Flow Diversion Banks: On earth slopes

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] Flow diversion banks are not commonly used as permanent drainage structures.

Symbol → DB →

Photo 8 – Flow diversion bank down-slope of a future pipeline installation

Photo 9 – Earth flow diversion bank used to direct runoff towards the *Slope Drain*

Key Principles

1. Key design parameters are the effective flow capacity of the structure, and the scour resistance of the embankment material.
2. The critical operational issue is usually preventing structural damage to the embankment as a result of high velocity flows or construction traffic.
3. Flow diversion banks are often favoured over *Catch Drains* in areas containing dispersive subsoil because their construction does not require exposure of the subsoils.

Design Information

The material contained within this fact sheet has been supplied for use by persons experienced in hydraulic design.

The recommended dimensional requirements of flow diversion banks are outlined in Table 1 (refer to the fact sheet: *Flow Diversion Banks – General*).

Recommended allowable flow velocities for open earth surfaces are provided in Table 4. The maximum flow velocity (i.e. the velocity most likely to cause erosion of the earth surface) is most likely to occur at the toe of the embankment where flow depth (y) is a maximum, as shown in Figure 3. In wide, shallow drains, such as typically occur adjacent flow diversion banks, the local flow velocity is dependent on the local flow depth rather than the hydraulic radius (R).

Table 5 presented the expected maximum flow velocity for various maximum flow depths and longitudinal channel gradients.

Tables 9 to 18 provide the expected flow capacity for flow diversion bank operating a various maximum flow depths on an open earth surface. These tables are based on an embankment side slope of 2:1 (H:V), and a Manning's roughness determined from Equation 1, but limited to a maximum value of, n = 0.2.

Note; flow capacity is presented in units of [L/s] in Tables 9 to 13, and units of [m^3/s] in Tables 14 to 18.

Table 4 – Allowable flow velocity for earth surfaces

Soil type	Allowable velocity	Comments
Extremely erodible soils	0.3m/s	• Dispersive clays are highly erodible even at low flow velocities and therefore must be either treated (e.g. with gypsum) or covered with a minimum 100mm of stable soil. • Highly erodible soils may include: Lithosols, Alluvials, Podzols, Siliceous sands, Soloths, Solodized solonetz, Grey podzolics, some Black earths, fine surface texture-contrast soils and Soil Groups ML and CL. • Moderately erodible soils may include: Red earths, Red or Yellow podzolics, some Black earths, Grey or Brown clays, Prarie soils and Soil Groups SW, SP, SM, SC. • Erosion-resistant soils may include: Xanthozem, Euchrozem, Krasnozems, some Red earth soils and Soil Groups GW, GP, GM, GC, MH and CH.
Sandy soils	0.45m/s	
Highly erodible soils	0.4 to 0.5m/s	
Sandy loam soils	0.5m/s	
Moderately erodible soils	0.6m/s	
Silty loam soils	0.6m/s	
Low erodible soils	0.7m/s	
Firm loam soils	0.7m/s	
Stiff clay very colloidal soils	1.1m/s	

Table 5 – Maximum flow velocity (toe of embankment) on earth surface (m/s) [1]

Flow depth	Gradient (S) along drain (%)									
	0.1	**0.2**	**0.4**	**0.6**	**0.8**	**1**	**2**	**4**	**6**	**8**
0.05	0.02	0.03	0.03	0.07	0.10	0.13	0.28	0.51	0.72	0.91
0.10	0.06	0.13	0.24	0.33	0.42	0.50	0.83	1.35	1.78	2.16
0.15	0.15	0.26	0.44	0.58	0.71	0.83	1.33	2.10		
0.20	0.23	0.38	0.62	0.81	0.99	1.14	1.80	2.79		
0.25	0.31	0.50	0.79	1.03	1.24	1.44	2.23			
0.30	0.38	0.61	0.96	1.24	1.49	1.72	2.64			
0.35	0.45	0.71	1.11	1.44	1.73	1.98				
0.40	0.52	0.82	1.27	1.63	1.95	2.24				
0.45	0.59	0.92	1.42	1.82	2.17					
0.50	0.65	1.01	1.56	2.00						

[1] Maximum flow velocity refers to the maximum local flow velocity, which would occur adjacent the toe of the flow diversion bank at the point of maximum flow depth. The velocity has been determined using Manning's equation based on a hydraulic radius (R) equal to the local flow depth (y), and Manning's roughness determined from Equation 1. These flow velocities are significantly greater than the "average" velocity within a given cross-section.

