APPENDIX H

Drainage Study

Cypress Point Subdivision
Drainage Study
Los Arbolitos Boulevard and Pala Road

Date Prepared:
March 19, 2021

Prepared for:
Concordia Homes
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Solana Beach, CA 92075

Prepared By:

ΩMEGA
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Declaration of Responsible Charge:
I hereby declare that I am the 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 City of Oceanside is confined to a review only and does not relieve me, as an engineer of work, of my responsibilities for project design.

Patric T. de Boer RCE 83583
Registration Expires 3-31-2023

REGISTERED PROFESSIONAL ENGINEER
PATRIC T DEBOER
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CIVIL
STATE OF CALIFORNIA

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Appendices

Site & Project Description

This drainage study has been prepared for the development of vacant lot at the west end of Pala Road.

The project will involve the regrading of the 7.28 acre site, and the construction 54 single family homes. The project will also include four biofiltration basins, for stormwater quality and Hydromodification Compliance.

The project will also extend Pala Road to a proposed cul-de-sac at the southeast corner of the site. The project will include storm drains on and off -site to intercept runoff and convey it to a discharge point to a vegetated basin adjacent to San Luis Rey River.

Offsite runoff currently enters the site from the Aspen Street and Pala Road. Private and public storm drains will intercept this flow and convey it through the site to the discharge point.

Methodology

This drainage report has been prepared in accordance with current City of Oceanside regulations and procedures. The Modified Rational Method was used to determine the peak flowrates generated by the existing and proposed site conditions. The flowrates generated by sub-basins were confluenced according to the junction equations as detailed on page 3-24 of the San Diego County Hydrology Manual.

Initial Time of Concentration was determined via Table 3-2 of the County Hydrology Manual. Travel Time was determined via the Kirpich Formula for natural drainage areas. For developed drainage areas, the Travel Time was determined by the specific pipe hydraulics, or when applicable, the Gutter and Roadway Discharge Velocity Chart from the San Diego County Hydraulic Design Manual.

See the attached calculations for particulars. The following references have been used in preparation of this report:

(1) Handbook of Hydraulics, E.F. Brater & H.W. King, 6th Ed., 1976.
(2) County of San Diego Hydrology Manual, 2003

Existing Conditions

The existing site is a bare, pad with no permanent improvements. Ground surface conditions consist of seasonal grasses and shrubs. Onsite drainage is overland flow and concentrated natural flow.

Runoff from the residential area to the west flows onto the site at the dead-end of Aspen Street. It then flows across the site in a graded channel and enters a concrete drainage channel that runs along the east side of the site, discharging to a vegetated area adjacent to San Luis Rey River

Runoff from Pala road enters the site immediately south of the intersection of Los Arbolitos Boulevard and Pala Road. This runoff flows east across the undeveloped right-of-way and discharges to the same vegetated area as the onsite flows.

The County of San Diego Soil Hydrologic Group Map indicates Group 'A' Soil on the site, but the entire site has a layer of artificial fill. As a conservative measure the soils onsite are assumed to be Type 'D'.

The project is in a Special Flood Hazard Area, as designated by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) map number 06073C0752G.

Proposed Conditions

In the proposed conditions, 54 single family homes will be constructed. Onsite areas will surface drain to the proposed private streets, and then to one of four onsite biofiltration BMPs. The BMPs will drain via a private storm drain system.

Flow from offsite areas that drain to the site will be intercepted and conveyed through the site. Runoff from offsite tributary areas and onsite areas will confluence in the proposed storm drain under Pala Road and will be discharged via a 60" storm drain to a headwall located at the existing point of discharge southwest of the site.

Existing Rational Analysis

The existing area of analysis was modeled as 8 separate basins, 4 onsite, and 4 offsite.
Basins O-1 and O-2 contain the neighborhood immediately east of the site. This runoff enters the site at the dead end of Aspen Street. Basins O-3 and O-4 contain areas that drain to both sides of Pala Road extending east of the site for approximately ½ mile. This project does not propose changes within Basins O-1 through O-4.

Basins E-1, E-2, E-3 are entirely onsite. Basin E-4 contains the offsite extension of Pala road.

C values were determined using table 3-1 of the county hydrology manual, included as Appendix 5 of this report. The initial time of concentration (Ti) and maximum overland flow length (Lm) were determined using Table 3-2 of the Hydrology Manual. Travel Time (Tt) was determined via the kirpich method, Manning's Equation for Pipes, and the Gutter and Roadway Discharge Velocity Chart. The 100-yr, 6-hr storm depth (P_6) was determined using the isopluvial map included as Appendix 2 of this report.

The total time of concentration was determined by adding the Ti value to the travel time (Tt).

$$Tc = Ti + Tt$$

The Tc and the P_6 values were entered into the peak intensity formula from page 3-7 of the hydrology manual to determine the intensity of the rainfall during the peak of the 100-year, 6-hr storm.

$$\mathbf{I = 7.44 \times P_6 \times Tc^{-0.645}}$$
$$\mathbf{I = 7.44 \times 3.6 \times 8.0^{-0.645}}$$

The peak discharge rate was determine using the Rational Method Formula.

$$\mathbf{Q = C \times I \times A}$$

Below is a summary of the input data for the 100-year, 6- hour storm.

Existing Rational Calculation Summary

Basin	Impervious %	C	Area (ac)
E-1	0	0.35	1.65
E-2	0	0.35	1.17
E-3	0	0.35	3.95
E-4	0	0.35	0.64
O-1	50	0.63	8.72
O-2	50	0.63	0.63
O-3	50	0.63	25.17
O-4	50	0.63	31.88

The peak flowrates determined for each basin were confluenced according to the junction equations from page 3-24 of the San Diego County Hydrology Manual.

Junction Equations:

$$T_1 < T_2 < T_3$$
$$Q_{T1} = Q_1 + \frac{T_1}{T_2} Q_2$$
$$Q_{T2} = Q_2 + \frac{I_1}{I_2} Q_1$$

The confluenced flowrate from all basins is 93.11 cfs

Proposed Rational Analysis

The proposed site was modeled as 11 separate basins. 7 onsite basins, and the same 4 offsite basins that were included in the existing analysis. The proposed basins are referred to as P-1.1, P-1.2, P-1.3, P-1.4, P-1.5, P-1.6 and P-2.1.

The average slope of the basins varies from 0.5% to 0.7%. Weighted runoff coefficients vary from 0.35 to 0.83 The initial time of concentration (Ti) and maximum overland flow length (Lm) were determined using Table 3-2 of the Hydrology Manual. The total time of concentration was determined by adding the Ti value to the travel time (Tt). Tt was calculated by determining the flow velocity in the gutters and storm drains and dividing the travel length by the velocity.

The time of concentration, peak intensity and the peak flowrate were determined using the same formulas and methods as in the existing conditions. Below is a summary of the input data and resulting flowrates generated by each basin for the 100-year, 6-hr storm.

Proposed Rational Calculation Summary

Basin	Impervious %	C	Area (ac)
P-1.1	59	0.68	0.91
P-1.2	0	0.35	0.21
P-1.3	58	0.67	0.92
P-1.4	67	0.72	2.73
P-1.5	87	0.83	0.53
P-1.6	60	0.68	1.75
P-2.1	0	0.35	0.37
O-1	50	0.63	8.72
O-2	50	0.63	0.63
O-3	50	0.63	25.17
O-4	50	0.63	31.88

The peak flowrates determined for each basin were confluenced according to the junction equations from page 3-24 of the San Diego County Hydrology Manual.

Junction Equations:

$$T_1 < T_2 < T_3$$

$$Q_{T1} = Q_1 + \frac{T_1}{T_2} Q_2$$

$$Q_{T2} = Q_2 + \frac{I_1}{I_2} Q_1$$

The confluenced, unmitigated peak runoff at the discharge point is 107.40 cfs. This is an increase of 14.29 cfs over existing conditions.

