SPEAKER SESSION 6

GIS INTERFACE FOR STORM WATER MANAGEMENT PLANS

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Abstract:

Storm water management plans have, become increasingly important for agencies due to the need for both a plan of damage and a master plan of Best Management Practices. Geographic Information Systems provide a data management source that supplies numeric data that run storm water management analysis models while also providing graphical data for display purposes as well as mapping and other hard copy products. In this paper, GIS is integrated with storm water management plan computer software to provide a workable tool for agencies that require the ability to evaluate 'what if' scenarios involving both flood plain management as storm water quality issues.

GIS INTERFACE FOR STORM WATER MANAGEMENT PLANS

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<u>Abstract</u>

Proceedings: Flood Management Association, 1995 Spring Conference, March 29-31, 1995.

pjw#2/Proj.Prof./DRAINAGE-Water/04-93

Residential Landscaping (Lawn, Shrubs, etc.) - The pervious portions of commercial establishments, single and multiple family dwellings, trailer parks and schools where the predominant land cover is lawn, shrubbery and trees.

Row Crops - Lettuce, tomatoes, beets, tulips or any field crop planted in rows far enough apart that most of the soil surface is exposed to rainfall impact throughout the growing season. At plowing, planting and harvest times it is equivalent to fallow.

Small Grain - Wheat, oats, barley, flax, etc. planted in rows close enough that the soil surface is not exposed except during planting and shortly thereafter.

Legumes - Alfalfa, sweetclover, timothy, etc. and combinations are either planted in close rows or broadcast.

Fallow - Fallow land is land plowed but not yet seeded or tilled.

Woodland - grass - Areas with an open cover of broadleaf or coniferous trees usually live oak and pines, with the intervening ground space occupied by annual grasses or weeds. The trees may occur singly or in small clumps. Canopy density, the amount of ground surface shaded at high noon, is from 20 to 50 percent.

Woodland - Areas on which coniferous or broadleaf trees predominate. The canopy density is at least 50 percent. Open areas may have a cover of annual or perennial grasses or of brush. Herbaceous plant cover under the trees is usually sparse because of leaf or needle litter accumulation.

Chaparral - Land on which the principal vegetation consists of evergreen shrubs with broad, hard, stiff leaves such as manzonita, ceanothus and scrub oak. The brush cover is usually dense or moderately dense. Diffusely branched evergreen shrubs with fine needle-like leaves, such as chamise and redchank, with dense high growth are also included in this soil cover.

Annual Grass - Land on which the principal vegetation consists of annual grasses and weeds such as annual bromes, wild barley, soft chess, ryegrass and filaree.

Irrigated Pasture - Irrigated land planted to perennial grasses and legumes for production of forage and which is cultivated only to establish or renew the stand of plants. Dry land pasture is considered as annual grass.

Meadow - Land areas with seasonally high water table, locally called cienegas. Principal vegetation consists of sod-forming grasses interspersed with other plants.

Orchard (Deciduous) - Land planted to such deciduous trees as apples, apricots, pears, walnuts, and almonds.

Orchard (Evergreen) - Land planted to evergreen trees which include citrus and avocados and coniferous plantings.

Turf - Golf courses, parks and similar lands where the predominant cover is irrigated mowed close-grown turf grass. Parks in which trees are dense may be classified as woodland.

SOIL COVER
TYPE DEFINITIONS

Figure C-2

Curve Numbers of Hydrologic Soil-Cover Complexes For Pervious Areas-AMC II

Cover Type (3)	Quality of Cover (2)	Soil Group A	B	C	D
NATURAL COVERS -					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparral, Broadleaf (Manzonita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparral, Narrowleaf (Chamise and redshank)	Poor	71	82	88	91
	Fair	55	72	81	86
Grass, Annual or Perennial	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Meadows or Cienegas (Areas with seasonally high water table, principal vegetation is sod forming grass)	Poor	63	77	85	88
	Fair	51	70	80	84
	Good	30	58	71	78
Open Brush (Soft wood shrubs - buckwheat, sage, etc.)	Poor	62	76	84	88
	Fair	46	66	77	83
	Good	41	63	75	81
Woodland (Coniferous or broadleaf trees predominate. Canopy density is at least 50 percent.)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Woodland, Grass (Coniferous or broadleaf trees with canopy density from 20 to 50 percent)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
URBAN COVERS -					
Residential or Commercial Landscaping (Lawn, shrubs, etc.)	Good	32	56	69	75
Turf (Irrigated and mowed grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
AGRICULTURAL COVERS -					
Fallow (Land plowed but not tilled or seeded)		77	86	91	94

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CURVE NUMBERS FOR PERVIOUS AREAS

Curve Numbers of Hydrologic Soil-Cover Complexes For Pervious Areas-AMC II					
Cover Type (3)	Quality of Cover (2)	Soil Group			
		A	B	C	D
AGRICULTURAL COVERS (Continued)					
Legumes, Close Seeded (Alfalfa, sweetclover, timothy, etc.)	Poor	66	77	85	89
	Good	58	72	81	85
Orchards, Evergreen (Citrus, avocados, etc.)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Pasture, Dryland (Annual grasses)	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Pasture, Irrigated (Legumes and perennial grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Row Crops (Field crops - tomatoes, sugar beets, etc.)	Poor	72	81	88	91
	Good	67	78	85	89
Small grain (Wheat, oats, barley, etc.)	Poor	65	76	84	88
	Good	63	75	83	87

Notes:

1. All curve numbers are for Antecedent Moisture Condition (AMC) II.
2. Quality of cover definitions:

   Poor-Heavily grazed, regularly burned areas, or areas of high burn potential. Less than 50 percent of the ground surface is protected by plant cover or brush and tree canopy.

   Fair-Moderate cover with 50 percent to 75 percent of the ground surface protected.

   Good-Heavy or dense cover with more than 75 percent of the ground surface protected.
3. See figure C-2 for definition of cover types.
4. Impervious areas are assigned curve number 98.

ACTUAL IMPERVIOUS COVER

Land Use (1)	Range-Percent	Recommended Value For Average Conditions-Percent (2)
Natural or Agriculture	0 - 0	0
Public Park	10 - 25	15
School	30 - 50	40
Single Family Residential: (3)		
2.5 acre lots	5 - 15	10
1 acre lots	10 - 25	20
2 dwellings/acre	20 - 40	30
3-4 dwellings/acre	30 - 50	40
5-7 dwellings/acre	35 - 55	50
8-10 dwellings/acre	50 - 70	60
More than 10 dwellings/acre	65 - 90	80
Multiple Family Residential:		
Condominiums	45 - 70	65
Apartments	65 - 90	80
Mobile Home Park	60 - 85	75
Commercial, Downtown Business or Industrial	80 - 100	90

Notes:

1. Land use should be based on ultimate development of the watershed. Long range master plans for the County and incorporated cities should be reviewed to insure reasonable land use assumptions.

2. Recommended values are based on average conditions which may not apply to a particular study area. The percentage impervious may vary greatly even on comparable sized lots due to differences in dwelling size, improvements, etc. Landscape practices should also be considered as it is common in some areas to use ornamental gravels underlain by impervious plastic materials in place of lawns and shrubs. A field investigation of a study area shall always be made, and a review of aerial photos, where available, may assist in estimating the percentage of impervious cover in developed areas.

