

Rain Gardens

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How does rainwater harvesting prevent flooding & positively impact Tucson's groundwater levels?

WHAT: I will design and build a rain garden.

HOW: I'll successfully do this by:

- Researching water harvesting; its importance, the difference between passive and active.
- Researching the importance of rain gardens; the pros and cons.
- Researching the different elements of a rain garden and materials needed.
- Determining a site to build a rain garden.
- Planning the rain garden based on acquired knowledge.
- Building a rain garden based on plans.

WHY: In order to prevent flooding and to help recharge the underground aquifer.

Standards

Science Standards:

- HS.E1U3.14 Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.
- HS+E.E1U3.9 Construct an explanation, based on evidence, for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- HS+E.E1U3.11 Develop and use a quantitative model to illustrate the relationship among Earth systems and the degree to which those relationships are being modified due to human activity

Science and Engineering Practices:

- **Developing and Using Models** A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations.
- **Obtaining, Evaluating, and Communicating Information** Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate.
- **Constructing Explanations and Designing Solutions** The end-products of science are explanations and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world.

Crosscutting Concepts:

- **Structure and Function** The way an object is shaped or structured determines many of its properties and functions.
- **Systems and System Models** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

ELA Standards:

- W.2 Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
- W.7 Conduct short as well as more sustained research projects to answer a question or solve a problem
- SL.4 Present information, findings, and supporting evidence in an organized, developed style appropriate to purpose, audience, and task

Unit Hook

Create a poem about water. Options to help students brainstorm ideas:

- Make a mind map about all of the things that come to mind from the word “water”. (5 minutes) Use these ideas to help you write a poem or narrative.
- Start with the word “water” and write a list of words, never stopping. Let the last word inspire the next word. (The final word may not relate to water at all, and that’s ok!) (3 minutes) Use these ideas to write a poem or a narrative.
- Write a story about your experience with water. It can be about anything: the rain, the beach, the pool, drinking water, drought, watering plants, etc. Make it personal.
- Start with the title “Water is Life” or “Agua es vida” and write from there.

What is a water harvesting?

Why should we have rain gardens?

Learning Target: What am I learning today?	I am learning: definitions and examples of water harvesting; the difference between active and passive water harvesting; the benefits of rain water harvesting, and rain gardens in particular.
Success Criteria: How will I know that I have learned it?	I can: define water harvesting and identify examples; explain the difference between active and passive water harvesting; describe the benefits of rain water harvesting and rain gardens.
Why am I learning this?	This is important because as water becomes more scarce, it is important to know how to harvest rain and help to replenish the groundwater.

What is water harvesting?

the collection & storage of rain, instead of allowing it to run off.

two ways to harvest: active & passive

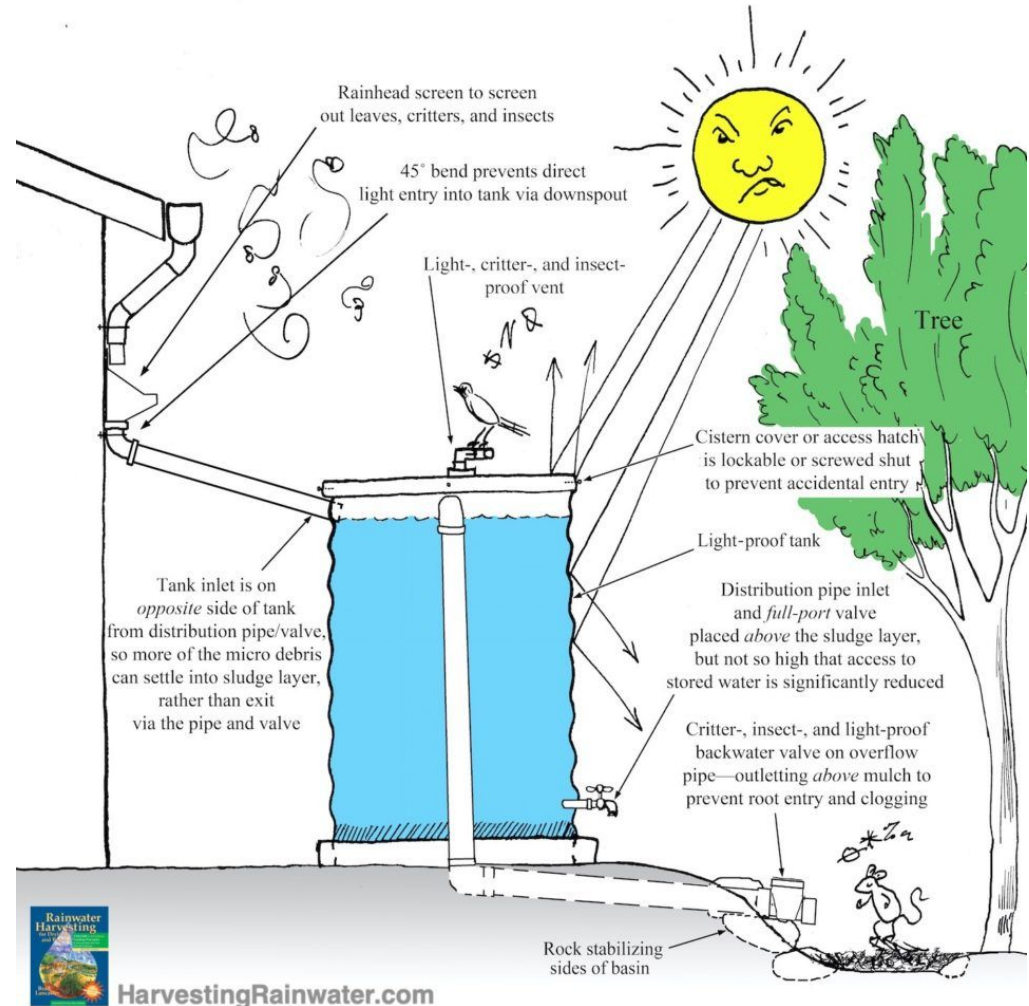


What is active rainwater harvesting?

