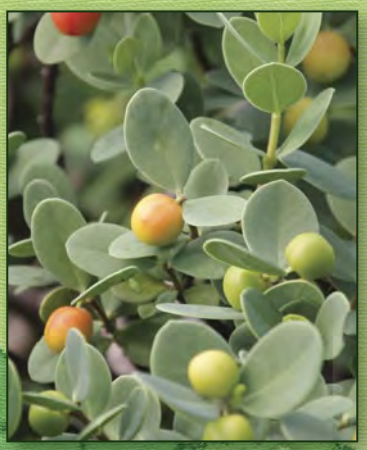
# Hawai'i Residential
# Rain Garden Manual





Hui o Ko'olaupoko

hui o ko'olaupoko

*Protecting ocean health by restoring the 'āina: mauka to makai*

Hui o Koʻolaupoko implements on-the-ground restoration projects such as riparian restoration, storm water improvements, native fish restoration, scientific data collection and information dissemination. To learn more about the organization, volunteer, rain garden construction questions or to donate, please visit www.huihawaii.org or email info@huihawaii.org

Text and photos by Todd Cullison, Executive Director of Hui o Koʻolaupoko.
Rain garden drawings and depictions by Merrick Patten, Arch.D.
All photos by Hui o Koʻolaupoko, unless otherwise noted.
Manual Design by Turner & de Vries.

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# Table of Contents

# Introduction

Urban areas, including residential neighborhoods, are a leading cause of non-point source pollution in Hawai'i. Streams and the ocean are negatively impacted from pollutants including nutrients, heavy metals and sediment from sources such as fertilizers, pesticides, eroding stream banks, automobiles, roads and animal waste. These pollutants build up on impervious surfaces such as roofs, sidewalks, driveways and roads. Following rains, pollutants are washed and carried into storm drains, streams and ultimately the ocean. Collectively, building rain gardens can be an effective, low-cost tool for reducing the amount of stormwater and pollution that reaches our streams and the ocean.

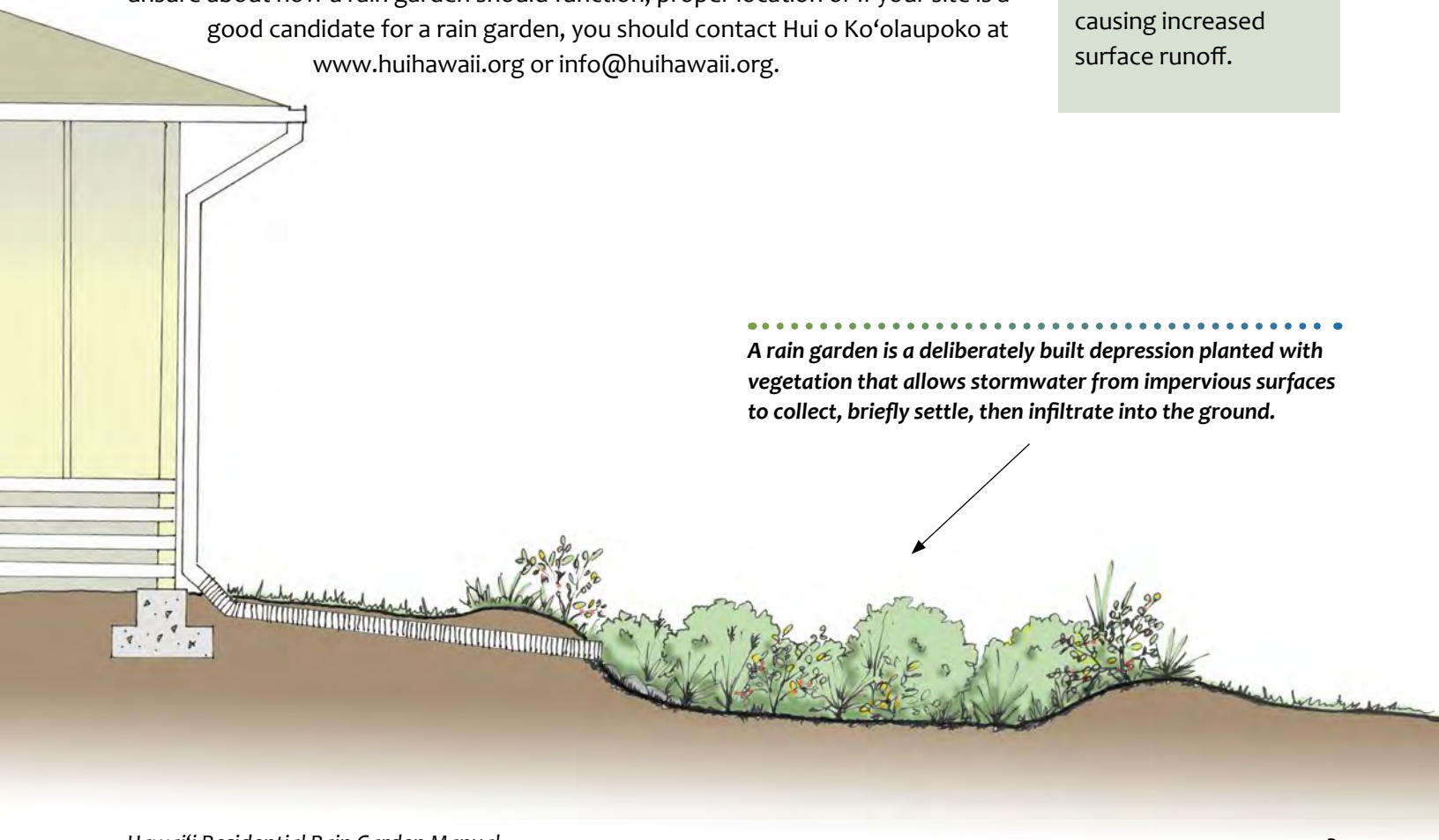
The purpose of the *Hawai'i Residential Rain Garden Manual* is to teach residents of Hawai'i the procedure of building a rain garden leading to the protection of Hawai'i's natural resources. This Manual addresses how to assess your site for the amount of stormwater to be captured, appropriate size, required materials, plant selection and maintenance.

The Manual will provide homeowners enough information to safely design and construct a rain garden based on historic rainfall patterns, soil properties and drainage areas. Additionally, this manual can easily transfer to schools or more developed urban areas to construct a rain garden. If, after reading this Manual, you are still unsure about how a rain garden should function, proper location or if your site is a good candidate for a rain garden, you should contact Hui o Ko'olaupoko at www.huihawaii.org or info@huihawaii.org.

## Definitions

**Non-point source pollution:** Pollution that is caused by a diffused source generated from stormwater runoff, such as rainfall, that carries pollutants into storm drains, stream and the ocean.

**Impervious surface:** A hard surface such as a roof, road, parking lot or other surface that does not allow water to infiltrate causing increased surface runoff.



***A rain garden is a deliberately built depression planted with vegetation that allows stormwater from impervious surfaces to collect, briefly settle, then infiltrate into the ground.***

## Definitions

**Watershed:**
The area that drains to a common waterway, such as a stream, estuary, wetland, or the ocean.

**Ahupua‘a:**
Land division usually extending from the upland to the sea.

## Stormwater

Rain gardens are a beautiful and beneficial way to help reduce stormwater runoff.

Stormwater runoff is a major source of pollution that enters Hawai‘i waters.

## Why build a rain garden?

Rain gardens have the ability to reduce the amount of pollution entering streams and the ocean by intercepting stormwater. Rain gardens are ‘designed with nature’ as they mimic natural processes by treating and infiltrating stormwater into the ground and evaporating it back into the air, much like undeveloped areas. As *ahupua‘a* or watersheds have developed in Hawai‘i, water quality has degraded. Pollutants such as pesticides, fertilizers, oils, grease, pet waste and sediment build up on impervious surfaces. During rains, pollutants run off the landscape and flow into storm drains, streams and the ocean. As a result, non-point source pollution is a leading cause of poor water quality in streams and ocean swimming areas and is a major contributor to coral reef degradation.

*Stormwater runoff from impervious surfaces flow into storm drainages, like this one in Lanikai, delivering unfiltered sediment and pollutants that damage ocean ecosystems.*

## Rain garden benefits

Rain gardens are an effective tool for individual homeowners who want to reduce the amount of pollution entering Hawai'i's streams and the ocean from their own properties. By constructing a rain garden, individuals are taking an active role to protect watersheds, streams and the ocean by:

- Filtering pollutants;
- Assisting with groundwater recharge;
- Improving the landscape with native vegetation; and
- Reducing flood volumes.

*When plants mature in your rain garden, they should cover the entire surface. Healthy plants will help with soil health and more capacity to filter pollutants.*

## Do rain gardens breed mosquitos?

Rain gardens are designed to infiltrate water within 30 hours of a rain event in order to accept more water from the next storm; they are not a wetland or a pond. Constructed properly, rain gardens will infiltrate water quickly enough to eliminate the potential for breeding mosquitoes.

## Construction timeline

*Three recommended native plants for rain gardens are, from top, ʻAeʻae, Ilima and ʻĀkia.*

*See more in Section 8.*

### Construction sequence

It is a good idea to plan ahead and have all supplies, materials, plants, compost and mulch on site before the rain garden is started. Additionally, make sure you have enough volunteers to help you start and finish the project. The following graph will help you plan your construction sequence.

