ARTICLE V

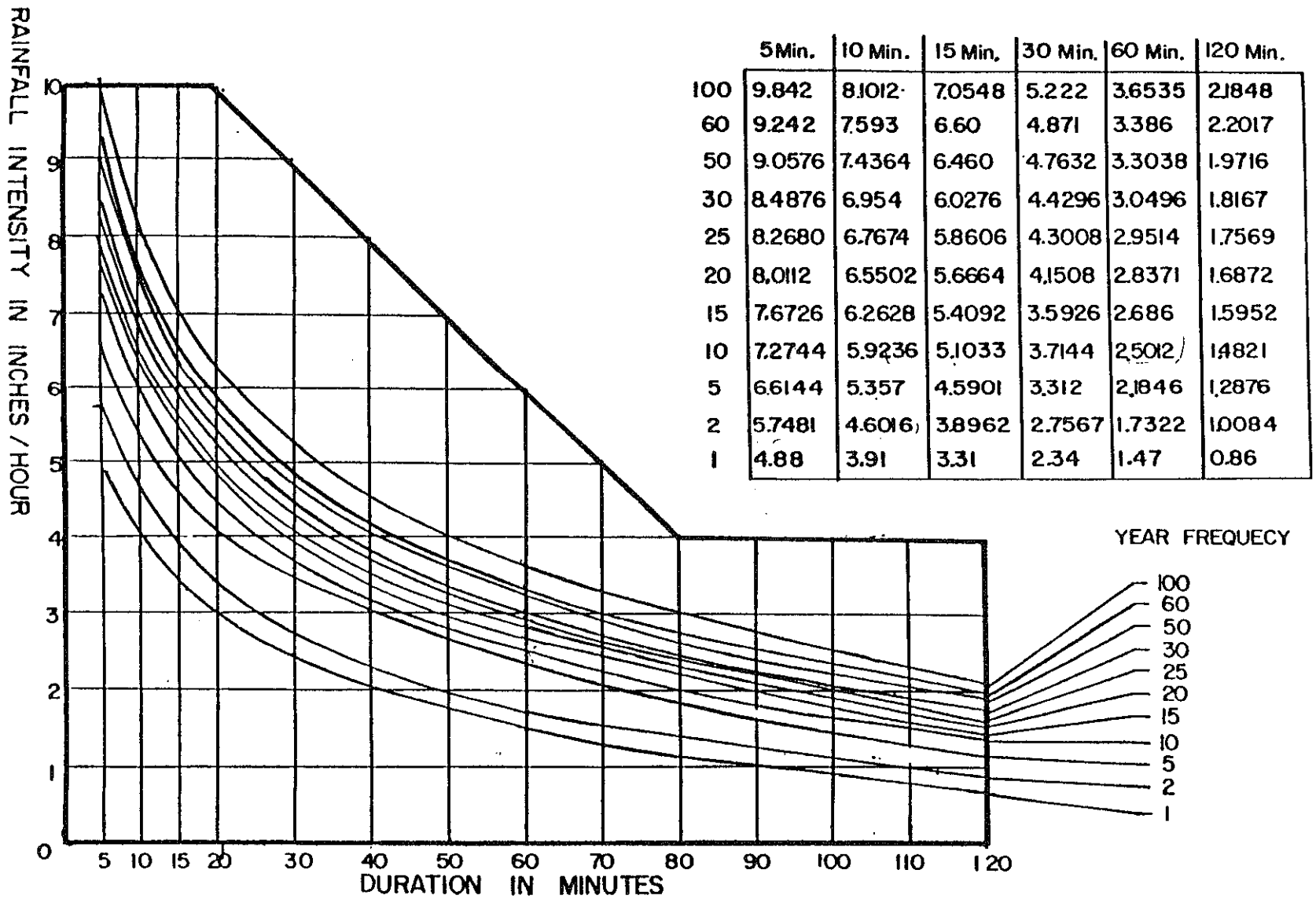
STORM DRAINAGE

SECTION 508.00 - EXHIBITS

EXHIBITS	PLATE
Rainfall Intensity vs. Duration	V-A
Overland Flow Time	V-B
Pipe Capacities Flowing Full by Manning's Formula	V-C
Head Losses at Bends Other Than 90°	V-D
Storm Water Inlet Computation Sheet	V-E
Storm Sewer Design Computation Sheet	V-F
Culvert Headwater Computation Sheet	V-J
Hydraulic Grade Line Computation Sheet	V-H
Unit Inflow Hydrographs - 10 Year, 2 Hour Storm	
Tc = 5 Minutes	V-I
Tc = 10 Minutes	V-J
Tc = 15 Minutes	V-K
Tc = 20 Minutes	V-L
Tc = 25 and 30 Minutes	V-M
Unit Inflow Hydrographs - 100 Year, 2 Hour Storm	
Tc = 5 Minutes	V-N
Tc = 10 Minutes	V-0
Tc = 15 Minutes	V-P
Tc = 20 Minutes	V-Q
Tc = 25 Minutes	V-R
Tc = 30 Minutes	V-S
Incremental Unit Hydrograph Values	V-T

(Used with the Rational Formula)

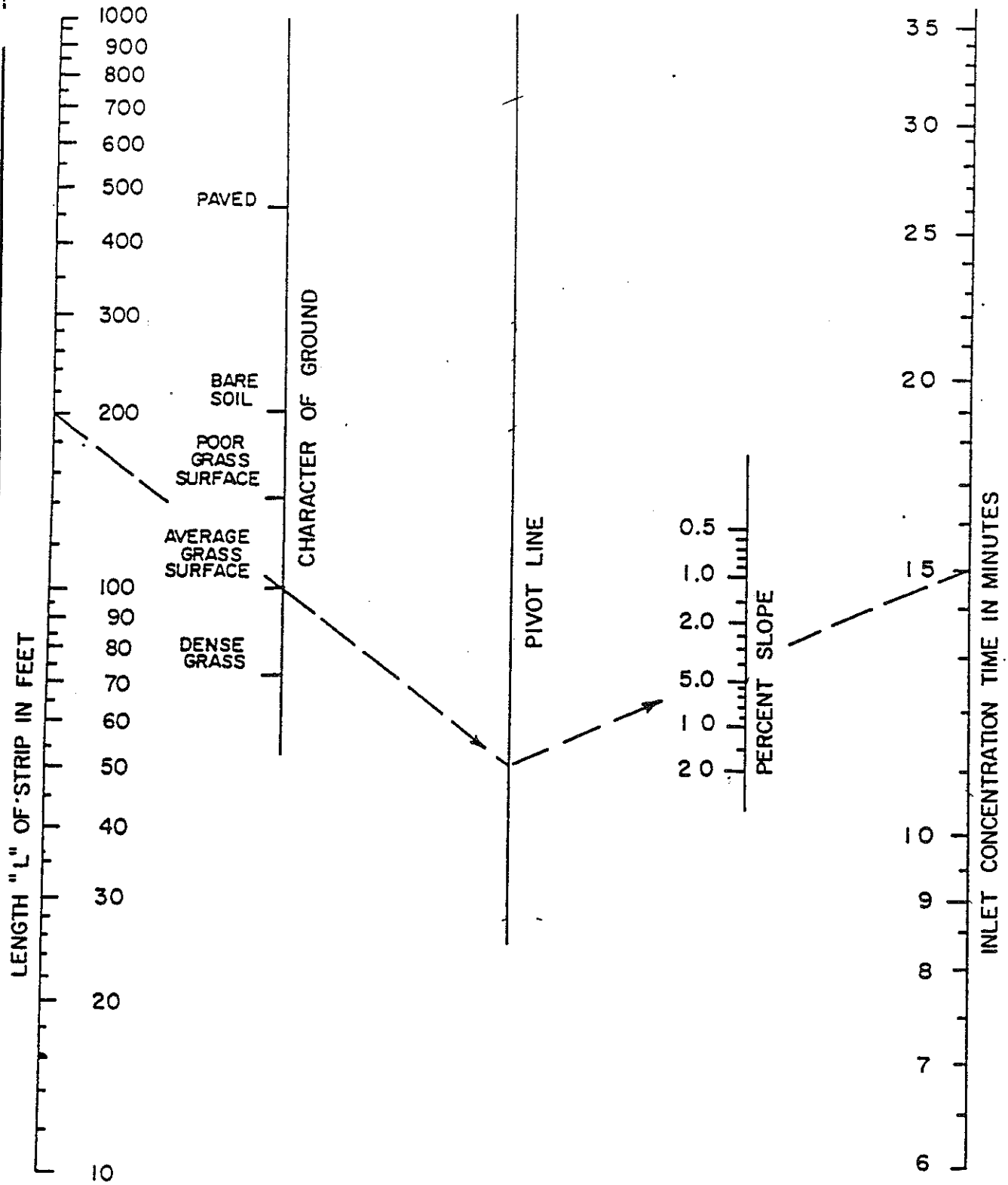
PLATE V-A



	5 Min.	10 Min.	15 Min.	30 Min.	60 Min.	120 Min.
100	9.842	8.1012	7.0548	5.222	3.6535	2.1848
60	9.242	7.593	6.60	4.871	3.386	2.2017
50	9.0576	7.4364	6.460	4.7632	3.3038	1.9716
30	8.4876	6.954	6.0276	4.4296	3.0496	1.8167
25	8.2680	6.7674	5.8606	4.3008	2.9514	1.7569
20	8.0112	6.5502	5.6664	4.1508	2.8371	1.6872
15	7.6726	6.2628	5.4092	3.5926	2.686	1.5952
10	7.2744	5.9236	5.1033	3.7144	2.5012	1.4821
5	6.6144	5.357	4.5901	3.312	2.1846	1.2876
2	5.7481	4.6016	3.8962	2.7567	1.7322	1.0084
1	4.88	3.91	3.31	2.34	1.47	0.86

