and there is a threat of flooding, barricades are put up in places where roads cross washes or at low points prone to flooding. The water depth and swiftness of a flowing wash can be greater than they appear and they change rapidly. A barricade means that the road is CLOSED. DO NOT go around it! Don't let your parents or any driver you know attempt to cross a flooded wash. For each foot that water rises, a car's weight is reduced by about 1,500 lbs. Most cars will temporarily float in only two feet of water. A driver can lose control of a vehicle in only one foot of flowing water because buoyancy causes the tires to fail to grip the road.

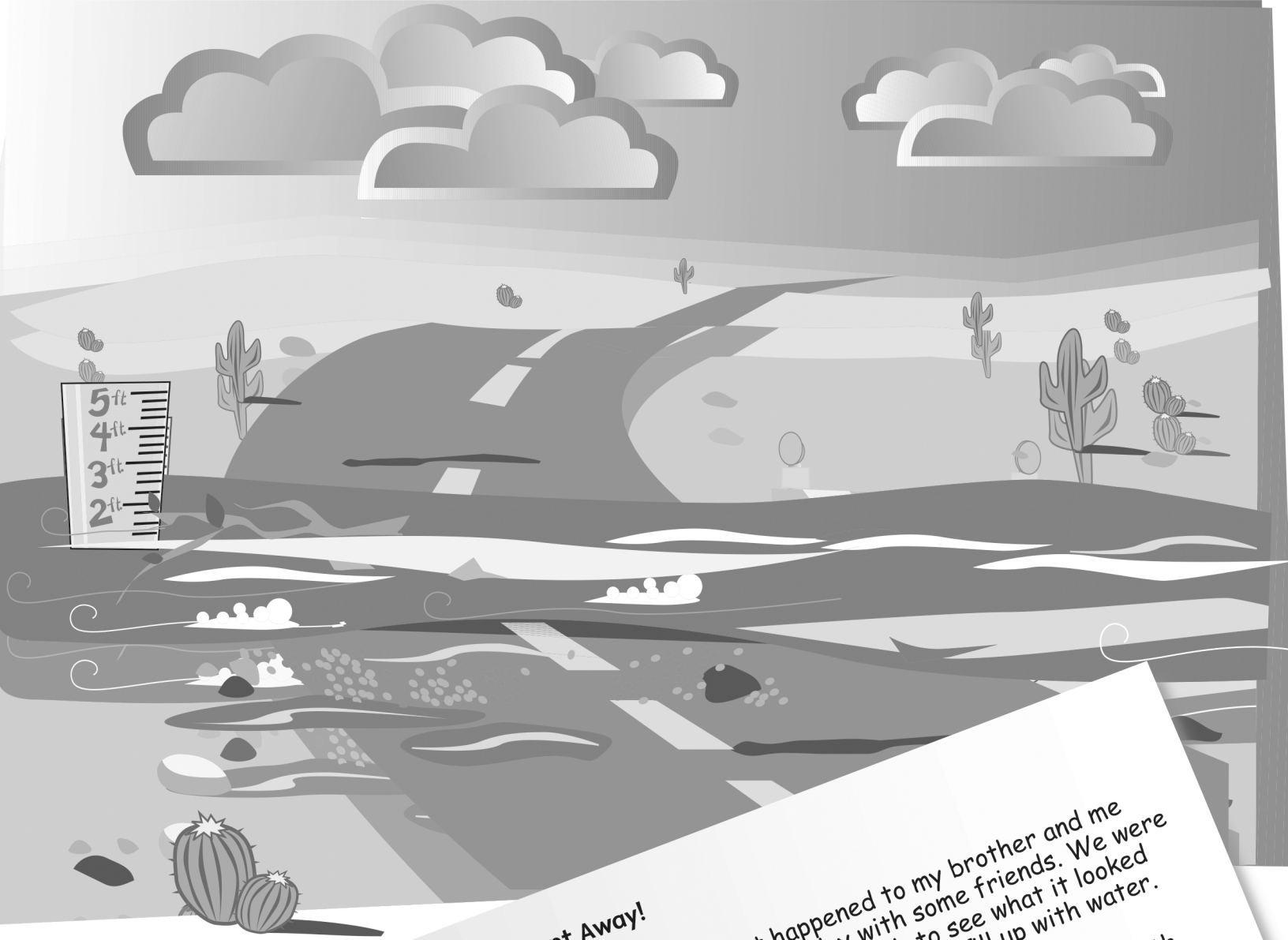


A hydrograph is a way to show the change in water depth in a stream over time. This hydrograph shows the rapid rise of water during a flash flood.