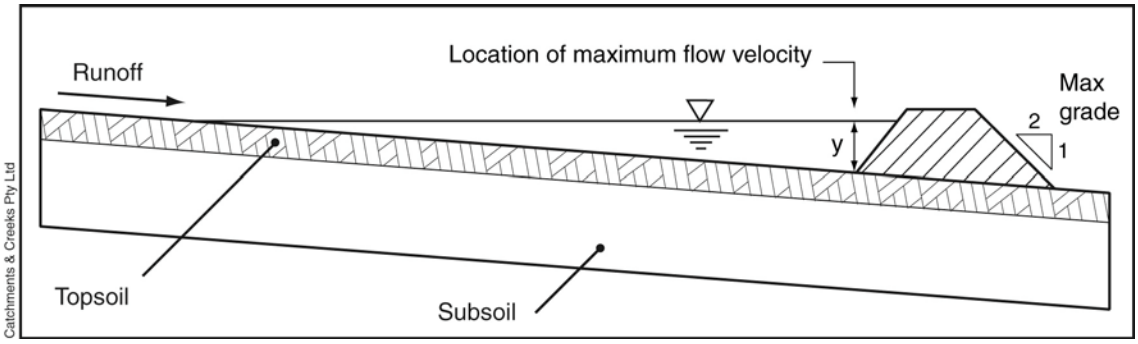

Figure 3 – Location of maximum flow velocity

Tables 6 to 8 provide typical Manning's n values.

Table 6 – Typical Manning's n roughness for deepwater flow conditions [1]

Channel description	Manning's roughness	Channel description	Manning's roughness
Smooth earth surface, few, if any, irregularities, sediment deposits, or loose surface material.	0.02	Concrete (smooth)	0.013
		Concrete (rough)	0.015
		Asphalt (smooth)	0.013
Slightly irregular earth surface with minor irregularities equivalent to that produced if an *Erosion Control Blanket* was pinned across the surface.	0.04	Asphalt (rough)	0.016
		Excavated open soil	0.020
		Gravel lined	0.025
		Earth with short grass	0.030

[1] Developed from Chow (1959)

Table 7 – Manning's roughness for various channel linings [1]

Material	Flow depth less than 150mm	Flow depth of 150 to 600mm	Flow depth greater than 600mm
Plastic sheeting		0.013	
Concrete	0.015	0.013	0.013
Asphalt	0.018	0.016	0.016
Straw (loose) covered with net	0.065	0.033	0.025
Jute net/mesh	0.028	0.022	0.019
Wood excelsior blanket	0.066	0.035	0.028
Turf Reinf. Mat – unvegetated	0.036	0.026	0.020
Turf Reinf. Mat – grassed	0.023	0.020	0.020

[1] Developed from Fifield (2001)

Table 8 – Manning's roughness for earth and lightly grassed surfaces [1]

R (m)	Drain slope in direction of flow (%)					
	1	**2**	**3**	**4**	**5**	**10**
0.05	0.100	0.070	0.059	0.053	0.049	0.040
0.10	0.043	0.037	0.034	0.032	0.031	0.027
0.15	0.034	0.030	0.028	0.027	0.026	0.024
0.20	0.030	0.027	0.025	0.025	0.024	0.022
0.25	0.028	0.025	0.024	0.023	0.023	0.021
0.30	0.026	0.024	0.023	0.022	0.022	0.020
0.40	0.024	0.022	0.022	0.021	0.020	0.020
0.50	0.023	0.022	0.021	0.020	0.020	0.020

[1] Values developed from Class E curve (Equation 1) for earth, burnt grass and lightly grassed surfaces (units of R [m] and S [m/m]). Note, minimum recommended Manning's roughness, n = 0.02. Caution use of Equation 1 for low values of hydraulic radius (negative values can occur).

