Appendix I1

Preliminary Hydrology Calculations

Thienes Engineering, Inc.
CIVIL ENGINEERING • LAND SURVEYING

PRELIMINARY HYDROLOGY CALCULATIONS

FOR

NORTHERN GATEWAY LOGISTICS CENTER
EVANS ROAD BETWEEN ETHANAC ROAD AND MCLAUGHLIN ROAD
RIVERSIDE COUNTY, CALIFORNIA

PREPARED FOR

LOVETT INDUSTRIAL
120 NEWPORT CENTER DRIVE SUITE 217
NEWPORT BEACH, CA 92660
PHONE: (949) 402-2760

JANUARY 12, 2023
REVISED APRIL 10, 2023
REVISED APRIL 21, 2023
REVISED APRIL 27, 2023
REVISED JULY 28, 2023
REVISED SEPTEMBER 7, 2023
REVISED OCTOBER 25, 2023

JOB NO. 4118

PREPARED BY

THIENES ENGINEERING
14349 FIRESTONE BLVD.
LA MIRADA, CALIFORNIA 90638
PHONE (714) 521-4811

PRELIMINARY HYDROLOGY CALCULATIONS

FOR

NORTHERN GATEWAY LOGISTICS CENTER

PREPARED UNDER
THE SUPERVISION OF

REGISTERED PROFESSIONAL ENGINEER
REINHARD STENZEL
R.C.E. NO. 56155
Exp. 12-31-24
CIVIL
STATE OF CALIFORNIA

10/25/2023

REINHARD STENZEL, P.E. DATE:
R.C.E. 56155
EXP. 12/31/2024

Table of Contents

INTRODUCTION

A: PROJECT LOCATION

The project site is located along the east side of Evans Road north of McLaughlin Road in the city of Menifee. See the following page for a vicinity map.

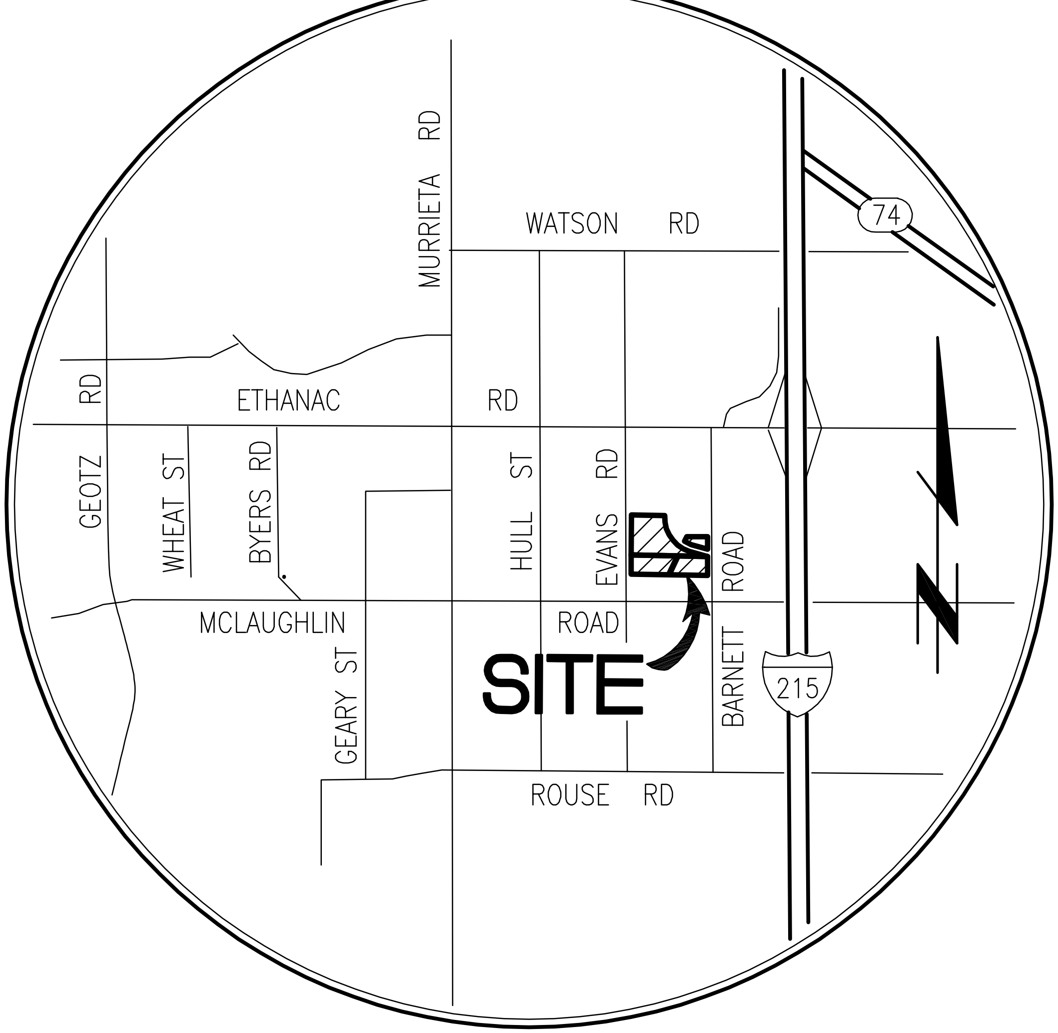
B: STUDY PURPOSE

The purpose of this study is to determine the 100-year existing and proposed condition peak flow rates from the project site.

C: PROJECT STAFF:

Thienes Engineering staff involved in this study include:

Reinhard Stenzel
Brian Weil



VICINITY MAP

N.T.S.

DISCUSSION

The project site encompasses approximately 18.74 acres. Proposed improvements for the site include two warehouse buildings, 105,326 square feet for Building 1 and 292,715 square feet for Building 2. Each building has a proposed truck yard, vehicular parking and trailer parking. There is landscaping along Evans Road, Barnett Road and located throughout the site. There is a proposed driveway along the southerly property line.

Master Plan Hydrology

The project site is part of the Riverside County Flood Control and Water Conservation District (RCFC&WCD) Romoland Master Drainage Plan – Zone 4. The Master Drainage Plan (MDP) was completed in April 1988 and Revision No. 1 was completed in March 2006. The project site was designated as Light Industrial in the corresponding hydrologic calculations.

The Ethanac Wash (MDP Line A) is a large open channel facility adjacent to the easterly property line of the project site. Line A originates to the southeast of the project site and generally flows in a westerly direction. After the facility crosses Interstate 215, the channel turns north near the project site. The channel then crosses Ethanac Road and turns west immediately adjacent to the north side of Ethanac Road. The channel continues in a generally west and northwest direction to the San Jacinto River. North of the project site, the MDP 100-year flow rate in Line A is 3,673 cfs.

MDP facility Line A-8 is shown traversing northerly through the easterly portion of the project site. However, recent County storm drain plans show this facility traversing easterly through the northerly portion of the Building 2 site ultimately connecting to Line A. The MDP 100-year flow rate in Line A-8 shown on the Master Drainage Plan map is 292 cfs, although the storm drain plan shows 283 cfs. Either way, the peak flow rates are comparable.

The MDP map does not show specific drainage areas. The site is clearly tabled to Line “A”, it is just not clear whether it was intended to drain directly to the Channel or to Line A-8 or via a proposed storm drain in Evans Road. It does not appear that detention will be necessary since the existing County facilities are designed for the 100-year storm event and the project site was considered as commercial development.

See Appendix “A” for Master Drainage Plan reference material.

FEMA Flood Zone

The project site is located on Flood Insurance Rate MAP (FIRM) Number 06065C2055H that has an effective date of January 24, 2022. According to this FIRM, the westerly portion of the sites area within Flood Zone X (shaded) and the easterly portion of the site is within Flood Zone X (unshaded). Flood Zone X (shaded) is defined as “areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood”. Flood Zone X (unshaded) is defined as “areas determined to be outside the 0.2% annual chance floodplain”.

See Appendix "A" for Flood Insurance Rate Map reference material.

Existing Storm Drains

Romoland MDP Line A is a large open channel facility along the project's easterly border. The channel has a design base width of 50', 3:1 side slopes, and is unlined. Lateral A-8 runs along the northerly portion of the southerly portion of the project site. This facility is a 10' wide x 6' high reinforced concrete box (RCB). The RCB traverses easterly through the project site and connects to MDP Line "A". Both facilities are maintained by RCFC&WCD.

See Appendix "A" for reference storm drain material.

Proposed Master Plan Storm Drain

The existing Lateral A-8, as designed by SB&O, Inc., will be removed and relocated approximately 200' northerly along the same alignment to avoid conflicts with the proposed improvements. The relocated storm drain will maintain the same size (10'Wx6'H RCB) and downstream hydraulic controls as the existing SB&O drain.

The downstream controlling hydraulic grade line (HGL) was taken to be elevation 1419.10, which is the approximate ultimate HGL of Romoland MDP Line A per the SB&O, Inc. design of the original Lateral A-8. The hydraulic model was revised to include proposed connections from the project site. The relocated RCB will continue to discharge to Romoland MDP Line A per a proposed headwall, equivalent to existing conditions.

See Appendix "A" for pertinent reference materials.

Existing Condition

Currently, the site is mostly undeveloped agricultural land and relativity flat. Existing topography indicates that the northerly portion (Nodes 100-101) and southerly portion (Nodes 200-202) all drain westerly to Evans Road. The 100-year peak flow rate for these two areas are 6.0 cfs and 17.4 cfs, respectively.

The total 100-year peak flow rate for the site is approximately 23.4 cfs.

See Appendix "A" for existing condition hydrology calculations and Appendix "D" for existing condition hydrology map.

Proposed Condition

As described above, runoff will drain to the MDP Line A, "Ethanac Wash".

The northerly portion of Building 1 and the northerly drive aisle (Nodes 100-102) will drain to catch basins located in the northerly drive aisle. A proposed onsite storm drain system will capture and convey flows southerly around the proposed building to the southerly drive aisle. Flows from the Building 1 truck yard (Nodes 110-113) will confluence in the proposed system in the easterly drive aisle (Node 114). Flows continue southerly to the proposed 10'x6' RCB (Node 126) that ultimately discharges in the MDP channel.

The northerly portion of Building 2, northerly truck yard and northerly driveway (Nodes 120-124) drain to catch basins located in the northerly truck yard. A separate onsite storm drain system conveys flows northerly to the proposed RCB and discharges at the same location as the flows from the north (Node 125).

The total 100-year peak flow rate to this area of the proposed RCB is approximately 42.6 cfs.

The easterly parking area (Nodes 200-201) drains to a catch basin located in the parking area. A proposed onsite storm drain system will convey flows southerly then westerly around the proposed building. Flows from the southerly portion of Building 2 (Nodes 202-205) will enter the storm drain system through roof drains. The storm drain will continue northerly and collect flows from the westerly drive aisle (Nodes 206-207). The onsite system ultimately discharges to the proposed 10'x6' RCB. The 100-year peak flow rate to the RCB from these areas is approximately 12.2 cfs. cfs.

The proposed driveway (Nodes 300-305) will drain to proposed catch basins located along the curb. Flows will be conveyed westerly through the proposed driveway and ultimately discharge into the existing 5.0'x4.5' RCB in Evans Road. The landscaped area and driveways servicing Evans Road will sheet flow directly offsite to the street. Flows will be collected in a proposed street catch basin and confluenced in the existing box. The 100-year peak flow rate from to the existing box is approximately 8.2 cfs.

The total 100-year peak flow rate from the site is approximately 63.0 cfs.

As previously mentioned, the MDP channel was designed to convey the 100-year peak flow rate for the ultimate commercial build-out of the site, so onsite detention will not be required.

See Appendix "A" for proposed condition hydrology calculations and Appendix "D" for proposed condition hydrology map.

Methodology

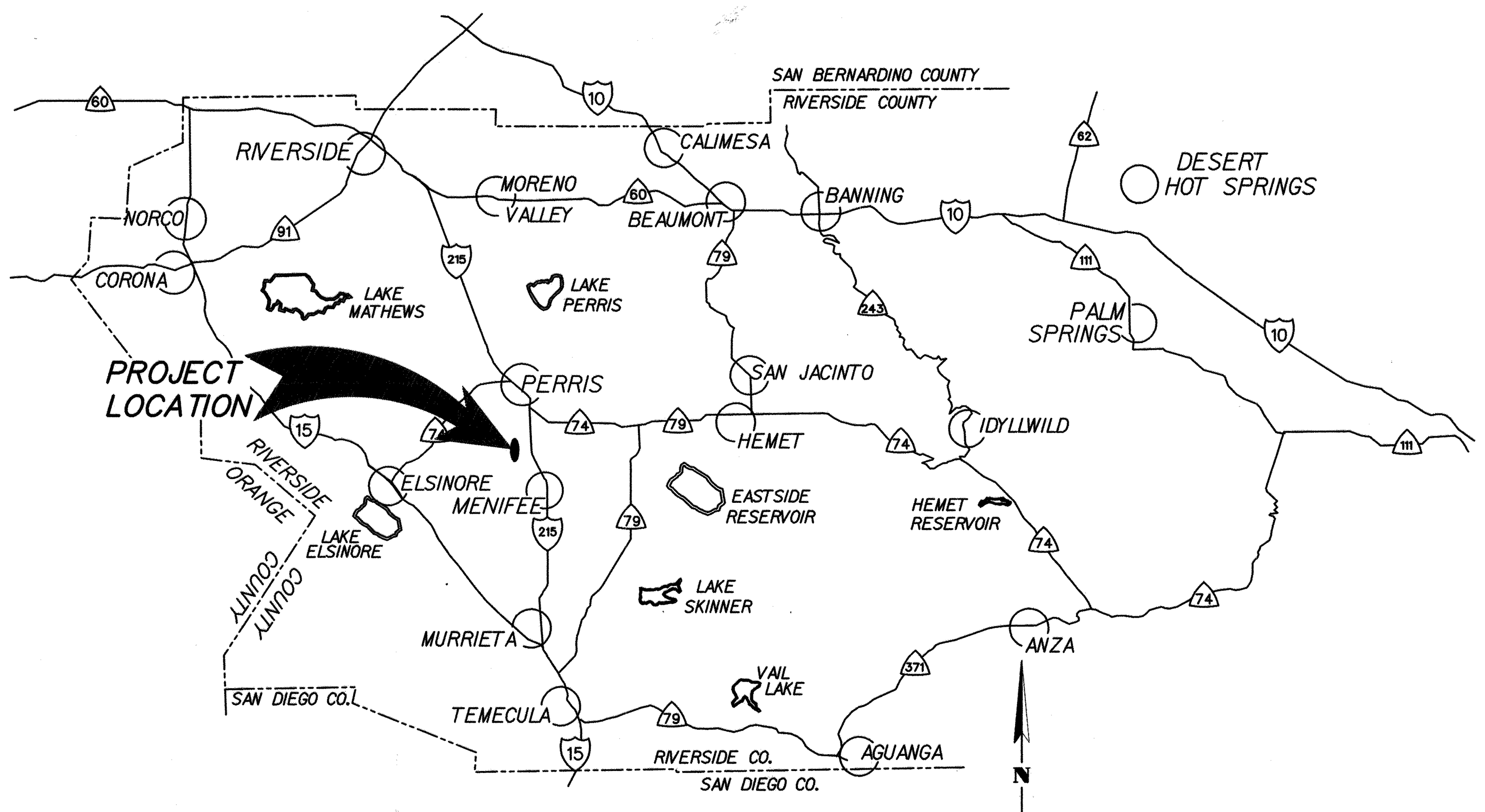
Rational Method calculations were computed using AES Software in compliance with the RCFC&WCD Hydrology Manual. The 2-year, 1-hour rainfall is 0.48" and the 100-year, 1-hour rainfall is 1.27". The site is within hydrologic soil types "C" per the Riverside County Hydrology Manual. See Appendix "A" for reference material from the Hydrology Manual.

APPENDIX	DESCRIPTION
A	REFERENCE MATERIALS
B	HYDROLOGY CALCULATIONS
C	HYDRAULIC CALCULATIONS
D	HYDROLOGY MAPS

APPENDIX A

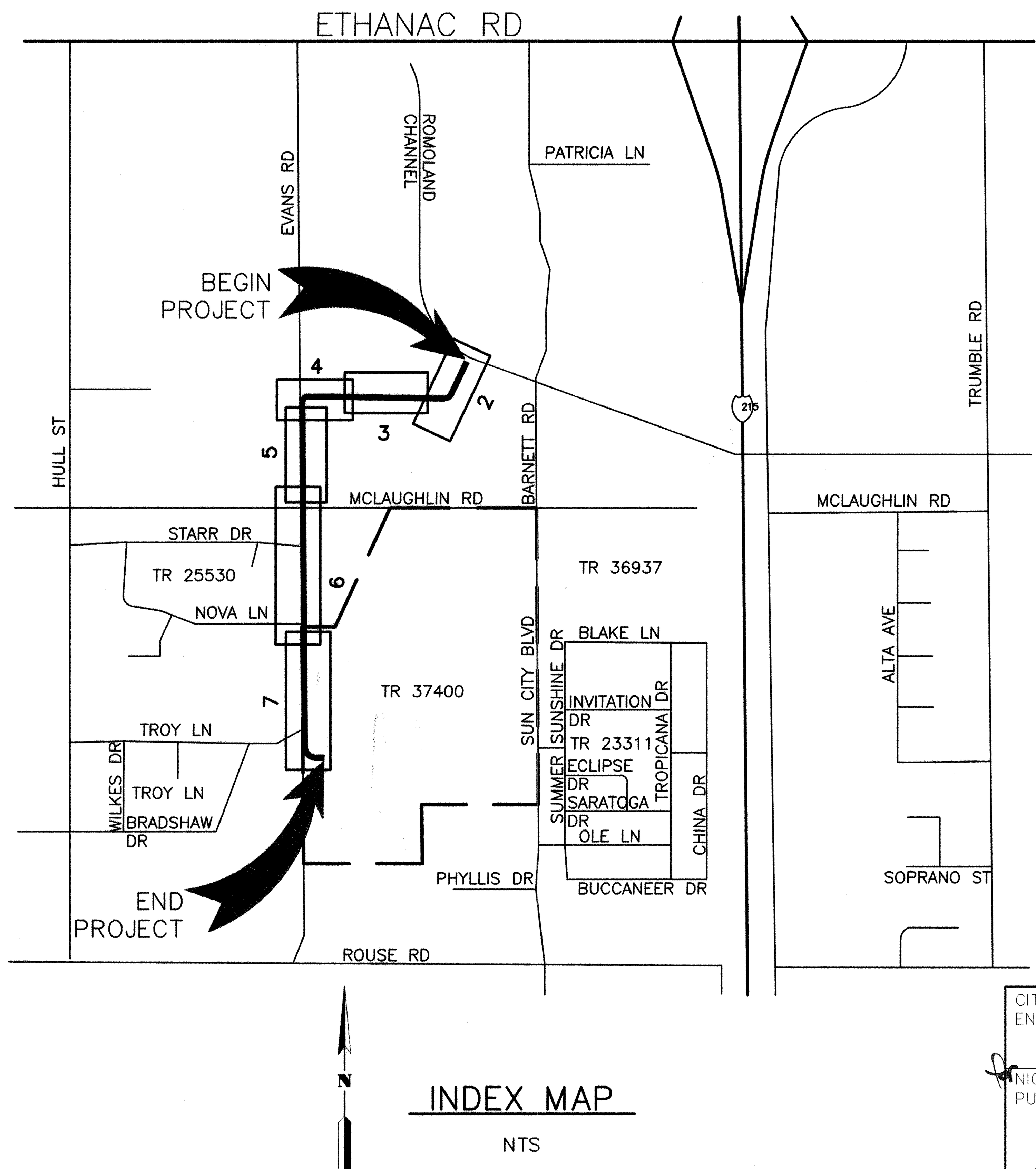
REFERENCE MATERIALS

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT



VICINITY MAP

NTS



INDEX MAP

NTS

INDEX

R.C.F.C. & W.C.D. STANDARD DRAWINGS

CB110	CONCRETE DROP INLET
JS228	JUNCTION STRUCTURE No. 3
JS230	JUNCTION STRUCTURE No. 5
JS233	JUNCTION STRUCTURE No. 8
MH253	MANHOLE No. 3
MH260	MANHOLE FRAME AND COVER
M816	CONCRETE BULKHEAD
M819	MAXIMUM CHORD LENGTHS FOR CURVED SECTIONS

CALTRANS STANDARD DRAWINGS

D80	CAST-IN-PLACE RCB
D82	CAST-IN-PLACE RCB MISC DETAILS
D83A	PRECAST RCB
D84	BOX CULVERT HEADWALL & WINGWALLS

APWA STANDARD DRAWINGS

360–2	SLOPED PROTECTION BARRIER

LIST OF ABBREVIATIONS

BC	BEGIN CURVE	JS	JUNCTION STRUCTURE
C&G	CURB AND GUTTER	L	LENGTH
CL	CENTER LINE	MH	MANHOLE
CONC	CONCRETE	PR	PROPOSED
CP	CONNECTOR PIPE	R	RADIUS
EC	END CURVE	RCB	REINFORCED CONCRETE BOX
EG	EXISTING GRADE	RCP	REINFORCED CONCRETE PIPE
EL	ELEVATION	RT	RIGHT
ESMT	EASEMENT	RW	RECYCLED WATER
EX	EXISTING	R/W	RIGHT-OF-WAY
FL	FLOWLINE	SD	STORM DRAIN
FO	FIBER OPTIC CABLE	STD	STANDARD
FS	FINISH SURFACE	T	TANGENT
HGL	HYDRAULIC GRADE LINE	TF	TOP OF FOOTING
IE	INVERT ELEVATION	TW	TOP OF WALL
INV	INVERT	TOE	BOTTOM OF SLOPE
		ULT	ULTIMATE

GENERAL NOTES

1. THE CONTRACTOR SHALL CONSTRUCT THE FLOOD CONTROL IMPROVEMENTS SHOWN ON THE DRAWINGS IN CONFORMANCE WITH THE REQUIREMENTS OF THE RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT'S (DISTRICT) M.O.U. STANDARD SPECIFICATIONS DATED MARCH 2020 AND DISTRICT STANDARD DRAWINGS. FOR THE LATEST STANDARD DRAWINGS, PLEASE REFER TO THE "ENGINEERING TOOLS" PAGE FOUND ON THE "BUSINESS" SECTION OF THE DISTRICT'S WEBSITE.
2. CONTACT THE ENCROACHMENT PERMIT ENGINEER AT 951.955.1266 IF AN ENCROACHMENT PERMIT IS REQUIRED FROM THE DISTRICT. AFTER THE PERMIT IS ISSUED, THE DISTRICT MUST BE NOTIFIED ONE (1) WEEK PRIOR TO CONSTRUCTION.
3. CONTACT CONSTRUCTION MANAGEMENT AT 951.955.1288 IF CONSTRUCTION INSPECTION WILL BE PERFORMED BY THE DISTRICT. THE DISTRICT MUST BE NOTIFIED TWENTY (20) DAYS PRIOR TO CONSTRUCTION.
4. ALL STATIONING REFERS TO CENTERLINE OF CONSTRUCTION UNLESS OTHERWISE NOTED.
5. STATIONING FOR LATERALS AND CONNECTOR PIPES REFER TO THE CENTERLINE INTERSECTION STATIONS.
6. FORTY–EIGHT (48) HOURS BEFORE EXCAVATION, CALL UNDERGROUND SERVICE ALERT AT 1.800.227.2600.
7. ALL ELEVATIONS SHOWN ARE IN FEET AND DECIMALS THEREOF BASED ON THE NORTH AMERICAN VERTICAL DATUM BM 600–29–68 EL.=1429.249 NGVD29 DATUM.
8. ALL COORDINATES ARE SHOWN IN FEET AND DECIMALS THEREOF BASED ON THE NORTH AMERICAN DATUM (NAD 83), CALIFORNIA COORDINATE SYSTEM (CCS), ZONE 6 AND EPOCH 2010.
9. ALL CROSS SECTIONS ARE TAKEN LOOKING DOWNSTREAM.
10. ELEVATIONS OF UTILITIES ARE APPROXIMATE UNLESS OTHERWISE NOTED.
11. UNLESS OTHERWISE SPECIFIED, MINIMUM STREET RECONSTRUCTION SHALL BE 4" TYPE "A" HOT MIX ASPHALT OVER 6" CLASS 2 AGGREGATE BASE, IN KIND, OR AS SPECIFIED BY THE CITY OF MENIFEE.
12. OPENINGS RESULTING FROM THE CUTTING OR PARTIAL REMOVAL OF EXISTING CULVERTS, PIPES OR SIMILAR STRUCTURES TO BE ABANDONED SHALL BE SEALED WITH 6" OF CLASS "B" CONCRETE.
13. PIPE CONNECTED TO THE MAINLINE PIPE SHALL CONFORM TO JUNCTION STRUCTURE NO. 4 (JS 229) UNLESS OTHERWISE NOTED.
14. PIPE BEDDING SHALL CONFORM TO DISTRICT STANDARD DRAWING NO. M815.
15. BH–1 INDICATES SOIL BORING LOCATIONS BASED ON THE ALBUS–KEEFE SOILS REPORT DATED 2/14/2018 AND THE GEOTEK SOILS REPORT DATED 8/27/2018. LOCATIONS SHOWN ARE APPROXIMATE.
16. "V" IS THE DEPTH OF CATCH BASINS MEASURED FROM THE TOP OF CURB TO INVERT OF CONNECTOR PIPE.
17. CATCH BASINS SHALL BE LOCATED SO THAT LOCAL DEPRESSION SHALL BEGIN AT EXISTING CURB RETURN JOINT, UNLESS OTHERWISE SPECIFIED.
18. ALL CURBS, GUTTERS, SIDEWALKS, DRIVEWAYS AND OTHER EXISTING IMPROVEMENTS ARE TO BE RECONSTRUCTED IN KIND AND AT THE SAME ELEVATION AND LOCATION AS THE EXISTING IMPROVEMENTS UNLESS OTHERWISE NOTED.
19. STANDARD DRAWINGS CALLED FOR ON THE PLAN AND PROFILE SHALL CONFORM TO DISTRICT STANDARD DRAWINGS UNLESS NOTED OTHERWISE.
20. THE CONTRACTOR IS REQUIRED TO CALL ALL UTILITY AGENCIES REGARDING TEMPORARY SHORING AND SUPPORT REQUIREMENTS FOR THE VARIOUS UTILITY LINES SHOWN ON THESE PLANS.
21. DURING ROUGH GRADING OPERATIONS AND PRIOR TO CONSTRUCTION OF PERMANENT DRAINAGE STRUCTURES, TEMPORARY DRAINAGE CONTROL SHOULD BE PROVIDED TO PREVENT PONDING WATER AND DAMAGE TO ADJACENT PROPERTIES.
22. APPROVAL OF THESE PLANS BY DISTRICT DOES NOT RELIEVE THE DEVELOPER'S ENGINEER OF RESPONSIBILITY FOR THE ENGINEERING DESIGN. IF FIELD CHANGES ARE REQUIRED, IT WILL BE THE RESPONSIBILITY OF THE DESIGN ENGINEER TO MAKE THE NECESSARY CORRECTIONS.
23. THE CONTRACTOR OR DEVELOPER SHALL SECURE ALL REQUIRED ENCROACHMENT AND/OR STATE AND FEDERAL REGULATORY PERMITS PRIOR TO THE COMMENCEMENT OF ANY WORK.
24. THE CONCRETE COATING ON THE INSIDE OF ALL REINFORCED CONCRETE PIPES AND STRUCTURES MUST BE INCREASED TO PROVIDE A MINIMUM OF 1–1/2" OVER THE REINFORCING STEEL AND INCREASED TO A MINIMUM OF 3 1/2" OVER REINFORCING STEEL FOR BOX CULVERT, WHEN DESIGN VELOCITIES EXCEED 20' PER SECOND. THE CONCRETE DESIGN STRENGTH FOR REINFORCED CONCRETE PIPE AND STRUCTURES IN THESE REACHES SHALL BE F'C=5,000 PSI FOR VELOCITIES EXCEEDING 20' PER SECOND AND F'C=6,000 PSI FOR VELOCITIES EXCEEDING 30' PER SECOND.
25. CONSTRUCTION JOINTS FOR CALTRANS STANDARD REINFORCED CONCRETE BOX SHALL BE PLACED ACCORDING TO DISTRICT STANDARD DRAWING NO. BOX 401.
26. ROCK FOR ACCESS ROADS, TURN AROUNDS AND OTHER AREAS WITHIN DISTRICT RIGHT OF WAY AS SHOWN ON THE PROJECT DRAWINGS AND AS DIRECTED BY THE ENGINEER SHALL MEET THE REQUIREMENTS FOR 1" X NO. 4 COARSE AGGREGATE AS PER SECTION 90–1.02C(4)(B) OF THE CALTRANS SPECIFICATIONS. X VALUES FOR ROCK GRADATION SHALL BE 75 AND 15 FOR 3/4" AND 3/8" RESPECTIVELY. ROCK SHALL ADDITIONALLY MEET THE SPREADING AND COMPACTION REQUIREMENTS OF SECTIONS 26–1.03D AND 26–1.03E OF THE CALTRANS SPECIFICATIONS. FURTHERMORE, ROCK DEPTH SHALL NOT EXCEED 3" AND SHALL BE SUBJECT TO APPROVAL BY THE ENGINEER. ROCK SHALL NOT CONTAIN RECYCLED CONCRETE PRODUCTS.

CITY OF MENIFEE
ENGINEERING DEPARTMENT

NICOLAS FIDLER — RCE 61069 — 10-13-21 DATE
PUBLIC WORKS DIRECTOR — EXP. 12/31/22

RECOMMENDED BY: — 10-13-21 DATE

SEAL
CITY OF MENIFEE — OCTOBER 1, 2008

TRACT 37400; IP20–016SD1 MDC

REGISTERED PROFESSIONAL ENGINEER — DANIEL J. O'ROURKE — No. 47677 — CIVIL — STATE OF CALIFORNIA

SB&O INC.
PLANNING ENGINEERING SURVEYING
41689 Enterprise Circle North, Suite 126
Temecula, Ca. 92590
951–695–8900

DANIEL J. O'ROURKE — 9-28-21 DATE

DESIGNED BY: BCK
DRAWN BY: CVV
CONSTR. SET: 9/27/2021
CHECKED BY: DJO
P8 NUMBER: 238677

Don't Dig...Until You Call U.S.A. Toll Free
1–800–422–4133
for the location of buried utility lines.
Don't disrupt vital services.
BURIED CABLE
TWO WORKING DAYS BEFORE YOU DIG

PERMANENT BENCH MARK
B.M. NO. 600–29–68
BRASS DISK IN TOP OF CONCRETE POST AT CATHOLIC CHURCH IN SUN CITY, 0.4 NORTH OF INTERSECTION OF MURRIETA ROAD AND CHERRY HILLS ROAD.
1429.249' EL.

