Tri-Dimensional Engineering, Inc.
ENGINEERING • PLANNING • SURVEYING

HYDROLOGY/HYDRAULIC STUDY

T.M. 5509

Paseo Village Townhomes

Day Street
Ramona, California

Prepared for:

Woodcrest Homes
and
The County of San Diego

REGISTERED PROFESSIONAL ENGINEER
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No. C047327
Exp: 12-31-09
CIVIL
STATE OF CALIFORNIA
9-19-08

Prepared by:

Tri-Dimensional Engineering, Inc.
January 31, 2008

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SUMMARY AND CURRENT CONDITIONS: The subject 2.28 acre property consists of four existing lots, two of which are 0.41 acres, one is 0.83 acres and the other is 0.62 acres. They are located on the easterly side of Day Street between La Brea and Vermont Streets in Ramona, an unincorporated area of San Diego County. The 0.62 acre lot adjacent to Day Street is vacant while the other three lots have existing single family residences and driveways. The property, which has very minor slopes, is split by a minor ridge line which defines the drainage onsite. Approximately two thirds of the property generally slopes from northeast to southwest into Day Street and into an existing 18" apron inlet. The other third flows north and west into La Brea Street.

The owners seek to consolidate the lots into one, demolish the existing structures and construct 31 condominiums. Surface drainage will be utilized where practicable to return flow to the soil. Where needed for safety, efficiency, and landscaping, an underground drainage system will be constructed. Runoff will be detained onsite so as to release flow rates equal to those of pre-construction. In accordance with the Grading Ordinance, general flow patterns will be maintained.

Please refer to the preliminary grading plan for this project for detailed drainage information.

SCOPE AND PURPOSE: This is a hydrology/hydraulic study to analyze the developed runoff from and across the site and the adequacy of the proposed surface drainage features that have been designed to safely convey runoff to the existing natural watercourse in the event of a 100-year storm.. Water Quality will be addressed in the project's Storm Water Management Plan.

CALCULATION METHODS: The Rational Method was used to determine total flow quantity at time of concentration for a 100-year-storm for each critical area. Where noted, the following equation was used to calculate time of concentration:

$Tc = Ti + Tt;$

Ti was determined from Table 3.2 of the San Diego County Hydrology Manual;

Tt was calculated using travel times from overland, gutter and pipe flows, as appropriate.

Where noted, the following equation was used to calculate rainfall intensity:

$$i = 7.44(P_6)(D)^{-0.645}$$

Where noted, the manning equation, as follows, was used to determine flow quantities and velocities of flow:

$Q = A * V$, where

$V = (1.49/n) * r^{2/3} * s^{1/2}$

Where noted, the following equation was used to approximate coefficient of runoff, C, for drainage areas with multiple coefficients:

$$C = [(C_{Area\ 1})(A_{Area\ 1})+(C_{Area2})(A_{Area2})+\ldots] / [A_{Area1}+A_{Area2}+\ldots]$$

Where needed, the Bernoulli equation (along with Q=AV above) was used to determine flow characteristics:

$$p_1/\gamma + Z_1 + V^2/2g = p_2/\gamma + Z_2 + V^2/2g + h_L$$

EXISTING WATERSHED CONTRIBUTION:

There is some incidental runoff affecting the site from the neighbor to the north (see Drainage Map 'B'). Runoff in Vermont Street, Day Street and La Brea Street remains in the streets and do not encroach onto the subject property and no other offsite runoff affects the site.

FLOW AREAS AND CRITICAL SECTIONS:

Drainage Map 'A' depicts the pre-construction hydrology drainage basins areas for the on-site flows and the off-site flows of Vermont, Day and La Brea Streets that are or will be routed to the project's drainage system.

Drainage Map 'B' depicts the post-construction hydrology drainage basin areas for the on-site flows and the off-site flows of Vermont, Day and La Brea Streets and will be routed to the project's drainage system. Tables 1 and 2, Appendix A, are summaries of the pre-construction and post construction hydrology basins and all pertinent hydrologic data thereto.

Conditions were analyzed for (1) pipe adequacy, (2) inlet capacity, and (3) detention system adequacy. The design of the storm drain system occurred concurrently with the preparation of this study. All pipes analyzed meet 100-year-flow criteria.

(1) Pipe capacity and adequacy were analyzed and appear in the attached Table 3, Appendix C. Refer to Drainage Map 'B' for the proposed drainage basin and storm line routing.

(2) Area X (detained rate) will be discharged to the southwest corner of the lot into the proposed 18 inch perforated drain line, then routed to the proposed curb inlet at Day and La Brea Streets. The rate and velocity was analyzed to determine the direct effect on post construction flow compared to pre construction. There is no difference. See Appendix A for the Hydrologic Data Tables and Appendix C for detailed results for these sections.

(3) The Detention System was designed so that maximum discharge rate from the site would remain the same as it was prior to construction. This alleviates the need for an exhaustive evaluation or upgrade of the downstream system. The calculations appear in Appendix E.

CONCLUSIONS:

This study indicates that, if the project is constructed per plan, the storm drain system at the subject site will be adequate to handle 100-year-storm conditions. As for all underground drainage facilities, regular maintenance will prolong the life and function of the system.

Furthermore, discharge flow rates (Q) and velocities (V) would remain the same or less than they were prior to construction.

Q(Pre-construction) = 4.97 CFS

Q(Post-construction) = 6.72 CFS

Q(Detained) = 3.03 CFS

Modifications to the proposed system would warrant a re-evaluation of the hydraulics by Tri-Dimensional Engineering, Inc..

DECLARATION OF RESPONSIBLE CHARGE:

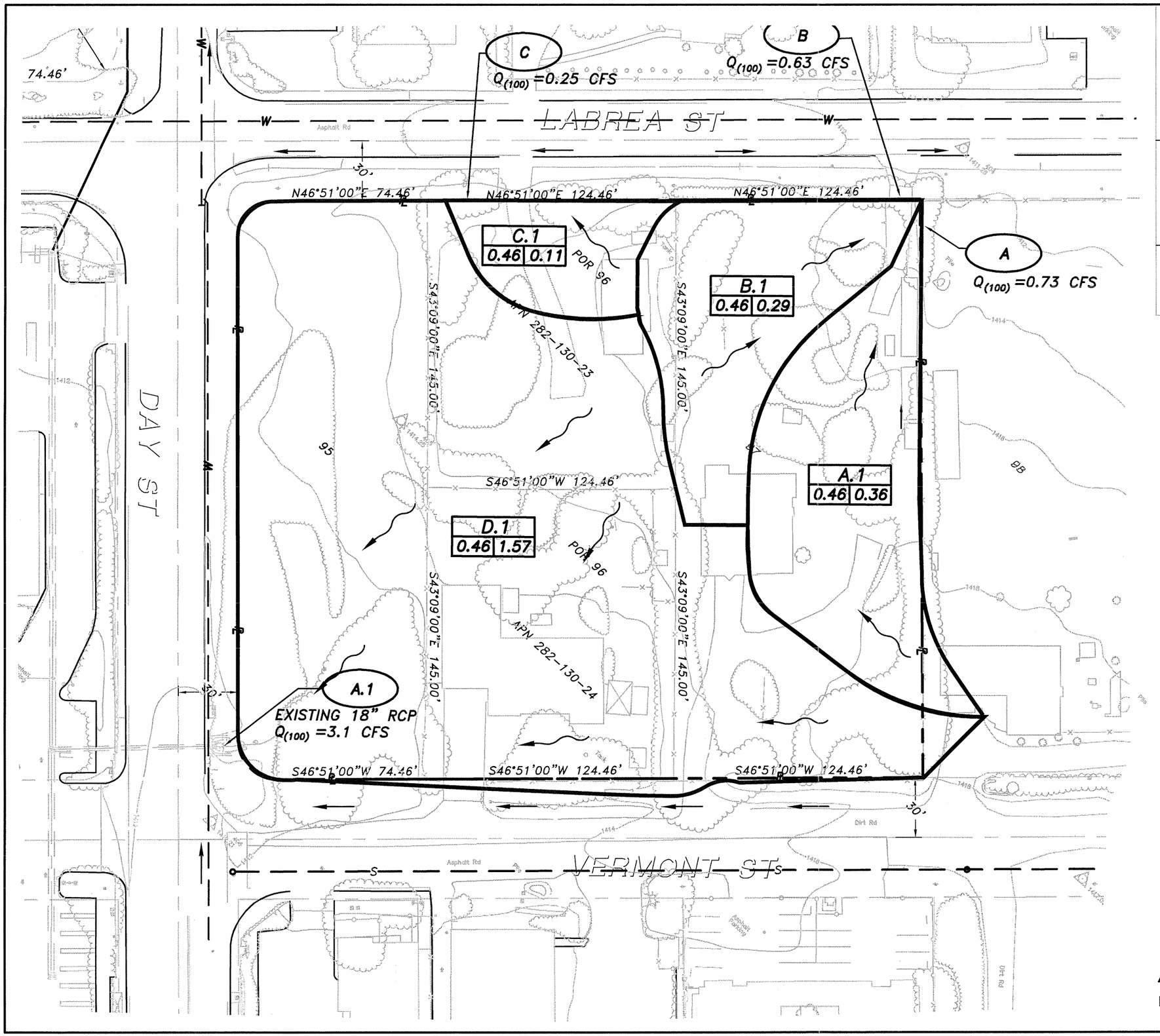
I hereby declare that I am the Civil Engineer of work for this project, that I have exercised responsible charge over the design of the project as defined in section 6703 of the Business and Professions Code, and that the design is consistent with current standards.

