2.4 Gutter and Downspout Sizing and Location Calculations

Both Metric and English units: Remember to save this spreadsheet to your own computer.

This spread sheet will help you calculate the gutter width and maximum distance between downspouts based on your maximum rainfall, roof area, and style of gutter. There are two major factors to consider when deciding a gutter design. The first is to make it wide and deep enough to collect all of the rainwater during the hardest rainfall. The second is to slope the gutter downward enough to allow good drainage and flow, but not so much that you drift so far below the edge of the roof that the water overshoots the gutter. We will calculate both simultaneously for you.

We will present calculations for four common gutter designs; a semicircle, a V trough of which you can very the inside angle; a box (square trough), and a trapezoid.

First: We'll decide what area of the roof is applicable to the calculations. This will dictate the amount of water that the gutter needs to be able to carry during the hardest rain storms. As you proceed, keep in mind the different areas of your roof that you measured in section 2.2 Calculating your roof area for rainwater harvesting.

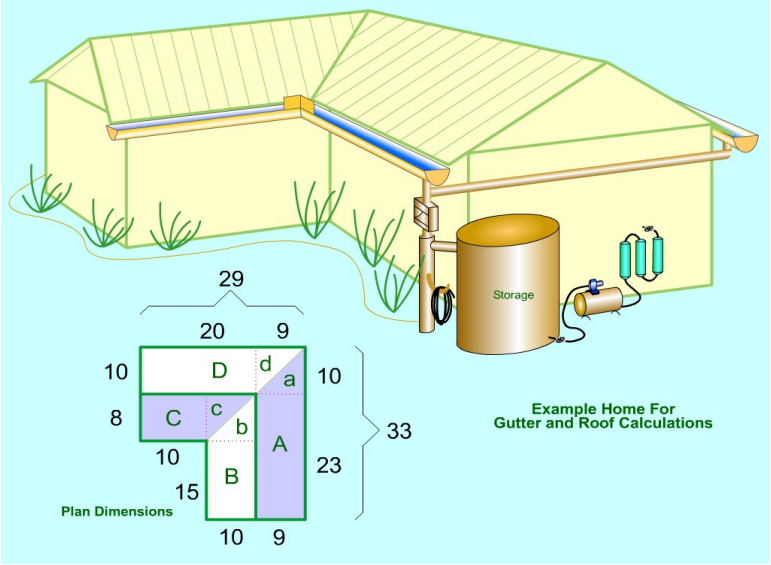
Second: We will enter data about your highest intensity of rainfall, followed by an assumed gutter efficiency, and finally the friction factor of the material that you will make your gutter out of.

Third: If the distance between downspouts turns out to be too short for your home, we will let you enter trial gutter widths until the length, drop and width work well with each other.

Fourth: We'll discuss your downspout size, location and a few comments.

Results will be tabulated so that you can easily see results as you change variables. Detail drawings and dimensions will follow the table for each of the gutter designs.

First: Get the dimension of the roof areas that you want to gutter. These are the areas that you calculated in section *2.2 Calculating your roof area for rainwater harvesting*. We are going to assume that values are in feet and square feet. As a reminder, the areas are Aa at 252 sq ft & 33' long, Bb at 190 sq ft & 15', Cc at 120 sq ft & 10', and Dd at 245 sq ft & 29'.



We are going to assume that you want to make your gutters around your home, look the same as far as material of construction, width and design are concerned. This allows us to size the gutters based on the longest length between downspouts. Any shorter lengths of gutter will have no problem handling the water volume or the slope. Pick the largest area to be drained between downspouts. This will dictate the width of the gutter. This isn't obvious in this example. Section Aa is 33 feet long with an area of 252 sq ft, but notice that section Bb and Cc share the same gutter. Their combined length is 25 ft and their combined area is 310 sq ft. We will need to do calculations on both areas to insure the right gutter size.

We will use the larger of the two or 310 sq ft for our first calculation.

Second: Enter Data

First we will find the maximum amount of rain that will be captured in gallons per minute

Enter the plan area of your first roof section(s) in square feet here	310	sq feet	28.8 sq m
Enter the maximum rainfall intensity here in inches per hour. Use these default numbers if you can't find this data for your location.	4.75	inches/hr	2.0 mm/min

Gross gallons per minute =	15.3
Gross Liters per minute =	58
Assumed collection efficiency = 85 percent	
Net gallons per minute =	13.0
Net liters per minute =	49

Note: Don't make this number too small, we are already assuming a 3/4 full gutter at its maximum depth. This efficiency number is to take care of splash and gable losses.

