Hallmark-Barham Specific Plan EIR

Technical Appendices

Appendix J.1

Drainage Report

Preliminary Drainage Report

943 Barham Drive
TM 20- /SDP 20-

City of San Marcos, CA
County of San Diego

PREPARED FOR:

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PREPARED BY:

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CIVIL
STATE OF CALIFORNIA

Allen L. Butcher, PE 47107

June 15, 2020 V1.0

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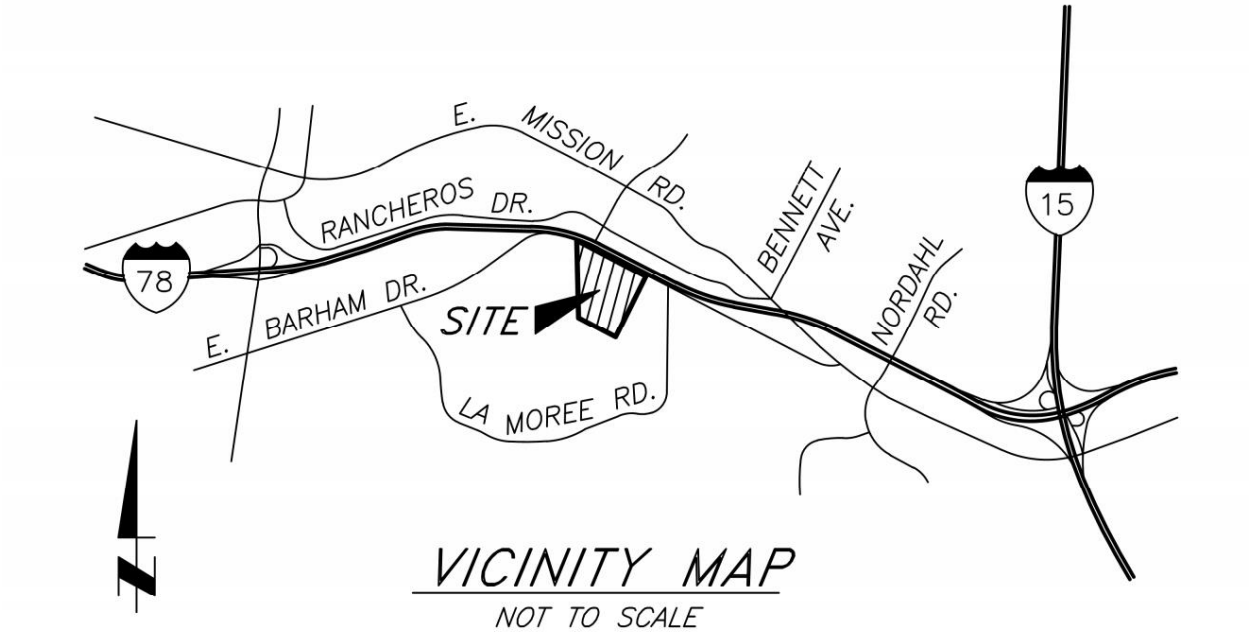

VICINITY MAP

NOT TO SCALE

1. Scope of Report

The project is subject to storm water treatment and HMP mitigation requirements. By definition, *HMP compliance minimizes the potential for altering flow regimes and creating excessive erosion in receiving waters*. This is accomplished by limiting increases in flow rates and durations based upon the pre-development range of geomorphically significant flows. Sizing of treatment Best Management Practices (BMPs), and analyses of hydromodification impacts are provided in the Storm Water Quality Management Plan (SWQMP) prepared by SB&O Inc.

The purpose of this report is to document the project changes in the flood level peak flow rates. Due to the potential near term storm drain capacity constraints, the report will include detention routing to verify that the 100-year post development runoff does exceed the existing peak flow rates. Therefore, capacity analyses of the downstream facilities are not warranted.

Detailed pipe calculations and inlet sizing will be provided during the final design report.

2. Hydrology

2.1 Design Criteria

Rational Method calculations were prepared in accordance with the County of San Diego of Hydrology Manual (June 2003 Edition) to calculate the peak flow rates for the 100-year storm events. (See Appendix for Reference Materials, Charts & Tables)

2.2 Soils

Onsite surface soils are generally classified as granular. Based on the project Preliminary Geotechnical report, the hydrologic soil classification is Type "D" (See Appendix for Hydrologic Soil Group Map).

2.3 Runoff Coefficient (C-Factors)

Runoff coefficients in the rational method were assigned based upon the impervious ratio of the tributary area, and assigned based upon soil type as follows;

Runoff Coefficients - Type "B" Soil		
Condition	**% Impervious**	**Runoff Coefficient**
Existing site /upstream hillside	10	0.41
Proposed Site – HDR	80	0.79
Barham R/W	90	0.85

2.4 Rainfall

Rainfall intensities were calculated using the rainfall data from the County 6-Hour and 24-Hour Isopluvial Maps as follows:

Storm Event	6-Hour Rainfall (in)	24-Hour Rainfall (in)	Ratio P6/P24	Adjusted P6 (in)
100-Year	3.3	5.7	58%	3.3
50-Year	2.8	5.3	53%	2.8
25-Year	2.6	4.6	57%	2.6
10-Year	2.2	3.7	59%	2.2
5-Year	1.9	3.3	58%	1.9
2-Year	1.52	2.4	63%	1.52

See Appendix for Isopluvial Maps and Figure 3-1 to determine the adjusted 6-hour rainfall.

2.5 Time of Concentration

Rainfall intensities were calculated using times of concentration in accordance with the procedures noted in the June 2003 Hydrology manual. This includes the limitations on maximum overland flow length and initial times of concentration as noted in Table 3-2. The initial times of concentration are restricted based upon the Land Use / Density (% Impervious) and slope.

3. Existing Site

The property is located in the eastern portion of San Marcos, south of SR-78, between Nordahl Road & Twin Oaks Valley Road. The existing site is approximately 10 acres in size, with frontage along the south side of Barham Road, between La Morcee Road & Woodland Parkway.

The existing site is vacant and includes a hillside along the southern limits. Drainage is "natural" and generally overland toward the Barham Road frontage. Drainage patterns are generally southeast to northwest and includes run-on from the hillside above the site. The majority of site runoff is directed overland to the Barham gutter. A small depression is near the northwest corner of the site. A storm drain riser is located near the northeast corner of the site and is connected to the public storm drain in Barham Road (MS-4).

See Existing Drainage Exhibit Map Pocket #1.

Existing Hydrology						
Location	Basin	Area (ac)	CivilD Node	"C"	Tc (min)	Q100 (cfs)
Existing Site & Hillside	A-1	13.931		0.41	11.08	29.73
Barham Frontage & Cut Slope	A-2,3	0.923		0.85	8.47	4.856
Existing Total		14.854			11.08	33.81

The existing hydrology calculations (CivilD) are available for review in Exhibit "A".

4. Project Hydrology

The Barham Drive project is a high-density multi-family residential development with private streets, driveways and alleys. Several multi-story buildings with individual parking garages and surface parking will be constructed. A recreation area and building are also included. The majority of the developed runoff will be conveyed by the site private storm drain system to the northwest corner of the site for treatment and flow control (HMP & Detention). The proposed basin which will discharge to the existing storm drain system in Barham Road.

See the Proposed Drainage Exhibit in Map Pocket #2.

Due to the hillside nature of the development, runoff from the steep driveway entries and frontage slopes will discharge to the Barham gutter. These flow will be intercepted by a proposed inlet on Barham Road near the northwest corner of the site.

The uphill section of the project will include manufactured cut slopes at the existing hillside. Runoff from the existing and proposed slopes will be intercepted in the bypass drainage ditches and storm drain, then directed to the westerly limits and then conveyed to a proposed inlet near the northwest corner of the property, which is connected to the existing Barham storm drain (MS-4).

Post development site runoff is summarized below;

Post Development Hydrology						
Location	Basin	Area (ac)	CivilD Node	"C"	Tc (min)	Q100 (cfs)
Developed site	P1-P5,C	7.51	13-17	0.79	8.0	38.07
Barham	A, B	1.92	1-10	0.76	8.47	9.06
Slopes/Bypass	E-1 to E-5	5.43	18	0.41	9.39	13.32
Post Development		14.86				60.45

The proposed hydrology calculations (CivilD) are available for review in Exhibit "B".

5. Detention

The project is required to provide water quality treatment and flow control for post development runoff. The project proposes a surface biofiltration basin with enhanced below grade storage to provide treatment and flow control. The surface basin has additional storage depth and an overflow structure with both a weir opening and grated top to provide attenuation of larger storm events. A concrete lined ramp provides an emergency overflow path to the driveway and then Barham Drive. In order to ensure that post development flows do not exceed existing peak flows, detention routing analyses were prepared to determine peak outflows, and to provide adjusted discharge estimate for comparison to the existing condition.

6. Rational Method Hydrograph Methodology

The County of San Diego Hydrology Manual includes a procedure to develop a time-based runoff series. The methodology assumes a simple triangular runoff hydrograph, and is based the 6-hour rainfall total, and the Rational Method input variables. The methodology provides runoff values at time intervals equal to multiples of the time of concentration. Details related to the procedure to develop the hydrograph are provided in Chapter 6 of the County of San Diego Hydrology Manual (See Appendix for details).

Rational method hydrographs for the 6-hour storms were prepared for the area tributary to the detention basin. Hydrographs were not prepared for the Barham /frontage slopes or the hillside / bypass drain system, or the existing development conditions.

See Exhibit "C" for the 6-hour Rational Method Hydrograph calculations & time series.

7. Detention Models

The detention models are based upon the basin and flow control openings determined by the SWMM analysis. Discharge values were estimated using standard weir and orifice flow equations. A Storage-Indication-Outflow table was prepared using the following data;

Main Basin Storage 54,724 cf. (1.26 ac-ft) @ 4.95' surface depth

Elevation	Description	Dimension/Size	Comment
647.15	Bottom of Crushed Rock	6,764 sf	40% Void Ratio
647.15	Low Flow Orifice	2" dia.	
648.15	Bottom of Soil Layer	6,764 sf	30% Void Ratio
650.15	Floor of Surface Basin	6,764 sf	
650.65	surface depth @ 6"	7,330 sf	Treatment Surface Area
653.90	3" overflow opening	11,027 sf	3.75' surface depth
654.60	Grated overflow 5' x5'	11,931 sf	4.45' surface depth
655.10	Surface Overflow	12,594 sf	4.95' surface depth
656.10	Top of Earth Berm	14,575 sf	5.95' surface depth

The Storage Indication Outflow table are located in Exhibit "D".

The 6-hour rational method hydrographs were routed to determine the attenuated peak outflow and maximum storage depth. A review of the results indicates a peak outflow to the storm drain is 5.61 cfs, with a maximum depth of 7.75 feet (4.75' surface depth). The maximum 100-year water surface elevation is estimated at 654.9, which is 0.2' below the overflow ramp.

The detention routing analysis is located in Exhibit "E".

8. Post Development Hydrology

In order to assess the potential hydrology impacts of the development, an adjusted comparison is summarized as follows;

Post Development Hydrology – Adjusted Discharge						
Location	Basin	Area (ac)	CivilD Node	"C"	Tc (min)	Q100 (cfs)
Developed site	Detention	7.51			8.0	**5.61**
Barham	A, B	1.92	1-10	0.76	8.47	9.06
Slopes/Bypass	E-1 to E-5	5.43	18	0.41	9.39	**13.32**
Post Development		14.86				27.99
Existing Total		14.85			11.08	33.81
					Change	-5.82

The comparison illustrates that the detention basin will attenuate post development flows to at or below the existing conditions.

The existing storm drain to the site is shown on City of San Marcos plan IP 4729 Sheet 39B as

Interim 18" RCP Storm Drain @ 0.39% with an Interim Capacity = 10.2 cfs, which will be connected to the future Storm Drain 48" RCP @ 0.66% Q100 = 117.4 cfs

The estimated post project 100-year peak discharge to the interim storm drain is 18.93 cfs (detention outflow + bypass), compared to the exiting peak flow of 29.73 cfs.

9. Conclusion

The project proposes a single combination basin to provide treatment, flow control and attenuation of storm flows from the development envelope. The calculations and detention analysis confirm that the post project peak flows will not exceed the existing condition.

Due to the hillside nature of the development, runoff from the steep driveway entries and frontage slopes will discharge to the Barham gutter, and will avoid the detention basin. These flows will continue westerly to the existing curb inlet on Barham Road near the church driveway.

The uphill section of the project will include manufactured cut slopes. Runoff from the existing and proposed slopes will be intercepted in the bypass drainage ditches and storm drain, directed to the westerly limits and conveyed to a proposed inlet near the northwest corner of the property, which is connected to the existing Barham Drive storm drain (MS-4).

EXHIBIT A

EXISTING CONDITIONS

RATIONAL METHOD (CIVILD)

Barham Existing Site

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2014 Version 9.0

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 06/04/20

********* Hydrology Study Control Information **********

Program License Serial Number 6334

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.300
24 hour precipitation(inches) = 5.700
P6/P24 = 57.9%
San Diego hydrology manual 'C' values used

++
Process from Point/Station 1.000 to Point/Station 2.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL]
(1.0 DU/A or Less)
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Initial subarea total flow distance = 1615.000(Ft.)
Highest elevation = 874.000(Ft.)
Lowest elevation = 649.400(Ft.)
Elevation difference = 224.600(Ft.) Slope = 13.907 %
Top of Initial Area Slope adjusted by User to 14.025 %
Bottom of Initial Area Slope adjusted by User to 14.025 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 14.03 %, in a development type of
1.0 DU/A or Less
In Accordance With Table 3-2
Initial Area Time of Concentration = 6.40 minutes
(for slope value of 10.00 %)
The initial area total distance of 1615.00 (Ft.) entered leaves a
remaining distance of 1515.00 (Ft.)
Using Figure 3-4, the travel time for this distance is 4.68 minutes
for a distance of 1515.00 (Ft.) and a slope of 14.03 %
with an elevation difference of 212.48(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
= 4.677 Minutes
Tt=[(11.9*0.2869^3)/(212.48)]^.385= 4.68
Total initial area Ti = 6.40 minutes from Table 3-2 plus
4.68 minutes from the Figure 3-4 formula = 11.08 minutes

Rainfall intensity (I) = 5.205(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.410
Subarea runoff = 29.731(CFS)
Total initial stream area = 13.931(Ac.)
End of computations, total study area = 13.931 (Ac.)