when water is collected from the roof and stored for later use

- water is collected in a tank or cistern

benefits: provides free water when there's no rain



where have you seen active rainwater harvesting before?

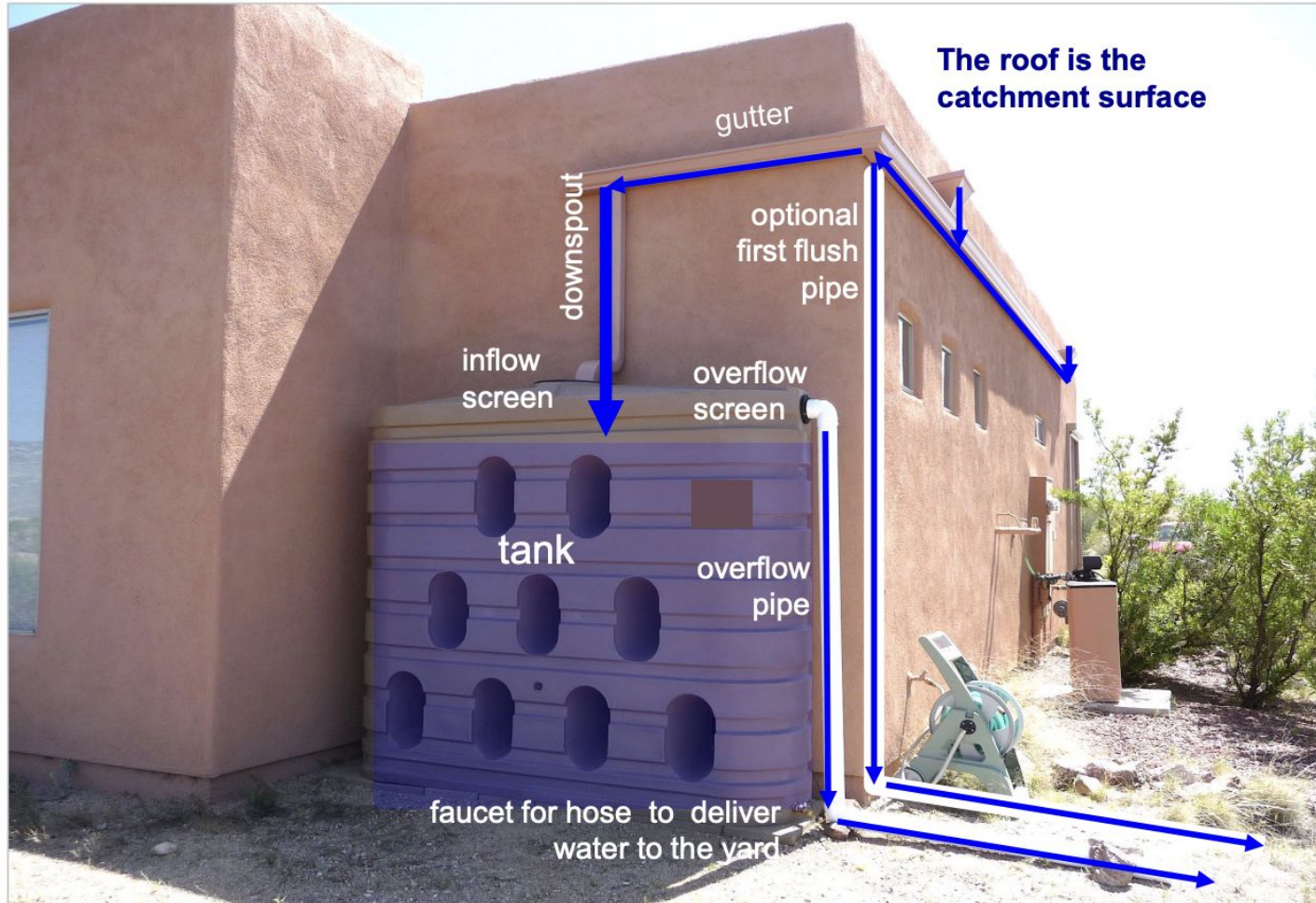
what do you think the benefits would be?

