TEXAS

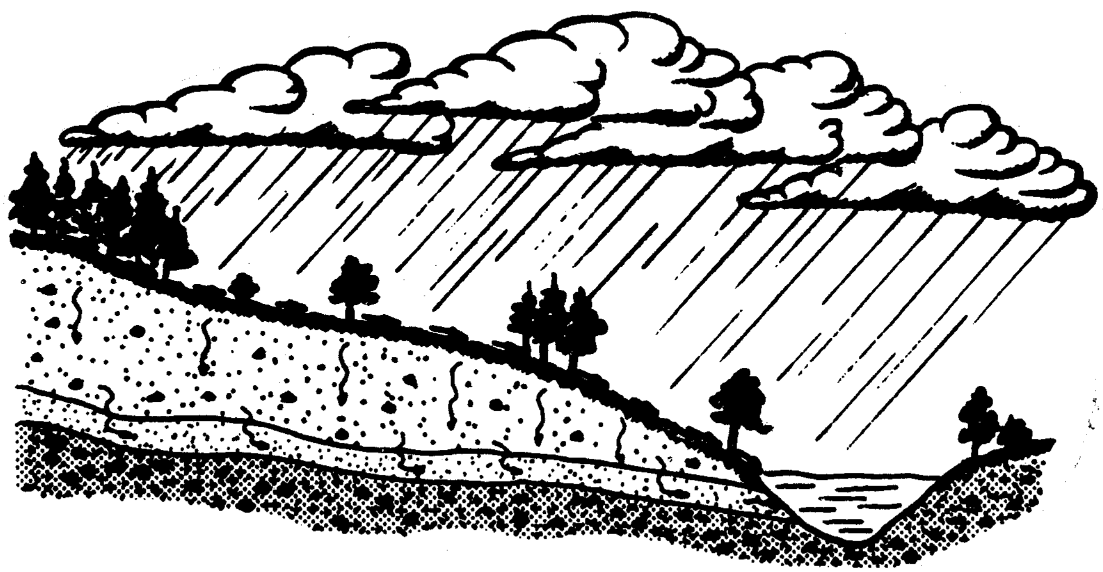
ENGINEERING TECHNICAL NOTE

Subject : HYDROLOGY

No. : 210-18-TX5

Reference : ESTIMATING RUNOFF FOR CONSERVATION PRACTICES

Date : OCTOBER 1990



SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE

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INTRODUCTION

This Technical Note is provided as a specific adaptation of the (National) Engineering Field Manual, Chapter 2 (EFM-2) for use in Texas. Provided herein are the necessary data for runoff curve number, runoff, and peak discharge computations. Data for the rest of the nation is eliminated. This effort significantly reduces the amount of material needed to make these computations.

This Technical Note presents procedures for estimating volume of runoff and peak discharge from small rural watersheds for use in designing soil and water conservation measures. These procedures for determining peak discharge are applicable to drainage areas in Texas that range in size from 1 to 2,000 acres. There is a MS-DOS microcomputer program, EFM2, that duplicates the manual computation procedures of EFM-2 and this technical note. The program will save time in applying the manual procedures by eliminating most table look-ups and plot or graph reading. It will also provide printout documentation to support conservation measure design. Computational errors are eliminated and data entry errors are reduced through some limited data checking.

Tables, figures, exhibits, and worksheets are included for a quick and reliable way to estimate peak discharge and runoff for a range of rainfall amounts, soil types, land use, and cover conditions. The data for the peak discharge exhibits were computed using procedures from the Soil Conservation Service (SCS) National Engineering Handbook Section 4 (NEH-4). NEH-4, or Technical Release 55 (TR-55), "Urban Hydrology for Small Watersheds," or Technical Release 20 (TR-20), "Project Formulation, Hydrology," should be used to estimate peak discharge for conditions beyond the limits of this Technical Note and for special situations and areas where procedures of this Technical Note may be considered too general to provide good estimates.

This Technical Note incorporates the two separate rainfall distributions for Texas, conservation tillage curve numbers, and hydrologic soil groupings. Computation of the watershed time of concentration (Tc) has been incorporated into the procedure so that peak flow can be estimated for any watershed slope and shape without using any correction factors.

FACTORS AFFECTING SURFACE RUNOFF

General

Rainfall is the primary source of water that runs off the surface of small rural watersheds. The main factors affecting the volume of rainfall that runs off are the kind of soil and the type of vegetation in the watershed. Factors that affect the rate at which water runs off are the watershed topography and shape along with conservation practices on a watershed.

Rainfall

The peak discharge from a small rural watershed is usually caused by intense rainfall. The intensity of rainfall affects the peak discharge more than it does the volume of runoff. Intense rainfall that produces high peak discharges in small watersheds usually does not extend over a large area. Therefore, the same intense rainfall that causes flooding in a small tributary is not likely to cause major flooding in a main stream that drains 10 to 20 square miles. This Technical Note considers only rainfall-generated runoff and not runoff generated from snowmelt.

However, to avoid the use of a different set of rainfall intensities for each drainage area, a set of synthetic rainfall distributions having "nested" rainfall intensities was developed. This set maximizes the rainfall intensities by including selected short-duration intensities with those needed for longer duration.

For the size of the watershed for which SCS typically provides assistance, a storm duration of 24 hours was chosen for the synthetic rainfall distribution. The 24-hour storm, while longer than that needed to determine peak discharges, is suitable for determining runoff volumes. Thus, a single storm duration and associated synthetic rainfall distribution can be used to estimate peak discharges for a wide range of watershed areas.

The intensity of rainfall varies considerably during the storm period. Storm distributions for a duration of 24 hours were developed by SCS from U.S. National Weather Service data as typical design storms. These distributions, Type II and Type III, are associated with the climatic regions of Texas.

Type III represents gulf of Mexico and Atlantic coastal areas where tropical storms bring large 24-hour rainfalls. The Type II storm distribution is typical of the more intense storms that occur over the remainder of the state. Type III intensities are less than Type II intensities. Figure 1 is a map showing the approximate geographic boundary for these two rainfall distributions. Figure 2 is a map showing approximate geographic boundary recommended for use on a county-wide basis.

Hydrologic Soil Groups

Soils have been classified into four hydrologic soil groups as shown in Table 1. The four groups are defined by SCS soil scientists as follows:

> Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of sands and gravels that are deep, well drained to excessively drained, and have a high rate of water transmission (greater than 0.30 in/hr).
>
> Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of soils that are moderately deep to deep, moderately well drained to well drained, and have moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15 to 0.30 in/hr).
>
> Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils having a layer that impedes downward movement of water and soils of moderately fine to fine texture. These soils have a slow rate of water transmission (0.05 to 0.15 in/hr).
>
> Group D soils have a high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0 to 0.05 in/hr).

Cover Type

Cover type affects runoff in several ways. The foliage and its litter maintain the soil's infiltration potential by preventing the impact of the raindrops from sealing the soil surface. Some of the raindrops are retained on the surface of the foliage, increasing their chance of being evaporated back into the atmosphere. Some of the intercepted moisture takes so long to drain from the plant down to the soil that it is withheld from the initial period of runoff. Ground cover also allows soil moisture from previous rains to transpire, leaving a greater void in the soil to be filled. Vegetation, including its ground litter, forms numerous barriers along the path of the water flowing over the surface of the land. This increased surface roughness causes water to flow more slowly, lengthening the time of concentration and reducing the peak discharge.

Treatment

Treatment or conservation practices reduce erosion and thereby maintain greater infiltration capabilities at the soil surface. This reduces the runoff, but the effect diminishes rapidly with increases in storm magnitude.

Contouring and terracing reduce erosion and decrease the amount of runoff by forming small reservoirs. Closed-end level terraces act as storage reservoirs without spillways. Land areas in which level terraces have been constructed may be excluded from the drainage area above downstream measures if the terrace system has enough capacity to store the depth of runoff commensurate with the frequency of the runoff event. Gradient terraces increase the distance water must travel and thereby increase the time of concentration.

Hydrologic Conditions

In most cases, the hydrologic condition of the site affects the volume of runoff more than any other single factor. The hydrologic condition considers the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant cover and residue on the ground surface. Good hydrologic condition indicates that the site usually has a lower runoff potential. Crop residue tilled into the soil and the residual root system from grasses that have been in crop rotations produce a good hydrologic condition.

A grassland cover is good if the vegetation covers 75 percent or more of the ground surface and is lightly grazed. A cover is poor if vegetation covers less than 50 percent of the ground surface or is heavily grazed. Grass cover is evaluated on the basal area of the plant, whereas trees and shrubs are evaluated on the basis of canopy cover.

Topography

The slopes in a watershed have a major effect on the peak discharge at downstream points. Slopes have little effect on how much of the rainfall will run off. As watershed slope increases, velocity increases, time of concentration decreases, and peak discharge increases. An average small watershed is fan shaped. As the watershed becomes elongated or more rectangular, the flow length increases and the peak discharge decreases.

Potholes may trap a small amount of rain, thus reducing the amount of expected runoff. Peak rate of runoff should be reduced to reflect this condition. In some cases where potholes and marshland areas do not intercept the drainage, these areas may be excluded from the drainage area for estimating peak, depending on site specific topographic conditions. Where pond and swamp areas occur, a considerable amount of surface runoff may be retained in temporary storage which reduces the peak rate of runoff. In lieu of preparing hydrographs and flood routings for this condition, the following tabulation adjustment factor (Fp) provides satisfactory approximation to peak discharge reduction from pond and swamp areas that are spread throughout the watershed.

Percentage of Pond and Swamp Areas	Fp
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

All areas greater than 5 percent would be limited to a Fp of 0.72. It should be emphasized that sound judgment must be exercised in applying this procedure. The procedure cannot be used blindly for the purpose of obtaining smaller design peak discharge values. If potholes constitute more than one-third of the total drainage or if they intercept the drainage, the procedures in NEH-4 should be used to estimate the peak discharge.

Runoff Curve Numbers

The SCS runoff equation is:

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

Where: Q = runoff in inches,
P = rainfall in inches,
Ia = initial abstraction in inches, and
S = potential maximum retention after runoff begins in inches.

Initial abstraction (Ia) includes all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, and water lost to evaporation and infiltration. Ia is highly variable but is generally correlated with soil and cover parameters (see Table 4). Through studies of many small agricultural watersheds, Ia was found to be approximated by:

$$Ia = 0.2S \qquad \text{(Eq. 2)}$$

Removing Ia as an independent parameter allows use of a combination of S and P to produce unique runoff volumes. Substituting Equation 2 into Equation 1 gives:

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

The potential maximum retention can range from zero on a smooth, impervious surface to infinity in deep gravel. For greater convenience the "S-values" were converted to runoff curve numbers (CN's) by the following transformation:

$$CN = \frac{1000}{10 + S} \qquad \text{(Eq. 4)}$$

According to Equation 4, the CN is 100 when S is zero and approaches zero as S approaches infinity. Runoff curve numbers can be any value from zero to 100, but for practical applications are limited to a range of 40 to 98.

Rearranging and substituting Equation 4 into Equation 3 results in an equation that can be used to compute runoff in terms of P and CN.

$$Q = \frac{[P - (200/CN) + 2]^2}{P + (800/CN) - 8} \qquad \text{(Eq. 5)}$$

The runoff curve numbers in Table 2 were developed by examining rainfall runoff data from small agricultural watersheds. The runoff curve number for a given soil-cover type is not a constant but varies from storm to storm. The index of runoff potential for a given storm is the antecedent runoff condition (ARC) referenced as antecedent moisture condition (AMC) in Chapter 4, NEH-4. ARC is an attempt to account for the variation in CN at a site from storm to storm.

NEH-4 gives three levels of AMC; AMC I is the lowest runoff potential; AMC II is the average condition, and AMC III is the highest runoff potential. The runoff curve numbers in Table 2 are for an average ARC (condition II). Table 3 has the runoff curve numbers for the three condition levels.

Various studies of hydrologic basic data indicate that ARC II is not the average throughout the state of Texas. Based on considerable investigations, it appears that the average condition ranges from ARC I in West Texas to between ARC II and ARC III in East Texas.

From Figure 5 the average condition runoff curve number can be computed by applying the adjustment shown for any location in Texas. Using the CN associated with ARC II (Table 2), the CN's for ARC I or III needed to complete the adjustment can be found in Table 3. When the adjustment results in an average runoff condition curve number less than 60, the CN of 60 will be selected as the minimally applicable number. If the unadjusted CN is less than 60, that number will be used without adjustment by Figure 5. This procedure would not be applicable on irrigated land or other conditions that would cause an ARC greater than predicted by Figure 5.

Although ARC II may not be the average throughout the state, historically the design of conservation practices using CN's associated with ARC II has proven to be very successful. Therefore, prudent judgment should be exercised in using the adjusted average condition runoff curve number procedure. Experience has indicated that use of this procedure is more appropriate to the dry subhumid and semiarid regions of the state.

A representative curve number for a watershed can be estimated by area weighting using TX-ENG-66 (Rev.) as shown in Example Problem 1.

Rainfall

The 24-hour rainfall depths for a desired county and frequency can be obtained from Figure 6. The rainfall maps were reproduced from the U.S. National Weather Service, Technical Paper 40.

Estimating Runoff

The runoff from a watershed may be expressed as the average depth of water that would cover the entire watershed. The depth is usually expressed in inches. The volume of runoff is computed by converting depth over the drainage area to volume and is usually expressed in acre-feet. When CN and rainfall (P) have been determined for the watershed, determine runoff (Q) by using Figure 3 or Equation 5.

General

Time of concentration (Tc) is the time it takes for runoff to travel from the hydraulically most distant point of the watershed to the outlet. Tc influences the peak discharge. For the same size watershed, the shorter the Tc, the larger the peak discharge. This means that peak discharge has an inverse relationship with Tc.