RAINFALL INTENSITY VS. DURATION

PLATE V-B



OVERLAND FLOW TIME

with n = 0.013 for concrete pipe

$$Q = a \times \frac{1.486}{0.013} \times \left(\frac{a}{p}\right)^{2/3} \times s^{1/2}$$

$$F = a \times \frac{1.486}{0.013} \times \frac{a}{p}^{2/3}$$

$$Q = F \times (s)^{1/2}$$

PIPE DIAMETER, inches	F
12"	35.64
15"	64.59
18"	105.04
21"	158.32
24"	226.20
27"	309.50
30"	410.20
33"	528.90
36"	666.60
42"	1006.10
48"	1436.00
54"	1965.00
60"	2604.00
66"	3357.00
72"	4234.00
78"	5242.00
84"	6387.00
90"	7679.00
96"	9119.00

$(s)^{1/2}$ values

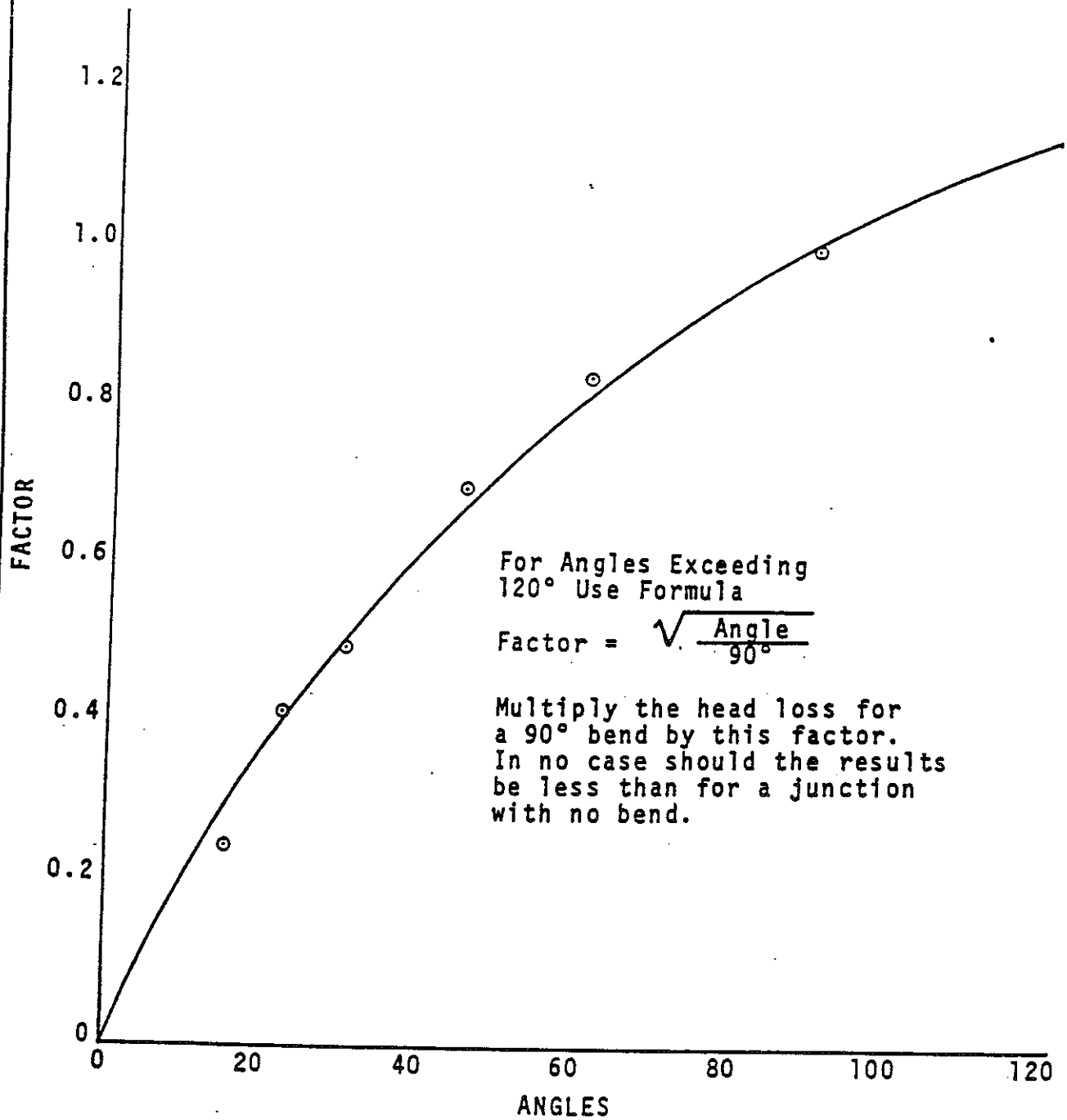
Number	.-----0	.-----1	.-----2	.-----3	.-----4	.-----5	.-----6	.-----7	.-----8	.-----9
.00001	.003162	.003317	.003464	.003606	.003742	.003873	.004000	.004123	.004243	.004359
.00002	.004472	.004583	.004690	.004796	.004899	.005000	.005099	.005196	.005292	.005385
.00003	.005477	.005568	.005657	.005745	.005831	.005916	.006000	.006083	.006164	.006245
.00004	.006325	.006403	.006481	.006557	.006633	.006708	.006782	.006856	.006928	.007000
.00005	.007071	.007141	.007211	.007280	.007348	.007416	.007483	.007550	.007616	.007681
.00006	.007746	.007810	.007874	.007937	.008000	.008062	.008124	.008185	.008246	.008307
.00007	.008367	.008426	.008485	.008544	.008602	.008660	.008718	.008775	.008832	.008888
.00008	.008944	.009000	.009055	.009110	.009165	.009220	.009274	.009327	.009381	.009434
.00009	.009487	.009539	.009592	.009644	.009695	.009747	.009798	.009849	.009899	.009950
.00010	.010000	.010050	.010100	.010149	.010198	.010247	.010296	.010344	.010392	.010440
.0001	.01000	.01049	.01095	.01140	.01183	.01225	.01265	.01304	.01342	.01378
.0002	.01414	.01449	.01483	.01517	.01549	.01581	.01612	.01643	.01673	.01703
.0003	.01732	.01761	.01789	.01817	.01844	.01871	.01897	.01924	.01949	.01975
.0004	.02000	.02025	.02049	.02074	.02098	.02121	.02145	.02168	.02191	.02214
.0005	.02236	.02258	.02280	.02302	.02324	.02345	.02366	.02387	.02408	.02429
.0006	.02449	.02470	.02490	.02510	.02530	.02550	.02569	.02588	.02608	.02627
.0007	.02646	.02665	.02683	.02702	.02720	.02739	.02757	.02775	.02793	.02811
.0008	.02828	.02846	.02864	.02881	.02898	.02915	.02933	.02950	.02966	.02983
.0009	.03000	.03017	.03033	.03050	.03066	.03082	.03098	.03114	.03130	.03146
.0010	.03162	.03178	.03194	.03209	.03225	.03240	.03256	.03271	.03286	.03302
.001	.03162	.03317	.03464	.03606	.03742	.03873	.04000	.04123	.04243	.04359
.002	.04472	.04583	.04690	.04796	.04899	.05000	.05099	.05196	.05292	.05385
.003	.05477	.05568	.05657	.05745	.05831	.05916	.06000	.06083	.06164	.06245
.004	.06325	.06403	.06481	.06557	.06633	.06708	.06782	.06856	.06928	.07000
.005	.07071	.07141	.07211	.07280	.07348	.07416	.07483	.07550	.07616	.07681
.006	.07746	.07810	.07874	.07937	.08000	.08062	.08124	.08185	.08246	.08307
.007	.08367	.08426	.08485	.08544	.08602	.08660	.08718	.08775	.08832	.08888
.008	.08944	.09000	.09055	.09110	.09165	.09220	.09274	.09327	.09381	.09434
.009	.09487	.09539	.09592	.09644	.09695	.09747	.09798	.09849	.09899	.09950
.010	.10000	.10050	.10100	.10149	.10198	.10247	.10296	.10344	.10392	.10440
.01	.1000	.1049	.1095	.1140	.1183	.1225	.1265	.1304	.1342	.1378
.02	.1414	.1449	.1483	.1517	.1549	.1581	.1612	.1643	.1673	.1703
.03	.1732	.1761	.1789	.1817	.1844	.1871	.1897	.1924	.1949	.1975
.04	.2000	.2025	.2049	.2074	.2098	.2121	.2145	.2168	.2191	.2214
.05	.2236	.2258	.2280	.2302	.2324	.2345	.2366	.2387	.2408	.2429
.06	.2449	.2470	.2490	.2510	.2530	.2550	.2569	.2588	.2608	.2627
.07	.2646	.2665	.2683	.2702	.2720	.2739	.2757	.2775	.2793	.2811
.08	.2828	.2846	.2864	.2881	.2898	.2915	.2933	.2950	.2966	.2983
.09	.3000	.3017	.3033	.3050	.3066	.3082	.3098	.3114	.3130	.3146
.10	.3162	.3178	.3194	.3209	.3225	.3240	.3256	.3271	.3286	.3302

To obtain Q, multiply F by the square root of the slope, S, in ft. per ft.