Class E roughness:

$$n = \frac{R^{1/6}}{67.10 + 23.35\log_{10}(R^{1.4}.S^{0.4})} \quad \text{(Eqn 1)}$$

Hydraulic design of flow diversion banks:

Step 1 Determine the required design discharge based on the effective catchment area of the flow diversion bank.

Step 2 Determine the cross-sectional profile and surface condition. This fact sheet assumes the flow surface primarily consists of fully exposed or poorly vegetated earth.

Step 3 Determine the allowable flow velocity for the surface material from Table 4. Note; this is based on the surface of least scour resistance, whether the embankment or the adjacent slope.

Step 4 If the longitudinal gradient (S) of the drainage channel formed by the bank is known (i.e. set by site conditions), then determine the maximum allowable flow depth (y) from Table 5 given the allowable flow velocity determined in Step 3.

The maximum allowable flow depth (y) can also be determined directly from:

$$y = \frac{(n.V)^{3/2}}{S^{3/4}} \qquad \text{(S has units of m/m)}$$

If the longitudinal gradient of the drainage channel is not set by site conditions, then nominate a gradient from Table 5 based on a desirable maximum flow depth.

The maximum allowable longitudinal drainage gradient (S) can also be determined directly from:

$$S = \frac{(n.V)^{2}}{y^{4/3}} \qquad \text{(S has units of m/m)}$$

Step 5 Determine the Manning's roughness (n) from Tables 6 to 8, or Equation 1, as appropriate for the site conditions.

Step 6 Determine the cross-sectional flow area (A) and hydraulic radius (R).

Step 7 Determine the maximum allowable flow capacity (Q) of the flow diversion bank based on the values of n, A, R and S determined above.

Manning equation: $Q = (1/n)\, A\, R^{2/3}\, S^{1/2}$

Tables 9 to 18 provide flow capacities based on a simple triangular cross-sectional profile, an embankment side slope of 2:1 (H:V), and a Manning's roughness for open earth determined from Equation 1, but limited to a maximum value of, n = 0.2.

If the maximum flow capacity is less than the design discharge determined in Step 1, then it will be necessary to reduce the effective catchment area and design discharge of the flow diversion bank.

Alternatively, the scour resistance of the surface condition could be improved through appropriate erosion control measures, or the longitudinal gradient (S) of the drainage channel. Determine the required gradient (S) using Manning's equation.

$$S = \frac{(n.V)^{2}}{y^{4/3}} \qquad \text{(S has units of m/m)}$$

Step 8 Determined the required freeboard given the embankment type – refer to Table 1 in fact sheet: *Flow Diversion Banks – General*.

Step 9 Ensure suitable conditions exist (e.g. machinery access) to construct and maintain the embankment.

Step 10 Specify the overall dimensions of the flow diversion bank, including freeboard.

Step 11 Ensure the drainage embankment discharges to an appropriate, stable outlet.

Step 12 Appropriately consider all likely safety issues, and modify the embankment and/or surrounding environment where required.

Design example:

Design a short-term, non-vegetated, topsoil flow diversion bank capable of carrying a design discharge of $0.2m^3/s$ across a slope with a gradient of 5% (20:1) (note; this is the gradient of the land slope, not the drain slope). Both the topsoil embankment and the exposed earth surface is considered to be representative of erosion-resistant, loamy soil.

Step 1 The required design discharge is $0.2m^3/s$.

Step 2 Assume a simple triangular cross-sectional profile with fully exposed earth surface.

Step 3 From Table 4, adopt an allowable flow velocity, $V_{allow} = 0.7m/s$.

Step 4 A non-vegetated embankment is assumed, thus the recommended minimum freeboard is 300mm. This means for an embankment height of 500mm, the maximum flow depth (y) is 500 - 300 = 200mm. If is flow depth is insufficient, then an embankment height greater than 500mm may be considered.