Results and Conclusions

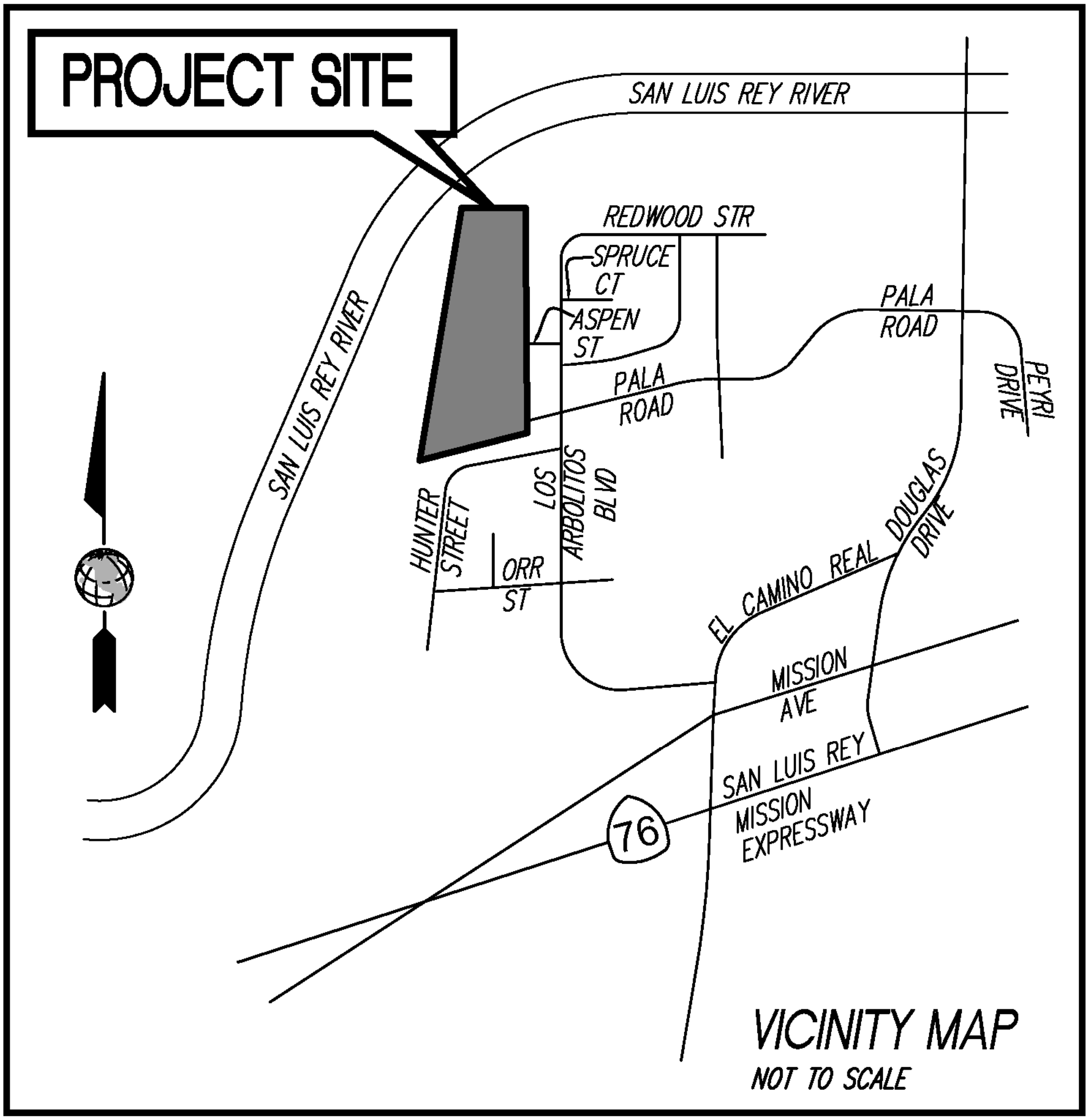
The proposed improvements result in an increase in the peak runoff flowrate generated by the area of analysis by approximately 15%.

This increase is not anticipated to create adverse downstream conditions, as all the proposed storm drains are designed with sufficient capacity to convey the flow to the outfall location.

No negative effects to downstream water ways are anticipated as a result of the increased flow during the peak of the 100 year storm. The outfall of the proposed 60" storm drain will have an invert that is below the 100-year flood elevation (per the FEMA Flood Profile for San Luis Rey River)

It is the opinion of Omega Engineering Consultants that the project will not cause flow related adverse effects to the downstream facilities or receiving waters during the peak of the 100-yr, 6-hr storm. A separate Storm Water Quality Management Plan has been prepared to discuss the water quality impacts for the proposed development.

Project Vicinity Map



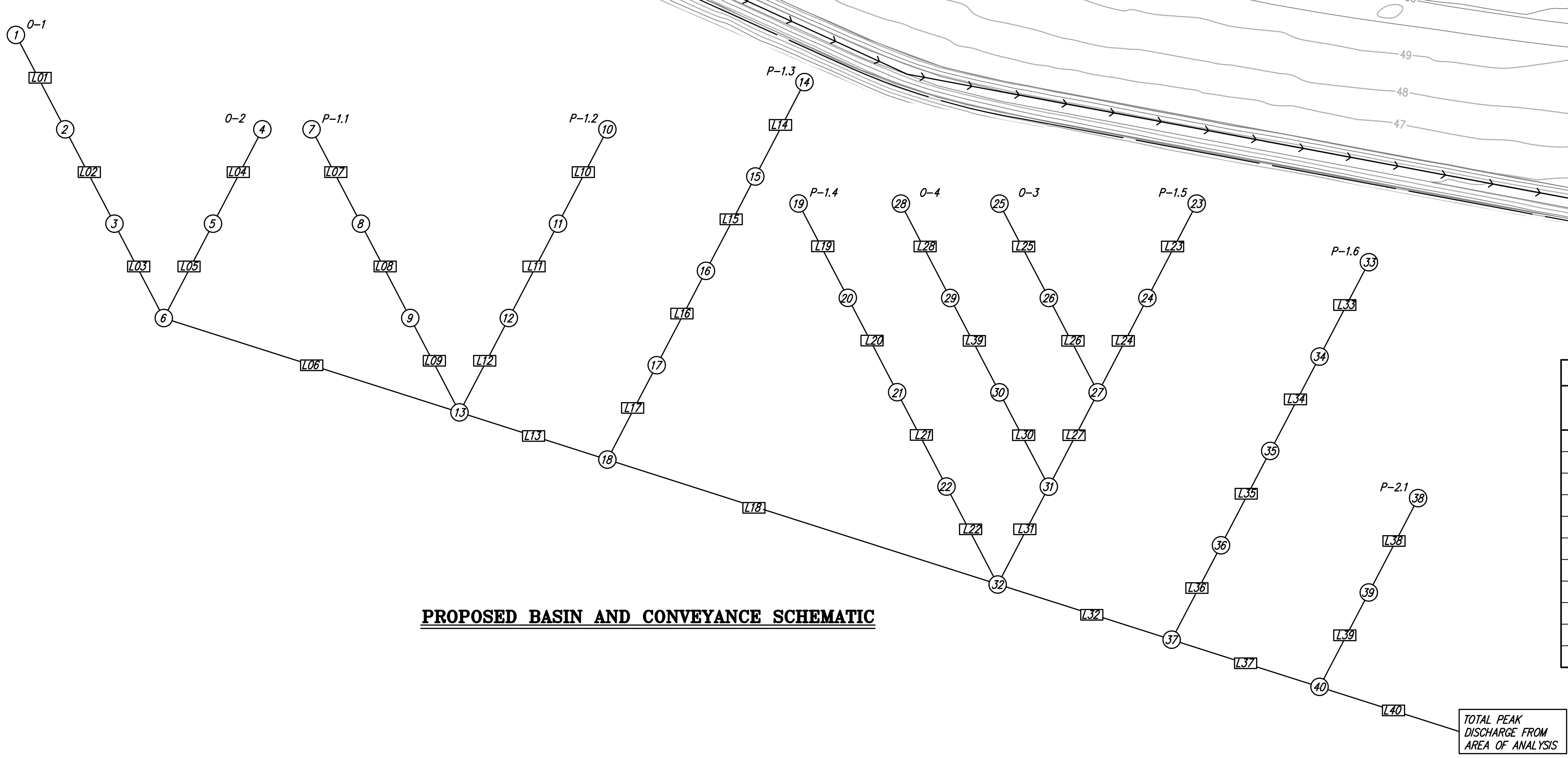
EXISTING BASIN AND CONVEYANCE SCHEMATIC

DRAINAGE BASIN DATA					
BASIN #	AREA (AC)	C-VALUE	T_C (MINS)	I_{100} (IN/HR)	Q_{100} (CFS)
E-1	1.65	0.35	24.50	2.55	16.52
E-2	1.17	0.35	16.68	3.27	1.34
E-3	3.95	0.35	14.67	3.55	4.91
E-4	0.64	0.35	32.71	2.12	76.60
O-1	8.72	0.63	20.13	2.90	15.91
O-2	0.63	0.63	10.20	4.49	1.80
O-3	25.17	0.63	28.94	2.29	36.35
O-4	31.88	0.63	27.61	2.36	47.46

