PROFESSIONAL ENGINEERING CONSULTANTS
PROFESSIONAL ASSOCIATION

DRAINAGE PLAN

AND

SUPPORTING CALCULATIONS

FOR

WILLOWOOD ESTATES ADDITION

WICHITA,
SEDGWICK COUNTY, KS

DECEMBER 6, 1996

303 S. TOPEKA
WICHITA, KANSAS 67202
(316) 262-2691
FAX (316) 262-3003

PROFESSIONAL ENGINEERING CONSULTANTS
PROFESSIONAL ASSOCIATION
303 S. TOPEKA
WICHITA, KANSAS
ZIP CODE / 67202

WILLOWOOD ESTATES ADDITION

Wichita, Sedgwick County, Kansas

12/07/96

Willowood Estates Addition is single lot development encompassing approximately 36 acres in Southeast Wichita, Kansas. It is divided into 193 mobile home lots with private streets and storm water drainage systems. It is a replat of the original plat known as Emery Park Addition platted in 1988. Two specific references have been used to justify concepts stated in this report. The first is the original drainage plan conceived for Emery Park Addition called, Drainage Plan and Supporting Calculations for Emery Park Addition to Wichita, Sedgwick County, Kansas, dated July 15, 1988, referred hereafter as Ref. 1. Another reference, Project No. 87-M-6150(001) MacArthur Road (Arkansas River to Hydraulic), hereafter referred to as Ref. 2, has also been used to determine existing drainage patterns. The computations and supporting data for the drainage plan of Willowood Estates Addition are presented herein.

Hydrology

The Rational Method has been used for hydrologic analysis of all detention systems and storm sewer systems that serve the residential streets and yards. The analysis made is based on the available site data which includes the following: 1" = 100' topographic map with 2' contours of the site and adjacent areas; Sedgwick County Soil Survey Map; Emery Park Addition drainage plan dated July 15, 1988; Camelot Addition Plat; MacArthur Road plans. No lots in this plat lie within an area defined as Floodplain by FEMA's Floodway Map.

The development has been divided into 5 drainage areas as shown in the enclosed drainage plan. Basins A, B and E will drain to a detention pond on the East side of the property via street flow and concrete flumes. Basins C will drain the to West to the existing Willowood Mobile Home Park (Camelot Addition). The runoff from basin C will be detained in an existing detention pond within the Camelot Addition development.

Ref. 2 indicates that 6.6 acres of runoff is intercepted by MacArthur Road storm sewers. Basin D is 6.6 acres and will drain to the MacArthur Road storm sewer via sump inlets and storm sewer at the entrance on MacArthur.

Pond Analysis

The detention pond has been sized using methods found in Ref. 1. The difference between the 100 year pre-developed peak flowrate and the 100 year post-developed peak flowrate is required to be detained. However, the designed detention pond is detaining the difference between the 100 year post developed peak flowrate and the maximum flowrate through a 15" pipe with 2 feet of head on the inlet side.

Inlet Design

Since private streets will serve the entire plat, a maximum curb-depth flow is not applicable. For each inlet connected to city storm sewers, street flooding and inlet capacity has been checked for the minor storm. It has been assumed 1/4 in./ft. street cross-slopes, City of Wichita 3-5/8" roll curb and gutter and Type 1A street inlets will be used throughout.

Pipe Design

Hydraulic computations for the pipe system were performed using Manning's equation. All pipes were assumed to be reinforced concrete with a Manning's "n" factor of 0.013. The optimum hydraulic grade line is at least one foot below the top of curb elevations for the minor storm in all cases. However, to match existing storm sewer systems in conjunction with the new storm sewer, as little as 1/2 foot of freeboard may be present below top of curb during 2 year storms.

To simplify analysis the following assumptions were made:

1. The time of concentration is identical for both pipe flow and street flow for both major and minor storm; a conservative estimate since pipe velocities generally exceed gutter velocities.

Channel Design

Two concrete flumes and one grass lined vee channel have been utilized to convey concentrated flow to a desired location. All flumes and ditches have been sized using Manning's equation and a flowrates generated from a 100 year storm.

Design Aids

This section includes material used to assist in designing the drainage system. A 1"=100' scale drainage plan map is enclosed in the pocket.

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WILLOWOOD ESTATES ADDITION

REVISED HYDROLOGY

12/6/96

BASIN #	AREA (ac)	C2	C100	tc	i2 (in/hr)	i100 (in/hr)	Q2 (cfs)	Q100 (cfs)
A	5.15	0.57	0.67	15	3.83	7.37	11.24	25.43
B	11.60	0.57	0.67	15	3.83	7.37	25.32	57.28
C	7.90	0.57	0.67	15	3.83	7.37	17.25	39.01
D (E)	2.82	0.57	0.67	15	3.83	7.37	6.16	13.92
D (W)	3.83	0.57	0.67	15	3.83	7.37	8.36	18.91
E	3.65	0.70	0.80	15	3.83	7.37	9.79	21.52

Total Area= 34.95 Acres

Total Q2= 78.12 cfs

Total Q100= 176.08 cfs

Note : Runoff coefficient based on class B soils and 1/8 acre lots.

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Project Willowood Estates Add.

Item Pond Analysis PDM/MWB

DETENTION POND ANALYSIS

CONTRIBUTING AREAS: A, B, E   A = 20.4 AC ≈ 60% OF SITE

TOTAL Q_p = 104.23 cfs.

CALCULATION METHODS FROM: DRAINAGE PLAN & SUPPORTING CALCULATIONS FOR EMERY PARK ADDITION TO WICHITA, SEDGWICK COUNTY, KANSAS, DATED JULY 15, 1988

HERE AFTER REFERED TO AS REF 1.

PRE-DEVELOPED INFORMATION FROM: MAC ARTHUR ROAD (ARKANSAS RIVER TO HYDRAULIC)

PROJECT NO. 87-M-6150 (001)

HEREAFTER REFERED TO AS REF 2.

PREDEVELOPED AREA TO MAC ARTHUR ROAD = 6.6 AC.

$Q = CIA$ $C_{100} = 0.68$ UNDEVELOPED URBAN FLOW

$i_{100} = 7.37$ (15 MIN T_c)

$Q = 0.68(7.37)(6.6) = 33.1$ cfs.

POST DEVELOPED TO MACARTHUR ROAD IS BASIN D.

$Q = CIA$ $C_{100} = 0.67$ 1/8 AC RESIDENTIAL LOTS

$i_{100} = 7.37$ (15 MIN T_c)

$A = 6.65$ AC

$Q = 0.67(7.37)(6.65) = 32.84$ cfs < 33.1 ok.

THE WEST PART OF BASIN D WILL BE CARRIED THROUGH THE STREET IN NNH PAR TO INLETS AT THE ENTRANCE THEN TO SWS IN MACARTHUR RD.

THE EAST PART OF BASIN D WILL BE CARRIED VIA OPEN DITCH TO A INLET

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Project Willowood Estates Addition

Item Pond Analysis PDM/MWB

REMAINING PRE-DEVELOPED AREA FLOWING TO THE SOUTH
IS 37 − 6.6 = 30.4 Ac.

PRE-DEVELOPED Q. $Q = CIA$

$C = .43$ URBAN AGRICULTURAL ARE[A]
$i = 7.37$ ($T_c = 15$ MIN)

$Q = 0.43(7.37)(30.4)$
$= 96.3$ cfs.

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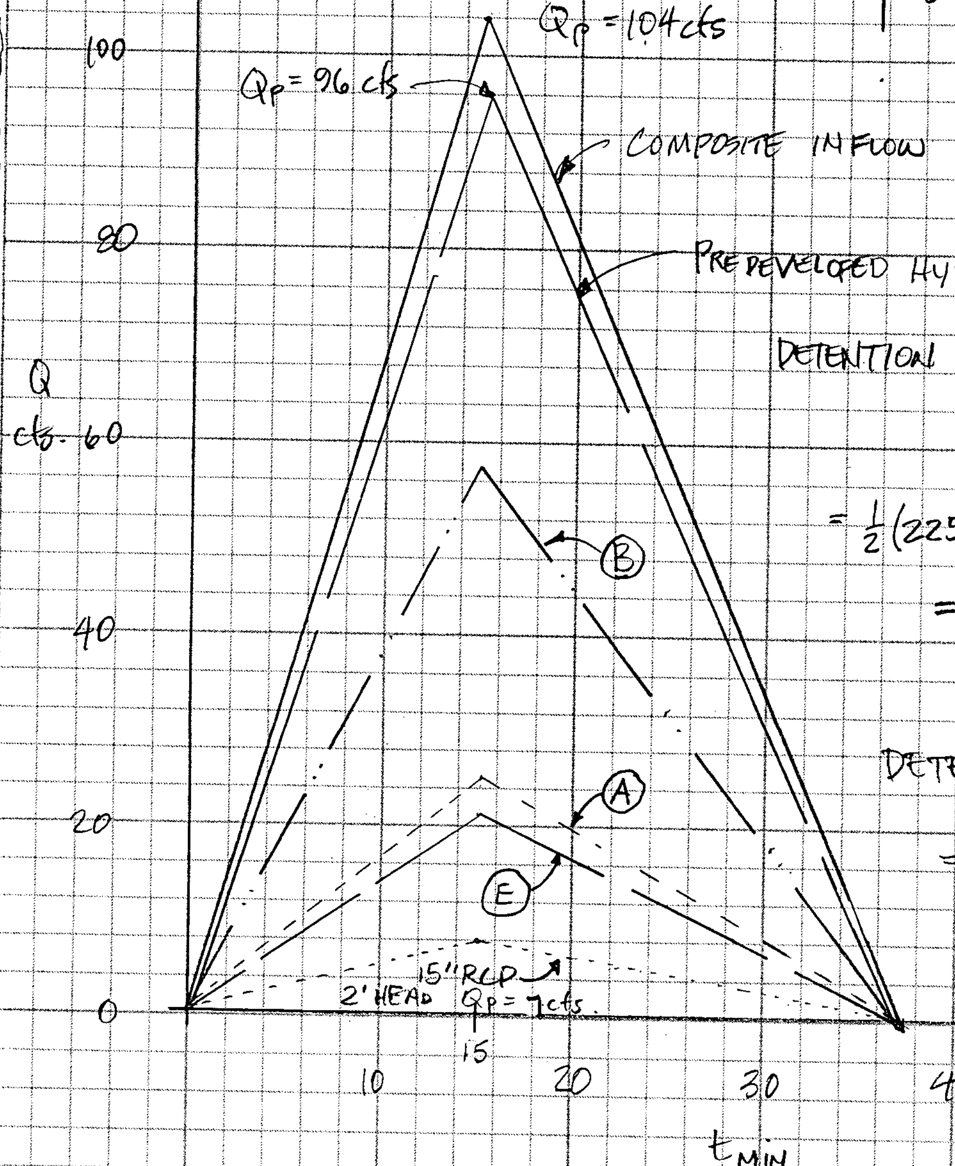
Item POND ANALYSIS PDM / MWB

BASIN	HSG	C	i_{100}	A (Ac)	Q (cfs)
A	B	.67	7.37	5.15	25.43
B	B	.67	7.37	11.60	57.28
C	B	.67	7.37	7.90	39.00
D	B	.67	7.37	6.65	32.84
E	B	.80	7.37	3.65	21.52



DETENTION REQ'D = AREA BETWEEN POST DEVELOPED & PREDEVEL. HYDROGRAPHS.

$= \frac{1}{2}(2250)(104) - \frac{1}{2}(2250)(96)$

$= 9000\ ft^3$

.21 Ac-Ft. REQ'D

DETENTION POND USED = AREA BETWEEN POST DEVELOPED & OUTLET CONTROL

$= \frac{1}{2}(2250)(104) - \frac{1}{2}(2250)(7)$

$= 109125\ ft^3$

= 2.50 Ac-Ft. USED.