#### Two Weeks Before Build

- Read Manual
- Map your property
- Determine slope
- Determine size of contributing draining area
- Determine size of rain garden
- Call about permits

#### One Week Before Build

- Call utilities before you dig
- Purchase plants
- Purchase mulch
- Purchase compost

#### Week of Build

- Secure volunteers
- Stage equipment and supplies on site

#### Day of Build

- Review Manual
- Dig, compost, mulch, plant
- Irrigate

# 1. Assess and map your site

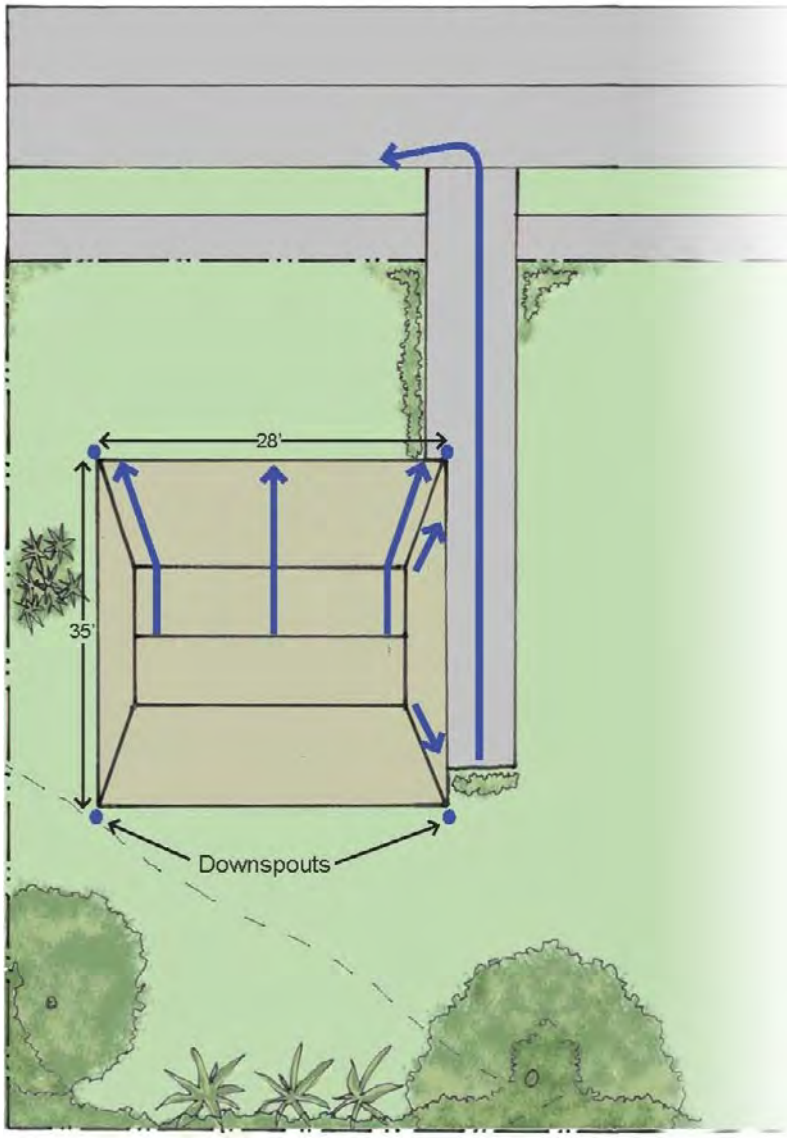
The following sections will lead you through a step-by-step process to build a rain garden. You will be able to assess your site, understand soil properties, determine the appropriate size, proper location, plant selection and perform maintenance.

## Site mapping

A very important step of the rain garden build is mapping your home to determine the rain garden's location. First, you should draw a schematic of your property detailing all structures, significant vegetation, retaining walls, driveways, slopes and utilities if known. You will also want to map the direction and flow patterns of stormwater across your property. Observe the way water flows on your property during the next rain. This map will help to avoid potential complications such as interference with utilities and overflow of excess stormwater. Alternatively, you can print an aerial photo of your property from internet sources to assist in the mapping.

While mapping your site, consider the following:

- Identify any slopes and low spots;
- Identify areas where water might drain to your neighbors' or other properties;
- Identify impervious surfaces;
- Identify areas that stay wet or pond water; and
- Identify areas where your rain garden can overflow safely (e.g.; to a storm drain).



