# PINNACLE PEAK ROAD
# DRAINAGE PROJECT
# 99TH AVENUE TO 104TH AVENUE

## DESIGN DATA REPORT

October 14, 2010
WP #093386

FCD Contract No. 2010C020
PCN 450.06.31

*Prepared For:* **Flood Control District of Maricopa County**
2801 West Durango Street
Phoenix, Arizona 85009

*Prepared in Cooperation with:* **City of Peoria**
9875 North 85th Avenue
Peoria, Arizona 852345

*Prepared By:* **Wood, Patel & Associates, Inc.**
2051 West Northern Avenue, Suite 100
Phoenix, Arizona 85021
(602) 335-8500

Registered Professional Engineer (Civil)
CERTIFICATE NO. 24999
JEFFREY R. MINCH
DATE SIGNED 10-14-10
ARIZONA, U.S.A.

EXPIRES: 9-30-12

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**LANDSCAPING AND AESTHETICS**

**DRAINAGE EXCAVATION QUANTITIES**

**CD**


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# HYDROLOGY

**WOOD/PATEL**
MISSION: CLIENT SERVICE™

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS • CONSTRUCTION MANAGERS

# MEMO

TO: Jeff Minch, P.E.

FROM: James Taillon, CFM

DATE: October 14, 2010

RE: Pinnacle Peak Road Drainage Project
99th Avenue to 104th Avenue (Final Submittal)

SUBJECT: Project Hydrology

## I. INTRODUCTION

This memo summarizes the assumptions and supporting calculations for the final project hydrology, based on the recommended option from the Pinnacle Peak Road Pre-Design Study prepared by Wood/Patel, December 2009.

## II. HYDROLOGY FOR THE RECOMMENDED ALTERNATIVE

The recommended alternative from the pre-design study is Option VA52 based on the results of the Value Analysis Workshop which is a variation on Option 2. The major elements for this alternative are that the peak flow at 103rd Avenue is diverted to south with a 10 cfs low-flow bypass into the wash through the Ironwood subdivision and the rest into two (2) basins in series located on the south of the Pinnacle Peak Road.

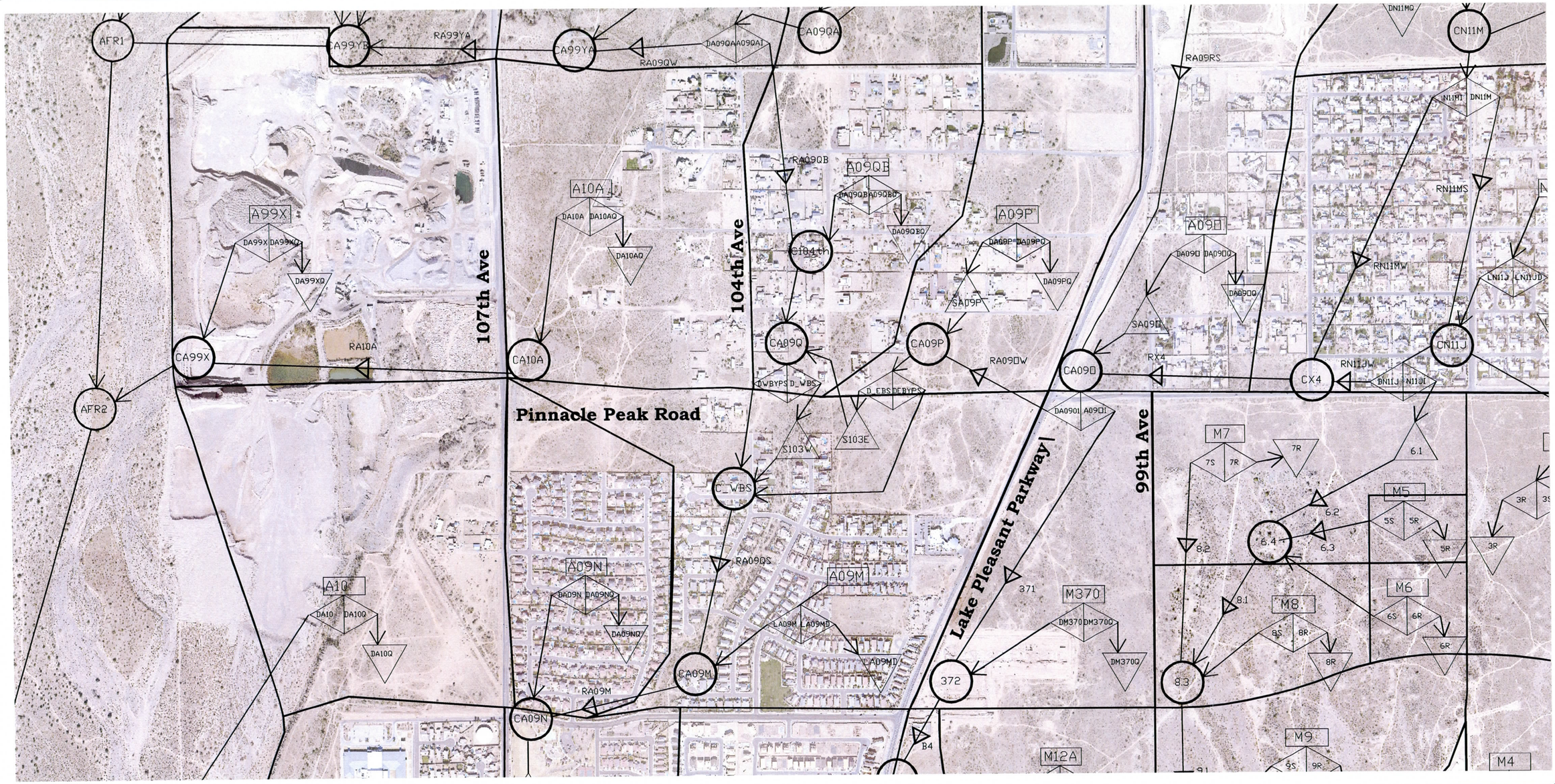
The base hydrologic model is the HEC-1 model developed for the Glendale Peoria ADMPU Northwest Region Update (GPNRU) developed by Wood, Patel & Associates in 2007 following procedures outlined in the Drainage Design Manual for Maricopa County, Volume I, Hydrology, revised January 1995. The base model was then updated using the District's DDMSW, Version 4.1.9 for land use and existing flood control improvements as necessary. As required by development agreement with the COP, the Camino A Lago development will convey flows from north of Pinnacle Peak Road and east of 99th Avenue to the south within their development. The base model was modified to reflect this change in concept for the Pinnacle Peak Road corridor. The future condition, 6-hour model was used in the pre-design study as the controlling model for each of the options considered for regional flood protection.

One of the project design objectives is that the system options would not exceed the downstream drainage systems peak discharge west of 107th Avenue including both Pinnacle Peak Road and Rose Garden Lane drainage systems. This objective is met with the proposed design; however, there will be additional total runoff volume (16 acre-ft.) conveyed to the Rose Garden Lane basin in the Agua Fria River. This project will direct additional excavation of the Rose Garden Lane basin to accommodate this additional volume. This eliminates the need to obtain additional drainage easements, flowage easements within the Agua Fria River or make off-site improvements. The hydrologic exhibits including soil data, land use data and sub-basin boundary delineations were submitted with the Final Pre-Design Study submittal.

For the recommended alternative, HEC-1 models were developed for existing conditions without CIP (capital improvement projects), for existing conditions with CIP, and for future conditions with CIP from the 100-year storm for the 6-hour and 24-hour durations. The tables for the HEC-1 models summary and the modeling results were included. The revised HEC-1 schematic for the recommended alternative within the project corridor was also included in this section. All HEC-1 models are included on the CD at the back of this report.



Wood, Patel & Associates, Inc. ♦ 2051 West Northern, Suite 100 ♦ Phoenix, Arizona 85021
Phone: (602) 335-8500 ♦ Fax: (602) 335-8580
E-Mail: woodpatel@woodpatel.com




## Legend

| | | | |
|---|---|---|---|
| Sub-Basin Boundary | | Combine Hydrograph | CN11C1 |
| Sub-Basin Hydrograph | N11C | Detention Storage Routing | LN11CW |
| Diversion | LN11CD LN11C | Channel Routing | R11DAS |

N

800 0 400 800

1 inch = 800 ft.

W:\2009 Projects\093386 - Pinnacle Peak Road and Channel\Project Support\Hydro\Exhibits\ HEC-1_Future_Alternative 52.dwg

PINNACLE PEAK ROAD AND CHANNEL

HEC-1 Schematic – Recommended Alternative

**WOOD/PATEL**

LAND DEVELOPMENT • WATER RESOURCES
TRANSPORTATION / TRAFFIC
WATER / WASTEWATER • SURVEYING
CONSTRUCTION MANAGEMENT

(602) 335-8500

PHOENIX • MESA • TUCSON • GOODYEAR

DRAWN BY: DF

JOB NO: 093386

Exhibit 1of1

## HEC-1 Models Summary

| HEC-1 Model Name and No. | | | Design Storm NOAA2 | | Landuse | | Camino A Lago Flow to South | | 103rd Ave.Flow Diversion to S. | | 103rd Ave. Basin | | 107rd Ave. Basin | | River Bottom Basin | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 100-Yr 24-Hr | 100-Yr 6-Hr | Existing Landuse | Future Landuse | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | |
| Name* | Option | No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 |
| L3R5DVR.DAT | RGL | E1 | | X | X | | | X | | X | | X | | X | | X | | | |
| FC06BASE.DAT | With Shape Files | E8 | | X | | X | | X | | X | | X | | X | | X | | | |
| FC24BASE.DAT | | E9 | X | | | X | | X | | X | | X | | X | | X | | | |
| EC06BASE.DAT | | E10 | | X | X | | X | | X | | | X | | X | | X | | | |
| EC24BASE.DAT | | E11 | X | | X | | X | | X | | | X | | X | | X | | | |
| EC06OPT1.DAT | 1 | A3 | | X | X | | X | | X | | | X | | X | | X | | | |
| EC24OPT1.DAT | | A4 | X | | X | | X | | X | | | X | | X | | X | | | |
| FC06OP52.DAT | | A52 | | X | | X | X | | 100% | | X | | | X | | X | | | |
| FC24OP52.DAT | | A52 | X | | | X | X | | 100% | | X | | | X | | X | | | |
| EC06OP52.DAT | | A52 | | X | X | | X | | 100% | | X | | | X | | X | | | |
| EC24OP52.DAT | | A52 | X | | X | | X | | 100% | | X | | | X | | X | | | |
| | | | | | | | | | | | | | | | | | | | |

## HEC-1 Modeling Results

| Project Name ===> | | | Pinnacle Peak Road | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location ===> | | | Routed from E. LPP | East of LPP | East of 103rd Ave. | 103rd Ave. | 107th Ave. | Agua Fria River | Agua Fria River | 103rd Diversion | | | | | | | | | | |
| Hydrograph Name ==> | | | RX4 | CA09O | CA09P | CA09Q | CA10A | CA99X/SAFR | CA99X/SAFR | A09QI | BY103 | DB103 | S103 | S103 | CN11FB | CN11FA | CX8 | CX10 | CA99V | CX10 |
| Model Name | Option | No. | (cfs) | (cfs) | (cfs) | (cfs) | (cfs) | (cfs) | (Ac-Ft) | (cfs) | (cfs) | (cfs | | | | | | | | |
| L3R5DVR.DAT | RGL | E1 | 250 | 474 | 563 | 729 | 1001 | 1030 | 132 | 0 | N/A | N/A | N/A | N/A | 227 | 1141 | 1058 | 1210 | 1193 | 152 |
| FC06BASE.DAT | With Shape Files | E8 | 516 | 513 | 518 | 606 | 617 | 653 | 118 | 0 | N/A | N/A | N/A | N/A | 144 | 315 | 242 | 559 | 554 | 102 |
| FC24BASE.DAT | | E9 | 362 | 376 | 409 | 489 | 510 | 542 | 118 | 0 | N/A | N/A | N/A | N/A | 89 | 261 | 200 | 520 | 516 | 116 |
| EC06BASE.DAT | | E10 | 106 | 219 | 54 | 272 | 262 | 691 | 46 | 272 | N/A | N/A | N/A | N/A | 142 | 1292 | 1203 | 1597 | 1584 | 250 |
| EC24BASE.DAT | | E11 | 72 | 160 | 49 | 216 | 230 | 649 | 48 | 216 | N/A | N/A | N/A | N/A | 89 | 1187 | 1125 | 1503 | 1522 | 268 |
| EC06OP1R.DAT | 1 | A1a | 106 | 219 | 54 | 272 | 327 | 322 | 16 | 272 | N/A | N/A | N/A | N/A | 142 | 1292 | 1203 | 1597 | 1584 | 250 |
| FC06P52A.DAT | 52 | A52 | 37 | 97 | 131 | 149 | 259 | 252 | 12 | 27 | 10 | 144 | 30 | 22 | 144 | 696 | 546 | 813 | 798 | 138 |
| FC24P52A.DAT | | A52 | 26 | 70 | 96 | 136 | 162 | 156 | 8 | 12 | 10 | 131 | 30 | 3 | 89 | 575 | 455 | 749 | 748 | 160 |

Model Naming Convention:
L3R5DVR = Rose Garden Lane model
Fxxxxxxx = Future conditions land use model
Exxxxxxx = Existing conditions land use model
xCxxxxxx = 100-Year storm frequency model
xx06xxxx = 6-Hour storm duration model
xx24xxxx = 24-Hour storm duration model
xxxxBASE = Effective model updated with land use shape files without capitol improvement projects
xxxxOPT1 = Proposed option 1 model with capitol improvement projects
xxxxOP52 = Recommended option model with capitol improvement projects

```
1****************************************
 *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
 *              JUN   1998              *
 *           VERSION 4.1                *
 *                                      *
 *  RUN DATE   09JUN10  TIME  13:17:35  *
 *                                      *
 ****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL  LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                    HEC-1 INPUT                                                    PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Project ID: PPR_FC06OPT2 - Major Basin: 01 - Return Period: 100 Years
  2           ID
  3           ID   ****************************************************************************
  4           ID   Pinnacle Peak Road and Channel Project                                     **
  5           ID   Original HEC-1 Model: FC06OPT1.DAT, Wood/Patel, August 2009                **
  6           ID                         100-Year 6-Hour HEC-1 Model for Future Conditions    **
  7           ID                         with CIP Improvements, NOAA2 and DDMSW419            **
  8           ID                         with Camino A Lago Improvements                      **
  9           ID                         100% Flows to South at 91st Ave. & 94th Ave.         **
 10           ID   Modified HEC-1 Model: FC06OP52.DAT, Wood/Patel, Jan. 2010                  **
 11           ID                         Option 52: Flow diversion and Offline Ret. Basin     **
 12           ID                                    are added at 103rd Ave.                   **
 13           ID                                                                              **
 14           ID   ****************************************************************************
 15           ID                                                                              **
 16           ID   Glendale/Peoria ADMP Northwest Region Update                               **
 17           ID   Original HEC-1 Model: EC06BASE.DAT, Wood/Patel, March 2007                 **
 18           ID                         100-Year 6-Hour HEC-1 Model for Existing Conditions **
 19           ID   Modified HEC-1 Model: FC06ADMP.DAT, Wood/Patel, SZ, May 2007               **
 20           ID                         100-Year 6-Hour HEC-1 Model for Future Conditions    **
 21           ID                         with CIP Improvements                                **
 22           ID   1) NOAA2 Rainfall Data                                                     **
 23           ID   2) DDMSW MCUHP1 V3.3.2 Used                                                **
 24           ID   3) Happy Valley Road Improvements Included                                 **
 25           ID   4) Pinnacle Peak Road and Channel Improvements Included                    **
 26           ID   5) Camino A Lago North Included                                            **
 27           ID   6) Beardsley Road Channel Included                                         **
 28           ID                                                                              **
 29           ID   ***************************************************************************
              *
 30           ID   ****************************************************************************
 31           ID   **                                                                          **
 32           ID   ** CONCEPT REFINEMENT STUDY FOR ROSE GARDEN LANE DRAINAGE IMPROVEMENTS      **
 33           ID   ** ORIGINAL HEC-1 FILE FROM GLENDAL/PEORIA ADMP UPDATE STUDY                **
```

```
34          ID   ** MODIFIED HEC-1 MODEL: LEVEL3R5.DAT, Wood/Patel & CVL, May 2005          **
35          ID   ** THIS IS THE PREFERRED ALTERNATIVE MODEL                                  **
36          ID   ** WPA REVISED APRIL 14, 2006 FOR DOVE VALLEY RANCH IMPROVEMENTS            **
37          ID   ** USING LATEST SURVEY DATA.                                                 **
38          ID   ***************************************************************************
            *
39          ID   ***************************************************************************
40          ID   **                                                                           **
41          ID   **                    Glendale/Peoria ADMP Update                            **
42          ID   **                                                                           **
43          ID   ***************************************************************************
44          ID   ***************************************************************************
45          ID   PROJECT:                Glendale Peoria ADMP Update
46          ID   CLIENT:                 Flood Control District of Maricopa County
47          ID   PREPARED BY:            Entellus, Inc.
48          ID   PROJECT No:             FCD 99-44              Entellus 310.017
49          ID   FILE NAME: LEVEL3.DAT             CREATED DATE: JUNE 6, 2001
50          ID   STORM:                  100-year 6-hour Storm
51          ID   DEVELOPMENT CONDITIONS: LEVEL 3 HYDROLOGY
52          ID
            *
            * ***************************************************************************
1                                          HEC-1 INPUT                                          PAGE  2

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

53          IT       2  1JAN99    1200    2000
54          IO       5
55          IN      15
            *
            *DIAGRAM
            *
56          JD   3.200  0.0001
57          PC   0.000   0.008   0.016   0.025   0.033   0.041   0.050   0.058   0.066   0.074
58          PC   0.087   0.099   0.118   0.138   0.216   0.377   0.834   0.911   0.931   0.950
59          PC   0.962   0.972   0.983   0.991   1.000
60          JD   3.181  0.5000
61          PC   0.000   0.008   0.016   0.025   0.033   0.041   0.050   0.058   0.066   0.074
62          PC   0.087   0.099   0.118   0.138   0.216   0.377   0.834   0.911   0.931   0.950
63          PC   0.962   0.972   0.983   0.991   1.000
64          JD   3.120     2.8
65          PC   0.000   0.009   0.016   0.025   0.034   0.042   0.051   0.059   0.068   0.077
66          PC   0.088   0.101   0.121   0.164   0.253   0.451   0.694   0.836   0.900   0.938
67          PC   0.950   0.963   0.975   0.988   1.000
68          JD   2.950    16.0
69          PC   0.000   0.015   0.020   0.030   0.048   0.063   0.076   0.090   0.105   0.119
70          PC   0.135   0.152   0.175   0.222   0.304   0.472   0.670   0.796   0.868   0.912
71          PC   0.946   0.960   0.973   0.987   1.000
72          JD   2.592    90.0
73          PC   0.000   0.021   0.035   0.051   0.071   0.087   0.105   0.125   0.143   0.160
74          PC   0.179   0.201   0.232   0.281   0.364   0.500   0.658   0.773   0.841   0.888
75          PC   0.927   0.945   0.964   0.982   1.000
            *
            * ***************************************************************************
            *
            * The Following Portion Came from the HEC-1 Model for the Tierra Del Rio
            * Development.  Model CREATED BY A. MERCIER, CMX, ON 01/16/04
            * FILE NAME: TDR6DC.DAT
            *
            * ***************************************************************************
            *

76          KK     CBA   BASIN
77          KM   SUB-BASIN CBA
78          BA   0.007
79          LG    0.25    0.17    6.80    0.15      39
80          UC   0.138   0.160
81          UA       0     3.0     5.0     8.0    12.0    20.0    43.0    75.0    90.0    96.0
82          UA     100
            *

83          KK    DCBA  DIVERT
84          KM   NEW RETENTIONOF 0.5  AC-FT IS ADDED FOR FUTURE LAND USE
85          DT   DCBAQ     0.5     0.0
86          DI     0.0   100.0  1000.0 10000.0     0.0     0.0     0.0     0.0     0.0     0.0
87          DQ     0.0   100.0  1000.0 10000.0     0.0     0.0     0.0     0.0     0.0     0.0
```

```
                *
                * This routing is disabled to make HEC-1 work
                *
                * KK  RCBA   ROUTE
                * KM CHANNEL ROUTING
                * RK  1479  0.0095   0.030            TRAP   0.100    4.00              40
                *
1                                                HEC-1 INPUT                                                          PAGE  3

LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  88            KK     P28   BASIN
  89            KM   SUB-BASIN P28
  90            BA   0.027
  91            LG    0.25    0.13   10.10    0.04      30
  92            UC   0.277   0.266
  93            UA       0     5.0    16.0    30.0    65.0    77.0    84.0    90.0    94.0    97.0
  94            UA     100
                *

  95            KK    CP28 COMBINE
  96            KM   COMBINE TWO HYDROGRAPHS
  97            HC       2
                *

  98            KK    DT28  DIVERT
  99            KM   Flow  Diversion
 100            DT    DB28     1.2     0.0
 101            DI     0.0   100.0   500.0  1000.0  5000.0     0.0     0.0     0.0     0.0     0.0
 102            DQ     0.0   100.0   500.0  1000.0  5000.0     0.0     0.0     0.0     0.0     0.0
                *

 103            KK     CBB   BASIN
 104            KM   SUB-BASIN CBB
 105            BA   0.017
 106            LG    0.25    0.25    4.60    0.39      43
 107            UC   0.147   0.114
 108            UA       0     4.5    12.6    23.2    35.8    50.0    64.2    76.8    87.4    95.5
 109            UA     100
                *
```

***The remainder of the input has been omitted from the hard copy output. The entire output file is located on the CD at the back of this report.***

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | CBA | 20. | 4.07 | 2. | 0. | 0. | .01 | | |
| + | DIVERSION TO | DCBAQ | 20. | 4.03 | 1. | 0. | 0. | .01 | | |
| + | HYDROGRAPH AT | DCBA | 19. | 4.10 | 1. | 0. | 0. | .01 | | |
| + | HYDROGRAPH AT | P28 | 63. | 4.10 | 7. | 2. | 1. | .03 | | |
| + | 2 COMBINED AT | CP28 | 82. | 4.10 | 8. | 2. | 1. | .03 | | |
| + | DIVERSION TO | DB28 | 48. | 3.97 | 2. | 1. | 0. | .03 | | |
| + | HYDROGRAPH AT | DT28 | 82. | 4.10 | 6. | 1. | 1. | .03 | | |
| + | HYDROGRAPH AT | CBB | 50. | 4.03 | 4. | 1. | 0. | .02 | | |
| + | DIVERSION TO | DCBBQ | 48. | 4.00 | 2. | 1. | 0. | .02 | | |
| + | HYDROGRAPH AT | DCBB | 48. | 4.07 | 2. | 0. | 0. | .02 | | |
| + | 2 COMBINED AT | CP28a | 124. | 4.10 | 8. | 2. | 1. | .05 | | |
| + | ROUTED TO | R28a | 86. | 4.30 | 7. | 2. | 1. | .05 | | |
| + | HYDROGRAPH AT | P27 | 124. | 4.13 | 17. | 4. | 1. | .06 | | |
| + | DIVERSION TO | DB27 | 59. | 3.90 | 3. | 1. | 0. | .06 | | |
| + | HYDROGRAPH AT | DT27 | 124. | 4.13 | 14. | 3. | 1. | .06 | | |
| + | 2 COMBINED AT | CP27 | 191. | 4.27 | 21. | 5. | 2. | .12 | | |
| + | HYDROGRAPH AT | P27A | 18. | 4.07 | 2. | 0. | 0. | .01 | | |
| + | DIVERSION TO | DB27A | 7. | 3.83 | 0. | 0. | 0. | .01 | | |
| + | HYDROGRAPH AT | DT27a | 18. | 4.07 | 1. | 0. | 0. | .01 | | |
| + | HYDROGRAPH AT | P27B | 28. | 4.07 | 3. | 1. | 0. | .01 | | |
| + | DIVERSION TO | DB27B | 11. | 3.87 | 1. | 0. | 0. | .01 | | |
| + | HYDROGRAPH AT | DT27b | 28. | 4.07 | 2. | 1. | 0. | .01 | | |
| + | HYDROGRAPH AT | CBL | 65. | 4.07 | 6. | 2. | 1. | .03 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| + | DIVERSION TO | DCBLQ | 24. | 3.83 | 1. | 0. | 0. | .03 |
| + | HYDROGRAPH AT | DCBL | 65. | 4.07 | 5. | 1. | 0. | .03 |
| + | 4 COMBINED AT | CCBL | 262. | 4.23 | 30. | 8. | 3. | .16 |
| + | ROUTED TO | RCBL | 259. | 4.27 | 30. | 8. | 3. | .16 |
| + | HYDROGRAPH AT | CBK | 138. | 4.10 | 12. | 3. | 1. | .05 |
| + | DIVERSION TO | DCBKQ | 138. | 4.10 | 7. | 2. | 1. | .05 |
| + | HYDROGRAPH AT | DCBK | 112. | 4.17 | 4. | 1. | 0. | .05 |
| + | 2 COMBINED AT | CCBK | 343. | 4.20 | 34. | 9. | 3. | .22 |
| + | ROUTED TO | RCBK | 349. | 4.20 | 35. | 9. | 3. | .22 |
| + | HYDROGRAPH AT | P14 | 22. | 4.03 | 2. | 0. | 0. | .01 |
| + | DIVERSION TO | RB14 | 22. | 4.03 | 2. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | RT14 | 0. | .00 | 0. | 0. | 0. | .01 |
| + | 2 COMBINED AT | CP14 | 349. | 4.20 | 35. | 9. | 3. | .22 |
| + | HYDROGRAPH AT | P15 | 9. | 4.17 | 1. | 0. | 0. | .01 |
| + | DIVERSION TO | DB15 | 9. | 4.17 | 1. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | DT15 | 0. | .00 | 0. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | CBJ | 38. | 4.10 | 3. | 1. | 0. | .01 |
| + | DIVERSION TO | DCBJQ | 38. | 4.10 | 2. | 1. | 0. | .01 |
| + | HYDROGRAPH AT | DCBJ | 25. | 4.20 | 1. | 0. | 0. | .01 |
| + | 3 COMBINED AT | CP15 | 374. | 4.20 | 36. | 9. | 3. | .25 |
| + | ROUTED TO | R15 | 369. | 4.23 | 36. | 9. | 3. | .25 |
| + | HYDROGRAPH AT | CBH | 39. | 4.03 | 3. | 1. | 0. | .01 |
| + | DIVERSION TO | DCBHQ | 38. | 4.00 | 2. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | DCBH | 36. | 4.07 | 1. | 0. | 0. | .01 |
| + | ROUTED TO | RCBH | 20. | 4.20 | 1. | 0. | 0. | .01 |

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|---|---|---|---|---|---|---|---|---|
| | HYDROGRAPH AT | | | | | | | |
| + | | P25S | 29. | 4.13 | 4. | 1. | 0. | .02 |
| | DIVERSION TO | | | | | | | |
| + | | DP25SQ | 29. | 4.13 | 2. | 0. | 0. | .02 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DP25S | 27. | 4.23 | 2. | 1. | 0. | .02 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP25S | 45. | 4.23 | 3. | 1. | 0. | .03 |
| | 2 COMBINED AT | | | | | | | |
| + | | AFR0 | 413. | 4.23 | 39. | 10. | 4. | .27 |
| | HYDROGRAPH AT | | | | | | | |
| + | | E1 | 44. | 4.03 | 3. | 1. | 0. | .01 |
| | DIVERSION TO | | | | | | | |
| + | | DE1Q | 41. | 3.97 | 1. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DE1 | 44. | 4.03 | 2. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | E2 | 35. | 4.07 | 3. | 1. | 0. | .02 |
| | ROUTED TO | | | | | | | |
| + | | RE2 | 34. | 4.10 | 3. | 1. | 0. | .02 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P13 | 153. | 4.07 | 12. | 3. | 1. | .06 |
| | DIVERSION TO | | | | | | | |
| + | | DB13 | 53. | 3.83 | 3. | 1. | 0. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT13 | 153. | 4.07 | 10. | 2. | 1. | .06 |
| | 3 COMBINED AT | | | | | | | |
| + | | CP13 | 228. | 4.07 | 14. | 4. | 1. | .09 |
| | ROUTED TO | | | | | | | |
| + | | R13 | 220. | 4.13 | 14. | 4. | 1. | .09 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P12 | 87. | 4.10 | 9. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | DB12 | 49. | 3.97 | 2. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT12 | 87. | 4.10 | 7. | 2. | 1. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP12 | 306. | 4.13 | 21. | 5. | 2. | .13 |
| | HYDROGRAPH AT | | | | | | | |
| + | | E3 | 111. | 4.27 | 15. | 4. | 1. | .08 |
| | DIVERSION TO | | | | | | | |
| + | | DE3Q | 88. | 4.10 | 3. | 1. | 0. | .08 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DE3 | 111. | 4.27 | 12. | 3. | 1. | .08 |
| | ROUTED TO | | | | | | | |
| + | | RE3 | 113. | 4.20 | 12. | 3. | 1. | .08 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P10 | 120. | 4.10 | 11. | 3. | 1. | .05 |
| | DIVERSION TO | | | | | | | |
| + | | DB10 | 44. | 3.87 | 2. | 1. | 0. | .05 |
| | HYDROGRAPH AT | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | DT10 | 120. | 4.10 | 9. | 2. | 1. | .05 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP10 | 210. | 4.20 | 21. | 5. | 2. | .14 |
| | ROUTED TO | | | | | | | |
| + | | R10 | 186. | 4.33 | 21. | 5. | 2. | .14 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P11 | 52. | 4.23 | 9. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | DB11 | 47. | 4.13 | 2. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT11 | 52. | 4.23 | 7. | 2. | 1. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP11 | 235. | 4.33 | 27. | 7. | 2. | .18 |
| | HYDROGRAPH AT | | | | | | | |
| + | | E4 | 52. | 4.23 | 8. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | DE4Q | 52. | 4.23 | 5. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DE4 | 31. | 4.57 | 3. | 1. | 0. | .04 |
| | ROUTED TO | | | | | | | |
| + | | RE4 | 30. | 4.63 | 3. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P9 | 100. | 4.07 | 10. | 2. | 1. | .05 |
| | DIVERSION TO | | | | | | | |
| + | | DB9 | 37. | 3.87 | 2. | 0. | 0. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT9 | 100. | 4.07 | 8. | 2. | 1. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | HV1 | 8. | 4.20 | 1. | 0. | 0. | .01 |
| | DIVERSION TO | | | | | | | |
| + | | DHV1Q | 8. | 4.13 | 0. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DHV1 | 8. | 4.20 | 1. | 0. | 0. | .01 |
| | 3 COMBINED AT | | | | | | | |
| + | | CP9 | 100. | 4.07 | 12. | 3. | 1. | .09 |
| | ROUTED TO | | | | | | | |
| + | | R9 | 99. | 4.10 | 12. | 3. | 1. | .09 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P8 | 17. | 4.17 | 3. | 1. | 0. | .01 |
| | DIVERSION TO | | | | | | | |
| + | | DB8 | 13. | 4.03 | 1. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT8 | 17. | 4.17 | 2. | 1. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P7 | 22. | 4.13 | 3. | 1. | 0. | .01 |
| | DIVERSION TO | | | | | | | |
| + | | DB7 | 13. | 3.97 | 1. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT7 | 22. | 4.13 | 2. | 1. | 0. | .01 |
| | 3 COMBINED AT | | | | | | | |
| + | | CP7 | 136. | 4.10 | 16. | 4. | 1. | .12 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | R7 | 134. | 4.13 | 16. | 4. | 1. | .12 |
| + | HYDROGRAPH AT | P6 | 55. | 4.37 | 14. | 4. | 1. | .07 |
| + | DIVERSION TO | DB6 | 55. | 4.30 | 4. | 1. | 0. | .07 |
| + | HYDROGRAPH AT | DT6 | 55. | 4.37 | 11. | 3. | 1. | .07 |
| + | 2 COMBINED AT | CP6 | 142. | 4.37 | 27. | 7. | 2. | .19 |
| + | 3 COMBINED AT | HPVLY | 556. | 4.20 | 75. | 19. | 7. | .50 |
| + | HYDROGRAPH AT | A11MA | 235. | 4.03 | 19. | 5. | 2. | .07 |
| + | DIVERSION TO | DA11MA | 235. | 4.03 | 15. | 4. | 1. | .07 |
| + | HYDROGRAPH AT | A11MAQ | 150. | 4.17 | 5. | 1. | 0. | .07 |
| + | ROUTED TO | SA11MA | 21. | 4.43 | 5. | 1. | 0. | .07 |
| + | ROUTED TO | RA11MA | 21. | 4.70 | 5. | 1. | 0. | .07 |
| + | HYDROGRAPH AT | A11MB | 547. | 4.07 | 51. | 13. | 5. | .19 |
| + | DIVERSION TO | DA11MB | 153. | 3.73 | 7. | 2. | 1. | .19 |
| + | HYDROGRAPH AT | A11MBQ | 547. | 4.07 | 43. | 11. | 4. | .19 |
| + | ROUTED TO | SA11MB | 293. | 4.27 | 41. | 11. | 4. | .19 |
| + | HYDROGRAPH AT | A11NA | 231. | 4.03 | 17. | 4. | 2. | .08 |
| + | DIVERSION TO | A11NAQ | 62. | 3.77 | 3. | 1. | 0. | .08 |
| + | HYDROGRAPH AT | DA11NA | 231. | 4.03 | 14. | 3. | 1. | .08 |
| + | ROUTED TO | SA11NA | 32. | 4.37 | 14. | 3. | 1. | .08 |
| + | ROUTED TO | RA11NA | 31. | 4.63 | 14. | 3. | 1. | .08 |
| + | 3 COMBINED AT | CA11MB | 315. | 4.27 | 60. | 15. | 6. | .34 |
| + | ROUTED TO | RA11MB | 276. | 4.50 | 59. | 15. | 6. | .34 |
| + | HYDROGRAPH AT | A11O | 141. | 4.07 | 12. | 3. | 1. | .06 |
| + | DIVERSION TO | DA11OQ | 36. | 3.77 | 2. | 0. | 0. | .06 |
| + | HYDROGRAPH AT | DA11O | 141. | 4.07 | 11. | 3. | 1. | .06 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | SA11O | 41. | 4.40 | 11. | 3. | 1. | .06 |
| + | ROUTED TO | RA11O | 39. | 4.67 | 11. | 3. | 1. | .06 |
| + | HYDROGRAPH AT | A11KB | 257. | 4.10 | 23. | 6. | 2. | .11 |
| + | ROUTED TO | SA11KB | 33. | 4.57 | 21. | 6. | 2. | .11 |
| + | HYDROGRAPH AT | A11KA | 219. | 4.03 | 19. | 5. | 2. | .08 |
| + | DIVERSION TO | A11KAQ | 5. | 3.23 | 1. | 0. | 0. | .08 |
| + | HYDROGRAPH AT | DA11KA | 219. | 4.03 | 17. | 4. | 2. | .08 |
| + | ROUTED TO | SA11KA | 31. | 4.43 | 17. | 4. | 2. | .08 |
| + | ROUTED TO | RA11KA | 31. | 4.70 | 17. | 4. | 2. | .08 |
| + | 3 COMBINED AT | CA11KB | 102. | 4.67 | 49. | 13. | 5. | .24 |
| + | ROUTED TO | RA11KB | 101. | 4.90 | 49. | 13. | 5. | .24 |
| + | HYDROGRAPH AT | A11G | 113. | 4.17 | 13. | 3. | 1. | .06 |
| + | DIVERSION TO | DA11GQ | 43. | 3.90 | 2. | 1. | 0. | .06 |
| + | HYDROGRAPH AT | DA11G | 113. | 4.17 | 11. | 3. | 1. | .06 |
| + | ROUTED TO | RA11GN | 105. | 4.33 | 11. | 3. | 1. | .06 |
| + | HYDROGRAPH AT | A11KC | 325. | 4.07 | 27. | 7. | 2. | .13 |
| + | DIVERSION TO | A11KCQ | 57. | 3.73 | 4. | 1. | 0. | .13 |
| + | HYDROGRAPH AT | DA11KC | 325. | 4.07 | 23. | 6. | 2. | .13 |
| + | ROUTED TO | SA11KC | 81. | 4.37 | 23. | 6. | 2. | .13 |
| + | 3 COMBINED AT | CA11KC | 243. | 4.40 | 83. | 21. | 8. | .44 |
| + | ROUTED TO | RA11KC | 239. | 4.53 | 83. | 21. | 8. | .44 |
| + | HYDROGRAPH AT | A11J | 202. | 4.23 | 28. | 7. | 3. | .11 |
| + | DIVERSION TO | DA11JQ | 120. | 4.00 | 6. | 2. | 1. | .11 |
| + | HYDROGRAPH AT | DA11J | 202. | 4.23 | 22. | 6. | 2. | .11 |
| + | ROUTED TO | SA11J | 89. | 4.67 | 22. | 6. | 2. | .11 |
| | 3 COMBINED AT | | | | | | | |

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| + | | CA11J | 511. | 4.57 | 158. | 41. | 15. | .89 |
| + | HYDROGRAPH AT | A11L | 423. | 4.23 | 70. | 17. | 6. | .25 |
| + | DIVERSION TO | DA11L | 389. | 4.13 | 21. | 5. | 2. | .25 |
| + | HYDROGRAPH AT | DA11LQ | 423. | 4.23 | 49. | 12. | 4. | .25 |
| + | ROUTED TO | RA11L | 401. | 4.47 | 49. | 12. | 4. | .25 |
| + | HYDROGRAPH AT | A11I | 340. | 4.13 | 43. | 11. | 4. | .15 |
| + | DIVERSION TO | DA11I | 340. | 4.13 | 24. | 6. | 2. | .15 |
| + | HYDROGRAPH AT | DA11IQ | 293. | 4.27 | 19. | 5. | 2. | .15 |
| + | 3 COMBINED AT | CA11I | 936. | 4.53 | 221. | 57. | 20. | 1.29 |
| + | ROUTED TO | RA11I | 905. | 4.77 | 219. | 57. | 20. | 1.29 |
| + | HYDROGRAPH AT | A11EA | 203. | 4.27 | 28. | 7. | 3. | .14 |
| + | DIVERSION TO | D11EAQ | 190. | 4.17 | 9. | 2. | 1. | .14 |
| + | HYDROGRAPH AT | D11EA | 203. | 4.27 | 19. | 5. | 2. | .14 |
| + | ROUTED TO | RA11EA | 192. | 4.47 | 19. | 5. | 2. | .14 |
| + | HYDROGRAPH AT | A11EB | 199. | 4.40 | 37. | 9. | 3. | .19 |
| + | DIVERSION TO | D11EBQ | 199. | 4.40 | 23. | 6. | 2. | .19 |
| + | HYDROGRAPH AT | D11EB | 136. | 4.73 | 15. | 4. | 1. | .19 |
| + | 3 COMBINED AT | CA11EB | 1005. | 4.77 | 244. | 63. | 23. | 1.63 |
| + | HYDROGRAPH AT | 41 | 160. | 4.07 | 11. | 3. | 1. | .05 |
| + | DIVERSION TO | D41Q | 140. | 3.97 | 5. | 1. | 0. | .05 |
| + | HYDROGRAPH AT | D41 | 160. | 4.07 | 6. | 1. | 1. | .05 |
| + | ROUTED TO | B41 | 90. | 4.17 | 6. | 1. | 1. | .05 |
| + | HYDROGRAPH AT | 42 | 212. | 4.10 | 18. | 5. | 2. | .08 |
| + | DIVERSION TO | D42Q | 186. | 4.00 | 8. | 2. | 1. | .08 |
| + | HYDROGRAPH AT | D42 | 212. | 4.10 | 10. | 3. | 1. | .08 |
| + | ROUTED TO | B42 | 130. | 4.20 | 10. | 3. | 1. | .08 |

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| + | 2 COMBINED AT | C41 | 218. | 4.20 | 16. | 4. | 1. | .13 |
| + | ROUTED TO | RC41 | 173. | 4.67 | 16. | 4. | 1. | .13 |
| + | HYDROGRAPH AT | A11F | 515. | 4.23 | 63. | 16. | 6. | .33 |
| + | DIVERSION TO | DA11FQ | 482. | 4.17 | 23. | 6. | 2. | .33 |
| + | HYDROGRAPH AT | DA11F | 515. | 4.23 | 40. | 10. | 4. | .33 |
| + | 2 COMBINED AT | CA11F | 515. | 4.23 | 56. | 14. | 5. | .46 |
| + | 2 COMBINED AT | CA11E | 1198. | 4.77 | 284. | 73. | 26. | 2.09 |
| + | ROUTED TO | RA11E | 1181. | 4.87 | 283. | 73. | 26. | 2.09 |
| + | HYDROGRAPH AT | A09U | 412. | 4.10 | 35. | 9. | 3. | .17 |
| + | DIVERSION TO | DA09UQ | 234. | 3.93 | 8. | 2. | 1. | .17 |
| + | HYDROGRAPH AT | DA09U | 412. | 4.10 | 26. | 7. | 2. | .17 |
| + | DIVERSION TO | A09UI | 0. | .00 | 0. | 0. | 0. | .17 |
| + | HYDROGRAPH AT | DA09U1 | 412. | 4.10 | 26. | 7. | 2. | .17 |
| + | ROUTED TO | RA09UW | 314. | 4.47 | 26. | 7. | 2. | .17 |
| + | HYDROGRAPH AT | A09T | 346. | 4.17 | 39. | 10. | 4. | .18 |
| + | DIVERSION TO | DA09TQ | 346. | 4.17 | 19. | 5. | 2. | .18 |
| + | HYDROGRAPH AT | DA09T | 328. | 4.23 | 20. | 5. | 2. | .18 |
| + | 2 COMBINED AT | CA09T | 473. | 4.47 | 46. | 12. | 4. | .36 |
| + | DIVERSION TO | A09TI | 0. | .00 | 0. | 0. | 0. | .36 |
| + | HYDROGRAPH AT | DA09T1 | 473. | 4.47 | 46. | 12. | 4. | .36 |
| + | ROUTED TO | RA09TW | 432. | 4.60 | 46. | 12. | 4. | .36 |
| + | HYDROGRAPH AT | A11A | 581. | 4.20 | 74. | 19. | 7. | .30 |
| + | DIVERSION TO | DA11A | 510. | 4.10 | 28. | 7. | 3. | .30 |
| + | HYDROGRAPH AT | DA11AQ | 581. | 4.20 | 46. | 12. | 4. | .30 |
| + | 3 COMBINED AT | CX23 | 1495. | 4.83 | 352. | 90. | 33. | 2.74 |

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| + | ROUTED TO | RX23 | 1457. | 5.03 | 350. | 90. | 33. | 2.74 |
| + | HYDROGRAPH AT | S1 | 169. | 4.27 | 23. | 6. | 2. | .12 |
| + | DIVERSION TO | DS1Q | 86. | 4.00 | 4. | 1. | 0. | .12 |
| + | HYDROGRAPH AT | DS1 | 169. | 4.27 | 19. | 5. | 2. | .12 |
| + | HYDROGRAPH AT | P2 | 126. | 4.07 | 11. | 3. | 1. | .05 |
| + | DIVERSION TO | RB2 | 126. | 4.07 | 9. | 2. | 1. | .05 |
| + | HYDROGRAPH AT | RT2 | 25. | 4.43 | 1. | 0. | 0. | .05 |
| + | 3 COMBINED AT | CS1 | 1470. | 5.03 | 360. | 93. | 34. | 2.92 |
| + | ROUTED TO | RS1 | 1470. | 5.07 | 360. | 93. | 34. | 2.92 |
| + | HYDROGRAPH AT | S2 | 37. | 4.03 | 3. | 1. | 0. | .01 |
| + | DIVERSION TO | DS2Q | 32. | 3.93 | 1. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | DS2 | 37. | 4.03 | 1. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | S3 | 19. | 4.00 | 1. | 0. | 0. | .01 |
| + | 3 COMBINED AT | CS2 | 1468. | 5.07 | 361. | 94. | 34. | 2.94 |
| + | ROUTED TO | RS2 | 1467. | 5.10 | 361. | 94. | 34. | 2.94 |
| + | HYDROGRAPH AT | P3 | 99. | 4.13 | 11. | 3. | 1. | .05 |
| + | DIVERSION TO | RB3 | 99. | 4.13 | 10. | 3. | 1. | .05 |
| + | HYDROGRAPH AT | RT3 | 12. | 4.90 | 1. | 0. | 0. | .05 |
| + | 2 COMBINED AT | CP3 | 1467. | 5.10 | 361. | 94. | 34. | 2.99 |
| + | HYDROGRAPH AT | P4b | 49. | 4.03 | 4. | 1. | 0. | .02 |
| + | DIVERSION TO | RB4B | 11. | 3.73 | 1. | 0. | 0. | .02 |
| + | HYDROGRAPH AT | RT4b | 49. | 4.03 | 3. | 1. | 0. | .02 |
| + | HYDROGRAPH AT | S4 | 21. | 4.17 | 3. | 1. | 0. | .01 |
| + | DIVERSION TO | DS4Q | 20. | 4.10 | 1. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | DS4 | 21. | 4.17 | 2. | 0. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | P1 | 57. | 4.13 | 7. | 2. | 1. | .03 |
| | DIVERSION TO | | | | | | | |
| + | | DB1 | 57. | 4.13 | 4. | 1. | 0. | .03 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT1 | 42. | 4.30 | 3. | 1. | 0. | .03 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP1 | 59. | 4.30 | 4. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | HV2 | 9. | 5.00 | 5. | 2. | 1. | .03 |
| | ROUTED TO | | | | | | | |
| + | | RHV2 | 9. | 5.07 | 5. | 2. | 1. | .03 |
| | DIVERSION TO | | | | | | | |
| + | | DBHV2 | 9. | 5.07 | 2. | 0. | 0. | .03 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DTHV2 | 8. | 5.40 | 4. | 1. | 0. | .03 |
| | HYDROGRAPH AT | | | | | | | |
| + | | P4a | 60. | 4.17 | 8. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | DB4A | 28. | 3.93 | 1. | 0. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DT4a | 60. | 4.17 | 6. | 2. | 1. | .04 |
| | 5 COMBINED AT | | | | | | | |
| + | | SOUTH | 1465. | 5.10 | 370. | 97. | 35. | 3.12 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N11O | 103. | 4.20 | 10. | 2. | 1. | .05 |
| | DIVERSION TO | | | | | | | |
| + | | DN11OQ | 103. | 4.20 | 6. | 1. | 1. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN11O | 77. | 4.33 | 4. | 1. | 0. | .05 |
| | DIVERSION TO | | | | | | | |
| + | | N11OI | 70. | 4.33 | 4. | 1. | 0. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN11O1 | 8. | 4.33 | 0. | 0. | 0. | .05 |
| | ROUTED TO | | | | | | | |
| + | | RN11OW | 3. | 5.37 | 0. | 0. | 0. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DRA09T | 0. | .00 | 0. | 0. | 0. | .36 |
| | ROUTED TO | | | | | | | |
| + | | RA09TS | 0. | .00 | 0. | 0. | 0. | .36 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A09R | 181. | 4.33 | 29. | 7. | 3. | .14 |
| | DIVERSION TO | | | | | | | |
| + | | DA09RQ | 181. | 4.33 | 21. | 5. | 2. | .14 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DA09R | 88. | 4.77 | 8. | 2. | 1. | .14 |
| | 3 COMBINED AT | | | | | | | |
| + | | CA09R | 87. | 4.77 | 8. | 2. | 1. | .20 |
| | DIVERSION TO | | | | | | | |
| + | | A09RI | 87. | 4.77 | 8. | 2. | 1. | .20 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DA09R1 | 1. | 5.03 | 0. | 0. | 0. | .20 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | RA09RW | 0. | 7.30 | 0. | 0. | 0. | .20 |
| + | HYDROGRAPH AT | A09S | 137. | 4.17 | 21. | 5. | 2. | .07 |
| + | DIVERSION TO | DA09S | 137. | 4.17 | 14. | 4. | 1. | .07 |
| + | HYDROGRAPH AT | DA09SQ | 82. | 4.47 | 7. | 2. | 1. | .07 |
| + | 2 COMBINED AT | CA09S | 82. | 4.47 | 7. | 2. | 1. | .27 |
| + | ROUTED TO | RA09SW | 74. | 4.60 | 7. | 2. | 1. | .27 |
| + | HYDROGRAPH AT | A09QA | 154. | 4.20 | 16. | 4. | 1. | .09 |
| + | DIVERSION TO | A09QAQ | 154. | 4.20 | 9. | 2. | 1. | .09 |
| + | HYDROGRAPH AT | DA09QA | 128. | 4.30 | 7. | 2. | 1. | .09 |
| + | 2 COMBINED AT | CA09QA | 126. | 4.30 | 14. | 3. | 1. | .36 |
| + | DIVERSION TO | A09QAI | 125. | 4.30 | 13. | 3. | 1. | .36 |
| + | HYDROGRAPH AT | DA09QI | 1. | 5.73 | 0. | 0. | 0. | .36 |
| + | ROUTED TO | RA09QW | 1. | 5.87 | 0. | 0. | 0. | .36 |
| + | HYDROGRAPH AT | A99YA | 205. | 4.13 | 19. | 5. | 2. | .10 |
| + | DIVERSION TO | A99YAQ | 205. | 4.13 | 11. | 3. | 1. | .10 |
| + | HYDROGRAPH AT | DA99YA | 182. | 4.23 | 9. | 2. | 1. | .10 |
| + | 2 COMBINED AT | CA99YA | 181. | 4.23 | 9. | 2. | 1. | .46 |
| + | ROUTED TO | RA99YA | 149. | 4.37 | 9. | 2. | 1. | .46 |
| + | HYDROGRAPH AT | A99YB | 395. | 4.13 | 38. | 9. | 3. | .17 |
| + | DIVERSION TO | A99YBQ | 395. | 4.13 | 21. | 5. | 2. | .17 |
| + | HYDROGRAPH AT | DA99YB | 359. | 4.20 | 16. | 4. | 1. | .17 |
| + | 3 COMBINED AT | CA99YB | 1460. | 5.10 | 381. | 100. | 36. | 3.76 |
| + | 3 COMBINED AT | AFR1 | 1565. | 5.07 | 457. | 119. | 43. | 4.53 |
| + | HYDROGRAPH AT | N11NA | 74. | 4.00 | 5. | 1. | 0. | .02 |
| + | DIVERSION TO | N11NAQ | 68. | 3.93 | 2. | 1. | 0. | .02 |

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|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | DN11NA | 74. | 4.00 | 2. | 1. | 0. | .02 |
| + | ROUTED TO | RN11NA | 35. | 4.47 | 2. | 1. | 0. | .02 |
| + | HYDROGRAPH AT | N11NC | 322. | 4.13 | 29. | 7. | 3. | .17 |
| + | DIVERSION TO | N11NCQ | 216. | 4.00 | 7. | 2. | 1. | .17 |
| + | HYDROGRAPH AT | DN11NC | 322. | 4.13 | 21. | 5. | 2. | .17 |
| + | 2 COMBINED AT | CN11NC | 322. | 4.13 | 24. | 6. | 2. | .19 |
| + | DIVERSION TO | N11NP | 149. | 4.07 | 16. | 4. | 1. | .19 |
| + | HYDROGRAPH AT | DN11NP | 173. | 4.13 | 7. | 2. | 1. | .19 |
| + | ROUTED TO | RN11NC | 157. | 4.27 | 7. | 2. | 1. | .19 |
| + | HYDROGRAPH AT | N11ND | 77. | 4.17 | 10. | 3. | 1. | .05 |
| + | HYDROGRAPH AT | N11K | 194. | 4.23 | 29. | 7. | 3. | .17 |
| + | 3 COMBINED AT | CN11K | 420. | 4.27 | 46. | 12. | 4. | .41 |
| + | DIVERSION TO | N11KP | 0. | .00 | 0. | 0. | 0. | .41 |
| + | HYDROGRAPH AT | DN11K | 420. | 4.27 | 46. | 12. | 4. | .41 |
| + | DIVERSION TO | DN11KS | 420. | 4.27 | 46. | 12. | 4. | .41 |
| + | HYDROGRAPH AT | DN11KW | 0. | .00 | 0. | 0. | 0. | .41 |
| + | ROUTED TO | RN11KW | 0. | .00 | 0. | 0. | 0. | .41 |
| + | HYDROGRAPH AT | BA09UI | 0. | .00 | 0. | 0. | 0. | .17 |
| + | ROUTED TO | RA09US | 0. | .00 | 0. | 0. | 0. | .17 |
| + | HYDROGRAPH AT | N11NB | 201. | 4.23 | 26. | 6. | 2. | .14 |
| + | DIVERSION TO | N11NBQ | 69. | 3.93 | 3. | 1. | 0. | .14 |
| + | HYDROGRAPH AT | DN11NB | 201. | 4.23 | 23. | 6. | 2. | .14 |
| + | 2 COMBINED AT | CN11NB | 201. | 4.23 | 23. | 6. | 2. | .14 |
| + | ROUTED TO | RN11NW | 183. | 4.67 | 23. | 6. | 2. | .14 |
| + | HYDROGRAPH AT | BN11OI | 70. | 4.33 | 4. | 1. | 0. | .05 |
| | ROUTED TO | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | RN11OS | 32. | 5.07 | 4. | 1. | 0. | .05 |
| + | HYDROGRAPH AT | N11M | 188. | 4.17 | 17. | 4. | 2. | .10 |
| + | DIVERSION TO | DN11MQ | 188. | 4.17 | 11. | 3. | 1. | .10 |
| + | HYDROGRAPH AT | DN11M | 142. | 4.30 | 6. | 2. | 1. | .10 |
| + | 3 COMBINED AT | CN11M | 211. | 4.63 | 33. | 8. | 3. | .24 |
| + | DIVERSION TO | N11MI | 53. | 4.63 | 8. | 2. | 1. | .24 |
| + | HYDROGRAPH AT | DN11M1 | 159. | 4.63 | 25. | 6. | 2. | .24 |
| + | ROUTED TO | RN11MS | 151. | 4.90 | 25. | 6. | 2. | .24 |
| + | HYDROGRAPH AT | N11J | 269. | 4.27 | 41. | 10. | 4. | .24 |
| + | DIVERSION TO | LN11JD | 100. | 4.00 | 4. | 1. | 0. | .24 |
| + | HYDROGRAPH AT | LN11J | 269. | 4.27 | 37. | 9. | 3. | .24 |
| + | 3 COMBINED AT | CN11J | 237. | 4.83 | 57. | 14. | 5. | .90 |
| + | DIVERSION TO | N11JI | 237. | 4.83 | 57. | 14. | 5. | .90 |
| + | HYDROGRAPH AT | DN11J | 0. | .00 | 0. | 0. | 0. | .90 |
| + | ROUTED TO | RN11JW | 0. | .00 | 0. | 0. | 0. | .90 |
| + | HYDROGRAPH AT | DRN11M | 53. | 4.63 | 8. | 2. | 1. | .24 |
| + | ROUTED TO | RN11MW | 47. | 5.20 | 8. | 2. | 1. | .24 |
| + | 2 COMBINED AT | CX4 | 41. | 5.23 | 7. | 2. | 1. | .90 |
| + | ROUTED TO | RX4 | 37. | 5.60 | 7. | 2. | 1. | .90 |
| + | HYDROGRAPH AT | A09O | 169. | 4.47 | 34. | 9. | 3. | .19 |
| + | DIVERSION TO | DA09OQ | 153. | 4.33 | 9. | 2. | 1. | .19 |
| + | HYDROGRAPH AT | DA09O | 169. | 4.47 | 25. | 6. | 2. | .19 |
| + | ROUTED TO | SA09O | 44. | 5.53 | 24. | 6. | 2. | .19 |
| + | HYDROGRAPH AT | BA09RI | 87. | 4.77 | 8. | 2. | 1. | .20 |
| + | ROUTED TO | RA09RS | 56. | 5.33 | 8. | 2. | 1. | .20 |
| + | 3 COMBINED AT | CA09O | 97. | 5.57 | 34. | 9. | 3. | 1.09 |

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|---|---|---|---|---|---|---|---|
| + | DIVERSION TO | A09OI | 0. | .00 | 0. | 0. | 0. | 1.09 |
| + | HYDROGRAPH AT | DA09O1 | 97. | 5.57 | 34. | 9. | 3. | 1.09 |
| + | ROUTED TO | RA09OW | 94. | 5.67 | 34. | 9. | 3. | 1.09 |
| + | HYDROGRAPH AT | A09P | 249. | 4.30 | 34. | 8. | 3. | .19 |
| + | DIVERSION TO | DA09PQ | 210. | 4.17 | 9. | 2. | 1. | .19 |
| + | HYDROGRAPH AT | DA09P | 249. | 4.30 | 25. | 6. | 2. | .19 |
| + | ROUTED TO | SA09P | 51. | 5.03 | 24. | 6. | 2. | .19 |
| + | 2 COMBINED AT | CA09P | 131. | 5.70 | 54. | 14. | 5. | 1.28 |
| + | DIVERSION TO | D_EBS | 126. | 5.70 | 49. | 12. | 4. | 1.28 |
| + | HYDROGRAPH AT | DEBYPS | 5. | 4.30 | 5. | 2. | 1. | 1.28 |
| + | HYDROGRAPH AT | BD_EBS | 126. | 5.70 | 49. | 12. | 4. | 1.28 |
| + | ROUTED TO | S103E | 24. | 7.30 | 11. | 3. | 1. | 1.28 |
| + | HYDROGRAPH AT | BA09QA | 125. | 4.30 | 13. | 3. | 1. | .36 |
| + | ROUTED TO | RA09QB | 102. | 4.83 | 13. | 3. | 1. | .36 |
| + | HYDROGRAPH AT | A09QB | 196. | 4.20 | 23. | 6. | 2. | .14 |
| + | DIVERSION TO | A09QBQ | 6. | 3.67 | 0. | 0. | 0. | .14 |
| + | HYDROGRAPH AT | DA09QB | 196. | 4.20 | 23. | 6. | 2. | .14 |
| + | 2 COMBINED AT | C104th | 196. | 4.20 | 36. | 9. | 3. | .50 |
| + | 2 COMBINED AT | CA09Q | 149. | 4.20 | 39. | 10. | 4. | 1.42 |
| + | DIVERSION TO | D_WBS | 144. | 4.20 | 34. | 9. | 3. | 1.42 |
| + | HYDROGRAPH AT | DWBYPS | 5. | 3.70 | 4. | 1. | 1. | 1.42 |
| + | HYDROGRAPH AT | BD_WBS | 144. | 4.20 | 34. | 9. | 3. | 1.42 |
| + | ROUTED TO | S103W | 19. | 7.60 | 8. | 2. | 1. | 1.42 |
| + | 3 COMBINED AT | C_WBS | 27. | 7.53 | 17. | 5. | 2. | 1.42 |
| + | DIVERSION TO | A09QI | 27. | 7.53 | 17. | 5. | 2. | 1.42 |

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| + | HYDROGRAPH AT | DA09Q | 0. | .00 | 0. | 0. | 0. | 1.42 |
| + | ROUTED TO | RA09QW | 0. | .00 | 0. | 0. | 0. | 1.42 |
| + | HYDROGRAPH AT | A10A | 348. | 4.20 | 35. | 9. | 3. | .19 |
| + | ROUTED TO | SA10A | 259. | 4.37 | 23. | 6. | 2. | .19 |
| + | 2 COMBINED AT | CA10A | 259. | 4.37 | 23. | 6. | 2. | .19 |
| + | ROUTED TO | RA10A | 252. | 4.43 | 23. | 6. | 2. | .19 |
| + | HYDROGRAPH AT | A99X | 686. | 4.10 | 66. | 17. | 6. | .26 |
| + | DIVERSION TO | DA99XQ | 686. | 4.10 | 66. | 17. | 6. | .26 |
| + | HYDROGRAPH AT | DA99X | 0. | .00 | 0. | 0. | 0. | .26 |
| + | 2 COMBINED AT | CA99X | 252. | 4.43 | 23. | 6. | 2. | .45 |
| + | 2 COMBINED AT | AFR2 | 1590. | 5.07 | 466. | 121. | 44. | 4.99 |
| + | HYDROGRAPH AT | BN11KS | 420. | 4.27 | 46. | 12. | 4. | .41 |
| + | ROUTED TO | 3.1 | 371. | 4.33 | 46. | 12. | 4. | .41 |
| + | HYDROGRAPH AT | M3 | 129. | 4.27 | 21. | 5. | 2. | .12 |
| + | DIVERSION TO | 3R | 129. | 4.27 | 17. | 4. | 2. | .12 |
| + | HYDROGRAPH AT | 3S | 43. | 5.00 | 4. | 1. | 0. | .12 |
| + | 2 COMBINED AT | 3.2 | 372. | 4.33 | 50. | 13. | 5. | .12 |
| + | ROUTED TO | 4.1 | 370. | 4.43 | 50. | 13. | 5. | .12 |
| + | HYDROGRAPH AT | M4 | 149. | 4.23 | 24. | 6. | 2. | .13 |
| + | DIVERSION TO | 4R | 149. | 4.23 | 18. | 5. | 2. | .13 |
| + | HYDROGRAPH AT | 4S | 66. | 4.83 | 6. | 2. | 1. | .13 |
| + | 2 COMBINED AT | 4.2 | 370. | 4.43 | 56. | 14. | 5. | .25 |
| + | HYDROGRAPH AT | M1 | 121. | 4.23 | 18. | 5. | 2. | .11 |
| + | DIVERSION TO | 1R | 121. | 4.23 | 15. | 4. | 1. | .11 |
| + | HYDROGRAPH AT | 1S | 42. | 4.90 | 4. | 1. | 0. | .11 |
| | ROUTED TO | | | | | | | |

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| + | | 2.1 | 41. | 5.07 | 4. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | M2 | 196. | 4.23 | 30. | 7. | 3. | .16 |
| + | DIVERSION TO | 2R | 196. | 4.23 | 21. | 5. | 2. | .16 |
| + | HYDROGRAPH AT | 2S | 102. | 4.70 | 9. | 2. | 1. | .16 |
| + | 2 COMBINED AT | 2.3 | 102. | 4.70 | 13. | 3. | 1. | .26 |
| + | DIVERSION TO | X5I | 2. | 4.70 | 0. | 0. | 0. | .26 |
| + | HYDROGRAPH AT | DX5 | 100. | 4.70 | 13. | 3. | 1. | .26 |
| + | ROUTED TO | 2.2 | 96. | 4.83 | 14. | 3. | 1. | .26 |
| + | 2 COMBINED AT | 4.3 | 370. | 4.43 | 70. | 18. | 6. | .52 |
| + | ROUTED TO | 10.1 | 363. | 4.57 | 69. | 17. | 6. | .52 |
| + | HYDROGRAPH AT | M10 | 173. | 4.13 | 25. | 6. | 2. | .09 |
| + | DIVERSION TO | 10R | 172. | 4.13 | 12. | 3. | 1. | .09 |
| + | HYDROGRAPH AT | 10S | 163. | 4.20 | 13. | 3. | 1. | .09 |
| + | 2 COMBINED AT | 10.2 | 416. | 4.57 | 80. | 20. | 7. | .61 |
| + | ROUTED TO | 11A.1 | 414. | 4.60 | 80. | 20. | 7. | .61 |
| + | HYDROGRAPH AT | M11A | 66. | 4.27 | 12. | 3. | 1. | .07 |
| + | DIVERSION TO | 11AR | 66. | 4.27 | 11. | 3. | 1. | .07 |
| + | HYDROGRAPH AT | 11AS | 6. | 6.03 | 1. | 0. | 0. | .07 |
| + | 2 COMBINED AT | 11A.2 | 412. | 4.60 | 81. | 20. | 7. | .67 |
| + | ROUTED TO | RN11G | 397. | 4.73 | 79. | 20. | 7. | .67 |
| + | HYDROGRAPH AT | N11DA | 351. | 4.23 | 54. | 14. | 5. | .26 |
| + | DIVERSION TO | LDAOUT | 325. | 4.17 | 16. | 4. | 1. | .26 |
| + | HYDROGRAPH AT | LN11DA | 351. | 4.23 | 38. | 10. | 3. | .26 |
| + | ROUTED TO | SN11DA | 126. | 4.87 | 38. | 10. | 3. | .26 |
| + | DIVERSION TO | D11DAS | 21. | 4.87 | 8. | 2. | 1. | .26 |
| + | HYDROGRAPH AT | N11DAW | 105. | 4.87 | 31. | 8. | 3. | .26 |

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| + | ROUTED TO | RN11DA | 105. | 5.03 | 31. | 8. | 3. | .26 |
| + | HYDROGRAPH AT | N11FB | 140. | 4.27 | 25. | 6. | 2. | .12 |
| + | DIVERSION TO | LN1FBD | 140. | 4.27 | 21. | 5. | 2. | .12 |
| + | HYDROGRAPH AT | LN11FB | 40. | 5.17 | 4. | 1. | 0. | .12 |
| + | 2 COMBINED AT | CN11FB | 144. | 5.17 | 35. | 9. | 3. | .38 |
| + | 2 COMBINED AT | C98RGL | 433. | 4.77 | 101. | 25. | 9. | 1.05 |
| + | ROUTED TO | RN11FB | 428. | 4.83 | 101. | 25. | 9. | 1.05 |
| + | HYDROGRAPH AT | DN11JI | 237. | 4.83 | 57. | 14. | 5. | .90 |
| + | ROUTED TO | 6.1 | 233. | 4.87 | 57. | 14. | 5. | .90 |
| + | ROUTED TO | 6.2 | 232. | 4.93 | 57. | 14. | 5. | .90 |
| + | HYDROGRAPH AT | M5 | 16. | 4.23 | 3. | 1. | 0. | .02 |
| + | DIVERSION TO | 5R | 16. | 4.20 | 1. | 0. | 0. | .02 |
| + | HYDROGRAPH AT | 5S | 16. | 4.27 | 2. | 0. | 0. | .02 |
| + | ROUTED TO | 6.3 | 16. | 4.37 | 2. | 0. | 0. | .02 |
| + | HYDROGRAPH AT | M6 | 26. | 4.20 | 4. | 1. | 0. | .02 |
| + | DIVERSION TO | 6R | 26. | 4.20 | 3. | 1. | 0. | .02 |
| + | HYDROGRAPH AT | 6S | 6. | 5.03 | 1. | 0. | 0. | .02 |
| + | 3 COMBINED AT | 6.4 | 268. | 4.70 | 65. | 16. | 6. | .04 |
| + | ROUTED TO | 8.1 | 268. | 4.77 | 65. | 16. | 6. | .04 |
| + | HYDROGRAPH AT | M7 | 98. | 4.30 | 19. | 5. | 2. | .11 |
| + | DIVERSION TO | 7R | 98. | 4.30 | 16. | 4. | 1. | .11 |
| + | HYDROGRAPH AT | 7S | 33. | 5.27 | 4. | 1. | 0. | .11 |
| + | ROUTED TO | 8.2 | 32. | 5.37 | 4. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | M8 | 76. | 4.23 | 12. | 3. | 1. | .07 |
| + | DIVERSION TO | 8R | 76. | 4.23 | 10. | 3. | 1. | .07 |

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| + | HYDROGRAPH AT | 8S | 15. | 5.20 | 1. | 0. | 0. | .07 |
| + | 3 COMBINED AT | 8.3 | 268. | 4.77 | 70. | 18. | 6. | .22 |
| + | ROUTED TO | 9.1 | 267. | 4.80 | 70. | 17. | 6. | .22 |
| + | HYDROGRAPH AT | M9 | 186. | 4.17 | 22. | 5. | 2. | .12 |
| + | DIVERSION TO | 9R | 186. | 4.17 | 17. | 4. | 1. | .12 |
| + | HYDROGRAPH AT | 9S | 81. | 4.57 | 5. | 1. | 0. | .12 |
| + | 2 COMBINED AT | 9.2 | 344. | 4.57 | 75. | 19. | 7. | .34 |
| + | ROUTED TO | 12A.1 | 342. | 4.60 | 75. | 19. | 7. | .34 |
| + | HYDROGRAPH AT | M12A | 206. | 4.13 | 20. | 5. | 2. | .11 |
| + | DIVERSION TO | 12AR | 206. | 4.13 | 16. | 4. | 1. | .11 |
| + | HYDROGRAPH AT | 12AS | 92. | 4.43 | 4. | 1. | 0. | .11 |
| + | 2 COMBINED AT | 12A.2 | 388. | 4.60 | 79. | 20. | 7. | .45 |
| + | ROUTED TO | 11B.1 | 385. | 4.60 | 79. | 20. | 7. | .45 |
| + | HYDROGRAPH AT | M11B | 27. | 4.13 | 3. | 1. | 0. | .02 |
| + | DIVERSION TO | 11BR | 27. | 4.13 | 2. | 1. | 0. | .02 |
| + | HYDROGRAPH AT | 11BS | 14. | 4.47 | 1. | 0. | 0. | .02 |
| + | HYDROGRAPH AT | MA1 | 12. | 4.20 | 2. | 1. | 0. | .01 |
| + | DIVERSION TO | A1R | 12. | 4.20 | 2. | 1. | 0. | .01 |
| + | HYDROGRAPH AT | A1S | 0. | 4.17 | 0. | 0. | 0. | .01 |
| + | 3 COMBINED AT | 11B.2 | 395. | 4.60 | 80. | 20. | 7. | .48 |
| + | ROUTED TO | RA09KS | 389. | 4.77 | 80. | 20. | 7. | .48 |
| + | HYDROGRAPH AT | N11FA | 237. | 4.23 | 39. | 10. | 4. | .18 |
| + | DIVERSION TO | LN1FAD | 237. | 4.23 | 16. | 4. | 1. | .18 |
| + | HYDROGRAPH AT | LN11FA | 231. | 4.30 | 24. | 6. | 2. | .18 |
| + | HYDROGRAPH AT | A09GA | 217. | 4.07 | 22. | 6. | 2. | .07 |
| | DIVERSION TO | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | L09GAD | 203. | 4.00 | 12. | 3. | 1. | .07 |
| + | HYDROGRAPH AT | LA09GA | 217. | 4.07 | 10. | 3. | 1. | .07 |
| + | 4 COMBINED AT | CN11FA | 696. | 4.83 | 177. | 45. | 16. | 1.78 |
| + | ROUTED TO | RN11FA | 691. | 4.87 | 177. | 45. | 16. | 1.78 |
| + | HYDROGRAPH AT | A09GB | 33. | 4.53 | 11. | 3. | 1. | .05 |
| + | DIVERSION TO | L09GBD | 33. | 4.53 | 6. | 1. | 1. | .05 |
| + | HYDROGRAPH AT | LA09GB | 25. | 5.10 | 5. | 1. | 0. | .05 |
| + | 2 COMBINED AT | CA09G | 685. | 4.87 | 180. | 45. | 16. | 1.84 |
| + | DIVERSION TO | A09GI | 126. | 4.90 | 35. | 9. | 3. | 1.84 |
| + | HYDROGRAPH AT | DA09G | 560. | 4.87 | 145. | 36. | 13. | 1.84 |
| + | ROUTED TO | RA09GW | 555. | 4.93 | 145. | 36. | 13. | 1.84 |
| + | HYDROGRAPH AT | DA09oI | 0. | .00 | 0. | 0. | 0. | 1.09 |
| + | ROUTED TO | 371 | 0. | .00 | 0. | 0. | 0. | 1.09 |
| + | HYDROGRAPH AT | M370 | 168. | 4.23 | 25. | 6. | 2. | .13 |
| + | DIVERSION TO | DM370Q | 168. | 4.23 | 11. | 3. | 1. | .13 |
| + | HYDROGRAPH AT | DM370 | 151. | 4.37 | 13. | 3. | 1. | .13 |
| + | 2 COMBINED AT | 372 | 151. | 4.37 | 13. | 3. | 1. | .13 |
| + | ROUTED TO | B4 | 13. | 5.57 | 9. | 3. | 1. | .13 |
| + | ROUTED TO | 12B.1 | 13. | 5.73 | 9. | 3. | 1. | .13 |
| + | HYDROGRAPH AT | M12B | 53. | 4.20 | 8. | 2. | 1. | .04 |
| + | DIVERSION TO | 12BR | 53. | 4.20 | 6. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | 12BS | 16. | 4.90 | 1. | 0. | 0. | .04 |
| + | 2 COMBINED AT | 12B.2 | 24. | 4.93 | 11. | 4. | 1. | .17 |
| + | ROUTED TO | A2.1 | 23. | 5.03 | 11. | 4. | 1. | .17 |
| + | HYDROGRAPH AT | MA2 | 34. | 4.17 | 5. | 1. | 0. | .03 |
| + | DIVERSION TO | A2R | 34. | 4.17 | 5. | 1. | 0. | .03 |

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|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT A2S | 0. | 4.13 | 0. | 0. | 0. | .03 |
| + | 2 COMBINED AT A2.2 | 23. | 5.03 | 11. | 4. | 1. | .20 |
| + | ROUTED TO RX7S | 21. | 5.50 | 10. | 4. | 1. | .20 |
| + | 2 COMBINED AT CX8 | 546. | 4.93 | 149. | 39. | 14. | 2.04 |
| + | ROUTED TO RX8W | 522. | 5.10 | 146. | 38. | 14. | 2.04 |
| + | HYDROGRAPH AT A09H | 243. | 4.33 | 50. | 13. | 5. | .24 |
| + | DIVERSION TO LA09HD | 243. | 4.33 | 26. | 7. | 2. | .24 |
| + | HYDROGRAPH AT LA09H | 199. | 4.63 | 25. | 6. | 2. | .24 |
| + | 2 COMBINED AT CA09H1 | 598. | 5.10 | 161. | 42. | 15. | 2.27 |
| + | HYDROGRAPH AT A09J | 198. | 4.27 | 34. | 9. | 3. | .17 |
| + | DIVERSION TO LA09JD | 198. | 4.27 | 16. | 4. | 1. | .17 |
| + | HYDROGRAPH AT LA09J | 182. | 4.40 | 19. | 5. | 2. | .17 |
| + | DIVERSION TO A09JI | 0. | .00 | 0. | 0. | 0. | .17 |
| + | HYDROGRAPH AT DA09J | 182. | 4.40 | 19. | 5. | 2. | .17 |
| + | ROUTED TO RA09JS | 151. | 4.73 | 19. | 5. | 2. | .17 |
| + | 2 COMBINED AT CA09H | 663. | 5.07 | 172. | 45. | 16. | 2.44 |
| + | ROUTED TO RA09H | 661. | 5.13 | 172. | 45. | 16. | 2.44 |
| + | HYDROGRAPH AT BA09QI | 27. | 7.53 | 17. | 5. | 2. | 1.42 |
| + | ROUTED TO RA09QS | 26. | 7.73 | 17. | 5. | 2. | 1.42 |
| + | HYDROGRAPH AT A09M | 333. | 4.33 | 51. | 13. | 5. | .25 |
| + | DIVERSION TO LA09MD | 333. | 4.33 | 24. | 6. | 2. | .25 |
| + | HYDROGRAPH AT LA09M | 321. | 4.40 | 28. | 7. | 2. | .25 |
| + | 2 COMBINED AT CA09M | 328. | 4.40 | 56. | 15. | 5. | .25 |
| + | ROUTED TO RA09M | 313. | 4.50 | 56. | 15. | 5. | .25 |
| + | HYDROGRAPH AT A09N | 169. | 4.20 | 24. | 6. | 2. | .11 |

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|---|---|---|---|---|---|---|---|---|
| + | DIVERSION TO | DA09NQ | 33. | 3.80 | 2. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | DA09N | 169. | 4.20 | 22. | 6. | 2. | .11 |
| + | 2 COMBINED AT | CA09N | 427. | 4.50 | 77. | 21. | 7. | .36 |
| + | ROUTED TO | LA09N | 171. | 4.93 | 68. | 21. | 7. | .36 |
| + | ROUTED TO | RA09N | 170. | 5.03 | 68. | 21. | 7. | .36 |
| + | HYDROGRAPH AT | DRA09J | 0. | .00 | 0. | 0. | 0. | .17 |
| + | ROUTED TO | RA09JW | 0. | .00 | 0. | 0. | 0. | .17 |
| + | HYDROGRAPH AT | A09L | 171. | 4.23 | 29. | 7. | 3. | .14 |
| + | 3 COMBINED AT | CA09L | 233. | 4.87 | 92. | 28. | 10. | .50 |
| + | ROUTED TO | LA09L | 230. | 4.93 | 91. | 28. | 10. | .50 |
| + | ROUTED TO | RA09LS | 227. | 5.07 | 91. | 28. | 10. | .50 |
| + | HYDROGRAPH AT | A09IH | 124. | 4.20 | 19. | 5. | 2. | .09 |
| + | DIVERSION TO | A09IHQ | 2. | 1.77 | 0. | 0. | 0. | .09 |
| + | HYDROGRAPH AT | DA09IH | 124. | 4.20 | 18. | 5. | 2. | .09 |
| + | 2 COMBINED AT | CA09IH | 247. | 5.03 | 104. | 32. | 11. | .59 |
| + | ROUTED TO | LA09IH | 202. | 5.37 | 101. | 32. | 11. | .59 |
| + | HYDROGRAPH AT | A09I | 161. | 4.27 | 30. | 7. | 3. | .13 |
| + | DIVERSION TO | LA09ID | 161. | 4.27 | 11. | 3. | 1. | .13 |
| + | HYDROGRAPH AT | LA09I | 159. | 4.33 | 19. | 5. | 2. | .13 |
| + | 3 COMBINED AT | CX10 | 813. | 5.13 | 256. | 69. | 25. | 3.15 |
| + | ROUTED TO | RX10 | 800. | 5.30 | 255. | 69. | 25. | 3.15 |
| + | HYDROGRAPH AT | A99V | 474. | 4.20 | 44. | 11. | 4. | .21 |
| + | DIVERSION TO | DA99VQ | 474. | 4.20 | 24. | 6. | 2. | .21 |
| + | HYDROGRAPH AT | DA99V | 409. | 4.27 | 20. | 5. | 2. | .21 |
| + | 2 COMBINED AT | CA99V | 798. | 5.30 | 267. | 72. | 26. | 3.36 |
| | HYDROGRAPH AT | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | A10 | 641. | 4.07 | 59. | 15. | 5. | .21 |
| | DIVERSION TO | | | | | | | |
| + | | DA10Q | 629. | 4.03 | 33. | 8. | 3. | .21 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DA10 | 621. | 4.10 | 25. | 6. | 2. | .21 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A99W | 357. | 4.33 | 52. | 13. | 5. | .22 |
| | DIVERSION TO | | | | | | | |
| + | | LA99WD | 357. | 4.33 | 26. | 7. | 2. | .22 |
| | HYDROGRAPH AT | | | | | | | |
| + | | LA99W | 342. | 4.40 | 26. | 7. | 2. | .22 |
| | 4 COMBINED AT | | | | | | | |
| + | | AFR3 | 1943. | 5.27 | 684. | 181. | 65. | 8.78 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DRA09G | 126. | 4.90 | 35. | 9. | 3. | 1.84 |
| | ROUTED TO | | | | | | | |
| + | | RA09GS | 121. | 5.47 | 35. | 9. | 3. | 1.84 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A09F | 529. | 4.37 | 85. | 21. | 8. | .37 |
| | DIVERSION TO | | | | | | | |
| + | | LA09FD | 497. | 4.27 | 31. | 8. | 3. | .37 |
| | HYDROGRAPH AT | | | | | | | |
| + | | LA09F | 529. | 4.37 | 54. | 14. | 5. | .37 |
| | 2 COMBINED AT | | | | | | | |
| + | | CA09F | 529. | 4.37 | 99. | 25. | 9. | .37 |
| | ROUTED TO | | | | | | | |
| + | | RA09FW | 518. | 4.53 | 99. | 25. | 9. | .37 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A09E | 185. | 4.27 | 34. | 9. | 3. | .15 |
| | DIVERSION TO | | | | | | | |
| + | | LA09ED | 185. | 4.27 | 18. | 4. | 2. | .15 |
| | HYDROGRAPH AT | | | | | | | |
| + | | LA09E | 154. | 4.50 | 16. | 4. | 1. | .15 |
| | 2 COMBINED AT | | | | | | | |
| + | | CA09E | 660. | 4.53 | 115. | 29. | 10. | .51 |
| | ROUTED TO | | | | | | | |
| + | | RA09E | 616. | 4.67 | 115. | 29. | 10. | .51 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A09D | 672. | 4.10 | 64. | 16. | 6. | .25 |
| | DIVERSION TO | | | | | | | |
| + | | LA09DD | 656. | 4.07 | 34. | 9. | 3. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | LA09D | 656. | 4.13 | 30. | 7. | 3. | .25 |
| | 2 COMBINED AT | | | | | | | |
| + | | CA09C* | 603. | 4.70 | 138. | 35. | 12. | .77 |
| | ROUTED TO | | | | | | | |
| + | | RA09C* | 598. | 4.70 | 137. | 35. | 12. | .77 |
| | HYDROGRAPH AT | | | | | | | |
| + | | A09C | 118. | 4.27 | 15. | 4. | 1. | .07 |
| | DIVERSION TO | | | | | | | |
| + | | DA09CQ | 118. | 4.27 | 9. | 2. | 1. | .07 |

