

Design Criteria for Grassed Waterways

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Grassed waterways dispose of runoff from terraces, diversions, structures, and natural concentrations.

Designing Waterways

In designing a grassed waterway, the shape, velocity, capacity, width, depth, and size of the side dikes must be determined.

Shape: Cross-sectional shape of a grassed waterway may be either trapezoidal or parabolic. See Figs. 1 and 2.

Velocity: Maximum permissible velocity for grassed waterways varies with the erodibility of the soil to be exposed in the channel of the waterway, the type and quality of vegetation that can be established and maintained, and the slope. See Table 1.

Capacity: The maximum rate of runoff expected in a 10-year period determines minimum channel capacity. Refer to UMC Guide 1518, "Estimating Peak Rates of Runoff from Small Watersheds."

Width: After the maximum rate of runoff, Q , and the design velocity have been determined, obtain the width of a trapezoidal waterway from Table 2 and the width of a parabolic waterway from Table 3. Widths given in Tables 2 and 3 are those required to carry expected runoff at the design velocity when vegetation is short.

The waterway should never be constructed narrower than the required width or the velocity will exceed the design velocity. However, it may be made wider than required to facilitate construction or maintenance. If the waterway is

TABLE 1
MAXIMUM PERMISSIBLE VELOCITIES,
Feet Per Second

Quality of Vegetation	Less Erodible Soils*		More Erodible Soils**	
	0 to 7	8 to 16	0 to 7	8 to 16
Fair	4	3	3	***
Good	5	4	4	3
Excellent	6****	5	5	4

* Less erodible soils are generally those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay and clay.

** More erodible soils are generally those that have a high content of fine sand or silt and lower plasticity. Typical soil textures are fine sand, silt, sandy loam and silty loam.

*** Must have good quality vegetation on these slopes.

**** The table giving the size of waterway for a velocity of 6 feet per second is in UMC Guide 1517, "Emergency Spillways - Part 2, Design."

maintained with farm machinery, use a minimum bottom width of 16 feet for trapezoidal waterways and a minimum top width of 20 feet for parabolic waterways.

If a waterway greater than 50 feet wide is required, consider dividing into two smaller parallel waterways. If water enters from both sides of a wide waterway, construct a small dike approximately 0.4 foot high in the center of the waterway to divide the flow. If the slope in a waterway is less than 1 percent, obtain the dimensions of the waterway from UMC Guide 1506, "Design Criteria for Diversions."

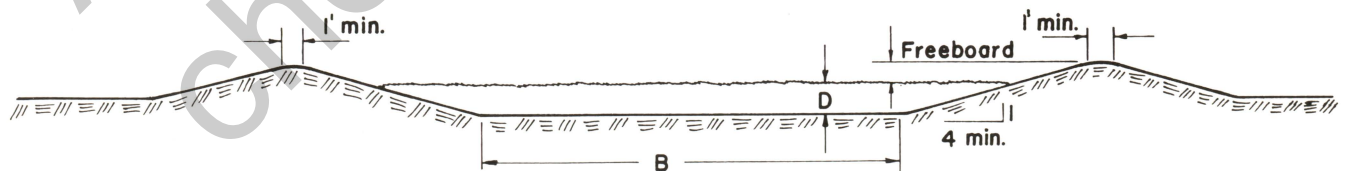


Figure 1. Cross section of a trapezoidal-shaped waterway, showing permanent side dikes.

