EROSION, SEDIMENT, AND STORM WATER CONTROL

ORDINANCE

APPENDIX A

WOODFORD COUNTY STANDARDS
FOR STORM WATER DESIGN ANALYSES

The following are the minimum standard methods and procedures to be used to comply with the storm water design requirements of the Woodford County Storm Water and Erosion Control Ordinance. If an applicant determines that different methods are necessary based on site specific conditions, the applicant must request approval for the Erosion Control Administrator to use other methods prior to submittal.

The design methods listed below are readily available in a number of computer programs, including the Soil Conservation Service's TR 20 (SCS) and HEC-1 (U.S. Army Corps of Engineers.) Additionally, a simplified methodology which is based on the use of these methods is available in TR 55 (SCS, 1986.) TR 55 can be applied using either manual computations or a computerize version.

Rainfall Depth and Intensity Data
Use data from the Illinois State Water Survey, BUL-70/89, 1989 as presented in attached Table 1 and graphically in Figure 1.

Storm Event Rainfall Runoff
Use the SCS Runoff Curve Number Method to determine rainfall runoff depth. See Figure 2-1 and Tables 2-2a through 2-2c (attached) from TR 55. Soil type information is available from the SCS Woodford County Soil Survey, 1992.

Storm Distribution (Cumulative rainfall versus time)
Use the SCS Type II storm distribution. See attached Table 3 and Figure 3.

Runoff Hydrograph
Use the SCS dimensionless hydrograph. See SCS (1974) for information regarding this procedure. As a substitute for detailed hydrograph analysis, TR 55 (SCS, 1986) can be used, either manually or computer program.

Storage Routing (Detention Pond Analysis)
Use the continuity equation, also known as the Modified-Puls and Storage indication methods. As a substitute for detailed storage routing of a hydrograph, TR 55 (SCS, 1986) can be used, either manually or computer program. If TR 55 is used and a detention basin with a two-stage outlet control structure including a rectangular weir and/or orifice outlet is included as a part of the control measures, use the attached detention basin outlet worksheet to determine and present the structure design information.

Table 1. Rainfall Depth-Duration-Frequency Data

Duration	Rainfall Depth (inches) for Given Frequency					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5-min	0.36	0.45	0.53	0.64	0.73	0.83
10-min	0.66	0.83	0.98	1.17	1.34	1.52
15-min	0.81	1.02	1.20	1.44	1.64	1.87
30-min	1.12	1.39	1.64	1.97	2.25	2.56
1-hr	1.42	1.77	2.09	2.50	2.86	3.25
2-hr	1.78	2.22	2.62	3.14	3.59	4.08
3-hr	1.93	2.41	2.85	3.41	3.89	4.43
6-hr	2.26	2.82	3.33	3.99	4.56	5.19
12-hr	2.62	3.27	3.87	4.63	5.29	6.02
18-hr	2.75	3.46	4.09	4.90	5.59	6.37
24-hr	3.02	3.76	4.45	5.32	6.08	6.92
48-hr	3.38	4.19	4.86	5.78	6.62	7.51
72-hr	3.70	4.55	5.26	6.15	7.25	8.16
5-day	4.17	5.11	5.84	6.96	7.98	9.21
10-day	5.12	6.27	7.10	8.19	9.10	10.18