Now decide on the material that the gutter will be made out of. We need this information to establish a friction factor for our calculations. You will find that the rougher the gutter material, the larger the gutter will need to be. The default friction factor of 0.02 is entered for galvanized metal. Simply select your friction factor from this table and type over the 0.02 already entered in the yellow box.

Material	Possible friction factors to enter in the yellow cell below
Rough, sandy, or bumpy material like bamboo, rough wood, or shingles	0.07
Relatively smooth wood	0.04
Galvanized metal	0.02
Very smooth material like plastic	0.01

Enter the friction factor from this list here --> 0.02

Gutters need to slope to a downspout. This keeps the rainwater moving faster so the leaves and dirt have less chance to build up. It also reduces the chances of stagnant pools forming that will attract mosquitoes and other critter growth. A good slope would be 0.5° and it has been entered for you here. However, this 0.5° will not be consistent throughout the length of gutter. Slope the first 2/3 of gutter length one-half the amount of the last third of gutter. For example; we have entered a 0.5° slope for the last 1/3 of gutter length here and you would install the first 2/3 of gutter at half that slope. The slope is very important because it, and the gutter width, dictates how far you can go between downspouts. If you went too far between downspouts, the gutter would be so far below the roof edge that the rainwater would overshoot the outside edge of the gutter.

Type over the 0.5° if you want to see how other slopes will perform here	0.5	degree		The drop is calculated here for you	
slope the first 2/3 of gutter, farthest from the downspout	4	mm / meter	0.1570836	in / yard	1 : 229
slope the last 1/3 of gutter length just before the downspout	9	mm / meter	0.3141672	in / yard	1 : 115

You can change this inside angle of the V trough if you like.

This is the minimum size of gutter that you will need for the **quantity of water** that you will be collecting from this area(s) of roof. If the Max Length to Downspout is too short for your house, use the calculator to the right to find the

Enter **larger** gutter widths in the yellow boxes to find out how wide your gutters need to be **given the length that you want to go between downspouts**. Remember, two gutter lengths can share the same downspout, so if you calculate the max gutter to be 40 feet, you could put a downspout halfway in an 80 foot length.

	Minimum Top Opening Width		Max Length to Downspout		Enter a " What-if " Top Opening Width in mm in the yellow boxes		Your " What-If " Max Length to Downspout		Total width of building material
	inches	mm	feet	meters	mm	inches	meters	feet	mm
Semi Circle	3.52924775	90	26.6	8.1	100	3.9370079	9.5	31.2	157
90 degree V Trough	3.71604657	94	28.8	8.8	100	3.9370079	9.5	31.2	141
Square Box	1.61554074	41	1.6	0.5	100	3.9370079	9.5	31.2	300
Trapezoid	2.91045229	74	18.6	5.7	100	3.9370079	9.5	31.2	150

Third: Increase gutter width if needed to increase distance between downspouts

Notice that as far as carrying the water is concerned in this example, you don't need much of a gutter width to get the job done (depending on the design you choose). Also, due to the 0.5 degree slope, if you use a V trough gutter you can go 27.7 ft or 8.5 meters before you need a downspout (double that if you put the downspout in the middle of a run). Areas Cc and Bb have a total length of only 25 ft or 7.6 m of connected gutter. We can conclude that a V trough, 92 mm across the top will work fine for these combined areas. There is no need to do any " what-ifs ". You can see the detail design below.

Before going any further, let's go back to the beginning and see what would happen if we chose a very long run of gutter. Assume we connect areas Dd and Aa with one gutter. The total area would be 245 + 252 = 497 sq ft. The total length would be 29' + 33' = 62'. Go back to cell G21 and type in 497. Leave the slope at 0.5° for now. You will immediately notice that the calculated V trough, minimum width is 111mm and you get 35.9 (10.9 m) before a downspout. We need 62'. You have several choices:

1 Leave the slope at 0.5 and use the " what-if " calculator to see what would happen with widths wider than 111 mm. Try it. Type in 111 mm in the yellow box at cell H54 and notice we get 35.7 feet to the downspout (just checking!). Now type in 150 mm. We get 63.9 feet. We needed 62', so this would be a good width. Go ahead and type in 150 for the other gutter designs. You'll notice that they will all give you 63.9 feet to a downspout, but notice the total width of building material column. If you made the gutter into a box, you would need more than twice the building material than if you made it into a V trough or Trapezoid!