To utilize this table for values of n* other than 0.013, first obtain Q based on 0.013, then multiply this Q by the ratio: other value of n divided into .013.

PIPE CAPACITIES FLOWING FULL BY MANNING'S FORMULA

PLATE V-D



HEAD LOSSES AT BENDS OTHER THAN 90°

PLATE V-E

RTE _____ PROJ _____ DATE _____

INLET NUMBER	INLET TYPE	INLET LENGTH (FT)	STATION	DRAINAGE AREA (AC)	C	CA	Σ CA	I IN/HR	Q INCR (CFS)	Q CARRY-OVER (CFS)	Q_T GUTTER FLOW	S GUTTER SLOPE (FT/FT)	S_X CROSS SLOPE (FT/FT)	T(SPREAD)	W(FT)	W/T	Sw(FT/FT)	Sw/Sx	Eo(#10)	a	Sw-a/(12W)	Se(FT/FT)= Sx + SwEo	L_T(FT)15	P EFFEC LENGTH FT	L/L_T	d(FT)	E(#16)	h(FT)	Q: INTERC-EPTED CFS	d/h	Qb CARRY-OVER CFS	T SPREAD FT @ SAG	REMARK

SHEET ____ OF ____

STORM WATER INLET COMPUTATION SHEET

PLATE V-F

ROUTE_____ PROJ._____
COUNTY_____ DISTRICT_____
DESCRIPTION_____

SHEET_____ OF_____

FROM POINT	TO POINT	AREA DRAIN. "A"	RUN-OFF COEF.	CA		INLET TIME	RAIN FALL	RUNOFF Q	INVERT ELEVATIONS		LENGTH	SLOPE	DIA.	CAPA-CITY	VEL.	FLOW TIME	REMARKS
		ACRES	C	INCRE-MENT	ACCUM-ULATED	MIN-UTES	IN./HR.	C.F.S.	UPPER END	LOWER END	FT.	FT./FT.	IN.	C.F.S.	F.P.S.	SEC.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)

STORM SEWER DESIGN COMPUTATION SHEET

PLATE V-G

Project: _____

Designer _____

Date _____

Hydrologic And Channel Information

Q_1 = _____

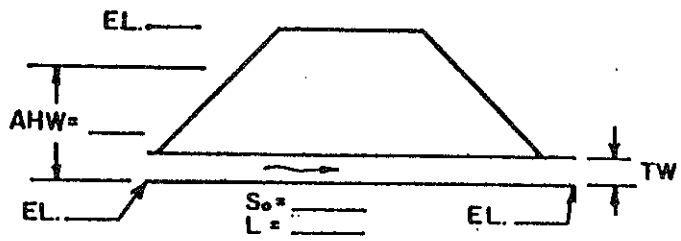
Q_2 = _____

TW_1 = _____

TW_2 = _____

SKETCH

Station _____



Allowable Outlet Velocity = _____

Culvert Type	O	Size	Headwater Computation									Controlling HW	Outlet Velocity	Cost	Comments
			Inlet Cont.		Outlet Contol										
			$\frac{HW}{D}$	HW	K_e	d_c	$\frac{d_c+O}{2}$	h_o	H	LS_o	HW				

Summary & Recommendations:

CULVERT HEADWATER COMPUTATION SHEET

PROJECT

PLATE V-H

INLET STATION	Outlet Water Surface Elev.	D_o	Q_o	L_o	S_{f_o} %	H_f	JUNCTION LOSS												Final H	Inlet Water Surface Elev.	Rim Elev.
							V_o	H_b	Q_i	V_i	Q_iV_i	$\frac{V_i^2}{2g}$	H_i	Angle	H_Δ	H_t	$1.3\ H_t$	$0.5\ H_t$			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)

$H_i = 0.35 \frac{V_i^2}{2g}$ $H_o = 0.25 \frac{V_o^2}{2g}$ $H_\Delta = K \frac{V_i^2}{2g}$ FINAL $H = H_f + H_t$

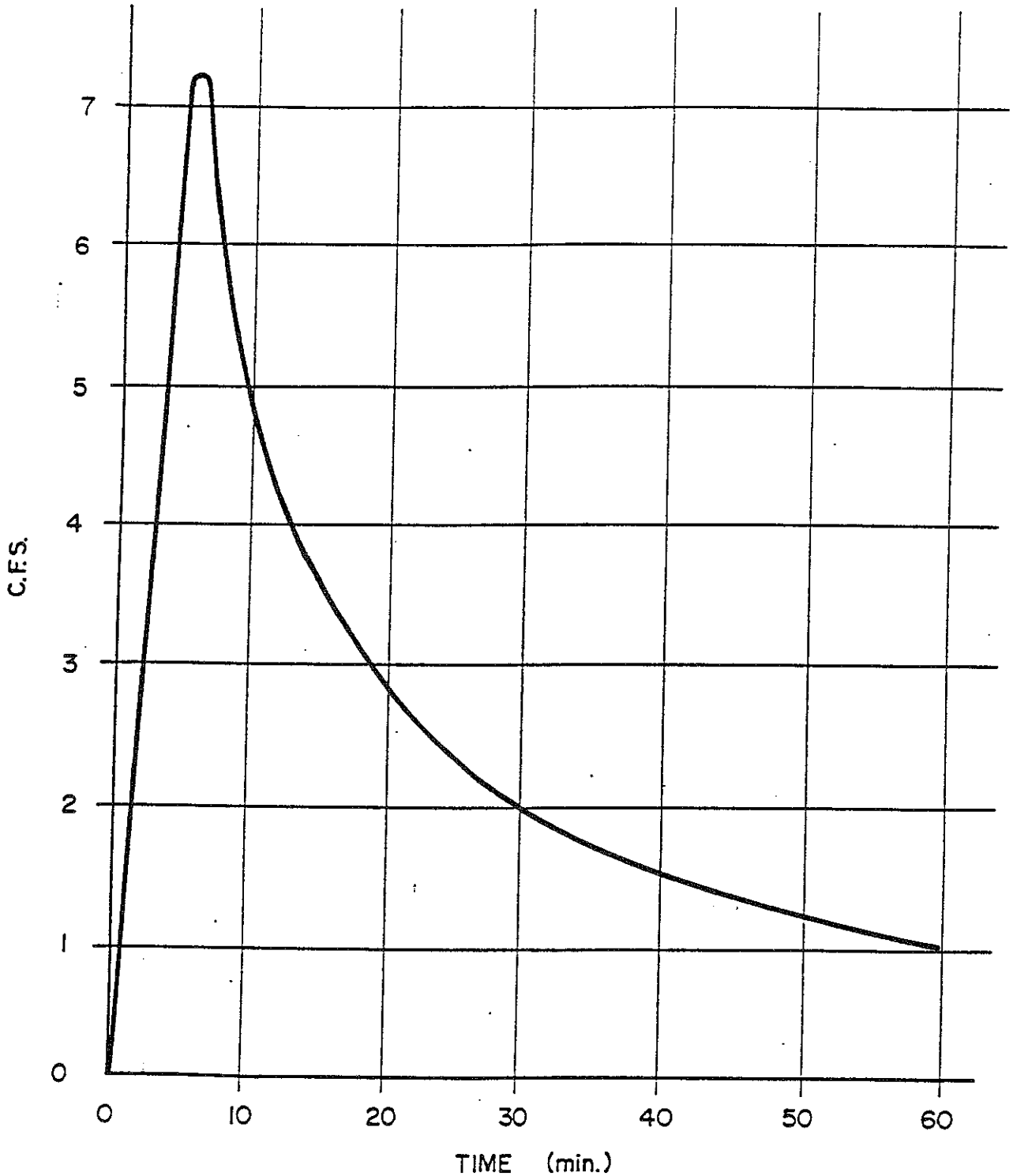
$H_t = H_o + H_i + H_\Delta$

SEE LD-72(D)67

90°	K = 0.70	50°	K = 0.47	20°	K = 0.16
80°	K = 0.66	40°	K = 0.38	15°	K = 0.10
70°	K = 0.61	30°	K = 0.28		
60°	K = 0.55	25°	K = 0.22		