Estimating Time of Concentration

Tc can be estimated for small rural watersheds using the following empirical relationship:

$$Tc = \frac{(L)^{0.8}[(1000/CN) - 9]^{0.7}}{1140\ Y^{0.5}} \qquad \text{(Eq. 6)}$$

Where: Tc = time of concentration in hours,
L = flow length in feet,
CN = runoff curve number, and
Y = average watershed slope in percent.

Figure 4 is a nomograph for solving Equation 6. Tc is determined using watershed parameters L, CN, and Y. TX-ENG-66 (Rev.) can be used to document Tc computation. Example Problem 2 demonstrates this procedure. For watersheds where hydraulic conditions are such that velocities of water flow need to be estimated (urban areas, etc.), then Tc should be estimated using TR-55 methods. NEH-4 describes the upland method (limited to 2000 acres) which can also be used in rural watersheds to obtain estimated velocity based on condition and slope of longest flow path.

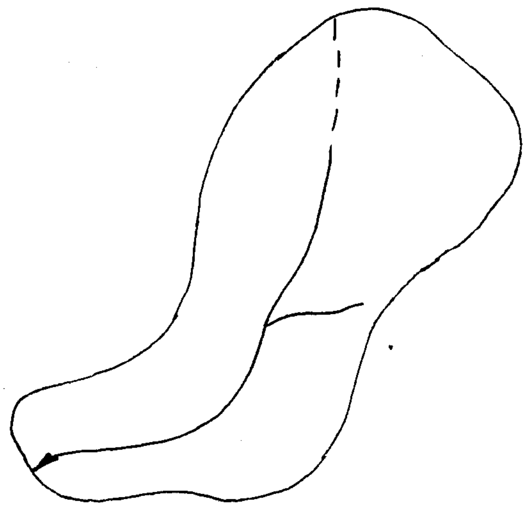
Average Watershed Slope

The average watershed slope (Y) is the slope of the land and not the watercourse. It can be determined from soil survey data or topographic maps. Hillside slopes can be measured with a hand level, Locke level, or clinometer in the direction of overland flow. Average watershed slope is an average of individual land slope measurements. For watersheds with land slopes that are not uniform, the average watershed slope can be estimated by area weighting as shown in Example Problem 1 using TX-ENG-66 (Rev.). Average watershed slope (Y) is expressed in percent. The procedure to determine average watershed slope discussed in EFM-2 may also be used.

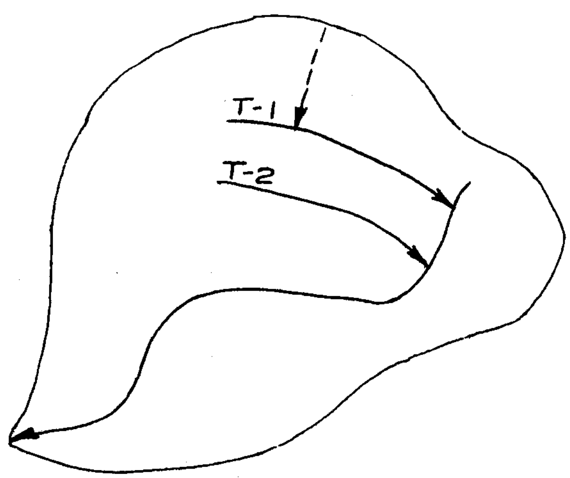
Flow Length

Flow length (L) is the longest flow path in the watershed from the watershed divide to the outlet. It is the total path water travels overland and in small channels on the way to the outlet. The flow length can be determined using a map wheel or it can be marked along the edge of a paper and converted to feet. Some typical examples of determining the flow length are shown below.

Natural watershed: In this case, water flows from the watershed divide to a small channel, down the small channel to the main stream, and from there to the watershed outlet.



Watershed with Terraces: In this case, water flows from the divide to the terrace, along the terrace to the outlet or main stream, and then along the main stream to the outlet.



PEAK DISCHARGE

General

Using Ia/P, time of concentration, and rainfall distribution, the unit peak discharge can be estimated from Exhibit 1 or 2. The peak discharge is computed from the unit peak discharge, runoff volume, and drainage area.

Ia/P Ratio

The watershed CN is used to determine the initial abstraction (Ia) from Table 4. Ia/P ratio is a parameter that indicates how much of the total rainfall is needed to satisfy the initial abstraction. The larger the Ia/P ratio, the lower the unit peak discharge (q_u) for a given Tc. This indicates that when initial abstraction is a high portion of rainfall, the peak discharge will be lower. Thus, the Ia/P ratio is greater for smaller storms.

If the computed Ia/P ratio is outside the range shown (0.1 to 0.50) in Exhibit 1 or 2, then the limiting values should be used; i.e., use 0.1 if less than 0.1 and use 0.5 if greater than 0.5. If the ratio falls between the limiting values, use linear interpolation.

Estimating Peak Discharge

The unit peak discharge (q_u) is obtained from Exhibit 1 or 2 (Type II or Type III), depending on the rainfall type. Figures 1 and 2 show the boundary for the two types of rainfall distributions in Texas. Tc and Ia/P values are needed to obtain a value for (q_u) from Exhibit 1 or 2. The peak discharge (q_p) is computed as the product of the unit peak discharge (q_u), the drainage area (A) in acres, and the runoff (Q) in inches.

$$q_p = q_u \times A \times Q \qquad \text{(Eq. 7)}$$

If a pond and swamp adjustment is made, then multiply q_p by the adjustment factor (Fp) to compute estimated peak discharge.

LIMITATIONS

The watershed drainage area must be greater than 1.0 acre and less than 2,000 acres. If the drainage area is outside these limits, another procedure such as TR-55 or TR-20, should be used to estimate peak discharge.

- The watershed should have only one main stream. If more than one exists, the branches must have nearly equal Tc's.
- The watershed must be hydrologically similar; i.e., able to be represented by a weighted CN. Land use, soils, and cover are distributed uniformly throughout the watershed. The land use must be primarily rural. If urban conditions are present and not uniformly distributed throughout the watershed, or if they represent more than 10 percent of the watershed, TR-55 or other procedures must be used.
- If the computed Tc is less than 0.1 hr, use 0.1 hr. If the computed Tc is greater than 10 hours, peak discharge should be estimated by using NEH-4 procedures, which are automated in the TR-20 computer program.
- When the flow length is less than 200 feet or greater than 26,000 feet, use another procedure to estimate Tc. TR-55 provides an alternative procedure for estimating Tc and peak discharge.
- When the average watershed slope is greater than 64 percent or less than 0.5 percent, use another procedure to estimate Tc. An alternative procedure is shown in TR-55 for estimating Tc and peak discharge.
- When the average watershed slope is less than 0.5 percent, use the Delmarva (DMV) unit hydrograph with Tc computed by applicable method or use TR-55 with DMV unit hydrograph or TR-20 with 256 peak factor unit hydrograph or use ENG Tech. Note 210-18-TX8 "Guide to Determine Instantaneous Peak Flow for Flatland Areas." See TX8 for limitations on the use of that procedure.
- When weighted CN is less than 40 or more than 98, use another procedure to estimate peak discharge.
- If potholes constitute more than one-third of the total drainage area, or if they intercept the drainage the procedures in NEH-4 should be used.
- Runoff and peak discharge from snowmelt or rain on frozen ground cannot be estimated using these procedures. NEH-4 provides a procedure for estimating peak discharge in these situations.

Accuracy of peak discharge estimated by this method will be reduced if Ia/P ratio used is outside the range given in Exhibit 1 or 2. The limiting Ia/P ratios are to be used; i.e., if Ia/P in Exhibit 1 or 2 is less than 0.1, use 0.1; and if Ia/P is greater than 0.5, use 0.5.

EXAMPLES

Example Problem 1

Mr. Hector Gomez needs a waterway in a cropland field. The 83-acre watershed is located in Bell County, Texas. Type II storm distribution is applicable. The watershed consists of 32 acres of pasture in good condition on Austin Soil (2 percent slope), 38 acres of small grain on Branyon Soil (1 percent slope), and 13 acres of small grain on Wilson Soil (1 percent slope) farmed with good crop residue.

Determine weighted curve number and average watershed slope for the watershed. The solution is displayed on the following TX-ENG-66 (Rev.) form.

Example Problem 2

Determine the time of concentration and peak discharge for Mr. Gomez's waterway. The watershed flow length is 4000 feet. See TX-ENG-66 (Back side) for the solution of this example problem.

U.S. Department of Agriculture
Soil Conservation Service

TX-ENG-66
Rev. 10/90
(Front Side)

(Example Problem No. 1)

WATERSHED RUNOFF COMPUTATION

SWCD Central Texas FIELD OFFICE Temple

COOPERATOR Hector Gomez TYPE OF PRACTICE Waterway

STRUCTURE NO. WW#1 PROGRAM (ACP,GPCP,OTHER) ACP

COMPUTATIONS BY JLH DATE 5/9/90 CHECKED BY LAG DATE 5/9/90

Determination of Runoff Curve Number (Table 2, pg.37-40)*

Land Use or Cover	Cover Condition	Soil Name	Soil Group	Land Slope	Area Acres	Curve No.	Acres X Curve No.	Acres X Slope
Pasture	Good	Austin	C	2	32	74	2368	64
Small Grain	Straight & CR Good	Branyon	D	1	38	84	3192	38
Small Grain	Straight & CR Good	Wilson	D	1	13	84	1092	13
				TOTAL =	83		6652	115

Weighted Curve No. = $\frac{\text{(Acres x Curve No.)}}{\text{Total No. Acres}} = \frac{6652}{83} = 80.1$: Use 80

Average Watershed Slope = $\frac{\text{(Acres x Slope)}}{\text{Total No. Acres}} = \frac{115}{83} = 1.39$: Use 1.4

*Reference - Engineering Technical Note 210-18-TX5 or Engineering Field Manual for Conservation Practices (EFM), Chapter 2

Remarks: No adjustment was made for average condition runoff curve number.

U.S. Department of Agriculture
Soil Conservation Service

TX-ENG-66
Rev. 10/90
(Back Side)

(Problem 2)

Estimating time of concentration

1. Data:
   Rainfall distribution type (II or III), pg. 19 or 20.............. = II
   Drainage area.. A = 83 ac
   Runoff curve number...CN = 80
   Average Watershed slope... Y = 1.4 %
   Flow length.. L = 4000 ft
2. T_c using L, Y, CN and Figure 4, pg. 22............................ = 1.4 hrs

   or using equation

$$T_c = \frac{(L)^{0.8}\left[\left(\frac{1000}{CN}\right) - 9\right]^{0.7}}{1140\ Y^{0.5}} = \frac{(\ 4000\ )^{0.8}(\ 3.50\ )^{0.7}}{1140(\ 1.4\ )^{0.5}} \ldots\ldots\ldots\ldots = 1.36 \text{ hrs}$$

Use 1.4 hrs

Estimating peak discharge*

		Storm #1	Storm #2	Storm #3
1.	Frequency (refer to NHCP).............................. yr	10		
2.	Rainfall, P (24-hour) Figure 6, pg. 24-29............ in.	6.7		
3.	Initial abstraction, I_a (Table 4), pg. 42.............. in.	0.5		
4.	Compute I_a/P ratios**	0.07		
5.	Unit peak discharge, q_u (Exhibit 1 or 2)........ cfs/ac/in. pg. 17 or 18	.455		
6.	Runoff, Q (Figure 3), pg. 21.......................... in.	4.4		
7.	Peak discharge, q_p ($q_p = q_uAQ$) .... cfs	166		
8.	Correction for Pond or Swampy Area, F_p, pg. 5.........	N/A		
9.	Corrected Peak Discharge ($q_p x F_p$) .... cfs	166		

* Reference - ENG Tech. Note 210-18-TX5
** Use 0.10 for all I_a/P values less than 0.10.

Remarks:

