

CHAPTER 2

HYDROLOGY

2.7 Simplified SCS Method

2.7.1 Overview

The following SCS procedures were taken from the SCS Technical Release 55 (*TR-55) which presents simplified procedures to calculate storm runoff volume, peak rate of discharges and hydrographs. These procedures are applicable to small drainage areas and include provisions to account for urbanization. The following procedures outline the use of the SCS-TR 55 method.

2.7.2 Peak Discharges

The SCS peak discharge method is applicable for estimating the peak runoff rate from watersheds with a homogeneous land uses. The following method is based on the results of computer analyses performed using TR-20, “Computer Program for Project Formulation – Hydrology” (SCS 1983).

The peak discharge equation is:

$$Q_p = quAQF_p \quad (\text{Eq 2.7.2-1})$$

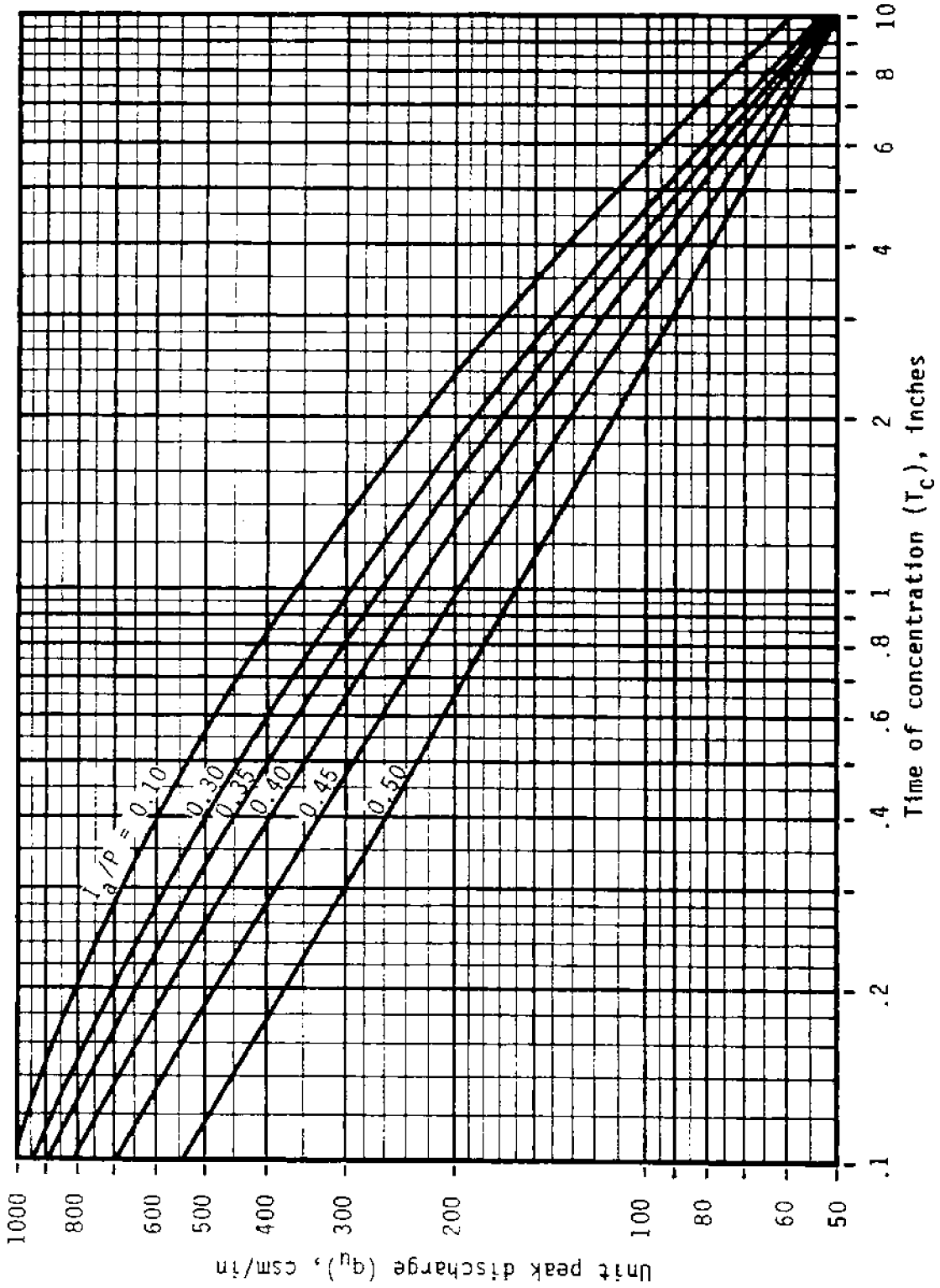
Where: Q_p = peak discharge (cfs)
 q_u = unit peak discharge (cfs/mi²/in)
 A = drainage area (mi²)
 Q = runoff (in)
 F_p = pond and swamp adjustment factor

The input requirements for this method are as follows:

1. T_c – hours
2. Drainage area – mi²
3. Type II rainfall distribution
4. 24-hour design rainfall
5. CN value
6. Pond and Swamp adjustment factor (If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, and adjustment is needed.)