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|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | DA09C | 79. | 4.50 | 6. | 2. | 1. | .07 |
| + | 2 COMBINED AT | CA09C | 632. | 4.70 | 142. | 36. | 13. | .84 |
| + | ROUTED TO | RA09C | 612. | 4.80 | 141. | 36. | 13. | .84 |
| + | HYDROGRAPH AT | A09B | 125. | 4.03 | 12. | 3. | 1. | .04 |
| + | DIVERSION TO | DA09BQ | 2. | .77 | 0. | 0. | 0. | .04 |
| + | HYDROGRAPH AT | DA09B | 125. | 4.03 | 11. | 3. | 1. | .04 |
| + | ROUTED TO | RA09B | 96. | 4.43 | 11. | 3. | 1. | .04 |
| + | HYDROGRAPH AT | A09A | 104. | 4.40 | 20. | 5. | 2. | .08 |
| + | 3 COMBINED AT | CA09A | 699. | 4.80 | 167. | 43. | 15. | .96 |
| + | ROUTED TO | RA09AW | 576. | 5.47 | 164. | 43. | 15. | .96 |
| + | HYDROGRAPH AT | A99T | 95. | 4.00 | 7. | 2. | 1. | .03 |
| + | DIVERSION TO | LA99TD | 22. | 3.77 | 2. | 0. | 0. | .03 |
| + | HYDROGRAPH AT | LA99T | 95. | 4.00 | 5. | 1. | 0. | .03 |
| + | ROUTED TO | RA99T | 83. | 4.13 | 5. | 1. | 0. | .03 |
| + | HYDROGRAPH AT | A09 | 370. | 4.17 | 38. | 10. | 3. | .18 |
| + | DIVERSION TO | DA09Q | 142. | 3.90 | 7. | 2. | 1. | .18 |
| + | HYDROGRAPH AT | DA09 | 370. | 4.17 | 31. | 8. | 3. | .18 |
| + | 3 COMBINED AT | CA09 | 568. | 5.47 | 191. | 50. | 18. | 1.17 |
| + | HYDROGRAPH AT | A99U | 121. | 4.20 | 16. | 4. | 1. | .07 |
| + | DIVERSION TO | DA99UQ | 102. | 4.07 | 5. | 1. | 0. | .07 |
| + | HYDROGRAPH AT | DA99U | 121. | 4.20 | 11. | 3. | 1. | .07 |
| + | 3 COMBINED AT | AFR4 | 2125. | 5.33 | 817. | 216. | 78. | 10.02 |
| + | HYDROGRAPH AT | A07G | 491. | 4.17 | 68. | 17. | 6. | .26 |
| + | DIVERSION TO | LA07GD | 491. | 4.17 | 31. | 8. | 3. | .26 |
| + | HYDROGRAPH AT | LA07G | 461. | 4.23 | 37. | 9. | 3. | .26 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | RA07G | 419. | 4.43 | 37. | 9. | 3. | .26 |
| + | HYDROGRAPH AT | A07F | 223. | 4.50 | 49. | 12. | 4. | .23 |
| + | ROUTED TO | RA07F | 221. | 4.60 | 49. | 12. | 4. | .23 |
| + | HYDROGRAPH AT | A07E | 486. | 4.17 | 63. | 16. | 6. | .23 |
| + | 3 COMBINED AT | CA07E | 827. | 4.43 | 145. | 37. | 13. | .72 |
| + | ROUTED TO | RA07E | 803. | 4.50 | 145. | 37. | 13. | .72 |
| + | HYDROGRAPH AT | A07C | 275. | 4.27 | 37. | 9. | 3. | .17 |
| + | DIVERSION TO | DA07CQ | 275. | 4.27 | 20. | 5. | 2. | .17 |
| + | HYDROGRAPH AT | DA07C | 256. | 4.37 | 18. | 5. | 2. | .17 |
| + | 2 COMBINED AT | CA07C | 949. | 4.50 | 160. | 41. | 15. | .89 |
| + | ROUTED TO | RA07C | 937. | 4.53 | 160. | 41. | 15. | .89 |
| + | HYDROGRAPH AT | A07H | 251. | 4.07 | 24. | 6. | 2. | .09 |
| + | DIVERSION TO | DA07HQ | 8. | 3.27 | 2. | 1. | 0. | .09 |
| + | HYDROGRAPH AT | DA07H | 251. | 4.07 | 22. | 5. | 2. | .09 |
| + | ROUTED TO | RA07H | 231. | 4.20 | 22. | 5. | 2. | .09 |
| + | HYDROGRAPH AT | A08B | 162. | 4.23 | 22. | 5. | 2. | .10 |
| + | ROUTED TO | RA08B | 150. | 4.60 | 22. | 5. | 2. | .10 |
| + | HYDROGRAPH AT | A07D | 149. | 4.77 | 40. | 10. | 4. | .23 |
| + | DIVERSION TO | DA07DQ | 37. | 4.07 | 1. | 0. | 0. | .23 |
| + | HYDROGRAPH AT | DA07D | 149. | 4.77 | 39. | 10. | 4. | .23 |
| + | 4 COMBINED AT | CA07D | 1179. | 4.57 | 231. | 59. | 21. | 1.31 |
| + | ROUTED TO | RA07D | 1119. | 4.77 | 231. | 59. | 21. | 1.31 |
| + | HYDROGRAPH AT | A99S | 91. | 4.40 | 16. | 4. | 1. | .08 |
| + | DIVERSION TO | DA99SQ | 91. | 4.40 | 8. | 2. | 1. | .08 |
| + | HYDROGRAPH AT | DA99S | 72. | 4.63 | 8. | 2. | 1. | .08 |
| | HYDROGRAPH AT | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | A08A | 99. | 4.57 | 24. | 6. | 2. | .14 |
| + | DIVERSION TO | DA08AQ | 2. | 2.50 | 0. | 0. | 0. | .14 |
| + | HYDROGRAPH AT | DA08A | 99. | 4.57 | 24. | 6. | 2. | .14 |
| + | ROUTED TO | RA08A | 97. | 4.73 | 24. | 6. | 2. | .14 |
| + | HYDROGRAPH AT | A99R | 83. | 4.10 | 8. | 2. | 1. | .04 |
| + | DIVERSION TO | DA99RQ | 55. | 3.97 | 2. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | DA99R | 83. | 4.10 | 5. | 1. | 0. | .04 |
| + | ROUTED TO | RA99R | 72. | 4.40 | 5. | 1. | 0. | .04 |
| + | 4 COMBINED AT | CA08 | 1245. | 4.77 | 260. | 66. | 24. | 1.57 |
| + | 2 COMBINED AT | AFR5 | 2652. | 5.30 | 1002. | 264. | 95. | 11.58 |
| + | HYDROGRAPH AT | N11P5 | 82. | 4.03 | 5. | 1. | 0. | .03 |
| + | DIVERSION TO | N11P5Q | 76. | 3.97 | 3. | 1. | 0. | .03 |
| + | HYDROGRAPH AT | DN11P5 | 82. | 4.03 | 2. | 1. | 0. | .03 |
| + | ROUTED TO | R11P5S | 47. | 4.27 | 2. | 1. | 0. | .03 |
| + | HYDROGRAPH AT | N11P1 | 112. | 4.20 | 11. | 3. | 1. | .06 |
| + | DIVERSION TO | N11P1Q | 112. | 4.20 | 7. | 2. | 1. | .06 |
| + | HYDROGRAPH AT | DN11P1 | 71. | 4.37 | 4. | 1. | 0. | .06 |
| + | 2 COMBINED AT | CN11P1 | 101. | 4.37 | 6. | 1. | 1. | .09 |
| + | ROUTED TO | R11P1E | 84. | 4.47 | 6. | 1. | 1. | .09 |
| + | HYDROGRAPH AT | N11P6 | 496. | 4.03 | 37. | 9. | 3. | .16 |
| + | DIVERSION TO | N11P6Q | 396. | 3.93 | 16. | 4. | 1. | .16 |
| + | HYDROGRAPH AT | DN11P6 | 496. | 4.03 | 20. | 5. | 2. | .16 |
| + | ROUTED TO | R11P6S | 430. | 4.13 | 20. | 5. | 2. | .16 |
| + | HYDROGRAPH AT | N11P9 | 117. | 4.07 | 7. | 2. | 1. | .04 |
| + | DIVERSION TO | N11P9Q | 117. | 4.07 | 5. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | DN11P9 | 101. | 4.13 | 2. | 1. | 0. | .04 |

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|---|---|---|---|---|---|---|---|---|
| + | 2 COMBINED AT | CN11P9 | 531. | 4.13 | 23. | 6. | 2. | .20 |
| + | ROUTED TO | R11P9S | 462. | 4.20 | 23. | 6. | 2. | .20 |
| + | HYDROGRAPH AT | N11P2 | 153. | 4.13 | 11. | 3. | 1. | .06 |
| + | 2 COMBINED AT | CN11P2 | 586. | 4.20 | 33. | 8. | 3. | .26 |
| + | 2 COMBINED AT | LEJOS | 586. | 4.20 | 39. | 10. | 4. | .36 |
| + | DIVERSION TO | VPRET | 586. | 4.20 | 20. | 5. | 2. | .36 |
| + | HYDROGRAPH AT | VPDIV | 388. | 4.30 | 19. | 5. | 2. | .36 |
| + | HYDROGRAPH AT | N11P4 | 83. | 4.17 | 9. | 2. | 1. | .05 |
| + | DIVERSION TO | N11P4Q | 28. | 3.90 | 1. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | DN11P4 | 83. | 4.17 | 8. | 2. | 1. | .05 |
| + | ROUTED TO | R11P4S | 80. | 4.27 | 8. | 2. | 1. | .05 |
| + | DIVERSION TO | N11P4E | 40. | 4.27 | 4. | 1. | 0. | .05 |
| + | HYDROGRAPH AT | DN11PS | 40. | 4.27 | 4. | 1. | 0. | .05 |
| + | 2 COMBINED AT | SDLEJ1 | 427. | 4.30 | 23. | 6. | 2. | .41 |
| + | HYDROGRAPH AT | N11P8 | 133. | 4.03 | 9. | 2. | 1. | .04 |
| + | DIVERSION TO | N11P8Q | 123. | 3.97 | 4. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | DN11P8 | 133. | 4.03 | 4. | 1. | 0. | .04 |
| + | ROUTED TO | R11P8S | 109. | 4.13 | 4. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | N11P7 | 184. | 4.03 | 10. | 2. | 1. | .06 |
| + | DIVERSION TO | N11P7Q | 183. | 4.00 | 6. | 2. | 1. | .06 |
| + | HYDROGRAPH AT | DN11P7 | 178. | 4.07 | 3. | 1. | 0. | .06 |
| + | 2 COMBINED AT | CN11P7 | 237. | 4.10 | 7. | 2. | 1. | .10 |
| + | DIVERSION TO | N11P7E | 47. | 4.10 | 1. | 0. | 0. | .10 |
| + | HYDROGRAPH AT | DN11PE | 190. | 4.10 | 6. | 1. | 1. | .10 |
| + | ROUTED TO | R11P7S | 139. | 4.20 | 6. | 1. | 1. | .10 |

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|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | RDP4E | 40. | 4.27 | 4. | 1. | 0. | .05 |
| + | 2 COMBINED AT | SUMP7S | 178. | 4.20 | 10. | 2. | 1. | .10 |
| + | 2 COMBINED AT | SDLEJ2 | 554. | 4.30 | 32. | 8. | 3. | .51 |
| + | ROUTED TO | RSDL2 | 508. | 4.33 | 32. | 8. | 3. | .51 |
| + | HYDROGRAPH AT | BN11NP | 149. | 4.07 | 16. | 4. | 1. | .19 |
| + | ROUTED TO | RN11NP | 159. | 4.20 | 16. | 4. | 1. | .19 |
| + | HYDROGRAPH AT | N11L5A | 73. | 4.13 | 8. | 2. | 1. | .05 |
| + | 2 COMBINED AT | C89 | 228. | 4.20 | 25. | 6. | 2. | .05 |
| + | DIVERSION TO | ED89 | 10. | 4.20 | 0. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | D89 | 218. | 4.20 | 24. | 6. | 2. | .05 |
| + | ROUTED TO | R89E | 220. | 4.27 | 24. | 6. | 2. | .05 |
| + | HYDROGRAPH AT | N11L3A | 50. | 4.10 | 5. | 1. | 0. | .03 |
| + | 2 COMBINED AT | C87 | 252. | 4.27 | 29. | 7. | 3. | .07 |
| + | DIVERSION TO | SOL | 6. | 4.27 | 0. | 0. | 0. | .07 |
| + | HYDROGRAPH AT | D87 | 246. | 4.27 | 29. | 7. | 3. | .07 |
| + | 2 COMBINED AT | C87BA | 704. | 4.33 | 60. | 15. | 5. | .58 |
| + | DIVERSION TO | 87BAS | 682. | 4.33 | 51. | 13. | 5. | .58 |
| + | HYDROGRAPH AT | 87BP | 22. | 3.87 | 10. | 2. | 1. | .58 |
| + | ROUTED TO | R87BP | 23. | 3.93 | 10. | 2. | 1. | .58 |
| + | HYDROGRAPH AT | 87 | 48. | 4.17 | 5. | 1. | 0. | .03 |
| + | DIVERSION TO | D87Q | 33. | 4.00 | 1. | 0. | 0. | .03 |
| + | HYDROGRAPH AT | D87A | 48. | 4.17 | 4. | 1. | 0. | .03 |
| + | HYDROGRAPH AT | R87B | 682. | 4.33 | 51. | 13. | 5. | .58 |
| + | 2 COMBINED AT | C87B | 754. | 4.33 | 56. | 14. | 5. | .03 |
| + | ROUTED TO | 87BA | 97. | 4.93 | 54. | 14. | 5. | .03 |
| | 2 COMBINED AT | | | | | | | |

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+                    87BOUT      116.   4.97        60.        16.        6.       .61
     ROUTED TO
+                    R87BA       116.   5.00        60.        16.        6.       .61
     DIVERSION TO
+                    87OUT       116.   5.00        60.        16.        6.       .61
     HYDROGRAPH AT
+                    D87BA         0.    .00         0.         0.        0.       .61
     HYDROGRAPH AT
+                    LACAI        61.   4.10         6.         1.        1.       .04
     DIVERSION TO
+                    LACAIQ       24.   3.90         1.         0.        0.       .04
     HYDROGRAPH AT
+                    DLACAI       61.   4.10         5.         1.        0.       .04
     ROUTED TO
+                    RTCAI        60.   4.13         5.         1.        0.       .04
     DIVERSION TO
+                    LECHE        20.   4.00         3.         1.        0.       .04
     HYDROGRAPH AT
+                    DNLECH       40.   4.13         2.         1.        0.       .04
     2 COMBINED AT
+                    SDLEJ3       36.   4.13         2.         0.        0.       .64
     HYDROGRAPH AT
+                    SUMMIT       43.   4.13         5.         1.        0.       .03
     HYDROGRAPH AT
+                    RDLECH       20.   4.00         3.         1.        0.       .04
     2 COMBINED AT
+                    LEJCHL       63.   4.13         8.         2.        1.       .03
     HYDROGRAPH AT
+                    RDP7E        47.   4.10         1.         0.        0.       .10
     ROUTED TO
+                    R11P7E       28.   4.37         1.         0.        0.       .10
     DIVERSION TO
+                    EAST83       18.   4.33         1.         0.        0.       .10
     HYDROGRAPH AT
+                    D2-18         9.   4.37         0.         0.        0.       .10
     2 COMBINED AT
+                    83CL         63.   4.13         8.         2.        1.       .13
     DIVERSION TO
+                    EAGLE        60.   4.10         8.         2.        1.       .13
     HYDROGRAPH AT
+                    24PIPE        3.   4.13         0.         0.        0.       .13
     2 COMBINED AT
+                    SDLEJ4       38.   4.13         2.         0.        0.       .77
     ROUTED TO
+                    RT83CL       31.   4.27         2.         0.        0.       .77
     HYDROGRAPH AT
+                    N11P3        47.   4.20         8.         2.        1.       .04
     2 COMBINED AT
+                    83SD         72.   4.27         9.         2.        1.       .81
     ROUTED TO
+                    R83SD        72.   4.27         9.         2.        1.       .81
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|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | BN11KP | 0. | .00 | 0. | 0. | 0. | .41 |
| + | ROUTED TO | R91 | 0. | .00 | 0. | 0. | 0. | .41 |
| + | HYDROGRAPH AT | N11L5 | 80. | 4.10 | 8. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | RED89 | 10. | 4.20 | 0. | 0. | 0. | .05 |
| + | ROUTED TO | R89S | 2. | 4.37 | 0. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | N11L2 | 21. | 4.10 | 2. | 0. | 0. | .01 |
| + | 4 COMBINED AT | CN11L5 | 101. | 4.10 | 10. | 2. | 1. | .05 |
| + | DIVERSION TO | DIVS89 | 17. | 4.10 | 0. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | D11L5 | 84. | 4.10 | 9. | 2. | 1. | .05 |
| + | ROUTED TO | RN11L5 | 85. | 4.13 | 9. | 2. | 1. | .05 |
| + | HYDROGRAPH AT | N11L3 | 75. | 4.10 | 7. | 2. | 1. | .04 |
| + | DIVERSION TO | N11L3Q | 58. | 4.00 | 2. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | DN11L3 | 75. | 4.10 | 5. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | RSOL | 6. | 4.27 | 0. | 0. | 0. | .07 |
| + | ROUTED TO | RTSOL | 1. | 4.30 | 0. | 0. | 0. | .07 |
| + | 3 COMBINED AT | PPSD1 | 159. | 4.13 | 15. | 4. | 1. | .09 |
| + | DIVERSION TO | DIVS87 | 37. | 4.13 | 1. | 0. | 0. | .09 |
| + | HYDROGRAPH AT | PPDIV | 122. | 4.07 | 14. | 3. | 1. | .09 |
| + | HYDROGRAPH AT | N11L4 | 14. | 4.20 | 2. | 0. | 0. | .01 |
| + | DIVERSION TO | N11L4Q | 10. | 4.03 | 0. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | DN11L4 | 14. | 4.20 | 1. | 0. | 0. | .01 |
| + | HYDROGRAPH AT | N21I1 | 122. | 4.17 | 16. | 4. | 1. | .08 |
| + | DIVERSION TO | N21I1Q | 1. | 3.13 | 0. | 0. | 0. | .08 |
| + | HYDROGRAPH AT | DN21I1 | 122. | 4.17 | 15. | 4. | 1. | .08 |
| + | HYDROGRAPH AT | 87OUT | 116. | 5.00 | 60. | 16. | 6. | .61 |

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|---|---|---|---|---|---|---|---|---|
| + | 4 COMBINED AT | PPSD | 306. | 4.30 | 92. | 24. | 9. | .18 |
| + | DIVERSION TO | DIVS86 | 0. | 4.33 | 0. | 0. | 0. | .18 |
| + | HYDROGRAPH AT | DIVS3 | 306. | 4.30 | 92. | 24. | 9. | .18 |
| + | ROUTED TO | RPPSD | 305. | 4.33 | 92. | 24. | 9. | .18 |
| + | HYDROGRAPH AT | N21I2 | 62. | 4.23 | 11. | 3. | 1. | .06 |
| + | HYDROGRAPH AT | N21I4 | 41. | 4.13 | 5. | 1. | 0. | .03 |
| + | 4 COMBINED AT | TEMPO | 408. | 4.33 | 105. | 27. | 10. | 1.08 |
| + | HYDROGRAPH AT | N21Z | 187. | 4.23 | 24. | 6. | 2. | .11 |
| + | DIVERSION TO | N21ZI | 187. | 4.23 | 14. | 3. | 1. | .11 |
| + | HYDROGRAPH AT | LN21Z | 157. | 4.40 | 11. | 3. | 1. | .11 |
| + | DIVERSION TO | DN21ZI | 0. | 4.40 | 0. | 0. | 0. | .11 |
| + | HYDROGRAPH AT | DN21ZO | 157. | 4.40 | 11. | 3. | 1. | .11 |
| + | DIVERSION TO | N21ZI* | 78. | 4.40 | 5. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | DN21Z* | 78. | 4.40 | 5. | 1. | 0. | .11 |
| + | ROUTED TO | RN21ZW | 62. | 4.63 | 5. | 1. | 0. | .11 |
| + | DIVERSION TO | D1/2ST | 12. | 4.53 | 3. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | 1/2ST | 50. | 4.63 | 3. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | R1/2ST | 12. | 4.53 | 3. | 1. | 0. | .11 |
| + | HYDROGRAPH AT | 18PIPE | 18. | 4.33 | 1. | 0. | 0. | .10 |
| + | HYDROGRAPH AT | CLDIV | 60. | 4.10 | 8. | 2. | 1. | .13 |
| + | 2 COMBINED AT | CPIPE | 76. | 4.33 | 9. | 2. | 1. | .23 |
| + | ROUTED TO | RCPIPE | 75. | 4.70 | 9. | 2. | 1. | .23 |
| + | HYDROGRAPH AT | N21I3 | 134. | 4.27 | 18. | 5. | 2. | .09 |
| + | 3 COMBINED AT | CN21I3 | 146. | 4.67 | 29. | 8. | 3. | .32 |
| + | DIVERSION TO | N21I3O | 146. | 4.67 | 29. | 8. | 3. | .32 |
| | HYDROGRAPH AT | | | | | | | |

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|---|---|---|---|---|---|---|---|
| + | | R21I3 | 0. | .00 | 0. | 0. | 0. | .32 |
| + | 2 COMBINED AT | PPK_E | 50. | 4.63 | 3. | 1. | 0. | .43 |
| + | DIVERSION TO | PPKEW3 | 50. | 4.63 | 3. | 1. | 0. | .43 |
| + | HYDROGRAPH AT | PPKEW2 | 0. | .00 | 0. | 0. | 0. | .43 |
| + | 2 COMBINED AT | US_BSN | 408. | 4.33 | 105. | 27. | 10. | 1.51 |
| + | DIVERSION TO | PPBAS | 10. | 3.63 | 10. | 3. | 1. | 1.51 |
| + | HYDROGRAPH AT | PPBP | 370. | 4.33 | 90. | 23. | 8. | 1.51 |
| + | ROUTED TO | R83BSN | 22. | 7.90 | 21. | 16. | 7. | 1.51 |
| + | HYDROGRAPH AT | RPPB | 10. | 3.63 | 10. | 3. | 1. | 1.51 |
| + | 2 COMBINED AT | JCT1 | 32. | 7.90 | 30. | 18. | 8. | 1.51 |
| + | HYDROGRAPH AT | RESD | 50. | 4.63 | 3. | 1. | 0. | .43 |
| + | 2 COMBINED AT | JCT | 57. | 4.73 | 32. | 19. | 8. | 1.51 |
| + | ROUTED TO | OUTLET | 55. | 4.90 | 32. | 19. | 8. | 1.51 |
| + | HYDROGRAPH AT | N21F | 185. | 4.27 | 33. | 8. | 3. | .13 |
| + | DIVERSION TO | DN21FQ | 32. | 3.73 | 2. | 0. | 0. | .13 |
| + | HYDROGRAPH AT | DN21F | 185. | 4.27 | 32. | 8. | 3. | .13 |
| + | 2 COMBINED AT | CN21F | 164. | 4.30 | 60. | 27. | 11. | 1.63 |
| + | HYDROGRAPH AT | N21G | 106. | 4.20 | 17. | 4. | 2. | .06 |
| + | HYDROGRAPH AT | DR21Z* | 78. | 4.40 | 5. | 1. | 0. | .11 |
| + | ROUTED TO | RN21ZS | 49. | 4.93 | 5. | 1. | 0. | .11 |
| + | 2 COMBINED AT | CN21G | 106. | 4.20 | 22. | 6. | 2. | .06 |
| + | DIVERSION TO | N21GI | 17. | 4.20 | 1. | 0. | 0. | .06 |
| + | HYDROGRAPH AT | DN21GO | 89. | 4.20 | 21. | 5. | 2. | .06 |
| + | ROUTED TO | RN21GS | 88. | 4.53 | 21. | 5. | 2. | .06 |
| + | HYDROGRAPH AT | N21E | 117. | 4.17 | 18. | 4. | 2. | .06 |
| + | 3 COMBINED AT | CN21E | 316. | 4.33 | 96. | 35. | 14. | 1.76 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | RN21E | 312. | 4.53 | 96. | 35. | 14. | 1.76 |
| + | HYDROGRAPH AT | N21D | 91. | 4.20 | 14. | 4. | 1. | .05 |
| + | DIVERSION TO | LN21DD | 91. | 4.20 | 8. | 2. | 1. | .05 |
| + | HYDROGRAPH AT | LN21D | 74. | 4.40 | 6. | 2. | 1. | .05 |
| + | 2 COMBINED AT | CN21D | 366. | 4.50 | 101. | 37. | 14. | 1.81 |
| + | DIVERSION TO | N21DI | 319. | 4.50 | 87. | 32. | 13. | 1.81 |
| + | HYDROGRAPH AT | DN21D | 47. | 4.50 | 14. | 4. | 2. | 1.81 |
| + | ROUTED TO | RN21DE | 42. | 5.27 | 14. | 4. | 2. | 1.81 |
| + | HYDROGRAPH AT | 20 | 106. | 4.07 | 10. | 3. | 1. | .04 |
| + | DIVERSION TO | D20Q | 30. | 3.73 | 1. | 0. | 0. | .04 |
| + | HYDROGRAPH AT | D20 | 106. | 4.07 | 9. | 2. | 1. | .04 |
| + | ROUTED TO | R20 | 105. | 4.10 | 9. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | 19 | 116. | 4.07 | 10. | 3. | 1. | .05 |
| + | DIVERSION TO | D19Q | 4. | 3.43 | 1. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | D19 | 116. | 4.07 | 10. | 2. | 1. | .05 |
| + | 2 COMBINED AT | HC6 | 220. | 4.07 | 19. | 5. | 2. | .09 |
| + | ROUTED TO | B19 | 91. | 4.37 | 12. | 4. | 2. | .09 |
| + | ROUTED TO | RHC6 | 90. | 4.37 | 12. | 4. | 2. | .09 |
| + | HYDROGRAPH AT | 21 | 63. | 4.10 | 7. | 2. | 1. | .03 |
| + | 2 COMBINED AT | HC7 | 124. | 4.33 | 18. | 6. | 2. | .11 |
| + | ROUTED TO | RHC7 | 120. | 4.47 | 18. | 6. | 2. | .11 |
| + | HYDROGRAPH AT | 33 | 86. | 4.07 | 9. | 2. | 1. | .04 |
| + | DIVERSION TO | D33Q | 1. | 1.43 | 0. | 0. | 0. | .04 |
| + | HYDROGRAPH AT | D33 | 86. | 4.07 | 9. | 2. | 1. | .04 |
| + | ROUTED TO | B33 | 6. | 4.93 | 5. | 2. | 1. | .04 |

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|---|---|---|---|---|---|---|---|---|
| + | ROUTED TO | R33 | 6. | 5.57 | 5. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | 34 | 86. | 4.00 | 6. | 2. | 1. | .03 |
| + | DIVERSION TO | D34Q | 6. | 3.43 | 1. | 0. | 0. | .03 |
| + | HYDROGRAPH AT | D34 | 86. | 4.00 | 6. | 1. | 1. | .03 |
| + | ROUTED TO | B34 | 5. | 4.40 | 4. | 1. | 1. | .03 |
| + | ROUTED TO | R34 | 5. | 4.90 | 4. | 1. | 1. | .03 |
| + | HYDROGRAPH AT | 35 | 52. | 4.20 | 9. | 2. | 1. | .04 |
| + | 4 COMBINED AT | HC8A | 166. | 4.43 | 35. | 12. | 4. | .23 |
| + | HYDROGRAPH AT | 22 | 125. | 4.03 | 10. | 3. | 1. | .04 |
| + | DIVERSION TO | D22Q | 43. | 3.80 | 2. | 1. | 0. | .04 |
| + | HYDROGRAPH AT | D22 | 125. | 4.03 | 8. | 2. | 1. | .04 |
| + | ROUTED TO | R22 | 121. | 4.10 | 8. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | 23 | 75. | 4.07 | 7. | 2. | 1. | .03 |
| + | 2 COMBINED AT | HC8 | 195. | 4.07 | 15. | 4. | 1. | .07 |
| + | ROUTED TO | B23 | 164. | 4.17 | 11. | 3. | 1. | .07 |
| + | HYDROGRAPH AT | 25 | 28. | 4.10 | 4. | 1. | 0. | .01 |
| + | 3 COMBINED AT | HC9 | 299. | 4.17 | 49. | 16. | 6. | .31 |
| + | ROUTED TO | RHC9 | 293. | 4.23 | 49. | 16. | 6. | .31 |
| + | HYDROGRAPH AT | 27 | 92. | 4.07 | 9. | 2. | 1. | .04 |
| + | HYDROGRAPH AT | 36 | 106. | 4.07 | 10. | 3. | 1. | .05 |
| + | DIVERSION TO | D36Q | 16. | 3.67 | 1. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | D36 | 106. | 4.07 | 9. | 2. | 1. | .05 |
| + | ROUTED TO | R36 | 104. | 4.13 | 9. | 2. | 1. | .05 |
| + | HYDROGRAPH AT | 37w | 11. | 4.20 | 2. | 0. | 0. | .01 |
| + | 4 COMBINED AT | C37W | 458. | 4.20 | 68. | 20. | 8. | .41 |
| | ROUTED TO | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | B37W | 360. | 4.40 | 68. | 20. | 8. | .41 |
| | ROUTED TO | | | | | | | |
| + | | RB37W | 358. | 4.47 | 68. | 20. | 8. | .41 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 37e | 21. | 4.10 | 2. | 1. | 0. | .01 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 24 | 49. | 4.07 | 5. | 1. | 0. | .02 |
| | DIVERSION TO | | | | | | | |
| + | | D24Q | 24. | 3.87 | 1. | 0. | 0. | .02 |
| | HYDROGRAPH AT | | | | | | | |
| + | | D24 | 49. | 4.07 | 4. | 1. | 0. | .02 |
| | ROUTED TO | | | | | | | |
| + | | R24 | 49. | 4.07 | 4. | 1. | 0. | .02 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 100 | 100. | 4.07 | 9. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | D100Q | 59. | 3.90 | 2. | 1. | 0. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | D100 | 100. | 4.07 | 7. | 2. | 1. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC100 | 148. | 4.07 | 10. | 3. | 1. | .06 |
| | ROUTED TO | | | | | | | |
| + | | R100 | 148. | 4.07 | 10. | 3. | 1. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 28R | 29. | 4.07 | 3. | 1. | 0. | .01 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC28R | 177. | 4.07 | 13. | 3. | 1. | .07 |
| | ROUTED TO | | | | | | | |
| + | | R28R | 173. | 4.13 | 13. | 3. | 1. | .07 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 26R | 168. | 4.07 | 13. | 3. | 1. | .06 |
| | DIVERSION TO | | | | | | | |
| + | | D26RQ | 103. | 3.90 | 3. | 1. | 0. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | D26R | 168. | 4.07 | 10. | 2. | 1. | .06 |
| | ROUTED TO | | | | | | | |
| + | | R26R | 163. | 4.10 | 10. | 2. | 1. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 29 | 82. | 4.07 | 8. | 2. | 1. | .03 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC11 | 243. | 4.10 | 18. | 4. | 2. | .10 |
| | ROUTED TO | | | | | | | |
| + | | B29 | 131. | 4.30 | 13. | 4. | 2. | .10 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 48 | 43. | 4.13 | 5. | 1. | 0. | .03 |
| | 5 COMBINED AT | | | | | | | |
| + | | HC12 | 580. | 4.33 | 99. | 30. | 11. | .61 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 49 | 40. | 4.13 | 5. | 1. | 0. | .02 |
| | ROUTED TO | | | | | | | |
| + | | B49 | 5. | 5.00 | 0. | 0. | 0. | .02 |

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|---|---|---|---|---|---|---|---|
| + | 2 COMBINED AT C-N24M | 575. | 4.33 | 99. | 30. | 11. | .64 |
| + | ROUTED TO RB49 | 535. | 4.70 | 99. | 30. | 11. | .64 |
| + | HYDROGRAPH AT N24V | 119. | 4.07 | 8. | 2. | 1. | .05 |
| + | DIVERSION TO DN24VQ | 115. | 4.03 | 4. | 1. | 0. | .05 |
| + | HYDROGRAPH AT DN24V | 115. | 4.10 | 4. | 1. | 0. | .05 |
| + | ROUTED TO RN24V | 30. | 5.20 | 4. | 1. | 0. | .05 |
| + | HYDROGRAPH AT N24M | 338. | 4.17 | 36. | 9. | 3. | .17 |
| + | DIVERSION TO DN24MQ | 338. | 4.17 | 27. | 7. | 2. | .17 |
| + | HYDROGRAPH AT DN24M | 167. | 4.43 | 9. | 2. | 1. | .17 |
| + | 3 COMBINED AT CN24M | 553. | 4.73 | 107. | 32. | 12. | .85 |
| + | ROUTED TO RN24M | 496. | 5.17 | 107. | 32. | 12. | .85 |
| + | HYDROGRAPH AT 45 | 172. | 4.03 | 14. | 3. | 1. | .06 |
| + | DIVERSION TO D45Q | 34. | 3.70 | 2. | 1. | 0. | .06 |
| + | HYDROGRAPH AT D45 | 172. | 4.03 | 12. | 3. | 1. | .06 |
| + | ROUTED TO R45 | 163. | 4.10 | 12. | 3. | 1. | .06 |
| + | HYDROGRAPH AT 47 | 91. | 4.07 | 9. | 2. | 1. | .04 |
| + | 2 COMBINED AT HC14 | 253. | 4.10 | 20. | 5. | 2. | .10 |
| + | ROUTED TO RHC14 | 243. | 4.13 | 20. | 5. | 2. | .10 |
| + | HYDROGRAPH AT 50 | 55. | 4.10 | 6. | 2. | 1. | .03 |
| + | ROUTED TO R50 | 52. | 4.17 | 6. | 2. | 1. | .03 |
| + | HYDROGRAPH AT 51 | 21. | 4.10 | 3. | 1. | 0. | .01 |
| + | 3 COMBINED AT HC15 | 315. | 4.13 | 29. | 7. | 3. | .14 |
| + | ROUTED TO B51 | 220. | 4.30 | 25. | 7. | 3. | .14 |
| + | HYDROGRAPH AT 46 | 177. | 4.03 | 14. | 4. | 1. | .06 |
| + | DIVERSION TO D46Q | 91. | 3.87 | 4. | 1. | 0. | .06 |

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|---|---|---|---|---|---|---|---|---|
| | HYDROGRAPH AT | | | | | | | |
| + | | D46 | 177. | 4.03 | 10. | 3. | 1. | .06 |
| | ROUTED TO | | | | | | | |
| + | | R46 | 169. | 4.13 | 10. | 3. | 1. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 52 | 86. | 4.10 | 10. | 2. | 1. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC16 | 254. | 4.10 | 20. | 5. | 2. | .10 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 53R | 172. | 4.07 | 16. | 4. | 1. | .07 |
| | DIVERSION TO | | | | | | | |
| + | | D53RQ | 33. | 3.70 | 2. | 1. | 0. | .07 |
| | HYDROGRAPH AT | | | | | | | |
| + | | D53R | 172. | 4.07 | 14. | 3. | 1. | .07 |
| | ROUTED TO | | | | | | | |
| + | | R53 | 164. | 4.10 | 14. | 3. | 1. | .07 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 54R | 43. | 4.10 | 5. | 1. | 0. | .02 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC17 | 207. | 4.10 | 18. | 5. | 2. | .09 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC17A | 460. | 4.10 | 38. | 10. | 3. | .19 |
| | ROUTED TO | | | | | | | |
| + | | B52 | 128. | 4.47 | 25. | 9. | 3. | .19 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 56R | 37. | 4.03 | 3. | 1. | 0. | .01 |
| | ROUTED TO | | | | | | | |
| + | | B56 | 16. | 4.20 | 2. | 0. | 0. | .01 |
| | 3 COMBINED AT | | | | | | | |
| + | | C-N24I | 333. | 4.33 | 52. | 16. | 6. | .35 |
| | ROUTED TO | | | | | | | |
| + | | R-N24I | 315. | 4.60 | 51. | 16. | 6. | .35 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 55 | 168. | 4.07 | 15. | 4. | 1. | .05 |
| | DIVERSION TO | | | | | | | |
| + | | D55Q | 83. | 3.87 | 5. | 1. | 0. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | D55 | 168. | 4.07 | 10. | 2. | 1. | .05 |
| | ROUTED TO | | | | | | | |
| + | | R55 | 167. | 4.07 | 10. | 2. | 1. | .05 |
| | HYDROGRAPH AT | | | | | | | |
| + | | 57R | 22. | 4.03 | 2. | 0. | 0. | .01 |
| | 2 COMBINED AT | | | | | | | |
| + | | HC18 | 188. | 4.07 | 12. | 3. | 1. | .06 |
| | ROUTED TO | | | | | | | |
| + | | B57R | 111. | 4.20 | 8. | 2. | 1. | .06 |
| | ROUTED TO | | | | | | | |
| + | | RB57R | 102. | 4.30 | 8. | 2. | 1. | .06 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N24I | 360. | 4.43 | 61. | 16. | 6. | .30 |
| | DIVERSION TO | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | DN24IQ | 227. | 4.23 | 13. | 3. | 1. | .30 |
| + | HYDROGRAPH AT | DN24I | 360. | 4.43 | 49. | 12. | 4. | .30 |
| + | 4 COMBINED AT | CP57R | 683. | 5.20 | 196. | 58. | 21. | 1.56 |
| + | HYDROGRAPH AT | N24H | 481. | 4.23 | 55. | 14. | 5. | .23 |
| + | DIVERSION TO | DN24HQ | 99. | 3.83 | 8. | 2. | 1. | .23 |
| + | HYDROGRAPH AT | DN24H | 481. | 4.23 | 47. | 12. | 4. | .23 |
| + | HYDROGRAPH AT | N24N | 210. | 4.20 | 26. | 7. | 2. | .13 |
| + | DIVERSION TO | DN24NQ | 208. | 4.17 | 11. | 3. | 1. | .13 |
| + | HYDROGRAPH AT | DN24N | 207. | 4.23 | 15. | 4. | 1. | .13 |
| + | ROUTED TO | RN24N | 128. | 4.87 | 15. | 4. | 1. | .13 |
| + | HYDROGRAPH AT | N24J | 142. | 4.40 | 27. | 7. | 2. | .12 |
| + | DIVERSION TO | DN24JQ | 3. | 2.97 | 1. | 0. | 0. | .12 |
| + | HYDROGRAPH AT | DN24J | 142. | 4.40 | 26. | 7. | 2. | .12 |
| + | 2 COMBINED AT | CN24J | 214. | 4.83 | 41. | 10. | 4. | .25 |
| + | ROUTED TO | RN24J | 211. | 4.90 | 41. | 10. | 4. | .25 |
| + | HYDROGRAPH AT | N24K | 204. | 4.50 | 44. | 11. | 4. | .21 |
| + | DIVERSION TO | DN24KQ | 59. | 4.10 | 4. | 1. | 0. | .21 |
| + | HYDROGRAPH AT | DN24K | 204. | 4.50 | 40. | 10. | 4. | .21 |
| + | 4 COMBINED AT | CN24I | 903. | 5.20 | 298. | 84. | 31. | 2.25 |
| + | ROUTED TO | RN24I | 890. | 4.70 | 297. | 84. | 31. | 2.25 |
| + | HYDROGRAPH AT | N21JA | 203. | 4.10 | 17. | 4. | 2. | .08 |
| + | DIVERSION TO | N21JAQ | 172. | 4.03 | 7. | 2. | 1. | .08 |
| + | HYDROGRAPH AT | DN21JA | 203. | 4.10 | 10. | 3. | 1. | .08 |
| + | ROUTED TO | RN21JS | 152. | 4.37 | 10. | 3. | 1. | .08 |
| + | HYDROGRAPH AT | N21JB | 300. | 4.17 | 30. | 8. | 3. | .17 |
| + | DIVERSION TO | N21JBQ | 187. | 4.00 | 6. | 2. | 1. | .17 |

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|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT DN21JB | 300. | 4.17 | 24. | 6. | 2. | .17 |
| + | 2 COMBINED AT CN21J | 364. | 4.33 | 34. | 9. | 3. | .25 |
| + | ROUTED TO RN21JE | 317. | 4.63 | 34. | 9. | 3. | .25 |
| + | 2 COMBINED AT CN24G* | 1069. | 4.70 | 322. | 90. | 33. | 2.50 |
| + | ROUTED TO RN24G* | 1055. | 4.83 | 321. | 90. | 33. | 2.50 |
| + | HYDROGRAPH AT N24G | 475. | 4.40 | 73. | 18. | 7. | .43 |
| + | DIVERSION TO LN24GD | 474. | 4.40 | 30. | 8. | 3. | .43 |
| + | HYDROGRAPH AT LN24G | 468. | 4.47 | 43. | 11. | 4. | .43 |
| + | 2 COMBINED AT CN24G | 1229. | 4.80 | 343. | 95. | 35. | 2.93 |
| + | HYDROGRAPH AT DRN21Z | 0. | 4.40 | 0. | 0. | 0. | .11 |
| + | ROUTED TO RN21ZE | 0. | 7.57 | 0. | 0. | 0. | .11 |
| + | 2 COMBINED AT CN24G+ | 1229. | 4.80 | 343. | 95. | 35. | 2.93 |
| + | ROUTED TO RN24G | 1217. | 4.83 | 342. | 95. | 35. | 2.93 |
| + | HYDROGRAPH AT N24F | 163. | 4.27 | 20. | 5. | 2. | .11 |
| + | DIVERSION TO DN24FQ | 124. | 4.10 | 5. | 1. | 0. | .11 |
| + | HYDROGRAPH AT DN24F | 163. | 4.27 | 15. | 4. | 1. | .11 |
| + | 2 COMBINED AT CN24F | 1249. | 4.83 | 352. | 98. | 36. | 3.03 |
| + | HYDROGRAPH AT N24D | 160. | 4.13 | 19. | 5. | 2. | .09 |
| + | DIVERSION TO DN24DQ | 3. | 2.97 | 1. | 0. | 0. | .09 |
| + | HYDROGRAPH AT DN24D | 160. | 4.13 | 18. | 5. | 2. | .09 |
| + | 2 COMBINED AT CN24D | 1270. | 4.83 | 363. | 101. | 37. | 3.12 |
| + | ROUTED TO LN24D | 13. | 18.03 | 13. | 11. | 10. | 3.12 |
| + | HYDROGRAPH AT N21H | 59. | 4.13 | 6. | 2. | 1. | .03 |
| + | HYDROGRAPH AT DRN21G | 17. | 4.20 | 1. | 0. | 0. | .06 |
| + | ROUTED TO RN21GE | 12. | 4.53 | 1. | 0. | 0. | .06 |

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|---|---|---|---|---|---|---|---|---|
| | 2 COMBINED AT | | | | | | | |
| + | | CN21H | 60. | 4.13 | 7. | 2. | 1. | .03 |
| | ROUTED TO | | | | | | | |
| + | | RN21H | 42. | 5.07 | 7. | 2. | 1. | .03 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N24E | 25. | 4.33 | 4. | 1. | 0. | .02 |
| | DIVERSION TO | | | | | | | |
| + | | DN24EQ | 25. | 4.33 | 2. | 1. | 0. | .02 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN24E | 17. | 4.63 | 2. | 0. | 0. | .02 |
| | ROUTED TO | | | | | | | |
| + | | RN24E | 13. | 5.00 | 2. | 0. | 0. | .02 |
| | 3 COMBINED AT | | | | | | | |
| + | | CN24D* | 44. | 5.23 | 16. | 13. | 10. | 3.18 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N27 | 357. | 4.27 | 61. | 15. | 6. | .28 |
| | DIVERSION TO | | | | | | | |
| + | | DN27Q | 357. | 4.27 | 30. | 8. | 3. | .28 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN27 | 310. | 4.43 | 31. | 8. | 3. | .28 |
| | ROUTED TO | | | | | | | |
| + | | RN27 | 247. | 4.80 | 31. | 8. | 3. | .28 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N26 | 100. | 4.13 | 10. | 2. | 1. | .04 |
| | DIVERSION TO | | | | | | | |
| + | | DN26Q | 100. | 4.13 | 6. | 1. | 1. | .04 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN26 | 75. | 4.20 | 4. | 1. | 0. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | CN26 | 254. | 4.80 | 35. | 9. | 3. | .32 |
| | ROUTED TO | | | | | | | |
| + | | RN26 | 222. | 5.07 | 35. | 9. | 3. | .32 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N25 | 364. | 4.37 | 58. | 15. | 5. | .24 |
| | DIVERSION TO | | | | | | | |
| + | | DN25Q | 364. | 4.37 | 37. | 9. | 3. | .24 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN25 | 235. | 4.67 | 22. | 5. | 2. | .24 |
| | 2 COMBINED AT | | | | | | | |
| + | | CN25 | 314. | 5.07 | 56. | 14. | 5. | .56 |
| | ROUTED TO | | | | | | | |
| + | | RN25 | 246. | 5.53 | 55. | 14. | 5. | .56 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N24 | 202. | 4.20 | 26. | 7. | 2. | .11 |
| | DIVERSION TO | | | | | | | |
| + | | DN24Q | 202. | 4.20 | 14. | 3. | 1. | .11 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN24 | 191. | 4.27 | 13. | 3. | 1. | .11 |
| | 3 COMBINED AT | | | | | | | |
| + | | CN24 | 289. | 5.47 | 85. | 32. | 17. | 3.85 |
| | ROUTED TO | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| + | | RCN24 | 166. | 6.47 | 64. | 25. | 15. | 3.85 |
| + | HYDROGRAPH AT | N23 | 515. | 4.27 | 85. | 21. | 8. | .39 |
| + | DIVERSION TO | DN23Q | 170. | 3.93 | 11. | 3. | 1. | .39 |
| + | HYDROGRAPH AT | DN23 | 515. | 4.27 | 74. | 19. | 7. | .39 |
| + | 3 COMBINED AT | CN23 | 317. | 4.33 | 128. | 41. | 21. | 6.05 |
| + | ROUTED TO | RN23 | 298. | 4.97 | 128. | 41. | 21. | 6.05 |
| + | HYDROGRAPH AT | BN21DI | 319. | 4.50 | 87. | 32. | 13. | 1.81 |
| + | ROUTED TO | RN21DS | 293. | 5.10 | 86. | 32. | 13. | 1.81 |
| + | HYDROGRAPH AT | N21C | 515. | 4.30 | 100. | 25. | 9. | .39 |
| + | DIVERSION TO | LN21CD | 52. | 3.67 | 6. | 1. | 1. | .39 |
| + | HYDROGRAPH AT | LN21C | 515. | 4.30 | 96. | 24. | 9. | .39 |
| + | 2 COMBINED AT | CN21C | 564. | 4.97 | 182. | 59. | 23. | .39 |
| + | HYDROGRAPH AT | N21 | 833. | 4.40 | 158. | 40. | 14. | .62 |
| + | DIVERSION TO | DN21Q | 49. | 3.43 | 12. | 3. | 1. | .62 |
| + | HYDROGRAPH AT | DN21 | 833. | 4.40 | 147. | 37. | 13. | .62 |
| + | 3 COMBINED AT | CN21 | 1097. | 4.83 | 408. | 120. | 50. | 7.06 |
| + | ROUTED TO | RN21 | 1087. | 5.13 | 407. | 120. | 50. | 7.06 |
| + | DIVERSION TO | N20DI | 1087. | 5.13 | 407. | 120. | 50. | 7.06 |
| + | HYDROGRAPH AT | N21-20 | 0. | .00 | 0. | 0. | 0. | 7.06 |
| + | HYDROGRAPH AT | N11DB | 379. | 4.23 | 54. | 14. | 5. | .25 |
| + | HYDROGRAPH AT | B11DAS | 21. | 4.87 | 8. | 2. | 1. | .26 |
| + | ROUTED TO | R11DAS | 21. | 5.40 | 8. | 2. | 1. | .26 |
| + | 2 COMBINED AT | C11DAB | 379. | 4.23 | 61. | 15. | 6. | .25 |
| + | DIVERSION TO | LNBOUT | 379. | 4.23 | 29. | 7. | 3. | .25 |
| + | HYDROGRAPH AT | LN11DB | 319. | 4.40 | 33. | 8. | 3. | .25 |
| + | DIVERSION TO | N11DI | 287. | 4.40 | 30. | 7. | 3. | .25 |

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|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | DN11D | 32. | 4.40 | 3. | 1. | 0. | .25 |
| + | ROUTED TO | RN11DE | 22. | 4.87 | 3. | 1. | 0. | .25 |
| + | HYDROGRAPH AT | DRX5 | 2. | 4.70 | 0. | 0. | 0. | .26 |
| + | ROUTED TO | RX5S | 0. | 4.73 | 0. | 0. | 0. | .26 |
| + | 2 COMBINED AT | CX1 | 22. | 4.87 | 3. | 1. | 0. | .25 |
| + | DIVERSION TO | X1I | 0. | .00 | 0. | 0. | 0. | .25 |
| + | HYDROGRAPH AT | DX1 | 22. | 4.87 | 3. | 1. | 0. | .25 |
| + | ROUTED TO | RX1E | 19. | 5.03 | 3. | 1. | 0. | .25 |
| + | HYDROGRAPH AT | DIVS1 | 17. | 4.10 | 0. | 0. | 0. | .05 |
| + | ROUTED TO | RNDV89 | 3. | 4.20 | 0. | 0. | 0. | .05 |
| + | HYDROGRAPH AT | DV1 | 127. | 4.20 | 19. | 5. | 2. | .09 |
| + | DIVERSION TO | DDV1Q | 2. | 1.77 | 0. | 0. | 0. | .09 |
| + | HYDROGRAPH AT | DDV1 | 127. | 4.20 | 19. | 5. | 2. | .09 |
| + | 2 COMBINED AT | CPD1 | 130. | 4.20 | 19. | 5. | 2. | .09 |
| + | ROUTED TO | RNCP1 | 130. | 4.20 | 19. | 5. | 2. | .09 |
| + | HYDROGRAPH AT | DV2 | 33. | 4.27 | 7. | 2. | 1. | .03 |
| + | 2 COMBINED AT | CPD2 | 162. | 4.23 | 26. | 7. | 2. | .12 |
| + | DIVERSION TO | DVRB | 53. | 4.03 | 7. | 2. | 1. | .12 |
| + | HYDROGRAPH AT | 89WRB | 109. | 4.23 | 19. | 5. | 2. | .12 |
| + | ROUTED TO | RNRDV2 | 103. | 4.30 | 19. | 5. | 2. | .12 |
| + | HYDROGRAPH AT | DV3 | 73. | 4.20 | 11. | 3. | 1. | .05 |
| + | 2 COMBINED AT | CPD3 | 172. | 4.27 | 30. | 8. | 3. | .17 |
| + | ROUTED TO | RNRDV3 | 170. | 4.33 | 30. | 8. | 3. | .17 |
| + | HYDROGRAPH AT | DV4 | 64. | 4.27 | 13. | 3. | 1. | .06 |
| + | HYDROGRAPH AT | DV5 | 52. | 4.13 | 6. | 2. | 1. | .03 |

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|---|---|---|---|---|---|---|---|---|
| | 3 COMBINED AT | | | | | | | |
| + | | CPD5 | 273. | 4.30 | 49. | 12. | 4. | .26 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV6 | 123. | 4.20 | 19. | 5. | 2. | .09 |
| | 2 COMBINED AT | | | | | | | |
| + | | CPDV6 | 392. | 4.27 | 68. | 17. | 6. | .35 |
| | ROUTED TO | | | | | | | |
| + | | RN11IS | 386. | 4.37 | 68. | 17. | 6. | .35 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N11EA | 308. | 4.30 | 58. | 15. | 5. | .26 |
| | 2 COMBINED AT | | | | | | | |
| + | | CN11EA | 665. | 4.37 | 125. | 32. | 11. | .61 |
| | ROUTED TO | | | | | | | |
| + | | RN11ES | 660. | 4.43 | 124. | 32. | 11. | .61 |
| | ROUTED TO | | | | | | | |
| + | | LX50 | 595. | 4.63 | 206. | 160. | 150. | .61 |
| | DIVERSION TO | | | | | | | |
| + | | DX50I | 444. | 4.63 | 181. | 149. | 142. | .61 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DX50 | 152. | 4.63 | 26. | 11. | 7. | .61 |
| | ROUTED TO | | | | | | | |
| + | | RX50E | 148. | 4.83 | 26. | 11. | 7. | .61 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DIVS2 | 37. | 4.13 | 1. | 0. | 0. | .09 |
| | ROUTED TO | | | | | | | |
| + | | RNDV87 | 9. | 4.30 | 1. | 0. | 0. | .09 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV7 | 200. | 4.30 | 31. | 8. | 3. | .13 |
| | DIVERSION TO | | | | | | | |
| + | | DDV7Q | 100. | 4.00 | 5. | 1. | 0. | .13 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DDV7 | 200. | 4.30 | 26. | 6. | 2. | .13 |
| | 2 COMBINED AT | | | | | | | |
| + | | CPD7 | 209. | 4.30 | 27. | 7. | 2. | .13 |
| | ROUTED TO | | | | | | | |
| + | | RNRDV7 | 206. | 4.43 | 27. | 7. | 2. | .13 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV8 | 139. | 4.23 | 23. | 6. | 2. | .09 |
| | 2 COMBINED AT | | | | | | | |
| + | | CPD8 | 329. | 4.40 | 50. | 13. | 5. | .22 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV9 | 111. | 4.07 | 10. | 2. | 1. | .04 |
| | 2 COMBINED AT | | | | | | | |
| + | | DVCP9 | 374. | 4.33 | 60. | 15. | 5. | .27 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DIVS13 | 0. | 4.33 | 0. | 0. | 0. | .18 |
| | ROUTED TO | | | | | | | |
| + | | RNRS86 | 0. | 4.33 | 0. | 0. | 0. | .18 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV10 | 382. | 4.20 | 48. | 12. | 4. | .21 |
| | DIVERSION TO | | | | | | | |

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+                    DDV10Q      39.   3.70        2.        1.        0.      .21
      HYDROGRAPH AT
+                     DDV10     382.   4.20       46.       11.        4.      .21
      2 COMBINED AT
+                     CPD10     382.   4.20       46.       11.        4.      .21
      ROUTED TO
+                    RNRD10     373.   4.27       46.       11.        4.      .21
      HYDROGRAPH AT
+                      DV11     281.   4.17       42.       11.        4.      .14
      3 COMBINED AT
+                     CPD11     959.   4.30      146.       37.       13.      .62
      ROUTED TO
+                    RCP11S     904.   4.43      146.       37.       13.      .62
      HYDROGRAPH AT
+                      N22A     497.   4.23       85.       21.        8.      .30
      2 COMBINED AT
+                     CN22A    1274.   4.37      227.       57.       21.      .92
      DIVERSION TO
+                    LN22DA     737.   4.07       38.        9.        3.      .92
      HYDROGRAPH AT
+                     LN22A    1274.   4.37      191.       48.       17.      .92
      ROUTED TO
+                     R22AS    1209.   4.57      191.       48.       17.      .92
      HYDROGRAPH AT
+                      N22B     302.   4.20       46.       12.        4.      .17
      DIVERSION TO
+                    LN22DB     302.   4.20       24.        6.        2.      .17
      HYDROGRAPH AT
+                     LN22B     267.   4.37       22.        5.        2.      .17
      3 COMBINED AT
+                      CN22    1337.   4.63      230.       62.       26.     1.71
      DIVERSION TO
+                      N22I     500.   4.23      141.       39.       18.     1.71
      HYDROGRAPH AT
+                      DN22     837.   4.63       89.       22.        8.     1.71
      ROUTED TO
+                     RN22W     828.   4.73       89.       22.        8.     1.71
      HYDROGRAPH AT
+                    DRX50I     444.   4.63      181.      149.      142.      .61
      ROUTED TO
+                     RX50W     439.   4.77      181.      149.      142.      .61
      HYDROGRAPH AT
+                     N11EB     392.   4.20       54.       13.        5.      .23
      4 COMBINED AT
+                     CN11E    1277.   4.73      310.      181.      154.     2.19
      DIVERSION TO
+                    LN11ED     144.   2.63       63.       16.        6.     2.19
      HYDROGRAPH AT
+                     LN11E    1277.   4.73      309.      181.      148.     2.19
      ROUTED TO
+                    R-WBE1    1276.   4.73      309.      181.      148.     2.19
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|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | WB1 | 175. | 4.23 | 28. | 7. | 3. | .12 |
| + | 2 COMBINED AT | CPWB1 | 1349. | 4.73 | 333. | 187. | 151. | 2.31 |
| + | ROUTED TO | R-R3 | 1347. | 4.77 | 331. | 187. | 149. | 2.31 |
| + | HYDROGRAPH AT | WB2 | 185. | 4.17 | 25. | 6. | 2. | .10 |
| + | 2 COMBINED AT | CPWB2 | 1403. | 4.73 | 353. | 192. | 151. | 2.41 |
| + | ROUTED TO | R-4-5 | 1375. | 4.83 | 295. | 178. | 143. | 2.41 |
| + | HYDROGRAPH AT | WB3 | 32. | 4.03 | 2. | 1. | 0. | .01 |
| + | 2 COMBINED AT | CPWB3 | 1375. | 4.83 | 295. | 178. | 144. | 2.42 |
| + | ROUTED TO | R-6 | 1384. | 4.83 | 294. | 177. | 143. | 2.42 |
| + | HYDROGRAPH AT | DRN22 | 500. | 4.23 | 141. | 39. | 18. | 1.71 |
| + | HYDROGRAPH AT | WB4 | 224. | 4.13 | 28. | 7. | 3. | .11 |
| + | 2 COMBINED AT | CPWB4 | 707. | 4.23 | 162. | 45. | 20. | .11 |
| + | ROUTED TO | R-R1 | 769. | 4.23 | 154. | 45. | 20. | .11 |
| + | HYDROGRAPH AT | WB5 | 284. | 4.10 | 29. | 7. | 3. | .11 |
| + | 2 COMBINED AT | CPWB5 | 990. | 4.23 | 181. | 52. | 22. | .22 |
| + | ROUTED TO | R-R2 | 609. | 4.67 | 129. | 48. | 22. | .22 |
| + | 2 COMBINED AT | CPR6 | 1972. | 4.83 | 425. | 226. | 166. | 2.64 |
| + | ROUTED TO | RCR26 | 1932. | 4.93 | 423. | 225. | 166. | 2.64 |
| + | HYDROGRAPH AT | WB7 | 103. | 4.10 | 12. | 3. | 1. | .05 |
| + | 2 COMBINED AT | CR6W7 | 1943. | 4.93 | 425. | 226. | 167. | 2.68 |
| + | ROUTED TO | R-R7 | 1935. | 4.97 | 425. | 226. | 166. | 2.68 |
| + | HYDROGRAPH AT | WB6 | 163. | 4.23 | 29. | 7. | 3. | .12 |
| + | ROUTED TO | R-R8 | 22. | 5.53 | 20. | 7. | 3. | .12 |
| + | 2 COMBINED AT | C7R8 | 1948. | 4.97 | 443. | 232. | 168. | 2.80 |
| + | ROUTED TO | RC78 | 1943. | 5.00 | 443. | 232. | 168. | 2.80 |

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|---|---|---|---|---|---|---|---|---|
| | HYDROGRAPH AT | | | | | | | |
| + | | WB8 | 47. | 4.60 | 18. | 5. | 2. | .07 |
| | 2 COMBINED AT | | | | | | | |
| + | | CP-678 | 1976. | 5.00 | 455. | 235. | 169. | 2.87 |
| | HYDROGRAPH AT | | | | | | | |
| + | | WB10 | 156. | 4.20 | 24. | 6. | 2. | .09 |
| | ROUTED TO | | | | | | | |
| + | | R-R9 | 63. | 4.73 | 23. | 6. | 2. | .09 |
| | 2 COMBINED AT | | | | | | | |
| + | | WBEOT | 2017. | 5.00 | 471. | 239. | 171. | 2.96 |
| | DIVERSION TO | | | | | | | |
| + | | TONRI | 100. | 4.83 | 79. | 60. | 48. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DVNR | 1917. | 5.00 | 392. | 179. | 123. | 2.96 |
| | DIVERSION TO | | | | | | | |
| + | | DCLUB | 432. | 5.00 | 74. | 23. | 11. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | CCLUB | 1485. | 5.00 | 319. | 155. | 112. | 2.96 |
| | ROUTED TO | | | | | | | |
| + | | RR287 | 1484. | 5.00 | 319. | 155. | 112. | 2.96 |
| | DIVERSION TO | | | | | | | |
| + | | DV87SI | 444. | 5.00 | 76. | 24. | 12. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV87S | 1039. | 5.00 | 242. | 131. | 100. | 2.96 |
| | ROUTED TO | | | | | | | |
| + | | RR289 | 1034. | 5.03 | 242. | 131. | 100. | 2.96 |
| | DIVERSION TO | | | | | | | |
| + | | DV89I | 444. | 5.03 | 60. | 15. | 5. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DS89 | 589. | 5.03 | 182. | 116. | 95. | 2.96 |
| | ROUTED TO | | | | | | | |
| + | | TODET | 586. | 5.10 | 182. | 116. | 95. | 2.96 |
| | DIVERSION TO | | | | | | | |
| + | | DV91I | 531. | 5.10 | 84. | 21. | 8. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DV91 | 125. | 5.70 | 103. | 96. | 87. | 2.96 |
| | HYDROGRAPH AT | | | | | | | |
| + | | WB9 | 213. | 4.37 | 48. | 12. | 4. | .22 |
| | ROUTED TO | | | | | | | |
| + | | R-R10 | 31. | 6.07 | 26. | 12. | 4. | .22 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DRX1I | 0. | .00 | 0. | 0. | 0. | .25 |
| | ROUTED TO | | | | | | | |
| + | | RX1S | 0. | .00 | 0. | 0. | 0. | .25 |
| | 3 COMBINED AT | | | | | | | |
| + | | CN11B1 | 150. | 5.70 | 125. | 105. | 91. | 3.18 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N11C | 356. | 4.23 | 51. | 13. | 5. | .25 |
| | DIVERSION TO | | | | | | | |
| + | | LN11CD | 356. | 4.23 | 25. | 6. | 2. | .25 |
| | HYDROGRAPH AT | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| + | | LN11C | 316. | 4.37 | 26. | 6. | 2. | .25 |
| | DIVERSION TO | | | | | | | |
| + | | N11CWI | 2. | 4.37 | 0. | 0. | 0. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN11CW | 314. | 4.37 | 26. | 6. | 2. | .25 |
| | DIVERSION TO | | | | | | | |
| + | | N11CEI | 15. | 4.37 | 3. | 1. | 0. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DN11CE | 299. | 4.37 | 23. | 6. | 2. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DRN11C | 2. | 4.37 | 0. | 0. | 0. | .25 |
| | ROUTED TO | | | | | | | |
| + | | LN11CW | 0. | 4.63 | 0. | 0. | 0. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DR11C* | 15. | 4.37 | 3. | 1. | 0. | .25 |
| | ROUTED TO | | | | | | | |
| + | | LN11CE | 3. | 6.40 | 3. | 1. | 0. | .25 |
| | 3 COMBINED AT | | | | | | | |
| + | | CN11C1 | 300. | 4.37 | 25. | 6. | 2. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | BN11DI | 287. | 4.40 | 30. | 7. | 3. | .25 |
| | 2 COMBINED AT | | | | | | | |
| + | | CN11D | 574. | 4.40 | 55. | 14. | 5. | .25 |
| | ROUTED TO | | | | | | | |
| + | | RWBW1 | 431. | 4.80 | 54. | 14. | 5. | .25 |
| | HYDROGRAPH AT | | | | | | | |
| + | | N11A | 763. | 4.50 | 189. | 48. | 17. | .93 |
| | 2 COMBINED AT | | | | | | | |
| + | | CWBW | 866. | 4.80 | 231. | 59. | 21. | 1.18 |
| | ROUTED TO | | | | | | | |
| + | | RBWB | 25. | 4.93 | 25. | 25. | 19. | 1.18 |
| | ROUTED TO | | | | | | | |
| + | | RWBW2 | 25. | 6.70 | 25. | 25. | 19. | 1.18 |
| | 2 COMBINED AT | | | | | | | |
| + | | CN11B | 170. | 5.70 | 149. | 130. | 108. | 4.36 |
| | HYDROGRAPH AT | | | | | | | |
| + | | S30D | 244. | 4.20 | 32. | 8. | 3. | .13 |
| | ROUTED TO | | | | | | | |
| + | | RS30D | 229. | 4.47 | 32. | 8. | 3. | .13 |
| | HYDROGRAPH AT | | | | | | | |
| + | | S30C | 600. | 4.30 | 117. | 29. | 11. | .45 |
| | 2 COMBINED AT | | | | | | | |
| + | | XX1 | 787. | 4.40 | 148. | 37. | 13. | .58 |
| | HYDROGRAPH AT | | | | | | | |
| + | | S30B | 395. | 4.53 | 87. | 22. | 8. | .40 |
| | 2 COMBINED AT | | | | | | | |
| + | | CS30B | 1074. | 4.43 | 228. | 58. | 21. | .98 |
| | DIVERSION TO | | | | | | | |
| + | | DS30BI | 524. | 4.43 | 51. | 13. | 5. | .98 |
| | HYDROGRAPH AT | | | | | | | |
| + | | DS30BO | 550. | 4.23 | 177. | 45. | 16. | .98 |

```
          ROUTED TO
+                        RS30BW      550.    4.70       177.       45.       16.       .98

          HYDROGRAPH AT
+                        DRTONR      100.    4.83        79.       60.       48.      2.96

          HYDROGRAPH AT
+                        BN20DI     1087.    5.13       407.      120.       50.      7.06

          HYDROGRAPH AT
+                           N20      960.    4.10        96.       24.        9.       .35

          DIVERSION TO
+                         DN20Q       26.    3.00         7.        2.        1.       .35

          HYDROGRAPH AT
+                          DN20      960.    4.10        89.       22.        8.       .35

          3 COMBINED AT
+                          CN20     1214.    5.10       537.      193.      104.      8.00
1
```

# HYDRAULICS

**WOOD/PATEL**
MISSION: CLIENT SERVICE™

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS • CONSTRUCTION MANAGERS

# MEMO

TO: Jeff Minch, P.E.

FROM: James Taillon, CFM

DATE: October 14, 2010

RE: Pinnacle Peak Road Drainage Project
99th Avenue to 104th Avenue (Final Submittal)

SUBJECT: Project Hydraulics

## I. INTRODUCTION

This memo summarizes the assumptions and supporting calculations for the final hydraulic design, based on the recommended option from the Pinnacle Peak Road Pre-Design Study prepared by Wood/Patel, December 2009.

The proposed system includes an open channel beginning immediately west of 99th Avenue which conveys flows to a closed conduit system beginning at 99th Lane. The open channel has a cross-section with varying side slopes and a meandering alignment based on feedback from EPG. From 99th Lane, the closed conduit system conveys the flow to the existing box culvert under Lake Pleasant Parkway. The closed conduit system continues from the downstream end of the existing box culvert to 101st Avenue where it transitions back to an open channel to 102nd Avenue. Flow will then be conveyed to the southwest under Pinnacle Peak Road within a culvert into a two basin retention system.

The east retention basin is located on a 10 acre parcel at the southwest corner of 102nd Avenue and Pinnacle Peak Road. A second basin, the west basin, is located on a 5 acre parcel adjacent to Pinnacle Peak Road and immediately west of the east basin. This basin serves to collect overland flows from the north as well as to accommodate overflow from the east basin in the design event. The overflow will be collected and conveyed to the west basin through a grated spillway structure located between the basins. The basins will have a combined storage capacity of 32.5 acre feet.

A bypass storm drain system will be provided to intercept initial base flows at the east and west basin inlets (10 cfs). These flows will be conveyed through the west basin in a closed conduit and ultimately into the Ironwood channel corridor. This small base flow to the south will help sustain vegetation in the corridor. In addition, in the design event it is anticipated that a peak flow of 19 cfs will flow from the basin into the downstream channel. This flow will exit the basin through a grated spillway structure located immediately upstream of the channel.

The runoff from west of 104th Avenue to 107th Avenue is conveyed overland via sheet flow almost due west and does not concentrate along the north side of Pinnacle Peak. This overland flow will ultimately concentrate and be collected and conveyed to the south in the existing channel at the northeast corner of 107th Avenue and Pinnacle Peak Road. A new box culvert will be constructed under Pinnacle Peak Road at this location to convey this flow to the south to the existing box culvert under 107th Avenue where it will be conveyed to its ultimate outfall into the Agua Fria River. By intercepting and conveying the storm water runoff from the east into retention basins and by taking advantage of the existing storm drainage system to the south, this system concept reduces project costs while maintaining the overall effectiveness of the entire regional storm water conveyance system.

Hydraulic design constraints as dictated by the Flood Control District of Maricopa County (FCDMC) are outlined briefly below, as well as a summary of the hydraulic modeling results for the final design.

## II. CONSTRAINTS

The hydraulic design constraints are summarized below:

1. ***107th Avenue Storm Drain Conveyance System*** – The 107th Avenue channel system was evaluated to determine the impact of the Pinnacle Peak Road Drainage Project to the existing channel system based on the planned hydrology. The HEC-RAS modeling results prepared for the existing channel system show that the design 100-year flood from the updated hydrology for the Pinnacle Peak Road project was fully contained within the channel at all locations except at the intersection of Deer Valley Road and 107th Avenue where the existing culvert, 10' x 2.5' box, does not have enough capacity to fully convey the 100-year flow without a small amount of overtopping. The HEC-RAS modeling results show that the designed Pinnacle Peak Road Drainage Project from 99th Avenue to 107th Avenue does not have any negative impact on the existing 107th Avenue channel system.

2. ***Peak Flow and Volume Discharge into the Agua Fria River*** – The designed Pinnacle Peak Road drainage system reduces the peak flow into the Rose Garden Lane basin in the Agua Fria River; however, the Rose Garden Lane basin will require additional excavation to accommodate the ultimate design storm water runoff volume delivered from the Pinnacle Peak basins.

3. ***Design Inlet Condition at 103rd Avenue*** – Two grated area drain inlets will be used to capture off-site flow on the north side of Pinnacle Peak Road immediately upstream of the west basin. A collector channel will be constructed to convey flow into these inlets. The headwater required for both the grated inlets and the proposed culverts were checked against the existing condition water-surface elevation, calculated using HEC-RAS, upstream of the proposed roadway to ensure that the system was not increasing flow depth at this location.

4. ***Retention Basin Dewatering*** – The Pinnacle Peak Road basins are designed as retention basins. However, the team expressed a desire to provide a system of draining the basins in the event that percolation alone will not dewater the system within the required 36-hours. A small perforated drain system will allow the basin to slowly drain into the Ironwood wash to achieve the required dewater time frame. The west basin outlet pipes will also include self-operating check valves to prevent flow in the bypass system from entering the basin.

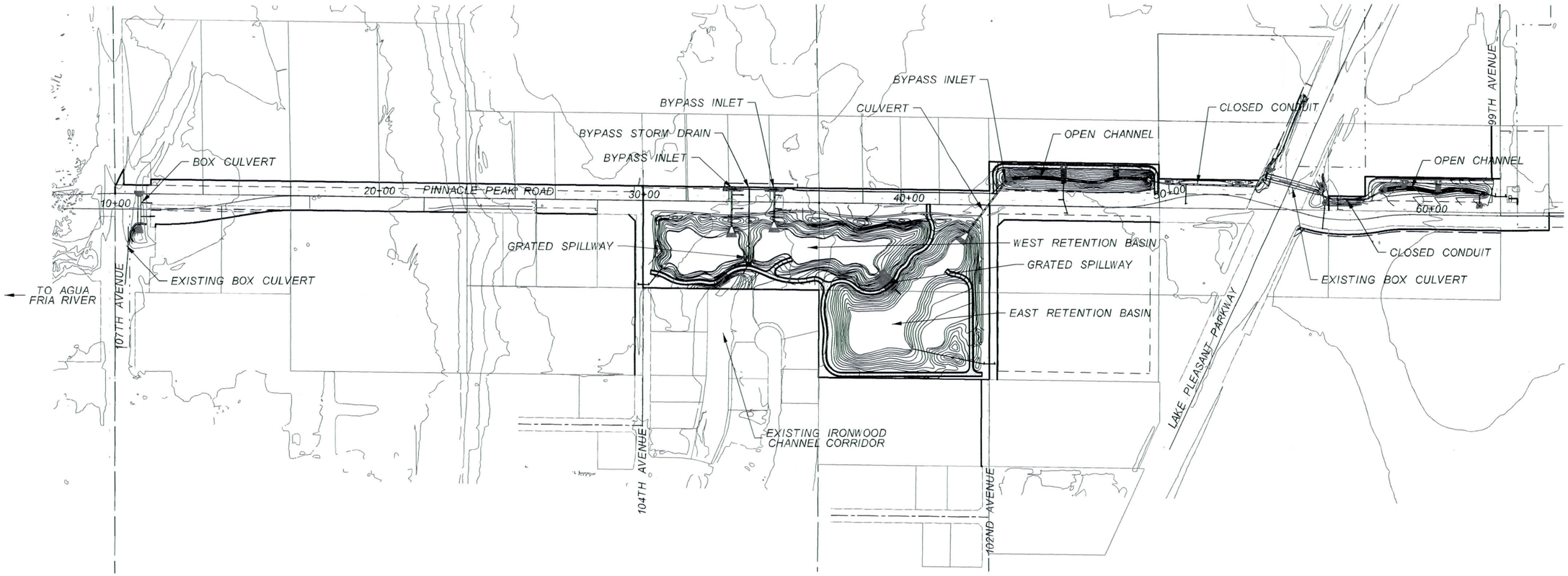
## III. STORM DRAIN AND OPEN CHANNEL HYDRAULICS

HEC-1 was used to quantify the design inflow for the storm drain system. The final hydraulic design was accomplished with HEC-RAS for the collector channel and StormCAD for the closed conduit portions of the storm drain system. The StormCAD model assumes standard values for headlosses at manholes and junctions and uses a Mannings's "n" value of 0.013 for the RGRCP. The open channel segments of the system were design with a Manning's "n" value of 0.040, a maximum velocity of 5 fps and to meet FCDMC freeboard requirements. The channel sections were also checked with a lower Manning's "n" value of 0.022 to ensure that maximum velocities were not exceeded prior to the establishment of landscaping and with a higher Manning's "n" value of 0.055 to ensure containment with excessive landscaping growth.

A detailed StormCAD pipe summary and hydraulic profile for the final design is provided with this memo.



