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# Final Drainage Report

**Hannah Ridge at  
Feathergrass  
Filing No. 3**

**July 25, 2017**  
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# Final Drainage Report

for

**Hannah Ridge at Feathergrass Filing No. 3**

**Project No. 60970-F3**

**July 25, 2017**

prepared for

**Feathergrass Investments, LLC**

4715 North Chestnut Street  
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60970 HR Fil, No. 3 Final Drainage Report.odt

# Statements and Acknowledgments

## Engineer's Statement

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the applicable master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

\_\_\_\_\_  
David R. Gorman, P.E.  
For and on Behalf of MVE, Inc.

Colorado No. 31672

\_\_\_\_\_  
Date

## Developer's Statement

I, the owner/developer have read and will comply with all of the requirements specified in this drainage report and plan.

\_\_\_\_\_  
Kenneth P. Driscoll, Manager  
Feathergrass Investments, LLC  
4715 North Chestnut Street  
Colorado Springs, CO 80907

\_\_\_\_\_  
Date

## El Paso County

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

\_\_\_\_\_  
Jennifer Irvine, P.E.,  
County Engineer / ECM Administrator

\_\_\_\_\_  
Date

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# Final Drainage Report

The purpose of this Final Drainage Report is to identify drainage patterns and quantities within and affecting the proposed Hannah Ridge at Feathergrass Filing No. 3. The development project is part of a phased residential development with approved Master Development Drainage Plan, Preliminary Drainage Report and Preliminary Plan documents on file. This report also addresses aspects of all phases (subdivision filings) of the project in order to present the drainage information in the context of the total project. The report will "identify specific solutions to problems on-site and off-site resulting from the proposed project."<sup>1</sup> The report and included maps present results of hydrologic and drainage facilities analyses. The report will discuss the recommended drainage improvements to the site and identify drainage requirements relative to the proposed project. This report has been prepared and submitted in accordance with the requirements of the El Paso County Final Plat approval process. An Appendix is included with this report with pertinent calculations and graphs used in the facility design and drainage analyses.

## 1 General Location and Description

### 1.1 Location

The proposed Hannah Ridge at Feathergrass Filing No. 3 site is located within the south one-half of Section 32, Township 13 South, Range 65 west of the 6th principal meridian in unincorporated El Paso County, Colorado. The site is situated on the north side of Constitution Avenue, west of Akers Drive and east of the old Rock Island Railroad right-of-way (a trail owned by the City of Colorado Springs). The proposed site is currently known as Tract FF, Hannah Ridge at Feathergrass Filing No. 1. A **Vicinity Map** is included in the **Appendix**.

Tract F, Hannah Ridge at Feathergrass Filing No. 1 (HRAFG Fil No. 1) recorded in June 2014, is adjacent along the east side of the site. Tract F is a drainage and greenway tract zoned PUD. The development of the 39 residential lots in Filing No. 2, located east of Tract F, is recently completed with streets, utilities and landscaping. Tract E HRAFG Fil No. 1 (a future park, zoned PUD) lies to the northeast of the site, Tract LL HRAFG Fil No. 1 (a future single family residential site zoned PUD) is adjacent to the northwest of the site. Tract GG HRAFG Fil No. 1 (a future single family residential site zoned PUD) lies to the west of the site and Tract BB HRAFG Fil No. 1 (a future multi-family residential site zoned RM-30) is adjacent to the south. The subject property and surrounding tracts were originally platted as the Industrial (M) zoned Akers Acres before being replatted into Hannah Ridge at Feathergrass Filing No. 1.

### 1.2 Description of Property

The entire Hannah Ridge at Feathergrass Filing No. 1 subdivision contained 117.81± acres. The Filing No. 1 plat included tracts for future multi-family residential, single family residential and commercial development in accordance with approved zoning and the Preliminary Plan for the site. Hannah Ridge at Feathergrass Filing No. 3 is the third phase of single family residential lots and streets which will be replatted from the 8.31± acres of the existing Tract FF.

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<sup>1</sup> DCM, 4-6.

The ground cover, which is in good condition, consists of native grasses, sparse brush and a few trees. A portion of the Filing No. 3 site has been disturbed as necessary for the construction of Filing No. 2. The existing site topography slopes to the east and south with grades that range from 1% to 8%. The existing flow path of the Sand Creek tributary that runs from north to south through the overall Hannah Ridge at Feathergrass property is located within the proposed Hannah Ridge at Feathergrass Filing No. 3 site. Once the tributary flows reach Constitution Avenue from the north, a channel/ditch cut along the north side of Constitution Avenue conveys the tributary flows to the east. Contributing on-site runoff joins the tributary flows, which are directed through the new double 10'w x 6' high Hannah Ridge Drive culvert. The flows continue east to the existing culvert crossing of Constitution Avenue, just west of Akers Drive.

Soils in this particular site as well as the entire surrounding Hannah Ridge at Feathergrass development are generally conducive for land development with some localized areas of unsuitability which shall be addressed in the site grading and drainage treatments for the proposed subdivision. These conditions are fully discussed in the project Soil, Geology and Geologic Hazard Studies and updates prepared by Entech Engineering.<sup>2 3</sup> According to the National Resource Conservation Service, the dominant soil in the immediate area of the Hannah Ridge at Feathergrass Filing No. 3 site is Blakeland loamy sand (map unit 8), The Blakeland loamy sand is typically deep and somewhat excessively drained. Permeability is rapid, surface runoff is slow, and the hazard of erosion is moderate. Blakeland loamy sand is classified as being part of Hydrologic Soil Group A. The soil has good potential for urban development, but is prone to water and wind erosion if protective vegetation is removed and not mitigated by proper erosion control practices.<sup>4 5</sup> A portion of the **Soil Map** and data tables from the National Cooperative Soil Survey are included in the **Appendix**.

Major drainageways through the site include the previously mentioned sub-tributary (Tributary 6) to the east fork of Sand Creek which flows into the north side of the overall Hannah Ridge property by way of an existing concrete box culvert in the old railroad embankment. The drainageway runs north to south through the site and then east along the north side of Constitution Avenue to an existing concrete box culvert crossing Constitution Avenue just west of Akers Drive. Existing Hannah Ridge Filing No. 1 and 2 are located east of this tributary. Another drainageway enters the Hannah Ridge property from the west and joins Tributary 6 along the north side of Constitution Avenue. The flows from this drainageway are conveyed by Constitution Avenue surface, a reinforced concrete pipe (RCP) located along the north side of Constitution Avenue and a old railway bridge opening on the west edge of the site.

## 2 Drainage Basins and Sub-Basins

### 2.1 Major Basin Descriptions

The Hannah Ridge at Feathergrass Filing No. 3 site is located in the Sand Creek Major Drainage Basin (FOFO4000) on the east side of Colorado Springs, which contains properties in both City of Colorado Springs and unincorporated El Paso County jurisdictions. The basin is a studied basin with an approved and operative Drainage Basin Planning Study (DBPS). The Basin stretches for approximately 17 miles on the east side of Colorado Springs and drains from northeast to southwest into Fountain Creek at a point just north of the crossing of Interstate 25 and US Highway 85-87. The site is located in the southeastern portion of the Sand Creek Major Drainage Basin on a tributary with approximately 1.07 square miles of drainage area upstream of the site. A copy of a portion of the "**Drainage Area Identification Study**"<sup>6</sup> map, showing the site location within the Basin is included in the **Appendix**.

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2 Soils Rep 1  
3 Soils Rep 2  
4 WSS El Paso County Area, Colorado.  
5 OSD  
6 Drain. Area Ident. Study

The Drainage Basin Planning Study for the Sand Creek Major Drainage Basin was completed in 1996 by Kiowa Engineering Corporation.<sup>7</sup> The site is contained within sub-basin 12, located just upstream of Design Point No. 8, as indicated in the 1996 report. Riprap channel improvements and channel check structures are called out in the DBPS for this sub-basin. Copies of the DBPS **Drainage Planning Study Map** and pertinent pages of the DBPS **Preliminary Design Plans** showing the site location within the basin as well as the DBPS planned improvements in the subject reach are included in the **Appendix**. A portion of the major channel is located within this site and proposed improvements for a portion of the major drainage system are to be constructed as part of Hannah Ridge at Feathergrass Filing No. 3.

Kiowa Engineering also prepared a report titled "Hydrology Analysis, East Fork Sand Creek, Tributary 6", having revision date of January 18, 2007.<sup>8</sup> The report served to amend the DBPS and was reviewed and accepted by El Paso County Development Services during the same time frame as the Preliminary Plan approval of the Hannah Ridge at Feathergrass project. The amendment specified that the existing 7'x7' railroad culvert crossing, located approximately 1/2 mile north of Constitution Avenue is to remain in place. Said DBPS amendment indicates that the existing ponding area on the upstream side of the railroad embankment is to remain in the current and future drainage conditions, thereby reducing the resultant developed flows through the properties downstream of the embankment, including the flows through the tributary in Hannah Ridge, the Hannah Ridge Drive culvert and the Constitution Ave / Akers Drive culvert downstream of the site. The 2007 DBPS Amendment Maps and hydrologic calculations are included in the **Appendix** to this report for easy reference.

Maintenance on the existing Rock Island Trail 7'x7' box culvert at Design Point 1 will be performed in accordance with the prior BOCC conditions of approval of the Preliminary Plan. Maintenance of the box culvert will be completed with the improvements of Hannah Ridge at Feathergrass Filing No. 3.

The existing 7' x 7' concrete box culvert was constructed under the Rock Island Railroad bed. We found no information regarding date of construction. The culvert is assumed to have been constructed according to the Rock Island Railroad Engineering Design criteria being used at the time. The railroad is no longer in existence and the railroad bed has had the tracks & ties removed. The land is now owned by the City of Colorado Springs and designated as the 'Rock Island Trail' by the Colorado Springs Parks Department. The condition of the concrete box culvert was by M.V.E., Inc. approximately 7 to 10 years ago and then again recently.

In the recent observation, the box culvert was inundated with water about one foot (1') in depth at the time of observation due to rainfall and the downstream channel conditions. The ponding condition will end once downstream channel obstructions are removed with proposed new channel construction.

The walls and floors are cast in place concrete. The bottom material was observed during the earlier visit, which was during a dry period. The deck is a combination railroad rails, used as beams, spanning the cast in place walls with brick laid in between the rails. Rusting of the rails is minor and there are no visible signs of deflection in the deck rails. We could not observe if there is a cast in place deck over the rail and brick deck as there is 18' to 20' of fill over said deck. The fill slopes are well vegetated.

The cast in place concrete walls are in fair condition with some cracking & spalling evident. No structural cracks were observed. The floor had been observed in the past with some spalling. We have no knowledge that said spalling was ever repaired. Probing & measuring upstream and downstream of the structure indicate minor scour holes of 1 cubic yard plus in size. Once the ponding is relieved, the actual size of the scouring may be determined.

We have the opinion that the box culvert is structurally sound and cosmetic repairs of exposed concrete surfaces should be completed. Also, rip-rap inlet & outlet aprons should be constructed in place. Both aprons will be Type H rip rap, 2.0 ft thick. The inlet apron will be 20' x 20' and the outlet apron will be 20' wide by 40' long. Costs for cosmetic surface repairs and the addition of rip-rap aprons for the existing box culvert are listed in the Opinion of Probable Costs section of this report.

7 1996 DBPS  
8 2007 DBPS Amend

Include line in  
FAE section 2.



The current Flood Insurance Study of the region includes Flood Insurance Rate Maps (FIRMs), effective March 17, 1997.<sup>9 10</sup> The project site is included in Community Panel Numbers 08041C0752 F and 08041C0756 F of the FIRMs for El Paso County, Colorado. The Flood boundaries for the subject Tributary 6 of the East Fork of Sand Creek, as shown on the FIRM, was most recently revised by Letter of Map Revision (LOMR) on March 24, 2004 and September 24, 2008.<sup>11 12</sup> According to the LOMR, the nearest Federal Emergency Management Agency (FEMA) designated floodplain boundary is approximately 1400 feet south of the project site, near Palmer Park Boulevard. No part of the site is shown to be included in a 100-year flood hazard area as determined by FEMA. The project site and surrounding property is Zone X, being "Areas of 500 year flood; Areas of 100-year flood with average depths of less than 1 foot with drainage areas less than 1 square mile; and Areas protected by levees from the 100-year flood". A portion of the current **FEMA Flood Insurance Rate Maps** as well as maps modified by the recent LOMR's with the site delineated is included in the **Appendix**.

The construction of the Constitution Avenue at Akers Drive Concrete Box Culvert Extension project for the Tributary 6 flows downstream of Constitution Avenue was completed in 2013. The box culvert extension was designed and constructed as detailed in the approved "Drainage Report, Constitution Avenue at Akers Drive Box Culvert Extension" dated August 15, 2011 by M.V.E., Inc.<sup>13</sup> The design of the box culvert extension considered developed flows from the Hannah Ridge at Feathergrass site as determined in the 2007 DBPS amendment.

The construction of the Hannah Ridge Drive Concrete Box Culvert for the Tributary 6 flows along Constitution Avenue was completed in 2016. This box culvert was designed and constructed as detailed in the approved "Drainage Report for Hannah Ridge at Feathergrass Filing No. 2", dated September 21, 2015 by M.V.E., Inc.<sup>14</sup> The design of the box culvert extension considered developed flows from the Hannah Ridge at Feathergrass site as determined in the 2007 DBPS amendment.

The owner of the Wilshire Development, located south of the box culvert extension project site, is obligated to construct the channelization of Tributary 6 from the El Paso County owned parcels, south of Constitution Avenue to its confluence with the East Fork Sand Creek before proceeding with any more subdivision filings within Wilshire. In the preparation of the Master Development Drainage Report for the Hannah Ridge at Feathergrass development, which was prepared in 2007 and updated in 2013, it was anticipated that the channelization would be completed during the first half of the residential development of Hannah Ridge at Feathergrass, consisting of approximately 38 acres located north of Hunter Jumper Drive and south of Winslow Park Drive. The subdivision phasing of Hannah Ridge changed from 2007 to 2013 so that 2007 Phase 1 is equal to the 2013 Phases 1, 2, 3 & 4. The approved Master Development Drainage Report analyzed the Tributary 6 drainageway downstream of Constitution Avenue and found that the development of the initial 38 acres of Hannah Ridge at Feathergrass to have negligible effects on the existing drainageway without detention.<sup>15</sup> Therefore, the Development of Hannah Ridge at Feathergrass Filings 1 and 2 with no on-site detention will not damage the downstream drainageway. Pertinent portions of the analysis completed as part of the MDDP for Hannah Ridge is included in this drainage report for easy reference. The need for on-site detention in the remaining phases will be determined in the Final Drainage Reports for the future phases. Once the downstream Wilshire channel improvements are completed, the needs of the drainageway regarding developed flow erosion and velocities in the tributary will be addressed. Since the Wilshire channel improvements were designed to accommodate the developed flows determined by the DBPS and the developed flows from Hannah Ridge do not cause the channel flow rates to be increased beyond the DBPS discharges at full basin build-out, On-site detention in Hannah Ridge will not be necessary. The Wilshire channel plans for

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9 FIS  
10 FIRM, Map No. 08041C0756 F  
11 LOMR 2004  
12 LOMR 2008  
13 CBC Rep  
14 HR 2 FDR  
15 MDDP

the tributary includes the reach from the El Paso County owned parcels located south of Constitution Avenue to the confluence with the East Fork Sand Creek.

## 2.2 Sub-Basin Description

### 2.2.1 Existing Drainage Patterns (On-Site)

The northern and central portion of the total existing Hannah Ridge at Feathergrass site drains to the center from both the east and west sides, and then southerly in the tributary to East Fork Sand Creek which flows from north to south through site. The off-site tributary discharges enter from the previously mentioned existing 7'x7' culvert under the old Rock Island Railroad grade that bounds the property on the west and north. The southern portion of the site drains southerly and easterly from the old Rock Island Railroad that bounds the property on the west. The site drains into a ditch running along the north side of Constitution Avenue right-of-way. This ditch also collects the existing 42" and 60" pipe storm water discharge at the southwestern corner of the proposed Hannah Ridge Preliminary Plan. This storm sewer system was designed and constructed in 1992 by El Paso County Department of public works to collect and route existing flows from the western side of the old Rock Island Railroad. A sump area was constructed to capture existing and future developed flows from this area. An **Existing Drainage Map** is included and shows existing basin delineations.

The 8.31 acre Filing No. 3 site is contained in existing sub-basins A7 and A9 which drain south towards Constitution Avenue. The existing site sheet flows into the tributary channel and exit the Filing No. 3 site to the south into existing Tract BB.

### 2.2.2 Off-Site Drainage Flow Patterns

Off-site drainage flows enter the total Hannah Ridge at Feathergrass site from both the north and from the west. The hydrologic analyses used in the drainage design of the proposed subdivision considered the projected Future Land Use Conditions of the upstream sub-basins and not existing conditions. The flow rates listed below are taken from the 2007 DBPS Amendment, the 2007 Hannah Ridge at Feathergrass MDDP and the 2013 Hannah Ridge at Feathergrass Preliminary Drainage Report, which are referenced in the next section of this report.

The northern entry point is at the existing 7'x7' concrete box crossing of the north railroad embankment. The drainage sub-basin draining to the existing 7x7 box is the northern 425 acre portion of the East Fork Sand Creek Tributary 6 watershed extending from the Rock Island Railroad Right-of-Way, north to Barnes Road. A complete description of this northern upstream watershed, along with the Land Use Map used in the hydrologic analyses are contained in Kiowa Engineering's 2007 Hydrology Analysis Report, which is hereby referenced and made a part of this report.<sup>16</sup> The sub-basin contains a mixture of land uses including areas of undeveloped Open Space, medium density Single-Family Residential, medium-high density Single-Family Residential and Industrial / Commercial. Flows originating in this basin travel from north to south in streets, storm drains and drainageways to the railroad embankment. Flow rates are attenuated from 360 cfs to 130 cfs in the 10-yr rainfall event and from 915 cfs to 640 cfs in the 100-yr rainfall event by ponding on the upstream side of the embankment as controlled by the existing 7'x7' concrete culvert before entering the site.

Flows of  $Q_{10} = 130$  cfs and  $Q_{100} = 283$  cfs also enter site from the westerly 105 acre sub-basin made up of medium density Single-Family Residential property. These flows are conveyed east towards the site in a Combination of Constitution Avenue Street flow ( $Q_5 = 39$  cfs and  $Q_{100} = 121$  cfs), flows of  $Q_5 = 87$  cfs and  $Q_{100} = 126$  cfs in an existing 36"/42" pipe system along the north side of Constitution Avenue, and overland flows of  $Q_5 = 19$  cfs and  $Q_{100} = 41$  cfs entering through the trellis opening in the westerly railroad embankment (trail). These flows continue south and east through Hannah Ridge at Feathergrass site to the existing double 12'x6' Constitution Avenue culvert, which was recently extended to the south with combined flows of  $Q_{10} = 457$  cfs and  $Q_{100} = 1076$  cfs. The culvert delivers the flows to the tributary drainageway south of Constitution Avenue. The flows continue to flow south to East Fork of Sand Creek approximately 6500 feet south of the project site.

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16 2007 DBPS Amend

Considering the 8.31 acre site of Hannah Ridge at Feathergrass Filing No. 3, existing Tract F is located along the east side, which drains south into Tract BB. No flows enter the site from the east. The western part of existing sub-basin A7 drains easterly in to the site to the tributary drainageway, which conveys the flows to the south. The site also accepts the tributary flows of  $Q_{10} = 130$  cfs and  $Q_{100} = 640$  cfs entering from the north. All site stormwater flows of  $Q_{10} = 130$  cfs and  $Q_{100} = 640$  cfs exit to the south into Tract BB and are directed to the existing ditch along the north side of Constitution Avenue with combined flows of  $Q_{10} = 130$  cfs and  $Q_{100} = 283$  cfs.

### 3 Drainage Design Criteria

#### 3.1 Development Criteria Reference

This Final Drainage Report for Hannah Ridge at Feathergrass Filing No. 3 has been prepared according to the report guidelines presented in the latest edition of *City of Colorado Springs/El Paso County Drainage Criteria Manual (DCM)*<sup>17</sup>. The on-site (local) hydrologic analysis is based on a collection of data from the DCM, the NCSS Web Soil Survey<sup>18</sup>, a topographic survey of the site prepared by the M.V.E., Inc., proposed site layout from the approved Preliminary Plan, property boundary information provided by M.V.E., Inc. and proposed grading and drainage system layout developed by MVE, Inc. and Classic Consulting Inc. Runoff flow data used in the preparation of the main drainage way (Tributary 6) facility design is in accordance with the hydrology presented in the 1996 DBPS as modified by the 2007 Hydrology Analysis Report. The Hydrologic Basin Map with sub-basin boundaries, design point locations and discharges from the 2007 Hydrology Analysis Report is included in the **Appendix** to this report for convenient reference.

#### 3.2 Previous Drainage Studies

The Sand Creek Major Drainage Basin DBPS and subsequent Hydrology Analysis Report for Tributary 6 has already been discussed at length. These reports present runoff flow rates for the main drainageway (Tributary 6) through the site, that result from Developed Conditions in the subject drainage basin. These flows are used in the design and hydraulic analysis of the proposed major drainage way through the site.

Both a Master Development Drainage Report for the entire Hannah Ridge at Feathergrass and a Preliminary Drainage Report for the residential phases of the development were prepared by M.V.E., Inc. during the approval process of the PUD Plan and Preliminary Plan.<sup>19 20</sup> These reports present preliminary drainage information for on-site sub-basins within the development. The preliminary information is updated, revised and expanded in this current drainage study and report.

The Final Drainage Report for Hannah Ridge at Feathergrass Filing No. 1 was prepared by M.V.E., Inc. and dated January 31, 2014.<sup>21</sup> The report addressed drainage for 45 residential lots in Filing No. 1 and contains the drainage plan for the entire Hannah Ridge development. No storm drain facilities were constructed as part of Hannah Ridge at Feathergrass Filing No. 1.

#### 3.3 Hydrologic Criteria

Flow rates at all design points in the subdivision with contributing areas greater than 100 acres are calculated using SCS hydrologic flow computation method in accordance with El Paso County criteria. Flow rates at all design points having contributing areas less than 100 acres are calculated using the Rational Method. Flow rates were calculated for 5-year, 10-year and 100-year rainfall recurrence intervals on the main drainageway and 5-year and 100-year events for the local drainage system.

The SCS method main drainage way (offsite) hydrology flows are taken from the previously mentioned 1996 and 2007 Kiowa reports. Flow rate values were produced for both the present

<sup>17</sup> DCM Section 4.3 and Section 4.4

<sup>18</sup> WSS

<sup>19</sup> MDDP

<sup>20</sup> PDR HR PH1-3

<sup>21</sup> HR 1 FDR



existing condition of the watershed and ultimate developed conditions. SCS hydrograph data for the 5-year and 100-year rainfall recurrence intervals was produced using the U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrograph Modeling package (HEC-1).<sup>22</sup> The computer model runs are included in the **Appendix** of this report for convenience. The model utilized NOAA Rainfall Frequency data of 3.0" and 4.4" of total 24-hour precipitation depth for the 5-year and 100-year rainfall events, respectively. The SCS Type IIa rainfall distribution was used to produce the storm rainfall hydrographs. Runoff hydrographs were computed using Curve number ratings developed according to County criteria and according to existing and proposed land uses for areas in the watershed. Times of Concentration (Tc) values for basin runoff was developed using the 'Overland Flow Equation' Page 5-11 in the DCM, and the channel flow component of the Tc was computed using Manning's equation under conveyance-full conditions.

Additional Data used in the study includes soils data from the NRCS Web Soil Survey<sup>23</sup>, Colorado Springs Utilities FIMS topographic mapping, SGS Topographic Mapping and site survey data and mapping by M.V.E., Inc.<sup>24 25 26</sup>

The Rational Method utilized 'Time Intensity-Frequency Curves' Figure 5-1 in the DCM to obtain the design rainfall values. The 'Overland Flow Equation' Page 5-11, and Manning's equation with estimated depths were used in time of concentration calculation. Table 5-1 'Recommended Average Runoff Coefficients and Percent Impervious' was utilized as a guide in estimating runoff coefficient values.

### 3.4 Hydraulic Criteria

The hydraulic design and analysis for the facilities in this Final Drainage Report including storm drain inlets, pipes, culverts, channels and streets have been prepared according to the provisions of the *City of Colorado Springs/El Paso County Drainage Criteria Manual (DCM)*<sup>27</sup>. Hydraulic properties and performance of parts of the drainage system were determined using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS) modeling Package.<sup>28</sup> Geometric data for the model cross sections were obtained from the M.V.E., Inc. topographic mapping in combination with proposed site construction drawings. Manning's roughness coefficient values for various drainage system components are in accordance with El Paso County criteria for the particular design materials.

Storm drainage inlet and piping analyses was performed with Autodesk Storm and Sanitary Analysis 2012 computer program.<sup>29</sup> System profiles and output is included in the **Appendix**. Culvert calculations were performed with the use of the "HY-8" computer application developed by the Federal Highway Administration.<sup>30</sup> In some cases, culvert calculations were also verified for comparable results with the use of HEC-RAS's "Special Culvert" routines.

The "Rational Formula-based FAA", Section 3.2.3 of the *Urban Drainage and Flood Control District Drainage Criteria Manual, Volume 2 (UDFCD)*, method was used for water quality and detention storage calculations with "Recommended Percentage imperviousness Values", Table 5-1 in the DCM, used to determine the site imperviousness. These sizing calculations along with the hydraulic performance of outlet structures and drain pipes, and routing of inflow hydrographs through storage volumes and outlet structures, were performed using the detention design spreadsheet, "UD-Detention\_v2.2", developed by the Urban Drainage and Flood Control District.<sup>31</sup>

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22 HEC-1  
 23 WSS  
 24 USGS  
 25 FIMS  
 26 MVE Topo  
 27 DCM Section 4.3 and Section 4.4  
 28 HEC-RAS  
 29 ADSS  
 30 HY-8  
 31 UDFCD



## 4 Drainage Facility Design

### 4.1 General Concept

The proposed Hannah Ridge at Feathergrass Filing No. 3 project will consist of 39 single family lots with average lot size of 6,036 square feet. The overall single family residential development also includes park space, landscape open space and natural open space areas. There are multi-family and commercial parcels south of the single family residential development along Constitution Avenue. These parcels will be developed in accordance with future separate Preliminary Plans and Final Drainage Reports. Access to Filing No. 3 will be from the westerly extensions of existing Hunter Jumper Drive and existing Winslow Park Drive. The proposed roads will be paved county streets within 50 and 60 foot of rights-of-way.

The entire Hannah Ridge at Feathergrass residential development is continuing to be platted and constructed in phases. The drainage infrastructure will also be constructed in phases to accommodate the existing and developed drainage as the project progresses. This Phase 3 includes a large diameter storm drain pipe in existing Tract F, smaller diameter storm drain pipes in the street rights-of-way, storm drain inlets, and permanent water quality facility.

The intent of the drainage concept presented in this Final Drainage Report is to accept and route the off-site basin discharges through the site, while conveying the on-site developed major and minor storm flows safely through the site and downstream, maintaining adequate flow capacity in the surface streets, storm drain system and channels and providing overflow routing for storms greater than the major (100-year) events in accordance with El Paso County drainage criteria.

Considering the overall Hannah Ridge at Feathergrass development, the proposed conditions will route local storm water flows over the site in sheet flow, shallow concentrated flow and stream flow, depending on the existing topography and the contributing flow areas. These flows will be routed to the streets. The five year frequency storm water flows in excess of street carrying capacities will be collected and routed to the main tributary channel/pipe. Curb & gutter will be constructed on the streets and route storm water flows to storm water inlets. An underground storm drain system will be installed in the right of ways and easements to deliver street flow to the main drainage ways. The Sand Creek Tributary through the site will be improved with channel grading, bed and bank stabilization, culverts and drainage pipe. Grading operations will be done in order to improve drainage conditions and to direct runoff to desired locations. Overlot grading will be necessary for subdivision development.

Runoff from off-site and on-site will be contained in the central north-south drainageway through the site in a combination of improved open channel and storm drain conduits that leads to the existing drainage channel on the north side of Constitution Avenue. Off-site flows from the west and flows from the southwestern part of the proposed development will also continue to flow to the existing drainage channel on the north side of Constitution Avenue to the existing double 12'x6', culvert crossing of Constitution Avenue. The existing channel along Constitution Avenue will not be improved until the development of the multi-family and commercial properties along Constitution Avenue occurs.

It is intended that the drainage system be owned and maintained by El Paso County in concert with the public transportation infrastructure through the mechanism of Public Right of Way and Public Drainage Easements through the site as it develops. Access over, across and adjacent to the proposed storm drainage system components will be provided. The private water quality facilities will be owned and maintained by the Communities at Feathergrass Homeowners Association.

There are no irrigation facilities that would become an encumbrance to the drainage ways or facilities. The site will have water mains and sewer mains located in the streets. Some proposed water mains will have local lowerings installed to avoid possible conflicts with storm drain laterals. All sanitary sewer crossings of the drainage system will be in streets. The sanitary sewer mains will tend to be constructed much lower than the proposed storm drain and drainage system. No encumbrances due to utilities are anticipated.

The existing drainage conditions and the proposed drainage concept are described in more detail below. Input data and results for all calculations are included in the **Appendix**. Drainage maps for the hydrology and drainageway hydraulics are also included in the **Appendix**.

## 4.2 Specific Details

### 4.2.1 Existing Hydrologic Conditions

The off-site drainage area north of the site, Basin OSA 1 (Basin No.'s 1, 2 & 5 on 2007 DBPS Amendment map) contains 425 acres draining to Tributary 6, East Fork of Sand Creek. The Tributary runoff enters the property through the old railroad embankment by way of an existing 7'x7' concrete box culvert. Discharges of  $Q_{10} = 360$  cfs and  $Q_{100} = 886$  cfs flow to the culvert. Flows are detained behind the embankment before entering the property so that the peak discharges flowing through are  $Q_{10} = 351$  cfs and  $Q_{100} = 627$  cfs. The existing 7'x7' culvert is to permanently remain in place per the 2007 DBPS Amendment.

Basins OSA2 (1.9 acres) and OSC1 (3.4 acres) comprise off-site area from the railroad embankment to the northern property boundary. The discharges generated by OSA2 are  $Q_5 = 2$  cfs and  $Q_{100} = 5$  cfs, which enters on-site Basin A4. The discharges generated by OSC1 are  $Q_5 = 5$  cfs and  $Q_{100} = 11$  cfs, which also enters on-site Basin A4 and continues to the south. Off-site Basin OSA3 (0.3 acres) is the west side of Akers Drive which drains onto the site at Electronic Drive with discharges of  $Q_5 = 1$  cfs and  $Q_{100} = 2$  cfs. The off-site flows on the east side of Akers Drive drains south down the street, towards Constitution Avenue and are collected in Akers Drive and directed to Tributary 6, just upstream of the Constitution Avenue CBC.

Existing Basin A4 is 38.1 acres in area and generates flows of  $Q_5 = 31$  cfs and  $Q_{100} = 71$  cfs. Basin A4 accepts flows from off-site Basin OSA1 on the north, OSA2 on the northeast, OSC1 on the northwest and OSA3 on the east. The combined flows travel overland to the central portion of the basin joining the flows in the tributary to East Fork of Sand Creek, traveling south to enter Basin A7 with combined flow rates of  $Q_{10} = 351$  cfs and  $Q_{100} = 627$  cfs.

Existing off-site drainage basins OSF1, OSF2 and OSF3, west of the site, drain easterly onto the site, into existing Basin A7. Basin OSF1 (Basin No. 3 on the 2007 DBPS Amendment Map), contains 105 acres draining towards the site from the west. Basin OSF1 discharges are discussed in detail below. Existing Basins OSF2 and OSF3 are the off-site area from the railroad embankment to the northern property boundary along the west side. Basin OSF2 (4.9 acres) delivers flows of  $Q_5 = 4$  cfs and  $Q_{100} = 10$  cfs to the west edge of Basin A7. Basin OSF3 (0.5 acres) generates flows of  $Q_5 = 1$  cfs and  $Q_{100} = 2$  cfs.

The DBPS amendment indicates total peak discharges generated by Basin OSF1 are  $Q_{10} = 130$  cfs and  $Q_{100} = 283$  cfs. These discharges are actually distributed among pipe flows in the Constitution Avenue storm drain system, overland flow through the trestle opening at Rock Island Trail, overland flow at the trail intersection with Constitution Avenue, and street flows in Constitution. Off-site drainage basins were delineated with the aid of previous drainage studies, including calculations by El Paso County utilized for the design of the Constitution Avenue storm drain system. Basin flows were calculated to determine runoff from different portions of Basin OSF1. There are no records available that indicate how much storm runoff is captured by the storm drain system. Every inlet and pipe in the entire existing storm drain system was not analyzed, but a reasonable estimate was made of the flows captured by the storm drain system and thereby the flow distribution, as explained below.

The off-site basin flowing to the intersection of Constitution Avenue and Canada Drive, containing residential area, produces discharges of  $Q_5 = 121$  cfs and  $Q_{100} = 230$  cfs. These flows reach the intersection both in the storm drain system and the streets connected to Constitution Avenue. To determine the amount of flows in the pipe system during both 5 year and 100 year rainfall events, the assumption was made that the system is flowing under pressure with the hydraulic grade line at rim elevation of the existing manhole at Constitution Avenue and Canada Drive. The assumption is reasonable since the section of storm drain at this location is limiting due to size, slope and depth. The resulting captured flow in the 36" CMP of 57 cfs is about 25% of the total 100 year discharge and about 47% of the total 5 year flow at this location. Since the upstream storm drain inlets would

generally have been designed to capture at least half of the available storm flows, it would seem that the pipe is already at maximum capacity during both 5 year and 100 year events at this point. However, additional capacity opens up further downstream of the system as discussed below. All remaining 5-year and 100 year flows not contained within the pipe continue east in Constitution Avenue. Additional flows are collected by inlets in Constitution Avenue about 750 feet west of the Hannah Ridge property line. At this point, the existing 42" CMP carries  $Q_5 = 66$  cfs and  $Q_{100} = 85$  cfs towards the east (max capacity of system without flooding). In the existing condition, pipe flows of  $Q_5 = 66$  cfs and  $Q_{100} = 85$  cfs are maintained easterly until the manhole intersection with 48" and 60" connections opposite Shawnee Drive. Developed discharges from proposed Living Waters will enter the system just downstream of manhole near the southwest corner of the Hannah Ridge site. There is ample capacity for the Living Waters discharges in the system at this point. An additional capacity of 72 cfs is also available in the pipe system downstream of the manhole. Also, an additional 100 cfs is available downstream of the Shawnee Drive Manhole.

The existing 60" RCP discharges into the open ditch located along the north side of Constitution Avenue approximately 650 west of Hannah Ridge Drive at the southeast corner of Bas A7 (discussed below) where the Tributary 6 drainageway changes course from south to east. Flows in the pipe are  $Q_5 = 87$  cfs and  $Q_{100} = 126$  cfs. The combined flows at the confluence at this point are  $Q_{10} = 393$  cfs and  $Q_{100} = 831$  cfs.

The northeast portion of Basin OSF1, containing residential and open areas drains to the trellis opening and into the site. Flows from Allens Park Drive are discharged from a storm drain outfall just west of the trellis opening and additional overland flows from Basin OSF1, OSF2 and OSF3 join the outfall. Considering the development of Living Waters and the flows that will be directed into the pipe system, the calculated discharges at the trellis opening are  $Q_5 = 19$  cfs and  $Q_{100} = 41$  cfs. Flows remaining in Constitution Avenue, flowing east, are  $Q_5 = 39$  cfs and  $Q_{100} = 121$  cfs. It appears that the existing condition of Constitution Avenue, with these calculated flows do not meet either 5-year or 100-year street drainage criteria. The allowable street flows on the north side of Constitution Avenue are  $Q_5 = 14$  cfs and  $Q_{100} = 37$  cfs (64 cfs and 108 cfs actual) and the allowable street flows on the south side of Constitution Avenue are  $Q_5 = 14$  cfs and  $Q_{100} = 38$  cfs (0 cfs and 65 cfs actual). This is an existing off-site condition. The development of Hannah Ridge does not contribute to or exacerbate this condition. These flows remain in Constitution Avenue and continue to flow east to the Constitution Avenue Culvert at Akers Drive. Calculations and exhibits for the western off-site basin flows and main trunk storm drain are contained in the Hannah Ridge MDDP and Hannah Ridge Preliminary Drainage Report, referenced above. These flows continue easterly and join the previously mentioned runoff flowing from the north in existing Basins A7 and A9.

Storm Runoff from Basins A7 & A9 drain overland southeasterly towards Constitution Avenue and flow in the existing earthen channel along the north side of Constitution Avenue to the existing double 12'x6' Concrete Box Culvert (CBC). Existing Basin A7 (30.2 acres) produces runoff quantities of  $Q_5 = 19$  cfs and  $Q_{100} = 45$  cfs while Basin A9 (33.6 acres) produces  $Q_5 = 20$  cfs and  $Q_{100} = 47$  cfs. Basin A16, on the east side of Akers Drive, drains south to Constitution Avenue and then westerly along Constitution Avenue to enter the double 12'x6' CBC. Runoff from existing Basin A16 (18.0 acres) has peak rates of  $Q_5 = 12$  cfs and  $Q_{100} = 26$  cfs.

Hannah Ridge at Feathergrass Filing No. 3 is located within existing sub-basins A7 and A9. The proportional flow rates for only the 8.31 acres that comprise the site are  $Q_5 = 5$  cfs and  $Q_{100} = 12$  cfs. These flows are combined with the total A7 and A9 flows which drain south.

Basin OSA8 (16.2 acres), on the east side of Akers Drive, drains south onto the eastern section of the property with peak discharges of  $Q_5 = 40$  cfs and  $Q_{100} = 78$  cfs. Off-site basins OSA11 and OSA12 contain portions of Constitution Avenue. These basins drain to the existing double 12' x 6' CBC under Constitution Avenue.

The portion of Basins OSA8 and A16 discharges flowing in and being intercepted by the existing 15' and 10' curb inlets on the east side of Akers Drive and 10' inlet on the west side of Akers Drive was calculated in the design drainage memo for Akers Drive prepared by M.V.E., Inc. at the time of Akers Drive construction.<sup>32</sup> The east side of Akers Drive carries flows of  $Q_5 = 9.2$  cfs and  $Q_{100} = 19.2$  cfs.

<sup>32</sup> AKers Drain Memo

trellis

No flow enters at  
Hannah Ridge Drive?



The two existing Akers Drive inlets on the east side of the street capture the entire 9.2 cfs in the 5-year event. The inlets collect 16.1 cfs in the 100-year rainfall event, leaving 3.1 cfs to continue westerly in Constitution Avenue. The discharges flowing south, on the west side of Akers Drive, at the Constitution Avenue intersection are  $Q_5 = 3.6$  cfs and  $Q_{100} = 6.8$  cfs. The existing 10' curb inlet collects 3.3 cfs in the 5-year rainfall event while 0.3 cfs flows by to Constitution Avenue. In the 100-year event, 4.8 cfs is captured and 2.0 cfs flows by. All the by-passed flows travel to the low spot located just east of the double 12'x6' culvert and are collected in sump condition at an existing 5' curb inlet which drains directly into the culvert and flows south.

The **Existing Drainage Map** depicts the existing topographic mapping, drainage basin delineations, drainage patterns, existing streets, drainage facilities, and runoff quantities with a data table including drainage areas and flow rates.

#### 4.2.2 Proposed Hydrologic Conditions

The surrounding off-site drainage basins will continue to drain to the site as in existing conditions. However, where the potential for off-site development exists, flow rates entering the property are adjusted to the developed condition. The 2007 DBPS Amendment takes into account the developed conditions of the entire Tributary 6 basin including the Hannah Ridge site and the drainage basins upstream and downstream of the site. These DBPS flow rates are utilized in this report for the main channel design.

The overall Hannah Ridge at Feathergrass site is divided into several developed drainage basins for analysis and design of the drainage system as indicated on the attached **Developed Drainage Map**. Specific drainage details are discussed according to the planned platting and construction phases. Developed runoff quantities and facilities are presented below.

**Phase 1** – The first 45 residential lots were platted with Hannah Ridge at Feathergrass Filing No. 1. The lots, streets and utilities associated with the previous subdivision filing are now constructed and complete. The eastern portions of Winslow Park and Hunter Jumper Drives, both connecting to Akers Drive were constructed along with the southern section of Equine Court and all of Farrier Court. Storm flows from Basins D1 (2.07 acres), D2 (1.19 acres), D3 (0.26 acres), D4 (2.22 acres), D5 (0.74 acres) and D6 (1.31 acres) all drain to the southwest and deliver flows to Design Point 15 at the corner of Equine Court and Hunter Jumper Drive. Cross pans were constructed at the intersection of Farrier Court and Equine Court and the intersection of Hunter Jumper Drive and Equine Court. Peak flow rates on the north side of Hunter Jumper Drive at Design Point 15 are  $Q_5 = 19.2$  cfs and  $Q_{100} = 38.0$  cfs. The 5 year and 100 year flows are contained within the street at this location in accordance with the County's street flow criteria. Drainage Basin D9 (0.85 acres) drains west on the south side of Hunter Jumper Drive. Developed flows of  $Q_5 = 1.9$  cfs and  $Q_{100} = 3.8$  cfs are contained in the south curb of Hunter Jumper Drive. The area north of Phase 1 was partially graded and drains west to the Tributary on the north side of Winslow Park Drive in accordance with the approved Phase 1 Grading & Erosion Control Plan. No storm drain facilities were constructed as part of Filing No. 1. Permanent water quality facilities were provided for the initial 45 lots by a sand filter basin which was completed as part of Phase 2.

**Phase 2** – Hannah Ridge at Feathergrass Filing No. 2 was platted with 39 residential lots. Both Hunter Jumper Drive and Winslow Park Drive were extended from Filing No. 1 to the west edge of Filing No. 2. Proposed Hannah Ridge Drive was constructed from Constitution Avenue north to Winslow Park Drive. Basin D7 (3.95 acres) contains the east edge of Filing No. 2 from Hunter Jumper Drive to Winslow Park Drive. The basin drains west to Hannah Ridge Drive and then south towards Hunter Jumper Drive with peak discharges of  $Q_5 = 8.9$  cfs and  $Q_{100} = 17.8$  cfs. Storm flows from developed Basins D1-D6, previously mentioned Design Point 15, travels west on the north side of Hunter Jumper Drive to the north east corner of Hannah Ridge Drive and Hunter Jumper Drive at Design Point 16, where they combine with Basin D7 flows. The combined discharges at DP 16 are  $Q_5 = 26.6$  cfs and  $Q_{100} = 52.8$  cfs. A 10' CDOT Type R Inlet collects a portion of the Basin D7 discharges from Hannah Ridge Drive at DP 16. This inlet collects 7.7 cfs during the 5-yr rainfall event and 11.7 cfs during the 100-yr. The remainder continues south in Hannah Ridge Drive to Basin D11. A second inlet at DP16, located on Hunter Jumper Drive, collects a portion of the flows from Basins D1-D6. The 15' inlet collect 12.0 cfs / 16.8 cfs during the 5-yr and 100-yr events,

respectively. The remainder turns south and travels south in Hannah Ridge Drive, joining bypass flows from Basin D7, to a low point in Hannah Ridge Drive (DP 17). Basin D11 (1.30 acres) drains west to Hannah Ridge Drive, joining the bypass flows from DP 16. A 15' sump inlet at the low point of DP 17 collects all the runoff on the east side of Hannah Ridge Drive for the 5-yr and 100-yr rainfall events. Basin D11 contains a permanent Sand Filter Water Quality Basin, treating runoff from Filing No. 1 and Filing No. 2.

Phase 2 included the recently constructed double 10'w x 6'h Concrete Box Culvert (CBC) under Hannah Ridge Drive, located at the tributary channel on the north sided of Constitution Avenue. The Phase 2 storm drain system conveys the flows from inlets to the CBC at (DP 28). The ultimate developed flow rates of the main drainageway at DP 28 is  $Q_5 = 428$  cfs and  $Q_{100} = 991$  cfs. The Hannah Ridge Drive CBC transitions to the existing drainage way channel upstream and downstream of the box. The channel improvements to the drainageway itself will be accomplished in later commercial phases of the Hannah Ridge development.

Drainage Basin D8 (3.06 acres) drains east to Hannah Ridge Drive and then south to Hunter Jumper Drive with peak discharges of  $Q_5 = 6.8$  cfs and  $Q_{100} = 13.4$  cfs. These flows continue south in Hannah Ridge Drive to the low point at DP 18. Basin D10 (0.37), located on the south side of Hunter Jumper Drive, drains east to Hannah Ridge Drive and then south in Hannah Ridge to the low point at DP18, joining flows from Basin D8. The combined peak discharges at DP 18 are  $Q_5 = 8.7$  cfs and  $Q_{100} = 18.1$  cfs. A 10' sump inlet collects all the flows from the 5-yr and 100-yr rainfall events and the storm drain system conveys the flows to the existing Hannah Ridge Drive CBC constructed with Phase 2.

Basin B7, in Winslow Park Drive, accepts flows from the east end of the street which was constructed in Filing No. 1 and located in Basin B5. The ultimate developed condition will contribute developed flows to Winslow Park Drive from the north. However, in the interim condition, the undeveloped area to the north drains west towards the tributary drainageway north of the street, but does not enter Winslow Park Drive in accordance with the approved Phase 2 Grading & Erosion Control Plan. The combined flows of B5 and B7 flow west in the street to a 15' Type R inlet located just west of Hannah Ridge Drive. This inlet collects 8.4 cfs during the 5-yr rainfall event and 14.1 cfs during the 100-yr event. The remaining flows continue west in Winslow Park Drive to DP 7. An 18" RC Pipe conveys the captured flows west. A 15' Type R Sump Inlet will be constructed on the north side of the street during Phase 3. Collected runoff is directed to a new 90" RCP storm drain flowing south through existing Tract F being constructed with the Phase 3 improvements. Permanent water quality treatment for stormwater generated by these sub-basins is being constructed during Phase 3 on the north side of Winslow Park Drive, opposite the northeast corner of Filing No. 3.

Basin E6 (1.80 acres) is located on the west side of Filing No. 2 and contains proposed Half Chaps Court. The basin drains south to the cul-de-sac bulb where a 5' sump inlet collects all storm discharges of  $Q_5 = 4.5$  cfs and  $Q_{100} = 9.0$  cfs at DP 21. These flows will be piped to the new 90" RCP storm drain pipe to be constructed with Phase 3.

**Phase 3** – The next 39 residential lots will be platted with this Hannah Ridge at Feathergrass Filing No. 3. Both Hunter Jumper Drive and Winslow Park Drive will be extended from Filing No. 2 to the west edge of Filing No. 3. Grand Prix Court and Horsemanship Court will be constructed north to south between Hunter Jumper and Winslow Park Drives. Basin B7 (0.72 acres), in Winslow Park Drive, accepts flows from the east end of the street which was constructed in Filing No. 1 and located in Basin B5. The ultimate developed condition will contribute developed flows to Winslow Park Drive from the north. However, in the interim condition, undeveloped flows are directed to the tributary drainageway, north of the Winslow Park Drive and does not enter the street. The combined flows of B5 and B7 flow east in the street to a new 15' Type R Sump Inlet on the north side of the street (DP 7), located at the east edge of Filing No. 3. A portion of these flows are collected in an existing 15' Type R inlet, constructed with Phase 2. The overflows from this inlet continue west to the new inlet at DP 7. The collected runoff is directed to a new 90" RCP storm drain flowing south through existing Tract F which will be constructed with the Phase 3. The ultimate peak discharge at DP 7, including future developed discharges from the north side of Winslow Park Drive is  $Q_5 = 20.4$  cfs and  $Q_{100} = 40.1$  cfs. The inlet collects the total remaining flows of 10.5 cfs during the 5-yr rainfall

where is WQCV?

west?

event and 26.0 cfs during the 100-yr event. Permanent water quality treatment for stormwater generated by these sub-basins (DP 7) is being constructed during Phase 3 on the north side of Winslow Park Drive, opposite the northeast corner of Filing No. 3. Basin B8 (0.14 acres), located on the south side of Winslow Park Drive, drains east to Basin E6 at existing Half Chaps Court with developed peak discharges of  $Q_5 = 0.5$  cfs and  $Q_{100} = 1.0$  cfs. A curb opening on the south side of the street will allow the water quality capture volume to enter Tract F and flow to a permanent water quality treatment area on the north edge of Hunter Jumper Drive. This same facility will also treat runoff from Basin E-7. The remaining Basin B8 flows then travel south on the west side of Half Chaps Court to the cul-de-sac bulb where the existing 5' sump inlet constructed in Phase 2 will collect the total storm discharges of  $Q_5 = 4.5$  cfs and  $Q_{100} = 9.0$  cfs at DP 21. These flows will be piped to the new 90" RCP storm drain pipe to be constructed with Phase 3 in an extended 18" RC Pipe. The previously mentioned 90" RC Pipe will collect all the flows of the Tributary 6 on the north side of Winslow Park Drive (DP 14). The ultimate peak discharge entering the pipe are  $Q_5 = 360$  cfs and  $Q_{100} = 640$  cfs. These flows continue south in the pipe and are joined by other previously mentioned flows from DP 7 and DP 21.

Basin E2 (2.80 acres) contains the west edge of Filing No. 3 from Hunter Jumper Drive to Winslow Park Drive. The basin drains east to Grand Prix Court and then south towards Hunter Jumper Drive with peak discharges of  $Q_5 = 6.7$  cfs and  $Q_{100} = 13.3$  cfs. The flows travel east, across Grand Prix Court to join additional flows in Basin E3. Basin E3 (0.97 acres), located on the east side of Grand Prix Court, drains south to Hunter Jumper Drive. The basin generates runoff discharges of  $Q_5 = 2.5$  cfs and  $Q_{100} = 5.0$  cfs. These flows join the Basin E2 flows from the west. In the interim condition, undeveloped discharges from the west sheet flows into the rear of the lots along Grand Prix Court and will drain to the southeast. These flows approximate the small discharges (one-half of the adjacent walk-out lots) that will drain into the rear of these same lots in the ultimate condition. Combined discharges from Basins E1, E2 and E3 at DP 19 has peak discharges of  $Q_5 = 11.9$  cfs and  $Q_{100} = 23.7$  cfs in the ultimate condition. A portion of these flows will be collected in a new 15' Type R Inlet at the northeast corner of Grand Prix Court and Hunter Jumper Drive (DP 19). This inlet collects 8.4 cfs during the 5-yr rainfall event and 11.9 cfs during the 100-yr. A proposed 24"/30" RC Pipe will convey these flows to the east and connect to the proposed 90" RC pipe. The remainder continues east in Hunter Jumper Drive to Basin E4. Proposed Basin E4 (2.74 acres) contains the lots west of Horsemanship Court. This basin drains east to the street and then south to Hunter Jumper Drive with developed peak discharges of  $Q_5 = 6.7$  cfs and  $Q_{100} = 13.3$  cfs. The flows travel east, across Horsemanship Court to join additional flows in Basin E5. Basin E5 (0.90 acres) is located on the east side of Horsemanship Court. The basin drains south to the Hunter Jumper Drive with peak discharges of  $Q_5 = 2.3$  cfs and  $Q_{100} = 4.7$  cfs. These flows join the flows from Basins E1, E2, E3, and E4 and continue east to Basin E7. The combined discharges of Basins E1, E2, E3, E4, E5, E7 at DP 20 are  $Q_5 = 23.4$  cfs and  $Q_{100} = 48.4$  cfs. All of the remaining (not collected by the inlet at DP19) 5 year flows of 15 cfs and the majority of 100 year flows of 36.5 cfs are collected in a proposed 15' sump inlet on the north side of Hunter Jumper Drive. A small amount of the 100 year flows cross to the south side of the street and are collected in another inlet. The collected flows are conveyed in a new 30' RC Pipe to the new 90" RCP storm drain pipe in Base E7. Basin E7 (2.33 acres) is located along the east side of Filing No. 3 and contains rear lots along proposed Horsemanship Court and existing Tract F. Tract F is an Open Space and Drainage tract which will contain the proposed 90" pipe and a permanent Sand Filter Basin, located just north of Hunter Jumper Drive. The basin drains south in Tract F with peak discharges of  $Q_5 = 3.3$  cfs and  $Q_{100} = 8.1$  cfs which enter the proposed Sand Filter Basin and then are collected in a proposed Type C inlet connecting to the new 30" RCP storm drain system in Hunter Jumper Drive. Basin E8 (0.65 acres) contains the south side of Hunter Jumper Drive. The basin drains east to a low point near Basin E7 with peak discharges of  $Q_5 = 1.8$  cfs and  $Q_{100} = 3.6$  cfs. A proposed sump 5' Type R inlet will collect the flows which are conveyed to the 30" RC Pipe in Hunter Jumper Drive and then to the proposed 90" RC Pipe.

The 2-year flows in the Hunter Jumper Drive storm drain system are extracted by a separate pipe and directed to the new Sand Filter Basin on the south side of the street in Tract BB. Any overflows in the sand filter basin are collected in an outlet box and redirected back to the 90" RC pipe. The 90" RC Pipe continues south towards the Constitution Avenue drainage ditch and will terminate at a



concrete headwall with wingwalls. The existing 60" RC Pipe located along the north side of Constitution Avenue will be extended in order to connect to the same headwall. The combined main channel flows travel east to the existing Hannah Ridge Drive double box culvert and on to the east as described above.

**Phases 4 through 8** – The detailed drainage information for Phases 4-8 residential development will be provided with updated drainage reports as they are plated.

(The latest template can be provided if needed.)