REF.	REVISIONS DESCRIPTION	APPR.	DATE

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

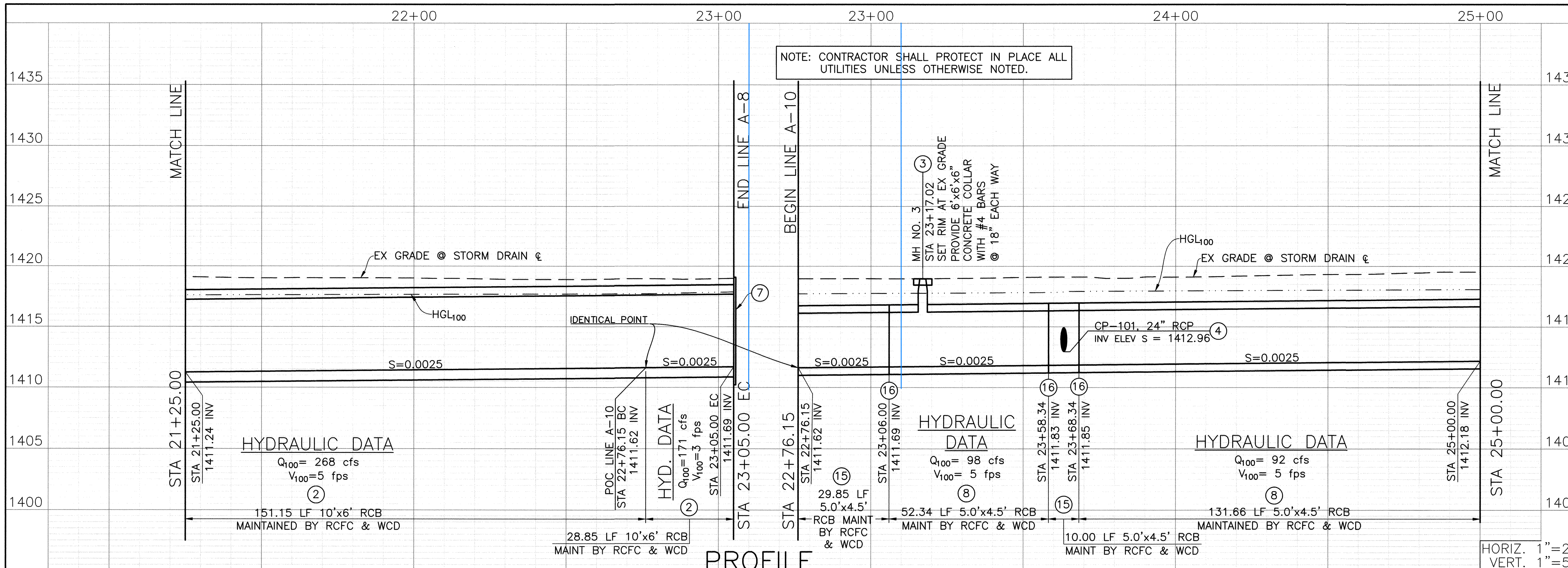
RECOMMENDED FOR APPROVAL BY: CHIEF, PLANNING — DATE: 10/27/2021
APPROVED BY: GENERAL MANAGER–CHIEF ENGINEER — DATE: 10/27/2021

ROMOLAND MDP LINE A–8
STAGE 2
ROMOLAND MDP LINE A–10
STAGE 1
TITLE SHEET

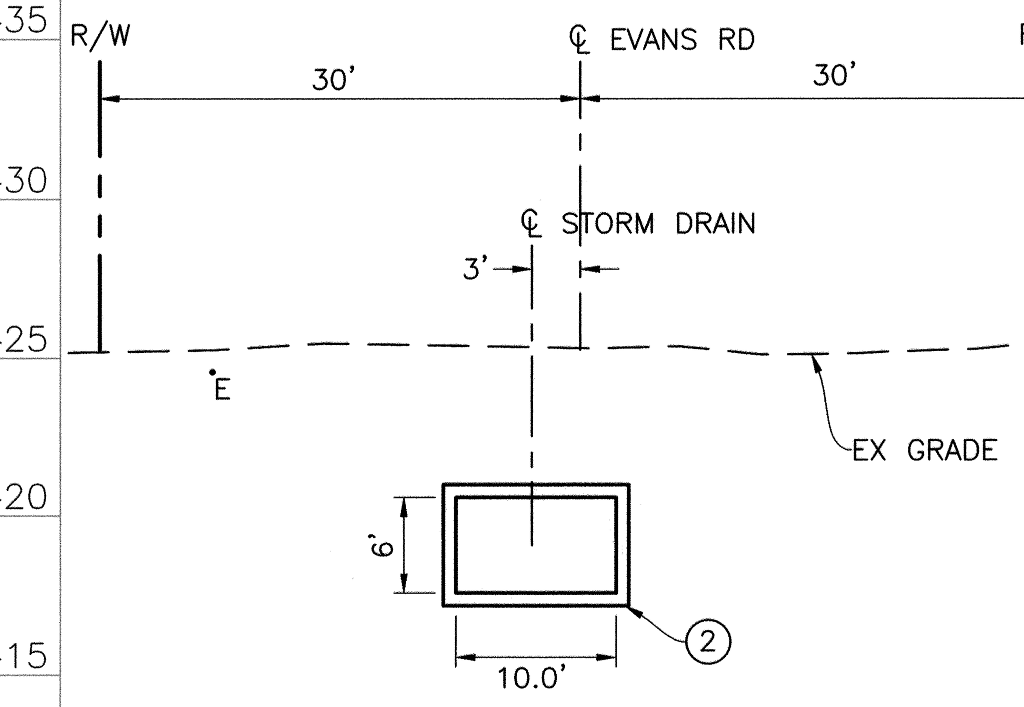
PROJECT NO. 4–0–00438–02 4–0–00197–01
DRAWING NO. 4–1168
SHEET NO. 1 OF 8

I:\75382 SAGEWOOD\DWG\Z–75382 SD–A8–A10.DWG 9/27/2021 7:20:55 PM

NOTE: CONTRACTOR SHALL PROTECT IN PLACE ALL UTILITIES UNLESS OTHERWISE NOTED.



PROFILE



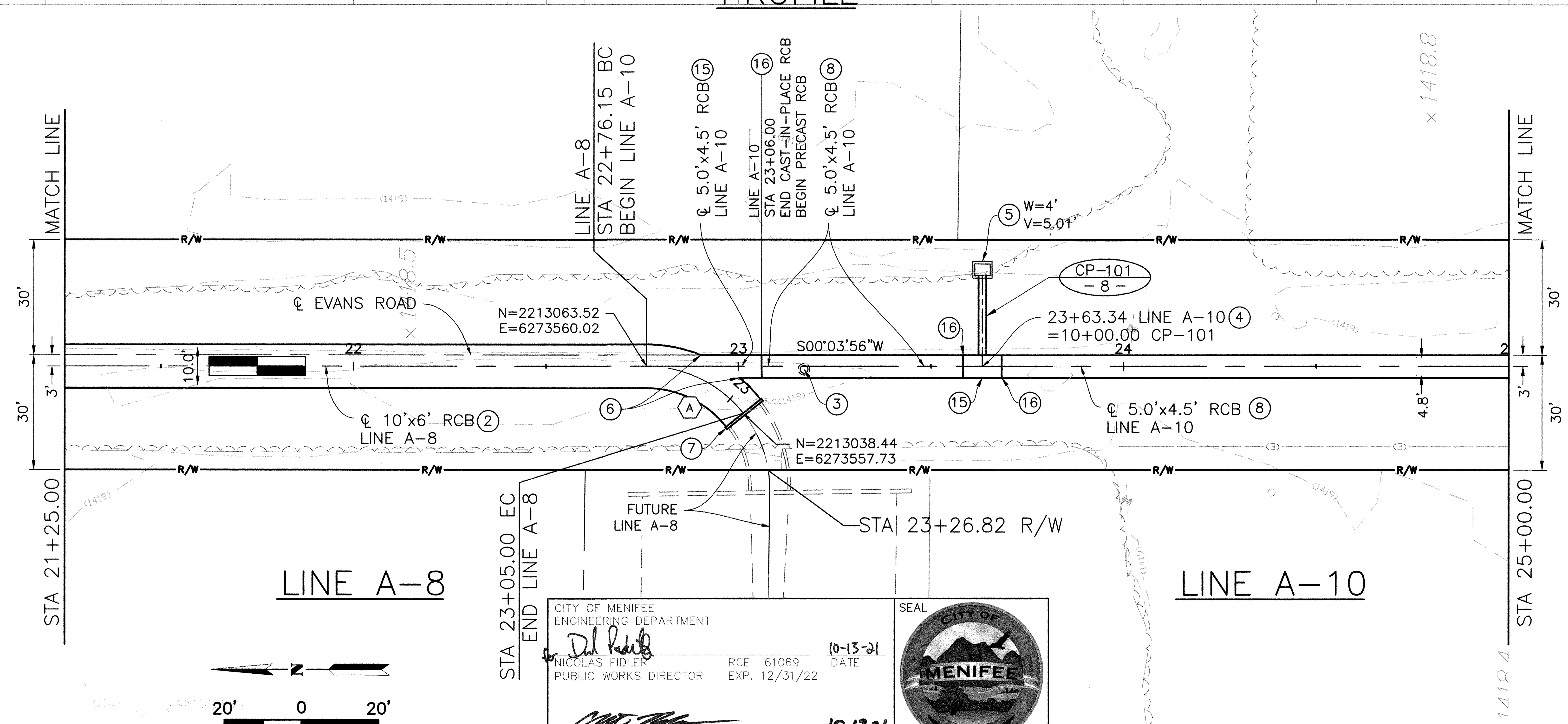
SECTION AT STA 21+75

TYPICAL FROM STA 21+25 TO STA 22+73.35

10' 0 10'

CURVE DATA		A
R		32.00'
∠		51°39'38"
L		28.85'
T		15.49'
B.C.		22+76.15
E.C.		23+05.00
P.I.	NORTHING	2213048.04
P.I.	EASTING	6273569.89

MANHOLE / JUNCTION STRUCTURE DATA					
LATERAL	℄ STATION	WALL STATION	STRUCTURE	A	C
–	23+17.02	–	MH NO. 3	–	–
CP-101	23+63.34	23+63.34	JS NO. 3	90°	–



NOTES

2. CONSTRUCT 10' WIDE X 6' HIGH RCB PER CALTRANS STD D80 S=10', H=6', MAX EARTH COVER=10', 'SLOPED' INVERT DOWN TO LEFT LOOKING DOWNSTREAM, AND PER RCFC & WCD STD M819.
3. CONSTRUCT MH NO. 3 PER STD MH253 AND PER PRECAST SUPPLEMENTAL REINFORCEMENT MANHOLE OPENING DETAIL ON SHEET 8.
4. CONSTRUCT JS NO. 3 PER STD JS228.
5. CONSTRUCT CONCRETE DROP INLET PER STD CB110 MODIFIED WITH FRONT AND BACK OPENINGS; W & V PER PLAN.
6. CONSTRUCT JS NO. 5 PER STD JS230, CASE AM10P10.
7. CONSTUCT CONCRETE BULKHEAD PER STD M816.
8. INSTALL 5' WIDE X 4.5' HIGH PRECAST RCB PER CALTRANS STD D83A S=5', H=4.5' (USE H=5' FOR REINFORCEMENT), MAX EARTH COVER=10', AND PER RCFC & WCD STD M819.
15. CONSTRUCT 5' WIDE X 4.5' HIGH CAST-IN-PLACE RCB PER CALTRANS STD D80 S=5', H=4.5' (USE H=5' FOR REINFORCEMENT), MAX EARTH COVER=10'.
16. CONNECT PRECAST RCB TO CAST-IN-PLACE RCB PER BUTT JOINT DETAIL ON SHEET 8; CAST-IN-PLACE HAUNCHES SHALL MATCH ADJACENT PRECAST RCB HAUNCHES.

CITY OF MENIFEE
ENGINEERING DEPARTMENT
NICOLAS FIDLER, PUBLIC WORKS DIRECTOR — RCE 61069, EXP. 12/31/22 — 10-13-21 DATE
RECOMMENDED BY: 10-13-21 DATE

SEAL: CITY OF MENIFEE

MDC

REGISTERED PROFESSIONAL ENGINEER — DANIEL J. O'ROURKE — No. 47677 — CIVIL — STATE OF CALIFORNIA

SB&O INC.
PLANNING ENGINEERING SURVEYING
41689 Enterprise Circle North, Suite 126
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951-695-8900

DANIEL J. O'ROURKE 9-28-21 DATE

DESIGNED BY:	BCK
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CONSTR. SET:	9/27/2021
CHECKED BY:	DJO
PB NUMBER:	238677

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1429.249' EL.

REVISIONS			
REF.	DESCRIPTION	APPR.	DATE

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
RECOMMENDED FOR APPROVAL BY: DATE: 10-27-2021
APPROVED BY: Edwin Quenang DATE: 10/27/2021

ROMOLAND MDP LINE A-8 STAGE 2
ROMOLAND MDP LINE A-10 STAGE 1
STA 21+25.00 – STA 25+00.00

PROJECT NO. 4-0-00438-02, 4-0-00197-01
DRAWING NO. 4-1168
SHEET NO. 5 OF 8

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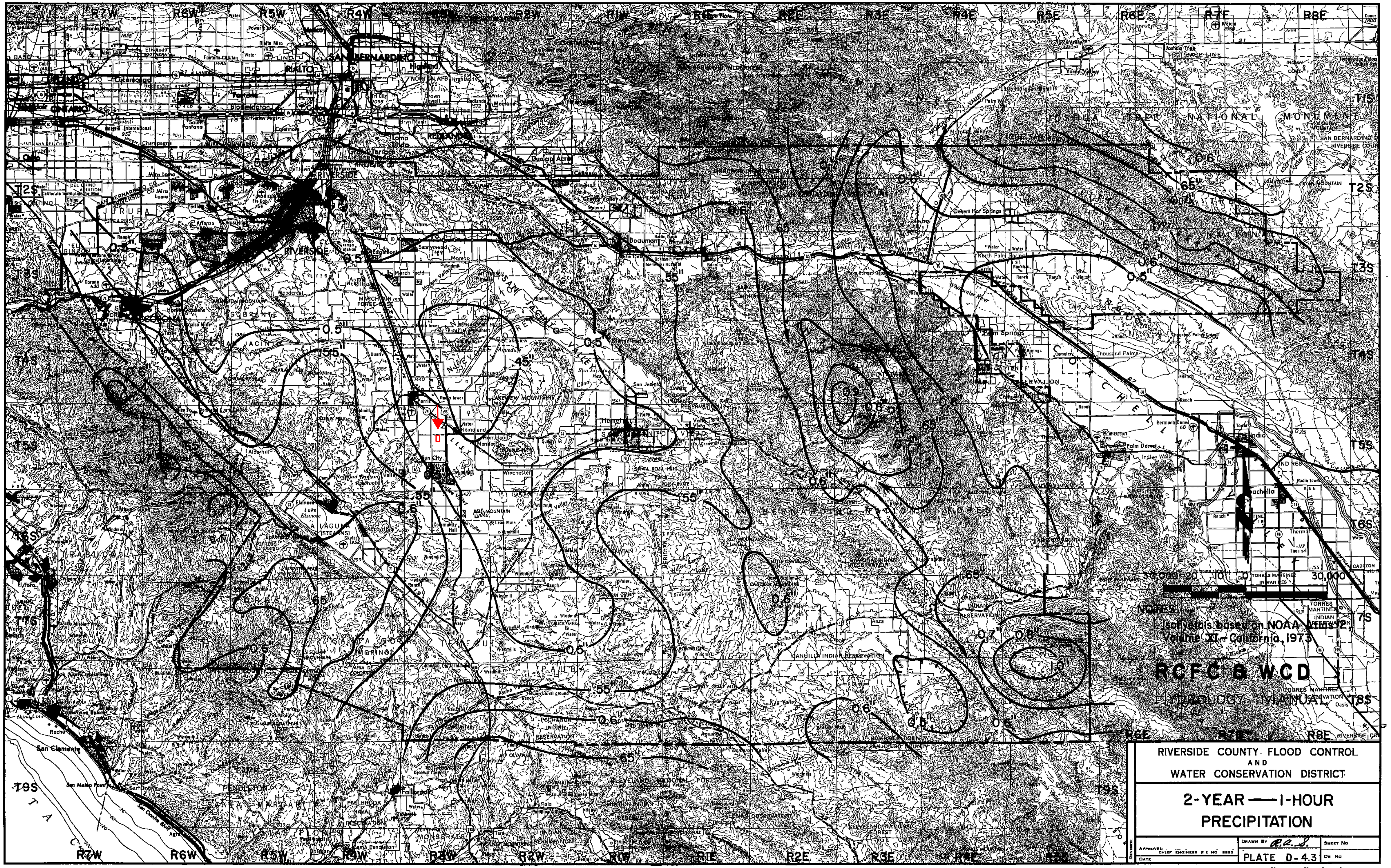
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
2-YEAR — 1-HOUR
PRECIPITATION
PLATE D-4.3
NOTES:
1. Isohyetals based on NOAA Atlas 2
Volume XI - California, 1973
RCFC & WCD
HYDROLOGY MANUAL
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO
RIVERSIDE
Palm Springs
Beaumont
Banning
Hemet
San Jacinto
Perris
Palm Desert
Indio
Coachella
San Clemente
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
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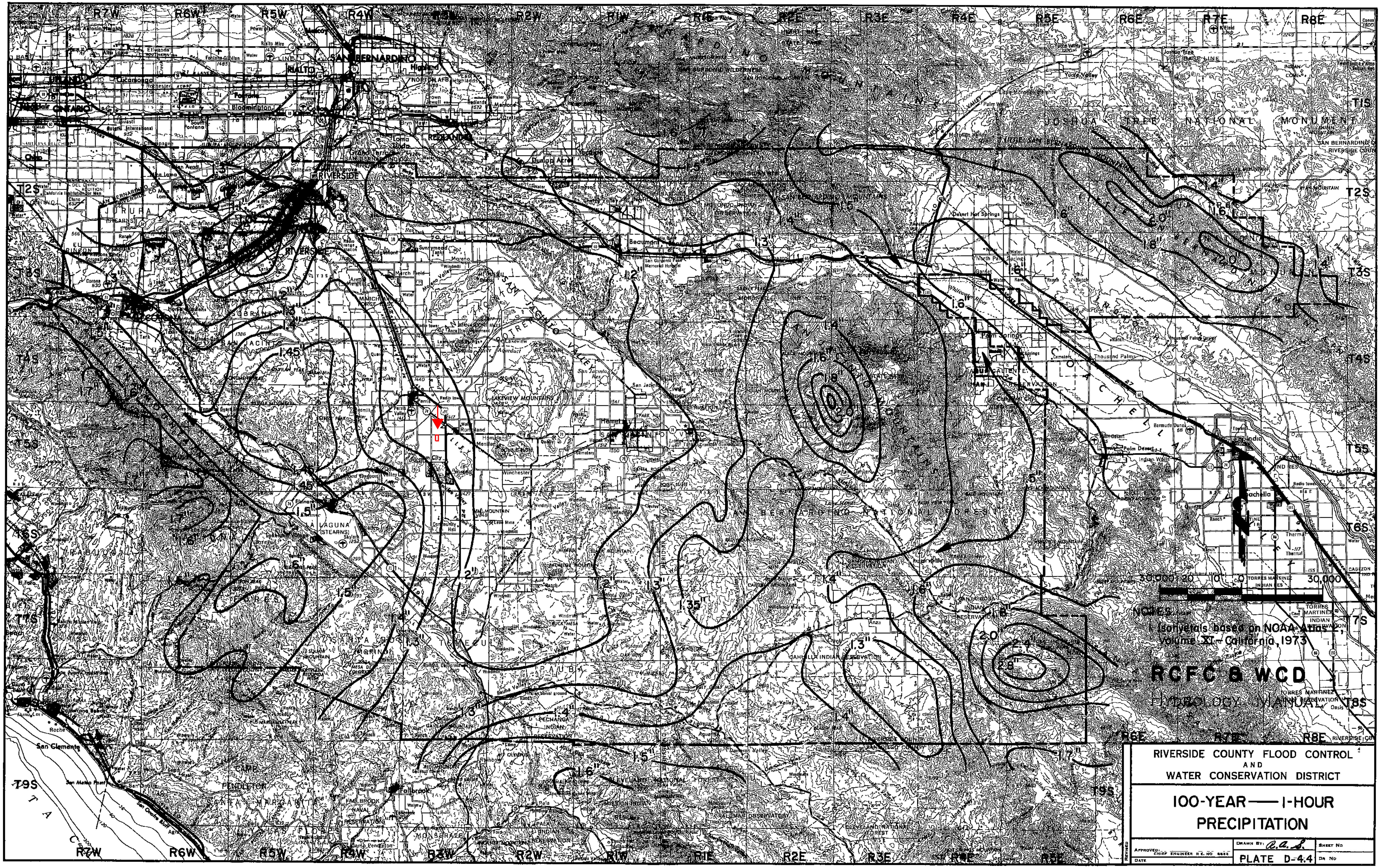
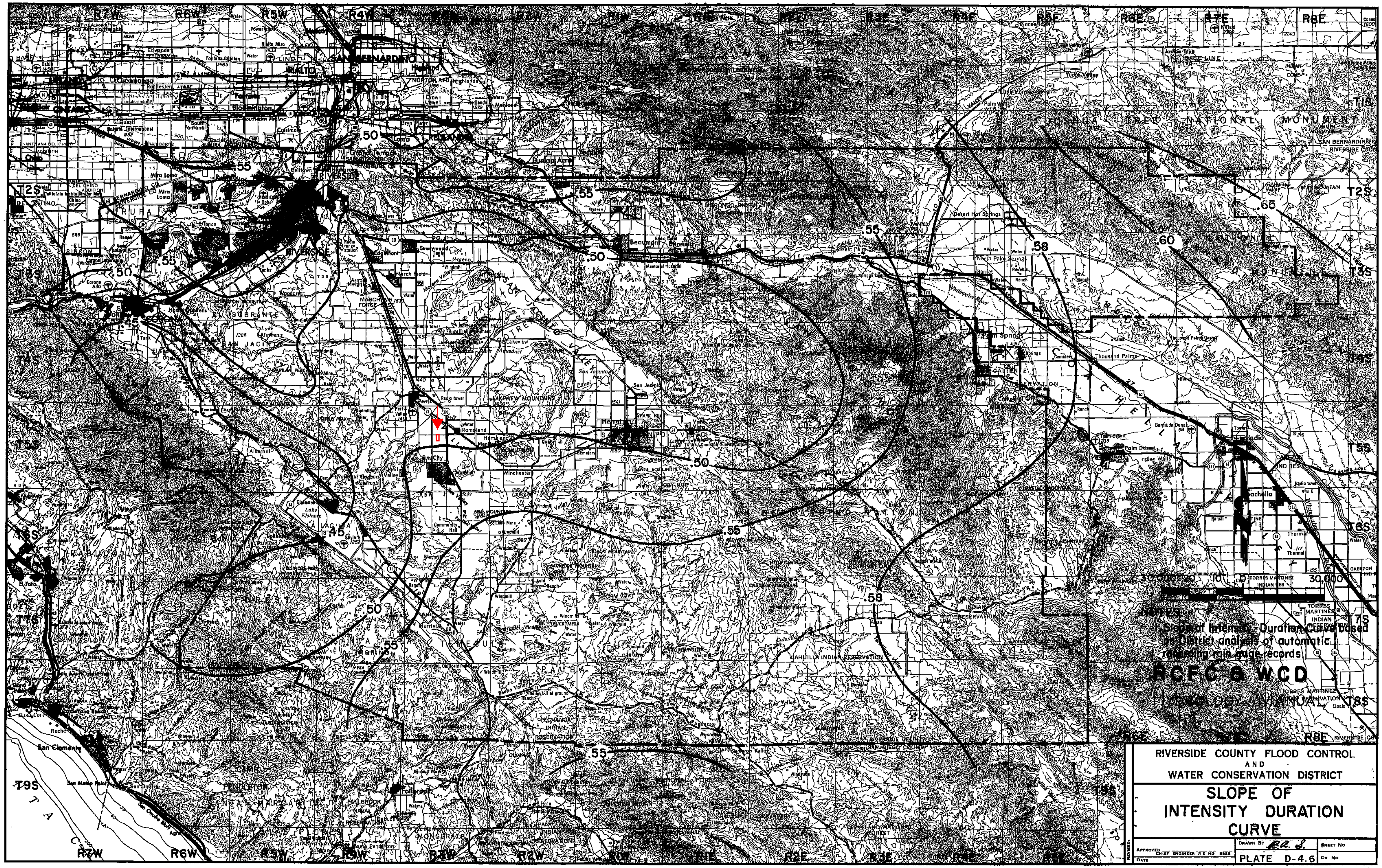
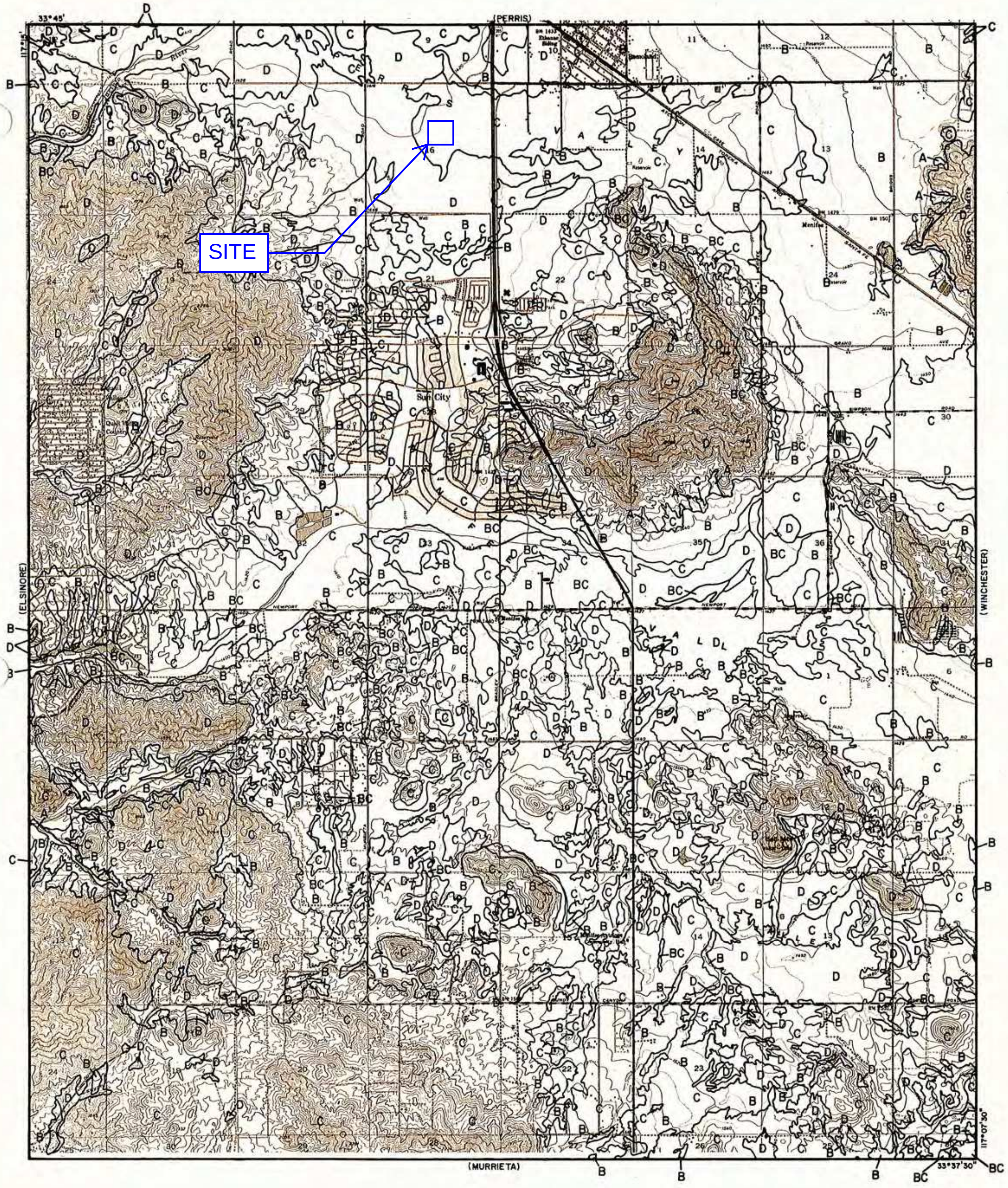


NOTES:
1. Isohyetals based on NOAA Atlas 2, Volume XI - California, 1973
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
100-YEAR —— 1-HOUR
PRECIPITATION
APPROVED:
CHIEF ENGINEER R.E. NO
DATE
REVISED
DRAWN BY: R.A.S.
SHEET NO
PLATE D-4.4
DR NO
SAN BERNARDINO
RIVERSIDE
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO NATIONAL FOREST
CLEVELAND NATIONAL FOREST
CAHUILLA INDIAN RESERVATION
PECHANGA INDIAN RESERVATION
San Clemente
Fallbrook
Beaumont
Hemet
Perris
Elsinore
Palm Springs
Coachella
Indio
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S


NOTES:
1. Slope of Intensity - Duration Curve based on District analysis of automatic recording rain gage records
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
SLOPE OF
INTENSITY DURATION
CURVE
APPROVED
CHIEF ENGINEER
DATE
REVISED:
DRAWN BY
PLATE D-4.6
SHEET NO
DR NO
.50
.55
.58
.60
.65
.45
RIVERSIDE
SAN BERNARDINO
JOSHUA TREE NATIONAL MONUMENT
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR ROMOLAND

PLATE C-1.42

APPENDIX B

HYDROLOGY CALCULATIONS

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
         RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                     (RCFC&WCD)  1978 HYDROLOGY MANUAL
          (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                     (Rational Tabling Version 23.0)
                  Release Date: 07/01/2016  License ID 1435

                           Analysis prepared by:

                         THIENES ENGINEERING, INC.
                            14349 FIRESTONE BLVD
                            LA MIRIADA, CA 90638
                                714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                      *
 * EXISTING CONDITIONS                                                      *
 * 10-YEAR STORM EVENT                                                      *
 **************************************************************************

  FILE NAME: W:\4118\X100-10.DAT
  TIME/DATE OF STUDY: 10:46 10/24/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =   10.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =   10.00   1-HOUR INTENSITY(INCH/HOUR) =   0.813
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN- / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
        ASSUMED INITIAL SUBAREA UNIFORM
        DEVELOPMENT IS: UNDEVELOPED WITH FAIR COVER
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   772.00
  UPSTREAM ELEVATION(FEET) =   1422.78
  DOWNSTREAM ELEVATION(FEET) =   1420.85
  ELEVATION DIFFERENCE(FEET) =      1.93
  TC = 0.709*[(  772.00**3)/(     1.93)]**.2 =   33.601
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.086
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .5801
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      3.37
  TOTAL AREA(ACRES) =      5.35   TOTAL RUNOFF(CFS) =      3.37
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        5.3  TC(MIN.) =     33.60
  PEAK FLOW RATE(CFS)   =       3.37
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                      (RCFC&WCD)  1978 HYDROLOGY MANUAL
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                      (Rational Tabling Version 23.0)
                   Release Date: 07/01/2016  License ID 1435

                            Analysis prepared by:

                          THIENES ENGINEERING, INC.
                             14349 FIRESTONE BLVD
                             LA MIRIADA, CA 90638
                                 714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
* TEI JOB NUMBER 4118                                                      *
* EXISTING CONDITION NODES 100-101                                         *
* 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: W:\4118\X100.DAT
  TIME/DATE OF STUDY: 08:15 01/12/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) =   1.270
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS: UNDEVELOPED WITH FAIR COVER
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   772.00
  UPSTREAM ELEVATION(FEET) =   1422.78
  DOWNSTREAM ELEVATION(FEET) =   1420.85
  ELEVATION DIFFERENCE(FEET) =      1.93
  TC = 0.709*[(  772.00**3)/(     1.93)]**.2 =   33.601
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.697
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .6652
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      6.04
  TOTAL AREA(ACRES) =      5.35   TOTAL RUNOFF(CFS) =      6.04
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        5.3  TC(MIN.) =     33.60
  PEAK FLOW RATE(CFS)   =       6.04
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                  (RCFC&WCD)  1978 HYDROLOGY MANUAL
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               Release Date: 07/01/2016  License ID 1435

                         Analysis prepared by:

                       THIENES ENGINEERING, INC.
                          14349 FIRESTONE BLVD
                          LA MIRIADA, CA 90638
                              714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
* TEI JOB NUMBER 4118                                                      *
* EXISTING CONDITIONS                                                      *
* 10-YEAR STORM EVENT                                                      *
 **************************************************************************

  FILE NAME: W:\4118\X200-10.DAT
  TIME/DATE OF STUDY: 10:47 10/24/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =   10.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =   10.00   1-HOUR INTENSITY(INCH/HOUR) =   0.813
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    200.00 TO NODE    201.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS: UNDEVELOPED WITH FAIR COVER
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   710.00
  UPSTREAM ELEVATION(FEET) =   1426.40
  DOWNSTREAM ELEVATION(FEET) =   1422.92
  ELEVATION DIFFERENCE(FEET) =      3.48
  TC = 0.709*[(  710.00**3)/(     3.48)]**.2 =   28.401
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.182
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .5973
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      5.01
  TOTAL AREA(ACRES) =      7.10   TOTAL RUNOFF(CFS) =      5.01