2 Change the slope to 0.3° and you get almost 69 feet for a 123 mm wide V trough.

3 Leave the slope at 0.5°, use a 111 mm wide V trough, and put in two tanks, one at the d-a corner of the house and one at the B corner.

My recommendation would be to put in one tank as shown in the example drawing: run the gutters at a 0.3° slope; use a 90° V trough design 125 mm (5") wide (or a 117 mm {4 1/2"} semicircle); make the gutter out of galvanized metal; connect areas D and A with one gutter; connect areas C and B with one gutter; then run two downspouts to the storage tank as shown on the house drawing.

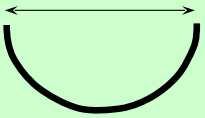
The following are detailed gutter design drawings based on the data that you entered above. They will automatically

Caution: Remember which width you chose above before you go any farther! Was it green, purple, blue or violet? You will need to ignore the other colored blocks.

These are dimensions based on the larger gutter width needed for longer distances between downspouts

These are dimensions based on the Minimum Gutter Width needed to carry the water

3.5292478



Semicircle Gutter inches

In Inches

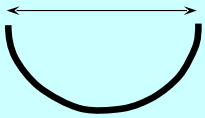
Semicircle width =	3.52925	in	total width of raw building material needed to make this gutter	5.54372
Subtracting 3/4" under the roof edge and 1/8" outside edge allowance	2.65425	in	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	1.85759	in	This assumes 4.7" per hour maximum rain intensity.	
Maximum distance to first downspout	26.6	feet	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

What-if values

3.937 in	6.18423
3.0315 in	
2.1771 in	
31.2 ft	

total width of a flat piece of building material

90



Semicircle Gutter mm

In mm

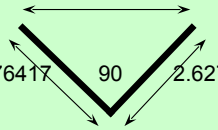
Semicircle width =	90	mm	total mm width of raw building material needed to make this gutter	141
Subtracting 20mm under the roof edge and 3mm outside edge allowance	67	mm	this is the width that is available for the rainwater to enter	
Maximum gutter drop before any downspout	47	mm	This assumes 2 mm per min maximum rain intensity.	
Maximum distance to first downspout	8.1	meters	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

What-if values

100 mm	157
77 mm	
55 mm	
9.5 M	

3.7160466

2.6276417 90 2.62764173



V Trough inches

In Inches

V Trough inside wall length	2.62764	in	total width of material = If you are going to use something thick like wood, remember to add the thickness of the wood to one side length	5.25528
V Trough top opening width	3.71605	in		
Subtracting 3/4" under the roof edge and 1/8" outside edge allowance	2.84105	in	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	2.00817	in	This assumes 4.7" per hour maximum rain intensity.	
Maximum distance to first downspout	28.8	feet	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

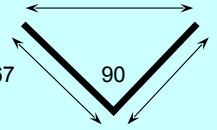
What-if values

2.7839 in	5.56777
3.937 in	
3.0315 in	
2.1771 in	
31.2 ft	

total width of a flat piece of building material

94

67 90 67



V Trough mm

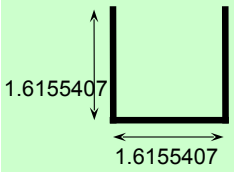
In mm

V Trough inside wall length	67	mm	total width of material = If you are going to use something thick like wood, remember to add the thickness of the wood to one side length	133
V Trough top opening width	94			
Subtracting 20mm under the roof edge and 3mm outside edge allowance	71	mm	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	51	mm	This assumes 2 mm per min maximum rain intensity.	