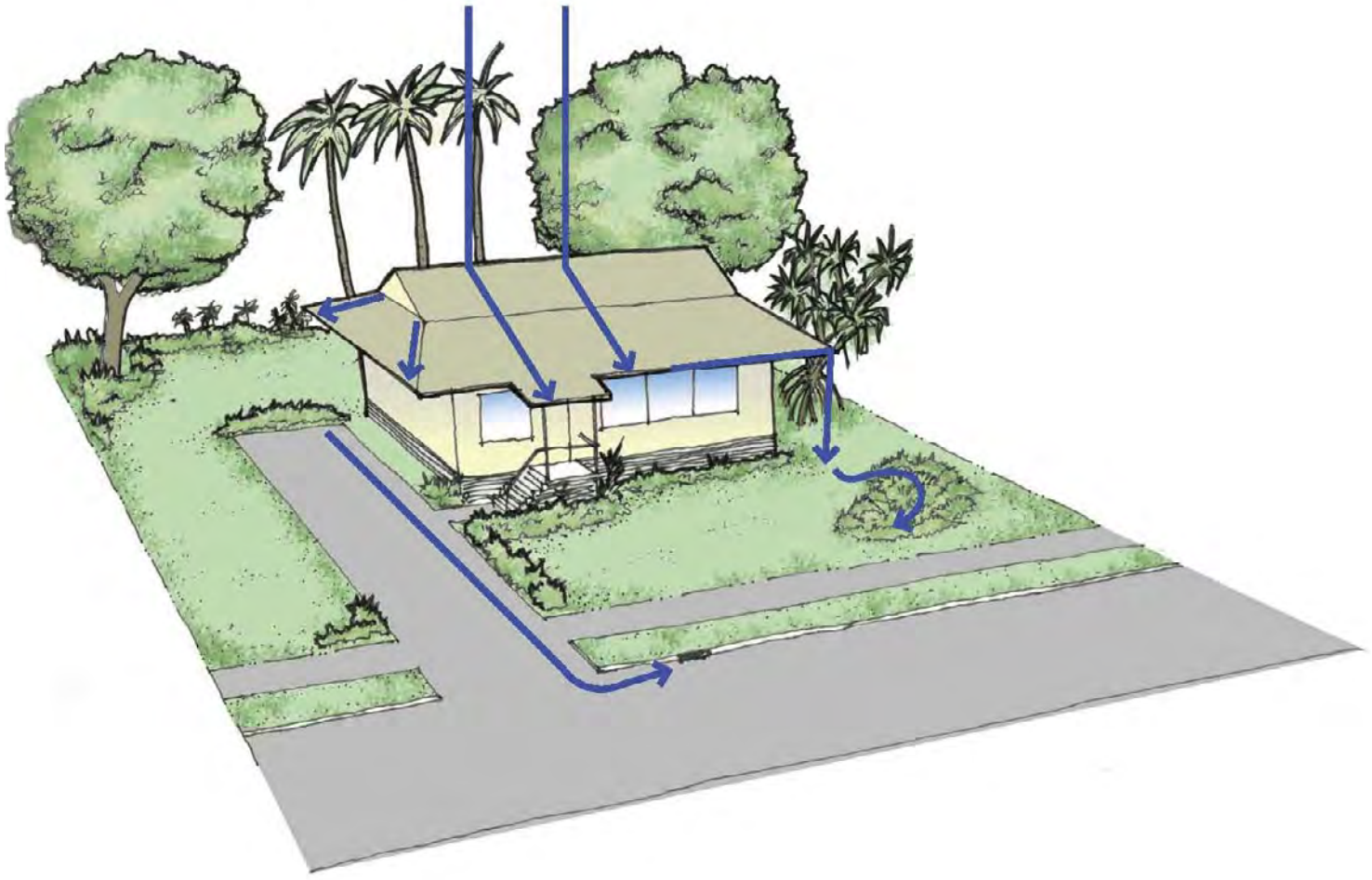

*Rooftop illustration showing how to map stormwater flow.*

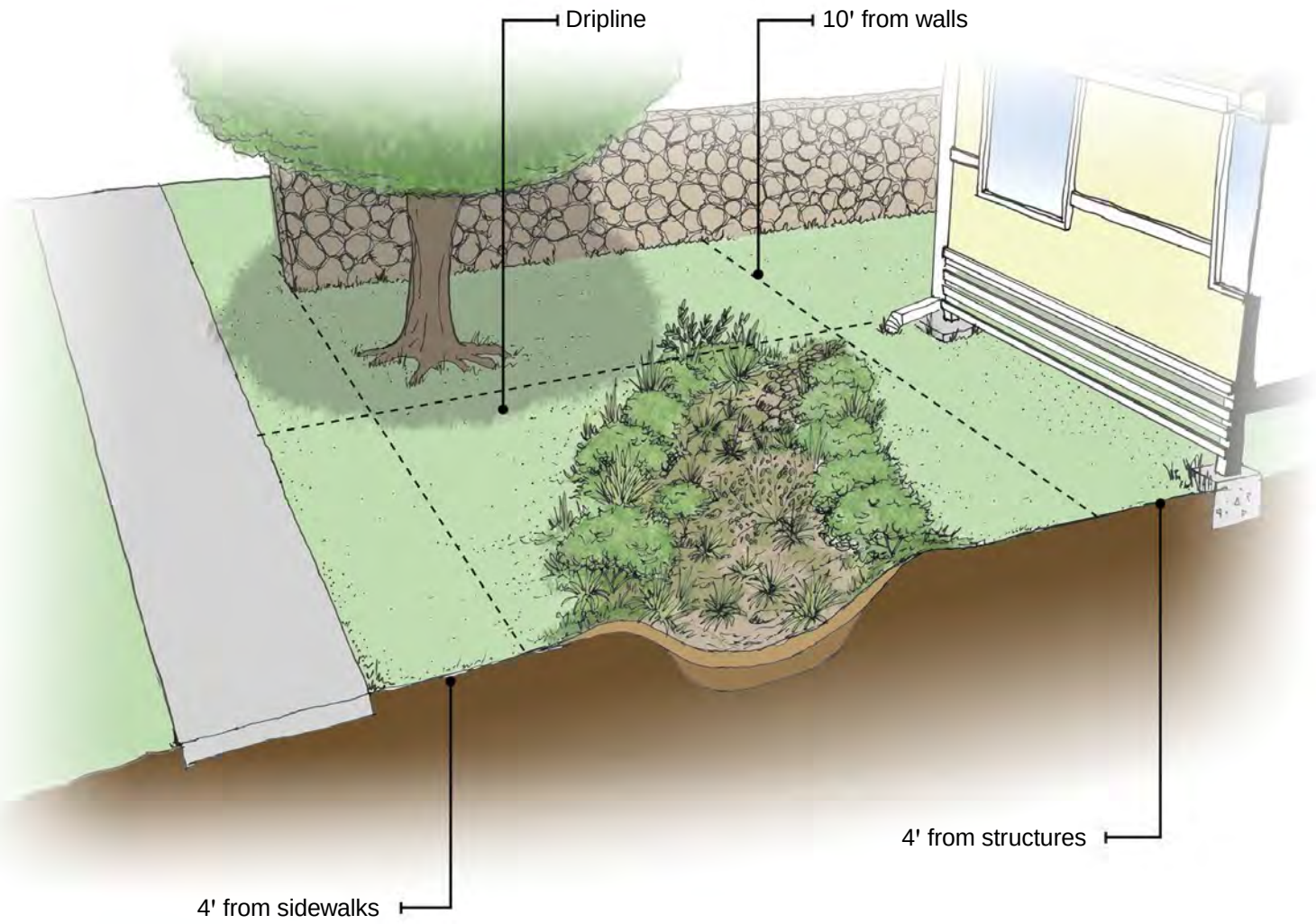
# 2. Siting your rain garden

Once the mapping of your property is completed, it's time to determine the location and size of your rain garden. You want your rain garden close to the area you are capturing water from, such as a downspout from your home's gutter or driveway. This will allow water to be easily directed into the rain garden. Determining where to build is largely dependent on the mapping of your property, flow of water and how much stormwater your rain garden will capture, ease of digging, aesthetics and visibility.

Rain gardens are built with an overflow to safely remove water during heavy rains. Overflowing water should be directed to an area for additional infiltration such as a lawn or flow to an existing storm drain.

*Illustration demonstrating how water flows from a typical house and enters the rain garden and storm drains. Building a rain garden can intercept a portion of this runoff, evaporate it into the air and infiltrate into the soil before it reaches the storm drain.*






There are several locations where a rain garden should **NOT** be built. To ensure against damage to other structures and your property, use the following guidelines when determining your rain garden's location:

- 4 feet from a crawl space or slab;
- 4 feet from a sidewalk/driveway;
- 10 feet from a basement;
- 10 feet from the top of a retaining/decorative wall;
- Avoid the drain field of a septic tank or cesspool;
- Avoid the dripline (edge of tree canopy) of trees or proximity to tree roots that could be damaged during digging;
- Avoid areas that stay consistently wet during the rainy season, this indicates poor draining soils; and
- Avoid soils that have drainage of less than ½ inch per hour infiltration (see Section 3)

## Measuring slope

In order to safely infiltrate water, do not build a rain garden on or adjacent to slopes with more than a ten-percent (10%) gradient. Placing a rain garden in an area with greater than ten-percent slope could cause soil to slide or shift, resulting in erosion or other problems. If your property does not allow for placing a rain garden in a safe area, you should contact a licensed landscape designer or engineer to discuss design options.

To calculate slope you will need the following tools:

- Two stakes
- Survey line/string
- Line Level
- Measuring Tape
- Calculator
- Hammer

1. Hammer a stake at both the top (inlet) and bottom (outlet) of the rain garden's potential location.

2. Attach the survey line, with level, between the two stakes making sure the line touches the ground on the stake at the top of the rain garden. Raise or lower the line on the bottom stake until the line is level.

3. Measure the horizontal distance (run) along the line between the two stakes.

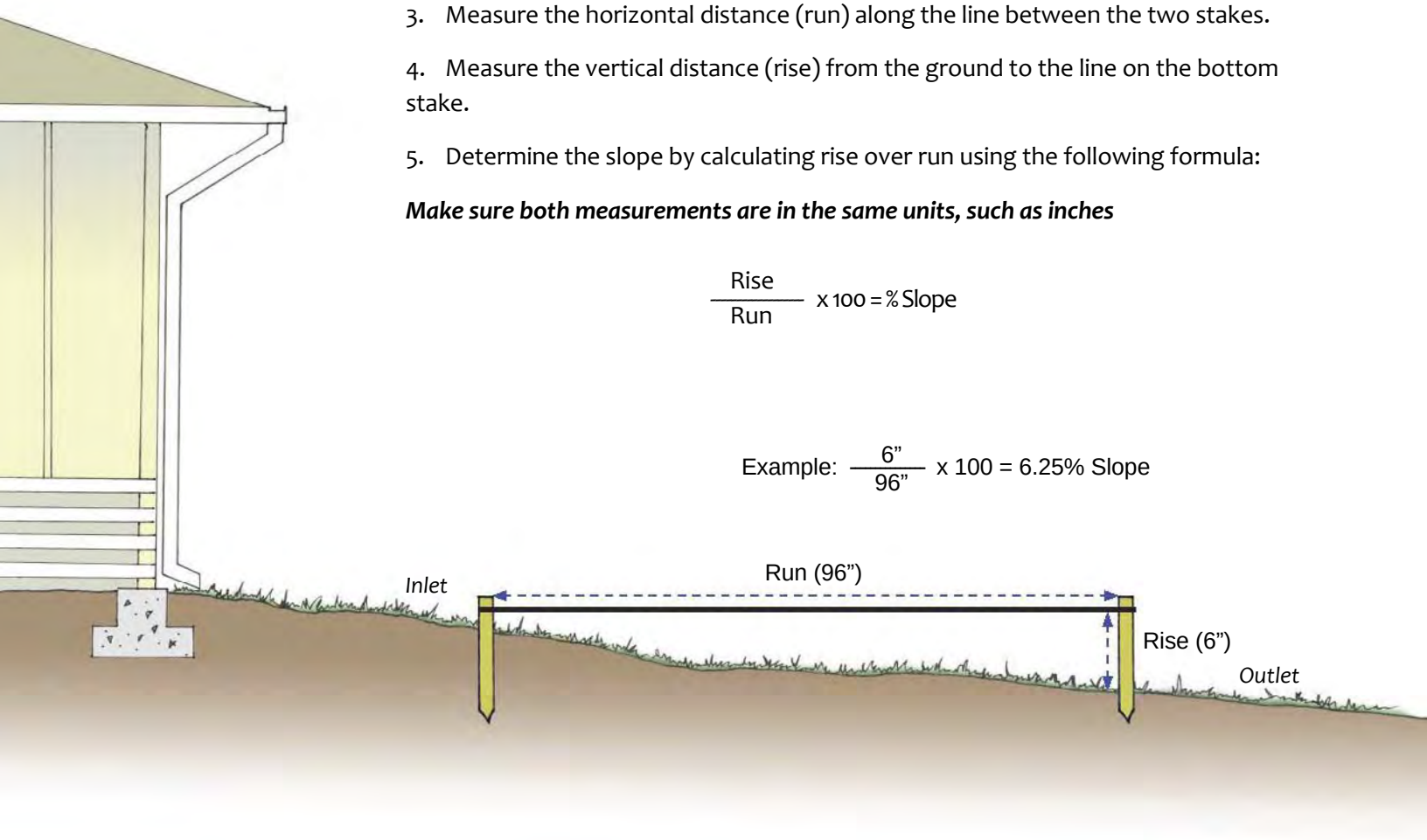
4. Measure the vertical distance (rise) from the ground to the line on the bottom stake.

5. Determine the slope by calculating rise over run using the following formula:

***Make sure both measurements are in the same units, such as inches***

$$\frac{\text{Rise}}{\text{Run}} \times 100 = \%\,\text{Slope}$$

Example: $\frac{6”}{96”} \times 100 = 6.25\%$ Slope



## Contributing drainage area (CDA)

The size of your rain garden is determined both by the size of the contributing drainage area (e.g; size of a roof, driveway or sidewalk), rainfall and soil infiltration rates. To determine the size of your contributing drainage area (CDA), measure the length and width of the area. Use the CDA calculation formula below.

Your contributing drainage area might be your driveway, patio or other impervious surfaces. In the example provided, one half of the house is 19 feet x 30 feet, totaling 570 square feet. Because there are two downspouts, each downspout drains approximately half of the roof, thus the contributing drainage area is approximately 285 square feet (half of 570).