When dry, washes are intriguing places for kids to play. Building forts, riding bikes, and digging in the sand may seem harmless, but playing in washes at any time is unsafe for several reasons. Washes can contain harmful debris like broken glass or wire, can have unstable sides, and can be home to dangerous wildlife like rattlesnakes, Gila monsters, and scorpions. Remind your younger brothers and sisters to find a safer place to play.

Flooded washes should never be entered - they are dangerous and even deadly! The force of the water can be so strong that a person can easily be swept away. A near-tragedy like this is just what happened to a local brother and sister who survived to tell their story. Lacie's story, "Swept Away", which she wrote to share with other middle-schoolers, bears the clear and important message:

"Don't get swept away, find a safer place to play!"



Swept Away!

My name is Lacie Seitz. I want to tell you a true story that happened to my brother and me when I was 12. On May 28th, 2005, my brother and I went to play with some friends. We were all playing outside when it began to rain. We decided to go to the wash to see what it looked like during a rainstorm. So we all walked over to look as the wash began to fill up with water.

We were standing on the side of the wash. The bank where we were standing was lined with concrete and sloped downward. There were bits of loose gravel on it. My nine-year-old brother KC lost his footing on the wet gravel, and suddenly he slipped and fell in! We all began to panic. Without hesitating, I jumped in, thinking I could help him out. But, to my surprise the water was so swift it took us both. We were swept away!

It was only a few seconds later that I caught up with KC. He hung on to my shirt. A huge boulder came tumbling right along beside us. Thank goodness it missed us! I kept trying to move us over to the side of the wash, but the water was too strong. I kept yelling for KC to grab anything he could in order to stay afloat. As the rain fell harder, the wash filled up more and more. The more the wash filled up, the faster the water flowed.

We bobbed up and down in the water for awhile. I saw a branch that was hanging out over the wash and grabbed for it. KC was still holding on to my shirt. All of a sudden, the force of the water split us apart, and I lost my grip on the branch! My brother continued drifting farther down the

wash. I grabbed another tree branch and pulled myself out of the water. All I could do was scream and yell, telling him to grab anything he could. I felt totally helpless. Within seconds, the only thing I could see was his head as he was swept farther away from me.

I was screaming for help. I ran along beside the wash, screaming, "Call 911! Call 911!" A man put his head over the wall and told me an ambulance was on its way. I felt some relief, knowing someone was coming to help KC. The man also told me to stay put and that the firemen were going to be here soon. I stayed put and soon saw the firemen. One firefighter carried me to an ambulance and covered me with blankets. People in the ambulance took my blood pressure, temperature, and checked my injuries. I had cuts, scrapes, and bruises on my arms, legs, and feet.

I kept asking if my brother had been found. No one knew or no one was telling me. Then, I overheard on the radio that they had found a little boy. I knew it was my brother. I didn't know if he was alive or not. I felt like I had done all I could do to try and get him out, but it wasn't enough.

That's when we drove to where they found KC. The water had carried him two miles downstream. My mom came running up to me in the ambulance. I was crying and kept saying, "I couldn't get him out, Mom, I couldn't get him out." She was saying, "It's OK, Baby (my nickname), he is fine. You are a brave little girl!"

There are no words to tell you how I felt when I heard that my brother was going to be okay. I barely remember seeing all the fire trucks, TV cameras, and newspaper reporters. I remember seeing my dad coming up from under the bridge; he was still out looking for me. His cell phone had gotten wet and he was unable to get a call in or out. He didn't know that we'd both been found alive.

I saw our family friend, Carl. He was having his blood pressure taken, too. At the time, it never crossed my mind why. I found out later that Carl had been helping my dad look for us. It was Carl who had gone into the wash to help KC. Carl was able to get himself about ten feet downstream from where KC was holding on to a branch. Carl held on to a big tree and yelled to KC to let go and he would catch him. KC let go of his branch, floated down, and was in Carl's arms in no time. KC had no energy left. Firefighters got there and threw a rope to Carl with a life vest for KC. They finally got KC back to land. Then they pulled in Carl. They both were OK.

We went with my mom in the ambulance to St. Joseph's Hospital. There, they ran lots of tests to see if we could get sick from the rainwater that we had swallowed. KC swallowed more than I did. They took x-rays to see if we had hit our heads or broken any bones. After the tests came back, the doctors said we would be fine once the scrapes, cuts, and bruises healed.

Now, all the physical damage is gone except for the scars on KC's knees where he was cut. The only thing left is the memory of how scary that day was, not knowing whether or not my brother and I were going to make it out of that wash unharmed. We are very lucky. I do not recommend going anywhere near a wash when it's raining. You may think you can handle the water, but looks are deceiving. The water moves more quickly than you could ever imagine. If someone you know ever thinks it would be a good idea to play near a wash, please share my story with him or her and let them know that it is not a very wise or safe decision.