Rainwater Tanks (also called cisterns and “rain barrels”)

Tanks store water collected from roofs for later use



Typical components of water harvesting tanks



A variety of above-ground tank materials and sizes



What is passive rainwater harvesting?

when water is collected via earthworks – basins, berms, dams, etc. – and infiltrates into the ground.

benefits: waters plants, replenishes groundwater



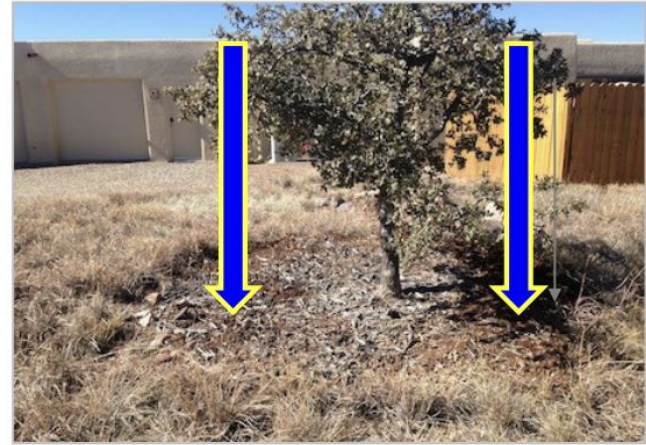
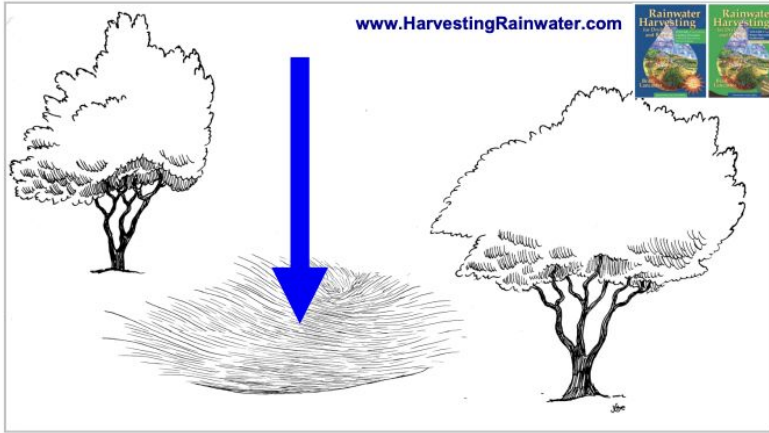
where have you seen passive rainwater harvesting
before?

what do you think the benefits would be?

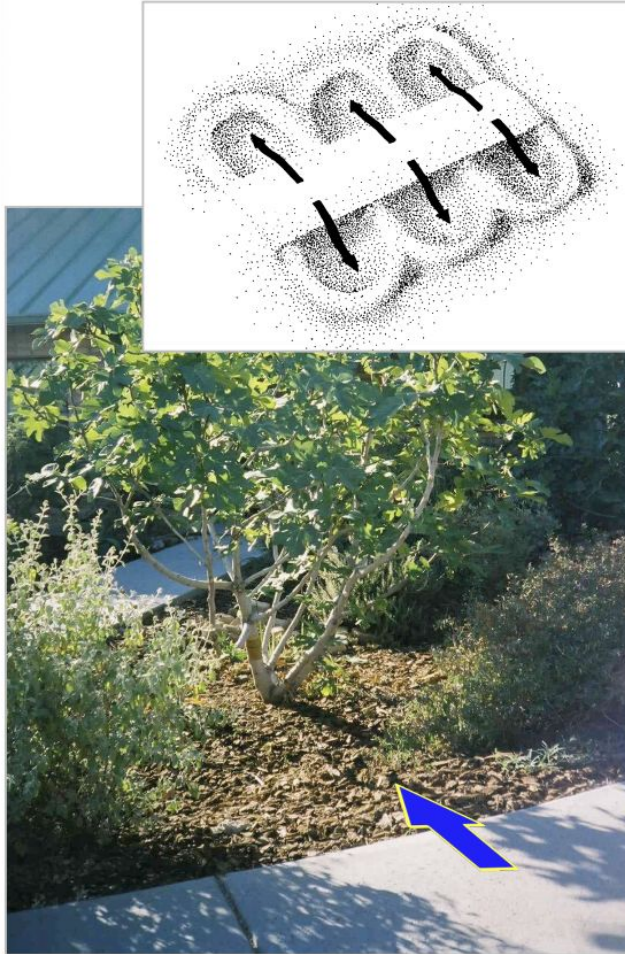
**Earthworks: Soil shaped to harvest and infiltrate water.
Also called rain gardens and “passive water harvesting”**



Earthworks: Microbasins without berms, built on flat land



Earthworks: Microbasins next to raised paths



What is a rain garden?

rain gardens slow down, capture and absorb water into the ground, reducing runoff that can overload streams and cause flooding

- this is passive rainwater harvesting

benefits: serves as a habitat, beautifies the landscape, protect water quality



2 years later...





