SOILS CONSERVATION SERVICE METHOD

SOIL CONSERVATION SERVICE METHOD

ESTIMATING RUNOFF FROM URBAN AREAS

Introduction

Effective rainfall is that portion of precipitation that produces direct runoff, which is water that enters the stream channels during a storm or soon after and forms a runoff hydrograph. Losses or abstractions are that portion of precipitation that does not contribute to direct runoff. Losses occurring on urban watersheds are similar to those occurring on natural watersheds. The amount of runoff from a storm event largely depends on detention, infiltration, evapotranspiration, etc., and is related to soil type, type of vegetation, and amount of impervious cover.

With proper modifications and assumptions, the soil-cover-complex method described in Publication NEH-4 can be used to estimate runoff from urban areas. The variables used in this method apply to runoff from both agricultural and urban watersheds. A combination of a hydrologic soil group (soil) and a land use and treatment class (cover) is used to determine the hydrologic soil-cover complex. The effect of the hydrologic soil-cover complex on the amount of rainfall that runs off that runs off is represented by a runoff curve number, referred to as CN. Chapters 7, 8, 9, and 10 of NEH-4 discuss the development of soil-cover complexes including soils, cover, treatment practices for agricultural areas, and resulting runoff.

In an urban watershed, the cover usually consists of both pervious and impervious surfaces. Impervious surfaces, such as roofs, streets, sidewalks, driveways, and parking lots, have some initial abstraction before runoff occurs. However, during an intense part of a storm event, nearly 100 percent of the rainfall may run off. Both initial abstraction and infiltration should be considered for pervious surfaces such as lawns, parks, and playing fields.

Runoff Equation

Figure 1 shows schematic curves of accumulated storm rainfall P, runoff Q, and infiltration plus initial abstraction ($F + I_a$). For convenience in estimating runoff, initial abstraction includes all the storm rainfall occurring before surface runoff starts.

Effect of Urbanization on Runoff

Initial abstraction consists of interception, infiltration, and depression storage that must be satisfied before runoff begins. Urban initial abstraction has been found to be correlated with slope of the impervious area. However, because of the limited scope of the research data available, no attempt has been made to revise the basic runoff equation to apply exclusively to urban area.

Investigations have also shown that runoff from small (less than annual) rainfall events comes primarily from the impervious areas. However, both the pervious and impervious areas contribute to runoff for the larger, less frequent events. If the pervious portion of an urban area has a CN of 60 to 65, approximately 2 inches of rainfall is needed before runoff begins. Most 24-hour rainfall values used in computing peak rates of flow are over 2 inches. Therefore, for urban analysis the total watershed area can be assumed to contribute to storm runoff.

Urban Runoff Curve Numbers

Several factors should be considered when computing the anticipated future CN for urban areas. The amount of runoff can vary depending on whether house gutters connect directly to storm drains, outlet onto impervious driveways, or outlet onto lawns or other pervious areas where infiltration can occur. General building practices or codes within a development may be helpful in determining runoff flow paths. Some areas have zoning ordinances on how storm runoff from individual houses must be handled.

In determining urban CN's, consideration should be given to whether heavy equipment compacted the soil significantly more than natural conditions, whether much of the pervious area is barren with little sod established, and whether grading has mixed the surface and subsurface soils causing a completely different hydrologic condition.

Any one of the above could cause a soil normally in hydrologic group A or B to be classified in group B or C, respectively. In many areas of the country, lawns are heavily irrigated. This may significantly increase the moisture content in the soil over that under natural rainfall conditions.

Table 2 gives CN's for agricultural, suburban, and urban land use classifications. The suburban and urban CN's are based on typical land use relationships that exist in some areas. They should only be used when it has been determined that the area under study meets the criteria for which these CN's were developed.

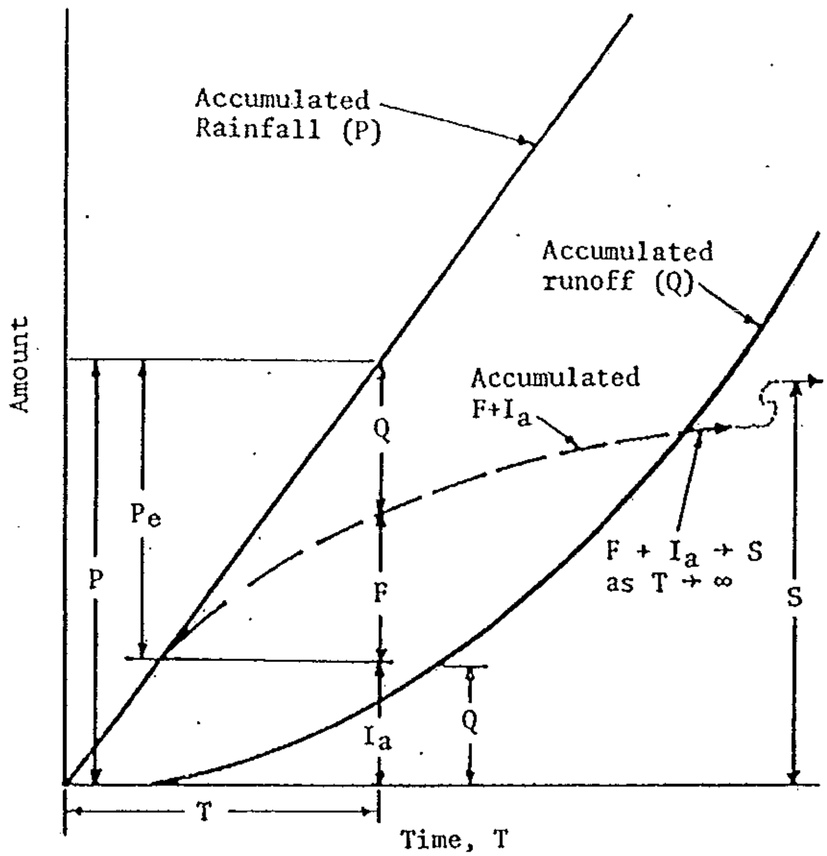


Figure 1. Schematic curves of accumulated rainfall (P), runoff (Q), and infiltration plus initial abstraction ($F + I_a$) showing the relation expressed by equation 2-5.

Assume $$\frac{F}{S} = \frac{Q}{P_e}$$ Equation 1

where F is the infiltration occurring after runoff begins in inches, S is the potential abstraction in inches, Q is the actual direct runoff in inches, and P_e is the potential runoff or effective storm runoff (storm rainfall minus the initial abstraction) in inches.

with $F = P_e - Q$, equation 1 can be written as:

$$Q = \frac{P_e^2}{P_e + S}$$ Equation 2

The initial abstraction (I_a) in inches, estimated from an empirical relation based on data from small watersheds, is

$$I_a = 0.2S \qquad \text{Equation 3}$$

Thus

$$P_e = P - I_a = P - 0.2S \qquad \text{Equation 4}$$

where P is the total storm rainfall in inches. Substituting equation 4 in equation 2,

$$A = \frac{(P-0.2S)^2}{P+0.8S} \qquad \text{Equation 5}$$

Potential abstraction S is related to the soil and cover conditions of a watershed. The runoff curve number, which is also related to soil and cover conditions, is related to potential abstraction S by

$$CN = \frac{1000}{S+10} \qquad \text{Equation 6}$$

from which

$$S = \frac{1000}{CN} - 10 \qquad \text{Equation 7}$$

The solution to equation 5 is shown in table 1 for a range of CN's and total rainfall amounts.

Table 1. Runoff depth in inches for selected CN's and rainfall amounts.

Rainfall (inches)	Curve Number (CN)[1/]								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0.03	0.08	0.17	0.32	.56	.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	.74	.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

[1/] To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use an arithmetic interpolation.

Table 2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land[1/]: without conservation treatment	72	81	88	91
: with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover[2/]	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious).	81	88	91	93
Residential:[3/]				
Average lot size — Average % Impervious[4/]				
1/8 acre or less — 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
Paved parking lots, roofs, driveways, etc.[5/]	98	98	98	98
Streets and roads:				
paved with curbs and storm sewers[5/]	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

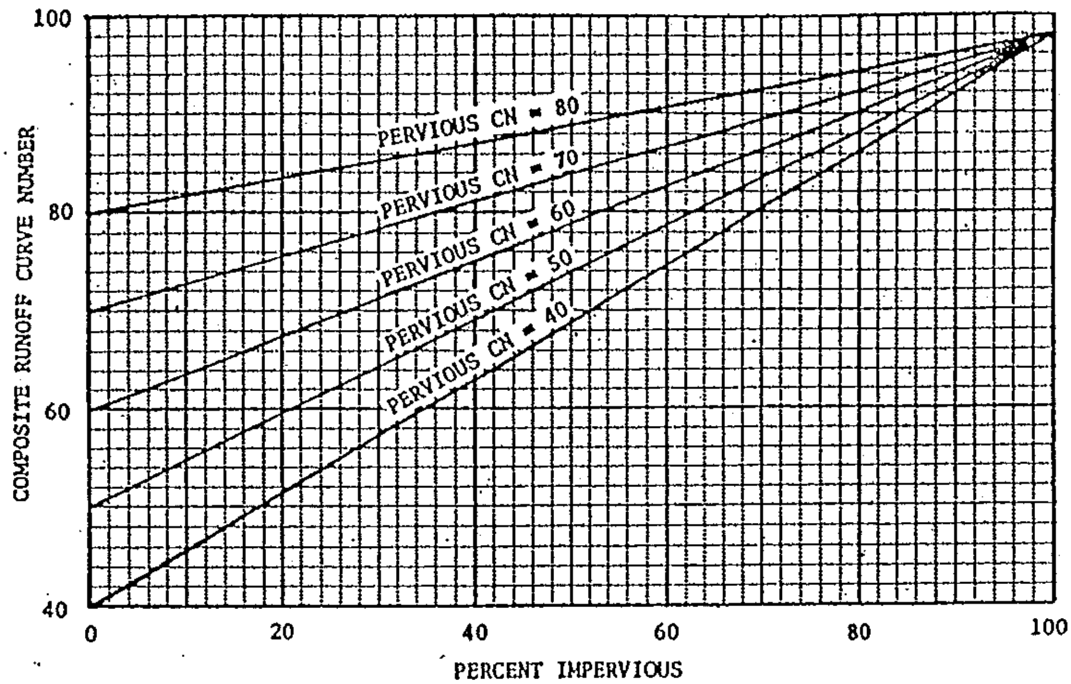


Figure 2. Percentage of impervious areas vs. composite CN's for given pervious area CN's.

There will be areas to which the values in table 2 do not apply. The percentage of impervious area for the various types of residential areas or the land use condition for the previous portions may vary from the conditions assumed in table 2. A curve for each pervious CN can be developed to determine the composite CN for any density of impervious area. Figure 2 has been developed assuming a CN of 98 for the impervious area. The curves in figure 2 can help in estimating the increase in runoff as more and more land within a given area is covered with impervious material.

There are a number of methods available for computing the percentage of impervious area in a watershed. Some methods include using U.S. Geological Survey topographic maps, land use maps, aerial photographs, and field reconnaissance. Care must be exercised when using methods based on such parameters as population density, street density, and age of the development as a means of determining the percentage of impervious area. The available data on runoff from urban areas are not yet sufficient to validate widespread use of these methods.

Example 1

Compute the runoff from 5 inches of rainfall for a 1,000-acre watershed to be converted to a suburban development. All the soils are in hydrologic soil group C. The proposed land use is 50 percent detached houses with lot size 1/4 acre; 10 percent townhouses with lot size 1/8 acre; 25 percent streets with curbs and gutters, schools, parking lots, plazas; and 15 percent open space, parks, schoolyards, etc., with good grass cover.

1. Compute the weighted runoff curve number.

Land Use	Percent	Table 2 curve number	Product
Detached houses with lot size 1/4 acre	50	83	4,150
Townhouses with lot size 1/8 acre	10	90	900
Streets with curbs, plaza, etc.	25	98	2,450
Open space, parks, etc.	15	74	1,110
	100		8,610

Thus $$\text{weighted CN} = \frac{8610}{100} = 86$$

2. From table 1 using CN = 86 and P = 5, interpolate to read Q = 3.47 inches.

Example 2

Compute the runoff from 6.3 inches of rainfall for a 1,000-acre watershed to be converted to a suburban development. The soils are in hydrologic soil group B. Forty percent of the development is impervious with all impervious areas connected; 60 percent is pervious and considered to be in good grass cover.

1. From table 2 read pervious CN = 61.

2. From figure 2 read CN = 76.

3. From table 1 using CN = 76 and P = 6.3 interpolate to read Q = 3.64 inches.

Example 3

Compute the runoff curve number for a 1,000-acre watershed. The hydrologic soil group is 50 percent B and 50 percent C interspersed throughout the watershed. The land use is:

40 percent residential area that is 30 percent impervious

12 percent residential area that is 65 percent impervious

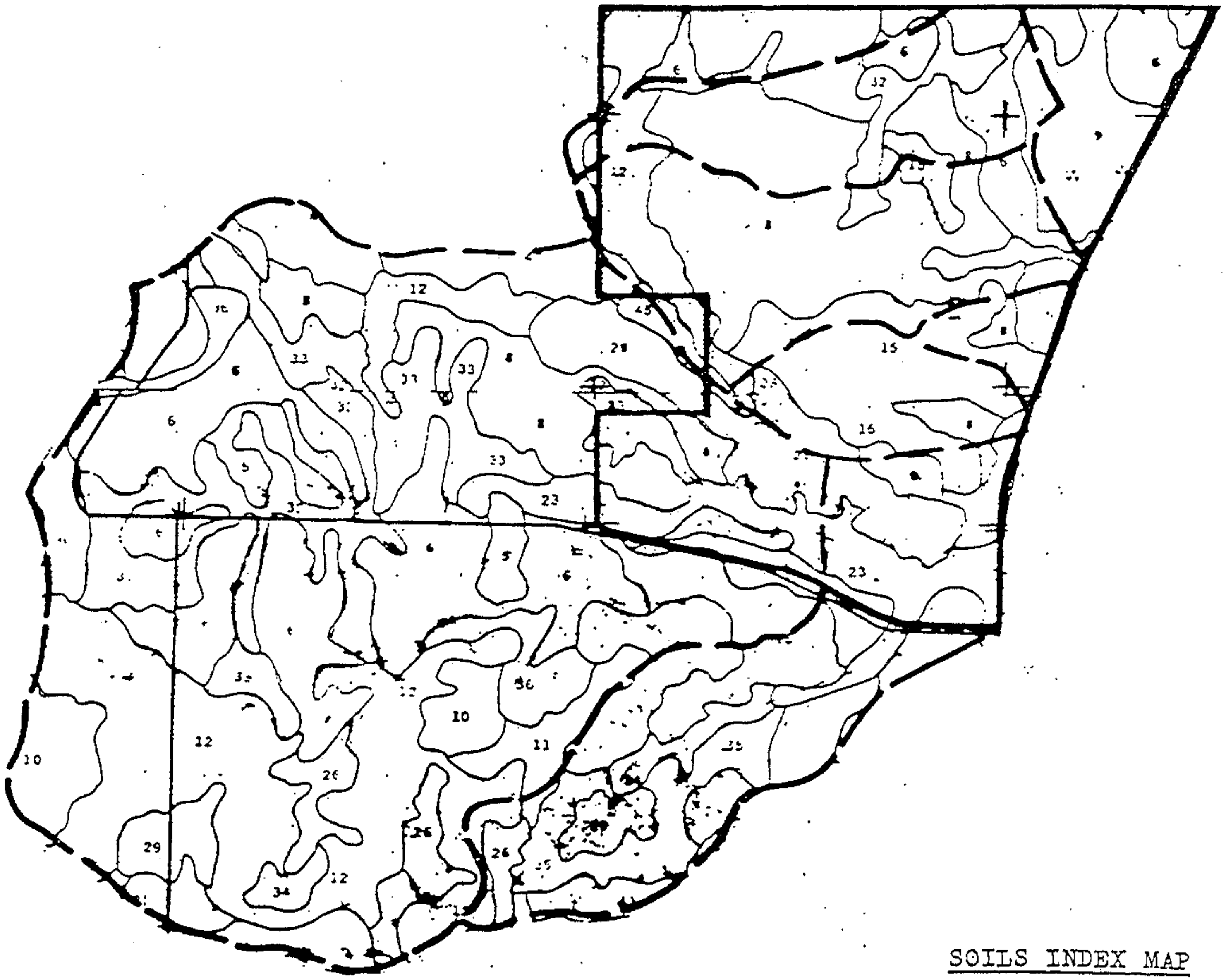
8 percent paved roads with open ditches

10 percent paved roads with curbs and storm sewers

16 percent open land with 50 percent fair cover and 50 percent good cover

14 percent parking lots, plazas, schools, etc. (all impervious)

Using table 2 and figure 2, display the data given and compute the runoff curve number.



