STONE CREEK
CAMINO RUIZ
SAN DIEGO, CA 92126

PTS# 67943
WO# 42-263
TM# 208328

PRELIMINARY HYDROLOGY AND HYDRAULICS REPORT

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Project: 04-23

E.O.W. R.C.E. 34867 DATE

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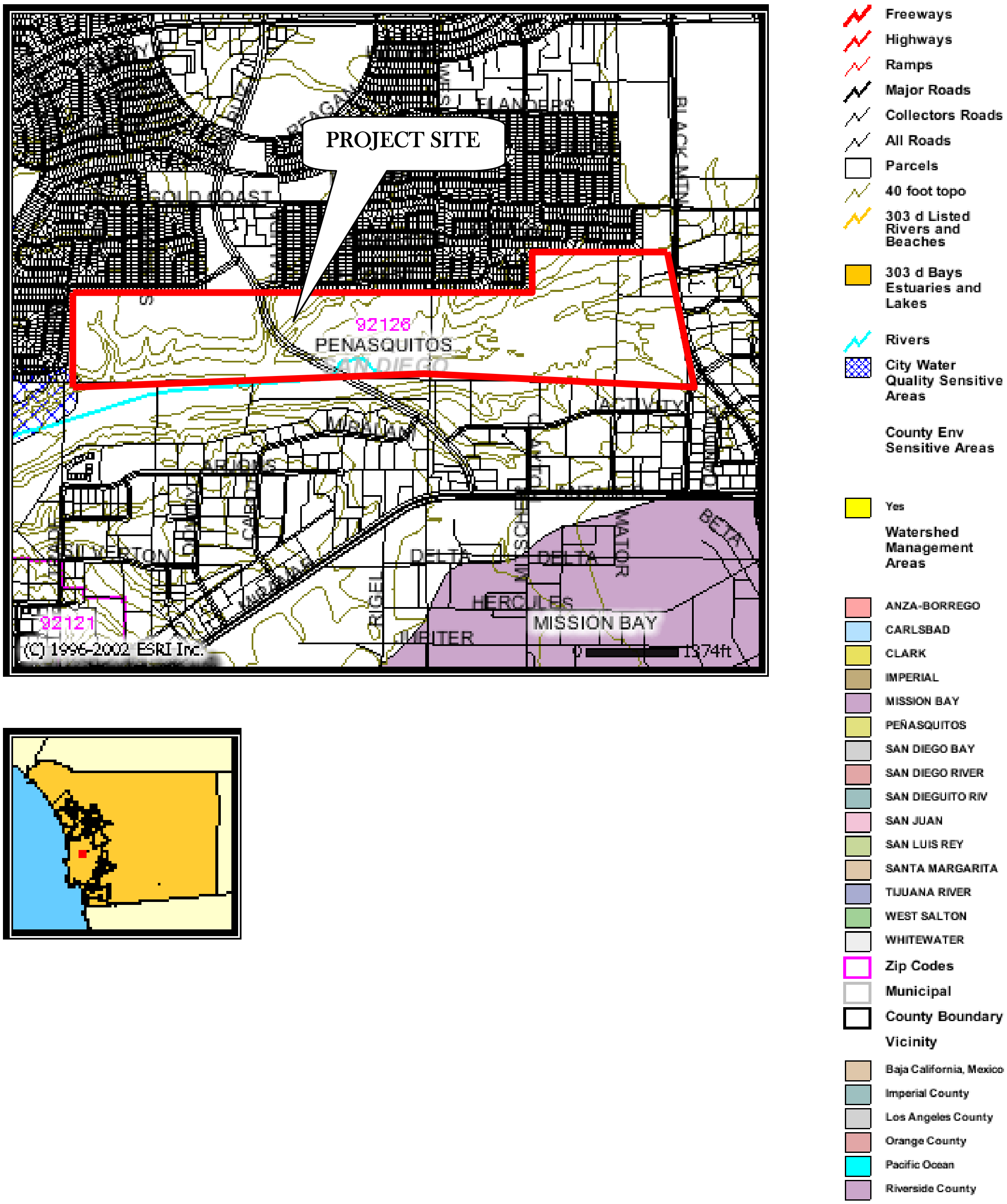
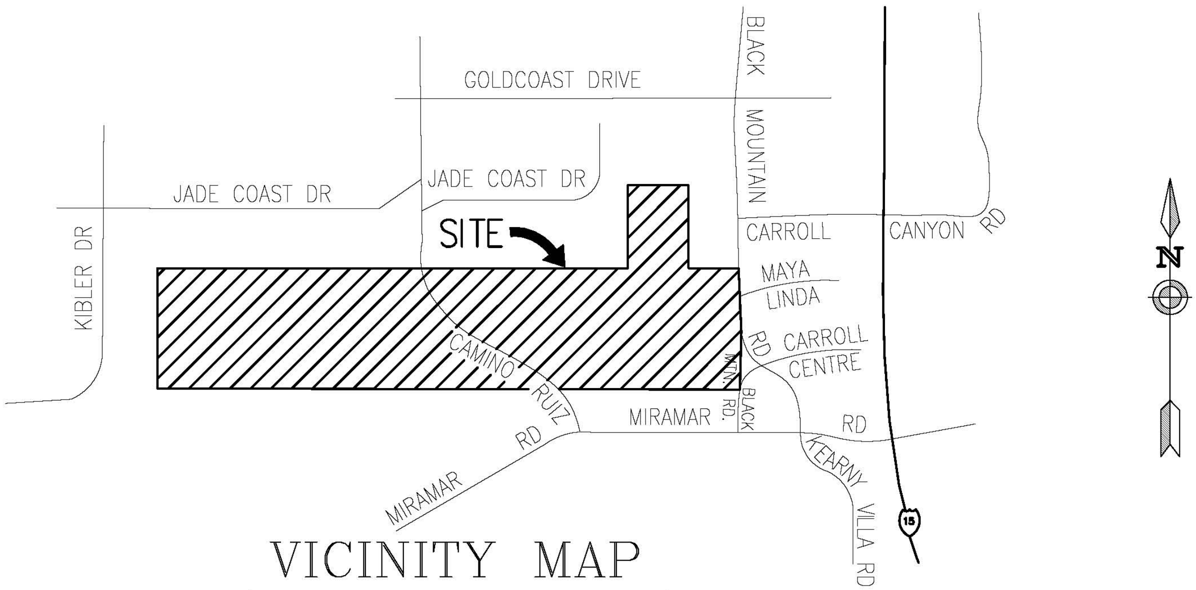




VICINITY MAP

NO SCALE

II. ENGINEERING QUALIFICATIONS

BDS Engineering Inc. (BDS) has over 30 years experience in water resources management including:

- Hydrology / Hydraulic Studies and Reports
- Storm Drain Design
- Drainage feasibility Studies and Reports

III. SCOPE OF WORK & PROJECT DESCRIPTION

The scope of this study is to provide the hydrology and hydraulic calculations for the Stone Creek project. The site is generally bound by Kibler Dr. on the east side and Black Mountain Rd. on the west side and between Jade Coast Dr. on the north and Miramar Rd. on the south. This report will encompass the reclamation phase and tentative plan phase. The proposed development for the reclamation plan phase will include rough grading approximately 195 acres on the east side of Camino Ruiz, a mining pit approximately 92 acres to the west of Camino Ruiz, construction of detention basins (west and east of Camino Ruiz), construction of sediment basins (east of Camino Ruiz) and a creek flowing from east to west through the south side of the entire site. The Ultimate Condition (VTM) will include the construction of utilities, roadways, and minor grading.

The underground storm drain system is sized to receive the ultimate development.

IV. HYDROLOGIC METHODOLOGY

A hydrologic analysis was made to estimate peak flood flows with return periods of 100 years.

This hydrologic analysis was made by the use of an aerial topographic survey by Digital Mapping Inc., September 27, 2005, a topographic image provided by SANGIS dated June 12, 2008 and the proposed grading plan.

The rational method of runoff computation was used to determine the quantity of storm water runoff.

The basic rational formula is Q=CIA where:

"Q" is the peak rate of flow in cubic feet per second (CFS).
"C" is a runoff coefficient expressed as that percentage of rainfall, which becomes surface runoff. We are using soil group 'D'.
"I" is the average rainfall intensity in inches per hour for a storm duration equal to the time of concentration (t_c) of the contributing drainage area.
"A" is the drainage area in acres tributary to design point.
"t_c" is the time of concentration required for runoff to flow from the most remote part of the watershed to the outlet point under consideration.

Runoff coefficients have been determined based on the proposed land use, see Table 3-1 of the County Hydrology Manual *(Appendix A: 2003 County of San Diego Hydrology Graphs & Tables)*. All calculations are based on soil type D. Natural areas shall have runoff coefficients of C=0.35, the roadway ranges from 65%-85% impervious and is assumed to be of a similar runoff coefficient to High Density Residential with C=0.79, and impervious areas have runoff coefficients of C=0.90. Flow data spreadsheets for the mining, reclamation, tentative and ultimate phases are included as *Appendix B: Flow Data Spreadsheet* in this report. For the purposes of pipe sizing, runoff coefficients for ultimate development *(Appendix C: runoff Coefficient Calculations)* shall be used as a worst case scenario.

StormCAD provided by Bentley was used to analyze pipe sizing by calculating storm water flow within a pipe system. The following criteria are used:

Inputs into StormCAD computer program

1) Area in acres per Excel spreadsheet *(Appendix B: Flow Data Spreadsheet)*
2) C coefficient *((Appendix C: runoff Coefficient Calculations)*
3) P_6
4) Top of grate elevations
5) Invert elevations if known

Outputs

1) Flow at discharge point
2) Time of concentration
3) Pipe sizes
4) Invert elevations
5) Hydraulic grade line information for all pipes

The StormCAD outputs, additional areas, and other flow information are summarized in *Appendix B: Flow Data Spreadsheet*. All StormCAD program outputs are provided in *Appendix G: Storm CAD Calculations*.

V. RECLAMATION PHASE HYDROLOGIC CONDITIONS

A. EXISTING CONDITION DURING RECLAMATION PHASE

This project will impact wetlands and therefore requires a 404 permit from U.S. Army Corps of Engineers (USACE) and a 401 State Water Quality certificate from the Regional Water Quality Control Board (RWQCB) pursuant to the Clean Water Act. A 1603 Streambed Alteration Agreement from California Department of Fish and Wildlife (CDFW) is also required for impacts to streambeds and associated riparian habitat

1. Creek
   The existing creek on site is will be intercepting an existing 24", 66" and 14' storm drain system located at the southeast corner of the site, heading west through the designed creek. See "Basis of Design" by PWA for additional creek information.

2. West of Camino Ruiz
   The area west of Camino Ruiz is approx. 92 acres and generally slopes from all around the pit to the mid southerly edge. During the pre-developed reclamation phase, this area is mined and therefore has a runoff coefficient of 0.35. The majority of the site will not have any discharge to a creek or MS4 system, as it will be a mined pit and runoff generated for this area will be evapotranspirated or infiltrated. A small sliver at the southern portion of the site will discharge southerly towards an existing creek.

3. East of Camino Ruiz
   The area east of Camino Ruiz is approx. 195 acres and generally slopes from northeast to southwest. Grades in this area are continually changing as it is currently being mined under the Conditional Use Permit. The runoff coefficient used for this area is 0.35.

4. Offsite
   Storm water runoff from offsite occurs along and east of Camino Ruiz. On the northerly side, an existing 42" RCP, 18" ACP, 24" ACP and 30" ACP outlet into the site. On the easterly side of the site, paralleling Black Mountain Rd., a 96" CIP and 66" RCP enter the site. The 66" RCP flows into the creek at the southerly part of the site.

OUTLET	Q_{100} (CFS)	MAX. CAPACITY (CFS)
42" RCP	52.90	77.93
18" ACP	23.40	12.41
24" ACP	38.40	46.30
30" ACP	70.90	71.90
96" CIP	n/a	n/a
66" RCP	n/a	n/a
14' CMPA	n/a	n/a

B. PROPOSED CONDITION FOR RECLAMATION PHASE

This project will impact wetlands and therefore requires a 404 permit from U.S. Army Corps of Engineers (USACE) and a 401 State Water Quality certificate from the Regional Water Quality Control Board (RWQCB) pursuant to the Clean Water Act. A 1603 Streambed Alteration Agreement from California Department of Fish and Wildlife (CDFW) is also required for impacts to streambeds and associated riparian habitat

1. Creek

   The creek west of Camino Ruiz shall remain untouched and the creek east shall be constructed per PWA's and Chang Consultant's design and calculations. The new creek shall capture storm water runoff from the existing 96" CIP, 66" RCP and 14' CMPA on the easterly side of the site.

2. West of Camino Ruiz

   The proposed work during the reclamation phase only consists of grading the 2:1 slopes with benching and a more moderately sloped entrance to the pit. Basin R-A shall sheet flow to the southerly end of the basin where it will discharge to the existing creek.

3. East of Camino Ruiz

   During this phase, construction of the creek shall take place as well as the grading and construction of strategically located sediment and detention basins. This phase also consists of rough grading the entire site for tentative phase preparation. Sediment basins R-C and R-I are constructed as temporary basins in the reclamation phase for their pollutant removal efficiencies and natural aesthetics, in accordance with design details and criteria from the CASQA BMP Construction Handbook dated January 2011. All Sediment Basins dimensions are at least two times greater in length than width and are designed for a particle size of 0.02 mm in diameter. The sediment basins shall be 4 feet in depth, with the bottom 1 foot designed for sediment storage. Sediment basin calculations for orifice sizing and flow rates are attached in *Appendix D: Sediment Basin Calculations*. Permanent extended detention basins R-D, R-F, and R-M shall be constructed during the reclamation phase. Volumes for detention basins are calculated by using Hydrograph and Hydromodification methods *(Appendix E: Detention Basin Calculations))*, in addition to design requirements for TC-22 in *Appendix G: BMP Fact Sheets*.

4. Offsite

   The offsite drainage mentioned previously shall continue to enter the site as it does in the existing conditions. Storm drains located along the easterly edge (96", 66", and 14' CMPA) shall be connected into the proposed creek. All existing offsite storm drain pipes along the northerly property line (42" RCP, 18" ACP, 24" ACP and 30" ACP) shall be routed using a storm drain system separate from the onsite generated storm water. As directed by the

City of San Diego Storm Water Standards, Section 4.5.2, offsite runoff shall be separated from onsite generated flows. Therefore offsite Outlets OS-0, OS-1, OS-2, OS-3, and OS-4 shall be routed through the site and directly to the new creek without addition of any onsite generated runoff.

5. Pre-Development and Post-Development Summary Table

Pre and Post Development Summary Table							
Drainage Area	DMA/ Sub-Area	C	Impervious Area	Pervious Area	Q (cfs)	Q Detained (cfs)	Q Released (cfs)
Pre-Development	M-A	0.35	0.00	91.74	101.00	0	101.00
	M-C	0.38	8.90	169.12	83.80	0	83.80
	M-D	0.35	0.00	16.35	7.10	0	7.10
Total		**0.36**	**8.90**	**277.21**	**191.90**	**0**	**191.90**
Post-Development	DMA 1-9	**0.70**	**161.88**	**89.00**	**208.58**	**16.68**	**191.90**
Difference:		0	+152.98	-188.21	+16.68	+16.68	0

	Volume (CF)
Detention Basin Required	456,332
Detention Basin Provided	1,581,182
Difference:	**+1,124,850**

Note: Post-development flows based on 100-year storm event will be the same or less than the pre-development flows to satisfy hydromodification and flow control requirements.

VI. ULTIMATE CONDITION (VTM) HYDROLOGIC CONDITIONS

This project will impact wetlands and therefore requires a 404 permit from U.S. Army Corps of Engineers (USACE) and a 401 State Water Quality certificate from the Regional Water Quality Control Board (RWQCB) pursuant to the Clean Water Act. A 1603 Streambed Alteration Agreement from California Department of Fish and Wildlife (CDFW) is also required for impacts to streambeds and associated riparian habitat

A. EXISTING CONDITION DURING ULTIMATE PHASE

The existing conditions for the ultimate phase are theoretically identical to the proposed development during the reclamation phase. (See previous description of proposed conditions during the reclamation phase)

B. PROPOSED CONDITION FOR ULTIMATE PHASE

1. Creek

The creek west of Camino Ruiz shall be constructed during the tentative phase. The creek east of Camino Ruiz was constructed during the reclamation phase and shall remain untouched during this phase.

2. West of Camino Ruiz

During the ultimate phase, the area west of Camino Ruiz shall be raised to finish grade and have constructed roadway, curb and gutter, sidewalks and associated utilities. Underground detention systems are proposed in 4 drainage area locations T-A-1-7, T-A-2-5, T-A-3-1, and T-A-4-15 to mitigate peak flow runoff and satisfy hydromodification requirements (see H3 Tentative Hydrology Map for cross sections). Proposed underground detention basins have been sized for the differential in 100 year storm runoff and Hydromodification. In addition, a hydrodynamic separator shall be installed upstream of the underground detention system to pretreat the storm water for sediment trash and debris and other pollutants before entering the detention system. By treating the storm water and minimizing sediment buildup prior to the detention system, costs for maintaining and operating the detention system are significantly decreased. No construction of buildings or structures will take place during this project. Storm water will be captured within the storm drain system by curb inlets for each corresponding drainage area. Drainage areas T-A-1 and T-A-3 generally flow southeasterly from the west side until reaching their corresponding detention basins. Drainage areas T-A-2 and T-A-4 flow southwesterly from the east side until reaching their corresponding detention basins. Captured runoff is retained throughout the storm event in the detention basins and discharged through outlet pipes. These outlet pipes are sized to release stored runoff into the creek at pre-development flow rates to meet hydromodification requirements. This ensures that there is no net increase in peak runoff and that receiving waters are not adversely affected by flows from the site.

3. <u>East of Camino Ruiz</u>

The sediment and detention basins constructed during the reclamation phase shall remain in place as the areas around them are graded and roadway, curb and gutter, sidewalk and associated utilities are constructed around them. Sediment basins in areas T-B-4, T-E-4, T-J-3, and T-K-1 are constructed as temporary basins in the ultimate phase for their pollutant removal efficiencies and natural aesthetics, in accordance with design details and criteria from the CASQA BMP Construction Handbook dated January 2011. All Sediment Basins dimensions are at least two times greater in length than width and are designed for a particle size of 0.02 mm in diameter. The sediment basins shall be 4 feet in depth, with the bottom 1 foot designed for sediment storage. Sediment basin calculations for orifice sizing and flow rates are attached in *Appendix D: Sediment Basin Calculations*. Permanent extended detention basins T-D-2, T-F-3, T-L-1, and T-N-1 shall be constructed during the ultimate phase. Volumes for detention basins are calculated by using Hydrograph and Hydromodification methods *(Appendix E: Detention Basin Calculations).* The detention basins constructed during the tentative phase are sized for the increased impervious surfaces created by this project and are sized for ultimate development. In addition, detention basins located in areas T-F-3, T-L-1, and T-N-1 have been sized to accommodate hydromodification and peak flow mitigation requirements for the increased impervious areas from roadways and sidewalks. During the ultimate phase the proposed underground detention basin located in area T-F-3 shall be constructed in place of the reclamation detention basin R-F. Sediment basins R-C and R-I shall be constructed during the reclamation phase as temporary basins. These temporary basins shall remain operational during the ultimate phase in areas T-C-5 and T-I-1, until future development takes its place.

4. <u>Offsite</u>

The offsite drainage mentioned previously shall continue to enter the site as it does in the existing conditions. Storm drains located along the easterly edge (96”, 66”, and 14’ CMPA) shall be connected into the proposed creek. All storm drain pipes along the northerly property line (42” RCP, 18” ACP, 24” ACP and 30” ACP) discharge to the creek by separate underground storm drain systems and shall not be connected to any onsite generated storm water for proper calculations of hydromodification.

VII. GENERAL OVERVIEW

This project will impact wetlands and therefore requires a 404 permit from U.S. Army Corps of Engineers (USACE) and a 401 State Water Quality certificate from the Regional Water Quality Control Board (RWQCB) pursuant to the Clean Water Act. A 1603 Streambed Alteration Agreement from California Department of Fish and Wildlife (CDFW) is also required for impacts to streambeds and associated riparian habitat

The project's existing site is approximately 286 acres and 0% impervious (c=0.35). From mining to reclamation phase, the site will increase discharge from 192.0 cfs to 287.2 cfs. After the reclamation plan phase, the tentative plan phase will be constructing utilities and roadway for the future ultimate development. Flow calculations *(Appendix B: Glow Data Spreadsheet)* are based on the ultimate site development and used to size the sediment and detention basins throughout the site to satisfy treatment and flow control requirements for hydromodification. The outlet discharges for unmitigated flows for the 100 year storm event are summarized in Table 1, where post-development flows exceed pre-development flows. In Table 2, the post-development flows are less than or equal to the pre-development flows due to detention basin runoff mitigation for a 100 year storm event. For the purposes of designing storm drain infrastructure, the amount of flow generated for each drainage area is based on ultimate development runoff coefficients and land use type *(Appendix C: Runoff Coefficient Calculations)*. Unmitigated flows for a 100-year storm event are estimated to be 940 cfs. Offsite discharge shall be routed by an underground storm drain system that is separate from any system with onsite generated storm water. Offsite storm water is directly discharged through Outlets OS-0, OS-1, OS-2, OS-3, and OS-4 into the creek with no change in flow rates (Table 3). Offsite runoff is kept separate in order to accurately calculate Hydromodification flow control requirements.

Pipe Sizing

Pipe sizing was calculated for a 100-year storm and is based on land use type for ultimate development. Land use types on the west side of Camino Ruiz include "Open Space", "Park", "Medium Density Residential", "Mixed-Use" and "High Density Residential". Land use types on the east side of Camino Ruiz include "Open Space", "Park", "Light Industrial", "Mixed-Use", "O.P. Com. – Business Park" and "High Density Residential". Runoff coefficients are calculated for each drainage subarea and are shown in *Appendix C: Runoff Coefficient Calculations*. These ultimate runoff coefficients used for pipe sizing would be the worst-case scenario.

Outlet Summary for Tentative Phase Prior to Mitigation Measures

Located on the west side of Camino Ruiz just south of Street 'A-A', Outlet 1 includes Areas T-A-1, T-A-2 and T-A-3. The calculated discharge for Outlet 1 (42" CMP) is approx. 135.2 cfs. Also located on the west side of Camino Ruiz just south of Street 'A' West, Outlet 2 includes the remaining area T-A-4. The calculated discharge for Outlet 2 (48" CMP) is approx. 91.6 cfs. Outlet 3 (36" RCP) is located on the easterly side of Camino Ruiz south of Carroll Canyon Road, and will discharge approx. 49.0 cfs. Outlet 4 (54" RCP), is located just west of Street '9' and south Carroll Canyon Road and shall discharge approx. 195.0 cfs. Outlet 5 (30" CMP) is located east of Camino Ruiz and just north of Street '15'. The 30"

CMP for Outlet 5 is calculated to discharge approx. 41.1 cfs. Outlet 6 (30" RCP) is located northeasterly of Maya Linda Road and released to the proposed creek with a discharge of approx. 33.8 cfs. Outlet 7 (30" CMP), is located south of Maya Linda Road and discharges to the proposed creek at approx. 22.9 cfs. Lastly, Outlet 8 (24" RCP) is located south of Carroll Canyon Road and west of Street '10'. The 24" CMP for Outlet 8 is calculated to discharge approx. 19.6 cfs. All of the above outlets are routed to a detention basin prior to discharging to the creek. The unmitigated flow rates above are calculated using StormCAD software (*Appendix G: Storm CAD Calculations)*, based on runoff coefficients and drainage areas for the ultimate site development *(Appendix B: Flow Data Spreadsheet).* The discharges from each detention basin outlet shall be less than or equal to pre-development peak flow rates for a 100 year storm and will also meet hydromodification requirements.

Hydromodification Management

This project is subject to Hydromodification Management and shall incorporate flow control and treatment control performance criteria to mitigate the increased impervious surfaces from the proposed ultimate development. The basin size requirements are summarized in the Storm Water Quality Management Plan (SWQMP).

VIII. OUTLET DISCHARGE SUMMARY – 100 YEAR STORM EVENT

Table 1: Outlet Discharge Summary (Without Mitigation)

OUTLET	LOCATION	CONTRIBUTING AREA (ACRE)	PIPE SIZE	PRE DEVELOPMENT(RECLAMATION PHASE) (CFS)	POST DEVELOPMENT(TENTATIVE PHASE) (CFS)
1 2	T-A-1,2,3 T-A-4	91.74	42" CMP 48" CMP	101.00	226.8
3	T-C-5, T-D-1,2	12.84	36" RCP	5.84	49.0
4	T-B,C,E,F,J,K	98.48	54" RCP	68.63	195.0
5	T-L-1,2,3,4,5	22.99	30" CMP	14.47	41.1
6	T-M-1,2,3	9.56	30" RCP	7.38	33.8
7	T-N-1	6.79	30" CMP	5.32	22.9
8	T-I-1	8.48	24" CMP	5.94	19.6
TOTAL	N/A	250.88 AC	N/A	208.58 CFS	588.2 CFS

Table 2: Outlet Discharge Summary (Including Detention Basin Runoff Mitigation)

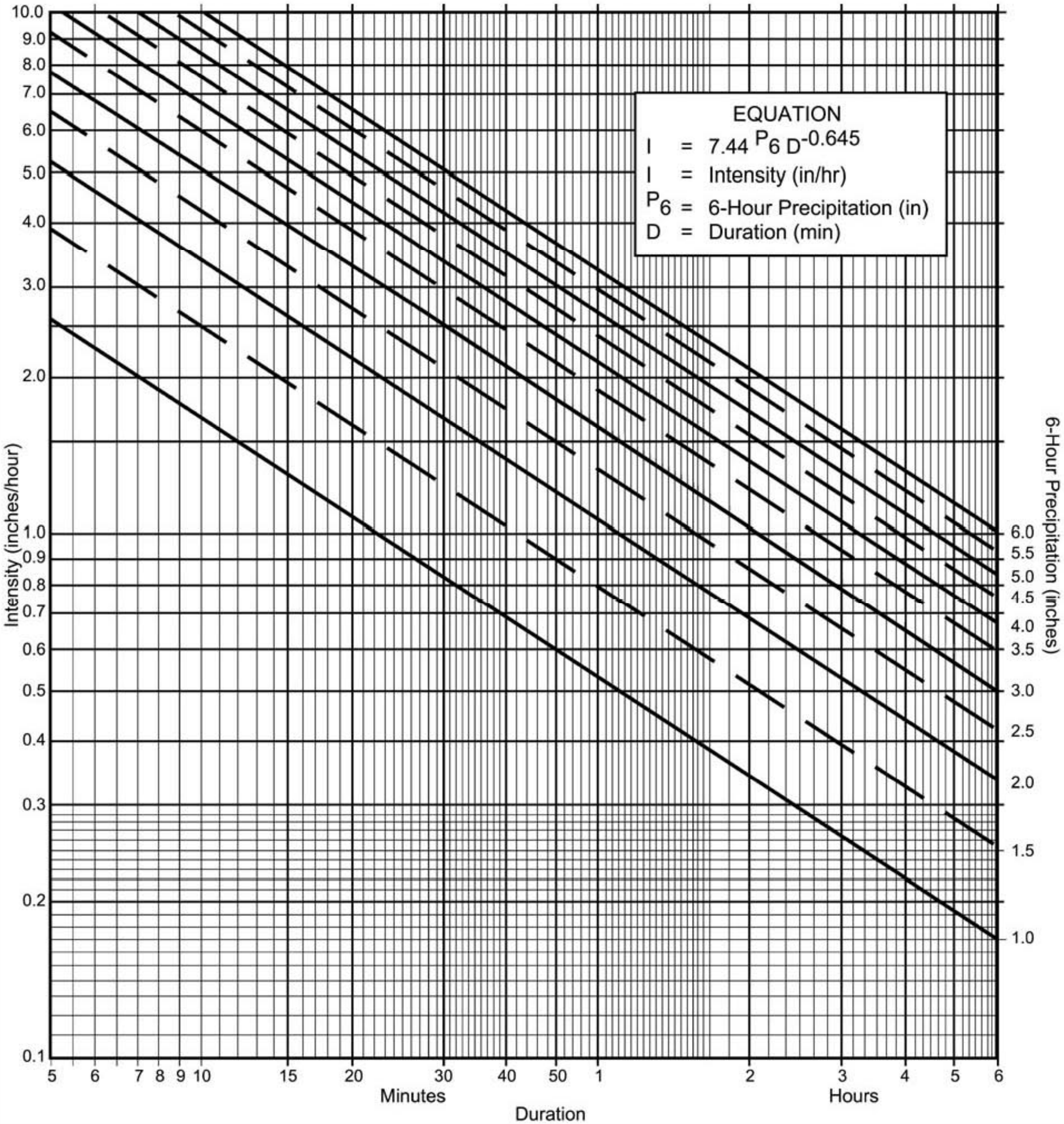
OUTLET	LOCATION	CONTRIBUTING AREA (ACRE)	PIPE SIZE	PRE DEVELOPMENT(RECLAMATION PHASE) (CFS)	POST DEVELOPMENT(TENTATIVE PHASE) (CFS)
1 2	T-A-1,2,3 T-A-4	91.74	42" CMP 48" CMP	101.00	101.00
3	T-C-5, T-D-1,2	12.84	36" RCP	5.84	5.84
4	T-B,C,E,F,J,K	98.48	54" RCP	68.63	68.63
5	T-L-1,2,3,4,5	22.99	30" CMP	14.47	14.47
6	T-M-1,2,3	9.56	30" RCP	7.38	7.38
7	T-N-1	6.79	30" CMP	5.32	5.32
8	T-I-1	8.48	24" CMP	5.94	5.94
TOTAL	N/A	250.88 AC	N/A	208.58 CFS	208.58 CFS

<u>Note:</u> Post development tentative flows based on 100-year storm event, will be the same or less than pre development reclamation flows to satisfy hydromodification and flow control requirements. Final calculations will be provided during the construction document phase.

Table 3: Outlet Discharge Summary (Offsite Drainage) – 100 YEAR STORM EVENT

OUTLET	LOCATION	CONTRIBUTING AREA (ACRE)	PIPE SIZE	PRE DEVELOPMENT(RECLAMATION PHASE) (CFS)	POST DEVELOPMENT(TENTATIVE PHASE) (CFS)
OS-0	OS-0	37.42	18” RCP	52.5	52.5
OS-1	OS-1	39.48	42” RCP	52.5	52.5
OS-2	OS-2	13.39	18” CMP	23.3	23.3
OS-3	OS-3	16.13	24” CMP	38.4	38.4
OS-4	OS-4	52.04	30” ACP	70.9	70.9
TOTAL	**N/A**	**158.46 AC**	**N/A**	**237.6 CFS**	**237.6 CFS**

Appendix A: 2003 County of San Diego Hydrology Graphs & Tables



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 ______ year

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

(c) Adjusted $P_6^{(2)}$ = ______ 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

$$C = 0.90 \times (\%\ Impervious) + C_p \times (1 - \%\ Impervious)$$

Where: C_p = Pervious Coefficient Runoff Value for the soil type (shown in Table 3-1 as Undisturbed Natural Terrain/Permanent Open Space, 0% Impervious). Soil type can be determined from the soil type map provided in Appendix A.

The values in Table 3-1 are typical for most urban areas. However, if the basin contains rural or agricultural land use, parks, golf courses, or other types of nonurban land use that are expected to be permanent, the appropriate value should be selected based upon the soil and cover and approved by the local agency.

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

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.