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2014 Version 9.0

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 05/05/20

********* Hydrology Study Control Information **********

Program License Serial Number 6334

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.300
24 hour precipitation(inches) = 5.700
P6/P24 = 57.9%
San Diego hydrology manual 'C' values used

++
Process from Point/Station 3.000 to Point/Station 4.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[INDUSTRIAL area type]
(Limited Industrial)
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Initial subarea total flow distance = 100.000(Ft.)
Highest elevation = 666.000(Ft.)
Lowest elevation = 663.800(Ft.)
Elevation difference = 2.200(Ft.) Slope = 2.200 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 70.00 (Ft)
for the top area slope value of 2.20 %, in a development type of
Limited Industrial
In Accordance With Table 3-2
Initial Area Time of Concentration = 3.10 minutes
(for slope value of 2.00 %)
The initial area total distance of 100.00 (Ft.) entered leaves a
remaining distance of 30.00 (Ft.)
Using Figure 3-4, the travel time for this distance is 0.47 minutes
for a distance of 30.00 (Ft.) and a slope of 2.20 %
with an elevation difference of 0.66(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
= 0.466 Minutes
Tt=[(11.9*0.0057^3)/(0.66)]^.385= 0.47
Total initial area Ti = 3.10 minutes from Table 3-2 plus
0.47 minutes from the Figure 3-4 formula = 3.57 minutes
Calculated TC of 3.566 minutes is less than 5 minutes,
resetting TC to 5.0 minutes for rainfall intensity calculations

```
Rainfall intensity (I) =      8.695(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =      1.153(CFS)
Total initial stream area =        0.156(Ac.)


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Process from Point/Station        4.000 to Point/Station        5.000
**** STREET FLOW TRAVEL TIME + SUBAREA FLOW ADDITION ****
________________________________________________________________________
Top of street segment elevation =   663.800(Ft.)
End of street segment elevation =   648.900(Ft.)
Length of street segment  =   850.000(Ft.)
Height of curb above gutter flowline  =    6.0(In.)
Width of half street (curb to crown)  =  32.000(Ft.)
Distance from crown to crossfall grade break  =  30.500(Ft.)
Slope from gutter to grade break (v/hz) =   0.020
Slope from grade break to crown (v/hz)  =   0.020
Street flow is on [1] side(s) of the street
Distance from curb to property line  =  10.000(Ft.)
Slope from curb to property line (v/hz) =   0.020
Gutter width =   1.500(Ft.)
Gutter hike from flowline =  1.500(In.)
 Manning's N in gutter =  0.0150
 Manning's N from gutter to grade break =  0.0150
 Manning's N from grade break to crown =  0.0150
Estimated mean flow rate at midpoint of street =      3.043(CFS)
Depth of flow =   0.293(Ft.), Average velocity =   2.886(Ft/s)
Streetflow hydraulics at midpoint of street travel:
Halfstreet flow width =   9.915(Ft.)
Flow velocity =   2.89(Ft/s)
Travel time =    4.91 min.     TC =    8.47  min.
 Adding area flow to street
Rainfall intensity (I) =      6.187(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[INDUSTRIAL area type                         ]
(Limited Industrial       )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Rainfall intensity =      6.187(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =      0.785
Subarea runoff =      3.701(CFS) for      0.767(Ac.)
Total runoff =      4.854(CFS)   Total area =       0.923(Ac.)
Street flow at end of street =      4.854(CFS)
Half street flow at end of street =      4.854(CFS)
Depth of flow =   0.334(Ft.), Average velocity =   3.229(Ft/s)
Flow width (from curb towards crown)=  11.967(Ft.)
End of computations, total study area =           0.923 (Ac.)
```

EXHIBIT B

PROPOSED SITE
BYPASS STORM DRAIN

RATIONAL METHOD (CIVILD)

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2014 Version 9.0

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 06/16/20

********* Hydrology Study Control Information **********

Program License Serial Number 6334

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.300
24 hour precipitation(inches) = 5.700
P6/P24 = 57.9%
San Diego hydrology manual 'C' values used

++
Process from Point/Station 13.000 to Point/Station 14.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[HIGH DENSITY RESIDENTIAL]
(43.0 DU/A or Less)
Impervious value, Ai = 0.800
Sub-Area C Value = 0.790
Initial subarea total flow distance = 80.000(Ft.)
Highest elevation = 692.000(Ft.)
Lowest elevation = 691.200(Ft.)
Elevation difference = 0.800(Ft.) Slope = 1.000 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 65.00 (Ft)
for the top area slope value of 1.00 %, in a development type of
43.0 DU/A or Less
In Accordance With Table 3-2
Initial Area Time of Concentration = 4.70 minutes
(for slope value of 1.00 %)
The initial area total distance of 80.00 (Ft.) entered leaves a
remaining distance of 15.00 (Ft.)
Using Figure 3-4, the travel time for this distance is 0.37 minutes
for a distance of 15.00 (Ft.) and a slope of 1.00 %
with an elevation difference of 0.15(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
= 0.370 Minutes
Tt=[(11.9*0.0028^3)/(0.15)]^.385= 0.37
Total initial area Ti = 4.70 minutes from Table 3-2 plus
0.37 minutes from the Figure 3-4 formula = 5.07 minutes
Rainfall intensity (I) = 8.617(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.790

```
Subarea runoff =      0.470(CFS)
Total initial stream area =        0.069(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       14.000 to Point/Station       15.000
**** STREET FLOW TRAVEL TIME + SUBAREA FLOW ADDITION ****
________________________________________________________________________
Top of street segment elevation =   691.200(Ft.)
End of street segment elevation =   688.000(Ft.)
Length of street segment  =   300.000(Ft.)
Height of curb above gutter flowline  =    6.0(In.)
Width of half street (curb to crown)  =  13.000(Ft.)
Distance from crown to crossfall grade break  =  11.500(Ft.)
Slope from gutter to grade break (v/hz) =   0.020
Slope from grade break to crown (v/hz)  =   0.020
Street flow is on [2] side(s) of the street
Distance from curb to property line  =  10.000(Ft.)
Slope from curb to property line (v/hz) =   0.020
Gutter width =   1.500(Ft.)
Gutter hike from flowline =  1.500(In.)
 Manning's N in gutter =  0.0150
 Manning's N from gutter to grade break =  0.0150
 Manning's N from grade break to crown =  0.0150
Estimated mean flow rate at midpoint of street =      6.917(CFS)
Depth of flow =   0.326(Ft.), Average velocity =   2.464(Ft/s)
Streetflow hydraulics at midpoint of street travel:
Halfstreet flow width =  11.543(Ft.)
Flow velocity =   2.46(Ft/s)
Travel time =    2.03 min.     TC =    7.10  min.
 Adding area flow to street
Rainfall intensity (I) =      6.935(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[HIGH DENSITY RESIDENTIAL                    ]
(43.0 DU/A or Less      )
Impervious value, Ai = 0.800
Sub-Area C Value = 0.790
Rainfall intensity =      6.935(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.790  CA =      1.946
Subarea runoff =     13.025(CFS) for      2.394(Ac.)
Total runoff =     13.494(CFS)   Total area =       2.463(Ac.)
Street flow at end of street =     13.494(CFS)
Half street flow at end of street =      6.747(CFS)
Depth of flow =   0.389(Ft.), Average velocity =   3.068(Ft/s)
Note:  depth of flow exceeds top of street crown.
Flow width (from curb towards crown)=  13.000(Ft.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       15.000 to Point/Station       16.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
________________________________________________________________________
Upstream point/station elevation =   678.000(Ft.)
Downstream point/station elevation =   670.500(Ft.)
Pipe length  =   155.00(Ft.) Slope =   0.0484  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    13.494(CFS)
Given pipe size =     12.00(In.)
NOTE: Normal flow is pressure flow in user selected pipe size.
```

```
The approximate hydraulic grade line above the pipe invert is
    21.604(Ft.)  at the headworks or inlet of the pipe(s)
 Pipe friction loss =     22.228(Ft.)
 Minor friction loss =      6.876(Ft.)K-factor =   1.50
Pipe flow velocity =     17.18(Ft/s)
Travel time through pipe =    0.15 min.
Time of concentration (TC) =     7.25 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       16.000 to Point/Station       17.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.842(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[HIGH DENSITY RESIDENTIAL                    ]
(43.0 DU/A or Less      )
Impervious value, Ai = 0.800
Sub-Area C Value = 0.790
Time of concentration =     7.25 min.
Rainfall intensity =      6.842(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.790  CA =      2.457
Subarea runoff =      3.316(CFS) for      0.647(Ac.)
Total runoff =     16.810(CFS)   Total area =       3.110(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       16.000 to Point/Station       17.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.842(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[HIGH DENSITY RESIDENTIAL                    ]
(43.0 DU/A or Less      )
Impervious value, Ai = 0.800
Sub-Area C Value = 0.790
Time of concentration =     7.25 min.
Rainfall intensity =      6.842(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.790  CA =      2.890
Subarea runoff =      2.962(CFS) for      0.548(Ac.)
Total runoff =     19.772(CFS)   Total area =       3.658(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       16.000 to Point/Station       17.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.842(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[HIGH DENSITY RESIDENTIAL                    ]
(43.0 DU/A or Less      )
```

```
Impervious value, Ai = 0.800
Sub-Area C Value = 0.790
Time of concentration =     7.25 min.
Rainfall intensity =      6.842(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.790  CA =      5.569
Subarea runoff =     18.329(CFS) for      3.391(Ac.)
Total runoff =     38.102(CFS)   Total area =       7.049(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       16.000 to Point/Station       17.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
________________________________________________________________________
Upstream point/station elevation =   670.500(Ft.)
Downstream point/station elevation =   649.600(Ft.)
Pipe length  =   465.00(Ft.) Slope =   0.0449  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    38.102(CFS)
Given pipe size =     24.00(In.)
Calculated individual pipe flow  =    38.102(CFS)
Normal flow depth in pipe =   16.15(In.)
Flow top width inside pipe =   22.52(In.)
Critical depth could not be calculated.
Pipe flow velocity =     16.94(Ft/s)
Travel time through pipe =    0.46 min.
Time of concentration (TC) =     7.71 min.
End of computations, total study area =           7.049 (Ac.)
```

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2014 Version 9.0

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 06/04/20

********* Hydrology Study Control Information **********

Program License Serial Number 6334

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.300
24 hour precipitation(inches) = 5.700
P6/P24 = 57.9%
San Diego hydrology manual 'C' values used