Wood, Patel & Associates, Inc. ♦ 2051 West Northern, Suite 100 ♦ Phoenix, Arizona 85021
Phone: (602) 335-8500 ♦ Fax: (602) 335-8580
E-Mail: woodpatel@woodpatel.com




TWO WORKING DAYS BEFORE YOU DIG, CALL
263-1100
BLUE STAKE

N

200 0 200 400
Scale: Horiz: 1"=400'

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | | | |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
**ENGINEERING DIVISION**

PINNACLE PEAK ROAD DRAINAGE PROJECT
99TH AVENUE TO 104TH AVENUE
FCD NO. 2010C020

100%
PRELIMINARY NOT FOR CONSTRUCTION

| | BY | DATE |
|---|---|---|
| DESIGNED | J. TAILLON | 09/2010 |
| DRAWN | D. BURMEISTER | 09/2010 |
| CHECKED | J. MINCH | 09/2010 |

WOOD/PATEL MISSION: CLIENT SERVICE™ PHOENIX • MESA • TUCSON 2051 W. Northern Ave. Phoenix, AZ 85021 (602) 353-8500

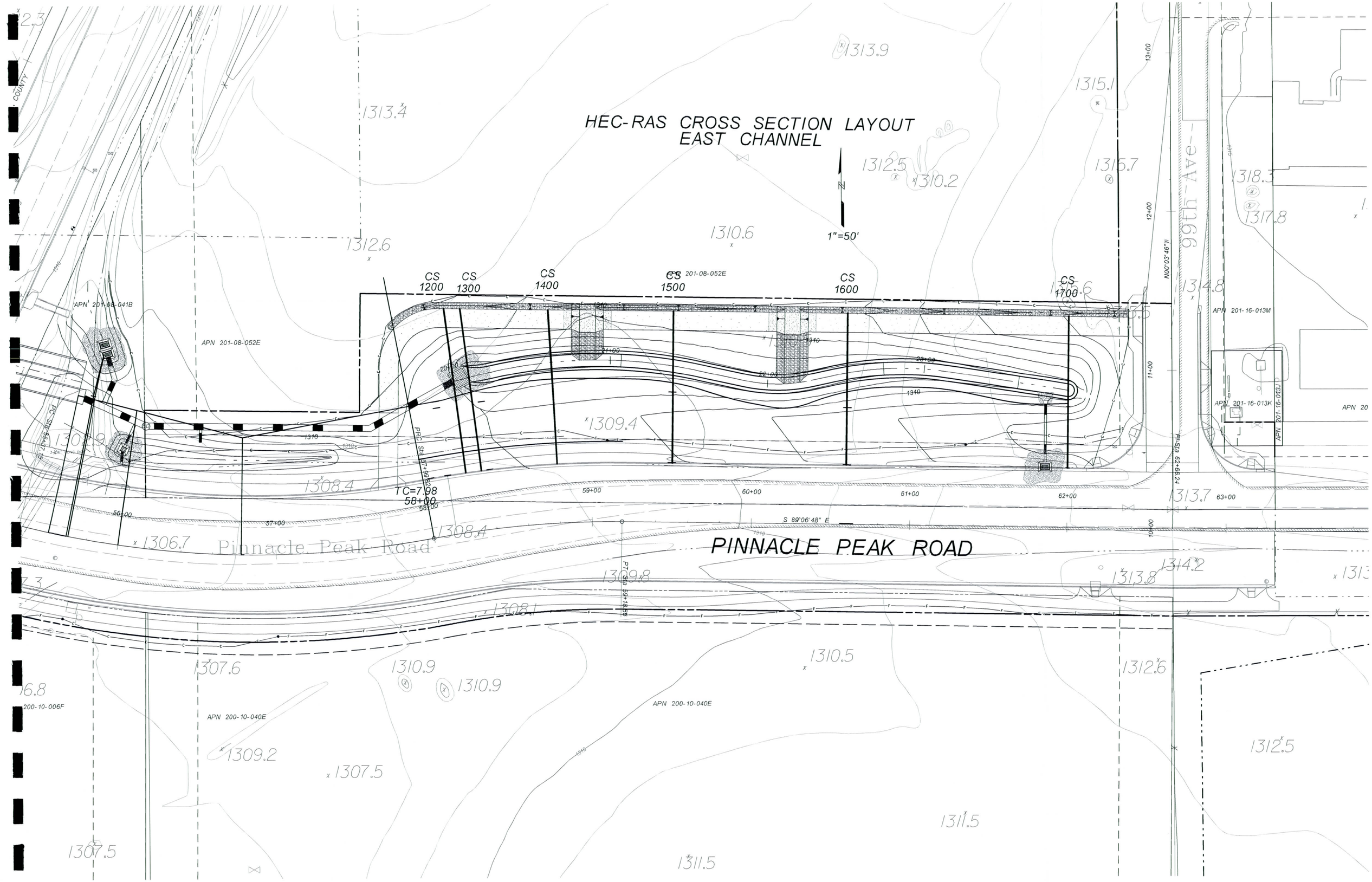
DRAWING NO. | HYDRAULIC OVERVIEW MAP | SHEET OF 89

# HEC-RAS

## East Channel

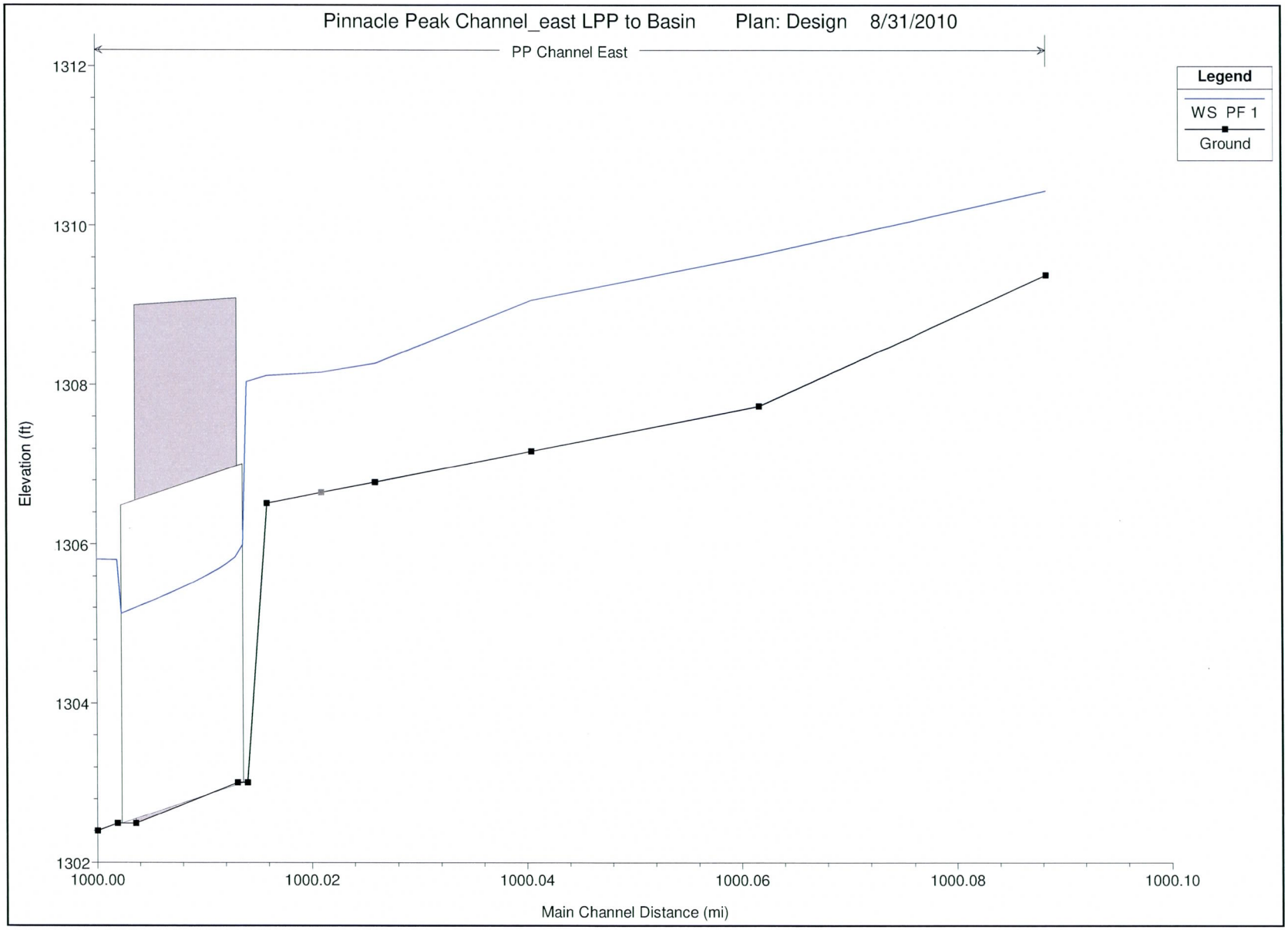
## West Channel

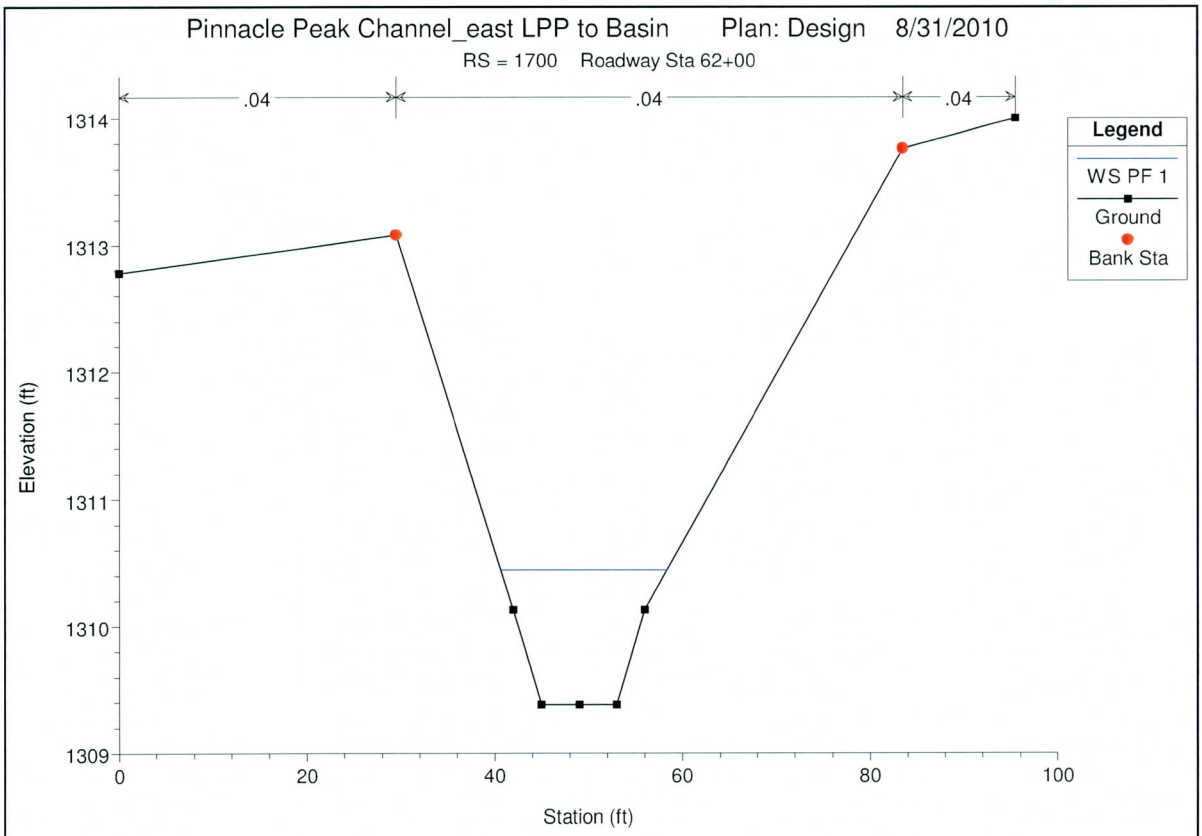
## Ironwood Wash

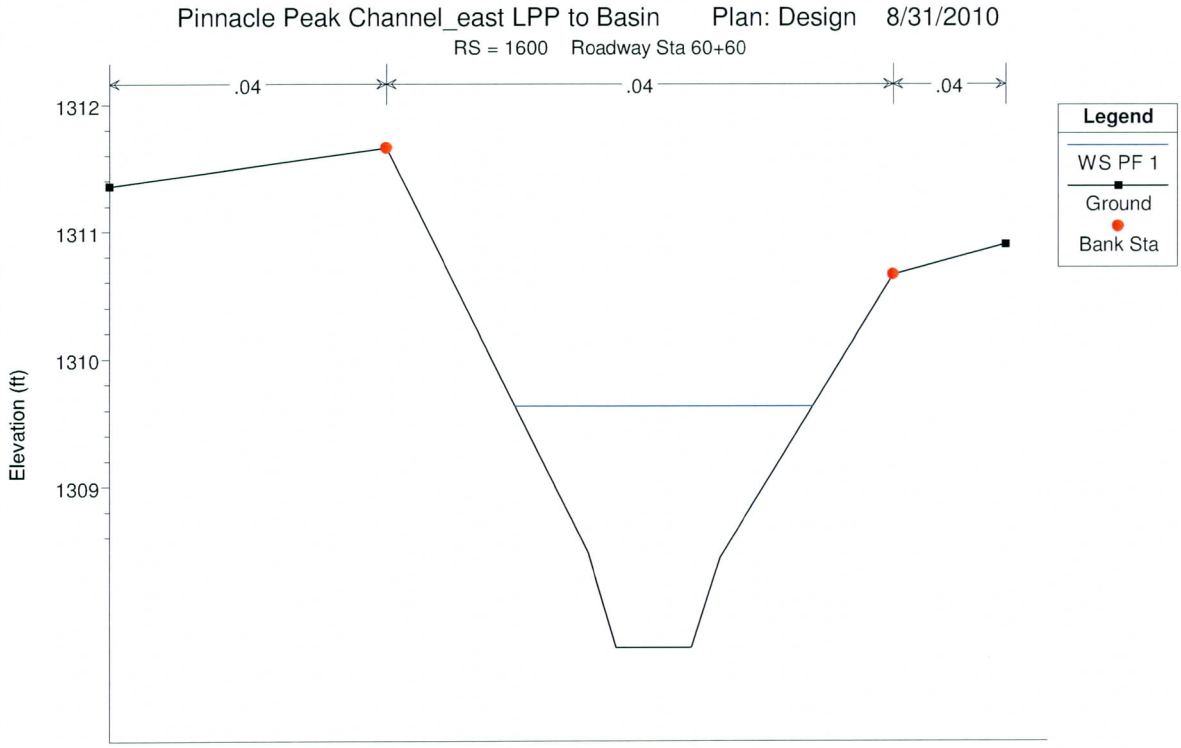

HEC-RAS CROSS SECTION LAYOUT
EAST CHANNEL
1"=50'
N
CS 1200
CS 1300
CS 1400
CS 1500
CS 1600
CS 1700
CS 201-08-052E
APN 201-08-041B
APN 201-08-052E
APN 201-16-013M
APN 201-16-013K
APN 201-16-013J
APN 200-10-040E
APN 200-10-006F
PC Sta 57+99.28
PT Sta 59+18.56
PI Sta 62+65.24
TC=7.98
58+00
S 89°06'48" E
N00°03'46"W
PINNACLE PEAK ROAD
Pinnacle Peak Road
99th Ave
56+00
57+00
58+00
59+00
60+00
61+00
62+00
63+00
10+00
11+00
12+00
13+00
1313.9
1313.4
1312.6
1315.1
1315.7
1312.5
1310.2
1310.6
1318.3
1317.8
1314.8
1309.4
1308.4
1306.7
1309.8
1308.1
1313.7
1314.2
1313.8
1307.6
1310.9
1310.5
1312.6
1309.2
1307.5
1311.5
1312.5

HEC-RAS Plan: Design River: PP Channel Reach: East Profile: PF 1

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| East | 1700 | PF 1 | 37.00 | 1309.38 | 1310.44 | 1310.14 | 1310.56 | 0.008650 | 2.81 | 13.15 | 17.66 | 0.57 |
| East | 1600 | PF 1 | 97.00 | 1307.73 | 1309.63 | | 1309.75 | 0.005037 | 2.79 | 34.81 | 31.70 | 0.47 |
| East | 1500 | PF 1 | 97.00 | 1307.17 | 1309.06 | | 1309.18 | 0.005078 | 2.71 | 35.82 | 34.29 | 0.47 |
| East | 1400 | PF 1 | 97.00 | 1306.78 | 1308.26 | | 1308.53 | 0.015487 | 4.14 | 23.42 | 27.34 | 0.79 |
| East | 1350.* | PF 1 | 97.00 | 1306.65 | 1308.15 | | 1308.27 | 0.004991 | 2.76 | 35.19 | 32.38 | 0.47 |
| East | 1300 | PF 1 | 97.00 | 1306.51 | 1308.11 | | 1308.17 | 0.002008 | 1.99 | 48.73 | 36.87 | 0.31 |
| East | 1200 | PF 1 | 97.00 | 1303.01 | 1308.03 | 1304.98 | 1308.16 | 0.000307 | 2.85 | 34.03 | 7.55 | 0.24 |
| East | 1150 | | Culvert | | | | | | | | | |
| East | 1100 | PF 1 | 97.00 | 1302.49 | 1305.81 | | 1306.10 | 0.000711 | 4.39 | 22.08 | 7.32 | 0.45 |
| East | 1000 | PF 1 | 97.00 | 1302.40 | 1305.81 | 1304.36 | 1306.09 | 0.000657 | 4.27 | 22.74 | 7.34 | 0.43 |


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
PP Channel East
Legend
WS PF 1
Ground
Elevation (ft)
1312
1310
1308
1306
1304
1302
1000.00
1000.02
1000.04
1000.06
1000.08
1000.10
Main Channel Distance (mi)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1700 Roadway Sta 62+00
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1314
1313
1312
1311
1310
1309
0
20
40
60
80
100
Station (ft)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
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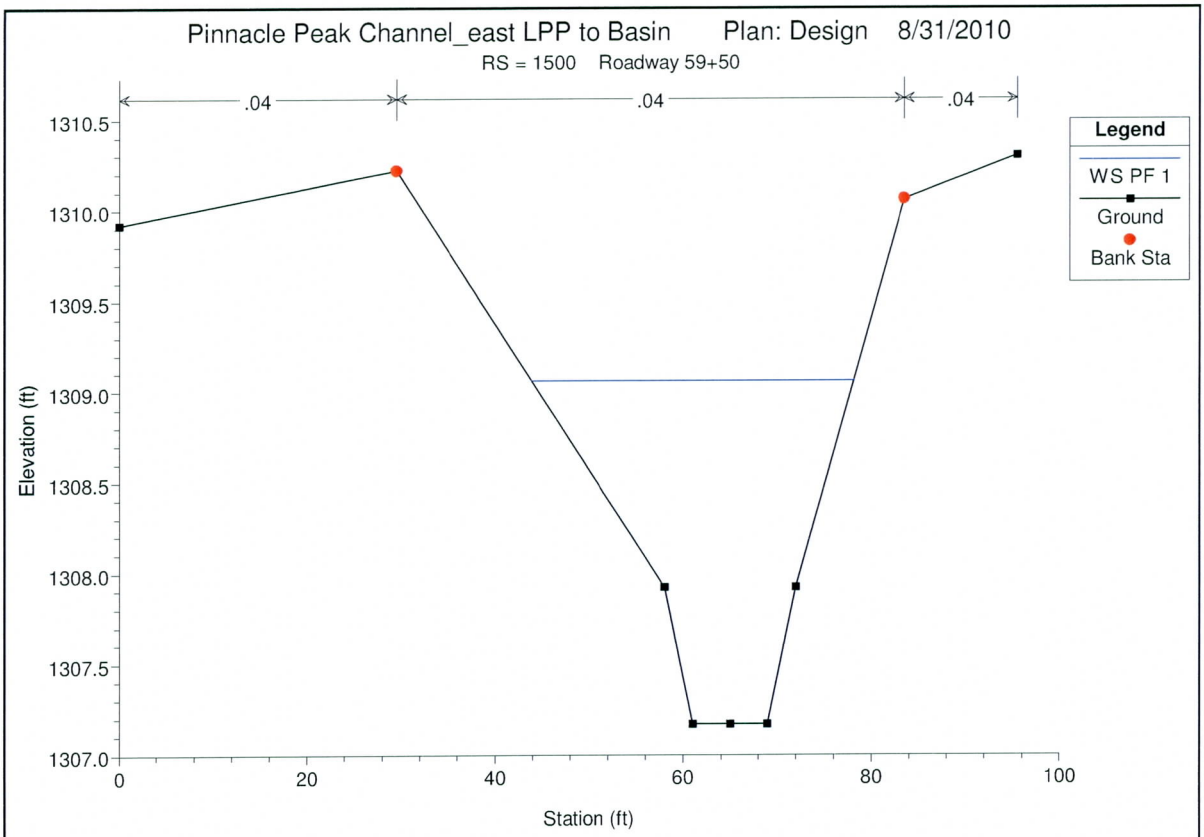
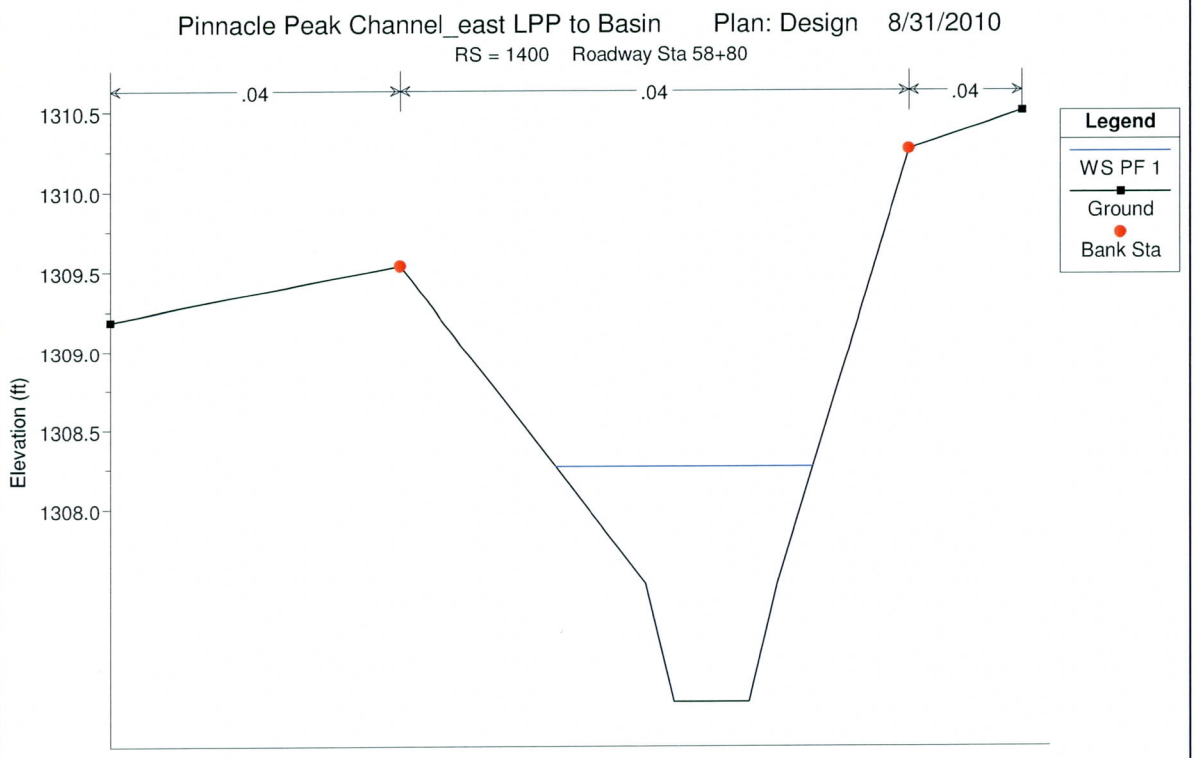
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1312
1311
1310
1309


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1500 Roadway 59+50
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1310.5
1310.0
1309.5
1309.0
1308.5
1308.0
1307.5
1307.0
0
20
40
60
80
100
Station (ft)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1400 Roadway Sta 58+80
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
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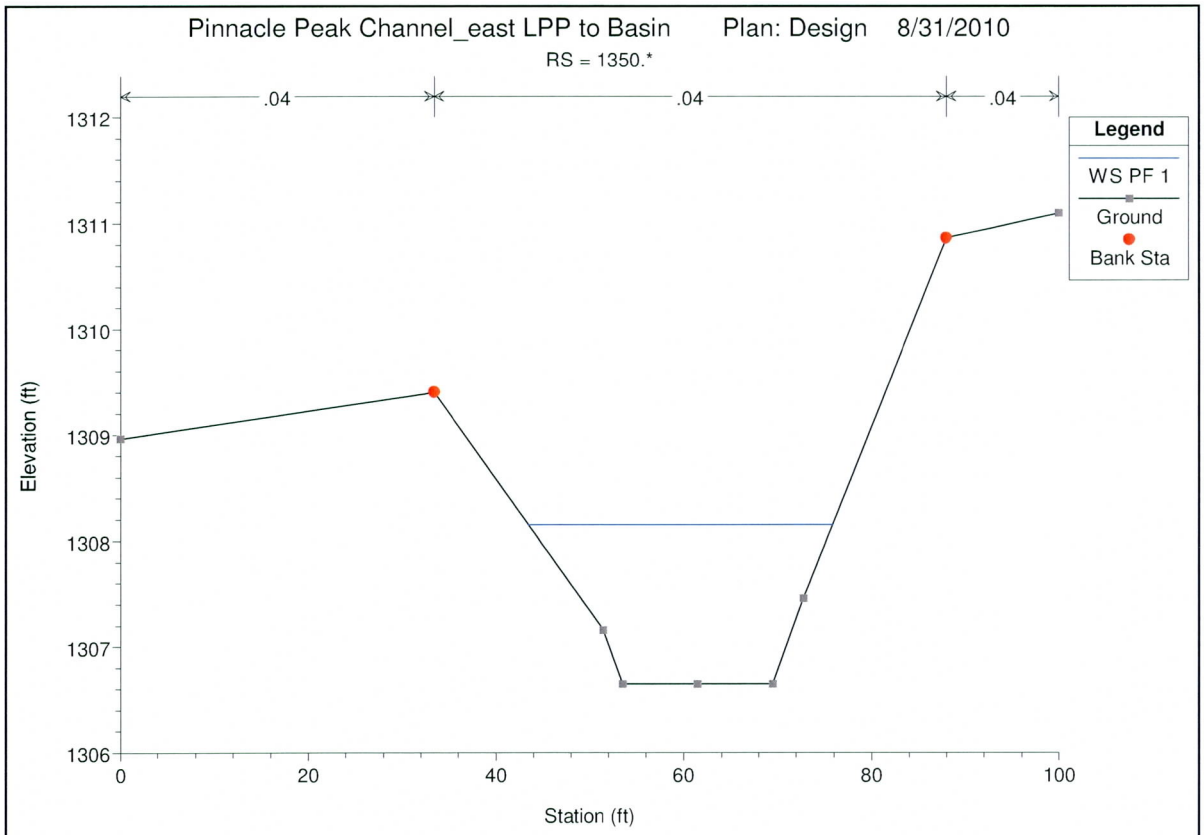
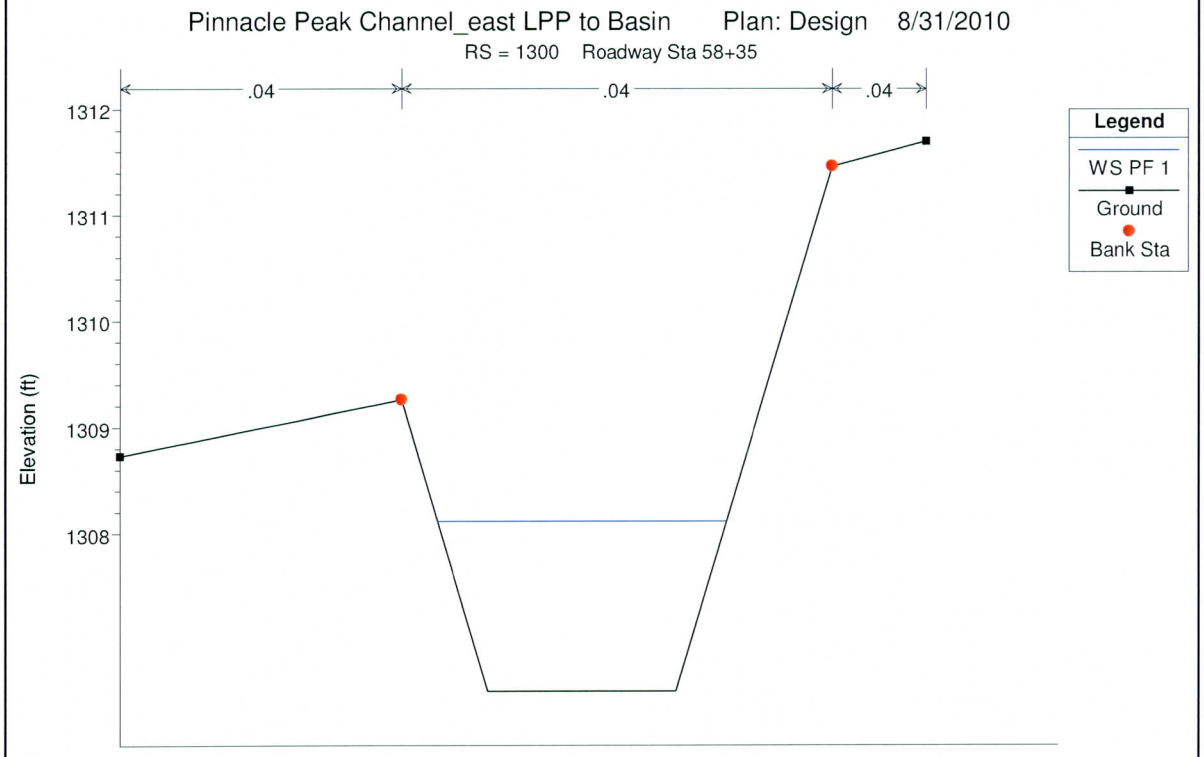
1310.0
1309.5
1309.0
1308.5
1308.0


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1350.*
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1312
1311
1310
1309
1308
1307
1306
0
20
40
60
80
100
Station (ft)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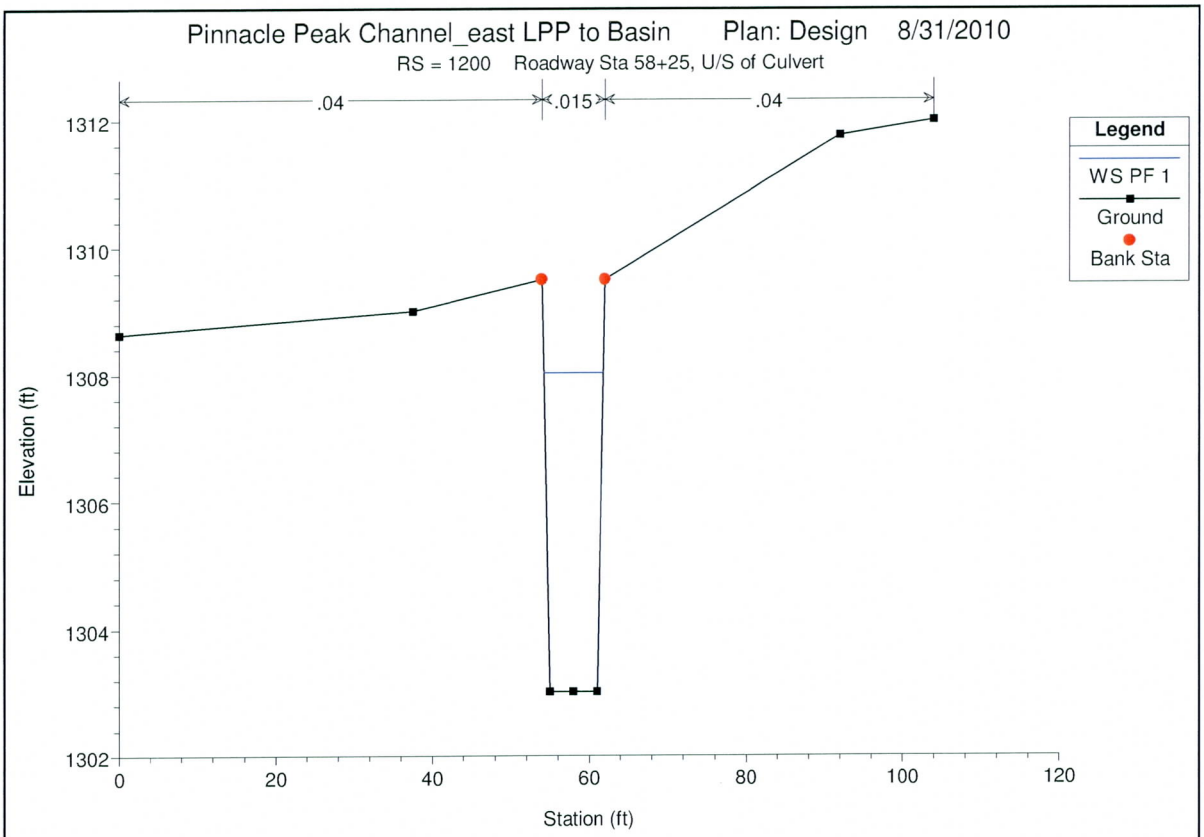
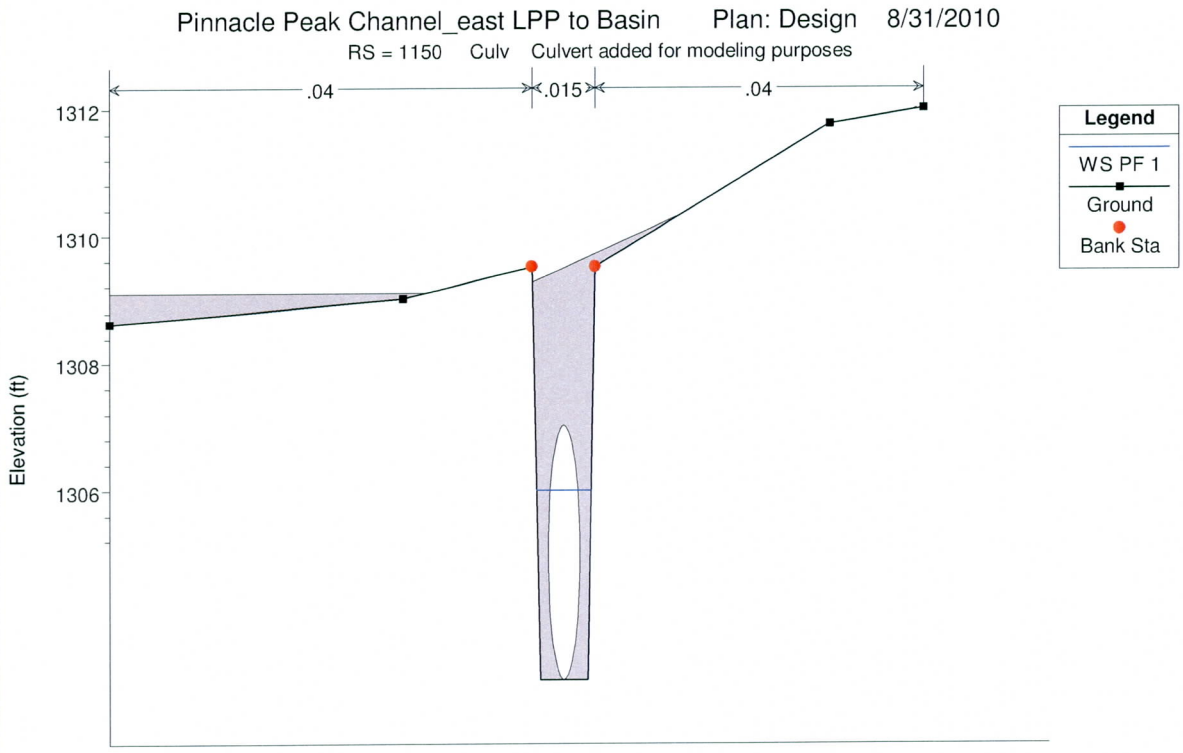
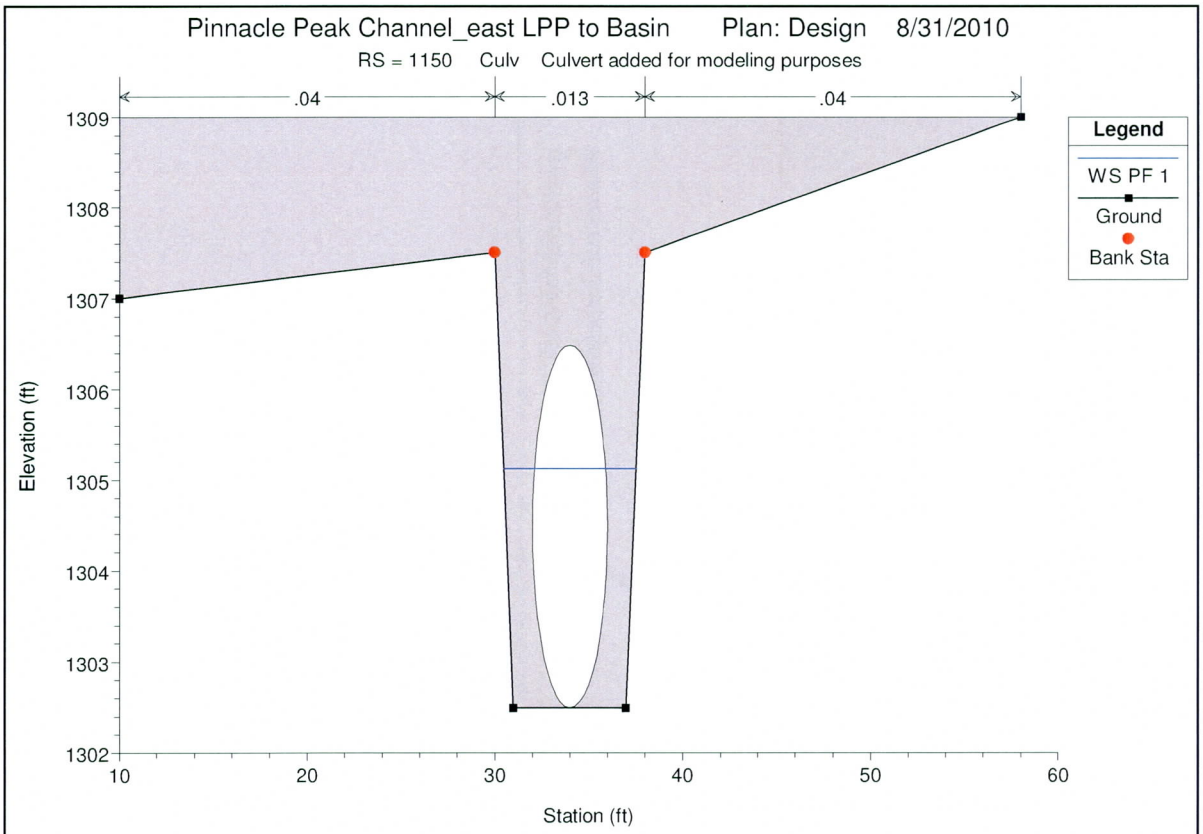
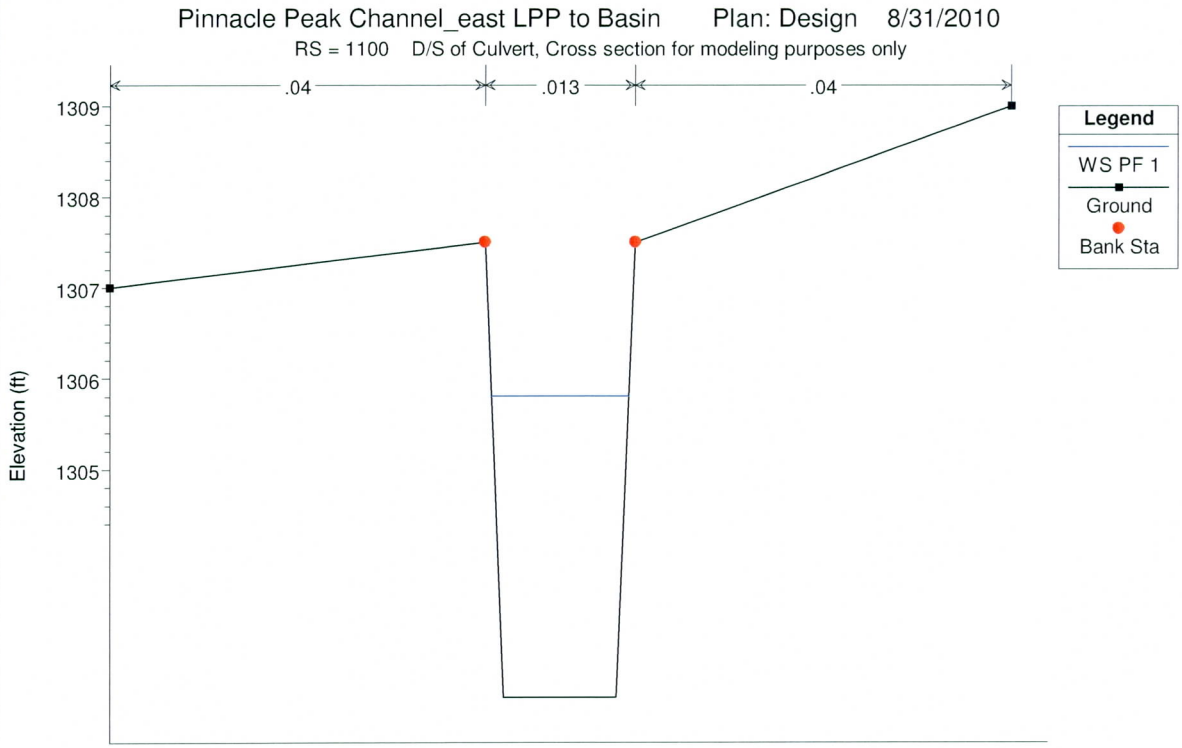
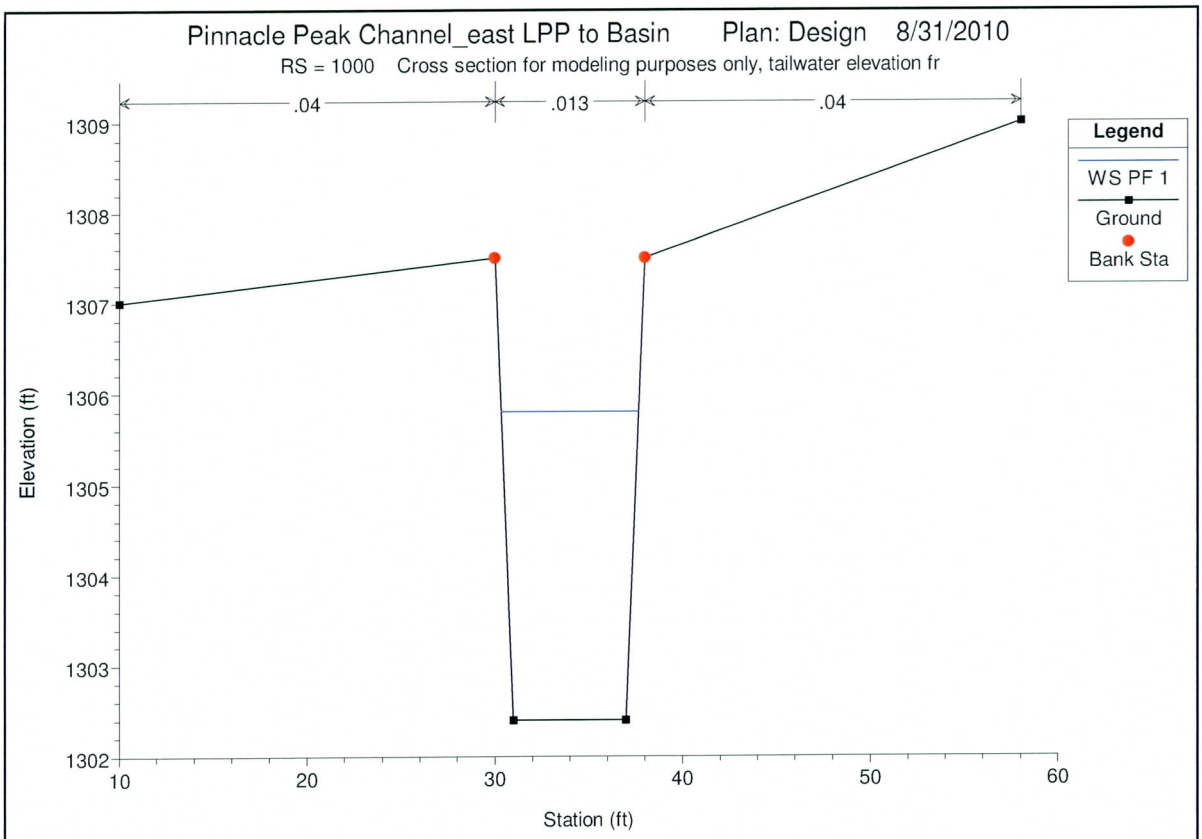
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1312
1311
1310
1309
1308

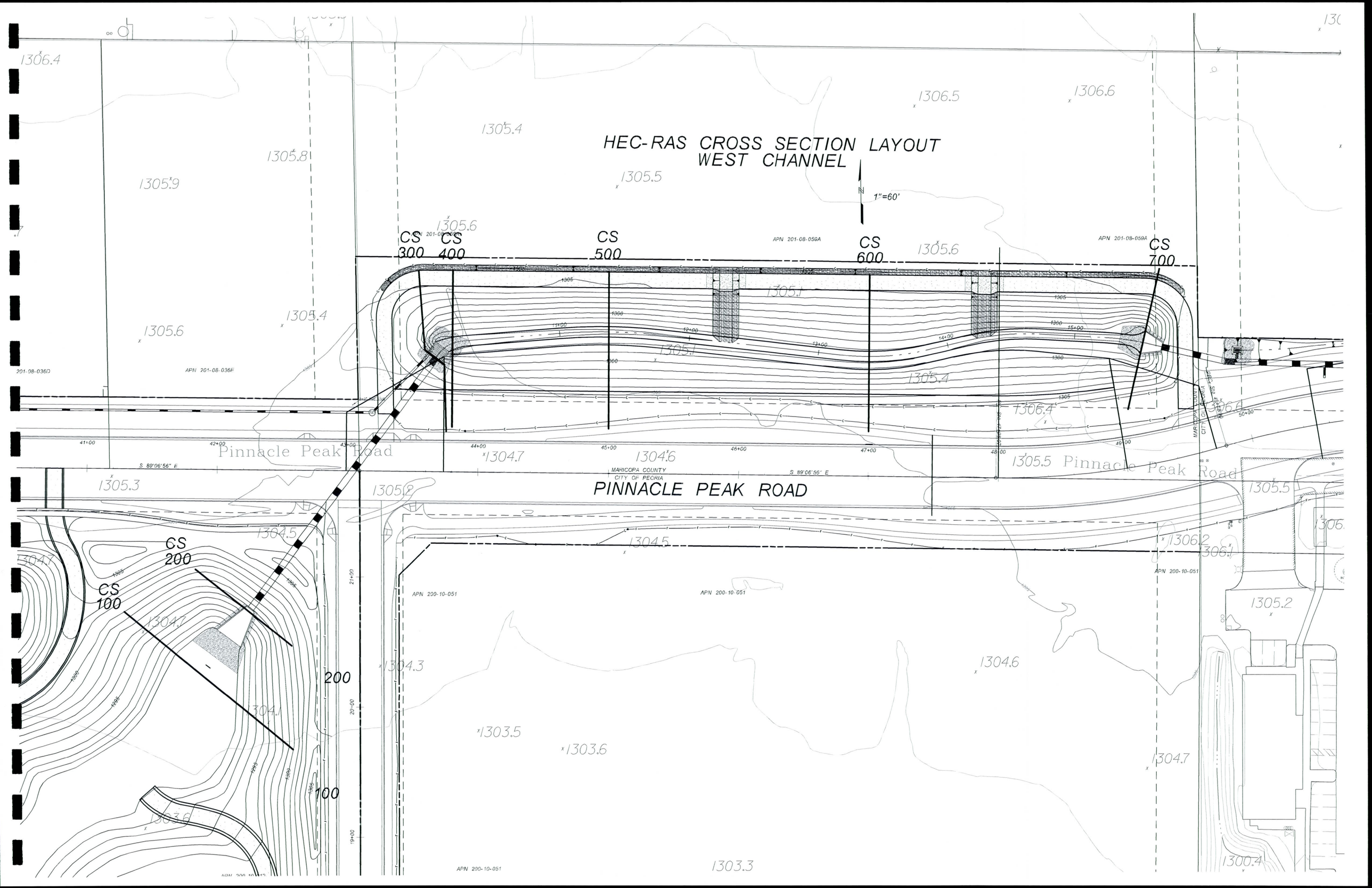

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1200 Roadway Sta 58+25, U/S of Culvert
.04
.015
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1312
1310
1308
1306
1304
1302
0
20
40
60
80
100
120
Station (ft)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1150 Culv Culvert added for modeling purposes
.04
.015
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1312
1310
1308
1306


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1150 Culv Culvert added for modeling purposes
.04
.013
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1309
1308
1307
1306
1305
1304
1303
1302
10
20
30
40
50
60
Station (ft)

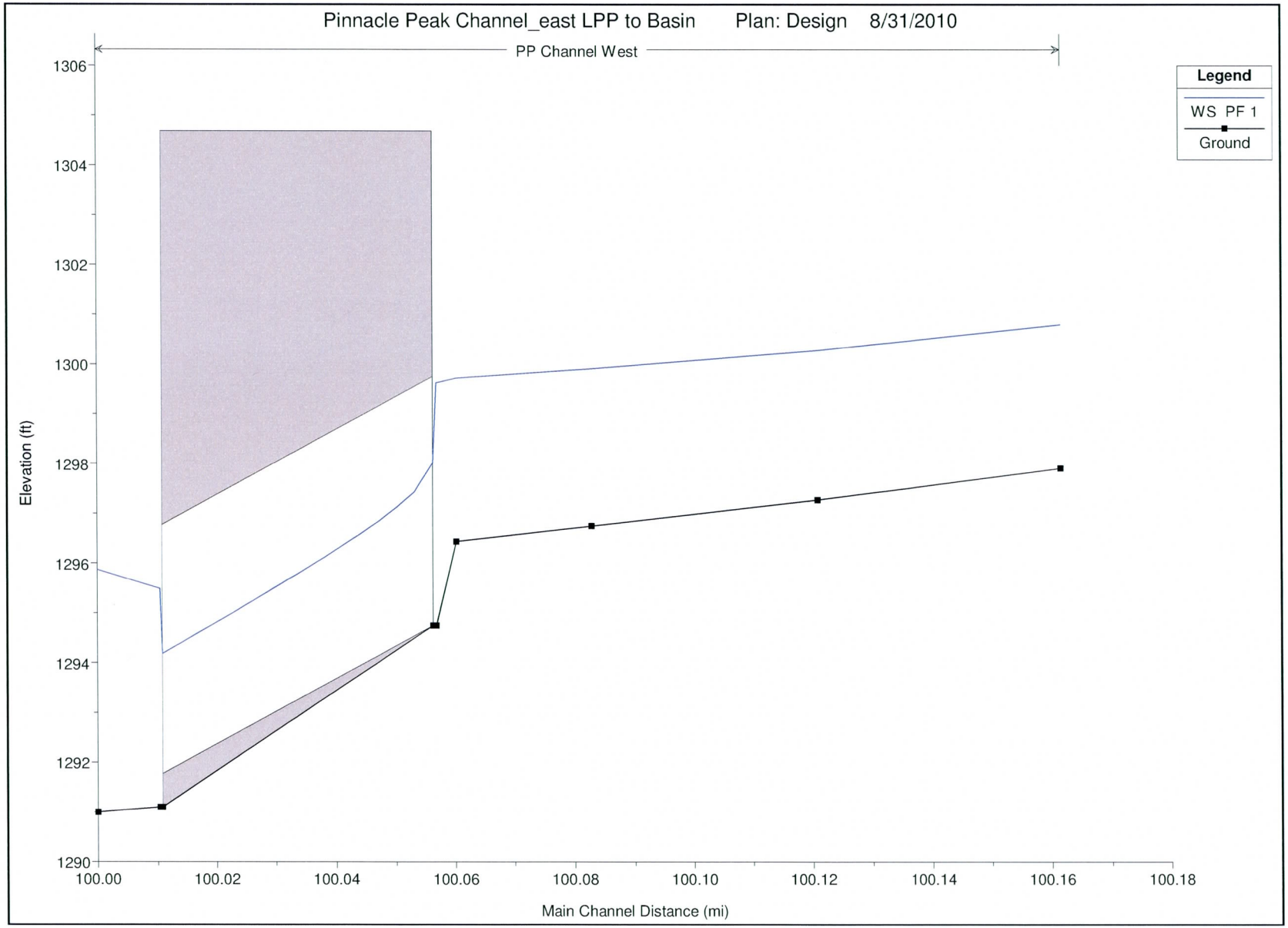

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1100 D/S of Culvert, Cross section for modeling purposes only
.04
.013
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1309
1308
1307
1306
1305

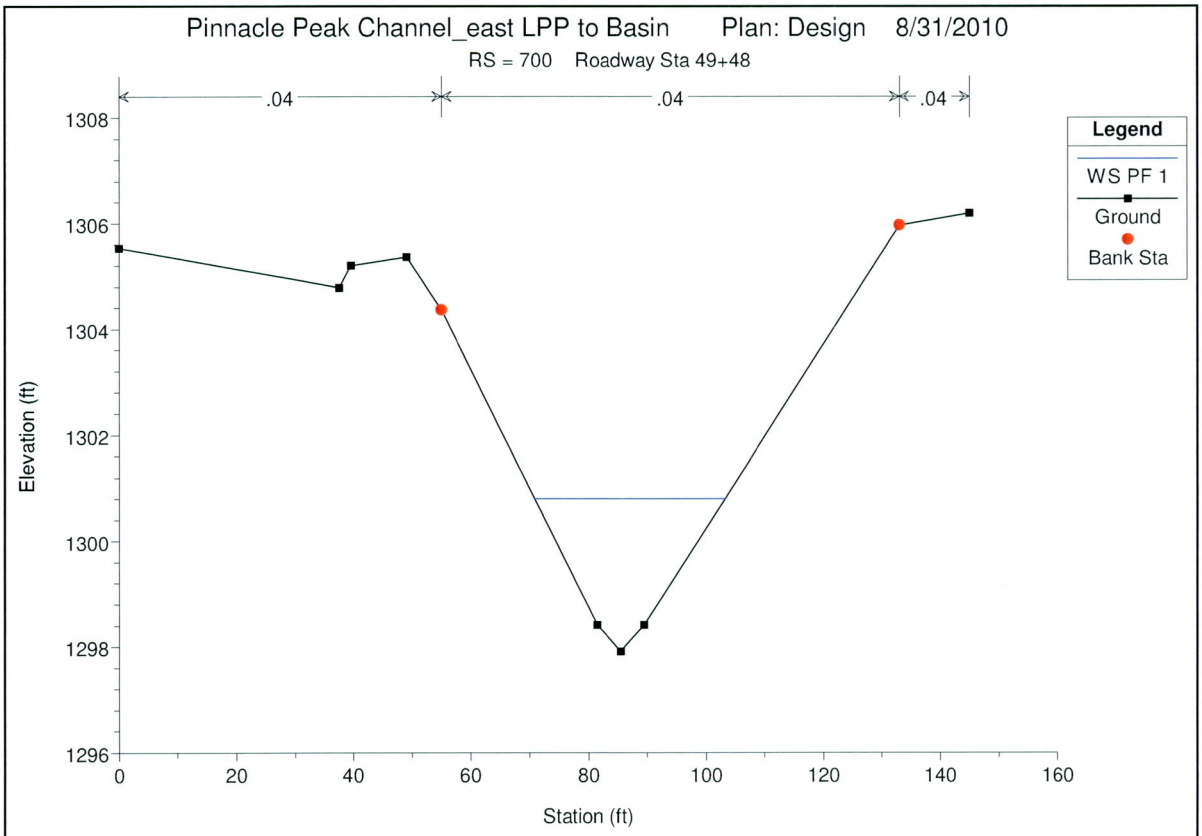

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 1000 Cross section for modeling purposes only, tailwater elevation fr
.04
.013
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1309
1308
1307
1306
1305
1304
1303
1302
10
20
30
40
50
60
Station (ft)

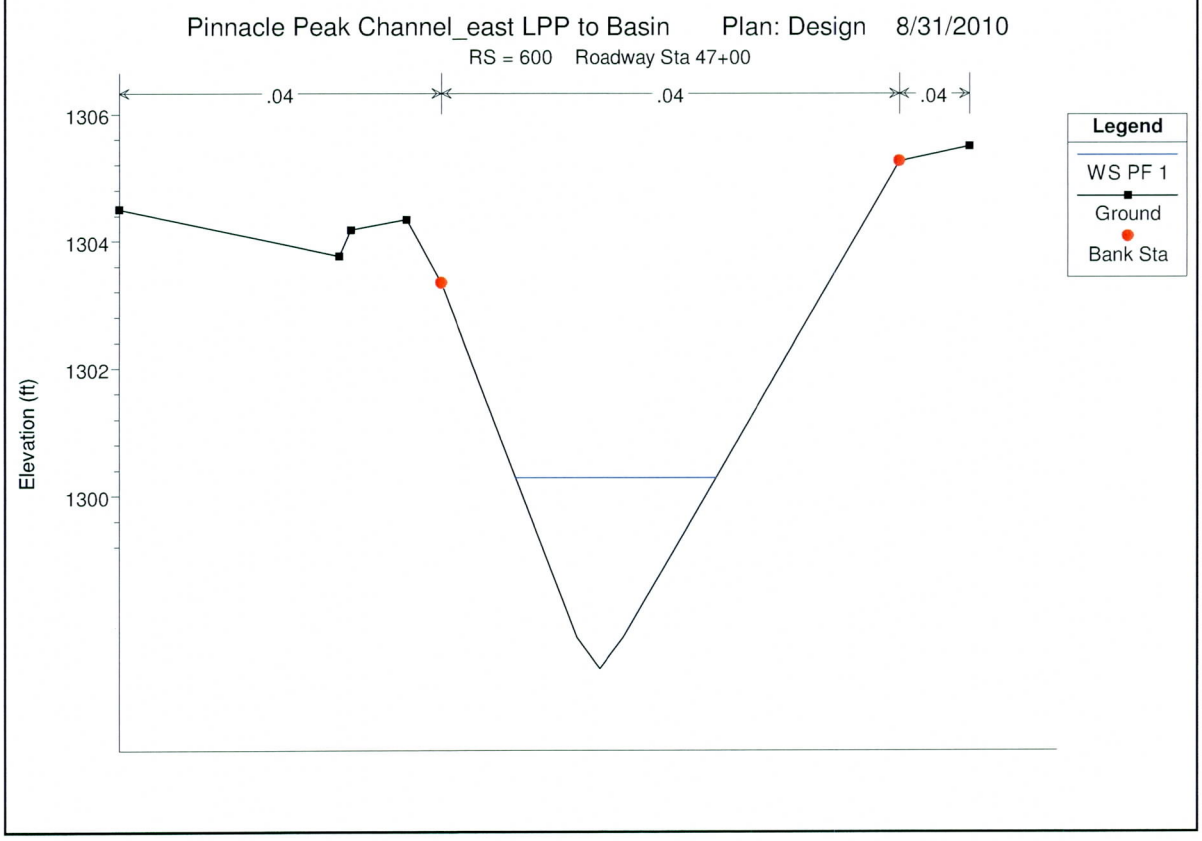

HEC-RAS CROSS SECTION LAYOUT
WEST CHANNEL
1"=60'
N
CS 300
CS 400
CS 500
CS 600
CS 700
CS 200
CS 100
200
100
APN 201-08-059A
APN 201-08-036D
APN 201-08-036F
APN 200-10-051
Pinnacle Peak Road
PINNACLE PEAK ROAD
S 89°06'56" E
MARICOPA COUNTY
CITY OF PEORIA
41+00
42+00
43+00
44+00
45+00
46+00
47+00
48+00
49+00
50+00
11+00
12+00
13+00
14+00
15+00
19+00
20+00
21+00
1305.3
1305.2
1304.5
1304.7
1304.1
1303.6
1304.3
1303.5
1303.6
1304.6
1303.3
1300.4
1305.5
1306.2
1306.1
1305.2
1305.5
1306.4
1305.5
1305.1
1305.4
1306.5
1306.6
1305.4
1305.8
1305.9
1305.6
1305.6
1305.6
1305.4
1306.4
1304.7
1304.6
1305.5

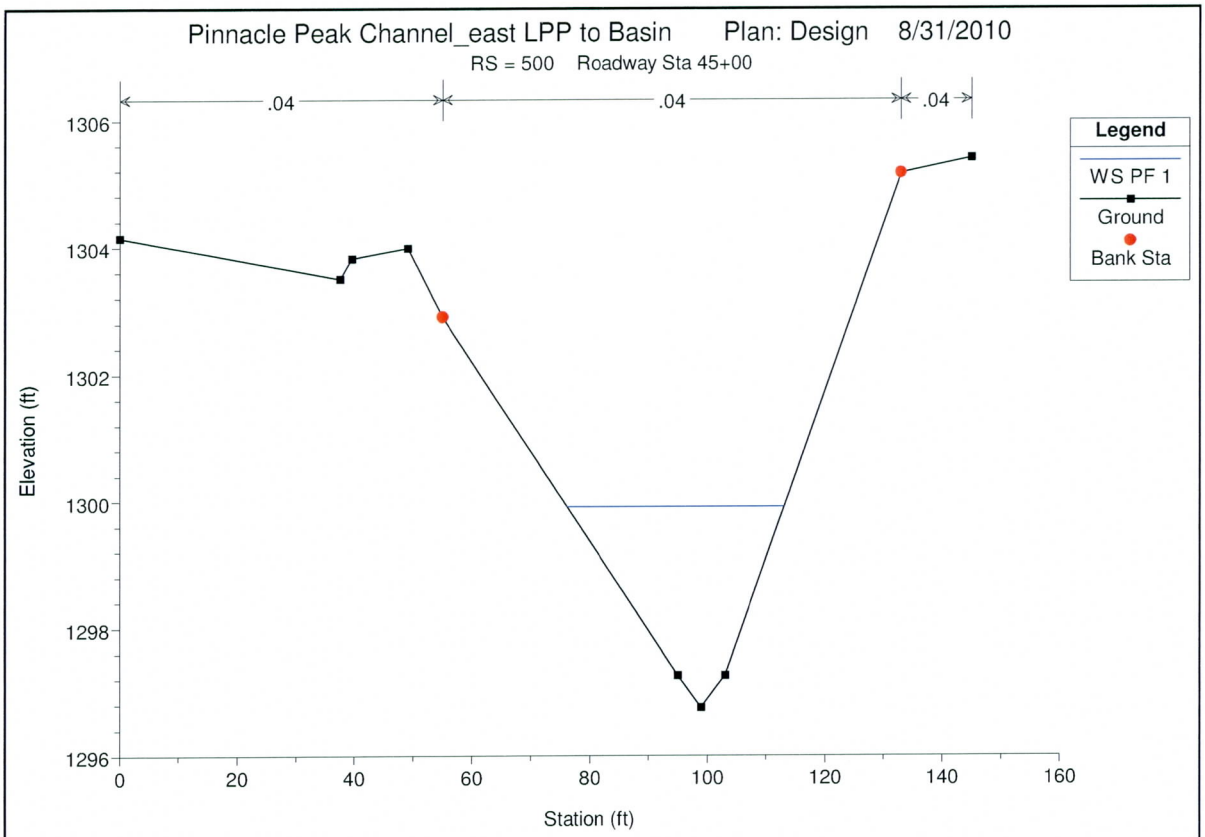
HEC-RAS Plan: Design River: PP Channel Reach: West Profile: PF 1

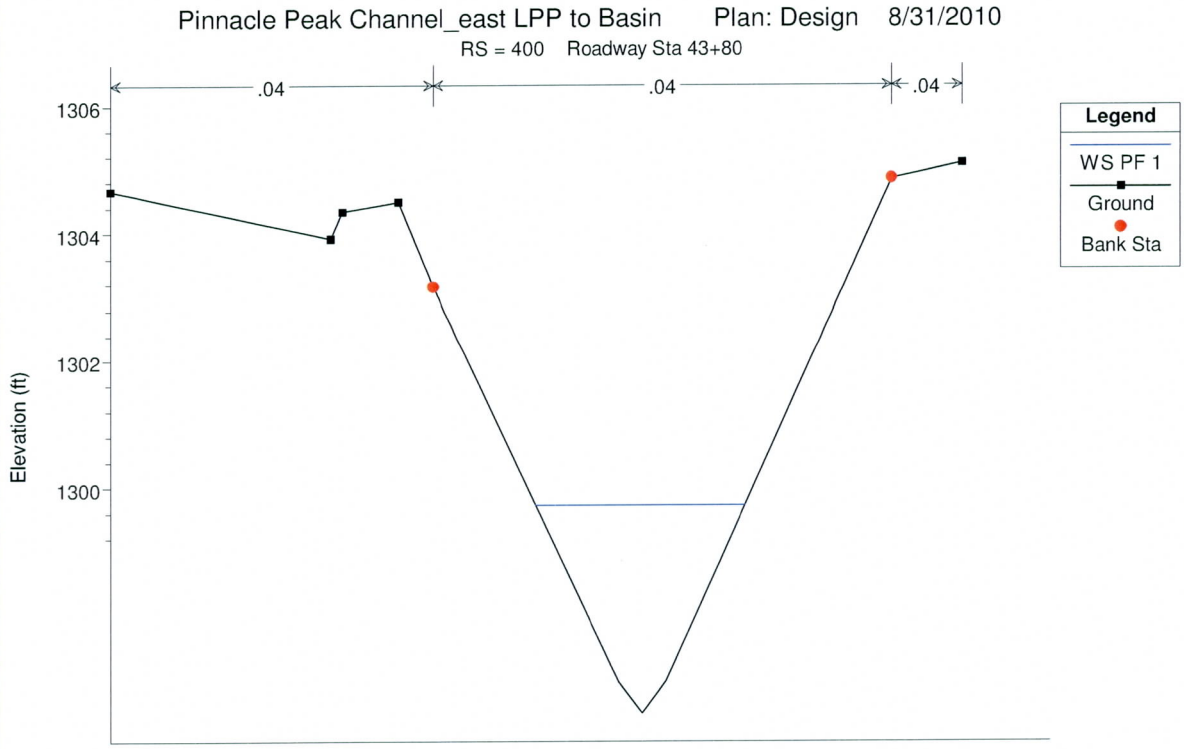
| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| West | 700 | PF 1 | 131.00 | 1297.91 | 1300.81 | 1299.78 | 1300.91 | 0.002772 | 2.60 | 50.46 | 32.47 | 0.37 |
| West | 600 | PF 1 | 131.00 | 1297.27 | 1300.28 | | 1300.37 | 0.002226 | 2.38 | 55.00 | 34.16 | 0.33 |
| West | 500 | PF 1 | 131.00 | 1296.75 | 1299.91 | | 1299.98 | 0.001668 | 2.12 | 61.88 | 36.96 | 0.29 |
| West | 400 | PF 1 | 131.00 | 1296.44 | 1299.72 | | 1299.79 | 0.001521 | 2.09 | 62.74 | 35.63 | 0.28 |
| West | 300 | PF 1 | 131.00 | 1294.75 | 1299.62 | 1296.75 | 1299.77 | 0.000310 | 3.10 | 42.27 | 9.34 | 0.26 |
| West | 250 | | Culvert | | | | | | | | | |
| West | 200 | PF 1 | 131.00 | 1291.10 | 1295.49 | | 1296.04 | 0.003590 | 5.97 | 21.95 | 46.14 | 0.50 |
| West | 100 | PF 1 | 131.00 | 1291.00 | 1295.87 | 1291.56 | 1295.87 | 0.000021 | 0.49 | 267.85 | 117.98 | 0.04 |

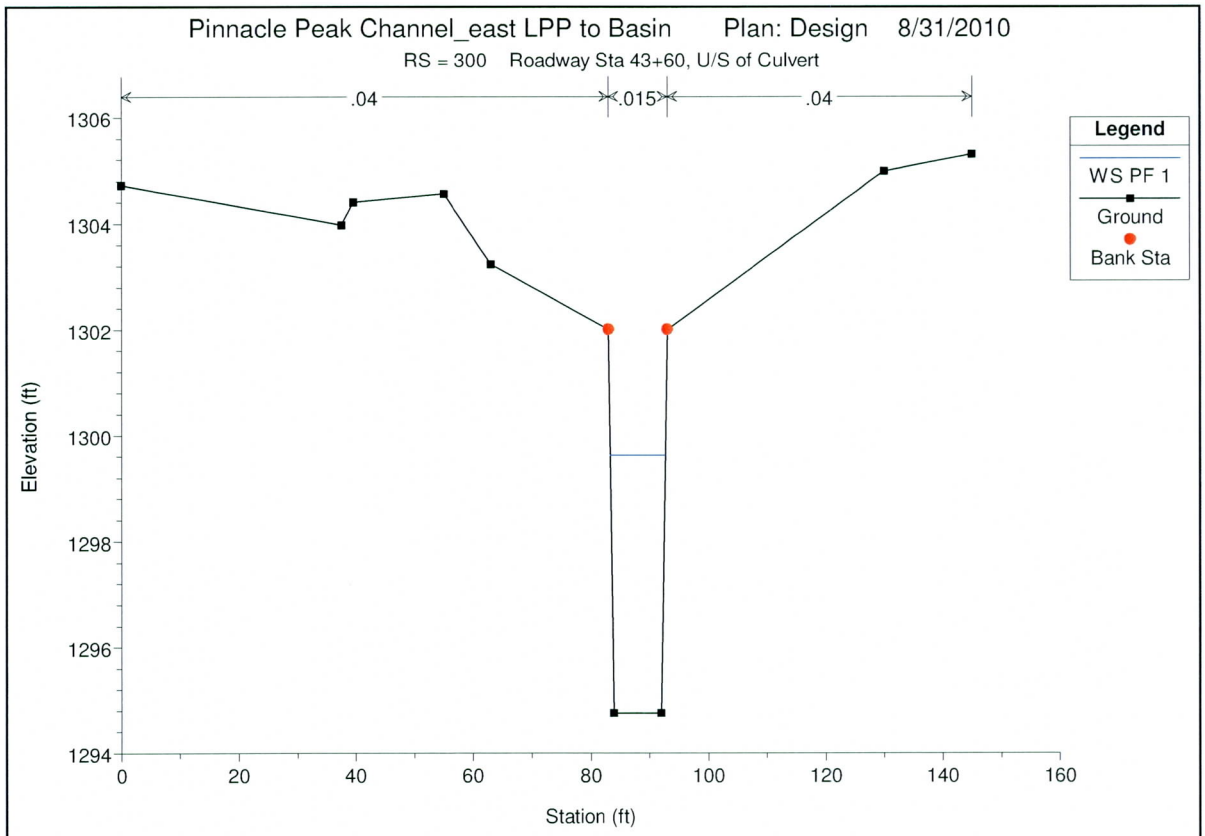

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
PP Channel West
Legend
WS PF 1
Ground
Elevation (ft)
1306
1304
1302
1300
1298
1296
1294
1292
1290
100.00
100.02
100.04
100.06
100.08
100.10
100.12
100.14
100.16
100.18
Main Channel Distance (mi)

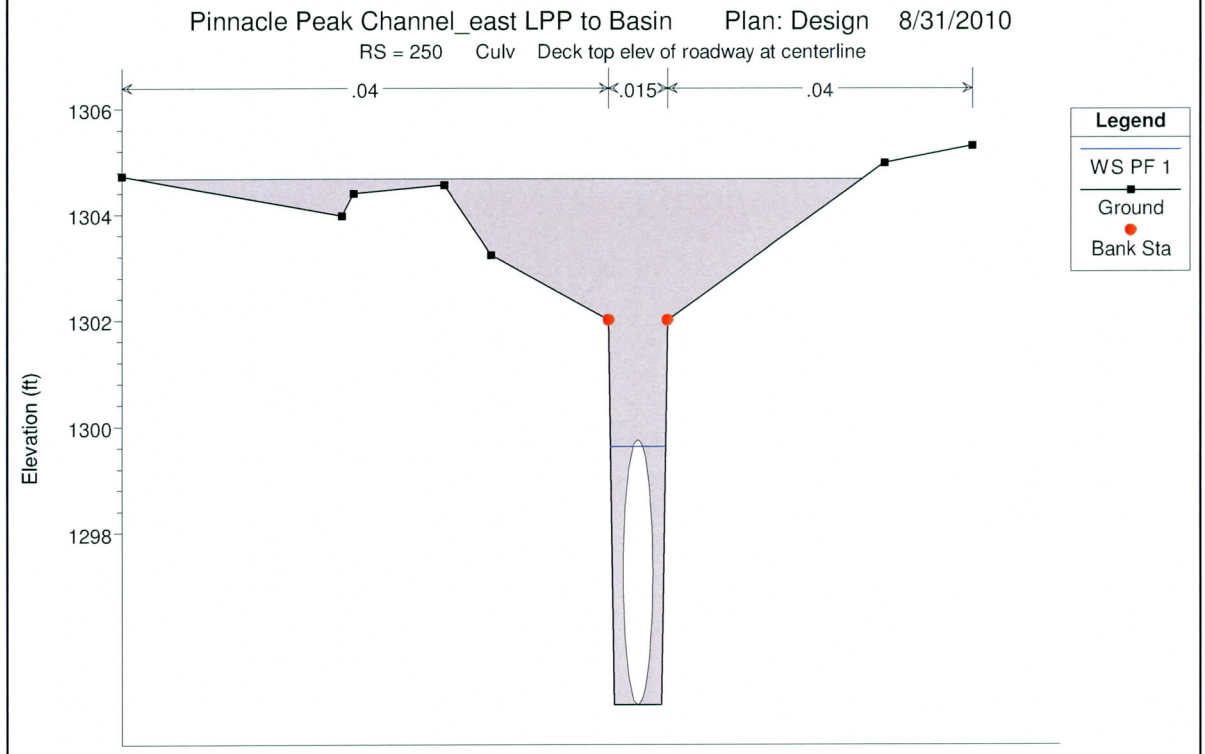

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 700 Roadway Sta 49+48
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1308
1306
1304
1302
1300
1298
1296
0
20
40
60
80
100
120
140
160
Station (ft)

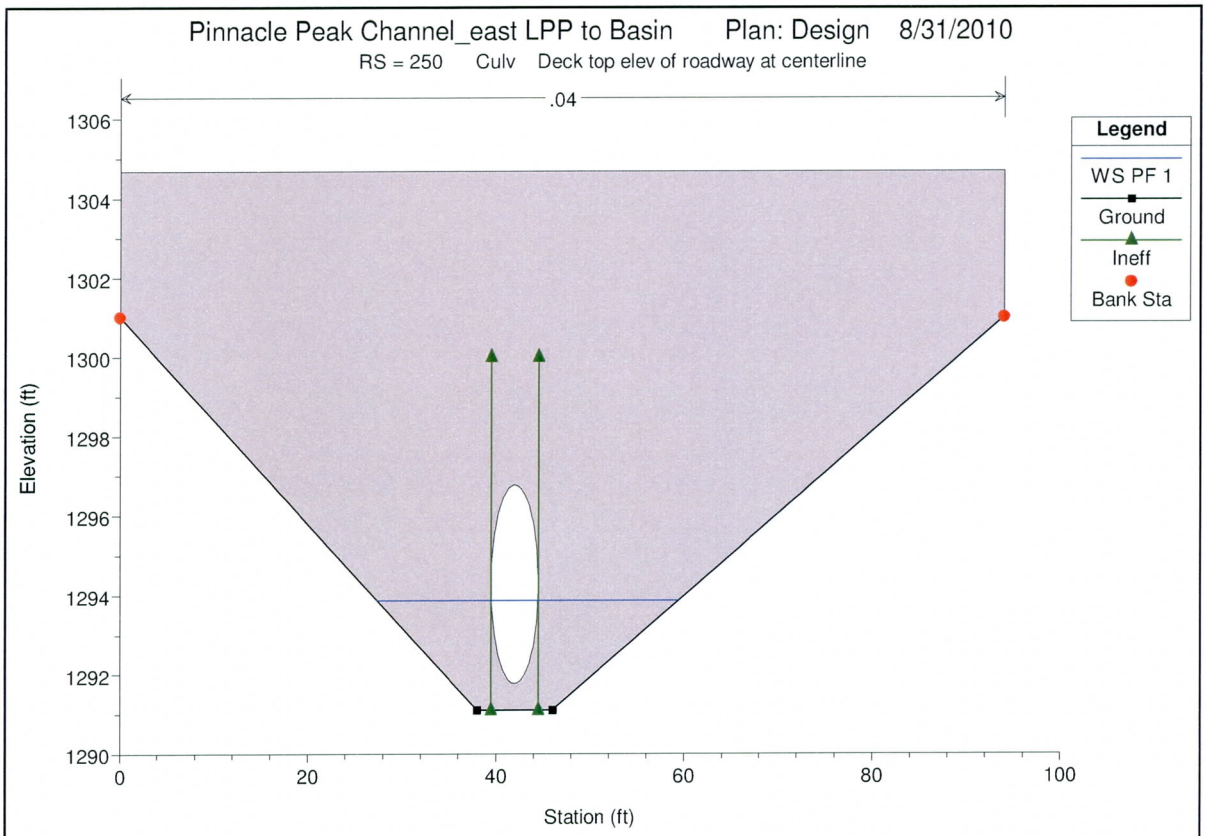

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 600 Roadway Sta 47+00
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300

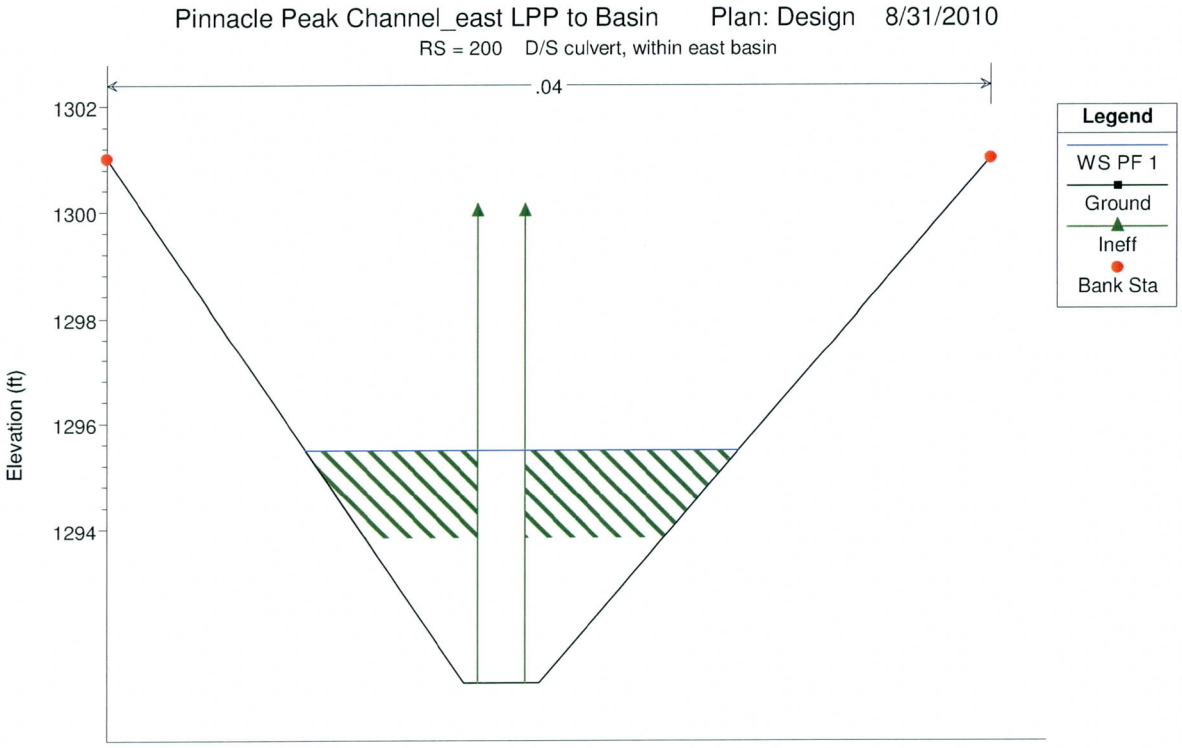

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 500 Roadway Sta 45+00
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300
1298
1296
0
20
40
60
80
100
120
140
160
Station (ft)

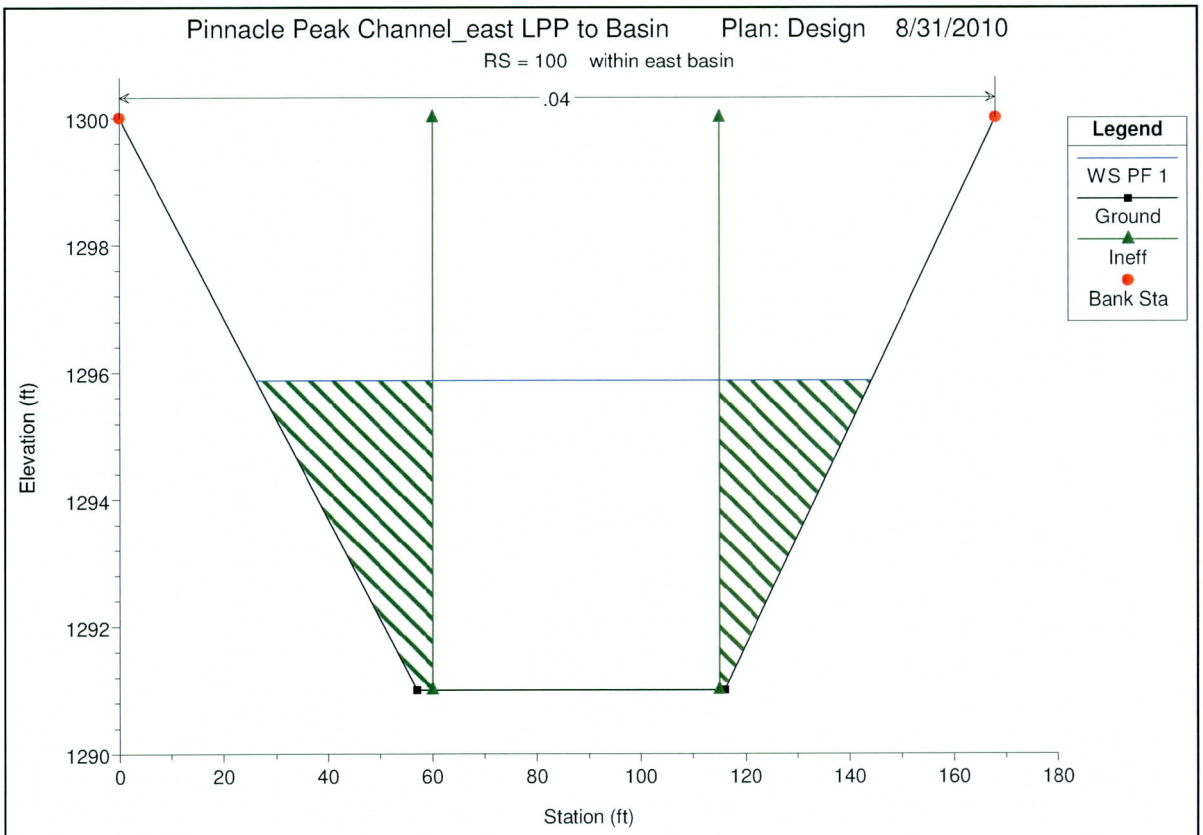

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 400 Roadway Sta 43+80
.04
.04
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300

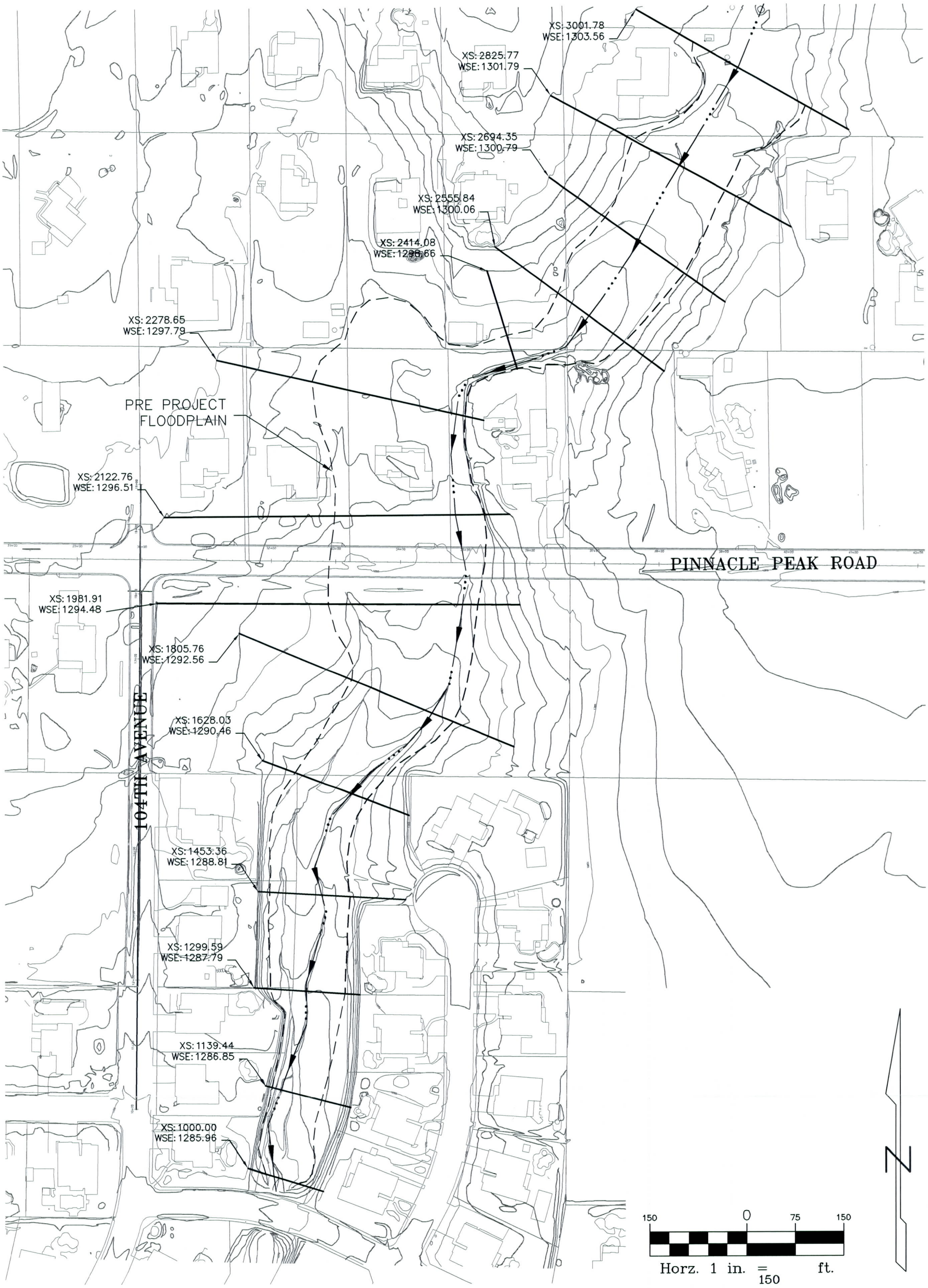

Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 300 Roadway Sta 43+60, U/S of Culvert
.04
.015
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300
1298
1296
1294
0
20
40
60
80
100
120
140
160
Station (ft)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 250 Culv Deck top elev of roadway at centerline
.04
.015
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300
1298


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 250 Culv Deck top elev of roadway at centerline
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1306
1304
1302
1300
1298
1296
1294
1292
1290
0
20
40
60
80
100
Station (ft)


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 200 D/S culvert, within east basin
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1302
1300
1298
1296
1294


Pinnacle Peak Channel_east LPP to Basin Plan: Design 8/31/2010
RS = 100 within east basin
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1300
1298
1296
1294
1292
1290
0
20
40
60
80
100
120
140
160
180
Station (ft)