SOILS INDEX MAP

TABLE 15.--SOIL AND WATER FEATURES

[The definition of "flooding" in the Glossary explains terms such as "rare" and "brief". The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Hardness		Uncoated steel	Concrete
					In				
1, 2 Ascalon	B	None	---	---	>60	---	Moderate	Moderate	Low.
3*:									
Baca	C	None	---	---	>60	---	Low	High	Low.
Wiley	B	None	---	---	>60	---	Low	High	Low.
4*:									
Bluerim	B	None	---	---	20-40	Rippable	Low	High	Low.
Peyton	B	None	---	---	>60	---	Moderate	Moderate	Low.
5, 6 Bresser	B	None	---	---	>60	---	Moderate	Moderate	Low.
7*:									
Bresser	B	None	---	---	>60	---	Moderate	Moderate	Low.
Cushman	C	None	---	---	20-40	Rippable	Low	High	Low.
8*:									
Bresser	B	None	---	---	>60	---	Moderate	Moderate	Low.
Stapleton	B	None	---	---	>60	---	Moderate	Moderate	Low.
9*:									
Bresser	B	None	---	---	>60	---	Moderate	Moderate	Low.
Truckton	B	None	---	---	>60	---	Moderate	Moderate	Moderate.
10, 11 Brussett	B	None	---	---	>60	---	Moderate	High	Low.
12 Coni	D	None	---	---	10-20	Hard	Moderate	Low	Low.
13 Cushman	C	None	---	---	20-40	Rippable	Low	High	Low.
14*:									
Cushman	C	None	---	---	20-40	Rippable	Low	High	Low.
Ascalon	B	None	---	---	>60	---	Moderate	Moderate	Low.
15*:									
Cushman	C	None	---	---	20-40	Rippable	Low	High	Low.
Hargreave	C	None	---	---	20-40	Rippable	Moderate	Moderate	Low.

See footnote at end of table.

TABLE 15.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Hardness		Uncoated steel	Concrete
					In				
16*:									
Cushman	C	None	---	---	20-40	Rippable	Low	High	Low.
Kutch	C	None	---	---	20-40	Rippable	Moderate	High	Moderate.
17 Elbeth	B	None	---	---	>60	---	Moderate	High	Moderate.
18*:									
Elbeth	B	None	---	---	>60	---	Moderate	High	Moderate.
Kettle	B	None	---	---	>60	---	Low	Moderate	Low.
19 Ellicott	A	Frequent	Brief	Mar-Jun	>60	---	Low	Moderate	Low.
20 Englewood	C	None	---	---	>60	---	Moderate	High	Low.
21*. Fluvaquents									
22*, 23*. Haplustolls									
24 Heldt	C	None	---	---	>60	---	Low	High	High.
25, 26 Holderness	C	None	---	---	>60	---	Moderate	High	Low.
27 Kettle	B	None	---	---	>60	---	Low	Moderate	Low.
28*:									
Kettle	B	None	---	---	>60	---	Low	Moderate	Low.
Rock outcrop.									
29, 30 Kutch	C	None	---	---	20-40	Rippable	Moderate	High	Moderate.
31*:									
Kutch	C	None	---	---	20-40	Rippable	Moderate	High	Moderate.
Louviers	D	None	---	---	8-20	Rippable	Low	High	Low.
32, 33 Nunn	C	None	---	---	>60	---	Moderate	High	Low.
34 Peyton	B	None	---	---	>60	---	Moderate	Moderate	Low.

See footnote at end of table.

TABLE 15.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Hardness		Uncoated steel	Concrete
					In				
35*:									
Peyton	B	None	---	---	>50	---	Moderate	Moderate	Low.
Elbeth	B	None	---	---	>60	---	Moderate	High	Moderate.
36*:									
Peyton	B	None	---	---	>60	---	Moderate	Moderate	Low.
Pring	B	None	---	---	>60	---	Moderate	Moderate	Low.
37 Pring	B	None	---	---	>60	---	Moderate	Moderate	Low.
38 Renohill	C	None	---	---	20-40	Rippable	Low	High	Low.
39*:									
Renohill	C	None	---	---	20-40	Rippable	Low	High	Low.
Louviers	D	None	---	---	8-20	Rippable	Low	High	Low.
40*:									
Torriorthents.									
Rock outcrop.									
41 Truckton	B	None	---	---	>60	---	Moderate	Moderate	Moderate.
42*:									
Truckton	B	None	---	---	>60	---	Moderate	Moderate	Moderate.
Renohill	C	None	---	---	20-40	Rippable	Low	High	Low.
43, 44 Weld	C	None	---	---	>60	---	Moderate	High	Low.
45*:									
Wiley	B	None	---	---	>60	---	Low	High	Low.
Baca	C	None	---	---	>60	---	Low	High	Low.

* See description of the map unit for composition and behavior characteristics of the map unit.

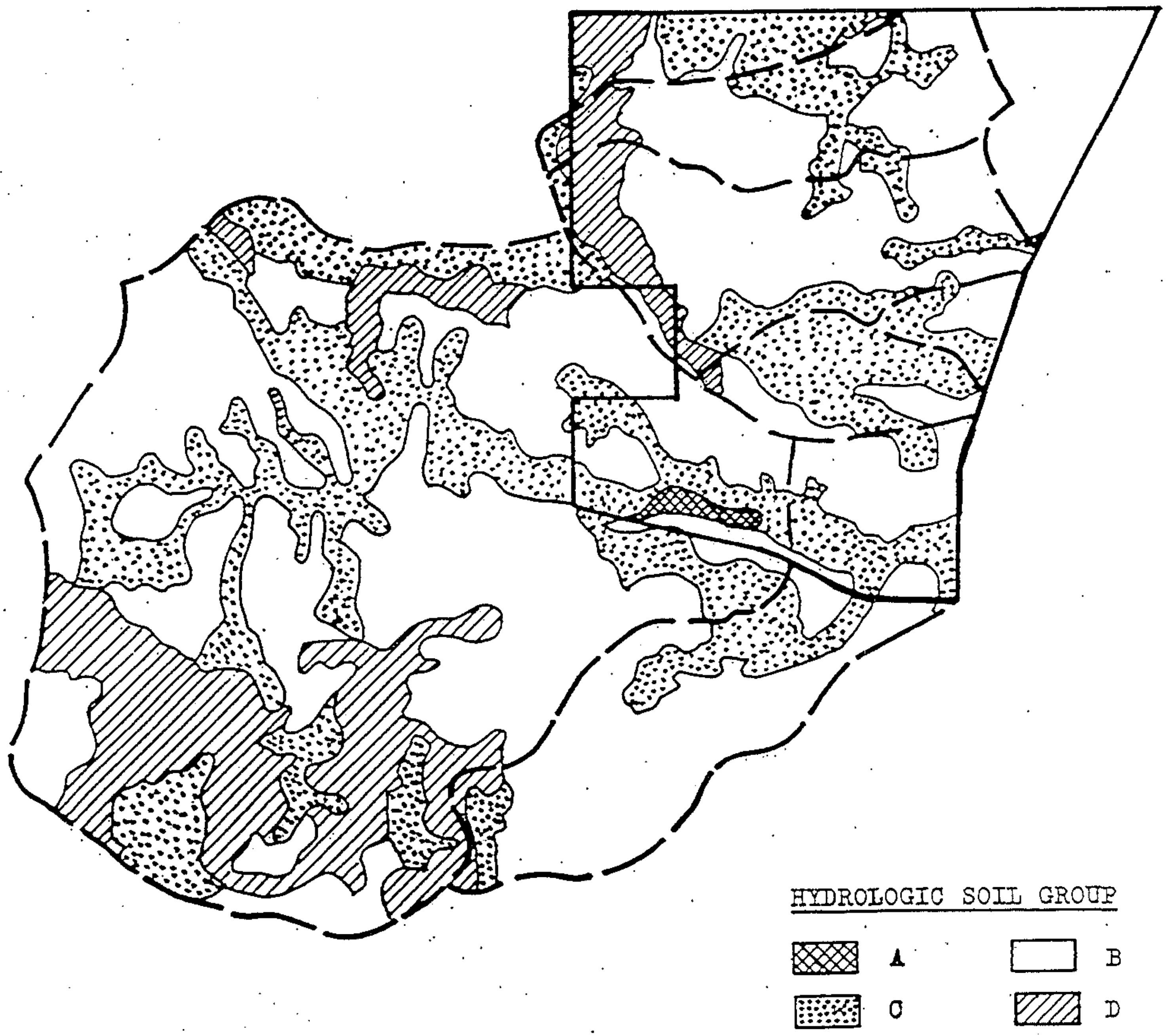

HYDROLOGIC SOIL GROUP
A
B
C
D

FIGURE S-4 RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES
(Antecedent moisture condition II, and I_a - 0.2 S)

Land use	Cover Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops 3/	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small 3/ grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ 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
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods (Isolated groves on farms & ranches)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		----	74	84	90	92

1/ Close-drilled or broadcast
2/ Including right-of-way
3/ Do not use adjustments for contoured or terraced treatments with storm frequencies greater than 10 years.

CO-EN-5 (Rev. 3/80)

For Use With "Peak Flows In Colorado"

U.S. Department of Agriculture

Soil Conservation Service

Colorado

HYDROLOGY DATA SUMMARY SHEET

Project Name ______________ Location BASIN "A"

Compiled by ______ Date ______ Checked by ______ Date ______

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
A	RANGE/FAIR	9.2	49	450.8
B	RANGE/FAIR	736.4	69	50,811.6
C	RANGE/FAIR	476.6	79	37,651.4
D	RANGE/FAIR	338.8	84	28,459.2
	TOTALS	1,561.0		117,373.0

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{117,373}{1,561} = 75.2$

CO-EN-5 (Rev. 3/80)

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Soil Conservation Service

Colorado

HYDROLOGY DATA SUMMARY SHEET

Project Name ________________ Location BASIN "B"

Compiled by ________ Date ________ Checked by ________ Date ________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
B	RANGE/FAIR	267.2	69	18,436.8
C	RANGE/FAIR	101.9	79	8,050.1
D	RANGE/FAIR	9.2	84	772.8
	TOTALS	378.3		27,259.7

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{27,259.7}{378.3} = 72.1$

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HYDROLOGY DATA SUMMARY SHEET

Project Name ______________________ Location BASIN "A+B"

Compiled by ____________ Date ____________ Checked by ____________ Date ____________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
A	RANGE/FAIR	9.2	49	450.8
B	RANGE/FAIR	1,003.6	69	69,248.4
C	RANGE/FAIR	578.5	79	45,701.5
D	RANGE/FAIR	348.0	84	29,232.0
	TOTALS	1,939.3		144,632.7

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{144,632.7}{1,939.3} = 74.6$

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HYDROLOGY DATA SUMMARY SHEET

Project Name ____________ Location BASIN "C"

Compiled by ________ Date ________ Checked by ________ Date ________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
B	RANGE/FAIR	32.2	69	2,221.8
C	RANGE/FAIR	70.7	79	5,585.3
D	RANGE/FAIR	1.8	84	151.2
	TOTALS	104.7		7,958.3

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{7,958.3}{104.7} = 76.0$

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HYDROLOGY DATA SUMMARY SHEET

Project Name ______________ Location BASIN "D"

Compiled by __________ Date __________ Checked by __________ Date __________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
B	RANGE/FAIR	173.6	69	11,978.4
C	RANGE/FAIR	60.6	79	4,787.4
D	RANGE/FAIR	40.4	84	3,393.6
	TOTALS	274.6		20,159.4

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{20,159.4}{274.6} = 73.4$

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HYDROLOGY DATA SUMMARY SHEET

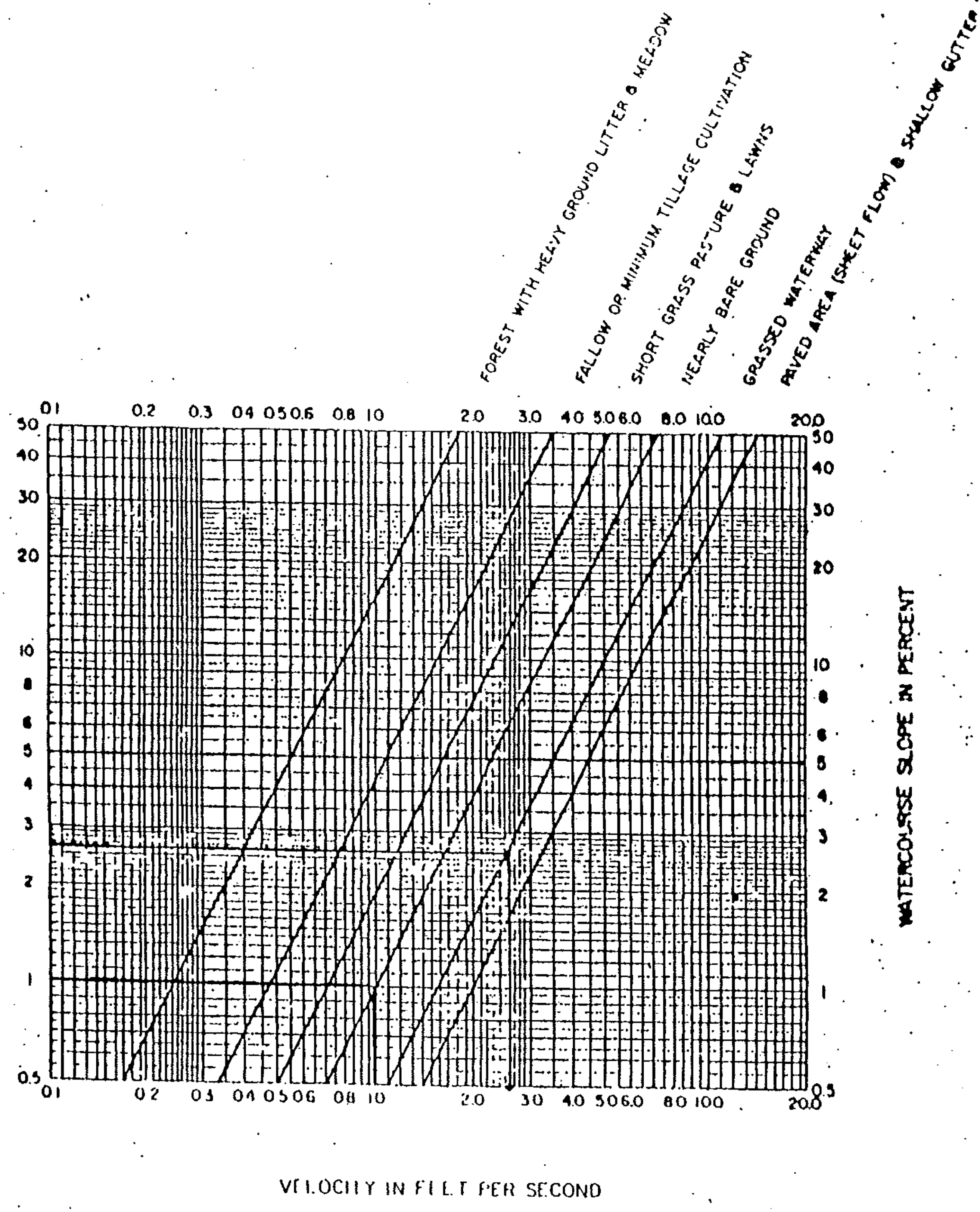
Project Name ______________________ Location BASIN "E"

Compiled by __________ Date __________ Checked by __________ Date __________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
B	RANGE/FAIR	125.8	69	8,680.2
C	RANGE/FAIR	50.5	79	3,989.5
D	RANGE/FAIR	12.9	84	1,083.6
	TOTALS	189.2		13,753.3

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}} = \frac{13,753.3}{189.2} = 72.7$



VELOCITIES FOR UPLAND METHOD OF ESTIMATING Tc

Computation of Tc Using Travel Time

$$T_c = \frac{\text{Length of Segment } (L_i)}{\text{Velocity Through Segment } (V_i)} = \frac{L_1}{V_1} + \frac{L_2}{V_2} + \frac{L_3}{V_3} + \ldots \frac{L_n}{V_n} \times \frac{1}{3600} = \text{Hrs.}$$

Li=Ft. Vi=Ft/Sec.