HYDRAULIC GRADE LINE COMPUTATION SHEET

PLATE V-I

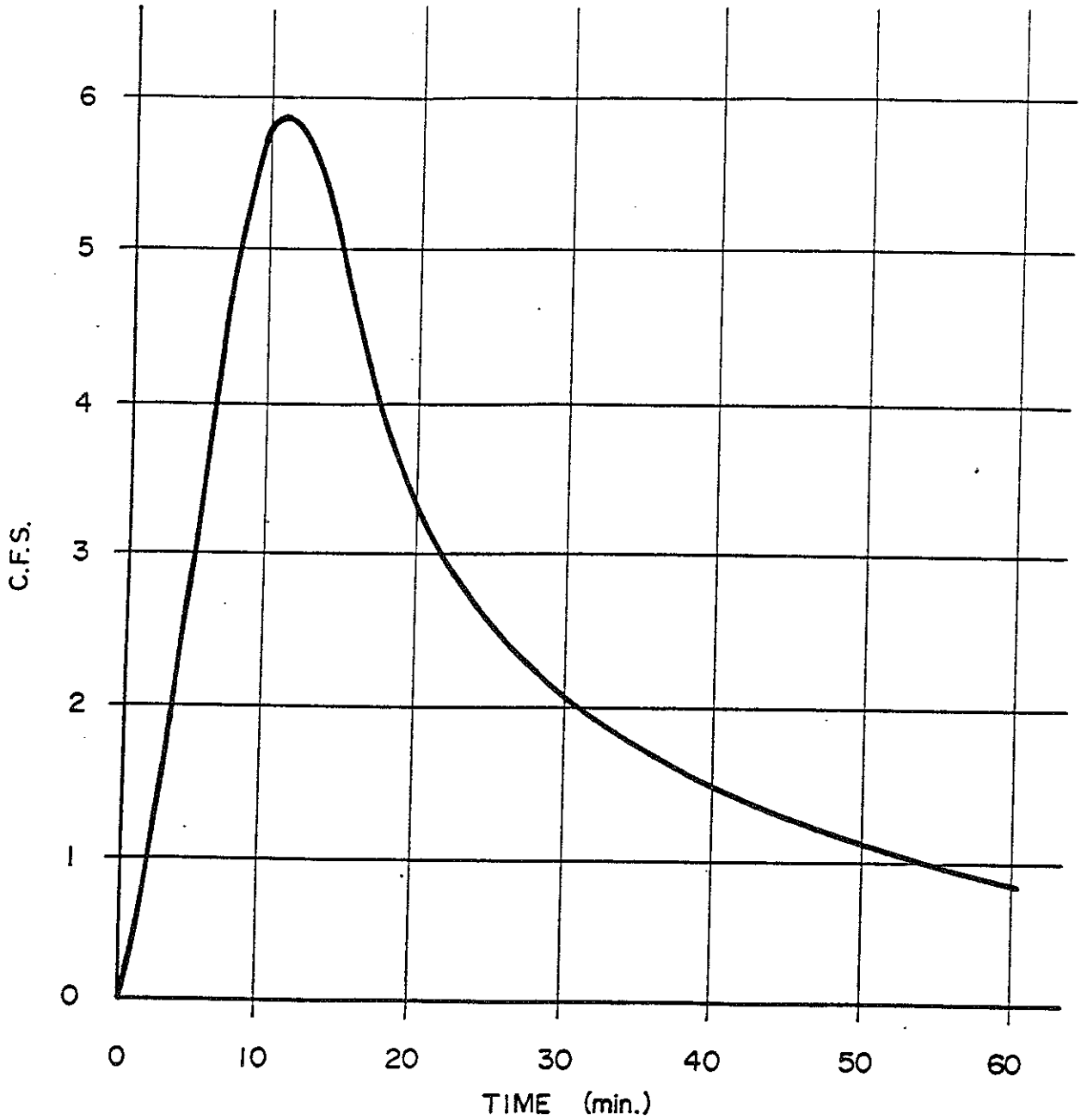


UNIT INFLOW HYDROGRAPH

10 YEAR, 2 HOUR STORM

Tc = 5 MINUTES

PLATE V-J

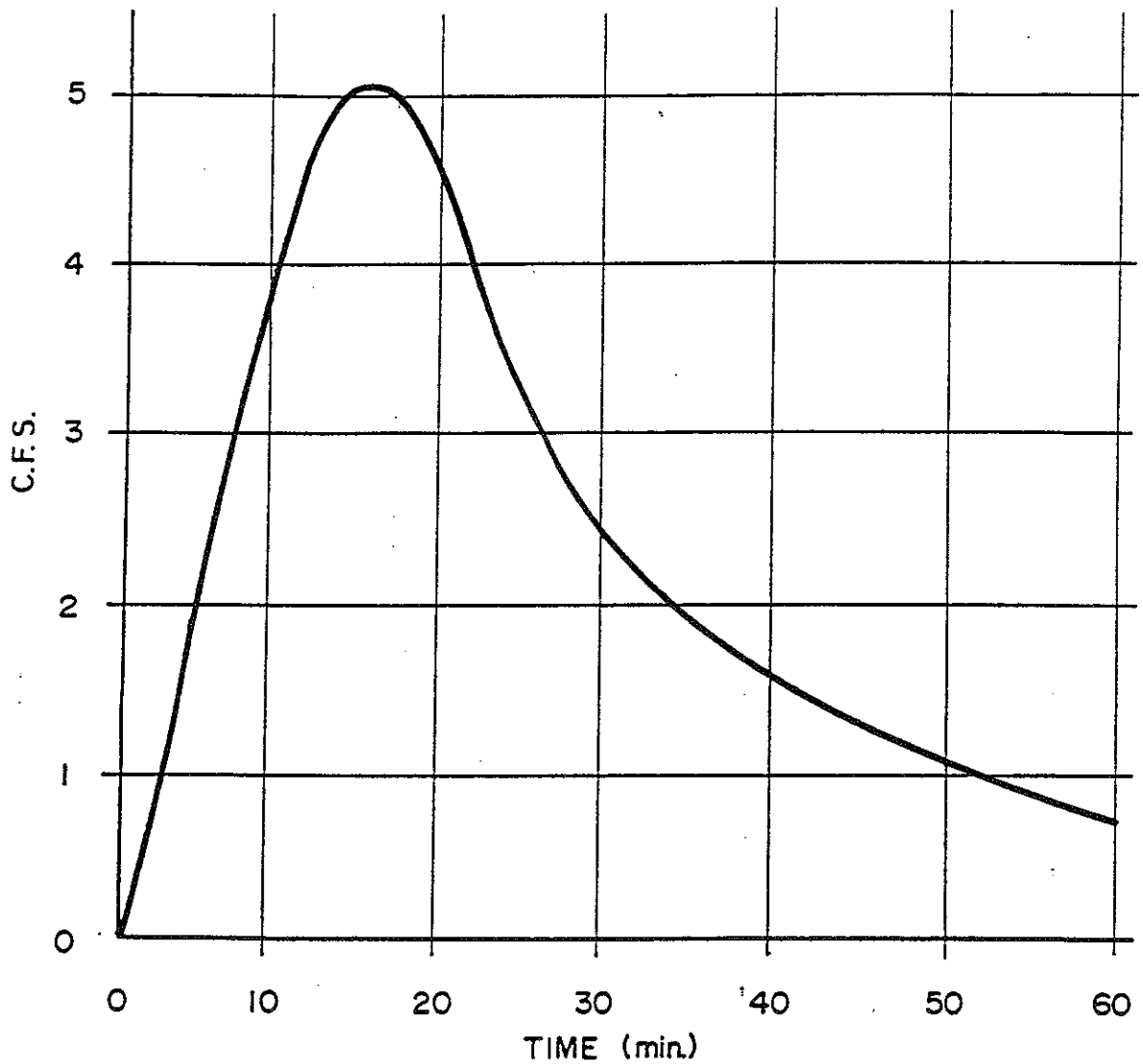


UNIT INFLOW HYDROGRAPH

10 YEAR, 2 HOUR STORM

Tc = 10 MINUTES

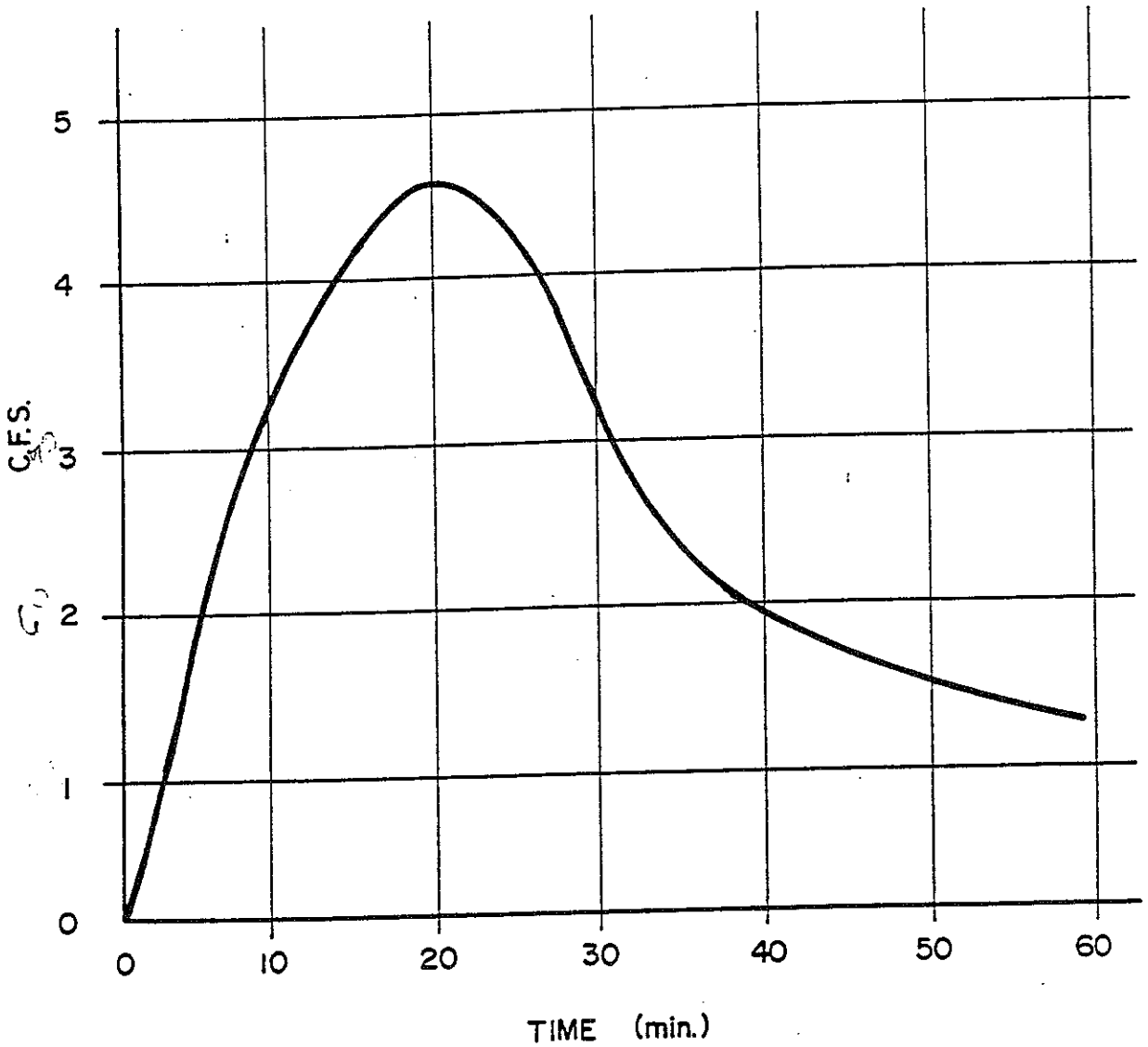
PLATE V-K



UNIT INFLOW HYDROGRAPH

10 YEAR, 2 HOUR STORM

Tc = 15 MINUTES

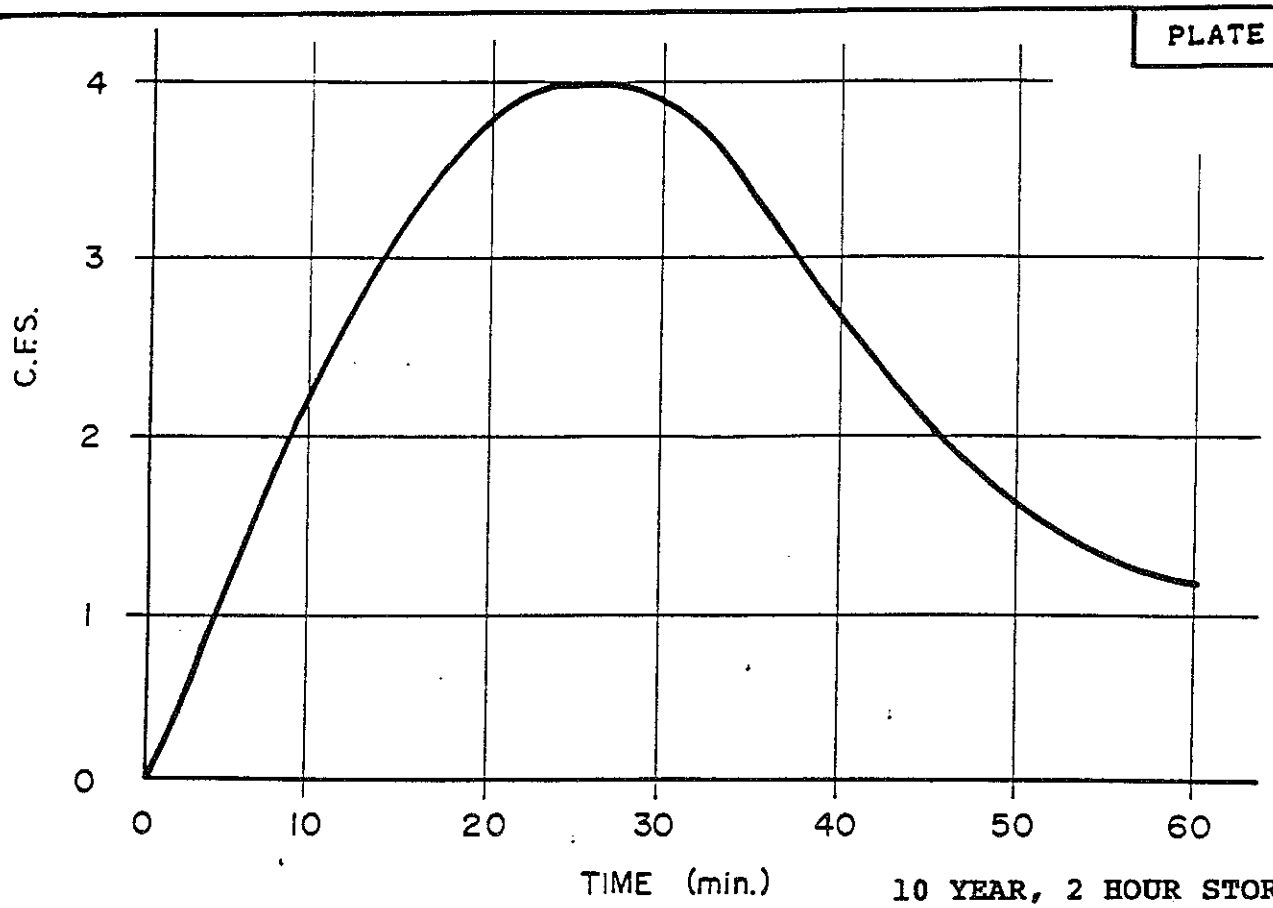


UNIT INFLOW HYDROGRAPH

10 YEAR, 2 HOUR STORM

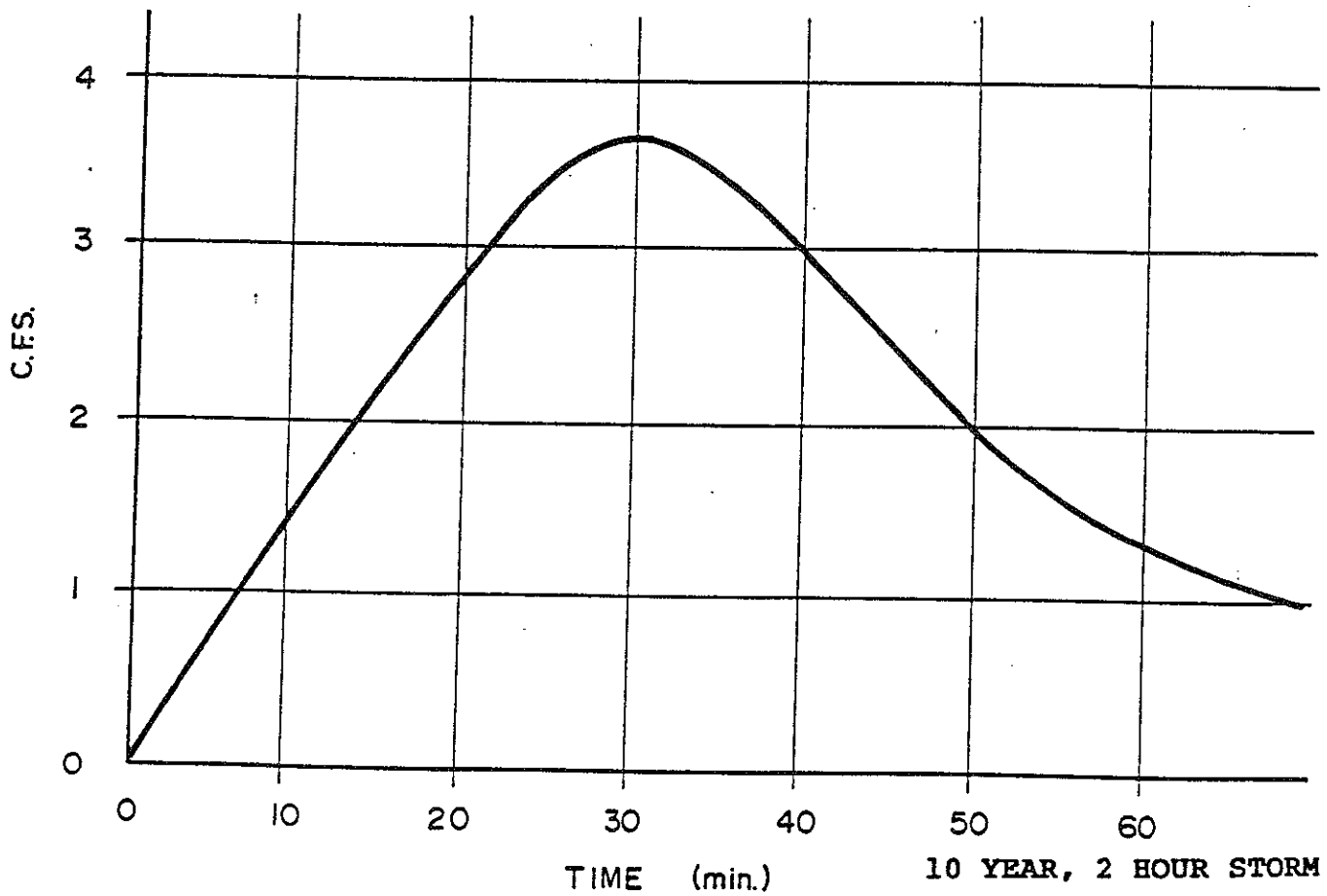
Tc = 20 MINUTES

PLATE V-M



10 YEAR, 2 HOUR STORM

Tc = 25 MINUTES

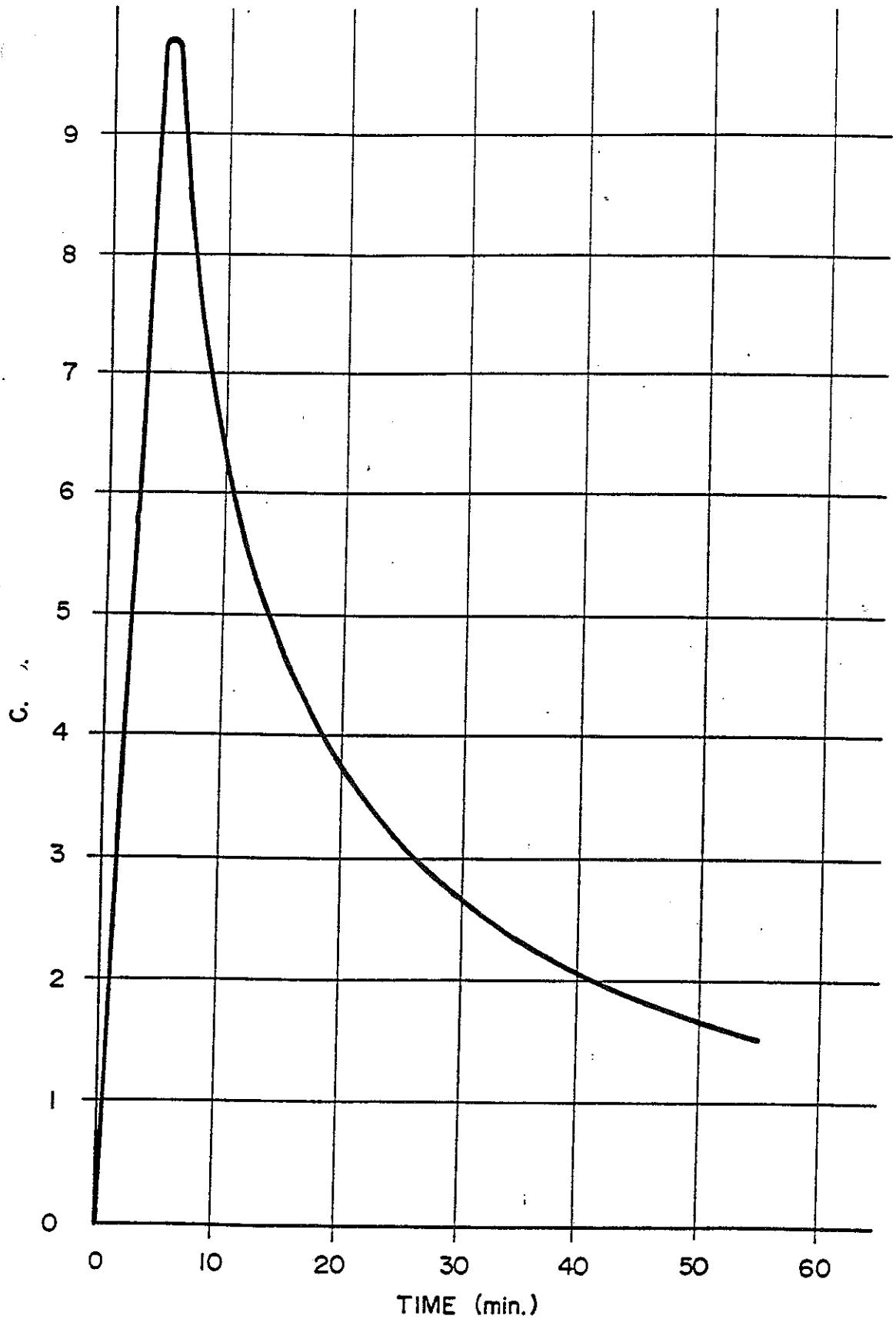


10 YEAR, 2 HOUR STORM

Tc = 30 MINUTES

UNIT INFLOW HYDROGRAPH

PLATE V-N

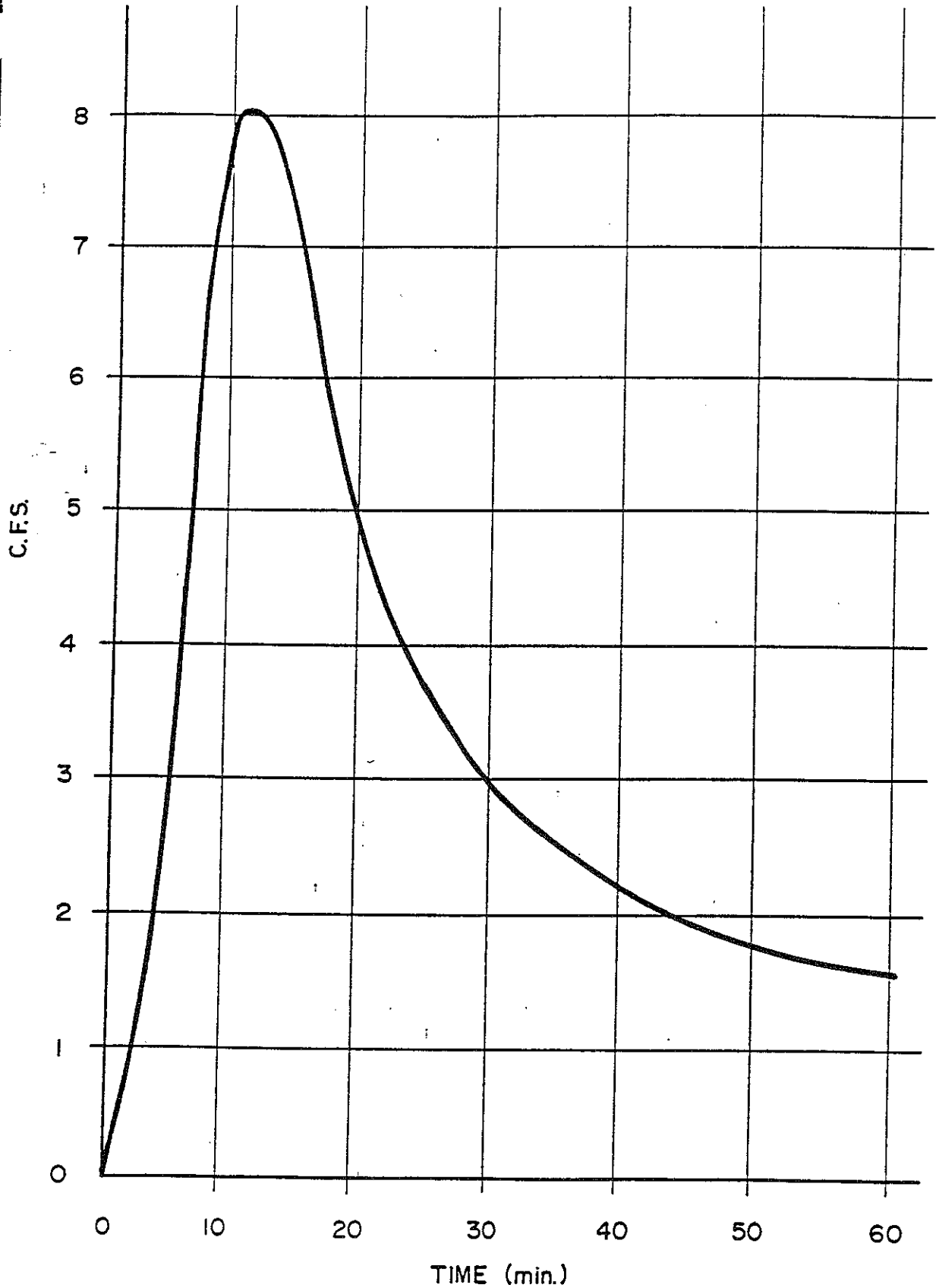


UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 5 MINUTES

PLATE V-O

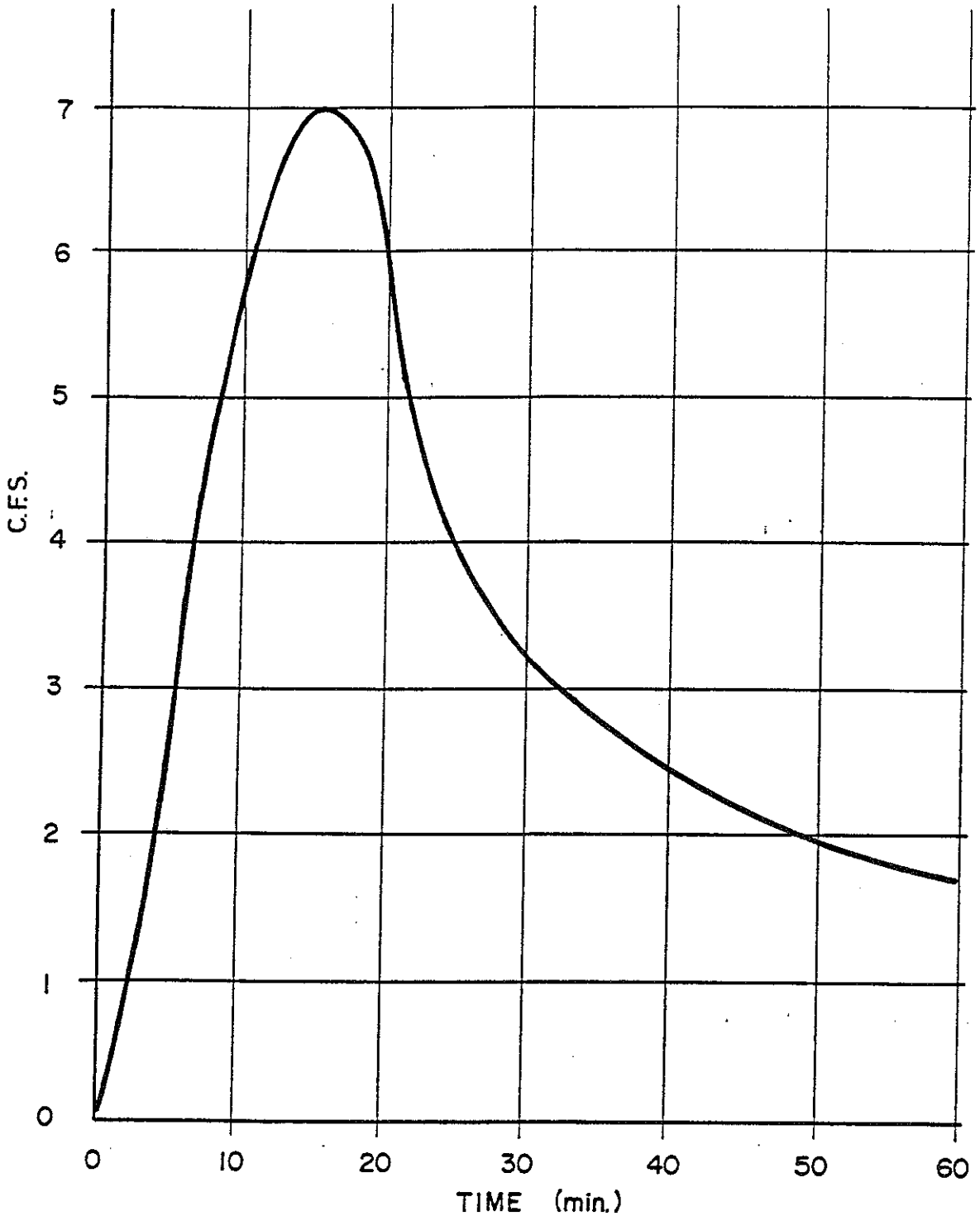


UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 10 MINUTES