#### 4.2.3 Drainage Facilities

Proposed drainage improvements include standard CDOT Type R curb inlets, RCP storm drain pipe with minimum diameter of 18 inches, standard CDOT storm drain manholes and water quality sand filter basins. The water quality capture volume is conveyed into the sand filter basins by an RC pipeline from either the final curb inlet box or the nearest storm drain manhole. The flow out of the inlet box or manhole to the sand filter basin is limited to the flow equivalent to the 80<sup>th</sup> percentile storm or approximately one-half of the 2-year rainfall event, by the installation of a flow restrictor plate in the box. All flows greater than the WQCV will continue in the storm drain system to the main tributary channel outfall.

The sand filter basins require periodic maintenance to insure proper function. Each sand filter basin will be maintained by the Hannah Ridge Homeowners Association in accordance with the Operation and Maintenance (O & M) Manual for the sand filter basins provided for this project. Each sand filter basin is adjacent to public right-of-way, which facilitate access. Each sand filter basin is located within an easement created with the standard El Paso County Detention Basin Maintenance Agreements which is being executed with this subdivision.

Access to the storm drain system is provided by the public right-of-way and drainage easements. The storm drain system, including the 90 inch main line, all have storm drain manhole and storm inlet manholes access. All of Tract E and Tract F are being provided for Storm Drain easements. Furthermore, the Final Plat of Hannah Ridge at Feathergrass Filing No. 1 provides the necessary Drainage Easement for the main drainageway pipeline and channel downstream of Hunter Jumper Drive.

Drainage Criteria Manual Volume 2 (DCM v2) requires the consideration of a "Four Step Process to Minimize Adverse Impacts of Urbanization" for receiving waters that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long term source controls".<sup>33</sup> Elements of the Four Step Process is incorporated in the project and the elements are discussed below.

- 1) Several Runoff Reduction Practices are being employed in the project. On each residential lot, runoff from much of the impervious roof area will be routed to the pervious areas of lawn and landscaping before entering the streets to drain to the storm drain system. Tract F, adjacent to the east side of the site, provides a Grass Buffer area where flows from a portion of Winslow Park Drive and the rear lots that abut the tract will drain. All these are factors constitute a degree of Minimized Directly Connected Impervious Area (MDCIA). Tract F also provides an overflow pathway for flows that exceed the 100-year storm in the main drainageway.
- 2) The project is being constructed with permanent BMP's providing Water Quality Capture Volume with slow release. Three sand filter basins will provide treatment of the WQCV for the subdivision. The sand filter basins are positioned to capture the WQCV from the lots and streets.
- 3) The drainage paths on the site are being stabilized with the development. The main tributary drainageway on the site is a constructed channel, the pathway of which has been modified several times over the the last 50 years by artificial and natural means. The portion of the constructed channel traversing north-south through Hannah Ridge at Feathergrass Filing No. 3 is being replaced by a 90 inch RC pipe system, beneath a shallow grassed swale. The pipe systems will discharge to the constructed channel located on the north side of Constitution Avenue. The channel downstream

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of the pipe outfall will be stabilized with rip rap lining. There are no other drainageways on the site and no additional stabilization measures are warranted.

4) The site contains no outdoor storage areas or storage of potentially harmful substances. No permanent Site Specific or Other Source Control BMP's are required. A Grading and Erosion Control Plan for the construction of the site has been prepared in accordance with the provisions of Drainage Criteria Manual Volume 2. The measures specified in the plan and ESQCP will be implemented to control erosion during the construction process.

#### **4.3 Downstream Facilities**

The existing 42"/60" RC pipe system along the north side of Constitution Avenue will be utilized for the connection of some of the proposed storm drain system in the multi-family Tracts AA and BB, which will undergo development in the future. Those tracts will have their own storm detention and water quality facilities. The hydraulic grade line will be maintained in a safe level as the County designed said system to capture developed flows from these areas as requested by the property owner.

The existing earthen channel along the north side of Constitution is adequate to carry existing and developed discharges to the existing culvert crossing of Constitution Avenue with a capacity of 2,316 cfs. The capacity of the existing double 12'x6' CBC at Constitution Avenue is adequate to carry the developed discharges from the site. The culvert has a capacity of 1,234 cfs with headwater up to the top of the concrete head wall. The calculated discharge at the culvert entrance is  $Q_{10} = 457$  cfs and  $Q_{100} = 1076$  cfs.

The existing drainage way downstream of Constitution Avenue was examined, considering three development conditions: Hannah Ridge Pre-Development with current upstream basin development, Hannah Ridge Phases 1 – 4 only and total Hannah Ridge build-out. The downstream drainage way consists of three distinct reaches from Constitution Avenue to the Confluence with the East Fork of Sand Creek. The channel downstream of Constitution (DP 8) to a point near the hypothetical extension of Palmer Park Boulevard (DP 6) is deep and narrow with steep side slopes. The channel from DP 6 to a future extension of River Walk Parkway (DP 7) contains a wide ponding area and sediment basin. Storm flows pass through the reach if the ponding area is filled. The downstream analysis considered no detention effects due to this reach. From DP 7 to the confluence with East Fork Sand Creek (DP 8a), the existing drainage way is wide and shallow with a less well defined flow path. This reach is an undeveloped open area and the existing characteristically wide flow path poses no dangers to structures or development. Discharge quantities were determined by modification of the Amended DBPS HEC-1 runs to reflect existing conditions with no Hannah Ridge development, development of only Phases 1 - 4 of Hannah Ridge, and Hannah Ridge fully developed. Hydrologic analyses for the downstream section is presented in the Appendix and the maps from the DBPS amendment, marked up with the existing flows are included in the map pocket.



Downstream Drainage Way Discharges						
Location	Hannah Ridge Pre - Development		Hannah Ridge Phases 1 – 4 Only		Hannah Ridge Phases 1 – 8 (Total)	
	Q10/Q100 (cfs)	Q10/Q100 (cfs)	Q10/Q100 (cfs)	Q10/Q100 (cfs)	Q10/Q100 (cfs)	Q10/Q100 (cfs)
(8) Constitution Ave	392	856	395	876	453	1041
(6) Extension of Palmer Park Blvd	410	1004	415	1030	577	1261
(7) Extension of River Walk Pkwy	429	1151	449	1180	629	1433
(8a) Confl. w/ E. Fork Sand Creek	609	1497	588	1523	826	1869

A basic hydraulic analysis was performed on the downstream reach to determine the adequacy of the existing drainage way in the existing condition and with Hannah Ridge development. Channel cross sections were taken with the use of recent existing topographic mapping obtained from Merrick & Co. as used in their design of the proposed Wilshire Channel. Results indicate that the downstream drainage way is adequate to deliver the existing and Hannah Ridge developed flow safely to East fork Sand Creek. The Hannah Ridge development will present no adverse effects on the existing downstream reach as the effects on the hydraulic properties are minimal and the existing drainage way is adequate to pass the developed flows. The construction of Phase 1, by itself, creates negligible downstream impacts. Calculations are attached in the Appendix of this report. Any mitigation for potential erosion and water quality effects of the Hannah Ridge will be addressed in the Final Plat and Final Drainage Report stage of the various phases of Hannah Ridge.

The proposed downstream Wilshire channel (by others) will have a capacity of at least 1,380 cfs, well above the calculated discharge of Q100 = 1076 cfs at the downstream end of the project. The downstream drainage system appears to have adequate capacity to carry the flows from the proposed project. The flows from the proposed project will be less than those planned for in the original DBPS due the change from Industrial to residential and commercial development and also due to the accounting for the natural detention provided on the upstream side of the railway embankment.

If the required upstream drainage/ponding easement has not been obtained, this needs to be done to protect the ponding area.

**5 Opinion of Probable Cost for Drainage Facilities**

The concrete box culverts and large diameter RC Pipe conveyance indicated by the drainage plan for the Tributary 6 main drainageway are not planned in the operative DBPS. However, these improvements are a functional substitute for the rip rap channel lining and check structure which are called for in the DBPS. Therefore, the cost of constructed drainage improvements for the Tributary 6 main drainageway are reimbursable up to the cost of the rip rap lining and check structures shown in the DBPS. These costs will generate credits which will be used to pay Drainage Fees due at the time of current and future subdivision platting in the Sand Creek basin.

The costs for the DBPS Authorized Improvements are estimated in the table below:

this subdivision

<b>Hannah Ridge at Feathergrass DBPS Improvements Costs (Reimbursable)</b>				
<b>Item</b>	<b>Quantity</b>	<b>Unit</b>	<b>Unit Cost</b>	<b>Cost</b>
Rip Rap Channel (20' BW, 4' H) L= 1350' (DBPS Sht. EF-23, EF-25)	6599	CY	\$98	\$646,702
Concrete Check for 20' BW channel Number = 2 (DBPS Sht. EF-23, EF-25)	6	CY	\$312	\$1,872
Rip Rap Channel (15' BW, 2' H) L= 840' (DBPS Sht. EF-23, EF-24)	2520	CY	\$98	\$246,960
Concrete Check for 15' BW channel Number = 1 (DBPS Sht. EF-24)	3	CY	\$312	\$936
Rip Rap Channel (30' BW, 4' H) L= 2430' (DBPS Sht. EF-21, EF-23)	14460	CY	\$98	\$1,417,080
Concrete Check for 30' BW channel Number = 3 (DBPS Sht. 21, 23)	12	CY	\$312	\$3,744
Rip Rap Channel (10' BW, 2' H) L= 660' (DBPS Sht. EF-22)	1613	CY	\$98	\$158,074
Concrete Check for 10' BW channel Number = 2 (DBPS Sht. EF-22)	4	CY	\$312	\$1,248
<b>GRAND TOTAL</b>				<b>\$2,476,616</b>

As a component of the Tributary 6 main drainageway improvements, the proposed 90" storm drain system with associated end treatments is eligible to generate Drainage Credits up to the amount of improvements indicated in the DBPS. Costs for reimbursable drainage improvement items in Hannah Ridge Filing No. 3 are listed in the table below:

<b>Hannah Ridge at Feathergrass Filing 3 Drainage Improvement Costs (Reimbursable)</b>				
<b>Item</b>	<b>Quantity</b>	<b>Unit</b>	<b>Unit Cost</b>	<b>Cost</b>
Concrete Box Culvert (10x6)	59	LF	\$480.00	\$28,320
90" Reinforced Concrete Pipe	1000	LF	\$383.00	\$383,000
60' Reinforced Concrete Pipe	360	LF	\$216.00	\$77,760
End Treatment- Headwall	1	EA	\$3,185.00	\$3,185

End Treatment- Wingwall	4	EA	\$2,740.00	\$10,960
End Treatment - Cutoff Wall	1	EA	\$300.00	\$300
Rip Rap Channel, d50 Size 6"- 24"	882	CY	\$98.00	\$86,436
<b>GRAND TOTAL</b>				<b>\$589,961</b>

Costs for the non-reimbursable drainage improvements for Hannah Ridge Filing No. 3 are listed in the table below:

<b>Hannah Ridge at Feathergrass Filing 3 Drainage Costs (Non-Reimbursable)</b>				
<b>Item</b>	<b>Quantity</b>	<b>Unit</b>	<b>Unit Cost</b>	<b>Cost</b>
18" Reinforced Concrete Pipe	223	LF	\$69.00	\$15,387
24" Reinforced Concrete Pipe	352	LF	\$84.00	\$29,568
30" Reinforced Concrete Pipe	90	LF	\$94.00	\$8,460
18" HDPE Pipe	122	LF	\$58.00	\$7,076
Flared End Section (FES) HDPE	1	EA	\$205.00	\$205
Curb Inlet (Type R) L=5', Depth<5'	1	EA	\$3,791.00	\$3,791
Curb Inlet (Type R) L =15', Depth<5'	2	EA	\$7,923.00	\$15,846
Curb Inlet (Type R) L =15', 5'-10' Depth	2	EA	\$8,000.00	\$16,000
Grated Inlet (Type C), < 5' deep	2	EA	\$3,270.00	\$6,540
Storm MH, Box Base, Depth < 15 feet	3	EA	\$8,592.00	\$8,592
Perm Water Quality Sand Filter Basin	1	EA	\$18,000.00	\$18,000
Rock Island Culvert resurfacing	1953	SF	\$1.10	\$2,148
Rock Island Culvert Rip Rap Aprons	89	CY	\$98.00	\$8,722
<b>GRAND TOTAL</b>				<b>\$140,335.30</b>

## 6 Drainage and Bridge Fees

The site is located in the Sand Creek Major Drainage Basin. Development in this basin carries Drainage Fees of \$16,270.00 per impervious acre and Bridge Fees of \$4,929.00 per impervious acre. Percent impervious is taken from the values listed in El Paso County Resolution 99-383, and is identical to those used and accepted for Hannah Ridge Ridge at Feathergrass Filings No. 1 and 2. The Drainage and Bridge Fees for the subdivision are calculated below:

### Hannah Ridge at Feathergrass Filing No. 3

#### Drainage Fees:

Drainage Fees = Platted Area x %imperviousness x \$16,270.00

**Drainage Fees = 8.31 Ac x 0.38 x \$16,270.00 = \$51,377.41**

These Drainage Fees will be paid by the Developer in the form of cash or credits which may be available at the time of recording of Hannah Ridge Filing No. 3.

At least 0.53 (per ECM Appendix L). This filing is only lots and streets. (47%-51% per pond calcs.)

#### Bridge Fees:

Bridge Fees = Platted Area x %imperviousness x \$4,929.00

**Bridge Fees = 8.31 Ac x 0.38 x \$4,929.00 = \$15,564.80**

These Bridge Fees will be paid by the Developer at the recording of Hannah Ridge at Feathergrass Filing No. 3.

## 7 Conclusion

This Final Drainage Report presents a drainage concept for the proposed subdivision. The subdivision development will function to route and convey the offsite and onsite storm runoff with the site grading and drainage facilities to be provided as part of the development. The proposed project with associated improvements will not, with respect to stormwater runoff, negatively impact the adjacent properties and downstream drainage facilities.

## References

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# Appendices

## **8 General Maps and Supporting Data**

Vicinity Map

Portions of Flood Insurance Rate Map and LOMR Maps

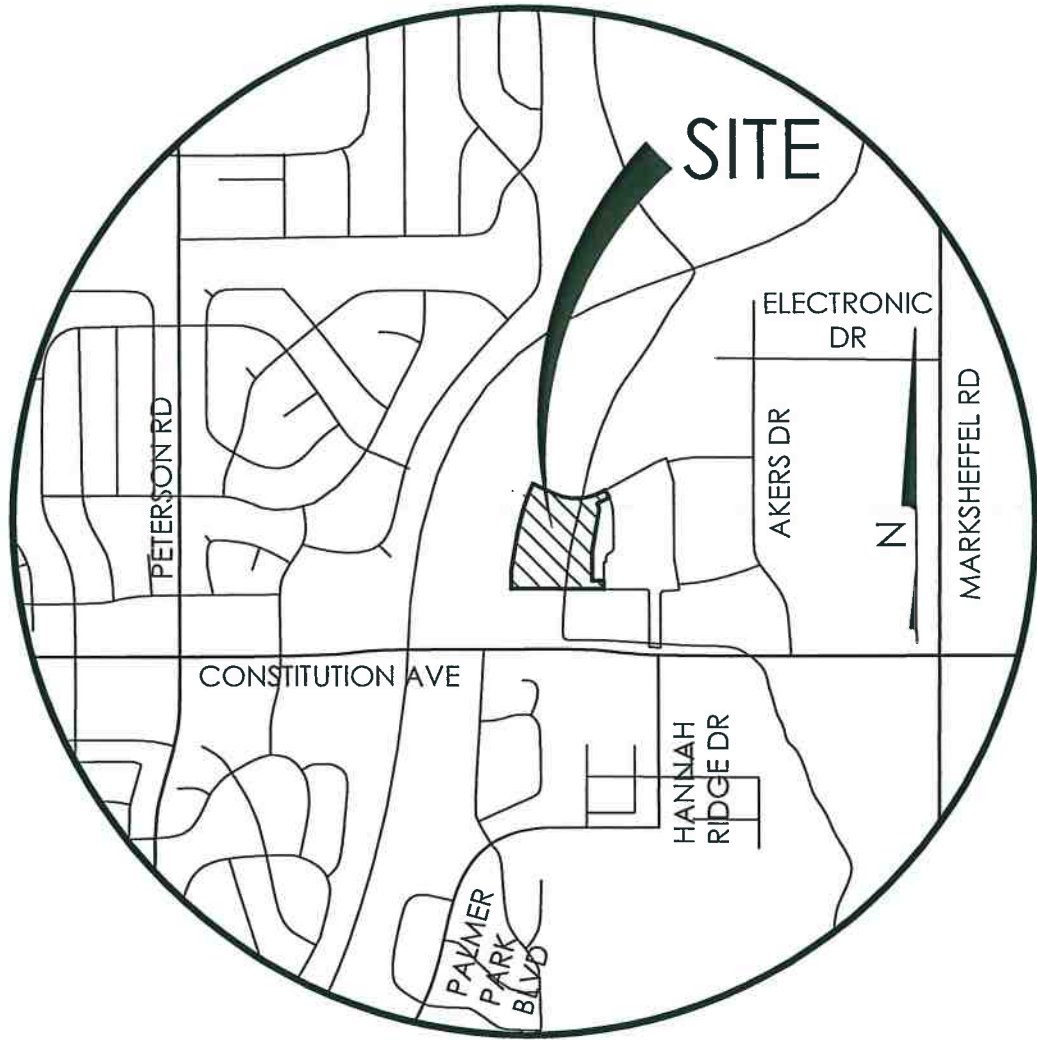
Portion of Drainage Area Identification Study Map

Portion of Exhibit 1 of 1996 Sand Creek Drainage Planning Study

Hydrologic Soil Group Mapping

1996 Sand Creek Drainage Planning Study Preliminary Design Plan

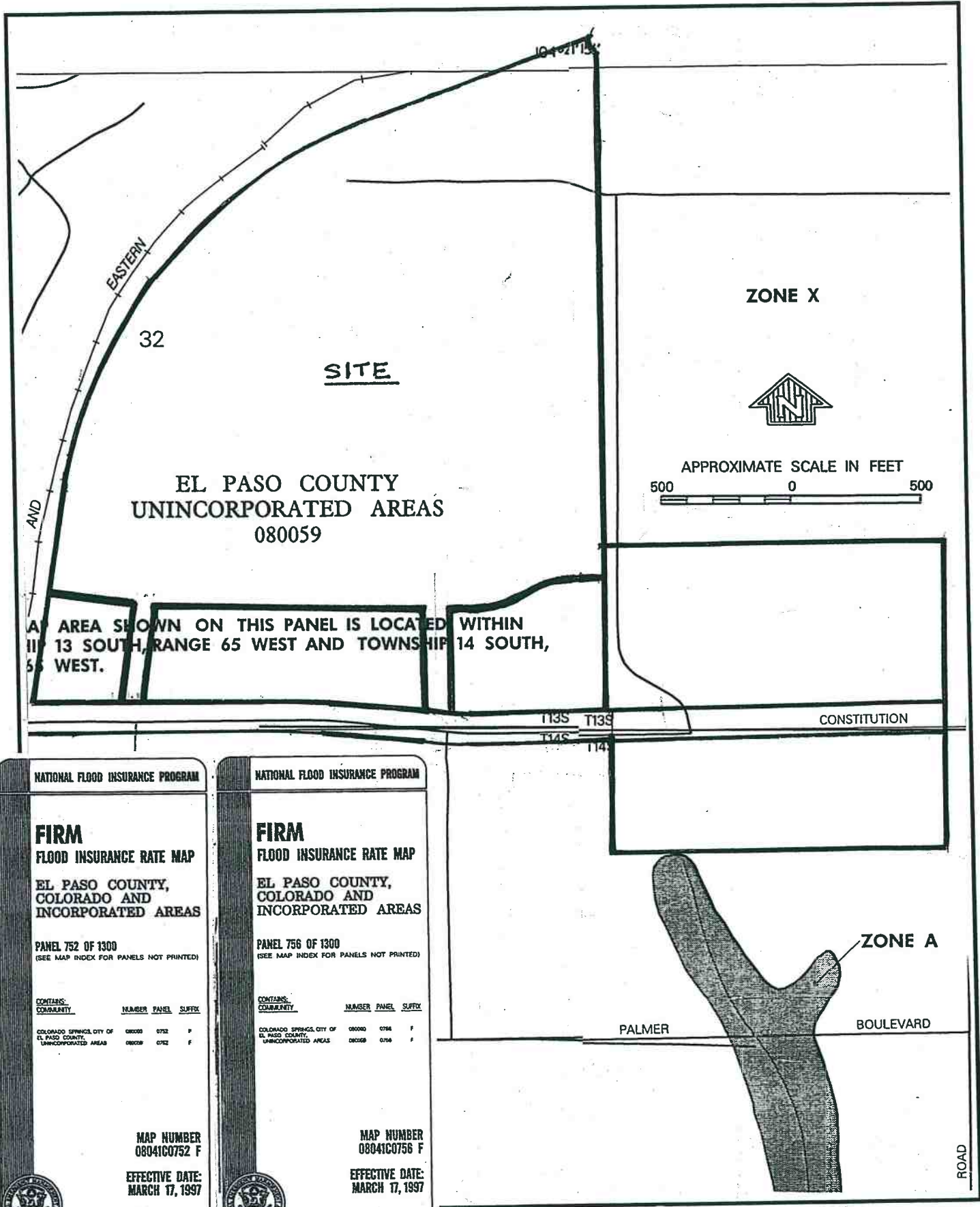




# VICINITY MAP

NTS





NATIONAL FLOOD INSURANCE PROGRAM

**FIRM**  
FLOOD INSURANCE RATE MAP

EL PASO COUNTY,  
COLORADO AND  
INCORPORATED AREAS

PANEL 752 OF 1300  
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:	NUMBER	PANEL	SUFFIX
COMMUNITY			
COLORADO SPRINGS CITY OF EL PASO COUNTY, UNINCORPORATED AREAS	08000	0752	F
	08008	0752	F

MAP NUMBER  
08041C0752 F

EFFECTIVE DATE:  
MARCH 17, 1997



Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

**FIRM**  
FLOOD INSURANCE RATE MAP

EL PASO COUNTY,  
COLORADO AND  
INCORPORATED AREAS

PANEL 756 OF 1300  
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:	NUMBER	PANEL	SUFFIX
COMMUNITY			
COLORADO SPRINGS CITY OF EL PASO COUNTY, UNINCORPORATED AREAS	08000	0756	F
	08008	0756	F

MAP NUMBER  
08041C0756 F

EFFECTIVE DATE:  
MARCH 17, 1997

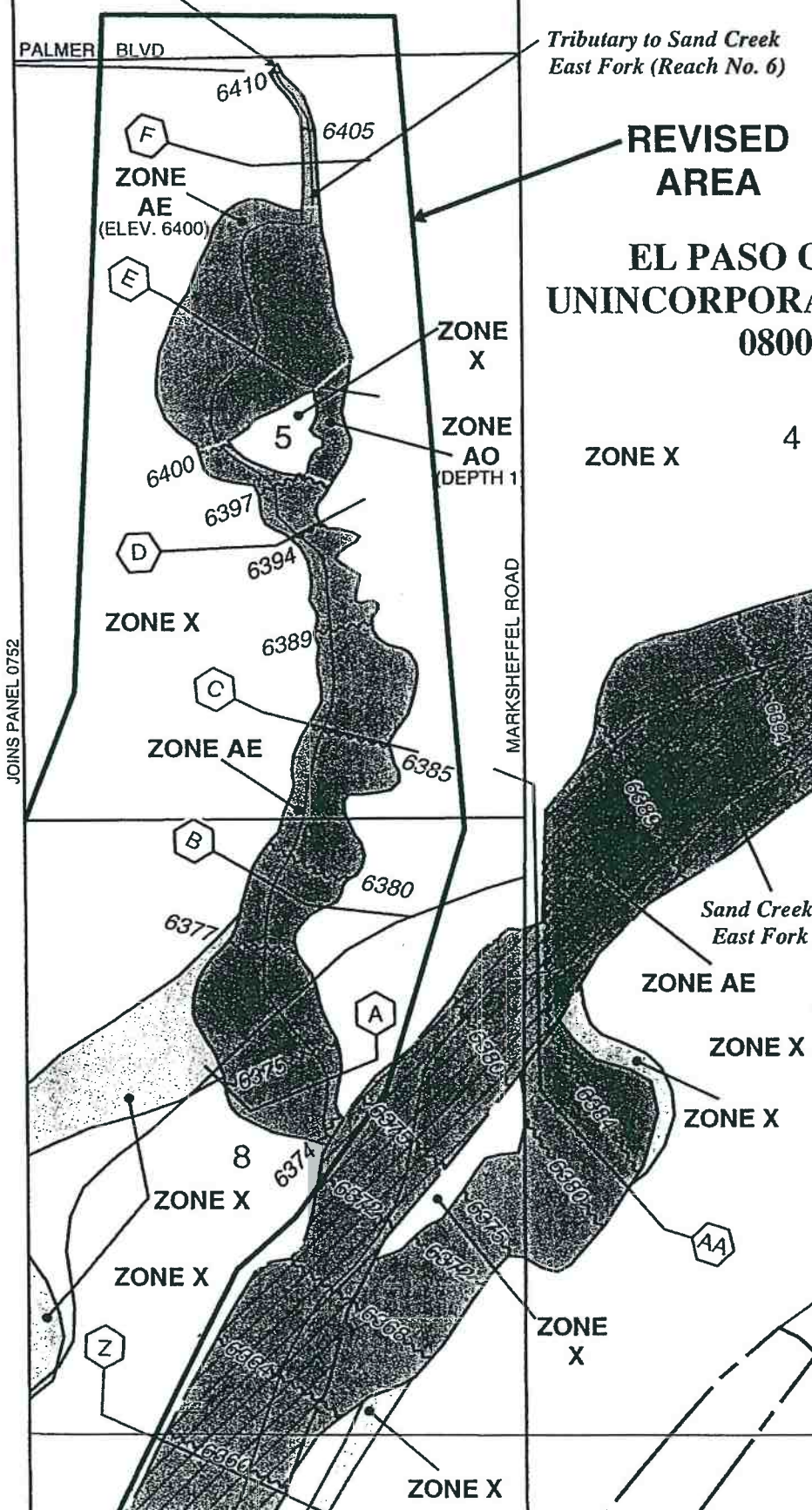


Federal Emergency Management Agency

MARCH 24, 2004 LOMR UPDATED  
ZONE A HAZARD AREA SHOWN ON  
THIS MAP.

SITE IS 1400 FT.  
NORTH, ADJACENT  
TO CONSTITUTION  
AVENUE.

LIMIT OF DETAILED STUDY



Sand Creek East Fork Subtributary

ZONE X

A 6425

6423  
ZONE AE

6418

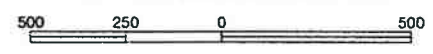
# REVISED AREA

## EL PASO COUNTY UNINCORPORATED AREAS 080059

ZONE X 4



APPROXIMATE SCALE IN FEET



NATIONAL FLOOD INSURANCE PROGRAM

### FIRM FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 756 OF 1300  
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:  
COMMUNITY NUMBER PANEL SUFFIX

EL PASO COUNTY, UNINCORPORATED AREAS 080059 0756 F

**REVISED TO REFLECT LOWWATER DATED MAR 24 2004**

MAP NUMBER 08041C0756 F

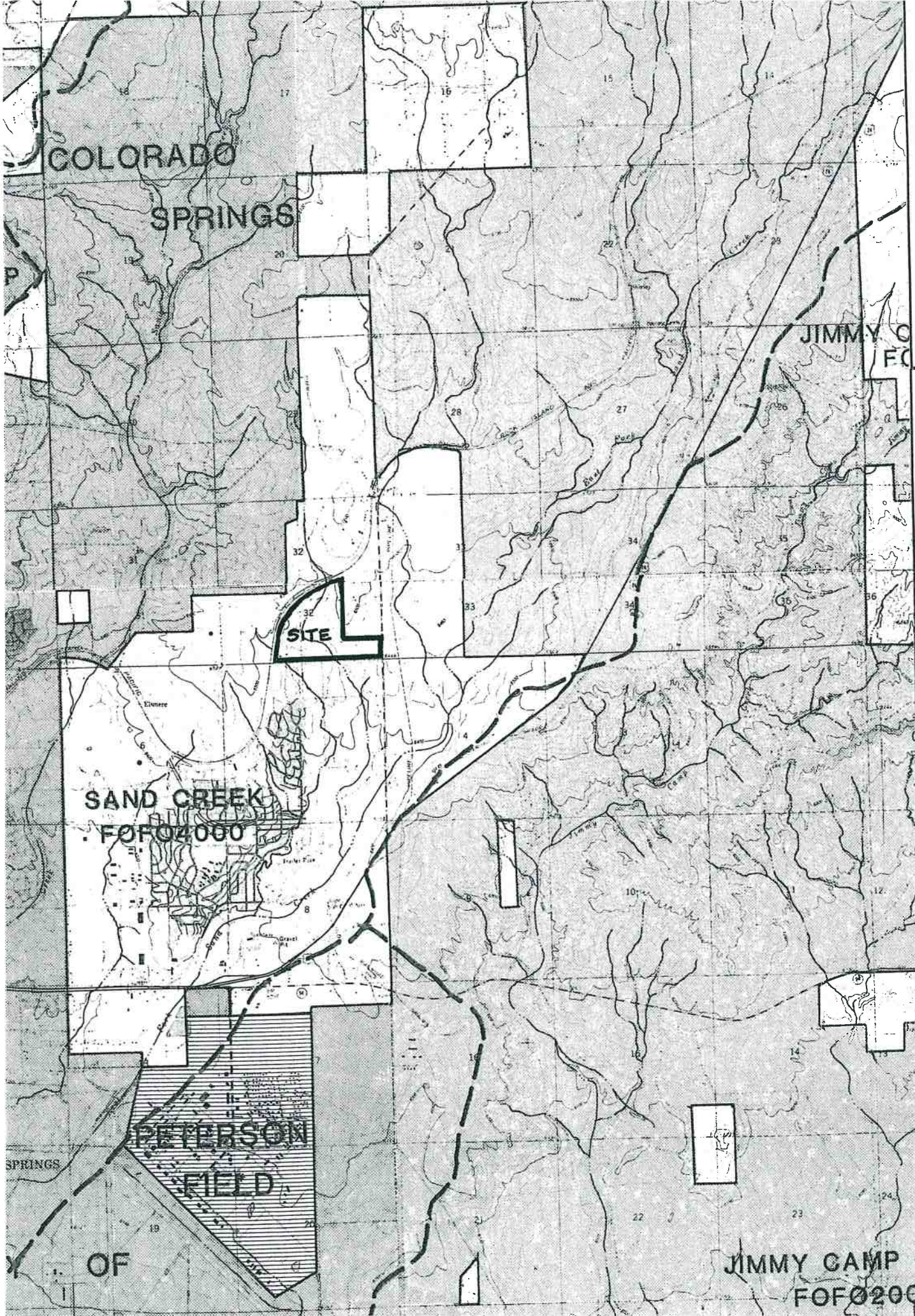
EFFECTIVE DATE: MARCH 17, 1997



Federal Emergency Management Agency

JOINS PANEL 0752





DRAINAGE AREA  
IDENTIFICATION STUDY

EL PASO COUNTY, COLORADO

Department of Transportation  
3170 CENTURY STREET, COLORADO SPRINGS, COLORADO 80907

DESIGNED	JTW	BAD	DATE	4/86
DRAWN	BMG	DATE	4/86	
CHECKED	LAM	DATE	4/86	
REVISED	JTW	DATE	10/88	

MULLER ENGINEERING COMPANY, INC.  
CONSULTING ENGINEERS  
7000 WEST COURTHOUSE AVENUE  
LAKEWOOD, COLORADO 80215  
(303) 232-9340

JIMMY CAMP  
FOF0200



# EXHIBIT I

## Sand Creek Drainage Planning Study

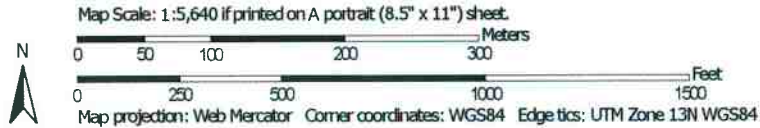




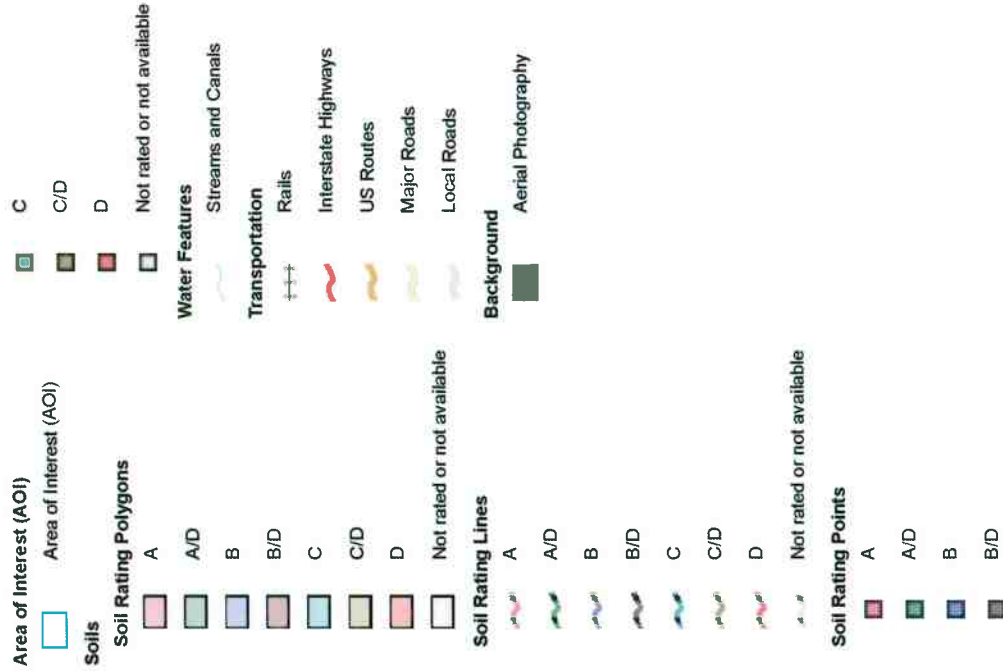
Hydrologic Soil Group—El Paso County Area, Colorado  
(Hannah Ridge at Feathergrass)



Soil Map may not be valid at this scale.



## MAP LEGEND



## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado  
 Survey Area Data: Version 14, Sep 23, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 15, 2011—Jun 17, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.



## Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — El Paso County Area, Colorado (CO625)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
8	Blakeland loamy sand, 1 to 9 percent slopes	A	103.8	100.0%
<b>Totals for Area of Interest</b>			<b>103.8</b>	<b>100.0%</b>

### Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

**Group A.** Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

**Group B.** Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

**Group C.** Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

**Group D.** Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

### Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

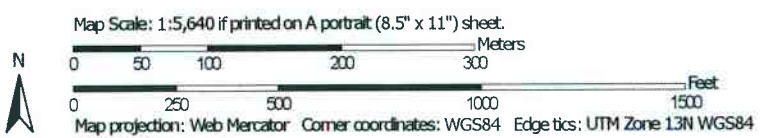
*Tie-break Rule:* Higher



Soil Map—El Paso County Area, Colorado  
(Hannah Ridge at Feathergrass)



Soil Map may not be valid at this scale.



## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

**Warning:** Soil Map may not be valid at this scale.  
Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
Web Soil Survey URL:  
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.



















































Soil Survey Area: El Paso County Area, Colorado  
Survey Area Data: Version 14, Sep 23, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 15, 2011—Jun 17, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## MAP LEGEND

 Area of Interest (AOI)	 Area of Interest (AOI)	 Spoil Area
 Soils	 Soil Map Unit Polygons	 Stony Spot
	 Soil Map Unit Lines	 Very Stony Spot
	 Soil Map Unit Points	 Wet Spot
	<b>Special Point Features</b>	 Other
	 Blowout	 Special Line Features
	 Borrow Pit	<b>Water Features</b>
	 Clay Spot	 Streams and Canals
	 Closed Depression	<b>Transportation</b>
	 Gravel Pit	 Rails
	 Gravelly Spot	 Interstate Highways
	 Landfill	 US Routes
	 Lava Flow	 Major Roads
	 Marsh or swamp	 Local Roads
	 Mine or Quarry	<b>Background</b>
	 Miscellaneous Water	 Aerial Photography
	 Perennial Water	
	 Rock Outcrop	
	 Saline Spot	
	 Sandy Spot	
	Severely Eroded Spot	
	Sinkhole	
	Slide or Slip	
	Sodic Spot	

## Map Unit Legend

El Paso County Area, Colorado (CO625)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
8	Blakeland loamy sand, 1 to 9 percent slopes	103.8	100.0%
<b>Totals for Area of Interest</b>		<b>103.8</b>	<b>100.0%</b>



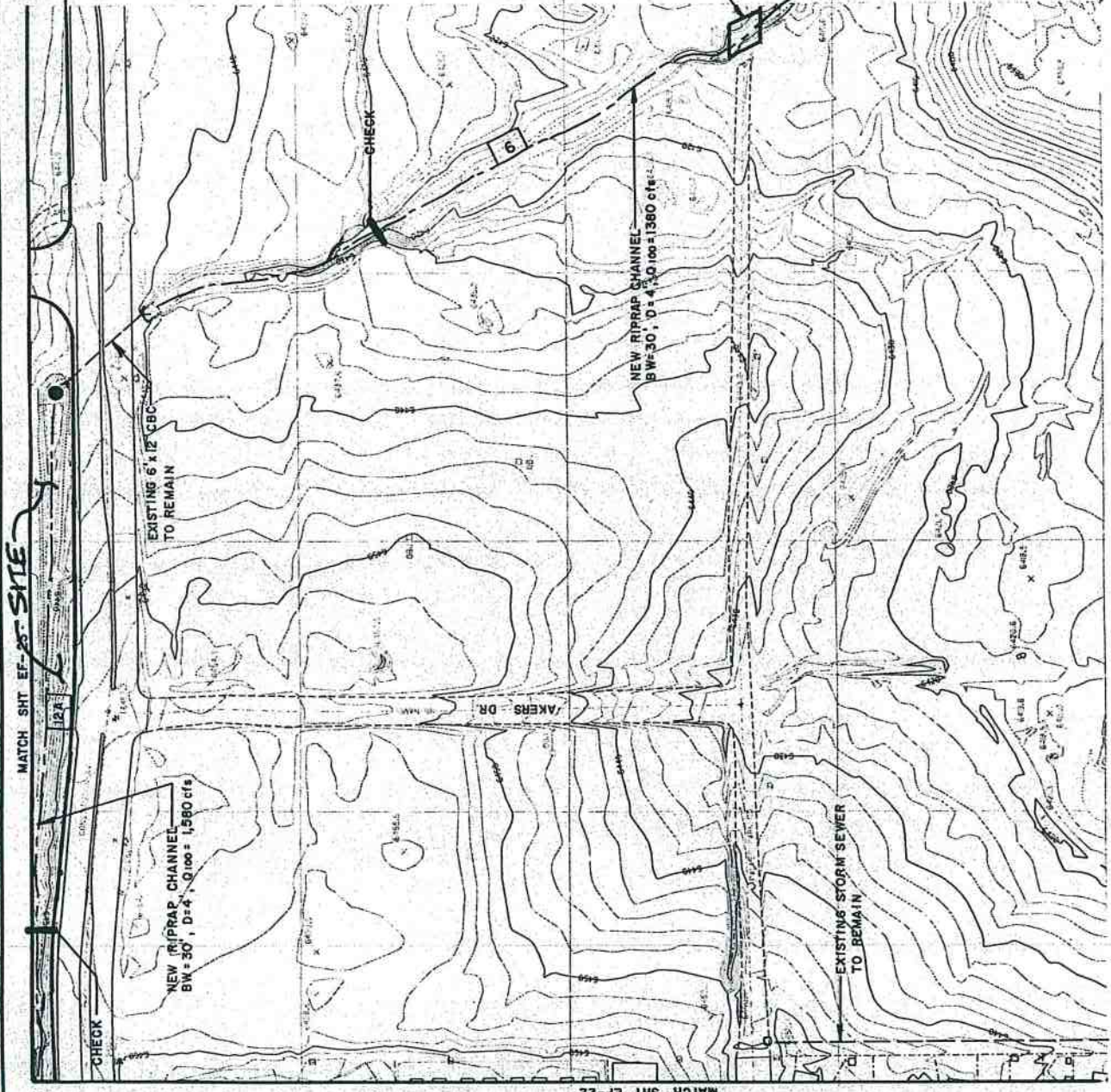
THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES. THESE PLANS ARE SUBJECT TO CHANGE.

Kiowa Engineering Corporation  
 419 W. Bijou Street  
 Colorado Springs, Colorado  
 80905-1308

SAND CREEK DRAINAGE  
 BASIN PLANNING STUDY  
 PRELIMINARY DESIGN PLANS

PROJECT No.	
DRAWING No.	
DATE	
DESIGNED BY	
CHECKED BY	
APPROVED BY	

EF-21



MATCH SHT EF-22

MATCH SHT EF-19



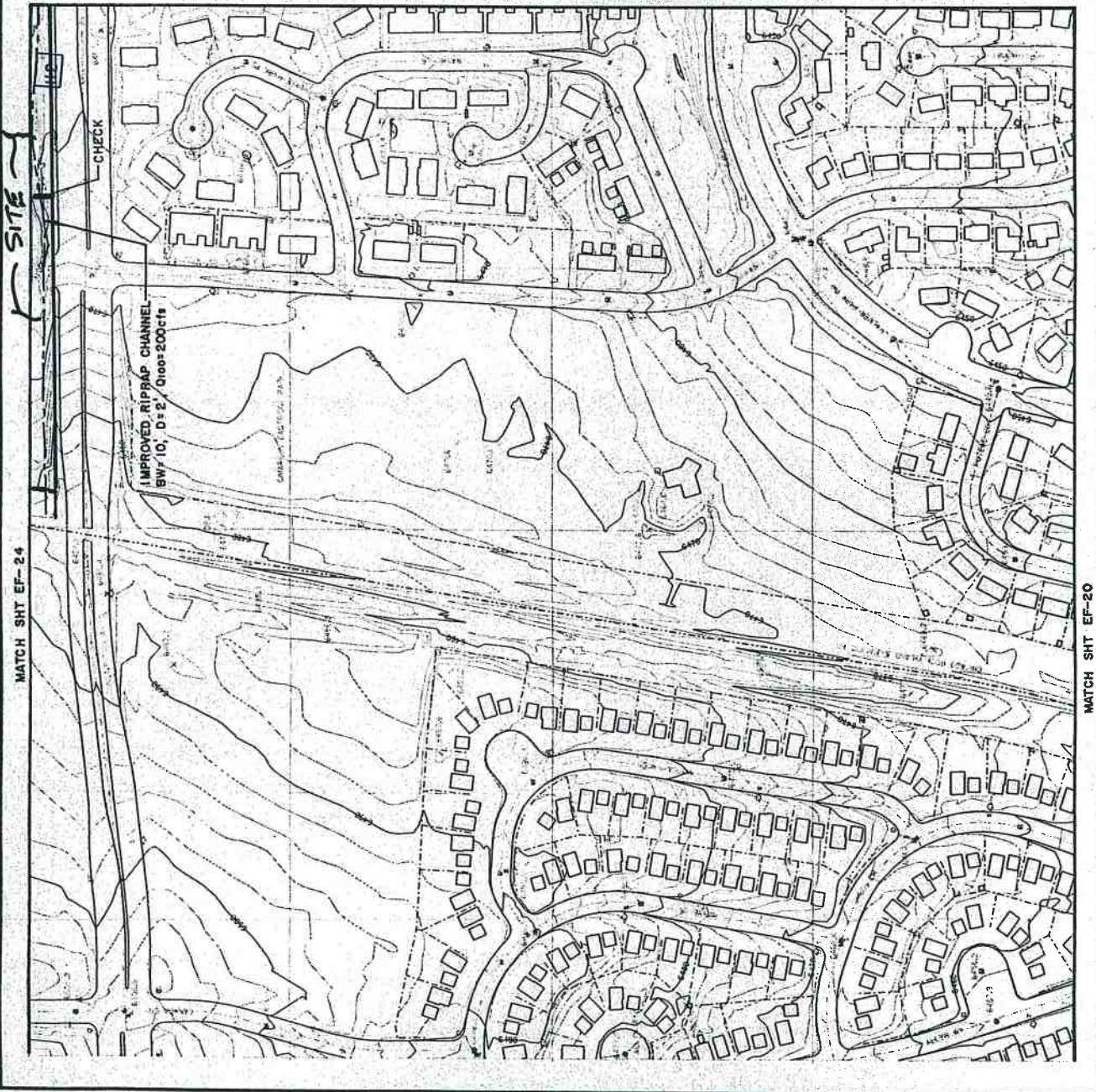
Kiowa Engineering Corporation  
419 W. Bijou Street  
Colorado Springs, Colorado  
80905-1308

SAND CREEK DRAINAGE  
BASIN PLANNING STUDY  
PRELIMINARY DESIGN PLANS

DATE	
BY	
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EF-22

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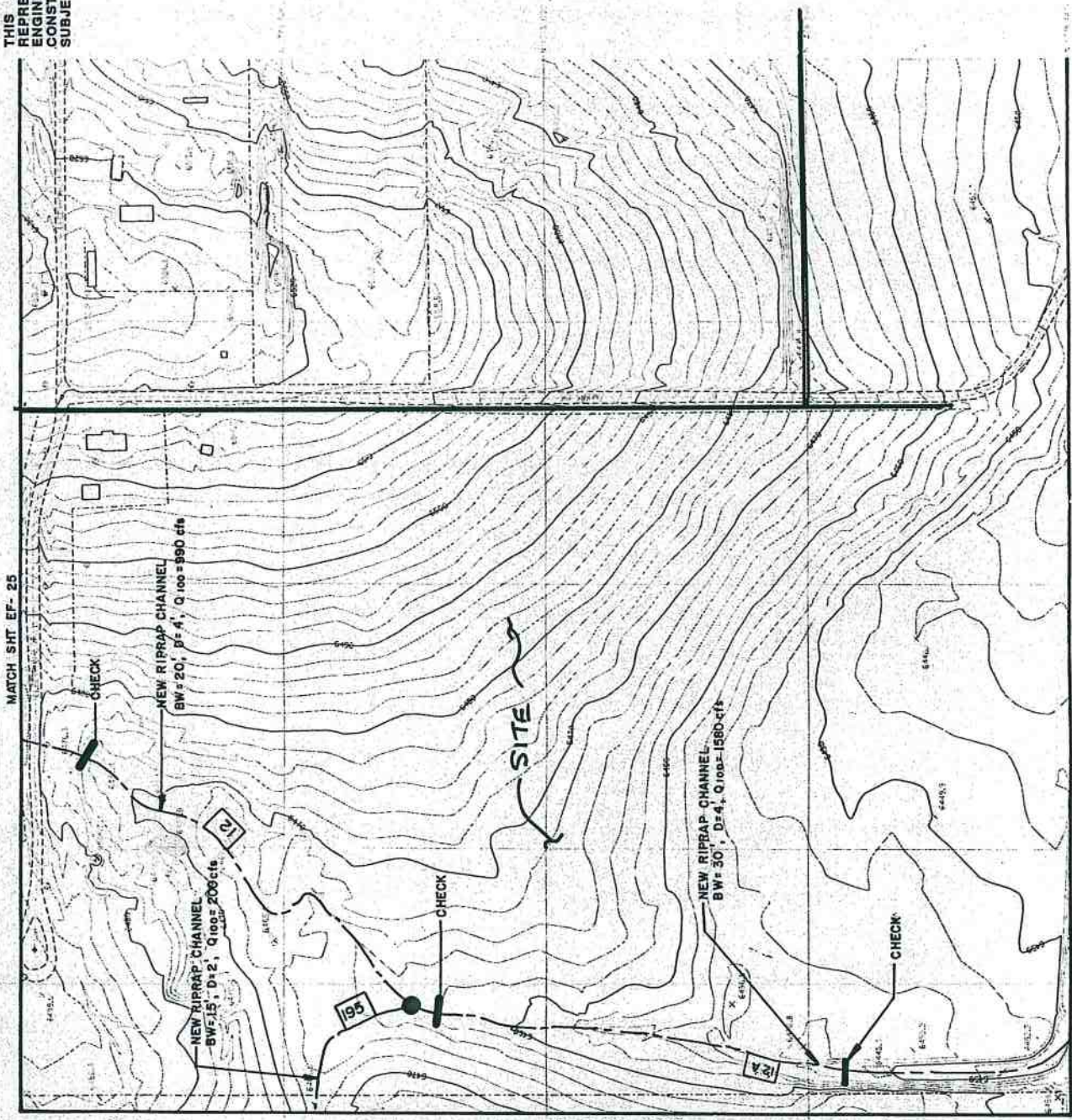
SAND CREEK DRAINAGE  
BASIN PLANNING STUDY  
PRELIMINARY DESIGN PLANS

Kiowa Engineering Corporation  
419 W. Bijou Street  
Colorado Springs, Colorado  
80905-1308

PROJECT NO.	
DATE	
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REVISIONS	

EF-23

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MATCH SHT EF-25

MATCH SHT EF-21

MATCH SHT EF-24



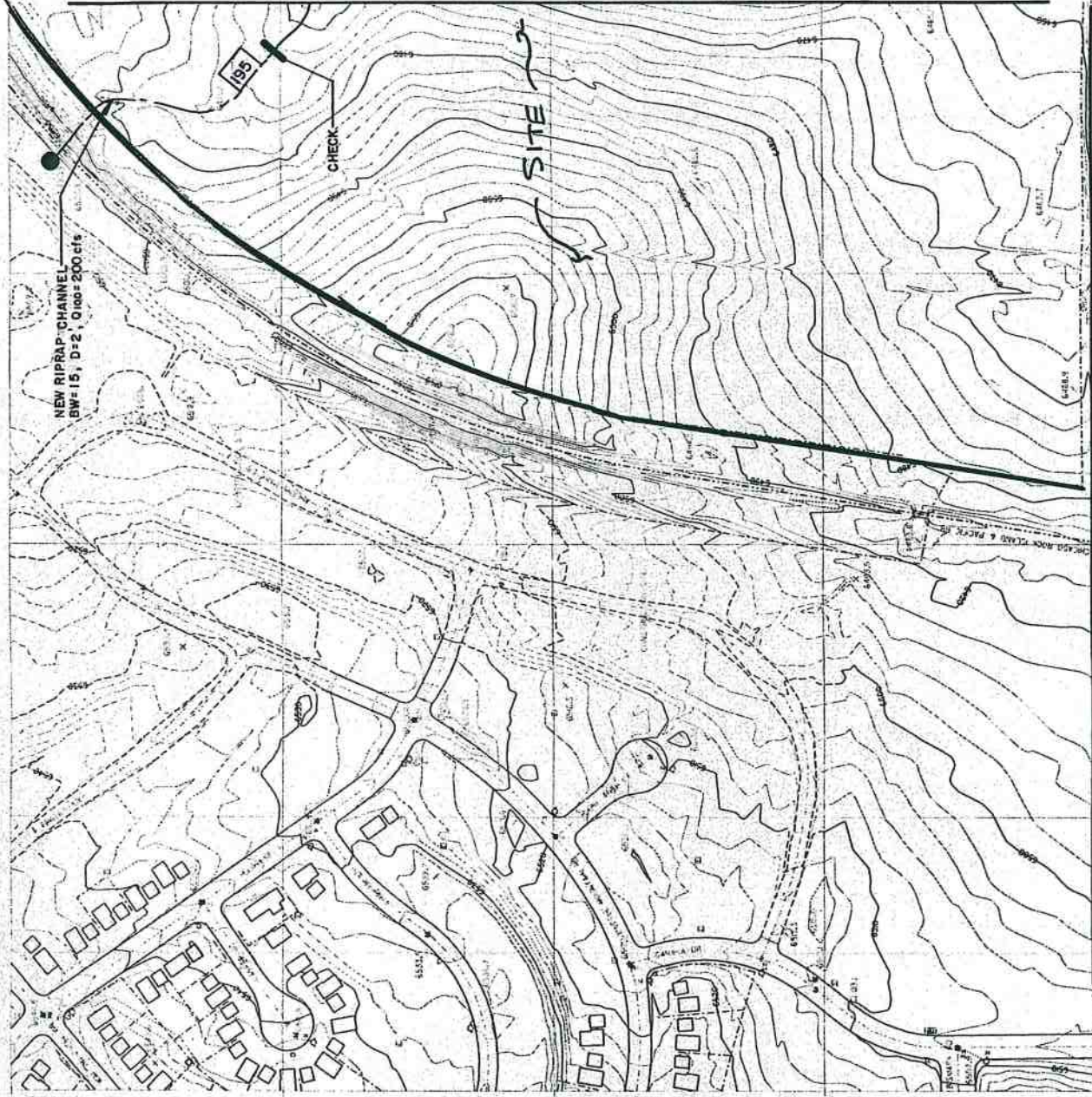
SAND CREEK DRAINAGE  
BASIN PLANNING STUDY  
PRELIMINARY DESIGN PLANS

Kiowa Engineering Corporation  
419 W. Bijou Street  
Colorado Springs, Colorado  
80905-1308