1 Basin "A" Design Point 1

L1 (25%) = 4,000' @ 4.0%	V1 = 3.2	Type = NAT. SW.
L2 (25%-50%) = 4,000' @ 2.5%	V2 = 2.4	Type = NAT. SW.
L3 (50%-75%) = 4,000' @ 1.5%	V3 = 1.9	Type = NAT. SW.
L4 (75%-100%) = 4,000' @ 1.0%	V4 = 1.6	Type = NAT. SW.
L5 ( ) =	V5 =	Type =
L6 ( ) =	V6 =	Type =

$$T_c = \frac{4{,}000}{3.2} + \frac{4{,}000}{2.4} + \frac{4{,}000}{1.9} + \frac{4{,}000}{1.6} + \underline{\quad} + \underline{\quad}$$

$$\times \frac{1}{3600} = 2.09 \text{ HR.}$$

2 Basin "B" Design Point 2

L1 (25%) = 2,125' @ 6.5%	V1 = 4.0	Type = NAT. SW.
L2 (25%-50%) = 2,125' @ 3.6%	V2 = 3.0	Type = NAT. SW.
L3 (50%-75%) = 2,125' @ 1.9%	V3 = 2.1	Type = NAT. SW.
L4 (75%-100%) = 2,125' @ 1.9%	V4 = 2.1	Type = NAT. SW.
L5 ( ) =	V5 =	Type =
L6 ( ) =	V6 =	Type =

$$T_c = \frac{2{,}125}{4.0} + \frac{2{,}125}{3.0} + \frac{2{,}125}{2.1} + \frac{2{,}125}{2.1} + \underline{\quad} + \underline{\quad}$$

$$\times \frac{1}{3600} = 0.91 \text{ HR.}$$

Computation of Tc Using Travel Time

$$Tc = \frac{\text{Length of Segment } (Li)}{\text{Velocity Through Segment } (Vi)} = \frac{L_1}{V_1} + \frac{L_2}{V_2} + \frac{L_3}{V_3} + \ldots \frac{Ln}{Vn} \times \frac{1}{3600} = \text{Hrs.}$$

Li=Ft. Vi=Ft/Sec.

3 Basin "A+B" Design Point 2

L1 (25%) = 4,000' @ 4.0% V1 = 3.2 Type = NAT.SW.

L2 (25%-50%) = 4,000' @ 2.5% V2 = 2.4 Type = NAT.SW.

L3 (50%-75%) = 4,000' @ 1.5% V3 = 1.9 Type = NAT.SW.

L4 (75%-100%) = 4,000' @ 1.0% V4 = 1.6 Type = NAT.SW.

L5 ( ) = 2,400' @ 0.8% V5 = 1.5 Type = NAT.SW.

L6 ( ) = ______ V6 = ______ Type = ______

$$Tc = \frac{4{,}000}{3.2} + \frac{4{,}000}{2.4} + \frac{4{,}000}{1.9} + \frac{4{,}000}{1.6} + \frac{2{,}400}{1.5} + \_\_\_\_$$

$$\times \frac{1}{3600} = 2.53 \text{ HR.}$$

4 Basin "C" Design Point 3

L1 (0-50%) = 2,000' @ 7.8% V1 = 4.4 Type = NAT.SW.

L2 (50-100%) = 2,000' @ 1.3% V2 = 1.8 Type = NAT.SW.

L3 = ______ V3 = ______ Type = ______

L4 = ______ V4 = ______ Type = ______

L5 ( ) = ______ V5 = ______ Type = ______

L6 ( ) = ______ V6 = ______ Type = ______

$$Tc = \frac{2{,}000}{4.4} + \frac{2{,}000}{1.8} + \_\_\_\_ + \_\_\_\_ + \_\_\_\_ + \_\_\_\_$$

$$\times \frac{1}{3600} = 0.43 \text{ HR.}$$

Computation of Tc Using Travel Time

$$Tc = \frac{\text{Length of Segment (Li)}}{\text{Velocity Through Segment (Vi)}} = \frac{L_1}{V_1} + \frac{L_2}{V_2} + \frac{L_3}{V_3} + \dots \frac{L_n}{V_n} \times \frac{1}{3600} = \text{Hrs.}$$

Li=Ft. Vi=Ft/Sec.

5 Basin "D" Design Point 4

L1 (0-33⅓%) = 2,333' @ 6.0% V1 = 3.9 Type = NAT.SW.
L2 (33⅓-66⅔%) = 2,333' @ 2.8% V2 = 2.6 Type = NAT.SW.
L3 (66⅔-100%) = 2,333' @ 2.8% V3 = 2.6 Type = NAT.SW.
L4 = ____ V4 = ____ Type = ____
L5 ( ) = ____ V5 = ____ Type = ____
L6 ( ) = ____ V6 = ____ Type = ____

$$Tc = \frac{2,333}{3.9} + \frac{2,333}{2.6} + \frac{2,333}{2.6} + \_\_ + \_\_ + \_\_$$

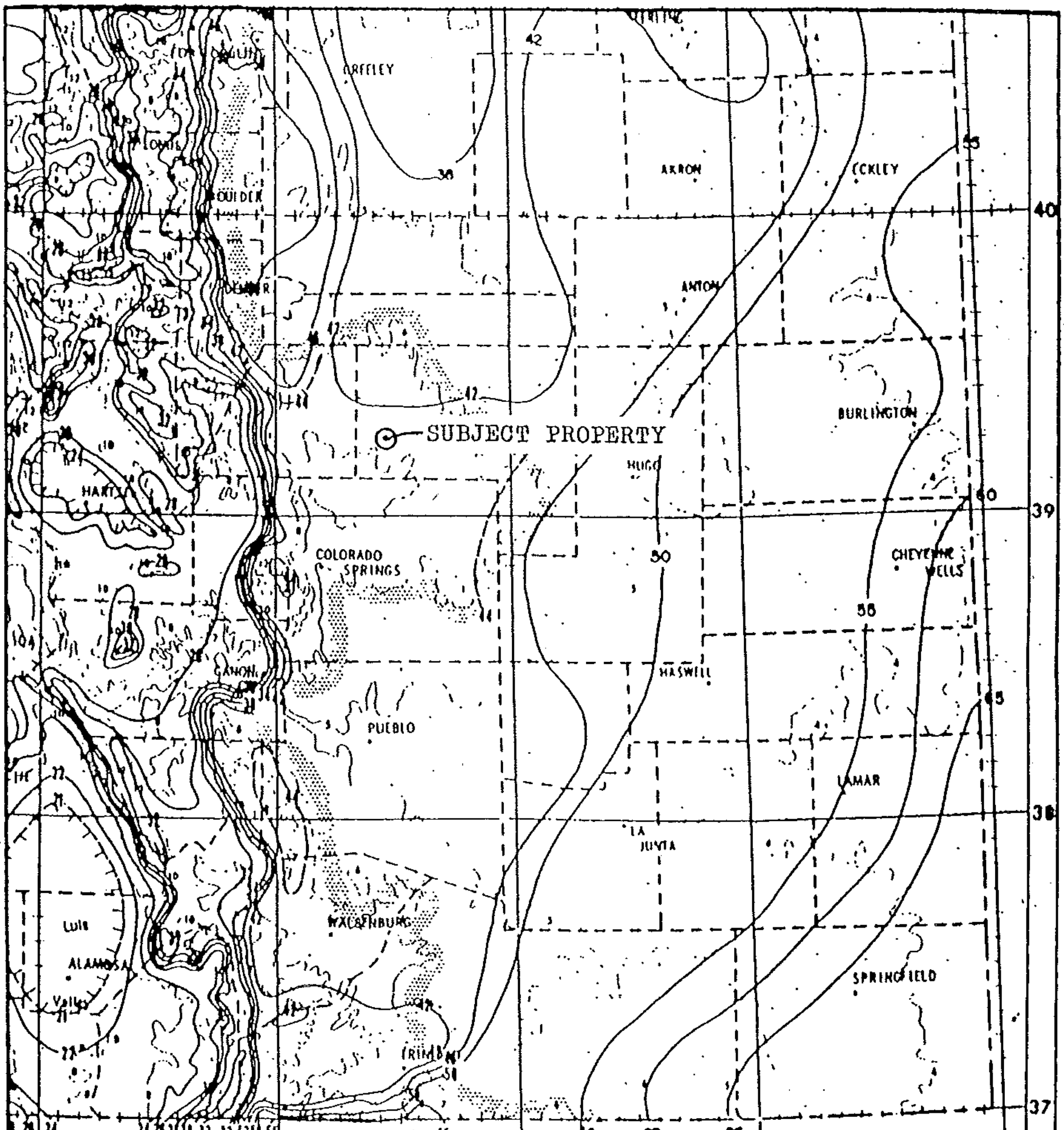
$$\times \frac{1}{3600} = 0.66 \text{ HR.}$$

6 Basin "E" Design Point 5

L1 (0-33⅓%) = 2,267' @ 5.5% V1 = 3.7 Type = NAT.SW.
L2 (33⅓-66⅔%) = 2,267' @ 3.5% V2 = 3.0 Type = NAT.SW.
L3 (66⅔-100%) = 2,267' @ 2.6% V3 = 2.6 Type = NAT.SW.
L4 = ____ V4 = ____ Type = ____
L5 ( ) = ____ V5 = ____ Type = ____
L6 ( ) = ____ V6 = ____ Type = ____

$$Tc = \frac{2,267}{3.7} + \frac{2,267}{3.0} + \frac{2,267}{2.6} + \_\_ + \_\_ + \_\_$$

$$\times \frac{1}{3600} = 0.62 \text{ HR.}$$



NOAA ATLAS 2, Volume III
Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION
IN TENTHS OF AN INCH

FIG. S-7

106 105 104 103 102

Figure S-1

Peak Discharge in
csm Per inch of Runoff
Versus
Time of Concentration, Tc
Type II Storm Distribution
Type II-A Storm Distribution

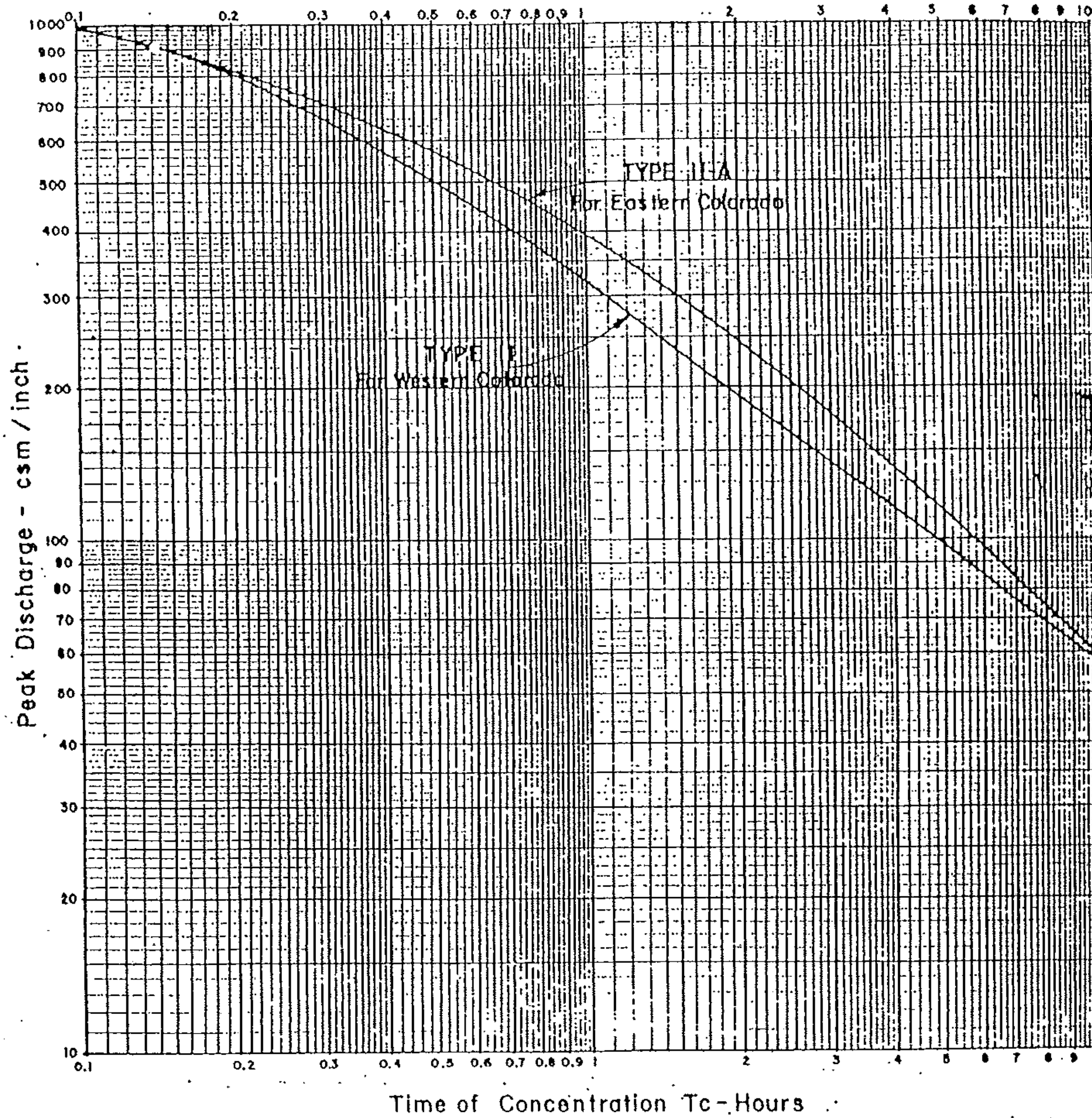


Table 2-1.--Runoff depth in inches for selected CN's and rainfall amounts

Rainfall (inches)	Curve Number (CN)[1/]								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0.03	0.08	0.17	0.32	.56	.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	.74	.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

1/ To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use an arithmetic interpolation.

SCS URBAN HYDROLOGY

DESIGN POINT	BASIN	D.A. $mi.^2$	T_c hr.	q csm/in.	CN	RUNOFF - in. R__	R__	R__	R 100	PEAK FLOWS - cfs Q__	Q__	Q__	Q 100
1	A	2.439	2.09	188	75.2				1.8727				858.7
2	B	0.591	0.91	345	72.1				1.6503				336.5
2	A+B	3.030	2.53	163	74.6				1.8287				903.2

RAINFALL: P 100 = 4.24

P____ =

P____ =

P____ =

Land use	Hydrologic soil group					
	B			C		
	Pct.	CN	Product	Pct.	CN	Product
Residential (30 pct. impervious)	20	72	1,440	20	81	1,620
Residential (65 pct. impervious)	6	85	510	6	90	540
Roads with open ditches	4	89	356	4	92	368
Roads with curbs and sewers	5	98	490	5	98	490
Open land:						
Fair cover	4	69	276	4	79	316
Good cover	4	61	244	4	74	296
Parking lots, plazas, etc.	7	98	686	7	98	686
	50		4,002	50		4,316

Thus $$\text{Weighted CN} = \frac{4002 + 4316}{100} = 83.18 \quad \text{(use 83)}$$

Example 4

A 175-acre watershed is 30 percent agricultural and 70 percent urban land. The agricultural area is 40 percent cultivated land with conservation treatment, 35 percent meadow in good condition, and 25 percent forest land with good cover. The urban area is residential: 60 percent is 1/3-acre lots, 25 percent is 1/4-acre lots, and 15 percent is streets and roads with curbs and storm sewers. The entire watershed is in B hydrologic soil group.

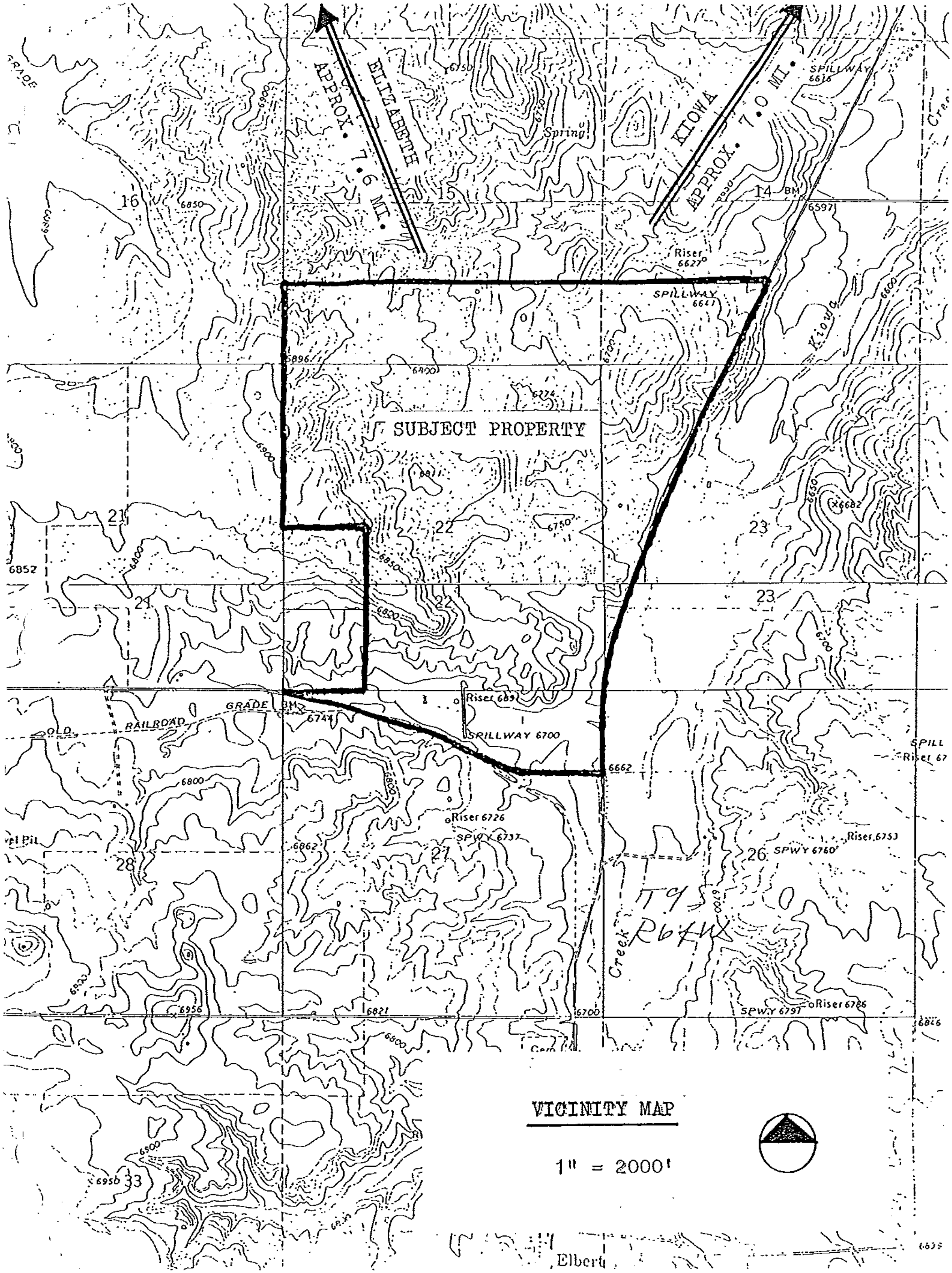
Display the data given and compute the weighted composite runoff curve number using curve numbers for the given land use in table 2.