I understand that the check of the project drawings and specifications by the County of San Diego is confined to a review only and does not relieve me, as engineer of work, of my responsibilities for project design.

Ernest H. Grabbe, Jr. RCE 047327

9-19-08
Date

REGISTERED PROFESSIONAL ENGINEER
ERNEST H. GRABBE JR
No. C047327
Exp: 12-31-09
CIVIL
STATE OF CALIFORNIA



A.1 ← BASIN I.D. NUMBER

.55 | 1.55

RUNOFF COEFFICIENT — BASIN AREA (IN ACRES)

DRAINAGE BASIN DATA

(EXAMPLE – FLOW FROM AREAS A.1, A.2, AND A.3) A.1–3 ← FLOW I.D. NUMBER

FLOW ANALYSIS LOCATION

DRAINAGE MAP LEGEND

NO SCALE

NOTE:

ALL SITE RUNOFF ENTERS STORM DRAIN

SCALE: 1"=50'

DRAINAGE MAP 'A' PRE-CONSTRUCTION

PASEO VILLAGE TOWNHOMES
DAY STREET
RAMONA, CA 92065

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A.1	
.55	1.55

BASIN I.D. NUMBER

RUNOFF COEFFICIENT

BASIN AREA (IN ACRES)

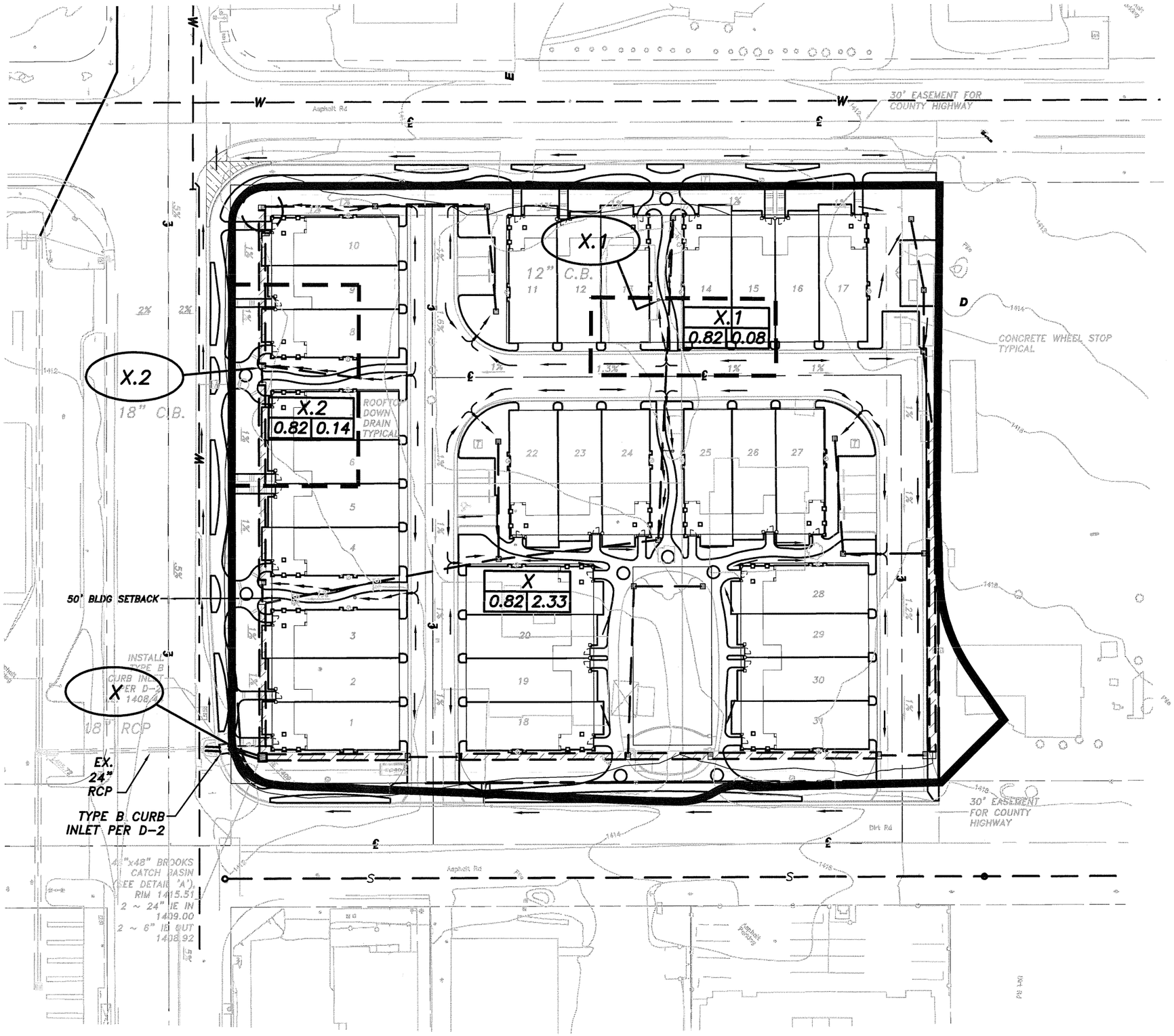
DRAINAGE BASIN DATA

(EXAMPLE – FLOW FROM AREAS A.1, A.2, AND A.3) A.1–3 FLOW I.D. NUMBER

FLOW ANALYSIS LOCATION

DRAINAGE MAP LEGEND

NO SCALE



SCALE: 1"=50'

DRAINAGE MAP 'B' POST-CONSTRUCTION

PASEO VILLAGE TOWNHOMES
DAY STREET
RAMONA, CA 92065

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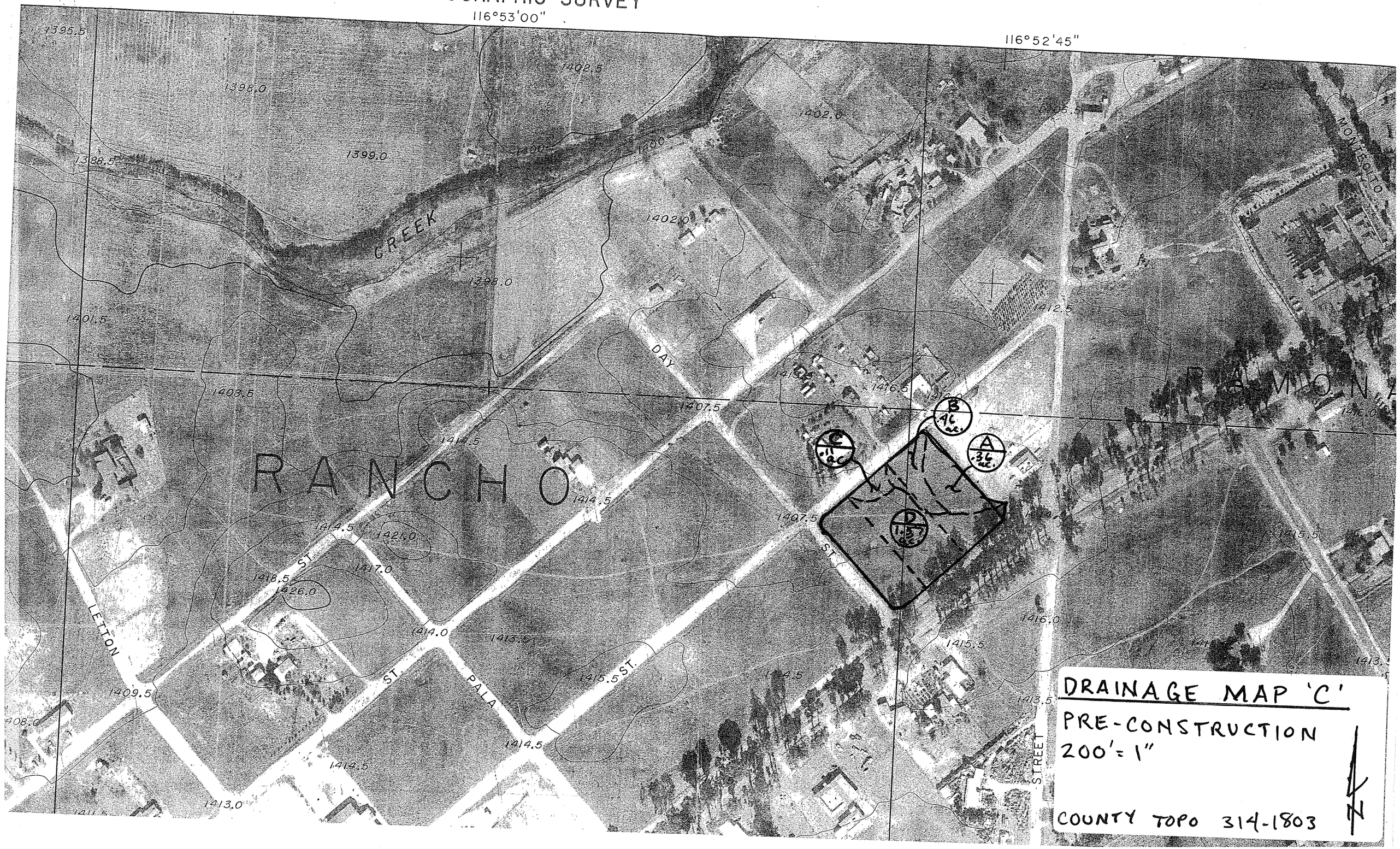
COUNTY OF SAN DIEGO