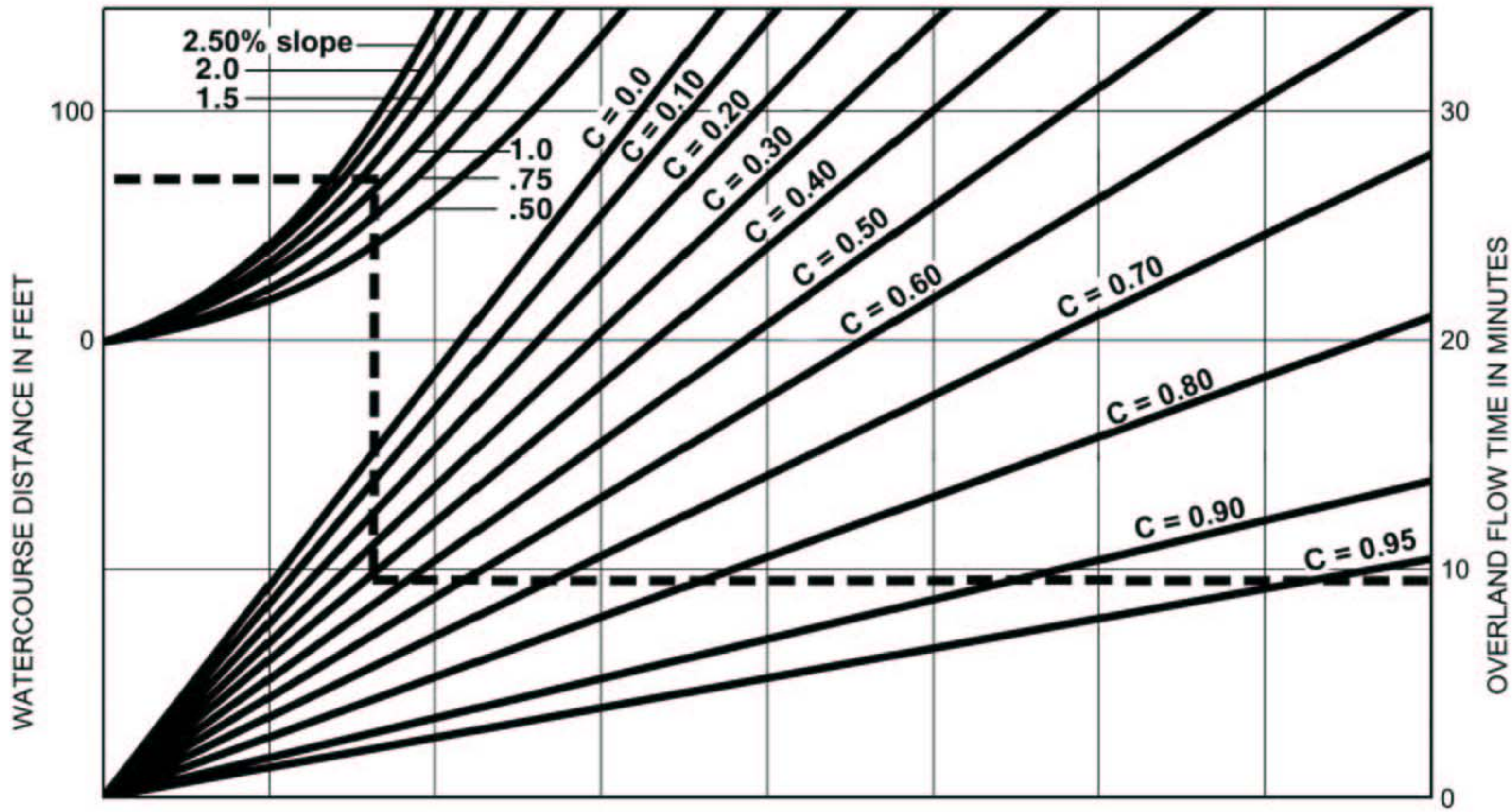
Table 3-2 provides limits of the length (Maximum Length (L_M)) of sheet flow to be used in hydrology studies. Initial T_i values based on average C values for the Land Use Element are also included. These values can be used in planning and design applications as described below. Exceptions may be approved 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/	.5%		1%		2%		3%		5%		10%	
	Acre	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



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

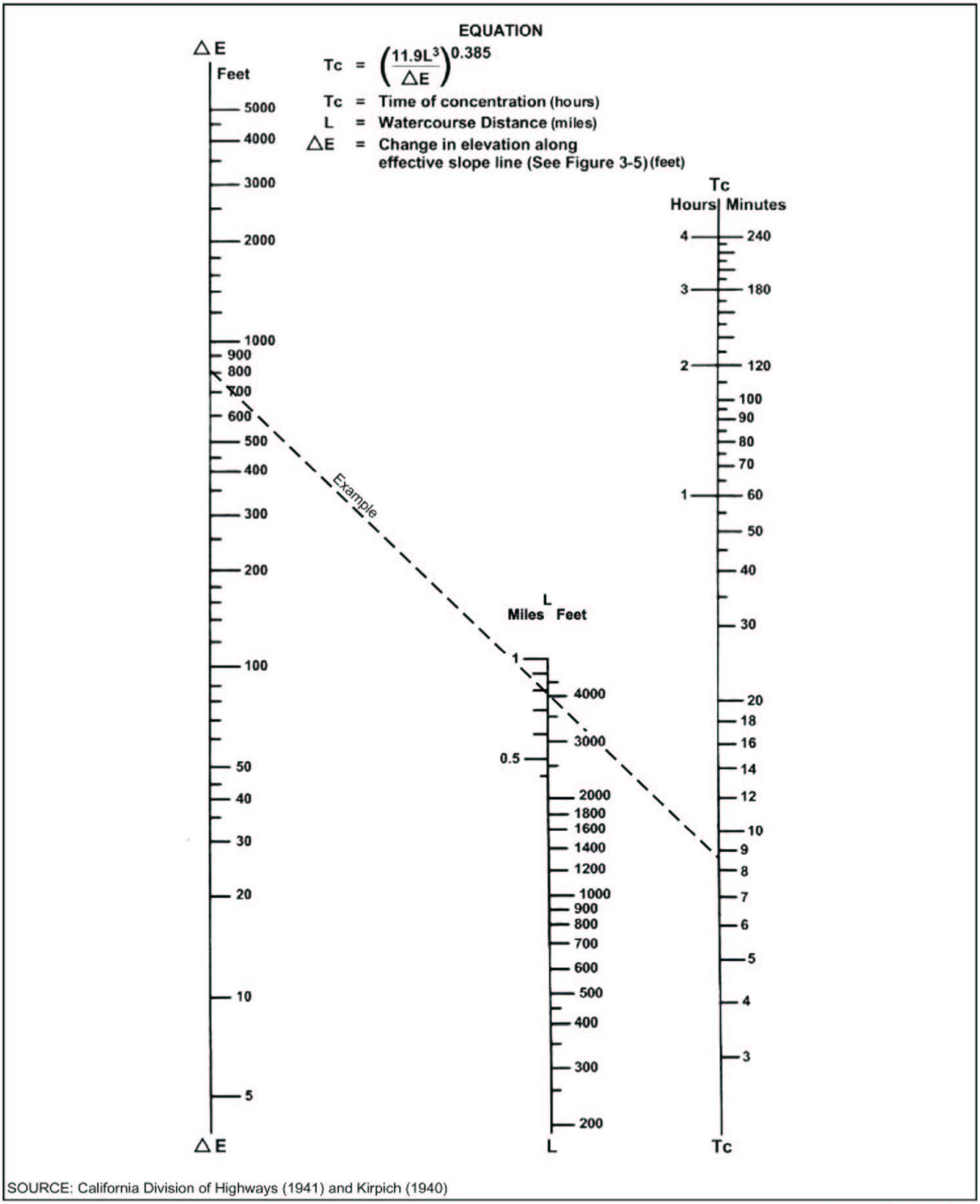
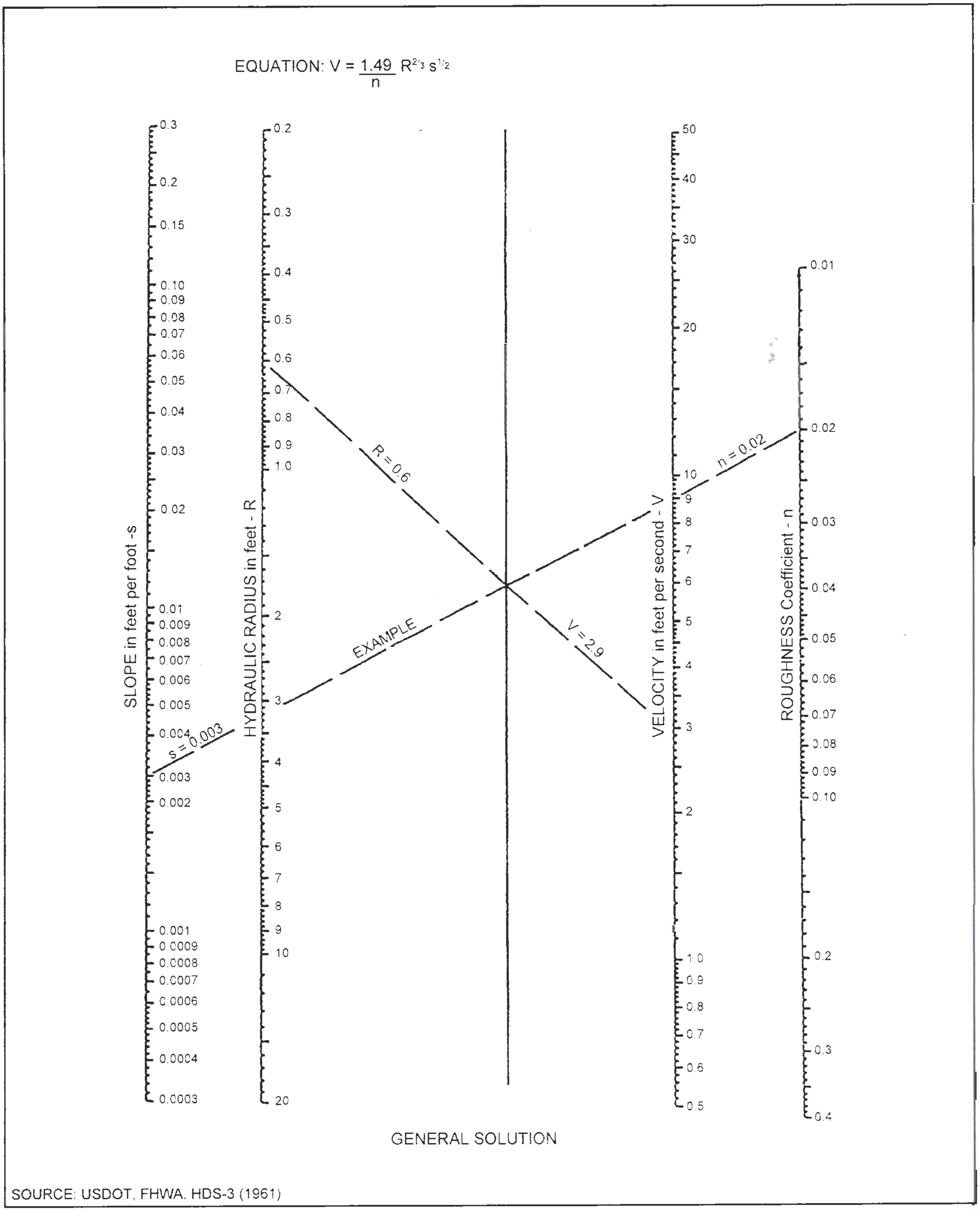


FIGURE **3-4**

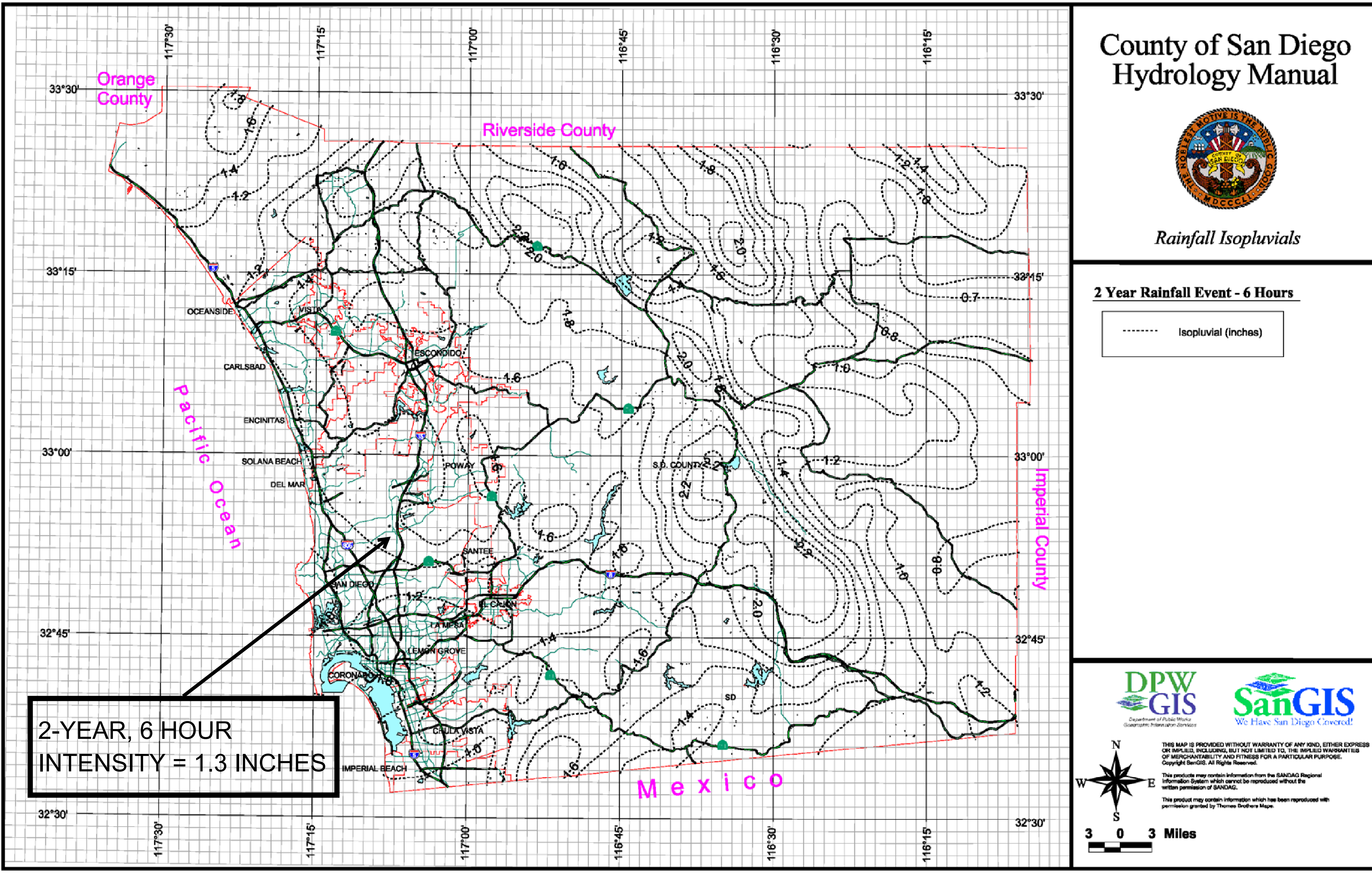
Nomograph for Determination of
Time of Concentration (Tc) or Travel Time (Tt) for Natural Watersheds



Manning's Equation Nomograph

FIGURE

3-7


County of San Diego
Hydrology Manual
Rainfall Isopluvials
2 Year Rainfall Event - 6 Hours
Isopluvial (inches)
2-YEAR, 6 HOUR
INTENSITY = 1.3 INCHES
Orange County
Riverside County
Imperial County
Pacific Ocean
Mexico
OCEANSIDE
VISTA
CARLSBAD
ESCONDIDO
ENCINITAS
SOLANA BEACH
DEL MAR
POWAY
SANTEE
SAN DIEGO
EL CAJON
LA MESA
LEMON GROVE
CORONADO
CHULA VISTA
IMPERIAL BEACH
S.D. COUNTY
SD
33°30'
33°15'
33°00'
32°45'
32°30'
117°30'
117°15'
117°00'
116°45'
116°30'
116°15'
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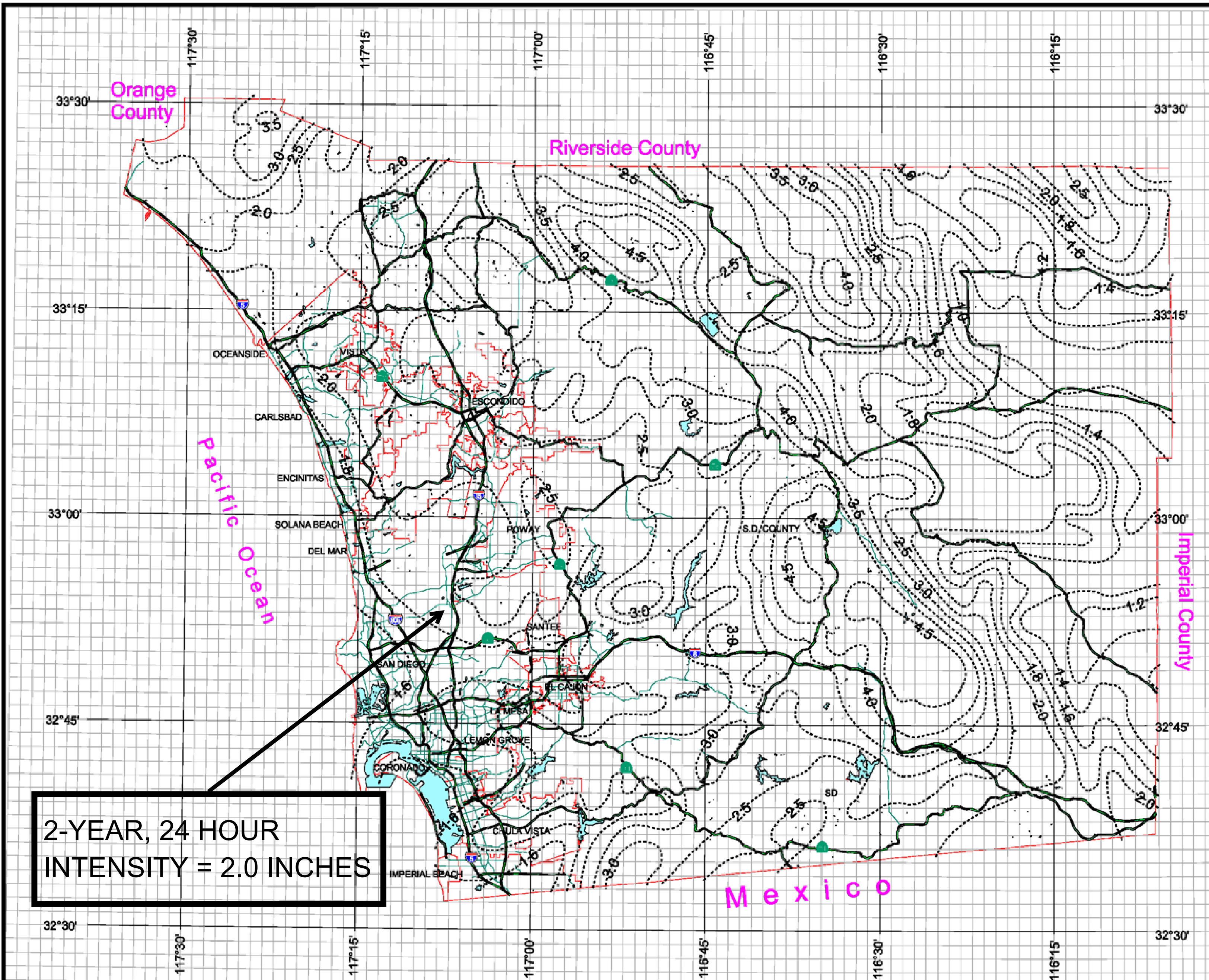

County of San Diego Hydrology Manual

Rainfall Isopluvials

2 Year Rainfall Event - 24 Hours

-------- Isopluvial (inches)

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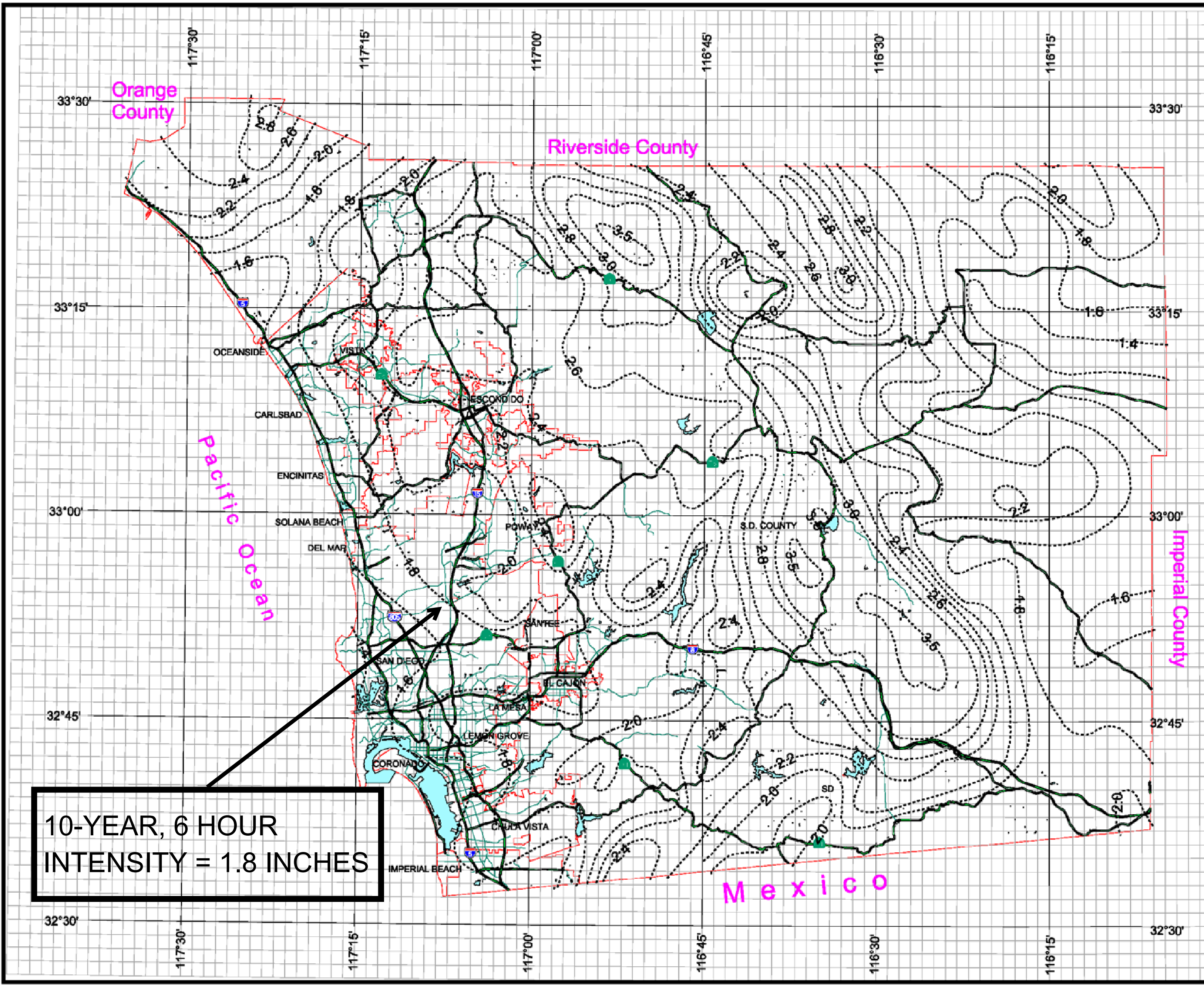

County of San Diego Hydrology Manual

Rainfall Isopluvials

10 Year Rainfall Event - 6 Hours

Isopluvial (inches)

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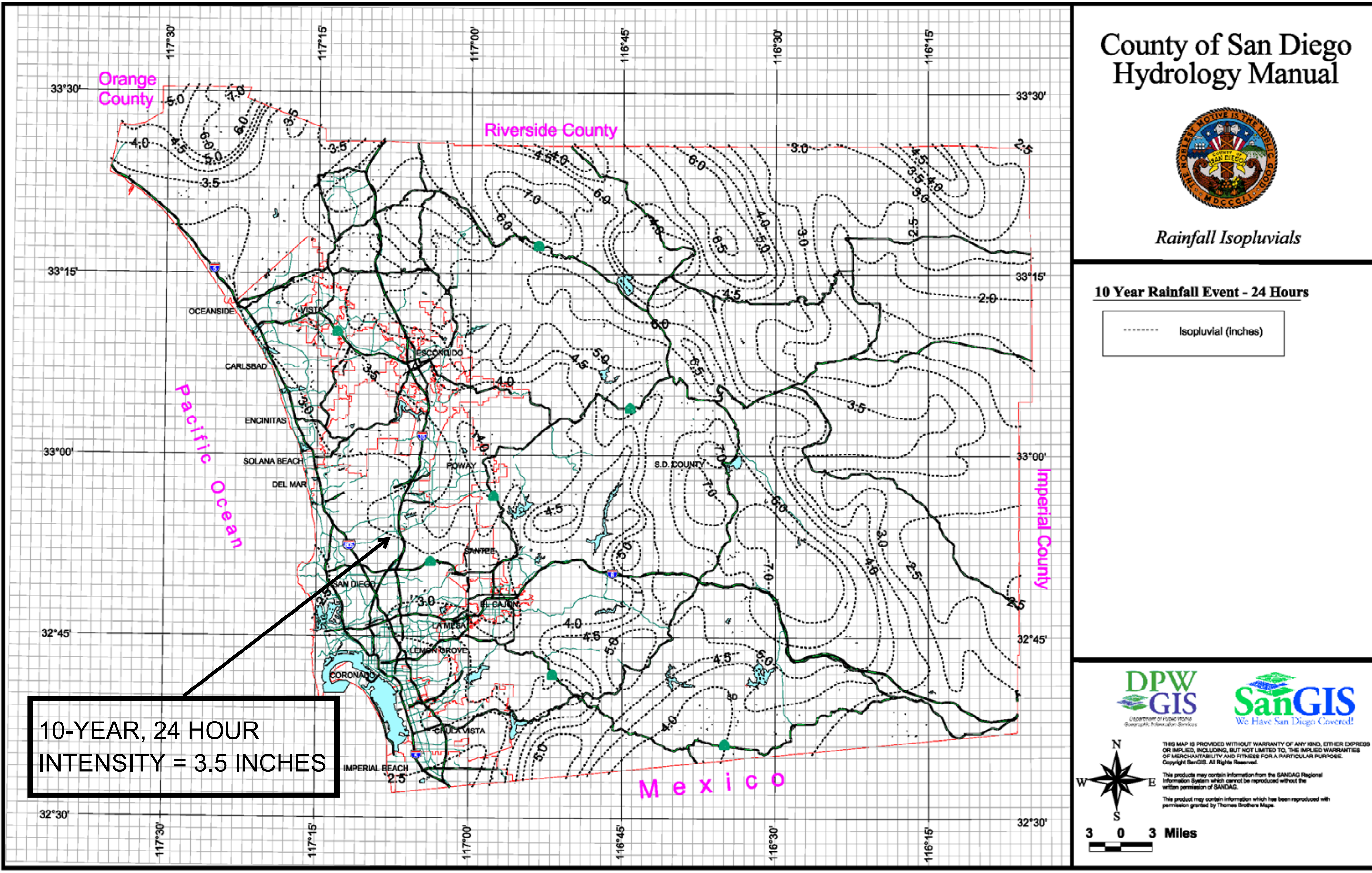
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Imperial County
Pacific Ocean
Mexico
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CHULA VISTA
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S.D. COUNTY
33°30'
33°15'
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32°45'
32°30'
117°30'
117°15'
117°00'
116°45'
116°30'
116°15'
10-YEAR, 24 HOUR
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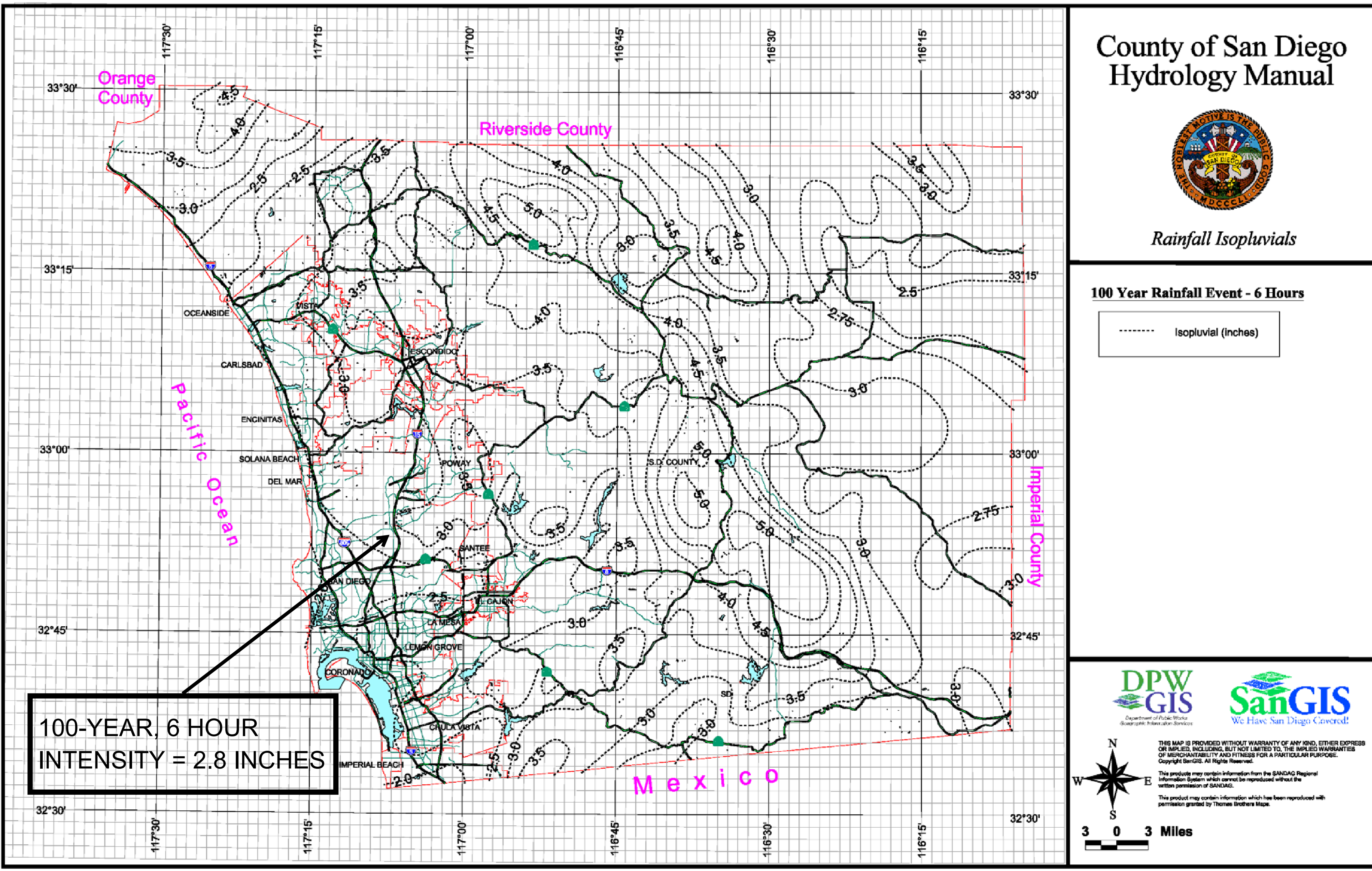
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100 Year Rainfall Event - 6 Hours
Isopluvial (inches)
Orange County
Riverside County
Imperial County
Pacific Ocean
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100-YEAR, 6 HOUR
INTENSITY = 2.8 INCHES
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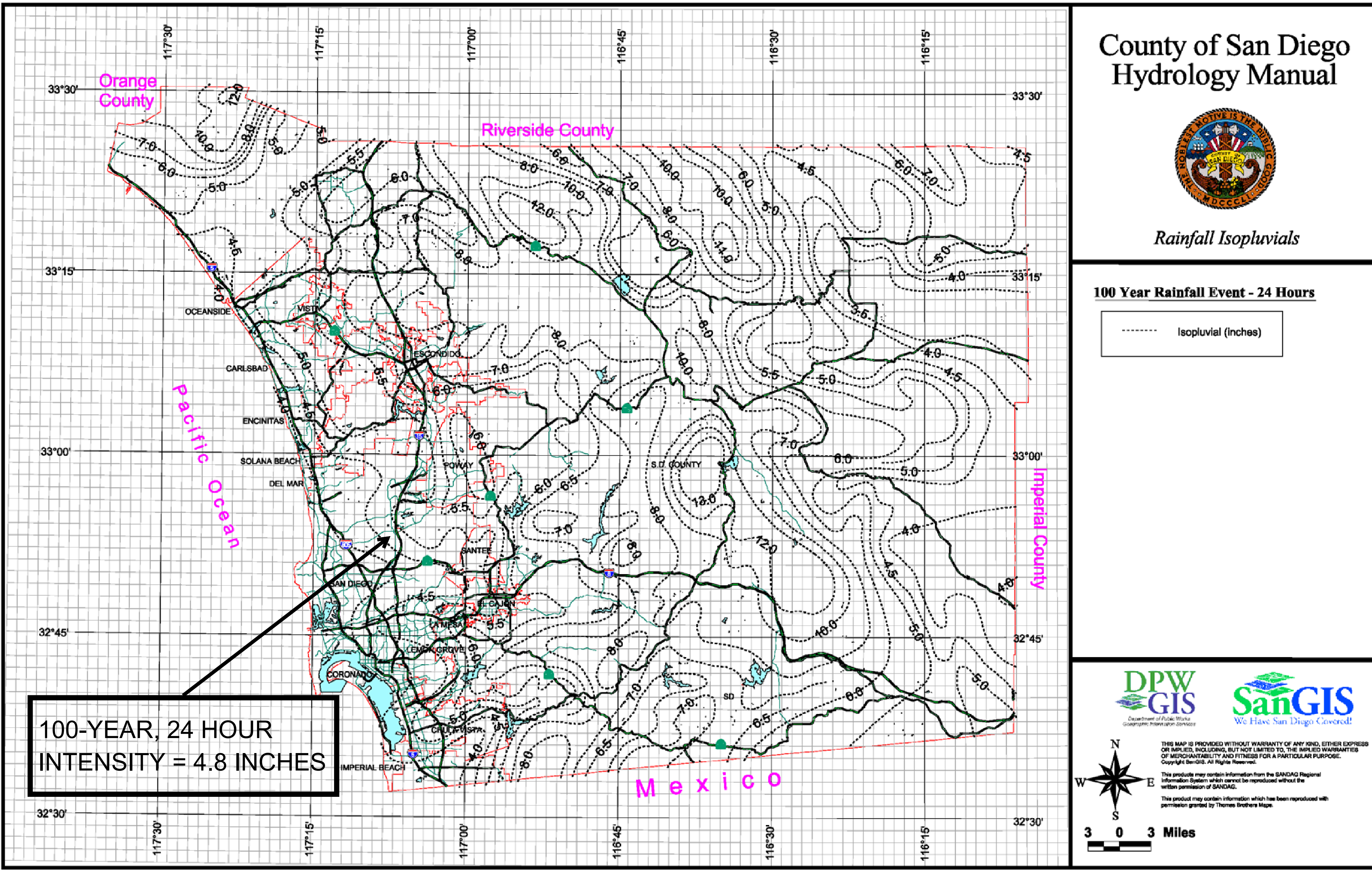
County of San Diego
Hydrology Manual
Rainfall Isopluvials
100 Year Rainfall Event - 24 Hours
Isopluvial (inches)
100-YEAR, 24 HOUR
INTENSITY = 4.8 INCHES
Orange County
Riverside County
Imperial County
Pacific Ocean
Mexico
OCEANSIDE
VISTA
CARLSBAD
ESCONDIDO
ENCINITAS
SOLANA BEACH
DEL MAR
POWAY
SANTEE
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Appendix B: Flow Data Spreadsheet

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: Stone Creek — PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan — DATE: 12/21/12 updated 11/13/18

R.C.E. NO.: ____________________

Year Storm	P_6	P_{24}	P_6 / P_{24}
2	1.3	2.0	65.0%
10	1.8	3.5	51.4%
100	2.8	4.8	58.3%

$T_{c,\ MINIMUM}$ = 5 minutes

DRAINAGE AREA NO.	AREA (AC.)	LENGTH OF FLOW (FT.)	SLOPE (%)	PERCENT IMPERVIOUS	C	Tc (per att. chart)	I (per att. chart)			Q (CFS)		
							2	10	100	2	10	100
MINING PHASE												
M-A	91.74	1270	16.9%	0.0%	0.35	19	1.46	2.02	3.15	46.9	64.9	101.0
M-B	NOT USED											
M-C	178.02	5000	1.6%	5.0%	0.38	79	0.58	0.80	1.25	38.9	53.9	83.8
M-D	16.35	4835	1.7%	0.0%	0.35	79	0.58	0.80	1.25	3.3	4.6	7.1
RECLAMATION PHASE												
R-A	91.74	1270	16.9%	0.0%	0.35	19	1.46	2.02	3.15	46.9	64.9	101.0
R-B	9.97	1420	4.4%	0.0%	0.35	31	1.05	1.46	2.27	3.7	5.1	7.9
R-C	13.46	1400	4.3%	0.0%	0.35	31	1.05	1.46	2.27	5.0	6.9	10.7
R-D	6.72	760	2.6%	0.0%	0.35	27	1.15	1.60	2.48	2.7	3.8	5.8
R-E	5.63	1530	4.9%	0.0%	0.35	31	1.05	1.46	2.27	2.1	2.9	4.5
R-F	29.04	1640	1.2%	0.0%	0.35	51	0.76	1.05	1.64	7.7	10.7	16.7
R-G	27.80	5400	1.5%	0.0%	0.35	46	0.82	1.13	1.76	8.0	11.0	17.2
R-H	4.57	375	1.0%	0.0%	0.35	26	1.18	1.63	2.54	1.9	2.6	4.1
R-I	9.57	1560	1.6%	0.0%	0.35	46	0.82	1.14	1.77	2.8	3.8	5.9
R-J	11.40	1100	1.4%	0.0%	0.35	40	0.90	1.24	1.93	3.6	4.9	7.7
R-K	35.24	2070	2.1%	0.0%	0.35	48	0.80	1.10	1.72	9.8	13.6	21.2
R-L	24.62	1925	1.7%	0.0%	0.35	50	0.78	1.08	1.68	6.7	9.3	14.5
R-M	9.56	1150	2.8%	0.0%	0.35	32	1.02	1.42	2.21	3.4	4.7	7.4
R-N	6.78	1015	2.5%	0.0%	0.35	32	1.04	1.44	2.24	2.5	3.4	5.3
NOTE 1: TEMPORARY SEDIMENT BASINS CONSTRUCTED DURING RECLAMATION PHASE ARE NOTED WITH *R-X*.												
NOTE 2: PERMENANT DETENTION BASINS CONSTRUCTED DURING RECLAMATION PHASE ARE NOTED WITH **R-X**.												
NOTE 3: RECLAMATION DRAINAGE AREAS R-A & R-F SHALL BE REPLACED BY UNDERGROUND DETENTION BASINS IN THE TENTATIVE PHASE.												
NOTE 4: AREA R-H FLOWS DIRECTLY INTO THE CREEK AREA R-G.												
TENTATIVE PHASE (ROADWAY IMPROVEMENTS ONLY)												
T-A-1-1	2.28	540	10.9%	8.3%	0.40	13	1.82	2.52	3.93	1.6	2.3	3.5
T-A-1-2	1.69	430	14.7%	12.2%	0.42	10	2.14	2.96	4.60	1.5	2.1	3.2
T-A-1-3	0.93	470	15.0%	26.1%	0.49	10	2.25	3.11	4.84	1.0	1.4	2.2
T-A-1-4	3.29	660	10.8%	10.9%	0.41	14	1.73	2.39	3.72	2.3	3.2	5.0
T-A-1-5	0.67	290	2.0%	38.9%	0.56	13	1.84	2.55	3.97	0.7	1.0	1.5
T-A-1-6	1.48	230	2.6%	24.4%	0.48	12	1.93	2.67	4.15	1.4	1.9	3.0
T-A-1-7	1.47	390	3.3%	0.0%	0.35	18	1.51	2.09	3.25	0.8	1.1	1.7
T-A-2-1	2.63	530	2.2%	28.9%	0.51	19	1.46	2.02	3.14	1.9	2.7	4.2
T-A-2-2	3.03	640	10.4%	13.6%	0.42	14	1.76	2.43	3.78	2.3	3.1	4.9
T-A-2-3	2.79	600	12.8%	12.9%	0.42	13	1.87	2.58	4.02	2.2	3.0	4.7
T-A-2-4	3.20	670	10.1%	9.7%	0.40	15	1.68	2.33	3.63	2.2	3.0	4.7
T-A-2-5	1.76	380	2.9%	0.0%	0.35	18	1.48	2.04	3.18	0.9	1.3	2.0
T-A-2-6	0.34	310	2.4%	87.2%	0.83	6	2.92	4.04	6.29	0.8	1.2	1.8
T-A-2-7	2.18	340	2.9%	29.4%	0.51	14	1.79	2.48	3.86	2.0	2.8	4.3
T-A-3-1	8.21	1100	8.2%	0.0%	0.35	22	1.31	1.81	2.82	3.8	5.2	8.1
T-A-3-2	1.49	460	5.3%	33.6%	0.53	13	1.89	2.62	4.08	1.5	2.1	3.2
T-A-3-3	3.75	670	3.7%	25.4%	0.49	18	1.48	2.05	3.18	2.7	3.8	5.9
T-A-3-4	1.58	410	3.8%	19.8%	0.46	15	1.69	2.34	3.63	1.2	1.7	2.6
T-A-3-5	2.78	490	4.0%	26.7%	0.50	15	1.68	2.32	3.61	2.3	3.2	5.0
T-A-3-6	2.89	490	3.8%	36.1%	0.55	14	1.76	2.44	3.79	2.8	3.9	6.0
T-A-4-1	1.47	450	3.0%	18.6%	0.45	17	1.54	2.14	3.33	1.0	1.4	2.2
T-A-4-2	0.21	330	3.6%	82.0%	0.80	6	2.94	4.06	6.32	0.5	0.7	1.0
T-A-4-3	2.78	840	8.7%	9.0%	0.40	18	1.51	2.09	3.26	1.7	2.3	3.6
T-A-4-4	2.50	660	5.4%	16.0%	0.44	17	1.53	2.12	3.30	1.7	2.3	3.6
T-A-4-5	2.14	500	3.5%	16.5%	0.44	18	1.52	2.11	3.28	1.4	2.0	3.1
T-A-4-6	1.23	280	4.1%	26.6%	0.50	11	2.02	2.79	4.34	1.2	1.7	2.6
T-A-4-7	0.97	330	3.5%	47.4%	0.61	11	2.12	2.94	4.57	1.3	1.7	2.7
NOTE 1: TEMPORARY SEDIMENT BASINS CONSTRUCTED DURING TENTATIVE PHASE ARE NOTED WITH *T-X-X*.												
NOTE 2: PERMENANT DETENTION BASINS CONSTRUCTED DURING TENTATIVE PHASE ARE NOTED WITH **T-X-X**.												
NOTE 3: FOR CREEK AREAS R-G (RECLAMATION) & T-G-1 (TENTATIVE); Tc (MIN) = LENGTH OF FLOW (FT) / VELOCITY (FT/S) / 60 (S).												
NOTE 4: VELOCITY FOR CREEK AREAS R-G & T-G-1 ARE CALCULATED USING FIGURE 3-7 FROM THE SAN DIEGO COUNTY HYDROLOGY MANUAL.												