DunbarSpringNeighborhoodForesters.org



difference between active & passive rainwater harvesting

CHARACTERISTICS	EARTHWORKS THAT PLANT THE RAIN	TANKS THAT TANK THE RAIN
Water uses	Provides large quantities of high quality rainwater to garden and landscape	Provides water for drinking, washing, fire control, flushing toilets (but first consider water-less composting toilets), and supplemental irrigation. Water quality will vary with catchment surface, tank construction, screening, maintenance, and first flush system. Rainwater has very low hardness.
Water collection areas	Can collect water from roofs, streets, vegetation, bare dirt, greywater drains, air conditioner condensate, etc.	Need a relatively clean collection surface (typically a metal, tiled, or slate roof) located higher than the tank
Water storage capacity	Very large potential to store water in the soil	Storage capacity limited by the size of the tank
Cost	Inexpensive to construct and maintain. Can build with hand tools, though earth-moving equipment can speed up the process	Much more expensive than earthworks to construct and maintain. Cost varies with size, construction material, above- or below-ground placement, self-built or prefab, etc.
Location	Do not locate within 10 feet (3 m) of wall or building foundation. May be difficult to fully implement in very small yards with adjacent large roofs	Can locate within 10 feet (3 m) of wall or building foundation, but you must be able to walk around entire above-ground tank to check for, and repair, leaks. Tanks increase water-storage potential in very small yards.
Time period water is available	Water available for limited to extended periods after rainfall depending on soil type, mulch, climate, and plant uptake	Water is available for extended periods after rainfall.
Maintenance	Earthworks work passively; require some maintenance after large rainfalls	Maintenance required; must turn valve to access water and may need pump to deliver water
Erosion control	Very effective for erosion control	Can assist with erosion control
Greywater collection	Very effective at harvesting greywater from household drains	Not appropriate to harvest greywater in tanks due to water-quality issues. Never store greywater in a rainwater tank.
Water quality impacts to environment	Pollutants in greywater and street runoff intercepted and bioremediated in the soil stay out of regional waterways	Less impact than earthworks to the broad environment
Impacts on urban infrastructure and flooding	Can capture large volumes of water, reducing need for municipal water, stormwater drains, stormwater treatment, and decreasing flooding	Can capture low to moderate volumes of water, reducing demand for municipal water, stormwater drains, stormwater treatment, and decreasing flooding
Groundwater recharge	Can directly recharge shallow ground-water tables. Use of rainwater and greywater in earthworks instead of municipal/well water for irrigation reduces groundwater depletion.	Not an efficient use of tank water. However, use of cistern water instead of municipal/well water reduces groundwater depletion.

think-pair-share: what do you think the benefits of having a rain garden are?

think about the benefits for:

- animals
- people
- the Santa Cruz River

think about the potential

- economic benefits
- environmental benefits
- financial benefits

Benefits of rainwater harvesting

- an efficient way to lower ones water usage
- lessens the pressure on our municipal water systems and the infrastructure that supports them
- can lower your water bill and conserve water
 - reduce peak demands during summer months
- recharges groundwater aquifers
 - decreases our dependence on groundwater
- prevents erosion
 - reduces runoff and flooding
- captures sediment & reduces contaminants
 - helps the water quality of rivers, affecting riparian habitats
- there is more vegetation counteracting the heat island effect
- plants have deeper roots
- can be used to irrigate during dry seasons
 - source of water for plants and landscape irrigation
- acts as a habitat for local wildlife
- can be a backup water supply for emergency situations
 - can be available for wildfires and help protect the house and property

Benefits of rainwater harvesting in Tucson

For you & your family: The City of Tucson provides up to a \$2000 rebate for those who install rainwater harvesting systems

How will rain gardens affect the Santa Cruz River?

Groundwater Recharge: Instead of letting rainfall flash-flood through concrete storm drains into the riverbed unused, basins act as "sponges" that hold the water long enough for it to percolate downward to replenish depleted groundwater tables.

Water Quality Improvement: As stormwater sits in the basins, sediments and urban pollutants (such as motor oils or trash) settle out or are naturally broken down by desert plants. This keeps downstream flows cleaner when the water eventually reaches the main river channel.

Riparian Restoration: When basins are utilized as rain gardens, they nourish local vegetation like mesquite trees and cottonwoods. This revived canopy helps shade the area, cool the local microclimate, and stabilize the riverbanks against future flood erosion and bringing back natural riverbank ecology.

Assessment:

Goal: Persuade people in Tucson to build a rain garden or set up a rain tank on their property!

You can create a pamphlet, a PSA (for radio or TV), or create a poster. It should be creative, colorful, **persuasive**, and informative.

Your project must include:

- the definition & benefits of rainwater harvesting
- the difference between active and passive harvesting & what each entails
- how rainwater harvesting would affect Tucson and the Santa Cruz River

Extension:

1. Ironwood Tree Experience [W.A.T.E.R Field Study](#):
 - a. Contact Deborah@ironwoodtreeexperience.org to set up a field trip. There are three options that would relate to this lesson: [Mapping the Invisible](#) and [Park Connections](#); [Sponge City](#) could also relate.
2. AZ Project WET: [Nature of Groundwater](#)

How do you design and build a rain garden?

Learning Target: What am I learning today?	I am learning: the necessary elements of a rain garden, which plants are best to plant in a rain garden and why, what materials are necessary to construct a rain garden, and how to create a rain garden.
Success Criteria: How will I know that I have learned it?	I can: identify plants that will succeed in rain gardens, outline the steps of creating a rain garden, and identify what tools or materials that are needed to help build a rain garden.
Why am I learning this?	This is important because if someone is going to use your pamphlet to build a rain garden they should have all of the needed information to be successful.