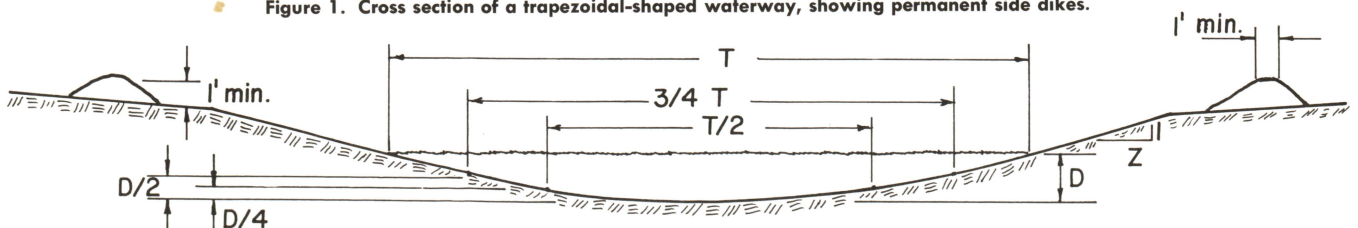


Figure 2. Cross section of a parabolic-shaped waterway, showing temporary side dikes.

TABLE 2
DIMENSIONS OF TRAPEZOIDAL WATERWAYS
(Velocity, 3 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
10	Q, cfs												
	B*												
	D**												
15	6 8 10 12 13 14 16 17 18 20 22												
	D												
20	5 10 12 15 17 19 20 22 23 25 27 29												
	D												
25	9 13 17 20 22 24 26 28 29 32 34 36												
	D												
30	12 17 21 24 27 29 31 33 35 39 42 45												
	D												
35	6 15 21 25 29 32 34 37 39 42 45 48 51												
	D												
40	8 18 25 29 34 37 40 42 45 48 52 55 58												
	D												
45	10 22 28 33 39 42 45 48 52 55 59 63 68												
	D												
50	12 25 32 38 44 47 50 53 58 62 66												
	D												
55	14 28 36 42 48 52 56 59 64 68												
	D***												
60	16 31 39 46 53 57 61 65												
	D												
65	19 34 43 50 57 62 67 71												
	D												
70	21 37 47 54 61 67												
	D												
75	23 40 50 58 66												
	D												
80	25 43 54 62												
	D												
90	30 49 61 66												
	D												
100	34 55 68												
	D												
120	43 66												
	D												
140	52												
	D												
160	60												
	D												

TABLE 2
(Continued)
(Velocity, 4 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
10	Q, cfs												
	B*												
	D**												
15	5 6 7 8 9 11 12 13												
	D												
20	5 7 9 10 11 12 13 15 17 19												
	D												
25	5 8 10 12 14 15 16 17 19 21 23												
	D												
30	7 10 13 15 17 19 20 21 24 26 28												
	D												
35	9 13 16 18 21 23 24 25 28 31 34												
	D												
40	6 12 16 19 22 24 26 28 30 33 36 39												
	D												
45	8 14 18 22 25 28 30 32 34 37 41 44												
	D												
50	10 17 21 25 28 31 33 36 38 41 46 50												
	D												
55	12 19 24 28 31 34 37 40 42 46 50 55												
	D												
60	14 21 27 31 34 37 40 43 46 50 54 59												
	D												
65	16 23 29 34 38 41 44 47 50 55 58 63												
	D												
70	18 26 32 37 41 45 48 51 54 59 62												
	D												
75	20 28 34 40 44 48 51 55 58 63												
	D												
80	22 30 36 43 47 51 55 59 62												
	D												
90	26 35 42 48 53 58 62 66												
	D												
100	30 40 48 54 59 64 69												
	D***												
120	37 49 58 66 72												
	D												
140	44 58 68												
	D												
160	51 67												
	D												
180	60 65												
	D												
200	70 75												
	D												

TABLE 2
(Continued)