Exhibit 1 —Unit peak discharge (q_u) for SCS Type II rainfall distribution

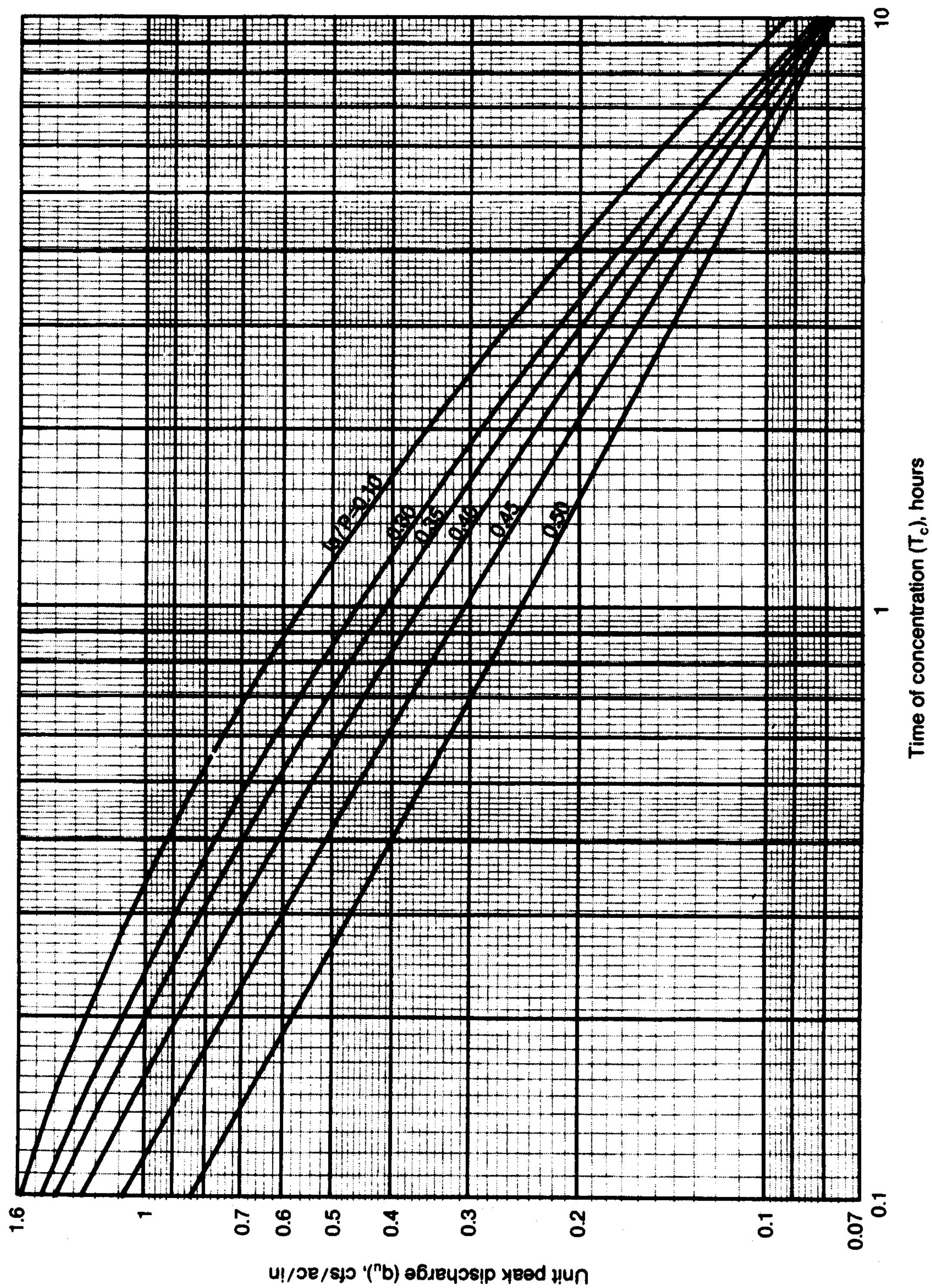


Exhibit 2 —Unit peak discharge (q_u) for SCS Type III rainfall distribution

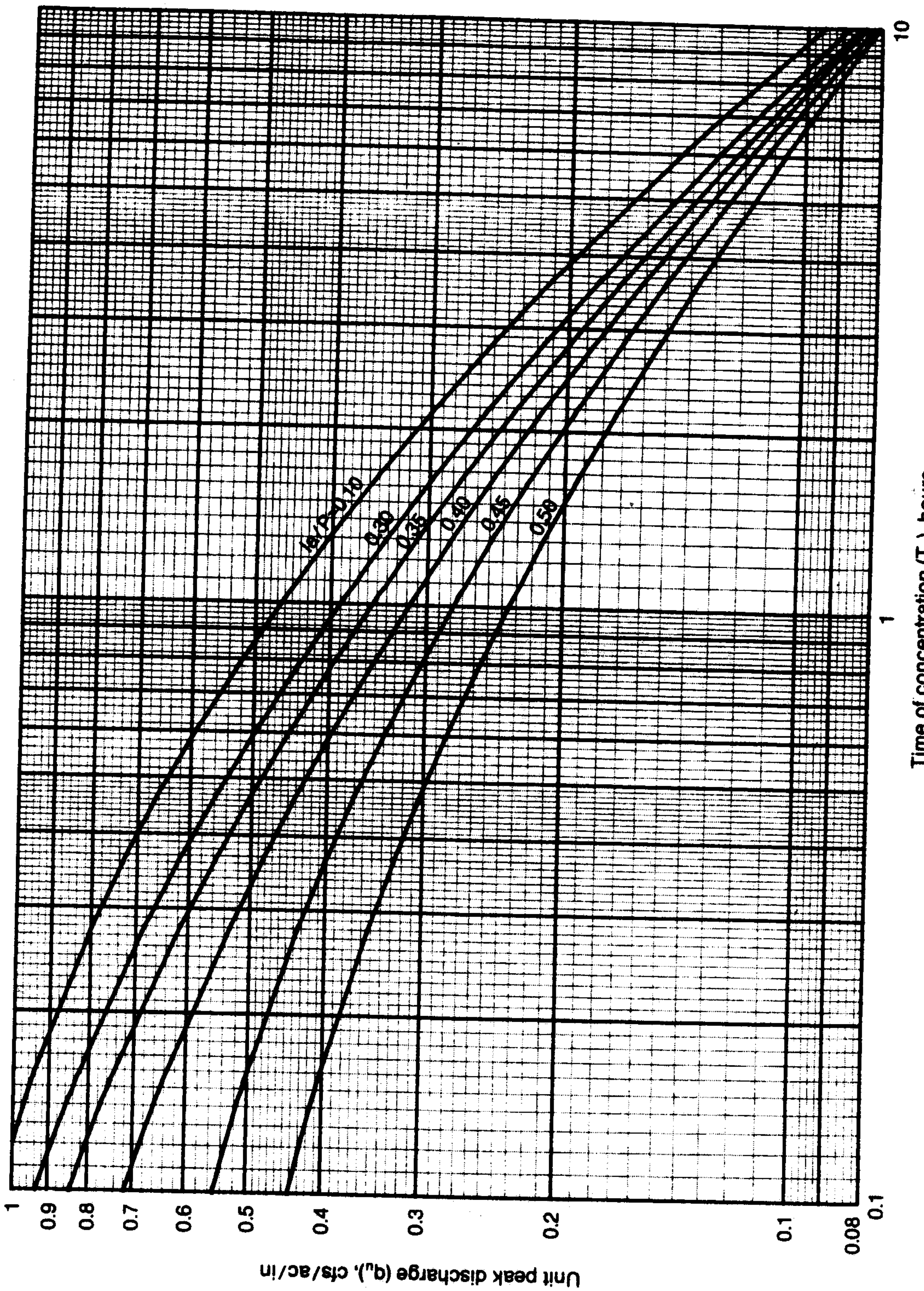
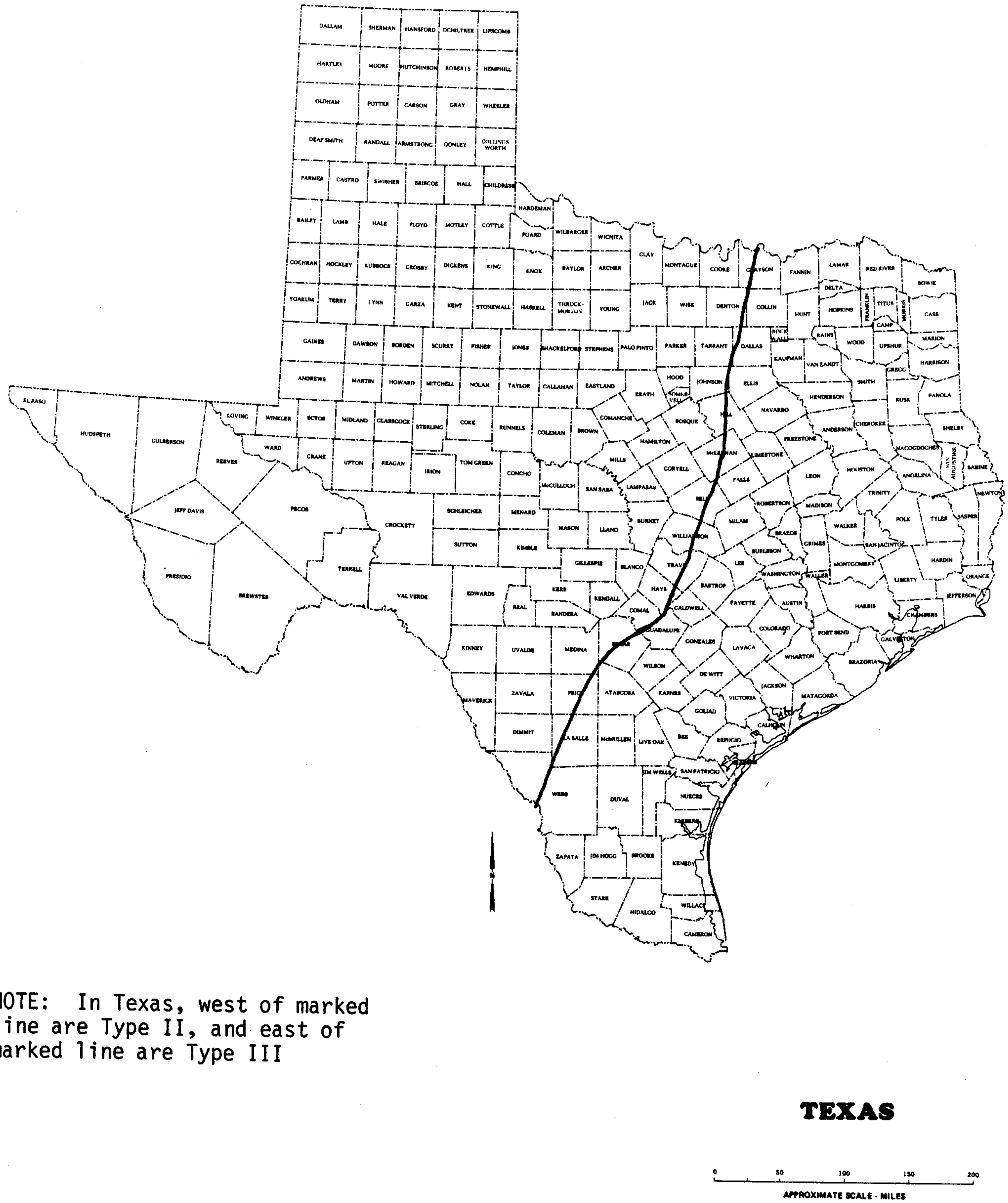


Figure 1

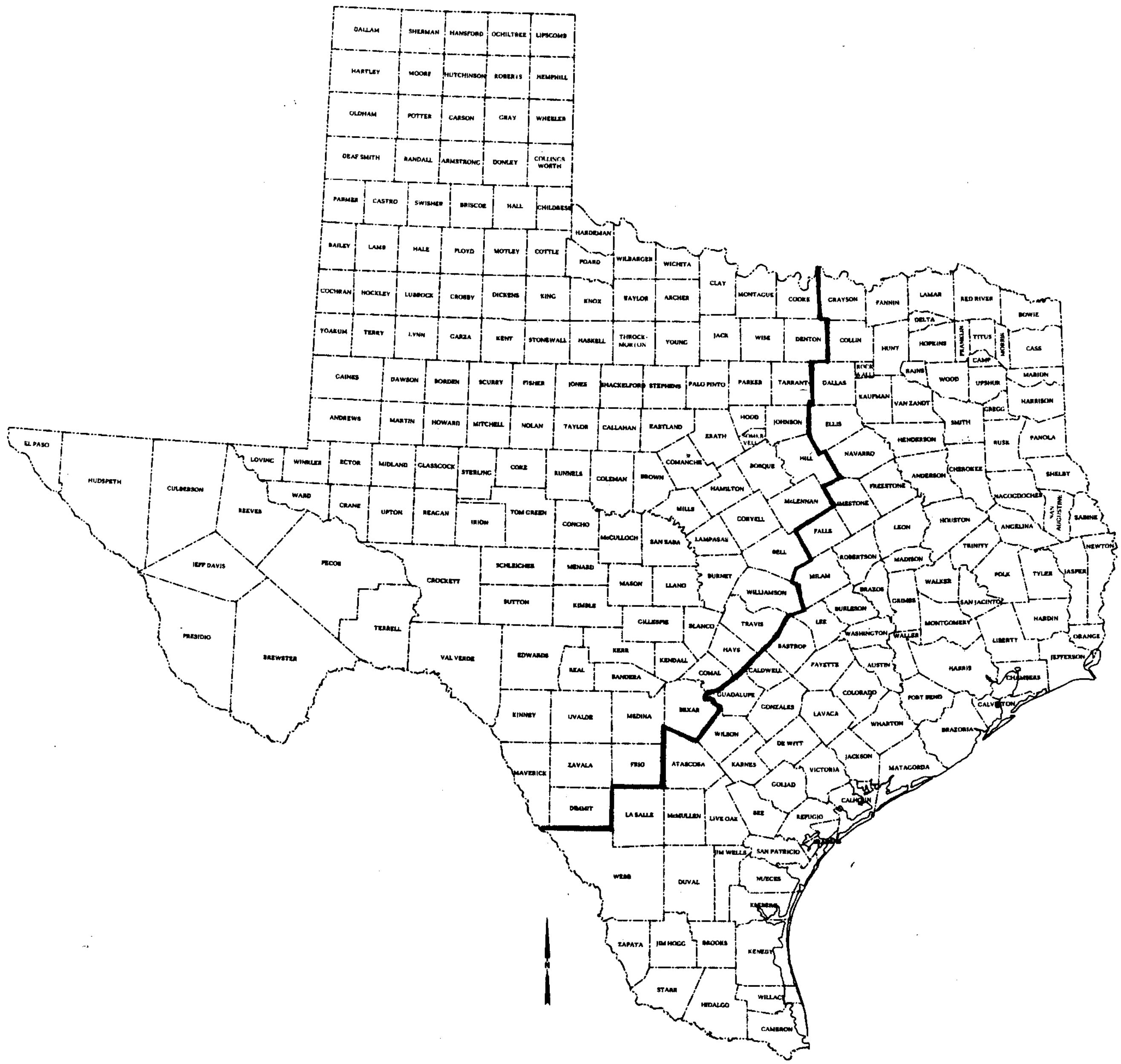
Boundary for SCS Rainfall Distribution Types



NOTE: In Texas, west of marked line are Type II, and east of marked line are Type III

Figure 2

Boundary for SCS
Rainfall Distribution Types
Based on County Lines



NOTE: All counties west of marked line are Type II, and all counties east of marked line are Type III

