

Graphical Hydrograph Method for Stormwater Detention

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**Purpose:** Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

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**Method:** Use the Rational Method to determine maximum rate of runoff

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$Q = C \cdot P \cdot A$   
Where:  
 $C$  = Runoff Coefficient  
 $P$  = Rainfall Intensity (in/hr)  
 $A$  = Drainage Area (acres)

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**Assumptions:** Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

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**For Existing Conditions:** Allowable release rate is based upon 20 minute, 2-year storm event for undeveloped flows where  $C = 0.35$ ,  $I = 3.50$  in/hr.

**For Existing Conditions:** Allowable release rate is based upon 20 minute, 10-year storm event for undeveloped flows where  $C = 0.35$ ,  $I = 5.80$  in/hr.

**For Existing Conditions:** Allowable release rate is based upon 20 minute, 25-year storm event for undeveloped flows where  $C = 0.35$ ,  $I = 6.75$  in/hr.

**For Existing Conditions:** Allowable release rate is based upon 20 minute, 50-year storm event for undeveloped flows where  $C = 0.35$ ,  $I = 7.40$  in/hr.

**For Existing Conditions:** Allowable release rate is based upon 20 minute, 100-year storm event for undeveloped flows where  $C = 0.35$ ,  $I = 8.30$  in/hr.

**For Proposed Conditions:** Use  $C = 0.75$  for multi-family development

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I. Determination of Allowable Release Rate - Existing Site

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Total site area	25.57	acres
Time of Concentration (Tc)	1.30	minutes
Rainfall intensity for 2-year storm (I=20 min)	3.50	in/hr
Detention runoff coefficient	0.35	
Max. Allowable release rate	38.79	cfs

Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (Tc)	10	minutes
Detention runoff coefficient for 2-year storm (I=20 min)	0.75	
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	1.60	cfs

Total off-site area passed through	4.60	acres
Time of Concentration (Tc)	20	minutes
Rainfall intensity for 2-year storm (I=15 min)	3.50	in/hr
Runoff coefficient	0.35	
Off-site pass-through rate	4.60	cfs

Total Allowable release rate from detention pond	34.19	cfs
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Total site area	25.57	acres
Time of Concentration (Tc)	1.30	minutes
Rainfall intensity for 10-year storm (I=20 min)	5.80	in/hr
Detention runoff coefficient	0.35	
Max. Allowable release rate	57.90	cfs

Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (Tc)	10	minutes
Detention runoff coefficient for 10-year storm (I=20 min)	0.75	
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	2.65	cfs

Total off-site area passed through	4.60	acres
Time of Concentration (Tc)	20	minutes
Rainfall intensity for 10-year storm (I=15 min)	5.80	in/hr
Runoff coefficient	0.35	
Off-site pass-through rate	4.60	cfs

Total Allowable release rate from detention pond	32.64	cfs
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Total site area	25.57	acres
Time of Concentration (Tc)	1.30	minutes
Rainfall intensity for 25-year storm (I=20 min)	6.75	in/hr
Detention runoff coefficient	0.35	
Max. Allowable release rate	67.00	cfs

Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (Tc)	10	minutes
Detention runoff coefficient for 25-year storm (I=20 min)	0.75	
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	3.61	cfs

Total off-site area passed through	4.60	acres
Time of Concentration (Tc)	20	minutes
Rainfall intensity for 25-year storm (I=15 min)	6.75	in/hr
Runoff coefficient	0.35	
Off-site pass-through rate	4.60	cfs

Total Allowable release rate from detention pond	36.61	cfs
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Total site area	25.57	acres
Time of Concentration (Tc)	1.30	minutes
Rainfall intensity for 50-year storm (I=20 min)	7.40	in/hr
Detention runoff coefficient	0.35	
Max. Allowable release rate	72.00	cfs

Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (Tc)	10	minutes
Detention runoff coefficient for 50-year storm (I=20 min)	0.75	
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	3.19	cfs

Total off-site area passed through	4.60	acres
Time of Concentration (Tc)	20	minutes
Rainfall intensity for 50-year storm (I=15 min)	7.40	in/hr
Runoff coefficient	0.35	
Off-site pass-through rate	4.60	cfs

Total Allowable release rate from detention pond	42.29	cfs
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**II. Required Storage Calculations, Return Period = 2 years**