Source: ISWS/BUL-70/89

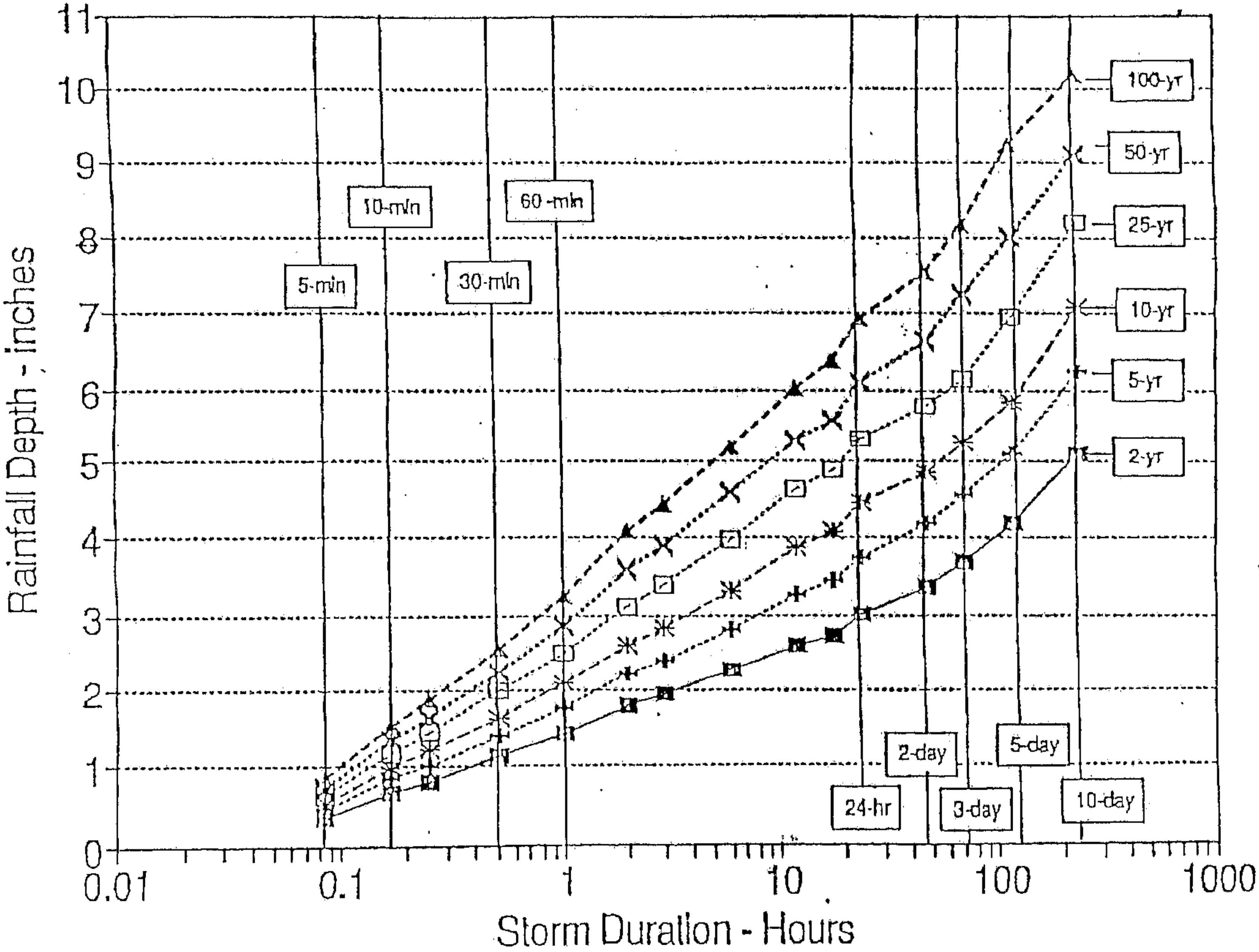

Figure 1. Rainfall Depth-Duration-Frequency Data

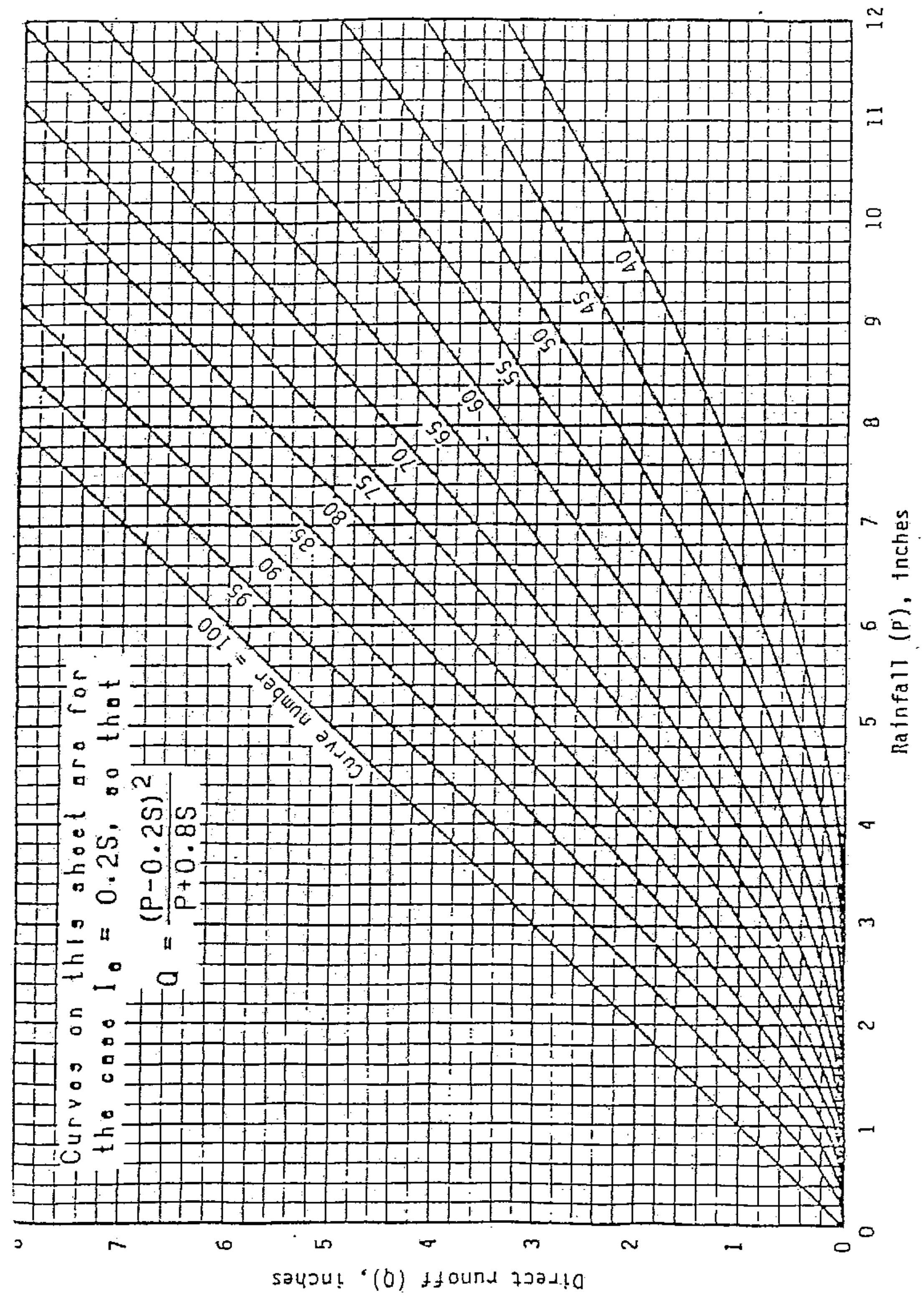

Figure 2-1.—Solution of runoff equation.

Chapter 2: Estimating runoff

SCS Runoff Curve Number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[Eq. 2-1]}$$

where

- Q = runoff (in),
- P = rainfall (in),
- S = potential maximum retention after runoff begins (in), and
- I_a = initial abstraction (in).

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S. \qquad \text{[Eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[Eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by

$$S = \frac{1000}{CN} - 10. \qquad \text{[Eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

Average runoff condition, and $I_a = 0.2S$.

Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 1. SCS Type II Rainfall Distribution

Time: Hour	Time: Fraction of Total	Fraction of Total Rainfall
0.50	0.021	0.005
1.00	0.042	0.011
1.50	0.063	0.017
2.00	0.083	0.023
2.50	0.104	0.029
3.00	0.125	0.035
3.50	0.146	0.042
4.00	0.167	0.049
4.50	0.188	0.056
5.00	0.208	0.064
5.50	0.229	0.072
6.00	0.250	0.080
6.50	0.271	0.090
7.00	0.292	0.100
7.50	0.313	0.110
8.00	0.333	0.120
8.50	0.354	0.134
9.00	0.375	0.147
9.50	0.396	0.163
10.00	0.417	0.181
10.50	0.438	0.204
11.00	0.458	0.235
11.25	0.468	0.260
11.50	0.479	0.300
11.75	0.490	0.420
12.00	0.500	0.663
12.25	0.510	0.710
12.50	0.521	0.735
13.00	0.542	0.772
13.50	0.563	0.799
14.00	0.583	0.820
14.50	0.604	0.835
15.00	0.625	0.850
15.50	0.646	0.865
16.00	0.667	0.880
16.50	0.688	0.889
17.00	0.708	0.898
17.50	0.729	0.907
18.00	0.750	0.916
18.50	0.771	0.925
19.00	0.792	0.934
19.50	0.813	0.943
20.00	0.833	0.952
20.50	0.854	0.958
21.00	0.875	0.964
21.50	0.896	0.970
22.00	0.917	0.976
22.50	0.938	0.982
23.00	0.958	0.988
23.50	0.979	0.994
24.00	1.000	1.000