"Don't get swept away, find a safer place to play!"

TRY THIS

Do the Right Thing

Pass on Lacie's message. Tell your younger brothers and sisters, cousins, and friends about Lacie's story. Just spreading the word about not playing around washes could help save someone's life. Do the right thing: stay away from washes and tell others to "find a safer place to play!"

Driving into a flowing wash can lead to a dangerous rescue and cost the driver thousands of dollars.

Get Online

• Go To: https://www.youtube.com/watch?v=-0qem9SAFVg&feature=youtu.be.

(characters are case sensitive)

The Flood Control District of Maricopa County (FCDMC) has produced a video with incredible images of desert stormwaters and flooding. Watch for the animation of how cars can float in just two feet of water and be swept away!

• Next, visit the City of Tucson's online stormwater education activity site at **www.tucsonstormwater.com** Click on "Swept Away" to view a docudrama which tells about a Tucson family's true-life near tragedy and heroic rescue of their child swept away in a flooded wash.

• Finally, FCDMC offers a real-time, interacive weather alert map at **http://alert.fcd.maricopa.gov/alert/Google/v3/gmap.html.** Be informed with rainfall amounts, streamflows, radar maps, flash flood alerts, and even look up historical weather data.

Earth's Water, Conservation and Rainwater Harvesting

Now that we have a "big picture" understanding of our water cycle, managing stormwater, and how to help protect it from pollution, let's get creative in putting stormwater to good use!

First, let's zoom out and examine our global water supply. Roughly 71% of Earth's surface is covered by water (about 97% of water in all of its forms). The remaining 3% exists as freshwater found in lakes, rivers, glaciers, aquifers, and water vapor. However, most of our freshwater is in glaciers and ice caps, leaving a tiny 1% of Earth's total water supply for usable water! That's very little water available for humans all around the world!

Zoom in to Arizona, one of the fastest growing states in the country at almost 7 million people. With our arid desert having limited water supplies, it becomes crucial for residents to practice water conservation efforts to ensure a sustainable future for the water we depend on. Using less water now means more available in times of shortage, and YOU can do your part!

In recent years, innovative ways for residents to conserve water have been developed. Arizona's residents, businesses, and governments have begun to reuse wastewater for irrigation, plant desert landscapes requiring minimal water, install water-reducing appliance fixtures (such as faucet aerators), offer incentives for usage reduction, and increase water conservation education to students and adults. Even in a large urban area like Central Arizona, one person's efforts can make a huge difference!

ACTIVITY

Toss n' Tally

Use math to demonstrate that the Earth is mostly water! Find a stuffed or inflatable Earth ball, and gather a group to stand in a circle. Toss the ball 100 times. Each time, the catcher should report where their right thumb is: on land, or on water? Record results as tally marks. After 100 tosses, do the math and the totals should represent around 70% for water and 30% for land!

ACTIVITY

Water Models

Use water to create a model of Earth's water distribution. Gather a 5 gallon bucket, standard measuring cups, a plastic metric syringe, 5 large cups and tape. Tear off pieces of tape and stick one piece to each cup. Writing on the tape, label each cup as: water vapor, soil moisture, rivers/streams/lakes, groundwater, or ice caps/glaciers. Fill the bucket to the top with water, which for now will represent Earth's total water supply. Using the appropriate measuring tools, remove the following amounts of water and drop into the coordinating cups: .2mL (water vapor), 1mL (soil moisture), 2mL (rivers/streams/lakes), 1/2 cup (groundwater), and 1-3/4 cups (ice caps/glaciers). What does the remaining water in the bucket represent? Our oceans! Now you can really see how our water is distributed and how little freshwater is available for use! What has surprised you about Earth's water distribution? What threats does the water cycle face? How does this change your thinking about water conservation? What are some ways that you could conserve water at home or school? Don't forget to empty your water on a tree or plant so it gets used wisely!

Get Online

• Get Online: Go To: https://www.phoenix.gov/waterservices/resourcesconservation/water-efficiency#!

Check out the City of Phoenix's interactive water site. View our water sources, learn about how tree rings indicate weather cycles, and gather ideas for water conservation.

• Then, visit **https://www.youtube.com/watch?v=4HSFKwho7MQ** (characters are case-sensitive). This is The National Aeronautics and Space Administration's (NASA) impressive video about our water distribution and usage. Amazing graphics!

How then are Central Arizona's limited water supply, water conservation efforts, and stormwater related? One way is by rainwater harvesting!