****************************************************************************
  FLOW PROCESS FROM NODE    201.00 TO NODE    202.00 IS CODE =  52
----------------------------------------------------------------------------
  >>>>>COMPUTE NATURAL VALLEY CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1422.92  DOWNSTREAM(FEET) =   1421.30
  CHANNEL LENGTH THRU SUBAREA(FEET) =   543.00   CHANNEL SLOPE =  0.0030
```

```
  CHANNEL FLOW THRU SUBAREA(CFS) =       5.01
  FLOW VELOCITY(FEET/SEC) =   1.15 (PER LACFCD/RCFC&WCD HYDROLOGY MANUAL)
  TRAVEL TIME(MIN.) =   7.85   Tc(MIN.) =   36.25
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    202.00 =    1253.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    202.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.046
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .5723
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    7.72   SUBAREA RUNOFF(CFS) =    4.62
  TOTAL AREA(ACRES) =       14.8   TOTAL RUNOFF(CFS) =       9.63
  TC(MIN.) =   36.25
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       14.8  TC(MIN.) =     36.25
  PEAK FLOW RATE(CFS)   =       9.63
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                  (RCFC&WCD)  1978 HYDROLOGY MANUAL
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               Release Date: 07/01/2016  License ID 1435

                          Analysis prepared by:

                        THIENES ENGINEERING, INC.
                           14349 FIRESTONE BLVD
                           LA MIRIADA, CA 90638
                               714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                      *
 * EXISTING CONDITION NODES 200-202                                         *
 * 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: W:\4118\X200.DAT
  TIME/DATE OF STUDY: 08:17 01/12/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) =   1.270
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    200.00 TO NODE    201.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS: UNDEVELOPED WITH FAIR COVER
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   710.00
  UPSTREAM ELEVATION(FEET) =   1426.40
  DOWNSTREAM ELEVATION(FEET) =   1422.92
  ELEVATION DIFFERENCE(FEET) =      3.48
  TC = 0.709*[(  710.00**3)/(     3.48)]**.2 =   28.401
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.846
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .6795
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      8.91
  TOTAL AREA(ACRES) =      7.10   TOTAL RUNOFF(CFS) =      8.91

****************************************************************************
  FLOW PROCESS FROM NODE    201.00 TO NODE    202.00 IS CODE =  52
----------------------------------------------------------------------------
  >>>>>COMPUTE NATURAL VALLEY CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1422.92  DOWNSTREAM(FEET) =   1421.30
  CHANNEL LENGTH THRU SUBAREA(FEET) =   543.00   CHANNEL SLOPE =  0.0030
```

```
  CHANNEL FLOW THRU SUBAREA(CFS) =       8.91
  FLOW VELOCITY(FEET/SEC) =   1.33 (PER LACFCD/RCFC&WCD HYDROLOGY MANUAL)
  TRAVEL TIME(MIN.) =   6.83   Tc(MIN.) =   35.23
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    202.00 =    1253.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    202.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.657
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .6611
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    7.72   SUBAREA RUNOFF(CFS) =    8.46
  TOTAL AREA(ACRES) =       14.8   TOTAL RUNOFF(CFS) =      17.36
  TC(MIN.) =   35.23
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       14.8  TC(MIN.) =     35.23
  PEAK FLOW RATE(CFS)   =      17.36
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                      (RCFC&WCD)  1978 HYDROLOGY MANUAL
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                   Release Date: 07/01/2016  License ID 1435

                           Analysis prepared by:

                         THIENES ENGINEERING, INC.
                            14349 FIRESTONE BLVD
                            LA MIRIADA, CA 90638
                                714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                      *
 * PROPOSED CONDITIONS                                                      *
 * 10-YEAR STORM EVENT                                                      *
 **************************************************************************

  FILE NAME: W:\4118\P100-10.DAT
  TIME/DATE OF STUDY: 10:55 10/24/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =   10.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =   10.00   1-HOUR INTENSITY(INCH/HOUR) =   0.813
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
        ASSUMED INITIAL SUBAREA UNIFORM
        DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   160.00
  UPSTREAM ELEVATION(FEET) =   1422.79
  DOWNSTREAM ELEVATION(FEET) =   1420.76
  ELEVATION DIFFERENCE(FEET) =      2.03
  TC = 0.303*[(  160.00**3)/(     2.03)]**.2 =    5.528
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.679
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8836
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      2.15
  TOTAL AREA(ACRES) =      0.91   TOTAL RUNOFF(CFS) =      2.15

****************************************************************************
  FLOW PROCESS FROM NODE    101.00 TO NODE    102.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.76  DOWNSTREAM(FEET) =  1416.51
  FLOW LENGTH(FEET) =   214.00   MANNING'S N =  0.012
```

```
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   7.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.02
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       2.15
  PIPE TRAVEL TIME(MIN.) =   0.89    Tc(MIN.) =    6.42
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    102.00 =     374.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    102.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.486
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8825
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.75   SUBAREA RUNOFF(CFS) =    1.65
  TOTAL AREA(ACRES) =        1.7   TOTAL RUNOFF(CFS) =       3.80
  TC(MIN.) =    6.42

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    103.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.51  DOWNSTREAM(FEET) =  1414.83
  FLOW LENGTH(FEET) =   316.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  15.0 INCH PIPE IS   9.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.47
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.80
  PIPE TRAVEL TIME(MIN.) =   1.18    Tc(MIN.) =    7.59
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    103.00 =     690.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    103.00 TO NODE    103.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.285
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8813
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.37   SUBAREA RUNOFF(CFS) =    0.75
  TOTAL AREA(ACRES) =        2.0   TOTAL RUNOFF(CFS) =       4.54
  TC(MIN.) =    7.59

****************************************************************************
  FLOW PROCESS FROM NODE    103.00 TO NODE    114.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1414.83  DOWNSTREAM(FEET) =  1413.90
  FLOW LENGTH(FEET) =   141.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  15.0 INCH PIPE IS  10.3 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.04
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.54
  PIPE TRAVEL TIME(MIN.) =   0.47    Tc(MIN.) =    8.06
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    114.00 =     831.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    114.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =    8.06
  RAINFALL INTENSITY(INCH/HR) =   2.22
  TOTAL STREAM AREA(ACRES) =     2.03
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      4.54

****************************************************************************
  FLOW PROCESS FROM NODE    110.00 TO NODE    111.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
```

```
       DEVELOPMENT IS COMMERCIAL
 TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   217.00
 UPSTREAM ELEVATION(FEET) =   1422.06
 DOWNSTREAM ELEVATION(FEET) =   1418.97
 ELEVATION DIFFERENCE(FEET) =      3.09
 TC = 0.303*[(  217.00**3)/(     3.09)]**.2 =    6.102
   10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.550
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8829
 SOIL CLASSIFICATION IS "C"
 SUBAREA RUNOFF(CFS) =      3.29
 TOTAL AREA(ACRES) =      1.46   TOTAL RUNOFF(CFS) =      3.29

****************************************************************************
 FLOW PROCESS FROM NODE    111.00 TO NODE    112.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1415.97  DOWNSTREAM(FEET) =  1415.31
 FLOW LENGTH(FEET) =    75.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  12.0 INCH PIPE IS   9.2 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   5.10
 ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       3.29
 PIPE TRAVEL TIME(MIN.) =   0.24    Tc(MIN.) =    6.35
 LONGEST FLOWPATH FROM NODE    110.00 TO NODE    112.00 =     292.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    112.00 TO NODE    112.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.500
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8826
 SOIL CLASSIFICATION IS "C"
 SUBAREA AREA(ACRES) =    0.68   SUBAREA RUNOFF(CFS) =    1.50
 TOTAL AREA(ACRES) =        2.1   TOTAL RUNOFF(CFS) =       4.79
 TC(MIN.) =    6.35

****************************************************************************
 FLOW PROCESS FROM NODE    112.00 TO NODE    113.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1415.31  DOWNSTREAM(FEET) =  1414.59
 FLOW LENGTH(FEET) =   127.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  15.0 INCH PIPE IS  11.5 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   4.76
 ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       4.79
 PIPE TRAVEL TIME(MIN.) =   0.44    Tc(MIN.) =    6.79
 LONGEST FLOWPATH FROM NODE    110.00 TO NODE    113.00 =     419.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    113.00 TO NODE    113.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.417
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8821
 SOIL CLASSIFICATION IS "C"
 SUBAREA AREA(ACRES) =    0.93   SUBAREA RUNOFF(CFS) =    1.98
 TOTAL AREA(ACRES) =        3.1   TOTAL RUNOFF(CFS) =       6.77
 TC(MIN.) =    6.79

****************************************************************************
 FLOW PROCESS FROM NODE    113.00 TO NODE    114.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1414.59  DOWNSTREAM(FEET) =  1413.90
 FLOW LENGTH(FEET) =    95.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  18.0 INCH PIPE IS  11.3 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   5.82
 ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       6.77
```

```
  PIPE TRAVEL TIME(MIN.) =   0.27    Tc(MIN.) =    7.06
  LONGEST FLOWPATH FROM NODE    110.00 TO NODE    114.00 =     514.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    114.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =    7.06
  RAINFALL INTENSITY(INCH/HR) =   2.37
  TOTAL STREAM AREA(ACRES) =     3.07
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      6.77

  ** CONFLUENCE DATA **
  STREAM     RUNOFF       Tc      INTENSITY      AREA
  NUMBER      (CFS)     (MIN.)   (INCH/HOUR)    (ACRE)
     1        4.54     8.06        2.218         2.03
     2        6.77     7.06        2.370         3.07

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
  STREAM     RUNOFF      Tc      INTENSITY
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)
     1       10.75     7.06       2.370
     2       10.88     8.06       2.218

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      10.88   Tc(MIN.) =    8.06
  TOTAL AREA(ACRES) =        5.1
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    114.00 =     831.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    126.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1413.90  DOWNSTREAM(FEET) =  1411.50
  FLOW LENGTH(FEET) =   195.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  13.2 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   7.86
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      10.88
  PIPE TRAVEL TIME(MIN.) =   0.41    Tc(MIN.) =    8.47
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    126.00 =    1026.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    126.00 TO NODE    126.00 IS CODE =  10
----------------------------------------------------------------------------
  >>>>>MAIN-STREAM MEMORY COPIED ONTO MEMORY BANK # 1 <<<<<
============================================================================

****************************************************************************
  FLOW PROCESS FROM NODE    120.00 TO NODE    121.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   210.00
  UPSTREAM ELEVATION(FEET) =   1422.24
  DOWNSTREAM ELEVATION(FEET) =   1419.66
  ELEVATION DIFFERENCE(FEET) =      2.58
  TC = 0.303*[(  210.00**3)/(     2.58)]**.2 =    6.203
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.529
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8828
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      4.13
  TOTAL AREA(ACRES) =      1.85   TOTAL RUNOFF(CFS) =      4.13

****************************************************************************
  FLOW PROCESS FROM NODE    121.00 TO NODE    122.00 IS CODE =  31
----------------------------------------------------------------------------
```

```
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.66  DOWNSTREAM(FEET) =  1416.11
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  10.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.73
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.13
  PIPE TRAVEL TIME(MIN.) =   0.80    Tc(MIN.) =    7.00
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    122.00 =     389.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    122.00 TO NODE    122.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.380
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8819
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.27   SUBAREA RUNOFF(CFS) =    2.67
  TOTAL AREA(ACRES) =        3.1   TOTAL RUNOFF(CFS) =       6.80
  TC(MIN.) =    7.00

****************************************************************************
  FLOW PROCESS FROM NODE    122.00 TO NODE    123.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.11  DOWNSTREAM(FEET) =  1415.56
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  13.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.21
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       6.80
  PIPE TRAVEL TIME(MIN.) =   0.71    Tc(MIN.) =    7.71
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    123.00 =     568.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    123.00 TO NODE    123.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.268
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8812
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.00   SUBAREA RUNOFF(CFS) =    2.00
  TOTAL AREA(ACRES) =        4.1   TOTAL RUNOFF(CFS) =       8.79
  TC(MIN.) =    7.71

****************************************************************************
  FLOW PROCESS FROM NODE    123.00 TO NODE    124.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.56  DOWNSTREAM(FEET) =  1415.00
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  16.2 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.42
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       8.79
  PIPE TRAVEL TIME(MIN.) =   0.67    Tc(MIN.) =    8.38
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    124.00 =     747.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    124.00 TO NODE    124.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.175
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8806
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.00   SUBAREA RUNOFF(CFS) =    1.92
  TOTAL AREA(ACRES) =        5.1   TOTAL RUNOFF(CFS) =      10.71
  TC(MIN.) =    8.38

****************************************************************************
```

```
  FLOW PROCESS FROM NODE    124.00 TO NODE    124.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.175
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8806
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    2.78   SUBAREA RUNOFF(CFS) =    5.32
  TOTAL AREA(ACRES) =        7.9   TOTAL RUNOFF(CFS) =      16.03
  TC(MIN.) =    8.38

****************************************************************************
  FLOW PROCESS FROM NODE    124.00 TO NODE    125.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.00  DOWNSTREAM(FEET) =  1411.52
  FLOW LENGTH(FEET) =    89.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  11.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  13.55
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      16.03
  PIPE TRAVEL TIME(MIN.) =   0.11    Tc(MIN.) =    8.49
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    125.00 =     836.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    125.00 TO NODE    126.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1411.52  DOWNSTREAM(FEET) =  1411.50
  FLOW LENGTH(FEET) =     7.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  27.0 INCH PIPE IS  22.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.63
  ESTIMATED PIPE DIAMETER(INCH) =  27.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      16.03
  PIPE TRAVEL TIME(MIN.) =   0.03    Tc(MIN.) =    8.52
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    126.00 =     843.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    126.00 TO NODE    126.00 IS CODE =  11
----------------------------------------------------------------------------
  >>>>>CONFLUENCE MEMORY BANK # 1 WITH THE MAIN-STREAM MEMORY<<<<<
============================================================================

  ** MAIN STREAM CONFLUENCE DATA **
  STREAM     RUNOFF      Tc      INTENSITY     AREA
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)   (ACRE)
     1       16.03     8.52       2.158        7.90
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    126.00 =     843.00 FEET.

  ** MEMORY BANK #  1 CONFLUENCE DATA **
  STREAM     RUNOFF      Tc      INTENSITY     AREA
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)   (ACRE)
     1       10.75     7.48       2.303        5.10
     2       10.88     8.47       2.163        5.10
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    126.00 =    1026.00 FEET.

  ** PEAK FLOW RATE TABLE **
  STREAM    RUNOFF       Tc      INTENSITY
  NUMBER     (CFS)     (MIN.)   (INCH/HOUR)
     1      24.82       7.48        2.303
     2      26.83       8.47        2.163
     3      26.89       8.52        2.158

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      26.89   Tc(MIN.) =    8.52
  TOTAL AREA(ACRES) =       13.0
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       13.0  TC(MIN.) =      8.52
  PEAK FLOW RATE(CFS)   =      26.89
  *** PEAK FLOW RATE TABLE ***
         Q(CFS)   Tc(MIN.)
  1       24.82       7.48
  2       26.83       8.47
  3       26.89       8.52
```

```
==============================================================================
==============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                      (RCFC&WCD)  1978 HYDROLOGY MANUAL
         (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                      (Rational Tabling Version 23.0)
                   Release Date: 07/01/2016  License ID 1435

                           Analysis prepared by:

                         THIENES ENGINEERING, INC.
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                            LA MIRIADA, CA 90638
                                714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                     *
 * PROPOSED CONDITIONS                                                     *
 * 100-YEAR STORM EVENT                                                    *
 **************************************************************************

  FILE NAME: W:\4118\P100.DAT
  TIME/DATE OF STUDY: 08:51 07/28/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) =   1.270
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   160.00
  UPSTREAM ELEVATION(FEET) =   1422.79
  DOWNSTREAM ELEVATION(FEET) =   1420.76
  ELEVATION DIFFERENCE(FEET) =      2.03
  TC = 0.303*[(  160.00**3)/(     2.03)]**.2 =    5.528
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  4.184
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8887
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      3.38
  TOTAL AREA(ACRES) =      0.91   TOTAL RUNOFF(CFS) =      3.38

****************************************************************************
  FLOW PROCESS FROM NODE    101.00 TO NODE    102.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.76  DOWNSTREAM(FEET) =  1416.51
  FLOW LENGTH(FEET) =   214.00   MANNING'S N =  0.012
```

```
  DEPTH OF FLOW IN  15.0 INCH PIPE IS   8.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.52
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.38
  PIPE TRAVEL TIME(MIN.) =   0.79    Tc(MIN.) =    6.32
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    102.00 =     374.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    102.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.914
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8881
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.75   SUBAREA RUNOFF(CFS) =    2.61
  TOTAL AREA(ACRES) =        1.7   TOTAL RUNOFF(CFS) =       5.99
  TC(MIN.) =    6.32

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    103.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.51  DOWNSTREAM(FEET) =  1414.83
  FLOW LENGTH(FEET) =   316.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  11.5 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.01
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       5.99
  PIPE TRAVEL TIME(MIN.) =   1.05    Tc(MIN.) =    7.37
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    103.00 =     690.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    103.00 TO NODE    103.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.624
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8872
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.37   SUBAREA RUNOFF(CFS) =    1.19
  TOTAL AREA(ACRES) =        2.0   TOTAL RUNOFF(CFS) =       7.18
  TC(MIN.) =    7.37

****************************************************************************
  FLOW PROCESS FROM NODE    103.00 TO NODE    114.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1414.83  DOWNSTREAM(FEET) =  1413.90
  FLOW LENGTH(FEET) =   141.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  12.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.66
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       7.18
  PIPE TRAVEL TIME(MIN.) =   0.42    Tc(MIN.) =    7.78
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    114.00 =     831.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    114.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =    7.78
  RAINFALL INTENSITY(INCH/HR) =   3.53
  TOTAL STREAM AREA(ACRES) =     2.03
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      7.18

****************************************************************************
  FLOW PROCESS FROM NODE    110.00 TO NODE    111.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
```

```
       DEVELOPMENT IS COMMERCIAL
 TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   217.00
 UPSTREAM ELEVATION(FEET) =   1422.06
 DOWNSTREAM ELEVATION(FEET) =   1418.97
 ELEVATION DIFFERENCE(FEET) =      3.09
 TC = 0.303*[(  217.00**3)/(     3.09)]**.2 =    6.102
  100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.982
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8882
 SOIL CLASSIFICATION IS "C"
 SUBAREA RUNOFF(CFS) =      5.16
 TOTAL AREA(ACRES) =      1.46   TOTAL RUNOFF(CFS) =      5.16

****************************************************************************
 FLOW PROCESS FROM NODE    111.00 TO NODE    112.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1415.97  DOWNSTREAM(FEET) =  1415.31
 FLOW LENGTH(FEET) =    75.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  15.0 INCH PIPE IS  10.2 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   5.80
 ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       5.16
 PIPE TRAVEL TIME(MIN.) =   0.22    Tc(MIN.) =    6.32
 LONGEST FLOWPATH FROM NODE    110.00 TO NODE    112.00 =     292.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    112.00 TO NODE    112.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.914
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8881
 SOIL CLASSIFICATION IS "C"
 SUBAREA AREA(ACRES) =    0.68   SUBAREA RUNOFF(CFS) =    2.36
 TOTAL AREA(ACRES) =        2.1   TOTAL RUNOFF(CFS) =       7.53
 TC(MIN.) =    6.32

****************************************************************************
 FLOW PROCESS FROM NODE    112.00 TO NODE    113.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1415.31  DOWNSTREAM(FEET) =  1414.59
 FLOW LENGTH(FEET) =   127.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  18.0 INCH PIPE IS  13.4 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   5.35
 ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       7.53
 PIPE TRAVEL TIME(MIN.) =   0.40    Tc(MIN.) =    6.71
 LONGEST FLOWPATH FROM NODE    110.00 TO NODE    113.00 =     419.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    113.00 TO NODE    113.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.797
 COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8877
 SOIL CLASSIFICATION IS "C"
 SUBAREA AREA(ACRES) =    0.93   SUBAREA RUNOFF(CFS) =    3.13
 TOTAL AREA(ACRES) =        3.1   TOTAL RUNOFF(CFS) =      10.66
 TC(MIN.) =    6.71

****************************************************************************
 FLOW PROCESS FROM NODE    113.00 TO NODE    114.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1414.59  DOWNSTREAM(FEET) =  1413.90
 FLOW LENGTH(FEET) =    95.00   MANNING'S N =  0.012
 DEPTH OF FLOW IN  21.0 INCH PIPE IS  13.5 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   6.50
 ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =      10.66
```

```
  PIPE TRAVEL TIME(MIN.) =   0.24    Tc(MIN.) =    6.96
  LONGEST FLOWPATH FROM NODE    110.00 TO NODE    114.00 =     514.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    114.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =    6.96
  RAINFALL INTENSITY(INCH/HR) =   3.73
  TOTAL STREAM AREA(ACRES) =     3.07
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     10.66

  ** CONFLUENCE DATA **
  STREAM     RUNOFF       Tc      INTENSITY      AREA
  NUMBER      (CFS)     (MIN.)   (INCH/HOUR)    (ACRE)
     1        7.18     7.78        3.526         2.03
     2       10.66     6.96        3.730         3.07

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
  STREAM     RUNOFF      Tc      INTENSITY
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)
     1       17.08     6.96       3.730
     2       17.26     7.78       3.526

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      17.26   Tc(MIN.) =    7.78
  TOTAL AREA(ACRES) =        5.1
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    114.00 =     831.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    114.00 TO NODE    126.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1413.90  DOWNSTREAM(FEET) =  1411.50
  FLOW LENGTH(FEET) =   195.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  16.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   8.76
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      17.26
  PIPE TRAVEL TIME(MIN.) =   0.37    Tc(MIN.) =    8.15
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    126.00 =    1026.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    126.00 TO NODE    126.00 IS CODE =  10
----------------------------------------------------------------------------
  >>>>>MAIN-STREAM MEMORY COPIED ONTO MEMORY BANK # 1 <<<<<
============================================================================

****************************************************************************
  FLOW PROCESS FROM NODE    120.00 TO NODE    121.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   210.00
  UPSTREAM ELEVATION(FEET) =   1422.24
  DOWNSTREAM ELEVATION(FEET) =   1419.66
  ELEVATION DIFFERENCE(FEET) =      2.58
  TC = 0.303*[(  210.00**3)/(     2.58)]**.2 =    6.203
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.950
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8881
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      6.49
  TOTAL AREA(ACRES) =      1.85   TOTAL RUNOFF(CFS) =      6.49

****************************************************************************
  FLOW PROCESS FROM NODE    121.00 TO NODE    122.00 IS CODE =  31
----------------------------------------------------------------------------
```

```
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.66  DOWNSTREAM(FEET) =  1416.11
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  12.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.17
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       6.49
  PIPE TRAVEL TIME(MIN.) =   0.72    Tc(MIN.) =    6.92
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    122.00 =     389.00 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE    122.00 TO NODE    122.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.740
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8876
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.27   SUBAREA RUNOFF(CFS) =    4.22
  TOTAL AREA(ACRES) =        3.1   TOTAL RUNOFF(CFS) =      10.71
  TC(MIN.) =    6.92

******************************************************************************
  FLOW PROCESS FROM NODE    122.00 TO NODE    123.00 IS CODE =  31
------------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.11  DOWNSTREAM(FEET) =  1415.56
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  24.0 INCH PIPE IS  16.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.69
  ESTIMATED PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      10.71
  PIPE TRAVEL TIME(MIN.) =   0.64    Tc(MIN.) =    7.55
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    123.00 =     568.00 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE    123.00 TO NODE    123.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.579
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8871
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.00   SUBAREA RUNOFF(CFS) =    3.18
  TOTAL AREA(ACRES) =        4.1   TOTAL RUNOFF(CFS) =      13.88
  TC(MIN.) =    7.55

******************************************************************************
  FLOW PROCESS FROM NODE    123.00 TO NODE    124.00 IS CODE =  31
------------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.56  DOWNSTREAM(FEET) =  1415.00
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  27.0 INCH PIPE IS  17.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.06
  ESTIMATED PIPE DIAMETER(INCH) =  27.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      13.88
  PIPE TRAVEL TIME(MIN.) =   0.59    Tc(MIN.) =    8.14
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    124.00 =     747.00 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE    124.00 TO NODE    124.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.447
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8867
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    1.00   SUBAREA RUNOFF(CFS) =    3.06
  TOTAL AREA(ACRES) =        5.1   TOTAL RUNOFF(CFS) =      16.94
  TC(MIN.) =    8.14

******************************************************************************
```

```
  FLOW PROCESS FROM NODE    124.00 TO NODE    124.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.447
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8867
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    2.78   SUBAREA RUNOFF(CFS) =    8.50
  TOTAL AREA(ACRES) =        7.9   TOTAL RUNOFF(CFS) =      25.44
  TC(MIN.) =    8.14

****************************************************************************
  FLOW PROCESS FROM NODE    124.00 TO NODE    125.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.00  DOWNSTREAM(FEET) =  1411.52
  FLOW LENGTH(FEET) =    89.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  13.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  15.17
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      25.44
  PIPE TRAVEL TIME(MIN.) =   0.10    Tc(MIN.) =    8.24
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    125.00 =     836.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    125.00 TO NODE    126.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1411.52  DOWNSTREAM(FEET) =  1411.50
  FLOW LENGTH(FEET) =     7.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  33.0 INCH PIPE IS  25.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.27
  ESTIMATED PIPE DIAMETER(INCH) =  33.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      25.44
  PIPE TRAVEL TIME(MIN.) =   0.02    Tc(MIN.) =    8.26
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    126.00 =     843.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    126.00 TO NODE    126.00 IS CODE =  11
----------------------------------------------------------------------------
  >>>>>CONFLUENCE MEMORY BANK # 1 WITH THE MAIN-STREAM MEMORY<<<<<
============================================================================

  ** MAIN STREAM CONFLUENCE DATA **
  STREAM     RUNOFF      Tc      INTENSITY     AREA
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)   (ACRE)
      1       25.44     8.26       3.422        7.90
  LONGEST FLOWPATH FROM NODE    120.00 TO NODE    126.00 =     843.00 FEET.

  ** MEMORY BANK #  1 CONFLUENCE DATA **
  STREAM     RUNOFF      Tc      INTENSITY     AREA
  NUMBER      (CFS)    (MIN.)   (INCH/HOUR)   (ACRE)
      1       17.08     7.33       3.634        5.10
      2       17.26     8.15       3.445        5.10
  LONGEST FLOWPATH FROM NODE    100.00 TO NODE    126.00 =    1026.00 FEET.

  ** PEAK FLOW RATE TABLE **
  STREAM    RUNOFF       Tc      INTENSITY
  NUMBER     (CFS)     (MIN.)   (INCH/HOUR)
      1      39.64       7.33        3.634
      2      42.36       8.15        3.445
      3      42.58       8.26        3.422