CYPRESS POINT SUBDIVISION EXISTING CONDITIONS EXHIBIT

ΩMEGA

EX. HYDROLOGY EXHIBIT



PROPOSED BASIN AND CONVEYANCE SCHEMATIC

DRAINAGE BASIN DATA

BASIN #	AREA (AC)	C-VALUE	T_C (MINS)	I_{100} (IN/HR)	Q_{100} (CFS)
P-1.1	0.91	0.68	11.98	4.05	2.50
P-1.2	0.21	0.65	14.83	3.53	0.26
P-1.3	0.92	0.67	16.13	3.34	2.07
P-1.4	2.73	0.72	16.27	3.32	6.53
P-1.5	0.53	0.83	11.10	4.25	1.86
P-1.6	1.76	0.68	16.87	3.25	3.86
P-2.1	0.37	0.35	14.61	3.56	0.46
0-1	8.72	0.63	20.13	2.90	15.91
0-2	0.63	0.63	10.20	4.49	1.80
0-3	25.17	0.63	28.94	2.29	36.35
0-4	31.88	0.63	27.61	2.36	47.46

CURB INLET DATA

CURB INLET #	TRIBUTARY AREA	Q_{100}	LENGTH (FT)	HEIGHT (FT)	GUTTER DEPRESSION (FT)	MAX FLOW DEPTH (FT)
1	0-1	15.91	14	0.5	0.33	0.18
2	0-2	1.80	14	0.5	0.33	0.10
3	0-3 & P-1.5	37.36	20	0.5	0.33	0.48
4	0-4	47.43	20	0.5	0.33	0.78

GRATED INLET DATA

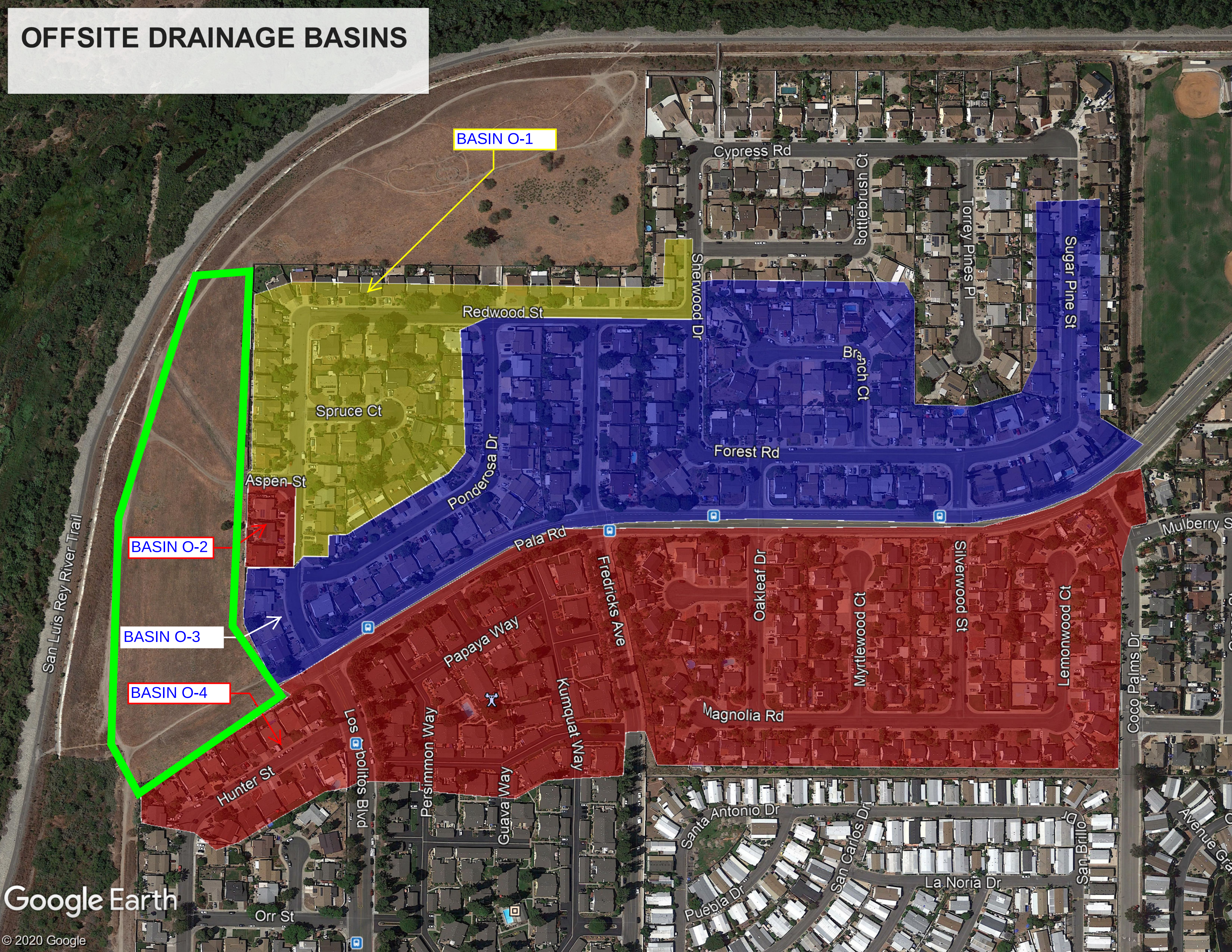
GRATED INLET #	TRIBUTARY AREA	Q_{100} (cfs)	MAX FLOW DEPTH (FT)
1	P-1.1	2.50	0.33
2	P-1.3	2.07	0.28
3	P-1.4	6.53	0.60
4	P-1.6	3.83	0.42

CYPRESS POINT SUBDIVISION PROPOSED CONDITIONS EXHIBIT

OMEGA

PROP. HYDROLOGY EXHIBIT

OFFSITE DRAINAGE BASINS



CYPRESS POINT SUBDIVISION
EXISTING CONDITIONS

12/23/2020

Sub-Basin	Upstream Node	Downstream Node	AREA Ac.	C	ΣA	CA	ΣCA	S(%) (avg.)	Ti mins	Tt mins	T_c mins	ΣT mins	I in/hr	Q cfs	Conduit V (fps)	Conduit L (ft)	Conduit T (mins)	NOTES 100-year, 6 hr storm
																		P(6) 2.7
O-1	1	2							8.20									Link 01 - Overland flow
	2	5	8.72	0.63	8.72	5.49	5.49	0.5%		11.93	**20.13**	**20.13**	2.90	**15.91**				Link 02 - Gutter Flow
O-2	3	4							8.20									Link 03 - Overland flow
	4	5	0.63	0.63	0.63	0.40	0.40	0.5%		2.00	**10.20**	**10.20**	4.49	**1.80**				Link 04 - Gutter Flow
					9.35		5.89					20.13	2.90	**17.07**				Confluence at Node 5
E-1									0.00							Flow through basin, Tt and CA added to incoming flow. Tt per Kirpich		
	5	8	1.65	0.35	11.01	0.58	6.47	1.1%		4.37		**24.50**	2.55	**16.52**				
E-2	6	7							12.50									Link 06 - Overland flow
	7	8	1.17	0.35	1.17	0.41	0.41	1.0%		4.18	**16.68**	**16.68**	3.27	**1.34**				Link 07 - Kirpich Flow
					12.18		6.88					24.50	2.55	**17.56**				Confluence at Node 8
	8	11			12.18		6.88			7.50		32.00	2.15	**14.78**				Link 08 - Kirpich Flow
E-3	9	10							10.90									
	10	11	3.95	0.35	3.95	1.38	1.38	1.7%		3.77	**14.67**	**14.67**	3.55	**4.91**				
					16.13		8.26					32.00	2.15	**17.76**				Confluence at Node 11
	11	17			16.13		8.26			3.82		35.82	2.00	**16.51**				Link 08 - Kirpich Flow
O-3	3	4							8.20									Link 12 - Overland flow
	4	5	25.17	0.63	25.17	15.86	15.86	0.5%		20.74	**28.94**	**28.94**	2.29	**36.35**				Link 13- Gutter Flow
O-4	3	4							8.20									Link 14 - Overland flow
	4	5	31.88	0.63	31.88	20.08	20.08	0.5%		19.41	**27.61**	**27.61**	2.36	**47.46**				Link 15- Gutter Flow
					57.05		35.94					28.94	2.29	**82.39**				Confluence at Node 16

CYPRESS POINT SUBDIVISION
EXISTING CONDITIONS

12/23/2020

Sub-Basin	Upstream Node	Downstream Node	AREA Ac.	C	ΣA	CA	ΣCA	S(%) (avg.)	Ti mins	Tt mins	T_c mins	ΣT mins	I in/hr	Q cfs	Conduit V (fps)	Conduit L (ft)	Conduit T (mins)	NOTES 100-year, 6 hr storm
																		P(6) 2.7
E-4									0.00									Flow through basin, Tt and CA added to
	16	17	0.64	0.35	57.40	0.23	36.17	1.7%		3.77		**32.71**	2.12	**76.60**				incoming flow. Tt per Kirpich
					73.53		44.43					32.71	2.12	**93.11**				Confluence at Node 17