++
Process from Point/Station 1.000 to Point/Station 2.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL]
(1.0 DU/A or Less)
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Initial subarea total flow distance = 625.000(Ft.)
Highest elevation = 874.000(Ft.)
Lowest elevation = 689.800(Ft.)
Elevation difference = 184.200(Ft.) Slope = 29.472 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 29.47 %, in a development type of
1.0 DU/A or Less
In Accordance With Table 3-2
Initial Area Time of Concentration = 6.40 minutes
(for slope value of 10.00 %)
The initial area total distance of 625.00 (Ft.) entered leaves a
remaining distance of 525.00 (Ft.)
Using Figure 3-4, the travel time for this distance is 1.55 minutes
for a distance of 525.00 (Ft.) and a slope of 29.47 %
with an elevation difference of 154.73(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
= 1.554 Minutes
Tt=[(11.9*0.0994^3)/(154.73)]^.385= 1.55
Total initial area Ti = 6.40 minutes from Table 3-2 plus
1.55 minutes from the Figure 3-4 formula = 7.95 minutes
Rainfall intensity (I) = 6.445(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.410

```
Subarea runoff =      6.627(CFS)
Total initial stream area =        2.508(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        2.000 to Point/Station        4.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   685.800(Ft.)
Downstream point/station elevation =   685.200(Ft.)
Pipe length  =   111.00(Ft.) Slope =   0.0054  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =     6.627(CFS)
Given pipe size =     12.00(In.)
NOTE: Normal flow is pressure flow in user selected pipe size.
The approximate hydraulic grade line above the pipe invert is
     4.898(Ft.)  at the headworks or inlet of the pipe(s)
 Pipe friction loss =      3.839(Ft.)
 Minor friction loss =      1.658(Ft.)K-factor =   1.50
Pipe flow velocity =      8.44(Ft/s)
Travel time through pipe =    0.22 min.
Time of concentration (TC) =     8.17 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        2.000 to Point/Station        4.000
**** CONFLUENCE OF MAIN STREAMS ****
------------------------------------------------------------------------
The following data inside Main Stream is listed:
In Main Stream number: 1
Stream flow area =      2.508(Ac.)
Runoff from this stream =      6.627(CFS)
Time of concentration =    8.17 min.
Rainfall intensity =     6.333(In/Hr)
Program is now starting with Main Stream No. 2


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** INITIAL AREA EVALUATION ****
------------------------------------------------------------------------
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Initial subarea total flow distance  =  510.000(Ft.)
Highest elevation =  856.000(Ft.)
Lowest elevation =  685.200(Ft.)
Elevation difference =  170.800(Ft.) Slope = 33.490 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of  33.49 %, in a development type of
 1.0 DU/A or Less
In Accordance With Table 3-2
Initial Area Time of Concentration =   6.40 minutes
 (for slope value of  10.00 %)
The initial area total distance of  510.00 (Ft.) entered leaves a
remaining distance of  410.00 (Ft.)
Using Figure 3-4, the travel time for this distance is   1.22 minutes
```

```
for a distance of 410.00 (Ft.) and a slope of 33.49 %
with an elevation difference of 137.31(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
 =    1.223 Minutes
Tt=[(11.9*0.0777^3)/(137.31)]^.385=  1.22
Total initial area Ti =   6.40 minutes from Table 3-2 plus
  1.22 minutes from the Figure 3-4 formula =   7.62 minutes
Rainfall intensity (I) =      6.624(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.410
Subarea runoff =      4.546(CFS)
Total initial stream area =        1.674(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** CONFLUENCE OF MAIN STREAMS ****
------------------------------------------------------------------------
The following data inside Main Stream is listed:
In Main Stream number: 2
Stream flow area =      1.674(Ac.)
Runoff from this stream =      4.546(CFS)
Time of concentration =    7.62 min.
Rainfall intensity =     6.624(In/Hr)
Summary of stream data:

Stream   Flow rate      TC            Rainfall Intensity
 No.       (CFS)       (min)                 (In/Hr)


1         6.627      8.17            6.333
2         4.546      7.62            6.624
Qmax(1) =
         1.000 *    1.000 *     6.627) +
         0.956 *    1.000 *     4.546) + =      10.974
Qmax(2) =
         1.000 *    0.933 *     6.627) +
         1.000 *    1.000 *     4.546) + =      10.727

Total of 2 main streams to confluence:
Flow rates before confluence point:
       6.627       4.546
Maximum flow rates at confluence using above data:
       10.974       10.727
Area of streams before confluence:
        2.508        1.674


Results of confluence:
Total flow rate =     10.974(CFS)
Time of concentration =     8.173 min.
Effective stream area after confluence  =      4.182(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        4.000 to Point/Station        5.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   685.200(Ft.)
Downstream point/station elevation =   684.500(Ft.)
Pipe length  =   127.00(Ft.) Slope =   0.0055  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    10.974(CFS)
Given pipe size =     12.00(In.)
```

```
NOTE: Normal flow is pressure flow in user selected pipe size.
The approximate hydraulic grade line above the pipe invert is
    15.891(Ft.)  at the headworks or inlet of the pipe(s)
 Pipe friction loss =     12.044(Ft.)
 Minor friction loss =      4.547(Ft.)K-factor =   1.50
Pipe flow velocity =     13.97(Ft/s)
Travel time through pipe =    0.15 min.
Time of concentration (TC) =     8.32 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        5.000 to Point/Station        6.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.258(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Time of concentration =     8.32 min.
Rainfall intensity =      6.258(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.410  CA =      1.813
Subarea runoff =      0.370(CFS) for      0.239(Ac.)
Total runoff =     11.344(CFS)   Total area =       4.421(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        5.000 to Point/Station        6.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   684.500(Ft.)
Downstream point/station elevation =   683.700(Ft.)
Pipe length  =   147.00(Ft.) Slope =   0.0054  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    11.344(CFS)
Given pipe size =     12.00(In.)
NOTE: Normal flow is pressure flow in user selected pipe size.
The approximate hydraulic grade line above the pipe invert is
    18.956(Ft.)  at the headworks or inlet of the pipe(s)
 Pipe friction loss =     14.897(Ft.)
 Minor friction loss =      4.859(Ft.)K-factor =   1.50
Pipe flow velocity =     14.44(Ft/s)
Travel time through pipe =    0.17 min.
Time of concentration (TC) =     8.49 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        6.000 to Point/Station        7.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.177(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
```

```
Sub-Area C Value = 0.410
Time of concentration =     8.49 min.
Rainfall intensity =      6.177(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.410  CA =      2.003
Subarea runoff =      1.029(CFS) for      0.464(Ac.)
Total runoff =     12.372(CFS)   Total area =       4.885(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        7.000 to Point/Station        6.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   683.700(Ft.)
Downstream point/station elevation =   682.600(Ft.)
Pipe length  =   108.00(Ft.) Slope =   0.0102  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    12.372(CFS)
Given pipe size =     18.00(In.)
NOTE: Normal flow is pressure flow in user selected pipe size.
The approximate hydraulic grade line above the pipe invert is
     1.540(Ft.)  at the headworks or inlet of the pipe(s)
 Pipe friction loss =      1.498(Ft.)
 Minor friction loss =      1.142(Ft.)K-factor =   1.50
Pipe flow velocity =      7.00(Ft/s)
Travel time through pipe =    0.26 min.
Time of concentration (TC) =     8.75 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        7.000 to Point/Station        8.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Rainfall intensity (I) =      6.060(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Time of concentration =     8.75 min.
Rainfall intensity =      6.060(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.410  CA =      2.109
Subarea runoff =      0.408(CFS) for      0.259(Ac.)
Total runoff =     12.780(CFS)   Total area =       5.144(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        7.000 to Point/Station        8.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   682.600(Ft.)
Downstream point/station elevation =   674.000(Ft.)
Pipe length  =   154.00(Ft.) Slope =   0.0558  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    12.780(CFS)
Given pipe size =     18.00(In.)
Calculated individual pipe flow  =    12.780(CFS)
Normal flow depth in pipe =    9.15(In.)
Flow top width inside pipe =   18.00(In.)
Critical Depth =   16.13(In.)
```

```
Pipe flow velocity =     14.15(Ft/s)
Travel time through pipe =    0.18 min.
Time of concentration (TC) =     8.93 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        8.000 to Point/Station        9.000
**** SUBAREA FLOW ADDITION ****
----------------------------------------------------------------------
Rainfall intensity (I) =      5.980(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Time of concentration =     8.93 min.
Rainfall intensity =      5.980(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.410  CA =      2.168
Subarea runoff =      0.183(CFS) for      0.143(Ac.)
Total runoff =     12.963(CFS)   Total area =       5.287(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        8.000 to Point/Station        9.000
**** SUBAREA FLOW ADDITION ****
----------------------------------------------------------------------
Rainfall intensity (I) =      5.980(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[LOW DENSITY RESIDENTIAL                    ]
(1.0 DU/A or Less       )
Impervious value, Ai = 0.100
Sub-Area C Value = 0.410
Time of concentration =     8.93 min.
Rainfall intensity =      5.980(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.410  CA =      2.227
Subarea runoff =      0.356(CFS) for      0.145(Ac.)
Total runoff =     13.318(CFS)   Total area =       5.432(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        8.000 to Point/Station        9.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
----------------------------------------------------------------------
Upstream point/station elevation =   674.000(Ft.)
Downstream point/station elevation =   659.000(Ft.)
Pipe length  =   155.00(Ft.) Slope =   0.0968  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    13.318(CFS)
Given pipe size =     24.00(In.)
Calculated individual pipe flow  =    13.318(CFS)
Normal flow depth in pipe =    7.07(In.)
Flow top width inside pipe =   21.88(In.)
Critical Depth =   15.77(In.)
Pipe flow velocity =     17.22(Ft/s)
Travel time through pipe =    0.15 min.
```

```
Time of concentration (TC) =     9.08 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        9.000 to Point/Station       10.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   659.000(Ft.)
Downstream point/station elevation =   647.500(Ft.)
Pipe length  =   171.00(Ft.) Slope =   0.0673  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    13.318(CFS)
Given pipe size =     24.00(In.)
Calculated individual pipe flow  =    13.318(CFS)
Normal flow depth in pipe =    7.78(In.)
Flow top width inside pipe =   22.46(In.)
Critical Depth =   15.77(In.)
Pipe flow velocity =     15.11(Ft/s)
Travel time through pipe =    0.19 min.
Time of concentration (TC) =     9.27 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        9.000 to Point/Station       19.000
**** PIPEFLOW TRAVEL TIME (User specified size) ****
------------------------------------------------------------------------
Upstream point/station elevation =   647.500(Ft.)
Downstream point/station elevation =   646.500(Ft.)
Pipe length  =    60.00(Ft.) Slope =   0.0167  Manning's N = 0.013
No. of pipes = 1  Required pipe flow  =    13.318(CFS)
Given pipe size =     18.00(In.)
Calculated individual pipe flow  =    13.318(CFS)
Normal flow depth in pipe =   14.48(In.)
Flow top width inside pipe =   14.27(In.)
Critical Depth =   16.33(In.)
Pipe flow velocity =      8.75(Ft/s)
Travel time through pipe =    0.11 min.
Time of concentration (TC) =     9.39 min.
End of computations, total study area =           5.432 (Ac.)
```

EXHIBIT C

RATIONAL METHOD HYDROGRAPHS

Barham Drive Preliminary Design 5-Jun-20

P-1 to P-5,C **Post Development Condition** **8 Minute Hydrograph**

Entry Basin

Rational Method Unit Hydrograph 6 hr Storm

County of San Diego Hydrology Manual - Chapter 6 7.44 P6 Tc ^-0.645

				Year							
Area	7.458	ac	Storm	2	P6	1.52	in	P24	2.40	in	63%
C	0.790			100		3.3	in		5.7	in	58%
Tc=	8.00										
Tc=	**8**	minutes			I2=	2.96	in/hr	Q2=	17.43		
Q2 =	17.43	cfs			I100=	6.42	in/hr	Q100=	37.83		
Q100=	37.83	cfs						32,509		(201)	
N=	45	Number of Precipitation Blocks					Vol	32,308	1.20	0.62%	

Barham Drive

360 5-Jun-20

Qn = 60 C A Pn/Tc

P-1 to P-5,C

Pt(n) = 0.124 P6 (n Tc)^0.355

Pn = Pt(n) - Pt(n-1)

Rational Method Hydrograph Transformation

N	Pt(n)	Pn	Q(n)	Q(n)
1	0.39	0.39	17.425	17.425
2	0.50	0.11	4.861	4.861
3	0.58	0.08	3.450	3.450
4	0.65	0.06	2.767	2.767
5	0.70	0.05	2.350	2.350
6	0.74	0.05	2.063	2.063
7	0.79	0.04	1.852	1.852
8	0.83	0.04	1.688	1.688
9	0.86	0.04	1.557	1.557
10	0.89	0.03	1.449	1.449
11	0.92	0.03	1.358	1.358
12	0.95	0.03	1.281	1.281
13	0.98	0.03	1.213	1.213
14	1.01	0.03	1.155	1.155
15	1.03	0.02	1.103	1.103
16	1.06	0.02	1.056	1.056
17	1.08	0.02	1.014	1.014
18	1.10	0.02	0.977	0.977
19	1.12	0.02	0.942	0.942
20	1.14	0.02	0.911	0.911
21	1.16	0.02	0.882	0.882
22	1.18	0.02	0.855	0.855
23	1.20	0.02	0.830	0.830
24	1.22	0.02	0.807	0.807
25	1.24	0.02	0.786	0.786
26	1.25	0.02	0.766	0.766
27	1.27	0.02	0.747	0.747
28	1.29	0.02	0.730	0.730
29	1.30	0.02	0.713	0.713
30	1.32	0.02	0.697	0.697
31	1.33	0.02	0.682	0.682
32	1.35	0.02	0.668	0.668
33	1.36	0.01	0.655	0.655
34	1.38	0.01	0.642	0.642
35	1.39	0.01	0.630	0.630
36	1.41	0.01	0.619	0.619
37	1.42	0.01	0.608	0.608
38	1.43	0.01	0.597	0.597
39	1.45	0.01	0.587	0.587
40	1.46	0.01	0.578	0.578
41	1.47	0.01	0.568	0.568
42	1.49	0.01	0.559	0.559
43	1.50	0.01	0.551	0.551
44	1.51	0.01	0.543	0.543
45	1.52	0.01	0.535	0.535
46	1.54	0.01	0.527	0.000

N	Time (min)	Time (hrs)	Qn (cfs)
1	248	4.13	17.425
2	240	4.00	4.861
3	232	3.87	3.450
5	224	3.73	2.350
6	216	3.60	2.063
8	208	3.47	1.688
9	200	3.33	1.557
11	192	3.20	1.358
12	184	3.07	1.281
14	176	2.93	1.155
15	168	2.80	1.103
17	160	2.67	1.014
18	152	2.53	0.977
20	144	2.40	0.911
21	136	2.27	0.882
23	128	2.13	0.830
24	120	2.00	0.807
26	112	1.87	0.766
27	104	1.73	0.747
29	96	1.60	0.713
30	88	1.47	0.697
32	80	1.33	0.668
33	72	1.20	0.655
35	64	1.07	0.630
36	56	0.93	0.619
38	48	0.80	0.597
39	40	0.67	0.587
41	32	0.53	0.568
42	24	0.40	0.559
44	16	0.27	0.543
45	8	0.13	0.535

N	Time (min)	Time (hrs)	Qn (cfs)
4	256	4.27	2.767
7	264	4.40	1.852
10	272	4.53	1.449
13	280	4.67	1.213
16	288	4.80	1.056
19	296	4.93	0.942
22	304	5.07	0.855
25	312	5.20	0.786
28	320	5.33	0.730
31	328	5.47	0.682
34	336	5.60	0.642
37	344	5.73	0.608
40	352	5.87	0.578
43	360	6.00	0.551
46	368	6.13	0.000