TOPOGRAPHIC SURVEY



DRAINAGE MAP 'C'

PRE-CONSTRUCTION

200' = 1"

COUNTY TOPO 314-1803

Appendix A
Drainage Area Hydrologic Data

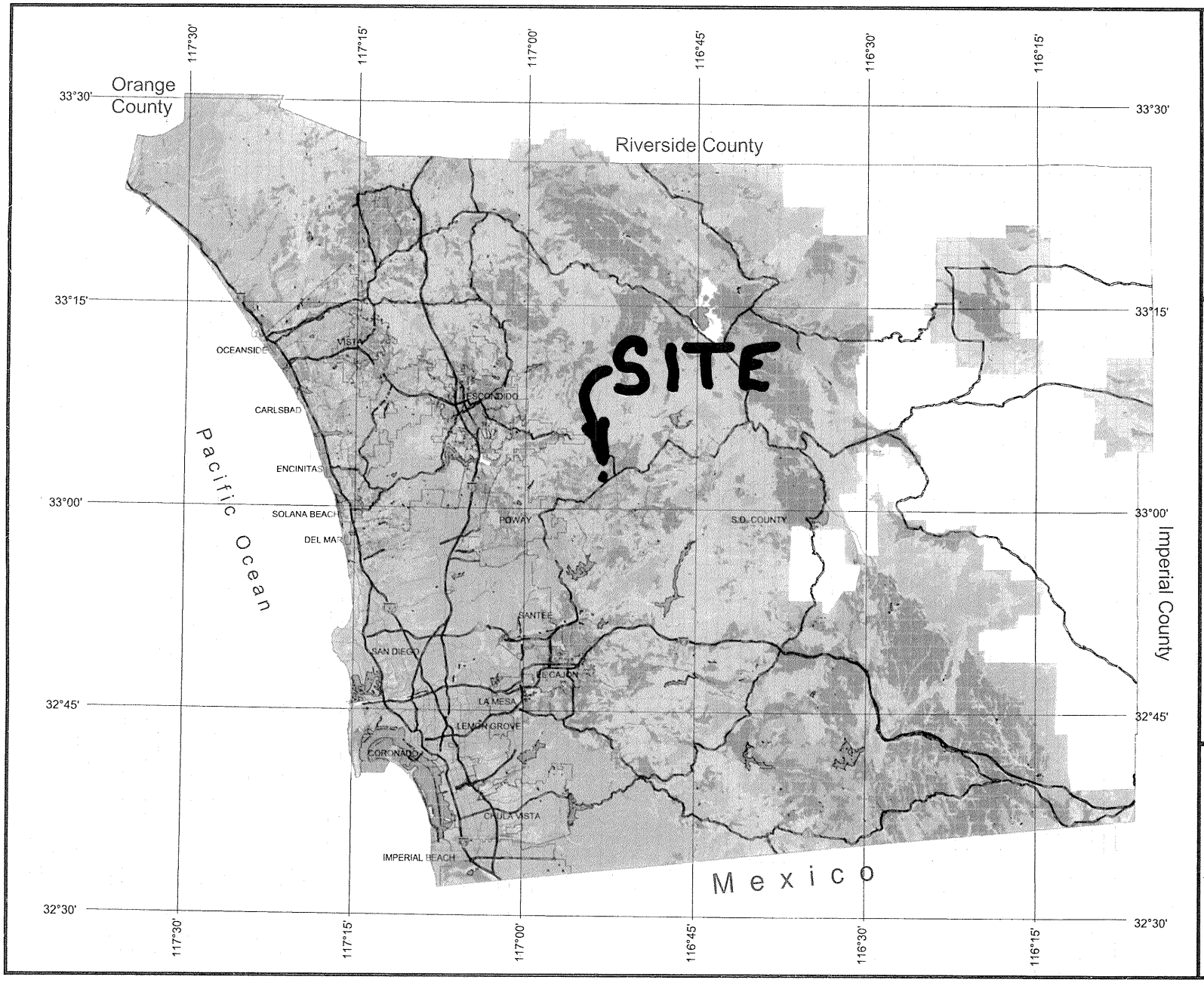
Flow Characteristics - Determine Tc and Q

	Natural Flows			Pipe/Urban Flows			(10m min)	(P=3.35)			
Flow ID	H	L	Time (nat)	Vel	Dist	Time (urb)	#VALUE!	I	C	A	**Qmax**
	(ft)	(ft)	(min)	(fps)	(ft)	(min)	(min)	(in/hr)		(acres)	(cfs)
A	7.1	295	12.62					4.86	0.42	0.36	0.73
B	5.7	155	11.35					5.20	0.42	0.29	0.63
C	3.6	80	10.75					5.39	0.42	0.11	0.25
D	7.4	370	13.34					4.69	0.42	1.57	3.09
A+B+C+D										2.33	4.71
X.1				Use minimum Tc			10	5.64	0.82	0.08	0.37
X.2				Use minimum Tc			10	5.64	0.82	0.14	0.65
X	6.5	437	14.26					4.49	0.82	2.33	8.58
X-D											5.49

Flow Characteristics - Hydraulics of Proposed Structures

											Results		
		Pipe			Chnnel					Design			Top
Flow ID	Flow Description	Size	Slope	n	Btm	Lt side	Rt side	Slope	n	Q	Depth	Vel	width
		(in)	(dec)		wdth(ft)	(ft:ft)	(ft:ft)	(dec)		(cfs)	(ft)	(fps)	(ft)
X	18" PVC @ 1%	18	0.010	0.013						3.01	0.37	5.13	

Appendix B
Charts, Graphs, Equations, Tables used in Design



County of San Diego Hydrology Manual

Soil Hydrologic Groups

Legend

Soil Groups

- Group A
- Group B
- Group C
- Group D
- Undetermined
- Data Unavailable

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3 0 3 Miles

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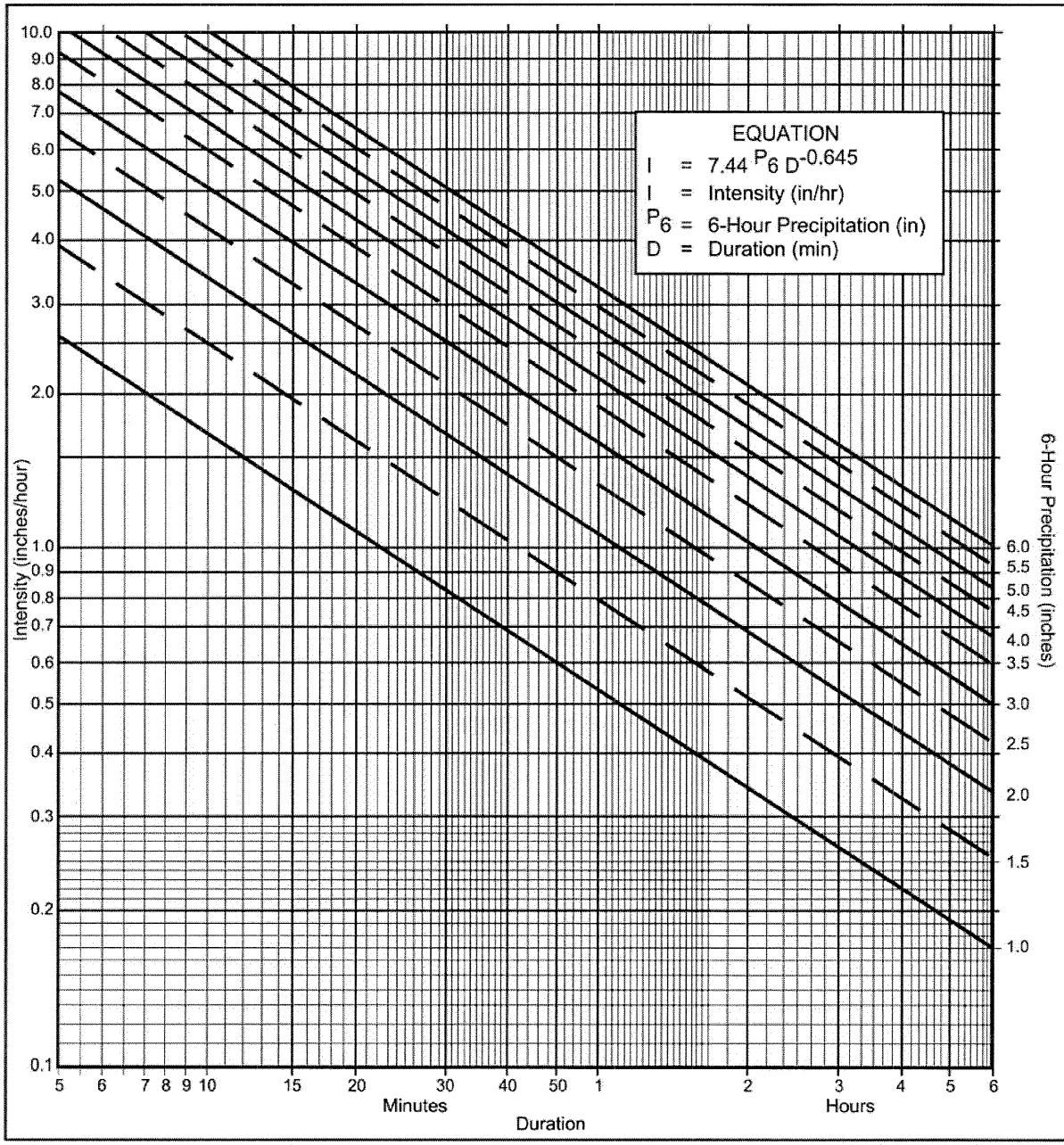
Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