Remind me:

- What is a rain basin or rain garden?
- Why do we need them?
- How is the Santa Cruz affected by rainwater harvesting?

read background knowledge on water-efficient landscapes

1. read & mark the text
2. discuss with a partner
3. discuss as a class

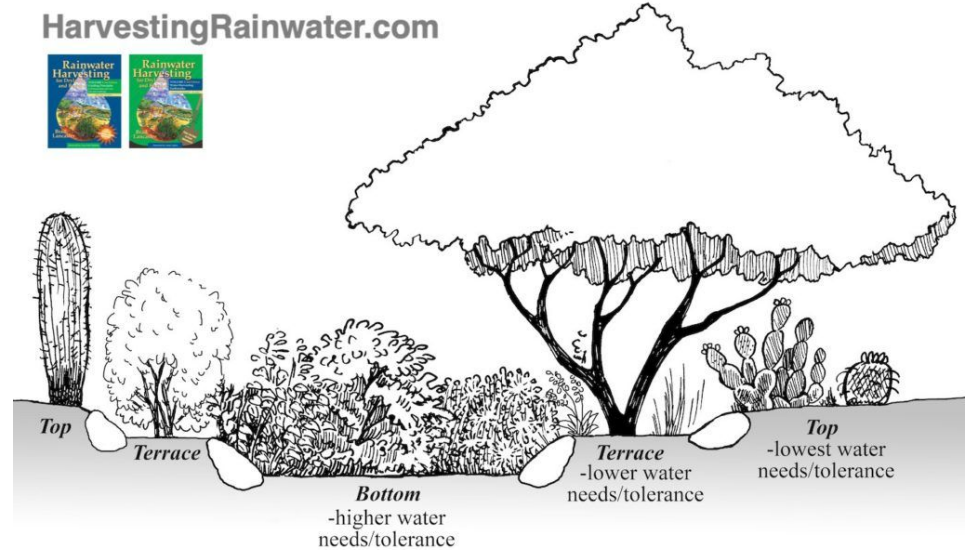
What are the different elements of a rain garden?

There are three rain-garden zones:

Top – the area beside a basin or on its banks, where plants' roots can access water harvested in basin; top of berm.

Terrace – typically atop a terrace or pedestal within a basin or swale. Sometimes water pools here, but shallowly.

Bottom – typically the bottom of a basin or swale. Often has temporary pooling of water.



How do you build a rain garden?

A step-by-step guide on how to quickly and easily transform your landscape into one that harvests rain, grows shade trees, and supports a native habitat.



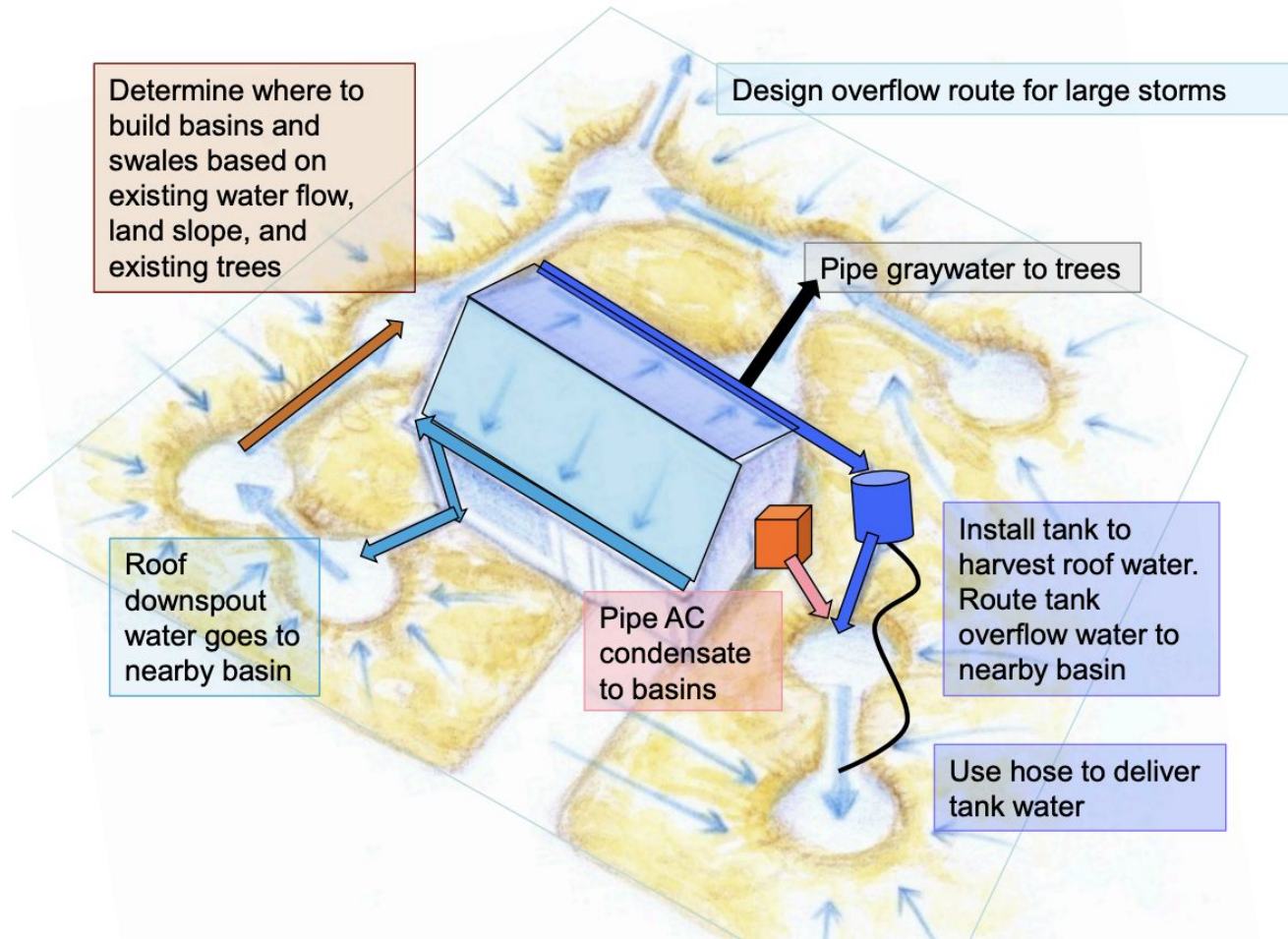
How do you build a rain garden?