3. For typical equestrian subdivisions increase impervious area 5 percent over the values recommended in the table above.

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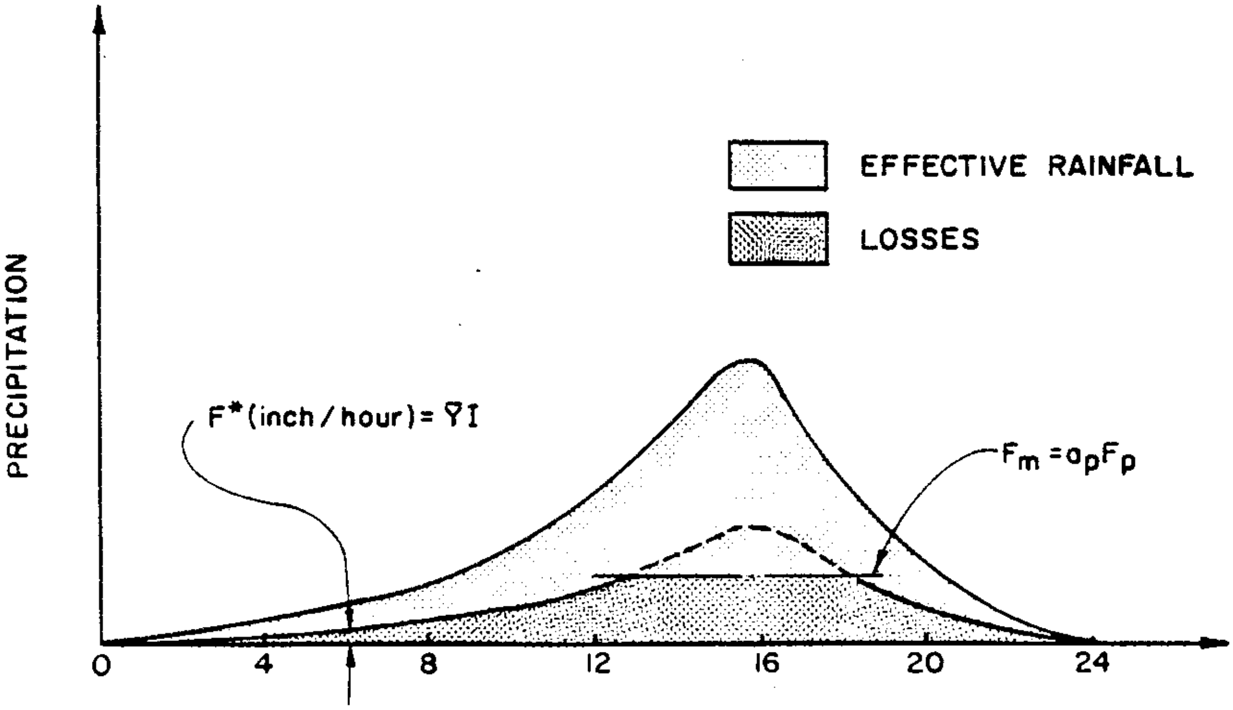
ACTUAL IMPERVIOUS COVER FOR DEVELOPED AREAS

Figure C-4



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DESIGN STORM
LOSS FUNCTION

Figure C-5

C.6. ESTIMATION OF LOSS RATES

In estimating infiltration rates for design hydrology, a watershed curve number (CN) is determined for each soil-cover complex within the watershed using Figure C-3. The CN scale has a range of 0 to 98, where a low CN indicates low runoff potential (high infiltration), and a high CN indicates high runoff potential (low infiltration). Selection of a CN takes into account the major factors affecting infiltration on pervious surfaces including the hydrologic soil group, cover type and quality, and antecedent moisture condition (AMC).

Also included in the CN selection are the effects of "initial abstraction" (Ia) which represents the combined effects of other effective rainfall losses including depression storage, vegetation interception, evaporation, and transpiration, among other factors.

C.6.1. Estimation of Initial Abstraction (Ia)

The initial abstraction (Ia) for an area is a function of land use, treatment, and condition; interception; infiltration; depression storage; and antecedent soil moisture. An estimate for Ia is given by the SCS as

$$Ia = 0.2S \tag{C.1}$$

where S is an estimate of total soil capacity given by

$$S = \frac{1000}{CN} - 10 \tag{C.2}$$

where CN is the area curve number.

C.6.2. Estimation of Storm Runoff Yield

Given the CN for a subarea A_j, the corresponding 24-hour storm runoff yield fraction, Y_j, is estimated by

$$Y_j = \frac{(P_{24} - Ia)^2}{(P_{24} - Ia + S)P_{24}} \qquad (C.3)$$

where

Y_j	=	24-hour storm runoff yield fraction for subarea A_j
P_{24}	=	24-hour storm rainfall
Ia	=	initial abstraction from (C.1)
S	=	see (C.2)

It is noted that should Ia be greater than P_{24} in (C.3), then Y_j is defined to be zero. In this manual, the notation Y and Y_j will represent the yield fraction rather than the volume of runoff.

If the area under study contains several (say m) CN designations, then the yield, Y, for the total area must represent the net effect of the several curve numbers. By weighting each of the subarea yield values according to the respective areas,

$$Y = (Y_1 A_1 + \cdots + Y_m A_m)/(A_1 + A_2 + \cdots + A_m) \qquad (C.4)$$

where each Y_j follows from (C.3).

C.6.3. Low Loss Rate, F*

In design storm runoff hydrograph studies, the following formula is used to estimate that portion of rainfall to be attributed to watershed losses:

$$\bar{Y} = 1 - Y \qquad (C.5)$$

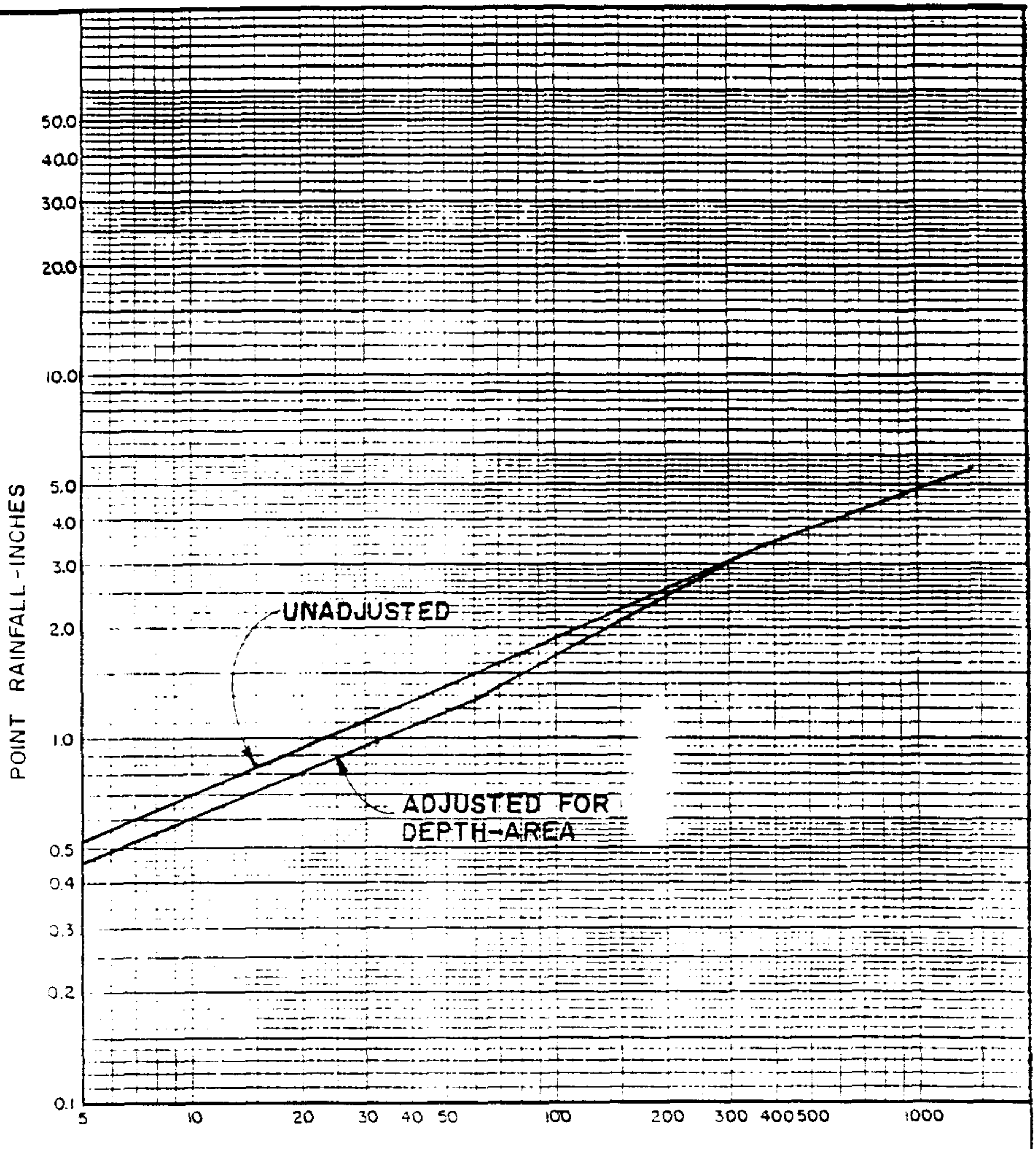
where

$\bar{Y}$	=	catchment low loss fraction
Y	=	catchment 24-hour storm runoff yield fraction computed from (C.4)

Using the low loss fraction, $\bar{Y}$, the corresponding low loss rate, F*, is given by

$$F^* = \bar{Y} \cdot I \qquad (C.6)$$

where I is the rainfall intensity and F* has units of inches/hour.



PROJECT LOCATION *EXAMPLE PROBLEM*

NOTES *100-YEAR STORM*

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AREA - AVERAGED MASS RAINFALL PLOTTING SHEET

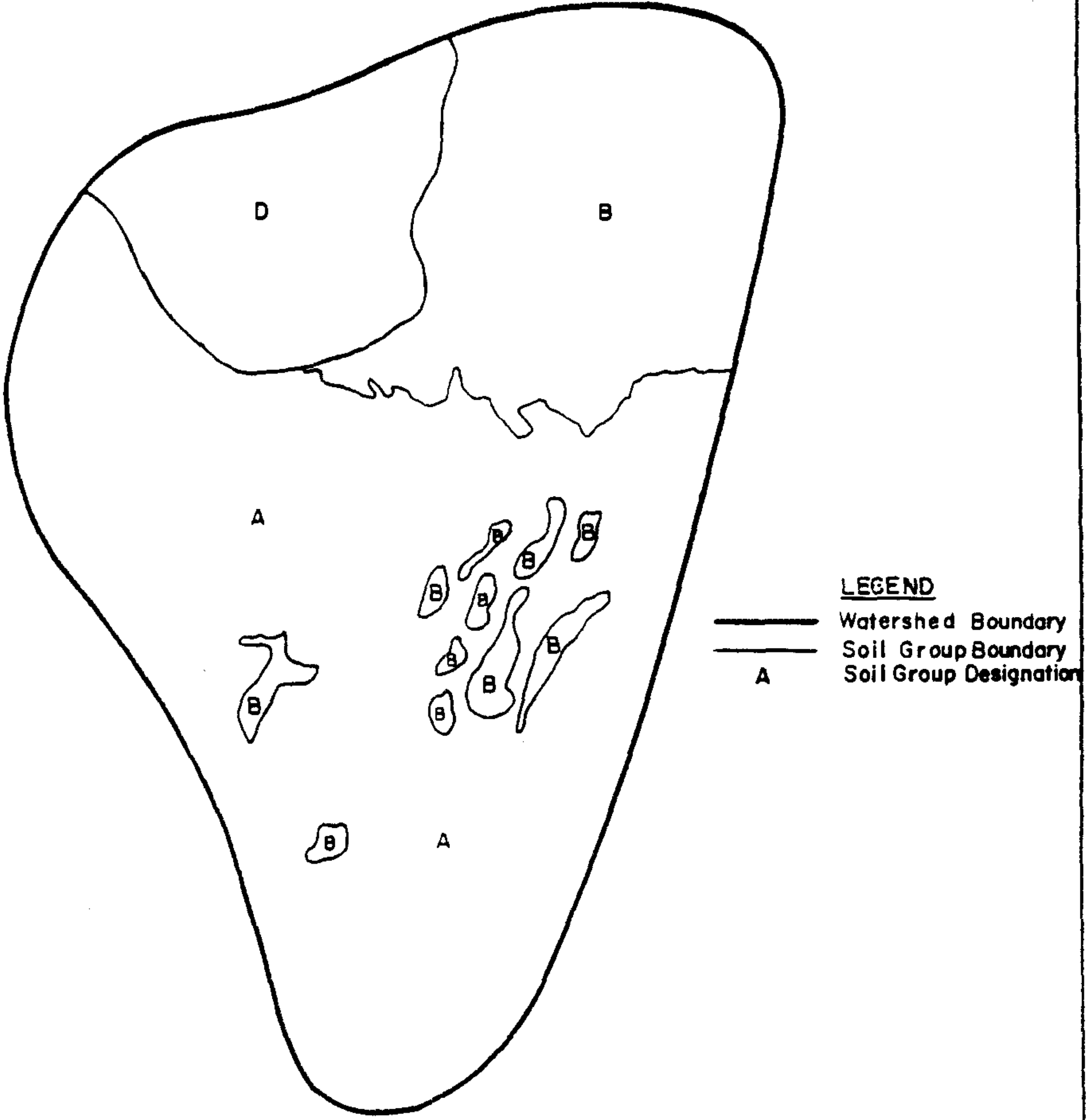
UNIT HYDROGRAPH STUDY:
EXAMPLE PROBLEM UNIT RAINFALL DETERMINATION

(Example Unit Period = 5 minutes)