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: Stone Creek   PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan   DATE: 12/21/12 updated 11/13/18

R.C.E. NO.: ____________

Year Storm	P_6	P_{24}	P_6 / P_{24}
2	1.3	2.0	65.0%
10	1.8	3.5	51.4%
100	2.8	4.8	58.3%

$T_{c,\ MINIMUM}$ = 5 minutes

DRAINAGE AREA NO.	AREA (AC.)	LENGTH OF FLOW (FT.)	SLOPE (%)	PERCENT IMPERVIOUS	C	Tc (per att. chart)	I (per att. chart)			Q (CFS)		
							2	10	100	2	10	100
T-A-4-8	0.94	370	5.7%	52.1%	0.64	9	2.35	3.25	5.06	1.4	1.9	3.0
T-A-4-9	0.62	260	3.7%	79.8%	0.79	6	3.10	4.29	6.67	1.5	2.1	3.3
T-A-4-10	1.08	390	4.4%	25.7%	0.49	13	1.83	2.53	3.93	1.0	1.3	2.1
T-A-4-11	3.38	770	4.0%	24.9%	0.49	19	1.44	1.99	3.09	2.4	3.3	5.1
T-A-4-12	1.14	360	5.0%	28.3%	0.51	12	1.96	2.72	4.22	1.1	1.6	2.4
T-A-4-13	0.60	420	8.0%	74.8%	0.76	6	2.97	4.11	6.39	1.3	1.9	2.9
T-A-4-14	7.91	660	6.8%	25.6%	0.49	15	1.70	2.35	3.66	6.6	9.1	14.2
T-A-4-15	6.29	1510	2.3%	0.0%	0.35	40	0.90	1.25	1.94	2.0	2.7	4.3
T-B-1	0.95	480	4.2%	10.6%	0.41	17	1.56	2.16	3.36	0.6	0.8	1.3
T-B-2	2.33	765	5.9%	18.9%	0.45	18	1.51	2.09	3.25	1.6	2.2	3.4
T-B-3	2.64	720	2.8%	21.2%	0.47	22	1.33	1.84	2.86	1.6	2.3	3.5
T-B-4	1.28	350	4.3%	2.3%	0.36	15	1.67	2.31	3.59	0.8	1.1	1.7
T-C-1	2.11	610	2.5%	27.9%	0.50	20	1.42	1.97	3.06	1.5	2.1	3.3
T-C-2	2.38	275	3.6%	29.0%	0.51	11	2.00	2.77	4.31	2.4	3.4	5.2
T-C-3	2.18	265	3.8%	28.9%	0.51	11	2.05	2.84	4.41	2.3	3.1	4.9
T-C-4	1.10	625	2.5%	53.4%	0.64	15	1.68	2.32	3.61	1.2	1.7	2.6
T-C-5	5.93	615	3.3%	4.4%	0.37	22	1.33	1.84	2.86	2.9	4.1	6.3
T-D-1	3.59	585	2.6%	75.3%	0.76	11	2.10	2.91	4.53	5.8	8.0	12.4
T-D-2	3.32	425	2.9%	0.0%	0.35	20	1.42	1.97	3.06	1.7	2.3	3.6
T-E-1	5.72	855	7.6%	12.1%	0.42	18	1.48	2.05	3.19	3.5	4.9	7.6
T-E-2	5.25	650	8.5%	14.9%	0.43	15	1.68	2.33	3.63	3.8	5.3	8.2
T-E-3	1.49	600	4.2%	46.4%	0.61	14	1.80	2.50	3.88	1.6	2.2	3.5
T-E-4	5.98	730	1.3%	10.4%	0.41	31	1.06	1.47	2.28	2.6	3.6	5.6
T-F-1	3.18	560	0.9%	76.4%	0.77	15	1.72	2.38	3.70	4.2	5.8	9.1
T-F-2	4.36	1110	1.4%	66.6%	0.72	21	1.38	1.90	2.96	4.3	5.9	9.2
T-F-3	10.92	940	1.1%	5.5%	0.38	38	0.92	1.27	1.98	3.8	5.3	8.2
T-G-1	35.27	5470	2.3%	0.0%	0.35	4	4.03	5.58	8.69	49.8	68.9	107.2
T-I-1	8.48	1040	3.8%	0.0%	0.35	28	1.13	1.56	2.43	3.3	4.6	7.2
T-J-1	2.59	565	14.2%	10.8%	0.41	12	1.93	2.67	4.15	2.0	2.8	4.4
T-J-2	2.34	550	13.6%	9.8%	0.40	12	1.92	2.65	4.13	1.8	2.5	3.9
T-J-3	6.44	1070	2.6%	14.6%	0.43	29	1.11	1.54	2.39	3.1	4.3	6.6
T-K-1	21.47	1400	5.4%	17.3%	0.45	25	1.21	1.67	2.60	11.5	16.0	24.9
T-K-2	7.92	1250	4.0%	13.5%	0.42	27	1.15	1.59	2.48	3.9	5.4	8.3
T-K-3	5.85	760	3.3%	27.2%	0.50	20	1.40	1.94	3.02	4.1	5.7	8.8
T-L-1	5.70	1220	1.3%	0.0%	0.35	43	0.85	1.18	1.84	1.7	2.4	3.7
T-L-2	0.28	110	0.9%	78.6%	0.78	6	2.98	4.12	6.41	0.7	0.9	1.4
T-L-3	7.64	1300	1.4%	10.6%	0.41	40	0.89	1.24	1.93	2.8	3.9	6.0
T-L-4	7.87	1450	1.4%	11.3%	0.41	42	0.87	1.20	1.87	2.8	3.9	6.0
T-L-5	1.50	460	2.2%	10.7%	0.41	21	1.38	1.91	2.97	0.8	1.2	1.8
T-M-1	5.85	860	2.9%	29.7%	0.51	22	1.33	1.84	2.86	4.0	5.5	8.6
T-M-2	2.69	670	3.1%	41.3%	0.58	17	1.57	2.17	3.38	2.4	3.4	5.2
T-M-3	1.02	330	2.7%	52.9%	0.64	11	2.09	2.89	4.50	1.4	1.9	2.9
T-N-1	6.79	1000	2.5%	10.9%	0.41	29	1.10	1.53	2.38	3.1	4.3	6.6
T-O-1	10.09	160	15.0%	0.0%	0.35	7	2.78	3.84	5.98	9.8	13.6	21.1

NOTE 1: SEDIMENT AND DETENTION BASINS CONSTRUCTED DURING RECLAMATION PHASE ARE LOCATED IN THE ABOVE HIGHLIGHTED AREAS.
NOTE 2: TEMPORARY SEDIMENT BASINS CONSTRUCTED DURING TENTATIVE PHASE ARE NOTED WITH *T-X-X*.
NOTE 3: PERMENANT DETENTION BASINS CONSTRUCTED DURING TENTATIVE PHASE ARE NOTED WITH **T-X-X**.
NOTE 4: PERMENANT TENTATIVE DETENTION BASINS T-A-1-7, T-A-2-5, T-A-3-1, & T-A-4-15 SHALL REPLACE RECLAMATION BASIN R-A.
NOTE 5: PERMENANT TENTATIVE DETENTION BASIN T-F-3 SHALL REPLACE RECLAMATION BASIN R-F.
NOTE 6: FOR CREEK AREAS R-G (RECLAMATION) & T-G-1 (TENTATIVE); Tc (MIN) = LENGTH OF FLOW (FT) / VELOCITY (FT/S) / 60 (S).
NOTE 7: VELOCITY FOR CREEK AREAS R-G & T-G-1 ARE CALCULATED USING FIGURE 3-7 FROM THE SAN DIEGO COUNTY HYDROLOGY MANUAL.

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: Stone Creek PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan DATE: 12/21/12 updated 11/13/18

R.C.E. NO.:

Year Storm	P_6	P_{24}	P_6 / P_{24}
2	1.3	2.0	65.0%
10	1.8	3.5	51.4%
100	2.8	4.8	58.3%

$T_{c, MINIMUM}$ = 5 minutes

DRAINAGE AREA NO.	AREA (AC.)	LENGTH OF FLOW (FT.)	SLOPE (%)	PERCENT IMPERVIOUS	C	Tc (per att. chart)	I (per att. chart) 2	I 10	I 100	Q (CFS) 2	Q 10	Q 100
ULTIMATE DEVELOPMENT (NOT A PART OF THIS PROJECT, USED FOR SD PIPE SIZING ONLY)												
T-A-1-1	2.28	540	10.9%	8.3%	0.47	12	1.97	2.72	4.23	2.1	2.9	4.6
T-A-1-2	1.69	430	14.7%	12.2%	0.51	9	2.35	3.25	5.06	2.0	2.8	4.4
T-A-1-3	0.93	470	15.0%	26.1%	0.61	8	2.57	3.56	5.54	1.5	2.0	3.1
T-A-1-4	3.29	660	10.8%	10.9%	0.50	13	1.89	2.62	4.07	3.1	4.3	6.7
T-A-1-5	0.67	290	2.0%	38.9%	0.80	7	2.66	3.68	5.73	1.4	2.0	3.0
T-A-1-6	1.48	230	2.6%	24.4%	0.80	6	3.04	4.21	6.56	3.6	5.0	7.7
T-A-1-7	1.47	390	3.3%	0.0%	0.72	9	2.33	3.22	5.01	2.5	3.4	5.3
T-A-2-1	2.63	530	2.2%	28.9%	0.79	10	2.21	3.06	4.76	4.6	6.4	9.9
T-A-2-2	3.03	640	10.4%	13.6%	0.57	11	2.05	2.83	4.41	3.5	4.9	7.6
T-A-2-3	2.79	600	12.8%	12.9%	0.57	10	2.19	3.03	4.71	3.5	4.8	7.5
T-A-2-4	3.20	670	10.1%	9.7%	0.54	12	1.94	2.69	4.19	3.4	4.7	7.3
T-A-2-5	1.76	380	2.9%	0.0%	0.69	10	2.17	3.00	4.67	2.6	3.6	5.6
T-A-2-6	0.34	310	2.4%	87.2%	0.83	6	2.92	4.04	6.29	0.8	1.2	1.8
T-A-2-7	2.18	340	2.9%	29.4%	0.79	7	2.68	3.72	5.78	4.6	6.4	9.9
T-A-3-1	8.21	1100	8.2%	0.0%	0.67	13	1.88	2.60	4.04	10.3	14.3	22.3
T-A-3-2	1.49	460	5.3%	33.6%	0.75	8	2.59	3.58	5.57	2.9	4.0	6.2
T-A-3-3	3.75	670	3.7%	25.4%	0.79	9	2.31	3.19	4.97	6.9	9.5	14.8
T-A-3-4	1.58	410	3.8%	19.8%	0.79	7	2.71	3.75	5.83	3.4	4.7	7.3
T-A-3-5	2.78	490	4.0%	26.7%	0.80	8	2.61	3.61	5.62	5.8	8.0	12.5
T-A-3-6	2.89	490	3.8%	36.1%	0.78	8	2.51	3.48	5.41	5.7	7.9	12.2
T-A-4-1	1.47	450	3.0%	18.6%	0.80	8	2.52	3.49	5.43	2.9	4.1	6.4
T-A-4-2	0.21	330	3.6%	82.0%	0.80	6	2.94	4.06	6.32	0.5	0.7	1.0
T-A-4-3	2.78	840	8.7%	9.0%	0.60	13	1.88	2.61	4.05	3.1	4.4	6.8
T-A-4-4	2.50	660	5.4%	16.0%	0.64	12	1.94	2.68	4.17	3.1	4.3	6.7
T-A-4-5	2.14	500	3.5%	16.5%	0.79	8	2.51	3.47	5.40	4.3	5.9	9.2
T-A-4-6	1.23	280	4.1%	26.6%	0.76	6	2.90	4.01	6.24	2.7	3.7	5.8
T-A-4-7	0.97	330	3.5%	47.4%	0.77	7	2.72	3.77	5.87	2.0	2.8	4.4
T-A-4-8	0.94	370	5.7%	52.1%	0.76	7	2.88	3.98	6.19	2.1	2.8	4.4
T-A-4-9	0.62	260	3.7%	79.8%	0.79	6	3.10	4.29	6.67	1.5	2.1	3.3
T-A-4-10	1.08	390	4.4%	25.7%	0.80	7	2.86	3.96	6.16	2.5	3.4	5.3
T-A-4-11	3.38	770	4.0%	24.9%	0.76	11	2.11	2.93	4.55	5.5	7.6	11.7
T-A-4-12	1.14	360	5.0%	28.3%	0.79	6	3.01	4.16	6.48	2.7	3.8	5.9
T-A-4-13	0.60	420	8.0%	74.8%	0.76	6	2.97	4.11	6.39	1.3	1.9	2.9
T-A-4-14	7.91	660	6.8%	25.6%	0.76	8	2.49	3.45	5.37	15.1	20.9	32.5
T-A-4-15	6.29	1510	2.3%	0.0%	0.60	26	1.17	1.62	2.52	4.4	6.1	9.5
T-B-1	0.95	480	4.2%	90.0%	0.67	11	2.11	2.92	4.54	1.3	1.8	2.9
T-B-2	2.33	765	5.9%	90.0%	0.68	12	2.00	2.77	4.31	3.2	4.4	6.9
T-B-3	2.64	720	2.8%	90.0%	0.80	10	2.13	2.95	4.59	4.5	6.2	9.7
T-B-4	1.28	350	4.3%	90.0%	0.79	6	2.93	4.06	6.31	3.0	4.1	6.4
T-C-1	2.11	610	2.5%	90.0%	0.69	13	1.81	2.51	3.90	2.6	3.6	5.7
T-C-2	2.38	275	3.6%	90.0%	0.81	6	3.16	4.38	6.81	6.1	8.4	13.1
T-C-3	2.18	265	3.8%	90.0%	0.80	6	3.19	4.41	6.86	5.6	7.7	12.0
T-C-4	1.10	625	2.5%	90.0%	0.80	10	2.22	3.07	4.78	2.0	2.7	4.2
T-C-5	5.93	615	3.3%	90.0%	0.79	9	2.32	3.21	5.00	10.9	15.1	23.5
T-D-1	3.59	585	2.6%	90.0%	0.82	9	2.38	3.29	5.12	7.0	9.7	15.1
T-D-2	3.32	425	2.9%	90.0%	0.79	8	2.52	3.48	5.42	6.6	9.1	14.2

NOTE 1: TEMPORARY SEDIMENT BASINS CONSTRUCTED DURING RECLAMATION PHASE ARE LOCATED IN THE ABOVE HIGHLIGHTED AREAS.

NOTE 2: PERMENANT DETENTION BASINS CONSTRUCTED DURING RECLAMATION PHASE, ARE NOTED WITH *T-X-X* DURING TENTATIVE PHASE.

NOTE 3: UNDERGROUND DETENTION BASINS CONSTRUCTED DURING THE TENTATIVE PHASE ARE NOTED WITH **T-X-X**.

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: Stone Creek PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan DATE: 12/21/12 updated 11/13/18

R.C.E. NO.: ____________

Year Storm	P_6	P_{24}	P_6 / P_{24}
2	1.3	2.0	65.0%
10	1.8	3.5	51.4%
100	2.8	4.8	58.3%

$T_{c, MINIMUM}$ = 5 minutes

DRAINAGE AREA NO.	AREA (AC.)	LENGTH OF FLOW (FT.)	SLOPE (%)	PERCENT IMPERVIOUS	C	Tc (per att. chart)	I (per att. chart)			Q (CFS)		
							2	10	100	2	10	100
T-E-1	5.72	855	7.6%	90.0%	0.64	12	1.93	2.67	4.15	7.1	9.8	15.3
T-E-2	5.25	650	8.5%	90.0%	0.44	15	1.71	2.36	3.67	4.0	5.5	8.6
T-E-3	1.49	600	4.2%	90.0%	0.82	8	2.60	3.60	5.60	3.2	4.4	6.8
T-E-4	5.98	730	1.3%	90.0%	0.75	15	1.65	2.29	3.56	7.4	10.3	16.0
T-F-1	3.18	560	0.9%	90.0%	0.82	12	1.90	2.63	4.10	5.0	6.9	10.7
T-F-2	4.36	1110	1.4%	90.0%	0.78	17	1.56	2.15	3.35	5.3	7.3	11.4
T-F-3	10.92	940	1.1%	90.0%	0.64	25	1.22	1.69	2.63	8.5	11.7	18.2
T-G-1	35.27	5470	2.3%	90.0%	0.60	4	4.03	5.58	8.69	85.3	118.2	183.8
T-I-1	8.48	1000	2.5%	90.0%	0.69	17	1.53	2.12	3.30	8.9	12.4	19.2
T-J-1	2.59	565	14.2%	90.0%	0.41	12	1.93	2.67	4.15	2.0	2.8	4.4
T-J-2	2.34	550	13.6%	90.0%	0.42	12	1.94	2.69	4.19	1.9	2.6	4.1
T-J-3	6.44	1070	2.6%	90.0%	0.81	12	1.91	2.64	4.11	10.0	13.8	21.5
T-K-1	21.47	1400	5.4%	90.0%	0.72	15	1.71	2.37	3.68	26.3	36.5	56.7
T-K-2	7.92	1250	4.0%	90.0%	0.70	16	1.62	2.25	3.50	9.0	12.5	19.5
T-K-3	5.85	760	3.3%	90.0%	0.80	10	2.17	3.00	4.67	10.1	14.0	21.7
T-L-1	5.70	1220	1.3%	90.0%	0.72	22	1.32	1.83	2.85	5.4	7.5	11.7
T-L-2	0.28	110	0.9%	90.0%	0.78	6	2.98	4.12	6.41	0.7	0.9	1.4
T-L-3	7.64	1300	1.4%	90.0%	0.70	23	1.26	1.75	2.72	6.7	9.3	14.5
T-L-4	7.87	1450	1.4%	90.0%	0.69	25	1.20	1.66	2.59	6.5	9.0	14.0
T-L-5	1.50	460	2.2%	90.0%	0.82	8	2.48	3.43	5.34	3.1	4.2	6.6
T-M-1	5.85	860	2.9%	90.0%	0.81	11	2.08	2.89	4.49	9.8	13.6	21.2
T-M-2	2.69	670	3.1%	90.0%	0.84	8	2.49	3.45	5.36	5.7	7.8	12.2
T-M-3	1.02	330	2.7%	90.0%	0.82	6	2.89	4.01	6.23	2.4	3.4	5.2
T-N-1	6.79	1000	2.5%	90.0%	0.81	12	1.95	2.70	4.20	10.8	14.9	23.2
T-O-1	10.09	160	15.0%	90.0%	0.57	5	3.43	4.74	7.38	19.6	27.1	42.2

NOTE 1: TEMPORARY SEDIMENT BASINS CONSTRUCTED DURING RECLAMATION PHASE ARE LOCATED IN THE ABOVE HIGHLIGHTED AREAS.

NOTE 2: PERMENANT DETENTION BASINS CONSTRUCTED DURING RECLAMATION PHASE, ARE NOTED WITH *T-X-X* DURING TENTATIVE PHASE.

NOTE 3: UNDERGROUND DETENTION BASINS CONSTRUCTED DURING THE TENTATIVE PHASE ARE NOTED WITH **T-X-X**.

NOTE 4: FOR CREEK AREAS R-G (RECLAMATION) & T-G-1 (TENTATIVE); Tc (MIN) = LENGTH OF FLOW (FT) / VELOCITY (FT/S) / 60 (S).

NOTE 5: VELOCITY FOR CREEK AREAS R-G & T-G-1 ARE CALCULATED USING FIGURE 3-7 FROM THE SAN DIEGO COUNTY HYDROLOGY MANUAL.

BDS Engineering, Inc.

CIVIL ENGINEERS

PROJECT: Stone Creek PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan DATE: 12/21/12 updated 11/13/18

R.C.E. NO.: ____________

Year Storm	P_6	P_{24}	P_6 / P_{24}
2	1.3	2.0	65.0%
10	1.8	3.5	51.4%
100	2.8	4.8	58.3%

$T_{c,\ MINIMUM}$ = 5 minutes

DRAINAGE AREA NO.	AREA (AC.)	LENGTH OF FLOW (FT.)	SLOPE (%)	PERCENT IMPERVIOUS	C	Tc (per att. chart)	I (per att. chart) 2	10	100	Q (CFS) 2	10	100
OFFSITE DRAINAGE												
OS-0	37.42	2325	0.7%	65.0%	0.71	38	0.92	1.27	1.98	24.4	33.7	52.5
OS-1	39.48	2480	0.6%	65.0%	0.71	42	0.87	1.21	1.88	24.4	33.7	52.5
OS-2	13.39	1400	0.9%	65.0%	0.71	27	1.14	1.58	2.46	10.8	15.0	23.3
OS-3	16.13	1210	3.1%	65.0%	0.71	17	1.56	2.17	3.37	17.9	24.7	38.4
OS-4	52.04	3000	0.9%	65.0%	0.71	40	0.89	1.24	1.93	32.9	45.6	70.9

100-YEAR TENTATIVE ULT PHASE		
STORMCAD SUMMARY		
OUTLET 1	135.20	CFS
OUTLET 2	91.60	CFS
OUTLET 3	49.00	CFS
OUTLET 4	195.00	CFS
OUTLET 5	41.10	CFS
OUTLET 6	33.80	CFS
OUTLET 7	22.90	CFS
OUTLET 8	19.60	CFS

DISCHARGES DIRECTLY TO CREEK		
(NO PIPE ROUTING)		
T-G-1	183.80	CFS
T-O-1	21.11	CFS
TOTAL	**204.92**	**CFS**

DISCHARGE SUMMARY FOR:				
RECLAMATION PHASE				
	2-YR	10-YR	100-YR	UNIT
PRE	89.1	123.4	191.98	CFS
POST	106.7	147.7	229.79	CFS
DIFF	**17.6**	**24.3**	**37.81**	**CFS**

DISCHARGE SUMMARY FOR:				
TENTATIVE PHASE (UNMITIGATED)				
	2-YR	10-YR	100-YR	UNIT
PRE	106.7	147.7	229.79	CFS
POST	217.3	300.9	468.08	CFS
DIFF	**110.6**	**153.2**	**238.3**	**CFS**

NOTE 1: PERMENANT DETENTION BASINS CONSTRUCTED DURING RECLAMATION PHASE, ARE NOTED WITH *T-X-X* DURING TENTATIVE PHASE.

NOTE 2: PERMENANT DETENTION BASINS CONSTRUCTED DURING THE TENTATIVE PHASE ARE NOTED WITH **T-X-X**.

NOTE 3: UNDERGROUND DETENTION BASINS CONSTRUCTED DURING THE TENTATIVE PHASE ARE NOTED WITH ***T-X-X***.

NOTE 4: RECLAMATION BASIN R-F SHALL BE REPLACED BY UNDERGROUND DETENTION BASIN T-F-3 IN THE TENTATIVE PHASE.

Appendix C: Runoff Coefficient Calculations

BDS Engineering, Inc.

CIVIL ENGINEERS

PROJECT: Stone Creek PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan DATE: December 21, 2012

URBAN RUNOFF COEFFICIENTS ARE BASED ON TABLE 3-1 OF THE COUNTY HYDROLOGY MANUAL

NATURAL (OPEN SPACE) = 0.35

MDR - MEDIUM DENSITY RESIDENTIAL 10.9 DU/A OR LESS = 0.60

PARK ASSUMED TO BE = 0.60

HDR - HIGH DENSITY RESIDENTIAL 24.0 DU/A OR LESS = 0.71

HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79

N. COM - MIXED USE COMMERCIAL/RESIDENTIAL = 0.79

O.P. COM - BUSINESS PARK / OFFICE PROFESSIONAL COMMERCIAL = 0.85

LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85

IMPERVIOUS = 0.90

FOR TENTATIVE PHASE RUNOFF COEFFICIENTS (C) REFER TO APPENDIX B - FLOW DATA CALCULATIONS.

TENTATIVE PHASE RUNOFF COEFFICIENTS (C) ARE CALCULATED USING FORMULA ON PAGE 3-5 IN THE SAN DIEGO COUNTY HYDROLOGY MANUAL PROVIDED IN APPENDIX A.

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
ULTIMATE DEVELOPMENT						
T-A-1-1	2.28	NATURAL	1.38	0.35	0.21	
		MDR	0.71	0.60	0.19	
		IMPERVIOUS	0.19	0.90	0.07	0.47
T-A-1-2	1.69	NATURAL	0.85	0.35	0.18	
		MDR	0.63	0.60	0.22	
		IMPERVIOUS	0.21	0.90	0.11	0.51
T-A-1-3	0.93	NATURAL	0.37	0.35	0.14	
		MDR	0.17	0.60	0.11	
		HDR	0.14	0.79	0.12	
		IMPERVIOUS	0.24	0.90	0.23	0.61
T-A-1-4	3.29	NATURAL	1.75	0.35	0.19	
		MDR	1.18	0.60	0.22	
		IMPERVIOUS	0.36	0.90	0.10	0.50
T-A-1-5	0.67	NATURAL	0.05	0.35	0.03	
		HDR	0.35	0.79	0.42	
		IMPERVIOUS	0.26	0.90	0.35	0.80
T-A-1-6	1.48	NATURAL	0.07	0.35	0.02	
		HDR	1.05	0.79	0.56	
		IMPERVIOUS	0.36	0.90	0.22	0.80
T-A-1-7	1.47	PARK	0.56	0.60	0.23	
		HDR	0.91	0.79	0.49	0.72
T-A-2-1	2.63	NATURAL	0.15	0.35	0.02	
		PARK	0.09	0.60	0.02	
		N. COM	0.31	0.79	0.09	
		HDR	1.32	0.79	0.40	
		IMPERVIOUS	0.76	0.90	0.26	0.79
T-A-2-2	3.03	NATURAL	1.63	0.35	0.19	
		HDR	0.99	0.79	0.26	
		IMPERVIOUS	0.41	0.90	0.12	0.57
T-A-2-3	2.79	NATURAL	1.49	0.35	0.19	
		HDR	0.94	0.79	0.27	
		IMPERVIOUS	0.36	0.90	0.12	0.57
T-A-2-4	3.20	NATURAL	1.88	0.35	0.21	
		HDR	1.01	0.79	0.25	
		IMPERVIOUS	0.31	0.90	0.09	0.54

BDS Engineering, Inc.

CIVIL ENGINEERS

PROJECT: Stone Creek PROJECT NO.: 04-23

ENGINEER: Armen Navasartyan DATE: December 21, 2012

URBAN RUNOFF COEFFICIENTS ARE BASED ON TABLE 3-1 OF THE COUNTY HYDROLOGY MANUAL

NATURAL (OPEN SPACE) = 0.35

MDR - MEDIUM DENSITY RESIDENTIAL 10.9 DU/A OR LESS = 0.60

PARK ASSUMED TO BE = 0.60

HDR - HIGH DENSITY RESIDENTIAL 24.0 DU/A OR LESS = 0.71

HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79

N. COM - MIXED USE COMMERCIAL/RESIDENTIAL = 0.79

O.P. COM - BUSINESS PARK / OFFICE PROFESSIONAL COMMERCIAL = 0.85

LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85

IMPERVIOUS = 0.90

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
T-A-2-5	1.76	PARK	0.95	0.60	0.32	
		N. COM	0.81	0.79	0.36	0.69
T-A-2-6	0.34	NATURAL	0.04	0.35	0.04	
		IMPERVIOUS	0.30	0.90	0.78	0.83
T-A-2-7	2.18	NATURAL	0.18	0.35	0.03	
		HDR	1.36	0.79	0.49	
		IMPERVIOUS	0.64	0.90	0.26	0.79
T-A-3-1	8.21	NATURAL	1.54	0.35	0.07	
		MDR	1.58	0.60	0.12	
		HDR	5.09	0.79	0.49	0.67
T-A-3-2	1.49	NATURAL	0.13	0.35	0.03	
		MDR	0.29	0.60	0.12	
		HDR	0.57	0.79	0.30	
		IMPERVIOUS	0.50	0.90	0.30	0.75
T-A-3-3	3.75	NATURAL	0.21	0.35	0.02	
		HDR	2.59	0.79	0.55	
		IMPERVIOUS	0.96	0.90	0.23	0.79
T-A-3-4	1.58	NATURAL	0.07	0.35	0.02	
		HDR	1.20	0.79	0.60	
		IMPERVIOUS	0.31	0.90	0.18	0.79
T-A-3-5	2.78	NATURAL	0.15	0.35	0.02	
		N. COM	1.34	0.79	0.38	
		HDR	0.55	0.79	0.16	
		IMPERVIOUS	0.74	0.90	0.24	0.80
T-A-3-6	2.89	NATURAL	0.31	0.35	0.04	
		HDR	1.54	0.79	0.42	
		IMPERVIOUS	1.04	0.90	0.32	0.78
T-A-4-1	1.47	NATURAL	0.05	0.35	0.01	
		HDR	1.15	0.79	0.62	
		IMPERVIOUS	0.27	0.90	0.17	0.80
T-A-4-2	0.21	NATURAL	0.04	0.35	0.06	
		IMPERVIOUS	0.17	0.90	0.74	0.80
T-A-4-3	2.78	NATURAL	1.26	0.35	0.16	
		HDR	1.27	0.79	0.36	
		IMPERVIOUS	0.25	0.90	0.08	0.60
T-A-4-4	2.50	NATURAL	0.95	0.35	0.13	
		HDR	1.15	0.79	0.36	
		IMPERVIOUS	0.40	0.90	0.14	0.64
T-A-4-5	2.14	NATURAL	0.07	0.35	0.01	
		HDR	1.72	0.79	0.64	
		IMPERVIOUS	0.35	0.90	0.15	0.79

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ENGINEER: Armen Navasartyan DATE: December 21, 2012

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NATURAL (OPEN SPACE) = 0.35

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PARK ASSUMED TO BE = 0.60

HDR - HIGH DENSITY RESIDENTIAL 24.0 DU/A OR LESS = 0.71

HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79

N. COM - MIXED USE COMMERCIAL/RESIDENTIAL = 0.79

O.P. COM - BUSINESS PARK / OFFICE PROFESSIONAL COMMERCIAL = 0.85

LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85

IMPERVIOUS = 0.90

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
T-A-4-6	1.23	NATURAL	0.18	0.35	0.05	
		HDR	0.73	0.79	0.47	
		IMPERVIOUS	0.33	0.90	0.24	0.76
T-A-4-7	0.97	NATURAL	0.16	0.35	0.06	
		HDR	0.35	0.79	0.28	
		IMPERVIOUS	0.46	0.90	0.43	0.77
T-A-4-8	0.94	NATURAL	0.18	0.35	0.07	
		HDR	0.27	0.79	0.22	
		IMPERVIOUS	0.49	0.90	0.47	0.76
T-A-4-9	0.62	NATURAL	0.13	0.35	0.07	
		IMPERVIOUS	0.50	0.90	0.72	0.79
T-A-4-10	1.08	NATURAL	0.05	0.35	0.02	
		HDR	0.75	0.79	0.55	
		IMPERVIOUS	0.28	0.90	0.23	0.80
T-A-4-11	3.38	NATURAL	0.35	0.35	0.04	
		PARK	0.15	0.60	0.03	
		HDR	2.04	0.79	0.48	
		IMPERVIOUS	0.84	0.90	0.22	0.76
T-A-4-12	1.14	NATURAL	0.07	0.35	0.02	
		HDR	0.75	0.79	0.52	
		IMPERVIOUS	0.32	0.90	0.26	0.79
T-A-4-13	0.60	NATURAL	0.15	0.35	0.09	
		IMPERVIOUS	0.45	0.90	0.67	0.76
T-A-4-14	7.91	NATURAL	0.56	0.35	0.02	
		PARK	0.93	0.60	0.07	
		N. COM	4.31	0.79	0.43	
		HDR	0.09	0.79	0.01	
		IMPERVIOUS	2.03	0.90	0.23	0.76
T-A-4-15	6.29	PARK	6.29	0.60	0.60	0.60
T-B-1	0.94	NATURAL	0.29	0.35	0.11	
		HDR	0.55	0.79	0.46	
		IMPERVIOUS	0.10	0.90	0.10	0.67
T-B-2	2.33	NATURAL	0.68	0.35	0.10	
		HDR	1.21	0.79	0.41	
		IMPERVIOUS	0.44	0.90	0.17	0.68
T-B-3	2.64	NATURAL	0.10	0.35	0.01	
		N. COM	1.98	0.79	0.59	
		IMPERVIOUS	0.56	0.90	0.19	0.80
T-B-4	1.28	N. COM	1.25	0.79	0.77	
		IMPERVIOUS	0.03	0.90	0.02	0.79

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HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79
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O.P. COM - BUSINESS PARK / OFFICE PROFESSIONAL COMMERCIAL = 0.85
LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85
IMPERVIOUS = 0.90

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
T-C-1	2.11	NATURAL	0.63	0.35	0.10	
		HDR	0.89	0.79	0.33	
		IMPERVIOUS	0.59	0.90	0.25	0.69
T-C-2	2.38	NATURAL	0.07	0.35	0.01	
		N. COM	1.62	0.79	0.54	
		IMPERVIOUS	0.69	0.90	0.26	0.81
T-C-3	2.18	NATURAL	0.10	0.35	0.02	
		N. COM	1.45	0.79	0.53	
		IMPERVIOUS	0.63	0.90	0.26	0.80
T-C-4	1.10	NATURAL	0.11	0.35	0.04	
		N. COM	0.40	0.79	0.29	
		IMPERVIOUS	0.59	0.90	0.48	0.80
T-C-5	5.93	N. COM	5.67	0.79	0.76	
		IMPERVIOUS	0.26	0.90	0.04	0.79
T-D-1	3.59	NATURAL	0.42	0.35	0.04	
		N. COM	0.47	0.79	0.10	
		IMPERVIOUS	2.70	0.90	0.68	0.82
T-D-2	3.32	N. COM	3.32	0.79	0.79	0.79
T-E-1	5.72	NATURAL	2.06	0.35	0.13	
		HDR	2.97	0.79	0.41	
		IMPERVIOUS	0.69	0.90	0.11	0.64
T-E-2	5.25	NATURAL	4.32	0.35	0.29	
		HDR	0.15	0.79	0.02	
		IMPERVIOUS	0.78	0.90	0.13	0.44
T-E-3	1.50	NATURAL	0.07	0.35	0.02	
		N. COM	0.74	0.79	0.39	
		IMPERVIOUS	0.69	0.90	0.41	0.82
T-E-4	6.00	NATURAL	0.67	0.35	0.04	
		HDR	4.71	0.79	0.62	
		IMPERVIOUS	0.62	0.90	0.09	0.75
T-F-1	3.18	NATURAL	0.20	0.35	0.02	
		PARK	0.49	0.60	0.09	
		N. COM	0.07	0.79	0.02	
		IMPERVIOUS	2.43	0.90	0.69	0.82
T-F-2	4.35	NATURAL	0.30	0.35	0.02	
		PARK	1.15	0.60	0.16	
		IMPERVIOUS	2.90	0.90	0.60	0.78