REF 1: $T_b = 2.5\ t_c = 2.5 * 15 = 37.5$ min
= 2250 s.

REF 1: Assummed T_c is constant = 15 min
Assummed T_b is constant ...

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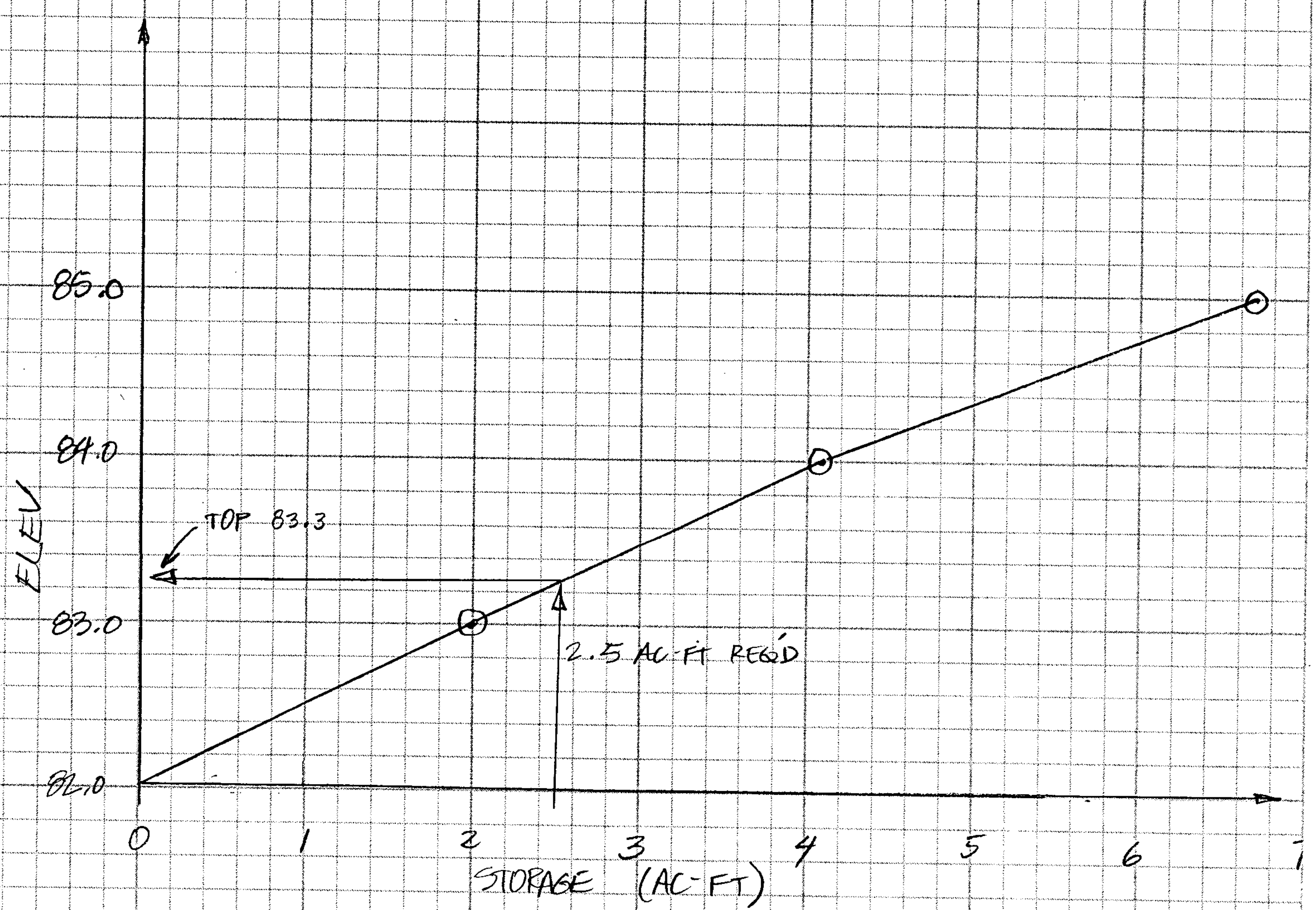
Project Willowood Estates Addition

Item Pond Analysis

414 / 200

STAGE-STORAGE OF DETENTION POND 4:1 Sides.

	ELEV	AREA (Ac)	Δd (ft)	Vol. (Ac-Ft)	Acc Vol (Ac-Ft)
Bottom	82.0	1.9	0	0	0
	83.0	2.0	1	2.0	2.0
	84.0	2.13	2	4.13	6.13
	85.0	2.25	3	6.75	12.88



TOP OF POND 83.3 + 1' FREEBOARD = 84.3 | TOP 84.5 Overflow 84 |

15" RCP CONTROLS OUTFLOW HW=2' Q=8 CFS.

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1440 EAST ENGLISH
WICHITA, KANSAS
ZIP CODE / 67211

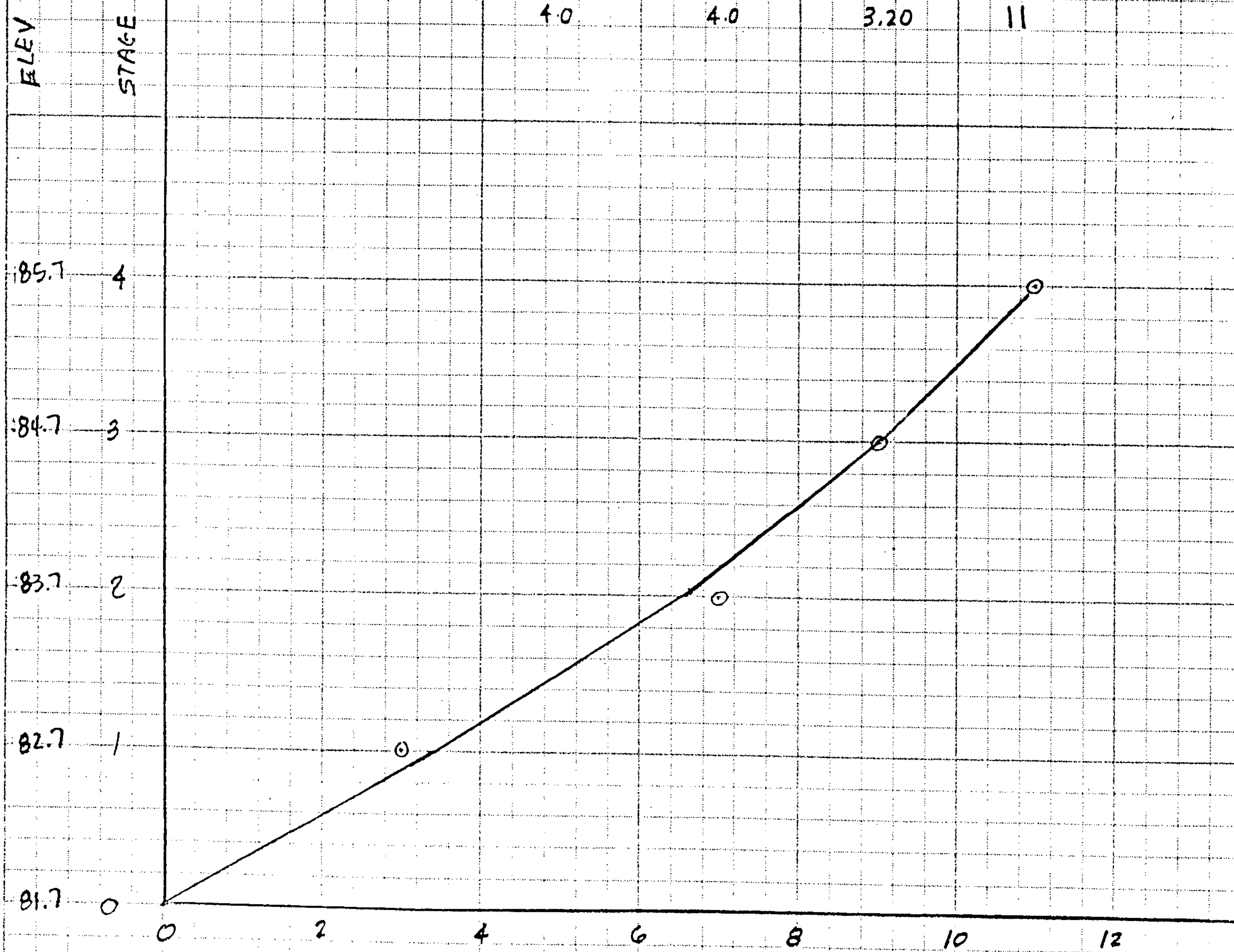
Date: July 1, 1988

Project: Emery Park Add.

Item: Drainage Detention

STAGE - DISCHARGE (DISCHARGE PIPE = 15" RCP)
inlet control

STAGE	HW	HW/D	Q
1.0	1.0	0.80	3
2.0	2.0	1.60	7
3.0	3.0	2.40	9
4.0	4.0	3.20	11



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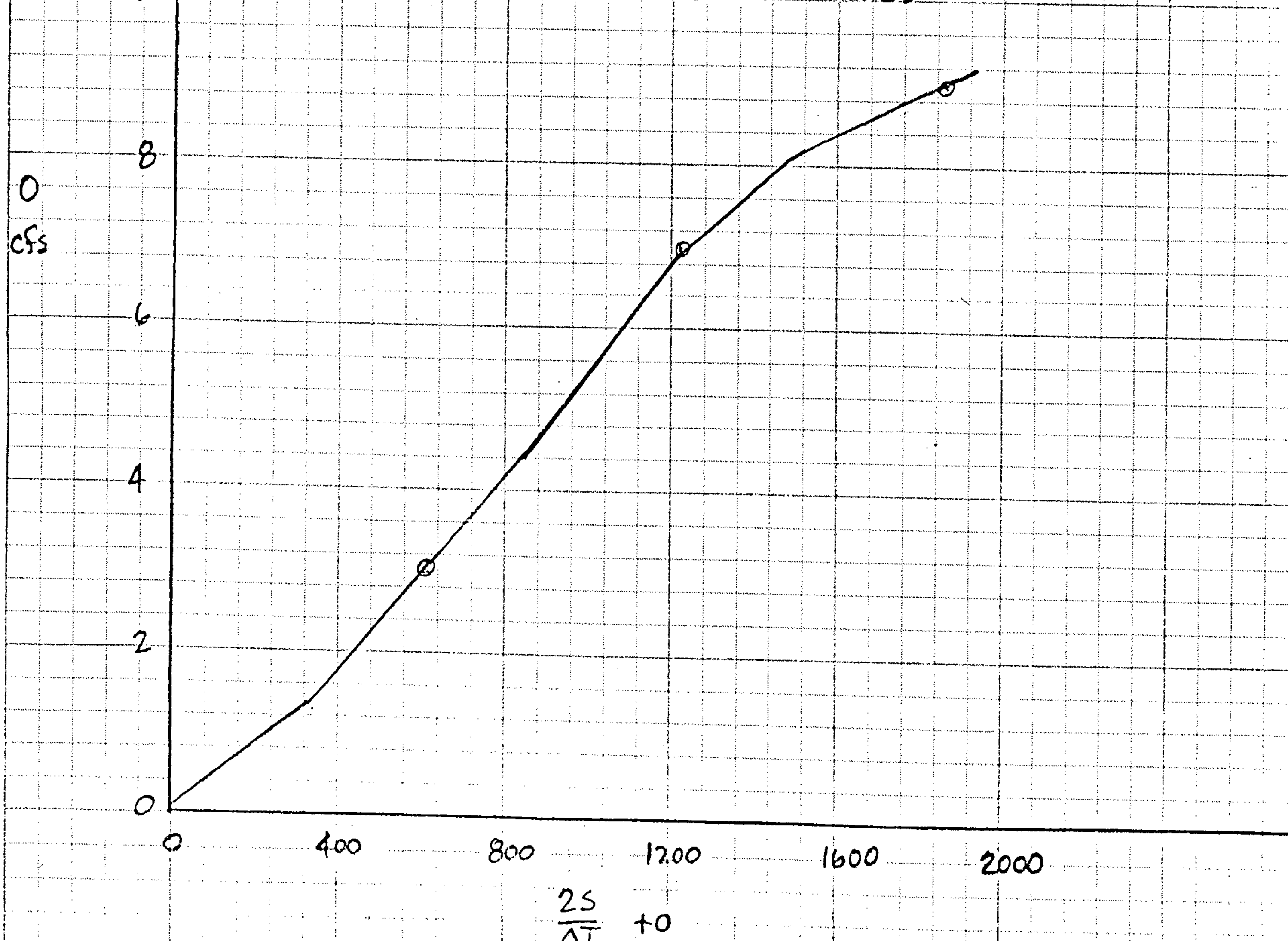
Date: July 1, 1988

Project: Emery Park Add.