Rainwater harvesting is the process of capturing, storing, and dispersing of rainwater (or stormwater) runoff to provide water for landscape plants. It means using stored stormwater as opposed to pulling additional water from our aquifers and other water sources, thereby prolonging the availability of usable water for other purposes!

In a rainwater harvesting system, the landscape may be shaped and contoured to capture falling rainwater and direct it to plants. In addition, rainwater falling from a rooftop can be collected and stored in a barrel, tank, or cistern. Systems can be simple, such as a barrel at the bottom of a gutter downspout; or complex, with multiple tanks, pumps, and controls. How much water can be stored from rainwater harvesting? An average-sized home in Central Arizona can yield around 7,000 gallons of water per year to be collected, stored, and dispersed for landscape watering. That's as much water as a small swimming pool holds!

Rainwater harvesting has numerous benefits: It reduces flooding and erosion from stormwater runoff, saves our groundwater reserves, reduces water utility bills, and helps keep potential pollutants out of our streets, washes, and rivers. By implementing water saving strategies at home and school, planting low-water use plants, and harvesting rainwater, we can save millions of gallons of our water supply for future use! In a desert environment like Central Arizona's with a limited water supply, harvesting stormwater makes sense!

ACTIVITY

Fill in the blanks below with the correct rainwater harvesting term. You'll discover the answers on the next two pages!

_____are used to catch and channel stormwater runoff from the roof.

_____are tanks used to store and collect rainwater.

_____capture runoff and allow it to seep into the soil.

A _____drain helps move water into the soil.

Covering plant beds with_____reduces evaporation and erosion.

A great place to store water is in your_____!

Get Online

• Get Online: Go To: http://www.azwater.gov/azdwr/StatewidePlanning/Conservation2/Residential/Graywater_Rainwater_Harvesting.htm

On Arizona's Department of Water Resources site, scroll down to "Rainwater Harvesting" and click on the "Rainwater Harvesting for Landscape Use" link. This manual offers basic information and design ideas for harvesting rainwater in a home, instructions on how to calculate plant water use requirements, and rainfall data around the state of Arizona.

• Interested to see a real rainwater harvesting system?

Visit **https://www.youtube.com/watch?v=drN6Z03WpZA**

• Calculate how much rainwater you can collect from your own house or school! Visit **http://wateruseitwisely.com/100-ways-to-conserve/rainwater-harvesting/**, click on the "Basic Components of a Rainwater Storage System" link, and scroll down to find the formula for calculating roof runoff.

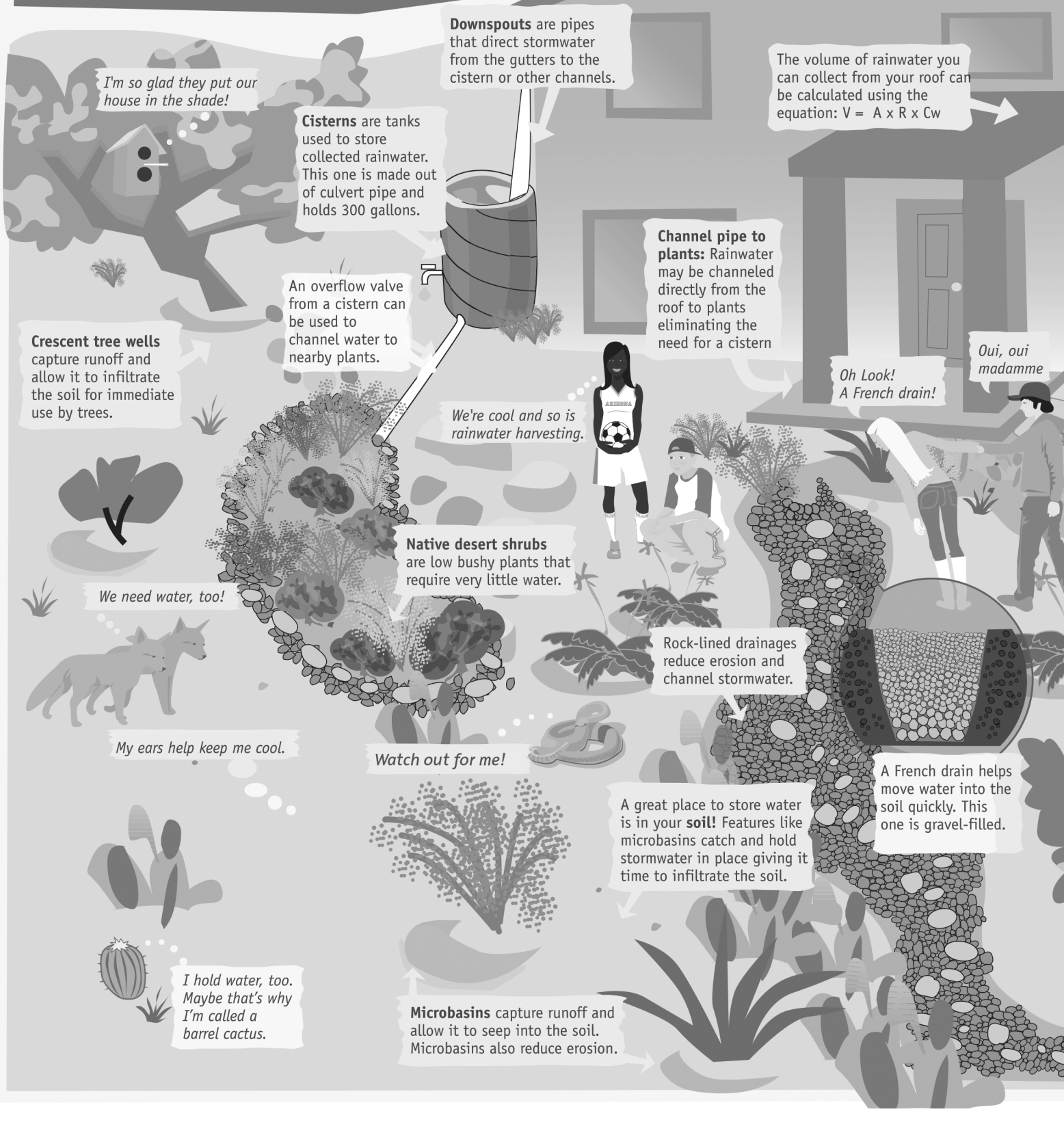
• Tour a more complex and creative rainwater harvesting system by award-winning author Brad Lancaster at **https://www.youtube.com/watch?v=xdvmJ-AFlRA&feature=youtu.be** (characters are case-sensitive).