CYPRESS POINT SUBDIVISION
PROPOSED CONDITIONS

3/22/2021

Sub-Basin	Upstream Node	Downstream Node	AREA Ac.	C	ΣA	CA	ΣCA	S(%) (avg.)	Ti mins	Tt mins	T_c mins	ΣT mins	I in/hr	Q cfs	Conduit V (fps)	Conduit L (ft)	Conduit T (mins)	NOTES 100-year, 6 hr storm
																		P(6) 2.7
O-1	1	2							8.20									Link 01 - Overland flow
	2	3	8.72	0.63	8.72	5.49	5.49	0.5%		11.93	**20.13**	**20.13**	2.90	**15.91**				Link 02 - Gutter Flow
	3	6			8.72		5.49			0.11		20.23	2.89	**15.86**	4.97	32	0.11	Link 03 - 24" pipe
O-2	4	5							8.20									Link 04 - Overland flow
	5	6	0.63	0.63	0.63	0.40	0.40	0.5%		2.00	**10.20**	**10.20**	4.49	**1.80**				Link 05 - Gutter Flow
					9.35		5.89					20.23	2.89	**17.01**				Confluence at Node 7
	6	12			9.35		5.89			0.30		20.54	2.86	**16.85**	5.04	92	0.30	Link 06 - 24" pipe
P-1.1	7	8							8.20									Link 07 - Overland flow
	8	9	0.91	0.68	0.91	0.62	0.62	0.4%		3.78	**11.98**	**11.98**	4.05	**2.50**				Link 08 - Gutter Flow
	9	13			0.91		0.62			0.11		12.08	4.03	**2.49**	3.15	20	0.11	Link 09 - 18" pipe
P-1.2	10	11							8.20									Link 10 - Overland flow
	11	12	0.21	0.35	0.21	0.07	0.07	0.5%		6.63	**14.83**	**14.83**	3.53	**0.26**				Link 11- Kirpich Flow
	12	13			0.21		0.07			2.41		17.24	3.20	**0.23**	1.87	270	2.41	Link 12 - 8" pipe
					10.47		6.58					20.54	3.53	**18.80**				Confluence at Node 13
	13	18			10.47		6.58			1.49		22.03	2.73	**17.99**	5.14	461	1.49	Link 13 - 30" pipe
P-1.3	14	15							8.20									Link 14 - Overland flow
	15	16	0.92	0.67	0.92	0.62	0.62	0.5%		7.93	**16.13**	**16.13**	3.34	**2.07**				Link 15 - Gutter Flow
	16	17			0.92		0.62			0.07		16.19	3.33	**2.06**	3.03	12	0.07	Link 16 - 18" pipe
	17	18			0.92		0.62			0.28		16.47	3.30	**2.04**	3.03	50	0.28	Link 17 - 18" pipe
					11.40		7.20					22.03	3.33	**19.68**				Confluence at Node 18
	18	32			11.40		7.20			0.93		22.96	2.66	**19.16**	5.21	290	0.93	Link 18 - 30" pipe

CYPRESS POINT SUBDIVISION
PROPOSED CONDITIONS

3/22/2021

Sub-Basin	Upstream Node	Downstream Node	AREA Ac.	C	ΣA	CA	ΣCA	S(%) (avg.)	Ti mins	Tt mins	T_c mins	ΣT mins	I in/hr	Q cfs	Conduit V (fps)	Conduit L (ft)	Conduit T (mins)	NOTES 100-year, 6 hr storm
																		P(6) 2.6
P-1.4	19	20							8.20									Link 19 - Overland flow
	20	21	2.73	0.72	2.73	1.97	1.97	0.5%		8.07	**16.27**	**16.27**	3.32	**6.53**				Link 20 - Gutter Flow
	21	22			2.73		1.97			0.08		16.36	3.31	**6.51**	4.05	20	0.08	Link 21 - 18" pipe
	22	32			2.73		1.97			0.12		16.48	3.30	**6.48**	4.04	30	0.12	Link 22 - 18" pipe
P-1.5	23	24							8.20									Link 23 - Overland flow
	24	27	0.53	0.83	0.53	0.44	0.44	0.5%		2.90	**11.10**	**11.10**	4.25	**1.86**				Link 24 - Gutter Flow
O-3	25	26							8.20									Link 25 - Overland flow
	26	27	25.17	0.63	25.17	15.86	15.86	0.5%		20.74	**28.94**	**28.94**	2.29	**36.35**				Link 26 - Gutter Flow
					25.70		16.30					28.94	2.29	**37.36**				Confluence at Node 27
	27	31			25.70		16.30			0.11		29.05	2.29	**37.26**	7.41	50	0.11	Link 27 - 24"x72" box
O-4	28	29							8.20									Link 28- Overland flow
	29	30	31.88	0.63	31.88	20.08	20.08	0.5%		19.41	**27.61**	**27.61**	2.36	**47.46**				Link 29 - Gutter Flow
	30	31			31.88		20.08			0.03		27.64	2.36	**47.43**	5.99	10	0.03	Link 30 - 24"x72" box
					57.58		36.38					27.64	2.36	**84.69**				Confluence at Node 31
	31	32			57.58		36.38			1.17		28.81	2.30	**83.64**	5.99	422	1.17	Link 32 - 60" box
					71.71		45.55					28.81	2.30	**104.71**				Confluence at Node 23
P-1.6	33	34							8.20									Link 33- Overland flow
	34	35	1.75	0.68	1.75	1.19	1.19	0.6%		8.67	**16.87**	**16.87**	3.25	**3.86**				Link 34 - Gutter Flow
	35	36			1.75		1.19			0.02		16.89	3.24	**3.86**	3.56	5	0.02	Link 35 - 18" pipe
	36	37			1.75		1.19			0.12		17.01	3.23	**3.84**	3.56	25	0.12	Link 36 - 18" pipe
					73.46		46.74					28.81	3.23	**106.98**				Confluence at Node 37

CYPRESS POINT SUBDIVISION
PROPOSED CONDITIONS

3/22/2021

Sub-Basin	Upstream Node	Downstream Node	AREA Ac.	C	ΣA	CA	ΣCA	S(%) (avg.)	Ti mins	Tt mins	T_c mins	ΣT mins	I in/hr	Q cfs	Conduit V (fps)	Conduit L (ft)	Conduit T (mins)	NOTES 100-year, 6 hr storm
																		P(6) 2.6
	37	40			73.46		46.74			0.56		29.37	2.27	**106.12**	3.56	120	0.56	Link 37 - 60" pipe
P-2.1	38	39							8.20									Link 33- Overland flow
	39	40	0.37	0.35	0.37	0.13	0.13	0.7%		14.61	**22.81**	**14.61**	3.56	**0.46**				Link 34 -Kirpich Flow
					73.83		46.86					28.81	3.56	**107.40**				Confluence at Node 37

Rectangular Channel Sizing Calculation

K'= Discharge Factor
n= Mannings coefficient
D=depth of water in channel
b=width of bottom of channel (ft)
Q= Discharge (cfs)
s=Pipe Slope (ft/ft)
n= 0.013

Rectangular Conduit

Q=(K'/n)*b^(8/3)*s^(0.5)

Q per conduit (cfs)	S (%)	Width (inches)	K'	D/b	Depth of water in conduit (inches)	Cross sectional area of flow (sf)	Velocity (ft/ sec)
37.36	0.30	72	0.0746	0.14	10.08	5.04	7.41
47.46	0.30	72	0.0948	0.22	15.84	7.92	5.99
84.69	0.30	72	0.1691	0.33	23.76	11.88	7.13