What-if values

71 mm	141
100 mm	
77 mm	
55 mm	

	Maximum distance to first downspout	8.8	meters	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	9.5 M



Square Box inches

In Inches

Square box height and width	1.61554	in	total width of material = If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length	4.84662
Subtracting 3/4" under the roof edge and 1/8" outside edge allowance	0.74054	in	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	0.10931	in	This assumes 4.7" per hour maximum rain intensity.	
Maximum distance to first downspout	1.6	feet	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

What-if values

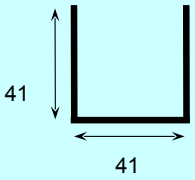
3.937 in 11.811

3.0315 in

2.1771 in

31.2 ft

total width of a flat piece of building material



Square Box mm

In mm

Square box height and width	41	mm	total width of material = If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length	123
Subtracting 20mm under the roof edge and 3mm outside edge allowance	18	mm	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	3	mm	This assumes 2 mm per min maximum rain intensity.	
Maximum distance to first downspout	0.5	meters	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

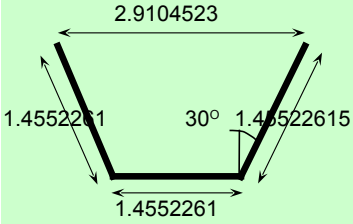
What-if values

100 mm 300

77 mm

55 mm

9.5 M



Trapezoid inches

In Inches

With sides at 30° the length of each side is	1.45523	in	total width of material = If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length	4.36568
The width at the top is	2.91045	in		
Subtracting 3/4" for under the roof edge and 1/8" outside edge allowance	2.03545	in	this is the width that is available for the rainwater to enter the gutter	
Maximum TOTAL gutter drop before any downspout	1.29744	in	This assumes 4.7" per hour maximum rain intensity.	
Maximum gutter length to a downspout	18.6	feet	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	

What-if values

1.9685 in 5.90551

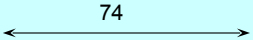
3.937 in

3.0315 in

2.1771 in

31.2 ft

total width of a flat piece of building material

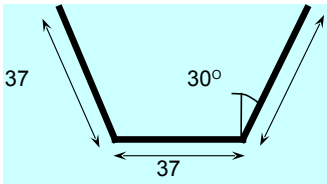


In mm

With sides at 30° the length of each side is	37	mm	total width of material = If you are going to use	111

What-if values

50 mm 150



37 The width at the top is	74	mm	something thick like wood, remember to add two times the thickness of the wood to the bottom length	100	mm
Subtracting 20mm for under the roof edge and 3mm outside edge allowance	51	mm	this is the width that is available for the rainwater to enter the gutter	77	mm
Trapezoid mm Maximum TOTAL gutter drop before any downspout	33	mm	This assumes 2 mm per min maximum rain intensity.	55	mm
Maximum distance to first downspout	5.7	meters	Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle)	9.5	M

Fourth: Downspout size, location, and a few other comments.

I don't recommend that you size your downspout based on pipe sizing tables or equations. I recommend you go outside and look at trees that overhang your roof. You'll need to put in a downspout that won't clog with the leaves that are going to land on your roof. For most of you, that will be a 4 inch or 110mm pipe. You might need to make this out of a piece of flexible material. Simply bend it into a semicircle with a diameter that is about the same size as the semicircle dimension that was calculated for you above. This will be plenty big for both the water and debris. You might want to visit the gutter manufacturer web sites to get an idea of how they would size a downspout.

http://www.hunterplastics.co.uk/rainwater/gutterdesign/default.html
http://copper.org/applications/architecture/arch_dhb/gutters_downspouts/downspouts.html
http://members.ozemail.com.au/~ksengs/DPcalc.html

Some manufacturers recommend a gutter slope of only 0.1 degrees. That's equivalent to about 1/2 inch of drop in 20 feet of length or about 1:500. Metrically that's only 1 mm in 5 meters. I would recommend you keep at least 0.3° (about 1:200) to 0.5° (about 1:115) for the last third of your gutter run, and half that for the first two-thirds.

Most manufacturers recommend maximum gutter lengths before a downspout of 20 to 40 feet (you can have 20 to 40 feet on each side). This will reduce problems with expansion, trash buildup in the gutter, maximum weight of the gutter when it gets full of rainwater, and is their rule of thumb given most manufacturers have fixed gutter widths that they are selling. They also do this because they have little incentive to reduce the number of downspouts. They are simply planning on dumping the water to the ground. Our requirements are different because we need to collect it; hopefully in a single tank. You will be able to confidently size your gutter based on calculators in this spread sheet, but keep in mind that gutter runs in excess of about 40 feet are going to drop several inches from the roof edge giving the gutter a distinct "Water Harvesting" look.