### CDA Calculation

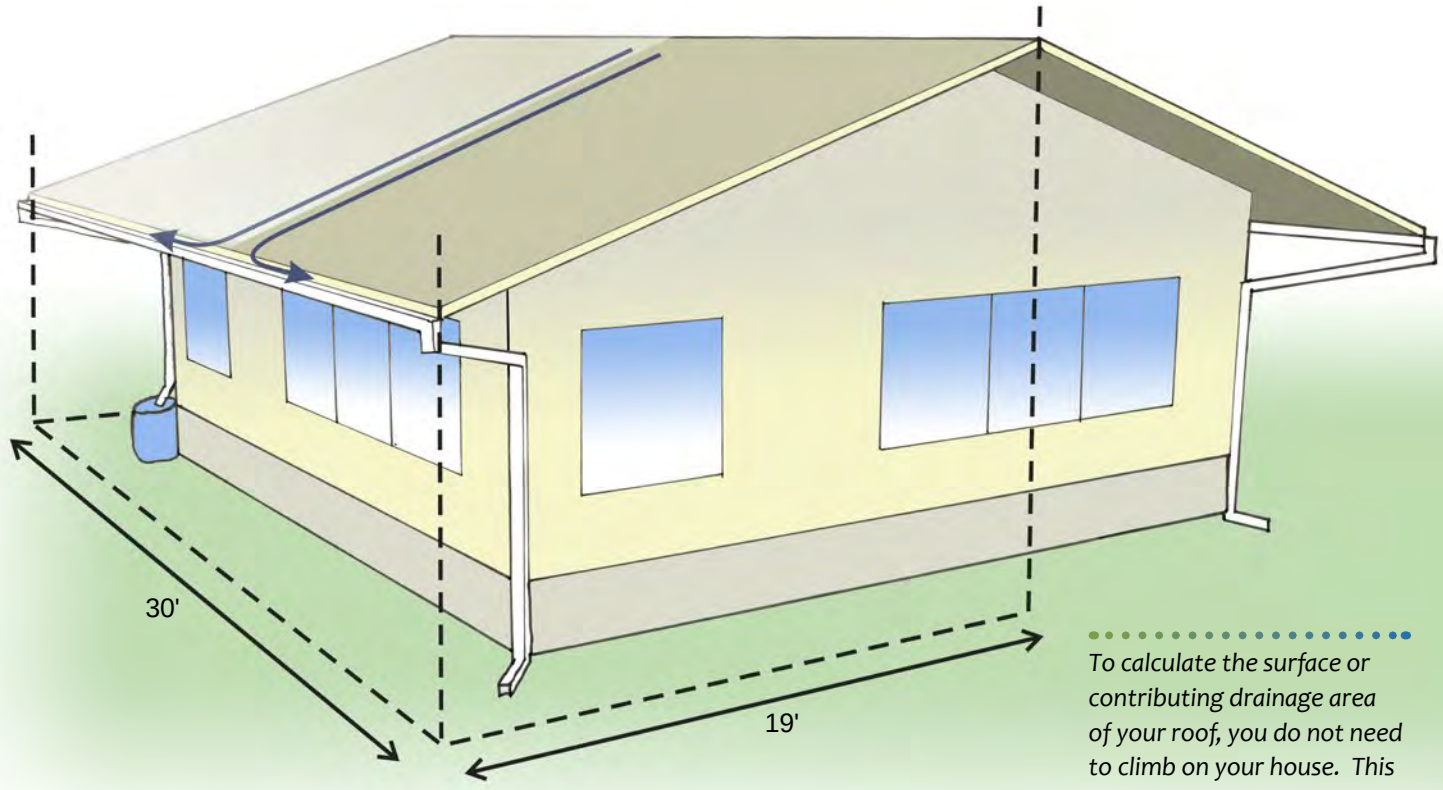
Width of Surface Area x Length of Surface Area = Area ÷ number of downspouts = CDA

19' (Width) x 30' (Length) = 570 square feet (Area) ÷ 2 downspouts = 285 square feet

### Definitions

**Contributing Drainage Area (CDA):** The area, such as a roof or other impervious surfaces, which contribute stormwater to your rain garden.

**Soil Infiltration:** The rate at which soil can absorb water.




*To calculate the surface or contributing drainage area of your roof, you do not need to climb on your house. This calculation can be conducted from the ground by measuring the width and length of your home.*

# 3. Soil Infiltration

*Examples*

To find your infiltration rate divide the inches that the water dropped by the hours it took.

$$\frac{2''}{8 \text{ hrs}} = 0.25$$

1/4 inch of infiltration/hr

...

$$\frac{6''}{8 \text{ hrs}} = 0.75$$

3/4 inch of infiltration/hr

The next step is to test the soil infiltration rates. If stormwater is not able to infiltrate into the soil below the rain garden, it will not be effective.

Different soils have different rates of infiltration. For example, soils high in clay content infiltrate water slowly compared to soils high in sand, which infiltrate water quickly. Soils with low infiltration rates results in a larger rain garden, while soils with high infiltration rates result in a smaller rain garden. The following is an easy method to determine approximate infiltration rates on your property. The method requires some digging and a little time to monitor infiltration; but, ***this is an important step that cannot be overlooked.***

To test infiltration you will need the following tools:




- Shovel
- Garden hose
- Yard stick/tape measure

**1.** Once the general location of your rain garden has been determined, a 10" to 15" test hole should be dug approximately in the middle of the rain garden location.

**2.** Fill the hole with water and allow the hole to drain, repeat a total of three times. Each draining may take several hours. For example, if your hole is 10" deep and only drains 1" per hour, this will take 10 hours. On the third filling, record the depth of water, time filling was completed/drained. The third test will mimic water infiltration rates during the rainy season when soils are more likely saturated.

**3.** The last step is to determine the infiltration rate. This is calculated by dividing the distance the water dropped by the time it took to drop.

If the water dropped 1 inch in 2 hours, 1 divided by 2 equals ½ inch per hour of infiltration.

$$\frac{1''}{2 \text{ hrs}} = 0.5$$

1/2 inch of infiltration/hr

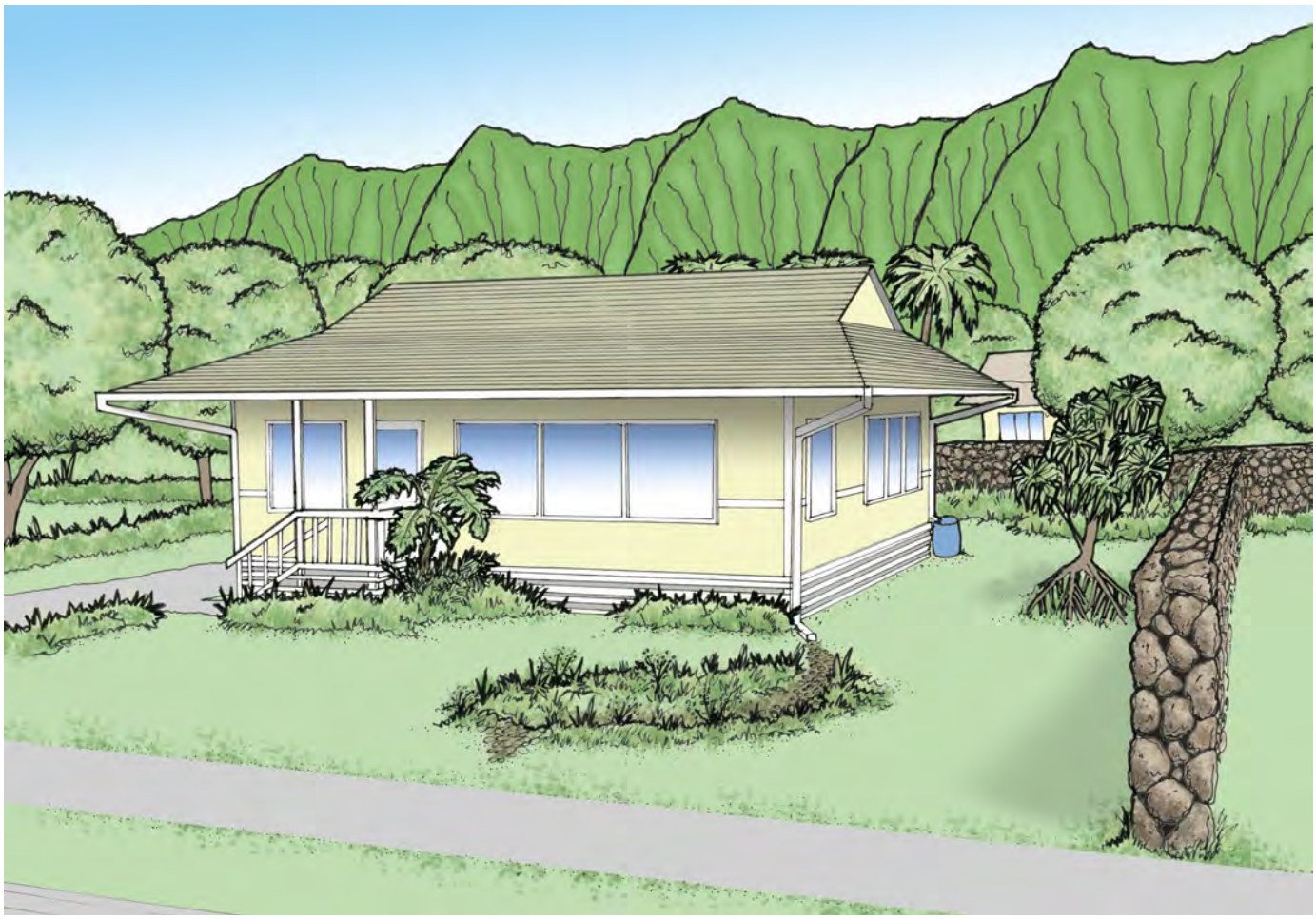
## What your calculations mean

If your test hole is draining at a minimum of ½ inch per hour, the location is a good candidate for your rain garden. If your soils are draining water at a rate of less than ½ inch per hour, the area is not a good candidate for a rain garden. It's recommended you consult with a landscape professional or engineer to change your design.

Some areas in Hawai'i have very high infiltration rates with as much as 12" or more per hour. Nevertheless, building a rain garden is still recommended as native plants, compost and mulch will help with capturing pollutants.

## Is this a good place to build a rain garden?

If your rain garden can be built to meet all criteria described in Section 2 and your soils are infiltrating water at a minimum of ½ inch per hour, this site is a good candidate for a rain garden.



*The properly placed rain garden (at the center of the illustration) is set back from the sidewalk and neighboring walls on a flat or gently sloping lawn. Water is easily directed into the rain garden from the downspout.*

# 4. Rain garden size

*Definition*

**Ponding Depth:**
The depth that water will reach before exiting the outlet of the rain garden. We recommend building your rain garden to a finished ponding depth of 9" with the outfall located approximately 2" below the top of the berm.