PROJECT NO.	
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EF-24

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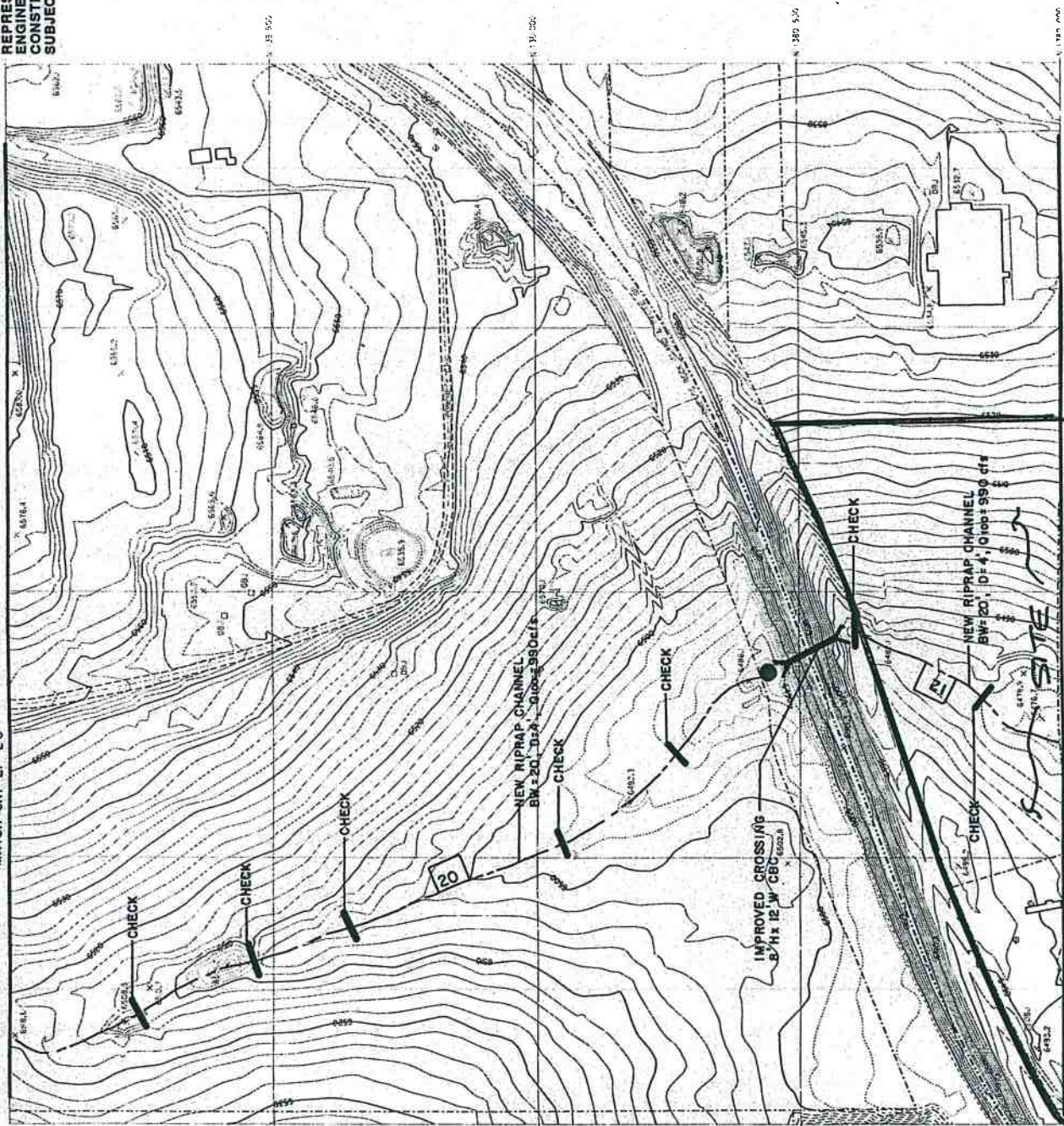
Kiowa Engineering Corporation  
 419 W. Bijou Street  
 Colorado Springs, Colorado  
 80905-1308

SAND CREEK DRAINAGE  
 BASIN PLANNING STUDY  
 PRELIMINARY DESIGN PLANS

Project No.	
Date	
Drawn	
Checked	
Reviewed	

EF-25

MATCH SHT EF-26



MATCH SHT EF-23

## **HYDROLOGIC ANALYSES**

**Hydrologic Analysis**  
**Rational Method Local Drainage**



**ON-SITE RUNOFF COEFFICIENTS**

Hydrologic Soil Group: **A**  
 Soil and Cover Condition: Fair

**Existing Basin Conditions**

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA2	Range	1.87	0.25	0.35
	Gravel	0.07	0.80	0.85
	Composite	1.94	0.27	0.37

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA3	Pavement and Roofs	0.23	0.90	0.95
	Lawns	0.03	0.25	0.35
	Composite	0.26	0.83	0.88

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSC1	Range	3.34	0.25	0.35
	Gravel	0.09	0.80	0.85
	Composite	3.43	0.26	0.36

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A4	Industrial - Light	5.90	0.70	0.80
	Range	32.20	0.25	0.35
	Composite	38.10	0.32	0.42

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA2-A4	OSA2	1.94	0.27	0.37
	OSA3	0.26	0.83	0.88
	OSC1	3.43	0.26	0.36
	A4	38.10	0.32	0.42
	Composite	43.73	0.32	0.42

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSF2	Residential - 1/8 Acre	0.50	0.60	0.70
	Gravel	0.12	0.80	0.85
	Range	4.26	0.25	0.35
	Composite	4.88	0.30	0.40

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSF3	Range	0.52	0.25	0.35
	Composite	0.52	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A7	Range	30.20	0.25	0.35
	Composite	30.20	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSB1	Pavement and Roofs	0.57	0.90	0.95
	Lawns	0.06	0.25	0.35
	Composite	0.63	0.84	0.89

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A9	Range	33.60	0.25	0.35
	Composite	33.60	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA8	Industrial - Light	16.20	0.70	0.80
	Composite	16.20	0.70	0.80

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A16	Pavement and Roofs	1.38	0.90	0.95
	Range	16.62	0.25	0.35
	Composite	18.00	0.30	0.40

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA11	Range	0.37	0.25	0.35
	Pavement and Roofs	3.34	0.90	0.95
	Composite	3.71	0.84	0.89

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA12	Range	0.21	0.25	0.35
	Pavement and Roofs	1.46	0.90	0.95
	Composite	1.67	0.82	0.87

**ON-SITE RUNOFF COEFFICIENTS**Hydrologic Soil Group: B  
Soil and Cover Condition: Fair**Developed Basin Conditions**

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA2	Range	1.87	0.25	0.35
	Gravel	0.07	0.80	0.85
	Composite	1.94	0.27	0.37

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A1	Residential - 1/8 Acre	1.83	0.60	0.70
	Lawns	0.79	0.25	0.35
	Composite	2.62	0.49	0.59

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A2	Residential - 1/8 Acre	1.03	0.60	0.70
	Composite	1.03	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSA3	Pavement and Roofs	0.23	0.90	0.95
	Lawns	0.03	0.25	0.35
	Composite	0.26	0.83	0.88

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A3	Pavement and Roofs	0.23	0.90	0.95
	Lawns	0.07	0.25	0.35
	Composite	0.30	0.75	0.81

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A4	Pavement and Roofs	0.13	0.90	0.95
	Lawns	0.02	0.25	0.35
	Composite	0.15	0.81	0.87

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A5	Pavement and Roofs	0.14	0.90	0.95
	Lawns	0.05	0.25	0.35
	Composite	0.19	0.73	0.79

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
A6	Residential - 1/8 Acre	0.87	0.60	0.70
	Range	3.07	0.25	0.35
	Composite	3.94	0.33	0.43

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B1	Residential - 1/8 Acre	2.04	0.60	0.70
	Lawns	0.48	0.25	0.35
	Composite	2.52	0.53	0.63

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B2	Residential - 1/8 Acre	1.09	0.60	0.70
	Composite	1.09	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B3	Pavement and Roofs	0.21	0.90	0.95
	Lawns	0.12	0.25	0.35
	Composite	0.33	0.66	0.73

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B4	Residential - 1/8 Acre	2.01	0.60	0.70
	Composite	2.01	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSB1	Pavement and Roofs	0.57	0.90	0.95
	Lawns	0.06	0.25	0.35
	Composite	0.63	0.84	0.89

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B5	Residential - 1/8 Acre	0.22	0.60	0.70
	Pavement and Roofs	0.19	0.90	0.95
	Lawns	0.11	0.25	0.35
	Composite	0.52	0.64	0.72

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B6	Residential - 1/8 Acre	1.08	0.60	0.70
	Composite	1.08	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B7	Pavement and Roofs	0.54	0.90	0.95
	Lawns	0.18	0.25	0.35
	Composite	0.72	0.74	0.80

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B8	Pavement and Roofs	0.11	0.90	0.95
	Lawns	0.04	0.25	0.35
	Composite	0.14	0.74	0.80

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
B9	Residential - 1/8 Acre	1.60	0.60	0.70
	Parks, golf courses, etc.	4.61	0.30	0.55
	Composite	6.21	0.38	0.59

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSC1	Range	3.34	0.25	0.35
	Gravel	0.09	0.80	0.85
	Composite	3.43	0.26	0.36

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C1	Residential - 1/8 Acre	5.13	0.60	0.70
	Composite	5.13	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C2	Residential - 1/8 Acre	0.84	0.60	0.70
	Composite	0.84	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C3	Residential - 1/8 Acre	1.02	0.60	0.70
	Composite	1.02	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C4	Residential - 1/8 Acre	1.44	0.60	0.70
	Composite	1.44	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C5	Residential - 1/8 Acre	2.56	0.60	0.70
	Composite	2.56	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C6	Residential - 1/8 Acre	0.73	0.60	0.70
	Composite	0.73	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C7	Residential - 1/8 Acre	0.84	0.60	0.70
	Composite	0.84	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C8	Residential - 1/8 Acre	0.71	0.60	0.70
	Composite	0.71	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C9	Residential - 1/8 Acre	2.44	0.60	0.70
	Composite	2.44	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C10	Residential - 1/8 Acre	1.80	0.60	0.70
	Parks, golf courses, etc.	0.70	0.30	0.55
	Composite	2.50	0.52	0.66

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C11	Residential - 1/8 Acre	2.15	0.60	0.70
	Composite	2.15	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
C12	Residential - 1/8 Acre	1.47	0.60	0.70
	Composite	1.47	0.60	0.70



Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D1	Residential - 1/8 Acre	2.07	0.60	0.70
	Composite	2.07	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D2	Residential - 1/8 Acre	1.19	0.60	0.70
	Composite	1.19	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D3	Pavement and Roofs	0.20	0.90	0.95
	Lawns	0.06	0.25	0.35
	Composite	0.26	0.75	0.81

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D4	Residential - 1/8 Acre	2.22	0.60	0.70
	Composite	2.22	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D5	Residential - 1/8 Acre	0.24	0.60	0.70
	Pavement and Roofs	0.24	0.90	0.95
	Lawns	0.26	0.25	0.35
	Composite	0.74	0.57	0.66

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D6	Residential - 1/8 Acre	1.31	0.60	0.70
	Composite	1.31	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D7	Residential - 1/8 Acre	3.95	0.60	0.70
	Composite	3.95	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D8	Residential - 1/8 Acre	3.06	0.60	0.70
	Composite	3.06	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D9	Range	0.52	0.25	0.35
	Pavement and Roofs	0.33	0.90	0.95
	Composite	0.85	0.50	0.58

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D10	Residential - 1/8 Acre	0.37	0.60	0.70
	Composite	0.37	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D11	Range	1.05	0.25	0.35
	Pavement and Roofs	0.25	0.90	0.95
	Composite	1.30	0.38	0.47

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
D12	Range	0.20	0.25	0.35
	Pavement and Roofs	0.32	0.90	0.95
	Composite	0.52	0.65	0.72

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E1	Residential - 1/8 Acre	1.23	0.60	0.70
	Composite	1.23	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E2	Residential - 1/8 Acre	2.80	0.60	0.70
	Composite	2.80	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E3	Residential - 1/8 Acre	0.97	0.60	0.70
	Composite	0.97	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E4	Residential - 1/8 Acre	2.74	0.60	0.70
	Composite	2.74	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E5	Residential - 1/8 Acre	0.90	0.60	0.70
	Composite	0.90	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E6	Residential - 1/8 Acre	1.80	0.60	0.70
	Composite	1.80	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E7	Residential - 1/8 Acre	1.00	0.60	0.70
	Parks, golf courses, etc.	1.33	0.30	0.55
	Composite	2.33	0.43	0.61

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E8	Residential - 1/8 Acre	0.65	0.60	0.70
	Composite	0.65	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
E9	Range	8.63	0.25	0.35
	Composite	8.63	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSF3	Range	0.52	0.25	0.35
	Composite	0.52	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
F1	Residential - 1/8 Acre	2.41	0.60	0.70
	Composite	2.41	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
F2	Residential - 1/8 Acre	1.26	0.60	0.70
	Composite	1.26	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
F3	Residential - 1/8 Acre	3.21	0.60	0.70
	Composite	3.21	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
F4	Residential - 1/8 Acre	0.32	0.60	0.70
	Composite	0.32	0.60	0.70

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
OSF2	Residential - 1/8 Acre	0.50	0.60	0.70
	Gravel	0.12	0.80	0.85
	Range	4.26	0.25	0.35
	Composite	4.88	0.30	0.40

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
F5	Range	3.67	0.25	0.35
	Composite	3.67	0.25	0.35

Basin:	Surface Type	Area (Ac)	C <sub>5</sub>	C <sub>100</sub> / CN
G1	Range	6.18	0.25	0.35
	Composite	6.18	0.25	0.35



Highlight or circle the areas of concern with this filing.

60970  
August 12, 2013

Hannah Ridge at Feathergrass

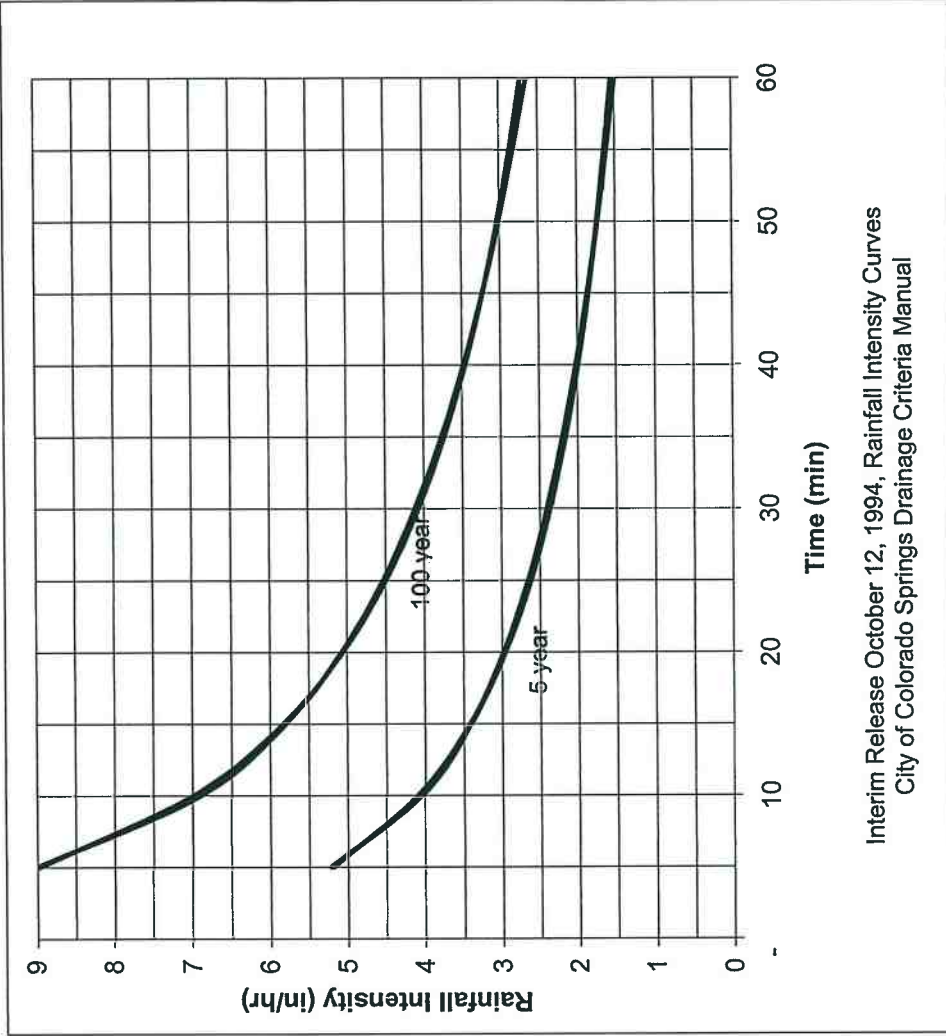
Drainage Basin Percent Impervious Calculations - Multi-Family & Commercial Parcels Undeveloped

Component  
% Impervious

<u>Basin</u>	0% Open Range (Ac)	0% Open Lawn (Ac)	80% Gravel Road (Ac)	95% Pavement & Roof (Ac)	65% 1/8 Ac Resid. (Ac)	75% Multi-Fam Resid. (Ac)	95% Commer. (Ac)	7% Park (Ac)	Total Acres (Ac)	Composite % Imp. (%)
OSA2	1.87		0.07						1.94	2.9%
A1		0.79			1.83				2.62	45.4%
A2					1.03				1.03	65.0%
OSA3		0.03		0.23					0.26	84.0%
A3		0.07		0.23					0.30	72.8%
A4		0.02		0.13					0.15	82.3%
A5		0.05		0.14					0.19	70.0%
A1-A5	0.00	0.96	0.00	0.73	2.86	0.00	0.00		4.55	56.1%
A6	3.07				0.87				3.94	14.4%
OSA2,A6	4.94	0.00	0.07	0.00	0.87	0.00	0.00		5.88	10.6%
B1		0.48			2.04				2.52	52.6%
B2					1.09				1.09	65.0%
B3		0.12		0.21					0.33	60.5%
B4					2.01				2.01	65.0%
OSB1		0.06		0.57					0.63	86.0%
B5		0.11		0.19	0.22				0.52	62.2%
B6					1.08				1.08	65.0%
B7		0.18		0.54					0.72	71.3%
B8		0.04		0.11					0.15	69.7%
B1-B8	0.00	0.99	0.00	1.62	6.44	0.00	0.00	0.00	9.05	63.3%
B9					1.60			4.61	6.21	21.9%
OSC1	3.34		0.09						3.43	2.1%
C1					5.13				5.13	65.0%
C2					0.84				0.84	65.0%
C3					1.02				1.02	65.0%
C4					1.44				1.44	65.0%
C5					2.56				2.56	65.0%
C6					0.73				0.73	65.0%
C7					0.84				0.84	65.0%
C8					0.71				0.71	65.0%
C9					2.44				2.44	65.0%
C10					1.80			0.70	2.50	48.8%
C11					2.15				2.15	65.0%
C12					1.47				1.47	65.0%
OSC1-C12	3.34	0.00	0.09	0.00	21.13	0.00	0.00	0.70	25.26	54.9%
D1					2.07				2.07	65.0%
D2					1.19				1.19	65.0%
D3		0.06		0.20					0.26	73.1%
D4					2.22				2.22	65.0%
D5		0.26		0.24	0.24				0.74	51.9%
D6					1.31				1.31	65.0%
D7					3.95				3.95	65.0%
D1-D7	0.00	0.32	0.00	0.44	10.98	0.00	0.00	0.00	11.74	64.4%
D8					3.06				3.06	65.0%
D9	0.52			0.33					0.85	36.9%
D10					0.37				0.37	65.0%
D11	1.05			0.25					1.30	18.3%
D1-D7, D9,D11	1.57	0.32	0.00	1.02	10.98	0.00	0.00	0.00	13.89	58.4%
D12	0.20			0.32					0.52	58.5%
D8,D10,D12	0.20	0.00	0.00	0.32	3.43	0.00	0.00	0.00	3.95	64.1%

<u>Basin</u>	<u>Open Range (Ac)</u>	<u>Open Lawn (Ac)</u>	<u>Gravel Road (Ac)</u>	<u>Pavement &amp; Roof (Ac)</u>	<u>1/8 Ac Resid. (Ac)</u>	<u>Mult-Fam Resid. (Ac)</u>	<u>Commer. (Ac)</u>	<u>Park (Ac)</u>	<u>Total Acres (Ac)</u>	<u>Composite % Imp. (%)</u>
D1-D12	1.77	0.32	0.00	1.34	14.41	0.00	0.00	0.00	17.84	59.6%
E1					1.23				1.23	65.0%
E2					2.80				2.80	65.0%
E3					0.97				0.97	65.0%
E4					2.74				2.74	65.0%
E5					0.90				0.90	65.0%
E1-E5	0.00	0.00	0.00	0.00	8.64	0.00	0.00	0.00	8.64	65.0%
E6					1.80				1.80	65.0%
E7		1.33			1.00				2.33	27.9%
E6-E7		1.33			2.80				4.13	44.1%
E8					0.65				0.65	65.0%
E1-E5,E8	0.00	0.00	0.00	0.00	9.29	0.00	0.00	0.00	9.29	65.0%
E1-E8	0.00	2.66	0.00	0.00	23.53	0.00	0.00	0.00	26.19	58.4%
E9	8.63								8.63	0.0%
E1-E9	8.63	2.66	0.00	0.00	23.53	0.00	0.00	0.00	34.82	43.9%
OSF3	0.52								0.52	0.0%
F1					2.41				2.41	65.0%
F2					1.26				1.26	65.0%
F3					3.21				3.21	65.0%
F4					0.32				0.32	65.0%
F5	3.67								3.67	0.0%
F1-F5	4.19	0.00	0.00	0.00	7.20	0.00	0.00	0.00	11.39	41.1%
G1	6.18								6.18	0.0%

**RAINFALL INTENSITY ESTIMATES FROM TIME OF CONCENTRATION**



Interim Release October 12, 1994, Rainfall Intensity Curves  
City of Colorado Springs Drainage Criteria Manual

Time of Cont. (min)	From Graph		Calculated	
	5 Year Intensity $i_5$ (in/hr)	100 Year Intensity $i_{100}$ (in/hr)	5 Year Intensity $i_5$ (in/hr)	100 Year Intensity $i_{100}$ (in/hr)
5	5.21	9.00	5.19	8.97
10	4.04	6.90	4.09	6.99
15	3.40	5.80	3.41	5.83
20	2.97	5.07	2.96	5.05
25	2.65	4.53	2.62	4.49
30	2.40	4.11	2.36	4.07
35	2.19	3.77	2.16	3.73
40	2.02	3.48	1.99	3.45
45	1.86	3.23	1.85	3.22
50	1.73	3.01	1.73	3.03
55	1.61	2.81	1.63	2.86
60	1.50	2.64	1.54	2.71

$$i = a(b + D)^{-n}$$

$a = 34$   
 $b = 8$   
 $n = 0.733$   
 $D = T_c$

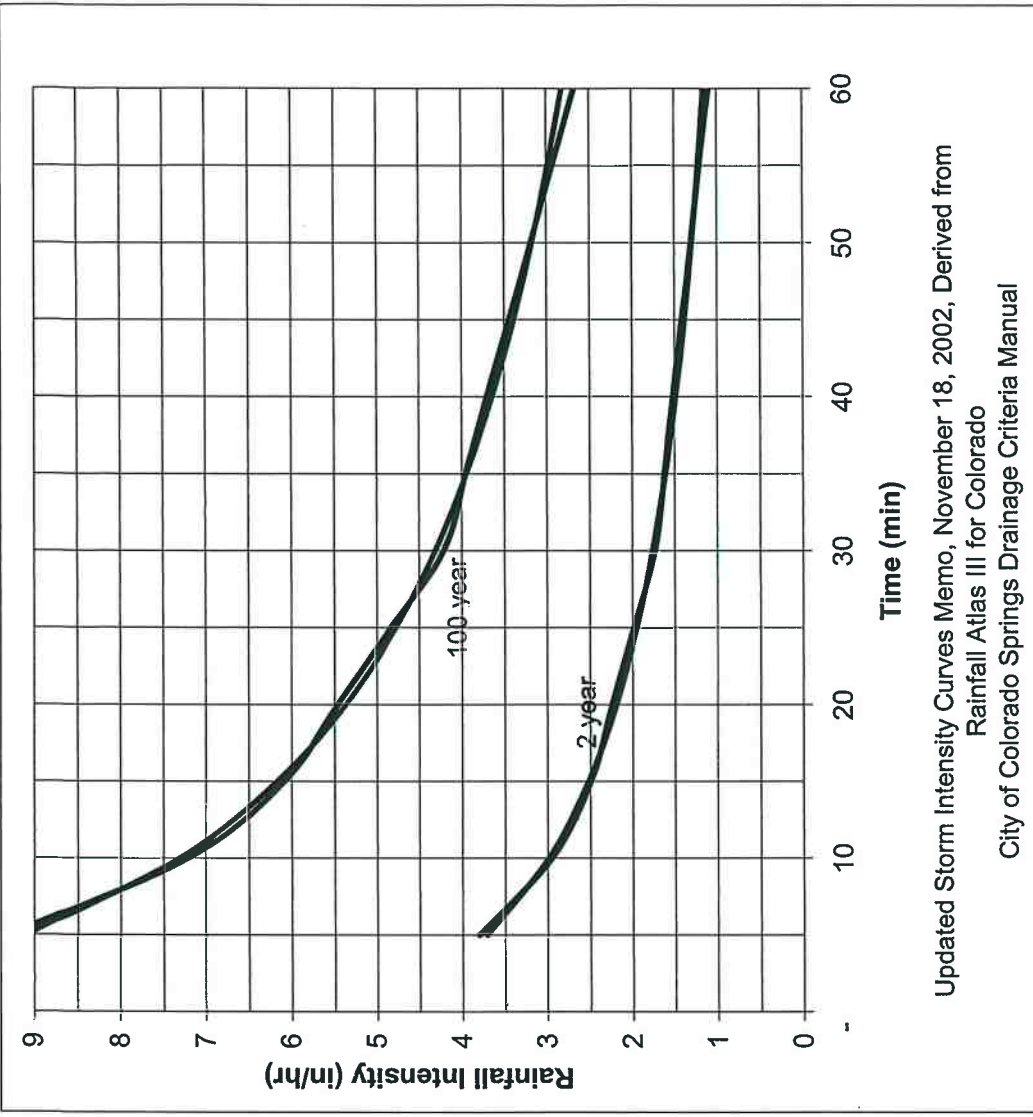


**RAINFALL INTENSITY ESTIMATES FROM TIME OF CONCENTRATION**

Time of Cont. T <sub>c</sub> (min)	From Table		Calculated	
	2 Year Intensity i <sub>5</sub> (in/hr)	100 Year Intensity i <sub>100</sub> (in/hr)	2 Year Intensity i <sub>5</sub> (in/hr)	100 Year Intensity i <sub>100</sub> (in/hr)
5	3.80	9.28	3.71	9.09
10	2.95	7.20	2.98	7.30
15	2.49	6.08	2.52	6.16
20	2.24	5.46	2.19	5.37
25	1.98	4.83	1.95	4.77
30	1.73	4.21	1.76	4.31
35	1.62	3.95	1.61	3.94
40	1.52	3.70	1.49	3.64
45	1.41	3.44	1.38	3.38
50	1.30	3.18	1.29	3.17
55	1.20	2.93	1.22	2.98
60	1.09	2.67	1.15	2.82

$$i = a * P^{1/(b + D)^n}$$

a = 26.65  
 b = 10  
 n = 0.76  
 D = T<sub>c</sub>



Updated Storm Intensity Curves Memo, November 18, 2002, Derived from  
 Rainfall Atlas III for Colorado  
 City of Colorado Springs Drainage Criteria Manual

M.V.E., Inc. 8/2/2013  
 Project: Hamah Ridge at Feathergrass

EXISTING CONDITIONS - CHANNEL CHARACTERISTICS

Channel Type	Channel #/VALUE/ Number	Surface Pipe or Curb Type	Dimensions	Manning Rough. n
Overland	0	-		-
Triangular	1	Weeds	Side Slope (H:V) = 3	0.060
Trapezoidal	2	Weeds	Base Width (ft) = 20	0.060
Curb/Road	3	Type 3	FL to Crown (ft) = 13	0.016
Circular	4	RCP	Diameter (In) = 48	0.013

EXISTING CONDITIONS - TIMES OF CONCENTRATION & DISCHARGES

Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>s</sub>	100 Yr. Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elevation Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>a</sub> (min)	5 Year Intensity I <sub>s</sub> (in/hr)	100 Year Intensity I <sub>100</sub> (in/hr)	5 Year Discharge Q <sub>5</sub> (cfs)	100 Year Discharge Q <sub>100</sub> (cfs)	
OSA2	0	1.9	0.27	0.37	-	110	14	0.127	-	5.72	0.77	1.76	3.24	7.0	8.8	4.29	7.35	2.2	5.2
OSA2	1	1.9	0.27	0.37	0.060	350	23	0.066	-	-	-	-	1.8	1.8	-	-	-	-	-
OSA3	0	0.3	0.83	0.88	-	25	1	0.024	-	-	-	-	1.9	1.9	-	-	-	-	-
OSA3	3	0.3	0.83	0.88	0.016	265	5	0.020	-	2.06	0.20	0.79	2.60	1.7	5.0	5.19	8.97	1.1	2.1
OSC1	0	3.4	0.26	0.36	-	100	26	0.260	-	-	-	-	5.3	5.3	-	-	-	-	-
A4	0	38.1	0.32	0.42	-	800	46	0.058	-	-	-	-	23.2	23.2	-	-	-	-	-
A4	1	38.1	0.32	0.42	0.060	101	4	0.040	-	74.83	2.21	14.67	5.10	0.3	-	-	-	-	-
A4	2	38.1	0.32	0.42	0.060	400	6	0.015	-	74.83	1.10	25.51	2.93	2.3	25.8	2.58	4.42	31.4	70.7
OSA2-A4	A4	38.1	0.32	0.42	-	200	0	-	-	85.38	1.33	31.85	2.68	25.8	25.8	2.58	4.42	35.7	80.6
OSA2-A4	2	43.7	0.30	0.40	0.060	290	13	0.045	-	11.13	1.28	4.91	2.27	15.5	-	-	-	-	-
OSF2	0	4.9	0.30	0.40	-	1,170	19	0.016	-	-	-	-	8.6	8.6	-	-	-	-	-
OSF2	1	4.9	0.30	0.40	0.060	50	16	0.320	-	-	-	-	3.6	3.6	-	-	-	-	-
OSF3	0	0.5	0.25	0.35	-	-	-	-	-	-	-	-	24.1	24.1	-	-	-	-	-
OSF2+OSF3	OSF2	4.9	0.30	0.40	0.060	-	-	-	-	12.17	1.45	6.29	1.93	0.0	24.1	2.67	4.58	4.3	9.7
OSF2+OSF3	1	5.4	0.29	0.39	-	563	37	0.066	-	53.06	1.81	9.88	5.37	20.3	-	-	-	-	-
A7	0	30.2	0.25	0.35	-	385	22	0.057	-	53.06	0.99	22.73	2.33	1.2	28.1	2.45	4.22	18.5	44.6
A7	1	30.2	0.25	0.35	0.060	934	10	0.011	-	-	-	-	6.7	6.7	-	-	-	-	-
OSB1	0	0.6	0.84	0.89	-	25	1	0.024	-	-	-	-	1.8	1.8	-	-	-	-	-
OSB1	3	0.6	0.84	0.89	0.016	670	11	0.016	-	5.06	0.28	1.67	3.03	3.7	5.5	5.04	8.70	2.7	4.9
A9	0	33.6	0.25	0.35	-	800	48	0.060	-	-	-	-	24.9	24.9	-	-	-	-	-
A9	1	33.6	0.25	0.35	0.060	273	16	0.059	-	52.98	1.80	9.77	5.42	0.8	-	-	-	-	-
A9	1	33.6	0.25	0.35	0.060	820	10	0.012	-	52.98	2.42	17.61	3.01	4.5	-	-	-	-	-
A9	2	33.6	0.25	0.35	0.060	250	2	0.008	-	52.98	1.08	24.99	2.12	2.0	32.2	2.27	3.91	19.0	45.9
OSB1+A9	A9	33.6	0.25	0.35	-	-	-	-	-	-	-	-	32.2	32.2	-	-	-	-	-
OSB1+A9	2	34.2	0.26	0.36	0.060	0	0	0.010	-	55.51	1.04	23.95	2.32	0.0	32.2	2.27	3.91	20.2	48.1
OSA8	0	16.2	0.70	0.80	-	665	20	0.030	-	-	-	-	13.4	13.4	-	-	-	-	-
OSA8	1	16.2	0.70	0.80	0.060	151	4	0.026	-	79.59	2.44	17.86	4.46	0.6	14.0	3.53	6.02	40.0	78.1
A16	0	18.0	0.30	0.40	-	650	14	0.022	-	-	-	-	29.6	29.6	-	-	-	-	-
A16	1	18.0	0.30	0.40	0.060	657	3	0.005	-	29.20	2.33	16.28	1.79	6.1	35.7	2.13	3.69	11.5	26.3
OSA8+A16	OSA8	16.2	0.70	0.80	-	620	14	0.022	-	123.36	2.98	26.71	4.62	14.0	-	-	-	-	-
OSA8+A16	1	34.2	0.49	0.59	0.060	500	3	0.005	-	123.36	3.93	46.37	2.66	2.2	19.3	3.01	5.14	50.3	103.3
OSA8+A16	1	34.2	0.49	0.59	0.060	-	-	-	-	-	-	-	3.1	3.1	-	-	-	-	-

M.V.E., Inc.  
Project No.: 60970

8/2/2013  
Project: Hannah Ridge at Feathergrass

EXISTING CONDITIONS - CHANNEL CHARACTERISTICS

Channel Type	Channel #VALUEI Number	Surface Pipe or Curb Type	Dimensions		Manning Rough. n
			Side Slope (H:V)	Maximum Depth (ft)	
Overland	0	--			
Triangular	1	Weeds	Side Slope (H:V) = 3	Maximum Depth (ft) = 3	0.060
Trapezoidal	2	Weeds	Side Slopes (H:V) = 3	Base Width (ft) = 20	0.060
Curb/Road	3	Type 3	Road Cross Slope = 2%	FL to Crown (ft) = 13	0.016
Circular	4	RCP	Diameter (In) = 48		0.013

EXISTING CONDITIONS - TIMES OF CONCENTRATION & DISCHARGES

Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>s</sub>	100 Yr Coef. or Curve No C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elevation Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	5 Year Intensity I <sub>5</sub> (in/hr)	100 Year Intensity I <sub>100</sub> (in/hr)	5 Year Discharge Q <sub>5</sub> (cfs)	100 Year Discharge Q <sub>100</sub> (cfs)
OSA11	0	3.7	0.84	0.89	--	300	11	0.037	--	--	--	--	5.6	--	--	--	--	--
OSA11	3	3.7	0.84	0.89	0.016	347	13	0.037	28.61	0.44	4.50	6.36	0.9	--	--	--	--	--
OSA11	3	3.7	0.84	0.89	0.016	268	3	0.011	28.61	0.55	7.09	4.04	1.1	7.6	7.78	14.1	25.7	
OSA12	0	1.7	0.82	0.87	--	164	2	0.012	--	--	--	--	6.3	--	--	--	--	--
OSA12	3	1.7	0.82	0.87	0.016	1,015	5	0.005	12.15	0.47	5.07	2.40	7.1	13.4	6.15	4.9	9.0	

\*Estimated using an initial 100 year intensity based on the corresponding Overland Time of Concentration.

\*\*Overland Time of Concentration,  $T_c = 1.87 (1.1 - C_s) L^{0.5} S^{-0.33}$

Channel Time of Concentration calculated using average flow velocities from Manning's formula.



DEVELOPED CONDITIONS - CHANNEL CHARACTERISTICS

Channel Type	Channel Type Number	Surface Pipe or Curb Type	Dimensions			Manning Rough. n	DEVELOPED CONDITIONS - TIMES OF CONCENTRATION & DISCHARGES											
			Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>e</sub>	100 Yr. Coef. or Curve No. C <sub>100</sub> or CN		Manning Rough. n	Length L (ft)	Elev Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont. T <sub>c</sub> (min)	5 Year Intensity I <sub>5</sub> (in/hr)	100 Year Intensity I <sub>100</sub> (in/hr)	5 Year Discharge Q <sub>5</sub> (cfs)
Overland	0	---	1.9	0.27	0.37	0.060	110	14	0.127	5.72	0.77	1.8	3.2	7.0	4.29	7.35	2.2	5.2
Triangular	1	Weeds	1.9	0.27	0.37	0.060	350	23	0.066	5.72	0.77	1.8	3.2	7.0	4.29	7.35	2.2	5.2
Trapezoidal	2	Weeds	2.6	0.49	0.59	0.016	70	1	0.020	12.16	0.39	3.3	3.7	7.5	4.00	6.83	5.2	10.6
Curb/Road	3	Type 3	1.0	0.60	0.70	0.016	60	1	0.020	6.18	0.30	2.0	3.1	5.8	4.20	7.19	2.6	5.2
Circular	4	RCP	2.6	0.49	0.59	0.016	660	10	0.015	17.80	0.48	5.2	3.4	10.5	4.00	6.83	7.6	15.6
	A1		3.7	0.52	0.62	0.016	1	0	0.010	2.06	0.20	0.8	2.6	1.9	5.19	8.97	1.1	2.1
	A1+A2		0.3	0.83	0.88	0.016	25	1	0.024	2.19	0.17	0.5	4.0	3.3	5.19	8.97	1.2	2.2
	OSA3		0.3	0.83	0.88	0.016	265	5	0.020	4.25	0.21	0.9	4.7	5.0	4.79	8.24	2.1	3.9
	A3		0.3	0.75	0.81	0.016	40	1	0.020	21.48	0.43	4.2	5.1	2.5	4.00	6.83	9.4	18.8
	A3		0.3	0.83	0.88	0.016	375	22	0.059	1.17	0.16	0.5	2.4	10.6	5.19	8.97	0.6	1.2
	OSA3+A3		0.6	0.78	0.84	0.016	420	25	0.059	22.50	0.45	4.6	4.9	10.6	3.91	6.68	9.7	19.2
	OSA3+A3		3.7	0.52	0.62	0.016	0	0	0.025	10.64	0.40	8.6	1.2	15.5	3.36	5.73	4.3	9.6
	A1+A2+OSA3+A3		4.2	0.56	0.65	0.016	36	1	0.022	15.15	0.19	3.8	4.0	2.5	5.19	8.97	0.7	1.3
	A1+A2+OSA3+A3		0.2	0.81	0.87	0.016	135	3	0.022	19.27	0.28	1.6	11.8	10.6	3.97	6.78	4.8	9.5
	A4		0.2	0.81	0.87	0.016	170	4	0.022	12.94	0.37	3.1	4.1	10.6	4.23	7.23	8.4	17.1
	A4		4.2	0.56	0.65	0.016	0	0	0.250	2.17	0.17	0.5	4.0	6.8	5.01	8.63	1.1	2.1
	A1+A2+OSA3+A3+A4		4.4	0.57	0.66	0.016	0	0	0.250	10.85	0.37	3.0	3.6	10.7	3.97	6.78	4.8	9.5
	A1+A2+OSA3+A3+A4		0.2	0.79	0.85	0.016	65	1	0.020	12.71	0.24	1.2	10.6	10.7	3.97	6.78	5.7	11.2
	A5		0.2	0.73	0.79	0.016	36	1	0.022	30.90	0.33	2.3	13.2	10.7	3.97	6.78	13.6	27.2
	A5		0.2	0.73	0.79	0.016	135	3	0.022	5.06	0.28	1.7	3.0	1.8	5.04	8.70	2.7	4.9
	A6		3.9	0.33	0.43	0.060	235	13	0.055	3.07	0.20	0.8	3.7	6.5	4.67	8.03	1.5	3.0
	A6		3.9	0.33	0.43	0.060	220	2	0.009	7.69	0.20	0.8	9.4	7.0	4.67	8.03	4.0	7.5
	OSA2+A6		3.9	0.33	0.43	0.060	0	0	0.250	38.11	0.35	2.7	13.9	10.7	3.97	6.78	17.0	33.5
	OSA2+A6		5.9	0.31	0.41	0.060	0	0	0.250	0	0	0	0	0.0	0.0	0.0	0.0	0.0
	B1		2.5	0.53	0.63	0.016	125	3	0.020	12.94	0.33	2.4	5.3	1.6	4.29	7.34	5.8	11.7
	B1		2.5	0.53	0.63	0.016	500	20	0.040	6.23	0.29	1.8	3.4	6.7	4.23	7.23	2.8	5.5
	B2		1.1	0.60	0.70	0.016	80	2	0.020	6.23	0.26	1.4	4.5	1.7	4.23	7.23	2.8	5.5
	B2		1.1	0.60	0.70	0.016	460	19	0.040	19.27	0.28	1.6	11.8	9.2	4.23	7.23	8.4	17.1
	B1+B2		3.6	0.55	0.65	0.016	0	0	0.250	2.17	0.17	0.5	4.0	4.1	5.01	8.63	1.1	2.1
	B1+B2		0.3	0.66	0.73	0.016	40	0	0.020	10.85	0.37	3.0	3.6	10.7	3.97	6.78	4.8	9.5
	B3		0.3	0.66	0.73	0.016	370	22	0.059	12.71	0.24	1.2	10.6	10.7	3.97	6.78	5.7	11.2
	B4		2.0	0.60	0.70	0.016	110	2	0.020	30.90	0.33	2.3	13.2	10.7	3.97	6.78	13.6	27.2
	B4		2.0	0.60	0.70	0.016	630	10	0.015	5.06	0.28	1.7	3.0	1.8	5.04	8.70	2.7	4.9
	B3+B4		2.3	0.61	0.70	0.016	0	0	0.250	3.07	0.20	0.8	3.7	6.5	4.67	8.03	1.5	3.0
	B1+B2+B3+B4		2.3	0.61	0.70	0.016	0	0	0.250	7.69	0.20	0.8	9.4	7.0	4.67	8.03	4.0	7.5
	B1+B2+B3+B4		6.0	0.58	0.67	0.016	0	0	0.250	38.11	0.35	2.7	13.9	10.7	3.97	6.78	17.0	33.5
	OSB1		0.6	0.84	0.89	0.016	25	1	0.024	12.94	0.33	2.4	5.3	1.6	4.29	7.34	5.8	11.7
	OSB1		0.6	0.84	0.89	0.016	670	11	0.016	6.23	0.29	1.8	3.4	6.7	4.23	7.23	2.8	5.5
	B5		0.5	0.64	0.72	0.016	100	4	0.040	19.27	0.28	1.6	11.8	9.2	4.23	7.23	8.4	17.1
	B5		0.5	0.64	0.72	0.016	0	0	0.250	2.17	0.17	0.5	4.0	4.1	5.01	8.63	1.1	2.1
	OSB1+B5		1.2	0.75	0.81	0.016	0	0	0.250	10.85	0.37	3.0	3.6	10.7	3.97	6.78	4.8	9.5
	OSB1+B5		6.0	0.58	0.67	0.016	0	0	0.250	12.71	0.24	1.2	10.6	10.7	3.97	6.78	5.7	11.2
	B1+B2+B3+B4+OSB1+B5		7.1	0.60	0.70	0.016	0	0	0.250	30.90	0.33	2.3	13.2	10.7	3.97	6.78	13.6	27.2

Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>s</sub>	100 Yr Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev Change (ft)	Average Slope S	Flow* Q (cfs)	Channel Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	5 Year Intensity I <sub>5</sub> (in/hr)	100 Year Intensity I <sub>100</sub> (in/hr)	5 Year Discharge Q <sub>5</sub> (cfs)	100 Year Discharge Q <sub>100</sub> (cfs)
B6	0	1.1	0.60	0.70	0.016	60	1	0.020	6.48	0.31	2.1	2.1	3.1	8.8	4.29	7.35	2.8	5.6
B6	3	1.1	0.60	0.70	0.016	580	9	0.015	43.94	0.51	6.1	7.2	10.7	10.8	3.96	6.76	19.5	38.5
B1+B2+B3+B4+OSB1+B5+B6	B1+B2+B3+B4+OSB1+B5+B6	7.1	0.60	0.70	0.016	30	1	0.040	5.18	0.25	1.3	4.0	3.4	6.0	4.91	8.45	2.6	4.9
B1+B2+B3+B4+OSB1+B5+B6	B1+B2+B3+B4+OSB1+B5+B6	0.7	0.74	0.80	0.016	635	22	0.035	48.38	0.54	6.9	7.0	10.8	12.3	3.74	6.38	20.4	40.1
B7	3	8.2	0.60	0.70	0.016	635	22	0.035	1.01	0.16	0.5	2.2	3.4	5.0	5.19	8.97	0.5	1.0
B1+B2+B3+B4+OSB1+B5+B6+B7	B1+B2+B3+B4+OSB1+B5+B6+B7	8.9	0.61	0.71	0.016	40	1	0.020	19.16	0.50	10.6	1.8	18.6	21.1	2.87	4.91	6.7	18.0
B8	0	0.1	0.74	0.80	0.016	160	3	0.020	26.59	0.51	6.08	4.37	12.2	12.2	3.76	6.42	11.6	23.1
B8	3	0.1	0.74	0.80	0.016	40	1	0.020	35.81	0.34	2.61	13.71	5.2	12.2	3.76	6.42	15.0	31.1
B9	0	6.2	0.38	0.59	0.060	300	6	0.020	5.22	0.27	1.54	3.40	6.3	7.9	4.48	7.68	2.3	4.5
B9	2	6.2	0.38	0.59	0.060	270	4	0.015	5.93	0.30	1.95	3.05	3.3	9.6	4.15	7.10	2.5	5.1
OSC1	0	3.4	0.26	0.36	0.016	100	26	0.260	7.18	0.26	1.38	5.21	8.7	10.5	4.01	6.85	3.5	6.9
C1	0	5.1	0.60	0.70	0.016	110	2	0.015	14.05	0.41	3.76	3.73	2.2	9.7	4.14	7.09	6.4	12.7
C1	3	5.1	0.60	0.70	0.016	915	13	0.015	0	0	0	0	12.2	12.2	3.76	6.42	15.0	31.1
OSC1+C1	OSC1+C1	8.6	0.47	0.57	0.016	40	1	0.015	5.22	0.27	1.54	3.40	6.3	7.9	4.48	7.68	2.3	4.5
OSC1+C1	OSC1+C1	0.8	0.60	0.70	0.016	550	12	0.022	5.93	0.30	1.95	3.05	3.3	9.6	4.15	7.10	2.5	5.1
C2	0	0.8	0.60	0.70	0.016	60	1	0.015	7.18	0.26	1.38	5.21	8.7	10.5	4.01	6.85	3.5	6.9
C2	3	0.8	0.60	0.70	0.016	60	1	0.015	14.05	0.41	3.76	3.73	2.2	9.7	4.14	7.09	6.4	12.7
C3	0	1.0	0.60	0.70	0.016	420	23	0.055	4.20	0.21	0.92	4.56	6.5	8.1	4.44	7.61	1.9	3.9
C3	3	1.0	0.60	0.70	0.016	420	23	0.055	4.20	0.21	0.92	4.56	6.5	8.1	4.44	7.61	1.9	3.9
C4	0	1.4	0.60	0.70	0.016	165	3	0.020	4.89	0.28	1.67	2.93	2.8	9.2	4.23	7.24	2.1	4.3
C4	3	1.4	0.60	0.70	0.016	165	3	0.020	4.89	0.28	1.67	2.93	2.8	9.2	4.23	7.24	2.1	4.3
C5	0	2.6	0.60	0.70	0.016	165	7	0.042	14.05	0.41	3.76	3.73	2.2	9.7	4.14	7.09	6.4	12.7
C5	3	2.6	0.60	0.70	0.016	495	7	0.015	14.05	0.41	3.76	3.73	2.2	9.7	4.14	7.09	6.4	12.7
C6	0	0.7	0.60	0.70	0.016	65	1	0.015	4.08	0.24	1.17	3.48	1.7	8.3	4.40	7.53	1.9	3.7
C6	3	0.7	0.60	0.70	0.016	65	1	0.015	4.08	0.24	1.17	3.48	1.7	8.3	4.40	7.53	1.9	3.7
C7	0	0.8	0.60	0.70	0.016	115	2	0.015	12.56	0.39	3.42	3.67	8.8	8.8	3.85	6.58	5.6	11.2
C7	3	0.8	0.60	0.70	0.016	200	3	0.015	12.56	0.35	2.75	4.57	10.9	11.7	3.82	6.52	4.9	10.7
C8	0	0.7	0.60	0.70	0.016	485	13	0.027	11.09	0.31	2.16	5.13	9.0	11.0	3.93	6.71	5.1	10.1
C8	3	0.7	0.60	0.70	0.016	485	13	0.027	11.09	0.31	2.16	5.13	9.0	11.0	3.93	6.71	5.1	10.1
C9	0	2.4	0.60	0.70	0.016	300	16	0.053	8.55	0.34	2.56	3.34	10.5	10.5	4.20	7.19	3.7	7.4
C9	3	2.4	0.60	0.70	0.016	265	11	0.040	8.55	0.34	2.56	3.34	10.5	10.5	4.20	7.19	3.7	7.4
C10	0	2.5	0.52	0.66	0.016	265	11	0.040	11.36	0.23	1.10	10.32	0.0	10.5	4.01	6.85	5.5	10.9
C10	3	2.5	0.52	0.66	0.016	265	11	0.040	11.36	0.23	1.10	10.32	0.0	10.5	4.01	6.85	5.5	10.9
C11	0	2.2	0.60	0.70	0.016	165	4	0.024	19.65	0.28	1.66	11.81	9.7	9.7	4.14	7.09	8.9	17.8
C11	3	2.2	0.60	0.70	0.016	430	7	0.015	19.65	0.28	1.66	11.81	9.7	9.7	4.14	7.09	8.9	17.8
C12	0	1.5	0.60	0.70	0.016	60	1	0.015	14.53	0.25	1.33	10.96	11.7	11.7	3.82	6.52	6.6	14.1
C12	3	1.5	0.60	0.70	0.016	600	9	0.015	14.53	0.25	1.33	10.96	11.7	11.7	3.82	6.52	6.6	14.1
C2+C4	C2+C4	1.4	0.60	0.70	0.016	0	0	0.250	16.22	0.26	1.44	11.27	11.5	11.5	3.85	6.58	7.3	14.5
C2+C4	C2+C4	2.3	0.60	0.70	0.016	0	0	0.250	16.22	0.26	1.44	11.27	11.5	11.5	3.85	6.58	7.3	14.5
C3+C5	C3+C5	2.6	0.60	0.70	0.016	0	0	0.250	15.29	0.26	1.38	11.10	11.0	11.0	3.93	6.71	7.1	14.1
C3+C5	C3+C5	2.5	0.52	0.66	0.016	0	0	0.250	15.29	0.26	1.38	11.10	11.0	11.0	3.93	6.71	7.1	14.1
C6+C10	C6+C10	3.2	0.53	0.67	0.016	0	0	0.250	31.61	0.54	6.78	4.66	17.1	13.2	3.63	6.19	13.4	26.6
C6+C10	C6+C10	2.4	0.60	0.70	0.016	475	7	0.015	31.61	0.54	6.78	4.66	17.1	13.2	3.63	6.19	13.4	26.6
C8+C9	C8+C9	3.2	0.60	0.70	0.016	90	2	0.020	11.59	0.31	2.06	5.64	7.1	8.9	4.28	7.32	5.3	10.6
C8+C9	C8+C9	3.2	0.60	0.70	0.016	630	31	0.050	11.59	0.31	2.06	5.64	7.1	8.9	4.28	7.32	5.3	10.6
C7+C11	C7+C11	1.2	0.60	0.70	0.016	75	2	0.020	6.88	0.26	1.39	4.96	2.3	8.7	4.31	7.38	3.1	6.1
C7+C11	C7+C11	1.2	0.60	0.70	0.016	685	34	0.050	6.88	0.26	1.39	4.96	2.3	8.7	4.31	7.38	3.1	6.1
C8+C9+C7+C11	C8+C9+C7+C11	3.0	0.60	0.70	0.016	0	0	0.250	18.26	0.27	1.57	11.60	0.0	8.9	4.28	7.32	8.4	16.7
C8+C9+C7+C11	C8+C9+C7+C11	3.0	0.60	0.70	0.016	475	7	0.015	18.26	0.27	1.57	11.60	0.0	8.9	4.28	7.32	8.4	16.7
D1	0	6.1	0.60	0.70	0.016	40	1	0.020	1.90	0.16	0.48	3.94	3.3	5.0	5.19	8.97	1.0	1.9
D1	3	6.1	0.60	0.70	0.016	320	20	0.063	1.90	0.16	0.48	3.94	3.3	5.0	5.19	8.97	1.0	1.9
D2	0	2.1	0.60	0.70	0.016	630	31	0.050	12.20	0.32	2.31	5.29	1.7	10.0	4.09	7.00	5.5	10.9
D2	3	2.1	0.60	0.70	0.016	630	31	0.050	12.20	0.32	2.31	5.29	1.7	10.0	4.09	7.00	5.5	10.9
D3	0	1.2	0.60	0.70	0.016	195	4	0.020	13.85	0.25	1.28	10.83	10.0	10.0	4.09	7.00	6.3	12.4
D3	3	1.2	0.60	0.70	0.016	195	4	0.020	13.85	0.25	1.28	10.83	10.0	10.0	4.09	7.00	6.3	12.4
D4	0	2.1	0.60	0.70	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0
D4	3	2.1	0.60	0.70	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0
D1+D2	D1+D2	3.3	0.60	0.70	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0
D1+D2	D1+D2	3.3	0.60	0.70	0.016	40	1	0.020	0	0	0	0	0.0	0.0	0	0	0	0
D3	0	0.3	0.75	0.81	0.016	320	20	0.063	0	0	0	0	0.0	0.0	0	0	0	0
D3	3	0.3	0.75	0.81	0.016	320	20	0.063	0	0	0	0	0.0	0.0	0	0	0	0
D4	0	2.2	0.60	0.70	0.016	100	2	0.020	0	0	0	0	0.0	0.0	0	0	0	0
D4	3	2.2	0.60	0.70	0.016	545	22	0.040	0	0	0	0	0.0	0.0	0	0	0	0
D4	3	2.2	0.60	0.70	0.016	195	4	0.020	0	0	0	0	0.0	0.0	0	0	0	0
D3+D4	D3+D4	2.2	0.60	0.70	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0
D3+D4	D3+D4	2.5	0.62	0.71	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0
D1+D2+D3+D4	D1+D2+D3+D4	2.5	0.62	0.71	0.016	0	0	0.250	0	0	0	0	0.0	0.0	0	0	0	0



Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>s</sub>	100 Yr Coef. or C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev. Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Travel T <sub>c</sub> (min)	Time of Travel Com** T <sub>c</sub> (min)	5 Year Intensity I <sub>5</sub> (in/hr)	100 Year Intensity I <sub>100</sub> (in/hr)	5 Year Discharge Q <sub>5</sub> (cfs)	100 Year Discharge Q <sub>100</sub> (cfs)
D1+D2+D3+D4	3	5.7	0.61	0.71	0.016	0	0	0.250	31.76	0.33	2.39	13.31	7.2	7.0	4.09	7.00	14.3	28.3
D5	0	0.7	0.57	0.66	0.016	140	6	0.043	3.87	0.22	0.97	3.98	7.2	8.5	4.36	7.46	1.9	3.6
D1+D2+D3+D4+D5	3	5.7	0.61	0.71	0.016	310	13	0.040	35.58	0.34	2.60	13.69	10.0	10.0	4.09	7.00	16.0	31.7
D6	0	1.3	0.60	0.70	0.016	60	0	0.250	7.52	0.27	1.60	4.69	6.6	6.6	4.18	7.15	3.3	6.6
D6	3	1.3	0.60	0.70	0.016	535	22	0.040	7.52	0.31	2.07	3.63	1.0	9.5	4.08	6.97	19.2	38.0
D6	3	1.3	0.60	0.70	0.016	210	4	0.020	42.78	0.51	5.94	7.20	10.0	10.0	3.77	6.43	8.9	17.8
D7	0	7.8	0.60	0.70	0.016	35	1	0.040	19.58	0.38	3.32	5.90	9.7	9.7	3.77	6.43	26.6	52.8
D7	0	4.0	0.60	0.70	0.016	140	2	0.015	19.58	0.46	4.80	4.08	1.1	12.1	4.42	7.58	1.9	3.8
D7	3	4.0	0.60	0.70	0.016	475	19	0.040	58.18	0.41	3.76	15.47	0.0	12.1	3.97	6.78	20.3	40.3
D7	3	4.0	0.60	0.70	0.016	270	4	0.015	4.28	0.23	1.12	3.83	10.0	10.0	3.77	6.43	28.2	56.0
D8	0	0.9	0.50	0.58	0.016	585	20	0.034	46.67	0.53	6.60	7.07	12.1	12.1	3.77	6.43	1.1	2.2
D8	3	7.8	0.60	0.70	0.016	300	11	0.036	61.69	0.42	3.93	15.69	0.0	12.1	3.68	6.28	7.6	15.1
D8	3	11.7	0.60	0.70	0.016	0	0	0.250	14.81	0.35	2.68	5.53	10.2	10.2	3.26	5.57	1.6	3.4
D8	3	3.1	0.60	0.70	0.016	120	0	0.010	14.81	0.41	3.89	3.81	1.2	12.8	4.85	8.35	1.1	2.2
D8	3	3.1	0.60	0.70	0.016	450	18	0.040	2.33	0.21	0.87	2.68	4.2	4.2	3.90	6.67	21.9	43.7
D8	3	3.1	0.60	0.70	0.016	270	4	0.015	16.61	0.26	1.47	11.33	12.8	12.8	3.71	6.33	29.6	59.0
D8	3	3.4	0.60	0.70	0.016	210	4	0.019	3.43	0.25	1.30	2.64	10.7	10.7	3.61	6.16	8.7	17.1
D8	3	1.3	0.38	0.47	0.016	95	1	0.015	51.42	0.64	9.77	5.27	0.4	11.2	4.93	8.50	1.7	3.2
D8	3	1.3	0.38	0.47	0.016	130	2	0.015	65.98	0.71	11.89	5.55	5.1	5.1	3.71	6.33	29.6	59.0
D8	3	0.5	0.65	0.72	0.016	140	2	0.015	3.33	0.24	1.25	2.67	0.8	0.8	3.61	6.16	8.7	17.1
D8	3	0.5	0.65	0.72	0.016	130	2	0.015	19.19	0.45	4.66	4.12	12.8	12.8	4.16	7.12	3.1	6.1
D8	3	3.4	0.60	0.70	0.016	130	2	0.015	7.08	0.31	2.08	3.40	6.5	6.5	3.96	6.77	6.7	13.3
D8	3	4.0	0.61	0.70	0.016	65	1	0.015	14.63	0.39	3.47	4.22	2.3	2.3	3.96	6.77	9.6	19.1
D8	3	1.2	0.60	0.70	0.016	615	11	0.018	21.06	0.29	1.75	12.02	10.8	10.8	3.96	6.77	9.6	19.1
D8	3	1.2	0.60	0.70	0.016	130	3	0.020	5.64	0.28	1.68	3.37	6.3	6.3	4.28	7.33	2.5	5.0
D8	3	2.8	0.60	0.70	0.016	580	11	0.020	26.13	0.31	2.06	12.68	10.8	10.8	3.96	6.77	11.9	23.7
D8	3	2.8	0.60	0.70	0.016	0	0	0.250	14.43	0.38	3.24	4.45	8.3	8.3	4.06	6.93	6.7	13.3
D8	3	2.8	0.60	0.70	0.016	125	3	0.020	40.45	0.54	6.75	5.99	10.8	10.8	3.84	6.56	17.8	35.5
D8	3	2.7	0.60	0.70	0.016	500	11	0.023	5.24	0.27	1.50	3.50	6.3	6.3	4.35	7.45	2.3	4.7
D8	3	2.7	0.60	0.70	0.016	295	8	0.025	45.16	0.37	3.11	14.52	11.6	11.6	3.84	6.56	19.9	39.7
D8	3	0.9	0.60	0.70	0.016	460	11	0.023	10.23	0.36	2.96	3.45	10.8	10.8	4.16	7.12	4.5	9.0
D8	3	7.7	0.60	0.70	0.016	0	0	0.250	8.58	0.33	2.34	3.66	14.1	14.1	3.33	5.69	3.3	8.1
D8	3	2.7	0.60	0.70	0.016	365	7	0.019	19.17	0.28	1.63	11.74	10.2	10.2	4.06	6.93	8.9	17.7
D8	3	2.7	0.60	0.70	0.016	0	0	0.250	29.94	0.49	5.42	5.52	10.2	10.2	4.01	6.85	12.8	27.2
D8	3	3.6	0.60	0.70	0.016	100	3	0.025	55.85	0.72	12.21	4.57	11.6	11.6	3.79	6.47	23.4	48.4
D8	3	6.0	0.63	0.67	0.016	100	3	0.025	1.0	0.10	1.0	1.0	0.4	0.4	1.0	1.0	1.0	1.0
D8	3	8.6	0.60	0.66	0.016	100	1	0.010	1.0	0.10	1.0	1.0	0.4	0.4	1.0	1.0	1.0	1.0





Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	5 Year Coef. C <sub>s</sub>	100 Yr Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	5 Year Intensity I <sub>5</sub> (In/hr)	100 Year Intensity I <sub>100</sub> (In/hr)	5 Year Discharge Q <sub>5</sub> (cfs)	100 Year Discharge Q <sub>100</sub> (cfs)
E8	3	0.7	0.60	0.70	0.016	610	40	0.030	4.10	0.24	1.21	3.39	4.1	7.1	4.65	7.98	1.8	3.6
E8	3	0.7	0.60	0.70	0.016	610	40	0.030	4.10	0.24	1.21	3.39	4.1	7.1	4.65	7.98	1.8	3.6
E9	0	8.6	0.25	0.35	0.016	300	0	0.020	14.56	0.38	3.32	4.38	21.9	24.4	2.66	4.56	5.7	13.8
E9	3	8.6	0.25	0.35	0.016	300	0	0.020	14.56	0.38	3.32	4.38	21.9	24.4	2.66	4.56	5.7	13.8
E9	4	8.6	0.25	0.35	0.013	170	12	0.010	14.56	0.86	1.98	7.35	0.4	5.0	5.19	8.97	0.7	1.6
OSF3	0	0.5	0.25	0.35	0.016	50	16	0.020	13.01	0.38	3.31	3.93	7.8	11.0	3.92	6.70	5.7	11.3
F1	0	2.4	0.60	0.70	0.016	110	2	0.020	13.01	0.38	3.31	3.93	3.2	11.0	3.92	6.70	5.7	11.3
F1	3	2.4	0.60	0.70	0.016	765	13	0.018	13.01	0.38	3.31	3.93	11.0	11.0	3.92	6.70	6.2	12.5
OSF3+F1	F1	2.4	0.60	0.70	0.016	0	0	0.250	14.41	0.25	1.32	10.94	0.0	11.0	3.92	6.70	6.2	12.5
OSF3+F1	3	2.9	0.54	0.64	0.016	60	1	0.015	14.41	0.25	1.32	10.94	6.3	9.6	4.16	7.11	3.1	6.3
F2	0	1.3	0.60	0.70	0.016	670	12	0.018	7.33	0.31	2.14	3.43	8.2	10.9	3.94	6.73	7.6	15.1
F2	3	1.3	0.60	0.70	0.016	140	4	0.025	7.33	0.31	2.14	3.43	2.7	10.9	3.94	6.73	7.6	15.1
F3	0	3.2	0.60	0.70	0.016	695	13	0.018	17.02	0.42	4.01	4.24	10.9	10.9	3.94	6.73	10.6	21.1
F3	3	3.2	0.60	0.70	0.016	695	13	0.018	17.02	0.42	4.01	4.24	10.9	10.9	3.94	6.73	10.6	21.1
F2+F3	F3	3.2	0.60	0.70	0.016	0	0	0.250	23.70	0.30	1.92	12.37	0.0	11.8	3.81	6.51	16.2	32.5
F2+F3	3	4.5	0.60	0.70	0.016	260	0	0.025	23.70	0.30	1.92	12.37	11.0	11.8	3.81	6.51	16.2	32.5
OSF3+F1+F2+F3	OSF3+F1	2.9	0.54	0.64	0.016	40	1	0.020	38.53	0.53	6.55	5.88	4.7	6.0	4.92	8.48	0.9	1.9
OSF3+F1+F2+F3	3	7.4	0.58	0.68	0.016	220	6	0.027	38.53	0.53	6.55	5.88	4.7	6.0	4.92	8.48	0.9	1.9
F4	0	0.3	0.60	0.70	0.016	220	20	0.045	2.02	0.19	0.69	2.93	15.5	20.9	2.89	4.95	4.2	9.6
F4	3	0.3	0.60	0.70	0.016	220	20	0.045	2.02	0.19	0.69	2.93	15.5	20.9	2.89	4.95	4.2	9.6
OSF2	0	4.9	0.30	0.40	0.016	290	13	0.045	11.13	0.37	3.03	3.67	5.3	20.9	2.89	4.95	4.2	9.6
OSF2	3	4.9	0.30	0.40	0.016	1,170	19	0.016	11.13	0.37	3.03	3.67	21.9	23.1	2.74	4.69	2.5	6.0
F5	0	3.7	0.25	0.35	0.016	300	6	0.020	6.19	0.25	1.32	4.70	0.2	23.1	2.74	4.69	2.5	6.0
F5	3	3.7	0.25	0.35	0.016	65	3	0.046	6.19	0.25	1.32	4.70	0.2	23.1	2.74	4.69	2.5	6.0
F5	3	3.7	0.25	0.35	0.016	205	5	0.024	6.19	0.28	1.67	3.70	20.9	20.9	2.74	4.69	2.5	6.0
OSF2+F5	OSF2	4.9	0.30	0.40	0.016	310	3	0.010	18.49	1.70	8.72	2.12	2.4	24.1	2.87	4.58	6.4	14.8
OSF2+F5	1	8.6	0.28	0.38	0.013	380	4	0.010	18.49	0.97	2.35	7.88	0.8	11.8	3.72	6.36	19.3	39.9
OSF2+F5	4	7.4	0.58	0.68	0.016	260	8	0.031	18.49	0.97	2.35	7.88	11.8	12.4	3.72	6.36	19.3	39.9
OSF3+F1+F2+F3+F5	OSF3+F1+F2+F3	11.1	0.47	0.57	0.016	260	8	0.031	48.44	0.56	7.20	6.73	20.9	20.9	3.09	5.29	4.8	11.4
OSF3+F1+F2+F3+F5	3	4.9	0.30	0.40	0.016	310	3	0.010	48.44	0.56	7.20	6.73	20.9	20.9	3.09	5.29	4.8	11.4
OSF2+OSF3+F1+F2+F3+F5	OSF2	16.0	0.42	0.52	0.013	380	4	0.010	47.13	2.42	17.59	2.68	1.9	23.4	2.72	4.66	18.0	38.3
OSF2+OSF3+F1+F2+F3+F5	1	16.0	0.42	0.52	0.013	380	4	0.010	47.13	1.57	4.59	10.26	0.6	17.9	2.72	4.66	18.0	38.3
OSF2+OSF3+F1+F2+F3+F5	4	6.2	0.25	0.35	0.016	300	11	0.037	47.13	1.57	4.59	10.26	17.9	17.9	2.72	4.66	18.0	38.3
G1	0	6.2	0.25	0.35	0.016	90	3	0.033	11.55	0.33	2.38	4.85	0.3	18.3	3.09	5.29	4.8	11.4
G1	3	6.2	0.25	0.35	0.016	90	3	0.033	11.55	0.33	2.38	4.85	0.3	18.3	3.09	5.29	4.8	11.4
G1	4	6.2	0.25	0.35	0.013	80	18	0.225	11.55	0.36	0.56	20.46	0.1	18.3	3.09	5.29	4.8	11.4

\*Estimated using an initial 100 year intensity based on the corresponding Overland Time of Concentration.

\*\*Overland Time of Concentration, T<sub>c</sub> = 1.87 (1.1 - C<sub>s</sub>) L<sup>0.55</sup> S<sup>0.33</sup>

Channel Time of Concentration calculated using average flow velocities from Manning's formula.

M.V.E., Inc.  
Project No.:

60970

8/17/2013

Project: Hannah Ridge at Feathergrass - Final  
(Multi-Family & Commercial Parcels Undeveloped) 2-year for water quality

DEVELOPED CONDITIONS - CHANNEL CHARACTERISTICS

Channel Type	Channel Type or Number	Surface Pipe or Curb Type	Dimensions				Manning Rough. n
			Side Slopes (H:V) = 3	Side Slopes (H:V) = 3	Base Width (ft) = 20	Max Depth (ft) = 3	
Overland	0	---	Side Slopes (H:V) = 3	Side Slopes (H:V) = 3	Base Width (ft) = 20	Max Depth (ft) = 3	0.060
Triangular	1	Weeds	Side Slopes (H:V) = 3	Side Slopes (H:V) = 3	Base Width (ft) = 20	Max Depth (ft) = 3	0.060
Trapezoidal	2	Type 3	Road Cross Slope = 2%	Road Cross Slope = 2%	Diameter (in) = 48		0.016
Curb/Road	3	RCP					0.013
Circular	4						

DEVELOPED CONDITIONS - TIMES OF CONCENTRATION & DISCHARGES															
Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	2 Year Coef. C <sub>2</sub>	100 Yr. Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	2 Year Intensity I <sub>2</sub> (In/hr)	2 Year Discharge Q <sub>2</sub> (cfs)
OSA2	0	1.9	0.27	0.37	0.060	110	14	0.127	2.21	0.54	0.9	2.6	7.0	3.06	1.6
OSA2	1	1.9	0.27	0.37	0.060	350	23	0.066	2.21	0.54	0.9	2.6	7.0	3.06	1.6
A1	0	2.6	0.49	0.59	0.016	70	1	0.020	4.71	0.28	1.6	2.9	2.3	2.84	3.7
A1	3	2.6	0.49	0.59	0.016	660	10	0.015	4.71	0.28	1.6	2.9	5.8	2.84	3.7
A2	0	1.0	0.60	0.70	0.016	60	1	0.020	2.36	0.22	1.0	2.4	4.5	2.95	1.8
A2	3	1.0	0.60	0.70	0.016	660	10	0.015	2.36	0.22	1.0	2.4	11.3	2.95	1.8
A1+A2	A1	2.6	0.49	0.59	0.016	1	0	0.010	6.89	0.34	2.5	2.7	0.0	2.84	5.4
A1+A2	3	3.7	0.52	0.62	0.016	25	1	0.024	6.89	0.34	2.5	2.7	1.9	2.84	5.4
OSA3	0	0.3	0.83	0.88	0.016	265	5	0.020	2.06	0.20	0.8	2.6	1.7	3.71	0.8
OSA3	3	0.3	0.83	0.88	0.016	40	1	0.020	2.06	0.20	0.8	2.6	3.3	3.71	0.8
A3	0	0.3	0.75	0.81	0.016	375	22	0.059	2.19	0.17	0.5	4.0	1.6	3.71	0.8
A3	3	0.3	0.75	0.81	0.016	375	22	0.059	2.19	0.17	0.5	4.0	5.0	3.71	0.8
OSA3+A3	OSA3	0.6	0.78	0.84	0.016	420	25	0.059	4.25	0.21	0.9	4.7	1.5	3.45	1.5
OSA3+A3	3	0.6	0.78	0.84	0.016	420	25	0.059	4.25	0.21	0.9	4.7	11.4	3.45	1.5
A1+A2+OSA3+A3	A1+A2	3.7	0.52	0.62	0.016	0	0	0.025	8.31	0.31	2.1	4.0	0.0	2.84	6.7
A1+A2+OSA3+A3	3	4.2	0.56	0.65	0.016	36	1	0.022	8.31	0.31	2.1	4.0	2.5	2.84	6.7
A4	0	0.2	0.81	0.87	0.016	135	3	0.022	1.17	0.16	0.5	2.4	0.9	3.71	0.5
A4	3	0.2	0.81	0.87	0.016	135	3	0.022	1.17	0.16	0.5	2.4	11.4	3.71	0.5
A1+A2+OSA3+A3+A4	A1+A2+OSA3+A3	4.4	0.56	0.65	0.016	170	4	0.022	8.71	0.32	2.2	3.9	0.7	2.76	6.8
A1+A2+OSA3+A3+A4	3	4.4	0.57	0.66	0.016	36	1	0.022	8.71	0.32	2.2	3.9	3.2	2.76	6.8
A5	0	0.2	0.73	0.79	0.016	135	3	0.022	1.35	0.17	0.55	2.45	0.9	3.71	0.5
A5	3	0.2	0.73	0.79	0.016	135	3	0.022	1.35	0.17	0.55	2.45	12.1	3.71	0.5
A1+A2+OSA3+A3+A4+A5	A1+A2+OSA3+A3+A4	4.4	0.57	0.66	0.016	8	0	0.010	9.16	0.68	1.43	6.42	0.0	2.76	7.2
A1+A2+OSA3+A3+A4+A5	4	4.6	0.57	0.67	0.013	235	13	0.055	9.16	0.68	1.43	6.42	12.6	2.76	7.2
A6	0	3.9	0.33	0.43	0.060	220	2	0.009	4.20	0.43	4.8	0.9	4.2	2.39	3.1
A6	2	3.9	0.33	0.43	0.060	220	2	0.009	4.20	0.43	4.8	0.9	16.8	2.39	3.1
OSA2+A6	A6	3.9	0.33	0.43	0.060	0	0	0.250	5.98	0.11	2.2	2.8	0.0	2.39	4.3
OSA2+A6	2	5.9	0.31	0.41	0.060	65	1	0.020	5.98	0.11	2.2	2.8	6.8	2.39	4.3
B1	0	2.5	0.53	0.63	0.016	125	3	0.020	4.98	0.27	1.5	3.3	0.6	3.05	4.1
B1	3	2.5	0.53	0.63	0.016	500	20	0.040	4.98	0.24	1.2	4.2	2.0	3.05	4.1
B1	3	2.5	0.53	0.63	0.016	500	20	0.040	4.98	0.24	1.2	4.2	6.7	3.05	4.1
B2	0	1.1	0.60	0.70	0.016	80	2	0.020	2.40	0.21	0.9	2.7	1.0	3.00	2.0
B2	3	1.1	0.60	0.70	0.016	170	3	0.020	2.40	0.18	0.7	3.5	2.2	3.00	2.0
B1+B2	B2	1.1	0.60	0.70	0.016	460	19	0.040	2.40	0.18	0.7	3.5	9.9	3.00	2.0
B1+B2	3	3.6	0.55	0.65	0.016	0	0	0.250	7.41	0.20	0.8	9.3	0.0	3.00	6.0
B3	0	0.3	0.66	0.73	0.016	40	1	0.020	2.17	0.17	0.5	4.0	4.1	3.00	0.8
B3	3	0.3	0.66	0.73	0.016	370	22	0.059	2.17	0.17	0.5	4.0	1.5	3.59	0.8
B4	0	2.0	0.60	0.70	0.016	110	2	0.020	4.20	0.26	1.5	2.8	7.8	2.82	3.4
B4	3	2.0	0.60	0.70	0.016	630	10	0.015	4.20	0.26	1.5	2.8	11.5	2.82	3.4
B3+B4	B4	2.0	0.60	0.70	0.016	0	0	0.250	4.93	0.17	0.6	8.4	0.0	2.82	4.0
B3+B4	3	2.3	0.61	0.70	0.016	0	0	0.250	4.93	0.17	0.6	8.4	11.5	2.82	4.0
B1+B2+B3+B4	B3+B4	2.3	0.61	0.70	0.016	0	0	0.250	11.97	0.23	1.1	10.4	0.0	2.82	9.7
B1+B2+B3+B4	3	6.0	0.58	0.67	0.016	0	0	0.250	11.97	0.23	1.1	10.4	11.5	2.82	9.7
OSB1	0	0.6	0.84	0.89	0.016	25	1	0.024	5.06	0.28	1.7	3.0	1.8	3.61	1.9
OSB1	3	0.6	0.84	0.89	0.016	670	11	0.016	5.06	0.28	1.7	3.0	3.7	3.61	1.9
B5	0	0.5	0.64	0.72	0.016	110	3	0.027	1.18	0.15	0.4	3.0	0.6	3.36	1.1
B5	3	0.5	0.64	0.72	0.016	100	4	0.040	1.18	0.15	0.4	3.0	7.1	3.36	1.1
OSB1+B5	B5	0.5	0.64	0.72	0.016	0	0	0.250	2.96	0.15	0.4	7.4	0.0	3.36	1.1
OSB1+B5	3	1.2	0.75	0.81	0.016	0	0	0.250	2.96	0.15	0.4	7.4	7.1	3.36	1.1

Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	2 Year Coef. C <sub>2</sub>	100 Yr Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	2 Year Intensity I <sub>s</sub> (In/hr)	2 Year Discharge Q <sub>2</sub> (cfs)
B1+B2+B3+B4+OSB1+B5	B1+B2+B3+B4	6.0	0.58	0.67	0.016	0	0	0.250	14.77	0.25	1.3	11.0	11.5	11.5	2.82	12.1
B1+B2+B3+B4+OSB1+B5	B6	7.1	0.60	0.70	0.016	60	1	0.020	2.48	0.22	1.0	2.5	5.8	5.8	3.02	2.0
B1+B2+B3+B4+OSB1+B5	B6	1.1	0.60	0.70	0.016	580	9	0.015	17.03	0.37	3.0	5.7	11.5	11.5	2.81	13.9
B1+B2+B3+B4+OSB1+B5+B6	B1+B2+B3+B4+OSB1+B5	8.2	0.60	0.70	0.016	30	1	0.040	5.18	0.25	1.3	4.0	3.4	3.4	3.53	1.9
B1+B2+B3+B4+OSB1+B5+B6	B7	0.7	0.74	0.80	0.016	635	22	0.035	18.75	0.39	3.4	5.6	11.6	11.6	2.64	14.4
B1+B2+B3+B4+OSB1+B5+B6+B7	B1+B2+B3+B4+OSB1+B5+B6+B7	8.2	0.60	0.70	0.016	635	22	0.035	18.75	0.39	3.4	5.6	11.6	11.6	2.64	14.4
B1+B2+B3+B4+OSB1+B5+B6+B7	B8	8.9	0.61	0.71	0.016	160	3	0.020	1.01	0.16	0.46	2.20	3.4	3.4	3.71	0.4
B1+B2+B3+B4+OSB1+B5+B6+B7+B8	B1+B2+B3+B4+OSB1+B5+B6+B7+B8	9.0	0.62	0.71	0.013	8	0	0.010	19.08	0.98	2.40	7.95	13.5	13.5	2.63	14.7
B1+B2+B3+B4+OSB1+B5+B6+B7+B8	B9	6.2	0.38	0.59	0.060	300	6	0.020	7.61	0.29	6.0	1.3	18.6	18.6	2.08	4.9
OSC1		6.2	0.38	0.59	0.060	270	4	0.015	10.35	0.37	2.99	3.46	3.5	3.5	3.65	3.3
C1		3.4	0.26	0.36	0.060	100	26	0.260	13.94	0.25	1.28	10.85	8.7	8.7	2.67	8.2
C1		5.1	0.60	0.70	0.016	110	2	0.015	13.94	0.25	1.28	10.85	13.1	13.1	2.67	10.7
C1		5.1	0.60	0.70	0.016	915	13	0.015	13.94	0.25	1.28	10.85	13.1	13.1	2.67	10.7
OSC1+C1		8.6	0.47	0.57	0.016	0	0	0.250	1.98	0.19	0.74	2.68	5.2	5.2	3.15	1.6
OSC1+C1		0.8	0.60	0.70	0.016	40	1	0.015	1.98	0.19	0.74	2.68	3.4	3.4	3.15	1.6
C2		0.8	0.60	0.70	0.016	550	12	0.022	2.28	0.21	0.95	2.41	6.3	6.3	2.93	1.8
C2		1.0	0.60	0.70	0.016	600	9	0.020	2.80	0.18	0.68	4.13	12	12	2.90	2.5
C3		1.4	0.60	0.70	0.016	290	16	0.055	5.43	0.29	1.84	2.95	7.5	7.5	2.95	4.5
C4		1.4	0.60	0.70	0.016	165	7	0.042	1.61	0.15	0.45	3.60	6.5	6.5	3.17	1.4
C5		2.6	0.60	0.70	0.016	495	7	0.015	1.88	0.20	0.81	2.32	6.3	6.3	2.99	1.5
C5		0.7	0.60	0.70	0.016	65	1	0.015	1.57	0.17	0.57	2.76	8.8	8.8	3.13	1.3
C6		0.7	0.60	0.70	0.016	420	23	0.055	4.89	0.28	1.68	2.91	1.1	1.1	2.75	4.0
C7		0.8	0.60	0.70	0.016	60	1	0.015	4.89	0.28	1.68	2.91	2.2	2.2	2.75	4.0
C7		0.8	0.60	0.70	0.016	500	8	0.015	4.89	0.25	1.35	3.61	10.9	10.9	2.78	3.6
C8		0.7	0.60	0.70	0.016	65	1	0.015	4.35	0.23	1.07	4.07	9.0	9.0	2.82	3.6
C8		0.7	0.60	0.70	0.016	365	10	0.027	4.29	0.27	1.52	2.82	2.5	2.5	2.82	3.6
C9		2.4	0.60	0.70	0.016	115	2	0.015	3.28	0.24	1.25	2.63	6.3	6.3	2.82	3.6
C9		2.4	0.60	0.70	0.016	200	3	0.015	3.28	0.24	1.25	2.63	3.8	3.8	2.97	2.6
C9		2.4	0.60	0.70	0.016	485	13	0.027	4.44	0.17	0.54	8.19	10.7	10.7	2.90	4.0
C9		2.4	0.60	0.70	0.016	300	16	0.053	7.60	0.20	0.81	9.34	10.3	10.3	2.95	6.3
C10		2.5	0.52	0.66	0.016	265	11	0.040	11.41	0.76	1.67	6.84	10.7	10.7	2.89	10.2
C10		2.5	0.52	0.66	0.016	165	4	0.024	25.76	1.15	2.97	8.67	13.1	13.1	2.84	19.8
C11		2.2	0.60	0.70	0.016	430	7	0.015	5.70	0.18	0.65	8.71	12.0	12.0	2.78	4.8
C11		1.5	0.60	0.70	0.016	60	1	0.015	5.70	0.18	0.65	8.71	6.3	6.3	2.82	2.6
C12		1.5	0.60	0.70	0.016	600	9	0.015	3.28	0.24	1.25	2.63	10.7	10.7	2.90	4.0
C2+C4+C3+C5	C2+C4	1.4	0.60	0.70	0.016	0	0	0.250	4.44	0.17	0.54	8.19	0.0	0.0	2.90	4.0
C2+C4+C3+C5	C3+C5	2.3	0.60	0.70	0.016	0	0	0.250	7.60	0.20	0.81	9.34	0.0	0.0	2.95	6.3
OSC1+C1+C2+C4+C3+C5	OSC1+C1	5.9	0.60	0.70	0.013	28	0	0.010	11.41	0.76	1.67	6.84	10.7	10.7	2.89	10.2
OSC1+C1+C2+C4+C3+C5	C10	14.4	0.52	0.62	0.013	230	2	0.010	25.76	1.15	2.97	8.67	13.1	13.1	2.84	19.8
OSC1+C1+C2+C4+C3+C5	C9	2.5	0.52	0.66	0.016	0	0	0.250	5.70	0.18	0.65	8.71	12.0	12.0	2.78	4.8
OSC1+C1+C2+C4+C3+C5	C8	3.2	0.53	0.67	0.016	0	0	0.250	5.70	0.18	0.65	8.71	12.2	12.2	2.75	5.2
OSC1+C1+C2+C4+C3+C5	C8+C9	2.4	0.60	0.70	0.016	0	0	0.250	6.32	0.19	0.71	8.93	11.5	11.5	2.82	5.1
OSC1+C1+C2+C4+C3+C5	C11	2.2	0.60	0.70	0.016	0	0	0.250	5.96	0.18	0.68	8.80	12.2	12.2	2.82	5.1
OSC1+C1+C2+C4+C3+C5	C7+C11	3.0	0.60	0.70	0.016	0	0	0.250	12.31	0.39	3.34	3.69	14.3	14.3	2.57	9.5
OSC1+C1+C2+C4+C3+C5	C8+C9	3.2	0.60	0.70	0.016	475	7	0.015	12.31	0.39	3.34	3.69	14.3	14.3	2.57	9.5
OSC1+C1+C2+C4+C3+C5	C8+C9+C7+C11	6.1	0.60	0.70	0.016	0	0	0.010	18.49	0.48	5.33	3.47	14.3	14.3	2.57	13.9
OSC1+C1+C2+C4+C3+C5	C8+C9+C7+C11	9.4	0.58	0.69	0.016	0	0	0.010	44.10	0.66	10.23	4.31	14.3	14.3	2.57	33.1
OSC1+C1+C2+C4+C3+C5	C8+C9+C7+C11	23.8	0.54	0.65	0.016	0	0	0.010	47.05	1.57	4.59	10.25	14.3	14.3	2.57	35.3
OSC1+C1+C2+C4+C3+C5	C8+C9+C7+C11	25.3	0.54	0.65	0.013	62	1	0.010	47.05	1.57	4.59	10.25	14.4	14.4	2.56	35.3



OSC1+C1+C2+C4+C3+C5  
OSC1+C1+C2+C4+C3+C5  
OSC1+C1+C2+C4+C3+C5  
OSC1+C1+C2+C4+C3+C5  
OSC1+C1+C2+C4+C3+C5



Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	2 Year Coef. C <sub>2</sub>	100 Yr. Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev. Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	2 Year Intensity I <sub>2</sub> (in/hr)	2 Year Discharge Q <sub>2</sub> (cfs)	
D1	0	2.1	0.60	0.70	0.16	90	2	0.020	4.47	0.22	1.00	4.45	7.1	9.4	3.05	3.8	
D1	3	2.1	0.60	0.70	0.16	630	31	0.050	4.47	0.22	1.00	4.45	2.4	9.4	3.05	3.8	
D2	0	1.2	0.60	0.70	0.16	75	2	0.020	2.64	0.18	0.67	3.92	6.4	9.4	3.06	2.2	
D2	3	1.2	0.60	0.70	0.16	685	34	0.050	2.64	0.18	0.67	3.92	2.9	9.4	3.06	2.2	
D1+D2	D1	2.1	0.60	0.70	0.16	0	0	0.020	7.04	0.20	0.77	9.17	9.4	0.0	9.4	3.05	6.0
D1+D2	3	3.3	0.60	0.70	0.16	40	1	0.020	7.04	0.20	0.77	9.17	3.3	9.4	3.05	6.0	
D3	0	0.3	0.75	0.81	0.16	320	20	0.063	1.90	0.16	0.48	3.94	7.4	5.0	3.71	0.7	
D3	3	0.3	0.75	0.81	0.16	100	2	0.020	1.90	0.16	0.48	3.94	7.4	5.0	3.71	0.7	
D4	0	2.2	0.60	0.70	0.16	545	22	0.040	4.72	0.23	1.13	4.18	2.2	10.6	2.91	3.9	
D4	3	2.2	0.60	0.70	0.16	195	4	0.020	4.72	0.26	1.47	3.21	1.0	10.6	2.91	3.9	
D4	D4	2.2	0.60	0.70	0.16	0	0	0.020	5.36	0.18	0.63	8.58	10.6	0.0	10.6	2.91	4.4
D3+D4	3	2.5	0.62	0.71	0.16	0	0	0.020	5.36	0.18	0.63	8.58	10.6	0.0	10.6	2.91	4.4
D1+D2+D3+D4	D3+D4	2.5	0.62	0.71	0.16	0	0	0.020	12.28	0.24	1.17	10.52	0.0	10.6	2.91	10.1	
D1+D2+D3+D4	3	5.7	0.61	0.71	0.16	140	6	0.043	12.28	0.24	1.17	10.52	7.2	10.6	2.91	10.1	
D5	0	0.7	0.57	0.66	0.16	310	13	0.040	1.49	0.16	0.47	3.15	10.6	8.8	3.12	1.3	
D5	3	0.7	0.57	0.66	0.16	0	0	0.020	1.49	0.16	0.47	3.15	10.6	8.8	3.12	1.3	
D1+D2+D3+D4+D5	D1+D2+D3+D4	5.7	0.61	0.71	0.16	0	0	0.020	13.76	0.25	1.27	10.82	0.0	10.6	2.91	11.4	
D1+D2+D3+D4+D5	3	6.5	0.60	0.70	0.16	60	1	0.013	13.76	0.25	1.27	10.82	6.6	10.6	2.91	11.4	
D6	0	1.3	0.60	0.70	0.16	535	22	0.040	2.89	0.20	0.78	3.70	2.4	10.2	2.96	2.3	
D6	3	1.3	0.60	0.70	0.16	210	4	0.020	2.89	0.22	1.01	2.87	1.2	10.2	2.96	2.3	
D6	D6	1.3	0.60	0.70	0.16	0	0	0.020	16.54	0.36	2.91	5.68	10.6	10.7	2.90	13.6	
D1+D2+D3+D4+D5+D6	D1+D2+D3+D4+D5	7.8	0.60	0.70	0.16	35	1	0.040	16.54	0.36	2.91	5.68	0.1	10.7	2.90	13.6	
D1+D2+D3+D4+D5+D6	3	4.0	0.60	0.70	0.16	140	2	0.015	16.54	0.36	2.91	5.68	9.7	10.7	2.90	13.6	
D7	0	4.0	0.60	0.70	0.16	475	19	0.040	7.66	0.28	1.64	4.88	1.7	12.8	2.70	6.4	
D7	3	4.0	0.60	0.70	0.16	270	4	0.015	7.66	0.33	3.23	3.23	1.4	12.8	2.70	6.4	
D7	D7	4.0	0.60	0.70	0.16	0	0	0.020	22.75	0.29	1.86	12.25	0.0	12.8	2.70	19.1	
D1+D2+D3+D4+D5+D6+D7	D7	11.7	0.60	0.70	0.16	0	0	0.020	22.75	0.29	1.86	12.25	0.0	12.8	2.70	19.1	
D1+D2+D3+D4+D5+D6+D7	3	0.9	0.50	0.58	0.16	40	1	0.020	1.63	0.17	0.54	3.02	3.2	8.8	3.12	1.3	
D9	0	0.9	0.50	0.58	0.16	585	20	0.034	1.63	0.17	0.54	3.02	3.2	8.8	3.12	1.3	
D9	3	0.9	0.50	0.58	0.16	300	11	0.036	1.63	0.17	0.54	3.02	10.7	11.6	2.81	14.4	
D1+D2+D3+D4+D5+D6+D9	D1+D2+D3+D4+D5+D6	7.8	0.60	0.70	0.16	0	0	0.020	18.05	0.38	3.23	5.88	12.8	12.8	2.70	20.2	
D1+D2+D3+D4+D5+D6+D9	3	11.7	0.60	0.70	0.16	0	0	0.020	18.05	0.38	3.23	5.88	12.8	12.8	2.70	20.2	
D1+D2+D3+D4+D5+D6+D7+D9	D1+D2+D3+D4+D5+D6+D7	12.6	0.59	0.69	0.16	0	0	0.020	24.12	0.30	1.94	12.43	0.0	12.8	2.70	20.2	
D1+D2+D3+D4+D5+D6+D7+D9	3	3.1	0.60	0.70	0.16	120	1	0.010	24.12	0.30	1.94	12.43	0.0	12.8	2.70	20.2	
D8	0	3.1	0.60	0.70	0.16	450	18	0.040	5.80	0.25	1.32	4.38	1.7	13.4	2.64	4.9	
D8	3	3.1	0.60	0.70	0.16	270	4	0.015	5.80	0.30	1.92	3.02	1.5	13.4	2.64	4.9	
D10	0	0.4	0.60	0.70	0.16	32	1	0.020	2.33	0.21	0.87	2.88	4.2	6.2	3.49	0.8	
D10	3	0.4	0.60	0.70	0.16	330	7	0.020	2.33	0.21	0.87	2.88	2.1	6.2	3.49	0.8	
D8+D10	D8	3.1	0.60	0.70	0.16	0	0	0.020	6.51	0.19	0.72	8.99	13.4	13.4	2.64	5.4	
D8+D10	3	3.4	0.60	0.70	0.16	210	4	0.019	6.51	0.19	0.72	8.99	0.0	13.4	2.64	5.4	
D11	0	1.3	0.38	0.47	0.16	95	1	0.015	1.36	0.18	0.65	2.10	15.9	16.6	2.40	1.2	
D11	3	1.3	0.38	0.47	0.16	0	0	0.015	1.36	0.18	0.65	2.10	0.8	16.6	2.40	1.2	
D1+D2+D3+D4+D5+D6+D9+D11	D1+D2+D3+D4+D5+D6+D9	8.6	0.59	0.69	0.16	130	2	0.015	19.88	0.46	4.78	4.16	11.6	12.1	2.76	15.5	
D1+D2+D3+D4+D5+D6+D9+D11	3	9.9	0.56	0.66	0.16	0	0	0.015	19.88	0.46	4.78	4.16	12.8	12.1	2.76	15.5	
D1+D2+D3+D4+D5+D6+D7+D9+D11	D1+D2+D3+D4+D5+D6+D7+D9	12.6	0.59	0.69	0.16	140	2	0.015	25.79	0.50	5.87	4.39	0.5	13.3	2.65	21.2	
D1+D2+D3+D4+D5+D6+D7+D9+D11	3	13.9	0.57	0.67	0.16	85	3	0.035	25.79	0.50	5.87	4.39	5.1	13.3	2.65	21.2	
D12	0	0.5	0.65	0.72	0.16	130	2	0.015	1.27	0.18	0.60	2.10	13.4	6.1	3.51	1.2	
D12	3	0.5	0.65	0.72	0.16	0	0	0.015	1.27	0.18	0.60	2.10	13.4	6.1	3.51	1.2	
D8+D10+D12	D8+D10	3.4	0.60	0.70	0.16	130	2	0.015	7.52	0.32	2.30	3.26	0.7	14.1	2.59	6.2	
D8+D10+D12	3	4.0	0.61	0.70	0.16	0	0	0.015	7.52	0.32	2.30	3.26	14.1	14.1	2.59	6.2	
D1+D2+D3+D4+D5+D6+D7+D9+D11+D8+D10+D12	D8+D10+D12	4.0	0.61	0.70	0.16	42	0	0.005	32.77	1.54	4.46	7.34	0.1	14.2	2.58	26.7	
D1+D2+D3+D4+D5+D6+D7+D9+D11+D8+D10+D12	4	17.8	0.58	0.68	0.16	65	1	0.015	32.77	1.54	4.46	7.34	6.5	14.2	2.58	26.7	
E1	0	1.2	0.60	0.70	0.16	615	11	0.018	2.72	0.22	1.01	2.88	8.5	10.4	2.94	2.2	
E1	3	1.2	0.60	0.70	0.16	130	3	0.020	2.72	0.22	1.01	2.88	8.5	10.4	2.94	2.2	
E2	0	2.8	0.60	0.70	0.16	580	11	0.020	5.69	0.28	1.70	3.94	2.9	11.4	2.83	4.8	
E2	3	2.8	0.60	0.70	0.16	0	0	0.020	5.69	0.28	1.70	3.94	11.4	11.4	2.83	4.8	
E1+E2	E1+E2	4.0	0.60	0.70	0.16	0	0	0.020	8.19	0.21	0.86	9.52	6.3	11.4	2.83	6.9	
E3	0	1.0	0.60	0.70	0.16	60	1	0.015	2.17	0.20	0.82	2.66	11.4	9.6	3.03	1.8	
E3	3	1.0	0.60	0.70	0.16	515	10	0.020	2.17	0.20	0.82	2.66	11.4	9.6	3.03	1.8	
E1+E2+E3	E1+E2	4.0	0.60	0.70	0.16	0	0	0.020	10.16	0.22	1.01	10.04	0.0	11.4	2.83	8.5	
E1+E2+E3	3	5.0	0.60	0.70	0.16	125	3	0.020	10.16	0.22	1.01	10.04	8.3	11.4	2.83	8.5	
E4	0	2.7	0.60	0.70	0.16	500	11	0.023	5.61	0.27	1.59	3.52	2.4	10.7	2.91	4.8	
E4	3	2.7	0.60	0.70	0.16	0	0	0.023	5.61	0.27	1.59	3.52	10.7	10.7	2.91	4.8	

Basin Label	Channel Type or Basin	Cont. Area A <sub>c</sub> (Ac)	2 Year Coef. C <sub>2</sub>	100 Yr. Coef. or Curve No. C <sub>100</sub> or CN	Manning Rough. n	Length L (ft)	Elev. Change (ft)	Average Slope S	Channel Flow* Q (cfs)	Flow Depth d (ft)	Flow Area A (ft <sup>2</sup> )	Flow Velocity v (ft/s)	Time of Cont** T <sub>c</sub> (min)	Total Time T <sub>c</sub> (min)	2 Year Intensity I <sub>2</sub> (in/hr)	2 Year Discharge Q <sub>2</sub> (cfs)
E1+E2+E3+E4	E1+E2+E3	5.0	0.60	0.70	0.016	295	8	0.025	15.73	0.38	3.32	4.73	11.4	12.4	2.73	12.7
E1+E2+E3+E4	E5	7.7	0.60	0.70	0.016	60	1	0.015	2.01	0.19	0.73	2.76	6.3	9.1	3.09	1.7
E1+E2+E3+E4+E5	E1+E2+E3+E4	7.7	0.60	0.70	0.016	460	11	0.023	17.56	0.27	1.53	11.49	12.4	12.4	2.73	14.2
E1+E2+E3+E4+E5	E6	8.6	0.60	0.70	0.016	105	0	0.029	3.94	0.26	1.45	2.73	6.8	10.3	2.95	3.2
E6	E7	1.8	0.60	0.70	0.016	575	8	0.015	3.40	0.24	1.17	2.91	14.1	16.2	2.43	2.4
E7	E8	2.3	0.43	0.61	0.016	365	7	0.019	6.38	0.29	1.88	3.39	16.2	16.2	2.43	5.0
E6+E7	E4+E5	2.7	0.60	0.70	0.016	0	0	0.019	7.45	0.20	0.80	9.30	10.7	10.7	2.91	6.3
E4+E5	E4+E5+E7	3.6	0.60	0.70	0.016	0	0	0.025	11.64	0.35	2.67	4.37	10.7	11.1	2.87	9.1
E4+E5+E7	E1+E2+E3+E4+E5	6.0	0.53	0.67	0.016	100	3	0.025	21.72	0.51	6.01	3.61	12.4	12.9	2.69	16.6
E1+E2+E3+E4+E5+E7	E8	8.6	0.60	0.70	0.016	100	1	0.030	4.10	0.24	1.21	3.39	4.1	7.1	3.36	1.3
E1+E2+E3+E4+E5+E7	E9	0.7	0.60	0.70	0.016	610	16	0.025	18.88	0.98	2.38	7.93	12.4	12.5	2.72	15.2
E1+E2+E3+E4+E5+E7	E1+E2+E3+E4+E5	8.6	0.60	0.70	0.013	50	1	0.010	5.79	0.28	1.66	3.49	21.9	21.9	1.95	4.2
E1+E2+E3+E4+E5+E7	E3	8.6	0.25	0.35	0.016	300	6	0.020	5.79	0.55	1.03	5.60	2.6	26.0	3.71	0.5
E3	E9	8.6	0.25	0.35	0.013	170	2	0.010	5.04	0.28	1.62	3.10	3.6	5.0	2.78	4.0
E9	OSF3	0.5	0.25	0.35	0.016	110	2	0.020	5.58	0.18	0.64	8.66	11.9	11.9	2.78	4.4
OSF3	F1	2.4	0.60	0.70	0.016	765	13	0.018	9.20	0.21	0.94	9.79	0.0	11.6	2.81	7.5
F1	OSF3+F1	2.4	0.60	0.70	0.016	0	0	0.250	14.93	0.38	3.22	4.64	6.3	10.5	2.93	2.2
OSF3+F1	F2	2.9	0.54	0.64	0.016	60	1	0.015	6.61	0.30	1.97	3.35	8.2	8.2	2.81	5.4
OSF3+F1	F3	1.3	0.60	0.70	0.016	670	12	0.018	9.20	0.21	0.94	9.79	11.9	11.9	2.81	7.5
F2	F3	3.2	0.60	0.70	0.016	140	4	0.025	14.93	0.38	3.22	4.64	6.3	10.5	2.93	2.2
F3	F2+F3	3.2	0.60	0.70	0.016	695	13	0.018	9.20	0.21	0.94	9.79	11.9	11.9	2.81	7.5
F2+F3	OSF3+F1	4.5	0.60	0.70	0.016	0	0	0.250	14.93	0.38	3.22	4.64	6.3	10.5	2.93	2.2
F2+F3	OSF3+F1+F2+F3	2.9	0.54	0.64	0.016	260	7	0.025	9.20	0.21	0.94	9.79	11.9	11.9	2.81	7.5
OSF3+F1	OSF3+F1+F2+F3	7.4	0.58	0.68	0.016	40	1	0.020	14.93	0.38	3.22	4.64	6.3	10.5	2.93	2.2
OSF3+F1+F2+F3	F4	0.3	0.60	0.70	0.016	220	6	0.027	2.02	0.19	0.69	2.93	15.5	15.5	3.54	0.7
F4	F4	0.3	0.60	0.70	0.016	290	13	0.045	4.41	0.27	1.51	2.92	6.7	22.2	2.07	3.0
F4	OSF2	4.9	0.30	0.40	0.016	1,170	19	0.016	4.41	0.27	1.51	2.92	6.7	22.2	2.07	3.0
OSF2	OSF2	4.9	0.30	0.40	0.016	300	6	0.020	2.46	0.18	0.66	3.74	21.9	21.9	2.02	1.9
OSF2	OSF2+F5	3.7	0.25	0.35	0.016	65	3	0.046	2.46	0.20	0.84	2.94	22.2	22.2	2.02	1.9
OSF2+F5	OSF2+F5	3.7	0.25	0.35	0.016	205	5	0.024	7.33	1.21	4.36	1.68	3.1	26.3	1.89	4.5
OSF2+F5	OSF3+F1+F2+F3+F5	8.6	0.28	0.38	0.060	310	3	0.010	7.33	1.21	4.36	1.68	3.1	26.3	1.89	4.5
OSF3+F1+F2+F3+F5	OSF3+F1+F2+F3+F5	8.6	0.28	0.38	0.013	380	4	0.010	7.33	0.61	1.22	6.00	1.1	26.3	1.89	4.5
OSF3+F1+F2+F3+F5	OSF3+F1+F2+F3+F5	11.1	0.47	0.57	0.016	260	8	0.031	18.77	0.40	3.53	5.31	12.8	13.7	2.62	13.6
OSF3+F1+F2+F3+F5	OSF3+F1+F2+F3+F5	11.1	0.47	0.57	0.016	35	0	0.010	19.44	0.99	2.43	8.00	13.7	13.7	2.62	14.0
OSF3+F1+F2+F3+F5	OSF2	4.9	0.30	0.40	0.013	35	0	0.010	19.44	0.99	2.43	8.00	13.7	13.7	2.62	14.0
OSF2	OSF2+OSF3+F1+F2+F3+F5	16.0	0.42	0.52	0.060	310	3	0.010	18.68	1.71	8.79	2.13	2.4	25.5	1.93	12.8
OSF2+OSF3+F1+F2+F3+F5	OSF2+OSF3+F1+F2+F3+F5	16.0	0.42	0.52	0.013	380	4	0.010	18.68	0.97	2.36	7.90	2.4	25.5	1.93	12.8
OSF2+OSF3+F1+F2+F3+F5	G1	6.2	0.25	0.35	0.016	300	11	0.037	4.59	0.24	1.19	3.86	17.9	17.9	2.28	3.5
OSF2+OSF3+F1+F2+F3+F5	G1	6.2	0.25	0.35	0.016	90	3	0.033	4.59	0.24	1.19	3.86	17.9	17.9	2.28	3.5
G1	G1	6.2	0.25	0.35	0.013	80	18	0.225	4.59	0.23	0.30	15.47	0.1	18.4	2.28	3.5

\*Estimated using an initial 100 year intensity based on the corresponding Overland Time of Concentration.

\*\*Overland Time of Concentration, T<sub>c</sub> = 1.87 (1.1 - C<sub>2</sub>) L<sup>0.5</sup> S<sup>0.33</sup>

Channel Time of Concentration calculated using average flow velocities from Manning's formula.

**Hydrologic Analysis  
HEC-1**

**East Fork Sand Creek Tributary 6**

**(Excerpts from DBPS Amendment by Kiowa Engineers)**



**HYDROLOGY ANALYSIS  
EAST FORK SAND CREEK  
TRIBUTARY 6**

**EL PASO COUNTY, COLORADO**

Prepared for

Mr. Chuck Crum

MVE, Inc.