1. Observe the rain - where does it pool? flow to or from?
2. Choose your basin location
3. Sketch
4. Dig your basin
5. Plan for overflow
6. Create gentle slopes
7. Plant like nature
8. Add mulch
9. Observe and adjust

give students [this booklet](#) to refer to

- 
- 1) Sketch out a simple drawing of your lot showing structures and driveway.
 - 2) Clearly mark entry and exit points of rainwater flowing in & out of the land.
 - 3) Draw current rainwater flow patterns from observation of monsoon rainfall.
 - 4) Pencil in desired water flow patterns.
 - 5) Circle areas that can reasonably be dug for basins or support rock dams.
 - 6) Mark where Rain Barrels may be located / needed.

Develop your water resources strategy



What plants would be good to have in a rain garden?

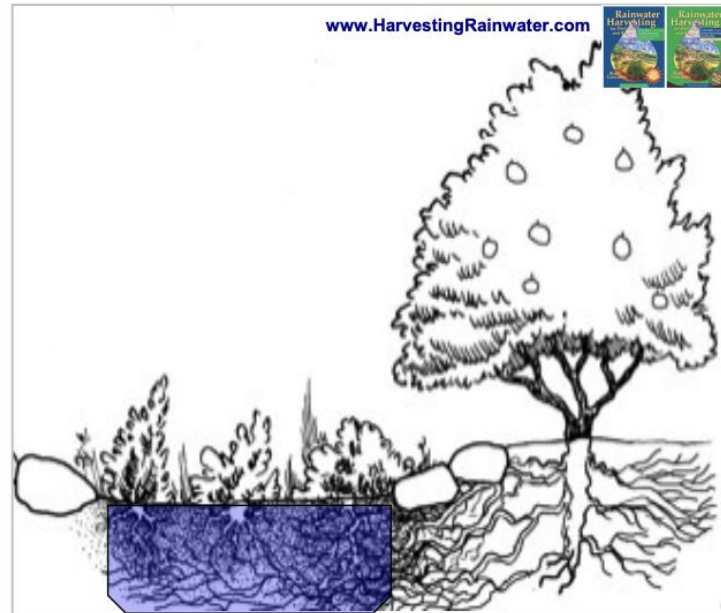
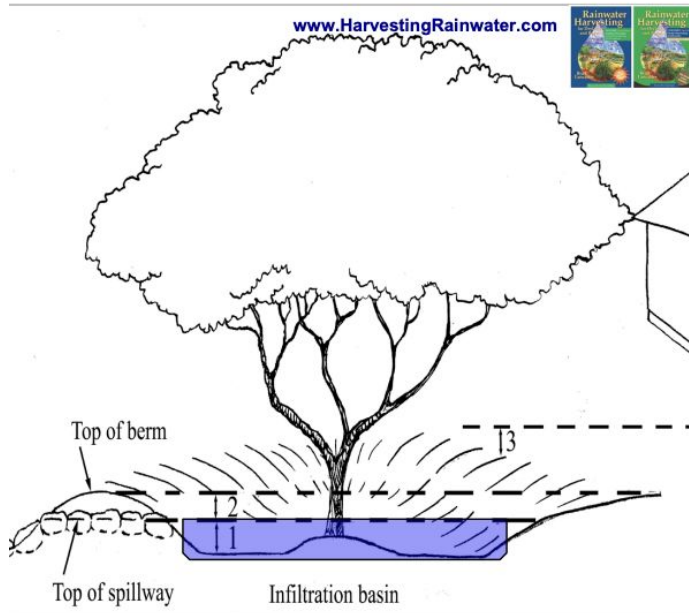
Native plants are best!

- already adapted to climate & soil
- best habitat for native life & pollinators

look at this [worksheet](#) or this [booklet](#):

- how many of these plants have you seen before?
- which of these plants would you like to see on campus?