Table 7-11. Values of K' in Formula $Q = \frac{K'}{n} b^{8/3} s^{1/2}$ for

Trapezoidal Channels

D = depth of water b = bottom width of channel

$\frac{D}{b}$	Side slopes of channel, ratio of horizontal to vertical									
	Vertical	¼–1	½–1	¾–1	1–1	1½–1	2–1	2½–1	3–1	4–1
.01	.00068	00068	.00069	.00069	.00069	.00069	.00069	.00069	.00070	.00070
.02	.00213	00215	.00216	.00217	.00218	.00220	.00221	.00222	.00223	.00225
.03	.00414	00419	.00423	.00426	.00428	.00433	.00436	.00439	.00443	.00449
.04	.00660	00670	.00679	.00685	.00691	.00700	.00708	.00716	.00723	.00736
.05	.00946	00964	.00979	.00991	.01002	.01019	.01033	.01047	.01060	.01086
.06	.0127	0130	.0132	.0134	.0136	.0138	.0141	.0143	.0145	.0150
.07	.0162	0166	.0170	.0173	.0175	.0180	.0183	.0187	.0190	.0197
.08	.0200	0206	.0211	.0215	.0219	.0225	.0231	.0236	.0240	.0250
.09	.0241	0249	.0256	.0262	.0267	.0275	.0282	.0289	.0296	.0310
.10	.0284	0294	.0304	.0311	.0318	.0329	.0339	.0348	.0358	.0376
.11	.0329	0343	.0354	.0364	.0373	.0387	.0400	.0413	.0424	.0448
.12	.0376	0393	.0408	.0420	.0431	.0450	.0466	.0482	.0497	.0527
.13	.0425	0446	.0464	.0480	.0493	.0516	.0537	.0556	.0575	.0613
.14	.0476	0502	.0524	.0542	.0559	.0587	.0612	.0636	.0659	.0706
.15	.0528	0559	.0585	.0608	.0627	.0662	.0692	.0721	.0749	.0805
.16	.0582	0619	.0650	.0676	.0700	.0740	.0777	.0811	.0845	.0912
.17	.0638	0680	.0716	.0748	.0775	.0823	.0866	.0907	.0947	.1026
.18	.0695	0744	.0786	.0822	.0854	.0910	.0960	.1008	.1055	.1148
.19	.0753	0809	.0857	.0899	.0936	.1001	.1059	.1115	.1169	.1277
.20	.0812	0876	.0931	.0979	.1021	.1096	.1163	.1227	.1290	.1414
.21	.0873	0945	.101	.106	.111	.120	.127	.135	.142	.156
.22	.0934	1015	.109	.115	.120	.130	.139	.147	.155	.171
.23	.0997	1087	.117	.124	.130	.141	.150	.160	.169	.187
.24	.1061	1161	.125	.133	.140	.152	.163	.173	.184	.204
.25	.1125	1236	.133	.142	.150	.163	.176	.188	.199	.222
.26	.119	131	.142	.152	.160	.175	.189	.202	.215	.241
.27	.126	139	.151	.162	.171	.188	.203	.218	.232	.260
.28	.132	147	.160	.172	.182	.201	.217	.234	.249	.281
.29	.139	155	.170	.182	.194	.214	.232	.250	.268	.302
.30	.146	163	.179	.193	.205	.228	.248	.267	.287	.324
.31	.153	172	.189	.204	.218	.242	.264	.285	.306	.347
.32	.160	180	.199	.215	.230	.256	.281	.304	.327	.371
.33	.167	189	.209	.227	.243	.271	.298	.323	.348	.396
.34	.174	198	.219	.238	.256	.287	.316	.343	.370	.423
.35	.181	207	.230	.251	.269	.303	.334	.363	.392	.450
.36	.189	216	.241	.263	.283	.319	.353	.385	.416	.478
.37	.196	225	.252	.275	.297	.336	.372	.406	.440	.507
.38	.203	234	.263	.288	.312	.353	.392	.429	.465	.537
.39	.211	244	.274	.301	.326	.371	.413	.452	.491	.568
.40	.218	253	.286	.315	.341	.389	.434	.476	.518	.600
.41	.226	263	.297	.328	.357	.408	.456	.501	.546	.633
.42	.233	273	.309	.342	.373	.427	.478	.526	.574	.668
.43	.241	283	.321	.357	.389	.447	.501	.553	.603	.703
.44	.248	293	.334	.371	.405	.467	.525	.580	.633	.740
.45	.256	303	.346	.386	.422	.488	.549	.607	.664	.777

CONDUIT SIZING CALCULATIONS

The following chart details the sizing parameters and for conduits that convey runoff on the site.
Flow parameters from *Handbook of Hydraulics, King & Brater* were used, see following page.

K'= Discharge factor	=	$(Q*n)/(d^{8/3}*s^{1/2})$
n= Mannings coefficient	=	0.013 for PVC & HDPE
d=diameter of conduit (ft)	=	per chart
Q= Discharge	=	based off portions of basins tributary to outlet
s=Minimum Pipe Slope (ft/ft)	=	per chart
D=depth of flow	=	From table 7-4 of the *Handbook of Hydraulics, King & Brater* See right
C_a= Flow factor	=	From table 7-14 of the *Handbook of Hydraulics, King & Brater* See right
A=Cross sectional area of flow	=	C_a*d^2
V=Velocity	=	Q/A

Pipe Flow

Link	Q (cfs)	S (%)	d (in)	K'	D/d	C_a	A (sf)	V (fps)
3 to 6	15.91	0.3	30	0.328	0.62	0.512	3.200	4.97
6 to 12	17.01	0.3	30	0.351	0.65	0.54	3.375	5.04
9 to 13	2.50	0.3	18	0.201	0.46	0.3527	0.794	3.15
12 to 13	0.26	0.3	8	0.179	0.43	0.3229	0.144	1.78
13 to 18	18.86	0.3	30	0.389	0.70	0.587	3.669	5.14
16 to 17	2.07	0.3	18	0.167	0.41	0.3032	0.682	3.03
17 to 18	2.06	0.3	18	0.166	0.41	0.3032	0.682	3.03
18 to 27	19.68	0.3	30	0.406	0.72	0.605	3.781	5.21
21 to 22	6.53	0.3	24	0.244	0.51	0.403	1.612	4.05
22 to 23	6.51	0.3	24	0.243	0.51	0.403	1.612	4.04
23 to 37	24.40	0.3	30	0.495	0.90	0.745	4.656	5.24
35 to 36	3.86	0.3	18	0.306	0.59	0.482	1.085	3.56
36 to 37	3.86	0.3	18	0.306	0.59	0.482	1.085	3.56
37 to 38	107.80	0.3	60	0.344	0.64	0.531	13.275	8.12

Table 7-4. For Determining the Area *a* of the Cross Section of a Circular Conduit Flowing Part Full

Let $\frac{\text{depth of water}}{\text{diameter of channel}} = \frac{D}{d}$ and C_a = the tabulated value. Then $a = C_a d^2$.

$\frac{D}{d}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.0000	.0013	.0037	.0069	.0105	.0147	.0192	.0242	.0294	.0350
.1	.0409	.0470	.0534	.0600	.0668	.0739	.0811	.0885	.0961	.1039
.2	.1118	.1199	.1281	.1365	.1449	.1535	.1623	.1711	.1800	.1890
.3	.1982	.2074	.2167	.2260	.2355	.2450	.2546	.2642	.2739	.2836
.4	.2934	.3032	.3130	.3229	.3328	.3428	.3527	.3627	.3727	.3827
.5	.393	.403	.413	.423	.433	.443	.453	.462	.472	.482
.6	.492	.502	.512	.521	.531	.540	.550	.559	.569	.578
.7	.587	.596	.605	.614	.623	.632	.640	.649	.657	.666
.8	.674	.681	.689	.697	.704	.712	.719	.725	.732	.738
.9	.745	.750	.756	.761	.766	.771	.775	.779	.782	.784

Table 7-14. Values of K' for Circular Channels in the Formula

$$Q = \frac{K'}{n} d^{8/3} s^{1/2}$$

D = depth of water d = diameter of channel

$\frac{D}{d}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0		.00007	.00031	.00074	.00138	.00222	.00328	.00455	.00604	.00775
.1	.00967	.0118	.0142	.0167	.0195	.0225	.0257	.0291	.0327	.0366
.2	.0406	.0448	.0492	.0537	.0585	.0634	.0686	.0738	.0793	.0849
.3	.0907	.0966	.1027	.1089	.1153	.1218	.1284	.1352	.1420	.1490
.4	.1561	.1633	.1705	.1779	.1854	.1929	.2005	.2082	.2160	.2238
.5	.232	.239	.247	.255	.263	.271	.279	.287	.295	.303
.6	.311	.319	.327	.335	.343	.350	.358	.366	.373	.380
.7	.388	.395	.402	.409	.416	.422	.429	.435	.441	.447
.8	.453	.458	.463	.468	.473	.477	.481	.485	.488	.491
.9	.494	.496	.497	.498	.498	.498	.496	.494	.489	.483
1.0	.463									

3.2.2.4 Grated Inlets in Sag

A grated inlet in a sag location operates as a weir at shallower depths and as an orifice at larger depths. The designer shall estimate the capacity of the inlet under both weir flow and orifice flow conditions, then adopt a design capacity equal to the smaller of the two results. Figure 3–5 provides a nomograph for calculating the capacity of grated inlets in sag locations.