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      42.58   Tc(MIN.) =    8.26
  TOTAL AREA(ACRES) =       13.0
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       13.0  TC(MIN.) =      8.26
  PEAK FLOW RATE(CFS)   =      42.58
  *** PEAK FLOW RATE TABLE ***
         Q(CFS)   Tc(MIN.)
  1       39.64       7.33
  2       42.36       8.15
  3       42.58       8.26
```

==
==
END OF RATIONAL METHOD ANALYSIS

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                  (RCFC&WCD)  1978 HYDROLOGY MANUAL
         (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                  (Rational Tabling Version 23.0)
               Release Date: 07/01/2016  License ID 1435

                          Analysis prepared by:

                        THIENES ENGINEERING, INC.
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 ************************** DESCRIPTION OF STUDY **************************
* TEI JOB NUMBER 4118                                                      *
* PROPOSED CONDITIONS                                                      *
* 10-YEAR STORM EVENT                                                      *
 **************************************************************************

  FILE NAME: W:4118\P200-10.DAT
  TIME/DATE OF STUDY: 10:56 10/24/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =   10.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =   10.00   1-HOUR INTENSITY(INCH/HOUR) =   0.813
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    200.00 TO NODE    201.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   348.00
  UPSTREAM ELEVATION(FEET) =   1424.54
  DOWNSTREAM ELEVATION(FEET) =   1421.61
  ELEVATION DIFFERENCE(FEET) =      2.93
  TC = 0.303*[(  348.00**3)/(     2.93)]**.2 =    8.188
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.201
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8807
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      3.22
  TOTAL AREA(ACRES) =      1.66   TOTAL RUNOFF(CFS) =      3.22

****************************************************************************
  FLOW PROCESS FROM NODE    201.00 TO NODE    202.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1418.61  DOWNSTREAM(FEET) =  1417.86
  FLOW LENGTH(FEET) =   296.00   MANNING'S N =  0.012
```

```
  DEPTH OF FLOW IN  15.0 INCH PIPE IS  11.5 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.18
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.22
  PIPE TRAVEL TIME(MIN.) =   1.55    Tc(MIN.) =    9.74
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    202.00 =     644.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    202.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.018
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8794
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.35   SUBAREA RUNOFF(CFS) =    0.62
  TOTAL AREA(ACRES) =        2.0   TOTAL RUNOFF(CFS) =       3.84
  TC(MIN.) =    9.74

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    203.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.86  DOWNSTREAM(FEET) =  1417.35
  FLOW LENGTH(FEET) =   208.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  11.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.36
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.84
  PIPE TRAVEL TIME(MIN.) =   1.03    Tc(MIN.) =   10.77
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    203.00 =     852.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    203.00 TO NODE    203.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.919
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8786
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.51   SUBAREA RUNOFF(CFS) =    0.86
  TOTAL AREA(ACRES) =        2.5   TOTAL RUNOFF(CFS) =       4.70
  TC(MIN.) =   10.77

****************************************************************************
  FLOW PROCESS FROM NODE    203.00 TO NODE    204.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.35  DOWNSTREAM(FEET) =  1417.09
  FLOW LENGTH(FEET) =   104.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  12.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.52
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.70
  PIPE TRAVEL TIME(MIN.) =   0.49    Tc(MIN.) =   11.26
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    204.00 =     956.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    204.00 TO NODE    204.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.877
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8782
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.51   SUBAREA RUNOFF(CFS) =    0.84
  TOTAL AREA(ACRES) =        3.0   TOTAL RUNOFF(CFS) =       5.54
  TC(MIN.) =   11.26

****************************************************************************
  FLOW PROCESS FROM NODE    204.00 TO NODE    205.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
```

```
  ELEVATION DATA: UPSTREAM(FEET) =  1417.09  DOWNSTREAM(FEET) =  1416.58
  FLOW LENGTH(FEET) =   208.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  12.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.69
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       5.54
  PIPE TRAVEL TIME(MIN.) =   0.94    Tc(MIN.) =   12.20
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    205.00 =    1164.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    205.00 TO NODE    205.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.803
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8776
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.66   SUBAREA RUNOFF(CFS) =    1.04
  TOTAL AREA(ACRES) =        3.7   TOTAL RUNOFF(CFS) =       6.58
  TC(MIN.) =   12.20

****************************************************************************
  FLOW PROCESS FROM NODE    205.00 TO NODE    206.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.58  DOWNSTREAM(FEET) =  1415.57
  FLOW LENGTH(FEET) =   285.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  14.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.26
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       6.58
  PIPE TRAVEL TIME(MIN.) =   1.12    Tc(MIN.) =   13.32
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    206.00 =    1449.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    206.00 TO NODE    206.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.726
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8768
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.29   SUBAREA RUNOFF(CFS) =    0.44
  TOTAL AREA(ACRES) =        4.0   TOTAL RUNOFF(CFS) =       7.02
  TC(MIN.) =   13.32

****************************************************************************
  FLOW PROCESS FROM NODE    206.00 TO NODE    207.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.57  DOWNSTREAM(FEET) =  1415.38
  FLOW LENGTH(FEET) =    79.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  15.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.83
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       7.02
  PIPE TRAVEL TIME(MIN.) =   0.34    Tc(MIN.) =   13.66
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    207.00 =    1528.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    207.00 TO NODE    207.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.704
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8766
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.39   SUBAREA RUNOFF(CFS) =    0.58
  TOTAL AREA(ACRES) =        4.4   TOTAL RUNOFF(CFS) =       7.61
  TC(MIN.) =   13.66

****************************************************************************
  FLOW PROCESS FROM NODE    207.00 TO NODE    208.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.38  DOWNSTREAM(FEET) =  1412.83
  FLOW LENGTH(FEET) =   230.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  10.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   7.04
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       7.61
  PIPE TRAVEL TIME(MIN.) =   0.54    Tc(MIN.) =   14.20
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    208.00 =    1758.00 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE    208.00 TO NODE    208.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  1.671
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8763
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.07   SUBAREA RUNOFF(CFS) =    0.10
  TOTAL AREA(ACRES) =        4.4   TOTAL RUNOFF(CFS) =       7.71
  TC(MIN.) =   14.20
==============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        4.4  TC(MIN.) =     14.20
  PEAK FLOW RATE(CFS)   =       7.71
==============================================================================
==============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
           RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
       RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                  (RCFC&WCD)  1978 HYDROLOGY MANUAL
        (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                  (Rational Tabling Version 23.0)
                Release Date: 07/01/2016  License ID 1435

                        Analysis prepared by:

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                             714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
* TEI JOB NUMBER 4118                                                      *
* PROPOSED CONDITIONS                                                      *
* 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: W:\4118\P200.DAT
  TIME/DATE OF STUDY: 08:34 07/28/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) =   1.270
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    200.00 TO NODE    201.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
         ASSUMED INITIAL SUBAREA UNIFORM
         DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   348.00
  UPSTREAM ELEVATION(FEET) =   1424.54
  DOWNSTREAM ELEVATION(FEET) =   1421.61
  ELEVATION DIFFERENCE(FEET) =      2.93
  TC = 0.303*[(  348.00**3)/(     2.93)]**.2 =    8.188
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.438
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8866
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      5.06
  TOTAL AREA(ACRES) =      1.66   TOTAL RUNOFF(CFS) =      5.06

****************************************************************************
  FLOW PROCESS FROM NODE    201.00 TO NODE    202.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1418.61  DOWNSTREAM(FEET) =  1417.86
  FLOW LENGTH(FEET) =   296.00   MANNING'S N =  0.012
```

```
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  13.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.58
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       5.06
  PIPE TRAVEL TIME(MIN.) =   1.38    Tc(MIN.) =    9.57
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    202.00 =     644.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    202.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.181
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8857
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.35   SUBAREA RUNOFF(CFS) =    0.99
  TOTAL AREA(ACRES) =        2.0   TOTAL RUNOFF(CFS) =       6.05
  TC(MIN.) =    9.57

****************************************************************************
  FLOW PROCESS FROM NODE    202.00 TO NODE    203.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.86  DOWNSTREAM(FEET) =  1417.35
  FLOW LENGTH(FEET) =   208.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  13.3 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.76
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       6.05
  PIPE TRAVEL TIME(MIN.) =   0.92    Tc(MIN.) =   10.49
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    203.00 =     852.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    203.00 TO NODE    203.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.038
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8852
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.51   SUBAREA RUNOFF(CFS) =    1.37
  TOTAL AREA(ACRES) =        2.5   TOTAL RUNOFF(CFS) =       7.42
  TC(MIN.) =   10.49

****************************************************************************
  FLOW PROCESS FROM NODE    203.00 TO NODE    204.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.35  DOWNSTREAM(FEET) =  1417.09
  FLOW LENGTH(FEET) =   104.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  15.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.93
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       7.42
  PIPE TRAVEL TIME(MIN.) =   0.44    Tc(MIN.) =   10.93
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    204.00 =     956.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    204.00 TO NODE    204.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.976
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8849
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.51   SUBAREA RUNOFF(CFS) =    1.34
  TOTAL AREA(ACRES) =        3.0   TOTAL RUNOFF(CFS) =       8.76
  TC(MIN.) =   10.93

****************************************************************************
  FLOW PROCESS FROM NODE    204.00 TO NODE    205.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
```

```
  ELEVATION DATA: UPSTREAM(FEET) =  1417.09  DOWNSTREAM(FEET) =  1416.58
  FLOW LENGTH(FEET) =   208.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  24.0 INCH PIPE IS  15.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.12
  ESTIMATED PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       8.76
  PIPE TRAVEL TIME(MIN.) =   0.84    Tc(MIN.) =   11.77
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    205.00 =    1164.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    205.00 TO NODE    205.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.867
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8844
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.66   SUBAREA RUNOFF(CFS) =    1.67
  TOTAL AREA(ACRES) =        3.7   TOTAL RUNOFF(CFS) =      10.43
  TC(MIN.) =   11.77

****************************************************************************
  FLOW PROCESS FROM NODE    205.00 TO NODE    206.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1416.58  DOWNSTREAM(FEET) =  1415.57
  FLOW LENGTH(FEET) =   285.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  24.0 INCH PIPE IS  15.3 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.94
  ESTIMATED PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      10.43
  PIPE TRAVEL TIME(MIN.) =   0.96    Tc(MIN.) =   12.73
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    206.00 =    1449.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    206.00 TO NODE    206.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.757
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8839
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.29   SUBAREA RUNOFF(CFS) =    0.71
  TOTAL AREA(ACRES) =        4.0   TOTAL RUNOFF(CFS) =      11.14
  TC(MIN.) =   12.73

****************************************************************************
  FLOW PROCESS FROM NODE    206.00 TO NODE    207.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.57  DOWNSTREAM(FEET) =  1415.38
  FLOW LENGTH(FEET) =    79.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  24.0 INCH PIPE IS  18.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.24
  ESTIMATED PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      11.14
  PIPE TRAVEL TIME(MIN.) =   0.31    Tc(MIN.) =   13.04
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    207.00 =    1528.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    207.00 TO NODE    207.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.724
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8838
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.39   SUBAREA RUNOFF(CFS) =    0.94
  TOTAL AREA(ACRES) =        4.4   TOTAL RUNOFF(CFS) =      12.08
  TC(MIN.) =   13.04

****************************************************************************
  FLOW PROCESS FROM NODE    207.00 TO NODE    208.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1415.38  DOWNSTREAM(FEET) =  1412.83
  FLOW LENGTH(FEET) =   230.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  21.0 INCH PIPE IS  12.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   7.89
  ESTIMATED PIPE DIAMETER(INCH) =  21.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      12.08
  PIPE TRAVEL TIME(MIN.) =   0.49    Tc(MIN.) =   13.53
  LONGEST FLOWPATH FROM NODE    200.00 TO NODE    208.00 =    1758.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    208.00 TO NODE    208.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.675
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8835
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.07   SUBAREA RUNOFF(CFS) =    0.17
  TOTAL AREA(ACRES) =        4.4   TOTAL RUNOFF(CFS) =      12.25
  TC(MIN.) =   13.53
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        4.4  TC(MIN.) =     13.53
  PEAK FLOW RATE(CFS)   =      12.25
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
        RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                      (RCFC&WCD)  1978 HYDROLOGY MANUAL
         (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                      (Rational Tabling Version 23.0)
                   Release Date: 07/01/2016  License ID 1435

                          Analysis prepared by:

                        THIENES ENGINEERING, INC.
                           14349 FIRESTONE BLVD
                           LA MIRIADA, CA 90638
                               714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                      *
 * PROPOSED CONDITIONS                                                      *
 * 10-YEAR STORM EVENT                                                      *
 **************************************************************************

  FILE NAME: W:\4118\P300-10.DAT
  TIME/DATE OF STUDY: 10:57 10/24/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =   10.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =   10.00   1-HOUR INTENSITY(INCH/HOUR) =   0.813
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    300.00 TO NODE    301.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
        ASSUMED INITIAL SUBAREA UNIFORM
        DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   123.00
  UPSTREAM ELEVATION(FEET) =   1424.00
  DOWNSTREAM ELEVATION(FEET) =   1422.41
  ELEVATION DIFFERENCE(FEET) =      1.59
  TC = 0.303*[(  123.00**3)/(     1.59)]**.2 =    4.957
  COMPUTED TIME OF CONCENTRATION INCREASED TO 5 MIN.
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.817
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8842
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      0.50
  TOTAL AREA(ACRES) =      0.20   TOTAL RUNOFF(CFS) =      0.50

****************************************************************************
  FLOW PROCESS FROM NODE    301.00 TO NODE    301.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.817
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7422
```

```
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.07   SUBAREA RUNOFF(CFS) =    0.15
  TOTAL AREA(ACRES) =        0.3   TOTAL RUNOFF(CFS) =       0.64
  TC(MIN.) =    5.00

****************************************************************************
  FLOW PROCESS FROM NODE    301.00 TO NODE    302.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1419.30  DOWNSTREAM(FEET) =  1418.52
  FLOW LENGTH(FEET) =   261.00   MANNING'S N =  0.012
  ESTIMATED PIPE DIAMETER(INCH) INCREASED TO 12.000
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   4.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   2.32
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       0.64
  PIPE TRAVEL TIME(MIN.) =   1.87    Tc(MIN.) =    6.87
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    302.00 =     384.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    302.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.403
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8820
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.40   SUBAREA RUNOFF(CFS) =    0.85
  TOTAL AREA(ACRES) =        0.7   TOTAL RUNOFF(CFS) =       1.49
  TC(MIN.) =    6.87

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    302.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.403
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7204
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.16   SUBAREA RUNOFF(CFS) =    0.28
  TOTAL AREA(ACRES) =        0.8   TOTAL RUNOFF(CFS) =       1.77
  TC(MIN.) =    6.87

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    303.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1418.52  DOWNSTREAM(FEET) =  1417.98
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   8.5 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   2.96
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       1.77
  PIPE TRAVEL TIME(MIN.) =   1.01    Tc(MIN.) =    7.88
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    303.00 =     563.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    303.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.244
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8810
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.42   SUBAREA RUNOFF(CFS) =    0.83
  TOTAL AREA(ACRES) =        1.2   TOTAL RUNOFF(CFS) =       2.60
  TC(MIN.) =    7.88

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    303.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.244
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7103
```

```
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.18   SUBAREA RUNOFF(CFS) =    0.29
  TOTAL AREA(ACRES) =        1.4   TOTAL RUNOFF(CFS) =       2.89
  TC(MIN.) =    7.88

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    304.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.98  DOWNSTREAM(FEET) =  1417.44
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  15.0 INCH PIPE IS   9.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.37
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       2.89
  PIPE TRAVEL TIME(MIN.) =   0.89    Tc(MIN.) =    8.77
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    304.00 =     742.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    304.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.127
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8802
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.41   SUBAREA RUNOFF(CFS) =    0.77
  TOTAL AREA(ACRES) =        1.8   TOTAL RUNOFF(CFS) =       3.65
  TC(MIN.) =    8.77

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    304.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.127
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7022
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.18   SUBAREA RUNOFF(CFS) =    0.27
  TOTAL AREA(ACRES) =        2.0   TOTAL RUNOFF(CFS) =       3.92
  TC(MIN.) =    8.77

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    305.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.44  DOWNSTREAM(FEET) =  1411.74
  FLOW LENGTH(FEET) =   161.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   6.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   9.24
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.92
  PIPE TRAVEL TIME(MIN.) =   0.29    Tc(MIN.) =    9.06
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    305.00 =     903.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    305.00 TO NODE    305.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
    10 YEAR RAINFALL INTENSITY(INCH/HOUR) =  2.093
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8800
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.62   SUBAREA RUNOFF(CFS) =    1.14
  TOTAL AREA(ACRES) =        2.6   TOTAL RUNOFF(CFS) =       5.06
  TC(MIN.) =    9.06
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        2.6  TC(MIN.) =      9.06
  PEAK FLOW RATE(CFS)   =       5.06
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM BASED ON
         RIVERSIDE COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT
                       (RCFC&WCD)  1978 HYDROLOGY MANUAL
          (c) Copyright 1982-2016 Advanced Engineering Software (aes)
                       (Rational Tabling Version 23.0)
                    Release Date: 07/01/2016  License ID 1435

                            Analysis prepared by:

                          THIENES ENGINEERING, INC.
                             14349 FIRESTONE BLVD
                             LA MIRIADA, CA 90638
                                 714-521-4811

 ************************** DESCRIPTION OF STUDY **************************
 * TEI JOB NUMBER 4118                                                      *
 * PROPOSED CONDITIONS                                                      *
 * 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: W:\4118\P300.DAT
  TIME/DATE OF STUDY: 08:53 07/28/2023
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.95
  2-YEAR, 1-HOUR PRECIPITATION(INCH) =  0.480
  100-YEAR, 1-HOUR PRECIPITATION(INCH) =  1.270
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) =   1.270
  SLOPE OF INTENSITY DURATION CURVE = 0.5000
  RCFC&WCD HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: CONSIDER ALL CONFLUENCE STREAM COMBINATIONS
        FOR ALL DOWNSTREAM ANALYSES
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    300.00 TO NODE    301.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
        ASSUMED INITIAL SUBAREA UNIFORM
        DEVELOPMENT IS COMMERCIAL
  TC = K*[(LENGTH**3)/(ELEVATION CHANGE)]**.2
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   123.00
  UPSTREAM ELEVATION(FEET) =   1424.00
  DOWNSTREAM ELEVATION(FEET) =   1422.41
  ELEVATION DIFFERENCE(FEET) =      1.59
  TC = 0.303*[(  123.00**3)/(     1.59)]**.2 =    4.957
  COMPUTED TIME OF CONCENTRATION INCREASED TO 5 MIN.
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  4.399
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8892
  SOIL CLASSIFICATION IS "C"
  SUBAREA RUNOFF(CFS) =      0.78
  TOTAL AREA(ACRES) =      0.20   TOTAL RUNOFF(CFS) =      0.78

****************************************************************************
  FLOW PROCESS FROM NODE    301.00 TO NODE    301.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  4.399
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7921
```

```
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.07   SUBAREA RUNOFF(CFS) =    0.24
  TOTAL AREA(ACRES) =        0.3   TOTAL RUNOFF(CFS) =       1.03
  TC(MIN.) =    5.00

****************************************************************************
  FLOW PROCESS FROM NODE    301.00 TO NODE    302.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1419.30  DOWNSTREAM(FEET) =  1418.52
  FLOW LENGTH(FEET) =   261.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   6.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   2.62
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       1.03
  PIPE TRAVEL TIME(MIN.) =   1.66    Tc(MIN.) =    6.66
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    302.00 =     384.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    302.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.811
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8878
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.40   SUBAREA RUNOFF(CFS) =    1.35
  TOTAL AREA(ACRES) =        0.7   TOTAL RUNOFF(CFS) =       2.38
  TC(MIN.) =    6.66

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    302.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.811
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7778
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.16   SUBAREA RUNOFF(CFS) =    0.47
  TOTAL AREA(ACRES) =        0.8   TOTAL RUNOFF(CFS) =       2.85
  TC(MIN.) =    6.66

****************************************************************************
  FLOW PROCESS FROM NODE    302.00 TO NODE    303.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1418.52  DOWNSTREAM(FEET) =  1417.98
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  15.0 INCH PIPE IS   9.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.36
  ESTIMATED PIPE DIAMETER(INCH) =  15.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       2.85
  PIPE TRAVEL TIME(MIN.) =   0.89    Tc(MIN.) =    7.55
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    303.00 =     563.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    303.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.580
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8871
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.42   SUBAREA RUNOFF(CFS) =    1.33
  TOTAL AREA(ACRES) =        1.2   TOTAL RUNOFF(CFS) =       4.19
  TC(MIN.) =    7.55

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    303.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.580
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7710
  SOIL CLASSIFICATION IS "C"
```

```
  SUBAREA AREA(ACRES) =    0.18   SUBAREA RUNOFF(CFS) =    0.50
  TOTAL AREA(ACRES) =       1.4   TOTAL RUNOFF(CFS) =       4.68
  TC(MIN.) =    7.55

****************************************************************************
  FLOW PROCESS FROM NODE    303.00 TO NODE    304.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.98  DOWNSTREAM(FEET) =  1417.44
  FLOW LENGTH(FEET) =   179.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  18.0 INCH PIPE IS  11.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.80
  ESTIMATED PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.68
  PIPE TRAVEL TIME(MIN.) =   0.78    Tc(MIN.) =    8.33
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    304.00 =     742.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    304.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.408
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8865
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.41   SUBAREA RUNOFF(CFS) =    1.24
  TOTAL AREA(ACRES) =       1.8   TOTAL RUNOFF(CFS) =       5.92
  TC(MIN.) =    8.33

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    304.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.408
  UNDEVELOPED WATERSHED RUNOFF COEFFICIENT = .7654
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.18   SUBAREA RUNOFF(CFS) =    0.47
  TOTAL AREA(ACRES) =       2.0   TOTAL RUNOFF(CFS) =       6.39
  TC(MIN.) =    8.33

****************************************************************************
  FLOW PROCESS FROM NODE    304.00 TO NODE    305.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1417.44  DOWNSTREAM(FEET) =  1411.74
  FLOW LENGTH(FEET) =   161.00   MANNING'S N =  0.012
  DEPTH OF FLOW IN  12.0 INCH PIPE IS   8.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  10.20
  ESTIMATED PIPE DIAMETER(INCH) =  12.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       6.39
  PIPE TRAVEL TIME(MIN.) =   0.26    Tc(MIN.) =    8.60
  LONGEST FLOWPATH FROM NODE    300.00 TO NODE    305.00 =     903.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    305.00 TO NODE    305.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
   100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  3.355
  COMMERCIAL DEVELOPMENT RUNOFF COEFFICIENT = .8864
  SOIL CLASSIFICATION IS "C"
  SUBAREA AREA(ACRES) =    0.62   SUBAREA RUNOFF(CFS) =    1.84
  TOTAL AREA(ACRES) =       2.6   TOTAL RUNOFF(CFS) =       8.24
  TC(MIN.) =    8.60
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        2.6  TC(MIN.) =      8.60
  PEAK FLOW RATE(CFS)   =       8.24
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
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APPENDIX C

HYDRAULIC CALCULATIONS

```
DATE:  9/ 7/2023
TIME: 11:17
                                                                F0515P
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                             PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     18    4                        1.50
 CD     24    4                        2.00
 CD     30    4                        2.50
 CD      1    3      0       0.00      6.00   10.00   0.00  0.00  0.00
                                                                F 0 5 1 5 P                                          PAGE NO   3

                            WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              RCFCD STORM DRAIN LINE A-8

HEADING LINE NO 3 IS -

                              100-YEAR
                                                                F 0 5 1 5 P                                          PAGE NO   2

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                      W S ELEV
                                 1071.62 1411.10    1                                         1419.10

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT             N                                   RADIUS  ANGLE  ANG PT  MAN H
                                 1140.51 1411.27    1             0.014                                  0.00   0.00    0.00     0

 ELEMENT NO   3 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT             N                                   RADIUS  ANGLE  ANG PT  MAN H
                                 1159.56 1411.32    1             0.014                                 22.50  45.00    0.00     0

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT             N                                   RADIUS  ANGLE  ANG PT  MAN H
                                 1263.92 1411.58    1             0.014                                  0.00   0.00    0.00     0

 ELEMENT NO   5 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1263.92 1411.58    1    30     0  0.014     17.0      0.0  1413.33     0.00  45.00    0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT             N                                   RADIUS  ANGLE  ANG PT  MAN H
                                 1270.56 1411.59    1             0.014                                  0.00   0.00    0.00     0

 ELEMENT NO   7 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1270.56 1411.59    1    30     0  0.014     23.3      0.0  1413.34     0.00  45.00    0.00
```

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THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING

 ELEMENT NO   8 IS A REACH           *         *     *
                     U/S DATA   STATION    INVERT  SECT              N                                   RADIUS  ANGLE  ANG PT  MAN H
                                  1777.97 1412.86    1             0.014                                   0.00   0.00   0.00     0

 ELEMENT NO   9 IS A JUNCTION        *         *     *     *                 *                   *               *
                     U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                  1777.97 1414.86    1    24     0  0.014     11.9      0.0  1414.86     0.00  45.00    0.00
                                                       F 0 5 1 5 P                                                  PAGE NO   3

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO  10 IS A REACH           *         *     *
                     U/S DATA   STATION    INVERT  SECT              N                                   RADIUS  ANGLE  ANG PT  MAN H
                                  1865.71 1413.08    1             0.014                                   0.00   0.00   0.00     0
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING

 ELEMENT NO  11 IS A REACH           *         *     *
                     U/S DATA   STATION    INVERT  SECT              N                                   RADIUS  ANGLE  ANG PT  MAN H
                                  1901.35 1413.17    1             0.014                                  22.50  90.00   0.00     0

 ELEMENT NO  12 IS A REACH           *         *     *
                     U/S DATA   STATION    INVERT  SECT              N                                   RADIUS  ANGLE  ANG PT  MAN H
                                  2122.93 1413.70    1             0.014                                   0.00   0.00   0.00     0

 ELEMENT NO  13 IS A SYSTEM HEADWORKS                *                      *
                     U/S DATA   STATION    INVERT  SECT                                          W S ELEV
                                  2122.93 1413.70    1                                               0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                                F0515P                                                   PAGE    1
                                                     WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         RCFCD STORM DRAIN LINE A-8
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.       Q       VEL     VEL     ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV   OF FLOW    ELEV                       HEAD   GRD.EL.   ELEV    DEPTH             DIA    ID NO.       PIER

 L/ELEM      SO                                          SF AVE     HF                   NORM DEPTH                  ZR
*********************************************************************************************************************************

  1071.62  1411.10    8.000  1419.100     320.2    5.36    0.446  1419.546   0.00    3.170            6.00   10.00  0.00   0   0.00

    68.89  0.00247                                      .001109     0.08                     3.680                  0.00

  1140.51  1411.27    7.906  1419.176     320.2    5.36    0.446  1419.622   0.00    3.170            6.00   10.00  0.00   0   0.00

    19.05  0.00263                                      .001109     0.02                     3.599                  0.00

  1159.56  1411.32    7.941  1419.261     320.2    5.36    0.446  1419.707   0.00    3.170            6.00   10.00  0.00   0   0.00

   104.36  0.00249                                      .001109     0.12                     3.667                  0.00

  1263.92  1411.58    7.796  1419.376     320.2    5.36    0.446  1419.822   0.00    3.170            6.00   10.00  0.00   0   0.00

JUNCT STR  0.00000                                      .001051     0.00                                            0.00

  1263.92  1411.58    7.867  1419.447     303.2    5.07    0.400  1419.847   0.00    3.057            6.00   10.00  0.00   0   0.00
```

6.64	0.00151					.000994	0.01			4.234			0.00		
1270.56	1411.59	7.863	1419.453	303.2	5.07	0.400	1419.853	0.00	3.057		6.00	10.00	0.00	0	0.00
JUNCT STR	0.00000					.000921	0.00						0.00		
1270.56	1411.59	7.941	1419.531	279.9	4.68	0.341	1419.872	0.00	2.898		6.00	10.00	0.00	0	0.00
507.41	0.00250					.000847	0.43			3.324			0.00		
1777.97	1412.86	7.101	1419.961	279.9	4.68	0.341	1420.302	0.00	2.898		6.00	10.00	0.00	0	0.00
JUNCT STR	0.00000					.000797	0.00						0.00		
1777.97	1414.86	5.014	1419.874	268.0	5.34	0.444	1420.318	0.00	2.816		6.00	10.00	0.00	0	0.00
9.98	-.02029					.000700	0.01			0.000			0.00		
1787.95	1414.66	5.265	1419.923	268.0	5.09	0.402	1420.325	0.00	2.816		6.00	10.00	0.00	0	0.00
10.81	-.02029					.000615	0.01			0.000			0.00		
1798.76	1414.44	5.528	1419.966	268.0	4.85	0.365	1420.331	0.00	2.816		6.00	10.00	0.00	0	0.00
11.64	-.02029					.000541	0.01			0.000			0.00		

WATER SURFACE PROFILE LISTING

TEI JOB NUMBER 4118
RCFCD STORM DRAIN LINE A-8
100-YEAR

STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH	NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR
1810.40	1414.20	5.805	1420.007	268.0	4.62	0.331	1420.338	0.00	2.816		6.00	10.00	0.00	0	0.00
8.51	-.02029					.000489	0.00			0.000			0.00		
1818.91	1414.03	6.000	1420.030	268.0	4.49	0.312	1420.342	0.00	2.816		6.00	10.00	0.00	0	0.00
46.80	-.02029					.000777	0.04			0.000			0.00		
1865.71	1413.08	6.986	1420.066	268.0	4.49	0.312	1420.378	0.00	2.816		6.00	10.00	0.00	0	0.00
35.64	0.00252					.000777	0.03			3.212			0.00		
1901.35	1413.17	6.986	1420.156	268.0	4.49	0.312	1420.468	0.00	2.816		6.00	10.00	0.00	0	0.00
221.58	0.00239					.000777	0.17			3.275			0.00		
2122.93	1413.70	6.628	1420.328	268.0	4.49	0.312	1420.640	0.00	2.816		6.00	10.00	0.00	0	0.00

TEI JOB NUMBER 4118
RCFCD STORM DRAIN LINE A-8
100-YEAR

```
                .         .         .         .         .         .         .         .         .         .         .
    1071.62    .I                               C                            H                   W    E              .    R
    1093.08    .                                                                                                     .
    1114.53    .                                                                                                     .
    1135.99    .                                                                                                     .
    1157.44    . I                                C                            H                  W    E             .    R
    1178.90    .  I                               C                            H                   W    E            .    R
    1200.35    .                                                                                                     .
    1221.81    .                                                                                                     .
    1243.26    .                                                                                                     .
    1264.72    .    I                                C                            H                 W    E           .    JX
    1286.17    .    I                               C                             H                  W   E           .    R
    1307.63    .     I                              C                             H                  W   E           .    JX
    1329.08    .     I                            C                               H                   W  E           .    R
    1350.54    .                                                                                                     .
    1371.99    .                                                                                                     .
    1393.45    .                                                                                                     .
    1414.90    .                                                                                                     .
    1436.36    .                                                                                                     .
    1457.82    .                                                                                                     .
    1479.27    .                                                                                                     .
    1500.73    .                                                                                                     .
    1522.18    .                                                                                                     .
    1543.64    .                                                                                                     .
    1565.09    .                                                                                                     .
    1586.55    .                                                                                                     .
    1608.00    .                                                                                                     .
    1629.46    .                                                                                                     .
    1650.91    .                                                                                                     .
    1672.37    .                                                                                                     .
    1693.82    .                                                                                                     .
    1715.28    .                                                                                                     .
    1736.73    .                                                                                                     .
    1758.19    .                                                                                                     .
    1779.65    .                  I                            C                               H          W   E      .    JX
    1801.10    .                                      I                            C                     W    E     H.    R
    1822.56    .                                    I                            C                        W   E  H   .    R
    1844.01    .                                  I                            C                          W   EH     .    R
    1865.47    .                               I                            C                              W HE      .    R
    1886.92    .                              I                           C                                X  E      .    R
    1908.38    .                    I                            C                               H         W   E     .    R
    1929.83    .                     I                            C                               H         W  E     .    R
    1951.29    .                                                                                                     .
    1972.74    .                                                                                                     .
    1994.20    .                                                                                                     .
    2015.65    .                                                                                                     .
    2037.11    .                                                                                                     .
    2058.56    .                                                                                                     .
    2080.02    .                                                                                                     .
    2101.47    .                                                                                                     .
    2122.93    .                          I                            C                                H     W  E   .    R
                .         .         .         .         .         .         .         .         .         .         .

              1411.10   1412.08   1413.05   1414.03   1415.00   1415.98   1416.96   1417.93   1418.91   1419.88   1420.86
```

N O T E S

1. GLOSSARY
   - I = INVERT ELEVATION
   - C = CRITICAL DEPTH
   - W = WATER SURFACE ELEVATION

H = HEIGHT OF CHANNEL
E = ENERGY GRADE LINE
X = CURVES CROSSING OVER
B = BRIDGE ENTRANCE OR EXIT
Y = WALL ENTRANCE OR EXIT

2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY

```
DATE:  4/27/2023
TIME:  7: 5
                                                                F0515P
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                              PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     30    4                        2.50
                                                        F 0 5 1 5 P                                                   PAGE NO   3

                            WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              PUBLIC LATERAL A8-1

HEADING LINE NO 3 IS -

                              100-YEAR
                                                        F 0 5 1 5 P                                                   PAGE NO   2

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                                1007.07 1413.33   30                                       1419.44

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT             N                                 RADIUS  ANGLE  ANG PT  MAN H
                                1015.07 1413.37   30             0.013                                 0.00   0.00    0.00     0

 ELEMENT NO   3 IS A SYSTEM HEADWORKS                  *                      *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                                1015.07 1413.37   30                                          0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                                   F0515P                                                     PAGE    1
                                                     WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         PUBLIC LATERAL A8-1
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.        Q       VEL     VEL     ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV   OF FLOW    ELEV                        HEAD   GRD.EL.   ELEV    DEPTH             DIA    ID NO.       PIER

 L/ELEM      SO                                           SF AVE     HF                   NORM DEPTH                 ZR
*******************************************************************************************************************************

  1007.07  1413.33    6.110  1419.440      17.0    3.46    0.186  1419.626   0.00    1.395             2.50    0.00  0.00   0   0.00

     8.00  0.00500                                       .001718     0.01                    1.374                 0.00

  1015.07  1413.37    6.084  1419.454      17.0    3.46    0.186  1419.640   0.00    1.395             2.50    0.00  0.00   0   0.00

** WARNING NO. 22 ** - NO PLOT GENERATED, BAD DATA OR NOT ENOUGH POINTS, 3 OR LESS
```

```
DATE:  4/27/2023
TIME:  7: 7
                                                              F0515P
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                             PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     30    4                        2.50
                                                       F 0 5 1 5 P                                                   PAGE NO   3

                            WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              PUBLIC LATERAL A8-2

HEADING LINE NO 3 IS -

                              100-YEAR
                                                       F 0 5 1 5 P                                                   PAGE NO   2

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                                1005.00 1413.34   30                                       1419.60

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                1013.00 1413.38   30              0.013                                 0.00   0.00    0.00     0

 ELEMENT NO   3 IS A SYSTEM HEADWORKS                  *                      *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                                1013.00 1413.38   30                                          0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                                 F0515P                                                    PAGE    1
                                                   WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         PUBLIC LATERAL A8-2
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.       Q       VEL     VEL     ENERGY   SUPER  CRITICAL          HGT/   BASE/    ZL   NO  AVBPR
             ELEV   OF FLOW    ELEV                       HEAD   GRD.EL.   ELEV    DEPTH            DIA    ID NO.       PIER

 L/ELEM      SO                                          SF AVE     HF                   NORM DEPTH                 ZR
*********************************************************************************************************************************

  1005.00  1413.34    6.260  1419.600      23.3    4.75    0.350  1419.950   0.00    1.643            2.50    0.00  0.00   0   0.00

     8.00  0.00500                                       .003227     0.03                   1.695                 0.00

  1013.00  1413.38    6.246  1419.626      23.3    4.75    0.350  1419.976   0.00    1.643            2.50    0.00  0.00   0   0.00

** WARNING NO. 22 ** - NO PLOT GENERATED, BAD DATA OR NOT ENOUGH POINTS, 3 OR LESS
```

DATE: 4/27/2023
TIME: 7: 9

F0515P

WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING PAGE 1

CARD CODE	SECT NO	CHN TYPE	NO OF PIERS	AVE PIER WIDTH	HEIGHT 1 DIAMETER	BASE WIDTH	ZL	ZR	INV DROP	Y(1)	Y(2)	Y(3)	Y(4)	Y(5)	Y(6)	Y(7)	Y(8)	Y(9)	Y(10)
CD	24	4			2.00														

F 0 5 1 5 P PAGE NO 3

WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

PUBLIC LATERAL A8-3

HEADING LINE NO 3 IS -

100-YEAR

F 0 5 1 5 P PAGE NO 2

WATER SURFACE PROFILE - ELEMENT CARD LISTING

```
 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                   W S ELEV
                                1007.07 1414.86   24                                       1418.99

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                1025.30 1414.95   24              0.013                                 22.50  45.00    0.00     0

 ELEMENT NO   3 IS A SYSTEM HEADWORKS                  *                      *
                    U/S DATA   STATION    INVERT  SECT                                   W S ELEV
                                1025.30 1414.95   24                                          0.00
```

NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC

LICENSEE: THIENES ENGINEERING F0515P PAGE 1

WATER SURFACE PROFILE LISTING

TEI JOB NUMBER 4118
PUBLIC LATERAL A8-3
100-YEAR

STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH / NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR
1007.07	1414.86	4.130	1418.990	11.9	3.79	0.223	1419.213	0.00	1.239	2.00	0.00	0.00	0	0.00
18.23	0.00494					.002767	0.05		1.290			0.00		
1025.30	1414.95	4.122	1419.072	11.9	3.79	0.223	1419.295	0.00	1.239	2.00	0.00	0.00	0	0.00

** WARNING NO. 22 ** - NO PLOT GENERATED, BAD DATA OR NOT ENOUGH POINTS, 3 OR LESS

```
DATE: 10/24/2023
TIME: 13:45
                                                                F0515P
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                             PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     18    4                        1.50
 CD     24    4                        2.00
 CD     30    4                        2.50
                                                        F 0 5 1 5 P                                                 PAGE NO   3

                            WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              STORM DRAIN LINE A

HEADING LINE NO 3 IS -

                              100-YEAR
                                                        F 0 5 1 5 P                                                 PAGE NO   2

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                                 1007.07 1415.75   30                                         0.00

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                                 1055.12 1412.90   30             0.012                                0.00   0.00    0.00     0
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING

 ELEMENT NO   3 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                                 1072.78 1412.96   30             0.012                               22.50  45.00    0.00     0

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                                 1119.49 1413.11   30             0.012                                0.00   0.00    0.00     0

 ELEMENT NO   5 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1123.49 1413.13   24    24     0  0.012     10.1      0.0  1413.38     0.00  90.00    0.00

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                                 1126.49 1413.77   24             0.012                                0.00   0.00    0.00     0

 ELEMENT NO   7 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                                 1130.49 1413.79   24             0.012                                0.00   0.00    0.00     1

 ELEMENT NO   8 IS A REACH             *         *     *
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                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1248.12 1414.31   24            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO   9 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1251.94 1414.32   24            0.012                                  22.50  20.00    0.00     0

 ELEMENT NO  10 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1280.71 1414.45   24            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO  11 IS A JUNCTION       *         *     *     *                  *                   *                *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1280.71 1414.45   24    18     0  0.012      1.2      0.0  1414.70     0.00  45.00    0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING ↑
                                                        F 0 5 1 5 P                                             PAGE NO   3

                           WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO  12 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1441.25 1415.16   24            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO  13 IS A TRANSITION     *         *     *
                    U/S DATA   STATION    INVERT  SECT              N
                                 1445.25 1415.17   18            0.012

 ELEMENT NO  14 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1476.77 1415.31   18            0.012                                  22.50  70.00    0.00     0

 ELEMENT NO  15 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1570.25 1415.72   18            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO  16 IS A JUNCTION       *         *     *     *                  *                   *                *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1574.25 1415.74   18    18     0  0.012      2.6      0.0  1415.72     0.00  45.00    0.00

 ELEMENT NO  17 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1748.41 1416.50   18            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO  18 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1756.26 1416.54   18            0.012                                  22.50  20.00    0.00     0

 ELEMENT NO  19 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1786.68 1416.67   18            0.012                                   0.00   0.00    0.00     0

 ELEMENT NO  20 IS A SYSTEM HEADWORKS               *                      *
                    U/S DATA   STATION    INVERT  SECT                                  W S ELEV
                                 1786.68 1416.67   18                                       0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC ↑
LICENSEE: THIENES ENGINEERING                                F0515P                                                 PAGE    1
                                                     WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         STORM DRAIN LINE A
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STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH	NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR
1007.07	1415.75	1.407	1417.157	17.3	6.08	0.574	1417.731	0.00	1.407		2.50	0.00	0.00	0	0.00
0.10	-.05931					.003811	0.00			0.000			0.00		
1007.17	1415.74	1.477	1417.221	17.3	5.73	0.510	1417.731	0.00	1.407		2.50	0.00	0.00	0	0.00
0.29	-.05931					.003276	0.00			0.000			0.00		
1007.46	1415.73	1.551	1417.278	17.3	5.41	0.454	1417.732	0.00	1.407		2.50	0.00	0.00	0	0.00
0.46	-.05931					.002833	0.00			0.000			0.00		
1007.92	1415.70	1.629	1417.328	17.3	5.11	0.405	1417.733	0.00	1.407		2.50	0.00	0.00	0	0.00
0.64	-.05931					.002465	0.00			0.000			0.00		
1008.56	1415.66	1.710	1417.372	17.3	4.84	0.363	1417.735	0.00	1.407		2.50	0.00	0.00	0	0.00
0.79	-.05931					.002162	0.00			0.000			0.00		
1009.35	1415.62	1.796	1417.411	17.3	4.58	0.326	1417.737	0.00	1.407		2.50	0.00	0.00	0	0.00
0.95	-.05931					.001912	0.00			0.000			0.00		
1010.30	1415.56	1.886	1417.444	17.3	4.36	0.295	1417.739	0.00	1.407		2.50	0.00	0.00	0	0.00
1.10	-.05931					.001710	0.00			0.000			0.00		
1011.40	1415.49	1.980	1417.473	17.3	4.15	0.267	1417.740	0.00	1.407		2.50	0.00	0.00	0	0.00
1.24	-.05931					.001548	0.00			0.000			0.00		
1012.64	1415.42	2.079	1417.498	17.3	3.97	0.244	1417.742	0.00	1.407		2.50	0.00	0.00	0	0.00
1.40	-.05931					.001427	0.00			0.000			0.00		
1014.04	1415.34	2.183	1417.520	17.3	3.80	0.225	1417.745	0.00	1.407		2.50	0.00	0.00	0	0.00
1.54	-.05931					.001347	0.00			0.000			0.00		
1015.58	1415.24	2.292	1417.537	17.3	3.67	0.209	1417.746	0.00	1.407		2.50	0.00	0.00	0	0.00
1.70	-.05931					.001321	0.00			0.000			0.00		

STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH	NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR

1017.28	1415.14	2.406	1417.551	17.3	3.57	0.198	1417.749	0.00	1.407		2.50	0.00	0.00	0	0.00
1.46	-.05931					.001406	0.00			0.000			0.00		
1018.74	1415.06	2.500	1417.558	17.3	3.52	0.193	1417.751	0.00	1.407		2.50	0.00	0.00	0	0.00
36.38	-.05931					.001503	0.05			0.000			0.00		
1055.12	1412.90	4.713	1417.613	17.3	3.52	0.193	1417.806	0.00	1.407		2.50	0.00	0.00	0	0.00
17.66	0.00340					.001516	0.03			1.493			0.00		
1072.78	1412.96	4.707	1417.667	17.3	3.52	0.193	1417.860	0.00	1.407		2.50	0.00	0.00	0	0.00
46.71	0.00321					.001516	0.07			1.521			0.00		
1119.49	1413.11	4.628	1417.738	17.3	3.52	0.193	1417.931	0.00	1.407		2.50	0.00	0.00	0	0.00
JUNCT STR	0.00500					.001190	0.00						0.00		
1123.49	1413.13	4.956	1418.086	7.2	2.29	0.082	1418.168	0.00	0.953		2.00	0.00	0.00	0	0.00
3.00	0.21333					.000863	0.00			0.340			0.00		
1126.49	1413.77	4.318	1418.088	7.2	2.29	0.082	1418.170	0.00	0.953		2.00	0.00	0.00	0	0.00
4.00	0.00500					.000863	0.00			0.900			0.00		
1130.49	1413.79	4.306	1418.096	7.2	2.29	0.082	1418.178	0.00	0.953		2.00	0.00	0.00	0	0.00
117.63	0.00442					.000863	0.10			0.930			0.00		
1248.12	1414.31	3.887	1418.197	7.2	2.29	0.082	1418.279	0.00	0.953		2.00	0.00	0.00	0	0.00
3.82	0.00262					.000863	0.00			1.084			0.00		
1251.94	1414.32	3.888	1418.208	7.2	2.29	0.082	1418.290	0.00	0.953		2.00	0.00	0.00	0	0.00
28.77	0.00452					.000863	0.02			0.922			0.00		
1280.71	1414.45	3.783	1418.233	7.2	2.29	0.082	1418.315	0.00	0.953		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00000					.000731	0.00						0.00		

WATER SURFACE PROFILE LISTING

TEI JOB NUMBER 4118
STORM DRAIN LINE A
100-YEAR

STATION	INVERT ELEV	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD	ENERGY GRD.EL.	SUPER ELEV	CRITICAL DEPTH		HGT/ DIA	BASE/ ID NO.	ZL	NO PIER	AVBPR
L/ELEM	SO					SF AVE	HF			NORM DEPTH			ZR		

1280.71	1414.45	3.827	1418.277	6.0	1.91	0.057	1418.334	0.00	0.866		2.00	0.00	0.00	0	0.00
160.54	0.00442					.000599	0.10			0.840			0.00		

1441.25	1415.16	3.214	1418.374	6.0	1.91	0.057	1418.431	0.00	0.866		2.00	0.00	0.00	0	0.00
TRANS STR	0.00250					.001690	0.01						0.00		
1445.25	1415.17	3.112	1418.282	6.0	3.40	0.179	1418.461	0.00	0.946		1.50	0.00	0.00	0	0.00
31.52	0.00444					.002780	0.09			1.010			0.00		
1476.77	1415.31	3.092	1418.402	6.0	3.40	0.179	1418.581	0.00	0.946		1.50	0.00	0.00	0	0.00
93.48	0.00439					.002780	0.26			1.010			0.00		
1570.25	1415.72	2.941	1418.661	6.0	3.40	0.179	1418.840	0.00	0.946		1.50	0.00	0.00	0	0.00
JUNCT STR	0.00500					.001837	0.01						0.00		
1574.25	1415.74	3.124	1418.864	3.4	1.92	0.057	1418.921	0.00	0.703		1.50	0.00	0.00	0	0.00
174.16	0.00436					.000893	0.16			0.710			0.00		
1748.41	1416.50	2.520	1419.020	3.4	1.92	0.057	1419.077	0.00	0.703		1.50	0.00	0.00	0	0.00
7.85	0.00510					.000893	0.01			0.680			0.00		
1756.26	1416.54	2.492	1419.032	3.4	1.92	0.057	1419.089	0.00	0.703		1.50	0.00	0.00	0	0.00
30.42	0.00427					.000893	0.03			0.710			0.00		
1786.68	1416.67	2.389	1419.059	3.4	1.92	0.057	1419.116	0.00	0.703		1.50	0.00	0.00	0	0.00

TEI JOB NUMBER 4118
STORM DRAIN LINE A
100-YEAR

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            .         .         .         .         .         .         .         .         .         .         .
1007.07    .                                             I                      X        E        H              .    R
1019.85    .                                             I                      CW       E       H               .    R
1032.63    .                                             I                      C W      E       H               .    R
1045.41    .                                             I                     C   W     E       H               .    R
1058.19    .                                            I                      C   W     E      H                .    R
1070.97    .                                           I                      C     W    E     H                 .    R
1083.75    .                                          I                      C       W   E     H                 .    R
1096.53    .                                         I                      C        W   E   H                   .    R
1109.31    .                                        I                      C         W   E  H                    .    R
1122.09    .                                       I                     C            W  E H                     .    R
1134.87    .                                     I                      C             W  X                       .    R
1147.66    .                                    I                     C               W H E                      .    R
1160.44    .                                  I                      C                X   E                      .    R
1173.22    .I                     C                 H                                  W  E                      .    R
1186.00    .I                      C                 H                                  W  E                     .    R
1198.78    .   I                      C                H                                 W  E                    .    JX
1211.56    .   I               C               H                                                WE               .    R
1224.34    .             I               C                H                                     WE               .    R
1237.12    .              I              C                H                                     WE               .    R
1249.90    .                      I               C               H                               WE             .    R
1262.68    .                      I               C                H                              WE             .    R
1275.46    .                                                                                                     .
1288.24    .                        I               C                H                            W E            .    JX
1301.02    .                        I             C                  H                             WE            .    R
1313.80    .                                                                                                     .
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    1326.58    .                                                                                                     .
    1339.36    .                                                                                                     .
    1352.14    .                                                                                                     .
    1364.92    .                                                                                                     .
    1377.70    .                                                                                                     .
    1390.48    .                                                                                                     .
    1403.27    .                                                                                                     .
    1416.05    .                                                                                                     .
    1428.83    .                                                                                                     .
    1441.61    .                                    I             C                 H                   X            .    TX
    1454.39    .                                    I              C        H                         W  E           .    R
    1467.17    .                                                                                                     .
    1479.95    .                                      I              C        H                         W  E         .    R
    1492.73    .                                                                                                     .
    1505.51    .                                                                                                     .
    1518.29    .                                                                                                     .
    1531.07    .                                                                                                     .
    1543.85    .                                                                                                     .
    1556.63    .                                                                                                     .
    1569.41    .                                                                                                     .
    1582.19    .                                             I              C        H                      W  E     .    JX
    1594.97    .                                             I          C            H                         WE    .    R
    1607.75    .                                                                                                     .
    1620.53    .                                                                                                     .
    1633.31    .                                                                                                     .
    1646.09    .                                                                                                     .
    1658.88    .                                                                                                     .
    1671.66    .                                                                                                     .
    1684.44    .                                                                                                     .
    1697.22    .                                                                                                     .
    1710.00    .                                                                                                     .
    1722.78    .                                                                                                     .
    1735.56    .                                                                                                     .
    1748.34    .                                                                                                     .
    1761.12    .                                                         I           C            H               WE .    R
    1773.90    .                                                          I          C            H               WE .    R
    1786.68    .                                                            I          C            H              X .    R
                .         .         .         .         .         .         .         .         .         .         .

              1412.90   1413.52   1414.14   1414.76   1415.39   1416.01   1416.63   1417.25   1417.87   1418.49   1419.12
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N O T E S

1. GLOSSARY
   - I = INVERT ELEVATION
   - C = CRITICAL DEPTH
   - W = WATER SURFACE ELEVATION
   - H = HEIGHT OF CHANNEL
   - E = ENERGY GRADE LINE
   - X = CURVES CROSSING OVER
   - B = BRIDGE ENTRANCE OR EXIT
   - Y = WALL ENTRANCE OR EXIT
2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY

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DATE: 10/25/2023
TIME:  7:14
                                                        F0515P
                              WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                         PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     18    4                        1.50
 CD     24    4                        2.00
                                                F 0 5 1 5 P                                            PAGE NO   3

                          WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              STORM DRAIN LINE B

HEADING LINE NO 3 IS -

                              100-YEAR
                                                F 0 5 1 5 P                                            PAGE NO   2

                          WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                     W S ELEV
                                 1001.75 1413.11   24                                       1418.09

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1110.59 1413.52   24             0.012                                 0.00   0.00    0.00     0

 ELEMENT NO   3 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1114.59 1413.53   24    18     0  0.012      3.2      0.0  1413.78     0.00  45.00    0.00

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1171.73 1413.74   24             0.012                                 0.00   0.00    0.00     0

 ELEMENT NO   5 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1175.73 1413.76   24             0.012                                 0.00   0.00    0.00     1

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1193.40 1413.83   24             0.012                                22.50  20.00    0.00     0

 ELEMENT NO   7 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1226.02 1413.95   24             0.012                                 0.00   0.00    0.00     0

 ELEMENT NO   8 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1229.66 1413.97   18    18     0  0.012      2.3      0.0  1413.97     0.00  90.00    0.00
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 ELEMENT NO   9 IS A REACH            *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                RADIUS  ANGLE  ANG PT  MAN H
                               1330.72 1414.34   18              0.012                                 0.00   0.00    0.00     0

 ELEMENT NO  10 IS A SYSTEM HEADWORKS                *                       *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                               1330.72 1414.34   18                                          0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                               F0515P                                                    PAGE    1
                                                    WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         STORM DRAIN LINE B
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.       Q       VEL     VEL    ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV   OF FLOW    ELEV                       HEAD   GRD.EL.   ELEV    DEPTH            DIA    ID NO.       PIER

 L/ELEM      SO                                          SF AVE     HF                  NORM DEPTH                 ZR
*********************************************************************************************************************************

  1001.75  1413.11    4.980  1418.090      10.7    3.41    0.180  1418.270   0.00    1.172            2.00    0.00  0.00   0   0.00

   108.84  0.00377                                       .001906     0.21                   1.244                  0.00

  1110.59  1413.52    4.777  1418.297      10.7    3.41    0.180  1418.477   0.00    1.172            2.00    0.00  0.00   0   0.00

JUNCT STR  0.00250                                       .001422     0.01                                          0.00

  1114.59  1413.53    4.916  1418.446       7.5    2.39    0.088  1418.534   0.00    0.973            2.00    0.00  0.00   0   0.00

    57.14  0.00367                                       .000937     0.05                   1.003                  0.00

  1171.73  1413.74    4.759  1418.499       7.5    2.39    0.088  1418.587   0.00    0.973            2.00    0.00  0.00   0   0.00

     4.00  0.00500                                       .000937     0.00                   0.920                  0.00

  1175.73  1413.76    4.748  1418.508       7.5    2.39    0.088  1418.596   0.00    0.973            2.00    0.00  0.00   0   0.00

    17.67  0.00396                                       .000937     0.02                   0.981                  0.00

  1193.40  1413.83    4.702  1418.532       7.5    2.39    0.088  1418.620   0.00    0.973            2.00    0.00  0.00   0   0.00

    32.62  0.00368                                       .000937     0.03                   1.003                  0.00

  1226.02  1413.95    4.613  1418.563       7.5    2.39    0.088  1418.651   0.00    0.973            2.00    0.00  0.00   0   0.00

JUNCT STR  0.00549                                       .001512     0.01                                          0.00

  1229.66  1413.97    4.631  1418.601       5.2    2.94    0.134  1418.735   0.00    0.878            1.50    0.00  0.00   0   0.00

   101.06  0.00366                                       .002088     0.21                   0.970                  0.00

  1330.72  1414.34    4.473  1418.813       5.2    2.94    0.134  1418.947   0.00    0.878            1.50    0.00  0.00   0   0.00

                          TEI JOB NUMBER 4118
                          STORM DRAIN LINE B
                          100-YEAR
```

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                .         .         .         .         .         .         .         .         .         .         .
    1001.75    .I                   C             H                                                  W  E            .    R
    1008.46    .                                                                                                     .
    1015.18    .                                                                                                     .
    1021.89    .                                                                                                     .
    1028.60    .                                                                                                     .
    1035.32    .                                                                                                     .
    1042.03    .                                                                                                     .
    1048.75    .                                                                                                     .
    1055.46    .                                                                                                     .
    1062.17    .                                                                                                     .
    1068.89    .                                                                                                     .
    1075.60    .                                                                                                     .
    1082.31    .                                                                                                     .
    1089.03    .                                                                                                     .
    1095.74    .                                                                                                     .
    1102.46    .                                                                                                     .
    1109.17    .                                                                                                     .
    1115.88    .       I                   C             H                                              W  E         .    JX
    1122.60    .       I               C                 H                                                 WE        .    R
    1129.31    .                                                                                                     .
    1136.02    .                                                                                                     .
    1142.74    .                                                                                                     .
    1149.45    .                                                                                                     .
    1156.16    .                                                                                                     .
    1162.88    .                                                                                                     .
    1169.59    .                                                                                                     .
    1176.31    .          I                C                 H                                              WE       .    R
    1183.02    .           I               C                 H                                              WE       .    R
    1189.73    .                                                                                                     .
    1196.45    .            I                C                H                                             W E      .    R
    1203.16    .                                                                                                     .
    1209.87    .                                                                                                     .
    1216.59    .                                                                                                     .
    1223.30    .                                                                                                     .
    1230.01    .              I                C                H                                            WE      .    JX
    1236.73    .              I              C          H                                                     W E    .    R
    1243.44    .                                                                                                     .
    1250.16    .                                                                                                     .
    1256.87    .                                                                                                     .
    1263.58    .                                                                                                     .
    1270.30    .                                                                                                     .
    1277.01    .                                                                                                     .
    1283.72    .                                                                                                     .
    1290.44    .                                                                                                     .
    1297.15    .                                                                                                     .
    1303.87    .                                                                                                     .
    1310.58    .                                                                                                     .
    1317.29    .                                                                                                     .
    1324.01    .                                                                                                     .
    1330.72    .                     I              C         H                                                  W E .    R
                .         .         .         .         .         .         .         .         .         .         .

              1413.11   1413.69   1414.28   1414.86   1415.44   1416.03   1416.61   1417.20   1417.78   1418.36   1418.95
```

N O T E S
1. GLOSSARY
   I = INVERT ELEVATION
   C = CRITICAL DEPTH
   W = WATER SURFACE ELEVATION

```
   H = HEIGHT OF CHANNEL
   E = ENERGY GRADE LINE
   X = CURVES CROSSING OVER
   B = BRIDGE ENTRANCE OR EXIT
   Y = WALL ENTRANCE OR EXIT
2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY
```

```
DATE: 10/25/2023
TIME:  9:17
                                                              F0515P
                                         WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                              PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     18    4                        1.50
 CD     24    4                        2.00
 CD     30    4                        2.50
                                                      F 0 5 1 5 P                                                  PAGE NO   3

                                 WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                                   TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                                   PUBLIC STORM DRAIN LINE C

HEADING LINE NO 3 IS -

                                   100-YEAR
                                                      F 0 5 1 5 P                                                  PAGE NO   2

                                 WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                     W S ELEV
                                 1002.50 1413.74   30                                        1420.47

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1184.15 1414.61   30             0.013                                  0.00   0.00    0.00     0

 ELEMENT NO   3 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1188.15 1414.63   30    18     0  0.012      1.7      0.0  1414.88     0.00  45.00    0.00

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1347.50 1415.40   30             0.013                                  0.00   0.00    0.00     0

 ELEMENT NO   5 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1351.50 1415.42   30             0.013                                  0.00   0.00    0.00     1
WARNING - ADJACENT SECTIONS ARE NOT IDENTICAL - SEE SECTION NUMBERS AND CHANNEL DEFINITIONS

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                  RADIUS  ANGLE  ANG PT  MAN H
                                 1544.16 1416.35   24             0.013                                  0.00   0.00    0.00     0

 ELEMENT NO   7 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1548.16 1416.37   24    18     0  0.012      1.8      0.0  1416.62     0.00  45.00    0.00

 ELEMENT NO   8 IS A REACH             *         *     *
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                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                1731.67 1416.92   24              0.013                              0.00   0.00    0.00     0

 ELEMENT NO   9 IS A REACH           *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                1735.47 1416.94   24              0.013                              0.00   0.00    0.00     1

 ELEMENT NO  10 IS A REACH           *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                1919.17 1417.49   24              0.013                              0.00   0.00    0.00     0

 ELEMENT NO  11 IS A JUNCTION        *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                1923.17 1417.51   24    18     0  0.012      1.9      0.0  1418.32     0.00  45.00    0.00^
                                                     F 0 5 1 5 P                                                   PAGE NO   3

                           WATER SURFACE PROFILE - ELEMENT CARD LISTING
WARNING - ADJACENT SECTIONS ARE NOT IDENTICAL - SEE SECTION NUMBERS AND CHANNEL DEFINITIONS

 ELEMENT NO  12 IS A REACH           *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                2139.10 1418.84   18              0.013                              0.00   0.00    0.00     0

 ELEMENT NO  13 IS A REACH           *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                2156.78 1418.95   18              0.013                              0.00   0.00    0.00     0

 ELEMENT NO  14 IS A REACH           *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                              RADIUS  ANGLE  ANG PT  MAN H
                                2157.32 1418.96   18              0.012                              0.00   0.00    0.00     0

 ELEMENT NO  15 IS A SYSTEM HEADWORKS              *                       *
                    U/S DATA   STATION    INVERT  SECT                                         W S ELEV
                                2157.32 1418.96   18                                               0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC ^
LICENSEE: THIENES ENGINEERING                                F0515P                                                  PAGE    1
                                                   WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         PUBLIC STORM DRAIN LINE C
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.       Q       VEL     VEL     ENERGY   SUPER  CRITICAL          HGT/   BASE/    ZL    NO  AVBPR
             ELEV   OF FLOW    ELEV                       HEAD    GRD.EL.   ELEV    DEPTH           DIA    ID NO.       PIER

 L/ELEM      SO                                          SF AVE     HF                  NORM DEPTH                ZR
*******************************************************************************************************************************

  1002.50  1413.74    6.730  1420.470      6.4    1.30    0.026  1420.496   0.00    0.838           2.50    0.00  0.00   0   0.00

   181.65  0.00479                                     .000243     0.04                   0.805                 0.00

  1184.15  1414.61    5.904  1420.514      6.4    1.30    0.026  1420.540   0.00    0.838           2.50    0.00  0.00   0   0.00

JUNCT STR  0.00500                                     .000160     0.00                                         0.00

  1188.15  1414.63    5.902  1420.532      4.7    0.96    0.014  1420.546   0.00    0.714           2.50    0.00  0.00   0   0.00

   159.35  0.00483                                     .000131     0.02                   0.684                 0.00

  1347.50  1415.40    5.153  1420.553      4.7    0.96    0.014  1420.567   0.00    0.714           2.50    0.00  0.00   0   0.00
```

4.00	0.00500					.000131	0.00			0.680			0.00		
1351.50	1415.42	5.134	1420.554	4.7	1.50	0.035	1420.589	0.00	0.763		2.00	0.00	0.00	0	0.00
192.66	0.00483					.000432	0.08			0.750			0.00		
1544.16	1416.35	4.287	1420.637	4.7	1.50	0.035	1420.672	0.00	0.763		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00500					.000254	0.00						0.00		
1548.16	1416.37	4.298	1420.668	2.9	0.92	0.013	1420.681	0.00	0.594		2.00	0.00	0.00	0	0.00
183.51	0.00300					.000164	0.03			0.660			0.00		
1731.67	1416.92	3.779	1420.699	2.9	0.92	0.013	1420.712	0.00	0.594		2.00	0.00	0.00	0	0.00
3.80	0.00526					.000164	0.00			0.570			0.00		
1735.47	1416.94	3.760	1420.700	2.9	0.92	0.013	1420.713	0.00	0.594		2.00	0.00	0.00	0	0.00
183.70	0.00299					.000164	0.03			0.660			0.00		
1919.17	1417.49	3.240	1420.730	2.9	0.92	0.013	1420.743	0.00	0.594		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00500					.000078	0.00						0.00		
1923.17	1417.51	3.229	1420.739	1.0	0.57	0.005	1420.744	0.00	0.373		1.50	0.00	0.00	0	0.00
215.93	0.00616					.000091	0.02			0.350			0.00		

LICENSEE: THIENES ENGINEERING F0515P PAGE 2

WATER SURFACE PROFILE LISTING

TEI JOB NUMBER 4118
PUBLIC STORM DRAIN LINE C
100-YEAR

STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH	NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR
2139.10	1418.84	1.919	1420.759	1.0	0.57	0.005	1420.764	0.00	0.373		1.50	0.00	0.00	0	0.00
17.68	0.00622					.000091	0.00			0.350			0.00		
2156.78	1418.95	1.811	1420.761	1.0	0.57	0.005	1420.766	0.00	0.373		1.50	0.00	0.00	0	0.00
0.54	0.01852					.000077	0.00			0.250			0.00		
2157.32	1418.96	1.801	1420.761	1.0	0.57	0.005	1420.766	0.00	0.373		1.50	0.00	0.00	0	0.00

TEI JOB NUMBER 4118
PUBLIC STORM DRAIN LINE C
100-YEAR

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             .         .         .         .         .         .         .         .         .         .         .
  1002.50   .I          C                   H                                                       WE     .    R
  1026.07   .                                                                                              .
  1049.64   .                                                                                              .
```

```
    1073.20    .                                                                                                     .
    1096.77    .                                                                                                     .
    1120.34    .                                                                                                     .
    1143.91    .                                                                                                     .
    1167.47    .                                                                                                     .
    1191.04    .            I           C                      H                                                X    .    JX
    1214.61    .            I         C                         H                                               X    .    R
    1238.18    .                                                                                                     .
    1261.75    .                                                                                                     .
    1285.31    .                                                                                                     .
    1308.88    .                                                                                                     .
    1332.45    .                                                                                                     .
    1356.02    .                       I         C                         H                                    WE   .    R
    1379.58    .                       I          C                 H                                           WE   .    R
    1403.15    .                                                                                                     .
    1426.72    .                                                                                                     .
    1450.29    .                                                                                                     .
    1473.86    .                                                                                                     .
    1497.42    .                                                                                                     .
    1520.99    .                                                                                                     .
    1544.56    .                                     I          C                H                                X  .    JX
    1568.13    .                                     I       C                   H                                X  .    R
    1591.69    .                                                                                                     .
    1615.26    .                                                                                                     .
    1638.83    .                                                                                                     .
    1662.40    .                                                                                                     .
    1685.96    .                                                                                                     .
    1709.53    .                                                                                                     .
    1733.10    .                                             I       C                   H                         X .    R
    1756.67    .                                             I       C                    H                        X .    R
    1780.24    .                                                                                                     .
    1803.80    .                                                                                                     .
    1827.37    .                                                                                                     .
    1850.94    .                                                                                                     .
    1874.51    .                                                                                                     .
    1898.07    .                                                                                                     .
    1921.64    .                                                     I       C                   H                 X .    JX
    1945.21    .                                                     I    C                H                       X .    R
    1968.78    .                                                                                                     .
    1992.35    .                                                                                                     .
    2015.91    .                                                                                                     .
    2039.48    .                                                                                                     .
    2063.05    .                                                                                                     .
    2086.62    .                                                                                                     .
    2110.18    .                                                                                                     .
    2133.75    .                                                                                                     .
    2157.32    .                                                                        I    C               H     X .    R
                .         .         .         .         .         .         .         .         .         .         .

              1413.74   1414.44   1415.15   1415.85   1416.55   1417.25   1417.96   1418.66   1419.36   1420.06   1420.77
```

N O T E S

1. GLOSSARY
   - I = INVERT ELEVATION
   - C = CRITICAL DEPTH
   - W = WATER SURFACE ELEVATION
   - H = HEIGHT OF CHANNEL
   - E = ENERGY GRADE LINE
   - X = CURVES CROSSING OVER
   - B = BRIDGE ENTRANCE OR EXIT