Plan to place trees within or next to basins



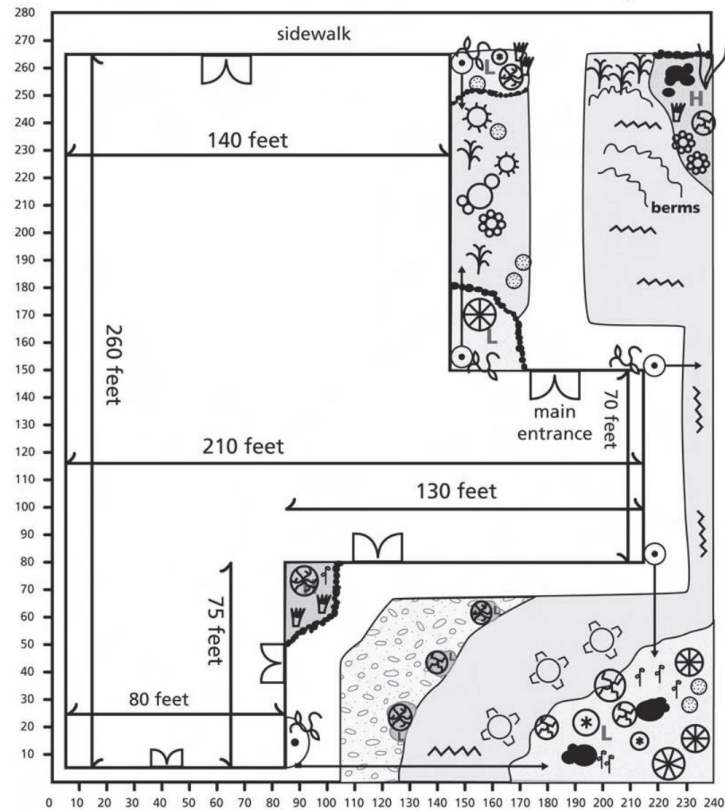
- Can plant inside basins on raised pedestal to keep root crowns dry
- Can plant on raised terraces within basins
- Can plant next to basins where roots will grow toward soil moisture
- Don't plant cacti inside basins
- Don't plant in drainage or spillways

example:

key

	white thorn acacia		common prickly pear		tufted evening primrose
	desert willow		ocotillo		grape ivy
	velvet mesquite		beargrass		Oregon grape
	ponderosa pine		banana yucca		saguaro
	Rocky Mountain juniper		blue grama		Engelmann's hedgehog
	four-wing saltbush		deer grass		canyon penstemon
	pink fairy duster		Bermuda grass		blanket flower
	turpentine bush		desert marigold		blue flax
	Apache plume		blackfoot daisy		owl's clover

School #1, Basin and Range area



This sketch includes the sidewalks, gravel areas, rainwater harvesting system, high and low areas, berms, picnic tables, rocks, and plants.

-  = doors
-  = rock
-  = rainwater holding tank
-  = rainwater holding tank
-  = picnic table



Assessment: continued

Goal: Persuade people in Tucson to build a rain garden or set up a rain tank on their property!

You can create a pamphlet, a PSA (for radio or TV), or create a poster. It should be creative, colorful, **persuasive**, and informative.

Add the following information to the project you've already started:

- **the necessary elements of a rain garden**
- **materials needed**
- **plants that are best to plant in rain gardens**

Extension:

AZ Project WET: [Planting for a Rainy Day \(PfaRD\)](#)

How can we design a rain garden for our campus?

Learning Target: What am I learning today?	I am learning: how to design a rain garden that will help my school campus minimize areas of flooding.
Success Criteria: How will I know that I have learned it?	I can: identify good spots on campus for a rain garden, sketch out a plan for a rain garden that will (ideally) help prevent flooding.
Why am I learning this?	This is important because when rain water pools it can affect the quality of the road, but it also becomes hard to infiltrate into the ground helping to replenish the groundwater. By building a rain garden, I will help water soak in and replenish the aquifer.

Assessment:

- Sketch out a rain garden plan. The plan should include:
 - a map of the location
 - what plants you want to plant
 - where they will be planted
 - what other materials you need to complete the rain garden
 - what tools you need
 - how long it should take to build it
- Create a presentation that includes your sketch. You will present your idea to your classmates!
 - The class will vote on the most thought out and completable rain garden so make sure you are thorough!

Procedure:

1. Get prepped
2. Walk around the campus and determine the best places to build rain gardens
3. Pick one spot & Brainstorm
4. Sketch
5. Share
6. Gallery Walk & Vote
7. Finalize the sketch
8. Prep
9. Construct a rain garden!
10. Celebrate & Make observations

Step 1: Get prepped

Get into a group of 4; determine tasks

1. Notetaker – makes a note of the location on the map
2. Time Keeper – makes sure the group returns on time
3. Cartographer – reads the map & makes sure the group doesn't get lost
4. Scientist – observes different places that rain gardens could potentially be built

Notetaker should retrieve:

- one clipboard for the group
- 2 campus maps – give one to the Cartographer
- a pencil

Talk about what area of the campus you want to check out.

Step 2: Walk around the campus and determine the best places to build rain gardens

As a group, walk around the campus and determine at least 5 sites where we could build a rain garden.

Things to look for:

- rain gardens that may already exist but need to be updated or maintained
- areas of flooding
- areas that may not flood, but could be prettier

On the campus map make a note of the 5+ sites. When your group is done, come back to the classroom. (You have 30 minutes)

Step 3: Pick one spot & Brainstorm

Pick one spot and start to sketch your rain garden.

Individually: Look at the map to help you, or if necessary, go back outside and make a sketch of the area in your nature journal.