(Velocity, 5 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
10	Q, cfs												
	B*												
	D**												
15	6 8 10												
	D												
20	6 7 8 9 11 13												
	D												
25	6 8 10 11 12 13 15												
	D												
30	8 10 11 13 14 15 17 19												
	D												
35	9 11 13 14 16 17 19 21 23												
	D												
40	8 11 13 15 17 19 20 22 24 26												
	D												
45	10 13 15 17 19 21 22 25 27 29												
	D												
50	7 11 15 17 20 22 24 25 28 30 33												
	D												
55	9 13 17 19 22 25 27 28 31 34 37												
	D												
60	11 15 19 22 25 27 29 31 34 37 40												
	D												
65	5 12 17 21 24 27 30 32 34 37 40 43												
	D												
70	6 14 19 23 26 29 32 35 37 40 42 45												
	D												
75	7 16 20 25 28 32 35 38 40 43 45 48												
	D												
80	9 17 22 27 31 34 37 40 42 47 48 51												
	D												
90	12 20 26 31 35 39 42 45 48 53 55 57												
	D												
100	14 23 30 35 39 43 47 51 54 59 63 67												
	D												
120	20 30 37 43 48 53 57 61 65												
	D												
140	5 25 36 44 51 57 63 68												
	D												
160	10 30 42 51 59 66												
	D												
180	14 35 48 58 67												
	D***												
200	18 40 54 65												
	D												

B* = Bottom width of waterway, feet. Widths under 5 feet not shown.
Bottom width and velocity based on short grass ("D" retardance).

D** = Depth of flow with rank growth, feet ("B" retardance).

*** = Waterways above this line may be difficult to maintain with larger farm machinery.

TABLE 3
DIMENSIONS OF PARABOLIC WATERWAYS
(Velocity, 3 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
D**, feet	2.0	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7
Q, cfs	Top Width T, feet*												
10	12	12	1.2	12	13	14	15	16	16	17	18	19	20
15	12	14	15	16	18	19	20	21	22	23	24	25	26
20	14	16	19	20	22	24	25	26	28	30	31	33	34
25	16	19	22	25	27	29	31	32	34	36	38	40	42
30	19	22	26	29	32	34	36	38	40	42	45	48	51
35	21	24	30	33	36	39	41	43	45	48	51	54	58
40	23	27	33	37	41	44	47	49	52	55	57	62	66
45	25	30	36	41	46	49	52	54	58	62	65	69	73
50	27	33	40	45	50	54	57	60	64	69	72	76	
55	29	36	44	49	55	59	63	66	69				
60	31	39	48	53	59	64	69	74					
65	33	42	51	57	63	69	74						
70	35	45	55	61	66	74							
75	38	48	60	65	70								
80	40	51	64	68	74								
90	44	57	72	76									
100	48	64	78										
120	56	75											
140	64												
160	74												

TABLE 3
(Continued)
(Velocity, 4 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
D**, feet	2.3	1.6	1.4	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8
Q, cfs	Top Width T, feet*												
10				10	10	11	11	12	12	13	13	14	14
15	10	11	12	12	13	14	14	14	15	16	17	18	19
20	11	12	13	14	16	17	18	19	19	20	22	23	25
25	12	14	15	17	19	20	21	22	23	23	26	28	30
30	13	15	17	19	21	23	25	26	27	28	30	32	35
35	14	17	20	22	24	26	28	29	30	31	34	37	40
40	16	18	22	24	27	29	31	33	34	36	39	42	45
45	17	20	24	27	30	32	35	36	38	40	43	46	50
50	18	22	26	30	33	35	38	40	42	44	48	51	55
55	19	24	29	33	36	39	41	44	46	48	52	56	60
60	21	25	31	35	39	42	44	48	50	52	57	61	65
65	22	27	33	37	42	46	48	51	53	56	60	66	70
70	23	29	34	40	44	49	52	55	57	61	64	72	
75	25	31	37	42	47	52	55	58	61	65	68		
80	26	33	40	45	50	54	58	62	65	69			
90	28	36	44	50	56	59	65	68	72				
100	31	40	48	56	61	64	71	75					
120	36	47	58	64	74	76							
140	41	54	68	74									
160	46	62	76										
180	51	68											
200	56	75											

TABLE 3
(Continued)
(Velocity, 5 feet per second)