Given y = 200mm, and $V_{allow} = 0.7m/s$, choose a longitudinal gradient (S) of 0.5% from Table 5.

Step 5 Hydraulic capacity will be determined from Table 12, therefore Manning's roughness will be based on Equation 1.

Step 6 There is no need to determine the cross-sectional flow area (A) and hydraulic radius (R) because the supplied design tables will be used. However, for demonstration purposes, given a maximum flow depth, y = 0.2m; embankment side slope, a = 2; and land slope, b = 20 (i.e. 5%); then:

$$A = 0.440m^2$$ (not final design)

$$R = 0.099m$$

$$n = 0.05$$

Step 7 Given a maximum flow depth, y = 0.2m; land slope of 5%; and longitudinal drain slope, S = 0.5%; from Table 12 the maximum flow capacity (Q) is:

$$Q_{max} = 125L/s = 0.125m^3/s < 0.2m^3/s$$ Problem!

Thus the flow diversion bank will not have adequate flow capacity to carry the design discharge of $0.2m^3/s$.

Thus, try an increased maximum flow depth, y = 0.3m (thus the minimum embankment height will now be 0.3 + 0.3 = 0.6m).

From Table 5, try a drain slope, S = 0.2%

From Table 14, $Q_{max} = 0.252m^3/s > 0.2m^3/s$ OK

Step 8 From Table 1 the required minimum freeboard for a non-vegetated earth embankment is 300mm.

Step 9 Ensure suitable conditions exist (e.g. machinery access) to construct and maintain the embankment.

Step 10 Specify the overall dimensions of the flow diversion bank, including freeboard.

Embankment height of 600mm

Embankment side slopes of 2:1 (H:V)

Base width of embankment of 2900mm

Freeboard of 300mm

Longitudinal gradient of embankment of 0.2%

Step 11 Ensure the drainage embankment discharges to an appropriate, stable outlet.

Step 12 Appropriately consider all likely safety issues, and modify the embankment and/or surrounding environment where required.

Note, the allowable flow depth (y) is limited by the drain gradient and the allowable flow velocity.

Table 9 – Flow capacity (L/s) for flow diversion banks on earth surface [1]

Flow diversion bank on earth surface						Flow depth, y = 0.05m				
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	1.72	2.43	3.44	4.22	4.87	5.44	7.70	10.9	16.2	25.3
2	0.88	1.24	1.75	2.15	2.48	2.77	3.92	5.54	8.16	12.8
3	0.59	0.84	1.19	1.46	1.68	1.88	2.66	3.76	5.48	8.63
4	0.45	0.64	0.91	1.11	1.28	1.43	2.03	2.87	4.14	6.53
5	0.37	0.52	0.74	0.90	1.04	1.17	1.65	2.33	3.33	5.28
6	0.31	0.44	0.62	0.77	0.88	0.99	1.40	1.98	2.80	4.44
7	0.27	0.38	0.54	0.67	0.77	0.86	1.22	1.72	2.41	3.84
8	0.24	0.34	0.48	0.59	0.68	0.77	1.08	1.53	2.12	3.39
9	0.22	0.31	0.44	0.54	0.62	0.69	0.98	1.38	1.89	3.03
10	0.20	0.28	0.40	0.49	0.56	0.63	0.89	1.26	1.71	2.75
12	0.17	0.24	0.34	0.42	0.48	0.54	0.77	1.08	1.44	2.33
15	0.14	0.20	0.29	0.35	0.40	0.45	0.64	0.90	1.16	1.90
20	0.11	0.16	0.23	0.28	0.32	0.36	0.51	0.73	0.89	1.46
25	0.10	0.14	0.20	0.24	0.28	0.31	0.44	0.62	0.76	1.19
33.3	0.08	0.11	0.16	0.20	0.23	0.25	0.36	0.51	0.62	0.91
50	0.06	0.09	0.13	0.15	0.18	0.20	0.28	0.40	0.49	0.61

[1] NOTE: Flow rate is presented in units of litres per second, not m^3/s as used in Tables 14 to 18.