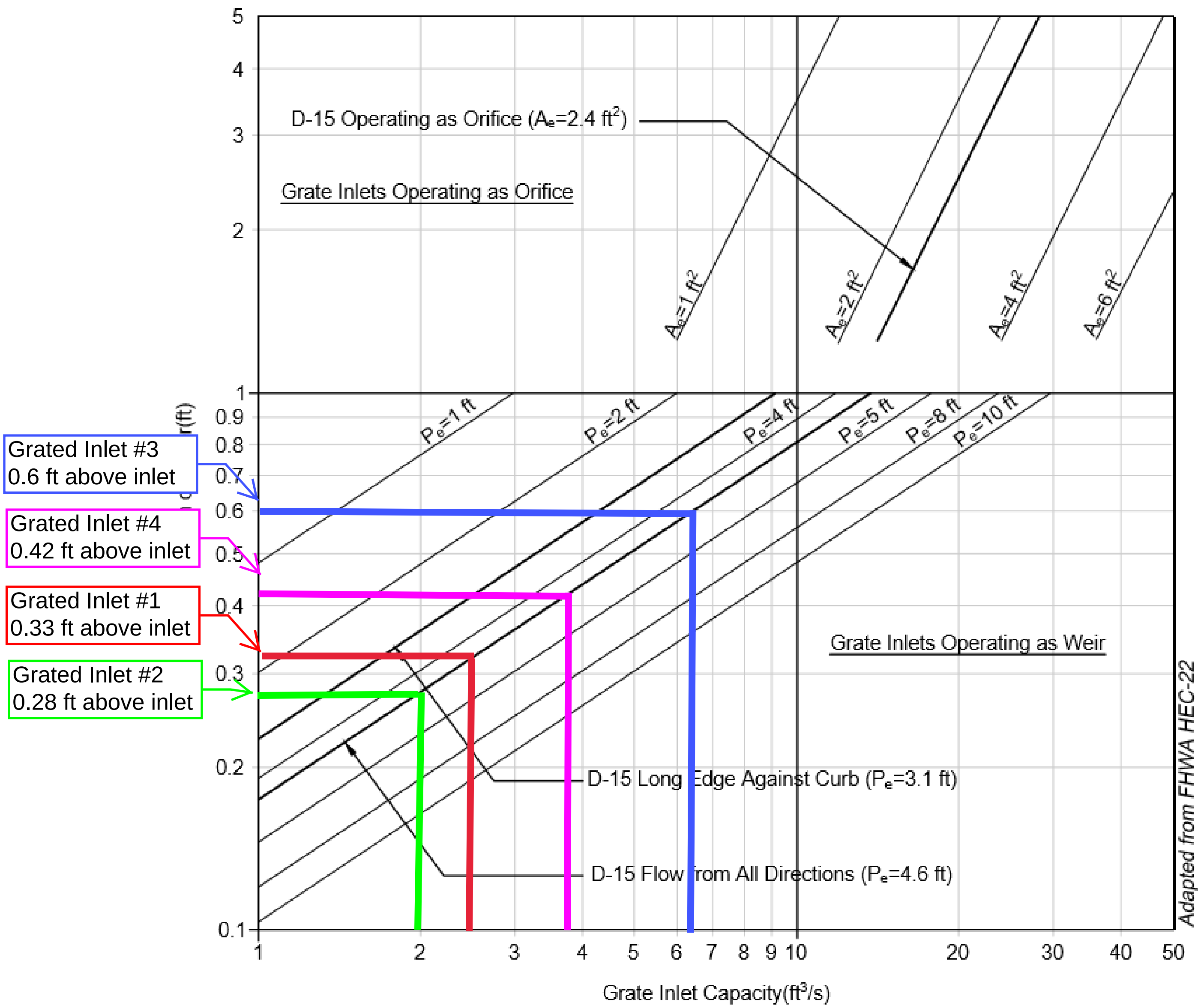


Figure 3-5. Capacity of Grate Inlets in Sag Locations

Step 1. Calculate the capacity of a grate inlet operating as a weir using the weir equation (Equation 3–10) with a length equivalent to perimeter of the grate. When the grate is located next to a curb, disregard the length of the grate against the curb.

Curb Inlet Sizing

	Opening Length (ft)	Opening Height (ft)	Q_{100}	Depth (ft)
Inlet #1	14	0.5	15.91	0.179
Inlet #2	14	0.5	1.80	0.002
Inlet #3	20	0.5	37.36	0.483
Inlet #4	20	0.5	47.43	0.778

$$Q = 0.67hL(2gd_o)^{1/2}$$

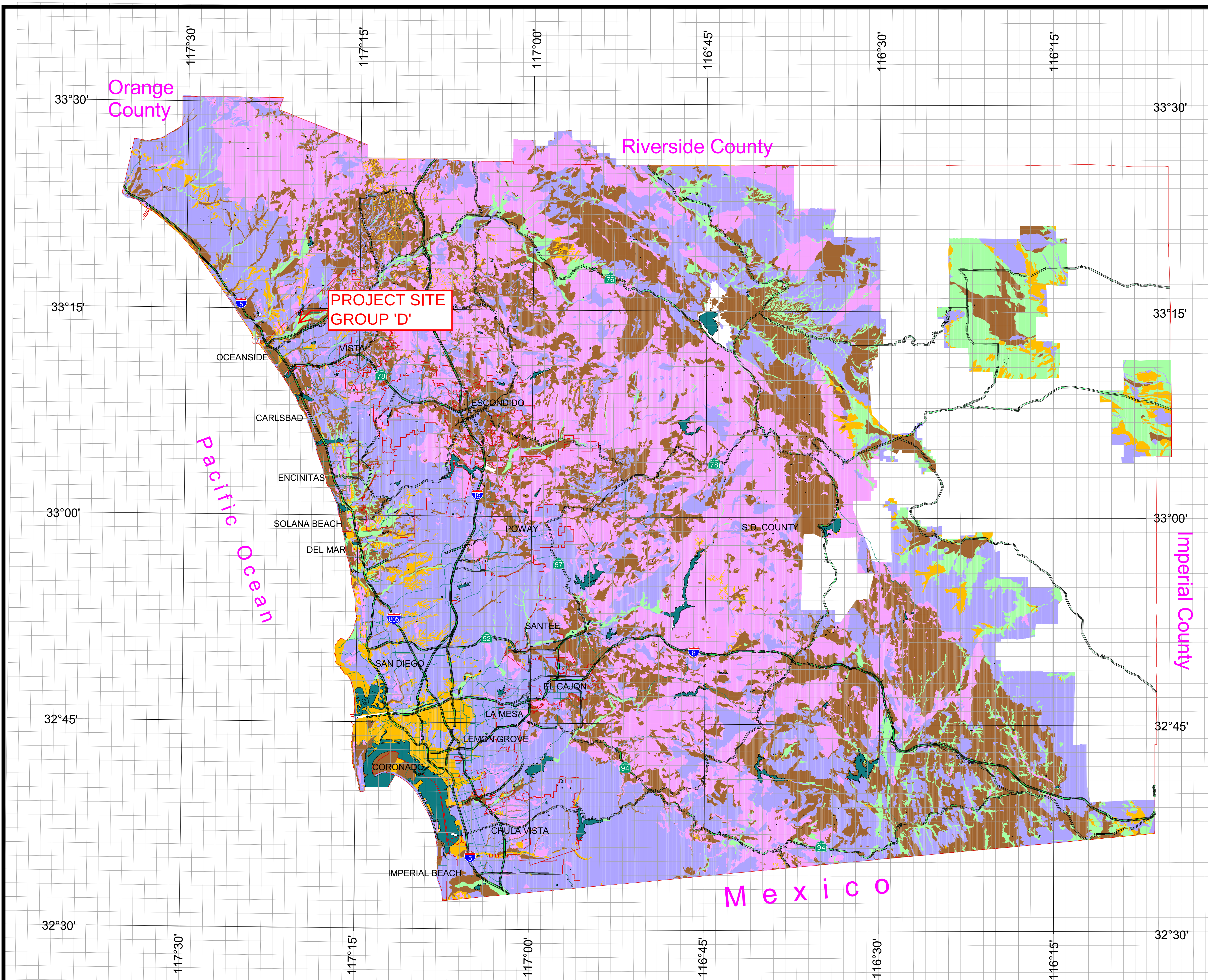
where:

Q	=	inlet capacity (ft^3/s)
h	=	curb opening height (ft)
L	=	curb opening length (ft)
g	=	gravitational acceleration (32.2 ft/s^2)
d_o	=	effective depth of flow at curb face (ft)