Barham Drive Preliminary Design 5-Jun-20

P-1 to P-5,C

Post Development Hydrographs - 6 Hour Rational Method

					Ratio X/2		1.250	1.447	1.711	1.842	2.171
					P6 Adj	1.52	1.9	2.2	2.6	2.8	3.3
					Pre-Deve	7.317	9.146	10.590	12.516	13.479	15.886
					Peak	17.425	21.781	25.220	29.806	32.099	37.831
			2 Year		Return /Yr	**2**	**5**	**10**	**25**	**50**	**100**
N	Time (min)	Time (hrs)	Qn (cfs)	Vol (cf)	Time (hrs)	Q(n)	Q(n)	Q(n)	Q(n)	Q(n)	Q(n)
	0	0.00	0.000	0	0.00	0.000	0.000	0.000	0.000	0.000	0.000
45	8	0.13	0.535	128	0.13	0.535	0.669	0.774	0.915	0.985	1.161
44	16	0.27	0.543	259	0.27	0.543	0.678	0.786	0.928	1.000	1.178
42	24	0.40	0.559	265	0.40	0.559	0.699	0.810	0.957	1.031	1.215
41	32	0.53	0.568	271	0.53	0.568	0.710	0.823	0.972	1.047	1.234
39	40	0.67	0.587	277	0.67	0.587	0.734	0.850	1.004	1.082	1.275
38	48	0.80	0.597	284	0.80	0.597	0.747	0.864	1.022	1.100	1.297
36	56	0.93	0.619	292	0.93	0.619	0.773	0.896	1.058	1.140	1.343
35	64	1.07	0.630	300	1.07	0.630	0.788	0.912	1.078	1.161	1.368
33	72	1.20	0.655	308	1.20	0.655	0.819	0.948	1.120	1.207	1.422
32	80	1.33	0.668	318	1.33	0.668	0.835	0.967	1.143	1.231	1.451
30	88	1.47	0.697	328	1.47	0.697	0.872	1.009	1.193	1.284	1.514
29	96	1.60	0.713	338	1.60	0.713	0.891	1.032	1.219	1.313	1.548
27	104	1.73	0.747	350	1.73	0.747	0.934	1.081	1.278	1.376	1.622
26	112	1.87	0.766	363	1.87	0.766	0.957	1.109	1.310	1.411	1.663
24	120	2.00	0.807	378	2.00	0.807	1.009	1.169	1.381	1.487	1.753
23	128	2.13	0.830	393	2.13	0.830	1.038	1.202	1.420	1.530	1.803
21	136	2.27	0.882	411	2.27	0.882	1.102	1.276	1.508	1.624	1.914
20	144	2.40	0.911	430	2.40	0.911	1.138	1.318	1.558	1.678	1.977
18	152	2.53	0.977	453	2.53	0.977	1.221	1.413	1.670	1.799	2.120
17	160	2.67	1.014	478	2.67	1.014	1.268	1.468	1.735	1.869	2.202
15	168	2.80	1.103	508	2.80	1.103	1.378	1.596	1.886	2.031	2.394
14	176	2.93	1.155	542	2.93	1.155	1.443	1.671	1.975	2.127	2.507
12	184	3.07	1.281	584	3.07	1.281	1.601	1.853	2.190	2.359	2.780
11	192	3.20	1.358	633	3.20	1.358	1.698	1.966	2.323	2.502	2.948
9	200	3.33	1.557	700	3.33	1.557	1.946	2.253	2.663	2.868	3.380
8	208	3.47	1.688	779	3.47	1.688	2.110	2.443	2.887	3.109	3.664
6	216	3.60	2.063	900	3.60	2.063	2.579	2.986	3.529	3.800	4.479
5	224	3.73	2.350	1,059	3.73	2.350	2.937	3.401	4.019	4.329	5.102
3	232	3.87	3.450	1,392	3.87	3.450	4.313	4.994	5.902	6.356	7.491
2	240	4.00	4.861	1,995	4.00	4.861	6.077	7.036	8.315	8.955	10.554
1	**248**	**4.13**	**17.425**	**5,349**	**4.13**	**17.425**	**21.781**	**25.220**	**29.806**	**32.099**	**37.831**
4	256	4.27	2.767	4,846	4.27	2.767	3.459	4.005	4.734	5.098	6.008
7	264	4.40	1.852	1,109	4.40	1.852	2.314	2.680	3.167	3.411	4.020
10	272	4.53	1.449	792	4.53	1.449	1.811	2.097	2.478	2.669	3.145
13	280	4.67	1.213	639	4.67	1.213	1.517	1.756	2.076	2.235	2.634
16	288	4.80	1.056	545	4.80	1.056	1.320	1.529	1.807	1.946	2.293
19	296	4.93	0.942	480	4.93	0.942	1.178	1.364	1.612	1.736	2.046
22	304	5.07	0.855	431	5.07	0.855	1.069	1.238	1.463	1.575	1.856
25	312	5.20	0.786	394	5.20	0.786	0.982	1.138	1.344	1.448	1.706
28	320	5.33	0.730	364	5.33	0.730	0.912	1.056	1.248	1.344	1.584
31	328	5.47	0.682	339	5.47	0.682	0.853	0.988	1.167	1.257	1.482
34	336	5.60	0.642	318	5.60	0.642	0.803	0.930	1.099	1.183	1.395
37	344	5.73	0.608	300	5.73	0.608	0.760	0.880	1.040	1.120	1.319
40	352	5.87	0.578	284	5.87	0.578	0.722	0.836	0.988	1.064	1.254
43	360	6.00	0.551	271	6.00	0.551	0.689	0.797	0.942	1.015	1.196
46	368	6.13	0.000	132	6.13	0.000	0.000	0.000	0.000	0.000	0.000

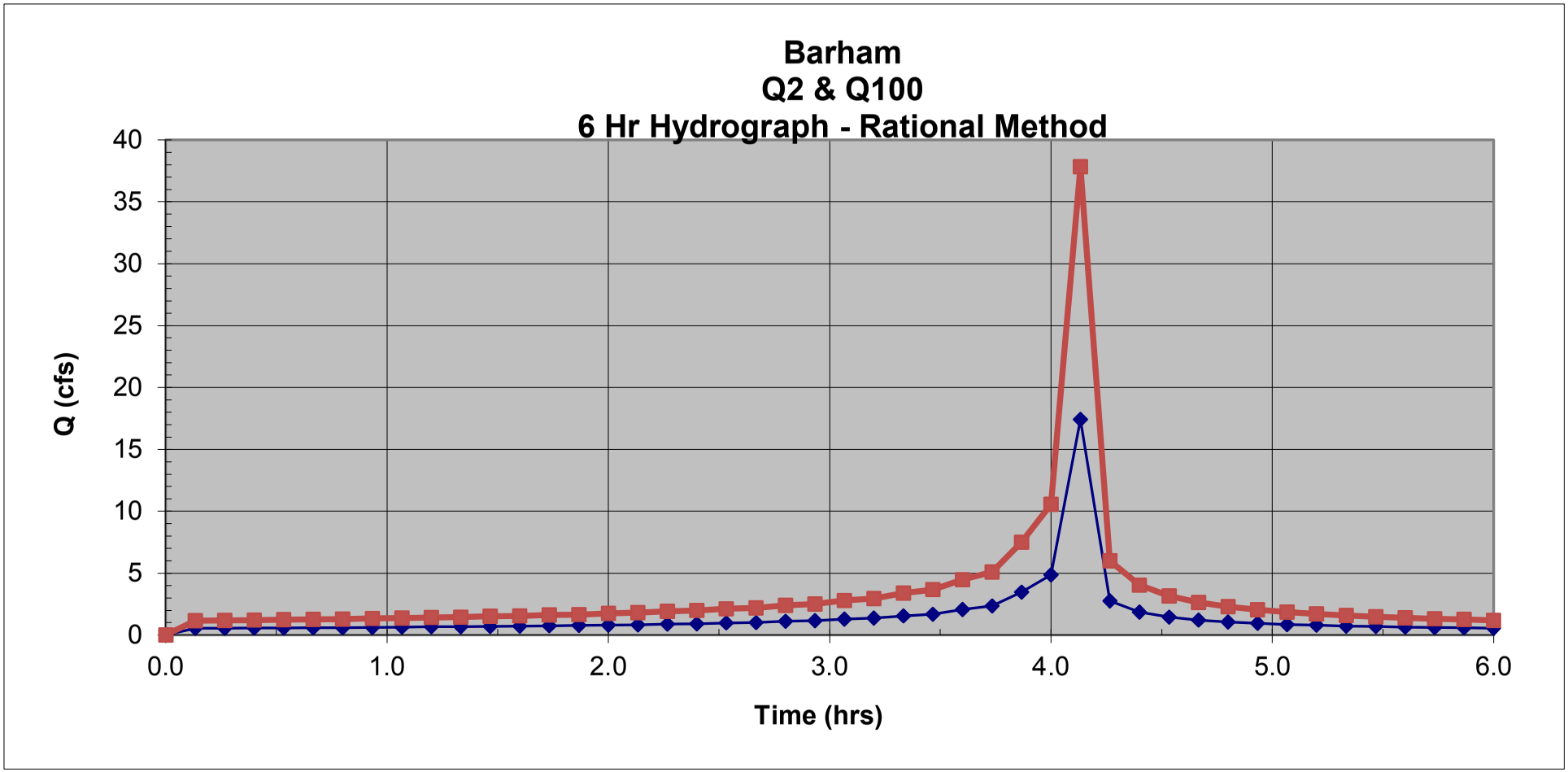

Barham
Q2 & Q100
6 Hr Hydrograph - Rational Method
Q (cfs)
40
35
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Time (hrs)