Item: Drainage Detention

Stage	Elev.	Storage (S) Ac-Ft.	Storage (S) Ac-In	Outflow (O) cfs	2S	2S/ΔT	2S/ΔT +O
0	81.7	0.0	0.0	0.0	0.0	0.0	0.0
1	82.7	2.1	25.2	3	50.4	607	610
2	83.7	4.2	50.4	7	100.8	1214	1221
3	84.7	6.4	76.8	9	153.6	1851	1860

ΔT = 5 Min = 0.083 hr.



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Date July 1, 1988

Project Emery Park Addition

Item Drainage Defeution

	Time hr.	In cfs	In + In+1	2S/ΔT − O	2S/ΔT + O	O	HW	Elev.
0	0	0	45	0	0	0	0	181.7
5	0.083	45	135	43	45	1	0.3'	182.0
10	0.167	90	226	176	178	1	0.3'	182.0
15	0.250	136	242	398	402	2	0.6'	182.3
20	0.333	106	182	636	640	3	0.9'	182.6
25	0.416	76	123	810	818	4	1.2'	182.9
30	0.500	47	65	923	933	5	1.5'	183.2
35	0.583	18	18	978	988	5	1.5'	
40	0.666	0	0	986	996	5	1.5'	
45	0.750	0	0	976	986	5	1.5'	
50	0.833	0	0	966	976	5	1.5'	
55	0.916	0	0	956	966	5	1.5'	
60	1.000	0	0	946	956	5	1.5'	
65	1.083	0	0	936	946	5		
70	1.167	0	0	926	936	5		
75	1.250	0	0	916	926	5		
80	1.333	0	0	906	916	5		
85	1.416	0	0	896	906	5		
90	1.500	0	0	888	896	4	1.2'	182.9
95	1.583	0	0	880	888	4		
100	1.666	0	0		880	4		

Etc, Etc.

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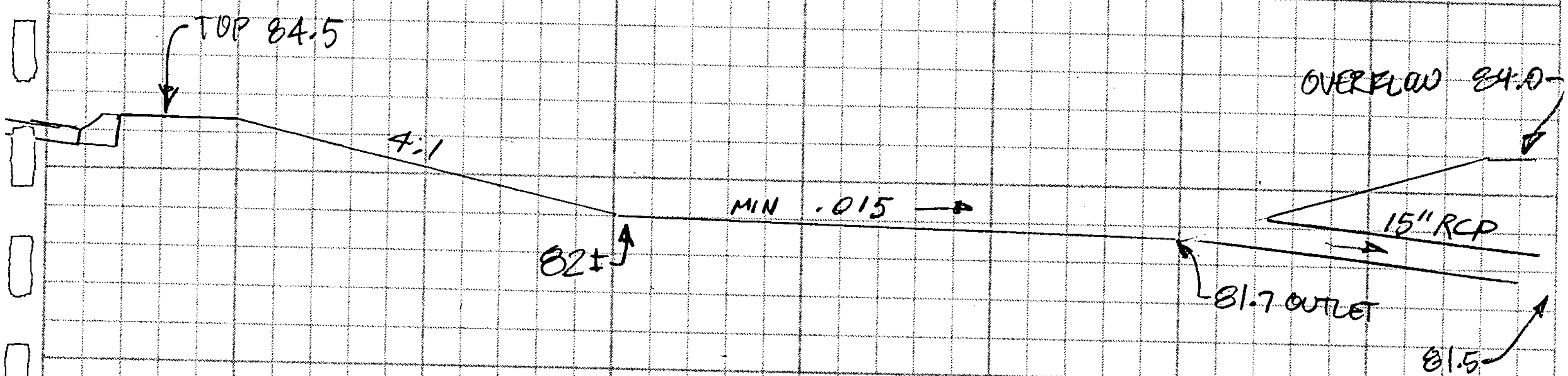
Project Willowood Estates Addition

Item POND SUMMARY



Q peak in = 104 cfs

Q peak out 7 cfs

DWS_{100} = 83.3

TOP BANK 84.5

OVER FLOW 84.0

Comp by: PDM

WILLOWOOD ESTATES ADDITION
STREET FLOW AND INLET DESIGN
12/6/96

Design Storm = Q 2   z=(1/Sx)/n= 3000

Hydrology			Approaching Flow				Inlet		On-Grade Inlet			Sump Inlet				
Node/ Basin	Initial Flow Qo (cfs)	Total Flow Qo+Qb (cfs)	C&G Slope So (%)	X-Slope Sx (in/ft)	Depth d (ft)	Spread T (ft)	Type	Length L (ft)	Slot Length Lt (ft)	L/Lt	Efficiency E	Sump Depth di (ft)	Curb Depth d (ft)	Spread T (ft)	Intercept Qi (cfs)	Bypass Qb (cfs)
D (E)	6.16		0.50	0.0208	0.33	15.84										
D (W)	8.36		0.30	0.0208	0.41	19.55										
4		14.52														
							1A	10				0.60	0.43	20.75	14.52	0.00
A	11.24		0.20	0.0208	0.49	23.57										
B	25.32		0.20	0.0208	0.67	31.94										
		36.57														

Maximum Street Flow by Manning's Equation

58 ft R.O.W.   29 ft Street

14.5 ft Parking   0.0208 Parking X-Slope

0.302 Curb Height   with 3 5/8 in. C.O.W. Roll Curb

$$Q_{max} = \frac{0.56}{S_x n} d^{8/3} \sqrt{So}$$

At Top of Curb (1/2 Street Capacity):

n (street) = 0.016 $S_{o(min)}$ = 0.20 %

n (curb) = 0.013

Composite n = 0.0154

Q2= 3.20 cfs

$$Q_{max} = \frac{1.486}{n} A R^{2/3} \sqrt{S_o}$$

At 0.302 ft. above Top of Curb (R.O.W.)

n (parking) = 0.030   A = 17.53 ft^2

n (street) = 0.016   P = 58.60 ft

n (curb) = 0.013   R = 0.30

Composite n = 0.0226

Q100= 36.38 cfs

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Project Willowood Estates Addition

Item Hydraulics PDM/MWB

DRAINAGE FOR BASIN D

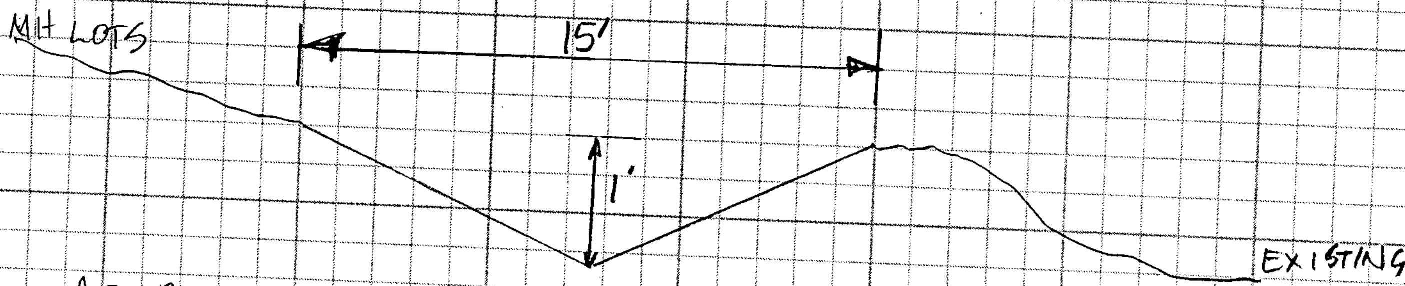
(I) EAST SIDE $A = 2.82$ Ac.

$Q_{100} = CIA$

$= 0.67(7.37)(2.82) = 13.9$ cfs say 14 cfs.

Channel REQ'D to carry East side flow. Q_{100}

Assumed section:



$A = 7.5 * 1 = 7.5 \text{ ft}^2$ $S = 0.3\%$

$P = 15.13$ ft $n = .025$ (Short grass, few weeds)

By Manning's Eqn for open channel flow:

$$Q = \frac{1.486}{n} A R^{2/3} S_o^{1/2}$$

$$Q_{ALLOW} = \frac{1.486}{.025}(7.5)\left(\frac{7.5}{15.13}\right)^{2/3}(.003)^{1/2}$$

$Q_{ALLOW} = 15.3$ cfs > 14 cfs OK ✓

STREET FLOW / INLET CAPACITY / PIPE CAPACITY

$Q_2 = CIA$ $C = 0.57$ $i = 3.83$ (15 min Tc)

$Q_2 = 0.57(3.83)(2.82) = 6.16$ cfs say 6.2 cfs

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Project Willowood Estates Addition

Item Hydraulics PDM/MWB

DRAINAGE FOR BASIN D (CON'T)

(II) WEST SIDE $A = 6.65 - 2.82 = 3.83$ Ac

$Q_2 = CIA$ $C = 0.57$ $i = 3.83$

$Q_2 = 0.57(3.83)(3.83) = 8.36$ cfs say 8.4 cfs.

ALL LOTS DRAIN TO INTERAL STREETS.

(III) INLET SIZING

TOTAL $Q_{WEST} = 8.4$ USE 5' Curb INLET TYPE 1A

CHART 12 → depth $= .65 - .167 = .483'$

OVER FLOWS AT $d_i = .312$ $S_x = 1/4''/ft$
.479

∴ $Q_{CATCH} = 6.5$ cfs.

$Q_{BY} = 8.4 - 6.5 = 1.9$ cfs TO OTHER INLET.

TOTAL $Q_{EAST} = 6.2$ cfs thru Vee channel

$Q_{by} = 1.9$ cfs from WEST TO INLET SIDE.

USE 5' Curb INLET "SPECIAL"

CHART 12 → depth $= .2 - .167 = .033'$

$Q_{CATCH} = 1.9$ cfs FROM STREET SIDE

$Q_{CATCH} = 6.2$ cfs FROM WEST SIDE.

$Q_{TOT} = 8.1$ cfs.

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Professional Association
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Zip Code / 67202

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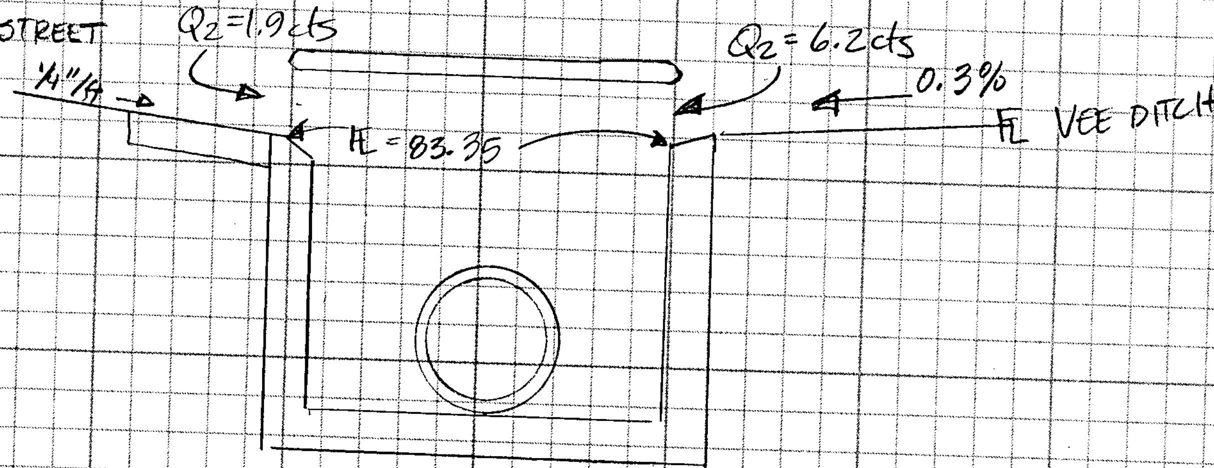
Item Hydraulics PDM/MWB

DRAINAGE FOR BASIN D (CON'T)

(IV) INLET "SPECIAL" ON WEST SIDE.