Table 10 – Flow capacity (L/s) for flow diversion banks on earth surface [1]

Flow diversion bank on earth surface						Flow depth, y = 0.10m				
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	10.9	15.5	21.9	33.4	50.4	66.7	140	262	366	460
2	5.56	7.87	11.1	16.8	25.5	33.8	70.8	133	186	234
3	3.77	5.34	7.55	11.3	17.2	22.8	47.9	89.8	126	158
4	2.88	4.07	5.76	8.57	13.0	17.3	36.4	68.4	95.8	121
5	2.34	3.31	4.68	6.91	10.5	14.0	29.5	55.5	77.8	97.9
6	1.98	2.81	3.97	5.80	8.87	11.8	24.9	46.9	65.8	82.8
7	1.73	2.44	3.46	5.01	7.67	10.2	21.6	40.7	57.2	72.0
8	1.54	2.17	3.07	4.42	6.77	9.03	19.2	36.1	50.7	63.8
9	1.39	1.96	2.77	3.95	6.08	8.11	17.2	32.5	45.7	57.5
10	1.27	1.79	2.54	3.58	5.51	7.37	15.7	29.6	41.6	52.5
12	1.09	1.54	2.18	3.01	4.67	6.25	13.4	25.3	35.6	44.9
15	0.91	1.28	1.82	2.45	3.82	5.13	11.0	21.0	29.5	37.2
20	0.73	1.03	1.46	1.87	2.95	4.00	8.69	16.6	23.4	29.5
25	0.62	0.88	1.24	1.52	2.42	3.30	7.26	13.9	19.7	24.9
33.3	0.51	0.72	1.02	1.25	1.88	2.59	5.80	11.2	15.9	20.2
50	0.40	0.56	0.80	0.98	1.29	1.82	4.26	8.40	12.0	15.2

[1] NOTE: Flow rate is presented in units of litres per second, not m^3/s as used in Tables 14 to 18.

Note, the allowable flow depth (y) is limited by the drain gradient and the allowable flow velocity.

Table 11 – Flow capacity (L/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface						Flow depth, y = 0.15m				
Land slope %	**Gradient (S) along drain (%)**									
	0.1	**0.2**	**0.4**	**0.6**	**0.8**	**1**	**2**	**4**	**6**	**8**
1	32.2	71.4	157	232	301	364	640	1082	1452	1780
2	16.4	36.1	79.5	118	153	185	325	550	738	905
3	11.1	24.3	53.7	79.6	103	125	220	372	500	613
4	8.49	18.5	40.8	60.5	78.5	95.3	168	284	381	467
5	6.91	14.9	33.1	49.1	63.7	77.3	136	230	309	380
6	5.85	12.6	27.9	41.5	53.8	65.4	115	195	262	321
7	5.10	10.9	24.2	36.0	46.8	56.8	100	170	228	279
8	4.53	9.60	21.4	31.9	41.5	50.4	88.8	150	202	248
9	4.09	8.61	19.3	28.7	37.3	45.3	80.0	136	182	224
10	3.74	7.82	17.6	26.1	34.0	41.3	73.0	124	166	204
12	3.21	6.62	14.9	22.3	29.0	35.3	62.4	106	142	175
15	2.68	5.42	12.3	18.4	24.0	29.2	51.8	88.0	118	145
20	2.15	4.20	9.68	14.5	19.0	23.1	41.1	70.0	94.2	116
25	1.83	3.45	8.07	12.2	15.9	19.4	34.6	59.1	79.6	97.8
33.3	1.50	2.67	6.42	9.75	12.8	15.7	28.1	48.0	64.8	79.7
50	1.17	1.84	4.68	7.21	9.55	11.7	21.2	36.6	49.5	61.0

[1] NOTE: Flow rate is presented in units of litres per second, not m^3/s as used in Tables 14 to 18.