EXHIBIT D

DETENTION BASIN
STORAGE INDICATION TABLE

Barham Drive

										Target 3.5'	0.430	0.194			
										Target @4'	4.296	0.208			
P-1 to P-5,C			Top	656.10		66,612 cf					Depth	0.00	6.75	7.95	7.45
			Storage @ Overflow	654.60		47,406 cf			1.09		Height	2.000	3		60
Basin Storage Volumes				140.52%		dT= 8			dT= 15		Width	2.000	3	120	60
											Elev	647.15	653.90	655.10	654.60
DEPTH (FT)	ELEVATION	AREA (SF)	Void Ratio	Volume (CF)	STORAGE (CF)	2S/dT (CFS)	2S/dT + O (CFS)	2S/dT (CFS)	2S/dT + O (CFS)		OUTFLOW (CFS)	#1 (CFS)	#2 (CFS)	#3 (CFS)	Overflow (CFS)
0.00	647.15	**6,764**	0.40	0	0	0.00	0.00	0.00	0.00		0.00	0.00			
0.10	647.25	6,764	0.40	270.6	271	1.13	1.14	0.60	0.61		0.01	0.01			
0.20	647.35	6,764	0.40	270.6	541	2.25	2.29	1.20	1.24		0.04	0.04			
0.30	647.45	6,764	0.40	270.6	812	3.38	3.43	1.80	1.85		0.05	0.05			
0.40	647.55	6,764	0.40	270.6	1,082	4.51	4.57	2.40	2.46		0.06	0.06			
0.50	647.65	6,764	0.40	270.6	1,353	5.64	5.70	3.01	3.07		0.07	0.07			
0.60	647.75	6,764	0.40	270.6	1,623	6.76	6.84	3.61	3.68		0.08	0.08			
0.70	647.85	6,764	0.40	270.6	1,894	7.89	7.97	4.21	4.29		0.08	0.08			
0.80	647.95	6,764	0.40	270.6	2,164	9.02	9.11	4.81	4.90		0.09	0.09			
0.90	648.05	6,764	0.40	270.6	2,435	10.15	10.24	5.41	5.51		0.09	0.09			
1.00	648.15	6,764	0.30	236.7	2,672	11.13	11.23	5.94	6.04		0.10	0.10			
1.10	648.25	6,764	0.30	202.9	2,875	11.98	12.08	6.39	6.49		0.11	0.11			
1.20	648.35	6,764	0.30	202.9	3,078	12.82	12.93	6.84	6.95		0.11	0.11			
1.30	648.45	6,764	0.30	202.9	3,281	13.67	13.78	7.29	7.41		0.12	0.12			
1.40	648.55	6,764	0.30	202.9	3,483	14.51	14.63	7.74	7.86		0.12	0.12			
1.50	648.65	6,764	0.30	202.9	3,686	15.36	15.48	8.19	8.32		0.12	0.12			
1.60	648.75	6,764	0.30	202.9	3,889	16.21	16.33	8.64	8.77		0.13	0.13			
1.70	648.85	6,764	0.30	202.9	4,092	17.05	17.18	9.09	9.23		0.13	0.13			
1.80	648.95	6,764	0.30	202.9	4,295	17.90	18.03	9.54	9.68		0.14	0.14			
1.90	649.05	6,764	0.30	202.9	4,498	18.74	18.88	10.00	10.14		0.14	0.14			
2.00	649.15	6,764	0.30	202.9	4,701	19.59	19.73	10.45	10.59		0.15	0.15			
2.10	649.25	6,764	0.30	202.9	4,904	20.43	20.58	10.90	11.05		0.15	0.15			
2.20	649.35	6,764	0.30	202.9	5,107	21.28	21.43	11.35	11.50		0.15	0.15			
2.30	649.45	6,764	0.30	202.9	5,310	22.12	22.28	11.80	11.96		0.16	0.16			
2.40	649.55	6,764	0.30	202.9	5,513	22.97	23.13	12.25	12.41		0.16	0.16			
2.50	649.65	6,764	0.30	202.9	5,716	23.81	23.98	12.70	12.86		0.16	0.16			
2.60	649.75	6,764	0.30	202.9	5,919	24.66	24.83	13.15	13.32		0.17	0.17			
2.70	649.85	6,764	0.30	202.9	6,121	25.51	25.68	13.60	13.77		0.17	0.17			
2.80	649.95	6,764	0.30	202.9	6,324	26.35	26.52	14.05	14.23		0.17	0.17			
2.90	650.05	6,764	0.30	202.9	6,527	27.20	27.37	14.51	14.68		0.18	0.18			
3.00	**650.15**	**6,764**	1.00	676.4	7,204	30.02	30.19	16.01	16.19		0.18	0.18			
3.10	650.25	6,877	1.00	682.1	7,886	32.86	33.04	17.52	17.71		0.18	0.18			
3.20	650.35	6,990	1.00	693.4	8,579	35.75	35.93	19.06	19.25		0.19	0.19			
3.30	650.45	7,104	1.00	704.7	9,284	38.68	38.87	20.63	20.82		0.19	0.19			
3.40	650.55	7,217	1.00	716.0	10,000	41.67	41.86	22.22	22.41		0.19	0.19			
3.50	650.65	**7,330**	1.00	727.3	10,727	44.70	44.89	23.84	24.03		0.19	0.19			
3.60	650.75	7,444	1.00	738.7	11,466	47.77	47.97	25.48	25.68		0.20	0.20			
3.70	650.85	7,558	1.00	750.1	12,216	50.90	51.10	27.15	27.35		0.20	0.20			
3.80	650.95	7,671	1.00	761.4	12,977	54.07	54.27	28.84	29.04		0.20	0.20			
3.90	651.05	7,785	1.00	772.8	13,750	57.29	57.50	30.56	30.76		0.21	0.21			
4.00	651.15	7,899	1.00	784.2	14,534	60.56	60.77	32.30	32.51		0.21	**0.21**			
4.10	651.25	8,013	1.00	795.6	15,330	63.87	64.09	34.07	34.28		0.21	0.21			
4.20	651.35	8,126	1.00	806.9	16,137	67.24	67.45	35.86	36.07		0.21	0.21			
4.30	651.45	8,240	1.00	818.3	16,955	70.65	70.86	37.68	37.89		0.22	0.22			
4.40	651.55	8,354	1.00	829.7	17,785	74.10	74.32	39.52	39.74		0.22	0.22			
4.50	651.65	8,468	1.00	841.1	18,626	77.61	77.83	41.39	41.61		0.22	0.22			
4.60	651.75	8,581	1.00	852.4	19,478	81.16	81.38	43.29	43.51		0.22	0.22			
4.70	651.85	8,695	1.00	863.8	20,342	84.76	84.98	45.20	45.43		0.23	0.23			
4.80	651.95	8,809	1.00	875.2	21,217	88.41	88.63	47.15	47.38		0.23	0.23			
4.90	652.05	8,923	1.00	886.6	22,104	92.10	92.33	49.12	49.35		0.23	0.23			
5.00	652.15	9,036	1.00	897.9	23,002	95.84	96.07	51.12	51.35		0.23	0.23			
5.10	652.25	9,150	1.00	909.3	23,911	99.63	99.87	53.14	53.37		0.24	0.24			
5.20	652.35	9,264	1.00	920.7	24,832	103.47	103.70	55.18	55.42		0.24	0.24			
5.30	652.45	9,378	1.00	932.1	25,764	107.35	107.59	57.25	57.49		0.24	0.24			
5.40	652.55	9,491	1.00	943.4	26,707	111.28	111.52	59.35	59.59		0.24	0.24			
5.50	652.65	9,605	1.00	954.8	27,662	115.26	115.50	61.47	61.72		0.24	0.24			
5.60	652.75	9,719	1.00	966.2	28,628	119.29	119.53	63.62	63.87		0.25	0.25			
5.70	652.85	9,833	1.00	977.6	29,606	123.36	123.61	65.79	66.04		0.25	0.25			
5.80	652.95	9,946	1.00	988.9	30,595	127.48	127.73	67.99	68.24		0.25	0.25			
5.90	653.05	10,060	1.00	1,000.3	31,595	131.65	131.90	70.21	70.46		0.25	0.25			
6.00	653.15	10,174	1.00	1,011.7	32,607	135.86	136.12	72.46	72.72		0.26	0.26			
6.10	653.25	10,288	1.00	1,023.1	33,630	140.13	140.38	74.73	74.99		0.26	0.26			
6.20	653.35	10,401	1.00	1,034.4	34,664	144.44	144.70	77.03	77.29		0.26	0.26			
6.30	653.45	10,515	1.00	1,045.8	35,710	148.79	149.05	79.36	79.62		0.26	0.26			
6.40	653.55	10,629	1.00	1,057.2	36,768	153.20	153.46	81.71	81.97		0.26	0.26			
6.50	653.65	10,743	1.00	1,068.6	37,836	157.65	157.92	84.08	84.35		0.27	0.27			
6.60	653.75	10,856	1.00	1,079.9	38,916	162.15	162.42	86.48	86.75		0.27	0.27			
6.70	653.85	10,970	1.00	1,091.3	40,007	166.70	166.97	88.91	89.18		0.27	0.27			
6.75	653.90	**11,027**	1.00	549.9	40,557	168.99	169.26	90.13	90.40		0.27	0.27	0.00		
6.85	654.00	11,156	1.00	1,109.2	41,666	173.61	173.90	92.59	92.88		0.29	0.27	0.02		
6.95	654.10	11,285	1.00	1,122.1	42,789	178.29	178.62	95.09	95.42		0.33	0.28	0.05		
7.05	654.20	11,414	1.00	1,135.0	43,923	183.01	183.39	97.61	97.98		0.38	0.28	0.10		
7.15	654.30	11,544	1.00	1,147.9	45,071	187.80	188.20	100.16	100.56		0.40	0.28	0.12		
7.25	654.40	11,673	1.00	1,160.8	46,232	192.63	193.06	102.74	103.16		0.43	0.28	0.14		
7.35	654.50	11,802	1.00	1,173.7	47,406	197.52	197.97	105.35	105.79		0.45	0.28	0.16		
7.45	654.60	**11,931**	1.00	1,186.6	48,593	202.47	202.93	107.98	108.45		0.46	0.28	0.18		0.00
7.55	654.70	12,064	1.00	1,199.7	49,792	207.47	208.93	110.65	112.11		1.46	0.29	0.19		0.98
7.65	654.80	12,196	1.00	1,213.0	51,005	212.52	215.79	113.35	116.61		3.27	0.29	0.21		2.77
7.75	654.90	12,329	1.00	1,226.3	52,232	217.63	223.24	116.07	121.68		5.61	0.29	0.22		5.09
7.85	655.00	12,461	1.00	1,239.5	53,471	222.80	231.16	118.82	127.19		8.37	0.29	0.23		7.84
7.95	655.10	**12,594**	1.00	1,252.8	54,724	228.02	239.52	121.61	133.11		11.50	0.29	0.24	0.00	10.96
8.05	655.20	12,731	1.00	1,266.2	55,990	233.29	249.23	124.42	140.36		15.94	0.30	0.26	0.98	14.41
8.15	655.30	12,868	1.00	1,279.9	57,270	238.62	260.12	127.27	148.76		21.49	0.30	0.27	2.77	18.16
8.25	655.40	13,004	1.00	1,293.6	58,564	244.01	271.87	130.14	157.99		27.85	0.30	0.28	5.09	22.18
8.35	655.50	13,141	1.00	1,307.3	59,871	249.46	284.36	133.05	167.95		34.90	0.30	0.29	7.84	26.47
8.45	655.60	13,278	1.00	1,321.0	61,192	254.97	297.53	135.98	178.54		42.56	0.30	0.30	10.96	31.00
8.55	655.70	13,415	1.00	1,334.6	62,526	260.53	311.31	138.95	189.73		50.78	0.31	0.31	14.41	35.76
8.65	655.80	13,552	1.00	1,348.3	63,875	266.14	325.67	141.94	201.47		59.53	0.31	0.31	18.16	40.75
8.75	655.90	13,688	1.00	1,362.0	65,237	271.82	340.58	144.97	213.73		68.76	0.31	0.32	22.18	45.95
8.85	656.00	13,825	1.00	1,375.7	66,612	277.55	356.01	148.03	226.49		78.46	0.31	0.33	26.47	51.35
8.95	656.10	**13,962**	1.00	1,389.4	68,002	283.34	371.94	151.12	239.72		88.60	0.31	0.34	31.00	56.95

EXHIBIT E

DETENTION ROUTING

Barham Drive

JN 75050.25

Tributary Areas

Prelim Design 5-Jun-20

P-1 to P-5,C 7.458
Includes Basin -

6-Hour Rational Method Hydrograph

Total 7.458 ac
Tc= 8

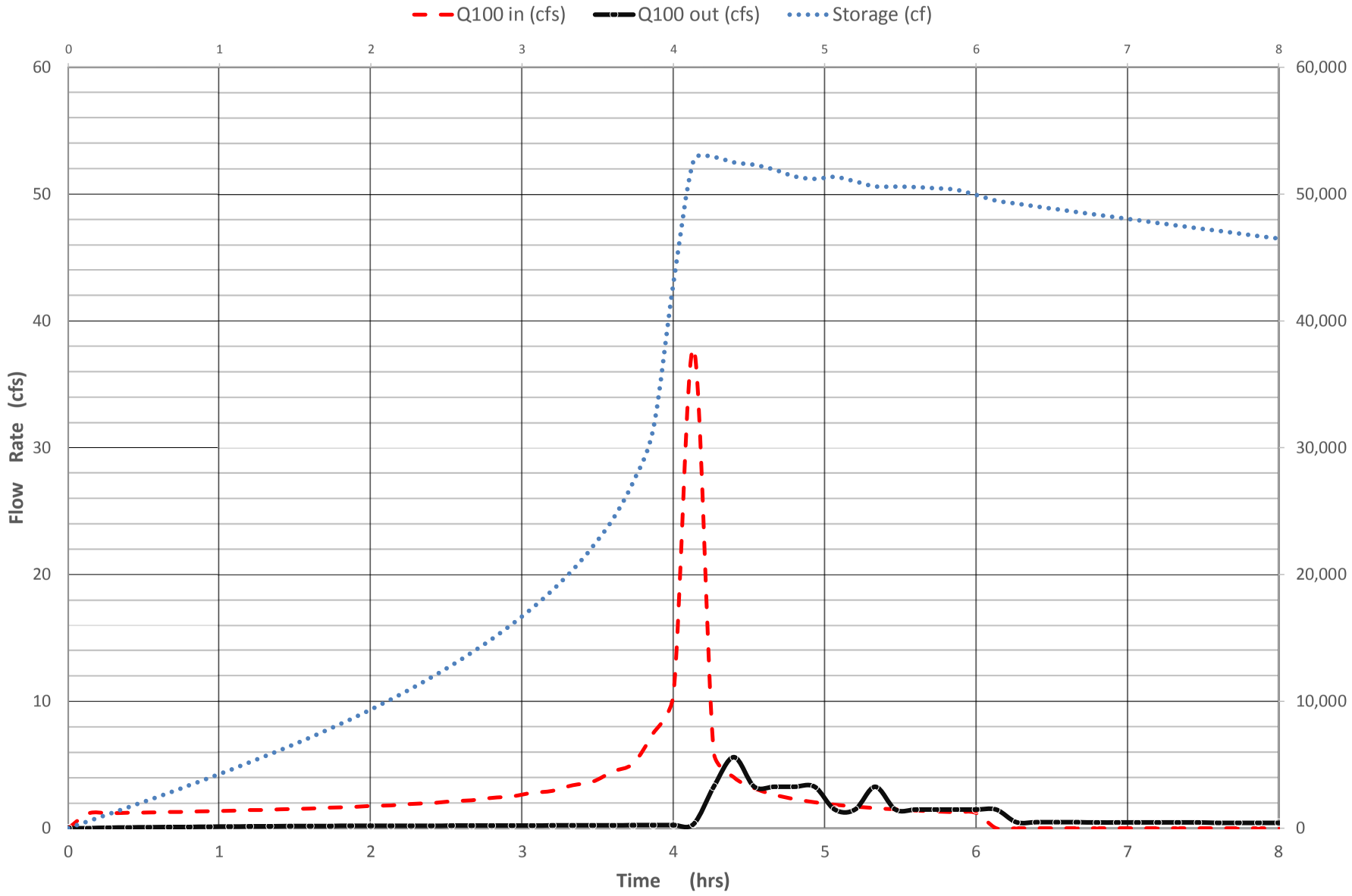
		Elev	Storage (cf)	Storage (ac-ft)	Total Depth (ft)
Bottom of Storage		647.15	0		
Floor of Basin		650.15	7,204	0.17	3.00
Surface Area @ 6" Depth	7,330	650.65	10,727	0.25	3.50
Surface Opening	3	653.90	40,557	0.93	6.75
Overflow Grate		654.60	48,593	1.12	7.45
I/O Weir		655.10	54,724	1.26	7.95
Top Of Berm		656.10	68,002	1.56	8.95

Storm Frequency	Qexist (cfs)	Qin (cfs)	Qout (cfs)	WSEL (ft)	Depth (ft)
10% Q2					
2 YEAR	7.32	17.43	0.25	652.75	5.60
5 YEAR	9.15	21.78	0.26	653.45	6.30
10 YEAR	10.59	25.22	0.29	654.00	6.85
25 YEAR	12.52	29.81	0.46	654.60	7.45
50 YEAR	13.48	32.10	1.46	654.70	7.55
100 YEAR	15.89	37.83	5.61	654.90	7.75
Target					

Outlet Control Structure — Use 4' x 4' structure (Inside Dimension)

Opening	Low Flow #1	Surface #2	Weir #3	Overflow - Grate
Elevation	647.2	653.9	655.10	654.6
Width (in)	2	3	0.0	4 feet
Height (in)	2	3	120.0	4 feet