Figure 2.7.2-1

SCS Type I Unit Peak Discharge



2.7.3 Computations

Computations for the peak discharge method proceed as follows:

2.7.3.1 The 24-hour rainfall depth is determined from the following table for the selected return frequency.

Frequency	24-hour Rainfall
Water Quality	1.20 in.
1-year	3.36 in.
2-year	3.84 in.
5-year	4.80 in.
10-year	5.52 in.
25-year	6.48 in.
50-year	7.20 in.
100-year	7.68 in.

2.7.3.2 The runoff curve number, CN, is estimated from Table 2.6.2.-1 and direct runoff, Q_p , is calculated using equation 2.7.2-1.

2.7.3.3 The CN value is used to determine the initial abstraction, I_a , from Table 2.7.3-1, and the ratio I_a/P is then computed. (P = accumulated 24-hour rainfall or potential maximum runoff.)

2.7.3.4 The watershed time of concentration is computed using the procedures in Section 2.6.5 and is used with the ratio I_a/P to obtain the unit peak discharge, q_u , from Figure 2.7.2-1. If the ratio I_a/P lies outside the range shown in Figure 2.7.2-1, either the limiting values or another peak discharge method should be used.

2.7.3.5 The pond and swamp adjustment factor, F_p , is estimated from below:

Pond & Swamp Areas (%*)	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

*Percent of entire drainage basin

2.7.3.6 The peak runoff rate is computed using equation 2.7.2-1.

Table 2.7.3-1

I_a

Values for Runoff Curve Numbers

<u>Curve Number</u>	<u>I_a (in)</u>	<u>Curve Number</u>	<u>I_a (in)</u>
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

2.7.4 Limitations

The accuracy of the peak discharge method is subject to specific limitations, including the following:

- 2.7.4.1 The watershed must be hydrologically homogeneous and describable by a single CN value.
- 2.7.4.2 The watershed may have only one main stream, or if more than one, the individual branches must have nearly equal time of concentrations.
- 2.7.4.3 Hydrologic routing cannot be considered.
- 2.7.4.4 The pond and swamp adjustment factor, F_p , applies only to areas located away from the main flow path.
- 2.7.4.5 Accuracy is reduced if the ratio I_a/P is outside the range given in figure 2-6. If I_a/P is less than 0.1, use the line in figure 2-6 corresponding to I_a/P equals 0.10.
- 2.7.4.6 The weighted CN value must be greater than or equal to 40 and less than or equal to 98.
- 2.7.4.7 The same procedure should be used to estimate pre- and post-development time of concentration when computing pre- and post-development peak discharge.
- 2.7.4.8 The watershed time of concentration must be between 0.1 and 10 hours.

2.7.5 Example Problem

Compute the 100-year peak discharge for a 50-acre wooded watershed which will be developed as follows:

- 2.7.5.1 Forest land – good cover (hydrologic soil group B) = 10 ac.
- 2.7.5.2 Forest land – good cover (hydrologic soil group C) = 10 ac.
- 2.7.5.3 Town house residential (hydrologic soil group B) = 20 ac.
- 2.7.5.4 Industrial development (hydrological soil group C) = 10 ac.

Other data include: percentage of pond and swamp area = 0.

Computations

1. Calculate rainfall excess:

- The 100-year, 24-hour rainfall is 7.68 inches.
- Composite weight runoff coefficient is:

<u>Dev. #</u>	<u>Area</u>	<u>% Total</u>	<u>Cn</u>	<u>Composite Cn</u>
1	10 ac.	0.20	55	11.0
2	10 ac.	0.20	70	14.0
3	20 ac.	0.40	85	34.0
4	10 ac.	0.20	91	18.2
Total	50 ac.	1.00	77.2	use 77

*From Equation 2-5 or Figure 2-4, Q=4.98 inches

2. Calculate time of concentration

- The hydrologic flow path for this watershed = 1,890 ft.