Table 12 – Flow capacity (L/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface						Flow depth, y = 0.20m				
Land slope %	**Gradient (S) along drain (%)**									
	0.1	**0.2**	**0.4**	**0.6**	**0.8**	**1**	**2**	**4**	**6**	**8**
1	187	264	488	680	852	1011	1687	2747	3625	4398
2	94.8	134	248	345	433	514	857	1397	1843	2236
3	64.1	90.6	168	234	293	348	581	947	1249	1516
4	48.7	68.9	128	178	223	265	442	721	952	1155
5	39.5	55.9	104	145	181	215	359	586	774	939
6	33.4	47.2	87.6	122	153	182	304	496	655	795
7	29.0	41.0	76.1	106	133	158	264	431	570	691
8	25.7	36.3	67.5	94.2	118	140	235	383	506	614
9	23.1	32.7	60.8	84.9	107	127	212	345	456	554
10	21.0	29.7	55.4	77.4	97.2	115	193	315	416	506
12	17.9	25.4	47.3	66.2	83.1	98.8	165	270	357	433
15	14.8	21.0	39.2	54.9	69.0	82.0	137	225	297	360
20	11.7	16.5	31.0	43.5	54.8	65.2	109	179	237	287
25	9.8	13.8	26.1	36.6	46.2	54.9	92.4	151	200	243
33.3	7.81	11.1	21.0	29.7	37.4	44.6	75.2	123	163	199
50	5.76	8.15	15.8	22.4	28.3	33.8	57.4	94.6	125	153

[1] NOTE: Flow rate is presented in units of litres per second, not m^3/s as used in Tables 14 to 18.

Note, the allowable flow depth (y) is limited by the drain gradient and the allowable flow velocity.

Table 13 – Flow capacity (L/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.25m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	439	621	1078	1464	1808	2123	3451	5513	7205	8691
2	223	315	548	744	919	1079	1754	2803	3664	4420
3	151	213	371	504	623	731	1189	1900	2484	2996
4	115	162	283	384	474	557	906	1448	1893	2284
5	93.2	132	229	312	385	453	736	1177	1539	1857
6	78.8	111	194	264	326	383	623	996	1302	1572
7	68.5	96.8	169	229	283	333	542	867	1134	1368
8	60.7	85.9	150	204	252	296	481	770	1007	1215
9	54.7	77.4	135	183	227	267	434	694	908	1096
10	49.9	70.5	123	167	207	243	396	634	829	1001
12	42.6	60.3	105	143	177	208	339	543	710	857
15	35.3	49.9	87.4	119	147	173	282	452	591	714
20	28.0	39.6	69.4	94.6	117	138	225	360	472	570
25	23.5	33.2	58.5	79.8	98.9	116	190	305	400	483
33.3	19.0	26.8	47.4	64.9	80.4	94.8	155	249	327	395
50	14.3	20.2	35.9	49.3	61.3	72.4	119	192	252	304

[1] NOTE: Flow rate is presented in units of litres per second, <u>not</u> m^3/s as used in Tables 14 to 18.

Table 14 – Flow capacity (m^3/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.30m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	0.680	1.185	1.992	2.666	3.263	3.809	6.093	9.615	12.49	15.01
2	0.345	0.602	1.012	1.355	1.659	1.937	3.098	4.890	6.353	7.635
3	0.234	0.408	0.686	0.918	1.124	1.312	2.100	3.315	4.307	5.176
4	0.178	0.310	0.522	0.699	0.857	1.000	1.601	2.527	3.283	3.946
5	0.144	0.252	0.424	0.568	0.696	0.813	1.301	2.054	2.669	3.208
6	0.122	0.213	0.359	0.481	0.589	0.688	1.101	1.739	2.259	2.716
7	0.106	0.185	0.312	0.418	0.512	0.598	0.958	1.513	1.967	2.364
8	0.094	0.164	0.277	0.371	0.455	0.531	0.851	1.344	1.747	2.100
9	0.085	0.148	0.250	0.335	0.410	0.479	0.767	1.212	1.576	1.894
10	0.077	0.135	0.228	0.305	0.374	0.437	0.700	1.107	1.439	1.730
12	0.066	0.116	0.195	0.262	0.321	0.374	0.600	0.949	1.233	1.483
15	0.055	0.096	0.162	0.217	0.267	0.311	0.499	0.790	1.027	1.235
20	0.043	0.076	0.129	0.173	0.212	0.248	0.398	0.630	0.820	0.986
25	0.036	0.064	0.109	0.146	0.179	0.210	0.337	0.534	0.695	0.836
33.3	0.029	0.052	0.089	0.119	0.146	0.171	0.275	0.437	0.569	0.684
50	0.022	0.039	0.067	0.091	0.112	0.131	0.212	0.337	0.439	0.528