Land Use		Runoff Coefficient "C"				
			Soil Type			
NRCS Elements	County Elements	% IMPER.	A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
					Pre-Construction	
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
					Post-Construction	
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.80	0.81	0.82
Commercial/Industrial (O.P. Com)	Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).
DU/A = dwelling units per acre
NRCS = National Resources Conservation Service



Directions for Application:

(1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).

(2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicaple to Desert).

(3) Plot 6 hr precipitation on the right side of the chart.

(4) Draw a line through the point parallel to the plotted lines.

(5) This line is the intensity-duration curve for the location being analyzed.

Application Form:

(a) Selected frequency 100 year

(b) P_6 = 3.35 in., P_{24} = 5.90, $\frac{P_6}{P_{24}}$ = 56.8 %(2)

(c) Adjusted $P_6^{(2)}$ = 3.35 in.

(d) t_x = _____ min.

(e) I = _____ in./hr.

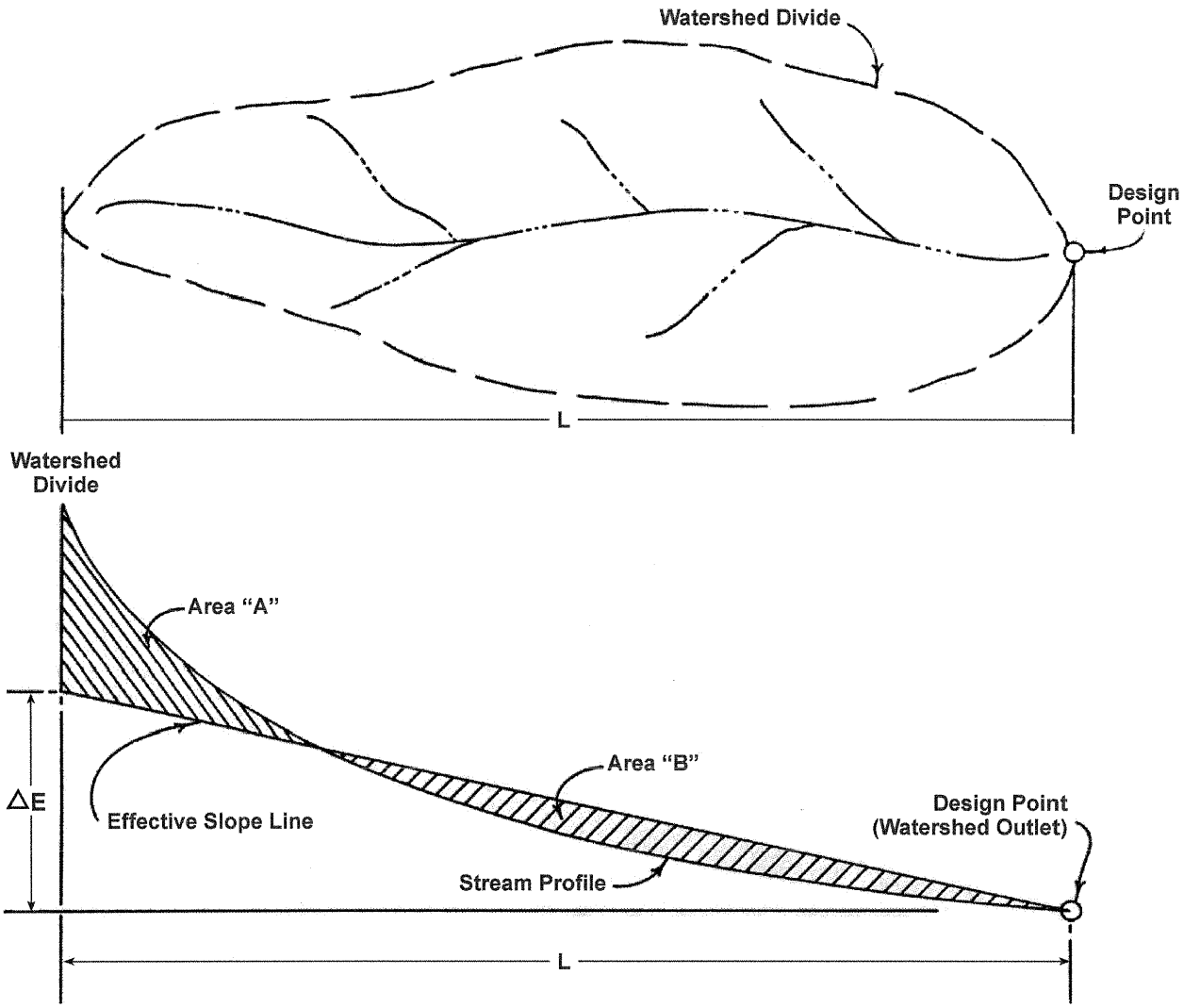
Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

P6	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Duration	I	I	I	I	I	I	I	I	I	I	I
5	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.86	13.17	14.49	15.81
7	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72
10	1.68	2.53	3.37	4.21	5.05	5.90	6.74	7.58	8.42	9.27	10.11
15	1.30	1.95	2.59	3.24	3.89	4.54	5.19	5.84	6.49	7.13	7.78
20	1.08	1.62	2.15	2.69	3.23	3.77	4.31	4.85	5.39	5.93	6.46
25	0.93	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67	5.13	5.60
30	0.83	1.24	1.66	2.07	2.49	2.90	3.32	3.73	4.15	4.56	4.98
40	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.13
50	0.60	0.90	1.19	1.49	1.79	2.09	2.39	2.69	2.98	3.28	3.58
60	0.53	0.80	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	3.18
90	0.41	0.61	0.82	1.02	1.23	1.43	1.63	1.84	2.04	2.25	2.45
120	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04
150	0.29	0.44	0.59	0.73	0.88	1.03	1.18	1.32	1.47	1.62	1.76
180	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.18	1.31	1.44	1.57
240	0.22	0.33	0.43	0.54	0.65	0.76	0.87	0.98	1.08	1.19	1.30
300	0.19	0.28	0.38	0.47	0.56	0.66	0.75	0.85	0.94	1.03	1.13
360	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92	1.00

