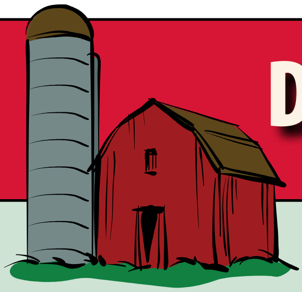


Designing Roof Gutters for Barns

Roof gutters may be needed with barns to divert clean water from livestock and fuel storage areas and to prevent uncontrolled channeling of rainwater resulting in the formation of gullies adjacent to barns.

Clean-water runoff

It is estimated that the annual runoff from a 40- by 80-foot barn roof near Folsom, La. will average about 60,000 gallons. Uncontaminated roof water can be discharged into the waters of the state or stored for farm use, such as watering livestock. Frequently, dairy barns present special problems because of their huge roof areas that require large gutters and downspout capacity.

Positioning gutters to reduce snow and ice slide failures may be a major consideration. If the building eave-line has a 2- to 3-percent slope, gutter capacity is increased compared to gutters mounted nearly level. Most gutters are mounted level for appearance, but a slope of one-sixteenth inch per foot is desirable for drainage.

An alternative to roof gutters for buildings with at least a 12-inch overhang and where an open channel will not be polluted is a surfaced channel or a stone-lined, tile-drained ditch alongside of the building. Also, an open channel could conduct water from a small gutter with multiple downspouts.

General information

In typical construction, downspouts are spaced from 20 feet to 50 feet with a 60-foot maximum. The final routing of the roof water may determine whether a small gutter with many downspouts will be more feasible than a large gutter with few downspouts. House-sized gutters are readily available. But in many rural locations, specially formed gutters may be quite expensive. Gutter hangers are normally spaced 3 feet on center (o.c.).

In an environment with broad temperature changes, the gutters need to move without being restrained by the hangers. An alternative is to build the gutter with shorter lengths, allowing a space between sections for expansion. Table 1 shows the thermal expansion/contraction of a 100-foot length of gutter with 100 degrees of temperature change.

Table 1. Coefficient of expansion and expansion/contraction of 100 feet of gutter with 100 degrees of temperature change.

Metal	Coefficient of expansion	Total movement
Aluminum	0.0000128	1.54 inch
Copper	0.0000093	1.12 inch
Galvanized steel	0.0000065	0.78 inch

Examples

This publication will work example problems to illustrate the use of roof gutters.

Example 1: Level gutters

Design a gutter/downspout system for a 40- by 80-foot free-stall barn located near Folsom, La., with a 4:12 gable roof. Assume a level rectangular gutter with a depth-to-width ratio of 0.75.

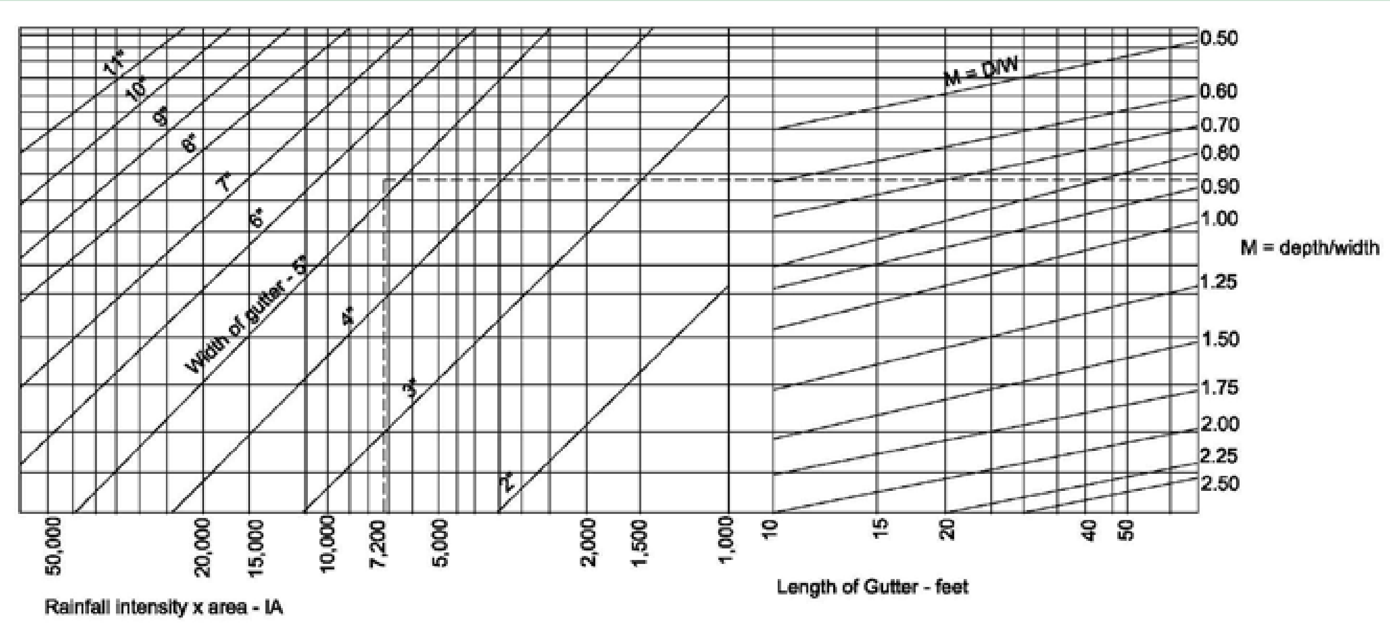
On the 80-foot-long roof, assume two downspouts on each side. Use the factor of 1.05 from Table 2 to adjust the roof plan-area for the 4:12 roof pitch.