Peak Rainfall Unit Number	Adjusted Mass Rainfall (inches)	Unit Rainfall (inches)
1	0.45	0.45
2	0.60	0.15
3	0.71	0.11
4	0.80	0.09
5	0.88	0.08
6	0.95	0.07
7	1.02	0.07
8	1.08	0.06
9	1.13	0.05
10	1.19	0.06
11	1.24	0.05
12	1.28	0.04
13	1.33	0.05
14	1.39	0.05
15	1.45	0.06
16	1.50	0.05
17	1.55	0.05
18	1.60	0.05
19	1.65	0.05
20	1.70	0.05
21	1.74	0.04
22	1.79	0.05
23	1.84	0.05
24	1.89	0.05
25	1.93	0.04
26	1.97	0.04
27	2.01	0.04
28	2.05	0.04
29	2.09	0.04
30	2.13	0.04
31	2.17	0.04
32	2.21	0.04
33	2.25	0.04
34	2.29	0.04
35	2.33	0.04
36	2.38	0.04

TIME = 3 HOURS

TOTAL = 2.38 INCHES



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EXAMPLE PROBLEM

WATERSHED-LOSS DETERMINATION

INFORMATION MAP

UNIT HYDROGRAPH STUDY:
EXAMPLE PROBLEM WATERSHED LOSS DETERMINATIONS

<u>Area-Averaged Low Loss Rate Fraction, $\bar{Y}$</u>

1. Referring to watershed soil group maps, estimate area-averaged composite curve numbers (see Section C):

Land Use and Condition	Area Fraction	Soil. Group	Curve Number $CN^{(1)}$ (Fig. C-3)		$S^{(2)}$	Pervious Area Yield Fraction $Y^{(3)}$
Woodland; good cover (100% pervious)	.15	B	55	(75)	3.33	0.53
Woodland; good cover (100% pervious)	.15	D	77	(93)	0.75	0.86
Residential: S.F. (1/2 acre) Lots (60% pervious)(5)	.25	A	32	(52)	9.23	0.20
	.17	A	98		0.20	0.96
Residential: S.F. (1/2 acre) Lots (60% pervious)(5)	.018	B	56	(76)	3.16	0.54
	.012	B	98		0.20	0.96
Commercial: (10% pervious)	.023	A	32	(52)	9.23	0.20
	.207	A	98		0.20	0.96
Commercial: (10% pervious)	.002	B	56	(76)	3.16	0.54
	.018	B	98		0.20	0.96

Area-Averaged Catchment Yield Fraction (Y) = 0.663

Area-Averaged Low Loss Fraction ($\bar{Y}$)(4) = <u>0.337</u>

<u>NOTES:</u>

(1): (75) indicates AMC III CN (Table C.1)

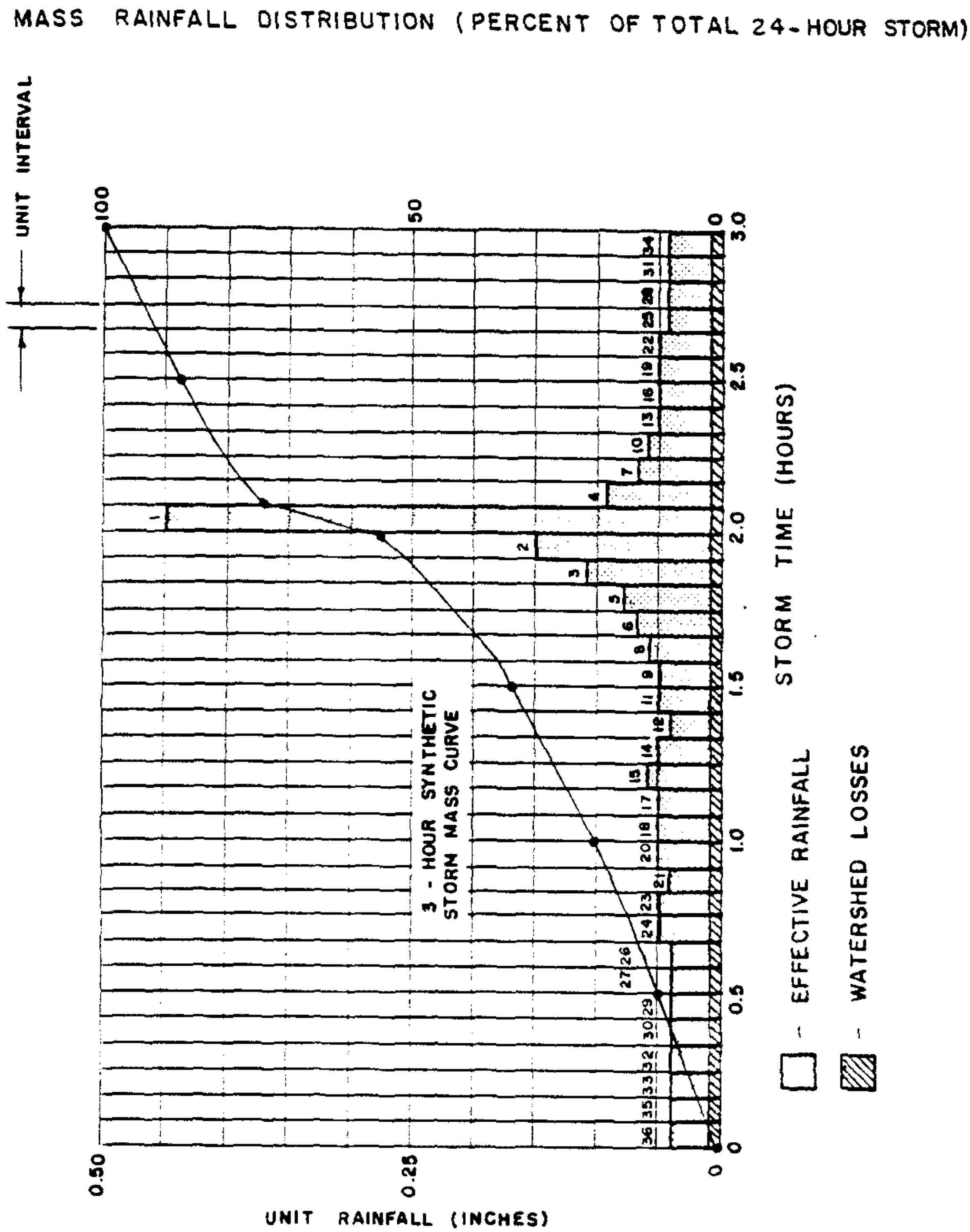
(2): $S = (1000/CN)-10$

(3): $Y = (P24-0.2S)^2/((P24+0.8S)P24)$

(4): $\bar{Y} = 1-Y$

(5): Field conditions indicate use of the lower end of the suggested pervious range

NOTE : THE EXAMPLE UNIT INTERVAL = 5 MINUTES.
NUMBERS ABOVE UNIT RAINFALLS CORRESPOND
TO UNIT NUMBERS IN UNIT RAINFALL DETERMINATION.