# PINNACLE PEAK ROAD
# IRONWOOD WASH

PRE PROJECT
HEC-RAS
SCHEMATIC

**WOOD/PATEL**

LAND DEVELOPMENT • WATER RESOURCES
TRANSPORTATION / TRAFFIC
WATER / WASTEWATER • SURVEYING
CONSTRUCTION MANAGEMENT

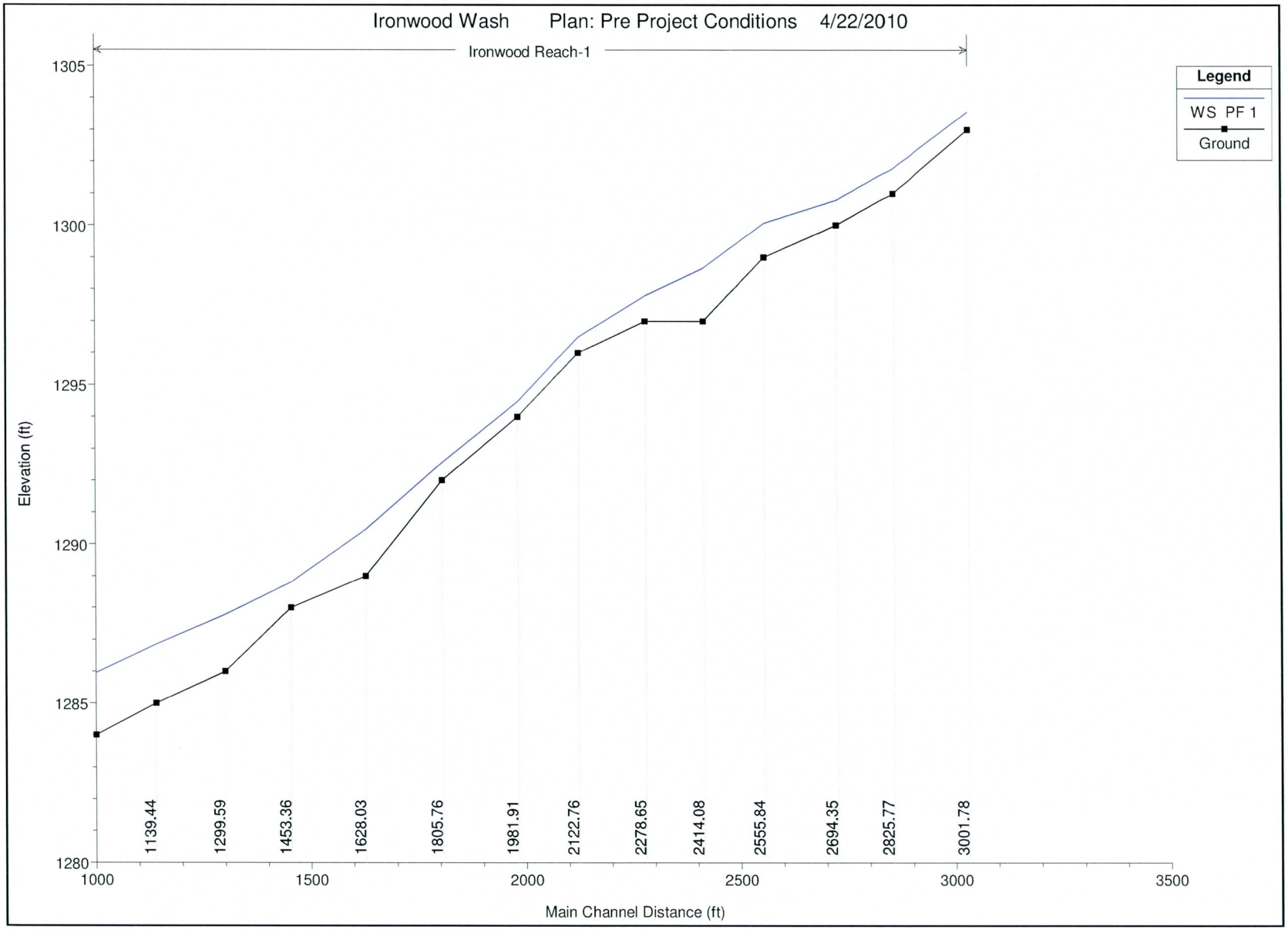
(602) 335-8500

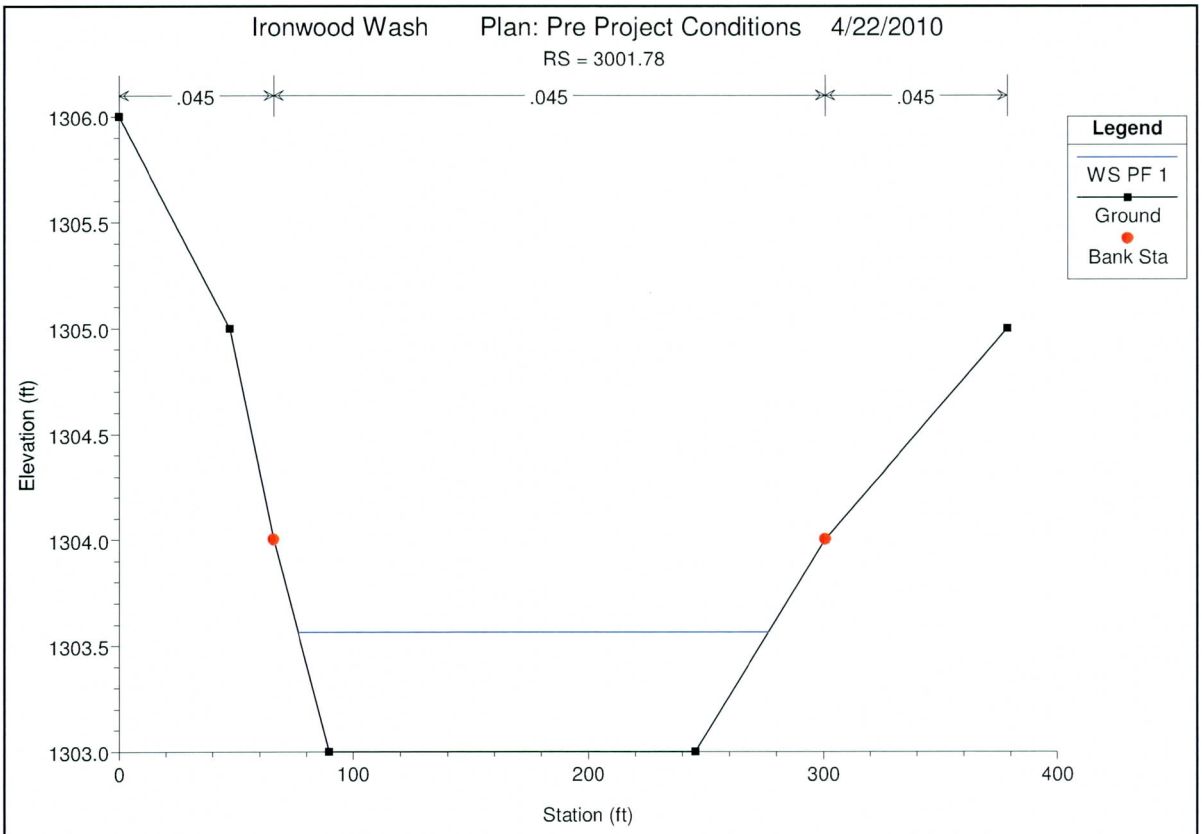
PHOENIX • MESA • TUCSON

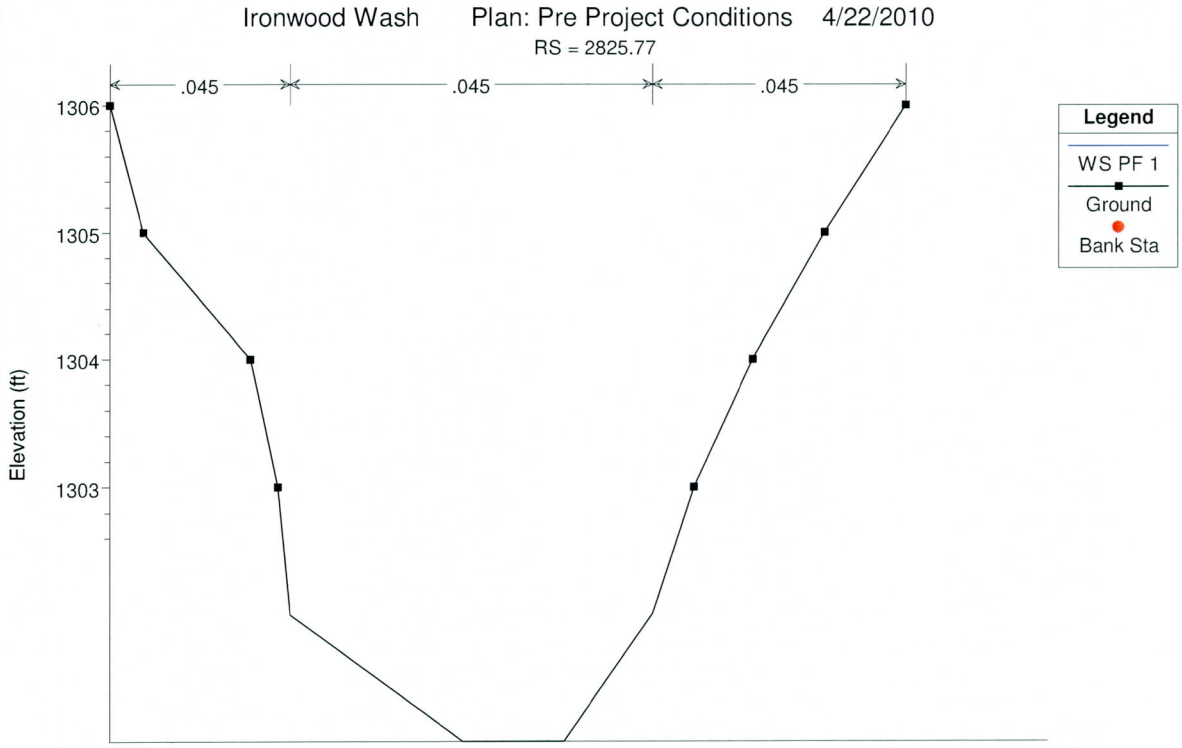
W:\2009 Projects\093386 - Pinnacle Peak Road and Channel\Project Support\Hydro\Exhibits\ Wash Crossings.dwg

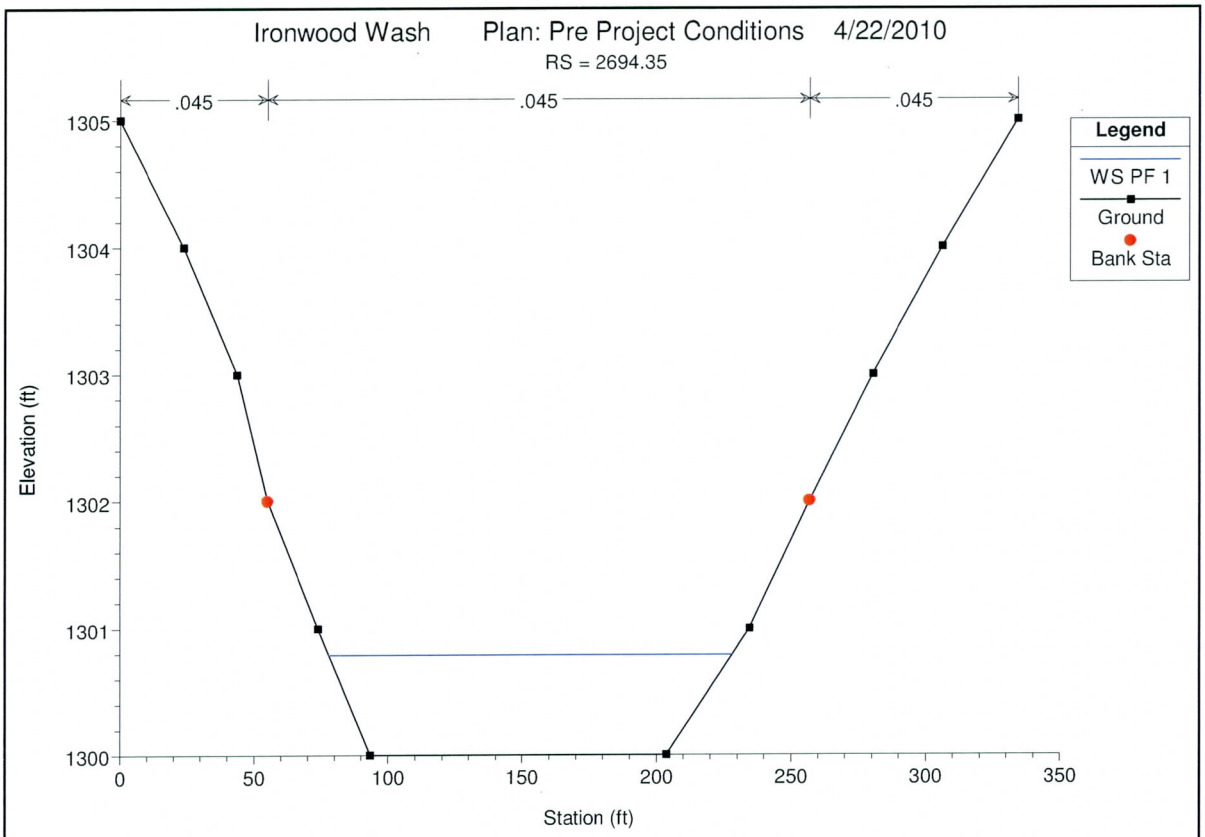
HEC-RAS Plan: PreProject River: Ironwood Reach: Reach-1 Profile: PF 1

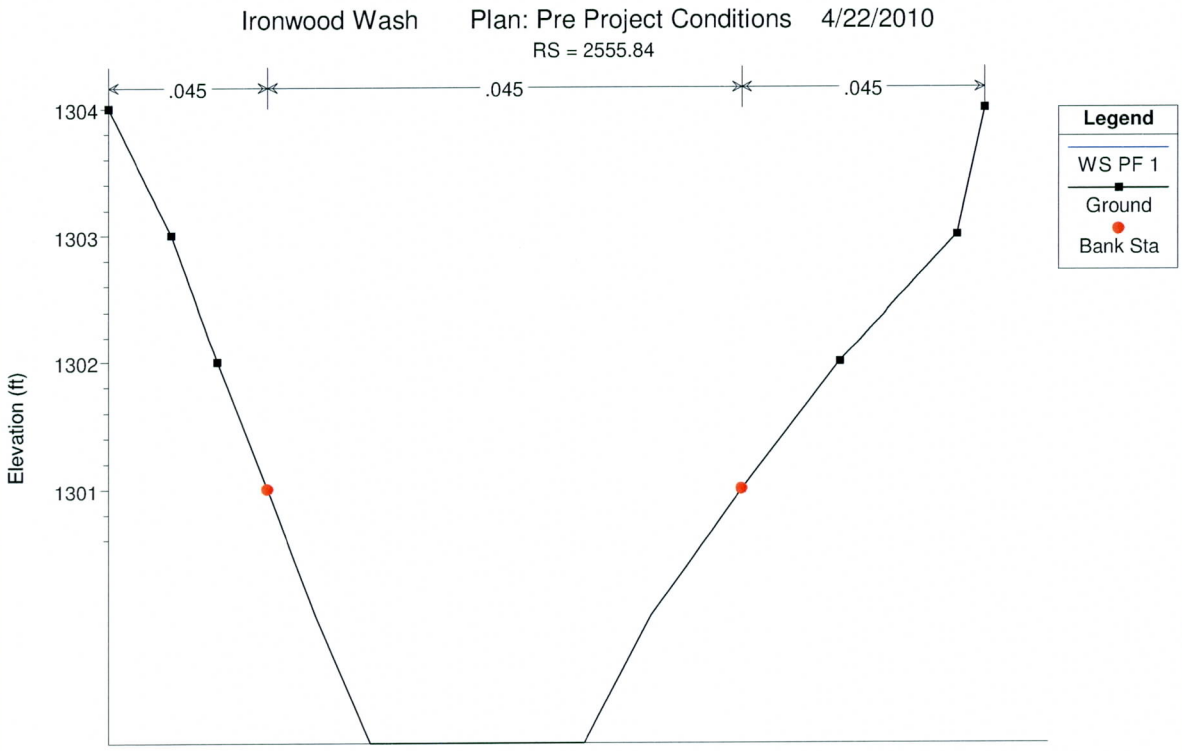
| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 3001.78 | PF 1 | 196.00 | 1303.00 | 1303.56 | | 1303.62 | 0.008753 | 1.95 | 100.54 | 200.56 | 0.49 |
| Reach-1 | 2825.77 | PF 1 | 196.00 | 1301.00 | 1301.79 | | 1301.87 | 0.011558 | 2.30 | 85.17 | 163.17 | 0.56 |
| Reach-1 | 2694.35 | PF 1 | 196.00 | 1300.00 | 1300.79 | | 1300.85 | 0.005516 | 1.91 | 102.87 | 150.18 | 0.41 |
| Reach-1 | 2555.84 | PF 1 | 196.00 | 1299.00 | 1300.06 | | 1300.11 | 0.003561 | 1.78 | 110.10 | 128.19 | 0.34 |
| Reach-1 | 2414.08 | PF 1 | 196.00 | 1297.00 | 1298.66 | 1298.66 | 1299.09 | 0.020147 | 5.53 | 41.10 | 53.07 | 0.86 |
| Reach-1 | 2278.65 | PF 1 | 196.00 | 1297.00 | 1297.79 | | 1297.82 | 0.003650 | 1.39 | 141.08 | 242.64 | 0.32 |
| Reach-1 | 2122.76 | PF 1 | 196.00 | 1296.00 | 1296.51 | | 1296.65 | 0.023193 | 2.98 | 65.84 | 143.43 | 0.77 |
| Reach-1 | 1981.91 | PF 1 | 196.00 | 1294.00 | 1294.48 | | 1294.54 | 0.010248 | 1.93 | 101.50 | 231.16 | 0.51 |
| Reach-1 | 1805.76 | PF 1 | 196.00 | 1292.00 | 1292.56 | | 1292.64 | 0.011306 | 2.25 | 87.14 | 169.94 | 0.55 |
| Reach-1 | 1628.03 | PF 1 | 196.00 | 1289.00 | 1290.46 | 1290.26 | 1290.57 | 0.012061 | 2.64 | 74.11 | 118.90 | 0.59 |
| Reach-1 | 1453.36 | PF 1 | 196.00 | 1288.00 | 1288.81 | | 1288.89 | 0.007747 | 2.27 | 86.21 | 124.56 | 0.48 |
| Reach-1 | 1299.59 | PF 1 | 196.00 | 1286.00 | 1287.79 | | 1287.86 | 0.005780 | 2.15 | 91.32 | 115.34 | 0.43 |
| Reach-1 | 1139.44 | PF 1 | 196.00 | 1285.00 | 1286.85 | | 1286.95 | 0.005577 | 2.48 | 79.17 | 78.52 | 0.43 |
| Reach-1 | 1000 | PF 1 | 196.00 | 1284.00 | 1285.96 | 1285.39 | 1286.11 | 0.006506 | 3.07 | 63.93 | 51.57 | 0.49 |

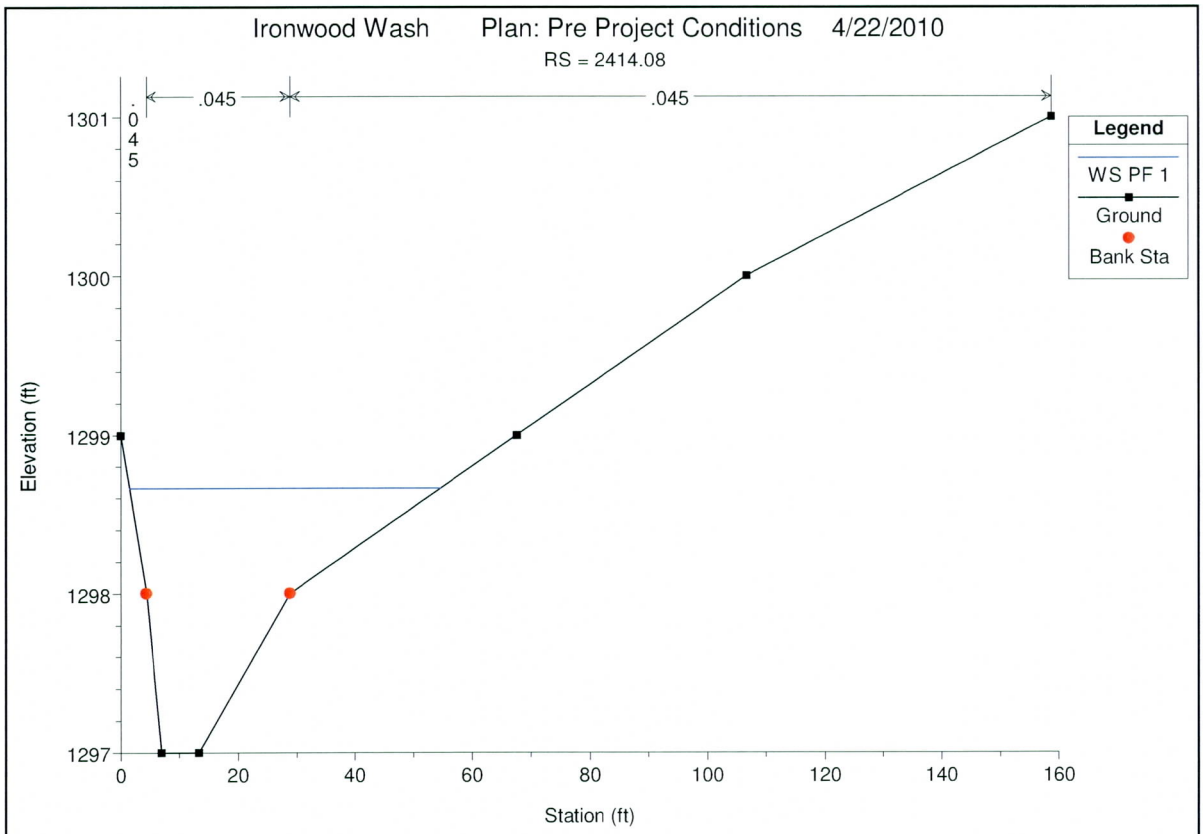

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
Ironwood Reach-1
Legend
WS PF 1
Ground
Elevation (ft)
1305
1300
1295
1290
1285
1280
1139.44
1299.59
1453.36
1628.03
1805.76
1981.91
2122.76
2278.65
2414.08
2555.84
2694.35
2825.77
3001.78
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)

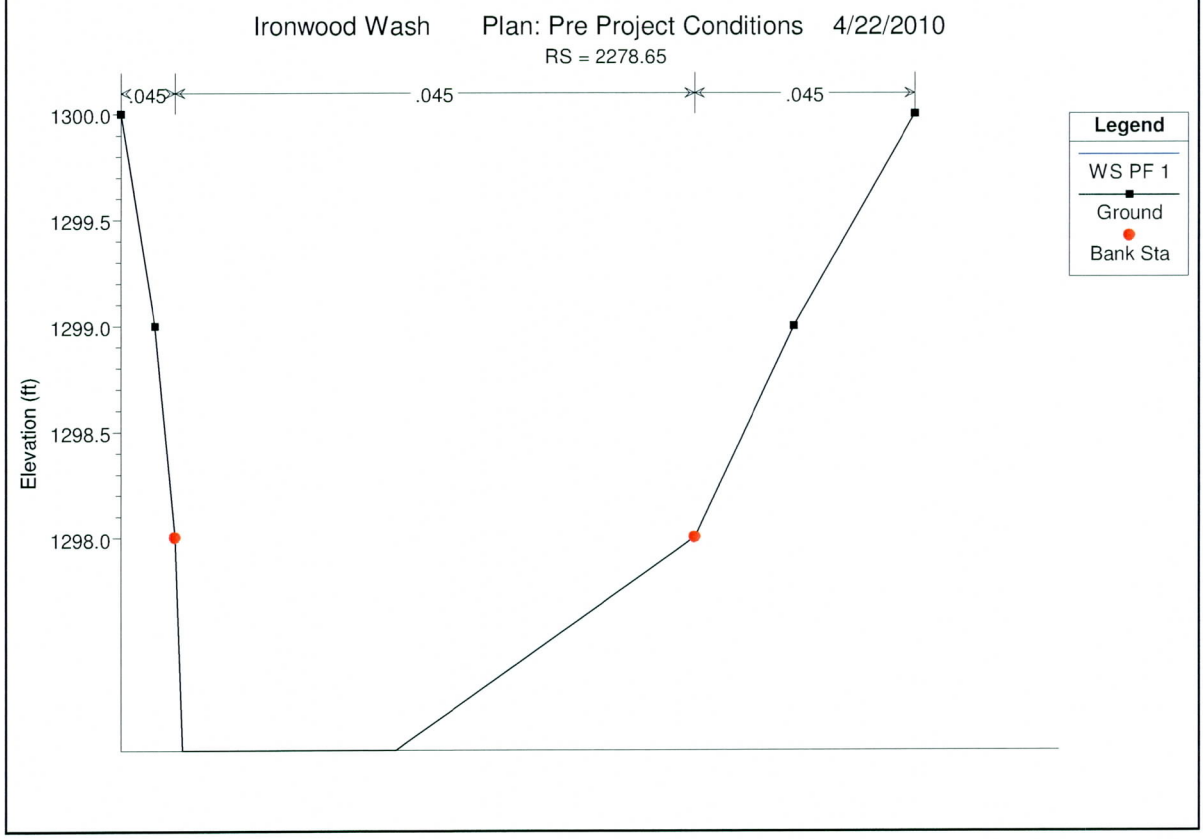

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 3001.78
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306.0
1305.5
1305.0
1304.5
1304.0
1303.5
1303.0
0
100
200
300
400
Station (ft)

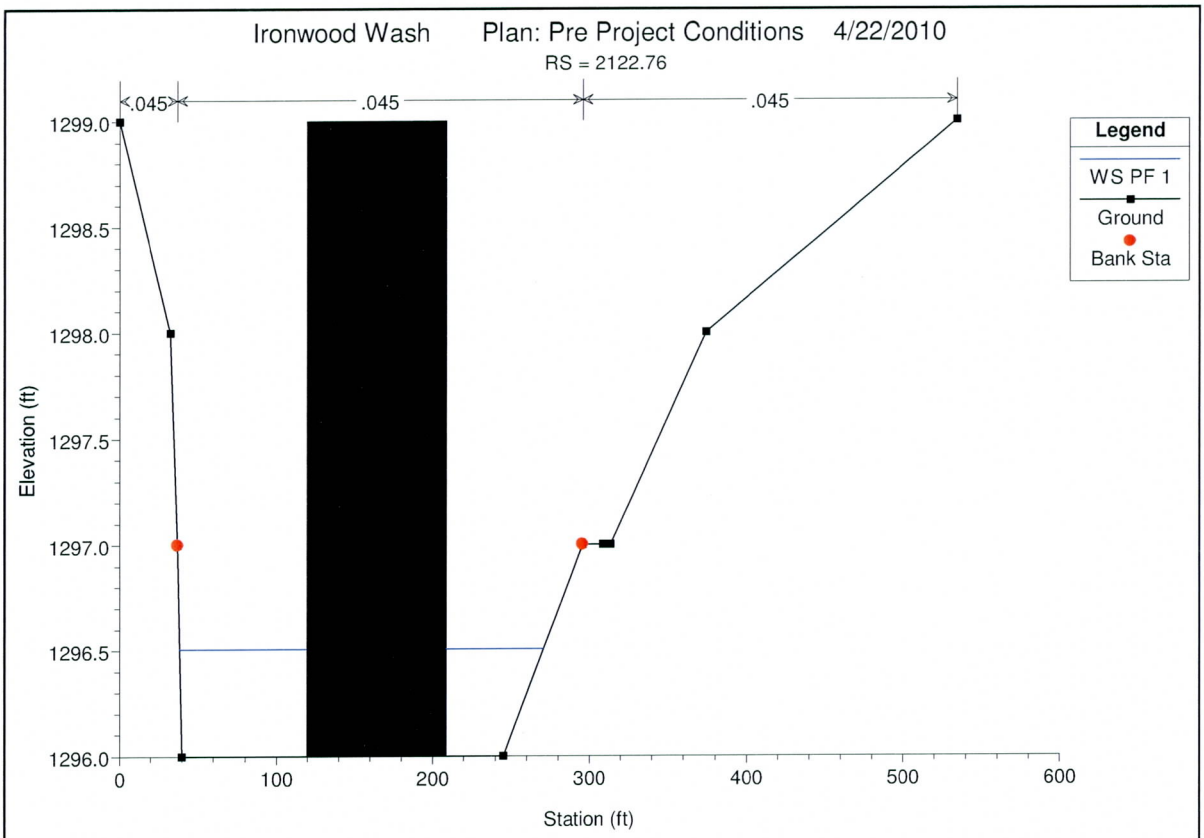

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 2825.77
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1306
1305
1304
1303

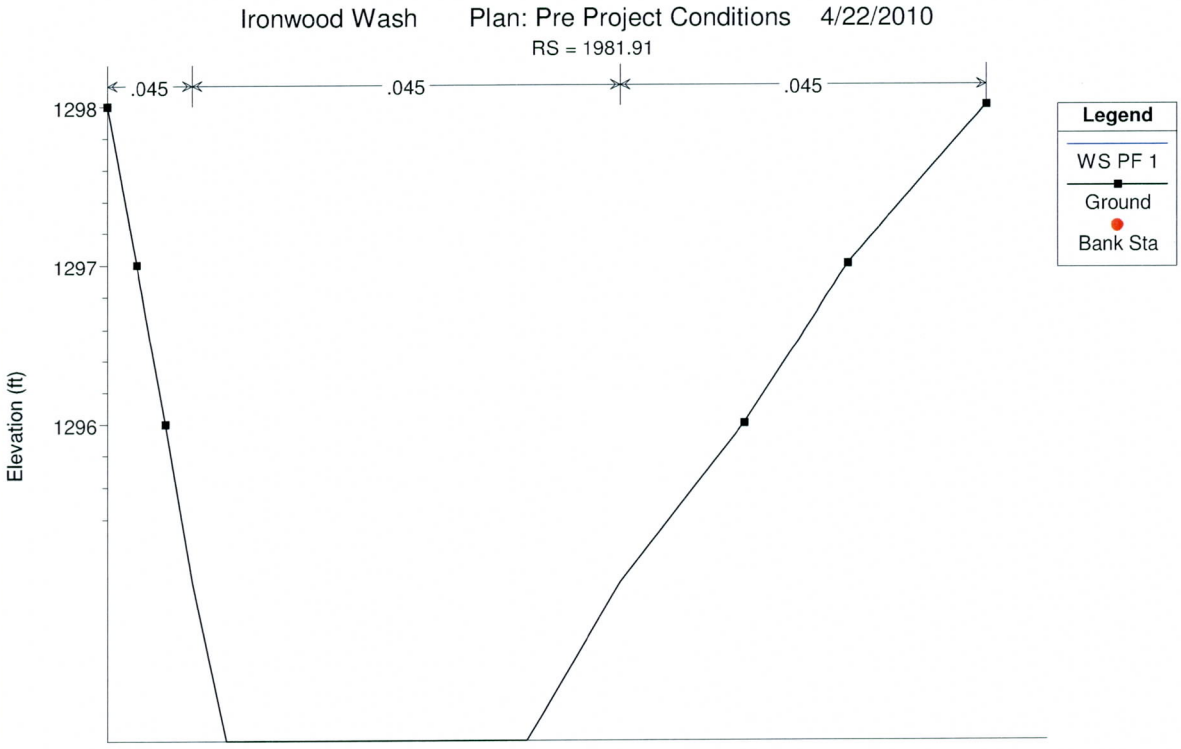

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 2694.35
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1305
1304
1303
1302
1301
1300
0
50
100
150
200
250
300
350
Station (ft)

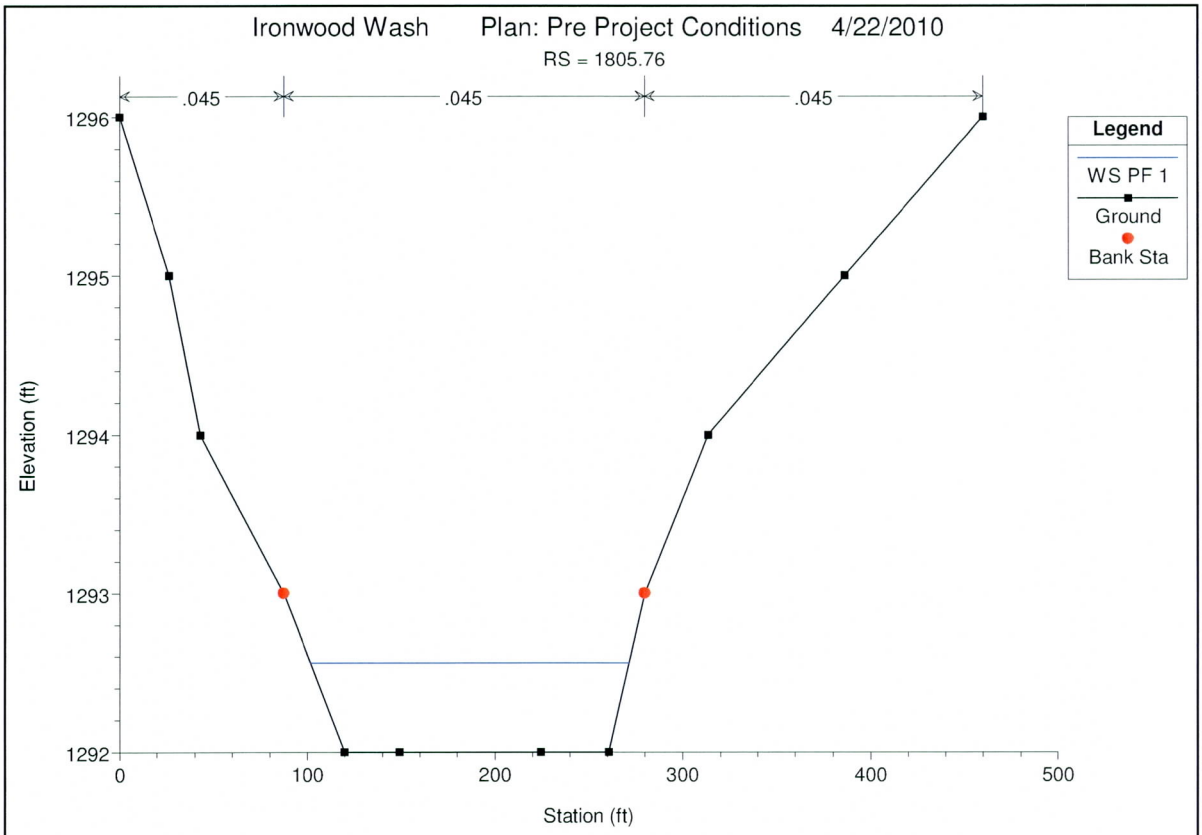

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 2555.84
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1304
1303
1302
1301

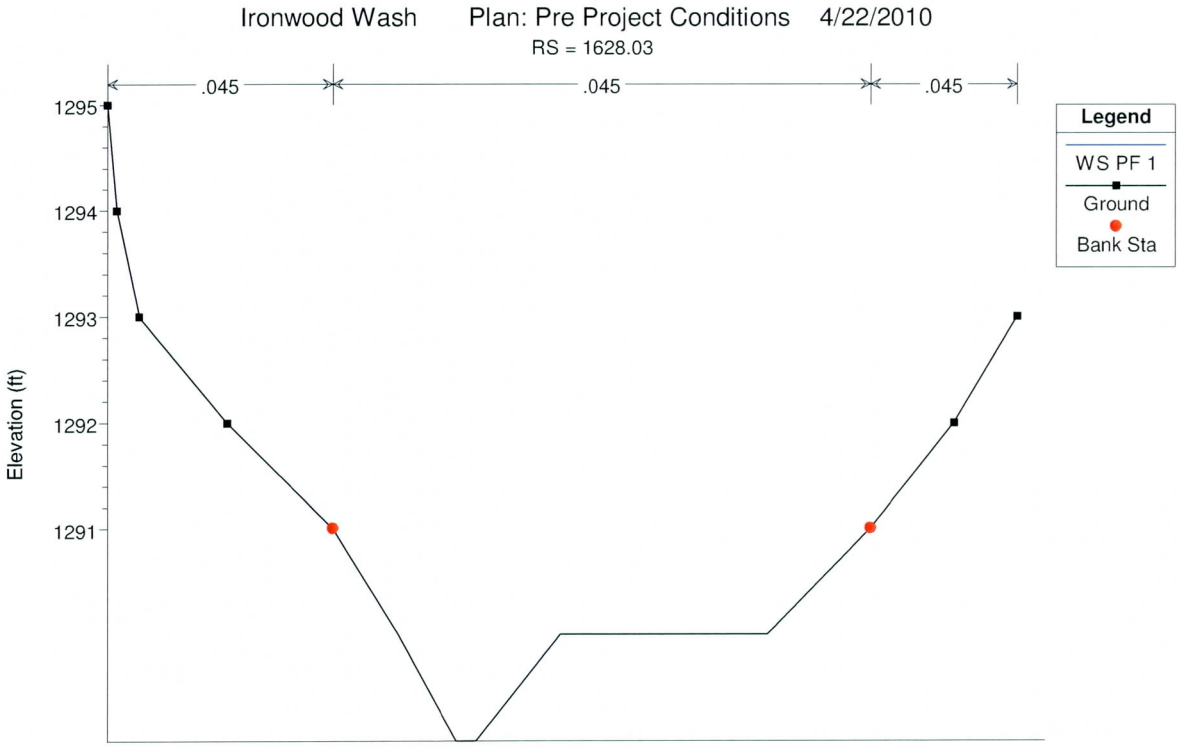

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 2414.08
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1301
1300
1299
1298
1297
0
20
40
60
80
100
120
140
160
Station (ft)

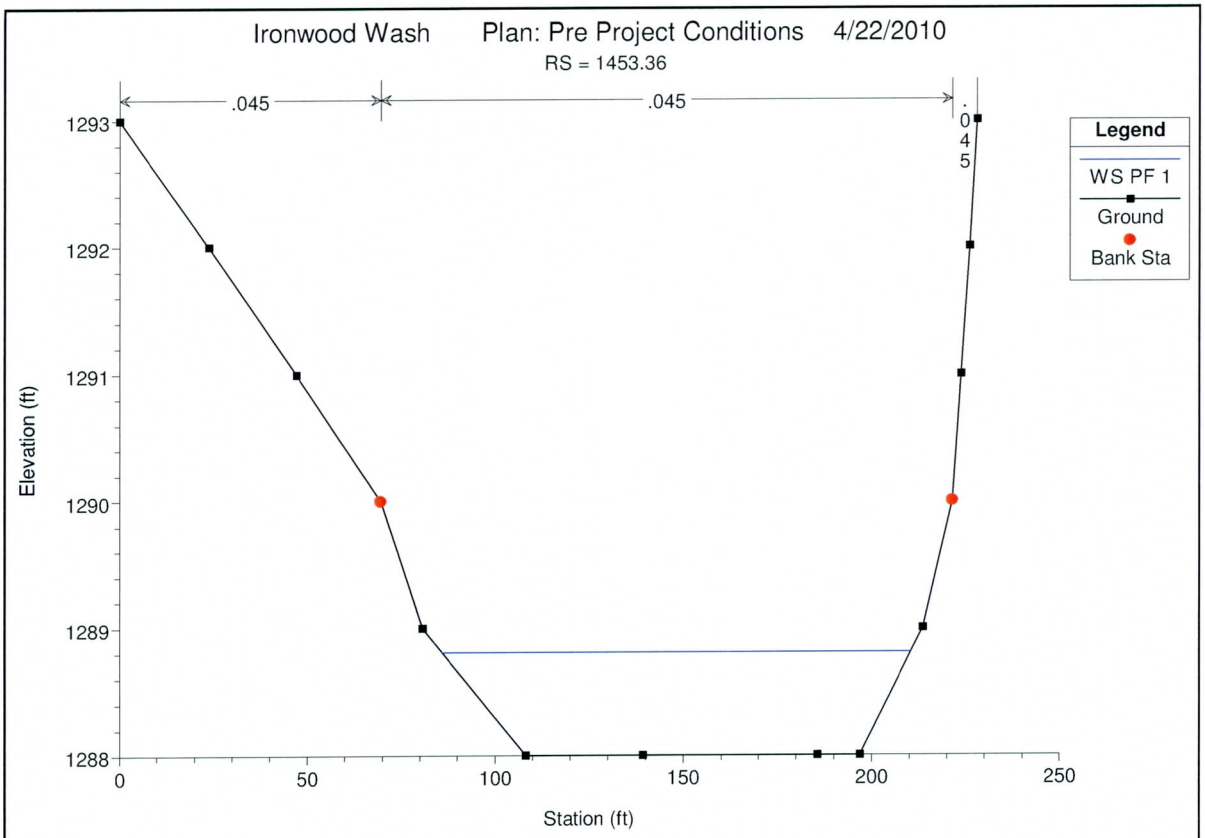

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 2278.65
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1300.0
1299.5
1299.0
1298.5
1298.0

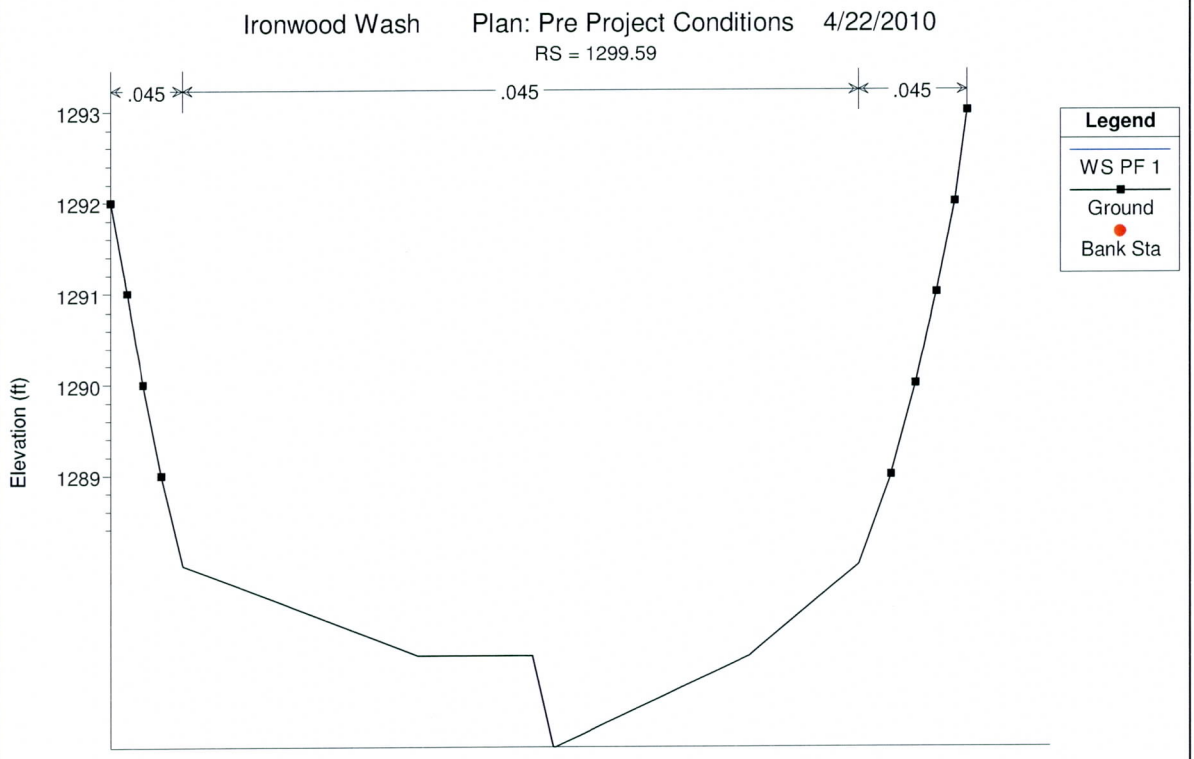

Ironwood Wash
Plan: Pre Project Conditions
4/22/2010
RS = 2122.76
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1299.0
1298.5
1298.0
1297.5
1297.0
1296.5
1296.0
0
100
200
300
400
500
600
Station (ft)

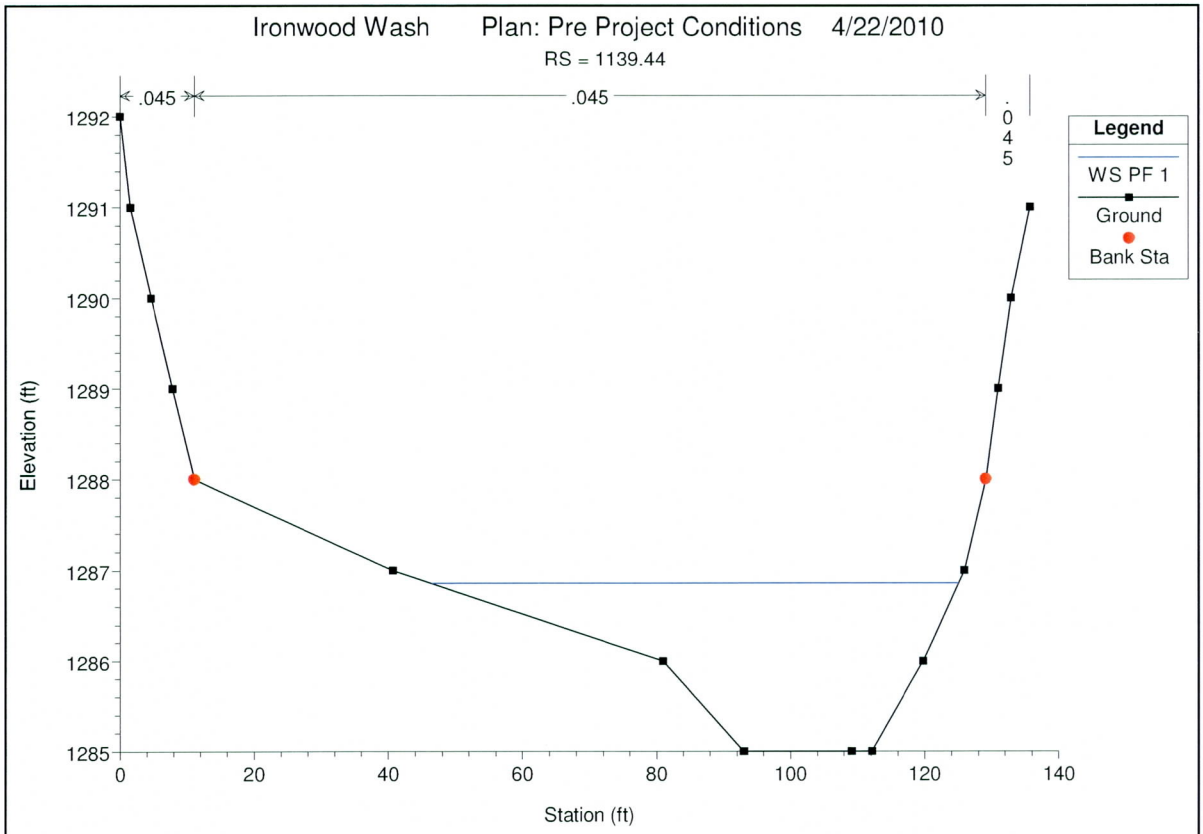

Ironwood Wash
Plan: Pre Project Conditions
4/22/2010
RS = 1981.91
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1298
1297
1296

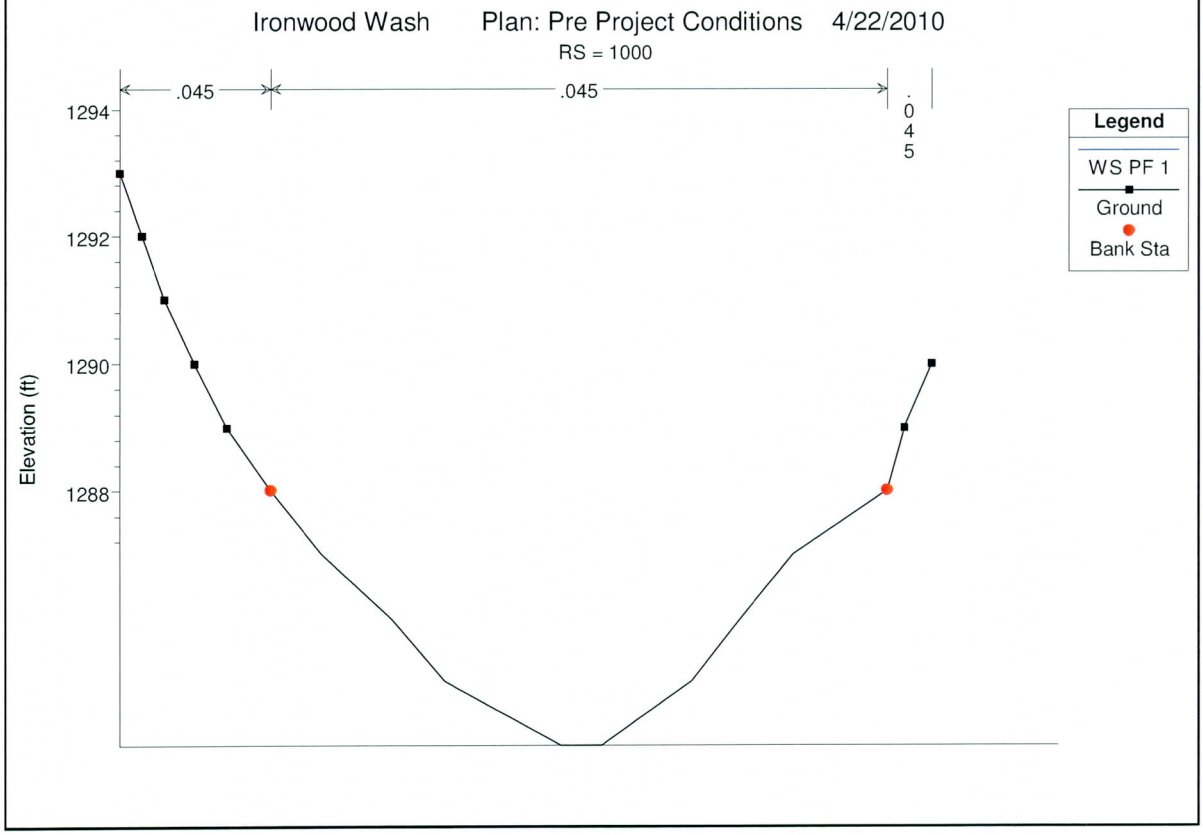

Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 1805.76
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1296
1295
1294
1293
1292
0
100
200
300
400
500
Station (ft)


Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 1628.03
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1295
1294
1293
1292
1291


Ironwood Wash
Plan: Pre Project Conditions
4/22/2010
RS = 1453.36
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1293
1292
1291
1290
1289
1288
0
50
100
150
200
250
Station (ft)

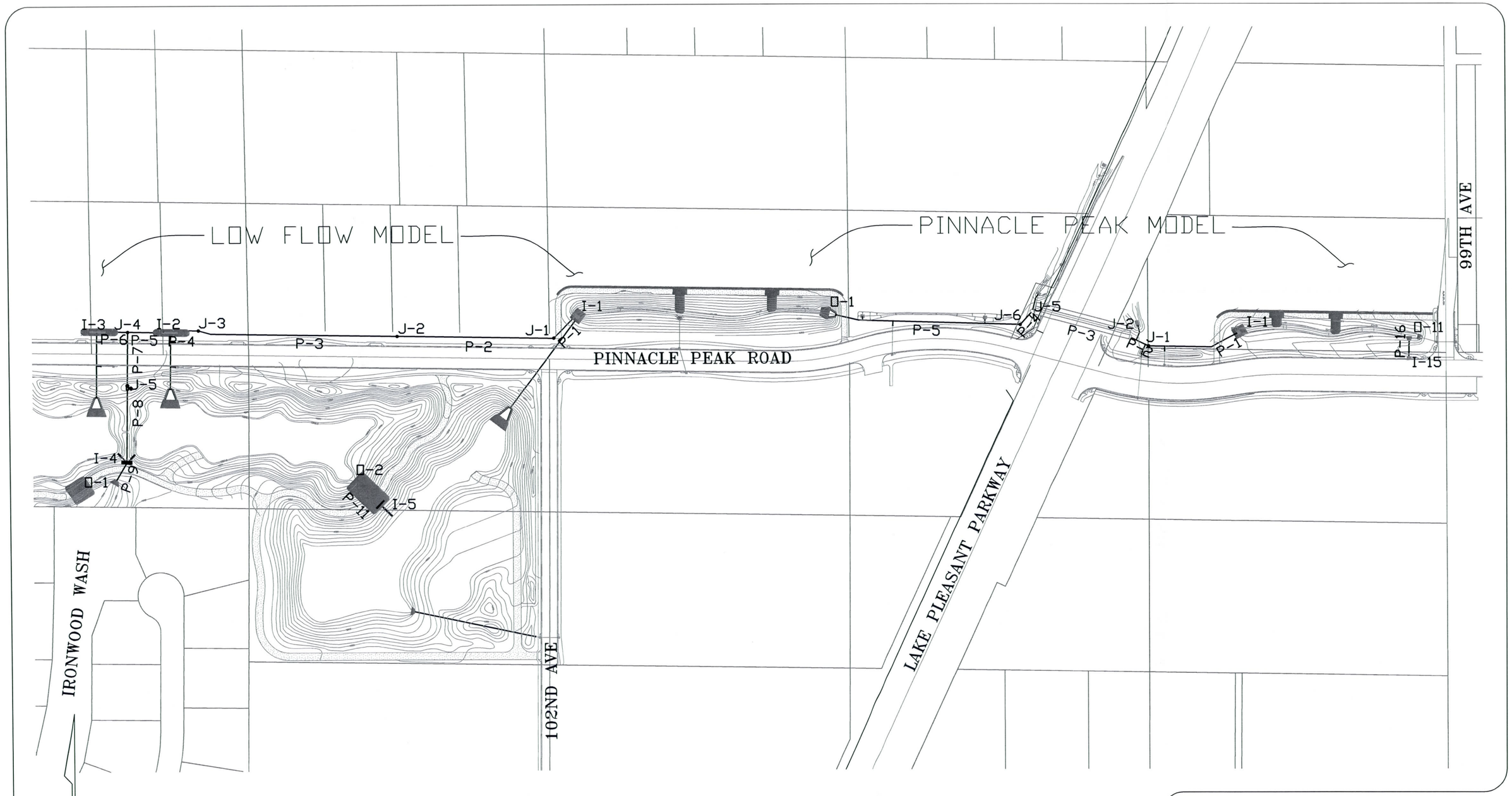

Ironwood Wash
Plan: Pre Project Conditions
4/22/2010
RS = 1299.59
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1293
1292
1291
1290
1289


Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 1139.44
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1292
1291
1290
1289
1288
1287
1286
1285
0
20
40
60
80
100
120
140
Station (ft)


Ironwood Wash Plan: Pre Project Conditions 4/22/2010
RS = 1000
.045
.045
.045
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1294
1292
1290
1288

# STORM CAD

## Main Storm Drain
## Low Flow Bypass




PRELIMINARY
NOT FOR CONSTRUCTION

200 0 100 200

Horz. 1 in. = 200 ft.

# PINNACLE PEAK DRAINAGE PROJECT

OVERALL
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SCHEMATIC

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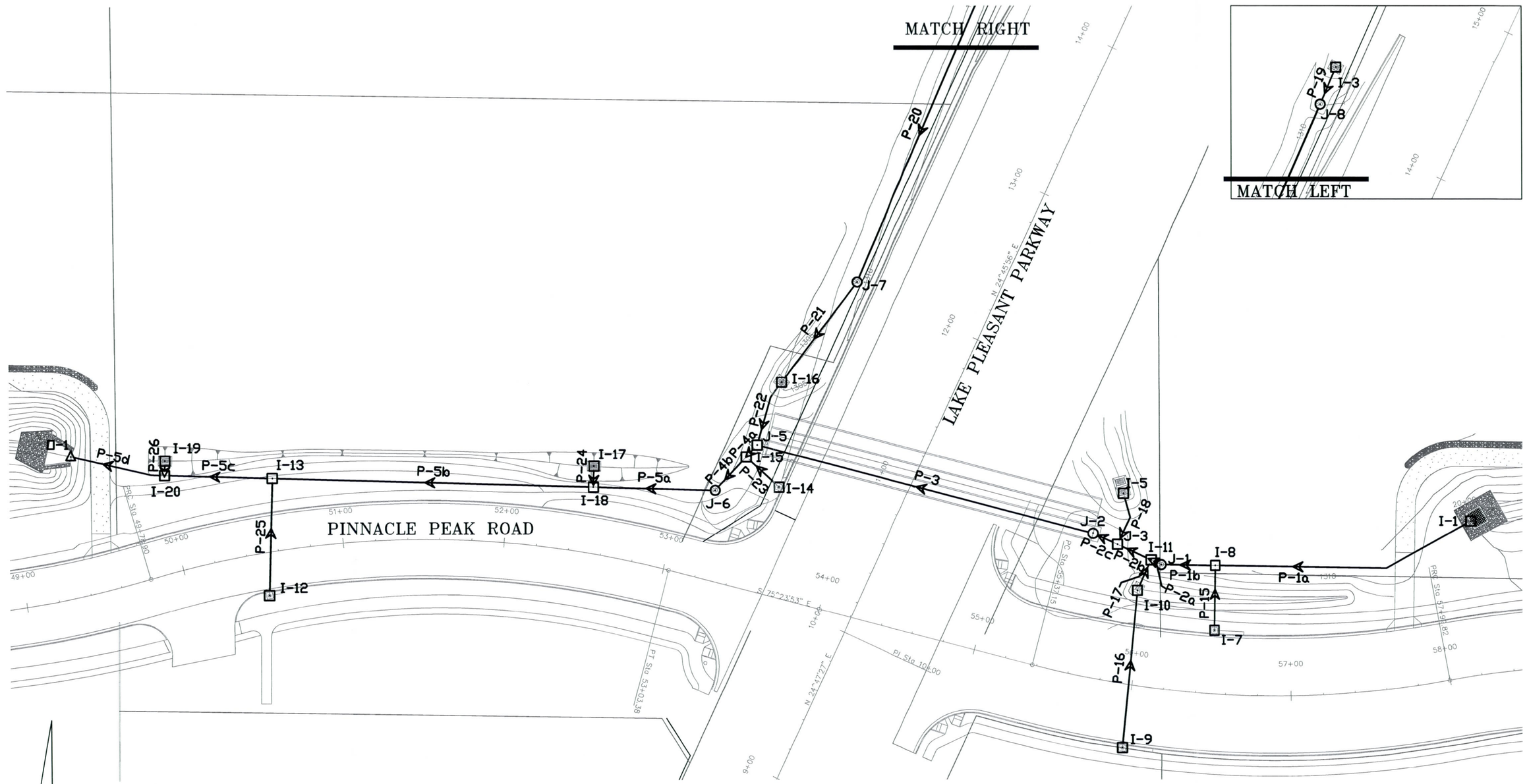
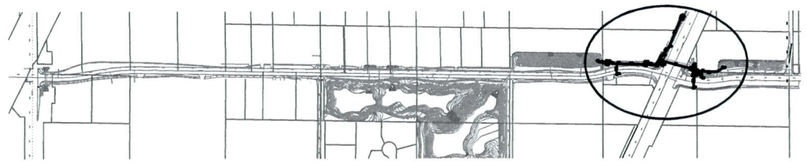
W:\2009 Projects\093386 – Pinnacle Peak Road and Channel\Project Support\Hydro\StormCad\Overall Schematic.dwg



KEY MAP

PRELIMINARY
NOT FOR CONSTRUCTION

60 0 30 60

Horz. 1 in. = 60 ft.

# PINNACLE PEAK MAIN STORM DRAIN

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W:\2009 Projects\093386 – Pinnacle Peak Road and Channel\Project Support\Hydro\StormCad\Pinnacle Peak Storm Drain System.dwg

## Scenario: Base

## Pipe Report

| Label | Upstream Node | Downstream Node | Length (ft) | Constructed Slope (ft/ft) | Section Size | Material | Mannings n | Total System Flow (cfs) | Upstream Invert Elevation (ft) | Downstream Invert Elevation (ft) | Hydraulic Grade Line In (ft) | Hydraulic Grade Line Out (ft) | Average Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1a | I-1 | I-8 | 167.00 | 0.009102 | 48 inch | Concrete | 0.013 | 97.00 | 1,303.01 | 1,301.49 | 1,306.00 | 1,304.00 | 11.83 |
| P-1b | I-8 | J-1 | 34.00 | 0.009412 | 48 inch | Concrete | 0.013 | 97.00 | 1,301.49 | 1,301.17 | 1,304.48 | 1,304.49 | 11.98 |
| P-2a | J-1 | I-11 | 7.00 | 0.021429 | 48 inch | Concrete | 0.013 | 97.00 | 1,301.07 | 1,300.92 | 1,304.06 | 1,303.55 | 16.40 |
| P-2b | I-11 | J-3 | 23.00 | 0.020870 | 48 inch | Concrete | 0.013 | 97.00 | 1,300.92 | 1,300.44 | 1,303.91 | 1,302.87 | 16.23 |
| P-2c | J-3 | J-2 | 13.00 | 0.020769 | 48 inch | Concrete | 0.013 | 97.00 | 1,300.44 | 1,300.17 | 1,303.43 | 1,302.71 | 16.21 |
| P-3 | J-2 | J-5 | 216.00 | 0.004907 | 8 x 4 ft | Concrete | 0.013 | 97.00 | 1,300.07 | 1,299.01 | 1,303.06 | 1,303.07 | 8.35 |
| P-4a | J-5 | I-15 | 10.00 | 0.003000 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.91 | 1,298.88 | 1,302.72 | 1,302.70 | 7.66 |
| P-4b | I-15 | J-6 | 28.00 | 0.002857 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.88 | 1,298.80 | 1,302.70 | 1,302.64 | 7.50 |
| P-5a | J-6 | I-18 | 75.00 | 0.002000 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.70 | 1,298.55 | 1,302.42 | 1,302.22 | 6.10 |
| P-5b | I-18 | I-13 | 199.00 | 0.002010 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.55 | 1,298.15 | 1,302.22 | 1,301.60 | 6.10 |
| P-5c | I-13 | I-20 | 67.00 | 0.001940 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.15 | 1,298.02 | 1,301.60 | 1,301.33 | 6.10 |
| P-5d | I-20 | O-1 | 60.00 | 0.002000 | 54 inch | Concrete | 0.013 | 97.00 | 1,298.02 | 1,297.90 | 1,301.33 | 1,300.88 | 6.10 |
| P-15 | I-7 | I-8 | 40.00 | 0.011500 | 18 inch | Concrete | 0.013 | 3.00 | 1,303.20 | 1,302.74 | 1,304.50 | 1,304.48 | 5.39 |
| P-16 | I-9 | I-10 | 98.00 | 0.003061 | 18 inch | Concrete | 0.013 | 4.90 | 1,303.40 | 1,303.10 | 1,304.47 | 1,304.20 | 3.69 |
| P-17 | I-10 | I-11 | 21.00 | 0.039524 | 18 inch | Concrete | 0.013 | 4.90 | 1,303.00 | 1,302.17 | 1,303.85 | 1,303.91 | 9.65 |
| P-18 | I-5 | J-3 | 34.00 | 0.017353 | 36 inch | Concrete | 0.013 | 50.00 | 1,301.55 | 1,300.96 | 1,303.85 | 1,303.43 | 12.83 |
| P-19 | I-3 | J-8 | 25.00 | 0.009600 | 30 inch | Concrete | 0.013 | 30.00 | 1,302.75 | 1,302.51 | 1,305.47 | 1,305.33 | 6.11 |
| P-20 | J-8 | J-7 | 209.00 | 0.009569 | 30 inch | Concrete | 0.013 | 30.00 | 1,302.41 | 1,300.41 | 1,305.16 | 1,304.04 | 6.11 |
| P-21 | J-7 | I-16 | 78.00 | 0.009615 | 30 inch | Concrete | 0.013 | 30.00 | 1,300.31 | 1,299.56 | 1,303.87 | 1,303.45 | 6.11 |
| P-22 | I-16 | J-5 | 38.00 | 0.009474 | 30 inch | Concrete | 0.013 | 30.00 | 1,299.56 | 1,299.20 | 1,303.27 | 1,303.07 | 6.11 |
| P-23 | I-14 | I-15 | 28.00 | 0.161429 | 18 inch | Concrete | 0.013 | 5.00 | 1,304.90 | 1,300.38 | 1,305.76 | 1,302.70 | 16.04 |
| P-24 | I-17 | I-18 | 13.00 | 0.113846 | 18 inch | Concrete | 0.013 | 10.00 | 1,301.57 | 1,300.09 | 1,302.79 | 1,302.22 | 17.24 |
| P-25 | I-12 | I-13 | 73.00 | 0.036027 | 18 inch | Concrete | 0.013 | 2.00 | 1,302.30 | 1,299.67 | 1,302.83 | 1,301.60 | 7.22 |
| P-26 | I-19 | I-20 | 9.00 | 0.145556 | 18 inch | Concrete | 0.013 | 10.00 | 1,300.83 | 1,299.52 | 1,302.05 | 1,301.33 | 18.84 |

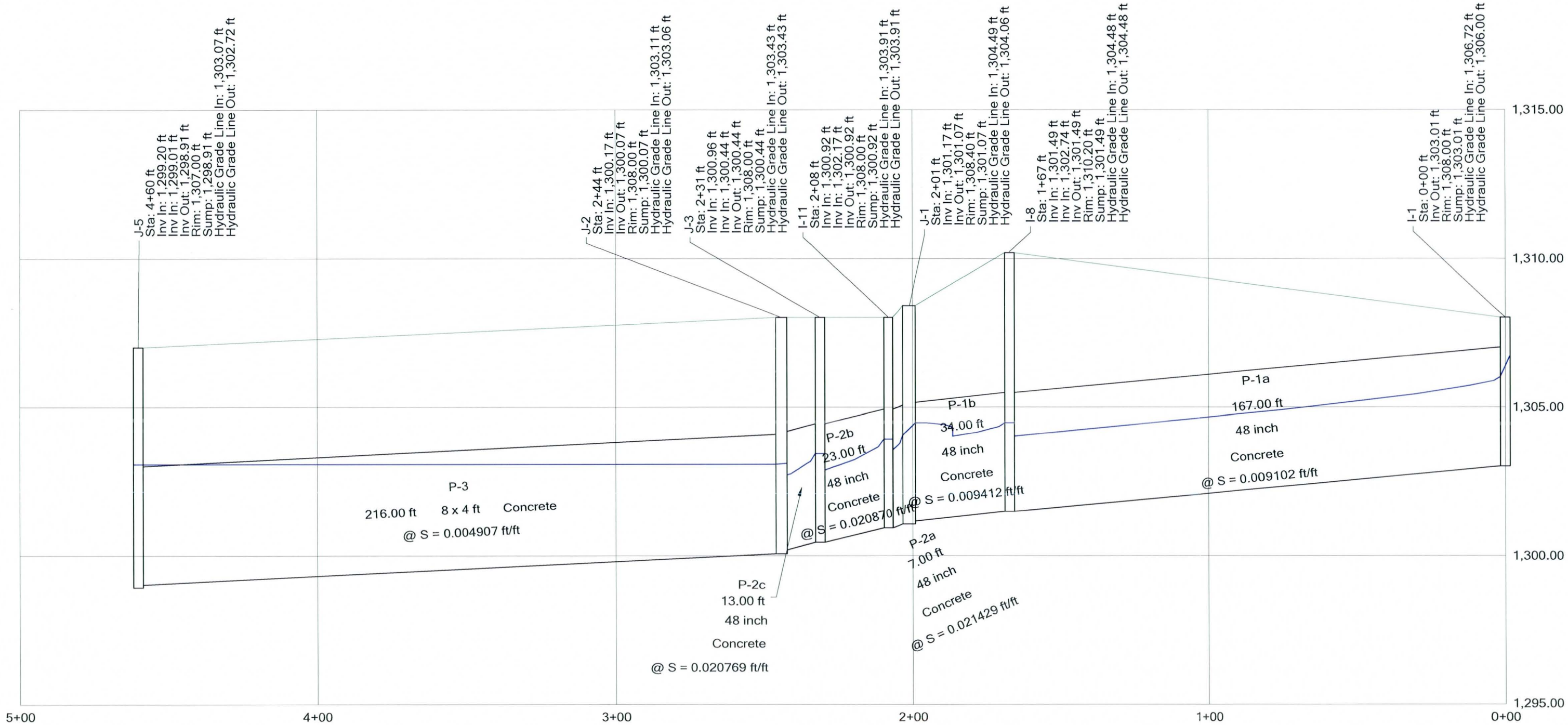
## Scenario: Base

## Node Report

| Label | Element Type | Ground Elevation (ft) | Headloss Coefficient | Sump Elevation (ft) | Additional Carryover (cfs) | Hydraulic Grade Line In (ft) | Hydraulic Grade Line Out (ft) | Velocity In (ft/s) | Energy Grade Line In (ft) |
|---|---|---|---|---|---|---|---|---|---|
| I-1 | Inlet | 1,308.00 | 0.50 | 1,303.01 | 0.00 | 1,306.72 | 1,306.00 | 9.64 | 1,308.16 |
| I-3 | Inlet | 1,307.00 | 1.00 | 1,302.75 | 0.00 | 1,306.05 | 1,305.47 | 6.11 | 1,306.63 |
| I-5 | Inlet | 1,306.25 | 1.00 | 1,301.55 | 0.00 | 1,305.00 | 1,303.85 | 8.59 | 1,306.15 |
| I-7 | Inlet | 1,306.70 | 1.00 | 1,303.20 | 0.00 | 1,304.55 | 1,304.50 | 1.84 | 1,304.60 |
| I-8 | Inlet | 1,310.20 | 0.00 | 1,301.49 | 0.00 | 1,304.48 | 1,304.48 | 9.64 | 1,305.92 |
| I-9 | Inlet | 1,306.34 | 1.00 | 1,303.40 | 0.00 | 1,304.67 | 1,304.47 | 3.63 | 1,304.88 |
| I-10 | Inlet | 1,306.50 | 1.00 | 1,303.00 | 0.00 | 1,304.20 | 1,303.85 | 4.73 | 1,304.55 |
| I-11 | Inlet | 1,308.00 | 0.00 | 1,300.92 | 0.00 | 1,303.91 | 1,303.91 | 9.64 | 1,305.35 |
| I-12 | Inlet | 1,305.80 | 1.00 | 1,302.30 | 0.00 | 1,303.03 | 1,302.83 | 3.55 | 1,303.23 |
| I-13 | Inlet | 1,307.00 | 0.00 | 1,298.15 | 0.00 | 1,301.60 | 1,301.60 | 7.41 | 1,302.46 |
| I-14 | Inlet | 1,308.40 | 1.00 | 1,304.90 | 0.00 | 1,306.11 | 1,305.76 | 4.77 | 1,306.47 |
| I-15 | Inlet | 1,307.00 | 0.00 | 1,298.88 | 0.00 | 1,302.70 | 1,302.70 | 6.74 | 1,303.40 |
| I-16 | Inlet | 1,308.00 | 0.30 | 1,299.56 | 0.00 | 1,303.45 | 1,303.27 | 6.11 | 1,304.03 |
| I-17 | Inlet | 1,306.00 | 1.00 | 1,301.57 | 0.00 | 1,303.45 | 1,302.79 | 6.50 | 1,304.10 |
| I-18 | Inlet | 1,307.00 | 0.00 | 1,298.55 | 0.00 | 1,302.22 | 1,302.22 | 6.99 | 1,302.98 |
| I-19 | Inlet | 1,305.00 | 1.00 | 1,300.83 | 0.00 | 1,302.71 | 1,302.05 | 6.50 | 1,303.36 |
| I-20 | Inlet | 1,306.00 | 0.00 | 1,298.02 | 0.00 | 1,301.33 | 1,301.33 | 7.73 | 1,302.26 |
| J-1 | Junction | 1,308.40 | 0.30 | 1,301.07 | | 1,304.49 | 1,304.06 | 9.64 | 1,305.93 |
| J-2 | Junction | 1,308.00 | 0.20 | 1,300.07 | | 1,303.11 | 1,303.06 | 4.06 | 1,303.37 |
| J-3 | Inlet | 1,308.00 | 0.00 | 1,300.44 | 0.00 | 1,303.43 | 1,303.43 | 9.64 | 1,304.87 |
| J-5 | Inlet | 1,307.00 | 0.50 | 1,298.91 | 0.00 | 1,303.07 | 1,302.72 | 6.76 | 1,303.78 |
| J-6 | Junction | 1,307.40 | 0.30 | 1,298.70 | | 1,302.64 | 1,302.42 | 6.90 | 1,303.38 |
| J-7 | Junction | 1,309.50 | 0.30 | 1,300.31 | | 1,304.04 | 1,303.87 | 6.11 | 1,304.62 |
| J-8 | Junction | 1,308.00 | 0.30 | 1,302.41 | | 1,305.33 | 1,305.16 | 6.11 | 1,305.91 |
| O-1 | Outlet | 1,305.00 | | 1,297.90 | | 1,300.88 | 1,300.88 | 0.00 | 1,300.88 |

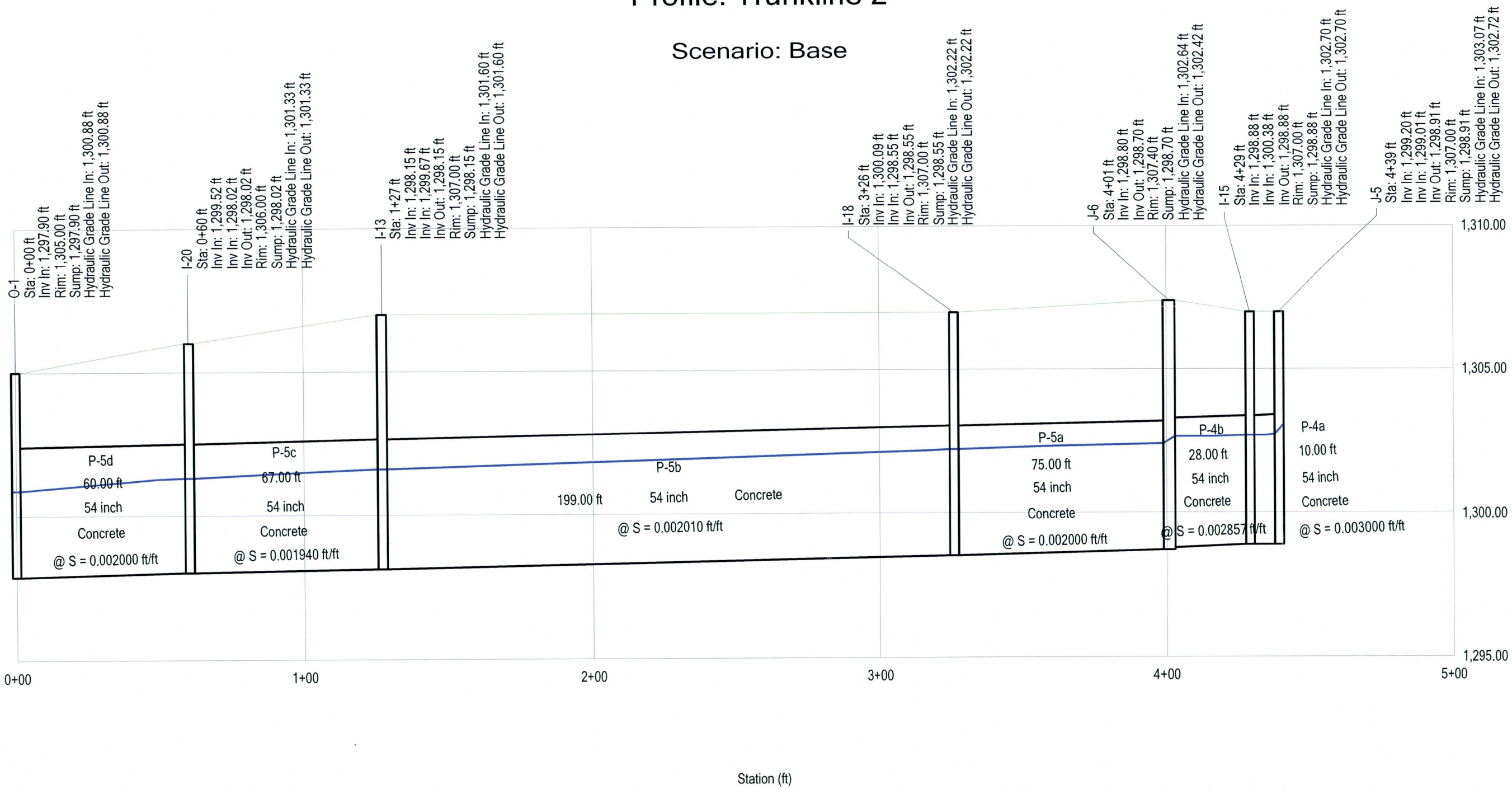
**Profile**
**Scenario: Base**

# Profile: Trunkline

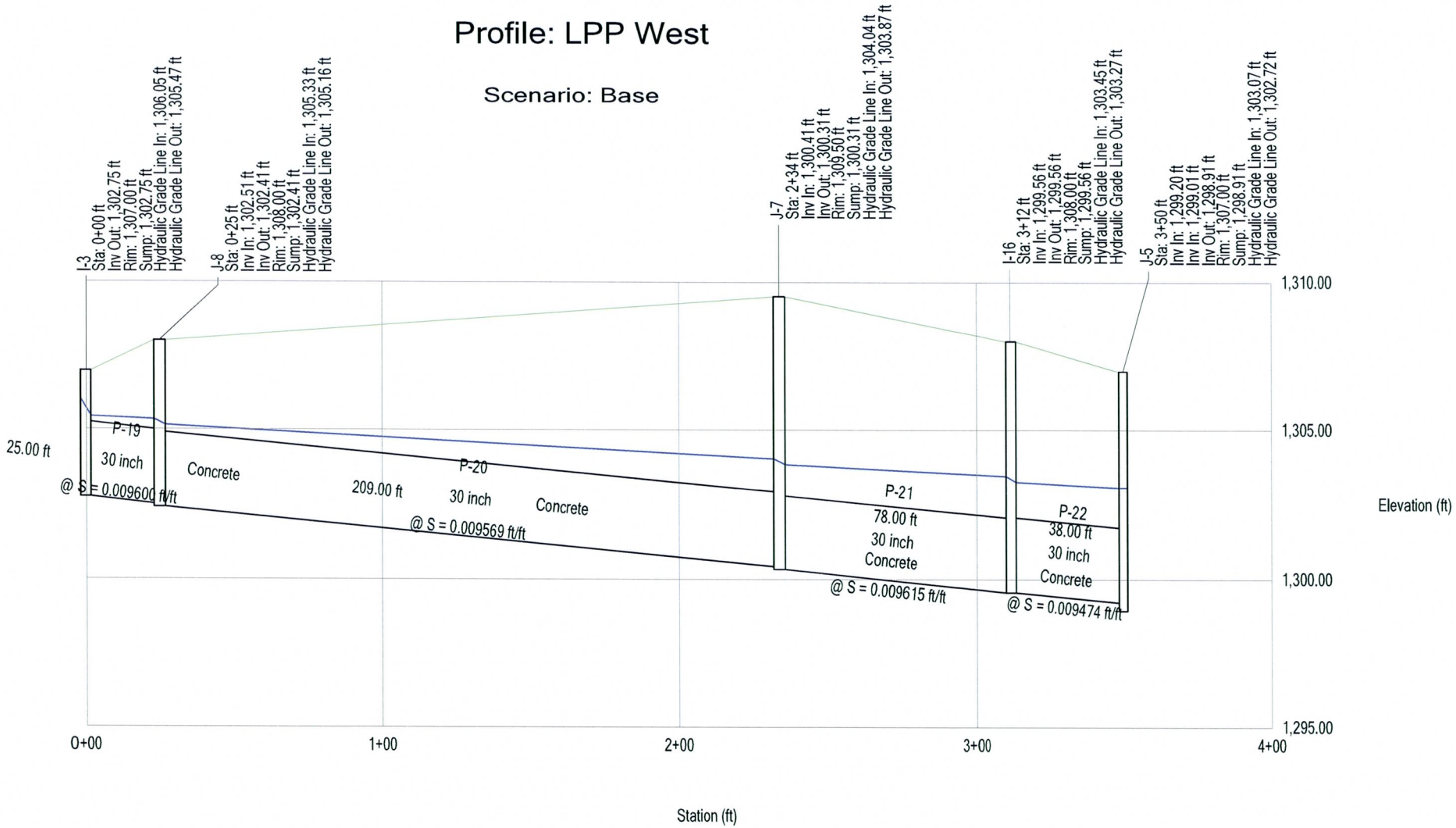


# Profile: Trunkline 2

## Scenario: Base



# Profile
## Scenario: Base




Title: Pinnacle Peak Storm Drain
w:\...\pinnacle peak storm drain system.stm
09/29/10 11:49:34 AM

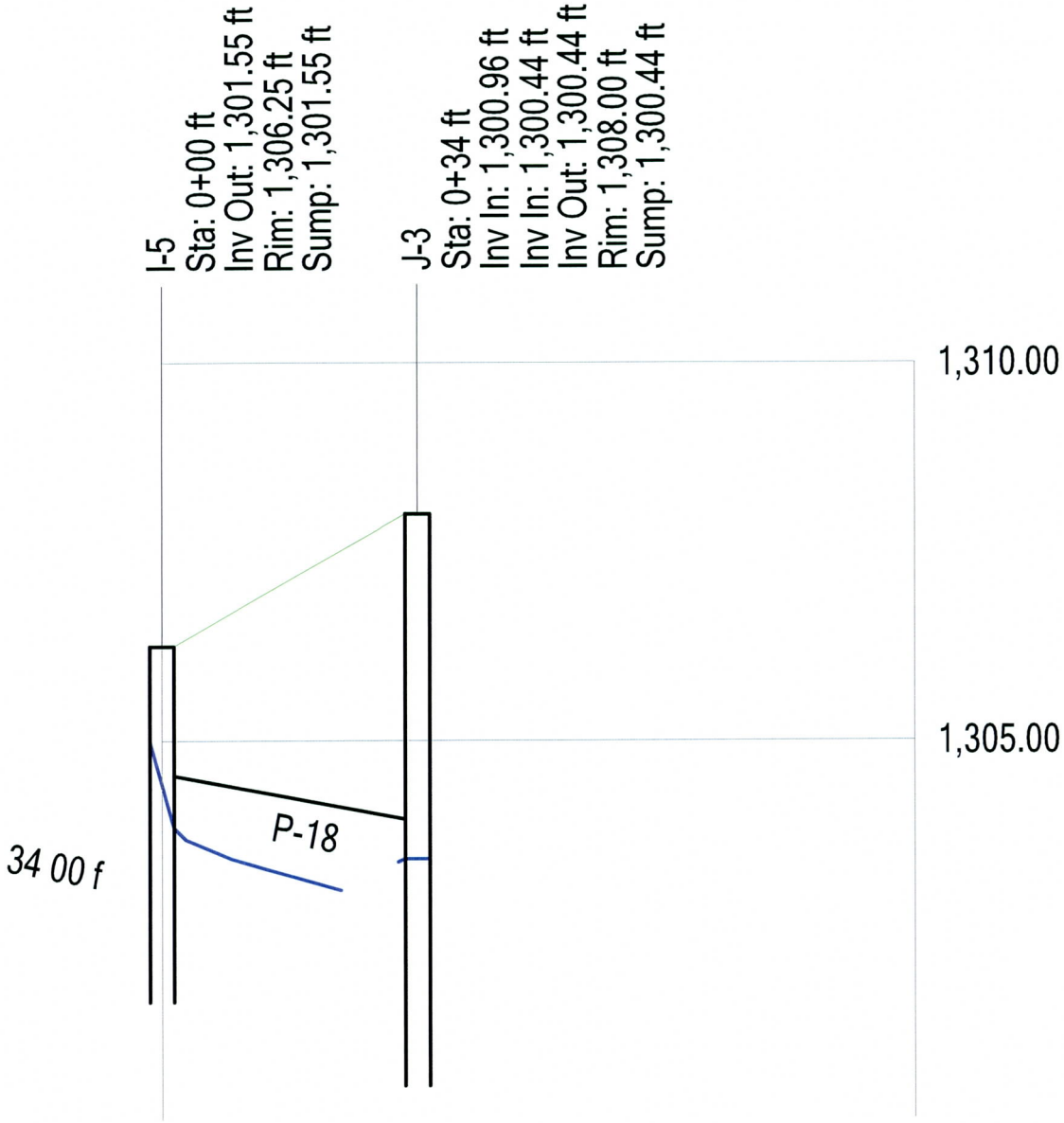
**Wood Patel and Assoc**

© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

Project Engineer: df
StormCAD v5.6 [05.06.012.00]