Land use	Acres	Curve Number	Product
Agricultural:	(52)		
Cultivated land (conservation treatment)	21	71	1,491
Meadow (good cover)	18	58	1,044
Forest (good cover)	13	55	715
Urban:	(123)		
1/3-acre lots	74	72	5,328
1/4-acre lots	31	75	2,325
Streets and roads with curbs and storm sewers	18	98	1,764
	175		12,667

Thus $$\text{Weighted CN} = \frac{12667}{175} = 72.4 \quad \text{(use 72)}$$

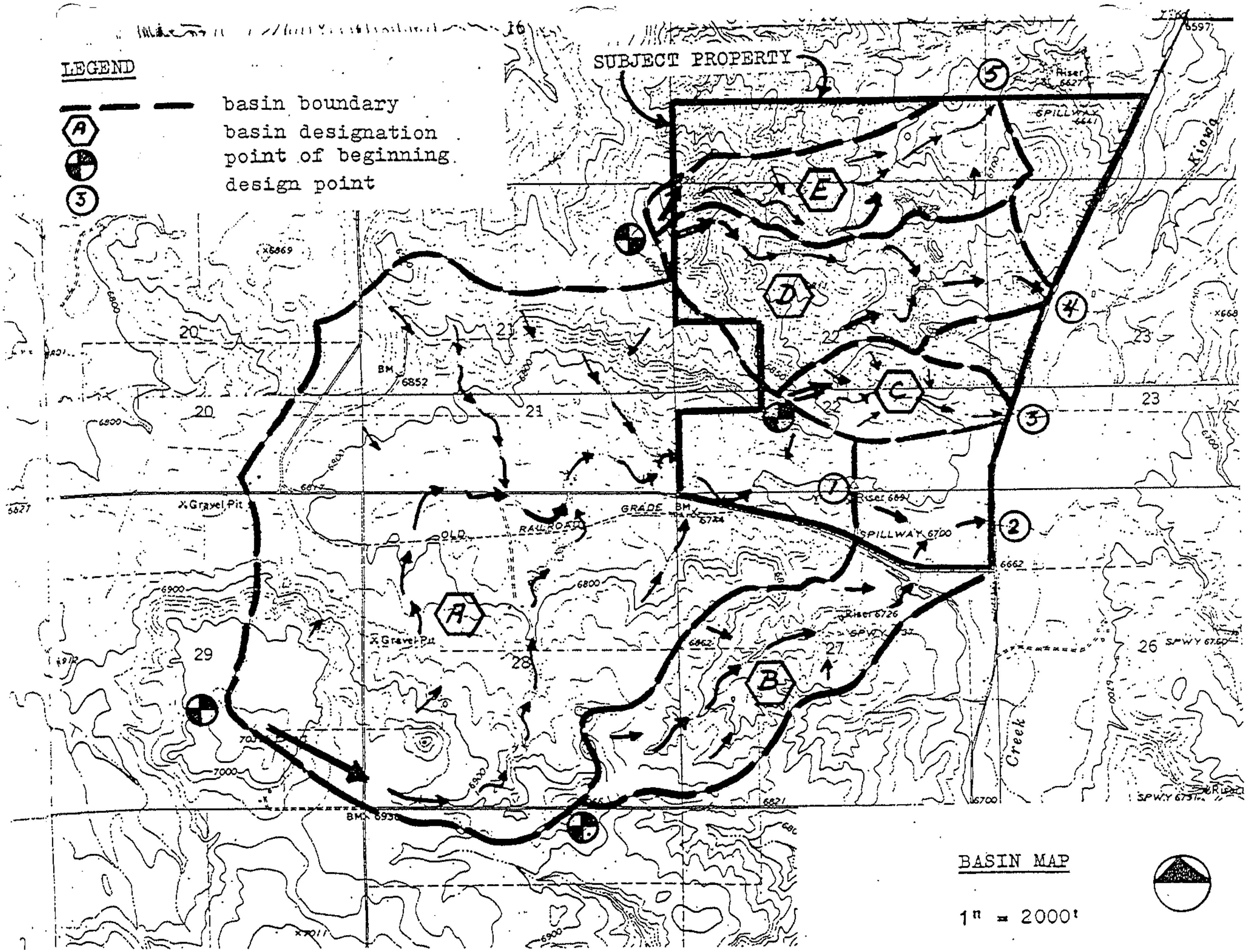
GENERAL EXAMPLE

VICINITY & OVERALL BASIN MAPS



VICINITY MAP

1" = 2000'



BASIN MAP

1" = 2000'

SOILS DATA

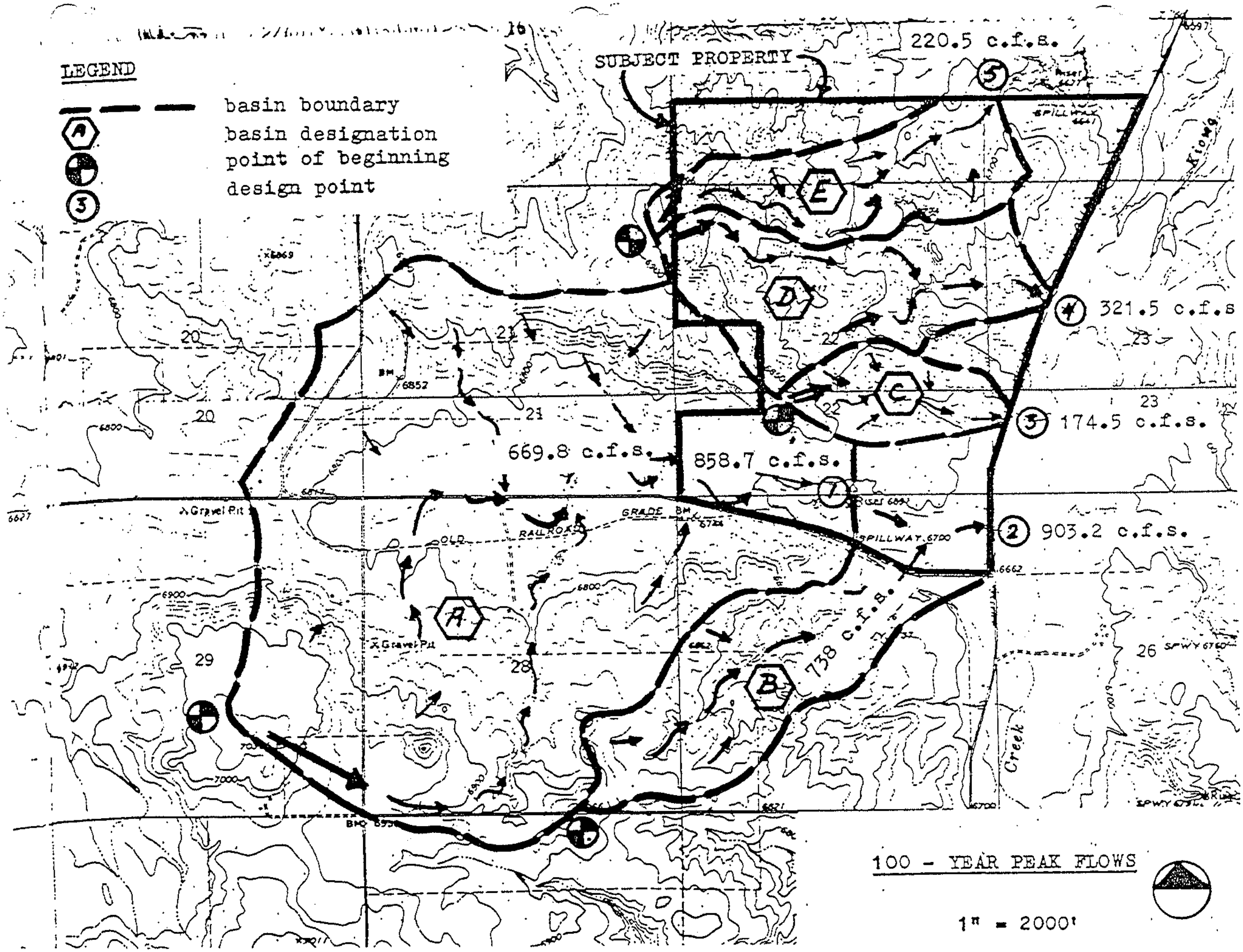
SCS URBAN HYDROLOGY

DESIGN POINT	BASIN	D.A. $mi.^2$	T_c hr.	q csm/in.	CN	RUNOFF - in.				PEAK FLOWS - cfs			
						R_	R_	R_	R 100	Q_	Q_	Q_	Q 100
3	C	0.164	0.43	550	76.0				1.9346				174.5
4	D	0.429	0.66	430	73.4				1.7430				321.5
5	E	0.296	0.62	440	72.7				1.6931				220.5

RAINFALL: P 100 = 4.24
P___ =
P___ =
P___ =

LEGEND

basin boundary
basin designation
point of beginning
design point



100 - YEAR PEAK FLOWS

1" = 2000'

TABLES & FIGURES

(SCS)

HYDROLOGIC DESIGN DATA SHEET

S C S METHOD: PART 1

LOCATION DATA

Subdivision Name ______________________ Tract No. ____________
Location: Section __________ Township __________ Range __________
Drainage Area Identification ______________________________

DESIGN DATA

Length of Drainage Area	________	Miles
Area of Drainage Area	________	Square Miles
Average Width of Drainage Area	________	Feet
Elevation		
Top of Drainage Area	________	Feet
At Subdivision	________	Feet
Differential	________	Feet
Average Slope of Drainage Area	________	%
Average Width of Drainage Area	________	Feet
Width Factor W_f	________	
Vegetative Cover Type	________	
Vegetative Cover Density	________	%
Soil Group	________	
Precipitation	________	
P = 6 Hour =	________	Inches
P = 24 Hour =	________	Inches

ESIGN COMPUTATIONS

Precipitation	P = 1 Hour =	________	Inches
Curve No.		________	
Runoff	Q =	________	Inches
Time of Concentration	Tc =	________	Hours
Time of Peak	$Tp = (Tc)(W_f)$	________	Hours

Peak Discharge $Qp = \frac{484\ AQ}{Tp} =$

= ________ cfs

Computed by ______________________________ Date ______________

EXAMPLE

100 YR

ARIZONA HIGHWAY DEPARTMENT
BRIDGE DIVISION

HYDROLOGIC DESIGN DATA SHEET

S C S METHOD: PART I

LOCATION DATA:

PROJECT	FIESTA RV RESORT
CITY, COUNTY	RIVIERA, MOHAVE
BASIN DESCRIPTION	

DESIGN DATA:

Design Frequency	100	years
Drainage Area	2.712	square miles
Drainage Length	28,000	feet
Elevation		
Top of Drainage Area	1480	feet
At Structure	550	feet
Drainage Area Slope	3.3	%
Drainage Width	2400 - 3000	feet
Width factor W_f	0.89	
Vegetative Cover Type	Desert Brush	
Vegetative Cover Density	10 - 20	%
Soil Group	B	
Precipitation		
P = 6 hour =	3.24	inches (FIGURE 1)
P = 24 hour =	4.02	inches (FIGURE 1)

DESIGN COMPUTATION:

Precipitation	P = 1 hour =	2.47	inches (FIGURE 1)
Curve Number		83 78	
Runoff	Q =	1.0 1.47	inches (FIGURE 2-4)
Time of Concentration	Tc	.88	hours (FIGURE 2-5)
Time of Peak	$Tp = (Tc)(W_f)$	.78	hours

Peak Discharge $Qp = \frac{484\,AQ}{Tp} = \frac{484 \times 2.71 \times 1.0}{.78}$

$= 1683$ cfs

Computed by RSS Date

50yr

ARIZONA HIGHWAY DEPARTMENT
BRIDGE DIVISION

HYDROLOGIC DESIGN DATA SHEET

S C S METHOD: PART I

LOCATION DATA:

PROJECT: Fiesta R.V. Resort
CITY, COUNTY: Riviera, Mohave
BASIN DESCRIPTION:

DESIGN DATA:

Design Frequency	50	years
Drainage Area	2.712	square miles
Drainage Length	28,000	feet
Elevation		
Top of Drainage Area	1480	feet
At Structure	550	feet
Drainage Area Slope	3.3	%
Drainage Width	2400-3000	feet
Width factor W_f	.89	
Vegetative Cover Type	Desert Brush	
Vegetative Cover Density	10-20	%
Soil Group	B	
Precipitation		
P = 6 hour =	2.86	inches (FIGURE 1)
P = 24 hour =	3.55	inches (FIGURE 1)

DESIGN COMPUTATION:

Precipitation	P = 1 hour =	2.18	inches (FIGURE 1)
Curve Number		83	
Runoff	Q =	.80	inches (FIGURE 2-4)
Time of Concentration	Tc	.78	hours (FIGURE 2-5)
Time of Peak	$T_p = (T_c)(W_f)$		hours

Peak Discharge $Q_p = \frac{484\,AQ}{T_p} = \frac{484 \times 2.712 \times .80}{.78}$

$= 1346$ cfs

Computed by PAH Date

10 yr.

ARIZONA HIGHWAY DEPARTMENT
BRIDGE DIVISION

HYDROLOGIC DESIGN DATA SHEET

S C S METHOD: PART I

LOCATION DATA:

PROJECT	FIESTA RV. RESORT
CITY, COUNTY	RIVIERA MOHAVE
BASIN DESCRIPTION	

DESIGN DATA:

Design Frequency	10	years
Drainage Area	2.712	square miles
Drainage Length	28,000	feet
Elevation		
Top of Drainage Area	1480	feet
At Structure	550	feet
Drainage Area Slope	3.3	%
Drainage Width	2400 – 3000	feet
Width factor W_f	0.89	
Vegetative Cover Type	DESERT BRUSH	
Vegetative Cover Density	10–20	%
Soil Group	B	
Precipitation		
P = 6 hour =	2.05	inches (FIGURE 1)
P = 24 hour =	2.47	inches (FIGURE 1)

DESIGN COMPUTATION:

Precipitation	P = 1 hour =	1.60	inches (FIGURE 1)
Curve Number		83	
Runoff	Q =	0.4	inches (FIGURE 2-4)
Time of Concentration	Tc	.88	hours (FIGURE 2-5)
Time of Peak	$Tp = (Tc)(W_f)$	.78	hours

Peak Discharge $Qp = \frac{484\,AQ}{Tp} = \frac{484 \times 2.712 \times .4}{.78}$

$= 673$ cfs

Computed by [signature] Date

CO-EN-5 (Rev. 3/80)

For Use With "Peak Flows In Colorado"

U.S. Department of Agriculture

Soil Conservation Service

Colorado

HYDROLOGY DATA SUMMARY SHEET

Project Name ______________________________ Location ______________

Compiled by ____________ Date ___________ Checked by _________ Date ___________

Basic Data for Determining Weighted Soil Cover Complex Number and Percent Impervious Area

Hydrologic Soil Group (Letter) (1)	Land Use, Treatment and Condition (2)	Area (Acres) (3)	Soil Cover Complex No. (Number) (4)	Complex No. Times Area (Cols. 3x4) (5)
	TOTALS			

Weighted Soil Cover Complex No. is $\frac{\text{(Total of Col. 5)}}{\text{(Total of Col. 3)}}$ = ________ =

Computation of Tc Using Travel Time

$$Tc = \frac{\text{Length of Segment (Li)}}{\text{Velocity Through Segment (Vi)}} = \frac{L_1}{V_1} + \frac{L_2}{V_2} + \frac{L_3}{V_3} + \ldots \frac{L_n}{V_n} \times \frac{1}{3600} = \text{Hrs.}$$

Li=Ft. Vi=Ft/Sec.