Note, the allowable flow depth (y) is limited by the drain gradient and the allowable flow velocity.

Table 15 – Flow capacity (m^3/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.35m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	1.181	1.998	3.290	4.361	5.309	6.171	9.766	15.28	19.76	23.68
2	0.600	1.015	1.672	2.217	2.699	3.138	4.966	7.771	10.05	12.05
3	0.406	0.688	1.133	1.503	1.829	2.127	3.366	5.268	6.815	8.168
4	0.309	0.524	0.863	1.145	1.394	1.621	2.566	4.016	5.196	6.227
5	0.251	0.426	0.701	0.930	1.133	1.317	2.086	3.265	4.224	5.063
6	0.212	0.360	0.593	0.787	0.959	1.115	1.765	2.764	3.576	4.286
7	0.185	0.313	0.516	0.685	0.834	0.970	1.536	2.406	3.113	3.731
8	0.164	0.278	0.458	0.608	0.741	0.861	1.365	2.137	2.765	3.315
9	0.148	0.250	0.413	0.548	0.668	0.777	1.231	1.928	2.495	2.991
10	0.135	0.228	0.377	0.501	0.610	0.709	1.124	1.760	2.278	2.731
12	0.115	0.196	0.323	0.429	0.522	0.608	0.963	1.509	1.953	2.341
15	0.095	0.162	0.269	0.357	0.435	0.506	0.802	1.257	1.627	1.951
20	0.076	0.129	0.214	0.284	0.346	0.403	0.640	1.003	1.300	1.558
25	0.064	0.109	0.181	0.240	0.293	0.341	0.542	0.850	1.102	1.321
33.3	0.052	0.089	0.147	0.196	0.239	0.279	0.443	0.696	0.902	1.083
50	0.039	0.067	0.113	0.150	0.184	0.214	0.341	0.537	0.697	0.837

Table 16 – Flow capacity (m^3/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.40m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	1.867	3.099	5.030	6.625	8.030	9.308	14.61	22.72	29.29	35.02
2	0.949	1.575	2.557	3.369	4.084	4.734	7.432	11.55	14.90	17.82
3	0.643	1.067	1.733	2.283	2.768	3.208	5.038	7.833	10.10	12.08
4	0.489	0.813	1.321	1.740	2.110	2.446	3.841	5.972	7.702	9.211
5	0.397	0.660	1.073	1.414	1.715	1.988	3.122	4.855	6.262	7.489
6	0.336	0.559	0.908	1.197	1.451	1.682	2.643	4.110	5.301	6.340
7	0.292	0.486	0.790	1.041	1.263	1.464	2.300	3.578	4.615	5.520
8	0.259	0.431	0.702	0.925	1.121	1.300	2.043	3.179	4.100	4.904
9	0.234	0.389	0.633	0.834	1.011	1.173	1.843	2.868	3.699	4.425
10	0.213	0.355	0.577	0.761	0.923	1.071	1.683	2.619	3.378	4.041
12	0.182	0.304	0.495	0.652	0.791	0.917	1.442	2.245	2.896	3.465
15	0.152	0.253	0.411	0.543	0.658	0.764	1.201	1.870	2.413	2.887
20	0.120	0.201	0.328	0.433	0.525	0.609	0.959	1.494	1.928	2.307
25	0.102	0.170	0.277	0.366	0.445	0.516	0.813	1.266	1.635	1.957
33.3	0.082	0.138	0.226	0.299	0.363	0.422	0.665	1.037	1.340	1.604
50	0.063	0.106	0.174	0.230	0.279	0.325	0.513	0.802	1.036	1.241

Note, the allowable flow depth (y) is limited by the drain gradient and the allowable flow velocity.