PLATE V-P

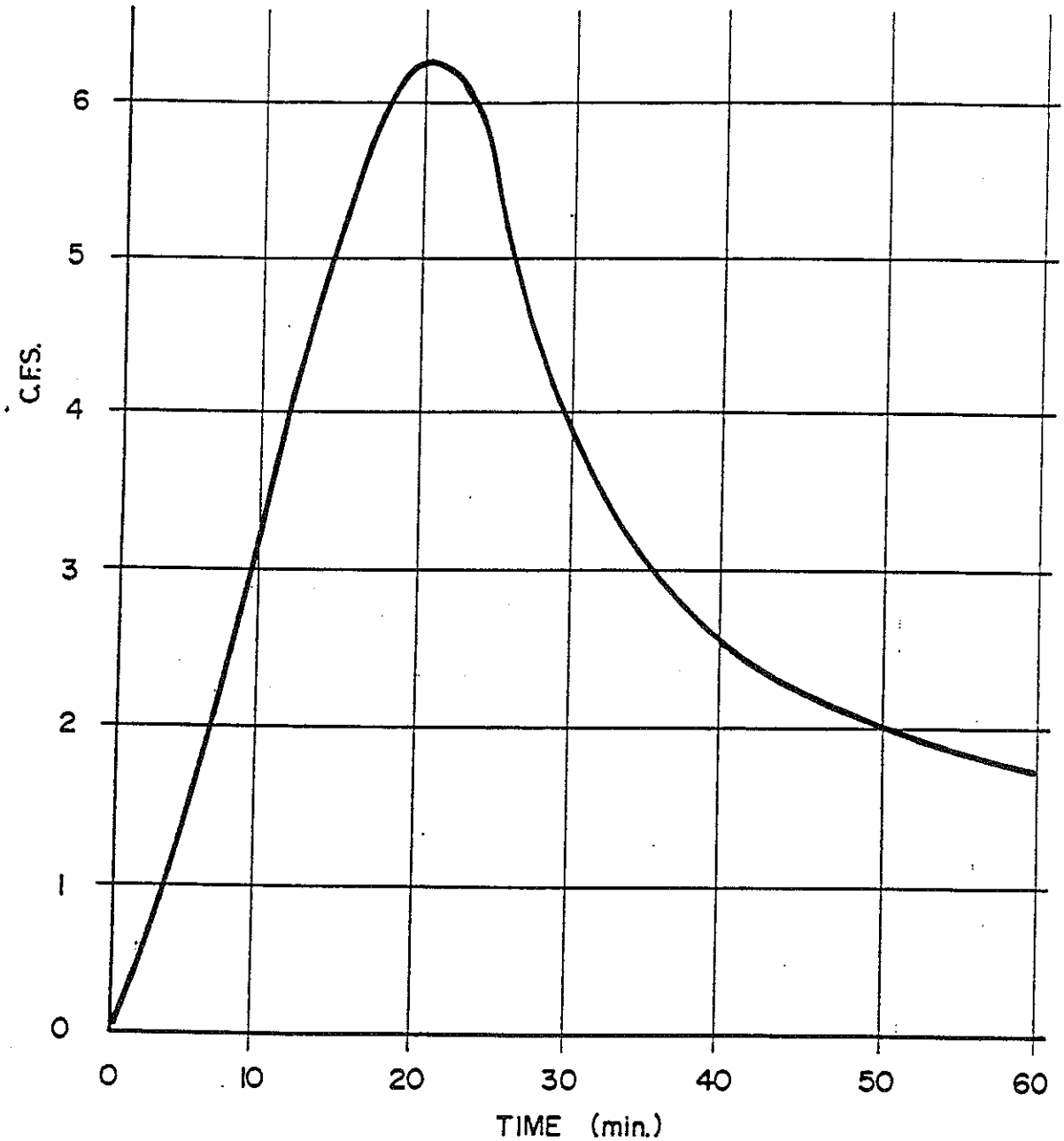


UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 15 MINUTES

PLATE V-Q

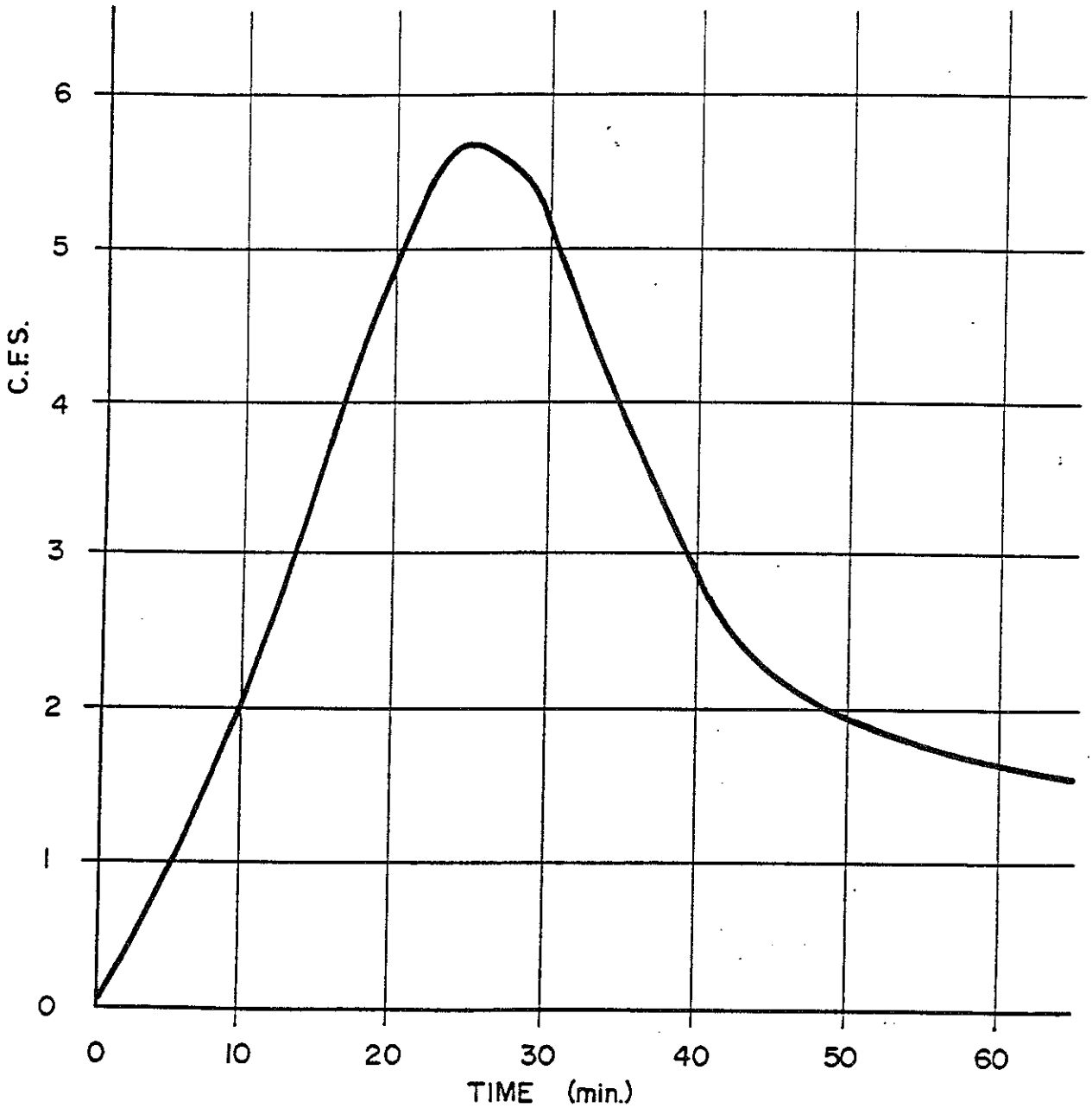


UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 20 MINUTES

PLATE V-R

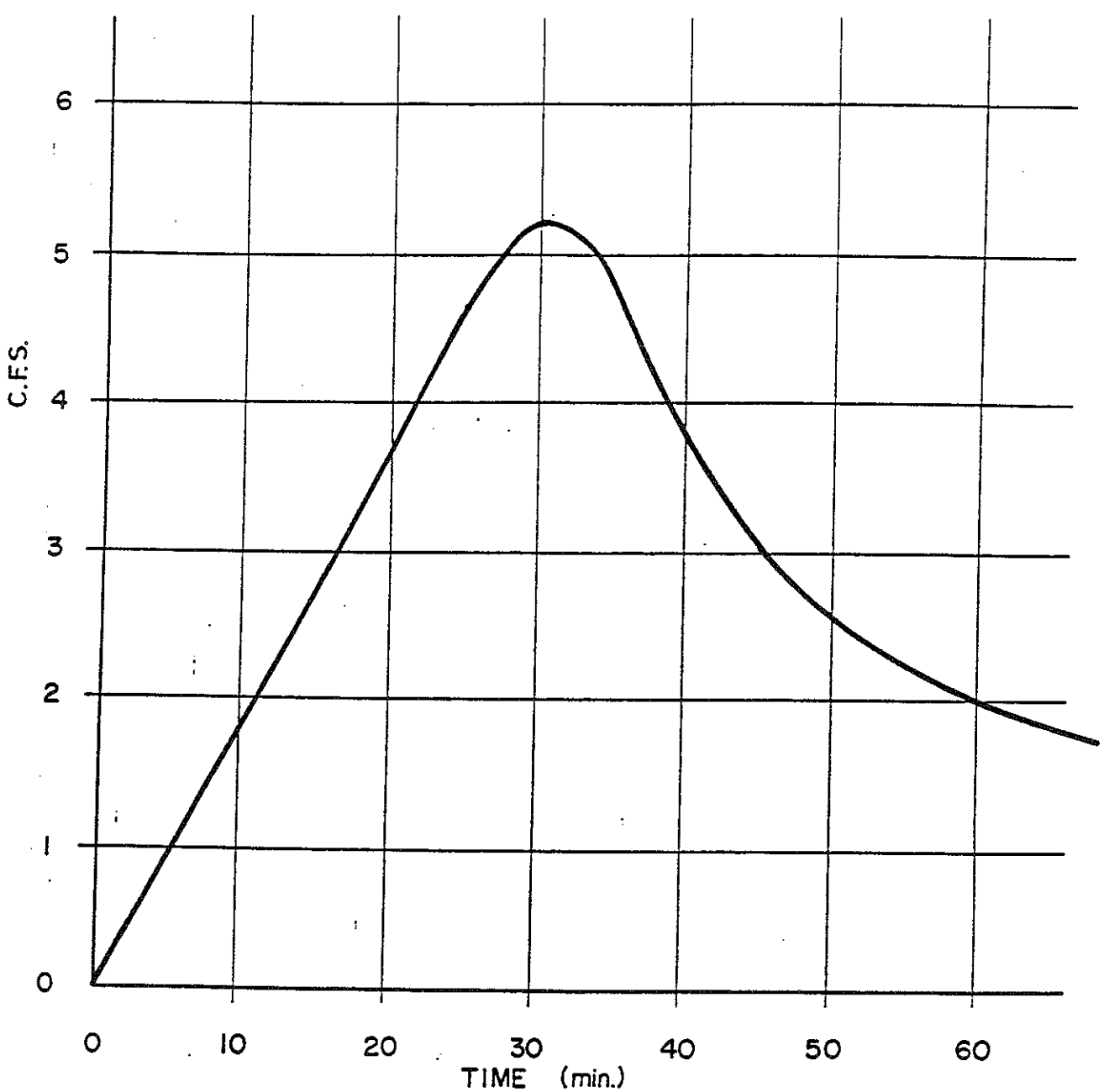


UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 25 MINUTES

PLATE V-5



UNIT INFLOW HYDROGRAPH

100 YEAR, 2 HOUR STORM

Tc = 30 MINUTES

PLATE V-T

INCREMENTAL UNIT HYDROGRAPH VALUES

	Tc \ Time	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
10-Year	5 min.	7.27	4.68	3.46	2.77	2.29	1.94	1.68	1.47	1.31	1.18	1.08	0.99						
	10 min.	3.25	5.92	4.53	3.14	2.43	1.99	1.67	1.41	1.21	1.04	0.92	0.80						
	15 min.	2.20	4.24	5.10	4.36	3.08	2.34	1.89	1.56	1.29	1.07	0.89	0.73						
	20 min.	1.98	3.37	4.20	4.56	4.16	3.02	2.22	1.83	1.58	1.41	1.27	1.17						