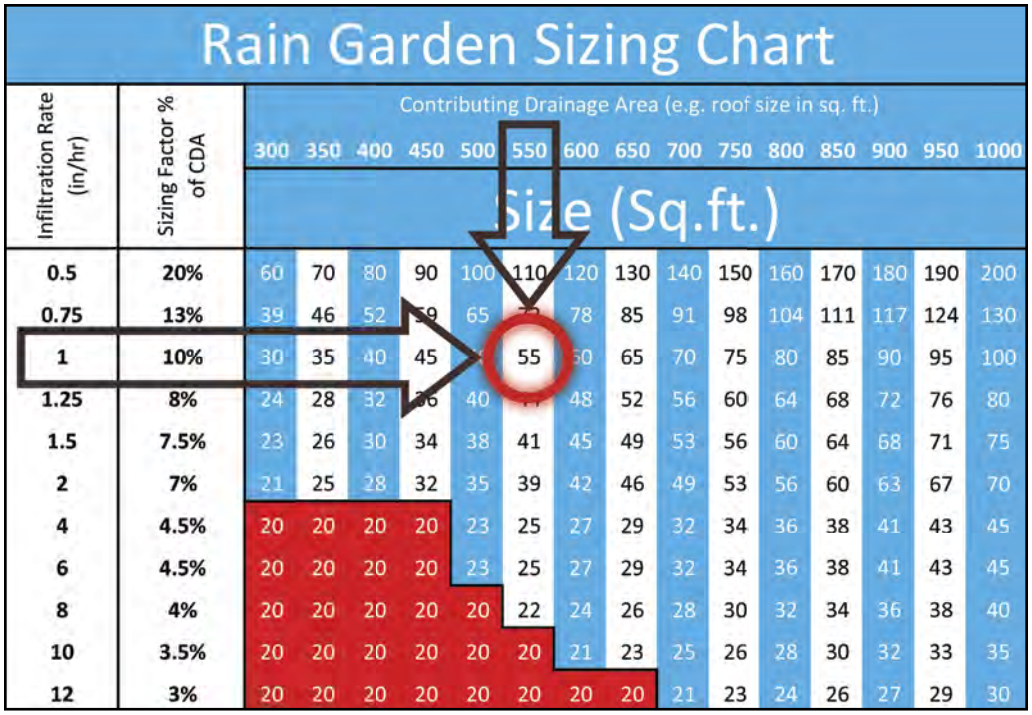
In this step, use the Rain Garden Sizing Chart to size our rain garden. Historic rainfall data from various locations has been used to develop these tables to make it simpler for the Hawai'i homeowner. Following the examples and building your rain garden based on your specific conditions, your rain garden will handle ninety percent of rainfall events.

The numbers in red are all twenty square-feet in size. This is a result of the need for 3H:1V sides on a rain garden, a rain garden should not be built any smaller than twenty-square feet or have a minimum width of 4.5 feet wide.

There are two examples provided to demonstrate how to utilize the chart and step you through the process of determining your rain garden size, each arriving at the same sizing in two different manners. Example 1 can be followed when your scenario is represented on the chart, for example your contributing drainage area falls between 300 and 1000 square feet. Example 2 can be followed when your contributing drainage area is not represented, smaller than 300 or larger than 1000 square feet. For both examples, refer to your soil's infiltration rate and round the infiltration rate number **down** to the next nearest value represented in the chart.

## Rain Garden Sizing Chart

| Infiltration Rate (in/hr) | Sizing Factor % of CDA | Contributing Drainage Area (e.g. roof size in sq. ft.) Size (Sq.ft.) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 |
| **0.5** | **20%** | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
| **0.75** | **13%** | 39 | 46 | 52 | 59 | 65 | 72 | 78 | 85 | 91 | 98 | 104 | 111 | 117 | 124 | 130 |
| **1** | **10%** | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| **1.25** | **8%** | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 |
| **1.5** | **7.5%** | 23 | 26 | 30 | 34 | 38 | 41 | 45 | 49 | 53 | 56 | 60 | 64 | 68 | 71 | 75 |
| **2** | **7%** | 21 | 25 | 28 | 32 | 35 | 39 | 42 | 46 | 49 | 53 | 56 | 60 | 63 | 67 | 70 |
| **4** | **4.5%** | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| **6** | **4.5%** | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| **8** | **4%** | 20 | 20 | 20 | 20 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| **10** | **3.5%** | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 25 | 26 | 28 | 30 | 32 | 33 | 35 |
| **12** | **3%** | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 |



| Rain Garden Sizing Chart | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Infiltration Rate (in/hr) | Sizing Factor % of CDA | Contributing Drainage Area (e.g. roof size in sq. ft.) Size (Sq.ft.) | | | | | | | | | | | | | | |
| | | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 |
| 0.5 | 20% | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
| 0.75 | 13% | 39 | 46 | 52 | 59 | 65 | 72 | 78 | 85 | 91 | 98 | 104 | 111 | 117 | 124 | 130 |
| 1 | 10% | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| 1.25 | 8% | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 |
| 1.5 | 7.5% | 23 | 26 | 30 | 34 | 38 | 41 | 45 | 49 | 53 | 56 | 60 | 64 | 68 | 71 | 75 |
| 2 | 7% | 21 | 25 | 28 | 32 | 35 | 39 | 42 | 46 | 49 | 53 | 56 | 60 | 63 | 67 | 70 |
| 4 | 4.5% | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| 6 | 4.5% | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| 8 | 4% | 20 | 20 | 20 | 20 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| 10 | 3.5% | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 25 | 26 | 28 | 30 | 32 | 33 | 35 |
| 12 | 3% | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 |

## PROJECT EXAMPLE 1:

In Project Example 1, find the intersection of the contributing drainage area (CDA) (calculated in Section 2) and your site's infiltration rate (calculated in Section 3) to determine your rain garden's size.

- Contributing Drainage Area = 550 square feet
- Infiltration Rate = 1 inch/hour
- Rain garden size: 55 square feet

## PROJECT EXAMPLE 2:

Project Example 2 can be followed when your specific scenario is not represented on the previous Rain Garden Sizing Chart. For example, your CDA might be 285 square feet as in Section 2, or 1,200 square feet. To determine the correct size of your rain garden, find your infiltration rate on the chart (calculated in Section 3) and use the associated Sizing Factor to determine your rain garden's size.

- Contributing Drainage Area = 1,200 square feet
- Infiltration Rate = 2 inches/hour
- Sizing Factor = 7%
- Rain garden size: 84 square feet
  (1,200 sq. ft. x .07 = 84 sq. ft.)

| Rain Garden Sizing Chart | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Infiltration Rate (in/hr) | Sizing Factor % of CDA | Contributing Drainage Area (e.g. roof size in sq. ft.) Size (Sq.ft.) | | | | | | | | | | | | | | |
| | | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 |
| 0.5 | 20% | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
| 0.75 | 13% | 39 | 46 | 52 | 59 | 65 | 72 | 78 | 85 | 91 | 98 | 104 | 111 | 117 | 124 | 130 |
| 1 | 10% | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| 1.25 | 8% | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 |
| 1.5 | 7.5% | 23 | 26 | 30 | 34 | 38 | 41 | 45 | 49 | 53 | 56 | 60 | 64 | 68 | 71 | 75 |
| 2 | 7% | 21 | 25 | 28 | 32 | 35 | 39 | 42 | 46 | 49 | 53 | 56 | 60 | 63 | 67 | 70 |
| 4 | 4.5% | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| 6 | 4.5% | 20 | 20 | 20 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 38 | 41 | 43 | 45 |
| 8 | 4% | 20 | 20 | 20 | 20 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| 10 | 3.5% | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 25 | 26 | 28 | 30 | 32 | 33 | 35 |
| 12 | 3% | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 |

## Call first

Call for utility location before you dig! It is the law to call at least five days before you begin digging, even for a rain garden. It is recommended you follow the preceding steps before calling. This will ensure that you have confirmed the rain garden's location and size before the utilities are checked.

The State of Hawai'i number is:
1-866-423-7287

On the web at:
callbeforeyoudig.org

# 5. Construction of a rain garden

## Permits

Check with your local planning office for any required permits, setback or other regulations regarding rain gardens:

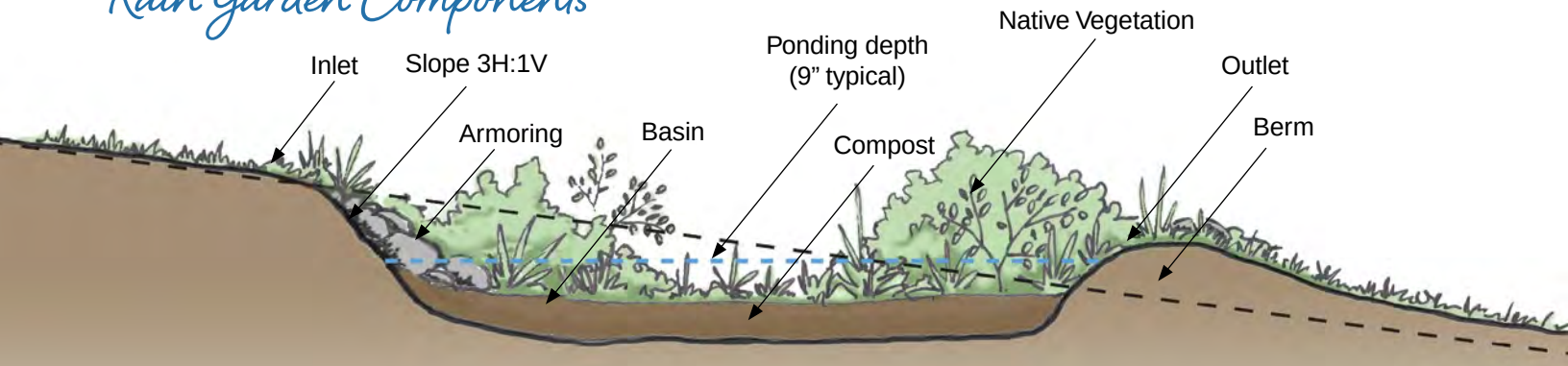
- County of Hawai'i (East Hawai'i): (808) 961-8288
- County of Hawai'i (West Hawai'i): (808) 323-4770
- City and County of Honolulu: (808) 768-8102
- County of Kaua'i (808) 241-4050
- County of Maui: (808) 270-7735