Slope, %	1	2	3	4	5	6	7	8	9	10	12	14	16
D**, feet	2.7	1.9	1.5	1.3	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.8
Q, cfs	Top Width T, feet*												
10						10	10	10	10	10	11	11	12
15						10	11	12	12	13	13	14	15
20					11	12	12	13	14	15	16	17	18
25			11	13	14	15	15	16	18	19	20	21	22
30		11	13	15	16	17	18	19	21	22	23	24	25
35	11	12	15	17	19	20	21	22	23	24	26	28	30
40	12	13	16	18	20	21	23	24	26	27	29	31	34
45	13	15	18	20	22	23	25	26	28	29	32	34	37
50	14	16	19	22	24	26	28	29	31	32	35	37	40
55	14	17	20	23	26	28	30	32	34	35	38	40	43
60	15	18	22	25	28	30	33	34	36	38	42	44	46
65	16	20	24	27	30	32	35	37	39	41	44	47	50
70	17	21	25	29	32	34	37	40	42	44	48	51	54
75	18	22	27	30	34	36	40	42	45	47	50	53	57
80	19	23	28	32	36	39	42	44	47	49	53	56	60
90	20	25	31	36	40	42	47	50	52	54	61	64	68
100	21	28	34	40	44	46	51	54	58	60	64	72	
120	25	32	40	47	51	56	60	64	68	72	76		
140	28	37	46	54	59	64	70	74	78				
160	31	42	52	60	67	74							
180	33	47	58	66	75								
200	37	52	64	72									

* Top width and velocity based on short grass ("D" retardance). Widths under 10 feet not shown.

D** Depth of flow with rank growth ("B" retardance).

*** Waterways above this line will have side slopes steeper than 4 to 1 and will be difficult to cross with farm machinery. Waterways less than 20 feet wide may be difficult to maintain with larger farm machinery.

Depth and Shape: The depth D given in Tables 2 and 3 is the depth of water to be expected with a rank growth of vegetation in the channel. This depth is indicated by "D" in Figures 1 and 2.

The shape of the parabolic waterway below this depth should conform to the dimensions given in Figure 2. The trapezoidal waterway should have side slopes 4 to 1 or flatter.

It is often desirable to construct waterways deeper than the depth D given in Tables 2 and 3. This may be necessary in order to bring terraces into the waterway on proper line or to allow for sediment buildup in the waterway.

The waterway above depth D should be shaped to best fit the topography and the maintenance requirements of the waterway. However, these side slopes should seldom be steeper than 4 to 1. (See Fig. 2, use Z of 4 or greater).

If permanent side dikes are needed to contain the flow, a freeboard of 0.3 foot should be added to assure future capacity as the dikes will be reduced in height with age. If a waterway is located so overflow would cause damage, add the freeboard deemed necessary to provide the protection.

At some locations where the slope in the waterway is less than 2 per cent, the waterway designed using the maximum permissible velocity given in Table 1 may be too deep and narrow to construct and maintain. If the waterway has been designed for a velocity of 4 or 5 feet per second, the depth can be decreased and width increased by using a design velocity of 3 feet per second. If the waterway is located on relatively flat land where occasional overflow would not cause significant damage and where inflowing water is relatively free of silt, the depth may be further reduced by the difference in depth required for a rank growth of grass compared to short grass. This difference is 0.7 foot on a 1 per cent slope and 0.5 foot on a 2 per cent slope. Keep the grass mowed to less than 6 inches to avoid occasional overflow.

Side Dikes: When permanent side dikes are needed for waterway capacity, construct them with side slopes no steeper than 4 to 1. Flatter side slopes may facilitate construction or maintenance. When possible, cut the waterway into the ground deep enough to eliminate the need for permanent side dikes. Build temporary side dikes to protect the waterway from runoff water from adjacent areas. Remove these dikes when the vegetation is well established, and spread the soil so it will not interfere with proper functioning of the waterway.

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