1903 Lelaray Street Suite 200

Colorado Springs, Colorado 80909

Prepared by

Kiowa Engineering Corporation

1604 South 21<sup>st</sup> Street

Colorado Springs, Colorado 80904

Project number 06040

August 31, 2006

Revised December 15, 2006

Revised January 18, 2007

**Hydrologic Analysis  
HEC-1**

**Main Line Tributary 6  
Existing Condition Input/Output Data (Kiowa Eng)**

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*****
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* JUN 1998 *
* VERSION 4.1 *
* RUN DATE 04SEP07 TIME 11:53:45 *
*****

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*****
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
* 609 SECOND STREET *
* DAVIS, CALIFORNIA 95616 *
* (916) 756-1104 *
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— Full Reach Existing Condition with undeveloped Hannam Ridge —  
*Kiewit Engineering 9/24/07*

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

LINE	ID	HEC-1 INPUT
1	ID	East Fork Subtributary hydrology PN: 06040
2	ID	Existing devel condition with storage at RR Embankment
3	ID	Sand Creek DBPS Hydrology update
4	ID	Existing culvert under RR in-place and no blockage
5	ID	10- and 100 Year, 24 hr Type IIA Storm FN efstd.dat
6	*DIAGRAM	
7	IT	5 0 0 300
8	IO	5 0
9	JR	PREC .68 1.0
10	KK	5
11	KM	RUNOFF - sub-basin 5
12	BA	.20
13	IN	15



53 RS 1 ELEV 83  
 54 SQ 0 75 325 480 575 675 775 850  
 55 SE 83 86 90 92 94 96 98 100  
 56 SV 0 .4 .8 1.7 4.6 8.9 17.6 31.6

57 KK RT-2B  
 58 KM  
 59 RD 2650 .005 .025 TRAP 1.6 4

60 KK 3  
 61 KM RUNOFF FROM SUB-BASIN 3  
 62 BA .164  
 63 LS 0 74.9  
 64 UD .12

65 KK RT-3A  
 66 KM  
 67 RD 1300 .02 .013 CIRC 3.5

68 KK RT-3  
 69 KM  
 70 RD 500 .02 .013 CIRC 5

71 KK 4  
 72 KM RUNOFF FROM SUB-BASIN 4  
 73 BA .147  
 74 LS 0 69  
 75 UD .144

76 KK DP-4A  
 77 KM  
 78 HC 3 COMBINE RUNOFF FROM RT-3, RT-2B AND SB 4

79 KK RT-2A  
 80 KM  
 81 RD 1200 .007 .035 TRAP 30 3  
 HEC-1 INPUT

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

82 KK 12  
 83 KM RUNOFF FROM SUB-BASIN 12  
 84 BA .053  
 85 LS 0 69  
 86 UD .058

87 KK 13  
 88 KM RUNOFF FROM SUB-BASIN 13  
 89 BA .047  
 90 LS 0 69  
 91 UD .06

H.R. SITE

H.R. SITE

H.R. SITE



3 COMBINED AT	DP-8	1.08	1	FLOW TIME	392.6.42	856.6.17						
ROUTED TO	RT-6A	1.08	1	FLOW TIME	390.6.42	852.6.17						
ROUTED TO	RT6	1.08	1	FLOW TIME	385.6.42	835.6.17						
HYDROGRAPH AT	6	.12	1	FLOW TIME	144.6.00	269.6.00						
2 COMBINED AT	DP -6	1.20	1	FLOW TIME	410.6.42	1004.6.17						
ROUTED TO	RT-7	1.20	1	FLOW TIME	402.6.50	993.6.25						
HYDROGRAPH AT	7	.17	1	FLOW TIME	69.6.17	174.6.17						
2 COMBINED AT	DP-7	1.37	1	FLOW TIME	429.6.50	1151.6.17						
ROUTED TO	RT-8	1.37	1	FLOW TIME	444.6.50	1144.6.42						
HYDROGRAPH AT	9	.14	1	FLOW TIME	72.6.25	159.6.17						
HYDROGRAPH AT	11	.15	1	FLOW TIME	134.6.08	275.6.00						
ROUTED TO	DB11	.15	1	FLOW TIME	52.6.25	56.6.33						