Barham Detention Basin ~ 100-Year



37.83

100 YEAR EVENT ~ 6 Hour STORM

5.61 Q Out
654.90 Max WSEL
53.87 hrs Drain Time

8 Min

Interval	T (HRS)	Q IN (CFS)	2S/dT+O	2S/dT-O (CFS)	O (CFS)	Basin WSEL
1	0.13	1.161	0.00	0.00	0.00	647.15
2	0.27	1.178	2.34	2.27	0.04	647.35
3	0.40	1.215	4.66	4.54	0.06	647.55
4	0.53	1.234	6.99	6.84	0.08	647.75
5	0.67	1.275	9.35	9.17	0.09	647.95
6	0.80	1.297	11.74	11.54	0.10	648.15
7	0.93	1.343	14.18	13.95	0.12	648.45
8	1.07	1.368	16.66	16.40	0.13	648.75
9	1.20	1.422	19.19	18.91	0.14	649.05
10	1.33	1.451	21.78	21.48	0.15	649.35
11	1.47	1.514	24.44	24.12	0.16	649.65
12	1.60	1.548	27.18	26.83	0.17	649.95
13	1.73	1.622	30.00	29.65	0.18	650.05
14	1.87	1.663	32.93	32.58	0.18	650.15
15	2.00	1.753	35.99	35.62	0.19	650.35
16	2.13	1.803	39.18	38.80	0.19	650.45
17	2.27	1.914	42.52	42.14	0.19	650.55
18	2.40	1.977	46.03	45.64	0.19	650.65
19	2.53	2.120	49.74	49.34	0.20	650.75
20	2.67	2.202	53.66	53.27	0.20	650.85
21	2.80	2.394	57.86	57.45	0.21	651.05
22	2.93	2.507	62.35	61.94	0.21	651.15
23	3.07	2.780	67.22	66.80	0.21	651.25
24	3.20	2.948	72.53	72.10	0.22	651.45
25	3.33	3.380	78.43	77.99	0.22	651.65
26	3.47	3.664	85.03	84.58	0.23	651.85
27	3.60	4.479	92.72	92.26	0.23	652.05
28	3.73	5.102	101.84	101.37	0.24	652.25
29	3.87	7.491	113.96	113.48	0.24	652.55
30	4.00	10.554	131.52	131.02	0.25	652.95
31	4.13	37.831	179.41	178.75	0.33	654.10
32	4.27	6.008	222.59	216.05	3.27	654.80
33	4.40	4.020	226.07	214.86	5.61	654.90
34	4.53	3.145	222.03	215.49	3.27	654.80
35	4.67	2.634	221.27	214.73	3.27	654.80
36	4.80	2.293	219.66	213.12	3.27	654.80
37	4.93	2.046	217.46	210.92	3.27	654.80
38	5.07	1.856	214.82	211.90	1.46	654.70
39	5.20	1.706	215.46	212.54	1.46	654.70
40	5.33	1.584	215.83	209.29	3.27	654.80
41	5.47	1.482	212.35	209.43	1.46	654.70
42	5.60	1.395	212.31	209.39	1.46	654.70
43	5.73	1.319	212.10	209.18	1.46	654.70
44	5.87	1.254	211.75	208.83	1.46	654.70
45	6.00	1.196	211.28	208.35	1.46	654.70
46	6.13	0.000	209.55	206.63	1.46	654.70

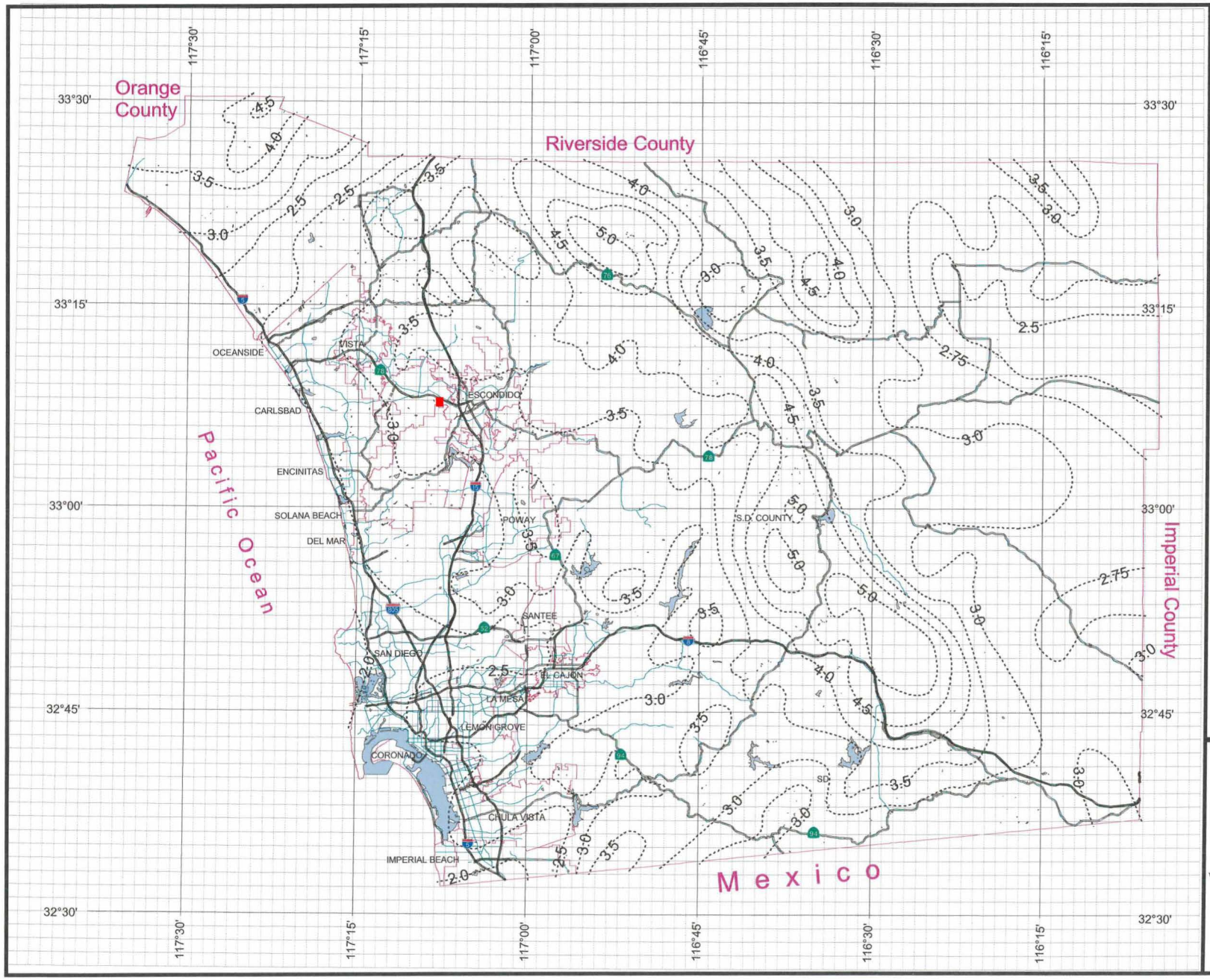
47	6.27	0.000	206.63	205.70	0.46	654.60
48	6.40	0.000	205.70	204.77	0.46	654.60
49	6.53	0.000	204.77	203.84	0.46	654.60
50	6.67	0.000	203.84	202.92	0.46	654.60
51	6.80	0.000	202.92	202.02	0.45	654.50
52	6.93	0.000	202.02	201.13	0.45	654.50
53	7.07	0.000	201.13	200.24	0.45	654.50
54	7.20	0.000	200.24	199.35	0.45	654.50
55	7.33	0.000	199.35	198.46	0.45	654.50
56	7.47	0.000	198.46	197.57	0.45	654.50
57	7.60	0.000	197.57	196.71	0.43	654.40
58	7.73	0.000	196.71	195.86	0.43	654.40
59	7.87	0.000	195.86	195.01	0.43	654.40
60	8.00	0.000	195.01	194.16	0.43	654.40
61	8.13	0.000	194.16	193.31	0.43	654.40
62	8.27	0.000	193.31	192.46	0.43	654.40
63	8.40	0.000	192.46	191.65	0.40	654.30
64	8.53	0.000	191.65	190.84	0.40	654.30
65	8.67	0.000	190.84	190.04	0.40	654.30
66	8.80	0.000	190.04	189.23	0.40	654.30
67	8.93	0.000	189.23	188.43	0.40	654.30
68	9.07	0.000	188.43	187.62	0.40	654.30
69	9.20	0.000	187.62	186.87	0.38	654.20
70	9.33	0.000	186.87	186.12	0.38	654.20
71	9.47	0.000	186.12	185.36	0.38	654.20
72	9.60	0.000	185.36	184.61	0.38	654.20
73	9.73	0.000	184.61	183.86	0.38	654.20
74	9.87	0.000	183.86	183.11	0.38	654.20
75	10.00	0.000	183.11	182.45	0.33	654.10
76	10.13	0.000	182.45	181.79	0.33	654.10
77	10.27	0.000	181.79	181.13	0.33	654.10
78	10.40	0.000	181.13	180.47	0.33	654.10
79	10.53	0.000	180.47	179.81	0.33	654.10
80	10.67	0.000	179.81	179.15	0.33	654.10
81	10.80	0.000	179.15	178.49	0.33	654.10
82	10.93	0.000	178.49	177.91	0.29	654.00
83	11.07	0.000	177.91	177.32	0.29	654.00
84	11.20	0.000	177.32	176.74	0.29	654.00
85	11.33	0.000	176.74	176.16	0.29	654.00
86	11.47	0.000	176.16	175.57	0.29	654.00
87	11.60	0.000	175.57	174.99	0.29	654.00
88	11.73	0.000	174.99	174.40	0.29	654.00
89	11.87	0.000	174.40	173.82	0.29	654.00
90	12.00	0.000	173.82	173.27	0.27	653.90
91	12.13	0.000	173.27	172.73	0.27	653.90
92	12.27	0.000	172.73	172.19	0.27	653.90
93	12.40	0.000	172.19	171.65	0.27	653.90
94	12.53	0.000	171.65	171.11	0.27	653.90
95	12.67	0.000	171.11	170.56	0.27	653.90
96	12.80	0.000	170.56	170.02	0.27	653.90
97	12.93	0.000	170.02	169.48	0.27	653.90
98	13.07	0.000	169.48	168.94	0.27	653.90

APPENDIX

COUNTY OF SAN DIEGO
HYDROLOGY MANUAL EXCERPTS

County of San Diego Hydrology Manual

Rainfall Isopluvials



100 Year Rainfall Event - 6 Hours

Isopluvial (inches)

DPW GIS
Department of Public Works
Geographic Information Services

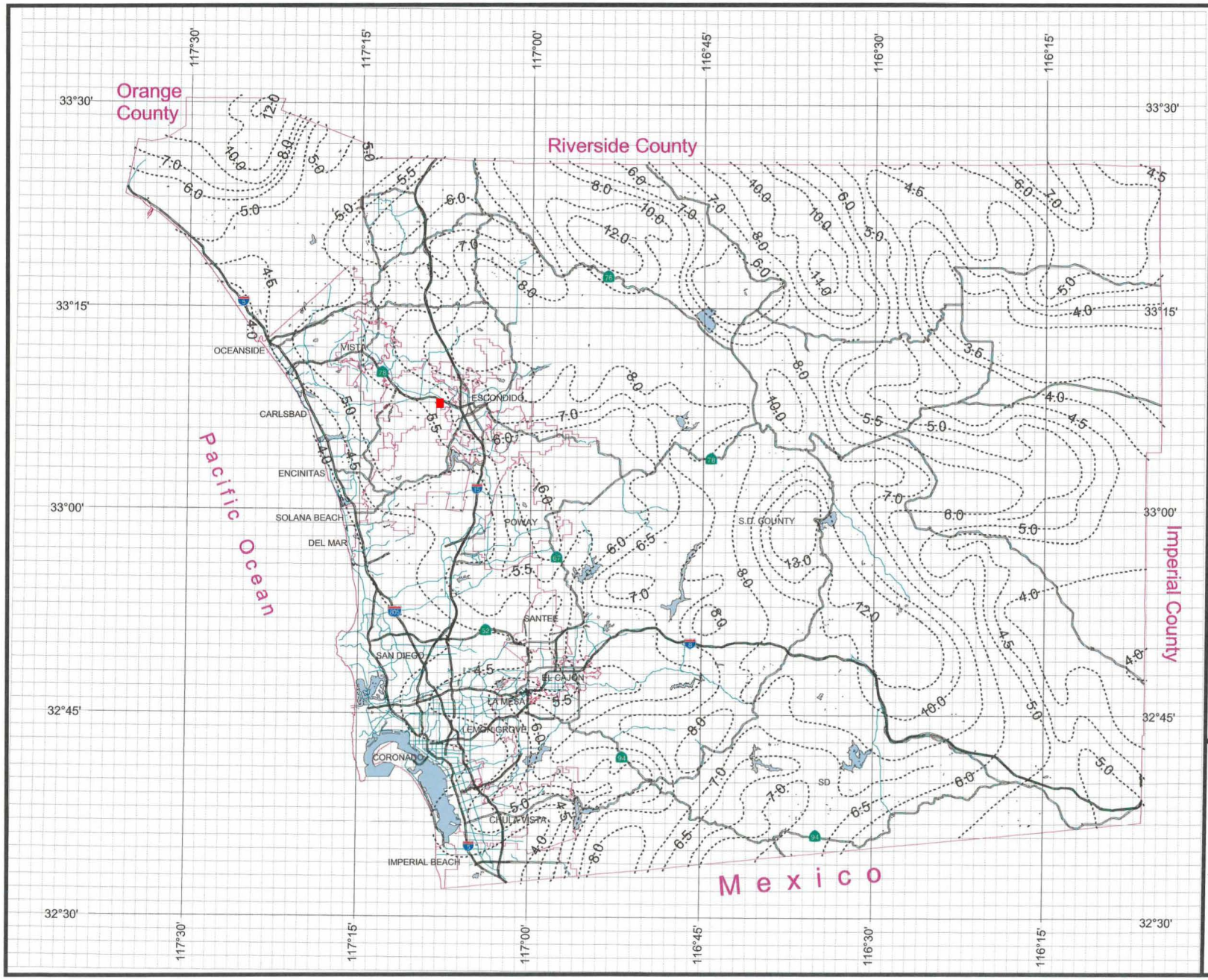
SanGIS
We Have San Diego Covered!