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URBAN RUNOFF COEFFICIENTS ARE BASED ON TABLE 3-1 OF THE COUNTY HYDROLOGY MANUAL

NATURAL (OPEN SPACE) = 0.35

MDR - MEDIUM DENSITY RESIDENTIAL 10.9 DU/A OR LESS = 0.60

PARK ASSUMED TO BE = 0.60

HDR - HIGH DENSITY RESIDENTIAL 24.0 DU/A OR LESS = 0.71

HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79

N. COM - MIXED USE COMMERCIAL/RESIDENTIAL = 0.79

O.P. COM - BUSINESS PARK / OFFICE PROFESSIONAL COMMERCIAL = 0.85

LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85

IMPERVIOUS = 0.90

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
T-F-3	10.92	NATURAL	0.06	0.35	0.00	
		PARK	9.06	0.60	0.50	
		N. COM	1.20	0.79	0.09	
		IMPERVIOUS	0.60	0.90	0.05	0.64
T-G-1	35.27	PARK	35.27	0.60	0.60	0.60
T-I-1	8.48	NATURAL	1.02	0.35	0.04	
		HDR	6.30	0.71	0.53	
		LIMITED I.	1.16	0.85	0.12	0.69
T-J-1	2.59	NATURAL	2.31	0.35	0.31	
		IMPERVIOUS	0.28	0.90	0.10	0.41
T-J-2	2.34	NATURAL	2.04	0.35	0.30	
		O.P. COM	0.07	0.85	0.03	
		IMPERVIOUS	0.23	0.90	0.09	0.42
T-J-3	6.43	NATURAL	0.60	0.35	0.03	
		O.P. COM	4.90	0.85	0.65	
		IMPERVIOUS	0.94	0.90	0.13	0.81
T-K-1	21.47	NATURAL	5.23	0.35	0.09	
		PARK	1.65	0.60	0.05	
		O.P. COM	2.12	0.85	0.08	
		LIMITED I.	8.76	0.85	0.35	
		IMPERVIOUS	3.71	0.90	0.16	0.72
T-K-2	7.91	NATURAL	2.43	0.35	0.11	
		LIMITED I.	4.41	0.85	0.47	
		IMPERVIOUS	1.07	0.90	0.12	0.70
T-K-3	5.85	NATURAL	0.40	0.35	0.02	
		PARK	0.81	0.60	0.08	
		LIMITED I.	3.05	0.85	0.44	
		IMPERVIOUS	1.59	0.90	0.24	0.80
T-L-1	5.68	HDR	5.24	0.71	0.66	
		LIMITED I.	0.44	0.85	0.07	0.72
T-L-2	0.28	NATURAL	0.06	0.35	0.08	
		IMPERVIOUS	0.22	0.90	0.71	0.78
T-L-3	7.64	NATURAL	2.44	0.35	0.11	
		LIMITED I.	4.39	0.85	0.49	
		IMPERVIOUS	0.81	0.90	0.10	0.70

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NATURAL (OPEN SPACE) = 0.35

MDR - MEDIUM DENSITY RESIDENTIAL 10.9 DU/A OR LESS = 0.60

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HDR - HIGH DENSITY RESIDENTIAL 24.0 DU/A OR LESS = 0.71

HDR - HIGH DENSITY RESIDENTIAL 43.0 DU/A OR LESS = 0.79

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LIMITED I. - LIGHT / LIMITED INDUSTRIAL = 0.85

IMPERVIOUS = 0.90

DRAINAGE SUB-AREA	TOTAL AREA (AC)	LAND USE TYPE	AREA (AC)	RUNOFF COEFFICIENT	WEIGHTED AVG COEFFICIENT	AVG RUNOFF COEFFICIENT
T-L-4	7.86	NATURAL	1.87	0.35	0.08	
		PARK	1.59	0.60	0.12	
		LIMITED I.	3.51	0.85	0.38	
		IMPERVIOUS	0.89	0.90	0.10	0.69
T-L-5	1.50	NATURAL	0.06	0.35	0.01	
		PARK	0.09	0.60	0.04	
		LIMITED I.	1.20	0.85	0.68	
		IMPERVIOUS	0.16	0.90	0.10	0.82
T-M-1	5.85	NATURAL	0.30	0.35	0.02	
		PARK	0.74	0.60	0.08	
		LIMITED I.	3.07	0.85	0.45	
		IMPERVIOUS	1.74	0.90	0.27	0.81
T-M-2	2.69	NATURAL	0.14	0.35	0.02	
		LIMITED I.	1.44	0.85	0.45	
		IMPERVIOUS	1.11	0.90	0.37	0.84
T-M-3	1.02	NATURAL	0.11	0.35	0.04	
		LIMITED I.	0.37	0.85	0.31	
		IMPERVIOUS	0.54	0.90	0.48	0.82
T-N-1	6.79	NATURAL	0.34	0.35	0.02	
		PARK	0.44	0.60	0.04	
		LIMITED I.	5.27	0.85	0.66	
		IMPERVIOUS	0.74	0.90	0.10	0.81
T-O-1	10.08	NATURAL	1.35	0.35	0.05	
		PARK	8.73	0.60	0.52	0.57

Appendix D: Sediment Basin Calculations

SEDIMENT BASIN CALCULATIONS

Q = CIA

As = 1.2Q/Vs

Trapezoidal Volume (CF): V = ((Area + Top Area) / 2) * Depth

Design Calculations are based on SE-2 in the CASQA BMP Construction Handbook (January 2011)

Sediment Basin Area	Pervious Area	Runoff C	Intensity I	Flow Q	Vs	As	Width	Length	Area	Top Area	Depth	Volume
(Reclamation Phase)	(AC)	(Unitless)	(IN/HR)	(CFS)	(FT/S)	(SF)	(FT)	(FT)	(SF)	(SF)	(FT)	(CF)
R-B	9.97	0.35	1.80	6.28	0.00118	6387.56	50.00	140.00	7000.00	14104.00	4.00	42208.00
R-C	13.46	0.35	1.80	8.48	0.00118	8623.53	45.00	200.00	9000.00	17864.00	4.00	53728.00
R-E	5.63	0.35	1.80	3.55	0.00118	3607.02	40.00	100.00	4000.00	9504.00	4.00	27008.00
R-I	9.57	0.35	1.80	6.03	0.00118	6131.29	50.00	140.00	7000.00	14104.00	4.00	42208.00
R-J	11.40	0.35	1.80	7.18	0.00118	7303.73	50.00	150.00	7500.00	14924.00	4.00	44848.00
R-K	35.24	0.35	1.80	22.20	0.00118	22577.49	100.00	230.00	23000.00	34584.00	4.00	115168.00

SEDIMENT BASIN CALCULATIONS

$Q = BC'A(2gH)^{0.5}$

BOTTOM ROW	UNITS	Basin R-B	Basin R-C	Basin R-E	Basin R-I	Basin R-J	Basin R-K
Q - Outflow Rate	(CFS)	0.088	0.088	0.050	0.088	0.088	0.196
Q_{total} - 2 Orifices per row	(CFS)	0.177	0.177	0.100	0.177	0.177	0.392
C' - Orifice Coefficient	(Unitless)	0.60	0.60	0.60	0.60	0.60	0.60
A - Area of Orifice	(SF)	0.022	0.022	0.012	0.022	0.022	0.049
g - gravity acceleration	(FT/S^2)	32.20	32.20	32.20	32.20	32.20	32.20
H - Head above Orifice	(FT)	2.83	2.83	2.88	2.83	2.83	2.75
B - Blockage Factor	(Unitless)	0.50	0.50	0.50	0.50	0.50	0.50
Orifice Diameter	(INCH)	2.00	2.00	1.50	2.00	2.00	3.00

MIDDLE ROW	UNITS	Basin R-B	Basin R-C	Basin R-E	Basin R-I	Basin R-J	Basin R-K
Q - Outflow Rate	(CFS)	0.076	0.076	0.043	0.076	0.076	0.167
Q_{total} - 2 Orifices per row	(CFS)	0.152	0.152	0.086	0.152	0.152	0.334
C' - Orifice Coefficient	(Unitless)	0.60	0.60	0.60	0.60	0.60	0.60
A - Area of Orifice	(SF)	0.022	0.022	0.012	0.022	0.022	0.049
g - gravity acceleration	(FT/S^2)	32.20	32.20	32.20	32.20	32.20	32.20
H - Head above Orifice	(FT)	2.08	2.08	2.13	2.08	2.08	2.00
B - Blockage Factor	(Unitless)	0.50	0.50	0.50	0.50	0.50	0.50
Orifice Diameter	(INCH)	2.00	2.00	1.50	2.00	2.00	3.00

TOP ROW	UNITS	Basin R-B	Basin R-C	Basin R-E	Basin R-I	Basin R-J	Basin R-K
Q - Outflow Rate	(CFS)	0.061	0.061	0.035	0.061	0.061	0.132
Q_{total} - 2 Orifices per row	(CFS)	0.121	0.121	0.069	0.121	0.121	0.264
C' - Orifice Coefficient	(Unitless)	0.60	0.60	0.60	0.60	0.60	0.60
A - Area of Orifice	(SF)	0.022	0.022	0.012	0.022	0.022	0.049
g - gravity acceleration	(FT/S^2)	32.20	32.20	32.20	32.20	32.20	32.20
H - Head above Orifice	(FT)	1.33	1.33	1.38	1.33	1.33	1.25
B - Blockage Factor	(Unitless)	0.50	0.50	0.50	0.50	0.50	0.50
Orifice Diameter	(INCH)	2.00	2.00	1.50	2.00	2.00	3.00

DRAWDOWN TIME	UNITS	Basin R-B	Basin R-C	Basin R-E	Basin R-I	Basin R-J	Basin R-K
Top Volume	(CF)	18978.00	24123.00	12528.00	18978.00	20118.00	48438.00
Outflow Rate 6 Orifices	(CFS)	0.450	0.450	0.256	0.450	0.450	0.990
Top Drawdown Time	(Hours)	11.72	14.90	13.61	11.72	12.43	13.58
Middle Volume	(CF)	7896.00	10097.25	5008.50	7896.00	8398.50	21681.00
Outflow Rate 4 Orifices	(CFS)	0.328	0.328	0.186	0.328	0.328	0.726
Middle Drawdown Time	(Hours)	6.68	8.54	7.47	6.68	7.10	8.29
Bottom Volume	(CF)	6915.00	8868.75	4252.50	6915.00	7372.50	20070.00
Outflow Rate 2 Orifices	(CFS)	0.177	0.177	0.100	0.177	0.177	0.392
Bottom Drawdown Time	(Hours)	10.86	13.93	11.79	10.86	11.58	14.22
Total Drawdown Time	(Hours)	29.26	37.37	32.87	29.26	31.11	36.10

Note: Q and Orifice sizing based on CASQA BMP Construction Handbook (January 2011)

Volumes for drawdown times have been separated into 3 Rows: Top Row, Middle Row, and Bottom Row.

Trapezoidal Volume: $V = LWH + 4LH^2 + 4wh^2 + 32H^3$: L = Length, W = Width, and H = Height of Basin Area.

Drawdown time is calculated using these 3 separate volumes and their corresponding outflow rates.

Appendix E: Detention Basin Calculations

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN SUMMARY   PROJECT NO.: 04-23

ENGINEER: Tara Mugane   DATE: March 26, 2019

R.C.E. NO.:

BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH METHOD FOR A 100 YEAR STORM EVENT

BASIN	LENGTH FT	WIDTH FT	REQ. DEPTH	REQ. VOLUME	ACTUAL DEPTH	ACTUAL VOLUME	FB+D FT	PRE Q CFS	POST Q CFS	DIFF CFS
T-A-1	70	70	2.82	13,830	6.50	31,850	8.00	13.0	27.1	14.1
T-A-2	90	80	0.8	5,788	6.50	46,800	8.00	17.5	21.7	4.2
T-A-3	80	120	0.9	8,668	6.50	62,400	8.00	22.8	29.4	6.6
T-A-4	170	100	1.2	20,751	6.50	110,500	8.00	36.6	51.6	15.0
T-D-2	70	70	1.8	8,819	4.00	30,608	5.50	11.2	16.6	5.4
T-F-3	275	220	1.5	92,622	6.50	393,250	8.00	56.5	98.1	41.6
T-L-1	90	90	1.1	9,128	4.00	45,968	5.50	13.5	16.6	3.1
T-M-1	95	60	2.0	11,299	4.00	34,768	5.50	7.4	14.4	7.0
T-N-1	65	20	1.9	2,478	4.00	12,688	5.50	5.3	6.5	1.2

-

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-A-1 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ________ **100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6=	2.8
Time of concentration (min.)	T_c=	14.5
Coefficient of runoff	C=	0.43
Basin area (acres)	A=	11.80

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ — T_p= 16.08

Time of hydrograph to begin

$T_B = 20 - T_p$ — T_B= 3.92

Time of hydrograph to end

$T_E = 20 + 1.5 T_p$ — T_E= 44.11

Peak flow

$Q_p = CIA$ — Q_p= 18.6

$I_{Tc} = 7.44\ P_6 / T_c^{0.645}$ = 3.71 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6$ = 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83$ = 1.24 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

I_s = 0.47 in/hr

$Q_s = C I_s A$ — Q_s= 2.4

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 18.7 min

$I = 7.44\ P_6 / T_c^{0.645}$ = 3.15 in/hr

$Q_N = CIA$ — Q_N= 13.0

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet — Vol= **5926**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-A-2 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ______________

100 YEAR STORM EVENT

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6=	2.8
Time of concentration (min.)	T_c=	14.1
Coefficient of runoff	C=	0.62
Basin area (acres)	A=	15.93

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ T_p= 15.61

Time of hydrograph to begin

$T_B = 20 - T_p$ T_B= 4.39

Time of hydrograph to end

$T_E = 20 + 1.5 T_p$ T_E= 43.42

Peak flow

$Q_p = CIA$ Q_p= 37.3

$I_{Tc} = 7.44\ P_6 / T_c^{0.645}$ = 3.78 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6$ = 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83$ = 1.23 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

I_s = 0.48 in/hr

$Q_s = C I_s A$ Q_s= 4.7

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 18.7 min

$I = 7.44\ P_6 / T_c^{0.645}$ = 3.15 in/hr

$Q_N = CIA$ Q_N= 17.5

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **20262**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-A-3 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ____________

100 YEAR STORM EVENT

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	$P_6=$	2.8
Time of concentration (min.)	$T_c=$	9.2
Coefficient of runoff	C=	0.74
Basin area (acres)	A=	20.70

COMPUTATION

Time to peak

$T_p=2.0T_cK_D / (1 + K_p) = 1.1072T_c$ $T_p=$ 10.20

Time of hydrograph to begin

$T_B = 20 - T_p$ $T_B=$ 9.80

Time of hydrograph to end

$T_E = 20 + 1.5T_p$ $T_E=$ 35.30

Peak flow

$Q_p=CIA$ $Q_p=$ 76.2

$I_{Tc} = 7.44\ P_6 / T_c^{0.645} =$ 4.97 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6 =$ 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6T_c^{0.355}) / 5.83 =$ 1.06 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

$I_s =$ 0.52 in/hr

$Q_s = CI_sA$ $Q_s=$ 8.0

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 $T_c=$ 18.7 min

$I= 7.44\ P_6 / T_c^{0.645} =$ 3.15 in/hr

$Q_N=CIA$ $Q_N=$ 22.8

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **36571**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-A-4 ULTIMATE   PROJECT NO.: 04-23

ENGINEER: T. MUGANE   DATE: 1/28/18

R.C.E. NO.: ____________   **100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6=	2.8
Time of concentration (min.)	T_c=	14.5
Coefficient of runoff	C=	0.71
Basin area (acres)	A=	33.23

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ T_p= 16.05

Time of hydrograph to begin

$T_B = 20 - T_p$ T_B= 3.95

Time of hydrograph to end

$T_E = 20 + 1.5 T_p$ T_E= 44.08

Peak flow

Q_p=CIA Q_p= 87.6

$I_{Tc} = 7.44 \, P_6 / T_c^{0.645}$ = 3.71 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44 \, P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785 \, P_6$ = 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83$ = 1.24 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5 \, T_c)$

I_s = 0.47 in/hr

$Q_s = C I_s A$ Q_s= 11.1

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 18.7 min

$I = 7.44 \, P_6 / T_c^{0.645}$ = 3.15 in/hr

Q_N=CIA Q_N= 36.6

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet   Vol= **53603**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-D-2 ULTIMATE   PROJECT NO.: 04-23

ENGINEER: T. MUGANE   DATE: 1/28/18

R.C.E. NO.: ______   **100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches) $P_6=$ 2.8

Time of concentration (min.) $T_c=$ 9.9

Coefficient of runoff C= 0.80

Basin area (acres) A= 12.84

COMPUTATION

Time to peak

$T_p=2.0T_cK_D / (1 + K_p) = 1.1072T_c$ $T_p=$ 10.93

Time of hydrograph to begin

$T_B = 20 - T_p$ $T_B=$ 9.07

Time of hydrograph to end

$T_E = 20 + 1.5T_p$ $T_E=$ 36.39

Peak flow

Q_p=CIA $Q_p=$ 48.9

$I_{Tc} = 7.44\ P_6 / T_c^{0.645} =$ 4.76 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6 =$ 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6T_c^{0.355}) / 5.83 =$ 1.08 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

$I_s =$ 0.51 in/hr

$Q_s = CI_sA$ $Q_s=$ 5.3

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 $T_c=$ 27.1 min

$I= 7.44\ P_6 / T_c^{0.645} =$ 2.48 in/hr

Q_N=CIA $Q_N=$ 11.2

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **27571**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-F-3 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ____________

100 YEAR STORM EVENT

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6=	2.8
Time of concentration (min.)	T_c=	21.1
Coefficient of runoff	C=	0.70
Basin area (acres)	A=	98.48

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ T_p= 23.36

Time of hydrograph to begin

$T_B = 20 - T_p$ T_B= -3.36

Time of hydrograph to end

$T_E = 20 + 1.5T_p$ T_E= 55.04

Peak flow

Q_p=CIA Q_p= 200.9

$I_{Tc} = 7.44\ P_6 / T_c^{0.645}$ = 2.91 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6$ = 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83$ = 1.42 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

I_s = 0.43 in/hr

$Q_s = CI_sA$ Q_s= 29.6

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 51.4 min

$I = 7.44\ P_6 / T_c^{0.645}$ = 1.64 in/hr

Q_N=CIA Q_N= 56.5

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **215653**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-L-1 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ____________ **100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	$P_6=$	2.8
Time of concentration (min.)	$T_c=$	26.8
Coefficient of runoff	C=	0.71
Basin area (acres)	A=	22.99

COMPUTATION

Time to peak

$T_p=2.0T_cK_D / (1 + K_p) = 1.1072T_c$ $T_p=$ 29.67

Time of hydrograph to begin

$T_B = 20 - T_p$ $T_B=$ -9.67

Time of hydrograph to end

$T_E = 20 + 1.5T_p$ $T_E=$ 64.51

Peak flow

Q_p=CIA $Q_p=$ 40.8

$I_{Tc} = 7.44\ P_6 / T_c^{0.645} =$ 2.50 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6 =$ 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6T_c^{0.355}) / 5.83 =$ 1.54 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

$I_s =$ 0.40 in/hr

$Q_s = CI_sA$ $Q_s=$ 6.6

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 $T_c=$ 49.6 min

$I= 7.44\ P_6 / T_c^{0.645} =$ 1.68 in/hr

Q_N=CIA $Q_N=$ 13.5

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **50869**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT:	STONE CREEK - BASIN T-M-1 Ultimate	PROJECT NO.:	04-23
ENGINEER:	T. MUGANE	DATE:	1/28/18
R.C.E. NO.:			**100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6= 2.8
Time of concentration (min.)	T_c= 11.6
Coefficient of runoff	C= 0.82
Basin area (acres)	A= 9.56

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ — T_p= 12.88

Time of hydrograph to begin

$T_B = 20 - T_p$ — T_B= 7.12

Time of hydrograph to end

$T_E = 20 + 1.5 T_p$ — T_E= 39.32

Peak flow

Q_p=CIA — Q_p= 33.5

$I_{Tc} = 7.44\ P_6 / T_c^{0.645} =$ 4.28 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6 =$ 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83 =$ 1.15 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

$I_s =$ 0.50 in/hr

$Q_s = C I_s A$ — Q_s= 3.9

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 32.5 min

I= $7.44\ P_6 / T_c^{0.645} =$ 2.21 in/hr

Q_N=CIA — Q_N= 7.4

RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet — Vol= **22336**

BDS Engineering, Inc.
CIVIL ENGINEERS

PROJECT: STONE CREEK - BASIN T-N-1 ULTIMATE PROJECT NO.: 04-23

ENGINEER: T. MUGANE DATE: 1/28/18

R.C.E. NO.: ____________ **100 YEAR STORM EVENT**

DETENTION BASIN STORAGE COMPUTATION, SINGLE HYDROGRAPH FROM

INPUT VARIABLES (URBAN CONDITIONS)

Six hour precipitation amount (inches)	P_6=	2.8
Time of concentration (min.)	T_c=	12.3
Coefficient of runoff	C=	0.81
Basin area (acres)	A=	6.79

COMPUTATION

Time to peak

$T_p = 2.0 T_c K_D / (1 + K_p) = 1.1072 T_c$ T_p= 13.62

Time of hydrograph to begin

$T_B = 20 - T_p$ T_B= 6.38

Time of hydrograph to end

$T_E = 20 + 1.5 T_p$ T_E= 40.43

Peak flow

Q_p=CIA Q_p= 22.7

$I_{Tc} = 7.44\ P_6 / T_c^{0.645}$ = 4.13 in/hr

Surrounding Flow (Q_s)

Depth of precipitation for 2 hours

$D_{120} = 7.44\ P_6 / 120^{0.645}$ (2hr)

$D_{120} = 0.6785\ P_6$ = 1.90 in

Depth of Precepitation for hydrograph

$D_H = (P_6 T_c^{0.355}) / 5.83$ = 1.17 in.

Surrounding intensity

$I_s = 60(D_{120} - D_H) / (120 - 2.5\ T_c)$

I_s = 0.49 in/hr

$Q_s = C I_s A$ Q_s= 2.7

PLOT HYDROGRAPH AND SURROUNDING FLOW

OUTFLOW / BASIN SIZE (NATURAL CONDITIONS)

Outflow

C= 0.35 T_c= 31.7 min

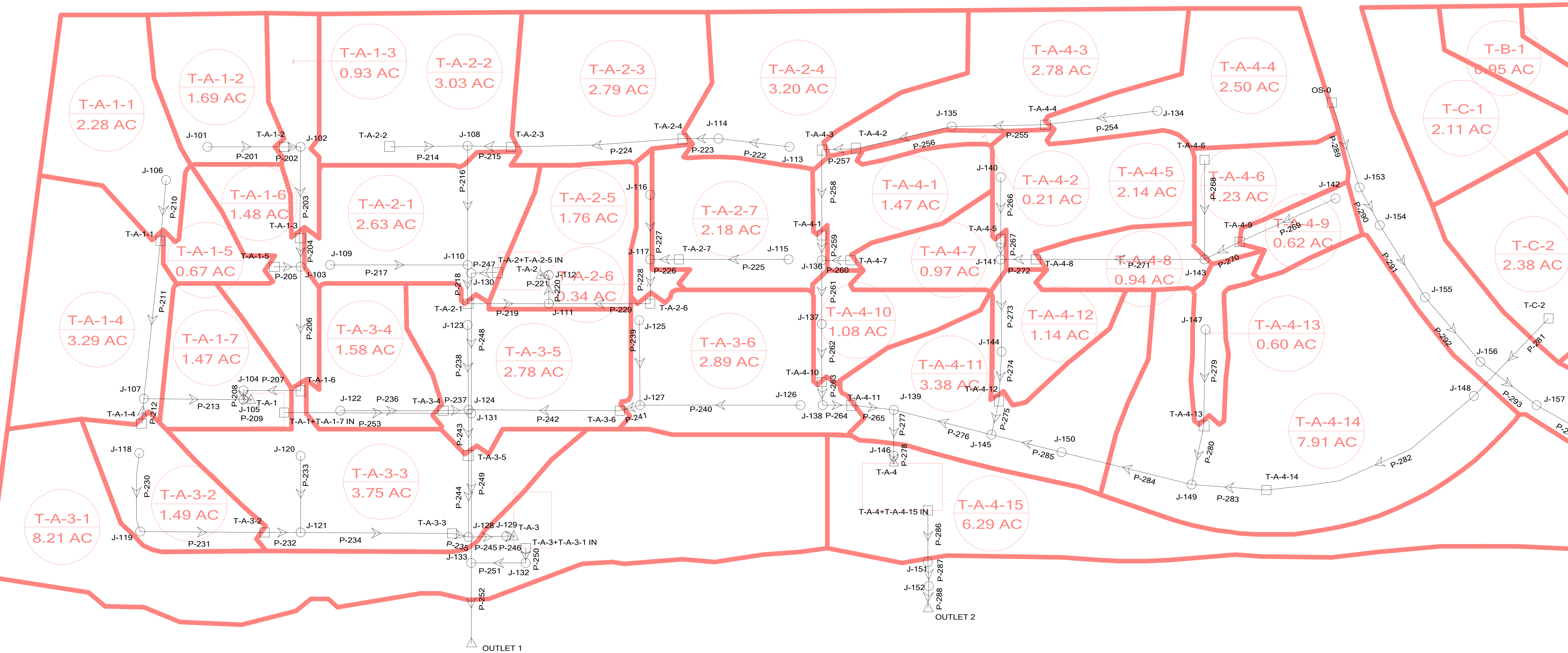
$I = 7.44\ P_6 / T_c^{0.645}$ = 2.24 in/hr

Q_N=CIA Q_N= 5.3

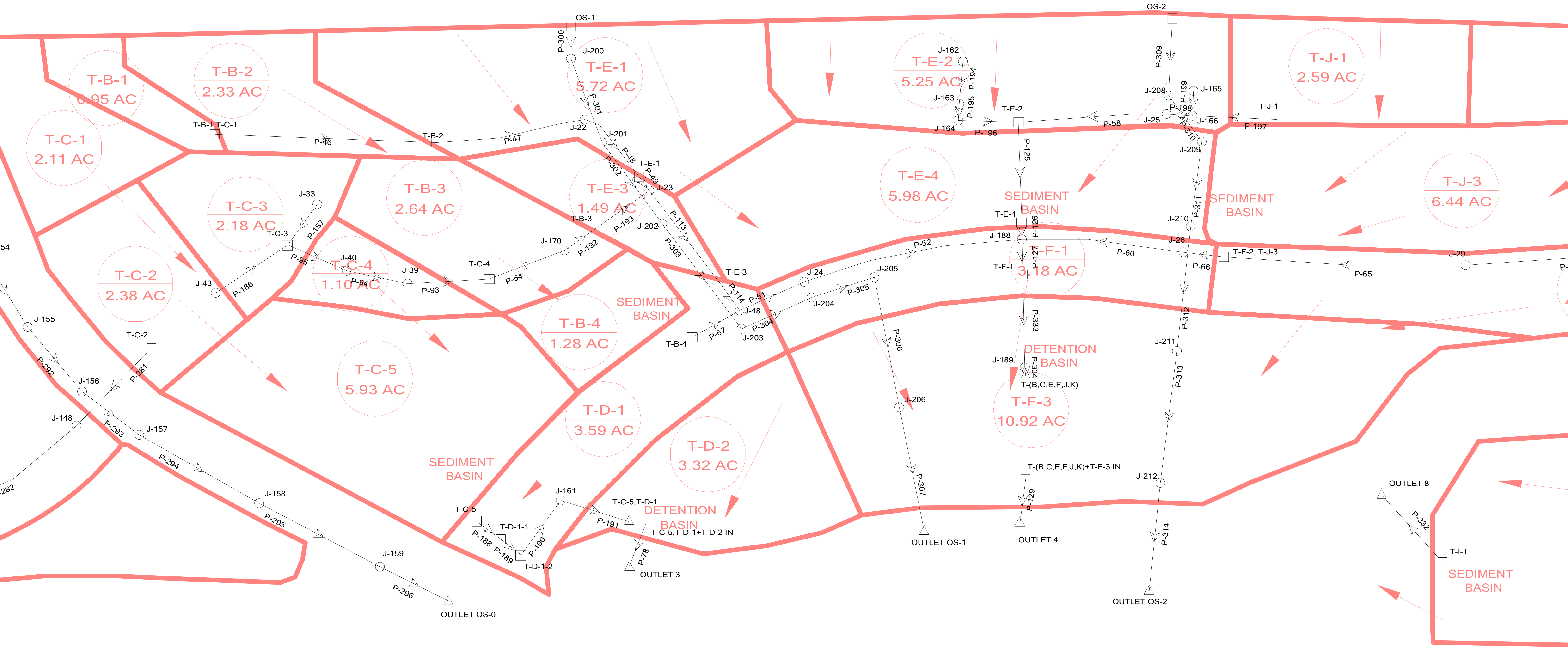
RESERVOIR VOLUME ABOVE Q_s LEVEL, Cubic feet Vol= **15637**

Appendix F: Storm CAD Calculations

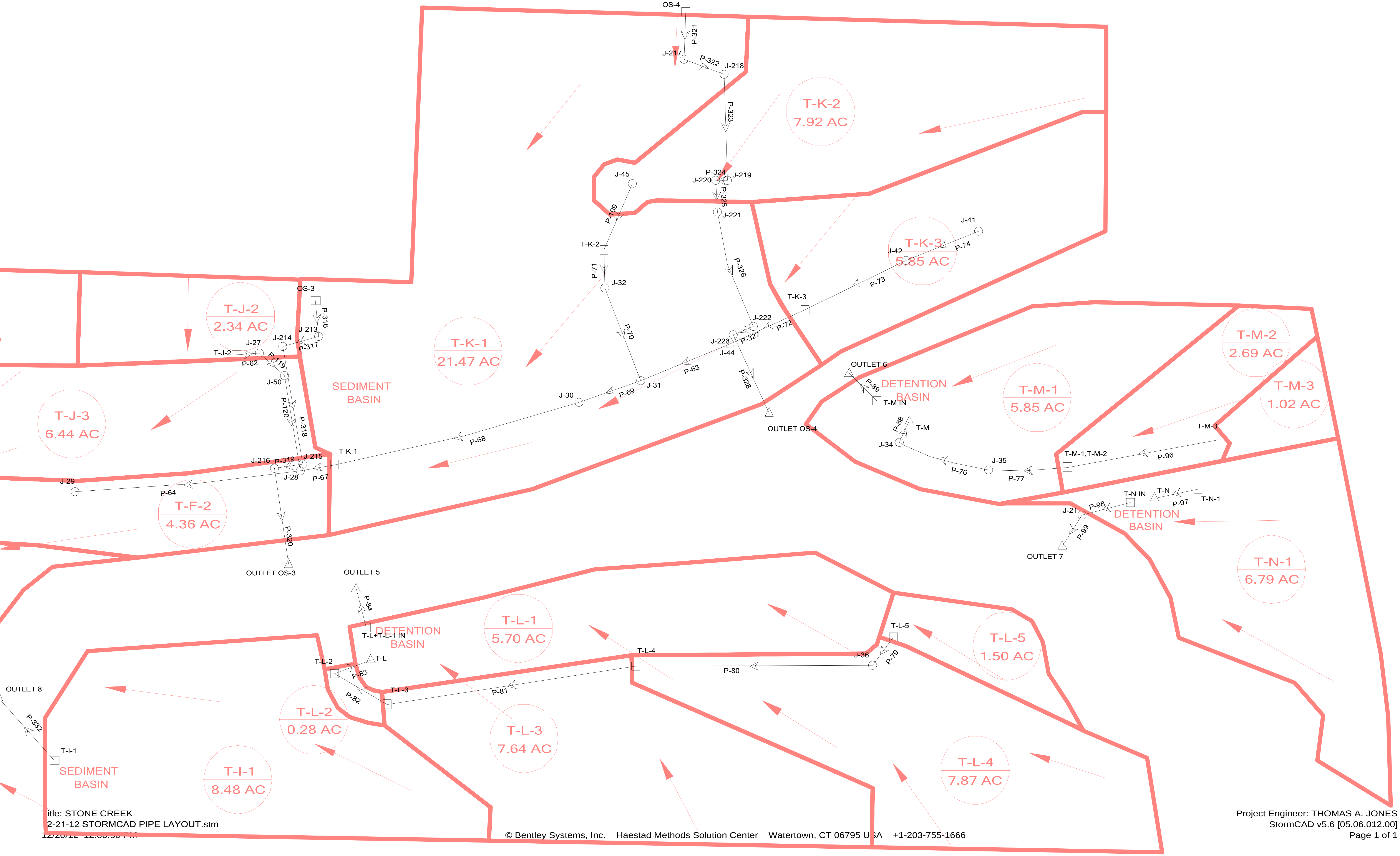
Scenario: Base



Scenario: Base



Scenario: Base



Title: STONE CREEK
12-21-12 STORMCAD PIPE LAYOUT.stm

Project Engineer: THOMAS A. JONES
StormCAD v5.6 [05.06.012.00]

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM NODE REPORT

Label	Area (acres)	Inlet C	System CA (acres)	Time of Concentration (min)	Total Flow (cfs)	Ground Elevation (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
OUTLET 3			2.62		49.04	340.00	335.35	335.35
T-C-5,T-D-1+T-D-2 IN	3.32	0.79	2.62	8.00	49.16	351.95	338.76	338.76
T-(B,C,E,F,J,K)			60.05		176.64	357.33	348.78	348.78
J-189			60.05		176.77	357.51	354.01	352.96
J-24			14.31		50.46	362.56	359.74	359.66
T-B-4	1.28	0.79	1.01	6.00	6.69	360.50	360.14	360.08
T-K-2	7.92	0.70	5.54	16.00	19.47	389.45	384.52	384.16
J-32			5.54		19.29	388.30	383.51	383.02
J-31			10.22		34.83	385.85	381.19	380.53
J-30			10.22		34.55	384.10	378.11	377.70
T-K-1	21.47	0.72	25.68	15.00	83.75	377.29	373.88	371.57
J-26			35.27		108.02	364.25	360.74	360.39
T-F-2, T-J-3	10.79	0.80	35.27	17.00	108.77	365.00	361.73	361.01
J-29			26.67		84.40	370.25	363.75	363.33
J-28			26.67		86.74	376.34	369.18	368.05
J-45			0.00		0.00	393.04	384.52	384.52
T-E-3	1.49	0.82	13.30	8.00	49.03	364.00	360.30	360.06
J-23			12.07		45.14	369.52	363.14	362.51
T-E-1	5.72	0.64	7.34	12.00	27.50	371.25	368.87	367.57
J-22			3.68		13.91	381.87	375.98	375.44
T-B-2	2.33	0.68	3.68	12.00	14.17	395.00	390.01	389.41
T-B-1,T-C-1	3.06	0.68	2.09	13.00	8.40	405.58	400.81	400.32
J-48			14.31		52.10	362.50	359.98	359.84
J-50			0.98		4.09	377.25	372.38	372.19
J-27			0.98		4.12	378.27	374.89	374.62
T-J-2	2.34	0.42	0.98	12.00	4.16	379.42	375.42	375.14
J-25			1.06		4.29	375.19	362.14	362.08
T-E-2	5.25	0.44	3.37	15.00	12.34	372.44	361.56	361.34
T-B-3	2.64	0.80	4.74	10.00	21.91	372.69	367.52	366.57
T-C-3	2.18	0.80	1.74	6.00	11.53	392.20	384.42	383.79
J-40			1.74		11.28	387.19	380.05	379.59
J-39			1.74		11.05	382.24	376.03	375.58
T-C-4	1.10	0.80	2.62	10.00	12.48	377.13	373.21	372.33
J-43			0.00		0.00	387.67	384.42	384.42
J-33			0.00		0.00	395.18	387.50	387.50
J-164			0.00		0.00	373.43	369.82	369.82
J-163			0.00		0.00	373.67	370.17	370.17
J-162			0.00		0.00	404.50	396.50	396.50
J-166			1.06		4.37	374.97	362.32	362.24
T-J-1	2.59	0.41	1.06	12.00	4.49	374.25	363.58	363.31
J-165			0.00		0.00	379.00	371.50	371.50
J-170			2.62		12.26	373.42	368.08	367.76
J-44			4.68		21.83	389.31	387.45	386.98
T-K-3	5.85	0.80	4.68	10.00	22.26	393.73	391.38	390.41
J-42			0.00		0.00	401.30	393.70	393.70
J-41			0.00		0.00	409.44	402.20	402.20
T-E-4	5.98	0.75	7.86	15.00	27.68	362.69	360.71	359.86
T-F-1	3.18	0.82	60.05	12.00	178.37	360.65	356.99	355.62
J-188			57.44		171.23	361.59	359.35	357.55
OUTLET 1			7.77		135.18	310.00	301.00	301.00
J-133			7.77		135.38	332.26	317.74	316.14
J-131			2.27		66.21	339.98	335.52	332.94
J-130			1.21		39.43	352.64	339.06	338.26