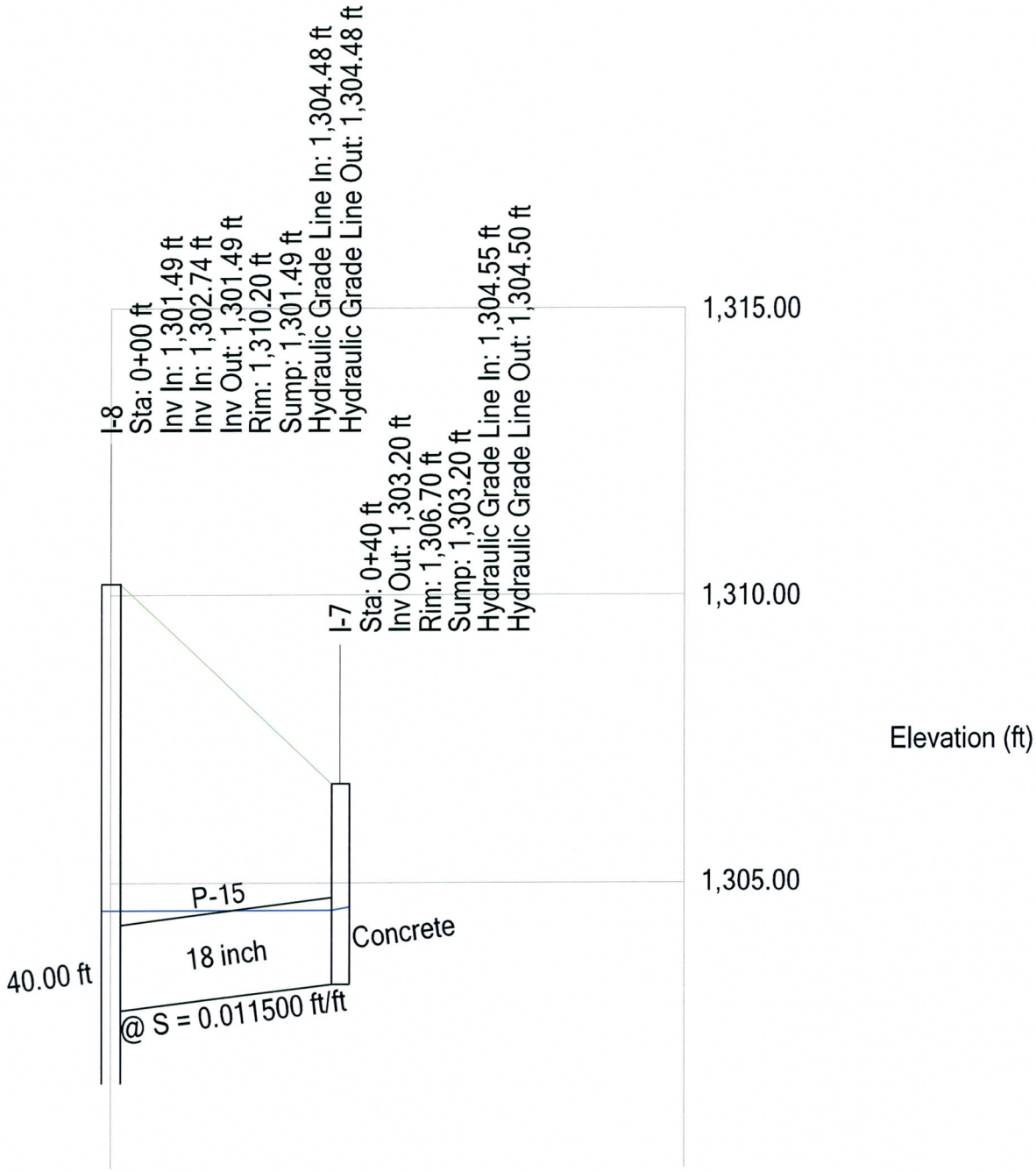
**Profile**
**Scenario: Base**

# Profile: LPP East



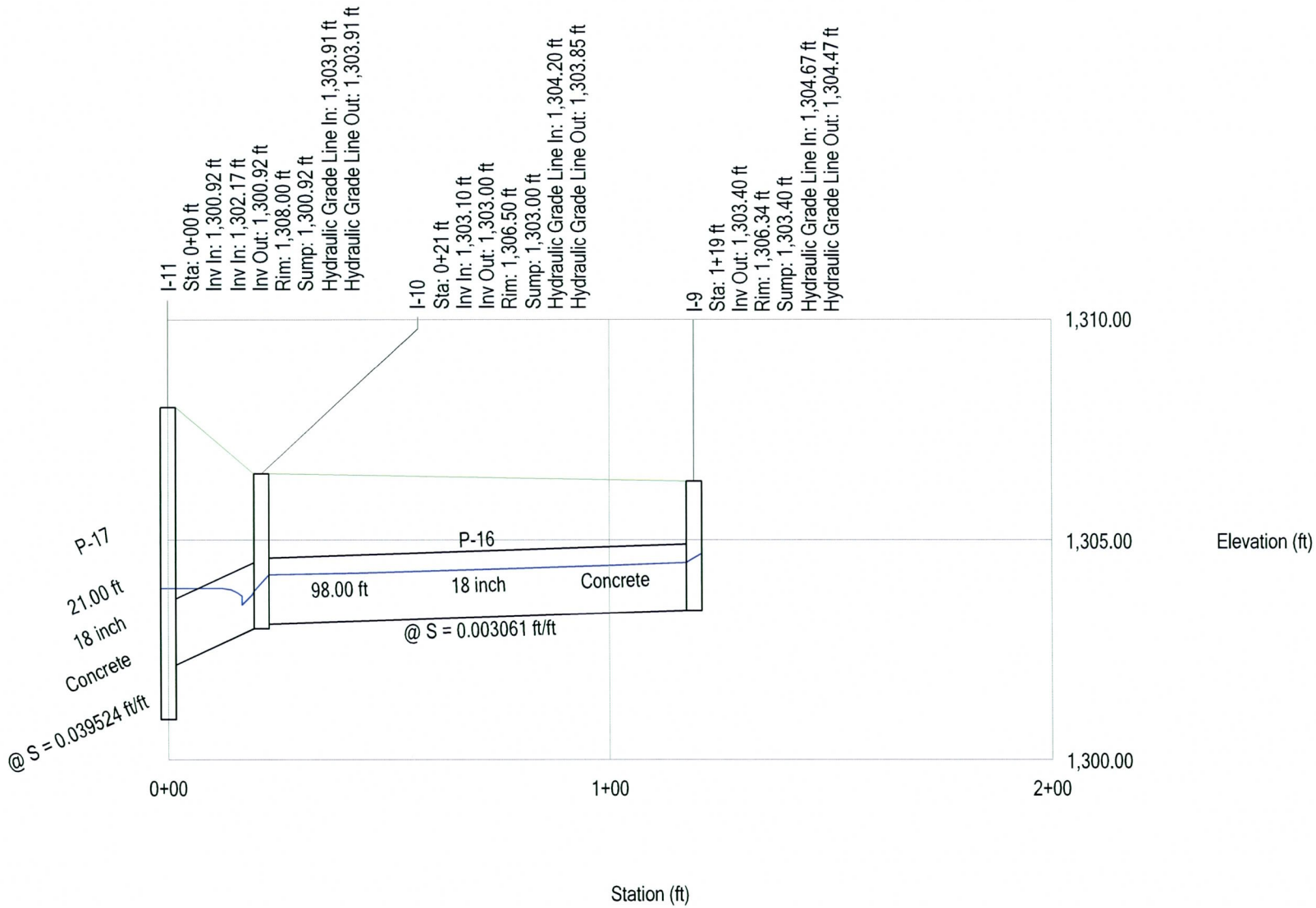
# Profile: PP 56+50

## Scenario: Base



# Profile: PP 56+00

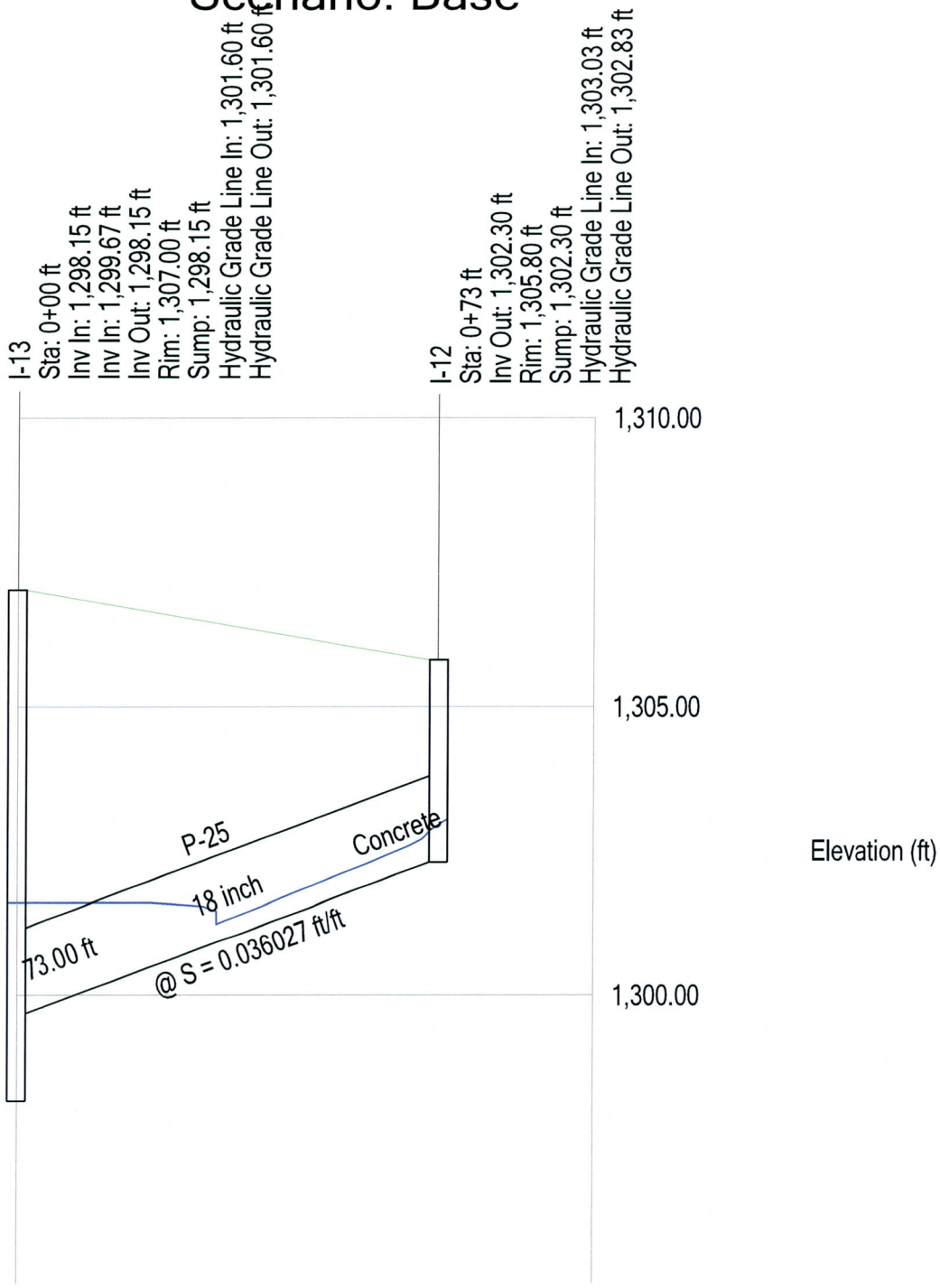
## Scenario: Base



**Profile**
**Scenario: Base**

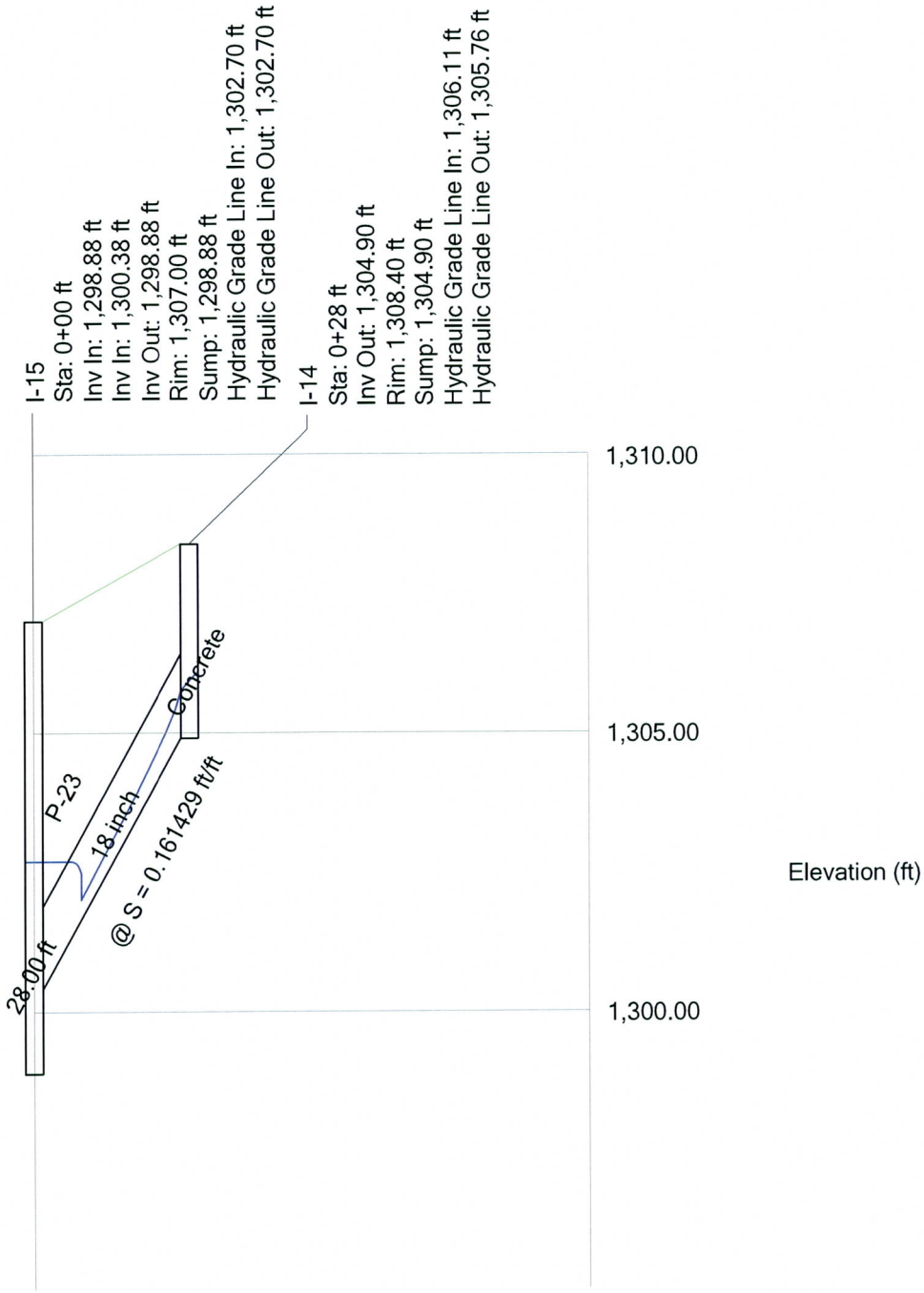
# Profile: PP 50+50

## Scenario: Base



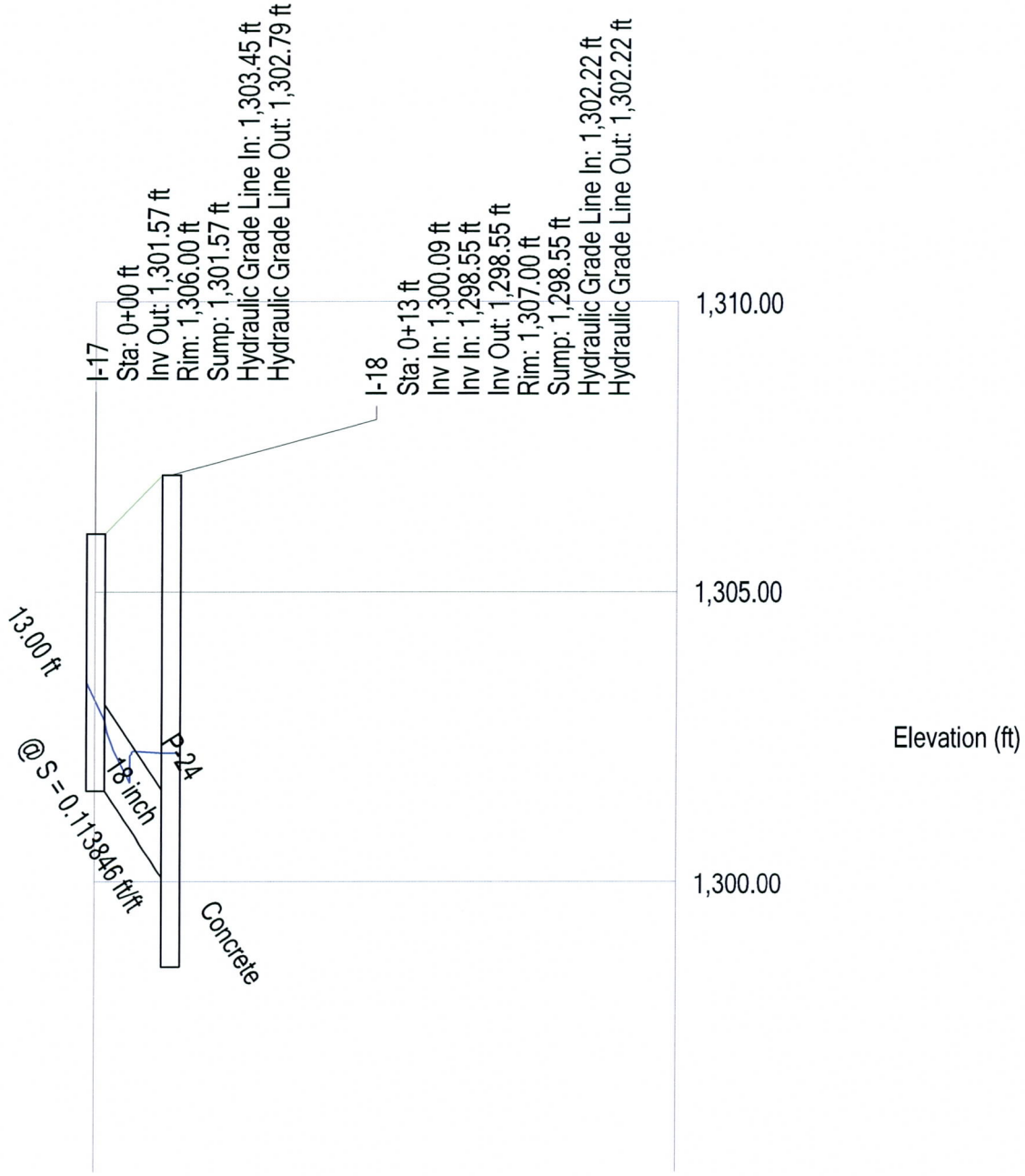
# Profile: LPP 10+60 LT

## Scenario: Base



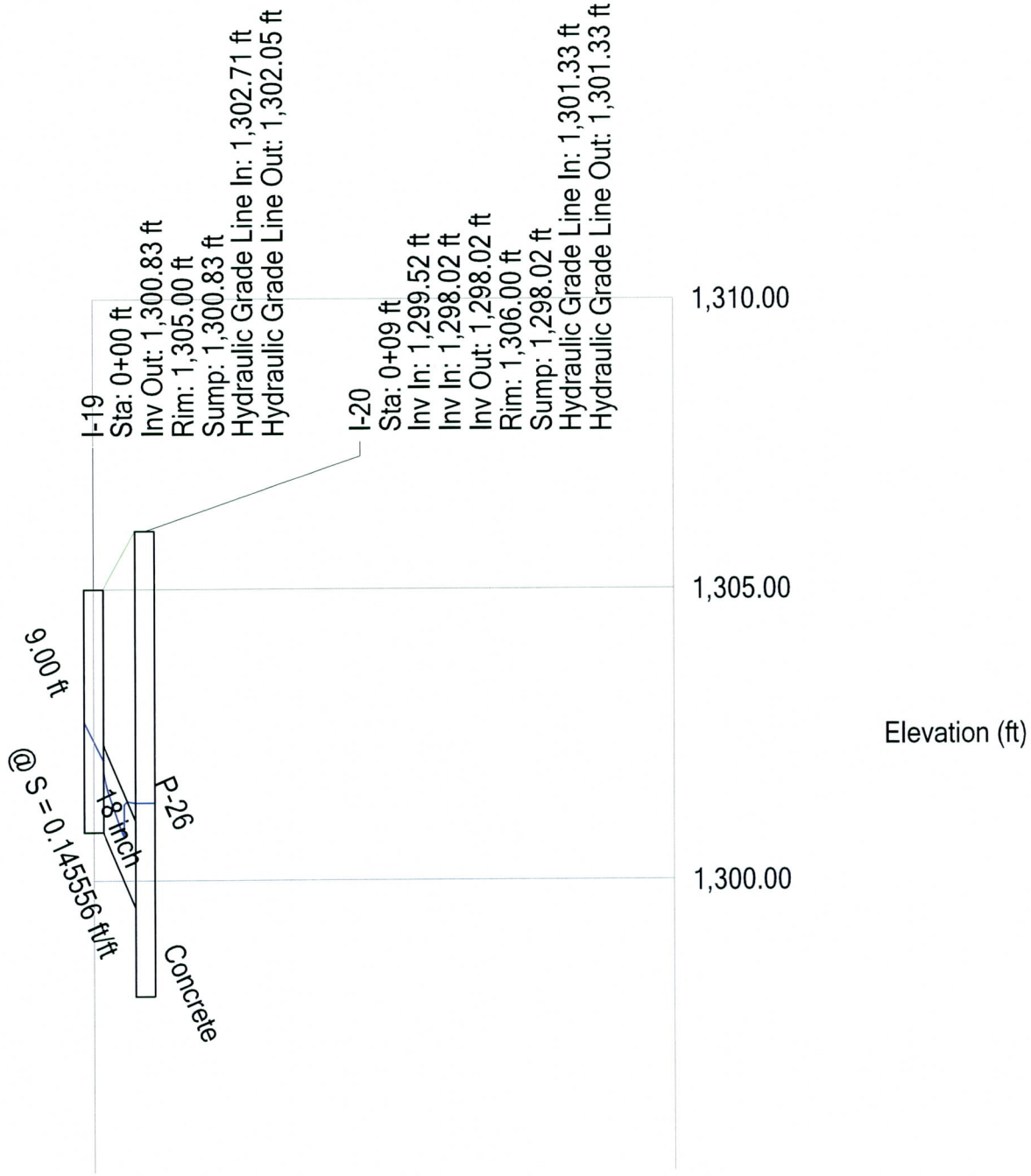
# Profile: Area Drain 52+50

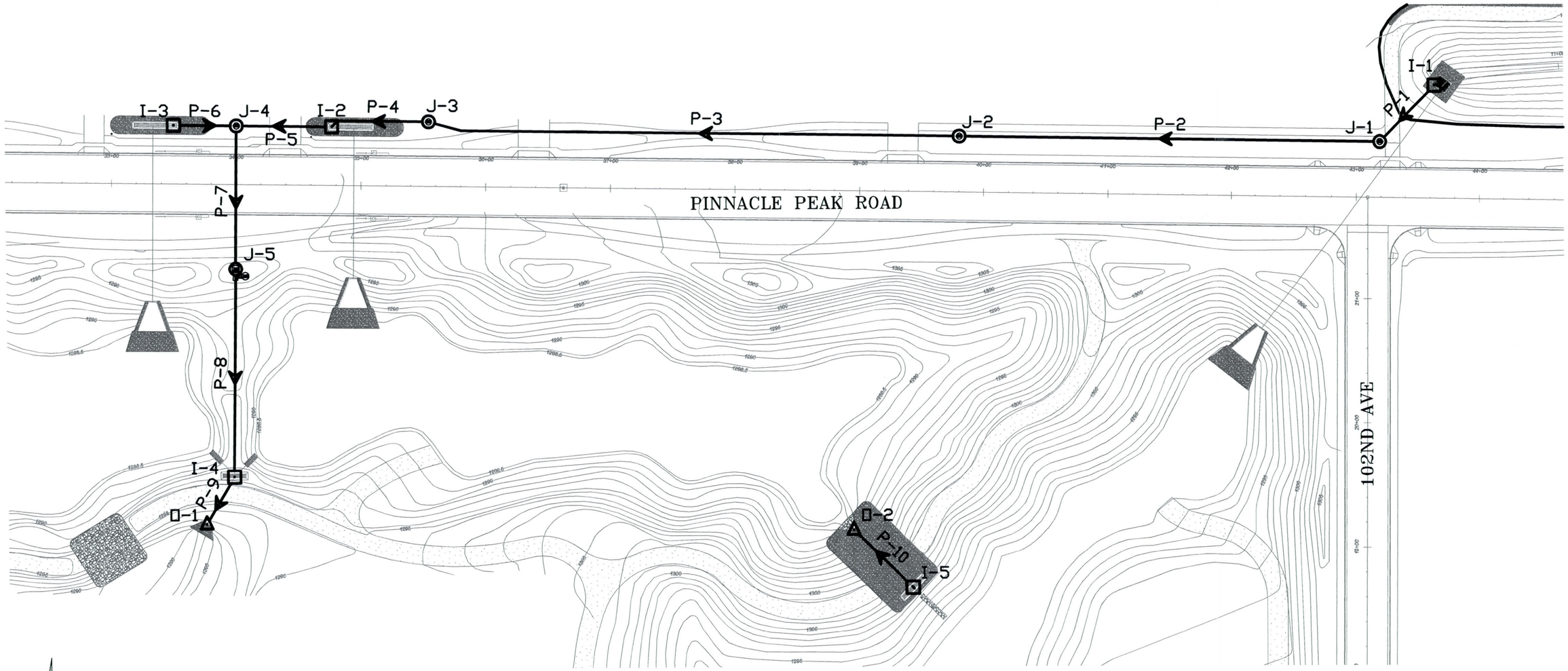
## Scenario: Base



# Profile: Area Drain 50+00

## Scenario: Base






N

PRELIMINARY
NOT FOR CONSTRUCTION

80 0 40 80

Horz. 1 in. = 80 ft.

# PINNACLE PEAK LOW FLOW STORM DRAIN

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## Scenario: No Basin Flow

## Pipe Report

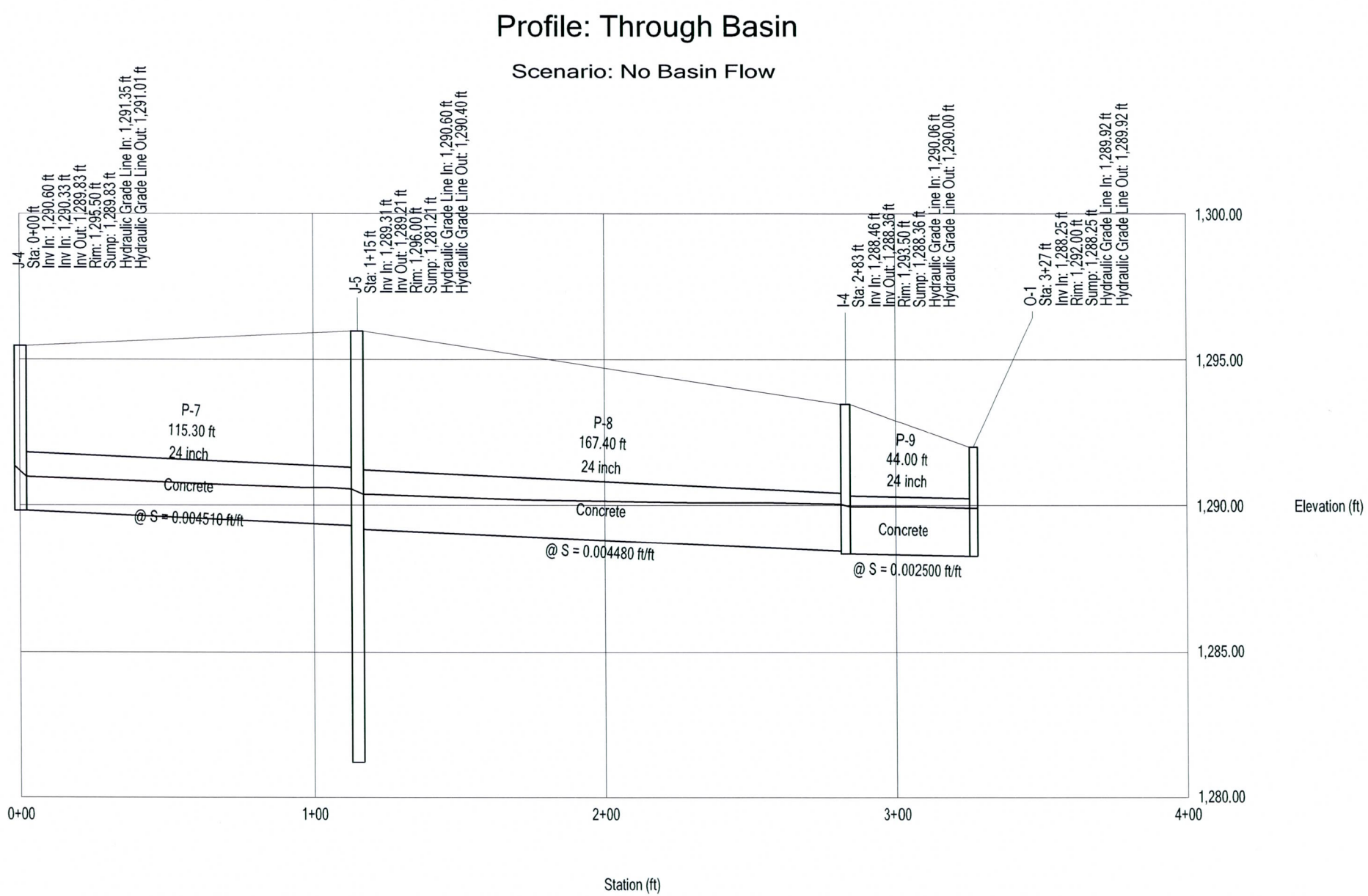
| Label | Upstream Node | Downstream Node | Length (ft) | Constructed Slope (ft/ft) | Section Size | Total System Flow (cfs) | Mannings n | Upstream Invert Elevation (ft) | Downstream Invert Elevation (ft) | Upstream Ground Elevation (ft) | Downstream Ground Elevation (ft) | Hydraulic Grade Line In (ft) | Hydraulic Grade Line Out (ft) | Velocity In (ft/s) | Velocity Out (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1 | I-1 | J-1 | 63.60 | 0.002673 | 18 inch | 5.00 | 0.013 | 1,293.40 | 1,293.23 | 1,302.00 | 1,304.70 | 1,294.58 | 1,294.43 | 3.36 | 3.30 |
| P-2 | J-1 | J-2 | 338.50 | 0.002718 | 18 inch | 5.00 | 0.013 | 1,293.13 | 1,292.21 | 1,304.70 | 1,305.50 | 1,294.26 | 1,293.34 | 3.51 | 3.51 |
| P-3 | J-2 | J-3 | 427.00 | 0.002717 | 18 inch | 5.00 | 0.013 | 1,292.11 | 1,290.95 | 1,305.50 | 1,298.00 | 1,293.33 | 1,292.47 | 3.25 | 2.83 |
| P-4 | J-3 | I-2 | 79.60 | 0.002638 | 18 inch | 5.00 | 0.013 | 1,290.85 | 1,290.64 | 1,298.00 | 1,294.16 | 1,292.43 | 1,292.25 | 2.83 | 2.83 |
| P-5 | I-2 | J-4 | 76.30 | 0.002752 | 18 inch | 7.50 | 0.013 | 1,290.54 | 1,290.33 | 1,294.16 | 1,295.50 | 1,291.96 | 1,291.39 | 4.34 | 5.61 |
| P-6 | I-3 | J-4 | 50.50 | 0.007921 | 18 inch | 2.50 | 0.013 | 1,291.00 | 1,290.60 | 1,294.16 | 1,295.50 | 1,291.60 | 1,291.35 | 3.80 | 2.85 |
| P-7 | J-4 | J-5 | 115.30 | 0.004510 | 24 inch | 10.00 | 0.013 | 1,289.83 | 1,289.31 | 1,295.50 | 1,296.00 | 1,291.01 | 1,290.60 | 5.16 | 4.68 |
| P-8 | J-5 | I-4 | 167.40 | 0.004480 | 24 inch | 10.00 | 0.013 | 1,289.21 | 1,288.46 | 1,296.00 | 1,293.50 | 1,290.40 | 1,290.06 | 5.15 | 3.71 |
| P-9 | I-4 | O-1 | 44.00 | 0.002500 | 24 inch | 10.00 | 0.013 | 1,288.36 | 1,288.25 | 1,293.50 | 1,292.00 | 1,290.00 | 1,289.92 | 3.63 | 3.57 |
| P-10 | I-5 | O-2 | 67.00 | 0.022090 | 24 inch | 24.00 | 0.013 | 1,290.48 | 1,289.00 | 1,299.00 | 1,294.00 | 1,294.25 | 1,293.50 | 7.64 | 7.64 |

## Scenario: No Basin Flow

## Node Report

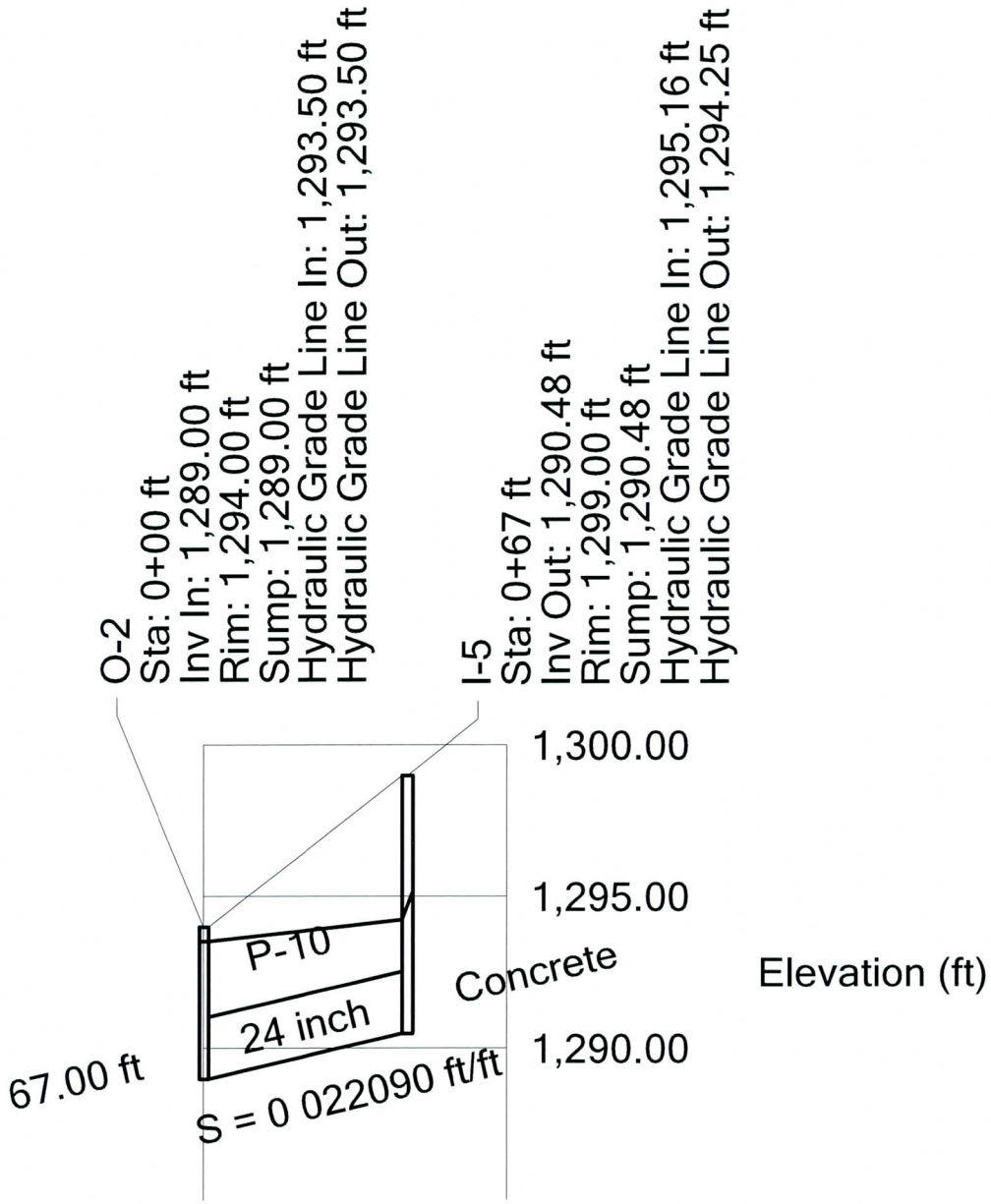
| Label | Element Type | Ground Elevation (ft) | Headloss Coefficient | Sump Elevation (ft) | Known Flow (cfs) | Hydraulic Grade Line In (ft) | Hydraulic Grade Line Out (ft) | Velocity In (ft/s) | Energy Grade Line In (ft) |
|---|---|---|---|---|---|---|---|---|---|
| I-1 | Inlet | 1,302.00 | 1.00 | 1,293.40 | 0.00 | 1,294.75 | 1,294.58 | 3.36 | 1,294.93 |
| I-2 | Inlet | 1,294.16 | 1.00 | 1,290.54 | 0.00 | 1,292.25 | 1,291.96 | 4.34 | 1,292.54 |
| I-3 | Inlet | 1,294.16 | 1.00 | 1,291.00 | 0.00 | 1,291.82 | 1,291.60 | 3.80 | 1,292.05 |
| I-4 | Inlet | 1,293.50 | 0.30 | 1,288.36 | 0.00 | 1,290.06 | 1,290.00 | 3.63 | 1,290.26 |
| I-5 | Inlet | 1,299.00 | 1.00 | 1,290.48 | 0.00 | 1,295.16 | 1,294.25 | 7.64 | 1,296.07 |
| J-1 | Junction | 1,304.70 | 0.90 | 1,293.13 | | 1,294.43 | 1,294.26 | 3.51 | 1,294.62 |
| J-2 | Junction | 1,305.50 | 0.05 | 1,292.11 | | 1,293.34 | 1,293.33 | 3.25 | 1,293.50 |
| J-3 | Junction | 1,298.00 | 0.30 | 1,290.85 | | 1,292.47 | 1,292.43 | 2.83 | 1,292.59 |
| J-4 | Junction | 1,295.50 | 0.80 | 1,289.83 | | 1,291.35 | 1,291.01 | 5.16 | 1,291.76 |
| J-5 | Junction | 1,296.00 | | 1,281.21 | | 1,290.60 | 1,290.40 | 5.15 | 1,291.01 |
| O-1 | Outlet | 1,292.00 | | 1,288.25 | | 1,289.92 | 1,289.92 | 0.00 | 1,289.92 |
| O-2 | Outlet | 1,294.00 | | 1,289.00 | | 1,293.50 | 1,293.50 | 0.00 | 1,293.50 |

# Profile
## Scenario: No Basin Flow



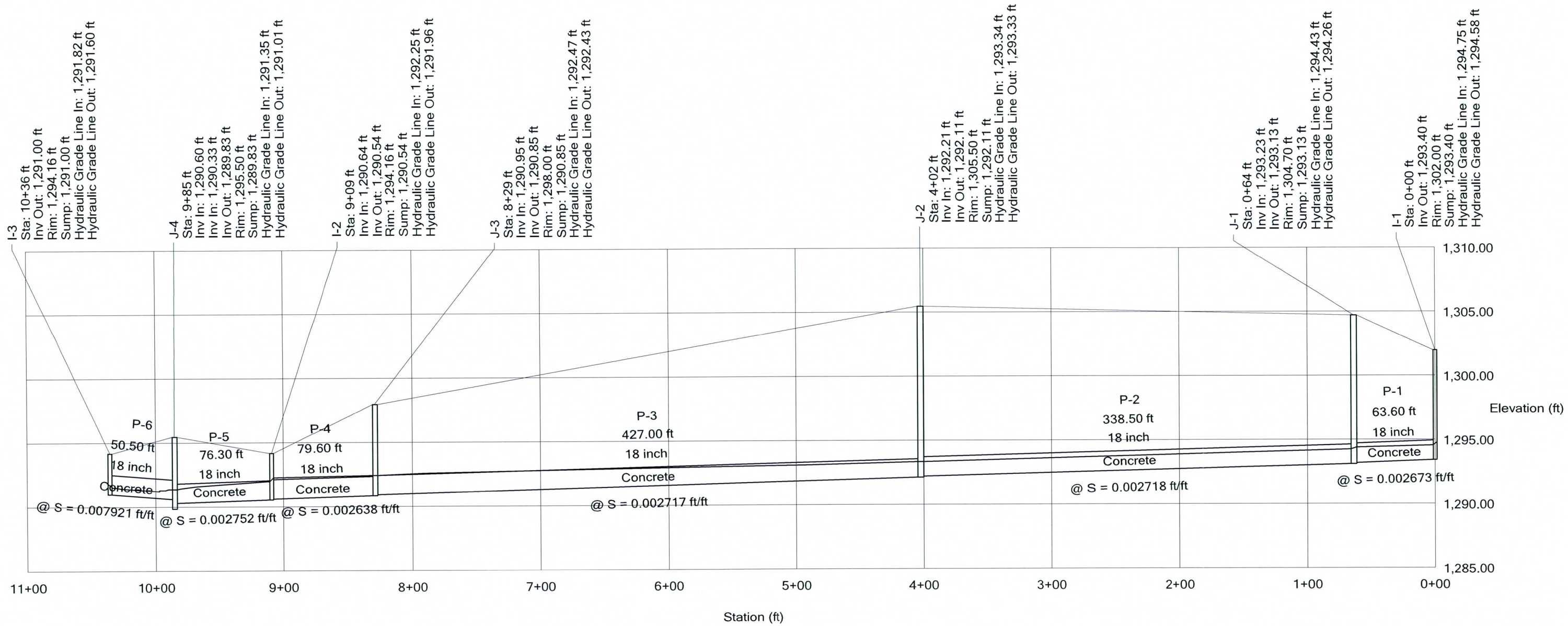
# Profile: East Basin Outlet

## Scenario: No Basin Flow



# Profile: Along Road

## Scenario: No Basin Flow



HY-8

# SPREADSHEETS

Pinnacle Peak Drainage Project
Open Channel Design
Velocity and Capacity Check

| | | | | | Design (n=0.04) | | | Velocity Check (n=0.022) | | | | Capacity Check (n=0.055) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel | River Sta | Q Total (cfs) | Min Ch El (ft) | Soil Type (1) | W.S. Elev (ft) | Vel Chnl (ft/s) | Froude # Chl | W.S. Elev (ft) | Vel Chnl (ft/s) | Allowed Vel (2) (ft/s) | Froude # Chl | W.S. Elev (ft) | Depth |
| East | 1700 | 37 | 1309.38 | Silty Sand | 1310.44 | 2.8 | 0.57 | 1310.14 | 4.4 | 5.0 | 1.01 | 1310.70 | |
| East | 1600 | 97 | 1307.73 | | 1309.63 | 2.8 | 0.47 | 1309.17 | 4.4 | | 0.83 | 1309.89 | |
| East | 1500 | 97 | 1307.17 | | 1309.06 | 2.7 | 0.47 | 1308.70 | 4.0 | | 0.74 | 1309.27 | |
| East | 1400 | 97 | 1306.78 | | 1308.26 | 4.1 | 0.79 | 1308.10 | 5.1 | | 1.01 | 1308.47 | |
| East | 1350 | 97 | 1306.65 | | 1308.15 | 2.8 | 0.47 | 1308.08 | 2.9 | | 0.51 | 1308.22 | |
| East | 1300 | 97 | 1306.51 | | 1308.11 | 2.0 | 0.31 | 1308.11 | 2.0 | | 0.31 | 1308.11 | |
| East | 1200 | 97 | 1303.01 | | 1308.03 | 2.9 | 0.24 | 1308.03 | 2.9 | | 0.24 | 1308.03 | |
| East | 1150 | Culvert | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| West | 700 | 131 | 1297.91 | Silty Gravel | 1300.81 | 2.6 | 0.37 | 1300.22 | 3.9 | 5.0 | 0.62 | 1301.17 | |
| West | 600 | 131 | 1297.27 | | 1300.28 | 2.4 | 0.33 | 1299.91 | 3.1 | | 0.45 | 1300.57 | |
| West | 500 | 131 | 1296.75 | | 1299.91 | 2.1 | 0.29 | 1299.77 | 2.3 | | 0.32 | 1300.06 | |
| West | 400 | 131 | 1296.44 | | 1299.72 | 2.1 | 0.28 | 1299.72 | 2.1 | | 0.28 | 1299.73 | |
| West | 300 | 131 | 1294.75 | | 1299.62 | 3.1 | 0.26 | 1299.62 | 3.1 | | 0.26 | 1299.62 | |
| West | 250 | Culvert | | | | | | | | | | | |

(1) Soil type per Ninyo & Moore, *Preliminary Geotechnical Evaluation Pinnacle Peak Road and Channel*, December 1, 2009.
(2) Allowed Velocity per Flood Control District of Maricopa County, *Drainage Design Manual Hydraulics*, March 2009, Table 6.2.

***Grated Inlet Capacity***

Seven MAG 537 double (4' x 2' each) grated inlets will be used at two locations immediately upstream of the west basin. The design flow at this location in 196 cfs. The two inlets locations are designed to capture up to 250 cfs combined. The structure inlet elevation is 1294.36. A depth of 1.2' is required to capture 125 csf at each location. The WSEl at the inlet will be 1295.56 which is below the existing condition WSEL upstream of Pinnacle Peak Road (1296.51) per HEC-RAS model.

**Weir EQ.** $Q_i = C_w P d^{1.5} Cf$

**Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} Cf$

**MAG 537 - Double Catch Basins**
**Modified MAG 539 - Double Grates**

**Note: Calculations for 7 double catch basins side by side.**

| 4" Vertical Opening (below grate) | | | Grate | | | Design Capacity |
|---|---|---|---|---|---|---|
| Opening Height (in) = 4.0<br>Cw = 3.0<br>P (ft) = 60<br>Area (ft^2) = 20.0<br>Cf = 0.8 | | | Co = 0.67<br>P (ft) = 44.38<br>Area (ft^2)= 33.83<br>Cf = 0.5 | | | Total 4" Vertical Opening + Grate Capacity |
| d (ft) | Weir (cfs) | Orifice (cfs) | d (ft) | Weir (cfs) | Orifice (cfs) | (cfs) |
| 0.00 | 0.00 | 0.00 | | | | 0.00 |
| 0.10 | 4.55 | 27.20 | | | | 4.55 |
| 0.20 | 12.88 | 38.47 | | | | 12.88 |
| 0.30 | 23.66 | 47.12 | | | | 23.66 |
| 0.40 | 36.43 | 54.41 | | | | 36.43 |
| 0.50 | 50.91 | 60.83 | 0.00 | 0.00 | 0.00 | 50.91 |
| 0.60 | 66.93 | 66.64 | 0.10 | 2.11 | 28.76 | 68.74 |
| 0.70 | 84.34 | 71.98 | 0.20 | 5.95 | 40.67 | 77.93 |
| 0.80 | 103.04 | 76.95 | 0.30 | 10.94 | 49.81 | 87.88 |
| 0.90 | 122.95 | 81.61 | 0.40 | 16.84 | 57.52 | 98.45 |
| 1.00 | 144.00 | 86.03 | 0.50 | 23.54 | 64.31 | 109.56 |
| 1.10 | 166.13 | 90.23 | 0.60 | 30.94 | 70.45 | 121.17 |
| **1.20** | **189.29** | **94.24** | **0.70** | **38.99** | **76.09** | **133.23** |
| 1.30 | 213.44 | 98.09 | 0.80 | 47.63 | 81.35 | 145.72 |
| 1.40 | 238.54 | 101.79 | 0.90 | 56.84 | 86.28 | 158.63 |
| 1.50 | 264.54 | 105.36 | 1.00 | 66.57 | 90.95 | 171.93 |
| 1.60 | 291.44 | 108.82 | 1.10 | 76.80 | 95.39 | 185.62 |
| 1.70 | 319.18 | 112.17 | 1.20 | 87.51 | 99.63 | 199.67 |
| 1.80 | 347.75 | 115.42 | 1.30 | 98.67 | 103.70 | 214.09 |
| 1.90 | 377.13 | 118.58 | 1.40 | 110.27 | 107.61 | 226.19 |
| 2.00 | 407.29 | 121.66 | 1.50 | 122.30 | 111.39 | 233.05 |
| 2.10 | 438.22 | 124.67 | 1.60 | 134.73 | 115.04 | 239.71 |
| 2.20 | 469.89 | 127.60 | 1.70 | 147.55 | 118.58 | 246.18 |
| 2.30 | 502.29 | 130.47 | 1.80 | 160.76 | 122.02 | 252.49 |
| 2.40 | 535.40 | 133.27 | 1.90 | 174.34 | 125.36 | 258.64 |
| 2.50 | 569.21 | 136.02 | 2.00 | 188.29 | 128.62 | 264.64 |

## ***Grated Spillway Inlet Capacity***

Five MAG 537 double (4' x 2' each) grated inlets will be used for the spillway design flow of 24 cfs from the east basin to the west basin. Four MAG 537 double grated inlets will be used for the spillway design flow of 19 cfs into the downstream Ironwood Channel. Only three sides of the catch basin will be used for weir inlet calculations. Since the maximum head available is only 0.5', weir capacity will control.

**Weir EQ.** $Q_i = C_w P d^{1.5} Cf$
**Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} Cf$

**MAG 537 - Double Catch Basins**
**Modified MAG 539 - Double Grates**

**4 double catch basins side by side.**

**4" Vertical Opening (below grate)**

**Opening Height (in) = 4.0**
**Cw = 3.0**
**P (ft) = 21.46**
**Area (ft^2) = 42.9**
**Cf = 0.8**

| d (ft) | Weir (cfs) | Orifice (cfs) |
|---|---|---|
| 0.00 | 0.00 | 0.00 |
| 0.10 | 1.63 | 58.38 |
| 0.20 | 4.61 | 82.56 |
| 0.30 | 8.46 | 101.12 |
| 0.40 | 13.03 | 116.76 |
| 0.50 | 18.21 | 130.54 |
| 0.60 | 23.94 | 143.00 |

**5 double catch basins side by side.**

**4" Vertical Opening (below grate)**

**Opening Height (in) = 4.0**
**Cw = 3.0**
**P (ft) = 25.92**
**Area (ft^2) = 43.8**
**Cf = 0.8**

| d (ft) | Weir (cfs) | Orifice (cfs) |
|---|---|---|
| 0.00 | 0.00 | 0.00 |
| 0.10 | 1.97 | 59.63 |
| 0.20 | 5.56 | 84.33 |
| 0.30 | 10.22 | 103.29 |
| 0.40 | 15.74 | 119.26 |
| 0.50 | 21.99 | 133.34 |
| 0.60 | 28.91 | 146.07 |

**Weir EQ.** $Q_i = C_w P d^{1.5} Cf$

**Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} Cf$

**MAG 537 - Single Catch Basin**
**Modified MAG 539 - Single Grate**

| 4" Vertical Opening (below grate) | | | Grate | | | Design Capacity |
|---|---|---|---|---|---|---|
| Cw = 3.0<br>P (ft) = 8<br>Area (ft^2) = 2.67<br>Cf = 0.8 | | | Co = 0.67<br>P (ft) = 6.25<br>Area (ft^2)= 2.25<br>Cf = 0.5 | | | Total 4" Vertical Opening + Grate Capacity |
| d (ft) | Weir (cfs) | Orifice (cfs) | d (ft) | Weir (cfs) | Orifice (cfs) | (cfs) |
| 0.00 | 0.00 | 0.00 | | | | 0.00 |
| 0.10 | 0.61 | 3.63 | | | | 0.61 |
| 0.20 | 1.72 | 5.14 | | | | 1.72 |
| 0.30 | 3.15 | 6.29 | | | | 3.15 |
| 0.40 | 4.86 | 7.26 | | | | 4.86 |
| 0.50 | 6.79 | 8.12 | 0.00 | 0.00 | 0.00 | 6.79 |
| 0.60 | 8.92 | 8.90 | 0.10 | 0.30 | 1.91 | 9.19 |
| 0.70 | 11.24 | 9.61 | 0.20 | 0.84 | 2.71 | 10.45 |
| 0.80 | 13.74 | 10.27 | 0.30 | 1.54 | 3.31 | 11.81 |
| 0.90 | 16.39 | 10.90 | 0.40 | 2.37 | 3.83 | 13.27 |
| 1.00 | 19.20 | 11.48 | 0.50 | 3.31 | 4.28 | 14.80 |
| 1.10 | 22.15 | 12.05 | 0.60 | 4.36 | 4.69 | 16.40 |
| 1.20 | 25.24 | 12.58 | 0.70 | 5.49 | 5.06 | 17.64 |
| 1.30 | 28.46 | 13.09 | 0.80 | 6.71 | 5.41 | 18.50 |
| 1.40 | 31.80 | 13.59 | 0.90 | 8.00 | 5.74 | 19.33 |
| **1.50** | **35.27** | **14.07** | **1.00** | **9.38** | **6.05** | **20.11** |
| 1.60 | 38.86 | 14.53 | 1.10 | 10.82 | 6.34 | 20.87 |
| 1.70 | 42.56 | 14.97 | 1.20 | 12.32 | 6.63 | 21.60 |
| 1.80 | 46.37 | 15.41 | 1.30 | 13.90 | 6.90 | 22.31 |
| 1.90 | 50.28 | 15.83 | 1.40 | 15.53 | 7.16 | 22.99 |
| 2.00 | 54.31 | 16.24 | 1.50 | 17.22 | 7.41 | 23.65 |
| 2.10 | 58.43 | 16.64 | 1.60 | 18.97 | 7.65 | 24.29 |
| 2.20 | 62.65 | 17.03 | 1.70 | 20.78 | 7.89 | 24.92 |
| 2.30 | 66.97 | 17.42 | 1.80 | 22.64 | 8.12 | 25.53 |
| 2.40 | 71.39 | 17.79 | 1.90 | 24.55 | 8.34 | 26.13 |
| 2.50 | 75.89 | 18.16 | 2.00 | 26.52 | 8.55 | 26.71 |

**Weir EQ.** $Q_i = C_w P d^{1.5} Cf$

**Orifice EQ.** $Q_i = C_o A (2gd)^{0.5} Cf$

**MAG 537 - Double Catch Basins**
**Modified MAG 539 - Double Grates**

**Note: Calculations for 8 double catch basins side by side.**

| 4" Vertical Opening (below grate) | | | Grate | | | Design Capacity |
|---|---|---|---|---|---|---|
| Opening Height (in) = 4.0<br>Cw = 3.0<br>P (ft) = 68<br>Area (ft^2) = 22.7<br>Cf = 0.8 | | | Co = 0.67<br>P (ft) = 50.22<br>Area (ft^2)= 38.66<br>Cf = 0.5 | | | Total 4" Vertical Opening + Grate Capacity |
| d (ft) | Weir (cfs) | Orifice (cfs) | d (ft) | Weir (cfs) | Orifice (cfs) | (cfs) |
| 0.00 | 0.00 | 0.00 | | | | 0.00 |
| 0.10 | 5.16 | 30.83 | | | | 5.16 |
| 0.20 | 14.60 | 43.60 | | | | 14.60 |
| 0.30 | 26.82 | 53.40 | | | | 26.82 |
| 0.40 | 41.29 | 61.66 | | | | 41.29 |
| 0.50 | 57.70 | 68.94 | 0.00 | 0.00 | 0.00 | 57.70 |
| 0.60 | 75.85 | 75.52 | 0.10 | 2.38 | 32.87 | 77.90 |
| 0.70 | 95.58 | 81.57 | 0.20 | 6.74 | 46.48 | 88.31 |
| 0.80 | 116.78 | 87.20 | 0.30 | 12.38 | 56.93 | 99.58 |
| 0.90 | 139.34 | 92.49 | 0.40 | 19.06 | 65.73 | 111.55 |
| 1.00 | 163.20 | 97.50 | 0.50 | 26.63 | 73.49 | 124.13 |
| 1.10 | 188.28 | 102.26 | 0.60 | 35.01 | 80.51 | 137.27 |
| **1.20** | **214.53** | **106.80** | **0.70** | **44.12** | **86.96** | **150.92** |
| 1.30 | 241.90 | 111.16 | 0.80 | 53.90 | 92.96 | 165.07 |
| 1.40 | 270.34 | 115.36 | 0.90 | 64.32 | 98.60 | 179.68 |
| 1.50 | 299.82 | 119.41 | 1.00 | 75.33 | 103.93 | 194.74 |
| 1.60 | 330.29 | 123.33 | 1.10 | 86.91 | 109.00 | 210.23 |
| 1.70 | 361.74 | 127.12 | 1.20 | 99.02 | 113.85 | 226.15 |
| 1.80 | 394.12 | 130.81 | 1.30 | 111.66 | 118.50 | 242.46 |
| 1.90 | 427.42 | 134.39 | 1.40 | 124.78 | 122.97 | 257.37 |
| 2.00 | 461.60 | 137.88 | 1.50 | 138.39 | 127.29 | 265.17 |
| 2.10 | 496.65 | 141.29 | 1.60 | 152.46 | 131.46 | 272.75 |
| 2.20 | 532.54 | 144.61 | 1.70 | 166.97 | 135.51 | 280.12 |
| 2.30 | 569.26 | 147.86 | 1.80 | 181.92 | 139.44 | 287.30 |
| 2.40 | 606.79 | 151.04 | 1.90 | 197.29 | 143.26 | 294.30 |
| 2.50 | 645.10 | 154.16 | 2.00 | 213.07 | 146.98 | 301.14 |

## Structure # 3 - 102nd Avenue and Pinnacle Peak Road

60" Pipe Inlet Structure and Access Barrier

| Access Barrier Computations | |
|---|---|
| **Rack Data** | |
| Panel Width (in) = | 30 |
| Bar Dia (in) = | 0.5 |
| Bar Spacing $C_L$ to $C_L$ (in) = | 5.9 |
| Open Area Space Between Bars (in) = | 5.4 |
| # of Spaces Between Bars= | 5 |
| Spacing Between Panels (in) = | 3 |
| Total Panel Width Including 1/2 Space Bet. Panels (in) = | 33 |
| Open Width Per Panel $W_P$ (ft) = | 2.50 |
| **Culvert Data** | |
| # Pipes = | 1 |
| Pipe Diameter (ft) = | 5 |
| Wall Thickness (in) = | 10 |
| Top Slab Thickness T (in) = | n/a |
| Area Pipe ($ft^2$) = | 19.6 |
| Min interior strutcure width [$\phi$ + 1.5'x(2)] = | 8.0 |
| Design Structure Interior Width = | 11.00 |
| Design Flow Q (cfs) = | 131 |
| **Panel Sizing Calculations** | |
| Rack/Culvert Open Area Ratio = | 3.75 |
| Required Rack Open Area $A_R$ ($ft^2$) = | 73.6 |
| Reduction Factor (% of Grate Clogged) = | 75% |
| Grate Open Area (% of Grate Not Clogged) = | 25% |
| Rack Open Area w/Clogging Factor Applied $A_{RC}$ ($ft^2$) = | 18.4 |
| # Panels (includes space between panels) = | 4.0 |
| Total Open Width for All Panels $W_{PT} = W_P$ * # Panels (ft) = | 10.0 |
| Panel Slope Length L = $A_R/W_{PT}$ (ft) = | 7.36 |
| Height (sill to WSEL) = | 3.18 |
| Horizontal Length from Sill (ft) = | 6.64 |
| Grate Installation Height = | 4.31 |
| ~ Horizontal Length from Culvert (ft) = | 9.00 |
| ~ Angle of Panel to Channel Bottom $\theta$ (degrees) = | 26 |
| **Head Loss Calculations** | |
| Gravitational Constant g ($ft/s^2$) = | 32.2 |
| Velocity Between Racks Vg = $Q/A_{RC}$ (ft/s) = | 7.1 |
| Approach velocity Va (ft/s) = | 2.8 |
| Hg = $1.5[Vg^2 - Va^2]/2g$ (ft) = | **1.00** |

**NOTE:**
Channel WSEL is below top of grate.
Calcs are based on slope length from sill to WSEL.

Channel WSEL = 1299.62
Sill Elev = 1296.44
Top of Grate Elevation = 1300.75

## Structure # 6 - 99th Lane and Pinnacle Peak Road

48" Pipe Inlet Structure and Access Barrier

| | |
|---|---|
| **Access Barrier Computations** | |
| **Rack Data** | |
| Panel Width (in) = | 30 |
| Bar Dia (in) = | 0.5 |
| Bar Spacing $C_L$ to $C_L$ (in) = | 5.9 |
| Open Area Space Between Bars (in) = | 5.4 |
| # of Spaces Between Bars= | 5 |
| Spacing Between Panels (in) = | 3 |
| Total Panel Width Including 1/2 Space Bet. Panels (in) = | 33 |
| Open Width Per Panel $W_P$ (ft) = | 2.50 |
| **Culvert Data** | |
| # Pipes = | 1 |
| Pipe Diameter (ft) = | 4 |
| Wall Thickness (in) = | 10 |
| Top Slab Thickness T (in) = | n/a |
| Area Pipe ($ft^2$) = | 12.6 |
| Min interior strutcure width [$\phi$ + 1.5'x(2)] = | 7.0 |
| Design Structure Interior Width = | 8.25 |
| Design Flow Q (cfs) = | 97 |
| **Panel Sizing Calculations** | |
| Rack/Culvert Open Area Ratio = | 5.45 |
| Required Rack Open Area $A_R$ ($ft^2$) = | 68.5 |
| Reduction Factor (% of Grate Clogged) = | 75% |
| Grate Open Area (% of Grate Not Clogged) = | 25% |
| Rack Open Area w/Clogging Factor Applied $A_{RC}$ ($ft^2$) = | 17.1 |
| # Panels (includes space between panels) = | 3.0 |
| Total Open Width for All Panels $W_{PT} = W_P$ * # Panels (ft) = | 7.5 |
| Panel Slope Length L = $A_R/W_{PT}$ (ft) = | 9.13 |
| Installation Height = | 1.49 |
| ~ Horizontal Length from Culvert (ft) = | 9.00 |
| ~ Angle of Panel to Channel Bottom $\theta$ (degrees) = | 9 |
| **Head Loss Calculations** | |
| Gravitational Constant g ($ft/s^2$) = | 32.2 |
| Velocity Between Racks Vg = $Q/A_{RC}$ (ft/s) = | 5.7 |
| Approach velocity Va (ft/s) = | 2.0 |
| Hg = $1.5[Vg^2 - Va^2]/2g$ (ft) = | **0.66** |

# WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS • CONSTRUCTION MANAGERS

PROJECT Pinnacle Peak Rd NO. 093386

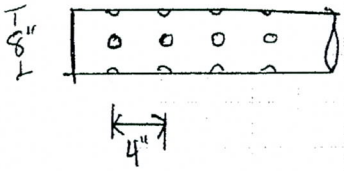
CALC'D BY DF CHK'D BY

SHEET 1 OF 1 DATE 4-8-10

Perforated Pipe Calcs for Retention Basins

- West Basin:

Per spreadsheet 'Drain time.xls', Effective area needed to drain basin < 36 hrs = 0.79 $ft^2$ = 114 $in^2$




4 holes (3/4" diameter) per row (⊥ to pipe axis)

Area per hole = $\pi(0.375)^2$ = 0.442 $in^2$

- Determine Length of pipe needed:

$$\frac{114\ in^2}{0.442} = 258 \text{ holes needed}$$

$$\frac{258 \text{ holes}}{4} = 64.5 \text{ rows } (4\ in) = 258\ in = 21.5\ ft$$

**Perforated Pipe = 22 LF**

- East Basin:

Effective area needed = 0.95 $ft^2$ = 137 $in^2$

$$\frac{137\ in^2}{0.442} = 310 \text{ holes needed}$$

$$\frac{310}{4 \text{ holes per row}} = 77.5 \text{ rows } (4") = 310\ in = 25.8\ ft$$

**Perforated pipe = 26 LF**

## TIME TO DRAIN CALCULATION

| | |
|---|---|
| Site: | Pinnacle Peak Road and Channel Imp |
| Location: | Peoria |
| Description: | Time to Drain Calculations |
| References: | City of Peoria, *Infrastructure Development Guidelines*, April, 2009.<br>Micheal R. Lindeburg, PE, *Civil Engineer Reference Manual*, 2001. |
| Date: | 4/6/2010 |

$$t = \frac{2 A_{bsn} (\sqrt{Z_1} - \sqrt{Z_2})}{C_d A_{orf} \sqrt{2g}}$$

**BASIN WEST**

| | | |
|---|---|---|
| **Bottom Area** | 80450 | $ft^2$ |
| **Top Area** | 148000 | $ft^2$ |
| **Depth** | 5 | ft |
| **$C_d$** | 0.6 | |
| **Effective Area Needed** | 0.79 | $ft^2$ |

| **Depth** [feet] | **Time required to drain step** [sec] | **Discharge Rate** [cfs] |
|---|---|---|
| 5.0 | 2645.32 | 8.5 |
| 4.9 | 2649.77 | 8.3 |
| 4.7 | 2655.02 | 8.2 |
| 4.6 | 2661.16 | 8.1 |
| 4.4 | 2668.27 | 7.9 |
| 4.3 | 2676.45 | 7.8 |
| 4.1 | 2685.80 | 7.7 |
| 4.0 | 2696.47 | 7.5 |
| 3.8 | 2708.58 | 7.4 |
| 3.7 | 2722.32 | 7.2 |
| 3.5 | 2737.87 | 7.1 |
| 3.4 | 2755.46 | 6.9 |
| 3.2 | 2775.36 | 6.8 |
| 3.1 | 2797.89 | 6.6 |
| 2.9 | 2823.40 | 6.4 |
| 2.8 | 2852.36 | 6.3 |
| 2.6 | 2885.31 | 6.1 |
| 2.5 | 2922.91 | 5.9 |
| 2.3 | 2965.98 | 5.7 |
| 2.2 | 3015.57 | 5.5 |
| 2.0 | 3072.99 | 5.3 |
| 1.9 | 3139.97 | 5.1 |
| 1.7 | 3218.76 | 4.9 |
| 1.6 | 3312.45 | 4.7 |
| 1.4 | 3425.33 | 4.5 |
| 1.3 | 3563.61 | 4.2 |
| 1.1 | 3736.63 | 4.0 |
| 1.0 | 3959.25 | 3.7 |
| 0.8 | 4256.89 | 3.4 |
| 0.7 | 4677.58 | 3.0 |
| 0.5 | 5326.78 | 2.7 |
| 0.4 | 6504.68 | 2.2 |
| 0.2 | 9833.40 | 1.7 |
| 0.0 | 9593.75 | 0.8 |
| **Total** | 122923 | sec |
| | 34 | Hours |
| **Max Discharge** | 8.5 | cfs |
| **Average Discharge** | 5.7 | cfs |

**BASIN EAST**

| | | |
|---|---|---|
| **Bottom Area** | 54000 | $ft^2$ |
| **Top Area** | 170900 | $ft^2$ |
| **Depth** | 8 | ft |
| **$C_d$** | 0.6 | |
| **Effective Area Needed** | 0.95 | $ft^2$ |

| **Depth** [feet] | **Time required to drain step** [sec] | **Discharge Rate** [cfs] |
|---|---|---|
| 8.0 | 3193.25 | 10.7 |
| 7.8 | 3176.48 | 10.5 |
| 7.5 | 3159.96 | 10.4 |
| 7.3 | 3143.75 | 10.2 |
| 7.0 | 3127.88 | 10.0 |
| 6.8 | 3112.41 | 9.9 |
| 6.6 | 3097.40 | 9.7 |
| 6.3 | 3082.92 | 9.5 |
| 6.1 | 3069.04 | 9.3 |
| 5.8 | 3055.86 | 9.1 |
| 5.6 | 3043.50 | 8.9 |
| 5.4 | 3032.08 | 8.8 |
| 5.1 | 3021.75 | 8.6 |
| 4.9 | 3012.69 | 8.4 |
| 4.6 | 3005.14 | 8.1 |
| 4.4 | 2999.36 | 7.9 |
| 4.2 | 2995.68 | 7.7 |
| 3.9 | 2994.51 | 7.5 |
| 3.7 | 2996.35 | 7.3 |
| 3.4 | 3001.86 | 7.0 |
| 3.2 | 3011.88 | 6.8 |
| 3.0 | 3027.49 | 6.5 |
| 2.7 | 3050.17 | 6.2 |
| 2.5 | 3081.91 | 6.0 |
| 2.2 | 3125.56 | 5.7 |
| 2.0 | 3185.21 | 5.3 |
| 1.8 | 3267.14 | 5.0 |
| 1.5 | 3381.39 | 4.7 |
| 1.3 | 3545.31 | 4.3 |
| 1.0 | 3791.97 | 3.9 |
| 0.8 | 4194.67 | 3.4 |
| 0.6 | 4964.12 | 2.8 |
| 0.3 | 7253.81 | 2.1 |
| 0.1 | 6820.26 | 1.1 |
| **Total** | 117023 | sec |
| | 33 | Hours |
| **Max Discharge** | 10.7 | cfs |
| **Average Discharge** | 7.2 | cfs |

Pinnacle Peak Drainage Project
Storm Drain Summary

| Upstream | | | Downstream | | | | Pipe | Pipe | Pipe | Upstream | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure | Station | Offset (ft) | Structure | Station | Offset (ft) | Pipe Size (in) | Length (ft) | Slope (ft/ft) | Material | Invert Elev (ft) | Rim Elev (ft) | Cover (ft) | Invert Elev |
| Struc #3 | 43+67.3 | 87.5 LT | MAG 501-3 | 42+26.2 | 107.0 RT | 60 | 240 | 0.0124 | Concrete | 1294.8 | 1302.0 | 2.3 | |
| MH #1 | 53+19.1 | 55.3 LT | MAG 501-3 | 49+48.3 | 86.5 LT | 54 | 401 | 0.0020 | Concrete | 1298.7 | 1307.4 | 4.2 | |
| Struc #4 | 53+35.8 | 88.6 LT | MH #1 | 53+19.1 | 55.3 LT | 54 | 36 | 0.0021 | Concrete | 1298.9 | 1307.0 | 3.6 | |
| MH #2 | 56+08.2 | 76.7 LT | Struc #5 | 55+60.6 | 87.4 LT | 48 | 43 | 0.0230 | Concrete | 1301.2 | 1308.4 | 3.2 | |
| Struc #6 | 58+26.4 | 95.4 LT | MH #2 | 56+08.2 | 76.7 LT | 48 | 202 | 0.0090 | Concrete | 1303.0 | 1309.3 | 2.3 | |
| MAG 537 | 61+85.0 | 41.0 LT | MAG 545 | 61+85.0 | 77.0 LT | 18 | 36 | 0.0167 | Concrete | 1309.0 | 1312.4 | 1.9 | |
| MAG 537 | 55+93.8 | 60.0 LT | NPI | 56+00.0 | 78.8 LT | 18 | 20 | 0.0380 | Concrete | 1303.0 | 1306.5 | 2.0 | |
| MAG 537 | 55+72.5 | 116.0 LT | NPI | 55+75.4 | 86.5 LT | 36 | 32 | 0.0256 | Concrete | 1301.8 | 1306.5 | 1.7 | |
| MAG 537 | 53+41.7 | 129.2 LT | Struc #4 | 53+37.7 | 93.7 LT | 30 | 37 | 0.0095 | Concrete | 1300.6 | 1305.0 | 2.0 | |
| MAG 537 | 52+49.2 | 52.2 LT | NPI | 52+49.2 | 43.2 LT | 18 | 9 | 0.1469 | Concrete | 1301.6 | 1306.3 | 3.2 | |
| MAG 537 | 49+97.7 | 69.0 LT | NPI | 49+97.7 | 63.9 LT | 18 | 6 | 0.0189 | Concrete | 1300.8 | 1305.0 | 2.7 | |
| Struc #1 | 33+49.5 | 47.3 LT | MH #3 | 34+00.0 | 47.3 LT | 18 | 51 | 0.0079 | Concrete | 1291.0 | 1294.0 | 1.5 | |
| Struc #2 | 34+77.3 | 47.3 LT | MH #3 | 34+00.0 | 47.3 LT | 18 | 78 | 0.0028 | Concrete | 1291.2 | 1294.0 | 1.3 | |
| MH #4 | 35+53.9 | 52.0 LT | Struc #2 | 34+77.3 | 47.3 LT | 18 | 80 | 0.0028 | Concrete | 1290.9 | 1298.0 | 5.6 | |
| MH #5 | 39+80.0 | 45.0 LT | MH #4 | 35+53.9 | 52.0 LT | 18 | 427 | 0.0027 | Concrete | 1292.1 | 1305.5 | 11.9 | |
| MH #6 | 43+02.6 | 45.0 LT | MH #5 | 39+80.0 | 45.0 LT | 18 | 339 | 0.0028 | Concrete | 1293.1 | 1304.7 | 10.1 | |
| Struc #3 | 43+62.6 | 90.8 LT | MH #6 | 43+02.6 | 45.0 LT | 18 | 64 | 0.0029 | Concrete | 1293.4 | 1302.0 | 7.1 | |
| MH #3 | 34+00.0 | 47.3 LT | Quality | 34+00.0 | 68.0 RT | 24 | 116 | 0.0045 | Concrete | 1289.8 | 1295.5 | 3.7 | |
| Quality | 34+00.0 | 68.0 RT | Struc #7 | 34+00.0 | 234.4 RT | 24 | 168 | 0.0045 | Concrete | 1289.2 | 1296.0 | 4.8 | |
| Struc #7 | 34+00.0 | 234.4 RT | MAG 501-1 | 33+76.1 | 273.5 RT | 24 | 44 | 0.0025 | Concrete | 1288.4 | 1293.5 | 3.1 | |
| Struc #1 | 33+33.0 | 46.3 LT | MAG 501-3 | 33+33.0 | 95.0 RT | 48 | 141 | 0.0021 | Concrete | 1288.8 | 1294.0 | 1.2 | |
| Struc #2 | 34+94.0 | 46.3 LT | MAG 501-3 | 34+94.0 | 74.8 RT | 48 | 121 | 0.0025 | Concrete | 1288.8 | 1294.0 | 1.2 | |
| Struc #8 | 39+45.8 | 297.7 RT | MAG 501-1 | 38+97.6 | 252.6 RT | 24 | 65 | 0.0227 | Concrete | 1290.5 | 1299.0 | 6.5 | |
| MAG 427 | 15+44.2 | 30.0 RT | MAG 501-1 | 15+97.5 | 73.3 RT | 18 | 69 | 0.0327 | Concrete | 1290.9 | 1297.6 | 5.2 | |
| MAG 427 | 15+82.1 | 30.0 LT | MAG 501-1 | 16+34.7 | 292.2 LT | 18 | 268 | 0.0259 | Concrete | 1297.9 | 1303.0 | 3.6 | |

# ROSE GARDEN LANE OUTFALL BASIN
# ANALYSIS AND DESIGN

# MEMO

**TO:** Jeff Minch, P.E.

**FROM:** Shimin Zou, Ph.D., P.E., CFM

**DATE:** October 14, 2010

**RE:** Pinnacle Peak Road and Channel Project
99th Avenue to the Agua Fria River
Contract FCD 2008C045
WP# 093386

**SUBJECT:** Estimation of Headcut / Tailcut due to Rose Garden Lane Drainage Basin Modification at the Agua Fria River

The Engineering Application Development and River Mechanics (EADRM) Branch of FCDMC documented their HEC-6 modeling procedures and modeling results for the Rose Garden Lane Basin within the Agua Fria River in a memo dated on December 18, 2009. It was concluded that the potential headcut and tailcut due to the proposed Rose Garden Lane drainage basin on Agua Fria River will not cause adverse impact on the adjacent properties. The entire FCD memo is attached.

Since the proposed Pinnacle Peak drainage improvements will divert additional flood water into the Rose Garden Lane basin, Wood/Patel was directed by the FCDMC to modify this basin to account for the additional flood volume. The purpose of this Memo is to document the modeling results for the modified basin following the procedures outlined in the EADRM Memo using HEC-6 models provided by the FCDMC.

**HEC-6 Modeling Results**

The proposed condition HEC-6 model was revised to reflect the modified basin geometry (modified basin is 12 ft deep) (REVSBASN.DAT in the CD at the back of this report) and the modeling results are shown in Table 1. The modeling results show that the worst scour occurs at the end of the flood. When the results are compared at cross-section 22.462 (the first cross-section upstream of the basin), the headcut in the revised proposed conditions is 1.06 ft and is about the same as in the existing conditions (1.08 ft). For downstream cross section 22.082, there is no tailcut in the revised proposed conditions and the maximum deposition is 0.06 ft, which is minimal. These modeling results meet the FCDMC's criterion as specified in the FCDMC's review comments (see attached for responses to the comments).

**Table 1 Rose Garden Lane Basin HEC-6 Modeling Results**

| Proposed (End of Flood) | | | Existing (End of Flood) | |
|---|---|---|---|---|
| | BED CHANGE | | | |
| SECTION NUMBER | FCDMC (ft) | REVSBASN.DAT (ft) | SECTION NUMBER | BED CHANGE (ft) |
| 23.409 | 0.04 | 0.02 | 23.409 | 0.05 |
| 22.935 | 0.04 | 0.06 | 22.935 | 0.03 |
| 22.462 | -1.29 | -1.06 | 22.462 | -1.08 |
| 22.368 | -1.74 | -2.07 | 22.368 | -0.61 |
| 22.336 | 3.00 | 3.84 | | |
| 22.322 | 2.89 | 3.62 | | |
| 22.273 | 4.04 | 4.09 | 22.273 | 0.88 |
| 22.177 | 0.75 | 0.53 | 22.177 | 0.42 |
| 22.109 | -0.30 | -0.30 | | |
| 22.082 | 0.09 | 0.06 | 22.082 | 2.08 |
| 21.986 | -0.11 | -0.11 | 21.986 | -0.12 |
| 21.893 | -0.53 | -0.53 | 21.893 | -0.52 |
| 21.798 | -0.20 | -0.20 | 21.798 | -0.19 |

**Conclusions**

The HEC-6 modeling results show that the modified Rose Garden Lane basin scour potentials are not significant and do not have significant adverse impact on adjacent properties.

However, as recommended in the EADRM Memo, a loose angular riprap or soil cement trench may be installed upstream of the basin slope near the existing and future power line towers or a maintenance plan should be in place to repair the headcut damage after each significant flood in the Agua Fria River to maintain the 50 ft maintenance radius for the power line towers.

W:\2009 Projects\093386 - Pinnacle Peak Road and Channel\Project Support\Reports\Final Drainage Submittal 10-15-10\Design Data Report\Rose Garden Basin Memo.doc

Wood, Patel & Associates, Inc.
2051 West Northern, Suite 100♦ Phoenix, Arizona 85021
Phone: (602) 335-8500 ♦ Fax: (602) 335-8580
E-Mail: woodpatel@woodpatel.com

# Flood Control District
of Maricopa County

**INTEROFFICE MEMORANDUM**

**Date:** December 18, 2009

**To:** Lynn Thomas, PE, Floodplain Permits Branch Manager, Floodplain Management and Services Division

**From:** Richard Waskowsky, Hydrologist, Engineering Application Development and River Mechanics Branch, Engineering Division

**Via:** Bing Zhao, PhD., P.E., Engineering Application Development and River Mechanics Branch Manager, Engineering Division

**Subject:** Verification of Headcut/tailcut due to Rose Garden Lane Drainage Basin at the Agua Fria River

The Engineering Application Development and River Mechanics (EADRM) Branch has verified that the potential headcut and tailcut due to the proposed Rose Garden Lane drainage basin on Agua Fria River will not cause adverse impact on the adjacent properties. However, since there is an existing APS power line tower and a future tower near the upstream side of the basin, it is recommended that a riprap trench be installed upstream of the basin slope. The following list presents the background information and steps that were used in this verification effort.

1) The report and construction plans by Wood Patel & Associates (October, 2008) were reviewed to assess the potential impact on the adjacent properties due to the proposed basin. The basin is about 10-feet deep (measured from 1200 feet contour line to 1190 feet contour line; 1200 feet contour line is the highest contour line that encloses the basin). It is located on Agua Fria River. The report's title is Rose Garden Lane Drainage Improvements Final Design Report prepared for City of Peoria and Flood Control District of Maricopa County.

2) The "existing conditions" and "proposed conditions" HEC-6 models are developed based upon a model for a sand and gravel permit application (SG06-007) downstream of Rose Garden Lane. Although the proposed Rose Garden Lane Drainage Basin is upstream of the Rose Garden Lane, the HEC-6 model for SG06-007 covers the area where Rose Garden Lane Drainage Basin is proposed.

3) In the existing and proposed conditions models, cross-section 19.862 was taken as the downstream cross-section. Therefore, the downstream rating curve was modified to match this cross-section. Three cross-sections (cross-sections 22.336, 22.322 and 22.177) were added to the proposed conditions model. These cross-sections were added to model the shape of the drainage basin. However, these sections were not added to the

existing conditions model. Please see Figure 1 for the general location of the cross-sections.

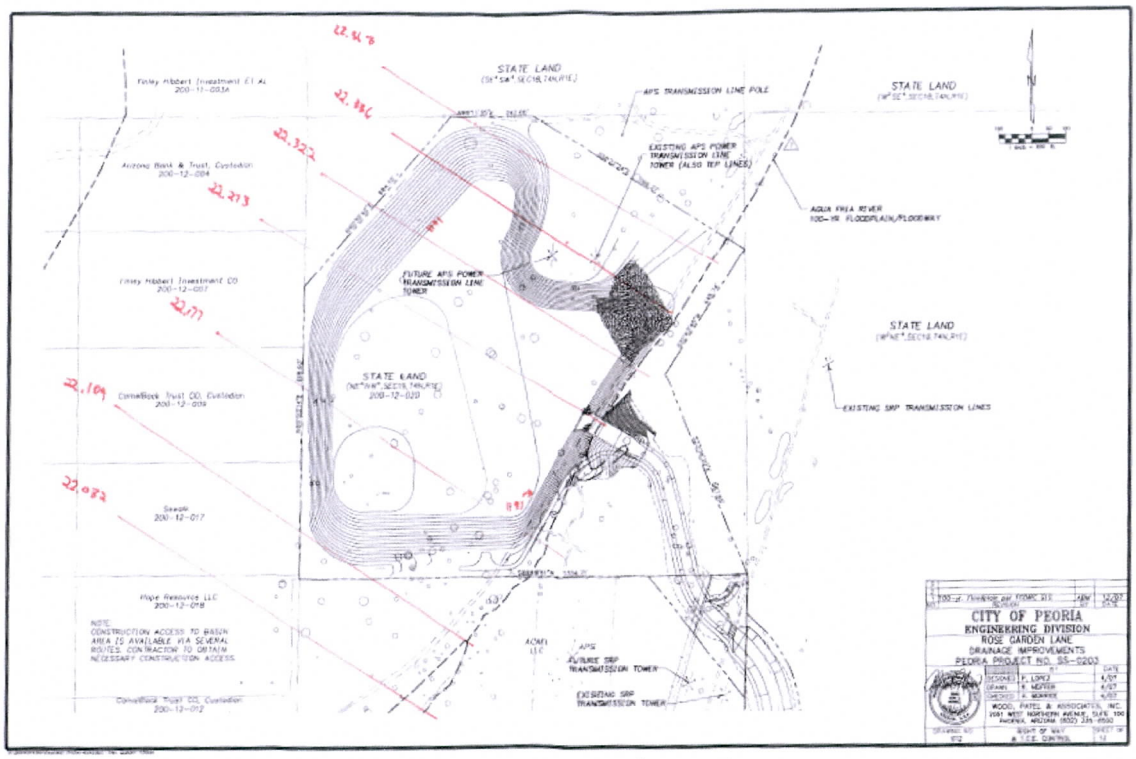



**Figure 1:** Sketch showing the locations of the cross-sections

4) In the existing and proposed conditions models, existing sand and gravel pits (located downstream of the drainage basin) were filled in the HEC-6 geometry. This modification was done to isolate the effects of the proposed drainage basin.