Appendix 1

County of San Diego Hydrology Manual

Soil Hydrologic Groups



Legend

Soil Groups

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

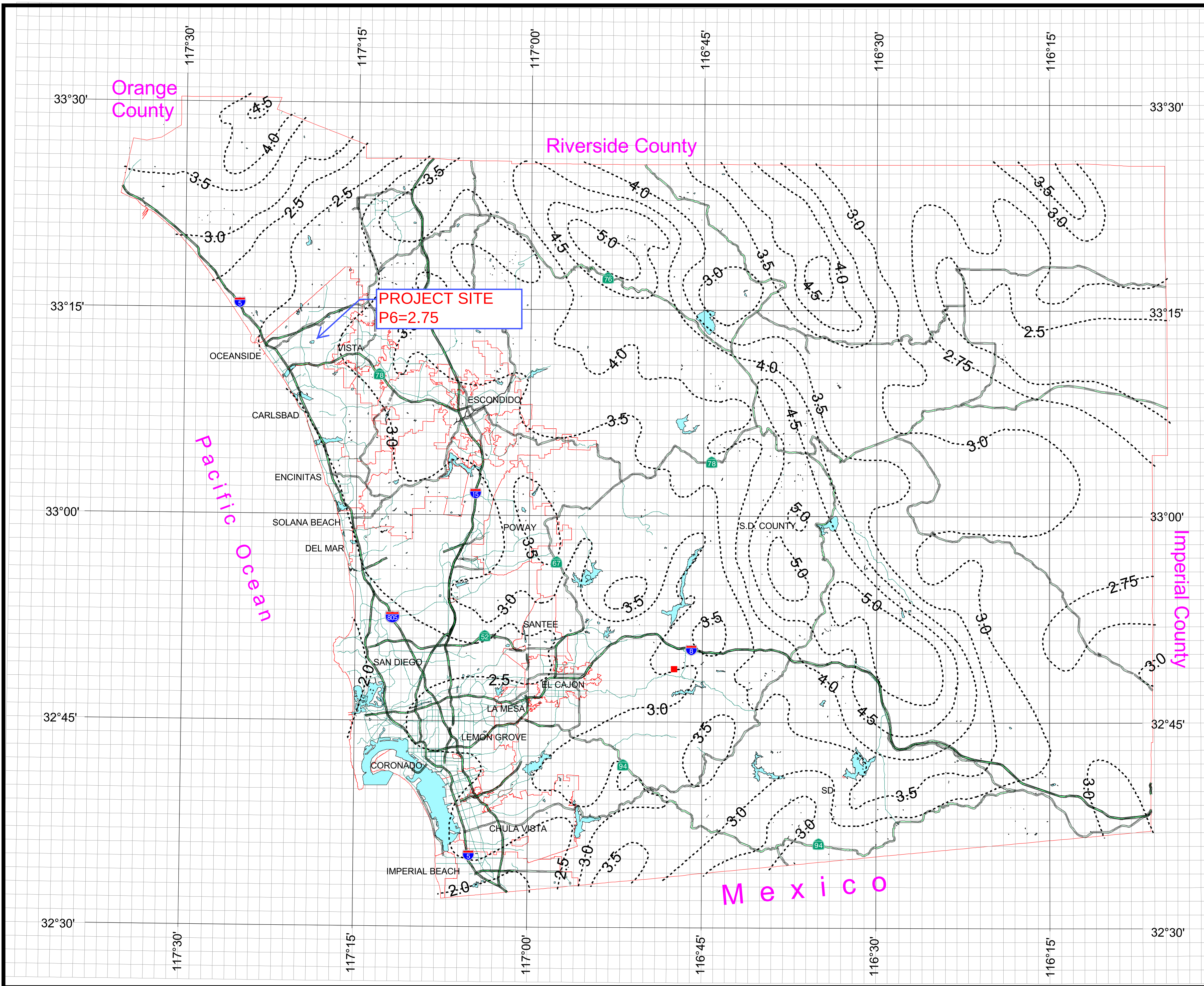
Department of Public Works
Geographic Information Services

We Have San Diego Covered!

N
W E
S

3 0 3 Miles

Appendix 2



County of San Diego Hydrology Manual

Rainfall Isopluvials

100 Year Rainfall Event - 6 Hours

Isopluvial (inches)

Department of Public Works
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N
W E
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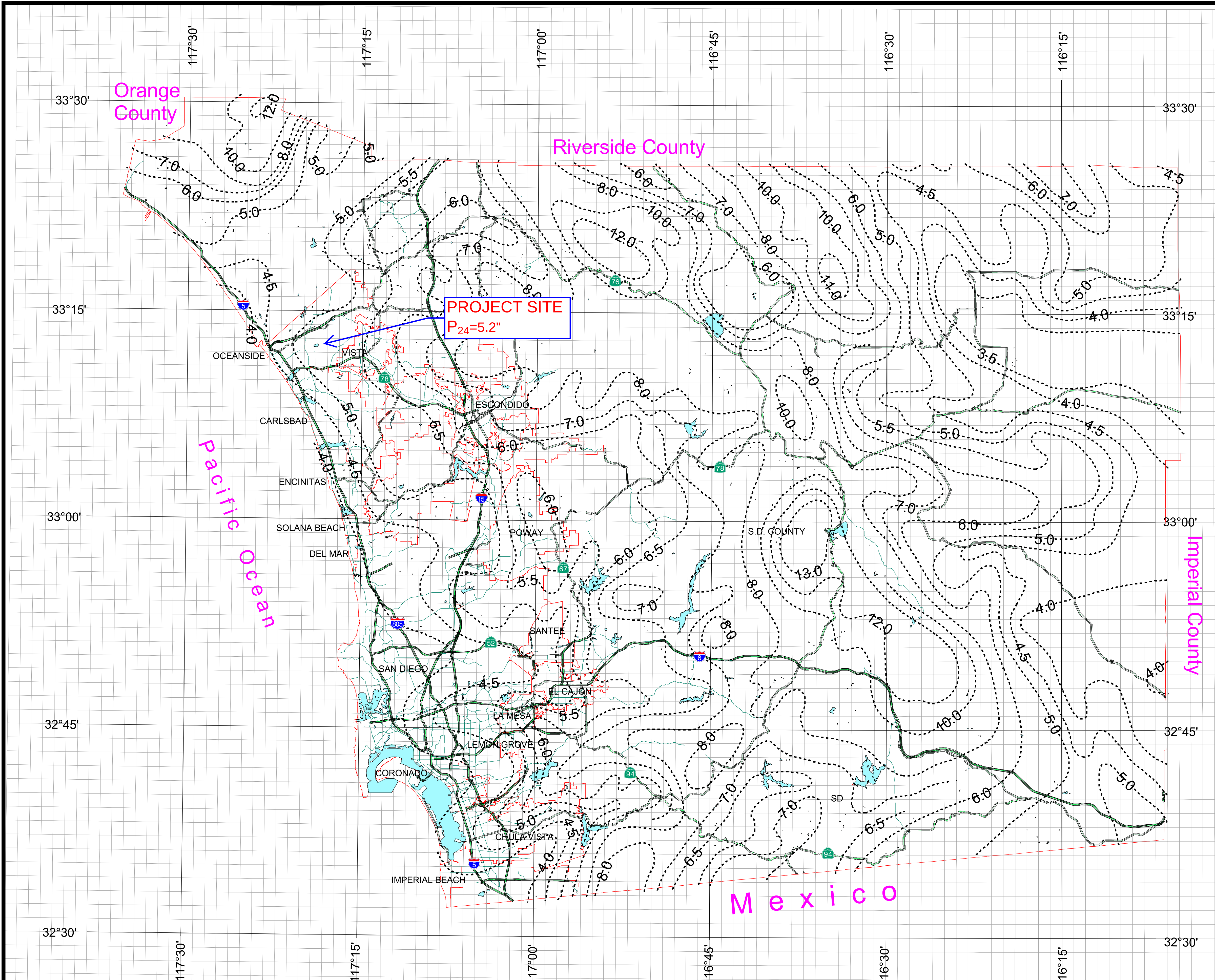
3 0 3 Miles

Appendix 3



County of San Diego Hydrology Manual

Rainfall Isopluviials

100 Year Rainfall Event - 24 Hours

Isopluvial (inches)