TEXAS

0 50 100 150 200

APPROXIMATE SCALE - MILES

BASE COMPILED FROM USGS NATIONAL ATLAS, 1970 EDITION

REVISED OCTOBER 1976. BASE 4-R-33677

Figure 3 —**Solution for runoff equation**

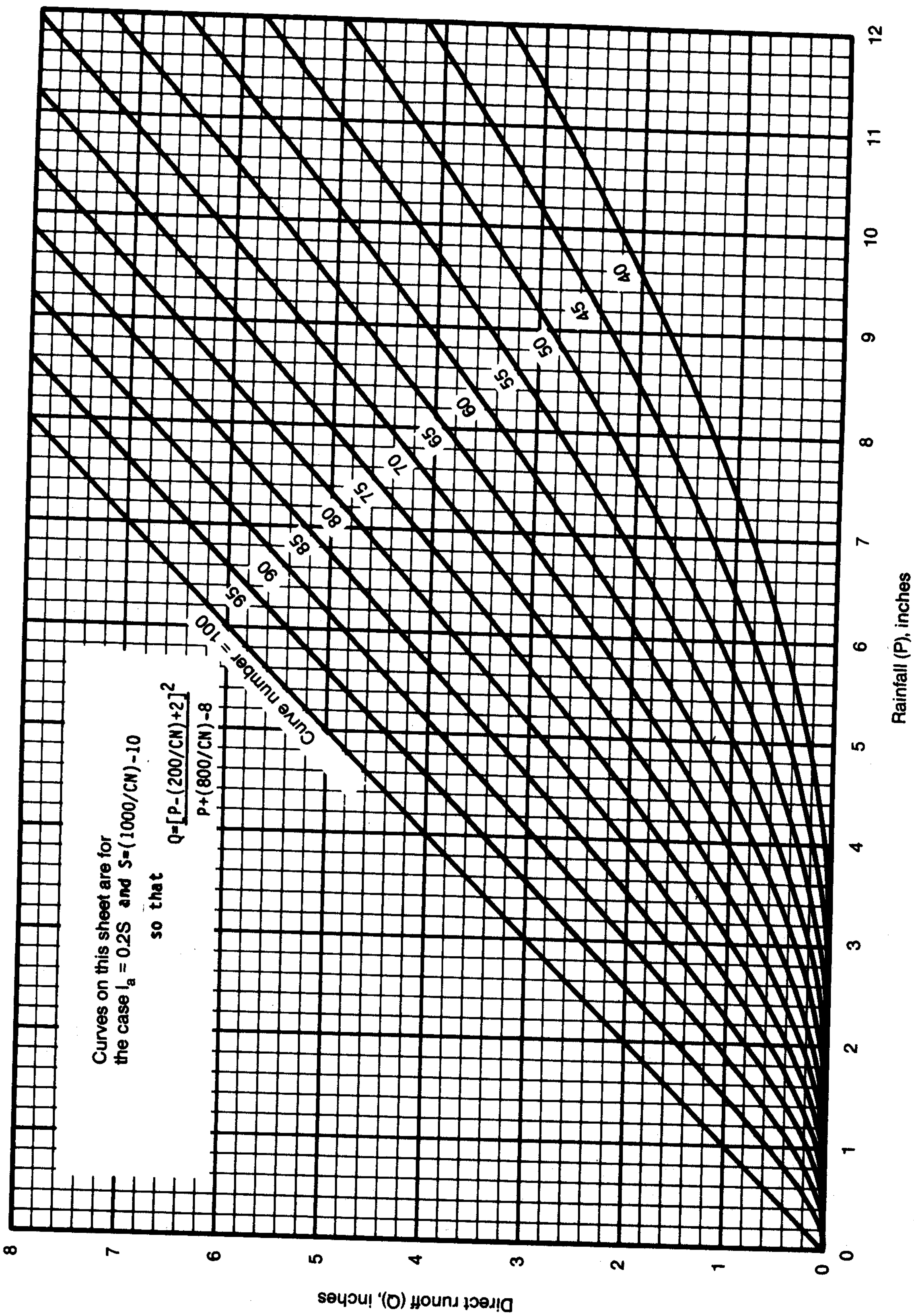
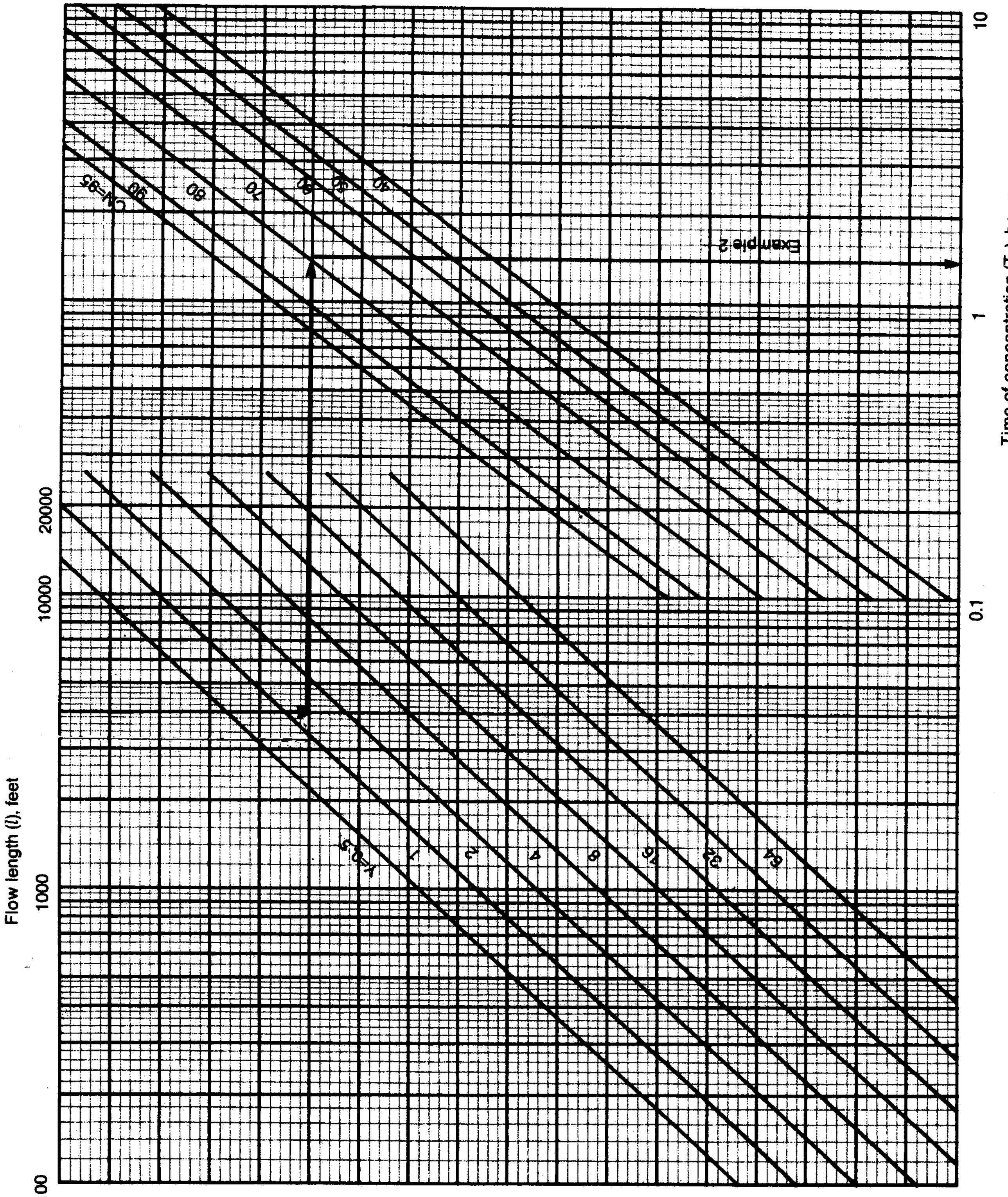


Figure 4 —Time of concentration (T_c) nomograph



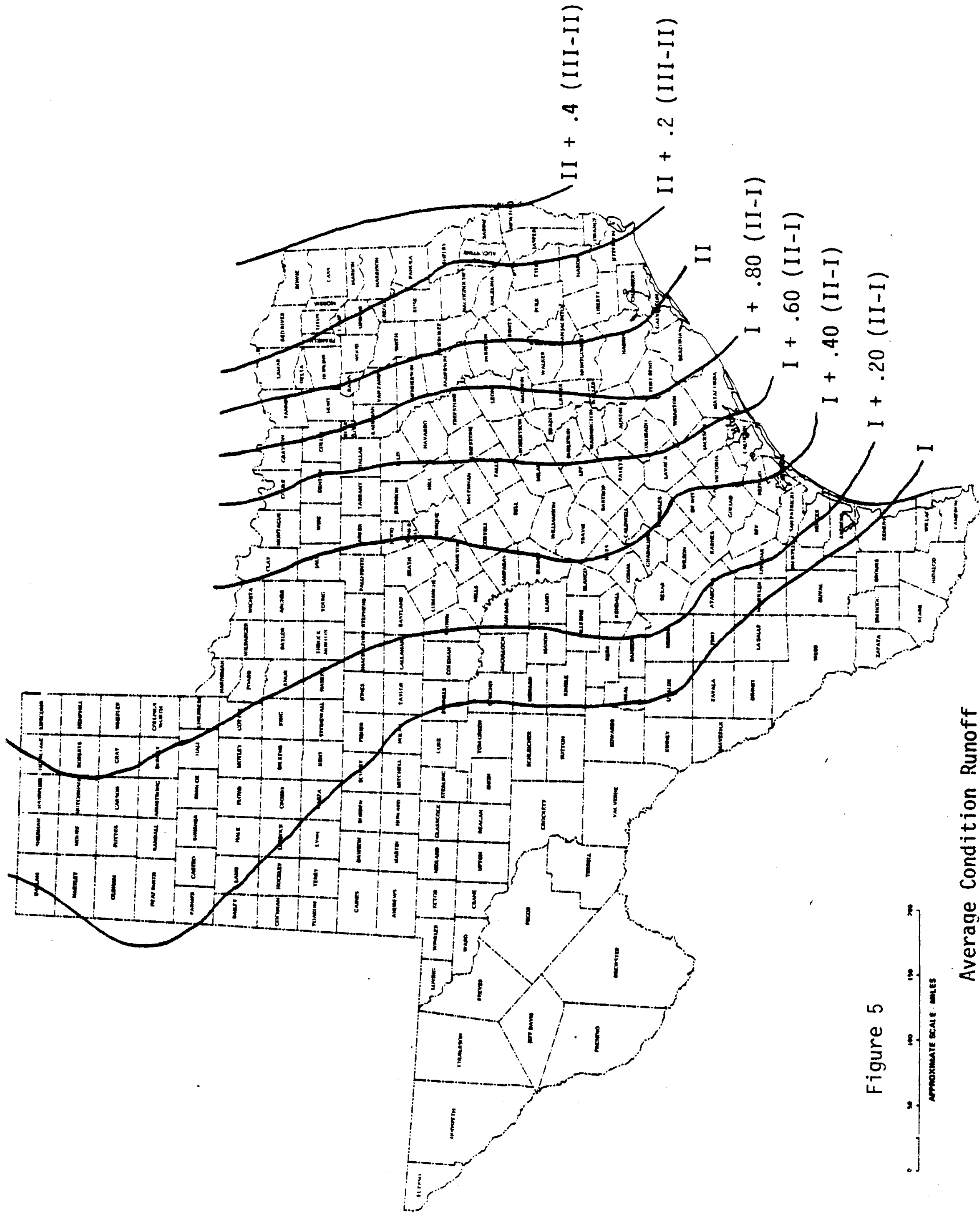


Figure 5

Average Condition Runoff
Curve Numbers

2-YEAR 24-HOUR RAINFALL (INCHES)