(V) PIPE SIZING FROM INLETS

FROM WEST INLET TO EAST INLET.

$Q = 6.5$ cfs

ASSUME MIN SLOPE 0.4%

$K = Q/\sqrt{S} = 6.5/\sqrt{.004} = 102.8$ ≈ USE 18" RCP K=105

TO MACARTHUR SWS

$Q_{TOT} = 8.1 + 6.5 = 14.6$ cfs.

$K = Q/\sqrt{S} = 14.6/\sqrt{.004} = 230.8$ ≈ USE 24" RCP K=226

GRADE ON EXIST 18" RCP IS 0.75%

∴ PIPE MUST BE REPLACED WITH 24" RCP TO HANDLE ADDITIONAL Q.

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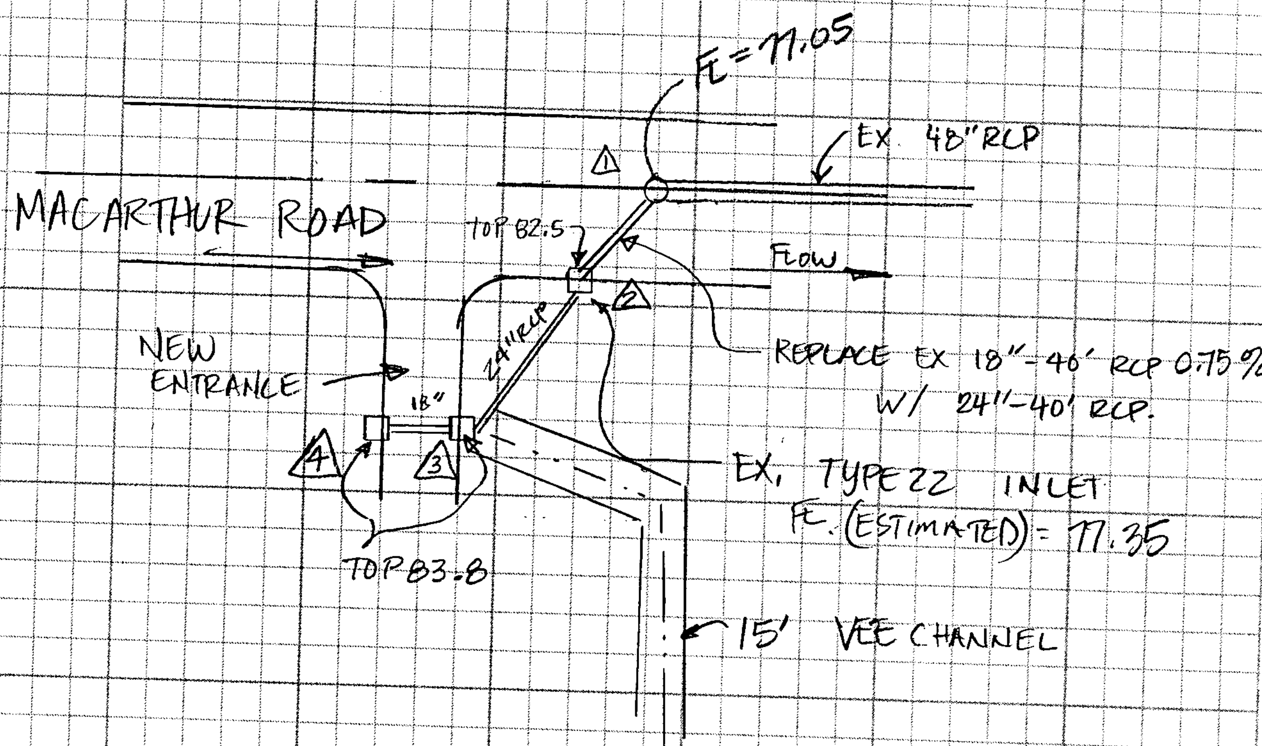
Item Exist System SWS PDM/MWB



WILLOWOOD ESTATES ADDITION
FILE O:\1996\96329\WW.STM
PDM 12/5/96

Input File: WW.STM

Date: 12-06-1996
Time: 12:43:22

Storm Frequency = 2-Year

* * * HYDROLOGY * * *

Tributary Area									Hydrology Summation				Conduit Data				
Node to	Node	C	Area (Ac)	Slope (%)	Length (Ft)	TC(0) (Min)	I(0) (In/Hr)	Q(0) (CFS)	TC (Min)	I (In/Hr)	Q (CFS)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)
2	1	.00	.00	.00	.0	15.00	3.83	.00	15.35	3.79	.00	14.55	18"	8.23	40.00	.08	15.43
3	2	.00	.00	.00	.0	15.00	3.83	8.10	15.23	3.80	8.05	14.55	18"	8.23	60.00	.12	15.35
4	3	.00	.00	.00	.0	15.00	3.83	6.50	15.00	3.83	6.50	6.50	18"	3.68	50.00	.23	15.23

Date: 12-06-1996
Time: 12:43:22

WILLOWOOD ESTATES ADDITION
FILE O:\1996\96329\WW.STM
PDM 12/5/96

Input File: WW.STM

Storm Frequency = 2-Year

*** HYDRAULICS ***

Node	Hyd-Slope (Ft/Ft)	Friction (Ft)	Bend (Ft)	Transition (Ft)	Manhole (Ft)	Deflection (Ft)	Junction (Ft)	Total (Ft)	Hyd-Gl Elevation	Desired Elevation	Diff. (Ft)
1	.00000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	79.1500	82.7000	3.55
2	.01917	.7669	.0000	.0000	.0526	.0164	.0960	.9320	80.0820	82.5000	2.42
3	.01917	1.1504	.0000	.0842	.0000	.0457	1.7444	3.0247	83.1066	83.8000	.69
4	.00383	.1915	.0000	.0000	.0000	.0000	.0000	.1915	83.2981	83.8000	.50

TOP OF STRUCTURE

FREEBOARD=
TC - HGL

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Item Flume Sizing

BASIN A → NORTH FLUME

$Q_p = 25.5$ cfs.

By MANNING'S EQN: $Q = \frac{1.486}{n} A R^{2/3} S_o^{1/2}$

TRY 8' TRAP 2:1 Sides 1' DEEP B = 4'

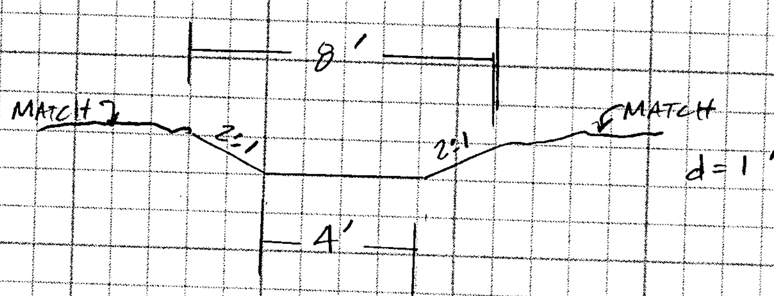
$A = 4 + 2 = 6$ ft²

$P = 4 + 2\sqrt{5} = 8.47$ ft²

$S = 0.2\%$

$Q = \frac{1.486}{0.13} (6) \left(\frac{6}{8.47}\right)^{2/3} (.002)^{1/2} = 24.4$ cfs. ok 100 year storm.

∴ FLUME SECTION FOR NORTH FLUME IS:



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[redacted]

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Project Willowood ESTATES Addition

Item FLUME SIZING.

BASIN B HAS LARGEST INFLOW FOR FLUME DRAINAGE

$$Q_P = 57.3 \text{ cfs.}$$

BY MANNINGS EQN:
$$Q = \frac{1.486}{n} A R^{2/3} S_o^{1/2}$$

TRY 10' TRAP. 2:1 SIDES., 1' deep, B = 6'

$A = 6 + 2 = 8 \text{ ft}^2$ $\quad n = .013$

$P = 6 + 2\sqrt{5} = 10.47 \text{ ft}$

$S = 0.2\%$

$$Q = \frac{1.486}{.013}(8)\left(\frac{8}{10.47}\right)^{2/3}(.002)^{1/2} = 34.2 \text{ cfs.}$$

TRY 18' TRAP 4:1 SIDES 1' deep B = 10'

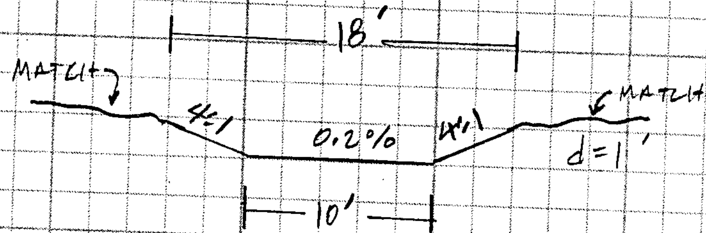
$A = 10 + 4 = 14 \text{ ft}^2$

$P = 10 + 2\sqrt{17} = 18.25 \text{ ft}$

$S = 0.2\%$

$$Q = \frac{1.486}{.013}(14)\left(\frac{14}{18.25}\right)^{2/3}(.002)^{1/2} = 60 \text{ cfs.}$$

∴ FLUME SECTION FOR SOUTH FLUME IS;