5) The 100-year hydrograph with a peak of 37,500 cfs was used as the input hydrology for both the existing and proposed conditions models.

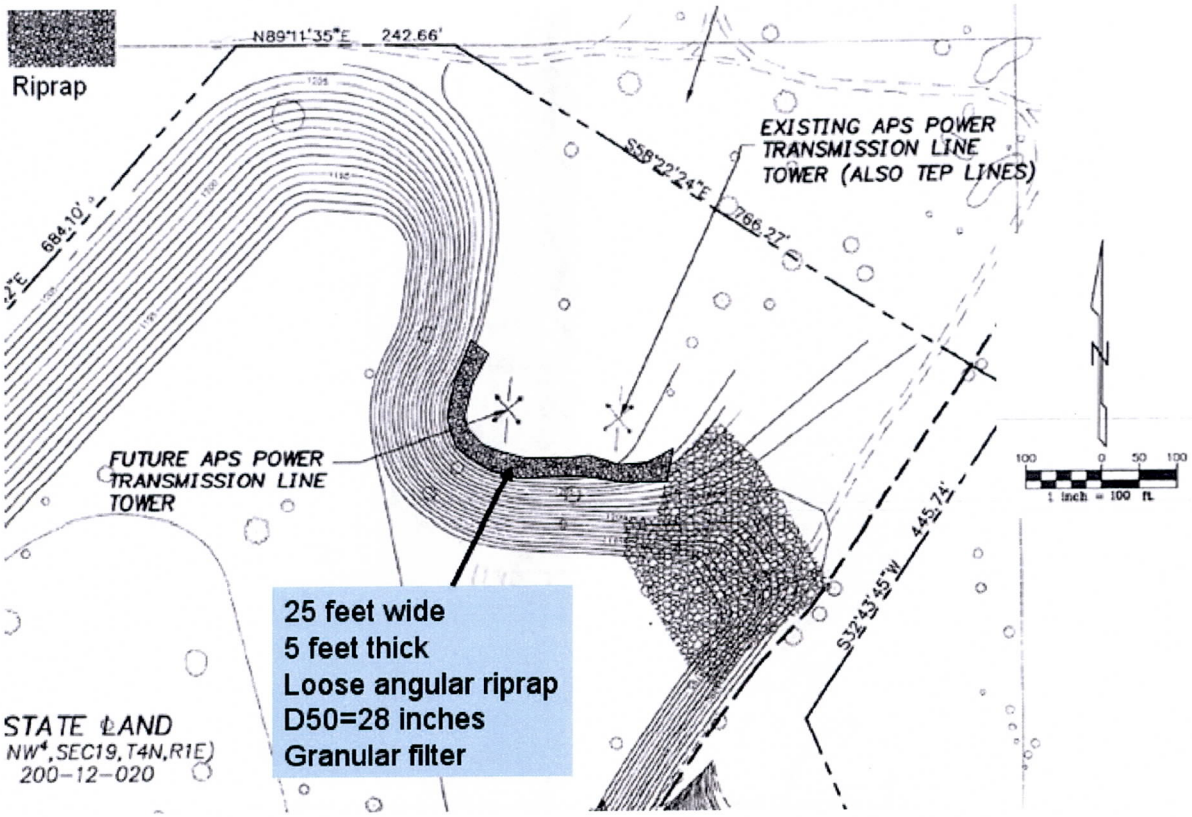
6) The results were compared at two times, the time of peak flow and at the end of flood. The results are shown in Table 1.

From Table 1, it is seen that the worst scour occurs at the end of the flood. When the results are compared at cross-section 22.368 (the first cross-section upstream of the basin), the scour in the proposed conditions is only 1.13 feet worse than in the existing conditions. 1.13 feet is within sediment transport modeling accuracy. For downstream cross section 22.082, as can be seen, it is aggradation for both existing and proposed condition. Therefore, in conclusion, the proposed drainage basin does not have adverse headcut and tailcut on adjacent properties.

**Table 1:** Comparison of results (pit area highlighted in a green color; flow direction is from higher section number to lower section number)

| Proposed (End of Flood) | | Existing (End of Flood) | | Proposed (at Peak) | | Existing (at Peak) | |
|---|---|---|---|---|---|---|---|
| SECTION NUMBER | BED CHANGE (ft) | SECTION NUMBER | BED CHANGE (ft) | SECTION NUMBER | BED CHANGE (ft) | SECTION NUMBER | BED CHANGE (ft) |
| 23.409 | 0.04 | 23.409 | 0.05 | 23.409 | 0.04 | 23.409 | 0.04 |
| 22.935 | 0.04 | 22.935 | 0.03 | 22.935 | 0.03 | 22.935 | 0.03 |
| 22.462 | -1.29 | 22.462 | -1.08 | 22.462 | -1.27 | 22.462 | -1.11 |
| 22.368 | -1.74 | 22.368 | -0.61 | 22.368 | -1.11 | 22.368 | -0.22 |
| 22.336 | 3 | | | 22.336 | 2.51 | | |
| 22.322 | 2.89 | | | 22.322 | 2.73 | | |
| 22.273 | 4.04 | 22.273 | 0.88 | 22.273 | 2.25 | 22.273 | 1.05 |
| 22.177 | 0.75 | 22.177 | 0.42 | 22.177 | 0.31 | 22.177 | 0.78 |
| 22.109 | -0.3 | | | 22.109 | -0.16 | | |
| 22.082 | 0.09 | 22.082 | 2.08 | 22.082 | 0.01 | 22.082 | 0.64 |
| 21.986 | -0.11 | 21.986 | -0.12 | 21.986 | -0.07 | 21.986 | -0.07 |
| 21.893 | -0.53 | 21.893 | -0.52 | 21.893 | -0.51 | 21.893 | -0.5 |
| 21.798 | -0.2 | 21.798 | -0.19 | 21.798 | -0.12 | 21.798 | -0.11 |

7) Since HEC-6 can only assess the general headcut/tailcut from an overall cross-section view and the proposed basin has an irregular shape which can not be represented exactly by cross-sections, local issues need to be carefully evaluated. There is an existing APS power line tower located upstream of the proposed basin. A future APS power line tower is also near the existing tower. It is recommended to install a loose angular riprap trench (25 feet wide and 5 feet deep) immediately upstream of the basin slope near the existing and future power line towers (see Figure 2 below). Figure 3 shows the profile. The riprap size D50 was estimated to be 28 inches. The 28-inch riprap will be stable on 5:1 slope if the riprap starts to launch. The riprap size is computed using the rock chute equation from Robinson and others (1998). The other gradation values and specifications for the granular filter can be found in FCDMC's Drainage Design Manual Volume II, Hydraulics Manual (1996).




8)

**Figure 2:** Approximate Limits of Proposed Riprap Trench

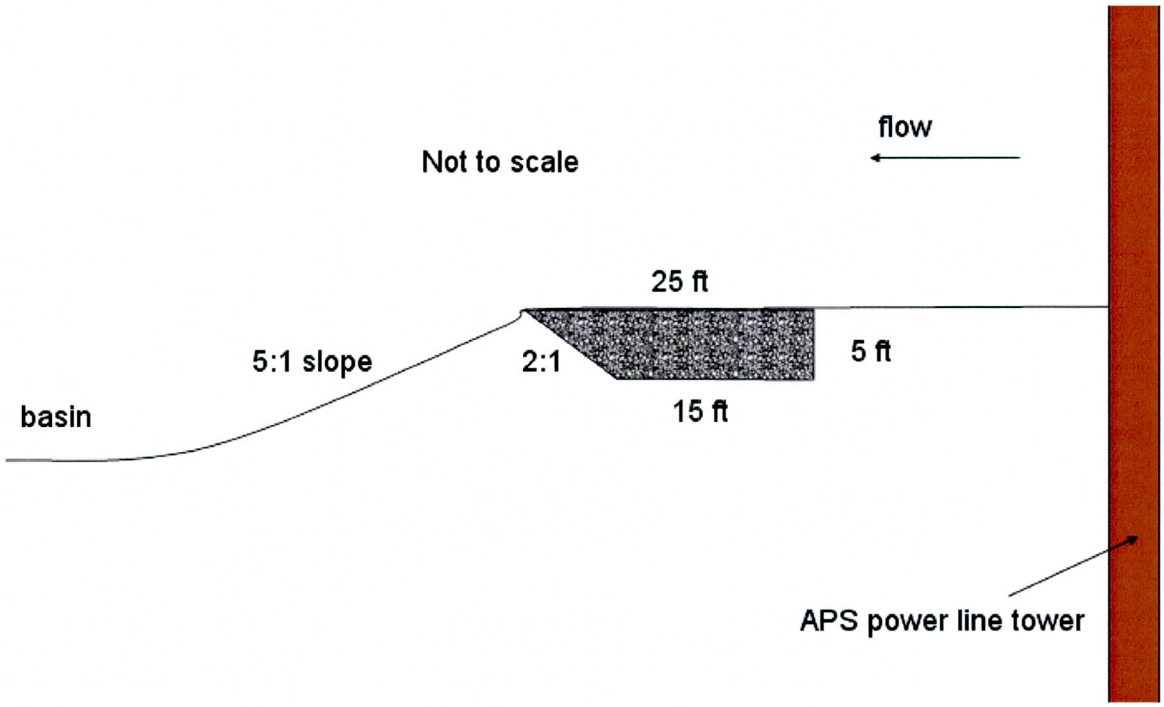



**Figure 3:** Riprap Trench Loose Angular Riprap Downstream of APS Power Line Towers

**Reference:**

Robinson, K. M., Rice, C. E., and K. C. Kadavy. (1998). Design of Rock Chutes. *Transactions of the ASAE*, *41* (3): 621-626.

# Flood Control District
of Maricopa County

INTEROFFICE MEMORANDUM

**Date:** August 20, 2010

**To:** Bobbie Ohler, Project Manager, Project Management Branch, Planning and Project Management Division

**From:** Richard Waskowsky, Hydrologist, Engineering Application Development and River Mechanics Branch, Engineering Division

**CC:** Bing Zhao, PhD, PE, Engineering Application Development and River Mechanics Branch Manager, Engineering Division

**Subject:** Rose Garden Lane Basin Scour Memorandum, dated August 16, 2010, prepared by Wood/Patel

The Engineering Application Development and River Mechanics (EADRM) Branch received the submittal on August 18, 2010. The EADRM Branch has finished its review and has the following comments. The consultant should submit written responses (with digital copy) to these comments to the FCDMC.

1) In other sand and gravel permit applications and in the original EADRM analysis, the proposed excavation is coded into the geometry of the full HEC-6 model to give the proposed conditions. This model would correspond to the "REVSBASN.DAT" model in the Wood/Patel submittal. Please use the results from this model to compare with the existing conditions results to ensure that the FCD criterion is met. The criterion is illustrated in Figure 1. Please revise the memorandum to show that the proposed modifications meet this criterion. Please remove the results from the "REVBASN3.DAT" model and the ADOT method.

   ***Wood/Patel response: Wood/Patel will update the Memo as suggested.***

2) In the original EADRM memorandum, a riprap trench (comprised of loose angular riprap) was proposed to provide erosion protection for the APS tower. However, the current memorandum proposes gabions and indicates that the original EADRM memorandum also proposed gabions. A trench that is comprised of either loose angular riprap or soil cement is recommended.

   ***Wood/Patel response: Wood/Patel will update the Memo as suggested.***

2801 West Durango Street Phoenix, Arizona 85009 Phone: 602-506-1501 Fax: 602-506-4601

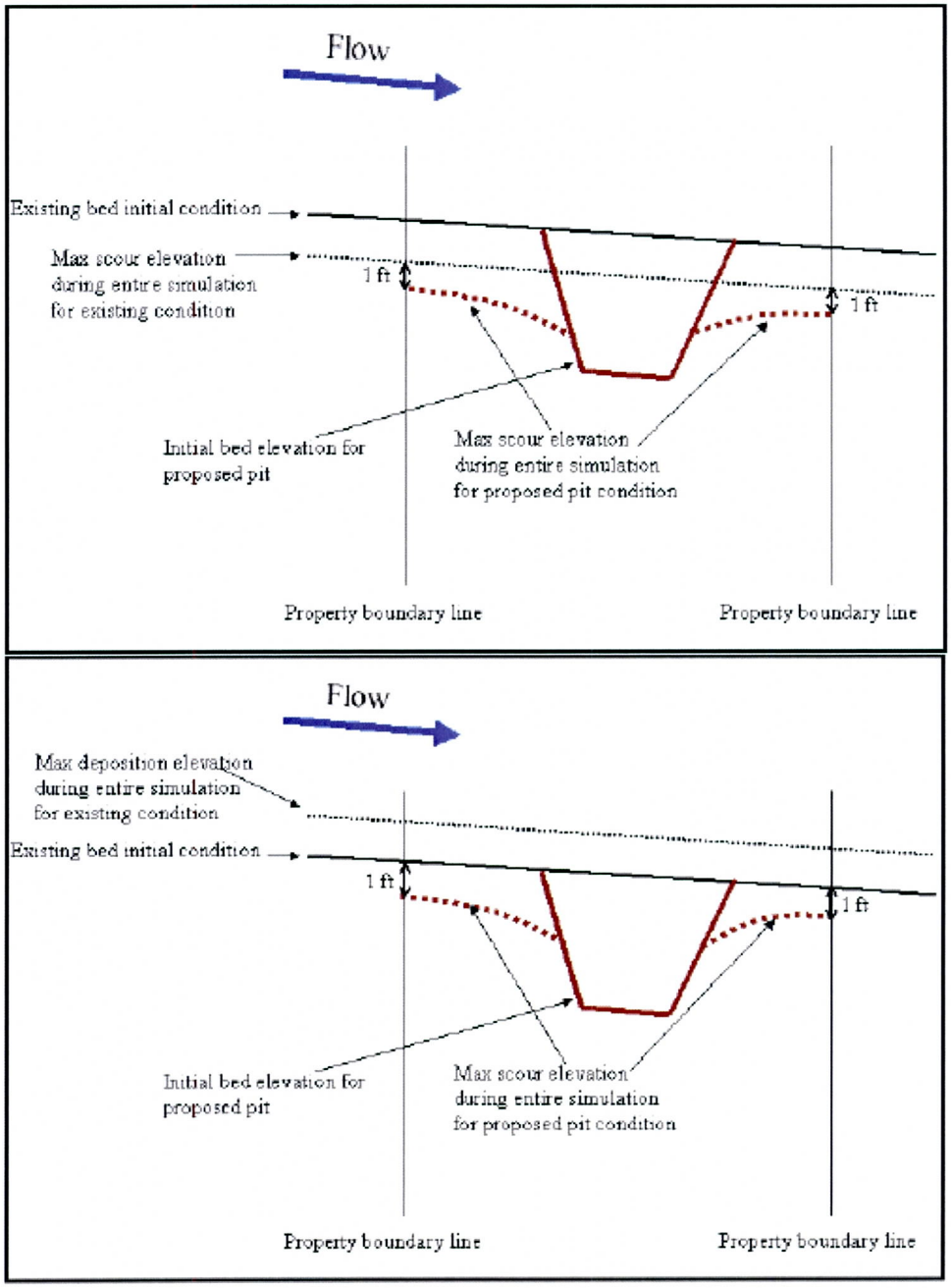
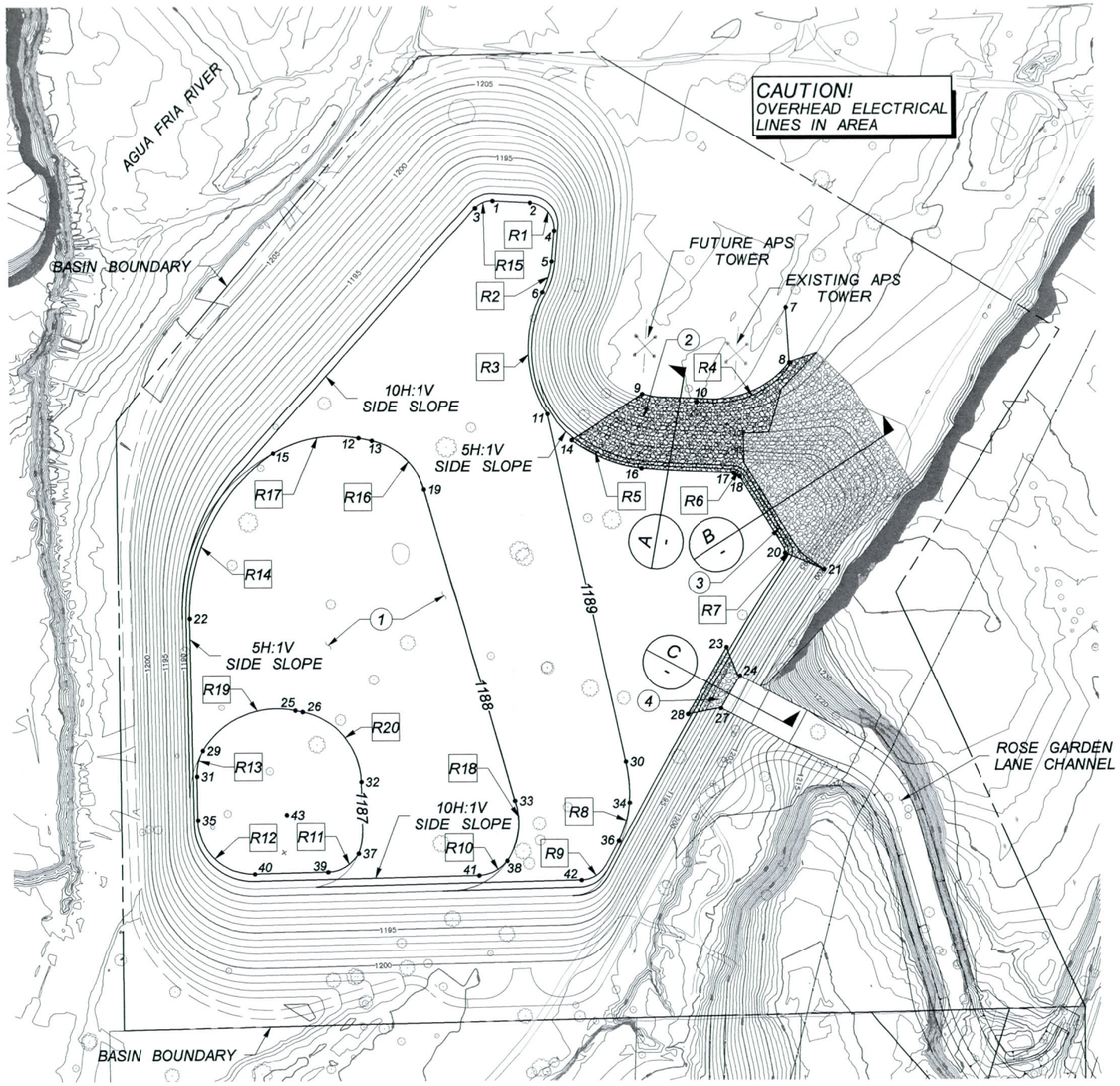



**Figure 1.** FCDMC criterion



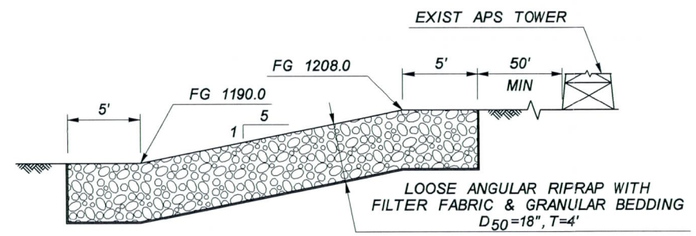

| BASIN CONTROL POINTS | | | |
|---|---|---|---|
| POINT | NORTHING | EASTING | ELEVATION |
| 1 | 975545.74 | 583041.56 | 1189.00 |
| 2 | 975542.23 | 583092.18 | 1189.00 |
| 3 | 975536.18 | 583017.46 | 1189.00 |
| 4 | 975503.45 | 583124.54 | 1189.00 |
| 5 | 975461.54 | 583119.89 | 1189.00 |
| 6 | 975419.69 | 583106.39 | 1189.00 |
| 7 | 975393.24 | 583438.76 | 1208.00 |
| 8 | 975317.65 | 583442.12 | 1208.00 |
| 9 | 975277.77 | 583239.93 | 1208.00 |
| 10 | 975265.18 | 583313.66 | 1208.00 |
| 11 | 975252.64 | 583109.35 | 1189.00 |
| 12 | 975224.45 | 582851.18 | 1188.00 |
| 13 | 975220.42 | 582869.47 | 1188.00 |
| 14 | 975216.11 | 583141.91 | 1190.00 |
| 15 | 975205.45 | 582733.80 | 1188.00 |
| 16 | 975175.85 | 583236.65 | 1190.00 |
| 17 | 975166.96 | 583362.19 | 1190.00 |
| 18 | 975162.08 | 583370.16 | 1190.00 |
| 19 | 975152.18 | 582939.39 | 1188.00 |
| 20 | 975056.37 | 583429.61 | 1190.00 |
| 21 | 975033.27 | 583481.97 | 1200.00 |

| BASIN CONTROL POINTS | | | |
|---|---|---|---|
| POINT | NORTHING | EASTING | ELEVATION |
| 22 | 974981.83 | 582614.69 | 1188.00 |
| 23 | 974928.91 | 583346.50 | 1190.00 |
| 24 | 974889.54 | 583363.78 | 1196.00 |
| 25 | 974852.45 | 582755.59 | 1187.00 |
| 26 | 974850.25 | 582765.41 | 1187.00 |
| 27 | 974844.74 | 583337.08 | 1196.00 |
| 28 | 974837.27 | 583291.88 | 1190.00 |
| 29 | 974799.75 | 582628.13 | 1187.00 |
| 30 | 974774.12 | 583205.71 | 1189.00 |
| 31 | 974764.83 | 582619.46 | 1187.00 |
| 32 | 974753.26 | 582843.56 | 1187.00 |
| 33 | 974723.44 | 583052.28 | 1188.00 |
| 34 | 974717.88 | 583209.60 | 1189.00 |
| 35 | 974705.10 | 582619.40 | 1187.00 |
| 36 | 974666.11 | 583193.32 | 1189.00 |
| 37 | 974655.49 | 582837.65 | 1187.00 |
| 38 | 974641.69 | 583039.81 | 1188.00 |
| 39 | 974630.80 | 582794.93 | 1187.00 |
| 40 | 974630.02 | 582694.99 | 1187.00 |
| 41 | 974622.41 | 583000.75 | 1188.00 |
| 42 | 974613.51 | 583140.53 | 1189.00 |
| 43 | 974709.89 | 582740.69 | 1186.50 |

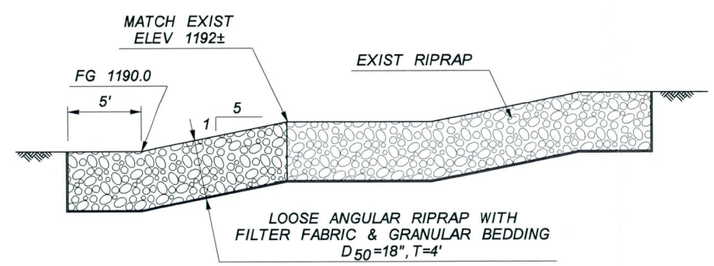
☐ REMOVE ☐

◯ CONSTRUCT ◯

1. DRAINAGE EXCAVATION — 36,469 CY
2. INSTALL LOOSE ANGULAR RIPRAP EROSION PROTECTION WITH FILTER FABRIC & GRANULAR BEDDING PER SPECIFICATIONS AND PER SECTION A THIS SHEET, $D_{50}$=18", T=4' — 3,404 CY
3. INSTALL LOOSE ANGULAR RIPRAP EROSION PROTECTION WITH FILTER FABRIC & GRANULAR BEDDING PER SPECIFICATIONS AND PER SECTION B THIS SHEET, $D_{50}$=18", T=4' — 346 CY
4. REGRADE EXIST RIPRARP AND INSTALL LOOSE ANGULAR RIPRAP EROSION PROTECTION WITH FILTER FABRIC & GRANULAR BEDDING PER SPECIFICATIONS AND PER SECTION C THIS SHEET, $D_{50}$=18", T=4' — 403 CY

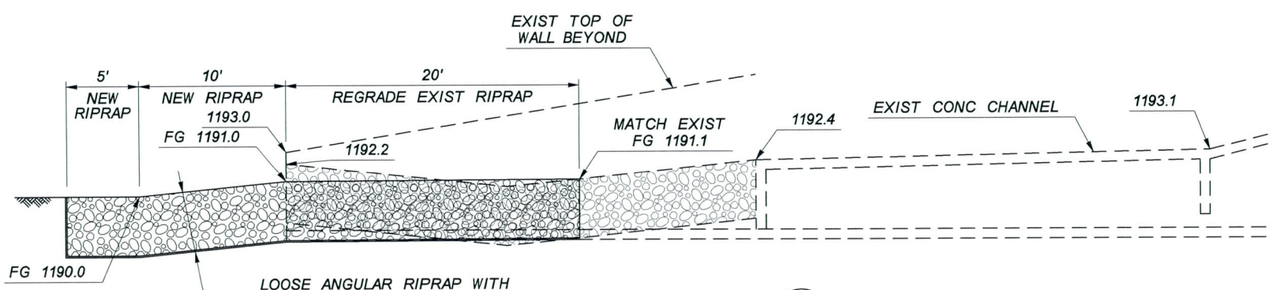



SECTION A
SCALE: NTS




SECTION B
SCALE: NTS

| CURVE TABLE | | | |
|---|---|---|---|
| POINT | DELTA | RADIUS (FT) | CONTOUR ELEVATION |
| R1 | 92°22'18" | 35.00 | 1189.00 |
| R2 | 23°3'40" | 110.00 | 1189.00 |
| R3 | 60°50'2" | 165.00 | 1189.00 |
| R4 | 51°44'43" | 130.00 | 1208.00 |
| R5 | 45°1'17" | 170.00 | 1190.00 |
| R6 | 55°45'25" | 15.00 | 1190.00 |
| R7 | 65°41'54" | 15.00 | 1190.00 |
| R8 | 24°5'47" | 130.00 | 1189.00 |
| R9 | 60°2'46" | 40.00 | 1189.00 |
| R10 | 51°38'34" | 50.00 | 1188.00 |
| R11 | 59°8'16" | 50.00 | 1187.00 |
| R12 | 90°30'31" | 75.00 | 1187.00 |
| R13 | 27°45'34" | 75.00 | 1187.00 |
| R14 | 55°57'50" | 270.00 | 1188.00 |
| R15 | 51°11'58" | 30.00 | 1189.00 |
| R16 | 61°53'30" | 95.00 | 1188.00 |
| R17 | 31°50'4" | 165.00 | 1188.00 |
| R18 | 46°12'36" | 93.00 | 1188.00 |
| R19 | 70°9'24" | 120.00 | 1187.00 |
| R20 | 77°2'42" | 100.00 | 1187.00 |




SECTION C
SCALE: NTS

N

50 0 50 100
Scale: Horiz: 1"=100'

TWO WORKING DAYS BEFORE YOU DIG, CALL 263-1100 BLUE STAKE

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | | | |

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

PINNACLE PEAK ROAD DRAINAGE PROJECT
99TH AVENUE TO 104TH AVENUE
FCD NO. 2010C020

100%
PRELIMINARY NOT FOR CONSTRUCTION

| | BY | DATE |
|---|---|---|
| DESIGNED | J. TAILLON | 09/2010 |
| DRAWN | D. BURMEISTER | 09/2010 |
| CHECKED | J. MINCH | 09/2010 |

WOOD/PATEL MISSION: CLIENT SERVICE™ PHOENIX • MESA • TUCSON 2051 W. Northern Ave. Phoenix, AZ 85021 (602) 335-8500

DRAWING NO. D2.08

ROSE GARDEN LANE BASIN REVISED GRADING

SHEET OF 31 89

# 107TH AVENUE DRAINAGE SYSTEM

**WOOD/PATEL**
MISSION: CLIENT SERVICE™

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS • CONSTRUCTION MANAGERS

# MEMO

TO: Jeff Minch, P.E.

FROM: James Taillon, CFM

DATE: October 14, 2010

RE: Pinnacle Peak Road Drainage Project
99th Avenue to 107th Avenue

SUBJECT: 107th Avenue Drainage System Analysis

## I. INTRODUCTION

The purpose of this memo is to document the methods and results of the hydraulic modeling of the 107th Avenue channel system and to evaluate the impact of the Pinnacle Peak Road Drainage Project from 99th Avenue to 107th Avenue to the existing channel system due to the updated hydrology.

## II. HYDROLOGY

The hydrologic modeling results from the recommended alternative (Option VA52) for future conditions with CIP from the 100-year, 6-hour storm were applied to the channel system analysis. The major elements for this alternative are that the peak flow at 103rd Avenue is diverted to south with a 10 cfs low-flow bypass into the wash through the Ironwood subdivision and the rest into two (2) basins in series located on the south of the Pinnacle Peak Road. Detailed information for the hydrologic modeling including data, exhibits, alternatives, and results were documented in the project hydrology memo dated June 17, 2010. The HEC-1 model which was used in this analysis is included in Appendix A and the HEC-1 schematic for the 107th Avenue channel system is presented in Exhibit A.

## III. HYDRAULICS

The hydraulics of the 107th Avenue channel system was modeled using the Army Corp of Engineers HEC-RAS 4.0 to determine the water surface elevations of the channels along the 107th Avenue alignment. The channel system starts from the outlet of the detention/retention basin at the southeast corner of Williams Road and 107th Avenue to just upstream of the detention/retention basin at the northeast corner of Rose Garden Lane and 107th Avenue. The model has two reaches, north and south, that were divided by the detention/retention basin at the northeast corner of Deer Valley Road and 107th Avenue.

The models were run in subcritical condition in order to generate conservative water surface elevations. The downstream boundary condition utilized for the South Reach was the headwater elevation from the 107th Avenue Box Culvert crossing, as shown in the *Rose Garden Lane Drainage Improvements Final Design Report, October 2008.* The downstream boundary condition for the North Reach was the water surface elevation from the most upstream cross section on the South Reach, cross section 11335.36 assuming that the pool elevation of the basin at the northeast corner of Deer Valley Road and 107th Avenue is constant.

Geometric data of the cross sections for the model were developed using surveyed existing ground points at predetermined locations along the reaches. Cross sections just upstream and downstream of the culverts were interpolated between the closest surveyed cross section and the existing inverts of the culverts. Culvert inverts were also surveyed, and culvert sizes were verified with a field visit. Manning's "n" values of .02 and .035 were used for the concrete and earthen areas of the channel and a value of .02 was used for the asphalt portions of the cross sections.

The HEC-RAS modeling results show that the design 100-year flood from the revised hydrology was fully contained within the channel at all locations except at the intersection of Deer Valley Road and 107th Avenue. The existing culvert crossing Deer Valley Road is a 10' x 2.5' box and does not have enough capacity to fully convey the 100-year flow without a small amount of overtopping. The HEC-RAS modeling results show that flood water at this location will spill out into 107th Avenue and flow over Deer Valley road at a depth of .09 feet.

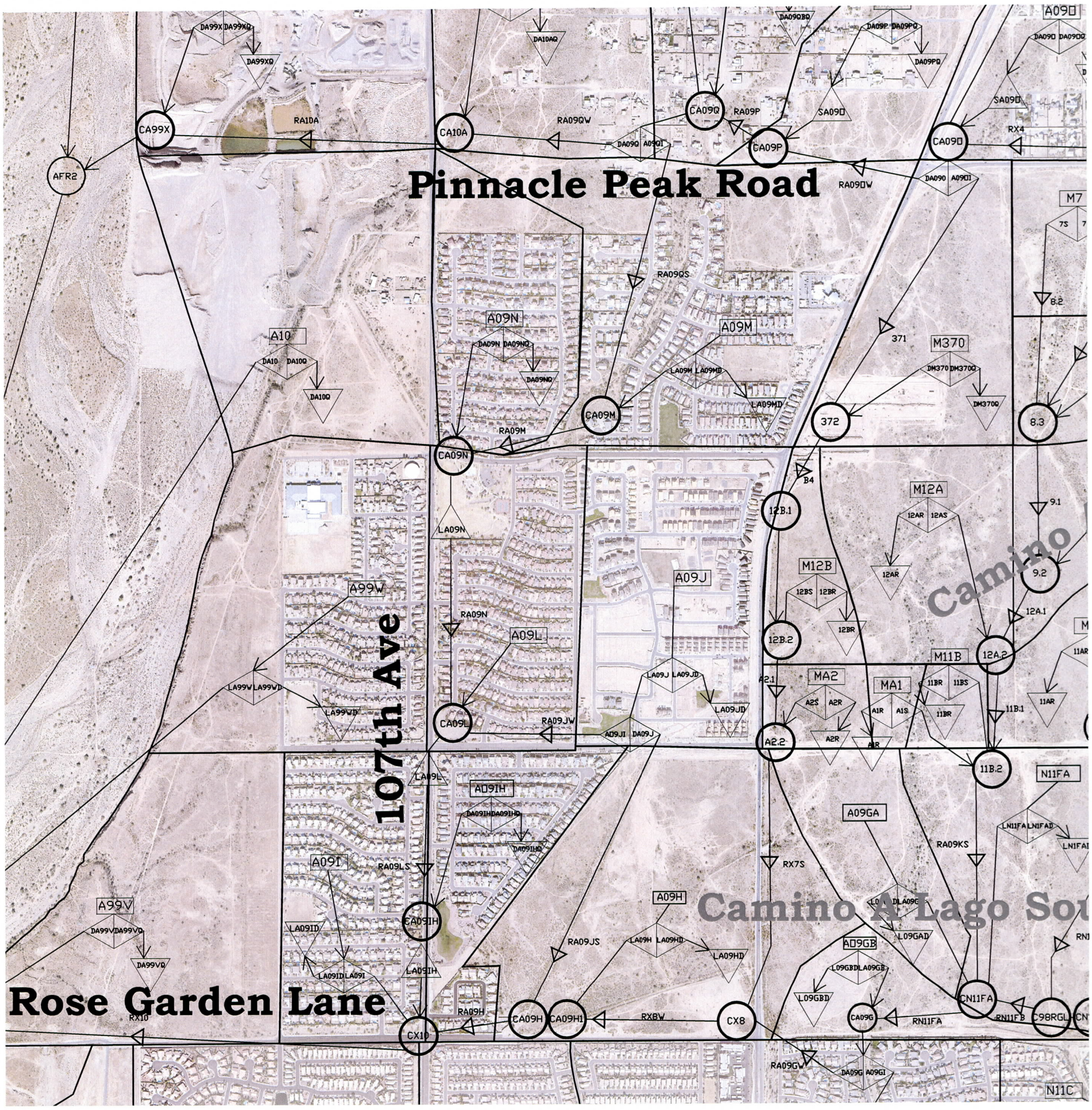
The HEC-RAS cross sections, profile table, and profile plots are provided In Appendix B. The HEC-RAS cross section locations, hydraulic data, and aerials are presented in Exhibit B.

## IV. CONCLUSIONS

The HEC-RAS modeling results show that the design 100-year flood from the updated hydrology for the Pinnacle Road project was fully contained within the channel at all locations except at the intersection of Deer Valley Road and 107th Avenue where the existing culvert of a 10' x 2.5' box does not have enough capacity to fully convey the 100-year flow without a small amount of overtopping. The HEC-RAS modeling results show that the designed Pinnacle Peak Road Drainage Project from 99th Avenue to 107th Avenue does not have any negative impact on the existing 107th Avenue channel system.



Wood, Patel & Associates, Inc. ♦ 2051 West Northern, Suite 100 ♦ Phoenix, Arizona 85021
Phone: (602) 335-8500 ♦ Fax: (602) 335-8580
E-Mail: woodpatel@woodpatel.com




# Legend

Sub-Basin Boundary

Sub-Basin Hydrograph — N11C

Diversion — LN11CD | LN11C

Combine Hydrograph — CN11C1

Detention Storage Routing — LN11CW

Channel Routing — R11DAS

Sub-Basin Retention — LN11CD

N

1000 0 500 1000

1 inch = 1000 ft.

PINNACLE PEAK ROAD
107TH AVENUE CHANNEL

EXHIBIT A
LOCAL HEC-1
SCEMATIC

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TRANSPORTATION / TRAFFIC
WATER / WASTEWATER • SURVEYING
CONSTRUCTION MANAGEMENT
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MATCH TO TOP RIGHT

MATCH TO BOTTOM LEFT

LEGEND

| | |
|---|---|
| XS | HEC-RAS CROSS SECTION |
| WSE | WATER SURFACE ELEVATION |
| Q100 | 100-HR, 6-HR Peak Flow |

100 0 50 100

Horz. 1 in. = 100 ft.

N

# PINNACLE PEAK ROAD 107TH AVE CHANNEL

EXHIBIT B
HEC-RAS
WORK MAP

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TRANSPORTATION / TRAFFIC
WATER / WASTEWATER • SURVEYING
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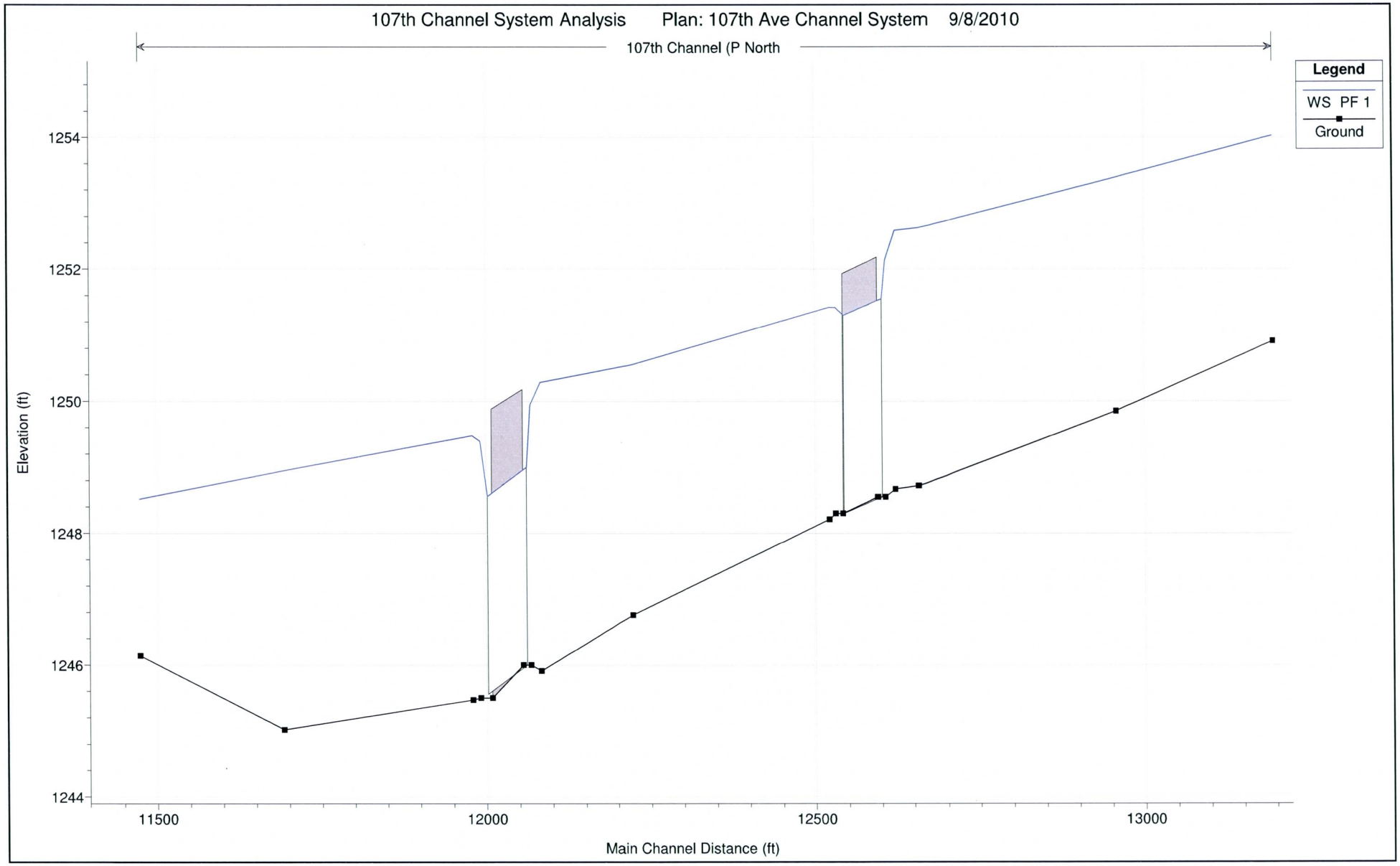
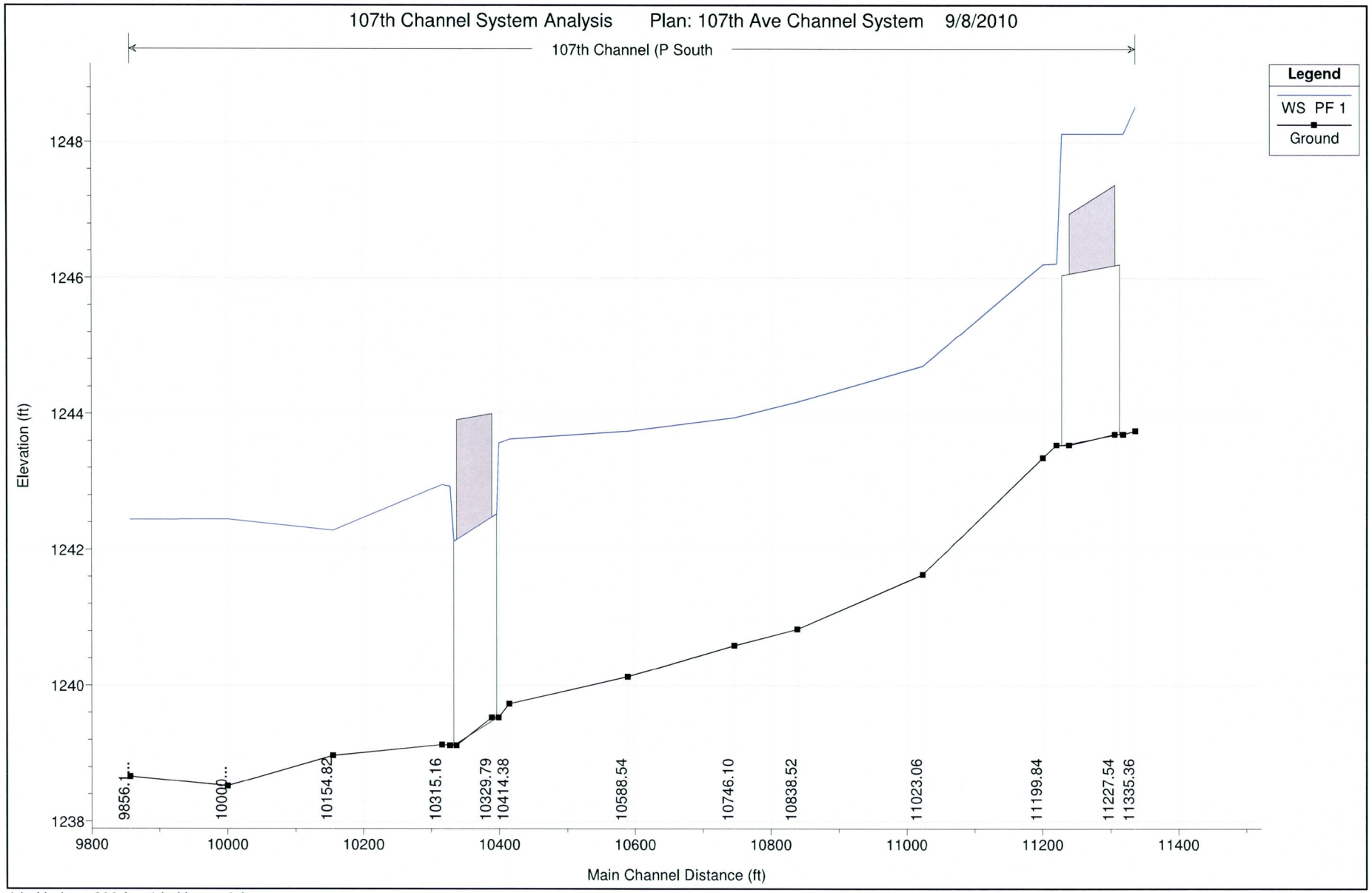
W:\2009 Projects\093386 - Pinnacle Peak Road and Channel\Project Support\Hydro\Exhibits\ Exhibit B - 107th Ave Channel HECRAS Workmap.dwg




1 in Horiz. = 200 ft 1 in Vert. = 2 ft




1 in Horiz. = 200 ft 1 in Vert. = 2 ft

HEC-RAS Plan: 100 yr- 6 hr Profile: PF 1

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| North | 13193.72 | PF 1 | 171.00 | 1250.91 | 1254.02 | | 1254.35 | 0.001698 | 4.58 | 37.36 | 19.13 | 0.58 |
| North | 12959.02 | PF 1 | 171.00 | 1249.85 | 1253.39 | | 1253.75 | 0.004168 | 4.91 | 38.28 | 22.08 | 0.54 |
| North | 12656.74 | PF 1 | 171.00 | 1248.72 | 1252.63 | 1251.29 | 1252.84 | 0.002108 | 3.88 | 49.53 | 26.97 | 0.39 |
| North | 12620.62 | PF 1 | 171.00 | 1248.67 | 1252.58 | 1251.10 | 1252.76 | 0.001695 | 3.52 | 53.98 | 26.41 | 0.35 |
| North | 12605.75 | PF 1 | 171.00 | 1248.55 | 1252.13 | 1250.89 | 1252.63 | 0.003291 | 5.70 | 30.02 | 22.50 | 0.53 |
| North | 12540.57 | | Culvert | | | | | | | | | |
| North | 12529.64 | PF 1 | 171.00 | 1248.30 | 1251.42 | | 1251.99 | 0.004467 | 6.06 | 28.23 | 17.49 | 0.60 |
| North | 12520.18 | PF 1 | 171.00 | 1248.21 | 1251.42 | | 1251.91 | 0.007796 | 5.63 | 30.35 | 14.65 | 0.69 |
| North | 12221.05 | PF 1 | 171.00 | 1246.76 | 1250.55 | | 1250.72 | 0.002124 | 3.23 | 52.97 | 23.49 | 0.38 |
| North | 12081.17 | PF 1 | 171.00 | 1245.91 | 1250.29 | | 1250.46 | 0.001547 | 3.45 | 53.97 | 27.60 | 0.33 |
| North | 12065.27 | PF 1 | 171.00 | 1246.00 | 1249.95 | 1248.42 | 1250.40 | 0.002607 | 5.41 | 31.58 | 28.42 | 0.48 |
| North | 12001.24 | | Culvert | | | | | | | | | |
| North | 11991.12 | PF 1 | 171.00 | 1245.50 | 1249.40 | | 1249.86 | 0.002743 | 5.49 | 31.16 | 20.76 | 0.49 |
| North | 11979.48 | PF 1 | 171.00 | 1245.47 | 1249.48 | | 1249.72 | 0.002507 | 3.93 | 44.56 | 19.53 | 0.41 |
| North | 11692.15 | PF 1 | 171.00 | 1245.02 | 1248.95 | 1247.29 | 1249.13 | 0.001614 | 3.46 | 53.16 | 23.81 | 0.34 |
| North | 11473.95 | PF 1 | 171.00 | 1246.14 | 1248.52 | 1247.63 | 1248.67 | 0.002693 | 3.16 | 55.90 | 44.81 | 0.42 |
| South | 11335.36 | PF 1 | 230.00 | 1243.75 | 1248.52 | | 1248.59 | 0.000199 | 2.22 | 146.87 | 130.62 | 0.21 |
| South | 11321.81 | PF 1 | 230.00 | 1243.70 | 1248.12 | 1246.25 | 1248.54 | 0.000674 | 5.20 | 44.24 | 41.02 | 0.44 |
| South | 11227.54 | | Culvert | | | | | | | | | |
| South | 11220.08 | PF 1 | 230.00 | 1243.54 | 1246.21 | 1246.07 | 1247.36 | 0.003615 | 8.60 | 26.73 | 23.63 | 0.93 |
| South | 11199.84 | PF 1 | 230.00 | 1243.35 | 1246.21 | 1246.21 | 1247.19 | 0.005438 | 7.97 | 28.87 | 14.89 | 1.01 |
| South | 11023.06 | PF 1 | 230.00 | 1241.63 | 1244.70 | | 1245.37 | 0.003127 | 6.57 | 35.02 | 15.62 | 0.77 |
| South | 10838.52 | PF 1 | 230.00 | 1240.83 | 1244.18 | | 1244.80 | 0.002915 | 6.36 | 36.17 | 16.23 | 0.75 |
| South | 10746.10 | PF 1 | 230.00 | 1240.59 | 1243.94 | | 1244.53 | 0.002731 | 6.16 | 37.32 | 16.84 | 0.73 |
| South | 10588.54 | PF 1 | 230.00 | 1240.13 | 1243.74 | | 1244.15 | 0.001596 | 5.12 | 44.90 | 17.48 | 0.56 |
| South | 10414.38 | PF 1 | 230.00 | 1239.73 | 1243.62 | | 1243.90 | 0.000935 | 4.24 | 55.13 | 24.16 | 0.45 |
| South | 10398.7 | PF 1 | 230.00 | 1239.53 | 1243.57 | 1241.73 | 1243.89 | 0.000585 | 4.53 | 50.74 | 28.86 | 0.40 |
| South | 10329.79 | | Culvert | | | | | | | | | |
| South | 10326.97 | PF 1 | 230.00 | 1239.12 | 1242.93 | | 1243.29 | 0.000706 | 4.80 | 47.94 | 25.17 | 0.43 |
| South | 10315.16 | PF 1 | 230.00 | 1239.13 | 1242.95 | | 1243.25 | 0.001007 | 4.35 | 52.99 | 20.15 | 0.46 |
| South | 10154.82 | PF 1 | 230.00 | 1238.97 | 1242.28 | | 1242.95 | 0.003095 | 6.55 | 35.11 | 15.60 | 0.77 |
| South | 10000 | PF 1 | 230.00 | 1238.52 | 1242.44 | | 1242.53 | 0.000949 | 2.34 | 98.50 | 40.31 | 0.26 |
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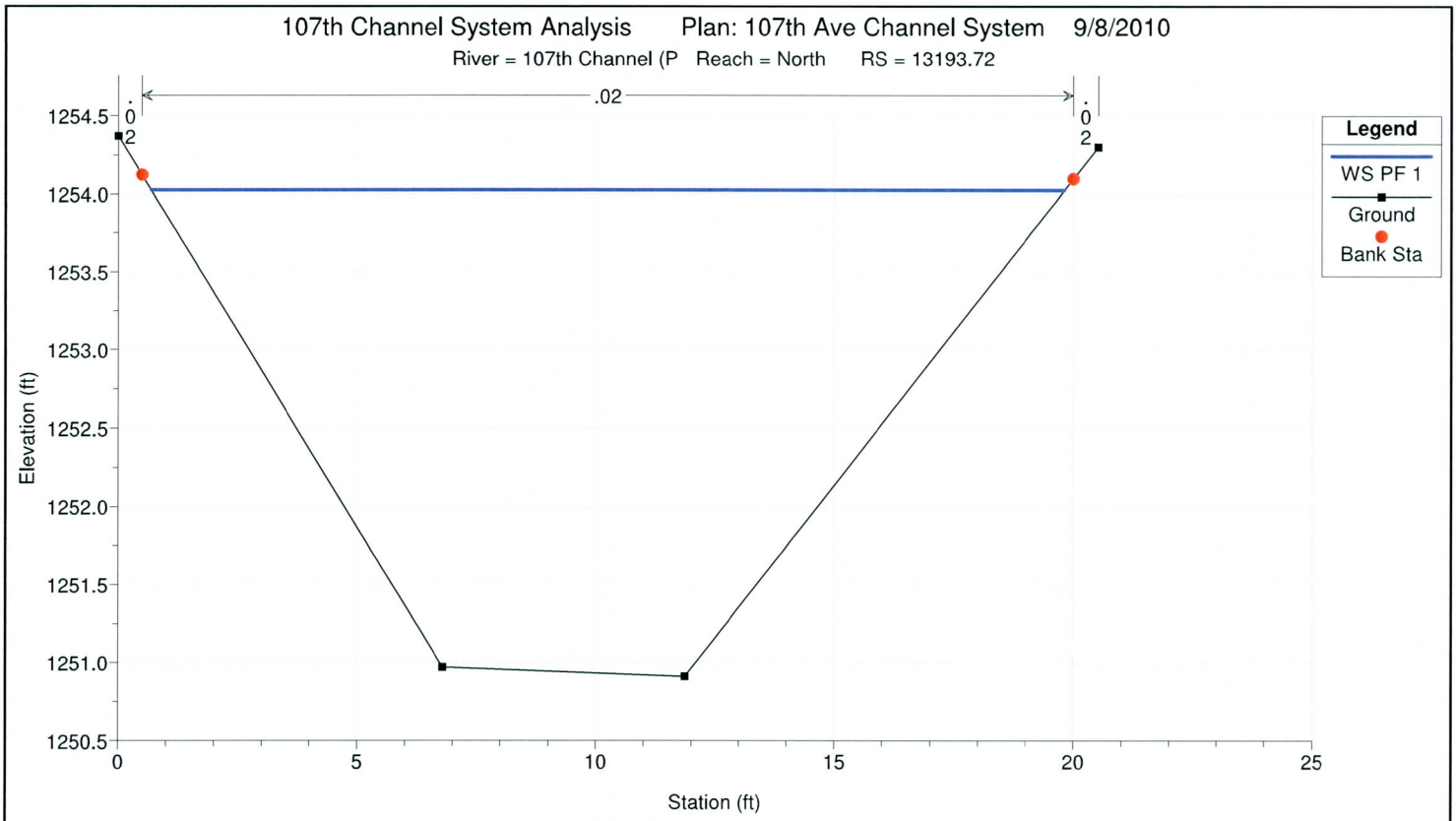
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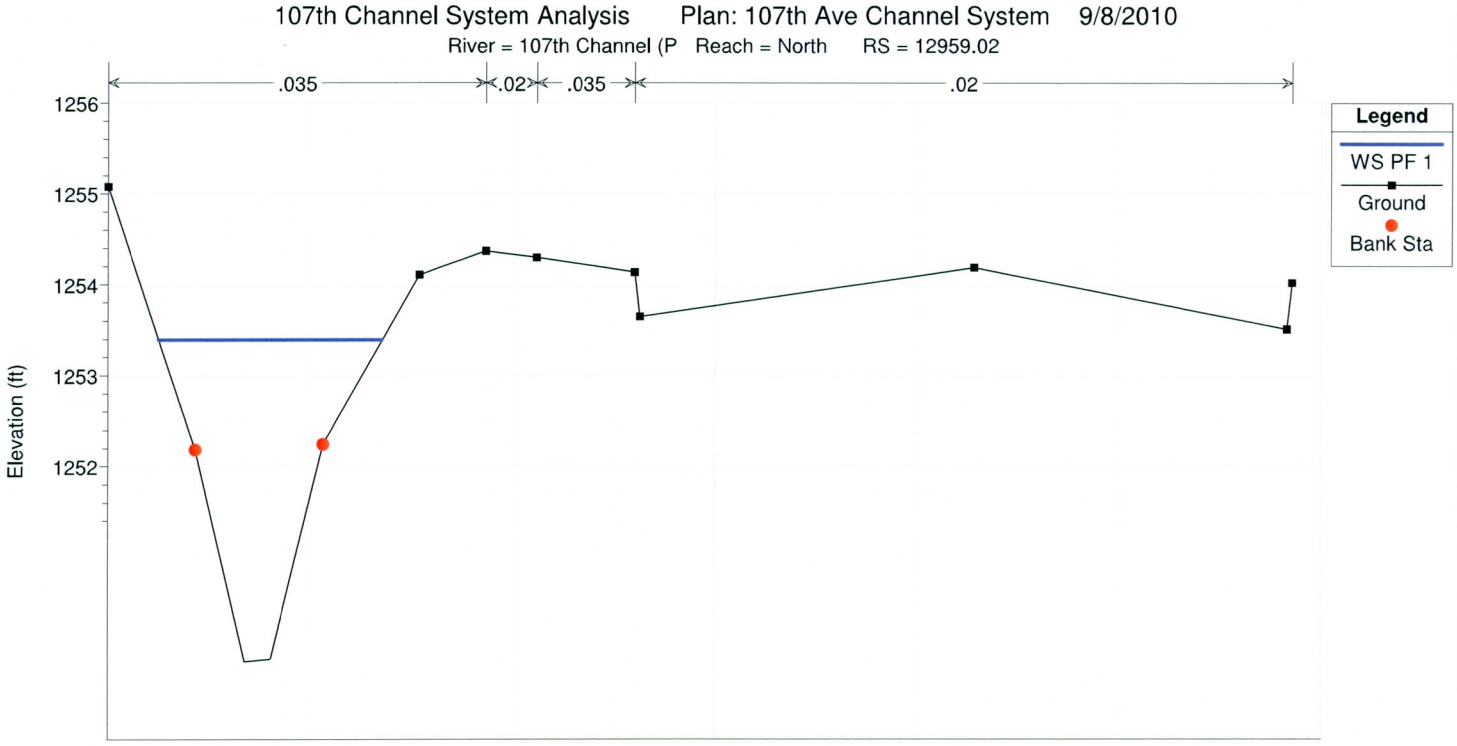
River = 107th Channel (P Reach = North RS = 13193.72
.02
.02
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1254.5
1254.0
1253.5
1253.0
1252.5
1252.0
1251.5
1251.0
1250.5
0
5
10
15
20
25
Station (ft)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.035
.02
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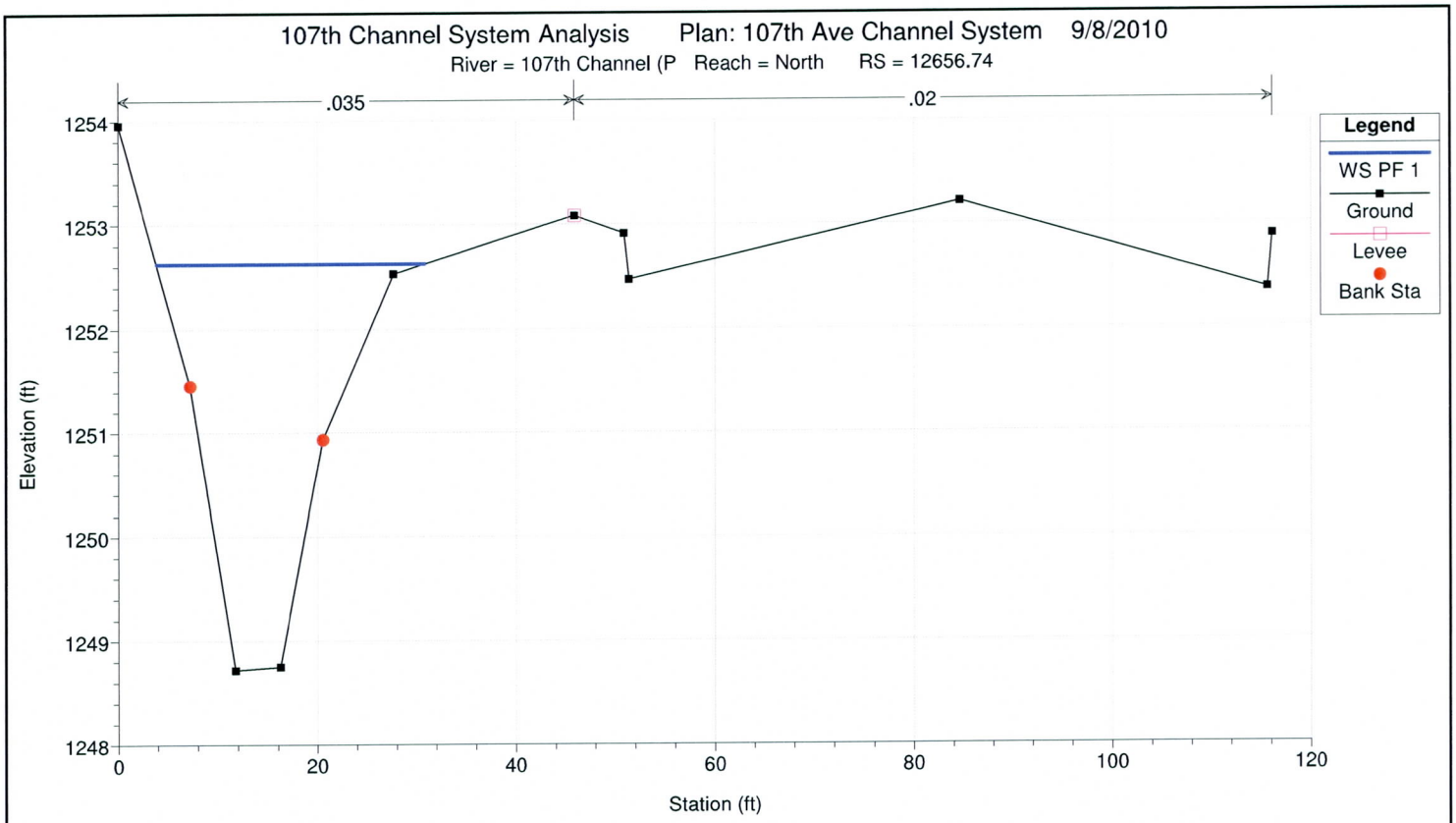
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1256
1255
1254
1253
1252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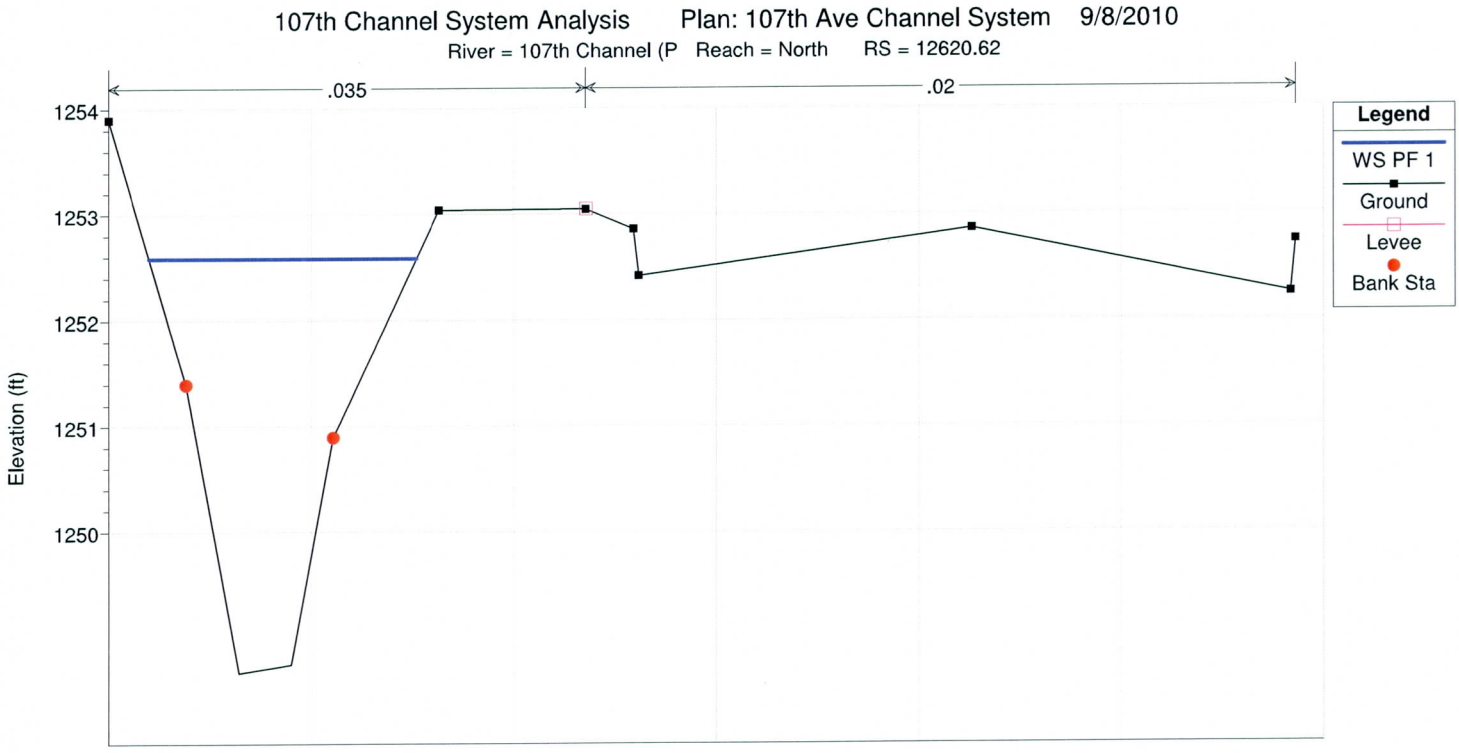
.035
.02
Legend
WS PF 1
Ground
Levee
Bank Sta
Elevation (ft)
1254
1253
1252
1251
1250
1249
1248
0
20
40
60
80
100
120
Station (ft)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Legend
WS PF 1
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Levee
Bank Sta
Elevation (ft)
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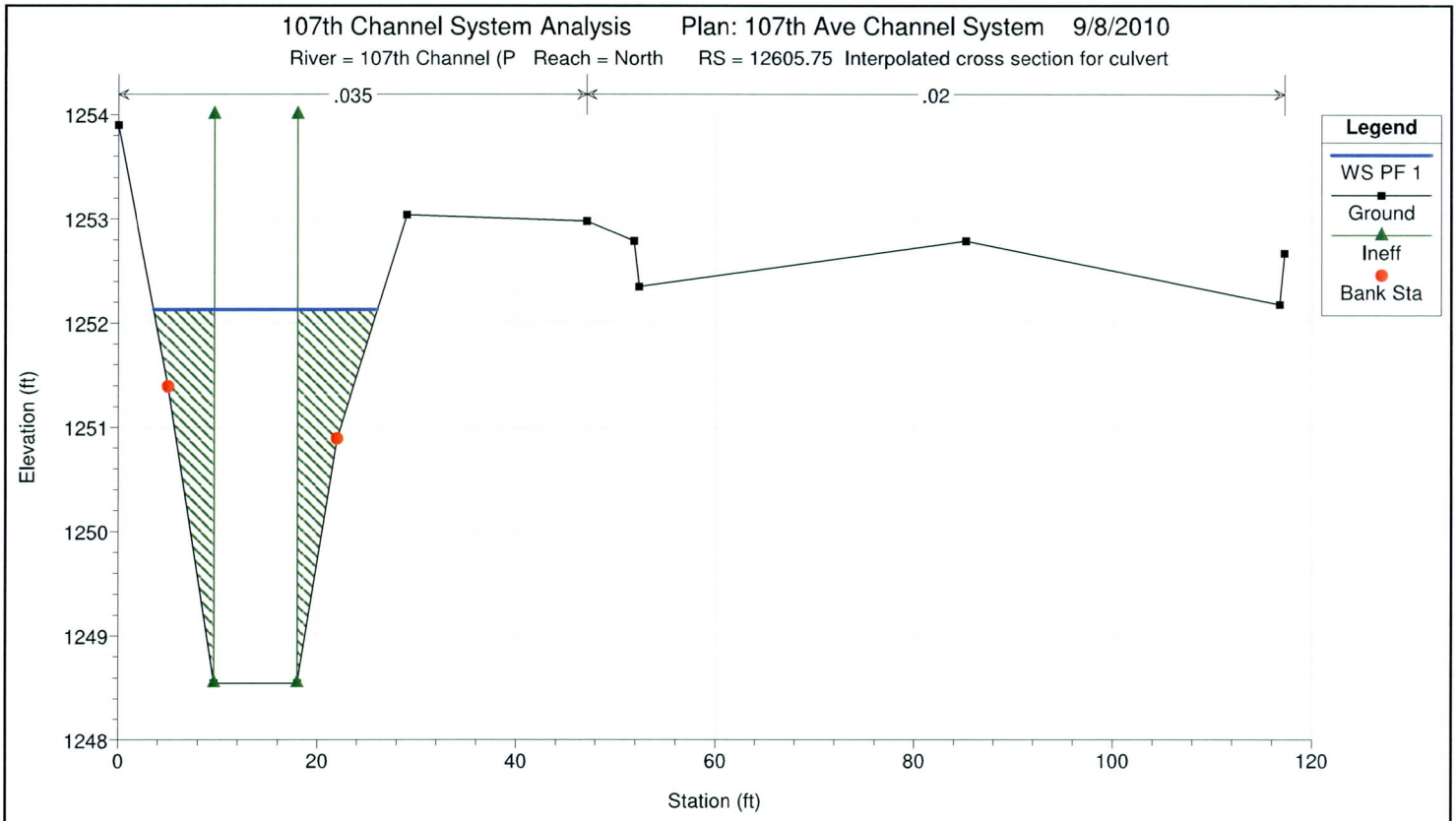
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.035
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Legend
WS PF 1
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Bank Sta
Elevation (ft)
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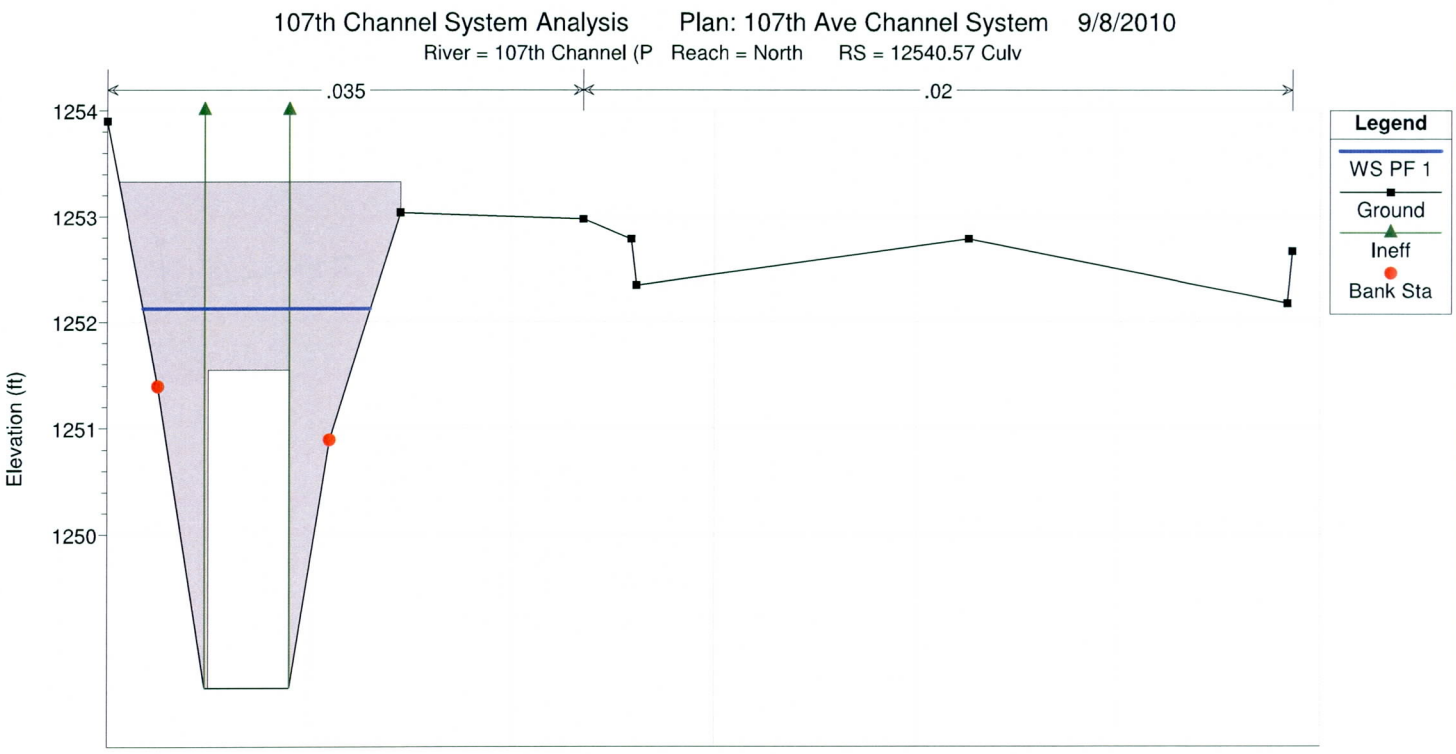
80
100
120
Station (ft)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Ineff
Bank Sta
Elevation (ft)
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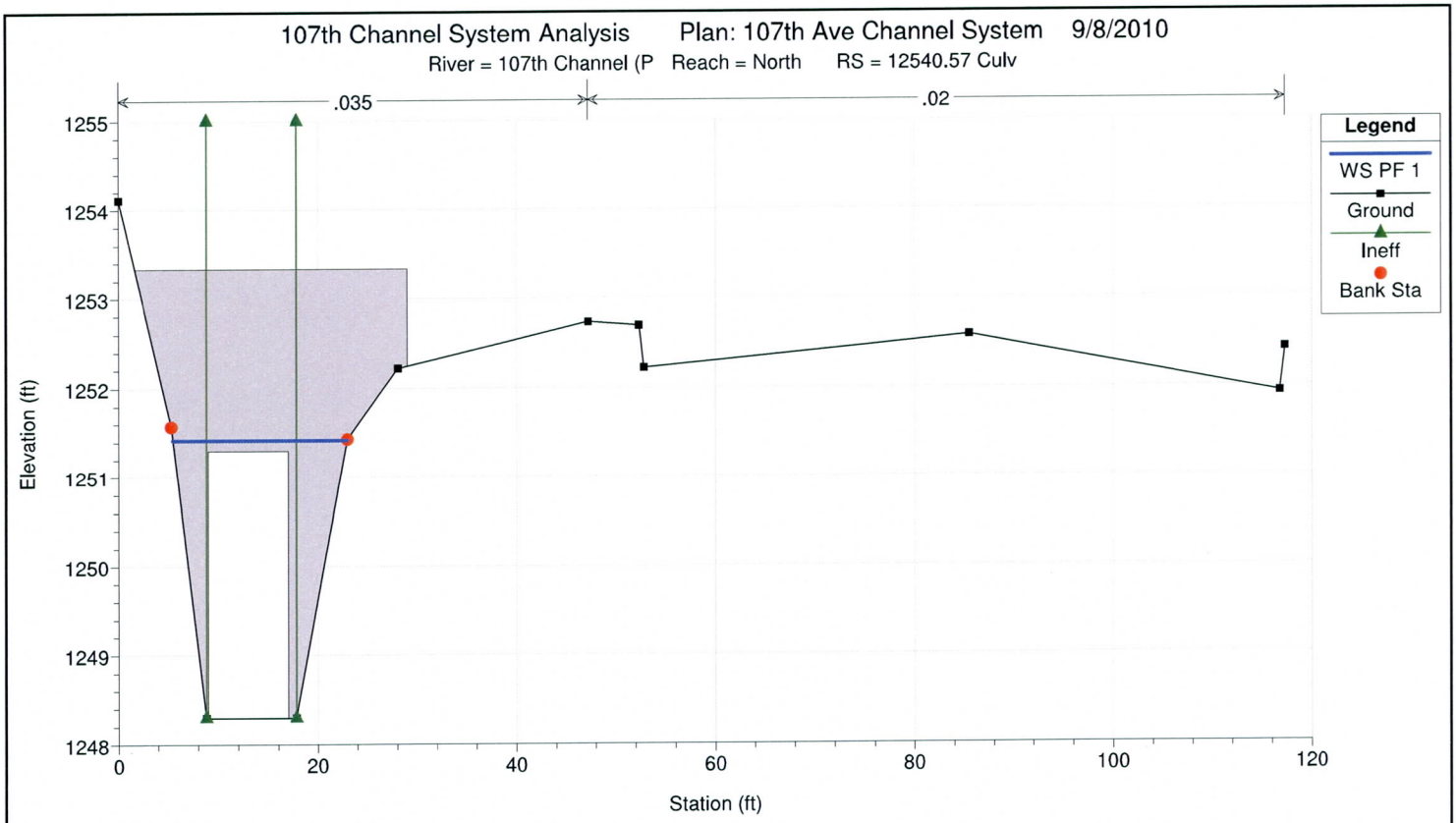
1251
1250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Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = North
RS = 12540.57 Culv
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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20
40
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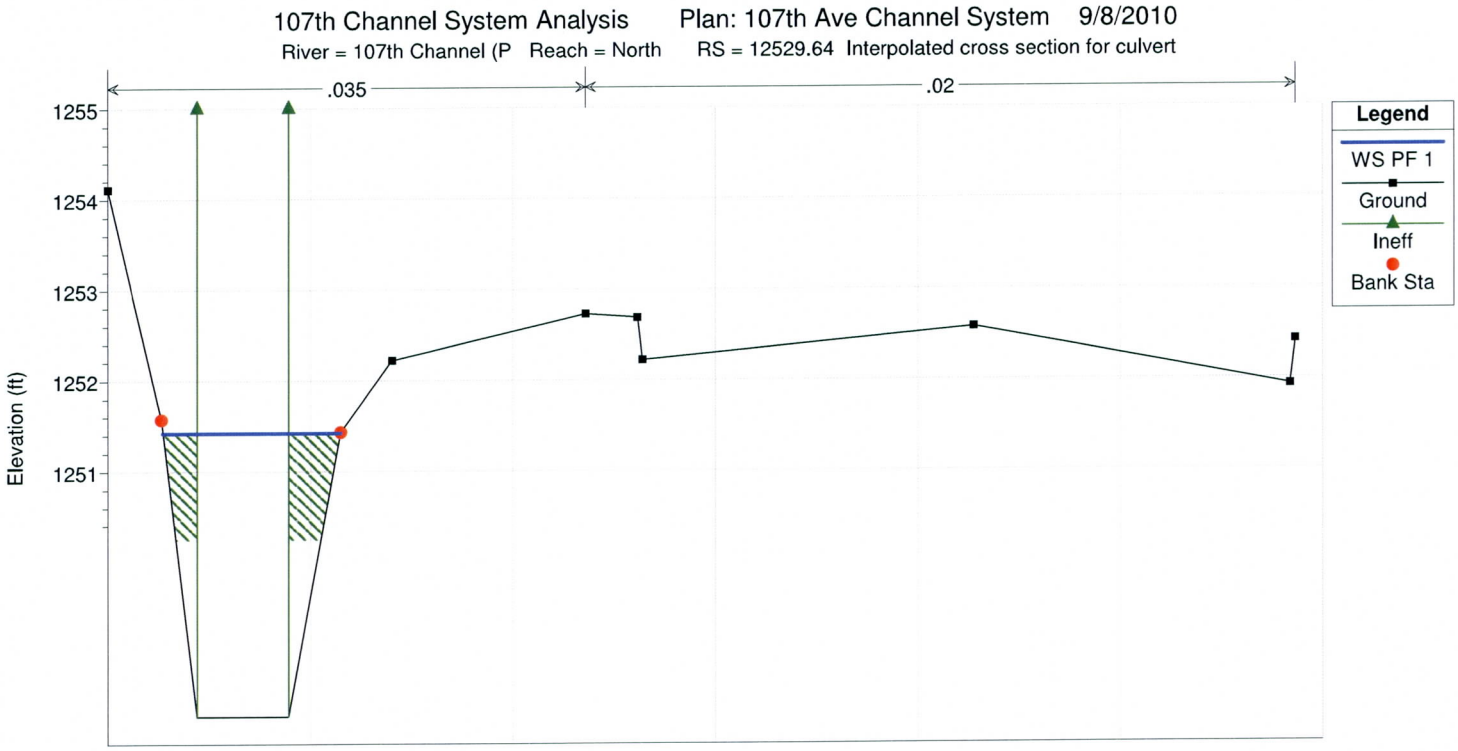
80
100
120
Station (ft)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Plan: 107th Ave Channel System
9/8/2010
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Reach = North
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.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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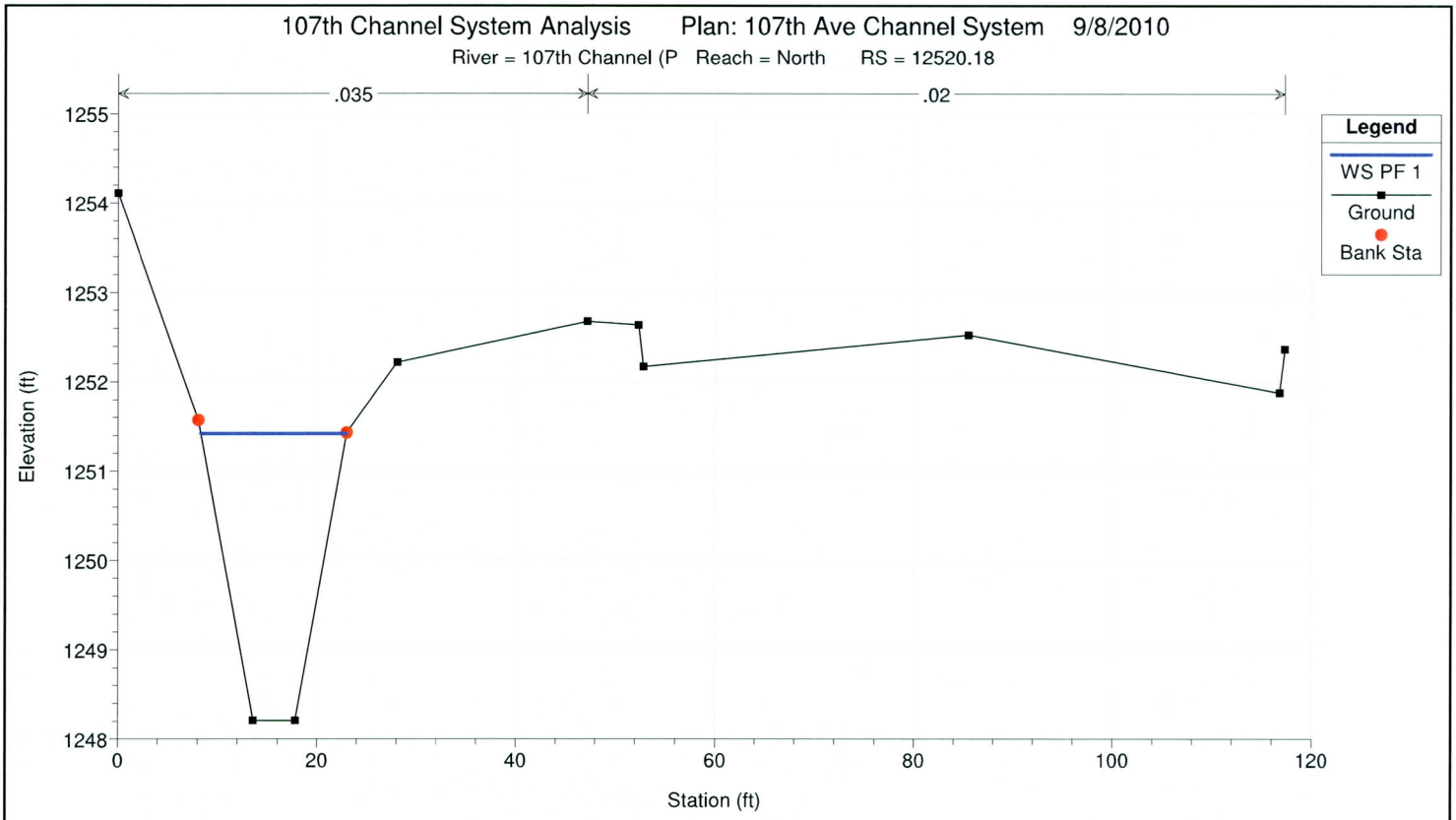
1254
1253
1252
1251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.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
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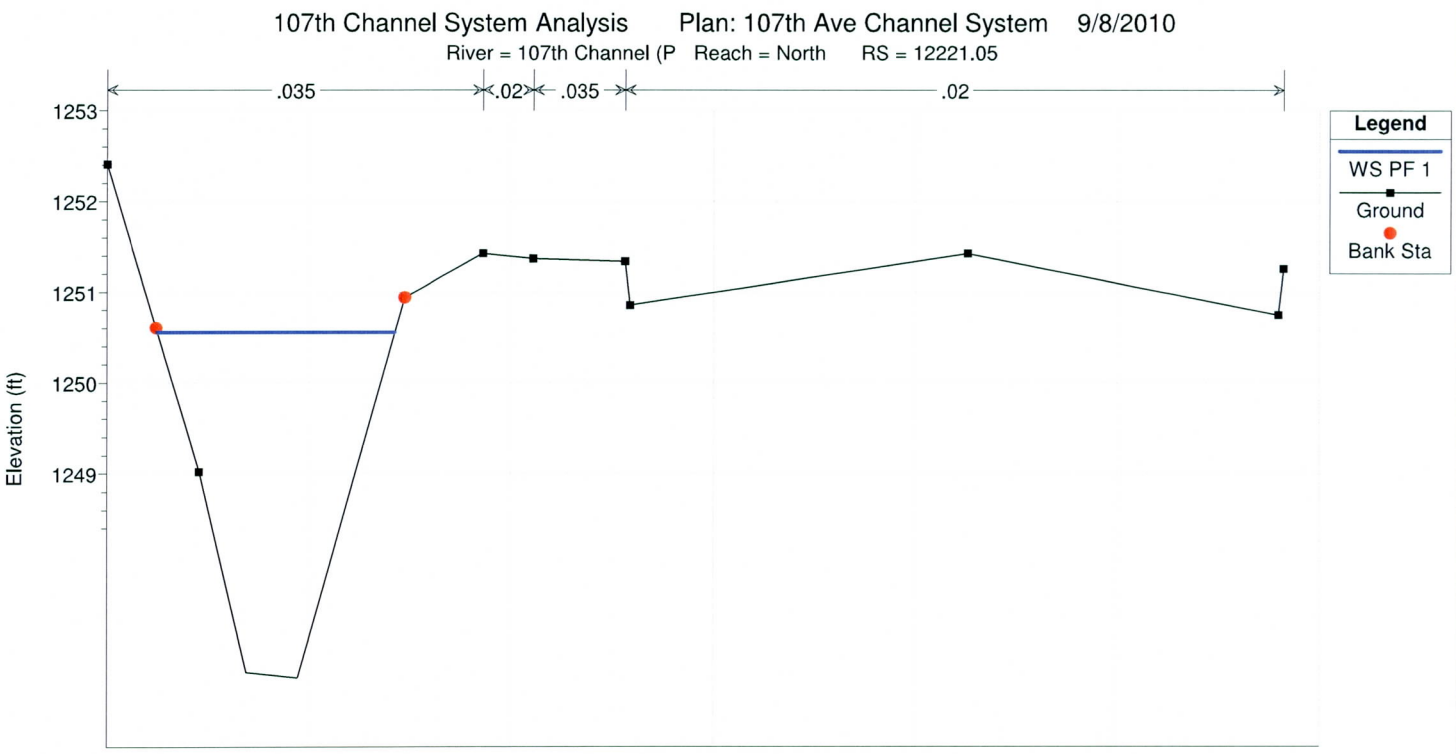
Station (ft)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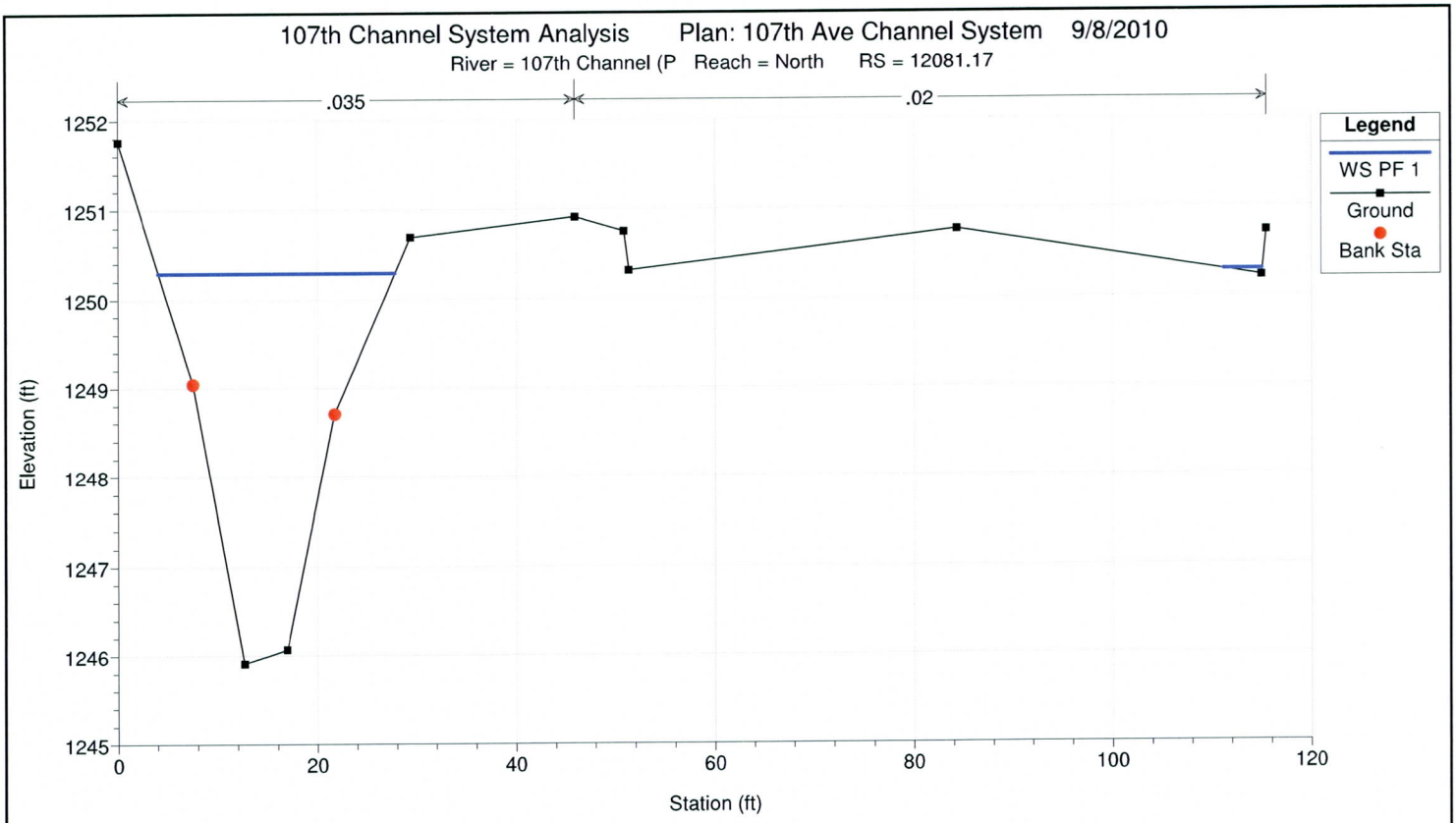
1249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.02
Legend
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Ground
Bank Sta
Elevation (ft)
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1251
1250
1249
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1247
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1245
0
20
40
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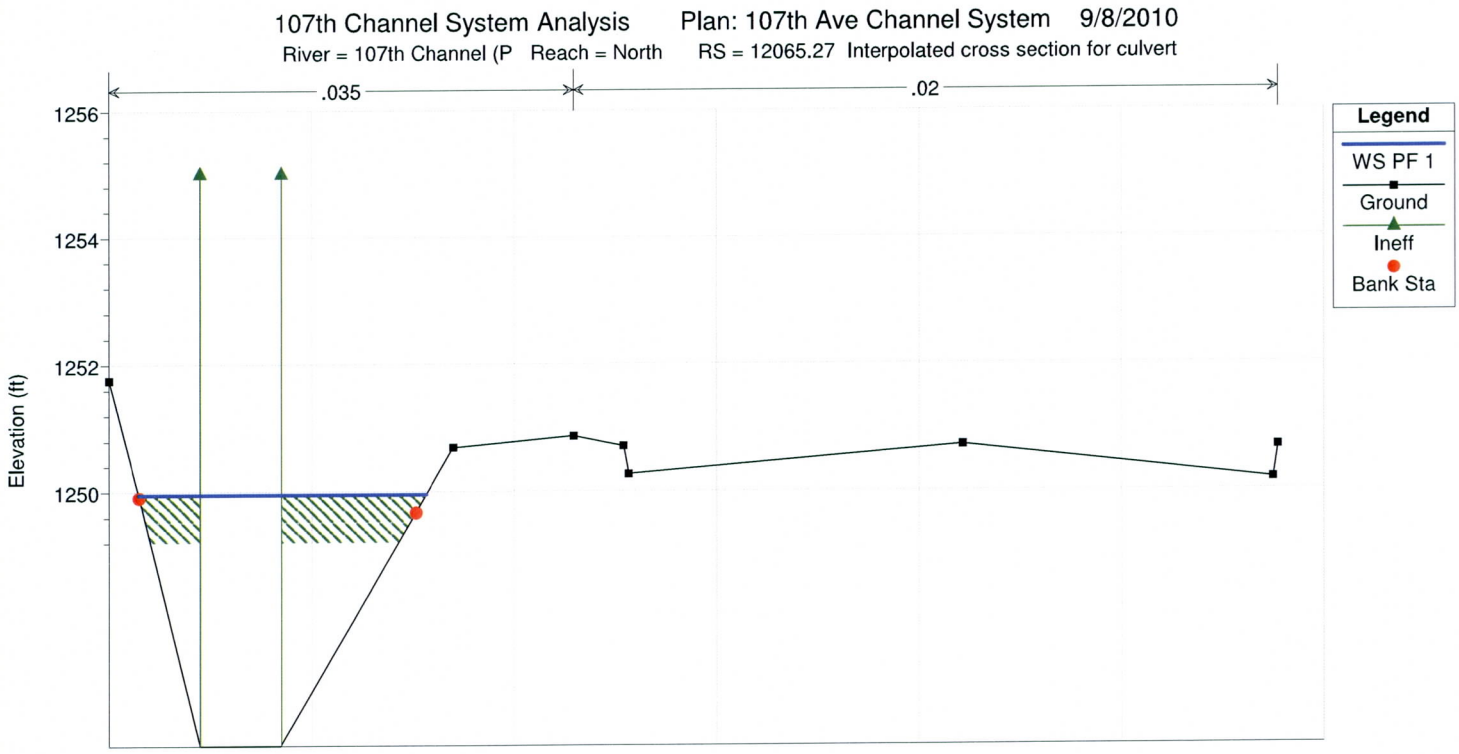
80
100
120
Station (ft)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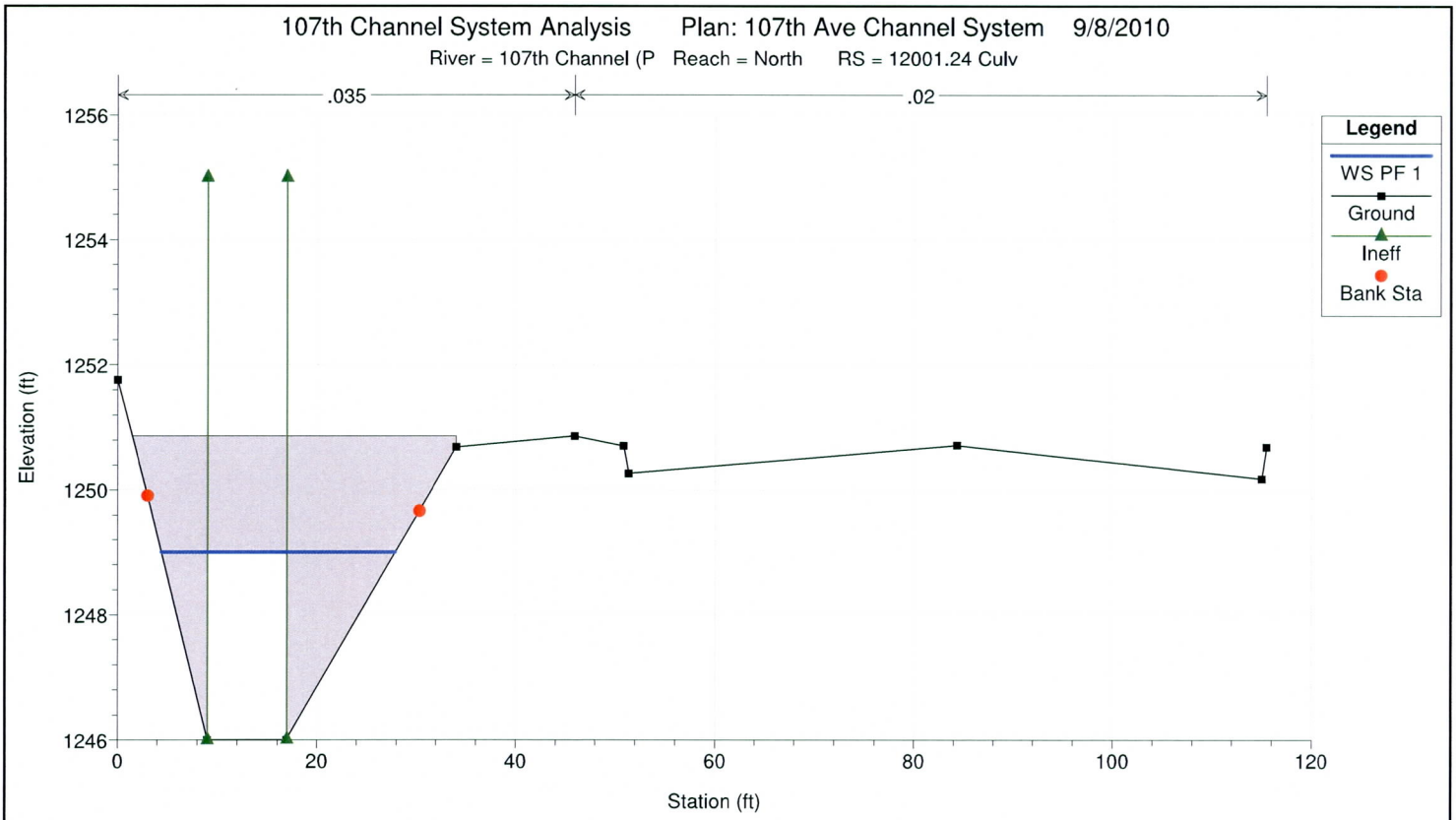
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1256
1254
1252
1250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.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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1254
1252
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1246
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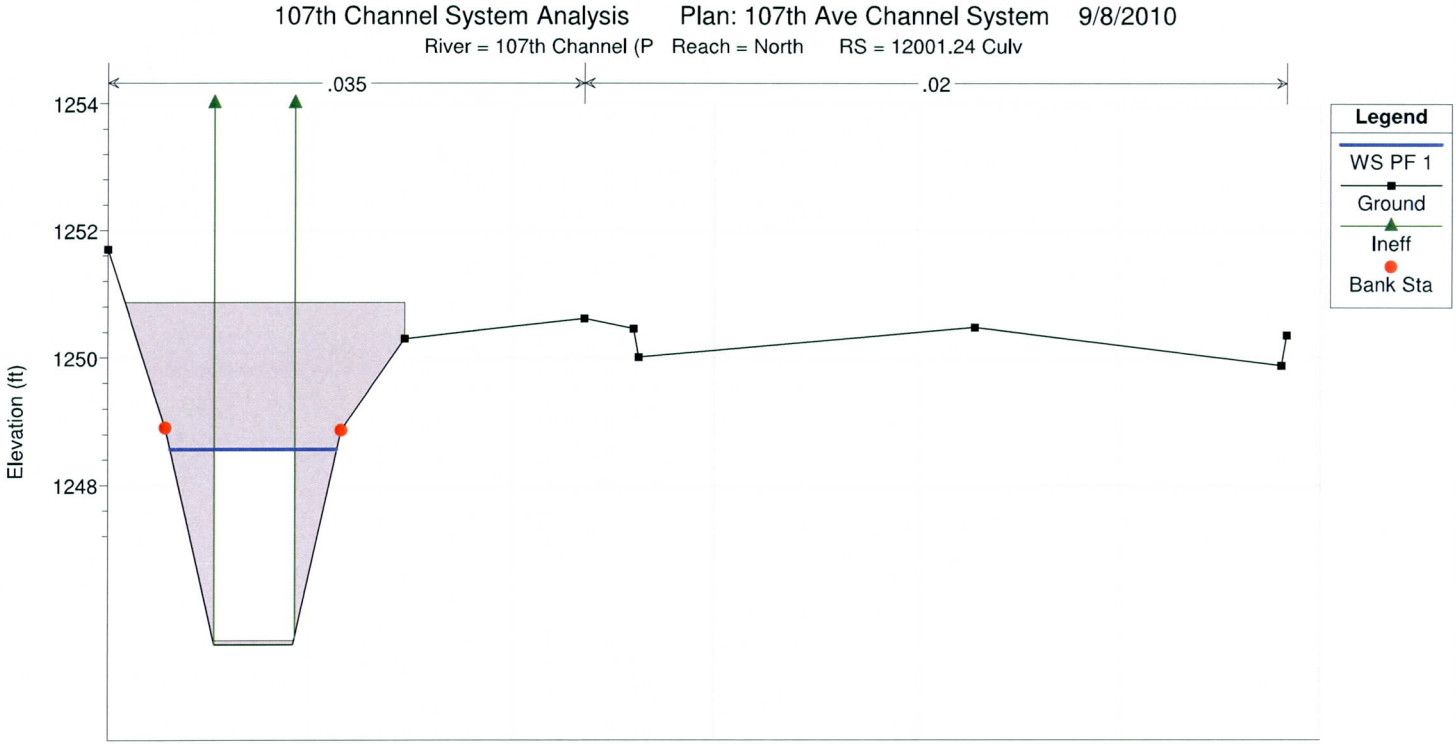
20
40
60
80
100
120
Station (ft)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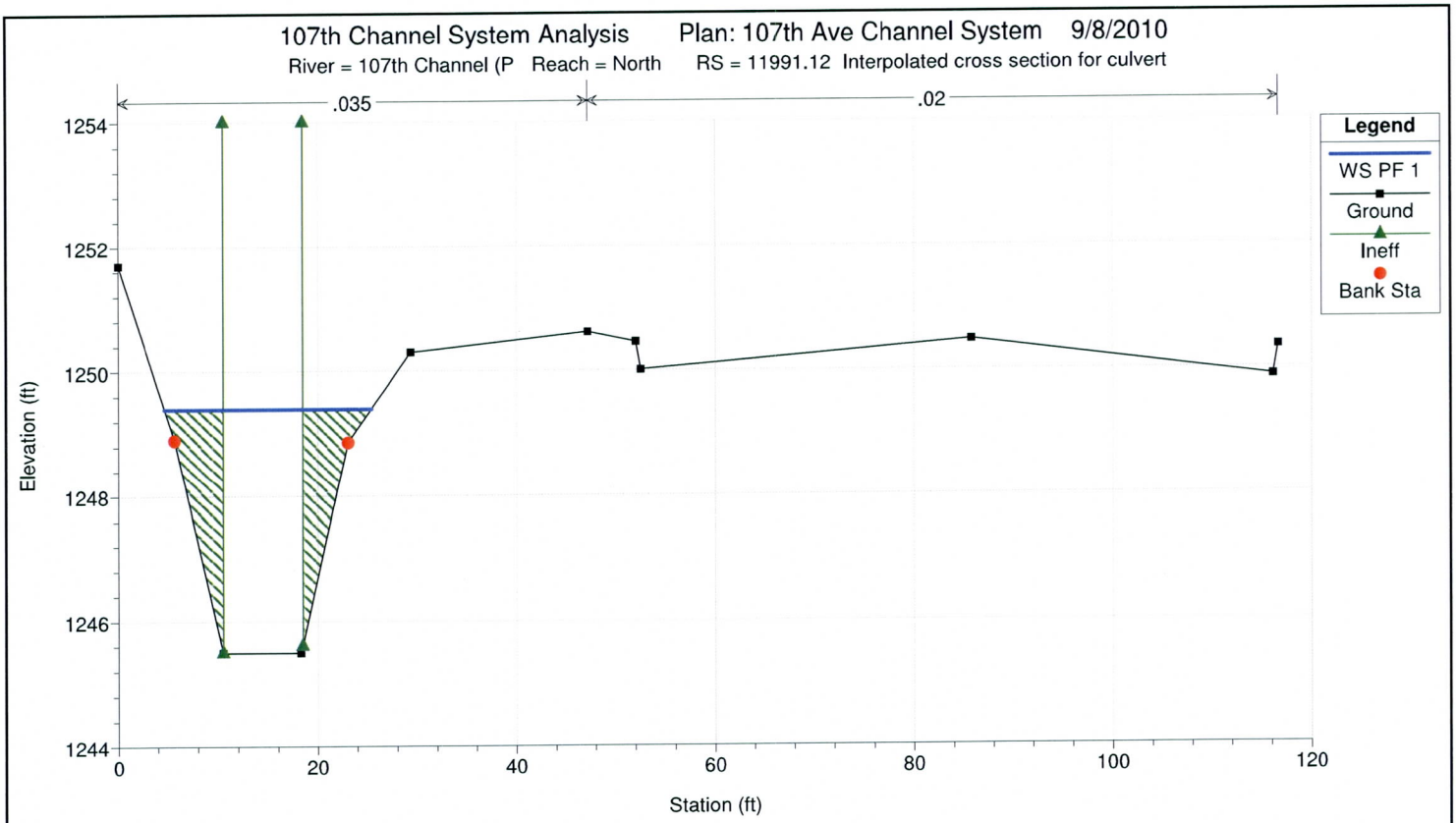
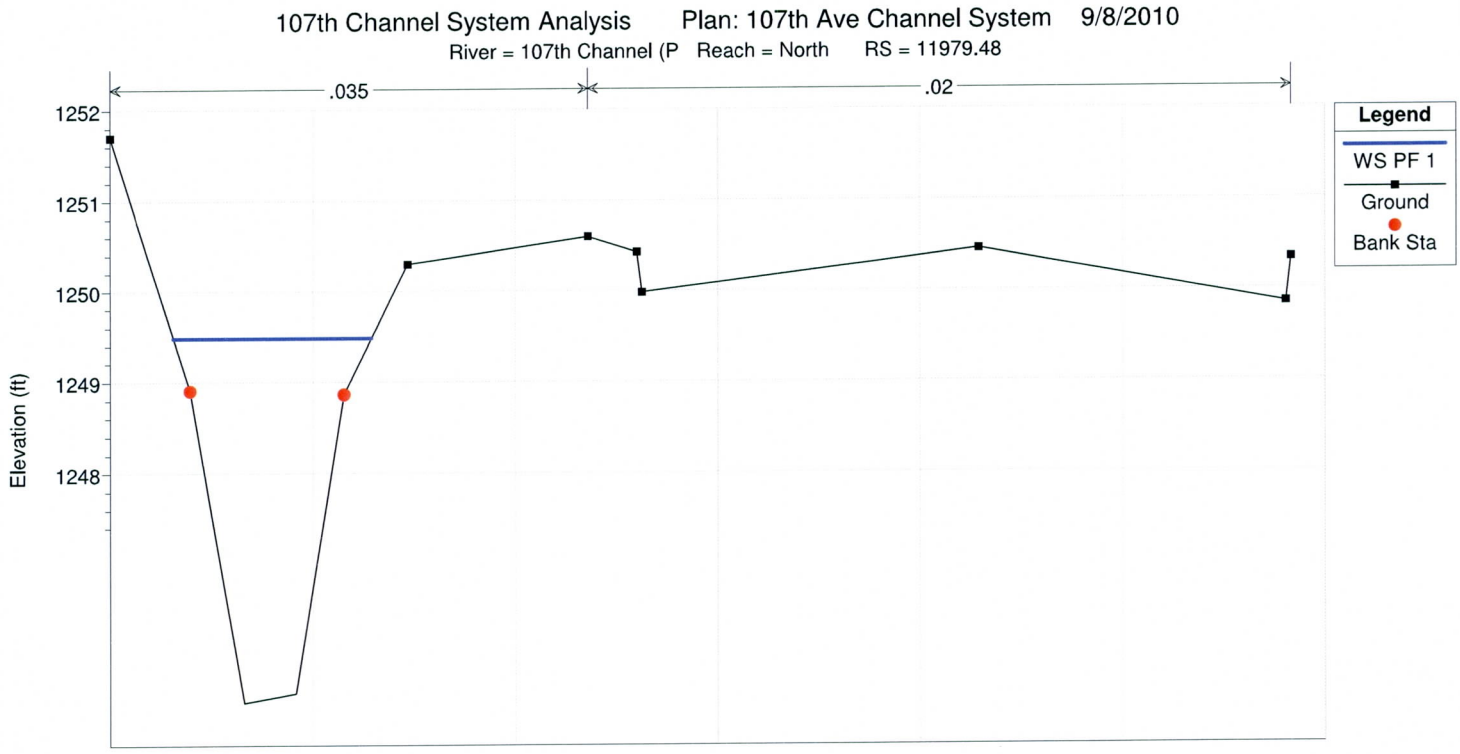
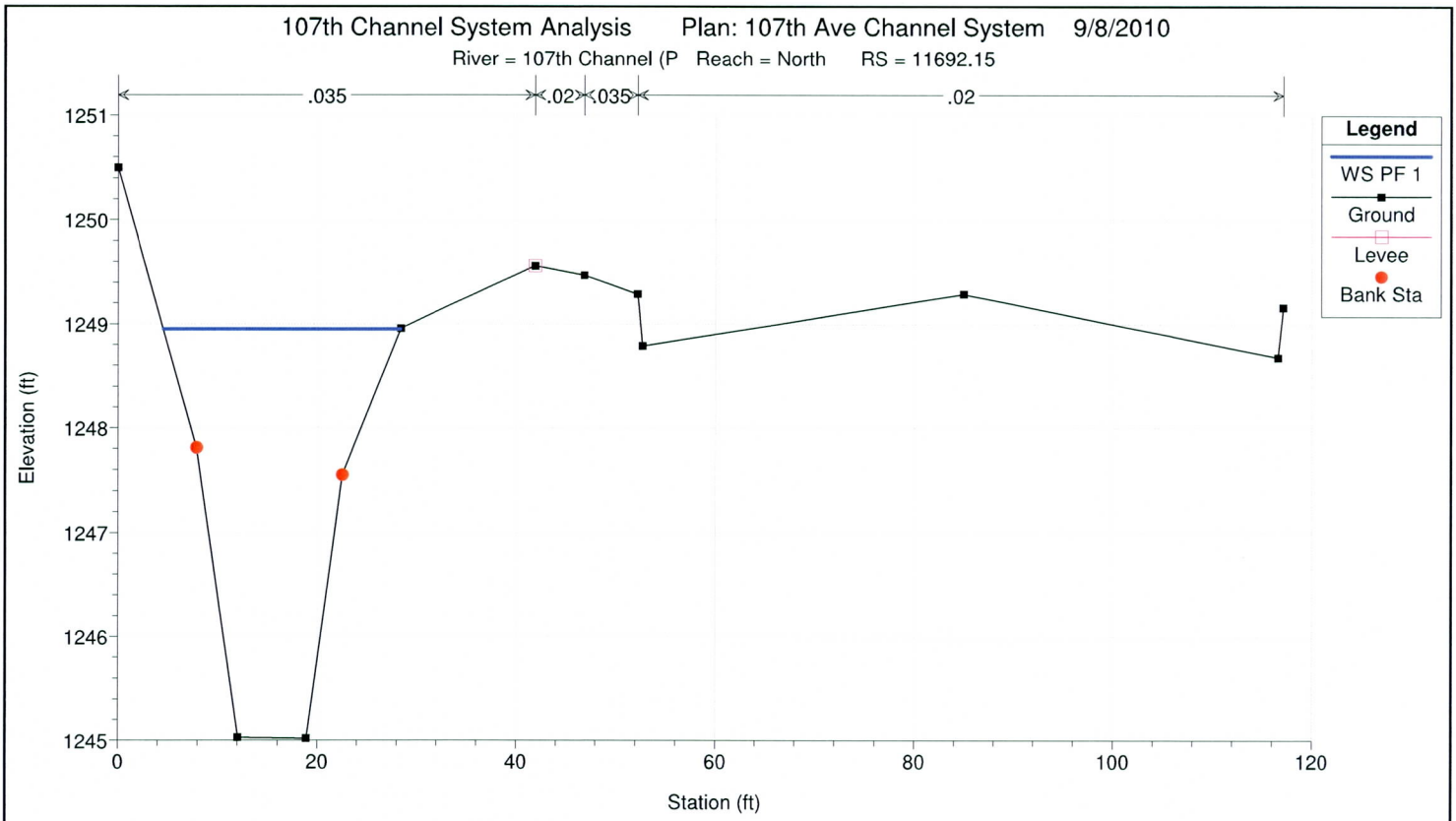
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1254
1252
1250
1248