Table 17 – Flow capacity (m^3/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.45m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	2.765	4.525	7.270	9.53	11.51	13.31	20.77	32.13	41.32	49.33
2	1.405	2.301	3.697	4.845	5.854	6.771	10.57	16.34	21.02	25.10
3	0.952	1.559	2.505	3.284	3.968	4.590	7.163	11.08	14.25	17.02
4	0.725	1.188	1.909	2.503	3.025	3.499	5.461	8.449	10.87	12.98
5	0.589	0.965	1.552	2.034	2.459	2.844	4.440	6.869	8.836	10.55
6	0.498	0.817	1.313	1.722	2.081	2.407	3.758	5.816	7.481	8.932
7	0.433	0.710	1.143	1.498	1.811	2.095	3.271	5.063	6.513	7.777
8	0.385	0.631	1.015	1.331	1.609	1.861	2.906	4.498	5.786	6.909
9	0.347	0.569	0.915	1.200	1.451	1.679	2.622	4.058	5.221	6.234
10	0.316	0.519	0.835	1.096	1.325	1.533	2.394	3.706	4.768	5.694
12	0.271	0.445	0.716	0.939	1.135	1.313	2.052	3.177	4.088	4.882
15	0.225	0.370	0.596	0.782	0.945	1.094	1.709	2.647	3.407	4.069
20	0.179	0.294	0.475	0.623	0.754	0.873	1.365	2.115	2.723	3.252
25	0.151	0.249	0.402	0.528	0.639	0.739	1.157	1.794	2.310	2.759
33.3	0.123	0.203	0.328	0.431	0.522	0.605	0.947	1.470	1.893	2.263
50	0.094	0.155	0.252	0.332	0.402	0.466	0.732	1.137	1.465	1.752

Table 18 – Flow capacity (m^3/s) for flow diversion banks on earth surface

Flow diversion bank on earth surface					Flow depth, y = 0.50m					
Land slope %	Gradient (S) along drain (%)									
	0.1	0.2	0.4	0.6	0.8	1	2	4	6	8
1	3.899	6.32	10.06	13.14	15.83	18.28	28.38	43.72	56.11	66.89
2	1.982	3.211	5.117	6.680	8.052	9.296	14.44	22.24	28.54	34.03
3	1.343	2.176	3.468	4.528	5.458	6.302	9.787	15.08	19.35	23.07
4	1.023	1.658	2.644	3.452	4.161	4.804	7.462	11.50	14.76	17.60
5	0.831	1.347	2.149	2.806	3.382	3.905	6.067	9.348	12.00	14.31
6	0.703	1.140	1.819	2.375	2.863	3.306	5.136	7.915	10.16	12.11
7	0.612	0.992	1.583	2.067	2.492	2.877	4.471	6.890	8.846	10.55
8	0.543	0.881	1.406	1.836	2.213	2.556	3.972	6.122	7.859	9.371
9	0.490	0.794	1.268	1.656	1.997	2.306	3.583	5.523	7.091	8.456
10	0.447	0.725	1.157	1.512	1.823	2.105	3.272	5.044	6.477	7.723
12	0.383	0.621	0.992	1.296	1.562	1.805	2.805	4.325	5.554	6.623
15	0.318	0.517	0.825	1.079	1.301	1.503	2.337	3.604	4.629	5.521
20	0.253	0.412	0.658	0.861	1.039	1.200	1.867	2.880	3.700	4.413
25	0.214	0.348	0.557	0.729	0.880	1.017	1.583	2.443	3.139	3.745
33.3	0.174	0.284	0.456	0.596	0.720	0.832	1.296	2.003	2.574	3.072
50	0.133	0.218	0.350	0.459	0.555	0.642	1.002	1.550	1.994	2.380