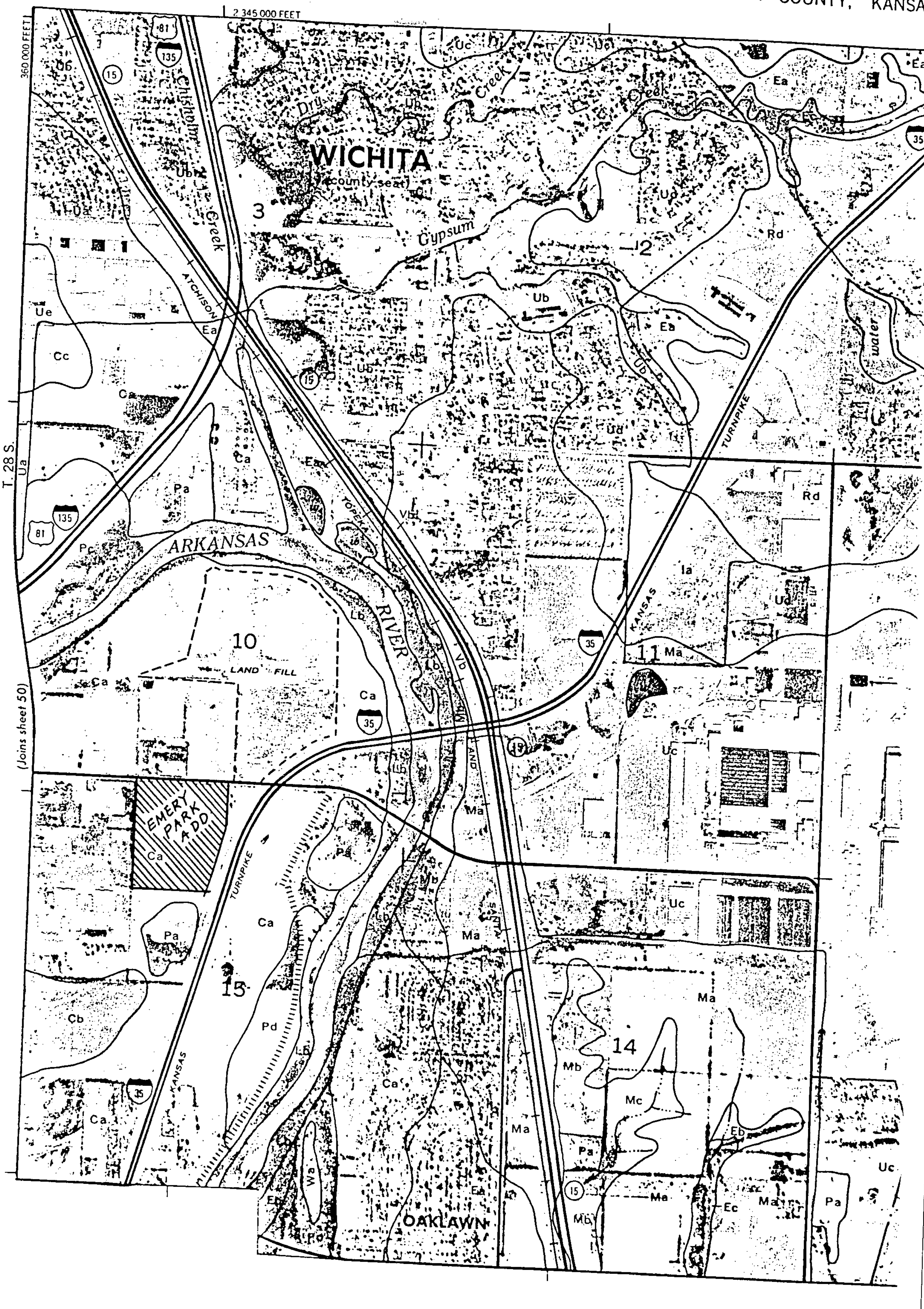

2 345 000 FEET
360 000 FEET
WICHITA
(county seat)
Dry Creek
Chisholm Creek
Gypsum
ATCHISON
TOPEKA
SANTA
AND
ARKANSAS
RIVER
LAND FILL
EMERY PARK ADD
TURNPIKE
KANSAS
OAKLAWN
water
T. 28 S.
(Joins sheet 50)
3
2
10
11
14
15
Ub
Ue
Ea
Cc
Ca
Pa
Pc
Lb
Vb
Rd
Ia
Uc
Ma
Mb
Mc
Cb
Pd
Wa
Eb
Ec
Ua
81
135
15
35

EXHIBIT NO. 1

SOIL LEGEND

SYMBOL	HYDROLOGIC GROUP	NAME
Aa	B	Albion-Shellabarger sandy loams, 1 to 4 percent slopes
Ab	B	Albion and Shellabarger sandy loans, 7 to 15 percent slopes
Ba	C	Blanket silt loam, 0 to 1 percent slopes
Bb	C	Blanket silt loan, 1 to 3 percent slopes
Ca	B	Canadian fine sandy loan
Cb	B	Canadian-Waldeck fine sandy loams
Cc	D	Carwile fine sandy loam
Cd	B	Clark-Ost clay loams, 1 to 4 percent slopes
Ce	C	Clime silty clay, 3 to 6 percent slopes
Ea	B	Elandco silt loam
Eb	B	Elandco silt loam, occasionally flooded
Ec	B	Elandco silt loam, frequently flooded
Fa	B	Farnum loam, 0 to 1 percent slopes
Fb	B	Farnum loam, 1 to 3 percent slopes
Fc	B	Farnum loam, sandy substratum, 0 to 1 percent slopes
Ga	D	Goessel silty clay, 0 to 1 percent slopes
Gb	D	Goessel silty clay, 1 to 2 percent slopes
Ia	D	Irwin silty clay loam, 1 to 3 percent slopes
Ib	D	Irwin silty clay loam, 3 to 6 percent slopes
Ic	D	Irwin silty clay loam, 2 to 6 percent slopes, eroded
La	C	Lesho loam
Lb	A	Lincoln soils
Ma	B	Milan loam, 1 to 3 percent slopes
Mb	B	Milan form, 3 to 6 percent slopes
Mc	B	Milan clay loam, 2 to 6 percent slopes, eroded
Na	B	Naron fine sandy loam
Oc	D	Owens clay loam, 1 to 3 percent slopes
Od	D	Owens-Rock outcrop complex, 3 to 10 percent slopes
Pa		Pits
Pb	D	Plevna fine sandy loam
Pc	A	Pratt loamy fine sand, undulating
Pd	A	Pratt-Tivoli complex, rolling
Ra	D	Renfrow silty clay loam, 1 to 3 percent slopes
Rb	D	Renfrow silty clay loam, 3 to 6 percent slopes
Rc	D	Renfrow-Owens clay loams, 1 to 4 percent slopes
Rd	D	Rosehill silty clay, 1 to 3 percent slopes
Sa	B	Shellabarger sandy loam, 1 to 3 percent slopes
Sb	B	Shellabarger sandy loam, 3 to 6 percent slopes
Sc	B	Shellabarger sandy loam, 3 to 6 percent slopes, eroded
Ta	D	Tabler silty clay loam
Tb	D	Tabler-Drummond complex
Ua	B	Urban land-Canadian complex
Ub	B	Urban land-Elandco complex
Uc	B	Urban land-Farnum complex, 0 to 3 percent slopes
Ud	D	Urban land-Irwin complex, 1 to 3 percent slopes
Ue	D	Urban land-Tabler complex
Va	B	Vanoss silt loam, 0 to 1 percent slopes
Vb	B	Vanoss silt loam, 1 to 3 percent slopes
Vc	B	Vanoss silt loam, 3 to 6 percent slopes
Vd	B	Vanoss silt loam, 3 to 6 percent slopes, eroded
Ve	D	Vernon sandy loam, 1 to 3 percent slopes
Vf	D	Vernon sandy loam, 3 to 6 percent lopes
Wa	C	Waldeck sandy loam
Wb	D	Waurika silt loam

(3 pages)

ATTACHMENT D

DRAINAGE CRITERIA

CITY OF WICHITA, KANSAS

RECOMMENDED RUNOFF COEFFICIENTS FOR RATIONAL METHOD AND PERCENT IMPERVIOUS FOR UNIT HYDROGRAPH METHOD

Land Use or Surface Characteristics	Percent Impervious	Frequency 2	5	10	100
1. Business:					
Downtown Areas	95	0.84	0.85	0.87	0.91
Neighborhood Areas	70	0.68	0.69	0.73	0.80
2. Residential:					
Single Family (Soil Group D)					
1/8 Acre	50	0.57	0.61	0.66	0.79
1/4 Acre	38	0.50	0.54	0.62	0.76
1/3 Acre	30	0.46	0.50	0.59	0.73
1/2 Acre	25	0.42	0.48	0.56	0.72
3/4 Acre	22	0.42	0.46	0.55	0.71
1 Acre	20	0.41	0.45	0.54	0.71
Multi-Family (Soil Group D)					
Multi-Unit (detacned)	60	0.62	0.66	0.72	0.82
Multi-Unit (attached)	65	0.64	0.68	0.73	0.83
Apartments	75	0.70	0.73	0.79	0.86
Single Family (Soil Group C)					
1/8 Acre	50	0.55	0.58	0.64	0.73
1/4 Acre	38	0.48	0.51	0.57	0.68
1/3 Acre	30	0.43	0.46	0.53	0.65
1/2 Acre	25	0.40	0.43	0.50	0.63
3/4 Acre	22	0.39	0.42	0.49	0.62
1 Acre	20	0.37	0.40	0.48	0.61
Multi-Family (Soil Group C)					
Multi-Unit (detached)	60	0.60	0.63	0.69	0.77
Multi-Unit (attached)	65	0.63	0.66	0.71	0.79
Apartments	75	0.68	0.72	0.77	0.83
Single-Family (Soil Group B)					
1/8 Acre	50	0.52	0.54	0.59	0.67
1/4 Acre	38	0.44	0.46	0.52	0.61
1/3 Acre	30	0.39	0.41	0.47	0.57
1/2 Acre	25	0.36	0.38	0.44	0.54
3/4 Acre	22	0.34	0.36	0.42	0.52
1 Acre	20	0.33	0.35	0.40	0.51
Multi-Family (Soil Group B)					
Multi-Unit (detached)	60	0.58	0.60	0.65	0.72
Multi-Unit (attached)	65	0.61	0.64	0.68	0.75
Apartments	75	0.67	0.70	0.74	0.80

Land Use or Surface Characteristics	Percent Impervious	Frequency 2	5	10	100
Single Family (Soil Group A)					
1/8 Acre	50	0.47	0.50	0.54	0.60
1/4 Acre	38	0.39	0.41	0.45	0.52
1/3 Acre	30	0.33	0.35	0.39	0.47
1/2 Acre	25	0.30	0.31	0.35	0.44
3/4 Acre	22	0.28	0.29	0.33	0.42
1 Acre	20	0.26	0.28	0.32	0.40
Multi-Family (Soil Group A)					
Multi-Unit (detached)	60	0.55	0.57	0.61	0.67
Multi-Unit (attached)	65	0.58	0.60	0.64	0.70
Apartments	75	0.65	0.68	0.72	0.77
3. Industrial:					
Light Areas	70	0.68	0.69	0.73	0.80
Heavy Areas	80	0.74	0.76	0.79	0.84
4. Playgrounds:	15	0.33	0.35	0.42	0.55
5. Schools:	40	0.49	0.51	0.56	0.66
6. Railroad Yard Areas:	30	0.43	0.45	0.50	0.62
7. Undeveloped Urban Areas: Offsite Flow Analysis (when land use not defined)	45	0.52	0.54	0.59	0.68
8. Streets:					
Paved	99	0.87	0.88	0.90	0.93
Gravel	00	0.24	0.26	0.33	0.48
9. Drive, Parking Lots and Walks:	96	0.87	0.87	0.88	0.89
10. Roofs:	90	0.80	0.85	0.90	0.93
11. Urban Lawn Areas (See Note No. 1 below):					
Soil Group A					
Slope less than 1%	00	0.08	0.09	0.13	0.23
Slope 1% to 4%	00	0.12	0.13	0.17	0.27
Slope more than 4%	00	0.16	0.17	0.21	0.31
Soil Group B					
Slope less than 1%	00	0.16	0.18	0.24	0.37
Slope 1% to 4%	00	0.20	0.22	0.28	0.41
Slope more than 4%	00	0.24	0.26	0.32	0.45
Soil Group C					
Slope less than 1%	00	0.24	0.27	0.35	0.51
Slope 1% to 4%	00	0.26	0.29	0.37	0.53
Slope more than 4%	00	0.28	0.31	0.39	0.55

Land Use or Surface Characteristics	Percent Impervious	Frequency 2	5	10	100
Soil Group D					
Slope less than 1%	00	0.28	0.33	0.43	0.63
Slope 1% to 4%	00	0.30	0.35	0.45	0.65
Slope more than 4%	00	0.32	0.37	0.47	0.67

Note No. 1: Coefficients shown in the above table are for pervious open space areas with thick turf which includes pervious areas in parks and cemeteries. Coefficients shown above must be increased 0.02 for use with agricultural pasture areas. Coefficients shown above must be reduced by 0.04 for use with agricultural cultivated areas. Group A soils are well-drained, coarse textured sands with high infiltration rates. Group B soils are moderately well-drained, moderately coarse textured soils with moderate infiltration rates. Group C soils are moderately poor-drained, moderately fine textured soils with slow infiltration rates. Group D soils are poor-drained, fine textured soils with very slow infiltration rates.

GENERAL NOTE: These Rational Formula Coefficients may not be valid for basins 320 acres or larger.