107th Channel System Analysis
Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = North
RS = 11991.12 Interpolated cross section for culvert
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1254
1252
1250
1248
1246
1244
0
20
40
60
80
100
120
Station (ft)


107th Channel System Analysis
Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = North
RS = 11979.48
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1252
1251
1250
1249
1248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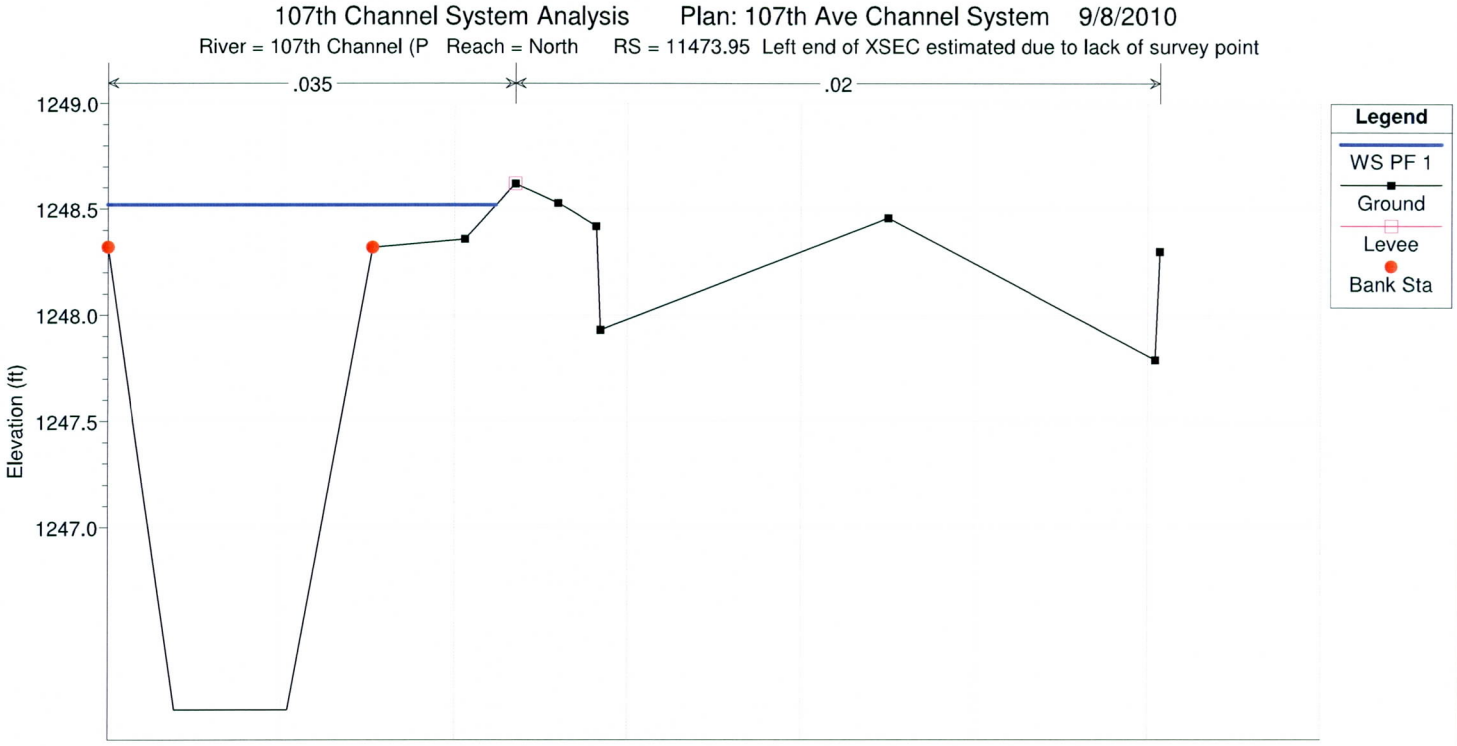
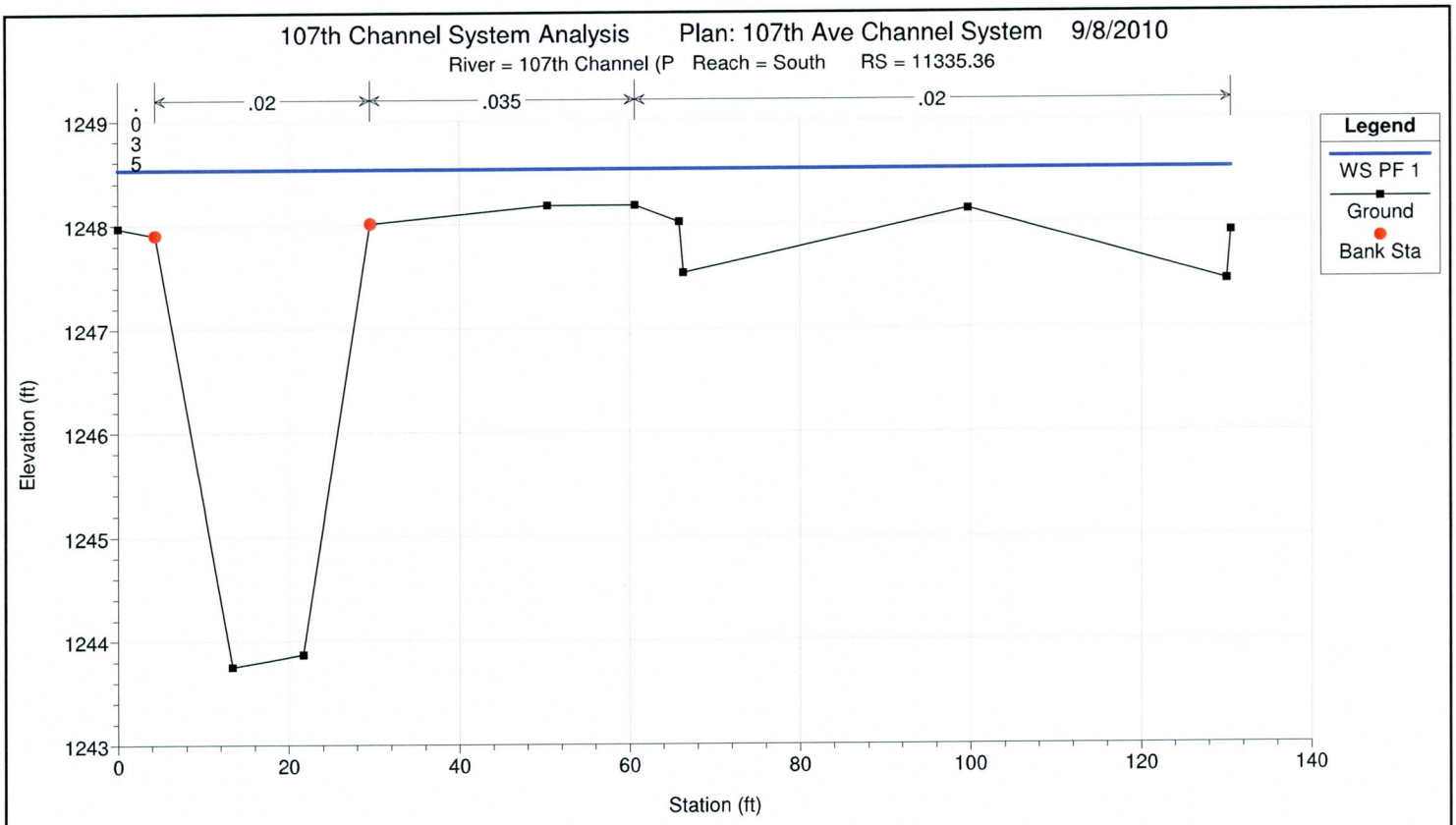
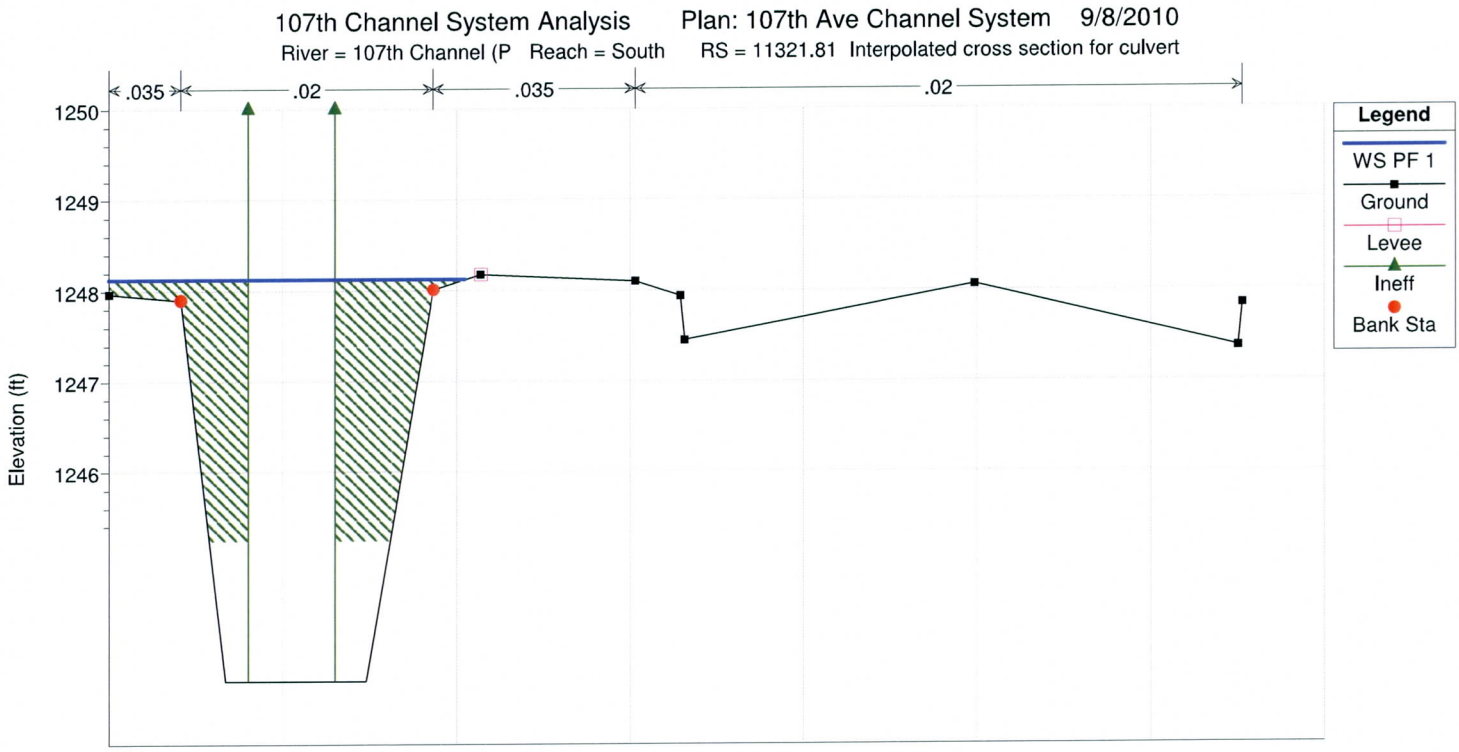
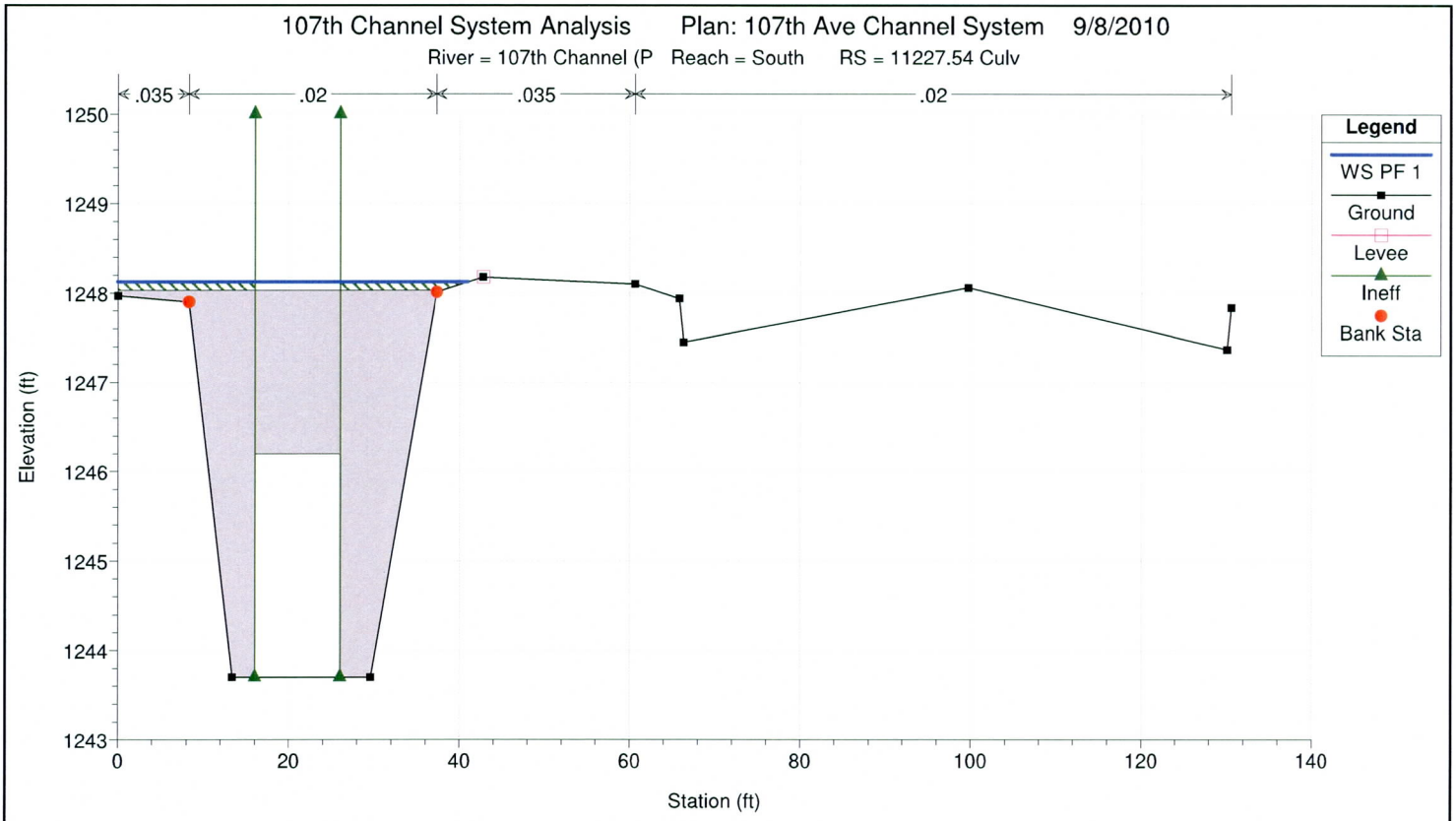
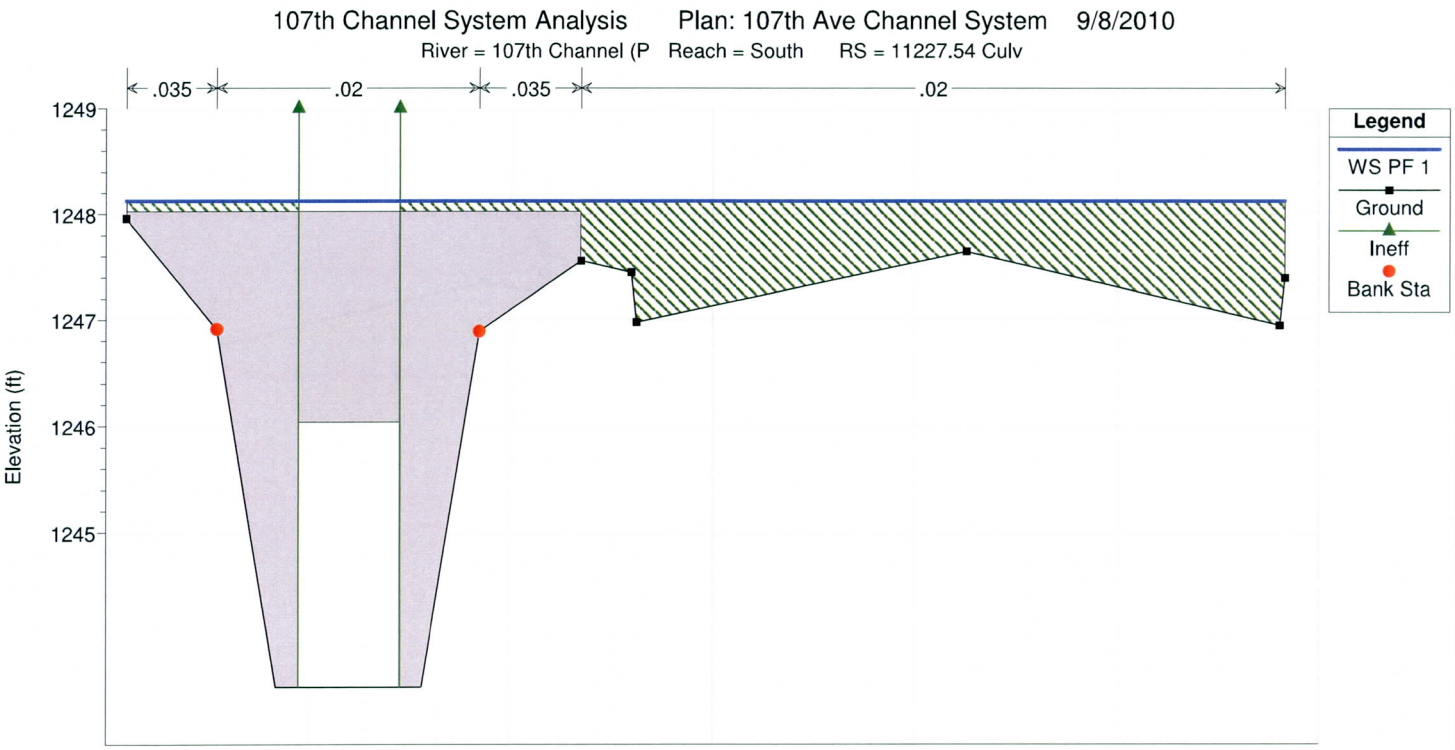
.035
.02
.035
.02
Legend
WS PF 1
Ground
Levee
Bank Sta
Elevation (ft)
1251
1250
1249
1248
1247
1246
1245
0
20
40
60
80
100
120
Station (ft)


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = North RS = 11473.95 Left end of XSEC estimated due to lack of survey point
.035
.02
Legend
WS PF 1
Ground
Levee
Bank Sta
Elevation (ft)
1249.0
1248.5
1248.0
1247.5
1247.0


107th Channel System Analysis
Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = South
RS = 11335.36
.02
.035
.02
.035
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
1249
1248
1247
1246
1245
1244
1243
0
20
40
60
80
100
120
140


107th Channel System Analysis
Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = South
RS = 11321.81
Interpolated cross section for culvert
.035
.02
.035
.02
Legend
WS PF 1
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1250
1249
1248
1247
1246


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 11227.54 Culv
.035
.02
.035
.02
Legend
WS PF 1
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1250
1249
1248
1247
1246
1245
1244
1243
0
20
40
60
80
100
120
140
Station (ft)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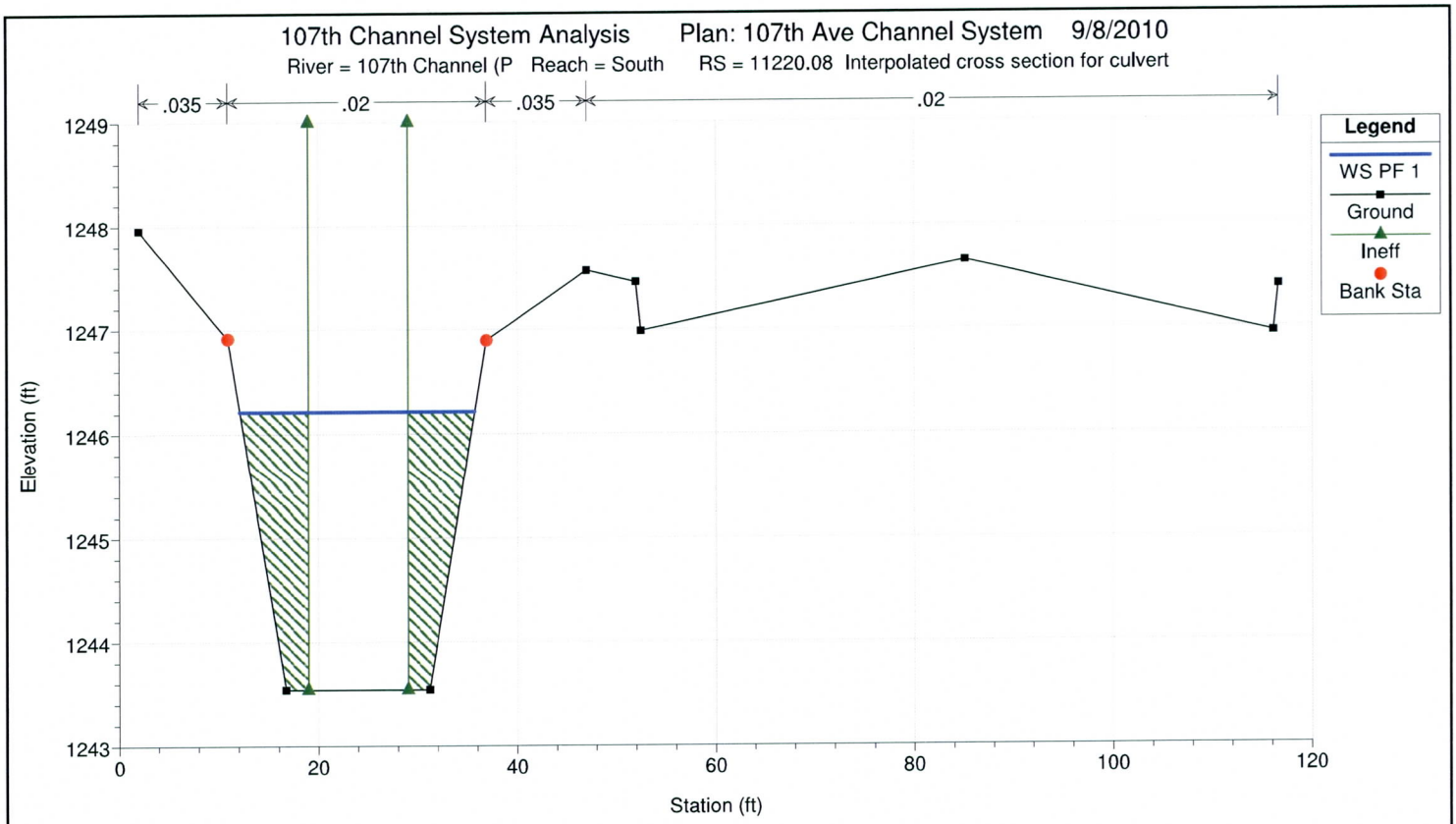
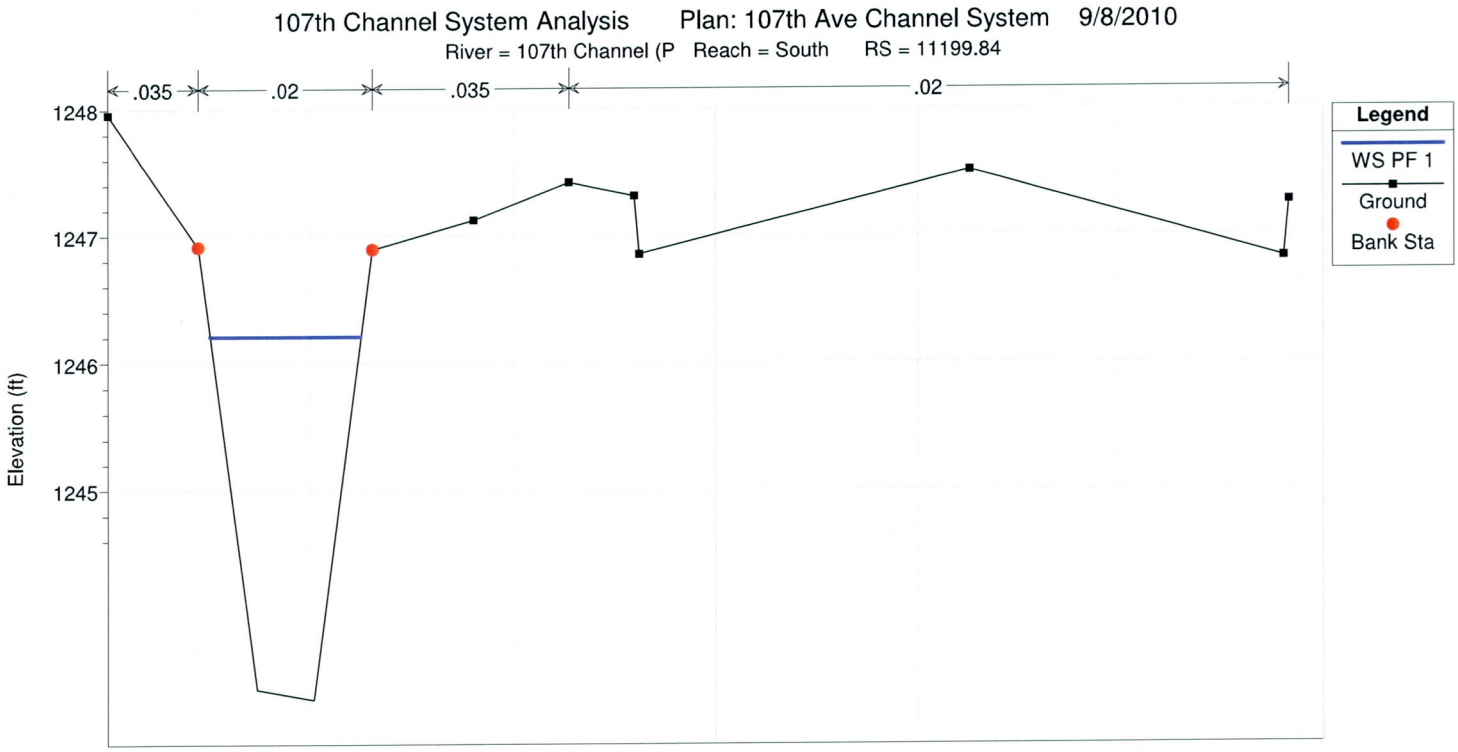
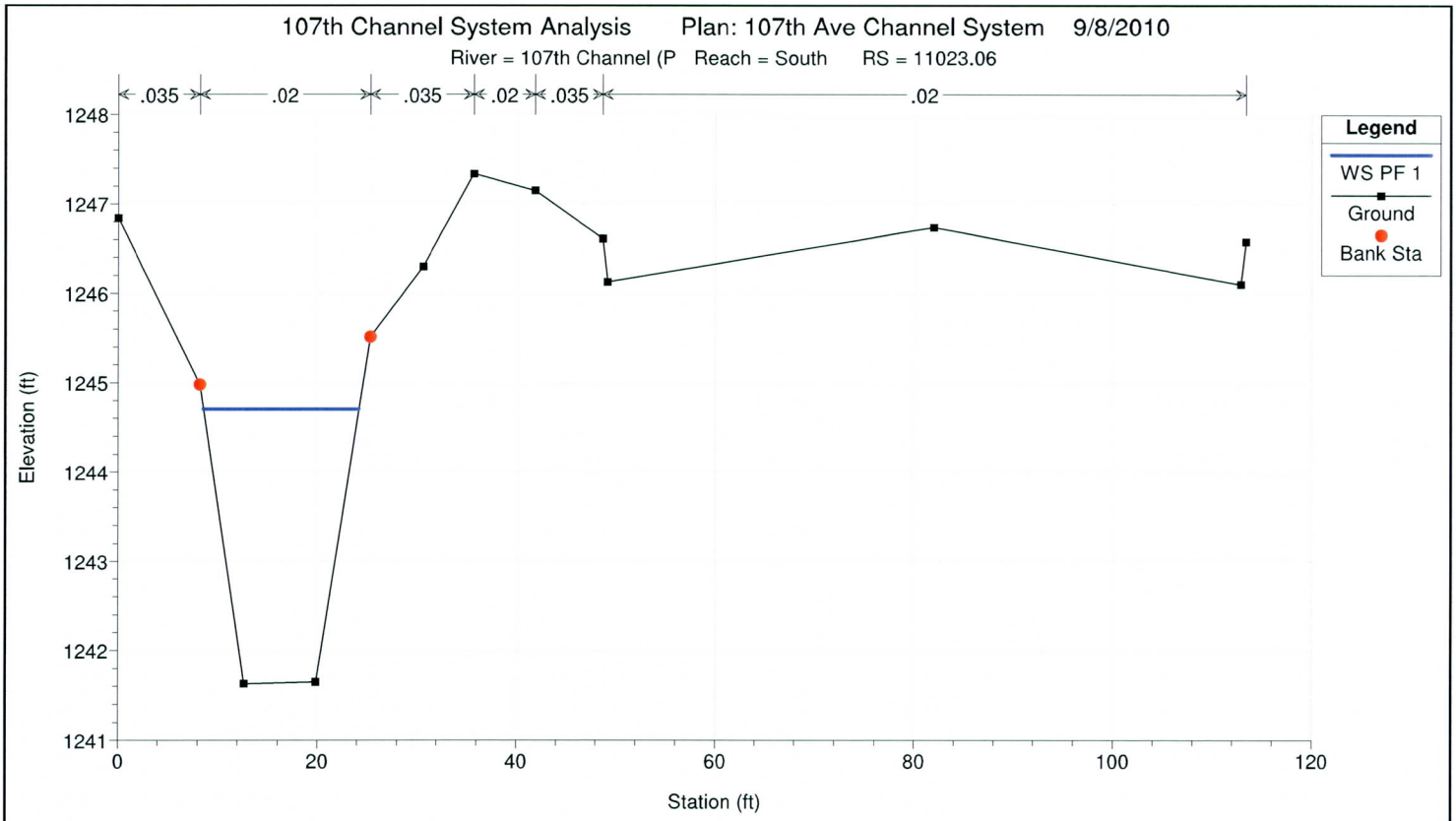
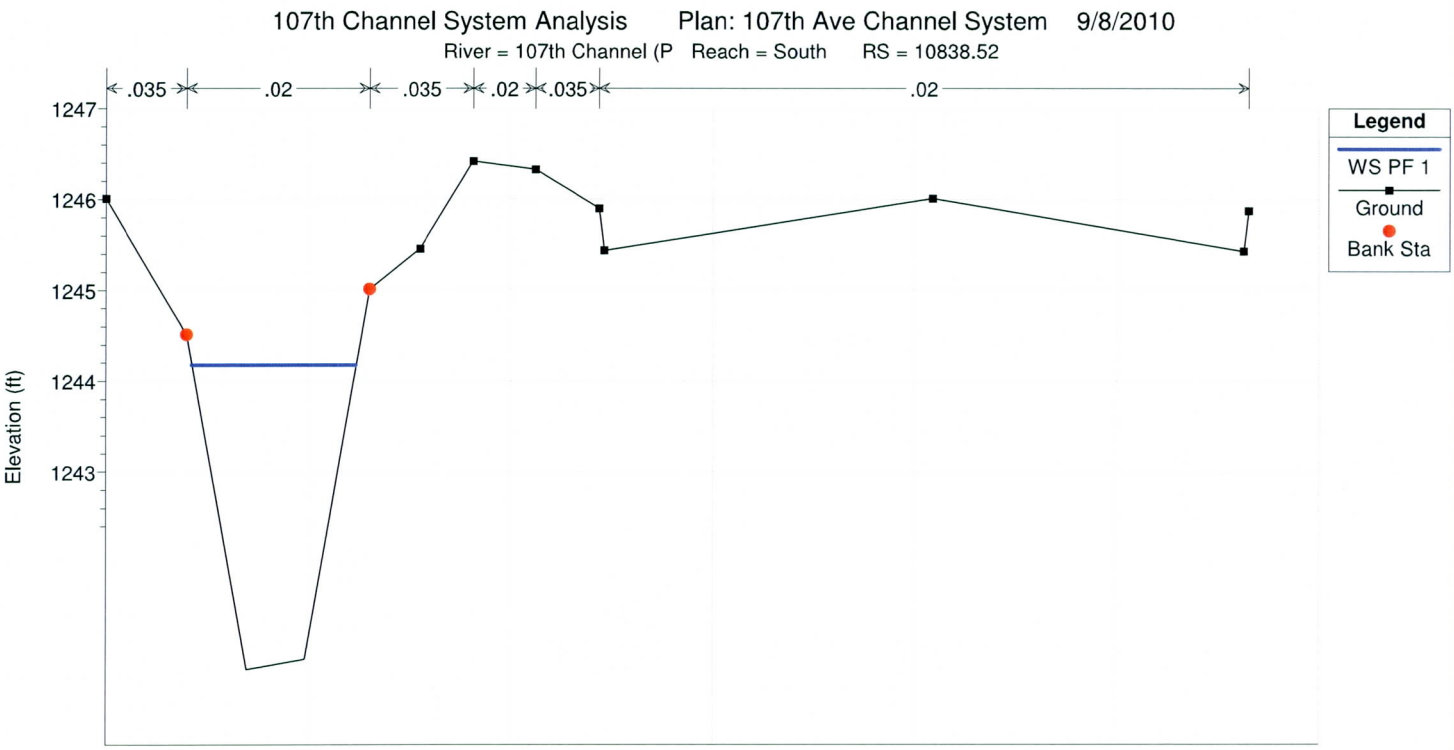
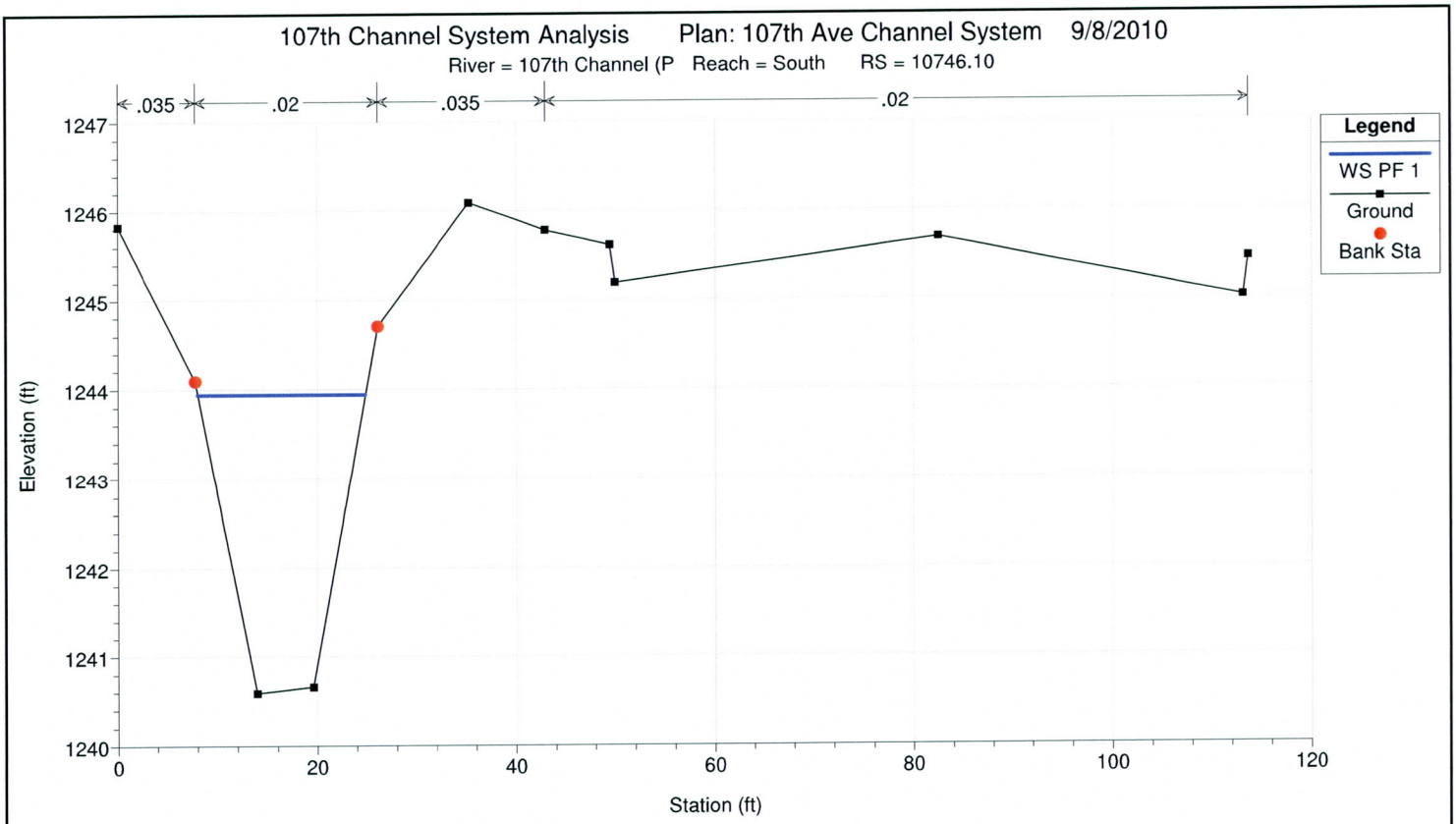
River = 107th Channel (P Reach = South RS = 11227.54 Culv
.035
.02
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1249
1248
1247
1246
1245

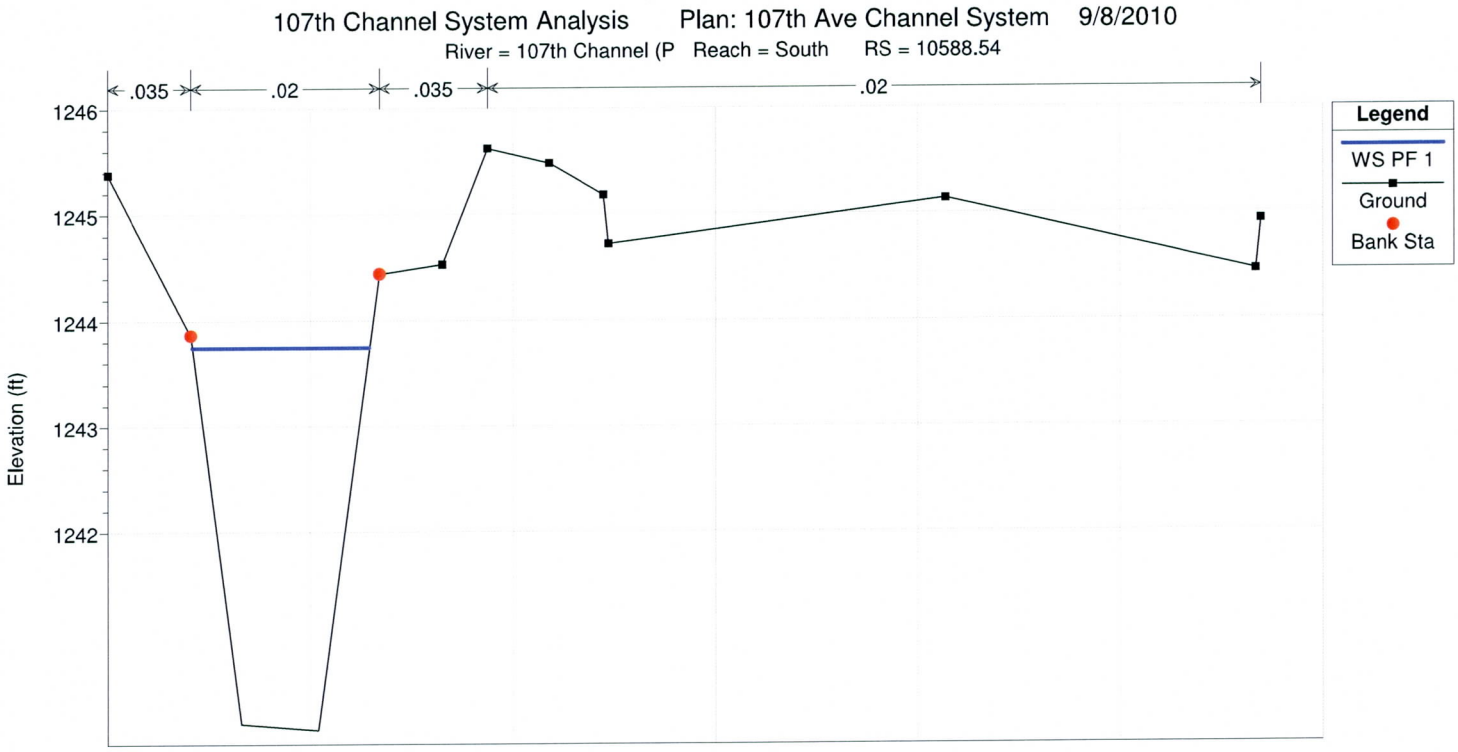

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 11220.08 Interpolated cross section for culvert
.035
.02
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1249
1248
1247
1246
1245
1244
1243
0
20
40
60
80
100
120
Station (ft)

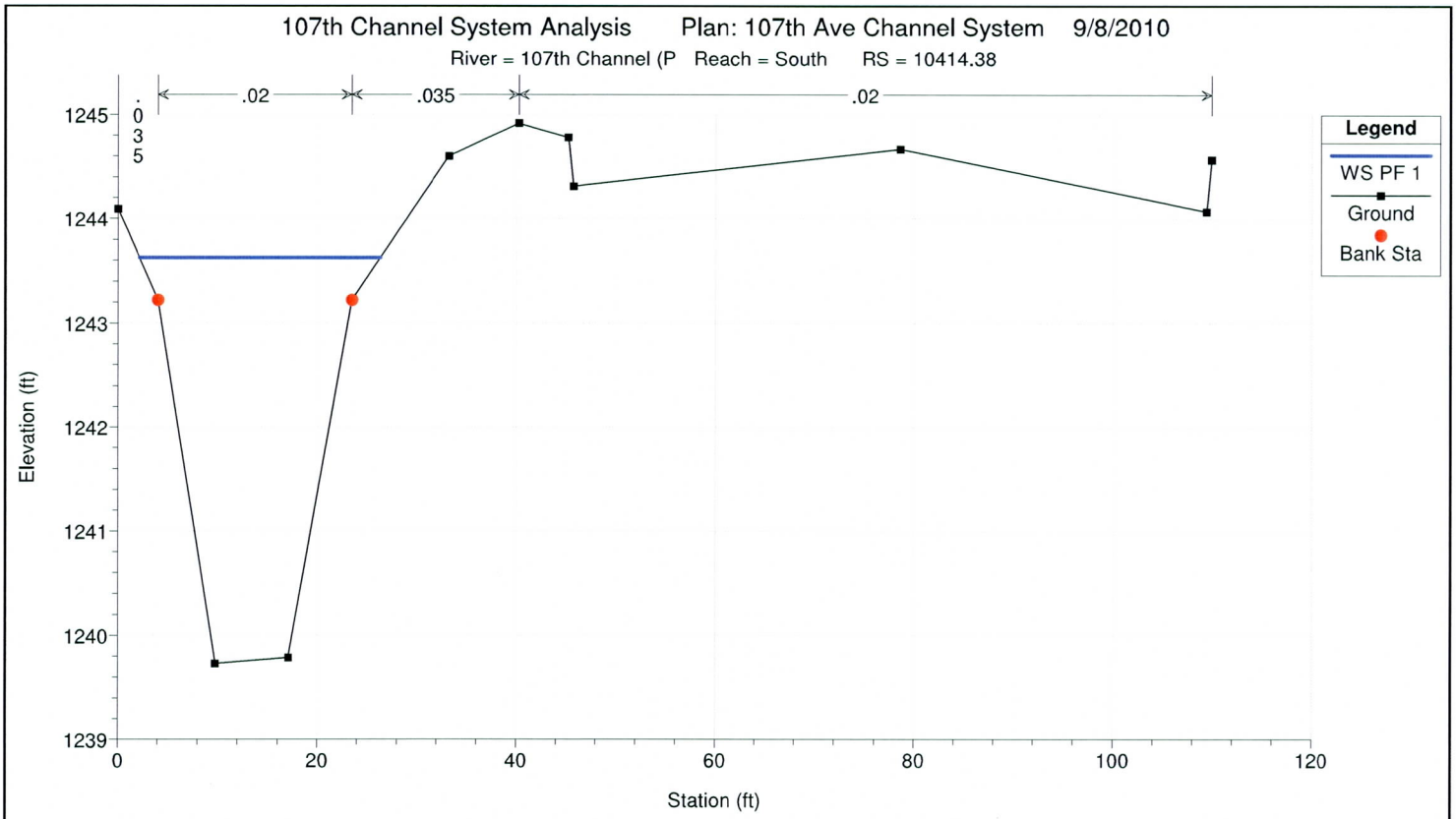

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 11199.84
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1248
1247
1246
1245

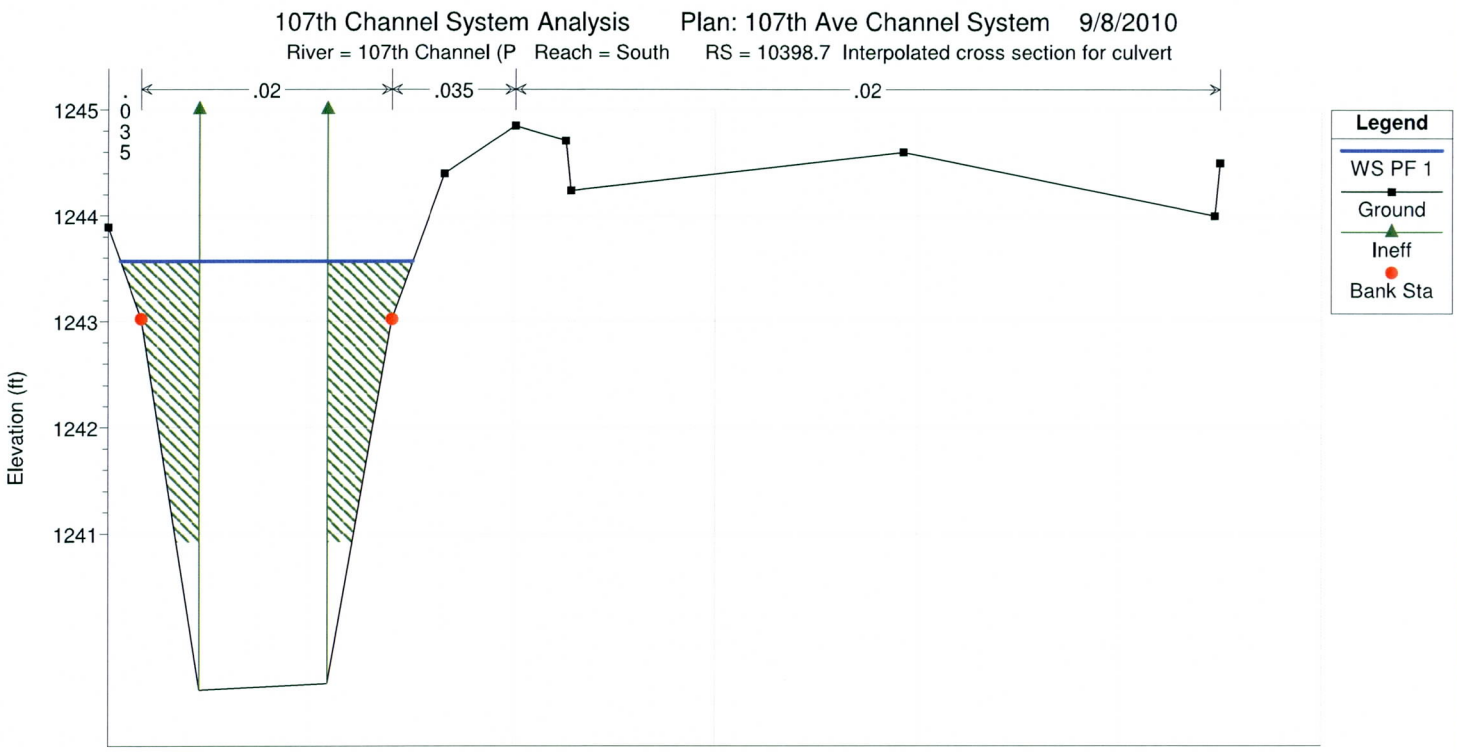

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 11023.06
.035
.02
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1248
1247
1246
1245
1244
1243
1242
1241
0
20
40
60
80
100
120
Station (ft)

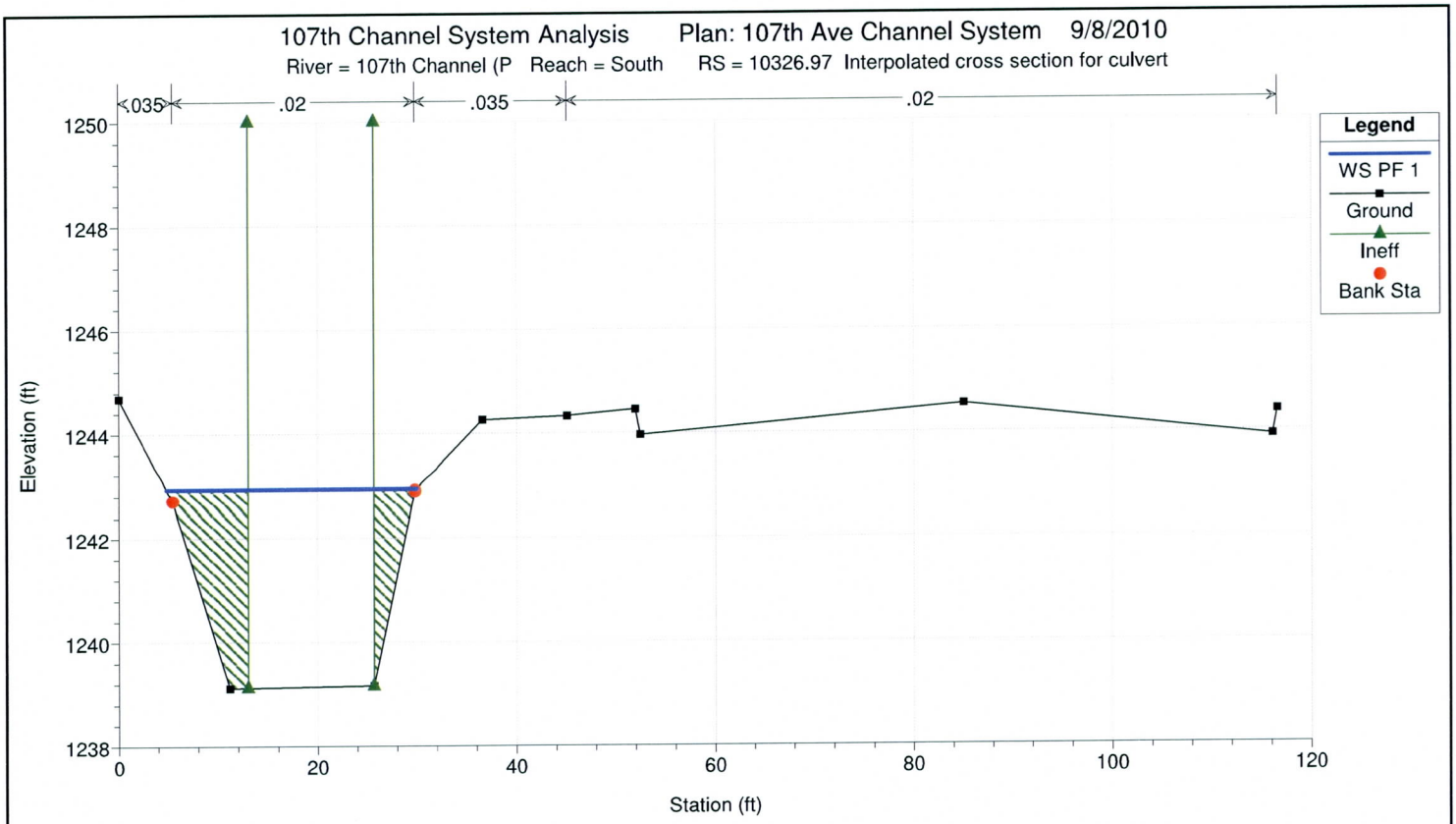

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10838.52
.035
.02
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1247
1246
1245
1244
1243