**II. Required Storage Calculations, Return Period = 10 years**

**II. Required Storage Calculations, Return Period = 25 years**

**II. Required Storage Calculations, Return Period = 50 years**

**II. Required Storage Calculations, Return Period = 100 years**

Duration (hours)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs)	Outflow Rate (cfs)	Outflow Volume (cfs)	Inflow - Outflow - Required Storage (ac-ft)
0.17	4.20	92.56	55.575	20.71	12.424	41.151
0.25	3.50	60.72	28.141	20.71	18.500	26.610
0.50	3.15	56.1	100.997	20.71	24.848	76.148
0.67	4.0	47.2	113.388	20.71	31.051	82.337
1.00	2.65	31.6	113.388	20.71	82.217	1.888
1.33	2.00	24.0	128.540	20.71	48.485	84.566
2.00	1.25	22.3	160.313	20.71	80.757	79.555
3.00	0.88	15.7	160.326	20.71	118.009	1.177
4.00	0.80	14.0	160.326	20.71	131.260	1.177
5.00	0.75	13.2	160.326	20.71	144.511	1.177
6.00	0.70	12.4	160.326	20.71	157.762	1.177
8.00	0.60	9.3	200.070	20.71	229.848	-29.778
10.00	0.50	6.3	192.375	20.71	192.576	-0.003
12.00	0.50	5.3	230.830	20.71	453.484	-222.654

Duration (hours)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs)	Outflow Rate (cfs)	Outflow Volume (cfs)	Inflow - Outflow - Required Storage (ac-ft)
0.17	7.20	125.3	76.520	32.64	15.586	57.944
0.25	6.50	115.8	104.550	32.64	24.480	79.712
0.50	5.85	100.997	151.900	32.64	50.172	114.728
0.67	4.05	72.1	173.138	32.64	48.965	124.173
1.00	3.00	53.4	102.925	32.64	68.551	123.474
1.33	2.25	40.0	128.540	32.64	88.137	123.474
2.00	1.50	30.0	160.313	32.64	127.808	130.505
3.00	1.00	20.0	160.326	32.64	186.068	1.177
4.00	0.80	16.0	160.326	32.64	211.419	1.177
5.00	0.75	15.0	160.326	32.64	236.770	1.177
6.00	0.70	14.0	160.326	32.64	262.121	1.177
8.00	0.60	10.0	207.800	32.64	303.481	-5.600
10.00	0.50	7.0	206.181	32.64	303.481	-4.324
12.00	0.47	8.4	301.065	32.64	362.335	-54.555

Duration (hours)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs)	Outflow Rate (cfs)	Outflow Volume (cfs)	Inflow - Outflow - Required Storage (ac-ft)
0.17	8.20	146.1	87.538	35.61	23.197	64.371
0.25	7.40	131.8	118.651	35.61	38.588	80.057
0.50	6.55	108.9	177.947	35.61	66.333	111.614
0.67	4.70	81.7	200.925	35.61	57.917	143.008
1.00	3.52	62.2	242.920	35.61	88.137	154.783
1.33	2.77	47.0	282.504	35.61	120.583	161.921
2.00	2.00	35.0	317.119	35.61	160.928	156.191
3.00	1.33	24.0	317.119	35.61	220.383	96.735
4.00	1.00	20.0	317.119	35.61	250.828	66.290
5.00	0.80	16.0	317.119	35.61	281.273	35.846
6.00	0.75	15.0	317.119	35.61	306.718	6.401
8.00	0.60	10.0	368.710	35.61	359.083	9.625
10.00	0.50	7.0	368.710	35.61	359.083	9.625
12.00	0.47	8.4	424.225	35.61	424.225	-9.606

Duration (hours)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs)	Outflow Rate (cfs)	Outflow Volume (cfs)	Inflow - Outflow - Required Storage (ac-ft)
0.17	8.20	146.1	87.538	35.61	23.197	64.371
0.25	7.40	131.8	118.651	35.61	38.588	80.057
0.50	6.55	108.9	177.947	35.61	66.333	111.614
0.67	4.70	81.7	200.925	35.61	57.917	143.008
1.00	3.52	62.2	242.920	35.61	88.137	154.783
1.33	2.77	47.0	282.504	35.61	120.583	161.921
2.00	2.00	35.0	317.119	35.61	160.928	156.191
3.00	1.33	24.0	317.119	35.61	220.383	96.735
4.00	1.00	20.0	317.119	35.61	250.828	66.290
5.00	0.80	16.0	317.119	35.61	281.273	35.846
6.00	0.75	15.0	317.119	35.61	306.718	6.401
8.00	0.60	10.0	368.710	35.61	359.083	9.625
10.00	0.50	7.0	368.710	35.61	359.083	9.625
12.00	0.47	8.4	424.225	35.61	424.225	-9.606