EXISTING CONDITION  
CONSTITUTION CURVE

\*\* PEAK STAGES IN FEET \*\*  
1 STAGE 6443.93 6446.82  
TIME 6.25 6.33

**Hydrologic Analysis  
HEC-1**

**Main Line Tributary 6  
DBPS Developed Condition Input/Output Data (Kiowa Eng)**



```

*****
*
* FLOOD HYDROGRAPH PACKAGE (HEC-1)
* JUN 1998
* VERSION 4.1
*
* RUN DATE 24MAY13 TIME 15:09:53
*
*****
*
* U.S. ARMY CORPS OF ENGINEERS
* HYDROLOGIC ENGINEERING CENTER
* 609 SECOND STREET
* DAVIS, CALIFORNIA 95616
* (916) 756-1104
*
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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

LINE	ID	HEC-1 INPUT
1	ID	East Fork Subtributary Hydrology PN: 60970
2	ID	Future developed condition (onsite and offsite) with storage at RR Emban
3	ID	Existing RR culvert in place and no blockage.
4	ID	5 yr, 10 yr and 100 Year, 24 hr Typee IIA Storm FN efscdv.dat
5	IT	5 0 0 300
6	IO	5 0
7	JR	PREC .59 .68 1.0
8	KK	5
9	KM	RUNOFF - Sub-basin 5
10	BA	.20
11	IN	15
12	PB	4.4
13	PC	0.0000 0.0005 0.0015 0.0030 0.0045 0.0060 0.0080 0.0100 0.0120 0.0143
14	PC	0.0165 0.0188 0.0210 0.0233 0.0255 0.0278 0.0320 0.0390 0.0460 0.0530
15	PC	0.0600 0.0750 0.1000 0.4000 0.7000 0.7250 0.7500 0.7650 0.7800 0.7900

LINE	ID	RD	2650	.005	.025	TRAP	16	4
58		RD	2650	.005	.025	TRAP	16	4
59		KK	3					
60		KM						
61		BA	.164					
62		LS	0	74.9				
63		UD	0.12					
64		KK	RT-3A					
65		KM						
66		RD	1300	.02	.013	CIRC	3.5	
67		KK	RT-3					
68		KM						
69		RD	500	.02	.013	CIRC	5	
70		KK	4					
71		KM						
72		BA	.147					
73		LS	0	83.5				
74		UD	0.144					
75		KK	DP-4A					
76		KM						
77		HC	3					
78		KK	RT-2A					
79		KM						
80		RD	1200	.007	.035	TRAP	30	3
81		KK	12					
82		KM						
83		BA	.053					
84		LS	0	92				
85		UD	0.058					
						HEC-1 INPUT		
		ID	1	2	3	4	5	6
			7	8	9	10		
86		KK	13					
87		KM						
88		BA	.047					
89		LS	0	88.5				
90		UD	0.06					
91		KK	DP-8					
92		KM						
93		HC	3					
94		KK	RT-6A					
95		KM						
96		RD	600	.02	.03	TRAP	2	3
97		KK	RT-6					

H.R. (

H.R. (

H.R. (

TIME 6.08 6.08 6.00

ROUTED TO

+ RT-5A .20 1 FLOW 108. 151. 322. 6.08 6.08 6.08

ROUTED TO

+ RT-5 .20 1 FLOW 104. 142. 313. 6.17 6.17 6.08

HYDROGRAPH AT

+ 1 .14 1 FLOW 86. 117. 242. 6.08 6.08 6.00

2 COMBINED AT

+ DP-1 .34 1 FLOW 180. 255. 551. 6.08 6.08 6.08

ROUTED TO

+ RT-1 .34 1 FLOW 170. 245. 518. 6.33 6.25 6.25

HYDROGRAPH AT

+ 2 .32 1 FLOW 145. 207. 467. 6.08 6.08 6.08

2 COMBINED AT

+ DP-14 (12) .66 1 FLOW 261. 374. 915. 6.25 6.25 6.17

Flow to CURVE

ROUTED TO

+ DB-14 (out) .66 1 FLOW 250. 360. 640. 6.25 6.25 6.33

out O/S Side

\*\* PEAK STAGES IN FEET \*\*

1 STAGE 88.80 90.45 95.31 6.25 6.25 6.33

ROUTED TO

+ RT-2B .66 1 FLOW 245. 352. 636. 6.42 6.33 6.42

HYDROGRAPH AT

+ 3 .16 1 FLOW 93. 130. 283. 6.00 6.00 6.00

ROUTED TO

+ RT-3A .16 1 FLOW 92. 126. 273. 6.08 6.08 6.00

ROUTED TO

+ RT-3 .16 1 FLOW 91. 126. 270. 6.08 6.08 6.00

HYDROGRAPH AT

+		4	.15	1	FLOW TIME	139. 6.08	179. 6.00	333. 6.00
+	3 COMBINED AT	DP-4A	.98	1	FLOW TIME	289. 6.42	428. 6.33	991. 6.08
+	ROUTED TO	RT-2A	.98	1	FLOW TIME	288. 6.42	425. 6.33	948. 6.17
+	HYDROGRAPH AT	12	.05	1	FLOW TIME	90. 6.00	107. 6.00	168. 6.00
+	HYDROGRAPH AT	13	.05	1	FLOW TIME	70. 6.00	85. 6.00	139. 6.00
+	3 COMBINED AT	DP-8	1.08	1	FLOW TIME	342. 6.00	457. 6.00	1076. 6.08
+	ROUTED TO	RT-6A	1.08	1	FLOW TIME	328. 6.00	448. 6.08	1069. 6.08
+	ROUTED TO	RT-6	1.08	1	FLOW TIME	326. 6.08	447. 6.08	1044. 6.08
+	HYDROGRAPH AT	6	.12	1	FLOW TIME	111. 6.00	144. 6.00	269. 6.00
+	2 COMBINED AT	DP-6	1.20	1	FLOW TIME	437. 6.08	588. 6.08	1299. 6.08
+	ROUTED TO	RT-7	1.20	1	FLOW TIME	419. 6.17	570. 6.17	1296. 6.17
+	HYDROGRAPH AT	7	.17	1	FLOW TIME	92. 6.17	125. 6.17	255. 6.17
+	2 COMBINED AT	DP-7	1.37	1	FLOW TIME	511. 6.17	695. 6.17	1551. 6.17
+	ROUTED TO	RT-8	1.37	1	FLOW TIME	552. 6.42	685. 6.42	1481. 6.42

*CONSTITUTION CURVE*

*DOWNSTREAM REACH*



## **HYDRAULIC ANALYSES**

## **Street Flow Capacity Calculations**

Project No.: 60970  
 Project Name: Hannah Ridge at Feathergrass  
 Date: 6/21/2013

# Provide for Constitution

### Street Flow Capacity Calculations (1/2 Street)

Street Name	Station	Street Data										Gutter Width Tg (ft)	Curb Height Hc (ft)	Section Res Factor n	Gutter Cr Slope Sg (ft/ft)	Slope Sb (ft/ft)	FL Depth to Crown (ft)	5-yr FL Depth d (ft)	5-year Capacity Qcap (cfs)	5-year Actual Flow (cfs)	5-year Flow to Crown (cfs)	5-year Crown Spillover (cfs)	100-yr FL Depth d (ft)	100-year Capacity Qcap (cfs)	100-year Actual Flow (cfs)							
		ROW Width Wr (ft)	FL-Crown Distance Tc (ft)	Street Cr Slope Sx (ft/ft)	Street Lg Slope So (ft/ft)	Curb Type	Note	Drainage Basin	Basin Q5 (cfs)	Basin Q100 (cfs)	Contrib Basin Area (%)																					
Breeches Way	PVC 1+59.16 L	50	14	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.41	0.50	17.3	2.3	OK	8.1	0.0	0.72	49.9	4.5	OK
Breeches Way	PVC 1+59.16 R	50	14	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.41	0.50	17.3	2.5	OK	8.1	0.0	0.72	49.9	5.1	OK
Breeches Way	PVC 2+69.72 L	50	14	0.020	0.040	VERT											2.0	0.50	0.016	0.083	0.020	0.41	0.50	24.5	2.6	OK	11.5	0.0	0.72	70.5	5.2	OK
Breeches Way	PVC 2+69.72 R	50	14	0.020	0.040	VERT											2.0	0.50	0.016	0.083	0.020	0.41	0.50	24.5	4.6	OK	11.5	0.0	0.72	70.5	9.3	OK
Breeches Way	PVC 4+15.43 L	50	17	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	16.9	1.9	OK	13.0	0.0	0.66	42.3	3.9	OK
Breeches Way	PVC 4+15.43 R	50	17	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	16.9	2.1	OK	13.0	0.0	0.66	42.3	4.3	OK
Breeches Way	PVC 5+34.89 L	50	17	0.020	0.030	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	20.8	2.0	OK	15.9	0.0	0.66	51.8	4.4	OK
Breeches Way	PVC 5+34.89 R	50	17	0.020	0.030	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	20.8	2.7	OK	15.9	0.0	0.66	51.8	5.4	OK
Breeches Way	PVT 5+84.89 L	50	17	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	16.9	4.4	OK	13.0	0.0	0.66	42.3	9.5	OK
Breeches Way	PVT 5+84.89 R	50	17	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	16.9	12.7	OK	13.0	0.0	0.66	42.3	25.3	OK
Grand Prix	PC 1+53.88 L	50	17	0.020	0.021	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	13.4	2.5	OK	13.4	N/A	0.66	43.6	5.0	OK
Grand Prix	PC 1+53.88 R	50	17	0.020	0.021	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	13.4	6.7	OK	13.4	N/A	0.66	43.6	13.3	OK
Grand Prix	PVC 13+48.64 L	50	17	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	11.2	11.0	OK	11.2	N/A	0.66	36.6	21.8	OK
Grand Prix	PVC 13+48.64 R	50	17	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	11.2	2.6	OK	11.2	N/A	0.66	36.6	5.3	OK
Grand Prix	PVT 14+91.64 L	50	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	4.4	OK	18.4	N/A	0.66	59.8	9.5	OK
Grand Prix	PVT 14+91.64 R	50	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	1.1	OK	18.4	N/A	0.66	59.8	2.1	OK
Dapples Court	PVT 1+54.50 L	50	14	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	11.5	5.8	OK	11.5	N/A	0.72	70.5	11.7	OK
Dapples Court	PVT 1+54.50 R	50	14	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	11.5	2.8	OK	11.5	N/A	0.72	70.5	5.5	OK
Dapples Court	PVT 6+29.63 L	50	14	0.020	0.020	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	8.1	1.2	OK	8.1	N/A	0.72	49.9	2.5	OK
Dapples Court	PVT 6+29.63 R	50	14	0.020	0.020	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	8.1	0.9	OK	8.1	N/A	0.72	49.9	1.8	OK
Equine Court	PC 1+46.00 L	50	17	0.020	0.020	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	13.0	3.3	OK	13.0	N/A	0.66	42.3	6.6	OK
Equine Court	PC 1+46.00 R	50	17	0.020	0.020	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	16.9	14.3	OK	13.0	1.3	0.66	42.3	28.3	OK
Equine Court	PVT 3+04.95 L	50	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	2.1	OK	18.4	N/A	0.66	59.8	4.3	OK
Equine Court	PVT 3+04.95 R	50	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	2.7	OK	18.4	N/A	0.66	59.8	5.4	OK
Equine Court	PC 9+56.53 L	50	17	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	11.2	2.8	OK	11.2	N/A	0.66	36.6	1.4	OK
Equine Court	PC 9+56.53 R	50	17	0.020	0.015	VERT											2.0	0.50	0.016	0.083	0.020	0.47	0.50	14.7	13.6	OK	11.2	2.4	0.66	36.6	27.2	OK
Equine Court	PC 16+58.82 L	50	14	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	7.1	2.6	OK	7.1	N/A	0.72	43.2	5.2	OK
Equine Court	PC 16+58.82 R	50	14	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	7.1	5.2	OK	7.1	N/A	0.72	43.2	10.6	OK
Farrier Court	PVT 1+49.50 L	50	14	0.020	0.050	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	12.9	5.3	OK	12.9	N/A	0.72	78.9	10.6	OK
Farrier Court	PVT 1+49.50 R	50	14	0.020	0.050	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	12.9	3.1	OK	12.9	N/A	0.72	78.9	6.1	OK
Half Chaps Court	PC 4+84.69 L	50	14	0.020	0.010	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	5.8	3.8	OK	5.8	N/A	0.72	35.3	7.6	OK
Half Chaps Court	PC 4+84.69 R	50	14	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.41	0.41	7.1	0.7	OK	7.1	N/A	0.72	43.2	1.4	OK
Hannah Ridge Drive	PVC 2+42.90 L	80	26	0.020	0.040	VERT	Center Median										2.0	0.50	0.016	0.083	0.020	0.65	0.50	16.0	0.9	OK	16.0	0.0	0.78	104.0	2.0	OK
Hannah Ridge Drive	PVC 2+42.90 R	80	26	0.020	0.040	VERT	Center Median										2.0	0.50	0.016	0.083	0.020	0.65	0.50	16.0	0.7	OK	16.0	0.0	0.78	104.0	1.3	OK
Hannah Ridge Drive	PVT 4+12.90 L	60	17	0.020	0.015	VERT	Center Median										2.0	0.50	0.016	0.083	0.020	0.47	0.50	14.7	8.1	OK	11.2	0.0	0.76	54.3	15.9	OK
Hannah Ridge Drive	PVT 4+12.90 R	60	17	0.020	0.015	VERT	need u/s Inlet										2.0	0.50	0.016	0.083	0.020	0.47	0.50	14.7	28.4	X	11.2	17.2	0.76	54.3	56.6	X
Hannah Ridge Drive	PC 5+75.00 L	60	17	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	11.2	5.5	OK	11.2	N/A	0.76	54.3	10.9	OK
Hannah Ridge Drive	PC 5+75.00 R	60	17	0.020	0.015	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	11.2	8.1	OK	11.2	N/A	0.76	54.3	16.2	OK
Hannah Ridge Drive	PVT 8+47.03 L	60	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	6.8	OK	18.4	N/A	0.76	88.7	13.4	OK
Hannah Ridge Drive	PVT 8+47.03 R	60	17	0.020	0.040	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	18.4	5.5	OK	18.4	N/A	0.76	88.7	11.0	OK
Horsemanship Court	PC 1+40.00 L	50	17	0.020	0.023	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	14.0	2.3	OK	14.0	N/A	0.66	45.6	4.7	OK
Horsemanship Court	PC 1+40.00 R	50	17	0.020	0.023	RAMP											2.0	0.50	0.016	0.083	0.020	0.47	0.47	14.0	6.7	OK	14.0	N/A	0.66	45.6	13.3	OK
Hunter Jumper Drive	PC 3+18.00 L	60	20	0.020	0.025	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	17.3	3.6	OK	17.3	0.0	0.70	57.5	7.2	OK
Hunter Jumper Drive	PC 3+18.00 R	60	20	0.020	0.025	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	17.3	6.2	OK	17.3	0.0	0.70	57.5	12.5	OK
Hunter Jumper Drive	PC 5+89.38 L	60	20	0.020	0.028	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	18.5	3.6	OK	18.5	0.0	0.70	61.4	7.1	OK
Hunter Jumper Drive	PC 5+89.38 R	60	20	0.020	0.028	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	18.5	0.6	OK	18.5	0.0	0.70	61.4	1.1	OK
Hunter Jumper Drive	PC 6+63.38 L	60	20	0.020	0.025	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	17.5	11.9	OK	18.5	0.0	0.70	61.4	23.7	OK
Hunter Jumper Drive	PC 6+63.38 R	60	20	0.020	0.025	VERT											2.0	0.50	0.016	0.083	0.020	0.53	0.50	17.5	0.6	OK						

**Hydraulic Analysis**  
**Autodesk Storm and Sanitary Analysis**  
**Storm Drain Inlet and Pipe System**

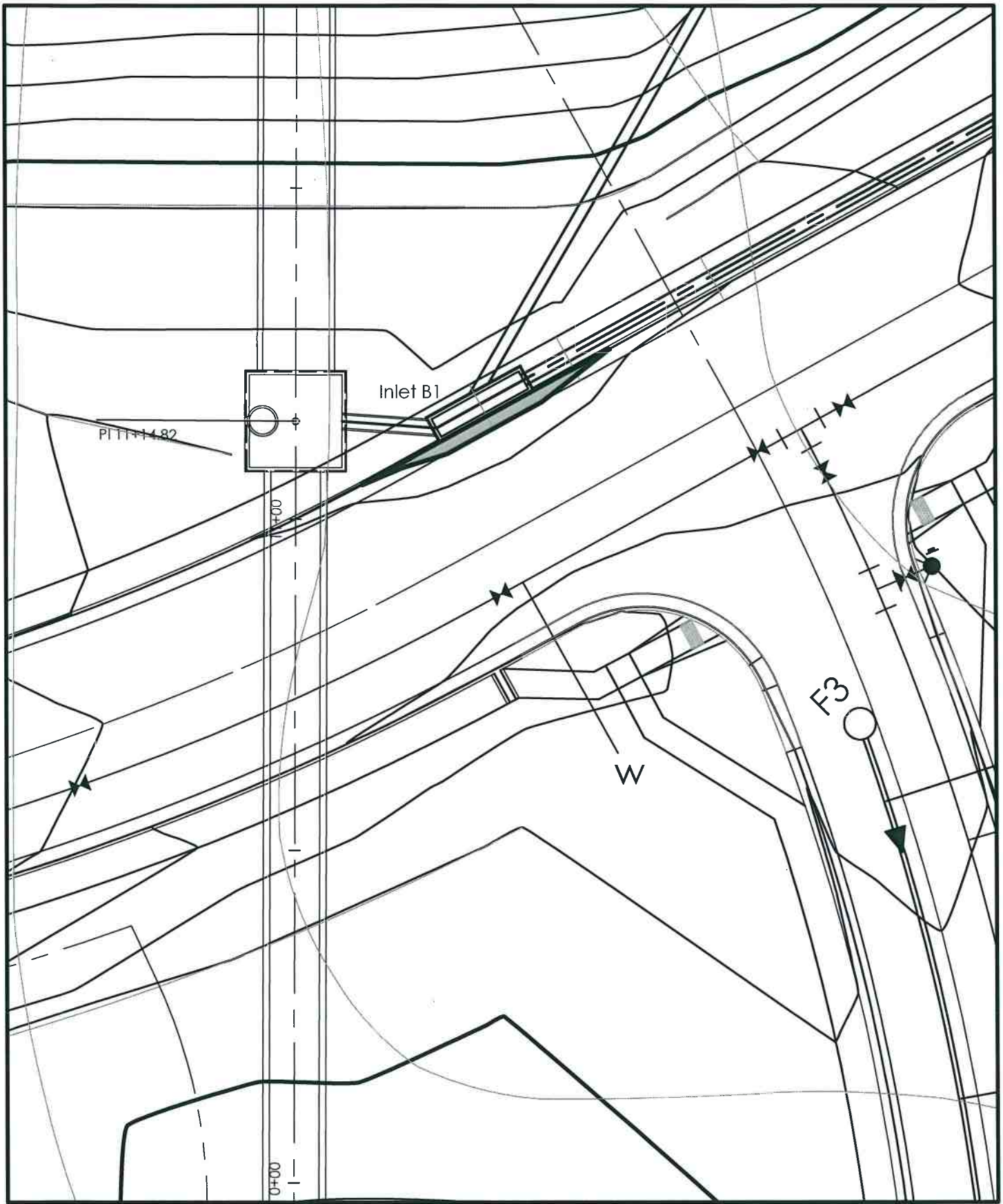


Inlet Summary - 5-year - Hannah Ridge at Feathergrass

SN	Element ID	Description	Inlet Location	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Roadway Long. Slope (ft/ft)	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Interc. by inlet (cfs)	Peak Flow Bypass. Inlet (cfs)	Inlet Eff. during Peak (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)
1	SDINLET A1	10' Type R	On Sag	6487.22	6496.07	8.85	N/A	9.23	9.23	N/A	N/A	N/A	21.57	6496.51	0.43
2	SDINLET A2	5' Type R	On Sag	6484.80	6496.07	11.27	N/A	0.72	0.72	N/A	N/A	N/A	2.23	6496.12	0.04
3	SDINLET B1	15' Type R	On Sag	6461.42	6467.30	5.88	N/A	9.16	0.84	N/A	N/A	N/A	16.49	6467.62	0.32
4	SDINLET B2	15' Type R	On Grade	6465.75	6470.75	5.00	0.040	18.30	18.30	9.9	8.4	53.9	15.88	6471.19	0.44
5	SDINLET C1	5' Type R	On Sag	6464.97	6469.97	5.00	N/A	3.69	3.69	N/A	N/A	N/A	15.33	6470.27	0.31
6	SDINLET C3	10' Type R	On Sag	6464.42	6469.42	5.00	N/A	6.60	6.60	N/A	N/A	N/A	16.79	6469.76	0.34
7	SDINLET C4	15' Type R	On Sag	6464.42	6469.42	5.00	N/A	12.18	12.18	N/A	N/A	N/A	20.90	6469.84	0.42
8	SDINLET C6	10' Type R	On Sag	6468.92	6473.92	5.00	N/A	5.51	5.51	N/A	N/A	N/A	14.73	6474.22	0.29
9	SDINLET C7	15' Type R	On Sag	6468.92	6473.92	5.00	N/A	8.90	8.90	N/A	N/A	N/A	16.09	6474.24	0.32
10	SDINLET C8	10' Type R	On Sag	6474.99	6479.99	5.00	N/A	10.22	8.62	N/A	N/A	N/A	23.44	6480.45	0.46
11	SDINLET C9	10' Type R	On Grade	6477.00	6481.75	4.75	0.015	6.62	6.62	4.9	1.7	74.1	12.76	6482.13	0.38
12	SDINLET D2	15' Type R	On Sag	6445.29	6450.29	5.00	N/A	12.43	3.86	N/A	N/A	N/A	21.24	6450.65	0.37
13	SDINLET D3	10' Type R	On Sag	6444.93	6449.93	5.00	N/A	9.78	9.78	N/A	N/A	N/A	22.62	6450.38	0.45
14	SDINLET D5	15' Type R	On Grade	6447.45	6451.95	4.50	0.015	19.34	19.34	12.0	7.4	61.8	19.77	6452.47	0.52
15	SDINLET D6	15' Type R	On Grade	6448.81	6453.80	5.00	0.015	9.02	9.02	7.7	1.3	85.5	14.53	6454.22	0.42
16	SDINLET E3	5' Type R	On Sag	6452.87	6457.86	5.00	N/A	1.80	1.80	N/A	N/A	N/A	7.06	6458.00	0.14
17	SDINLET E4	15' Type R	On Sag	6452.87	6457.86	5.00	N/A	12.46	9.33	N/A	N/A	N/A	21.28	6458.27	0.41
18	SDINLET E5	15' Type R	On Grade	6460.43	6465.43	5.00	0.028	11.94	11.94	8.4	3.6	70.1	14.35	6465.84	0.41
19	SDINLET E6	5' Type R	On Sag	6454.61	6459.45	4.83	N/A	5.18	5.18	N/A	N/A	N/A	20.59	6459.86	0.41
20	SDINLET F3	10' Type R	On Sag	6461.95	6466.95	5.00	N/A	5.13	5.13	N/A	N/A	N/A	13.52	6467.22	0.27
21	SDINLET F4	15' Type R	On Sag	6461.95	6466.95	5.00	N/A	13.45	13.45	N/A	N/A	N/A	22.63	6467.40	0.45

Inlet Summary - 100-year - Hannah Ridge at Feathergrass

SN	Element ID	Description	Inlet Location	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset	Roadway Long. Slope (ft/ft)	Peak Flow Lateral Inflow (cfs)	Peak Flow Interc. by Inlet (cfs)	Peak Flow Bypass Inlet (cfs)	Inlet Effic. during Peak (%)	Max Gutter Spread during Peak Flow (ft)		Max Gutter Water Elev. during Peak Flow (ft)		Max Gutter Water Depth during Peak Flow (ft)
												Peak Flow (cfs)	Peak Flow (ft)	Peak Flow (ft)	Peak Flow (ft)	
1	SDINLET A1	10' Type R	On Sag	6487.22	6496.07	8.85	N/A	18.5	N/A	N/A	N/A	37.5	6496.82	0.75		
2	SDINLET A2	5' Type R	On Sag	6484.80	6496.07	11.27	N/A	1.4	N/A	N/A	N/A	4.3	6496.16	0.09		
3	SDINLET B1	15' Type R	On Sag	6461.42	6467.30	5.88	N/A	2.7	N/A	N/A	N/A	36.7	6468.02	0.71		
4	SDINLET B2	15' Type R	On Grade	6465.75	6470.75	5.00	0.040	39.0	14.1	24.9	36.3	21.5	6471.31	0.56		
5	SDINLET C1	5' Type R	On Sag	6464.97	6469.97	5.00	N/A	7.4	N/A	N/A	N/A	26.6	6470.50	0.53		
6	SDINLET C3	10' Type R	On Sag	6464.42	6469.42	5.00	N/A	14.2	N/A	N/A	N/A	30.7	6470.04	0.61		
7	SDINLET C4	15' Type R	On Sag	6464.42	6469.42	5.00	N/A	24.2	N/A	N/A	N/A	36.0	6470.14	0.72		
8	SDINLET C6	10' Type R	On Sag	6468.92	6473.92	5.00	N/A	11.1	N/A	N/A	N/A	25.2	6474.42	0.50		
9	SDINLET C7	15' Type R	On Sag	6468.92	6473.92	5.00	N/A	17.9	N/A	N/A	N/A	28.7	6474.50	0.57		
10	SDINLET C8	10' Type R	On Sag	6474.99	6479.99	5.00	N/A	17.6	N/A	N/A	N/A	46.0	6480.88	0.89		
11	SDINLET C9	10' Type R	On Grade	6477.00	6481.75	4.75	0.015	13.6	7.2	6.4	52.8	17.2	6482.22	0.47		
12	SDINLET D2	15' Type R	On Sag	6445.29	6450.29	5.00	N/A	28.3	N/A	N/A	N/A	40.5	6451.03	0.75		
13	SDINLET D3	10' Type R	On Sag	6444.93	6449.93	5.00	N/A	18.2	N/A	N/A	N/A	36.9	6450.67	0.74		
14	SDINLET D5	15' Type R	On Grade	6447.45	6451.95	4.50	0.015	38.1	16.8	21.2	44.2	25.8	6452.59	0.64		
15	SDINLET D6	15' Type R	On Grade	6448.81	6453.80	5.00	0.015	18.5	11.7	6.8	63.1	19.4	6454.32	0.51		
16	SDINLET E3	5' Type R	On Sag	6452.87	6457.86	5.00	N/A	3.6	N/A	N/A	N/A	15.1	6458.16	0.30		
17	SDINLET E4	15' Type R	On Sag	6452.87	6457.86	5.00	N/A	28.7	N/A	N/A	N/A	41.0	6458.65	0.79		
18	SDINLET E5	15' Type R	On Grade	6460.43	6465.43	5.00	0.028	23.7	11.9	11.8	50.3	19.0	6465.93	0.51		
19	SDINLET E6	5' Type R	On Sag	6454.61	6459.45	4.83	N/A	9.8	N/A	N/A	N/A	32.5	6460.10	0.65		
20	SDINLET F3	10' Type R	On Sag	6461.95	6466.95	5.00	N/A	6.1	N/A	N/A	N/A	15.8	6467.27	0.32		
21	SDINLET F4	15' Type R	On Sag	6461.95	6466.95	5.00	N/A	33.3	N/A	N/A	N/A	46.2	6467.88	0.92		



HRFG Fil 3  
Inlet B1  
5 Yr

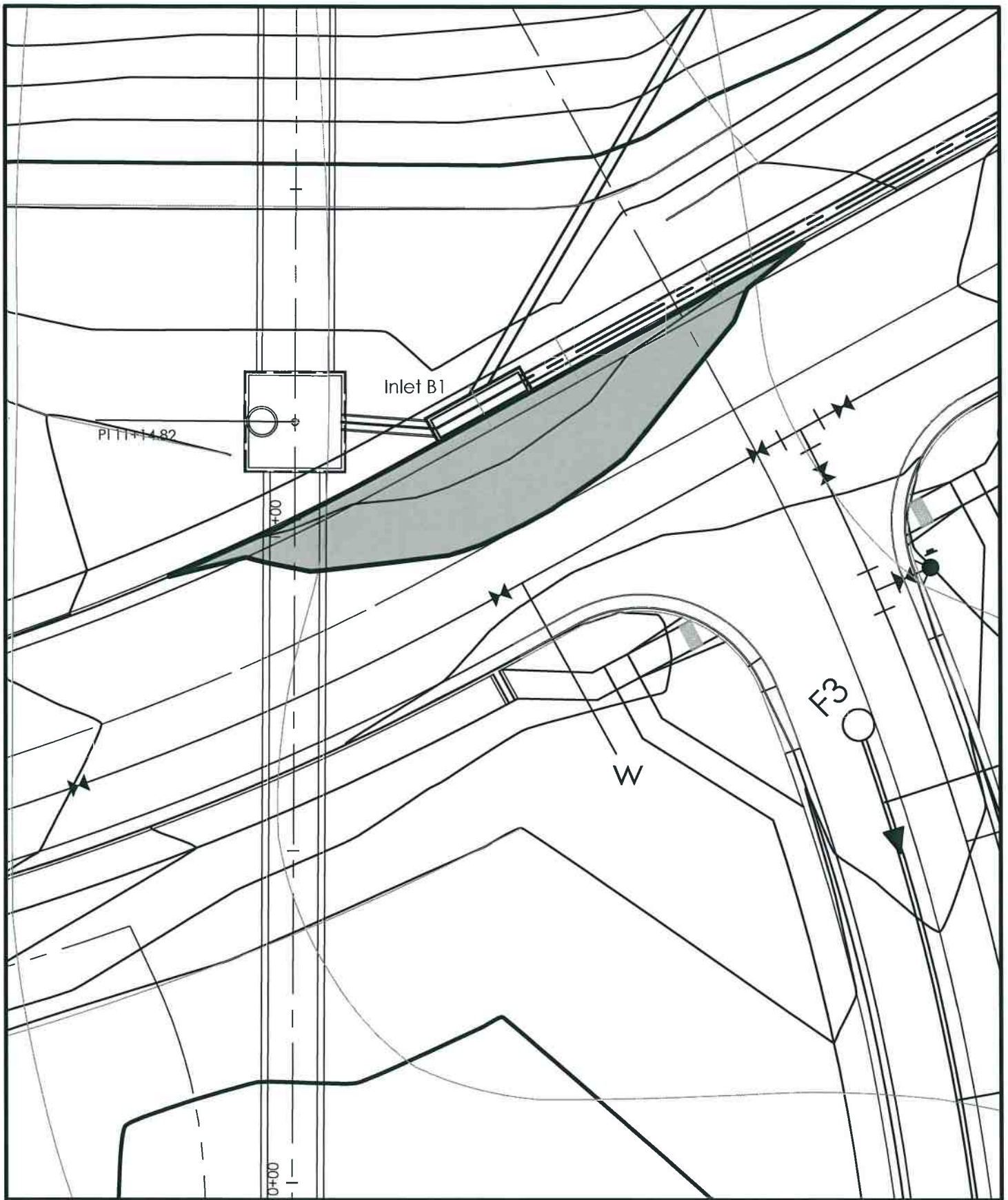
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HRFG Fil 3  
Inlet B1  
100 yr

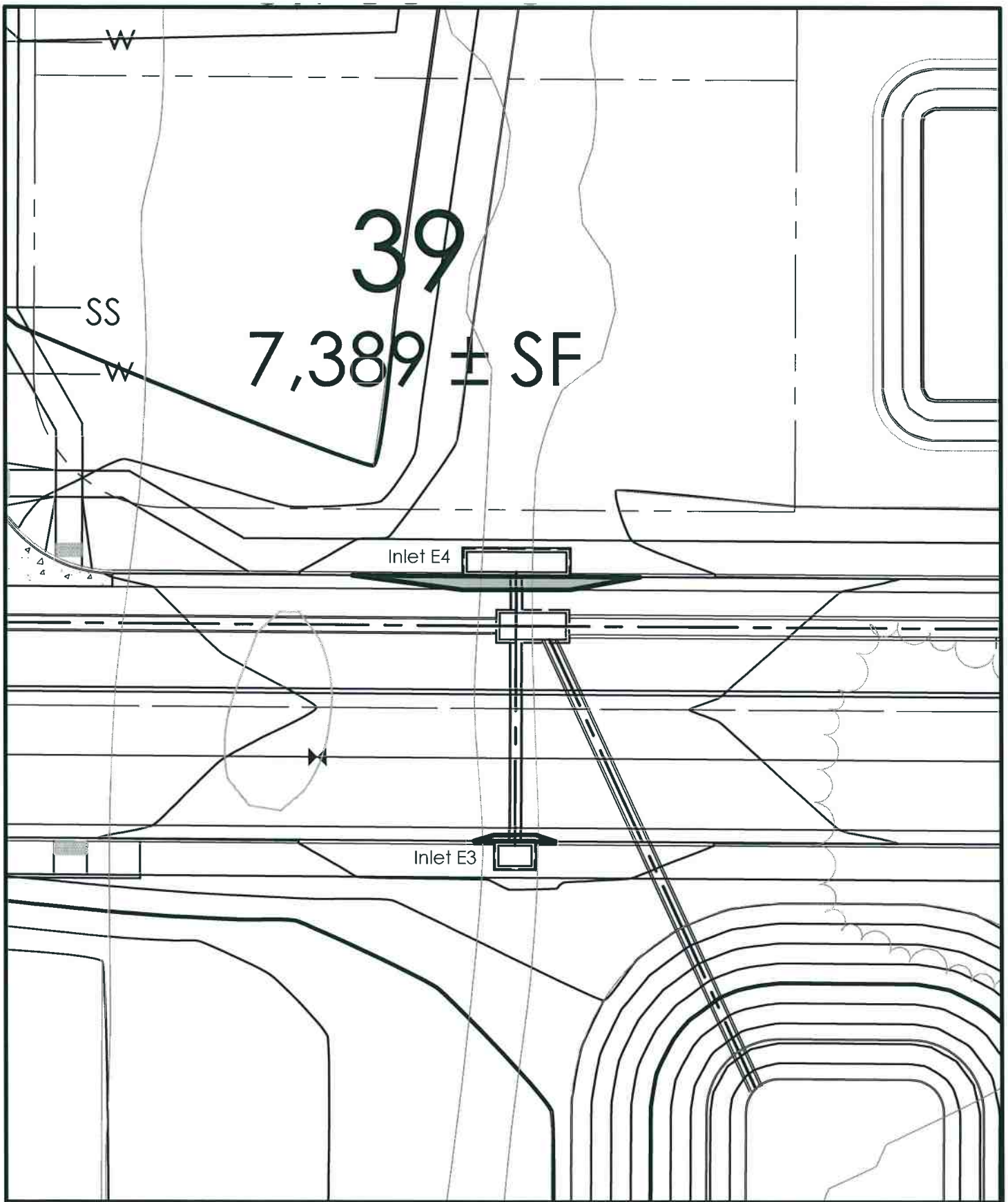
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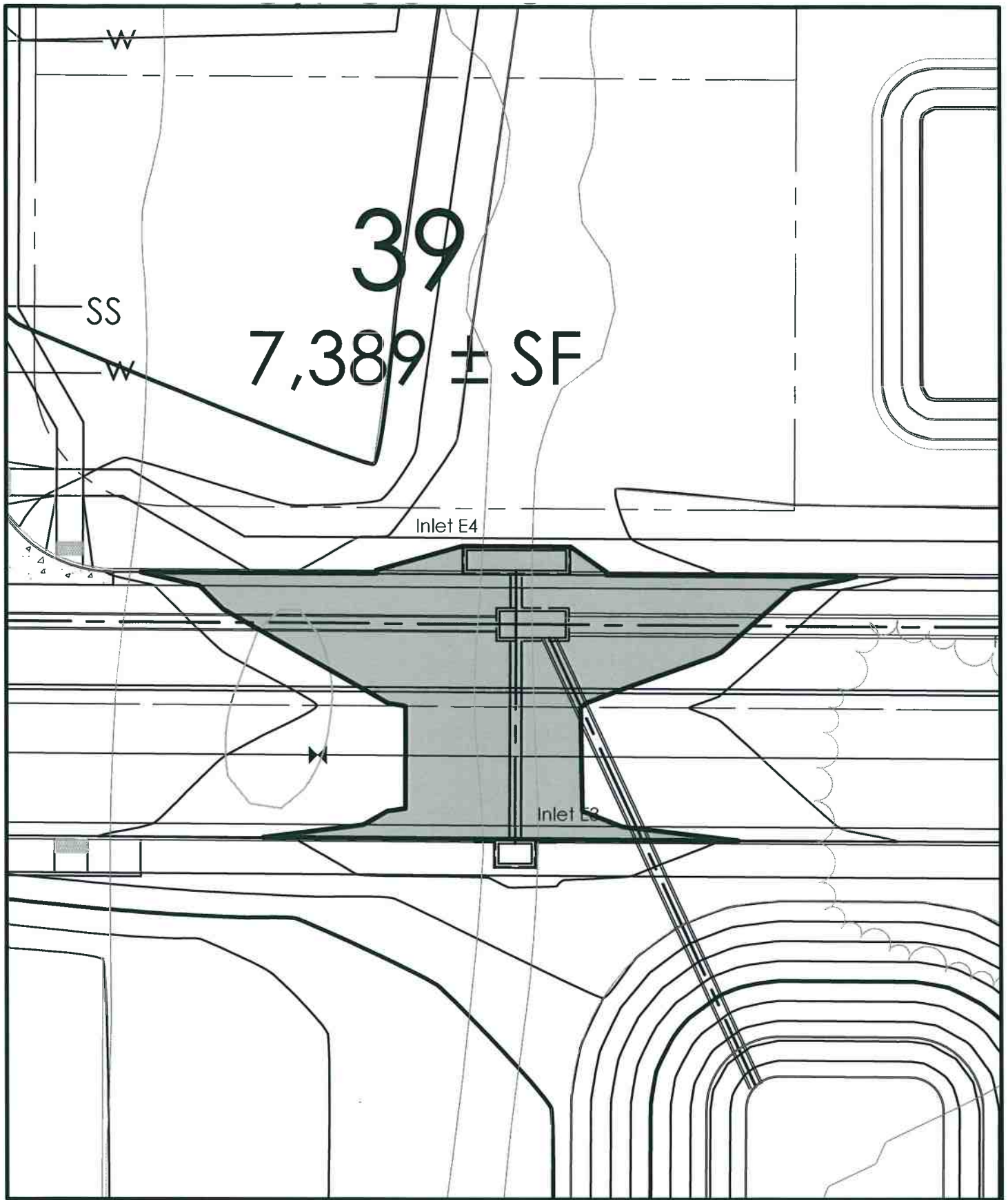
HRFG Fil 3  
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Inlet E3 & E4  
100 Yr

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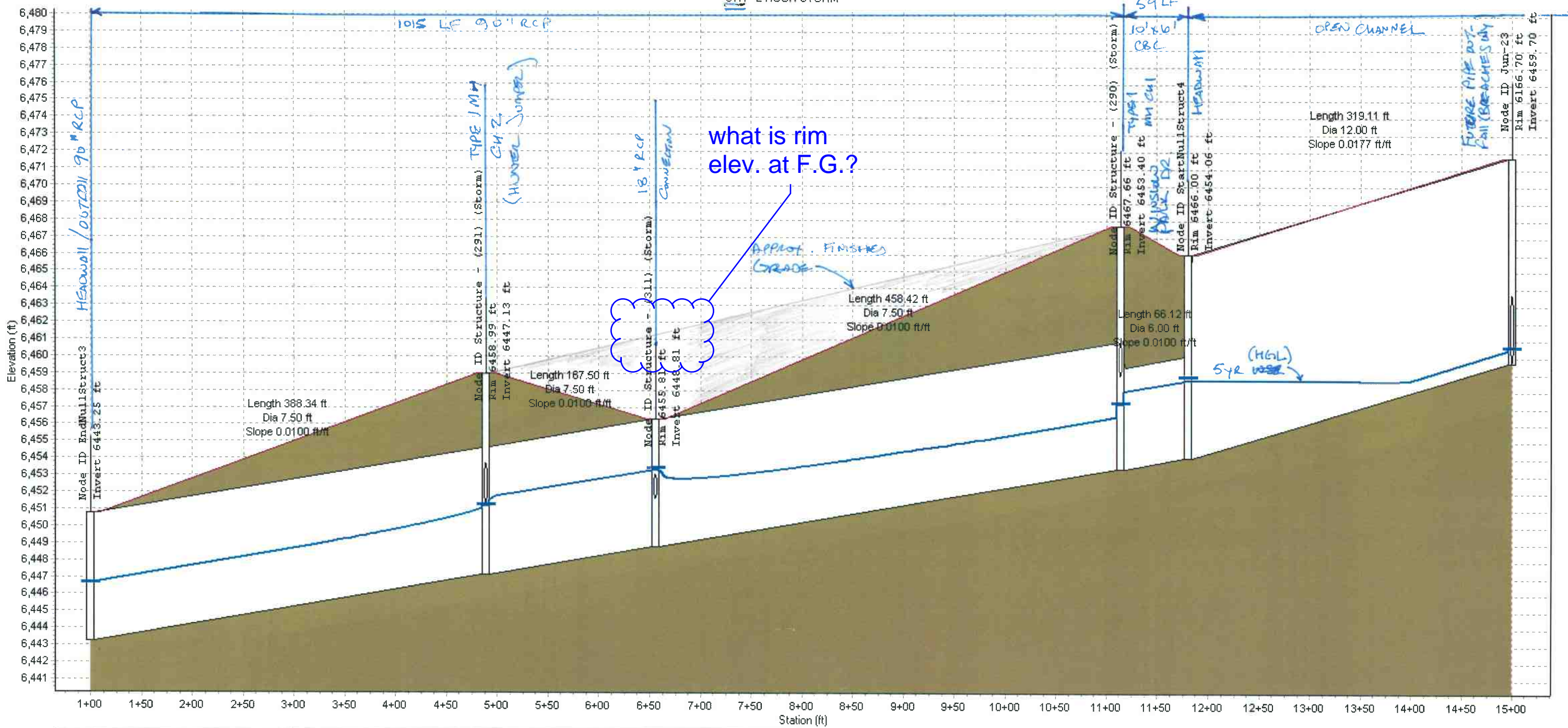
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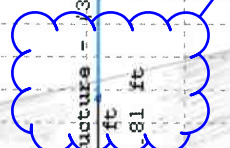
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*MAIN CHANNEL*  
HYDRAULIC ANALYSIS OF 90" & 10"x6" CBC  
5YR - 2 HOUR STORM



what is rim elev. at F.G.?



Node ID:		Structure - (291) (Storm)	Structure - (311) (Storm)	Structure - (290) (Storm)	Structure - (290) (Storm)	Jun-23
Rim (ft):		6458.99	6455.81	6467.66	6466.00	6166.70
Invert (ft):	6443.25	6447.13	6448.81	6453.40	6454.06	6459.70
Min Pipe Cover (ft):		4.35	0.00		0.00	0.00
Max HGL (ft):	6446.65	6451.22	6453.44	6457.31	6458.80	6460.61
Link ID:	Link-60	{Storm}.Pipe - (248) (2) (Storm)	{Storm}.Pipe - (248) (Storm)	{Storm}.Pipe - (249) (Storm)	Link-69	
Length (ft):	388.34	167.50	458.42	66.12	319.11	
Dia (ft):	7.50	7.50	7.50	6.00	12.00	
Slope (ft/ft):	0.0100	0.0100	0.0100	0.0100	0.0177	
Up Invert (ft):	6447.13	6448.81	6453.40	6454.06	6459.70	
Down Invert (ft):	6443.25	6447.14	6448.81	6453.40	6454.06	
Max Q (cfs):	280.61	273.23	272.27	270.47	274.80	
Max Vel (ft/s):	12.71	10.36	10.51	6.26	3.49	
Max Depth (ft):	3.75	4.36	4.27	4.32	2.82	

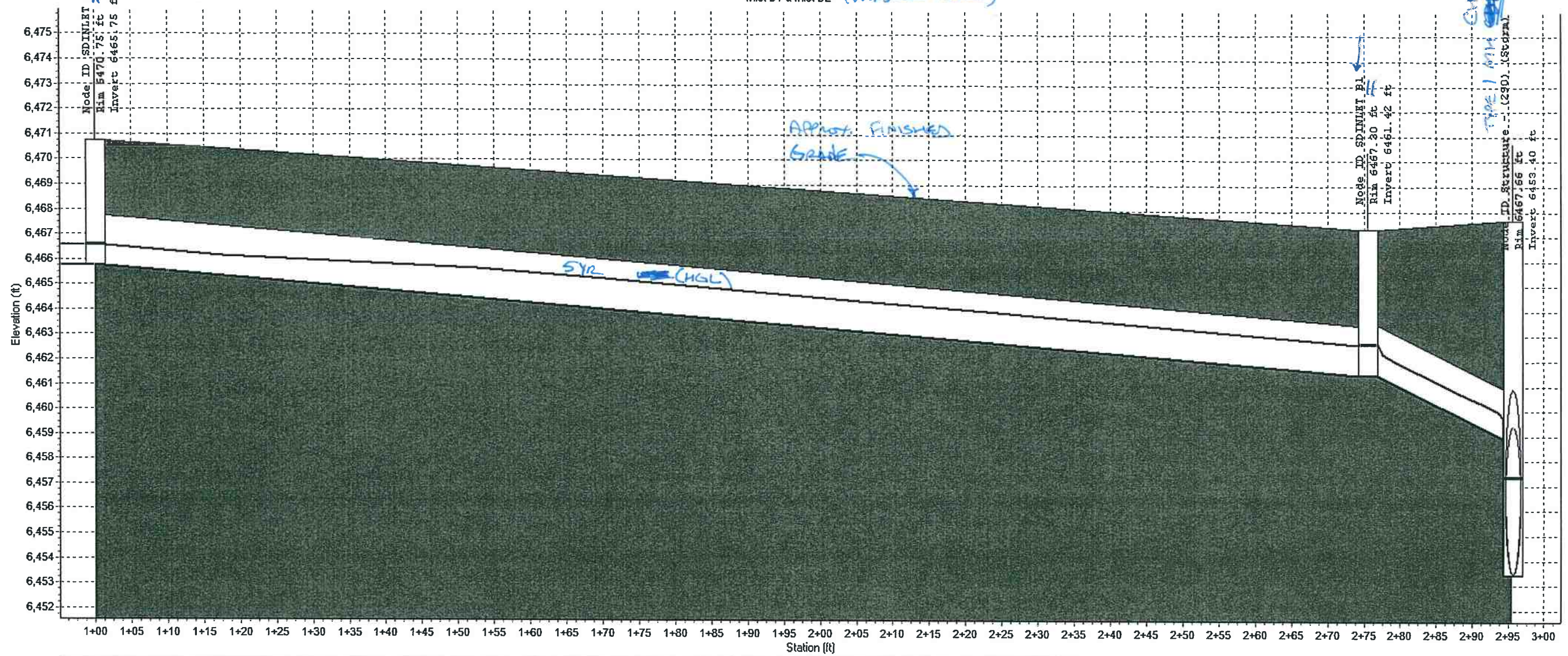
*DNSTRM INV.*  
Autodesk Storm and Sanitary Analysis



PIPE HYDRAULIC ANALYSIS

Profile Plot - 5YR 2 HOUR STORM

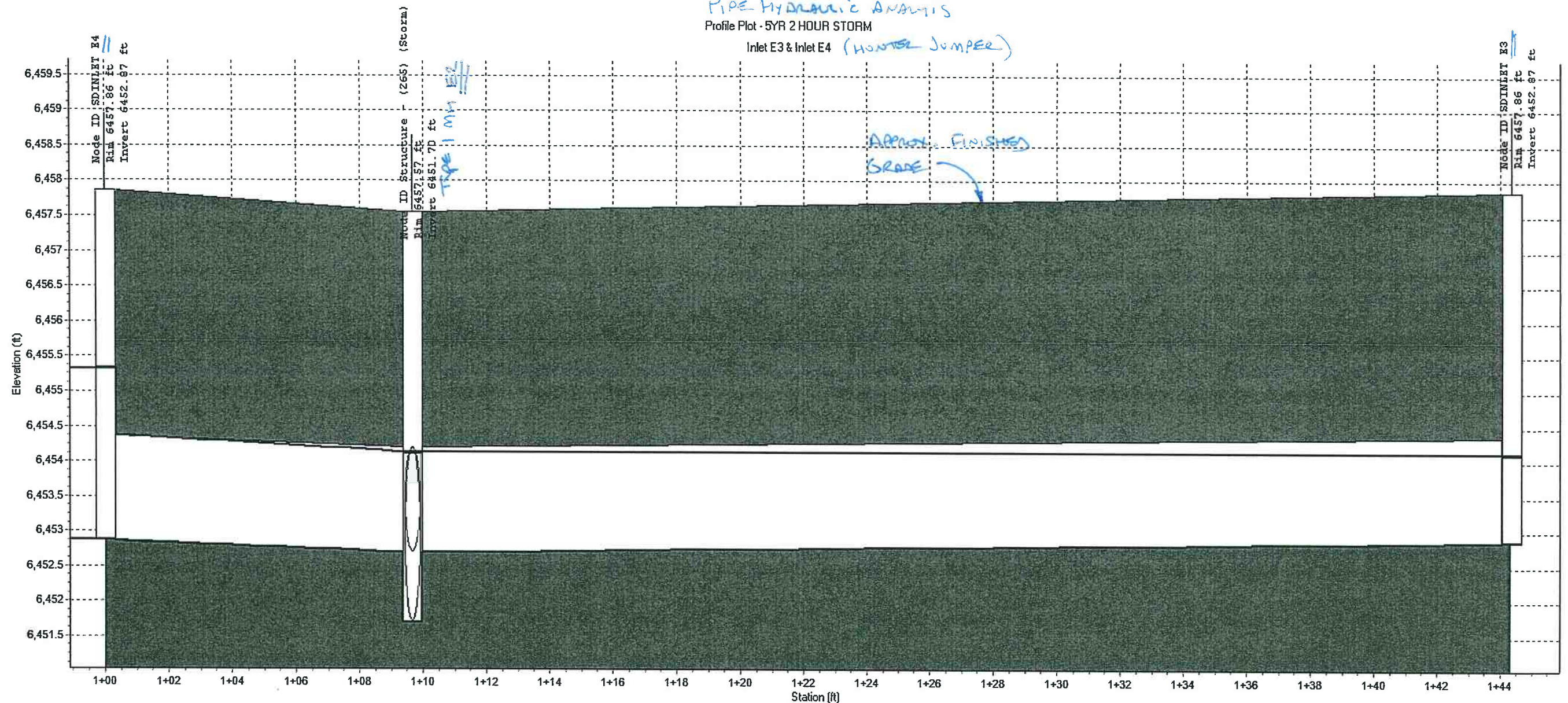
Inlet B1 & Inlet B2 (WINDLOW PARK)



Node ID:	SDINLET B2		SDINLET B1	
Rim (ft):	6470.75		6467.30	6467.66
Invert (ft):	6465.75		6461.42	6453.40
Min Pipe Cover (ft):				
Max HGL (ft):	6466.55		6462.64	6457.31
Link ID:		Link-51		Link-06
Length (ft):		175.54		19.91
Dia (in):		24.00		24.00
Slope (ft/ft):		0.0247		0.1267
Up Invert (ft):		6465.75		6461.42
Dn Invert (ft):		6461.42		6458.90
Max Q (cfs):		9.86		18.45
Max Vel (ft/s):		7.25		12.38
Max Depth (ft):		1.00		0.96



PIPE HYDRAULIC ANALYSIS  
 Profile Plot - 5YR 2 HOUR STORM  
 Inlet E3 & Inlet E4 (HORIZONTAL JUMPER)



Node ID:	SDINLET E4	Structure - (265) (Storm)	SDINLET E3
Rim (ft):	6457.86	6457.57	6457.86
Invert (ft):	6452.87	6451.70	6452.87
Min Pipe Cover (ft):		3.37	
Max HGL (ft):	6455.32	6454.12	6454.13
Link ID:	{Storm}.Pipe - (197) (Storm)		{Storm}.Pipe - (198) (Storm)
Length (ft):	9.66		34.67
Dia (in):	18.00		18.00
Slope (ft/ft):	0.0176		0.0049
Up Invert (ft):	6452.87		6452.87
Dn Invert (ft):	6452.70		6452.70
Max Q (cfs):	12.89		1.72
Max Vel (ft/s):	7.35		2.63
Max Depth (ft):	1.46		1.34

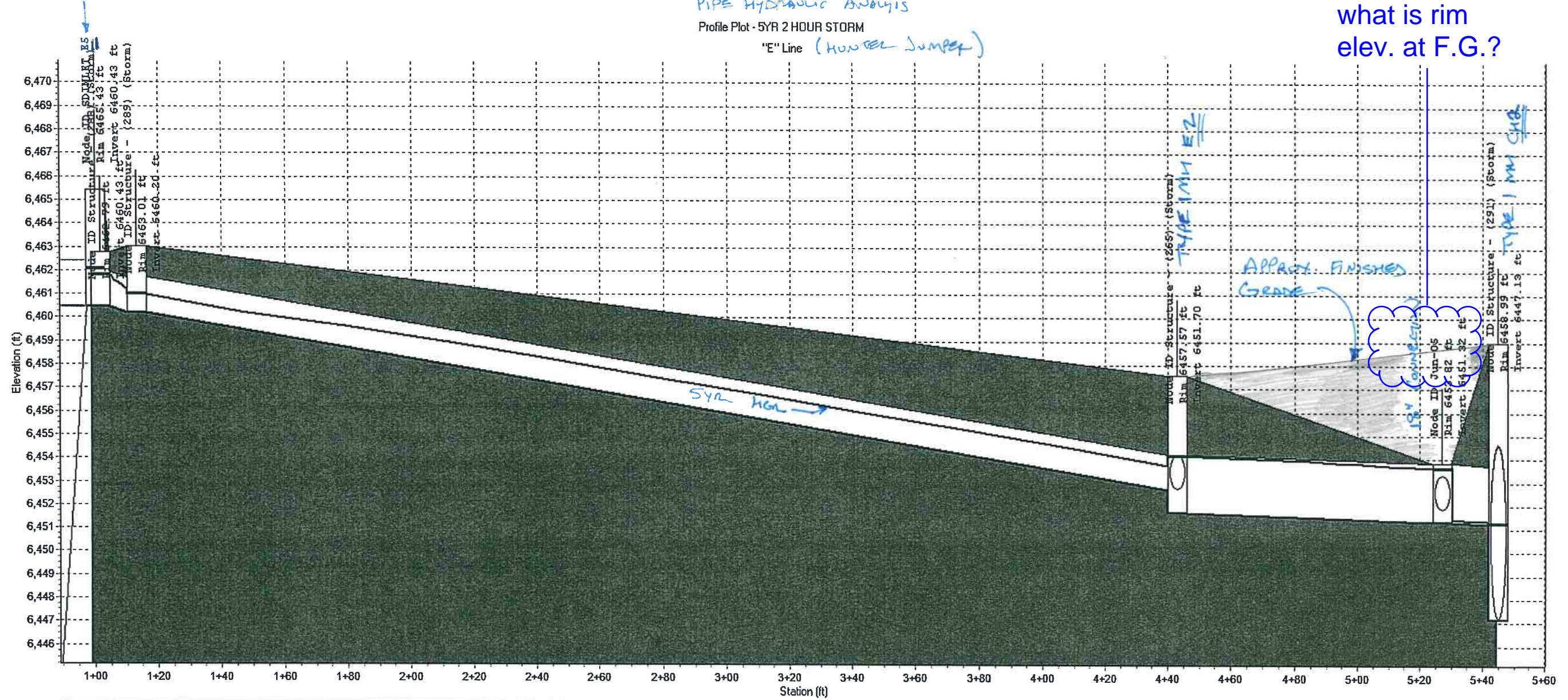


PIPE HYDRAULIC ANALYSIS

Profile Plot - 5YR 2 HOUR STORM

"E" Line (Horizontal Jumper)

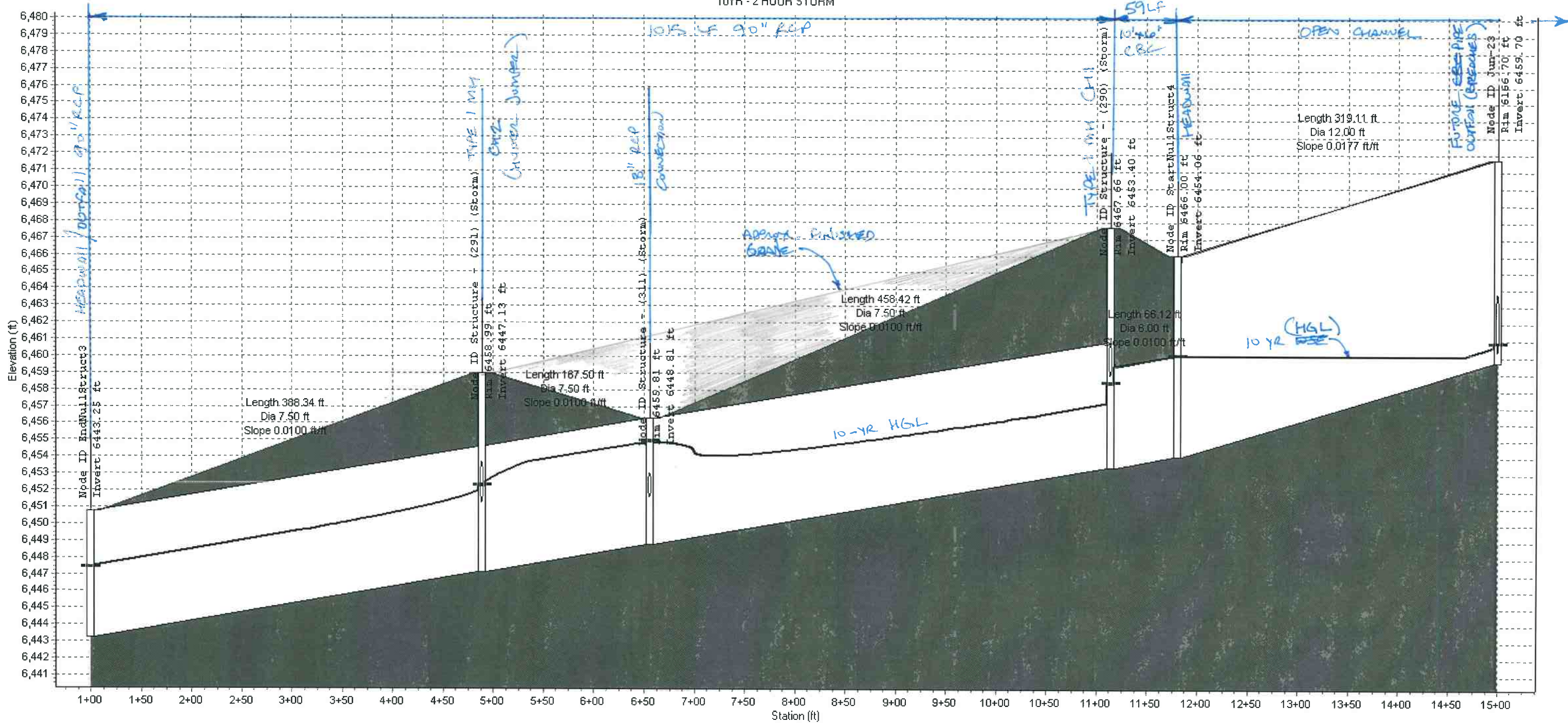
what is rim elev. at F.G.?



Node ID:	SDM-115 (289) (Storm)		Structure - (265) (Storm)		Jun-05
Rim (ft):	6463.01		6457.57		6453.82 6458.99
Invert (ft):	6460.20		6451.70		6451.32 6447.13
Min Pipe Cover (ft):	0.36 1.31		3.37		0.00 4.35
Max HGL (ft):	6460.97		6454.12		6453.61 6451.22
Link ID:		{Storm}.Pipe - (110) (Storm)		{Storm}.Pipe - (201) (2) (Storm)	Link-14
Length (ft):	1.54	329.65		84.29	17.74
Dia (in):	24.00	18.00		30.00	30.00
Slope (ft/ft):	0.00200	0.0228		0.0045	0.0056
Up Invert (ft):	6460.43	6460.20		6451.70	6451.32
Dn Invert (ft):	6460.20	6452.70		6451.32	6451.22
Max Q (cfs):	8.35	8.29		20.64	22.94
Max Vel (ft/s):	3.16	7.83		4.31	5.59
Max Depth (ft):	1.07	1.10		2.36	1.95



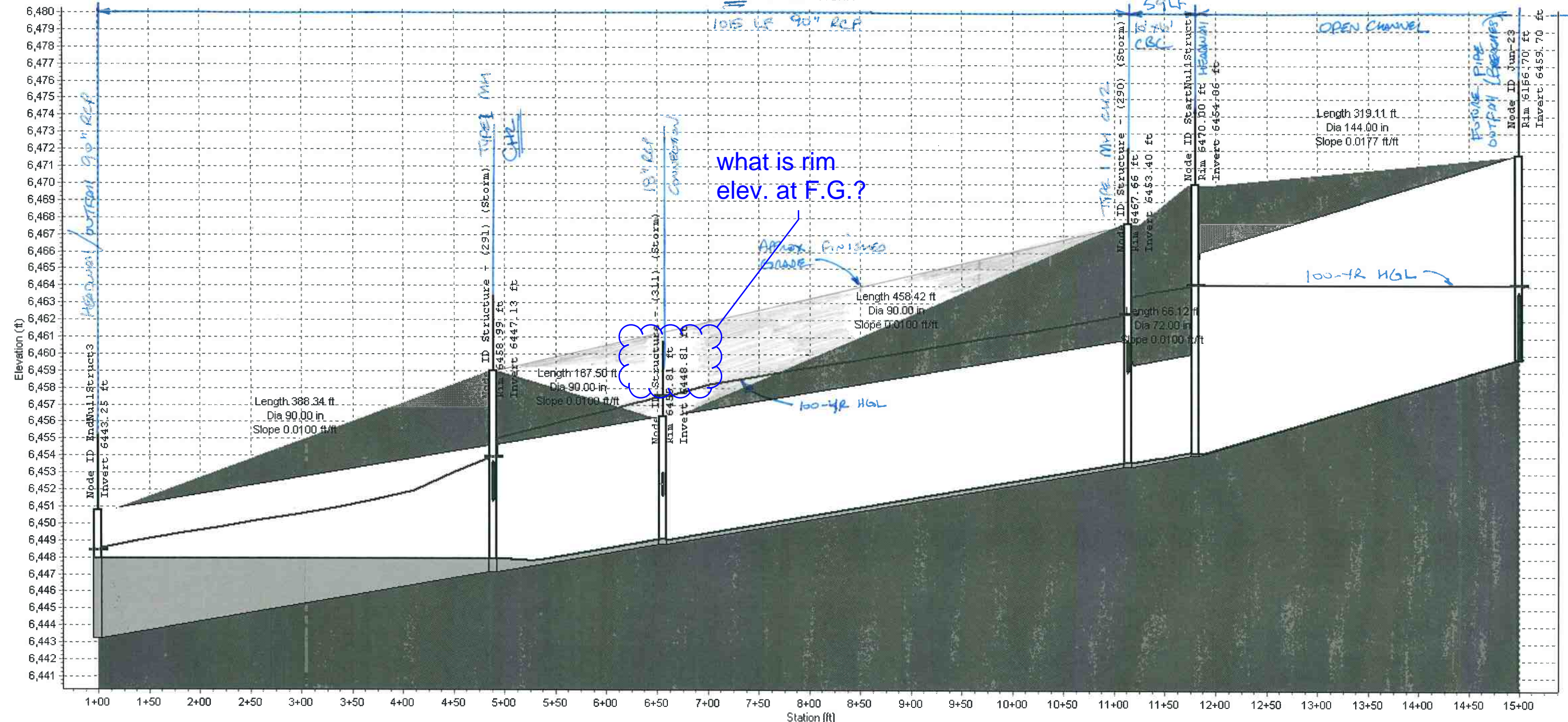
MAIN CHANNEL  
HYDRAULIC ANALYSIS OF 90" & 10x6' CBC  
10YR - 2 HOUR STORM



Node ID:		Structure - (291) (Storm)	Structure - (311) (Storm)	Structure - (290) (Storm)	StartNullStruct4	Jun-23
Rim (ft):		6458.99	6455.81	6467.66	6466.00	6166.70
Invert (ft):	6443.25	6447.13	6448.81	6453.40	6454.06	6459.70
Min Pipe Cover (ft):			0.00		0.00	0.00
Max HGL (ft):	6447.41	6452.30	6454.95	6458.44	6460.08	6460.81
Link ID:	Link-60	{Storm}.Pipe - (248) (2) (Storm)	{Storm}.Pipe - (248) (Storm)	{Storm}.Pipe - (249) (Storm)	Link-69	
Length (ft):	388.34	167.50	458.42	66.12	319.11	
Dia (ft):	7.50	7.50	7.50	6.00	12.00	
Slope (ft/ft):	0.0100	0.0100	0.0100	0.0100	0.0177	
Up Invert (ft):	6447.13	6448.81	6453.40	6454.06	6459.70	
Dn Invert (ft):	6443.25	6447.14	6448.81	6453.40	6454.06	
Max Q (cfs):	394.72	386.80	385.96	383.67	388.10	
Max Vel (ft/s):	13.66	10.90	10.95	6.96	3.83	
Max Depth (ft):	4.67	5.65	5.59	5.52	3.56	



MAIN CHANNEL  
HYDRAULIC ANALYSIS OF 90" & 10x6' CBC  
100YR - 24 HOUR STORM



what is rim elev. at F.G.?

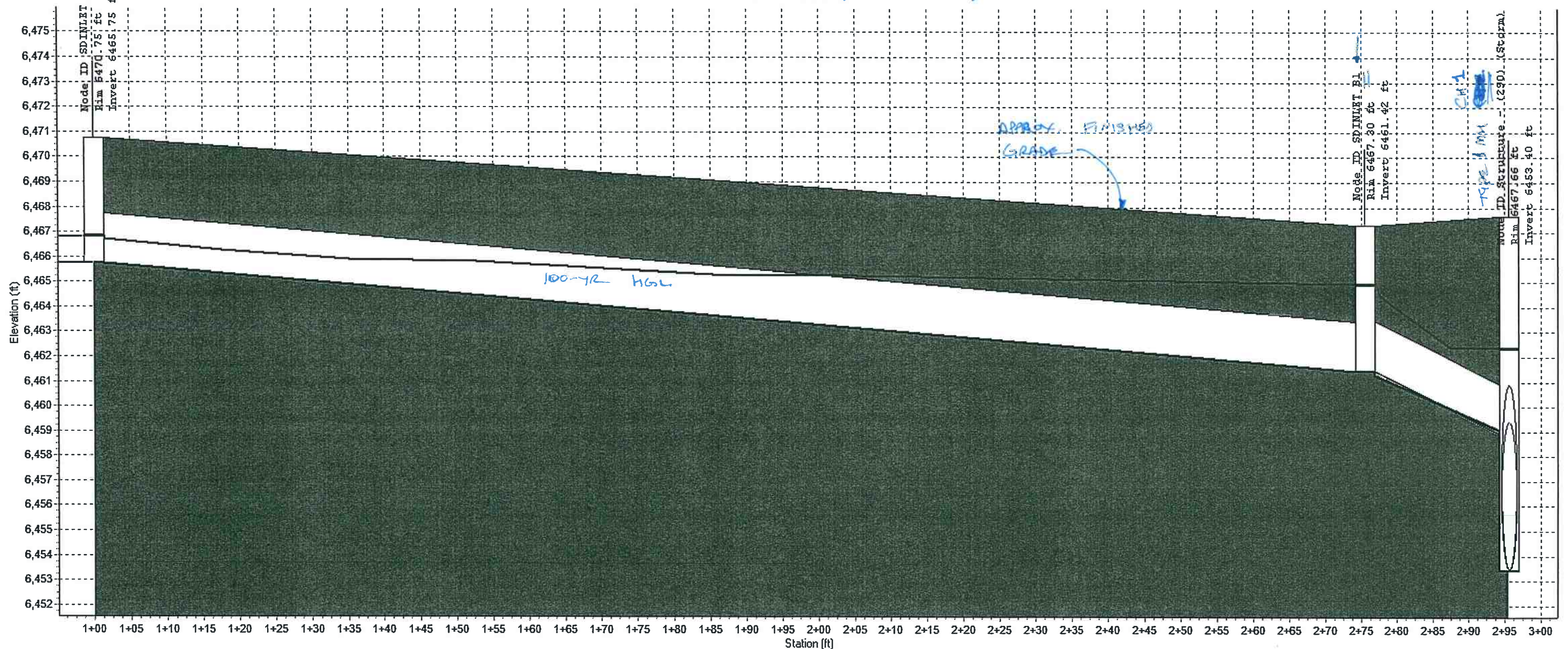
HGL is above MH

Node ID:		Structure - (291) (Storm)	Structure - (311) (Storm)	Structure - (290) (Storm)	Node ID StartWallStruct4	Jun-23
Rim (ft):		6458.99	6455.81	6467.66	6470.00	6166.70
Invert (ft):	6443.25	6447.13	6448.81	6453.40	6454.06	6459.70
Min Pipe Cover (ft):		4.35	0.00	6.77	3.94	0.00
Max HGL (ft):	6448.39	6453.89	6457.52	6462.35	6464.10	6464.08
Link ID:	Link-60	(Storm).Pipe - (248) [2] (Storm)	(Storm).Pipe - (248) (Storm)	(Storm).Pipe - (249) (Storm)	Link-69	
Length (ft):	388.34	167.50	458.42	66.12	319.11	
Dia (in):	90.00	90.00	90.00	72.00	144.00	
Slope (ft/ft):	0.0100	0.0100	0.0100	0.0100	0.0177	
Up Invert (ft):	6447.13	6448.81	6453.40	6454.06	6459.70	
Down Invert (ft):	6443.25	6447.14	6448.81	6453.40	6454.06	
Autodesk Storm and Sanitary Analysis	541.22	541.16	540.56	540.54	603.10	
Max Q (cfs):						
Max Vel (ft/s):	14.41	12.49	12.24	9.01	2.41	
Max Depth (ft):	5.95	7.13	7.50	6.00	7.19	

Downstream Invert



PIPE HYDRAULIC ANALYSIS  
 Profile Plot - 100YR 24 HOUR STORM  
 Inlet B1 & Inlet B2 (WINSLOW PARK)

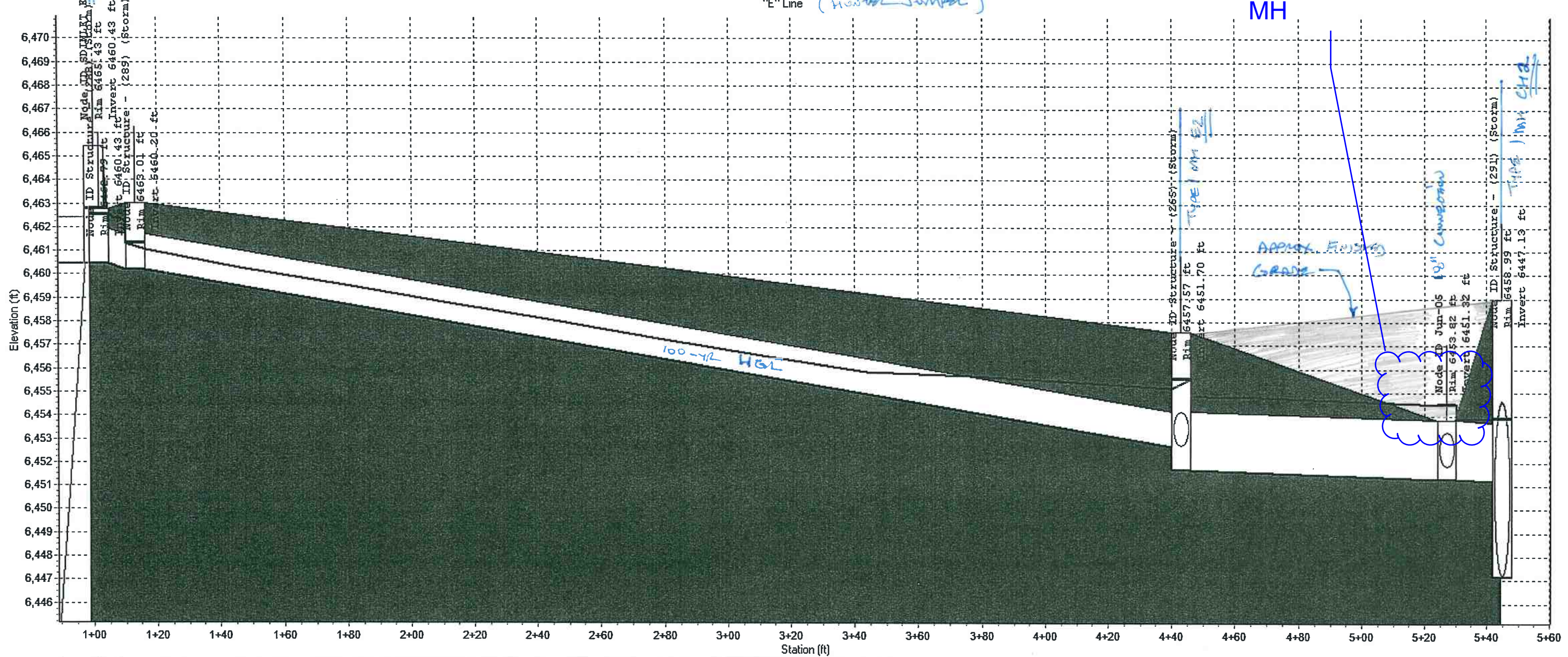


Node ID:	SDINLET B2		SDINLET B1	
Rim (ft):	6470.75		6467.30	6467.66
Invert (ft):	6465.75		6461.42	6453.40
Min Pipe Cover (ft):				6.77
Max HGL (ft):	6466.79		6464.91	6462.35
Link ID:		Link-51		Link-06
Length (ft):		175.54		19.91
Dia (in):		24.00		24.00
Slope (ft/ft):		0.0247		0.1267
Up Invert (ft):		6465.75		6461.42
Dn Invert (ft):		6461.42		6458.90
Max Q (cfs):		14.04		39.37
Max Vel (ft/s):		7.10		15.04
Autodesk Storm and Sanitary Analysis		1.52		1.53



PIPE HYDRAULIC ANALYSIS  
 Profile Plot - 100YR 24 HOUR STORM  
 "E" Line (Hwy on Jumper)

HGL is above  
 MH



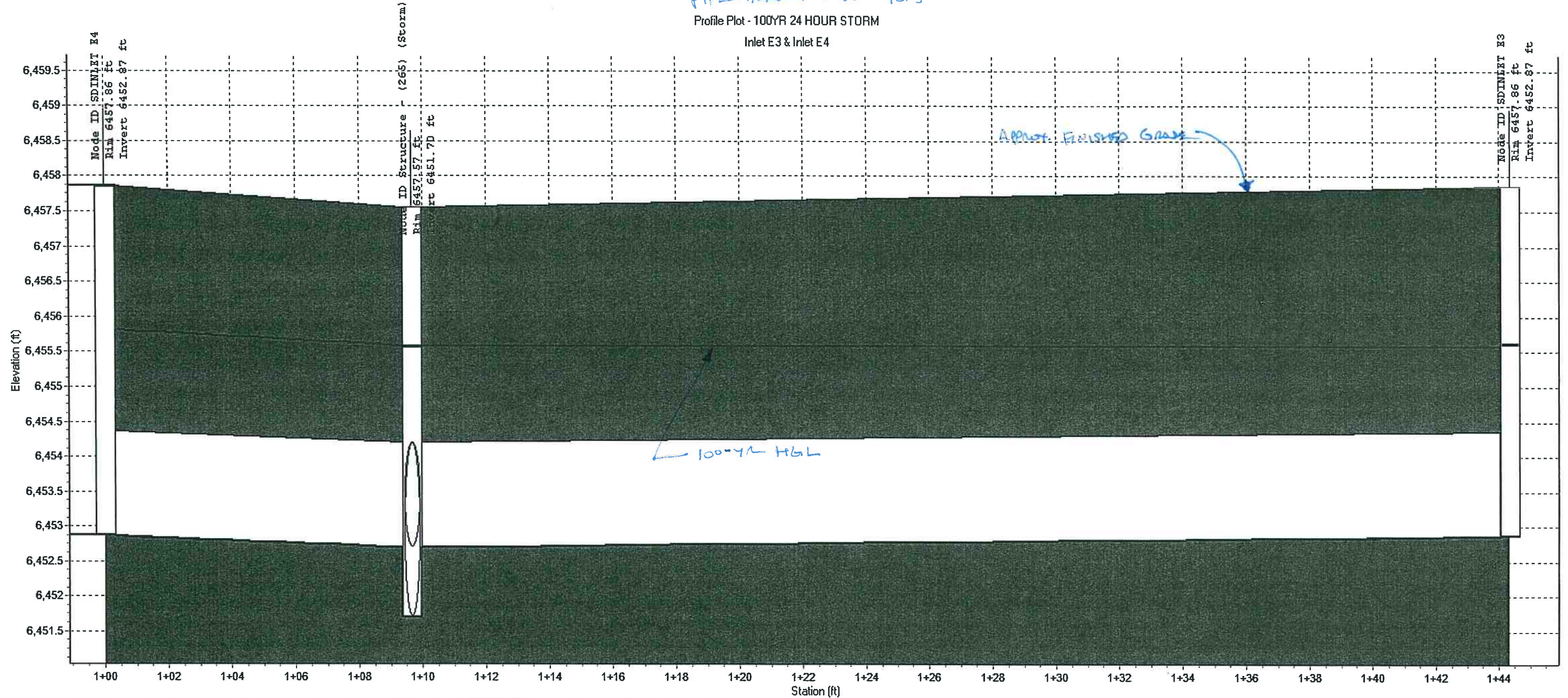
Node ID:	SDH-289 (Storm)	Structure - (265) (Storm)	Jun-05	
Rim (ft):	6463.01	6457.57	6453.82	6458.99
Invert (ft):	6460.20	6451.70	6451.32	6447.13
Min Pipe Cover (ft):	0.36 1.31	3.37	0.00	4.35
Max HGL (ft):	6461.32	6455.58	6454.51	6453.89
Link ID:		{Storm}.Pipe - (110) (Storm)	{Storm}.Pipe - (201) (2) (Storm)	Link-14
Length (ft):	1.511.54	329.65	84.29	17.74
Dia (in):	24.008.00	18.00	30.00	30.00
Slope (ft/ft):	0.000200	0.0228	0.0045	0.0056
Up Invert (ft):	6460.43	6460.20	6451.70	6451.32
Dn Invert (ft):	6460.20	6452.70	6451.32	6451.22
Max Q (cfs):	11.911.91	11.82	30.07	35.68
Max Vel (ft/s):	3.737.28	7.80	6.13	7.64
		1.31	2.50	2.50



PIPE HYDRAULIC ANALYSIS

Profile Plot - 100YR 24 HOUR STORM

Inlet E3 & Inlet E4



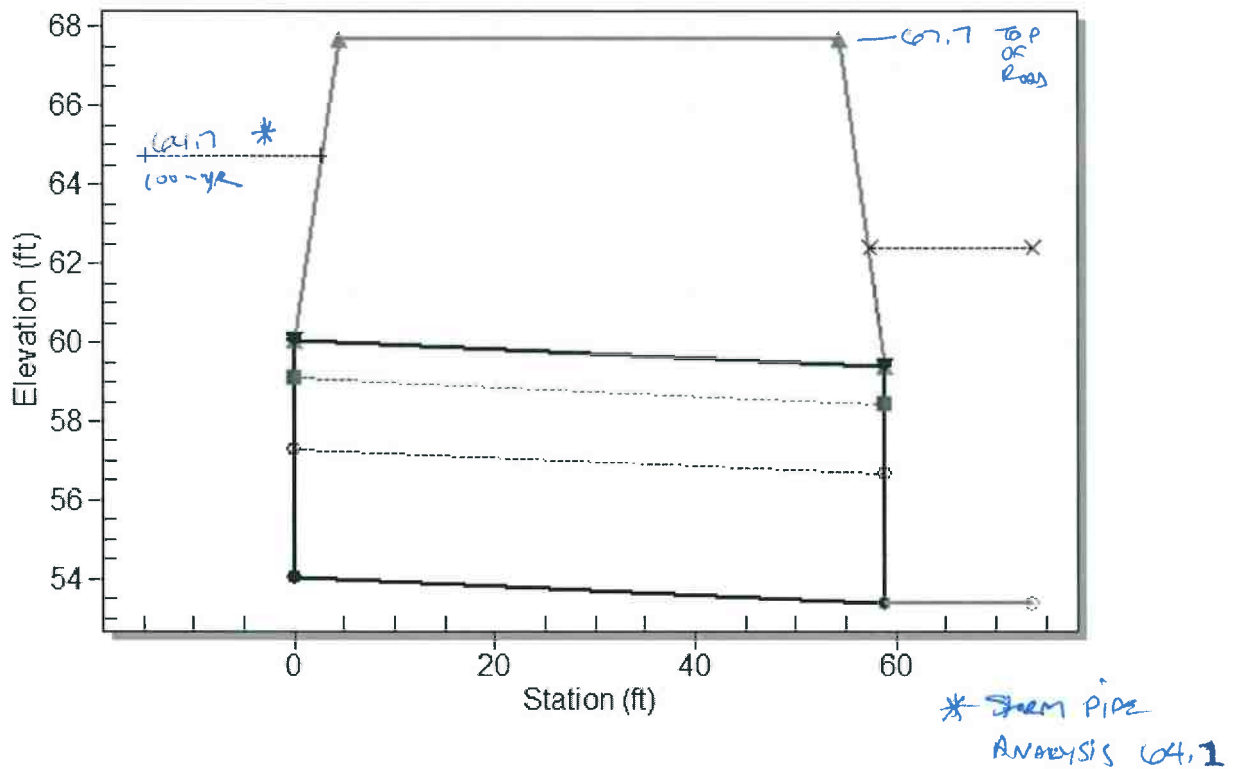
Node ID:	SDINLET E4	Structure - (265) (Storm)	SDINLET E3
Rim (ft):	6457.86	6457.57	6457.86
Invert (ft):	6452.87	6451.70	6452.87
Min Pipe Cover (ft):		3.37	
Max HGL (ft):	6457.86	6455.58	6455.61
Link ID:	{Storm}.Pipe - (197) (Storm)	{Storm}.Pipe - (198) (Storm)	
Length (ft):	9.66	34.67	
Dia (in):	18.00	18.00	
Slope (ft/ft):	0.0176	0.0049	
Up Invert (ft):	6452.87	6452.87	
Dn Invert (ft):	6452.70	6452.70	
Max Q (cfs):	17.51	3.63	
Max Vel (ft/s):	9.91	2.70	
Autodesk Storm and Sanitary Analysis	1.50	1.50	



## Water Surface Profile Plot for Culvert: 10'wx6'h CBC entrance to 90" RCP

Crossing - Winslow Park Drive, Design Discharge - 640.0 cfs

Culvert - 10'wx6'h CBC entrance to 90" RCP, Culvert Discharge - 640.0 cfs



### Site Data - 10'wx6'h CBC entrance to 90" RCP

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 54.06 ft

Outlet Station: 59.00 ft

Outlet Elevation: 53.40 ft

Number of Barrels: 1

### Culvert Data Summary - 10'wx6'h CBC entrance to 90" RCP

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130

Culvert Type: Straight

Inlet Configuration: 1:1 Bevel (45° flare) Wingwall

Inlet Depression: None

**Table 1 - Summary of Culvert Flows at Crossing: Winslow Park Drive**

	Headwater Elevation (ft)	Total Discharge (cfs)	10'wx6'h CBC entrance to 90" RCP Discharge (cfs)	Roadway Discharge (cfs)	Iterations
5 yr →	58.18	250.00	250.00	0.00	1
	58.62	289.00	289.00	0.00	1
	59.05	328.00	328.00	0.00	1
10 yr →	59.61	367.00	367.00	0.00	1
	60.14	406.00	406.00	0.00	1
	60.75	445.00	445.00	0.00	1
	61.54	484.00	484.00	0.00	1
	62.36	523.00	523.00	0.00	1
	63.21	562.00	562.00	0.00	1
	63.86	601.00	601.00	0.00	1
100 yr →	64.74	640.00	640.00	0.00	1
	67.70	962.93	962.93	0.00	Overtopping

**Stormwater Quality Sand Filter Basin Sizing Calculations  
UDFCD Design Worksheets**



## Design Procedure Form: Sand Filter (SF)

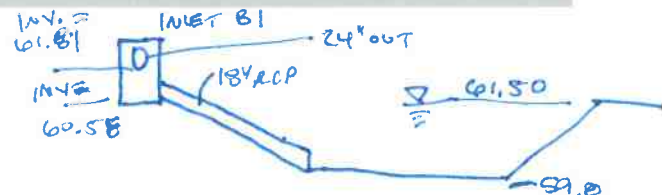
UD-BMP (Version 3.06, November 2016)

Sheet 1 of 2

**Designer:** D. Gorman  
**Company:** M.V.E., Inc.  
**Date:** August 7, 2017  
**Project:** Hannah Ridge at Feathergrass Filing No. 3  
**Location:** Sand Filter "B" ( for Basins OSB1-B7 and Basins OSC1-C12 - Combined)

<p>1. Basin Storage Volume</p> <p>A) Effective Imperviousness of Tributary Area, <math>I_a</math> (100% if all paved and roofed areas upstream of sand filter)</p> <p>B) Tributary Area's Imperviousness Ratio (<math>i = I_a/100</math>)</p> <p>C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time <math>WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)</math></p> <p>D) Contributing Watershed Area (including sand filter area)</p> <p>E) Water Quality Capture Volume (WQCV) Design Volume <math>V_{WQCV} = WQCV / 12 * Area</math></p> <p>F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm</p> <p>G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume</p> <p>H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)</p>	<p><math>I_a =</math> <u>46.3</u> %</p> <p><math>i =</math> <u>0.463</u></p> <p>WQCV = <u>0.16</u> watershed inches</p> <p>Area = <u>1,488,420</u> sq ft</p> <p><math>V_{WQCV} =</math> <u>19,485</u> cu ft</p> <p><math>d_6 =</math> <u>0.42</u> in</p> <p><math>V_{WQCV\ OTHER} =</math> <u>19,031</u> cu ft</p> <p><math>V_{WQCV\ USER} =</math> _____ cu ft</p>
<p>2. Basin Geometry</p> <p>A) WQCV Depth</p> <p>B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.</p> <p>C) Minimum Filter Area (Flat Surface Area)</p> <p>D) Actual Filter Area</p> <p>E) Volume Provided</p>	<p><math>D_{WQCV} =</math> <u>2.5</u> ft</p> <p><math>Z =</math> <u>3.00</u> ft / ft DIFFICULT TO MAINTAIN, INCREASE WHERE POSSIBLE</p> <p><math>A_{Min} =</math> <u>8614</u> sq ft</p> <p><math>A_{Actual} =</math> <u>8839</u> sq ft</p> <p><math>V_T =</math> <u>25850</u> cu ft</p>
<p>3. Filter Material</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> 18" CDOT Class B or C Filter Material</p> <p><input type="radio"/> Other (Explain): _____</p>
<p>4. Underdrain System</p> <p>A) Are underdrains provided?</p> <p>B) Underdrain system orifice diameter for 12 hour drain time</p> <p style="margin-left: 20px;">i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice</p> <p style="margin-left: 20px;">ii) Volume to Drain in 12 Hours</p> <p style="margin-left: 20px;">iii) Orifice Diameter, 3/8" Minimum</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> YES</p> <p><input type="radio"/> NO</p> <p><math>y =</math> <u>2.0</u> ft</p> <p><math>Vol_{12} =</math> <u>19,031</u> cu ft</p> <p><math>D_o =</math> <u>2</u> in</p>

$Q_2 = 14.4\ CFS$   
 $Q_{WQCV} = 1/2 Q_2 = 7.2\ CFS$   
 PIPE SIZE INTO SAND FILTER @ ATT @ INLET B1 = 18"  
 W/ RESTRICTOR PLATE 0.70' ABOVE INVERT



Design Procedure Form: Sand Filter (SF)

Sheet 2 of 2

Designer: D. Gorman  
Company: M.V.E., Inc.  
Date: August 7, 2017  
Project: Hannah Ridge at Feathergrass Filing No. 3  
Location: Sand Filter "B" ( for Basins OSB1-B7 and Basins OSC1-C12 - Combined)

5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Choose One \_\_\_\_\_  
 YES     NO

6-7. Inlet / Outlet Works

A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

FES and Rip Rap Pad at pipe outlet locations  
\_\_\_\_\_  
\_\_\_\_\_

Notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# Site-Level Low Impact Development (LID) Design Effective Impervious Calculator

## LID Credit by Impervious Reduction Factor (IRF) Method

US-BMP (Version 3.05, November 2016)

User Input		Calculated cells	
Design Storm: 1-Hour Rain Depth	0.60	WQCV Event	0.60
Minor Storm: 1-Hour Rain Depth	1.50	10-Year Event	1.50
Major Storm: 1-Hour Rain Depth	2.52	100-Year Event	2.52
Optional User Defined Storm		CUIP	
(CUIP) NOMA 1-Hour Rainfall Depth and Frequency for User Defined Storm		100-Year Event	

Designer: D. Gorman  
 Company: M.V.E., Inc.  
 Date: August 7, 2017  
 Project: Hannah Ridge at Feathergrass  
 Location: Sand Filter "B" (for Basins OSC1-B8 and Basins OSC1-C12 - Combined)

Max Intensity for Optional User Defined Storm: 0

### SITE INFORMATION (USER-INPUT)

Sub-basin Identifier	OSC1-B8	OSC1-C12
Receiving Previous Area Soil Type	Loamy Sand	Loamy Sand
Total Area (ac., Sum of DCIA, UIA, RPA, & SPA)	8.910	25.260
Directly Connected Impervious Area (DCIA, acres)	3.480	7.090
Unconnected Impervious Area (UUA, acres)	2.110	6.850
Receiving Previous Area (RPA, acres)	2.350	7.340
Separate Previous Area (SPA, acres)	0.990	4.040
RPA Treatment Type: Conveyance (C), Volume (V), or Permeable Pavement (PP)	C	C

### CALCULATED RESULTS (OUTPUT)

Total Calculated Area (ac, check against input)	8.910	25.260
Directly Connected Impervious Area (DCIA, %)	39.1%	27.8%
Unconnected Impervious Area (UUA, %)	23.7%	27.1%
Receiving Previous Area (RPA, %)	26.2%	29.1%
Separate Previous Area (SPA, %)	11.1%	16.0%
A <sub>s</sub> (RPA / UUA)	1.104	1.072
I <sub>s</sub> Check	0.480	0.480
f / f for WQCV Event:	3.2	3.2
f / f for 10-Year Event:	0.5	0.5
f / f for 100-Year Event:	0.4	0.4
f / f for Optional User Defined Storm CUIP:		
IRF for WQCV Event:	0.59	0.59
IRF for 10-Year Event:	0.89	0.89
IRF for 100-Year Event:	0.91	0.91
IRF for Optional User Defined Storm CUIP:		
Total Site Imperviousness: $I_{site}$	62.7%	54.9%
Effective Imperviousness for WQCV Event:	53.1%	44.0%
Effective Imperviousness for 10-Year Event:	60.0%	51.9%
Effective Imperviousness for 100-Year Event:	60.6%	52.5%
Effective Imperviousness for Optional User Defined Storm CUIP:		

### LID / EFFECTIVE IMPERVIOUSNESS CREDITS

WQCV Event CREDIT: Reduce Detention By:	12.5%	13.6%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10-Year Event CREDIT**:	4.4%	5.8%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
100-Year Event CREDIT**:	3.3%	4.4%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
User Defined CUIP CREDIT: Reduce Detention By:									

Total Site Imperviousness:	57.0%
Total Site Effective Imperviousness for WQCV Event:	46.3%
Total Site Effective Imperviousness for 10-Year Event:	54.0%
Total Site Effective Imperviousness for 100-Year Event:	54.6%
Total Site Effective Imperviousness for Optional User Defined Storm CUIP:	

### Notes:

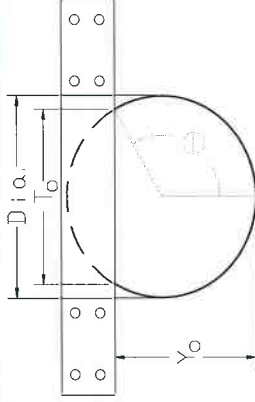
- \* Use Green-Ampt average infiltration rate values from Table 3.3.
- \*\* Flood control detention volume credit based on empirical equations from Storage Chapter of USDCM.
- \*\*\* Method assumes that 1-hour rainfall depth is equivalent to 1-hour intensity for calculation purposes



# RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: Hannah Ridge at Feathergrass

Basin ID: WQ inlet at Inlet B1 to Sand Filter B for Basins OSB1 to B7



X

### Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)

Water Surface Elevation at Design Depth	Elev: WS =	63.81	#1 Vertical Orifice	#2 Vertical Orifice
Pipe/Vertical Orifice Entrance Invert Elevation	Elev: Invert =	60.56		
Required Peak Flow through Orifice at Design Depth	Q =	7.20		
Pipe/Vertical Orifice Diameter (inches)	Dia =	18.0		
Orifice Coefficient	C <sub>o</sub> =	0.65		

### Full-flow Capacity (Calculated)

Full-flow area	A <sub>f</sub> =	1.77	sq ft
Half Central Angle in Radians	Theta =	3.14	rad
Full-flow capacity	Q <sub>f</sub> =	14.6	cfs
	Percent of Design Flow =	202%	

### Calculation of Orifice Flow Condition

Half Central Angle (0<Theta<3.1416)	Theta =	1.51	rad
Flow area	A <sub>o</sub> =	0.81	sq ft
Top width of Orifice (inches)	T <sub>o</sub> =	17.96	inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y <sub>o</sub> =	0.70	feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	61.26	feet
Resultant Peak Flow Through Orifice at Design Depth	Q <sub>o</sub> =	7.2	cfs

Width of Equivalent Rectangular Vertical Orifice

Equivalent Width =	1.16	feet
--------------------	------	------

## Design Procedure Form: Sand Filter (SF)

UD-BMP (Version 3.06, November 2016)

Sheet 1 of 2

**Designer:** D. Gorman  
**Company:** M.V.E., Inc.  
**Date:** August 7, 2017  
**Project:** Hannah Ridge at Feathergrass Filing No. 3  
**Location:** Sand Filter "E1" ( for Basins B8 & E7)

<p>1. Basin Storage Volume</p> <p>A) Effective Imperviousness of Tributary Area, <math>I_a</math> (100% if all paved and roofed areas upstream of sand filter)</p> <p>B) Tributary Area's Imperviousness Ratio (<math>i = I_a/100</math>)</p> <p>C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time <math>WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)</math></p> <p>D) Contributing Watershed Area (including sand filter area)</p> <p>E) Water Quality Capture Volume (WQCV) Design Volume <math>V_{WQCV} = WQCV / 12 * Area</math></p> <p>F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm</p> <p>G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume</p> <p>H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)</p>	<p><math>I_a =</math> <u>44.7</u> %</p> <p><math>i =</math> <u>0.447</u></p> <p>WQCV = <u>0.15</u> watershed inches</p> <p>Area = <u>186,546</u> sq ft</p> <p><math>V_{WQCV} =</math> <u>2,390</u> cu ft</p> <p><math>d_6 =</math> <u>0.42</u> in</p> <p><math>V_{WQCV\ OTHER} =</math> <u>2,334</u> cu ft</p> <p><math>V_{WQCV\ USER} =</math> _____ cu ft</p>
<p>2. Basin Geometry</p> <p>A) WQCV Depth</p> <p>B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.</p> <p>C) Minimum Filter Area (Flat Surface Area)</p> <p>D) Actual Filter Area</p> <p>E) Volume Provided</p>	<p><math>D_{WQCV} =</math> <u>2.0</u> ft</p> <p><math>Z =</math> <u>3.00</u> ft / ft <b>DIFFICULT TO MAINTAIN, INCREASE WHERE POSSIBLE</b></p> <p><math>A_{Min} =</math> <u>1042</u> sq ft</p> <p><math>A_{Actual} =</math> <u>1052</u> sq ft</p> <p><math>V_T =</math> <u>3013</u> cu ft</p>
<p>3. Filter Material</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> 18" CDOT Class B or C Filter Material</p> <p><input type="radio"/> Other (Explain): _____</p>
<p>4. Underdrain System</p> <p>A) Are underdrains provided?</p> <p>B) Underdrain system orifice diameter for 12 hour drain time</p> <p style="margin-left: 20px;">i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice</p> <p style="margin-left: 20px;">ii) Volume to Drain in 12 Hours</p> <p style="margin-left: 20px;">iii) Orifice Diameter, 3/8" Minimum</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> YES</p> <p><input type="radio"/> NO</p> <p><math>y =</math> <u>2.0</u> ft</p> <p><math>Vol_{12} =</math> <u>2,334</u> cu ft</p> <p><math>D_o =</math> <u>1 - 1 / 16</u> in</p>

Flow ENTER OVERLAND  
 NO PIPE INLET  
 $Q_2 = 1.9 + 0.4 = 2.3$   
 $Q_{WQCV} = 1/2 Q_2 = 1.2\ cfs$

Design Procedure Form: Sand Filter (SF)

Sheet 2 of 2

Designer: D. Gorman  
Company: M.V.E., Inc.  
Date: August 7, 2017  
Project: Hannah Ridge at Feathergrass Filing No. 3  
Location: Sand Filter "E1" ( for Basins B8 & E7)

5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Choose One \_\_\_\_\_  
 YES     NO

6-7. Inlet / Outlet Works

A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

FES and Rip Rap Pad at pipe outlet locations  
\_\_\_\_\_  
\_\_\_\_\_

Notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



# Site-Level Low Impact Development (LID) Design Effective Impervious Calculator

## LID Credit by Impervious Reduction Factor (IRF) Method

LID-BMP (Version 3.05; November 2016)

<p><b>User Input</b></p> <p>Design Storm: 1-Hour Rain Depth: _____ inches</p> <p>Minor Storm: 1-Hour Rain Depth: _____ inches</p> <p>Major Storm: 1-Hour Rain Depth: _____ inches</p> <p>Optional User Defined Storm: _____ inches</p> <p>(CUIP) NOAA 1-Hour Rainfall Depth and Frequency for User Defined Storm: _____ inches</p> <p>Max Intensity for Optional User Defined Storm: _____</p>	<p><b>Calculated cells</b></p> <p>WQCV Event: _____ inches</p> <p>10-Year Event: _____ inches</p> <p>100-Year Event: _____ inches</p> <p>CUIP: _____ inches</p> <p>100-Year Event: _____ inches</p>
--	---

Designer: D. Gorman  
 Company: M.V.E., Inc.  
 Date: August 7, 2017  
 Project: Hannah Ridge at Feathergrass Filing No. 3  
 Location: Sand Filter "E1" (for Basins B8 & E7)

**SITE INFORMATION (USER INPUT)**

Sub-basin Identifier	Receiving Previous Area Soil Type
E7/B8	Loamy Sand
	4.280
	0.960
	1.600
	1.720
	0.000
	C

Total Area (Ac., Sum of DCIA, UIA, RPA, & SPA): \_\_\_\_\_  
 Directly Connected Impervious Area (DCIA, acres): \_\_\_\_\_  
 Unconnected Impervious Area (UUA, acres): \_\_\_\_\_  
 Receiving Previous Area (RPA, acres): \_\_\_\_\_  
 Separate Previous Area (SPA, acres): \_\_\_\_\_  
 RPA Treatment Type: Conveyance (C), Volume (V), or Permeable Pavement (PP): \_\_\_\_\_

**CALCULATED RESULTS (OUTPUT)**

Total Calculated Area (Ac., check against input)	4.280
Directly Connected Impervious Area (DCIA, %)	22.4%
Unconnected Impervious Area (UUA, %)	37.4%
Receiving Previous Area (RPA, %)	40.2%
Separate Previous Area (SPA, %)	0.0%
A <sub>i</sub> (RPA / UUA)	1.075
I <sub>i</sub> Check	0.480
1 / I <sub>i</sub> for WQCV Event:	3.2
1 / I <sub>i</sub> for 10-Year Event:	0.5
1 / I <sub>i</sub> for 100-Year Event:	0.4
1 / I <sub>i</sub> for Optional User Defined Storm CUIP:	
IRF for WQCV Event:	0.59
IRF for 10-Year Event:	0.89
IRF for 100-Year Event:	0.91
IRF for Optional User Defined Storm CUIP:	
Total Site Imperviousness: <i>I<sub>site</sub></i>	59.8%
Effective Imperviousness for WQCV Event:	44.7%
Effective Imperviousness for 10-Year Event:	55.6%
Effective Imperviousness for 100-Year Event:	56.4%
Effective Imperviousness for Optional User Defined Storm CUIP:	

**LID / EFFECTIVE IMPERVIOUSNESS CREDITS**

WQCV Event CREDIT: Reduce Detention By:	10-Year Event CREDIT**:	100-Year Event CREDIT**:	User Defined CUIP CREDIT: Reduce Detention By:
18.5%	N/A	N/A	N/A
7.4%	N/A	N/A	N/A
5.5%	N/A	N/A	N/A

Total Site Imperviousness:	59.8%
Total Site Effective Imperviousness for WQCV Event:	44.7%
Total Site Effective Imperviousness for 10-Year Event:	55.6%
Total Site Effective Imperviousness for 100-Year Event:	56.4%
Total Site Effective Imperviousness for Optional User Defined Storm CUIP:	

Notes:  
 \* Use Green-Ampt average infiltration rate values from Table 3-3.  
 \*\* Flood control detention volume credits based on empirical equations from Storage Chapter of USDCM.  
 \*\*\* Method assumes that 1-hour rainfall depth is equivalent to 1-hour intensity for calculation purposes

# Weir Report

Also provide  
Q5 and Q100  
calcs.

## Curb Opening Basin B8 to Sand Filter

### Rectangular Weir

Crest = Sharp  
Bottom Length (ft) = 1.00  
Total Depth (ft) = 0.38

### Highlighted

Depth (ft) = 0.15  
Q (cfs) = 0.200  
Area (sqft) = 0.15  
Velocity (ft/s) = 1.31  
Top Width (ft) = 1.00

### Calculations

Weir Coeff. Cw = 3.33  
Compute by: Known Q  
Known Q (cfs) = 0.20

$Q_2 = 0.4 \text{ cfs}$

$Q_{weir} = \frac{1}{2} Q_2 = 0.2 \text{ cfs}$

Curb opening = 1.0'

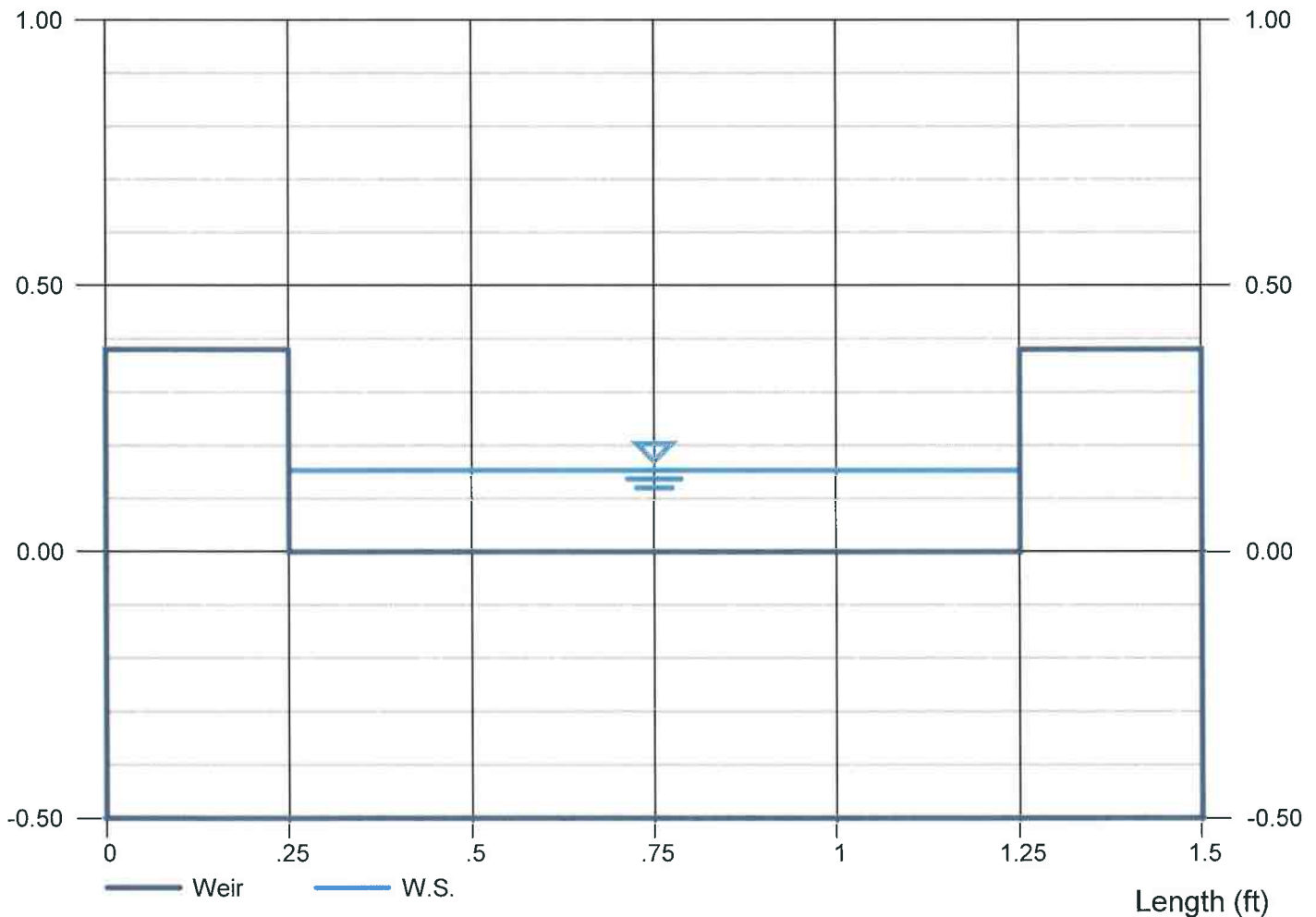
$d = 0.15'$  for weir flow

Can't find this on drainage plan or CDs

Depth (ft)

Curb Opening Basin B8 to Sand Filter

Depth (ft)



## Design Procedure Form: Sand Filter (SF)

UD-BMP (Version 3.06, November 2016)

Sheet 1 of 2

**Designer:** D. Gorman  
**Company:** M.V.E., Inc.  
**Date:** August 7, 2017  
**Project:** Hannah Ridge at Feathergrass Filing No. 3  
**Location:** Sand Filter "E2" (for Basins E1-E5, E8)

<p>1. Basin Storage Volume</p> <p>A) Effective Imperviousness of Tributary Area, <math>I_a</math> (100% if all paved and roofed areas upstream of sand filter)</p> <p>B) Tributary Area's Imperviousness Ratio (<math>i = I_a/100</math>)</p> <p>C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time <math>WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)</math></p> <p>D) Contributing Watershed Area (including sand filter area)</p> <p>E) Water Quality Capture Volume (WQCV) Design Volume <math>V_{wqcv} = WQCV / 12 * Area</math></p> <p>F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm</p> <p>G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume</p> <p>H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)</p>	<p><math>I_a =</math> <u>51.4</u> %</p> <p><math>i =</math> <u>0.514</u></p> <p>WQCV = <u>0.17</u> watershed inches</p> <p>Area = <u>405,049</u> sq ft</p> <p><math>V_{wqcv} =</math> <u>5,673</u> cu ft</p> <p><math>d_6 =</math> <u>0.42</u> in</p> <p><math>V_{WQCV\ OTHER} =</math> <u>5,541</u> cu ft</p> <p><math>V_{WQCV\ USER} =</math> _____ cu ft</p>
<p>2. Basin Geometry</p> <p>A) WQCV Depth</p> <p>B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.</p> <p>C) Minimum Filter Area (Flat Surface Area)</p> <p>D) Actual Filter Area</p> <p>E) Volume Provided</p>	<p><math>D_{wqcv} =</math> <u>2.0</u> ft</p> <p><math>Z =</math> <u>3.00</u> ft / ft DIFFICULT TO MAINTAIN, INCREASE WHERE POSSIBLE</p> <p><math>A_{Min} =</math> <u>2602</u> sq ft</p> <p><math>A_{Actual} =</math> <u>2919</u> sq ft</p> <p><math>V_T =</math> <u>7378</u> cu ft</p>
<p>3. Filter Material</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> 18" CDOT Class B or C Filter Material</p> <p><input type="radio"/> Other (Explain): _____</p>
<p>4. Underdrain System</p> <p>A) Are underdrains provided?</p> <p>B) Underdrain system orifice diameter for 12 hour drain time</p> <p style="margin-left: 20px;">i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice</p> <p style="margin-left: 20px;">ii) Volume to Drain in 12 Hours</p> <p style="margin-left: 20px;">iii) Orifice Diameter, 3/8" Minimum</p>	<p>Choose One _____</p> <p><input checked="" type="radio"/> YES</p> <p><input type="radio"/> NO</p> <p><math>y =</math> <u>2.0</u> ft</p> <p><math>Vol_{12} =</math> <u>5,541</u> cu ft</p> <p><math>D_o =</math> <u>1 - 11 / 16</u> in</p>

$Q_2 = 15.2$  cfs

$Q_{wqcv} = 1/2 Q_2 = 7.6$  cfs

PIPE SIZE INTO SAND FILTER = 18" @ 50 MPH EZ

w/RESTRICTOR PLATE @ 0.66' ABOVE INVERT



Design Procedure Form: Sand Filter (SF)

Sheet 2 of 2

Designer: D. Gorman  
Company: M.V.E., Inc.  
Date: August 7, 2017  
Project: Hannah Ridge at Feathergrass Filing No. 3  
Location: Sand Filter "E2" (for Basins E1-E5, E8)

5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Choose One \_\_\_\_\_  
 YES     NO

6-7. Inlet / Outlet Works

A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

FES and Rip Rap Pad at pipe outlet locations  
\_\_\_\_\_  
\_\_\_\_\_

Notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# Site-Level Low Impact Development (LID) Design Effective Impervious Calculator

## LID Credit by Impervious Reduction Factor (IRF) Method

LID-BMP (Version 3.06, November 2016)

<p><b>User Input</b></p> <p>WQCV Event: <input type="text" value="0.60"/> inches</p> <p>10-Year Event: <input type="text" value="1.50"/> inches</p> <p>100-Year Event: <input type="text" value="2.52"/> inches</p> <p>Optional User Defined Storm CUHP: <input type="text"/></p> <p>Optional User Defined Storm Frequency for User Defined Storm: <input type="text"/></p>	<p><b>Calculated cells</b></p> <p>WQCV Event: <input type="text" value="0.60"/> inches</p> <p>10-Year Event: <input type="text" value="1.50"/> inches</p> <p>100-Year Event: <input type="text" value="2.52"/> inches</p> <p>CUHP: <input type="text"/></p> <p>Frequency for User Defined Storm: <input type="text"/></p>
---	---

Designer: D. Gorman  
 Company: M.V.E., Inc.  
 Date: August 7, 2017  
 Project: Hannah Ridge at Feathergrass Filing No. 3  
 Location: Sand Filter "E2" (for Basins EL-ES, ES)

Max Intensity for Optional User Defined Storm:

### SITE INFORMATION (USER-INPUT)

Sub-basin Identifier	EL-ES, E8
Receiving Previous Area Soil Type	Loamy Sand
Total Area (ac., Sum of DCIA, UIA, RPA, & SPA)	9.300
Directly Connected Impervious Area (DCIA, acres)	2.870
Unconnected Impervious Area (UIA, acres)	3.180
Receiving Previous Area (RPA, acres)	3.250
Separate Previous Area (SPA, acres)	0.000
RPA Treatment Type: Conveyance (C), Volume (V), or Permeable Pavement (PP)	C

### CALCULATED RESULTS (OUTPUT)

Total Calculated Area (ac, check against input)	9.300
Directly Connected Impervious Area (DCIA, %)	30.9%
Unconnected Impervious Area (UIA, %)	34.2%
Receiving Previous Area (RPA, %)	34.9%
Separate Previous Area (SPA, %)	0.0%
A <sub>s</sub> (RPA / UIA)	1.022
I <sub>s</sub> Check	0.490
1/1 for WQCV Event:	3.2
1/1 for 10-Year Event:	0.5
1/1 for 100-Year Event:	0.4
1/1 for Optional User Defined Storm CUHP:	
IRF for WQCV Event:	0.60
IRF for 10-Year Event:	0.89
IRF for 100-Year Event:	0.91
IRF for Optional User Defined Storm CUHP:	
Total Site Imperviousness: <sup>100%</sup>	65.1%
Effective Imperviousness for WQCV Event:	51.4%
Effective Imperviousness for 10-Year Event:	61.2%
Effective Imperviousness for 100-Year Event:	62.0%
Effective Imperviousness for Optional User Defined Storm CUHP:	

### LID / EFFECTIVE IMPERVIOUSNESS CREDITS

WQCV Event CREDIT: Reduce Detention By:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10-Year Event CREDIT**:	6.1%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
100-Year Event CREDIT**:	4.5%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
User Defined CUHP CREDIT: Reduce Detention By:									

Total Site Imperviousness:	65.1%
Total Site Effective Imperviousness for WQCV Event:	51.4%
Total Site Effective Imperviousness for 10-Year Event:	61.2%
Total Site Effective Imperviousness for 100-Year Event:	62.0%
Total Site Effective Imperviousness for Optional User Defined Storm CUHP:	

Notes:

<sup>1</sup> Use Green-Ampt average infiltration rate values from Table B-3.

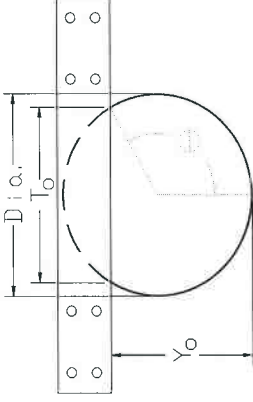
\*\* Flood control detention volume credits based on empirical equations from Storage Chapter of USDCM.

\*\*\* Method assumes that 1-hour rainfall depth is equivalent to 1-hour intensity for calculation purposes

# RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: Hannah Ridge at Feathergrass

Basin ID: WQ Inlet at MH E2 to Sand Filter E2 for Basins E1-E5, E8



X

### Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)

Elev: WS =	#1 Vertical Orifice	#2 Vertical Orifice
Elev: Invert =	54.71	
Q =	50.58	
Dia =	7.60	
C <sub>o</sub> =	18.0	
	0.65	

### Full-flow Capacity (Calculated)

Full-flow area	A <sub>f</sub> =	1.77	sq ft
Half Central Angle in Radians	Theta =	3.14	rad
Full-flow capacity	Q <sub>f</sub> =	17.0	cfs
	Percent of Design Flow =	223%	

### Calculation of Orifice Flow Condition

Half Central Angle (0<Theta<3.1416)	Theta =	1.45	rad
Flow area	A <sub>o</sub> =	0.75	sq ft
Top width of Orifice (inches)	T <sub>o</sub> =	17.87	inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y <sub>o</sub> =	0.66	feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	51.24	feet
Resultant Peak Flow Through Orifice at Design Depth	Q <sub>o</sub> =	7.6	cfs

### Width of Equivalent Rectangular Vertical Orifice

Equivalent Width =	1.14	feet
--------------------	------	------



## 10 Downstream Hydrologic & Hydraulic Analysis \*

Full Reach Developed Condition Hydrology with Developed Hannah Ridge (Directly From DBPS Hydrology Update – Kiowa Engineering 1/18/07) 10-yr, 100-year

Full Reach Existing Condition Hydrology with totally undeveloped Hannah Ridge (Directly From DBPS Hydrology Update – Kiowa Engineering 1/18/07) 10-yr, 100-year

Full Reach Existing Condition Hydrology with Fully Developed Hannah Ridge (Modified from From DBPS Hydrology Update) 10-yr, 100-year

Full Reach Existing Offsite Conditions Hydrology with Only Hannah Ridge Phases 1 – 4 Developed (Modified from From DBPS Hydrology Update) 10-yr, 100-year

HEC-RAS Data and output - Existing Condition Hydrology with totally undeveloped Hannah Ridge

HEC-RAS Data and output - Existing Condition Hydrology with Fully Developed Hannah Ridge

HEC-RAS Data and output - Existing Offsite Conditions Hydrology with Only Hannah Ridge Phases 1 – 4 Developed

\* FROM HANNAH RIDGE AT FEATHERGRASS MDOP  
M.V.E., INC., NOV. 15, 2007

**HANNAH RIDGE AT FEATHERGRASS  
MASTER DRAINAGE DEVELOPMENT PLAN**

**November 15, 2007  
Project No. 60754**

**PREPARED FOR:**

**FEATHERGRASS INVESTMENTS, LLC  
4715 North Chestnut Street  
Colorado Springs, CO 80907  
(719) 593-8367**

**Kenneth P. Driscoll, Manager**

**PREPARED BY:**

**M.V.E., Inc.  
1903 Lelaray Street, Suite 200  
Colorado Springs, CO 80909  
(719) 635-5736**





TOTAL TIME BASE 24.92 HOURS

ENGLISH UNITS

DRAINAGE AREA SQUARE MILES  
 PRECIPITATION DEPTH INCHES  
 LENGTH, ELEVATION FEET  
 FLOW CUBIC FEET PER SECOND  
 STORAGE VOLUME ACRES-FEET  
 SURFACE AREA ACRES  
 TEMPERATURE DEGREES FAHRENHEIT

JP MULTI-PLAN OPTION 1 NUMBER OF PLANS  
 NELAN




JR MULTI-RATIO OPTION  
 RATIOS OF PRECIPITATION  
 .68 1.00

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS: IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES  
 TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO PRECIPITATION	
				RATIO 1	RATIO 2
HYDROGRAPH AT	5	.20	1	154,	326.
				6.08	6.00
ROUTED TO	RT-5A	.20	1	151,	322.
				6.08	6.08
ROUTED TO	RT-5	.20	1	142,	313.
				6.17	6.08
HYDROGRAPH AT	1	.14	1	117,	242.
				6.08	6.00
COMBINED AT	DP-1	.34	1	255,	551.
				6.08	6.08
ROUTED TO	RT-1	.34	1	245,	518.
				6.25	6.25



+	3 COMBINED AT	DP-8	1.08	1	FLOW TIME	457.6.00	1076.6.08	
+	ROUTED TO	RT-6A	1.08	1	FLOW TIME	448.6.08	1069.6.08	
+	ROUTED TO	RT6	1.08	1	FLOW TIME	447.6.08	1044.6.08	
+	HYDROGRAPH AT	6	.12	1	FLOW TIME	144.6.00	269.6.00	
+	2 COMBINED AT	DP -6	1.20	1	FLOW TIME	588.6.08	1299.6.08	
+	ROUTED TO	RT-7	1.20	1	FLOW TIME	570.6.17	1296.6.17	
+	HYDROGRAPH AT	7	.17	1	FLOW TIME	125.6.17	255.6.17	
+	2 COMBINED AT	DP-7	1.37	1	FLOW TIME	695.6.17	1551.6.17	
+	ROUTED TO	RT-8	1.37	1	FLOW TIME	685.6.42	1481.6.42	
+	HYDROGRAPH AT	9	.14	1	FLOW TIME	72.6.25	159.6.17	
+	HYDROGRAPH AT	11	.15	1	FLOW TIME	134.6.08	275.6.00	
+	ROUTED TO	DB11	.15	1	FLOW TIME	52.6.25	56.6.33	

\*\* PEAK STAGES IN FEET \*\*  
 1 STAGE 6443.93 6446.82  
 TIME 6.25 6.33

ROUTED TO								
+	RT11A	.15	1	FLOW TIME	52.	56.		
					6.33	6.42		
ROUTED TO								
+	RT11B	.15	1	FLOW TIME	52.	56.		
					6.33	6.50		
HYDROGRAPH AT								
+	10	.07	1	FLOW TIME	61.	122.		
					6.08	6.08		
2 COMBINED AT								
+	DP10	.22	1	FLOW TIME	110.	175.		
					6.08	6.08		
2 COMBINED AT								
+	DP-9	.36	1	FLOW TIME	177.	325.		
					6.17	6.17		
ROUTED TO								
+	RT-9	.36	1	FLOW TIME	174.	321.		
					6.25	6.25		
HYDROGRAPH AT								
+	8	.19	1	FLOW TIME	187.	353.		
					6.17	6.08		
3 COMBINED AT								
+	D3-8A	1.91	1	FLOW TIME	925.	2088.		
					6.42	6.25		
1								



\*\*\* NORMAL END OF HEC-1 \*\*\*