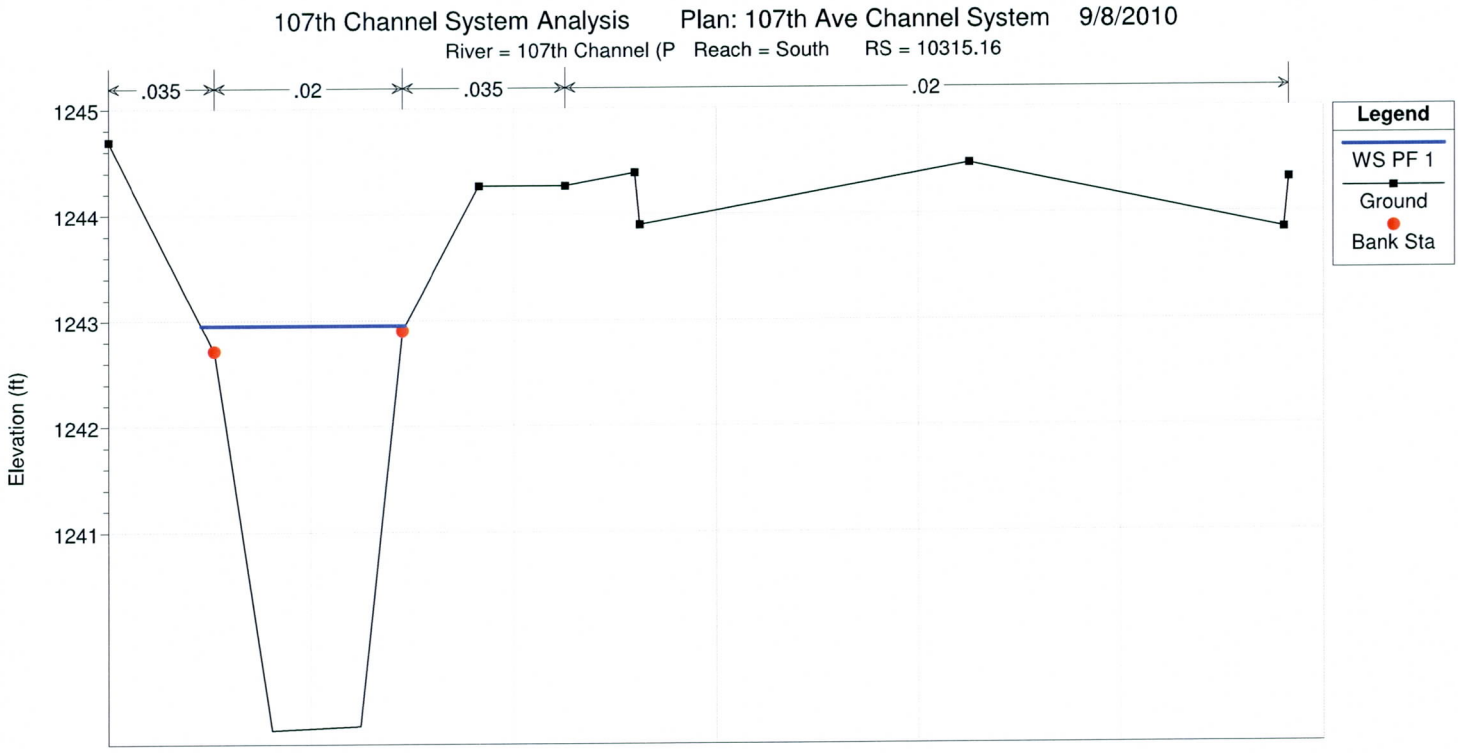

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10746.10
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1247
1246
1245
1244
1243
1242
1241
1240
0
20
40
60
80
100
120
Station (ft)

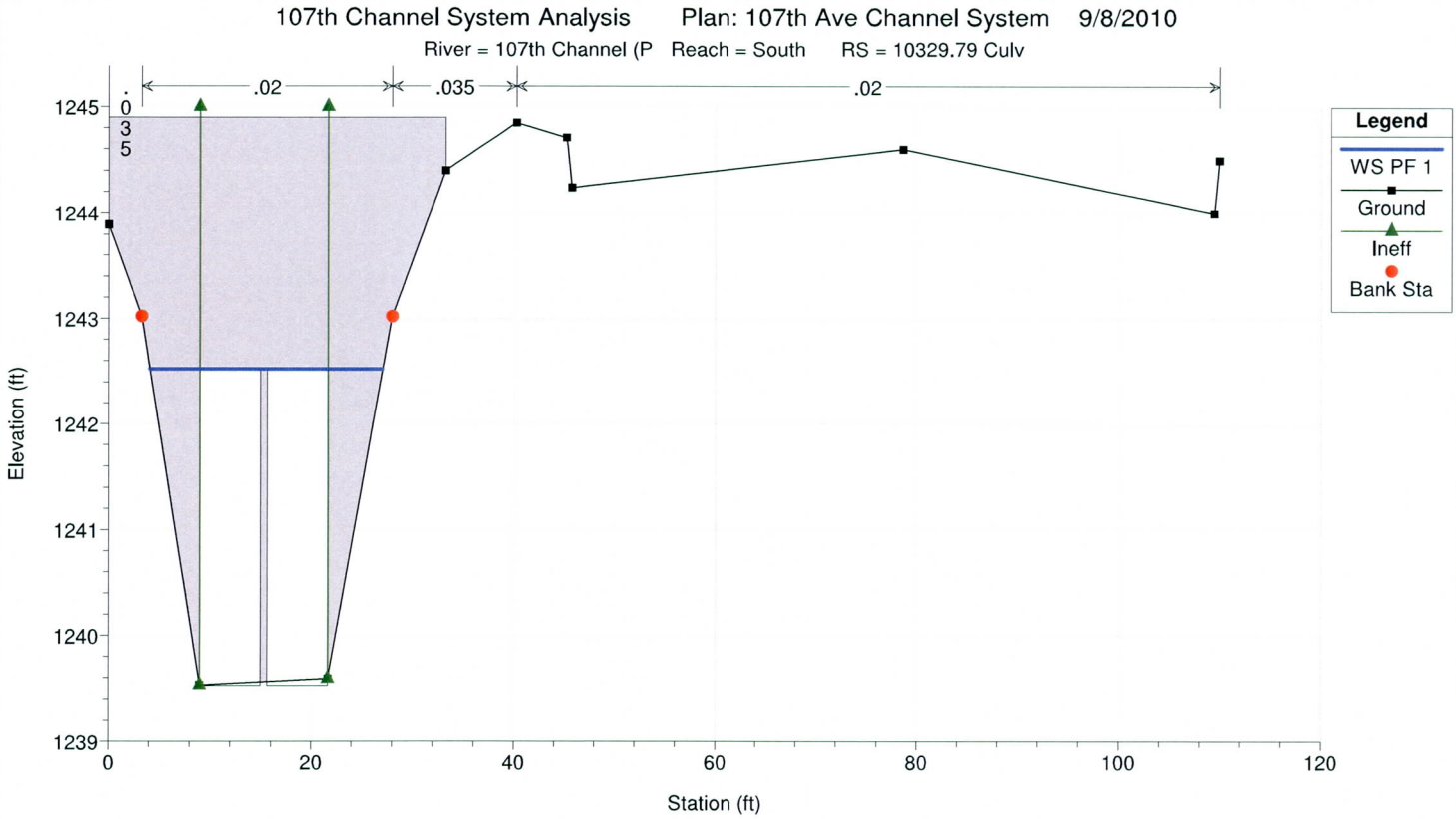

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10588.54
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1246
1245
1244
1243
1242

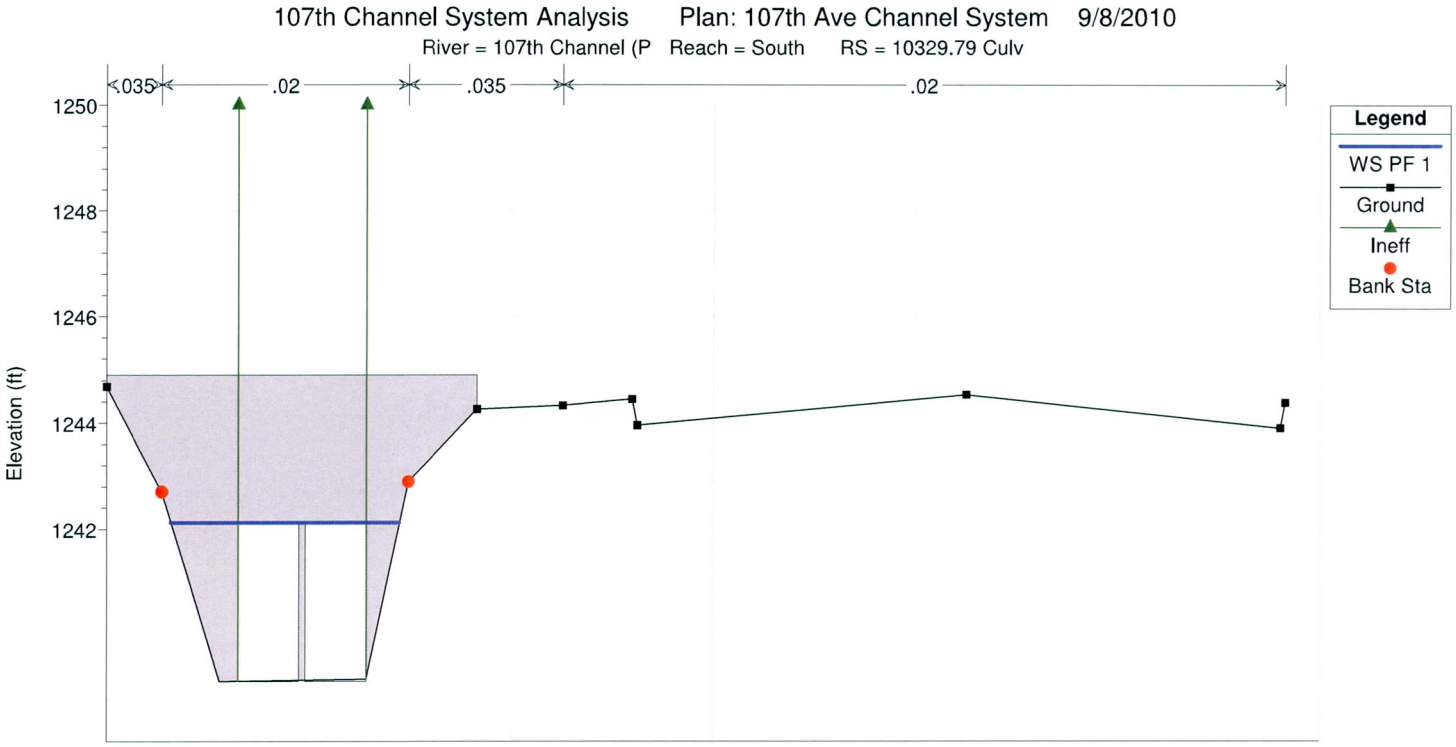

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10414.38
.02
.035
.02
.035
Elevation (ft)
Station (ft)
Legend
WS PF 1
Ground
Bank Sta

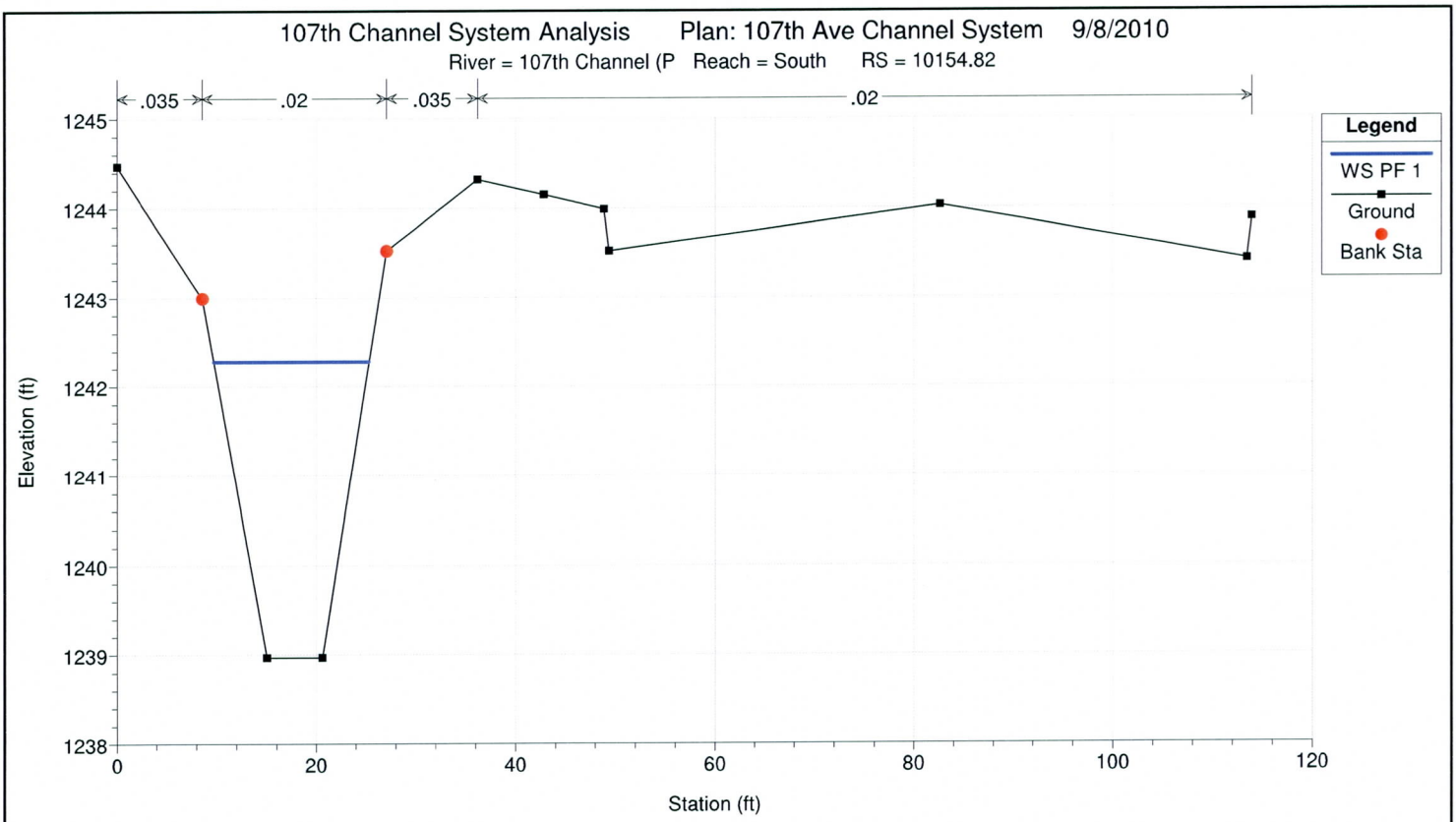

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10398.7 Interpolated cross section for culvert
.02
.035
.02
.035
Elevation (ft)
Legend
WS PF 1
Ground
Ineff
Bank Sta

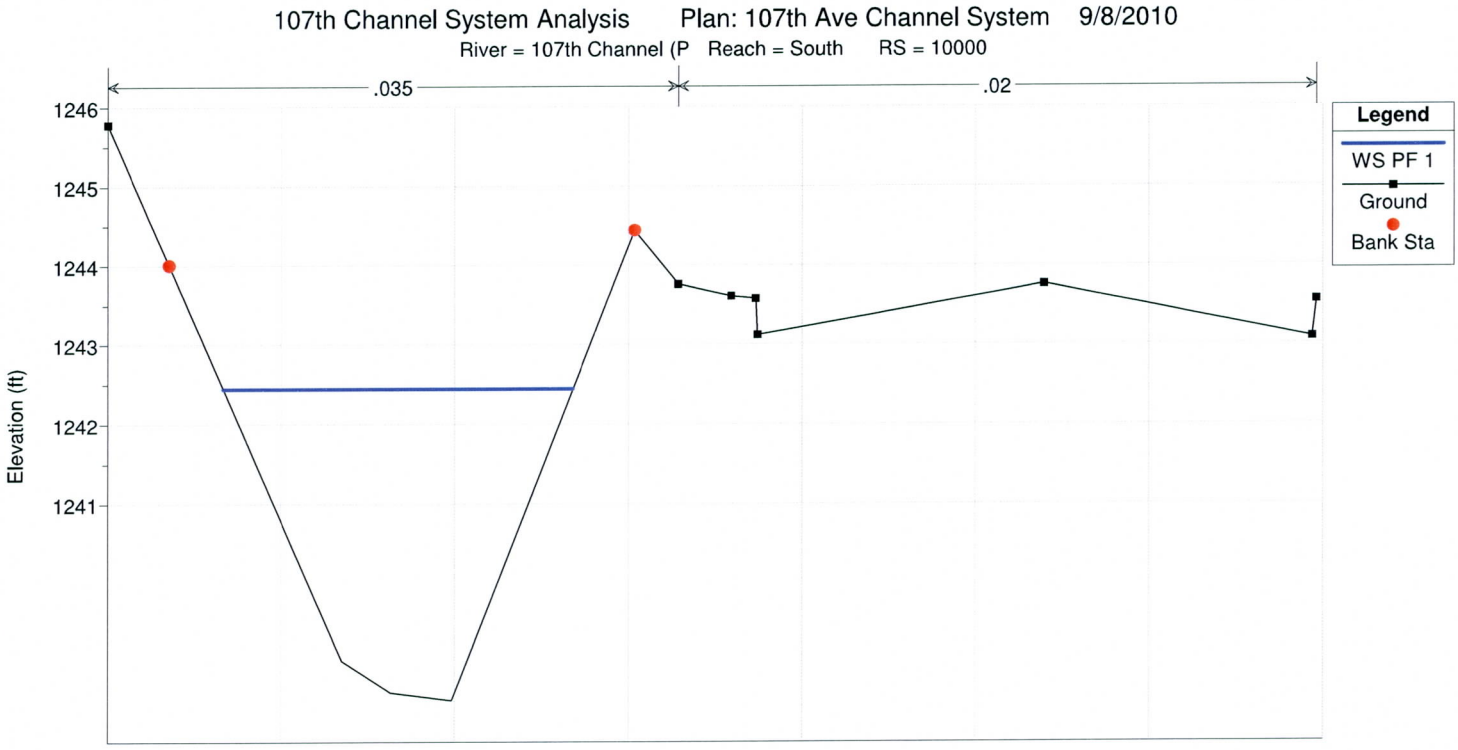

107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10326.97 Interpolated cross section for culvert
.035
.02
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1250
1248
1246
1244
1242
1240
1238
0
20
40
60
80
100
120
Station (ft)


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10315.16
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1245
1244
1243
1242
1241


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10329.79 Culv
.02
.035
.02
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1245
1244
1243
1242
1241
1240
1239
0
20
40
60
80
100
120
Station (ft)


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10329.79 Culv
.035
.02
.035
.02
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
1250
1248
1246
1244
1242


107th Channel System Analysis Plan: 107th Ave Channel System 9/8/2010
River = 107th Channel (P Reach = South RS = 10154.82
.035
.02
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1245
1244
1243
1242
1241
1240
1239
1238
0
20
40
60
80
100
120
Station (ft)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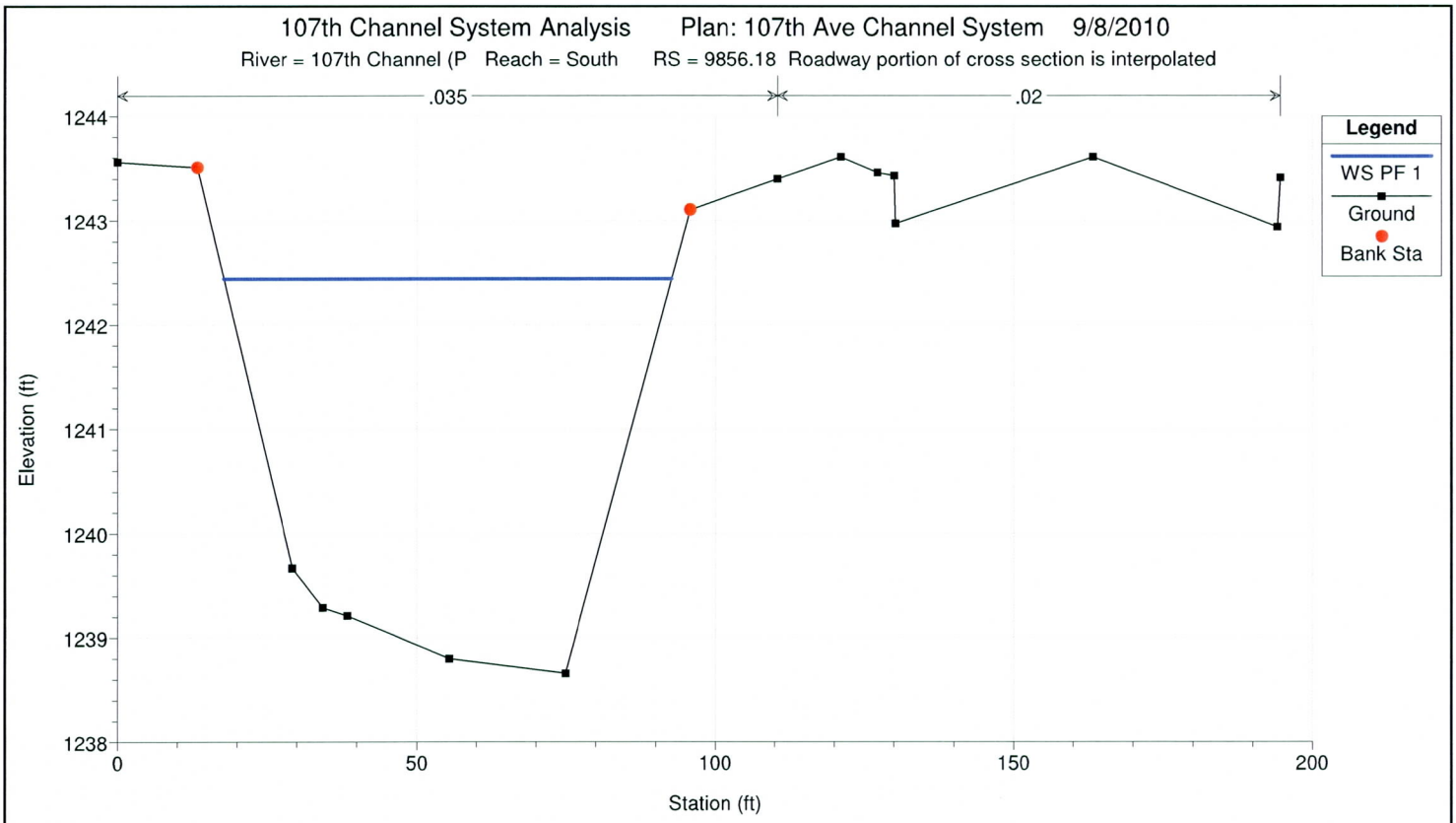
River = 107th Channel (P Reach = South RS = 10000
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1246
1245
1244
1243
1242
1241


107th Channel System Analysis
Plan: 107th Ave Channel System
9/8/2010
River = 107th Channel (P
Reach = South
RS = 9856.18
Roadway portion of cross section is interpolated
.035
.02
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1244
1243
1242
1241
1240
1239
1238
0
50
100
150
200
Station (ft)

# SEDIMENT YIELD ESTIMATION AND EROSION PROTECTION

**WOOD/PATEL**
MISSION: CLIENT SERVICE™

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS • CONSTRUCTION MANAGERS

# MEMO

TO: Jeff Minch, P.E.

FROM: Shimin Zou, Ph.D., P.E.

DATE: October 14, 2010

RE: Pinnacle Peak Road Drainage Project
99th Avenue to 104th Avenue (Final Submittal)

SUBJECT: Sediment Yield Estimation for the Pinnacle Peak Road Basins and Erosion Protection Design for the Drainage Structures

## I. INTRODUCTION

The objective of this appendix is to document the methods, assumptions and results of the sediment yield estimation and erosion protection design for the Pinnacle Peak Road Drainage project for the Final Submittal.

### Methodology

The methods used in the study are documented in the FCDMC's River Mechanics Manual for DDMSW, September 2009.

The sediment yield consists of two parts and is defined as the sum of the wash load and the total bed material load delivered to a point of interest. The *wash load* is calculated with the MUSLE method, and the *total bed material load* is calculated with the Zeller-Fullerton equation (Zeller and Fullerton, 1983). The sediment yield for a particular frequency (return period) = SDR*Wash+BedL, where SDR is the sediment delivery ratio, Wash and BedL are, respectively, the wash load and total bed material load based on the MUSLE and the Zeller-Fullerton equation for a flood of a particular return period.

The annual sediment yield is computed as SDR*Wash_P+BedL_P where SDR is the sediment delivery ratio, Wash_P is a probability-weighted average value for MUSLE over floods of different return periods, and BedL_P is a probability-weighted average value for the Zeller-Fullerton equation over floods of different return periods. The probability-weighted value over different return period floods is computed based on the equation developed by Mussetter et. al. (1994).

The channel design is checked using the long-term equilibrium slope method to see if the channel is stable (no erosion and deposition).

**Representative Hydraulic Cross Sections and Parameters**

For the purpose of estimating wash load and total bed load, the watershed is divided into three subbasins: EastCh – the contributing area to the east channel; WestCh – the drainage area for the west channel and east basin; and WestBa – the drainage area for the west basin. The representative cross sections are based on the HEC-RAS model for 100% design plans. The representative hydrologic concentration point for EastCh is CA09O, WestCh is CA09P, and the representative hydrologic concentration point for the WestBa is A09QB. The hydrologic and hydraulic data are included in this section of the report.

**Additional Input Data**

Soil gradation data for the total bed load: The sieve analysis was based on Preliminary Geotechnical Evaluation – Pinnacle Peak Road and Channel, 99th Avenue to 107th Avenue, Peoria, Arizona by Ninyo & Moore, October 2009. The following values for EastCh were used: $D_{10}$= 0.03mm, $D_{16}$= 0.05mm, $D_{50}$= 3mm, $D_{84}$ = 10.5mm which are the values from soil sample B-3 of the report. $D_{10}$= 0.03mm was used to represent $D_{50}$ of the wash load materials. The following values for WestCh were used: $D_{10}$= 0.03mm, $D_{16}$= 0.05mm, $D_{50}$= 4mm, $D_{84}$ = 20mm, which are the values from soil, sample B-2 of the report.

Topographic Factor LS: LS is a function of the slope length and slope of overland flows. The estimated slope length for EastCh and WestCh is 400 ft, and the estimated slope length for WestBa is 300 ft. The estimated slope for EastCh and WestCh is 0.7%, and the estimated slope for WestBa is 0.6%.

Subbasin drainage areas, the soil erodibility factor, the cover and management factor, sediment delivery ratio for wash load, the sediment deposit specific weight, and the impervious area percentage, were estimated by DDMSW based on the subbasin shape file, soil shape file, land use shape file, and default databases of the program.

**Modeling Assumptions and Related Issues**

Many factors affect the estimation of sediment yield for a watershed. The following are a few major factors and assumptions for this study:

a) Subbasin boundaries are approximate since there are some flow splits;
b) The total watershed yield to the west channel including the drainage to east channel is assumed to be the same as the sediment to the east basin;
c) There is no sediment flow from east basin to west basin because of the low flow bypass system and basin deposition.

**Watershed Yield Modeling Results**

The estimated total mean annual sediment yield for the east channel is 0.009 Ac-Ft per year. For 100-year

**Open Channel Equilibrium Slope Evaluation**

The east and west channels were checked by the long-term equilibrium slope method to evaluate the stability and deposition potential (no erosion and deposition). The east channel design slope is 0.005 ft/ft and the west channel design slope is 0.0026 ft/ft. The sediment inflow load (Qs) for the east channel is estimated to be 0.053 cfs based on the 10-year wash load. The sediment inflow load (Qs) for the west channel is estimated to be 0.076 cfs based on the 10-year bed load (supply reach). The modeling results show that these two channels are stable to carry 10-year to 50-year flows at the design slopes.

**Culvert Self-Cleaning Check**

The two major culverts following the open channels were evaluated for sediment concerns by using a spreadsheet developed in-house. The results show that there is no sediment deposition potential for these two culverts.

**Erosion Protection Design**

Loose riprap was designed for all of the crossing structure outlets for both the channels and basins. An exhibit was developed to show the locations of the structures. The design parameters for the riprap including gradation ($D_{50}$, $D_{15}$, and $D_{85}$), upstream width, downstream width, and length were estimated using the methods from the District manual, HEC-14, and FHWA's Highways in the River Environment – Hydraulic and Environmental Design Considerations.

The open channel flow velocities were also evaluated against the soil permissible velocities. The results show that the velocity for the design flows of the east and west channels are within the allowed limits.

Pinnacle Peak Drainage Project
Culvert Sedimentation Potential

| | Pipe Size (in) | Pipe Length (ft) | Pipe Slope (ft/ft) | Q Total (cfs) | Drainage Area (sq mi) | US Invert Elev (ft) | US WS Elev (ft) | DS Invert Elev (ft) | DS WS Elev (ft) | US Vel (fps) | Internal Vel (fps) | DS Vel (fps) | Min Vel (1) (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| East Channel Outfall 1 | 48 | 202 | 0.0090 | 97 | 1.09 | 1303.0 | 1306.7 | 1301.2 | 1304.1 | 9.6 | 11.9 | 8.7 | 3 |
| East Channel Outfall 2 | 8'x4' | 210 | 0.0049 | 97 | 1.09 | 1300.1 | 1303.1 | 1299.0 | 1303.1 | 4.0 | 8.4 | 3.0 | 3 |
| East Channel Outfall 3 | 54 | 401 | 0.0021 | 97 | 1.09 | 1298.7 | 1303.1 | 1297.9 | 1300.9 | 6.7 | 6.6 | 8.7 | 3 |
| West Channel Outlet | 60 | 240 | 0.0124 | 131 | 1.28 | 1294.8 | 1299.6 | 1291.8 | 1295.5 | 9.6 | 13.8 | 13.9 | 3 |
| Ironwood Wash East | 48 | 121 | 0.0025 | 125 | 0.32 | 1288.8 | 1295.6 | 1288.5 | 1291.8 | 9.9 | 10.1 | 11.2 | 3 |
| Ironwood Wash West | 48 | 141 | 0.0021 | 125 | 0.32 | 1288.8 | 1295.6 | 1288.5 | 1291.8 | 9.9 | 10.1 | 11.1 | 3 |

(1) Minimum Velocity for self cleaning per Flood Control District of Maricopa County, *Drainage Design Manual Hydraulics*, March 2009, criteria 5.3.2.2.

# Sedimentation at Culvert Crossings

Reference: Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona. December 1998. p11.17

## Computation Equation

**Project:** Pinnacle Peak Road & Channel **Project No.** 093386
**Location:** 49+50 East Channel Outlet Culvert

$$R_s = \frac{Q_{ac}}{Q_p}\left(\frac{S_{ac}}{S_p}\right)^{1.66}\left(\frac{n_{ac}}{n_p}\right)^{-1.55}\left(\frac{R_{ac}}{R_p}\right)^{0.91}$$

Where:

$R_s$ = sediment-transport ratio (channel to culvert);
$Q_{ac}$ = discharge in approach channel, in cubic feet per second;
$Q_p$ = total culvert discharge, in cubic feet per second;
$S_{ac}$ = longitudinal slope of approach channel, in feet/foot;
$S_p$ = longitudinal slope of culvert, in feet/foot;
$n_{nc}$ = Manning's roughness coefficient for the approach channel;
$n_p$ = Manning's roughness coefficient for the culvert;
$R_{ac}$ = hydraulic radius of flow in approach channel, in feet; and
$R_p$ = hydraulic radius of flow within the culvert, in feet.

If the value of Rs in the above equation is less than 1.0, the culvert will most likely be able to transport the sediment being delivered by the approach channel. If the value of Rs is greater than 1.0, sedimentation may occur, and alternate culvert parameters (eg. slope) should be considered.

## Input Data

| | | | |
|---|---|---|---|
| $Q_{ac}$ = | 97 cfs | $Q_p$ = | 97 cfs |
| $S_{ac}$ = | 0.005 | $S_p$ = | 0.0085 |
| $n_{nc}$ = | 0.04 | $n_p$ = | 0.013 |
| $R_{ac}$ = | 1.33 ft | $R_p$ = | 1.21 ft |

## Computed Result

# Sedimentation at Culvert Crossings

Reference: Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona. December 1998. p11.17

## Computation Equation

**Project:** Pinnacle Peak Road & Channel **Project No.** 093386
**Location:** 43+00 West Channel Outlet Culvert

$$R_s = \frac{Q_{ac}}{Q_p}\left(\frac{S_{ac}}{S_p}\right)^{1.66}\left(\frac{n_{ac}}{n_p}\right)^{-1.55}\left(\frac{R_{ac}}{R_p}\right)^{0.91}$$

Where:

$R_s$ = sediment-transport ratio (channel to culvert);
$Q_{ac}$ = discharge in approach channel, in cubic feet per second;
$Q_p$ = total culvert discharge, in cubic feet per second;
$S_{ac}$ = longitudinal slope of approach channel, in feet/foot;
$S_p$ = longitudinal slope of culvert, in feet/foot;
$n_{nc}$ = Manning's roughness coefficient for the approach channel;
$n_p$ = Manning's roughness coefficient for the culvert;
$R_{ac}$ = hydraulic radius of flow in approach channel, in feet; and
$R_p$ = hydraulic radius of flow within the culvert, in feet.

If the value of Rs in the above equation is less than 1.0, the culvert will most likely be able to transport the sediment being delivered by the approach channel. If the value of Rs is greater than 1.0, sedimentation may occur, and alternate culvert parameters (eg. slope) should be considered.

## Input Data

| | | | |
|---|---|---|---|
| $Q_{ac}$ = | 131 cfs | $Q_p$ = | 131 cfs |
| $S_{ac}$ = | 0.0026 | $S_p$ = | 0.0164 |
| $n_{nc}$ = | 0.04 | $n_p$ = | 0.013 |
| $R_{ac}$ = | 1.75 ft | $R_p$ = | 1.45 ft |

## Computed Result

## Sediment Yield from Watershed

Method: The Modified Universal Soil Loss Equations (MUSLE)
Reference: FCDMC, River Mechanics Manual for DDMSW, September 2009.

Project Name: PPR  Project No. East Channel

Sediment Size $D_{50}$ = 0.03 (mm) EastCh = 0.87 (mile²)

| Return Period (T) (years) | Runoff Volume (Q) (A-F) | Runoff Peak (q) (cfs) | Watershed Load (Yw) (tons) | Bed Load (Yb) (Ac-Ft) | |
|---|---|---|---|---|---|
| | | | | | |
| 2 | 1.8 | 9.7 | 3.69 | 0.003 | |
| 5 | 4.5 | 24.3 | 10.28 | 0.009 | |
| 10 | 6.3 | 34.0 | 14.99 | 0.014 | |
| 25 | 10.4 | 56.3 | 26.39 | 0.027 | |
| 50 | 13.9 | 74.7 | 36.25 | 0.039 | |
| 100 | 18.0 | 97.0 | 48.58 | 0.019 | |
| | | | | | |
| Weighted Annual Mean Yield (tons) = | | | 7.1 | 0.006 | |
| Specific Weight (lb/cubic ft) = | | | 69.37 | | |
| Sediment Delivery Ratio (SDR) = | | | 61.7 | (%) | |
| Impervious Area Percentage = | | | 11.1 | | |
| Annual Mean Yield (Ac-Ft/Yr) = | | | 0.003 | 0.006 | 0.009 |
| | | | | | |

| Soil Erodibility Factor (K) | Topographic Factor (LS) | Land Use Factor (C) | Erosion Control Factor (P) |
|---|---|---|---|
| 0.23 | 0.17 | 0.2 | 1 |
| 0.23 | 0.17 | 0.2 | 1 |
| 0.23 | 0.17 | 0.2 | 1 |
| 0.23 | 0.17 | 0.2 | 1 |
| 0.23 | 0.17 | 0.2 | 1 |
| 0.23 | 0.17 | 0.2 | 1 |

## Sediment Yield from Watershed

Method: The Modified Universal Soil Loss Equations (MUSLE)
Reference: FCDMC, River Mechanics Manual for DDMSW, September 2009.

Project Name: PPR Project No. West Channel

Sediment Size $D_{50}$ = 0.03 (mm) WestCh : 1.06 (mile²)

| Return Period (T) (years) | Runoff Volume (Q) (A-F) | Runoff Peak (q) (cfs) | Watershed Load (Yw) (tons) | Bed Load (Yb) (Ac-Ft) | |
|---|---|---|---|---|---|
| | | | | | |
| 2 | 2.8 | 13.1 | 7.48 | 0.002 | |
| 5 | 7.0 | 32.8 | 20.87 | 0.007 | |
| 10 | 9.8 | 45.9 | 30.42 | 0.010 | |
| 25 | 16.2 | 76.0 | 53.56 | 0.011 | |
| 50 | 21.6 | 100.9 | 73.57 | 0.008 | |
| 100 | 28.0 | 131.0 | 98.59 | 0.006 | |
| | | | | | |
| Weighted Annual Mean Yield (tons) = | | | 14.3 | 0.004 | |
| Specific Weight (lb/cubic ft) = | | | 69.37 | | |
| Sediment Delivery Ratio (SDR) = | | | 60.5 | (%) | |
| Impervious Area Percentage = | | | 7 | | |
| Annual Mean Yield (Ac-Ft/Yr) = | | | 0.005 | 0.004 | 0.009 |
| | | | | | |

| Soil Erodibility Factor (K) | Topographic Factor (LS) | Land Use Factor (C) | Erosion Control Factor (P) |
|---|---|---|---|
| 0.28 | 0.17 | 0.22 | 1 |
| 0.28 | 0.17 | 0.22 | 1 |
| 0.28 | 0.17 | 0.22 | 1 |
| 0.28 | 0.17 | 0.22 | 1 |
| 0.28 | 0.17 | 0.22 | 1 |
| 0.28 | 0.17 | 0.22 | 1 |

## Sediment Yield from Watershed

Method: The Modified Universal Soil Loss Equations (MUSLE)
Reference: FCDMC, River Mechanics Manual for DDMSW, September 2009.

Project Name: PPR Project No. West Basin

Sediment Size $D_{50}$ = 0.03 (mm) WestBa = 0.31 (mile²)

| Return Period (T) (years) | Runoff Volume (Q) (A-F) | Runoff Peak (q) (cfs) | Watershed Load (Yw) (tons) | Bed Load (Yb) (Ac-Ft) | | Soil Erodibility Factor (K) | Topographic Factor (LS) | Land Use Factor (C) | Erosion Control Factor (P) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.2 | 19.6 | 3.60 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| 5 | 3.0 | 49.0 | 10.05 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| 10 | 4.2 | 68.6 | 14.65 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| 25 | 7.0 | 113.7 | 25.80 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| 50 | 9.2 | 150.9 | 35.43 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| 100 | 12.0 | 196.0 | 47.48 | 0.00 | | 0.21 | 0.14 | 0.22 | 1 |
| Weighted Annual Mean Yield (tons) = | | | 6.9 | 0.00 | | | | | |
| Specific Weight (lb/cubic ft) = | | | 69.37 | | | | | | |
| Sediment Delivery Ratio (SDR) = | | | 68.7 | (%) | | | | | |
| Impervious Area Percentage = | | | 19.5 | | | | | | |
| Annual Mean Yield (Ac-Ft/Yr) = | | | 0.003 | 0.00 | 0.003 | | | | |

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 100 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 100-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 97 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 1.08 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.91 | (ft/s) | G = | 31.75 | |
| B = | 32.55 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 20.28 | (ft) | b = | 8 | (ft) |
| Vw = | 18 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 50 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 50-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 75 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.83 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 3.45 | (ft/s) | G = | 31.75 | |
| B = | 28.02 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 18.01 | (ft) | b = | 8 | (ft) |
| Vw = | 13.9 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 25 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 25-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 56 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.74 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 3.2 | (ft/s) | G = | 31.75 | |
| B = | 25.39 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 16.70 | (ft) | b = | 8 | (ft) |
| Vw = | 10.4 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 10 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 10-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 34 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.62 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.8 | (ft/s) | G = | 31.75 | |
| B = | 21.44 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 14.72 | (ft) | b = | 8 | (ft) |
| Vw = | 6.3 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 5 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 5-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 24 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.55 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.53 | (ft/s) | G = | 31.75 | |
| B = | 19.18 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 13.59 | (ft) | b = | 8 | (ft) |
| Vw = | 4.5 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East, 2 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 2-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 10 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.39 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 1.93 | (ft/s) | G = | 31.75 | |
| B = | 15.73 | (ft) | $r_s$ = | 110.3 | (lb/ft^3) |
| Avg. B = | 11.87 | (ft) | b = | 8 | (ft) |
| Vw = | 1.8 | (Ac-Ft) | | | |

**C d S di Di h**

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 100 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 100-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 131 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 1.71 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.17 | (ft/s) | G = | 42.50 | |
| B = | 35.74 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 21.87 | (ft) | b = | 8 | (ft) |
| Vw = | 28 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 50 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 50-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 101 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 1.41 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.4 | (ft/s) | G = | 42.50 | |
| B = | 29.85 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 18.93 | (ft) | b = | 8 | (ft) |
| Vw = | 21.6 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 25 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 25-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 76 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 1.19 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.61 | (ft/s) | G = | 42.50 | |
| B = | 25.43 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 16.72 | (ft) | b = | 8 | (ft) |
| Vw = | 16.2 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 10 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 10-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 46 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 0.95 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.62 | (ft/s) | G = | 42.50 | |
| B = | 20.81 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 14.41 | (ft) | b = | 8 | (ft) |
| Vw = | 9.8 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 5 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 5-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 33 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 0.84 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.41 | (ft/s) | G = | 42.50 | |
| B = | 18.6 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 13.30 | (ft) | b = | 8 | (ft) |
| Vw = | 7 | (Ac-Ft) | | | |

## Computed Sediment Discharge

# Total Bed Material Load Spreadsheet

**Reference:** FCDMC, River Mechanics Manual for DDMSW, September 2009.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West, 2 Year

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
$r_s$ = sediment deposit specific weight (lb/ft^3);
B and b = top and bottom width of the cross section (ft);
Avg. B = average width of the cross section (ft);
Vw = water volume (Ac-Ft).

## Input Data - 2-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 13 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 0.58 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 1.9 | (ft/s) | G = | 42.50 | |
| B = | 13.69 | (ft) | $r_s$ = | 112.8 | (lb/ft^3) |
| Avg. B = | 10.85 | (ft) | b = | 8 | (ft) |
| Vw = | 2.8 | (Ac-Ft) | | | |

**C d S di Di h**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Peak Flows and Volumes** | | | | | | |
| | Flows | | | | Volume | | |
| Frequency | East Ch | West Ch | West Basin | Ratio | East Ch | West Ch | West Basin |
| Q2 | 10 | 13 | 20 | 0.10 | 2 | 3 | 1 |
| Q5 | 24 | 33 | 49 | 0.25 | 5 | 7 | 3 |
| Q10 | 34 | 46 | 69 | 0.35 | 6 | 10 | 4 |
| Q25 | 56 | 76 | 114 | 0.58 | 10 | 16 | 7 |
| Q50 | 75 | 101 | 151 | 0.77 | 14 | 22 | 9 |
| Q100 | 97 | 131 | 196 | 1.00 | 18 | 28 | 12 |
| | CA09O | CA09P | A09QB | | CA09O | CA09P | A09QB |

## Hydraulic Input Data

| | Flows | Volume | Ave Vel | Normal D | Flow A | Ave W | Hydr d | B | b |
|---|---|---|---|---|---|---|---|---|---|
| Freq | East | East | East | East | East | East | East | East | East |
| Q2 | 10 | 1.8 | 1.93 | 0.46 | 5.37 | 11.87 | 0.39 | 15.73 | 8.00 |
| Q5 | 24 | 4.5 | 2.53 | 0.75 | 10.01 | 13.59 | 0.55 | 19.18 | 8.00 |
| Q10 | 34 | 6.3 | 2.80 | 0.90 | 12.98 | 14.72 | 0.62 | 21.44 | 8.00 |
| Q25 | 56 | 10.4 | 3.20 | 1.16 | 18.84 | 16.70 | 0.74 | 25.39 | 8.00 |
| Q50 | 75 | 13.9 | 3.45 | 1.33 | 23.40 | 18.01 | 0.83 | 28.02 | 8.00 |
| Q100 | 97 | 18.0 | 2.91 | 1.72 | 35.70 | 20.28 | 1.08 | 32.55 | 8.00 |

| | Flows | Volume | Ave Vel | Normal D | Flow A | Ave W | Hydr d | B | b |
|---|---|---|---|---|---|---|---|---|---|
| Freq | West | West | West | West | West | West | West | West | West |
| Q2 | 13 | 2.8 | 1.90 | 1.05 | 8.14 | 10.84 | 0.58 | 13.69 | 8.00 |
| Q5 | 33 | 7.0 | 2.41 | 1.52 | 16.00 | 13.30 | 0.84 | 18.60 | 8.00 |
| Q10 | 46 | 9.8 | 2.62 | 1.74 | 20.32 | 14.41 | 0.95 | 20.81 | 8.00 |
| Q25 | 76 | 16.2 | 2.61 | 2.19 | 30.46 | 16.71 | 1.19 | 25.43 | 8.00 |
| Q50 | 101 | 21.6 | 2.40 | 2.62 | 42.13 | 18.93 | 1.41 | 29.85 | 8.00 |
| Q100 | 131 | 28.0 | 2.17 | 3.19 | 61.07 | 21.87 | 1.71 | 35.74 | 8.00 |

# Equilibrium Slope Computation Sheet (Study Section)

**Reference:** ADWR, Design Manual for Engineering Analysis of Fluvial Systems, 1985.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** East Channel

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
B = top width of the cross section (ft).

## Input Data - 10-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 34 | (cfs) | $D_{50}$ = | 3 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 10.5 | (mm) |
| $Y_h$ = | 0.93 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.49 | (ft/s) | G = | 31.75 | |
| B = | 28.30 | (ft) | $r_s$ = | 70 | (lb/ft^3) |
| Avg. B = | 18.15 | (ft) | b = | 8 | (ft) |

## Computed Sediment Discharge

**$q_s$ = 0.00274 (cfs/ft)**

# Equilibrium Slope Computation Sheet (Study Section)

**Reference:** ADWR, Design Manual for Engineering Analysis of Fluvial Systems, 1985.

**Calculation:** Total Bed-Material Discharge. **Application:** Sand-Bed Channels.

**Project Name:** PPR **Section Name:** West Channel

## Sediment Transport Equation

Zeller and Fullerton (1983) developed the following equation based on the Empirical Power Relationship $qs = aY_h^b V^c$ by Simons, Li, and Fullerton (1981):

$$qs = \frac{0.0064\, n^{1.77} V^{4.32} G^{0.45}}{Y_h^{0.30} D_{50}^{0.61}}$$

**Where:** $q_s$ = bed-material discharge in cfs per unit width;
n = Manning's roughness coefficient;
V = mean velocity (ft/s);
G = gradation coefficient = $0.5(D_{84}/D_{50}+D_{50}/D_{16})$;
$Y_h$ = hydraulic depth (ft);
$D_{50}$ = median diameter (mm);
B = top width of the cross section (ft).

## Input Data - 10-year Flow

| | | | | | |
|---|---|---|---|---|---|
| Q = | 46 | (cfs) | $D_{50}$ = | 4 | (mm) |
| n = | 0.04 | | $D_{84}$ = | 20 | (mm) |
| $Y_h$ = | 1.31 | (ft) | $D_{16}$ = | 0.05 | (mm) |
| V = | 2.24 | (ft/s) | G = | 42.50 | |
| B = | 25.60 | (ft) | $r_s$ = | 70 | (lb/ft^3) |
| Avg. B = | 16.80 | (ft) | b = | 8 | (ft) |

## Computed Sediment Discharge

**$q_s$ = 0.00151 (cfs/ft)**

Pinnacle Peak Drainage Project
Erosion Protection Summary

| Name | Element & Size | Location | Design Flow (cfs) | Design Velocity (fps) | Wash bottom width (ft) | Tailwater Depth (ft) | Normal Depth (ft) | Flow Regime | Riprap Size D50 [in] | Min. Apron Length [ft] | Min. U/S Apron Width [ft] | Min. D/S Apron Width [ft] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 104th Onsite SD | 18" SD | 104th 16+00 | 2 | 6.5 | 10 | 0.5 | 0.3 | Super | 6 | 4 | 4 | 6 |
| 102nd Onsite SD | 18" SD | 102nd 16+40 | 3 | 7.1 | 10 | 0.6 | 0.4 | Super | 6 | 4 | 4 | 6 |
| Ironwood West | 48" SD | 33+50 | 125 | 11.0 | 18 | 4.0 | 4.0 | Sub | 6 | 16 | 32 | 42 |
| Low Flow Bypass | 24" SD | 33+80 | 29 | 4.9 | 6 | 2.4 | 0.9 | Super | 6 | 8 | 7 | 10 |
| Ironwood East | 48" SD | 35+00 | 125 | 11.2 | 18 | 4.0 | 4.0 | Sub | 6 | 16 | 32 | 42 |
| East Basin Outlet | 24" SD | 39+00 | 24 | 11.0 | 15 | 1.3 | 1.3 | Super | 8 | 7 | 6 | 11 |
| West Channel | 60" SD | 43+00 | 131 | 5.8 | 23 | 3.3 | 2.2 | Super | 12 | 18 | 30 | 42 |
| East Channel | 54" SD | 49+50 | 97 | 6.6 | 8 | 3.0 | 3.9 | Sub | 6 | 18 | 27 | 17 |
| 99th Ave Area Drain | 18" SD | 61+85 | 12 | 6.8 | 8 | 1.1 | 1.1 | Super | 6 | 5 | 7 | 10 |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** 104th Ave 16+00

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 2 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 1.5 | (ft) | (pipe diameter) |
| TW = | 0.5 | (ft) | (tailwater depth) |
| Yn = | 0.3 | (ft) | (culvert normal flow depth) |
| Wo = | 2 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | Yes | | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | Yes | | (Yes or No) |
| D' = | 0.9 | (ft) | (culvert D adjustment) |
| D = | 0.9 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 1 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 4 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** 102nd Ave 16+40

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 3 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 1.5 | (ft) | (pipe diameter) |
| TW = | 0.6 | (ft) | (tailwater depth) |
| Yn = | 0.4 | (ft) | (culvert normal flow depth) |
| Wo = | 2 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | Yes | | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | Yes | | (Yes or No) |
| D' = | 1.0 | (ft) | (culvert D adjustment) |
| D = | 1.0 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 2 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 4 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** Ironwood West, sta 33+50

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 125 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 4 | (ft) | (pipe diameter) |
| TW = | 4 | (ft) | (tailwater depth) |
| Yn = | 4 | (ft) | (culvert normal flow depth) |
| Wo = | 23.5 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | (ft²) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | No | (Yes or No) |
| D' = | 4.0 | (ft) | (culvert D adjustment) |
| D = | 4.0 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 6 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 16 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** Low Flow Bypass, sta 33+80

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 29 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 3 | (ft) | (pipe diameter) |
| TW = | 2.4 | (ft) | (tailwater depth) |
| Yn = | 0.9 | (ft) | (culvert normal flow depth) |
| Wo = | 3.3 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 6 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | No, Adjust TW | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | Yes | (Yes or No) |
| D' = | 2.0 | (ft) | (culvert D adjustment) |
| D = | 2.0 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 4 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 8 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** Ironwood East, sta 35+00

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 125 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 4 | (ft) | (pipe diameter) |
| TW = | 4 | (ft) | (tailwater depth) |
| Yn = | 4 | (ft) | (culvert normal flow depth) |
| Wo = | 23.5 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | (ft²) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | No | (Yes or No) |
| D' = | 4.0 | (ft) | (culvert D adjustment) |
| D = | 4.0 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 6 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 16 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** East Basin Outlet, sta 39+00

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 24 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 2 | (ft) | (pipe diameter) |
| TW = | 1.25 | (ft) | (tailwater depth) |
| Yn = | 1.3 | (ft) | (culvert normal flow depth) |
| Wo = | 3 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | Yes | (Yes or No) |
| D' = | 1.7 | (ft) | (culvert D adjustment) |
| D = | 1.7 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 7 | (in) |
| Design Riprap Size $D_{50}$ = | 8 | (in) |
| Class No. = | 2 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 12 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 7 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** West Channel, sta 42+00

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 131 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 5 | (ft) | (pipe diameter, = 0 for box) |
| TW = | 3.3 | (ft) | (tailwater depth) |
| Yn = | 2.2 | (ft) | (culvert normal flow depth) |
| Wo = | 22.3 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 100 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | Yes | (Yes or No) |
| D' = | 3.6 | (ft) | (culvert D adjustment) |
| D = | 3.6 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 9 | (in) |
| Design Riprap Size $D_{50}$ = | 12 | (in) |
| Class No. = | 3 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 5 | (in) |
| Design Riprap Size $D_{85}$ = | 18 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 18 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** East Channel, sta 49+50

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 97 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 4.5 | (ft) | (pipe diameter) |
| TW = | 3 | (ft) | (tailwater depth) |
| Yn = | 3.9 | (ft) | (culvert normal flow depth) |
| Wo = | 17.5 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 8 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | No | (Yes or No) |
| D' = | 4.5 | (ft) | (culvert D adjustment) |
| D = | 4.5 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 5 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 18 | (ft) |

# Riprap Apron Design Spreadsheet

**References:** US DOT, FHWA, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channel. Third Edition, July 2006, p10-16 to p10-18.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. March 2009.

**Project Name:** Pinnacle Peak Road and Channel **Project No.** 093386
**Location:** 99th Ave Area Drain, sta 61+85

**Equation:**

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

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 $ft/s^2$)

**Input Data:**

| | | | |
|---|---|---|---|
| Q = | 12 | (cfs) | (if multi-barrel, one barrel flow) |
| Dp = | 1.5 | (ft) | (pipe diameter) |
| TW = | 1.1 | (ft) | (tailwater depth) |
| Yn = | 1.1 | (ft) | (culvert normal flow depth) |
| Wo = | 4 | (ft) | (total culvert or D/S headwall apron width) |
| b = | 8 | (ft) | (wash bottom width) |
| P = | 0 | (ft) | (box wetted perimeter) |
| A = | N/A | ($ft^2$) | (box flow area) |
| R = | N/A | (ft) | (box hydraulic radius) |
| De = | N/A | (ft) | (box equivalent D) |
| Does TW meet the limits ? | | Yes | (0.4D<= TW <= 1.0D) |
| Is culvert flow supercritical ? | | Yes | (Yes or No) |
| D' = | 1.3 | (ft) | (culvert D adjustment) |
| D = | 1.3 | (ft) | (input D) |

**Riprap Size $D_{50}$:**

| | | |
|---|---|---|
| Computed Riprap Size $D_{50}$ = | 4 | (in) |
| Design Riprap Size $D_{50}$ = | 6 | (in) |
| Class No. = | 1 | |

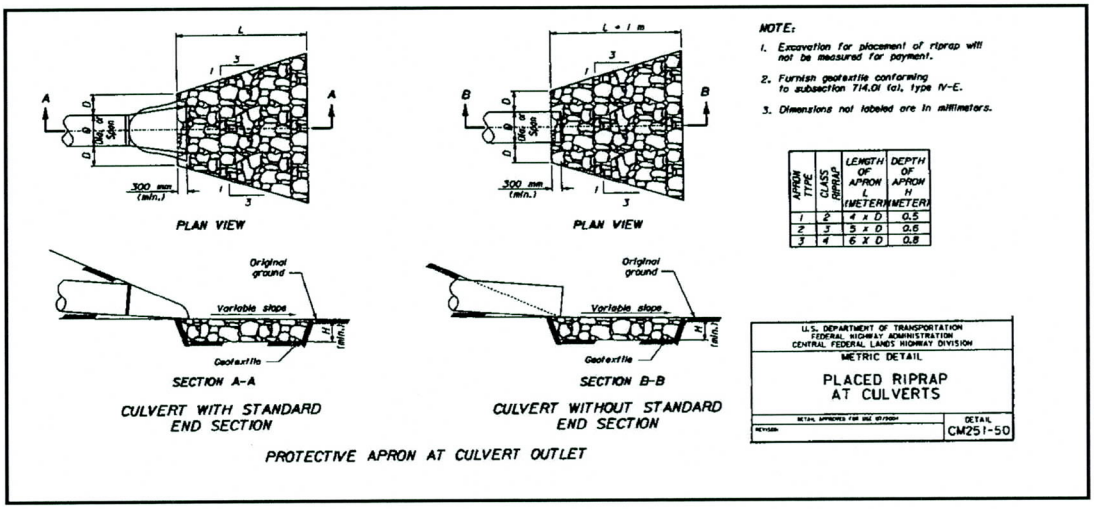
**Riprap Sizes $D_{15}$ and $D_{85}$:**

| | | |
|---|---|---|
| Design Riprap Size $D_{15}$ = | 3 | (in) |
| Design Riprap Size $D_{85}$ = | 9 | (in) |

**Riprap Apron Length:**

| | | |
|---|---|---|
| Riprap Apron Length = | 5 | (ft) |

## HEC-14 Figure 10.4 and Table 10.1




| APRON TYPE | CLASS RIPRAP | LENGTH OF APRON L (METER) | DEPTH OF APRON H (METER) |
|---|---|---|---|
| 1 | 2 | 4 x D | 0.5 |
| 2 | 3 | 5 x D | 0.6 |
| 3 | 4 | 6 x D | 0.8 |

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

**Riprap Classes and Apron Dimensions**

| Class | $D_{50}$ (in) | Apron Length (ft) | Apron Depth (ft) |
|---|---|---|---|
| 1 | 6 | 4D | $3.5D_{50}$ |
| 2 | 8 | 4D | $3.3D_{50}$ |
| 3 | 12 | 5D | $2.4D_{50}$ |
| 4 | 18 | 6D | $2.2D_{50}$ |
| 5 | 24 | 7D | $2.0D_{50}$ |
| 6 | 30 | 8D | $2.0D_{50}$ |
| 7 | 36 | 9D | $2.0D_{50}$ |

# LANDSCAPING AND AESTHETICS

PINNACLE PEAK ROAD AND CHANNEL PROJECT –
99TH AVE. TO THE AGUA FRIA RIVER

# IRRIGATION ASSUMPTIONS AND CALCULATIONS MEMO

**Drainage Package**

Prepared by:

**EPG, Inc**
4141 North 32nd Street
Suite 102
Phoenix, Arizona 85018
602.956.4370

Prepared for:

**Wood, Patel & Associates, Inc.**
2051 West Northern Avenue
Suite 100
Phoenix, Arizona 85021
(602) 335-8500

On Behalf of:

October 14, 2010

Jeffery R. Minch., P.E.
Vice-President – Directory of Hydrology
Wood, Patel & Associates
2051 West Northern Avenue
Suite 100
Phoenix, Arizona

Dear Mr. Minch,

The following standard practices and assumptions were used to determine projected irrigation needs for the Pinnacle Peak Road and Channel Project:

- Trees and shrubs are irrigated from separate valve zones.
- The Leit 4000 solar powered controller has a maximum of (8) stations available.
- The controllers are centered within the zones that they control in an effort to reduce the length of wire runs. The length of wire runs was a concern due to voltage loss for the solar controller.
- Points of connection are available off the potable water supply lines on 104th Avenue, the 16" water line at the Circle K, and a 16" water line on the south east corner of Lake Pleasant Parkway and Pinnacle Peak Road.
- The basin will have its own point of connection and controllers as shown on the 100% plans, independent of the streetscape.
- The east channel point of connection (Sta. 55+10) is sized to accommodate future inclusion of the streetscape improvements in order to minimize the number of meters required. Based on the final Roadway Design, the proposed point of connection will adequately service both phases.
- Typical maximum lateral line length for drip zones is 250'.
- Design requires 30 psi at furthest point from point of connection.
- Friction-loss through point of connection is +/- 15 psi.
- Point of connection will need to provide 65 psi.

The exhibit below, "Preliminary Friction-Loss Calculations", shows for each of the points of connection in the proposed final design, the condition of the valve running with the most pressure loss due to friction. This information was used in part to determine probable irrigation water-need, meter locations, and meter sizing.

# Preliminary Friction-Loss Calculations

**104 Avenue POC (Basin)**

Assuming 3/4" laterals schedule 40 PVC pipe, 1-1/2" mainline schedule 40 PVC, 17 gpm in the mainline with both controllers running

| Pipe Leg | GPM for this Pipe Leg | Length of this Pipe Leg (feet) | Pipe ID | Preliminary Friction Loss | Elevation Difference for this Pipe Leg (feet), negative for uphill positive for downhill | Pressure Difference from Elevation | Total Friction Loss This Leg |
|---|---|---|---|---|---|---|---|
| Leg #1 | 1 | 124 | 0.824 | -0.135 | 4.0 | 1.73 | 1.597 |
| Leg #2 | 3 | 172 | 0.824 | -1.436 | 0.0 | 0.00 | -1.436 |
| Leg #3 | 8 | 10 | 1.049 | -0.159 | 0.0 | 0.00 | -0.159 |
| | | | | | | | |
| PSI Loss through Pipe (from above) | | | | | | | -0.001 |
| PSI Needed at the Furthest Head | | | | | | | 30 |
| PSI Loss through zone valve | | | | | | | 5.2 |
| PSI Loss through Looped Main Line | | | | | | | 4.34 |
| PSI Loss through point of connection | | | | | | | 15 |
| Subtotal PSI Loss | | | | | | | 54.54 |
| 10% Contingency | | | | | | | 5.45 |
| Total PSI Needed at POC | | | | | | | **59.99** |

**Circle K POC (West Channel)**

Assuming 3/4" laterals schedule 40 PVC pipe, 1" mainline schedule 40 PVC

| Pipe Leg | GPM for this Pipe Leg | Length of this Pipe Leg (feet) | Pipe ID | Preliminary Friction Loss | Elevation Difference for this Pipe Leg (feet), negative for uphill positive for downhill | Pressure Difference from Elevation | Total Friction Loss This Leg |
|---|---|---|---|---|---|---|---|
| Leg #1 | 1 | 162 | 0.824 | -0.177 | 1.0 | 0.43 | 0.256 |
| Leg #2 | 5 | 247 | 0.824 | -5.313 | 0.0 | 0.00 | -5.313 |
| Leg #3 | 5 | 3 | 1.049 | -0.020 | 1.0 | 0.43 | 0.413 |
| Leg #4 | 5 | 442 | 1.049 | -2.937 | 0.0 | 0.00 | -2.937 |
| | | | | | | | |
| PSI Loss through Pipe (from above) | | | | | | | 7.580 |
| PSI Needed at the Furthest Head | | | | | | | 30 |
| PSI Loss through zone valve | | | | | | | 4.05 |
| PSI Loss through point of connection | | | | | | | 15 |
| Subtotal PSI Loss | | | | | | | 56.63 |
| 10% Contingency | | | | | | | 5.66 |
| Total PSI Needed at POC | | | | | | | **62.29** |

**SEC Lake Pleasant Parkway and Pinnacle Peak Road (East Channel)**

Assuming 3/4" laterals schedule 40 PVC pipe, 1" mainline schedule 40 PVC

| | |
|---|---|
| PSI Needed at the Furthest Head | 30 |
| PSI Loss through zone valve | 3.7 |
| PSI Loss through point of connection | 15 |
| Subtotal PSI Loss | 56.03 |
| 10% Contingency | 5.60 |
| Total PSI Needed at POC | **61.63** |

The following were used to address the City of Peoria concern regarding the distance of control valves from the solar controller:

- Leit 4000 manufacturer recommends a maximum of 1,500' wire runs for 14-gauge control wires from the controller to the valves.
- The available (8) stations and limited runs required a total of four controllers for the project.
- The design sizing assumes that use of multiple controllers from one point-of-connection may result in a worst-case situation where all controllers on the system may operate simultaneously.
- The controllers are approximately centered within the zones that they control in an effort to reduce the length of wire runs. The final design uses a maximum wire run of +/-825', or approximately 60% of that recommended by the manufacturer.

Respectfully submitted,

**EPG, Inc.**

John Griffin
Landscape Architect

Enclosures

PINNACLE PEAK ROAD AND CHANNEL PROJECT –
99TH AVE. TO THE AGUA FRIA RIVER

# STRUCTURAL AESTHETIC TREATMENTS TECHNICAL MEMO

Prepared by:

**EPG, Inc**
4141 North 32nd Street
Suite 102
Phoenix, Arizona 85018
602.956.4370

Prepared for:

**Wood, Patel & Associates, Inc.**
2051 West Northern Avenue
Suite 100
Phoenix, Arizona 85021
(602) 335-8500

On Behalf of:

**Flood Control District of Maricopa County**

October 14, 2010

Jeffery R. Minch., P.E.
Vice-President – Directory of Hydrology
Wood, Patel & Associates
2051 West Northern Avenue
Suite 100
Phoenix, Arizona

Dear Mr. Minch,

The following is a list of the structures known to be proposed for the Pinnacle Peak Road and Channel – Drainage Project:

| PINNACLE PEAK DRAINAGE PLANS - SUMMARY OF AESTHETIC TREATMENTS FOR HARD STRUCTURES | |
|---|---|
| **Description** | **Aesthetic Treatment** |
| | |
| MAG 501-1 Head Walls and Apron | Concrete surface texturing/patterning and coloring - See Details 1-3/L4.07 |
| MAG 501-3 Head Walls and Apron | Concrete surface texturing/patterning and coloring - See Detail 1-3/L4.08 |
| Bypass Inlets | Riprap color to match adjacent decomposed granite |
| Bypass Inlet with Trash Rack (Structure 3) | Undulated riprap edges or buried riprap with painted trash rack |
| Box Culvert Extensions (Structures 4 and 5) | Buried |
| Bypass Inlet with Trash Rack (Structure 6) | Undulated riprap edges with painted trash rack |
| Grated Spillways (Structures 7 and 8) | Riprap color to match adjacent decomposed granite; painted exposed metal |
| Rip-Rap Aprons | Buried or undulated exposed edges |
| Side Inlets | Pit-Run Riprap to match gravel mulch with scattered 3"-8" feathered edges - See Detail 1/L4.05 |

Respectfully submitted,

# DRAINAGE EXCAVATION QUANTITIES

# End Area Volume Report

Report Created: 2/16/2010
Time: 10:40am

**Cross Section Set Name:** 093386
**Alignment Name:** 093386
**Input Grid Factor:** 1.000000

**Note:** All units in this report are in feet, square feet and cubic yards unless specified otherwise.

| | Station Quantities | | | | | | | | Added Quantities | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | | | | Fill | | | | Cut | | | Fill | | | |
| Baseline Station | Factor | Area | Volume | Adjusted | Factor | Area | Volume | Adjusted | Factor | Volume | Adjusted | Factor | Volume | Adjusted | Mass Ordinate |
| 30+00.00 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 |
| 30+50.00 | 1.00 | 123.0 | 113.9 | 113.9 | 1.00 | 40.8 | 37.8 | 37.8 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 76.1 |
| 31+00.00 | 1.00 | 1341.8 | 1356.3 | 1356.3 | 1.00 | 0.0 | 37.8 | 37.8 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1394.6 |
| 31+50.00 | 1.00 | 1415.5 | 2553.1 | 2553.1 | 1.00 | 17.8 | 16.5 | 16.5 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 3931.2 |
| 32+00.00 | 1.00 | 1132.6 | 2359.4 | 2359.4 | 1.00 | 64.3 | 76.0 | 76.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 6214.6 |
| 32+50.00 | 1.00 | 923.1 | 1903.4 | 1903.4 | 1.00 | 138.8 | 188.0 | 188.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 7930.0 |
| 33+00.00 | 1.00 | 677.6 | 1482.1 | 1482.1 | 1.00 | 175.5 | 291.1 | 291.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 9121.0 |
| 33+50.00 | 1.00 | 429.3 | 1024.9 | 1024.9 | 1.00 | 222.0 | 368.1 | 368.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 9777.8 |
| 34+00.00 | 1.00 | 86.9 | 478.0 | 478.0 | 1.00 | 212.7 | 402.5 | 402.5 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 9853.3 |
| 34+50.00 | 1.00 | 643.3 | 676.1 | 676.1 | 1.00 | 185.1 | 368.4 | 368.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 10161.0 |
| 35+00.00 | 1.00 | 636.2 | 1184.7 | 1184.7 | 1.00 | 69.0 | 235.3 | 235.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 11110.4 |
| 35+50.00 | 1.00 | 1044.1 | 1555.8 | 1555.8 | 1.00 | 29.9 | 91.6 | 91.6 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 12574.6 |
| 36+00.00 | 1.00 | 1245.9 | 2120.4 | 2120.4 | 1.00 | 22.8 | 48.8 | 48.8 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 14646.2 |
| 36+50.00 | 1.00 | 1331.2 | 2386.2 | 2386.2 | 1.00 | 55.1 | 72.2 | 72.2 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 16960.2 |
| 36+62.31 | 1.00 | 1362.1 | 613.9 | 613.9 | 1.00 | 48.8 | 23.7 | 23.7 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 17550.4 |
| 37+00.00 | 1.00 | 1677.9 | 2121.9 | 2121.9 | 1.00 | 54.3 | 72.0 | 72.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 19600.4 |
| 37+50.00 | 1.00 | 3380.8 | 4684.0 | 4684.0 | 1.00 | 8.0 | 57.7 | 57.7 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 24226.7 |
| 38+00.00 | 1.00 | 4581.2 | 7372.2 | 7372.2 | 1.00 | 38.5 | 43.0 | 43.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 31555.8 |
| 38+50.00 | 1.00 | 5379.6 | 9223.0 | 9223.0 | 1.00 | 9.7 | 44.6 | 44.6 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 40734.2 |
| 39+00.00 | 1.00 | 5353.0 | 9937.6 | 9937.6 | 1.00 | 0.0 | 9.0 | 9.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 50662.8 |
| 39+50.00 | 1.00 | 4945.2 | 9535.4 | 9535.4 | 1.00 | 6.4 | 5.9 | 5.9 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 60192.3 |
| 40+00.00 | 1.00 | 5094.1 | 9295.6 | 9295.6 | 1.00 | 2.1 | 7.9 | 7.9 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 69480.0 |
| 40+50.00 | 1.00 | 4544.9 | 8925.0 | 8925.0 | 1.00 | 0.0 | 2.0 | 2.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 78403.1 |
| 41+00.00 | 1.00 | 3265.1 | 7231.5 | 7231.5 | 1.00 | 6.8 | 6.3 | 6.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 85628.3 |
| 41+50.00 | 1.00 | 3504.5 | 6268.2 | 6268.2 | 1.00 | 74.9 | 75.7 | 75.7 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 91820.8 |
| 42+00.00 | 1.00 | 3540.9 | 6523.6 | 6523.6 | 1.00 | 166.3 | 223.4 | 223.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 98121.0 |
| 42+50.00 | 1.00 | 2014.4 | 5143.8 | 5143.8 | 1.00 | 34.6 | 186.0 | 186.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 103078.8 |
| 43+00.00 | 1.00 | 0.0 | 1865.2 | 1865.2 | 1.00 | 0.0 | 32.0 | 32.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 104912.0 |

| Baseline Station | Station Quantities | | | | | | | | Added Quantities | | | | | | Mass Ordinate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | | | | Fill | | | | Cut | | | Fill | | | |
| | Factor | Area | Volume | Adjusted | Factor | Area | Volume | Adjusted | Factor | Volume | Adjusted | Factor | Volume | Adjusted | |
| Grand Total: | | | 107935.2 | 107935.2 | | | 3023.3 | 3023.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | |

# End Area Volume Report

Report Created: 6/15/2010
Time: 9:29am

**Cross Section Set Name:** CHANNEL WEST FOR END AREA
**Alignment Name:** 093386
**Input Grid Factor:** 1.000000 **Note:** All units in this report are in feet, square feet and cubic yards unless specified otherwise.

| Baseline Station | Station Quantities | | | | | | | | Added Quantities | | | | | | Mass Ordinate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | | | | Fill | | | | Cut | | | Fill | | | |
| | Factor | Area | Volume | Adjusted | Factor | Area | Volume | Adjusted | Factor | Volume | Adjusted | Factor | Volume | Adjusted | |
| 43+00.00 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 |
| 43+50.00 | 1.00 | 238.7 | 221.0 | 221.0 | 1.00 | 0.1 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 220.9 |
| 44+00.00 | 1.00 | 378.3 | 571.3 | 571.3 | 1.00 | 0.2 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 792.0 |
| 44+50.00 | 1.00 | 389.4 | 710.9 | 710.9 | 1.00 | 0.0 | 0.2 | 0.2 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1502.7 |
| 45+00.00 | 1.00 | 388.0 | 719.8 | 719.8 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 2222.5 |
| 45+50.00 | 1.00 | 380.1 | 711.2 | 711.2 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 2933.7 |
| 46+00.00 | 1.00 | 377.3 | 701.3 | 701.3 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 3634.9 |
| 46+50.00 | 1.00 | 360.6 | 683.2 | 683.2 | 1.00 | 0.3 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 4317.9 |
| 47+00.00 | 1.00 | 361.2 | 668.3 | 668.3 | 1.00 | 0.0 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 4985.8 |
| 47+50.00 | 1.00 | 375.6 | 682.2 | 682.2 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 5668.0 |
| 47+98.07 | 1.00 | 388.9 | 680.5 | 680.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 6348.5 |
| 48+00.00 | 1.00 | 389.1 | 27.8 | 27.8 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 6376.3 |
| 48+50.00 | 1.00 | 380.4 | 712.5 | 712.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 7088.8 |
| 49+00.00 | 1.00 | 348.0 | 674.5 | 674.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 7763.3 |
| 49+50.00 | 1.00 | 204.3 | 511.4 | 511.4 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 8274.7 |
| 49+78.90 | 1.00 | 0.0 | 109.3 | 109.3 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 8384.0 |
| 50+00.00 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 8384.0 |
| Grand Total: | | | 8385.3 | 8385.3 | | | 1.3 | 1.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | |

# End Area Volume Report

Report Created: 2/15/2010
Time: 2:31pm

**Cross Section Set Name:** CHANNEL WINE CL
**Alignment Name:** CHANNEL WINE CL
**Input Grid Factor:** 1.000000 **Note:** All units in this report are in feet, square feet and cubic yards unless specified otherwise.

| | Station Quantities | | | | | | | | Added Quantities | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | | | | Fill | | | | Cut | | | Fill | | | |
| Baseline Station | Factor | Area | Volume | Adjusted | Factor | Area | Volume | Adjusted | Factor | Volume | Adjusted | Factor | Volume | Adjusted | Mass Ordinate |
| 20+00.00 | 1.00 | 164.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 |
| 20+00.02 | 1.00 | 164.4 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.1 |
| 20+12.10 | 1.00 | 154.1 | 71.3 | 71.3 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 71.4 |
| 20+16.27 | 1.00 | 149.4 | 23.5 | 23.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 94.8 |
| 20+20.00 | 1.00 | 145.9 | 20.4 | 20.4 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 115.2 |
| 20+23.40 | 1.00 | 141.5 | 18.1 | 18.1 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 133.3 |
| 20+28.39 | 1.00 | 138.8 | 25.9 | 25.9 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 159.2 |
| 20+39.84 | 1.00 | 128.5 | 56.7 | 56.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 215.8 |
| 20+40.00 | 1.00 | 128.1 | 0.8 | 0.8 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 216.6 |
| 20+45.11 | 1.00 | 121.3 | 23.6 | 23.6 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 240.2 |
| 20+50.44 | 1.00 | 115.0 | 23.4 | 23.4 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 263.5 |
| 20+59.10 | 1.00 | 105.0 | 35.2 | 35.2 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 298.8 |
| 20+60.00 | 1.00 | 104.2 | 3.5 | 3.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 302.3 |
| 20+66.70 | 1.00 | 97.3 | 25.0 | 25.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 327.3 |
| 20+75.14 | 1.00 | 89.7 | 29.3 | 29.3 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 356.5 |
| 20+80.00 | 1.00 | 86.9 | 15.9 | 15.9 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 372.4 |
| 20+82.02 | 1.00 | 86.7 | 6.5 | 6.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 378.9 |
| 20+88.83 | 1.00 | 86.0 | 21.8 | 21.8 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 400.7 |
| 20+99.37 | 1.00 | 86.5 | 33.7 | 33.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 434.4 |
| 21+00.00 | 1.00 | 87.0 | 2.0 | 2.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 436.4 |
| 21+08.89 | 1.00 | 83.6 | 28.1 | 28.1 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 464.5 |
| 21+17.81 | 1.00 | 81.3 | 27.2 | 27.2 | 1.00 | 0.5 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 491.7 |
| 21+20.00 | 1.00 | 80.7 | 6.6 | 6.6 | 1.00 | 0.7 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 498.2 |
| 21+25.33 | 1.00 | 78.6 | 15.7 | 15.7 | 1.00 | 1.2 | 0.2 | 0.2 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 513.7 |
| 21+31.95 | 1.00 | 76.4 | 19.0 | 19.0 | 1.00 | 1.7 | 0.4 | 0.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 532.4 |
| 21+40.00 | 1.00 | 74.3 | 22.5 | 22.5 | 1.00 | 2.8 | 0.7 | 0.7 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 554.2 |
| 21+43.16 | 1.00 | 73.4 | 8.6 | 8.6 | 1.00 | 3.3 | 0.4 | 0.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 562.4 |
| 21+52.24 | 1.00 | 72.4 | 24.5 | 24.5 | 1.00 | 4.2 | 1.2 | 1.2 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 585.7 |
| 21+60.00 | 1.00 | 74.3 | 21.1 | 21.1 | 1.00 | 2.5 | 1.0 | 1.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 605.8 |
| 21+60.55 | 1.00 | 74.3 | 1.5 | 1.5 | 1.00 | 2.2 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 607.3 |
| 21+69.47 | 1.00 | 78.6 | 25.3 | 25.3 | 1.00 | 0.1 | 0.4 | 0.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 632.2 |
| 21+78.66 | 1.00 | 78.8 | 26.8 | 26.8 | 1.00 | 0.7 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 658.8 |
| 21+80.00 | 1.00 | 80.0 | 3.9 | 3.9 | 1.00 | 0.7 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 662.7 |
| 21+87.57 | 1.00 | 81.3 | 22.6 | 22.6 | 1.00 | 1.7 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 685.0 |
| 21+94.93 | 1.00 | 84.3 | 22.6 | 22.6 | 1.00 | 2.4 | 0.6 | 0.6 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 707.0 |

| Baseline Station | Station Quantities | | | | | | | | Added Quantities | | | | | | Mass Ordinate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut | | | | Fill | | | | Cut | | | Fill | | | |
| | Factor | Area | Volume | Adjusted | Factor | Area | Volume | Adjusted | Factor | Volume | Adjusted | Factor | Volume | Adjusted | |
| 22+46.59 | 1.00 | 101.3 | 21.1 | 21.1 | 1.00 | 0.2 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 884.6 |
| 22+51.70 | 1.00 | 104.0 | 19.4 | 19.4 | 1.00 | 0.9 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 904.0 |
| 22+59.16 | 1.00 | 104.8 | 28.8 | 28.8 | 1.00 | 1.7 | 0.4 | 0.4 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 932.4 |
| 22+60.00 | 1.00 | 104.6 | 3.3 | 3.3 | 1.00 | 1.6 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 935.6 |
| 22+66.99 | 1.00 | 102.8 | 26.8 | 26.8 | 1.00 | 2.3 | 0.5 | 0.5 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 962.0 |
| 22+74.49 | 1.00 | 102.0 | 28.5 | 28.5 | 1.00 | 2.7 | 0.7 | 0.7 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 989.7 |
| 22+80.00 | 1.00 | 103.4 | 21.0 | 21.0 | 1.00 | 2.5 | 0.5 | 0.5 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1010.2 |
| 22+89.20 | 1.00 | 110.3 | 36.4 | 36.4 | 1.00 | 2.0 | 0.8 | 0.8 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1045.8 |
| 22+96.76 | 1.00 | 117.5 | 31.9 | 31.9 | 1.00 | 1.8 | 0.5 | 0.5 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1077.2 |
| 23+00.00 | 1.00 | 122.2 | 14.4 | 14.4 | 1.00 | 1.7 | 0.2 | 0.2 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1091.3 |
| 23+05.63 | 1.00 | 129.0 | 26.2 | 26.2 | 1.00 | 1.4 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1117.2 |
| 23+13.36 | 1.00 | 138.1 | 38.2 | 38.2 | 1.00 | 1.1 | 0.3 | 0.3 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1155.1 |
| 23+20.00 | 1.00 | 144.6 | 34.7 | 34.7 | 1.00 | 0.1 | 0.1 | 0.1 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1189.7 |
| 23+23.01 | 1.00 | 146.5 | 16.2 | 16.2 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1205.9 |
| 23+31.82 | 1.00 | 150.1 | 48.4 | 48.4 | 1.00 | 0.1 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1254.3 |
| 23+40.00 | 1.00 | 149.9 | 45.4 | 45.4 | 1.00 | 0.1 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1299.7 |
| 23+41.09 | 1.00 | 150.0 | 6.1 | 6.1 | 1.00 | 0.1 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1305.8 |
| 23+47.71 | 1.00 | 151.1 | 36.9 | 36.9 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1342.7 |
| 23+54.20 | 1.00 | 150.6 | 36.3 | 36.3 | 1.00 | 0.1 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1378.9 |
| 23+59.59 | 1.00 | 154.1 | 30.4 | 30.4 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1409.3 |
| 23+60.00 | 1.00 | 154.6 | 2.3 | 2.3 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1411.7 |
| 23+68.97 | 1.00 | 156.2 | 51.6 | 51.6 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1463.3 |
| 23+73.12 | 1.00 | 155.7 | 24.0 | 24.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1487.2 |
| 23+80.00 | 1.00 | 155.7 | 39.7 | 39.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1526.9 |
| 23+80.29 | 1.00 | 155.8 | 1.7 | 1.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1528.6 |
| 23+84.81 | 1.00 | 156.6 | 26.1 | 26.1 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1554.7 |
| 23+89.71 | 1.00 | 157.4 | 28.5 | 28.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1583.3 |
| 23+95.36 | 1.00 | 159.1 | 33.1 | 33.1 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1616.3 |
| 24+00.00 | 1.00 | 160.6 | 27.5 | 27.5 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1643.8 |
| 24+00.29 | 1.00 | 160.6 | 1.7 | 1.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1645.5 |
| 24+05.78 | 1.00 | 162.6 | 32.9 | 32.9 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1678.4 |
| 24+10.48 | 1.00 | 165.9 | 28.6 | 28.6 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1707.0 |
| 24+14.15 | 1.00 | 168.2 | 22.7 | 22.7 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1729.7 |
| 24+17.30 | 1.00 | 169.6 | 19.8 | 19.8 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1749.4 |
| 24+17.31 | 1.00 | 168.6 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1.00 | 0.0 | 0.0 | 1749.5 |
| Grand Total: | | | 1762.3 | 1762.3 | | | 12.8 | 12.8 | | 0.0 | 0.0 | | 0.0 | 0.0 | |

**CD**

**Hydrology**
**HEC-RAS**
**HY-8**
**HEC-6**
**StormCAD**
**Sediment Yield**
**Erosion Protection**