Intensity-Duration Design Chart - Template

FIGURE

3-1



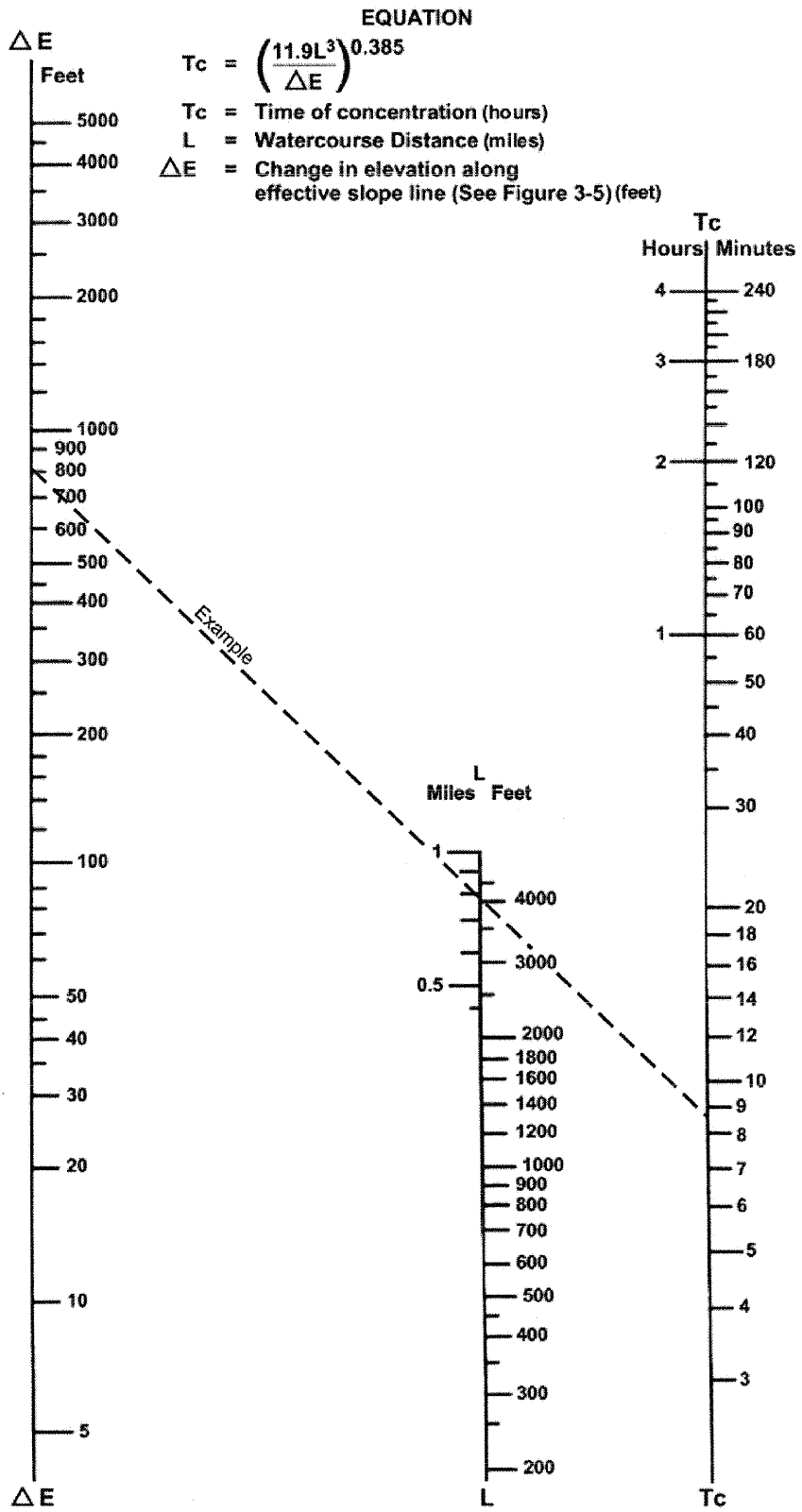
Area "A" = Area "B"

SOURCE: California Division of Highways (1941) and Kirpich (1940)

FIGURE

Computation of Effective Slope for Natural Watersheds

3-5

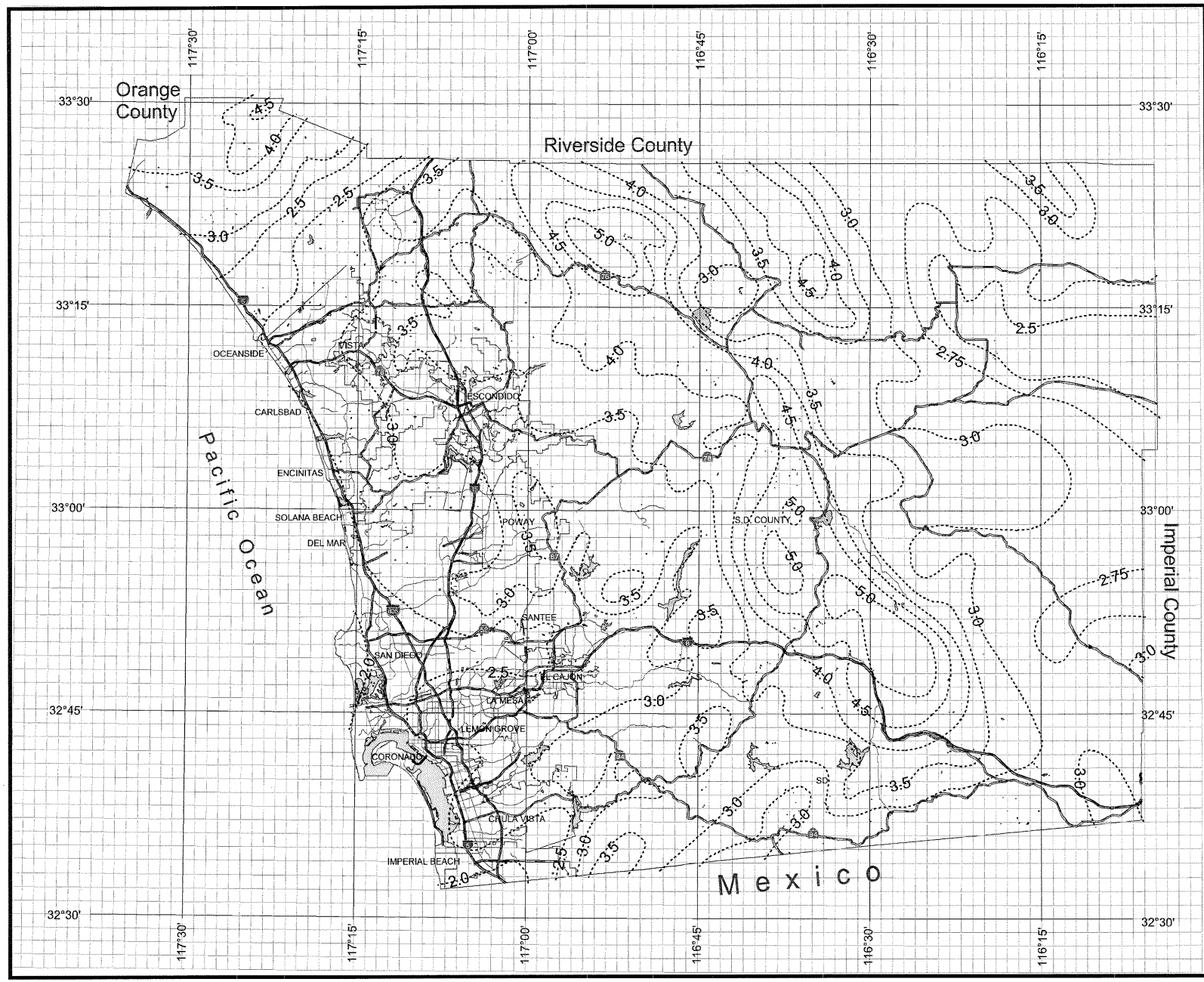


SOURCE: California Division of Highways (1941) and Kirpich (1940)

FIGURE

3-4

Nomograph for Determination of
Time of Concentration (Tc) or Travel Time (Tt) for Natural Watersheds



County of San Diego Hydrology Manual

Rainfall Isopluvials

100 Year Rainfall Event - 6 Hours

Isopluvial (inches)

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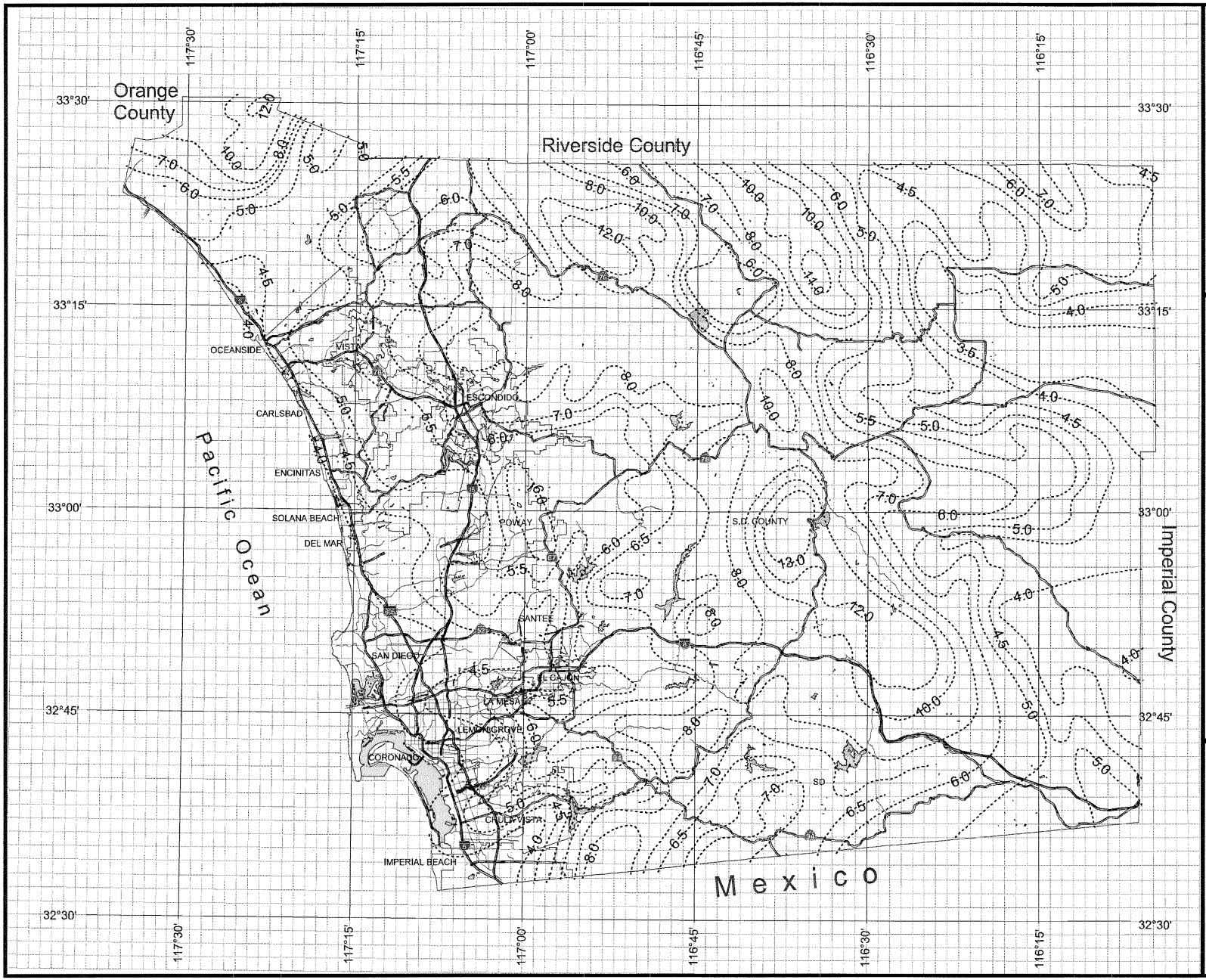