Individually: Brainstorm how you'd like the rain garden to look, what plants you'd like to have

use this [worksheet](#) to help guide you

use this [worksheet](#) to pick out plants that you'd like

I. Your Rainwater Harvesting System

Envision an area of land on one side of your school building. Where are the high points and where are the low points? What areas are level? Follow the directions on this page to design your rainwater harvesting system for the school of your choice (make all drawings on pages 136, 137, or 138).

1. Keep all drawing within the box that represents the edge of the school grounds.
2. Indicate high points with a plus sign. Use a red pencil.
3. Indicate low points with a minus sign. Use a blue pencil.
4. Indicate level areas by lightly shading them. Use a yellow pencil.
5. Draw the street that the school is located on, sidewalks and walkways, and other non-vegetated areas (playing courts, sand or gravel areas, etc.). Draw rocks and boulders in landscaped areas. Use a black pen.
6. Design your rainwater capturing system. Think about:
 - Where does the water drain off the roof?
 - Do you want to direct the water into holding tanks or into natural holding areas?
 - If the water runs directly off of the roof, how will you capture it and direct it onto plants?
 - Are there places where you want to construct berms to slow the flow of runoff?
 - If you are using a holding tank with a hose attached, how will you design your watering system to get water to plants?
7. Draw roof drains, rainwater holding tanks, watering systems, berms, and other features of your rainwater system (using symbols and a key to them) onto the layout of your choice. Use a black pen.

II. Choosing Native Plants for Your Landscaping

1. Start with a new copy of the school outline. This time you will design your landscaped areas and add plants to make the grounds attractive and shaded.
2. Choose from the list of native plants on pages 141–143. These plants have evolved in the arid Southwest and are good choices for landscaping that uses minimal water. *The only plant on the list that is not native is Bermuda grass, which is a turf grass.* Think carefully about how much turf you need since it uses the most water (73 gal. per square foot on average, compared with 17 gal. per square foot on average for native desert landscaping).
3. Color-code each type of plant from the chart (for example, use green for all trees, purple for shrubs, brown for cacti, and so on).
4. Use the icons shown beside the plants' names to represent them on your design layout.
5. Think about the low and high areas. Locate plants that need water regularly in low areas.
6. As you design your landscaping, plan for natural cooling of the building.
7. You can use the same plant species more than once in your design. Think about what will look beautiful, considering the colors the flowers will be when blooming, what heights the plants will be, what places in your school yard have the most shade and sun, etc.

III. Make a key for your landscaping design to tell which colors and symbols are used for which types of plants, etc. Write a paragraph or more describing your landscape design.

Step 4: Sketch

As a group: Share your preliminary sketches and decide which elements from each person's design your group would like to incorporate.

Get a poster post-it and sketch the rain garden. Include:

- what plants you want to plant
- where they will be planted
- what other materials you need to complete the rain garden
- what tools you need
- how long it should take to build it

Make it as detailed as possible!

Step 5: Share

Each group presents their sketch

As groups present, in your nature journals, write down ideas that you like and would want to incorporate into your sketch.

Step 6: Gallery Walk & Vote

Put out all of the sketches and walk around, looking at them, and decide which ones are the most viable, easiest, and/or the most fun to work on.

Put a sticky note on the sketch that you think we should build. If you have any comments, changes you'd make, etc., put those on the sticky note too.

Step 7: Finalize the Sketch

As a class, determine the final sketch:

- location of the proposed rain garden
- what plants will be planted
- what materials are needed
- what tools are needed

Step 8: Prep

1. Pick a date
2. Make a flyer
3. Promote the event
4. Reach out to community organizations (like [Watershed Management](#)) for help procuring materials and for the day of
5. Gather materials – plants, rocks, mulch, tools, etc.
6. Assign roles

Step 9: Construct a rain garden

Get outside and construct the rain garden!

Step 10: Celebrate & Make observations

When you are done, celebrate your hard work!

Throughout the year, make observations of the rain garden, particularly when it rains.

Other activities involving the rain garden:

- conducting bird surveys
- nature journaling
- measuring rainfall
- propose additions to the rain garden to increase biodiversity

How does rainwater harvesting prevent flooding & positively impact Tucson's groundwater levels?

Learning Target: What am I learning today?	I am learning: about rain gardens, their importance and how to build them.
Success Criteria: How will I know that I have learned it?	I can: design and build a rain garden, after presenting my idea to my school administration.
Why am I learning this?	This is important because I am a steward of the land and want to help conserve water since we live in the Sonoran Desert and we're in a drought.

Assessment

With the help of Watershed Management and your classmates, build the rain garden based on your design.

Reach out to Watershed Management (or another local organization) and ask for their help in building the rain garden and providing you with plants, tools, etc.

Extension:

Pick some sites around campus to set up active rain water harvesting (rain barrels).

Write a grant to get funds to purchase rain barrels. Set up active rain water harvesting at your school site.

YPAR Ideas:

1. Write a letter to the TUSD Governing Board asking for additional rain gardens to be constructed around TUSD school sites.
 - governingboard@tusd1.org
2. Write a proposal for Budget de la Gente to get a rain garden built in your neighborhood, especially in areas that already flood.
 - <https://budgetdelagente.tucsonaz.gov/>
3. Plan a rain garden for your own yard
 - [Rain Gardens · Tucson Clean & Beautiful](#)