## Materials and equipment list

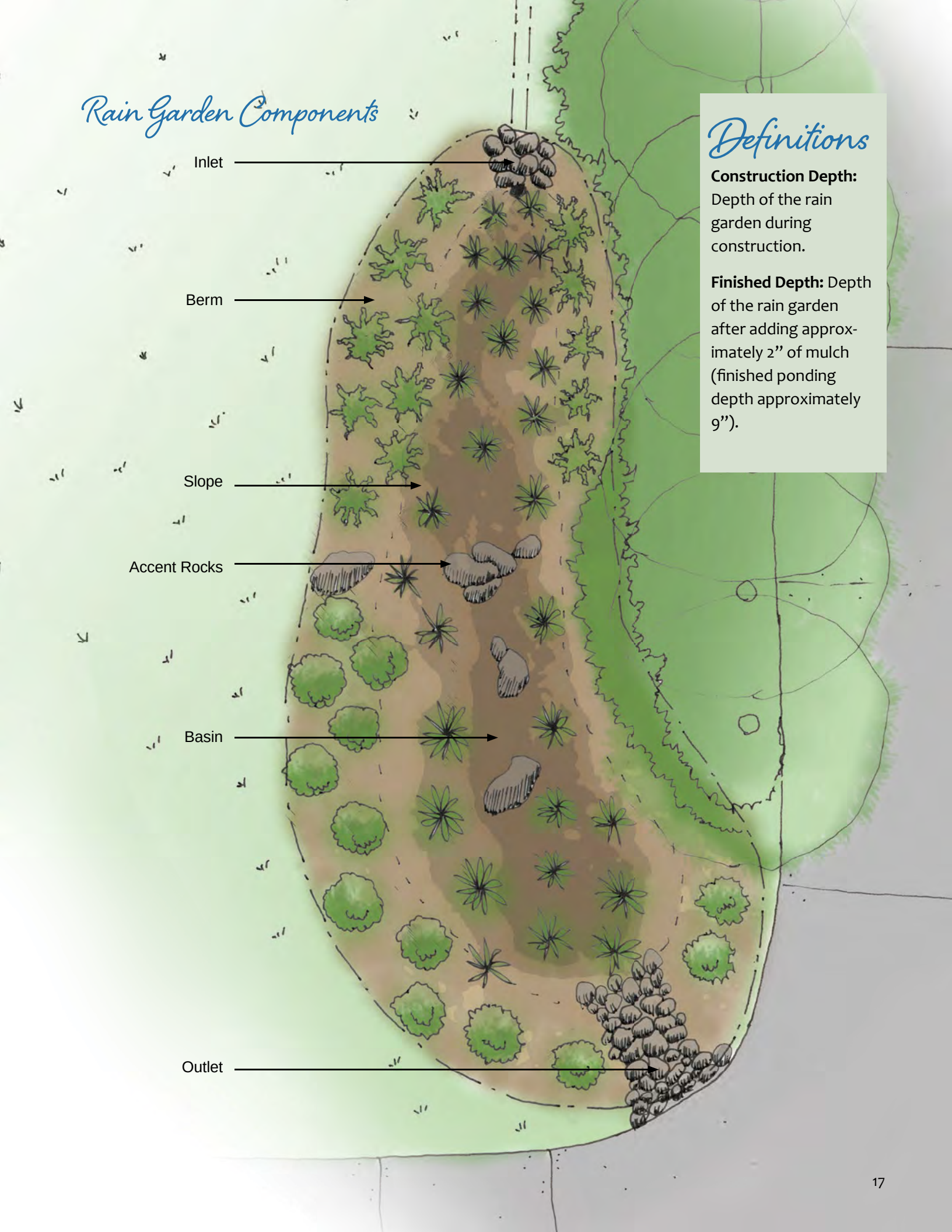
In addition to the equipment list needed for determining slope, the following materials and equipment list will allow you to construct your rain garden:

- Shovels
- Hammers
- Gloves
- Rope, garden hose or spray paint (enough to outline your rain garden)
- 3' level
- 2" to 3" washed rocks
- Wheel barrow
- 10' x 10' tarp
- Rakes
- Line and live levels (two is best)
- Stakes
- Measuring tape
- Compost
- Mulch
- Plants
- Rototiller (optional)

## Rain Garden Components



# Rain Garden Components




## Definitions

**Construction Depth:** Depth of the rain garden during construction.

**Finished Depth:** Depth of the rain garden after adding approximately 2" of mulch (finished ponding depth approximately 9").

## 3 to 1 Slope

*For every one foot of vertical (V), the sides are three feet horizontal (H). If the rain garden is 11" deep, you will need sloping sides that are 33" wide.*

## Outline the rain garden

Use the rope or garden hose to create an outline of your rain garden that is roughly the size calculated in Section 4. The rain garden need not be a square; in fact, creating a rain garden with an aesthetically pleasing shape will add beauty and value to your yard. See sample rain garden design examples on pages 28 and 29.

*Right: A long rope is an easy way to create an outline the desired shape of your rain garden.*

*Below: Connect an ABS coupler to your downspout, if needed, use screws to secure the connection.*

*Below right: If using pipe to convey water from your contributing drainage area to the rain garden, no more than a 2% slope is needed.*

## Connecting the rain garden

In order for your rain garden to be effective at capturing stormwater, runoff needs to be routed to the area. There are two general ways to route water to a rain garden, underground via a pipe or above ground via surface flow. If routing water underground, a solid or flexible corrugated 3" to 4" diameter ABS pipe is recommended. If connecting to an existing downspout, it may require buying different size couplers to fit your specific application. Depending on the length of the run from your downspout to the rain garden, incorporating a clean out half-way with a T-coupler accessible above ground is a good idea. This will allow the pipe to be washed of debris such as leafs and prevent clogging. The pipe should be buried a minimum of four inches deep; however, if you plan on driving over the area with a riding lawn mower, it should be buried deeper.

If you chose the option for above ground, dig a trench and line it with 2" to 3" rock or route water across a grassed area. This option could save time with less digging but could limit access to other parts of your property for a lawn mower or other equipment.

In either case, the slope should be approximately a 2% gradient to the rain garden. Determine the slope for this with the same method as you calculated the slope for the rain garden, with stakes, line and line level.

Horsley Witten Group

*Top: An above ground rock inlet route can be used instead of a buried ABS pipe.*

*Above: Using a line and line level will ensure the bottom of the rain garden is level and your inlet and outlet are placed at the proper heights. Place rock in the outlet to prevent erosion.*

## Excavators

*The Manual is presented in a manner that assumes rain gardens are being constructed with shovels and friends and not excavators. However, if you use an excavator, it is recommended the machine never drive over the area to be used as the rain garden as compaction will occur resulting in less infiltration. Spend some time thinking about construction sequence and the best way to access the rain garden and where to drive, be sure you don't 'double-back' to an already excavated area to re-grade, this will increase the risk of compaction.*

## Excavating

Most of the planning is now complete and you are ready to build a rain garden with your friends and neighbors. Based on the sizing calculations from Section 4, excavate soil to the required rain garden size. Two inches of compost will be added and needs to be factored in when digging.

When excavating the rain garden, it's critical to keep the bottom of the basin level to allow water to spread evenly throughout the rain garden before overflowing at the outlet. Ensuring the bottom is level is accomplished by using a line level and tape measure; measure from the line to the bottom of the rain garden at various locations. Having two line levels will save time if constructing a large rain garden.

The sides of the rain garden should be built with a 3H:1V slopes, meaning that for every three feet of run, there is one foot of rise. If you have a rain garden with a depth of eleven inches, your sides should be thirty-three inches wide on each side of the berm. Having 3H:1V slopes or flatter allows for more surface area for water to infiltrate, good planting and reduces the risk of erosion. Sides should be lightly compacted with foot pressure and planted to prevent erosion. (See Section 8 for plant selection.)

The soil removed from the excavation of the rain garden should be used for constructing the slope and berm around the edge of the rain garden. Any additional soil can be used in other areas of your yard and planted with grass or native vegetation.

*Left: Excavate the rain garden to the proper depth with hand tools and volunteers.*

*Right: Shape the sides of your rain gardens with hand tools to a minimum 3H:1V slope.*

Once you have your inlet into the rain garden, it is important that you armor the area with 2" to 3" rocks and vegetation; this will protect the area from erosion.

An overflow, or outlet, should be installed once the rain garden has been dug and the sides are shaped. Position the outlet in an area of the rain garden so the water doesn't flow to your neighbors' property or flow to an area with poor drainage. The outlet should be placed lower than the top of the berm and allow for your desired ponding depth. The outlet should also be armored with rocks and plants to protect against erosion.

## Compost

Before planting, you should mix in compost with the existing soil to ensure healthy plant growth, pollution removal and increased microbial activity. This can be done with shovels and rakes or the optional rototiller. Finding weed/seed free compost is the best choice to reduce the risk of invasive vegetation in your rain garden. Place approximately two inches of compost in the basin of your rain garden and up the sides approximately halfway.

*Top left: Using two line levels will save time and help ensure the bottom of the rain garden is level.*

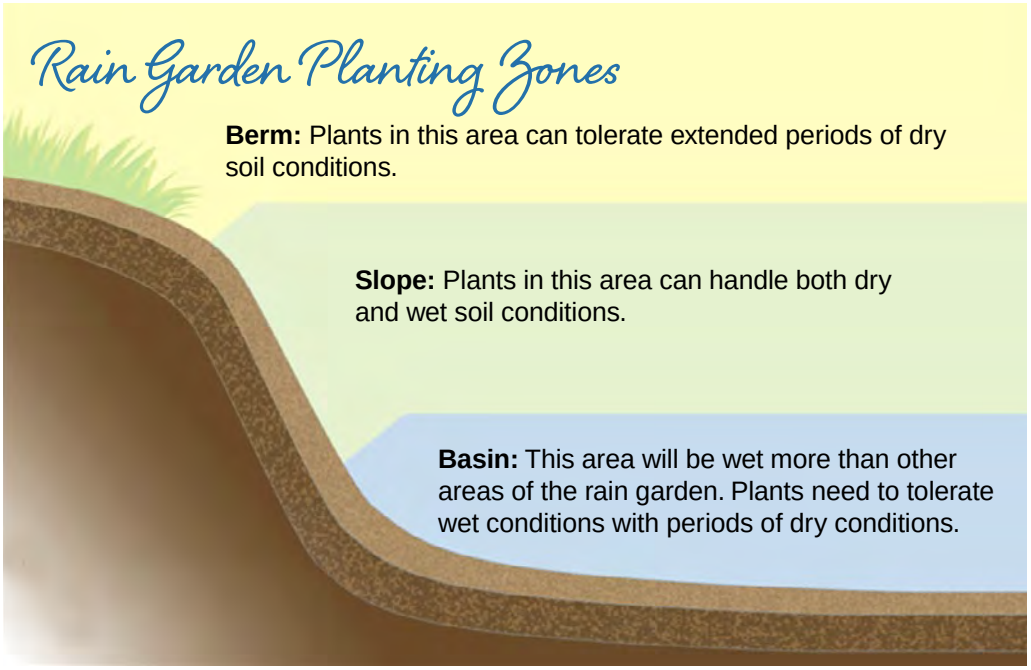
*Top right: Armor the inlet/ outlet with rocks to prevent erosion.*

*Above: Mix in approximately 2" of compost with existing soil before planting. Adding compost will help newly planted vegetation grow.*

# 6. Planting the rain garden

By design, rain gardens are built to reduce pollution entering streams and the ocean. It is important to plant your rain garden with plants that can grow in your local micro-climate without the use of fertilizers and pesticides. Native plants are an excellent choice; however, other ornamental plants may do well as long as they are ***not invasive***. If you are interested in using plants not listed in this manual, consult with a landscape professional in your area on proper plant selection. You can also consult the book *Growing Hawai'i's Native Plants* (Kerin E. Lilleeng-Rosenberger) to learn which plants are appropriate for your area. See Section 8 for more resources on native plants.