April 15, 1986

ATTACHMENT A
DRAINAGE CRITERIA MANUAL

CITY OF WICHITA, KANSAS

RAINFALL INTENSITY TABLE FOR SEDGWICK COUNTY, KANSAS

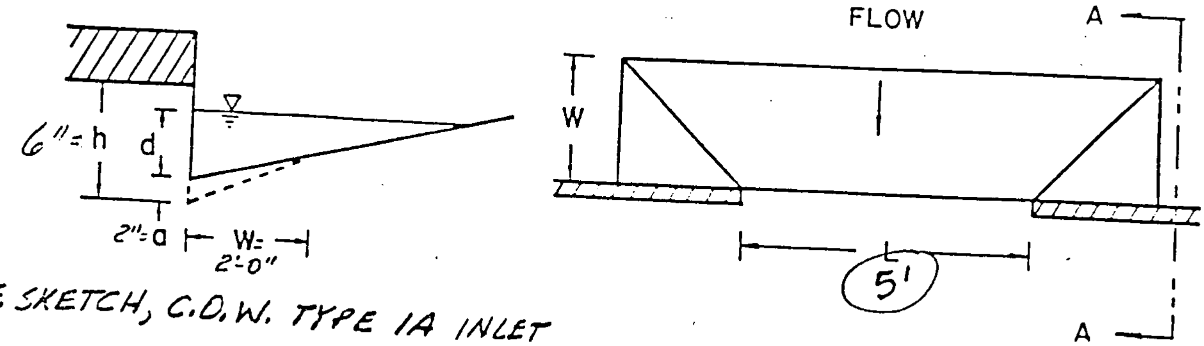
The following tabulation contains rainfall intensity in inches per hour as derived from ESSA Weather Bureau Technical Paper 40 Modified to NWS Hydro-35, 1977 During First Hour

DURATION IN MINUTES	RETURN PERIODS OF						
	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5	4.18	5.57	6.53	7.41	8.52	9.48	10.32
6	3.99	5.32	6.25	7.09	8.16	9.09	9.89
7	3.81	5.09	5.99	6.81	7.84	8.74	9.50
8	3.66	4.89	5.75	6.55	7.55	8.42	9.15
9	3.52	4.70	5.54	6.31	7.28	8.13	8.83
10	3.39	4.52	5.34	6.09	7.04	7.86	8.54
11	3.27	4.36	5.16	5.89	6.81	7.61	8.27
12	3.18	4.21	4.99	5.71	6.60	7.38	8.02
13	3.05	4.08	4.84	5.53	6.41	7.17	7.79
14	2.96	3.95	4.69	5.37	6.23	6.97	7.57
15	2.87	3.83	4.56	5.22	6.06	6.78	7.37
16	2.78	3.72	4.43	5.08	5.90	6.60	7.18
17	2.71	3.61	4.31	4.95	5.75	6.44	7.00
18	2.63	3.51	4.20	4.83	5.61	6.29	6.84
19	2.56	3.42	4.10	4.71	5.47	6.14	6.68
20	2.50	3.33	4.00	4.60	5.35	6.00	6.53
21	2.44	3.25	3.90	4.50	5.23	5.87	6.39
22	2.38	3.17	3.81	4.40	5.12	5.75	6.26
23	2.32	3.10	3.73	4.31	5.01	5.63	6.13
24	2.27	3.03	3.65	4.22	4.91	5.52	6.01
25	2.22	2.96	3.57	4.13	4.81	5.41	5.90
26	2.20	2.90	3.50	4.05	4.72	5.31	5.79
27	2.16	2.84	3.43	3.98	4.63	5.21	5.69
28	2.14	2.78	3.37	3.90	4.55	5.12	5.59
29	2.11	2.72	3.30	3.83	4.47	5.03	5.49
30	2.08	2.67	3.24	3.76	4.39	4.94	5.40
31	2.05	2.62	3.19	3.70	4.32	4.86	5.32
32	2.02	2.57	3.10	3.63	4.25	4.79	5.22
33	1.99	2.52	3.05	3.57	4.18	4.71	5.14
34	1.96	2.48	3.01	3.51	4.11	4.63	5.07
35	1.93	2.44	2.98	3.46	4.05	4.56	5.00
36	1.91	2.39	2.93	3.41	3.99	4.50	4.93
37	1.89	2.35	2.88	3.36	3.93	4.43	4.86
38	1.87	2.32	2.84	3.31	3.87	4.37	4.79
39	1.85	2.28	2.80	3.26	3.82	4.31	4.73
40	1.83	2.24	2.76	3.22	3.76	4.25	4.66
41	1.81	2.21	2.72	3.17	3.71	4.19	4.60
42	1.79	2.18	2.68	3.13	3.66	4.13	4.54
43	1.77	2.14	2.64	3.09	3.61	4.08	4.49
44	1.75	2.11	2.61	3.05	3.57	4.03	4.43
45	1.73	2.08	2.57	3.01	3.52	3.98	4.38

DURATION IN MINUTES	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
			RETURN PERIODS OF				
46	1.70	2.05	2.54	2.97	3.48	3.93	4.33
47	1.67	2.02	2.50	2.93	3.44	3.88	4.28
48	1.66	2.00	2.47	2.90	3.39	3.84	4.23
49	1.64	1.97	2.44	2.86	3.35	3.79	4.18
50	1.61	1.95	2.41	2.83	3.32	3.75	4.13
51	1.59	1.92	2.38	2.79	3.28	3.71	4.09
52	1.56	1.89	2.35	2.76	3.24	3.67	4.05
53	1.54	1.86	2.33	2.73	3.20	3.63	4.00
54	1.52	1.84	2.30	2.70	3.17	3.59	3.96
55	1.50	1.81	2.27	2.67	3.14	3.55	3.92
56	1.47	1.79	2.25	2.64	3.10	3.51	3.88
57	1.45	1.76	2.22	2.61	3.07	3.48	3.84
58	1.43	1.74	2.20	2.59	3.04	3.44	3.81
59	1.42	1.72	2.18	2.56	3.01	3.41	3.77
60	1.40	1.69	2.15	2.53	2.98	3.37	3.73
61	1.38	1.67	2.13	2.51	2.95	3.34	3.70
62	1.36	1.65	2.11	2.48	2.92	3.31	3.67
63	1.34	1.63	2.09	2.46	2.89	3.28	3.63
64	1.33	1.61	2.07	2.44	2.86	3.25	3.60
65	1.31	1.59	2.05	2.41	2.84	3.22	3.57
66	1.30	1.57	2.03	2.39	2.81	3.19	3.54
67	1.28	1.56	2.01	2.37	2.79	3.16	3.51
68	1.26	1.54	1.99	2.35	2.76	3.13	3.48
69	1.25	1.52	1.97	2.33	2.74	3.10	3.45
70	1.24	1.50	1.95	2.31	2.71	3.08	3.42
71	1.22	1.49	1.93	2.28	2.69	3.05	3.39
72	1.21	1.47	1.92	2.26	2.67	3.02	3.36
73	1.20	1.46	1.90	2.25	2.64	3.00	3.34
74	1.18	1.44	1.88	2.23	2.63	2.98	3.31
75	1.17	1.43	1.86	2.21	2.61	2.95	3.29
76	1.16	1.41	1.85	2.19	2.58	2.93	3.26
77	1.15	1.40	1.83	2.17	2.55	2.90	3.24
78	1.13	1.38	1.82	2.15	2.53	2.88	3.22
79	1.12	1.37	1.80	2.14	2.50	2.86	3.19
80	1.11	1.36	1.79	2.12	2.48	2.84	3.16
81	1.10	1.34	1.77	2.10	2.46	2.82	3.13
82	1.09	1.33	1.76	2.08	2.43	2.79	3.10
83	1.08	1.32	1.74	2.06	2.41	2.76	3.07
84	1.07	1.31	1.73	2.04	2.39	2.74	3.04
85	1.06	1.30	1.72	2.02	2.37	2.71	3.01
86	1.05	1.28	1.70	2.00	2.34	2.69	2.99
87	1.04	1.27	1.69	1.99	2.32	2.66	2.96
88	1.03	1.26	1.68	1.97	2.30	2.64	2.93
89	1.02	1.25	1.68	1.95	2.28	2.62	2.91
90	1.01	1.24	1.66	1.93	2.26	2.59	2.88

DURATION IN MINUTES	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
91	1.00	1.23	1.65	1.92	2.24	2.57	2.86
92	1.00	1.22	1.63	1.90	2.22	2.55	2.83
93	0.99	1.21	1.62	1.89	2.20	2.53	2.81
94	0.98	1.20	1.61	1.87	2.19	2.51	2.79
95	0.97	1.19	1.59	1.85	2.17	2.49	2.76
96	0.96	1.18	1.58	1.84	2.15	2.46	2.74
97	0.96	1.17	1.57	1.82	2.13	2.44	2.72
98	0.95	1.16	1.56	1.81	2.12	2.42	2.70
99	0.94	1.15	1.54	1.80	2.10	2.41	2.67
100	0.93	1.14	1.53	1.78	2.08	2.39	2.65
101	0.93	1.13	1.52	1.77	2.07	2.39	2.65
102	0.92	1.13	1.51	1.75	2.05	2.35	2.61
103	0.91	1.12	1.50	1.74	2.04	2.33	2.59
104	0.90	1.11	1.49	1.73	2.02	2.31	2.57
105	0.90	1.10	1.47	1.72	2.01	2.30	2.55
106	0.89	1.09	1.46	1.70	1.99	2.28	2.54
107	0.88	1.09	1.45	1.69	1.98	2.26	2.52
108	0.88	1.08	1.44	1.68	1.96	2.25	2.50
109	0.87	1.07	1.43	1.67	1.95	2.23	2.48
110	0.87	1.06	1.42	1.65	1.93	2.21	2.46
111	0.86	1.06	1.41	1.64	1.92	2.20	2.45
112	0.85	1.05	1.40	1.63	1.91	2.18	2.43
113	0.85	1.04	1.39	1.62	1.89	2.17	2.41
114	0.84	1.03	1.38	1.61	1.88	2.15	2.40
115	0.84	1.03	1.37	1.60	1.87	2.14	2.38
116	0.83	1.02	1.36	1.59	1.86	2.12	2.36
117	0.82	1.01	1.36	1.58	1.84	2.11	2.35
118	0.82	1.01	1.35	1.57	1.83	2.09	2.33
119	0.81	1.00	1.34	1.56	1.82	2.08	2.32
120	0.81	0.99	1.33	1.55	1.81	2.07	2.30

DURATION IN HOURS	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
2	0.81	0.99	1.33	1.55	1.81	2.07	2.30
3	0.59	0.72	0.97	1.13	1.32	1.51	1.68
4	0.47	0.58	0.78	0.91	1.06	1.21	1.35
5	0.40	0.49	0.66	0.77	0.89	1.02	1.14
6	0.35	0.42	0.57	0.67	0.78	0.89	0.99
8	0.28	0.34	0.46	0.53	0.62	0.71	0.79
10	0.23	0.29	0.39	0.45	0.52	0.60	0.67
12	0.20	0.25	0.33	0.39	0.45	0.52	0.58
18	0.15	0.18	0.24	0.28	0.33	0.38	0.42
24	0.12	0.15	0.20	0.23	0.27	0.31	0.34