	25 min.	1.28	2.40	3.25	3.83	4.03	3.89	3.35	2.68	2.05	1.58	1.29	1.12						
	30 min.	0.80	1.57	2.32	3.00	3.52	3.71	3.48	3.03	2.49	1.97	1.58	1.32	1.11	0.97				
100-Year	5 min.	9.84	6.37	4.73	3.74	3.13	2.65	2.33	2.07	1.88	1.69	1.55							
	10 min.	3.68	8.10	6.47	4.44	3.50	2.86	2.43	2.17	1.93	1.78	1.67	1.58						
	15 min.	2.81	5.99	7.05	5.69	3.89	3.17	2.73	2.40	2.16	1.98	1.83	1.68						
	20 min.	1.43	3.36	5.33	6.52	5.15	3.78	3.03	2.55	2.23	2.00	1.87	1.75						
	25 min.	0.98	2.26	3.79	5.05	5.75	5.17	3.99	2.90	2.28	1.96	1.77	1.65	1.53	1.43	1.39			
	30 min.	0.97	1.88	2.80	3.79	4.73	5.22	4.78	3.92	3.04	2.52	2.20	1.97	1.81	1.65	1.55	1.51	1.49	1.45

INCREMENTAL UNIT HYDROGRAPH VALUES

ARTICLE VI

MISCELLANEOUS DESIGN STANDARDS

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ARTICLE VI

MISCELLANEOUS DESIGN STANDARDS

601.00 GENERAL REQUIREMENTS FOR LOT GRADING

601.01 Grading Plan Requirements: The following items are to be included on all grading plans:

A. Spot elevations are required to be shown at all house entrances, at the driveway entrance and at all changes in grade of the driveway. Spot elevations should be shown at each corner of the house. Walkout basements should be indicated on the plans, showing the entrance and the appropriate spot elevations.

B. The minimum size allowed for a driveway culvert is 12 inches and the inverts for the pipe must be shown. In any case, where a driveway culvert must be larger than 12 inches based on the flow, culvert computations must be submitted.

C. A parking pad at least 360 square feet in area shall be allotted on driveways for parking. This parking pad should be at no greater than 5% grade and no less than 1%. A 180 square foot parking pad will be allowed for houses that include a single car garage or carport. No parking pad is required for houses that include a garage or a carport for two or more vehicles. The portion of the driveway from the street to the parking pad should be on grade of no more than 15% and no less than 1%. A waiver request shall accompany any plans which do not conform to these driveway standards.

D. The lead walk and all risers must be shown on the plan and the elevations at all landings must be specified.

E. In subdivisions where yard lights are required, their locations must be shown on each individual lot.

F. The grading of the front of the lot along with whatever cuts and fills are proposed should be shown inasmuch as they define the ditch line and the location of the driveway culvert.

G. Erosion controls are required for all areas on the lot where the ground will be disturbed. The original erosion controls for the subdivision are satisfactory for areas that they will cover as long as the erosion controls won't be removed (or the escrow