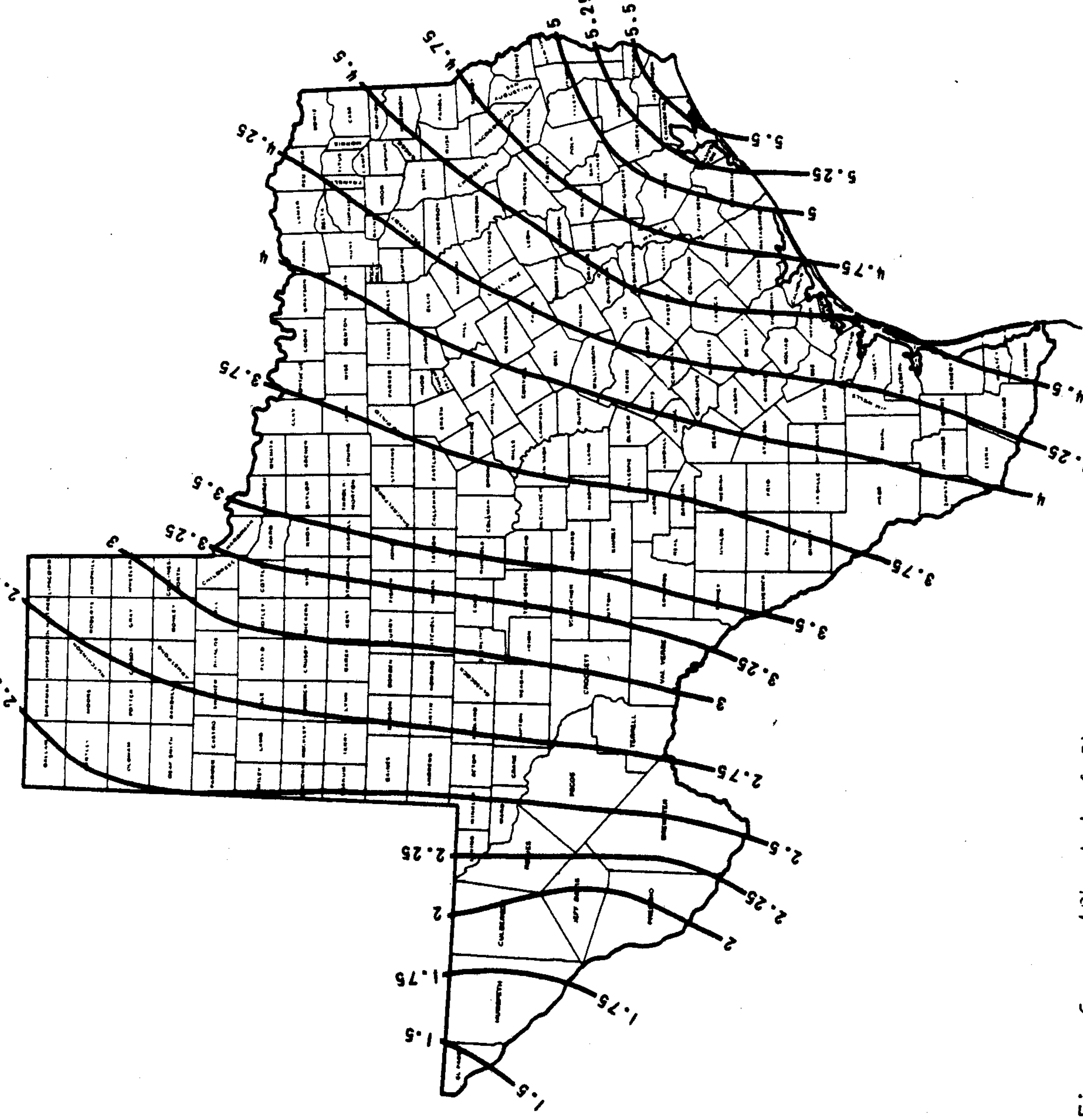
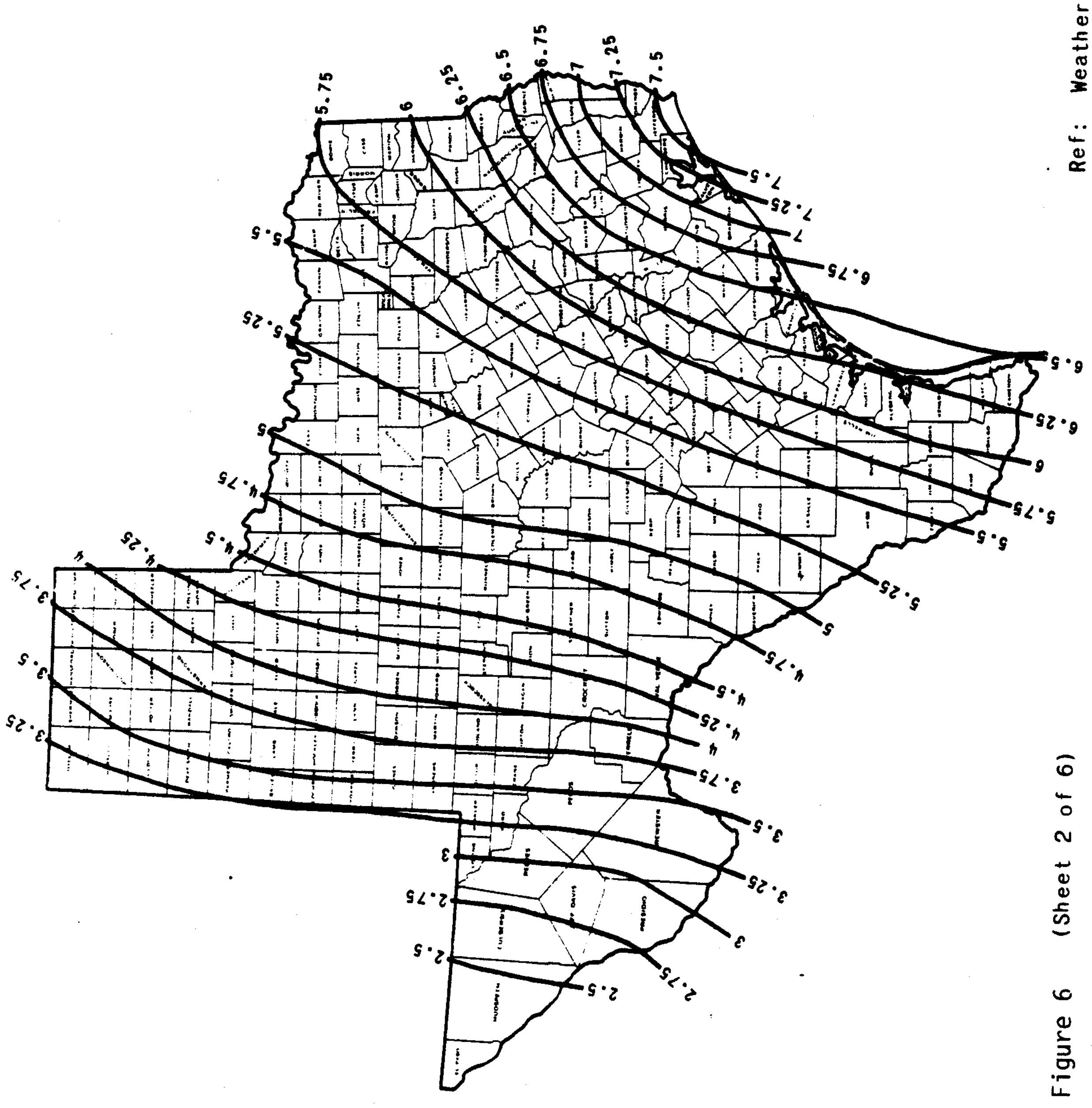


Figure 6 (Sheet 1 of 6)

Ref: Weather Bureau TP No. 40

5-YEAR 24-HOUR RAINFALL (INCHES)



Ref: Weather Bureau TP No. 40

Figure 6 (Sheet 2 of 6)

10-YEAR 24-HOUR RAINFALL (INCHES)

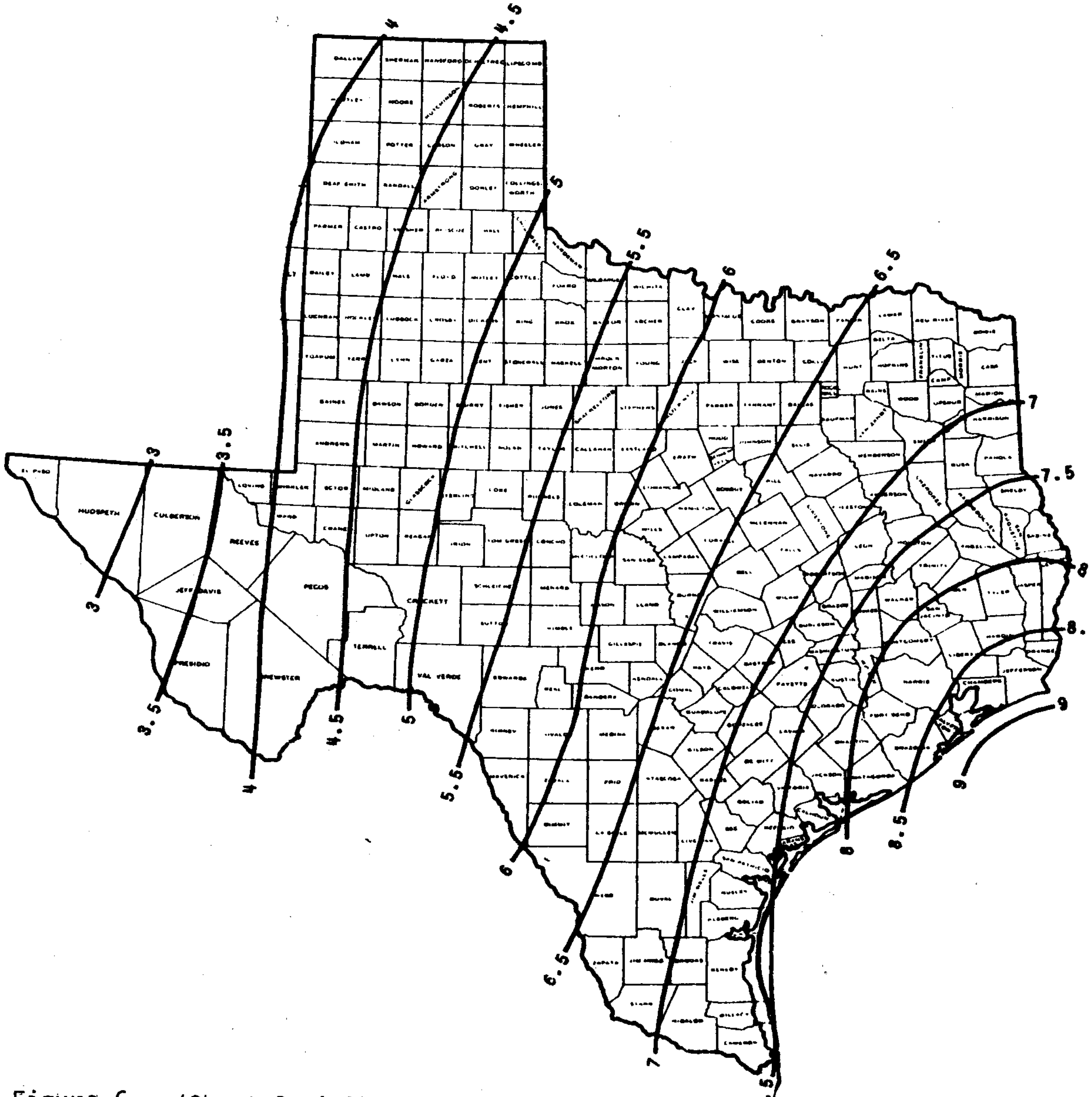


Figure 6 (Sheet 3 of 6)

Ref: Weather Bureau TP No. 40

25-YEAR 24-HOUR RAINFALL (INCHES)

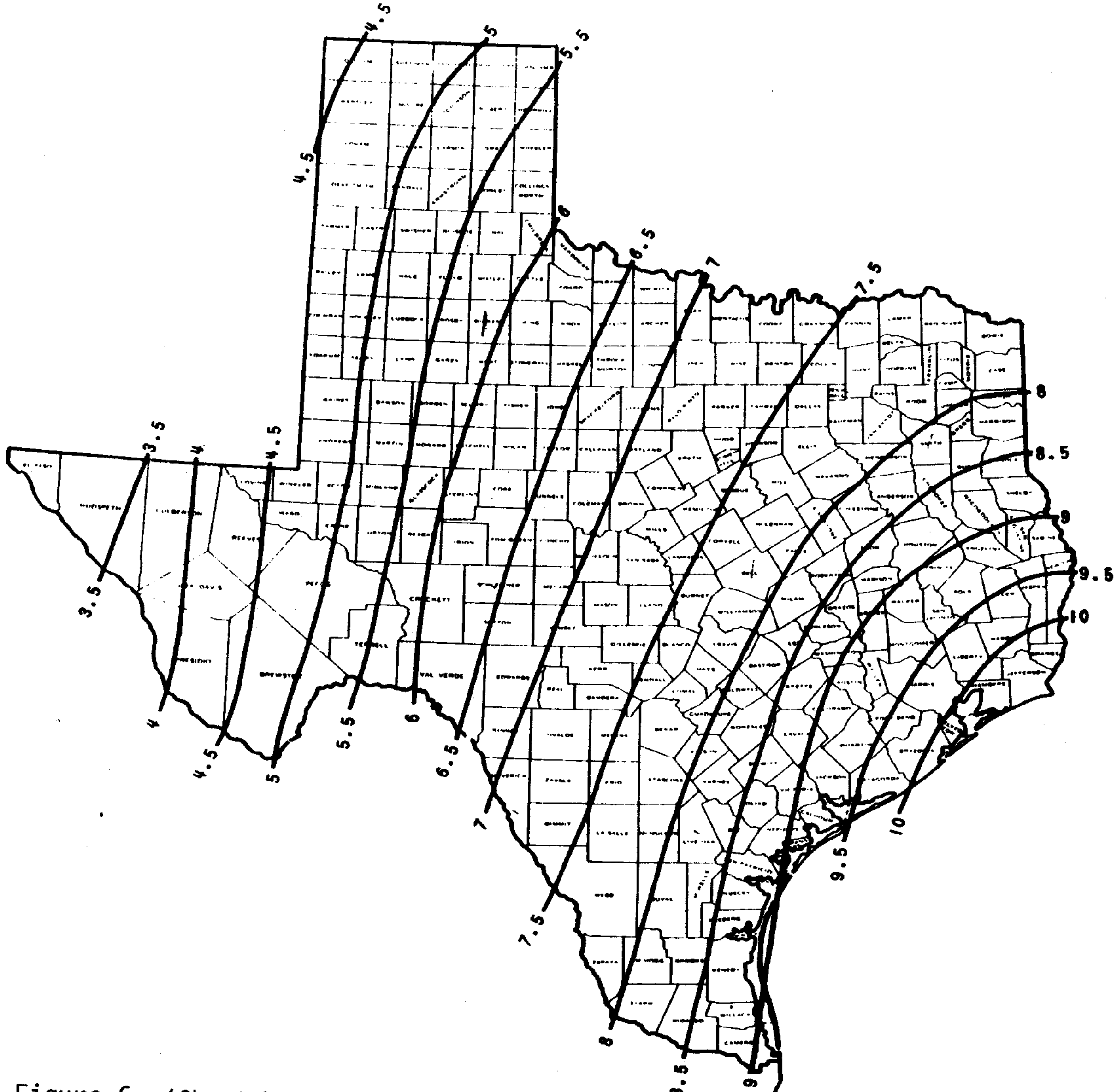
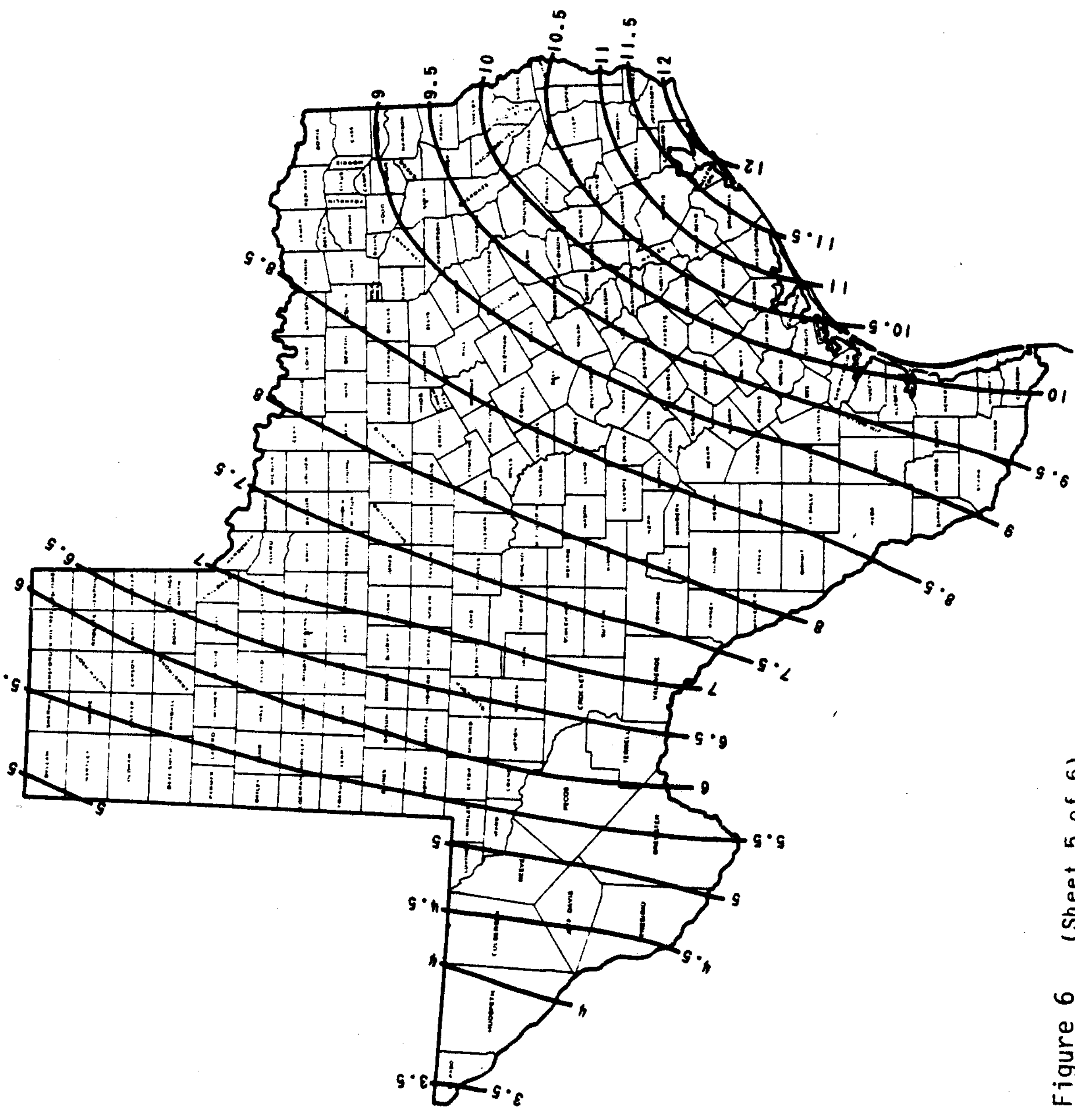