DEF. SKETCH, C.O.W. TYPE 1A INLET

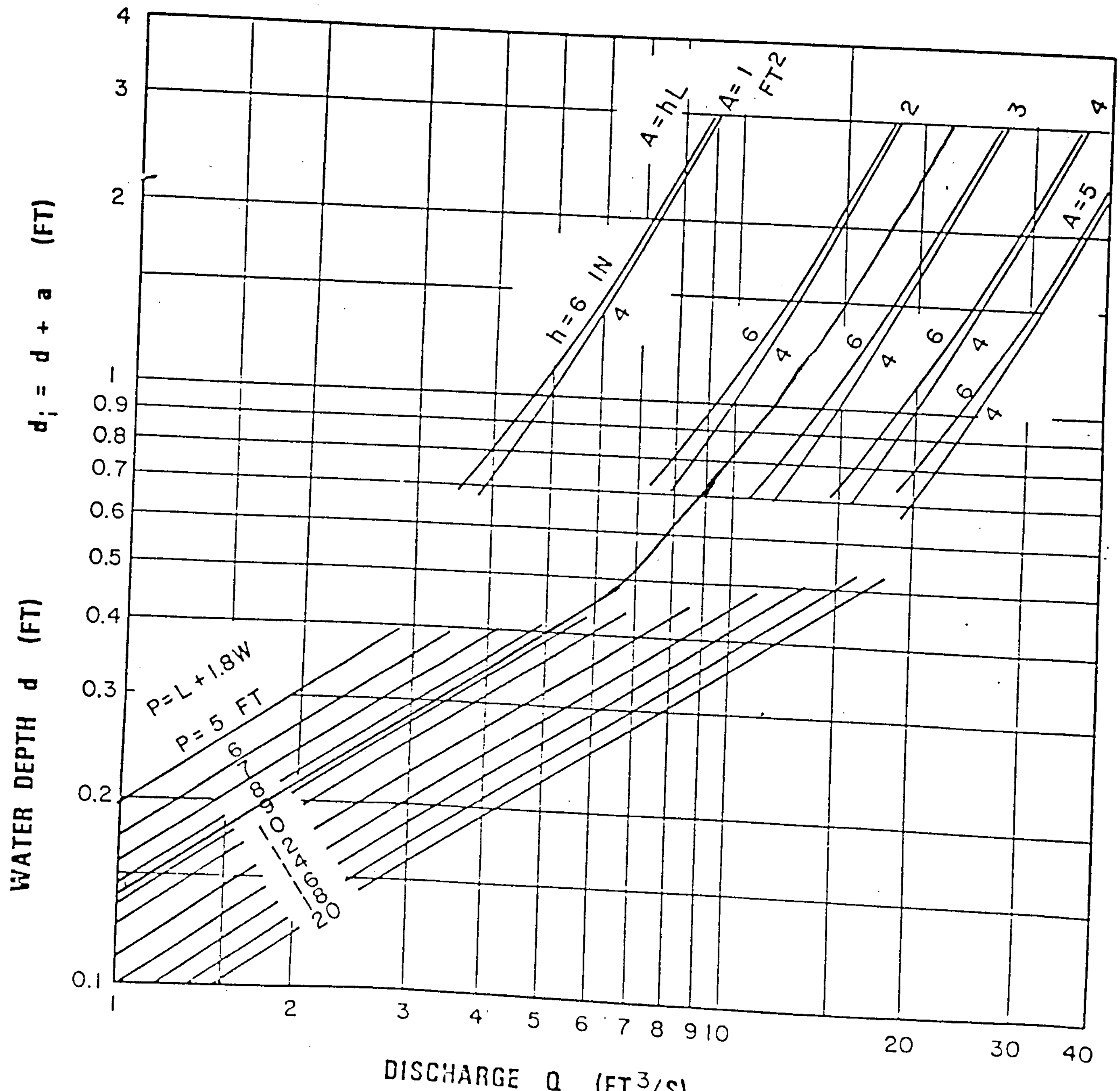
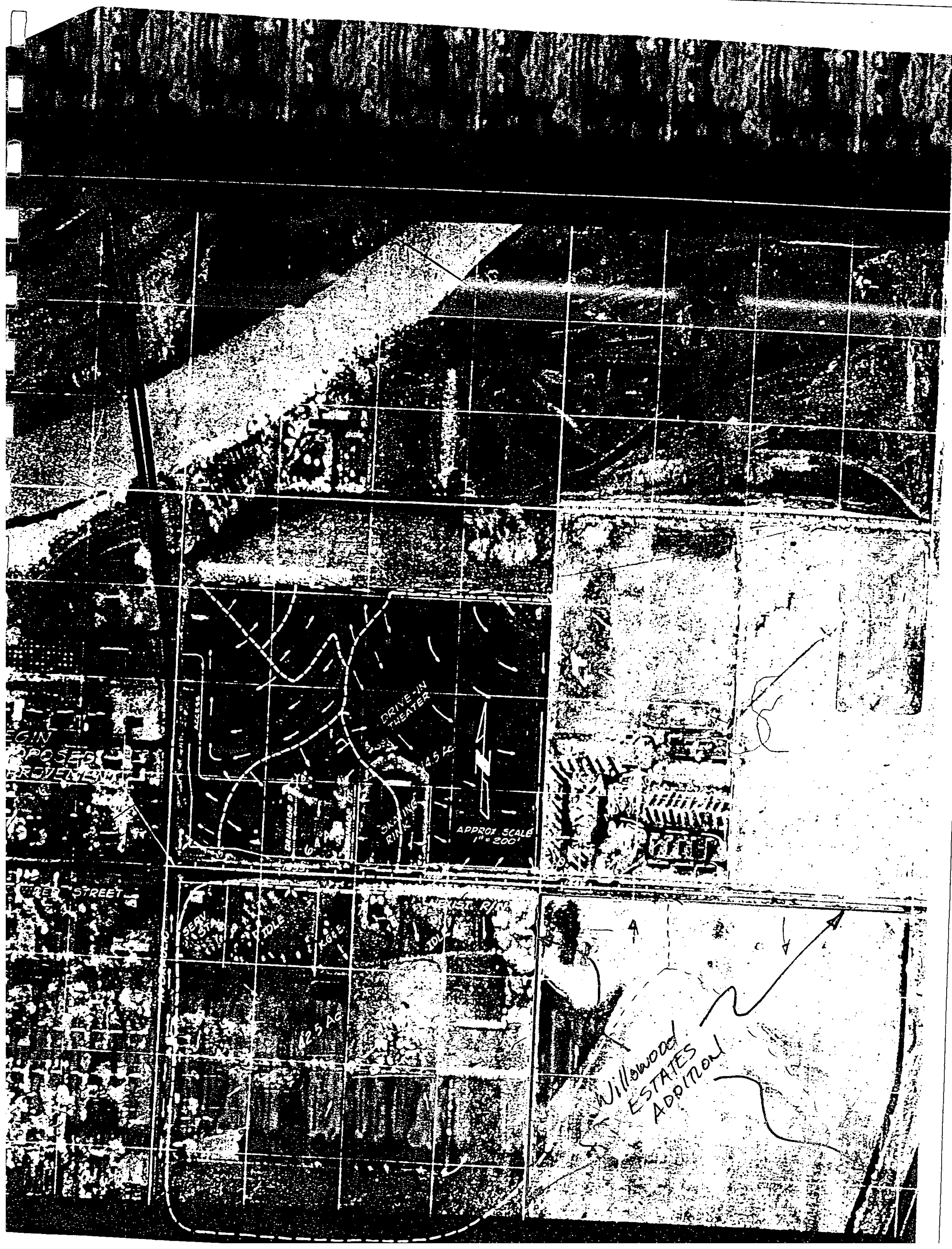


CHART 12. Depressed curb-opening inlet capacity in sump locations.

FROM: HEC-12, Drainage of Highway Pavements, F.H.W.A., MAR., 1984


DRIVE-IN
THEATER
14.5 Ac
SKATING
RINK
6 Ac
APPROX SCALE
1" = 200'
STREET
SERV.
STA.
IDLE
K.G.&E.
EXIST. R/W
IDLE
42.5 Ac
Willowood
ESTATES
ADDITION

Appendix A.—TABLES

Table 1.—Manning roughness coefficients, n [1]

	Manning's n range [2]
I. Closed conduits:	
A. Concrete pipe	0.011–0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2⅔ by ½-in. corrugation (riveted pipe): [3]	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021–0.018
(2) Flow 0.8 depth	0.021–0.016
(3) Flow 0.6 depth	0.019–0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012–0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009–0.011
F. Brick	0.014–0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
I. Laminated treated wood	0.015–0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined [4] (straight alinement): [5]	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017–0.020
2. Random stone in mortar	0.020–0.023
3. Dry rubble (riprap)	0.023–0.033
D. Brick	0.014–0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011–0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017–0.020
2. Irregular section	0.022–0.027
III. Open channels, excavated [4] (straight alinement, [5] natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016–0.018
2. Clean, after weathering	0.018–0.020
3. With short grass, few weeds	0.022–0.027
4. In gravelly soil, uniform section, clean	0.022–0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022–0.025
2. Grass, some weeds	0.025–0.030
3. Dense weeds or aquatic plants in deep channels	0.030–0.035
4. Sides clean, gravel bottom	0.025–0.030
5. Sides clean, cobble bottom	0.030–0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028–0.033
2. Light brush on banks	0.035–0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035–0.040
b. Jagged and irregular	0.040–0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08–0.12
2. Clean bottom, brush on sides	0.05–0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11
4. Dense brush, high stage	0.10–0.14

Footnotes to table 1 appear at the top of page 101.

	Manning's n range [2]
IV. Highway channels and swales with maintained vegetation [4,7] (values shown are for velocities of 2 and 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.07–0.045
b. Length 4–6 inches	0.09–0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18–0.09
b. Length about 24 inches	0.30–0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14–0.08
b. Length about 24 inches	0.25–0.13
B. Depth of flow 0.7–1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.05–0.035
b. Length 4 to 6 inches	0.06–0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12–0.07
b. Length about 24 inches	0.20–0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10–0.06
b. Length about 24 inches	0.17–0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of n by	*0.002*
VI. Natural stream channels: [8]	
A. Minor streams [9] (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	*0.01–0.02*
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	*0.01–0.02*
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05
b. Bottom of cobbles, with large boulders	0.05–0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030–0.035
b. High grass	0.035–0.05
2. Cultivated areas:	
a. No crop	0.03–0.04
b. Mature row crops	0.035–0.045
c. Mature field crops	0.04–0.05
3. Heavy weeds, scattered brush	0.05–0.07
4. Light brush and trees: [10]	
a. Winter	0.05–0.06
b. Summer	0.06–0.08
5. Medium to dense brush: [10]	
a. Winter	0.07–0.11
b. Summer	0.10–0.16
6. Dense willows, summer, not bent over by current	0.15–0.20
7. Cleared land with tree stumps, 100–150 per acre:	
a. No sprouts	0.04–0.05
b. With heavy growth of sprouts	0.06–0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10–0.12
b. Flood depth reaches branches	0.12–0.16
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited [8] if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033

S = ft/ft

FULL FLOW COEFFICIENT VALUES CIRCULAR CONCRETE PIPE

$Q = K\sqrt{S}$

$K = Q/\sqrt{S}$

D Pipe Diameter (inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$			
			n=0.010	n=0.011	n=0.012	n=0.013
8	0.349	0.167	15.8	14.3	13.1	12.1
10	0.545	0.208	28.4	25.8	23.6	21.8
12	0.785	0.250	46.4	42.1	38.6	35.7
15	1.227	0.312	84.1	76.5	70.1	64.7
18	1.767	0.375	137	124	114	105
21	2.405	0.437	206	187	172	158
24	3.142	0.500	294	267	245	226
27	3.976	0.562	402	366	335	310
30	4.909	0.625	533	485	444	410
33	5.940	0.688	686	624	574	530
36	7.069	0.750	867	788	722	666
42	9.621	0.875	1308	1189	1090	1006
48	12.566	1.000	1867	1698	1556	1436
54	15.904	1.125	2557	2325	2131	1967
60	19.635	1.250	3385	3077	2821	2604
66	23.758	1.375	4364	3967	3636	3357
72	28.274	1.500	5504	5004	4587	4234
78	33.183	1.625	6815	6195	5679	5242
84	38.485	1.750	8304	7549	6920	6388
90	44.170	1.875	9985	9078	8321	7681
96	50.266	2.000	11850	10780	9878	9119
102	56.745	2.125	13940	12670	11620	10720
108	63.617	2.250	16230	14760	13530	12490
114	70.882	2.375	18750	17040	15620	14420
120	78.540	2.500	21500	19540	17920	16540
126	86.590	2.625	24480	22260	20400	18830
132	95.033	2.750	27720	25200	23100	21330
138	103.870	2.875	31210	28370	26010	24010
144	113.100	3.000	34960	31780	29130	26890