Y = WALL ENTRANCE OR EXIT
2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY↑

```
DATE: 10/25/2023
TIME:  7:12
                                                                  F0515P
                                          WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                              PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD     18    4                        1.50
 CD     24    4                        2.00
 CD     30    4                        2.50
                                                         F 0 5 1 5 P                                                    PAGE NO   3

                            WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                              TEI JOB NUMBER 4118

HEADING LINE NO 2 IS -

                              STORM DRAIN LINE D

HEADING LINE NO 3 IS -

                              100-YEAR
                                                         F 0 5 1 5 P                                                    PAGE NO   2

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                        W S ELEV
                                 1005.00 1413.27   30                                             0.00

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                    RADIUS  ANGLE  ANG PT  MAN H
                                 1038.91 1413.43   30             0.012                                    0.00   0.00    0.00     0

 ELEMENT NO   3 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                    RADIUS  ANGLE  ANG PT  MAN H
                                 1042.91 1413.44   30             0.012                                    0.00   0.00    0.00     1

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                    RADIUS  ANGLE  ANG PT  MAN H
                                 1055.77 1413.50   30             0.012                                    0.00   0.00    0.00     0

 ELEMENT NO   5 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1058.37 1413.52   24    24     0  0.012     11.5      0.0  1413.52     0.00  90.00    0.00

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                    RADIUS  ANGLE  ANG PT  MAN H
                                 1164.63 1414.01   24             0.012                                    0.00   0.00    0.00     0

 ELEMENT NO   7 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1167.57 1414.03   24    24     0  0.012      3.2      0.0  1414.03     0.00  90.00    0.00

 ELEMENT NO   8 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                    RADIUS  ANGLE  ANG PT  MAN H
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                              1273.83 1414.52   24             0.012                              0.00   0.00    0.00     0

 ELEMENT NO   9 IS A JUNCTION         *         *     *     *                  *                    *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                              1276.77 1414.54   18    18     0  0.012      4.2      0.0  1414.54     0.00  90.00    0.00

 ELEMENT NO  10 IS A REACH            *         *     *
                    U/S DATA   STATION    INVERT  SECT               N                             RADIUS  ANGLE  ANG PT  MAN H
                              1383.03 1415.03   18             0.012                              0.00   0.00    0.00     0

 ELEMENT NO  11 IS A SYSTEM HEADWORKS                 *                       *
                    U/S DATA   STATION    INVERT  SECT                                    W S ELEV
                              1383.03 1415.03   18                                            0.00
                                                  F 0 5 1 5 P                                                       PAGE NO   3

                            WATER SURFACE PROFILE - ELEMENT CARD LISTING
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                               F0515P                                                       PAGE    1
                                                   WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER 4118
                         STORM DRAIN LINE D
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.        Q       VEL     VEL     ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL    NO  AVBPR
             ELEV   OF FLOW    ELEV                        HEAD    GRD.EL.   ELEV    DEPTH            DIA    ID NO.        PIER

 L/ELEM      SO                                           SF AVE     HF                  NORM DEPTH                 ZR
*****************************************************************************************************************************************

  1005.00  1413.27    1.718  1414.988      25.4    7.06    0.775  1415.763   0.00    1.718            2.50    0.00  0.00   0   0.00

     6.10  0.00472                                        .004812     0.03                   1.740                  0.00

  1011.10  1413.30    1.740  1415.039      25.4    6.96    0.753  1415.792   0.00    1.718            2.50    0.00  0.00   0   0.00

    27.81  0.00472                                        .004729     0.13                   1.740                  0.00

  1038.91  1413.43    1.740  1415.170      25.4    6.96    0.753  1415.923   0.00    1.718            2.50    0.00  0.00   0   0.00

     4.00  0.00250                                        .004509     0.02                   2.500                  0.00

  1042.91  1413.44    1.808  1415.248      25.4    6.68    0.693  1415.941   0.00    1.718            2.50    0.00  0.00   0   0.00

    12.86  0.00467                                        .004360     0.06                   1.750                  0.00

  1055.77  1413.50    1.784  1415.284      25.4    6.78    0.713  1415.997   0.00    1.718            2.50    0.00  0.00   0   0.00

JUNCT STR  0.00769                                        .003825     0.01                                          0.00

  1058.37  1413.52    2.771  1416.291      13.9    4.42    0.304  1416.595   0.00    1.343            2.00    0.00  0.00   0   0.00

   106.26  0.00461                                        .003217     0.34                   1.400                  0.00

  1164.63  1414.01    2.623  1416.633      13.9    4.42    0.304  1416.937   0.00    1.343            2.00    0.00  0.00   0   0.00

JUNCT STR  0.00680                                        .002561     0.01                                          0.00

  1167.57  1414.03    2.859  1416.889      10.7    3.41    0.180  1417.069   0.00    1.172            2.00    0.00  0.00   0   0.00

   106.26  0.00461                                        .001906     0.20                   1.164                  0.00
```

```
  1273.83  1414.52    2.571  1417.091      10.7    3.41    0.180  1417.271   0.00    1.172            2.00    0.00  0.00   0   0.00

JUNCT STR  0.00680                                      .002584     0.01                                         0.00

  1276.77  1414.54    2.717  1417.257       6.5    3.68    0.210  1417.467   0.00    0.986            1.50    0.00  0.00   0   0.00

   106.26  0.00461                                      .003263     0.35                     1.050               0.00

  1383.03  1415.03    2.574  1417.604       6.5    3.68    0.210  1417.814   0.00    0.986            1.50    0.00  0.00   0   0.00
```

```
                          TEI JOB NUMBER 4118
                          STORM DRAIN LINE D
                          100-YEAR


               .         .         .         .         .         .         .         .         .         .         .
   1005.00    .I                                    X                EH                                             .    R
   1012.71    .I                                     X                X                                             .    R
   1020.43    .                                                                                                     .
   1028.14    .                                                                                                     .
   1035.86    .                                                                                                     .
   1043.57    .   I                                     X                X                                          .    R
   1051.29    .   I                                     C W              X                                          .    R
   1059.00    .     I                                    C W               X                                        .    JX
   1066.72    .     I                            C             H                W      E                            .    R
   1074.43    .                                                                                                     .
   1082.15    .                                                                                                     .
   1089.86    .                                                                                                     .
   1097.58    .                                                                                                     .
   1105.29    .                                                                                                     .
   1113.01    .                                                                                                     .
   1120.72    .                                                                                                     .
   1128.44    .                                                                                                     .
   1136.15    .                                                                                                     .
   1143.87    .                                                                                                     .
   1151.58    .                                                                                                     .
   1159.30    .                                                                                                     .
   1167.01    .                I                            C              H             W     E                    .    JX
   1174.73    .                I                         C                 H                  W   E                 .    R
   1182.44    .                                                                                                     .
   1190.16    .                                                                                                     .
   1197.87    .                                                                                                     .
   1205.59    .                                                                                                     .
   1213.30    .                                                                                                     .
   1221.02    .                                                                                                     .
   1228.73    .                                                                                                     .
   1236.45    .                                                                                                     .
   1244.16    .                                                                                                     .
   1251.88    .                                                                                                     .
   1259.59    .                                                                                                     .
   1267.31    .                                                                                                     .
   1275.02    .                           I                         C                 H            W   E            .    JX
   1282.74    .                           I                     C          H                          W    E        .    R
   1290.45    .                                                                                                     .
   1298.17    .                                                                                                     .
   1305.88    .                                                                                                     .
   1313.60    .                                                                                                     .
   1321.31    .                                                                                                     .
   1329.03    .                                                                                                     .
   1336.74    .                                                                                                     .
```

```
    1344.46    .                                                                                                   .
    1352.17    .                                                                                                   .
    1359.89    .                                                                                                   .
    1367.60    .                                                                                                   .
    1375.32    .                                                                                                   .
    1383.03    .                                       I                     C          H                      W   E .    R
                .         .         .         .         .         .         .         .         .         .         .

              1413.27   1413.72   1414.18   1414.63   1415.09   1415.54   1416.00   1416.45   1416.90   1417.36   1417.81
```

N O T E S

1. GLOSSARY
   - I = INVERT ELEVATION
   - C = CRITICAL DEPTH
   - W = WATER SURFACE ELEVATION
   - H = HEIGHT OF CHANNEL
   - E = ENERGY GRADE LINE
   - X = CURVES CROSSING OVER
   - B = BRIDGE ENTRANCE OR EXIT
   - Y = WALL ENTRANCE OR EXIT
2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY

```
DATE: 10/25/2023
TIME:  9:47
                                                            F0515P
                                        WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                              PAGE    1

 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE     ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH               DROP

 CD     10    4                        0.83
 CD     12    4                        1.00
 CD     18    4                        1.50
 CD     24    4                        2.00
                                                     F 0 5 1 5 P                                                      PAGE NO   3

                              WATER SURFACE PROFILE - TITLE CARD LISTING

HEADING LINE NO 1 IS -

                                TEI JOB NUMBER

HEADING LINE NO 2 IS -

                                STORM DRAIN LINE E

HEADING LINE NO 3 IS -

                                100-YEAR
                                                     F 0 5 1 5 P                                                      PAGE NO   2

                              WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *
                    U/S DATA   STATION    INVERT  SECT                                      W S ELEV
                                 1014.55 1414.83   24                                        1419.87

 ELEMENT NO   2 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1032.23 1414.87   24             0.012                                22.50  45.00    0.00     0

 ELEMENT NO   3 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1036.23 1414.88   24             0.012                                 0.00   0.00    0.00     1

 ELEMENT NO   4 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1052.96 1414.91   24             0.012                                 0.00   0.00    0.00     0

 ELEMENT NO   5 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1056.96 1414.92   24             0.012                                 0.00   0.00    0.00     1

 ELEMENT NO   6 IS A REACH             *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                 RADIUS  ANGLE  ANG PT  MAN H
                                 1191.82 1415.19   24             0.012                                 0.00   0.00    0.00     0

 ELEMENT NO   7 IS A JUNCTION          *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1191.82 1415.19   24    12     0  0.012     1.2      0.0  1415.69     0.00  45.00    0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
```

```
 ELEMENT NO   8 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1315.09 1415.43   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO   9 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1319.09 1415.44   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  10 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1366.89 1415.44   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  11 IS A JUNCTION       *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1366.89 1415.54   24    12     0  0.012      1.6      0.0  1415.79     0.00  45.00    0.00
```


WATER SURFACE PROFILE - ELEMENT CARD LISTING

```
 ELEMENT NO  12 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1454.05 1415.71   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  13 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1490.04 1415.78   24             0.012                                    22.50  45.00    0.00     0

 ELEMENT NO  14 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1597.50 1416.00   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  15 IS A JUNCTION       *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1601.50 1416.50   24    10     0  0.012      1.4      0.0  1416.53     0.00  90.00    0.00

 ELEMENT NO  16 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 1931.35 1418.87   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  17 IS A JUNCTION       *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 1935.35 1418.88   24    10     0  0.012      1.3      0.0  1419.01     0.00  90.00    0.00

 ELEMENT NO  18 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 2243.35 1417.29   24             0.012                                     0.00   0.00    0.00     0
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING

 ELEMENT NO  19 IS A JUNCTION       *         *     *     *                  *                   *               *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                                 2247.35 1417.30   24    10     0  0.012      1.0      0.0  1417.43     0.00  90.00    0.00

 ELEMENT NO  20 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 2362.43 1417.53   24             0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  21 IS A REACH          *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                 2397.77 1417.60   24             0.012                                    22.50  45.00    0.00     0
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                         WATER SURFACE PROFILE - ELEMENT CARD LISTING

 ELEMENT NO  22 IS A REACH            *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                2504.87 1417.81   24              0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  23 IS A REACH            *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                2512.72 1417.83   24              0.012                                    22.50  20.00    0.00     0

 ELEMENT NO  24 IS A REACH            *         *     *
                    U/S DATA   STATION    INVERT  SECT              N                                     RADIUS  ANGLE  ANG PT  MAN H
                                2543.81 1417.89   24              0.012                                     0.00   0.00    0.00     0

 ELEMENT NO  25 IS A SYSTEM HEADWORKS                 *                      *
                    U/S DATA   STATION    INVERT  SECT                                          W S ELEV
                                2543.81 1417.89   24                                                0.00
NO EDIT ERRORS ENCOUNTERED-COMPUTATION IS NOW BEGINNING
** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVERT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
LICENSEE: THIENES ENGINEERING                                F0515P                                                       PAGE    1
                                                      WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER
                         STORM DRAIN LINE E
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.        Q       VEL      VEL     ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV  OF FLOW    ELEV                          HEAD   GRD.EL.   ELEV    DEPTH             DIA    ID NO.       PIER

 L/ELEM      SO                                            SF AVE     HF                    NORM DEPTH                 ZR
*************************************************************************************************************************************

  1014.55  1414.83    5.040  1419.870      11.6    3.69    0.212  1420.082   0.00    1.223           2.00    0.00  0.00   0   0.00

    17.68  0.00226                                       .002240    0.04                   1.630                  0.00

  1032.23  1414.87    5.070  1419.940      11.6    3.69    0.212  1420.152   0.00    1.223           2.00    0.00  0.00   0   0.00

     4.00  0.00250                                       .002240    0.01                   1.550                  0.00

  1036.23  1414.88    5.079  1419.959      11.6    3.69    0.212  1420.171   0.00    1.223           2.00    0.00  0.00   0   0.00

    16.73  0.00179                                       .002240    0.04                   2.000                  0.00

  1052.96  1414.91    5.087  1419.997      11.6    3.69    0.212  1420.209   0.00    1.223           2.00    0.00  0.00   0   0.00

     4.00  0.00250                                       .002240    0.01                   1.550                  0.00

  1056.96  1414.92    5.096  1420.016      11.6    3.69    0.212  1420.228   0.00    1.223           2.00    0.00  0.00   0   0.00

   134.86  0.00200                                       .002240    0.30                   1.770                  0.00

  1191.82  1415.19    5.128  1420.318      11.6    3.69    0.212  1420.530   0.00    1.223           2.00    0.00  0.00   0   0.00

JUNCT STR  0.00000                                       .002020    0.00                                          0.00

  1191.82  1415.19    5.199  1420.389      10.4    3.31    0.170  1420.559   0.00    1.155           2.00    0.00  0.00   0   0.00

   123.27  0.00195                                       .001801    0.22                   1.571                  0.00

  1315.09  1415.43    5.180  1420.610      10.4    3.31    0.170  1420.780   0.00    1.155           2.00    0.00  0.00   0   0.00
```

4.00	0.00250					.001801	0.01			1.412			0.00		
1319.09	1415.44	5.178	1420.618	10.4	3.31	0.170	1420.788	0.00	1.155		2.00	0.00	0.00	0	0.00
47.80	0.00000					.001801	0.09			0.000			0.00		
1366.89	1415.44	5.264	1420.704	10.4	3.31	0.170	1420.874	0.00	1.155		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00000					.001545	0.00						0.00		
1366.89	1415.54	5.238	1420.778	8.8	2.80	0.122	1420.900	0.00	1.058		2.00	0.00	0.00	0	0.00
87.16	0.00195					.001289	0.11			1.370			0.00		

WATER SURFACE PROFILE LISTING

TEI JOB NUMBER
STORM DRAIN LINE E
100-YEAR

STATION / L/ELEM	INVERT ELEV / SO	DEPTH OF FLOW	W.S. ELEV	Q	VEL	VEL HEAD / SF AVE	ENERGY GRD.EL. / HF	SUPER ELEV	CRITICAL DEPTH	NORM DEPTH	HGT/ DIA	BASE/ ID NO.	ZL / ZR	NO PIER	AVBPR
1454.05	1415.71	5.180	1420.890	8.8	2.80	0.122	1421.012	0.00	1.058		2.00	0.00	0.00	0	0.00
35.99	0.00194					.001289	0.05			1.370			0.00		
1490.04	1415.78	5.174	1420.954	8.8	2.80	0.122	1421.076	0.00	1.058		2.00	0.00	0.00	0	0.00
107.46	0.00205					.001289	0.14			1.343			0.00		
1597.50	1416.00	5.092	1421.092	8.8	2.80	0.122	1421.214	0.00	1.058		2.00	0.00	0.00	0	0.00
JUNCT STR	0.12500					.001100	0.00						0.00		
1601.50	1416.50	4.668	1421.168	7.4	2.36	0.086	1421.254	0.00	0.967		2.00	0.00	0.00	0	0.00
329.85	0.00719					.000912	0.30			0.822			0.00		
1931.35	1418.87	2.599	1421.469	7.4	2.36	0.086	1421.555	0.00	0.967		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00250					.000766	0.00						0.00		
1935.35	1418.88	2.647	1421.527	6.1	1.94	0.059	1421.586	0.00	0.874		2.00	0.00	0.00	0	0.00
308.00	-.00516					.000620	0.19			0.000			0.00		
2243.35	1417.29	4.428	1421.718	6.1	1.94	0.059	1421.777	0.00	0.874		2.00	0.00	0.00	0	0.00
JUNCT STR	0.00250					.000527	0.00						0.00		
2247.35	1417.30	4.455	1421.755	5.1	1.62	0.041	1421.796	0.00	0.796		2.00	0.00	0.00	0	0.00
115.08	0.00200					.000433	0.05			0.960			0.00		
2362.43	1417.53	4.275	1421.805	5.1	1.62	0.041	1421.846	0.00	0.796		2.00	0.00	0.00	0	0.00
35.34	0.00198					.000433	0.02			0.960			0.00		

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  2397.77  1417.60    4.226  1421.826       5.1    1.62    0.041  1421.867   0.00    0.796            2.00    0.00  0.00   0   0.00

   107.10  0.00196                                       .000433     0.05                    0.962                  0.00

  2504.87  1417.81    4.062  1421.872       5.1    1.62    0.041  1421.913   0.00    0.796            2.00    0.00  0.00   0   0.00

     7.85  0.00255                                       .000433     0.00                    0.892                  0.00
LICENSEE: THIENES ENGINEERING                                  F0515P                                                    PAGE    3
                                                   WATER SURFACE PROFILE LISTING
                         TEI JOB NUMBER
                         STORM DRAIN LINE E
                         100-YEAR

 STATION    INVERT   DEPTH     W.S.        Q       VEL     VEL     ENERGY   SUPER  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV   OF FLOW    ELEV                        HEAD   GRD.EL.   ELEV    DEPTH             DIA    ID NO.       PIER

 L/ELEM      SO                                           SF AVE     HF                   NORM DEPTH                ZR
*************************************************************************************************************************************

  2512.72  1417.83    4.050  1421.880       5.1    1.62    0.041  1421.921   0.00    0.796            2.00    0.00  0.00   0   0.00

    31.09  0.00193                                       .000433     0.01                    0.970                  0.00

  2543.81  1417.89    4.003  1421.893       5.1    1.62    0.041  1421.934   0.00    0.796            2.00    0.00  0.00   0   0.00

                          TEI JOB NUMBER
                          STORM DRAIN LINE E
                          100-YEAR


                 .         .         .         .         .         .         .         .         .         .         .
    1014.55    .I               C          H                                        W  E                        .    R
    1045.76    .I               C          H                                         W  E                       .    R
    1076.97    .I               C          H                                          W  E                      .    R
    1108.18    . I               C          H                                         W  E                      .    R
    1139.39    . I               C          H                                          W E                      .    R
    1170.60    .                                                                                                .
    1201.81    .     I               C          H                                          W  E                 .    JX
    1233.02    .     I              C           H                                           W E                 .    R
    1264.23    .                                                                                                .
    1295.43    .                                                                                                .
    1326.64    .        I               C           H                                           W E             .    R
    1357.85    .        I               C           H                                           W E             .    R
    1389.06    .        I               C           H                                            W  E           .    JX
    1420.27    .         I              C             H                                           W E           .    R
    1451.48    .                                                                                                .
    1482.69    .            I              C             H                                          W E         .    R
    1513.90    .             I              C             H                                          WE         .    R
    1545.11    .                                                                                                .
    1576.32    .                                                                                                .
    1607.53    .                I              C             H                                          WE      .    JX
    1638.74    .                       I             C             H                                     WE     .    R
    1669.95    .                                                                                                .
    1701.16    .                                                                                                .
    1732.37    .                                                                                                .
    1763.58    .                                                                                                .
    1794.78    .                                                                                                .
    1825.99    .                                                                                                .
    1857.20    .                                                                                                .
    1888.41    .                                                                                                .
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    1919.62    .                                                                                                     .
    1950.83    .                                                        I             C              H       WE      .    JX
    1982.04    .                                                         I           C               H        WE     .    R
    2013.25    .                                                                                                     .
    2044.46    .                                                                                                     .
    2075.67    .                                                                                                     .
    2106.88    .                                                                                                     .
    2138.09    .                                                                                                     .
    2169.30    .                                                                                                     .
    2200.51    .                                                                                                     .
    2231.72    .                                                                                                     .
    2262.93    .                                  I           C               H                                 WE   .    JX
    2294.13    .                                  I          C                H                                  WE  .    R
    2325.34    .                                                                                                     .
    2356.55    .                                                                                                     .
    2387.76    .                                      I          C                H                               X  .    R
    2418.97    .                                      I           C                H                              WE .    R
    2450.18    .                                                                                                     .
    2481.39    .                                                                                                     .
    2512.60    .                                         I           C                H                            X .    R
    2543.81    .                                          I          C                H                            X .    R
                .         .         .         .         .         .         .         .         .         .         .