Basin ________ Design Point ________

L1 (25%) = ________ V1 = ________ Type = ________

L2 (25%-50%) = ________ V2 = ________ Type = ________

L3 (50%-75%) = ________ V3 = ________ Type = ________

L4 (75%-100%) = ________ V4 = ________ Type = ________

L5 (   ) = ________ V5 = ________ Type = ________

L6 (   ) = ________ V6 = ________ Type = ________

Tc = ____ + ____ + ____ + ____ + ____ + ____

$\times \frac{1}{3600}$ = ________ HR.

Basin ________ Design Point ________

L1 (25%) = ________ V1 = ________ Type = ________

L2 (25%-50%) = ________ V2 = ________ Type = ________

L3 (50%-75%) = ________ V3 = ________ Type = ________

L4 (75%-100%) = ________ V4 = ________ Type = ________

L5 (   ) = ________ V5 = ________ Type = ________

L6 (   ) = ________ V6 = ________ Type = ________

Tc = ____ + ____ + ____ + ____ + ____ + ____

$\times \frac{1}{3600}$ = ________ HR.

Table 2-1.--Runoff depth in inches for selected CN's and rainfall amounts

Rainfall (inches)	Curve Number (CN)[1]								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0.03	0.08	0.17	0.32	.56	.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	.74	.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

[1] To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use an arithmetic interpolation.

SCS URBAN HYDROLOGY

DESIGN POINT	BASIN	D.A. $mi.^2$	T_c hr.	q csm/in.	CN	RUNOFF - in.				PEAK FLOWS - cfs			
						R__	R__	R__	R__	Q__	Q__	Q__	Q__

RAINFALL: P____ =
P____ =
P____ =
P____ =

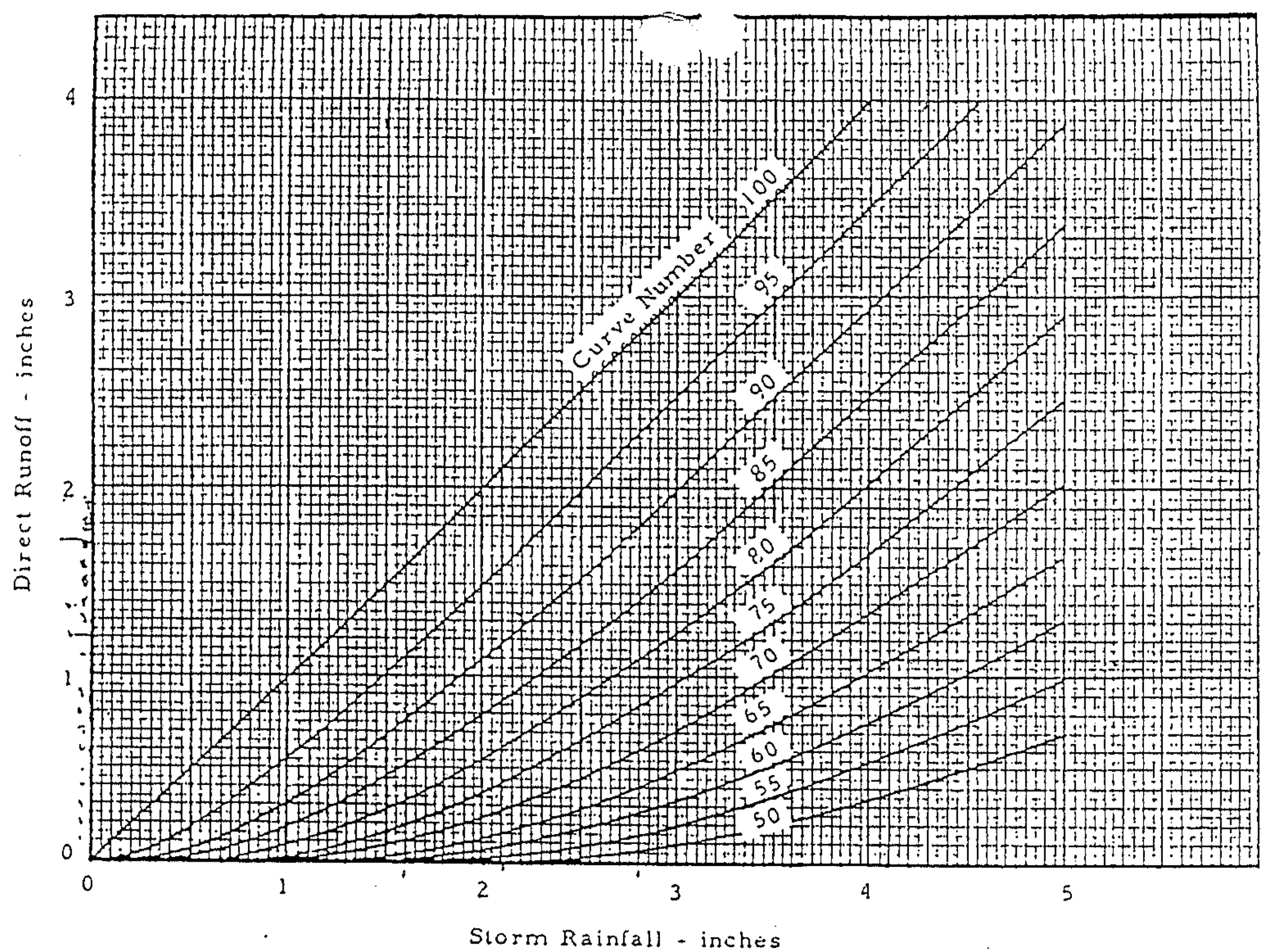


Fig. 2-4

SOLUTION OF
RAINFALL - RUNOFF EQUATION

Soil Conservation Service

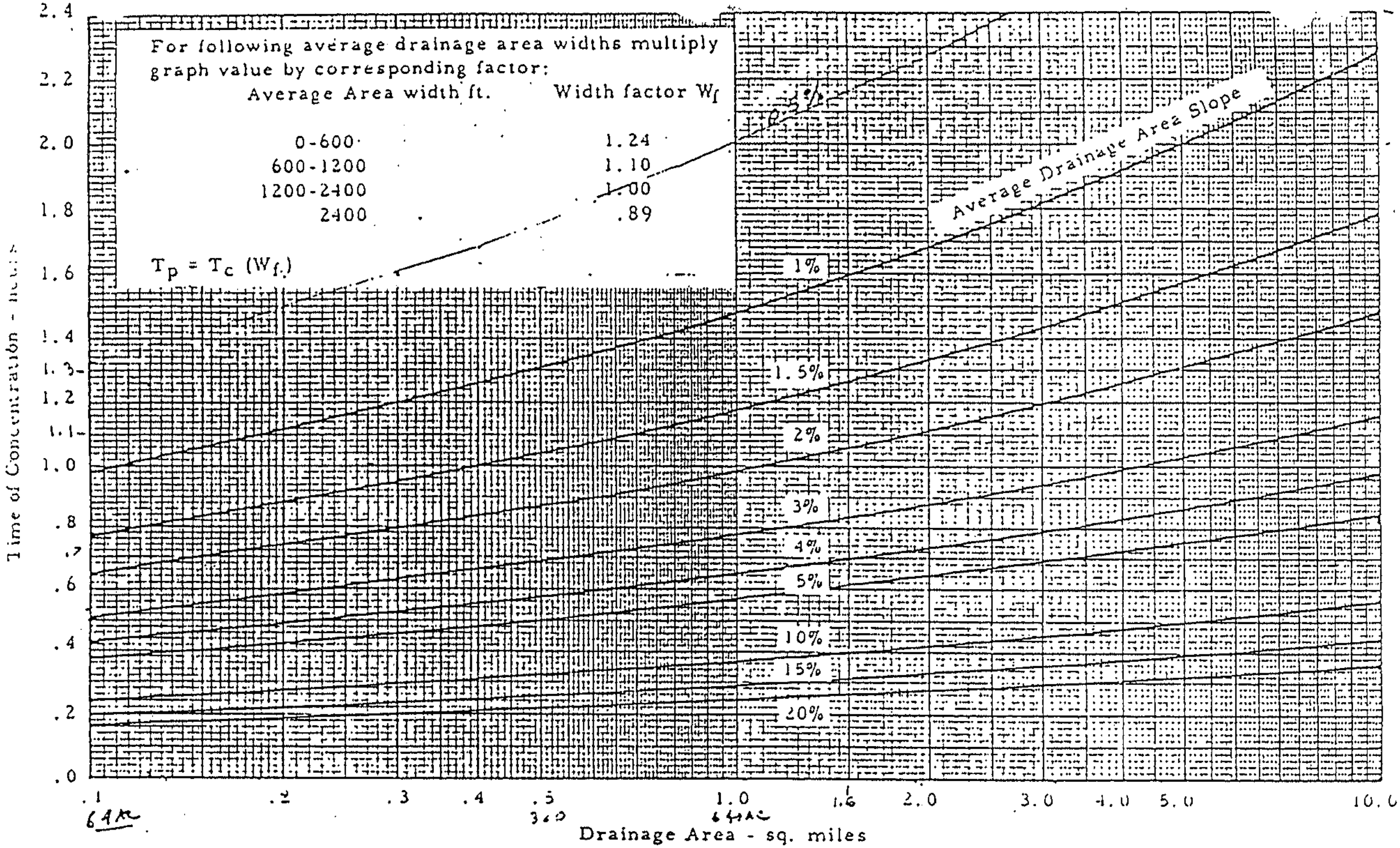


Fig. 2-5

TIME OF CONCENTRATION
FOR
DRAINAGE AREAS LESS THAN 10 SQ. MILES

Soil Conservation Service

Project

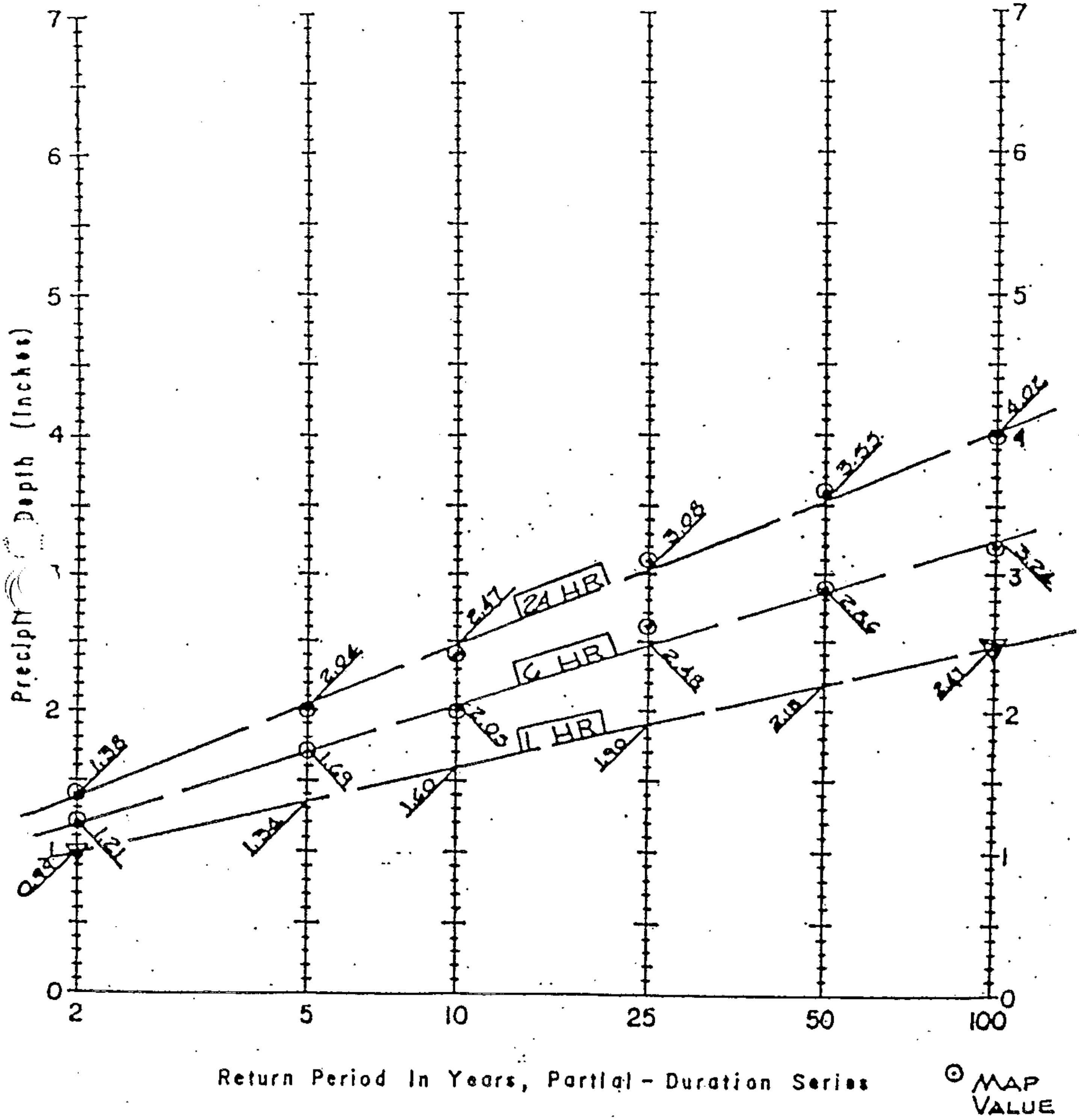
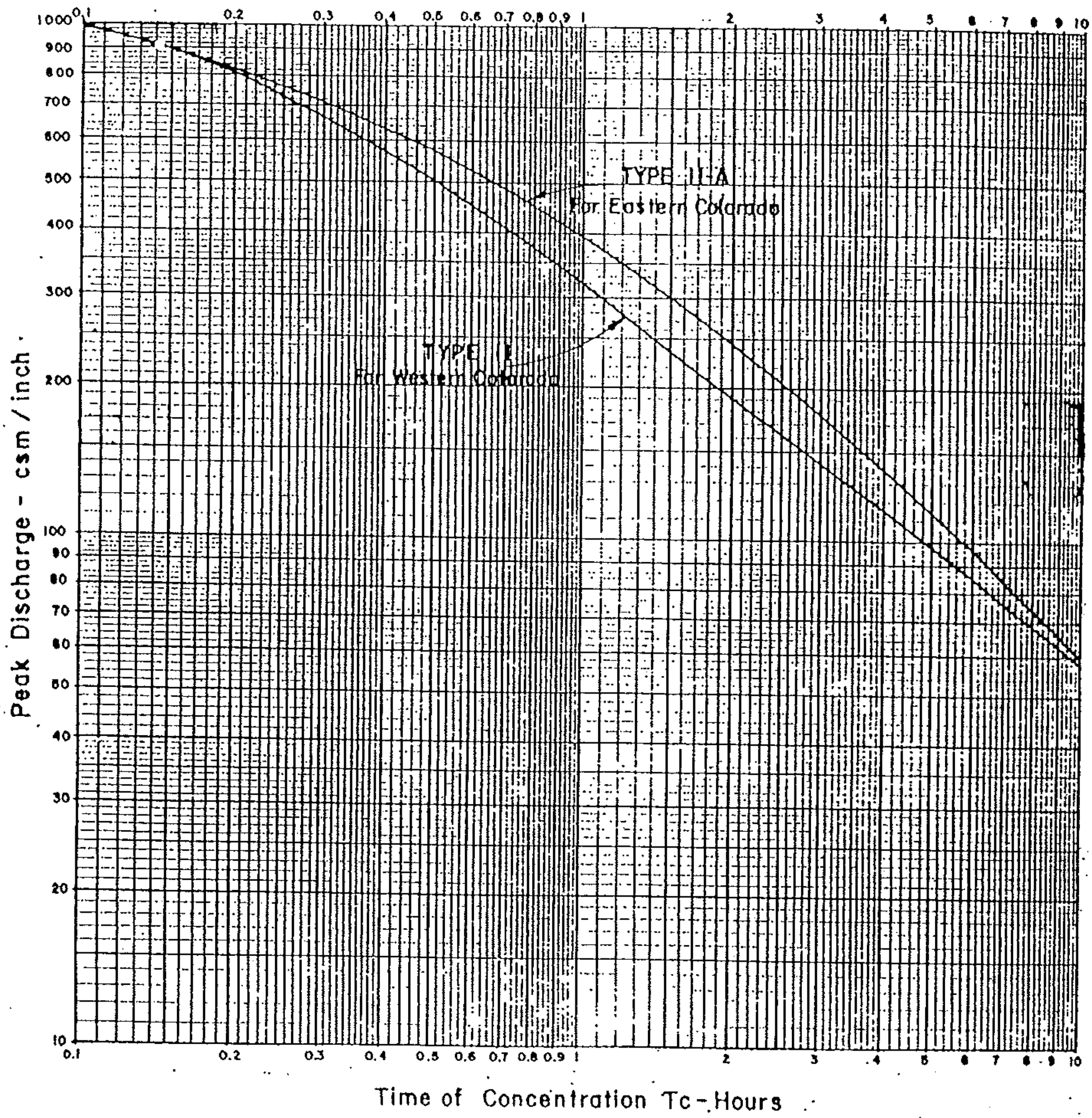
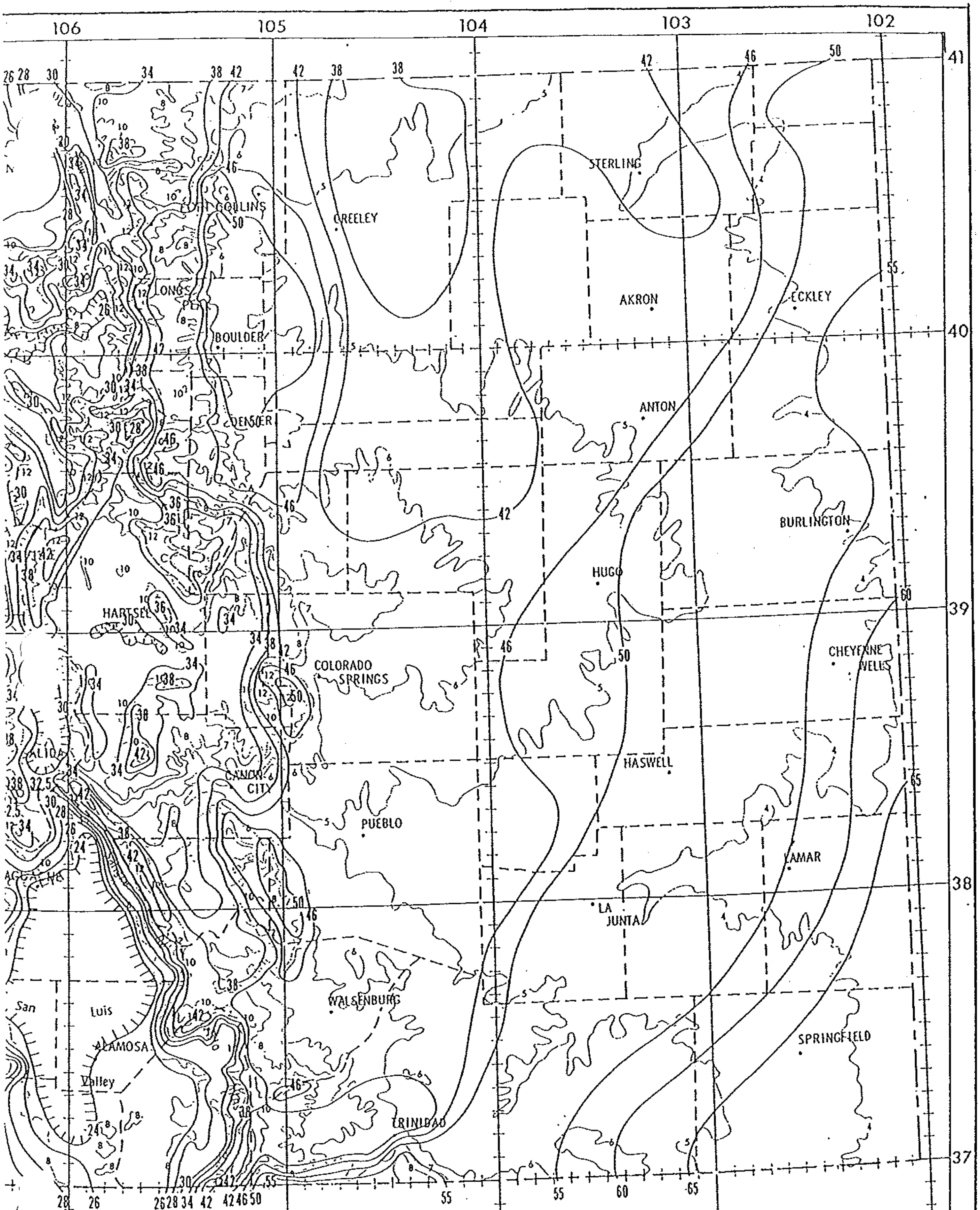