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM NODE REPORT

Label	Area (acres)	Inlet C	System CA (acres)	Time of Concentration (min)	Total Flow (cfs)	Ground Elevation (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
T-A-2+T-A-2-5 IN	1.76	0.69	1.21	10.00	39.45	353.49	339.57	339.57
J-132			5.50		71.19	331.24	319.00	318.32
T-A-3+T-A-3-1 IN	8.21	0.67	5.50	13.00	71.27	331.69	319.15	319.15
T-A-1+T-A-1-7 IN	1.47	0.72	1.06	9.00	27.15	347.75	337.18	337.18
T-A-1			5.87		23.00	350.30	341.47	341.47
J-105			5.87		23.02	350.73	344.63	343.72
J-107			2.72		10.83	354.72	349.72	349.33
T-A-1-1	2.28	0.47	1.07	12.00	4.53	361.00	357.65	357.32
J-106			0.00		0.00	363.90	359.40	359.40
J-104			3.15		14.52	351.36	344.98	344.71
T-A-1-6	1.48	0.80	3.15	6.00	14.92	348.41	345.85	345.50
J-103			1.97		9.58	355.83	352.34	351.94
T-A-1-3	0.93	0.61	1.43	8.00	7.02	357.38	354.37	353.91
T-A-1-2	1.69	0.51	0.86	9.00	4.39	362.50	358.92	358.59
J-101			0.00		0.00	363.89	359.39	359.39
J-102			0.86		4.35	362.25	358.50	358.24
T-A-1-5	0.67	0.80	0.54	7.00	3.21	356.55	352.97	352.73
T-A-1-4	3.29	0.50	1.65	13.00	6.60	353.65	350.54	350.14
T-A-2			9.13		34.82	354.95	342.78	342.78
J-112			9.13		34.86	355.17	346.04	345.20
J-111			9.13		35.08	352.84	347.18	346.48
J-108			5.05		20.14	361.82	356.58	355.81
T-A-2-3	2.79	0.57	3.32	10.00	13.37	362.45	357.29	356.72
T-A-2-4	3.20	0.54	1.73	12.00	7.31	364.53	361.08	360.60
J-114			0.00		0.00	364.80	361.08	361.08
T-A-2-2	3.03	0.57	1.73	11.00	7.72	362.50	359.53	359.08
J-109			0.00		0.00	356.25	351.75	351.75
J-110			5.05		19.79	353.08	350.27	349.68
T-A-2-6	0.34	0.83	2.00	6.00	11.65	355.55	352.45	351.65
T-A-2-1	2.63	0.79	7.13	10.00	27.79	350.00	348.46	347.96
J-113			0.00		0.00	367.68	363.18	363.18
J-117			1.72		10.15	358.30	355.13	354.53
J-116			0.00		0.00	361.70	357.20	357.20
T-A-2-7	2.18	0.79	1.72	7.00	10.31	358.53	356.24	355.71
J-115			0.00		0.00	364.19	359.69	359.69
T-A-3			9.81		49.18	331.22	321.26	321.26
J-129			9.81		49.26	330.51	324.27	323.71
T-A-3-3	3.75	0.79	4.08	9.00	20.77	328.93	325.69	325.22
J-121			1.12		6.07	339.70	335.87	335.57
T-A-3-2	1.49	0.75	1.12	8.00	6.14	342.20	339.07	338.66
J-119			0.00		0.00	349.72	345.22	345.22
J-128			9.81		49.71	329.23	325.32	324.53
T-A-3-5	2.78	0.80	5.73	8.00	29.90	335.95	333.22	332.31
J-124			3.50		18.45	339.87	336.43	335.83
T-A-3-4	1.58	0.79	1.25	7.00	7.47	340.11	337.55	337.06
T-A-3-6	2.89	0.78	2.25	8.00	12.38	347.20	344.01	343.47
J-127			0.00		0.00	348.25	344.01	344.01
J-118			0.00		0.00	352.30	347.80	347.80
J-120			0.00		0.00	344.56	340.06	340.06
J-122			0.00		0.00	345.00	340.50	340.50
J-123			0.00		0.00	348.04	343.54	343.54
J-125			0.00		0.00	353.83	349.33	349.33
J-126			0.00		0.00	357.86	353.36	353.36

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM NODE REPORT

Label	Area (acres)	Inlet C	System CA (acres)	Time of Concentration (min)	Total Flow (cfs)	Ground Elevation (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
T-A-4			21.92		81.96	356.65	343.81	343.81
J-146			21.92		82.01	357.38	348.42	347.31
J-139			21.92		82.26	363.16	354.97	353.18
J-145			13.13		65.89	368.20	359.08	357.65
J-149			8.40		45.21	369.30	361.70	361.20
T-A-4-14	7.91	0.76	7.94	8.00	43.60	367.00	363.60	362.59
T-A-4-13	0.60	0.76	0.46	6.00	3.01	375.58	371.99	371.74
J-148			1.93		12.18	387.70	373.02	372.75
T-C-2	2.38	0.81	1.93	6.00	12.75	383.40	376.78	376.28
J-150			8.40		43.41	369.84	360.02	359.73
J-147			0.00		0.00	394.46	389.96	389.96
T-A-4-11	3.38	0.76	8.79	11.00	33.33	361.00	356.28	355.57
T-A-4-10	1.08	0.80	6.22	7.00	23.94	360.14	358.22	357.32
J-137			5.36		20.77	363.75	360.83	360.38
T-A-4-7	0.97	0.77	0.75	7.00	4.47	368.60	365.21	364.91
J-136			5.36		20.97	366.50	363.95	363.14
T-A-4-1	1.47	0.80	4.61	8.00	18.18	367.07	364.81	364.29
J-138			6.22		23.82	358.19	356.79	356.49
T-A-4-12	1.14	0.79	4.73	6.00	24.83	372.55	365.15	364.39
J-144			3.83		20.26	375.44	371.75	371.43
J-141			3.83		20.85	377.64	374.28	373.69
T-A-4-5	2.14	0.79	1.69	8.00	9.28	378.07	375.35	374.75
T-A-4-8	0.94	0.76	2.14	7.00	12.76	380.90	377.74	377.19
J-143			1.42		8.95	400.53	390.26	389.92
T-A-4-9	0.62	0.79	0.49	6.00	3.24	406.44	396.39	396.13
T-A-4-6	1.23	0.76	0.93	6.00	6.18	396.90	393.73	393.36
J-142			0.00		0.00	415.85	406.85	406.85
J-140			0.00		0.00	379.80	375.35	375.35
T-A-4-2	0.21	0.80	1.77	6.00	7.22	370.19	366.48	366.14
J-135			1.60		6.65	377.70	374.46	374.20
T-A-4-4	2.50	0.64	1.60	12.00	6.76	384.24	381.19	380.75
J-134			0.00		0.00	392.50	388.00	388.00
T-A-4-3	2.78	0.60	3.44	13.00	13.80	369.20	366.07	365.54
OUTLET 2			3.77		91.59	310.00	306.00	306.00
J-152			3.77		91.60	324.01	316.26	315.57
J-151			3.77		91.60	345.32	340.35	339.66
T-A-4+T-A-4-15 IN	6.29	0.60	3.77	26.00	91.65	353.26	340.64	340.64
OUTLET OS-0			0.00		52.50	343.00	331.50	331.50
J-159			0.00		52.50	345.00	342.23	341.29
J-158			0.00		52.50	359.80	356.07	355.13
J-157			0.00		52.50	379.75	376.02	375.08
J-156			0.00		52.50	388.00	384.27	383.33
J-155			0.00		52.50	401.09	397.36	396.42
J-154			0.00		52.50	411.79	408.06	407.12
J-153			0.00		52.50	415.83	412.10	411.16
OS-0	0.00	0.00	0.00	0.00	52.50	420.50	418.33	418.33
T-C-5,T-D-1			7.63		36.58	351.45	336.68	336.68
J-161			7.63		37.40	347.59	340.13	339.44
T-D-1-2	1.80	0.82	7.63	9.00	38.24	343.65	341.04	340.41
T-C-5	5.93	0.79	4.68	9.00	23.84	345.62	341.47	341.28
T-D-1-1	1.79	0.82	6.15	9.00	31.04	344.58	341.36	341.02
T-L			12.23		30.82	378.03	372.53	372.53
T-L-2	0.28	0.78	12.23	6.00	30.98	378.34	375.54	374.78

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM NODE REPORT

Label	Area (acres)	Inlet C	System CA (acres)	Time of Concentration (min)	Total Flow (cfs)	Ground Elevation (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
T-L-3	7.64	0.70	12.01	23.00	30.67	379.52	376.26	375.66
T-L-4	7.87	0.69	6.66	25.00	17.54	387.16	382.21	381.63
J-36			1.23		6.63	395.36	390.91	390.65
T-L-5	1.50	0.82	1.23	8.00	6.75	395.82	391.81	391.46
OUTLET 5			4.10		41.14	365.00	362.50	362.50
T-L+T-L-1 IN	5.70	0.72	4.10	22.00	41.17	377.22	374.15	374.15
T-M			7.83		33.81	395.63	388.45	388.45
T-M-1,T-M-2	8.54	0.82	7.83	11.00	35.04	405.35	400.97	400.01
J-35			7.83		34.58	399.60	395.77	395.25
J-34			7.83		34.00	394.70	391.70	390.98
T-M-3	1.02	0.82	0.84	6.00	5.53	416.14	410.00	409.66
OUTLET 6			0.00		33.81	395.00	385.00	385.00
T-M IN	0.00	0.00	0.00	0.00	33.81	390.79	387.93	387.93
T-N			5.50		22.93	412.02	407.00	407.00
T-N-1	6.79	0.81	5.50	12.00	23.25	414.23	409.75	409.21
OUTLET 7			0.00		22.93	381.48	375.98	375.98
J-21			0.00		22.93	402.00	398.56	398.13
T-N IN	0.00	0.00	0.00	0.00	22.93	409.89	405.63	405.63
OUTLET 4			6.99		195.00	355.00	346.24	346.24
T-(B,C,E,F,J,K)+T-F-3 IN	10.92	0.64	6.99	25.00	195.04	353.24	351.68	351.68
OUTLET OS-3			0.00		38.40	375.00	365.00	365.00
J-216			0.00		38.40	375.46	373.00	373.00
J-215			0.00		38.40	376.31	373.90	373.90
J-214			0.00		38.40	379.20	377.22	376.46
J-213			0.00		38.40	382.00	378.74	377.98
OS-3	0.00	0.00	0.00	0.00	38.40	390.00	387.94	387.94
OUTLET OS-4			0.00		70.90	390.00	380.20	380.20
J-223			0.00		70.90	389.35	385.31	385.31
J-222			0.00		70.90	390.07	385.67	385.67
J-221			0.00		70.90	395.00	389.00	389.00
J-220			0.00		70.90	396.46	390.01	390.01
J-219			0.00		70.90	396.30	391.28	391.28
J-218			0.00		70.90	400.50	394.84	393.87
J-217			0.00		70.90	398.00	396.89	395.96
OS-4	0.00	0.00	0.00	0.00	70.90	440.50	435.44	435.44
J-206			0.00		52.50	358.13	349.79	349.30
J-205			0.00		52.50	362.91	350.70	350.70
J-204			0.00		52.50	362.78	351.98	351.39
J-203			0.00		52.50	361.69	352.99	352.20
J-202			0.00		52.50	371.40	365.14	364.65
J-200			0.00		52.50	390.50	387.86	387.27
OS-1	0.00	0.00	0.00	0.00	52.50	410.66	407.43	407.43
J-201			0.00		52.50	379.87	376.23	375.64
OUTLET OS-1			0.00		52.50	355.00	345.00	345.00
OUTLET OS-2			0.00		23.30	360.00	350.00	350.00
J-212			0.00		23.30	357.96	353.95	353.95
J-211			0.00		23.30	366.10	356.73	356.73
J-210			0.00		23.30	365.87	363.09	363.09
J-209			0.00		23.30	372.78	365.95	365.95
J-208			0.00		23.30	380.00	372.18	372.18
OS-2	0.00	0.00	0.00	0.00	23.30	445.90	443.88	443.88
OUTLET 8			5.85		19.60	360.00	351.00	351.00
T-I-1	8.48	0.69	5.85	17.00	19.76	365.40	361.60	361.60

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM PIPE REPORT

Label	Upstream Node	Downstream Node	Upstream Inlet Area (acres)	Upstream Inlet Rational Coefficient	Upstream Calculated System CA (acres)	System Intensity (in/hr)	Total System Flow (cfs)	Length (ft)	Constructed Slope (ft/ft)	Number of Sections	Section Size	Mannings n	Full Capacity (cfs)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Upstream Ground Elevation (ft)	Downstream Ground Elevation (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
P-78	T-C-5,T-D-1+T-D-2 IN	OUTLET 3	3.32	0.79	2.62	4.76	49.16	96.00	0.011771	1	36 inch	0.013	72.36	336.48	335.35	351.95	340.00	12.47	1.65	338.76	337.21
P-51	J-48	J-24	N/A	N/A	14.31	3.61	52.10	151.00	0.005695	1	54 inch	0.013	148.40	353.43	352.57	362.50	362.56	4.57	5.49	359.84	359.74
P-52	J-24	J-188	N/A	N/A	14.31	3.50	50.46	470.00	0.005000	1	54 inch	0.013	139.04	352.57	350.22	362.56	361.59	5.49	6.87	359.66	359.35
P-57	T-B-4	J-48	1.28	0.79	1.01	6.56	6.69	114.00	0.005000	1	24 inch	0.013	16.00	356.50	355.93	360.50	362.50	2.00	4.57	360.08	359.98
P-64	J-28	J-29	N/A	N/A	26.67	3.23	86.74	528.00	0.009015	1	42 inch	0.013	95.52	365.15	360.39	376.34	370.25	7.69	6.36	368.05	363.75
P-65	J-29	T-F-2, T-J-3	N/A	N/A	26.67	3.14	84.40	510.00	0.008078	1	48 inch	0.013	129.10	359.89	355.77	370.25	365.00	6.36	5.23	363.33	361.73
P-66	T-F-2, T-J-3	J-26	10.79	0.80	35.27	3.06	108.77	86.00	0.010233	1	54 inch	0.013	198.91	355.27	354.39	365.00	364.25	5.23	5.36	361.01	360.74
P-67	T-K-1	J-28	21.47	0.72	25.68	3.24	83.75	81.00	0.038519	1	36 inch	0.013	130.90	368.77	365.65	377.29	376.34	5.52	7.69	371.57	369.18
P-68	J-30	T-K-1	N/A	N/A	10.22	3.35	34.55	589.00	0.011919	1	36 inch	0.013	72.81	375.79	368.77	384.10	377.29	5.31	5.52	377.70	373.88
P-69	J-31	J-30	N/A	N/A	10.22	3.38	34.83	152.00	0.018553	1	36 inch	0.013	90.84	378.61	375.79	385.85	384.10	4.24	5.31	380.53	378.11
P-70	J-32	J-31	N/A	N/A	5.54	3.45	19.29	233.00	0.007854	1	24 inch	0.013	20.05	381.44	379.61	388.30	385.85	4.86	4.24	383.02	381.18
P-71	T-K-2	J-32	7.92	0.70	5.54	3.48	19.47	88.00	0.008182	1	24 inch	0.013	20.46	382.16	381.44	389.45	388.30	5.29	4.86	384.16	383.51
P-60	J-26	J-188	N/A	N/A	35.27	3.04	108.02	343.00	0.012157	1	54 inch	0.013	216.82	354.39	350.22	364.25	361.59	5.36	6.87	360.39	359.35
P-109	J-45	T-K-2	N/A	N/A	0.00	0.00	0.00	169.00	0.009586	1	18 inch	0.013	10.28	384.28	382.66	393.04	389.45	7.26	5.29	384.52	384.52
P-46	T-B-1,T-C-1	T-B-2	3.06	0.68	2.09	3.98	8.40	468.00	0.022756	1	18 inch	0.013	15.85	399.20	388.55	405.58	395.00	4.88	4.95	400.32	390.01
P-47	T-B-2	J-22	2.33	0.68	3.68	3.82	14.17	319.00	0.043730	1	24 inch	0.013	47.30	388.05	374.10	395.00	381.87	4.95	5.77	389.41	375.98
P-48	J-22	T-E-1	N/A	N/A	3.68	3.75	13.91	169.00	0.049408	1	24 inch	0.013	50.28	374.10	365.75	381.87	371.25	5.77	3.50	375.44	368.87
P-49	T-E-1	J-23	5.72	0.64	7.34	3.72	27.50	38.00	0.085526	1	24 inch	0.024	35.83	365.75	362.50	371.25	369.52	3.50	5.02	367.57	363.83
P-113	J-23	T-E-3	N/A	N/A	12.07	3.71	45.14	248.00	0.020726	1	48 inch	0.013	206.78	360.50	355.36	369.52	364.00	5.02	4.64	362.51	360.30
P-114	T-E-3	J-48	1.49	0.82	13.30	3.66	49.03	69.00	0.020725	1	48 inch	0.013	206.78	355.36	353.93	364.00	362.50	4.64	4.57	360.06	359.98
P-62	T-J-2	J-27	2.34	0.42	0.98	4.19	4.16	54.00	0.009630	1	18 inch	0.013	10.31	374.36	373.84	379.42	378.27	3.56	2.93	375.14	374.89
P-119	J-27	J-50	N/A	N/A	0.98	4.16	4.12	78.00	0.031026	1	18 inch	0.013	18.50	373.84	371.42	378.27	377.25	2.93	4.33	374.62	372.38
P-120	J-50	J-28	N/A	N/A	0.98	4.12	4.09	226.00	0.018894	1	18 inch	0.013	14.44	371.42	367.15	377.25	376.34	4.33	7.69	372.19	369.18
P-58	J-25	T-E-2	N/A	N/A	1.06	4.01	4.29	313.00	0.009457	1	18 inch	0.013	10.21	359.86	356.90	375.19	372.44	13.83	14.04	362.08	361.56
P-125	T-E-2	T-E-4	5.25	0.44	3.37	3.63	12.34	213.00	0.006479	1	24 inch	0.013	18.21	356.40	355.02	372.44	362.69	14.04	5.67	361.34	360.71
P-126	T-E-4	J-188	5.98	0.75	7.86	3.50	27.68	34.00	0.067647	1	24 inch	0.013	58.84	355.02	352.72	362.69	361.59	5.67	6.87	359.86	359.35
P-54	T-C-4	J-170	1.10	0.80	2.62	4.72	12.48	170.00	0.023529	1	18 inch	0.013	16.11	371.00	367.00	377.13	373.42	4.63	4.92	372.33	367.99
P-93	J-39	T-C-4	N/A	N/A	1.74	6.29	11.05	173.00	0.019133	1	18 inch	0.013	14.53	374.31	371.00	382.24	377.13	6.43	4.63	375.58	373.21
P-94	J-40	J-39	N/A	N/A	1.74	6.42	11.28	131.00	0.030534	1	18 inch	0.013	18.35	378.31	374.31	387.19	382.24	7.38	6.43	379.59	376.03
P-95	T-C-3	J-40	2.18	0.80	1.74	6.56	11.53	137.00	0.030584	1	18 inch	0.013	18.37	382.50	378.31	392.20	387.19	8.20	7.38	383.79	380.05
P-186	J-43	T-C-3	N/A	N/A	0.00	0.00	0.00	180.00	0.009278	1	18 inch	0.013	10.12	384.17	382.50	387.67	392.20	2.00	8.20	384.42	384.42
P-187	J-33	T-C-3	N/A	N/A	0.00	0.00	0.00	107.00	0.046729	1	18 inch	0.013	22.71	387.50	382.50	395.18	392.20	6.18	8.20	387.50	384.42
P-192	J-170	T-B-3	N/A	N/A	2.62	4.63	12.26	87.00	0.018391	1	24 inch	0.013	30.68	366.50	364.90	373.42	372.69	4.92	5.79	367.76	367.52
P-193	T-B-3	J-23	2.64	0.80	4.74	4.59	21.91	132.00	0.018182	1	24 inch	0.013	30.50	364.90	362.50	372.69	369.52	5.79	5.02	366.57	363.76
P-194	J-162	J-163	N/A	N/A	0.00	0.00	0.00	90.00	0.292556	1	18 inch	0.013	56.81	396.50	370.17	404.50	373.67	6.50	2.00	396.50	370.17
P-195	J-163	J-164	N/A	N/A	0.00	0.00	0.00	35.00	0.010000	1	18 inch	0.013	10.50	370.17	369.82	373.67	373.43	2.00	2.11	370.17	369.82
P-196	J-164	T-E-2	N/A	N/A	0.00	0.00	0.00	128.00	0.100938	1	18 inch	0.013	33.37	369.82	356.90	373.43	372.44	2.11	14.04	369.82	361.56
P-197	T-J-1	J-166	2.59	0.41	1.06	4.19	4.49	178.00	0.011348	1	18 inch	0.013	11.19	362.50	360.48	374.25	374.97	10.25	12.99	363.31	362.32
P-198	J-166	J-25	N/A	N/A	1.06	4.09	4.37	55.00	0.011273	1	18 inch	0.013	11.15	360.48	359.86	374.97	375.19	12.99	13.83	362.24	362.14
P-199	J-165	J-166	N/A	N/A	0.00	0.00	0.00	51.00	0.216078	1	18 inch	0.013	48.83	371.50	360.48	379.00	374.97	6.00	12.99	371.50	362.32
P-127	J-188	T-F-1	N/A	N/A	57.44	2.96	171.23	74.00	0.005000	1	54 inch	0.013	139.04	350.22	349.85	361.59	360.65	6.87	6.30	357.55	356.99
P-74	J-41	J-42	N/A	N/A	0.00	0.00	0.00	182.00	0.046703	1	18 inch	0.013	22.70	402.20	393.70	409.44	401.30	5.74	6.10	402.20	393.70
P-73	J-42	T-K-3	N/A	N/A	0.00	0.00	0.00	263.00	0.016996	1	18 inch	0.013	13.69	393.70	389.23	401.30	393.73	6.10	3.00	393.70	391.38
P-72	T-K-3	J-44	5.85	0.80	4.68	4.72	22.26	193.00	0.017720	1	24 inch	0.013	30.11	388.73	385.31	393.73	389.31	3.00	2.00	390.41	387.45
P-63	J-44	J-31	N/A	N/A	4.68	4.63	21.83	226.00	0.025221	1	24 inch	0.013	35.93	385.31	379.61	389.31	385.85	2.00	4.24	386.98	380.74
P-333	T-F-1	J-189	3.18	0.82	60.05	2.95	178.37	196.00	0.005051	1	54 inch	0.013	139.75	349.85	348.86	360.65	357.51	6.30	4.15	355.62	354.01
P-334	J-189	T-(B,C,E,F,J,K)	N/A	N/A	60.05	2.92	176.77	16.00	0.005000	1	54 inch	0.013	139.04	348.86	348.78	357.51	357.33	4.15	4.05	352.96	352.64
P-247	T-A-2+T-A-2-5 IN	J-130	1.76	0.69	1.21	3.78	39.45	55.00	0.010182	1	30 inch	0.013	41.39	336.28	335.72	353.49	352.64	14.71	14.42	339.57	339.06
P-248	J-130	J-131	N/A	N/A	1.21	3.76	39.43	296.00	0.017601	1	30 inch	0.013	54.41	335.72	330.51	352.64	339.98	14.42	6.97	338.26	335.52
P-249	J-131	J-133	N/A	N/A	2.27	3.66	66.21	316.00	0.052848	1	30 inch	0.013	94.29	330.51	313.81	339.98	332.26	6.97	15.95	332.94	317.74
P-252	J-133	OUTLET 1	N/A	N/A	7.77	3.62	135.38	171.00	0.069064	1	42 inch	0.024	143.21	312.81	301.00	332.26	310.00	15.95	5.50	316.14	303.71
P-250	T-A-3+T-A-3-1 IN	J-132	8.21	0.67	5.50	3.98	71.27	30.00	0.010000	1	42 inch	0.013	100.60	314.76	314.46	331.69	331.24	13.43	13.28	319.15	319.00
P-251	J-132	J-133	N/A	N/A	5.50	3.97	71.19	116.00	0.014224	1	42 inch	0.013	119.99	314.46	312.81	331.24	332.26	13.28	15.95	318.32	317.74

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM PIPE REPORT

Label	Upstream Node	Downstream Node	Upstream Inlet Area (acres)	Upstream Inlet Rational Coefficient	Upstream Calculated System CA (acres)	System Intensity (in/hr)	Total System Flow (cfs)	Length (ft)	Constructed Slope (ft/ft)	Number of Sections	Section Size	Mannings n	Full Capacity (cfs)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Upstream Ground Elevation (ft)	Downstream Ground Elevation (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
P-253	T-A-1+T-A-1-7 IN	J-131	1.47	0.72	1.06	3.89	27.15	396.00	0.011263	1	30 inch	0.013	43.53	334.97	330.51	347.75	339.98	10.28	6.97	337.18	335.52
P-210	J-106	T-A-1-1	N/A	N/A	0.00	0.00	0.00	129.00	0.022481	1	18 inch	0.013	15.75	359.40	356.50	363.90	361.00	3.00	3.00	359.40	357.65
P-211	T-A-1-1	J-107	2.28	0.47	1.07	4.19	4.53	335.00	0.023433	1	18 inch	0.013	16.08	356.50	348.65	361.00	354.72	3.00	4.57	357.32	349.72
P-213	J-107	J-105	N/A	N/A	2.72	3.96	10.83	210.00	0.029238	1	24 inch	0.013	38.68	348.15	342.01	354.72	350.73	4.57	6.72	349.33	344.63
P-201	J-101	T-A-1-2	N/A	N/A	0.00	0.00	0.00	161.00	0.009938	1	18 inch	0.013	10.47	359.39	357.79	363.89	362.50	3.00	3.21	359.39	358.92
P-202	T-A-1-2	J-102	1.69	0.51	0.86	5.05	4.39	35.00	0.010000	1	18 inch	0.013	10.50	357.79	357.44	362.50	362.25	3.21	3.31	358.59	358.50
P-203	J-102	T-A-1-3	N/A	N/A	0.86	5.01	4.35	193.00	0.023627	1	18 inch	0.013	16.15	357.44	352.88	362.25	357.38	3.31	3.00	358.24	354.37
P-204	T-A-1-3	J-103	0.93	0.61	1.43	4.87	7.02	61.00	0.025410	1	18 inch	0.013	16.74	352.88	351.33	357.38	355.83	3.00	3.00	353.91	352.02
P-205	T-A-1-5	J-103	0.67	0.80	0.54	5.94	3.21	56.00	0.012857	1	18 inch	0.013	11.91	352.05	351.33	356.55	355.83	3.00	3.00	352.73	352.34
P-206	J-103	T-A-1-6	N/A	N/A	1.97	4.83	9.58	262.00	0.028321	1	24 inch	0.013	38.07	350.83	343.41	355.83	348.41	3.00	3.00	351.94	345.85
P-207	T-A-1-6	J-104	1.48	0.80	3.15	4.70	14.92	121.00	0.010000	1	24 inch	0.013	22.62	343.41	342.20	348.41	351.36	3.00	7.16	345.50	344.98
P-208	J-104	J-105	N/A	N/A	3.15	4.58	14.52	20.00	0.009500	1	24 inch	0.013	22.05	342.20	342.01	351.36	350.73	7.16	6.72	344.71	344.63
P-209	J-105	T-A-1	N/A	N/A	5.87	3.89	23.02	15.00	0.036000	1	24 inch	0.013	42.92	342.01	341.47	350.73	350.30	6.72	6.83	343.72	342.78
P-212	T-A-1-4	J-107	3.29	0.50	1.65	3.98	6.60	52.00	0.009615	1	18 inch	0.013	10.30	349.15	348.65	353.65	354.72	3.00	4.57	350.14	349.72
P-223	J-114	T-A-2-4	N/A	N/A	0.00	0.00	0.00	76.00	0.009868	1	18 inch	0.013	10.43	360.30	359.55	364.80	364.53	3.00	3.48	361.08	361.08
P-224	T-A-2-4	T-A-2-3	3.20	0.54	1.73	4.19	7.31	363.00	0.010055	1	18 inch	0.013	10.53	359.55	355.90	364.53	362.45	3.48	5.05	360.60	357.29
P-215	T-A-2-3	J-108	2.79	0.57	3.32	4.00	13.37	92.00	0.013043	1	24 inch	0.013	25.84	355.40	354.20	362.45	361.82	5.05	5.62	356.72	356.58
P-216	J-108	J-110	N/A	N/A	5.05	3.96	20.14	251.00	0.024382	1	24 inch	0.013	35.32	354.20	348.08	361.82	353.08	5.62	3.00	355.81	350.27
P-214	T-A-2-2	J-108	3.03	0.57	1.73	4.44	7.72	164.00	0.020122	1	18 inch	0.013	14.90	358.00	354.70	362.50	361.82	3.00	5.62	359.08	356.58
P-217	J-109	J-110	N/A	N/A	0.00	0.00	0.00	290.00	0.012655	1	18 inch	0.013	11.82	351.75	348.08	356.25	353.08	3.00	3.50	351.75	350.27
P-218	J-110	T-A-2-1	N/A	N/A	5.05	3.89	19.79	81.00	0.025679	1	24 inch	0.013	36.25	348.08	346.00	353.08	350.00	3.00	2.00	349.68	348.46
P-219	T-A-2-1	J-111	2.63	0.79	7.13	3.87	27.79	170.00	0.010000	1	30 inch	0.013	41.01	345.50	343.80	350.00	352.84	2.00	6.54	347.96	347.18
P-229	T-A-2-6	J-111	0.34	0.83	2.00	5.77	11.65	215.00	0.028140	1	18 inch	0.013	17.62	350.35	344.30	355.55	352.84	3.70	7.04	351.65	347.18
P-220	J-111	J-112	N/A	N/A	9.13	3.81	35.08	60.00	0.010000	1	30 inch	0.013	41.01	343.80	343.20	352.84	355.17	6.54	9.47	346.48	346.04
P-221	J-112	T-A-2	N/A	N/A	9.13	3.79	34.86	17.00	0.024706	1	30 inch	0.013	64.47	343.20	342.78	355.17	354.95	9.47	9.67	345.20	344.38
P-222	J-113	J-114	N/A	N/A	0.00	0.00	0.00	150.00	0.019200	1	18 inch	0.013	14.55	363.18	360.30	367.68	364.80	3.00	3.00	363.18	361.08
P-227	J-116	J-117	N/A	N/A	0.00	0.00	0.00	138.00	0.028261	1	18 inch	0.013	17.66	357.20	353.30	361.70	358.30	3.00	3.50	357.20	355.13
P-228	J-117	T-A-2-6	N/A	N/A	1.72	5.85	10.15	93.00	0.026344	1	18 inch	0.013	17.05	353.30	350.85	358.30	355.55	3.50	3.20	354.53	352.45
P-225	J-115	T-A-2-7	N/A	N/A	0.00	0.00	0.00	233.00	0.024292	1	18 inch	0.013	16.37	359.69	354.03	364.19	358.53	3.00	3.00	359.69	356.24
P-226	T-A-2-7	J-117	2.18	0.79	1.72	5.94	10.31	60.00	0.012167	1	18 inch	0.013	11.59	354.03	353.30	358.53	358.30	3.00	3.50	355.71	355.13
P-231	J-119	T-A-3-2	N/A	N/A	0.00	0.00	0.00	263.00	0.028593	1	18 inch	0.013	17.76	345.22	337.70	349.72	342.20	3.00	3.00	345.22	339.07
P-232	T-A-3-2	J-121	1.49	0.75	1.12	5.45	6.14	76.00	0.032895	1	18 inch	0.013	19.05	337.70	335.20	342.20	339.70	3.00	3.00	338.66	335.79
P-234	J-121	T-A-3-3	N/A	N/A	1.12	5.39	6.07	320.00	0.033656	1	24 inch	0.013	41.50	334.70	323.93	339.70	328.93	3.00	3.00	335.57	325.69
P-233	J-120	J-121	N/A	N/A	0.00	0.00	0.00	163.00	0.029816	1	18 inch	0.013	18.14	340.06	335.20	344.56	339.70	3.00	3.00	340.06	335.87
P-243	J-124	T-A-3-5	N/A	N/A	3.50	5.23	18.45	95.00	0.041263	1	30 inch	0.013	83.31	334.37	330.45	339.87	335.95	3.00	3.00	335.83	333.22
P-244	T-A-3-5	J-128	2.78	0.80	5.73	5.18	29.90	173.00	0.044624	1	30 inch	0.013	86.64	330.45	322.73	335.95	329.23	3.00	4.00	332.31	325.32
P-235	T-A-3-3	J-128	3.75	0.79	4.08	5.05	20.77	36.00	0.019444	1	30 inch	0.013	57.19	323.43	322.73	328.93	329.23	3.00	4.00	325.22	325.32
P-237	T-A-3-4	J-124	1.58	0.79	1.25	5.94	7.47	53.00	0.011887	1	18 inch	0.013	11.45	336.00	335.37	340.11	339.87	2.61	3.00	337.06	336.26
P-241	J-127	T-A-3-6	N/A	N/A	0.00	0.00	0.00	43.00	0.024419	1	18 inch	0.013	16.41	343.75	342.70	348.25	347.20	3.00	3.00	344.01	344.01
P-242	T-A-3-6	J-124	2.89	0.78	2.25	5.45	12.38	321.00	0.022835	1	24 inch	0.013	34.18	342.20	334.87	347.20	339.87	3.00	3.00	343.47	336.43
P-230	J-118	J-119	N/A	N/A	0.00	0.00	0.00	167.00	0.015449	1	18 inch	0.013	13.06	347.80	345.22	352.30	349.72	3.00	3.00	347.80	345.22
P-236	J-122	T-A-3-4	N/A	N/A	0.00	0.00	0.00	218.00	0.020642	1	18 inch	0.013	15.09	340.50	336.00	345.00	340.11	3.00	2.61	340.50	337.55
P-238	J-123	J-124	N/A	N/A	0.00	0.00	0.00	181.00	0.045138	1	18 inch	0.013	22.32	343.54	335.37	348.04	339.87	3.00	3.00	343.54	336.43
P-239	J-125	J-127	N/A	N/A	0.00	0.00	0.00	181.00	0.030829	1	18 inch	0.013	18.44	349.33	343.75	353.83	348.25	3.00	3.00	349.33	344.01
P-240	J-126	J-127	N/A	N/A	0.00	0.00	0.00	340.00	0.028265	1	18 inch	0.013	17.66	353.36	343.75	357.86	348.25	3.00	3.00	353.36	344.01
P-245	J-128	J-129	N/A	N/A	9.81	5.03	49.71	80.00	0.010125	1	36 inch	0.013	67.11	322.23	321.42	329.23	330.51	4.00	6.09	324.53	324.27
P-246	J-129	T-A-3	N/A	N/A	9.81	4.98	49.26	16.00	0.010000	1	36 inch	0.013	66.69	321.42	321.26	330.51	331.22	6.09	6.96	323.71	323.34
P-283	T-A-4-14	J-149	7.91	0.76	7.94	5.45	43.60	159.00	0.012013	1	36 inch	0.013	73.10	360.44	358.53	367.00	369.30	3.56	7.77	362.59	361.70
P-280	T-A-4-13	J-149	0.60	0.76	0.46	6.56	3.01	126.00	0.087698	1	18 inch	0.013	31.11	371.08	360.03	375.58	369.30	3.00	7.77	371.74	361.70
P-284	J-149	J-150	N/A	N/A	8.40	5.34	45.21	283.00	0.006961	1	36 inch	0.013	55.65	358.53	356.56	369.30	369.84	7.77	10.28	361.20	360.02
P-281	T-C-2	J-148	2.38	0.81	1.93	6.56	12.75	227.00	0.015419	1	24 inch	0.013	28.09	375.00	371.50	383.40	387.70	6.40	14.20	376.28	373.02
P-282	J-148	T-A-4-14	N/A	N/A	1.93	6.27	12.18	495.00	0.020323	1	24 inch	0.013	32.25	371.50	361.44	387.70	367.00	14.20	3.56	372.75	363.60
P-279	J-147	T-A-4-13	N/A	N/A	0.00	0.00	0.00	203.00	0.093005	1	18 inch	0.013	32.03	389.96	371.08	394.46	375.58	3.00	3.00	389.96	371.99