Figure 6 (Sheet 4 of 6)

Ref: Weather Bureau TP No. 40

50-YEAR 24-HOUR RAINFALL (INCHES)



Ref: Weather Bureau TP No. 40

Figure 6 (Sheet 5 of 6)

100-YEAR 24-HOUR RAINFALL (INCHES)

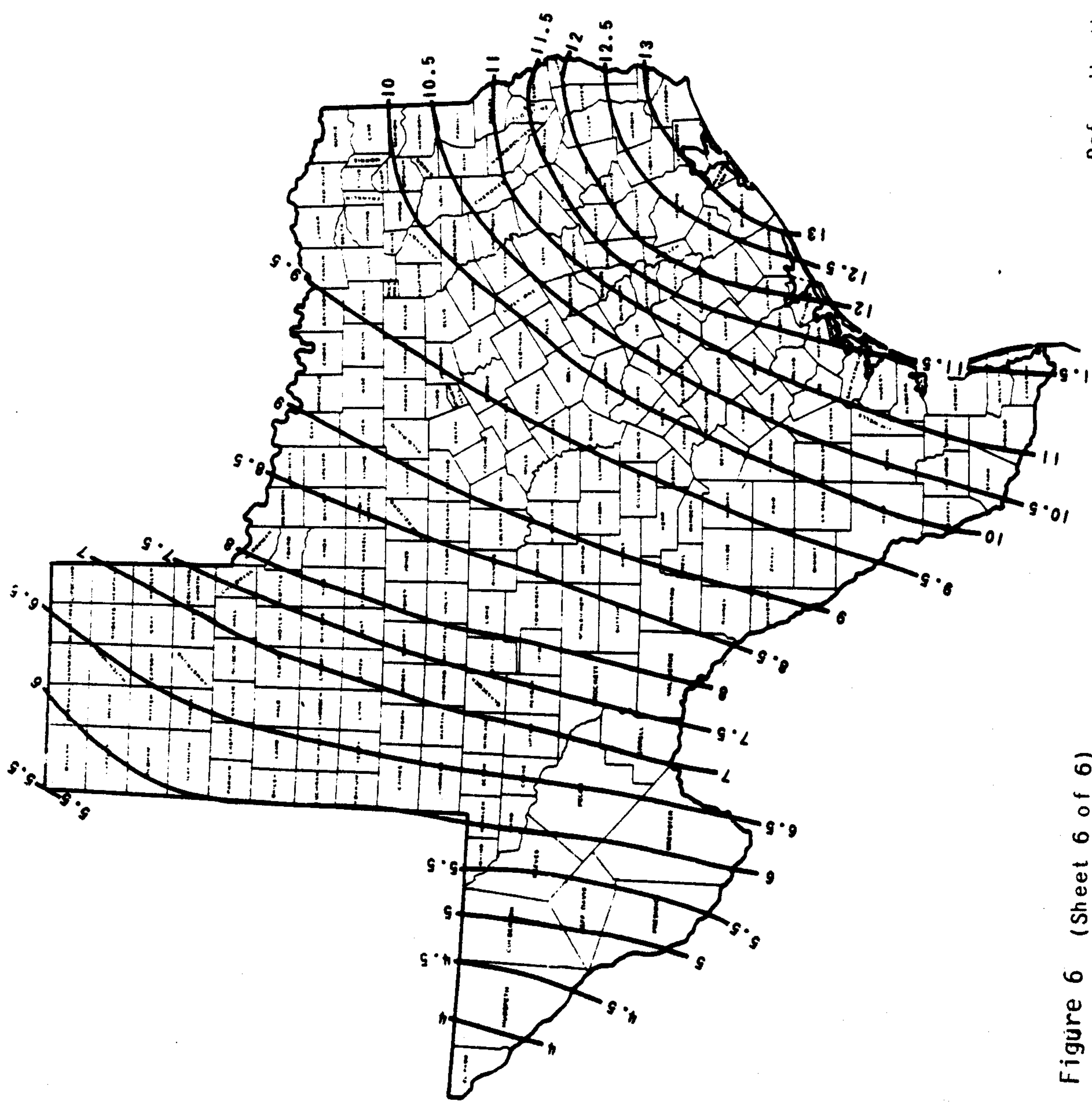


Figure 6 (Sheet 6 of 6)

Ref: Weather Bureau TP No. 40

Table 1
Hydrologic Groups of the Soils of Texas

ABILENE	C	ARVANA	C	BLANKET	C	CALLISBURG	C
ACADIA	D	ASA	B	BLEAKWOOD	C	CAMARGO	B
ACME	C	ASHFORD	D	BLEIBLERVILLE	D	CAMERON	D
ACOVE	C	ASPERMONT	B	BLEVINS	B	CAMPBELLTON	C
ACUFF	B	ATASCO	C	BLUEGROVE	C	CANUTIO	B
ACUNA	C	ATCO	B	BLUEPOINT	A	CAPLEN	D
ADATON	D	ATTOYAC	B	BLUM	C	CAPPS	B
ADDICKS	D	AUBREY	C	BOBILLO	B	CARADAN	D
ADDIELOU	B	AUBREY	C	BOERNE	B	CARBENGLE	B
AGUILARES	B	AUFCO	D	BOLAR	C	CAREY	B
AGUSTIN	B	AUSTIN	C	BONHAM	C	CART	B
ALAGA	A	AUSTWELL	D	BONN	D	CASPIANA	B
ALAZAN	B	AXTELL	D	BONTI	C	CASS	B
ALDINE	D	BACLIFF	D	BONWIER	C	CASTELL	C
ALEDO	C	BADLAND	D	BONWIER GRADED	D	CASTEPHEN	C
ALGOA	C	BALMORHEA	C	BOOKOUT	C	CASTROVILLE	B
ALLAMORE	D	BALSORA	B	BOONVILLE	D	CATARINA	D
ALTITA	C	BARBAROSA	D	BORACHO	C	CATILLA	B
ALTO	C	BARRADA	D	BOSQUE	B	CATTO	D
ALTOGA	C	BASTROP	B	BOWIE	B	CHACON	D
ALTUDA	D	BASTSIL	B	BOY	B	CHAMBERINO	C
ALTUS	B	BATESVILLE	C	BOYKIN	B	CHANEY	C
ALUF	A	BAUMAN	C	BRACKETT	C	CHARCO	C
ALUM	B	BAYUCOS	D	BRANYON	D	CHARGO	D
ALUSA	D	BAZETTE	C	BRAZITO	A	CHATT	C
AMARILLO	B	BEACH	D	BRAZORIA	D	CHAZOS	C
AMBIA	D	BEAUMONT	D	BREMOND	D	CHICKASHA	B
AMISTAD	D	BECKMAN	D	BRENHAM	C	CHICOLETE	C
AMPHION	C	BEHRING	D	BRENNAN	B	CHIGLEY	C
AMY	D	BELK	D	BREWSTER	D	CHILICOTAL	B
ANAHUAC	D	BENCHLEY	C	BRILEY	B	CHIRENO	D
ANAPRA	B	BENITO	D	BRONTE	C	CHISPA	B
ANGELINA	D	BENKLIN	C	BROOME	B	CHO	C
ANGELO	C	BERDA	B	BROWNDELL	D	CHOATES	C
ANGIE	D	BERGSTROM	B	BROWNFIELD	A	CHRISTINE	D
ANHALT	D	BERINO	B	BRUNDAGE	D	CHURCH	D
ANNONA	D	BERNALDO	B	BRUNO	A	CIENO	D
ANOCON	C	BERNARD	D	BRYARLY	D	CIRCLEBACK	A
ANTHONY	B	BERTHOUD	B	BRYSTAL	B	CISCO	B
ANTOSA	B	BESNER	B	BUB	C	CLAIREMONT	B
APALO	B	BETIS	A	BUCHEL	D	CLAREVILLE	C
AQUILLA	A	BEXAR	D	BUKREEK	B	CLEARFORK	D
ARANSAS	D	BIBB	D	BUNYAN	B	CLEMVILLE	B
ARCH	B	BIENVILLE	A	BURCO	D	CLICK	A
ARENOSA	A	BIGBROWN	C	BURKEVILLE	D	CLODINE	D
ARENTS,CLAYEY	D	BIGETTY	B	BURLESON	D	COAHUILA	B
ARIS	D	BIGFOOT	C	BURLEWASH	D	COARSEWOOD	B
ARNO	D	BILLYHAW	D	BURSON	C	COASTAL BEACH	A/D
AROL	D	BIPPUS	B	CADELAKE	D	COASTAL DUNES	A
ARRADA	D	BIROME	C	CADELL	D	COBB	B
ARRIOLA	D	BISSONNET	D	CAID	B	COCHINA	D
ARROYADA	D	BLAKENEY	C	CALLAHAN	D	COLIBRO	B

COLITA	D
COLORADO	B
COMFORT	D
COMITAS	A
CONA	C
CONALB	B
CONGER	C
CONLEN	B
CONROE	B
CONTEE	D
COPANO	D
COPITA	B
COQUAT	D
CORKSTONE	D
CORLENA	A
CORRIGAN	D
COSH	C
COTTONWOOD	C
COTULLA	D
COURTHOUSE	D
COVING	C
COY	D
COYANOSA	D
CRANFILL	B
CRAWFORD	D
CREVASSE	A
CROCKETT	D
CROSSTELL	D
CROWLEY	D
CUERO	B
CUEVITAS	D
CULP	C
CUTHAND	B
CUTHBERT	C
CUTHBERT GRADED	D
CYPRESS	D
CZAR	B
DACOSTA	D
DALBY	D
DALCO	D
DALHART	B
DALLAM	B
DALLARDSVILLE	C
DALUPE	B
DANJER	D
DANT	D
DARBONNE	B
DARCO	A
DARDANELLE	B
DARDEN	A
DARL	C
DARNELL	C