TABLE 4

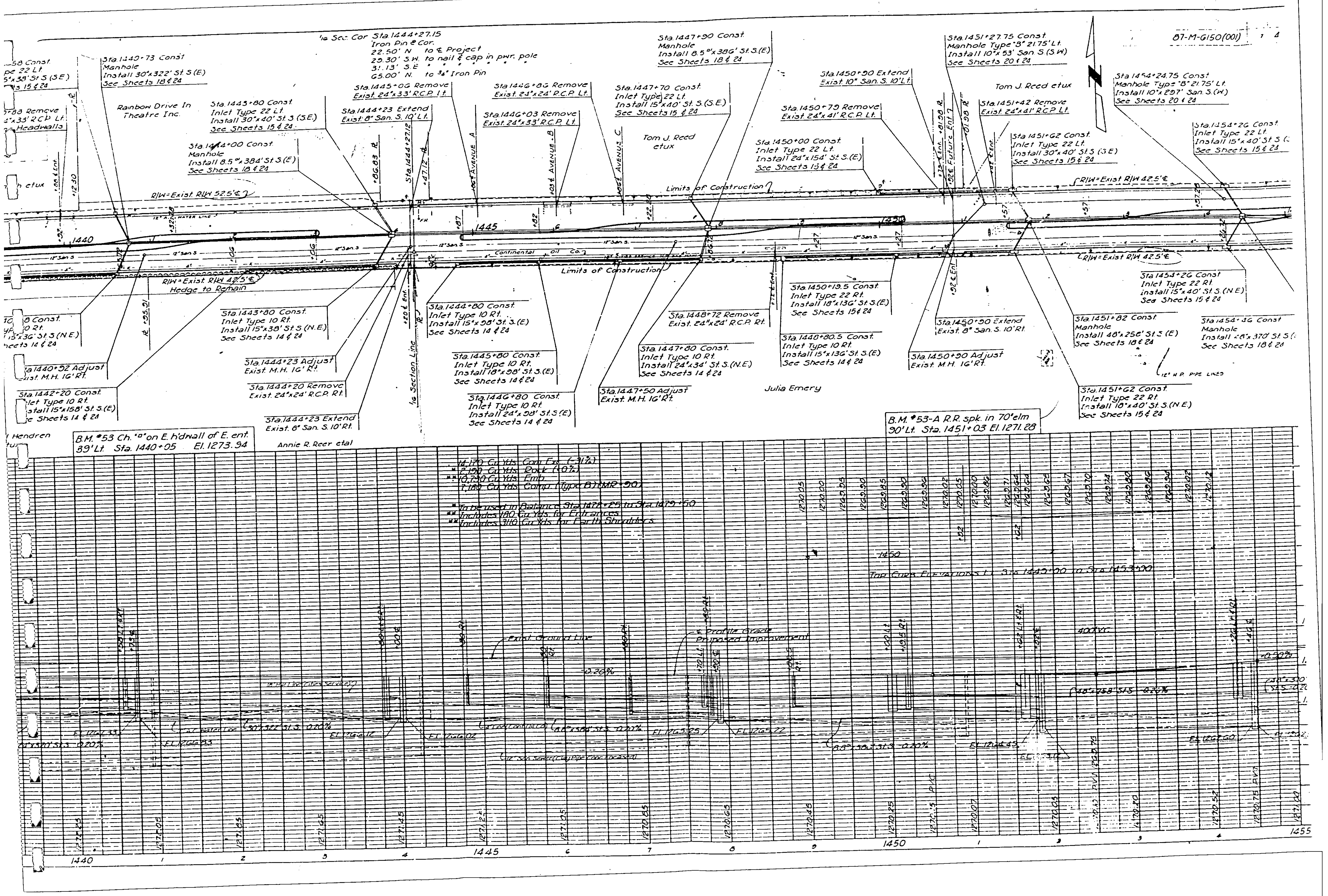
FULL FLOW COEFFICIENT VALUES ELLIPTICAL CONCRETE PIPE

Pipe Size R x S (HE) S x R (VE) (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$			
				n = 0.010	n = 0.011	n = 0.012	n = 0.013
14 x 23	18	1.8	0.367	138	125	116	108
19 x 30	24	3.3	0.490	301	274	252	232
22 x 34	27	4.1	0.546	405	368	339	313
24 x 38	30	5.1	0.613	547	497	456	421
27 x 42	33	6.3	0.686	728	662	607	560
29 x 45	36	7.4	0.736	891	810	746	686
32 x 49	39	8.8	0.812	1140	1036	948	875
34 x 53	42	10.2	0.875	1386	1260	1156	1067
38 x 60	48	12.9	0.969	1878	1707	1565	1445
43 x 68	54	16.6	1.106	2635	2395	2196	2027
48 x 76	60	20.5	1.229	3491	3174	2910	2686
53 x 83	66	24.8	1.352	4503	4094	3753	3464
58 x 91	72	29.5	1.475	5680	5164	4734	4370
63 x 98	78	34.6	1.598	7027	6388	5856	5406
68 x 106	84	40.1	1.721	8560	7790	7140	6590
72 x 113	90	46.1	1.845	10300	9365	8584	7925
77 x 121	96	52.4	1.967	12220	11110	10190	9403
82 x 128	102	59.2	2.091	14380	13070	11980	11060
87 x 136	108	66.4	2.215	16770	15240	13970	12900
92 x 143	114	74.0	2.340	19380	17620	16150	14910
97 x 151	120	82.0	2.461	22190	20180	18490	17070
106 x 166	132	99.2	2.707	28630	26020	23860	22020
116 x 180	144	118.6	2.968	36400	33100	30340	28000

TABLE 5

FULL FLOW COEFFICIENT VALUES CONCRETE ARCH PIPE

Pipe Size R x S (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$			
				n = 0.010	n = 0.011	n = 0.012	n = 0.013
11 x 18	15	1.1	0.25	65	59	54	50
13½ x 22	18	1.6	0.30	110	100	91	84
15½ x 26	21	2.2	0.36	165	150	137	127
18 x 28½	24	2.8	0.45	243	221	203	187
22½ x 36¼	30	4.4	0.56	441	401	368	339
26⅝ x 43¾	36	6.4	0.68	736	669	613	566
31⁵⁄₁₆ x 51⅛	42	8.8	0.80	1125	1023	938	866
36 x 58½	48	11.4	0.90	1579	1435	1315	1214
40 x 65	54	14.3	1.01	2140	1945	1783	1646
45 x 73	60	17.7	1.13	2851	2592	2376	2193
54 x 88	72	25.6	1.35	4641	4219	3867	3569
62 x 102	84	34.6	1.57	6941	6310	5784	5339
72 x 115	90	44.5	1.77	9668	8789	8056	7436
77¼ x 122	96	51.7	1.92	11850	10770	9872	9112
87⅛ x 138	108	66.0	2.17	16430	14940	13690	12640
96⅞ x 154	120	81.8	2.42	21975	19977	18312	16904
106½ x 168¼	132	99.1	2.65	28292	25720	23577	21763



07-M-G150(001)
Sta 1440+73 Const
Manhole
Install 30"x322' St S (E)
See Sheets 18 & 24
Rainbow Drive In Theatre Inc.
Sta 1443+80 Const
Inlet Type 22 Lt
Install 30"x40' St S (E)
See Sheets 15 & 24
Sta 1444+00 Const
Manhole
Install 8.5"x384' St S (E)
See Sheets 18 & 24
¼ Sec. Cor. Sta 1444+27.15
Iron Pin & Cor.
Sta 1445+06 Remove
Exist. 24"x33' R.C.P. Lt
Sta 1444+23 Extend
Exist. 8" San. S. 10' Lt
Sta 1446+86 Remove
Exist. 24"x24' R.C.P. Lt
Sta 1446+03 Remove
Exist. 24"x33' R.C.P. Lt
Sta 1447+70 Const.
Inlet Type 22 Lt
Install 15"x40' St S (S E)
See Sheets 15 & 24
Sta 1447+90 Const.
Manhole
Install 8.5"x389' St S (E)
See Sheets 18 & 24
Tom J. Reed etux
Sta 1450+50 Extend
Exist. 10" San. S. 10' Lt
Sta 1450+79 Remove
Exist 24"x41' R.C.P. Lt
Sta 1450+00 Const
Inlet Type 22 Lt
Install 24"x154' St S (E)
See Sheets 15 & 24
Sta 1451+27.75 Const
Manhole Type "B" 21.75' Lt
Install 10"x 53' San S (S W)
See Sheets 20 & 24
Tom J. Reed etux
Sta 1451+42 Remove
Exist 24"x41' R.C.P. Lt
Sta 1451+62 Const
Inlet Type 22 Lt
Install 30"x40' St S (S E)
See Sheets 15 & 24
Sta 1454+24.75 Const
Manhole Type "B" 21.75' Lt
Install 10"x 57' San S (W)
See Sheets 20 & 24
Sta 1454+26 Const
Inlet Type 22 Lt
Install 15"x40' St S
See Sheets 15 & 24
Limits of Construction
R/W = Exist R/W 42.5' E
Hedge to Remain
Sta 1443+80 Const
Inlet Type 10 Rt
Install 15"x30' St S (N E)
See Sheets 14 & 24
Sta 1444+23 Adjust
Exist M.H. 16' Rt
Sta 1444+20 Remove
Exist. 24"x24' R.C.P. Rt
Sta 1444+23 Extend
Exist. 8" San. S. 10' Rt
¼ Section Line
Sta 1444+80 Const
Inlet Type 10 Rt
Install 15"x 58' St S (E)
See Sheets 14 & 24
Sta 1445+80 Const
Inlet Type 10 Rt
Install 18"x 58' St S (E)
See Sheets 14 & 24
Sta 1446+80 Const
Inlet Type 10 Rt
Install 24"x 58' St S (E)
See Sheets 14 & 24
Sta 1447+50 Adjust
Exist M.H. 16' Rt
Sta 1447+80 Const.
Inlet Type 10 Rt
Install 24"x34' St S (N E)
See Sheets 14 & 24
Sta 1448+72 Remove
Exist. 24"x24' R.C.P. Rt
Julia Emery
Sta 1450+13.5 Const
Inlet Type 22 Rt
Install 18"x136' St S (E)
See Sheets 15 & 24
Sta 1448+80.5 Const
Inlet Type 10 Rt
Install 15"x136' St S (E)
See Sheets 14 & 24
Sta 1450+50 Extend
Exist. 8" San. S. 10' Rt
Sta 1450+50 Adjust
Exist M.H. 16' Rt
Sta 1451+62 Const
Manhole
Install 48"x 256' St S (E)
See Sheets 18 & 24
Sta 1451+62 Const
Inlet Type 22 Rt
Install 18"x 40' St S (N E)
See Sheets 15 & 24
Sta 1454+26 Const
Inlet Type 22 Rt
Install 15"x40' St S (N E)
See Sheets 15 & 24
Sta 1440+52 Adjust
Exist M.H. 16' Rt
Sta 1442+20 Const.
Inlet Type 10 Rt
Install 15"x158' St S (N E)
See Sheets 14 & 24
B.M. #53 Ch. "o" on E. h'dwall of E. ent.
89' Lt Sta. 1440+05 El. 1273.94
Annie R Reer etal
B.M. #53-A R.R. spk. in 70" elm
90' Lt Sta. 1451+03 El. 1271.28
Exist Ground Line
Profile Grade Proposed Improvement
Top Curb Elevations
1440
1445
1450
1455