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM PIPE REPORT

Label	Upstream Node	Downstream Node	Upstream Inlet Area (acres)	Upstream Inlet Rational Coefficient	Upstream Calculated System CA (acres)	System Intensity (in/hr)	Total System Flow (cfs)	Length (ft)	Constructed Slope (ft/ft)	Number of Sections	Section Size	Mannings n	Full Capacity (cfs)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Upstream Ground Elevation (ft)	Downstream Ground Elevation (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
P-285	J-150	J-145	N/A	N/A	8.40	5.13	43.41	152.00	0.009934	1	36 inch	0.013	66.48	356.56	355.05	369.84	368.20	10.28	10.15	359.73	359.08
P-276	J-145	J-139	N/A	N/A	13.13	4.98	65.89	213.00	0.021878	1	36 inch	0.013	98.65	355.05	350.39	368.20	363.16	10.15	9.77	357.65	354.97
P-260	T-A-4-7	J-136	0.97	0.77	0.75	5.94	4.47	61.00	0.034426	1	18 inch	0.013	19.49	364.10	362.00	368.60	366.50	3.00	3.00	364.91	363.95
P-259	T-A-4-1	J-136	1.47	0.80	4.61	3.91	18.18	52.00	0.010962	1	24 inch	0.013	23.68	362.07	361.50	367.07	366.50	3.00	3.00	364.29	363.95
P-261	J-136	J-137	N/A	N/A	5.36	3.88	20.97	134.00	0.020522	1	24 inch	0.013	32.41	361.50	358.75	366.50	363.75	3.00	3.00	363.14	360.83
P-262	J-137	T-A-4-10	N/A	N/A	5.36	3.85	20.77	124.00	0.029113	1	24 inch	0.013	38.60	358.75	355.14	363.75	360.14	3.00	3.00	360.38	358.22
P-263	T-A-4-10	J-138	1.08	0.80	6.22	3.82	23.94	48.00	0.040625	1	24 inch	0.013	45.59	355.14	353.19	360.14	358.19	3.00	3.00	357.32	356.79
P-264	J-138	T-A-4-11	N/A	N/A	6.22	3.80	23.82	62.00	0.009677	1	30 inch	0.013	40.35	352.69	352.09	358.19	361.00	3.00	6.41	356.49	356.28
P-265	T-A-4-11	J-139	3.38	0.76	8.79	3.76	33.33	90.00	0.013333	1	30 inch	0.013	47.36	352.09	350.89	361.00	363.16	6.41	9.77	355.57	354.97
P-277	J-139	J-146	N/A	N/A	21.92	3.72	82.26	97.00	0.060515	1	36 inch	0.013	164.07	350.39	344.52	363.16	357.38	9.77	9.86	353.18	348.42
P-278	J-146	T-A-4	N/A	N/A	21.92	3.71	82.01	16.00	0.044375	1	36 inch	0.013	140.49	344.52	343.81	357.38	356.65	9.86	9.84	347.31	346.06
P-267	T-A-4-5	J-141	2.14	0.79	1.69	5.45	9.28	44.00	0.009773	1	18 inch	0.013	10.38	373.57	373.14	378.07	377.64	3.00	3.00	374.75	374.25
P-270	T-A-4-9	J-143	0.62	0.79	0.49	6.56	3.24	84.00	0.072500	1	18 inch	0.013	28.28	395.44	389.35	406.44	400.53	9.50	9.68	396.13	390.26
P-268	T-A-4-6	J-143	1.23	0.76	0.93	6.56	6.18	210.00	0.014524	1	18 inch	0.013	12.66	392.40	389.35	396.90	400.53	3.00	9.68	393.36	390.09
P-269	J-142	T-A-4-9	N/A	N/A	0.00	0.00	0.00	221.00	0.051629	1	18 inch	0.013	23.87	406.85	395.44	415.85	406.44	7.50	9.50	406.85	396.39
P-271	J-143	T-A-4-8	N/A	N/A	1.42	6.23	8.95	355.00	0.036479	1	24 inch	0.013	43.21	388.85	375.90	400.53	380.90	9.68	3.00	389.92	377.74
P-272	T-A-4-8	J-141	0.94	0.76	2.14	5.92	12.76	74.00	0.044054	1	24 inch	0.013	47.48	375.90	372.64	380.90	377.64	3.00	3.00	377.19	374.28
P-266	J-140	T-A-4-5	N/A	N/A	0.00	0.00	0.00	129.00	0.013411	1	18 inch	0.013	12.16	375.30	373.57	379.80	378.07	3.00	3.00	375.35	375.35
P-273	J-141	J-144	N/A	N/A	3.83	5.40	20.85	195.00	0.011487	1	30 inch	0.013	43.96	372.14	369.90	377.64	375.44	3.00	3.04	373.69	371.75
P-274	J-144	T-A-4-12	N/A	N/A	3.83	5.25	20.26	104.00	0.069327	1	30 inch	0.013	107.99	369.90	362.69	375.44	372.55	3.04	7.36	371.43	365.15
P-275	T-A-4-12	J-145	1.14	0.79	4.73	5.21	24.83	73.00	0.097808	1	30 inch	0.013	128.27	362.69	355.55	372.55	368.20	7.36	10.15	364.39	359.08
P-256	J-135	T-A-4-2	N/A	N/A	1.60	4.12	6.65	208.00	0.036106	1	18 inch	0.013	19.96	373.20	365.69	377.70	370.19	3.00	3.00	374.20	366.29
P-257	T-A-4-2	T-A-4-3	0.21	0.80	1.77	4.05	7.22	72.00	0.013750	1	24 inch	0.013	26.53	365.19	364.20	370.19	369.20	3.00	3.00	366.14	366.07
P-254	J-134	T-A-4-4	N/A	N/A	0.00	0.00	0.00	239.00	0.034561	1	18 inch	0.013	19.53	388.00	379.74	392.50	384.24	3.00	3.00	388.00	381.19
P-255	T-A-4-4	J-135	2.50	0.64	1.60	4.19	6.76	198.00	0.033030	1	18 inch	0.013	19.09	379.74	373.20	384.24	377.70	3.00	3.00	380.75	374.46
P-258	T-A-4-3	T-A-4-1	2.78	0.60	3.44	3.98	13.80	181.00	0.011768	1	24 inch	0.013	24.54	364.20	362.07	369.20	367.07	3.00	3.00	365.54	364.81
P-286	T-A-4+T-A-4-15 IN	J-151	6.29	0.60	3.77	2.55	91.65	110.00	0.005000	1	48 inch	0.013	101.57	337.31	336.76	353.26	345.32	11.95	4.56	340.64	340.35
P-287	J-151	J-152	N/A	N/A	3.77	2.53	91.60	51.00	0.472353	1	48 inch	0.024	534.72	336.76	312.67	345.32	324.01	4.56	7.34	339.66	316.26
P-288	J-152	OUTLET 2	N/A	N/A	3.77	2.53	91.60	46.00	0.145000	1	48 inch	0.024	296.26	312.67	306.00	324.01	310.00	7.34	0.00	315.57	307.62
P-289	OS-0	J-153	0.00	0.00	0.00	0.00	52.50	189.00	0.037937	1	30 inch	0.013	79.89	416.00	408.83	420.50	415.83	2.00	4.50	418.33	412.10
P-290	J-153	J-154	N/A	N/A	0.00	0.00	52.50	90.00	0.044889	1	30 inch	0.013	86.90	408.83	404.79	415.83	411.79	4.50	4.50	411.16	408.06
P-291	J-154	J-155	N/A	N/A	0.00	0.00	52.50	180.00	0.059444	1	30 inch	0.013	100.00	404.79	394.09	411.79	401.09	4.50	4.50	407.12	397.36
P-292	J-155	J-156	N/A	N/A	0.00	0.00	52.50	179.00	0.073128	1	30 inch	0.013	110.91	394.09	381.00	401.09	388.00	4.50	4.50	396.42	384.27
P-293	J-156	J-157	N/A	N/A	0.00	0.00	52.50	151.00	0.054636	1	30 inch	0.013	95.87	381.00	372.75	388.00	379.75	4.50	4.50	383.33	376.02
P-294	J-157	J-158	N/A	N/A	0.00	0.00	52.50	290.00	0.068793	1	30 inch	0.013	107.58	372.75	352.80	379.75	359.80	4.50	4.50	375.08	356.07
P-295	J-158	J-159	N/A	N/A	0.00	0.00	52.50	290.00	0.047724	1	30 inch	0.013	89.60	352.80	338.96	359.80	345.00	4.50	3.54	355.13	342.23
P-296	J-159	OUTLET OS-0	N/A	N/A	0.00	0.00	52.50	161.00	0.046335	1	30 inch	0.013	88.29	338.96	331.50	345.00	343.00	3.54	9.00	341.29	332.93
P-191	J-161	T-C-5,T-D-1	N/A	N/A	7.63	4.86	37.40	149.00	0.005034	1	36 inch	0.013	47.32	337.43	336.68	347.59	351.45	7.16	11.77	339.44	338.67
P-190	T-D-1-2	J-161	1.80	0.82	7.63	4.97	38.24	143.00	0.005035	1	36 inch	0.013	47.32	338.15	337.43	343.65	347.59	2.50	7.16	340.41	340.13
P-188	T-C-5	T-D-1-1	5.93	0.79	4.68	5.05	23.84	64.00	0.010156	1	36 inch	0.013	67.21	339.35	338.70	345.62	344.58	3.27	2.88	341.28	341.36
P-189	T-D-1-1	T-D-1-2	1.79	0.82	6.15	5.01	31.04	53.00	0.010377	1	36 inch	0.013	67.94	338.70	338.15	344.58	343.65	2.88	2.50	341.02	341.04
P-79	T-L-5	J-36	1.50	0.82	1.23	5.45	6.75	84.00	0.009524	1	18 inch	0.013	10.25	390.45	389.65	395.82	395.36	3.87	4.21	391.46	390.91
P-80	J-36	T-L-4	N/A	N/A	1.23	5.35	6.63	552.00	0.015290	1	18 inch	0.013	12.99	389.65	381.21	395.36	387.16	4.21	4.45	390.65	381.97
P-81	T-L-4	T-L-3	7.87	0.69	6.66	2.61	17.54	588.00	0.010238	1	30 inch	0.013	41.50	380.21	374.19	387.16	379.52	4.45	2.83	381.63	376.26
P-82	T-L-3	T-L-2	7.64	0.70	12.01	2.53	30.67	142.00	0.005000	1	36 inch	0.013	47.16	373.69	372.98	379.52	378.34	2.83	2.36	375.66	375.54
P-83	T-L-2	T-L	0.28	0.78	12.23	2.51	30.98	90.00	0.005000	1	36 inch	0.013	47.16	372.98	372.53	378.34	378.03	2.36	2.50	374.78	374.30
P-84	T-L+T-L-1 IN	OUTLET 5	5.70	0.72	4.10	2.50	41.17	94.00	0.101064	1	30 inch	0.024	70.63	372.00	362.50	377.22	365.00	2.72	0.00	374.15	363.87
P-76	J-35	J-34	N/A	N/A	7.83	4.38	34.58	218.00	0.019495	1	30 inch	0.013	57.27	393.25	389.00	399.60	394.70	3.85	3.20	395.25	391.70
P-77	T-M-1,T-M-2	J-35	8.54	0.82	7.83	4.44	35.04	185.00	0.025676	1	30 inch	0.013	65.72	398.00	393.25	405.35	399.60	4.85	3.85	400.01	395.77
P-88	J-34	T-M	N/A	N/A	7.83	4.31	34.00	56.00	0.009821	1	30 inch	0.013	40.65	389.00	388.45	394.70	395.63	3.20	4.68	390.98	390.23
P-96	T-M-3	T-M-1,T-M-2	1.02	0.82	0.84	6.56	5.53	358.00	0.027235	1	18 inch	0.013	17.33	408.75	399.00	416.14	405.35	5.89	4.85	409.66	400.97
P-89	T-M IN	OUTLET 6	0.00	0.00	0.00	0.00	33.81	91.00	0.010440	1	30 inch	0.013	41.91	385.95	385.00	390.79	395.00	2.34	7.50	387.93	386.72
P-97	T-N-1	T-N	6.79	0.81	5.50	4.19	23.25	104.00	0.005000	1	30 inch	0.013	29.00	407.52	407.00	414.23	412.02	4.21	2.52	409.21	408.64

Scenario: Base

100-YEAR STORM EVENT FOR ULTIMATE PHASE

BDS ENGINEERING CUSTOM PIPE REPORT

Label	Upstream Node	Downstream Node	Upstream Inlet Area (acres)	Upstream Inlet Rational Coefficient	Upstream Calculated System CA (acres)	System Intensity (in/hr)	Total System Flow (cfs)	Length (ft)	Constructed Slope (ft/ft)	Number of Sections	Section Size	Mannings n	Full Capacity (cfs)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Upstream Ground Elevation (ft)	Downstream Ground Elevation (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
P-98	T-N IN	J-21	0.00	0.00	0.00	0.00	22.93	118.00	0.063559	1	30 inch	0.013	103.40	404.00	396.50	409.89	402.00	3.39	3.00	405.63	398.56
P-99	J-21	OUTLET 7	N/A	N/A	0.00	0.00	22.93	87.00	0.235862	1	30 inch	0.024	107.90	396.50	375.98	402.00	381.48	3.00	3.00	398.13	376.76
P-129	T-(B,C,E,F,J,K)+T-F-3 IN	OUTLET 4	10.92	0.64	6.99	2.61	195.04	92.00	0.015652	1	54 inch	0.013	246.01	347.68	346.24	353.24	355.00	1.06	4.26	351.68	349.55
P-316	OS-3	J-213	0.00	0.00	0.00	0.00	38.40	84.00	0.125000	1	24 inch	0.024	43.32	386.00	375.50	390.00	382.00	2.00	4.50	387.94	378.74
P-317	J-213	J-214	N/A	N/A	0.00	0.00	38.40	87.00	0.015287	1	30 inch	0.013	50.71	375.00	373.67	382.00	379.20	4.50	3.03	377.98	377.22
P-318	J-214	J-215	N/A	N/A	0.00	0.00	38.40	279.00	0.006667	1	30 inch	0.013	33.49	373.67	371.81	379.20	376.31	3.03	2.00	376.46	373.90
P-319	J-215	J-216	N/A	N/A	0.00	0.00	38.40	67.00	0.013433	1	30 inch	0.013	47.54	371.81	370.91	376.31	375.46	2.00	2.05	373.90	372.67
P-320	J-216	OUTLET OS-3	N/A	N/A	0.00	0.00	38.40	226.00	0.026150	1	30 inch	0.013	66.33	370.91	365.00	375.46	375.00	2.05	7.50	373.00	366.37
P-327	J-222	J-223	N/A	N/A	0.00	0.00	70.90	50.00	0.036000	1	36 inch	0.013	126.54	383.00	381.20	390.07	389.35	4.07	5.15	385.67	385.31
P-328	J-223	OUTLET OS-4	N/A	N/A	0.00	0.00	70.90	200.00	0.005000	1	36 inch	0.013	47.16	381.20	380.20	389.35	390.00	5.15	6.80	385.31	382.87
P-322	J-217	J-218	N/A	N/A	0.00	0.00	70.90	99.00	0.010101	1	36 inch	0.013	67.03	392.00	391.00	398.00	400.50	3.00	6.50	395.96	394.84
P-321	OS-4	J-217	0.00	0.00	0.00	0.00	70.90	111.00	0.369369	1	30 inch	0.024	135.02	433.00	392.00	440.50	398.00	5.00	3.50	435.44	396.89
P-323	J-218	J-219	N/A	N/A	0.00	0.00	70.90	248.00	0.009637	1	36 inch	0.013	65.47	391.00	388.61	400.50	396.30	6.50	4.69	393.87	391.28
P-324	J-219	J-220	N/A	N/A	0.00	0.00	70.90	27.00	0.047037	1	36 inch	0.013	144.65	388.61	387.34	396.30	396.46	4.69	6.12	391.28	389.28
P-325	J-220	J-221	N/A	N/A	0.00	0.00	70.90	74.00	0.031622	1	36 inch	0.013	118.60	387.34	385.00	396.46	395.00	6.12	7.00	390.01	389.00
P-326	J-221	J-222	N/A	N/A	0.00	0.00	70.90	281.00	0.007117	1	36 inch	0.013	56.27	385.00	383.00	395.00	390.07	7.00	4.07	389.00	385.67
P-307	J-206	OUTLET OS-1	N/A	N/A	0.00	0.00	52.50	266.00	0.007632	1	42 inch	0.013	87.89	347.03	345.00	358.13	355.00	7.60	6.50	349.30	346.95
P-300	OS-1	J-200	0.00	0.00	0.00	0.00	52.50	69.00	0.292174	1	42 inch	0.024	294.56	405.16	385.00	410.66	390.50	2.00	2.00	407.43	387.86
P-301	J-200	J-201	N/A	N/A	0.00	0.00	52.50	189.00	0.061534	1	42 inch	0.013	249.56	385.00	373.37	390.50	379.87	2.00	3.00	387.27	376.23
P-302	J-201	J-202	N/A	N/A	0.00	0.00	52.50	213.00	0.051596	1	42 inch	0.013	228.52	373.37	362.38	379.87	371.40	3.00	5.52	375.64	365.14
P-303	J-202	J-203	N/A	N/A	0.00	0.00	52.50	278.00	0.044784	1	42 inch	0.013	212.90	362.38	349.93	371.40	361.69	5.52	8.26	364.65	352.99
P-304	J-203	J-204	N/A	N/A	0.00	0.00	52.50	162.00	0.005000	1	42 inch	0.013	71.14	349.93	349.12	361.69	362.78	8.26	10.16	352.20	351.98
P-305	J-204	J-205	N/A	N/A	0.00	0.00	52.50	138.00	0.005000	1	42 inch	0.013	71.14	349.12	348.43	362.78	362.91	10.16	10.98	351.39	350.67
P-306	J-205	J-206	N/A	N/A	0.00	0.00	52.50	280.00	0.005000	1	42 inch	0.013	71.14	348.43	347.03	362.91	358.13	10.98	7.60	350.70	349.79
P-313	J-211	J-212	N/A	N/A	0.00	0.00	23.30	280.00	0.010000	1	24 inch	0.013	22.62	355.01	352.21	366.10	357.96	9.09	3.75	356.73	353.95
P-309	OS-2	J-208	0.00	0.00	0.00	0.00	23.30	162.00	0.472037	1	18 inch	0.013	72.17	442.40	365.93	445.90	380.00	2.00	12.57	443.88	372.18
P-310	J-208	J-209	N/A	N/A	0.00	0.00	23.30	121.00	0.009917	1	18 inch	0.013	10.46	365.93	364.73	380.00	372.78	12.57	6.55	372.18	366.21
P-311	J-209	J-210	N/A	N/A	0.00	0.00	23.30	180.00	0.015889	1	24 inch	0.013	28.51	364.23	361.37	372.78	365.87	6.55	2.50	365.95	362.74
P-312	J-210	J-211	N/A	N/A	0.00	0.00	23.30	266.00	0.023910	1	24 inch	0.013	34.98	361.37	355.01	365.87	366.10	2.50	9.09	363.09	356.20
P-314	J-212	OUTLET OS-2	N/A	N/A	0.00	0.00	23.30	229.00	0.009651	1	24 inch	0.013	22.22	352.21	350.00	357.96	360.00	3.75	8.00	353.95	351.72
P-332	T-I-1	OUTLET 8	8.48	0.69	5.85	3.35	19.76	193.00	0.046632	1	24 inch	0.013	48.85	360.00	351.00	365.40	360.00	3.40	7.00	361.60	351.89

Appendix G: BMP Fact Sheets

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

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relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).

- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Outlet designed to discharge the capture volume over a period of hours.

- Length to width ratio of at least 1.5:1 where feasible.

- Basin depths optimally range from 2 to 5 feet.

- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.

- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction / Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.

- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_0))^{0.5}$$

where:
- Q = discharge (ft^3/s)
- C = orifice coefficient
- A = area of the orifice (ft^2)
- g = gravitational constant (32.2)
- H = water surface elevation (ft)
- H_0 = orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_0. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

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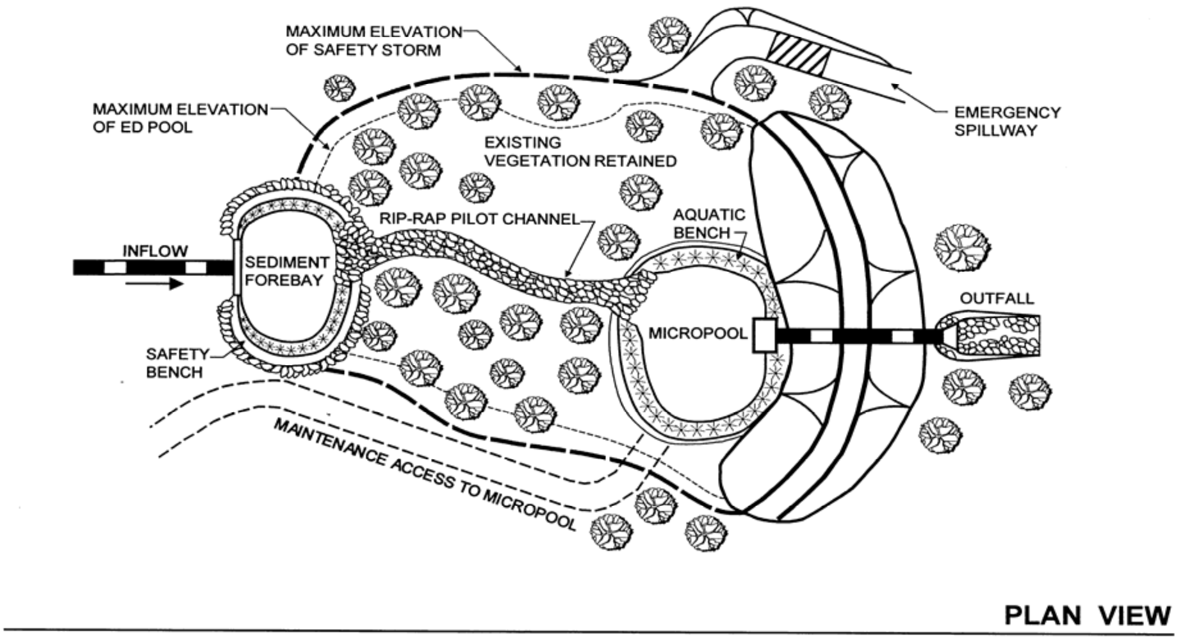

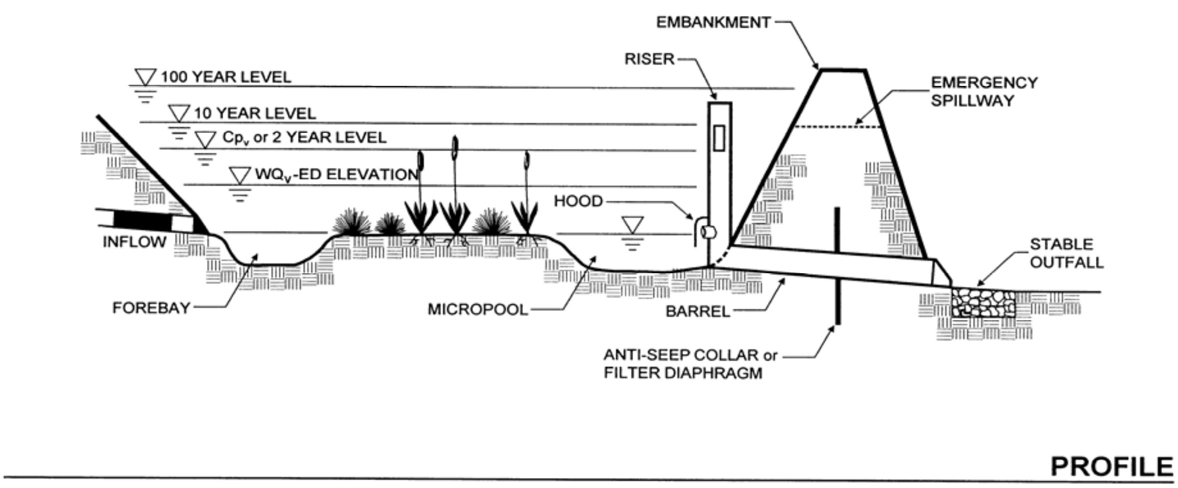

Schematic of an Extended Detention Basin (MDE, 2000)

Maintenance Concerns, Objectives, and Goals

- Clogged Soil or Outlet Structures
- Invasive Species
- Vegetation/Landscape Maintenance
- Erosion
- Channelization of Flow
- Aesthetics

General Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through a sand bed and is subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Inspection/Maintenance Considerations

Bioretention requires frequent landscaping maintenance, including measures to ensure that the area is functioning properly, as well as maintenance of the landscaping on the practice. In many cases, bioretention areas initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor, who may already be hired at the site. In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■
☑	Oxygen Demanding	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Inspection Activities	Suggested Frequency
■ Inspect soil and repair eroded areas.	Monthly
■ Inspect for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the strips are ready for winter. However, additional inspection after periods of heavy runoff is desirable. ■ Inspect to ensure grass is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket. ■ Check for debris and litter, and areas of sediment accumulation. ■ Inspect health of trees and shrubs.	Semi-annual inspection
Maintenance Activities	**Suggested Frequency**
■ Water plants daily for 2 weeks.	At project completion
■ Remove litter and debris.	Monthly
■ Remove sediment. ■ Remulch void areas. ■ Treat diseased trees and shrubs. ■ Mow turf areas. ■ Repair erosion at inflow points. ■ Repair outflow structures. ■ Unclog underdrain. ■ Regulate soil pH regulation.	As needed
■ Remove and replace dead and diseased vegetation.	Semi-annual
■ Add mulch. ■ Replace tree stakes and wires.	Annual
■ Mulch should be replaced every 2 to 3 years or when bare spots appear. Remulch prior to the wet season.	Every 2-3 years, or as needed

Additional Information

Landscaping is critical to the function and aesthetic value of bioretention areas. It is preferable to plant the area with native vegetation, or plants that provide habitat value, where possible. Another important design feature is to select species that can withstand the hydrologic regime they will experience. At the bottom of the bioretention facility, plants that tolerate both wet and dry conditions are preferable. At the edges, which will remain primarily dry, upland species will be the most resilient. It is best to select a combination of trees, shrubs, and herbaceous materials.

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Appendix H: Basis of Design by ESA

CARROLL CANYON

Geomorphic Basis of Design for Carroll Canyon at the Stone Creek Project Site

Prepared for
Vulcan Materials Company

December 4, 2012

ESA PWA

CARROLL CANYON

Geomorphic Basis of Design for Carroll Canyon at the Stone Creek Project Site

Prepared for
Vulcan Materials Company

December 4, 2012

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This memo describes the geomorphic basis for the channel restoration of Carroll Canyon Creek within the Stone Creek project site, San Diego County. The geomorphic basis establishes key design parameters that control the creek design, including the channel form, equilibrium gradient, substrate, planform, width, depth and bank treatments.

Project setting, geology and watershed context

Carroll Canyon is a tributary of Los Penasquitos Creek, located 9 miles upstream of Los Penasquitos Lagoon where the watershed meets the Pacific Ocean. The canyon drains a watershed of 7.1 square miles, incorporating Miramar Lake and a small portion of the Marine Corps Air Station (MCAS) Miramar lands to the south. The headwaters lie in the foothills of the Laguna Mountains, with a maximum elevation of approximately 1,000 feet. The canyon emerges at a sharp mountain front 1 mile east of the project site (Figures 1 and 2), onto the flat but dissected Mira Mesa at around 450 feet above sea level. Prior to mining, the project site was a deeply entrenched canyon reach. It is currently a sand and gravel quarry that has lowered some of the surrounding mesa. The existing creek is located in an artificial channel constructed through the quarry working area.

The headwaters of Carroll Canyon dissect a series of middle Eocene rock formations including (from youngest to oldest) the Pomerado Conglomerate (ancient stream gravels), the Mission Valley Formation (marine sandstone with cobble conglomerate), the Stadium Conglomerate (a massive cobble conglomerate) and the Torey Sandstone. Downstream of the headwaters (approximately delineated by the alignment of I-15) the creek drains west across Mira Mesa, crossing a series of uplifted Pleistocene marine terraces of decreasing age. The Stone Creek project site is currently the Vulcan sand and gravel quarry, and lies across the Mira Mesa Terrace and the Tierra Santa Terrace. These terraces are composed of strandline, beach, estuarine and colluvial deposits that are primarily sand and gravel. The creek has cut through these formations and the lower valley walls are composed of Stadium Conglomerate. The former valley floor through the project site is made up of late Pleistocene and Holocene alluvial floodplain deposits, made up in part of reworked sediment from the surrounding units described above.

The project area has a Mediterranean climate, with mild winters and a pronounced summer drought. Mean annual rainfall at Miramar Naval Station is 11 inches, mostly falling between November and March.

Historic channel form

Review of aerial photos and historic maps shows that prior to urbanization of the watershed, Carroll Canyon had a braided wash form (Figure 3). The riparian corridor was composed of multiple wide, shallow channels with little riparian vegetation along the margins. This channel form is characteristic of steep watersheds with a high coarse sediment delivery rate and ephemeral flow conditions. Braiding is typically a response to environments where sediment delivery exceeds sediment transport capacity, resulting in deposition and lateral widening. This is consistent with the site’s location at the transition between the steep headwaters in the Coastal Ranges and the gentler mesa sloping to the west. The geology of the headwaters, valley floor and the undercut canyon walls includes a large quantity of marine conglomerate that provides an abundant source of coarse sediment (cobbles, gravel and sand) and which accounts for the presence of the current aggregate quarries in this part of the watershed. The historic channel had a slope of approximately 1.3% and a sinuosity of 1.1.

Changes in the watershed

A review of USGS topographic quads from 1903 (Figure 2) to 1999 (Figure 4) reveals the pattern of extensive urbanization that has taken place in the watershed since the early 1960s. The majority of the watershed has been densely urbanized, while the construction of Lake Miramar has changed the water and sediment flow regime from the remaining non-urbanized portion of the watershed. These changes have had several likely effects and are described below for the three subwatersheds draining into the project site:

- Lake Miramar cut off 1 square mile of the northern subwatershed at the project site (a seventh of the total watershed). The lake is a store for imported water, and is managed so as not to discharge into Carroll Canyon. As a result both effective discharge and coarse sediment from the watershed was reduced by a seventh though the balance between sediment delivery and transport was likely not changed.
- The northern tributary to the project site is heavily urbanized (97% urbanized, 39% impervious surface for the area downstream of Lake Miramar). While runoff has presumably increased significantly due to the increase in impervious surface area, the area where the channel can entrain and transport sediment into the project site has been greatly reduced.
- The middle tributary is 96% urbanized (43% impermeable) and appears to have no natural channel that can erode sediment. We assume that this area contributes water but no sediment to the project site.
- The mainstem is 76% urbanized (20% impervious). It has presumably experienced a significant increase in stormwater flows and a reduction in sediment supply, though the one mile reach immediately upstream of I-15 does appear to be relatively natural and in sediment transport equilibrium. We assume that this reach supplies more water and less sediment than historically, but that it is closer to sediment transport equilibrium than the other subwatersheds.
- Urbanization and hardening of large parts of Carroll Canyon upstream of the project site have greatly reduced sediment delivery to the site. There is thus a ‘hungry water’ effect at the upstream boundary of the project site, with elevated sediment transport capacity and reduced sediment load. This creates a high potential for channel erosion within the project site.
- Irrigation of lawns and landscaping has led to year round low flows, shifting the creek from ephemeral to perennial conditions and encouraging vegetation growth in reaches that were likely dry historically. This in turn has affected channel form through the stabilizing effect of vegetation in some areas, pushing the channel to a more sinuous, single thread form.

Hydrology

ESA PWA reviewed the FEMA Flood Insurance Study (FIS) for San Diego County (FEMA, 2001) and the effective HEC-2 flood model. The FIS lists peak flows at Carroll Canyon Rd (downstream of the project site), which has a reported watershed area of 12 square miles. Of the reported 12 square mile watershed, 1 square mile drains directly into Lake Miramar, an off-line reservoir that is operated to retain all runoff for water supply.

After removing the non-contributing area above Miramar Reservoir, the contributing watershed area above Camino Ruiz Rd is 5.4 square miles (calculated using watershed delineation tools and USGS topo data). We pro-rated the published FIS flows at Carroll Canyon Road by contributing watershed area to estimate discharge at the project site. ESA PWA also calculated the recurrence intervals of more frequent flows by plotting the prorated FIS discharges on a log-log scale and performing a regression analysis. The published FIS and pro-rated flows at the project site are provided in Table 1.

Table 1. Estimated flows for Carroll Canyon Creek

Location	Total Watershed Area (sq miles)	Contributing Watershed Area	5-year flow	10-year flow	50-year flow	100-year flow	500-year flow
Carroll Canyon Rd	12.0	11	na	1,000*	3,000*	4,500*	12,500*
Camino Ruiz (Study Site)	6.4	5.4	190	491	1,473	2,209	6,136

In addition to pro-rating Carroll Canyon flows, ESA PWA investigated the published effective HEC-2 model to determine the volume of channel and overbank flow during the 100-year event. The effective model reports a 100-year discharge of 3500 cfs between FEMA cross-section AT (located approximately 1 mile below the project site) and cross-section CI (located at the upstream boundary of the project site). The first cross-section upstream of the project site (CJ) reports a discharge of 1100 cfs for the 100-yr event which suggests the reported effective model flows do not adequately reflect the decrease in contributing watershed area between section AT and CJ and across the project site.

FEMA records indicate a hydrology study for the watershed was completed by the California Department of Water Resources under contract H-3947 using “approximate methods.” ESA PWA has requested additional information and supporting documentation from FEMA however flows were likely calculated using a combination of regional regression equations, basin storage information, and hydrologic routing. If obtained, the established hydrologic methods could be reapplied to obtain flows that adequately represent 100-year flood conditions at the project site. Despite this uncertainty, we expect 100-year design flows to be closer to our prorated value of 2209 than the published value since the project site is located closer to cross-section CJ than AT. It should be noted that additional hydrologic studies may be required by FEMA for any development activities located below Miramar Reservoir.

Calculation of stable channel form and dimensions (width, depth and gradient)

Background

Channels with erodible boundaries generally adjust their gradient and cross section dimensions over time to achieve an equilibrium or stable channel form (width, depth and channel gradient) in response to the delivery of water and coarse sediment from the watershed. An equilibrium channel is one that transports the available sediment load with no net erosion or deposition over a period of several years (though there will be small-scale fluctuations in erosion and deposition both over short time periods and spatially within a reach). When the mixture of water and sediment is changed, for example due to urbanization of the watershed, the channel gradient and dimensions will change. This section of the basis of design is intended to develop channel dimensions that will be in equilibrium for the sections of creek that will be restored or reconstructed under the development plan.