N
W E
S

3 0 3 Miles

County of San Diego Hydrology Manual

Rainfall Isopluvials



100 Year Rainfall Event - 24 Hours

Isopluvial (inches)

DPW GIS
Department of Public Works Geographic Information Services

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N
W E
S

3 0 3 Miles

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

0.74 USGD for 70% Dry

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

*See Table 3-1 for more detailed description

SECTION 6
RATIONAL METHOD HYDROGRAPH PROCEDURE

6.1 INTRODUCTION

The procedures in this section are for the development of hydrographs from RM study results for study areas up to approximately 1 square mile in size. The RM, discussed in Section 3, is a mathematical formula used to determine the maximum runoff rate from a given rainfall. It has particular application in urban storm drainage, where it is used to estimate peak runoff rates from small urban and rural watersheds for the design of storm drains and small drainage structures. However, in some instances such as for design of detention basins, the peak runoff rate is insufficient information for the design, and a hydrograph is needed. Unlike the NRCS hydrologic method (discussed in Section 4), the RM itself does not create hydrographs. The procedures for detention basin design based on RM study results were first developed as part of the East Otay Mesa Drainage Study. Rick Engineering Company performed this study under the direction of County Flood Control. The procedures in this section may be used for the development of hydrographs from RM study results for study areas up to approximately 1 square mile in size.

6.2 HYDROGRAPH DEVELOPMENT

The concept of this hydrograph procedure is based on the RM formula:

$$Q = C\ I\ A$$

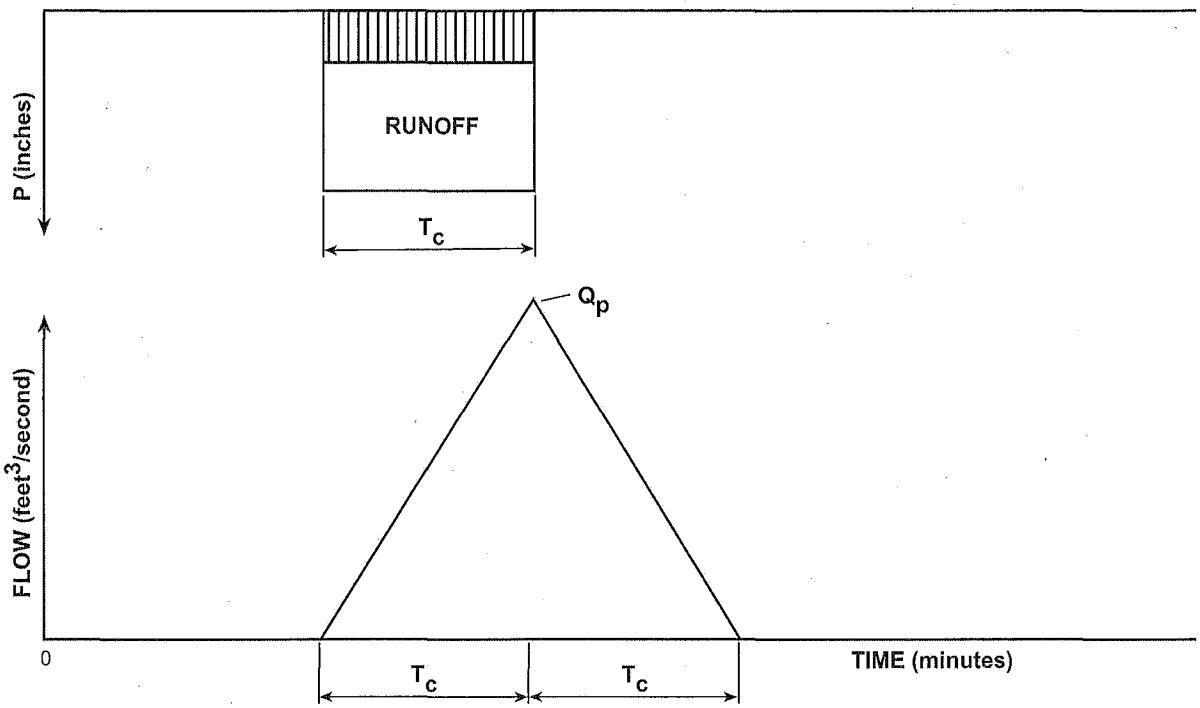
Where:
- Q = peak discharge, in cubic feet per second (cfs)
- C = runoff coefficient, proportion of the rainfall that runs off the surface (no units)
- I = average rainfall intensity for a duration equal to the T_c for the area, in inches per hour
- A = drainage area contributing to the design location, in acres

The RM formula is discussed in more detail in Section 3.

An assumption of the RM is that discharge increases linearly over the T_c for the drainage area until reaching the peak discharge as defined by the RM formula, and then decreases linearly. A linear hydrograph can be developed for the peak flow occurring over the T_c as shown in Figure 6-1. However, for designs that are dependent on the total storm volume, it is not sufficient to consider a single hydrograph for peak flow occurring over the T_c at the beginning of a 6-hour storm event because the hydrograph does not account for the entire volume of runoff from the storm event. The volume under the hydrograph shown in Figure 6-1 is equal to the rainfall intensity multiplied by the duration for which that intensity occurs (T_c), the drainage area (A) contributing to the design location, and the runoff coefficient (C) for the drainage area. For designs that are dependent on the total storm volume, a hydrograph must be generated to account for the entire volume of runoff from the 6-hour storm event. The hydrograph for the entire 6-hour storm event is generated by creating a rainfall distribution consisting of blocks of rain, creating an incremental hydrograph for each block of rain, and adding the hydrographs from each block of rain. This process creates a hydrograph that contains runoff from all the blocks of rain and accounts for the entire volume of runoff from the 6-hour storm event. The total volume under the resulting hydrograph is equal to the following equation:

$$VOL = CP_6A \qquad \text{(Eq. 6-1)}$$

Where: VOL = volume of runoff (acre-inches)
P_6 = 6-hour rainfall (inches)
C = runoff coefficient
A = area of the watershed (acres)



FIGURE

6-1

Triangular Hydrograph

6.2.1 Rainfall Distribution

Figure 6-2 shows a 6-hour rainfall distribution consisting of blocks of rain over increments of time equal to T_c. The number of blocks is determined by rounding T_c to the nearest whole number of minutes, dividing 360 minutes (6 hours) by T_c, and rounding again to the nearest whole number. The blocks are distributed using a (2/3, 1/3) distribution in which the peak rainfall block is placed at the 4-hour time within the 6-hour rainfall duration. The additional blocks are distributed in a sequence alternating two blocks to the left and one block to the right of the 4-hour time (see Figure 6-2). The total amount of rainfall ($P_{T(N)}$) for any given block (N) is determined as follows:

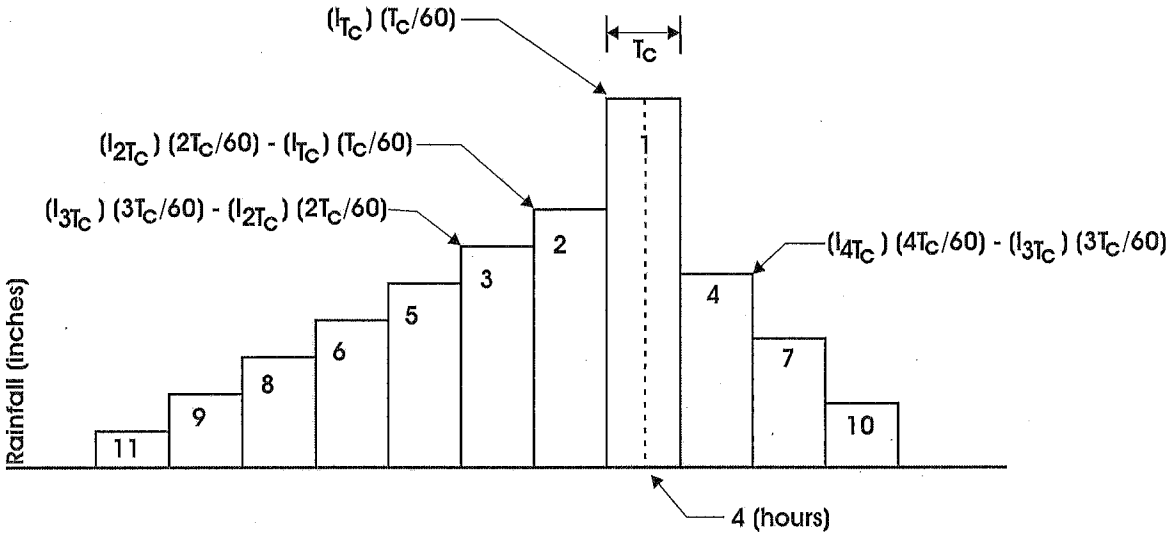
$$P_{T(N)} = (I_{T(N)}\ T_{T(N)}) / 60$$

Where: $P_{T(N)}$ = total amount of rainfall for any given block (N)
$I_{T(N)}$ = average rainfall intensity for a duration equal to $T_{T(N)}$ in inches per hour
$T_{T(N)} = NT_c$ in minutes (N is an integer representing the given block number of rainfall)

Intensity is calculated using the following equation (described in detail in Section 3):

$$I = 7.44\ P_6\ D^{-0.645}$$

Where: I = average rainfall intensity for a duration equal to D in inches per hour
P_6 = adjusted 6-hour storm rainfall
D = duration in minutes



FIGURE

6-2

Rainfall Distribution

Substituting the equation for I in the equation above for $P_{T(N)}$ and setting the duration (D) equal to $T_{T(N)}$ yields:

$$P_{T(N)} = [(7.44\ P_6/T_{T(N)}^{0.645})(T_{T(N)})] / 60$$
$$P_{T(N)} = 0.124\ P_6 T_{T(N)}^{0.355}$$

Substituting NT_c for T_T (where N equals the block number of rainfall) in the equation above yields:

$$P_{T(N)} = 0.124\ P_6\ (NT_c)^{0.355} \qquad \text{(Eq. 6-2)}$$

Equation 6-2 represents the total rainfall amount for a rainfall block with a time base equal to $T_{T(N)}$ (NT_c). The actual time base of each rainfall block in the rainfall distribution is T_c, as shown in Figure 6-2. The actual rainfall amount (P_N) for each block of rain is equal to P_T at N ($P_{T(N)}$) minus the previous P_T at N–1 ($P_{T(N-1)}$) at any given multiple of T_c (any NT_c). For example, the rainfall for block 2 is equal to $P_{T(N)}$ at $T_{T(N)} = 2T_c$ minus the $P_{T(N)}$ at $T_{T(N)} = 1T_c$, and the rainfall for block 3 equals $P_{T(N)}$ at $T_{T(N)} = 3T_c$ minus the $P_{T(N)}$ at $T_{T(N)} = 2T_c$, or P_N can be represented by the following equation:

$$P_N = P_{T(N)} - P_{T(N-1)} \qquad \text{(Eq. 6-3)}$$

For the rainfall distribution, the rainfall at block N = 1, ($1T_c$), is centered at 4 hours, the rainfall at block N = 2, ($2T_c$), is centered at 4 hours – $1T_c$, the rainfall at block N = 3, ($3T_c$), is centered at 4 hours – $2T_c$, and the rainfall at at block N = 4, ($4T_c$), is centered at 4 hours + $1T_c$. The sequence continues alternating two blocks to the left and one block to the right (see Figure 6-2).

6.2.2 Construction of Incremental Hydrographs

Figure 6-1 shows the relationship of a single block of rain to a single hydrograph. Figure 6-3 shows the relationship of the rainfall distribution to the overall hydrograph for the storm event. The peak flow amount from each block of rain is determined by the RM formula, Q = CIA, where I equals I_N (the actual rainfall intensity for the rainfall block). I_N is determined by dividing P_N by the actual time base of the block, T_c. The following equation shows this relationship:

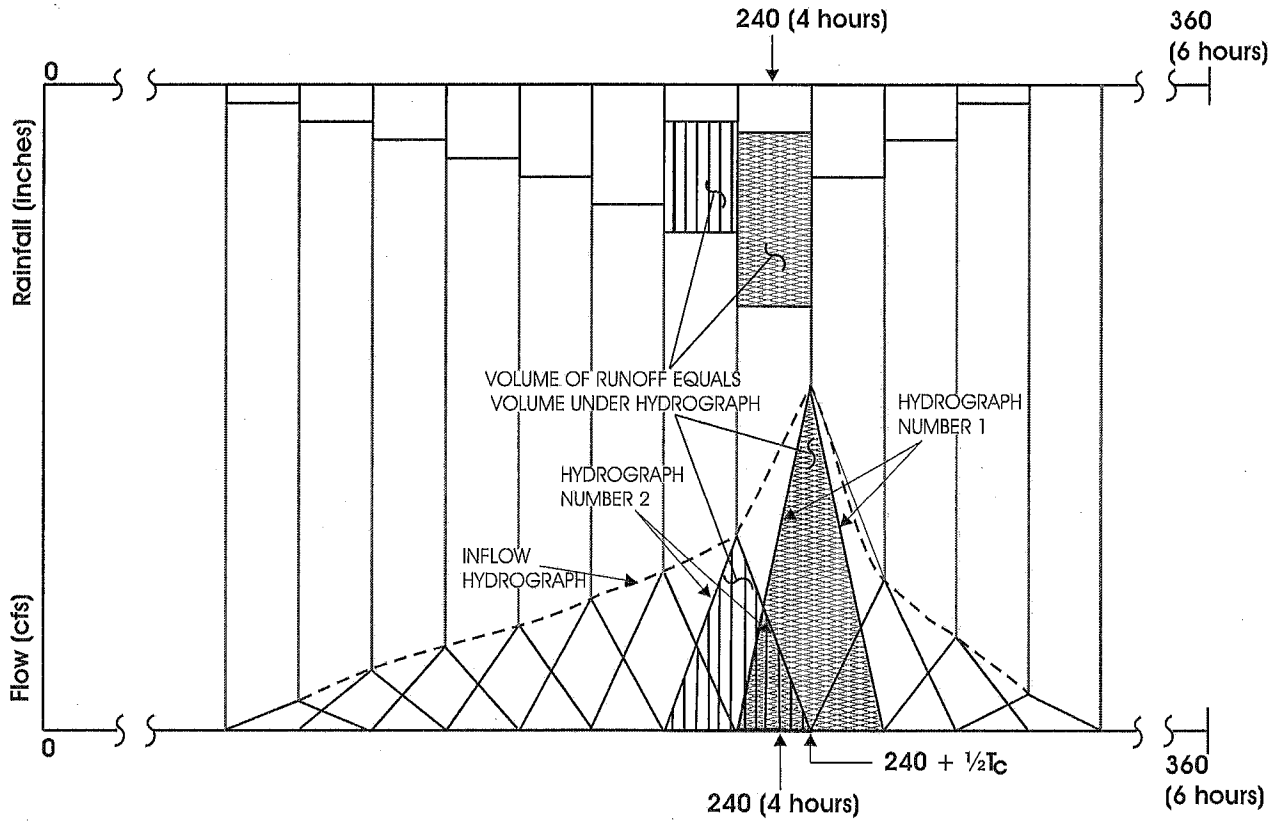
$$I_N = 60\ P_N/T_c \qquad \text{(Eq. 6-4)}$$

Where: I_N = average rainfall intensity for a duration equal to T_c in inches per hour
P_N = rainfall amount for the block in inches
T_c = time of concentration in minutes

By substituting equation 6-4 into the rational equation, the following relationship is obtained:

$$Q_N = 60\ CAP_N/T_c\ (cfs) \qquad \text{(Eq. 6-5)}$$

Finally, the overall hydrograph for the storm event is determined by adding all the hydrographs from each block of rain. Since the peak flow amount for each incremental hydrograph corresponds to a zero flow amount from the previous and proceeding hydrographs, as shown in Figure 6-3, the inflow hydrograph can be plotted by connecting the peak flow amounts (see the dashed line in Figure 6-3).