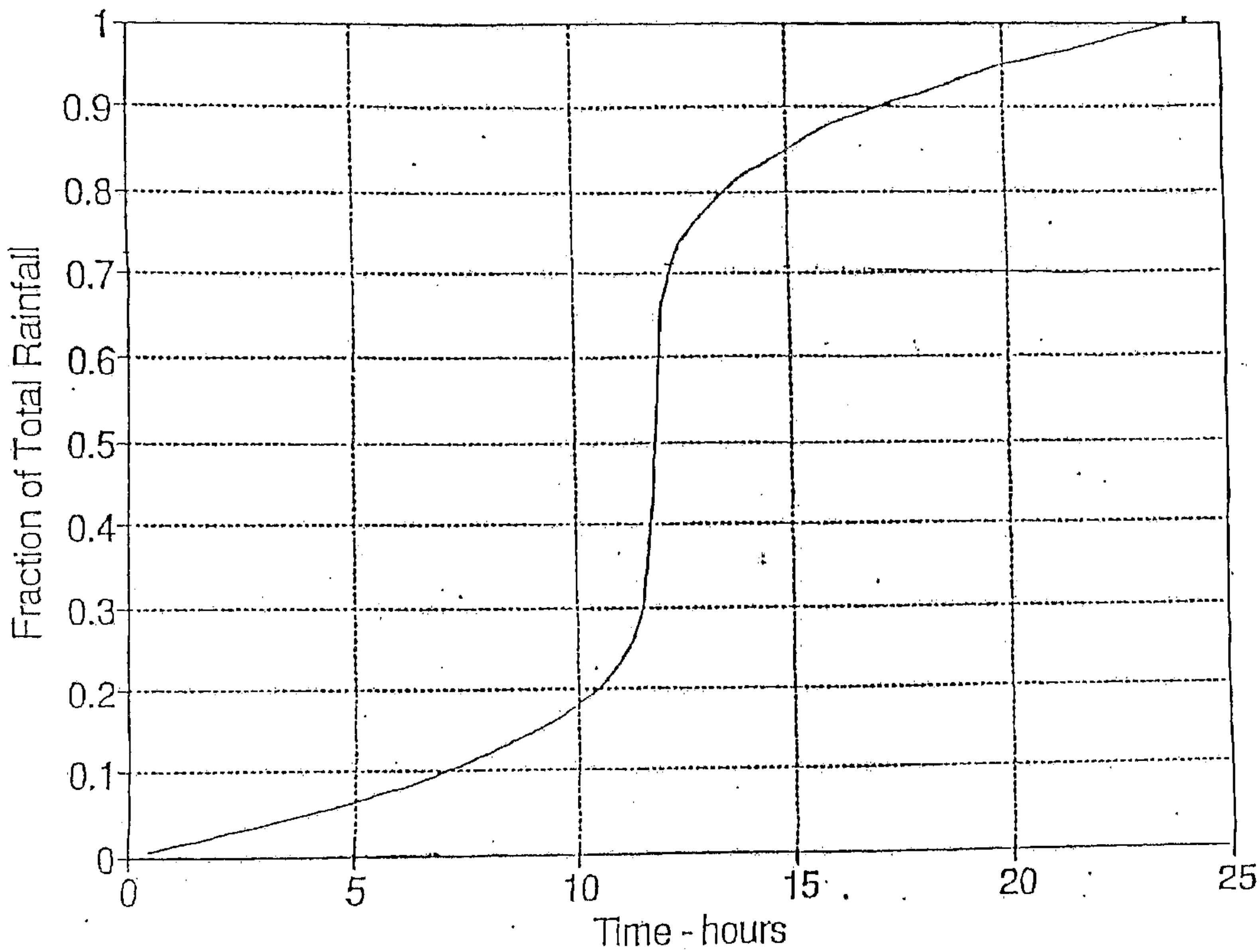

Figure 3. SCS Type II Storm Distribution

COMPUTATION SHEET
FOR 2-STAGE DETENTION BASIN OUTLET DESIGN

(to be used with TR 55 worksheet 6a or computer printout for storage routing)

Project Name: ____________________ Structure ID: ____________________ Date:______

Note: attach TR 55 worksheet 6a or computer printout with basin routing information

FIRST STAGE

Maximum stage for 2-year storm (E_{2-yr}) = ________ ft
First stage control elevation (E_1) = ________ ft
Head on first stage structure ($H_{2-yr} = E_{2-yr} - E_1$) ________ ft

Allowable discharge for 2-yr storm (q_{2-yr}) = ________ cfs

For rectangular weir outlet:

Required weir length $L_1 = q_{2-yr} / (3.2 * H_{2-yr}^{1.5})$
____ / (3.2 * ____$^{1.5}$) = ____________ ft

For orifice outlet:

Required orifice area $A_1 = q_{2-yr} / (4.98 * H_{2-yr}^{0.5})$
= ____ / (4.98 * ____$^{0.5}$) = ________ sq ft

SECOND STAGE

Maximum stage for 25-year storm (E_{25-yr}) = ________ ft
Second stage control elevation (E_2) = ________ ft
Head on second stage structure ($H_{25-yr} = E_{25-yr} - E_2$) ________ ft

Allowable discharge for 25-yr storm (q_{25-yr}) = ________ cfs

25-yr Storm Discharge through first stage:

Weir: $q' = 3.2 * L_1 * (E_{25-yr} - E_1)^{1.5}$ = 3.2*_______*(_______ - _______)$^{1.5}$
= ________ cfs

Orifice: $q' = 4.98 * A_1 * (E_{25-yr} - E_1)^{0.5}$ = 4.98*_______*(_______ - _______)$^{0.5}$
= _______ cfs

Allowable discharge through second stage ($q'' = q_{25-yr} - q'$) = ________ cfs

For rectangular weir outlet:

Required weir length $L_2 = q'' / (3.2 * H_{25-yr}^{1.5})$
= ______ / (3.2 * ______$^{1.5}$) = ____________ ft

For orifice outlet:

Required orifice area $A_2 = q'' / (4.98 * H_{25-yr}^{0.5})$
= ______ / (4.98 * ______$^{0.5}$) = ________ sq ft