Figure 1 Precipitation Depth Versus Return Period for Partial - Duration Series

Figure S-1

Peak Discharge in
csm Per inch of Runoff
Versus
Time of Concentration, Tc
Type II Storm Distribution
Type II-A Storm Distribution





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National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

Figure 31

ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

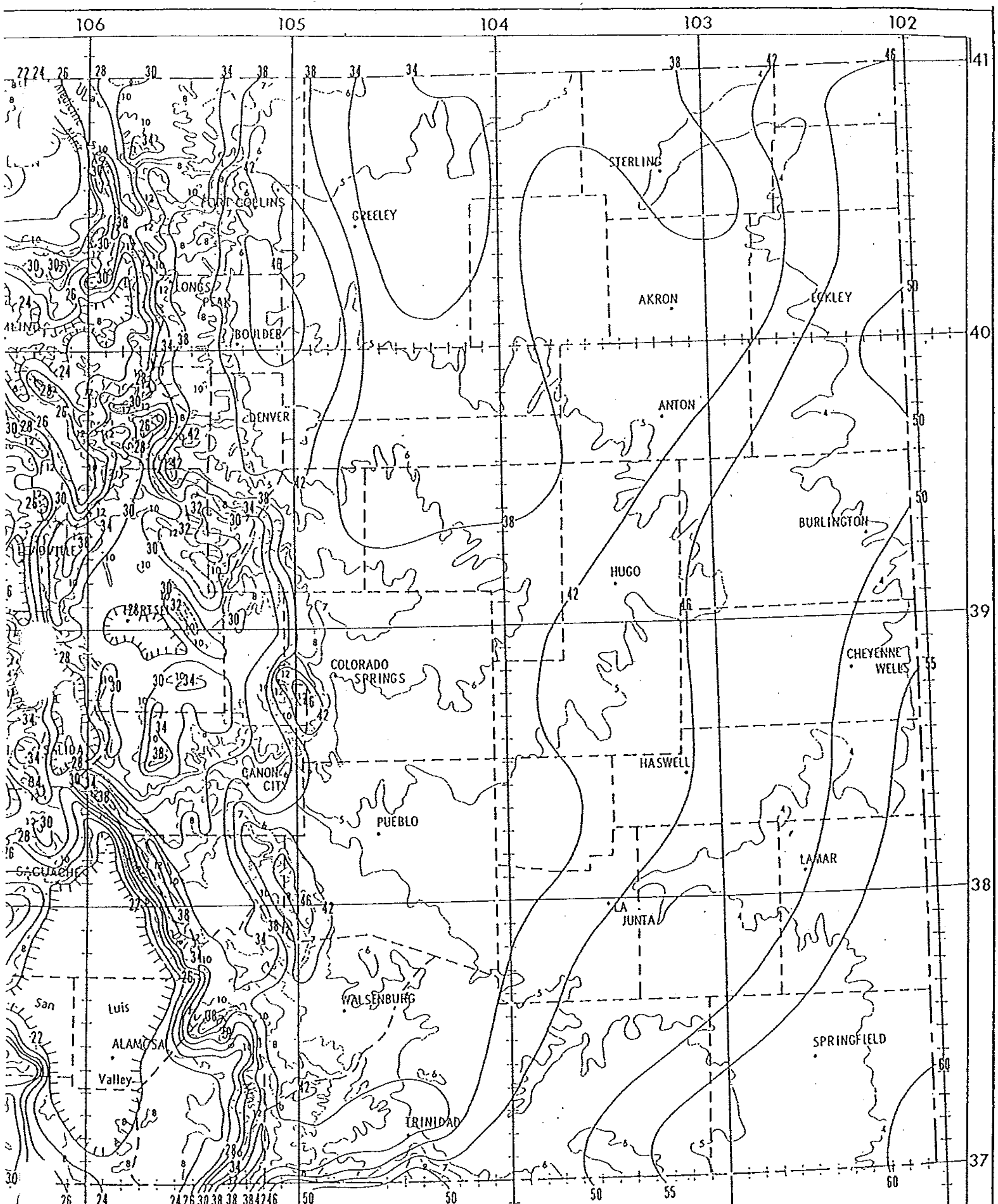

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Figure 30

ISOPLUVIALS OF 50-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

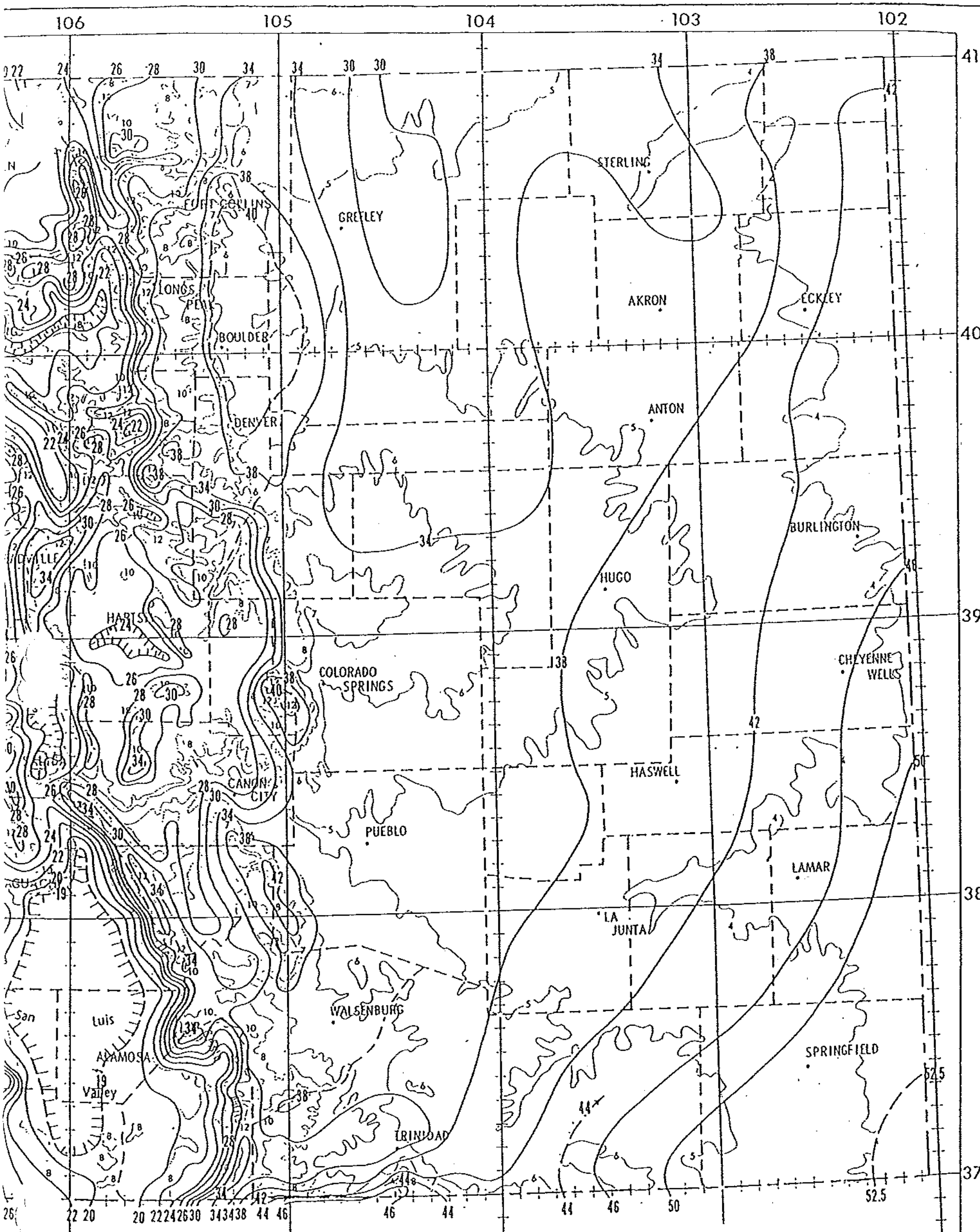

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Figure 29

ISOPLUVIALS OF 25-YR 24-HR PRECIPITATION
IN TENTHS OF AN INCH

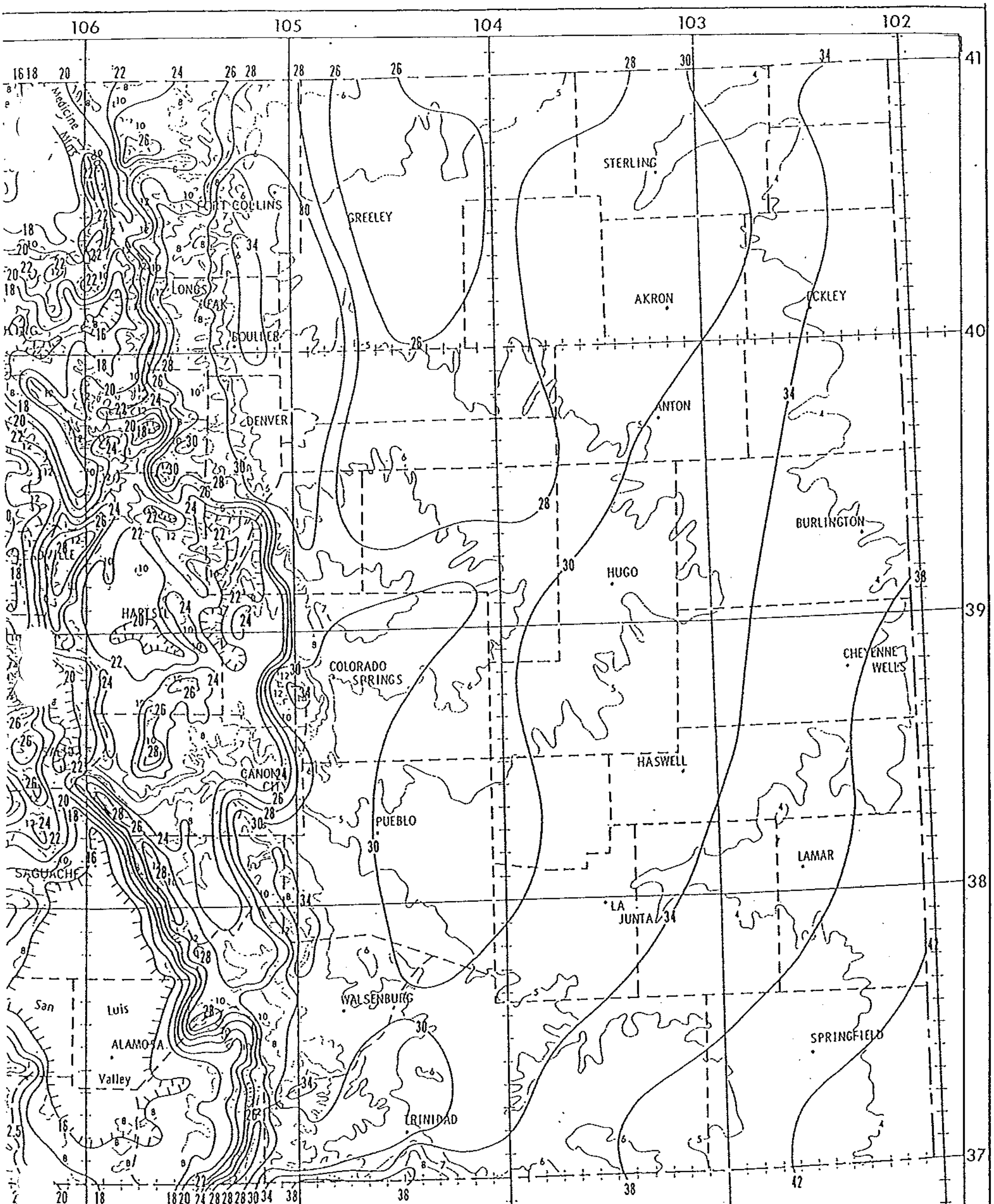

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Figure 28

ISOPLUVIALS OF 10-YR 24-HR PRECIPITATION
IN TENTHS OF AN INCH

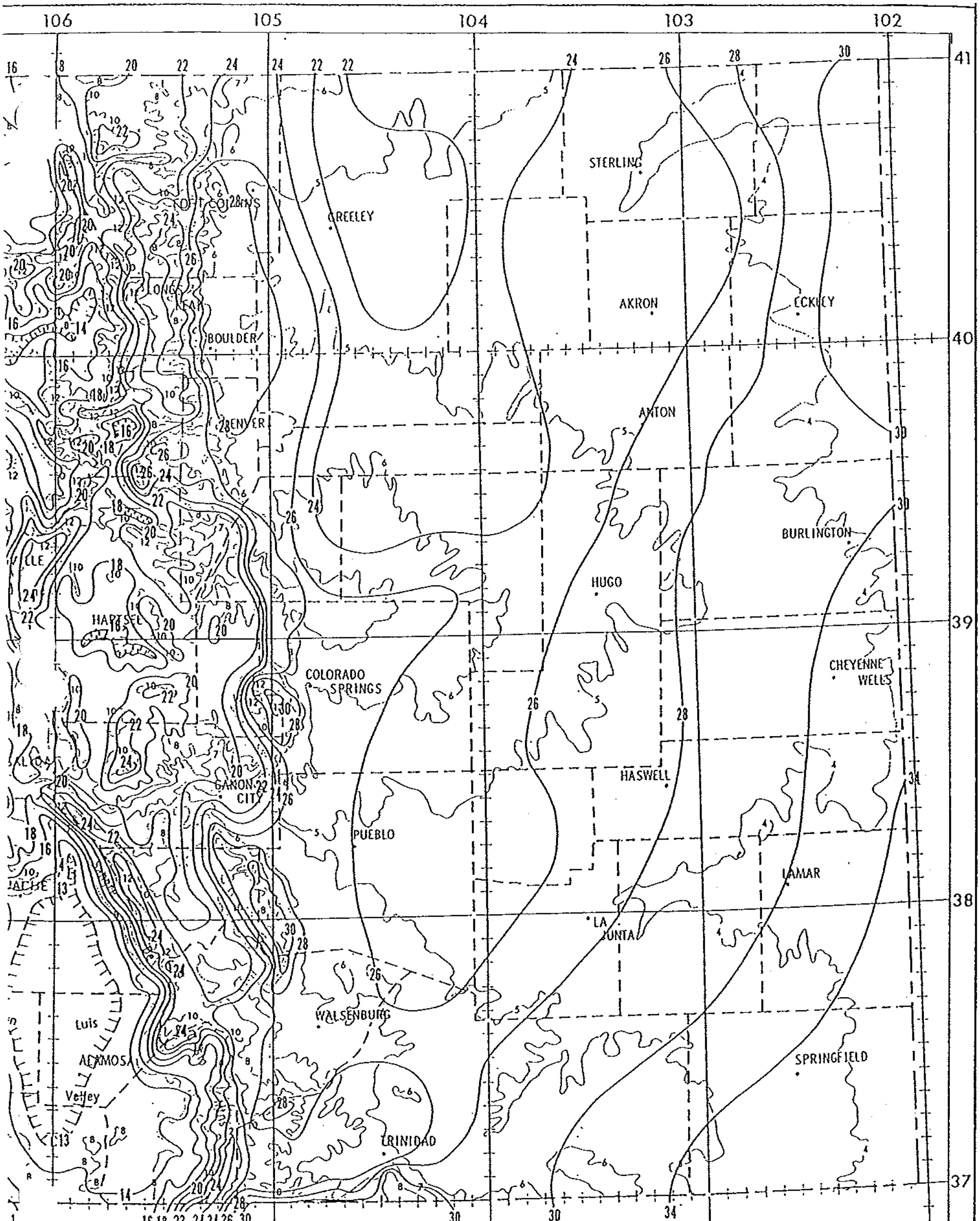

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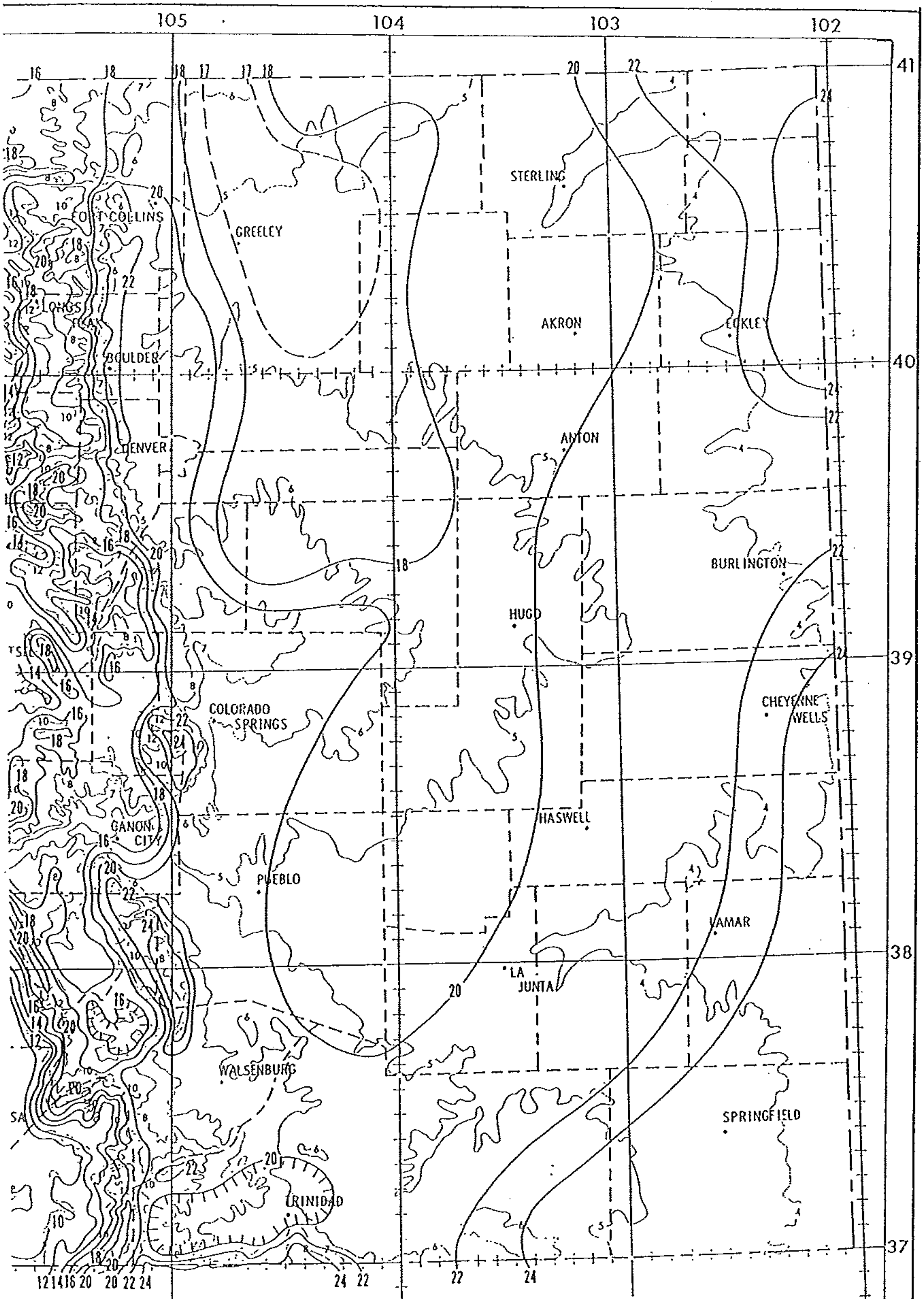
Figure 27

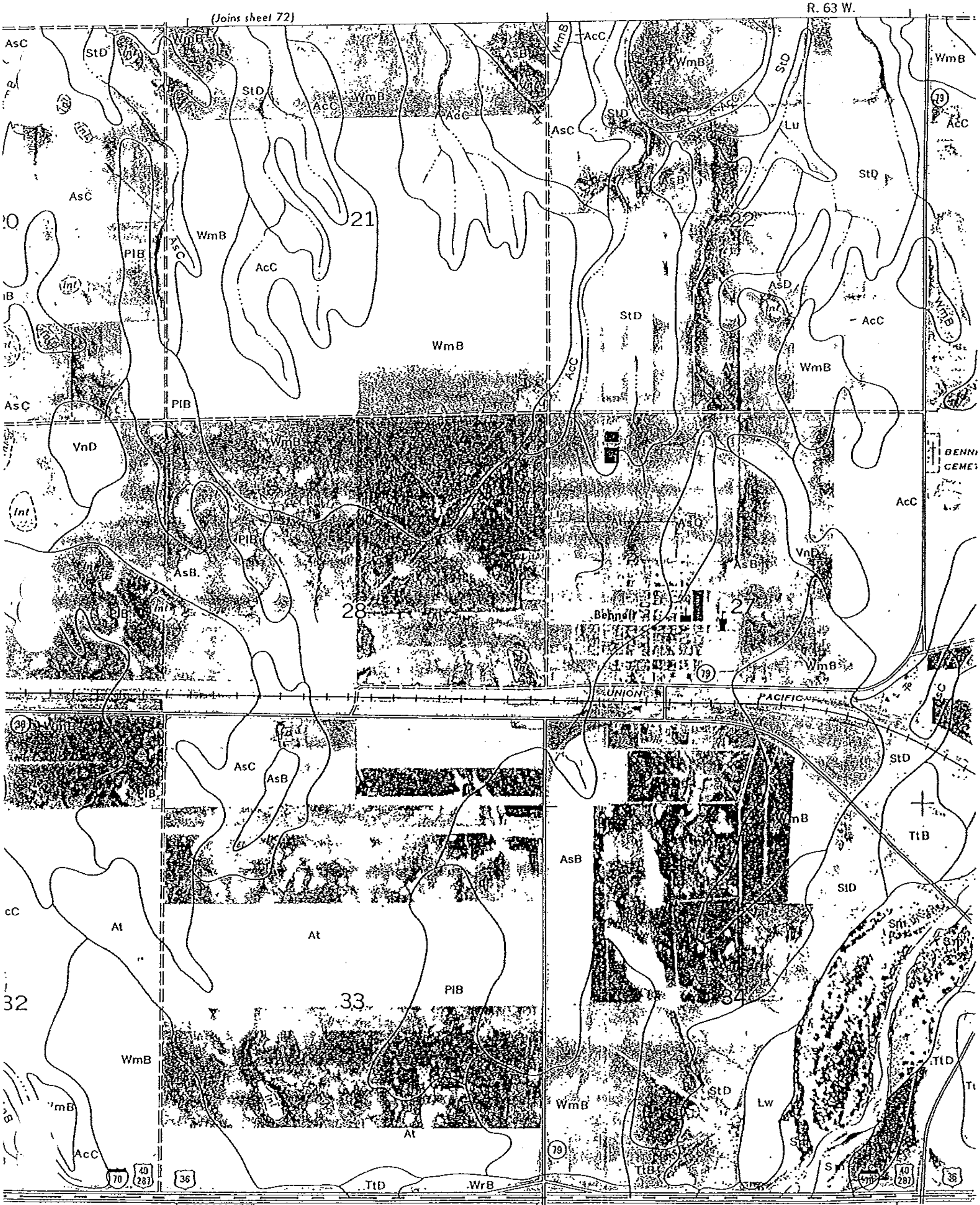
ISOPLUVIALS OF 5-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH



olume III
epartment of Commerce
d Atmospheric Administration
ervice, Office of Hydrology
epartment of Agriculture,
ervice, Engineering Division

Figure 26

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH


(Joins sheet 72)
R. 63 W.
AsC
StD
WmB
AcC
AsB
Lu
PlB
VnD
AsD
21
22
28
27
33
34
32
Bennett
UNION
PACIFIC
TtB
At
Lw
TtD
WrB
79
36
70
40
287
38
2 295 000 FEET
ARAPAHOE COUNTY

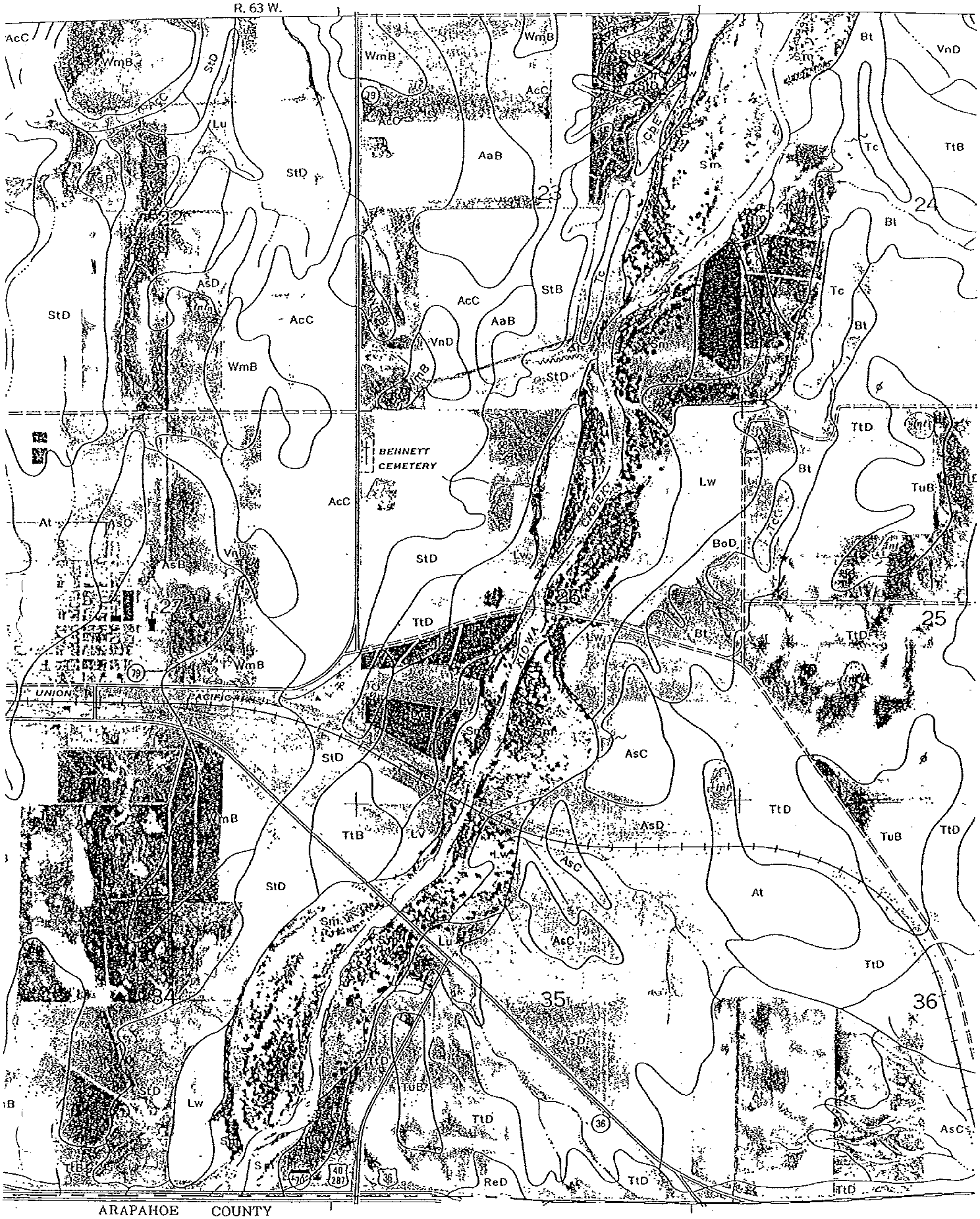

R. 63 W.
BENNETT CEMETERY
UNION PACIFIC
KIOWA CREEK
22
23
24
25
26
27
34
35
36
ARAPAHOE COUNTY

TABLE 6.—*Estimated properties*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The soil for referring to the other series that appear in the first colu

Soil series and map symbols	Depth from surface	Classification — USDA texture	Unified	AASHO
	Inches			