*Above: Plants should be spaced so when mature, the entire rain garden is covered with vegetation. Lay out all your plants in their pots to arrange for aesthetics and proper spacing before planting. A rule of thumb is 12" to 24" spacing between plants.*



*Proper plant placement and planting technique will help ensure plants are healthy and grow well.*

## Proper planting techniques

To install your selected plants into the rain garden, dig a hole that is slightly deeper and twice as wide as the pot the plant is in. Gently remove the plant from its pot by squeezing the sides to loosen the soil.

If plants have rotting roots at the base of the plant, gently remove dead roots by hand and loosen soil. If roots appear root bound, you can soak the soil and root ball in a bucket of water to loosen soil or separate roots. Place the plant in the ground and fill in the sides around the plant with the soil that was removed from the hole. Pack soil firmly around the plants to remove any air pockets which invite pests and fungus. Create a moat or a dam around the plant on the rain garden's slope or berm to capture and retain water. The level of the replaced soil surrounding the plant should be no higher than ¼ inch from the soil that existed in the pot. Burying the plant too deep or too shallow will cause the plant to rot or root poorly.

Plants should be spaced for complete coverage when mature. This requires some layout prior to installing plants and some understanding of the size of your native vegetation.

Water plants gently every other day for a few weeks, or until new growth is noticed. Reduce watering to once weekly or only during dry conditions.

*Top left: Rocks found on site, native Kupukupu ferns and mulch in a rain garden.*

*Top right: Large rocks are dramatic accents in the center of this rain garden.*

*Right: Mulch is visible between plants in this newly built rain garden.*

## Mulch

One cubic yard of mulch or compost spread three inches thick will cover about 100 sq. ft.

## Mulch

Once your rain garden is planted, spreading mulch 2" to 3" thick in the basin, slope and the top of the berms is important for keeping soils moist, blocking weeds, providing organic material and protecting against erosion. While applying mulch, be sure to keep it from touching the base of the plant directly, this may cause rot or disease to the plant.

## Accent features

In addition to plants having an aesthetic role in your rain garden, so too can other materials such as lava rock or other local material. These features will add structure and function, such as slowing water flow throughout your rain garden. Before placing any of these structures in your rain garden, be sure to wash the materials thoroughly so additional dirt is not added to the rain garden.

# 7. Maintaining a healthy rain garden

Healthy plants are the key to a successful rain garden. In addition to following the previous recommendations for watering, the following routine maintenance activities are recommended:

**Weeding:** as often as needed until planted vegetation is established;

**Pruning/manicuring:** trim vegetation or allow to grow depending on the 'look' you desire;

**Mulch:** replace mulch until vegetation has covered all exposed dirt; and

**Plant replacement:** replace dead, dying or diseased plants. Before doing so, determine why that species didn't survive. Examples might include poor planting, too much or not enough water, planted in the wrong zone, animal damage, etc.

*Placing mulch around the new plants will hold moisture and slow weed growth. Mulch should be placed around the entire rain garden approximately 2" to 3" thick.*

*Native plants, from left: 'Ahu'awa, Pōhuehue and Loulu.*

## Natives

You can see photos and find out more about these recommended native plants at these websites:

www.plantpono.org

plantnativehawaii.com

www.huihawaii.org/raingardens

*Kupukupu*

*Naio papa*

*Kawelu*

# 8. Plants list

There are many different plants found only in Hawai‘i that will grow well in rain gardens. The following charts are broken up in two major categories: dry and wet climate. Examples for wet climate would include Hilo and Kāne‘ohe and dry climates are Waikiki and Kihei. Hawai‘i has many different rainfall patterns, as such, it is impossible to develop a plant list for each zone. However, this list will provide an idea of the different plants that will grow well in the different regions as well as provide direction where to plant them within the rain garden. Rain gardens are not wetlands, plants that grow well in dry and wet climates will have the greatest success.

There are three main planting zones in your rain garden: basin (the bottom of the rain garden, the wettest), slope (sides of the rain garden, more dry) and berm (top of the rain garden, driest). Each zone has different types of plants that can tolerate different amounts of water and soil moisture. For example, plants that can tolerate wet conditions should be planted nearest the inlet of the rain garden while plants that thrive in drier conditions should be planted further away from the inlet, on the slope or on top of the berm.

Lastly, using native plants will allow you to establish and maintain your vegetation with less water and no fertilizer and pesticide. If you choose to use plants other than what are listed in this manual, please determine that they are not invasive species.

## Wet and Dry Climate Plants

| ***Hawaiian Name*** | ***Scientific Name*** | ***Placement*** | ***Growth*** |
|---|---|---|---|
| ‘Ahu‘awa* | *Mariscus javanicus* | Basin | sedge |
| ‘Ākia* | *Wikstroemia uva-ursi* | Slope/berm | low shrub |
| ‘Ākulikuli* | *Sessuvium portulacastrum* | Inlet | ground cover |
| Carex* | *Carex wahuensis* | Basin | sedge |
| ‘Ilie‘e* | *Plumbago zeylanica* | Slope/berm | low shrub |
| Koki‘o ke‘oke‘o* | *Hibiscus arnottianus* | Accent | tall shrub |
| Ko‘oko‘olau* | *Bidens torta* | Basin | low shrub |
| Kupukupu* | *Nephrolepis cordifolia* | Slope/berm | fern |

* These plants will grow well both in dry and wet climates

## Dry Climate Plants

| *Hawaiian Name* | *Scientific Name* | *Placement* | *Growth* |
|---|---|---|---|
| ʻAʻaliʻi | Dodonaea viscosa | Accent | bush |
| ʻĀhinahina | *Artemisia mauiensis* | Basin | herb/low shrub |
| ʻAkoko | *Chamaesyce celastroides* | Slope/berm | bush |
| ʻĀweoweo | *Chenopodium oahuensis* | Accent | shrub |
| Hinahina ewa | *Achyranthes splendens rotundata* | Accent | bush |
| Ihi | *Portulaca villosa* | Basin | ground cover |
| ʻIlima | *Sida fallax* | Slope/berm | low shrub |
| Kāwelu | *Eragrostis Variabilis* | Slope/berm | bunching grass |
| Kuluʻī | *Nototrichium humile sandwicense* | Accent | shrub |
| Maiapilo | *Capparis sandwichiana* | Slope/berm | low shrub |
| Naio papa | *Myoporum sandwicenses* | Slope/berm | low shrub |
| ʻOhai | *Sesbania Tomentosa* | Slope/berm | low shrub |
| ʻŌhelo kai | *Lycium sandwicense* | Slope/berm | shrub |
| Pāʻūohiʻiaka | *Jacquemontia ovalifolia* | Slope/berm | vine |
| Pōhinahina | *Vitex rotundifolia* | Slope/berm | low shrub |
| Pōhuehue | *Ipomea pes-caprae* | Slope/berm | vine |
| ʻŪlei | *Osteomeles anthyllidifolia* | Slope/berm | low shrub |

## Wet Climate Plants

| *Hawaiian Name* | *Scientific Name* | *Placement* | *Growth* |
|---|---|---|---|
| ʻAeʻae | *Bacopa mannieri* | Inlet | ground cover |
| Aʻkaʻakai | *Schoenoplectella tabernae-montani* | Basin | tall rush |
| ʻAlaʻala wai nui | *Plectranthus parviflorus* | Slope/berm | herb |
| Alaheʻe | *Psydrax odoratum* | Accent | tree |
| Hapuʻu | *Cibotium sp.* | Basin | tall fern |
| Ihiʻihilauakea | *Marsillia villosa* | Inlet | ground cover |
| ʻIliahi | *Santalum freycinetianum* | Accent, Basin | tree |
| Loulu | *Pritchardia sp.* | Basin | tree |
| Makaloa | *Cyperus laevigatus* | Basin | tall sedge |
| Māmake | *Pipturus albidus* | Accent, Basin | tree |
| Mauʻu ʻaki ʻaki | *Fimbristylis cymosa* | Basin | bunching grass |
| Nehe | *Melanthera integrifola* | Basin | ground cover |
| Puʻukaʻa | *Cyperus trachysanthos* | Basin | sedge |
| Uki | *Machaerina angustifolia* | Basin | sedge |
| ʻUkiʻuki | *Dianella sandwicensis* | Basin | sedge |