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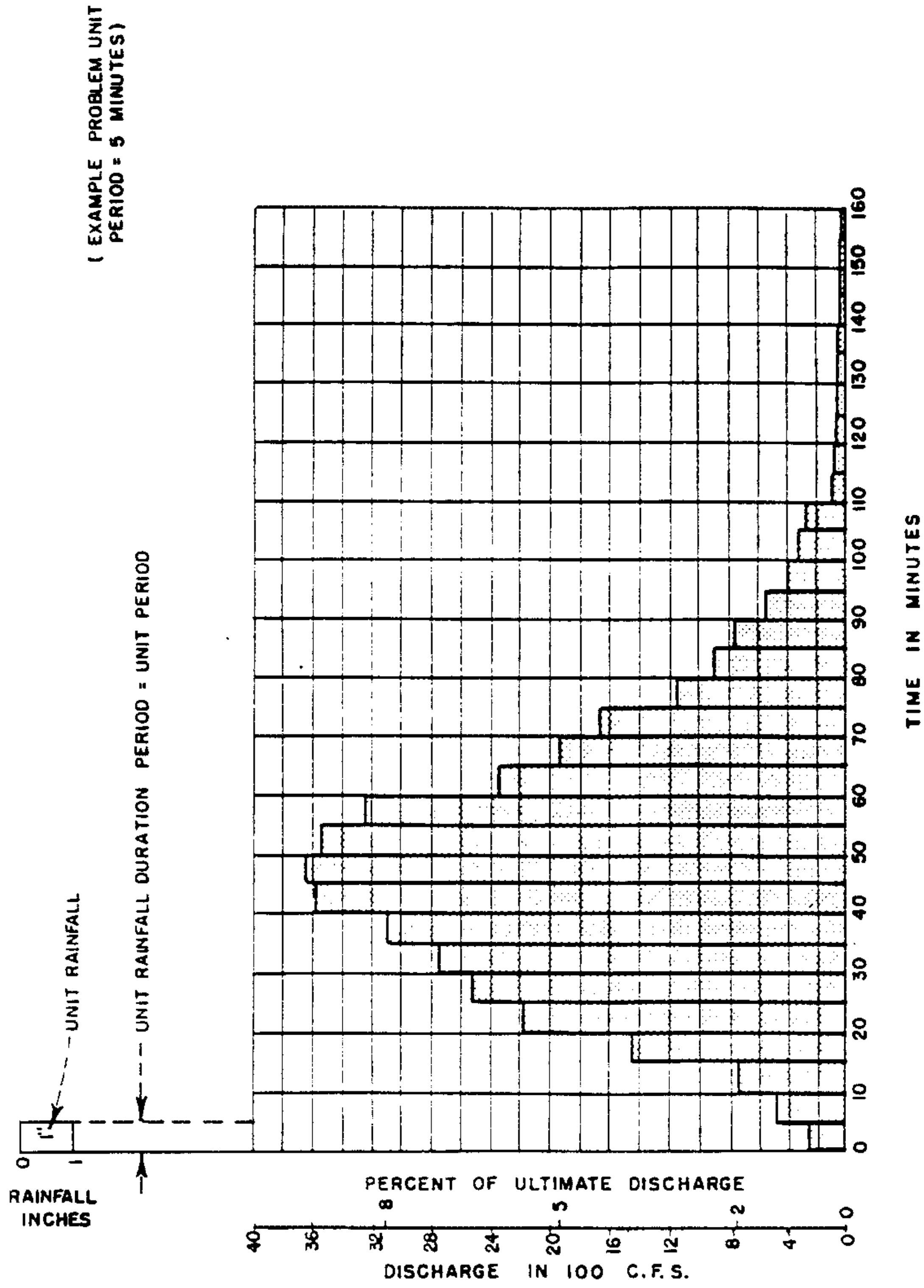
EXAMPLE
SYNTHETIC 3-HOUR
CRITICAL STORM



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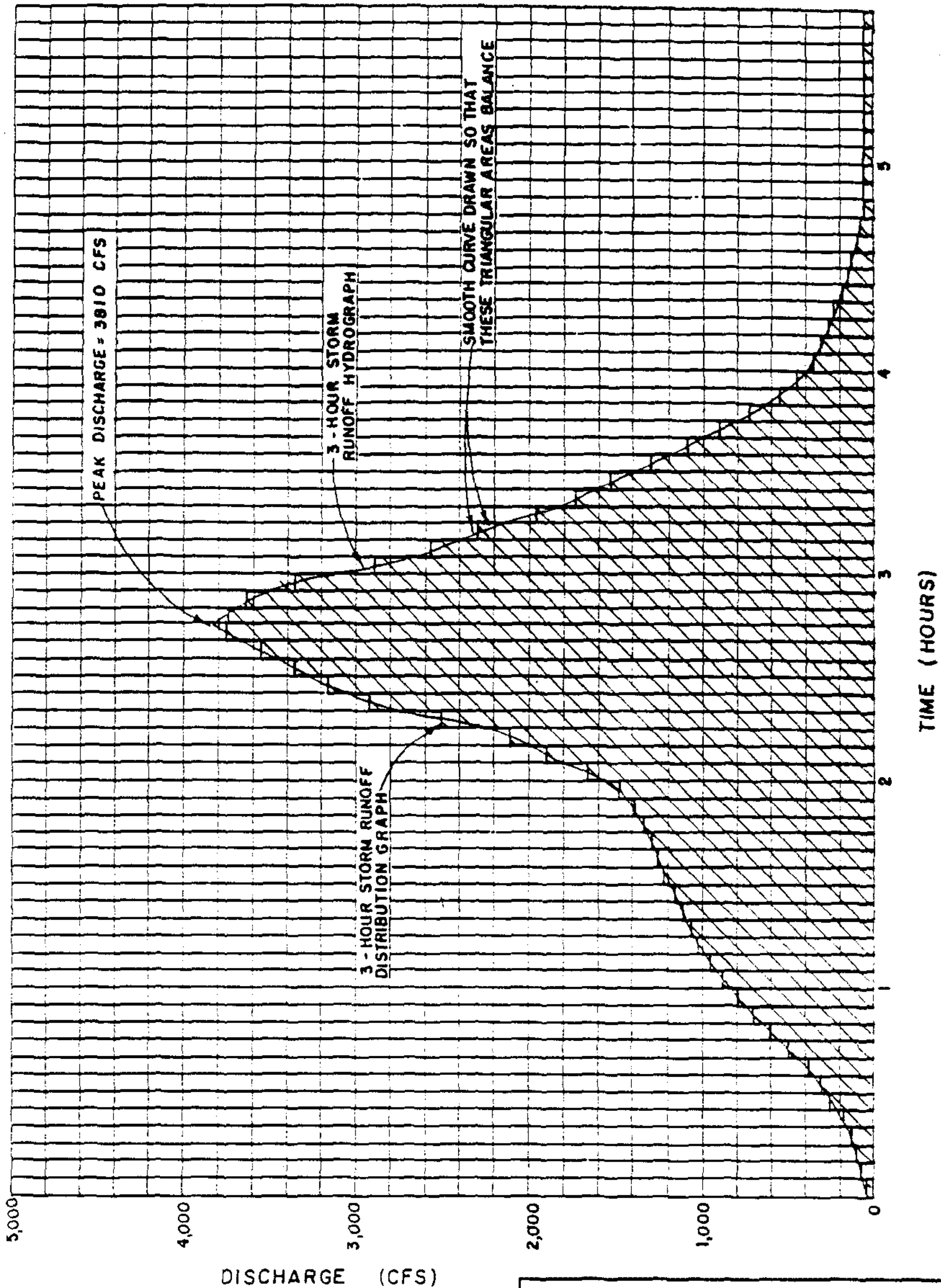
EXAMPLE PROBLEM