County of San Diego Hydrology Manual

Rainfall Isopluvials

100 Year Rainfall Event - 24 Hours

Isopluvial (inches)

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Figure 4-3

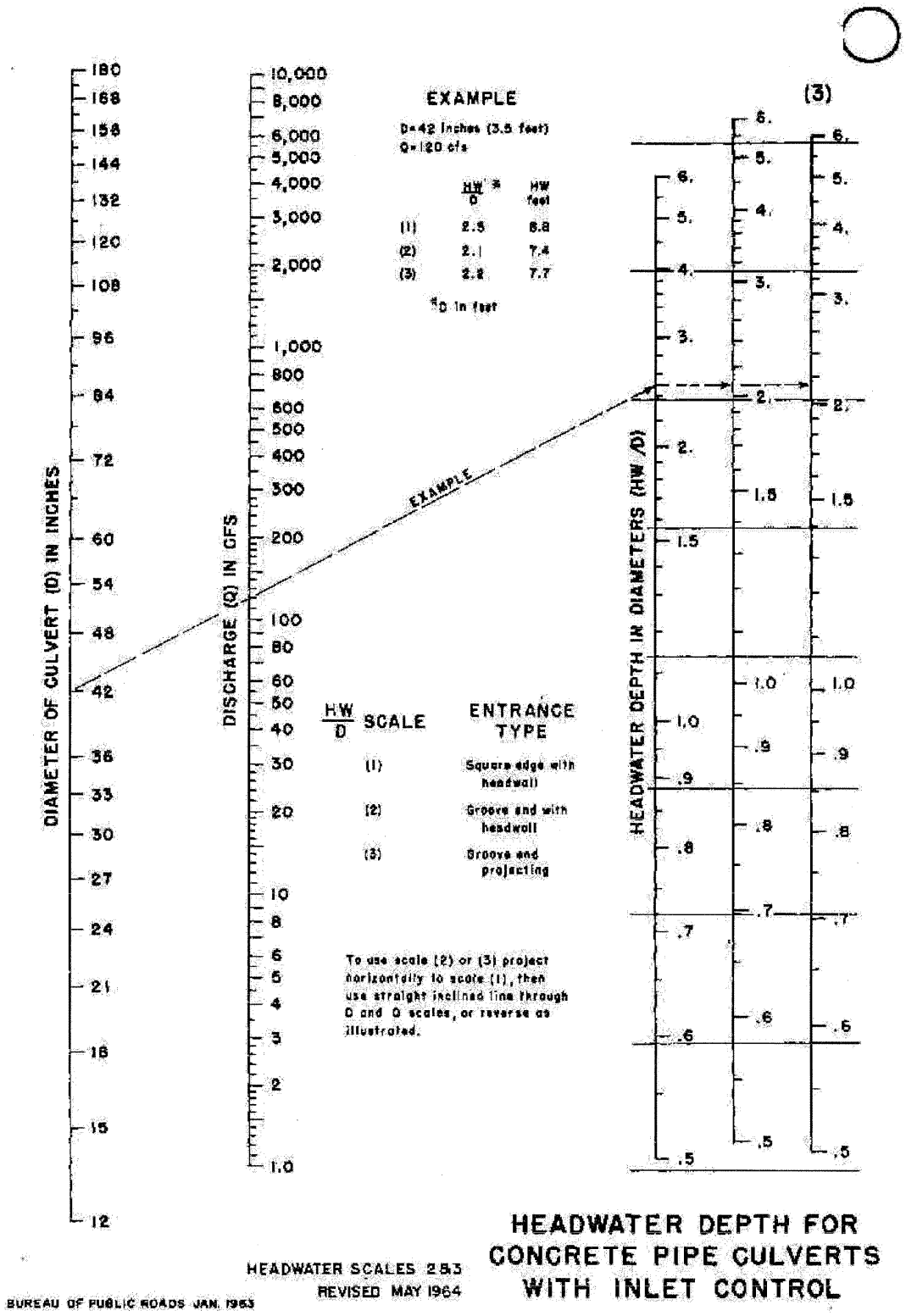
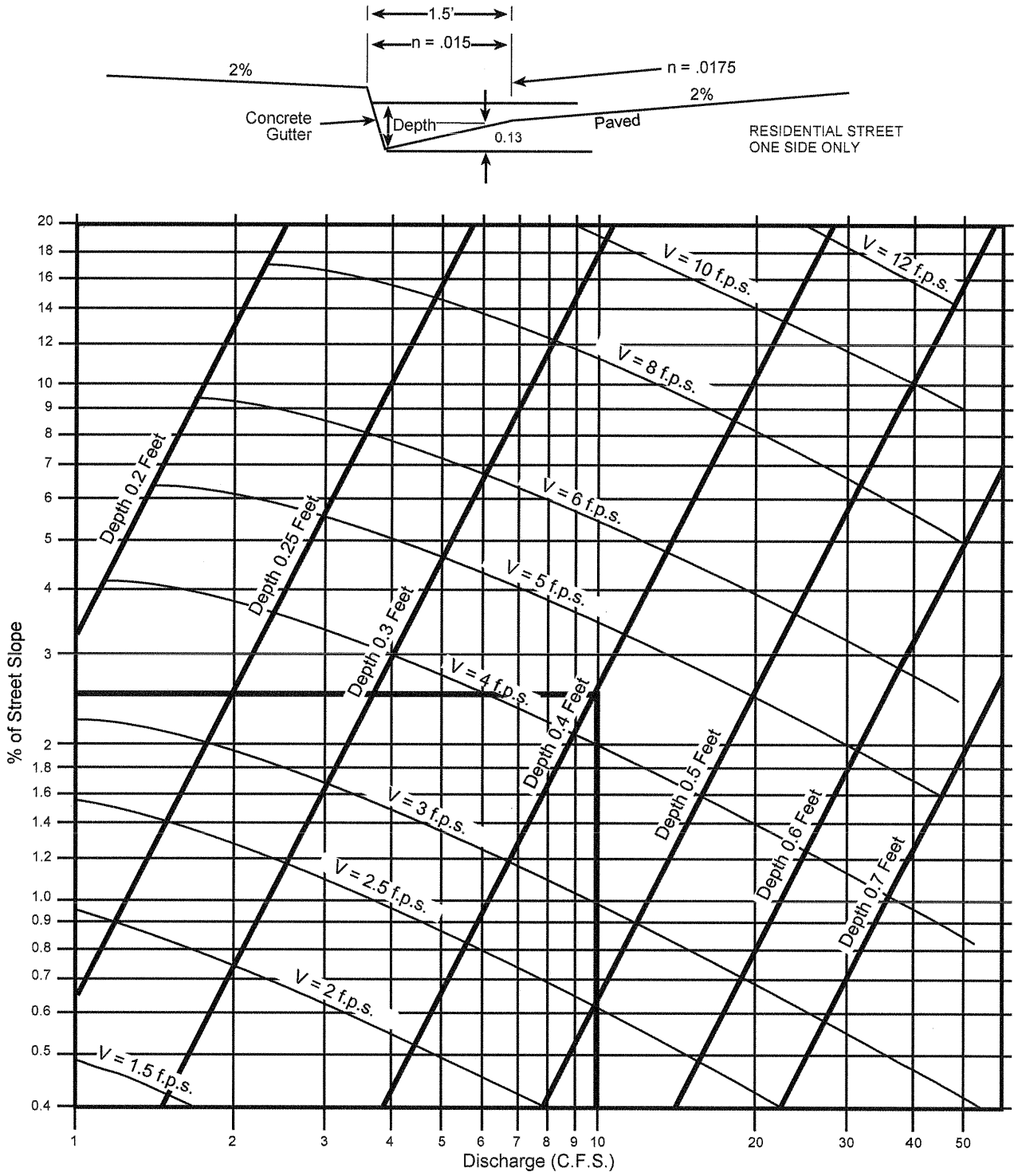