```

150 . . . . . DE10.....
153 . . . . . DP-9.....
      V
      V
156 . . . . . RT-9
159 . . . . . 8
164 . . . . . DP-8A.....

```

(\*\*\*) RUNOFF ALSO COMPUTED AT THIS LOCATION

```

*****
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* JUN 1998 *
* VERSION 4.1 *
* RUN DATE 04SEP07 TIME 11:53:45 *
*****

```

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

```

- Full Reach Exist Condition w/ undeveloped Hannah Ridge -  
 Kiowa Eng. 9/5/07

East Fork Subtributary hydrology FN: 06040  
 Existing devel condition with storage at RR Embankment  
 Sand Creek DBPS Hydrology update  
 Existing culvert under RR in-place and no blockage  
 10- and 100 Year, 24 hr Type IIA Storm FN efsrd.dat

```

7 IO OUTPUT CONTROL VARIABLES
      IPRINT 5 PRINT CONTROL
      IFLOT 0 ELOT CONTROL
      QSCAL 0. HYDROGRAPH PLOT SCALE

```

```

IT HYDROGRAPH TIME DATA
      NMIN 5 MINUTES IN COMPUTATION INTERVAL
      IDATE 1 0 STARTING DATE
      ITIME 0000 300 NUMBER OF HYDROGRAPH ORDINATES
      NDDATE 2 0 ENDING DATE
      NDTIME 0055 ENDING TIME
      ICENT 19 CENTURY MARK

```

COMPUTATION INTERVAL .08 HOURS

TOTAL TIME BASE 24.92 HOURS

ENGLISH UNITS

DRAINAGE AREA SQUARE MILES  
 PRECIPITATION DEPTH INCHES  
 LENGTH, ELEVATION FEET  
 FLOW CUBIC FEET PER SECOND  
 STORAGE VOLUME ACRE-Feet  
 SURFACE AREA ACRES  
 TEMPERATURE DEGREES FAHRENHEIT

JP MULTI-PLAN OPTION 1 NUMBER OF PLANS  
 NPLAN

JR MULTI-RATIO OPTION  
 RATIOS OF PRECIPITATION  
 .68 1.00

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES  
 TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO PRECIPITATION	
				RATIO 1	RATIO 2
HYDROGRAPH AT	5	.20	1	154.	326.
ROUTED TO				6.08	6.00
ROUTED TO	RT-5A	.20	1	151.	322.
ROUTED TO				6.08	6.08
HYDROGRAPH AT	1	.14	1	142.	313.
ROUTED TO				6.17	6.08
ROUTED TO	DP-1	.34	1	117.	242.
ROUTED TO				6.08	6.00
ROUTED TO	RT-1	.34	1	255.	551.
ROUTED TO				6.08	6.08
ROUTED TO	RT-1	.34	1	245.	518.
ROUTED TO				5.25	6.25



+ 3 COMBINED AT



DP-8 1.08 1 392. 856.  
6.42 6.17

+ Routed TO

RT-6A 1.08 1 390. 852.  
6.42 6.17

+ Routed TO

RT6 1.08 1 385. 835.  
6.42 6.17

+ HYDROGRAPH AT

6 .12 1 144. 269.  
6.00 6.00

+ 2 COMBINED AT



DP -6 1.20 1 410. 1004.  
6.42 6.17

+ Routed TO

RT-7 1.20 1 402. 993.  
6.50 6.25

+ HYDROGRAPH AT

7 .17 1 69. 174.  
6.17 6.17

+ 2 COMBINED AT



DP-7 1.37 1 429. 1151.  
6.50 6.17

+ Routed TO

RT-8 1.37 1 444. 1144.  
6.50 6.42

+ HYDROGRAPH AT

9 .14 1 72. 159.  
6.25 6.17

+ HYDROGRAPH AT

11 .15 1 134. 275.  
6.08 6.00

+ Routed TO

DB11 .15 1 52. 56.  
6.25 6.33

\*\* PEAK STAGES IN FEET \*\*

1 STAGE 6443.93 6446.82  
TIME 6.25 6.33



ROUTED TO									
+	RT11A	.15	1	FLOW TIME	52.	56.			
					6.33	6.42			
ROUTED TO									
+	RT11B	.15	1	FLOW TIME	52.	56.			
					6.33	6.50			
HYDROGRAPH AT									
+	10	.07	1	FLOW TIME	61.	122.			
					6.08	6.08			
2 COMBINED AT									
+	DP10	.22	1	FLOW TIME	110.	175.			
					6.08	6.08			
2 COMBINED AT									
+	DP-9	.36	1	FLOW TIME	177.	325.			
					6.17	6.17			
ROUTED TO									
+	RT-9	.36	1	FLOW TIME	174.	321.			
					6.25	6.25			
HYDROGRAPH AT									
+	8	.19	1	FLOW TIME	77.	194.			
					6.17	6.17			
3 COMBINED AT									
+	DP-8A	1.91	1	FLOW TIME	609.	1497.			
					6.50	6.42			
1									



\*\*\* NORMAL END OF HEC-1 \*\*\*

```

. . . . .
. . . . . DP10.....
. . . . .
. . . . .
. . . . .
. . . . . DP-9.....
. . . . . V
. . . . . V
. . . . . RT-9
. . . . .
. . . . . 8
. . . . .
. . . . .
. . . . . DP-8A.....

```

(\*\*\*) RUNOFF ALSO COMPUTED AT THIS LOCATION

```

1*****
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* JUN 1998 *
* VERSION 4.1 *
* RUN DATE 19OCT07 TIME 09:48:32 *
* *****
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
* 609 SECOND STREET *
* DAVIS, CALIFORNIA 95616 *
* (916) 756-1104 *
* *****

```

*Full Reach Exist Condition w/ Developed Hannan Ridge*

East Fork Subtributary Hydrology PN: 60754  
 Existing Offsite Development Condition with Developed On-Site Hannah  
 with storage at RR Embankment, Existing RR culvert in place and no  
 blockage.  
 10- and 100 Year, 24 hr Typee IIA Storm FN efsceo.dat

```

7 IO OUTPUT CONTROL VARIABLES
IPRNT 5 PRINT CONTROL
IPLOT 0 PLOT CONTROL
QSCAL 0. HYDROGRAPH PLOT SCALE

```

```

IT HYDROGRAPH TIME DATA
NMIN 5 MINUTES IN COMPUTATION INTERVAL
IDATE 1 0 STARTING DATE
ITIME 0000 STARTING TIME
NQ 300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE 2 0 ENDING DATE
NDTIME 0055 ENDING TIME
ICENT 19 CENTURY MARK

```

COMPUTATION INTERVAL .08 HOURS

TOTAL TIME BASE 24.92 HOURS

ENGLISH UNITS  
 DRAINAGE AREA SQUARE MILES  
 PRECIPITATION DEPTH INCHES  
 LENGTH, ELEVATION FEET  
 FLOW CUBIC FEET PER SECOND  
 STORAGE VOLUME ACRE-FEET  
 SURFACE AREA ACRES  
 TEMPERATURE DEGREES FAHRENHEIT

JP MULTI-PLAN OPTION 1 NUMBER OF PLANS  
 NPLAN

JR MULTI-RATIO OPTION  
 RATIOS OF PRECIPITATION  
 .68 1.00

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES  
 TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO PRECIPITATION	
				RATIO 1	RATIO 2
HYDROGRAPH AT	5	.20	1	154.	326.
+				6.08	6.00
ROUTED TO	RT-5A	.20	1	151.	322.
+				6.08	6.08
ROUTED TO	RT-5	.20	1	142.	313.
+				6.17	6.08
HYDROGRAPH AT	1	.14	1	117.	242.
+				6.08	6.00
2 COMBINED AT	DP-1	.34	1	255.	551.
+				6.08	6.08
ROUTED TO	RT-1	.34	1	245.	518.
+				6.25	6.25

HYDROGRAPH AT	2	.32	1	FLOW TIME	181. 6.08	429. 6.08
+						
2 COMBINED AT	DP-14	.66	1	FLOW TIME	360. 6.25	886. 6.17
+						
ROUTED TO	DB-14	.66	1	FLOW TIME	351. 6.25	627. 6.33
+						
				** PEAK STAGES IN FEET **		
			1	STAGE TIME	90.33 6.25	95.05 6.33
ROUTED TO	RT-2B	.66	1	FLOW TIME	340. 6.33	624. 6.42
+						
HYDROGRAPH AT	3	.16	1	FLOW TIME	130. 6.00	283. 6.00
+						
ROUTED TO	RT-3A	.16	1	FLOW TIME	126. 6.08	273. 6.00
+						
ROUTED TO	RT-3	.16	1	FLOW TIME	126. 6.08	270. 6.00
+						
HYDROGRAPH AT	4	.15	1	FLOW TIME	179. 6.00	333. 6.00
+						
3 COMBINED AT	DP-4A	.98	1	FLOW TIME	416. 6.33	966. 6.08
+						
ROUTED TO	RT-2A	.98	1	FLOW TIME	406. 6.33	931. 6.17
+						
HYDROGRAPH AT	12	.05	1	FLOW TIME	107. 6.00	168. 6.00
+						
HYDROGRAPH AT	13	.05	1	FLOW TIME	85. 6.00	139. 6.00
+						



3 COMBINED AT

+ DP-8 1.08 1 FLOW TIME 453. 6.00 1041. 6.08



ROUTED TO

+ RT-6A 1.08 1 FLOW TIME 438. 6.00 1033. 6.08

ROUTED TO

+ RT-6 1.08 1 FLOW TIME 436. 6.08 1006. 6.17

HYDROGRAPH AT

+ 6 .12 1 FLOW TIME 144. 6.00 269. 6.00

2 COMBINED AT

+ DP-6 1.20 1 FLOW TIME 577. 6.08 1261. 6.08



ROUTED TO

+ RT-7 1.20 1 FLOW TIME 560. 6.17 1259. 6.17

HYDROGRAPH AT

+ 7 .17 1 FLOW TIME 69. 6.17 174. 6.17

2 COMBINED AT

+ DP-7 1.37 1 FLOW TIME 629. 6.17 1433. 6.17



ROUTED TO

+ RT-8 1.37 1 FLOW TIME 632. 6.42 1391. 6.42

HYDROGRAPH AT

+ 9 .14 1 FLOW TIME 72. 6.25 159. 6.17

HYDROGRAPH AT

+ 11 .15 1 FLOW TIME 134. 6.08 275. 6.00

ROUTED TO

+ DB11 .15 1 FLOW TIME 52. 6.25 56. 6.33

\*\* PEAK STAGES IN FEET \*\*

1 STAGE 6443.93 6446.82  
TIME 6.25 6.33

ROUTED TO									
+	RT11A	.15	1	FLOW TIME	52.	56.	6.33	6.42	
ROUTED TO									
+	RT11B	.15	1	FLOW TIME	52.	56.	6.33	6.50	
HYDROGRAPH AT									
+	10	.07	1	FLOW TIME	61.	122.	6.08	6.08	
2 COMBINED AT									
+	DP10	.22	1	FLOW TIME	110.	175.	6.08	6.08	
2 COMBINED AT									
+	DP-9	.36	1	FLOW TIME	177.	325.	6.17	6.17	
ROUTED TO									
+	RT-9	.36	1	FLOW TIME	174.	321.	6.25	6.25	
HYDROGRAPH AT									
+	8	.19	1	FLOW TIME	77.	194.	6.17	6.17	
3 COMBINED AT									
+	DP-8A	1.91	1	FLOW TIME	826.	1869.	6.42	6.25	
1									



\*\*\* NORMAL END OF HEC-1 \*\*\*

164 DP-8A.....

(\*\*\*) RUNOFF ALSO COMPUTED AT THIS LOCATION

```

*****
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* JUN 1998 *
* VERSION 4.1 *
* RUN DATE 13NOV07 TIME 11:49:01 *
*****

```

*- Existing offsite conditions w/ KANAWA RIDGE PHASES 1-4 DEVELOPED ONLY*

```

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

```

East Fork Subtributary Hydrology PN: 60754  
 Existing Offsite Development Condition with Developed Phase 1 Hannah only  
 with storage at RR Embankment, Existing RR culvert in place and no  
 blockage.  
 10- and 100 Year, 24 hr Type II A Storm FN efscdph1.dat

```

7 IO OUTPUT CONTROL VARIABLES
IPRNT 5 PRINT CONTROL
IPIOT 0 PLOT CONTROL
QSCAL 0. HYDROGRAPH PLOT SCALE

```

```

IT HYDROGRAPH TIME DATA
NMIN 5 MINUTES IN COMPUTATION INTERVAL
IDATE 1 0 STARTING DATE
ITIME 0000 STARTING TIME
NQ 300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE 2 0 ENDING DATE
NDTIME 0055 ENDING TIME
ICENT 19 CENTURY MARK

```

```

COMPUTATION INTERVAL .08 HOURS
TOTAL TIME BASE 24.92 HOURS

```

```

ENGLISH UNITS
DRAINAGE AREA SQUARE MILES
PRECIPITATION DEPTH INCHES
LENGTH, ELEVATION FEET
FLOW CUBIC FEET PER SECOND
STORAGE VOLUME ACRE-FEET
SURFACE AREA ACRES
TEMPERATURE DEGREES FAHRENHEIT

```

```

JP MULTI-PLAN OPTION
NPLAN 1 NUMBER OF PLANS

```

```

JR MULTI-RATIO OPTION
RATIOS OF PRECIPITATION

```

.68 1.00

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES  
 TIME TO PEAK IN HOURS

RATIOS APPLIED TO PRECIPITATION  
 RATIO 1 RATIO 2  
 .68 1.00

OPERATION	STATION	AREA	PLAN	FLOW TIME	STAGE	PRECIPITATION
HYDROGRAPH AT	5	.20	1	154. 326. 6.08 6.00		
ROUTED TO	RT-5A	.20	1	151. 322. 6.08 6.08		
ROUTED TO	RT-5	.20	1	142. 313. 6.17 6.08		
HYDROGRAPH AT	1	.14	1	117. 242. 6.08 6.00		
2 COMBINED AT	DP-1	.34	1	255. 551. 6.08 6.08		
ROUTED TO	RT-1	.34	1	245. 518. 6.25 6.25		
HYDROGRAPH AT	2	.32	1	181. 429. 6.08 6.08		
2 COMBINED AT	DP-14	.66	1	360. 886. 6.25 6.17		
ROUTED TO	DB-14	.66	1	351. 627. 6.25 6.33		
				** PEAK STAGES IN FEET **		
				90.33	95.05	
				6.25	6.33	
ROUTED TO	RT-2B	.66	1	340. 624. 6.25 6.33		

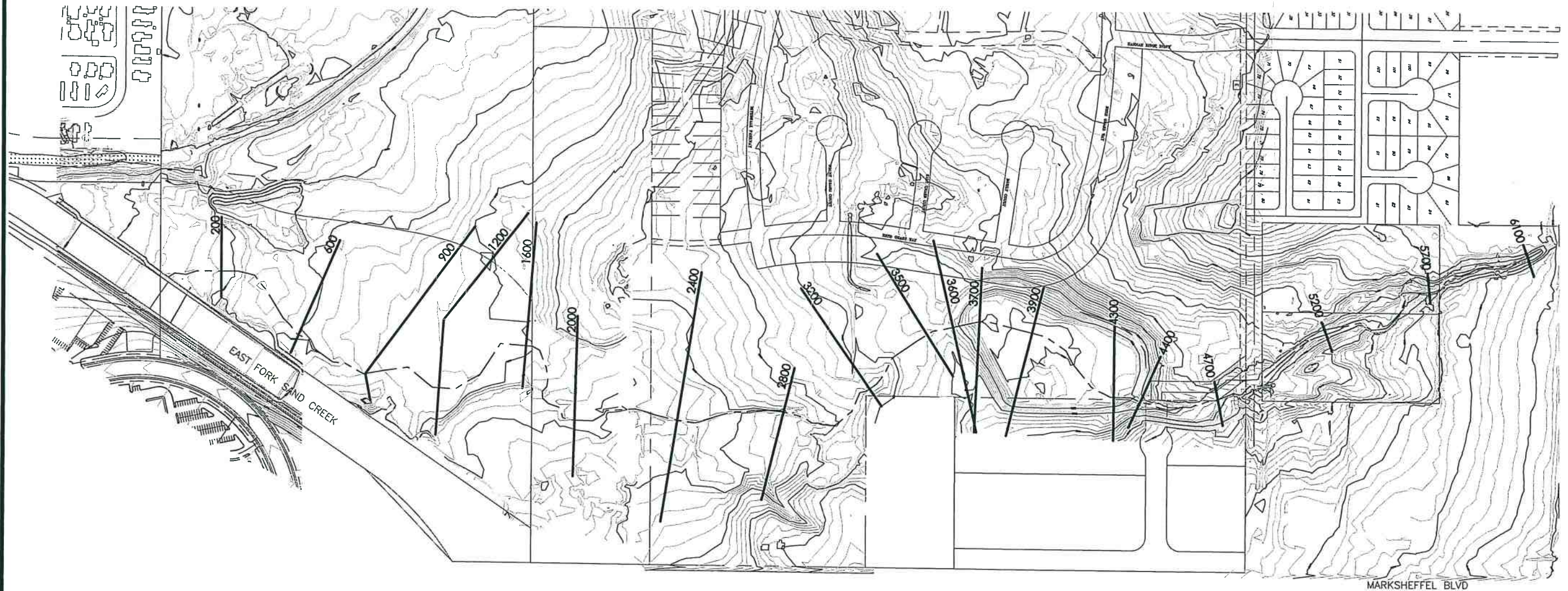


HYDROGRAPH AT				TIME	6.33	6.42
+	3	.16	1	FLOW TIME	130.6.00	283.6.00
ROUTED TO						
+	RT-3A	.16	1	FLOW TIME	126.6.08	273.6.00
ROUTED TO						
+	RT-3	.16	1	FLOW TIME	126.6.08	270.6.00
HYDROGRAPH AT						
+	4	.15	1	FLOW TIME	90.6.08	205.6.08
3 COMBINED AT						
+	DP-4A	.98	1	FLOW TIME	397.6.33	853.6.08
ROUTED TO						
+	RT-2A	.98	1	FLOW TIME	387.6.42	842.6.17
HYDROGRAPH AT						
+	12	.05	1	FLOW TIME	37.6.00	85.6.00
HYDROGRAPH AT						
+	13	.05	1	FLOW TIME	42.6.00	89.6.00
3 COMBINED AT						
+	DP-8	1.08	1	FLOW TIME	395.6.42	876.6.17
ROUTED TO						
+	RT-6A	1.08	1	FLOW TIME	394.6.42	873.6.17
ROUTED TO						
+	RT-6	1.08	1	FLOW TIME	390.6.42	862.6.17
HYDROGRAPH AT						
+	6	.12	1	FLOW TIME	144.6.00	269.6.00
2 COMBINED AT						
+	DP-6	1.20	1	FLOW TIME	415.6.42	1030.6.17









MARKSHEFFEL BLVD

CONSTITUTION AVENUE



**MONUMENT VALLEY ENGINEERS INC.**

\*\*\* ENGINEERS \*\*\* SURVEYORS \*\*\*  
 (719) 635-5736 1903 LELARAY ST., COLORADO SPRINGS, COLORADO 80909

HYDR. MAP-TRIB. E. FORK SAND CR.



HEC-RAS Version 4.0 Beta  
U.S. Army Corp of Engineers  
Hydrologic Engineering Center  
609 Second Street  
Davis, California

X	X	XXXXXX	XXXX	XXXX	XX	XXXX
X	X	X	X	X	X	X
X	X	X	X	X	X	X
X	X	XXXXXX	XXX	XXXXX	XXXXX	XXXX
X	X	X	X	X	X	X
X	X	X	X	X	X	X
X	X	XXXXXX	XXXX	X	X	XXXXX

\*\*\*\*\*

PROJECT DATA  
Project Title: Hanna Ridge - d/s Reach EFSC *W/ HANNAH RIDGE DEVELOPED (Full DEV.)*  
Project File : 60754EFSC.prj  
Run Date and Time: 10/22/2007 9:20:14 AM

Project in English units

\*\*\*\*\*

PLAN DATA

Plan Title: Hannah Ridge - EFSC - D/S  
Plan File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSC.p05

Geometry Title: Hannah Ridge - EFSC - D/S  
Geometry File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSC.g04  
Flow Title : Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSC.f04

Plan Summary Information:

Number of: Cross Sections = 19 Multiple Openings = 0  
Culverts = 0 Inline Structures = 0  
Bridges = 0 Lateral Structures = 0

Computational Information

water surface calculation tolerance = 0.01  
Critical depth calculation tolerance = 0.01  
Maximum number of iterations = 20  
Maximum difference tolerance = 0.3  
Flow tolerance factor = 0.001

Computation Options

Critical depth computed only where necessary  
Conveyance Calculation Method: At breaks in n values only  
Friction Slope Method: Average Conveyance  
Computational Flow Regime: Subcritical Flow

\*\*\*\*\*

FLOW DATA

Flow Title: Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSC.f04

Flow Data (cfs)

```

*****
* River          Reach          RS          * PF 1 *
* RIVER-1       Reach-1       6100        * 1041 *
* RIVER-1       Reach-1       4700        * 1261 *
* RIVER-1       Reach-1       3200        * 1433 *
* RIVER-1       Reach-1       200         * 1433 *
*****
Boundary Conditions
*****
* River          Reach          Profile      * Upstream      * Downstream    *
* RIVER-1       Reach-1       PF 1        *              * Normal S = 0.0125
*****
*****

```

SUMMARY OF MANNING'S N VALUES

```

River: RIVER-1
*****
* Reach          * River Sta. * n1          * n2          * n3          *
* Reach-1       * 6100       * .045*       * .035*       * .045*       *
* Reach-1       * 5700       * .045*       * .035*       * .045*       *
* Reach-1       * 5200       * .045*       * .035*       * .045*       *
* Reach-1       * 4700       * .045*       * .035*       * .045*       *
* Reach-1       * 4400       * .045*       * .035*       * .045*       *
* Reach-1       * 4300       * .045*       * .035*       * .045*       *
* Reach-1       * 3900       * .045*       * .035*       * .045*       *
* Reach-1       * 3700       * .045*       * .035*       * .045*       *
* Reach-1       * 3600       * .045*       * .035*       * .045*       *
* Reach-1       * 3500       * .045*       * .035*       * .045*       *
* Reach-1       * 3200       * .045*       * .035*       * .045*       *
* Reach-1       * 2800       * .045*       * .035*       * .045*       *
* Reach-1       * 2400       * .045*       * .035*       * .045*       *
* Reach-1       * 2000       * .045*       * .035*       * .045*       *
* Reach-1       * 1600       * .045*       * .035*       * .045*       *
* Reach-1       * 1200       * .045*       * .035*       * .045*       *
* Reach-1       * 900        * .045*       * .035*       * .045*       *
* Reach-1       * 600        * .045*       * .035*       * .045*       *
* Reach-1       * 200        * .045*       * .035*       * .045*       *
*****

```

SUMMARY OF REACH LENGTHS

```

River: RIVER-1
*****
* Reach          * River Sta. * Left        * Channel      * Right       *
* Reach-1       * 6100       * 390*       * 400*       * 370*       *
* Reach-1       * 5700       * 410*       * 500*       * 420*       *
* Reach-1       * 5200       * 470*       * 500*       * 470*       *
* Reach-1       * 4700       * 320*       * 300*       * 260*       *
* Reach-1       * 4400       * 80*        * 100*       * 140*       *
* Reach-1       * 4300       * 300*       * 400*       * 360*       *
* Reach-1       * 3900       * 190*       * 200*       * 220*       *
* Reach-1       * 3700       * 80*        * 100*       * 130*       *
* Reach-1       * 3600       * 80*        * 100*       * 150*       *
* Reach-1       * 3500       * 280*       * 300*       * 290*       *
* Reach-1       * 3200       * 490*       * 400*       * 310*       *
* Reach-1       * 2800       * 370*       * 400*       * 380*       *
* Reach-1       * 2400       * 370*       * 400*       * 410*       *
* Reach-1       * 2000       * 270*       * 400*       * 200*       *
*****

```

*Reach-1	*	1600	*	350*	400*	230*
*Reach-1	*	1200	*	120*	300*	270*
*Reach-1	*	900	*	330*	300*	360*
*Reach-1	*	600	*	330*	400*	430*
*Reach-1	*	200	*	0*	0*	0*

\*\*\*\*\*

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS  
River: RIVER-1

* Reach	* River Sta.	* Contr.	* Expan.
*Reach-1	* 6100	* .1*	* .3*
*Reach-1	* 5700	* .1*	* .3*
*Reach-1	* 5200	* .1*	* .3*
*Reach-1	* 4700	* .1*	* .3*
*Reach-1	* 4400	* .1*	* .3*
*Reach-1	* 4300	* .1*	* .3*
*Reach-1	* 3900	* .1*	* .3*
*Reach-1	* 3700	* .1*	* .3*
*Reach-1	* 3600	* .1*	* .3*
*Reach-1	* 3500	* .1*	* .3*
*Reach-1	* 3200	* .1*	* .3*
*Reach-1	* 2800	* .1*	* .3*
*Reach-1	* 2400	* .1*	* .3*
*Reach-1	* 2000	* .1*	* .3*
*Reach-1	* 1600	* .1*	* .3*
*Reach-1	* 1200	* .1*	* .3*
*Reach-1	* 900	* .1*	* .3*
*Reach-1	* 600	* .1*	* .3*
*Reach-1	* 200	* .1*	* .3*

Profile Output Table - user Table 1

* Reach	* River Sta	* Profile	* Length chn1 (ft)	* Q Total (cfs)	* Min Ch E1 (ft)	* W.S. Elev (ft)	* Max Ch1 (ft)	* Dpth (ft)	* Vel Chn1 (ft/s)	* Top Width (ft)	* Froude #	* Ch1
*Reach-1	* 200	* PF 1	* 400.00	* 1433.00	* 6364.10	* 6365.54	* 1.44	* 1.44	* 5.26	* 269.73	* 0.86	* 0.90
*Reach-1	* 600	* PF 1	* 300.00	* 1433.00	* 6369.50	* 6370.84	* 1.34	* 1.34	* 5.26	* 413.69	* 0.90	* 0.90
*Reach-1	* 900	* PF 1	* 300.00	* 1433.00	* 6372.09	* 6374.05	* 1.96	* 1.96	* 4.43	* 683.65	* 0.65	* 0.65
*Reach-1	* 1200	* PF 1	* 400.00	* 1433.00	* 6373.55	* 6375.31	* 1.75	* 1.75	* 2.99	* 711.13	* 0.42	* 0.42
*Reach-1	* 1600	* PF 1	* 400.00	* 1433.00	* 6375.00	* 6376.54	* 1.54	* 1.54	* 4.31	* 502.46	* 0.66	* 0.66
*Reach-1	* 2000	* PF 1	* 400.00	* 1433.00	* 6376.90	* 6379.15	* 2.25	* 2.25	* 4.57	* 256.03	* 0.69	* 0.69
*Reach-1	* 2400	* PF 1	* 400.00	* 1433.00	* 6381.76	* 6383.60	* 1.84	* 1.84	* 5.80	* 304.15	* 0.93	* 0.93
*Reach-1	* 2800	* PF 1	* 400.00	* 1433.00	* 6385.00	* 6387.85	* 2.85	* 2.85	* 6.05	* 320.76	* 0.74	* 0.74
*Reach-1	* 3200	* PF 1	* 400.00	* 1433.00	* 6392.00	* 6394.37	* 2.37	* 2.37	* 6.19	* 326.62	* 0.90	* 0.90
*Reach-1	* 3500	* PF 1	* 300.00	* 1261.00	* 6396.28	* 6398.02	* 1.74	* 1.74	* 4.78	* 338.38	* 0.78	* 0.78
*Reach-1	* 3600	* PF 1	* 100.00	* 1261.00	* 6396.50	* 6398.90	* 2.40	* 2.40	* 5.35	* 161.37	* 0.78	* 0.78
*Reach-1	* 3700	* PF 1	* 100.00	* 1261.00	* 6399.20	* 6399.39	* 9.19	* 9.19	* 0.67	* 329.30	* 0.05	* 0.05
*Reach-1	* 3900	* PF 1	* 200.00	* 1261.00	* 6399.00	* 6399.39	* 9.39	* 9.39	* 0.35	* 472.10	* 0.02	* 0.02
*Reach-1	* 4300	* PF 1	* 400.00	* 1261.00	* 6391.47	* 6399.39	* 7.92	* 7.92	* 0.60	* 315.47	* 0.04	* 0.04
*Reach-1	* 4400	* PF 1	* 100.00	* 1261.00	* 6395.90	* 6400.89	* 4.98	* 4.98	* 10.33	* 75.10	* 0.85	* 0.85
*Reach-1	* 4700	* PF 1	* 300.00	* 1261.00	* 6402.00	* 6405.06	* 3.06	* 3.06	* 8.33	* 79.02	* 0.99	* 0.99
*Reach-1	* 5200	* PF 1	* 500.00	* 1041.00	* 6407.37	* 6411.46	* 4.09	* 4.09	* 9.67	* 49.76	* 0.90	* 0.90
*Reach-1	* 5700	* PF 1	* 500.00	* 1041.00	* 6411.39	* 6416.46	* 5.07	* 5.07	* 11.01	* 38.10	* 0.92	* 0.92
*Reach-1	* 6100	* PF 1	* 400.00	* 1041.00	* 6419.00	* 6423.85	* 4.85	* 4.85	* 11.58	* 21.65	* 1.00	* 1.00

HEC-RAS Version 4.0 Beta  
U.S. Army Corp of Engineers  
Hydrologic Engineering Center  
609 Second Street  
Davis, California

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X	X	X	X	X	X	X
X	X	X	X	X	X	X
XXXXXXXX	XXXX		XXX	XXXXX	XXXXX	XXXX
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X	X	X	X	X	X	X
X	X	XXXXXX	XXXX	X	X	XXXXX

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PROJECT DATA  
Project Title: Hanna Ridge - d/s Reach EFSC w/ Hannah Ridge UNDEVELOPED

Project File : 60754EFSceX.prj  
Run Date and Time: 10/22/2007 9:36:22 AM

Project in English units

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PLAN DATA

Plan Title: Hannah Ridge - EFSC - D/S  
Plan File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSceX.p05

Geometry Title: Hannah Ridge - EFSC - D/S  
Geometry File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSceX.g04

Flow Title : Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSceX.f04

Plan Summary Information:				
Number of:	Cross Sections =	19	Multiple Openings =	0
	Culverts =	0	Inline Structures =	0
	Bridges =	0	Lateral Structures =	0

Computational Information

Water surface calculation tolerance =	0.01
Critical depth calculation tolerance =	0.01
Maximum number of iterations =	20
Maximum difference tolerance =	0.3
Flow tolerance factor =	0.001

Computation Options

Critical depth computed only where necessary	
Conveyance Calculation Method: At breaks in n values only	
Friction Slope Method: Average Conveyance	
Computational Flow Regime: Subcritical Flow	

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FLOW DATA

Flow Title: Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSceX.f04

Flow Data (cfs)



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*****
* River          Reach          RS          * PF 1 *
* RIVER-1       Reach-1       6100        *   856 *
* RIVER-1       Reach-1       4700        *  1004 *
* RIVER-1       Reach-1       3200        *  1151 *
* RIVER-1       Reach-1       200         *  1151 *
*****

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Boundary Conditions

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*****
* River          Reach          Profile          * Upstream          * Downstream          *
* RIVER-1       Reach-1       PF 1          *          * Normal S = 0.0125 *
*****

```

SUMMARY OF MANNING'S N VALUES

```

River: RIVER-1
*****
* Reach          River Sta. * n1          * n2          * n3          *
* Reach-1       6100        * .045*       * .035*       * .045*
* Reach-1       5700        * .045*       * .035*       * .045*
* Reach-1       5200        * .045*       * .035*       * .045*
* Reach-1       4700        * .045*       * .035*       * .045*
* Reach-1       4400        * .045*       * .035*       * .045*
* Reach-1       4300        * .045*       * .035*       * .045*
* Reach-1       3900        * .045*       * .035*       * .045*
* Reach-1       3700        * .045*       * .035*       * .045*
* Reach-1       3600        * .045*       * .035*       * .045*
* Reach-1       3500        * .045*       * .035*       * .045*
* Reach-1       3200        * .045*       * .035*       * .045*
* Reach-1       2800        * .045*       * .035*       * .045*
* Reach-1       2400        * .045*       * .035*       * .045*
* Reach-1       2000        * .045*       * .035*       * .045*
* Reach-1       1600        * .045*       * .035*       * .045*
* Reach-1       1200        * .045*       * .035*       * .045*
* Reach-1       900         * .045*       * .035*       * .045*
* Reach-1       600         * .045*       * .035*       * .045*
* Reach-1       200         * .045*       * .035*       * .045*
*****

```

SUMMARY OF REACH LENGTHS

```

River: RIVER-1
*****
* Reach          River Sta. * Left          * Channel * Right          *
* Reach-1       6100        * 390*         * 400*         * 370*
* Reach-1       5700        * 410*         * 500*         * 420*
* Reach-1       5200        * 470*         * 500*         * 470*
* Reach-1       4700        * 320*         * 300*         * 260*
* Reach-1       4400        * 80*          * 100*         * 140*
* Reach-1       4300        * 300*         * 400*         * 360*
* Reach-1       3900        * 190*         * 200*         * 220*
* Reach-1       3700        * 80*          * 100*         * 130*
* Reach-1       3600        * 80*          * 100*         * 150*
* Reach-1       3500        * 280*         * 300*         * 290*
* Reach-1       3200        * 490*         * 400*         * 310*
* Reach-1       2800        * 370*         * 400*         * 380*
* Reach-1       2400        * 370*         * 400*         * 410*
* Reach-1       2000        * 270*         * 400*         * 200*
*****

```

* Reach-1	*	1600	*	350*	400*	230*
* Reach-1	*	1200	*	120*	300*	270*
* Reach-1	*	900	*	330*	300*	360*
* Reach-1	*	600	*	330*	400*	430*
* Reach-1	*	200	*	0*	0*	0*

\*\*\*\*\*

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS  
RIVER: RIVER-1

* Reach	* River Sta.	* Contr.	* Expan.
* Reach-1	* 6100	* .1*	* .3*
* Reach-1	* 5700	* .1*	* .3*
* Reach-1	* 5200	* .1*	* .3*
* Reach-1	* 4700	* .1*	* .3*
* Reach-1	* 4400	* .1*	* .3*
* Reach-1	* 4300	* .1*	* .3*
* Reach-1	* 3900	* .1*	* .3*
* Reach-1	* 3700	* .1*	* .3*
* Reach-1	* 3600	* .1*	* .3*
* Reach-1	* 3500	* .1*	* .3*
* Reach-1	* 3200	* .1*	* .3*
* Reach-1	* 2800	* .1*	* .3*
* Reach-1	* 2400	* .1*	* .3*
* Reach-1	* 2000	* .1*	* .3*
* Reach-1	* 1600	* .1*	* .3*
* Reach-1	* 1200	* .1*	* .3*
* Reach-1	* 900	* .1*	* .3*
* Reach-1	* 600	* .1*	* .3*
* Reach-1	* 200	* .1*	* .3*

Profile Output Table - user Table 1

* Reach	* River Sta	* Profile	* Length chnl (ft)	* Q Total (cfs)	* Min Ch El (ft)	* W.S. Elev (ft)	* Max Chl Dpth (ft)	* vel Chnl (ft/s)	* Top width (ft)	* Froude #	* Ch1
* Reach-1	* 200	* PF 1	* 400.00	* 1151.00	* 6364.10	* 6365.40	* 1.30	* 4.83	* 262.28	* 0.84	*
* Reach-1	* 600	* PF 1	* 300.00	* 1151.00	* 6369.50	* 6370.72	* 1.22	* 4.87	* 370.19	* 0.88	*
* Reach-1	* 900	* PF 1	* 300.00	* 1151.00	* 6372.09	* 6373.92	* 1.83	* 4.23	* 640.19	* 0.65	*
* Reach-1	* 1200	* PF 1	* 400.00	* 1151.00	* 6373.55	* 6375.17	* 1.62	* 2.78	* 694.72	* 0.40	*
* Reach-1	* 1600	* PF 1	* 400.00	* 1151.00	* 6375.00	* 6376.41	* 1.41	* 4.03	* 489.40	* 0.65	*
* Reach-1	* 2000	* PF 1	* 400.00	* 1151.00	* 6376.90	* 6379.00	* 2.10	* 4.12	* 232.10	* 0.66	*
* Reach-1	* 2400	* PF 1	* 400.00	* 1151.00	* 6381.76	* 6383.46	* 1.70	* 5.41	* 294.21	* 0.93	*
* Reach-1	* 2800	* PF 1	* 400.00	* 1151.00	* 6385.00	* 6387.69	* 2.69	* 5.68	* 315.32	* 0.72	*
* Reach-1	* 3200	* PF 1	* 300.00	* 1004.00	* 6392.00	* 6394.22	* 2.22	* 5.75	* 291.06	* 0.87	*
* Reach-1	* 3500	* PF 1	* 300.00	* 1004.00	* 6396.28	* 6397.87	* 1.58	* 4.52	* 328.02	* 0.79	*
* Reach-1	* 3600	* PF 1	* 100.00	* 1004.00	* 6396.50	* 6398.75	* 2.25	* 4.73	* 153.71	* 0.71	*
* Reach-1	* 3700	* PF 1	* 100.00	* 1004.00	* 6390.20	* 6399.13	* 8.93	* 0.56	* 324.09	* 0.04	*
* Reach-1	* 3900	* PF 1	* 200.00	* 1004.00	* 6390.00	* 6399.13	* 9.13	* 0.29	* 469.40	* 0.02	*
* Reach-1	* 4300	* PF 1	* 400.00	* 1004.00	* 6391.47	* 6399.14	* 7.66	* 0.49	* 313.17	* 0.03	*
* Reach-1	* 4400	* PF 1	* 100.00	* 1004.00	* 6395.90	* 6400.46	* 4.56	* 9.44	* 63.93	* 0.81	*
* Reach-1	* 4700	* PF 1	* 300.00	* 1004.00	* 6402.00	* 6404.75	* 2.75	* 7.76	* 76.29	* 0.99	*
* Reach-1	* 5200	* PF 1	* 500.00	* 856.00	* 6407.37	* 6411.09	* 3.72	* 9.12	* 47.80	* 0.90	*
* Reach-1	* 5700	* PF 1	* 500.00	* 856.00	* 6411.39	* 6416.02	* 4.63	* 10.37	* 36.41	* 0.91	*
* Reach-1	* 6100	* PF 1	* 400.00	* 856.00	* 6419.00	* 6423.30	* 4.30	* 10.96	* 21.15	* 1.00	*

HEC-RAS Version 4.0 Beta  
U.S. Army Corp of Engineers  
Hydrologic Engineering Center  
609 Second Street  
Davis, California

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PROJECT DATA

Project Title: Hanna Ridge - d/s Reach EFSC WITH HANNAH RIDGE PHASE 1 DEVELOPED ONLY  
Project File : 60754EFSCPH1.prj  
Run Date and Time: 11/15/2007 10:31:16 AM

Project in English units

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PLAN DATA

Plan Title: Hannah Ridge - EFSC - D/S  
Plan File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSCPH1.p05

Geometry Title: Hannah Ridge - EFSC - D/S  
Geometry File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSCPH1.g04  
Flow Title : Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSCPH1.f04

Plan Summary Information:

Number of: Cross Sections = 19 Multiple Openings = 0  
Culverts = 0 Inline Structures = 0  
Bridges = 0 Lateral Structures = 0

Computational Information

Water surface calculation tolerance = 0.01  
Critical depth calculation tolerance = 0.01  
Maximum number of iterations = 20  
Maximum difference tolerance = 0.3  
Flow tolerance factor = 0.001

Computation Options

Critical depth computed only where necessary  
Conveyance calculation Method: At breaks in n values only  
Friction Slope Method: Average Conveyance  
Computational Flow Regime: Subcritical Flow

\*\*\*\*\*

FLOW DATA

Flow Title: Hannah Ridge - EFSC - D/S  
Flow File : C:\Documents and Settings\User\My Documents\HEC Data\RAS\Hannah\60754EFSCPH1.f04

Flow Data (cfs)