DARROUZETT	C
DARST	C
DAVILLA	D
DEANDALE	D
DECORDOVA	B
DEGOLA	B
DELA	B
DELCOMB	D
DELEON	C
DELFINA	B
DELMITA	C
DELNORTE	C
DELWIN	A
DEMONA	C
DENHAWKEN	D
DENTON	D
DEPALT	D
DEPCOR	B
DEPORT	D
DERLY	D
DESAN	A
DESHA	D
DEV	A
DEVINE	C
DEVOL	B
DEWEYVILLE	D
DIANOLA	D
DIBOLL	D
DIETRICH	C
DILL	B
DILLEY	C
DIMEBOX	D
DINA	C
DIVOT	C
DODSON	C
DOSS	C
DOUCETTE	B
DOUDLE	B
DOUGHERTY	A
DOURO	B
DRAKE	B
DUBINA	C
DUFFAU	B
DUFFERN	A
DUGOUT	D
DUMAS	B
DUNE LAND	A
DUTEK	A
DUVAL	B
DYLAN	D
EASTWOOD	D
ECKERT	D

ECKRANT	D
ECTOR	D
EDDY	C
EDGE	D
EDNA	D
EDROY	D
ELANDCO	B
ELBON	B
ELGEE	A
ELINDIO	C
ELLEN	B
ELLIS	D
ELMENDORF	D
ELMINA	C
ELROSE	B
ELYSIAN	B
ELYSIAN VARIANT	C
ENERGY	B
ENGLE	B
ENTERPRISE	B
EOLA	D
ERNO	B
ESPY	C
ESTACADO	B
ESTES	D
ETOILE	D
EUFAULA	A
EUSTIS	A
EVADALE	D
EVANT	D
EXRAY	D
EYLAU	C
FADDIN	D
FAIRLIE	D
FALBA	D
FALFURRIAS	A
FASHING	D
FASKIN	B
FAUSSE	D
FELIPE	D
FERRIS	D
FETT	D
FETZER	C
FIELDCREEK	B
FLATONIA	D
FLO	A
FLOMOT	B
FLORESVILLE	C
FLYNN	B
FOLLET	D
FORDTRAN	C
FRANCITAS	D

FRANKIRK	C
FREESTONE	C
FRELSBURG	D
FRIENDS	C
FRIO	B
FRIONA	C
FRIOTON	C
FULLER	D
FULSHEAR	C
GADDY	A
GAGEBY	B
GALILEE	C
GALLIME	B
GALVESTON	A
GANADO	D
GARCENO	C
GARCITAS	C
GARNER	D
GASIL	B
GAUSE	C
GEORGETOWN	D
GESSNER	B/D
GHOLSON	B
GIBBONSCREEK	C
GILA	B
GIST	D
GLADEWATER	D
GLENDALE	B
GLENRIO	D
GOLDFINCH	C
GOLDMIRE	C
GOLIAD	C
GOMERY	B
GOMEZ	B
GORE	D
GOREEN	D
GOWEN	B
GOWKER	C
GRACEMORE	C
GRANDFIELD	B
GRANDMORE	B
GRAYROCK	C
GREDGE	D
GREENVINE	D
GROSEBECK	B
GRUENE	D
GRULLA	D
GRUVER	C
GUADALUPE	B
GULLIED LAND	D
GUNTER	B
GUYTON	D

Table 1 (cont)
Hydrologic Groups of the Soils of Texas

HALLETTSVILLE	D
HAMBY	C
HANIS	C
HANNAHATCHEE	B
HARDEMAN	B
HARGILL	B
HARJO	D
HARKEY	B
HARLINGEN	D
HARPER	D
HARPERSVILLE	D
HARRIS	D
HASSEE	D
HATLIFF	C
HEARNE	C
HEARNE GRADED	D
HEATLY	A
HEATON	A
HEBBRONVILLE	B
HEIDEN	D
HENCO	B/D
HENSLEY	D
HERTY	D
HEXT	B
HICOTA	B
HIDALGO	B
HIGHBANK	C
HILGRAVE	B
HILLCO	B
HINDES	C
HITILO	A
HOBAN	B
HOCKLEY	C
HOCKLEY GRADED	D
HODGINS	B
HOLLISTER	D
HOLLOMAN	D
HOLLOMEX	B
HOPCO	C
HORNSBY	C
HOULA	B
HOUSTON BLACK	D
HOWE	C
HUECO	C
HUMBARGER	B
HUNTSBURG	D
HURDS	B
HYE	B
IJAM	D
IMA	B
IMOGENE	D
IMOGENE FLOODED	C
INCELL	D
INEZ	D
INGRAM	D
IRAAN	B
IUKA	C
IVANHOE	D
JAL	B
JALMAR	A
JARDIN	D
JARRON	D
JASCO	D
JEDD	C
JIMENEZ	C
JOLLY	C
JOURDANTON	B
JUSTIN	B
KAMAY	D
KANEBREAK	C
KARANKAWA	D
KARDE	B
KARMA	B
KARNES	B
KATEMCY	C
KATY	D
KAUFMAN	D
KAVETT	D
KEECHI	C
KEESE	D
KEETER	C
KEITHVILLE	C
KELTYS	B
KEMAH	D
KEMP	C
KENEFICK	B
KENNEY	A
KERMIT	A
KERRICK	B
KERRVILLE	C
KERSHAW	A
KIAN	C
KIMBROUGH	D
KINCHELOE	D
KINCO	A
KIOMATIA	A
KIRBYVILLE	B
KIRKLAND	D
KIRVIN	C
KIRVIN	D
KISATCHIE	D
KITTERLL	D
KLUMP	B
KNIPPA	C
KNOCO	D
KNOLLE	B
KOETHER	D
KOKERNOT	C
KONAWA	B
KONSIL	B
KOPPERL	B
KOSSE	B
KOURY	C
KRADE	B
KRUM	D
KULLIT	B
KURTEN	D
KURTH	C
KUY	A
LACERDA	D
LACOSTE	C
LAGLORIA	B
LAJITAS	D
LAKE CHARLES	D
LALINDA	B
LAMAR	B
LAMKIN	B
LAMPASAS	D
LANDMAN	B
LANGTRY	D
LAPARITA	C
LAREDO	B
LARTON	A
LARUE	A
LASALLE	D
LASKA	B
LASSITER	B
LATCH	A
LATEX	C
LATINA	D
LATIUM	D
LATOM	D
LATTAS	D
LAVENDER	B
LEA	C
LEAGUEVILLE	B/D
LEEMONT	D
LEERAY	D
LEGGETT	C
LEMING	C
LESON	D
LETNEY	A
LETON	D
LEWISVILLE	B
LEXTON	B
LIGON	D
LIKES	A
LILBERT	B
LIMPIA	C
LINCOLN	A
LINDALE	C
LINDY	C
LIPAN	D
LIV	D
LIVIA	D
LOFTON	D
LOGHOUSE	B
LOIRE	B
LOMALTA	D
LOMART	B
LOMETA	C
LOS TANOS	C
LOTT	C
LOU	B
LOZANO	B
LOZIER	D
LUCKENBACH	C
LUEDERS	C
LUFKIN	D
LULING	D
LUMMUS	C
LUPE	B
LUSK	C
LUTIE	B
LYFORD	C
MABANK	D
MABEN	C
MADRONE	C
MAINSTAY	D
MALBIS	B
MALOTERRE	D
MANGUM	D
MANSKER	B
MANTACHIE	C
MANZANO	B
MARCADO	D
MARCELINAS	D
MARGIE	C
MARIETTA	C
MARISCAL	D
MARKLAKE	C
MARQUEZ	C
MATA	C
MATAGORDA	D
MATAMOROS	C
MATHISTON	C
MAVCO	C
MAVERICK	C

Table 1 (cont)

Hydrologic Groups of the Soils of Texas

MAY	B
MCALLEN	B
MCCARRAN	B
MCKAMIE	D
MCLENNAN	C
MEDLEY	B
MEDLIN	D
MEGUIN	B
MELHOMES	D
MENARD	B
MENO	C
MERCEDES	D
MERETA	C
METCALF	D
METH	C
MIDESSA	B
MIDLAND	D
MIERHILL	C
MIGUEL	D
MILBY	B
MILES	B
MILLER	D
MIMBRES	B
MINCO	B
MINERVA	B
MINGO	C
MINWELLS	C
MIRASOL	B
MITRE	C
MOBEETIE	B
MOCAREY	D
MOGLIA	C
MOLLVILLE	D
MONAHANS	B
MONAVILLE	B
MONTELL	D
MONTEOLA	D
MONTEROSA	D
MONTOYA	D
MOOREVILLE	C
MORALES	D
MOREY	D
MORSE	D
MOSHEIM	D
MOSWELL	D
MOTEN	C
MOTLEY	B
MULDROW	D
MULTEY	B
MURRAY	B
MUSKOGEE	C
MUSQUIZ	C
MUSTANG	A/D
NACLINA	D
NACOGDOCHES	B
NADA	D
NAHATCHE	C
NARTA	D
NASS	D
NAVACA	D
NAVASAN	A
NAVIDAD	B
NAVO	D
NEBGEN	D
NESS	D
NEWCO	D
NEWULM	B
NICKEL	B
NIDO	C
NIKFUL	D
NIMROD	C
NIPSUM	C
NIWANA	B
NOBSCOT	A
NOCKEN	C
NOELKE	D
NORMANGEE	D
NORWOOD	B
NUECES	C
NUFF	C
NUGENT	A
NUKRUM	D
NUVALDE	B
OAKALLA	B
OAKHURST	D
OAKWOOD	B
OBARO	B
OBEN	C
OCHLOCKONEE	B
ODEM	A
OGLESBY	D
OIL-WASTE LAND	D
OKAY	B
OKLARED	B
OLMITO	D
OLMOS	C
OLTON	C
OPELIKA	D
OPLIN	C
ORELIA	D
ORELIA, CLAYEY SUBSOIL	D
ORIF	A
ORLA	B
OSIER	A/D
OTANYA	B
OVAN	D
OWENS	D
OWENTOWN	B
OZAN	D
OZIAS	D
PADINA	B
PADRONES	B
PADUCAH	B
PAJARITO	B
PALACIOS	D
PALAFOX	C
PALOBIA	B
PALODURO	B
PALOPINTO	D
PALUXY	B
PANTERA	B
PAPAGUA	C
PAPALOTE	C
PARISIAN	D
PARRITA	D
PASTURA	D
PATILO	B
PATRICIA	B
PATRICK	B
PATROLE	C
PAYNE	C
PEBBLEPOINT	C
PECOS	D
PEDERNALES	C
PENWELL	A
PERCILLA	D
PERICO	B
PERNITAS	C
PERRY	D
PERSONVILLE	B
PETTUS	C
PHANTOM	C
PHARR	B
PICKTON	A
PICOSA	C
PIDCOKE	D
PINETUCKY	B
PINETUCKY GRADED	C
PINTAS	B
PIRKEY	C
PITS	D
PITZER	C
PLACEDO	D
PLACK	D
PLANK	D
PLEDGER	D
PLUCK	C
PLUMMER	B/D
POINT ISABEL	C
POLAR	B
PONDER	D
PONTOTOC	B
POPHERS	C
PORFIRIO	C
PORT	B
PORTALES	B
PORTALTO	B
PORTERSPRINGS	C
PORUM	D
POSEY	B
POTEET	C
POTH	C
POTTER	C
PRATLEY	C
PRYOR	C
PSAMMENTS	A
PUERTA	D
PULEXAS	B
PULLMAN	D
PURSLEY	B
PURVES	D
PYOTE	A
QUANAH	B
QUAY	B
QUEENY	D
QUEMADO	C
QUIHI	C
QUINLAN	C
QUITERIA	B
RACOMBES	B
RADER	D
RAHAL	C
RAINO	D
RAMADERO	B
RANDADO	C
RANDALL	B
RAYBURN	D
RAYEX	D
RAYLAKE	D
RAYMONDVILLE	D
REAGAN	B
REAKOR	B
REAL	D
REAP	D
REDCO	D
REDLAKE	D