Figure 4-3 Sample Inlet Control Nomograph



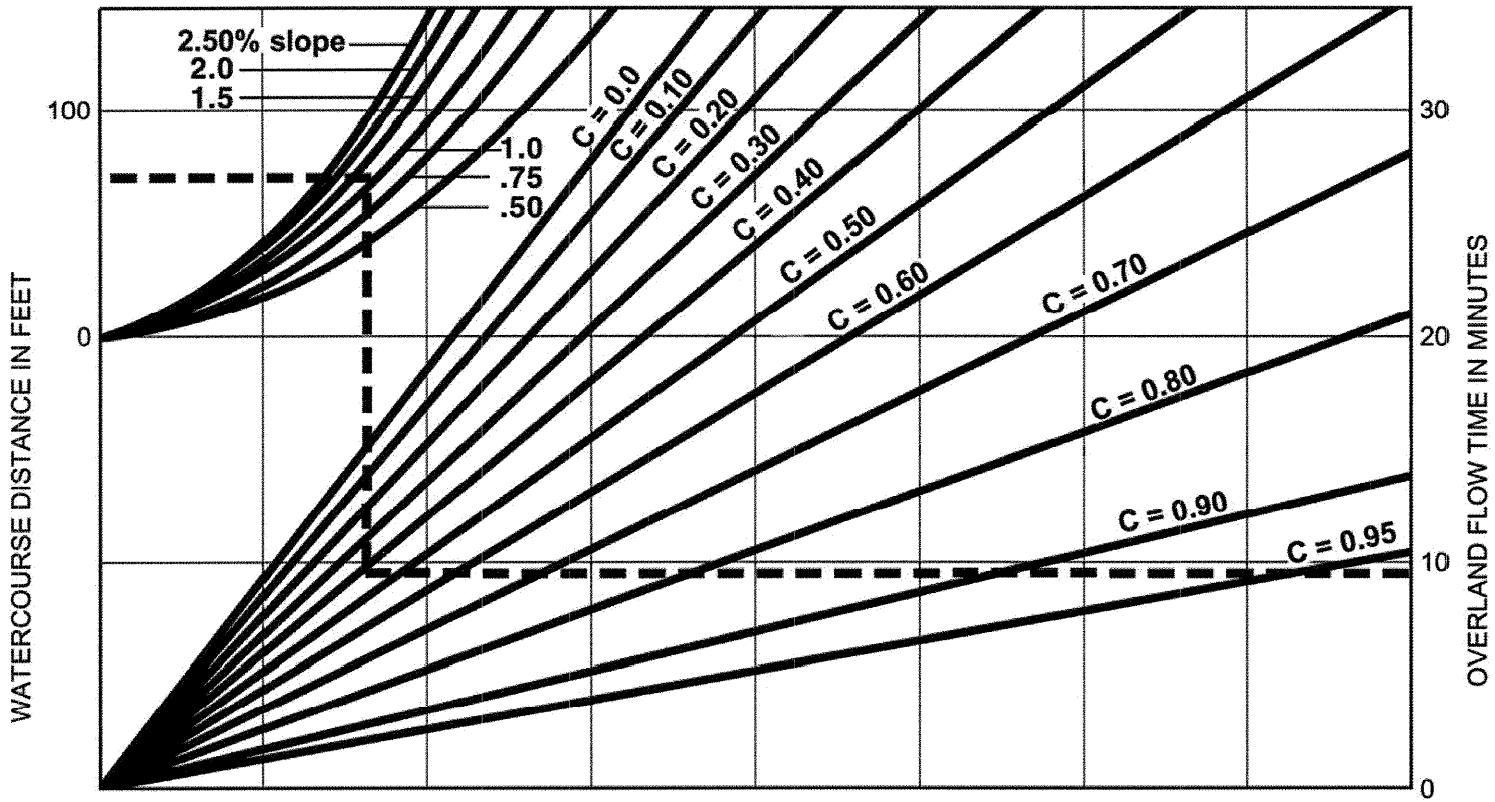
EXAMPLE:
Given: Q = 10 S = 2.5%
Chart gives: Depth = 0.4, Velocity = 4.4 f.p.s.

SOURCE: San Diego County Department of Special District Services Design Manual

FIGURE

Gutter and Roadway Discharge - Velocity Chart

3-6



EXAMPLE:

Given: Watercourse Distance (D) = 70 Feet
Slope (s) = 1.3%
Runoff Coefficient (C) = 0.41
Overland Flow Time (T) = 9.5 Minutes

$$T = \frac{1.8\,(1.1-C)\sqrt{D}}{\sqrt[3]{s}}$$

SOURCE: Airport Drainage, Federal Aviation Administration, 1965

Rational Formula - Overland Time of Flow Nomograph

FIGURE

3-3

PIPE FLOW PROGRAM
18" PVC

DATE: 02-06-2007
TIME: 10:52:36

(1) Diameter (inches) ... 18.	(2) Mannings n ..... .013
(3) slope (ft/ft) ..... .0050	(4) Q (cfs) 3.03
(5) depth (ft) 0.67	(6) depth/Diameter ... 0.44
Velocity (fps) 3.99	Velocity Head 0.25
Area (Sq. Ft.) 0.76	
Critical Depth 0.66	Critical Slope ... 0.0051
Critical Velocity ... 4.03	Froude Number 0.98

Appendix D
Inlet Capacity analysis

PASEO VILLAGE TOWN HOMES | 7-3-06 | 2006-011

INLET CAPACITY

SUB-BASIN X.1 WORST CASE FOR 12"x12" C.B.
Q = 0.37 CFS

BERNOULLI

$$H_w = Z = \frac{V^2}{2g} \quad \text{WHERE } V = Q/A$$

FOR 12"x12" C.B.

$$A = 1\ ft^2 \times 0.70 \times 0.5 = 0.35\ ft^2$$

0.70 ↑ OPEN GRATE FACTOR

0.5 ↑ CLOG FACTOR

$$V = \frac{0.37}{0.35} = 1.06\ fps \Rightarrow Z = \frac{1.06^2}{2(32.2)} = 0.017' = 0.2'' \quad \text{O.K.}$$

SUB-BASIN X.2 WORST CASE FOR 18"x18" C.B.
Q = 0.65 CFS

FOR 18"x18"

$$A_1 = 1.5' \times 1.5' \times 0.7 \times 0.5 = 0.788\ ft^2$$

$$V = \frac{0.65}{0.79} = 0.82\ fps$$

$$Z = \frac{0.82^2}{2(32.2)} = 0.01' = 0.13'' \quad \text{O.K.}$$

Appendix E
Detention System Design

Detention System

The detention system is required to limit the 100-year maximum discharge to pre-construction rates in lieu of an exhaustive downstream analysis or upgrade of the existing storm drain system. In this case post construction runoff of the entire site (hydrologic sub-basin 'X') is discharging to the same outfall point as the existing hydrologic sub-basin 'D'. Therefore maximum post-construction discharge of the entire site is limited to the pre-construction discharge of sub-basin'D':

Pre-Construction: $Q_{100}(D) = 3.09$ cfs
Post-Construction: $Q_{100}(X) = 8.58$ cfs $\rightarrow \rightarrow \Delta = 5.49$ cfs must be detained

(the following design process was iterative, the results of the iterations are shown below):

Propose three discharge pipes, 5" inside diameter. Because distance to exit is so short, orifice capacity equation should govern over all else:

$a = 0.136$ ft^2
$h = 1414.57 - 1409.17 = 5.40$ ft elevation head
$c = 0.62$ (coefficient for squared-off/standard cut pipe)

$Q_{(4"\ PVC\ Pipe)} = (0.62)(0.136)*SQRT[(2)(32.2)(5.40)] = 1.01$ cfs

For three 4" pipes Q = 3 x 1.01 = 3.03 cfs where 3.09 cfs is allowed

Determine maximum storage capacity required for a 100-year-storm of any duration (see attached spreadsheet):

The maximum demand occurs at 14 minutes. The basin requires 4746 ft^3 of storage.