Table 2. Design-area adjustment factor for pitched roofs. Multiply the plan area of the roof by the adjustment factor corresponding to the roof pitch.

Roof pitch[1]	Factor
Level to 3 inches per foot	1.00
4 inches to 5 inches per foot	1.05
6 inches to 8 inches per foot	1.10
9 inches to 11 inches per foot	1.20
12 inches per foot	1.30

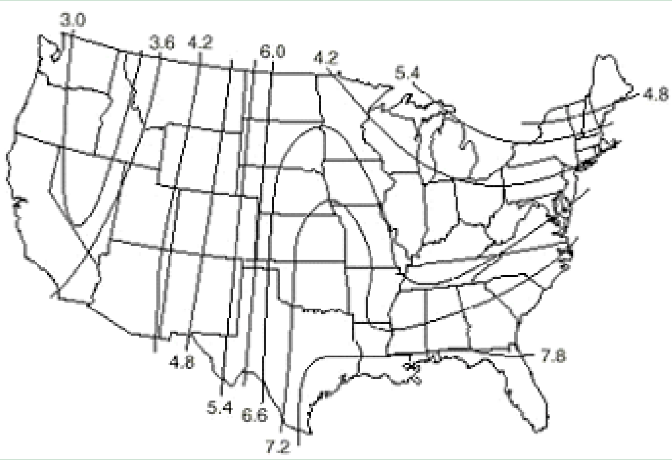
[1]When the roof is sloped, neither the plan area nor the actual roof area should be used in sizing drainage.

Figure 1. Width of level rectangular gutters for given roof areas and rainfall intensities.



Use Figure 1 to find the width of gutter for 40-foot lengths of gutter. Use the rainfall intensity value of 8 inches per hour for Folsom from Figure 2. For a segment of roof 20 feet wide by 40 feet long, the adjusted "IA" value will be: IA = 20 feet x 40 feet x 1.05 x 8.0 = 6,720. From Figure 1, for a depth/width ratio of 0.75, the required gutter width is 5.1 inches; use 6 inches. For a depth/width ratio of 0.75 and a rectangular gutter width of 6 inches, the depth should be 4.5 inches deep.

Figure 2. Rainfall intensity (10 year, 5-minute storm). Map shows rainfall intensity in inches per hour for 5-minute periods to be expected once in 10 years. Normally, this is adequate for design, but storms have been twice as intense in some areas. See local records for more accurate data.



Example 2: Sloped gutters

Assume the foundation, eave height and gutter for the free-stall barn are sloped at 0.5 percent for drainage. To determine the width of a rectangular gutter, see Table 3. Refer to Table 4 to determine the diameter of a semicircular gutter to carry runoff from a 40-foot-long portion of the building.

Table 3. Capacity for rectangular roof gutters.

Depth of gutter = 0.75 x width.
Capacities calculated using Manning's formula for open channel flow:
Q = 1.486 x S $^{0.667}$) with n = 0.012 for smooth metal, smooth concrete or planed lumber and P = wetted perimeter in feet.

Gutter width (inches)	Gutter slope (percent)				
	0.5	1	2	3	4
	Capacity, cfs (cubic feet per second)				
4	0.16	0.22	0.31	0.38	0.44
5	0.28	0.40	0.57	0.70	0.80
6	0.46	0.65	0.92	1.13	1.31
7	0.70	0.98	1.29	1.70	1.97
8	1.00	1.41	1.99	2.44	2.82
9	1.36	1.93	2.72	3.34	3.85
10	1.80	2.55	3.61	4.42	5.11
12	2.94	4.16	5.88	7.20	8.31

Table 4. Capacity for smooth semicircular gutters, such as PVC, at various slopes.