<u>Segment</u>	<u>Type of Flow</u>	<u>Length</u>	<u>Slope (%)</u>
1	Overland n = 0.24	40 ft.	2.0 %
2	Shallow channel	750 ft.	1.7 %
3	Main channel*	1100 ft.	0.50 %

*For the main channel, n = .06 (estimated), width = 10 feet, depth=2 feet, rectangular channel.

- Segment 1 – Travel time from equation 2.7 with $P_2 = 3.84$ in.

$$T_t = \left[0.42(0.24 * 40)^8 \right] / \left[(3.84)^5 (.020)^4 \right]$$

$T_t = 6.26$ minutes

- Segment 2 – Travel time from Figure 2-5 or equation 2.13

$$V = 2.1 \text{ ft/sec (from equation 2.13)}$$

$$T_t = 750 / 60 (2.1) = 5.95 \text{ minutes}$$

- Segment 3 – Using equation 2.15

$$V = (1.49/.06) (1.43)^{-67} (.005)^{-5} = 2/23 \text{ ft/sec}$$

$$T_t = 1100 / 60 (2.23) = 8.22 \text{ minutes}$$

$$T_c = 6.26 + 5.95 + 8.22 + 20.43 \text{ minutes (.34 hours)}$$

3. Calculate I_a/P for Cn = 77 (Table 2-7), $I_a = .597$ (Table 2-9)

$$I_a/P = (.597 / 7.68) = .08$$

(Note: Use $I_a/P = .10$ to facilitate use of charts in Appendix A. Straight line interpolation could also be used.)

4. Estimate unit discharge q_u from Figure 2-6 = 650 cfs.
5. Calculate peak discharge with $F_p = 1$ using equation 2.17
 $Q_{100} = 650 (50/640) (4.98) (1) = 253$ cfs.

2.7.6 Hydrograph Generation

In addition to estimating the peak discharge, the SCS method can be used to estimate the entire hydrograph. The Soil Conservation Service has developed a Tabular Hydrograph procedure which can be used to generate the hydrograph for small drainage areas (less than 2000 acres). The Tabular Hydrograph procedure uses unit discharge hydrographs which have been generated for a series of time of concentrations see example on next page).

The tables in Section 2.11 give the unit discharges (csm/in) for different times of concentration which are applicable to the City of Lawrenceville. The values that should be used are those with a travel time equal to zero. The other travel times indicate the unit hydrographs which would result if the hydrographs were routed through a channel system for a length of time equal to the travel time. Thus using these unit hydrographs would account for the effects of channel routing. Straight line interpolation can be used for time of concentrations and travel times between the values given in the appendix.

2.7.7 Composite Hydrograph

The procedures given in this chapter are for generation of a hydrograph from a homogeneous developed drainage area. For drainage areas which are not homogeneous where hydrographs need to be generated from sub-areas and then routed and combined at a point downstream, the engineer is referred to the procedures outlined by the SCS in the 1986 version of TR-55 available from the National Technical Information Service in Springfield, Virginia 22161. The catalog number for TR-55, "Urban Hydrology for Small Watersheds," is PB87-101580.

2.7.8 Example Problem

For the example problem in 2.7.5, calculate the entire hydrograph from the 50 acre development.

Using the chart in Section 2.11 with a time of concentration of .34 hours and $I_a/P = 0.10$, the following hydrograph can be generated (using

straight line interpolation between time of concentration of .3 and .4 hours).

The values given in the charts are in csm/in or cubic feet per second per square mile per inch of runoff. Thus for this example all values from the chart must be multiplied by (50 acres/640 acres) per square mile times 4.98 inches of runoff times 1 for the ponding factor – $(50/640)(4.98)(1) = .389$

As an example, from the chart in Section 2.11 with TC = .34 hours and LA/P = 0.10, the unit discharge at time 12.1 hours is 377 cfs. Thus the ordinate on the hydrograph for this example would be $377 (.389) = 147$ cfs. This calculation must be done for all hydrograph values. The results for selected time values are given below.

<u>Hydrograph Time</u> (hours)	<u>Unit Discharge</u> (csm/in)	<u>Hydrograph</u> (cfs)
11.0	19	7
11.3	27	11
11.6	39	15
11.9	102	40
12.0	197	77
12.1	377	147
12.2	593	231
12.3	642	250
12.4	505	196
12.5	342	133
12.6	237	92
12.7	216	84
12.8	134	52
13.0	90	35
13.2	70	27
13.4	59	23
13.6	53	21
13.8	47	18
14.0	43	17
14.3	37	14
14.6	33	13
15.0	31	12
15.5	28	11
16.0	24	9
16.5	22	9
17.0	20	8
17.5	19	7
18.0	18	7

END OF SECTION 2.7