Discovering Rainwater Harvesting

Rainwater harvesting is a way to collect, store, and use rainwater. Harvesting rainwater reduces the amount of runoff, provides an additional water source for landscape plants, and conserves water. With Central Arizona being a desert environment, harvesting rainwater makes sense!

The scene below shows a typical desert home with a rainwater harvesting system. Learn how to harvest rainwater as you look for these items:

- gutters
- downspout
- bird house
- desert tree
- golf club
- desert shrubs
- mountain lion
- two dogs

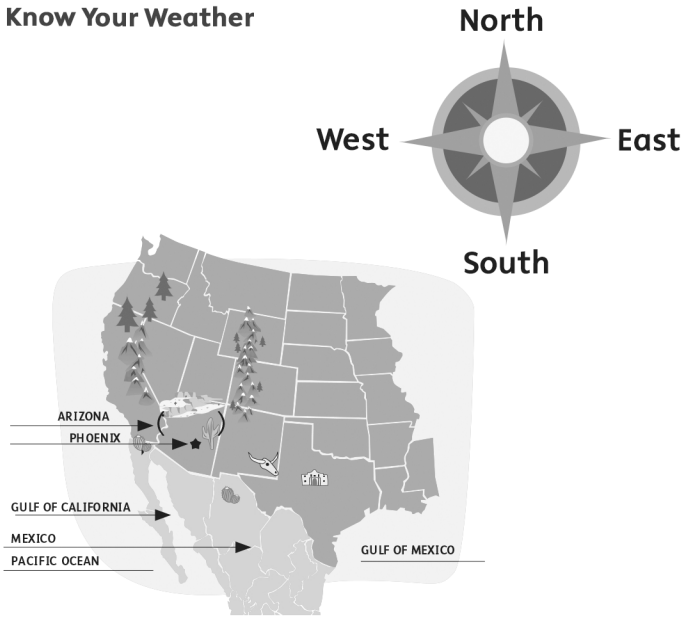


French Drain
barrell cactus
landscape holding area
coyote pups
microbasins
pervious surfaces
hammock
soccer ball
crescent tree well
rock lined drainage
rattlesnake
mulch
Harris' Hawk
roof
soil
slope
formula
overflow valve
cistern
I see you all the time. Ever look up and see me?
Because water runs downhill, it is important to know which way your yard **slopes** when installing rainwater harvesting features.
I hear they use reclaimed water at this golf course.
Five bucks says he misses the putt.
Native desert trees are adapted to desert conditions. They require less water than other landscape trees and still provide great shade.
Don't run away if you see me. Get large and move slow.
Gutters are used to catch and channel stormwater runoff from the roof.
I just love flowers
Covering plant beds with mulch reduces evaporation and erosion.
Sunburn? Ouch!
Lemonade would hit the spot.
This looks like a good hiding spot.
This patio is a pervious surface. It uses spaced paving blocks and gravel for greater stormwater infiltration.
Scoop my poop, please.
V = A x R x Cw
V = runoff volume
A = area
R = rainfall amount
Cw = runoff coefficient
I hope she likes flowers.
I like it hot!
I gotta take my car to the car wash because they recycle water.
Yes, it's a lovely home. They're really harvesting rainwater!
POOP BAG
Landscape holding areas store water for direct use by plants.
I smell a wabbit.