FIGURE

6-Hour Rational Method Hydrograph

6-3

6.3 GENERATING A HYDROGRAPH USING RATHYDRO

The rainfall distribution and related hydrographs can be developed using the RATHYDRO computer program provided to the County by Rick Engineering Company. A copy of this program is available at no cost from the County. The output from this computer program may be used with HEC-1 or other software for routing purposes.

The design storm pattern used by the RATHYDRO program is based on the (2/3, 1/3) distribution described in Sections 4.1.1 and 6.2.1. The ordinates on the hydrograph are calculated based on the County of San Diego Intensity-Duration Design Chart (Figure 3-1), which uses the intensity equation described in Sections 3.1.3 and 6.2.1 to relate the intensity (I) of the storm to T_c, $I = 7.44\ P_6 D^{-0.645}$. The computer program uses equations 6-2 and 6-3 described above and calculates I_N directly. The intensity at any given multiple of T_c is calculated by the following equation:

$$I_N = [(I_{T(N)})\ (T_{T(N)}) - (I_{T(N-1)})\ (T_{T(N-1)})] / T_c \qquad \text{(Eq. 6-6)}$$

Where: N = number of rainfall blocks

$T_{T(N)}$ = time of concentration at rainfall block N in minutes (equal to NT_c)

I_N = actual rainfall intensity at rainfall block N in inches per hour

$I_{T(N)}$ = rainfall intensity at time of concentration $T_{T(N)}$ in inches per hour

Figure 6-2 shows the rainfall distribution used in the RM hydrograph, computed at multiples of T_c. The rainfall at block N = 1, ($1T_c$), is centered at 4 hours, the rainfall at block N = 2, ($2T_c$), is centered at 4 hours – $1T_c$, the rainfall at block N = 3, ($3T_c$), is centered at 4 hours – $2T_c$, and the rainfall at at block N = 4, ($4T_c$), is centered at 4 hours + $1T_c$. The sequence continues alternating two blocks to the left and one block to the right (see Figure 6-2).

As described in Section 6.2.2, the peak discharge (Q_N) of the hydrograph for any given rainfall block (N) is determined by the RM formula Q = CIA, where $I = I_N$ = the actual

rainfall intensity for the rainfall block. The RATHYDRO program substitutes equation 6-6 into the RM formula to determine Q_N yielding the following equation:

$$Q_N = [(I_{T(N)})(T_{T(N)}) - (I_{T(N-1)})(T_{T(N-1)})]\, CA / T_c \qquad \text{(Eq. 6-7)}$$

Where: Q_N = peak discharge for rainfall block N in cubic feet per second (cfs)
N = number of rainfall blocks
$T_{T(N)}$ = time of concentration at rainfall block N in minutes (equal to NT_c)
$I_{T(N)}$ = rainfall intensity at time of concentration $T_{T(N)}$ in inches per hour
C = RM runoff coefficient
A = area of the watershed (acres)

To develop the hydrograph for the 6-hour design storm, a series of triangular hydrographs with ordinates at multiples of the given T_c are created and added to create the hydrograph. This hydrograph has its peak at 4 hours plus ½ of the T_c. The total volume under the hydrograph is equal to the following equation (equation 6-1):

$$VOL = CP_6A$$

Where: VOL = volume of runoff (acre-inches)
P_6 = 6-hour rainfall (inches)
C = runoff coefficient
A = area of the watershed (acres)

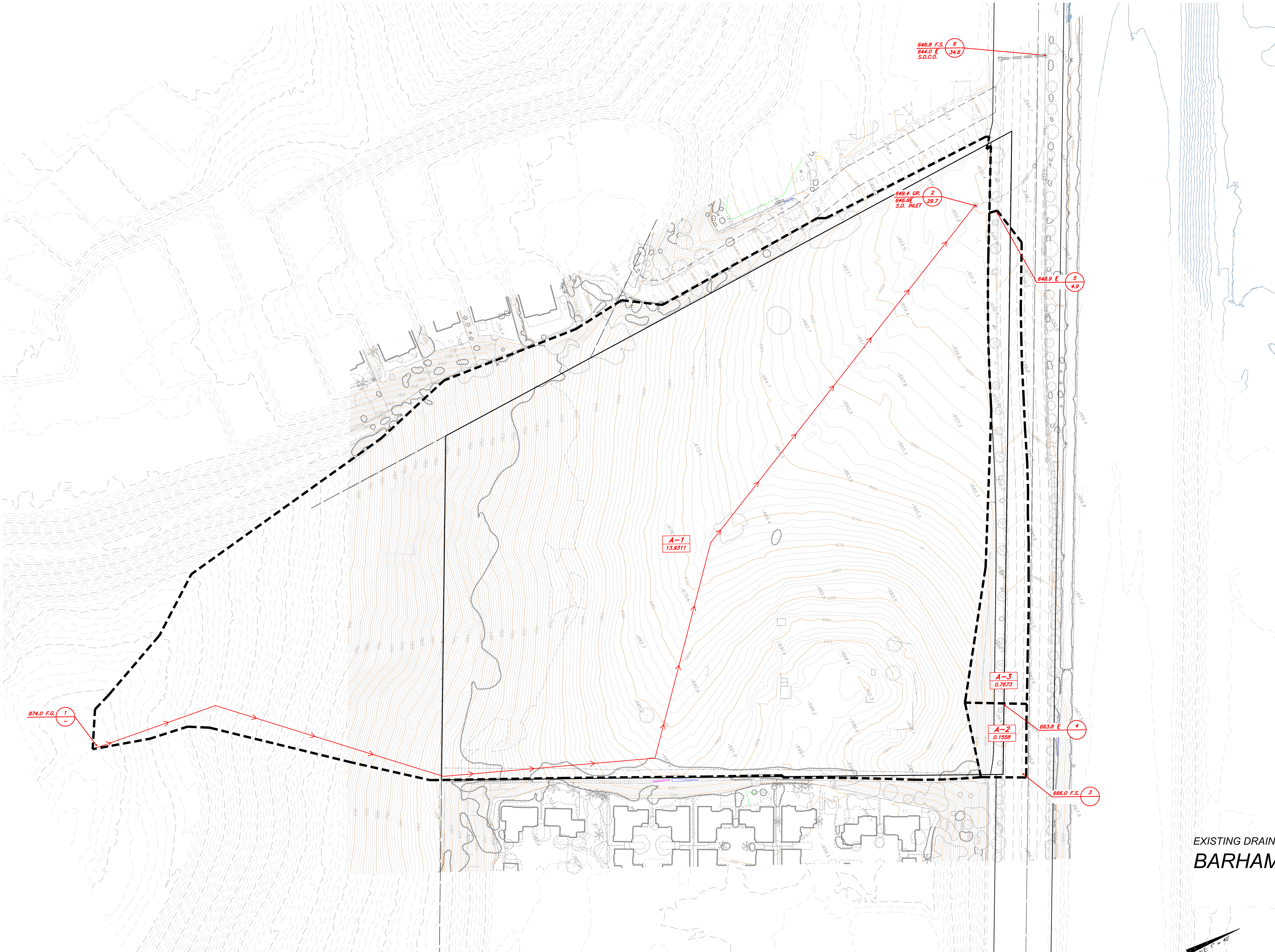
RATIONAL METHOD HYDROGRAPH PROGRAM

RUN DATE 8/23/2012
HYDROGRAPH FILE NAME Text1
TIME OF CONCENTRATION 7 MIN.
6 HOUR RAINFALL 0.95 INCHES
BASIN AREA 17.35 ACRES
RUNOFF COEFFICIENT 0.74
PEAK DISCHARGE 25.87 CFS

TIME (MIN) = 0	DISCHARGE (CFS) = 0
TIME (MIN) = 7	DISCHARGE (CFS) = 0.7
TIME (MIN) = 14	DISCHARGE (CFS) = 0.8
TIME (MIN) = 21	DISCHARGE (CFS) = 0.8
TIME (MIN) = 28	DISCHARGE (CFS) = 0.8
TIME (MIN) = 35	DISCHARGE (CFS) = 0.8
TIME (MIN) = 42	DISCHARGE (CFS) = 0.8
TIME (MIN) = 49	DISCHARGE (CFS) = 0.9
TIME (MIN) = 56	DISCHARGE (CFS) = 0.9
TIME (MIN) = 63	DISCHARGE (CFS) = 0.9
TIME (MIN) = 70	DISCHARGE (CFS) = 1
TIME (MIN) = 77	DISCHARGE (CFS) = 1
TIME (MIN) = 84	DISCHARGE (CFS) = 1.1
TIME (MIN) = 91	DISCHARGE (CFS) = 1.1
TIME (MIN) = 98	DISCHARGE (CFS) = 1.2
TIME (MIN) = 105	DISCHARGE (CFS) = 1.2
TIME (MIN) = 112	DISCHARGE (CFS) = 1.3
TIME (MIN) = 119	DISCHARGE (CFS) = 1.4
TIME (MIN) = 126	DISCHARGE (CFS) = 1.5
TIME (MIN) = 133	DISCHARGE (CFS) = 1.6
TIME (MIN) = 140	DISCHARGE (CFS) = 1.8
TIME (MIN) = 147	DISCHARGE (CFS) = 2
TIME (MIN) = 154	DISCHARGE (CFS) = 2.3
TIME (MIN) = 161	DISCHARGE (CFS) = 2.7
TIME (MIN) = 168	DISCHARGE (CFS) = 3.5
TIME (MIN) = 175	DISCHARGE (CFS) = 5.1
TIME (MIN) = 182	DISCHARGE (CFS) = 25.87
TIME (MIN) = 189	DISCHARGE (CFS) = 7.2
TIME (MIN) = 196	DISCHARGE (CFS) = 4.1
TIME (MIN) = 203	DISCHARGE (CFS) = 3.1
TIME (MIN) = 210	DISCHARGE (CFS) = 2.5
TIME (MIN) = 217	DISCHARGE (CFS) = 2.2
TIME (MIN) = 224	DISCHARGE (CFS) = 1.9
TIME (MIN) = 231	DISCHARGE (CFS) = 1.7
TIME (MIN) = 238	DISCHARGE (CFS) = 1.6
TIME (MIN) = 245	DISCHARGE (CFS) = 1.4
TIME (MIN) = 252	DISCHARGE (CFS) = 1.4
TIME (MIN) = 259	DISCHARGE (CFS) = 1.3
TIME (MIN) = 266	DISCHARGE (CFS) = 1.2
TIME (MIN) = 273	DISCHARGE (CFS) = 1.1
TIME (MIN) = 280	DISCHARGE (CFS) = 1.1
TIME (MIN) = 287	DISCHARGE (CFS) = 1
TIME (MIN) = 294	DISCHARGE (CFS) = 1
TIME (MIN) = 301	DISCHARGE (CFS) = 1
TIME (MIN) = 308	DISCHARGE (CFS) = 0.9
TIME (MIN) = 315	DISCHARGE (CFS) = 0.9
TIME (MIN) = 322	DISCHARGE (CFS) = 0.9
TIME (MIN) = 329	DISCHARGE (CFS) = 0.8
TIME (MIN) = 336	DISCHARGE (CFS) = 0.8
TIME (MIN) = 343	DISCHARGE (CFS) = 0.8
TIME (MIN) = 350	DISCHARGE (CFS) = 0.8
TIME (MIN) = 357	DISCHARGE (CFS) = 0.7
TIME (MIN) = 364	DISCHARGE (CFS) = 0

EXISTING DRAINAGE EXHIBIT

BARHAM DRIVE



EXISTING DRAINAGE EXHIBIT

BARHAM DRIVE

SCALE: 1" = 40'

GRAPHIC SCALE

40 0 40 80 120

SB&O INC.
PLANNING ENGINEERING SURVEYING
3990 Ruffin Road, Suite 120
San Diego, Ca. 92123
858-560-1141
858-560-8157 Fax

FILE NAME: D:\75051 BARHAM DRIVE\03 DWG\DX\EXISTING DRAINAGE.DWG, PLOTTED BY: JONAT

DATE

JOB NO.

PROPOSED DRAINAGE EXHIBIT FOR:
BARHAM DRIVE

SB&O INC.
PLANNING ENGINEERING SURVEYING
3990 Ruffin Road, Suite 120
San Diego, Ca. 92123
858-560-1141
858-560-8157 Fax

6-30-20

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