Duration (hours)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs)	Outflow Rate (cfs)	Outflow Volume (cfs)	Inflow - Outflow - Required Storage (ac-ft)
0.17	9.00	161.6	104.238	48.46	29.075	75.163
0.25	8.30	147.8	137.456	48.46	43.612	93.844
0.50	7.40	131.8	200.925	48.46	87.224	113.701
0.67	5.85	100.997	227.331	48.46	101.582	125.749
1.00	4.0	72.1	267.718	48.46	145.082	122.636
1.33	3.00	53.4	308.103	48.46	188.582	119.521
2.00	2.00	35.0	348.588	48.46	232.082	116.506
3.00	1.33	24.0	389.073	48.46	275.582	113.491
4.00	1.00	20.0	429.558	48.46	319.082	110.476
5.00	0.80	16.0	470.043	48.46	362.582	107.461
6.00	0.75	15.0	510.528	48.46	406.082	104.446
8.00	0.60	10.0	551.013	48.46	449.582	101.431
10.00	0.50	7.0	591.500	48.46	493.082	98.416
12.00	0.47	8.4	631.985	48.46	536.582	95.401

Duration (hr)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cfs-hr)	Outflow Rate (cfs)	Outflow Volume (cfs-hr)	Inflow - Outflow - Required Storage (cfs-hr)
0.17	9.00	161.6	104.238	48.46	29.075	75.163
0.25	8.30	147.8	137.456	48.46	43.612	93.844
0.50	7.40	131.8	200.925	48.46	87.224	113.701
0.67	5.85	100.997	227.331	48.46	101.582	125.749
1.00	4.0	72.1	267.718	48.46	145.082	122.636
1.33	3.00	53.4	308.103	48.46	188.582	119.521
2.00	2.00	35.0	348.588	48.46	232.082	116.506
3.00	1.33	24.0	389.073	48.46	275.582	113.491
4.00	1.00	20.0	429.558	48.46	319.082	110.476
5.00	0.80	16.0	470.043	48.46	362.582	107.461
6.00	0.67	13.3	509.528	48.46	406.082	103.446
7.00	0.60	12.0	549.013	48.46	449.582	99.431
8.00	0.50	10.0	588.500	48.46	493.082	95.416
9.00	0.40	8.0	627.985	48.46	536.582	91.401
10.00	0.33	6.7	667.470	48.46	580.082	87.386
12.00	0.25	5.0	756.955	48.46	673.582	83.371
15.00	0.20	4.0	846.440	48.46	767.082	79.356
18.00	0.17	3.3	885.925	48.46	810.582	75.341
20.00	0.15	3.0	925.410	48.46	854.082	71.326
25.00	0.10	2.0	1014.895	48.46	947.582	67.311
30.00	0.08	1.3	1054.380	48.46	991.082	63.296
35.00	0.07	1.0	1093.865	48.46	1034.582	59.281
40.00	0.06	0.7	1133.350	48.46	1078.082	55.266
45.00	0.05	0.5	1172.835	48.46	1121.582	51.251
50.00	0.04	0.4	1212.320	48.46	1165.082	47.236
60.00	0.03	0.3	1251.805	48.46	1208.582	43.221
70.00	0.02	0.2	1291.290	48.46	1252.082	39.206
80.00	0.02	0.2	1330.775	48.46	1295.582	35.191
90.00	0.01	0.1	1370.260	48.46	1339.082	31.176
100.00	0.01	0.1	1409.745	48.46	1382.582	27.161
120.00	0.01	0.1	1449.230	48.46	1426.082	23.146
140.00	0.01	0.1	1488.715	48.46	1469.582	19.131
160.00	0.01	0.1	1528.200	48.46	1513.082	15.116
180.00	0.01	0.1	1567.685	48.46	1556.582	11.101
200.00	0.01	0.1	1607.170	48.46	1600.082	7.086
250.00	0.01	0.1	1686.655	48.46	1693.582	3.071
300.00	0.01	0.1	1766.140	48.46	1787.082	-0.944
350.00	0.01	0.1	1845.625	48.46	1880.582	-4.959
400.00	0.01	0.1	1925.110	48.46	1974.082	-8.974
450.00	0.01	0.1	2004.595	48.46	2067.582	-12.989
500.00	0.01	0.1	2084.080	48.46	2161.082	-16.994
600.00	0.01	0.1	2203.565	48.46	2308.082	-24.517
700.00	0.01	0.1	2323.050	48.46	2455.082	-31.990