Glossary

1. **Berms -** Mounds of soil used to retain stormwater or to direct its flow.
2. **Cistern -** A tank used to store collected rainwater.
3. **Condensation -** The process of a vapor becoming liquid (the formation of clouds).
4. **Cresent tree wells -** Dug depressions around trees to catch runoff and direct it to the roots.
5. **Desert shrubs -** Low, bushy native plants that require very little water.
6. **Desert trees -** Tall, shading native plants that are adapted to desert conditions.
7. **Downspouts -** Vertical pipes that drain stormwater downward from the gutters.
8. **Gutters -** Channels along a roof's edge to catch and direct stormwater.
9. **Evaporation -** The process of liquid water becoming a vapor.
10. **Flash flood -** Rapidly rising water in a wash or river that is usually caused by heavy rainfall.
11. **French drain -** Gravel-filled hole or trench placed so that stormwater can seep in.
12. **Impervious -** Not allowing water or other liquids to pass through a surface.
13. **Infiltration -** The movement of water through the soil surface into the soil.
14. **Landscape holding areas -** Planted parts of the yard with loose soil or gravel to store water for direct use by the plants.
15. **Microbasins -** Small, dug out or bermed depressions that catch water and let it soak in.
16. **Monsoon -** A seasonal pattern of wind and rainfall.
17. **Mulch -** Covering of organic matter such as bark or wood chips on top of the soil.
18. **Percolate -** The movement of water through the soil to the water table.
19. **Pervious -** Allowing the passage of water or other liquids through a surface.
20. **Pervious pavement -** Driveways, walkways and patios made with gravel, crushed stone, open paving blocks, or special porous concrete to allow greater stormwater infiltration.
21. **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.
22. **Precipitation -** Water falling from the atmosphere in the form of rain, snow, sleet, or hail.
23. **Rock-lined drainage channels-** Natural gullies or dug ditches lined with boulders.
24. **Runoff coefficient -** An estimated proportion of rainfall that becomes specific surfaces depending on how much water they can absorb.
25. **Soil -** Composed of gravel, sand, silt, and clay, soil is the growing medium for plants and can be a great place to store captured stormwater.
26. **Stormwater runoff -** Rainwater that hits the ground and flows over the Earth's surface.
27. **Swale -** A long, shallow trough between two areas of higher ground in the yard.
28. **Transpiration -** The process in which water vapor is released from plants into the atmosphere.
29. **Water cycle -** The natural sequence through which water passes into the atmosphere as water vapor, precipitates to Earth in liquid or solid form, and ultimately returns to the atmosphere through evaporation.
30. **Water harvesting -** Collecting and putting rainwater or stormwater to beneficial use.
31. **Watershed -** An area of land that sheds water and directs it downhill to a particular watercourse or point.

Know Your Weather



Storm Words, page 5

Winter - cool; drizzle; puddles; overcast; sprinkle; gentle; cold; misty; showers; prolonged

Summer - cool; flashflood; monsoon; brief; torrential; puddles; sudden; downpour; deluge; cloudburst; showers, thunder; intense; pouring; lightening; windy; thunderhead, violent; humid; brief

Central Arizona's Water Cycle Words. page 7

1.	condensation	C
2.	infiltration	F
3.	transpiration	A
4.	stormwater runoff	E
5.	precipitation	D
6.	evaporation	B
7.	percolation	G

Calculating Runoff, pages 18-19

1. Length = 3 inches
   Width = 2 inches
2. Length = 90 feet
   Width = 60 feet
3. 5400 ft^2 = 90 ft x 60 ft
   A = 5400 ft^2
4. June rainfall = 0.4 inches
5. 0.4 inches x 0.623 (gal/ ft^2)/inch = 0.2492 gal/ft^2
   R = 0.2492 gal/ft^2
6. Cw = 0.9
7. V = 5400 ft^2 x 0.2492 gal/ft^2 x 0.9
   V = 1211.112 gal
8. V = 5400 ft^2 x 0.2492 gal/ft^2 x 0.17
   V = 228.7656 gal
9. Which variable do you have to change and why? **Runoff coefficient. Because you are calculating runoff from a different surface.**
10. Is there more runoff from a soccer field or a parking lot? **There is more runoff from a parking lot.**