Capacities calculated using Manning's formula for open channel flow: $Q = 1.486 \times S^{0.0667}$) with n = 0.010 and P = wetted perimeter in feet (flow depth = 50 percent of diameter).

Gutter width (inches)	Gutter slope (percent)				
	0.5	1	2	3	4
	Capacity, cfs (cubic feet per second)				
4	0.07	0.10	0.14	0.17	0.20
5	0.13	0.18	0.25	0.31	0.36
6	0.20	0.29	0.41	0.50	0.58
8	0.44	0.62	0.88	1.08	1.24
10	0.80	1.13	1.60	1.96	2.26
12	1.30	1.84	2.60	3.18	3.67

First, determine the roof runoff:

$$\text{runoff rate} = \frac{20 \text{ feet} \times 40 \text{ feet} \times 1.05^{*} \times 8.0 \text{ inches per hour}}{12 \text{ inches per foot} \times 3{,}600 \text{ seconds per hour}} = 0.16 \text{ cfs (cubic feet per second)}$$

* = Roof area adjustment factor for 4:12 roof slopes.

Select a gutter with at least 0.16 cfs capacity at 0.5 percent slope. From Table 3, select a rectangular gutter 4 inches wide (depth = 0.75 times width = 0.75 x 4 inches = 3.0 inches). Select a semicircular gutter 6 inches in diameter (Table 4).

Example 3: Sizing downspouts

Select an adequate downspout to accommodate 0.16 cfs flow with 3.0-inch head from the rectangular gutter in Example 2.

In Table 5 (next page), we find that with a 3-inch head, a 4-inch diameter downspout will be required. If the downspout is calculated to be wider than the width of the gutter, a transition pipe can be used to increase the pipe size to the larger required downspout. For example, if you have a 5-inch-wide gutter and calculate that a 6 inch downspout is required, a rectangular 5- by 6-inch transition may be used to connect the 6-inch round downspout to the 5-inch gutter. An alternative would be to increase the head above the 6-inch downspout by means of a drop box.

Downspout capacity

Downspout capacity can be increased by using a tapered transition to enlarge the downspout entrance in the bottom of the gutter, thus increasing the inlet area. Or, you may add a drop box at each downspout location to increase the head of water above the downspout entrance. See Table 5 for the capacity of various downspout diameter sizes at various heads.

A rule of thumb for sizing the tapered inlet or drop-box inlet is for the cross-sectional (horizontal) area to be at least 1.5 times the downspout cross-sectional area and the vertical drop from the gutter to the downspout entrance to be at least twice the downspout diameter.

Using the 0.16 cfs downspout capacity needed for the 40-foot sloped gutter in Example 2, determine the total head necessary to cause 0.16 cfs to enter a 3-inch diameter downspout.

From Table 5, by interpolation, we find that 5 inches of head will cause 0.16 cfs to enter the 3-inch downspout.

Using the rules of thumb above, we would select a 5-inch-deep drop box (or a tapered transition) with a horizontal area of at least 10.6 square inches. See the following formula:

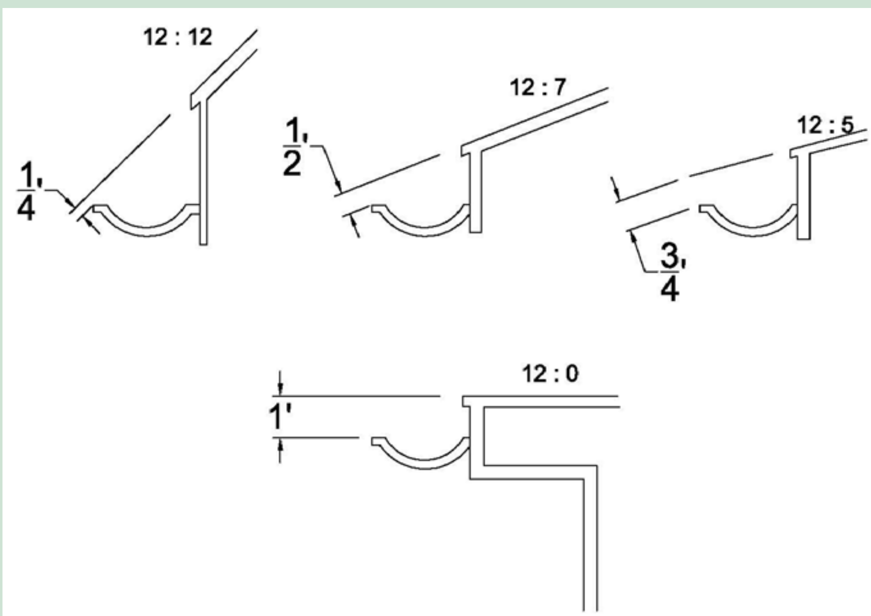
Required area = 1.5 x (radius of downspout)2(π) (π = 3.14)
Required area = 1.5 x 1.52(3.14) = 1.5 x 7.065 = 10.6 square inches

Table 5. Capacity of circular downspouts based on orifice flow.