DPW GIS
Department of Public Works
Geographic Information Services

SanGIS
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N
W E
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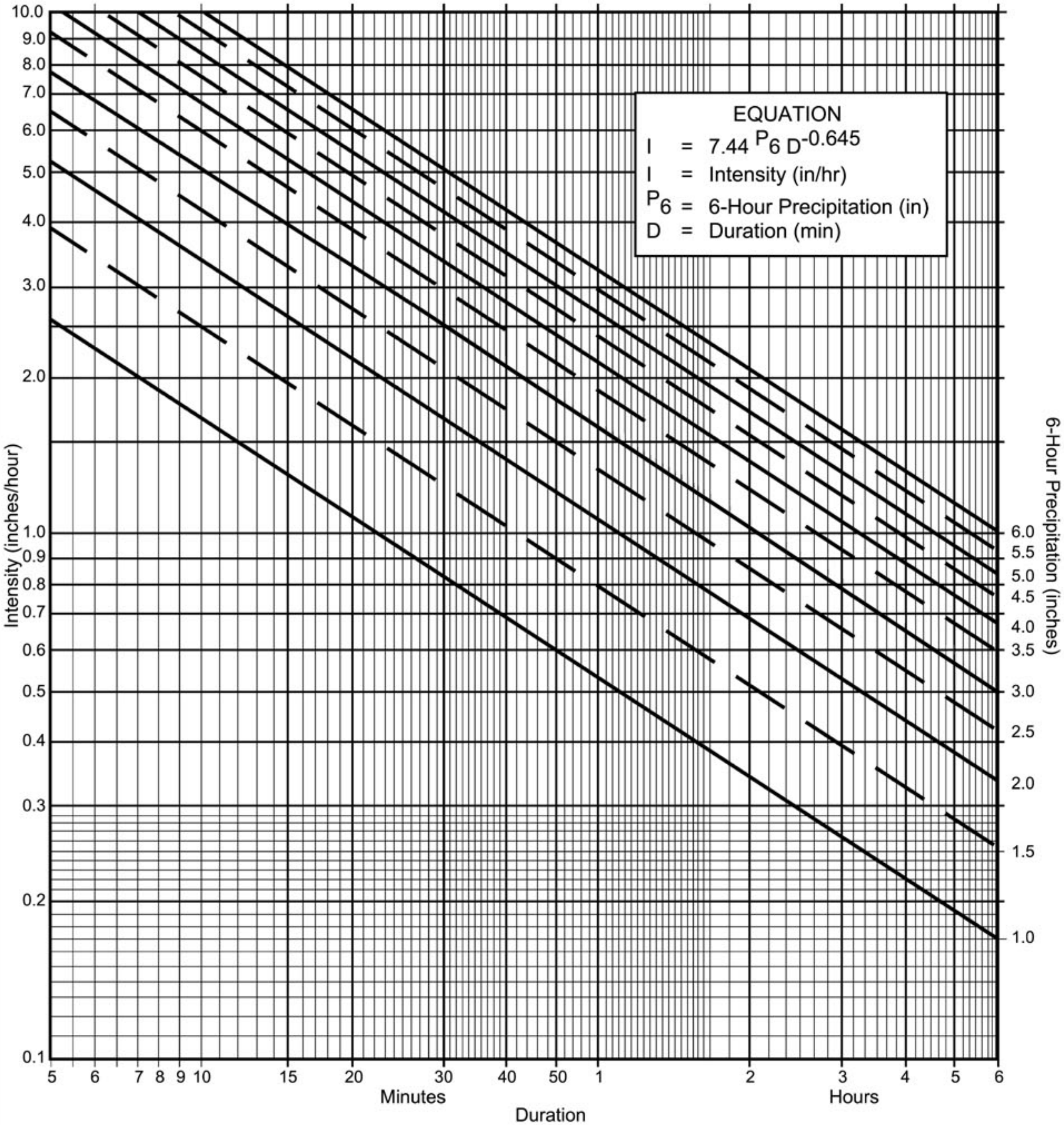
3 0 3 Miles

APPENDIX 3.0

Appendix 4



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 applicable 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 = 2.7 in., P_{24} = 5.3, $\frac{P_6}{P_{24}}$ = 51 %(2)

(c) Adjusted $P_6^{(2)}$ = n/a in.

(d) t_x = ______ min. **T & I per Rational**

(e) I = ______ in./hr. **Calc sheet**

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

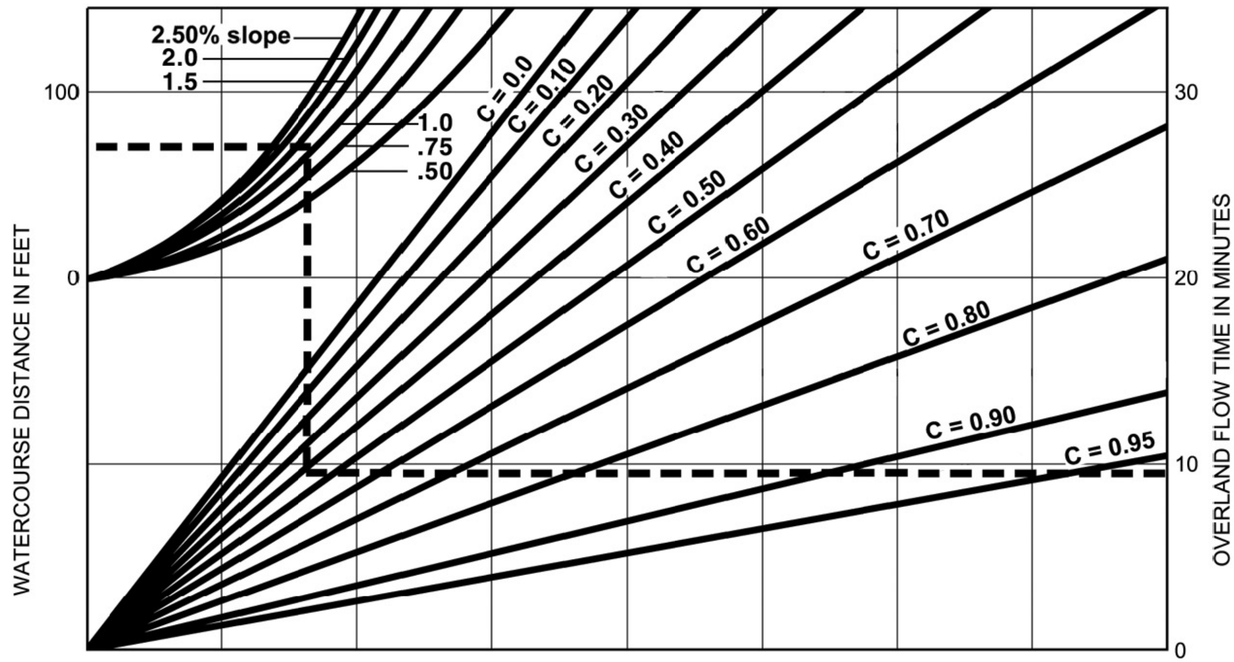
Appendix 5

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
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
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

Appendix 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

FIGURE 3-3

Rational Formula - Overland Time of Flow Nomograph

Appendix 7

Note that the Initial Time of Concentration should be reflective of the general land-use at the upstream end of a drainage basin. A single lot with an area of two or less acres does not have a significant effect where the drainage basin area is 20 to 600 acres.

Table 3-2 provides limits of the length (Maximum Length (L_M)) of sheet flow to be used in hydrology studies. Initial T_i values based on average C values for the Land Use Element are also included. These values can be used in planning and design applications as described below. Exceptions may be approved by the "Regulating Agency" when submitted with a detailed study.

Table 3-2

MAXIMUM OVERLAND FLOW LENGTH (L_M) & INITIAL TIME OF CONCENTRATION (T_i)

Element*	DU/ Acre	.5%		1%		2%		3%		5%		10%	
		L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i
Natural		50	13.2	70	12.5	85	10.9	100	10.3	100	8.7	100	6.9
LDR	1	50	12.2	70	11.5	85	10.0	100	9.5	100	8.0	100	6.4
LDR	2	50	11.3	70	10.5	85	9.2	100	8.8	100	7.4	100	5.8
LDR	2.9	50	10.7	70	10.0	85	8.8	95	8.1	100	7.0	100	5.6
MDR	4.3	50	10.2	70	9.6	80	8.1	95	7.8	100	6.7	100	5.3
MDR	7.3	50	9.2	65	8.4	80	7.4	95	7.0	100	6.0	100	4.8
MDR	10.9	50	8.7	65	7.9	80	6.9	90	6.4	100	5.7	100	4.5
MDR	14.5	50	8.2	65	7.4	80	6.5	90	6.0	100	5.4	100	4.3
HDR	24	50	6.7	65	6.1	75	5.1	90	4.9	95	4.3	100	3.5
HDR	43	50	5.3	65	4.7	75	4.0	85	3.8	95	3.4	100	2.7
N. Com		50	5.3	60	4.5	75	4.0	85	3.8	95	3.4	100	2.7
G. Com		50	4.7	60	4.1	75	3.6	85	3.4	90	2.9	100	2.4
O.P./Com		50	4.2	60	3.7	70	3.1	80	2.9	90	2.6	100	2.2
Limited I.		50	4.2	60	3.7	70	3.1	80	2.9	90	2.6	100	2.2
General I.		50	3.7	60	3.2	70	2.7	80	2.6	90	2.3	100	1.9

*See Table 3-1 for more detailed description