Propose using a 36" diameter PVC pipe for storage/detention

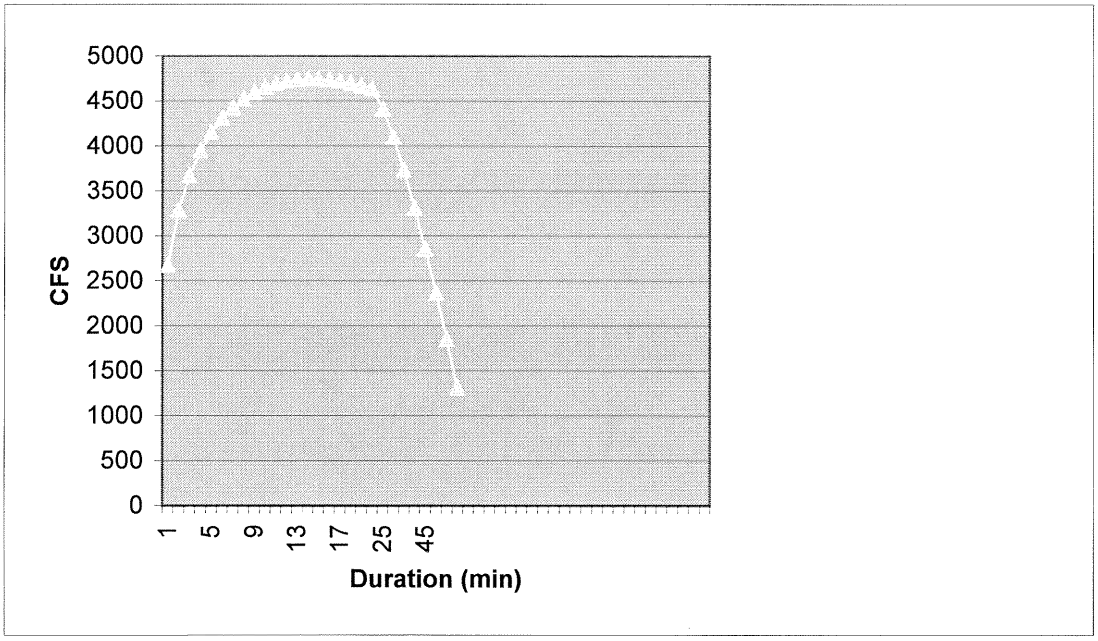
4746 ft^3/(3.14*1.5^2) ft^2 = **672 feet of pipe required**.

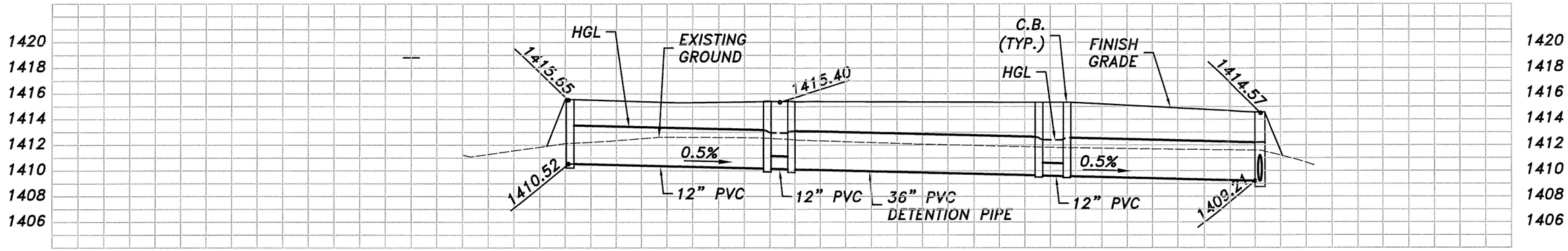
Emergency overflow is provided with the detention discharge basin in the event of an unforeseen clog or greater than 100-year intensity storm.

See plans for final design of system.

Please also consider that some re-infiltration will occur for low flows (though not considered for detention design purposes for safety reasons), that will enable these low flows to never enter the County's storm drain system and have the benefit of potential filtration (important if any bacteria-laden flows make it to this point in the system).

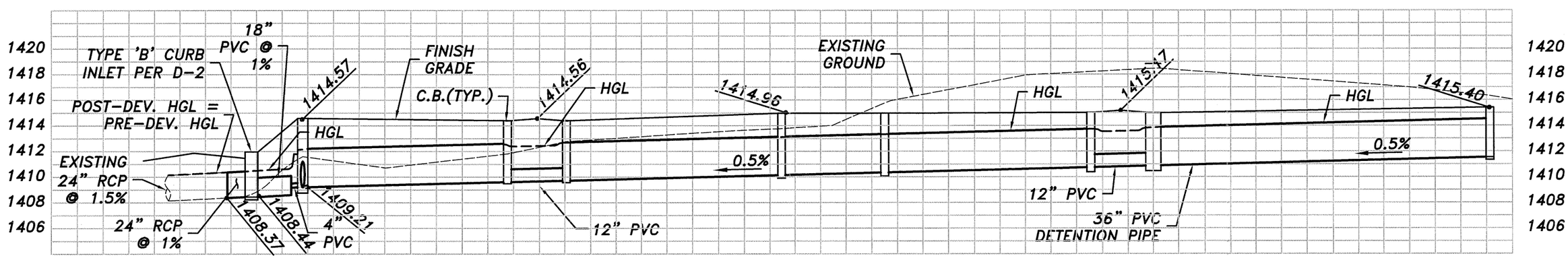
Storm			Discharge	100-year-storm		
Duration	C	A	Vol (3.03 cfs)	I	Inflow Total	Water In Basin
(min)			(cu ft)		(cu ft)	(cu. ft)
1	0.82	2.330	182	24.92	2857	2675
2	0.82	2.330	364	15.94	3654	3291
3	0.82	2.330	545	12.27	4220	3675
4	0.82	2.330	727	10.19	4674	3947
5	0.82	2.330	909	8.83	5059	4150
6	0.82	2.330	1091	7.85	5397	4307
7	0.82	2.330	1273	7.10	5701	4428
8	0.82	2.330	1454	6.52	5978	4523
9	0.82	2.330	1636	6.04	6233	4597
10	0.82	2.330	1818	5.64	6471	4653
11	0.82	2.330	2000	5.31	6693	4693
12	0.82	2.330	2182	5.02	6903	4722
13	0.82	2.330	2363	4.77	7102	4739
14	0.82	2.330	2545	4.54	7291	4746
15	0.82	2.330	2727	4.35	7472	4745
16	0.82	2.330	2909	4.17	7645	4737
17	0.82	2.330	3091	4.01	7812	4721
18	0.82	2.330	3272	3.86	7972	4699
19	0.82	2.330	3454	3.73	8126	4672
20	0.82	2.330	3636	3.61	8276	4640
25	0.82	2.330	4545	3.13	8958	4413
30	0.82	2.330	5454	2.78	9557	4103
35	0.82	2.330	6363	2.52	10094	3731
40	0.82	2.330	7272	2.31	10584	3312
45	0.82	2.330	8181	2.14	11036	2855
50	0.82	2.330	9090	2.00	11457	2367
55	0.82	2.330	9999	1.88	11851	1852
60	0.82	2.330	10908	1.78	12223	1315


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
CFS
1
5
9
13
17
25
45
Duration (min)



SECTION 'B' : ON-SITE DETENTION / STORM DRAIN SYSTEM

HORIZONTAL SCALE: 1"=40'
VERTICAL SCALE: 1"=8'



SECTION 'A' : ON-SITE DETENTION / STORM DRAIN SYSTEM

HORIZONTAL SCALE: 1"=40'
VERTICAL SCALE: 1"=8'

PASEO VILLAGE 2-5-07 2006-011
TOWN HOMES

HYDRAULIC GRADE CALCULATION: $HGL = P/\gamma + h$

36" PVC DETENTION PIPES- FULL FLOW AT MAXIMUM CAPACITY
GRAVITY FLOW

$HGL = \cancel{P/\gamma}^{0} + h = 36''$

THREE 4" PIPES - $Q = \frac{3.03 \text{ CFS}}{3} = 1.01 \text{ CFS}$

$A = 0.136 \text{ ft}^2$

$V = \frac{Q}{A} = \frac{1.01}{0.136} = 7.43 \text{ ft/s} \rightarrow \frac{V^2}{2g} = \frac{(7.43)^2}{2(32.2)} = 0.86'$

$\therefore HGL = 3' - 0.86' = 2.14'$

ASSUME EXISTING 24" RCP IS ALREADY AT MAXIMUM CAPACITY, $HGL_{(EX.)} = 24''$

$$HGL_{(POST\text{-}CONSTRUCTION)} = 24'' - \frac{\left[\frac{(3.09 \text{ CFS} - 3.03 \text{ CFS})}{\pi}\right]^2}{2(32.2)} = 24''$$

THERE IS ACTUALLY AN INSIGNIFICANT DROP IN THE EXISTING 24" RCP HGL. THEREFORE NO CHANGES OR MITIGATION TO THE EXISTING STORM DRAIN SYSTEM ARE NECESSARY NOR ARE THEY PROPOSED.

12" PIPES

$A = \pi(.5)^2 = 0.785 \text{ ft}^2$

$V = \frac{3.03}{0.785} = 3.86 \text{ fps} \longrightarrow \frac{V^2}{2g} = \frac{(3.86)^2}{2(32.2)} = 0.23'$

$\therefore HGL = 3' - 0.23' = 2.77'$