Use the orifice coefficient of 0.6 in the following formula:
Q = CA (2gh)0.5 where A = cross-sectional area of downspout in square feet and h = head in feet.

Head (inches)	Downspout diameter (inches)					
	3	4	5	6	7	8
	Capacity, cfs (cubic feet per second)					
2	0.10	0.17	0.27	0.39	0.53	0.69
3	0.12	0.21	0.33	0.47	0.64	0.83
4	0.14	0.24	0.38	0.55	0.74	0.97
5	0.16	0.27	0.42	0.61	0.83	1.08
6	0.17	0.30	0.46	0.67	0.91	1.19
7	0.18	0.32	0.50	0.72	0.98	1.28
8	0.19	0.34	0.54	0.77	1.05	1.37
9	0.21	0.36	0.57	0.82	1.11	1.45
10	0.22	0.38	0.60	0.86	1.17	1.53
11	0.23	0.40	0.63	0.91	1.28	1.68
12	0.24	0.42	0.66	0.95	1.39	1.82
13	0.25	0.44	0.69	0.99	1.39	1.82
14	0.26	0.45	0.71	1.02	1.39	1.82
15	0.27	0.47	0.74	1.06	1.44	1.88
16	0.27	0.49	0.76	1.09	1.49	1.94
17	0.28	0.50	0.78	1.13	1.54	2.00
18	0.29	0.51	0.80	1.16	1.58	2.06
20	0.31	0.54	0.85	1.22	1.66	2.17
21	0.32	0.56	0.87	1.25	1.70	2.23
22	0.32	0.57	0.89	1.28	1.74	2.28
23	0.33	0.58	0.91	1.31	1.78	2.33
24	0.33	0.59	0.93	1.34	1.82	2.38

Figure 3. Properly position gutters. Snow and ice can slide off the roof clear of the gutter. Steeper pitch roofs require less clearance.



Clearance for snow and ice slides

Clearance for snow and ice slides should be taken into account in positioning the gutters. In general, the flatter the roof pitch, the greater the clearance required. Use Figure 3 as a guide in positioning gutters for the snow and ice clearance.

Standard downspouts

Table 6 provides data for selecting sizes for various shapes of standard downspouts, based on cross-sectional area.

Table 6. Standard downspout sizes.

Type	Area square (inches)	Nominal size (inches)	Actual size diameter (inches)
Plain round	7.07	3	3
	12.57	4	4
	19.63	5	5
	28.27	6	6
Corrugated round	5.94	3	3
	11.04	4	4
	17.72	5	5
	25.97	6	6
			(depth x width)
Corrugated rectangular	3.80	2	1-3/4 x 2-1/4
	7.73	3	2-3/8 x 3-1/4
	11.70	4	2-3/4 x 4-1/4
	18.75	5	3-3/4 x 5
Plain rectangular	3.94	2	1-3/4 x 2-1/4
	6.00	3	2 x 3
	12.00	4	3 x 4
	20.00	5	3-3/4 x 4-3/4
	24.00	6	4 x 6

Pipes to carry water from downspouts

Downspouts can be discharged into a pipe suspended on the side of the building at some design slope, laid on the ground alongside the building or buried underground at the design slope. Use Table 7 (next page) to select the pipe size based on the required capacity and the pipe slope. The capacities are based on water flowing in the pipe at a depth equal to 70 percent of the inside pipe diameter.

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Table 7. Gravity flow for smooth pipes, such as PVC, at various slopes.

Manning's formula for open channel flow: Q = 1.486 x S0.667) with n = 0.010 and P = wetted perimeter in feet (flow depth = 70 percent of diameter).

Slope (percent)	Pipe diameter (inches)					
	4	5	6	8	10	12
	Capacity cfs (cubic feet per second)					
0.5	0.12	0.22	0.36	0.78	1.41	2.29
1	0.17	0.31	0.51	1.10	1.99	3.24
2	0.24	0.44	0.72	1.56	2.82	4.59
3	0.30	0.54	0.88	1.90	3.45	5.62
4	0.35	0.63	1.02	2.20	3.99	6.48
5	0.39	0.70	1.14	2.46	4.46	7.25
6	0.42	0.77	1.25	2.69	4.88	7.94
8	0.49	0.89	1.44	3.11	5.64	9.17
10	0.55	0.99	1.62	3.48	6.31	10.26
12	0.60	1.09	1.77	3.81	6.91	11.23
14	0.65	1.18	1.91	4.12	7.46	12.13
16	0.69	1.26	2.04	4.40	7.98	12.97

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