*ʻOhai*

*Pōhinahina*

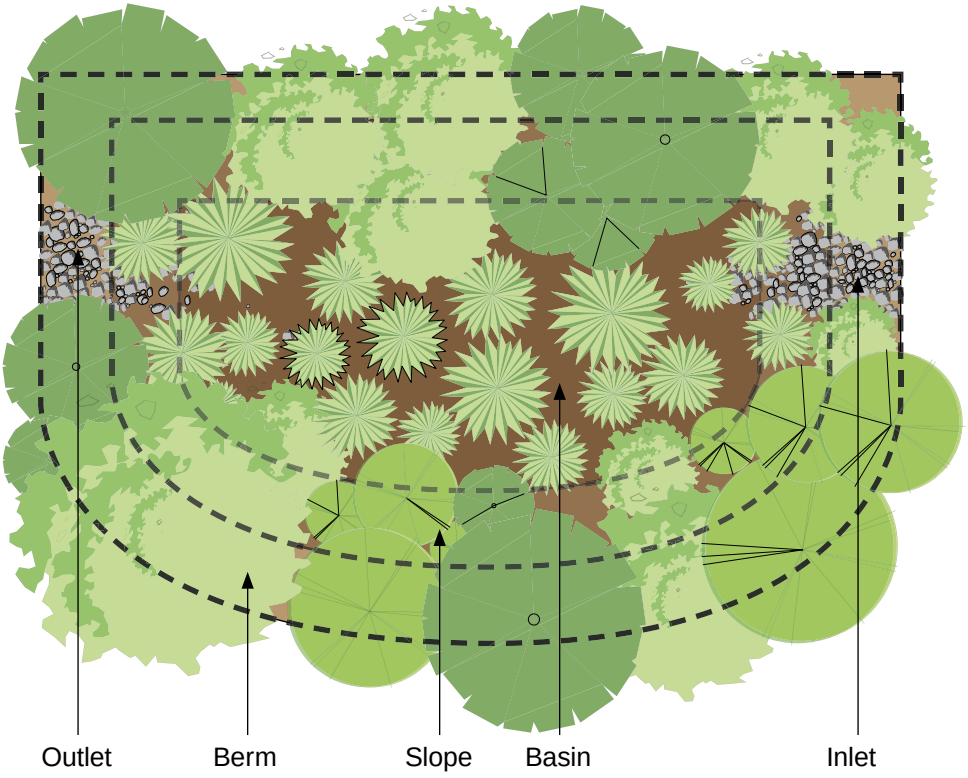
*ʻŪlei*

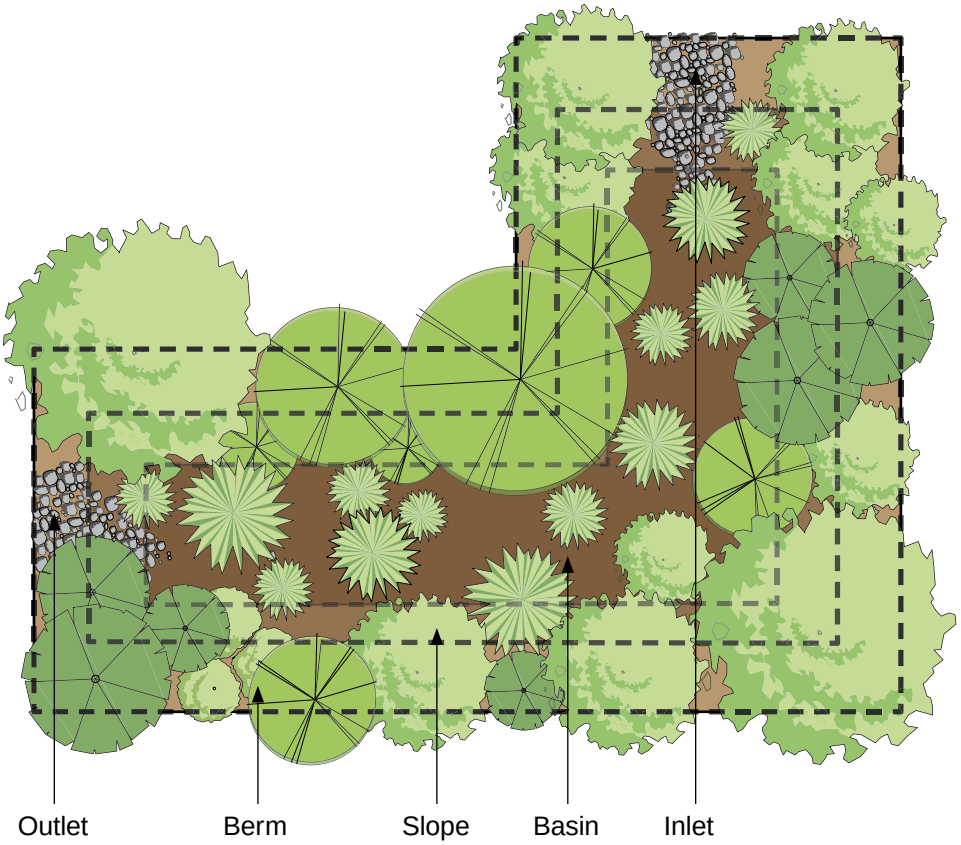
### Invasives

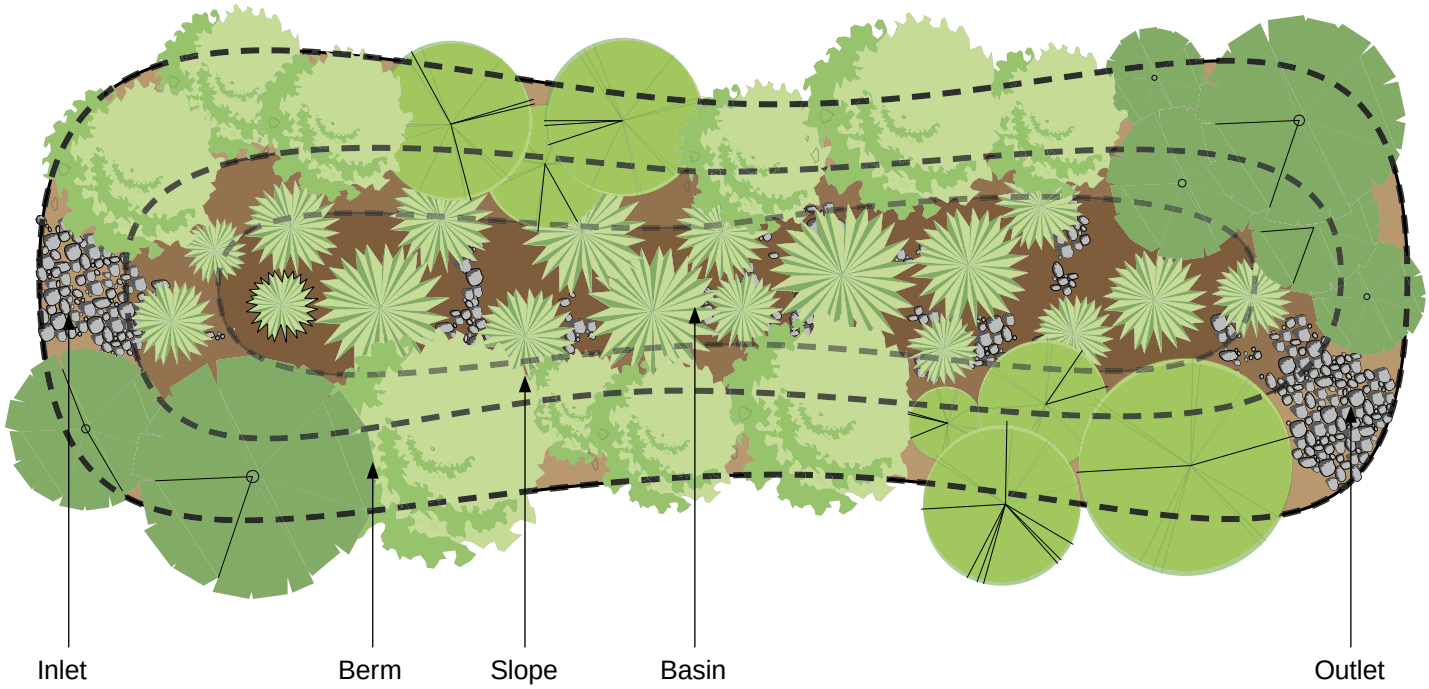
Invasive species are a significant problem in Hawaiʻi. Introduced invasive species from personal gardens are a common way in which these plants continue to spread. For more information please see www.plantpono.org.

# 9. Sample rain garden shapes

*Your rain garden shape should be designed with your current landscaping in mind. Be creative when designing the shape of your rain garden, it need not be square.*




Inlet
Berm
Slope
Basin
Outlet


Inlet
Berm
Slope
Basin
Outlet

*Koki'o ke'oke'o*

*Hinahina ewa*

*'Uki'uki*

# 10. Resources

## Sample Rain Garden Budget ~ 100 sq. ft.

| *Item* | *Unit* | *Price/unit* | *Total* |
|---|---|---|---|
| Hand excavation | | | |
| Compost | cubic yard | $55 - $70 | $55 - $70 |
| Mulch | cubic yard | $0 - $35 | $0 - $35 |
| Plants | 30 - 50 | $3 - $5 | $90 - $250 |
| Pipe | 10 feet | $40 | $40 |
| Rock | cubic feet | $4 - $8 | $25-$50 |
| Miscellaneous pipe connectors | variable | variable | $25 |
| Miscellaneous tools | variable | variable | $0 - $75 |
| **Sub Total** | | | **$235 - $545** |

| ***Optional Equipment*** | | | |
|---|---|---|---|
| Excavator | day | $175 | $175 |
| Excavator operator (4 hr min.) | 4 hours | $50 | $200 |
| Excavator (delivery/pickup) | roundtrip | $250 | $250 |
| Rototiller | day | $60 | $60 |
| **Optional Sub Total** | | | **$685** |
| **Estimated Total** | | | **$920 - $1230** |

## Websites for more information

www.hawaii.gov/health/environmental/water/cleanwater/prc

water.epa.gov/polwaste/nps/urban_facts.cfm

www.plantpono.org

www.plantnativehawaii.com

www.huihawaii.org/raingardens

http://www.hbws.org/cssweb/display.cfm?sid=1360

# *Mahalo*

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