800.00	0.01	0.1	2442.535	48.46	2602.082	-39.463
900.00	0.01	0.1	2562.020	48.46	2749.082	-46.936
1000.00	0.01	0.1	2681.505	48.46	2896.082	-54.409
1200.00	0.01	0.1	2840.990	48.46	3138.082	-67.092
1400.00	0.01	0.1	2999.475	48.46	3380.082	-79.607
1600.00	0.01	0.1	3158.960	48.46	3622.082	-92.122
1800.00	0.01	0.1	3318.445	48.46	3864.082	-104.637
2000.00	0.01	0.1	3477.930	48.46	4106.082	-117.152
2500.00	0.01	0.1	3817.415	48.46	4594.082	-151.667
3000.00	0.01	0.1	4156.900	48.46	5082.082	-186.182
3500.00	0.01	0.1	4496.385	48.46	5570.082	-220.697
4000.00	0.01	0.1	4835.870	48.46	6058.082	-255.212
4500.00	0.01	0.1	5175.355	48.46	6546.082	-289.727
5000.00	0.01	0.1	5514.840	48.46	7034.082	-324.242
6000.00	0.01	0.1	6194.325	48.46	7966.082	-371.757
7000.00	0.01	0.1	6873.810	48.46	8898.082	-419.272
8000.00	0.01	0.1	7553.295	48.46	9830.082	-466.787
9000.00	0.01	0.1	8232.780	48.46	10762.082	-514.302
10000.00	0.01	0.1	8912.265	48.46	11694.082	-561.817
12000.00	0.01	0.1	9891.750	48.46	13178.082	-626.332
14000.00	0.01	0.1	10871.235	48.46	14662.082	-690.847
16000.00	0.01	0.1	11850.720	48.46	16146.082	-755.362
18000.00	0.01	0.1	12830.205	48.46	17630.082	-819.877
20000.00	0.01	0.1	13809.690	48.46	19114.082	-884.392
25000.00	0.01	0.1	15729.175	48.46	21598.082	-968.907
30000.00	0.01	0.1	17648.660	48.46	24082.082	-1053.422
35000.00	0.01	0.1	19568.145	48.46	26566.082	-1137.937
40000.00	0.01	0.1	21487.630	48.46	29050.082	-1222.452
45000.00	0.01	0.1	23407.115	48.46	31534.082	-1306.967
50000.00	0.01	0.1	25326.600	48.46	34018.082	-1391.482
60000.00	0.01	0.1	29126.085	48.46	39386.082	-1559.997
70000.00	0.01	0.1	32925.570	48.46	44754.082	-1728.512
80000.00	0.01	0.1	36725.055	48.46	50122.082	-1897.027
90000.00	0.01	0.1	40524.540	48.46	55490.082	-2065.542
100000.00	0.01	0.1	44324.025	48.46	60858.082	-2234.057
120000.00	0.01	0.1	52123.510	48.46	71736.082	-2451.572
140000.00	0.01	0.1	59923.000	48.46	82614.082	-2669.087
160000.00	0.01	0.1	67722.485	48.46	93492.082	-2886.602
180000.00	0.01	0.1	75521.970	48.46	104370.082	-3104.117
200000.00	0.01	0.1	83321.455	48.46	115248.082	-3321.632
250000.00	0.01	0.1	99120.940	48.46	136626.082	-3741.147
300000.00	0.01	0.1	114920.425	48.46	158004.082	-4160.662
350000.00	0.01	0.1	130719.910	48.46	179382.082	-4580.177
400000.00	0.01	0.1	146519.395	48.46	200760.082	-5000.692
450000.00	0.01	0.1	162318.880	48.46	222138.082	-5420.207
500000.00	0.01	0.1	178118.365	48.46	243516.082	-5839.722
600000.00	0.01	0.1	203917.850	48.46	285894.082	-6559.237
700000.00	0.01	0.1	229717.335	48.46	328272.082	-7278.752
800000.00	0.01	0.1	255516.820	48.46	370650.082	-7998.267
900000.00	0.01	0.1	281316.305	48.46	413028.082	-8717.782
1000000.00	0.01	0.1	307115.790	48.46	455406.082	-9437.297
1200000.00	0.01	0.1	351515.275	48.46	523784.082	-10522.812
1400000.00	0.01	0.1	395914.760	48.46	592162.082	-11608.327
1600000.00	0.01	0.1	440314.245	48.46	660540.082	-12693.842
1800000.00	0.01	0.1	484713.730	48.46	728918.082	-13779.357