Channel gradient, width and depth

Because estimates of equilibrium channel slope are subject to a large amount of natural variability and uncertainty, ESA PWA used two different methods: estimation of equilibrium slope using a pair of simple sediment transport models (the USACE HEC RAS Stable Channel Design Tool and the Bedload Assessment of Gravel-bedded Streams (BAGS) model, and use of a stream power versus channel bed empirical relationship developed for streams in Southern California (Bledsoe et al., 2010). Because the City of San Diego Channel Design Manual requires channels to be sized to contain the five year flood unless dominant discharge can be shown to be different, we also compared our channel sizes with the dimensions required to convey the five year flow. As a check on the validity of using the five-year flow rather than a different bankfull flow, such as the two-year flow, we performed an effective discharge analysis. This involved running area-weighted daily flow data from the nearest USGS flow gage from 1964 through 2012 through an uncalibrated sediment transport model of a typical cross section at the project site to calculate which flows cumulatively transported the most sediment. This showed that the most effective discharge was centered on 180 cfs, very close to the 190 cfs flow for the 5-year event. Based on this we used the five-year flow as our effective or bankfull flow.

ESA PWA performed the analysis using the USACE HEC RAS Stable Channel Design Tool, and the BAGS model. Both models employ an at-a-station sediment transport model that calculates the possible combinations of channel width, depth and slope that will transport the incoming water and sediment load in equilibrium. HEC RAS uses the Brownlie and the Mayer Peter Muller equations, while for BAGS we selected the Wilcox equation. We used the predicted 5-year recurrence interval design flow of 190 cfs as a hydraulic input, and divided the upstream watershed into three subwatersheds. For each sub watershed we estimated the likely sediment contribution as a percentage of the maximum sediment transport potential for the last earth channel reach before the channels became hardened. The watersheds and aerial photos of the sediment source reaches are shown in Figure 5. This qualitative assessment based on best professional judgment included a site walk to the contributing watersheds and aerial photo interpretation to estimate the extent to which the channels were able to entrain exposed sediment (e.g. evidence of bank erosion and bed erosion or deposition). The sub watersheds are described below.

Sub watershed for sediment sources	Location	Watershed Area (sq mi)	Assumed sediment contribution (% of sediment transport capacity)	Evidence for sediment delivery rate
Mainstem	Black Mountain Rd	3.0	>50%	1 mile of natural channel with mild bank erosion and bed deposition upstream of channelized portion
Middle tributary	Black Mountain Rd	0.5	0%	Watershed is 96% urban, 43% impermeable, entire channel system hardened
Northern Tributary	Black Mountain Rd	1.1 (excl. area of Miramar Lake)	~25%	1,600 ft of earth channel upstream of channelized portion

For each subwatershed we calculated the sediment supply rate from the closest extensive (>1,000 ft length) reach of natural channel upstream of the project site during the 5-year flow initially assuming that the channel was *transport limited* (i.e. that the sediment delivery rate was equal to the maximum sediment transport capacity of the discharge given the channel dimensions, valley gradient and sediment size distribution). Channel dimensions were extracted from Google Earth, valley gradient was taken from a USGS DEM of the area and sediment size distribution was taken from a sediment sample on Carroll Canyon upstream of the confluence with Flanders Canyon (collected as part of the Los Penasquitos TMDL sediment source inventory – ESA PWA 2011). Because of the history of urbanization and channelization, we then adjusted the sediment inputs from the maximum sediment transport capacity on the assumption that the subwatersheds were *supply limited* to varying degrees. We applied an adjustment based on the qualitative assessment of assumed sediment supply percentage to the sediment loads calculated by the sediment transport models. Combining the assumed sediment loads and the measured water loads from all three subwatersheds led to a series of composite sediment concentrations for different locations along the project site. These were then used as inputs into the sediment transport model to calculate the channel dimensions (width, depth and gradient) that would be in equilibrium when carrying this load. This formed the basis for the equilibrium slope assessment. Because the sediment reduction is based on best professional judgement, we performed a sensitivity analysis to determine whether other reasonable sediment reduction values or sediment transport equations would have resulted in significantly different channel gradients. Use of the three different sediment transport equations provided an additional sensitivity analysis.

The results are as follows for the key nodes along the channel:

Reach	Average equilibrium gradient from HEC RAS and BAGS	Notes from sensitivity analysis	Recommended channel gradient
Mainstem from Black Mountain to Middle Tributary confluence	1.1%	~0.8 to 1.3% for sediment delivery rates ranging from 40-75%	0.8%
Mainstem after Middle Tributary joins	1.0%		0.8%
Northern Tributary at Black Mountain	1.5%	1.2 – 1.9% depending on sediment delivery (10-25%) and channel widths (10-20 ft) used	1.4%
Mainstem between NT confluence and Camino Ruiz	1.2%	0.8 – 1.2% depending on sediment delivery and channel widths assumed (same assumptions as for tributaries)	0.8%
Mainstem between Camino Ruiz and downstream project boundary	1.2%	0.8 – 1.2% depending on sediment delivery and channel widths assumed (same assumptions as for tributaries)	Leave at existing gradient (1.1 – 1.2%)

As a cross check on the result we took the range of potential equilibrium channel dimensions and applied them to the empirical model of Bledsoe et al. (2010) (Figure 6). This model, developed as part of the SCCWRP hydromod channel vulnerability tools for the San Diego HMP, is based on a large number of observed channels in southern California. It classified their observed conditions (stable or unstable) and correlated it to the relationship between stream power (a function of discharge and stream gradient) and channel resistance (mean particle size). By plotting where a channel lies on this plot, it is possible to predict the probability of a channel becoming unstable. The potential channel dimensions were plotted on the graph to estimate the probability of the channel being stable or unstable.

We recommend two different approaches to the channel design due to different opportunities and constraints east and west of Camino Ruiz. Since the channel in the eastern part of the project site is going to be completely reconstructed except for the first few hundred feet, we recommend using the most conservative gradient from the range predicted. Conservatism is recommended because newly constructed channels tend to be more prone to erosion in their first few years, until bank toe vegetation becomes more established and the bed and banks have adjusted to the first few winters of flow. For this reach we recommend a gradient of 0.8% for the mainstem, with a gradient of 1.4% for the Northern tributary. These reaches should have a less than 10% risk of incision based on the Bledsoe et al. graph.

For the mainstem downstream of Camino Ruiz we propose leaving the bed at its existing gradient of 1.1 – 1.2%, which is at the steepest end of the envelope of stable gradients. This recommendation is made for several reasons:

- There will continue to be coarse sediment sources in the unchanged reach at the upstream end of the mainstem within the property (see Figure 7).
- This reach appears to be stable at its existing gradient, and the project should not significantly change the upstream conditions.
- Much of this reach will be preserved in its existing location rather than being reconstructed; it is undesirable to impact the bed by adding step-pool structures if it is currently within the range of potential equilibrium gradients.

Step pool design

Because the proposed gradient of the channel east of Camino Ruiz is flatter than the existing gradient, some steps or drops will be required in the profile. The channel has a length of 4,800 feet from Camino Ruiz to the base of the drop where the channel enters the property at the east boundary, and a vertical loss of 52 feet. Assuming an equilibrium gradient of 0.8%, 38 feet of loss will be taken up by the channel, with a deficit of 13 feet (numbers do not add up due to rounding difference). For the northern tributary the horizontal distance is 825 feet, with a drop of 23 feet (existing gradient of 2.8%). For a stable gradient of 1.4% approximately 12 feet of drop would be taken up by the channel with the remaining 12 feet having to be taken up by vertical drops.

These differences will be taken up in a series of ungrouted boulder step-pools. These have several advantages over more traditional methods such as grouted rip rap drop structures:

- Boulder step-pools are a naturally occurring channel form in steep channels in Southern California and elsewhere, and they are becoming widely used as a more environmentally-friendly method of grade control.
- Use of ungrouted boulders allows vegetation to become established on the steps, increasing their ecological function and providing a more aesthetically pleasing and natural appearance.
- Ungrouted boulders allow some settling and adjustment to occur in response to local bed scour or consolidation of the channel following construction.

Experience suggests that boulder step-pools function best from a hydraulic, stability and ecological perspective when they are smaller than 3 feet per drop. On this basis we recommend 5 step-pools for the mainstem and 6 step-pools for the northern tributary, with an average step height of around 2.5 feet. All step-pools will have a buried toe ramp with excess rock that will protect the toe in the event that the equilibrium slope is zero degrees (i.e. were a completely flat slope to extending upstream from a lower step-pool in the form of a head cut, it would not undermine the next step-pool upstream.) All step-pools will be tied in to the nearest graded slopes so that if a channel becomes blocked by debris or vegetation, scour of a new alignment across the floodplain will not be possible.

A preliminary rock sizing exercise was conducted to develop rock sizes for the step-pools. Based on a series of rock sizing methods we calculated that the crest rocks should be approximately 2-2.5 feet in diameter. Additional rock sizing will be performed as the design advances.

Bed Materials

For newly constructed reaches the bed materials should be similar to the existing distribution of materials, with a mean particle size of 34mm or larger to meet the equilibrium slope criteria. The bed materials should be consolidated to 95% compaction underneath the step-pool structures in order to support the boulders.

References

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Coleman, D., MacRae, C., Stein, E.D. (2005). Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams – Southern California Coastal Water Research Project Technical Report 450.

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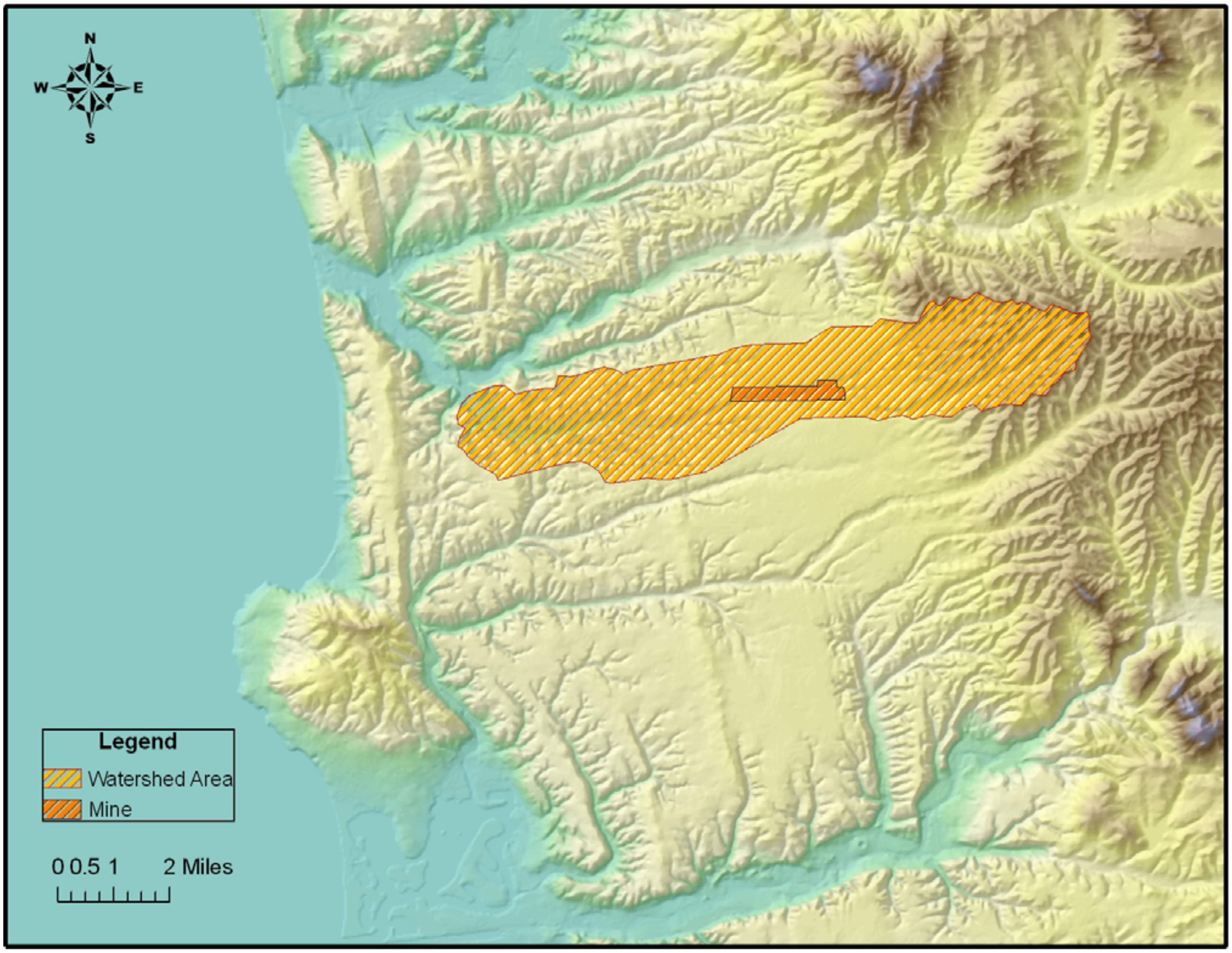
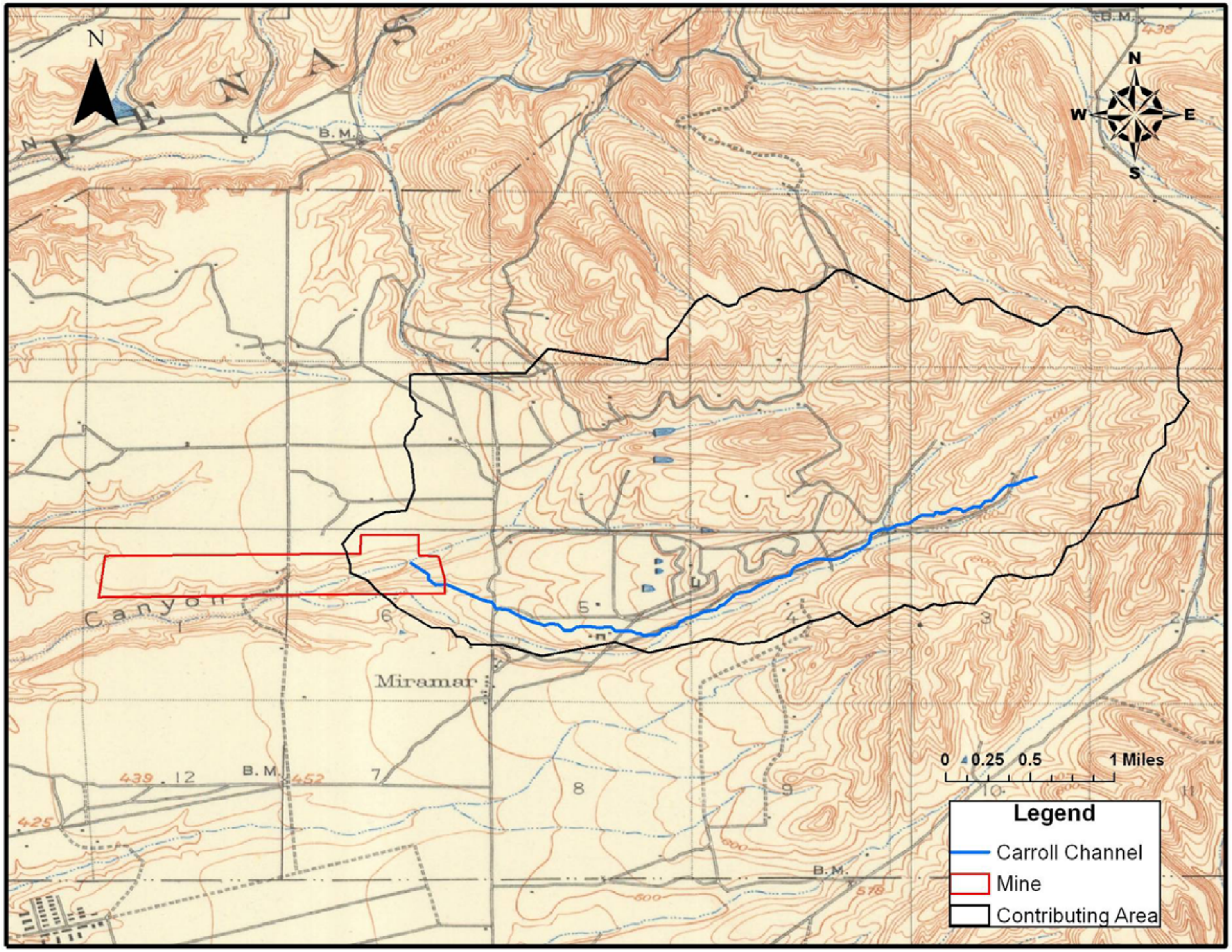


SOURCE:

Carroll Canyon #120380

Figure 1
Carroll Canyon Watershed and Stone Creek Project Site (mine)

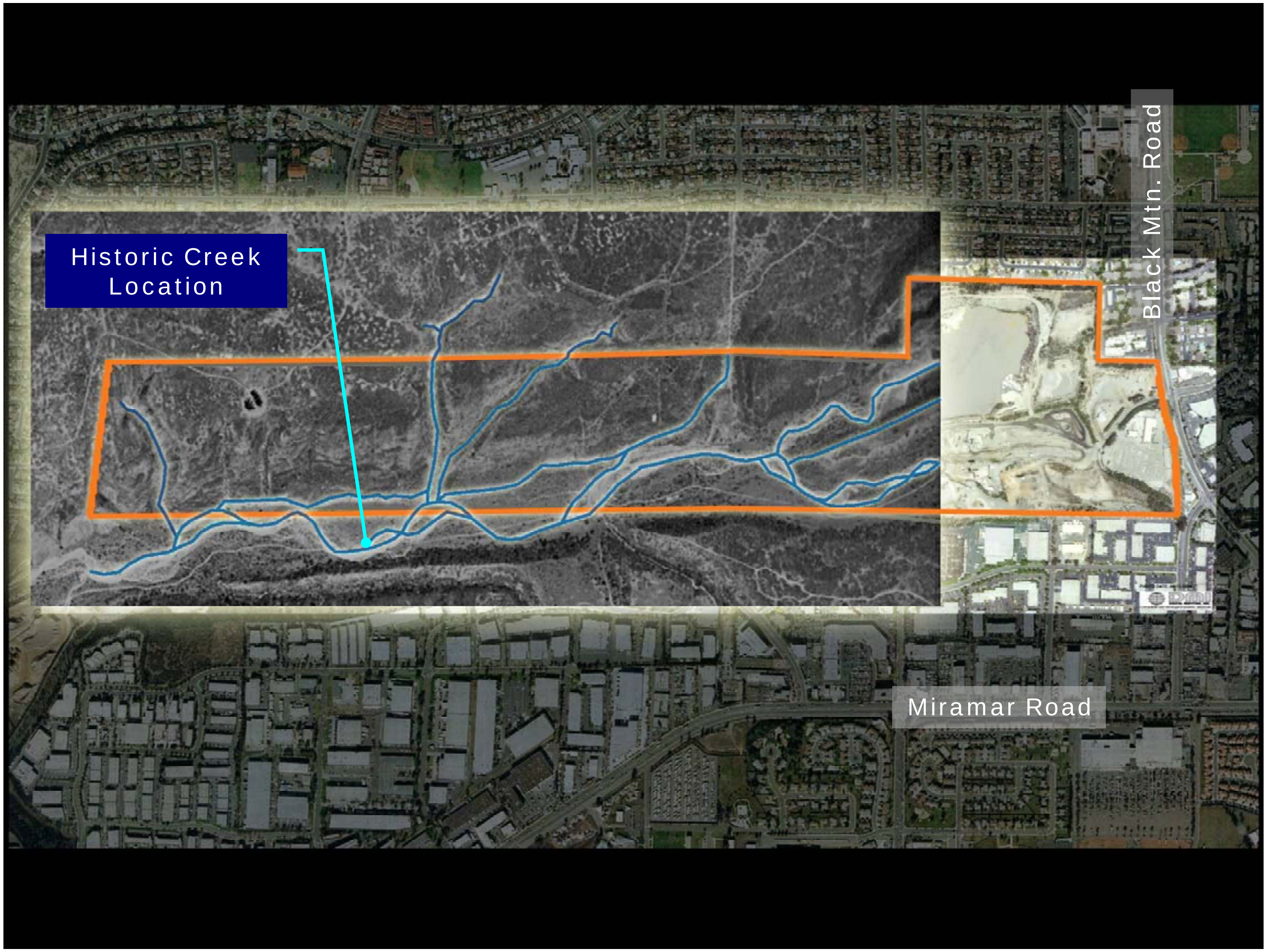


SOURCE: USGS

Carroll Canyon #120380

Figure 2

Historic setting (1903) and topography of the Stone Creek Project Site

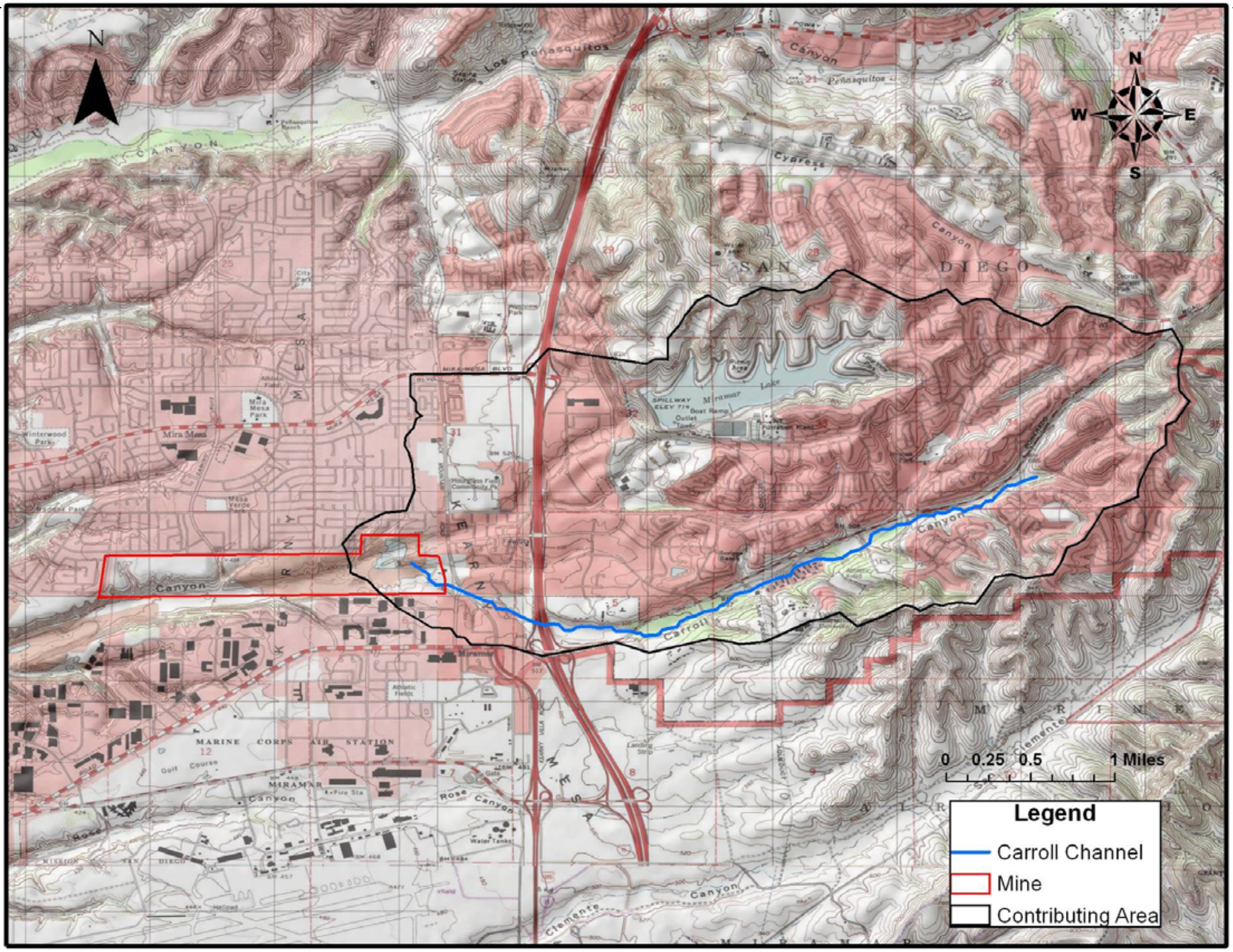


SOURCE: Vulcan Mining Company. Date unknown, believed to be early 1940s.

Carroll Canyon #120380

Figure 3

Historic channel form prior to urbanization of the watershed

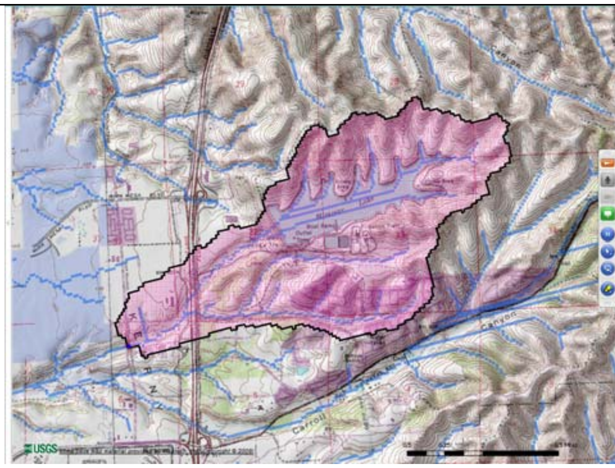


SOURCE: USGS

Carroll Canyon #120380

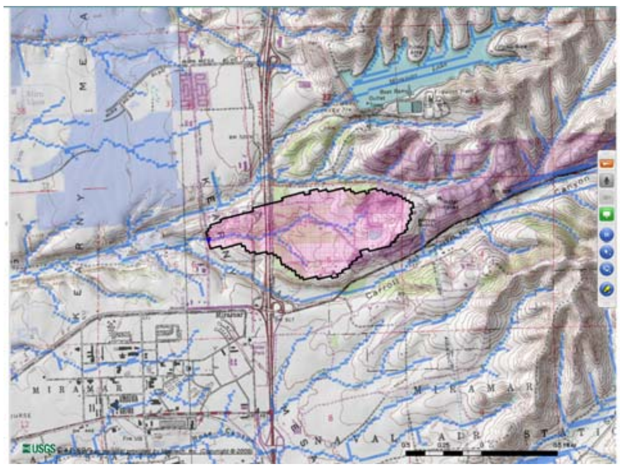
Figure 4

Carroll Canyon watershed in 1999



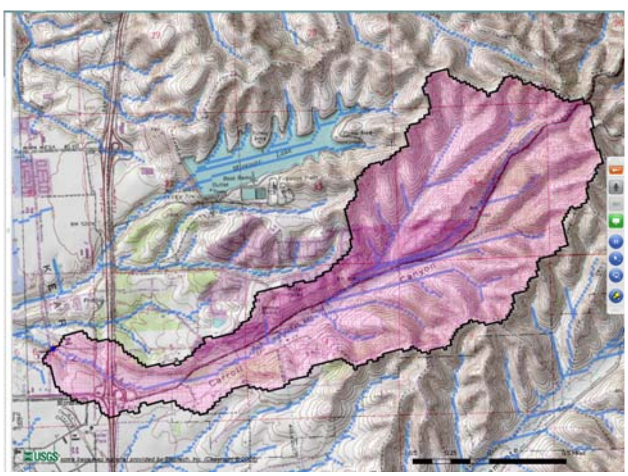
North tributary (1.1 sq miles excluding area above Miramar Lake)

Assumed sediment supply - 25% max



Middle tributary (0.5 sq miles)

Assumed sediment supply - zero



Mainstem (3 sq miles)

Assumed sediment supply – 50% max

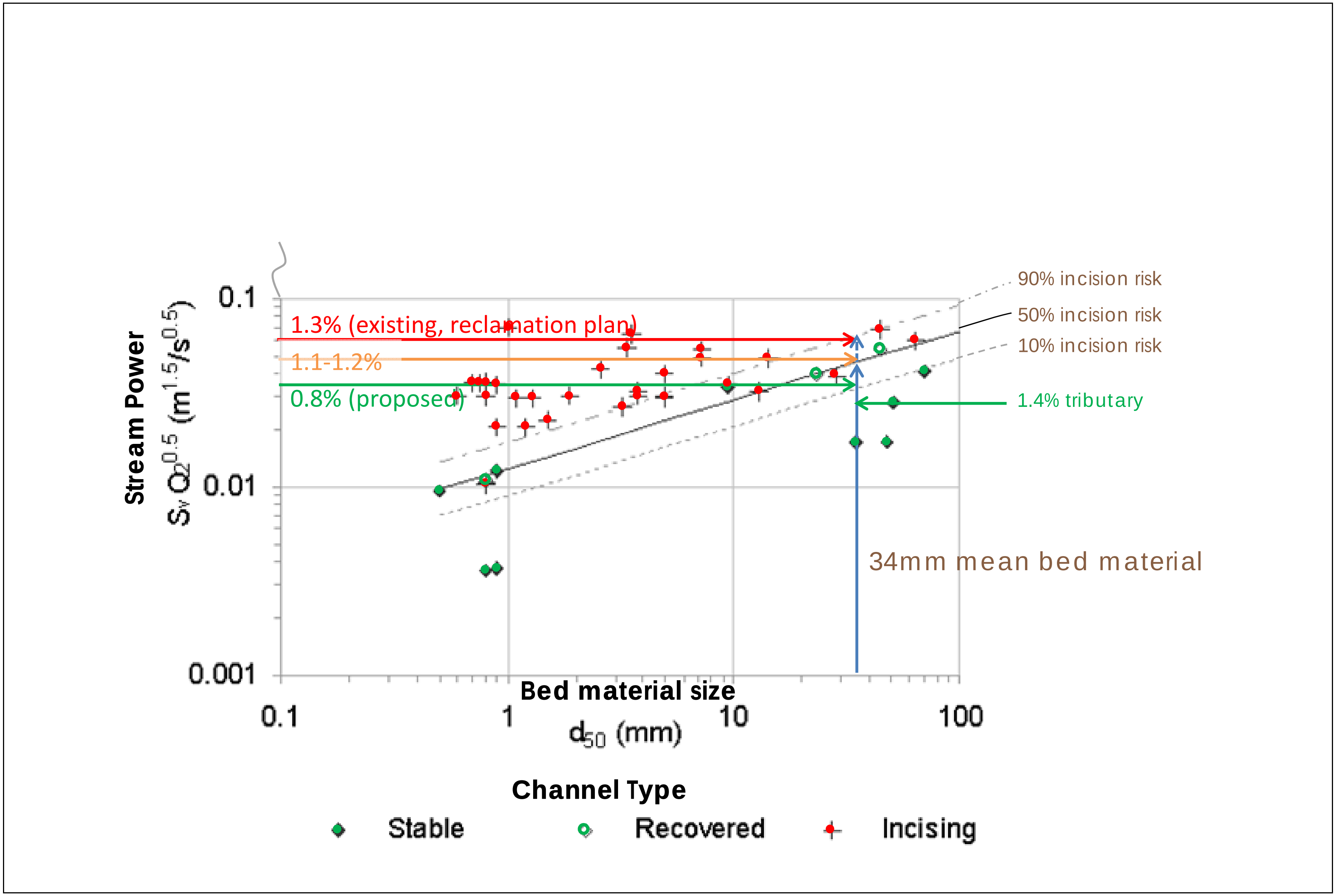
Assumed sediment supply is percentage of maximum sediment transport capacity for the reach shown

SOURCE: USGS StreamStats and Google Earth

Carroll Canyon #120380

Figure 5

Carroll Canyon Contributing Watersheds and Sediment Sources



SOURCE: Source: Bledsoe, Hawley, Stein and Booth, 2010 Hydromod screening tools

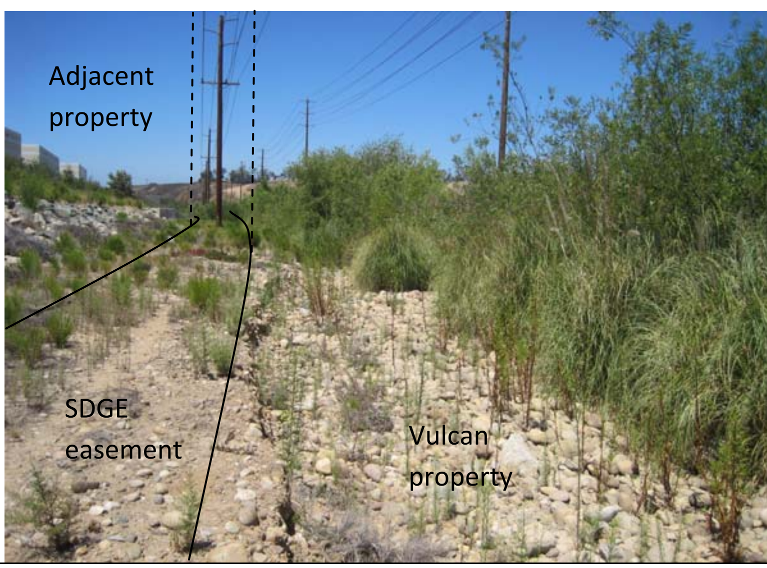
Carroll Canyon #120380

Figure 6

Existing and Proposed Channel Gradients Plotted on Channel Stability Chart for Southern Californian

Sediment sources along Carroll Canyon 200 ft downstream of Black Mountain Road (existing to be preserved in this reach)

Bedload in Carroll Canyon 200 ft downstream of Black Mountain Road



Carroll Canyon downstream of Camino Ruiz showing existing conditions and left bank property constraints

Figure 7
Sediment Sources and Channel Properties Within Carroll Canyon

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Memorandum

date 10/29/2013

to

from Andy Collision, PhD & Aaron Fulton

subject Carroll Canyon (Stone Creek) Preliminary Hydraulic Analysis

Introduction

This memorandum summarizes preliminary hydraulic analyses conducted by ESA-PWA staff at the request of Vulcan Materials Company to inform channel design and development planning and quantify existing and proposed flooding patterns across the proposed Stone Creek development. Site-specific and watershed-scale geomorphic and hydrologic information for the primary flooding source at the site, Carroll Canyon Creek, can be found in the project basis of design report (ESA-PWA, 2012). The purpose of this memorandum is to review the hydraulic analyses conducted to date and provide project graphics reflecting the anticipated changes to flood patterns across the site. It is anticipated that when the site design is more advanced a CLOMR application will be prepared and submitted; this memo is intended to convey a streamlined version of the information that will subsequently go into the CLOMR to help City of San Diego staff to evaluate the proposed project at this earlier stage in the planning process.

ESA-PWA staff constructed three one-dimensional hydraulic models using the Hydrologic Engineering Center's River Analysis System (HEC-RAS version 4.1, 2010). HEC-RAS is a hydraulic model capable of predicting flow velocity, water surface elevations, stage, water depths, and a suite of other hydraulic variables. The three preliminary model scenarios investigated include:

Table 1 – Stone Creek (Carroll Canyon) model scenario summary.

Scenario	Conditions	Area	Notes
1	100-yr Post-Project	East of Camino Ruiz (~6,300 LF)	Proposed Grading
2	100-yr Existing	West of Camino Ruiz (~3,700 LF)	Corrected Effective Model
3	100-yr Post-Project	West of Camino Ruiz (10,000 LF)	Proposed Grading

Scenario 1 was developed to delineate the post-project floodway and floodplain east of Camino Ruiz (Figure 1). An existing conditions model was not conducted for areas east of Camino Ruiz with the assumption that all impacts to flood patterns will be contained within the project boundary. West of Camino Ruiz, Vulcan Materials Company is not the sole landowner adjacent to the floodplain. Therefore, scenarios 2 & 3 were developed to quantify existing flood conditions and guide project design to achieve a "no-net-rise" (Figure 1). Scenario 2 is commensurate with a FEMA "corrected effective" model and reflects changes in channel topography since the effective model was completed and the present condition. It should be noted that future efforts to re-map the floodplain along the entire project site may require various FEMA NFIP documentation efforts (CLOMR,

LOMR) including additional hydraulic and hydrologic analyses. This memorandum does not constitute a CLOMR submittal but provides the necessary detail to quantify anticipated flood patterns as the project is currently designed.

Data Acquisition & Model Development

HEC-RAS model development requires topographic, discharge, and other model parameters to accurately represent the scenario of interest. For example, the post-project conditions should reflect the final design grade of the site including the channel restoration, building pads, and park grading elements abutting Carroll Canyon Creek. Table 2 lists the topographic, discharge, and other model inputs for the three modeled scenarios. All topographic data was converted to the project datum (NGVD29) prior to model development. To compare design grades and predicted water surface elevations to published FEMA base flood elevations (BFSs) model results were converted to the NAVD88 datum using a conversion of +2.119 ft (NGVD29 + 2.119 = NAVD88) based on the VERTCON solution for the site. A preliminary floodway analysis was completed for each of the modeled scenarios using a target surcharge of 1.0 feet.

Table 2 – Stone Creek (Carroll Canyon) model inputs.