Stormwater Word Search, page 15

C	J	B	Y	1C	L	O	U	D	G	U	L	F	O	F	C	A	L	I	F	O	R	N	I	A
S	P	D	D	O	G	P	O	O	P	J	R	S	V	O	K	R	R	D	W	Q	B	J	G	O
A	A	2W	I	N	D	K	D	X	3P	U	D	D	L	E	S	W	E	P	T	A	W	A	Y	G
S	C	R	H	D	J	R	W	B	E	T	4S	U	M	M	E	R	M	V	W	O	H	G	Q	K
C	I	Q	M	5E	V	A	6P	O	R	A	T	I	O	N	S	Z	I	W	I	P	N	C	W	J
E	F	Q	A	N	A	I	E	B	C	S	O	S	B	K	E	H	C	E	G	R	D	K	Q	G
R	I	Q	B	S	C	N	R	D	O	W	R	B	7F	L	O	W	R	G	A	V	T	K	A	T
D	C	8W	W	A	H	G	V	C	L	B	M	K	L	R	W	Q	O	D	Z	M	O	L	Q	R
C	O	A	W	T	E	A	I	V	A	K	W	E	A	H	D	D	B	D	W	9M	L	A	A	E
W	C	T	S	I	M	U	O	S	10T	R	A	N	S	P	11I	R	A	T	I	O	N	N	L	S
L	E	E	L	O	I	G	U	T	E	K	T	B	H	G	N	A	S	Y	N	N	T	D	W	E
E	A	R	E	N	C	E	S	W	S	V	E	A	F	W	F	I	I	U	J	S	S	S	T	D
C	N	C	N	Q	A	D	E	D	D	G	R	T	L	G	I	N	N	W	Q	O	D	C	J	N
C	Y	Y	N	T	L	M	I	B	C	F	R	E	O	A	L	A	S	B	I	O	V	A	X	A
V	C	C	A	R	S	U	S	G	K	H	U	L	O	I	T	G	T	L	S	N	W	P	12P	R
A	S	L	H	W	Q	W	Q	X	S	B	N	F	D	J	R	E	Y	13W	K	T	R	E	O	O
14P	R	E	C	I	P	I	T	A	T	I	O	N	C	F	A	W	R	A	I	N	M	R	L	N
H	E	J	L	S	W	N	R	Q	F	L	F	T	B	N	T	S	L	T	P	E	O	Q	L	O
O	T	W	R	D	F	T	G	S	U	R	F	A	C	E	15I	M	P	E	R	V	I	O	U	S
E	T	W	T	U	H	E	D	C	S	T	G	Q	K	L	O	T	C	R	S	D	S	R	T	A
N	U	16W	A	T	E	R	H	A	R	V	E	S	T	I	N	G	E	S	D	Q	T	G	I	K
I	G	A	G	U	L	F	O	F	M	E	X	I	C	O	R	Y	W	H	A	H	U	L	O	U
X	D	S	F	17R	U	N	O	F	F	C	O	E	F	F	I	C	I	E	N	T	R	Y	N	I
F	E	H	T	N	K	W	S	A	G	T	W	Q	C	B	P	I	R	D	Y	T	E	N	L	G

Pervious and Impervious Surfaces, page 20

Surface	Pervious or Impervious
parking area	impervious
grassy play area	pervious
sidewalk	impervious
soccer field	pervious
basketball court	impervious
rooftop	impervious
desert landscape	pervious
driveway	impervious
patio	impervious
street	impervious

Changes you can make so this yard soaks up

ANSWERS:

more rainwater:

Parking – **install a gravel parking area instead of concrete**

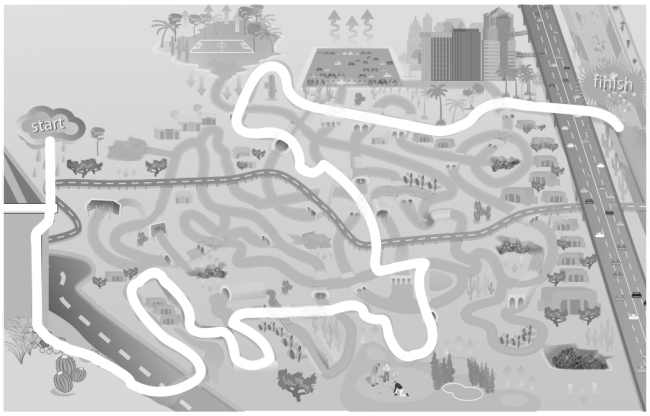
Rooftop – **install a cistern to store collecctedstormwater**