```

*****
* River          Reach          RS          PF 1 *
* RIVER-1       Reach-1       6100       876 *
* RIVER-1       Reach-1       4700       1030 *
* RIVER-1       Reach-1       3200       1180 *
* RIVER-1       Reach-1       200        1180 *
*****
Boundary Conditions
*****
* River          Reach          Profile          Upstream          Downstream *
* RIVER-1       Reach-1       PF 1           *****          *****
* RIVER-1       Reach-1       PF 1           *****          *****
*****
Normal S = 0.0125
*****
*****

```

SUMMARY OF MANNING'S N VALUES

```

River:RIVER-1
*****
* Reach          River Sta.          n1          n2          n3 *
* Reach-1       6100          .045        .035        .045 *
* Reach-1       5700          .045        .035        .045 *
* Reach-1       5200          .045        .035        .045 *
* Reach-1       4700          .045        .035        .045 *
* Reach-1       4400          .045        .035        .045 *
* Reach-1       4300          .045        .035        .045 *
* Reach-1       3900          .045        .035        .045 *
* Reach-1       3700          .045        .035        .045 *
* Reach-1       3600          .045        .035        .045 *
* Reach-1       3500          .045        .035        .045 *
* Reach-1       3200          .045        .035        .045 *
* Reach-1       2800          .045        .035        .045 *
* Reach-1       2400          .045        .035        .045 *
* Reach-1       2000          .045        .035        .045 *
* Reach-1       1600          .045        .035        .045 *
* Reach-1       1200          .045        .035        .045 *
* Reach-1       900           .045        .035        .045 *
* Reach-1       600           .045        .035        .045 *
* Reach-1       200           .045        .035        .045 *
*****

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SUMMARY OF REACH LENGTHS

```

River: RIVER-1
*****
* Reach          River Sta.          Left          Channel          Right *
* Reach-1       6100          390          400          370 *
* Reach-1       5700          410          500          420 *
* Reach-1       5200          470          500          470 *
* Reach-1       4700          300          300          260 *
* Reach-1       4400          80          100          140 *
* Reach-1       4300          300          400          360 *
* Reach-1       3900          190          200          220 *
* Reach-1       3700          80          100          130 *
* Reach-1       3600          80          100          150 *
* Reach-1       3500          280          300          290 *
* Reach-1       3200          490          400          310 *
* Reach-1       2800          370          400          380 *
* Reach-1       2400          370          400          410 *
* Reach-1       2000          270          400          200 *
*****

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* Reach-1	* 1600	* 350*	* 400*	* 230*
* Reach-1	* 1200	* 120*	* 300*	* 270*
* Reach-1	* 900	* 330*	* 300*	* 360*
* Reach-1	* 600	* 330*	* 400*	* 430*
* Reach-1	* 200	* 0*	* 0*	* 0*

\*\*\*\*\*

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

River: RIVER-1

* Reach	* River Sta.	* Contr.	* Expan.
* Reach-1	* 6100	* .1*	* .3*
* Reach-1	* 5700	* .1*	* .3*
* Reach-1	* 5200	* .1*	* .3*
* Reach-1	* 4700	* .1*	* .3*
* Reach-1	* 4400	* .1*	* .3*
* Reach-1	* 4300	* .1*	* .3*
* Reach-1	* 3900	* .1*	* .3*
* Reach-1	* 3700	* .1*	* .3*
* Reach-1	* 3600	* .1*	* .3*
* Reach-1	* 3500	* .1*	* .3*
* Reach-1	* 3200	* .1*	* .3*
* Reach-1	* 2800	* .1*	* .3*
* Reach-1	* 2400	* .1*	* .3*
* Reach-1	* 2000	* .1*	* .3*
* Reach-1	* 1600	* .1*	* .3*
* Reach-1	* 900	* .1*	* .3*
* Reach-1	* 600	* .1*	* .3*
* Reach-1	* 200	* .1*	* .3*

Profile Output Table - user Table 1

* Reach	* River Sta	* Profile	* Length (ft)	* Q Total (cfs)	* Min Ch El (ft)	* W.S. Elev (ft)	* Max Ch1 Dpth (ft)	* Vel Chn1 (ft/s)	* Top width (ft)	* Froude # Ch1
* Reach-1	* 200	* PF 1	* 400.00	* 1180.00	* 6364.10	* 6365.41	* 1.31	* 4.88	* 263.06	* 0.84
* Reach-1	* 600	* PF 1	* 300.00	* 1180.00	* 6369.50	* 6370.73	* 1.23	* 4.91	* 373.94	* 0.88
* Reach-1	* 900	* PF 1	* 300.00	* 1180.00	* 6372.09	* 6373.93	* 1.84	* 4.25	* 643.17	* 0.65
* Reach-1	* 1200	* PF 1	* 400.00	* 1180.00	* 6373.55	* 6375.19	* 1.64	* 2.80	* 696.47	* 0.41
* Reach-1	* 1600	* PF 1	* 400.00	* 1180.00	* 6375.00	* 6376.43	* 1.43	* 4.06	* 492.03	* 0.65
* Reach-1	* 2000	* PF 1	* 400.00	* 1180.00	* 6376.90	* 6379.02	* 2.12	* 4.16	* 232.56	* 0.66
* Reach-1	* 2400	* PF 1	* 400.00	* 1180.00	* 6381.76	* 6383.48	* 1.72	* 5.44	* 295.79	* 0.72
* Reach-1	* 2800	* PF 1	* 400.00	* 1180.00	* 6385.00	* 6387.71	* 2.71	* 5.72	* 315.89	* 0.86
* Reach-1	* 3200	* PF 1	* 400.00	* 1180.00	* 6392.00	* 6394.25	* 2.25	* 5.76	* 296.99	* 0.80
* Reach-1	* 3500	* PF 1	* 300.00	* 1030.00	* 6396.28	* 6397.88	* 1.59	* 4.58	* 328.68	* 0.80
* Reach-1	* 3700	* PF 1	* 100.00	* 1030.00	* 6396.50	* 6398.77	* 2.27	* 4.79	* 154.73	* 0.72
* Reach-1	* 3900	* PF 1	* 200.00	* 1030.00	* 6390.20	* 6399.16	* 8.96	* 0.57	* 324.67	* 0.04
* Reach-1	* 4400	* PF 1	* 400.00	* 1030.00	* 6390.00	* 6399.16	* 7.69	* 0.29	* 469.71	* 0.02
* Reach-1	* 4700	* PF 1	* 300.00	* 1030.00	* 6395.90	* 6400.51	* 4.61	* 9.52	* 64.51	* 0.81
* Reach-1	* 5200	* PF 1	* 500.00	* 876.00	* 6402.00	* 6404.79	* 2.79	* 7.78	* 76.67	* 0.98
* Reach-1	* 5700	* PF 1	* 500.00	* 876.00	* 6411.39	* 6416.08	* 3.77	* 9.16	* 48.05	* 0.90
* Reach-1	* 6100	* PF 1	* 400.00	* 876.00	* 6419.00	* 6423.35	* 4.35	* 10.44	* 36.61	* 0.91
* Reach-1	* 6100	* PF 1	* 400.00	* 876.00	* 6419.00	* 6423.35	* 4.35	* 11.06	* 21.19	* 1.01

Reach	River Sta	Profile	Length Chnl (ft)	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dpth (ft)	Vel Chnl (ft/s)	Top Wldth (ft)	Froude # Chl
Reach-1	200	PF 1		1151.00	6364.10	6365.40	1.30	4.83	262.28	0.84
Reach-1	600	PF 1	400.00	1151.00	6369.50	6370.72	1.22	4.87	370.19	0.88
Reach-1	900	PF 1	300.00	1151.00	6372.09	6373.92	1.83	4.23	640.19	0.65
Reach-1	1200	PF 1	300.00	1151.00	6373.55	6375.17	1.62	2.78	694.72	0.40
Reach-1	1600	PF 1	400.00	1151.00	6375.00	6376.41	1.41	4.03	489.40	0.65
Reach-1	2000	PF 1	400.00	1151.00	6376.90	6379.00	2.10	4.12	232.10	0.66
Reach-1	2400	PF 1	400.00	1151.00	6381.76	6383.46	1.70	5.41	294.21	0.93
Reach-1	2800	PF 1	400.00	1151.00	6385.00	6387.69	2.69	5.68	315.32	0.72
Reach-1	3200	PF 1	400.00	1151.00	6392.00	6394.22	2.22	5.75	291.06	0.87
Reach-1	3500	PF 1	300.00	1004.00	6396.28	6397.87	1.58	4.52	328.02	0.79
Reach-1	3600	PF 1	100.00	1004.00	6396.50	6398.75	2.25	4.73	153.71	0.71
Reach-1	3700	PF 1	100.00	1004.00	6390.20	6399.13	8.93	0.56	324.09	0.04
Reach-1	3900	PF 1	200.00	1004.00	6390.00	6399.13	9.13	0.29	469.40	0.02
Reach-1	4300	PF 1	400.00	1004.00	6391.47	6399.14	7.66	0.49	313.17	0.03
Reach-1	4400	PF 1	100.00	1004.00	6395.90	6400.46	4.56	9.44	63.93	0.81
Reach-1	4700	PF 1	300.00	1004.00	6402.00	6404.75	2.75	7.76	76.29	0.99
Reach-1	5200	PF 1	500.00	856.00	6407.37	6411.09	3.72	9.12	47.80	0.90
Reach-1	5700	PF 1	500.00	856.00	6411.39	6416.02	4.63	10.37	36.41	0.91
Reach-1	6100	PF 1	400.00	856.00	6419.00	6423.30	4.30	10.96	21.15	1.00

HANNAN RIDGE DAM

HEC-RAS Plan: EFSC River: RIVER-1 Reach: Reach-1 Profile: PF 1

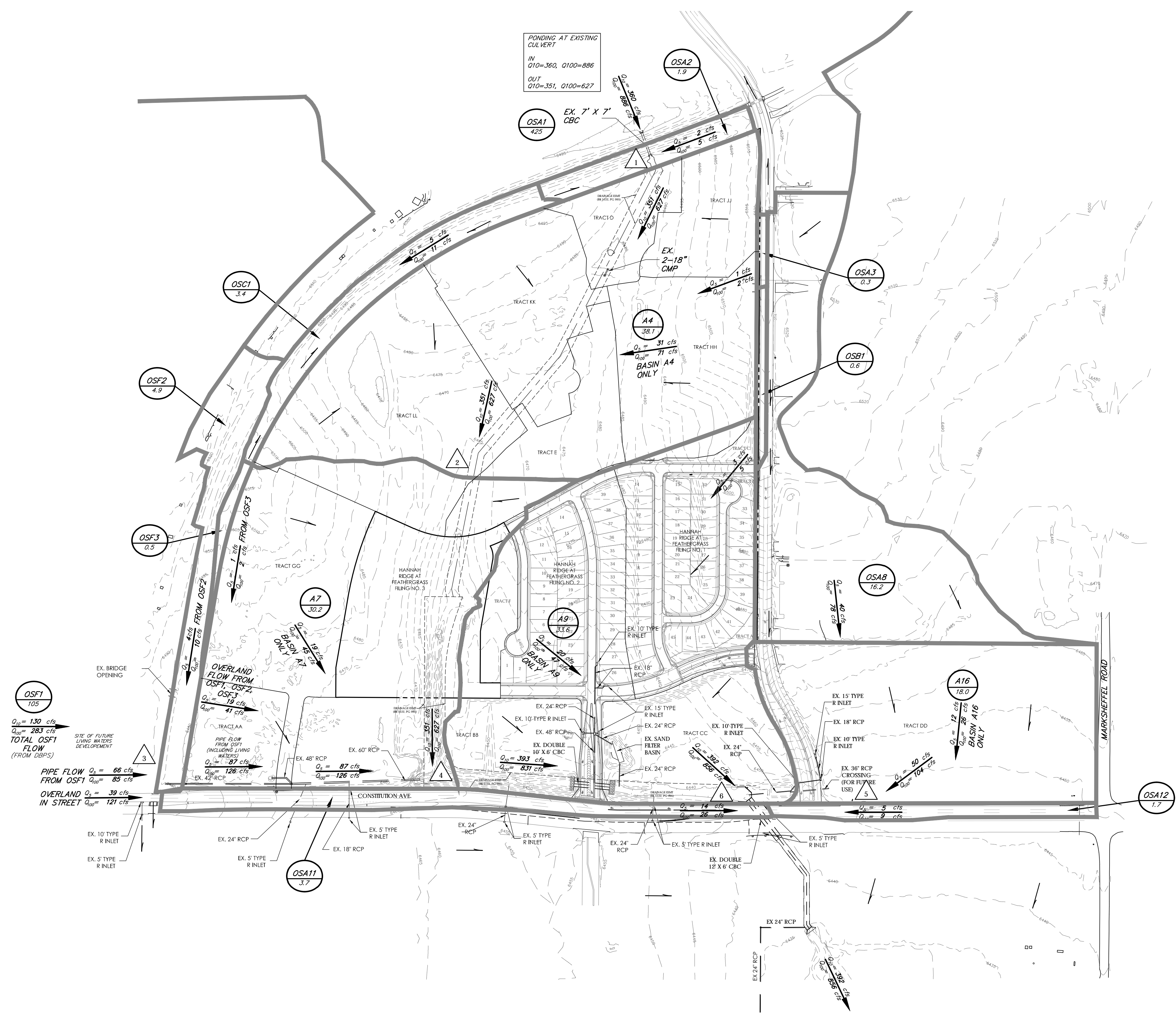
Reach	River Sta	Profile	Length Chnl (ft)	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dpth (ft)	Vel Chnl (ft/s)	Top Width (ft)	Froude # Chl
Reach-1	200	PF 1		1433.00	6364.10	6365.54	1.44	5.26	269.73	0.86
Reach-1	600	PF 1	400.00	1433.00	6369.50	6370.84	1.34	5.26	413.69	0.90
Reach-1	900	PF 1	300.00	1433.00	6372.09	6374.05	1.96	4.43	683.65	0.65
Reach-1	1200	PF 1	300.00	1433.00	6373.55	6375.31	1.75	2.99	711.13	0.42
Reach-1	1600	PF 1	400.00	1433.00	6375.00	6376.54	1.54	4.31	502.46	0.66
Reach-1	2000	PF 1	400.00	1433.00	6376.90	6379.15	2.25	4.57	256.03	0.69
Reach-1	2400	PF 1	400.00	1433.00	6381.76	6383.60	1.84	5.80	304.15	0.93
Reach-1	2800	PF 1	400.00	1433.00	6385.00	6387.85	2.85	6.05	320.76	0.74
Reach-1	3200	PF 1	400.00	1433.00	6392.00	6394.37	2.37	6.19	326.62	0.90
Reach-1	3500	PF 1	300.00	1261.00	6396.28	6398.02	1.74	4.78	338.38	0.78
Reach-1	3800	PF 1	100.00	1261.00	6396.50	6398.90	2.40	5.35	161.37	0.78
Reach-1	3700	PF 1	100.00	1261.00	6390.20	6399.39	9.19	0.67	329.30	0.05
Reach-1	3900	PF 1	200.00	1261.00	6390.00	6399.39	9.39	0.35	472.10	0.02
Reach-1	4300	PF 1	400.00	1261.00	6391.47	6399.39	7.92	0.60	315.47	0.04
Reach-1	4400	PF 1	100.00	1261.00	6395.90	6400.89	4.98	10.33	75.10	0.85
Reach-1	4700	PF 1	300.00	1261.00	6402.00	6405.06	3.06	8.33	79.02	0.99
Reach-1	5200	PF 1	500.00	1041.00	6407.37	6411.46	4.09	9.67	49.76	0.90
Reach-1	5700	PF 1	500.00	1041.00	6411.39	6416.46	5.07	11.01	38.10	0.92
Reach-1	6100	PF 1	400.00	1041.00	6419.00	6423.85	4.85	11.58	21.65	1.00

Reach	River Sta	Profile	Length Chnl (ft)	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Max Chl Dpth (ft)	Vel Chnl (ft/s)	Top Width (ft)	Froude # Chl
Reach-1	200	PF 1		1180.00	6364.10	6365.41	1.31	4.88	263.06	0.84
Reach-1	600	PF 1	400.00	1180.00	6369.50	6370.73	1.23	4.91	373.94	0.88
Reach-1	900	PF 1	300.00	1180.00	6372.09	6373.93	1.84	4.25	643.17	0.65
Reach-1	1200	PF 1	300.00	1180.00	6373.55	6375.19	1.64	2.80	696.47	0.41
Reach-1	1600	PF 1	400.00	1180.00	6375.00	6376.43	1.43	4.06	492.03	0.65
Reach-1	2000	PF 1	400.00	1180.00	6376.90	6379.02	2.12	4.16	232.56	0.66
Reach-1	2400	PF 1	400.00	1180.00	6381.76	6383.48	1.72	5.44	295.79	0.92
Reach-1	2800	PF 1	400.00	1180.00	6385.00	6387.71	2.71	5.72	315.89	0.72
Reach-1	3200	PF 1	400.00	1180.00	6392.00	6394.25	2.25	5.76	296.99	0.86
Reach-1	3500	PF 1	300.00	1030.00	6396.28	6397.88	1.59	4.58	328.68	0.80
Reach-1	3600	PF 1	100.00	1030.00	6396.50	6398.77	2.27	4.79	154.73	0.72
Reach-1	3700	PF 1	100.00	1030.00	6390.20	6399.16	8.96	0.57	324.67	0.04
Reach-1	3900	PF 1	200.00	1030.00	6390.00	6399.16	9.16	0.29	469.71	0.02
Reach-1	4300	PF 1	400.00	1030.00	6391.47	6399.16	7.69	0.51	313.43	0.03
Reach-1	4400	PF 1	100.00	1030.00	6395.90	6400.51	4.61	9.52	64.51	0.81
Reach-1	4700	PF 1	300.00	1030.00	6402.00	6404.79	2.79	7.78	76.67	0.98
Reach-1	5200	PF 1	500.00	876.00	6407.37	6411.14	3.77	9.16	48.05	0.90
Reach-1	5700	PF 1	500.00	876.00	6411.39	6416.08	4.69	10.44	36.61	0.91
Reach-1	6100	PF 1	400.00	876.00	6419.00	6423.35	4.35	11.06	21.19	1.01



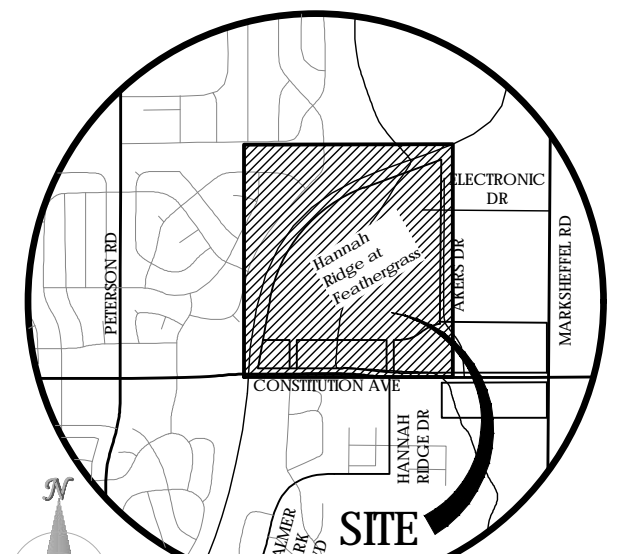
E. Fork Sand Creek - Reach downstream of Constitution Ave.

River Sta	H.R. Undev W.S. Elev (ft)	H.R. Dev W.S. Elev (ft)	Difference from Exist (ft)	H.R. PH1 W.S. Elev (ft)	Difference from Exist (ft)
200	6365.40	6365.54	0.14	6365.41	0.01
600	6370.72	6370.84	0.12	6370.73	0.01
900	6373.92	6374.05	0.13	6373.93	0.01
1200	6375.17	6375.31	0.14	6375.19	0.02
1600	6376.41	6376.54	0.13	6376.43	0.02
2000	6379.00	6379.15	0.15	6379.02	0.02
2400	6383.46	6383.60	0.14	6383.48	0.02
2800	6387.69	6387.85	0.16	6387.71	0.02
3200	6394.22	6394.37	0.15	6394.25	0.03
3500	6397.87	6398.02	0.15	6397.88	0.01
3600	6398.75	6398.90	0.15	6398.77	0.02
3700	6399.13	6399.39	0.26	6399.16	0.03
3900	6399.13	6399.39	0.26	6399.16	0.03
4300	6399.14	6399.39	0.25	6399.16	0.02
4400	6400.46	6400.89	0.43	6400.51	0.05
4700	6404.75	6405.06	0.31	6404.79	0.04
5200	6411.09	6411.46	0.37	6411.14	0.05
5700	6416.02	6416.46	0.44	6416.08	0.06
6100	6423.30	6423.85	0.55	6423.35	0.05



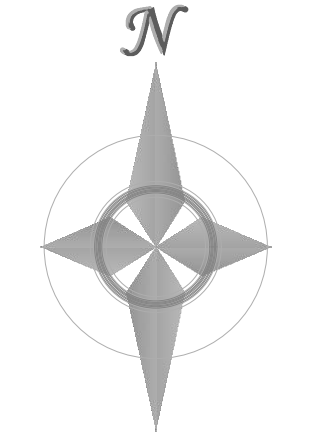
EXISTING SUMMARY RUNOFF TABLE				
BASIN or DESIGN POINT	CONTRIBUTING BASINS	CONTRIBUTING AREA (AC)	5-YR (Q5) RUNOFF (CFS)*	100-YR (Q100) RUNOFF (CFS)
OSA1 (IN)		425	360 *	886 (IN)
1 (OUT)	OSA1	425	351 *	627 (OUT)
OSA2		1.9	2	5
OSA3		0.3	1	2
OSC1		3.4	5	11
A4		38.1	31	71
2	OSA1, OSA2, OSA3, OSC1, A4	468.7	351 *	627
3	OSF1	105	130 *	283
OSF2		4.9	4	9
OSF3		0.5	1	2
A7		30.2	19	45
4	OSA1, OSA2, OSA3, OSC1, A4, OSF1, OSF2, OSF3, F7	137.1	393 *	831
OSB1		0.6	3	5
A9		33.6	19	46
OSA8		16.2	40	78
A16		18.0	12	26
5	OSA8, A16	34.2	50	103
OSA11		3.7	12	21
OSA12		1.7	5	9
6	OSA1, OSA2, OSA3, OSC1, A4, OSF1, OSF2, OSF3, A7, A9, OSB1, OSA8, A16, OSA11, OSA12	650.5	392 *	856

\* NOTE: MAIN CHANNEL MINOR STORM FLOW RATES ARE 10-YEAR IN ACCORDANCE WITH DRAINAGE BASIN PLANNING STUDY



VICINITY MAP

BENCHMARK  
 THE BENCHMARK FOR THESE PLANS IS THE TOP OF #4 REBAR, PANEL POINT NO. 1, LOCATED ON THE SOUTH EDGE OF CONSTITUTION AVE AND THE WEST EDGE OF THE ROCK ISLAND TRAIL, 535 FEET WEST OF THE CENTERLINE OF SHAWNEE DR. ELEVATION = 6486.63. (EPC DATUM ELEVATION = 6485.29).



1" = 200' 1:2,400

**LEGEND**

- EXISTING INDEX CONTOUR
- EXISTING STORM DRAIN CURB INLET
- EXISTING STORM DRAIN LINE
- EXISTING PROPERTY LINE
- EXISTING ROAD
- DRAINAGE BASIN BOUNDARY
- DRAINAGE BASIN DESIGNATION
- DRAINAGE BASIN AREA
- FLOW DIRECTION AND QUANTITIES
- FLOW DIRECTION
- DESIGN POINT

REVISIONS

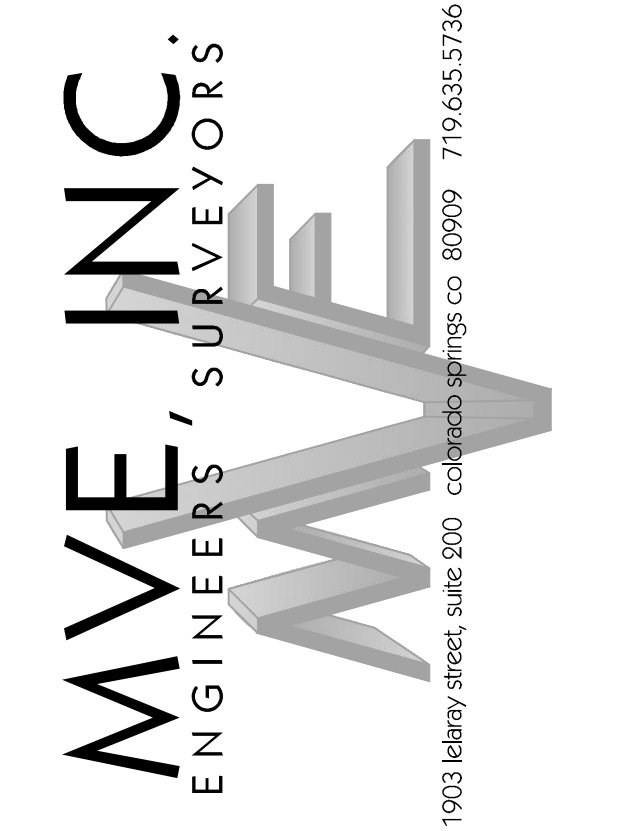
DESIGNED BY  
 DRAWN BY  
 CHECKED BY  
 AS-BUILTS BY  
 CHECKED BY

**Hannah Ridge at Feathergrass**

**EXISTING DRAINAGE MAP**

MVE PROJECT 60970  
 MVE DRAWING 60970111-F3

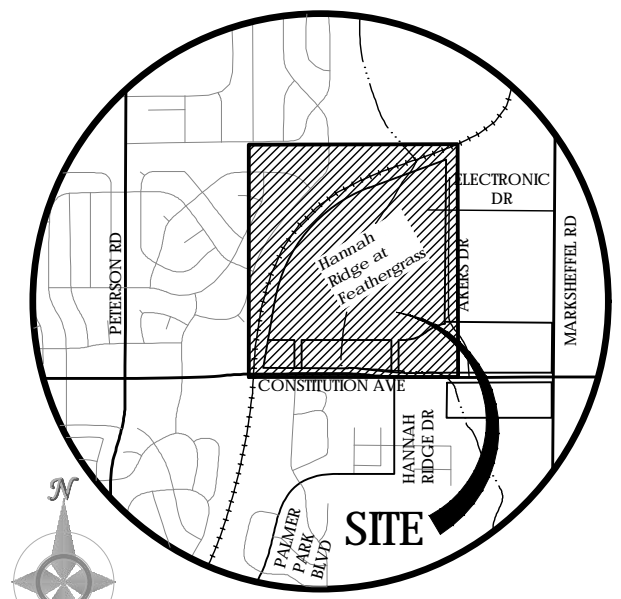
April 20, 2017  
 SHEET 1 OF 1





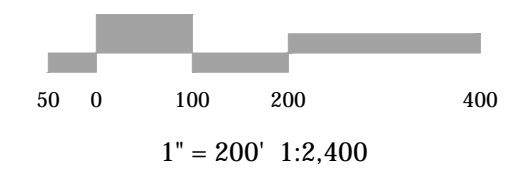
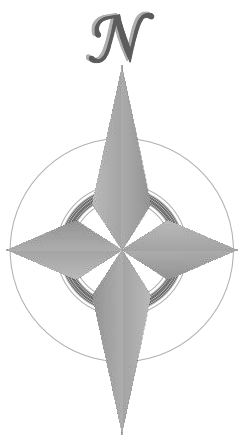
**LEGEND**

- EXISTING INDEX CONTOUR
- EXISTING STORM DRAIN CURB INLET
- EXISTING STORM DRAIN LINE
- EXISTING PROPERTY LINE
- EXISTING ROAD
- DRAINAGE BASIN BOUNDARY
- DRAINAGE BASIN DESIGNATION  
DRAINAGE BASIN AREA
- 
- FLOW DIRECTION AND QUANTITIES
- FLOW DIRECTION
- DESIGN POINT



VICINITY MAP

BENCHMARK  
THE BENCHMARK FOR THESE PLANS IS THE TOP OF #4 REBAR, PANEL POINT NO. 1, LOCATED ON THE SOUTH EDGE OF CONSTITUTION AVE AND THE WEST EDGE OF THE ROCK ISLAND TRAIL, 535 FEET WEST OF THE CENTERLINE OF SHAWNEE DR. ELEVATION = 6486.63. (EPC DATUM ELEVATION = 6485.29).



DEVELOPED SUMMARY RUNOFF TABLE					
BASIN or DESIGN POINT	CONTRIBUTING BASINS	CONTRIBUTING AREA (AC)	5-YR(Q5) RUNOFF (CFS)*	100-YR (Q100) RUNOFF (CFS)	DESCRIPTION
OSA1 (IN)		425	374 *	915 (IN)	
1 (OUT)	OSA1	425	360 *	640 (OUT)	EX 7x7 CBC
2	OSA1, OSA2, A6	430.8	360 *	640 *	12'Wx6'H CBC
3	A1,A2,OSA3,A3	4.2	9.4	18.8	CROSS PAN
4	A1,A2,OSA3,A3,A4	4.4	9.7	19.2	10' TYPE R INLET (SUMP)
5	A5	0.2	0.7	1.3	5' TYPE R INLET (SUMP)
6	OSB1,B1,B2,B3,B4,B5,B6	8.2	19.5	38.5	CROSS PAN
7	OSB1,B1,B2,B3,B4,B5,B6,B7	8.9	20.4	40.1	15' TYPE R (SUMP), 15' TYPE R INLETS
8	OSC1,C1	8.6	15.0	31.1	10' TYPE R (SUMP), 10' TYPE R INLETS
9	C3,C5	3.6	8.9	17.8	15' TYPE R INLET (SUMP)
10	C2,C4	2.3	5.5	10.9	10' TYPE R INLET (SUMP)
11	C7,C8,C9,C11	6.1	13.4	26.6	15' TYPE R INLET (SUMP)
12	C6,C10	3.2	6.6	14.1	10' TYPE R INLET (SUMP)
13	C12	1.5	3.7	7.4	5' TYPE R INLET (SUMP)
14	OSA1-A6,OSB1-B9, OSC1-C12	476	360 *	640 *	10'Wx6'H CBC & 90" RCP
15	D1,D2,D3,D4,D5,D6	7.8	19.2	38.0	CROSS PAN
16	D1,D2,D3,D4,D5,D6,D7	11.7	26.6	52.8	10' TYPE R & 15' TYPE R INLETS
17	D1-D7,D9,D11	13.9	29.6	59.0	15' TYPE R INLET (SUMP)
18	D8,D10,D12	4.0	8.7	17.1	10' TYPE R INLET (SUMP)
19	E1,E2,E3	5.0	11.9	23.7	15' TYPE R INLET
20	E1,E2,E3,E4,E5,E7	11.0	23.4	48.4	15' TYPE R (SUMP), TYPE C INLETS
21	E6	1.8	4.5	9.0	5' TYPE R INLET (SUMP)
22	E8	0.7	1.8	3.6	5' TYPE R INLET (SUMP)
23	OSF1,F1,F2,F3	7.4	16.2	32.5	CROSS PAN
24	OSF1,F1,F2,F3,F5	11.0	23.4	48.4	15' TYPE R (SUMP), TYPE C INLETS
25	F4	0.3	0.9	1.9	5' TYPE R INLET (SUMP)
26	OSF2	4.9	4.2	9.6	TYPE D INLET (SUMP)
27	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5	619	428 *	991 *	OPEN CHANNEL
28	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5, D1-D12	647	428 *	991 *	DBL 10'Wx6'H CBC
29	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5, D1-D12, G1	685	457 *	1076 *	EXISTING DBL 12'Wx6'H CBC

\* NOTE: MAIN CHANNEL MINOR STORM FLOW RATES ARE 10-YEAR IN ACCORDANCE WITH DRAINAGE BASIN PLANNING STUDY

REVISIONS

DESIGNED BY \_\_\_\_\_  
DRAWN BY \_\_\_\_\_  
CHECKED BY \_\_\_\_\_  
AS-BUILTS BY \_\_\_\_\_  
CHECKED BY \_\_\_\_\_

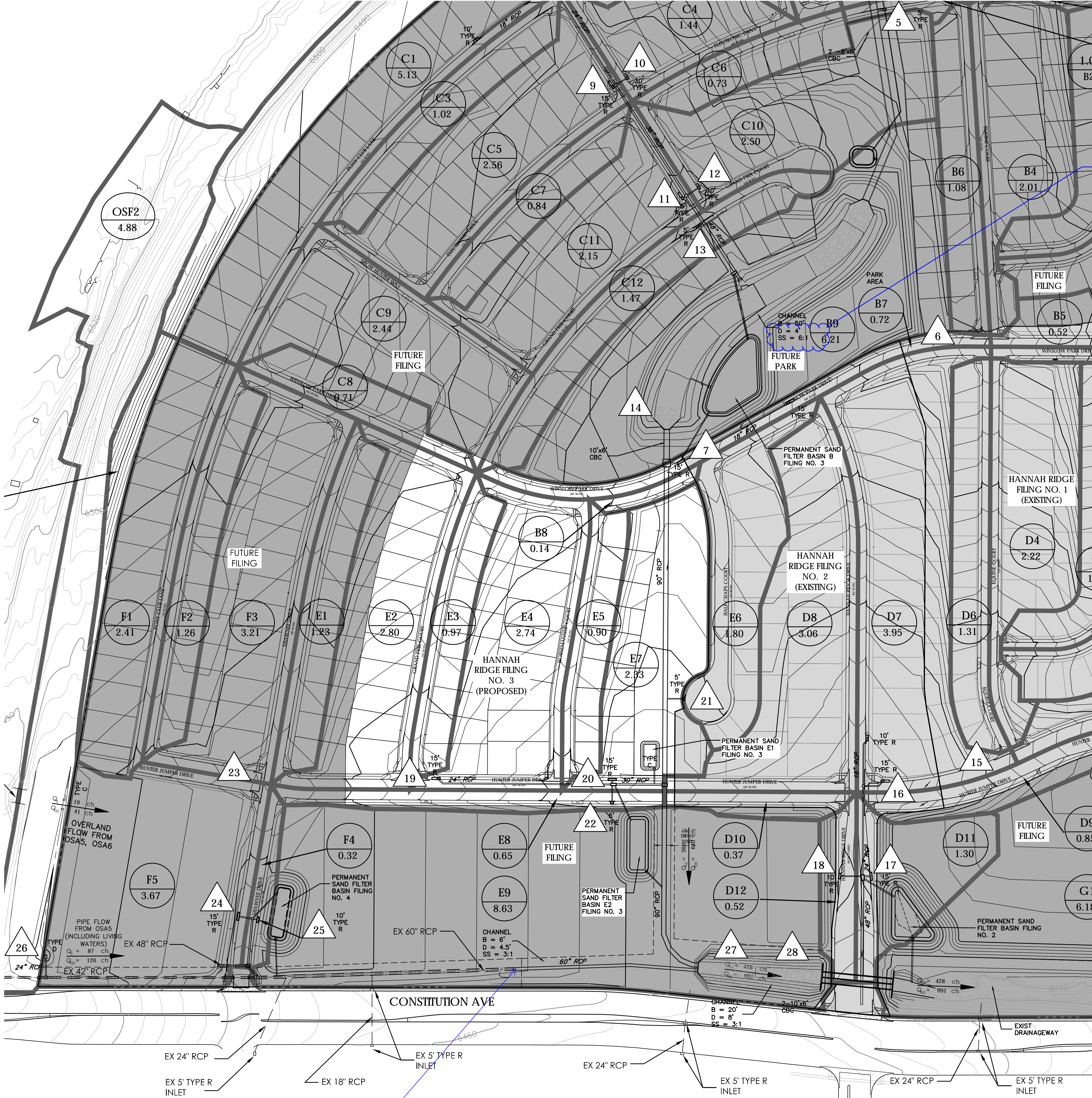
**Hannah Ridge at Feathergrass**

**Filing No. 3**  
**DEVELOPED**  
**Drainage Map**

MVE PROJECT **60970**  
MVE DRAWING **60970112-F3**

April 20, 2017  
SHEET 1 OF 2





provide s=  
(slope - this  
channel grade  
looks steep)

label  
proposed 60"  
tie-in

NOTE: SEE INCLUDED GRADING PLAN  
FOR INTERM GRADES OF HANNAH  
RIDGE AT FEATHERGRASS FILING NO. 3

**LEGEND**

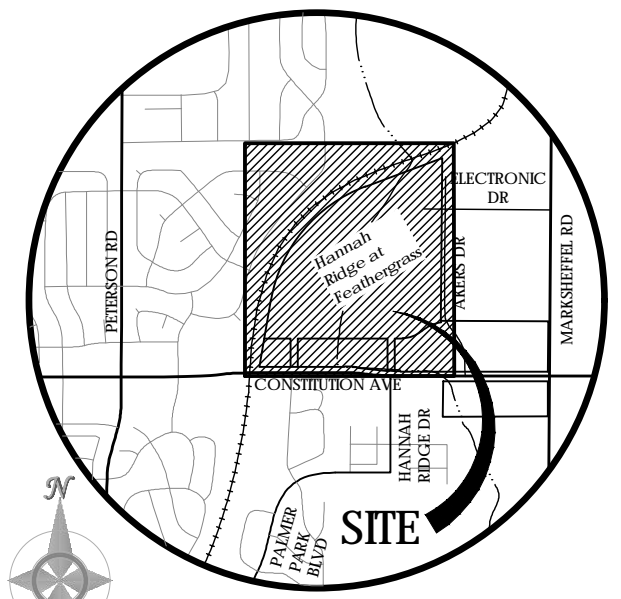
- EXISTING INDEX CONTOUR
- EXISTING STORM DRAIN CURB INLET
- EXISTING STORM DRAIN LINE
- EXISTING PROPERTY LINE
- EXISTING ROAD
- DRAINAGE BASIN BOUNDARY
- DRAINAGE BASIN DESIGNATION
- DRAINAGE BASIN AREA
- FLOW DIRECTION AND QUANTITIES
- FLOW DIRECTION
- DESIGN POINT

Provide an exhibit/plan showing all drainage  
maintenance access roads/trails and  
easements.

DEVELOPED SUMMARY RUNOFF TABLE

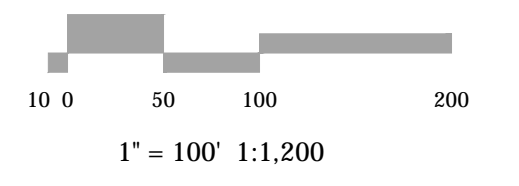
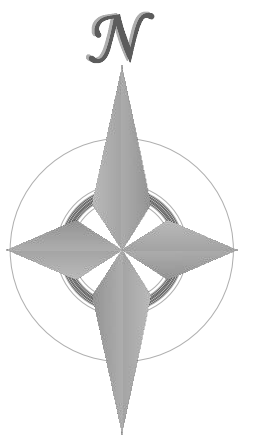
BASIN of DESIGN POINT	CONTRIBUTING BASINS	CONTRIBUTING AREA (AC)	5-YR(Q5) RUNOFF (CFS)*	100-YR (Q100) RUNOFF (CFS)	DESCRIPTION
OSA1 (IN)		425	374 *	915 (IN)	
1 (OUT)	OSA1	425	360 *	640 (OUT)	EX 7x7 CBC
2	OSA1, OSA2, A6	430.8	360 *	640 *	12'Wx6'H CBC
3	A1,A2,OSA3,A3	4.2	9.4	18.8	CROSS PAN
4	A1,A2,OSA3,A3,A4	4.4	9.7	19.2	10' TYPE R INLET (SUMP)
5	A5	0.2	0.7	1.3	5' TYPE R INLET (SUMP)
6	OSB1,B1,B2,B3,B4,B5,B6	8.2	19.5	38.5	CROSS PAN
7	OSB1,B1,B2,B3,B4,B5,B6,B7	8.9	20.4	40.1	15' TYPE R (SUMP), 15' TYPE R INLETS
8	OSC1,C1	8.6	15.0	31.1	10' TYPE R (SUMP), 10' TYPE R INLETS
9	C3,C5	3.6	8.9	17.8	15' TYPE R INLET (SUMP)
10	C2,C4	2.3	5.5	10.9	10' TYPE R INLET (SUMP)
11	C7,C8,C9,C11	6.1	13.4	26.6	15' TYPE R INLET (SUMP)
12	C6,C10	3.2	6.6	14.1	10' TYPE R INLET (SUMP)
13	C12	1.5	3.7	7.4	5' TYPE R INLET (SUMP)
14	OSA1-A6,OSB1-B9, OSC1-C12	476	360 *	640 *	10'Wx6'H CBC & 90" RCP
15	D1,D2,D3,D4,D5,D6	7.8	19.2	38.0	CROSS PAN
16	D1,D2,D3,D4,D5,D6,D7	11.7	26.6	52.8	10' TYPE R & 15' TYPE R INLETS
17	D1-D7,D9,D11	13.9	29.6	59.0	15' TYPE R INLET (SUMP)
18	D8,D10,D12	4.0	8.7	17.1	10' TYPE R INLET (SUMP)
19	E1,E2,E3	5.0	11.9	23.7	15' TYPE R INLET
20	E1,E2,E3,E4,E5,E7	11.0	23.4	48.4	15' TYPE R (SUMP), TYPE C INLETS
21	E6	1.8	4.5	9.0	5' TYPE R INLET (SUMP)
22	E8	0.7	1.8	3.6	5' TYPE R INLET (SUMP)
23	OSF1,F1,F2,F3	7.4	16.2	32.5	CROSS PAN
24	OSF1,F1,F2,F3,F5	11.0	23.4	48.4	15' TYPE R (SUMP), TYPE C INLETS
25	F4	0.3	0.9	1.9	5' TYPE R INLET (SUMP)
26	OSF2	4.9	4.2	9.6	TYPE D INLET (SUMP)
27	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5	619	428 *	991 *	OPEN CHANNEL
28	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5, D1-D12	647	428 *	991 *	DBL 10'Wx6'H CBC
29	OSA1-A6,OSB1-B9, OSC1-C12, E1-E9, OSF1-OSF3, F1-F5, D1-D12, G1	685	457 *	1076 *	EXISTING DBL 12'Wx6'H CBC

\* NOTE: MAIN CHANNEL MINOR STORM FLOW RATES ARE 10-YEAR IN ACCORDANCE WITH DRAINAGE BASIN PLANNING STUDY

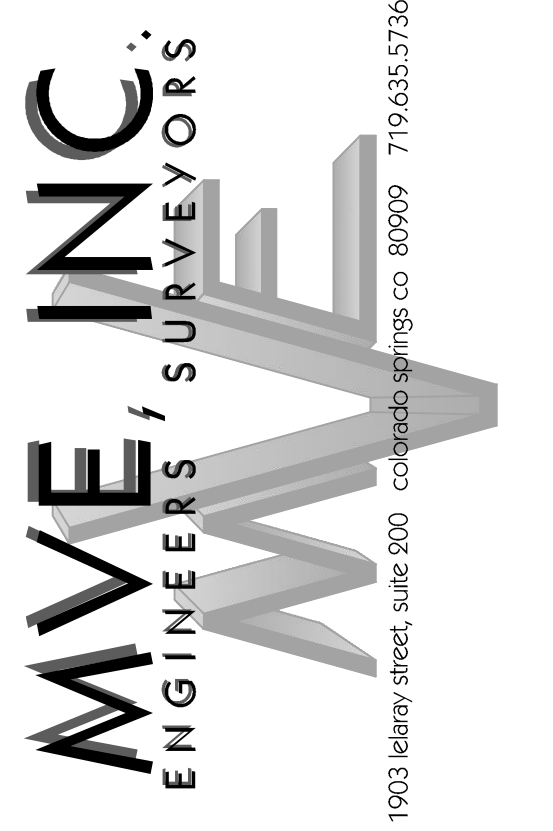


**VICINITY MAP**

BENCHMARK  
THE BENCHMARK FOR THESE PLANS IS THE TOP OF #4 REBAR, PANEL POINT NO. 1, LOCATED ON THE SOUTH EDGE OF CONSTITUTION AVE AND THE WEST EDGE OF THE ROCK ISLAND TRAIL, 535 FEET WEST OF THE CENTERLINE OF SHAWNEE DR. ELEVATION = 6486.63. (EPC DATUM ELEVATION = 6485.29).



1" = 100' 1:1,200



REVISIONS

DESIGNED BY  
DRAWN BY  
CHECKED BY  
AS-BUILTS BY  
CHECKED BY

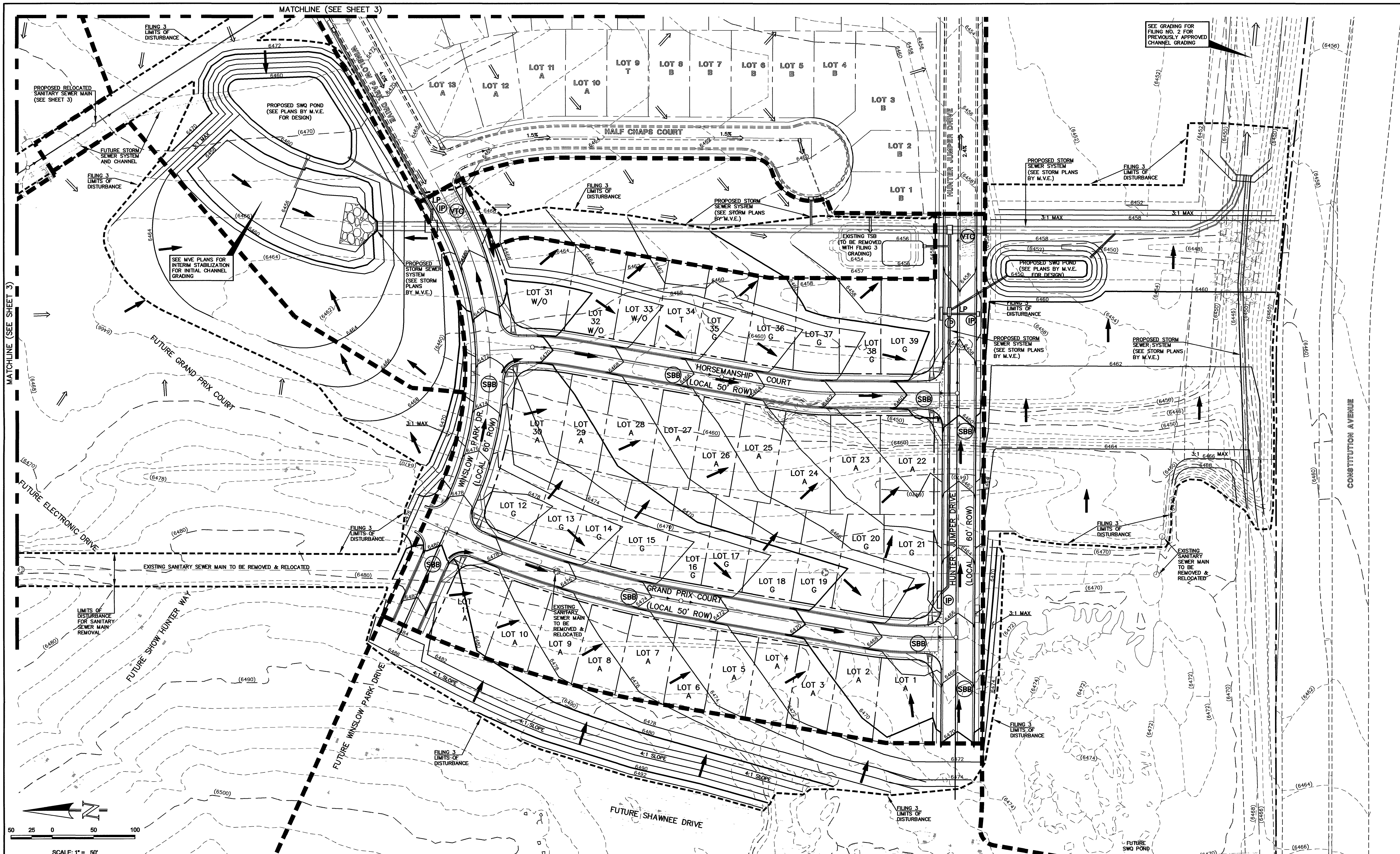
**Hannah Ridge at Feathergrass**

**Filing No. 3  
DEVELOPED  
DRAINAGE MAP**

MVE PROJECT 60970  
MVE DRAWING 60970112-F3

April 20, 2017  
SHEET 2 OF 2





LEGEND	
EXISTING CONTOUR	(6060) ---
PROPOSED CONTOUR	6060 ---
PHASE LINE	-----
A LOT	"A"
B LOT	"B"
WALKOUT LOT	"W/O"
GARDEN LOT	"G"
TRANSITION LOT	"T"
PROPOSED FLOW	→
EXISTING FLOW	→
INLET PROTECTION	IP
SILT FENCE	SF
VEHICLE TRACKING CONTROL	VTC
(2) STRAW BALE CHECK DAM (BOTH SIDES OF ROADWAY)	SBB

48 HOURS BEFORE YOU DIG,  
CALL UTILITY LOCATORS  
**811**  
UTILITY NOTIFICATION OF COLORADO  
IT'S THE LAW

THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE CAUSED BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.

NO	REVISION	DATE

REVIEW.

PREPARED UNDER MY DIRECT SUPERVISION FOR AND ON BEHALF OF CLASSIC CONSULTING ENGINEERS AND SURVEYORS, LLC

KYLE R. CAMPBELL, COLORADO P.E. #29794      DATE

**CLASSIC**  
CONSULTING ENGINEERS & SURVEYORS

6385 Corporate Drive, Suite 101  
Colorado Springs, Colorado 80919

(719) 785-0790  
(719) 785-0799 (fax)

HANNAH RIDGE AT FEATHERGRASS FILING NO. 3 OVERLOT GRADING AND EROSION CONTROL PLAN			
DESIGNED BY	KRC	SCALE	DATE 04/11/17
DRAWN BY	MES	(H) 1" = 50'	SHEET 2 OF 4
CHECKED BY		(V) 1" = N/A	JOB NO. 1116 03

X:\111600\DRAWINGS\CONSTRUCTION\FILING 3\111600-FIL3-06-02.dwg, 7/21/2017 3:46:24 PM, CCESSonora.rvt, g3





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**Page Label:** 19  
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**Author:** dsdrice  
**Date:** 8/29/2017 10:59:10 AM  
**Color:** ■

(The latest template can be provided if needed.)



**Subject:** Callout  
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**Checkmark:** Unchecked  
**Author:** dsdrice  
**Date:** 8/29/2017 8:33:20 AM  
**Color:** ■

If the required upstream drainage/ponding easement has not been obtained, this needs to be done to protect the ponding area.



**Subject:** Callout  
**Page Label:** 21  
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**Author:** dsdrice  
**Date:** 8/28/2017 4:31:28 PM  
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this subdivision



**Subject:** Cloud+  
**Page Label:** 24  
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**Date:** 8/29/2017 12:33:22 PM  
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At least 0.53 (per ECM Appendix L). This filing is only lots and streets. (47%-51% per pond calcs.)



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**Date:** 8/29/2017 11:33:26 AM  
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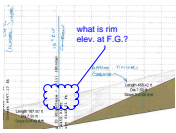
Highlight or circle the areas of concern with this filing.



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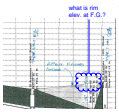
Provide for Constitution





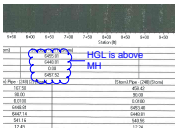
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**Color:** ■

what is rim elev. at F.G.?



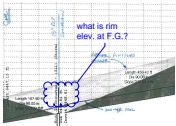
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**Date:** 8/29/2017 11:40:41 AM  
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what is rim elev. at F.G.?



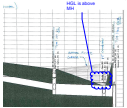
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HGL is above MH



**Subject:** Cloud+  
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**Date:** 8/29/2017 11:42:20 AM  
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what is rim elev. at F.G.?



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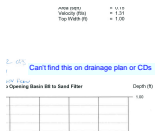
HGL is above MH



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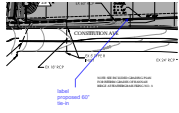
Also provide Q5 and Q100 calcs.





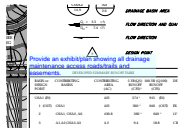
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Can't find this on drainage plan or CDs



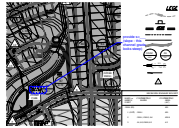
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label proposed 60" tie-in



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**Date:** 8/29/2017 3:28:49 PM  
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Provide an exhibit/plan showing all drainage maintenance access roads/trails and easements.



**Subject:** Cloud+  
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**Date:** 8/29/2017 12:37:16 PM  
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provide s=\_\_\_\_  
(slope - this channel grade looks steep)