UNIT DISTRIBUTION GRAPH



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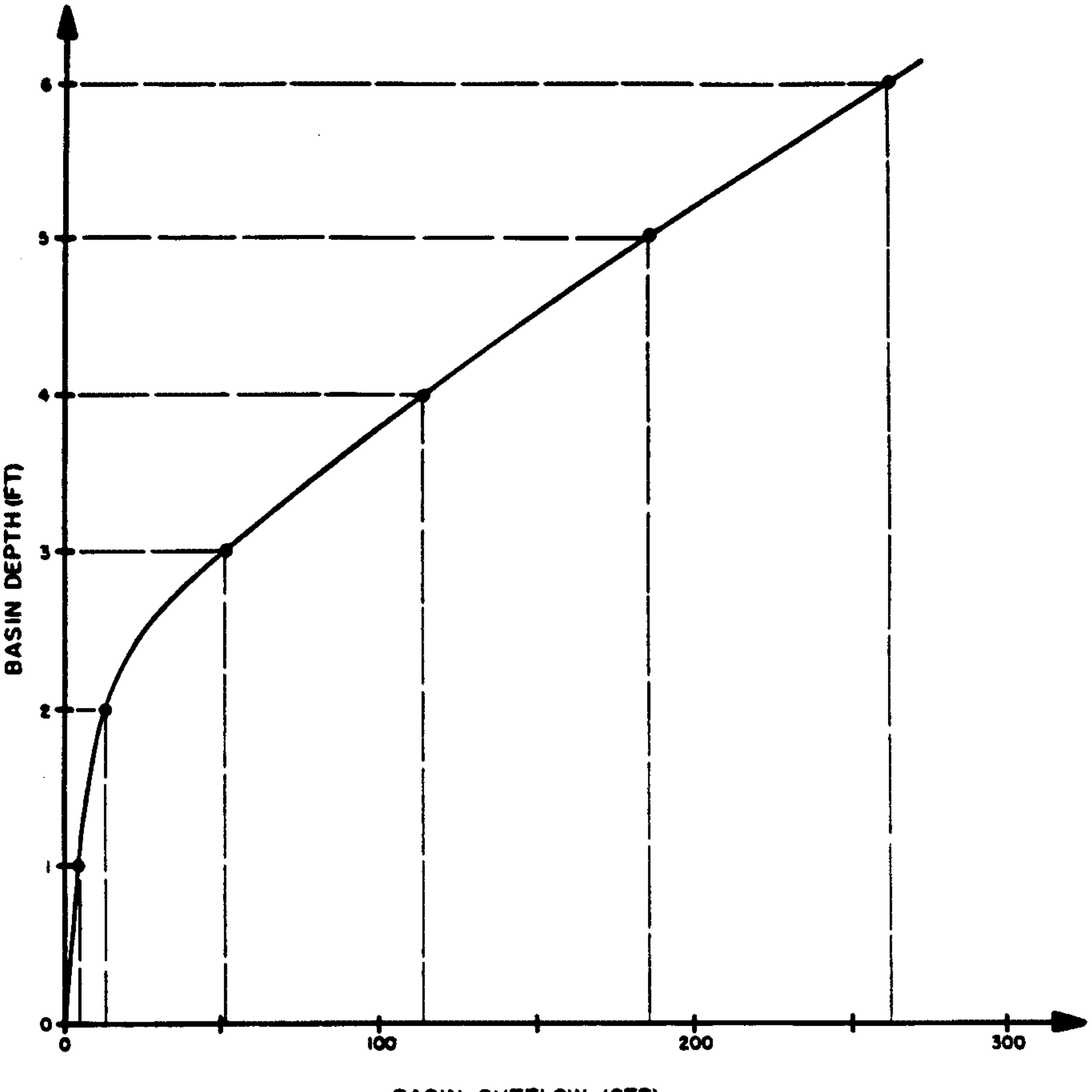
EXAMPLE PROBLEM

3-HOUR STORM

RUNOFF HYDROGRAPH



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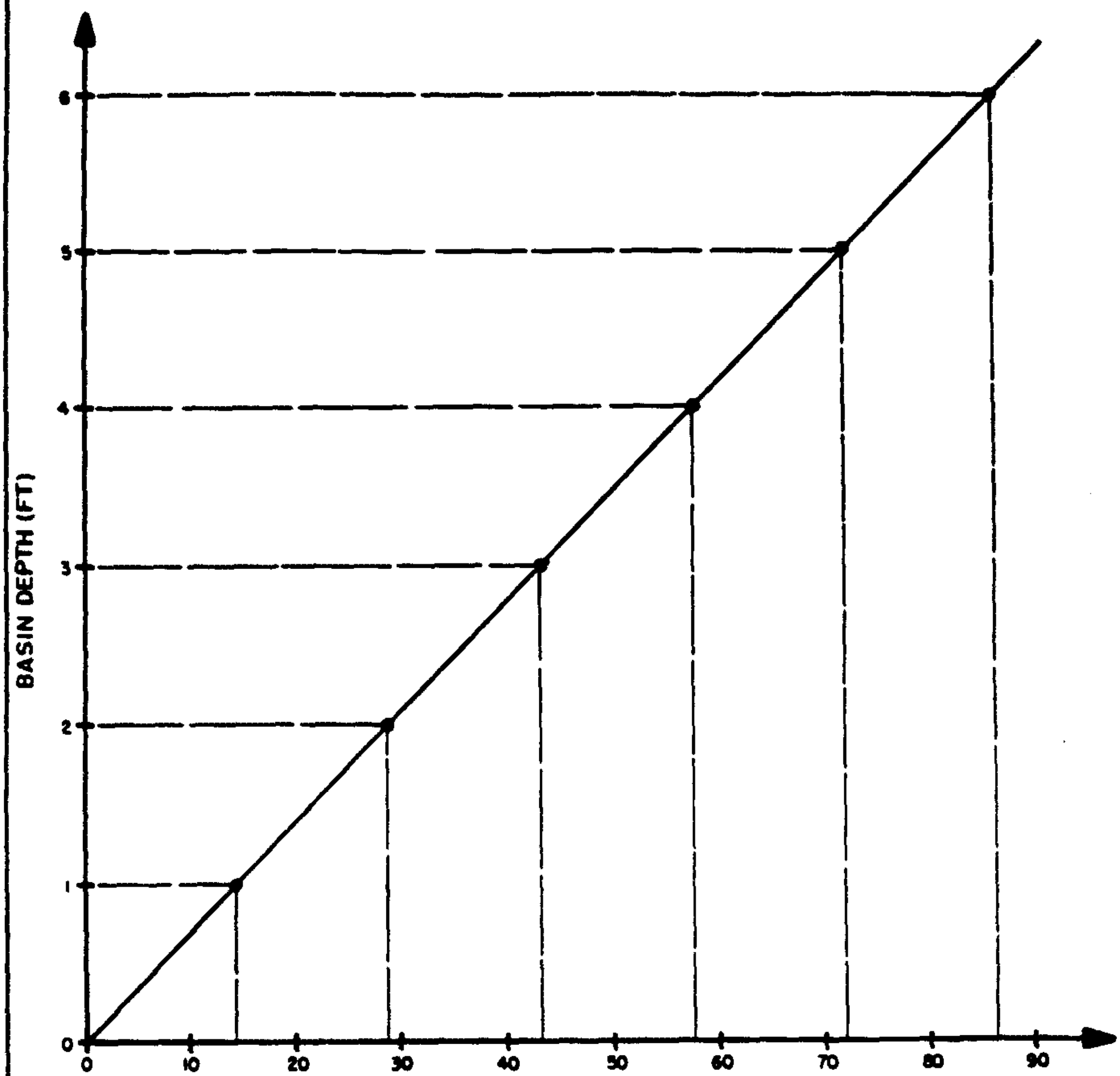
EXAMPLE PROBLEM
DETENTION BASIN OUTFLOW (CFS)
AS A FUNCTION OF DEPTH (FT)