              1414.83   1415.54   1416.25   1416.96   1417.67   1418.38   1419.09   1419.80   1420.51   1421.22   1421.93
```

N O T E S

1. GLOSSARY
   - I = INVERT ELEVATION
   - C = CRITICAL DEPTH
   - W = WATER SURFACE ELEVATION
   - H = HEIGHT OF CHANNEL
   - E = ENERGY GRADE LINE
   - X = CURVES CROSSING OVER
   - B = BRIDGE ENTRANCE OR EXIT
   - Y = WALL ENTRANCE OR EXIT
2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY

Lovett Menifee Logistics - Riverside County
Riprap Apron Analysis

Parameters

Variable	Description	Value
Q	design discharge, (cfs)	320.20
D	culvert rise (rectangular), (ft)	6.00
B	culvert span (rectangular), (ft)	10.00
V	culvert exit velocity, (ft/s)	5.36

Urban Drainage and Flood Control District in Denver Colorado (UD&FCD, 2004)

Variable	Description	Value
D50	riprap size, (ft)	0.46
Q	design discharge, (cfs)	320.20
D	culvert rise (rectangular), (ft)	6.00
B	culvert span (rectangular), (ft)	10.00
TW	tailwater depth, (ft)	2.40

D50 = 0.014*D*(Q/(B*D^1.5))*(D/TW)
TW = assumed at low end of applicable range to maximize D50

Berry (1948) and Peterka (1978)

Variable	Description	Value
D50	riprap size, (ft)	0.36
a	unit conversion constant, (0.0126)	0.0126
V	culvert exit velocity, (ft/s)	5.36

D50 = a*V^2

HEC-14 (Searcy (1967)) and HEC-11 (Brown and Clyde (1989))

Variable	Description	Value
D50	riprap size, (ft)	0.19
S	riprap specific gravity	2.65
V	culvert exit velocity, (ft/s)	5.36
g	acceleration due to gravity, (32.2 ft/sec^2)	32.20

D50 = (0.692/(S-1))*(V^2/2g)

Bohan - Minimum Tailwater (1970)

Variable	Description	Value
D50	riprap size, (ft)	0.58
D	culvert rise (rectangular), (ft)	6.00
Fro	froude number at the outlet defined as Vo/(gD)^0.5	0.39
Vo	culvert exit velocity, (ft/s)	5.36
g	acceleration due to gravity, (32.2 ft/sec^2)	32.20

D50 = 0.25*D*Fro

Bohan - Maximum Tailwater (1970)

Variable	Description	Value
D50	riprap size, (ft)	-0.32
D	culvert rise (rectangular), (ft)	6.00
Fro	froude number at the outlet defined as Vo/(gD)^0.5	0.39
Vo	culvert exit velocity, (ft/s)	5.36
g	acceleration due to gravity, (32.2 ft/sec^2)	32.20

D50 = D*(0.25*Fro - 0.15)

Fletcher and Grace (1972)

Variable	Description	Value
D50	riprap size, (ft)	1.67
Q	design discharge, (cfs)	320.20
D	culvert rise (rectangular), (ft)	6.00
TW	tailwater depth, (ft)	2.40

D50 = 0.020*D*((Q/(D^2.5))^(4/3))*(D/TW)
TW = assumed at low end of applicable range to maximize D50

Maximum D50 from the Applicable Methods

Variable	Description	Value
D50	riprap size, (ft)	1.67
	riprap class	6
L	apron length, (ft)	48.00
H	apron depth, (ft)	3.35
Wo	apron width (at storm drain outlet), (ft)	22.00
W	apron width (at end), (ft)	54.00

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Hydraulic Design of Energy Dissipators for Culverts and Channels

National Highway Institute

CHAPTER 10: RIPRAP BASINS AND APRONS

Riprap is a material that has long been used to protect against the forces of water. The material can be pit-run (as provided by the supplier) or specified (standard or special). State DOTs have standard specifications for a number of classes (sizes or gradations) of riprap. Suppliers maintain an inventory of frequently used classes. Special gradations of riprap are produced on-demand and are therefore more expensive than both pit-run and standard classes.

This chapter includes discussion of both riprap aprons and riprap basin energy dissipators. Both can be used at the outlet of a culvert or chute (channel) by themselves or at the exit of a stilling basin or other energy dissipator to protect against erosion downstream. Section 10.1 provides a design procedure for the riprap basin energy dissipator that is based on armoring a pre-formed scour hole. The riprap for this basin is a special gradation. Section 10.2 includes discussion of riprap aprons that provide a flat armored surface as the only dissipator or as additional protection at the exit of other dissipators. The riprap for these aprons is generally from State DOT standard classes. Section 10.3 provides additional discussion of riprap placement downstream of energy dissipators.

10.1 RIPRAP BASIN

The design procedure for the riprap basin is based on research conducted at Colorado State University (Simons, et al., 1970; Stevens and Simons, 1971) that was sponsored by the Wyoming Highway Department. The recommended riprap basin that is shown on Figure 10.1 and Figure 10.2 has the following features:

- The basin is pre-shaped and lined with riprap that is at least $2D_{50}$ thick.
- The riprap floor is constructed at the approximate depth of scour, h_s, that would occur in a thick pad of riprap. The h_s/D_{50} of the material should be greater than 2.
- The length of the energy dissipating pool, L_s, is $10h_s$, but no less than $3W_o$; the length of the apron, L_A, is $5h_s$, but no less than W_o. The overall length of the basin (pool plus apron), L_B, is $15h_s$, but no less than $4W_o$.
- A riprap cutoff wall or sloping apron can be constructed if downstream channel degradation is anticipated as shown in Figure 10.1.

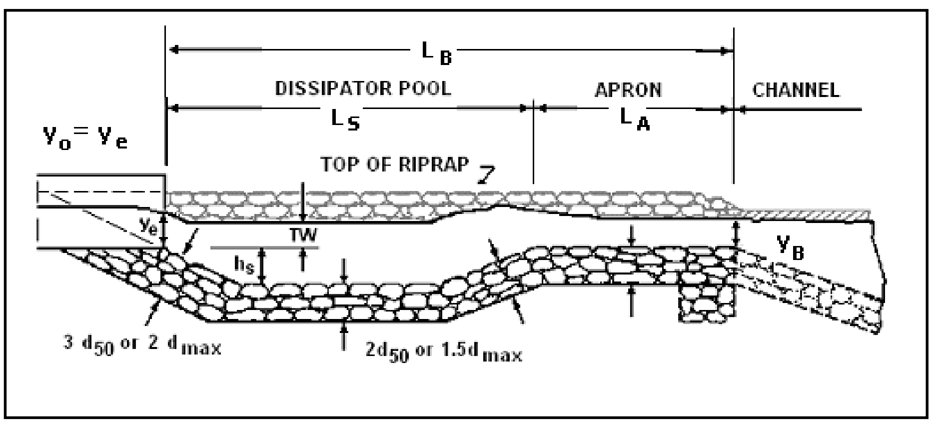


Figure 10.1. Profile of Riprap Basin

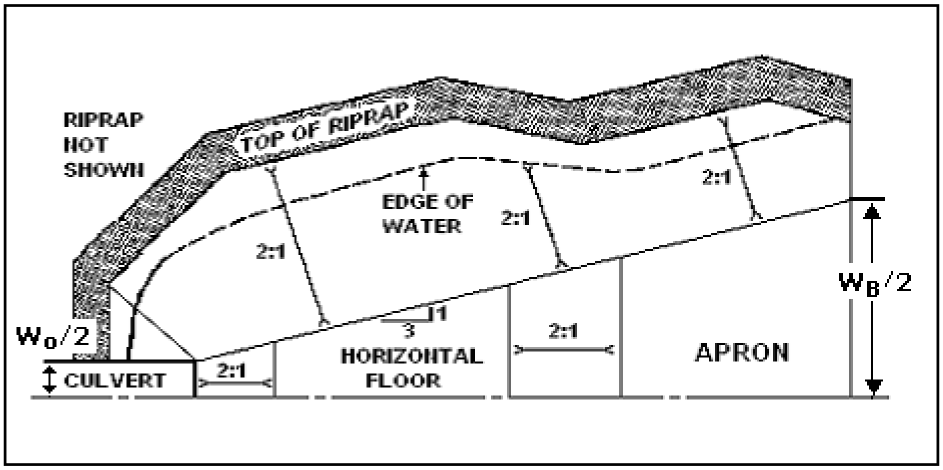


Figure 10.2. Half Plan of Riprap Basin

10.1.1 Design Development

Tests were conducted with pipes from 152 mm (6 in) to 914 mm (24 in) and 152 mm (6 in) high model box culverts from 305 mm (12 in) to 610 mm (24 in) in width. Discharges ranged from 0.003 to 2.8 m^3/s (0.1 to 100 ft^3/s). Both angular and rounded rock with an average size, D_{50}, ranging from 6 mm (1.4 in) to 177 mm (7 in) and gradation coefficients ranging from 1.05 to 2.66 were tested. Two pipe slopes were considered, 0 and 3.75%. In all, 459 model basins were studied. The following conclusions were drawn from an analysis of the experimental data and observed operating characteristics:

- The scour hole depth, h_s; length, L_s; and width, W_s, are related to the size of riprap, D_{50}; discharge, Q; brink depth, y_o; and tailwater depth, TW.
- Rounded material performs approximately the same as angular rock.
- For low tailwater ($TW/y_o < 0.75$), the scour hole functions well as an energy dissipator if $h_s/D_{50} > 2$. The flow at the culvert brink plunges into the hole, a jump forms and flow is generally well dispersed.
- For high tailwater ($TW/y_o > 0.75$), the high velocity core of water passes through the basin and diffuses downstream. As a result, the scour hole is shallower and longer.
- The mound of material that forms downstream contributes to the dissipation of energy and reduces the size of the scour hole. If the mound is removed, the scour hole enlarges somewhat.

Plots were constructed of h_s/y_e versus $V_o/ (gy_e)^{1/2}$ with D_{50}/y_e as the third variable. Equivalent brink depth, y_e, is defined to permit use of the same design relationships for rectangular and circular culverts. For rectangular culverts, $y_e = y_o$ (culvert brink depth). For circular culverts, $y_e = (A/2)^{1/2}$, where A is the brink area.

Anticipating that standard or modified end sections would not likely be used when a riprap basin is located at a culvert outlet, the data with these configurations were not used to develop the design relationships. This assumption reduced the number of applicable runs to 346. A total of 128 runs had a D_{50}/y_e of less than 0.1. These data did not exhibit relationships that appeared useful for design and were eliminated. An additional 69 runs where $h_s/D_{50}<2$ were also eliminated by the authors of this edition of HEC 14. These runs were not considered reliable for design, especially those with $h_s = 0$. Therefore, the final design development used 149 runs from the study. Of these, 106 were for pipe culverts and 43 were for box culverts. Based on these data, two design relationships are presented here: an envelope design and a best fit design.

To balance the need for avoiding an underdesigned basin against the costs of oversizing a basin, an envelope design relationship in the form of Equation 10.1 and Equation 10.2 was developed. These equations provide a design envelope for the experimental data equivalent to the design figure (Figure XI-2) provided in the previous edition of HEC 14 (Corry, et al., 1983). Equations 10.1 and 10.2, however, improve the fit to the experimental data reducing the root-mean-square (RMS) error from 1.24 to 0.83.

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o \qquad (10.1)$$

where,

- h_s = dissipator pool depth, m (ft)
- y_e = equivalent brink (outlet) depth, m (ft)
- D_{50} = median rock size by weight, m (ft)
- C_o = tailwater parameter

The tailwater parameter, C_o, is defined as:

$$\begin{array}{ll} C_o = 1.4 & TW/y_e < 0.75 \\ C_o = 4.0(TW/y_e) - 1.6 & 0.75 < TW/y_e < 1.0 \\ C_o = 2.4 & 1.0 < TW/y_e \end{array} \qquad (10.2)$$

A best fit design relationship that minimizes the RMS error when applied to the experimental data was also developed. Equation 10.1 still applies, but the description of the tailwater parameter, C_o, is defined in Equation 10.3. The best fit relationship for Equations 10.1 and 10.3 exhibits a RMS error on the experimental data of 0.56.

$$\begin{array}{ll} C_o = 2.0 & TW/y_e < 0.75 \\ C_o = 4.0(TW/y_e) - 1.0 & 0.75 < TW/y_e < 1.0 \\ C_o = 3.0 & 1.0 < TW/y_e \end{array} \qquad (10.3)$$

Use of the envelope design relationship (Equations 10.1 and 10.2) is recommended when the consequences of failure at or near the design flow are severe. Use of the best fit design relationship (Equations 10.1 and 10.3) is recommended when basin failure may easily be addressed as part of routine maintenance. Intermediate risk levels can be adopted by the use of intermediate values of C_o.

10.1.2 Basin Length

Frequency tables for both box culvert data and pipe culvert data of relative length of scour hole ($L_s/h_s < 6$, $6 < L_s/h_s < 7$, $7 < L_s/h_s < 8$ . . . $25 < L_s/h_s < 30$), with relative tailwater depth TW/y_e in increments of 0.03 m (0.1 ft) as a third variable, were constructed using data from 346 experimental runs. For box culvert runs L_s/h_s was less than 10 for 78% of the data and L_s/h_s was less than 15 for 98% of the data. For pipe culverts, L_s/h_s was less than 10 for 91% of the data and, L_s/h_s was less than 15 for all data. A 3:1 flare angle is recommended for the basins walls. This angle will provide a sufficiently wide energy dissipating pool for good basin operation.

10.1.3 High Tailwater

Tailwater influenced formation of the scour hole and performance of the dissipator. For tailwater depths less than 0.75 times the brink depth, scour hole dimensions were unaffected by tailwater. Above this the scour hole became longer and narrower. The tailwater parameter defined in Equations 10.2 and 10.3 captures this observation. In addition, under high tailwater conditions, it is appropriate to estimate the attenuation of the flow velocity downstream of the culvert outlet using Figure 10.3. This attenuation can be used to determine the extent of riprap protection required. HEC 11 (Brown and Clyde, 1989) or the method provided in Section 10.3 can be used for sizing riprap.

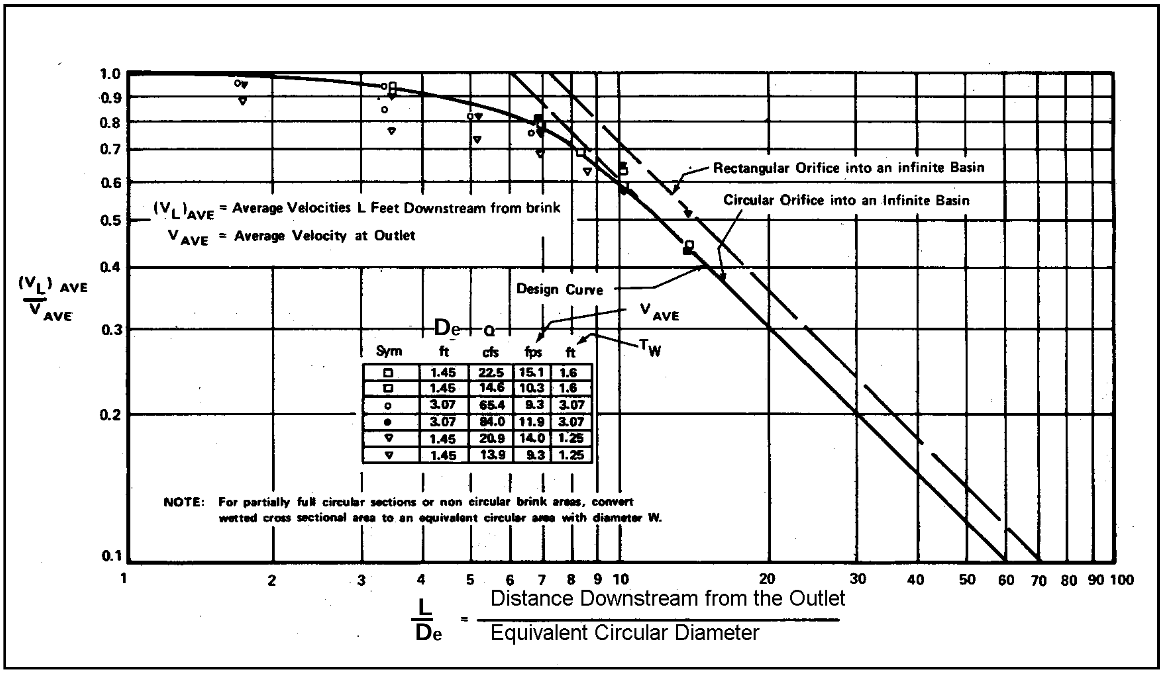


Figure 10.3. Distribution of Centerline Velocity for Flow from Submerged Outlets

10.1.4 Riprap Details

Based on experience with conventional riprap design, the recommended thickness of riprap for the floor and sides of the basin is $2D_{50}$ or $1.50D_{max}$, where D_{max} is the maximum size of rock in the riprap mixture. Thickening of the riprap layer to $3D_{50}$ or $2D_{max}$ on the foreslope of the roadway culvert outlet is warranted because of the severity of attack in the area and the necessity for preventing undermining and consequent collapse of the culvert. Figure 10.1 illustrates these riprap details. The mixture of stone used for riprap and need for a filter should meet the specifications described in HEC 11 (Brown and Clyde, 1989).

10.1.5 Design Procedure

The design procedure for a riprap basin is as follows:

Step 1. Compute the culvert outlet velocity, V_o, and depth, y_o.

For subcritical flow (culvert on mild or horizontal slope), use Figure 3.3 or Figure 3.4 to obtain y_o/D, then obtain V_o by dividing Q by the wetted area associated with y_o. D is the height of a box culvert or diameter of a circular culvert.

For supercritical flow (culvert on a steep slope), V_o will be the normal velocity obtained by using the Manning's Equation for appropriate slope, section, and discharge.

Compute the Froude number, Fr, for brink conditions using brink depth for box culverts ($y_e=y_o$) and equivalent depth ($y_e = (A/2)^{1/2}$) for non-rectangular sections.

Step 2. Select D_{50} appropriate for locally available riprap. Determine C_o from Equation 10.2 or 10.3 and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$. If h_s/D_{50} or D_{50}/y_e is out of this range, try a different riprap size. (Basins sized where h_s/D_{50} is greater than, but close to, 2 are often the most economical choice.)

Step 3. Determine the length of the dissipation pool (scour hole), L_s, total basin length, L_B, and basin width at the basin exit, W_B, as shown in Figures 10.1 and 10.2. The walls and apron of the basin should be warped (or transitioned) so that the cross section of the basin at the exit conforms to the cross section of the natural channel. Abrupt transition of surfaces should be avoided to minimize separation zones and resultant eddies.

Step 4. Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$ and compare with the allowable exit velocity, V_{allow}. The allowable exit velocity may be taken as the estimated normal velocity in the tailwater channel or a velocity specified based on stability criteria, whichever is larger. Critical depth at the basin exit may be determined iteratively using Equation 7.14:

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$ by trial and success to determine y_B.

$V_c = Q/A_c$

z = basin side slope, z:1 (H:V)

If $V_c \leq V_{allow}$, the basin dimensions developed in step 3 are acceptable. However, it may be possible to reduce the size of the dissipator pool and/or the apron with a larger riprap size. It may also be possible to maintain the dissipator pool, but reduce the flare on the apron to reduce the exit width to better fit the downstream channel. Steps 2 through 4 are repeated to evaluate alternative dissipator designs.

Step 5. Assess need for additional riprap downstream of the dissipator exit. If $TW/y_o \leq 0.75$, no additional riprap is needed. With high tailwater ($TW/y_o \geq 0.75$), estimate centerline velocity at a series of downstream cross sections using Figure 10.3 to determine the size and extent of additional protection. The riprap design details should be in accordance with specifications in HEC 11 (Brown and Clyde, 1989) or similar highway department specifications.

Two design examples are provided. The first features a box culvert on a steep slope while the second shows a pipe culvert on a mild slope.

Design Example: Riprap Basin (Culvert on a Steep Slope) (SI)

Determine riprap basin dimensions using the envelope design (Equations 10.1 and 10.2) for a 2440 mm by 1830 mm reinforced concrete box (RCB) culvert that is in inlet control with supercritical flow in the culvert. Allowable exit velocity from the riprap basin, V_{allow}, is 2.1 m/s. Riprap is available with a D_{50} of 0.50, 0.55, and 0.75 m. Consider two tailwater conditions: 1) TW = 0.85 m and 2) TW = 1.28 m. Given:

Q = 22.7 m^3/s

y_o = 1.22 m (normal flow depth) = brink depth

Solution

Step 1. Compute the culvert outlet velocity, V_o, depth, y_o, and Froude number for brink conditions. For supercritical flow (culvert on a steep slope), V_o will be V_n

$y_o = y_e = 1.22$ m

$V_o = Q/A = 22.7/ [1.22 (2.44)] = 7.63$ m/s

$Fr = V_o / (9.81y_e)^{1/2} = 7.63/ [9.81(1.22)]^{1/2} = 2.21$

Step 2. Select a trial D_{50} and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$.

Try D_{50} = 0.55 m; $D_{50}/y_e = 0.55/1.22 = 0.45$ (≥ 0.1 OK)

Two tailwater elevations are given; use the lowest to determine the basin size that will serve the tailwater range, that is, TW = 0.85 m.

$TW/y_e = 0.85/1.22 = 0.7$, which is less than 0.75. Therefore, from Equation 10.2, $C_o = 1.4$

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.45)^{-0.55}(2.21) - 1.4 = 1.55$$

$h_S = (h_S /y_e)y_e = 1.55 (1.22) = 1.89$ m

$h_S/D_{50} = 1.89/0.55 = 3.4$ and $h_S/D_{50} \geq 2$ is satisfied

Step 3. Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(1.89) = 18.9$ m

L_S min = $3W_o = 3(2.44) = 7.3$ m, use L_S = 18.9 m

$L_B = 15h_S = 15(1.89) = 28.4$ m

L_B min = $4W_o = 4(2.44) = 9.8$ m, use L_B = 28.4 m

$W_B = W_o + 2(L_B/3) = 2.44 + 2(28.4/3) = 21.4$ m

Step 4. Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$22.7^2/9.81 = 52.5 = [y_c(21.4 + 2y_c)]^3/ (21.4 + 4y_c)$

By trial and success, $y_c = 0.48$ m, $T_c = 23.3$ m, $A_c = 10.7$ m^2

$V_B = V_c = Q/A_c = 22.7/10.7 = 2.1$ m/s (acceptable)

The initial trial of riprap ($D_{50} = 0.55$ m) results in a 28.4 m basin that satisfies all design requirements. Try the next larger riprap size to test if a smaller basin is feasible by repeating steps 2 through 4.

Step 2 (2nd iteration). Select riprap size and compute basin depth.

Try $D_{50} = 0.75$ m; $D_{50}/y_e = 0.75/1.22 = 0.61$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.61)^{-0.55}(2.21) - 1.4 = 1.09$$

$h_S = (h_S/y_e)y_e = 1.09\,(1.22) = 1.34$ m

$h_S/D_{50} = 1.34/0.75 = 1.8$ and $h_S/D_{50} \geq 2$ is not satisfied. Although not available, try a riprap size that will yield h_S/D_{50} close to, but greater than, 2. (A basin sized for smaller riprap may be lined with larger riprap.) Repeat step 2.

Step 2 (3rd iteration). Select riprap size and compute basin depth.

Try $D_{50} = 0.71$ m; $D_{50}/y_e = 0.71/1.22 = 0.58$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.58)^{-0.55}(2.21) - 1.4 = 1.16$$

$h_S = (h_S/y_e)y_e = 1.16\,(1.22) = 1.42$ m

$h_S/D_{50} = 1.42/0.71 = 2.0$ and $h_S/D_{50} \geq 2$ is satisfied.

Step 3 (3rd iteration). Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(1.42) = 14.2$ m

L_S min $= 3W_o = 3(2.44) = 7.3$ m, use $L_S = 14.2$ m

$L_B = 15h_S = 15(1.42) = 21.3$ m

L_B min $= 4W_o = 4(2.44) = 9.8$ m, use $L_B = 21.3$ m

$W_B = W_o + 2(L_B/3) = 2.44 + 2(21.3/3) = 16.6$ m

However, since the trial D_{50} is not available, the next larger riprap size ($D_{50} = 0.75$ m) would be used to line a basin with the given dimensions.

Step 4 (3rd iteration). Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$22.7^2/9.81 = 52.5 = [y_c(16.6 + 2y_c)]^3/ (16.6 + 4y_c)$

By trial and success, $y_c = 0.56$ m, $T_c = 18.8$ m, $A_c = 9.9$ m^2

$V_B = V_c = Q/A_c$ = 22.7/9.9 = 2.3 m/s (greater than 2.1 m/s; not acceptable). If the apron were extended (with a continued flare) such that the total basin length was 28.4 m, the velocity would be reduced to the allowable level.

Two feasible options have been identified. First, a 1.89 m deep, 18.9 m long pool, with a 9.5 m apron using D_{50} = 0.55 m. Second, a 1.42 m deep, 14.2 m long pool, with a 14.2 m apron using D_{50} = 0.75 m. Because the overall length is the same, the first option is likely to be more economical.

Step 5. For the design discharge, determine if $TW/y_o \le 0.75$.

For the first tailwater condition, TW/y_o = 0.85/1.22 = 0.70, which satisfies $TW/y_o \le$ 0.75. No additional riprap needed downstream.

For the second tailwater condition, TW/y_o = 1.28/1.22 = 1.05, which does not satisfy $TW/y_o \le 0.75$. To determine required riprap, estimate centerline velocity at a series of downstream cross sections using Figure 10.3.

Compute equivalent circular diameter, D_e, for brink area:

$A = \pi D_e^2 /4 = (y_o)(W_o) = (1.22)(2.44) = 3.00\ m^2$

$D_e = [3.00(4)/ \pi]^{1/2} = 1.95$ m

Rock size can be determined using the procedures in Section 10.3 (Equation 10.6) or other suitable method. The computations are summarized below.

L/D_e	L (m)	V_L/V_o (Figure 10.3)	V_L (m/s)	Rock size, D_{50} (m)
10	19.5	0.59	4.50	0.43
15	29.3	0.42	3.20	0.22
20	39.0	0.30	2.29	0.11
21	41.0	0.28	2.13	0.10

The calculations above continue until $V_L \le V_{allow}$. Riprap should be at least the size shown. As a practical consideration, the channel can be lined with the same size rock used for the basin. Protection must extend at least 41.0 m downstream from the culvert brink, which is 12.6 m beyond the basin exit. Riprap should be installed in accordance with details shown in HEC 11.

Design Example: Riprap Basin (Culvert on a Steep Slope) (CU)

Determine riprap basin dimensions using the envelope design (Equations 10.1 and10.2) for an 8 ft by 6 ft reinforced concrete box (RCB) culvert that is in inlet control with supercritical flow in the culvert. Allowable exit velocity from the riprap basin, V_{allow}, is 7 ft/s. Riprap is available with a D_{50} of 1.67, 1.83, and 2.5 ft. Consider two tailwater conditions: 1) TW = 2.8 ft and 2) TW = 4.2 ft. Given:

Q = 800 ft^3/s

y_o = 4 ft (normal flow depth) = brink depth

Solution

Step 1. Compute the culvert outlet velocity, V_o, depth, y_o, and Froude number for brink conditions. For supercritical flow (culvert on a steep slope), V_o will be V_n.

$y_o = y_e = 4$ ft

$V_o = Q/A = 800/ [4 (8)] = 25$ ft/s

$Fr = V_o / (32.2y_e)^{1/2} = 25/ [32.2(4)]^{1/2} = 2.2$

Step 2. Select a trial D_{50} and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$.

Try $D_{50} = 1.83$ ft; $D_{50}/y_e = 1.83/4 = 0.46$ (≥ 0.1 OK)

Two tailwater elevations are given; use the lowest to determine the basin size that will serve the tailwater range, that is, TW = 2.8 ft.

$TW/y_e = 2.8/4 = 0.7$, which is less than 0.75. From Equation 10.2, $C_o = 1.4$

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.46)^{-0.55}(2.2) - 1.4 = 1.50$$

$h_S = (h_S /y_e)y_e = 1.50 (4) = 6.0$ ft

$h_S/D_{50} = 6.0/1.83 = 3.3$ and $h_S/D_{50} \geq 2$ is satisfied

Step 3. Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(6.0) = 60$ ft

L_S min $= 3W_o = 3(8) = 24$ ft, use $L_S = 60$ ft

$L_B = 15h_S = 15(6.0) = 90$ ft

L_B min $= 4W_o = 4(8) = 32$ ft, use $L_B = 90$ ft

$W_B = W_o + 2(L_B/3) = 8 + 2(90/3) = 68$ ft

Step 4. Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$800^2/32.2 = 19{,}876 = [y_c(68 + 2y_c)]^3/ (68 + 4y_c)$

By trial and success, $y_c = 1.60$ ft, $T_c = 74.4$ ft, $A_c = 113.9$ ft^2

$V_B = V_c = Q/A_c = 800/113.9 = 7.0$ ft/s (acceptable)

The initial trial of riprap ($D_{50} = 1.83$ ft) results in a 90 ft basin that satisfies all design requirements. Try the next larger riprap size to test if a smaller basin is feasible by repeating steps 2 through 4.

Step 2 (2nd iteration). Select riprap size and compute basin depth.

Try $D_{50} = 2.5$ ft; $D_{50}/y_e = 2.5/4 = 0.63$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e}=0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right)-C_o=0.86(0.63)^{-0.55}(2.2)-1.4=1.04$$

$h_S = (h_S/y_e)y_e = 1.04 (4) = 4.2$ ft

$h_S/D_{50} = 4.2/2.5 = 1.7$ and $h_S/D_{50} \geq 2$ is not satisfied. Although not available, try a riprap size that will yield h_S/D_{50} close to, but greater than, 2. (A basin sized for smaller riprap may be lined with larger riprap.) Repeat step 2.

Step 2 (3rd iteration). Select riprap size and compute basin depth.

Try $D_{50} = 2.3$ ft; $D_{50}/y_e = 2.3/4 = 0.58$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e}=0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right)-C_o=0.86(0.58)^{-0.55}(2.2)-1.4=1.15$$

$h_S = (h_S/y_e)y_e = 1.15 (4) = 4.6$ ft

$h_S/D_{50} = 4.6/2.3 = 2.0$ and $h_S/D_{50} \geq 2$ is satisfied.

Step 3 (3rd iteration). Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(4.6) = 46$ ft

L_S min $= 3W_o = 3(8) = 24$ ft, use $L_S = 46$ ft

$L_B = 15h_S = 15(4.6) = 69$ ft

L_B min $= 4W_o = 4(8) = 32$ ft, use $L_B = 69$ ft

$W_B = W_o + 2(L_B/3) = 8 + 2(69/3) = 54$ ft

However, since the trial D_{50} is not available, the next larger riprap size ($D_{50} = 2.5$ ft) would be used to line a basin with the given dimensions.

Step 4 (3rd iteration). Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$800^2/32.2 = 19{,}876 = [y_c(54 + 2y_c)]^3/ (54 + 4y_c)$

By trial and success, $y_c = 1.85$ ft, $T_c = 61.4$ ft, $A_c = 106.9$ ft^2

$V_B = V_c = Q/A_c = 800/106.9 = 7.5$ ft/s (not acceptable). If the apron were extended (with a continued flare) such that the total basin length was 90 ft, the velocity would be reduced to the allowable level.