*Adena: AaB, AaC, AcC, AcD. For properties of Colby soils in AcC and AcD, refer to Colby series.	0–11	Loam, clay loam, silty clay loam.	ML or CL	A–4 or A–6
	11–60	Silty clay loam, silt loam	ML or CL	A–4 or A–6
Arvada: AdB	0–4	Loam, sandy loam	SM or ML	A–4 or A–2
	4–28	Clay, sandy clay	CL or CH	A–7
	28–60	Sandy loam	SM	A–2 or A–4
*Ascalon: ArB, ArC, AsB, AsC, AsD, At, AvC. For properties of Platner soils in At and Vona soils in AvC, refer to their respective series.	0–21	Loamy sand, sandy loam, and sandy clay loam.	SM or SC	A–2 or A–4
	21–60	Sandy loam	SM	A–2 or A–4
*Blakeland: BoD, Bt. For properties of Truckton soils in Bt, refer to Truckton series.	0–60	Loamy sand and sand	SP–SM or SM	A–2 or A–3
Colby: CbE	0–60	Loam and fine sandy loam	ML	A–4
Dacono: DaA, DaB	0–9	Loam	ML	A–4
	9–17	Clay	CH	A–7
	17–26	Sandy clay loam	SC	A–4
	26–60	Very coarse loamy sand, sand, and gravel.	SP or SM, SP–SM, or GP–GM	A–1
Deertrail. Mapped only in a complex with Weld soils.	0–9	Very fine sandy loam and loam	ML	A–4
	9–21	Clay	CH	A–7
	21–60	Silty clay loam and loam	CL or ML	A–4 or A–6
Gravelly land-Shale outcrop complex: Gr. Properties too variable to be estimated.				
Gullied land: Gu. Properties too variable to be estimated.				
Heldt: HlB, HlD	0–32	Clay	CH	A–7
	32–60	Silty clay loam, sandy clay loam.	CL	A–6
Loamy alluvial land:				
Lu	0–60	Loam, silt loam, and clay loam	ML or CL	A–4 or A–6
Lv	0–20	Stratified loam	ML	A–4
	20–60	Sand and gravel	SP or GP	A–1
Lw	0–36	Loam, clay, and stratified loam	ML or CL	A–4 or A–6
	36	Gravel	GP	A–1
Nunn:				
NlA, NlB	0–9	Loam and clay loam	ML	A–4 or A–6
	9–23	Clay	CH	A–7
	23–60	Loam and silt loam	CL or ML	A–4
NuA, NuB	0–9	Clay loam	CL	A–6
	9–23	Clay	CH	A–7
	23–60	Loam and silt loam	CL or ML	A–6 or A–4
Platner: PlB, PlC	0–9	Loam	ML	A–4
	9–18	Clay	CH	A–7
	18–60	Clay loam, loam, and sandy loam.	SM, ML, or CL	A–6 or A–4
Renohill: ReB, ReD	0–9	Loam and clay loam	ML or CL	A–6
	9–28	Clay and clay loam	CH	A–7
	28	Shale and sandstone.		