Figure F-1



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EXAMPLE PROBLEM
DETENTION BASIN STORAGE (AF)
AS A FUNCTION OF DEPTH (FT)

Figure F-2

PROJECT: EXAMPLE PROBLEM DATE:

ENGINEER:

1. Enter the hydrograph unit interval duration (minutes) 60

2. Enter total number of basin depth-versus-outflow values (maximum of 20) 7

3. Enter basin outflow (cfs) and storage volume (AF) for each basin depth value in the following table. Enter values in order of increasing outflow basin depth:

Entry No.	Water Surface Elevation (FT)	Basin Depth (FT)	Basin Storage (AF)	Basin Outflow (CFS)
1	100	0.0 (defined)	0	0.0 (defined)
2	101	1	14.4	4.2
3	102	2	28.8	12.0
4	103	3	43.2	51.7
5	104	4	57.6	114.7
6	105	5	72.0	186.8
7	106	6	86.4	263.2
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

4. Enter assumed initial depth (feet) of water in detention basin 0

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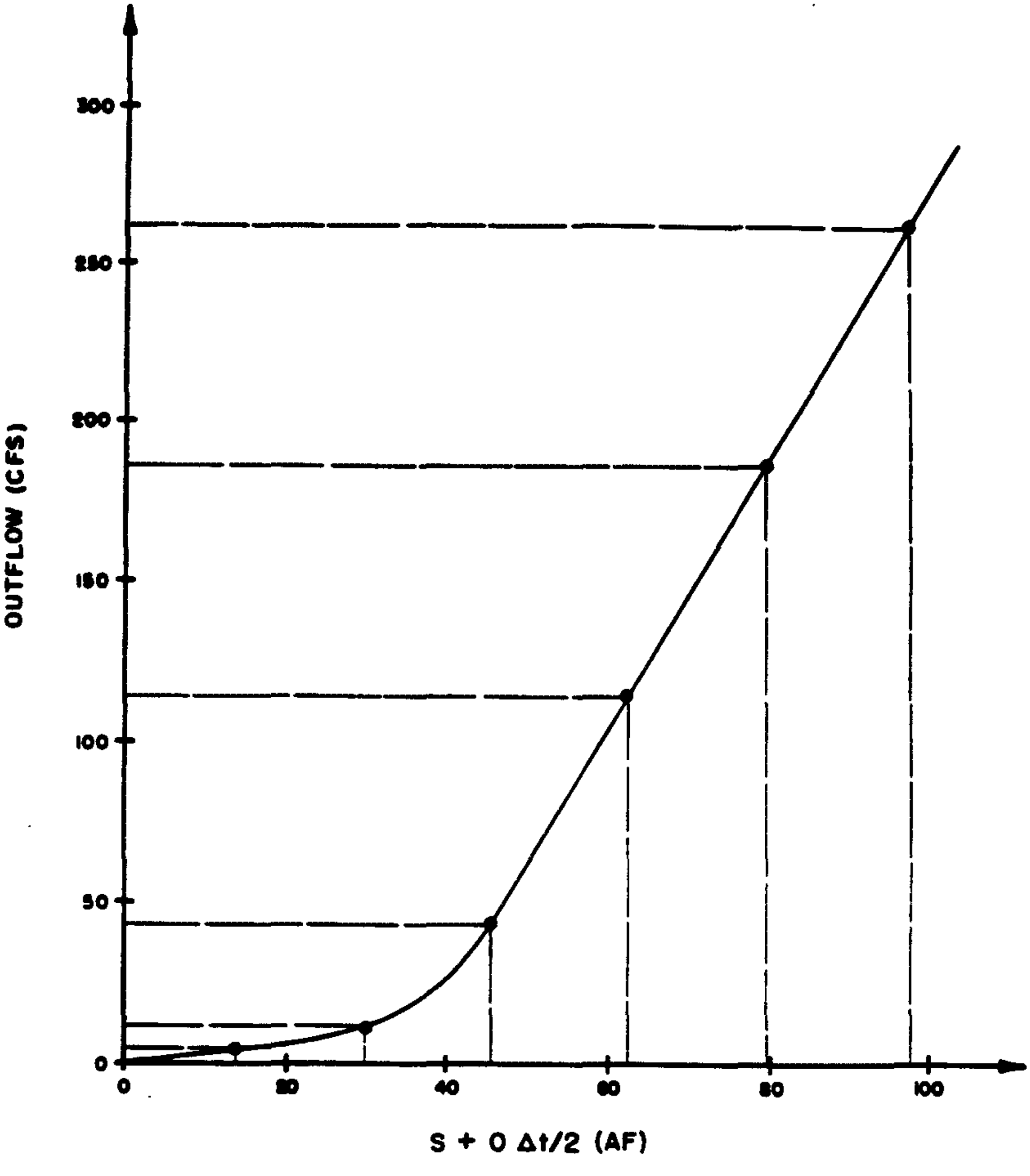
DETENTION BASIN
INFORMATION FORM