Hydrologic Groups of the Soils of Texas

REDONA	B
REDSPRINGS	B
REDSPRINGS GRADED	D
REEVES	B
REHBURG	C
REHM	C
RENFROW	D
RENICK	D
RENISH	C
RENTZEL	C
REYNOSA	B
RICKMORE	C
RIESEL	C
RIO	D
RIO DIABLO	C
RIO GRANDE	B
RIOCONCHO	C
RIVERWASH	A
ROBCO	C
ROBINSONVILLE	B
ROCHELLE	C
ROCK OUTCROP	D
ROCKHOUSE	A
RODESSA	D
ROEBUCK	D
ROEMER	C
ROETEX	D
ROGAN	B
ROSALIE	B
ROSANKY	C
ROSCOE	D
ROSENWALL	D
ROTAN	C
ROUGH BROKEN LAND	C
ROUGHCREEK	D
ROWDEN	C
ROWENA	C
ROXTON	D
RUIZ	A
RUMLEY	B
RUMPLE	C
RUNGE	B
RUNN	D
RUPLEY	A
RUSTON	B
RUTERSVILLE	C
RYDOLPH	C
SABENYO	B
SABINE	A
SACUL	C
SAFFELL	B
SAGERTON	C
SALCO	B
SALGA	C
SAN ANTONIO	C
SAN JON	C
SAN SABA	D
SANDERSON	B
SANDOW	B
SANELI	D
SANGER	D
SANTO	B
SANTO TOMAS	B
SARAGOSA	B
SARDIS	C
SARITA	A
SARNOSA	B
SASPAMCO	B
SATATTON	D
SATIN	C
SAUCEL	D
SAUZ	B
SAWTOWN	C
SAWYER	C
SAYERS	A
SCHATTEL	C
SCOTTSVILLE	C
SEAGOVILLE	D
SEALY	B
SEARSVILLE	D
SEAWILLOW	B
SEGNO	C
SEGUIN	B
SEJITA	D
SELDEN	C
SET	C
SEVERN	B
SHALBA	D
SHANKLER	A
SHARVANA	C
SHATRUCE	C
SHAVASH	C
SHEP	B
SHERM	D
SHINER	C
SHIPS	D
SHIRO	C
SHUMLA	C
SIEVERS	C
SILAWA	B
SILSTID	A
SILVERN	A
SIMONA	D
SINGLETON	D
SINTON	B
SLAUGHTER	C
SLICKSPOTS	D
SLIDELL	D
SMITHDALE	B
SMITHVILLE	B
SMITHWICK	D
SOCAGEE	D
SOLIS	C
SOMERVELL	B
SORTER	D
SPADE	B
SPECK	D
SPICEWOOD	C
SPILLER	C
SPIRES	D
SPLENDORA	C
SPRINGER	B
SPROUL	D
SPUR	B
SPURGER	C
SPURLOCK	B
ST. PAUL	B
STAMFORD	D
STEGALL	C
STEPHEN	C
STEPHENVILLE	B
STILSKIN	C
STONEBURG	B
STOWELL	D
STRABER	C
STRINGTOWN	B
STRINGTOWN GRADED	C
STYX	B
SUMMERFIELD	D
SUMPF	D
SUNEV	B
SUNRAY	B
SURFSIDE	D
SWAN	D
SWEETWATER	D
TABOR	D
TAHOULA	D
TALCO	D
TALPA	D
TARPLEY	D
TARRANT	D
TASAJAL	B
TASCOSA	B
TATLUM	D
TATTON	D
TEHRAN	A
TELA	B
TELFERNER	D
TELLER	B
TENAHA	B
TENCEE	D
TERLINGUA	D
TEXANA	D
TEXARK	D
TEXLINE	B
TEXROY	B
THAGE	C
THENAS	C
THROCK	C
THURBER	D
TIGUA	D
TILLMAN	C
TINN	D
TIOCANO	D
TIPTON	B
TIVOLI	A
TOBOSA	D
TONIO	B
TONKAVAR	A
TONKAWA	A
TOPIA	D
TOPSEY	C
TORDIA	D
TORNILLO	B
TORRIORTHENTS	C
TOYAH	B
TRACOSA	D
TRAVIS	C
TRAWICK	B
TREADWAY	D
TREMONA	C
TREP	B
TRINITY	D
TRIOMAS	B
TRUCE	C
TUCKERMAN	D
TULIA	B
TURCOTTE	B
TURNEY	B
TUSCOSSO	B
UDIFLUVENTS	B/D
UHLAND	B
UPTON	C
URBAN LAND	D
URBO	D

URLAND	C
USTIFLUVENTS	D
USTIFLUVENTS, BROKEN	A
USTORTHENTS	B
UVALDE	B
VADO	B
VALCO	C
VALENTINE	A
VALERA	C
VALVERDE	B
VAMONT	D
VARGAS	C
VARRO	B
VASHTI	C
VAUGHAN	D
VEAL	B
VELASCO	D
VELOW	B
VENUS	B
VERDUN	D
VERHALEN	D
VERICK	C
VERLAND	D
VERNIA	A
VERNON	D
VERTEL	D
VESEY	B
VESTON	D
VIBORAS	D
VICTINE	D
VICTORIA	D
VIDAURI	D
VIDRINE	D
VIEJA	D
VIMVILLE	D
VINEGARROON	C
VINGO	B
VINTON	B
VOCA	C
VOLCO	D
VOLENTE	C
VONA	B
VOSS	B
WALLER	B/D
WARNOCK	B
WASKOM	C
WAURIKA	D
WEATHERFORD	B
WEBB	C
WEESATCHE	B
WEIGANG	C
WESTFORK	D
WESWIND	C
WESWOOD	B
WEYMOUTH	B
WHAKANA	B
WHITESBORO	C
WHITEWRIGHT	C
WICHITA	C
WICKETT	C
WIERGATE	D
WILCO	C
WILLACY	B
WILLAMAR	B
WILSON	D
WINDTHORST	C
WINK	B
WINTERHAVEN	B
WINTERS	C
WISE	C
WOCKLEY	C
WODEN	B
WOLFPEN	A
WOODTELL	D
WOODVILLE	D
WOODWARD	B
WRIGHTSVILLE	D
WYICK	D
YAHOLA	B
YATES	D
YEATON	C
YOLOGO	D
YOMONT	B
YTURRIA	A
ZACK	D
ZALCO	A
ZALLA	A
ZAPATA	C
ZAVALA	B
ZAVCO	C
ZILABOY	D
ZITA	B
ZORRA	D
ZULCH	D

NOTE: Two hydrologic soil groups such as B/D indicate the drained/undrained situation.

Table 2a —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	Poor	72	81	88	91
		Good	67	78	85	89
	Straight row + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured + 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
	Contoured & terraced + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Straight row + CR	Poor	64	75	83	86
		Good	60	72	80	84
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured + CR	Poor	62	73	81	84
		Good	60	72	80	83
	Contoured & terraced	Poor	61	72	79	82
		Good	59	70	78	81
	Contoured & terraced + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured & terraced	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition.

[2] *Crop residue cover (CR)* applies only if residue is on at least 5% of the surface throughout the year.

[3] 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 2b—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	30[4]	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	30[4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition.
[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 have been 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 2c —Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average runoff condition. For rangelands in humid regions, use table 2b.

[2] *Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30% to 70% ground cover.
Good: >70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Table 2d —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 2-2a).					

[1] Average runoff condition, $I_a = 0.2S$.
[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.
[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 based on the impervious area (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 the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 3 Curve numbers (CN) and constants for the case $I_a = 0.2\ S$

1	2	3	4	5	1	2	3	4	5
CN for condition II	CN for conditions I	III	S values*	Curve* starts where P =	CN for condition II	CN for conditions I	III	S values*	Curve* starts where P =
			(inches)	(inches)				(inches)	(inches)
100	100	100	0	0	60	40	78	6.67	1.33
99	97	100	.101	.02	59	39	77	6.95	1.39
98	94	99	.204	.04	58	38	76	7.24	1.45
97	91	99	.309	.06	57	37	75	7.54	1.51
96	89	99	.417	.08	56	36	75	7.86	1.57
95	87	98	.526	.11	55	35	74	8.18	1.64
94	85	98	.638	.13	54	34	73	8.52	1.70
93	83	98	.753	.15	53	33	72	8.87	1.77
92	81	97	.870	.17	52	32	71	9.23	1.85
91	80	97	.989	.20	51	31	70	9.61	1.92
90	78	96	1.11	.22	50	31	70	10.0	2.00
89	76	96	1.24	.25	49	30	69	10.4	2.08
88	75	95	1.36	.27	48	29	68	10.8	2.16
87	73	95	1.49	.30	47	28	67	11.3	2.26
86	72	94	1.63	.33	46	27	66	11.7	2.34
85	70	94	1.76	.35	45	26	65	12.2	2.44
84	68	93	1.90	.38	44	25	64	12.7	2.54
83	67	93	2.05	.41	43	25	63	13.2	2.64
82	66	92	2.20	.44	42	24	62	13.8	2.76
81	64	92	2.34	.47	41	23	61	14.4	2.88
80	63	91	2.50	.50	40	22	60	15.0	3.00
79	62	91	2.66	.53	39	21	59	15.6	3.12
78	60	90	2.82	.56	38	21	58	16.3	3.26
77	59	89	2.99	.60	37	20	57	17.0	3.40
76	58	89	3.16	.63	36	19	56	17.8	3.56
75	57	88	3.33	.67	35	18	55	18.6	3.72
74	55	88	3.51	.70	34	18	54	19.4	3.88
73	54	87	3.70	.74	33	17	53	20.3	4.06
72	53	86	3.89	.78	32	16	52	21.2	4.24
71	52	86	4.08	.82	31	16	51	22.2	4.44
70	51	85	4.28	.86	30	15	50	23.3	4.66
69	50	84	4.49	.90					
68	48	84	4.70	.94	25	12	43	30.0	6.00
67	47	83	4.92	.98	20	9	37	40.0	8.00
66	46	82	5.15	1.03	15	6	30	56.7	11.34
65	45	82	5.38	1.08	10	4	22	90.0	18.00
64	44	81	5.62	1.12	5	2	13	190.0	38.00
63	43	80	5.87	1.17	0	0	0	infinity	infinity
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

*For CN in column 1.

Table 4 —I_a values for runoff curve numbers

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

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WATERSHED RUNOFF COMPUTATION

SWCD ______________________ FIELD OFFICE ______________________

COOPERATOR ______________________ TYPE OF PRACTICE ______________________

STRUCTURE NO. ______________________ PROGRAM (ACP,GPCP,OTHER) ______________________

COMPUTATIONS BY ______________ DATE ______ CHECKED BY ______________ DATE ______

Determination of Runoff Curve Number (Table 2, pg. 37-40)*

Land Use or Cover	Cover Condition	Soil Name	Soil Group	Land Slope	Area Acres	Curve No.	Acres X Curve No.	Acres X Slope
				TOTAL =				

Weighted Curve No. = $\frac{\text{(Acres x Curve No.)}}{\text{Total No. Acres}}$ = __________ = _____ : Use __________

Average Watershed Slope = $\frac{\text{(Acres x Slope)}}{\text{Total No. Acres}}$ = __________ = _____ : Use __________

*Reference - Engineering Technical Note 210-18-TX5 or Engineering Field Manual for Conservation Practices (EFM), Chapter 2

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Estimating time of concentration

1. Data:
   Rainfall distribution type (II or III), pg. 19 or 20............. = ________
   Drainage area... A = ________ ac
   Runoff curve number...CN = ________
   Average Watershed slope... Y = ________ %
   Flow length... L = ________ ft
2. T_c using L, Y, CN and Figure 4, pg. 22............................. = ________ hrs

   or using equation

$$T_c = \frac{(L)^{0.8}\left[\left(\frac{1000}{CN}\right) - 9\right]^{0.7}}{1140\ Y^{0.5}} = \frac{(\quad)^{0.8}(\quad)^{0.7}}{1140(\quad)^{0.5}}$$ .... = ________ hrs

Use ________ hrs

Estimating peak discharge*

		Storm #1	Storm #2	Storm #3
1. Frequency (refer to NHCP)..............................	yr			
2. Rainfall, P (24-hour) Figure 6, pg. 24-29...........	in.			
3. Initial abstraction, I_a (Table 4), pg. 42.............	in.			
4. Compute I_a/P ratios**				
5. Unit peak discharge, q_u (Exhibit 1 or 2)........ pg. 17 or 18	cfs/ac/in.			
6. Runoff, Q (Figure 3), pg. 21..........................	in.			
7. Peak discharge, q_p ($q_p = q_u AQ$)	cfs			
8. Correction for Pond or Swampy Area, F_p, pg. 5.........				
9. Corrected Peak Discharge ($q_p x F_p$)	cfs			

* Reference - ENG Tech. Note 210-18-TX5
** Use 0.10 for all I_a/P values less than 0.10.

Remarks:

APPENDIX A: COMPUTER PROGRAM

The EFM2 procedures have been incorporated in a microcomputer program. Standard SCS microcomputers having one floppy disk, an MS-DOS operating system, and sufficient capacity (512K memory necessary for loading the program) will operate the program. Additional information on the use of the program and an introduction to the system is included on the system diskette in a file called "README.1ST". Users of the program, however, still need to be familiar with the procedures in EFM-2. Features of the program include the following:

- The full screen (24 lines, 80 columns) is displayed. Data entry is aided by the use of input screens. Flexibility of coding allows movement about the screen for quick modifications.

- Function keys provide menu power to move to different routines within the program. These call such functions as print, load data, save data, and compute.

- "Help" screens provide pertinent information to the user. Two types of help information are included: (1) explain the use of special keys, and (2) describe input parameters. There are 9 "Help" screens.

- User files provide for optional entry of rainfall-frequency data for each county.

Once the county rainfall-frequency data has been properly entered in a user file, the county name can be entered on the data entry screen to invoke the data. Proper entry of the county name will cause the rainfall-frequency data to be automatically entered in the runoff and peak discharge output table.

A training module has been developed and is available for use. The module is intended as a companion to the EFM2 microcomputer program. It is a self-paced, self-study module for individual or group sessions. This study guide is part of the Hydrology Training Series and is entitled "Module 151-EFM2 Microcomputer Program."

The EFM2 program is similar to the currently available Technical Release 55, "Urban Hydrology for Small Watersheds" peak flow procedures and computer program. Both procedures can also be used for rural areas. For predominantly urban areas, TR-55 should be used.

The EFM2 program is nationally developed and maintained. The current EFM2 program is Version 1.1 dated March 1989.

A printout of the example problem follows.

EFM-2 ESTIMATING RUNOFF AND PEAK DISCHARGE VERSION 1.10

Curve Number Computation

Client : HECTOR GOMEZ
County : BELL State: TX
Practice: GRASSED WATERWAY

By: JLH Date: 05-09-90
Checked: LAG Date: 5/9/90

COVER DESCRIPTION		Hydrologic Soil Group A Acres (CN)	B	C	D
CULTIVATED AGRICULTURAL LANDS					
Small grain SR + Crop residue	good	-	-	-	51(84)
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	good	-	-	32(74)	-
Total Area (by Hydrologic Soil Group)				32 =====	51 =====

TOTAL DRAINAGE AREA: 83 Acres WEIGHTED CURVE NUMBER: 80

Client : HECTOR GOMEZ By: JLH Date: 05-09-90
County : BELL State: TX Checked: LAG Date: 5/9/90
Practice: GRASSED WATERWAY

Drainage Area	:	83 *	Acres
Curve Number	:	80 *	
Watershed Length	:	4000	Feet
Watershed Slope	:	1.4	Percent
Time of Concentration	:	1.36	Hours
Rainfall Type	:	II	

Storm Number	1
Frequency (yrs)	10
24-Hr Rainfall (in)	6.7
Ia/P Ratio	0.07
Used	0.10
Runoff (in)	4.42
Unit Peak Discharge (cfs/acre/in)	0.459
Peak Discharge (cfs)	168

* - Value(s) provided by CN subroutine (F9)