Two feasible options have been identified. First, a 6-ft-deep, 60-ft-long pool, with a 30-ft-apron using $D_{50} = 1.83$ ft. Second, a 4.6-ft-deep, 46-ft-long pool, with a 44-ft-apron using $D_{50} = 2.5$ ft. Because the overall length is the same, the first option is likely to be more economical.

Step 5. For the design discharge, determine if $TW/y_o \leq 0.75$.

For the first tailwater condition, $TW/y_o = 2.8/4.0 = 0.70$, which satisfies $TW/y_o \leq 0.75$. No additional riprap needed downstream.

For the second tailwater condition, $TW/y_o = 4.2/4.0 = 1.05$, which does not satisfy $TW/y_o \leq 0.75$. To determine required riprap, estimate centerline velocity at a series of downstream cross sections using Figure 10.3.

Compute equivalent circular diameter, D_e, for brink area:

$A = \pi D_e^2 /4 = (y_o)(W_o) = (4)(8) = 32 \text{ ft}^2$

$D_e = [32(4)/ \pi]^{1/2} = 6.4 \text{ ft}$

Rock size can be determined using the procedures in Section 10.3 (Equation 10.6) or other suitable method. The computations are summarized below.

L/D_e	L (ft)	V_L/V_o (Figure 10.3)	V_L (ft/s)	Rock size, D_{50} (ft)
10	64	0.59	14.7	1.42
15	96	0.42	10.5	0.72
20	128	0.30	7.5	0.37
21	135	0.28	7.0	0.32

The calculations above continue until $V_L \leq V_{allow}$. Riprap should be at least the size shown. As a practical consideration, the channel can be lined with the same size rock used for the basin. Protection must extend at least 135 ft downstream from the culvert brink, which is 45 ft beyond the basin exit. Riprap should be installed in accordance with details shown in HEC 11.

<u>Design Example: Riprap Basin (Culvert on a Mild Slope) (SI)</u>

Determine riprap basin dimensions using the envelope design (Equations 10.1 and 10.2) for a pipe culvert that is in outlet control with subcritical flow in the culvert. Allowable exit velocity from the riprap basin, V_{allow}, is 2.1 m/s. Riprap is available with a D_{50} of 0.125, 0.150, and 0.250 m. Given:

D = 1.83 m CMP with Manning's n = 0.024
S_o = 0.004 m/m
Q = 3.82 m^3/s
y_n = 1.37 m (normal flow depth in the pipe)
V_n = 1.80 m/s (normal velocity in the pipe)
TW = 0.61 m (tailwater depth)

<u>Solution</u>

Step 1. Compute the culvert outlet velocity, V_o, and depth, y_o.

For subcritical flow (culvert on mild slope), use Figure 3.4 to obtain y_o/D, then calculate V_o by dividing Q by the wetted area for y_o.

$K_u Q/D^{2.5} = 1.81 (3.82)/1.83^{2.5} = 1.53$

$TW/D = 0.61/1.83 = 0.33$

From Figure 3.4, $y_o/D = 0.45$

$y_o = (y_o/D)D = 0.45(1.83) = 0.823$ m (brink depth)

From Table B.2, for y_o /D = 0.45, the brink area ratio $A/D^2 = 0.343$

$A = (A/D^2)D^2 = 0.343(1.83)^2 = 1.15\ m^2$

$V_o = Q/A = 3.82/1.15 = 3.32$ m/s

$y_e = (A/2)^{1/2} = (1.15/2)^{1/2} = 0.76$ m

$Fr = V_o / [9.81(y_e)]^{1/2} = 3.32/ [9.81(0.76)]^{1/2} = 1.22$

Step 2. Select a trial D_{50} and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$.

Try $D_{50} = 0.15$ m; $D_{50}/y_e = 0.15/0.76 = 0.20$ (≥ 0.1 OK)

$TW/y_e = 0.61/0.76 = 0.80$. Therefore, from Equation 10.2,

$C_o = 4.0(TW/y_e) -1.6 = 4.0(0.80) – 1.6 = 1.61$

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.20)^{-0.55}(1.22) - 1.61 = 0.933$$

$h_S = (h_S /y_e)y_e = 0.933\ (0.76) = 0.71$ m

$h_S/D_{50} = 0.71/0.15 = 4.7$ and $h_S/D_{50} \geq 2$ is satisfied

Step 3. Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(0.71) = 7.1$ m

L_S min $= 3W_o = 3(1.83) = 5.5$ m, use $L_S = 7.1$ m

$L_B = 15h_S = 15(0.71) = 10.7$ m

L_B min $= 4W_o = 4(1.83) = 7.3$ m, use $L_B = 10.7$ m

$W_B = W_o + 2(L_B/3) = 1.83 + 2(10.7/3) = 9.0$ m

Step 4. Determine the basin exit depth, $y_B = y_c$ and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$3.82^2/9.81 = 1.49 = [y_c(9.0 + 2y_c)]^3/ (9.0 + 4y_c)$

By trial and success, $y_c = 0.26$ m, $T_c =10.0$ m, $A_c = 2.48\ m^2$

$V_c = Q/A_c = 3.82/2.48 = 1.5$ m/s (acceptable)

The initial trial of riprap (D_{50} = 0.15 m) results in a 10.7 m basin that satisfies all design requirements. Try the next larger riprap size to test if a smaller basin is feasible by repeating steps 2 through 4.

Step 2 (2nd iteration). Select a trial D_{50} and obtain h_s/y_e from Equation 10.1.

Try $D_{50} = 0.25$ m; $D_{50}/y_e = 0.25/0.76 = 0.33$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.33)^{-0.55}(1.22) - 1.61 = 0.320$$

$h_S = (h_S / y_e) y_e = 0.320\ (0.76) = 0.24$ m

$h_S/D_{50} = 0.24/0.25 = 0.96$ and $h_S/D_{50} \geq 2$ is not satisfied. Although not available, try a riprap size that will yield h_S/D_{50} close to, but greater than 2. (A basin sized for smaller riprap may be lined with larger riprap.) Repeat step 2.

Step 2 (3rd iteration). Select a trial D_{50} and obtain h_s/y_e from Equation 10.1.

Try $D_{50} = 0.205$ m; $D_{50}/y_e = 0.205/0.76 = 0.27$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.27)^{-0.55}(1.22) - 1.61 = 0.545$$

$h_S = (h_S / y_e) y_e = 0.545\ (0.76) = 0.41$ m

$h_S/D_{50} = 0.41/0.205 = 2.0$ and $h_S/D_{50} \geq 2$ is satisfied. Continue to step 3.

Step 3 (3rd iteration). Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(0.41) = 4.1$ m

L_S min $= 3W_o = 3(1.83) = 5.5$ m, use $L_S = 5.5$ m

$L_B = 15h_S = 15(0.41) = 6.2$ m

L_B min $= 4W_o = 4(1.83) = 7.3$ m, use $L_B = 7.3$ m

$W_B = W_o + 2(L_B/3) = 1.83 + 2(7.3/3) = 6.7$ m

However, since the trial D_{50} is not available, the next larger riprap size ($D_{50} = 0.25$ m) would be used to line a basin with the given dimensions.

Step 4 (3rd iteration). Determine the basin exit depth, $y_B = y_c$ and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3 / (W_B + 2zy_c)$

$3.82^2/9.81 = 1.49 = [y_c(6.7 + 2y_c)]^3 / (6.7 + 4y_c)$

By trial and success, $y_c = 0.31$ m, $T_c = 7.94$ m, $A_c = 2.28$ m^2

$V_c = Q/A_c = 3.82/2.28 = 1.7$ m/s (acceptable)

Two feasible options have been identified. First, a 0.71 m deep, 7.1 m long pool, with an 3.6 m apron using $D_{50} = 0.15$ m. Second, a 0.41 m deep, 5.5 m long pool, with a 1.8 m apron using $D_{50} = 0.25$ m. The choice between these two options will likely depend on the available space and the cost of riprap.

Step 5. For the design discharge, determine if $TW/y_o \leq 0.75$

$TW/y_o = 0.61/0.823 = 0.74$, which satisfies $TW/y_o \leq 0.75$. No additional riprap needed.

Design Example: Riprap Basin (Culvert on a Mild Slope) (CU)

Determine riprap basin dimensions using the envelope design (Equations 10.1 and 10.2) for a pipe culvert that is in outlet control with subcritical flow in the culvert. Allowable exit velocity from the riprap basin, V_{allow}, is 7.0 ft/s. Riprap is available with a D_{50} of 0.42, 0.50, and 0.83 ft. Given:

D	=	6 ft CMP with Manning's n = 0.024
S_o	=	0.004 ft/ft
Q	=	135 ft^3/s
y_n	=	4.5 ft (normal flow depth in the pipe)
V_n	=	5.9 ft/s (normal velocity in the pipe)
TW	=	2.0 ft (tailwater depth)

Solution

Step 1. Compute the culvert outlet velocity, V_o, depth, y_o and Froude number.

For subcritical flow (culvert on mild slope), use Figure 3.4 to obtain y_o/D, then calculate V_o by dividing Q by the wetted area for y_o.

$K_uQ/D^{2.5} = 1.0(135)/6^{2.5} = 1.53$

TW/D = 2.0/6 = 0.33

From Figure 3.4, $y_o/D = 0.45$

$y_o = (y_o/D)D = 0.45(6) = 2.7$ ft (brink depth)

From Table B.2 for $y_o/D = 0.45$, the brink area ratio $A/D^2 = 0.343$

$A = (A/D^2)D^2 = 0.343(6)^2 = 12.35\ ft^2$

$V_o = Q/A = 135/12.35 = 10.9$ ft/s

$y_e = (A/2)^{1/2} = (12.35/2)^{1/2} = 2.48$ ft

$Fr = V_o / [32.2(y_e)]^{1/2} = 10.9/ [32.2(2.48)]^{1/2} = 1.22$

Step 2. Select a trial D_{50} and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$.

Try $D_{50} = 0.5$ ft; $D_{50}/y_e = 0.5/2.48 = 0.20$ (≥ 0.1 OK)

$TW/y_e = 2.0/2.48 = 0.806$. Therefore, from Equation 10.2,

$C_o = 4.0(TW/y_e) -1.6 = 4.0(0.806) -1.6 = 1.62$

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{g y_e}}\right) - C_o = 0.86(0.20)^{-0.55}(1.22) - 1.62 = 0.923$$

$h_S = (h_S/y_e)y_e = 0.923\ (2.48) = 2.3$ ft

$h_S/D_{50} = 2.3/0.5 = 4.6$ and $h_S/D_{50} \geq 2$ is satisfied

Step 3. Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(2.3) = 23$ ft

L_S min = $3W_o = 3(6) = 18$ ft, use $L_S = 23$ ft

$L_B = 15h_S = 15(2.3) = 34.5$ ft

L_B min = $4W_o = 4(6) = 24$ ft, use $L_B = 34.5$ ft

$W_B = W_o + 2(L_B/3) = 6 + 2(34.5/3) = 29$ ft

Step 4. Determine the basin exit depth, $y_B = y_c$ and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$135^2/32.2 = 566 = [y_c(29 + 2y_c)]^3/ (29 + 4y_c)$

By trial and success, $y_c = 0.86$ ft, $T_c = 32.4$ ft, $A_c = 26.4$ ft^2

$V_c = Q/A_c = 135/26.4 = 5.1$ ft/s (acceptable)

The initial trial of riprap ($D_{50} = 0.5$ ft) results in a 34.5 ft basin that satisfies all design requirements. Try the next larger riprap size to test if a smaller basin is feasible by repeating steps 2 through 4.

Step 2 (2nd iteration). Select a trial D_{50} and obtain h_s/y_e from Equation 10.1.

Try $D_{50} = 0.83$ ft; $D_{50}/y_e = 0.83/2.48 = 0.33$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.33)^{-0.55}(1.22) - 1.62 = 0.311$$

$h_S = (h_S/y_e)y_e = 0.311\ (2.48) = 0.8$ ft

$h_S/D_{50} = 0.8/0.83 = 0.96$ and $h_S/D_{50} \geq 2$ is not satisfied. Although not available, try a riprap size that will yield h_S/D_{50} close to, but greater than 2. (A basin sized for smaller riprap may be lined with larger riprap.) Repeat step 2.

Step 2 (3rd iteration). Select a trial D_{50} and obtain h_s/y_e from Equation 10.1.

Try $D_{50} = 0.65$ ft; $D_{50}/y_e = 0.65/2.48 = 0.26$ (≥ 0.1 OK)

From Equation 10.1,

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o = 0.86(0.26)^{-0.55}(1.22) - 1.62 = 0.581$$

$h_S = (h_S/y_e)y_e = 0.581\ (2.48) = 1.4$ ft

$h_S/D_{50} = 1.4/0.65 = 2.15$ and $h_S/D_{50} \geq 2$ is satisfied. Continue to step 3.

Step 3 (3rd iteration). Size the basin as shown in Figures 10.1 and 10.2.

$L_S = 10h_S = 10(1.4) = 14$ ft

L_S min = $3W_o = 3(6) = 18$ ft, use $L_S = 18$ ft

$L_B = 15h_S = 15(1.4) = 21$ ft

L_B min = $4W_o$ = 4(6) = 24 ft, use L_B = 24 ft

$W_B = W_o + 2(L_B/3) = 6 + 2(24/3) = 22$ ft

However, since the trial D_{50} is not available, the next larger riprap size (D_{50} = 0.83 ft) would be used to line a basin with the given dimensions.

Step 4 (3rd iteration). Determine the basin exit depth, $y_B = y_c$ and exit velocity, $V_B = V_c$.

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$

$135^2/32.2 = 566 = [y_c(22 + 2y_c)]^3/ (22 + 4y_c)$

By trial and success, y_c = 1.02 ft, T_c =26.1 ft, A_c = 24.5 ft^2

$V_c = Q/A_c$ = 135/24.5 = 5.5 ft/s (acceptable)

Two feasible options have been identified. First, a 2.3-ft-deep, 23-ft-long pool, with an 11.5-ft-apron using D_{50} = 0.5 ft. Second, a 1.4-ft-deep, 18-ft-long pool, with a 6-ft-apron using D_{50} = 0.83 ft. The choice between these two options will likely depend on the available space and the cost of riprap.

Step 5. For the design discharge, determine if $TW/y_o \le 0.75$

TW/y_o = 2.0/2.7 = 0.74, which satisfies $TW/y_o \le 0.75$. No additional riprap needed.

10.2 RIPRAP APRON

The most commonly used device for outlet protection, primarily for culverts 1500 mm (60 in) or smaller, is a riprap apron. An example schematic of an apron taken from the Federal Lands Division of the Federal Highway Administration is shown in Figure 10.4.

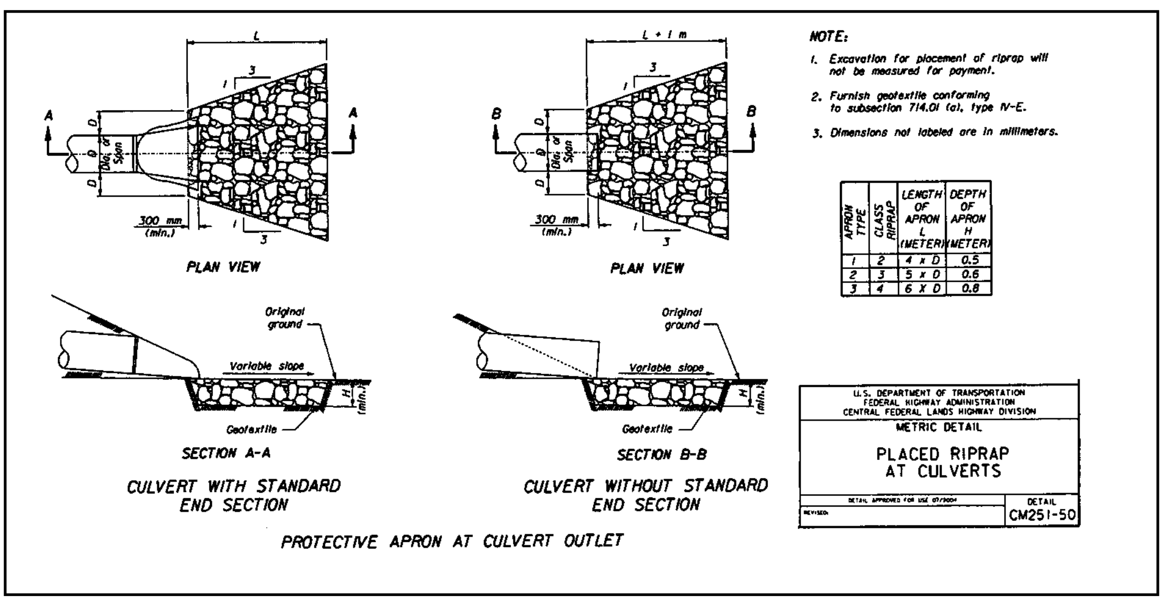


Figure 10.4. Placed Riprap at Culverts (Central Federal Lands Highway Division)

They are constructed of riprap or grouted riprap at a zero grade for a distance that is often related to the outlet pipe diameter. These aprons do not dissipate significant energy except through increased roughness for a short distance. However, they do serve to spread the flow helping to transition to the natural drainage way or to sheet flow where no natural drainage way exists. However, if they are too short, or otherwise ineffective, they simply move the location of potential erosion downstream. The key design elements of the riprap apron are the riprap size as well as the length, width, and depth of the apron.

Several relationships have been proposed for riprap sizing for culvert aprons and several of these are discussed in greater detail in Appendix D. The independent variables in these relationships include one or more of the following variables: outlet velocity, rock specific gravity, pipe dimension (e.g. diameter), outlet Froude number, and tailwater. The following equation (Fletcher and Grace, 1972) is recommended for circular culverts:

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) \tag{10.4}$$

where,

D_{50} = riprap size, m (ft)

Q = design discharge, m^3/s (ft^3/s)

D = culvert diameter (circular), m (ft)

TW = tailwater depth, m (ft)

g = acceleration due to gravity, 9.81 m/s^2 (32.2 ft/s^2)

Tailwater depth for Equation 10.4 should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D.

Whenever the flow is supercritical in the culvert, the culvert diameter is adjusted as follows:

$$D' = \frac{D + y_n}{2} \tag{10.5}$$

where,

D' = adjusted culvert rise, m (ft)

y_n = normal (supercritical) depth in the culvert, m (ft)

Equation 10.4 assumes that the rock specific gravity is 2.65. If the actual specific gravity differs significantly from this value, the D_{50} should be adjusted inversely to specific gravity.

The designer should calculate D_{50} using Equation 10.4 and compare with available riprap classes. A project or design standard can be developed such as the example from the Federal Highway Administration Federal Lands Highway Division (FHWA, 2003) shown in Table 10.1 (first two columns). The class of riprap to be specified is that which has a D_{50} greater than or equal to the required size. For projects with several riprap aprons, it is often cost effective to use fewer riprap classes to simplify acquiring and installing the riprap at multiple locations. In such a case, the designer must evaluate the tradeoffs between over sizing riprap at some locations in order to reduce the number of classes required on a project.

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1]D is the culvert rise.

The apron dimensions must also be specified. Table 10.1 provides guidance on the apron length and depth. Apron length is given as a function of the culvert rise and the riprap size. Apron depth ranges from $3.5D_{50}$ for the smallest riprap to a limit of $2.0D_{50}$ for the larger riprap sizes. The final dimension, width, may be determined using the 1:3 flare shown in Figure 10.4 and should conform to the dimensions of the downstream channel. A filter blanket should also be provided as described in HEC 11 (Brown and Clyde, 1989).

For tailwater conditions above the acceptable range for Equation 10.4 (TW > 1.0D), Figure 10.3 should be used to determine the velocity downstream of the culvert. The guidance in Section 10.3 may be used for sizing the riprap. The apron length is determined based on the allowable velocity and the location at which it occurs based on Figure 10.3.

Over their service life, riprap aprons experience a wide variety of flow and tailwater conditions. In addition, the relations summarized in Table 10.1 do not fully account for the many variables in culvert design. To ensure continued satisfactory operation, maintenance personnel should inspect them after major flood events. If repeated severe damage occurs, the location may be a candidate for extending the apron or another type of energy dissipator.

Design Example: Riprap Apron (SI)

Design a riprap apron for the following CMP installation. Available riprap classes are provided in Table 10.1. Given:

Q = $2.33\ m^3/s$

D = 1.5 m

TW = 0.5 m

Solution

Step 1. Calculate D_{50} from Equation 10.4. First verify that tailwater is within range.

TW/D = 0.5/1.5 = 0.33. This is less than 0.4D, therefore,

use TW = 0.4D = 0.4(1.5) = 0.6 m

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) = 0.2\,(1.5)\left(\frac{2.33}{\sqrt{9.81}(1.5)^{2.5}}\right)^{4/3}\left(\frac{1.5}{0.6}\right) = 0.13\text{ m}$$

Step 2. Determine riprap class. From Table 10.1, riprap class 2 (D_{50} = 0.15 m) is required.

Step 3. Estimate apron dimensions.

From Table 10.1 for riprap class 2,

Length, L = 4D = 4(1.5) = 6 m

Depth = $3.3D_{50}$ = 3.3 (0.15) = 0.50 m

Width (at apron end) = 3D + (2/3)L = 3(1.5) + (2/3)(6) = 8.5 m

Design Example: Riprap Apron (CU)

Design a riprap apron for the following CMP installation. Available riprap classes are provided in Table 10.1. Given:

Q = 85 ft^3/s
D = 5.0 ft
TW = 1.6 ft

Solution

Step 1. Calculate D_{50} from Equation 10.4. First verify that tailwater is within range.

TW/D = 1.6/5.0 = 0.32. This is less than 0.4D, therefore,

use TW = 0.4D = 0.4(5) = 2.0 ft

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) = 0.2\,(5.0)\left(\frac{85}{\sqrt{32.2}(5.0)^{2.5}}\right)^{4/3}\left(\frac{5.0}{2.0}\right) = 0.43\text{ ft} = 5.2\text{ in}$$

Step 2. Determine riprap class. From Table 10.1, riprap class 2 (D_{50} = 6 in) is required.

Step 3. Estimate apron dimensions.

From Table 10.1 for riprap class 2,

Length, L = 4D = 4(5) = 20 ft

Depth = $3.3D_{50}$ = 3.3 (6) = 19.8 in = 1.65 ft

Width (at apron end) = 3D + (2/3)L = 3(5) + (2/3)(20) = 28.3 ft

10.3 RIPRAP APRONS AFTER ENERGY DISSIPATORS

Some energy dissipators provide exit conditions, velocity and depth, near critical. This flow condition rapidly adjusts to the downstream or natural channel regime; however, critical velocity may be sufficient to cause erosion problems requiring protection adjacent to the energy dissipator. Equation 10.6 provides the riprap size recommended for use downstream of energy dissipators. This relationship is from Searcy (1967) and is the same equation used in HEC 11 (Brown and Clyde, 1989) for riprap protection around bridge piers.

$$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right) \quad (10.6)$$

where,

D_{50} = median rock size, m (ft)

V = velocity at the exit of the dissipator, m/s (ft/s)

S = riprap specific gravity

The length of protection can be judged based on the magnitude of the exit velocity compared with the natural channel velocity. The greater this difference, the longer will be the length required for the exit flow to adjust to the natural channel condition. A filter blanket should also be provided as described in HEC 11 (Brown and Clyde, 1989).

APPENDIX D: RIPRAP APRON SIZING EQUATIONS

A variety of relationships for sizing riprap aprons have been developed. Six are summarized and compared in this appendix. The first is from the Urban Drainage and Flood Control District in Denver Colorado (UD&FCD, 2004). These equations consider tailwater in addition to a measure of flow intensity.

$$D_{50} = 0.023D\left(\frac{Q}{\alpha D^{2.5}}\right)\left(\frac{D}{TW}\right)^{1.2} \qquad \text{(D.1a)}$$

$$D_{50} = 0.014D\left(\frac{Q}{\alpha BD^{1.5}}\right)\left(\frac{D}{TW}\right) \qquad \text{(D.1b)}$$

where,

D_{50} = riprap size, m (ft)
Q = design discharge, m^3/s (ft^3/s)
D = culvert diameter (circular) or culvert rise (rectangular), m (ft)
B = culvert span (rectangular), m (ft)
TW = tailwater depth, m (ft)
α = unit conversion constant, 1.811 (SI) and 1.0 (CU)

An equation in Berry (1948) and Peterka (1978) has been used for apron riprap sizing. It is only based on velocity.

$$D_{50} = \alpha V^2 \qquad \text{(D.2)}$$

where,

V = culvert exit velocity, m/s (ft/s)
α = unit conversion constant, 0.0413 (SI) and 0.0126 (CU)

A relationship used in the previous edition of HEC 14 from Searcy (1967) and also found in HEC 11 (Brown and Clyde, 1989) for sizing riprap protection for piers is based on velocity.

$$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right) \qquad \text{(D.3)}$$

where,

S = riprap specific gravity

Bohan (1970) developed two relationships based on laboratory testing that considered, among other factors, whether the culvert was subjected to "minimum" tailwater (TW/D < 0.5) or "maximum" tailwater (TW/D > 0.5). The equations for minimum and maximum tailwater, respectively, are as follows:

$$D_{50} = 0.25DFr_o \qquad \text{(D.4a)}$$

$$D_{50} = D(0.25Fr_o - 0.15) \qquad \text{(D.4b)}$$

where,

Fr_o = Froude number at the outlet defined as $V_o/(gD)^{0.5}$

Fletcher and Grace (1972) used the laboratory data from Bohan and other sources to develop a similar equation to Equation D.1.

$$D_{50} = 0.020D\left(\frac{Q}{\alpha D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) \tag{D.5}$$

where,

α = unit conversion constant, 0.55 (SI) and 1.0 (CU)

Finally, the USDA/SCS has a series of charts for sizing riprap for aprons. These charts appear to be based on Bohan (Equation D.4a and D.4b).

Equation D.2 (Berry) and Equation D.3 (Searcy) are similar in their exclusive reliance on velocity as the predictor variable and differ only in terms of their coefficient. Equation D.1 (UD&FCD), Equation D.4 (Bohan), and Equation D.5 (Fletcher and Grace) incorporate some sort of flow intensity parameter, i.e. relative discharge or Froude number, as well as relative tailwater depth. (Bohan incorporates tailwater by having separate minimum and maximum tailwater equations.) UD&FCD and Fletcher and Grace have identical forms but differ in their coefficient and exponents.

These equations and the USDA charts were compared based on a series of hypothetical situations. A total of 10 scenarios were run with HY8 to generate outlet velocity conditions for testing the equations. The 10 scenarios included the following variations:

- Two culvert sizes, 760 and 1200 mm (30 to 48 in) metal pipe culverts
- Discharges ranging from (1.1 to 4.2 m^3/s) (40 to 150 ft^3/s)
- Slope and tailwater changes resulting in 5 inlet control and 5 outlet control cases

Figures D.1, D.2, and D.3 compare the recommended riprap size, D_{50}, relative to the outlet velocity, V, discharge intensity, $Q/D^{2.5}$, and relative tailwater depth, TW/D. The recommended D50 varies widely, but it is clear that the Berry equation (Equation D.2) results in the highest values for the range of conditions evaluated.

Equations D.2 and D.3 are not recommended because they do not consider tailwater effects. Equation D.4 is not further considered because it treats tailwater only as two separate conditions, minimum and maximum. Equations D.1 and D.5 are similar in their approach and are based on laboratory data. Both would probably both generate reasonable designs. For the ten hypothetical cases evaluated Equation D.1 produced the higher recommendation 3 times and the lower recommendation 7 times. Therefore, Equation D.5 is included in Chapter 10 of this manual.

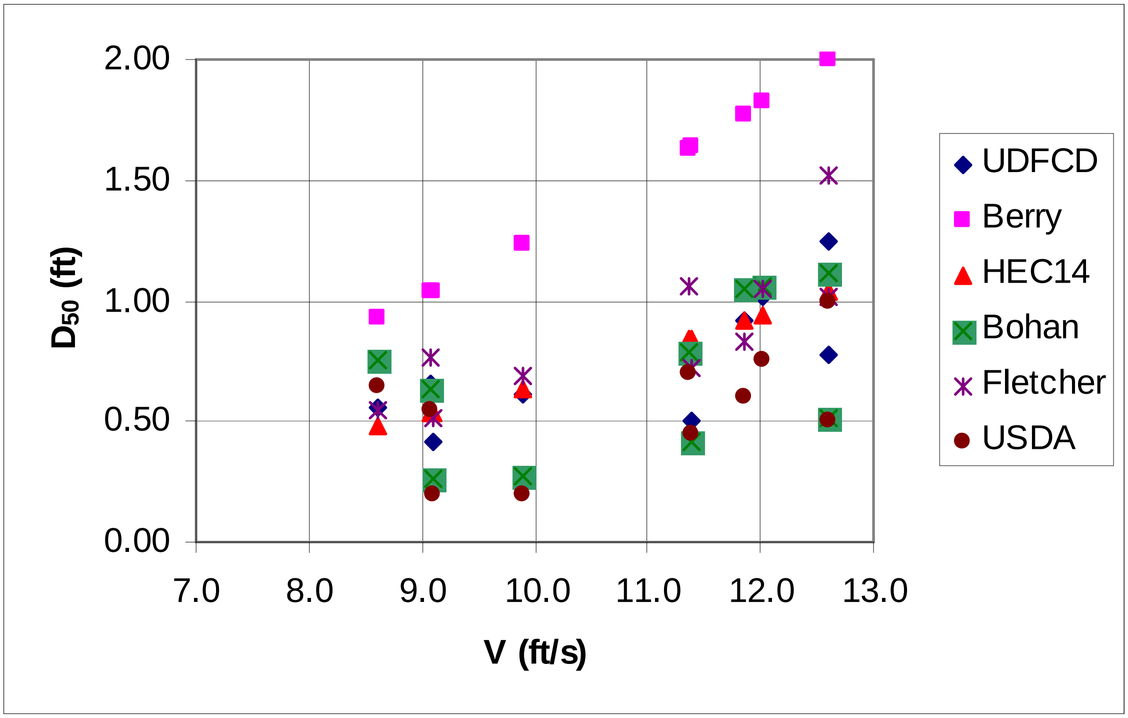


Figure D.1. D_{50} versus Outlet Velocity

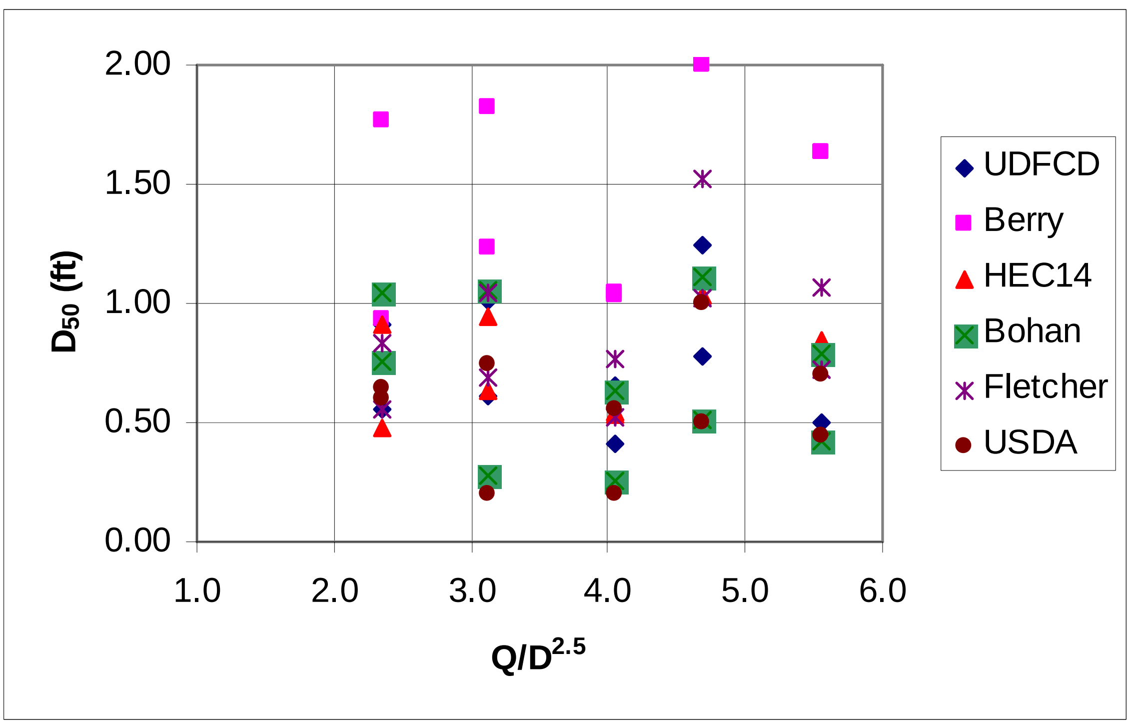


Figure D.2. D_{50} versus Discharge Intensity

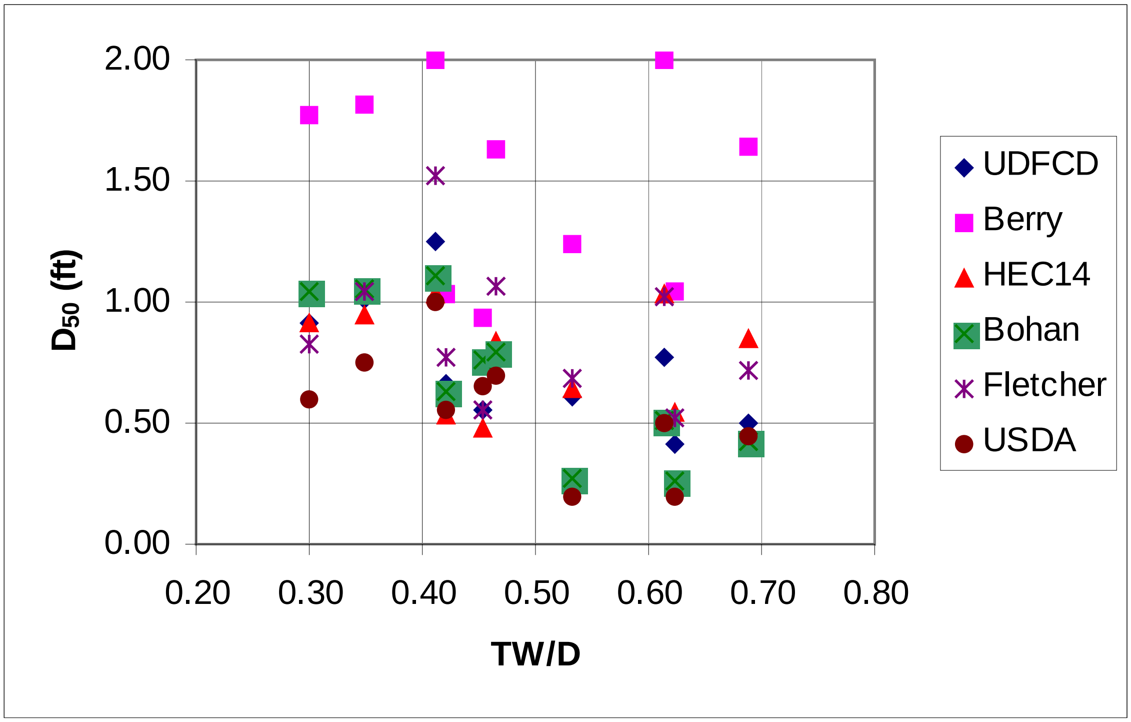
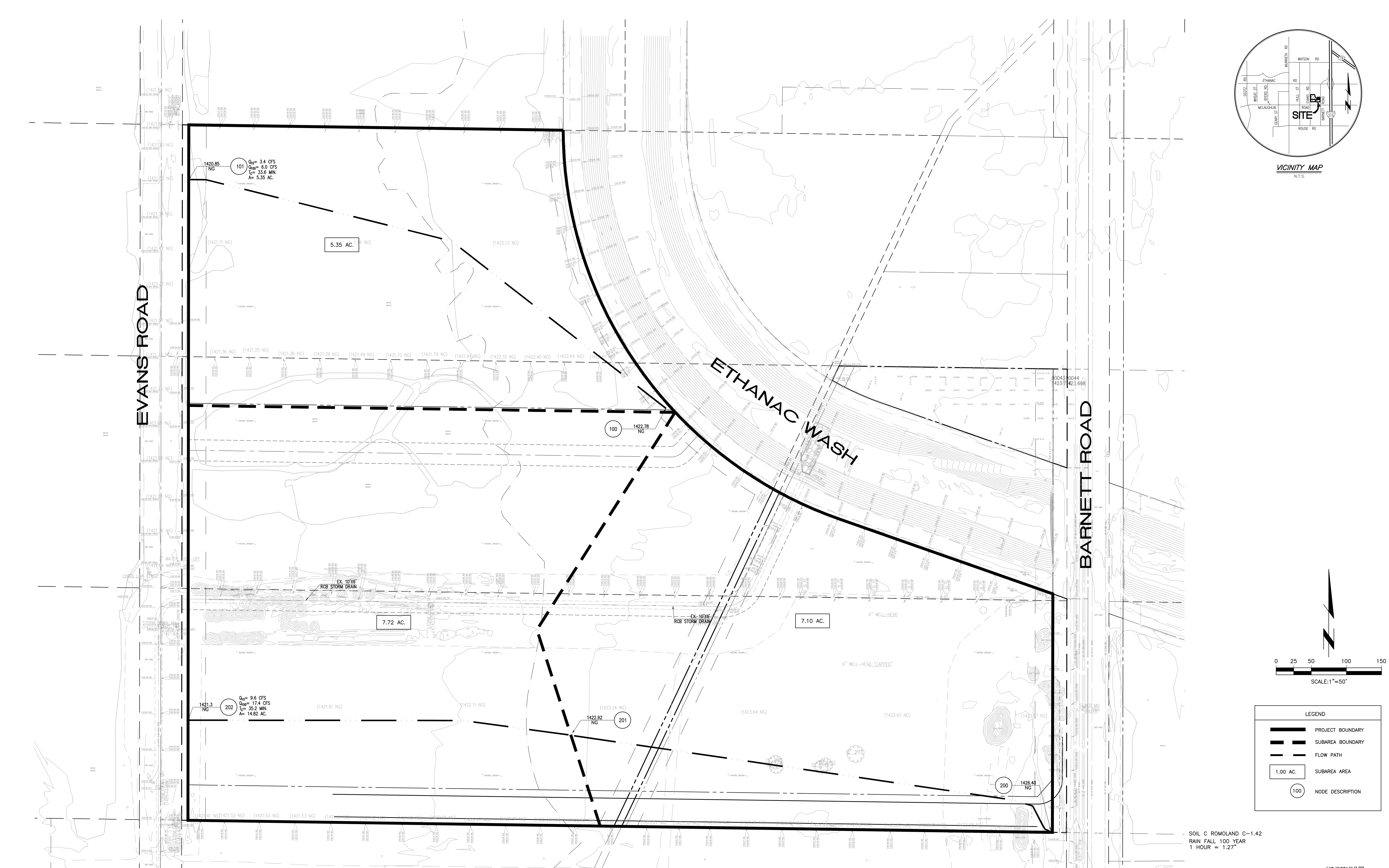


Figure D.3. D_{50} versus Relative Tailwater Depth

APPENDIX D

HYDROLOGY MAPS



LEGEND	
(thick solid line)	PROJECT BOUNDARY
(thick dashed line)	SUBAREA BOUNDARY
(dash-dot line)	FLOW PATH
1.00 AC.	SUBAREA AREA
(100)	NODE DESCRIPTION

SOIL C ROMOLAND C-1.42
RAIN FALL 100 YEAR
1 HOUR = 1.27"

Last Update: 11/1/23
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COUNTY OF RIVERSIDE
PUBLIC WORKS DEPARTMENT

EXISTING CONDITION HYDROLOGY MAP

NORTHERN GATEWAY LOGISTICS CENTER
EVANS ST BETWEEN ETHANAC RD AND McLAUGHLIN RD.

PREPARED FOR:
LOVETT INDUSTRIAL
120 NEWPORT CENTER DRIVE, SUITE 217
NEWPORT BEACH, CA 92660
PHONE: (949) 402-2760

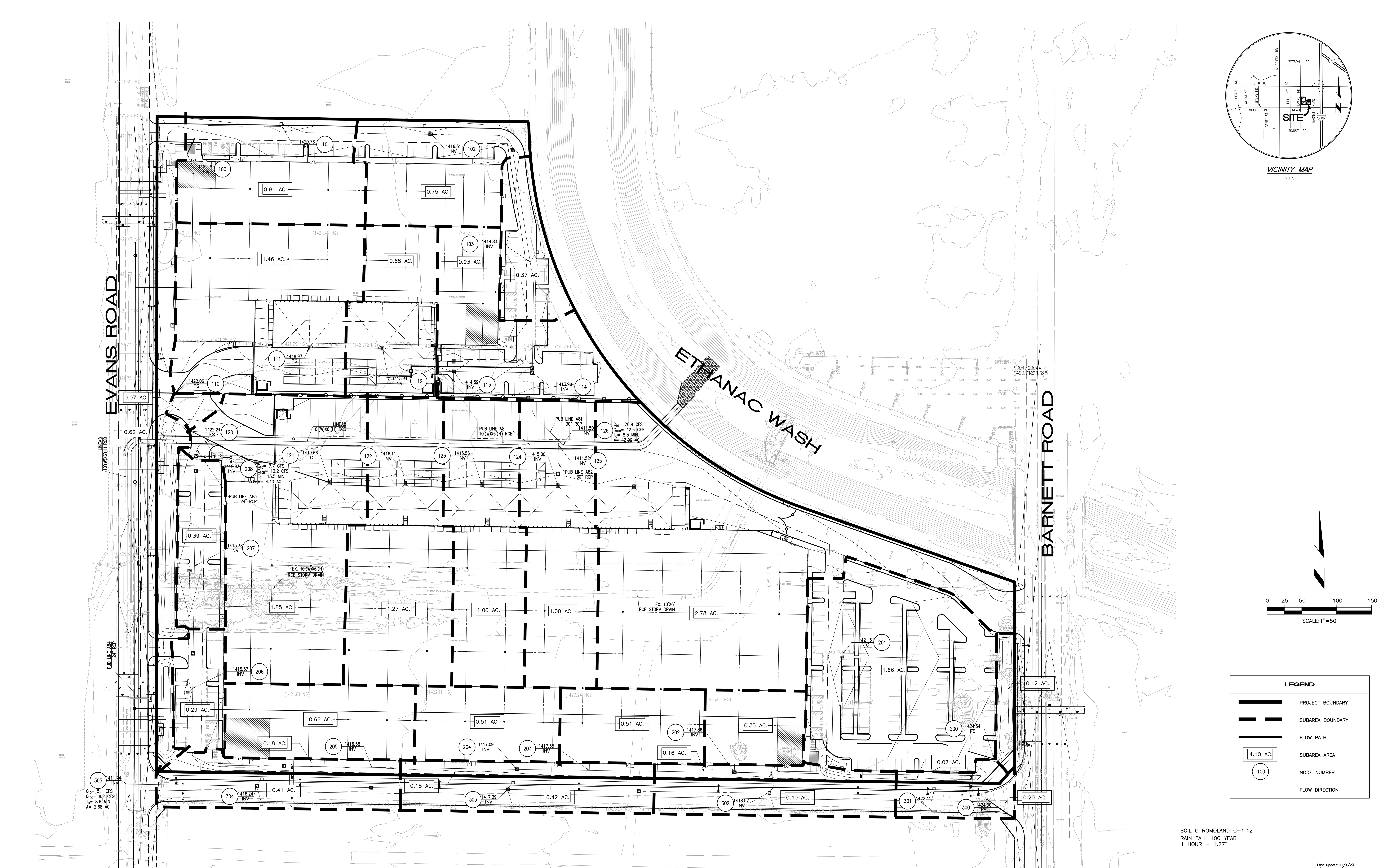
PREPARED BY:
Thienes Engineering, Inc.
CIVIL ENGINEERING • LAND SURVEYING
14349 FIRESTONE BOULEVARD
LA MIRADA, CALIFORNIA 90638
PH.(714)521-4811 FAX(714)521-4173

Designed by ____
Date ____
Checked by ____
Date ____
Designed by ____
Date ____
Checked by ____
Date ____

Approved by Date ____
Public Works Director R.C.E. ____

Sheet 1 of 1 Sheets

4118/1 OF 1 SHEET



SOIL C ROMOLAND C-1.42
RAIN FALL 100 YEAR
1 HOUR = 1.27"

Last Update: 11/1/23
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COUNTY OF RIVERSIDE
PUBLIC WORKS DEPARTMENT

PROPOSED CONDITION HYDROLOGY MAP

NORTHERN GATEWAY
LOGISTICS CENTER
EVANS ST BETWEEN ETHANAC RD AND McLAUGHLIN RD.

PREPARED FOR:
LOVETT INDUSTRIAL
120 NEWPORT CENTER DRIVE, SUITE 217
NEWPORT BEACH, CA 92660
PHONE: (949) 402-2760

PREPARED BY:
Thienes Engineering, Inc.
CIVIL ENGINEERING • LAND SURVEYING
14349 FIRESTONE BOULEVARD
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PH.(714)521-4811 FAX(714)521-4173

Designed by ______ Date ______
Checked by ______ Date ______
Designed by ______ Date ______
Checked by ______ Date ______

Approved by ______ Date ______
Public Works Director ______ R.C.E. ______

Sheet 1 of 1 Sheets

4118/1 OF 1 SHEET