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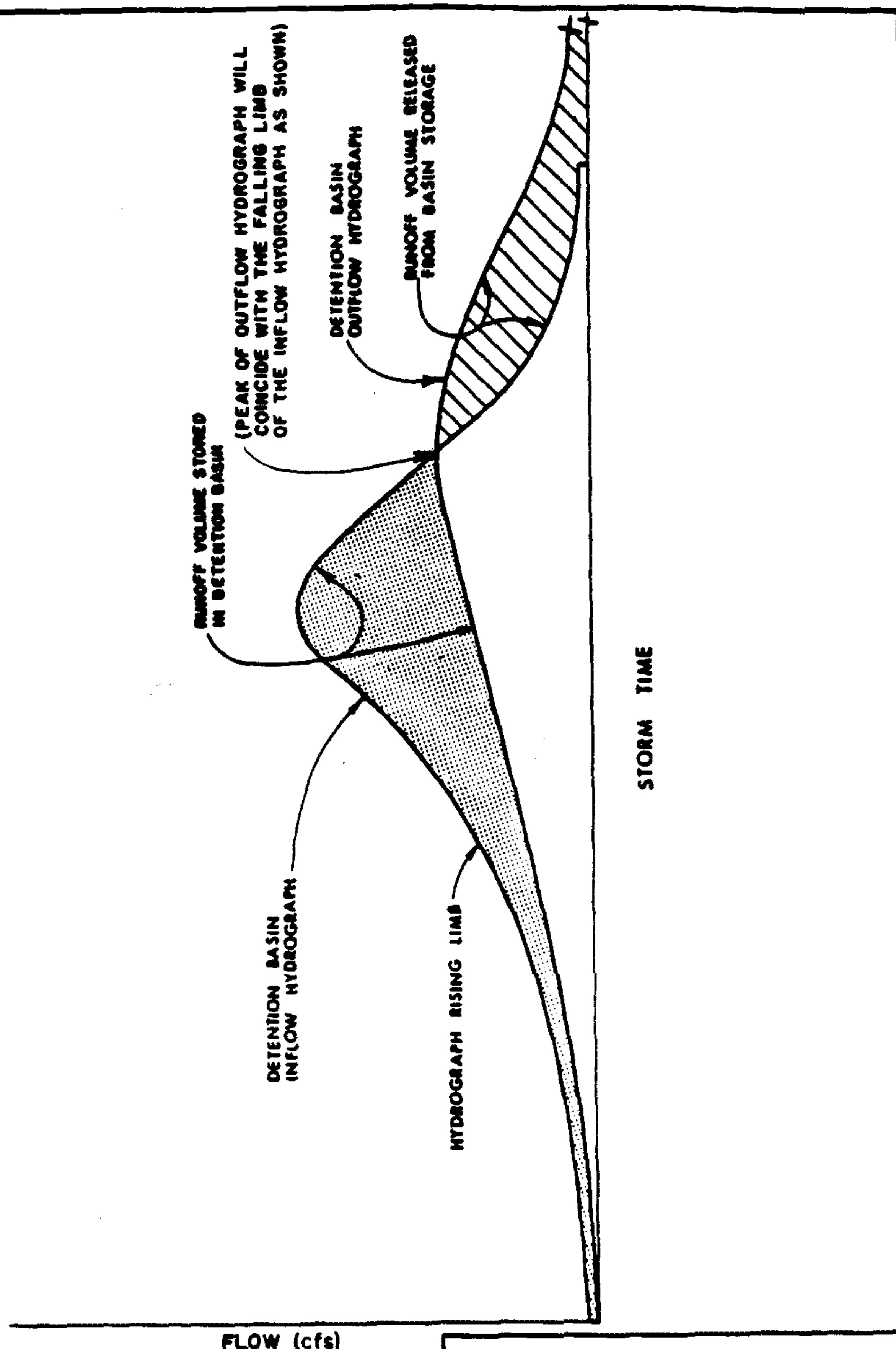
EXAMPLE PROBLEM

STORAGE-INDICATION CURVE

Figure F-4

TABLE F.2.
EXAMPLE PROBLEM BASIN ROUTING TABULATION

Time (min.)	Inflow (cfs)	Average Inflow (cfs)	$(I_1+I_2)\,\Delta t/2$ (AF)	$S_1-O_1\,\Delta t/2$ (AF)	$S_2+O_2\,\Delta t/2$ (AF)	Outflow (cfs)	Storage (AF)
0	0					0	0
		30	2.48	0	2.48		
60	60					.7	2.45
		90	7.44	2.42	9.86		
120	120					2.8	9.74
		200	16.53	9.62	26.16		
180	280					10.3	25.73
		265	21.90	25.31	47.21		
240	250					58.6	44.79
		235	19.42	42.37	61.79		
300	220					112.7	57.14
		170	14.05	52.48	66.53		
360	120					132.1	61.07
		110	9.09	55.61	64.70		
420	100					124.5	59.56
		80	6.61	54.41	61.02		
480	60					109.8	56.48
		30	2.48	51.94	54.42		
540	0					85.4	50.89
		0	0	47.36	47.36		
600	0					59.20	44.91
		0	0	42.46	42.46		



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DETENTION BASIN INFLOW AND OUTFLOW HYDROGRAPHS

Figure F-5

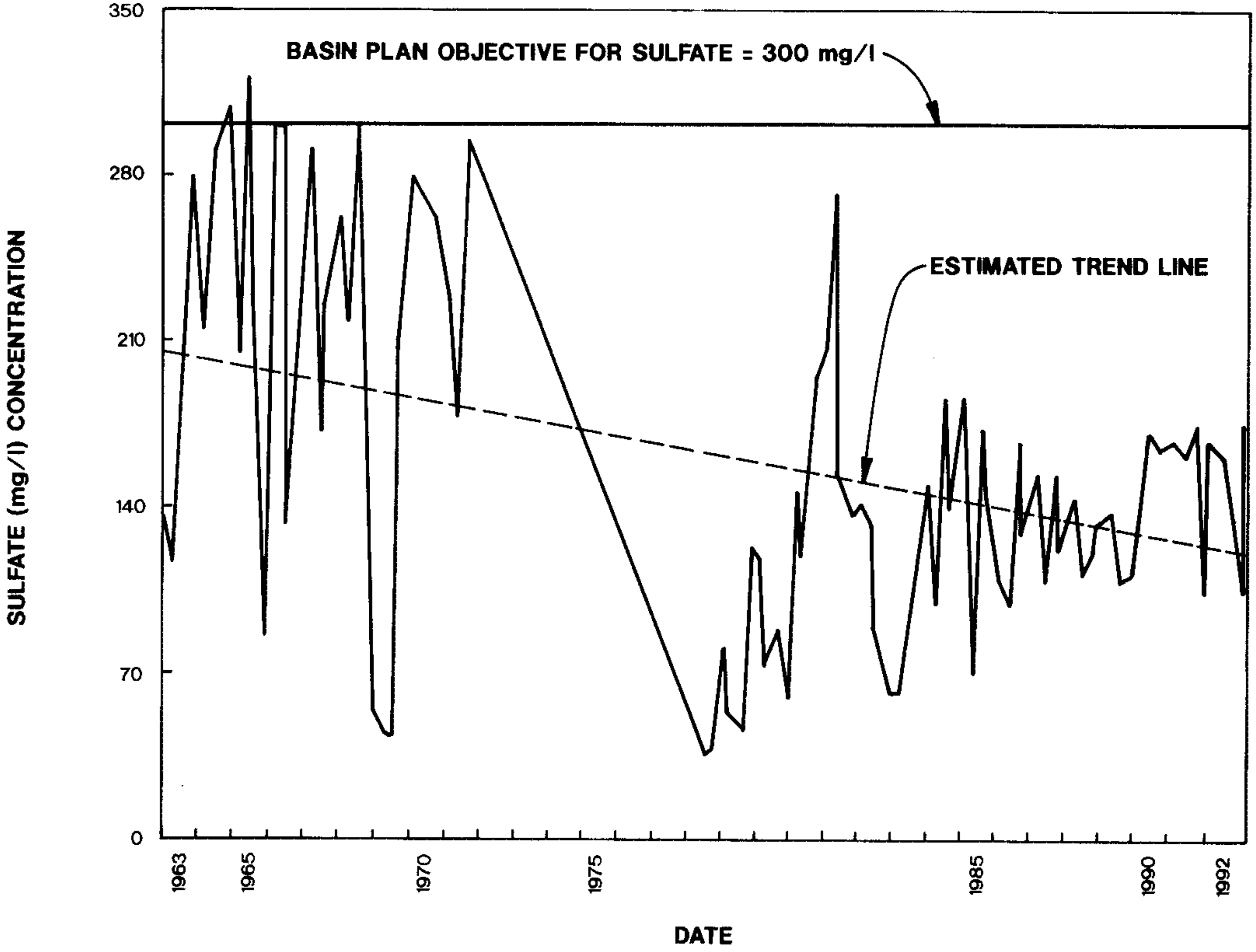

FIGURE 2. TREND ANALYSIS PLOT OF SULFATE CONCENTRATION