2000000.00	0.01	0.1	529113.215	48.46	797296.082	-14864.872
2500000.00	0.01	0.1	623112.700	48.46	941274.082	-16415.387
3000000.00	0.01	0.1	717112.185	48.46	1085252.082	-17965.902
3500000.00	0.01	0.1	811111.670	48.46	1229230.082	-19516.417
4000000.00	0.01	0.1	905111.155	48.46	1373208.082	-21066.932
4500000.00	0.01	0.1	999110.640	48.46	1517186.082	-22617.447
5000000.00	0.01	0.1	1093110.125	48.46	1661164.082	-24167.962
6000000.00	0.01	0.1	1281109.610	48.46	1959142.082	-26657.477
7000000.00	0.01	0.1	1469109.095	48.46	2257120.082	-29146.992
8000000.00	0.01	0.1	1657108.580	48.46	2555098.082	-31636.507
9000000.00	0.01	0.1	1845108.065	48.46	2853076.082	-34126.022
10000000.00	0.01	0.1	2033107.550	48.46	3151054.082	-36615.537
12000000.00	0.01	0.1	2417107.035	48.46	3739032.082	-43213.052
14000000.00	0.01	0.1	2801106.520	48.46	4327010.082	-49810.567
16000000.00	0.01	0.1	3185106.005	48.46	4914988.082	-56408.082
18000000.00	0.01	0.1	3569105.490	48.46	5502966.082	-63005.597
20000000.00	0.01	0.1	3953104.975	48.46	6090944.082	-69603.112
25000000.00	0.01	0.1	4777104.460	48.46	7374922.082	-80574.627
30000000.00	0.01	0.1	5601103.945	48.46	8658900.082	-91546.142
35000000.00	0.01	0.1	6425103.430	48.46	9942878.082	-102517.657
40000000.00	0.01	0.1	7249102.915	48.46	11226856.082	-113489.172
45000000.00	0.01	0.1	8073102.400	48.46	12510834.082	-124460.687
50000000.00	0.01	0.1	8897101.885	48.46	13794812.082	-135432.202
60000000.00	0.01	0.1	10537101.370	48.46	16154790.082	-155816.717
70000000.00	0.01	0.1	12177100.855	48.46	18514768.082	-176201.232
80000000.00	0.01	0.1	13817100.340	48.46	20874746.082	-196585.747
90000000.00	0.01	0.1	15457100.825	48.46	23234724.082	-216970.262
100000000.00	0.01	0.1	17097100.310	48.46	25594702.082	-237354.777
120000000.00	0.01	0.1	19937100.795	48.46	29874680.082	-278876.292
140000000.00	0.01	0.1	22777100.280	48.46	34154658.082	-320397.807
160000000.00	0.01	0.1	25617100.765	48.46	38434636.082	-361919.322
180000000.00	0.01	0.1	28457100.250	48.46	42714614.082	-403440.837
200000000.00	0.01	0.1	31297100.735	48.46	46994592.082	-444962.352
250000000.00	0.01	0.1	37137101.220	48.46	56394570.082	-531162.867
300000000.00	0.01	0.1	42977101.705	48.46	65794548.082	-617363.382
350000000.00	0.01	0.1	48817102.190	48.46	75194526.082	-703563.897
400000000.00	0.01	0.1	54657102.675	48.46	84594504.082	-789764.412
450000000.00	0.01	0.1	60497103.160	48.46	93994482.082	-875964.927
500000000.00	0.01	0.1	66337103.645	48.46	103394460.082	-962165.442
600000000.00	0.01	0.1	78137104.130	48.46	122194438.082	-1140165.957
700000000.00	0.01	0.1	89937104.615	48.46	140994416.082	-1318166.472
800000000.00	0.01	0.1	101737105.100	48.46	159794394.082	-1496166.987
900000000.00	0.01	0.1	113537105.585	48.46	178594372.082	-1674167.502
1000000000.00	0.01	0.1	125337106.070	48.46	197394350.082	-1852168.017
1200000000.00	0.01	0.1	143737106.555	48.46	226194328.082	-2140168.532
1400000000.00	0.01	0.1				