TABLE 6.—*Estimated properties*

Soil series and map symbols	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Rough broken land: Ro. Properties too variable to be estimated.				
*Samsil: SaE, ShF. For properties of Shingle soils in ShF, refer to Shingle series.	0–14 14	Silty clay Shale.	CL or CH	A–7
Sandy alluvial land: Sm. Properties too variable to be estimated.				
Satanta: SnA, SnB	0–48 48–60	Loam, clay loam Fine sandy loam and loamy sand.	CL or ML SM	A–6 A–2 or A–4
*Shingle: SrE. For properties of Renohill soils in this unit, refer to Renohill series.	0–12 12	Loam Interbedded sandstone and shale.	ML	A–4
Stoneham: StB, StD	0–13 13–60	Loam, sandy clay loam Gravelly loam, gravelly sandy loam.	SC or CL SM	A–4 or A–6 A–4 or A–2
Tassel. Mapped only in complexes with Terry, Ulm, and Vona soils.	0–18 18	Fine sandy loam Sandstone.	ML or SM	A–4
Terrace escarpments: Tc. Properties too variable to be estimated.				
*Terry: TeB, TeD, TrE, TsE. For properties of Tassel soils in TrE and TsE, Ulm soils in TrE, and Vona soils in TsE, refer to their respective series.	0–39 39	Loamy fine sand and fine sandy loam. Sandstone.	ML and SM	A–4
Truckton: TtB, TtD, TuB, TuC, TuD	0–21 21–60	Loamy sand and sandy loam Loamy sand and sand	SM SM or SM-SP	A–2 or A–4 A–2 or A–3
Ulm: UlB, UlC, UlD	0–30 30–48 48	Loam and clay Clay loam Shale and sandstone.	CL or CH CL	A–6 or A–7 A–6
Valent: VaD	0–60	Loamy sand and loamy fine sand.	SM or SM–SP	A–2 or A–3
*Vona: VnB, VnD, VoA, VoB, VoC, VsD. For properties of Ascalon soils in VsD, refer to Ascalon series.	0–40 40–60	Loamy sand and sandy loam Loamy sand	SM SM	A–2 or A–4 A–2
*Weld: WmB, WrB. For properties of Deertrail soils in WrB, refer to Deertrail series.	0–21 21–68	Loam and clay Loam, fine sandy loam, silt loam, and very fine sandy loam.	ML and MH CL or ML	A–4 and A–7 A–4 or A–6
Wet alluvial land: Wt. Properties too variable to be estimated.				
*Wiley: WuE. For properties of Adena and Renohill soils in this unit, refer to their respective series.	0–24 24–60	Loam and clay loam Very fine sandy loam	ML or CL ML	A–4 or A–6 A–4

TABLE 7.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The soils in referring to the other series

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
*Adena: AaB, AaC, AcC, AcD. For interpretations of Colby soils in AcC and AcD, refer to Colby series.	Generally fair but good in upper 4 inches.	Unsuited: more than 50 percent fines; no gravel.	Fair to poor: A-4 and A-6.	Unstable silty material below depth of 10 inches.
Arvada: AdB	Poor: saline-alkali clay at a depth of 4 inches.	Unsuited: more than 50 percent fines; no gravel.	Poor: A-7	Flooding hazard; plastic soils.
*Ascalon: ArB, ArC, AsB, AsC, AsD, At, AvC. For interpretations of Platner soils in At and Vona soils in AvC, refer to their respective series.	Fair to poor: sandy loam and loamy sand.	Poor: poorly graded; 30 to 50 percent fines; less than 25 percent gravel.	Good to fair: A-2 and A-4.	Severe hazard of soil blowing in borrow areas.
*Blakeland: BoD, Bt. For interpretations of Truckton soils in Bt, refer to Truckton series.	Poor: loamy sand	Good to fair for sand: 5 to 15 percent fines; no gravel.	Good: A-2 or A-3.	Severe hazard of soil blowing in borrow areas.
Colby: CbE	Fair: very calcareous.	Unsuited: more than 50 percent fines; no gravel.	Fair: A-4	Silty material
Dacono: DaA, DaB	Generally fair but good in upper 9 inches.	Good for sand below a depth of 35 inches; poorly graded. Good for gravel below a depth of 35 inches.	Fair to poor to a depth of 35 inches. Good below a depth of 35 inches; A-1, A-4, and A-7.	Clay and sandy clay loam to a depth of 35 inches; sand and gravel below a depth of 35 inches.
Deertrail. Mapped only in a complex with Weld soils.	Poor: saline-alkali soils; clayey subsoil.	Unsuited: more than 50 percent fines; no gravel.	Fair to poor: A-4 to A-7.	Saline-alkali material.
Gravelly land-Shale outcrop complex: Gr	Poor: gravel and shale.	Spotty source of good gravel; unsuitable for sand.	Fair to poor: shale and gravel spots.	Steep slopes; gravel and shale.
Gullied land: Gu	Poor: eroded soils susceptible to erosion.	Unsuited: more than 50 percent fines; no gravel.	Poor: gullied land.	Steep slopes; erodible soils.

See footnote at end of table.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
Heldt: HlB, HlD	Poor: high clay content; moderately alkaline.	Unsuited: more than 50 percent fines; no gravel.	Poor: A–6 and A–7.	Flooding hazard; plastic soils; high shrink-swell potential.
Loamy alluvial land:				
Lu	Generally fair but good in upper 10 inches.	Poor: sand and gravel stratified with silt.	Fair to poor: A–4 and A–6.	Subject to flooding
Lv	Generally poor but good in upper 6 inches.	Good below a depth of 10 to 20 inches; water table in gravel.	Fair to a depth of 20 inches; A–4; seasonal high water table. Good below depth of 20 inches; A–1.	High water table; subject to flooding.
Lw	Generally fair but good in upper 10 inches.	Good at a depth of 20 to 40 inches; seasonal water table at depth of about 3 feet.	Fair to poor to a depth of 36 inches; A–4 or A–6. Good below depth of 36 inches; A–1; seasonal water table at a depth of about 3 feet.	High water table; subject to flooding.
Nunn:				
NlA, NlB	Generally fair but good in upper 6 inches.	Unsuited: more than 50 percent fines; less than 5 percent gravel.	Fair to poor: A–4 to A–7.	High shrink-swell potential; A–4 and A–6.
NuA, NuB	Fair: clay loam	Unsuited: more than 50 percent fines; less than 5 percent gravel.	Fair to poor: A–4 to A–7.	Moderately plastic materials; A–4, A–6, and A–7.
Platner: PlB, PlC	Generally fair but good in upper 8 inches.	Poor: more than 50 percent fines; 10 percent sand and gravel below depth of 2 or 3 feet.	Fair to poor: A–4 to A–7.	Moderately plastic materials to depth of 2 or 3 feet.
Renohill: ReB, ReD	Fair to good: loam and clay loam; clay subsoil.	Unsuited: more than 50 percent fines; no gravel.	Poor: A–6 and A–7	Moderately plastic materials; shale and sandstone at depth of 20 to 36 inches.
Rough broken land: Ro. Interpretations too variable to be estimated.				
*Samsil: SaE, ShF. For interpretations of Shingle soils in ShF, refer to Shingle series.	Poor: clay	Unsuited: more than 50 percent fines; no gravel.	Poor: A–7	Interbedded shale and sandstone at depth of 6 to 20 inches; contains gypsiferous layers.
Sandy alluvial land: Sm. Interpretations too variable to be estimated.				

See footnote at end of table.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
Satanta: SnA, SnB	Generally fair but good in upper 9 inches.	Unsuited: more than 50 percent fines; no gravel.	Poor to a depth of 48 inches; A–6. Fair to good below a depth of 48 inches; A–2 or A–4.	Moderate shrink-swell potential.
*Shingle: SrE. For interpretations of Renohill soils in this unit, refer to Renohill series.	Poor: loam at depth of 10 to 20 inches over shale.	Unsuited: more than 50 percent fines; no gravel.	Fair: A–4; limited by sandstone and shale at depth of 10 to 20 inches.	Interbedded unstable sandstone and shale at depth of 10 to 20 inches.
Stoneham: StB, StD	Good to fair: loam and sandy clay loam.	Fair to poor for sand: 20 to 40 percent fines; less than 25 percent gravel.	Fair to good: A–2 to A–4.	Moderate shrink-swell potential to depth of about 1 foot.
Tassel. Mapped only in complexes with Terry, Ulm, and Vona soils.	Poor: sandstone at depth of 10 to 20 inches.	Poor to unsuited: 40 to 55 percent fines; no gravel.	Fair: A–4; sandstone at depth of 10 to 20 inches.	Irregular topography; fine-grained sandstone at depth of 10 to 20 inches.
[T]errace escarpments: Tc	Poor	Fair to good: extremely variable.	Good to fair: A–1 to A–4.	Steep slopes
[T]erry: TeB, TeD, TrE, TsE. For interpretations of Tassel soils in TrE and TsE, Ulm soils in TrE, and Vona soils in TsE, refer to their respective series.	Good to fair: sandstone at depth of 20 to 40 inches	Poor to unsuited: 35 to 55 percent fines; no gravel.	Fair: A–4	Severe hazard of soil blowing in borrow areas.
Truckton: TtB, TtD, TuB, TuC, TuD	Poor to fair: loamy sand to sandy loam.	Fair source for fine sand; no gravel.	Good: A–2 and A–3.	Hazard of soil blowing in borrow areas.
Ulm: UlB, UlC, UlD	Generally fair but good in upper 7 inches.	Unsuited: more than 50 percent fines; less than 15 percent gravel.	Poor: A–6 and A–7.	Moderately plastic materials; shale and sandstone below depth of 4 feet.
Valent: VaD	Poor: loamy sand	Fair where fine sands are desirable; poorly graded; no gravel.	Good: A–2 and A–3.	Severe hazard of soil blowing in borrow areas; low dunes.
*Vona: VnB, VnD, VoA, VoB, VoC, VsD. For interpretations of Ascalon soils in VsD, refer to Ascalon series.	Fair to poor: loamy sand and sandy loam.	Fair source for sand; no gravel.	Good to fair: A–2 and A–4.	Moderate hazard of soil blowing in borrow areas.

[Se]e footnote at end of table.

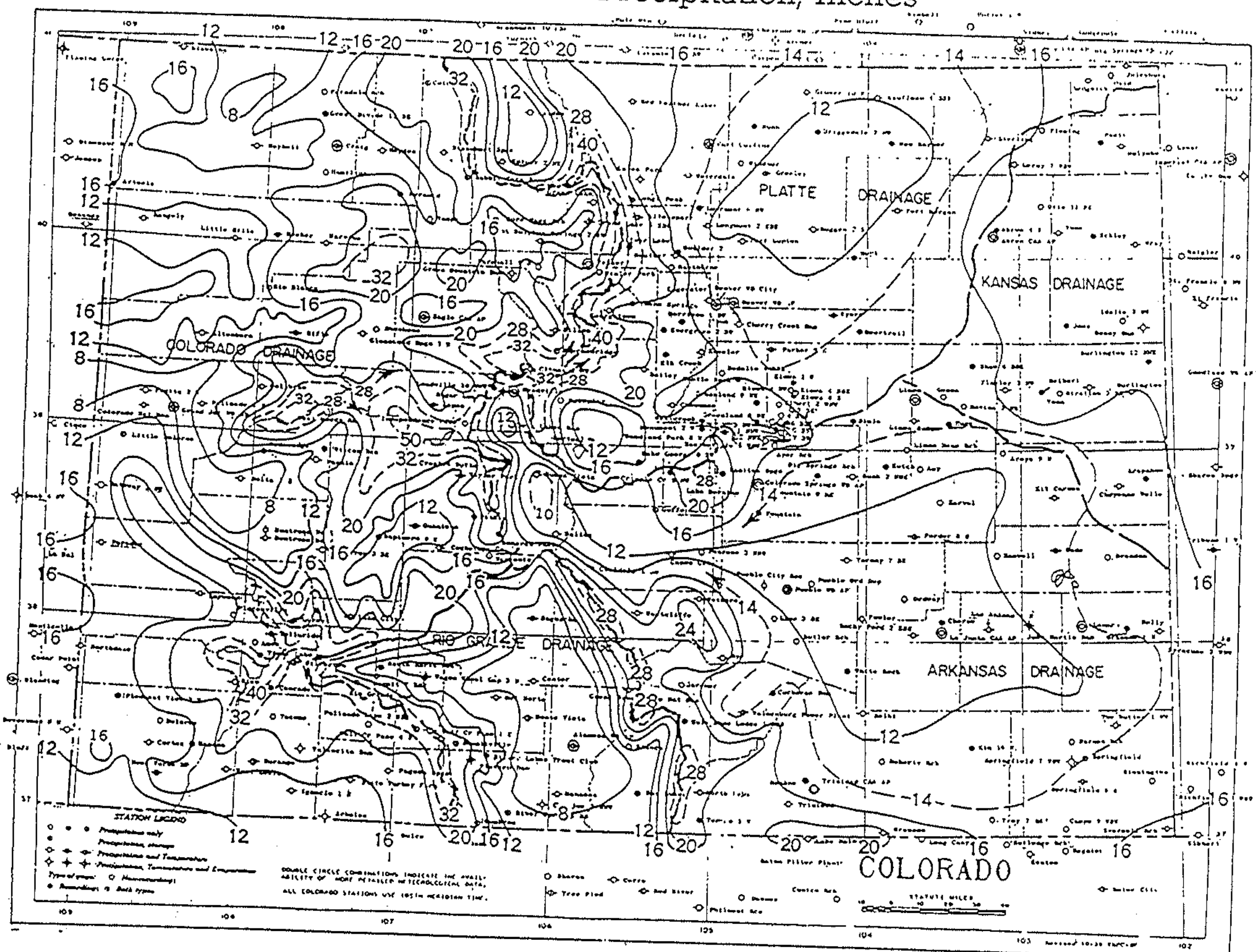
TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
*Weld: WmB, WrB. For interpretations of Deertrail soils in WrB, refer to Deertrail series.	Generally poor but good in upper 6 inches.	Unsuited: more than 50 percent fines; no gravel.	Poor to fair: A-4 and A-7.	Moderately plastic materials; A-4 and A-7.
Wet alluvial land: Wt.	Poor to fair: variable texture.	Fair to good below depth of 2 feet.	Poor: water table at depth of about 2 feet most of the time.	Poor drainage; frequent flooding.
*Wiley: WuE. For interpretations of Adena and Renohill soils in this unit, refer to their respective series.	Fair: clay loam below depth of 3 inches.	Unsuited: more than 50 percent fines; no gravel.	Fair to poor: A-4 and A-6.	Fair to poor compaction and stability; A-4 and A-6.

[1] Degree of limitation does not consider hazard of pollution to ground water.

Additional information on the soils in the County can be found in "Soil Survey Arapahoe County," USDA, SCS, March 1971

Mean Annual Precipitation, Inches



Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.