Sidewalk – **install a gravel walkway or pervious pavers instead**

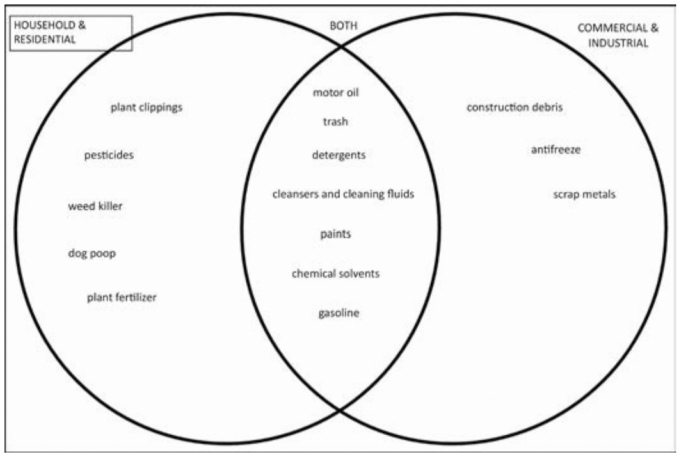
Driveway – **install a gravel or pervious pavement instead of concrete**

Patio – **install pervious pavers instead of concrete**

Our Amazing Stormwater System Maze, pages 22-23



Pollutants ID'd!, page 24



motor oil	BOTH
trash	BOTH
plant clippings	H & R
pesticides	H & R
detergents	BOTH
weed killer	H & R
dog poop	H & R
plant fertilizer	H & R
construction debris	C & I
antifreeze	C & I
cleansers and cleaning fluids	BOTH
paints	BOTH
chemical solvents	BOTH
scrap metals	C & I
gasoline	BOTH

Jumbled Pollutants, page 27

OIL
GREASE
PAINT
DOG POOP
PESTICIDES
SPRAY CANS
CAR BATTERIES
DRAIN CLEANER
HOUSEHOLD WASTES

Secret Message:
ONLY RAIN IN THE DRAIN!

Discovering Rainwater Harvesting Words, page 33

gutters
cisterns
microbasins
French
mulch
soil
drainages

Notes

Acknowledgements

STORMWATER IN THE DESERT was developed for the STormwater Outreach for Regional Municipalities organization (known as STORM) in partnership with the Environmental Education Exchange.

STORM is a regional organization promoting stormwater quality education within Central Arizona, including the greater Phoenix metropolitan area. STORM was founded in 2002, in response to federal regulations requiring certain municipalities to implement measures to educate the public on ways to protect the quality of stormwater runoff. Learn more about STORM on their website at azstorm.org.

The Environmental Education Exchange is a nonprofit organization focused on increasing environmental literacy. The Exchange develops a wide variety of conservation and environmental education programs and materials in response to a growing demand for environmental education in schools K-12 nationwide. Visit the Exchange's website at eeexchange.org.

STORM would like to thank the following Central Arizona counties, cities, and organizations that were instrumental in the development of ***STORMWATER IN THE DESERT***: Arizona Department of Transportation, Apache Junction, Avondale, Buckeye, Chandler, El Mirage, Environmental Education Exchange, Flood Control District of Maricopa County, Fountain Hills, Gilbert, Glendale, Goodyear, Litchfield Park, Luke Air Force Base, Maricopa County Environmental Services Department, Mesa, Paradise Valley, Peoria, Phoenix, Pinal County, Queen Creek, Scottsdale, Surprise, Tempe, Tolleson and Watershed Management Group.

Graphic Design, Layout and Illustrations by:
Boelts Design, Tucson, Arizona
www.boeltsdesign.com

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Only rain in the stormdrain

environmental
EDUCATION
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STORMWATER IN THE DESERT

A Middle School Activity Book

What fans have to say about ***Stormwater in the Desert...***

"Stylish, back stage look at rain, flooding, and life in the big desert cities."
- *Taylor Swift*

"Makes cleaning up dog poop seem like a cool science fair project!"
- *Mr. Science*

"We could've used this water harvesting technology back on Tatooine!"
- *Luke Skywalker*

"More mysteries solved here than Harry Potter ever dreamed!"
- *Dumbledore*

"A fabulously stormy plot... flooded with excitement! This book crackles like a desert monsoon in late July."
- *Tony Stark*

"Savvy! I perused this novel with an egregious patch over me eye!"
- *Jack Sparrow*