Scenario	**Topography**	**Discharge**	**Roughness (Manning's *n*)**	**Boundary Condition**	**Flow Regime**
1	ESA-PWA & KTUA, 2012	FEMA Effective Flows (3,500 cfs)	Channel *n* = 0.05 Overbank *n* = 0.06	Normal Depth	Subcritical
2	2011 & 2008 Aerial Surveys	FEMA Effective Flows (3,500 cfs)	Channel *n* = 0.05 Overbank *n* = 0.06	Normal Depth	Subcritical
3	KTUA, ESA-PWA, & BDS, 2012	FEMA Effective Flows (3,500 cfs)	Channel *n* = 0.05 Overbank *n* = 0.06	Normal Depth	Subcritical

Topographic Data

Scenario 1

Cross sections locations were chosen based on the proposed alignment of the restored Carroll Canyon Creek. Factors influencing cross section spacing included the location of proposed grade control structures, significant changes in floodplain and channel area, and orientation of flood flows. Design grade topography for the Stone Creek park facilities (KTUA) and the channel design (ESA-PWA) were married and converted to a Digital Elevation Model (DEM) that represents the entire model flow domain east of Camino Ruiz. The DEM was sampled using ArcGIS spatial analyst and the Geo-RAS extension and imported to HEC-RAS for simulation. A total of 83 cross sections were delineated east of Camino Ruiz including 26 cross sections along the tributary that joins Carroll Canyon Creek midway through the project site. Ineffective flow areas were defined for portions of the floodplain that are not anticipated to contribute to channel conveyance. For reference the effective FEMA model includes only 13 sections along the 6,300 foot reach (east of Camino Ruiz) (Figure 2).

Scenario 2

A DEM was compiled for both the 2008 and 2011 aerial surveys. Each survey covered the entire model domain west of Camino Ruiz. All but seven model cross sections were extracted from the 2011 aerial survey since it represents the latest topographic data for the project site. Data was extracted from the 2008 survey in seven locations that better matched field observed conditions (depth of channel, height of power pole berms). Cross sections were chosen based on the existing channel alignment and were spaced to capture significant changes in floodplain and channel area. The DEMs were sampled using ArcGIS spatial analyst and the Geo-RAS extension and imported to HEC-RAS for simulation. A total of 69 cross sections were delineated west of Camino Ruiz extending approximately 3,700 lineal feet downstream. Ineffective flow areas were defined for portions of the floodplain that are not anticipated to contribute to channel conveyance. For reference the effective FEMA model includes only 8 cross sections in this reach (Figure 2).

Scenario 3

The BDS, KTUA, and ESA-PWA design grade surfaces west of Camino Ruiz were compiled into a DEM representing proposed building pads, fill slopes, and channel geometry. Cross section locations were identical to Scenario 2 to enable a direct comparison of existing and proposed conditions models. The DEM was sampled using ArcGIS spatial analyst and the Geo-RAS extension and imported to HEC-RAS for simulation. A total of 69 cross sections were delineated west of Camino Ruiz and extended approximately 3,700 lineal feet downstream. Cross sections from Scenario 1 (Post-Project) were appended to the Scenario 3 model to generate a comprehensive post-project conditions model of the entire project reach (east and west of Camino Ruiz).

Bridge & Culvert Design

The Stone Creek project entails constructing 3 new channel-spanning bridge structures and extending the double barrel 8 foot by 12 foot box culvert under Camino Ruiz. Detailed bridge design elevations will be finalized in subsequent design phases and were not explicitly represented in the hydraulic model. The culvert at Camino Ruiz was represented in the model by assuming the same culvert dimensions and channel slope and extending the culvert to a total length of 472 feet.

Discharge Data

ESA PWA reviewed the FEMA Flood Insurance Study (FIS) for San Diego County (FEMA, 2012) and the effective 100-yr HEC-2 flood model. The effective model reports a 100-year discharge of 3,500 cfs between FEMA cross-section AT (located approximately 1 mile below the project site) and cross-section CI (located at the upstream boundary of the project site). The first cross-section upstream of the project site (CJ) reports a discharge of 1100 cfs for the 100- yr event which suggests the reported effective model flows do not adequately reflect the decrease in contributing watershed area between section AT and CJ and across the project site. In the absence of more detailed hydrologic studies of the watershed we utilized the published 100-yr FEMA discharge at the upstream project boundary in all hydraulic analyses (3,500 cfs).

Base Flood Elevations

The effective DFIRM database and Flood Insurance Study (FIS) were obtained from FEMA. The effective FIS for unincorporated and incorporated San Diego County is dated May 12th, 2012. Published DFRIM BFE shapefiles were projected to the project datum (NAD27) in ArcGIS.

Results

Scenario 1 - Proposed Conditions East of Camino Ruiz

The post-project floodplain and floodway east of Camino Ruiz is shown in Figure 3. When preliminary model results are compared against published FEMA BFEs it is apparent that the project will both increase and decrease flood elevations in different locations. Post-project 100-yr flood elevations will vary between ~9 feet higher and 12 feet lower than published values (Figure 3). The increases in flood elevation are due to raises in the elevation of the creek invert (currently lowered by historic mining activities and channel incision) and filling of depressions in the quarry that currently lie within the 100-year floodplain. All rises in flood elevation are contained within the planned creek corridor (a mixture of habitat restoration areas and open space) and within the project property boundary. A large (~15 foot) proposed waterfall structure near the upstream boundary of the project prevents backwater impacts from propagating upstream of the site and potentially raising flood levels in adjacent parcels. Near Camino Ruiz, the post-project 100-yr water surface elevations are approximately 1 foot higher than a recently completed LOMR covering the project site. It should be noted that the predicted water surface elevation at the downstream extent of the culvert is 1 foot lower than the published LOMR model (Chang, 2008). The discrepancy in predicted flood elevations at either end of the culvert is likely to do the location of the upstream and downstream model cross sections, assumed top of culvert elevation, and delineation of ineffective flow areas immediately upstream of the culvert. Final culvert sizing & design should verify that existing flood elevations at Camino Ruiz are not exceeded.

Scenario 2 - Existing Conditions West of Camino Ruiz (Corrected Effective)

A comparison between the existing conditions model "corrected effective" and FEMA BFEs indicate a difference of negative 2 feet (lower) and positive six feet (higher) (Figure 4). This disparity in published BFEs and model results compiled from the latest topographic data available indicates the channel and/or floodplain has undergone considerable adjustment since the published BFE model was developed. As part of any CLOMR and LOMR application submittal, the project applicant would have to tie into the effective model downstream of the project site.

Scenario 3 - Proposed Project Conditions West of Camino Ruiz

Existing (corrected effective) and post-project floodplain areas are provided in Figure 4. Under project conditions the floodplain would narrow slightly along the northern channel bank. Potential losses in floodplain conveyance will be offset by in-channel grading and bank setbacks along the northern channel banks to maintain overall conveyance. Therefore, based on hydraulic modeling using the 2011 and 2008 aerial surveys and the proposed grading plans, the project will have a "no-net-rise" downstream of Camino Ruiz.

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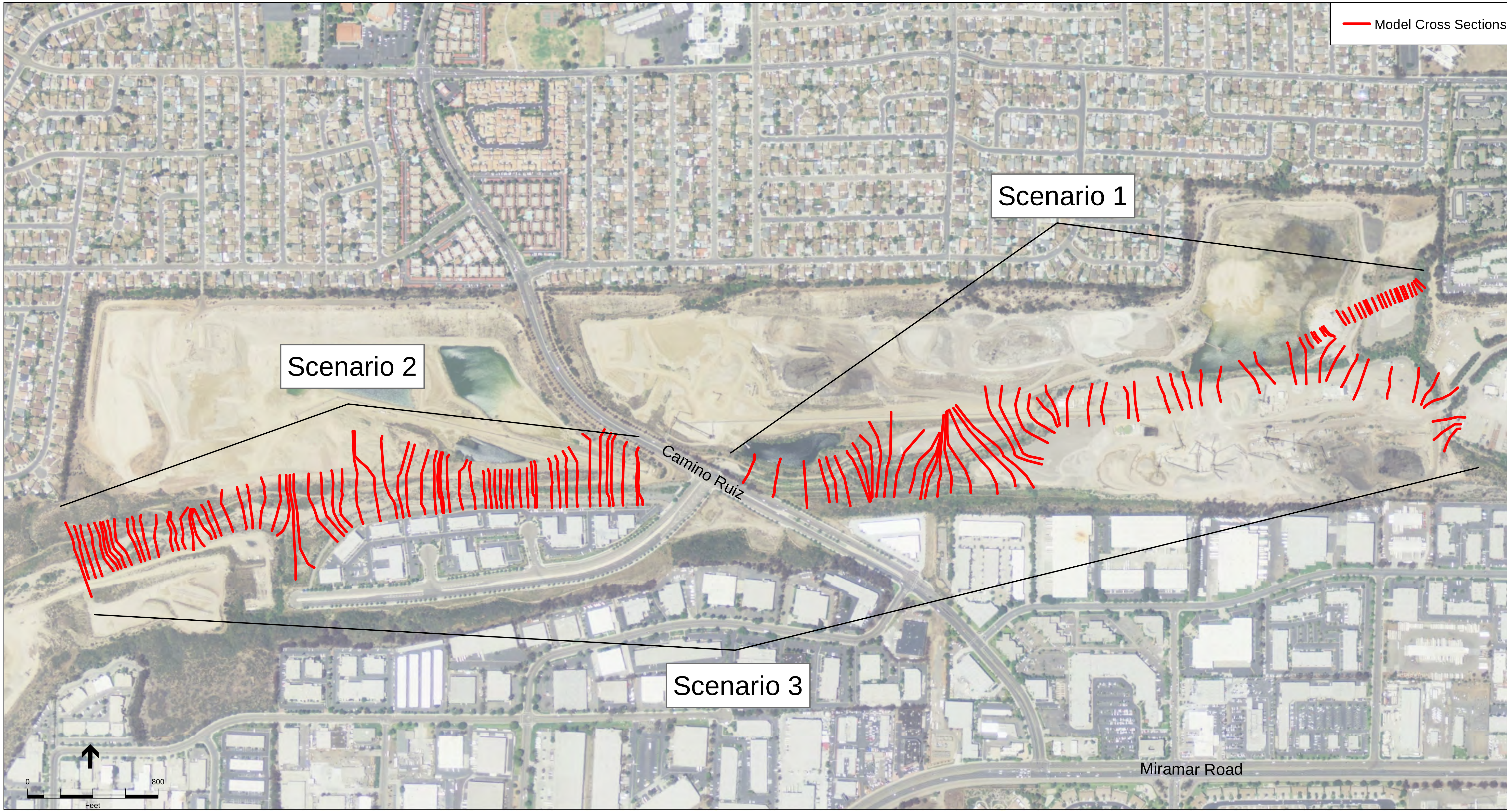
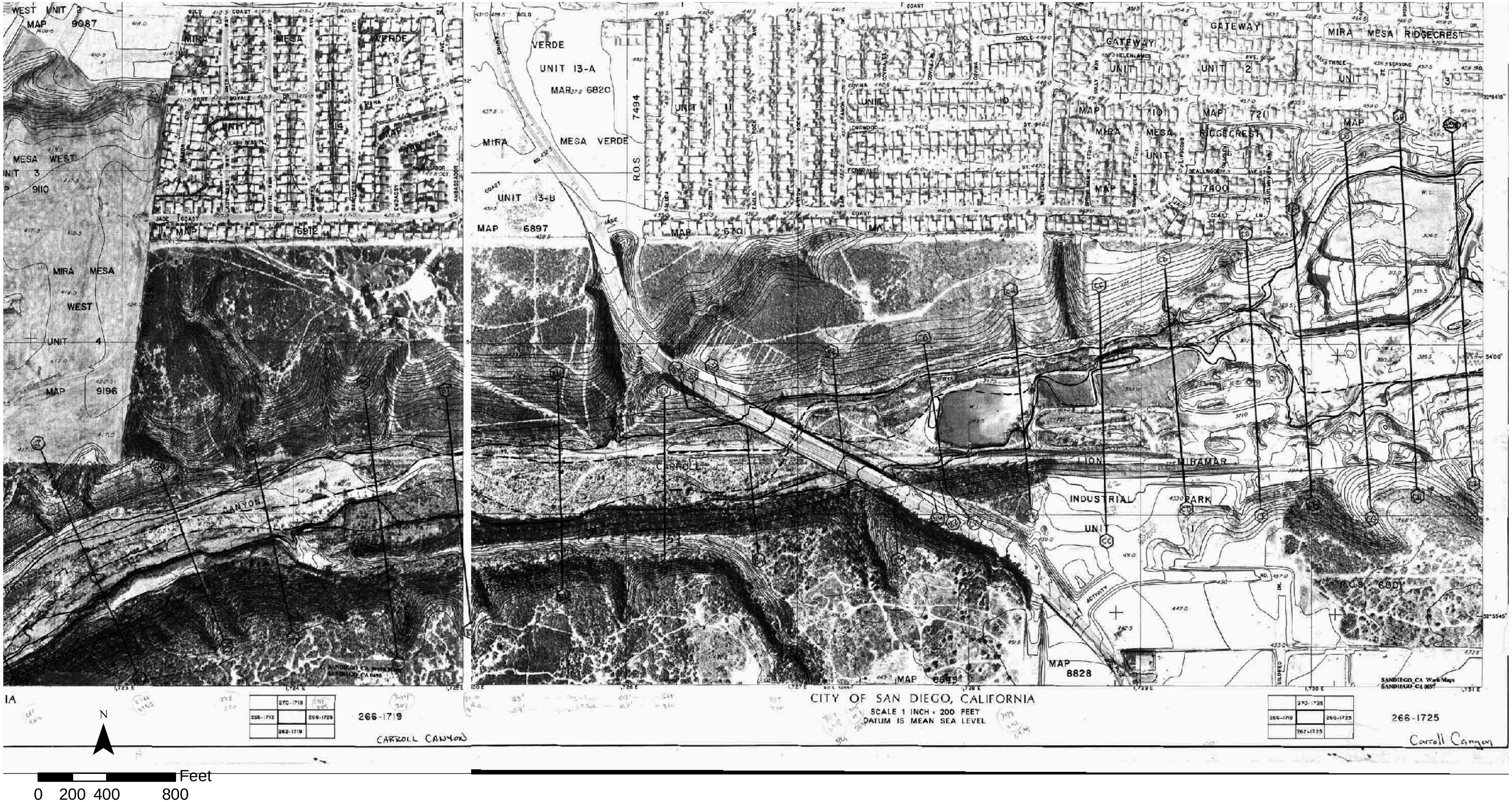


SOURCE: 2012 NAIP

Carroll Canyon Channel Design . D120380

Figure 1

Carroll Canyon (Stone Creek) Model Domain



Carroll Canyon Channel Design . D120380

Figure 2

Effective FEMA Cross Sections -Carroll Canyon

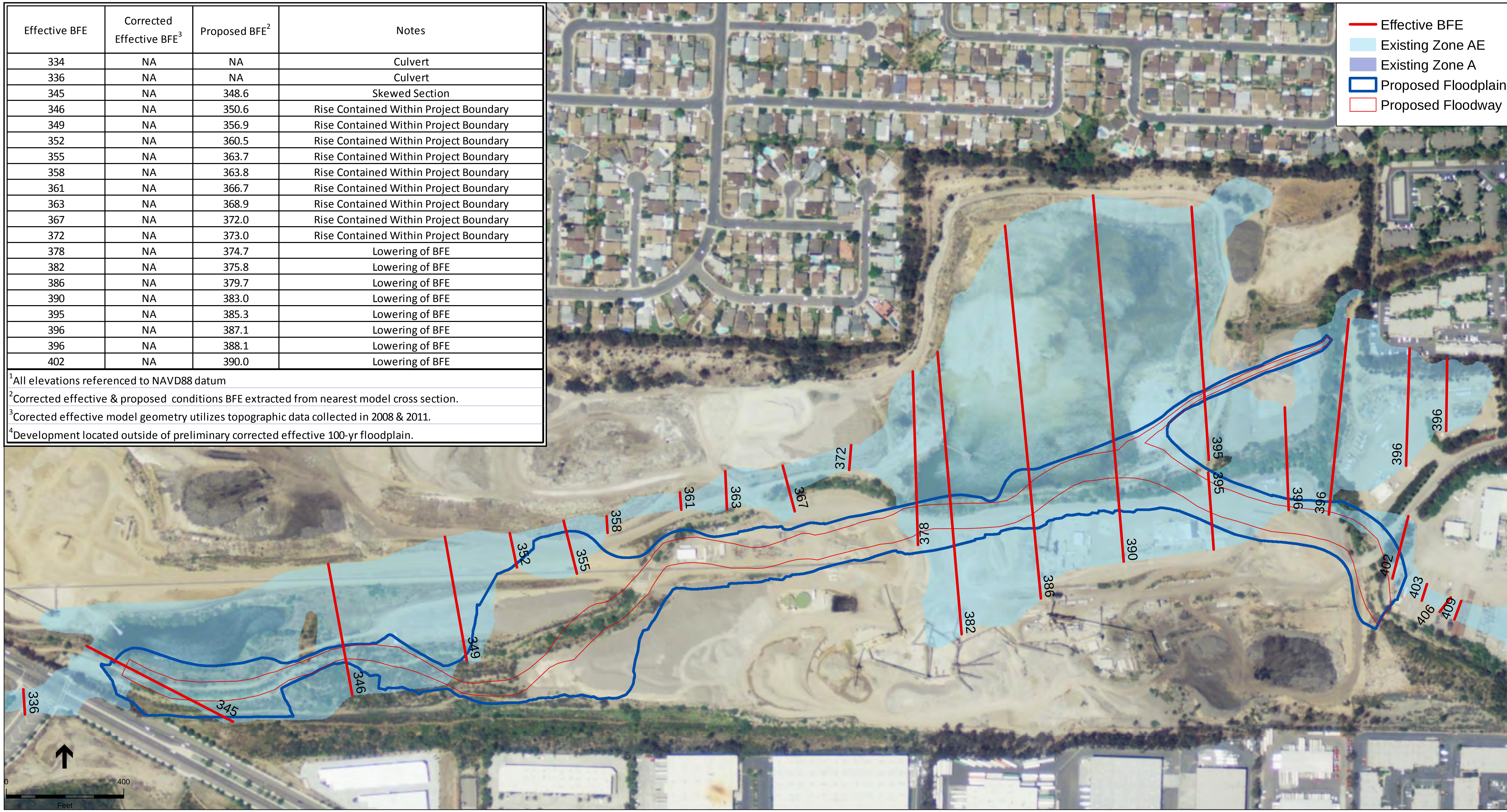
Effective BFE	Corrected Effective BFE[3]	Proposed BFE[2]	Notes
334	NA	NA	Culvert
336	NA	NA	Culvert
345	NA	348.6	Skewed Section
346	NA	350.6	Rise Contained Within Project Boundary
349	NA	356.9	Rise Contained Within Project Boundary
352	NA	360.5	Rise Contained Within Project Boundary
355	NA	363.7	Rise Contained Within Project Boundary
358	NA	363.8	Rise Contained Within Project Boundary
361	NA	366.7	Rise Contained Within Project Boundary
363	NA	368.9	Rise Contained Within Project Boundary
367	NA	372.0	Rise Contained Within Project Boundary
372	NA	373.0	Rise Contained Within Project Boundary
378	NA	374.7	Lowering of BFE
382	NA	375.8	Lowering of BFE
386	NA	379.7	Lowering of BFE
390	NA	383.0	Lowering of BFE
395	NA	385.3	Lowering of BFE
396	NA	387.1	Lowering of BFE
396	NA	388.1	Lowering of BFE
402	NA	390.0	Lowering of BFE

[1]All elevations referenced to NAVD88 datum

[2]Corrected effective & proposed conditions BFE extracted from nearest model cross section.

[3]Corected effective model geometry utilizes topographic data collected in 2008 & 2011.

[4]Development located outside of preliminary corrected effective 100-yr floodplain.



SOURCE: 2012 NAIP, FEMA FIS/DFIRM, San Diego County 05/16/2013

Carroll Canyon Channel Design . D120380

Figure 3

Scenario 1 - Existing Floodplain And Proposed BFEs

Effective BFE	Corrected Effective BFE[3]	Proposed BFE[2]	Notes
278	283.3	283.3	No Rise From Corrected Effective[4]
280	286.7	286.7	No Rise From Corrected Effective[4]
285	291.6	291.6	No Rise From Corrected Effective[4]
289	294.3	294.3	No Rise From Corrected Effective[4]
294	298.3	298.3	Begin Project, No Rise From Corrected Effective[4]
299	299.3	299.3	No Rise From Corrected Effective[4]
306	305.2	305.2	No Rise From Corrected Effective[4]
312	315.9	315.9	No Rise From Corrected Effective[4]
317	317.7	317.7	No Rise From Corrected Effective[4]
322	320.2	320.2	No Rise From Corrected Effective[4]
327	327.1	327.1	No Rise From Corrected Effective[4]
329	331.6	331.6	No Rise From Corrected Effective[4]

[1]All elevations referenced to NAVD88 datum

[2]Corrected effective & proposed conditions BFE extracted from nearest model cross section.

[3]Corected effective model geometry utilizes topographic data collected in 2008 & 2011.

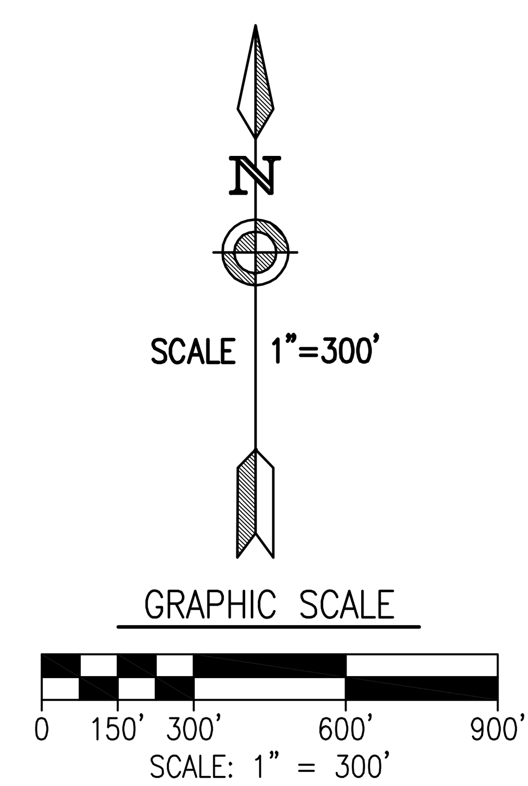
[4]Development located outside of preliminary corrected effective 100-yr floodplain.

SOURCE: 2012 NAIP, FEMA FIS/DFIRM, San Diego County 05/16/2013

Carroll Canyon Channel Design . D120380

Figure 4

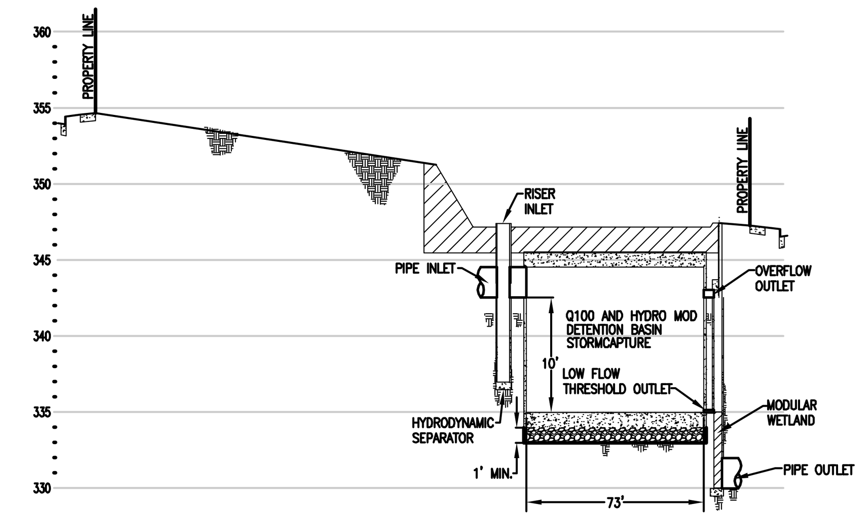
Scenario 2 - Corrected Floodplain And Proposed BFEs



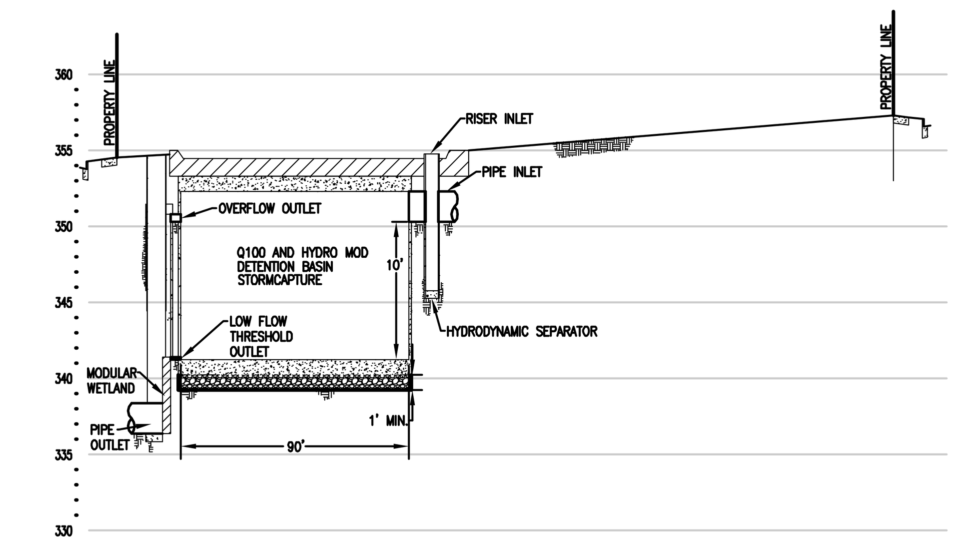
PRE–DEVELOPMENT HYDROLOGY MAP
(OFFSITE AREAS INCLUDED)

ENGINEER OF WORK:
BDS ENGINEERING, INC.
CIVIL ENGINEERING
LAND SURVEYING
6859 Federal Boulevard
Lemon Grove, California 91945
(619) 582–4992

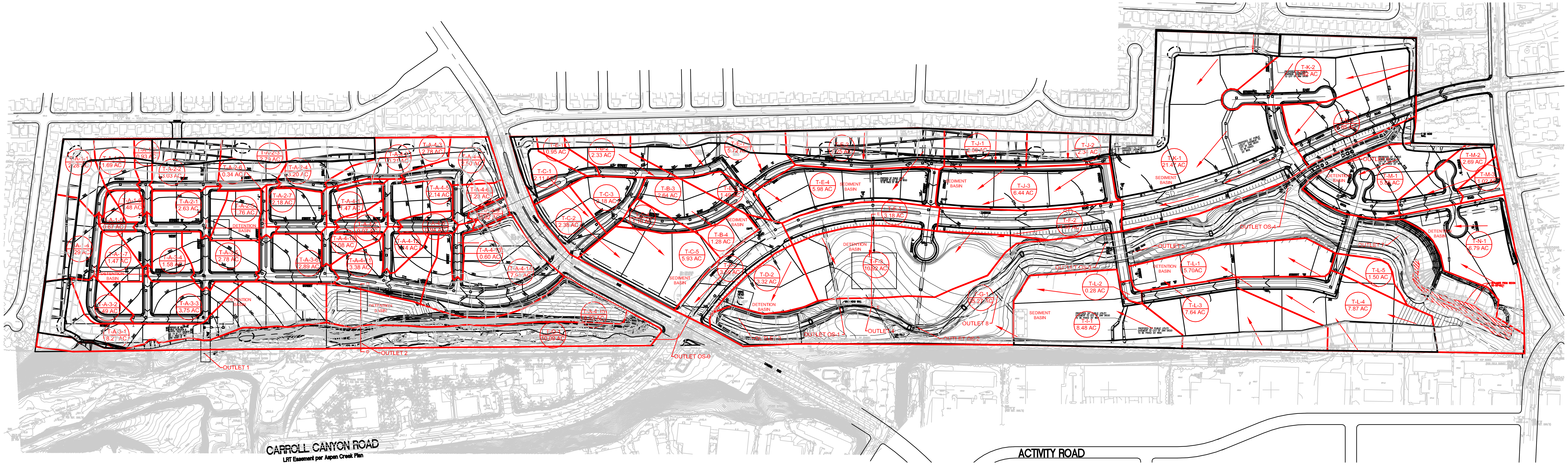
04–23
JOB NO.



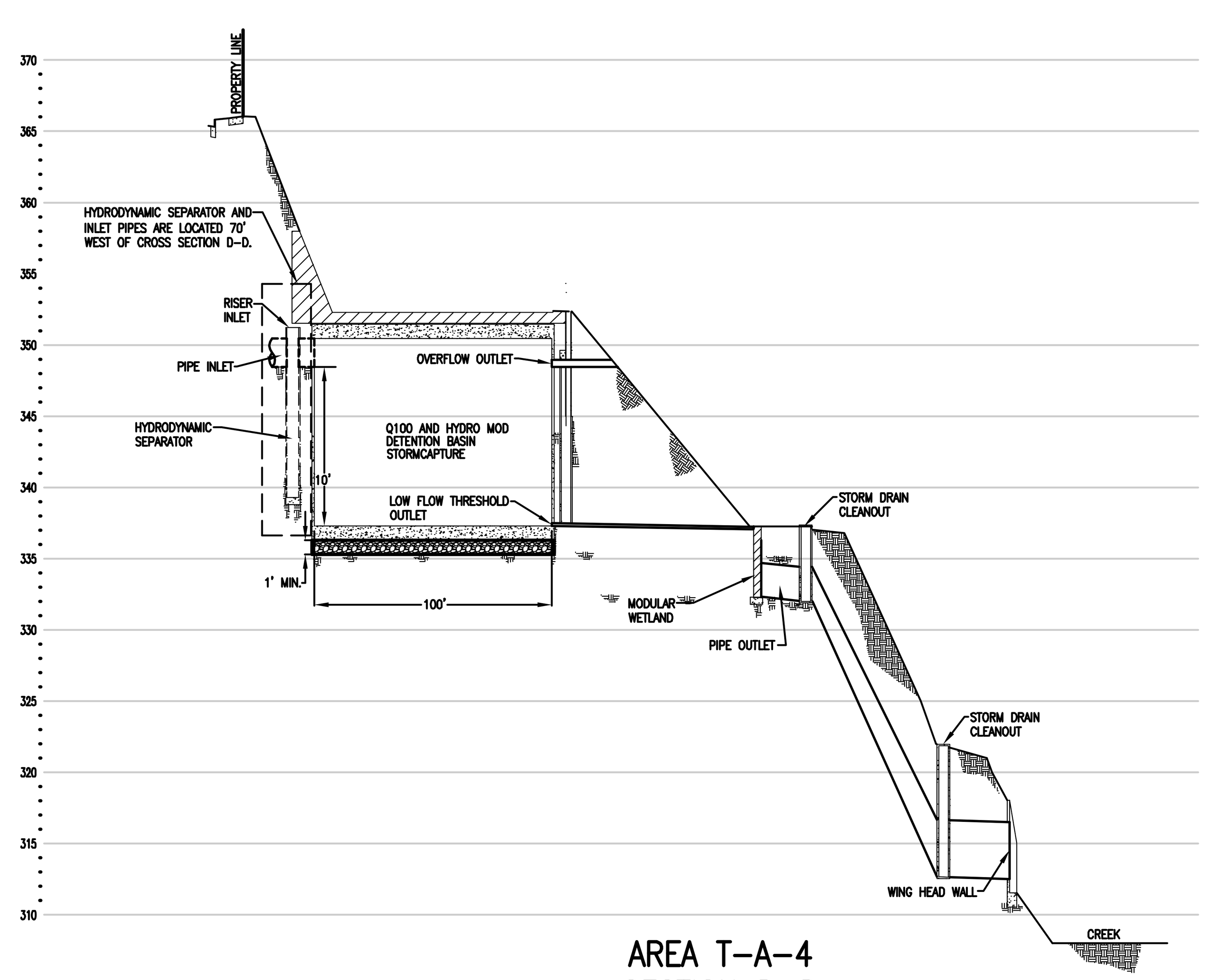
AREA T–A–1
SECTION A–A
SCALE: NO SCALE



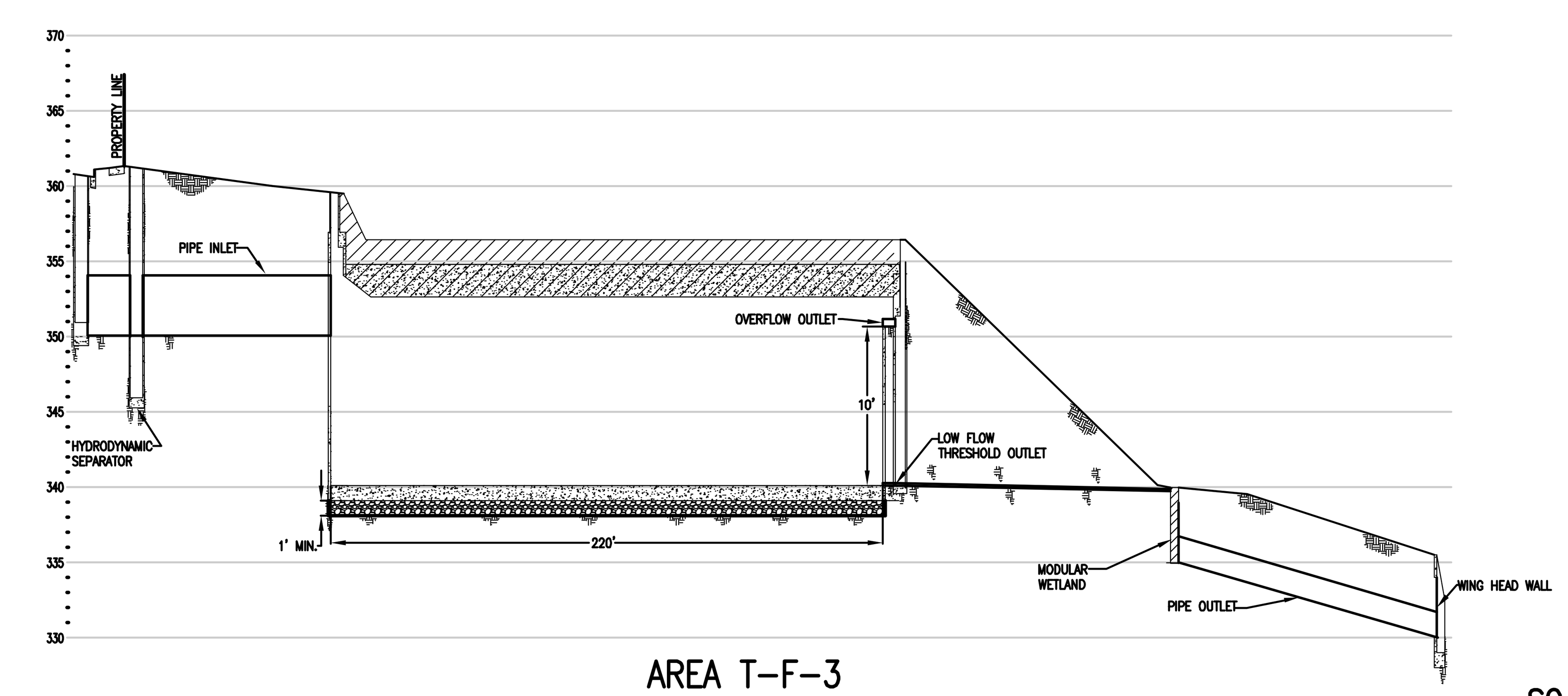
AREA T–A–2
SECTION B–B
SCALE: NO SCALE



POINTS OF COMPLIANCE
OUTLETS 1, 2, 3, 4, 5, 6, 7



AREA T–A–4
SECTION D–D
SCALE: NO SCALE



AREA T–F–3
SECTION E–E
NO SCALE

N

SCALE 1"=300'

GRAPHIC SCALE
0 150' 300' 600' 900'
SCALE: 1" = 300'

POST DEVELOPMENT TENTATIVE HYDROLOGY MAP
STONE CREEK – TENTATIVE PHASE

ENGINEER OF WORK:
BDS ENGINEERING, INC.
CIVIL ENGINEERING
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6859 Federal Boulevard
Lemon Grove, California 91945
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POST DEVELOPMENT TENTATIVE OVERALL REVISED 03–26–2019.dwg

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